NATIONAL HIGH MAGNETIC FIELD LABORATORY

2015 ANNUAL REPORT

ANNUAL REPORT 2015

National High Magnetic Field Laboratory

DIRECTOR
Gregory Boebinger

DEPUTY LAB DIRECTOR
Eric Palm

USERS PROGRAM, CHIEF OF STAFF
Anke Toth

PHONE NUMBER
850-644-0311

FAX NUMBER
850-644-8350

NATIONAL MAGLAB

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DIRECTOR'S EXECUTIVE SUMMARY

Record Number of Users, High-Quality Research and Engaging Education

A Worldwide User Resource

In 2015, the National MagLab established, once again, a record number of 1,615 users, representing single investigators from 175 universities, government labs, and private companies in the United States, and more than 300 institutions worldwide. About 20 percent of the 2015 users identified as female (with 8 percent of our users choosing not to respond) and 6 percent identified as minority (with 12 percent of our users choosing not to identify). New researchers continue to rotate into the MagLab community: 24 percent of the 492 principal investigators in 2015 were first-time principal investigators and 755 (or 47 percent) of our users at the postdoc and student levels conducted their first experiments at the lab in 2015.

At the end of each year, MagLab users submit brief summaries of their experiments, research, and scholarly endeavors. In 2015, users generated 478 research reports. All reports are available online at: https://nationalmaglab.org/research/publications-all/research-reports

The most appropriate measure of the quality of the research performed at the National MagLab is represented by the 431 articles published in peer-reviewed journals in 2015, many in the scientific community's most prestigious journals, including *Nature, Science, Physical Review Letters, Analytical Chemistry, Energy Fuels,* and *The Proceedings of the National Academy of Sciences.* For a full listing of the 2015 publications, visit https://nationalmaglab.org/research/publications-all/publications-search.

MagLab users are not only scientifically productive during their visits, they are also positive about their time at the lab. The sixth annual user survey was conducted in summer 2015 and, with 227 users responding, the survey continues to show overwhelming satisfaction with the MagLab user experience:

- 99 percent of users were satisfied with the assis-tance provided by MagLab technical staff.
- 96 percent of users were satisfied with the per-formance of the facility and equipment.
- 93 percent of users were satisfied with the proposal process.
- 91 percent of users plan to publish in a peer-reviewed journal as a result of their magnet time.

Attracting New Users

Across the National MagLab's seven user facilities, enhancements and upgrades were completed in 2015 to continue to serve the user community in delivering experimental environments for transformative research. Enhancements to user facilities included:

- The ICR facility opened the user program on the *first actively-shielded 21 tesla Fourier transform ion cyclotron resonance mass spectrometer*. The 21 tesla magnet is the highest field superconducting magnet ever used for FT-ICR and features high spatial homogeneity, high temporal stability, and negligible liquid helium consumption
- *New interphase transformers and passive filters* were installed in all four DC Field power supplies in 2015 providing a higher power level and more effective noise filters, reducing even further the ripple on the DC current supplying the resistive and hybrid magnets.
- The *four DC Field cooling towers* that are the final stage of heat transfer between the resistive magnets and the atmosphere underwent a complete rebuild during 2015.
- The *1.3 GW generator / utility interface breakers* at the Pulsed Field Facility were refurbished to prevent problems and minimize downtime.
- *A hybrid photon counting pixel array X-ray detector* was tested as part of the X-ray diffractometer development for the 25 T split helix magnet.
- DC Field staff worked on the development of a *vibrating coil magnetometer* for characterizing high temperature superconductors by allowing for the investigation of very high critical currents and magnetization currents in HTS materials over a wide range of angle, field, and temperature.

DIRECTOR'S EXECUTIVE SUMMARY

- In the High B/T facility, ultra-low-noise radiofrequency capabilities are being added to Bay 2 to enable *resistance-detected NMR* of quantum Hall samples. This technique will help probe the spin properties of exotic fractional quantum Hall states. In the AMRIS and NMR/MRI facilities, *new probe development* included the creation of a triple resonance magic angle spinning low-E probe for the 750 MHz NMR instrument, as well as first-generation probes for the soon-to-be-commissioned 36T Series Connected Hybrid (SCH) magnet that deliver an upgrade to unprecedented operating frequencies for high-resolution NMR.
- Continued development of *dynamic nuclear polarization* across the lab including on the 4.7 and 11.1 tesla MRI systems.

Magnet Science and Technology (MS&T) and the Applied Superconductivity Center (ASC) continued to develop high-performance magnet systems and advance our understanding of new materials for use in magnets.

- The 36 T Series Connected Hybrid (SCH) magnet has been fully assembled! Continued work on the monitor and control system is underway, which will be followed by system testing and, ultimately, commissioning for our user program.
- Final prototype-testing and coil-winding for the 32 T All-Superconducting magnet was completed in 2015. This magnet in prototype reached a field of 27 T on June 5, which, thus, already claims the world record for field strength for an all-superconducting magnet.
- Pulsed magnets made a significant step forward in 2015. The workhorse 65 T short-pulse magnet was upgraded to a 74 T magnet system with the bore of 7 mm. The magnet operates stably and has delivered more than 50 shots above 70 T for users to perform successful experiments at temperatures as low as 500mK.

In 2015, more than 400 lectures, talks or presentations were given by MagLab staff across 20 countries, a major contributor to the continued attraction of new users to the lab. Nine conferences and workshops were held in 2015 including the User Summer School, which hosted 28 early career experimentalists, and the Winter Theory School, which hosted 72 participants.

The launch of the MagLab's new website at the start of 2015 was one of our biggest highlights. The new site offers more content for scientific experts and a modern, mobile-friendly look that better showcases the lab's instruments, research output and expertise. With user-focused features introduced on the new website, traffic to the user-specific scientific sections of the website saw a 55 percent increase in a single year.

Staff changes and accolades

A number of important staff changes took place in 2015. The most prominent is the addition of National Academy of Science member Laura Greene who became the MagLab's chief scientist on August 17, bringing more than 30 years of scientific expertise and perspective to the MagLab's upper management team. Chris Hendrickson was named director of lab's ICR Facility, just as the facility unveiled the new world-record 21 tesla magnet system. Alan Marshall assumed the role of Chief Scientist of the ICR Program.

Researchers across the lab were widely recognized in 2015 for the impact of their leadership and research:

- Greg Boebinger, Director of the National MagLab, was awarded the Francis G. Slack Award by the Southeastern Section of the American Physical Society for his service to advancing physics across the region and nation. Boebinger was also selected as the inaugural chair of the newly formed Global High Magnetic Field Forum (HiFF) with the signing of a memorandum of understanding in July 2015. HiFF includes representatives from the major high magnetic field laboratories in China, Europe, Japan and the United States, working together to promote research and technology development using high magnetic fields.
- National MagLab and Los Alamos National Laboratory physicist Albert Migliori won the top instrumentation prize of the American Physical Society – the Joseph F. Keithley Award for Advances in Measurement Science.
- Lev Gor'kov was a 2015 Ugo Fano Prize winner for his key contributions to the theory of superconductivity.
- Mike Davidson was named a Distinguished Scientist by the Microscopy Society of America. Known for his groundbreaking work with florescent proteins, Davidson inspired recent Nobel Prize winner Eric Betzig in the development of his photo-activated localization microscopy (PALM).

DIRECTOR'S EXECUTIVE SUMMARY

- The Institute of Electrical and Electronics Engineers (IEEE) presented their Award for Continuing and Significant Contributions in the Field of Large Scale Applications of Superconductivity to W. Denis Markiewicz. Markiewicz led the development of the MagLab's 900 MHz Ultra Wide Bore NMR/MRI magnet and is now working on the 32 T All-Superconducting magnet project.

In addition to the above individual accomplishments, 96 Ph.D. Dissertations and Master Theses were awarded in 2015 for research performed using MagLab facilities.

Commitment to Diversity, Education, and Collaborations

Following the decision to retool the diversity efforts at the MagLab late last year, the Diversity Committee developed in 2015 a new strategic plan and expanded the membership of both the internal Diversity Committee and the External Advisory Committee to draw upon a broader range of expertise in diversity and inclusion.

The MagLab consistently develops new partnerships and collaborations with universities, other laboratories, private companies, and community and educational groups. In 2015, the lab had over 100 partnerships, nearly half of which were with industry.

The MagLab continued to reach students, teachers, and the public throughout 2015. Across the lab's three sites, more than 7,200 K-12 students had a tour or received outreach in 2015. Scientists from across the lab helped facilitate an annual Open House that hosted 5,700 visitors, and another 73 researchers engaged in additional outreach to more than 2,450 people in 2015. More than 113 K-12 students participated in long-term mentorship, internship or camp programs during the year, with another 24 undergraduates participating in the eight-week Research Experiences for Undergraduates across all three sites.

As has already been mentioned, the MagLab launched a new website with additional content for our users. The new website also includes a revamped education section, Magnet Academy, designed for teachers, students, and other curious visitors looking for information on electricity and magnetism. The site caters to diverse learning styles featuring a "ways to learn" option and enables site visitors to filter content by age, grade level, and topic. In its first year alone, the website has received more than a million page views.

Looking ahead …

The MagLab continues to make great progress on a number of large magnet projects. The Series Connected Hybrid (SCH) magnet is nearing completion, preparing to provide 36 T at 1 ppm homogeneity while consuming only 14 MW of power. Additionally, the transformational 32 T All-Superconducting Magnet is also nearing completion and is expected to come online in 2016. This magnet will provide users with a nearly 50% increase in fields available from superconducting magnets. Work is also continuing on a 40 tesla-class resistive magnet that will use the full capacity of our recently upgraded DC magnet power supplies.

Researchers will continue to explore the potential application of "no insulation" REBCO magnet technology, a new technology which set a world record for a high-temperature superconducting (HTS) coil operating inside a high-field resistive magnet at 40.2 T. In addition to eclipsing the previous record of 35.4 T, the test demonstrated the impressive potential of a new way of making high-field superconducting magnets that may offer robust protection against quenching, although much testing remains to be done.

Other facilities and departments around the lab are continuing to make great progress on a wide variety of instrumentation developments and enhancements for users. These are described in their individual chapters.

Finally, we could not summarize the year without including in that summary the terrible loss that occurred at the MagLab on October 21, 2015 when one of our employees suffered fatal injuries while performing construction work on the Series Connected Hybrid magnet. This devastating loss of a friend and coworker has strengthened the MagLab's affirmation of and dedication to the supreme importance of safety at our laboratory. New procedures, processes, infrastructure, and training have been put in place to better ensure that all staff, users, and visitors are safe while at the MagLab. These are described in more detail in the Safety section of this annual report.

CHAPTER 1
2015 YEAR AT A GLANCE

A Range of Research Possibilities

1 LAB, 3 SITES, 7 USER FACILITIES,

3 IN-HOUSE RESEARCH GROUPS & MAGNET DEVELOPMENT

The only facility of its kind in the United States, the National High Magnetic Field Laboratory (National MagLab) is the largest and highest-powered magnet laboratory in the world.

Located at Florida State University, the University of Florida and Los Alamos National Laboratory, the National MagLab expands the boundaries of scientific knowledge and advances basic science, engineering and technology in the 21st century.

In 2015, 1,615 researchers from academia and the corporate world conducted cutting-edge research using our unique, world-record instruments. The MagLab exists for these users to explore promising new materials, research pressing global energy problems and expand our understanding of the biochemistry that underlies living things by performing experiments in our seven user facilities:

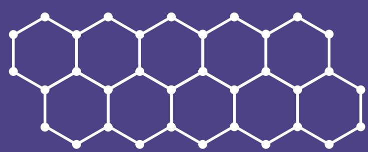
- **Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS)**
- **DC Field**
- **Electron Magnetic Resonance**
- **High B/T**
- **Ion Cyclotron Resonance**
- **Nuclear Magnetic Resonance & Magnetic Resonance Imaging/ Spectroscopy**
- **Pulsed Field**

The lab also has a number of important in-house research groups that complement the user facilities through development of new techniques, theories and equipment, including **Materials & Condensed Matter Science, Geochemistry** and **Cryogenics.**

The MagLab's **Magnet Science & Technology (MS&T)** group and **Applied Superconductivity Center (ASC)** work to develop the most efficient and strongest resistive, pulsed, superconducting and hybrid magnets in the world.

WE USE MAGNETS TO STUDY

MATERIALS



Scientists use our magnets to explore semiconductors, superconductors, crystals, and atomically thin materials — research that reveals the secret workings of materials and empowers us to develop new technologies.

- Graphene
- Correlated Electrons
- Topological Matter
- Kondo/Heavy Fermion Systems
- Magnetism and Magnetic Materials
- Quantum Fluids and Solids
- Qubits & Quantum Entanglement
- Semiconductors
- Superconductivity
- Molecular Conductors

ENERGY

Scientists use magnets to study energy and the environment. They work to optimize petroleum refining, advance potential biofuels such as pine needles and algae, and fundamentally change the way we store and deliver energy by developing better batteries.

- Petroleomics
- Catalysis
- Dissolved Organic Matter
- Lithium Battery Imaging
- Biofuels
- Superconductivity - Applied Research
- Fuel Cell Membranes
- Geochemistry
- Environmental Analysis

LIFE

Scientists study the foundational science of protein and disease molecules that underlies the cells and creates life itself. This work could improve future treatment of AIDS, cancer, Alzheimer's and other diseases.

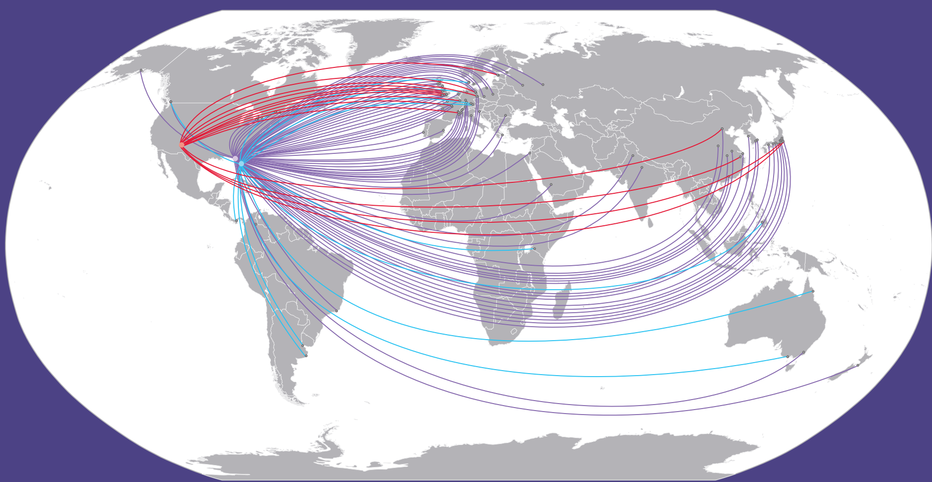
- Natural Products
- Quadrupolar NMR
- Dynamic Nuclear Polarization
- Sodium MRI
- Membrane Proteins
- Metabolomics
- Biomarkers

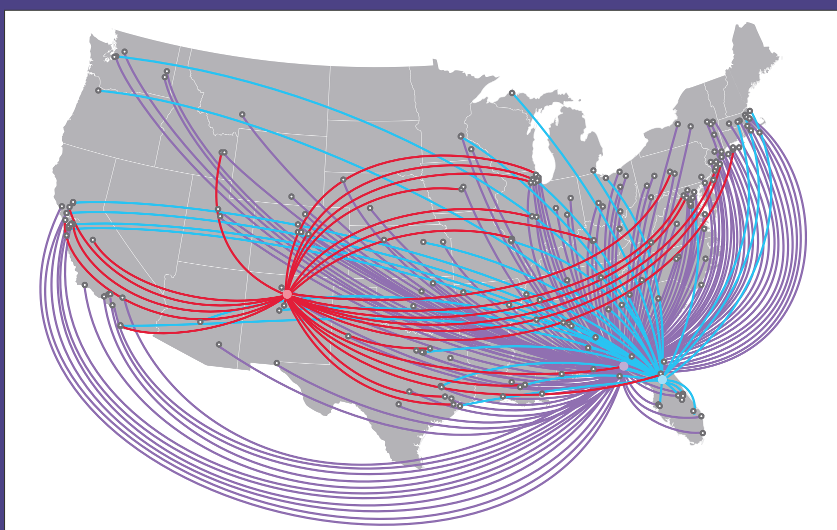
2015 LAB STATS

Users	1,615
Percentage of Users who were new	24
Awards & Honors	14
MagLab World Records	14
Articles Published in Peer-reviewed Journals	431
Patents & Other Products	4
Number of Principal Investigators	492
Books, Chapters, Reviews & other One-time Publications	6
Ph.D. Dissertations & Master Theses	96

MagLab's Worldwide User Community

In 2015, the MagLab's **1,615** users represented **175** universities, government labs and private companies in the United States and a total of **314** worldwide.





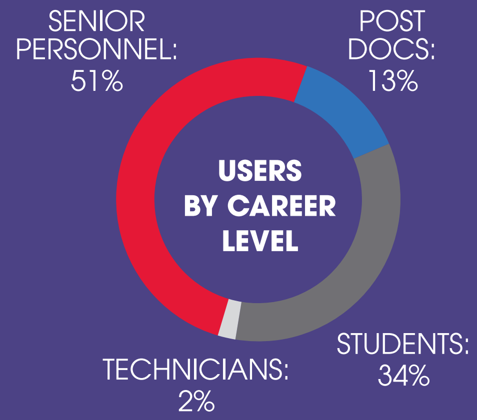
DOMESTIC INSTITUTIONS

- 131 UNIVERSITIES
- 32 GOVERNMENT LABS
- 12 PRIVATE COMPANIES

INTERNATIONAL INSTITUTIONS

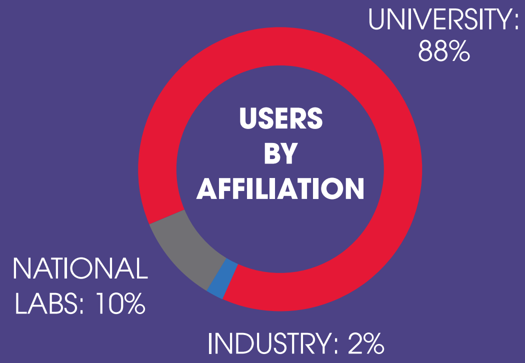
- 102 UNIVERSITIES
- 30 GOVERNMENT LABS
- 7 PRIVATE COMPANIES

USER DIVERSITY



DC FIELD - **555**
NMR - **226**
AMRIS - **257**
PULSED FIELD - **160**
HIGH B/T - **21**
EMR - **157**
ICR - **239**

29% OF STUDENTS AND **27%** OF POSTDOCS ARE FEMALE



WHAT OUR USERS SAY

96%

OF USERS WERE SATISFIED WITH PERFORMANCE OF THE FACILITIES AND EQUIPMENT.

99%

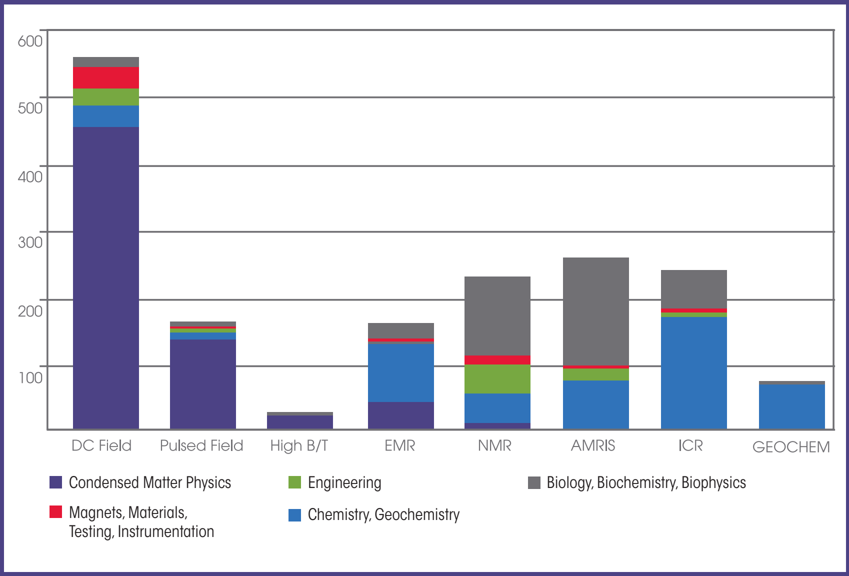
OF USERS WERE SATISFIED WITH THE ASSISTANCE PROVIDED BY MAGLAB TECHNICAL STAFF.

91%

OF USERS PLAN TO PUBLISH IN A PEER-REVIEWED JOURNAL AS A RESULT OF THEIR MAGNET TIME.

Data reflects external users only. All users were surveyed anonymously.

2015 USERS BY DISCIPLINE



The MagLab's interdisciplinary research environment brings scientists from a variety of disciplines to explore materials, energy and life.

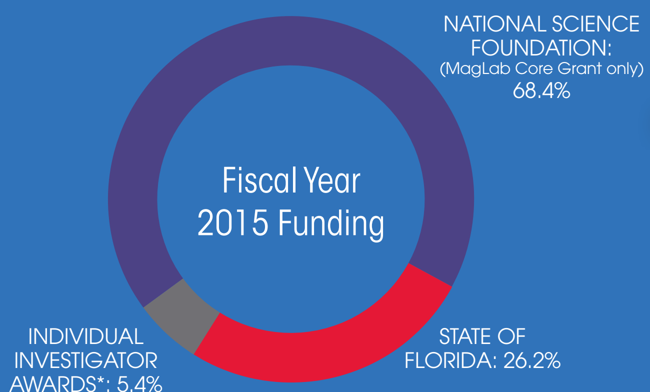
We had a great and extremely productive week while we were in Tallahassee. **Our experiment went as smoothly as it could have thanks to the Millikelvin staff.** They were always there to help us load our samples and prepare the probes that needed a bit of modification for our experiment. They were perfect. Furthermore, we had great interactions with other scientists there who were not even formally part of the experiment … who spoke with us about the theoretical implications and interpretations of our data. **These discussions were invaluable.** The trip to Tallahassee would have been worth it just to speak with them!

— Tyler Merz, Stanford University
Millikelvin Facility (DC Field Facility) user March 2015

Dollars and Cents

FINANCIAL REPORT

TOTAL BUDGET: $49,240,407



Physics & Materials Research: **47%**
Magnets, Materials & Engineering: **25%**
Chemistry: **9%**
Biology & Biochemistry: **7%**
Management & Administration: **10%**
Education/Diversity: **2%**

*These are new 2015 awards from funding other than the NSF core grant and State of Florida that benefit the MagLab user program.

PARTNERS

UNIVERSITIES **16**
SPINOFFS **8**
INDUSTRY **47**
LABS & INSTITUTES **17**
COMMUNITY & EDUCATIONAL GROUPS **12**

100
Cross-Sector Partners

The MagLab develops partnerships with the private sector to bring new technologies to the marketplace.

4% of MagLab users plan to acquire a patent as a result of their experiment at our facility.

SHARING A STAKE IN SCIENCE

Multiple Investments = Multiplied Impacts

For every $1 invested by the National Science Foundation, the MagLab leverages an additional $1 for infrastructure, buildings and staff.

ECONOMIC IMPACT

THE MAGLAB **ANNUALLY GENERATES**		OVER THE NEXT 20 YEARS, **PROJECTED TO GENERATE**
IN THE USA		IN THE USA
$182 million in economic output	→	**$3.6 billion** in economic output
more than **1,560 jobs**		more than **31,000 jobs**

RETURN ON INVESTMENT

$1 INVESTED BY THE STATE = **$6.57** ECONOMIC ACTIVITY IN FLORIDA

Building the STEM Pipeline

ENGAGING THE COMMUNITY

5,700 visitors at 2015 Open House.

1,000+ people toured the lab.

73 scientists engaged in community outreach to **2,450+** people.

1 MILLION page views to newly launched website.

ENGAGING STUDENTS & TEACHERS

7,270 K-12 students participated in outreach or a tour.

24 students in Research Experiences for Undergraduates program across all 3 sites. **88%** from underrepresented groups.

113 students in long-term mentorship, internship or camp programs. **68%** from underrepresented groups.

ENGAGING EARLY CAREER SCIENTISTS

400+ lectures, talks or presentations given by MagLab staff across 20 countries.

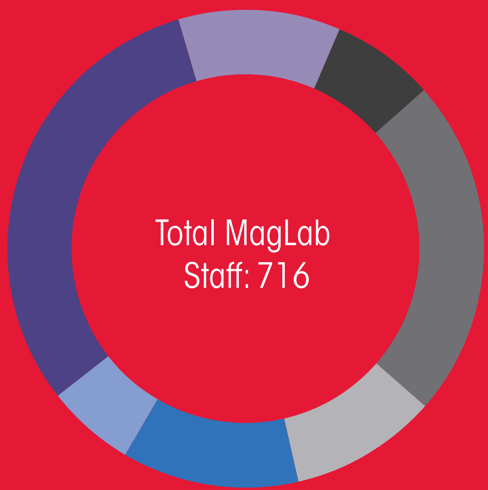
28 participated in User Summer School.

72 participated in Theory Winter School.

755 of the MagLab's users were postdocs or students.

MAGLAB STAFFING

Personnel at FSU, UF & LANL includes employees funded by the NSF Core Grant or State of Florida.



Senior Personnel: **228**
Other Professional: **88**
Postdoc: **58**
Graduate Student: **159**
Undergraduate Student: **69**
Support Staff - Technical/Managerial: **81**
Support Staff - Secretarial/Clerical: **33**

Postdocs, graduate students and undergraduate students make up **40%** of the staff.

42% OF UNDERGRADS
39% OF GRAD STUDENTS
34% OF POSTDOCS
ARE FEMALE

CHAPTER 2
LABORATORY MANAGEMENT

CHAPTER 2 – LABORATORY MANAGEMENT

1. Organizational Chart

The Florida State University (FSU), the University of Florida (UF) and Los Alamos National Laboratory (LANL) jointly operate the National High Magnetic Field Laboratory (NHMFL or MagLab) for the National Science Foundation (NSF) under a cooperative agreement that establishes the lab's goals and objectives. FSU, as the signatory of the agreement, is responsible for establishing and maintaining administrative and financial oversight of the lab and ensuring that the operations are in line with the objectives outlined in the cooperative agreement.

The structure of the MagLab is shown in the four figures below. **Figure 1** illustrates the external oversight and advisory committees, as well as the three internal committees that provide guidance to NHMFL leadership.

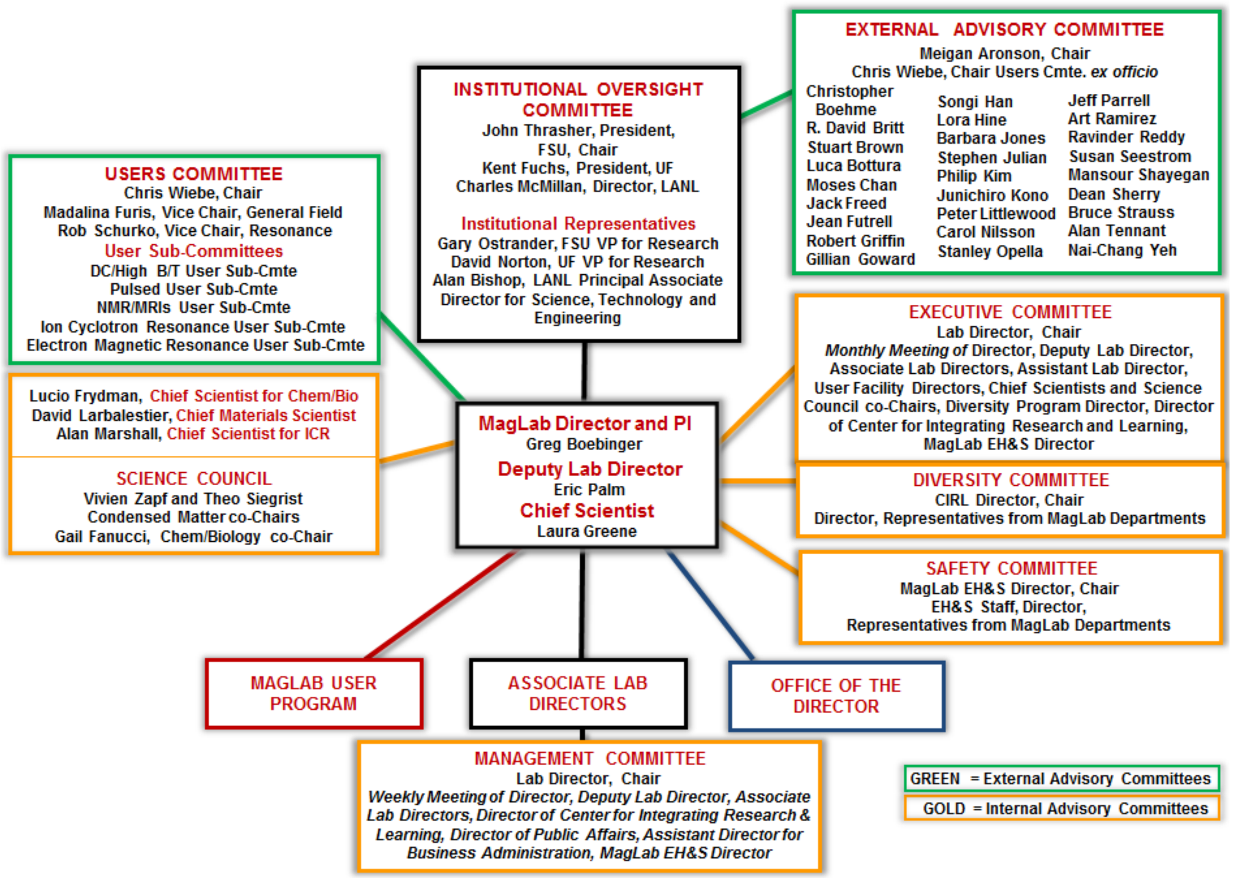


Figure 1: *Advisory Committees of the MagLab, showing internal and external advisory committees (as of June 6, 2016).*

CHAPTER 2 – LABORATORY MANAGEMENT

Greg Boebinger is the Director of the MagLab and PI of the cooperative agreement. Together, the Director and Deputy Laboratory Director, **Eric Palm**, function as a team to provide management oversight for the laboratory. The management committee — consisting of the Associate Lab Directors, co-chairs of the Science Council, Director of CIRL, EH&S Director and the Assistant Director for Business Administration — meets on a weekly basis to discuss issues of importance across the MagLab. The Executive Committee meets on a monthly basis to discuss lab wide issues as well as program – specific issues.

The lab's scientific direction is overseen by the Science Council, a multidisciplinary "think-tank" group of distinguished faculty from all three sites. Members are: Vivien Zapf (co-chair), Theo Siegrist (co-chair), Gail Fanucci (co-chair), Luis Balicas, Zhehong Gan, Lev Gor'kov, Neil Harrison, Stephen Hill, Kevin Ingersent, Jurek Krzystek, Joanna Long (ex officio), Ross McDonald, Amy McKenna, Mark Meisel, Albert Migliori (ex officio), Dragana Popovic, Ryan Rodgers, John Singleton, Stanley Tozer, Glenn Walter and Huub Weijers including the four chief scientists Laura Greene (Chief Scientist), Lucio Frydman (Chief Scientist for Chemistry & Biology), David Larbalestier (Chief Materials Scientist) and Alan Marshall (Chief Scientist for ICR).

Two external committees meet regularly to provide critical advice on important issues. The **External Advisory Committee**, made up of representatives from academia, government, and industry, offers advice on matters critical to the successful management of the lab. The **Users Committee,** which reflects the broad range of scientists who conduct research at the lab, provides guidance on the development and use of facilities and services in support of the work of those scientists. These committees and their 2015 meetings are further described below.

Figure 2 shows the structure of the user program with its seven user facilities – DC Magnet Field Facility, Pulsed Magnetic Field Facility, High B/T Facility, Electron Magnetic Resonance Facility, Nuclear Magnetic Resonance and Magnetic Resonance Imaging at Florida State University and at University of Florida and Ion Cyclotron Resonance.

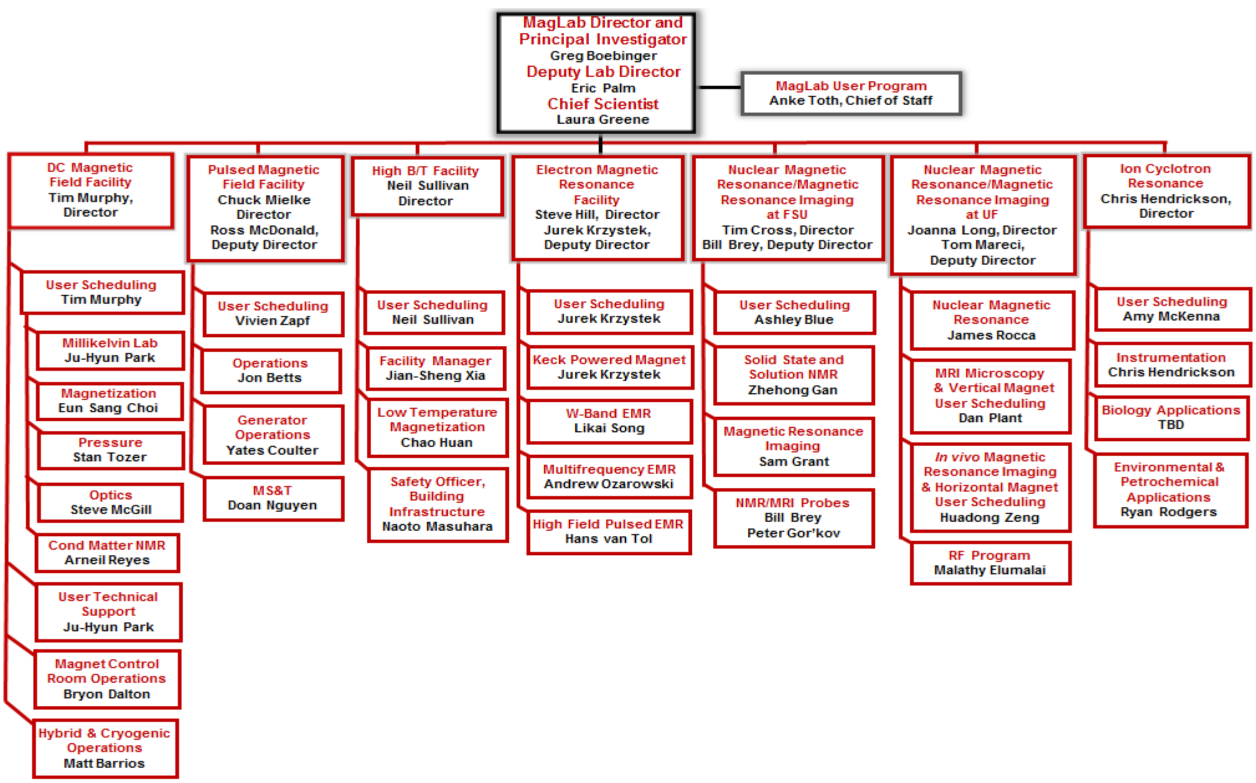


Figure 2: *NHMFL User Program (as of June 6, 2016).*

CHAPTER 2 – LABORATORY MANAGEMENT

Figure 3 displays the internal, operational organization of the laboratory. It includes the seven user facilities, all Associate Lab Directors as well as the Office of the Director structure.

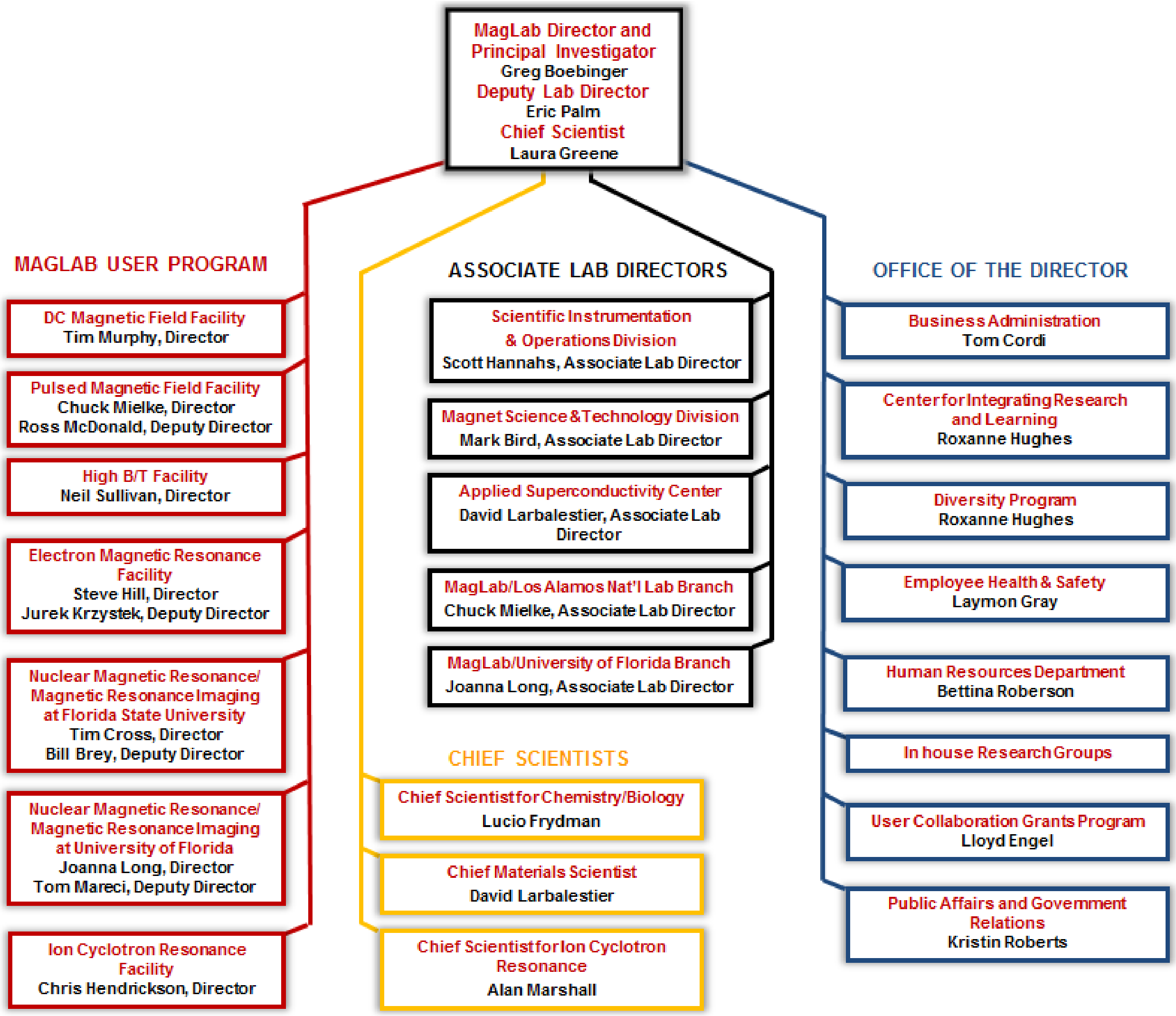


Figure 3*: MagLab Organizational Chart (as of June 6, 2016).*

CHAPTER 2 – LABORATORY MANAGEMENT

2. External Advisory Committee

The External Advisory Committee met August 4-6, 2015, in Tallahassee. This report called out the success of the MagLab and provided advice in the form of recommended actions and priorities of the MagLab. This advice spanned challenges faced by budgetary constraints and the lab's renewal in coming years. The list below shows External Advisory Committee members at the date of their 2015 meeting.

EXTERNAL ADVISORY COMMITTEE MEMBERS & AFFILIATIONS

Meigan Aronson
External Advisory Committee Chair
Texas A&M University

Chris Wiebe
User Committee Chair (ex officio member of EAC)
University of Winnipeg

Lora Hine
Director of Educational Programs for the Cornell High Energy Synchrotron Source

Magnet Technology and Materials Subcommittee
Luca Bottura
Magnets, Superconductors and Cryostats
Jeff Parrell
Oxford Superconducting Technology
Bruce P. Strauss
US Department of Energy

Biology and Chemistry Subcommittee
R. David Britt
UC-Davis
Jack Freed
Cornell University
Jean Futrell
Battelle
Gillian R. Goward
McMaster University
Robert Griffin
MIT
Songi Han
University of California, Santa Barbara
Carol Nilsson
University of Texas Medical Branch
Stanley Opella
UC- San Diego
Ravinder Reddy
University of Pennsylvania
Dean Sherry
UT Southwestern

Condensed Matter Subcommittee
Stuart Brown
University of California, Los Angeles
Moses Chan
Penn State University
Barbara A. Jones
IBM Almaden Research Center
Stephen Julian
University of Toronto
Philip Kim
Columbia University
Junichiro Kono
Rice University
Peter Littlewood
Argonne National Laboratory
Art Ramirez
University of California, Santa Cruz
Susan Seestrom
Los Alamos National Laboratory
Mansour Shayegan
Princeton University
Nai-Chang Yeh
California Institute of Technology

CHAPTER 2 – LABORATORY MANAGEMENT

3. Users Committee

The Magnet Lab's Users Committee represents the MagLab's broad, multidisciplinary user community and advises the lab's leadership on all issues affecting users of our facilities. The Users Committee is elected from the user base of the NHMFL. Each facility has a subcommittee elected by its users to represent their interests to the NHMFL. DC Field and High B/T facilities have a single, combined subcommittee representing the two user facilities. Likewise, the NMR facilities at UF and FSU have a single, combined subcommittee. Pulsed Field, ICR, and EMR facilities have their individual subcommittees. Each subcommittee then elects members to represent it on the Users Executive Committee. This Users Executive Committee elects a chair and two vice chairs. The DC Field/High B/T Advisory Committee, the Pulsed Field Advisory Subcommittee, the EMR Advisory Subcommittee, the NMR/MRI Advisory Committee, and the representative from the ICR Advisory Committee met October 27-29 in Los Alamos, NM to discuss the state of the laboratory and provide feedback to the NSF and MagLab management.

USER ADVISORY COMMITTEE MEMBERS & AFFILIATIONS

DC Field/Pulsed Field/High B/T Advisory Committee

James Analytis, University of California, Berkeley
Kenneth Burch, University of Toronto
Jason Cooley, Los Alamos National Laboratory
Nathanael Fortune*, Smith College
Madalina Furis*, University of Vermont
Wei Pan, Sandia National Laboratory
Jeanie Lau, University of California, Riverside
Makariy Tanatar, US DOE The Ames Laboratory
Chris Wiebe*, University of Winnipeg

EMR Advisory Committee

Chris Key, University College London
Christos Lampropoulos, University of North Florida
Dane McCamey, The University of New South Wales
Stefan Stoll, Department of Chemistry
Kurt Warncke*, Emory University
Sergei Zvyagin, Dresden High Magnetic Field Laboratory

ICR Advisory Committee

Jonathan Amster, University of Georgia
Michael Chalmers, Eli Lilly and Company
Michael Freitas, Ohio University Medical Center
Elizabeth Kujawinski, Woods Hole Oceanographic Institution
John Shaw, University of Alberta
Forest White, Massachusetts Institute of Technology

NMR/MRIs Advisory Committee

Ed Chekmenev, Vanderbilt University
Joanna Collingwood, University of Warwick
Linda Columbus*, University of Virginia
Myriam Cotton, Hamilton College
Oc Hee Han, Korea Basic Science Institute
Brian Hansen, University of Aarhus
Michael Harrington, Huntington Medical Research Institute
Doug Kojetin, Scripps Institute
Manish Mehta, Oberlin College
Len Mueller, University of California, Riverside
Tatyana Polenova, University of Delaware
Scott Prosser, University of Toronto
Marek Pruski, Ames Laboratory, Iowa State University
Rob Schurko*, University of Windsor
Fang Tian, Penn State University

*Member of User Executive Committee

CHAPTER 2 – LABORATORY MANAGEMENT

4. Personnel

A. KEY FACULTY AND STAFF

As of January 13, 2016, seven hundred sixteen people (716) worked for or were affiliated with the MagLab at FSU, UF, and LANL in 2015 compared to 725 in 2014. A list of MagLab key faculty and staff is presented below. All information in the Personnel section is as of January 13, 2016.

PRINCIPLE INVESTIGATORS

Greg Boebinger
Director/Professor, Professor of Physics
Joanna Long
MagLab Chemistry & Biology Director and Associate Professor, Biochemistry & Molecular Biology (UF)
Alan Marshall
Ion Cyclotron Resonance (FSU)
Charles Mielke
Director, Pulsed Field Facility at LANL and Deputy Group Leader
Neil Sullivan
High B/T Facility (UF)

USER FACILITY DIRECTORS

Timothy Cross
Nuclear Magnetic Resonance (FSU)
Stephen Hill
Electron Magnetic Resonance
Joanna Long
Nuclear Magnetic Resonance (UF)
Chris Hendrickson
Ion Cyclotron Resonance
Chuck Mielke
Pulsed Field Facility
Tim Murphy
DC User Program
Neil Sullivan
High B/T Facility

KEY PERSONNEL

Director's Office

Boebinger, Gregory
Director/Professor, Professor of Physics
Hughes, Roxanne
Assistant Scholar/Scientist, Director, Center for Integrating Research and Learning
Palm, Eric
Deputy Lab Director
Roberson, Bettina
Assistant Director, Administrative Services
Roberts, Kristin
Director of Public Affairs
Rodman, Christopher
Interim - Asst Dir, Environmental, Safety, Health & Security Services

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Management and Administration

Cordi, Thomas
Assistant Lab Director, Business Administration
Greene, Laura
Chief Scientist
Kynoch, John
Assistant Director
McEachern, Judy
Assistant Director, Business Systems
Rea, Clyde
Assistant Director, Business & Financial / Auxiliary Services
Wood, Marshall
Facilities Electrical Supervisor

DC Instrumentation

Barrios, Matthew
Research Engineer
Dalton, Bryon
Scientific Research Specialist, Control Room Head
Hannahs, Scott
Research Faculty III
Jensen, Peter
Network Administrator
Powell, James
Research Engineer (Electronic Shop)
Williams, Vaughan
Research Engineer (Machine Shop)

Magnet Science and Technology

Adkins, Todd
Research Engineer
Bird, Mark
Research Faculty III, Director, Magnet Science & Technology
Bole, Scott
Research Engineer
Cantrell, Kurtis
Research Engineer
Dixon, Iain
Research Faculty III
Gavrilin, Andrey
Research Faculty III
Goddard, Robert
Scientific Research Specialist
Godeke, Arno
Research Faculty II
Gundlach, Scott
Research Engineer
Guo, Wei
Professor
Han, Ke
Research Faculty III
Hilton, David
Research Faculty I
Lu, Jun
Research Faculty II
Markiewicz, William
Research Faculty III
Marks, Emsley
Research Engineer
Marshall, William
Sr Research Associate
Miller, George
Research Engineer

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Noyes, Patrick
Associate in Research
O'Reilly, James
Research Engineer
Painter, Thomas
Sr Research Associate
Toth, Jack
Research Faculty III
Van Sciver, Steven
Professor
Viouchkov, Youri
Research Engineer
Voran, Adam
Research Engineer
Walsh, Robert
Sr Research Associate
Weijers, Hubertus
Research Faculty II
Xin, Yan
Research Faculty II
Zavion, Sheryl
Sr Research Associate (MS&T Operations Manager)

Condensed Matter Science

Albrecht-Schmitt, Thomas
Professor
Baek, Hongwoo
Research Faculty I
Balicas, Luis
Research Faculty III
Baumbach, Ryan
Research Faculty I
Beekman, Christianne
Assistant Professor
Bonesteel, Nicholas
Professor
Cao, Jianming
Professor
Chiorescu, Irinel
Professor
Choi, Eun Sang
Research Faculty II
Coniglio, William
Research Faculty I
Dalal, Naresh
Professor
Dobrosavljevic, Vladimir
Professor
Engel, Lloyd
Research Faculty III
Fajer, Piotr
Professor
Gao, Hanwei
Assistant Professor
Gor'kov, Lev
Professor
Graf, David
Research Faculty I
Hill, Stephen
Professor/EMR Director
Hoch, Michael
Visiting Scientist/Researcher
Jaroszynski, Jan
Research Faculty II
Knappenberger, Kenneth
Assistant Professor
Kovalev, Alexey
Assistant In Research
Krzystek, Jerzy
Research Faculty III
Kuhns, Philip
Research Faculty III
Li, Zhiqiang
Research Faculty I
Manousakis, Efstratios
Professor
McGill, Stephen
Research Faculty II
Murphy, Timothy
Director, DC Field Facility
Oates, William
Assistant Professor
Ozarowski, Andrzej
Research Faculty II
Park, Ju-Hyun
Research Faculty II
Popovic, Dragana
Research Faculty III
Ramakrishnan, Subramanian
Associate Professor
Reyes, Arneil
Research Faculty III
Riggs, Scott
Research Faculty I
Rikvold, Per
Professor
Schlottmann, Pedro
Professor
Shatruk, Mykhailo
Assistant Professor

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Siegrist, Theo
Professor
Smirnov, Dmitry
Research Faculty III
Smith, Julia
Research Faculty I
Song, Likai
Research Faculty I
Suslov, Alexey
Research Faculty III
Telotte, John
Associate Professor
Tozer, Stanley
Research Faculty III
Trociewitz, Bianca
Research Engineer
Vafek, Oskar
Associate Professor
van Tol, Johan
Research Faculty III
Whalen, Jeffrey
Research Faculty I
Yang, Kun
Professor

LANL

Balakirev, Fedor
Staff Member
Betts, Jonathan
Technical Staff Member
Chan, Mun Keat
Staff Members
Coulter, Yates
Head of Generator Operations
Crooker, Scott
Staff Member
Harrison, Neil
Staff Member
Hinrichs, Mark
Electrical Engineer
Jaime, Marcelo
Staff Member
Maiorov, Boris
Staff Member
McDonald, Ross
Deputy Director, Pulsed Field Facility
Mielke, Charles
Director, Pulsed Field Facility at LANL and Deputy Group Leader
Migliori, Albert
Staff Member and LANL Fellow
Nguyen, Doan
Director of Pulsed Field Facility Magnet Science and Technology
Ramshaw, Brad
Staff Member
Singleton, John
Staff Member and LANL Fellow
Zapf, Vivien
Director of Pulsed Field User Program/ Staff Member

NMR

Alamo, Rufina
Professor
Arora, Rajendra
Professor
Brey, William
Research Faculty III
Cross, Timothy
Professor
Frydman, Lucio
Scholar / Scientist
Fu, Riqiang
Research Faculty III
Gaffney, Betty
Professor of Biology
Gan, Zhehong
Research Faculty III
Gor'kov, Peter
Sr Research Associate
Grant, Samuel
Associate Professor
Hallinan, Daniel
Assistant Professor
Houpt, Thomas
Professor
Hu, Yanyan
Assistant Professor
Hung, Ivan
Assistant in Research

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Kim, Jeong-su
Assistant Professor
Kitchen, Jason
NMR Engineer
Litvak, Ilya
Assistant in Research
Paravastu, Anant
Assistant Professor
Qin, Huajun
Associate in Research
Ranner, Steven
Research Engineer
Rosenberg, Jens
Visiting Research Faculty I
Schepkin, Victor
Research Faculty II
Shekar, Srinivasan
Research Faculty I
Smith, James
Professor
Wi, Sungsool
Research Faculty II
Zhang, Fengli
Research Faculty I
Zhou, Huan-Xiang
Associate Professor

ICR

Blakney, Gregory
Research Faculty II
Corilo, Yuri
Research Faculty I
Kaiser, Nathan
Research Faculty I
Lobodin, Vladislav
Research Faculty I
Lu, Jie
Assistant in Research
Marshall, Alan
Professor, Chief Scientist for Ion Cyclotron Resonance (ICR) and Robert O. Lawton Distinguished Professor of Chemistry
McKenna, Amy
Research Faculty II
Podgorski, David
Research Faculty I
Quinn, John
Research Engineer
Rodgers, Ryan
Research Faculty III
Young, Nicolas
Research Faculty I

UF

Abernathy, Cammy
Professor, Materials Science & Engineering, Dean, College of Engineering
Andraka, Bohdan
Associate Research Professor
Angerhofer, Alexander
Professor, Chemistry
Ashizawa, Tetsuo
Melvin Greer Professor and Chairman, Department of Neurology, Executive Director McKnight Brain Institute
Biswas, Amlan
Associate Professor of Physics
Blackband, Stephen
Professor, Neuroscience
Bowers, Clifford
Associate Professor, Chemistry
Brey, Wallace
Professor Emeritus, Chemistry
Butcher, Rebecca
Assistant Professor
Cheng, Hai Ping
Professor of Physics
Christou, George
Drago Professor
Douglas, Elliot
Associate Professor, Materials Science & Engineering
Elumalai, Malathy
RF Engineer

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Eyler, John
Professor Emeritus, Chemistry
Fanucci, Gail
Associate Professor
Febo, Marcelo
Assistant Professor
Fitzsimmons, Jeffrey
Professor, Radiology
Forder, John
Associate Professor of Radiology
Hamlin, James
Assistant Professor
Hebard, Arthur
Distinguished Professor of Physics
Hershfield, Selman
Professor
Hirschfeld, Peter
Professor
Ingersent, Kevin
Chair of UF Physics Department & Professor, Chair, UF Physics Dept.
Kumar, Pradeep
Professor
Labbe, Greg
Senior Engineer, Cryogenics Facility
Lai, Song
Associate Professor, Director, CTSI Human Imaging Core McKnight Brain Institute
Lee, Yoonseok
Professor
Long, Joanna
Associate Professor, NHMFL Director of AMRIS
Luesch, Hendrik
Associate Professor
Mareci, Thomas
Professor
Maslov, Dmitrii
Professor
Masuhara, Naoto
Senior Engineer, Microkelvin Laboratory
Meisel, Mark
Professor
Murray, Leslie
Assistant Professor
Pearton, Stephen
Distinguished Professor, Alumni Professor of Materials Science & Engineering
Polfer, Nicolas
Assistant Professor
Stanton, Christopher
Professor
Stewart, Gregory
Professor
Sullivan, Neil
Professor, Director of High B/T Facility
Takano, Yasumasa
Professor
Talham, Daniel
Professor
Tanner, David
Distinguished Professor of Physics
Vaillancourt, David
Associate Professor
Vandenborne, Krista
Professor
Vasenkov, Sergey
Associate Professor
Walter, Glenn
Associate Professor
Xia, Jian-Sheng
Associate Scientist
Zeng, Huadong
Specialist, Animal MRI/S Applications

ASC

Abraimov, Dmytro
Research Faculty II
Griffin, Van
Associate In Research
Hellstrom, Eric
Professor
Jiang, Jianyi
Research Faculty II
Kametani, Fumitake
Research Faculty I
Kim, Youngjae
Research Faculty 1
Larbalestier, David
Chief Materials Scientist, Director, Applied Superconductivity Center
Lee, Peter
Research Faculty III
Pamidi, Sastry
Assistant Scholar / Scientist

CHAPTER 2 – LABORATORY MANAGEMENT

Polyanskii, Anatolii
Research Faculty II
Starch, William
Associate in Research
Tarantini, Chiara
Research Faculty I
Trociewitz, Ulf
Research Faculty II

Geochemistry

Chanton, Jeff
Professor
Cooper, William
Professor
Froelich, Philip
Scholar / Scientist
Humayun, Munir
Professor
Odom, Leroy
Professor
Sachi-Kocher, Afi
Scientific Research Specialist
Salters, Vincent
Professor, Director, Geochemistry
Wang, Yang
Professor
White, Gary
Scientific Research Specialist
Zateslo, Theodore
Senior Engineer

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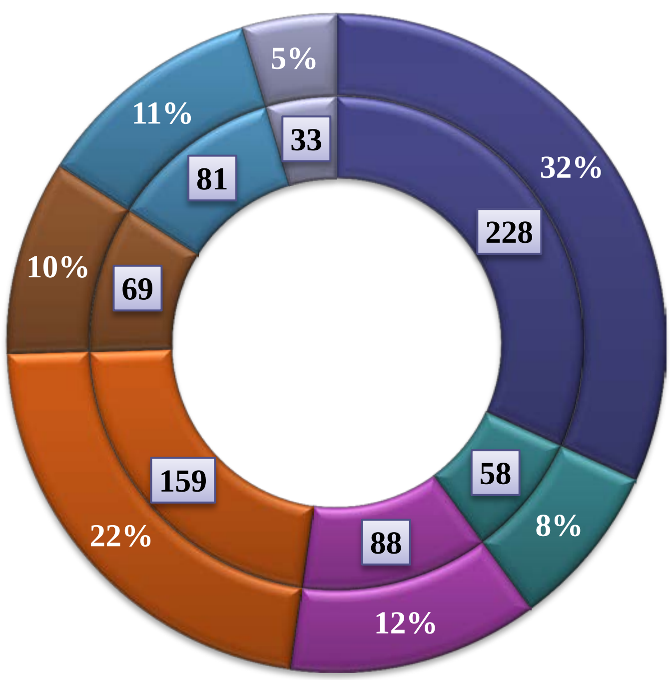
B. STAFFING AND DEMOGRAPHICS

The MagLab comprises 716 people at its three sites, who are paid by NSF use grant, State of Florida funding, individual investigator awards, as well as home institutions and other sources. Of that number, senior personnel represent the largest group at 32%, followed by graduate students at 22% and other professionals at 12%. The total distribution by NSF classification appears in **Figure 1.**

MagLab Staffing



Personnel at FSU, UF, and LANL includes NHMFL employees paid by the NSF Core Grant or State of Florida funding, plus all Affiliated Professors, Postdoctoral Researchers and Graduate Students.

- Senior Personnel, Total: 32%
- Postdoc, Total: 8%
- Other Professional, Total: 12%
- Graduate Student, Total: 22%
- Undergraduate Student, Total: 10%
- Support Staff - Technical/Managerial, Total: 11%
- Support Staff - Secretarial/Clerical, Total: 5%

***Figure 1:** MagLab Staffing*
Distribution by NSF Classification as of January 13, 2016, Total Personnel: 716

The NHMFL is committed to expanding and maintaining a diverse and inclusive organization to ensure a broad pool of highly qualified applicants for open positions to enhance our diversity efforts. Search committees are strongly encouraged to recruit minorities from underrepresented groups. Positions are advertised in venues that target women and minorities, e.g., Association for Women in Science (AWIS), National Society of Black Physicists (NSBP), etc. Additional contact is made through special subgroups of professional organizations, focused conferences and workshops. The Director's letter to each search committee chair for Senior Personnel provides guidelines for best practices to increase the

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recruitment of members of underrepresented groups. In addition, chairs of search committees for scientific staff meet with the Diversity Committee both before and after the search. This allows the Diversity Committee to help the search committee conduct a search that is as diverse as possible and then collects lessons learned from each committee to pass on to future search committees.

New permanent hires in 2015: Ten scientific senior personnel were hired (5 white males, 1 asian male, 2 asian females, 2 white females). Three of the senior personnel were hired as visiting faculty. Three changed from visiting faculty to permanent faculty. 1 is an Associate Professor in the College of Engineering. The remaining were hired after an extensive recruitment. Sixteen Postdoctoral Research Associate were hired (6 white males, 3 white females, 5 asian males, 2 asian females). Additionally, we hired one STEM related employee (black male).

Overall distribution of diversity for all three sites of the MagLab includes 52.50% white males, 23.20% Asian males and females, 18.90% white females, 4.60% black or African American, 5.60% Hispanic and <1% American Indian. The total distribution by Diversity appears in **Figure 2.**

MagLab Demographics

Personnel at FSU, UF, and LANL includes NHMFL employees paid by the NSF Core Grant or State of Florida funding, plus all Affiliated Professors, Postdoctoral Researchers and Graduate Students.

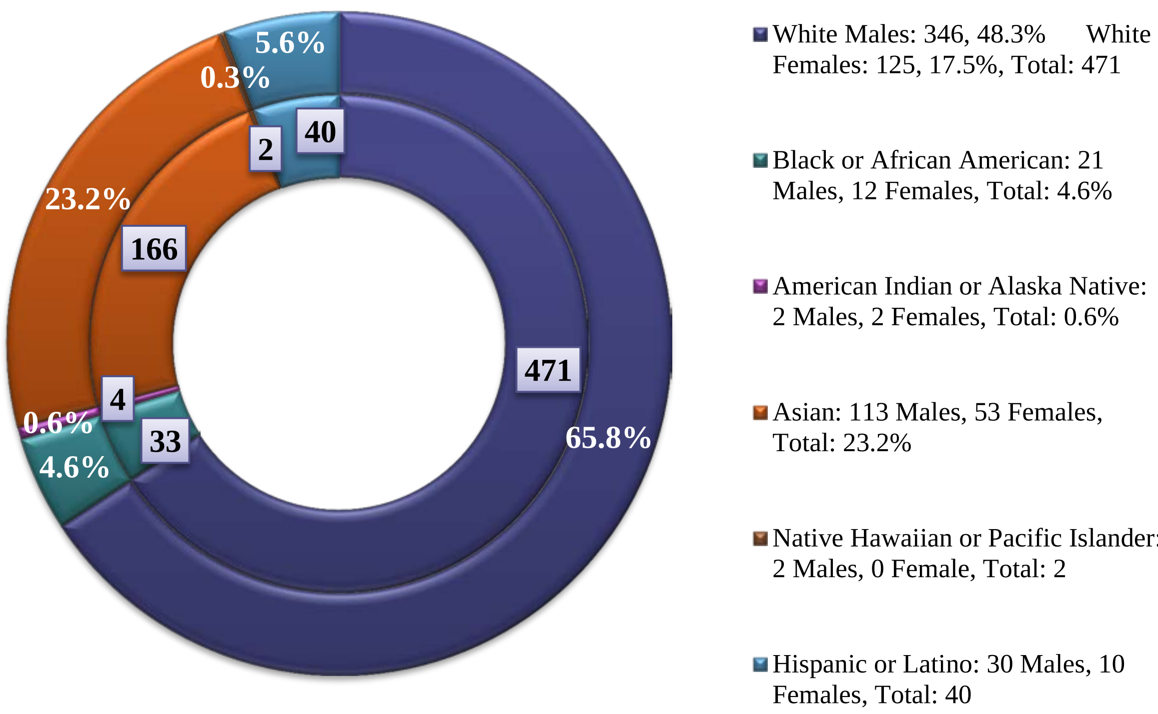

Figure 2: *MagLab Demographics*
Distribution by Diversity as of January 13, 2016, Total Personnel: 716

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5. Diversity and Inclusion

The National High Magnetic Field Laboratory (NHMFL) is committed to diversity. In late 2014, Dr. Roxanne Hughes was approved as the Diversity Chair for the NHMFL Diversity Committee. As part of this role, she and her staff completed two reports to help guide an updated strategic plan:

1. The first report helped the Diversity Committee and Lab Leadership determine trends and areas for us to focus on for our strategic plan. It included:
- A comparison of NHMFL diversity demographics to LANL and NSF statistics;
- NHMFL personnel demographics historically by job code, department, and year.
2. The second comprehensive report that included:
- A description of the lab's historical diversity programs and practices;
- A comparison of NHMFL diversity initiatives to DOE labs;
- A summary of best practices outlined by NSF ADVANCE grant awardees;
- A plan for utilizing these best practices along with addressing concerns raised by the APS climate survey, NSF, and the NHMFL Diversity Taskforce.

Both of these reports helped the Diversity Committee to update and develop their new strategic plan in 2015 which can be found at the end of this chapter. In addition, we expanded the membership of our External Advisory Committee to include a broader group of experts in diversity and inclusion initiatives. The members of the NHMFL Diversity Committee in 2015 were:

- Chair: Roxanne Hughes, FSU
- Gregory Boebinger, NHMFL Director
- Shermane Benjamin, FSU-Graduate Student
- Nick Bonesteel, FSU
- Marcelo Febo, UF
- Miranda Hacker, FSU Diversity Staff
- Ke Han, FSU
- Eric Hellstrom, FSU
- Steve Hill, FSU
- Jan Jaroszynski, FSU
- Jason Kitchen, FSU
- Amy McKenna, FSU
- Doan Ngyuen, LANL
- Dragana Popovic, FSU
- Bettina Roberson, FSU
- Kari Roberts, FSU
- Kristin Roberts, FSU
- Andreas Stier, LANL Postdoc
- Yasu Takano, UF
- Komalavalli Thirunavukkuarasu, FSU Postdoc
- Anke Toth, FSU
- Elizabeth Webb, UF
- Laurel Winter, LANL Postdoc

The members of our External Advisory Committee in 2015 were:

- C.J. Bacino, LANL Diversity Director
- Susan Blessing, FSU Physics Professor, Women in Math, Science, and Engineering Living and Learning (WIMSE) Director
- Alberto Camargo, Diversity Program Manager, Argonne National Laboratory
- Charmane Caldwell, Diversity and Inclusion Coordinator for Florida Agricultural and Mechanical University-Florida State University College of Engineering
- Simon Capstick, FSU Physics Professor
- Donna Dean, Tulane University School of Science and Engineering retired, Research focuses on improving mentoring for women
- Ted Hodapp, American Physical Society Director of Education and Diversity
- Keisha John, Director of Diversity Programs, Graduate and Postdoctoral Affairs, University of Virginia
- Michelle Douglas, Florida State University Director of Equal Opportunity and Compliance
- Nancy Marcus, FSU Dean of Graduate School
- Karen Molek, University of West Florida, Chemistry Associate Professor
- Bob Parks, Director of University of Florida Training and Organizational Development

In December of 2015, the approved Strategic Plan was sent to the External Advisory Committee for their feedback.

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The new strategic plan focuses on improving diversity within the STEM pipeline (which includes the NHMFL workforce but also the national STEM workforce). To accomplish this goal, our efforts are focused on: **outreach** to underrepresented and underserved populations in STEM from K-early career scientists; utilizing best practices in our **recruitment and hiring** strategies to improve the representation of underrepresented minority groups at the lab and in the STEM workforce; and the NHMFL is committed to creating a climate where all personnel feel that they have equal opportunities to career development and **mentoring** leading them to want to remain at the lab/within the STEM workforce (**retention**). As part of this updated strategic plan, the diversity committee has reorganized our subcommittee structure and our budget to align with these. In 2015 we formed three subcommittees to guide this process:

1. ***The Compliance Subcommittee***

This subcommittee ensures that hiring committees for STEM positions follow the proper procedures outlined in the hiring committee checklist found at the end of this chapter. Members review each hiring committees' initial advertisement for new positions to ensure that the advertisements are sent to networks that reach underrepresented groups and that the descriptions follow the best practices outlined by current research. Before hiring committees make a final offer to a candidate, they meet (in person or via email) with the compliance subcommittee for their final review of the process. This subcommittee also votes on Dependent Care Travel Grant requests.

2. ***The Recruitment Subcommittee***

This subcommittee reviews the lab's current recruiting practices and provides suggestions for improvement. Part of the Diversity Budget is allocated for recruitment (e.g. travel to conferences or Minority Serving Institutions.) This committee will receive all requests for recruitment trips and determine allocation of funds for travel. Individuals who go on recruitment trips provide a written report to the recruitment committee. This report will include: number of potential recruits; specific networking connections (e.g. connected recruit to person at the lab); and overall benefit of the trip. This subcommittee reports on their activities at the full Diversity Committee meeting.

3. ***The Retention, Advancement, and Mentoring Subcommittee***

This subcommittee plans annual sessions to address professional development and mentoring needs. A portion of the diversity budget is allocated for these sessions. In addition, this subcommittee votes on all budget requests for travel related to retention/advancement to determine which requests will be granted. This subcommittee reports their activities to the full Diversity Committee meeting. This subcommittee reviews the annual climate survey each year.

Diversity and Inclusion Budget

In order to align our Diversity and Inclusion budget with our strategic plan and our subcommittee structures, the full committee decided to structure the 2015 budget as it appears in Table 1. In 2016 we will address whether changes need to be made in terms of allotment of funds. (The diversity budget includes $100,000 from the NSF core grant and $70,000 from state).

Table 1: *2015 Diversity and Inclusion Budget*

Strategic Plan Category	Budget Item	Description	Estimated Allotment
Recruitment	FSU Physics Graduate Student Fellowships	$3000 is provided to up to 2 physics graduate students per year and can be renewed for one additional year. The diversity committee approves the graduate students and the chair of the physics department sends the offer letter.	< $12,000

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Strategic Plan Category	Budget Item	Description	Estimated Allotment
	GEM Membership	The MagLab is an employer member of this organization. GEM recruits high quality underrepresented students looking to pursue Master's and Doctoral degrees in applied science and engineering, and matches their specific skills to the specific technical needs of GEM employer members. Through this membership we can advertise positions with GEM to their more than 4000 members.	$5,000
	Recruitment Travel	This funding is set aside for MagLab staff to use for recruitment of underrepresented groups. It can be used to cover travel to Minority Serving Institutions or to travel to conferences that serve underrepresented minority groups in some format. (These replace the CO-WIN travel grants).	~$12,000
Retention, Advancement, and Mentoring	Professional Development Travel	This funding is set aside for MagLab staff to use for professional development that serves his/her individual development as well as the diversity mission of the lab.	~$12,000
	Bridge Funding	This funding is used to support students or postdocs for a limited time if the individual's current funding source has expired. This application must be submitted by the faculty member who will be supervising the student or postdoc. Graduate students and undergraduate students can be funded for up to one semester annually. Postdocs can be funded for up to 3 months annually.	~$70,000
Other	Discretionary funding	We have set aside a certain amount in case money is needed in any of our other categories.	$59,000

*Outreach is omitted from this budget because that is paid for by CIRL and PA's budget. (See Chapter 4). In 2015, we did not see any need to fund compliance issues since these were under the purview of Human Resources and lab Leadership.

The funding opportunities were not finalized until May of 2015 and were announced subsequently in June. The awards for 2015 are summarized below:

Recruitment Travel (Total funds spent in 2015 = $1150)

- Dr. Huan Chen, a Postdoctoral Associate in the Ion Cyclotron Resonance facility used a recruitment travel award to travel to Morgan State University (MSU). MSU is an HBCU in Maryland. Dr. Chen's visit included presentations to faculty and students about the NHMFL, the research occurring there, and her own research. The trip resulted in mentor connections for Dr. Chen and has resulted in a collaboration with the NHMFL, MSU, and Florida Agricultural and Mechanical University for a NSF NRT grant proposal (PI: Dr. Amy McKenna, NHMFL-ICR).

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Professional Development Travel (Total funds spent in 2015 = $9,879)

Five MagLab scientists utilized the professional development funds in 2015.

- *Dr. David Podorski*, from ICR, used his funds to travel to the Democratic Republic of the Congo to work on collaborative research on Watershed Management. Through this trip, Dr. Podorski strengthened the MagLab's work in environmental science initiatives and learned new environmental sampling techniques that will benefit the lab. He was also able to broaden the impact of our research by networking with faculty from various disciplines.
- *Ying Wang*, a graduate student from the Condensed Matter Science (CMS) group, used her funds to travel to the Big Ideas in Quantum Materials Conference where she also attended a workshop on sampling techniques. This trip resulted in Ying presenting her research and connecting herself and her supervisor, Dmitry Smirnov, to potential collaborators from University of California San Diego.
- *Dr. Komu Thirunavukkuarasu*, a postdoctoral researcher in the (CMS) group, used her funds to travel to the American Physical Society (APS) Conference. This trip occurred at a crucial transitional time in her career trajectory as she was searching for an academic position. The trip resulted in multiple new connections and strengthened some of her older collaborations.
- *Adewale Abiodun Akinfaderin*, a graduate student in the EMR group, used the funds to travel to the National Society of Black Physicists conference. He also volunteered at the booth at this conference to connect prospective students with opportunities at the MagLab. Over 100 people came to the booth, mainly undergraduates, and Adewale was able to tell them about the MagLab's REU program and the APS Bridge Program where he serves as a graduate student mentor.
- *Dr. Nihar Pradhan*, a postdoctoral research in the DC Field group, used his funds to travel to the Energy Materials Nanotechnology Fall meeting. This international conference aims to be a unique platform for leading scientists, researchers, scholars and engineers from academia, R&D laboratories and industry around the world to exchange, share and learn the most recent advancement on various aspects related to nanotechnology, and energy-related materials. Dr. Pradhan was able to present research conducted by a diverse group of his team including two high school interns that had worked with him on the research. The conference benefited the lab by broadening the audience of individuals who are familiar with our research.

Dependent Care Travel Grant (DCTG) Program

In 2015, the DCTG program was utilized by five early career scientists ($2328). Both *Dr. Thirunavukkuarasu* and *Dr. Pradhan* utilized the DCTG in addition to their Professional Development travel to provide support for their young children's care while on their respective trips. A research faculty member from Geochemistry used the funds to support the travel of his daughter to a conference. Two users were able to utilize the funds for travel to conduct research in Tallahassee at the MagLab.

Bridge Funding (Total funds spent in 2015 = ~$91,139)

In 2015, the Diversity Bridge Funding supported four graduate students, one postdoc, and 5 undergraduate students.

- Dr. Sam Grant from the NMR facility used the funds to support a female graduate student whose mentor, Dr. Jim Brooks passed away unexpectedly. These funds supported Ms. Amouzandeh for the spring semester.
- Dr. Gail Fanucci, from the UF AMRIS facility, was awarded funds to support her graduate student, Jackie Esquiaqui, for the fall semester in between NSF grants.
- Dr. George Christou, a UF Affiliated faculty member, was awarded funds to support his female graduate student between two NSF grants during the fall 2015 semester.
- Dr. Dragana Popovic, from the CMS group, was awarded funds to support a female postdoc in her group for 3 months as the team searched for other funding.
- Dr. Steve Hill, from the EMR group, was awarded a small supplement for his graduate student, Livia Batista of $240 per month for 6 months in 2015.

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- Dr. Vivien Zapf, from LANL, was awarded funds to support 5 female undergraduates from Harvey Mudd College to introduce them to graduate level research.

New Subcommittee Structure

Three new subcommittees were formed in April of 2015. The **Retention, Advancement, and Mentoring Subcommittee,** chaired by Eric Hellstrom, served mainly in the capacity of approving Bridge funding requests and Professional development requests. 2016 will include broadening professional development sessions and assessing the results of the climate survey to improve retention and advancement at the lab. The **Recruitment Subcommittee,** chaired by Kristin Roberts, approved all recruitment applications. In addition the team met regularly (every other month) to brainstorm plans for improving recruitment. They discussed improving incentives for faculty to participate in recruitment and lab leadership plans to recognize faculty for outreach and diversity efforts just as we do for safety based on the recommendations from this subcommittee. This subcommittee also compiled a list of conferences and meetings for organizations who serve underrepresented minorities combined with a list of the top HBCU and high Hispanic enrollment institutions from the NSF Higher Education Research and Development Survey. The subcommittee created sub-lists to show the top ten HBCUs and High Hispanic Institutions for engineering and physical science funding. The subcommittee plans to share these lists with hiring committees and use them directly to help create more targeted recruitment efforts for new users, staff and students. Plans for 2016 include increased advertisement for the Recruitment travel funds and potential workshops that could help us learn best practices for recruitment.

The **Diversity Compliance Subcommittee (DCS)**, chaired by Jason Kitchen, was formed, with the mission of increasing the instances where a diverse pool of applicants, especially those from underrepresented groups, can be fairly evaluated for consideration of each faculty level job opening at NHMFL. The DCS met with each hiring Search Committee at the start of the search process. These preliminary meetings ensured that each position search would follow the guidelines developed in 2015, including that at least one member from the Diversity Committee serve on each Search Committee, and that the position announcement would be posted with at least three organizations that serve underrepresented groups, such as the NSBP, AWIS, SACNAS, and NOBCChE. Also, all members of each Search Committee had to complete FRED (Implicit Bias) training, with the goals of reducing implicit biases in the search process that have historically discriminated against underrepresented groups. The DCS has developed tracking worksheets for each search where these metrics are recorded. After a candidate was selected for a position, the DCS was notified for its review and approval of the interview process. The DCS met with eight Search Committees during 2015 for faculty hires. Of those searches, four have been filled and four are still in process. One of the closed searches resulted in the hire of a member of an under-represented group. Plans for 2016 include to obtain more data on how candidates found out about position postings and to evaluate the effectiveness of the various outreach avenues for each position announcement.

Internal and External Assessment

In October of 2015, the Diversity Committee finalized an annual climate survey. This survey was sent to all MagLab personnel at all three sites. The survey included a weekly reminder to all personnel and was left open for 6 weeks. The results were analyzed in December and the full report will be presented in January 2016. Results of this internal assessment will allow the Diversity Committee and Lab leadership determine areas that need improvement and ways to address these needs. In December of 2015, Dr. Hughes sent our final Diversity and Inclusion Strategic plan with a deadline for feedback in February 2016 to our External Advisory Committee. We will use their feedback to guide our strategic plan as we move toward the Renewal process.

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MagLab Diversity Committee Strategic Plan
Completed May 2015

Mission statement: The Magnet Lab is committed to increasing diversity in the STEM workforce at the Magnet Lab and throughout the nation through our outreach, education, and mentoring programs.
The Magnet Lab is committed to building the STEM workforce through the following strategies:

1. The Magnet Lab's educational **outreach** programs strive to increase the public's understanding of the importance of STEM education, and to build a more diverse STEM pipeline by reaching underrepresented and underserved populations from pre-school children through early career scientists as well as the general public.
2. The Magnet Lab is committed to the **recruitment and hiring** of diverse candidates into STEM positions, both at the Magnet Lab and elsewhere in the STEM workforce.
3. The Magnet Lab is committed to the **retention and advancement** of our current STEM staff.
4. The Magnet Lab is committed to **career-long mentoring** for our scientific and engineering staff.
5. The Magnet Lab seeks **external guidance and advice** to advance our diversity goals. Members of this Advisory Diversity Committee can be found on our website https://nationalmaglab.org/staff-all/diversity/diversity-committees

Goals, Programming, and Metrics

Outreach

1. The Magnet Lab's **outreach** programs strive to increase the public's understanding of the importance of STEM education, and to build a more diverse STEM pipeline by reaching underrepresented and underserved populations from pre-school children through early career scientists as well as the general public.

Programs in existence to accomplish our outreach goals	Metrics for ensuring that our goals are reached.
K-12 outreach in classrooms – 50% or more of outreach occurs in Title I (low income) schools.	Post survey to teachers whose classes participated in outreach. (Comparison across Title I and non-Title I schools to ensure that teachers are satisfied).
Middle School Mentorship – This program includes students from Title I schools and from underrepresented groups.	Pre/post surveys with students and post survey with mentors. Student surveys measure changes in understanding of STEM research and STEM careers. Annual survey measuring STEM interest and career plans. Mentor survey measures levels of satisfaction and motivation for participating.
SciGirls Summer Camp – This program exposes girls to hands-on STEM opportunities and to STEM role models.	Pre/post student surveys that measure perceptions of STEM careers and professionals and interest in STEM careers. Annual survey measuring STEM interest and career plans.
Magnet Lab Summer Camp - This program includes students from Title I schools and from underrepresented groups.	Pre/post student surveys that measure perceptions of STEM careers and professionals and interest in STEM careers. Annual survey measuring STEM interest and career plans.

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Programs in existence to accomplish our outreach goals	Metrics for ensuring that our goals are reached.
NHMFL Internships - This program includes students from Title I schools and from underrepresented groups.	Pre/post student surveys that measure changes in understanding of STEM research and STEM careers. Annual survey measuring STEM interest and career plans. Mentor survey measures levels of satisfaction and motivation for participating.
Research Experiences for Teachers (RET) – 6 week program in the summer (~33% from Title I schools)	Pre/post teacher survey that measures changes in their understanding of STEM and confidence in teaching STEM. Post survey with mentors to determine motivations for participating and satisfaction.
Internships (e.g. volunteer and paid, APS Bridge Program) – this program includes underrepresented minority groups.	For students who participate in the internship program facilitated by CIRL (pre/post surveys measuring changes in understanding of STEM research and STEM careers).
Research Experiences for Undergraduates (REU) – this program includes participants from underrepresented minority groups.	For students - pre/post surveys measuring changes in understanding of STEM research and STEM careers. Annual survey measuring STEM interest and career plans. Mentor survey measures levels of satisfaction and motivation for participating.
User Summer School and Winter Theory School (coordinated by Condensed Matter Science) – this program reaches a diverse representation	Post surveys with participants to determine overall satisfaction with program, reactions to lectures, tours, and activities, and ideas for future schools.

Recruitment

2. The Magnet Lab is committed to the **recruitment and hiring** of diverse candidates into STEM positions, both at the Magnet Lab and elsewhere in the STEM workforce.

Age level or position level	Programmatic aspects	Metrics
Pre or early college (recruiting students to major in STEM)	Begins in middle school with our SciGirls program, middle school programs, and high school programs.	Annual survey measures plans to major in STEM in college or pursue a STEM career.
College (already STEM majors)	CIRL recruits for REU and internship participants at Minority Serving institutions and conferences.	Count the number of conferences and schools recruitment has occurred at. On application ask participants where they heard about the program.
	APS Bridge Program	Reviews by APS during the year.
Graduate School	MagLab staff tour perspective graduate students and attend minority serving conferences and universities to recruit.	Survey incoming graduate students to find out why they came to the department associated with the lab.

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Age level or position level	Programmatic aspects	Metrics
Postdoc	MagLab staff tour perspective postdocs and attend minority serving conferences and universities to recruit.	Survey incoming postdocs to find out why they came to the department associated with the lab.
Scientist hires	Hiring committees must complete the hiring checklist and return it to HR when a hire has been completed for all STEM hires. All members of hiring committees must attend a training session (e.g. FSU Supervisor Series, FRED training, other) on best practices for recruitment and hiring.	Hiring committees must present the job description and plan for recruitment to the diversity committee before the position opens. Hiring committees must present their final choice of candidate to the diversity committee before they make an offer. An annual report of all applicants, interviewees, and final hires will be created each year and presented to the diversity committee. This is already compiled by HR. An annual report of promotions for faculty will be created by HR each year and presented to the diversity committee.
Visiting Scientist hires	Any person who plans to hire a visiting scientist must create a one page document that will be reviewed and confirmed via email by the compliance committee to HR	The one page statement must include: Description of how the candidates meet the diversity mission; Description of how this position is necessary for the lab mission and why the need for a quick hire. An annual report of visiting scientist positions including those who have left the lab or been promoted to a Research I faculty position or staff scientist. This will be presented to the diversity committee annually to review and determine trends. We can compare hires and promotions across departments/facilities, particularly for URMs.
Users		The diversity committee will review the demographics of users by facility each year.

Retention and Advancement

3. The Magnet Lab is committed to the **retention and advancement** of our current STEM staff.

Program	Metrics
Colloquium or seminar sessions from Magnet Lab and visiting scientists for all interested staff.	Count number of sessions and who attended by each department.
Professional Development Sessions for all interested staff (e.g. Supervisor Series, project management series) We could add more professional development series based on the best practices report or the first climate survey.	Annual climate survey should ask which sessions each person attended and how these affected their work. The annual climate survey would be summarized in an executive summary for the diversity committee and executive committee to review annually

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Program	Metrics
Diversity bridge funding for postdocs and graduate students	Pre summary of why the funds are needed.
Funding for travel for professional development and recruitment travel purposes.	Upon their return, recipients write a short description of the benefit of this travel.
Climate survey	Assesses whether staff needs are being met and how welcoming and supportive they find the climate.

Metrics for retention and advancement: We propose a three-year assessment of retention and advancement rates at the lab to compare advancement within the lab for majority and underrepresented minorities. (The first occurred in 2014.)

Mentoring

4. The Magnet Lab is committed to **career-long mentoring** for our scientific and engineering staff.

Program	Metrics
Existing mentoring	The climate survey will include a question on whether each person is satisfied with their mentoring at the lab and what could be done to improve it.
Classes on mentoring should be offered annually and all supervisors should be required to take them. (e.g. Supervisor series is one example)	The annual climate survey would be summarized to determine how the professional development and individual mentoring are working for each respondent at the lab. This survey would be summarized in an executive summary and presented to the diversity committee and the executive committee.

Checklist for Faculty and Management Hiring Committees

1. Send an email request to NHMFL HR to determine budget availability and rate.	Date completed	Date approved if applicable
2. Once approved HR will give the hiring committee chair the Director's Letter and this checklist. Then HR will notify the Compliance subcommittee chair to set up a date for the first presentation by the hiring committee	Date completed	Date approved if applicable
3. A position description will be developed by the hiring lead. This description must be approved by the diversity compliance subcommittee, HR, and the VP of Research	Date completed	Date approved if applicable
4. Once approval is received from all three offices, the advertisement will be posted or sent to the following		
OMNI	Date posted	
Public Affairs to be posted on the website and social media	Date sent	
At least 3 of the organizations (or an equivalent) from the list of Organizations that Serve Underrepresented Minorities in STEM Fields	List of Minority serving organizations, their websites, and/or professional journals	Dates posted

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Qualified underrepresented minorities were contacted directly by members of the hiring committee to urge them to apply	(Yes, if applicable who was contacted and by whom)	
5. NHMFL requires a minimum of 30 days for advertisements.	How many days was this position listed:	
6. The Hiring committee must include one member of the Diversity Committee.	Name of Diversity Committee Member	
7. All members of the hiring committee participated in the FRED training or an equivalent that is approved by the Diversity committee.	Names of all members and the year they participated in the FRED training.	
8. A final report must be submitted to HR and the Diversity Committee Chair		
a. Include how these interviewed applicants heard about the position	table format	
b. Agenda or process for each applicant.	List questions	
c. Strengths and weaknesses for each	Open ended	
d. Summary of how the final candidate was selected, benefit to the research of the department.	Open ended	
e. This report must be approved by the Diversity Compliance Subcommittee before an offer is made	Date of approval by subcommittee	
9. Please see the hiring requirements for the rest of these positions.		

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6. Safety

A central tenet of the National High Magnetic Field Laboratory (NHMFL or MagLab) is the provision of a safe working and educational environment for our employees, users, and other visitors. The MagLab's Environmental, Health, and Safety (EH&S) team works collaboratively with management, researchers, staff, and users, as well as with other public and private entities, to proactively mitigate hazards in our industrial, laboratory, and office settings.

Despite these efforts, on October 21, 2015, a MagLab employee suffered fatal injuries during construction work on the Series Connected Hybrid (SCH) Magnet. An immediate "stop work" was implemented in our DC Field Facility pending the completion of a months-long investigation into the root causes of the accident, an investigation led by the Director of Environmental Health and Safety at Argonne National Laboratory, Elizabeth Grom. The investigative team identified safety improvement strategies that laboratory personnel have diligently addressed.

In the wake of this accident and in response to the investigative team's recommendations, the lab is enhancing safety procedures for lock/tag/verify work, assigning a dedicated construction site supervisor for large-scale magnet projects, and implementing improvements to the lab's Integrated Safety Management (ISM) program to better address safe conduct of complex operations at the lab.

Investments

Several examples of management and employee investments in safety serve to illustrate additional dedication of resources to protect MagLab personnel, property, and the environment. As part of the ongoing commitment to the lab's *Integrated Safety Management (ISM)* program, a comprehensive lab-wide safety program launched in 2013, the MagLab strategically invested over $200,000 in 2015 for safety-related equipment, training, and processes.

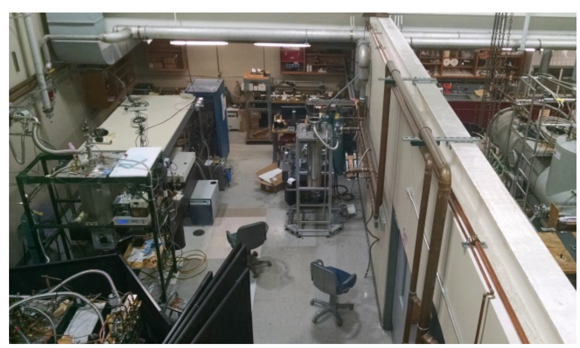
The following are a few of the wide-ranging investments in health and safety at this unique research and development laboratory:

Fume Hood Upgrade for Lab Worker Safety and Increased Efficiency ($99,000)

Fume hoods were upgraded that fell into three different categories. First, fume hoods that are used for work utilizing "particularly hazardous chemicals," a category of chemicals that includes arsenic and hydrofluoric acid. The second category involved replacing fume hoods and their duct work damaged by corrosive chemicals. These fume hoods and ducting replacements are designed to withstand corrosive chemical use. The third category includes fume hoods used for general chemicals and solvents that have been in use for 20 years and benefited from being upgraded to the latest technology.

Laser Induced Fluorescence Imaging Facility (LIFIF) Renovation ($15,500)

The Cryogenics Group at the MagLab conducts a variety of research projects that involve science and technology at temperatures below 100 degrees Kelvin. A major component of the MagLab Cryogenics Group is the Laser Induced Fluorescence Imaging Facility. LIFIF consists of a femtosecond pump laser, two wavelength-tunable imaging lasers, and a cryostat with five optical access ports for flow visualization studies in helium. The area was renovated to isolate the imaging lasers from the rest of the Cryogenics Lab.



Biosafety Laboratory (BSL-2) Renovation ($6,800)

Biosafety Level 2 laboratories are designed for work involving infectious agents or biological material of moderate potential hazard to personnel and the environment. This MagLab facility is used for bacterial and mammalian cell culture-based research, including human tissue cultures, human serum, and bacterial isolates from the environment. Renovations included purchasing and installing a BSL-2 certified safety cabinet and fitting the lab with the additional safety equipment.

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Personal Protective Equipment: Fall Protection Equipment ($10,800)

In 2015, the MagLab Safety Department finalized the Fall Protection and Fall Hazard Reduction program. The implementation of the program came with the added initial cost of new fall protection equipment. This equipment is assigned directly to each individual worker for their own protection. We have supplied fall protection equipment in the past to comply with OSHA, but our last major order was in 2009-2010 and most of this equipment had to be taken out of service. The life expectancy for this equipment is about 5 years.

Other Maglab Safety Investments Involved These Upgrades and Training:

- Access Security and Video Surveillance System Upgrade ($12,000)

National Fire Protection Association: 70E Arc Flash Electrical Safety Training ($8,000)

Roof Access Policy

In October of 2015, the MagLab established a Roof Access Safety sub-committee to identify and mitigate hazards concerning work on the roofs at the MagLab headquarters facility in Tallahassee. The committee developed, established, and implemented a Roof Access policy. This policy is intended for all who access a roof at the MagLab (employees, contractors, and FSU maintenance personnel). All personnel were trained using this new policy.

The main elements of this policy worked to establish guidelines and boundaries in the following areas:

- Notification to the MagLab's Safety Department and/or Facility Manager prior to accessing the roof.
- Sign in/out sheet denoting time of access and departure to and from the roof.
- Description of the type of work, location on the roof where the work is taking place, and what equipment is being affected.
- Two person rule and radio communications required.
- Utilization of tie off bollards, implementing the OSHA standard for parapet height and the establishing and marking of "exclusion zones."
- Proper training on using fall protection and safety harnesses for work inside of the exclusion zone.
- Purchasing and installing guardrails for areas within the exclusion zone, to serve as an engineering control.

Integrated Safety Management (ISM)

The safety department worked with a specially-appointed work group to review the ISM program and recommend changes that needed to be made in the wake of the accident. The ISM program was enhanced in December to connect disparate processes and procedures under one overarching policy, including:

- Establishing a lab-wide Task Hazard Analysis form with the Task Hazards being based on qualifications, training, knowledge, recognition of hazards, and familiarity with the machine, equipment, and/or system.
- Establishing an Equipment Specific maintenance procedure program.
- Establishing a Construction Site Superintendent program.
- Developing additional Training and Qualification Programs, including task and system specific Lock/Tag/Verify training, Site Supervisor training and an Arc Flash Qualification program.

Onsite/Hands-On Electrical Safety Training

In September of 2015, the MagLab hosted the NTT 2015 Electrical Safety Training, which includes 3 days of lectures, demonstrations of PPE care and use, and hands-on training with electrical equipment. The MagLab employees were joined by Florida A&M University and Florida State University staff. This training is a part of the MagLab's annual 2-year qualification program for all employees who must be qualified to work on electrical systems.

Safety Highlights-NADO Award

The National Association of Development Organizations (NADO) has selected the MagLab and its partners to receive its 2015 Innovation Award in recognition of the innovation and teamwork that went

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into collaborating in the highly successful exercise "Operation Deep Freeze."

NADO is a Washington, DC-based association that promotes programs and policies that strengthen local governments, communities, and economies through regional cooperation, program delivery, and comprehensive strategies.

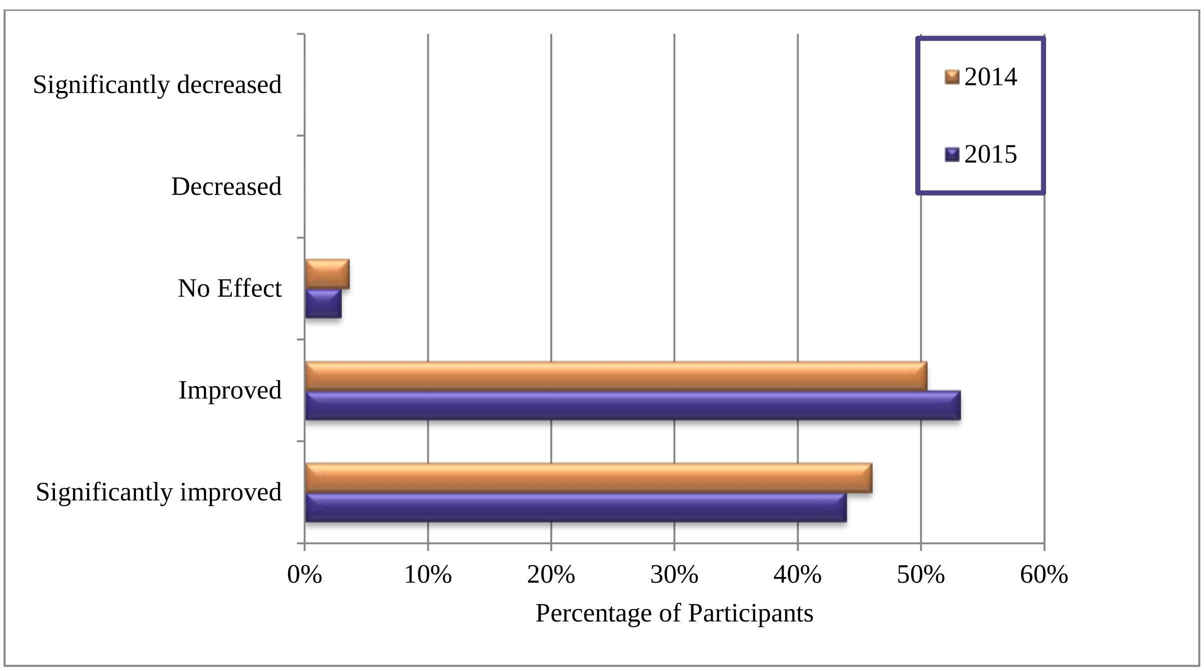
Regional first responders collaborated with the MagLab Safety Department and administration to simulate a terrorist attack at the lab. The level of teamwork and coordination between all the various departments demonstrated that we could effectively work together in the event of an emergency to save lives, property, and the environment.

Local safety response agencies include:

- *MagLab Safety Department and Administration*
- *Tallahassee and FSU Police Departments*
- *Tallahassee Fire Department - Hazmat and Search and Rescue Teams*
- *Leon County Emergency Medical Services*
- *Tallahassee Memorial Emergency Center*

Safety Survey 2015

In order to gauge the continued effectiveness of the safety program and the overall attitude toward safety at the MagLab, the Safety Department, with the support and guidance of the CIRL department, conducted the MagLab's Annual Safety Survey. The data from over 220 respondents provided reliable and measurable feedback. The results of the 2015 Safety Survey continue to document a favorable climate for the EH&S department and the ISM program, one aspect of which is reflected in the chart below, showing responses to the question: what impact do you feel ISM has had overall in improving safety at the lab?



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7. Budget

Table 1: *Summary Proposal Budget January - December 2015*

	NSF - Funded Person-months			Funds Requested by Proposer
	CAL	ACAD	SUMR	
A. (60) TOTAL SENIOR PERSONNEL	437.0	0.00	0.00	3,661,782
B. OTHER PERSONNEL				
1. (10) POSTDOCTORAL ASSOCIATES	110	0.00	0.00	487,090
2. (70) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	575.00	0.00	0.00	2,785,274
3. (4) GRADUATE STUDENTS				49,843
4. (6) UNDERGRADUATE STUDENTS				35,871
5. (16) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				137,763
6. (0) OTHER Temporary				0
TOTAL SALARIES AND WAGES				7,157,623
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				2,242,622
TOTAL SALARIES, WAGES AND FRINGE BENEFITS				9,400,245
D. EQUIPMENT				1,574,984
E. TRAVEL				
1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				236,511
2. FOREIGN				38,261
F. PARTICIPANT SUPPORT				
1. STIPENDS 87,000				
2. TRAVEL 12,000				
3. SUBSISTENCE 20,000				
4. OTHER 2,158				
TOTAL NUMBER OF PARTICIPANTS (30)	TOTAL PARTICIPANT COSTS			121,158

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G. OTHER DIRECT COSTS	
1. MATERIALS AND SUPPLIES	2,601,655
2. PUBLICATION/DOCUMENTATION/DISSEMINATION	0
3. CONSULTANT SERVICES	0
4. COMPUTER SERVICES	0
5. SUBAWARDS	8,677,111
6. OTHER	2,426,405
TOTAL OTHER DIRECT COSTS	13,705,171
H. TOTAL DIRECT COSTS	25,076,330
I. INDIRECT COSTS Rate: 70.0% Base $12,276,672	8,593,670
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)	33,670,000

The primary funding source for operation of the seven user programs of the National High Magnetic Field Laboratory (NHMFL) remains the National Science Foundation (NSF) and funds provided through the participating institutions: the Florida State University, the University of Florida, and the Los Alamos National Laboratory.

A. Personnel

The current level of staffing is required for the Lab to maintain user support, technology development, and science (NHMFL User Collaboration Grant Program) activities. Actual salary rates, plus a 3% increase, of existing NHMFL Staff have been used in the cost calculations. Florida State University's fringe benefit rates for permanent staff fluctuate depending on the benefit package chosen by the staff member. Therefore, an average fringe benefit rate of 34.75% is used to calculate the cost of fringe benefits for permanent staff. This rate includes social security, Medicare, health insurance, retirement, workers comp, and terminal leave payout. FSU's fringe benefit rate for postdocs and non-students is 1.55% plus the cost of health insurance. The fringe rate for Graduate and Undergraduate Students is 0.10% plus the subsidy for health insurance for Graduate Students of either $850 or $1,500 per FSU policy. In accordance with state law, Florida State University is providing health insurance coverage to OPS employees working 30 hours or more per week. The annual rate for family insurance is $15,169 per employee while individual coverage is $7,098 per year.

Since the NHMFL is a large, complex, multidisciplinary user facility, there is a requirement for a larger than normal level of research and non-research support staff. The faculty included in the budget are twelve (12) month specialized research faculty, and not tenured or tenure track nine (9) month teaching and research faculty. Therefore, the effort of these research faculty and the effort of other research and administrative staff identified in this proposed budget exceed the NSF two month limitation associated with regular tenure/tenure track nine (9) month teaching faculty.

Due to the mission of the NHMFL, a higher level of administrative support is required to insure successful operation of the facility. The primary responsibility of the NHMFL's administration is to ensure compliance with the terms and conditions of our sponsored project while facilitating the day-to-day work for our users and scientific staff. The NHMFL is an extension of Florida State University. Because of the requirements of the NSF Cooperative Agreement, the administrative staff exceeds the level of staff routinely provided by the university. To insure performance, the staff offers

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direct, on-site services to the user and research community. The administrative staff is responsible for a core set of activities including budget and finance; accounting; purchasing, shipping and receiving; human resources; facilities management and engineering; as well as safety, security and environmental protection. In addition to central departments and activities, the user divisions have a Program Associate to support and facilitate the non-science related tasks required to insure that the user program's operational needs are met. The services being provided by administrative staff are accrued solely for the benefit of the NHMFL core mission and user program and exclusively support the NSF Cooperative Agreement. The total FTE required for administrative, secretarial, and clerical services to directly support this NSF project is thirty-one. The total administrative staff is comprised of 3.9 FTE in Secretarial/Clerical staff and 4.7 FTE in administrative staff classified as Other Professionals.

B. Equipment

Equipment funds will be devoted to mitigating equipment failures, purchasing new and updated equipment for the User Programs, and new Magnet technology. Within the five years of this grant, the overwhelming majority of equipment funds represent essential expenditures to maintain and enhance User Support.

Anticipated major equipment purchases are listed below by MagLab division. Note the total for the equipment listed below is more than our budget for equipment purchases. A portion of the equipment funds will be allocated to needs that arise throughout the project that cannot be specifically determined at this date. This need is based on historical experience in having to address unanticipated needs throughout the project period. We believe this to be a conservative estimate to cover those needs that will arise.

Throughout the year, equipment purchases will be approved based upon users' scientific needs and the progress of major projects. Our highest priority is to continue to maintain the highest quality of User Science.

Table 2: *NHMFL Specifically Budget Equipment*

Magnet Science and Technology	
CuNb for 100T – Pulsed Magnet Support	200,000
32T Components and Hardware	108,000
Instrumentation Upgrades	30,000
28 MW Resistive Magnet	2,136,000
Applied Superconductivity Center	
OX-1 Bi2212 Insert Magnet, Conductor	110,000
LANL Bi2212 Insert and Conductor	190,000
Lakeshore Controller	5,000
Thermal Gravimetric Analysis/Differential Thermal Analysis	50,000

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DC Field Facility	
Lockin Amplifiers SRS124	14,000
LakeShore 372 AC Resistance Bridge	19,000
Data Acquisition Computers	17,400
Active Vibration Cancellation Systems	120,000
Current and Voltage Preamps	20,000
Voltmeters	20,000
Lockin Amplifiers SRS830	15,000
Nuclear Magnetic Resonance	
550-1000 MHz 1k Watt Amplifier	60,000
500W 500-1000 MHz Amplifier	38,000
600-800 MHz 800 Watt Amplifier	26,000
Ion Cyclotron Resonance	
High Pumping Speed Turbo-Molecular Pumps (2)	70,000
UV Laser System	50,000
Various Equipment for the improvement of Mass Spectrometers	84,382
Electron Magnetic Resonance	
Microwave source for Bruker spectrometer	14,000
170-260 GHZ Frequency Doubler	7,250
Solid state 115 GHz source	24,000

C. Travel

Travel budget levels are required to maintain a basic level of user support, technology development and science activities. Total dollars of $236,511 are requested for domestic travel while $38,261 is requested for foreign travel. Based on conference attendance and research performed in the past, the following expenditures are anticipated for travel to the following countries in 2015:

Scientific Conferences held in the United States, United Kingdom, China, South Korea, Argentina, Netherlands, France and Spain.

Workshops held in in the United States, United Kingdom and Germany.

Research held in the United States, United Kingdom, France, and Germany.

D. Participant Support – Stipends

Research for Undergraduates:

This item is an estimate of the budget required to support the Research Experience for Undergraduates (REU) Program. Although students are recruited from across the United States, the requested funding is an estimate. If participants include students from FAMU or FSU (local students), housing and travel expenses are not incurred. This creates the flexibility to support more students than originally anticipated.

This summer internship program matches qualified undergraduate students with scientists and researchers at the NHMFL's three sites. The eight-week research experience offers unique opportunities to explore science at the extremes of magnetic field, pressure and temperature. Students explore contemporary science and engineering issues, working alongside some of the finest scientists, magnet designers and engineers in the world. Each student accepted by the program

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receives a stipend, and, if necessary, travel support and housing.

The NHMFL offers a wide range of science, math, engineering and interdisciplinary experiences in physics, chemistry, biological sciences, geochemistry, materials science and magnet science and engineering. Summer interns, working closely with their faculty mentors, are thoroughly integrated into these research and development activities. Students broaden their knowledge of the diverse research that takes place here by attending weekly seminars and colloquia.

In 2014, there were 29 students, 17 males and 12 females. Of the 29 participants, 14 were minorities. Examples of student projects may be seen on the NHMFL website at https://nationalmaglab.org/education. In 2015, the goal is to continue our efforts to increase the number of students from underrepresented groups including women, African Americans, and Hispanic students. A special effort will be made to recruit students from HBCU, colleges and universities that serve a large percentage of African Americans, Hispanic, and other underrepresented students.

Costs: Approximately $5,880 per student – incudes $3,600 stipend; $1,000 housing; $600 non-local travel; and a program total of $2,158 for mentors to purchase various supplies required for scientific experiments. Excess travel allowance not paid to local participants enables the lab to utilize these funds to increase the number of participates. The total amount of funds requested to support the REU program is $106,158 based on twenty participants.

The Research Experience for Teachers (RET) Program is a six week summer residential program that gives K-12 teachers the chance to participate in the real-world science of cutting-edge magnetic field research. Through various program activities, the teachers develop strategies and resources to translate the experience into material for their classrooms. In 2014 there were 10 teachers, 6 males and 4 females. Of the 10 participants, 7 were minorities.

The cost of the program is approximately $5,376 per teacher which includes a stipend, housing, and non-local travel. The funding for the RET Program will be split between the NSF budget and other university funding. NSF funds will be used for stipends, while all other expenses will be covered by funds from other sources.

E. Other Direct Costs: Materials and Supplies

Approximately 1375 scientists annually request 'magnet time' for performing research and subsequently publishing the results of their research in premier scientific journals. Other Direct expenses are necessary due to the complexity of operating and maintaining a large, international user facility while supporting the development of new magnet technology for the science community. In many cases these items may be charged to another source; however, since the NHMFL is a NSF funded user facility, these charges are directly related to the scope set forth in the Cooperative Agreement. The FY 2015 budget for direct expenses is slightly less than the FY 2014 budget.

Specific purchases in this category include but are not limited to:

- Helium and nitrogen are required components for the operation of the assorted magnets located within the lab. These commodities represent a significant amount of the materials and supplies budget.
- Computer hardware and software which are dedicated to or support scientific instrumentation in the user facility or are required for experiment control, data acquisition, or scientific analysis. As a user facility, the NHMFL supports a variety of computing systems and services for international, academic, and government researchers which require computing hardware and specialized software. These costs are necessary to support the operations of a user facility and can be identified readily with the NSF Cooperative Agreement.
- Instrumentation and lab equipment such as voltmeters, current sources, thermometers, pumps, glassware, tape, etc. are required for various labs used by researchers and users.
- Chemicals and raw materials such as acids and bases, reagents, metal, plastics, etc. are required for researchers to conduct their research.
- Safety equipment such as safety glasses, gloves, fall protection, harnesses, electrical safety gear, etc. These items are required to insure the safety of the staff.
- Postage expense is used for activities required by the NSF Cooperative Agreement

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such as: MagLab Reports and other research reports to national and international users and prospective user, other documents deemed necessary to meet the needs of our users and to further our commitment to education, research and learning. In order to support education at all levels, K-12, technical, undergraduate, graduate and postdoctoral, the dissemination of educational materials through the mail becomes greater than customary in an academic department. These mailings are readily identifiable and significantly exceed the level of postage normally associated with other sponsored projects.

F. Subawards

The proposed level of funding is required to maintain the level of operations for the AMRIS, High B/T and Pulsed Magnet User Programs that promote magnet-related research for the scientific user community. Detailed budgets and budget justifications for each individual division reflect their specific spending plan. A sub award to Steven Beu, Consultant, will be funded from the Ion Cyclotron Resonance (ICR) User Program fund. As in the past five years, Dr. Beu will continue to consult with the ICR Program on the development of new ion transfer optics and techniques for improved ion transmission and decreased time-of-flight mass discrimination in FT-ICR mass spectra.

G. Other Direct Cost

Electricity – Funds to cover part of the electrical costs for magnet use is requested. This cost is an extraordinary cost for electrical power and represents unlike circumstances since the magnets require large amounts of electricity to operate. The electrical costs attributed to the magnet operation which has been direct charged to the NSF Core since NSF first began funding the Lab is not included in FSU's indirect cost but has been treated as other direct costs charged to grants and included in our research base when preparing our F&A rate proposal.

These costs represent unlike circumstances because the electrical power does not support the general power needs required of all buildings and labs, i.e. overhead lights, small office and lab equipment, room heating and cooling, etc. The electrical power usage for the magnet operation is separately metered from other normal electrical demands. Because the magnet operations require such a huge amount of power, this is a cost directly required in order to support a user facility. The amount of available user time will be impacted without these funds to assist in covering the costs of magnet operations. The total electricity budget for FY 2015 is $2,645,323 of which $1,800,000 is a part of the NSF budget. The budget was based on the average cost of electricity over the last few years. Funds received from FSU in the amount of $845,323 will be used to subsidize the cost of electricity.

Florida State University receives two power bills each month. One is the Electric Contract (Interruptible) and the other is the Electric Large Demand (Firm). These bills are generated from two different sets of meters. The electrical system is segregated into (1)the power required to run the high power DC Field magnets (Interruptible) and (2) all power that is for general building operations (lighting, heating and cooling, computers and any scientific equipment (Firm). For the magnets (Interruptible) the NHMFL has a special rate, since the City of Tallahassee can contact the lab and interrupt the power for magnets if the need occurs. Florida State University pays for the Electric Large Demand (Firm) from university funds, while the Electric Contract (Interruptible) is paid with NSF funds since that electricity is directly used for magnet operations.

Tuition - Florida State University policy requires that In-State tuition waivers be paid and tuition rates do not include student related fees. For FSU FY 2015-2016, the tuition rate per hour is $466.30. Graduate students are required to be enrolled for nine hours each semester. The cost of tuition for nine hours per semester is $4,197. These costs, which are the standard tuition rates for FSU, were used to calculate the tuition for each Graduate Student based on the length of their appointment. The total cost of tuition for Graduate Students for FY 2015 is $50,360. Tuition rates and annual increases are set annually by the Florida Legislature and the Florida State University Board of Trustees. The current approved rate of increase is 7.5% per year.

User Collaboration Grant Program (UCGP) - The National Science Foundation has charged (through the Cooperative Agreement) the NHMFL

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with developing an in-house research program that utilizes the NHMFL facilities to carry out high quality high field research at the forefront of science and engineering; and advances the NHMFL facilities and their scientific and technical capabilities. To this end, the NHMFL's Users Collaboration Grants Program seeks to achieve these objectives through funded research projects of normally 2 years duration in the following categories:

- Collaborations between internal and/or external investigators that utilize their complementary expertise;
- Bold but risky efforts which hold significant potential to extend the range and type of experiments;
- Initial seed support for new faculty and research staff, targeted to magnet laboratory enhancements.

The UCGP strongly encourages collaboration between NHMFL scientists and external users of the NHMFL facilities.

Funds in the amount of $576,045 have been designated to support UCGP funding for FY2015.

H. Indirect Cost

Per the Florida State University's Indirect Cost Rate Agreement, the approved indirect cost rate for NHMFL awards is 70% modified total direct costs (MTDC).

FY 2015 BUDGET JUSTIFICATION

UF – HIGH B/T

A. Personnel

Neil S. Sullivan (0.36 summer) is the Director of the High B/T Facility and is responsible for the overall operation of the Ultra-Low Temperature program of the NHMFL. He is a full-time professor of physics at the University of Florida and also directs the University of Florida Microkelvin Laboratory in which the High B/T facility is located.

Liang Yin (12 cal.) is a research scientist who operates both Bay 2 and Bay 3 of the Microkelvin Laboratory for external users. He is directly responsible for co-ordination with new users and the planning of experimental cells for installation on the nuclear demagnetization refrigerators.

Alessandro Serafin (12 cal.) is a postdoctoral fellow who leads the development of new instrumentation for users and who assists Liang Yin in the design and setup of experiments for users.

Allen Majewski (12 cal.) is a graduate student who is developing a specialized nuclear quadrupole spectrometer for deployment in the High B/T facility for low temperature high field studies. This technology is needed by users exploring the properties of quantum phase transitions in organic quantum magnets.

B. Equipment

We have budgeted $35,000 for the purchase of new equipment in the High B/T facility in 2015 to support advanced instrumentation for the NHMFL external user program. This includes equipment for replacing a helium-three pump that is not performing adequately, an ultra-stable DC source for precision conductivity measurements, and a new power supply for a superconducting magnet.

C. Travel

We have budgeted $7,500 for travel. This includes $5,000 which is requested to provide partial assistance for 2 people to attend the March Meeting of the American Physical Society in Baltimore, USA, and for one person to attend the Quantum Fluids and Solids Symposium in Boulder, Colorado in August, 2015. In addition, we seek $2,500 for international travel for partial support for one person to attend the Solid State NMR Conference in France in the fall of 2015.

E. Other Direct Costs: Materials and Supplies

We have budgeted for $82,000 in materials and supplies. The principal cost is that for liquid helium which is provided at a cost of $2.80 per liquid liter and we are budgeting for 26,000 liters for operation of Bay 2, Bay 3 and the fast turn- around facility for at least 300 days of the year for a total cost of $72,800. In addition, we have budgeted $9,200 for small items such as tools, small electronic components, vacuum and gas plumbing, and miscellaneous supply items.

G. Other Direct Cost

Tuition - The tuition costs for the graduate student will be paid from the principal investigator's current returned overhead funds.

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Table 3: *High B/T Facility Specifically Budgeted Equipment*

Helium-three pump	17,700
Ultra-Stable DC source for precision conductivity	4,800
Power supply for superconducting magnet	12,500

FY 2015 BUDGET JUSTIFICATION

UF - AMRIS

A. Personnel

Joanna Long (3.0 cal) is the AMRIS Director and co-PI of the subcontract and is responsible for the overall operation of the AMRIS user program, distributing the NHMFL supply money to pay for AMRIS fees, and annual reporting. She also directs the dynamic nuclear polarization technology program to enhance the NHMFL external user program. She has 3 months total effort, divided into 1.8 months for AMRIS and 1.2 months for the DNP initiative.

Thomas H. Mareci (1.2 calendar months) is the AMRIS Associate Director and directs the high field structural and functional MRI program to enhance the NHMFL external user program.

Arthur S. Edison (1.2 calendar months) directs the high sensitivity NMR technology program to enhance the NHMFL external user program and serves on the NHMFL diversity committee.

Glenn Walter (1.2 cal) leads the molecular imaging technology program to enhance the NHMFL external user program and serves on the Science Advisory board.

Steve Blackband (1.2 cal) leads the microimaging technology program to enhance the NHMFL external user program and is also the UF liaison in discussions of HTS magnet development projects.

Gail Fanucci (1.2 cal) is a member of the Science Advisory board and develops technology in the DNP program; she is also the UF liaison between the EMR and NMR groups of the NHMFL.

Denise Mesa (3.6 cal) is responsible for the reporting and secretarial activities necessary to run the NHMFL external user program.

Malathy Elumalai (12 cal) is the RF engineer responsible for designing, constructing, testing, and maintaining unique RF coils for the horizontal animal imaging systems and the WB 750 system within the AMRIS facility as well as coordinating with new RF projects pursued by the NMR probe development group in Tallahassee. No funds are requested for salary as funding is provided from User's fees.

B. Equipment

We have budgeted $100,000 each year for the purchase of new equipment in the AMRIS facility to support the NHMFL external user program. This includes equipment for 8 spectrometers, an RF engineering laboratory, and staff scientists. Typical items include new RF or gradient amplifiers, new NMR probes, RF frequency generators, computer workstations, network analyzers, and animal monitoring equipment.

In FY 2015 we plan to specifically directing these funds to upgrading the ^{1}H RF coils on our world unique 11 T / 40 cm MRI/S system ($5,000), to developing new low temperature coils for DNP experiments ($5,000), to developing quadrature coils for the WB 750 animal imaging system ($5,000), to developing ^{13}C volume coils for the 11T and 4.7 T MRI/S systems ($5,000), and to purchasing a high power amplifier for ^{13}C excitation on these systems ($30,000). An additional $50,000 will be directed to upgrading the 11 T system to dual transmit capabilities for ^{1}H imaging.

C. Travel

The travel budget in the NHMFL subcontract includes funds for the NHMFL investigators affiliated with the AMRIS facility to travel to the requisite annual meetings for the NHMFL NSF site visit, the Users Committee meeting, and the External Advisory Committee meeting. Each of these is estimated at $400 per person to cover two nights hotel, the meeting registrations, and travel to Tallahassee from Gainesville. Two people, three meetings totals $2400; if the UC meeting occurs in Los Alamos in fall 2015 (as it likely will), an

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additional $1000 will be needed to cover the cost of airfares. Total $3400.

We cover the costs of three of the members of the Users Committee to travel to the annual Users Committee meeting. Each of these is estimated at $1000 to cover airfare, two-three nights hotel, and meeting registration. This totals $3000.

Drs. Long, Mareci, and Edison also make about four trips per year to the NSF, labs the NHMFL is collaborating with, HBCUs for outreach activities, and vendors to discuss designs and specifications. Each of these trips is estimated at $750 per person to cover airfare, one night hotel, and meals. Four trips total $3000.

Drs. Long, Mareci, Edison, Blackband, Walter, and Fanucci travel to Tallahassee for face-to-face meetings as needed with NHMFL colleagues. Most communication is through email and skype, but approximately 10 trips per year total are made. Each of these trips is estimated at $250 for one person to cover hotel, meals, and transit to Tallahassee. This is a total of $2500.

Both Dr. Long and Dr. Edison attend the Experimental NMR Conference each year to publicize technical developments at the NHMFL and our user program. The AMRIS RF engineer, Malathy Elumalai, will also attend this year to present new capabilities developed for high field animal imaging. This is the premier conference of the NMR community in the U.S. This year the conference is in April in Pacific Grove, CA. Each person is estimated to cost $2000 for airfare, registration, hotel and meals. This is a total of $6000.

Drs. Mareci and Walter will attend the 23rd Annual Meeting of the International Society for Magnetic Resonance in Medicine to publicize technical developments at the NHMFL and our user program. An AMRIS staff scientist, Huadong Zheng, will also attend this year to attend training workshops and meet with external users. This is the premier international conference of the MRI community. This year the conference is in June in Toronto, CA. The cost for this conference is estimated at $2500 per person for airfare, registration, hotel and meals. This is a total of $7500.

Dr. Long will be attending the 5th International DNP symposium in Egmond aan Zee, The Netherlands, August 31- September 3, 2015, and the 9th Alpine NMR conference in Chamonix, France, September 13-17, 2015. The first conference is the leading international conference in DNP and the second conference is the premier international conference of the solid state NMR community. She will be presenting new technology developments at the NHMFL in DNP and solid state NMR spectroscopy in support of expanding the user base in these areas. Her intention is to visit the labs of collaborators and to take personal time in Europe between September 3 and 13 to minimize travel costs. The cost for each conference is estimated at $1500 for registration, hotel and meals and train between the venues; a transatlantic airfare is ~$1000. This is a total of $4000.

The total of all travel listed above is $29,400. A contingency fund of $2879 to cover cost overruns is also budgeted, since all trips listed above were conservatively estimated. This brings the total travel budget to $32,279.

E. Other Direct Costs: Materials and Supplies

We have budgeted $343,000 for materials and supplies. The funds will be used to pay for AMRIS instrument time and staff fees for the NHMFL external user program. The AMRIS facility operates under federal cost accounting standards (CAS) and is required to charge users fees for all users. These fees are billed hourly for each instrument and for each staff member that provides direct support to a project via consulting rates. Our fee structure is audited annually so that our facility runs cost neutral and hourly rates are publicized on our website. These funds also pay for development time on the instruments for NHMFL initiatives, and an RF engineer who is responsible for designing, constructing, testing, and maintaining unique RF coils for the external user program as well as coordinating with new RF projects pursued by the NMR probe development group at the NHMFL-Tallahassee.

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Table 4: AMRIS Facility Specifically Budgeted Equipment

RF coils on our world unique 11 T / 40 cm MRI/S system	5,000
Develop new low temperature coils for DNP experiments	5,000
Develop quadrature coils for the WB 750 animal imaging system	5,000
Develop volume coils for the 11T and 4.7 T MRI/S systems	5,000
High power amplifier for ^{13}C excitation	30,000
Upgrading the 11 T system to dual transmit capabilities for ^{1}H imaging	50,000

FY 2015 BUDGET JUSTIFICATION

LOS ALAMOS NATIONAL LABORATORY

We intend to operate the Pulsed Field Facility at Los Alamos National Laboratory to continue to provide NHMFL users with access to pulsed magnetic fields for reviewed and approved research. We will continue to develop state-of-the-art pulsed magnet systems and operate them for qualified users. The total FY15 budget of $7,400,000 will be used for operation of the user program, which includes salaries, materials and supplies, and consumables such as liquid cryogens and a travel budget.

A. Personnel

Charles H. Mielke (0.0 cal.) is the Director of the Pulsed Field Facility and is responsible for the overall operation of the Los Alamos National Laboratory based NHMFL-PFF. He is a full time Research and Development manager at LANL based at the NHMFL-PFF in Los Alamos, NM, his salary is fully paid for by LANL for the purpose of directing the facility and managing the personnel.

Scientific User Support Staff (61.2 cal.) will be assigned to directly working with qualified NHMNFL-PFF users to conduct experiments in high magnetic fields. The expert scientific staff possess demonstrated competencies in magneto-transport, magnetic susceptibility, magneto-optical spectroscopy, thermal transport, radio frequency contactless transport, specialized non-metallic cryogenic systems and pulsed field diagnostic and analysis specializations. This skill set from this group of 9 individuals is first rate in the world for state-of-the-art pulsed magnetic field experimentation. Working to enable users to return home with a complete set of data that is analyzed and interpreted is an essential function of the NHMFL-PFF.

Engineering Staff (24.0 cal.) consist of two individuals who are responsible for the development of pulsed magnet systems and the engineering support/operation of the 1.43 billion watt generator system located at LANL. The world class 100 tesla Multi-Shot Magnet has set the World record for highest non-destructive pulsed magnetic field and more importantly delivered nearly 1000 high field pulses for users. This system requires expert attention and monitoring to safely operate it and maintain it for future experiments. The insert magnet system requires highly specialized design and optimization and monitoring, the NHMFL-PFF team of two scientist/engineers delivers for users and are fully committed to the smooth operation of this world-class system, their participation and dedication is essential.

Technician Support (84.0 cal.) at the NHMFL covers direct interfacing with users to provide needed technical resources for a successful user experience, infrastructure support to maintain our user "magnet cells" and ancillary equipment, two technicians provide support here. All of the 65 tesla user magnets (our current workhorse magnets) are manufactured fully in house because these are highly specialized units under tremendous stresses each shot. The workhorse magnets are fired approximately 6000 times each year for users and we need to replace these magnets about every 1000-1200 shots. Two technicians are dedicated to this effort currently. The operation and maintenance of the 1.43 billion watt generator system is used for the 100 tesla multi-shot magnet and the 60 tesla long pulse magnet. This generator system can safely

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deliver up to 600 million Joules of energy in its current configuration and is arguably the best and safest way to deliver the very large electrical energy pulse to our largest magnet systems. Three technicians are dedicated to operation of this system and the maintenance of the generator. The NHMFL-PFF has achieved first ever status on several magnet systems in part due to this LANL resource made fully available to the NHMFL-PFF program and our technicians are highly trained professionals needed to safely operate this system to deliver magnet pulses of immense electrical energy magnitudes. A total of seven technicians are required to operate the NHMFL-PFF as described above.

Postdocs and Students (36 cal.) are an important aspect to the NHMFL-PFF. A total of ten postdocs and students are currently active at the NHMFL-PFF while the core funding is currently providing only a fraction of their financial support. Often a postdoc or student will be attached to a science staff member and funded through another research channel such as LANL sponsored LDRD grants or DOE-BES channels. Students that are funded through core NSF program support are of strategic design. The funded students are engaged in strategic scientific areas or targeted diversity development opportunities.

Contractor (7.2 cal.) support is highly focused and relatively temporary in nature at the NHMFL-PFF. Contracts are annually renewed and may be task specific. An effort of 6.0 cal. is directed towards magnet design and 3-D modeling, working very closely with the design engineers responsible for bringing our unique and world leading pulsed magnet designs forward into the future and ahead of the competition. The generator system requires the precise development and updating of its extensive control system and an effort of 6.6 cal. is directed toward that project and the maintenance of the generator control system. That effort is essential as control components age beyond useful repair life cycles and must be repaired or replaced with safety certified components. A total of more than 5000 diagnostic signals are actively monitored and controlled continuously for every pulse of our 1.43 billion watt generator system and the controls engineer contractor is essential for completing the systems upgrades and maintenance to the level we need for sustained operations.

B. Equipment

A total of $0.00 is currently budgeted for equipment as we will leverage LANL investments for institutional capability developments and needed equipment. Specific program equipment may be requested as supplemental budgetary requests should the need arise.

C. Travel

A total of $45,000 has been budgeted for travel that includes experimental user support efforts at the NHMFL-DC Field Facility (a total of 6 trips to the DC Field facility are budgeted for FY15 at $2,000 each), the APS March meetings (12 people attending at $2,200 each) and two domestic scientific conferences (three people attending at $2,200 each). LANL institutional funds will be used for scientific outreach efforts both domestically and internationally, allowing the NHMFL to leverage LANL commitment to the accomplishments of the NHMFL as a partner in success.

D. Other Direct Costs: Materials and Supplies

A total of $629,059 is needed for materials and supplies and this figure is determined by considering historical rates of consumption of products like liquid cryogens and magnet winding materials and allocating a flexible amount of remaining funds from our budget positioning projections based on labor planning so that low cost consumables may be purchased to enable the scientific staff, technicians and postdocs and students to have the flexibility to develop new pulsed field probes and measurement techniques based on general materials and consumables. Fiberglass rods, thermometer chips, fiber optical cable, and machined specialized parts are broadly used for these developments. The staff spend a significant portion of their time using these materials for developing new research probes for pulsed field diagnostic developments.

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FY 2015 BUDGET JUSTIFICATION

S.C. BEU CONSULTING

Dr. Steven Beu will perform objective scientific analysis in support of new development in Fourier Transform Ion Cyclotron Resonance (FT-ICR) mass spectrometry, including but not limited to:

- Development of new methods of ion injection into high magnetic fields by use of rf multipole ion guides,
- Simultaneous excitation and detection for enhanced mass resolving power and quantitation,
- Combined electron capture and infrared multiphoton dissociation (ECD/IRMPD) in narrow bore (<110 mm) magnets,
- Minimization of m/z discrimination due to time-of-flight dispersion during ion injection into the ICR cell,
- Development and testing of new ICR cell geometries.
- Integration of all developed technologies into a 21 T FT-ICR mass spectrometer.

Dr. Beu will conceive new methods, develop models and experiments to test the methods, collect and interpret data, prepare manuscripts, present his findings at national meetings, and recommend future directions.

Services will be billed quarterly at a rate of $100 per hour. Total time billed for the 2015 calendar year will not exceed 550 hours for a total amount payable not to exceed $55,000.

Table 5: *Statement of Residual Funds – FY 2015*

$97,920,000	**NSF Budget Allocation for FY 2013-2015**
(97,638,373)	Total Expenses and Encumbrances (including Indirect Cost)
Reconciliations	
5,245,542	Personnel and indirect funds encumbered on Dec 31, 2015 for personnel costs from Jan 1, 2016 – April 30, 2016. Costs encumbered in FY 2015, but budgeted and paid from FY 2016 funds.
2,466,667	LANL operating cost funded in FY 2015 but budgeted and paid from FY 2016 funds.
Obligations	
(1,332,552)	User Collaboration Grants Program awards obligated to the PI's. Funds are to be expensed over next two years.
(931,010)	Construction of the 28 MW/41T Magnet.
(355,889)	Ion Cyclotron Resonance Facility residual balance as of 12/31/2015.
(713,000)	Additional personnel costs projected for FY 2017 for Magnet, Science and Technology Department.
(340,000)	Applied Superconductivity Center new projects for FY 2015 and 2016
(2,733,888)	Reserve funds for new and on-going projects, deferred annual magnet replacement parts, magnet upgrades, and applicable indirect cost.
Residual Funds	
$1,587,497	

Accounting standards dictate that encumbered funds be reported at FY end.

Advanced funding for FY 2016 was received in September 2015. These funds were encumbered in FY 2015 for personnel cost and the related indirect cost for the period of January 1, 2016 through April 30, 2016.

LANL first increment of 2016 was paid in December 2015 and must be included in the total expenses of 2015. This payment is budgeted and paid from 2016 funds that are not included in total budget above.

Lines 5-10: Funds obligated for specific purposes but not yet expended.

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Table 6: *Statement of Expenses and Encumbrances (January 2013 thru December 2015)*

	CUMULATIVE	As of 12/31/15		2015	As of 12/31/15	
	2013 - 2015 EXPENSED	**ENCUMBERED**	**TOTAL COSTS 2013 - 2015**	**EXPENSED**	**ENCUMBERED**	**TOTAL COSTS 2015**
A-C. TOTAL SALARIES, WAGES AND FRINGE BENEFITS	23,212,941	3,085,613	**26,298,554**	6,342,342	3,085,613	**9,427,955**
D. TOTAL EQUIPMENT	4,080,029	810,223	**4,890,252**	2,622,559	810,223	**3,432,781**
E. TRAVEL 1. DOMESTIC	630,923	26,011	**656,934**	195,859	26,011	**221,870**
2. FOREIGN	199,020	15,563	**214,583**	85,871	15,563	**101,434**
F. PARTICIPANT SUPPORT						
1. STIPENDS	366,430	-		124,604		
2. TRAVEL	16,943	-		-		
3. SUBSISTENCE	56,205	-		17,895		
4. OTHER	-	-		-		
TOTAL PARTICIPANT COSTS	439,578	-	**439,578**	142,499	-	**142,499**
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES	6,600,468	569,472	**7,169,939**	2,273,787	569,472	**2,843,259**
2. PUBLICATION/DOCUMENTATION/ DISSEMINATION	-	-	**-**	-		**-**
3. CONSULTANT SERVICES	-	-	**-**	-		**-**
4. COMPUTER SERVICES	-	-	**-**	-		**-**
5. SUBAWARDS	27,922,293	784,096	**28,706,389**	11,223,406	784,096	**12,007,502**
6. OTHER	5,174,101	-	**5,174,101**	1,522,297	-	**1,522,297**
TOTAL OTHER DIRECT COSTS	39,696,862	1,353,568	**41,050,429**	15,019,490	1,353,568	**16,373,058**
H. TOTAL DIRECT COSTS (A THROUGH G)	68,259,354	5,290,977	**73,550,330**	24,408,621	5,290,977	**29,699,597**
I. INDIRECT COSTS (F&A) *Base*	*30,643,352*	*3,696,658*	*34,340,010*	*8,897,860*	*3,696,658*	*12,594,518*
Rate	*70%*	*70%*	*70%*	*70%*	*70%*	*70%*
TOTAL INDIRECT COSTS (F&A)	21,500,382	2,587,661	**24,088,043**	10,155,859	2,587,661	**12,743,520**
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)	**89,759,736**	**7,878,638**	**97,638,374**	**34,564,480**	**7,878,638**	**42,443,117**

Note: Rebudgeting to reduce personnel expense and increase the IDC rate to 70% occurred in FY 2015.

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8. MagLab Cost Recovery Report

Seldom does the NHMFL incur costs due to resources used or sacrificed for companies doing proprietary research. On occasion, companies will need access to the unique equipment at the NHMFL, and they will contract for the use of said equipment. The NHMFL has established procedures to accumulate and report costs continuously, routinely, and consistently for all such contracts based upon an agreed-upon schedule of fees and costs to cover the use of such equipment that involves proprietary research.

If the MagLab receives program income defined as "gross income earned by the non-Federal entity that is directly generated by a supported activity or earned as a result of the Federal award during the period of performance", this income must be reported in a cost recovery report. (200.80). According to 200.307 (f), there are no Federal requirements governing the disposition of income earned after the end of the period of performance of the Federal award, unless the Federal awarding agency regulations or terms and conditions specify otherwise."

During 2015, the MagLab recovered a total of $6,367.87 from private industry for the use of NSF – funded equipment during the period of performance of our Federal award.

The breakdown of funds recovered are as follows:

$5,259	Applied Materials for the use of the 25T split magnet
$1,108	Graphitic Nano Onion for EPR measurements on the E-680 spectrometer

We intend to reinvest these funds in the Core Program by the end of the semester.

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9. Industrial Partners and Collaborations

INDUSTRY (49)

89 North, Burlington, VT
Scientists at the MagLab are working with applications specialists at 89 North to develop light-emitting diode technology for fluorescence microscopy. This collaboration involves testing the power output and usability of new high power LED technology in the emission region between 490 and 590 nanometers, a spectral region that is central to microscopy investigations.
(MagLab contact: Mike Davidson, Optical Microscopy)

Advanced Conductor Technologies, Boulder, CO
The Applied Superconductivity Center and the Magnet Science and Technology division of the MagLab are collaborating with Advanced Conductor Technologies on the development and testing of Coated Conductor Stranded Cable (CCSC), using multilayer spiraling tapes around a core, for magnet applications. Danko van der Laan, director of the company and associated with NIST/University of Colorado Boulder, is developing compact cables based on REBCO coated conductors, a high temperature superconductor. The ongoing collaboration on measurements of HTS cables at low temperature and high magnetic fields (4 K and 20 T in Cell 4) continues to set new benchmarks for peak current, current density, bend radius and ramp rates.
(MagLab contact: Huub Weijers, MS&T)

Agilent Technologies, Santa Clara, CA
Agilent Technologies is entering the imaging arena with a new "Monolithic" laser combiner featuring acousto-optic-tunable filter (AOTF) control. The MagLab is collaborating with Agilent to prototype the laser system for use in super-resolution imaging.
(MagLab contact: Mike Davidson, Optical Microscopy)

Allele Biotech, San Diego, CA
Allele is a manufacturer and distributor of fluorescent protein constructs made by Robert Campbell and Nathan Shaner. The MagLab is collaborating with Allele to develop fusion vectors of selected fluorescent proteins.
(MagLab contact: Mike Davidson, Optical Microscopy)

Andor-Tech, Belfast, Northern Ireland
Andor-Tech is an imaging specialist involved with development of CCD camera systems designed to produce images at extremely low light levels. The MagLab is collaborating with Andor-Tech to produce interactive tutorials describing electron multiplying CCD (EMCCD) technology and will work with the company to test new camera products in live-cell imaging.
(MagLab contact: Mike Davidson, Optical Microscopy)

B&B Microscopes, Pittsburgh, PA
Scientists in the Optical Microscopy facility at the MagLab are working with B&B engineers to develop new live-cell imaging techniques using the wide array of products offered by the company. Eventually, an educational website is planned.
(MagLab contact: Mike Davidson, Optical Microscopy)

Bioptechs, Butler, PA
The MagLab is involved with Bioptechs of Pennsylvania to develop live-cell imaging techniques using the company's advanced culture chambers. The collaboration involves timelapse imaging of living cells over periods of 36-72 hours using techniques such as differential interference contrast, fluorescence, and phase contrast.
(MagLab contact: Mike Davidson, Optical Microscopy)

Bruker EAS GmbH, Hanau, Germany
Bruker EAS is manufacturing accelerator quality Nb_3Sn strands based on the powder-in-tube process that have the potential to provide the performance necessary for higher magnetic field upgrades to the Large Hadron Collider at CERN and the Applied Superconductivity Center is collaborating with Bruker and CERN to optimize the performance of

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the wire utilizing the electromagnetic testing and advanced microstructural and microchemical analysis facilities at the MagLab.
(MagLab contacts: Chiara Tarantini, Peter J. Lee and David C Larbalestier, ASC)

Bruker Biospin Corp, USA
The EMR and NMR groups have entered into a collaborative effort with Bruker Biospin regarding the Dynamic Nuclear Polarization (DNP) program. In particular, the effort aims at improving Bruker's recently acquired products (395 GHz gyrotron, 600 MHz/14.1 T DNP probe) beyond their normal commercial uses by making technical modifications. The modifications allow the DNP instruments to be more user program friendly without voiding the warranty.
(MagLab contact: Stephen Hill, EMR)

Bruker Biospin Corp., Billerica, MA
The MagLab's NMR instrumentation program and Bruker Biospin collaborate on the development of Low-E probes for solid-state NMR in heat sensitive biological samples, such as proteins. Bruker Biospin manufactures a line of Efree probes based on the Low-E design developed at our lab.
(MagLab contact: Peter Gor'kov, NMR)

Callaghan Innovations, Lower Hutt, New Zealand
The Applied Superconductivity Center and the Magnet Science and Technology division of the MagLab are collaborating with researchers at New Zealand's Industrial Research Limited on the testing of Roebel-style cables based on REBCO coated conductors, a high temperature superconductor. Testing of a 15-strand cable with transposed 5 mm wide strands is in preparation. Roebel-style cables represent one of three viable concepts for REBCO coated conductor cables suitable for high field magnets.
(MagLab contact: Bob Walsh, MS&T)

Chroma, Rockingham, VT
A major supplier of Interference filters for fluorescence microscopy and spectroscopy applications, Chroma is collaborating with the MagLab to build educational tutorials targeted at fluorescence microscopy. Working in conjunction with Nikon, engineers from Chroma and scientists from the MagLab are examining the characteristics of a variety of filter combinations.
(MagLab contact: Mike Davidson, Optical Microscopy)

The Cooke Corp., Romulus, MI
Scientists at the MagLab are working with applications specialists at Cooke to field test the company's cooled and electron-multiplied scientific CCD camera systems. Demanding applications in quantitative image analysis and high-resolution images are being explored, as well as time-lapse fluorescence microscopy and resonance energy transfer imaging.
(MagLab contact: Mike Davidson, Optical Microscopy)

CoolLed Ltd., Andover, Hampshire, United Kingdom
Scientists at the MagLab are working with applications specialists at CoolLed to develop light-emitting diode technology for fluorescence microscopy. This collaboration involves testing the power output and usability of new LED technology in the emission region between 490 and 590 nanometers, a spectral region that is central to microscopy investigations.
(MagLab contact: Mike Davidson, Optical Microscopy)

Covance Research Products, Berkeley, CA
Covance is a biopharmaceutical company involved with research and diagnostic antibody production. MagLab scientists are working with Covance researchers to examine immunofluorescence staining patterns in rat and mouse brain thin and thick sections using a wide spectrum of antibodies.
(MagLab contact: Mike Davidson, Optical Microscopy)

Criotec Impianti, Piedmont, Italy; ENEA, Rome, Italy The MagLab is collaborating with Criotec Impianti, an Italian cryogenic systems manufacturing company, and ENEA, an Italian Fusion Energy Research Organization, to jacket the cable-in-conduit superconductor for the outsert coils of the series-connected hybrid magnets. Th is work includes the welding and inspection of the stainless steel conduit, insertion of the cabled superconductor strands into the conduit, and compaction of the assembled conductor to a rectangular cross-section.
(MagLab contact: Iain Dixon, MS&T)

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Danfoss Turbocor Inc, Tallahassee, FL
Danfoss Turbocor Inc. is a company specializing in compressors, particularly the totally oil-free compressors. The compressors are specifically designed for the heating, ventilation, air conditioning and refrigeration (HVACR) industry and need high performance soft and hard magnet materials. The company and the laboratory have a joint research project on selection, characterization, and development of permanent magnet materials and other materials for high performance and environmentally friendly compressors.
(MagLab contact: Ke Han, MS&T)

Diagnostic Instruments, Sterling Heights, MI
Scientists at the MagLab are working with applications specialists at Diagnostics to field test the company's new line of cooled scientific CCD systems. Demanding applications in quantitative image analysis and high-resolution images are being explored, as well as time-lapse fluorescence microscopy and resonance energy transfer imaging.
(MagLab contact: Mike Davidson, Optical Microscopy)

Evrogen, Moscow, Russia
Evrogen is a manufacturer and distributor of fluorescent protein constructs made by Dmitriy Chudakov and Vladislav Verkhusha. The MagLab is collaborating with Evrogen to develop fusion vectors of selected fluorescent proteins.
(MagLab contact: Mike Davidson, Optical Microscopy)

EXFO, Mississauga, Ontario, Canada
The MagLab is collaborating with EXFO to examine the spectra and output power of various illumination sources for microscopy including metal halide lamps, light engines, LEDs, and the LiFi illumination system.
(MagLab contact: Mike Davidson, Optical Microscopy)

FullScaleNANO, Inc., Tallahassee, FL
FullScaleNANO is an analytical consultancy and software development company established in 2012 and focused on creating a full solution for automatic characterization of nanomaterials called NanoMet. NanoMet converts images into useful data using powerful image processing algorithms combined with an intuitive, robust and fast user interface. The core technology of NanoMet was licensed from the Georgia Institute of Technology and is now commercially available to both academia and industry as the NanoMet WebApp.
(MagLab contact: Jeffrey Whalen)

Hamamatsu Photonics, Bridgewater, NJ
Scientists at the MagLab are working with applications specialists at Hamamatsu to field test the company's cooled and electron-multiplied scientific CCD camera systems. Demanding applications in quantitative image analysis and high-resolution images are being explored, as well as time-lapse fluorescence microscopy and resonance energy transfer imaging.
(MagLab contact: Mike Davidson, Optical Microscopy)

Hyper Tech Research Inc, Columbus, OH
Hyper Tech Research Inc. develops and manufactures MgB_2 superconducting wires for MRI applications. In this collaboration, the Magnet Science and Technology division measures critical current of MgB_2 wires developed by Hyper Tech Research. The critical current measurements are performed at 4.2 K and in 0 – 10 tesla magnetic fields.
(MagLab contact: Jun Lu, MS&T)

Leco Corporation
The ICR Program collaborates with the instrumentation and application scientists at Leco to determine the utility of high resolution mass spectrometry in energy and fuel research. Current work focuses on pyrolysis gas chromatographic analysis performed with a high resolution time-of-flight mass spectrometer.
(MagLab Contact: Ryan Rodgers, ICR)

Linkam, Surrey, United Kingdom
Scientists at the MagLab collaborate with Linkam engineers to design heating and cooling stages for observation of liquid-crystalline phase transitions in the optical microscope. In addition, microscopists are assisting Linkam in introducing a new heating stage for livecell imaging in fluorescence microscopy.
(MagLab contact: Mike Davidson, Optical Microscopy)

Lumencor Inc., Beaverton, OR
The MagLab is collaborating with Lumencor to ex-

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amine the spectra and output power of various illumination sources for microscopy including metal halide lamps, light engines, LEDs, and the LiFi illumination system.
(MagLab contact: Mike Davidson, Optical Microscopy)

MBL International, Woburn, MA
Scientists at the MagLab are collaborating with MBL to develop new fluorescent proteins for live-cell imaging applications. These include both optical highlighters and fluorescence resonance energy transfer (FRET) biosensors.
(MagLab contact: Mike Davidson, Optical Microscopy)

Media Cybernetics, Silver Spring, MD
Programmers at the MagLab are collaborating with Media Cybernetics to develop imaging software for timelapse optical microscopy. In addition, the Optical Microscopy group is working to add new interactive tutorials dealing with fundamental aspects of image processing and analysis of data obtained with the microscope.
(MagLab contact: Mike Davidson, Optical Microscopy)

Mevion Medical Systems, Littleton, MA
Mevion is a pioneer in the development of proton radiation therapy systems for the non-invasive treatment of cancer. The center of the systems is the proton accelerator that utilizes low temperature superconductors. NHMFL provides engineering support to Mevion by assisting in qualification testing of full-scale high current superconductors in background fields at low temperatures. The tests require NHMFL's unique test facility designed for tests of large conductors in a 12 tesla split solenoid superconducting magnet system.
(MagLab contact: Bob Walsh, MS&T)

Molecular Probes/Invitrogen, Eugene, OR
A major supplier of fluorophores for confocal and wide-field microscopy, Molecular Probes is collaborating with the MagLab to develop educational tutorials on the use of fluorescent probes in optical microscopy.
(MagLab contact: Mike Davidson, Optical Microscopy)

Nikon, Melville, NY
The MagLab maintains close ties with Nikon on the development of an educational and technical support microscopy website, including the latest innovations in digital-imaging technology. As part of the collaboration, the MagLab is field-testing new Nikon equipment and developing new methods of fluorescence microscopy.
(MagLab contact: Mike Davidson, Optical Microscopy)

Olympus America, Melville, NY
The MagLab is developing an education/technical website centered on Olympus products and will be collaborating with the firm on the development of a new tissue culture facility at the MagLab in Tallahassee. This activity will involve biologists at the MagLab and will feature Total Internal Reflection Fluorescence microscopy.
(MagLab contact: Mike Davidson, Optical Microscopy)

Olympus Corp., Tokyo, Japan
Investigators at the MagLab have been involved in collaboration with engineers at Olympus to develop and test new optical microscopy systems for education and research. In addition to pacing the microscope prototypes through basic protocols, the Optical Microscopy group is developing technical support and educational websites as part of the partnership.
(MagLab contact: Mike Davidson, Optical Microscopy)

Omega Optical, Brattleboro, VT
The MagLab is involved in collaboration with Omega to develop interactive tutorials targeted at education in fluorescence filter combinations for optical microscopy. Engineers at Omega work with MagLab microscopists to write review articles about interference filter fabrication and the interrelationships between various filter characteristics and fluorophore excitation and emission.
(MagLab contact: Mike Davidson, Optical Microscopy)

Oxford Instruments Superconducting Technology, Carteret, NJ
Oxford Instruments Superconducting Technology (OST) is one of the major manufacturers of superconducting wires. In this collaboration, the Magnet

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Science and Technology division measures hysteresis loss of Nb_3Sn wires developed by OST. The hysteresis loss measurements are performed at 4.2 K and in 0 – 5 tesla magnetic fields by a vibrating sample magnetometer.
(MagLab contact: Jun Lu, MS&T)

nGiMat LLC, Lexington, KY
nGiMat LLC is a small business specializing in manufacturing oxides nanopowders, and insulation of superconducting wires. MagLab collaborates with nGiMat LLC on a small business innovation research grant funded by US Department of Energy. The goal of this research is to improve the quality of ceramic insulation for $Bi_2Sr_2CaCu_2O_{8-x}$ superconducting wire.
(MagLab contact: Jun Lu, MS&T)

Photometrics (Roper Scientific Inc.), Tucson, AZ
The microscopy research team at the MagLab is exploring single molecule fluorescence microscopy using electron-multiplying CCD camera systems developed by Photometrics. In addition, the team is conducting routine fixed-cell imaging with multiple fluorophores to gauge camera performance.
(MagLab contact: Mike Davidson, Optical Microscopy)

Prior Scientific Inc, Rockland, MA
Prior is a major manufacturer of illumination sources and filter wheels for fluorescence microscopy. The MagLab team is collaborating with Prior to develop new illumination sources and mechanical stages for all forms of microscopy.
(MagLab contact: Mike Davidson, Optical Microscopy)

Qimaging, Burnaby, British Columbia, Canada
High-resolution optical imaging is the focus of the MagLab collaboration with Qimaging, a Canadian corporation that specializes in CCD digital cameras for applications in quantitative image analysis and high-resolution images for publication. Target applications are interactive tutorials and image galleries that will be displayed on the Internet.
(MagLab contact: Mike Davidson, Optical Microscopy)

Oxford Instruments, Abingdon, UK
Oxford Instruments is under contract to deliver a 15 T large-bore low temperature superconductor magnet to the NHMFL, to be combined with 17 T YBCO-coated conductor coils under development at the NHMFL to create the first 32 T all-superconductor magnet. In case of a quench, the LTS and HTS coils interact in a complex manner. The quench protection systems for the individual coil sets are inter-dependent. This cannot be handled by routine specifications in a standard vendor relationship. Therefore, Oxford Instruments and NHMFL Magnet Science and Technology are collaborating on quench protection to endure compatibility of the coil sets and are developing a numerical code to model quench in combined YBCO-LTS magnets.
(MagLab contact: Huub Weijers, MS&T)

Oxford Superconducting Technology, Carteret, NJ
Extensive collaborations exist between ASC and OST on both Nb_3Sn and Bi-2212 conductor development, aided by direct support of R&D on these materials from DOE-High Energy Physics to ASC PIs and to OST through the Conductor Development Program managed out of Lawrence Berkeley National Laboratory. In this way OST has been able to develop the most advanced Nb_3Sn and Bi-2212 conductors made.
(MagLab contacts: David Larbalestier, Eric Hellstrom, Peter Lee, Chiara Tarantini, Jianyi Jiang, ASC)

Revolution NMR LLC, Fort Collins, CO
Revolution NMR has licensed from FSU the Low-E probe technology developed at MagLab in order to fabricate static NMR probes for biological (protein) samples. Additionally, the MagLab's NMR instrumentation program and Revolution NMR collaborate on the development of stators for magic angle spinning NMR.
(MagLab contact: Peter Gor'kov, NMR)

Semrock, Rochester, NY
The MagLab Optical Microscopy group is collaborating with Semrock to develop interactive tutorials targeted at education in fluorescence filter combinations for optical microscopy. Engineers and support personnel at Semrock work with MagLab microscopists to write review articles about interference filter fabrication and the interrelationships between various filter characteristics and fluorophore excitation and emission. In addition, MagLab scientists produce images of living cells with Semrock filter com-

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binations.
(MagLab contact: Mike Davidson, Optical Microscopy)

SuperPower Inc, Schenectady, NY
The Applied Superconductivity Center and the Magnet Science and Technology division of the MagLab are collaborating with SuperPower Inc. on the characterization of YBCO coated conductors. This material has the potential to transform the field of high-field superconducting magnet technology and is in an early stage of commercialization. We work to improve our understanding of this product in support of the NHMFL 32 T project as well as to provide guidance to SuperPower on enhancing the quality of their product. We have also taken the lead in encouraging a Coated Conductor Round Table of users of coated conductors at which much information about the long length performance of coated conductors has been shared.
(MagLab contacts: David C Larbalestier, Dmytro Abraimov and Jan Jaroszynski, ASC and Huub Weijers MS&T)

SupraMagnetics Inc, Plantsville, CT
The Applied Superconductivity Center is participating in the development of a superconducting Nb_3Sn wire that uses artificial flux-pinning centers to achieve high critical current densities. The MagLab provides microstructural and microchemical support for this work.
(MagLab contact: Peter J. Lee, ASC)

Sutter Instrument, Novato, CA
The MagLab is collaborating with Sutter to examine the spectra and output power of various illumination sources for microscopy including metal halide lamps and the LiFi illumination system.
(MagLab contact: Mike Davidson, Optical Microscopy)

Thomas Keating LtD, UK
The EMR group has entered into a partnership with Thomas Keating (TK) LtD in the UK as part of its program aimed at developing a new characterization tool, Dynamic Nuclear Polarization Nuclear Magnetic Resonance (DNP - NMR) at high fields (14.1 T / 600 MHz). TK draws on tool-making skills to design and develop quasi-optical Terahertz systems and subsystems.
(MagLab contact: Stephen Hill, EMR)

Waters Corporation
The ICR and Future Fuels Institute are a Waters Corporation, Center of Innovation and collaborate on advances in instrumentation for biological and petroleum applications. Instrument and ion source advances are provided to both facilities before their commercial release and allow for applications development well before mainstream introduction.
(MagLab contact: Ryan Rodgers, ICR)

Zeiss Micro Imaging, Thornwood, NY
The Optical Microscopy group at the MagLab is negotiating a contract with Zeiss on the development of an educational and technical support microscopy website, including the latest innovations in digital imaging technology. As part of the collaboration, microscopists are field-testing new Zeiss equipment and developing new methods of fluorescence microscopy.
(MagLab contact: Mike Davidson, Optical Microscopy)

NATIONAL OR INTERNATIONAL LABS/INSTITUTES (20)

CERN, Geneva, Switzerland
The Large Hadron Collider (LHC) at CERN uses a 27 km ring of superconducting magnets based on Nb-Ti to accelerate particles in the world's largest and most powerful collider but plans to increase the energy capability of LHC will require higher magnetic fields. The Applied Superconductivity Center is collaborating with CERN to characterize and optimize a new generation of accelerator quality Nb_3Sn strands based on the powder-in-tube process that have the potential to provide the performance necessary for the next step in LHC upgrades.
(MagLab contacts: David Larbalestier, Chiara Tarantini and Peter Lee, ASC)

Dana-Farber Cancer Institute, Boston, MA
Current collaboration between Dana-Farber Cancer Institute and the Magnetic Lab is aimed at determining the molecular details of HIV envelope protein gp41 using electron paramagnetic resonance methods. Other goals include characterization of antibody-induced structural changes of gp41, and developing optimized vaccine immunogens by structural approaches.
(MagLab contact: Likai Song, EMR)

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EUCARD2 (European Collaboration for Accelerator R&D)
EUCARD2 is a European Framework collaboration of about 10 European labs aimed at developing kiloamp high temperature superconductor cables for future application to a high energy LHC. The European emphasis is on Roebel cables of REBCO coated conductors but an equally attractive cable for accelerator purposes is a round wire cable made in the Rutherford style out of Bi-2212 ($Bi_2Sr_2CaCu_2O_{8-x}$). This conductor has been developed at the MagLab under DOE-HEP support in the context of the Bismuth Strand and Cable Collaboration (BSCCo) that unites the MagLab, BNL, FNAL, LBNL and OST in a team developing this material for accelerator use. The MagLab is now the US point of contact for collaborations between EUCARD2 and the US program.
(MagLab contacts: David Larbalestier, Eric Hellstrom and Jianyi Jiang, ASC)

European MicroKelvin Platform (EMP)
The University of Florida MicroKelvin Laboratory and the National High Magnetic Field Laboratory's High B/T Facility has entered into a co-operative agreement with the European Microkelvin Platform (EMP) to establish a program of collaborative research in areas of mutual interest at ultra-low temperatures, with a focus on promoting and facilitating, where feasible, exchange visits for scientists and students. The EMP is a consortium of 20 leading ultralow temperature physics and technology partners in Europe. The main aim of the consortium is the further integration of ultralow temperature research for the development of new ideas, knowledge, technology, applications and commercial exploitation to enhance further the innovation potential in this field. In addition to research activities, the parties to this agreement will co-operate in the training of ultra-low temperature physicists through course offerings to qualified candidates such as the European Advanced Cryogenics Course and the Cryogenics Course at the University of Florida.
(MagLab contacts: Neil Sullivan, UF)

Fermilab, Batavia, IL
The shaping of Nb sheet to produce superconducting RF cavities introduces microstructural defects that may impact cavity performance; in collaboration with Fermilab the Applied Superconductivity Center is studying the surface and bulk superconductivity in deformed niobium wires. Controlled deformation is introduced into the Nb samples wire drawing and the resulting defects are quantified and compared to the measured superconducting properties.
(MagLab contact: Peter J. Lee, ASC)

Future Fuels Institute
The Future Fuels Institute (FFI) was established to enhance the existing Ion Cyclotron Resonance (ICR) Program at the NHMFL to deal specifically with biological and fossil fuels, particularly for heavy oils and synthetic crudes. Supported by sponsoring companies and collaborative entities (instrument companies, universities and research institutes), the FFI works to develop and advance novel techniques for research applications and problem solving. FFI is actively seeking up to 6 industrial collaborators as corporate MEMBERS to support core research programs. Each of these corporate members will be asked to provide $250,000/year for 4 years. The MEMBER may terminate the membership by giving the INSTITUTE 30 days written notice prior to the membership renewable date.
Current corporate members include:

- Total
- Petrobras
- Reliance Industries
- Ecopetrol

The institute also serves as a training center for fuel-related science and technology.
(MagLab contact/Director: Ryan Rodgers)

Helmholtz Zentrum Berlin, Berlin, Germany
The MagLab has partnered with the Helmholtz Zentrum Berlin (HZB) to develop the highest field magnet worldwide for neutron scattering at HZB. In March 2007, HZB (formerly the Hahn-Meitner Institute) signed an agreement with Florida State University Magnet Research and Development Inc. The magnet is intended to provide 25 T on-axis using 4.4 megawatts of DC power and have upstream and downstream scattering angles of 30 degrees. The magnet reached 26 T on October 16, 2014. Since then it has been moved from the test site into the neutron guide hall and served the first users in July 2015. We are now discussing an agreement for assistance with ongoing operations and maintenance.
(MagLab contact: Mark D. Bird, MS&T)

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Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) of Chinese Academy of Sciences
The collaboration between the IVPP and the MagLab is related to the investigation of Late Cenozoic Vertebrate Paleontology and Paleoenvironments of the Tibetan Plateau (China). Samples collected in this project are analyzed in the Geochemistry Laboratories in the Maglab.
(MagLab contact: Yang Wang, Geochemistry Program)

International Thermonuclear Experimental Reactor (ITER International Organization), Cadarache, France US-ITER Project Office, Oak Ridge, TN University of Twente, Enschede, the Netherlands
The Applied Superconductivity Center has for the last 5 years played a major role in helping ITER-IO understand the properties of the cables being wound into the Central Solenoid (CS) and the Tokamak Field (TF) coils. A central task has been the disassembly and metallographic analysis of the prototype Cable-in-Conduit-Conductors (CICCs) needed for TF and CS coils after testing in the SULTAN facility in conditions designed to simulate ITER operations. Many of these conductors Toroidal Field (ITER Organization) and Central Solenoid (US-ITER) CICCs typically suffered significant performance degradation during cyclic loading and occasional warm-up and cool-down cycles. The tests performed at the MagLab were able to identify many of the causes for this degradation and were instrumental in developing new cable patterns that resolved the degradation. This work was collaborative with groups at CEA-Cadarache, the University of Twente in the Netherlands and US-ITER.
(MagLab contacts: Peter J. Lee and David C Larbalestier, ASC)

International Thermonuclear Experimental Reactor (ITER), US-ITER Project Office, Oak Ridge National Laboratory (ORNL), Oak Ridge, TN
The United States is part of an exciting international collaboration to demonstrate the feasibility of an experimental fusion reactor that is under construction in France. The MS&T's Mechanical Properties Lab is the US-ITER primary materials research and qualification laboratory supporting the US effort. The Tokamak machine consists of three types of very large, complex superconducting magnets that all utilize Cable-in-Conduit Conductors (CICC) as the main structural components. Another important component for stress management of the Central Solenoid is a massive CS pre-compression structure (Tie Plates). The conduit and tie plate alloys, and their welds, are being studied and characterized here to ensure their performance and reliability. The funding for this research is provided by US-DOE, US-ITER Project Office at ORNL.
(MagLab contact: Bob Walsh, MS&T)

Jefferson Lab, Newport News, VA
Recently Nitrogen and Titanium doping have emerged as highly effective methods of improving the quality factor on Nb SRF cavities; the Applied Superconductivity Center is working with scientists at Jefferson Lab to evaluate the interaction between prior cold-work and doping treatment of Nb samples and their influence on the superconducting properties. Doping is carried out at Jefferson Lab and superconducting property measurements, including magneto optical imaging area carried out at the MagLab..
(MagLab contact: Peter J. Lee, ASC)

Key Laboratory of Electromagnetic Processing of Materials, Northeastern University, Shenyang, China
The collaboration between the Northeastern University and the MagLab is related to the magnetic field impact on fabrication of high strength conductors. A professor visited MagLab in 2015 and a MagLab faculty member visited Northeastern University in 2015. They published two joint papers in 2015.
(MagLab contact: Ke Han, MS&T)

Large Accelerator Project for the HiLumi upgrade of the CERN LHC, Brookhaven National Lab, Upton, NY
Accelerator magnets based on Nb_3Sn wires are required to provide the increased magnetic fields for the next LHC upgrade. The Applied Superconductivity Center is collaborating with Brookhaven National Lab to understand the design and heat treatment optimization of accelerator magnet quality strand fabricated by the internal Sn process with a view to driving high current density strands to smaller filament sizes. Close collaboration with the R&D billets being manufactured for LARP under the Conductor Development Program of DOE High

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Energy Physics is a key part of the work.
(MagLab contacts: Chiara Tarantini, Peter J. Lee and David C Larbalestier, ASC)

Lawrence Berkeley Laboratory, Accelerator and Fusion Research, Berkeley, CA
The Applied Superconductivity Center and the Magnet Science and Technology division of the MagLab are collaborating with researchers at the Berkeley National Laboratory on the testing of Roebel-style cables based on REBCO coated conductors, a high temperature superconductor. Testing of a 10-strand cable with transposed 2 mm wide strands is in preparation. Roebel-style cables represent one of three viable concepts for REBCO coated conductor cables suitable for high field magnets.
(MagLab contact: Huub Weijers, MS&T)

Los Alamos National Laboratory Community Programs Office, NM
CIRL works closely with our counterpart, the Los Alamos National Laboratory Community Programs Office. Over the last year we have developed a partnership wherein we share information and resources on our educational activities. The community programs office has a large staff that oversees more than 15 different educational/community outreach programs including the Bradbury Museum.
(MagLab Contact: Roxanne Hughes, Carlos Villa, Educational Programs)

School of Mechanical Engineering and Automation, Fuzhou University, Fuzhou, China
The collaboration between the Fuzhou University and the MagLab is related to the characterization of high strength conductors. They published two joint papers in 2015.
(MagLab contact: Ke Han, MS&T)

Scripps Research Institute
We continue to collaborate with Dr. Ming Guo (Scripps Florida), for structural characterization of transfer RNA synthetases functioning in roles other than protein synthesis. Those functions result from complexation of a given synthetase with one or more other proteins. Synthetase mutations lead to various diseases. Scripps provides the mutants, and we use hydrogen/deuterium exchange monitored by FT-ICR mass spectrometry to map the protein:protein contact surfaces in the complexes to establish structure function relationships.
(MagLab Contact: Alan Marshall, ICR)

Southeast Center for Integrated Metabolomics, University of Florida, FL
With a new $9 million grant from National Institutes for Health, the University of Florida created a Southeast Center for Integrated Metabolomics which joins a consortium of five other regional resource centers and a national coordinating center to spur metabolomics research in the United States by funding training, technology development, standards synthesis and data-sharing initiatives. Metabolomics draws from many scientific disciplines, including chemistry, physiology, statistics, genetics, computer science and systems design and, as such, has many partners: the National High Magnetic Field Laboratory at Florida State University, Sanford-Burnham Medical Research Institute, Ohio State University, the University of Georgia, Imperial College London, the University of Geneva and industry partners IROA Technologies and Thermo Fisher Scientific.
(MagLab contact: Arthur Edison, AMRIS)

Thomas Jefferson National Accelerator Facility, Newport News, VA
Large-grain Nb has become a viable alternative to fine-grain Nb for the fabrication of superconducting radio-frequency cavities. NHMFL collaborated with engineers at Jefferson Lab to evaluate the effect of thermal processing and grain size on the mechanical properties of Nb. The mechanical properties evaluation was carried out at MS&T's Mechanical Properties Lab.
(*MagLab contact: Bob Walsh, MS&T*)

Woods Hole Oceanographic Institute
As part of FSU's Gulf Research Initiative Consortium, NHMFL collaborates with Christopher Reddy and Robert Nelson at WHOI in characterization of petroleum oil spills at the molecular level, by gas chromatography x gas chromatography and FT-ICR mass analysis. Characterization of the 2010 Macondo wellhead oil has been completed, and current research focuses on subsequent physical, chemical, and biological changes as the spill propagates into the environment.
(MagLab Contact: Ryan Rodgers, ICR)

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UNIVERSITIES (12)

Florida State University, College of Education, Tallahassee, FL
The Center for Integrating Research & Learning works closely with faculty from the FSU College of Education to network and strengthen programs on campus and at the lab. Currently, we utilize the expertise of FSU faculty for research projects. We also recruit graduate students from FSU departments to conduct research on CIRL programs.
(MagLab Contact: Roxanne Hughes, Educational Programs)

Korea Advanced Institute of Science and Technology (KAIST) Professor Hyoungsoon Choi's group at the Korea Institute of Science and Technology (KAIST) has developed a cooperative agreement with Professor Yoonseok Lee and the National High Magnetic Field Laboratory's High B/T Facility for the study and development of the design of coolant materials used in nuclear demagnetization refrigerators. The collaboration focuses on the techniques and expertise required to produce high residual resistant ratios for the metallic materials used for the coolants and the associated components. KAIST is a leading center for ultra-low temperature research in Korea.
(MagLab contacts: Yoonseok Lee, UF)

Nagoya University, Nagoya, Japan
Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany
Leibniz Institute for Solid State and Materials Research (IFW), Dresden, Germany
The Applied Superconductivity Center is collaborating Nagoya University, the Karlsruhe Institute of Technology, and the Leibniz Institute in the investigation of iron-based superconductors in order to establish their intrinsic properties and determine their potential for applications using electromagnetic characterization techniques also in high field and expertise available in the MagLab.
(MagLab contact: Chiara Tarantini, ASC)

Michigan State University, Lansing, MI
The Applied Superconductivity Center is collaborating Michigan State University on a US-DOE funded project to study the impact of grain boundaries and associated microstructural defects on the performance of superconducting cavities using the advance microstructural, microchemical, and electromagnetic characterization techniques and expertise available in the MagLab.
(MagLab contact: Peter J. Lee, ASC)

Osaka City University, Japan
The EMR group received joint funding with the University of Modena in Italy and Osaka City University in Japan through an International Program sponsored by the Air Force's Asian Office of Aerospace Research and Development (AOARD). This joint program focuses on quantum properties of molecular magnets. A cooperative agreement between Osaka City University and Florida State University has been established in order to formalize this collaboration.
(MagLab contact: Stephen Hill, EMR)

Radboud University, Nijmegen, The Netherlands
The MagLab has partnered with the High Magnetic Field Lab in The Netherlands to develop a 45 T hybrid magnet using only 24 MW of power. The project was funded by the Dutch government in 2006 and in 2012 an agreement was signed for the MagLab to play a leading role in the development of the Nb_3Sn cable-in-conduit superconducting coil for this magnet system. This will be the 4th hybrid outsert to be developed at the MagLab (MagLab 45 T, HZB, FSU SCH, Nijmegen) and the Dutch lab will benefit from our extensive experience. When complete it is expected to be one of the three 45 T systems worldwide. Cable-in-conduit conductors have arrived and are being wound into the coil. This will be followed by jointing, reaction, impregnating and final assembly.
(MagLab contact: Mark D. Bird, MS&T)

Shanghai University, Shanghai, China
The collaboration between the Shanghai University and the MagLab is related to the solidification of metallic materials. A scientist from Shanghai University will join the MagLab as a visiting scientist for one year to do the research on microstructure of high strength materials. They have published on joint paper.
(MagLab contact: Ke Han, MS&T)

St. Andrews University, UK
The EMR group has an ongoing partnership with St. Andrews University in the UK, involving the devel-

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opment of a high-power (1 kW) high-frequency (94 GHz) pulsed EPR spectrometer (HiPER) for its user program.
(MagLab contact: Stephen Hill, EMR)

Texas A&M University, College Station, TX
Texas A&M University is fabricating Nb sheet and tubes with ultra-fine grain size and controlled textures for superconducting RF cavities by using the Equal Channel Angular Extrusion (ECAE) process; the Applied Superconductivity Center is providing microstructural characterization of the Nb primarily using the new fast-camera crystallographic orientation mapping system at the MagLab.
(MagLab contact: Peter J. Lee, ASC)

University of Colorado Boulder, Boulder, CO
Nb_3Sn is the primary superconductor for providing magnetic fields in the 11-22 T range but is brittle and there is the potential for filament fracture when subjected to the high Lorentz forces produced when the superconducting magnets are energized. The University of Colorado Boulder, (using the NIST-Boulder electromechanical testing facilities) has determined the strain sensitivity of a wide range of commercial Nb_3Sn wires and has found a large variation in irreversibility strains (the limit in strain that the wire can be subjected to before unrecoverable degradation in performance), and the Applied Superconductivity Center has been working with UC-Boulder to try and the understand reasons for these variations so that future strands will be able to withstand the forces generated at high magnetic fields.
(MagLab contact: Peter J. Lee, ASC)

University of Modena, Italy
The EMR group received joint funding with the University of Modena in Italy and Osaka City University in Japan through an International Program sponsored by the Air Force's Asian Office of Aerospace Research and Development (AOARD). This joint program focuses on quantum properties of molecular magnets.
(MagLab contact: Stephen Hill, EMR)

University of Texas Medical Branch at Galveston
The ICR Program collaborates with Profs. Carol L. Nilsson and Mark R. Emmett. One current project is proteomics and glycomics of brain cancer-derived stem-like cells correlated to gene expression data and patient outcomes. A second project involves FT-ICR mapping of lipid alterations in spinal cord injury.
(MagLab Contact: Alan Marshall, ICR)

COMMUNITY GROUPS/ EDUCATIONAL GROUPS (12)

CAISE - Center for the Advancement of Informal Science Education
The Center for the Advancement of Informal Science Education (CAISE) works in collaboration with the National Science Foundation (NSF) Advancing Informal STEM Learning (AISL) Program to strengthen and advance the field of professional informal science education and its infrastructure by providing resources for practitioners, researchers, evaluators and STEM-based professionals. CAISE also facilitates conversation, connection and collaboration across the ISE field — including in media (TV, radio, and film), science centers and museums, zoos and aquariums, botanical gardens and nature centers, cyberlearning and gaming, and youth, community, and out of school time programs. The Center for Integrating Research & Learning (CIRL) has worked with CAISE to provide advice for reaching Principal Investigators and improving the evaluation of broader impacts.
(MagLab Contact: Roxanne Hughes, Educational Programs)

Community Classroom Consortium, Tallahassee, FL
The Community Classroom Consortium (CCC) is a coalition of more than thirty cultural, scientific, natural history, and civic organizations in north Florida and South Georgia that provide educational experiences and resources to the public, especially K-12 teachers and students. Representatives from CIRL and Public Affairs represent the Lab on the board of this organization and as general members.
(MagLab Contact: Kristen Coyne, Public Affairs)

Florida Afterschool Network, Tallahassee, FL
The Florida Afterschool Network (FAN) is an organization that is working toward creating and sustaining a statewide infrastructure to establish collaborative public and private partnerships that connect local, state, and national resources supporting afterschool programs that are school-based or school-

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linked; develop quality afterschool standards that are endorsed and promoted by statewide stakeholders and through Florida Afterschool Network; and promote public awareness and advocate for policy that expands funding, quality improvement initiatives, and accessibility of afterschool programs. The Center for Integrating Research & Learning is a member of the advisory council for this organization.
(MagLab Contact: Roxanne Hughes, Educational Programs)

Future Physicists of Florida
Future Physicists of Florida is an organization dedicated to recognizing talented middle school math and science students and providing educational guidance to these students to prepare them for careers in physics and engineering. CIRL is a partner in the organization.
(MagLab Contact: Roxanne Hughes, Educational Programs)

Leon County and City of Tallahassee Commission on the Status of Women and Girls
The Commission on the Status of Women and Girls was formed in April of 2011 by the Leon County Board of County Commissioners. The CSWG was established as a citizens advisory committee. In March of 2013, the City of Tallahassee proudly joined Leon County and created the new Tallahassee/Leon County Commission on the Status of Women and Girls (CSWG). By establishing and supporting this Commission, the City of Tallahassee and Leon County have taken a strong stand in support of women and girls in our community. Roxanne Hughes was selected to serve a two-year term by county commissioner Kristin Dozer.
(MagLab Contact: Roxanne Hughes, Educational Programs)

Leon County Schools, FL
CIRL works closely with Leon County Schools (LCS) through our K-12 outreach and our middle school mentorship program. In 2014, CIRL staff worked with Title I elementary school teachers from LCS to develop and facilitate a year-long teacher professional development that culminated in a STEM challenge for students.
(MagLab Contact: Roxanne Hughes or Carlos Villa, Educational Programs)

Los Angeles County Museum of Natural History
The collaboration between the IVPP and the MagLab is related to the investigation of Late Cenozoic Vertebrate Paleontology and Paleoenvironments of the Tibetan Plateau (China). Stable isotopic compositions of the samples collected in this project are analyzed in the Geochemistry Laboratories in the MagLab.
(MagLab contact: Yang Wang, Geochemistry Program)

Oasis Center for Women and Girls, FL
The Oasis Center is a nonprofit organization in Tallahassee whose mission is to "improve the lives of women and girls through celebration and support". They are focused on personal, professional, and economic concerns facing women, girls and their families. CIRL has worked closely with this center through outreach including providing mentors and/or tours for their science summer camps.
(MagLab Contact: Roxanne Hughes, Educational Programs)

Palmer Munroe Teen Center, FL
The Palmer Munroe Teen Center is a community center that focuses on teens from low income neighborhoods in Tallahassee. The center is run by the City of Tallahassee. CIRL works closely with students and staff at the center through outreach.
(MagLab Contact: Roxanne Hughes, Educational Programs)

Panhandle Area Educational Consortium (PAEC), FL
The Panhandle Area Educational Consortium serves 13 school districts in the panhandle of Florida. PAEC provides leadership and support services to these districts, increases networking among members, and maximizes resources. Over the years, CIRL has provided teacher workshops and high school summer information sessions to students and teachers from these districts with PAEC's facilitation.
(MagLab Contact: Roxanne Hughes, Educational Programs)

South Florida Water Management District (SFWMD)
The collaboration between the SFWMD and the MagLab is related to the investigation of land-use and change on food web structure and mercury cy-

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cling in the Everglades. Isotopic compositions of the samples collected in this project were analyzed in the Geochemistry Laboratories in the MagLab.
(MagLab contact: Yang Wang, Geochemistry Program)

WFSU-TV, Tallahassee, FL
The Center for Integrating Research & Learning partners with WFSU-TV, the area's public television station, to administer SciGirls. The program is a 2-week camp for middle and high school girls with an interest in science. The collaboration between the MagLab and WFSU-TV has resulted in a successful 6-year camp that has engaged the larger community. In addition, WFSU-TV and the Center partner to provide summer physics experiences for students entering high school.
(MagLab contact: Roxanne Hughes, Educational Programs)

SPIN OFFS (4)

High Performance Magnetics (HPM)
High Performance Magnetics was founded in 2008 by Thomas Painter, an engineer at the National High Magnetic Field Laboratory. High Performance Magnetics established a nearly half-mile long superconducting cable jacketing facility located at the Tallahassee Regional Airport. High Performance Magnetics jacketed Toroidal Field Nb_3Sn cable-in-conduit conductors for Oak Ridge National Laboratory as part of the United States contribution to an international clean energy experiment, ITER, being built in France. These high-current, high-field superconducting cables were jacketed according to the strictest quality standards required by the nuclear industry.
(MagLab contact: Tom Painter)

MAXIKAT, Inc.
Maxikat is a spinoff company that performs data analysis for petroleum industry. It was formed in 2015.
(MagLab contact: Vladislav Lobodkin)

Omics LLC
Omics LLC is a spinoff company that serves the data analysis and interpretation needs of the high resolution mass spectrometry market. It was formed 8 years ago and has grown over the years to address a wider analytical community.
(MagLab contact: Ryan Rodgers)

Specialized Crystal Processing, Inc.
Specialized Crystal Processing, Inc. (SCPI) is an advanced materials processing, manufacturing and consultation spin-off of the National High Magnetic Field Laboratory. The SCPI home base facility in Tallahassee, FL has the infrastructure for both R&D and manufacturing of highly specialized single crystal products. These crystals can be used for a variety of applications, including but not limited to high tech devices and sensors, advanced materials basic science research and crystalline additives for composite materials.
(MagLab contact: Jeffrey Whalen, Theo Siegrist)

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10. MagLab Data Management Plan

The National High Magnetic Field Laboratory (NHMFL) provides seven high magnetic field user facilities across the three campuses of the NHMFL at Florida State University, the University of Florida, and Los Alamos National Laboratory. These user facilities are the DC Field Facility, Pulsed Field Facility, High B/T Facility; and the Nuclear Magnetic Resonance (NMR), Electron Magnetic Resonance (EMR), Ion Cyclotron Resonance (ICR), and Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS) Facilities. Each user facility is built around unique magnetic-field facilities and world-leading scientific expertise serving a multi- and inter-disciplinary scientific research community. Though each facility has a unique environment and tradition of data management, many items are handled in a consistent way across sites. Most of our data management practices are driven by our user community and the standards of the associated funding agencies. The policy is reviewed annually to stay current with user demands and changes in technology.

Data Types

Our user facilities data consists primarily of electronic records of measurements taken during a scheduled experiment. Data from a facility can be generated on either a facility computer system, visiting user's computer, or special data acquisition systems provided by a user. These electronic records may or may not exist on a facility computer during the course of an experiment.

The NHMFL scientific staff develops, maintains and updates many software routines for analysis of data tailored to the different needs of the user facilities.

Data Standards

The standards for data vary across user facilities as required by the experimental methods and equipment used. The most open standard for the DC Magnet facility is for ASCII text files in column format. High data rate experiments such as the Pulsed Field Facility necessitate the use of open binary formats or custom file formats developed by NHMFL personnel. The ICR facility also stores data in an NHMFL-developed format. For NMR experiments, data formats are dictated by the research equipment used, such as the vendor-specific format for NMR data collected by Bruker spectrometers. Magnetic Resonance Imaging data from our AMRIS facility is in DICOM images for OSIRIX viewer. Data is made available to researchers through the use of the current picture archiving and communication systems (PACS) with dedicated computers on a local high speed network.

All NHMFL-developed formats are open. Specifications and software to read and analyze data in these formats is available to the scientific community for free or at nominal reproduction costs. These software tools are provided on laboratory web sites and software storage areas.

Meta-data can be recorded with the raw data files at the option of the researchers. Other meta-data is recorded in the users written notebooks, computer files, or other media at the option of the principal investigator. Management of the meta-data associated with standard data files is exclusively the purview of the principal investigator.

Data Access Policies

The principal investigator in charge of a user experiment has exclusive rights to all data related to that experiment, including raw data and meta-data. Access to experiment data is granted only to individuals designated by the principal investigator. The principal investigator retains full control of the use of the data, including its publication in refereed literature. The principal investigator is responsible for adhering to the policies and procedures of their funding agency.

The NHMFL's data management and sharing practices align with the policy applied to NSF and NIH single investigator grants, as the NHMFL user community consists primarily of researchers supported by these types of awards.

Data Re-use Policies

Data is not reused nor are any data-mining operations performed by the NHMFL on historical user data. Once data is collected and provided to the user, it is solely the property of that particular user. Any reuse within their own program (external to NHMFL) is strictly at their discretion. Users are

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encouraged to make their research findings and final data readily available for research purposes to qualified individuals within the scientific community by publishing the results in peer-reviewed journals and by presenting the findings at conferences. In addition, the NHMFL requires all users to submit a one-page annual research report on each project for inclusion in the NHMFL Annual Report. These reports are available on the NHMFL web site and serve to illustrate the quantity, quality and breadth of research activities at the lab. Each year, thirty to forty of these reports are chosen as highlights to be published in a Special Issue of MagLab Reports, the NHMFL's quarterly magazine that is widely distributed to scientists, students, and granting agencies.

Users are reminded to follow all regulations of the NSF and NIH data sharing policies by posting of this policy (http://grants.nih.gov/grants/policy/ data_sharing) on the AMRIS webpage (http://amris.mbi.ufl.edu) as well as via periodic emails to the user group. (see NIH Grants Policy Statement: http://grants.nih.gov/policy/nihgps/index.htm and NSF Award and Administration Guide http://www.nsf.gov/pubs/policydocs/pappguide/nsf11001/aag_6.jsp). When appropriate, users are encouraged to deposit standard data formats in existing repositories, such as the "Protein Data Bank" and "Biological Magnetic Resonance Data Bank".

Data Archiving

Data collected and stored on an NHMFL facility computer system are backed-up to local hard drives, tape storage or other common backup media. Data archiving is primarily the responsibility of the PI at their home institutions, but archived user data are retained at the NHMFL facility for a period ranging from six months to two years after collection at the NHMFL. This retention policy is reviewed annually and may be revised at the request of our user community, or in response to the continually evolving capabilities and reduction in costs of data storage. Archived data will only be made available to individuals at the request of the principal investigator of the project.

Users may transfer their data to portable storage devices or other computers, both local and remote, in accordance with local facility administration policies. Upon request user data will be archived on optical or other similarly permanent media and provided to the user.

CHAPTER 3
USER FACILITIES

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1. User Program

The MagLab is one user program with seven user facilities - DC Field, Pulsed Field, High B/T, NMR-MRI@FSU, NMR-MRI@UF (AMRIS), EMR, and ICR – each with exceptional instrumentation and highly qualified staff scientists and staff, comprise the MagLab's User Program. In this chapter of the annual report, information is being presented about the proposal review process, user safety training, special user funding opportunities, and user committee report.

A. PROPOSAL REVIEW PROCESS

Across all seven facilities, proposals for magnet time are submitted online (https://users.magnet.fsu.edu/) and reviewed in accordance with the NHMFL User Proposal Policy (https://users.m agnet.fsu.edu/Documents/UserProposalPolicy.pdf). In brief, each user facility has a User Proposal Review Committee (UPRC) comprising at least seven members, with more external members than internal. UPRC memberships are treated confidentially by the laboratory but are available for review by NSF and NHMFL advisory committees. Proposal reviews are conducted in strict confidence and are based on two criteria: (1) the scientific and/or technological merit of the proposed research, and (2) the "broader impacts" of the proposed work. They are graded online according to a scale, ranging from "A" Proposal is high quality and magnet time must be given a high priority; to "C" Proposal is acceptable and magnet time should be granted at NHMFL discretion; to "F" – Proposal has little/no merit and magnet time should not be granted. The Facility Directors dovetail the UPRC recommendations with availability and scheduling of specific magnets, experimental instrumentation, and user support scientists and make recommendations for magnet time assignments to the NHMFL Director. The NHMFL Director is responsible for final decisions on scheduling of magnet time based on these recommendations.

Table 1: *MagLab Facility Usage Profile (Type of Affiliation) for 2015*

	Total Days* Allocated / User Affil.	Condensed Matter Physics	Chem. Geochem.	Engineering	Magnets, Materials, Test, Instr.	Biology, Biochem., Biophys
NHMFL-Affiliated	**2,271**	586	355	2	211	1,117
Local	**1,054**	74	180	85	14	701
U.S. University	**3,691**	1,527	936	111	70	1,047
U.S. Govt. Lab.	**172**	101	14	3	8	46
U.S. Industry	**37**	0	28	0	0	9
Non-U.S.	**1,648**	709	579	36	56	268
Test, Calibration, Set-up, Maintenance, Inst. Dev.	**1,206**	132	74	0	863	137
Total:	**10,079**	**3,129**	**2,166**	**237**	**1,222**	**3,325**

** User Units are defined as magnet days for four types of magnets. One magnet day is 7 hours in a water cooled resistive or hybrid magnet in Tallahassee. One magnet day is 12 hours in any pulsed magnet in Los Alamos and 24 hours in superconducting magnets in Tallahassee and the High B/T system in Gainesville. Magnet days for AMRIS instruments in Gainesville: Verticals (500, 600s, & 750 MHz), 1 magnet day = 24 hours (7 days/week); Horizontals (4.7, 11.1, and 3T), 1 magnet day = 8 hours (5 days/week).*

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In 2015, 1,615 users from around the world enjoyed access to magnet time at the lab's seven user facilities at three sites. The MagLab was extremely pleased to welcome requests for magnet time from 85 new principal investigators in 2015: 13 in the DC Field Facility; 3 in the Pulsed Field; 1 in the High B/T; 1 in NMR-MRI@FSU; 8 in NMR-MRI@UF (AMRIS); 18 in EMR; and 42 in ICR. All 85 of these new PIs submitted a request and received magnet time or have been scheduled to receive magnet time during the year.

Table 2: *MagLab User Profile (Demographics) for 2015*

	Users	Male	Female	No Response to Gender	Minority [1]	Non-Minority [1]	No Respond to Race	Affil. Users [2]	Local Users [2]	Uni. Users [3,5]	Indus. Users [5]	Nation. Lab Users [4,5]
Senior Personnel, U.S.	**620**	481	93	46	26	539	55	171	97	526	14	80
Senior Personnel, non-U.S.	**205**	164	20	21	15	159	31	4	0	156	13	36
Postdocs, U.S.	**168**	113	41	14	11	135	22	39	48	151	0	17
Postdocs, non-U.S.	**42**	27	10	5	2	31	9	2	0	27	0	15
Students, U.S.	**453**	296	130	27	29	364	60	62	134	449	1	3
Students, non-U.S.	**92**	67	17	8	6	68	18	1	0	85	1	6
Technician U.S.	**32**	23	8	1	2	29	1	14	12	29	3	0
Technician non-U.S.	**3**	3	0	0	0	3	0	0	0	3	0	0
Total:	**1,615**	**1,174**	**319**	**122**	**91**	**1,328**	**196**	**293**	**291**	**1,426**	**32**	**157**

1. *NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander (and if more than one has been selected). The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin.*
2. *NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators". "Users Sending Sample" refers to users who send the sample to the facility and the experiment is conducted by in-house user support personnel. Users at UF, FSU, and LANL cannot be "sample senders" for facilities located on their campuses.*
3. *In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.*
4. *In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.*
5. *The total of university, industry, and national lab users will equal the total number of users.*

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B. RESEARCH REPORTS

At the end of each year, MagLab users and faculty at FSU, UF and LANL submit brief abstracts of their experiments, research and scholarly endeavors. All reports are available online at: https://nationalmaglab.org/research/publications-all/research-reports
Users generated 478 research reports in 2015.

***Table 3:** 2015 Research Reports by Facility*

FACILITIES	NUMBER OF REPORTS
DC Field Facility	138
Pulsed Field Facility	66
High B/T Facility	6
NMR-MRI@FSU	65
NMR-MRI@UF (AMRIS)	63
EMR Facility	49
ICR Facility	29
MAGLAB DEPARTMENTS & RELATED GROUPS	**NUMBER OF REPORTS**
Applied Superconductivity Center	18
Condensed Matter Theory/ Experiment (FSU)	15
Magnet Science & Technology	11
UF Physics	3
Geochemistry	15
TOTAL REPORTS	**478**

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C. USER SAFETY TRAINING BY FACILITIES

Safety training, across all facilities, is an important component of the Lab's Integrated Safety Management.

DC Field Facility

Users of the DC Field Facility must complete the appropriate online safety training prior to being issued a badge and receiving access to the DC Magnet Building. Users are assigned training modules that are appropriate to the experiment they are conducting and the part of the facility they will be working in. When magnet time is awarded, the safety training status of the researchers who are traveling to the MagLab is checked by the DC Field User Program Coordinator several weeks prior to their arrival. Any users who either have not taken the required training or whose training has expired are directed to the training website:
https://training.magnet.fsu.edu/Login/Default.aspx
to take the appropriate training. Users who arrive at the lab without having completed the training are set up in one of our user offices so that they can complete the training before they are granted access the magnet cells.

During the user's magnet time they are assigned an in-house scientist as well as a technician in order to provide scientific and technical support. This also ensures that the user performs their experiment in a safe manner. In addition, the control room operators monitor the magnet cells via cameras located in each cell. User operations on the 45 T hybrid magnet are also monitored directly by a hybrid operator who is present on the user platform while the hybrid magnet is in use.

Pulsed Field Facility

Users of the Pulsed Field Facility (PFF) are treated equally as full time employees at Los Alamos National Laboratory (LANL) with respect to hazardous work activities and authorization.

All LANL workers are educated on a comprehensive approach towards safe work practices within the context of Integrated Safety Management at LANL before being authorized to perform hazardous work activities. The approach that LANL takes is based on "Human Performance Improvement" or HPI (available at: http://energy.gov/sites/prod/files/2013/06/f1/doe-hdbk-1028-2009_volume1.pdf) The use of engineering controls are preferred to keep workers safe and reduce the risk of a human based error whenever possible (example: door interlocks and "Kirk Keys" used to ensure safe equipment configuration in pulsed capacitor bank operations at the PFF). The knowledge of HPI practices and the approach to safety management is central to the safety aware work culture at the PFF and throughout LANL. All safety management is governed by LANL policies and procedures. All work performed at the PFF is categorized into one of three hazard classes (Low, Medium, or High). By default no Medium or High hazard work activities are permitted at the PFF unless needed and authorized.

All hazardous work that is categorized as Medium or High Hazard work activities (based on the LANL hazard categorization matrix found in the LANL Integrated Work Management policy P300 Hazard Grading Table Attachment B) require a written and approved work control process (called an Integrated Work Document or IWD) and documented work authorization by the Safety Responsible Line Manager (SRLM). All LANL workers (staff and users performing hazardous work) use an online system (called U-Train) to assign and track training and work authorization. All users are assigned one or two PFF Scientists to assist and support scheduled experiments. When users arrive they first complete a briefing by the assigned Scientist and the program specialist. The program specialist, based on the nature of the visit, then assigns any additional training to the user. Live training or on-line content is then completed by the user and tracked in U-Train. If hazardous work is to be performed by the user (e.g. operate the PFF User Capacitor Bank) the IWD is read, training is verified by the SRLM, and based on need and agreement with the Person In Charge of the IWD, the work authorization is granted by the SRLM (tracked in U-Train). At this time, PFF users may be authorized on work that is categorized as

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low or medium hazard work. All of the infrastructure and management support of the above work control process at LANL is provided by institutional support of programs.

High B/T Facility

All members of a user group carrying out experiments at the High B/T Facility must observe all the safety precautions required by the National High Magnetic Field Laboratory and the University of Florida. New Users are asked to review the NHMFL Integrated Safety Management plan and to familiarize themselves with the High B/T User's manual. On the first day of their visit Users are introduced to the facility and its layout and the safety precautions for working in the area (use of O2 sensors, covering of all pits, location of safety goggles and tools and exits in case of a magnet quench etc.). Access to the Microkelvin Laboratory is limited to authorized personnel who will be provided with an access key. Prior to carrying out an experiment, all members of the user group must pass the safety training provided by the National High Magnetic Field Laboratory. All users must comply with the following rules that are specific to the High B/T facility:

1. No user may transfer cryogenic fluids.
2. No user may charge or discharge any magnets in the facility.
3. All undergraduate students must be accompanied by a supervising faculty or staff member at all times.
4. Users may not be present in the lower floor area when the dewars or electromagnetic shields (socks") are being raised or lowered and when the pit covers are temporarily open.

Access to the High B/T facility is limited to authorized personnel who will be provided with a UF key for entry. Users will receive a key on notification they have passed the safety training.

Detailed information regarding safety procedures is available on the facility web page http://www.phys.ufl.edu/microkelvin/Safety.html.

NMR Facility

External Users

Each external user prior to carrying out an experiment at the NMR Facility is required to pass the online safety training course(s) provided by the NHMFL (https://nationalmaglab.org/user-facilities/) This is currently enforced by the NMR Administrative Assistant and/or CIMAR Coordinator, who will not issue a laboratory access card or any keys without all trainings being completed and passed.

Prior to an experiment, potential safety issues are discussed individually with each new user. During the actual experiments, users are accompanied/ supervised by one of the NMR science staff. All non-routine or increased-risk operations, such as refilling the magnets with liquid helium, are performed by NMR staff rather than by the user.

Internal Users

All of the NMR group members have become familiar with the ISM (Integrated Safety Management) principles. All of them attend the quarterly NHMFL Safety Meetings. A representative of the NMR group attends the monthly NHMFL Safety Committee meetings and reports on pertinent issues to the NMR group during its meetings.

NMR staff and faculty group meetings are conducted weekly. Every 6 weeks a meeting is dedicated to safety, safety issues and/ or safety training. All members of the NMR group are required to complete and pass the NHMFL online safety training courses and, they are required to keep those trainings current.

AMRIS Facility

All internal and external users that will assist in data acquisition (*i.e.* anyone who will enter the facility without direct supervision of AMRIS personnel) are required to attend a one hour safety class as a first step to getting keyed access. In this class, safe operation in high magnetic fields, working with RF cables, and the principles of ISM are presented and discussed. Anyone working with animals is required to carry documentation of their IUCAC approved protocol when working with animals in the AMRIS facility. The UF IUCAC office oversees all animal related safety training and authorization of work with animals at UF, including for external users. Users wanting to work independently in the 11 T room (*i.e.* without an AMRIS staff person present) are required to demonstrate instrument proficiency to AMRIS personnel and to attend an additional hour of safety training specific to the 11 T system.

AMRIS personnel have weekly staff meetings and at each of these meetings we review whether there are any safety issues or training needing discus sion. If so, time is dedicated to discussing any incidents or changes in training/operation and ensuring all AMRIS personnel are apprised of them. We also

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regularly update our web pages to reflect current safety policies. All AMRIS personnel are required to keep both the NHMFL and UF safety training current. Regular inspections of AMRIS facilities are performed by the UF office of Environmental Health & Safety as well as by the IUCAC. AMRIS personnel directly accompany all new users in the facility and regularly interact with experienced users to discuss any issues which might arise during their facility use. All non-routine, increased-risk operations, such as refilling the magnets with cryogens, are performed by trained AMRIS personnel. Any use of cryogens during experiments to cool samples requires additional training in safe handling of cryogens.

All access to the AMRIS facility is via RFID keys; these keys are monitored and regulated through the UF Police Department so we have a record of their use and can revoke access to an individual user at any point in time if needed.

EMR Facility

External Users

Each external user prior to carrying out an experiment at the EMR Facility is obliged to pass the on-line safety training course(s) provided by the NHMFL (https://nationalmaglab.org/user-resources/safety). This is currently enforced by the EMR Administrative Assistant, who will not issue a laboratory entrance card or any keys without proof of completion of the required course(s). Prior to an experiment, potential safety issues are discussed individually with each new user. During the actual experiments, each user is accompanied/ supervised by one of the EMR science staff. All non-routine or increased-risk operations such as refilling the magnets with liquid helium or sample changes are performed by the staff rather than the user.

Internal Users

All the EMR group members have become familiar with the ISM (Integrated Safety Management) principles. All of them also attend the quarterly NHMFL Safety Meetings. A representative of the EMR group attends the monthly NHMFL Safety Committee meetings and reports on pertinent issues to the EMR group during its meetings.

ICR Facility

All internal ICR personnel and external users that will assist in data acquisition are required to select the labs that they will be working in prior to assignment of safety training. Safety training is assigned based on the working hazards that are within each lab space. For example, each person who will work in the ICR high bay is required to take the following safety training courses: cryogen safety, high magnetic field, general safety, laser safety and electrical safety. Additionally, no one is allowed to perform any cryogen fills or operate any instrument systems without extensive, supervised, hands-on safety training by an ICR staff member.

All users that will be entering all ICR lab spaces are required to complete online safety training, but are assisted by an internal ICR group member for all sample preparation, instrument start up and shutdown, and data acquisition. All ICR magnet system usage is limited to trained ICR personnel. No external users are allowed to start up or shut down ICR magnet systems. In addition, access to the ICR 21 T high bay is limited to only personnel that approved for access to the high bay area. All visitors are required to have an escort at all times, and everyone who enters any ICR lab space (C330, B239, B240, NM 113 and NM 117) is required to wear safety glasses with no exceptions. No food and drink is allowed in any ICR lab space except in designated areas that are marked with appropriate signs. Safety glasses are mandatory at all times in all ICR laboratory and high bay spaces.

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D. USER COLLABORATION GRANTS PROGRAM

The National Science Foundation charged the National High Magnetic Field Laboratory with developing an internal grants program that utilizes the NHMFL facilities to carry out high quality research at the forefront of science and engineering and advances the facilities and their scientific and technical capabilities. User Collaboration Grants Program (UCGP), established in 1996, stimulates magnet and facility development and provides intellectual leadership for research in magnetic materials and phenomena.

The UCGP seeks to achieve these objectives by funding research projects of normally one- to two-year duration in the following categories:

- small, seeded collaborations between internal and/or external investigators that utilize their complementary expertise;
- bold but risky efforts that hold significant potential to extend the range and type of experiments; and
- initial seed support for new faculty and research staff, targeted to magnet laboratory enhancements.

The Program strongly encourages collaboration between NHMFL scientists and external users of NHMFL facilities. Projects are also encouraged to drive new or unique research, i.e., serve as seed money to develop initial data leading to external funding of a larger program. In accord with NSF policies, the NHMFL cannot fund clinical studies.

Nineteen (19) UCGP solicitations have now been completed with a total of 538 pre-proposals being submitted for review. Of the 538 proposals, 279 were selected to advance to the second phase of review, and 122 were funded (23% of the total number of submitted proposals).

2014-15 Solicitation and Awards

The NHMFL UCGP has been highly successful as a mechanism for supporting outstanding projects in the various areas of research pursued at the laboratory. The proposal submission and two-stage proposal review process has been handled by means of a web-based system.

The 2014-15 solicitation was announced in January, 2015.

Of the 26 pre-proposals received in 2014-15, the committee recommended that 12 pre-proposals be moved to the full proposal state. Of the 12 full proposals, 5 were awarded. A breakdown of the review results is presented in **Tables 1 and 2**.

Table 1: *UCGP Proposal Solicitation Results – 2014-15*

Research Area	Pre-Proposals Submitted	Pre-Proposals Proceeding to Full Proposal	Projects Funded
Condensed Matter Science	12	7	2
Biological & Chemical Sciences	10	4	2
Magnet & Magnet Materials Technology	4	1	1
Total	**26**	**12**	**5**

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Table 2: *UCGP Funded Projects from 2014-15 Solicitation.*

Principal Investigator	NHMFL Institution	Project Title	Funding
Seungyong Hahn	NHMFL-FSU	Partial No-Insulation and Metallic Cladding Insulation Techniques for Compact, Self-Protecting, and Low-Cost REBCO Magnets	$ 240,000
Yan-Yan Hu	NHMFL-FSU	Innovative in situ and operando characterization capabilities for energy materials research	$ 199,904
David Graf	NHMFL-FSU	High Pressure Measurements of Magnetization by Field Modulation	$ 223,397
Johan van Tol	NHMFL-FSU	High Field Integrated EPR and NMR for DNP Applications	$ 200,000
Scott Crooker	NHMFL-LANL	Free-space ultrafast optics and time-domain terahertz spectroscopy in pulsed magnetic fields	$ 240,463

2015-16 Solicitation

The 2015-16 Solicitation announcements should be released around November, 2016. Awards will be announced by the end of next year.

Results Reporting

To assess the success of the UCGP, reports were requested in December 2015, on grants issued from the solicitations held in the years 2009 through 2014, which had start dates respectively near the beginnings of years 2010 through 2015. At the time of the reporting, some of these grants were in progress, and some had been completed. For this "retrospective" reporting, PIs were asked to include external grants, NHMFL facilities enhancements, and publications that were generated by the UCGP. Since UCGP grants are intended to seed new research through high risk initial study or facility enhancements, principal investigators (PIs) were allowed and encouraged to report results that their UCGP grant had made possible, even if these were obtained after the term of the UCGP grant was complete. Results were compiled from reports on 30 awards.

The PIs reported:

- Lab enhancements which were used by 80 different external user groups, as listed in **Table 3.**
- At least partial support for 8 undergraduate researchers, 54 grad students and 23 postdocs.
- 17 funded external grants which were seeded by results from UCGP awards. The total dollar value of the external grants was $10.8 M.
- 93 publications, many in high profile journals, as summarized in **Table 4.**

Table 3: *Facility Enhancements Reported from 2007-2011 UCGP Solicitations*

Enhancement and available date	Users *
Ball bonder (1/10)	1
EPR field standard using lines of the H-atom entrapped in octa-isobutyl-silsesquioxane (7/10)	2
Resonant ultrasound uniaxial pressure probe (1/10)	2
microsurface coils at 14.1 and 17.6 Tesla+ strong planar gradient coils (7/11)	5
Fiber Bragg Grating based magnetostriction pulsed field and dc magnets (3/12)	21
500 MHz solid state NMR system and MAS probe on existing 600 MHz (10/10)	2
force magnetometers for unprecedented low T, high B (11/12)	2

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Enhancement and available date	Users *
dielectric-based cylindrical waveguide structure for the 900 UWB magnet. (12/11)	2
3.2mm double resonance MAS NMR probe for ultra-narrow bore 830 MHz magnet (11/13)	5
Reel-to-reel magnetometer for 4.2 K conductor characterization (7/13)	2
Imaging and measurement of photocurrent and photoluminescence in high magnetic field (9/12)	1
Faraday magnetometer for the 20 T (6/13)	1
Expanded range of magnetic field sweep rates in the 60 T shaped-pulse magnet (10/13)	2
Probes for free space Raman measurement, Photoluminescence excitation, fluorescence line narrowing, magnetic cicular dichroism (12/14)	7
Arduino-controlled, NMR spectrometer-synchronized near-infrared high power laser tuning system (8/15)	3
Three (3) cryogenic NMR probes, all with through-space optical access (9/12-8/15)	10
Ac suceptometers (12/12)	2
variable temperature (VT) magic-angle spinning (MAS) probe for the 900 MHz NMR (6/14)	1
direct-optics setup for PL, reflectance, Raman magneto-spectroscopy at B<14.5T and T=4-300K (6/15)	3
Modified 1800 C tube furnace for molten metal flux growth of uranium compounds (1/15)	1
Development of capabilities for hazardous substance handling (1/15)	4
mK (^{3}He and dilution fridge) NMR probes (8/15)	7

* Number of external users (PI's only) reported to have used the enhancement.

Table 4: *Publications Reported, awards starting at beginning of 2010 to beginning of 2015*

Journal Name	Counts
Applied Materials & Interfaces	1
App. Phy. Lett	1
Biomacromolecules	1
Chem. Science	1
Chinese J Magn. Reson	1
Emerging Materials Research	1
Inorganic. Chem	1
IEEE Trans. Microw. Theory Techn	1
J. Cryst. Growth	1
J. of Chem. Physics	6
J. of Applied Physics	1
J. of Controlled Release	1
J. of American Chemical Society	3
J. of Magnetic Resonance	3

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Journal Name	Counts
J. of Membrane Science	3
J. of Molecular Biology	4
J. Phys. Condens. Mat	2
Langmuir	1
Magnetic Reson. Med	1
Materials Science Forum	1
Materials Science & Engineering	1
Molecular Pharmaceutics	2
Nano Letters	2
Nature Communications	1
Nature Materials	1
Nature Physics	1
Nature Struct. Mol. Biol	1
NeuroImage	2
Optics Express	2
Conference proceedings	6
Proceedings Nat Acad Sci	2
Proceedings of SPIE	3
Phys. Rev. B	17
Phys. Rev. Lett	5
Physica C	1
PLoS One	1
RSC Advances	1
Science and Technology of Advanced Materials	1
Spintronics	1
Superconductor Sci. Technology	1

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E. DEPENDENT CARE TRAVEL GRANT PROGRAM

Eligible recipients are early career scientists, including undergraduate and graduate students, post-docs, and scientists with fewer than 10 years of active professional work since receiving a Ph.D. To be eligible, a scientist must be:

- An early career user traveling to a Magnet Lab facility in Tallahassee, Gainesville or Los Alamos to conduct an experiment as part of a user program (not including employees of Florida State University, the University of Florida or Los Alamos National Laboratory).
- A Magnet Lab early career scientist employed by any of the three Magnet Lab partner institutions who is selected to present results at scientific meetings, conferences or workshops.

A dependent is defined as 1) a child, newborn through 12 years of age (or any physically or mentally disabled child under the age of 18 who is unable to care for himself or herself), who resides with the applicant and for whom the applicant provides primary support, or 2) a disabled adult/elder (spouse, parent, parent-in-law, or grandparent) who spends at least eight hours per day in the applicant's home and for whom the applicant has responsibility.

The Dependent Care Travel Grant Program (DCTGP) is described in detail at https://nationalmaglab.org/user-resources/funding-opportunities/1126.

In 2015, four scientists benefited from this funding. One external user Melissa Soule (F) who is a scientist at Woods Hole Oceanographic Institution applied and received $120 to pay for child care support for her children while she came to the lab to analyze samples from September 13-18, 2015. Three MagLab scientists applied and received funds during 2015. Shalinee Chikara is a postdoc at LANL who received $800 in child care support while she traveled the Tallahassee to conduct research at the 45T hybrid in October 2015. Komalavalli Thirunavukkuarasu, a postdoc at the lab, received $158.20 for child care support while she attended the APS March Meeting in 2015. Nihar Pradhan, a postdoc at the lab, received $800 in funds to pay for his dependents' travel and child care support while the traveled to a conference pertinent to his professional development in November of 2015.

F. FIRST-TIME USER SUPPORT

The NHMFL is charged by the National Science Foundation with developing and maintaining facilities for magnet-related research that are open to all qualified scientists and engineers through a peer-reviewed proposal process. Facilities are generally available to users without cost. In an effort to encourage new research activities, first-time users are provided financial support for travel expenses. International users are provided $ 1,000 of support and domestic users are provided $500 of support for their travel costs. Support for this funding is provided by the State of Florida and is available for Tallahassee facilities only.

In 2015, fourteen requests for first time user support have been submitted and granted.

G. VISITING SCIENTIST PROGRAM

The National High Magnetic Field Laboratory provides researchers from academia, industry, and national laboratories the opportunity to utilize the unique, world-class facilities of the laboratory to conduct magnet-related research. In 2015, the Visiting Scientist Program provided a total of $131,500 financial support for 11 research projects on a competitive basis. The primary intent of this program is to provide greater access to the unique facilities at the Magnet Lab and to seed research programs that help advance the laboratory. State funding is being used and principally intended to partially support travel and local expenses. Requests for stipends are considered but given a lower priority. The amount of support generally ranges from a few thousand to $20,000. Beyond conducting the research as approved and maintaining fiscal integrity, the researcher has one additional responsibility, which is to provide the Magnet Lab with a progress report on request and a final report on their research to be included in the online version of **the NHMFL Annual Report. Participants in the NHMFL Visitors Program are expected to acknowledge support provided by the NHMFL in any publications coming from work during their visit or collaboration with the NHMFL.** To apply for support from the Visiting Scientist Program, interested researchers are required to submit an application and a proposal that will be reviewed by appropriate facility directors and scientists at the NHMFL. All requests for support must be submitted online at https://vsp.magnet.fsu.edu/ at any time throughout the year.

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H. USER ADVISORY COMMITTEE REPORT

Report on the 2015 NHMFL User Advisory Committee meeting held in Santa Fe/Los Alamos, NM, from October 27th to 29th, 2015

Chair: Chris Wiebe, Department of Chemistry, University of Winnipeg/University of Manitoba (adjunct, Department of Physics and Astronomy, McMaster University)
DC/Pulsed/High B/T Vice-Chair: Madalina Furis, Department of Physics, University of Vermont
NMR/MRI/ICR/EMR Vice-Chair: Robert Schurko, Department of Chemistry and Biochemistry, University of Windsor

USER COMMITTEE MEMBERS:

DC/PFF/High B/T committee: Chuck Agosta (Clark University), Kirsten Alberi (National Renewal Energy Lab), James Analytis (University of California, Berkeley), Kenneth Burch (Boston College), Jason Cooley (Los Alamos National Laboratory), Nathanael Fortune (Smith College, Executive Committee Member), Madalina Furis (Chair for DC/ Pulsed Field /High B/T, University of Vermont), Malte Grosche (Cambridge University), Zhigang Jiang (Georgia Institute of Technology), Lu Li (University of Michigan), Philip Moll (Max Planck Institute for Chemical Physics of Solids), Jeanie Lau (University of California, Riverside), Jamie Manson (Eastern Washington University), Wei Pan (Sandia National Laboratories), Filip Ronning (Los Alamos), Chris Wiebe (University of Winnipeg, User Committee Chair), James Williams (University of Maryland)
NMR/MRI committee: R.W. Schurko (Chair, University of Windsor), Marek Pruski (Ames Lab, Iowa), Michael Harrington (Huntington Medical Research Institute), Brian Hansen (University of Aarhus), Eduard Chekmenev (Vanderbilt University), Oc Hee Han (Korea Basic Science Institute), Doug Kojetin (Scripps Research Institute), Len Mueller (UC Riverside), Fang Tian (Penn State University), Tatyana Polenova (University of Delaware), Scott Prosser (University of Toronto)
EMR committee: Kurt Warncke (Emory University, U.S.; Chair), Chris Kay (University College, U.K.), Dane McCamey (University of New South Wales, Australia), Christos Lampropoulos (University of North Florida, U.S.), Stefan Stoll (University of Washington, U.S.)
ICR User Advisory Committee: Jonathan Amster (Franklin College), Michael Chalmers (Eli Lilly and Company DCR&T Analytical), Michael Freitas (Ohio University Medical Center), Elizabeth Kujawinski (Woods Hole Oceanographic Institution), John Shaw (University of Alberta), Forest White (MIT)

On behalf of the User Committee, we would like to express our deep sympathy to the family of Glenn Nix, who recently lost his life in a tragic accident just a week before the User Committee meeting. In these difficult times, we commend the NHMFL for taking active steps to confront the safety issues related to this event and to avoid its recurrence. We would furthermore like to emphasize that the NHMFL's safety record has been very good over the long term, and it is our view that the lab has the user's safety at the forefront of its mission.

We would like to thank the Los Alamos branch of the NHMFL for hosting a well- attended and informative User Committee meeting. All three branches of the NHMFL participated and played a role in organization. The general consensus of the user community was that the meeting was a great success, with highlights being the articulation of the future Science Drivers, the tours of the Los Alamos laboratory, and the careful consideration given to responding to issues that arose from our last report. We are very confident that all three branches of the magnet lab will continue to be involved in transformative research across many disciplines, and we are excited and optimistic to see how the three sites will evolve in the future.

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1) Executive Summary

Before addressing the particular issues which arose from the various subcommittees, we would like to first discuss general developments which affect all of the subcommittees at the NHMFL (and the broad user community). The remainder of the report details specific issues which are unique to the different subcommittees.

(i) Recompetition/Renewal

The User Committee was very pleased to hear that the recompetition is now a renewal proposal. We see this as a very positive development. However, there is a considerable amount of work left to complete with the renewal project. The NHMFL has taken this task extremely seriously, and we were excited to hear about the new Science Drivers and the new projects proposed in the breakout sessions. As a community, we would like to refine some of these Science Drivers more, and also have time to consider the many directions that the NHMFL can take in the future. We are confident that together we can articulate the future vision of the magnet lab. We are pleased with the general directions of the Science Drivers as they were presented at our meeting.

(ii) Housing

The User Committee emphatically supports the new housing project at FSU for users. We would like to give the strongest possible endorsement for an immediate solution to the housing problem in Tallahassee for users. Many national laboratories have housing in place for external users that make travel for experiments more feasible. The NHMFL needs this, and we strongly recommend that the NSF provides support for the proposed housing project. The housing problem is less of an issue at the UF and Los Alamos sites (although we did hear from users that readily available parking passes from UF might be useful in the future).

(iii) Future hiring strategies

The recent hires at the NHMFL (and the proposed hires in the future) are to be commended. This was a chief concern of the UAC from our last report, and we are very encouraged to see the NHMFL following through with their commitments to having the best faculty and support available. In particular, the hiring of Dr. Laura Greene as Chief Scientist is an excellent addition to the condensed matter physics capabilities of the lab. We are confident that she will be able to provide the significant leadership and vision in the future. Director Boebinger also detailed other strategic hires across many disciplines that we find exciting and necessary for the renewal proposal. The UAC was very pleased to hear about a long range plan for the hiring and retaining talent at the NHMFL.

(iv) Diversity

The User Committee was very impressed by the detailed report given by Director Boebinger for increasing diversity at the NHMFL. There are many promising future developments, including the new five part plan, and initiatives such as the American Physical Society's MS-to-PhD Bridge program. While we still understand that there is room for improvement in increasing diversity at the NHMFL, we acknowledge that the magnet lab is aware of many of the issues an

(v) The new website

The new website is visually appealing, informative, and overall very well done. This is reflected in many of the metrics that have been used to track how users are increasingly seeing the value of the new site and how information is processed. The work is truly excellent, and we see the website as a model for how national laboratories can help users and the general public learn more about magnetism and the work done at the magnet lab. We have had very good feedback from the user base, as well, concerning the changes, and in particular how many experiments can now be planned with ease from the new drop down menus.

(vi) Safety

On behalf of the UAC, we would like to again express our condolences with respect to the recent tragedy at the magnet lab in Tallahassee. The UAC applauds the response of the NHMFL as compassionate and pro-active. An independent Investigating Committee has been convened to determine the cause of the accident and make recommendations for changes in the future. We believe the approach of the NHMFL to suspend operations on both in-house magnet development and DC program operations until the end of the scheduled shutdown to be appropriate. The UAC found the update on safety initiatives, protocols, and success stories to be exceptional. While there is always room for improvement in terms of safety at national facilities, we feel that the NHMFL is leading the way for safety standards.

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(vii) Summer school and outreach

The UAC is continually impressed by the tremendous educational activities which are organized every year by the NHMFL. The summer schools are essential as training programs for future users and have a great impact in the user community. We are also very happy with the excellent outreach activities from all three branches of the magnet lab. Keep up the spectacular work!

(viii) User committee changes

The UAC discussed minor changes to the bylaws that were completed over the last year. There was also a discussion of the protocol to maintain confidentiality among scientists conducting experiments at the NHMFL. In general, users at the NHMFL feel that their data is secure.

2) Report on the DC/ Pulsed Field /High B/T Facility

Contributors to the DC/ Pulsed Field /High B/T report:
The committee is comprised of:

- Chuck Agosta (Clark University)
- Kirsten Alberi (National Renewal Energy Lab)
- James Analytis (University of California, Berkeley)
- Kenneth Burch (Boston College)
- Jason Cooley (Los Alamos National Laboratory)
- Nathanael Fortune (Smith College, Executive Committee Member)
- Madalina Furis (Chair for DC/ Pulsed Field /High B/T, University of Vermont)
- Malte Grosche (Cambridge University)
- Zhigang Jiang (Georgia Institute of Technology)
- Lu Li (University of Michigan)
- Philip Moll (Max Planck Institute for Chemical Physics of Solids)
- Jeanie Lau (University of California, Riverside)
- Jamie Manson (Eastern Washington University)
- Wei Pan (Sandia National Laboratories)
- Filip Ronning (Los Alamos)
- Chris Wiebe (University of Winnipeg, User Committee Chair)
- James Williams (University of Maryland)

(i) General comments

The user committee commends the DC/Pulsed Field/ High B/T facilities for the superb effort made to respond to all committee recommendations from the previous year. We would also like to once again state that the support for the user community was excellent over the last year, and we are continually impressed by the level of professionalism displayed by all three branches of the magnet lab. In particular, we were very excited by the progress made at the DC facility with the 32 T high T_C superconducting magnet, the progress on a 40 T / 28 MW resistive magnet development and the projected opening of the third bay in Gainesville to users. The UAC also applauds the DC facility's focus on allowing new capabilities that extend the available experiments at high field to include spectroscopic probes including NMR (relevant to understanding quantum matter and molecular biology), IR/Raman (probing dynamics of quantum and biological systems with symmetry specificity) and scanning tunneling probes (allowing, for the first time, atomic resolution of the magnetic response of a myriad of materials when the magnetic field is on a comparable energy scale to other interactions in the system.) We would like to reiterate that one of the chief concerns that the DC field facility has is with finding more time in fields up to 40 T and beyond. The 45 T hybrid, for example, is still very much oversubscribed. The 40 T resistive magnet should be able to handle some of these experiments, but long term planning of the magnet lab should include alternatives to reaching these fields (in case either of these systems break down, for example). We feel that this should be a key part of the renewal

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proposal. The progress made in the development of a pulsed magnet system with a space-free –optics compatible tail that would operate in a horizontal geometry is fantastic. The committee believes that this will greatly contribute to possibly creating a "spectroscopy cluster" at the lab. This cluster would encompass complementary spectroscopy techniques such as NMR, EPR, ESR, MCD, cyclotron resonance and other flavors of optical, far infrared and THz spin-resolved ultrafast measurements that altogether address electronic systems with complex thermodynamic behavior. This magnet will also be great alternative to users that seek optical spectroscopy measurements compatible with fast acquisition times, significantly relieving some of the pressure currently existing on the DC HELIX magnet scheduling.

The committee was very excited to learn about the plans to build dedicated user housing units next to the Tallahassee laboratory and expresses its gratitude towards the Florida State University leadership who made this possible. The housing situation is truly very critical and the overall modest increases in NSF single investigator grant budgets compared to the rising cost of travel and housing on the open commercial market are really felt as an increasing burden by the users. The committee also stresses the need for a temporary solution until the new building becomes functional. The alternative would be a substantial increase in traveling budgets for single investigators that are DC facility users.

On behalf of the NHMFL users, the committee members extend their condolences for the most unfortunate work-related accident that resulted in the tragic loss of life for a member of the DC facility team. This came as a great shock to all of us especially since, as users, we always experience the lab as a very safe working environment with excellent risk management and safety procedures in place. The users are regarding this as a most unfortunate incident and encourage the lab to continue their excellent work in identifying potential risks and periodically updating their policies and procedures on safety. We would like to reiterate as well that the community understands that the incident happened during a construction operation at the NHMFL, and not in an area where users would conduct experiments.

The committee endorses the PFF's innovations in both extending its range of available magnetic fields to 150 T and in employing nanofabrication techniques to allow more experiments. From the perspective of the UAC it is important to stay competitive internationally both in making higher magnetic fields available and in making new experiments possible. The utilization of Focused Ion Beam micro-structuring and other nano-fabrication facilities will enable users to measure quantum transport properties on materials with extremely low resistivity (ultra-clean materials). In addition, it may enable faster rise-time magnets to be useful by significantly reducing sample heating during a pulse, by reducing the volume of the material probed. Experiments designed for a faster rise time magnet could facilitate the use of smaller magnets, which are easier to replace and can pulse significantly more frequently. This in turn will allow a much greater throughput of experiments and a faster (and cheaper) turnaround of magnets as they approach the end of their lifetime.

In last year's report, we commented on the need for enhanced communication between the PFF and DC/High B/T committees. Many of the materials and problems addressed by both communities have a fair deal of overlap. Even though the PFF and DC/High B/T subcommittees had separate breakout sessions at the UAC meeting, we felt that there was good communication between both groups. There is always room for improvement, though, and we feel that we can enhance communication and collaborations in the future.

The committee also endorses future Science Drivers to enhance the current limits of pulsed and DC fields at the magnet lab, to explore new techniques and improving experimental capabilities, and to increase field homogeneity. These will open new fields of research and enable truly cutting-edge science to be completed at the magnet lab. We look forward to playing a role in shaping the Science Drivers in the Renewal proposal.

(ii) Priority list of recommendations and executive summary

- We encourage the development of new capabilities at the NHMFL, including the 32 T high T_C superconducting magnet, the 40 T/28 MW resistive magnets, and the 3rd experimental bay in Gainesville.
- The UAC is very pleased to hear about the new housing units in Tallahassee for users, and the support given by Florida State University towards this goal. We recommend that the NSF also supports this new

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initiative.

- The optics program is developing well and the possibility of a "spectroscopy cluster" is exciting and novel. Additional support may be required through new positions.
- We are still developing a way for the PFF and DC communities to interact in a more constructive manner to encourage more synergy between the subcommittees. This will take time and communication. The two subfields are highly related to each other and have worked well together in the past.
- We continue to recommend future developments of higher fields (up to 150 T) and new techniques at the PFF and nanofabrication facilities.
- The User Committee is encouraged by the new Science Drivers mentioned at the meeting. We support the general themes expressed in the Renewal proposal, and we would like to play a part in shaping these themes in the future.

3) Report of the Magnetic Resonance Division User Committees Sections:
I NMR and MRI
II EMR
III ICR

I NMR and MRI

NMR/MRI UAC and contributors to this section of the report:
At UCM:

- Robert Schurko (Chair, Windsor)
- Eduard Chekmenev (Vanderbilt)
- Michael Harrington (Huntington Medical Research Institute)
- Brian Hansen (Aarhus)
- Oc Hee Han (Korea Basic Science Institute)
- Fang Tian (Penn State)

Remote participants:

- Linda Columbus (Virginia)
- Doug Kojetin (Scripps, FL)
- Len Mueller (UC Riverside)

1. Overview. The Users' Advisory Committee for the MR division (hereafter referred to as the UAC) is impressed with progress made at the MagLab in terms of magnet technologies, probe construction, publication quality and count, and recruitment and outreach activities. High-field NMR and MRI facilities are providing research groups from the United States and around the world with access to unprecedented experimental capabilities, and have supported major research initiatives in materials science, structural biology and MR imaging. The UAC *strongly endorses* investment in new personnel (especially in probe development and maintenance), and support for acquisitions and developments of consoles and magnets. The MagLab is still the world leader in high-field MR methods – an enormous investment has already been made in this successful institute, and continued investment must be made to maintain this position of leadership.

2. Personnel. The UAC is concerned about hiring of technical staff in the MR division. Last year, it was recommended that an rf engineer be hired for probe development. The current workload of building and designing new probes (e.g., for the new SCH system), as well as maintaining all of the active probes for all of the current systems (i.e., DNP, MRI), lies with Peter Gor'kov (team leader),

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Jason Kitchener (probe engineer) and Richard Desilets (machinist). There are only two indirectly involved support staff, Ilya Litvak (Research Assistant, SCH project) and Steve Ranner (Research Engineer). The plans for probe development for all of the NMR and MRI systems (including new systems under development) are very impressive (*vide infra*); however, additional support is desperately needed in this area - the workload is much more than the current team can manage. The UAC recommends the hiring of two rf engineers for probe maintenance and development: one for solid-state and solution NMR and one for MRI. The UAC is also concerned that a replacement for Rafael Bruschweiler was not found over the past year, as this hire is critical for both FSU and the MagLab. However, we are encouraged to hear that there is a future faculty line for this position, and the development of an associated 30 T NMR spectrometer is in progress for future research on intrinsically disordered proteins, metabolomics, and protein dynamics. If this new faculty member is hired in the next year, it is crucial that an 800 MHz NMR spectrometer be offered as part of a start-up package, since there will be some wait for the completion of the aforementioned 30 T system. The UAC believes that a replacement for Anant Paravastu should be found (he departed for Georgia Tech this past year). A faculty member with similar research interests (biomaterials, biopolymers, amyloid fibers, etc.) would be an active external user of the MagLab facilities. Finally, the UAC is encouraged by the recruitment of Matt Merritt to UF, who will aid in growing research efforts in DNP and in vivo NMR spectroscopy. In addition, while it is unfortunate that Art Edison departed for the University of Georgia, it is good that a strong working relationship will exist with the MagLab for continued work on HTS probes.

3. Equipment, Infrastructure and Use of Facilities. *Intro.* The total count for active NMR and MRI instruments associated with the MagLab is 21 (13 at FSU/MagLab, Tallahassee and 8 at UF/AMRIS, Gainesville). Magnetic field strengths vary from 3.0 to 21.1 T, with an incredibly wide range of capabilities for solid-state NMR, solution NMR and MRI. Research areas and applications include SSNMR of materials and biosolids, biological solution NMR (e.g., proteins, metabolomics, clinical, in vivo) and (micro-)imaging of samples, animals and humans. The installation dates for these spectrometers range from 1994-2013, and numerous recent upgrades have been made at both locations. Exciting new technologies are being developed, including HTS and SCH magnets for ultra-high field NMR spectroscopy, new DNP NMR spectrometers (both for dissolution in solutions and solid samples), and numerous specialty probes for NMR and MRI (vide infra). Given this impressive array of equipment, and many of the associated technologies that are unique to the MagLab, the UC makes one of its strongest recommendations: funding and resources must be put in place to not only maintain the aforementioned systems, but also to support the acquisition of new systems and the development of new hardware (i.e., magnets, probes and gradients).

Highlights - FSU. Several research highlights across areas of solution and solids NMR, as well as MRI, are mentioned, including the determination of protein structure in the *M. tuberculosis* cell division apparatus (Cross group, FSU), in vivo ^{35}Cl and ^{23}Na MRI of rat glioma (Schepkin *et al.*, NHMFL), the use of ^{35}Cl SSNMR to probe polymorphism in active pharmaceutical ingredients (Schurko group, Windsor, Canada), and ^{17}O SSNMR of low-barrier hydrogen bonds in nicotinic acid (G. Wu, Queens, Canada). The UAC was also very impressed with the development of the first facility in the U.S. to perform SSNMR experiments at temperatures up to 750 C (Y.Y. Hu, FSU), and continued probe development for the new 36 T SCH instrument, as well as other spectrometers (*vide infra*). The UAC feels that support is needed for: (*i*) Hiring of additional personnel for probe construction and maintenance (see *Sec. 2*). (*ii*) Equipment and Supply/OPS budgets (these budget lines have been flat for years, and increases are desperately needed). The UAC is surprised that the NMR/MRI groups have little access to overhead funds, and must continually make requests for even small amounts of funding (ranging from $1-5 K). Furthermore, in reviewing MagLab reports from 2013 and 2014, it seems that the MR division only receives ca. 15-20% of the total budget, while accounting for ca. 30% of output in terms of publication count. (*iii*) A new console for the flagship 21.1 T NMR system, including new gradients, amps and shims (for enhanced resolution for NMR/MRI experiments).

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Highlights - AMRIS. Two major research highlights are mentioned, including work by the Mareci lab on new contrast types generated by combination of high resolution diffusion weighted imaging and modelling (featured on the cover of Magnetic Resonance in Medicine), and MR microscopy work by the Blackband group on fly brain allowing anatomical segmentation of the drosophila brain in 3D (which received media attention). The UAC also highlights the following issues: (*i*) The 750 MHz WB is oversubscribed by users, indicating that this instrument is of great importance to many research groups. (*ii*) Staging equipment for the 600 MHz magnet for *in vivo* imaging would significantly reduce the load on the 750; this is a good plan for expansion and maximizing the return on investment. (*iii*) Microimaging of cells and tissues is leading the field; however, Bruker coils on high field magnets are often not working. In-house design and construction of rf-coils and gradients may be the best option.

Publications, Usage & Funding. The FSU team reports 61 publications in 41 different journals (including 2 in JACS, 2 in PNAS and 1 in Nature Chemistry), and 71 different credited grants (25 from NSF, 21 from NIH and 25 other sources, including internationals). Most of the publications are associated with the 21.1 T instrument. In addition, they report the participation of 106 senior personnel, 34 PDFs, 80 students and 9 technicians. The UF/AMRIS team reports 45 publications, and 233 users, including 81 senior personnel, 30 PDFs, 85 students and 15 technicians. The FSU and UF/AMRIS teams report 3347 (for 2015) and 1653 (for 2014) user hours, respectively.

User Recruitment & Outreach. The UAC is pleased to hear that recruitment and outreach activities continue at both facilities. The new MagLab web site is extremely attractive and well-organized, and has been very popular for regular users and new recruits to the facility, as well as to the general public. At FSU, an open house day was well attended, numerous tours of the MagLab facilities were offered, and a biological SSNMR winter school was offered. The UAC is happy to hear of possible plans for future winter schools in SSNMR of materials and MRI methods and applications. At UF/AMRIS, workshops on SECIM metabolomics (60 participants) and real-time FI and neurofeedback (200 participants) were offered. AMRIS is planning a future coil building workshop as well.

Twenty groups toured the AMRIS facilities, and activities are offered in undergrad and K-12 research, as well as graduate student (80) and PDF (35) training. The UAC recommends that recruitment and outreach activities are continued and strengthened, for the purposes of increasing the user base and related scientific output, and for attracting young people to research in chemistry, biology and physics.

4. Magnet Technologies and Probe Development.

Magnet technologies. As discussed in previous reports, an important feature of the MagLab which places it ahead of all other facilities in the world is the continued development of new magnetic field technologies that will be transformative in the way that NMR spectroscopy is utilized. In particular, the Keck (25 T), Platypus (30 T), SCH (36 T) and NHMFL Hybrid (45 T) magnets and spectrometers all present different degrees of field strength and resolution that will enable a broad variety of applications. There was not a large focus on new developments in this area at this year's UCM (rather, focus was upon consoles and probes, *vide infra*), with the exception of the 36 T SCH, which is coming online in mid-2016. This system currently has a field homogeneity of 1 ppm (^{1}H, 1.59 GHz), and will be used for an enormous variety of experiments over the coming year. The UC is impressed by the potential for experiments on quadrupolar nuclides in inorganic and organic materials, investigations of biological samples, and unprecedented developments in MRI at this field. The UAC would also like to point out that imaging gradients will need to be developed for the SCH system, very likely in collaboration with external partners.

Probes. At this year's UCM, much discussion of new technologies for NMR and MRI focused upon probe development, an area lead by Peter Gor'kov (NHMFL, Tallahassee). One of the most important developments is tune cards, which can be inserted into probes to tune them over broad frequency ranges. This is crucial for probe use at high magnetic fields, due to the great variation of frequency ranges for nuclides across the periodic table. The UAC feels that this technology could be a real game-changer for probe development around the world, and perhaps inspire a new generation of broadband probes for both NMR and MRI purposes. The UAC is also glad to hear of the

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development of several probes for the 36 T SCH: (*i*) A 2.0 mm HXY indirect direction MAS probe has been developed with a sensor for magnetic field regulation, external lock signal and passive ferroshims – this is crucial for operation under conditions of fluctuating B_0 fields. (*ii*) A 3.2 mm single-channel low-gamma MAS probe has been built with operation between 50 and 280 MHz, which will be ideal for the study of many quadrupolar nuclides that cannot be studied at lower fields.

5. DNP. The NMR/MRI group at the MagLab has done an excellent job in getting the DNP program off the ground. This is a titanic effort given the engineering and the instrumental (cost and complexity) requirements. There are no focused programs on hyperpolarization (including DNP) at NSF, NIH or DOD to the best of our knowledge; however, there are targeted programs receiving tremendous support in Europe and the U.K. The UAC feels that the DNP program at NHMFL will face fierce global competition, and must act to remain ahead of the pack. Since hyperpolarization/ DNP techniques require deep expertise in magnetic resonance and physics (two areas of enormous strength at the NHMFL), the MagLab should play a leading international role in this area. The UAC is pleased with a number of developments, including: (*i*) the hiring of Matt Merritt (UF) to play a leading role in the DNP program. (*ii*) Clear plans for developing a number of rf probes for use in DNP/hyperpolarization experiments. (*iii*) Insuring that there is operational DNP equipment, and planning for the acquisition of more instrumentation in the future. The UAC encourages significant expansion of the modes of hyperpolarization at both sites and increased synergies between the Tallahassee and UF groups. Specifics include: (*i*) MagLab teams should pursue all current and suggested plans for DNP program. (*ii*) Hiring of additional faculty and staff (engineer and technician) to support the expansion of hyperpolarized NMR/MRI program. (*iii*) Installation of parahydrogen generators (commercial or home-built) at UF and Tallahassee sites. (*iv*) Leveraging of existing faculties at UF (e.g., Russ Bowers) to develop other hyperpolarized modalities at the MagLab facilities. (*v*) Support of a collaborative program between hyperpolarized NMR/MRI users and the high B/T facility. (*vi*) Establish optical-pumping Xe hyperpolarization capabilities at UF and/or Tallahassee site. These activities require significant investments in personnel, equipment and maintenance; again, if the NHMFL is to maintain world leadership in polarization techniques, this support is well justified.

6. MRI. The UAC was pleased to learn of a variety of developments and advances in MRI research and equipment development (see also the AMRIS section above), including high resolution imaging of live (perfused) brain slices (Blackbland) which is expected to allow studies that can inform interpretation of clinical MRI. The UAC is impressed with plans to support 9 cm small-animal MRI at 30 T within the SCH magnet program (this is remarkable, since the nearest commercial small-animal MRI system is limited to ca, 15 T). In addition, the idea to have a stage 600/14 T MHz MRI capability probe(s) for performing preliminary experiments before working at the higher fields is an outstanding initiative. This will save a lot of experimental time at higher fields, increase the throughput for external users, and serve to attract new users. It is also highly synergistic with dissolution DNP program and hyperpolarization efforts in general. The 900 is still the world leader for *in vivo* MRI. Upgrades to the original console can be expected to extend the sensitivity of the MRI experiment. In addition, plans for a wider bore (89 mm) SCH magnet for imaging are very exciting, as this will enable unprecedented sensitivity for functional sodium MRI. Increased spatial resolution in many MR modalities will enable new discoveries in brain imaging as it will extend focus to more prevalent but less structurally severe pathologies (concussion and dysfunctional brain disorders) in rodent models of disease. The UAC again emphasizes that it would be a great advantage to hire additional support staff to support MRI probe development. The probe team mentioned in *Sec. 2*, along with Bill Brey, Sam Grant, Victor Schepkin and Jens Rosenberg, provide great user support for the MRI. An additional probe engineer to assist in the construction of multi- and single-nuclide probes (e.g., for rats/mice, and in vivo without anesthetic), is regarded as a top priority.

7. Other Items. The UAC is very happy to hear of the very positive responses from users who have interacted with the staff in the MR division of the Maglab. In addition, the UAC is pleased to hear that a new residence for MagLab visitors is

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underway in Tallahassee. This will make a major difference for visiting scientists, grad students and PDF, and certainly encourage increased usage of the MagLab facilities.

8. Priority List of Recommendations and Executive Summary In summary, the UAC is impressed with progress over the past year in the MR division of the MagLab. In order for the MagLab remain the preeminent NMR, MRI and DNP NMR facility in the world, we believe the following recommendations must be considered. Continued support for acquisition and maintenance of spectrometers and consoles. In particular, support for a new console for the flagship 21.1 T spectrometer is a top priority. We emphasize that funding must be in place to support and expand the most impressive fleet of NMR spectrometers in the world. The hiring of two rf engineers for probe maintenance and development: one for solid- state and solution NMR and one for MRI.

- A replacement faculty position for Rafael Bruschweiler in structural biology. An 800 MHz NMR spectrometer will be needed for this faculty member during the wait for access to the new 30 T spectrometer.
- A replacement faculty position for Anant Paravastu in the areas of materials, biomaterials, biopolymers and/or amyloid fibers.
- Expanded support for development and acquisition of probes and gradients (both NMR and MRI).
- Increased *Equipment* and *Supply/OPS* budget lines.
- Access to overhead funds to reduce the administrative burden and costs associated with requesting small amounts of support funding (e.g., 1-5 K).
- Expansion of DNP/polarization research is crucial; in order to maintain an international leadership position in this area, investment must be made, as many impressive new laboratories and facilities are active around the world.
- The MagLab should continue to maintain a healthy working relationship with Bruker, for both acquisition of new equipment and future exchange of IP.

II EMR

EMR UAC:

- Kurt Warncke (Emory University, U.S.; Chair)
- Erik Cizmar (P. J. Safarik University, Slovakia)
- Christopher Kay (University College London, U.K.)
- Dane McCamey (University of New South Wales, Australia)
- Christos Lampropoulos (University of North Florida, U.S.)
- Stefan Stoll (University of Washington, U.S.)

PROGRAM, DIRECTOR AND PERSONNEL

Program

- Overall the EMR UAC was very impressed with the accomplishments of the Electron Magnetic Resonance (EMR) program in the past year.
- The EMR program continues to be a world-leading high-field (HF) EMR facility.
- The productivity is outstanding. The EMR group had 38 publications in the preceding period (2014), and is on pace in the 2015 period to match or surpass this mark.
- The EMR user base is strong, with 143 to date. The significant increase seen in 2013 (144) was sustained.
- The user program is heavily utilized (oversubscribed).
- A user survey conducted by the UAC just prior to the meeting indicates great satisfaction with the current program.

Director

The EMR director, Stephen Hill, shows highly effective leadership, combining in-depth technical expertise and knowledge of the multi-disciplinary science being performed.

- The EMR director displays a high degree of commitment and responsiveness to user needs, and to user-driven scientific directions.

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Personnel

- EMR staff (Jurek Krzystek, Andrew Ozarowski, Likai Song, Johan van Tol) have excellent technical expertise and, by using their respective instruments, are driving the science in their areas.
- Postdoc Sebastian Stoian has made strong contributions to EMR and Mössbauer spectroscopies.
- Postdoc Thierry Dubroca (hired by Hill; originally supported by Hill and NHFML) makes innovative, critical contributions to the Dynamic Nuclear Polarization (DNP) effort.
- Engineer Bianca Trociewitz (hired by Hill; originally supported by Hill and NHFML) has made innovative, strong contributions to DNP and to the HF CW-EPR (17 T) spectrometer.
- University of Florida (UF) faculty Alexander Angerhofer and Gail Fanucci continue to make strong contributions to the program, as science drivers, and by interfacing with the other magnetic resonance programs.
- New Hire, Postdoc Johannes McKay (from the group of Graham Smith at St. Andrews; builder of the HiPER instrument) is an exceptionally well-targeted hire. He brings expertise about HiPER to the NHMFL.

INSTRUMENTATION

HiPER W-band EMR spectrometer

- The high power (1 kW) amplifier and associated components (including laser with a silicon switch, as well as an Attocube drive) were installed in August, 2015. This was the top-priority recommendation by the UAC last year. This is an excellent completion of the HiPER capabilities, enabling pulsed experiments with significantly increased sensitivity.
- For HiPER, thin-layer sample holders for solution samples were developed, in response to the request of users. These holders out-perform commercial W-band sample holders by an order of magnitude in concentration sensitivity.
- The UAC is pleased that the first data obtained on the HiPER spectrometer, with co-author Fanucci, has been been submitted for publication.

HF (17 T) CW transmission EMR spectrometer:

- The aging 180 A power supply for the 17 T magnet was replaced. This was a crucial and top-priority recommendation by the UAC last year. The new power supply provides renewed, reliable operation.

HF pulsed quasioptical EMR spectrometer:

- Routine operation continues with high sensitivity up to frequencies of 240 GHz. Operation to 330 GHz is possible with reduced sensitivity (limited source power).

SCH, 35 T Magnet System:

- A transmission probe for the 35 T magnet was designed and constructed in a collaboration between NHMFL (staff members, Krzystek and Trociewitz) and the Dresden High Magnetic Field Laboratory (external user, Zvyagin). The UAC is particularly pleased to acknowledge the contributions of engineer Trociewitz. This is an eminent, research-enabling step forward, which shows that the EMR program has capabilities to develop unique, state-of-the-art probes.

DNP:

- The gyrotron source was modified to enable DNP experiments for both solution and solid state samples, simultaneously (spearheaded by postdoc Dubroca). This shows that the EMR program is crucial and central for the success of the DNP program. It should be noted that much of the DNP development was financed by a NSF MRI grant to PI Hill.

RECOMMENDATIONS – INSTRUMENTATION

1. Make HiPER W-band EMR spectrometer available for routine use.

DEER is a cutting-edge and effective technique in structural biophysics that should be exploited fully by using HiPER.

- Now that the high-power features of HiPER have been installed, the UAC urges that the outstanding pulse-programming software issues be solved by the St. Andrews group, so that the spectrometer can be brought into regular and routine use by users.
- Results from the first-run set of high-power HiPER experiments should be published as soon as possible, in order to showcase the capabilities and to recruit users.
- The liquid state probe head that has been developed for HiPER should be made available for routine use by users.

2. Integrate photoexcitation.

- Integrate ultraviolet (UV)/ visible photoexcitation into the HF pulsed quasioptical EMR spectrometer, the HF cw spectrometer, and the HiPER spectrometer. A pulsed YAG laser is present on-site, and has already been used on the HF quasioptical pulsed EMR spectrometer. This will enable high-impact applications to, for example, time-resolved spin dynamics [inter-system crossing (ISC)] and photonics, electron transfer in semiconductors, solar cells, quantum computing, and magnetoreception in birds.

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- Engage Engineer Trociewitz to design and lead construction of the UV/visible photoexcitation into the pulsed EPR experiments.
- Add a tunable laser source (Nd:YAG-pumped OPO), which will create a worldwide-unique user facility for time resolved investigations of photonic materials.

3. ***Extend source frequency range available for 17 T and 35 T magnets.***

- Extend to ≥1 THz the multi-frequency capability of the 17 T CW EPR spectrometer. A tunable or broad-band THz source will significantly expand the science that is accessible with the current magnet. The source, from Virginia Diodes Inc. (VDI), should also cover gaps in the current source frequency range. The terahertz source is acutely needed to facilitate full utilization, and provides world EMR leadership opportunity, which will come on-line with the series connected hybrid (SCH) 35 T magnetic field.
- Extend sample temperature capability of the 17 T CW EPR down to 300 mK. Benefits include the study of Science-Driver topics in magnetically ordered ground states and spin frustration at $T \leq 2$ K, using temperature as a third axis.

4. ***Expand capabilities of quasioptical pulsed EMR spectrometer.***

- Purchase a high-power source for the quasi-optical pulsed-EMR spectrometer, to improve SNR and to increase the range of timescales that can be accessed. This is required to maintain world leadership by enabling >220 GHz operation (specifically, 330 GHz).
- Introduce phase-quadrature detection.

RECOMMENDATIONS – PERSONNEL, OTHER

1. ***Spread staff expertise.***
   At least two permanent/scientific staff members should be expert operators of each of the following instruments: HiPER, 17 T transmission CW EMR spectrometer, pulsed quasioptical pulsed EMR spectrometer. Implementation of this plan will make the group more robust to unforeseen personnel changes.
2. ***Get a stable hire for an EMR administrative assistant position.***
   Hire an administrative assistant for the EMR program. Organization and book-keeping is severely compromised by the lack of stability at this position. This affects user administration, user statistics, UAC committee terms and elections process. Reliable administrative support is absolutely critical for the well-being of the EMR users program.
3. ***Organize EMR user workshop.***
   Convene a regular EMR user workshop to continue to build and broaden the EMR userbase, and to continue to expand the science output of the EMR program. The user workshop should be held annually at the NHMFL.

III ICR

ICR UAC AND CONTRIBUTORS TO THIS SECTION OF THE REPORT:

At UCM:

- Jon Amster (Chair)
- Michael A. Freitas
- Forest White
- Elizabeth Kujawinski.

Remote participants:

- John Shaw
- Michael Chalmers

Summary

The ICR User Advisory committee was very impressed with the progress of the diverse set of projects ongoing at the ICR User Facility. The NHMFL ICR Facility continues to maintain its competitive edge with regard to the innovations in ICR magnet and MS instrument design. The UAC was especially impressed by progress implementing the high field 21T horizontal bore, zero boil-off magnet. The facility has continued to advance innovations in ICR cells and instrument carts.

The facility has actively pursued the application of this instrument to a variety of applications. Successful application of ICR to the challenging field of petroleomics has opened many avenues for analysis of other complex analytes. Several examples of emerging scientific applications were presented that included natural organic matter,

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lipidomics, metabolomics and clusters/nanomaterials. The UAC felt that there is potential for growth in these areas by leveraging the tremendous domain knowledge borrowed from the field of petroleomics.

The ICR facility is also considered a leader in the application of ICR to Hydrogen Deuterium eXchange (HDX). High-field ICR enables structural analysis of larger protein complexes. The UAC supports the application of ICR to the emerging bioanalytical challenges in the fields of lipidomics, metabolomics, top-down proteomics, native MS and MALDI imaging. The UAC feels the hire of the biological applications director staff position will be critical for application of high field ICR to biological problems.

Petroleomics

- This application is a clear scientific and economic driver for the development of higher field magnets, improvements in cell design and innovations in the ICR technique.
- The ICR has done a tremendous job developing novel methods for complex mixture analysis. The UAC supports the facilities decision to transition from method development to greater emphasis on implementing methods for large scale analysis of samples. Separations are still an important component of complex mixture analysis. The UAC supports continued development of offline and online separations techniques for all applications.
- The UAC was impressed with the efforts to develop industrial collaborations and submit joint industrial proposals to support research activities.
- The UAC was also impressed with the development of chemometric tools for petroleomics. The facility has taken the UACs advice to distribute the PetroOrg software to users at no cost. Continued improvement and extension of software for analysis of complex mixtures whether in petroleum or other types of mixtures is fully supported.
- Ion Mobility Separations were proposed as a method for separating isobaric isomers in complex mixtures, with potential application to a variety of ongoing research.
- PetroOrg has been modified to work with IMS data as well as high res ICR data.

Natural Organic Matter

- Existing capabilities address current user needs very well.
- Program is well-administered by a new and energetic staff scientist. Program development shows promise for growing user base in this area.
- NOM-specific data processing and visualization software (EnviroOrg E-1.0) is under development, building on previously successful algorithms in PetroOrg. We recommend that this software be made available (free of charge) to all environmental users.
- Analysis of environmental mixtures could be a growth area for the science capabilities at the facility. Application of separation and ionization techniques proven to be successful in petroleum-ics could be applied here to complement existing capabilities and develop new science areas in NOM characterization and environmental processing.
- Cross-over science questions between petroleomics and NOM would be a particularly ripe area for growth for the facility. These questions could include fracking, oil weathering and pollution, and combustion-derived compounds in different environments.

Carbon Clusters

- The laboratory has built a state-of-the-art laser-desorption/supersonic-expansion cluster source that allows them to prepare metal clusters and organometallic materials, such as metalloendofullerenes.
- This instrumentation will be useful for nano-materials research and discovery of new nano organometallic materials and fundamentals of new materials synthesis.
- This application can establish links with the medical and astrochemistry research communities.
- The laboratory is engaging scientists from academia and government laboratories; Seven nanomaterials collaborators/users and five astrochemists/astrophysics users have been identified (including NASA).
- The high-resolution of FTICR provides the means to identify the stoichiometry some of novel clusters.

HDX, Metabolomics, Lipidomics

- Metabolomics is an exciting growth area where the facility's existing expertise in complex mixture analysis could be successfully leveraged. The lab is already moving in the direction of LC/NMR/MS through collaboration between the ICR facility and the NMR facility. We encourage continued

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collaboration with experts in LC-NMR, such as Rafael Brüschweiler.

- In particular, building a focused capability in LC-based untargeted metabolomics could be a core strength in the next 2-5 years, particularly in the area of metabolite identification and integration into the biomedical sciences.
- Developments in lipidomics are moving apace and we encourage the facility staff to continue these developments.
- HDX experiments continue to be a strength of the current facility, with capabilities that are uniquely available to this facility's users, for example using resolution of isotopic fine structure to circumvent the conventional methods of deconvolution of overlapping isotope distributions.

Top Down Proteomics

- Top-down mass spectrometry of large proteins continues to be a driver for high-field FT- ICR MS instrument development
- Significant improvement in LC-MS/MS at 21 T will drive demand from top-down MS of proteins over 30 kDa.
- Existing collaboration with Neil Kelleher's MS center at Northwestern has brought state- of-the art top-down proteomics methods to the 21 T. This will greatly benefit the user community.
- Separation of proteins remains a challenge for top-down LC-MS/MS. Continued development in this area is justified.
- The apparent mismatch between product ion spectral complexity and the product ions assigned with the current top down database search software could become a critical issue if data obtained with the 21 T system cannot be presented to the search engine. Innovation and improvements in top-down software development are needed.

Imaging, Native MS

- Small molecule tissue imaging of drugs, metabolites, and peptides is a clear driver for high resolution and mass accuracy. 21 T instrument will allow for faster analysis time and improved analysis of selected molecules. This application area has potential for high impact. The ICR facility should prioritize development of an imaging source in the near future and should engage with leaders in this area.

Software

- We recommend consideration of implementing applications as server-based or Software As a Service.
- We recommend implementation of open-source data formats for integration with emerging data repositories for complex mixtures (e.g. MetaboLights).

ICR User Facility

- The ICR Facility has an impressive number of users / PIs and has been growing nicely over the past five years. In 2015, the total number of users/PIs is expected to be the highest since 2011.
- According to surveys, users are very satisfied with the ICR program, its capabilities and its staff. One continued challenge is the user response rate. Options for improved surveys or different survey times are being discussed.
- Only a few additional requests were made by users including additional options for advanced top-down capabilities, additional fragmentation capabilities and additional separations for complex mixtures. The ICR Facility has plans to address each of these requests.
- Outreach programs have been successfully implemented for K-12 students.
- Undergraduate research opportunities are available.
- ICR Program participates in MagLab Summer School
- We recommend an ICR Specific Summer School with external instructors and engagement from the UAC.

Instrumentation

- UAC was impressed with the progress on bringing the 21 T online. The instrument is performing extremely well.
- Developed a novel ICR cell for 3 Ω detection. The progress is exceptional, but improvement in sensitivity is still required. The UAC supports continued development of the 3Ω cell as well as other novel designs.
- The facility has plans to develop a vacuum system that allows coupling with multiple vendor instruments.
- The facility will begin development of an in-house frontend controlled by the in-house data acquisition software. This plan is critical for testing cart innovations

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- The implementation of fETD and UVPD will provide users with greater fragmentation options. These techniques will be valuable for future offline and online top-down MS.
- Coupling IMS with ICR was discussed. The UAC supports technology innovations in this area. One of the challenges in this area is the different time scales associated with IM and ICR. Long-term option is to use IM to filter isomeric species based on drift time for analysis by ICR.

Biological Applications Staff Search

- Four applicants for the biological applications position were identified and discussed.
- The UAC supports the move to immediately interview the top three candidates.

To Do Items for the UAC

The UAC needs to reconcile terms with the MagLab committee bylaws. Two members need to rotate off early, and two members need to rotate off late.

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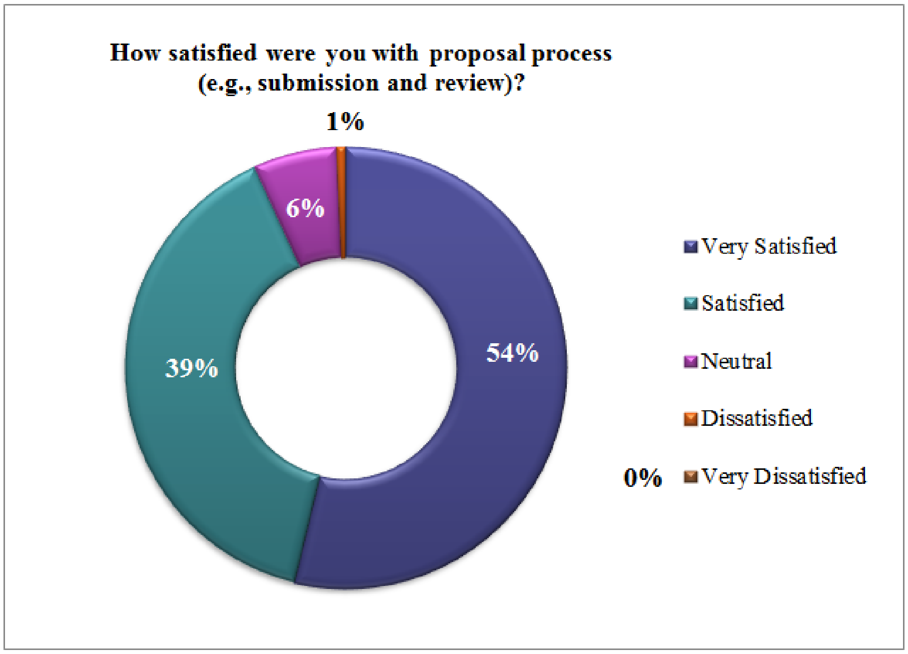
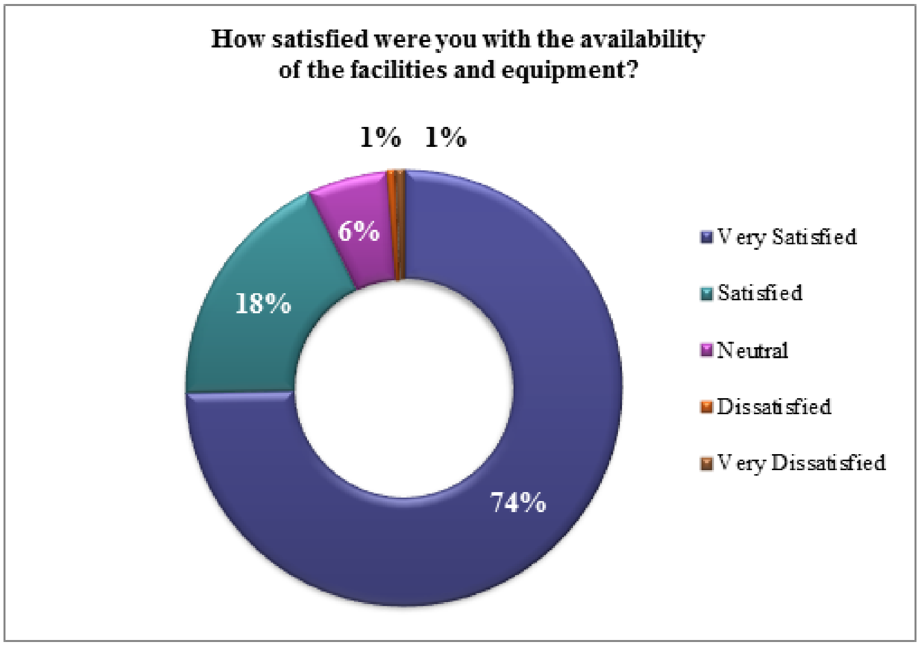
E. ANNUAL USER PROGRAM SURVEY

The National High Magnetic Field Laboratory conducted its sixth annual user survey between June 1, 2015 and July 1, 2015. User input assisted all seven facilities to respond to user needs, improve facilities and services, and guided the MagLab in setting priorities and planning for the future. This request was sent to all MagLab User Principal Investigators (PI) and to their collaborators who received magnet time between June 1, 2014 and May 31, 2015, including PIs who sent samples, where the experiment was performed by laboratory staff scientists.





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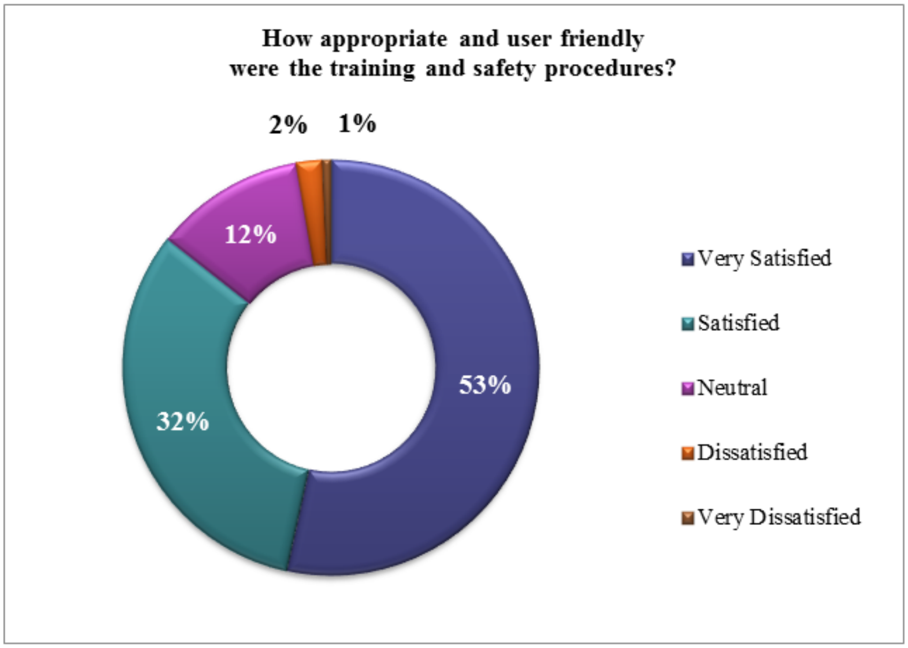

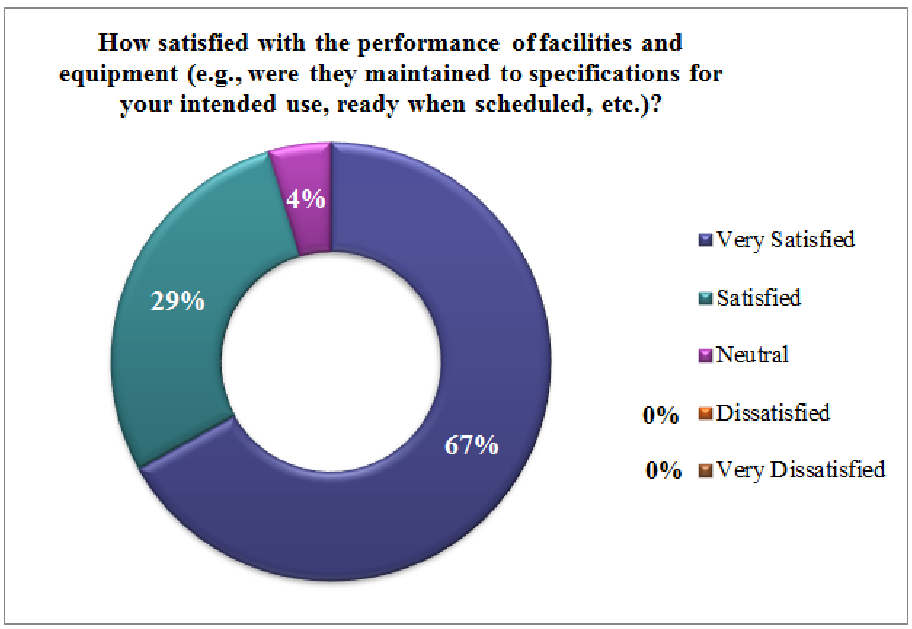

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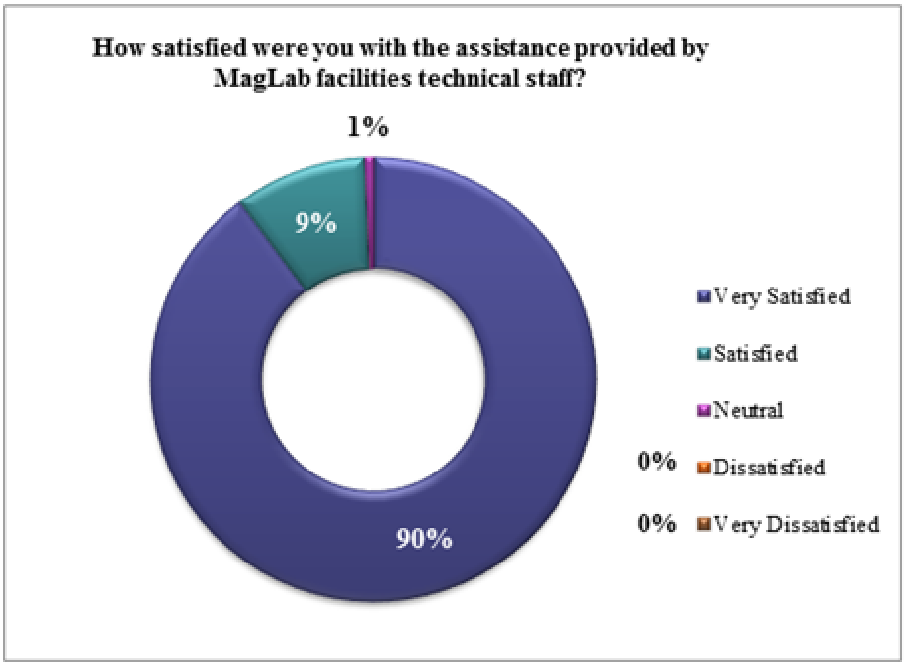

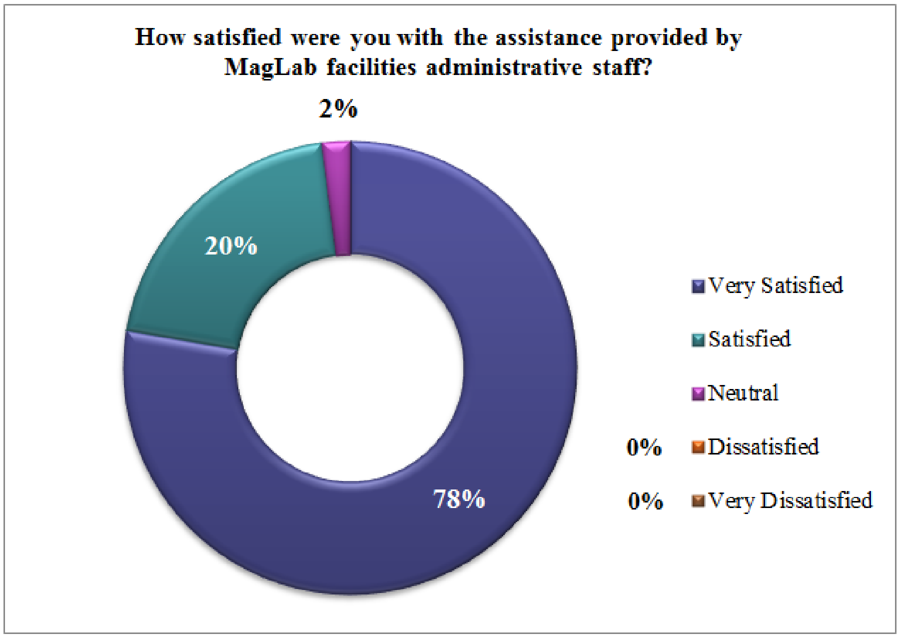

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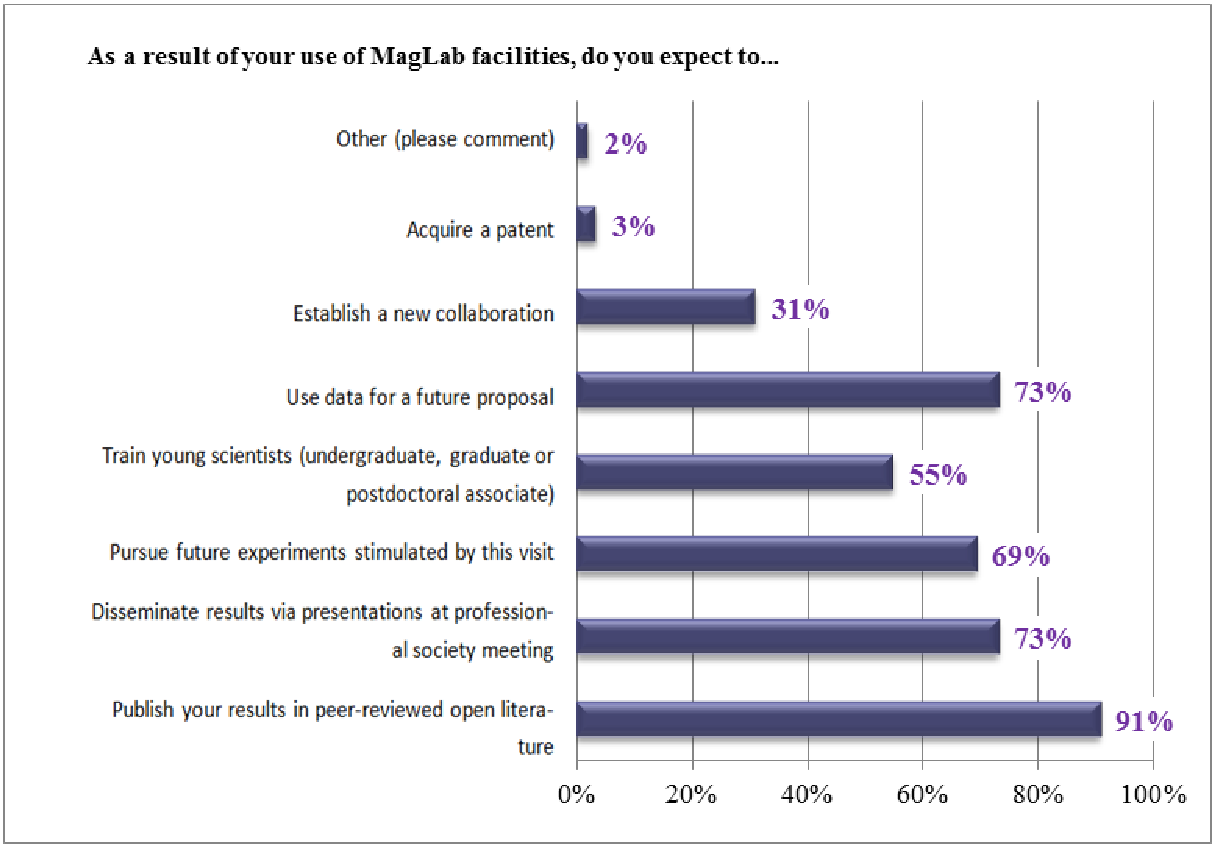

All user responses were treated anonymously.
*All presented figures exclude internal responders.

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2. User Facilities

DC FIELD FACILITY

Summary

The DC Field Facility in Tallahassee serves its large and diverse user community by providing continuously variable magnetic fields in a range and quality unmatched anywhere in the world. The DC Field user community is made up of undergraduate students, graduate students, post docs and senior investigators from around the country and the world. State-of-the-art instrumentation is developed and coupled to these magnets through the efforts of our expert scientific and technical staff. The users of the DC Field Facility are supported throughout their visit by the scientific, technical and administrative staff to ensure that their visit is as productive as possible. The interaction between the NHMFL scientific and technical staff with the students, post docs and senior investigators who come to the DC Field Facility to perform their research results in a continuous mix of scientific ideas and advanced techniques that are passed both to and from users.

1. Unique Aspects of Instrumentation Capability

FLORIDA-BITTER and HYBRID MAGNETS		
Field, Bore, (Homogeneity)	**Power (MW)**	**Supported Research**
45 T, 32 mm, (25 ppm/mm)	30.4	Magneto-optics – ultra-violet through far infrared; Magnetization; Specific heat; Transport – DC to microwaves; Magnetostriction; High Pressure; Temperatures from 30 mK to 1500 K; Dependence of optical and transport properties on field, orientation, etc.; Materials processing; Wire, cable, and coil testing. Low to medium resolution NMR, EMR, and sub/millimeter wave spectroscopy.
35 T, 32 mm (x2)	19.2	
31 T, 32 mm to 50 mm[1] (x2)	18.4	
30.5 T, 32 mm (~50 ppm/mm)[2]	18.3	
17 T, 195mm	18	
25 T, 52 mm, (10 ppm/mm)[2]	18.6	
25 T, 32 mm bore (with optical access ports)[3]	27	
SUPERCONDUCTING MAGNETS		
Field (T), Bore (mm)	**Sample Temperature**	**Supported Research**
18/20 T, 52 mm	20 mK – 1 K	Magneto-optics – ultra-violet through far infrared, Magnetization, Specific heat, Transport – DC to microwaves, Magnetostriction; High pressure, Temperatures from 20 mK to 300 K, Dependence of optical and transport properties on field, orientation, etc. Low to medium resolution NMR, EMR, and sub/millimeter wave spectroscopy.
18/20 T, 52 mm	0.3 K – 300 K	
17.5 T, 47 mm	4 K – 300 K	
10 T, 34 mm[3]	0.3 K – 300 K	

1. A coil for modulating the magnetic field and a coil for superimposing a gradient on the center portion of the main field are wound on 32 mm bore tubes.
2. Higher homogeneity magnet for magnetic resonance measurements.
3. Optical ports at field center with 4 ports each 11.4° vertical x 45° horizontal taken off of a 5mm sample space

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The table above lists the magnets in the DC Field Facility. The NHMFL leads the world in available continuous magnetic field strength, number of high field DC magnets available to users and accessibility for scientific research. The 45 T hybrid magnet is the highest field DC magnet in the world, which is reflected in the number of proposals from PIs located overseas. The 35 T, 32 mm bore and 31 T, 50 mm bore magnets are coupled to top loading cryogenic systems that have impressive performance, flexibility and ease of use. The 25 T Split-Helix magnet is the highest field direct optical access / scattering magnet in the world. With 4 optical ports located at field center each having a 11.4° vertical x 45° horizontal taken off of a 5mm opening, the ability to perform ultrafast, time resolved and x-ray scattering experiments are now a reality at high magnetic fields.

2. Facility Developments and Enhancements

DC Power Supply Improvements

New interphase transformers and passive filters were installed in all four power supplies in 2015. The installation of the new interphase transformers and passive filters (**Fig. 1**) in the power supplies accomplishes two important functions. First, they operate at a higher power level than the original units which allows the power supplies to run at 14 MW each. Second, they are more effective noise filters than the original set of transformers and filters reducing even further the ripple on the DC current supplying the resistive and hybrid magnets.

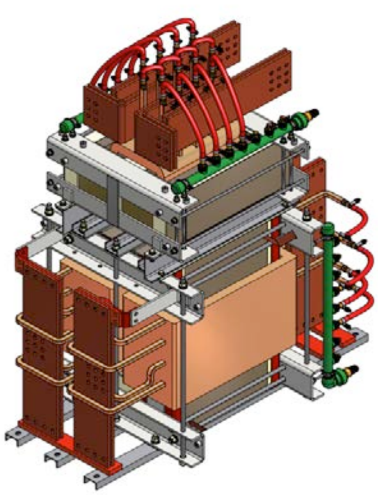

Figure 1: *New interphase transformer for the DC power supplies.*

X-ray Diffractometer Development in the Split Helix Magnet ***A hybrid photon counting pixel array X-ray detector*** (**Fig. 2**) was tested by Alexey Suslov and Theo Siegrist as part of the X-ray diffractometer development for the 25 T split helix magnet. A modified PILATUS3 detector was loaned to the MagLab from Dectris Ltd. for the purpose of determining how well the detector would function in the fringe field of the split helix magnet. The detector was specially modified to allow the control electronics for the detector array to be placed in a separate enclosure that was connected via a 3 m long cable. The detector was tested with a direct X-ray beam and functioned as designed with the performance independent of magnetic field up to the magnet maximum of 25 T. As a further test of the detector a sample of 301 stainless steel was placed at field center to measure the austenite-to-martensite transition at 300 K. The spectra in **Fig. 3** shows the amount of austenite phase does not change after returning the magnetic field to zero.

Figure 2*: Dectris PILATUS3 detector mounted on a linear motion platform in front of one of the four scattering ports on the split helix magnet.*

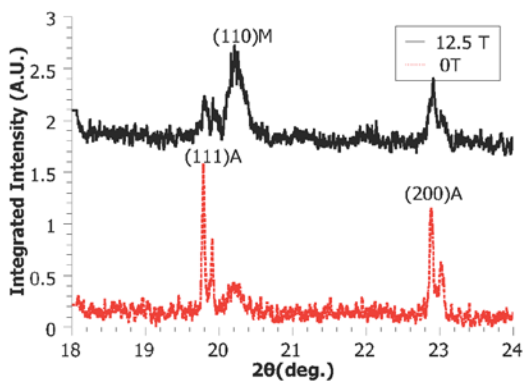

Figure 3: *X-ray spectra of 301 stainless steel showing the field induced austenite to martensite phase transition (denoted by "M" & "A" above).*

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Low Temperature Thermometry Improvements

Resistance thermometers (Cernox and ruthenium oxide) are used extensively in the DC Field Facility for measurements at low temperatures. While these thermometers have excellent temperature sensitivity, they also have varying degrees of sensitivity to magnetic field (magnetoresistance) resulting in an error in the measured temperature at high magnetic fields. An effort is underway involving Jeongoon Ha, Hongwoo Baek and Ju-Hyun Park to ***calibrate the magnetoresistance of the low temperature thermometers*** used in the DC Field Facility against magnetic field-independent temperature standards. In the first phase of this project the temperature range of 0.3 K – 4.2 K is being addressed using the vapor pressure of ^3He and ^4He as a magnetic field independent, primary thermometry standard. Data for one of the thermometers is shown in **Fig. 4**. This data will be used to create an interpolation table that will enable a LabView VI to instantaneously display the corrected temperature at any given applied magnetic field. Field independent temperature standards for use below 0.3 K are currently being explored.

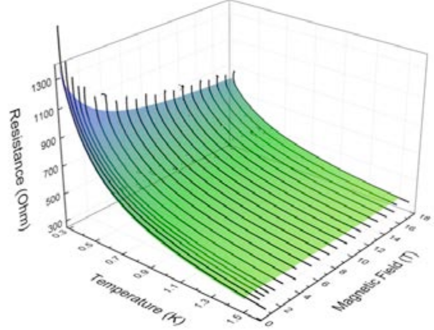


Figure 4: *Plot of measured magnetoresistance data (black curves) and fitted data (green surface) for a single Cernox sensor.*

Development of a vibrating coil magnetometer for characterizing high temperature superconductors

High temperature superconducting (HTS) materials continue to be a major area of study at the MagLab both by users exploring the fundamental physics of these materials and by scientists and engineers who wish to use these materials to make wire and cable to construct magnets. Prior to manufacturing a conductor that could be used to make a magnet from these materials the properties must be well known. Progress on these materials has resulted in very high critical currents (i_c) which reach can reach kiloamperes at liquid helium temperatures. Measuring i_c in these materials using electrical transport methods at high fields presents great difficulties due to cooling and space limitations. An elegant solution to this problem has been developed by Anca-Monia Constantinescu and Jan Jaroszynski. They have developed a vibrating coil magnetometer (**Figs. 5 & 6**) that allows for angular dependent measurements of HTS samples in very high magnetic fields. This allows for the investigation of i_c and spurious magnetization currents in HTS materials over a wide range of angle, field and temperature.

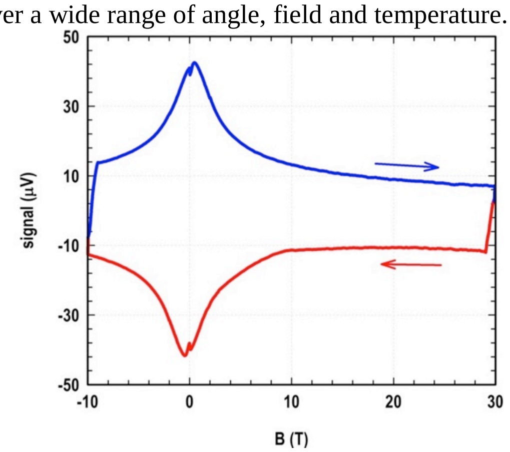


Figure 5: *Magnetization loop in YBCO conductor to 30 T*

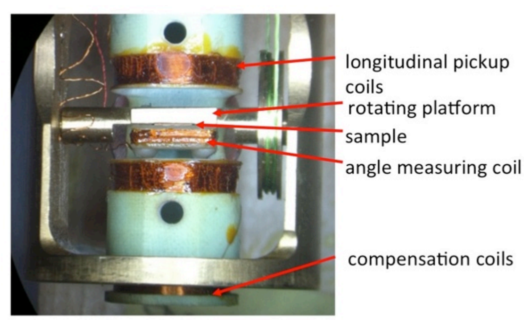


Figure 6: *Photograph of vibrating coil magnetometer. Transverse coils are removed for clarity.*

Cooling Tower Refurbishment

The four cooling towers that are used as the final stage of heat transfer between the resistive magnets and the atmosphere underwent a complete rebuild during 2015 as ***part of our long-term strategy of maintaining and upgrading MagLab facilities***. As can be seen in **Fig. 7** the external fiberglass skin of the towers were removed, internal components were replaced and rebuilt as needed and new fans and gearboxes were installed on top. The final step was the installation of new fiberglass skin for cooling towers.

Figure 7: *MagLab cooling towers undergoing renovation.*

3. Major Research Activities and Discoveries

Research by the users of the DC Field Facility spanned multiple regions of scientific interest in 2015. Guillaume Gervais and co-workers from McGill University and Yuanbo Zhang and co-workers from Fudan University explored the properties of ***atomically thin black phosphorus*** in high magnetic fields through the observation of quantum oscillations and the integer quantum hall effect. ***SmB_6*** continued to be a material of intense study by our users and resulted in the finding of quantum oscillations arising from the insulating bulk by Suchitra Sebastian and co-workers from Cambridge and Fermi surface measurements on SmB_6 to 45 T by group of Lu Li from the University of Michigan. Discoveries also continued apace in the area of ***high temperature superconductivity*** with the group of Louis Taillefer observing a small hole pocket in the Fermi surface of $Yb_2Cu_3O_y$ consistent with a charge density wave state and work by Boebinger et. al. illuminating an unexpected magnetic-field-driven phase transition within the superconducting phase of $YBa_2Cu_3O_{6.47}$ and $YBa_2Cu_3O_{6.43}$.

4. Facility Plans and Directions

In 2016, we will ***commission and begin user operations in the 36 T Series Connected Hybrid.*** Initial work will focus on the implementation and optimization of the active and passive shim system to achieve a total system homogeneity of 1 ppm. Several probes have already been constructed for solution NMR measurements and the spectrometer from Bruker is anticipated to be delivered in the second quarter of 2016. Quantum matter experiments in the SCH will be performed in an advanced, top-loading cryogenic system that is scheduled to be delivered in the first quarter of 2016 with the system ready for users in the third quarter of 2016.

The 32 T all superconducting magnet will be tested and commissioned in the third quarter of 2016 with user operations projected to begin in the fourth quarter of 2016. A variable temperature insert (VTI) with a temperature range of 1.5 K – 300 K is scheduled for delivery in the third quarter of 2016 with probes and sample holders designed and fabricated in-house.

A unique approach to low temperature sample-in-vacuum sample environments utilizing our advanced top loading 3He cryostat located in cell 9 (31 T) will complete its testing and commissioning phase in the third quarter of 2016 and is projected to be available for users in the fourth quarter of 2016. This probe allows the user to employ the entire sample space of the system without the need for a vacuum can and low temperature, hermetically sealed electrical feed-throughs. Sample in vacuum environments are critical in a number of experimental techniques including: heat capacity, thermal conductivity, thermal hall effect, etc.

Modernization of the resistive magnet protection system (RMPS) will begin in 2016 and is expected to be completed and implemented in 2017. This will involve transitioning from a system that relies on a Macintosh computer for computing power to a compactRIO system. The RMPS system continuously monitors key operational parameters of the resistive magnets and quickly shuts the system down should they exceed their pre-determined envelope.

5. Outreach to Generate New Proposals-Progress on STEM and Building User Community

The DC Field Facility continued to be oversubscribed in 2015 as can be seen in the usage tables in **Appendix I**. In spite of this demand, however, the

CHAPTER 3 – USER FACILITIES

DC Field Facility has continued to make bringing new investigators into the NHMFL a priority. We continue our efforts to reach out wherever possible in order to expand our user program and enable principal investigators (PIs) from backgrounds underrepresented in the scientific community. In particular, the NHMFL sponsored a booth at the APS March Meeting in Baltimore to advertise our capabilities and opportunities. The booth is staffed by NHMFL scientists & staff who explain the spectrum of research possibilities and support available at the NHMFL. In addition our DC Field Facility user support scientists regularly travel to conferences to present results and showcase the capabilities of the laboratory and recruit new users.

In 2015, the DC Field Facility continued to attract new researchers. **Appendix I, Table 7** shows we attracted ***18 new PIs in 2015.*** This is in addition to the 16 new PIs which we reported last year (2014) and 11in 2013. These new PI's came from institutions as varied as the University of Warwick, Rutgers, National Institute of Materials Science (NIMS) - Japan, and Fermilab. Two of the new PIs in 2015 are female.

The DC Field Facility also hosted the ***2015 NHMFL User Summer School*** that attracted 28 graduate students and post doc attendees (**Fig. 8**). It is a five-day series of lectures and practical exercises in experimental condensed matter physics techniques developed and taught by the MagLab scientific staff from the 3 sites. It has proven to be an excellent vehicle for communicating valuable knowledge to the next generation of scientists from the enormous trove of experience encompassed by the MagLab scientific staff. The summer school is an annual event and will be presented again in 2016. Feedback from participants and their advisors continues to be very positive.

Figure 8: *2015 User Summer School participants.*

6. Facility Operations Schedule

At the heart of the DC Field Facility are the four 14 MW, low noise, DC power supplies. Each resistive magnet requires two power supplies to run and the 45 T hybrid magnet requires three power supplies. Thus the DC Field Facility operates in the following manner; in a given week there can be four resistive magnets + three superconducting magnets operating or the 45 T hybrid, two resistive magnets and three superconducting magnets. The powered DC resistive and hybrid magnets operated for 46 weeks out of the year in 2015 with a 4 week shutdown for infrastructure maintenance from November 16 to December 14 and a 2 week shutdown period for the university mandated holiday break from December 24, 2015 to January 4, 2016. The three superconducting magnets operated for 48 weeks out of the year with staggered maintenance periods as required. The hourly operation schedule for the resistive and hybrid magnets is as follows: 16 hours/day on Monday and 21 hours/day Tuesday-Friday. The superconducting magnets operate 24 hours/day.

CHAPTER 3 – USER FACILITIES

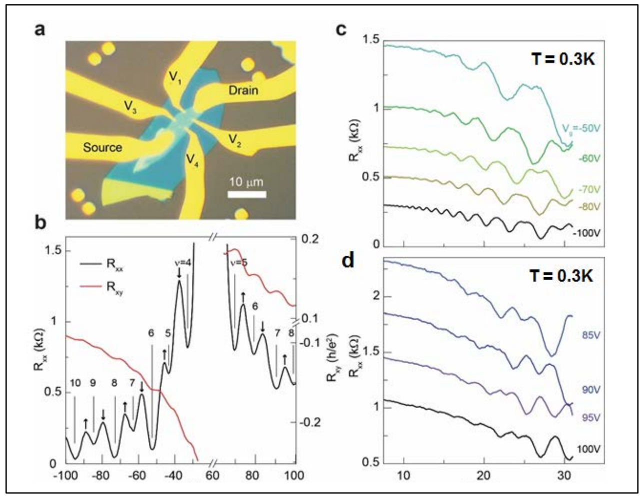
Quantum Oscillations in Black Phosphorus Two-dimensional Electron Gas

Likai Li[1], Guo Jun Ye[2], Vy Tran[3], Ruixiang Fei[3], Guorui Chen[1], Huichao Wang[4], Jian Wang[4], Kenji Watanabe[5], Takashi Taniguchi[5], Li Yang[3], Xian Hui Chen[2] and Yuanbo Zhang[1]
(1. Fudan University; 2. University of Science and Technology of China; 3. Washington University in St. Louis; 4. Peking University; 5. National Institute for Material Science)

Black phosphorus has recently emerged as a new member in the family of two-dimensional (2D) atomic crystals. _Black phosphorus is a semiconductor with a tunable bandgap and high carrier mobility – materials properties of central importance to potential opto-electronic, light-harvesting and high-speed electronic device applications._

In this work, we achieve a record-high carrier mobility in black phosphorus by placing it on hexagonal boron nitride (h-BN) substrate (Fig. 1a). A 2D electron and hole gas is induced at the black phosphorus/h-BN interface by the gate electric field. _The intense magnetic field, coupled with the exceptional mobility of the 2D carriers confined at the interface, allows us to observe quantum oscillations for the first time in black phosphorus (Figs. 1b,c,d)._ From the temperature dependence of the quantum oscillations, we measure a 2D hole effective mass of $0.34m_0$ and a 2D electron effective mass of $0.47m_0$, each of which is significantly larger than values measured in bulk samples, a likely result of quantum confinement effects. The quantum carrier lifetime is determined to be ~0.1ps.

Our experimental results place black phosphorus 2D electron gases in the elite family of high quality electron systems, opening the door to future research on quantum transport and electron correlations in this new material.



(a) _Optical image of our black phosphorus device with h-BN substrate._
(b) R_{xx} _(black) and_ R_{xy} _(red) measured as a function of_ V_g _with magnetic field fixed at_ $B = 31$ _T. Filling factors are indicated in the figure. The arrows indicate the spin-up and spin-down Landau levels._
R_{xx} _as a function of magnetic field measured at various gate voltages. Quantum oscillations are observed for_ **(c)** _holes and_ **(d)** _electrons_

Facility:
DC Field Facility, Tallahassee, FL
Instrument/Magnet:
Cell 9, 31 T Resistive Magnet
References:

Quantum oscillations in a two dimensional electron gas in black phosphorus thin films, Likai Li, Guo Jun Ye, Vy Tran, Ruixiang Fei, Guorui Chen, Huichao Wang, Jian Wang, Kenji Watanabe, Takashi Taniguchi, Li Yang, Xian Hui Chen and Yuanbo Zhang,
Nature Nanotechnology, Advance Online Publication, DOI:10.1038/nnano.2015.91 (2015).

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Unconventional Fermi Surface in an Insulating State

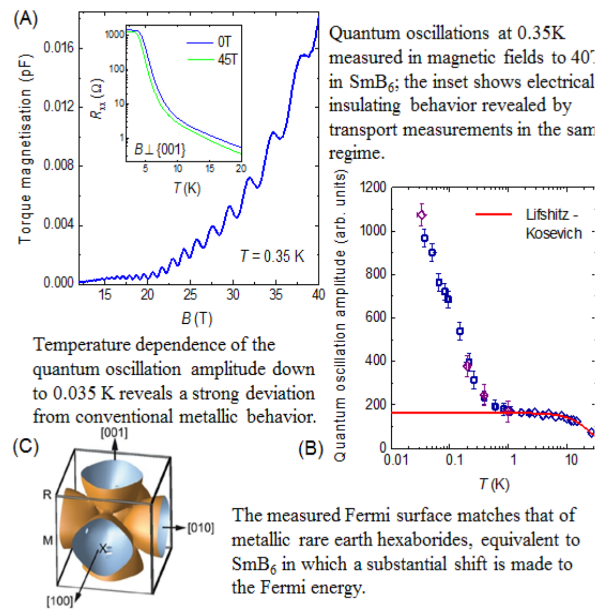
B. S. Tan[1], Y.-T. Hsu[1], B. Zeng[2], M. Ciomaga Hatean[3], N. Harrison[2], Z. Zhu[2], M. Hartstein[1], M. Kiourlappou[1], A. Srivastava[1], M. D. Johannes[4], T. P. Murphy[2], J.-H. Park[2], L. Balicas[2], G. G. Lonzarich[1], G. Balakrishnan[3], Suchitra E. Sebastian[1] (1. University of Cambridge; 2. National High Magnetic Field Laboratory; 3. University of Warwick; 4. Naval Research Laboratory)

Samarium hexaboride, SmB_6, is a Kondo insulator at low temperatures due to an energy gap formed by collective hybridization between *d*- and *f*-electrons. Magnetic field measurements reveal a surprising finding of quantum oscillations arising from the insulating bulk of SmB_6 **(Fig. A).**

Electrical transport measurements find a strong insulating character of SmB_6, with a thousand-fold increase in resistance exhibited when the sample is cooled below 10K. However, using torque magnetometry in the 45 T hybrid magnet, quantum oscillations in the magnetization are clearly revealed, the angular dependence of which reveals a Fermi surface that corresponds to a large three-dimensional section occupying half the Brillouin zone **(Fig. C).**

Strikingly, at dilution refrigerator temperatures, the quantum oscillation amplitude measured as a function of temperature in SmB_6 deviates strongly from the well known Lifshitz-Kosevich form that is characteristic of fermionic quasiparticles in interacting metals **(Fig. B).**

The unconventional character of the SmB_6 ground state is therefore revealed by simultaneous electrically insulating behavior and quantum oscillations in the magnetisation, the temperature dependence of which deviates from the characteristic Lifshitz-Kosevich form universally observed in interacting metals.



Quantum oscillations at 0.35K measured in magnetic fields to 40T in SmB_6; the inset shows electrical insulating behavior revealed by transport measurements in the same regime.

Temperature dependence of the quantum oscillation amplitude down to 0.035 K reveals a strong deviation from conventional metallic behavior.

The measured Fermi surface matches that of metallic rare earth hexaborides, equivalent to SmB_6 in which a substantial shift is made to the Fermi energy.

Facility:
DC Field Facility, Tallahassee, FL

Instrument/Magnet:
45 T hybrid & 35 T Resistive Magnets

References:

Unconventional Fermi surface in an insulating state, B. S. Tan, Y.-T. Hsu, B. Zeng, M. Ciomaga Hatean, N. Harrison, Z. Zhu, M. Hartstein, M. Kiourlappou, A. Srivastava, M. D. Johannes, T. P. Murphy, J.-H. Park, L. Balicas, G. G. Lonzarich, G. Balakrishnan, S. E. Sebastian, Science 349 (2015) 287-290.

PFF

CHAPTER 3 – USER FACILITIES

PFF

PULSED FIELD FACILITY

Summary

The National High Magnetic Field Laboratory - Pulsed Field Facility (NHMFL–PFF) is located in Los Alamos, New Mexico, at the Los Alamos National Laboratory (LANL) – also home to another world class user program, the Center for Integrated Nano Technology (CINT). The NHMFL–PFF utilizes LANL and US Department of Energy (DOE) owned equipment and resources to provide world record pulsed magnetic fields to users from the scientific and engineering community worldwide. The pulsed field users program is engineered to provide researchers with a balance of the highest research magnetic fields and robust scientific diagnostics specifically designed to operate in pulsed magnets. The connection with the DC Field Facility is strong and complementary in expertise. Although achieving the highest research magnetic fields possible is a fundamental competency at the NHMFL-PFF, we also strive to create the very best high-field research environment and to provide users with support from the world's leading experts in pulsed magnet science. All of the user support scientists are active researchers and collaborate with multiple users per year. A fully multiplexed (6-output) and computer controlled, 4.0 mega-Joule (32 mF @ 16 kV) capacitor bank system is at the heart of the short pulse magnet activities. Many thousands of shots are fired for the User Program, which accommodates approximately 150 different users each year and fires more than 7000 high magnetic field pulses each year for users. Beyond the *workhorse* shortpulse magnets, we provide users with the highest non-destructive magnetic fields available worldwide. The 100's of mega-Joules necessary are provided by a 1.4 GW AC generator that is a truly unique pulsed power supply that dwarfs the pulsed power systems of all other magnet labs. The AC rectification allows for a greatly flexible pulsed power waveform to be delivered and customized to optimize performance of the associated magnet system (enabling technology for both the 100 T multishot and 60 T controlled waveform magnets). Pulsed field users have access to magnetic fields exceeding 100 T using the *semidestructive* Single Turn magnet system which produces 6 microsecond duration magnetic field pulsed approaching 300 tesla.

1. Unique Aspects of Instrumentation Capability

Capacitor Driven Pulsed Magnets		
Magnet, Field (T), Bore (mm)	**Duration FWHM (ms)**	**Supported Research**
Cell 1, 65 T, 15.5 mm **Cell 2, 72 T, 7.0 mm** **Cell 3, 65 T, 15.5 mm** **Cell 4, 65 T, 15.5 mm** **Cell 294 Pulsed Power Test cell** **Bldg 125 Single Turn, 300 T, 10mm**	20 20 20 20 N/A 0.003	Magneto-optics (IR through UV), magnetization (susceptibility, extraction and torque), and magneto-transport, (DC- MHz & GHz conductivity), Pulse Echo Ultra-sound spectroscopy, Fiber Bragg grating dilatometry, all from 350 mK to 300 K. In-situe sample rotation and pressures up to 100 kbar are available for compatable techniques. IR & FIR transmission in the Single Turn Magnet.
Generator Driven Magnets		
Magnet, Field (T), Bore (mm)	**Duration FWHM (ms)**	**Supported Research**
100 T Multi-Shot, 101 T, 10 mm **60 T Controlled Waveform, 60 T, 32** mm	15 300	The same as for the capicator driven magnets including magnetothermal studies (heat capacity and magnetocaloric measurements) FIR and THz optics and larger sample volumes ing the long pulse magnets.

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The table above lists the pulsed magnets available to users of the NHMFL-PFF. The short pulse magnets serve the majority of users with maximum fields currently in the 65-72 T range. The 100 T multi-shot magnet is the first and only magnet in the world to successfully perform a magnetic field pulse to 100 tesla in a non-destructive manner. The NHMFL pulsed magnets are arguably the best and most capable pulsed magnets in the world that are available to any qualified user through the NSF-DMR supported user program. The expertise in pulsed power engineering and access to world-class materials scientists at both LANL and FSU focus attention on development and characterization of the best materials for magnets. The PFF at LANL is also home to the 60 T Controlled Waveform (A.K.A. "Long Pulse") magnet which has the ability to customize pulse waveforms for optimal user research. The 300 tesla single turn magnet at the PFF (initially funded by LANL) provides users with access fields in excess of 100 T – routine pulses are to 170 tesla with a pulse duration of 6 microseconds. This research platform is mainly suitable to optical studies, but is being expanded with highly specialized sample preparation techniques. An example of such highly specialized techniques is shown in **figure 1** with a superconducting sample that was pattered with a focused ion beam system at LANL.

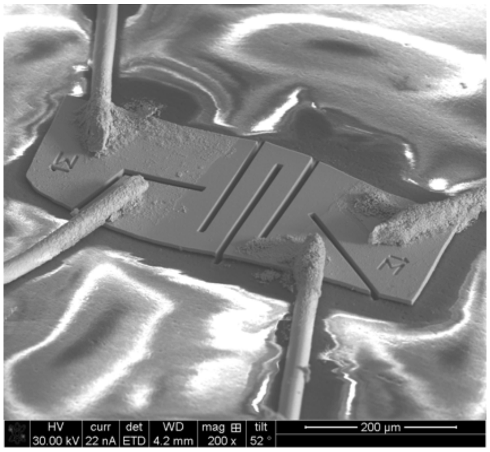


Figure 1: *A superconductor sample that was custom micro-machined using the focused ion beam capability at LANL's Materials Science Lab.*

The PFF is at the forfront of pulsed field compatable instrumentation: For example, contactless conductivity methods were highly developed at the PFF in collaboration with researchers at the DC facility and at Clark University. The tunnel diode method (TDO) has mainly given way to the Proximity Detector Oscillator (PDO) method over the past several years. This specialized method is an excellent tool for users detect upper critical field transitions in superconductors and this turns out to be a great tool for users to search for magneto-quantum oscillations in metals in very high fields. Sample preparation is extremely straightforward and usually involves simply placing an oriented sample in a ~1mm rf coil and securing it to the probe with grease. Other configurations include wrapping coils directly around samples which increases the filling factor and hence the signal to noise.

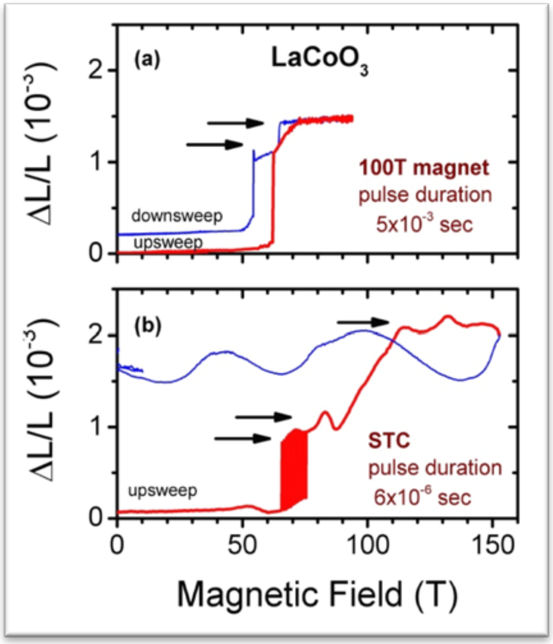


Figure 2: (a) *Optical FBG dilation experiment in a $LaCoO_3$ single crystal sample in pulsed magnetic field to 100 T. A sharp sample elongation is observed at Co-spin transitions in the 60-80 T range.* ***(b)*** *Similar experiment performed using an ultrafast coherent optical time-domain spectrometer to interrogate the FBG strain gauge sensor in the NHMFL single turn coil (STC) magnet to 150 T. A feature is observed above 100 T that could be related to (i) additional Co-spin transition or (b) fracture propagation in the sample. Both are potentially interesting as the reveal magnetic and stress/strain properties of the material. The later could explain irreversibility in the data when magnetic field sweeps down to zero.*

CHAPTER 3 – USER FACILITIES

Pulsed field measurements that probe thermodynamic properties are especially valuable to condensed matter physicists. For example, magnetostriction due to the coupling of the lattice to the magnet moment of quasi-particles and localized moments. For pulsed field environments magnetostriction is measured by mechanically bonding a length dependent optical reflector (a fiber Bragg grating) to a crystal. The fiber Bragg grating dilatometer technique has resulted in numerous user experiments in all of our magnets – in 2015 the technique was expanded to the extreme fields of the Single Turn Magnet system. **Figure 2** shows a recent experiment by M. Jaime et al. performed in the Single Turn magnet up to 150 tesla. The lack of electromagnetic interference, primarily due to the optical readout method, is an important factor that merits continued development of this thermodynamic probe.

The liquid helium recovery system at the PFF is fully operational with an efficiency of 88-92%. All user cells including the Single Turn are now plumbed into the recovery system. In 2015 a helium flow monitoring system was built and has been providing data to the Director of Operations with goal of monitoring and improving our helium usage and efficiency.

3. Major Research Activities and Discoveries

During 2015 significant advances in optical spectroscopies in pulsed fields were demonstrated on very topical materials such as the transition metal dichalcogenides (TMDs). The materials in this class hold great promise for device applications as they have many of the characteristic properties of the materials in the topological insulators but they are true semi-conductors. In collaboration with the Naval Research Laboratory and Rice University pulsed field spectroscopy of atomically thin transition metal disulphides (WS_2 and MoS_2) and diselenides WSe_2 and $MoSe_2$) the reflection spectroscopy measurements are reported in the journal *Nature Communications* [A. V. Stier et al., DOI: 10.1038/ ncomms 10643]. The small quadratic diamagnetic shifts are observed in pulsed fields up to 65 tesla. The shifts of A and B exciton are subtle effects that require the amplified intensity of pulsed magnetic fields. **Figure 3** below shows an example of the diamagnetic shift observed in WS_2 measured in pulsed magnetic field

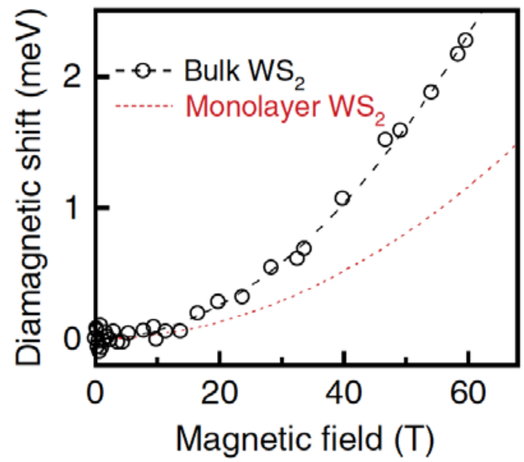


***Figure 3:** The diagmagnetic shift of WS2 comparison of bulk to atomically thin. The measurement emphasizes the need for careful characterization of materials where the reduced size alters functionality and response to external perturbations.*

up to 65 tesla. The use of high magnetic fields to suppress superconductivity and reveal fundamental electronic structure has been a staple of the NHMFL-PFF capabilities and competency since the mid 1990's. The expertise in measurement science and diagnostic development pays off as evidenced by the scientific discoveries made using the NHMFL magnets and the techniques developed in collaboration with users. **Figure 4** shows a clear example of why the world's highest available magnetic fields at the NHMFL-PFF are critical for materials physics discovery and the accompanying of state-of-the-art measurement science. The data are taken from a recent publication by Ramshaw and co-workers reported in Science in 2015 [B. Ramshaw et al., *Science*, vol **348**, issue 6232, pp. 317-320 (2015)]. The magneto-quantum oscillations (MQOs) measured in multiple dopings of YBCO are resolved by utilizing either magnetotransport or the proximity detector method. The temperature dependence of the MQOs is used to determine the quasi-particle effective mass for the range of dopings of samples approaching optimal T_c doping. The fundamental purpose of the experiment is to better understand the nature of the superconducting mechanism in the material. As the oxygen doping approaches the optimal value the quasi-particle effective mass increases as does the upper critical field thus making the determination of the effective mass more challenging. Use of the 101 tesla pulsed magnet at the NHMFL a critical instrument in this investigation.

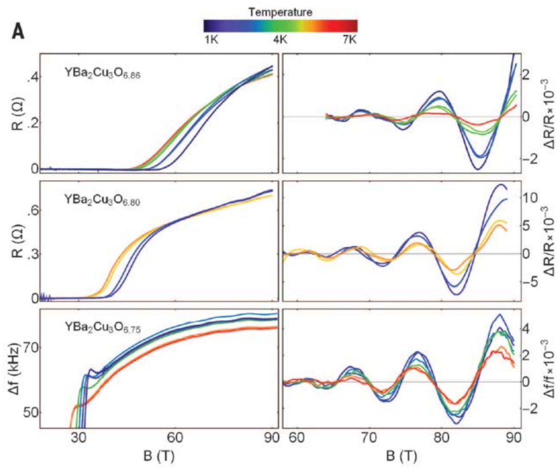


Figure 4: *The measurements of the electrical resistivity and penetration depth as a function of applied magnetic field. Measurements extending beyond 90 tesla are necessary to reveal the MQOs and the quasi-particle effective mass.*

4. Facility Plans and Directions

During 2015 the NHMFL-PFF made significant advances in construction of a new user experimental cell in the large magnet hall (TA-35 building 294) that is to be used for the new Duplex magnet. The magnet tooling for winding was completed in late 2015 and winding has begun in 2016. It is anticipated that the Duplex magnet will begin commissioning in late 2016. The magnet design allow for routine operation at a peak magnetic field of 75 tesla.

Specialized operation of the magnet can withstand peak magnetic fields of up to 80 tesla but for a significantly reduced lifetime. The magnet bore is identical to the 65 tesla user magnets at 15.5 mm inside diameter.

In 2015 a decision to seek institutional investments was coordinated with LANL administration in the directorate for experimental physical sciences. An assessment team was commissioned requests for infrastructure to better position the NHMFL-PFF for addressing the needs of the user community and the recommendations of the National Academies report on the need for high magnetic field research capabilities [see the National Academies Press *High Magnetic Field Science and Its Application in the United States: Current Status and Future Directions*, DOI: 10.17226/18355]. The need for generation of 150 tesla pulsed magnetic fields in a non-destructive manner on a time scale of milliseconds requires pulsed power sources with stored energies of the order of 1500-2000 MJ. Plans for installation of a flywheel energy storage device on the existing 1430 MVA generator system are being considered as well as the modernization of the exciter and drive circuits which could accommodate the required energy storage upgrade.

5. Outreach to Generate New Proposals- Progress on STEM and Building User Community

During 2015 the PFF hosted and participated in numerous outreach events. PFF scientists participated in the Expanding Your Horizons event in Santa Fe, NM. The event was specifically designed for middle school girls with interest in STEM and it attracted approximately 700 students.

Figure 5: *LANL and NHMFL-PFF scientist Vivien Zapf demonstrates cryogenic properties to a group of students at the Expanding Your Horizons outreach event in Santa Fe, NM.*

The IEEE student group from New Mexico Tech toured the facility as well as the McDermott scholars from Dallas, Texas. The local PFF user support scientists visited area schools and gave presentations on the physics of magnetism and pulsed magnets. PFF Director Chuck Mielke participated in the “Scientist Ambassador” program sponsored by the Bradbury science museum in March of 2015 in celebration of “Pi Day”. LANL was pleased to sponsor the visit of NSF Director France Cordova in which she toured multiple LANL facilities, gave a presentation and then took a detailed tour of the PFF. In **figure 6**, Dr. Cordova stands in front of LANL’s 1.4 GVA generator system along with LANL Associate Director Mary Hockaday and PFF Director Chuck Mielke.

Figure 6: *NSF Director France Cordova touring the NHMFL-PFF with PFF Director Chuck Mielke and LANL Associate Director Mary Hockaday.*

6. Facility Operations Schedule

The PFF has operated for two years now with a quarterly scheduling model and has solicited the quarterly call in concert with the DC facility. The reason for the change is to better serve users by fixing the schedules of the PFF user support scientists. The rolling model does not allow for planning for the user support scientists more than a few weeks out. Hours of operation are from 8:00am – 5:00pm. A16KV 4MJ User accessible capacitor bank is used to drive the 65 T short pulse magnets, 4 cells are equipped with these magnets and typically 3 are in use Monday – Friday 7:30am to 10:30pm. Preventative maintenance is scheduled each week (Monday 8:00am-10:00am) or performed on an as needed basis.

PFF

CHAPTER 3 – USER FACILITIES

PFF

Quasiparticle Mass Enhancement Approaching Optimal Doping in a High-T_c Superconductor

B. J. Ramshaw[1], S. Sebastian[2], R. D. McDonald[1], J. Day[3], B. Tan[2], Z. Zhu[1], J. B. Betts[1], R. Liang[3], W. N. Hardy[3], D. A. Bonn[3], N. Harrison[1] (1. Los Alamos National Labs – Pulsed Field Facility; 2. Cambridge University; 3. University of British Columbia)

Unconventional superconductivity, where Cooper pairing is driven by something other than electron-phonon coupling, often appears in proximity to magnetic order. The heavy-fermion and organic superconductors provide two families of materials that serve as examples of this phenomenon. By varying pressure or chemical doping, the transition temperature to the magnetic phase can be suppressed to T = 0, resulting in a quantum phase transition, and a quantum-critical point (QCP) when critical behavior is observed.

This QCP often coincides with the maximum superconducting T_c, suggesting that unconventional superconductivity and quantum criticality are linked. High-T_c cuprates lack this magnetic transition near optimal T_c, but may instead have a different type of QCP driving superconductivity.

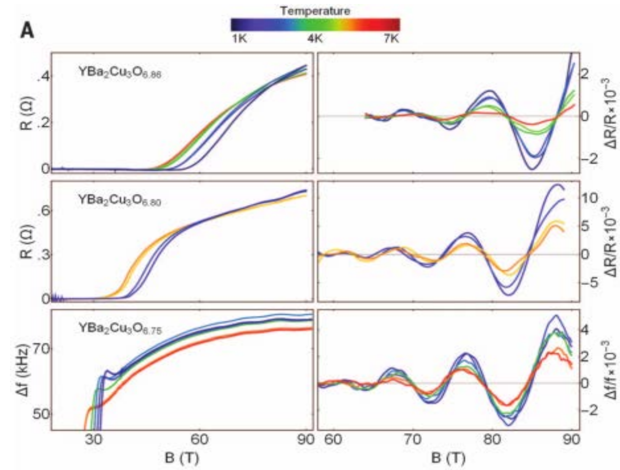
Magnetic fields exceeding 90 teslas were utilized to search for a QCP near optimal doping in the high-T_c cuprate superconductor $YBa_2Cu_3O_{6+x}$. We found that the quasiparticle effective mass is greatly enhanced as the material is doped toward optimal T_c **(Fig.1)**—a common signature of increased electron-electron interactions in the vicinity of a QCP. An extrapolation of the data to determine the doping at which the maximum mass enhancement occurs finds the same doping at which superconductivity survives to the highest magnetic fields **(Fig.2)**, suggesting that quantum-criticality drives or enhances superconductivity in this system.

Underlying any QCP is a broken-symmetry phase of matter, such as magnetism. It remains to be discovered what the broken-symmetry phase is in the high-T_c cuprates: one possible contender is charge-density wave order, which has recently been shown to extend to near-optimal T_c in $YBa_2Cu_3O_{6+x}$.

Facilities: 65 T and 100 T magnets at the Pulsed Field Facility

Acknowledgements: Canadian Institute for Advanced Research; DOE BES "Science at 100 T"

References: B.J. Ramshaw, S.E. Sebastian, R.D. McDonald, James Day, B.S. Tan, Z. Zhu, J.B. Betts, Ruixing Liang, D.A. Bonn, W.N. Hardy, N. Harrison, *"Quasiparticle mass enhancement approaching optimal doping in a high-Tc superconductor."* Science 348:6232 (317-320). 2015



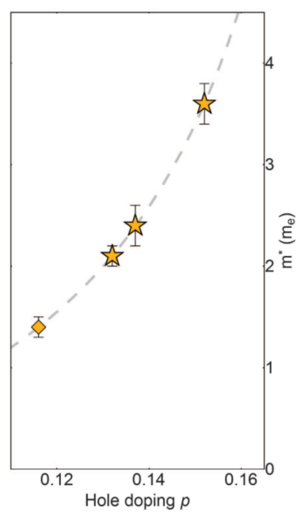


Figure 1: *Oscillations of the magnetoresistance.* ***(A)*** *The magnetoresistance of $YBa_2Cu_3O_{6+x}$ for x = 0.75, 0.80, and 0.86, which gives T_c = 75, 86, and 91 K. Left panels show the raw resistance up to 90 T; right panels show the oscillatory component after a smooth, monotonic background has been removed.* ***(B)*** *Effective mass as determined from the temperature dependence of the oscillation amplitude using standard Lifshitz-Kosevich analysis.*

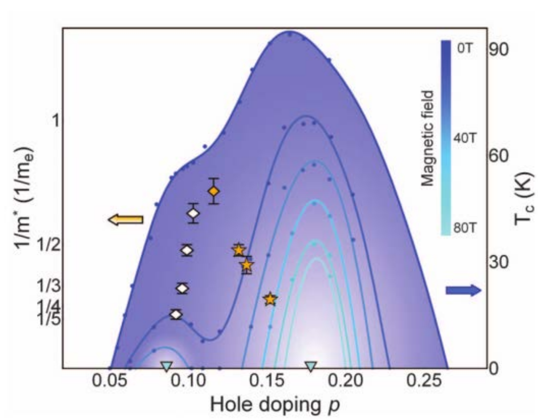


Figure 2: *Superconducting phase diagram in a magnetic field. Blue contours denote $T_c(p)$ at 0, 15, 30, 50, 70, and 82T (right axis). The inverse of the effective mass (left axis) is overlaid, with the orange star data points coming from the data in Fig.1, and the white points coming from an earlier work. Note that the extrapolation of the inverse effective mass is p=0.18—the same doping around which superconductivity is most resistant to a magnetic field.*

CHAPTER 3 – USER FACILITIES

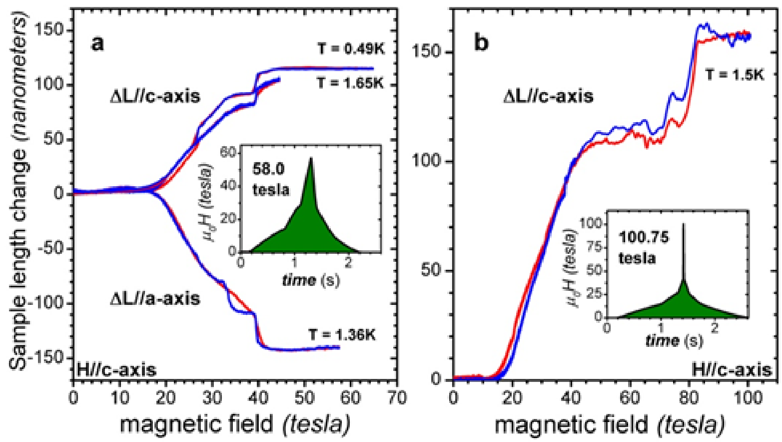
Atomic Pantograph Tunes Magnetic Ground State in a Solid

G. Radtke[1], A. Saul[2,3], H.A. Dabkowska[4], M.B. Salamon[5,6], M. Jaime [6] (1. Sorbonne Univ.; 2. Aix-Marseille Univ.; 3. MIT; 4. McMaster Univ.; 5. Univ. of Texas, Dallas; 6. NHMFL)

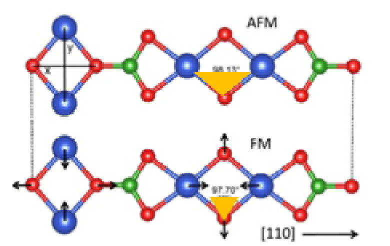
A pantograph is a jointed framework that can stretch or contract easily. Examples include the extendable claw used to reach items on the top shelf, or to connect an electric streetcar to the overhead power line.

Researchers using the MagLab's pulsed magnets up to 100 T have found that magnetic fields can increase the length of pantograph-like structures on the atomic scale in $SrCu_2(BO_3)_2$ (SCBO) . Thus, for this material, applied magnetic fields act like a "negative pressure". *When the magnetic field is sufficiently high and the elastic energy cost associated with deformation is relatively small, the angle α from Cu-O-Cu (orange triangle in lower figure) can change as much as 0.4º.* Although, seemingly a small change, α determines the magnitude of the magnetic interaction ***J*** between the two nearest neighbor Cu atoms via superexchange through the O atom.

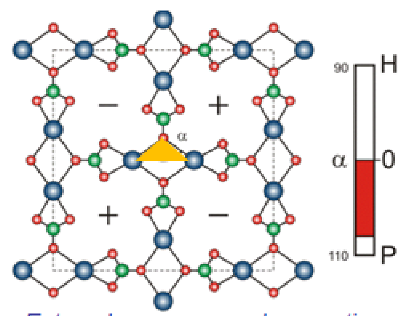
Combining pulsed field magnetostriction experiments and Density Functional Theory (DFT), researchers found that minute changes in the sample length imply 50x larger changes in α, and as much as a 10% reduction in ***J***. *This is enough to drive the system across a quantum phase transition between spin dimer and antiferromagneic ground states. The correlation between sample length and superexchange angle α makes it possible to tune the magnetic properties of SCBO with either an external magnetic field or pressure.*



Sample length vs magnetic field in 60T controlled-waveform and 101T pulse magnets



Pantograph structure in $SrCu_2(BO_3)_2$ Blue:Cu; Red:O; Green:B



External pressures and magnetic fields tune superexchange angle α

Facilities: Pulsed Field Facility at the Pulsed Field Facility
Instrument/Magnet: 60 T long pulse and 100 T repetitive pulse
Citation: *Magnetic nanopantograph in the $SrCu_2(BO_3)_2$ Shastry-Sutherland lattice*, G. Radtke, A. Saul, H.A. Dabkowska, M.B. Salamon, M. Jaime, Proceedings of the National Academy of Science, Early Edition, February 2, 2015.

CHAPTER 3 – USER FACILITIES

HIGH B/T FACILITY

Summary

The High B/T Facility provides users with access to a unique combination of high magnetic fields (up to 16 T) and temperatures down to 0.4 mK. The experimental cells provide an ultra-quiet environment with advanced vibration isolation and electromagnetic shielding that is needed for high sensitivity measurements such as magnetic susceptibilities of small samples.

1. Unique Aspects of Instrumentation Capability

Dr. Jiang-sheng Xia and Dr. Liang Yin have developed a unique cell (see **Fig. 1**) for high sensitivity measurements of the dielectric susceptibility of samples down to 4 mK. The cell was used to determine the ferroelectric properties of the perovskite $PbCrO_3$ and the unusual magneto-electric effects in dichloro-tetrakis-thiourea-nickel (or DTN).

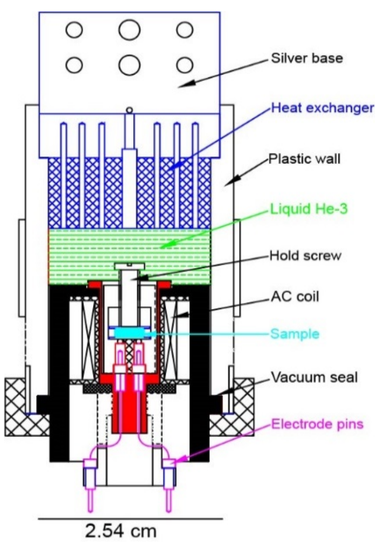


Figure 1: *Cross-section of dielectric susceptibility cell for studies of the magneto-electric effects in $PbCrO_3$ and in the Bose-glass state of DTN. The brass heat exchangers contain sintered Ag and the cell is filled with superfluid ^{3}He.*

High B/T scientists have also developed specialized magnetic susceptometers for high sensitivity AC susceptibility measurements at ultra-low temperatures (see **Fig. 2**). These devices use sintered Ag posts to thermalize the leads entering the cell. These cells have been used to measure weak magnetic susceptibilities down to 0.5 mK for frustrated magnet systems and organic quantum magnets in fields up to 14 T.

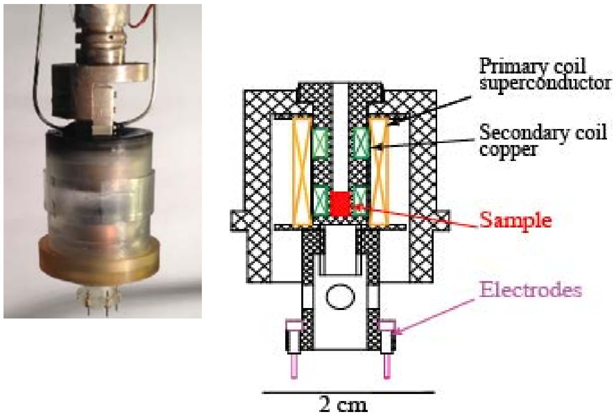


Figure 2: *Photo and cross-section of AC magnetic susceptibility cell that employs superfluid ^{3}He for thermalization of samples.*

A campus-wide helium gas recovery system that employs unique real-time monitoring of recovery rates and helium pressures at the sites of user experiments at the High B/T Facility and at other NHMFL and related facilities at the University of Florida (AMRIS, Chemistry and Materials Sciences). The monitoring provides a valuable safety system in case of malfunction of the large superconducting magnets that are employed at the different sites.

2. Facility Developments and Enhancements

Ultra-low noise radiofrequency capabilities including superconducting coaxial cabling are being added to Bay 2 of the Facility to enable resistance detected NMR of quantum Hall effect samples. This technique will help probe the spin properties of exotic fractional quantum Hall states.

Ultra-low temperature contactless techniques using high stability tunnel diodes are being

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developed to measure radio-frequency conductivities. These devices are being designed to operate in high magnetic fields at millikelvin temperatures.

3. Major Research Activities and Discoveries

A. Discovery of complex metamagnetic phase diagram of Ce_3TiSb_5. James Hamlin, graduate student Daniel Jackson, and REU student Tracy Stevenson, have succeeded in mapping the complex phase diagram of single crystals of the hexagonal compound Ce_3TiSb_5. The results shown in **Fig. 3** are consistent with Kondo lattice behavior with anti-ferromagnetic ordering below 5.5 K. For magnetic fields applied perpendicular to the c-axis, metamagnetic transitions appear and are accompanied by a large negative magnetoresistance. High sensitivity electrical resistivity measurements were used to determine the phase diagram down to 0.030 K.

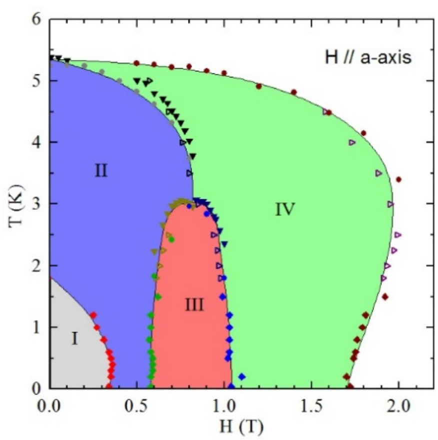

Figure 3: *Magnetic phase diagram of Ce_3TiSb_5, down to 0.030 K. Slightly below 2 T, this material exhibits a region of apparent re-entrant disorder, i.e., cooling the sample results in a disorder-order-disorder sequence of phases.*

B. Phase separation in quantum solid mixtures.

High sensitivity NMR techniques using low temperature RF amplifiers have been used to determine the phase separation of dilute solid ^3He-^4He mixtures down to ^3He concentrations as low as 16 ppm. These transitions are of fundamental interest because they are first order transitions with a conserved order parameter, and the dynamics is several orders of magnitude faster than those in metallic alloys as a result of the quantum tunneling that drives the motion. The dependence of the phase transitions on ^3He concentration are in good agreement with solution theory provided one uses the correct quantum free energies for the components.

C. Ferroelectric behavior in multiferroic $PbCrO_3$

Understanding the insulator-metal Mott transition in correlated electron systems is important for testing the underlying physics of these materials. To explore the ferroelectric behavior of these materials Shanmin Wang and colleagues [1] have measured the dielectric constant of the perovskite $PbCrO_3$ using the high sensitivity capabilities (section 1 above) of the high B/T facility.

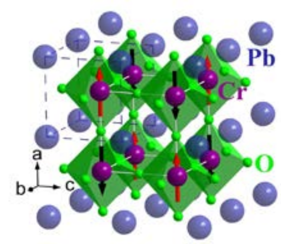

Figure 4: *Structure of $PbCrO_3$ with alternating up and down Cr spins along the α-axis. [1]*

A step-like reduction in the dielectric constant is seen below a ferroelectric transition at 65 K which is correlated with lattice anomalies. No further change is seen in the dielectric constant down to 30 mK. The authors [1] conclude that a-$PbCrO_3$ is a hybrid multiferroic system with both proper and improper ferroelectric characteristics.

[1] S. Wang *et al.*, Proc. Nat. Acad. Sciences 112 (5), 15320-15325 (2015).

4. Facility Plans and Directions

We are planning to add a 19T/5 mK superconducting magnet/dilution refrigerator ensemble to extend available parameter space for users. This addition is critically needed to reduce the length of time in the queue for assignment of magnet time to users whose research proposals have been approved. A new site will need to be identified for the location of the ensemble and additional staffing will be needed to operate it as a user facility.

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High B/T

5. Outreach to Generate New Proposals- Progress on STEM and Building User Community

The NHMFL created a new position at the University of Florida in 2015 to help coordinate outreach at the High B/T and AMRIS Facilities. In the fall of 2015, Elizabeth Webb, the new NHMFL Outreach/Facilities Coordinator at UF, started a K-12 classroom outreach program in Gainesville, akin to the NHMFL classroom program in Tallahassee. High B/T post-docs and graduate students assist with these hands-on lessons, teaching students about the NHMFL, uses of magnets, and basic magnet science. In 2015, six classrooms were visited. Faculty from the Facility also visited local after school programs for low income students, bringing with them physics demonstrations and hands-on activities. Additionally, Facility Faculty mentored 5 REU students over the summer, gave periodic tours of the High B/T Facility, and performed low temperature physics demonstrations at local community events such as the downtown farmer's market and the inaugural celebration for the new UF president.

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Above: *Prof. Hamlin leads a group through the Gainesville Community Sciences Coalition (Nov. 2015). Photo credit: Aida Mallard for the Gainesville Guardian*

The High B/T Facility has established a collaborative agreement with the European MicroKelvin Platform (EMF) to promote research and educational efforts between the High B/T Facility and institutions in Europe. The training of students in low temperature techniques, nuclear demagnetization techniques, low temperature thermometry and cryogenic engineering is of special interest.

6. Facility Operations Schedule

Almost all experiments at the High B/T facility require special cell design and preparation in collaboration with the users. The experiments themselves can take one to nine months to complete, depending on the complexity of the measurements. For this reason the facility operates 24/7 for 340 days a year. There were planned shutdowns for maintenance and servicing. In 2015, these shutdowns were chosen to coincide with the times for major international meetings, namely for the March meeting of the American Physical Society and for the Quantum Fluids and Solids Symposium held in Buffalo.

7. Newly Established Performance Goals – Present and Future

We plan to take advantage of the rapid progress in realization of stable high temperature super-conducting magnet to work with the Magnet Design and Development group on possible designs of a 25-30 T class magnet that would be sufficiently stable and quiet to be used at dilution refrigerator temperatures. If this is successful, the addition would provide access to fields well beyond the current limit of 16.5 T and would be equipped with low temperature inserts.

Isotropic vs. Anisotropic Transport in the Field Induced Wigner-crystal state in 2D hole

Xuan P. A. Gao[1], Nicholas J. Gable[1], Alessandro Serafin[2], Jiang-Sheng Xia[2], Loren N. Pfeiffer[3] and Kenneth W. West[3] (1. Case Western Reserve University; 2. University of Florida; 3. Princeton University)

Field Induced Wigner-Crystal States

Strong Coulomb interactions are expected to drive two-dimensional (2D) carriers in semiconductor hetero-interfaces into a crystal ground state in the ultra-low density regime. A perpendicular magnetic field can stabilize this Wigner crystal (WC) at higher carrier densities such that the disorder effect is weak. A number of isotropic or anisotropic states have been predicted theoretically [1], including a reentrant insulating phase.

Experimental

The transport of strongly interacting 2D holes in high mobility GaAs quantum wells was studied to determine the effects of current transport direction on the magnetic field induced WC state in low fields which is shown to lead to a reentrant insulating phase (RIP) in the magneto-transport data [2]. Low temperature measurements were performed on high mobility GaAs QW samples from wafers grown on (311) $Al_{0.1}Ga_{0.9}As$ barriers. All the samples have density p ~ 1.3 $\times 10^{10}/cm^2$ and mobility m=5×10^5 cm^2/Vs without gating.

Results and Discussion

The RIP due to WC formation at low B has been observed to exist for two current directions, the [233] and [011] directions. A clear insulating peak is found around ~0.3 Tesla for both directions, indicating that the RIP is isotropic, not due to orientation order such as one expects in stripe phases.

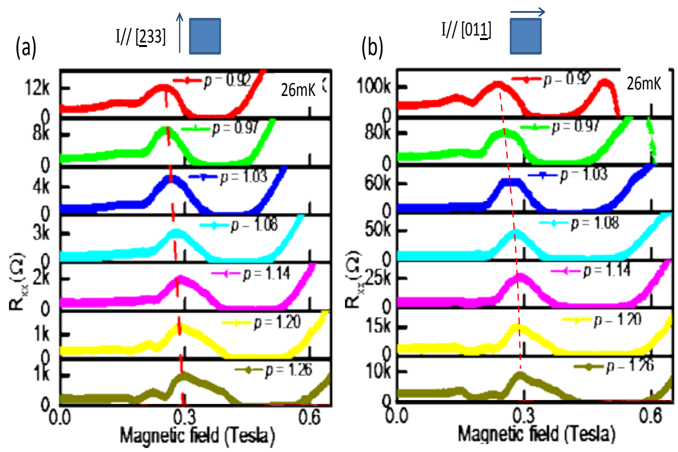

Figure: *Magneto-resistance of a square shaped 2D hole GaAs quantum well sample measured with current along two perpendicular directions. The density p is in units of $10^{10}/cm^2$. The sample temperature was 26mK. The red dashed line in both* ***(a)*** *and* ***(b)*** *indicate the location of a reentrant insulating phase due to Wigner crystallization*

Facility:
High B/T Facility, University of Florida, Gainesville, FL.

Instrument/Magnet:
Bay 3, Microkelvin Laboratory

Citation:

[1] B. Spivak and S. A. Kivelson, Annals of Physics 321, 2071 (2006).

[2] R. L. J. Qiu, X. P.A. Gao, L. N. Pfeiffer, K. W. West, *Phys. Rev. Lett.***108**, 106404 (2012).

High B/T

CHAPTER 3 – USER FACILITIES

High B/T

Phase Separation in ^3He-^4He Solid Solutions

Chao Huan[1], Don Candela[2], Brian Cowan[3], Liang Yin[1], Jian-sheng Xia[1] (1. University of Florida, 2. University of Massachusetts at Amherst, 3. Royal Holloway College, London.)

Introduction

Phase separation in ^3He-^4He mixtures represents an especially clear example of a first order phase transition with a conserved order parameter. The quantum nature of the diffusion sets "fast" time scales (~ hours) for the phase separation dynamics (in contrast to that for metal alloys), enabling measurements on experimental time scales. ^3He-^4He mixtures have very few defects, and substantial supercooling is possible. The separation is well understood [1-5] for high concentrations but has not been tested for very low concentrations, i.e. tens of ppm where the transitions are especially sensitive to asymmetries in the mixing interaction and free energy differences of the hcp and bcc phases.

Experimental

The samples were prepared with carefully controlled ^3He concentrations and grown slowly in an NMR cell under pressures such that the homogeneous mixtures are solid solutions but for which the ^3He separates as a liquid phase. The sample was thermally linked to a dilution refrigerator via sintered silver. Pulsed NMR techniques were used to monitor the NMR amplitude that undergoes a sharp drop at the separation because of the reduced susceptibility of the Fermi liquid.

Results and Discussion

The phase separation temperatures were found to be in excellent agreement with the predictions of regular solution theory given by

$$T_{ps} = \frac{0.76}{k_B}\frac{(1-2x_3)+A_3}{\left[ln\frac{1}{x_3}-1\right]}$$

A_3 is a correction that accounts for the different free energies of the different lattice structures of pure ^3He and pure ^4He.

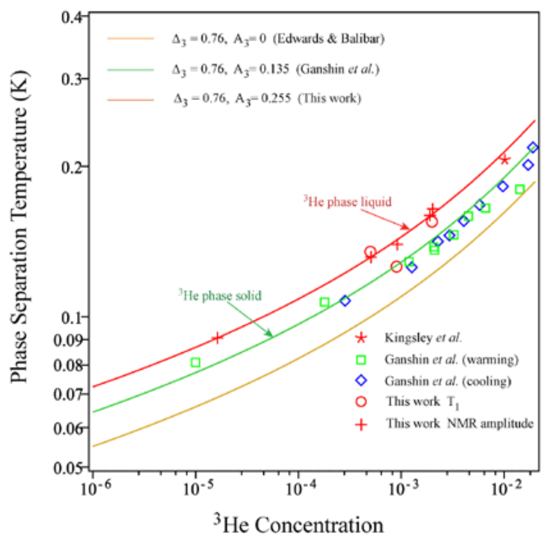

Figure: *Variation of the phase separation temperatures with ^3He concentrations for solid solutions of ^3He in ^4He.*

Facility:
High B/T Facility, University of Florida, Gainesville, FL.

Instrument/Magnet:
Bay 3, MicroKelvin laboratory

Conclusions:
The observed phase separation temperatures for solid ^3He-^4He mixtures are in excellent agreement with regular solution theory provided one accounts for the difference in free energy of the bcc ^3He and hcp ^4He structures.

References:

[1] D. O. Edwards and S. Balibar, Phys. Rev. **B39**, 4083(1989).
[2] S. J. C. Kingsley *et al*., J. Low Temp. Phys. **110**, 399 (1998).
[3] M. Poole *et al*. Phys. Rev. Lett. **100**, 075301 (2008).
[4] A. N. Ganshin *et al*. Low Temp. Phys. **26**, 869 (2000).
[5] V. Maidanov *et al*. J. Low Temp. Phys. **122**, 475 (2001).

NMR

NMR

CHAPTER 3 – USER FACILITIES

NMR/MRI FACILITY, TALLAHASSEE

Summary

The NMR and MRI User Program in Tallahassee is a partner with the AMRIS facility of the NHMFL at the University of Florida in Gainesville. The Tallahassee facility offers scientists access to high magnetic fields with the world's highest sensitivity NMR and MRI probe technology. Our flagship 900 MHz ultra-wide bore spectrometer is the world's highest field instrument for *in vivo* imaging and also offers the world's highest sensitivity probes for materials and biological solid state NMR. We now offer Dynamic Nuclear Polarization spectroscopy at 600 MHz as a user facility. This instrument provides much higher sensitivity for biological solids and for materials research than is available from NMR. Lower field instruments offer users additional unique capabilities in solution, solid state NMR and imaging. Our technology efforts continue to be focused on the development of innovative probes for triple resonance solid state NMR for both oriented sample and magic angle sample spinning, high field *in vivo* imaging and spectroscopy as well as high sensitivity solution NMR probes. Preparations are also underway for the launch of the 36 T (1.54 GHz) magnet for NMR spectroscopy based on a series connected hybrid (SCH) magnet with 1 ppm homogeneity and stability that will become available for initial experiments later in 2016.

1. Unique Aspects of Instrument Capability

A decade of successful science on the Ultra-Wide Bore 900 MHz magnet designed and constructed at the NHMFL has occurred since it was brought to field in mid – 2004. This instrument has generated 75 publications with an average of 10 publications per year over the last few years, as the user community has come to recognize the superb capabilities of this instrument for biological solid state NMR and for MRI/S.

A unique user facility has been launched in the United States at the NHMFL – a 600 MHz Dynamic Nuclear Polarization (DNP) Facility that takes advantage of NIH funding for a sweepable 14.1±0.13 T magnet and an NSF MRI grant for a gyrotron plus NSF and State of Florida NHMFL support to assemble this instrument that provides ultra high sensitivity NMR spectroscopy of materials and biological solid state NMR to our national and international user community.

Two new technologies are being installed for NMR at the NHMFL. The first is a pair of 0.75 mm 110 kHz MAS spinners for solid state NMR. Fast MAS spinners are ushering in a new era for NMR, one in which proton detection is possible with ultra high spectral resolution and sensitivity. This is similar to the revolution that occurred in the 1980's when solution NMR spectroscopy gained proton detection capabilities. That opened a flood-gate for protein structural characterization of water soluble proteins. Now for solid state NMR a similar flood-gate can be opened for proteins that are not water soluble such as membrane proteins and proteins that form fibrils, such as amyloid fibers.

The second revolution is occurring with magnet technology. The future of NMR is going to be at field strengths far above those that can be generated with Low-Temperature Superconductors (LTS). High Temperature Superconducting (HTS) materials development is progressing apace with the potential to more than double current NMR field strengths and the magnet lab is at the forefront of this technology thanks to support from NSF, NIH and DOE. While it will still be a while before such high field superconducting magnets become a reality, the NHMFL is about to launch a 36 T Series Connected Hybrid magnet. This magnet will have 1.5 times the field of the highest commercial NMR magnets. This opens great new avenues for spectroscopy and for imaging. Sensitivity for many nuclei increase with $B_0^{3/2}$ and signal averaging time decreases at the square of this factor. For quadrupolar nuclei the sensitivity factor can be $B_0^{5/2}$ or even $B_0^{7/2}$. One of the most exciting prospects in the biological sciences is the study of ^{17}O. It is at the oxygen atoms where much of biological chemistry takes place and yet it has not been possible to routinely observe these nuclei because of the poor sensitivity and severe resonance overlap. Fortunately, high fields dramatically enhance the prospects for doing this spectroscopy routinely on biological macromolecules.

2. Facility Developments and Enhancements

Despite years of development effort to get DNP to be a commercial product there is a great deal of work left to be done to have this technology be a routine tool, such as NMR spectroscopy. Robust infrastructure needs to be installed, more robust probes than what is available commercially needs to be developed. Sample preparation techniques need

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to be developed to gain the highest benefit from this technology. Additional temperature range is needed for many studies.

For the probe development on the SCH magnet a first generation of probes for MAS NMR and for oriented sample NMR have been designed and built, but this 50% jump in magnetic field is a huge jump in frequency and there will be multiple generations of probes that enhance NMR performance over the years to come. Indeed, this is very exciting, because there is an opportunity to do this prior to the development of very high field and very expensive HTS magnets.

3. Major Research Activities and Discoveries

One of the major scientific developments in the field of structural biology is the recognition that the lipid bilayer of cellular membranes has an influence on the structure of the proteins that inhabit these membranes. At one level this seems obvious, but for a scientific community that has been trying to calculate the structures of proteins from the amino acid sequence alone or a scientific community that wants to believe that these structures can be characterized in the absence of lipids by crystallography this has been difficult to accept. Membrane proteins account for 60% of all drug targets – some progress has been made by technologies that have replaced membranes with mimetics, but the technology that has potential to characterize the three dimensional structures in native membrane is solid state NMR. Higher fields and faster MAS spinners will aid in achieving that goal.

4. Facility Plans and Directions

The continued acceleration of scientific success on the 900 is moving toward MRI MRS science. We are planning to expand the RF engineering effort in this arena during the next funding period for the NHMFL along with a new console and new gradient coils for the magnet that will make optimal use of the bore dimension. Probe development for MRI and MRS is particularly challenging because *in vitro* and especially *in vivo* samples all have different spatial requirements for the RF coils and special requirements for the probes. Having an RF engineer dedicated to this activity will greatly facilitate the MRI and MRS science.

The NMR science on the SCH is going to be very challenging. We are hoping to perform high resolution solid state NMR spectroscopy on a DC Powered magnet – this has not been done before (unless one counts some of the early NMR spectroscopy from the middle of the last century). In collaborating with Prof. Jeffrey Schiano at Penn State the NHMFL has been developing technology to stabilize powered magnets. That technology continues to evolve and to improve. Soon we will have a chance to see if we can perform a variety of experiments that will allow us to explore the potential of very high magnetic fields.

5. Outreach to Generate New Proposals-Progress on STEM and Building User Community

Our first external DNP user who had not been associated with the DNP grant writing efforts was Asst. Prof. Kendra Frederick from UT Southwestern, a new user for the NHMFL. We are continuing to develop our strategy of recruiting new users by one on one contact with potential users at national and international meetings with follow up to bring those users here. A greater challenge that we are beginning to work on, is to recruit users who are not NMR spectroscopists, but scientists that could use NMR data for the science they do. This opens the NHMFL facility to a much broader and more diverse community of biological and chemical scientists.

6. Facility Operations Schedule

The NMR/MRI facilities are open 24/7 and for 365 days of the year. The only down time is when there is a failure of an instrument.

NMR

CHAPTER 3 – USER FACILITIES

NMR

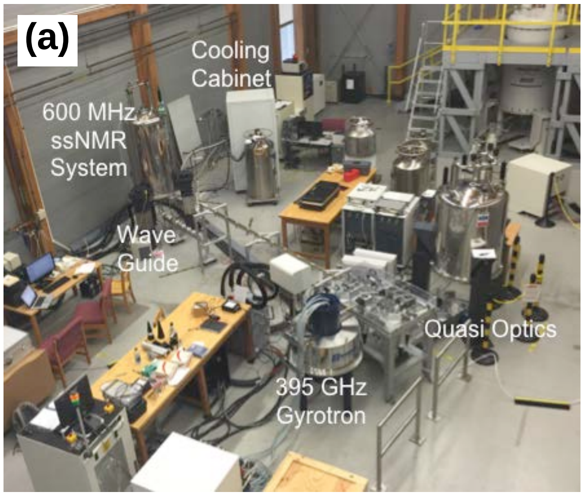
An approach for Dynamic Nuclear Polarization of Membrane Proteins

Adam N. Smith[1,2], Thierry Dubroca[2], Gail E. Fanucci[1], Joanna R. Long[1,2] (1. University of Florida; 2. National High Magnetic Field Laboratory)

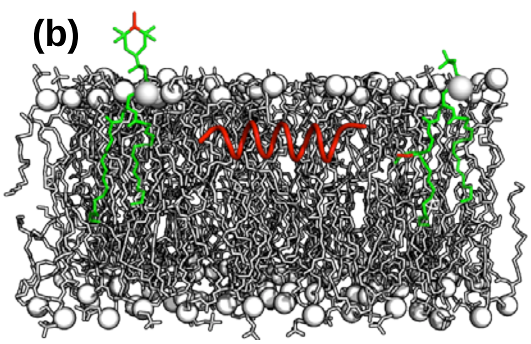
Dynamic Nuclear Polarization (DNP) coupled with magic angle spinning (MAS) is an exciting new technique for solid state NMR spectroscopy (ssNMR), because it can provide orders of magnitude enhancement to normally weak NMR signals, _which enables the study of inherently dilute proteins such as membrane proteins._

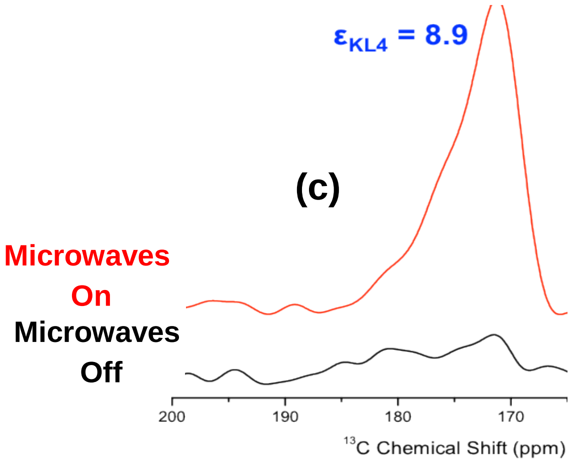
This study utilized (a) the MagLab's unique, 600 MHz (14.1 T) DNP MAS ssNMR instrument to develop an approach toward the efficient transfer of electron polarization to membrane proteins. The intense magnetic field polarizes unpaired electrons that have been doped into the sample. High-power microwave irradiation then transfers the large polarization to the NMR-active nuclei of interest. We obtained nearly an order of magnitude in signal enhancement of KL_4, a membrane peptide mimetic of the C-terminus of surfactant protein-B.

We showed that nitroxide labeled lipids, incorporated into proteoliposomes, are efficient polarization agents for DNP MAS ssNMR experiments. Our approach of using nitroxide labeled lipids as polarization agents for membrane protein DNP MAS ssNMR studies provides a general, non-perturbing means for sample preparation. In addition, we observed nearly 2.5 times the signal enhancement compared to standard DNP sample preparations utilizing nitroxide biradicals. The location of the nitroxides also mitigated the enhancement gradient typically observed with the use of water soluble nitroxide biradicals in heterogeneous systems.



(a) The 14.1 T / 600 MHz ^{1}H MAS DNP ssNMR system at the MagLab. At this field the electrons' precess at 395 GHz.





(b) A model of our sample preparation strategy; the nitroxide labeled lipids are in green with the radical distributed over the N-O bond shown in red and the membrane peptide KL_4 is shown in red. (c) Comparison of microwave-on versus microwave-off spectra. These are ^{13}C DNP CP MAS ssNMR spectra showing 8.9x signal enhancement of the membrane peptide KL_4.

Facilities: NMR & EMR Facilities at Florida State University
Instruments: 395 GHz gyrotron and 600 MHz (14.1 T) ssNMR system
Citation: Smith A.N., Caporini M.A., Fanucci G.E., Long J.R., ***Angew. Chem. Int. Ed.*****, 54**:1542 (2015)

CHAPTER 3 – USER FACILITIES

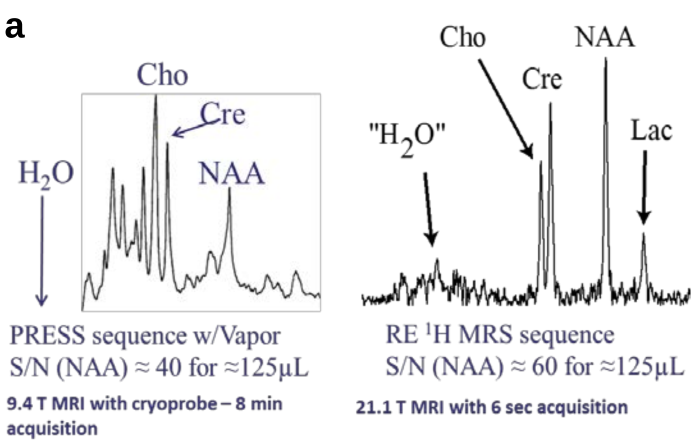
A Decade of Science on the Ultra-Wide-Bore 900 MHz NMR Spectrometer

Tim Cross, Bill Brey, Denis Markiewicz (National High Magnetic Field Laboratory, FSU)

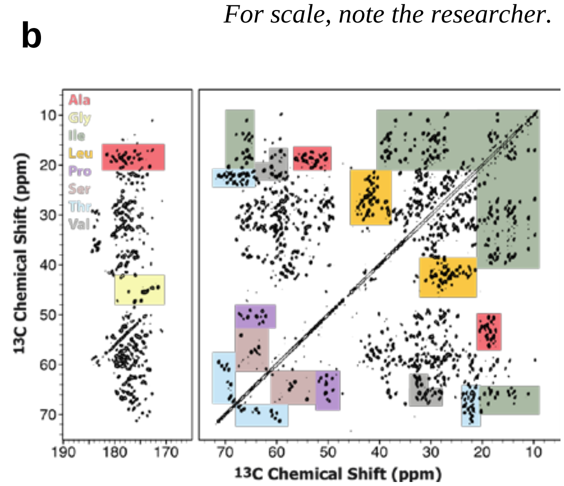
The MagLab's 900 MHz Ultra-Wide-Bore (UWB) NMR magnet was designed and built in-house as one of our flagship magnets. On the tenth anniversary of its debuting as a user facility in 2005, we review the origins of the magnet and discuss its considerable impact on advancing NMR and MRI research. A decade of user operations has resulted in 69 publications and the rate of publications is rapidly increasing, with 26 papers reporting on the work of 83 different users appearing since the beginning of 2014.

The unprecedentedly large bore (105 mm diameter) for a 21.1 T NMR-quality magnet has found great utility as a unique resource for solid state NMR and magnetic resonance imaging, illustrated by the three results noted here: (a) metabolomics research, demonstrating the suppression of the unwanted water signal that is achievable at ultra-high magnetic fields; (b) high-resolution 2D NMR spectroscopy at 21 T, yielding structural information on membrane proteins, including pharmaceutical targets on bacterial and viral membranes; and (c) MRI on nuclei other than hydrogen, including sodium mapping in healthy and cancerous brain tissue.

The 900 MHz UWB magnet. For scale, note the researcher.



Metabolic properties in vivo N. Shemesh et al. Nature Comm. 5: 4958 (2014).



Structural Plasticity in HIV-1 Capsid Protein Assemblies. Y. Han, et al. J. Am. Chem. Soc., 135:17793-17803 (2013).

Facility:
NMR User Program, Magnet Science & Technology

Citation:
A Decade of Experience with the Ultra-Wide-Bore 900 MHz NMR Magnet, Markiewicz, W.D.; Brey, W.W.; Cross, T.A.; Dixon, I.R.; Gorkov, P.L.; Grant, S.C.; Marks, E.L.; Painter, T.A.; Schepkin, V.D. and Swenson, C.A., IEEE Trans. Appl. Supercond., 25, 3, 1-6 (2015)

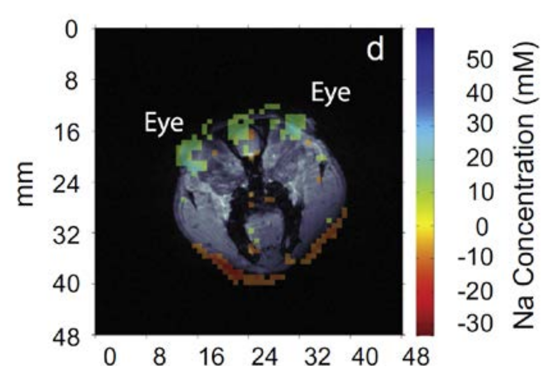


Figure right: *Sodium concentration mapping in the brain.* M.L. Truong, et al. J. Magn. Reson 247:88-95 (2014).

AMRIS

CHAPTER 3 – USER FACILITIES

AMIRS

ADVANCED MAGNETIC RESONANCE IMAGING AND SPECTROSCOPY (AMRIS)

Summary

The AMRIS facility at the University of Florida supports nuclear magnetic resonance (NMR) and magnetic resonance imaging (MRI) studies of chemical compounds, biomolecular systems, tissues, small animals, large animals, and humans. We currently offer nine systems with different magnetic fields and configurations to users for magnetic resonance experiments. AMRIS has ten professional staff members to assist users, maintain instrumentation, build new coils and probes, and help with administration.

1. Unique Aspects of Instrument Capability

Several of the AMRIS instruments offer users unique capabilities: the 750 MHz wide bore provides outstanding high-field microimaging for excised tissues and small animals; the 11.1 T horizontal MRI is the largest field strength magnet in the world with a 400 mm bore; the 600 MHz 1.5-mm HTS cryoprobe is the most mass-sensitive NMR probes in the world for ^{13}C detection and is ideal for natural products research; the 5T DNP polarizer enables both fundamental studies of DNP mechanisms as well as *in vivo* metabolism measurements when coupled to either the 4.7 or 11.1 T systems. These systems support a broad range of users from natural product identification to solid-state membrane protein structure determination to cardiac studies in animals and humans to tracking stem cells and gene therapy in vivo to functional MRI in humans.

2. Facility Developments and Enhancements

With funding from the NHMFL, in 2015 we were able to accomplish three important goals within the AMRIS facility: 1) enhance solid state NMR capabilities on the 750 MHz NMR instrument with the installation of a triple resonance MAS low-E probe constructed by the NHMFL RF group; 2) offer ^{13}C coils for the 4.7 and 11.1 T MRI/S systems to support *in vivo* studies of metabolism enabled by dissolution dynamic nuclear polarization (dDNP) capabilities; and 3) upgrade our 11.1 T MRI/S system with a cantilever support system installed in the fall and the purchase of a new RF console and RF coils (installation in July 2016).

3. Major Research Activities and Discoveries

This year we saw continued growth in three new user areas developed during this funding cycle. The first area is in fundamental DNP studies and their application to *in vivo* metabolic studies. We also saw growth in the area of metabolomics through support of the NIH-funded SECIM grant which provides comprehensive and complementary resources for clinical and basic science metabolomics studies and has enabled us to expand our user program. A third area of growth was in the use of *in vivo* MRI and MRS to study rodent models up to 17.6 T. In September 2015, Matt Merritt joined the faculty of UF and will be leading development of the DNP program for *in vivo* applications as well as further development of HTS cryoprobes for ultrasensitive ^{2}H and ^{13}C isotopomer analyses of metabolic flux. AMRIS facility users reported 40 peer-reviewed publications and 11 theses and dissertations for 2015.

4. Facility Plans and Directions

In spite of the continued challenging budgetary climate, our users have consistently successfully pursued federal funding to support their research programs and assisted the AMRIS facility in writing proposals to upgrade instrumentation. The successful partnership of the NHMFL user program with individual investigator research grants also provides constant scientific motivation for our technology development. We are looking forward to the upgrade of the 11.1 T RF console and coils in July 2016. We are also pursuing funding to develop a user program for biological EMR within AMRIS.

5. Outreach to Generate New Proposals - Progress on STEM and Building User Community

The NHMFL created a new position at the University of Florida in 2015 to help coordinate outreach at the High B/T and AMRIS Facilities. In the

CHAPTER 3 – USER FACILITIES

fall of 2015, Elizabeth Webb, the new NHMFL Outreach/Facilities Coordinator at UF, started a K-12 classroom program in Gainesville, akin to the NHMFL classroom program in Tallahassee. AMRIS postdocs and graduate students assist with these hands-on lessons, teaching students about the NHMFL, uses of magnets, and basic magnet science. In 2015, six classrooms were visited. Additionally, faculty associated with the AMRIS Facility mentored 5 NHMFL REU students over the summer and gave periodic tours of the AMRIS Facility.

The 8-10 core faculty associated with the AMRIS facility are all active in recruiting and training undergraduate researchers as well as high school summer students. We consistently have ~20 of these participants working on projects at any given time.

The NHMFL has been working with the NMR and MRI communities to develop a funding initiative to integrate new high temperature superconducting (HTS) materials into MRI and NMR magnets, enabling a significant increase in achievable persistent magnetic fields for these technologies. A workshop on ultrahigh field NMR and MRI was held in Washington, DC, in November 2015 and attended by representatives of the NMR and MRI communities as well as program officers from NIH, NSF, and DOE. The Director of AMRIS, Joanna Long, co-moderated a panel discussion on NMR and MRI user facilities and the deployment of new HTS magnets into these facilities.

6. Facility Operations Schedule

The AMRIS facility operates year round, except for during the last week of December when the University of Florida is shut down. Vertical instruments for ex vivo samples are scheduled 24/7, including holidays and weekends. Horizontals operate primarily 8 hr/day, 5 days/week due to the difficulty in running animal or human studies overnight. The AMRIS facility operates as an auxiliary under federal cost accounting standards. Local and NHMFL-affiliated users pay for magnet time from federally funded projects (primarily individual investigator grants); the NHMFL funds magnet time for users from outside the UF system and development projects.

NMR & MRI SYSTEMS IN THE AMRIS FACILITY AT UF IN GAINESVILLE

^{1}H Frequency	Field (T), Bore (mm)	Homogeneity	Measurements
750 MHz	17.6, 89	1 ppb	Solution/solid state NMR and MRI
600 MHz	14.1, 52	1 ppb	NMR and microimaging
600 MHz	14.1, 52	1 ppb	Solution NMR (cryoprobe)
600 MHz	14.1, 54	1 ppb	Solution NMR (HTS cryoprobe)
500 MHz	11.7, 52	1 ppb	Solution/solid state NMR
470 MHz	11.1, 400	0.1 ppm	DNP, MRI and NMR of animals
212 MHz	5.0, 89	1 ppm	DNP polarization
200 MHz	4.7, 330	0.1 ppm	DNP, MRI and NMR of animals
130 MHz	3.0, 900	0.1 ppm	MRI/S of humans, large animals

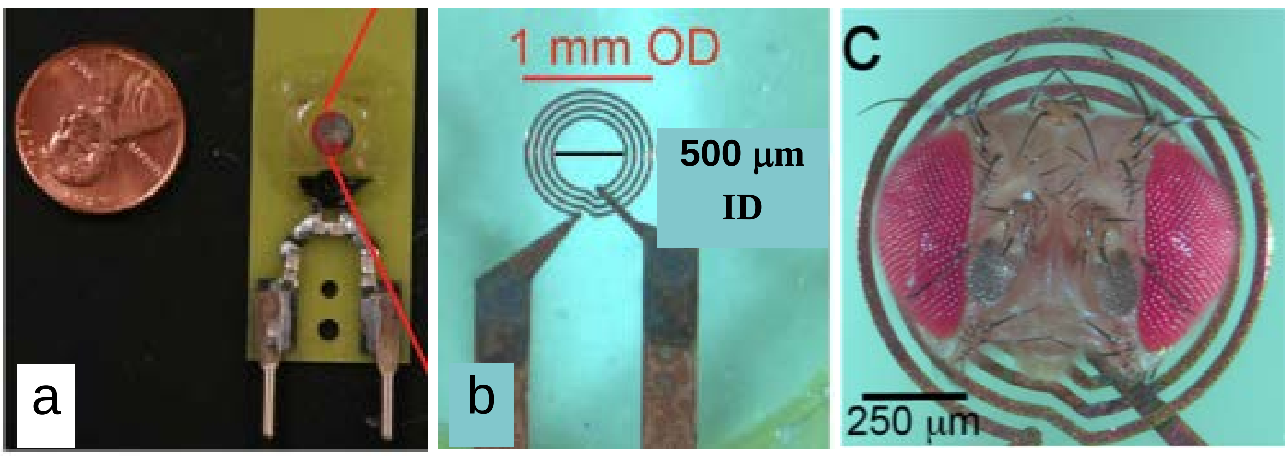
CHAPTER 3 – USER FACILITIES

Magnetic Resonance Imaging of an intact fruit fly brain at 10 micron resolution

Choong H. Lee[1], Stephen J. Blackband[1,2] and Pedro Fernandez-Funez[1] (1. University of Florida; 2. National High Magnetic Field Laboratory)

Understanding the complex architecture, connectivity, and pathology of the brain is a major application of magnetic resonance imaging (MRI). Despite its wide array of applications, however, MRI is still unable to provide resolution of entire organs at the cellular level. *Here we describe research that created the highest 3D resolution of an intact animal head reported to date.*

We used state-of-the-art hardware including powerful planar gradients, size-optimized planar microcoils, and the 600 MHz (14.1 T) magnet at the MagLab's UF AMRIS facility to image brain architecture in a <1 mm diameter fruit fly head. Three-dimensional (3D) fast low angle shot imaging (FLASH) produced strong signal in most internal tissues, particularly in the cortex. However, only 3D diffusion weighted imaging (DWI) was able to reveal the modular organization of the fly brain, delivering hyperintense signal in the synaptic domains.



The Magnetic Resonance Microscopy (MRM) hardware is shown at left: (a) Detail of the RF microcoil. Red lines indicate the position of the sample well. (b) Magnification of the sample well with the planar 500 µm diameter microcoil. (c) Drosophila Melanogaster head on the RF microcoil, prepared for imaging at 10 micron isotropic resolution (10 mm x 10 mm x 10 mm voxels), which gives nearly cellular resolution.

The resulting MRM-based 3D map of the Drosophila brain architecture: (d) Frontal view of the brain neuropil and the eyes. The antennal lobes (yellow) are the anterior most neuropil of the fly brain. (e) Posterior view of the brain neuropil. The domains of the eye and optic lobes are clearly delineated: retina (purple), lamina (cyan), medulla (orange), lobula plate (green), and lobula (blue).

Facilities: MagLab/AMRIS & 600 MHz (14.1 T) vertical-bore magnet at the University of Florida

Citation: Visualization of synaptic domains in the Drosophila brain by magnetic resonance microscopy at 10 micron isotropic resolution. Choong HL, Blackband SJ and Fernandez-Funez P. ***Scientific Reports*** **5**, 8920 (2015); DOI:10.1038/srep08920

CHAPTER 3 – USER FACILITIES

Single-File Diffusion of Mixed and Pure Gases by High Field NMR

Akshita R. Dutta, Poorvajan Sekar, Muslim Dvoyashkin, Clifford R. Bowers, Kirk J. Ziegler, and Sergey Vasenkov
(University of Florida)

Molecules restricted to diffuse through unidimensional channels – channels so narrow that molecules cannot pass each other – may exhibit single-file diffusion (SFD). Here we report the first experimental evidence of SFD in a mixture of different types of diffusing species (**Fig 1**).

^{13}C NMR diffusometry using high magnetic field (17.6 T) NMR and ultra-high magnetic field gradients (up to 30 T/m) revealed single-file diffusion in dipeptide nanochannels for one-component CO and CH_4 gasses as well as for a gaseous mixture of CO and CH_4.

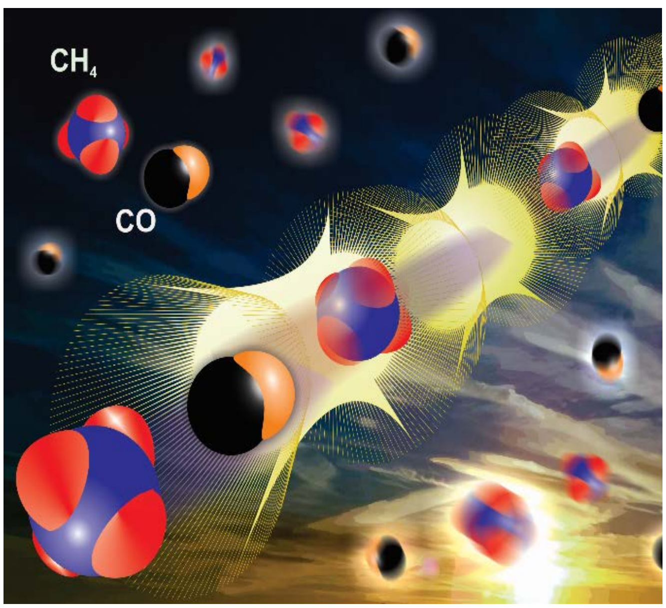


Figure 1: *Schematic presentation of SFD in a nanotube.*

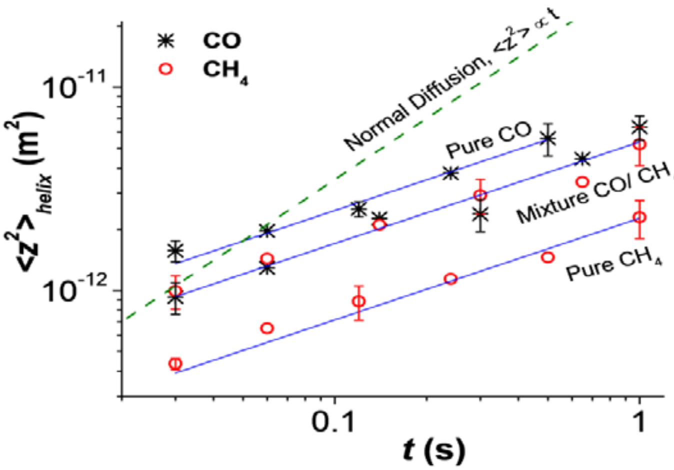


Figure 2: *Measured time dependence of the MSD at 298 K.*

While CO and CH_4 individually have different SFD mobilities, we demonstrate that both species start exhibiting the same SFD mobility when mixed (**Fig. 2**). *In contrast to the relationship commonly observed for normal diffusion of mixed gasses, the mobility of the mixed gas in the unidimensional channel is only slightly smaller than that of pure CO, and much faster than pure CH_4.*

Recent theoretical and computational studies suggest that induction of single-file conditions in nanoporous membranes and catalysts can lead to a dramatic enhancement of the performance of these systems in separations and catalysis. *Our work utilizes high magnetic fields to pioneer experimental studies of this performance enhancement.*

Facilities: AMRIS (17.6 T NMR spectrometer), University of Florida

Citation: Dutta, A.; Sekar, P.; Dvoyashkin, M.; Bowers, C.; Ziegler, K. J.; Vasenkov, S., Relationship between Single-File Diffusion of Mixed and Pure Gases in Dipeptide Nanochannels by High Field Diffusion NMR. *Chemical Communications*, **51**, 13346-13349 (2015).

EMR

CHAPTER 3 – USER FACILITIES

EMR

EMR FACILITY

Summary

Electron Magnetic Resonance (EMR) covers a variety of magnetic resonance techniques associated with the electron. The most widely employed is Electron Paramagnetic/Spin Resonance (EPR/ESR), which can be performed on anything that contains unpaired electron spins. EPR/ESR has thus proven to be an indispensable tool in a large range of applications in physics, materials science, chemistry and biology, including studies of impurity states, molecular clusters, molecular magnets; antiferromagnetic/ferromagnetic compounds in bulk as well as thin films and nanoparticles; natural or induced radicals, optically excited paramagnetic states, electron spin-based quantum information devices; transition-metal based catalysts; and for structural and dynamical studies of metalloproteins, spin-labeled proteins and other complex bio-molecules and their synthetic models.

1. Unique Aspects of the Instrumentation

The EMR facility at the NHMFL offers users several home built high-field and multi-high-frequency instruments covering the continuous frequency range from 9 GHz to ~1 THz, with additional frequencies up to 2.5 THz using a molecular gas laser. Several transmission probes are available for continuous-wave (c.w.) measurements, which are compatible with a range of magnets at the lab, including the highest field 45 T hybrid. Some of the probes can be configured with resonant cavities, providing enhanced sensitivity as well as options for in-situ rotation of single-crystal samples in the magnetic field, and the simultaneous application of pressure (up to ~3 GPa). Quasi-optical (QO) reflection spectrometers are also available in combination with high-resolution 12 and 17 T superconducting magnet systems; a simple QO spectrometer has also been developed for use in the resistive and hybrid magnets (up to 45 T). EMR staff members can assist users in the DC field facility using broadband tunable homodyne and heterodyne spectrometers as well.

In addition to c.w. capabilities, the NHMFL EMR group boasts the highest frequency pulsed EPR spectrometer in the world, operating at 120, 240 and 336 GHz with <100 ns time resolution. A new quasi-optical 94 GHz spectrometer (HiPER) with 1 ns time resolution was upgraded for high power (1 kW) operation in 2015, becoming available to users at the end of the year. A commercial Bruker Elexsys 680 operating at 9/95 GHz (X-/W-band) is also available upon request. This unique combination of c.w. and pulsed instruments may be used for a large range of applications in addition to EPR, including the study of optical conductivity and electron cyclotron resonance.

2. Facility Developments and Enhancements

The first results using HiPER were generated in 2015, with the first publication appearing early in 2016. HiPER is a 94 GHz quasioptical pulsed EPR spectrometer, offering exceptional sensitivity and low deadtime. The spectrometer was developed at St. Andrews University and delivered to the MagLab in 2014. It is the only instrument of its kind that is part of a user program. Initial operation was limited to a low power mode (< 200 mW) with applications primarily involving c.w. EPR. In 2015, HiPER was upgraded to a high power mode through integration of a state-of-the-art Extended Interaction Klystron amplifier, enabling pulses with 1 kW instantaneous power and up to 1 GHz bandwidth. This capability makes possible $\pi/2$ pulses for spin $S = ½$ of just a few ns (shorter for larger spin values). HiPER features exceptional cross-polar isolation, enabling induction-mode detection while excitation pulses are incident on the sample. Thus, HiPER offers true nanosecond deadtime and the possibility to perform fourier-transform-type HFEPR measurements, akin to what is routinely achieved in NMR. Phase and frequency can be controlled on nanosecond timescales, permitting highly complex spin manipulations (with sequences of up to 16 pulses of arbitrary phase) and repetition rates of up to 80 kHz. HiPER represents the centerpiece of the EMR program's growth into biophysical/biochemical EPR applications, whilst also bringing important new capabilities for users interested in spin quantum computing.

As part of the growth of the biological user program, a HiPER postdoc, Johannes McKay (PhD 2015, St. Andrews University, Scotland), joined the group in 2015.

The Dynamic Nuclear Polarization (DNP) effort at the Maglab was also greatly expanded in 2015,

CHAPTER 3 – USER FACILITIES

with the addition of a new 14.1 T (600 MHz) sweepable magnet and state-of-the-art magic angle spinning (MAS) NMR spectrometer. This new instrument, coupled with the existing gyrotron source, is now part of the user program (see NMR section of this report). The existing 395 GHz quasi-optical beam transport and control system has been modified to run experiments in the new magnet. Its field-sweeping capability and high homogeneity allow for polarization of a wide range of radicals and, therefore, dramatically extended types of samples that can benefit from the large DNP NMR signal enhancement. An article has already been submitted to the Journal of Physical Chemistry by an external user, while other new users are lining up to gain access to this instrument, which is the only 600 MHz MAS DNP system in the world that is available to qualified users free of charge.

Finally, a new 15/17 T homodyne/transmission spectrometer came online in 2015 in order to alleviate some of the oversubscription on the existing instrument. The new system leverages an older 15/17 T superconducting magnet that was under utilized, together with a series of older Gunn diode sources and harmonic multipliers that had been replaced by multiplier chains. The new spectrometer enables measurements in the following frequency bands: 70-102 GHz, 180-204 GHz, and 270-306 GHz. It also offers comparable sensitivity to the existing workhorse system, thereby providing a very credible alternative/backup. In addition, the existing 15/17 homodyne spectrometer received a new magnet power supply during 2015 to prevent fairly frequent quenches that were starting to impact user operations.

3. Research Productivity and Achievements

In 2015 a large number of research groups and projects were accommodated by the EMR group, resulting in the submission of 49 research reports. In addition, 38 peer-reviewed journal articles were reported by our users, as well as numerous presentations at conferences. Many publications appeared in high-impact journals including: Journal of the American Chemical Society (4); Chemical Science (2); Chem. Comm. (2); Inorganic Chemistry (8); Dalton Transactions in Chemistry (3); Physical Review B (1). In addition, two major collaborative review articles were published in 2015, involving EMR scientists and their users. Projects spanned a range of disciplines from applied materials research to studies of proteins; see also highlights below.

4. Facility Plans and Directions

The EMR program has several plans for new capabilities in 2016, as well as solutions to oversubscription issues on some of its existing instruments. The group will also welcome another new postdoctoral researcher to bolster its biophysical/ biochemical research program.

The DNP program will see major development in the form of an *in situ* 395 GHz EPR spectrometer. An extension of the existing quasi-optical set-up will be installed on the MAS DNP instrument such that the EPR spectrometer can be inserted into the microwave system. This will allow current users of the MAS DNP instrument to obtain an EPR spectrum of their as-prepared samples. This information is extremely important in order to best prepare samples optimized for DNP. The 395 GHz EPR spectrometer will also be easily transportable, so that it can be used elsewhere within the MagLab user programs. In particular, it will be employed extensively in the 600 MHz Overhauser DNP system, but may also be used within the DC facility, as well as enabling pulsed EPR in the 12 T heterodyne spectrometer.

Finally, HiPER is continually undergoing upgrades, including integration of an NMR capability for development of Electron-Nuclear Double Resonance (ENDOR) and pulsed DNP.

5. Outreach to Generate New Proposals, Progress on STEM & Building a User Community

The EMR user program continues to grow, as measured by the total number of 71 proposals on file, which is up from just 42 as recently as 2012, and ~65 in 2013/14. During 2015, we received 16 proposals from first time users, meaning that 23% of our users were new to the program. This growth may be attributed to several new experimental capabilities that came online in 2014/15, including the 8 T Mössbauer spectrometer and HiPER. In addition, several new postdocs have joined the group, which has helped in providing the required increase in user support. The EMR program assisted 157 individual researchers in 2015 (again up from 143 in 2014), of

CHAPTER 3 – USER FACILITIES

which about a quarter of those reporting were either female (16%) or minority (7%). In an effort to attract new users, the EMR group continues to provide up to $500 of financial support to first time visitors to the lab ($1,000 for overseas users). The EMR group has also made tremendous progress in terms of the diversity of its own students and staff: 41% are female and 14% minority.

Members of the EMR group continue to make aggressive efforts to advertise the facility at international workshops and conferences. These efforts included attending and presenting at conferences outside of their own immediate research areas. The group also organized or participated in focused sessions/symposia at major conferences (e.g. APS and ACS) and provided financial support in the form of student travel grants for the two main EPR conferences in the US in 2015, as well as a European EPR Summer School. In 2016, the EMR Director will Chair a Gordon Research Conference that will be attended by many users of the facility. Finally, the EMR group has participated in several outreach activities, including the mentorship of REU students and local high-school interns.

6. Facility Operations Schedule

The most heavily used instrument in the program is the 17 T homodyne transmission spectrometer. This instrument has reached a point where it is significantly over-subscribed; at the time of writing, it is fully booked for the foreseeable future, with users running 7 days per week, 24 hours per day. The spectrometer was available for all of 2015, with the exception of 20 days due to a minor repair and installation of a new magnet power supply. The usage (including maintenance) during 2015 was 338 days, implying that it was in use on EVERY SINGLE weekday, as well as on >90 weekend days and/or holidays.

The 12 T heterodyne/pulsed instrument was also available for most of 2015. Just one day was dedicated to repairs, maintenance and installation of new hardware. This spectrometer is not straightforward to use, requiring constant oversight by the EMR staff member (van Tol) responsible for the instrument. Consequently, users are not usually scheduled when this staff member is traveling. 214 days of usage were reported in 2015, constituting ~85% of the available working days (not including weekends and holidays).

The two Mössbauer instruments were available throughout the year, with the exception of 46 days required for maintenance and repairs. When available, the high-field instrument was used practically constantly day and night due to the nature of the Mössbauer experiment. 390 total days were logged on the two instruments during 2015.

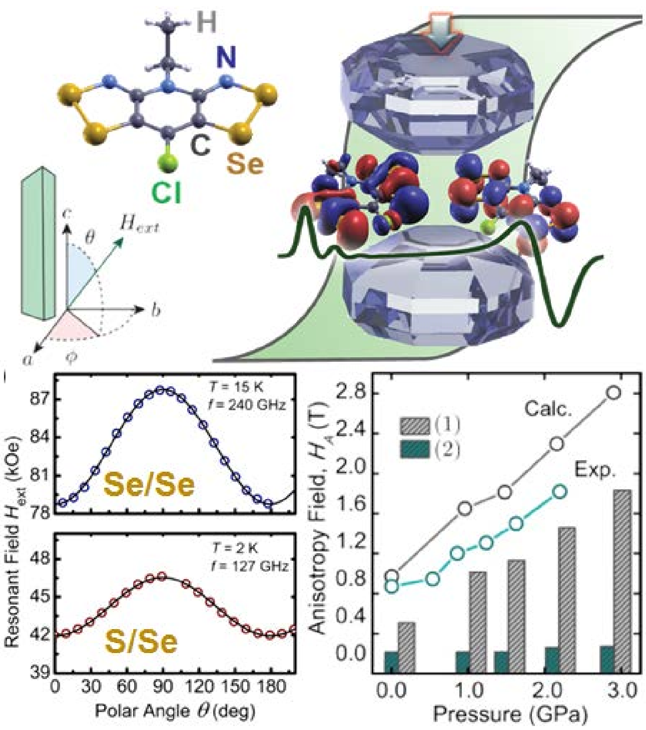
The Bruker spectrometer was also over-subscribed in 2015, with total usage of 267 days. The instrument is shared between the FSU biology department and the EMR user program. Only 30% of the machine time was originally designated for the MagLab user program. In 2015, due to high demand from users, 73% of its usage (including holidays and weekends) was allocated for user operations.

CHAPTER 3 – USER FACILITIES

EMR

Controlled Under Pressure: Exchange Anisotropy in Organic Magnets

S. M. Winter[1], K. Thirunavukkuarasu[2], C. C. Beedle[2], A. E. Kovalev[2], S. Hill[2,3] and R. T. Oakley[1] (1. University of Waterloo; 2. National High Magnetic Field Laboratory; 3. Florida State University)



Facilities: EMR
Instrument/Magnet: Broadband MVNA
Citation: *Pressure dependence of the exchange anisotropy in an organic ferromagnet*, K. Thirunavukkuarasu, S.M. Winter, C.C. Beedle, A. E. Kovalev, R.T. Oakley and S. Hill, Phys. Rev. B 91, 014412 (2015); also *Magnetic Ordering and Anisotropy in Heavy Atom Radicals,* S.M. Winter, S. Hill and R.T. Oakley, Perspective Article in J. Am. Chem. Soc. (2015); DOI 10.1021/jacs.5b00672.

In a 1928 treatise on ferromagnetism, Werner Heisenberg concluded that the presence of atoms with principal quantum number (PQN) >3 was a fundamental requirement for magnetic order. The discovery of ferromagnetism in "light atom" organic radicals (PQN=2) appeared to violate this axiom, prompting parallels with the comment of Dr. Johnson on seeing a dog walk on its hind legs: *"it is not done well, but you are surprised to find it done at all"*.

Unfortunately, the ordering temperatures and coercivities (ability to withstand external demagnetizing influences) of these light atom materials are low. *However, recent synthetic efforts have afforded "heavy atom" organic radicals, spin-½ molecular species containing heavy elements (S, Se, PQN = 3, 4), which display magnetic properties once considered exclusive to conventional metal-based magnets*. In essence, Heisenberg was right: spin density on the heavy atoms (see figure) promotes increased isotropic and anisotropic exchange coupling between spins, mediated by spin-orbit interactions. These factors give rise to respectable ferromagnetic ordering temperatures and coercivities.

MagLab users have employed a combination of ab-initio theory and a newly developed high-pressure, high-field ferromagnetic resonance technique, which is uniquely sensitive to anisotropic magnetic interactions. *This research elucidates the importance of spin-orbit coupling effects in a range of organic materials, where spin-orbit effects are usually considered to be small. The findings may impact topics as diverse as spintronics and topological spin phases.*

EMR

CHAPTER 3 – USER FACILITIES

EMR

Tweaking Molecular Structure to Tune Chemical Reactivity

Blake R. Reed,[1] Sebastian A. Stoian,[2] Richard L. Lord,[3] Stanislav Groysman[1] (1. Wayne State University; 2. National High Magnetic Field Laboratory; 3. Grand Valley State University)

Metal-containing molecules are usually comprised of a metal ion that is bound to organic ligands. Ligands that can easily tune the numbers of electrons stored in their chemical bonds are known as **redox-active**. Some redox-active ligands have been shown to induce a dramatic enhancement in the chemical reactivity of the bound metal ion. *As a result, redox-active ligands have the potential to create molecules that function as new catalysts capable of enabling exquisite control of challenging chemical reactions of tremendous technological importance.*

Recently, a team of researchers have shed light on a surprising electronic structure change due to a minor variation of a redox-active ligand: nickel complexes supported by bis(*imino*)pyridine ligands revealed that replacement of CH_3 side-groups with H atoms induces a dramatic transformation of a typical Ni(II)-ion with a square planar geometry to an unusual non-planar Ni(I) site. In other words, *a minor change in the periphery of the ligand led to the intramolecular transfer of one unpaired electron from the ligand to the metal, concomitant with the conversion of a diamagnetic Ni(II) to a paramagnetic Ni(I) site with a S = 1/2 spin state*. In effect, the H atom "reels in" an electron from the ligand to the nickel ion. (**Fig. 1**), resulting in a dramatic change in the reactivity of this compound.

These conclusions result from high-magnetic-field electron paramagnetic resonance (EPR) experiments at the ultra-high microwave frequency of 406.4 GHz. (**Fig. 2**)

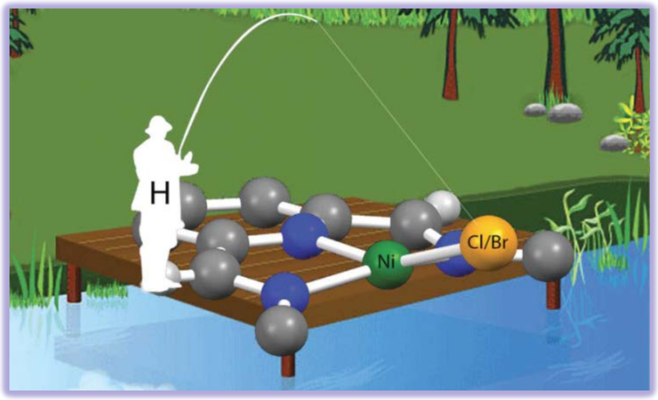


***Figure 1:** Structural change induced by the replacement of CH_3 side-groups with H atoms. This modification also leads to the intramolecular transfer of an unpaired electron from the ligand to the metal ion.*

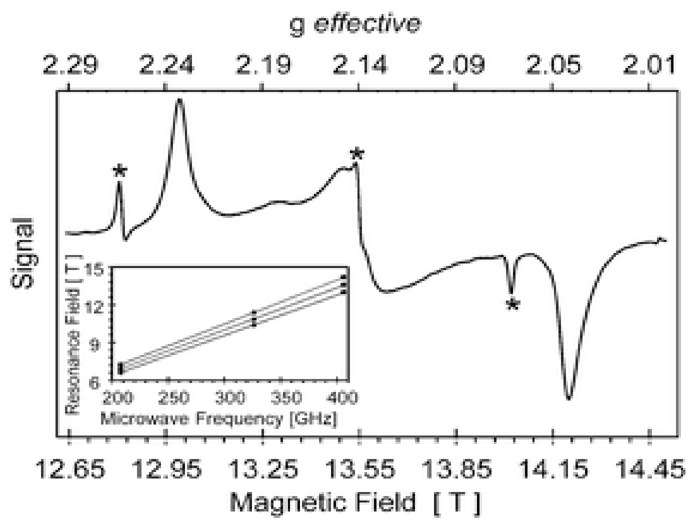


***Figure 2:** High-field EPR spectrum recorded at 406.4 GHz*

Facilities: EMR
Instrument/Magnet: 17 T Electron Paramagnetic Resonance Magnet and Spectrometer
Citation: *The aldimine effect in bis(imino)pyridine complexes: non-planar nickel(I) complexes of a bis(aldimino)pyridine ligand,* Blake R. Reed, Sebastian A. Stoian, Richard L. Lord, Stanislav Groysman. *Chem. Commun.* 51, 6496-6499 (2015).

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ICR FACILITY

Summary

During 2015, the Fourier Transform Ion Cyclotron Resonance (ICR) Mass Spectrometry program continued instrument and technique development as well as pursuing novel applications of FT-ICR mass spectrometry. These methods are made available to external users through the NSF National High-Field FT-ICR Mass Spectrometry Facility. The facility features seven staff scientists who support instrumentation, software, biological, petrochemical, and environmental applications, as well as a machinist, technician, and several rotating postdocs who are available to collaborate and/or assist with projects.

1. Unique Aspects of Instrumentation Capability

The Ion Cyclotron Resonance facility provides operations for sample analysis that requires the ultra-high resolution ($m/\Delta m_{50\%}$ > 1,000,000 at *m/z* 500, where $\Delta m_{50\%}$ is the full mass spectral peak width at half-maximum peak height) and sub-ppm mass accuracy only achievable by FT-ICR MS coupled to high magnetic fields (*Int. J. Mass Spectrom.*, **377**, 410-420 (2015)). Research areas included biomolecular analysis (e.g., top-down proteomics, hydrogen-deuterium exchange), and environmental and petrochemical mixture analysis. The facility's four FT-ICR mass spectrometers feature high magnetic fields < 21 tesla, and are compatible with multiple ionization and fragmentation techniques.

ICR Systems at the Magnet Lab in Tallahassee		
Field (T), Bore (mm)	**Homogeneity**	**Ionization Techniques**
21, 123	< 1 ppm	ESI, AP/LIAD-CI, APCI, DART
14.5, 104	1 ppm	ESI, AP/LIAD-CI, APCI, DART
9.4, 220	1 ppm	ESI, AP/LIAD-CI, APCI, APPI FT-ICR, DART, DAPPI
9.4, 155	1 ppm	FD, LD FT-ICR

2. Facility Developments and Enhancements

In 2015, the ICR facility revealed describe the design and initial performance of the **first actively-shielded 21 tesla Fourier transform ion cyclotron resonance mass spectrometer**. The 21 tesla magnet is the highest field superconducting magnet ever used for FT-ICR and features high spatial homogeneity, high temporal stability, and negligible liquid helium consumption (*J. Am. Soc. Mass Spectrom.*, **26**, 1626-1632 (2015)). Mass resolving power of 150,000 ($m/\Delta m50\%$) is achieved for bovine serum albumin (66 kDa) for a 0.38 second detection period (**see Figure 1**), and greater than 2,000,000 resolving power is achieved for a 12 second detection period. Externally calibrated broadband mass measurement accuracy is typically less than 150 ppb rms, with resolving power greater than 300,000 at m/z 400 for a 0.76 second detection period. Combined analysis of electron transfer and collisional dissociation spectra results in 68% sequence coverage for carbonic anhydrase. The instrument is part of the NSF High-Field FT-ICR User Facility and is available free of charge to qualified users.

Figure 1 shows a single-scan electrospray FT-ICR mass spectrum of the isolated 48+ charge state of bovine serum albumin following a 0.38 s detection period. Mass resolving power is approximately 150,000, and the signal-to-noise ratio for the highest magnitude peak is greater than 150:1. The ion accumulation period was 250 ms and the ion number target was 5,000,000.

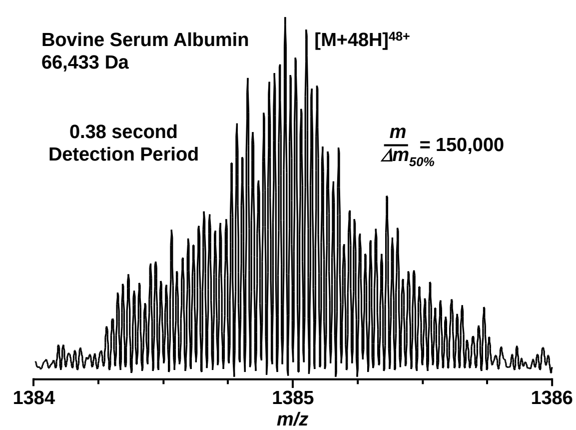

Figure 1 *shows a single-scan electrospray FT-ICR mass spectrum of the isolated 48+ charge state of bovine serum albumin following a 0.38 s detection period.*

ICR

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ICR

The instrument includes a commercial dual linear quadrupole trap front end that features high sensitivity, precise control of trapped ion number, and collisional and electron transfer dissociation. A third linear quadrupole trap offers high ion capacity and ejection efficiency, and rf quadrupole ion injection optics deliver ions to a novel dynamically harmonized ICR cell.

An **actively-shielded 14.5 T**, 104 mm bore system offers the highest mass measurement accuracy (<300 parts-per-billion rms error) and highest combination of scan rate and mass resolving power available in the world (*Protein Sci*., **19**, 703-715 (2010)). The spectrometer features electrospray, atmospheric pressure photoionization (APPI), atmospheric pressure chemical ionization sources (APCI), ; linear quadrupole trap for external ion storage, mass selection, and collisional dissociation (CAD); and automatic gain control (AGC) for accurate and precise control of charge delivered to the ICR cell. The combination of AGC and high magnetic field make sub-ppm mass accuracy routine without the need for an internal calibrant. Mass resolving power > 200,000 at m/z 400 is achieved at one scan per second, which is ideal for *de novo* sequencing (*Rapid Commun. Mass Spectrom.* **29**, 659-666 (2015)) and facilitates automated data reduction for H/D exchange experiments (*J. Mass Spectrom.*, **50**, 812-819 (2015)). Robotic sample handling allows unattended or remote operation. An additional pumping stage has been added to improve resolution of small molecules.

The **9.4 T, passively-shielded**, 220 mm bore system offers a unique combination of mass resolving power ($m/\Delta m$ = 8,000,000 at mass 9,000 Da) and dynamic range (>10,000:1), as well as high mass range, mass accuracy, dual-electrospray source for accurate internal mass calibration, efficient tandem mass spectrometry (as high as MS^8), and long ion storage period (*J. Am. Soc. Mass Spectrom.*, **25**, 943-949 (2014)). A redesign to the custom-built mass spectrometer coupled to the 9.4T, 200 mm bore superconducting magnet designed around custom vacuum chambers has improved ion optical alignment, minimized distance from the external ion trap to magnetic field center and facilitates high conductance for effective differential pumping. (*J. Am. Soc. Mass Spectrom*. **22**, 1343-1351, (2011)).

The length of the transfer optics is 30% shorter than the prior system, for reduced time-of-flight mass discrimination and increased ion transmission and trapping efficiency at the ICR cell. The ICR cell, electrical vacuum feed through, and cabling have been improved to reduce the detection circuit capacitance (and improve detection sensitivity) 2-fold (*Anal. Chem.* **87**, 4072-4075 (2015)). When applied to compositionally complex organic mixtures such as dissolved organic matter (*Environ. Sci. Technol.*, **49**, 14239-14248 (2015)) and petroleum fractions (*Energy Fuels.*, **29**, 7150-7155 (2015), (*Int. J. Mass Spectrom.* **378**, 186-192 (2015), (*Energy Fuels*, **29**, 2342-2350 (2015)), mass spectrometer performance improves significantly, because those mixtures are replete with mass "splits" that are readily separated and identified by FT-ICR MS (*Energy Fuels*, **29**, 641-648 (2015)). The magnet is passively shielded to allow proper function of all equipment and safety for users. The system features external mass selection prior to ion injection for further increase in dynamic range and rapid (~100 ms time scale) MS/MS. Available dissociation techniques include collision-induced (CID), infrared multiphoton-induced (IRMPD) (*J. Am. Soc. Mass Spectrom.*, **23**, 644-654 (2012)), and electron capture-induced (ECD) (*J. Phys. Chem. A.*, **117**, 1189-1196 (2013).

A new mass spectrometric based approach applied to demonstrate that **ion-neutral collision cross sections and high-resolution mass spectra of biomolecule ions** obtained simultaneously by Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) to understand biomolecule function. Collision cross-sections were calculated from an exponential fit of the transient time-domain ICR signal, based on a high kinetic energy ion-neutral collision model on the NHMFL 9.4 T passively shielded FT-ICR mass spectrometer (*Phys. Chem. Phys.*, **17**, 9060-9067 (2015), (*Anal. Chem.* **87**, 4072-4075 (2015)).

The **9.4 T actively shielded** FT-ICR instrument is available for analysis of complex nonpolar mixtures and instrumentation development. The 9.4 T magnet is currently used for field desorption (*Mol. Phys.*, **113**, 2359-2361 (2015)) and elemental cluster analysis, and reported the formation of the smallest fullerene by stabilization through cage encapsulation of a metal by use of a pulsed laser vaporization cluster source (*J. Am. Chem. Soc.*, **134**, 9380-9389 (2012), which reported bottom-up formation of metallofullerenes for the first time (*Nat. Commun.*, **5 (5844)**, 1-8 (2014)).

3. Major Research Activities and Discoveries

Automated broadband phase correction of FT-ICR data can in principle produce and absorption-

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mode spectrum with mass resolving power as much as a factor of 2 higher than conventional magnitude-mode display, an improvement otherwise requiring a more expensive increase in magnetic field strength.

We have developed and implemented a robust and rapid automated method to enable accurate broadband phase correction for all peaks in the mass spectrum and present experimental FT-ICR absorption-mode mass spectra with increased number of resolved peaks and higher mass accuracy relative to magnitude mode spectra, and produce more complete and more reliable elemental composition assignments for nickel and vanadyl porphyrins in natural petroleum seeps (**Figure 2,** *Energy Fuels*., **28**, 2454-2462 (2014)).

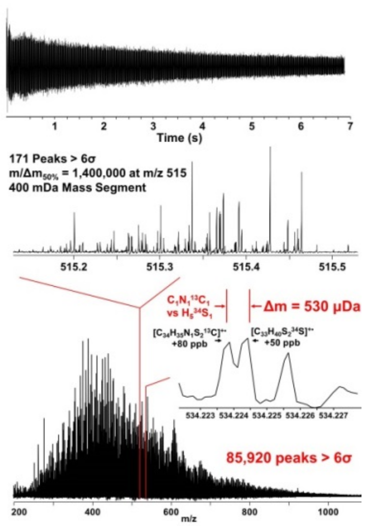

Figure 2: *Broadband positive-ion APPI FT-ICR mass spectrum for an Il Duomo asphalt volcano sample. The achieved resolving power* $m/\Delta m_{50\%}$ = *1,400,000 at m/z 515 enables resolution of 85,920 mass spectral peaks, each with magnitude greater than 6σ of baseline rms noise (m/z 200-1100) with a mass distribution centered at m/z 400. The mass scale-expanded segment at m/z 515 shows ~171 peaks. The theoretical resolving power required to separate two equally abundant species that differ in mass by ~548 μDa at 9.4 tesla is 890,000. The presently achieved resolving power (*$m/\Delta m_{50\%}$ = *1,400,000 at m/z 515) enables separation of species that differ in mass by* $C_1N_1{}^{13}C_1$ *versus* $H_5{}^{34}S_1$*, both of nominal mass 39 Da, and differing in mass by 530 μDa—i.e., less than the mass of an electron (548 μDa).*

To the best of our knowledge, this mass spectrum represents the most peaks resolved and identified in a single spectrum of any kind, and represents the highest broadband resolving power for any petroleum mass spectrum, and emphasizes the need for ultra-high resolving power achievable only by FT-ICR MS sufficient to separate isobaric overlaps prevalent in complex seep samples.

Enhancements to the ion source and transfer optics of our 9.4 T Fourier transform ion cyclotron resonance (ICR) mass spectrometer have resulted in improved ion transmission efficiency for more sensitive mass measurement of complex mixtures at the MS and MS/MS levels. The tube lens/skimmer has been replaced by a dual ion funnel and the following octopole by a quadrupole for reduced ion cloud radial expansion before transmission into a mass-selective quadrupole (**Figure 3**). The number of ions that reach the ICR cell is increased by an order of magnitude for the funnel/quadrupole relative to the tube lens/skimmer/octopole. (*J. Mass Spectrom.,* **50**, 280-284 (2015)).

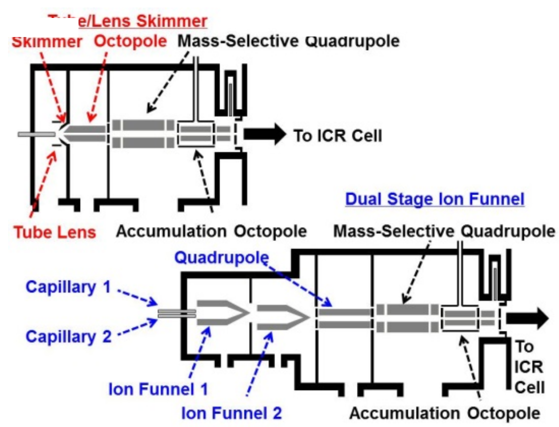

Figure 3: *Schematic diagrams of the front end of the 9.4 T FT-ICR mass spectrometer.* ***Top:*** *the prior instrument configuration with tube lens/skimmer followed by an octopole ion guide.* ***Bottom:*** *current instrument configuration with dual capillaries and PNNL-designed dual ion funnel followed by a quadrupole ion guide.*

The detailed characterization of large protein assemblies in solution remains challenging to impossible. Nonetheless, these large complexes are common and often of exceptional importance. **Hydrogen/deuterium exchange** mass spectrometry (HDX-MS) applied to the contact surfaces in a protein complex may be mapped from the differences in solvent exposure (based on accessibility to deuterium uptake for protein backbone amide hydrogens) between free and complexed protein (**Figure 4**). The **recombinant food allergen protein**, cashew Ana o 1, free and complexed with its monoclonal antibody, mAb 2G4, was subjected to solution-phase H/D exchange followed by proteolysis to generate numerous overlapping fragments whose masses (and thus solvent accessibility) were measured by on-line liquid chromatography coupled to NHMFL's 14.5 T FT-ICR mass spectrometer (*J. Mass Spectrom.* **50**, 812-819 (2015)).

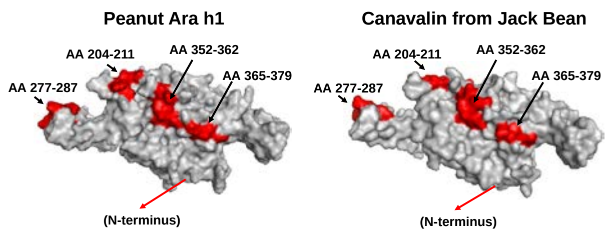

Figure 4: *Potential epitope-contributing regions of Ana o 1 mapped onto the homolog model of Ana o 1. Left: Ara h 1 from peanut (P43237, SwissProt), Right: Canavalin from jack bean (pdb 2CAV). The N-terminus, about 120 amino acid long, is not structured, and is therefore not mapped onto either model.*

Despite 50 years of study about siroheme-dependent assimilatory NADPH-sulfite reductase (SiR) structure and enzyme activity, we do not know how its subunits assemble, and therefore how they work to catalyze electron transfer. We report the structural elements of each subunit that are important for assimilatory NADPH-SiR assemby and propose a model that invokes four structural SiRFP molecules for each functional SiRFP:SiRHP dimer, shown in **Figure 5**. Further, we have shown that the N-terminus of SiRHP plays important roles in mediating both the SiRFP:SiRHP interaction and oligomerization of apo, non-functional SiRHP proteins that cannot make a complex with SiRFP. Taken together, these observations suggest a model for quality control of SiR assembly in organisms that use this oligomeric assembly. We have mapped the contact surfaces of the SiR complex by comparing H/D exchange of the backbone amide hydrogens of SiRHP, both free and complexed with flavin-binding flavoprotein (SiRFP), monitored by on-line HPLC positive electrospray ionization 14.5 T Fourier transform ion cyclotron resonance mass spectrometry. H/ D exchange shows that the α8β4 SiR holoenzyme assembles through the N-terminus of SiRHP and the NADPH-binding domain of SiRFP. We propose that homo-tetramerization of apo-SiRHP serves as a quality control mechanism to prevent formation of inactive holoenzyme in the case of limiting cellular siroheme. (*J. Biol. Chem.* **290**, 19319-19333 (2015)).

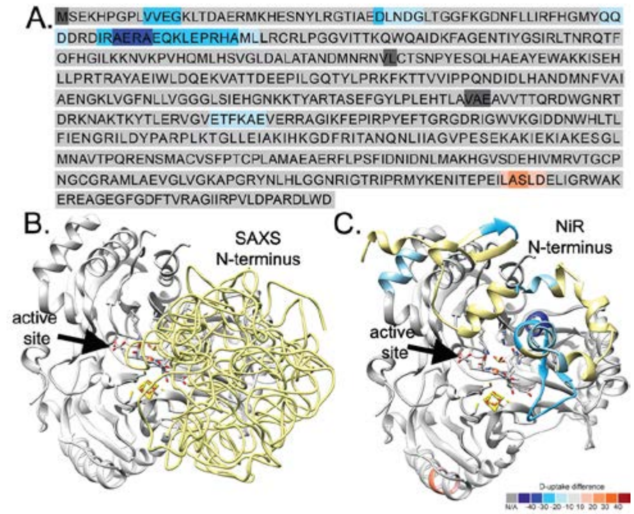

Figure 5: *Deuterium uptake map for SiRHP HDX and small-angle x-ray scattering (SAXC) modeling. HDX shows that the N-terminus of SiRHP is buried in the SiR complex.* ***(A)*** *Sequence of SiRHP in which light-to-dark blue shows increasingly buried residues and pink-to-red shows increasingly exposed residues, measured by absolute deuterium uptake. Leu80 is in bold.* ***(B)*** *Six independent models of the N-terminus in E. coli SiRHP built from SAXS data, super-imposed, show that the compact N-terminal 80 amino acids (yellow, displayed as pseudo-chain models), which are missing in the X-ray crystallographic structure, sit over the active site. Colors as in* ***(A),*** *modeled from PDB files 2AKJ (yellow, N-terminal amino acids 1-80, as in* ***(B)*** *and 2GEP (gray, amino acids 80-570).*

Coal tar and its distilled products (e.g., creosote) are commonly applied wood preservatives and asphalt sealants that have been identified as significant sources of polycyclic aromatic hydrocarbons (PAHs) to the environment. Expanding the target analyte list will improve our capacity to gauge the inputs and impacts of organic compounds released from coal tar and its products into the environment. Atmospheric pressure photoionization (APPI) FT-ICR MS revealed ~14 000 mass spectral peaks be-

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tween 150 and 900 Da, mainly aromatics and heterocycles with up to two nitrogen or three oxygen atoms per molecule (**Figure 6**). Relative abundance-weighted average DBE, H:C ratio, and carbon numbers calculated from elemental compositions are shown in red for each heteroatom class. Heteroatom-containing analogues of C_{27} hydrocarbons in the coal sample would exhibit different boiling points and therefore would not be in the same distillate cut, and confirm the identification as a whole coal tar, and not creosote distillate (*Energy Fuels*, **25**, 641-648 (2015)).

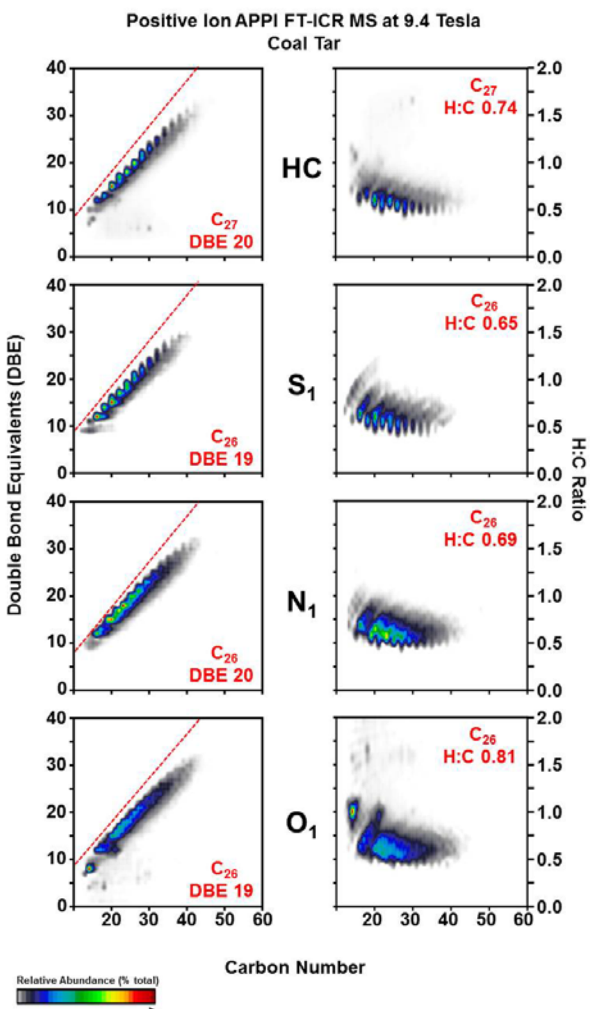

Figure 6: *Isoabundance-contoured plots of double bond equivalents (DBE) and H:C ratio vs carbon number for the hydrocarbon (HC), S_1, N_1, and O_1 heteroatom classes respectively obtained from positive-ion APPI FT-ICR MS.*

Sulfur compounds in petroleum samples are **separated into reactive and non-reactive sulfur fractions** by ligand exchange chromatography (LEC) on a silver-modified strong-cation exchange (SCX) solid-phase extraction (SPE) cartridge. LEC separation takes advantage of the bonding affinity of different sulfur types with silver-cations. The elution of a particular sulfur type (reactive or nonreactive) depends on the "strength" of the solvent used. One solvent mixture elutes nonreactive sulfur compounds (thiophenics and diaryl sulfides) into the first fraction. A second solvent mixture elutes reactive S-compounds (sulfides and disulfides) into the second fraction. A third reactive sulfur class (thiols) irreversibly reacts with the impregnated silver-ion to form silver thiolates that are insoluble in the solvent mixtures employed. The distribution of reactive and nonreactive sulfur in a sample can be determined by measurement of sulfur content in separated fractions **(Figure 7).** The isolated fractions are also well-suited for molecular characterization by a variety of techniques including gas chromatography-based methods (e.g., GC or GC × GC-SCD, GC-MS) and Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) (*Energy Fuels*, **25**, 641-648 (2015)).

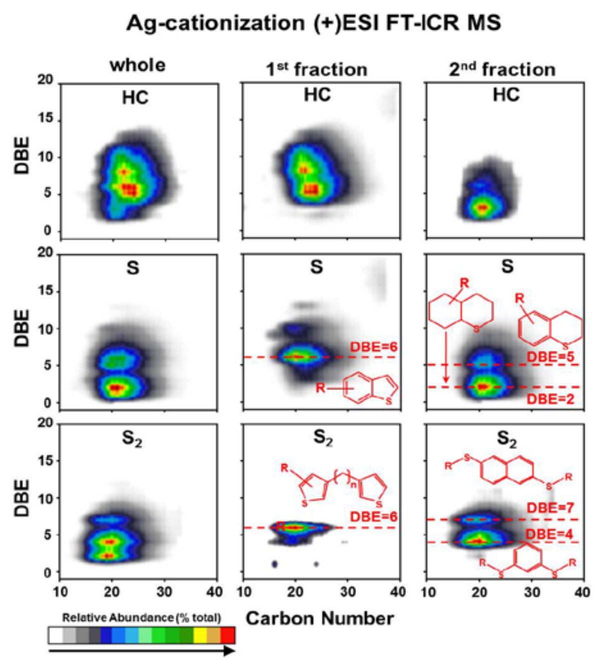

Figure 7: *Iso-abundance-contoured DBE vs carbon number plots for HC, S_1, and S_2 classes, for a whole sample of vacuum gas oil* ***(left column),*** *the first (nonreactive S) fraction (middle column), and the second (reactive S) fraction* ***(right column).***

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The **extraction of bitumen from surface mining** from Canada's Athabasca oil sands depoits results in vast Quantities of processed water. The current practice of storing the processed water in tailing ponds is not sustainable, and much research is geared at developing reclamation strategies. Polar organic compounds such as naphthenic acids (i.e., the acid-extractable fraction) are suspected to be among the principal toxic components of the processed water. Here, we use utrahigh resolution negative-ion electrospray ionization 9.4 T Fourier transform ion cyclotron mass spectrometry(FT-ICR MS) to define the elemental composition ($C_cH_hN_nO_oS_s$) of each of thou sands of compounds found in Athabasca oil sands processed water treated by: (A) coagulation-flocculent with lime and bentonite, (B) coagulation-flocculent with lime and bentonite followed by activated carbon, and (C) combined ozonation and ultrasonication. The number of rings plus double bonds to carbon (i.e., DBE = double bond equivalents) was computed for each elemental composition (**Figure 8**) (*Energy Fuels*, **29**, 2768-2773 (2015)).

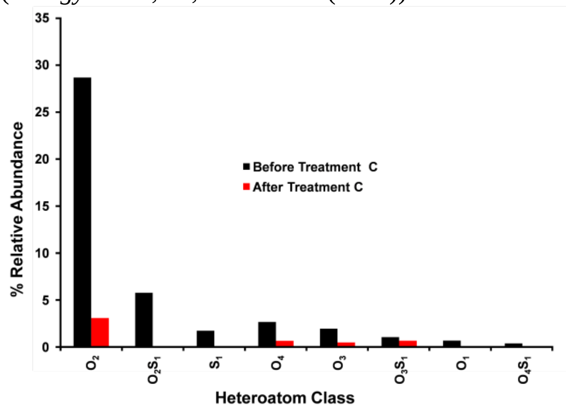

Figure 8: *FT-ICR MS characterization of the distribution of Ox (x=1-4), S1, OxS1 (x=1-3) heteroatom classes of oil sands processed water treated by combined ozonation and ultrasonication. For treatment A, little or no change in DBE distributions was observed for the various heteroatom compound classes (i.e., OoNnSs). Treatments B and C resulted in the reduction of total NAFCs by 26 ± 1.4, and 89 ± 1.1 %. (see Figure 1). For the latter treatments there was evidence for selective and substantial removal of the S and OxSy heteroatomic species at the molecular level; along with a reduction in the DBE values for all species. These results provide detailed molecular-level description of the effects of attempts to remediate the high organic acid content of oil sands processed water.*

As levels of **natural organic matter (NOM)** in surface water rise, the minimization of potentially harmful disinfection by-products (DBPs) becomes increasingly critical. We introduce the advantage that chromatographic prefractionation brings to investigating compositional changes to NOM caused by chlorination (*Env. Sci.*, **29**, 2768-2773 (2015)). Fractionation reduces complexity, making it easier to observe changes and attribute them to specific components. Under the conditions tested (0.1−0.4 g of Cl to g of C without further additives), the differences between highly and less oxidized NOM were striking.
Highly oxidized NOM formed more diverse Cl-containing DPB, had a higher propensity to react with multiple Cl, and tended to transform so drastically as to no longer be amenable to electrospray-ionization mass spectral detection.

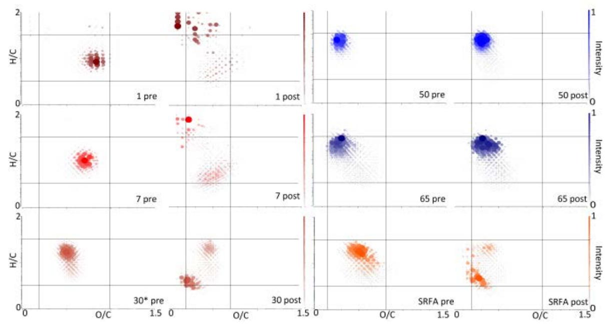

Figure 9: *van Krevelen plots of all formulae assigned for fractions 1, 7 30, 50 and 65 pre-chlorination* ***(left)*** *and post-chlorination* ***(right)****. Red corresponds to early eluting compounds, whereas blue for late-eluting compounds. HPLC-fractionation prior to chlorination reveals differences between pre and post chlorination spectra not accessible from bulk measurements of whole water and avails detail as to which components are relatively inert, and thus selectively enriched or highly reactive, and thus substantially converted.*

Less-oxidized material tended to incorporate one Cl and retain its humic-like composition. N-containing, lipidlike, and condensed aromatic structure (CAS)-like NOM were selectively enriched in mass spectra, suggesting that such components do not react as extensively with NaOCl as their counterparts. Carbohydrate-like NOM, conversely, was selectively removed from spectra by chlorination. Under the conditions tested (0.1- 0.4 g Cl to g C without further additives), the differences between highly and less oxidized NOM were striking (**Figure 9**).

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Determining the **chemical constituents of natural organic matter** (NOM) by FT-ICR MS remains the ultimate measure for probing its source material, evolution, and transport; however, lability and the fate of organic matter (OM) in the environment remain controversial. FT-ICR MS-derived elemental compositions are presented in this study to validate a new interpretative method to determine the extent of NOM lability from various environments. A molecular lability boundary (MLB) was developed from the FTICRMS molecular data, visualized from van Krevelen diagrams, dividing the data into more and less labile constituents *(Rapid Commun. Mass Spectrom.* **29**, 2385-2401 (2015)). NOM constituents above the MLB at H/C ≥1.5 correspond to more labile material, whereas NOM constituents below the MLB, H/C <1.5, exhibit less labile, more recalcitrant character. Of all marine, freshwater, and glacial environments considered for this study, glacial ecosystems were calculated to contain the most labile OM.

The **fluorescent properties of dissolved organic matter** (DOM) in fens and bogs in a Northern Minnesota peatland were contrasted using excitation emission matrix fluorescence spectroscopy with parallel factor analysis (EEMPARAFAC). EEM-PARAFAC identified four humic-like components and one protein-like component and the dynamics of each were evaluated based on their distribution with depth as well as across sites differing in hydrology and major biological species (*Photochemistry Photobiology*, **91**, 684-695 (2015)). The PARAFAC-EEM experiments were supported by dissolved organic carbon measurements (DOC), optical spectroscopy (UV-Vis), and compositional characterization by ultrahigh resolution Fourier transform ion cyclotron resonance mass spectroscopy (FT-ICR MS). The FTICR MS data (**Figure 10**) indicate that metabolism in peatlands reduces the molecular weights of individual components of DOM, and oxygen-rich less aromatic molecules are selectively biodegraded.

Precipitation of **calcium naphthenate soaps** from acidic crude oils poses significant operational challenges. Calcium naphthenate deposition in oil fields results from the interaction of a family of spe cial polycyclic tetracarboxylic acids, known as ARN acids, with divalent metal ions (Ca^{2+}) present in produced water. Calcium naphthenate scaling is being increasingly reported from oil fields in South America. We report detailed analyses of three field deposits from various crude-oil-producing fields in South America. All the field deposits were confirmed as calcium naphthenate scale via advanced analytical

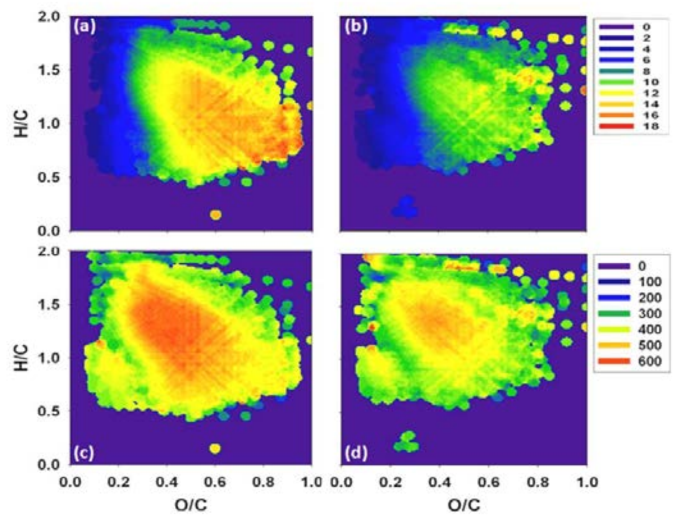

Figure 10: *Three dimensional van Krevelen plots (elemental H/C vs O/C in each formula) for (a, c) surface WWT fen DOM and (b,d) deep WWT fen DOM. Number of oxygen atoms is the z-axis parameter for plots (a) and (b), whereas the molecular weight (in Da) is the z-axis parameter for plots (c) and (d).The characteristics of these new compounds in deeper horizons (low O/C, high H/C and low aromaticity) suggest that these are microbially produced.*

probes such as mass spectrometry and high-temperature gas chromatography. These field deposits consisted predominantly of polycyclic tetracarboxylic ARN acids **(Figure 11)**. Presence of ARN acids was also validated in South American crude oils. Furthermore, low molecular weight ARN acids with a C_{70}–C_{72} hydrocarbon skeleton were identified in all the calcium naphthenate field deposits as well as in the crude oil samples. Another interesting observation reported is the striking resemblance in the molecular signature of ARN acids from South America to those from West Africa (*Energy Fuels*, **29**, 2342-2350 (2015)).

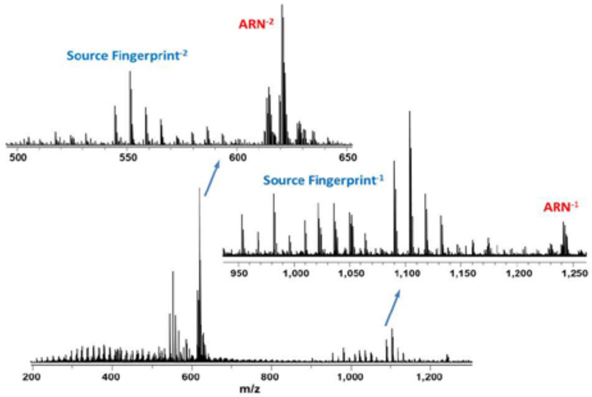

Figure 11: *Negative ion ESI FT-ICR MS of the off-load pump deposit-B2, zoom mass insets (950−1250 m/z and 500−650 m/z). Zoom mass insets at m/z 950−1250 and m/z 500−650 of the 9.4 T negative ion ESI FT-ICR mass spectrum of deposit-B2 displayed clearly show the distinctive group of peaks due to singly and doubly charged anions detected in the mass spectrum. Lower molecular weight ARN acid species as identified in the electrostatic treater deposit (deposit-B1) are also observed between m/z 1000 and 1150, representing a lower molecular weight homologous series of ARN acids. Thus, both field deposits-B1 and -B2 are confirmed as calcium naphthenate scale by negative ion ESI mass spectrometry.*

Water-in-oil emulsions are one issue commonly encountered during petroleum production and refining. If left untreated, these emulsions can cause severe corrosion issues and equipment failure. Therefore, a key objective in petroleum production is to understand what compounds partition to the oil/water interface. We report a novel method to isolate these species (i.e. interfacial material) (*Energy Fuels*, **29**, 7150-7155 (2015)). Water was added to silica gel to generate four different silica gels (17.6, 33.3, 53.8, and 66.6% water g^{-1} silica gel). Immediately after IM isolation, silica gels 17.6-53.8% water g^{-1} are "stained" The staining is the result of irreversible adsorption of non-interfacially active species to the silica gel surface. However, once the silica gel is water-saturated (66.6% water g^{-1} silica gel), a sufficient number of water monolayers are present (~26) to prevent irreversible adsorption, and IM compounds are selectively isolated. Subsequent analysis by FT-ICR MS (**Figure 12**) reveals that interfacially active crude oil components are highly enriched in oxygen-containing functionalities, and thus function as naturally occurring surfactants. Even though the surfactants comprise only ~1% of the crude oil mass, their removal prevents stable emulsion formation in the 99% (by weight) that remains. Emulsion tests with isolated interfacial material yield emulsions that are stable for days (inset, **Figure 9**).

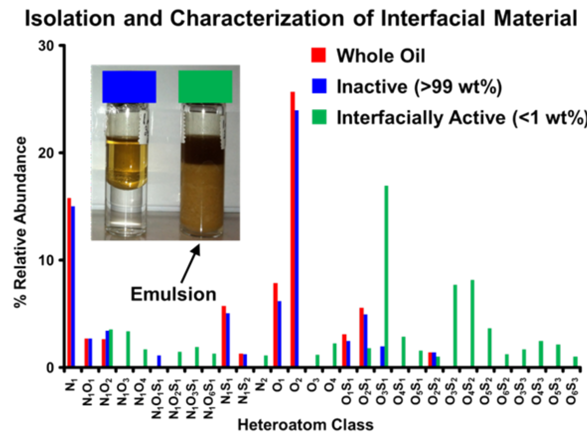

Figure 12. *Heteroatom class distribution for Athabasca bitumen IM species of oil (red), inactive (blue), and interfacially active (green) species.*

Although **naphthenic acids** are minor constituents in petroleum, their characterization is crucial because they are geochemically important tracers and play a key role in corrosion processes in refineries. Moreover, different isomers may exhibit different reactivity and may serve as potential biomarkers. However, determination of acid isomers in petroleum/hydrocarbon matrices remains analytically challenging. We achieve the separation and structural characterization of isomeric homologue series of naphthenic acids in petroleum samples by negative-ion mobility time-of-flight mass spectrometry (IM-TOF MS). IM-TOF MS data processing and molecular formula assignments (for most abundant heteroatom classes), integrated with ion mobility data by PetroOrg© software, expose structural differences and patterns among petroleum compounds, and facilitate the identification of series of isomers (*Energy Fuels*, **29**, 3626-3633 (2015)). A family of isomeric acids ($C_cH_hO_2$) of double bond equivalents (DBE) = 5 and carbon number ranging from C_{28}-C_{34} appears to correspond to steranoic acids, whereas $CcHhO_2$ isomers of DBE = 1 likely correspond to linear and isoprenoid acids. Ultrahigh resolution 9.4 T FT-ICR

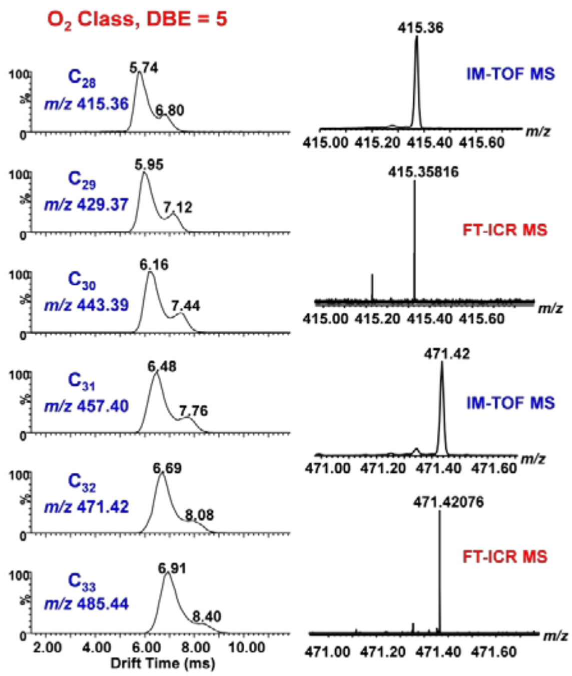

Figure 13: Left: *Mobiligram segments for O_2 class species of DBE = 5 from C_{28} to C_{34}. Two IM peaks for each m/z suggest the presence of two structures that could be isomers or isobars (unresolved by TOF MS).* ***Right:*** *Mass scale-expanded segments of IM-TOF and FT-ICR mass spectra for ions of nominal m/z 415 and 471; the single FT-ICR MS peak in each case confirms that the species are indeed isomers, not isobars.*

mass spectra serve to validate molecular formula assignments by IM-TOF and determine whether or not isobaric ions of different mobility are isomers (**Figure 13**).

Fullerenes have been studied for nearly three decades and enormous advances have been made. Mass spectrometry is commonly used for investigations on the distribution of fullerenes formed from evaporated graphite targets, and soot produced from such targets. We report distributions of fullerenes formed by graphite evaporation by use of a pulsed supersonic cluster source and compare them to certain distributions synthesised by other techniques, such as arc discharge and combustion methods. We highlight the fact that physical processes can occur during the mass spectral analysis of fullerenes under certain conditions that may skew the observed distribution of cage sizes present in a sample. In some cases, an analysis of fullerene-containing soot can greatly exaggerate the relative abundance of large fullerenes compared to C_{60} and medium-sized fullerenes, depending on the particular experimental setup.

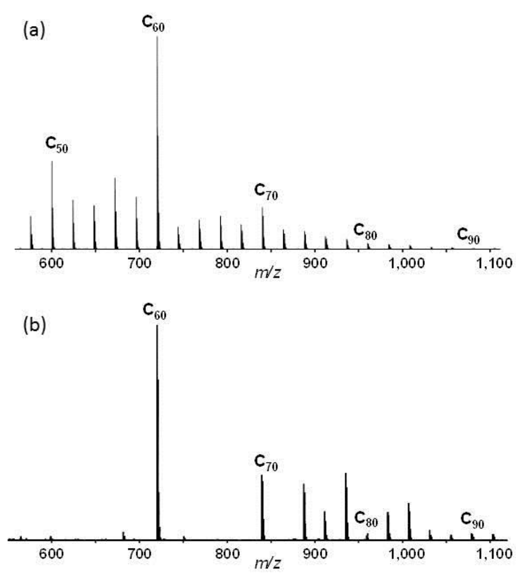

Figure 14: *Fullerenes formed by the vaporization of graphite:* ***(a)*** *Fourier transform ion cyclotron resonance (FT-ICR) mass spectrum of the medium sized to the larger fullerene region for C_{2n} positive ions observed directly from the vaporization of graphite by the use of a pulsed laser vaporization cluster source,* ***(b)*** *mass spectrum of fullerenes produced by the arc discharge method from an o-xylene extracted fullerene-containing soot.*

Figure 14 shows that such phenomena can cause significant errors in an interpretation of the relative abundances of smaller ($C_{2n} < C_{60}$–C_{70}) with respect to medium (~C_{80}–C_{100}) and in particular the much larger fullerene cages ($C_{2n} > C_{100}$–C_{500}) from fullerene-containing soot or extracted samples. Although fullerenes originally detected were produced by the laser ablation of graphite, commercial samples are now typically generated by a carbon arc discharge in an inert atmosphere, such as helium or by the combustion of methane and other hydrocarbons. **Figure 14(a)** shows the cluster cations directly produced by laser vaporization of graphite in a pulsed supersonic cluster source. In that experimental setup, fullerenes remain in the gas phase until they are detected by the mass spectrometry. When the arc discharge method is used, the fullerenes produced in the gas phase are generally solvent-extracted from the carbon soot also produced by the process. Solvent extraction with toluene and similar solvents, for example, is a common way to extract popular fullerenes from the bulk soot. **Figure 14(b)** shows the fullerene distribution from an o-xylene extract of soot produced by an arc discharge of graphite. C_{72}, C_{68}–C_{62}, and all fullerenes smaller than C_{60}, however, are not detected in the fullerene-containing soot because they are insoluble or 'react away' (i.e., unstable) in the solid state. In fact, a large number of fullerene species – especially large ones – appear to be insoluble in common solvents and thus the comparison of all small-, medium-, and large-sized cages in a given extract is not an accurate reflection of the fullerene cage size distribution actually produced by the vaporisation of graphite (*Molecular Physics,* **113**, 2359-2361 (2015)).

The regioselective synthesis of easily isolable **purebismethano derivatives of C_{60} and C_{70}** with high steric congestion is described using 1,3-dibenzoylpropane bis-*p*-toluenesulfonyl hydrazone as the addend precursor. When the addition occurs at two [6,6] ring junctions within the same hexagon, bisadducts with mirror symmetry are obtained for both C_{60} and C_{70} (**Figure 15**). When the addition occurs at two [5,6] ring junctions in C_{60}, a symmetrical adduct is formed, which readily undergoes photo-oxygenation and ring opening to yield a fullerene with a hole in the cage. In this work, we also propose a simple and general system to name all of the possible [6,6] bisadduct isomers on C_{70}. New double addition products of both C_{60} and C_{70} have been prepared with both additions occurring within one six-membered ring of the fullerene through the use of 1,3- dibenzoylpropane bis-*p*-toluenesulfonyl hydrazone as the addend precursor. When the addition occurs at two [6,6] ring junctions within a hexagon, bisadducts 2 and 4 with mirror symmetry have been obtained for both C_{60} and C_{70}. When the addition occurs at two [5,6] ring junctions of C_{60}, a symmetrical bisfulleroid is formed. This adduct readily undergoes photo-oxygenation and ring opening to yield a fullerene with a 12-membered hole in the cage. Electrochemical measurements showed that the reduction potentials of all synthesized bisadducts were shifted cathodically between 200 and 300 mV compared to the corresponding values for the pristine fullerenes (*J. Am. Chem. Soc.,* **137**, 7502-7508 (2015)).

4. Facility Plans and Directions

The ICR facility will continue to expand its user facility and include user access to the world's first 21 tesla FT-ICR mass spectrometer in 2016.

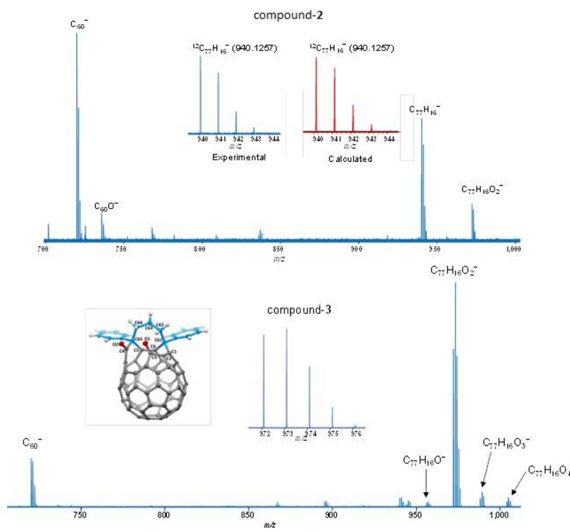

Figure 15: *Laser desorption FT-ICR mass spectrum of compound-**2** **(top)** and compound-**3** **(bottom)** dissolved in toluene without matrix. The deviation from calculated isotopic distribution is due to protonation of the sample.*

5. Outreach to Generate New Proposals-Progress on STEM and Building User Community

The ICR program had **42** new principal investigators in 2015. The ICR program also enhanced its undergraduate research and outreach program for 4 undergraduate scientists (two females), three high school interns (two African-Americans) and three female middle school students. The ICR program in 2015 supported the attendance of research faculty, postdoctoral associates, graduate, undergraduate and high school students at numerous national conferences to present current results.

6. Facility Operations Schedule

The ICR facility operates year-round, with weekend instrument scheduled. Two shifts (8 hours each) are scheduled for each instrument year-round,

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including holiday shut-downs, which are utilized for routine instrument maintenance.

7. The FUTURE FUELS INSTITUTE

The Future Fuels Institute completed its third full year in 2015, with 4 full share members ($250K each / year for 4 years) to support research that to address challenges associated with petroleum production, processing and upgrading. In 2015, it will expand to 5 members. The Future Fuels Institute currently supports 2 fulltime Technicians and 4 fulltime Research Faculty to pursue analytical method development. For 2014 / 2015 the corporate members are: Reliance, ConocoPhillips, Total, PetroBras and EcoPetrol. Additionally, the FFI partners with 2 instrument manufacturers (Leco Instruments, Waters Instrument Company) for state-of-the-art instrumentation prior to commercial release.

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ICR

Protein Modifications in Human Breast Cancer

Yu Chen[1], Michael E. Hoover[2], Xibei Dang[3], Alan A. Shomo[3], Xiaoyan Guan[1], Alan G. Marshall[1,3], Michael A. Freitas[2]*, and Nicolas L. Young[1]* (1. NHMFL, Tallahassee; 2. The Ohio State University College of Medicine; 3. Chemistry & Biochemistry, FSU)

Breast cancer was the second leading cause of cancer related mortality for females in 2014. By exploiting the ultrahigh mass resolution of high-magnetic-field ion cyclotron resonance, we here isolate an individual “proteoform” (i.e., a protein with a particular combination of mutations and chemical modifications) as gas-phase ions. We then dissociate the ions to weigh the fragments, then identify and quantitate the mutated or modified site(s) as breast cancer cells progress through their cell cycle.

We find histone proteins H1.2 and H1.4 metastatic breast cells of type MDA-MB-231, whereas an additional histone variant, histone H1.3, is seen only in non-cancerous MCF-10A cells. *Notably, phosphorylation of histones H1.2 and H1.4 increases significantly during cell division (mitosis, or the “M phase”), suggesting that these events are cell cycle-dependent and may serve as biomarkers for proliferation of cancer cells during breast cancer invasion.* T146 and T154 are the only phosphorylated sites observed at higher rates in metastatic versus non-neoplastic cells.

These experiments require the ultrahigh mass resolution provided by NHMFL’s 14.5 T Fourier Transform – Ion Cyclotron Resonance (FT-ICR) mass spectrometer due to the complexity of the resonance peak patterns from the fragment ions.

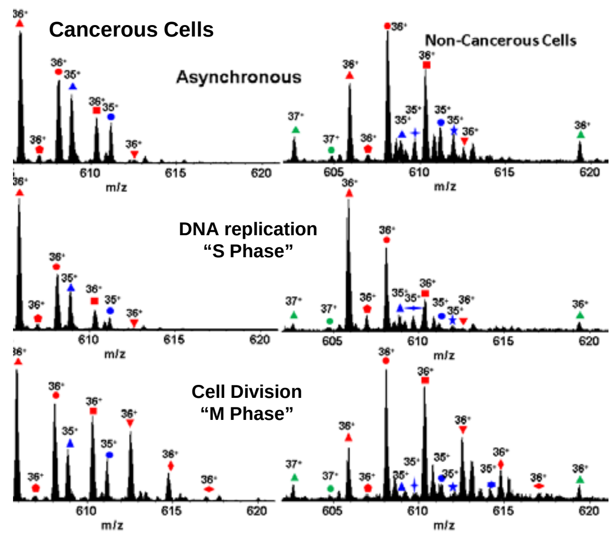

Figure 1: *FT-ICR mass spectra annotated for the proteoforms observed in* ***(left)*** *cancerous and* ***(right)*** *non-cancerous cells. Cells were grown asynchronously (at top) or blocked during DNA replication - the “S phase” - (at middle) or during mitosis - “the M phase” - (at bottom). Proteoforms (different symbols) for H1.2, H1.3 and H1.4 are shown in blue, green and red.*

Facilities: 14.5 T Ion Cyclotron Resonance Magnet, NHMFL/FSU

Citation: Chen, Y.; Hoover, M. E.; Dang, X.; Shomo, A. A.; Guan, X.; Marshall, A. G.; Freitas, M. A.; Young, N. L, Top-down Characterization of Histone H1 Phosphorylated Proteoforms during Breast Cancer Invasion, to appear in *Mol. Cell. Proteomics* (2015).

ICR

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ICR

FT-ICR Mass Spectrometry Enables Peptide *de novo* Sequencing

Naomi C. Brownstein[1,2], Xiaoyan Guan[1], Yuan Mao [2,3], Qian Zhang[2], Peter A. DiMaggio[4], Qiangwei Xia[3,5], Lichao Zhang[6], Alan G. Marshall[1,2] and Nicolas L. Young[1] (NHMFL; 2. FSU; 3. Regeneron Pharmaceuticals; 4. Imperial College London; 5. CMP Scientific; 6. UVA)

Proteins consist of a **sequence** of **amino acids**, adjacent groups of which are called **peptides**. Accurate sequencing is vital to the discovery of proteins that might be biomarkers of disease or environmental exposure, regardless of whether or not the genome under study is known.

We describe a method for *de novo* peptide sequencing with high accuracy and multiple levels of confidence. Samples are digested separately by two proteases, Lys-C and Lys-N. Resulting complementary pairs of ions may be analyzed together to measure confidence in the identification.

The method capitalizes on the high mass accuracy produced by the powerful Fourier Transform Ion Cyclotron Resonance (FT-ICR) mass spectrometers at the MagLab. A key feature is the innate ability to distinguish amino-terminal ("b") from carboxy-terminal ("y") cleavage products.

Sequence identity and additional variability, such as post-translational modifications that add functional groups to the protein after its initial synthesis, are essential to understanding biological function and disease. By facilitating the discovery of new peptides with multiple levels of confidence, this method validates peptides from databases and promises future characterization of post-translational modifications in terms of their role in the overall protein function.

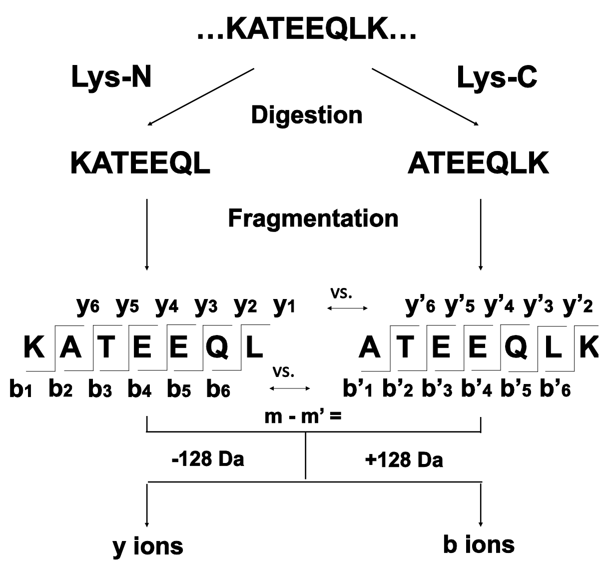

Figure 1: *Illustration of the method for a hypothetical protein. Digestion results in precursor ions with identical mass and fragment ion pairs with known mass differences. Pairs increase confidence in identification.*

Facility: 14.5 Tesla Ion Cyclotron Resonance Magnet System

Citation: *Paired Single Residue-Transposed Lys-N and Lys-C Digestions for Label-Free Identification of N-Terminal and C-Terminal MS/MS Peptide Product Ions: Ultrahigh Resolution Fourier Transform Ion Cyclotron Resonance Mass Spectrometry and Tandem Mass Spectrometry for Peptide De Novo Sequencing,* Naomi C. Brownstein , Xiaoyan Guan , Yuan Mao , Qian Zhang , Peter A. DiMaggio, Qiangwei Xia, Lichao Zhang , Alan G. Marshall, and Nicolas L. Young, Rapid Communications in Mass Spectrometry 29, 659-666 (2015).

CHAPTER 4
EDUCATION & OUTREACH

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1. Education and Outreach

In 2015, the Center for Integrating Research and Learning worked closely with Public Affairs to continue broaden the educational and outreach impacts of the Magnet Lab for students of all ages and the general public. CIRL continues to evaluate our educational programs so that we can ensure that our programs are meeting our goals. Our expansion of K-12 outreach at Magnet Lab facilities at University of Florida and Los Alamos National Laboratory are progressing well. These outreach efforts include kits for scientists and staff to share their science to students at schools and events. Elizabeth Webb at UF is also applying for funding to begin a MagLab summer camp at UF. Kari Roberts has worked closely with postdoctoral associates (postdocs) at all three sites to ensure their professional development and mentoring needs are being met. This includes working with postdocs to discuss their annual evaluation with their respective mentors through the Individual Development Plan (IDP) process. As always, our programs and the work that we do is part of our mission to expand scientific literacy and to encourage interest in and the pursuit of scientific studies among educators and students of all ages has become more specifically targeted to encourage students – particularly students from underrepresented groups – to pursue STEM career paths. We also maintain a strong research agenda that keeps us at the forefront of knowledge related to educational outreach and informal education so that the Magnet Lab can maintain its commitment to broader impacts.

Students Exploding Marshmallows in SciGirls Camp

K-12 STUDENTS

On-Site and Classroom Outreach conducted through CIRL

CIRL staff and Magnet Lab scientists conduct outreach in local schools each year. We record this outreach during the school year as opposed to the calendar year. During the 2014-2015 school year CIRL's Outreach Coordinator, Carlos Villa, provided outreach to over 6,000 students from school districts in Northern Florida and Southwest Georgia. One-half of the schools reached through our outreach programs are Title I schools. The outreach staff offered 12 types of programs to all three educational levels. The top three outlets from which teachers learned about our programs included colleague communication (29.0%), magnet lab staff (21.0%), and the magnet lab website (21.0%).

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Outreach Coordinator Carlos Villa at the 2015 Open House

In October of 2015, Carlos Villa worked closely with Elizabeth Webb at UF to train MagLab faculty, staff, and students in three different outreach activities: Electromagnets, Magnet Exploration, and Nature of Science. In 2015, UF MagLab personnel conducted outreach in two schools, reaching 145 students. As part of the NSF's recommendation to make the outreach efforts across all three Magnet Lab locations more synergistic, CIRL's outreach coordinator, Carlos Villa, has worked closely with Janelle Vigil-Maestas from the Community Programs Office (CPO) at LANL. The CPO handles outreach and classroom visits at LANL. In 2015, Carlos sent the CPO Magnet Exploration lesson developed by CIRL. During that year, the lesson was used for a summer program that was held in San Ildefonso, NM, July 23, 64 students, K-9, all Native American. The Magnet Exploration lesson includes: a complete lesson plan for that activity, 30 kits to use with individual K-12 classrooms.

Middle School Mentorship

The MagLab Middle School Mentorship Program continues to expand in terms of mentors volunteering and mentees applying. In 2015, 17 students from middle schools in Leon County participated with 11 Magnet Lab scientists serving as mentors: Bruce Barnett, Ryan Baumbach, Dan Brown, Lloyd Engel, Ke Han, Amy McKenna, Vince Toplosky, Hans VanTol, Bob Walsh, Yang Wang, and Gary White. The students worked with their mentors over an entire semester. The program culminates in a presentation by each group to an audience of their family, teachers, principals, and mentors. This year's class was comprised of 70.6% underrepresented minorities in STEM (3 African American students, 1 Hispanic student, 10 female students, and 3 students from Title I schools)

Summer Programs

CIRL's busiest time of year is the summer. In 2015 we housed four middle school summer camps (MagLab Summer Camp 1 and 2, and SciGirls 1 and 2).

MagLab Summer Camp

The MagLab Summer Camp was held for its fifth year. This camp runs for two one-week sessions. There were 32 students who participated in the program. This camp is run by Carlos Villa. In 2015, 44% of the campers were female, 16% of the campers were African American, and 3% were Hispanic. Highlights from the 2015 camp were building their own speakers and the Robotic World Cup games.

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2015 MagLab Summer Camp Participants Preparing to Build their own Speakers

SciGirls Summer Camp

The SciGirls Summer camp celebrated its 10th summer in 2015. This program is based on a partnership between the Magnet Lab and our local public television station, WFSU. The program is closely associated with the SciGirls Connect program, an NSF funded national SciGirls Program associated with Minnesota Public Television. The camp includes two two-week camps for middle school girls. In 2015, 32 girls participated, 28% of whom were African American and 16% were Hispanic. The highlight of this year's camp was the benefits of longevity. One of our SciGirls from 2006 is now a graduate student a Georgia Tech in Engineering and she volunteered with the camp for a week. In addition, Kristen Coyne wrote a feature story on two of our SciGirls who are now pursuing engineering degrees.

2015 SciGirls Camp participants getting ready to conduct their archaeological dig and the SciGirls Feature story

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K-12 TEACHER

Leon County Schools Workshop

Teachers Discussing Ideas for their Classes

In 2015, the Leon County Schools district was awarded an AT&T grant to develop a STEM Bowl Challenge in all of the districts' elementary schools. CIRL staff members, Jose Sanchez and Carlos Villa, worked closely with the PI on the grant and the elementary teachers. The program began with a workshop in January 2015. CIRL staff facilitated a workshop that helped teachers understand how to incorporate engineering concepts and problem-solving activities in their classrooms and clubs. Then throughout the semester, CIRL staff visited each elementary school's STEM Bowl club to help the teachers and students develop, plan, and test their skills. The program culminated in a STEM Bowl Challenge (a thermal insulation challenge) that involved over 19 schools and 25 teachers. The teachers credited the success of the STEM challenge to CIRL's dedication to the project. This partnership is further evidence of CIRL and the Magnet Lab's commitment to education in Leon County.

Research Experiences for Teachers (RET)

The Magnet Lab RET program has been in existence since 1998. In 2015, nine teachers from the United States participated in the program and two teachers from Israel spent four weeks with the program. The RET program is a 6-week program wherein teachers are paired with scientist mentors. In 2015, of the 9 U.S. teachers, 78% came from Title I schools, 44% were African American, 22% were Hispanic, and 56% were male.

2015 RET Participants

MagLab Educators Club

The MagLab Educators Club is an email list that CIRL utilizes to send information about Magnet Lab community events, outreach, programs, and other exciting opportunities at the lab. We have over 300 members, providing further evidence of the interest of educators in Magnet Lab programs.

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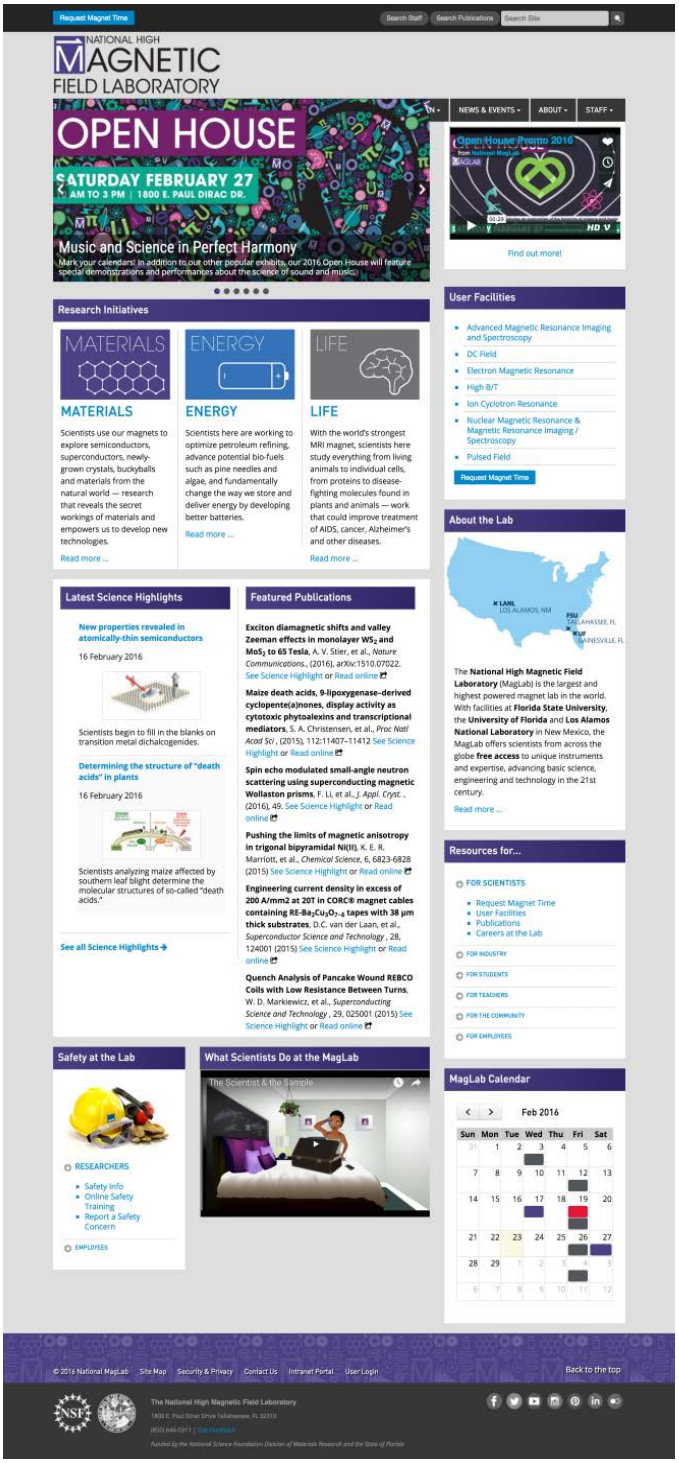

Magnet Academy – For Teachers

The Magnet Academy is the outreach portion of the Magnet Lab's website. This site has a page that focuses on teachers (https://nationalmaglab.org/education-magnet-academy/teachers). This page provides lesson plans, science demonstrations, and interactive activities for teachers of students of all ages.

Public Affairs and CIRL

In collaboration with Public Affairs, the Magnet Lab also expanded its outreach efforts to the public in 2015. The Public Affairs team, under the direction of Kristin Roberts, uses a wide variety of communications tools to share scientific news with the Magnet Lab's diverse audiences:

Website:

The Magnet Lab's website, overseen by Web Content Director Kristen Coyne and Webmaster Nilubon Tabtimtong, is a critical tool for communicating important information about the lab to a variety of audiences, including: scientists, teachers/students, and the general public. A new website launched by the National High Magnetic Field Laboratory in January offers site visitors more science content, a revamped education section, and a modern, mobile-friendly look that better showcases the lab's instruments, research output and expertise. Integrating the National MagLab's new brand, the site features significant enhancements for its varied audiences, including:

For scientists

- Dozens of new pages written by scientists that showcase the measurement techniques available to scientists at the lab's seven facilities.
- Details on new magnets being built at the MagLab that will open new frontiers in Research.
- Monthly science highlights that promote the most exciting new research at the lab.
- Updates on high-profile publications generated by MagLab research.
- Search functions for finding the magnets and measurement techniques needed for your experiment.
- Easy access to experiment schedules and to the system for submitting proposals.

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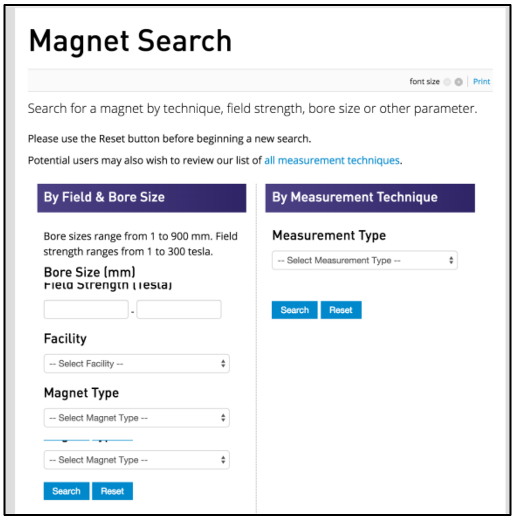

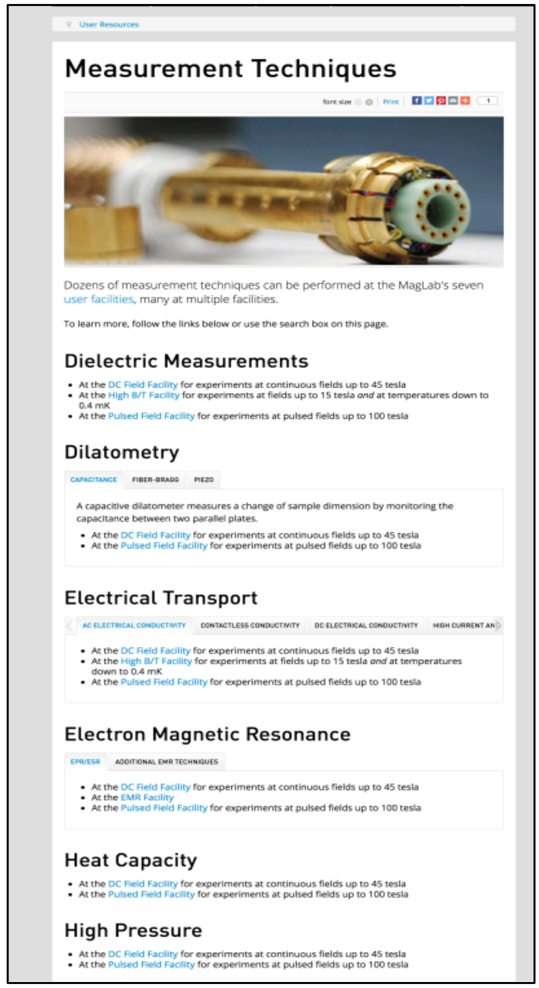

For everyone

- A responsive site that adapts to your device.
- A clean, modern design featuring more photos, image galleries and lab panoramas.
- A calendar to keep you up to date on MagLab events and deadlines.
- Better integration with MagLab social media.
- More stories for lay readers on the lab's people, research and tools.
- Numerous features that make it easier to find content including content tagging across the site.

For educators and students

- A new educational section called "Magnet Academy" designed for teachers, students and other curious people with information on electricity and magnetism in a variety of formats including lesson plans, interactive tutorials, videos, and articles.
- Dozens of interactive tutorials updated with a fresh look that works across platforms.
- Ability to filter educational content by age, grade level and topic.

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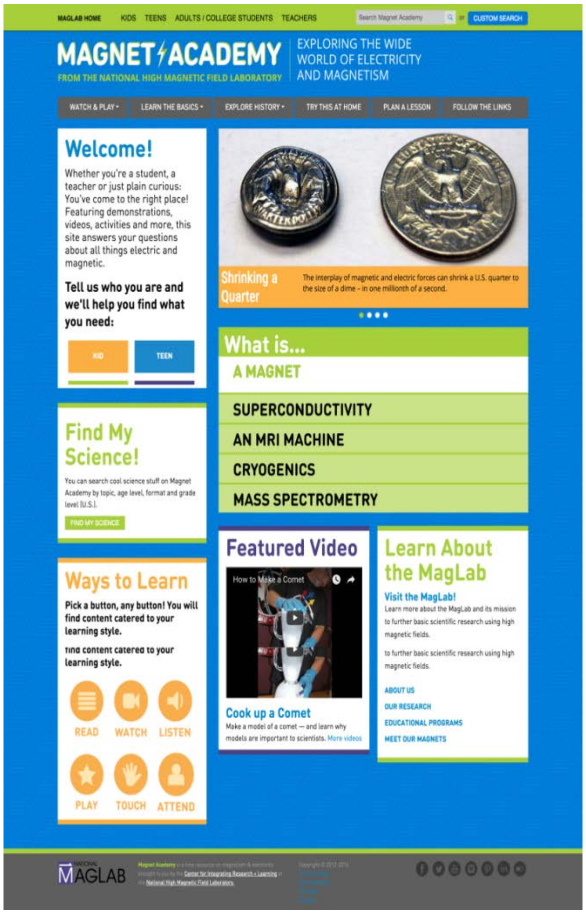


The new format for Magnet Academy

Web Trends from 2015:

In the first year, the lab's new site has over a million page views. Around 68% of site users are between the age of 18 and 44 with the largest group between 25 and 34. Site users are 65% male and 35% female and come from all over the world. The top ten countries for web users are the Unites States, India, United Kingdom, Canada, Germany, China, Australia, Japan, Brazil and France.

The new website has shown exciting growth across key MagLab audiences in 2015. Traffic grew in a number of sections including:

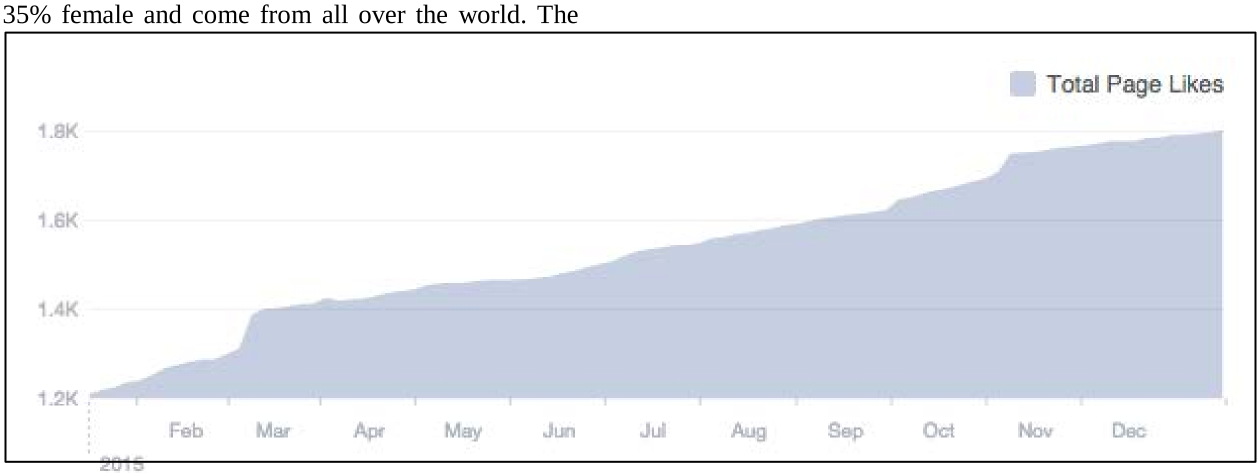
- All user sections of the site (User Facilities, User Resources) show a 55% increase on the new site reflecting the interest in the new user-oriented content and search tools described above.
- The About section of the site increased 52% with new content added weekly This Week at the Lab series, 5 entries of What Goes in the Magnet, and the launch of the new Meet the User series.
- The News section of the site saw a 46% growth with a new calendar tool, 18 press releases and 13 feature stories added in 2015.

In 2014, on the old site, social media was responsible for 1.7% of sessions to the site. In 2015, on the new site, social media was responsible for 3.4% of total sessions on the site. The quality of traffic on our new site has also improved with visitors staying longer and viewing more pages.

Social Media:

In 2015, the MagLab's online presence continued to expand through the use of social media.

Our Facebook fan page saw a 49 % growth from January to December. The lab's Facebook page is almost evenly split male and female (48% female compared to 51% male) and is most popular with people between the ages of 24-44. While most of the fans are based in the United States, the lab's Facebook page has an international audience with fans from 45 countries including Brazil, India, Columbia, Kenya, Russia and the United Kingdom.



Facebook fan growth over 2015: From 1209 on January 1, 2015 to 1800 on December 31st.

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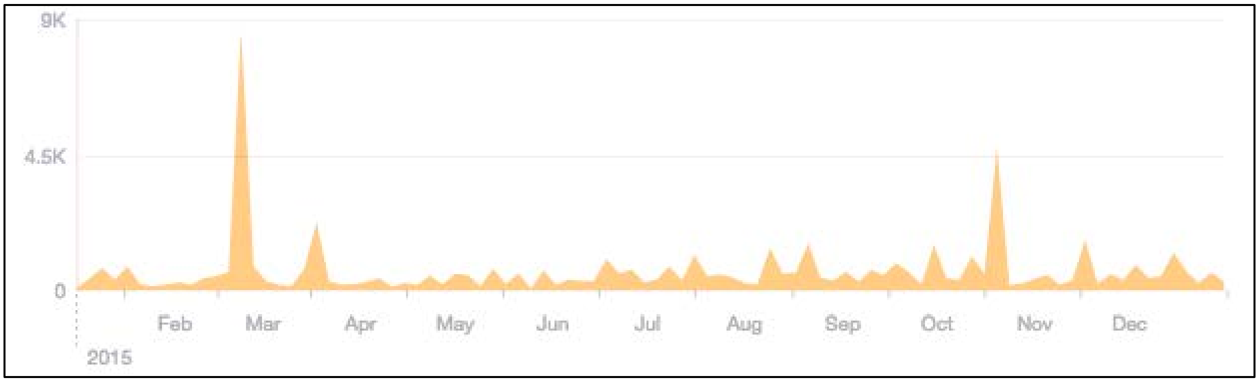
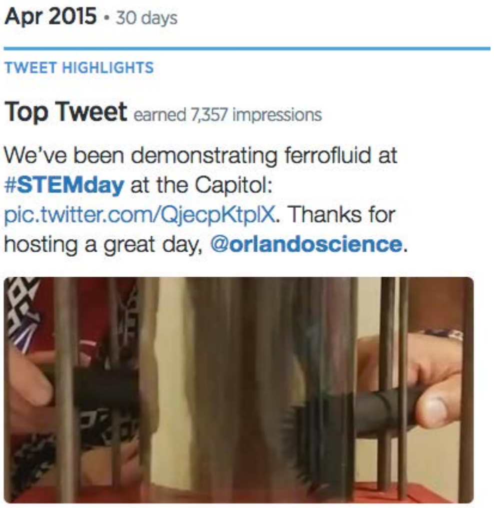


Facebook Total Post Reach 2015: The number of people who were served any activity from your Page including your posts, posts to your Page by other people, Page like ads, mentions and check-ins.

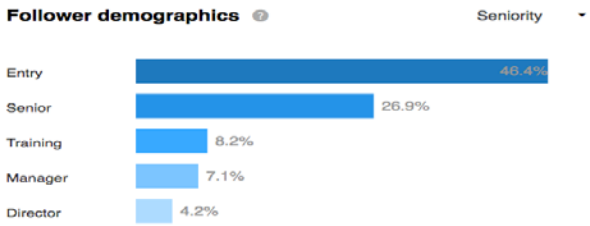
60% of the people reached by our Facebook posts are women and 39 % male. Bangladesh, Brazil, Canada, UK, Germany, Mexico, Spain and Japan are the countries reached most by our content.

Our **Twitter** page earned 298 followers in 2015, about a 21% increase from the year before.

Throughout the year, our over 550 twitter posts earned over 250,000 impressions with over 400 mentions. The lab's Twitter followers are comprised of 61% male and 39% female and come from the United States, United Kingdom, India, Canada, France, Spain, Turkey and Mexico. Selected Top Tweets are highlighted below:



The lab's **LinkedIn** presence continued to grow in 2015 – growing from 110 followers in January to 388 in December – an increase of 253%. The followers are predominately entry-level researchers with 33.5% coming from the research sector and 28% coming from higher education.



The MagLab's LinkedIn followers are predominantly entry level (46%).

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Pinterest has continued to grow with over 815 average daily impressions and nearly 500 average daily viewers. Over 60% of our Pinterest audience is female and the most popular content on Pinterest is the Science and Literature board where science-related books for people of all ages are featured. This content was formerly hosted on the MagLab website. Other popular Pinterest boards are STEM Learning which features lessons and activities and the Magnets Study Materials board which highlights materials-based research performed in the MagLab's powerful magnets.

Instagram is continuing to grow as an impactful social media tool with about 200 total followers at the end of 2015.

Overall, the most clicked social media content of the year was the news release on the 32 T all superconducting magnet achieving a record field in prototype form from June 2015 – https://nationalmaglab.org/news-events/news/maglab-claims-record-with-novel-superconducting-magnet.

Other highly clicked content from 2015 includes:

- A feature story to recognize the 10th birthday of the 900 MHz (July)
- https://nationalmaglab.org/news-events/feature-stories/900-birthday
- A feature story on 10 years of the SciGirls program highlighting two former SciGirls who are pursuing careers in STEM (July)
- https://nationalmaglab.org/news-events/feature-stories/from-scigirsl-to-sciwomen
- Summer internship application reminder (March)
- Job recruitment for videographer position (February)

The Magnet Lab has had an active YouTube page since 2008. This channel now has over 702 subscribers with 125 new subscriptions in 2015. There are over 1.5 million lifetime views from around the world with 58,383 from 2015 alone. New video content was added in 2015, including:

- Stuck on Science: A video to promote the Open House event (276 views)
- MagLab 2015 Open House (958 views)
- What Do You Love About Science (194 views)
- A Strange Way to Win a Nobel Prize (96 views)
- Resolving Everything (23 views)
- Resolution is Not Everything (18 views)
- From the Macroworld to the Nanoworld in 400 years (41 views)
- Science Café: The Aesthetics of the MagLab's Magnets (131 views)
- Science Café: Popcorn, Radar & Cell Phones: How Microwaves Rule the World (164 views)
- Summer at the MagLab: An interview with an RET (141 views)
- Dynamic Nuclear Polarization (85 views)
- Science in a Sentence: Materials, Energy & Life (165 views)
- Introducing the 21 T FT-ICR Magnet (476 views)
- This Week At The Lab: Scaffold Removal from the 36 T SCH (168 views)
- Science Café: Taming Tumors: Exploring the Role of Powerful MRIs in Cancer Care (73 views)
- This Week At The Lab: When Materials Get Think (153 views)
- This Week At The Lab: A New NMR Magnet (83 views)
- Science in a Sentence: Mapping Chemical Properties of the Artic (82 views)

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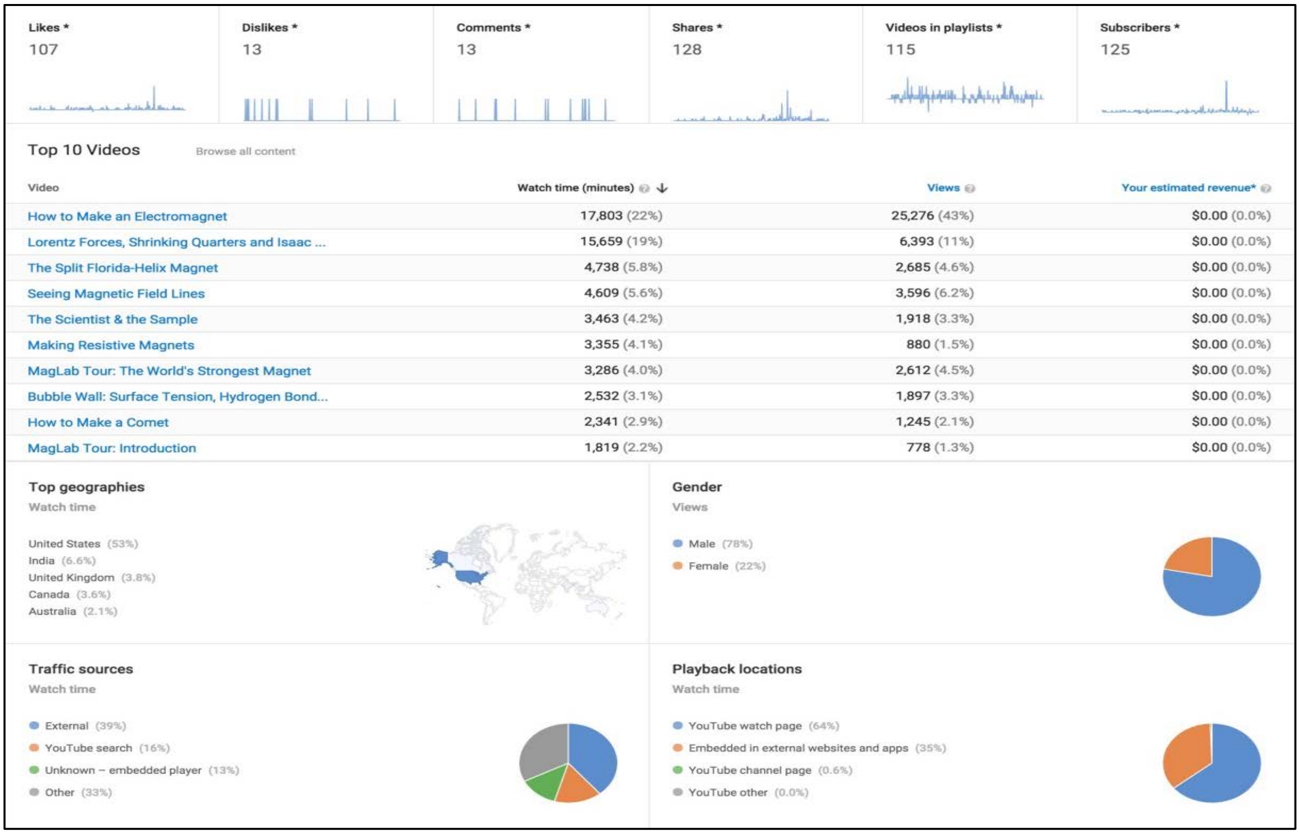
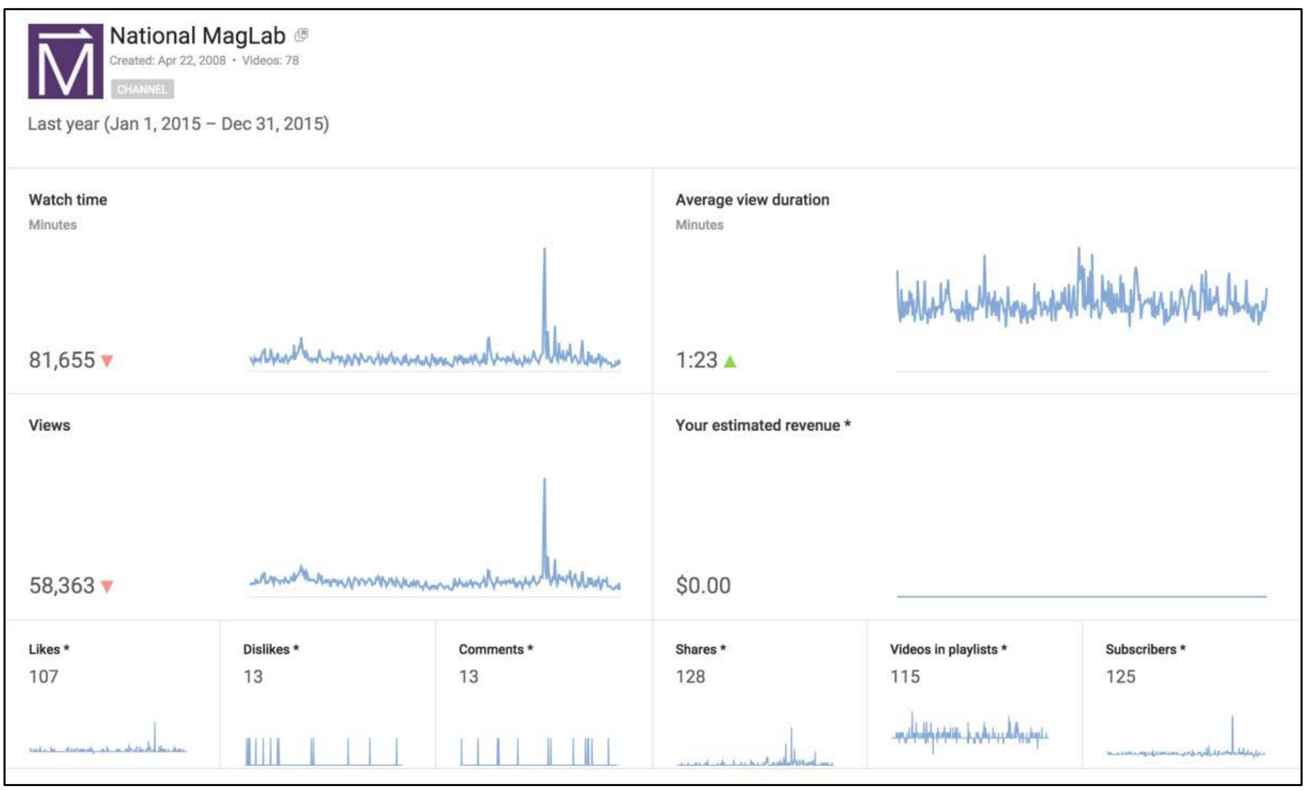


Video	Watch time (minutes)	Views	Your estimated revenue*
How to Make an Electromagnet	17,803 (22%)	25,276 (43%)	$0.00 (0.0%)
Lorentz Forces, Shrinking Quarters and Isaac ...	15,659 (19%)	6,393 (11%)	$0.00 (0.0%)
The Split Florida-Helix Magnet	4,738 (5.8%)	2,685 (4.6%)	$0.00 (0.0%)
Seeing Magnetic Field Lines	4,609 (5.6%)	3,596 (6.2%)	$0.00 (0.0%)
The Scientist & the Sample	3,463 (4.2%)	1,918 (3.3%)	$0.00 (0.0%)
Making Resistive Magnets	3,355 (4.1%)	880 (1.5%)	$0.00 (0.0%)
MagLab Tour: The World's Strongest Magnet	3,286 (4.0%)	2,612 (4.5%)	$0.00 (0.0%)
Bubble Wall: Surface Tension, Hydrogen Bond...	2,532 (3.1%)	1,897 (3.3%)	$0.00 (0.0%)
How to Make a Comet	2,341 (2.9%)	1,245 (2.1%)	$0.00 (0.0%)
MagLab Tour: Introduction	1,819 (2.2%)	778 (1.3%)	$0.00 (0.0%)



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Science Café
The Magnet Lab's Science Café series continued in 2015 with quarterly café's. The Cafés were also video recorded, posted on the Magnet Lab's YouTube channel, and shared via social media, allowing this local series to have a broader impact than just the Tallahassee geographic area.

Science Café Presentations in 2015

Date	Topic	Speaker	Number of attendees/views online
February 25, 2015	The Aesthetics of the MagLab's Magnets	Greg Boebinger	50 attendees 131 views
June 24, 2015	Popcorn, Radar & Cell Phones: How Microwaves Rule the World	Thierry Dubroca	75 attendees 164 views
October 6, 2015	Taming Tumors: Exploring the Role of MRIs in Cancer Care	Cathy Levenson	70 attendees 73 views

Open House Every February, the Magnet Lab invites the public to spend the day at our world-class research laboratory, and in 2015, about 5,700 people attended. The free event transforms our 370,000 square foot lab into an interactive science playground featuring more than 80 hands-on demonstrations, self-guided tours, food, and the chance to meet and chat with Magnet Lab scientists. Open House visitors brought nearly 2,000 pounds of canned food to be donated to Second Harvest, a community food bank in the Big Bend area.

Tours The Magnet Lab, led by Public Affairs, holds monthly Public Tours on the third Wednesday of each month at 11:30 am. In addition, all Magnet Lab personnel with proper safety training are welcome to provide tours to students, families, and general members of the public. Each year CIRL holds a Magnet Lab tour training for interested Magnet Lab personnel with an actual walk through of the lab for new tour guides interested in providing outreach. In 2015, 897 people (outside of our K-12 student tours) received a tour of the lab.

Presentations in 2015 In addition to these many forms of outreach, CIRL staff also present at conference for teachers and the general public to inform them about our programs and the research conducted at the NHMFL. The 2015 educational outreach presentations included:

- R. Hughes (January 2015) "Broader Impacts at the National High Magnetic Field Laboratory." Presentation at the Condensed Matter Science Broader Impacts Meeting, Washington, DC.
- J. Sanchez (March 2015). REU and Internship presentation at the Florida Georgia Louis Stokes Alliance for Minority Participation Summit, Leesburg, FL.
- C. Villa and K. Roberts (April 2015). "National High Magnetic Field Laboratory." Presentation at the National Science and Engineering X-STEM Festival, Washington, DC.
- R. Hughes (May 2015). "Outreach at a National Lab." Presentation at the Network for Broader Impacts Annual Conference, Madison, WI
- C. Villa (September 2015). "National High Magnetic Field Laboratory." Presentation at the National Organization for Black Chemists and Chemical Engineers, Orlando, FL.
- C. Villa (October 2015). "The Maglab Presents: The Attraction of Magnets". Presentation at the Florida Association of Science Teachers, Tallahassee, FL.
- J. Sanchez (October 2015). "REU program." Morehouse Hopps Symposium, Atlanta, GA.
- J. Sanchez (November 2015). National High Magnetic Field Laboratory Exhibitor Booth. American Indian Science and Engineering Society, Phoenix, AZ.
- R. Hughes (December 2015). "SciGirls Tallahassee". Presentation at the National SciGirls Conference, Seattle, WA.

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UNDERGRADUATE, GRADUATE, AND POSTDOCS

Magnet Lab Internship Program (For students 17 years or older)

The Magnet Lab Internship program is facilitated by Jose Sanchez. The program runs on a semester basis. The fall and spring semester students volunteer, however, during the summer, students are paid for their internship work. This program provides stellar high school students with an interest in research to work with a scientist at the lab. It also provides undergraduates who may not have the research and course experience for acceptance into an REU program with the opportunity to gain that experience. In 2015, 32 high school and college students participated in this program, of these: 28% were female, 12% were African American, 3% were Hispanic, and 6% were Native American.

Undergraduate – Research Experiences for Undergraduates (REU)

The Magnet Lab's REU program has been facilitated by CIRL since 1999. Since then more than 300 students have participated. This program is one of CIRL's finest in its historical quality and demonstration of the commitment of the Magnet Lab to mentoring early career scientists. The director of the REU program is Jose Sanchez. Each year he is committed to diversity in his recruitment of undergraduates to apply to the REU program, visiting Minority Serving Institutions and speaking to Minority Serving Organizations at colleges and universities. In 2015, 24 undergraduates participated in the REU program at all three Magnet Lab sites, of these students: 63% were female, 25% were African American, 29% were Hispanic, and 21% came from Minority Serving Institutions.

Graduate Students and Postdocs Professional Development

Kari Roberts continues to serve as our Postdoc Liaison and Evaluation Coordinator for the lab. She works closely with Postdocs to ensure that their mentoring and professional development needs are being met. The professional development opportunities that she organizes are also open to graduate students and any other Magnet Lab staff. In 2015 these professional development opportunities included:

Session Topic	Date	Presenter
Academic Job Search	January 2015	Dr. Janet Lenz, FSU Career Center
Interviewing	February 2015	Dr. Janet Lenz, FSU Career Center
American Physical Society Presentation Practice Session	February 2015	Dr. Audrey Grockowiak and Dr. Nihar Pradhan, NHMFL
Mentoring Roundtable	March 2015	National Postdoctoral Association
Cultivating Habits of Writing and Time Management	May 2015	Dr. Tamara Bertrand Jones, FSU
Special Postdoc Lecture by Dr. Peter Hitchcock, University of Michigan: ***Institutional resources and a two directional relationship between sponsor and mentee, leads to competitive independent scientists***	September 2015*	Dr. Peter Hitchcock, University of Michigan
FSU Postdoc Symposium	September 2015	FSU Office of Postdoctoral Affairs
Working in Industry After Training at FSU	December 2015	Dr. Cleyde Helena, Gerstel Technologies

**No sessions were held during the summer based on previous feedback that many people travel during the summer.*

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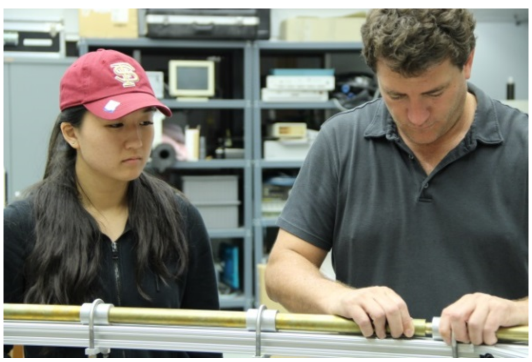
In addition to these live sessions, postdocs also have access to recorded sessions on many of these topics online, which allows postdocs to revisit these topics at their leisure and as often as they find necessary.

Postdoc Seminars

Another available resource to postdocs at the lab is the Postdoc Seminar Series. This series provides postdocs with the opportunity to present, but the seminar itself is open to anyone at the Magnet Lab. This seminar series is designed to give postdocs the chance to perfect their presentation skills to a wider audience who may not be familiar with their research and to network with colleagues at the lab. Postdocs will often use these seminars as a chance to practice for upcoming conference presentations and job talks. After each talk, attendees are given the opportunity to give feedback to the presenter.



A MagLab Postdoc mentoring a 2015 REU student

Mentoring for MagLab Postdocs

Postdocs at the MagLab have opportunities to be both a mentor and a mentee. The lab has a large number of potential mentors for postdocs including MagLab research staff, professors at nearby universities, and users. Additionally, the lab has about 175 undergraduate and graduate students that postdocs could mentor. However, only 44% of our postdocs believe they have mentored others at the lab, but the majority feel that they are prepared to mentor (72%). Based on the annual postdoc survey responses, the majority of postdocs report that their PI or supervisor acts as a mentor, and that they are satisfied with the mentoring they receive. While the majority of postdocs see their supervisor as a mentor (74%), very few (31%) report having mentors beyond their supervisor. CIRL maintains a list of scientists who have agreed to serve as secondary mentors to postdocs, however postdocs are encouraged to contact any scientist at the lab that they would like to speak with. Next year, we will be piloting a formalized mentoring program to help postdocs make connections with more mentors to facilitate greater networking for postdocs. We plan to begin a formalized mentoring program similar to LANL's mentoring program in 2016.

Annual Survey to Postdocs and Graduate Students

For the 2015 Postdoc Annual survey 35% of the 57 postdocs at all three sites completed the survey. The survey asked postdocs about their interests in professional development topics as well as their satisfaction with the mentoring they received as well as their experience overall. The majority of postdocs appear to be satisfied with their overall experience at the lab (64%, with 26% claiming they are neutral). There were a few postdocs who expressed some concerns with their experience. While the survey was confidential, it was not anonymous, so we are able to follow up privately with the postdocs who voiced concerns and complaints.

The demographics of the respondents overall resembles the demographics of the total postdoc population at the Magnet Lab. The survey also allowed us to collect new demographics on postdocs that are unavailable through other lab systems (e.g. year postdoc received PhD and length of postdoc position).

Race and Ethnicity

Race/Ethnicity	Number	%age (N= 19)
Hispanic or Latino/a	0	0.0%
Asian	9	47.3%
Black/African American	1	5.3%
American Indian or Alaska Native	2	10.6%
Native Hawaiian or Pacific Islander	1	5.3%
White/Caucasian	11	57.9%

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Gender

Male	Female
10 (52.7%)	9 (47.3%)

Year Respondent Received Ph.D.

Year	Number	%age (N= 19)
2007	1	5.3%
2008	1	5.3%
2009	0	0.0%
2010	1	5.3%
2011	4	21.1%
2012	3	15.7%
2013	2	10.5%
2014	4	21.1%
2015	3	15.7%

Citizenship Status

US Citizen or Permanent Resident	Visa Holder
8 (42%)	11 (58%)

Length of Postdoc Position

Duration	Number	%age (N= 16)
<2 years	4	25.0%
2 years	4	25.0%
3 years	5	31.3%
>3 years	3	18.7%

Future Plans

Postdocs were surveyed to assess their interest in professional development topics as well as a general sense of their ideal career path. Fewer postdocs indicated an interest in an academic position compared to last year (58% in 2015, down from 69%. 21% indicated that they would like to pursue a career in industry next, and another 16% said they planned to take another postdoc position. 5% (n=1) responded "other" and in the comments section said they were unsure of their next steps. Because we utilize an annual survey we can better meet the professional development needs of our postdocs by tailoring our sessions to their current and future plans.

In addition, in 2015 Kari formed a Postdoc Advisory Committee, comprised of postdocs to gather more information and ideas about how the lab can better serve them.

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NHMFL SCIENTISTS' AND STAFFS' COMMITTMENT TO OUTREACH

Undergraduate Tour Group 2015

NHMFL Personnel Outreach

CIRL is only one piece of the NHMFL's outreach, without the scientists and staff at the lab, there would be no role models to motivate students to pursue STEM and to inform the community about the NHMFL's commitment to materials, energy, and life. In 2015, 73 NHMFL scientists and staff members reported doing at least one type of outreach in the community. The outreach conducted by these scientists reached 2,453 people. Outreach conducted by NHMFL staff reached a wide range of ages, from elementary school students to senior scientists. The representation of these groups is:

- 36% Middle and High School Students
- 31% General Public
- 29% Undergraduate and Graduate Students
- 20% Elementary School Students
- 1% K-12 Teachers
- 1% Scientists and Faculty

In 2015, 55 scientists participated in long-term commitment outreach efforts, reaching a total of 99 individuals. As part of CIRL programs, these scientists mentored 17 middle school mentorship students, 32 interns, 10 RETs, and 24 REUs.

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Department		Number of People Reached					
	Number of Scientists	Elementary Students	Middle/High Students	Undergraduate and Graduate Students	Scientists and Faculty	General Public	K-12 Teachers
ASC	5		101	1		14	2
NMR	4		1	3			
EMR	3		5	1		30	
ICR	5	250	112	89	27	150	
CMS	12		10	7			2
UF	9		24	85	3	450	
DC	3	230	65				
Geochem	7		16	3			4
MS&T	14	100	510	61			2
Scientific Instrumentation and Operations	5		34				
Director's Office*	4		5			50	
LANL	2			6			

RESEARCH AND EVALUATION

Evaluation

Kari Roberts conducts all evaluation for our programs. Her evaluation and research statistical expertise allow CIRL to maintain high quality programs of a list of our evaluation efforts can be found in the table below.

Outreach	Form of Evaluation
Classroom outreach	Post-survey to teachers after outreach conducted (formative assessment)
RET/REU/Summer Camps/Middle School Mentorship	Pre-/post-survey measuring attitudes toward STEM careers, perceptions of STEM careers, and self-efficacy in STEM (for teachers in teaching STEM) Annual tracking of past participants to determine persistence over time
Graduate Student/Postdoc Professional Development	Annual survey to current postdocs to determine professional development needs and assess mentoring, post-session surveys after each professional development event, annual tracking of graduate students and postdocs to determine career trajectories, and starting in 2015, entrance and exit interviews with postdocs.
NHMFL Winter Theory School and NHMFL Users Summer Schools	Post-survey assessing perceived value of program on their career trajectories.

Research

In 2015, CIRL staff members (Kari Roberts and Roxanne Hughes) worked with FSU graduate student *Samantha Nix* to analyze and write the results of a research study that focused on FSU's STEM majors from 2001 to 2006. This resulted in a paper titled: Female Undergraduate STEM Persistence: A Focus on the Role of Living and Learning Communities which was accepted for presentation at the 2014 Research on Women and Education Conference, the 2014 Florida Educational Research Association Conference, and the 2015 American Educational Research Association Conference. The paper focuses on persistence rates for women who were part of a STEM living and learning community at FSU to the persistence rates of men and women from the general population of STEM majors during the same time.

In 2014, Roxanne Hughes worked with FSU graduate student Martin Bremer on a research project

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paid for by an FSU Council on Research and Creativity Planning grant. The researchers interviewed FSU physics majors to determine their motivations for majoring in physics, the obstacles they encountered in their major, and how they maintained their desire to persist. This study is the foundation for a larger study which would compare individuals who persist in physics to those who leave for other majors to determine ways that universities can address retention issues in STEM disciplines.

This research resulted in the following presentations in 2015:

- S. Nix, K. Roberts, and R. Hughes (April 2015) Female Undergraduate STEM Persistence: A Focus on the Role of Living and Learning Communities. Presentation at the American Educational Research Association Chicago, IL
- R. Hughes (February 2015). Gender Stereotypes: Do women who persist in STEM maintain negative gender stereotypes. Presentation at the annual American Association for the Advancement of Science Conference San Jose, CA.

The following are a list of CIRL staff publications in 2015:

Peer-reviewed articles:

- Hughes, R. (2015). An Investigation into the Longitudinal Identity Trajectories of Women in STEM. *Journal of women and Minorities in Science and Engineering*, 21(3),181-213.

Grants Submitted in 2015

CIRL's research agenda includes applications for external funding through grants. As part of this agenda, we submit proposals for outside funding to address our research needs. These proposals build on the expertise that Dr. Hughes brings to informal science education and strengthen our diversity impact.

Funding organization	Submission date	Title of Grant	Underrepresented group that was part of grant
NSF- IUSE	11/3/15 Hughes PI	A Comparative Case Study of Undergraduate Chemistry and Physics Programs within Three Diverse College Campuses	Underrepresented undergraduate students in physics and chemistry
NSF-AISL	11/4/15 Hughes PI	Exploring How Linking STEM to Sports can Increase Middle School Students Interest in STEM Careers	Low income students
NSF-AISL	11/4/15 Hughes co-PI	SciGirls CONNECT2: Investigating the Use of Gender Equitable Teaching Strategies in a National STEM Education Network	Girls in STEM

Plans for 2016 include:

- Strengthen outreach partnerships with UF and LANL
- Publication of research conducted in 2014 and 2015
- Continue annual tracking of all participants
- Maintain up-to-date knowledge of best practices in broader impacts

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CIRL's 2015 Educational Programs included:

2015 REU Participants

Participant	School	Research	Mentor
Beau Billings	Florida State University	Manganese Biogeochemistry in the Bay of Bengal	Peter Morton
Deanna Bousalis	Florida State University	Analysis of Cellulose Hydrolysis Kinetics	John Telotte
Jamie Burke	Florida State University	Radio Frequency Signal Leakage in Mutilated Micro-Coaxial Cable	Stan Tozer
Ramon Cabrera	Stony Brook University	A Conformational Study for the Validity of a Valproic Acid Induced Rat Model of the Autism Spectrum Disorder	Marcelo Febo (UF)
Winston Chu	Florida State University	Arduino Control System for a Temperature Bath	Theo Siegrist
Anne Collar	Florida State University	Duchenne Muscular Dystrophy Genetic Modifiers	Glenn Walter (UF)
Hector Colon	University of Puerto Rico at Mayaguez	Optimization of Milling and Sintering time in Synthesis of K-doped Ba-122 Superconductor	Eric Hellstrom
Brian Giraldo,	Montclair State University	Synthesis and Reduction of K5BiMo4O16	Theo Siegrist
Leon Gonzalez	Florida State University	Lithium Diffusion in Graphene System through Molecular Dynamics	Jose Cortes
Jasmine James	Claflin University	Systems Genetics of cold tolerance in a natural population of Drosophila melanogaster	Dan Hahn
Sania Kamran	University of Miami	Free Water Difference in the Cerebellum and Basal Ganglia of Essential Tremor Patients	David Vaillancourt (UF)
Brittany Keys	Jackson State University	Instrumentation for High Magnetic Fields	Chris Beedle (LANL)
Mishu Amanatullah Khan	University of Florida	Analysis of Magnet Stability Under Various Parameters via Using a Modified Superconducting Coil Simulation Code (GANDALF)	Iain Dixon

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Participant	School	Research	Mentor
Hannah Landy	Hampton University	Measuring the Concentration of Anions in Aqueous Samples by Ion Chromatography	Bill Landings
Kaylee Ludden	University of Florida	Construction of a Continuous Flow High-Field Pasadena Hydrogenation Reactor for Analysis of Stereoselectivity of Concerted Addition to Triple Bonds	Russ Bowers (UF)
Brittany McGregor	Florida State University	Extraction of Lithium From Seawater Using Ion Exchange Chromatography	Roy Odom
Colleen Munroe	Roger Williams University	Determination Of Spin-Lattice Relaxation Times Of 7Li Doped With Various Concentrations Of Mn(Ii)	Bill Brey
Raysa Pereira	Buffalo State College - SUNY	Development of High Field Magnet Technology for High Temperature Superconductor - 2223 Initiative	Arno Godeke
Carena Ramos	Washington State University	Decomposition of Two Dimensional 13C-13C Solid State NMR Correlation Spectra for Structural Determination of Proteins	Zhehong Gan
Nikole Roland	Gardner-Webb University	Photochemical Degradation of Petroleum-Derived Water-Soluble Organics into Dissolved Organic Matter	David Podgorski
Scott Saunders	Iowa State University	Synthesis and Characterization of CeCu2Si2-xPx	Ryan Baumbach
Alysha Sheets	Tallahassee Community College	Solvent Extraction of Organic Compounds from Shale Rock	Amy McKenna
Brent Summers	Florida State University	Supply of Natural and Industrial Aerosols to the	Peter Morton

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Participant	School	Research	Mentor
		Indian Ocean	
Damon Williams	Florida Agricultural and Mechanical University	Rheology of Fmoc-FF/Methanol Hydrogel	Subramanian Ramakrishnan
Tatiana Yugay	Simmons College	High power microwave beam-splitter	Steve Hill

2015 RET Participants

Participant	School	Research	Mentor
John Branch	Alief Elsik High School Houston, Texas	Halogen Chemistry by LA-ICP-MS	Munir Humayun
Donald Bush	Lake Region High School Eagle Lake, Florida	Halogen Chemistry by LA-ICP-MS	Munir Humayun
Tami Church	Lapwai High/Middle School Lapwai, Idaho	Analyzing Nanoribbon Structure of Cu-Ag Composites for use in High Tesla Nondestructive Magnets	Bob Goddard
Mark Dignan	James S. Rickards High School Tallahassee, Florida	The Reconstruction of Ancient Diets and Environments	Yang Wang
Ashley Harvey	Apalachee Elementary School Tallahassee, Florida	Experimental Characterization of Azobenzene Photomechanical Polymers	William Oates
Jorge Natal	East Lake High School Tarpon Springs, Florida	The Reconstruction of Ancient Diets and Environments	Yang Wang
Stephanie Parramore	Oak Ridge Elementary School Tallahassee, Florida	Density measurements of Bi-2212 filaments - towards high-field magnet applications	Eric Hellstrom
Tia Paul	Paul Laurence Dunbar Middle School Fort Myers, Florida	Density measurements of Bi-2212 filaments - towards high-field magnet applications	Eric Hellstrom
Cedric Ward	Dr. Robert B. Ingram Elementary Opa-Locka, Florida	Experimental Characterization of Azobenzene Photomechanical Polymers	William Oates

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2015 Middle School Mentorship Participants

Participant	School	Research Area	Mentor
Dominic Andrews **Rohan Davidi**	Nims Middle School Fairview Middle School	The Polariscope: A Mechanism to Visualize Stress Patterns	Vince Toplosky & Bob Walsh
Julian Lee-Sursin **Parul Singh**	Fairview Middle School Montford Middle School	Building a Solar Powered Car	Hans Van Tol
Kenzi-Alayna Campbell **Katie Mann** **Shae Murphy**	Swift Creek Middle School Montford Middle School Trinity Catholic School	Molecular Level Characterization of Dissolved Organic Matter in Tallahassee Lakes	Amy McKenna
Sanjita Choudhary **T. Perry O'Connor**	Fairview Middle School Champion Prep Academy	The Acceleration of Gravity	Lloyd Engel
Tanvi Haldiya **Christopher Simonsen**	Fairview Middle School Deerlake Middle School	The Alternative to Neodymium	Ke Han & Dan Brown
Brodrick Brockman **Joseph Torrescano**	Nims Middle School Cobb Middle School	Arduino Build	Gary White
Emily Abbott **Kira Valdes**	Fort BradenSchool Cobb Middle School	Photosynthetic Pathway of Bamboo: C3 vs. C4	Yang Wang & Bruce Barnett
Madeline Feiock **Neha Iyer**	Cobb Middle School Deerlake Middle School	Crystal Synthesis of Cuprate Superconductors	Ryan Baumbach

Education Programs in Diversity Classification

2015	Total	% Women	%African American	% Hispanic	%Native American
Research Experiences for Undergraduates (REU) summer	24 undergraduates	63%	25%	29%	NA
Research Experiences for Teachers (RET) summer	9 K-12 teachers	44%	44%	22%	NA
Middle school Mentorship (Fall)	17 middle school students	59%	18%	6%	NA
Internship	32 (high school and college)	28%	12%	3%	6%
MagLab Summer Camp (Two 1-week camps)	32 (middle school students)	44%	16%	3%	NA
SciGirls Summer camp (Two 2-week camps)	32 (middle school students)	100%	28%	16%	NA

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2. Conferences and Workshops

Throughout the year, the National High Magnetic Field Laboratory hosts or sponsors a variety of workshops and conferences related to our science.

Winter Theory School
January 5 – 9. 2015
Tallahassee, FL

At the 4th Theory Winter School, lectures focused on frustrated magnetism, a subject of continuing relevance in Condensed Matter and Materials Research Theory. Ten leading experts in this active area of research presented tutorial lectures on the most relevant concepts, mathematical and numerical techniques, as well as experimental reviews of the field, to understand the complex physical phenomena emerging from frustrated magnets.

In addition, there were poster sessions during in which junior participants had the opportunity for direct exchange of ideas with lecturers and each other. Nearly 60 people attended.

APS Reception
March 4, 2015
San Antonio, TX

The MagLab hosted a reception at the American Physical Society's March Meeting. Sponsored by Florida State University, University of Florida and the MagLab, about 200 researchers from around the world were in attendance.

North American Fourier Transform Mass Spectrometry Conference
April 12 – 15, 2015
Key West, FL

The FT MS Conference is held every two years and is the premier of its kind in the field of Fourier Transform Mass Spectrometry and its applications. The 10th North American FT MS Conference featured presentations ranging from instrumentation to technique development in the biological/ biomedical sciences ranging from pharmaceutical metabolism to proteomics, environmental analysis and petroleomics, with special emphasis on new developments. As in the past, partial support for several contributed posters for graduate students was offered. This four day conference hosted 76 attendees, 24 invited speakers and, awarded 13 student awards. Conference ended with a plenary from talk from Jean Futrell of Pacific Northwest National Laboratory and a banquet dinner at the Hemingway House.

Prof. James Brooks Memorial Symposium
May 16, 2015
Tallahassee, FL

The Prof. James Brooks Memorial Symposium was a one-day event during which colleagues and friends will have the opportunity to share research done in collaboration with Dr. Brooks as well as reminiscences from their life experiences. More than 80 people were in attendance.

User Summer School
May 18-22, 2015
Tallahassee, FL

The 6th annual User Summer School introduced 28 students, early-career scientists and potential users to the MagLab's infrastructure, experimental options, and support staff. Through a combination of tutorials, talks and practical exercises, the User Summer School helped attendees develop skills for use in both their home laboratory and across user facilities worldwide.

This weeklong event features tutorials on measurement techniques, practical exercises and plenary talks from experts in the field of condensed matter physics.

Empowerment Project Event
August 8, 2015

The MagLab and WFSU co-hosted an event dedicated to empowering girls in the Big Bend community. The free event focused on middle and high school girls, but girls of any age and families are welcome. Part of the event will be a showing of the documentary film, The Empowerment Project, which interviews 9 women who have overcome obstacles to achieve success in their fields. More than 250 girls and their families, as well as community members attended the event.

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The Southeast Magnetic Resonance Conference (SEMRC)
October 9-11, 2015
Daytona Beach, FL

SEMRC is held every year and rotates among various locations in the southeastern United States and has a long history of bringing together leading scientists to discuss the latest developments in NMR, EPR, and MRI. The focus of the conference is the exchange of ideas and recent magnetic resonance research highlights, including new applications and technique development. Particular emphasis is placed on activities in the region. The SEMRC puts a special emphasis on the participation of young scientists (students and postdocs) and provides excellent opportunities to exchange new exciting results with their peers as well as with the leaders in the field. This year, there were 110 participants.

Saturday Morning Physics: Science & Technology of Magnets
November 7, 2015
Tallahassee, FL

The MagLab hosted a special program for the Saturday Morning Physics series, which is coordinated by the Florida State University Physics Department. MagLab Director Greg Boebinger and Prof. Irinel Chiorescu discussed the science and technology of magnets to about 120 students and parents from the local Tallahassee area.

Pacifichem 2015 - Advances in Biological Solid-State NMR
December 15-20, 2015
Honolulu, HI
The 2015 International Chemical Congress of Pacific Basin Societies (PAC CHEM™) is the seventh in the series of successful Congresses. Founded in 1984, these conferences have been held in Honolulu, Hawaii about every five years. The theme this year was, *Chemical Networking: Building Bridges Across the Pacific*, emphasizing the collaborative nature of chemistry as a multidisciplinary science and the opportunities to network with Pan-Pacific research \roups at the Pacifichem meetings. The meeting attracted over 14,000 scientists from 71 different countries representing all degree levels and all fields of chemistry and the chemical sciences.

Weekly Seminar Series:
January 13, 2015: Seminar by Louk Rademaker, Kavli Institute of Theoretical Physics: *Glassy dynamics in geometrically frustrated Coulomb liquids without disorder*

January 13, 2015: Seminar by Tony Heinz, Stanford University

January 16, 2015: Seminar by Ganpathy Murthy, University of Kentucky: *Composite Fermions for fractionally filled Chern Bands*

January 23, 2015: Seminar: *Matteo Tropeano, Columbus Superconductors: Progress in MgB2 wire development from promising features to industrial production*

January 23, 2015: Seminar: Sean Hartnoll, Stanford University

January 30, 2015: Seminar: Ching-Kai Chiu, University of British Columbia: *Classification of Topological Crystalline Semimentals and Nodal Superconductors*

February 12, 2015: Seminar: Magnet Science & Technology by Mark Bird, National High Magnetic Field Laboratory: *An Overview of Magnet Science and Technology at the MagLab*

March 10, 2015: Seminar by Shouvik Sur, McMaster University: *Non-Fermi liquid at antiferromagnetic quantum critical point near3 dimensions*

March 13, 2015: Seminar by John J. Quinn, University of Tennessee: *The Absence of Higher Generations of Composite Fermions in Quantum Hall Systems*

March 16, 2015: Seminar by Avadh Saxena, Los Alamos National Lab: *Skyrmions in Chiral Magnets: Twisted Topological Excitations*

March 17, 2015: Talks by Nobel Laureate Eric Betzig and Harald Hess:

- Talk for Undergraduates: *Fantastic Voyage: Moving from the Macroworld to the Nanoworld in 400 Years*, Eric Betzig

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- Colloquia: *A Strange Way to Win a Nobel Prize*, Eric Betzig; *Resolving Everything*, Harald Hess; *Resolution Is Not Everything*, Eric Betzig

March 27, 2015: Seminar by John Tranquada, Brookhaven National Laboratory: *Exploring Intertwined Orders in High-Temperature Superconductors*

April 10, 2015: Seminar by Dr. Seunghyun Moon, the CEO of SuNAM Co. Ltd.: *26-T/35-mm No-Insulation Multi-Width All-REBCO Magnet: Design, Construction, and 4.2-K Operation*

April 10, 2015: Seminar by Erica Carlson, Purdue University: *Decoding Spatial Complexity in Strongly Correlated Electronic Systems*

April 17, 2015: Seminar by Scott Marshall, National High Magnetic Field Laboratory: *Magnet Science & Technology Design, Construction and Testing of the 20 kA Binary Vapor-Cooled / HTS Current Leads for the MagLab Series-Connected Hybrid Magnet*

April 29, 2015: Seminar by Dr. Laura Greene Department of Physics, Materials Research Laboratory, and Center for Emergent Superconductivity, University of Illinois at Urbana-Champaign: *Detection of electron matter in Fe-pnictides, Fe-chalcogenides, and heavy fermions*

July 21, 2015: Seminar by Najib Cheggour, Senior Research Associate - National Institute of Standards and Technology Physical Measurement Laboratory Electromagnetics Division: *The strain irreversibility cliff in Nb3Sn RRP® wires and its consequences on the fabrication of quadrupole magnets for the LHC luminosity upgrade*

August 10, 2015: Seminar by Ying Wang, Florida State University Condensed Matter Science: *Infrared Study of Topological Crystalline Insulator in Magnetic Field*

August 28, 2015: Seminar by Zi-Xiang Hu, Chong-Qing University, China: *Quasiparticle tunneling and its scaling behavior in the fractional quantum Hall effect*

September 9, 2015: Seminar by Jun Yan, University of Massachusetts: *Probing transition metal dichalcogenide atomic layers with helicity-resolved Raman scattering*

September 19, 2015: Seminar by Christoph Emanuel Gull, University of Michigan: *Superconductivity and the pseudogap in the two-dimensional Hubbard model*

September 25, 2015: Seminar by Jose L. Mendoza-Cortes, Florida State University: *New Computational methods and its applications to Renewable Energy, Semiconductors and the Porous Materials Genome*

October 6, 2015: Seminar by Seungyong Hahn, Applied Superconductivity Center: *No-Insulation Winding Technique for Compact, Reliable, and Low-Cost HTS DC Magnets and Speaker: Denis Markiewicz, Magnet Science & Technology Title: Quench of a Pancake Wound REBCO Coil with Resistance between Turns*

October 9, 2015: Seminar by Sung-Sik Lee, Perimeter Institute: *Ab Initio Holography*

October 23, 2015: Seminar by Nicola Lanata, FSU, NHMFL: *First principle calculations of Strongly Correlated Materials and description of the correlated electrons based on Quantum Entanglement Speaker*

October 30, 2015: Seminar by Ludwig Schultz, an IEEE Distinguished Lecturer: *Interaction of Ferromagnetic and Superconducting Permanent Magnets: Superconducting Levitation*

November 6, 2015: Seminar by Dmitri Khveshchenko, University of North Carolina: *Demystifying the holographic mystique.*

November 12, 2015: Seminar by Dr. Michael Schillo, Varian Medical Systems: *Overview on Proton Therapy and Equipment*

November 16, 2015: Seminar by Mamoru Hamada: *Development of 1020 MHz NMR superconducting magnet using Bi-2223 innermost coil*

November 30, 2015: Seminar by Zili Zhang, Applied Superconductivity Center: *Investigation of*

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melt and growth process of $YbBa_2Cu_3O_{7-\delta}$ powder and tapes Speaker

December 4, 2015: Seminar by M. Janoschek, Condensed Matter & Magnet Science, Los Alamos National Laboratory: *Neutron Spectroscopy of Strongly Correlated Electron Materials Speaker*

December 11, 2015: Seminar by Zhiqiang Mao, Department of Physics and Engineering Physics, Tulane University, New Orleans: *Quantum transport properties of topological semimetals TaP and $Sr_{1-y}Mn_{1-z}Sb_2$*

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3. Broadening Outreach

In addition to the Diversity and Education sections which speak to the MagLab's work in broadening outreach through education and underrepresented groups, the lab's staff are regularly presenting new research and sharing information about our user program at national and international conferences, workshops and seminars. Each presentation, poster or abstract opportunity offers the chance for scientists around the world the opportunity to learn more about the lab's research capabilities and broaden our user program to appeal to new scientists from varying levels – from graduate students and postdoc to seasoned scientists.

In 2015, MagLab staff gave more than 400 lectures, talks and presentations across 20 countries:

Conferences:

- 10th North American FT MS Conference
- 11th International Conference on Materials and Mechanisms of Superconductivity
- 170th Meeting of Acoustical Society of America
- 2015 Aspen Winter Conference
- 2015 International Symposium on Quantum Fluids and Solids
- 2015 MRS Spring Meeting, Symposium VV - Science and Technology of Superconducting Materials
- 250th American Chemical Society Fall Meeting Symposium on Synthetic Chemistry Approaches to Magnetic Materials
- 43rd annual International europsychological Society meeting
- 44th Southeastern Magnetic Resonance Conference
- 56th Experimental Nuclear Magnetic Resonance Conference
- 59th Annual Meeting of Biophysical Society
- 63nd American Society for Mass Spectrometry Conference on Mass Spectrometry and Allied Topics
- Advanced Qualification of Additive Manufacturing Materials
- American Association for the Advancement of Science
- American Chemical Society Spring Meeting Symposium in Honor of Kim R. Dunbar
- American Chemical Society Spring Meeting
- Symposium on Chemical Approaches to Spintronics Research
- American Educational Research Association
- American Horticultural Therapy Association Annual Meeting
- American Society for Microbiology 115th General Meeting
- American Society of Pharmacognosy's (ASP) 2015 Annual Meeting
- APS March Meeting
- Association for Clinical and Translational Science
- Biologically enabled self-assembly Workshop
- California Separation Science Society 12th Symposium on the Practical Applications of Mass Spectrometry in the Biotechnology Industry
- Conference on Unifying Concepts in Glass Physics
- Discovery on Parade
- Eastern Analytical Symposium, EAS Award for Outstanding Achievements in the Fields of Analytical Chemistry Symposium
- Energy Materials and Nanotechnology Fall Meeting
- FCC week 2015
- Florida Annual Meeting and Exposition
- Fundamental Optical Processes of Semiconductors (FOPS2015)
- Future Circular Collider Workshop

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- Geological Society of America Annual Meeting
- Geological Society of America Southeastern Section Meeting
- Gordon Research Conference: Enzymes, Coenzymes & Metabolic Pathways
- Grand Challenges in Quantum Fluids and Solids Workshop
- GRC Quantum control
- Greater Everglades Ecosystem Restoration
- Gulf of Mexico Oil Spill & Ecosystem Science Conference
- ICAM Conference: Strongly Correlated Topological Insulators: SmB6 and Beyond
- Ingot Niobium CRADA Workshop
- International Conference on Research in High Magnetic Fields
- International Cryogenic Materials Conference CEC/ICMC-2015
- La Jolla Workshop on Big Ideas in Quantum Materials
- Large Scale Facilities Workshop
- LTSW 2015 Low Temperature Superconductivity Workshop
- Metals in Biology Gordon Research Conference
- MRS-2015 - Materials Research Society Spring Meeting
- MSACL
- National SciGirls Conference
- National Society of Black Physicists conference
- NMR Inaugural Symposium
- North American Solid State Chemistry Conference
- Pacifichem 2015 – The International Chemical Congress of Pacific Basin Societies
- PCSI-42
- PittCon 2015, Petroleomics Symposium
- Rocky Mountain Conference on Analytical Chemistry
- Science and Technology of 2D Materials
- SEUFC conference
- Southeastern Biogeochemistry Symposium
- Summer Biomechanics, Bioengineering and Biotransport Conference
- Telluride Workshop, Enhanced Functionalities in 4 and 5d Containing Material from Large Spin-Orbit Coupling
- Telluride Workshop: Competing Interactions and Colossal Responses in Transition Metal Oxides
- The Low Temperature High Field Superconducting Workshop
- Workshop on "Emerging Frontiers in Experimental Condensed Matter Physics of Strongly Correlated Electron Systems"
- Workshop on Molecular Electron Spin Qubits
- Workshop on Multifunctional Nanomaterials (WMN) /9th Workshop on Frontiers in Electronics (WOFE-2015)
- Workshop on Quantum Criticality: Heavy Fermion Systems and Beyond
- Workshop on Ultrahigh Field NMR and MRI: Science at the Crossroads

University/Lab-based:

- 2015 PEP Summer Research Colloquium at Tulane University
- 7th Annual Postdoctoral Research Symposium
- Department physics and astronomy colloquium, University of Kentucky
- Departmental seminar at the Rensselaer Polytechnic Institute
- Departmental Seminar at the University of Connecticut
- DOE BES/AMOS Program Review
- Florida State University
- General Atomics
- Kickoff Meeting for Brookhaven National Lab's Center for Material Design Lab
- Lawrence Berkeley National Lab
- Los Alamos National Laboratory Leadership
- Michigan State University
- Nanoscience Technology Center UCF
- Network for Broader Impacts
- NIST Center for Neutron Research, Colloquium
- Northwestern University

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- Oakridge National Laboratory
- Physics Department Colloquium, Lehigh University, Bethlehem, PA
- Physics Department, Seoul National University
- Physics Seminar, City College of the City University of New York
- Physics Seminar, Rutgers University
- Rice University Physics and Astronomy Department
- Seminar of Condensed Matter Group, Physics Department, University of Wisconsin-Milwaukee
- SNS/HFIR User Group Meeting
- Stanford Linear Accelerator Center
- Trinity College
- University of Florida
- University of Georgia
- University of Maryland
- University of Missouri - Saint Louis
- University of Pennsylvania
- University of Tennessee
- University of Wisconsin-Madison, Mechanical Engineering Department

CHAPTER 5
IN-HOUSE RESEARCH

CHAPTER 5 – IN-HOUSE RESEARCH

1. Magnets and Magnet Materials

Introduction

A central feature of the MagLab's mission is the provision of unique, high-performance magnet systems that exploit the latest materials and magnet design developments for our users. As we move forward, maintaining a balance of development of new magnet systems with development of new technology is of critical importance to keep us at the forefront. Collaborations with other leading industrial, academic and government groups that develop these new magnet technologies is built into many of these thrusts.

Executive Summary

During 2015, the MagLab made progress on many fronts. In particular:

1) The 36 T Series-Connected Hybrid magnet has been fully assembled! Work on the monitor and control system is still underway as well as cool-down which will be followed by system testing. The magnet includes current-density grading in the innermost resistive coils to cancel the z2 term. After full-field testing, shims and a stabilization system will be installed to enable the magnet to reach uniformity and stability of 1 ppm over a 10 mm diameter spherical volume, raising the field available for condensed-matter NMR 44%! This low-power resistive magnet, combined with probes developed in-house and a console from the commercial sector, will open a new era in ultra-high field (UHF) NMR which should build the case for UHF high-resolution NMR magnets.

2) In 2015, the final prototype-testing and coil-winding for the 32 T superconducting magnet was completed (**Fig. 1**). This magnet should be the first UHF magnet using High-Temperature Superconducting (HTS) materials to be put into routine service to the scientific community later this year.

3) We believe the next 5 – 10 years will feature a proliferation of UHF HTS magnets for various applications as a number of practical HTS conductors now exist and are being employed in a number of ways: a) No-Insulation REBCO coils promise to be more compact and less expensive than insulated ones, b) Bi2223 is now available in a high-strength version that shows great promise for NMR magnets due to its lower smaller filament size than REBCO, c) Bi2212 Wind and React technology advanced on many essential coil aspects, including insulation and coil-sized overpressure (OP) reaction furnace technology. It has also now been made in a high-strength form and also shows great promise for NMR magnets due to its multi-filamentary nature and round, isotropic structure.

4) Great progress continues to be made on both HTS and LTS conductor technology. A major effort to understand length-wise variations of REBCO coated conductors has shown up many kinds of defects that appear in as-delivered and as-tested wires. Major effort, in collaboration with DOE-High energy Physics and the industrial base has been put into assuring new powder suppliers and into understanding the parameters that must be specified in order to specify "good" powder. Major successes in understand the highest current-density forms of Nb_3Sn, RRP and PIT, have shown the vital role played by ternary phase (Nausite, a Sn-Nb-Cu intermetallic) membranes in mediating Sn diffusion.

Figure 1: *The innermost REBCO coil of the 32 T all-superconducting user magnet is pressed to measure elastic modulus.*

5) Pulsed magnets made a significant step forward in 2015. We were able to install an additional layer

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of conductor and reinforcement inside the 15.5 mm bore of the present design of 65 T magnet to create a 74 T magnet with the bore size of 7 mm. The magnet operates stably and has delivered more than 50 shots above 70 T for users to perform successful experiments in that small bore and at temperatures as low as 500 mK. We are considering the possibility of moving to smaller bores in a variety of magnet systems, and the impact on instrumentation, etc.

HTS MAGNETS AND MATERIALS

32 T Magnet Project

The MagLab intends to commission the world's first 32 T superconducting user-magnet during the summer of 2016. This will be the first user-magnet to emerge from the ultra-high-field (UHF) coil-development effort based on high-temperature superconductors (HTS) that began in 1991.

This 34 mm-bore magnet consists of a large-bore 15 T magnet based on Low Temperature Superconductors (LTS, NbTi & Nb_3Sn) combined with a pair of separately powered 17 T insert coils based on REBCO (Rare-Earth-Barium-Copper-Oxide) High Temperature Superconductor (HTS). One hour to full field is the target ramp-rate. Quench protection is provided by active quench heaters [1]. The design represents a breakthrough in superconducting magnet technology as the first user-magnet capable of > 30 T, well beyond the present limit of 23.5 for existing user-magnets, relying on HTS for more than half of the total magnetic field. (While various HTS test-coils have been built over the years reaching fields up to 40 T, we expect this 32 T system to be first to be put into routine service.) In the past year significant progress was made in two main areas of the project: 1) testing of prototype REBCO HTS coils in the final 15 T LTS coils, and 2) construction of the final 32 T REBCO coils.

1. *Prototype REBCO coil-testing in the 15 T LTS outsert*

Prototype coils, very similar in design to the 32 T REBCO coils but of reduced height, have been tested again, this time in the 15 T background magnetic field of the final 32 T LTS magnet that is now available [2]. The test protocol emphasized two areas: 1) observation of the interaction between the HTS and LTS coils during deliberate quenches, and 2) performance of the HTS prototypes at high stress-strain levels.

A deliberate quench at 24 T, with the LTS outsert at 15 T while the HTS coils generate 9 T, illustrated that the quench detection and protection in both HTS and LTS coils was effective in preserving the coils, with the HTS current reduced to 1/e of its initial value of 200 A in about 1 second. Numerical quench analysis gives a similar result. Quenches at lower LTS fields show that the current-decay in the REBCO coils is nearly independent of background field, but does depend on HTS coil-current and quench-heater power. In consequence, a quench-heater power-value that is adequate at full field, will be effective at low magnetic field values too in the 32 T magnet.

Peak stress-levels equivalent to the 32 T design-conditions were reached over a dozen times in the smaller of the two prototype coils, while the larger prototype coil was operated forty-four times to between 105 and 115% of design hoop stress. During this process a central magnetic field of 25 T was reached a dozen times, at relatively fast rates of 1 A/sec (2.9 T/minute) in the prototype coils. The prototypes were then slowly charged to 243 A and two days later to 264 A (> 150% of 32 T design-current) in the 15 T LTS magnet, generating central magnetic fields of 26 and 27 T respectively (see **Fig 2** and **3**). The latter, in June 2015, was the highest magnetic field ever generated by an all-superconducting magnet. An LTS plus REBCO magnet built by RIKEN and tested at NIMS in Japan broke that record in January 2016. However, those REBCO coils damaged themselves irreversibly at 27.6 T just before reaching the 28 T target, illuminating the challenging nature of high-field HTS-LTS magnet technology.

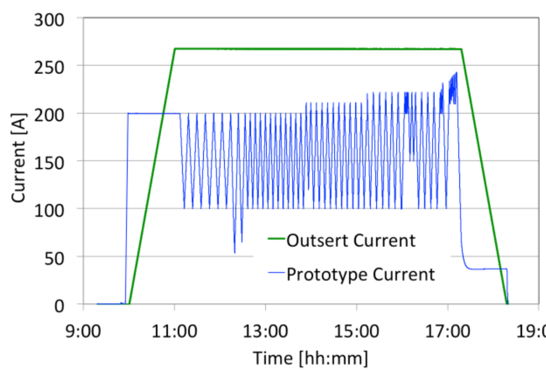

Figure 2: *History of the prototype current and Outsert current during one day of load cycling. At 268 A the Outsert generates 15.0 T, and at 243 A the prototypes generate 11 T for a total of 26 T at hoop stress levels above 32 T design values.*

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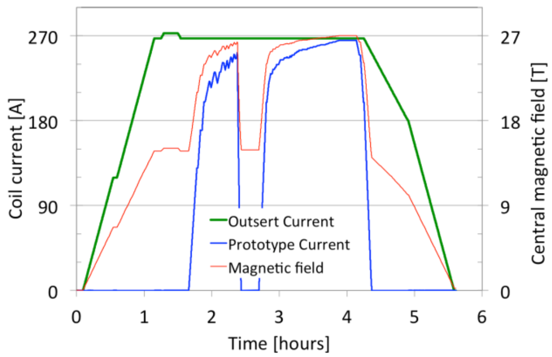

Figure 3: *Measured central magnetic field and current in the outsert and the prototype coils on June 5th, 2015. A stable peak field of 27.0 T was held for 16 minutes.*

At 27 T, the 32 T prototypes operated at 121% and 135% of 32 T design-stress. None of the 32 T experiments described above caused observable degradation of the coils' properties, increasing confidence in the quench-protection system and the stress-tolerance of the coils as designed. However, the quench-protection has its limits. The prototypes can be ramped aggressively (>2 A/sec) to above 220 A, far above the 0.05 A/sec and 177 A design limits of 32 T, which will reduce temperature margins in the prototypes to levels where quench is likely and the quench-protection is no longer effective. This was observed in an aborted attempt to rapidly load-cycle the prototype coils, when one module was somewhat damaged in a quench. Operating the 32 T magnet within the design-limits of current and ramp-rate will maintain the effectiveness of its quench-heaters.

2. 32 T Construction

All 56 double pancakes (modules) of the two REBCO coils were wound and impregnated with paraffin by the end of 2015, with assembly into coils underway. **Figure 3** shows REBCO Coil 1 under axial pre-compression in Dec 2015. Completion of the assembly of both REBCO coils and integration with the LTS outer magnet is projected to take until June 2016.

3. Summary

Two prototype coils for the 32 T superconducting magnet were extensively tested, being subjected to deliberate quenches at high magnetic field and operated repeatedly at and above the stress-levels of the equivalent coils for the 32 T magnet. The generation of record magnetic field values and absence of observable degradation in the prototype-coils when operated 20-50% beyond 32 T operating-parameters for stress and current give confidence in the 32 T design. The final magnet construction is underway with first operation anticipated in the summer of 2016.

References

1] Markiewicz, W.D., et al., IEEE Trans. Appl. Supercond., **22**, 4300707 (2012).

[2] Weijers, H.W., et al., IEEE Transactions on Applied Superconductivity, **26**-4 4300807 (2016).

[3] Personal communication and http://www.clst.riken.jp/en/topics/research/160411reseacheng/, accessed May 9, 2016.

No-insulation REBCO coil-development

1. Background and significance

REBCO tapes have been regarded as promising candidates for high-field magnets, mainly owing to their superb mechanical strength (>700 MPa tension with 95% critical-current retention) and large in-field current-carrying capacities (e.g., >1,000 A/mm^2 at 4.2 K and a 5 T "c-axis parallel" field). Yet, conventional REBCO magnets with insulation between turns have to be designed with a relatively low coil current-density, typically 200 A/mm^2, at a nominal operating-temperature of 4.2 K, due to the need to for sufficient Cu for quench protection.

First introduced in 2010, the no-insulation (NI) winding technique enables an NI-HTS magnet to be essentially *self-protecting*. The key idea is elimination of turn-to-turn insulation within the HTS pancake coils so that the coil current can automatically bypass normal zones in the superconducting turns by the turn-to-turn contacts. This shorting prevents overheating of the initial quench-spot and thus protects the magnet. Owing to this self-protecting feature, a minimal amount of stabilizer is required, just that required for ease of splicing and handling. Consequently an NI-HTS magnet is very compact and operates at a substantially higher engineering current-density than its insulated counterpart. The elimination of insulation and stabilizer layers, both mechanically "softer" than the REBCO tape itself, significantly enhances the mechanical robustness of an NI winding, which is another major benefit particularly relevant to UHF (>30 T) magnets.

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Magnets & Magnet Materials

A major drawback of the NI technique is the intrinsic *charging delay*, due to the radial current-path through turn-to-turn contacts within an NI coil. The detrimental effects of the turn-to-turn shorts and the radial "leak" current include: 1) Joule-heating during charging and consequent extra liquid helium consumption; 2) difficulty in precise field-control; 3) uncertainty in post-quench electromagnetic behavior. Recently, variations of the NI technique, e.g., partial insulation and metallic cladding insulation, have been introduced to mitigate the charging delay issues, together with operational approaches including active feedback control and current overshooting.

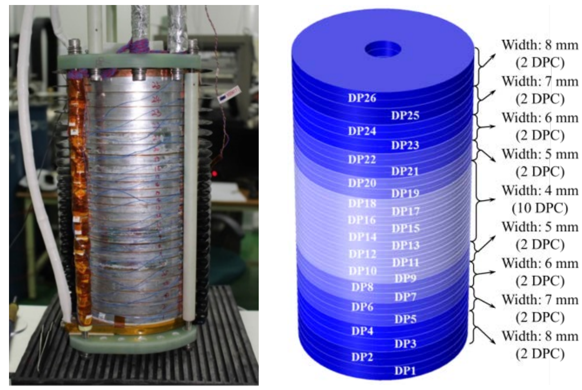
2. 26 T, 35 mm multi-width no-insulation all-REBCO magnet for KBSI

To date, >100 NI modules (small double-pancakes) and >10 NI test-coils have been designed, built, and tested. All of them showed the self-protecting feature at both 77 K (liquid nitrogen) and 4.2 K (liquid helium). **Fig 4** shows a 26 T, 35 mm winding-diameter all-REBCO NI test-coil that was designed by S. Hahn (Applied Superconductivity Center, MagLab) and constructed by the SuNAM Co., Ltd. in 2015 for the Korean Basic Science Institute. The magnet adopted the "multi-width (MW)" winding technique, essentially a conductor-grading approach for an HTS magnet consisting of a stack of double-pancake (DP) coils. A combination of NI and MW techniques not only satisfies key operational requirements in protection and stability but also enables MW-NI-HTS magnets to be highly compact, which will lead to significant reduction in magnet construction cost.

The test-coil consists of 26 DP modules using tape of five different widths. M1, wound with the narrowest width (4.1 mm) GdBCO tape, is located at the magnet center, while the others (M2 – M5) wound of progressively wider tapes (5.1 – 8.1 mm) toward the top and bottom of the magnet. The magnet has an inductance of 12.79 H, a charging time-constant of 947 seconds, and a stored energy of 370 kJ at its full field of 26.4 T.

3. Full-field quench-tests and "electromagnetic" quench-propagation

In April 2015, the magnet was first tested at SuNAM Co. Ltd. and reached 26.4 T at 242 A, a record high field for any all-HTS magnet to date. In September 2015, the magnet was temporarily moved



(a) (b)

Figure 4: *(a) picture of the 26 T 35 mm winding diameter NI all-REBCO test-coil, designed by S. Hahn (ASC-MagLab) and constructed by SuNAM, Co., Ltd.; (b) to-scale drawing of the magnet that consists of a stack of 26 double-pancake coils wound with "multi-width (MW)" REBCO tapes.*

to the Applied Superconductivity Center at the MagLab and full-field quench-tests were performed in a bath of liquid helium at 4.2 K in order to investigate the post-quench behavior of the magnet. The magnet was first quenched at 230 A during charging, lower than the previous record of 242 A for 26.4 T, mainly due to the faster ramping rate, (3 A/min vs 0.6 A/min in the previous test). After the first quench, the magnet was re-energized at an average ramping rate of 1.9 A/min and quenched again at 235 A. During the second charging, no discernible degradation was observed. **Fig 5** shows the measured terminal voltages of all 26 double-pancakes (modules) during the second quench. The initial quench started in DP18 and then propagated "electromagnetically" to other modules due to the turn-to-turn shorts within each NI module and the magnetic coupling between modules. The quench-propagation of the entire coil was completed within 1 second. The quench-propagation velocity is many times greater than in an unprotected insulated HTS coils. These tests provided the first experimental evidence for electromagnetic quench-propagation in a multi-module NI test-coil on a scale appropriate for a high field user magnet.

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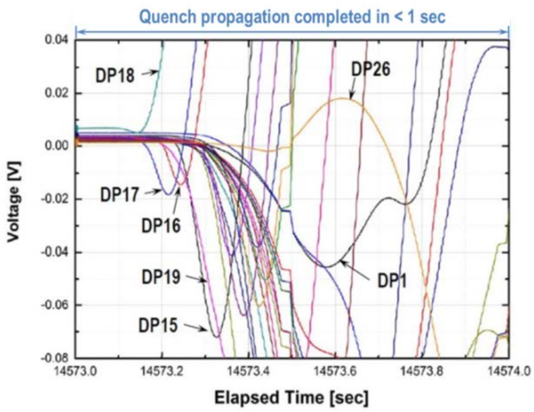

Figure 5: *Voltage signals of individual DPs during the second quench-test. The quench was initiated at DP18 and then the "fast electromagnetic quench propagation" was observed to the rest of DP coils (DP18→DP17→ DP16→ DP19→··· →DP26 →DP19). The quench propagation to the entire coil was completed within 1 second, >100 times faster than the "thermal" quench propagation observed in un-protected insulated HTS coils.*

REBCO conductor

1. Lengthwise variations of superconducting properties:

We continued to measure the I_c continuously along magnet-relevant long lengths of REBCO Coated Conductor (CC) using our unique reel-to-reel system developed at LANL and substantially modified at ASC. This instrument makes it possible to measure I_c using the usual 4-probe method versus position, magnetic field and magnetic field orientation. In addition, we have also developed non-contact I_c measurement by magnetization obtained using Hall probe arrays, a technique that is faster and provides higher spatial resolution.

We are using this system to investigate conductor lengths extracted from deconstructed test coils built for the 32 T all-SC magnet, now in the final stage of construction. Post-mortem examination of sections that underperformed during magnet tests provides us with valuable information on the sources of degradation. Recently we also characterized REBCO CC from deconstructed CORC cables and no-insulation NI-40 T magnet project, again focusing on defective locations to determine the origin of the observed underperformance. We found that, regardless of origin, faulty regions predominantly show not only a substantially reduced overall I_c but also an angular dependence that is dramatically modified as shown in **Fig 6**.

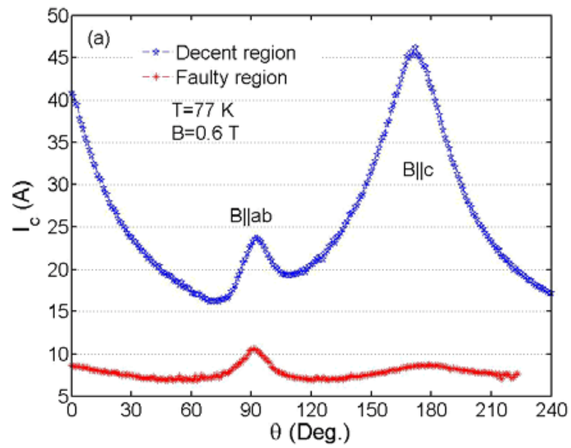

Figure 6: *Comparison of angular I_c in bad and in good regions shows a much stronger (by a factor of ~2.5) reduction of I_c parallel to the c-peak than to the ab-plane peak. REBCO tape is from deconstructed CORC but such peculiar behavior is observed also in tapes unwound from test magnets.*

In the good regions, the c-axis peak dominates over the ab-plane peak, as expected for this $BaZrO_3$ engineered conductor. However, the reduction in the c-peak is much stronger than the ab-plane peak in the bad spots, a very surprising result, because one would expect angle-independent I_c reductions if locally reduced conductor cross sections were the mechanism for the I_c drop. These new results, in contrast, suggest that there is a significant change in the pinning mechanism in these locations, perhaps due to high temperatures or high stress, an unexpected result since $BaZrO_3$ nanorods are believed very robust. Exploration of the problem by TEM is underway. These unique measurements are possible because we can apply a magnetic field of 0.6 T both perpendicular and parallel to the tape at 77 K, thus allowing variations of c-axis and ab-plane properties to be clearly distinguished in the temperature and field regime where strong pinning defects are obvious. Our new findings based on the position-, angular-, field-, and temperature-

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dependence of $I_c(x)$, that cross-section variations alone cannot explain $I_c(x)$ variations in all cases is demonstrated along the length of a tape in **Fig 7**, where c-minima are accompanied by maxima.

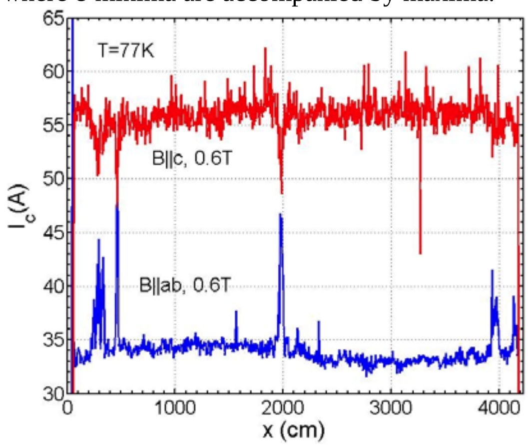

Figure 7: *Critical current as a function of position along the conductor (I_c (x)) for B off-plane (B||c-axis) and B|| in-plane (B||ab-plane). It is clearly seen that the observed minima of I_c (x) for off-plane configuration correspond to a maxima for in-plane B.*

Our high resolution TEM capability also allows us to investigate the possible microstructural sources of the pinning center variations indicated by I_c measurements; As we show in **Fig 8** where a region of observed anti-correlation, $BaZrO_3$ additions form much thicker and shorter precipitates than the normally observed columnar rods along the c-axis. This finding calls for more stringent control of the growth conditions in these Zr-doped coated conductors.[1]

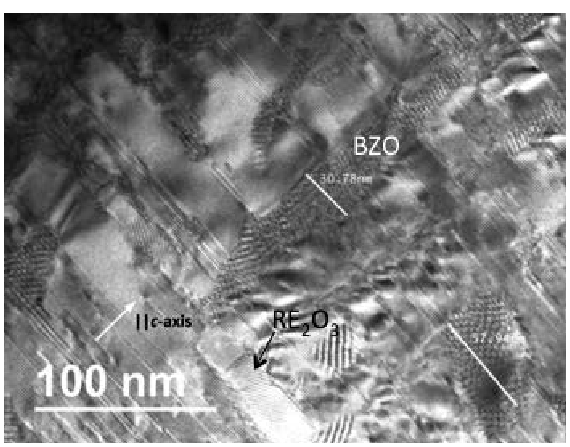

Figure 8: *Longitudinal TEM image of the anti-correlated region clearly shows unusually thick $BaZrO_3$ formations consistent with loss of the* c-axis *I_c peak.*

Reference s

[1] L. Rossi, X. Hu, F. Kametani, D. Abraimov, A. Polyanskii, J. Jaroszynski, and D. C. Larbalestier, “Sample and length-dependent variability of 77 and 4.2 K properties in nominally identical RE123 coated conductors,” *Superconductor Science and Technology*, vol. 29, no. 5, p. 54006, May 2016.

Bi-2212 Coil Development (“Platypus”)

The NHMFL is committed to the development of high field quality magnets beyond 30 T (~1.3 GHz) for high-resolution NMR spectroscopy using high temperature superconductors (HTS) [1]. This requires substantial R&D work towards the development of a magnet technology that does not yet exist. During the past year we designed, built, and characterized several $Bi_2Sr_2CaCu_2O_{8-x}$ (Bi-2212) round wire test coils and one large insert magnet using that was operated inside our 16.5 T, 110 mm bore low temperature superconducting (LTS) Oxford magnet.

A whole suit of analytical and multi-physics FEA **models were developed and results were implement**ed into the coil designs to understand and control the mechanical and electro-magnetic properties of these complex, multi-component coil assemblies. Besides describing the electromagnetic properties, these efforts covered all operational scenarios, ranging from the high heat treatment temperatures of up to 1163 K (890C) to cool down to 4.2 K and their operation under large mechanical stresses. Round wire-wound coils require an ortho-cyclic winding approach that can introduce asymmetries in the coil geometry and hence inhomogeneities in the generated field. A procedure, which involved clocking the wire crossovers, was developed to address this issue and a full size model coil using Cu-wire was made for verification. This procedure is now being applied to all layer-wound coils that we make. A total of three layer-wound short (2 cm high) and thick (18 layers) test coils, one long (24 cm, 179 turns) and thin (4 layers) solenoid and a full size NMR demonstration solenoid **(Fig 9a)** of 24 cm length (18 layers, 179 turns) plus a compensation coil pair to correct for the Z2 field component were built using 1.3 mm diameter internally twisted Bi-2212 wire from Oxford Superconducting Technology (OST). The conductor for these coils was dip-coat insulated using our in-house developed coating facility, which yields a thin

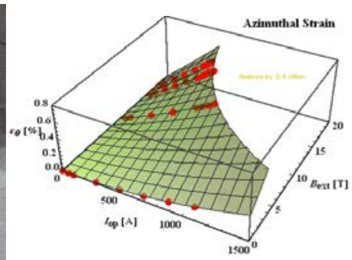

Figure 9b (top): *The computed operating envelope for the third test coil ("Platypus-3").*

Figure 9a (left): *The fully assembled Platypus magnet (solenoid and compensation coil pair) with CORC buses and instrumentation wiring attached.*

and uniform ceramic layer consisting of TiO_2 on the conductor after the heat treatment. The first three coils were processed in the new Deltech high pressure furnace at 50 bar total pressure using a gas mix of Ar-2%O_2. They were tested in the 20 cm large bore resistive magnet (LBRM), while the latter one was nested inside our Oxford Instruments 16.5 T low temperature superconducting (LTS) outsert magnet. For this coil an electrical bus system was developed in collaboration with Advanced Conductor Technologies (ACT, Danko van der Laan) using REBCO CORC^{TM} cable to provide power to both the solenoid and compensation coil pair.

Since 2212 is a wind-and-react technology, there is great flexibility in the conductor architecture provided that the magnet builder takes responsibility for insulation, reaction, impregnation etc. Heat treatment is especially challenging as the coil must be heated to near the melting point of the Ag wire sheath. Leakage of 2212 through the sheath was not observed in any of the four test coils after the overpressure heat treatment. A small electrical short, however, was observed within the winding pack of the third short test coil. All three short coils generated field inside the LBRM. For coils 1 and 3, an operating enveloped was calculated and the tests showed that the coils performed close to the predicted specifications, reaching a nominal strain of ~0.6%, **Fig 9b**. The third coil was deliberately quenched and its short disappeared. The fourth long test coil was only tested with respect to its resistance due to time restrictions. In contrast to the test coils, the full size solenoid and compensation coil pair developed several leaks and severe electrical shorts throughout the winding pack after the high pressure heat treatment process. The electrical shorts prevented the coil from performing to full specification, as only large field screening could be measured during the testing in the LTS outsert magnet. The reasons for the leaks and shorts are still under investigation and more test coils will have to be made to understand the issue before tackling another full size solenoid. Our early investigations show that there are some circumstances in which Ag extrusions from the outer wire sheath penetrate the TiO_2 insulation layer.

Although Bi-2212 round wire does not have the excellent mechanical properties of REBCO tape or strengthened Bi-2223 tape, it is available in long, uniform continuous lengths of over 1 km and its round cross-section gives it electro-magnetically isotropic behavior, and it is multifilamentary. It can also be cabled easily and can be twisted to reduce ramping losses and field screening effects. It also has no bending strain sensitivity due to the wind & react approach. A practical procedure to make persistent joints has been developed and successfully applied to a small test coil [2]. Last but not least there is a very productive relationship with the leading conductor manufacturer, Oxford Instruments, which is giving us input on and control over many aspects of the conductor manufacturing process. Another epoxy impregnated, non-reinforced coil that, in contrast to the other test coils, used TiO_2 coating and alumino-silicate braiding was tested recently inside our cryo-cooled 8.5 T LTS magnet and exceeded all of our expectations when we ran it to a nominal strain level of > 0.8%. Further tests are pending.

Reference s

[1] D. Larbalestier *et al.*, Nature Materials 13, 375-381 (2014).

[2] U.P. Trociewitz *et al.*, U.S. Patent pending, FSU Ref.: 15-131.

Bi-2212 – Conductor Development

1. Effect of overpressure on diameter and critical current of open-ended 2212 round wires

Using 100 bar overpressure (OP) processing, the engineering current density (J_E) of long 2212 wires was increased several times compared to wires processed at 1 bar due to the increase in density and connectivity of the 2212 filaments. Sealing the ends of the wire is critical for high densification, so it is critical to know what happens if the ends are not completely sealed during the OP heat treatment. We investigated I_c and the wire diameter along the length of the open-end wire to determine how far from the open ends the wire fully densifies.

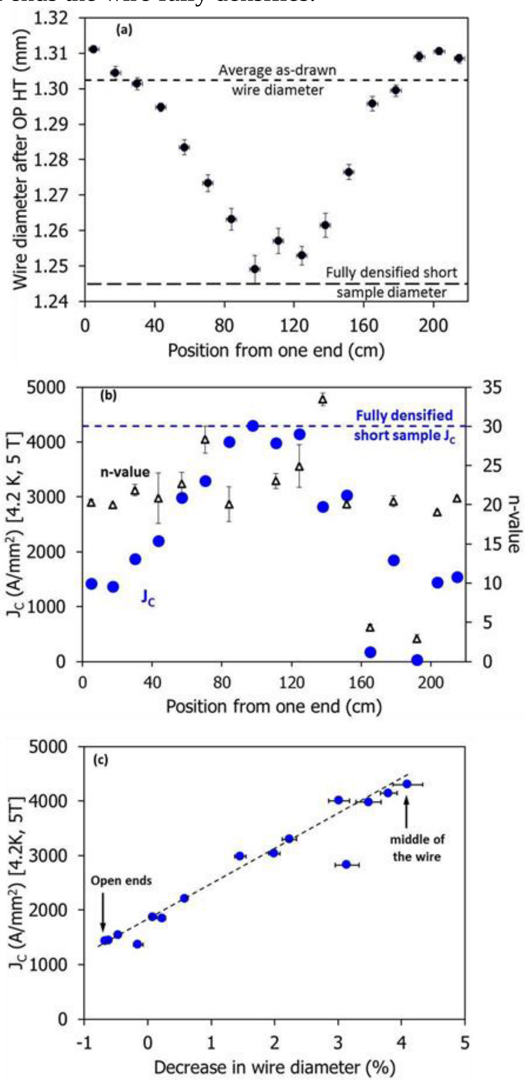

Figure 10: *(a) diameter as a function of position for a 2.2 m long wire heat treated at 100 atm with both ends open.* ***(b)*** *I_c and n-value as a function of position for the same wire.* ***(c)*** *Data from (a) replotted to show I_c at 4.2 K and 5 T as a function of the decrease in wire diameter. Note that in (c) the negative of the change in wire diameter has been plotted so the plot shows increasing I_c with increasing densification.*

Fig 10a shows that 1 m away from the open ends of the wire, the wire diameter is the same as the short samples, meaning that the open-ended wire is then fully densified. **Fig 10b** shows that $I_c(x)$ curve has an inverse relationship with diameter with the lowest I_c being at the ends of the wire and the highest I_c at the center. The n-value of the samples is relatively constant at 22 ± 2. However, two low I_c samples at 165 and 192 cm also show very low n-values (4.4 and 2.9 respectively), indicating that they were damaged by handling. **Fig 10c** shows a strong linear trend between I_c and the change in wire diameter, which is directly linked to the filament density. (The two damaged samples are not shown in this graph.) These results show that adding at least 1 m of extra wire to each current junction (which is cut off after OP processing) end guarantees that the entire length of wire in the coil will be fully densified, even if a wire-end seal is bad. The strong linear relationship between I_c and change in wire diameter also suggests that I_c can be predicted from the wire diameter after the OP heat treatment.

2. Evaluation of Bi-2212 powders

One of the key components for manufacturing Bi-2212 wire is the precursor powder, whose quality affects the wire performance significantly. The "gold standard" Bi-2212 powder was for many years that made by Nexans, but they left the business of superconducting materials in 2015. Potential replacement powder is now being made by MetaMateria, nGimat and Solid Materials Solutions (SMS) under DOE-HEP SBIR support. Composition, impurity levels, particle size and its distribution, tap density, and other properties are being investigated and their correlation with the superconducting properties are being established. In order to further improve the performance of the Bi-2212 wire, we must distinguish those properties that need to be tightly controlled from those where much looser specifications are acceptable.

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A problem with the last big lot made by Nexans (powder lot 82 (2013)) is that the powder contains ~50 µm hard particles. In 2015, we investigated Nexans powder lot 87 (2014) and powders made by MetaMateria and nGimat (KZA-017018). Conductors made from these powders by Oxford Superconducting Technology (OST) and by SupraMagnetics were evaluated by 50 bar or 100 bar overpressure (OP) processing.

Our analysis showed that the final Nexans lot 87 still contained some hard particles, but that they were typically smaller than the conductor filament size (about 15 µm), so that they caused no wire breaks (OST are now regularly producing one-piece wire of their starting billets of 10 kg, typically > 1 km for 1 mm diameter wires). Hard particles were not found in nGimat phase-II powder KZA-017018, but most of MetaMateria powders contained large Bi-2201 particles. **Fig. 11** shows in-field critical current density (J_c) of four wires made with four different powders. All of the four powders developed a good J_c(4.2 K, 5 T) higher than 4000 A/mm^2 reported previously [1]. New record J_c(4.2 K, 5 T) of 5092 A/mm^2 and J_E(4.2 K, 5 T) of 1064 A/mm^2 were achieved for OST wire pmm150105. The critical current for wires made from MetaMateria and nGimat phase-II powders are comparable to that of the best wire made from previous Nexans powder.

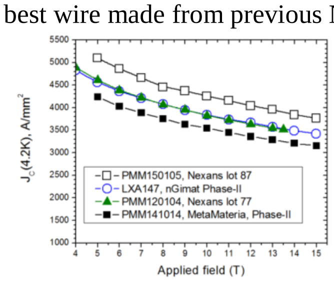

Figure 11: *J_c (H) (defined on the basis of dense cross-sections) for wires made by OST from Nexans powders (pmm150105, 121x18, 1.3 mm; and pmm120104, 85x18, 1.2 mm), and MetaMateria phase-II powder (pmm141014, 85x18, 1.2 mm) and wires made by SupraMagnetics from nGimat phase-II powder (LAX147) after OP processing.*

Strengthening studies are likely to open up several issues relevant to the future architecture of 2212 wires. We have performed coupled mechanical and I_c studies both internally and by passing OP-processed wires to partner laboratories. Studies in Scheuerlein's group at CERN have shown that filament fracture commences at about 0.6% strain in tensile strain experiments, as do wires tested here at the MagLab. Samples of ours tested in the Walter's spring at NIST by Cheggour generally show damage onsets at slightly smaller strains. Transverse pressure tests on strand relevant to the dipole forces imposed on a Rutherford cable have been performed with our samples by Senatore's group at the U. of Geneva. They find that damage onset occurs at strains slightly smaller but very similar to those observed for PIT and RRP Nb_3Sn conductors.

A program to define the mechanical limits of 2212 wires and to do as much as possible to strengthen Bi-2212 wires is vital. One example, performed with Alex Otto at SMS under a small contract from us has more than tripled the strength at 0.4% strain (425 MPa vs. 125 MPa for standard wire), while maintaining the same 0.6% fracture strain. As shown in **Fig. 12**, a high modulus superalloy (E = 220 GPa) has been diffusion bonded to 2212 wires rolled to an aspect ratio of <2 at NHMFL. Although not yet suitable for round wire, a strengthened rectangular conductor is highly appropriate for our high field NMR project. This work clearly overlaps the studies of highly strengthened Bi-2223 that follows.

References

[Bi-2212] Larbalestier, D. C., *et al.*, *Nature Materials*, 13 (4), 375-381 (2014).

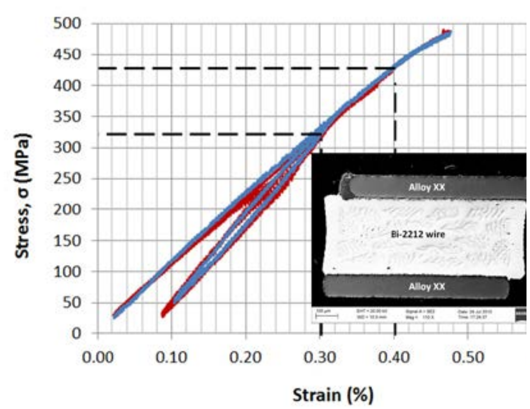

Figure 12: *Stress-strain diagram for slightly aspected Bi-2212 wire with high-strength, 230 GPa high-E, strips (Alloy XX) diffusion-bonded on two sides. The inset shows a transverse cross section of the laminated wire.*

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Bi2223 Coil Development

We performed a systematic feasibility study on a new high-strength 0.26 x 4.5 mm^2 $Bi_2Sr_2Ca_2Cu_3O_x$ (Bi-2223) tape-conductor for high-field solenoid applications. The investigated conductor is a pre-production version of DI-BSCCO Type HT-NX, which has recently become available from Sumitomo Electric Industries (SEI) [1]. It is based on their DI-BSCCO Type H tape, which is comprised of brittle Bi-2223 filaments that are embedded in an

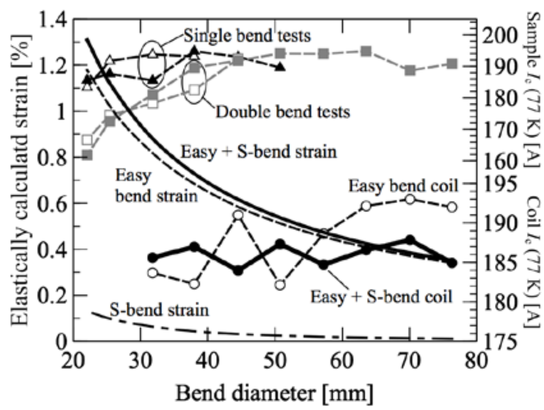

Figure 13: *I_c versus bend diameter for bent tape samples and bent coil sections.*

Ag/Ag-alloy matrix. The HT-NX version is laminated with a high-strength Ni-alloy. We used stress-strain characterizations at 77 K, single- and double bend tests at room temperature and easy- and hard-way bent coil turns at various radii that were tested at 77 K, straight and helical samples that were tested in up to 31.2 T background field, and small 20-turn coils that were tested in up to 17 T background field to systematically determine the electro-mechanical limits in magnet-relevant conditions. In longitudinal tensile tests at 77 K, we found critical stress and strain levels of 516 MPa and 0.57%, respectively. In three decidedly different experiments we detected an amplification of the allowable strain with a combination of pure bending and Lorentz loading to ≥ 0.85% (calculated elastically at the outer tape edge).

Tapes were bent or double bent, straightened, and the I_c was measured at 77 K. Tapes were also wrapped around G10 cylinders of various diameters with a single pitch or a single pitch plus s-bend, representing the central and end turns of a solenoid, respectively. The results, including strain levels, are summarized in **Fig. 13.** Degradation occurs below 25 mm and 40 mm diameter in the single and double bed tests, respectively, while no I_c degradation was observed in the coil sections. The maximum conductor strain in the single bend experiment at which no I_c degradation is observed is 1%.

Self-supporting 20-turn coils of 51, 83, and 114 mm diameter were tested in up to 17 T field. Coil voltages versus current for the largest diameter coil are shown in **Fig. 14**. The coil was not degraded at 675 A, corresponding to 0.85% total strain, whereas damage (depicted in the inset of **Fig. 14**) occurred at 722 A, corresponding to 0.9% total strain.

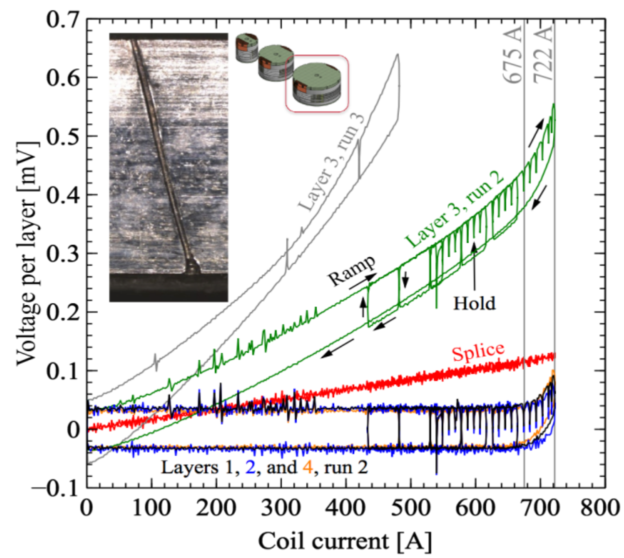

Figure 14: *Layer voltages versus ramping coil current for a 114 mm diameter coil.*

In hoop stress tests on 1.2 m long helical samples up to 31.2 T (**Fig. 15**) no I_c reduction was observed until failure occurred close to 0.95% total strain. Safe strain levels ≥ 0.85% are thus achieved in tests with only winding strain (bend tests), high winding- plus low hoop strain (helical samples) and low winding- but high hoop strain.

These results are very encouraging for the high field use of Bi-2223-NX since the critical strains and stresses are comparable to REBCO coated conductors, both also being reacted conductors ready for winding. The multifilament nature of Bi-2223 means that it has a lower magnetization than REBCO and is thus more suitable for high homogeneity NMR use.

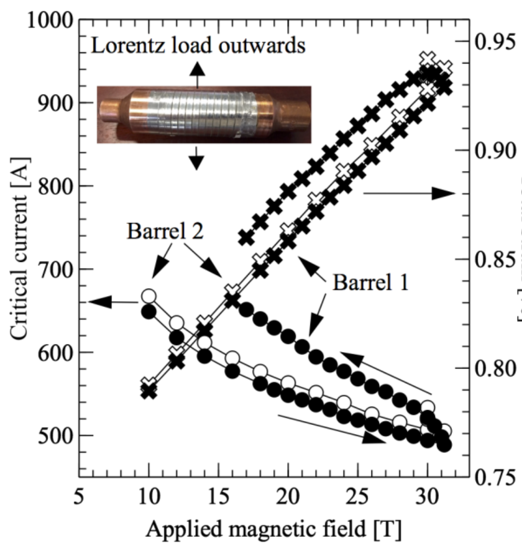

***Figure 15:** Hoop stress test of 1.2 m helical samples.*

References

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Iron-based superconductors (FBS)

1. Stability studies of bulk FBS

We carried out chemical stability experiments to quantify how oxygen and water vapor degrade $BaFe_2As_2$ (Ba-122) samples so as to be able to design protocols for handling, storing, and shipping samples and to ensure reproducibility between measurements, and to help elucidate how extrinsic defects form in these materials.

We studied changes in T_c and J_c of K-doped Ba-122 single crystals and polycrystalline samples with compositions x = 0.40 (optimally doped) and x = 0.60 (over-doped) (in $(Ba_{1-x}K_x)Fe_2As_2$). (Only data for the x =0.40 sample is shown here.) Samples were stored under various conditions for up to 11 weeks. These conditions were: 1) in air (O_2 and moisture), 2) in a desiccator (O_2 and reduced moisture), and 3) in an Ar atmosphere glovebox that actively removed O_2 and moisture.

For the single crystals there were essentially no changes in T_c (**Fig. 16 a**) or J_c (**Fig. 16 b**) for any of the three exposure conditions, except for a slight decrease in T_c in air. This suggests that large single crystals can be exposed to the atmosphere for extended periods of time without degradation, but as shown below for the polycrystalline samples, it is best to store the single crystals in a desiccator or glovebox.

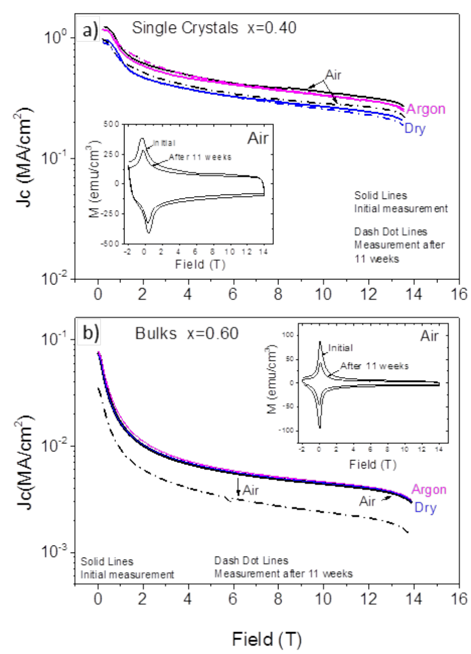

***Figure 16:** Magnetization J_c plots at 4.2 K of optimally doped **a)** single crystals **b)** polycrystals stored under the three conditions. Solid lines are at t = 0 and dash-dot lines are after 11 weeks of exposure. J_c was not affected for the single crystals for any of the conditions, whereas it was reduced by a factor of 2.6 for polycrystalline samples stored in air, but not significantly affected when stored in a*

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desiccator or the glove box. Insets show magnetization loops at 4.2 K of polycrystals stored in air.

In contrast to single crystals, polycrystalline samples showed a decrease in T_c (**Fig. 16 b**) and J_c after being held in air, but T_c and J_c did not change significantly after being held in the desiccator or in the glovebox. These results indicate that water vapor has the greatest effect in degrading K-doped Ba-122.

$$Ba_{Ba}^{x} + 2Fe_{Fe}^{x} + 2As_{As}^{x} + 2H_2O$$
$$\rightarrow V_{Ba}^{''} + 2Fe_{Fe}^{x} + 2As_{As}^{x} + 2Fe_{Fe}^{x} + 2h^{\bullet}$$
$$+ Ba(OH)_2 + H_{2(g)}$$
$$\rightarrow 2FeAs + Ba(OH)_2 + H_{2(g)}$$

Figure 17: *Reaction between $BaFe_2As_2$ and H_2O*

Based on our observations, water reacts with Ba-122 forming $Ba(OH)_2$ and with secondary phases FeAs (and/or Fe_2As) and Ba-vacancies as shown in **Fig 17**. The reaction with water likely occurs because Ba (and K) readily react with H_2O to form a hydroxide.

2. FBS thin film studies

The superconducting properties of Fe-based compounds in form of thin films have been investigated in ASC and in the DC user facility up to high field in collaboration with the Institute for Technical Physics at Karlsruhe Institute of Technology (KIT), the Institute for Metallic Materials at IFW-Dresden and Nagoya University. P-doped $BaFe_2As_2$ thin films showed an unusually high critical current density despite the absence of defects that could produce pinning [1]: this behavior was related to a strong enhancement of the vortex core energy driven by in-plane strain. Co-doped $BaFe_2As_2$ films with extended planar and c-axis correlated defects revealed that, apart from these correlated pinning, the critical current density is influenced by the multi-band nature of this compound and strongly related to the Hc2 anisotropy [2]. An ongoing investigation of clean NdFeAs(O,F) films is revealing interesting properties determined by both intrinsic and extrinsic pinning mechanisms [3].

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LTS Magnets and Materials

FSU Series-Connected Hybrid

The Series-Connected Hybrid (SCH) magnet at FSU will provide 36 T in a warm bore of 48 mm for condensed-matter NMR. It is designed to have a uniformity of 1 ppm over a 10 mm diameter spherical volume. It features state-of-the-art compact room-temperature shims for spatial compensation and a temporal field-stabilization system developed in collaboration with Penn State University. The focus in 2015 was primarily on completing the mechanical assembly, initiating the system connections to the house utilities, fabrication of probes, and holding an external readiness review.

The final tasks prior to closing of the cryostat included: attachment of the 20 kA current-leads, installation of the thermal shields and multi-layer insulation (MLI), and final high-voltage Paschen-testing. In early 2015 the 20 kA current leads, which contain Bi2223 HTS was fully validated by conducting tests to full current and by observing its robustness to a loss of nitrogen cooling. These tests were conducted by our colleagues at the High Magnetic Field Laboratory in Nijmegen, The Netherlands. Following the tests, the leads were returned to Tallahassee, had external insulation applied to them, were installed into the cryostat, and finally soldered to the NbTi cable-in-conduit bus to link them to the superconducting coil. The leads and cold mass are pictured in **Fig 18.**

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With the leads installed, much of the mechanical assembly could be completed. The thermal shields consist of stainless steel panels traced with liquid nitrogen. The panels mostly surround the cold mass

Figure 18: *SCH Cold Mass, encircled by Plumbing for Liquid Helium, with the HTS Current Leads, coated in blue insulation, supported by the Top Plate of the Cryostat.*

and are a welded assembly. A few layers of MLI cover the cold mass and several layers cover the thermal shields. Following the MLI installation and wiring of the voltage taps and temperature sensors, the superconducting sub-system was enclosed in its cryostat and leak-checked.

Connection of the SCH to the house utilities continues but is nearing completion. These connections include the helium transfer-line to the cryogenic distribution box, liquid nitrogen lines to feed the shields and thermal intercept of the current leads, magnet cooling water lines to the resistive coils and the several sensors and voltage tap instrumentation wires to the electronic racks.

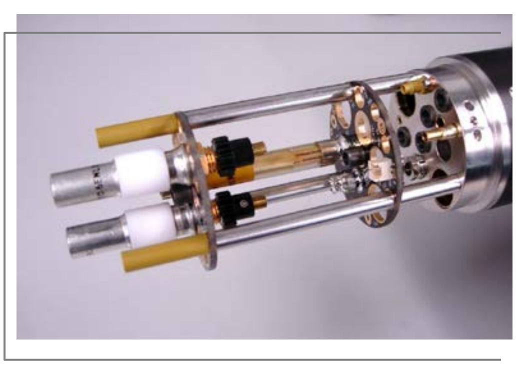

Figure 19: *RF Circuit Platforms of Partially Assembled Low Gamma MAS Probe*

The plan for the NMR hardware development for the SCH magnet includes a set of probes for solid-state NMR spectroscopy to be fully developed in-house before the commissioning phase of the project. Two probes are under construction at the moment: a CP-MAS probe and a single-channel MAS probe for low-gamma isotopes, shown in **Fig 19.** Design work on the static solid-state NMR probe began in late September of 2015. The static probe will be based on our 720 MHz probe design but will use a smaller sample to fit a smaller rf coil required for operation at 1.5 GHz.

The NMR spectrometer contract was awarded to Bruker Biospin in 2014 under a separate grant (NSF DMR 1039938). The technical details were worked out over 2015 and delivery is expected in three phases over the first two quarters of 2016. Oxford NMR was awarded a contract early in 2015 to build the active shims. Trials of the Z0 shim were successfully performed to demonstrate the flexible circuit technology and fabrication of the full set commenced.

Over the years that the SCH project has spanned, several design reviews were held prior to the purchase or manufacture of major sub-systems/components. A list of the reviews is contained in **Table 1**. In 2015 an external production-readiness review was held on the controls and protection sub-system. It centered on the requirements the various subsystems (resistive magnet, superconducting magnet, cryogenics, etc.) place on the control/protection system, and how the control/protection system is designed to meet those needs.

Table 1: *List of System Design and Sub-System Readiness Reviews*

Date	Review
Nov. 2007	Supercon. Coil Design*
3Q' 2008	Nb_3Sn Strand Specification*
Jan. 2009	SC Coil design, CICC testing, Cryostats, Refrigeration*
1Q' 2009	Cabling Specification
2Q' 2009	Conduit Specification
2Q' 2009	FSU Refrigerator Specification
Jan. 2010	CICC fabrication, HZB Cryostat Design, Cold-Mass Details*
Sept. 2009	(HZB Cryostat)
May 2010	FSU Cryogenic Distribution Box*

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Date	Review
July 2010	FSU Cryostat*
Dec. 2010	FSU Power system*
Feb. 2011	SC Coil winding, Cold-Mass details, FSU Cryostat*
May 2011	Cold Mass
July 2011	Impregnation Facility
Oct. 2011	VPI Facility*
Jan. 2012	FSU Cryostat
Mar. 2012	SC Coil Fabrication, Resistive Inserts*
Mar. 2012	Lifting Equipment
July 2012	Jointing Process
Aug. 2012	Reaction Process
Aug. 2012	Iron Shield
Dec. 2012	Bi2223 Tape Specification
Jan. 2013	(HZB Resistive Insert)
Feb. 2013	SC Coil Fab, Resistive Inserts, HTS Leads, Shims, System Integration*
April 2013	Coil Handling Equipment
Aug. 2013	FSU Insert Housing
Sept. 2013	HTS Leads & Supports
June 2013	Shims
Feb. 2014	Cryostat Assembly Frame
April 2014	(HZB Controls & Safety)*
May 2014	FSU Resistive Insert
Nov. 2015	FSU Controls and Safety*

*indicates external reviewers were included.

We expect the magnet to reach field in mid-2016.

LTS Conductor Understanding

High critical current-density, J_c, Nb_3Sn wire ($J_c \geq 2500$ A/mm², 12 T/4.2 K) can be manufactured by the internal Sn (IT) or powder in tube (PIT) processes. Our studies are aimed at improving the properties of both types primarily for applications in high energy physics. The highest critical current density wires are those produced by the IT-based "RRP" process at Oxford Superconducting Technologies (OST). However, the PIT wires produced by Bruker offer potentially better magnet stability due to their smaller effective filament diameters. Below we summarize our principal findings for both OST RRP® and Bruker PIT wires:

1. Lower Sn content sub-elements have recently been introduced into the RRP® design to reduce the potential for Sn leakage into the Cu stabilizer and this change has been successful enough to become the standard design for the upgrade to the high-performance interaction-region quadrupoles for the LHC. We show by microstructural/microchemical and specific heat **(Fig 20)** characterizations that the Ti doping of this generation of RRP® strands produces a much more chemically homogeneous A15 layer than the previous Ta-doping technology, even with reduced Sn designs.[LTS1] Specific heat, C_p, analyses of the Ti-doped wires reveal a more uniform and higher temperature in-field distribution with respect to Ta-doped wire. Remarkably, the Ti-wires also have a 2 T higher upper critical field. Thus the success of the reduced-Sn wire design can largely be attributed to the more efficient use of Sn when in the presence of Ti rather than Ta.

2. Our microstructural analysis of RRP® strand has shown the importance of the Nausite (Sn, Nb, Cu phase) membrane (formed between 200C and 400C) on the regulation of Sn diffusion. This membrane encapsulates the Sn core and stalls the outwards Sn diffusion while allowing inward Cu diffusion through the membrane (analogous to osmosis). Furthermore, holding the reaction temperature at 400C for 48 h reduces the Sn content inside the membrane from ~40 at. % Sn to ~32 at. % Sn **(Fig 21)**. This Sn reduction is in fact a crucial step in the heat treatment because residual η phase will liquefy above 408 C, then quickly dissolving the closest Nb filaments as Nausite, which then decomposes on heating into largely disconnected, large grained Nb_3Sn which is known to be detrimental to current density. Importantly, it was found that wires with uniform Nausite membranes in which the Cu diffusion was most effective in reducing the η phase content had lower Nausite and higher current density.

3. Although the PIT process offers potentially

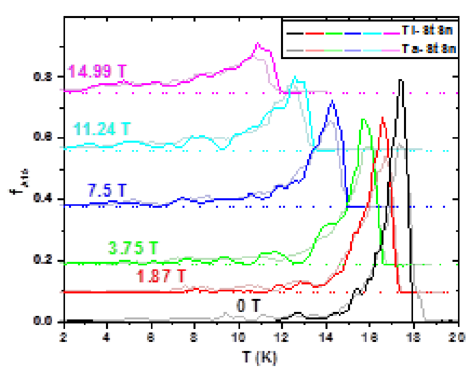

Figure 20: *In field T_c-distribution of the A15 phase, fA15, for standard Sn content (a) Ti-doped and Ta-doped RRP® wires. The curves are vertically shifted proportionally to the applied field.*

better magnet stability than RRP® due to smaller filament size, its critical current density is reduced by a layer of large grain (LG) Nb_3Sn that does not carry transport current [LTS2]; by performing metallographic analysis of a broad spread of pull-outs during the heat treatment of PIT strands and coupling this with DTA (Differential Thermal Analysis) to identify the temperature ranges over which the most important phase transformations occur, we have gained new insights into the formation of the LG A15 layer. Most importantly we have found that the amount of high critical current density small-grain A15 which forms before the LG layer grows increases with increasing A15 reaction temperature. To exploit this discovery we are now developing two-stage heat treatments that are designed to minimize the thickness of the LG layer.

4. To carry high current and reduce eddy current losses the Nb_3Sn strands are cabled prior to winding the magnets and this cabling process deforms the interior filaments sufficiently that Sn can escape into the surrounding Cu matrix, increasing the local resistivity and reducing the magnet stability. To combat this we have been modelling the deformation of filaments so we can design strategies to reduce cable degradation. We now have a sufficiently developed model such that we can obtain excellent matches between observed and simulated deformations (**Fig 22**). This model can be used to better understand the consequences of geometrical and structural changes within the strand, and to predict under what processing condition Sn leakage will occur.

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[LTS2] C. Tarantini, C. Segal, Z. H. Sung, P. J. Lee, L. Oberli, A. Ballarino, L. Bottura, and D. C. Larbalestier, *"Composition and connectivity variability of the A15 phase in PIT Nb_3Sn wires,"* Superconductor Science and Technology, vol. 28, no. 9, p. 95001, Sep. 2015.

Structural Materials for LTS Magnets

Structural materials-research for high field LTS magnets is driven by the need to improve magnet

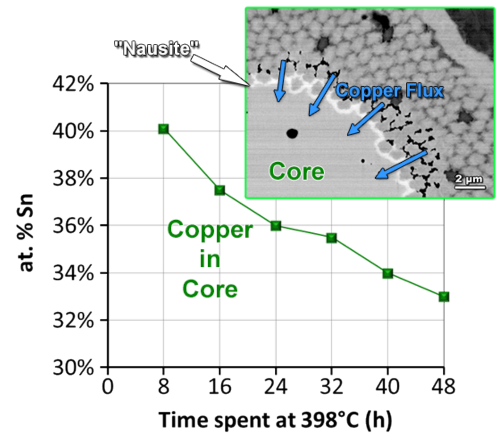

Figure 21: *In this series of diffusion reactions at 398C , we observe a diffusion of Cu into the core of a sub-element of a Nb_3Sn strand leaving voids between the filaments. The Sn-Nb-Cu "Nausite" membrane appears to play a beneficial role, controlling Cu and Sn counter diffusion.*

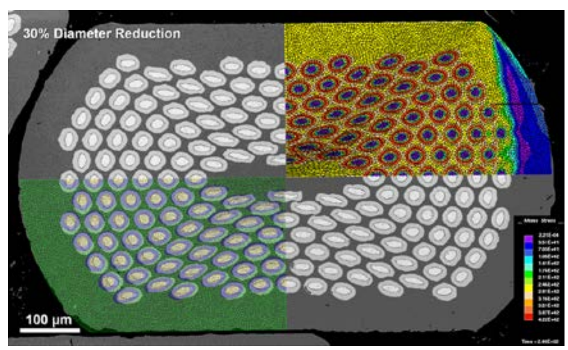

Figure 22: *Image of PIT strand cross section after rolling to 30% thickness reduction.* ***Top right*** *overlay shows Mises stress map.* **Bottom left** *transparent overlay shows filament position and shape.*

reliability, efficiency, and costs. Cable-in-conduit conductor (CICC) technology is an application where high-strength steel is used to enhance the performance of the strain-sensitive Nb_3Sn composite superconductor. In addition to the conduit; magnet cryostats, magnet support structures and fiber-reinforced insulations are other areas of LTS magnet technology that require structural materials with high 4 K strength, fracture-toughness and fatigue-endurance. Austenitic stainless steel is frequently chosen due to its face-centered cubic structure (fcc) that remains ductile and tough at cryogenic temperatures [1].

Conduit-alloys have the additional requirement of retaining good 4 K mechanical properties after long-term exposure (100 – 200 hrs) to the Nb_3Sn reaction heat-treatment (~650 C) which can be detrimental to the 4 K properties of most austenitic steels. JK2LB is a low thermal-expansion steel developed for CICC applications that contains >20 wt% Mn, an austenite stabilizer that makes the alloy maintain fcc structure even at 4K. We studied mechanical properties (cryogenic tensile, fracture toughness, fatigue crack growth rate (FCGR), and axial fatigue life) of JK2LB and its welds[2].

The tests of specimens removed directly from the conduit allow evaluation of the effect of conduit processing variables such as; compaction (AC), cold work (CW) and aging (AG, exposure to the reaction heat-treatment for Nb_3Sn). Room-temperature tests of the base metal show that CW increases both yield and tensile strength (YS = 435, TS = 618 MPa) but has limited influence on elongation. Welded samples have higher strength but lower elongation than base metals.

At 4 K, the conduit base metal, in the AC+CW+AG condition, has excellent tensile properties (YS = 1076 MPa, TS = 1456 MPa, Elongation = 42%). Weld samples have lower strength, elongation (YS = 1031 MPa, TS = 1432 MPa, Elongation = 34%), and fracture-toughness [K_{IC} (base metal) = 357 MPa*$m^{0.5}$, K_{IC} (weld) = 244 MPa*$m^{0.5}$] than the base metal. FCGR tests show the 4 K properties of the base metal and weld are similar to the published database for more conventional 316LN conduit alloy (**Fig 23**)[2]. The data from the fracture-toughness and FCGR tests allow for the specification of allowable defect or flaw size, a specification that is necessary for the magnet's reliability and service-life. This specification is directly related to fabrication costs and inspection techniques used during conduit fabrication. The data show that JK2B is one of the best candidate alloys for CICC magnets.

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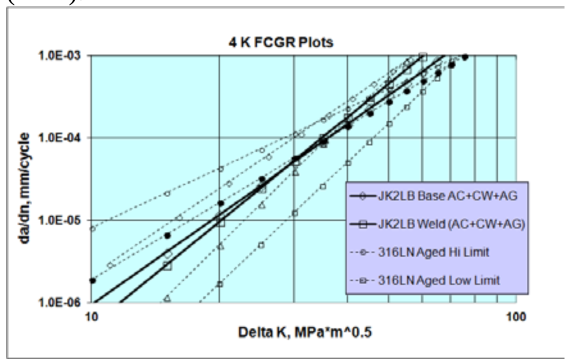

Figure 23: *4 K fatigue crack growth rate data graph along with reference data for comparison.*

Resistive Magnets and Materials

DC Magnets

In 2014, the MagLab completed the electromagnetic and structural design for a 4-coil resistive insert for the 36 T, 1 ppm SCH. This insert employs a combination of axial current-density grading in the *A*-Coil plus a ~22 mm gap in the *B*-Coil to meet the z^2-term homogeneity requirements (**Fig 24**). Fabrication and assembly of the resistive insert coils were completed on time in fall 2015. Since then, system integration into the combined hybrid system is nearing completion with testing, commissioning and field homogeneity tuning planned for 2016.

To support smooth operation of the resistive user program, the NHMFL has completed fabrication and assembly of seven resistive spare coils as part of the routine 2015 maintenance program. Considering, that this is in addition to two spare coils delivered to HZB plus the four new coils for the FSU-SCH insert, 2015 has been another very busy and productive year for the NHMFL Resistive Magnet Program.

Pulsed Magnets

1. The short-pulsed 65 T workhorse magnets: **Figure 25** depicts the performance of these magnets for the last five years from 2011 to 2015. In 2015, the four user cells of these magnets operated near their full capacity to deliver a total of ~ 7300 shots, of which ~2700 shots are 60 T and above. The steady

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Magnets & Magnet Materials

Figure 24: *Snapshot of the completed resistive insert for the FSU-SCH (including 4 nested Florida-Bitter coils).*

increase of number of shots over the years indicates an increased demand from users and significant improvement in the magnet-performance. Higher magnetic fields for users can be obtained simply by reducing the bore size of the magnets. In 2015, we were able to install an additional winding layer and its reinforcement inside the 15.5 mm bore of the present design of 65 T magnet to create a 74 T magnet with the bore size of 7 mm. The magnet still operates stably and has delivered more than 50 shots above 70 T for users to perform successful experiments in that small bore and at temperatures as low as 500 mK. These achievements provide two important suggestions for magnet development strategies at the pulsed field facility: (1) by using a suitable conductor, we possibly reduce the present 10-mm-bore size of our 100 T magnet in order to increase its peak magnetic fields, and (2) with advances in instrumentation/ experimental techniques for smaller sample sizes, many experiments can be done smoothly in a magnet-bore smaller than 10 mm.

2. 60 T controlled waveform (CW) magnet:

As reported last year, our 60 T CW magnet softly expired in December 2014 after delivery of 1032 shots between 55-61 T. Both autopsy and simulation assessment found that coils 3, 4 and 7 need to be upgraded to address the variation of mechanical properties of actual materials. Simulations showed that, if the mechanical strength of reinforcement metal shells and conductors is 5% lower than what was determined in the original designs, coils 3, 4 and 7 would experience considerable strains, consistent with the post failure analysis. Since the magnet is a critical and versatile tool for our users, coils 3, 4 and 7 will be rebuilt as soon as the funding is available.

We plan to redesign the rebuilt coils with a mix of metal shells and Zylon fiber for the winding reinforcements. The dimensions of those coils, however, will be kept the same so that they can still be assembled with other undamaged coils. The calculations showed that the redesigned structure will provide significantly stronger reinforcement for the hoop load and we would expect an improvement in the magnet lifetime.

3. 100 T magnet system:

In 2015, the system delivered 152 shots, of which 59 shots are above 80 T and 28 shots are above 90T. In 2015 and in the first 5 months of 2016, we have installed two insert magnets for the 100 T system. One of those insert coils died prematurely. An effort to determine the reason of this accelerated aging is ongoing.

4. 75 T duplex magnet:

Fabrication of the tooling and parts for this magnet was completed in late 2015 and the winding for the magnet is expected to be finished at the middle of 2016. Some modifications for power-infrastructure and switching-systems will be completed in the third quarter of CY 2016 and the magnet will be tested in the last quarter of 2016.

High-Strength Conductors

In 2015, the high-strength conductor effort focused primarily on developing and characterizing copper-matrix composites for both maintenance of existing user-magnets and preparation of proposed next-generation magnets. In collaboration with scientists and engineers in Los Alamos National Laboratory (New Mexico), Ames National Laboratory (Iowa), ACI Alloys, Inc. (California), Northeastern University (China), and Tanaka Kikinzoku Group (Japan), we made considerable progress in the development of Cu-Ag composites, which are among the strongest conductors available for use in high field dc and pulsed magnets. The strength of these composites is the result of the formation of Ag-precipitates during their fabrication. Understanding the kinetics of Ag precipitation in proeutectic Cu helped us to produce hypoeutectic Cu–Ag alloys of the highest possible strength and the highest possible electrical conductivity. We analyzed the kinetics of Cu-Ag samples that had been first solution-treated and then aged at different temperatures for 2 hours [1]. Because aging was

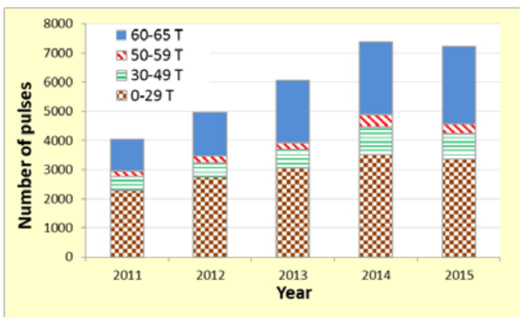

Figure 25: *Performance of 65 T workhorse magnets over the last five years, from 2011 to 2015.*

incomplete at the 2-hour mark, we used differential scanning calorimetry (DSC) for our analyses by measuring peak temperatures for further precipitation in DSC. We also used transmission electron microscopy (TEM) to reveal Ag precipitation and dissolution in aged samples. The Ag undergoes both exothermic precipitation and endothermic dissolution in aged Cu-Ag composite heated to temperatures higher than 250 C. Precipitation occurs between 250 C and 405 C (at the exothermic peak temperature), and Ag dissolution occurs between 405 C and 500 C. That is, precipitation is favored over dissolution and dissolution is favored over precipitation at high temperatures as long as the Ag content remains constant.

Even though low temperatures clearly favor precipitation, the kinetics of this precipitation remains slow. That is, a large volume fraction is possible, at these temperatures but it will take significantly longer than 2 hours to complete the process. At the two-hour mark and low temperatures, the volume fraction of dissolved Ag remains quite high because the process is far from complete. Consequently, the driving force for further precipitation remained high. Thus, the temperature measured by DSC to reach peak temperature for precipitation is relatively low. At higher temperatures, up to 405 C, precipitation occurs more rapidly, so less dissolved Ag remains in the proeutectic Cu at the two-hour mark, thus reducing the driving force for further precipitation. This pushes the peak temperature for precipitation higher in subsequent DSC measurements. Samples that had been aged at 405 C were found to contain more Ag precipitates than samples aged at other temperature. Samples aged at temperatures higher than 405 C, on the other hand, were found to contain more Ag dissolved in the Cu. This reduced the measured peak temperature for precipitation. We concluded that the precipitation and the dissolution of Ag are competitive processes at all temperatures we have probed.

We performed microhardness and electrical resistivity measurements on solution-treated and aged samples. At the aging temperature of 405 C, electrical resistivity was at its lowest. In other words, the Ag in the sample aged at 405 C had the least scattering of electrons, reflecting more Ag precipitation from Cu matrix than at other temperatures, thus producing the highest possible conductivity. The highest possible hardness (or strength), however, is produced in samples aged at 475 C. Samples aged at temperatures above 475 C showed coarsened Ag precipitates and increased dissolved Ag, leading to both reduced hardness and elevated electrical resistivity. The effect of the dissolution of Ag on electrical resistivity was also investigated in Cu-Ag samples treated under a high magnetic field (HMF). An interface-scattering model [2] was used to estimate electrical resistivity by evaluating the effect of HMF on both the solubility of Ag and the microstructure parameters of the Cu-Ag alloy. HMF increased the solubility of Ag in proeutectic Cu, thus increasing resistivity, as well as magnetoresistivity (MR). We decided to focus on procedures that would both minimize electrical resistivity and MR, and maximize hardness by increasing precipitation and decreasing dissolution of Ag in proeutectic Cu. Doing so enabled us to produce CuAg >17 mm^2 cross-section wires with high strength and high conductivity and with

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bending diameter smaller than 7 mm, more than 30% smaller than previously possible. (These wires are potentially useful for future +100 T pulsed magnet inserts.) We were also able to secure a supply of 250 mm-wide sheet conductors for our 45 T hybrid magnet.

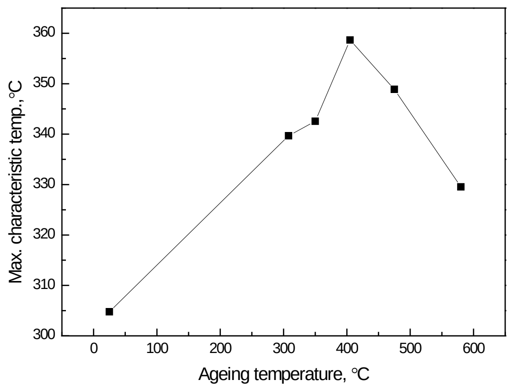

Figure 26. *DSC peak temperatures vs. prior aging temperatures applied for 2 hours show the precipitation temperatures in samples after aging: at these temperatures, maximum precipitation in CuAg alloys was reached [1].*

In collaboration with scientists in Nanoelectro (Russia), Fuzhou University (China), and Chongqing University (China), we continued our on-going research on Cu-Nb composite, another high strength conductor suitable for high field pulsed magnets. We studied the thermal stability of Cu–Nb microcomposite wires that had Cu–Nb interface density of up to 21.6 $\mu m^2/\mu m^3$[3]. An interface density this high results in high hardness and strength. DSC results showed a broad exothermic peak from 200 to 350 C, indicating stress relaxation and recovery in micronscaled-Cu. Annealing up to 500 C caused no significant changes in interface density, grain size, or hardness values. Our Cu–Nb composite wires showed high thermal stability below 500 C because of their refined spacing and high stability of their interfaces. At higher temperatures starting from 500 C, DSC showed an increased exothermic profile, attributable to a significant drop in crystallographic lattice distortion and recovery within submicron-Cu, nanoscaled-Cu and Nb ribbon in Cu-Nb composite. In samples annealed at temperatures below 500 C, TEM studies of both Cu-Ag and Cu-Nb revealed that Cu-Nb composite showed a delay of distortion and stress relaxation within submicton-Cu and nanoscaled-Cu matrices. At 500 C, both lattice distortion and interface area density in Cu-Nb started to drop, resulting in a decrease in hardness, but overall crystal orientation remained stable. As temperatures rose higher than 500 C, however, recrystallization caused hardness to decrease rapidly. The higher the deformation strain, the more rapid the decrease in hardness. We observed pronounced grain growth and lattice distortion relaxation after annealing at 800 C. We found that Cu-Nb responds to heat treatment very differently from Cu-Ag. We observed neither precipitation nor detectable solid solution in Cu-Nb during the fabrication and annealing process. Our work with Cu-Nb enabled us to develop Cu-Nb conductor wires with cross-section of >30 mm^2. We characterized the basic properties of this conductor and found that this wire is about 20% stronger than the GlidCop wire of the same cross-section that we had developed previously for the 100 T pulsed magnet. This wire has great potential for use in our future outer coils for the proposed new long-pulsed magnet. This will be a critical stepping stone for building high-field pulsed magnets of >100 T.

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CMS

2. Condensed Matter Science

This section contains reports represent the widely varied activity of NHMFL's in-house condensed matter experimental scientists, and is not intended to be a complete summary of all in-house experimental work in that area.

CMS/EXPERIMENT

Synthesis and Characterization of the Divalent Samarium Zintl-phases $SmMg_2Bi_2$ and $SmMg_2Sb_2$

D. Ramirez, A. Gallagher, R. Baumbach, T. Siegrist

Divalent samarium in $SmMg_2Sb_2$ and $SmMg_2Bi_2$ are stabilized in mixed magnesium rich fluxes. Electronic transport studies show that the materials behave as poor metals suggesting that electronic conduction is the result of sample impurities. The magnetic behavior follows Van Vleck behavior expected for Sm^{2+} ions having the $[Xe]4f^6$ electronic state,. The similarity between the structures for $SmMg_2Bi_2$ and $EuMg_2Bi_2$ allowed accurate calculation of the entropy of the antiferromagnetic transition of $EuMg_2Bi_2$. (Supported by Department of Energy, Office of Basic Sciences, Division of Materials Sciences under Award DE-SC0008832)

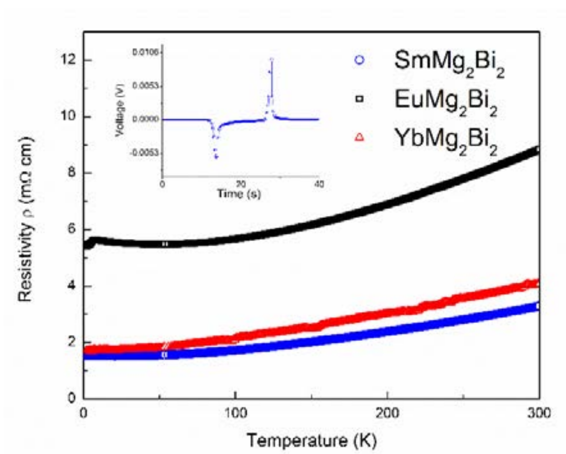

Figure 1: Resistivity of all Bi-containing compounds between 1.8 K and 300 K. The inset is the voltage through the sample with heat applied to the positive terminal (+) and to the negative terminal (-).

Complex magnetism and strong electronic correlations in Ce_2PdGe_3

R. E. Baumbach, A. Gallagher, T. Besara, J. Sun, T. Siegrist, D. J. Singh, J. D. Thompson, F. Ronning and E. D. Bauer

We have discovered the new compound Ce_2PdGe_3, which is related to the α-$ThSi_2$ – type structure. Our calculations and measurements show that this compound exhibits Kondo-driven hybridization between the f- and conduction electrons. We find complex magnetic ordering at low temperatures, with a two-part antiferromagnetic transition at $T_{N,1}$ = 10.7 K and $T_{N,2}$ = 9.6 K, and ferromagnetism below T_C ≈2.25 K.

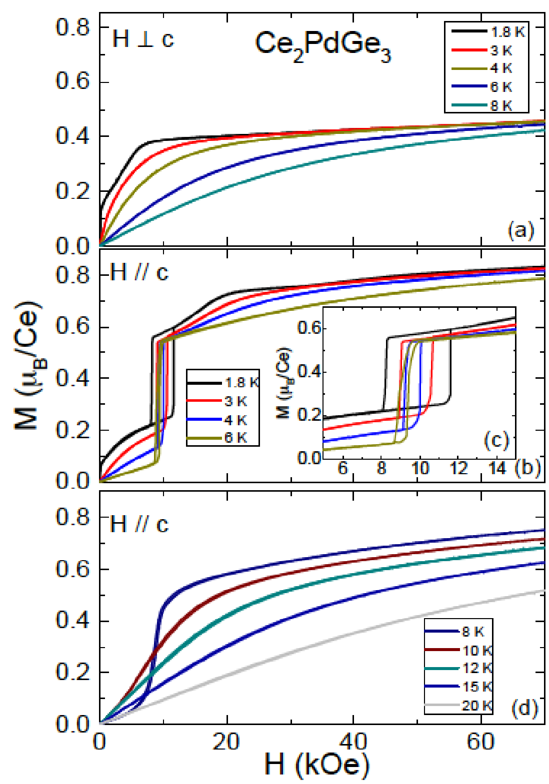

Figure 2: Magnetization M vs. magnetic field H applied perpendicular to the c-axis for Ce_2PdGe_3. ***(b)*** *M(H) for H applied parallel to the c-axis in the low temperature range 1.8 K < T < 6 K.* ***(c)*** *Close-up of the hysteresis region HM = 8-11 kOe.* ***(d)*** *M(H) for H applied parallel to the c-axis in the intermediate temperature range 8 K < T < 20 K.*

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This work was supported in part by Department of Energy, Basic Energy Sciences, Materials Sciences and Engineering Division and the GO! ORNL program, under DE-SC0008832, and PECASE funding from the US DOE, OBES, Division of Material Science and Engineering.

Straining to enhance magnetoelectric coupling.
A. F. Hebard, A. Biswas, P. Kumar

Magnetoelectric coupling, the induction of electric (magnetic) polarization via magnetic (electric) fields, is important due to both its complex physical origins and potential technological applications. This paper reports on a surprisingly large linear magnetoelectric coupling between magnetic and electric dipoles that are simultaneously present (i.e., multiferroic) in pulsed-laser deposited thin films of $BiMnO_3$. Our observations are particularly perplexing because bulk crystalline $BiMnO_3$, a transition-metal perovskite oxide that is both strongly ferromagnetic and insulating, has been shown by experiment and theory to be centrosymmetric, thus preserving an intrinsic structural symmetry that does not allow electric dipoles (hence ferroelectricity) to be present. To resolve this question of why multiferroic behavior occurs in thin-film but not bulk $BiMnO_3$, we find that substrate-induced strain together with "hidden" antiferromagnetic ordering of the magnetic dipoles combine to break centrosymmetry and give rise to ferroelectric behavior with surprisingly large magnetoelectric coupling. Our study based on straightforward thermodynamics opens a new perspective on maximizing the magnetoelectric coefficient in the design of novel multiferroics that increases physical understanding and might eventually have practical application.

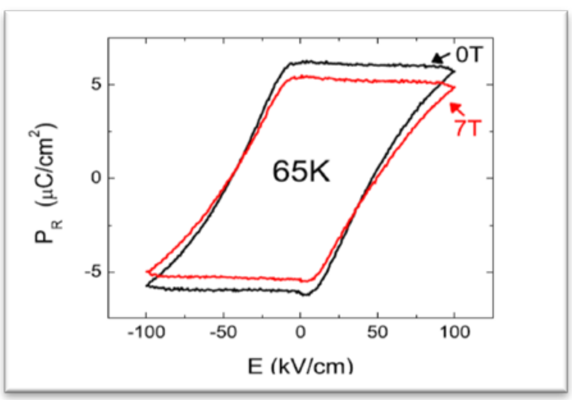

Figure 3 (left): *Magnetic field dependence of electric polarization loops. Hysteretic polarization loops span a temperature range of ≈100 K with a maximum remanent polarization, P_R, of 23 $\mu C/cm^2$ at 5 K. As shown in the figure, a magnetic field of 7 T (red) decreases the ferroelectric polarization by ≈10%(red) from its value in zero field.*

"Proximate transition temperatures amplify linear magnetoelectric coupling in strain-disordered multiferroic $BiMnO_3$" Patrick R. Mickel, Hyoungjeen Jeen, Pradeep Kumar, Amlan Biswas, and Arthur F. Hebard, Phys. Rev. B **93**,1342059 (2016). http://link.aps.org/doi/10.1103/PhysRevB.93.134205

Antiferromagnetic order in single crystals of the S = 2 quasi-one-dimensional material $MnCl_3$(bpy)
M. W. Meisel

A collaboration between teams at UF-NHMFL and Physics, UF Chemistry, and the AHMF (Center for Advanced High Magnetic Field Studies) at Osaka University in Japan have identified antiferromagnetic order in single crystals of the S = 2 quasi-one-dimensional material $MnCl_3$(bpy) [1]. The findings clarify earlier work performed at the NHMFL in Tallahassee when one of the superconducting magnets, now housed in the NHMFL Millikelvin Facility, was temporally operating in the DC cell hall [2]. Subtle differences between the experimentally observed and theoretically predicted resonances shown in the figure have been resolved by expanding the analysis to include a four sub-lattice description with the Dzyaloshinskii-Moriya interaction [3]. These results provide a basis of evaluating the possibility of real S = 2 chains accessing a range of symmetry-protected topological phases.

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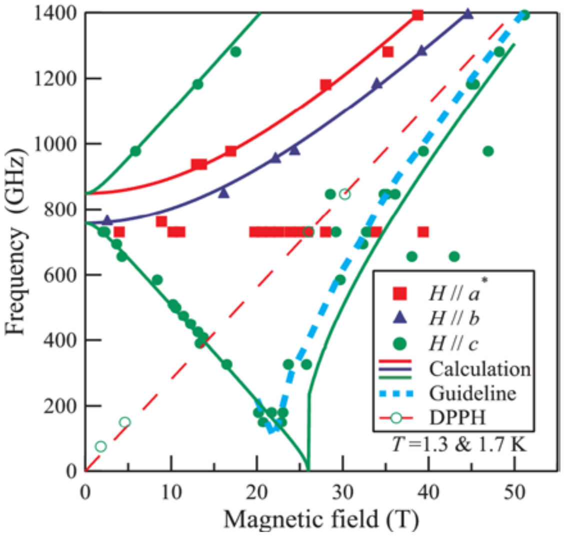

Figure 4: *The frequencies of the antiferromagnetic resonance modes are shown as a function of magnetic field [1]. The data points were acquired with a pulsed magnet system at the AHMF at Osaka University. The disagreement between the data and the calculated lines near and above the spin-flop field of 22 T has recently been resolved [3].*

Uncovering the behavior of Hf_2Te_2P and the candidate Dirac metal Zr_2Te_2P

K. W. Chen, S. Das, D. Rhodes, S. Memaran, T. Besara, T. Siegrist, E. Manousakis, L. Balicas, and R. E. Baumbach

Results were recently reported for single crystal specimens of Hf_2Te_2P and compared to its structural analogue Zr_2Te_2P,**[1]** which had been proposed to be a potential reservoir for Dirac physics in a metallic system. [2] Both materials were produced in the Baumbach laboratory at the NHMFL-FSU using the iodine vapor phase transport method. Similar to the topological insulators $Bi_2(Se,Te)_3$, these materials crystallize in the tetradymite structure and are exfoliable. The bulk electrical transport and thermodynamic properties indicate Fermi liquid behavior at low temperature for both compounds. Quantum oscillations are observed in magnetization measurements for fields applied parallel but not perpendicular to the *c*-axis, suggesting that the Fermi surfaces are quasi-two dimensional. Frequencies were determined from quantum oscillations for several parts of the Fermi surfaces.

Lifshitz–Kosevich fits to the temperature dependent amplitudes of the oscillations reveal small effective masses, with a particularly small value m_{eff} = 0.046m0 for the α branch of Zr_2Te_2P. Electronic structure calculations are in good agreement with quantum oscillation results and illustrate the effect of a stronger spin–orbit interaction going from Zr to Hf. These results suggest that by using appropriate tuning parameters this class of materials may deepen the pool of novel Dirac phenomena.

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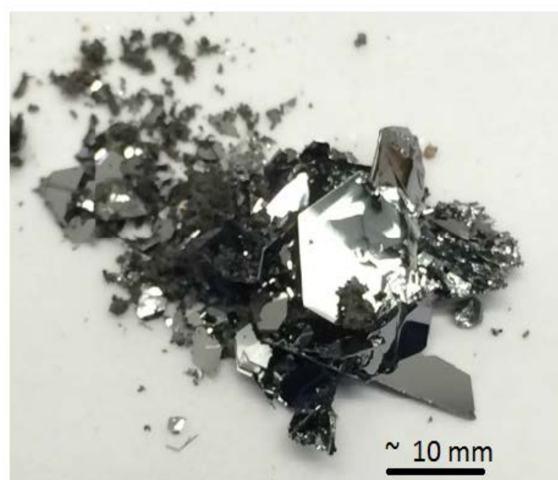

Figure 5: *Single crystal specimens of Zr_2Te_2P produced using the iodine vapor transport method in the Baumbach laboratory at the NHMFL.*

Single reconstructed Fermi surface pocket in an underdoped single layer cuprate superconductor

M. K. Chan, R. D. McDonald, B. J. Ramshaw, K. A. Modic, N. Barisic, M. Greven, N. Harrison

The identification of broken symmetry states, particularly in the pseudogap region, is essential for understanding the cuprate phase diagram. The surprising discovery of a small Fermi surface from quantum oscillations (QOs) measured in very high magnetic fields in underdoped $YBa_2Cu_3O_{6+x}$ (Y123) [1] motivated proposals for a crystal-lattice-symmetry-breaking order parameter [2-3] that recon-

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structs either the large Fermi surface identified in overdoped cuprates [4-5] or the `Fermi-arcs' of the pseudogap state. The spectrum of quantum oscillations is, in principle, a distinct probe of the Fermi surface morphology and is thus a signature of the broken symmetry state. However, despite the availability of exquisitely detailed QO studies in Y123 [6-7], its complicated multi-frequency spectrum (as shown in **Fig. 6 (a)**&**(b)**) has prevented a consensus on the exact model for Fermi-surface reconstruction. The difficulty stems from the crystal structure of Y123, particularly the bilayer splitting of the elementary Fermi pockets due to the two CuO_2 planes per unit cell. Different models are sensitive to the magnitude and momentum dependence of the bilayer coupling, which are controversial.

Here we show that high resolution QO measurements in the *single* layer cuprate $HgBa_2CuO_{4+\delta}$ (Hg1201) permits a resolution of the reconstructed electronic structure. In addition to featuring a very high superconducting transition temperature (T_c ~ 97 K at optimal doping), its tetragonal crystal symmetry consisting of only a single CuO_2 plane means that the analysis of the experimental data is free from complications associated with bilayer coupling. Using pulsed magnetic fields extending to 90 T combined with contactless resistivity measurements, we find the QOs in Hg1201 to be remarkably simple: *a single oscillation frequency exhibiting a monotonic magnetic field dependence characteristic of a single Fermi surface pocket*, as shown for two Hg1201 samples in **Fig. 6(a),(c)&(d).**

The relatively simple crystal structure of Hg1201 allows for a quantitative comparison of Fermi-surface reconstruction models with our experimental data. Evidence for charge-density-wave order (CDW) has been found from spectroscopic scattering experiments[8,9], though their exact nature has been contentious. We find quantitative agreement between the observed single QO frequency in Hg1201 and that from a diamond-shaped electron pocket resulting from biaxial charge-density-wave (CDW) reconstruction. There are no signatures of the predicted additional small hole-like pocket [10] reported for Y123 [6]. This could be due to the antinodal states, which constitute these hole pockets, being gapped by the pseudogap phenomena. We also determine a very small c-axis transfer integral for Hg1201, which precludes reconstruction models based on an alternating `criss-cross' pattern of uniaxial charge stripes on consecutive CuO_2 planes proposed in Ref. [11]. *Overall, our results point to biaxial CDW reconstruction acting on the short nodal Fermi arcs produced by the pseudogap phenomena.*

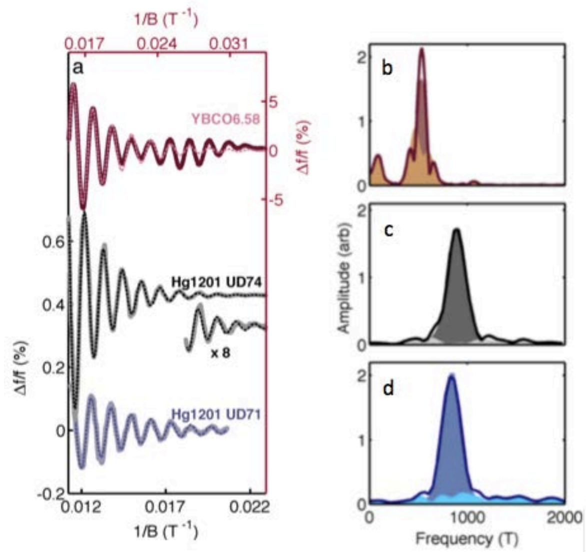

Figure 6: Spectrum of quantum oscillations in Hg1201 and Y123 (a) *Percentage change of the resonance frequency Δf/f as a function of inverse applied field 1/B for oscillatory circuits used to measure contactless resistivity in Y123 with x = 0.58 (T_c = 60 K, red), Hg1201 UD74 (T_c = 74 K; black) and Hg1201 UD71 (T_c = 71 K; blue). The small amplitude oscillations for Hg1201 UD74 at low fields (large 1/B) are magnified x8 for clarity. Single frequency fits to the data with the Lifshitz-Kosevich formula[12] are indicated by dashed lines.* ***(b)-(d)*** *Corresponding Fourier transform for Y123 and Hg1201 showing the spectrum of QO frequencies. The solid lines are FFT of the data and the dark shaded regions represent the FFT of the single-frequency fits in* ***(a).*** *The light shaded regions are the FFT of the spectrum not represented by the single frequency fit.*

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Impurity dependent superconductivity, Berry phase and bulk Fermi surface of the Weyl type-II semi-metal candidate $MoTe_2$

D. Rhodes, Q. Zhou, R. Schonemann, Q. R. Zhang, E. Kampert, Y. Shimura, G, T. McCandless, J. Y. Chan, S. Das, E. Manousakis, M. D. Johannes, and L. Balicas

Orthorhombic $MoTe_2$ and its isostructural compound WTe_2 were recently claimed to belong to a new class (type II) of Weyl semi-metals characterized by a linear touching between hole and electron Fermi surfaces in addition to nodal lines. To validate these predictions, we synthesized high quality single-crystals of β-$MoTe_2$, finding that its superconducting transition temperature depends on disorder as quantified by the ratio between the room- and low-temperature resistivities. Its magnetoresitivity does not saturate at high magnetic fields and can easily surpass 10^6 %, with the superimposed Shubnikov de Haas oscillations revealing a non-trivial Berry phase of ≃ π. The geometry of the Fermi surface, determined from the quantum oscillations, is distinct from the calculated one: a broad anomaly in the heat capacity and in the Hall-effect indicates that the crystallographic and the electronic structures evolve upon cooling below 100 K. This may explain the discrepancy between recent predictions and our experimental observations.

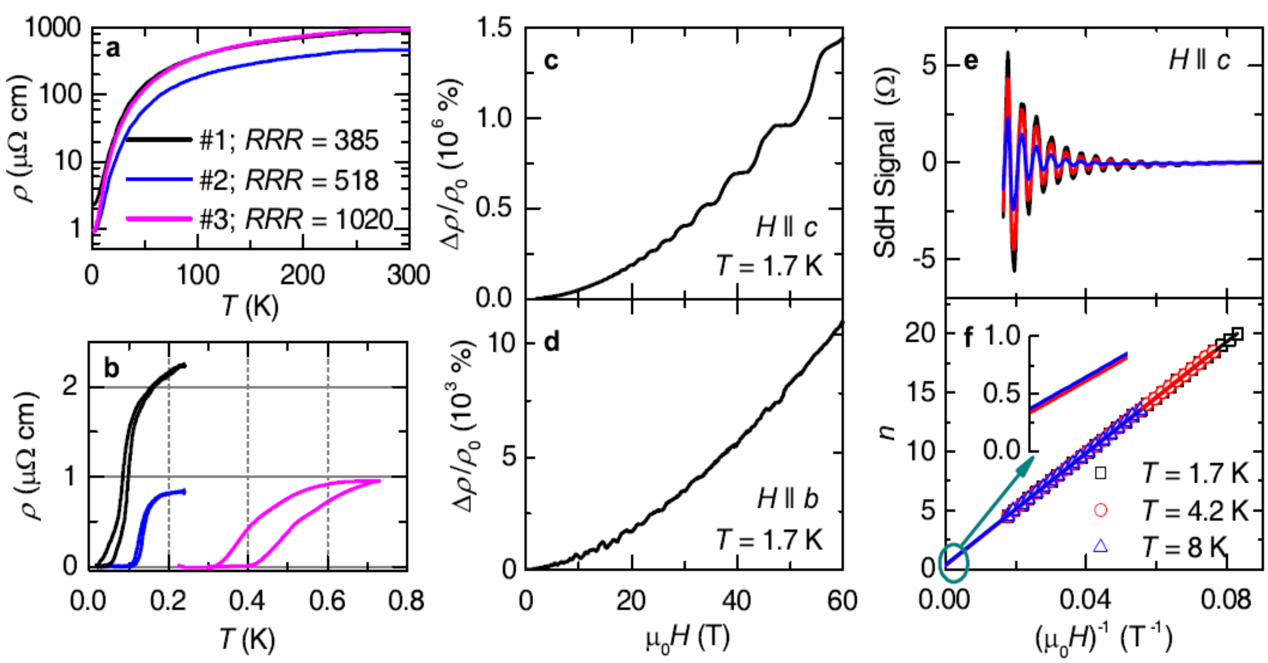

Figure 7 a: *Resistivity ρ(T) for currents along the a−axis (3 representative single crystals) showing RRR between 380 and ∼ 1000.* ***b****, ρ(T) indicating that Tc depends on sample quality (hysteresis due to non-ideal thermal coupling between sample, heater and thermometer).* ***c****, $\rho(\mu_0 H)$ applied along the c-axis at T = 1.7 K. Notice i) non-saturation of $\rho(\mu_0 H)$, and ii) $\Delta\rho(\mu_0 H)/\rho_0$ at T = 2 K surpasses 1.4 × 10^6 % at H = 60 T.* ***d****, $\rho(\mu_0 H)$ along the b−axis at T = 1.7 K.* ***e****, Shubnikov de Haas signal for H∥ c−axis and T = 8 K (blue), 4.2 K (red), 1.7 K (black).* ***f****, Landau-index plot vs inverse magnetic field $(\mu_0 H)^{-1}$: extrapolation to H=0 yields an intercept at 0.37 (inset), indicative of a non-trivial Berry phase $\Phi_B \simeq \pi$.*

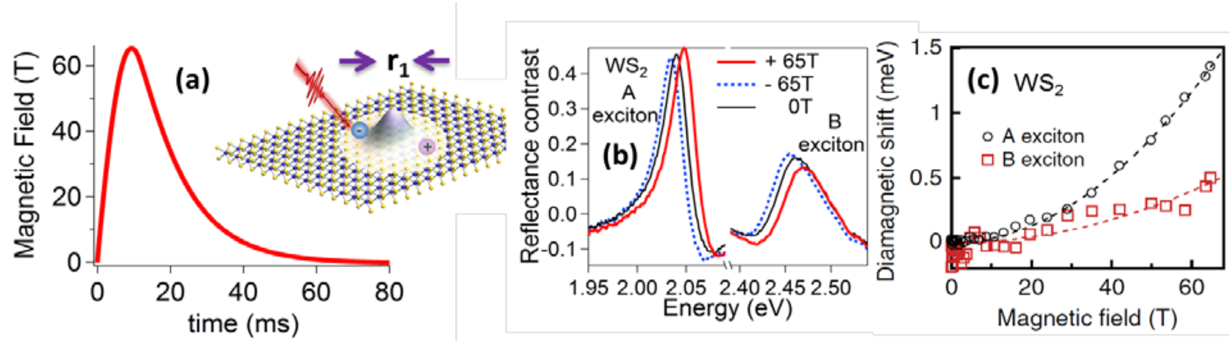

***Figure 8: a)** 65 T spectroscopy of monolayer semiconductors. **b)** Polarized magneto-reflection shows the Valley Zeeman Effect for A and B excitons. **c)** Small quadratic diamagnetic shifts directly reveal the exciton radius.*

Magneto-optical spectroscopy of excitons in atomically-thin semiconductors using pulsed magnetic fields

Andreas V. Stier, Scott A. Crooker, Kathy M. McCreary, Berend T. Jonker & Junichiro Kono

Magneto-optical spectroscopy has historically played a central role in revealing the fundamental properties of excitons in bulk and low-dimensional semiconductors, such as mass, size, spin, binding energy, and dimensionality. This will be especially true for the recently-discovered family of atomically-thin semiconductors known as the monolayer transition metal dichalcogenides (TMDs) such as MoS_2 and WSe_2. Much of the great interest in these new 2D semiconductors derives from their strong spin-valley coupling and *valley-specific* optical selection rules. Despite a number of low-magnetic-field studies to date, many fundamental properties of TMDs such as exciton size, exciton binding energy, and even carrier masses are either still experimentally unknown or subject to considerable ongoing debate. In part, this is because (in contrast to conventional semiconductors like GaAs) the carrier masses and exciton binding energies are believed to be quite large in TMDs, which motivates a clear need for magneto-optical spectroscopy in extremely high magnetic fields.

Over the last year have developed capabilities for performing polarized magneto-reflection studies of atomically-thin WS_2 and MoS_2 in very high (pulsed) magnetic fields to 65 tesla [1,2]. Clear splittings of both the A *and* the B excitons were observed, giving valley *g*-factors = -4.0 for *both* excitons. This unexpected and surprising result suggests that the Valley Zeeman Effect in these 2D semiconductors originates primary from the atomic orbital magnetic moment *alone* – that is, the much-discussed Berry curvature in TMDs, which should be rather different for A and B excitons owing to their different mass, appears to have minimal influence. Even more importantly, the use of large 65 T fields allowed the first observation of the small quadratic *diamagnetic shift* of excitons in the TMD semiconductors. Diamagnetic shifts are important because they provide a direct experimental measure of the exciton size, a fundamental material parameter. The data reveal very small r.m.s. radii of 1.53 nm and 1.16 nm for the A and B excitons in monolayer WS_2, confirming their tightly-bound nature due to reduced dimensionality. Finally, we show how diamagnetic shifts can also be used to constrain estimates of the (very large) exciton binding energy in these TMDs, further highlighting the utility of high magnetic fields for understanding new 2D semiconductors.

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Long-lived electron spin relaxation and spin coherencein monolayer transition-metal dichalcogenide semiconductors

Luyi Yang, Nikolai A. Sinitsyn, Weibing Chen, Jiangtan Yuan, Jing Zhang, Jun Lou, Kathleen M. McCreary Berend T. Jonker, Scott A. Crooker

Interest in atomically-thin transition metal dichalcogenide (TMD) semiconductors has exploded in the last few years, driven by the new and exciting

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physics of coupled spin and valley degrees of free dom that exist in these 2D materials. Although robust spin and valley degrees of freedom have been inferred from polarized photoluminescence (PL) studies of excitons, PL timescales are necessarily constrained by short-lived (3–30 ps) recombination of *excitons*. Direct probes of spin/valley dynamics of the *resident* carriers in electron- (or hole-) doped TMDs, which may persist long after recombination ceases, are still at an early stage.

Over the last year, we have directly measured the coupled spin-valley dynamics of the *resident* electrons in *n*-type monolayer MoS_2 using Time Resolved Kerr Rotation [1], and revealed very long spin lifetimes exceeding 3 ns at 5 K - orders of magnitude longer than typical exciton lifetimes (**Fig. 9**). In contrast with conventional III-V or II-VI semiconductors, spin relaxation accelerates rapidly in small transverse magnetic fields B_y. This indicates a novel mechanism of electron spin dephasing in monolayer TMDs that is driven by rapidly-fluctuating internal spin-orbit fields that, in turn, are due to fast electron scattering between the *K* and *K'* conduction bands [1].

Additionally, a small but surprisingly long-lived oscillatory signal is also observed, indicating the spin *coherence* of a small population of localized states [2]. These coherence signals are observed in a variety of samples and are studied as a function of applied field and temperature. We note that spin relaxation and spin coherence have been observed not only in MoS_2, but also in other monolayer TMDs such as $MoSe_2$ and WS_2 [3]. These studies provide direct insight into the physics underpinning the spin and valley dynamics of electrons in the new monolayer TMD semiconductors.

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Strong quantum-confinement effect on the Seebeck coefficient in PbSe nanowire thin films

N. Mishra, M. Jaime, Jennifer A. Hollingsworth

More than half of the energy generated worldwide is lost as heat. Such waste heat can originate from large point sources (e.g., industrial processes) or smaller distributed sources (e.g., automobiles). Thermoelectric (TE) conversion of heat into electricity taking advantage of the Seebeck Effect has the potential to address this energy source and utilization challenge.[1,2] The device performance is characterized by the thermoelectric figure of merit, $ZT = S2\sigma T/\kappa$, where *S* is the Seebeck coefficient, σ is the electrical conductivity, *T* is the absolute temperature, and κ is the thermal conductivity from both lattice and charge carrier contributions. For a solid state thermoelectric module to compete on the commercial market, a value of ZT > 3 is considered necessary. Due to the interrelated nature of *S*, σ, and κ, traditional bulk materials have not achieved a value of ZT greater than unity[3]. Recently, theoretical predictions[4,5] and exper-

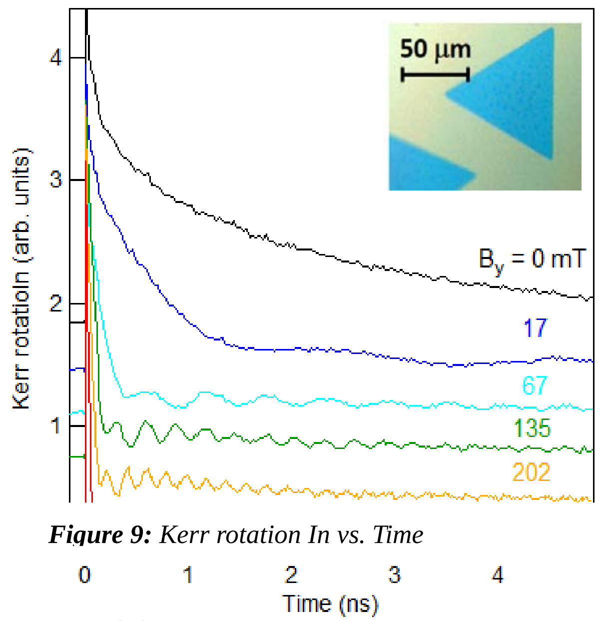

Figure 9: *Kerr rotation In vs. Time*

iments[6-10] have indicated that nanoscale semiconductors are increasingly viewed as viable TE materials capable of realizing a high ZT, where nanostructuring can be used to reduce phonon transport and, ideally, to simultaneously increase another key ZT parameter, the Seebeck coefficient, via direct modification of the semiconductor electronic density-of-states (DOS).[10] As predicted by Mahan and Sofo, quantum confinement leads to sharp delta-function-like peaks in the DOS, which could be the best possible electronic structure for a thermoelectric material.[12] Furthermore a calculation by Humphrey and Linke[15] predicts that optimized nanostructured materials with a delta-like DOS can have *ZT* approaching 10.

Bulk Lead Chalcogenides possess a relatively high ZT, so synthesizing these materials as one-dimensional structures is a promising method for further improvement in the figure-of-merit with potential applications in automotive waste-heat recovery. Here, we synthesized PbSe nanowires (NWs) with nano-structuring designed for optimized Seebeck coefficient. It has been demonstrated experimentally by others for PbSe quantum dots (QDs) that quantum-confinement effects can be used to modify DOS and, thereby, to dramatically increase thermopower. In an attempt to combine nanoscale effects on thermal conductivity and Seebeck coefficient with improved electrical conductivity anticipated for 1-dimensional NWs compared to 0-dimensional QDs, we compared Seebeck coefficients for different-diameter NWs. PbSe NWs were prepared using metal-catalyzed solution-liquid-solid (SLS) growth, taking advantage of the stoichiometry control afforded by single-source precursors. Novel thin-film TE-devices were fabricated and used to assess TE parameters as a function of different environments. Seebeck coefficient at room temperature of up to 524 mV/K, on 9 nm diameter nanowires, and up to 585 mV/K, on quantum dots 4 nm in diameter, was obtained. In both cases the increase in physical dimension (diameter) results in a decrease of the Seebeck coefficient as expected.

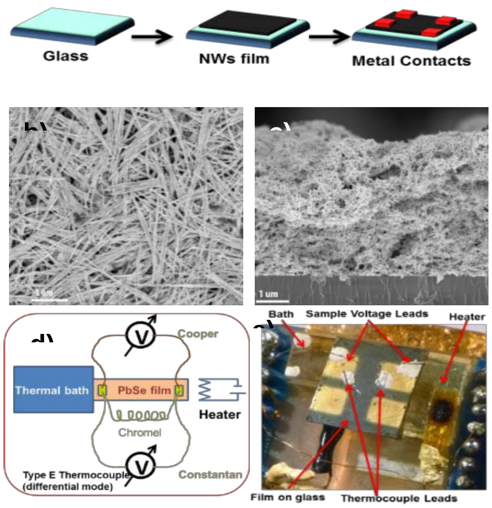

Figure 10: *Nanowire sample deposition and patterning for Seebeck effect measurements* ***(a)*** *Schematic of the making PbSe nanowires films with lateral electrode (Cr 10nm /Au 150 nm) configuration.* ***(b), (c)*** *are the top and cross-sectional SEM images respectively of densely-packed PbSe nanowires films spin coated from a solution of nanowires dispersed in toluene. Multiple steps are involved for the film preparation. The thickness at the central region of the film was about 4-5 µm.* ***(d)*** *Representative schematic of the experimental setup for the measurement of Seebeck coefficient.* ***(e)*** *Our actual device image in operational mode under optical microscope. The different parts of the measurement setup are labeled in the image.*

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Shubnikov-de Haas oscillations in doped PbSe.

N. Anand, D. B. Tanner C. Martin, Ramapo College; G. Gu (Brookhaven National lab.)

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CHAPTER 5 – IN-HOUSE RESEARCH

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PbSe is a low-gap semiconductor with excellent infrared photodetection properties. In order to study the dynamics of free carriers, its coexisting electronic systems, and the nature of the Fermi surface, we measured the high magnetic field and low temperature electrical properties of a moderately doped PbSe single crystal. The measurements were done at the MagLab in Tallahassee. The single crystal had a p-type bulk carrier density of around 1×10^{18} cm^{-3}. Longitudinal resistance (R_{xx}) and Hall resistance (R_{xy}) were simultaneously measured between 0 and 18 T at several temperatures between 0.8 and 25 K using a top loading sorption pumped He-3 cryogenic system. These measurements show high positive magnetoresistance of about 400% for both configurations. Quantum oscillations were seen above 6 T. In the figure below, the oscillation amplitude is shown vs. the inverse of the magnetic field for the longitudinal configuration, A similar oscillatory trend was found in the Hall configuration. The quantum oscillation frequency is ~15 T, giving an estimate for the carrier density of each L pocket in the BZ participating in these oscillations. The effective mass of the free carriers is estimated from the temperature dependence of oscillation amplitudes. Samples were mounted on a rotating probe allowing the sample rotation with respect to the magnetic field at an angular resolution better than 1°. These measurements show oscillatory behavior at all angles between 0° and 90°. The oscillation frequency, and therefore the
cyclotron orbit area, decreases 5-fold at an angle of 30° and higher. These angle dependent measurements reveal the magneto-transport properties of a 3D Fermi surface.

NMR Study of HD molecules constrained to the pores of Z-1200

Y. Ji, J. A. Hamida, T. Tang, N. Sullivan

The technique of nuclear relaxation spectroscopy [1-2] has been used to determine the energy level structure of HD molecules localized in the cavities of a Z-type metal-organic framework, Z-1200. For exact filling of one molecule per cage the temperature dependence of the nuclear-spin-lattice relaxation time shows distinct peaks at well-defined temperatures **(Figure 11).** These peaks can be understood in terms of the discrete energy levels expected for the translational degrees of freedom of the molecules in the quasi-spherical pores. In the relaxation process a bottleneck occurs in the relaxation process between the nuclear spins and the coupling to the walls via the phonons associated with the translational motion. The heat capacities corresponding to these energy levels lead to peaks in the overall relaxation rates. This is the basis of the method of nuclear relaxation spectroscopy. The cages in Z-MOF are of course not per-

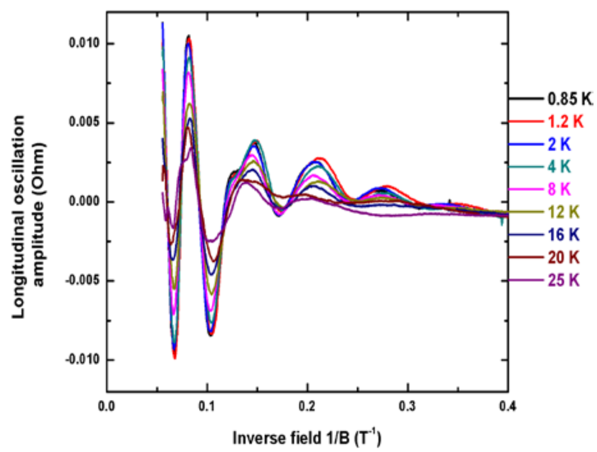

Figure 11: *Longitudinal oscillation amplitude vs. Inverse field*

fect and that may explain why the line widths are appreciably narrower than one would expect for a simple sum of Schottky heat capacity peaks.

Optical manipulation of nuclear spin polarization in GaAs quantum wells: effects of magnetic field, strain and quantum confinement

C. R. Bowers

Nuclear spins are promising candidates as qubits for quantum computing, but initialization in a pure quantum state poses a significant challenge. In III-V semiconductors like GaAs, nuclear spin ordering is achievable by optical dynamic nuclear polarization (ODNP).

In this UCGP-funded research, the effects of high magnetic field, quantum confinement, and lat-

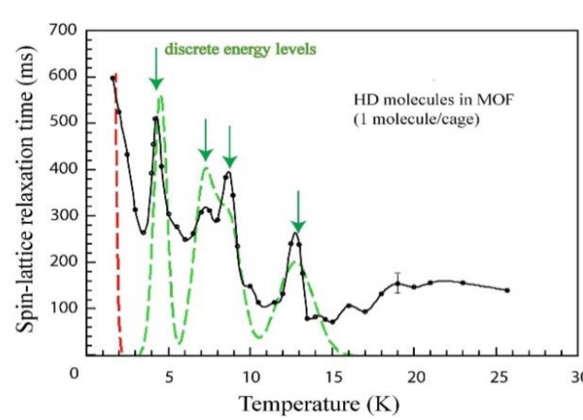

Figure 12 (right): *Temperature variation of the nuclear spin-lattice relaxation time for HD molecules in Z-MOF. The broken line is the theoretical variation for molecules confined to molecular cages.*

tice strain on the photon energy dependence of ODNP were investigated by NMR. A special cryogenic NMR probe with optical access was constructed for studies in NHMFL's Ultrafast Optics Lab.

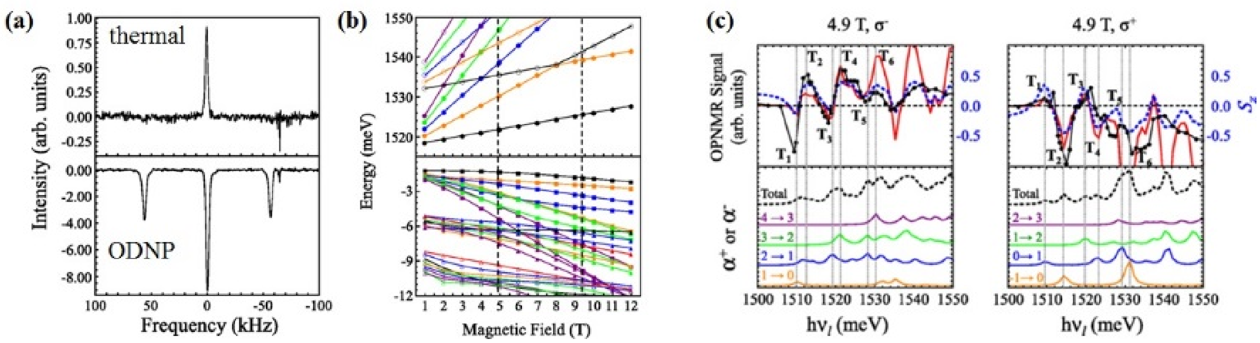

__Figure 13: a)__ Thermal and ODNP-polarized NMR signal acquired at 9.4 T, 4.2 K. __b)__ Calculated magnetic field dependence of the conduction bands and valence bonds in the 30 nm GaAs quantum well. __c)__ Upper panels: Photon energy dependence of ODNP-NMR at 5 K and 4.9 T for left and right circularly polarized light. Red curve: calculated ODNP-NMR; dashed blue: theoretical electron spin polarization. Gray dotted vertical lines mark specific assignments of features in the ODNP-NMR to interband optical transitions. Wood, R. M.; Saha, D.; McCarthy, L. A.; Tokarski, J. T.; Sanders, G. D.; Kuhns, P. L.; McGill, S. A.; Reyes, A. P.; Reno, J. L.; Stanton, C. J.; Bowers, C. R., PRB 90, 155317 (2014).

Figure 13a presents the thermally-polarized and ODNP-polarized Ga-71 NMR spectra of an MBE-grown multiple quantum well thin film consisting of 30 nm GaAs quantum wells separated by 360 nm $Al_{0.1}Ga_{0.9}As$ barriers. For photon energies below the AlGaAs band gap, ODNP-NMR is sensitive to the nuclei confined to the GaAs wells while the thermally polarized NMR spectrum is dominated by the signal from the barriers. The lattice strain in the wells can be accurately determined from the quadrupole splitting of the NMR line. This was used as input into a calculation of the electronic energy levels (**Figure 13b**) and spin-dependent absorption coefficients and combined with a dynamical model for electron-nuclear cross-relaxation, allowing one to determine the assignment of the peaks in the ODNP-NMR photon energy dependence (**Figure 13c**).

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Phase separation and superparamagnetic cluster dynamics at low temperatures in the shape memory alloy $Ni_{43}Co_7Mn_{40}Sn_{10}$

S.Yuan, P.L. Kuhns, A.P.Reyes, and M.J.R. Hoch V.Srivastava, R.D. James, and C. Leighton

Off-stoichiometric shape memory Heusler alloys, such as $Ni_{50}Mn_{25+y}X_{25-y}$ (X = Sn, In, Ga *etc.*), exhibit unusual, and potentially useful magnetic properties. It has recently been established that the quaternary alloys $Ni_{50-x}Co_x Mn_{40} Sn_{10}$ ($5 < x < 8$), which undergo a martensitic transition above 350 K, are particularly promising for applications in sensors, actuators, magnetic refrigerators and thermal-to-electric energy converters. The phase diagram for the quaternary alloys reveals that for a range of x values, superparamagnetism (SP) and intrinsic exchange bias (EB) effects are important at low temperatures in the martensitic phase. However, the microscopic origins of these effects have remained unclear.

Recent work at the NHMFL has established that ^{55}Mn spin echo nuclear magnetic resonance (NMR is a powerful technique for probing the magnetic properties of Heusler alloys at the nanoscale level via the hyperfine field distribution at Mn sites (Yuan S. *et al. Phys. Rev. B* **91**, 214421 (2015)). The multipeak NMR spectra cover a wide frequency range as shown in **Figure 14** for x = 0 at 1.6 K. The best fit multiple Gaussian components are identified with coexisting ferromagnetic (F) clusters and antiferromagnetic (AF) matrix regions.

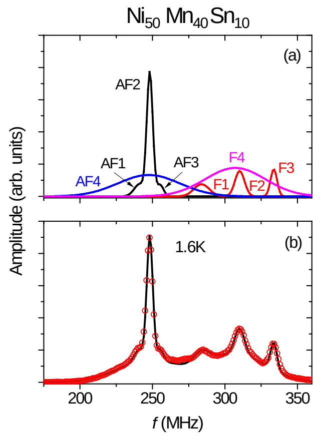

***Figure 14**: ^{55}Mn NMR spectrum for $Ni_{50}Mn_{40}Sn_{10}$ at 1.6 K (a) the F (f > 275 MHz) and AF (f < 275 MHz)best-fit Gaussian components and (b) the recorded spectrum (red) with the fit (black).Multiple F and AF components are identified. The narrow lines correspond to large (~ 6 nm) F and AF clusters observable up to 300 K. The broad components (F4 and AF4) disappear above 10 K and are due to small clusters and interface regions.*

Figure 15 compares the 1.6 K spectra for x = 0, 7 and 14.Substitution of Co on a fraction of Ni sites produces changes in the local electronic structure which lead to new spectral features at high frequencies attributed to Co rich F nanoclusters. A cluster model, which incorporates SP blocking concepts, has been developed for use in the analysis of the results. Information has been obtained on the nanoscale size distributions of the various magnetic regions and on

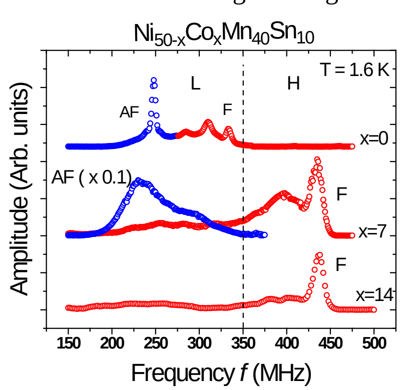

***Figure 15:** 2 ^{55}Mn ZF NMR spectra for $Ni_{50-x}Co_xMn_{40}Sn_{10}$ at 1.6 K with x = 0, 7 and 14. Spectra associated with F (red) and AF (blue) regions are indicated. The amplitude of the AF component is reduced by a factor 10 for x =7. Substitution of Co for Ni (x = 7 and 14) produces F clusters with new features above 350 MHz.*

the evolution of the cluster correlation times with temperature. The results provide detailed, and previously unavailable, information the local magnetic properties of these materials and the origins of the SP and EB effects are clarified (Yuan S. *et al. Phys. Rev. B* **93**, 094425 (2016)).

Austenite-to-martensite transition in stainless steel

S. Wang, A. E. Kovalev, A.V. Suslov, J.H. Smith, K. Han, T. Siegrist

We used the newly developed X-ray diffractometer setup for the split-coil 25T magnet [*Rev. Sci. Instrum.* **86**, 123902 (2015)] to study the austenite-to-martensite transition in stainless steel under applied magnetic fields The upgraded system used a motor-controlled X-ray detector support allowing precise detector positioning close to the magnet.

Martensitic transformations are first-order diffusionless structural phase transitions, which can be affected by an applied magnetic field. For practical applications, the effect of the magnetic field on the martensite transition can be of significant interest because the mechanical properties of stainless steel strongly depend on the amount of martensitic phase.

We investigated the austenite-to-martensite transformation in stainless steel SS301 at 25 °C. The as-received sample was first annealed at 1050°C for several hours to produce an almost 100% austenite state. The sample was then placed inside the magnet and the strength of the α(011) X-ray diffraction peak associated with the martensitic phase was measured at several different magnetic fields. **Figure 16** shows the evolution of the martensitic phase by following the α(011) reflection. This transition is irreversible and the amount of the austenite phase does not change after removing the field. The fact that this transition can be induced easily at room temperature will require further studies.

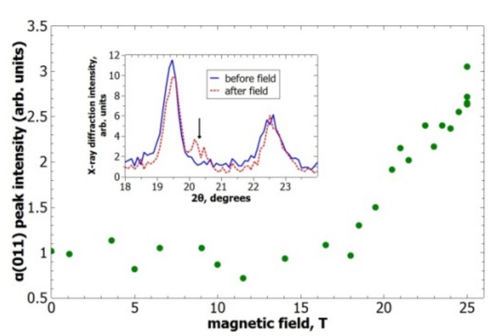

***Figure 16:** The evolution of the α(011) martensite peak in the applied magnetic field. Inset: the X-ray diffraction spectra before and after magnetic field application. The arrow shows the martensitic peak location.*

CHAPTER 5 – IN-HOUSE RESEARCH

THEORY

1. Berry phases and the intrinsic thermal Hall effect in high temperature cuprate superconductors

Vladimir Cvetkovic and Oskar Vafek

The Bogoliubov quasiparticles move in a practically uniform magnetic field in the vortex state of high temperature cuprate superconductors. In this paper (*Nature Comm.* **6**, 6518 (2015)) the authors for the first time calculate the temperature, **H**-field and the *d*-wave pairing gap Δ dependence of the intrinsic thermal Hall conductivity, κ_{xy}. They find that the intrinsic contribution to κ_{xy} displays a rapid onset with increasing temperature, which compares favorably with existing experiments at high **H**-fields on the highest purity samples. This finding may help to settle a much-debated question of the bulk value of the pairing strength in cuprate superconductors in magnetic field. (This work was supported in part by the NSF CAREER award under Grant No. DMR-0955561).

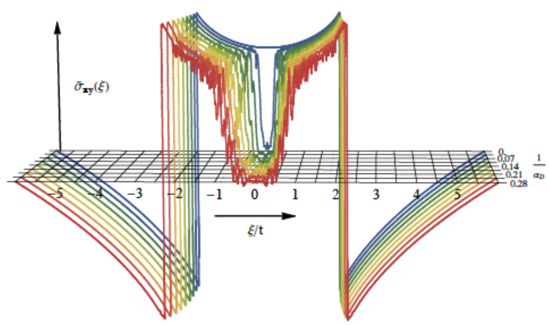

Figure 1: *Energy ξ dependence of the σ_{xy}, which is proportional to the T = 0 spin Hall conductivity when all the quasiparticle bands below ξ are occupied, for various values of the Dirac cone nisotropy α_D.*

2. Bad-Metal Behavior Reveals Mott Quantum Criticality in Doped Hubbard Models

J. Vučičević, D. Tanasković, M. J. Rozenberg, and V. Dobrosavljević

Bad-metal (BM) behavior featuring linear temperature dependence of the resistivity extending to well above the Mott-Ioffe-Regel (MIR) limit is often viewed as one of the key unresolved signatures of strong correlation. In this paper (*Phys. Rev. Lett.* **115**, 025701 (2015)), the authors associate the BM behavior with the Mott quantum criticality by examining a fully frustrated Hubbard model where all long-range magnetic orders are suppressed, and the Mott problem can be rigorously solved through dynamical mean-field theory (DMFT). They show that for the doped Mott insulator regime, the coexistence dome and the associated first-order Mott metal-insulator transition are confined to extremely low temperatures, while clear signatures of Mott quantum criticality emerge across much of the phase diagram. Remarkable scaling behavior is identified for the entire family of resistivity curves, with a quantum critical region covering the entire BM regime, providing not only insight, but also quantitative understanding around the MIR limit, in agreement with the available experiments. (V. D. was supported by the NSF Grants DMR-1005751 and DMR-1410132. Numerical simulations were run on the AEGIS e-Infrastructure, supported in part by FP7 projects EGI-InSPIRE and PRACE-3IP.)

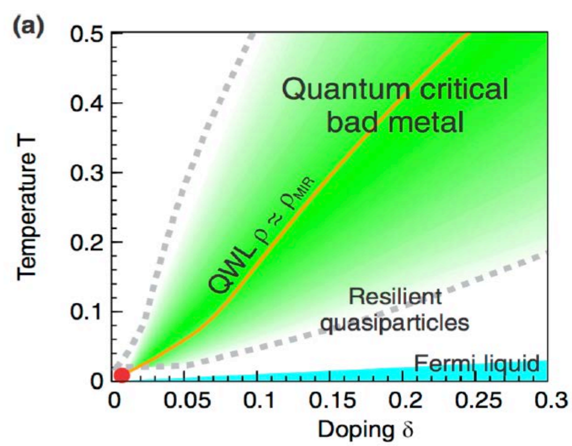

Figure 2: *DMFT phase diagram of the doped Mott insulator on a frustrated lattice. The bad-metal (green) region matches perfectly the region of quantum critical scaling.*

3. Monte Carlo studies of the self-correcting properties of the Majorana quantum error correction code under braiding

Fabio L. Pedrocchi, N. E. Bonesteel, and David P. DiVincenzo

The Majorana code is an example of a stabilizer code where the quantum information is stored in a system supporting well-separated Majorana bound

CHAPTER 5 – IN-HOUSE RESEARCH

states (MBSs). In this paper (*Phys. Rev.* B **92**, 115441 (2015)), the authors focus on one-dimensional realizations of the Majorana code, as well as networks of such structures, and investigate their lifetime when coupled to a parity-preserving thermal environment. They apply the Davies prescription, a standard method that describes the basic aspects of a thermal environment, and derive a master equation in the Born-Markov limit. They first focus on a single wire with immobile MBSs and perform error correction to annihilate thermal excitations. In the high-temperature limit, they show both analytically and numerically that the lifetime of the Majorana qubit grows logarithmically with the size of the wire. We study the occurrence of dangerous error processes that prevent the lifetime of the Majorana code from growing with the size of the trijunction. The origin of the dangerous processes is the braiding itself, which separates pairs of excitations and renders the noise nonlocal; these processes arise from the basic constraints of moving MBSs in one-dimensional (1D) structures. We confirm our predictions with Monte Carlo simulations in the low-temperature regime, i.e., the regime of practical relevance. Our results put a restriction on the degree of self-correction of this particular 1D topological quantum computing architecture. (N.E.B. was supported in part by US DOE Grant No. FG02-97ER45639.)

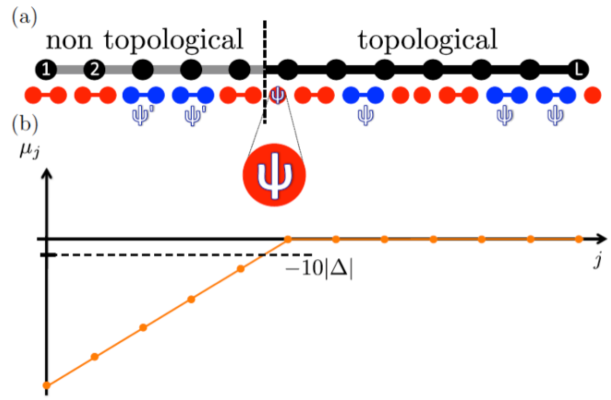

Figure 3: (a) *Pictorial representation of the Kitaev wire with topological (black) and nontopological (gray) segments. The large black dots describe the fermionic sites, while the line in between describes hopping and superconducting pairing. The smaller dots below represent the Majorana modes whose pairing is depicted by lines connecting the dots. Pairings in the topological segment are shifted as compared to pairings in the nontopological segment. A possible pattern of ψ and ψ excitations is shown.* ***(b)*** *Value of the chemical potentials μj corresponding to the situation in* ***(a).*** *The chemical potentials in the nontopological segment have a gradient in order to localize the ψ - excitations.*

Geochemistry

CHAPTER 5 – IN-HOUSE RESEARCH

3. Geochemistry

Overview: The facility primarily investigates natural processes, both recent and ancient, through the analysis of trace element contents and isotopic compositions.

Introduction: The Geochemistry Program funding is through grants from the Geoscience directorate at NSF, NASA and the USGS. All tenure-track faculty have their appointments in FSUs' College of Arts and Sciences. The facility has six mass spectrometers, which are available to outside users. Three instruments are single collector inductively coupled plasma mass spectrometers for elemental analysis. One instrument is dedicated to in-situ trace element analyses on solid materials using laser ablation. The other two are for elemental analyses of solutions. The facility has three instruments dedicated to determination of isotopic compositions. One is a multi-collector inductively coupled plasma mass spectrometer (NEPTUNE) used for determination of isotopic abundances of metals. A second is a thermal ionization multi collector mass spectrometer, which is mainly used for Sr-isotopic compositions. The third mass spectrometer is designed for the measurement of the light stable isotope compositions (C, N, O). In the coming year we are adding a mass spectrometer that will be dedicated to sulfur isotope analyses.

Publications and Outreach: The group members have published 28 peer reviewed publications and a similar number of presentations at meetings and invited presentations at other institutions.

Science Highlights: Mercury is a pollutant and especially in the southeastern US mercury levels in aquatic systems and in the organisms that live in these waters is high. Mercury has seven natural occurring isotopes and exhibits both mass dependent and mass independent isotope fractionation during natural biological induced or chemical transformations. Mass dependent fractionation can occur during any reaction, but mass independent fractionation is restricted to reactions that are photo-induced. The Macondo well oil spill in 2010 provided the opportunity to investigate whether the large influx of organic matter into the Gulf changed the cycling of Hg, through isotopic studies. Our research has shown that; gulf fish, like grouper and snapper, show systematic differences in mass dependent isotope fractionation between liver and muscle tissue, indicating that Hg is processed in fish and fish can fractionate Hg-isotopes; Hg-concentrations in fish muscle tissue decreases with proximity to the Macondo well. Combined with increasing methyl mercury concentrations in sediments and high sedimentation rates associated with the oil spill indicates bio-dilution and a significant change in mercury cycling where methyl Hg is removed from the water column through sedimentation.

The redox state of the deep Earth is controlled by iron, sulfur and carbon and usually determined by the ferric ferrous ratio in magmas. However, this ratio can be perturbed during eruption because of the oxidizing conditions at the Earth's surface. We have developed a proxy for the redox state with the V/Sc ratio. The different valence states of V makes it sensitive to redox conditions while Sc solid melt partitioning is independent of oxygen fugacity. Our laser ablation data on mid-ocean ridge basalt glasses shows that those that come from a more depleted source are formed under more oxidizing conditions. Since Fe and S show no systematic differences in ridge basalts from between depleted and enriched sources the difference in redox state are attributed to differences in carbon content.

Progress on Stem and Building the User Community: The facility is open to users of all disciplines, and we have a long-time collaboration with the USGS and the South Florida Water Management District. In the past year three new faculty members (and their students) from the department of Earth Ocean and Atmospheric Science at FSU became affiliated with the program. During the summer we hosted one undergraduate student from the REU program; three undergraduate students are involved in research throughout the year. In the last year 71 users, of which 52% are female, used our analytical facilities. Within the area of Geosciences the faculty has collaborations with researchers throughout the US, Europe as well as Asia. The disciplines we service at a more local level range from magnet science to pharmacy. We also receive several requests per year from the public to identify rock samples that are found, often with the expectation that the sample is a meteorite.

4. Cryogenics Research Group

Summary

The Cryogenics Laboratory located in the MagLab is a fully developed facility for conducting low temperature experimental research and development. A number of specialized experimental equipment are available in the lab, which include the Cryogenic Helium Experimental Facility (CHEF) for horizontal single and two-phase heat transfer and flow research, the Liquid Helium Flow Visualization Facility (LHFVF) for high Reynolds number He II flow visualization research, the Laser Induced Fluorescence Imaging Facility (LIFIF) for high precision molecular tagging velocimetry measurement in both gaseous and liquid helium, and the Cryogenic Magnetic Levitation Facility (CMLF) for studying cryogenic fluid hydrodynamics in micro-gravity. The laboratory supports in-house development projects as well as contracted scientific work directed by two faculty members, Dr. Van Sciver and Dr. Guo, of the Mechanical Engineering department at Florida State University. The major research focus of the cryogenics lab currently includes: 1) fundamental turbulence and heat transfer study in He II; 2) quantized vortex-line imaging in levitated helium drops; 3) heat and mass transfer phenomena associated with a catastrophic loss of vacuum accidents in liquid helium cooled systems. These research activities are supported by the NSF and DoE. The cryogenics lab also conducts NASA contracted work on measuring the thermal conductivities of multilayer insulation materials.

Turbulence research with He II: Many flows in nature have extremely high Reynolds (Re) or Rayleigh (Ra) numbers, such as those generated by flying aircraft and atmospheric convection. Better understanding of these flows can have profound positive impacts on everyday life, such as improving the design in energy efficient applications and our understanding of climate change. To achieve large Re values in laboratory, a common route is to increase the characteristic length of the flow, which normally requires the construction of expensive and energy consuming large-scale flow facilities and wind tunnels. An alternative route is to use a fluid material with very small kinematic viscosity. At the cryogenics lab, helium-4 is adopted as the working fluid. Helium-4 has extremely small kinematic viscosity (3 orders of magnitudes smaller than that for air) which enables the generation of highly turbulent flows in compact table-top equipment. Furthermore, when helium-4 is cooled below about 2.17 K, it undergoes a phase transition into a superfluid phase (He II) which consists of two intermiscible fluid components: a viscous normal component and an inviscid superfluid fluid component. Turbulence in He II is a cutting-edge research area that is important both in fundamental science and in practical applications of He II as a coolant. In order to make quantitative flow field measurements, a powerful molecular line tagging technique has been developed at the cryogenics lab based on tracking thin lines of He_2 excimer tracers created via femtosecond-laser field ionization of helium atoms (see **Fig. 1**). Besides this technique, seeded micron-sized frozen hydrogen particles are also used as tracers for particle imaging velocimetry and particle tracking velocimetry measurements in He II.

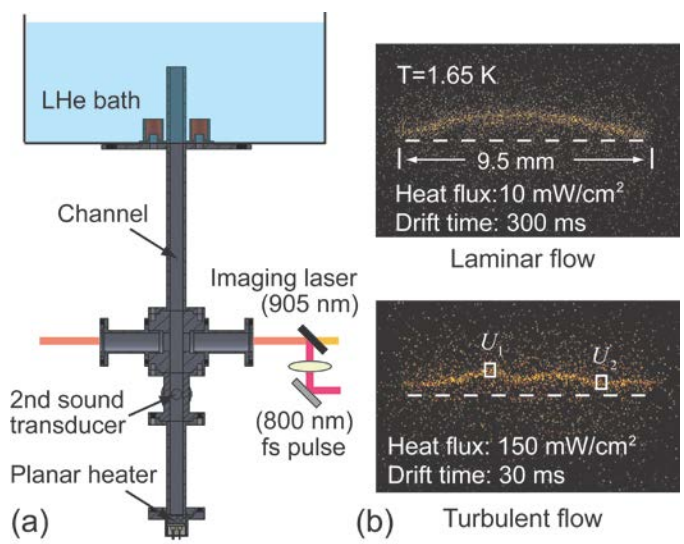

Figure 1:* *(a) *Schematic diagram of the experimental setup for flow visualization using He2 molecules. A high intensity femto-second laser (red beam) through the windows ionizes helium atoms and creates a tracer line of He2 excimer molecules. Then the imaging laser at 905 nm (yellow beam) drives the tracers to produce fluorescent light (640 nm) for the imaging.* ***(b)*** *Typical images of the tracer line in thermal counterflow generated by an applied heat flux in He II. The deformation of the tracer lines provides quantitative information about the velocity field in He II.*

CHAPTER 5 – IN-HOUSE RESEARCH

Cryogenics Research Group

Vortex imaging in levitated helium drops: The motion of quantized vortex lines is responsible for a wide range of phenomena, such as the decay of quantum turbulence and the initiation of dissipation in type-II superconductors, and it is also implicated in the appearance of glitches in neutron star rotation and the formation of cosmic strings in the early universe. A systematic study of vortex-line dynamics promises broad significance spanning multiple physical science disciplines. In He II, vortex lines can be directly visualized by imaging tracer particles trapped on the lines. However, producing tracers in helium at low temperatures and imaging the trapped tracers remains challenging, and the container walls can often affect the vortex-line motion. In the cryogenics lab, a magnetically levitated helium-4 drop is used as the working system, in which the vortices can be produced via fast evaporative cooling and controllable drop rotation (see **Fig.2**). These vortices can be decorated with He_2 excimer tracers or fluorescence nano-particles which can be imaged via laser-induced fluorescence. This process can enable unprecedented insight into the behavior of a rotating superfluid drop and will untangle some key issues in quantum turbulence research.

Loss-of-vacuum heat and mass transfer: High performance superconducting magnets and superconducting radio frequency (SRF) cavities are essential components of almost all future high energy particle accelerators. These magnets and SRF cavities are normally cooled by liquid helium. The study of the heat and mass transfer processes that can occur during a sudden catastrophic loss of vacuum (SCLV) incident in a liquid-helium cooled system is therefore of great importance to the design and safe operation of the superconducting magnets and SRF cavities. A project has been launched in the cryogenics lab to study how a gas such as atmospheric air/nitrogen will condense inside a liquid-helium cooled vacuum tube while the gas simultaneously propagates down the vacuum space. The experiments are coupled with analytic and numerical analysis in an effort to develop a general understanding of the process and to assist with future development.

These research programs have provided opportunities for graduate students and postdocs to gain experience in fluid dynamics, cryogenics, and advanced laser technologies. These skills are applicable to many other STEM-related fields, giving the students and postdocs the technical dexterity necessary to excel in today's job market. The cryogenics lab has also hosted undergraduate students through the REU summer program at the NHMFL. In the last two years, two REU students have been mentored, and their research experiences have motivated them to pursue advanced studies in STEM fields. These students are now graduate students at the University of Notre Dame and Florida A&M University. The cryogenics lab is also involved in various outreach activities, such as the contributing demonstration experiments during the annual open house event at the NHMFL. In the spring of 2017, the cryogenics lab will host a three-day international workshop on quantum turbulence research, sponsored by the NHMFL, FSU, and the NSF. This event is expected to enhance FSU's profile in quantum fluid research and will provide young researchers the opportunity to interact with eminent scientists in the quantum fluid field.

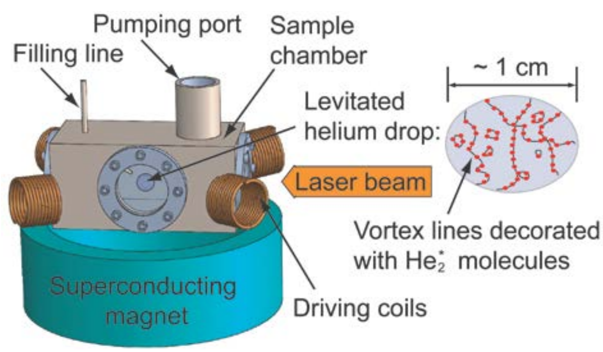

***Figure 2:** Schematic of the experimental apparatus inside the optical cryostat for visualizing quantized vortex lines in a magnetically levitated helium drop.*

CHAPTER 6
ACCOMPLISHMENTS & DISCOVERIES

CHAPTER 6 – ACCOMPLISHMENTS & DISCOVERIES

Products of Maglab Users and Faculty (as of 1/27/2016)

The laboratory continued its strong record of publishing, with **431** articles appearing in peer-reviewed scientific and engineering journals in 2015. The full listing, along with citations for over **403** presentations, is available on the Magnet Lab's Web site https://nationalmaglab.org/research/publications-all/publications-search

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This chapter lists publications by user facility, followed by publications attributed to Magnet Science & Technology, the NHMFL Applied Superconductivity Center, UF Physics, the Condensed Matter Theory/Experiment group, the Center for Integrating Research & Learning Geochemistry, and Optical Microscopy. Please note that publications may be listed with more than one facility or group, as the research may have resulted from e.g., using both DC and Pulsed Field Facilities, or from a collaboration that involves both user/ experimentalists and theorists.

Of the **431** publications, **236 (55%)** appeared in significant journals.

Presented on the remaining pages of this chapter are lists of one-time publications, internet disseminations, patents, awards, PhD dissertations, and Master theses.

Table 1: *Submitted Peer-Reviewed Publications from OPMS live database, the point-in-time snapshot was on January 27, 2016. A total number of publications per year should NOT be drawn from this report because a submitter may, as appropriate, link a publication to two facilities.*

FACILITY/ DEPARTMENT	2015 Peer Reviewed	2015 Significant Peer Reviewed
DC Field Facility	78	52
Pulsed Field Facility	29	25
High B/T Facility	7	4
NMR Facility	44	26
MBI-UF AMRIS	51	9
EMR Facility	38	17
ICR Facility	35	20
MS & T	34	26
Applied Superconductivity Center	34	30
UF Physics	32	21
CMT/E	54	39
Education (NHMFL only)	1	0
Geochemistry Facility	30	3
Optical Microscopy	22	8

CHAPTER 6 – ACCOMPLISHMENTS & DISCOVERIES

DC FIELD FACILITY PUBLICATIONS (78)

Abraimov, D.; Ballarino, A.; Barth, C.; Bottura, L.; Dietrich, R.; Francis, A.; Jaroszynski, J.; Majkic, G.S.; McCallister, J; Polyanskii, A.; Rossi, L.; Rutt, A.; Santos, M.; Schlenga, K.; Selvamanickam, V.; Senatore, C.; Usoskin, A. and Viouchkov, Y.L., *Double disordered YBCO coated conductors of industrial scale: high currents in high magnetic field*, Superconductor Science and Technology, 28, 114007 (2015)

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CHAPTER 6 – ACCOMPLISHMENTS & DISCOVERIES

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BOOKS, CHAPTERS, REVIEWS AND OTHER ONE-TIME PUBLICATIONS (6)

Bowers, C.R., "Hyperpolarized Xe-129 NMR Characterization of Single-File Diffusion in Nanotubes", *Hyperpolarized Xenon-129 Magnetic Resonance*, 4, 200-233, 2015.

Dunk, P.W., "Chapter 11", *C60 Buckminsterfullerene: Some Inside Stories*, 1, 149-174, 2015.

Gor'kov, L.P., "Selected papers of Lev P Gor'kov", *World Scientific*, 2015.

Ingersent, K., "NRG with bosons", *Chapter 6 in Many-Body Physics: From Kondo to Hubbard (Modeling and Simulation, Vol. 5), edited by E. Pavarini, E. Koch, and P. Coleman*, 2015.

Sart, S.; Bejarano, F.C.; Yan, Y.; Grant, S.C. and Li, Y., "Labeling Pluripotent Stem Cell-Derived Neural Progenitors with Iron Oxide Particles for Magnetic Resonance Imaging", *Methods in Molecular Biology: Methods and Protocols*, 1283, 43-52, 2015.

Shen, T.; Jiang, J. and Hellstrom, E., "Book Chapter: Powder-in-tube Superconducting Wires: Fabrication, Properties, Applications, and Challenges", *Applied Superconductivity: Handbook on Devices and Applications, Wiley-VCH*, 328-354, 2015.

INTERNET DISSEMINATIONS (9)

Brambleby, J.;Goddard, P.A.; Johnson, R.D.; Liu, J.; Kaminski, D.; Ardavan, A.; Steele, A.J.; Lancaster, T.; Manuel, P.; Baker, P.J.; Singleton, J.; Schwalbe, S.G.; Spurgeon, P.M.; Tran, E.H.; Peterson, P.K.; Corbey, J.F.; Manson, J.L., *The magnetic ground state of two isostructual polymeric quantum magnets, [Cu(HF$_ {2}$)(pyrazine)$_{2}$]SbF$_ {6}$ and [Co(HF$_ {2}$)(pyrazine)$_{2}$] SbF$_{6}$, investigated with neutron powder diffraction*, http://xxx.lanl.gov/abs/1505.08092, (2015)

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Dobrosavljevic, V., *SPICE-Workshop: "Bad Metal Behavior in Mott Systems: From Holographic Duality to Mottronics, Synaptic Devices, and Beyond," Schloß Waldthausen, Mainz, Germany; Principal Workshop Organizer (with M. J. Rozenberg, Isao Inoue, and Jairo Sinova).*, https://www.spice.uni-mainz.de/bad-metals-2015/, (June 29 - July 2 2015)

Drichko, I.L.; Smirnov, I.Y.; Suslov, A.V.; Pfeiffer, L.N.; West, K.W. and Galperin, Y.M., *Drichko, I.L.; Smirnov, I.Y..; Suslov, A.V.; Pfeiffer, L.N.; West, K.W and Galperin, Y.M., Wigner crystal in a two-dimensional electron system in the vicinity of filling factor 1/5: Acoustic studies*, http://arxiv.org/abs/1511.05376, (17 Nov 2015)

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Jiao, L.; Chen, Y.; Kohama, Y.; Graf, E.D.; Bauer, D.; Singleton, J.; Zhu, J.X.; Weng, Z.F.; Pang, G.M.; Shang, T.; Zhang, J.L.; Lee, H.O.; Park, T.; Jaime, M.; Thompson, J. D. ; Steglich, F.; Si, Q. ; Yuan, H. Q., *Fermi surface reconstruction and multiple quantum phase transitions in the antiferromagnet CeRhIn$_5$*, http://xxx.lanl.gov/abs/1501.01890, (2015)

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Johnson, R.D.; Williams, S.; Haghighirad, A.A.; Singleton, J.; Zapf, V.; Manuel, P.; Mazin, I.I.; Li, Y.; Jeschke, H.O.; Valenti, R. and Coldea, R., *The monoclinic crystal structure of α-$RuCl_3$ and the zigzag antiferromagnetic ground state*, http://xxx.lanl.gov/abs/1509.02670, (2015)

Rupnik, K., *Intelliom*,, http://www.intelliome.com, (2015)

PATENTS & OTHER PRODUCTS (4)

Manning, T.; Plummer, S. and Baker, T., "*Tablet Composition for Anti-Tuberculosis Antibiotics*," Utility patent application (2015)

Pradhan, N.R.; Manousakis, E. and Balicas, L., "*Optoelectronic switch based on intrinsic dual Schottky diodes in ambipolar MoSe2 field-effect transistors*," Filed (2015)

Singleton, J.; Krawczyk, F.; CommScope of North Carolina and others, "*A Feed network & electromagnetic radiation source*," European Patent 13819122.6 -1812 (2015)

Singleton, J.; Krawczyk, F.; Linehan, K. and Schmidt, A.C., "*Feed network and electromagnetic radiation source*," US Patent 20150325914 (2015)

AWARDS, HONORS, AND SERVICE (14)

Balicas, L.,
Referee - Agence Nationale de la Recherche (France) on behalf of EU - Graphene Flagship Program (2015)

Balicas, L.,
Referee- National Science Foundation - Division of Materials Research (2015)

Davidson, Michael,
Distinguished Scientist by the Microscopy Society of America (2015)

Dhuley, R.C. and Van Sciver, S.W.,
Cryogenic Engineering Conference- Student Meritorious Paper Award (2015)

Gor'kov, L.P.,
Ugo Fano Gold Medal (2015)

Han, K.,
Distinguished University Scholar (2015-2015)

Hill, Stephen,
PAI Award for Excellence in Teaching and Research (2015-present)

Larbalestier, D.,
Fellow of the AAAS (American Association for the Advancement of Science) (2015-2015)

Manning, T.; Baker, T. and Plummer, S.,
Finalist, Big Ocean Pitch (2015-present)

Markiewicz, Denis W.,
Award for Continuing and Significant Contributions in the Field of Large Scale Applications of Superconductivity (2015)

Migliori, Albert,
Joseph F. Keithley Award For Advances in Measurement Science (2015)

Singleton, John,
Member at Large of the Executive Committee of the Division of Materials Physics (DMP) of the APS (2015-present)

Tang, S.,
Dirac-Hellman awards (2015-2015)

Wang, Y.,
GSA Fellow (2015-2015)

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PH.D. DISSERTATIONS (85)

Eighty-five (85) Ph.Ds. were reported for 2015: 31 were awarded to users/students at FSU or UF; 54 were awarded to users at other academic institutions.

Ph.Ds. awarded to users/students at FSU or UF (31):

Anand, Naween, "*Characterization of electronic systems through optical and transport techniques*," University of Florida, Department of Physics, advisor: David B. Tanner (2015)

Aoyama, C.P., "*Experimental studies of low dimensional quantum antiferromagnets*," University of Florida, Physics, advisor: Takano, Y. (2015)

Chen, T., "*A Novel FT-ICR Ion Trap For Ultra-high Resolution Mass Spectrometry and Its Biological Application*," Florida State University, Dept. of Chemistry & Biochemistry, advisor: Alan Marshall (2015)

Chowdhury, T., "*A Study of Quantum Phase Transitions in Quantum Impurity Systems*," University of Florida Department of Physics, advisor: K. Ingersent (2015)

Diefenbach, Kariem, "*Magnetic behavior of Heavy Elements and Heterobimetallic Systems*," Florida State University, Department of Chemistry and Biochemistry, advisors: Naresh Dalal and Thomas Albrecht-Schmitt (2015)

Ekanayake, E. Vindana, "*Wild-Type and Drug Resistant M2 Proton Channel from Influenza A: Structural Influences of Cholesterol, Drug and Proton Binding*," Florida State University, Department of Chemistry and Biochemistry, advisor: Timothy A. Cross (2015)

Farst, Carley, "*Isolation of Marine Siderophores by Immobilized Metal Affinity Chromatography*," Florida State University, Chemistry and Biochemistry, advisor: William M. Landing (2015)

Feng, Weibo, "*Non-Abelian Quantum Error Correction*," Florida State University, Department of Physics, advisor: N.E. Bonesteel (2015)

Huang, D., "*Effects of lipids and hydrophobic surfaces on Abeta aggregated structures*," Florida State University, Department of Chemical and Biomedical Engineering, advisor: Paravastu, Anant (2015)

Javan Mard, H., "*Disordered Strongly Correlated Electronic Systems*," Florida State University, Physics, advisor: Dobrosavljevic, V. (2015)

Kinyon, Jared, "*Mixed Trichlorocuprates: A New Family of Multiferroics*," Florida State University, Chemistry and Biochemistry, advisor: Naresh Dalal (2015)

Laurel E. Winter, "*High Frequency Inductive Measurements of Organic Conductors with the Application of High Magnetic Fields and Low Temperatures*," Florida State University Department of Physics, advisor: James S. Brooks (2015)

Lusk, M.G., "*Characterization of the sources, chemical composition, and bioavailability of organic nitrogen in an urban coastal watershed*," University of Florida- Soil and Water Science Department, advisors: GS Toor and PW Inglett, co-advisors (2015)

Mahmoudian, S., "*Coulomb Pseudogaps and their role at Metal-Insulator Transitions*," Florida State University, Physics, advisor: Dobrosavljevic, V. (2015)

Martens, Mathew S., "*Understanding and Controlling Spin-Systems Electron Spin Resonance Techniques*," Florida State University, Physics Dept, advisor: I. Chiorescu (2015)

Miao, Yimin, "*Structure, dynamics and pro ton conductance mechanism of the M2 protein histidine tetrad*," Florida State University, Chemistry and Biochemistry, advisor: Timothy A. Cross (2015)

Morris, D., "*Use of zinc to improve outcomes after traumatic brain injury*," Florida State University, College of Medicine, advisor: Cathy Levenson (2015)

Pascualini, Matias Ezequiel, "*Synthesis and Characterization of a Family of M2+ Complexes Supported by a Trianionic ONO3- Pincer Ligand: Towards the Stabilization of High-Spin Square-Planar Complexes*," University of Florida, advisor: Veige S Adam (2015)

Peprah, Marcus K.A., "*Influence of Pressure and LIght on the Magnetic Properties of Prussian Blue Analogues and Hofmann-like Frameworks*," Univer-

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sity of Florida, Department of Physics, advisor: Mark W. Meisel (2015)

Quintero, Pedro A., "*Magnetic and Electrical-transport Studies of Molecule-based Magnets,*" University of Florida, Department of Physics, advisor: Mark W. Meisel (2015)

Ramaswamy, V., "*Development of High-Temperature-Superconducting Probe Technology for Nuclear Magnetic Resonance Spectroscopy,*" University of Florida, Department of Biomedical Engineering, advisor: Arthur S. Edison (2015)

Rowland, S., "*Characterization of Oxygen-Containing Compounds in Crude Oils by Chromatographic and Mass Spectral Analysis,*" Florida State University, Dept. of Chemistry & Biochemistry, advisor: Alan Marshall (2015)

Shiddiq, Muhandis, "*Quantum Entanglement And Coherence In Molecular Magnets,*" Florida State University, Physics, advisor: Stephen Hill (2015)

Smith, Adam, "*Development of methodologies for the study of membrane proteins with magic angle spinning dynamic nuclear polarization,*" University of Florida, Departments of Chemistry, advisor: Gail Fanucci (2015)

Tremaine, D.M., "*Dynamic Physicochemical Influences on Speleothem Paleoclimate Proxy Archives: A Story of Four North Florida Caves,*" Florida State University, Department of Earth, Ocean, and Atmospheric Science, advisor: Munir Humayun (2015)

Twahir, Umar T., "*Investigations Into The Enzymatic Mechanism Of Bacillus Subtilis Oxalate Decarboxylase: An Electron Paramagnetic Resonance Approach,*" University of Florida, Department of Chemistry, advisor: Angerhofer, A. (2015)

VanZomeren, Christine, "*Biogeochemical Cycling of Organic Nitrogen in Subtropical Wetlands,*" University of Florida, Soil and Water Science Department, advisor: K. Ramesh Reddy (2015)

Weiss, J.D., *Synthesis and Characterization of Superconducting Ferropnictide Bulks and Wires,*" Florida State University, Materials Science and Engineering, advisor: Hellstrom, E.E. (2015)

Wright, Anna, "*Application of Solid State Nuclear Magnetic Resonance in Drug Discovery,*" Florida State University; Department: Molecular Biophysics, advisor: T.A. Cross (2015)

Yi, Chongyue, "*Structure-dependent Optical Properties and Electronic Relaxation Dynamics of Colloidal Nanoparticles,*" Florida State University, Chemistry and biochemistry, advisor: Ken Knappenberger (2015)

Yuan, Shaojie, "*NMR Study of Magnetism and Superpramgentism,*" Florida State University, advisor: Dr. Pedro Schlottmand & Dr. Arneil P. Reyes (2015)

Ph.Ds. awarded by other academic institutions to external users/students (54):

Abhyankar, Nandita, "*Size and Morphology Variation in Multiferroic MOFs: A Magnetic, Dielectric and Spectroscopic Study,*" FSU, Department of Chemistry & Biochemistry, advisor: Naresh S. Dalal (2015)

Aivazian, Grant, "*Optoelectronic properties of 2-dimensional materials,*" University of Washington at Seattle, Physics, advisor: Xiaodong Xu (2015)

Brozek, Carl, "*The Reactivity and Cation Exchange of MOF-5,*" MIT, Chemistry, advisor: Mircea Dinca (2015)

Burg, Jonathan, "*Lysine-Specific Demethylase 1A (LSD1/KDM1A): Identification, Characterization, and Biological Implications of an Extended Recognition Interface for Product and Substrate Binding,*" Duke University, Department of Chemistry, advisor: Dewey G. McCafferty (2015)

Cairns, Shayne, "*Topological Transport in Antimony Quantum Wells,*" University of Oklahoma, Department of Physics and Astronomy, advisor: Sheena Murphy (2015)

Chen, Xunchi, "*Point Contact Spectroscopy study of*

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Topological Superconductivity," Georgia Institute of Technology, School of Physics, advisor: Zhigang Jiang (2015)

Darkazalli, Ali, *"Not provided,"* Not provided, advisor: Cathy W Levenson (2015)

Das, Sitikantha, *"Anisotropic studies on frustrated quantum systems and pnictide superconductors,"* University of Cambridge, Physics, advisor: Suchitra Sebastian (2015)

Dhomkar, Siddharth, *"Growth and Characterization of Type-II Submonolayer ZnCdTe/ZnCdSe Quantum Dot Superlattices for Efficient Intermediate Band Solar Cells,"* The City University of New York; Physics Department of Queens College, advisor: Igor L Kuskovsky (2015)

Diefenbach, Kariem, *"Magnetic Interactions Of Heavy Elements And Heterobimetallic Systems,"* Chemistry and Biochemistry, advisor: Albrecht-Schmitt, Thomas (2015)

Eom, Man Jin, *"Investigation of the stripe orbital order in transition metal pnictides and chalcogenides,"* POSTECH, Physics, advisor: Jun Sung Kim (2015)

Faeth, Julia, *"Fast Liquefaction of Microalgae,"* University of Michigan, Chemical Engineering Department, advisor: Phillip E. Savage (2015)

Feng, Xiaowen, *"Slow Magnetic Relaxation in Single-Chain Magnets and Light Actuated Single Molecule Magnets,"* UC Berkeley, Chemistry, advisor: Jeffrey R. Long (2015)

Foszcz, Eileen D., *"Understanding the Interplay Between Geometry and Ultrafast Dynamics in Ligand Field States of Inorganic Chromophores,"* Michigan State University, Department of Chemistry, advisor: James McCusker (2015)

Gallo, Giraldo, *"Phase Separation in BaPb1-xBixO3 and Fermiology of Hole-Doped PbTe: Insights to Understand Superconductivity in Valence-Disproportionated Systems,"* Stanford, Physics, advisor: Ian Fisher (2015)

Giraldo-Gallo, Paula, *"Phase separation in bapb1−xbixo3 and fermiology of hole-doped pbte: insights to understand superconductivity in valence-disproportionated systems,"* Stanford University, Department of Physics, advisor: Ian Fisher (2015)

Gomez-Aguirre, Lilian Clauda, *"not provided,"* University of Coruna, Spain, Chemistry, advisor: Maria Antonia Senariz-Rodriguez (2015)

Guan, Tong, *"Experimental study of spin properties in low dimensional electron systems,"* University of Chinese Academy of Sciences / Institute of Physics, Chinese Academy of Sciences, advisor: Yongqing Li (2015)

Heras, Carlos, *"Tautomería de valencia en moléculas con número par de electrones. Transición térmica al estado electrónico triplete inducida por un cambio conformacional. Nuevos materiales con comportamientos ferromagnéticos,"* Dept. of Organic Chemistry, University of Barcelona, Spain, advisor: Francisco López-Calahorra (2015)

Holliday, Michael, *"Allosteric Communication Networks and Enzymatic Regulation as Mediated by Conformational Dynamics in the Cyclophilin Family of,"* University of Colorado Denver, Molecular Biology, advisor: Elan Eisenmesser (2015)

Hu, Jiuning, *"Transport studied in graphene based materials and structures,"* Purdue University, Electrical and Computer Engineering, advisor: Yong P. Chen (2015)

Ji, Haojie, *"Properties of Type-II ZnTe/ZnSe Submonolayer Quantum Dots Studied via Excitonic Aharonov-Bohm Effect and Polarized Optical Spectroscopy,"* The City University of New York; Physics Department of Queens College, advisor: Igor L Kuskovsky (2015)

Kirton, J.W., *"Regional white mater lesion volume and depressive symptom dimensions: Cerebrovascular aging after 40 and in late life,"* Department of Clinical and Health Psychology, University of Florida, advisor: Vonetta M. Dotson (2015)

Koolen, Héctor, *"Mass Spectrometry and Ion Mobility applications for complex mixtures: Petroleomics,"* Woods Hole Oceanographic Institution, advisor: Fabio Gozzo (2015)

Kurth, Fritz, *"High Magnetic Field Properties of Fe-Pnictide Thin Films,"* Technical University of Dresden, advisor: Ludwig Schultz (2015)

Lu, Lu, *"Nuclear Magnetic Resonance Study of Ferromagnetism and Local Symmetry Breaking in Double Perovskite Mott Insulator Ba2NaOsO6,"* Brown University, Department of Physics, advisor: Vesna F. Mitrović (2015)

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Maher, Patrick, "*Tunable SU(4) Symmetry in Bilayer Graphene*," Columbia University Physics Department, advisor: Philip Kim (2015)

Manalundong, Yusoph C. II, "*Bioactivity-Guided Isolation of Pheophytin A from the Crude Hexane Extract of the Leaves and Stems of Digitaria setigera Roem & Schult*," Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines, advisor: not provided (2015)

Mulet-Gas, Marc, "*Metallofullerenes: Characterization, Properties and Growth*," Universitat Rovira I Virgili, Departament de Quimica Fisica Inorganica, advisor: Josep M. Poblet (2015)

Neubauer, Andreas, "*Modeling and Validation of Ionic Regulatory Processes with X-Nuclei-MRI*," Heidelberg University, Physics, advisors: Lothar Schad and Victor Schepkin (2015)

Pundogar, Princess T., "*Bioactivity-Guided Isolation of Ursolic Acid from the Chloroform Extract of Prunus grisea ("Tanga-Tanga") Leaves*," Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines, advisor: unknown (2015)

Putzke, Carsten, "*Fermi surface and quantum critical phenomena of high temperature superconductors*," University of Bristol, Physics, advisor: A Carrington (2015)

Rawat, Naveen, "*Exchange Mechanisms in macroscopic ordered organic magnetic semiconductors*," University of Vermont, Physics Department, advisor: Madalina I. Furis (2015)

Rebar, Drew, "*Exploring unconventional superconductivity in the chiral superconductor AuBe*," Louisiana State University, Department of Physics and Astronomy, advisor: John DiTusa (2015)

Rohde, Gregory, "*Mono- and Dinuclear Nonheme Iron Model Complexes: O-O Bond Activation, Structural Characterization and Reactivity Study*," Chemistry Department University of Minnesota, advisor: Lawrence Que Jr. (2015)

Sanchez-Yamagishi, Pablo, "*Superlattices and Quantum Spin Hall States in Graphene and Hexagonal Boron Nitride Heterostructures*," MIT, Physics, advisor: Pablo Jarillo-Herrero (2015)

Sesti, Erika, "*Development of optically-pumped and optically-detected nuclear magnetic resonance in a longitudinal magnetic field and studies of GaAs quantum wells*," Washington University in St. Louis, Department of Chemistry, advisor: Sophia E. Hayes (2015)

Shapiro, Maxwell, "*Elastoresistance in URu2Si2*," Stanford University, Applied Physics, advisor: Ian Fisher (2015)

Sheckelton, John, "*Geometric Magnetic Frustration in Cluster Magnets*," Johns Hopkins University, Chemistry, advisor: Tyrel McQueen (2015)

Shi, Jiawanjun, "*Crystal structure, electrical and magnetic properties of Aurivillius oxides*," Alfred University, Ceramic engineering department, advisor: Scott Misture (2015)

Shrestha, Keshav, "*Magnetotransport Studies on Topological Insulators*," University of Houston, Department of Physics, advisor: Paul C. W. Chu (2015)

Stegen, Z., "*Magnetotransport of an Underdoped High Temperature Superconductor*," NHMFL-FSU, advisor: Greg Boebinger (2015)

Svanidze, Eteri, "*Itinerant Magnets without Magnetic Constituents*," Rice University, Physics, advisor: Emilia Morosan (2015)

Tan, Beng, "*Quantum oscillation studies on unconventional correlated systems*," University of Cambridge, Physics, advisor: Suchitra Sebastian (2015)

Tremblay, Marie-Laurence, "*The Structural Characterization Of Argiope Trifasciata Spider Wrapping Silk By Solution-State NMR*," Biochemistry and Molecular Biology, advisor: Dr. Jan Rainey (2015)

Tremblay, Marie-Laurence, "*The Structural Characterization Of Argiope Trifasciata Spider Wrapping Silk By Solution-State NMR.*," Dalhousie University, Department of Biochemistry & Molecular Biology, advisor: Jan K. Rainey (2015)

Turner, Walter, "*Wireless implants for increased signal sensitivity of nuclear magnetic resonance monitoring of a bio-artificial pancreas*," Department of Electrical Engineering, University of Florida, advisor: Rizwan Bashirullah (2015)

Vitaly, Malysh, "*High frequency transport in Si/Ge-based quantum-dimensional systems. Contactless measurement techniques.*," A.F.Ioffe Physico-Technical Institute of Russian Academy of Sciences, advisor: Irina Drichko (2015)

Wang, Cuiyu, "*Nanostructures of Bent-Core Liquid Crystals - Transmission Electron Microscopy, X-Ray*

CHAPTER 6 – ACCOMPLISHMENTS & DISCOVERIES

and Polarizing Microscopy Studies," Kent State University Chemical Physics Interdisciplinary Program, advisor: A. Jakli (2015)

Wang, DaWei, "*Garnet and LISICON-type Solid Electrolytes: Synthesis, Performance, and Ionic Diffusion Dynamics,"* Chemistry Department, Xiamen University, China, advisor: Prof. Yong Yang (2015)

Watson, Matthew, "*Electronic and magnetic properties of iron-based superconductors,"* Oxford, Physics, advisor: Amalia I Coldea (2015)

Wolgast, Steven, "*Samarium Hexaboride: The First True 3D Topological Insulator,"* University of Michigan, Physics Department, advisor: Cagliyan Kurdak (2015)

Ye, Allen, "*Multiple-Scale Analysis on the Fractal Structure of the Brain using Diffusion Magnetic Resonance Imaging,"* University of Illinois at Chicago, advisor: Richard L Magin (2015)

Yuan, Shaojie, "*NMR Study of Magnetism and Superparamagnetism,"* Physics, advisors: Schlottmann, P. and Reyes, A. P. (2015)

MASTER THESES (11)

Beachman, Julie, "*FT-ICR Studies of mycolic acid from Mycobacterium Tuberculosis,"* Valdosta State University, advisor: Thomas Manning (2015)

Bowman, Chelsie, "*Paleodietary reconstruction of late Miocene herbivores from the Dove Spring Formation,"* Earth, Ocean and Atmospheric Science, advisor: Yang Wang (2015)

Gašper, Gregorič, "*Study of the triangular Heisenberg antiferromagnet KCrO2 with electron paramagnetic resonance,"* Faculty of mathematics and physics, University of Ljubljana, advisor: Andrej Zorko (2015)

Jaroszewicz, M.J., "*Frequency-Swept Pulses in Ultra-Wideline NMR,"* University of Windsor, Chemistry and Biochemistry, advisor: S. Rehse (2015)

Mauney, Tyler, "*Biogenic ethane production in hypersaline lagoons,"* Florida State University, advisor: Jeff Chanton (2015)

McLaren, M.E., "*The relationship between symptom dimensions of subthreshold depression and grey matter volumes in older adults,"* Department of Clinical and Health Psychology, University of Florida, advisor: Vonetta M. Dotson (2015)

Memaran, Shahriar, "*Photovoltaic Effect in p-n Junctions based on Few Layered Transition Metal Dichalcogenides,"* Florida State University, Department of Physics, advisor: Luis Balicas (2015)

Penman, Christine, "*Gardening Modifies the Patterns of Brain Activation and Enhances the Mental Health Profile of Healthy Women,"* University of Florida and Environmental Horticulture, advisor: Charles L. Guy (2015)

Salazar, Allison, "*Serum Iipidomic identification of disease biomarkers from Mycobacterium bovis and Mycobacterium avium subsp. paratuberculosis by Fourier transform ion cyclotron resonance mass spectrometry,"* New Mexico State University, Dept. of Animal Science, advisor: Tanner Schaub (2015)

Sekar, P., "*Nmr Studies Of Anomalous Diffusion Of Mixed And Pure Gases In Nanochannels,"* University of Florida, Chemical Engineering Department, advisor: Vasenkov, S. (2015)

Tada, Ryota, "*Survey of T-P-B phase diagram of HMTSF-TCNQ,"* Osaka City University, Physics, advisor: Keizo Murata (2015)

APPENDIX I
USER FACILITY STATISTICS

APPENDIX I – USER FACILITY STATISTICS

DC Field

Seven user facilities — DC Field, Pulsed Field, High B/T, NMR-MRI@FSU, NMR-MRI@UF (AMRIS), EMR, and ICR — each with exceptional instrumentation and highly qualified staff scientists and staff, comprise the magnet lab's user program. In this appendix, each facility presents detailed information about its user demographics, operations statistics and requests for magnet time.

A user is an individual or a member of a research group that is allocated magnet time. The user does not have to be "on site" for the experiment. A researcher who sends samples for analysis; a scientist who uses new lab technologies to conduct experiments remotely; or a PI who sends students to the magnet lab, are all considered users. All user numbers reflect distinct individuals, i.e. If a user has multiple proposals (different scientific thrusts) or is allocated magnet time more than once during the year, he/she is counted only once. All user data in the user facility statistic is as of January 27th, 2016.

DC FIELD FACILITY

***Table 1** – User Demographic*

DC Field Facility	Users	Male	Female	Prefer Not to Respond to Gender	Minority[1]	Non-Minority[1]	Prefer Not to Respond to Race	Users Pre-sent	Users Operating Remotely[2]	Users Sending Sample[3]	Off-Site Collabo-rators[4]
Senior Personnel, U.S.	**172**	143	15	14	3	152	17	109	0	26	37
Senior Personnel, non-U.S.	**68**	55	6	7	3	56	9	29	0	13	26
Postdocs, U.S.	**61**	47	8	6	2	48	11	54	0	1	6
Postdocs, non-U.S.	**25**	18	3	4	0	20	5	17	0	0	8
Students, U.S.	**174**	136	25	13	4	142	28	152	0	4	18
Students, non-U.S.	**51**	41	7	3	2	41	8	36	0	1	14
Technician, U.S.	**2**	2	0	0	0	2	0	2	0	0	0
Technician, non-U.S.	**2**	2	0	0	0	2	0	1	0	0	1
Total:	**555**	**444**	**64**	**47**	**14**	**463**	**78**	**400**	**0**	**45**	**110**

[1] NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin

[2] "Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.

[3] "Users Sending Sample" refers to users who send the sample to the facility and the experiment is conducted by in-house user support personnel. Users at UF, FSU, and LANL cannot be "sample senders" for facilities located on their campuses.

[4] "Off-Site Collaborators" are scientific or technical participants on the experiment; who will not be present, sending sample, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).

***Note:** Users using multiple facilities are counted in each facility listed.*

APPENDIX I – USER FACILITY STATISTICS

***Table 2** – User Affiliation*

DC Field Facility	Users	NHMFL-Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users[4]	National Lab Users[3,4]
Senior Personnel, U.S.	**172**	56	14	145	1	26
Senior Personnel, non-U.S.	**68**	0	0	50	0	18
Postdocs, U.S.	**61**	11	8	54	0	7
Postdocs, non-U.S.	**25**	1	0	15	0	10
Students, U.S.	**174**	20	19	173	0	1
Students, non-U.S.	**51**	0	0	46	0	5
Technician, U.S.	**2**	2	0	2	0	0
Technician, non-U.S.	**2**	0	0	2	0	0
Total:	**555**	**90**	**41**	**487**	**1**	**67**

[1]NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.
The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators".
[2]In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
[3]In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
[4]The total of university, industry, and national lab users will equal the total number of users.

***Table 3** – Users by Discipline*

DC Field Facility	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Senior Personnel, U.S.	**172**	136	9	7	16	4
Senior Personnel, non-.S.	**68**	53	3	4	3	5
Postdocs, U.S.	**61**	52	0	2	4	3
Postdocs, non-U.S.	**25**	20	3	1	1	0
Students, U.S.	**174**	139	16	10	7	2
Students, non-U.S.	**51**	49	0	2	0	0
Technician, U.S.	**2**	0	0	0	2	0
Technician, non-U.S.	**2**	1	0	1	0	0
Total:	**555**	**450**	**31**	**27**	**33**	**14**

***Table 4** – User Facility Operations*

DC Field Facility	Resistive Magnets & Hybrid	Superconducting Magnets	Total Days Used / User Affil.	Percentage Used / User Affil.
	Number of Magnet Days[1]			
NHMFL-Affiliated	128	237	**365**	**21.45%**
Local	11	42	**53**	**3.10%**
U.S. University	298	557	**855**	**50.19%**
U.S. Govt. Lab.	30	14	**44**	**2.61%**
U.S. Industry	0	0	**0**	**0.00%**
Non-U.S.	211	126	**337**	**19.79%**
Test, Calibration, Set-up, Maintenance, Inst. Dev.	21	28	**49**	**2.86%**
Total:	**699**	**1,004**	**1,703**	**100.00%**

[1] ***Note:*** *Since each resistive magnet requires two power supplies to run and the 45 T hybrid magnet requires three power supplies, there can be four resistive magnets + three superconducting magnets or the 45 T hybrid, two resistive magnets + three superconducting magnets operated in a given week. User Units are defined as magnet days. Users of water-cooled resistive or hybrid magnets can typically expect to receive enough energy for 7 hours a day of magnet usage so a magnet day is defined as 7 hours. Superconducting magnets are scheduled typically 24 hours a day. There is an annual four weeks shutdown in fall of powered DC resistive and hybrid magnets for infrastructure maintenance and a two weeks shutdown period for the university mandated holiday break.*

DC Field

DC Field

APPENDIX I – USER FACILITY STATISTICS

***Table 5** – Operations by Discipline*

DC Field Facility	Total Days[1] Allocated/ User Affil.	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
	Number of Magnet Days[1]					
NHMFL-Affiliated	**365**	281	0	2	73	10
Local	**53**	46	7	0	0	0
U.S. University	**855**	784	42	6	14	9
U.S. Govt. Lab.	**44**	36	0	0	8	0
U.S. Industry	**0**	0	0	0	0	0
Non-U.S.	**337**	306	15	11	5	0
Test, Calibration, Set-up, Maintenance, Inst. Dev.	**49**	29	0	0	20	0
Total:	**1,703**	**1,482**	**64**	**18**	**120**	**19**

[1] ***Note:*** *Since each resistive magnet requires two power supplies to run and the 45 T hybrid magnet requires three power supplies, there can be four resistive magnets + three superconducting magnets or the 45 T hybrid, two resistive magnets + three superconducting magnets operated in a given week. User Units are defined as magnet days. Users of water-cooled resistive or hybrid magnets can typically expect to receive enough energy for 7 hours a day of magnet usage so a magnet day is defined as 7 hours. Superconducting magnets are scheduled typically 24 hours a day. There is an annual four weeks shutdown in fall of powered DC resistive and hybrid magnets for infrastructure maintenance and a two weeks shutdown period for the university mandated holiday break.*

***Table 6** – User Program Experiment Pressure*

DC Field Facility					
Experiment Requests Received	Experiment Requests Deferred from Prev. Year	Experiment Requests Granted	Experiment Requests Declined/Deferred	Experiment Requests Reviewed	Subscription Rate
344	118	270 (58.44%)	192 (41.56%)	462	171%

***Table 7** – New User PIs[1]*

First Name	Last Name	Organization
Geetha	**Balakrishnan**	University of Warwick
Christopher	**Beedle**	NHMFL
C. W. (Paul)	**Chu**	University of Houston
John	**Durrell**	University of Cambridge
Arno	**Godeke**	NHMFL
Kazumasa	**Iida**	Nagoya University
Bruce	**Kane**	Laboratory for Physical Sciences, University of Maryland
Denis	**Karaiskaj**	University of South Florida
Xianglin	**Ke**	Michigan State University
Hitoshi	**Kitaguchi**	National Institute for Materials Science
Minhyea	**Lee**	University of Colorado Boulder
Kin Fai	**Mak**	Penn State University
James	**McCusker**	Michigan State University
Seongshik	**Oh**	Rutgers, the State University of New Jersey
Miquel	**Pons**	University of Barcelona
Yuriy	**Sakhratov**	Kazan State Power Engineering University
Tengming	**Shen**	Fermilab
Andrea	**Young**	University of California
TOTAL		**18**

[1]*PI who received magnet time for the first time across all facilities.*

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***Table 8** – Research Proposals Profile with Magnet Time*

DC Field Facility	Total	Minority[2]	Female[3]	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Number of Proposals	**156**	2	15	121	8	3	20	4

[1]A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
[2]The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
[3]The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

***Table 9** – User Proposal*

This report lists all proposals that were allocated magnet time from January-December 2015 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users.
(S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
Philip Kim (S)	Harvard University	Department of Physics	Department of Energy DEFG02-05ER46215	Tunable Quantum Hall in Graphene Heterostructures P02330	Condensed Matter Physics	2	12.87
Peide Ye (S)	Purdue University	School of Electrical and Computer Engineering	Other - SRC, SEMATECH Other - Sematech, Intel National Science Foundation 1157490	Studies of Novel Two Dimensional Material Phosphorene P08405	Condensed Matter Physics	3	21
Taichi Terashima (S)	National Institute for Materials Science	Nano-quantum Transport Group	Other - NIMS, Japan	de Haas-van Alphen measurements on exotic superconductors and metals P07187	Condensed Matter Physics	2	7.32
Clifford Bowers (S)	University of Florida	Chemistry	NHMFL User Collaboration Grants Program Condensed Matter Physics FSU# 227000-520-022742/ NSF# DMR-0654118	A New Probe for NMR Signal Detection of Optically Addressable Samples P02073	Magnets, Materials, Testing, Instrumentation	1	7
Chenglin Zhang (S)	The University of Tennessee	Department of Physics and Astronomy	Department of Energy DE-FG02-05ER46202 National Science Foundation DMR-0454672	Magneto-optical Spectroscopy of Iron-based Superconductors P02263	Condensed Matter Physics	2	11
James Hone (S)	Columbia University	Mechanical Engineering	National Science Foundation 1122594	Quantum Oscillations in Two-Dimensional Transition Metal Dichalcogenide Heterostructures P08332	Condensed Matter Physics	2	8.1
Nathanael Fortune (S)	Smith College	Department of Physics	NHMFL Visiting Scientist Program 12411	Calorimetric studies of magnetic-field-induced phase transitions in strongly correlated systems P02364	Condensed Matter Physics	2	10.9
Yoram Dagan (S)	Tel Aviv University	School of Physics and Astronomy	Other - Israel Science foundation	Superconducting-ferroelectric oxide interface P08423	Condensed Matter Physics	2	13.33
Yuanbo Zhang (S)	Dept. of Physics, Fudan University	Physics	Other - Fudan University, China	Tunable Electron-electron Interaction in Graphene in Fractional Quantum Hall Regime P02467	Condensed Matter Physics	3	16.23
Michael Zudov (S)	University of Minnesota	School of Physics and Astronomy	Department of Energy ER 46640 – SC0002567 National Science Foundation DMR-1309578	Magnetotransport in quantum Hall systems driven by sub-terahertz radiation P02426	Condensed Matter Physics	4	28

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
N. Phuan Ong (S)	Princeton University	Physics	U.S. Army Army Research Office W911NF-11- 1-0379 National Science Foundation 0819860	Shubnikov–de Haas quantum oscillations of Weyl Semimetal Cd3As2 at high fields P07241	Condensed Matter Physics	1	0.45
Scott Riggs (S)	NHMFL	CMS	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Symmetry specific response of quantum oscillations in URu2Si2 P08428	Condensed Matter Physics	1	3.92
Alexey Suslov (S)	NHMFL	Condensed Matter Science	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Development of dilatometer with optical readout P08339	Magnets, Materials, Testing, Instrumentation	1	6
Joseph Checkelsky (S)	MIT	Physics	Other - MIT	Interplay of Magnetism and Topological Phases P08337	Condensed Matter Physics	4	26.91
Vinh Nguyen (S)	Virginia Tech	Physics	National Science Foundation ECCS 1358564	Magneto-optical studies of Er optical centers in semiconductors (Si and GaN) at high magnetic fields P08327	Condensed Matter Physics	1	7
Lloyd Engel (S)	NHMFL	CMS	Department of Energy DE-FG02-05ER46212	Microwave spectroscopy of exotic electron solids in wide quantum wells P08420	Condensed Matter Physics	4	23.94
Thomas Herrmannsdoerfer (S)	Helmholtz-Zentrum Dresden-Rossendorf	Dresden High Magnetic Field Laboratory	Other - EMFL	Anomalous Metamagnetic Transition in a Doped Heavy Fermion System P08426	Condensed Matter Physics	1	4.78
Ivan Bozovic (S)	Brookhaven National Lab	Condensed Matter and Materials Science	Department of Energy MA-509-MACA	Determination of the upper critical field of cuprates by electrical transport under high magnetic field P02266	Condensed Matter Physics	2	10.54
Marc-Henri JULIEN (S)	CNRS Grenoble	Laboratoire National des Champs Magnétiques Intenses	Other - French ANR	High-field NMR study of charge order in high-Tc cuprates P08431	Condensed Matter Physics	1	6.1
Alimamy Bangura (S)	Max Planck Institute for Solid State Physics	Quantum Materials	Other - Max Planck Institute for Solid State Research, Heisenbergstrasse 1, D-70569 Stuttgart, Germany	Quantum transport and spin orbit interaction in d-electron two dimensional electron gases P02449	Condensed Matter Physics	2	9.68
Dmitry Smirnov (S)	NHMFL	Instrumentation & Operations	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Magneto-Raman spectroscopy of correlated electron systems P08432	Condensed Matter Physics	3	25.13
Rui-Rui Du (S)	Rice University	Physics and Astronomy	Department of Energy DE-FG02-06ER46274 National Science Foundation DMR1207562 Other - Welch Foundation C-1682	Quantum Transport of Exciton Condensates in InAs/GaSb Quantum Wells P08338	Condensed Matter Physics	4	21.84
Bruce Kane (S)	Laboratory for Physical Sciences, University of Maryland	Physics	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	High magnetic field investigation of a valley-degenerate two-dimensional electron system on a hydrogen-terminated Si(111) surface P08444	Condensed Matter Physics	1	5.48
Miquel Pons (S)	University of Barcelona	Organic Chemistry	Other - Spanish Ministry of Economy and competitiveness	Neutral even electron molecules with thermally accessible triplet states. P08446	Chemistry, Geochemistry	1	7
James	Michigan State	Chemistry	National Science Foundation	Differentiating Ultrafast Intersystem Crossing	Chemistry, Geochemistry	1	4.2

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
McCusker (S)	University		1300096	from Vibrational Cooling Dynamics in the Excited-state Relaxation Dynamics of Transition Metal Complexes P08328			
Janice Musfeldt (S)	University of Tennessee, Knoxville	Department of Chemistry	National Science Foundation DMR-1233118 Department of Energy DE-FG02-01ER-45885	High field spectroscopy of materials P02415	Chemistry, Geochemistry	3	14.7
Junichiro Kono (S)	Rice University	Electrical and Computer Engineering	National Science Foundation DMR-1006663	Ultrafast Spectroscopy of Cooperative Phenomena in Photoexcited Semiconductor Quantum Wells in High Magnetic Fields P02390	Condensed Matter Physics	2	28
John Durrell (S)	University of Cambridge	Engineering Department	Other - The Boeing Company Boeing Research & Technology Other - Engineering and Physical Sciences Research Council (UK)	Crack Resistant High Temperature Bulk Superconductors P08509	Engineering	2	10.67
Yuriy Sakhratov (P)	Kazan State Power Engineering University	Department of Physics	Other - Kazan State Power Engineering University, Russia	High field copper NMR studies of $CuCrO_2$ P08424	Condensed Matter Physics	2	12.16
Guillaume Gervais (S)	McGill University	Physics department	Other - CRSNG (canada), Cifar (Canada) FRQNT (Qc)	Berry's Phase in 2D Condensed Matter Systems P08310	Condensed Matter Physics	4	24.77
Aimin Liu (S)	Georgia State University	Chemistry	National Institutes of Health R01GM108988	High-Field EPR of Trp-Derived Radicals in TTQ Cofactor Biogenesis P08448	Biology, Biochemistry, Biophysics	1	5.22
Yong Chen (S)	Purdue University	Physics	Other - DARPA MESO Program Grant N66001-11-1-4107	Quantum Oscillations in Topological Insulators and Related Materials P02358	Condensed Matter Physics	4	33.11
Feng Wang (S)	University of California, Berkeley	Department of physics	Department of Energy DE-SC0003949	Magneto-optical Spectroscopy of Graphene on Boron Nitride substrate P02456	Condensed Matter Physics	2	20.9
Feng Wang (S)	University of California, Berkeley	Department of physics	Department of Energy DE-SC0003949	Magneto-transport of Perfectly Aligned Graphene on Boron Nitride substrate P09523	Condensed Matter Physics	1	7
David Goldhaber-Gordon (S)	Stanford University	Physics	Other - Moore Foundation	Spin and Valley Effects and Fractional Quantum Hall Effect in Graphene p-n Junctions P02275	Condensed Matter Physics	1	2.34
Irina Drichko (S)	A.F.Ioffe PTI	Physics of Semiconductors and Dielectrics	Other - Russian Foundation for Basic Research	High Frequency Magnetotransport in High-Mobility n-AlGaAs/GaAs/AlGaAs Heterostructures in the Fractional Quantum Hall Regime. Acoustic Studies. P02442	Condensed Matter Physics	1	7
Kim Dunbar (S)	Texas A&M University	Chemistry	Department of Energy DE-FG02-02ER45999	EPR Spectroscopy Studies to Investigate the Role of Spin-Orbit Coupling/Zero-field Splitting Effects on The Properties of Vandium(III) Compounds, P02155	Chemistry, Geochemistry	2	12.72
Naoki Kikugawa (S)	National Institute for Materials Science	Superconducting Properties Unit	Other - MEXT, Japan	High-Field Magneto-Transport Study of a Metallic Delafossite Oxide, P07189	Condensed Matter Physics	1	5.42

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
Guo-Qing Zheng (S)	Okayama University	Department of Physics	Other - Ministry of Education, Sports, Science and Technology	Revealing the low-temperature normal state of high temperature superconductors by high-field NMR P07194	Condensed Matter Physics	1	4.16
Xiaodong Xu (S)	University of Washington	Physics	Department of Energy DE-SC0008145	Cooling of Hot-Carriers with Landau Levels in Graphene P02040	Condensed Matter Physics	2	28
Kenneth Knappenberger (S)	Florida State University	Chemistry and Biochemistry	Other - Department of Defense	State-Resolved Electron Dynamics in Structurally Precise Metal Clusters P08433	Chemistry, Geochemistry	1	7
Haidong Zhou (S)	University of Tennessee	Physics and Astronomy	National Science Foundation NSF-DMR-1350002	Probing the ground sates of new quantum magnets by using AC susceptibility P02341	Condensed Matter Physics	3	21
Igor Kuskovsky (S)	Queens College of CUNY	Physics	National Science Foundation DMR-1006050	Temperature studies of Aharonov Bohm oscillations in type-II magneto-excitons P02083	Condensed Matter Physics	1	4.16
Ryan Baumbach (S)	National High Magnetic Field Laboratory	CMS	Other - State of Florida: E&G NHMFL User Collaboration Grants Program CMS Other - 227000-520-030759 NHMFL Renewal Proposal Department of Energy DE-FG02-04ER46105 Other - UCGP	High magnetic fields, applied pressure, and materials science: A toolbox to understand Quantum Criticality P02269	Condensed Matter Physics	6	40.09
Theo Siegrist (S)	CMS	Chemical and Biomedical Engineering	National Science Foundation 1257649	Test of an X-ray diffractometer for the Florida Split Coil 25T Magnet P02431	Magnets, Materials, Testing, Instrumentation	1	3.68
Wei Pan (S)	Sandia National Labatories	Semiconductor Devices and Science	Department of Energy 93220	Optical and Electronic Properties in Ferromagnetic Oxide Nanostructures P02072	Condensed Matter Physics	2	14
Kee Hoon Kim (S)	Seoul National University	School of Physics	Other - Creative Research Initiatives	Thermal properties of low-dimensional antiferromagnetic systems under high magnetic field P07211	Condensed Matter Physics	1	5.56
Chun Ning (Jeanie) Lau (S)	University of California, Riverside	Department of Physics and Astronomy	National Science Foundation Department of Energy	Magneto-transport and Symmetry-broken Quantum Hall States in Few Layer Graphene P02457	Condensed Matter Physics	7	46.56
Jun Zhu (S)	Penn State University	Physics	U.S. Navy N00014-11-1-0730	Symmetry breaking and kink states in few-layer graphene nanostructures P08487	Condensed Matter Physics	2	14
Christian Rueegg (S)	Paul Scherrer Institute	Laboratory for Neutron Scattering and Imaging	Other - Swiss National Science Foundation	Pressure-controlled Dimensionality of a Bi-layer Quantum Magnet P08412	Condensed Matter Physics	1	7
Malte Grosche (S)	University of Cambridge	Cavendish Laboratory	Other - EPSRC of the United Kingdom EP/K012894/1	Quantum oscillations in Mott insulators metallised under high pressure P08323	Condensed Matter Physics	1	4.61
Zhigang Jiang (S)	Georgia Institute of Technology	School of Physics	Department of Energy DE-FG02-07ER46451 National Science Foundation DMR-0820382	Quantum Transport and Infrared Spectroscopy of Graphene P02425	Condensed Matter Physics	3	42
YounJung Jo (S)	Kyungpook National University	Physics	Other - National Research Funding	Unconventional anisotropic magnetoresistance in a	Condensed Matter Physics	2	11.6

DC Field

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
				canted antiferromagnet P09542			
Eun Sang Choi (S)	NHMFL	Physics Department	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Study of Magnetic Phase transitions and Multiferroicity of Triangular Lattice Antiferromagnets P02366	Condensed Matter Physics	3	18.41
Lu Li (S)	University of Michigan	Physics	Department of Energy DE-SC0008110 National Science Foundation ECCS ECCS-1307744	Interaction-Driven Topological Materials P08418	Condensed Matter Physics	5	32.05
Zhiqiang Li (S)	National High Magnetic Field Laboratory	DC Field CMS	NHMFL User Collaboration Grants Program DC field	Magneto-transport and Magneto-optical Study of Topological Insulators P02349	Condensed Matter Physics	3	39
Sheena Murphy (S)	University of Oklahoma	Physics and Astronomy	National Science Foundation 1207537	Quantum Interference in Ultra-Thin Film Antimony P08333	Condensed Matter Physics	2	14
Martin Greven (S)	University of Minnesota	Physics and Astronomy	Department of Energy DE-SC0006858	Kohler's Rule in the Normal-State Magnetoresistance of the model cuprate superconductor HgBa2CuO4+d P02470	Condensed Matter Physics	1	6.78
David Graf (S)	Florida State University	DC Field CMS	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Two-axis rotation using a piezo-stepper platform P02453	Magnets, Materials, Testing, Instrumentation	2	15
C. W. (Paul) Chu (S)	University of Houston	Physics	Other - U.S. Air Force Office of Scientific Research FA9550-09-1-0656 Other - State of Texas through the Texas Center for Superconductivity at the University of Houston	High-Field Studies of Topological Insulators with Bulk Metallic Properties P09547	Condensed Matter Physics	1	5.19
Louis Taillefer (S)	University of Sherbrooke	Physics	Other - CFI, NSERC, CIFAR, FRQNT	Pressure studies of high-temperature superconductors P08341	Condensed Matter Physics	2	9.12
Tony Heinz (S)	Columbia University	Department of Physics	National Science Foundation 1124894 No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Magneto-Optical Study of Atomically Thin Transition Metal Dichalcogenide Crystals P07177	Condensed Matter Physics	5	42
Dragana Popovic (S)	NHMFL	Condensed Matter Science / Experimental	National Science Foundation 1307075	Magnetotransport in Underdoped Cuprates P08411	Condensed Matter Physics	6	41.08
Cory Dean (S)	The City College of New York	Physics	National Science Foundation 1351337 Other - New Faculty Start Up Funds	Resistively detected NMR study of spin polarization in 13C graphene P02272	Condensed Matter Physics	5	36.67
Kang Wang (S)	UCLA	Electrical Engineering	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Investigation of multi-functional electric/magnetic/spin properties in magnetic topological insulators and related heterostructures P09552	Condensed Matter Physics	2	13
Christian Rueegg (S)	Paul Scherrer Institute	Laboratory for Neutron Scattering and Imaging	Other - Swiss naitional laboratory, Paul Scherrer Institute Laboratory for Neutron Scattering and Imaging	Systematic pressure control of dimensionality in Cs2CuCl4 P09535	Condensed Matter Physics	1	6.44
Huiqiu Yuan	Zhejiang	Physics	No other support (i.e. this	Determination of the P-	Condensed	1	5.85

DC Field

DC Field

APPENDIX I – USER FACILITY STATISTICS

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
(S)	University	Department	experiment is entirely supported by NHMFL users services via its core grant) Other - Zhejiang University	B phase diagram of CeRhIn5 P09558	Matter Physics		
Satoru Nakatsuji (S)	University of Tokyo	Institute for Solid State Physics	Other - Grants-in-aid for Japan Society for the Promotion of Science (JSPS), Institute for Complex Adaptive Matter (ICAM) Other - Japanese Society for the Promotion of Science (JSPS) R2604, 15J08663	Field and Pressure Tuning of Anomalous Metallic State in the Mixed Valence Compound a-YbAlB4 P09560	Condensed Matter Physics	3	18.49
Luis Balicas (S)	NHMFL	Condensed Matter Experiment	Department of Energy DE-SC0002613	Evaluating Coulomb blockade thermometry under high magnetic fields P09564	Magnets, Materials, Testing, Instrumentation	1	7
Satoru Nakatsuji (S)	University of Tokyo	Institute for Solid State Physics	Other - Grants-in-aid for Japan Society for the Promotion of Science (JSPS), Institute for Complex Adaptive Matter (ICAM)	Field-Induced Quadrupolar Quantum Critical Phenomena in PrV2Al20 P09566	Condensed Matter Physics	1	7
Cagliyan Kurdak (S)	University of Michigan	Applied Physics	National Science Foundation DMR-1006500 and DMR-1441965	Study of Two-Dimensional Electron Systems on the Surface of a Topological Kondo Insulator SmB6 P02461	Condensed Matter Physics	1	5.74
James Hamlin (S)	University of Florida	Dept. of Physics	NHMFL User Collaboration Grants Program	High field studies of pressure-tuned quantum phase transitions P08434	Condensed Matter Physics	2	12.87
Cedomir Petrovic (S)	Brookhaven National Laboratory	Condensed Matter Physics	Department of Energy DE-AC02-98CH10886	High field quantum oscillation study of Dirac materials with layered structure P02172	Condensed Matter Physics	2	11.55
Woun Kang (S)	Ewha Womans University	Department of Physics	Other - National Research Foundation of Korea	Study of metallic state of (TMTTF)2Br - Unified model for the quasi-one-dimensional conductors P09531	Condensed Matter Physics	1	4.96
Xianglin Ke (S)	Michigan State University	Department of Physics and Astronomy	Other - University Start-up	de Haas-van Alphen study on the Fermi Surface topology of transition-metal doped Sr2RuO4 P09567	Condensed Matter Physics	1	7
Eden Steven (S)	NHMFL	Physics	National Science Foundation 1309146	Electrical properties of Mott insulators beta'-ET2XCl2 (X=I, Au) under high quality hydrostatic pressure generated by diamond anvil cell P08394	Condensed Matter Physics	1	7
George Schmiedeshoff (S)	Occidental College	Department of Physics	National Science Foundation 1408598	Quantum criticality & phase diagrams of heavy fermion YbAgGe and YbBiPt studied with high-precision dilatometry P07155	Condensed Matter Physics	3	21
Vivien Zapf (S)	NHMFL-LANL	Physics	Department of Energy 20140177ER	Spin-state transitions as a route to multifunctionality P07242	Condensed Matter Physics	2	6.02
James Gleeson (S)	Kent State University	Physics	National Science Foundation DMR-1307674	Magneto-optical studies on complex fluids P07193	Condensed Matter Physics	1	6.11
Stephen McGill (S)	NHMFL	Condensed Matter Science	National Science Foundation DMR-1229217	Mechanisms of Reactivity and Dynamics of the Photoexcited Charge-transfer State in Cytochrome Complex	Biology, Biochemistry, Biophysics	2	9.7

APPENDIX I – USER FACILITY STATISTICS

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
				(Cyt c) P09572			
Vesna Mitrovic (S)	Brown University	Physics	Other - Brown University NHMFL User Collaboration Grants Program CMP/DC fields	Resistively and inductively detected NMR as probe of 3D topological Kondo Insulators P07206	Condensed Matter Physics	2	15
Harold Hwang (S)	Stanford University	Applied Physics	Department of Energy DE-AC02-76SF00515	Superconductivity and Quantum Transport in Asymmetric and Symmetric SrTiO3 Structures P09573	Condensed Matter Physics	2	14
David Tanner (S)	University of Florida	Associate Director of MICROFABRITECH	Department of Energy DE-FG02-02ER45984	Searching for quantum oscillations in new candidates for topological insulators 2 P02102	Condensed Matter Physics	1	7
Greg Scholes (S)	Princeton University	Chemistry	Other - Princeton University Startup	Broadband pump-probe spectroscopy of light-harvesting phycobiliproteins in a high magnetic field P09574	Chemistry, Geochemistry	1	3.15
Jun Sung Kim (S)	POSTECH	Physics	Other - National Research Funding in Korea	Quantum oscillations and magnetotransport properties of layered transition-metal chalcogenide single crystals P09571	Condensed Matter Physics	3	21.14
Xuefeng Sun (S)	Hefei National Laboratory for Physical Sciences at the Microscale, University of Science and Technology of China	Physics	Other - National Basic Research Program of China 2011CBA00111 Other - Fundamental Research Fund for Central Universities (China) WK2340000035	Magnetic Susceptibility of the Pyrochlore Magnet Yb2Ti2O7 at Magnetic High Fields P02280	Condensed Matter Physics	1	7
N. Phuan Ong (S)	Princeton University	Physics	National Science Foundation 0819860	High-field experiments on the Topological Crystalline Insulator Pb1-xSnxSe/Pb1-xSnxTe P02446	Condensed Matter Physics	1	7
Ulf Trociewitz (S)	NHMFL	ASC	National Science Foundation 1157490	High Field Magnets with Bi-2212 Round Wire and REBCO Coated Conductor P02359	Magnets, Materials, Testing, Instrumentation	2	3.32
William Halperin (S)	Northwestern University	Physics	Department of Energy DE-FG02-05ER46248	Vortex structures in Hg1201 single crystals: competition with antiferromagnetism and the pseudo gap P07171	Condensed Matter Physics	2	9.3
Scott Riggs (S)	NHMFL	CMS	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	High Field specific heat near a QCP P09582	Condensed Matter Physics	2	17.19
Mark Murrie (S)	University of Glasgow	Chemistry	National Science Foundation DMR1309463	Single-ion magnets with giant axial magnetic anisotropy P08335	Chemistry, Geochemistry	1	7.86
Jan Jaroszynski (S)	NHMFL	CMS	NHMFL User Collaboration Grants Program	Comparative study of usual and contact-free methods of the angular critical current measurement in YBCO coated conductors by means of Vector Vibrating Sample Magnetometer under	Magnets, Materials, Testing, Instrumentation	2	11.62

APPENDIX I – USER FACILITY STATISTICS

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
				development P02376			
Andrey Chabanov (S)	University of Texas at San Antonio	Physics	Other - UTSA Other - AFRL Sensors Directorate	Induced Microwave Transmission and Giant Faraday Effect in Co Thin Films Applied to Wide-Aperture, Wide-Angle Isolator Design P02187	Engineering	2	9.92
Amalia Coldea (S)	Oxford University	Clarendon Laboratory	Other - EPSRC, UK	Using ultra-high magnetic fields to access the electronic structure of novel superconducting materials P09591	Condensed Matter Physics	1	5.18
Dmitry Smirnov (S)	NHMFL	Instrumentation & Operations	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) DC Field / CMS	Magneto-optics of 2D semiconducting transiton metal dichalcogenides P07197	Condensed Matter Physics	2	14.94
James Analytis (S)	University of California, Berkeley	Physics	Other - Lawrence Berkeley National Laboratory Material Science Division	Investigating the Fermi surface of the Pd-based Superconductor Ta4Pd3Te16 in high magnetic fields P09594	Condensed Matter Physics	1	5.82
Dmitry Smirnov (S)	NHMFL	Instrumentation & Operations	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Testing new magneto-optical probes and new magneto-spectroscopy techniques P09590	Magnets, Materials, Testing, Instrumentation	3	21
Suchitra Sebastian (S)	Cambridge University	Physics	Other - ERC	A search for topological surface states P08397	Condensed Matter Physics	1	4.27
N. Phuan Ong (S)	Princeton University	Physics	National Science Foundation 0819860	The thermal Hall conductivity of Dirac quasiparticles in YBa2Cu3O6+y in high fields P02268	Condensed Matter Physics	1	4.43
Kazumasa Iida (S)	Nagoya University	Dep. of Crystalline Materials Science, Graduate School of Engineering	Other - Nagoya University	High field transport properties of LnFeAs(O,F) coated conductors P09519	Condensed Matter Physics	1	4.15
Luis Balicas (S)	NHMFL	Condensed Matter Experiment	U.S. Army ARO W911NF-11-1-0362	Studying the electronic structure of WTe2 as a function of the number of atomic layers P08406	Condensed Matter Physics	1	5.62
Danko van der Laan (S)	National Institute of Standards and Technology	687.03	Department of Energy DE-SC0007660 Department of Energy DE-SC0009545 Department of Energy DE-AI05-98OR22652	Critical current measurements of high-temperature superconducting CORC magnet cables at 4.2 K and high magnetic fields P08425	Magnets, Materials, Testing, Instrumentation	2	3.82
Chris Palmstrom (S)	UC Santa Barbara	ECE-Material Science	Other - Microsoft Research	Quantum Hall effect in narrow band gap semiconductors with superconducting contacts P07217	Condensed Matter Physics	2	14
Yung Woo Park (S)	Seoul National University	Physics	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Investigation on Zero Magneto Conductance Phenomena in Low Dimensional Systems: Polymer Nanofibers and Charge Density Wave Materials P02331	Condensed Matter Physics	1	6

APPENDIX I – USER FACILITY STATISTICS

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
Kresimir Rupnik (S)	Louisiana State University	Chemistry Department	NHMFL User Collaboration Grants Program physics/material 227000-520-022742 Other - LSU	Ultrafast Polarization Phase Selective (PPS) Studies: Areas of Fundamental Significance to Biochemistry/Biophysics P08452	Biology, Biochemistry, Biophysics	1	4.09
Tengming Shen (S)	Fermilab	Magnet Systems Department	Department of Energy FY12 Early Career Award to T.S.	Early Career: Engineering high-field superconducting materials for frontier accelerator technology P09570	Magnets, Materials, Testing, Instrumentation	1	4.5
Martin Nikolo (S)	Saint Louis University	Physics	Other - Saint Louis University, Presidential Research Fund	Upper critical fields, magneto-transport properties and thermally activated flux flow in Ba(Fe0.91Co0.09)2As2, Ba(Fe0.95Ni0.05)2As2, and Ba(Fe0.94Ni0.06)2As2 superconductors P07274	Condensed Matter Physics	1	7
Johnpierre Paglione (S)	University of Maryland	Center for Nanophysics and Advanced Materials, Department of Physics	Department of Energy DE-SC-0010605	High field magnetotransport behavior and Fermi surface study by quantum oscillation for topological semimetals P11491	Condensed Matter Physics	1	3.22
Satoru Nakatsuji (S)	University of Tokyo	Institute for Solid State Physics	Other - Grants-in-Aid from Japan Society for the Promotion of Science, and Institute for Complex Adaptive Matter (ICAM)	Anisotrpic Multipole Phase in Quadrupole Kondo System PrV2Al20 P09554	Condensed Matter Physics	1	7.51
Denis Karaiskaj (S)	University of South Florida	Physics	Department of Energy DE-SC0012635 National Science Foundation DMR-1409473	Exploring Two-dimensional Electron systems at Extreme Magnetic Fields with Optical and Terahertz 2DFT Spectroscopy P08413	Condensed Matter Physics	2	1.53
Martin Greven (S)	University of Minnesota	Physics and Astronomy	National Science Foundation NSF DMR-1006617	Temperature and field dependence of the c-axis resistivity in the electron-doped superconductor Nd2-xCexCuO4-d and Sm2-xCexCuO4-d P02468	Condensed Matter Physics	1	5.57
Ian Fisher (S)	Stanford University	Applied Physics	Other - U.S. Air Force Air Force Office of Scientific Research 1176248-100-TAADD	High-field study of Superconducting thallium doped lead telluride (Pb1-xTlxTe) P02297	Condensed Matter Physics	1	5.93
Shinya Uji (S)	National Institute for Materials Science	Nanomaterials Laboratory	Other - NIMS research fund	Quest for novel high-magnetic-field superconducting phases in 2D organic superconductors P11504	Condensed Matter Physics	1	10.04
Hitoshi Kitaguchi (S)	National Institute for Materials Science	Superconducting Wire Unit	Other - National Institute for Materials Science, Japan	High field performance evaluation of new, high strength Bi-2223 HTS tapes P11499	Magnets, Materials, Testing, Instrumentation	1	5.3
Christopher Beedle (P)	NHMFL	MPA-CMMS	Department of Energy LANLF100	High magnetic field and high-frequency cyclotron resonance studies of the underdoped cuprate YBa2Cu3O6+y (YBCO) and related materials P11508	Condensed Matter Physics	1	5.87

APPENDIX I – USER FACILITY STATISTICS

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
Zhiqiang Li (S)	National High Magnetic Field Laboratory	DC Field CMS	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Testing, calibrating and improving the new IR transmission probe in SCM3 P08449	Magnets, Materials, Testing, Instrumentation	1	7
David Graf (S)	Florida State University	DC Field CMS	Department of Energy DE-NA0001979	High Pressure Studies of Dirac Fermion Systems P09586	Condensed Matter Physics	1	5.38
Susanne Stemmer (S)	UC Santa Barbara	Materials	U.S. Army Physics W911NF-14-1-0379	Confined two-dimensional electron liquids in oxide heterostructures P11511	Condensed Matter Physics	1	7
Kin Fai Mak (S)	Penn State University	Physics	Other - Penn State University startup	Probing superconductivity in atomically thin transition metal dichalcogenides P11513	Condensed Matter Physics	1	4.07
Mitsuhiko Maesato (S)	Kyoto University	Division of Chemistry, Graduate School of Science	Other - KAKENHI from JSPS	Quantum Criticality in a Frustrated Quantum Magnet P11516	Condensed Matter Physics	1	7
Satoru Nakatsuji (S)	University of Tokyo	Institute for Solid State Physics	Other - Grants-in-aid for Japan Society for the Promotion of Science (JSPS), Institute for Complex Adaptive Matter (ICAM)	Anisotropic metal-insulator transition and magneto-electric effect in Nd2Ir2O7 P11517	Condensed Matter Physics	1	7
Paul Cadden-Zimansky (S)	Bard College	Physics	Other - Research Corporation for Science Advancement, Bard College Science Research Fund	The Quantum Hall Effect in Hybrid Graphene P02377	Condensed Matter Physics	1	4.49
Mohindar Seehra (S)	West Virginia University	Department of Physics and Astronomy	Other - West Virginia University Department of Physics and Astronomy	Understanding the nature of magnetism in transition-metal substituted phthalocyanines through high-field, low-temperature magnetic measurements at the NHMFL P11507	Condensed Matter Physics	1	6
Christian Rueegg (S)	Paul Scherrer Institute	Laboratory for Neutron Scattering and Imaging	Other - Marie-Curie COFUND Other - Swiss National Science Foundation	Frustrated Sulfospinels under pressure: tuning exchange parameter ratios in MnSc2S4 and driving through a Quantum Critical Point in FeSc2S4 P11521	Condensed Matter Physics	1	7.05
C. W. (Paul) Chu (S)	University of Houston	Physics	Other - U.S. Air Force Office of Scientific Research FA9550-09-1-0656 Other - U.S. Air Force Office of Scientific Research FA2386-14-1-3007 Other - T. L. L. Temple Foundation Other - John J. and Rebecca Moores Endowment Other - State of Texas through the Texas Center for Superconductivity at the University of Houston	High-Field Studies of Metallic Bismuth Telluride P11515	Condensed Matter Physics	1	5.81
Makoto Takayasu (S)	Massachusetts Institute of Technology	Plasma Science and Fusion Center	Department of Energy Office of Fusion Energy Science DE-FC02-93ER54186 Department of Energy DE-FC02-93ER54186, DE-SC0004062	HTS Tape Conductor Characterization P02059	Magnets, Materials, Testing, Instrumentation	2	1.71

DC Field

APPENDIX I – USER FACILITY STATISTICS

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
Mansour Shayegan (S)	Princeton University	Department of Electrical Engineering	National Science Foundation 1157490 National Science Foundation DMR -1157490	Magnetotransport measurements in low-dimensional, interacting electronic systems P02480	Condensed Matter Physics	2	20.07
James Analytis (S)	University of California, Berkeley	Physics	Other - Moore Foundation	Thermodynamic Studies of 3-D Stripy Honeycomb Iridates P11523	Condensed Matter Physics	1	7.39
Ke Han (S)	NHMFL	MS&T	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Improvement of Permanent Magnetic Material Properties by High Magnetic Field Annealing P02241	Engineering	1	1.79
Andrea Young (S)	University of California	Physics	Other - University of California Physics	Magnetocapacitance matrix for bilayer two dimensional electron systems P11522	Biology, Biochemistry, Biophysics	1	5.19
Stephen McGill (S)	NHMFL	Condensed Matter Science	National Science Foundation 1229217	Charge-Spin-Lattice Coupling in Low-Dimensional Magnets P07215	Condensed Matter Physics	1	14
Venkat Selvamanickam (S)	University of Houston	Mechanical Engineering	Department of Energy DE-AR0000196	Critical current characterization of Zr-doped REBa2Cu3Ox coated conductors at 4 K for high field magnet applications above 25 T P02261	Magnets, Materials, Testing, Instrumentation	1	5.41
Yasu Takano (S)	University of Florida	Physics	National Science Foundation DMR-1350002 Other - JSPS	Magnetic and thermal properties of novel quantum magnets P11528	Condensed Matter Physics	2	12
Nathanael Fortune (S)	Smith College	Department of Physics	NHMFL Visiting Scientist Program 173	Field-Rotatable Low-Temperature Calorimeters: 0 - 45 T, 0.1 - 10 K P02447	Magnets, Materials, Testing, Instrumentation	1	7
Seongshik Oh (S)	Rutgers, the State University of New Jersey	Physics and Astronomy	Other - Gordon and Betty Moore Foundation EPiQS Initiative GBMF4418	Search for quantum Hall effect in interface-engineered Bi2Se3 thin films with record low sheet carrier density and high mobility P11509	Condensed Matter Physics	1	4.89
Alexey Suslov (S)	NHMFL	Condensed Matter Science	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Test of cryostat for X-ray experiments in the Split Helix Magnet P11533	Magnets, Materials, Testing, Instrumentation	1	5
Geetha Balakrishnan (S)	University of Warwick, Coventry, CV4 7AL, UK	Physics	Other - EPSRC (U.K.)	High magnetic field measurements of novel correlated topological insulators P12545	Condensed Matter Physics	1	7
Suchitra Sebastian (S)	Cambridge University	Physics	Other - European Research Council (ERC)	Accessing the normal state of the cuprate superconductors P12546	Condensed Matter Physics	1	3.84
Stan Tozer (S)	NHMFL	Physics	Other - NNSA NNSA SSAP DE-NA0001979	High pressure magnetostriction studies of actinides and related materials P02128	Condensed Matter Physics	1	6.14
Alexey Suslov (S)	NHMFL	Condensed Matter Science	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Graphite levitation at the NHMFL hybrid P12566	Magnets, Materials, Testing, Instrumentation	1	3
Tim Murphy (S)	NHMFL	Operations	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) Operations	Maintenance and testing of hybrid, resistive magnets and their associated infrastructure P02230	Magnets, Materials, Testing, Instrumentation	2	3.27

DC Field

APPENDIX I – USER FACILITY STATISTICS

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Scheduled	# of Days Used
Zhiqiang Mao (S)	Tulane University	Physics Department	National Science Foundation 1205469	Studies of Quantum Oscillations in the Dirac semimetal SrMnSb2 and Weyl semimetal TaP P12574	Condensed Matter Physics	2	11.08
Timir Datta (S)	University of South Carolina	Department of Physics and Astronomy	Department of Energy DE-NA0002630	Linear magnetoresistance in 3-dimensional carbon nanostructure with periodic spherical voids P13598	Condensed Matter Physics	1	7
Ju-Hyun Park (S)	NHMFL	Instrumentation & Operations, User Support	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Thermometry Control in High Magnetic Fields P08414	Condensed Matter Physics	2	14
Sergei Zvyagin (S)	Dresden High Magnetic Field Laboratory	EPR	Other - DFG agency	Magnetic properties of quantum spin systems P07174	Condensed Matter Physics	1	1.91
Dmitry Shulyatev (S)	National University of Science and Technology "MISIS"	Theoretical Physics	Other - Russian Foundation for Basic Research	Weak localisation in decogonal qusicrystal Al-Cu-Co. P02363	Condensed Matter Physics	2	14
Ziling Xue (S)	University of Tennessee	Chemistry	National Science Foundation CHE-1362548	Probing Molecular Magnetism by Infrared and Raman Spectroscopies in Magnetic Fields P13617	Chemistry, Geochemistry	1	7
Luis Balicas (S)	NHMFL	Condensed Matter Experiment	Department of Energy DE-SC0002613	Exploring the electronic properties of Weyl semimetal candidates P11512	Condensed Matter Physics	1	5.45
Sergey Suchalkin (S)	SUNY at Stony Brook	Electrical and Computer Engineering	National Science Foundation DMR1160843	Magneto-spectroscopy of metamorphic InAsSb narrow band semiconductors P07180	Condensed Matter Physics	1	7
Hans-Henning Klauss (S)	Technical University Dresden	Institute for Solid States Physics	Other - Deutsche Forschungsgemenschaft GRK1621	High field response of the pseudogap phase in the 10-3-8 iron arsenide superconductors P13632	Condensed Matter Physics	1	1.53
David Hilton (S)	University of Alabama-Birmingham	Physics	National Science Foundation DMR-1056827	Development of Ultrafast Terahertz Spectroscopy Experiments for SCM3 P02175	Condensed Matter Physics	1	0.92
Minhyea Lee (S)	University of Colorado Boulder	Physics	Department of Energy DE-SC0006888	Investigation of magnetic anisotropy in low dimensional systems P13639	Condensed Matter Physics	1	7
Stephen McGill (S)	NHMFL	Condensed Matter Science	National Science Foundation 1229217	Charge Dynamics in Narrow-Gap Mott Insulators P13641	Condensed Matter Physics	1	14
Emanuel Tutuc (S)	The University of Texas at Austin	Electrical and Computer Engineering	Other - Semiconductor Research Corporation	Magnetotransport Properties of Interacting Electrons in van der Waals Heterostructures P11534	Condensed Matter Physics	1	5.74
Arno Godeke (S)	NHMFL	MS&T and ASC	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) MS&T and ASC	High field performance of new, high strength Bi-2223 HTS tapes and coils P13645	Magnets, Materials, Testing, Instrumentation	1	2.59
Alexey Suslov (S)	NHMFL	Condensed Matter Science	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Making Probes for Ultrasonic Measurements at the NHMFL DC Field Facility P09589	Magnets, Materials, Testing, Instrumentation	1	7
Total Proposals:				**156**	**Total Experiments:**	**269**	**1,703**

APPENDIX I – USER FACILITY STATISTICS

PULSED FIELD FACILITY

***Table 1** – User Demographic*

PFF Facility	Users	Male	Female	Prefer Not to Respond to Gender	Minority[1]	Non-Minority[1]	Prefer Not to Respond to Race	Users Present	Users Operating Remotely[2]	Users Sending Sample[3]	Off-Site Collaborators[4]
Senior Personnel, U.S.	**69**	58	6	5	3	61	5	36	0	18	15
Senior Personnel, non-U.S.	**24**	20	2	2	0	20	4	5	0	13	6
Postdocs, U.S.	**18**	14	3	1	1	14	3	15	0	1	2
Postdocs, non-U.S.	**4**	3	1	0	0	3	1	0	0	1	3
Students, U.S.	**33**	23	6	4	1	24	8	21	0	6	6
Students, non-U.S.	**12**	6	2	4	0	7	5	8	0	2	2
Technician, U.S.	**0**	0	0	0	0	0	0	0	0	0	0
Technician, non-U.S.	**0**	0	0	0	0	0	0	0	0	0	0
Total:	**160**	**124**	**20**	**16**	**5**	**129**	**26**	**85**	**0**	**41**	**34**

[1]NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin
[2]"Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
[3]"Users Sending Sample" refers to users who send the sample to the facility and the experiment is conducted by in-house user support personnel. Users at UF, FSU, and LANL cannot be "sample senders" for facilities located on their campuses.
[4]"Off-Site Collaborators" are scientific or technical participants on the experiment; who will not be present, sending sample, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).
***Note:** Users using multiple facilities are counted in each facility listed.*

***Table 2** – User Affiliation*

PFF Facility	Users	NHMFL-Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users[4]	National Lab Users[3,4]
Senior Personnel, U.S.	**69**	24	9	41	0	28
Senior Personnel, non-U.S.	**24**	0	0	18	1	5
Postdocs, U.S.	**18**	4	5	10	0	8
Postdocs, non-U.S.	**4**	0	0	1	0	3
Students, U.S.	**33**	6	4	31	0	2
Students, non-U.S.	**12**	0	0	11	0	1
Technician, U.S.	**0**	0	0	0	0	0
Technician, non-U.S.	**0**	0	0	0	0	0
Total:	**160**	**34**	**18**	**112**	**1**	**47**

[1]NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site. The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators".
[2]In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
[3]In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
[4]The total of university, industry, and national lab users will equal the total number of users.

APPENDIX I – USER FACILITY STATISTICS

Pulsed Field

***Table 3** – Users by Discipline*

PFF Facility	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Senior Personnel, U.S.	**69**	57	4	3	0	5
Senior Personnel, non-.S.	**24**	22	0	0	0	2
Postdocs, U.S.	**18**	17	0	1	0	0
Postdocs, non-U.S.	**4**	4	0	0	0	0
Students, U.S.	**33**	30	1	0	1	1
Students, non-U.S.	**12**	11	1	0	0	0
Technician, U.S.	**0**	0	0	0	0	0
Technician, non-U.S.	**0**	0	0	0	0	0
Total:	**160**	**141**	**6**	**4**	**1**	**8**

***Table 4** – User Facility Operations*

PFF Facility	Short Pulse	Mid Pulse	Long Pulse	100T	Single Turn	Total Days Used / User Affil.	Percentage Used / User Affil.
	Number of Magnet Days[1]						
NHMFL-Affiliated	119	0	0	6	10	**135**	**22.39%**
Local	28	0	0	0	0	**28**	**4.64%**
U.S. University	228	0	0	16	0	**244**	**40.46%**
U.S. Govt. Lab.	65	0	0	0	0	**65**	**10.78%**
U.S. Industry	0	0	0	0	0	**0**	**0.00%**
Non-U.S.	101	0	0	1	0	**102**	**16.92%**
Test, Calibration, Set-up, Maintenance, Inst. Dev.	0	0	0	12	17	**29**	**4.81%**
Total:	**541**	**0**	**0**	**35**	**27**	**603**	**100.00%**

[1]*User Units are defined as magnet days. Magnets are scheduled typically 12 hours a day.*

***Table 5** – Operations by Discipline*

PFF Facility	Total Days[1] Allocated / User Affil.	Con-densed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
	Number of Magnet Days[1]					
NHMFL-Affiliated	**135**	122	0	0	13	0
Local	**28**	28	0	0	0	0
U.S. University	**244**	225	14	0	5	0
U.S. Govt. Lab.	**65**	65	0	0	0	0
U.S. Industry	**0**	0	0	0	0	0
Non-U.S.	**102**	102	0	0	0	0
Test, Calibration, Set-up, Mainte-nance, Inst. Dev.	**29**	0	0	0	29	0
Total:	**603**	**542**	**14**	**0**	**47**	**0**

[1]*User Units are defined as magnet days. Magnets are scheduled typically 12 hours a day.*

Pulsed Field

Pulsed Field

APPENDIX I – USER FACILITY STATISTICS

***Table 6** – User Program Experiment Pressure*

PFF Facility					
Experiment Requests Received	Experiment Requests Deferred from Prev. Year	Experiment Requests Granted	Experiment Requests Declined/Deferred	Experiment Requests Reviewed	Subscription Rate
121	30	85 (56%)	66 (44%)	151	178%

***Table 7** – New User PIs[1]*

First Name	Last Name	Organization
Moaz	**Altarawneh**	LANL
Michael	**Baenitz**	Max Planck Institute for chemical physics of Solids
Geetha	**Balakrishnan**	University of Warwick, Coventry, CV4 7AL, UK
Nicholas	**Butch**	National Institute of Standards and Technology
Kirk	**Flippo**	LANL
Venkatraman	**Gopalan**	Pennsylvania State University
Shuang	**Jia**	Peking University (Non-U.S. University)
John	**Mitchell**	Argonne National Laboratory
Gwenaelle	**Rousse**	UPMC
Andreas	**Stier**	Los Alamos National Laboratory
Stefan	**Sullow**	TU Braunschweig
Alexander	**Tsirlin**	National Institute of Chemical Physics and Biophysics
Rena	**Zieve**	University of California, Davis
Total:		**13**

[1]PI who received magnet time for the first time across all facilities.

***Table 8** – Research Proposals Profile with Magnet Time*

PFF Facility	Total	Minority[2]	Female[3]	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Number of Proposals	**58**	0	6	51	1	0	5	1

[1]A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
[2]The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
[3]The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

***Table 9** – User Proposal*

This report lists all proposals that were allocated magnet time from January-December 2015 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users.
(S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Gang Cao (S)	University of Kentucky	Department of Physics and Astronomy	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) National Science Foundation DMR-1265162	Probing Spin-Orbit Coupled 5d-Electron Iridates Using High Magnetic Field P02050	Condensed Matter Physics	4	23.00
Lu Li (S)	University of Michigan	Physics	Department of Energy DE-SC0008110	Magnetic property of high temperature superconductors in ultrahigh magnetic fields P02065	Condensed Matter Physics	1	12.00

APPENDIX I – USER FACILITY STATISTICS

Pulsed Field

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Sang Wook Cheong (S)	Rutgers University	Physics and Astronomy	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Multiferroic behavior and slow dynamics in Ca3CoMnO6 and Sr3NiIrO6 P02092	Condensed Matter Physics	3	15.00
Stan Tozer (S)	NHMFL	Physics	Department of Energy NNSA SSAA DE-NA0001979	High pressure magnetostriction studies of actinides and related materials P02128	Condensed Matter Physics	1	5.00
David Tanner(S)	University of Florida	Associate Director of MICRO-FABRITECH	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	High magnetic field SdH oscillations in BiTeI P02134	Condensed Matter Physics	1	5.00
James Analytis(S)	University of California, Berkeley	Physics	Other - University of California, Berkeley Physics	High field magneto-transport near a quantum critical point in high temperature superconductors. P02226	Condensed Matter Physics	2	10.00
Ivan Bozovic (S)	Brookhaven National Lab	Condensed Matter and Materials Science	Department of Energy MA-509-MACA	Determination of the upper critical field of cuprates by electrical transport under high magnetic field P02266	Condensed Matter Physics	1	5.00
Ryan Baumbach(S)	National High Magnetic Field Laboratory	CMS	Other - 227000-520-030759 NHMFL Renewal Proposal No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	High magnetic fields, applied pressure, and materials science: A toolbox to understand Quantum Criticality P02269	Condensed Matter Physics	2	16.00
James Analytis(S)	University of California, Berkeley	Physics	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	High field magnetometry of strong spin-orbit coupled oxides P02271	Condensed Matter Physics	1	24.00
Jonathan Betts(S)	LANL	NHMFL-PFF	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Maintenance of 1.4GW Generator system P02322	Magnets, Materials, Testing, Instrumentation	1	12.00
Janice Musfeldt(S)	University of Tennessee, Knoxville	Department of Chemistry	National Science Foundation 1063880	High field spectroscopy of materials P02415	Chemistry, Geochemistry	1	14.00
Tian-Heng Han(P)	University of Chicago	Physics	Department of Energy DE-AC02-06CH11357	Quantum Spin Liquids in High Fields P02458	Condensed Matter Physics	1	5.00
Cagliyan Kurdak(S)	University of Michigan	Applied Physics	National Science Foundation DMR-1006500 and DMR-1441965	Study of Two-Dimensional Electron Systems on the Surface of a Topological Kondo Insulator SmB6 P02461	Condensed Matter Physics	1	14.00
Vivien Zapf (S)	NHMFL-LANL	Physics	Department of Energy F100	Spin-state transitions as a route to multi-functionality P07242	Condensed Matter Physics	2	7.00

APPENDIX I – USER FACILITY STATISTICS

Pulsed Field

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Emilia Morosan(S)	Rice University	Physics and Astronomy	National Science Foundation 0847681	High Field Magnetization in an Itinerant Antiferromagnet P07269	Condensed Matter Physics	1	11.00
Martin Nikolo (S)	Saint Louis University	Physics	Other - Saint Louis University Other - Saint Louis University, Presidential Research Fund	Upper critical fields, magneto-transport properties and thermally activated flux flow in Ba(Fe0.91Co0.09)2As2, Ba(Fe0.95Ni0.05)2As2, and Ba(Fe0.94Ni0.06)2As2 superconductors P07274	Condensed Matter Physics	2	14.00
Mark Wartenbe (G)	FSU	Director's Office	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	QCPs in (Ca-Sr)RuO3 P07304	Condensed Matter Physics	1	5.00
Nicholas Cornell(G)	University of Texas at Dallas	Physics	Other - UT Dallas Other - Univ. of Texas, Dallas Department of Physics	?(T,H=const) and (H,T) phase diagram determination for Fe(SeXTe1-X) P08325	Condensed Matter Physics	2	10.00
Krzysztof Gofryk(S)	Idaho National Laboratory	Fuel Performance & Design	Other - NEAMS Nuclear Fuels and Materials	Spin-lattice coupling in uranium dioxide probed by magnetostriction measurements at high magnetic fields P08358	Condensed Matter Physics	1	5.00
Scott Riggs (S)	NHMFL	CMS	Other - NHFML	Calibration of custom designed Cernox calorimeters P08402	Condensed Matter Physics	1	5.00
Mun Chan (P)	Los Alamos Natl Lab	Pulsed field Facility	Department of Energy SC0006858 Department of Energy 100T Science	The ground-state of the cuprate high-temperature superconductor HgBa2CuO4+d P08467	Condensed Matter Physics	6	55.00
Huiqiu Yuan (S)	Zhejiang University	Physics Department	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Measurements of Magnetization and dHvA Effect of CrAs P08506	Condensed Matter Physics	1	10.00
Wei Pan (S)	Sandia National Laboratories	Semiconductor Devices and Science	Department of Energy 93220	Ultra-High Magnetic Field Transport Studies in Novel Two-Dimensional Electron Systems P09538	Condensed Matter Physics	3	14.00
Jamie Manson(S)	Eastern Washington University	Chemistry and Biochemistry	National Science Foundation 1306158	Systematic dimensionality reduction of molecule-based quantum magnets to untangle magnetochemical properties P09540	Condensed Matter Physics	3	22.00

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Pulsed Field

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Jamie Manson(S)	Eastern Washington University	Chemistry and Bio-chemistry	National Science Foundation 1306158	Using magnetization to explore spin-dimensionality in Cu(II) coordination polymers P09541	Condensed Matter Physics	1	5.00
Neil Harrison (S)	NHMFL-LANL	Physics	Department of Energy LANLF100	Electronic structure of URu2Si2 and related strongly correlated materials in strong magnetic fields P09543	Condensed Matter Physics	1	5.00
Brad Ramshaw (P)	National High Magnetic Field Lab - Los Alamos	MPA-CMMS	Department of Energy LANLF100	C-axis magnetoquantum oscillations in underdoped YBa2Cu3O6+x P09545	Condensed Matter Physics	1	18.00
Pei-Chun Ho (S)	California State University, Fresno	Physics	National Science Foundation DMR-1104544	Mapping Fermi Surfaces of CeOs4Sb12, NdOs4Sb12, and SmOs4Sb12 P09549	Condensed Matter Physics	1	7.00
Paul Goddard (S)	Warwick University	Department of Physics	Other - EPSRC (UK)	Investigating magnetic order stabilized by spin-orbit interactions and electron correlations P09563	Condensed Matter Physics	1	5.00
John Mitchell (S)	Argonne National Laboratory	Materials Science Division	Department of Energy F100 Department of Energy XW5D	Spin state transition, multifunctionality and percolation in La1-xSrxCoO3 P09568	Condensed Matter Physics	2	10.00
James Analytis (S)	University of California, Berkeley	Physics	Department of Energy DE-AC02-05CH11231	Pulsed field studies of Fermi surface topology and superconductivity in thin film cuprate superconductors P09580	Condensed Matter Physics	1	9.00
James Analytis(S)	University of California, Berkeley	Physics	Department of Energy DE-AC02-05CH11231	Magnetoresistance Near the Quantum Critical Point of an Unconventional Superconductor P09583	Condensed Matter Physics	1	5.00
Philip Moll (G)	ETH Zurich	Laboratory for Solid State Physics	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Field-tuned chiral anomaly in the Weyl semi-metal Cd3As2 P09592	Condensed Matter Physics	2	16.00
Geetha Balakrishnan (S)	University of Warwick, Coventry	Physics	Other - European Research Commission	Quantum oscillations in a topological insulator P09597	Condensed Matter Physics	2	11.00
Gil Lonzarich (S)	Cambridge University	Physics	Other - European Research Commission	High magnetic field measurements of high temperature superconductors P09598	Condensed Matter Physics	1	10.00

APPENDIX I – USER FACILITY STATISTICS

Pulsed Field

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Andreas Stier (P)	Los Alamos National Laboratory	MPA-CMMS	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Spin flip resonance on (BiSb)2Te3 utilizing the single turn magnet at the NHMFL pulsed field facility P11454	Magnets, Materials, Testing, Instrumentation	1	15.00
Sergey L Bud'ko(S)	Iowa State University	Ames Laboratory	Department of Energy DE-AC02-07CH11358	Anisotropies in unconventional superconductors and related strongly correlated materials in high magnetic fields P11463	Condensed Matter Physics	1	5.00
Shuang Jia (S)	Peking University (Non-U.S. University)	Physics	Other - 973 project Chinese Department of Science and Technology.	Quantum Oscillations in the First Observed Weyl Fermion System TaAs P11498	Condensed Matter Physics	1	5.00
Filip Ronning (S)	Los Alamos National Laboratory	MPA-CMMS	Other - Los Alamos National Lab LDRD	Weyl Semimetals in high magnetic fields P11503	Condensed Matter Physics	1	23.00
Stefan Sullow (S)	TU Braunschweig	IPKM	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Magnetostrain in UPt_2Si_2 P11506	Condensed Matter Physics	2	10.00
Nicholas Butch(S)	National Institute of Standards and Technology	NIST Center for Neutron Research	Other - National Institute of Standards and Technology	High Field Studies of Actinide Antiferromagnets P11514	Condensed Matter Physics	2	10.00
Raivo Stern (S)	NICPB	Chemical Physics	Other - Estonian Research Council ETAg NA PUT 210	Spin-Peierls transition in the S=1/2 compound TiPO4 with large intrachain coupling - the H-T phase diagram P11527	Condensed Matter Physics	1	5.00
Krzysztof Gofryk (S)	Idaho National Laboratory	Fuel Performance & Design	Other - INL LDRD	Spin-lattice interactions in uranium mononitride measured by magnetostriction and magnetization at high magnetic fields. P11529	Condensed Matter Physics	1	5.00
Alexander Tsirlin (S)	National Institute of Chemical Physics and Biophysics	Chemical physics	Other - Tech. Univ. Augsburg, Germany	(H,T)-phase diagram of the frustrated spin-1/2 chain system in beta-TeVO4 P11530	Condensed Matter Physics	1	5.00
Rena Zieve (S)	University of California, Davis	Physics	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	First Order Reversal Curve Analysis on the Mangetostructural Transition of Fe$_{1+y}$Te in a Pulsed Field P11538	Condensed Matter Physics	1	5.00

APPENDIX I – USER FACILITY STATISTICS

Pulsed Field

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Andreas Stier (P)	Los Alamos National Laboratory	MPA-CMMS	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Polarization sensitive photoluminescence and reflection spectroscopy of novel atomically thin materials in ultrahigh magnetic fields at the NHMFL. P12557	Condensed Matter Physics	4	24.00
Kirk Flippo (S)	LANL	P-24	Department of Energy 20140541ER	Testing of Faraday rotation diagnostics for testing of laser-driven high field coils P13607	Magnets, Materials, Testing, Instrumentation	1	12.00
Luis Balicas (S)	NHMFL	Condensed Matter Experiment	Department of Energy DE-SC0002613	Exploring the electronic properties of Weyl semimetal candidates P13622	Condensed Matter Physics	1	5.00
Nicholas Butch (S)	National Institute of Standards and Technology	NIST Center for Neutron Research	Other - Department of Commerce	High Field Studies of Electron-Doped Cuprate Thin Films P13626	Condensed Matter Physics	1	5.00
Hidekazu Tanaka (S)	Tokyo Institute of Technology	Physics	Other - Grant-in-Aid for Scientific Research (A) Japan Society for the Promotion of Science	Magnetostriction of Ba2MSi2O6Cl2 (M=Co, Ni, Cu) in pulsed magnetic fields P13631	Condensed Matter Physics	1	5.00
Paul Goddard (S)	Warwick University	Department of Physics	Other - University of Warwick	Kondo insulators under high hydrostatic pressure P13634	Condensed Matter Physics	1	5.00
Paul Goddard (S)	Warwick University	Department of Physics	Other - University of Warwick	Mapping out the Fermi surface of CMR manganites P13635	Condensed Matter Physics	1	5.00
Michael Baenitz (S)	Max Planck Institute for chemical physics of Solids	Physics of quantum matter	National Science Foundation 1157490	High Field Magnetic Anisotropy of RuCl3 using Torque Magnetometry P13638	Condensed Matter Physics	1	5.00
Venkatraman Gopalan (S)	Pennsylvania State University	Materials Science and Engineering	National Science Foundation DMR 0820404	Strong magnetoelectric coupling in Ca3(Ru1-xTix)2O7 single crystal in pulsed magnetic field P13644	Magnets, Materials, Testing, Instrumentation	1	5.00
Greg Boebinger (S)	NHMFL	Directors Office	Other - NHFML	Accessing the normal state in high-temperature superconductors throughout the critical region near optimal doping. P13647	Condensed Matter Physics	1	5.00
Gwenaelle Rousse (S)	UPMC	College de France FRE	Other - UPMC, Paris Other - LABEX MATISSE, France	Li2O(CuSO4)2 : A rare realization of frustrated spin-1/2	Biology, Biochemistry, Biophysics	1	5.00

APPENDIX I – USER FACILITY STATISTICS

Pulsed Field

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
		3677 Chimie Solide Energie		two-leg ladder P13651			
Moaz Altarawneh (S)	MPA-CMMS	NHMFL-PFF	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Technique Development: Radio Frequency Transmission in Passive Band Pass Circuits for Performing Contactless Conductivity in High Magnetic Fields P14664	Condensed Matter Physics	1	12.00
Jonathan Betts (S)	LANL	NHMFL-PFF	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Testing of Pulsed Field Probes P14783	Magnets, Materials, Testing, Instrumentation	1	3.00
Total Proposals:				**58**	**Total Experiments:**	**85**	**603.00**

APPENDIX I – USER FACILITY STATISTICS

HIGH B/T FACILITY

***Table 1** – User Demographic*

HBT Facility	Users	Male	Female	Prefer Not to Respond to Gender	Minority[1]	Non-Minority[1]	Prefer Not to Respond to Race	Users Present	Users Operating Remotely[2]	Users Sending Sample[3]	Off-Site Collaborators[4]
Senior Personnel, U.S.	**12**	11	0	1	0	11	1	7	0	4	1
Senior Personnel, non-U.S.	**1**	1	0	0	0	1	0	1	0	0	0
Postdocs, U.S.	**2**	2	0	0	0	2	0	2	0	0	0
Postdocs, non-U.S.	**0**	0	0	0	0	0	0	0	0	0	0
Students, U.S.	**4**	2	0	2	0	1	3	3	0	0	1
Students, non-U.S.	**2**	2	0	0	0	2	0	2	0	0	0
Technician, U.S.	**0**	0	0	0	0	0	0	0	0	0	0
Technician, non-U.S.	**0**	0	0	0	0	0	0	0	0	0	0
Total:	**21**	**18**	**0**	**3**	**0**	**17**	**4**	**15**	**0**	**4**	**2**

[1]NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin
[2]"Users Operating remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
[3]"Users Sending Sample" refers to users who send the sample to the facility and the experiment is conducted by in-house user support personnel. Users at UF, FSU, and LANL cannot be "sample senders" for facilities located on their campuses.
[4]"Off-Site Collaborators" are scientific or technical participants on the experiment; who will not be present, sending sample, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).
***Note:** Users using multiple facilities are counted in each facility listed.*

***Table 2** – User Affiliation*

HBT Facility	Users	NHMFL-Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users[4]	National Lab Users[3,4]
Senior Personnel, U.S.	**12**	6	0	9	0	3
Senior Personnel, non-U.S.	**1**	0	0	1	0	0
Postdocs, U.S.	**2**	1	1	2	0	0
Postdocs, non-U.S.	**0**	0	0	0	0	0
Students, U.S.	**4**	0	3	4	0	0
Students, non-U.S.	**2**	0	0	2	0	0
Technician, U.S.	**0**	0	0	0	0	0
Technician, non-U.S.	**0**	0	0	0	0	0
Total:	**21**	**6**	**5**	**18**	**0**	**3**

[1]NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.
The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators".
[2]In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
[3]In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
[4]The total of university, industry, and national lab users will equal the total number of users.

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***Table 3** – Users by Discipline*

HBT Facility	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Senior Personnel, U.S.	**12**	11	0	1	0	0
Senior Personnel, non-.S.	**1**	1	0	0	0	0
Postdocs, U.S.	**2**	2	0	0	0	0
Postdocs, non-U.S.	**0**	0	0	0	0	0
Students, U.S.	**4**	4	0	0	0	0
Students, non-U.S.	**2**	2	0	0	0	0
Technician, U.S.	**0**	0	0	0	0	0
Technician, non-U.S.	**0**	0	0	0	0	0
Total:	**21**	**20**	**0**	**1**	**0**	**0**

***Table 4** – User Facility Operations*

HBT Facility	16T Bay 3	8T Bay 2	10T Williamson Hall	4T Williamson Hall	Total Days Used / User Affil.	Percentage Used / User Affil.
	Number of Magnet Days[1]					
NHMFL-Affiliated	0	0	133	0	**133**	**15.80%**
Local	0	0	0	0	**0**	**0%**
U.S. University	230	46	173	0	**449**	**53.33%**
U.S. Govt. Lab.	0	0	0	0	**0**	**0%**
U.S. Industry	0	0	0	0	**0**	**0%**
Non-U.S.	0	0	0	157	**157**	**18.65%**
Test, Calibration, Set-up, Maintenance, Inst. Dev.	0	103	0	0	**103**	**12.23%**
Total:	**230**	**149**	**306**	**157**	**842**	**100.00%**

[1]*User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.*

***Table 5** – Operations by Discipline*

HBT Facility	Total Days[1] Allocated / User Affil.	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
	Number of Magnet Days[1]					
NHMFL-Affiliated	**133**	133	0	0	0	0
Local	**0**	0	0	0	0	0
U.S. University	**449**	449	0	0	0	0
U.S. Govt. Lab.	**0**	0	0	0	0	0
U.S. Industry	**0**	0	0	0	0	0
Non-U.S.	**157**	157	0	0	0	0
Test, Calibration, Set-up, Maintenance, Inst. Dev.	**103**	103	0	0	0	0
Total:	**842**	**842**	**0**	**0**	**0**	**0**

[1]*User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.*

High B/T

High B/T

APPENDIX I – USER FACILITY STATISTICS

***Table 6** – User Program Experiment Pressure*

HBT Facility					
Experiment Requests Received	Experiment Requests Deferred from Prev. Year	Experiment Requests Granted	Experiment Requests Declined/Deferred	Experiment Requests Reviewed	Subscription Rate
13	2	10 (66.67%)	5 (33.33%)	15	150.00%

***Table 7** – New User PIs[1]*

First Name	Last Name	Organization
Naoto	**Masuhara**	University of Florida
Total:		**1**

[1]PI who received magnet time for the first time across all facilities.

***Table 8** – Research Proposals Profile with Magnet Time*

HBT Facility	Total	Minority[2]	Female[3]	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Number of Proposals	6	0	0	6	0	0	0	0

[1]A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
[2]The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
[3]The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

***Table 9** – User Proposal*

This report lists all proposals that were allocated magnet time from January-December 2015 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users.
(S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
James Hamlin (S)	University of Florida	Dept. of Physics	National Science Foundation	Metamagnetism and complex low temperature phase diagram ofCe3TiSb5 P11451	Condensed Matter Physics	2	133.00
Jian Huang (S)	Wayne State University	Department of Physics and Astronomy	Other – Wayne State University Department of Energy	Preliminary Exploration of Wigner Crystallization Effects in HIGFET Devices P02007	Condensed Matter Physics	4	277.00
Guillaume Gervais (S)	McGill University	Physics department	Department of Energy	Measurement of 1D-1D Coulomb Drag in the T=0 Limit P02503	Condensed Matter Physics	1	157.00
Haidong	University of	Physics and	National Science Foundation,	Magnetic properties of a new spin-liquid	Condensed Matter Physics	1	126.00

APPENDIX I – USER FACILITY STATISTICS

High B/T

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Zhou (S)	Tennessee	Astronomy	NSF-DMR-1350002	candidate P11435			
Naoto Masuhara (S)	University of Florida	Microkelvin Laboratory, Physics	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Electrical Detection of NMR of 2D Electrons in GaAs hetero-structures P12570	Condensed Matter Physics	1	103.00
Nicholas Curro (S)	University of California	Physics	National Science Foundation	NMR Investigation of hidden magnetism in CeRhIn5 under high pressure P14673	Condensed Matter Physics	1	46.00
Total Proposals:				**6**	**Total Experiments:**	**10**	**842.00**

NMR

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APPENDIX I – USER FACILITY STATISTICS

NMR FACILITY

Table 1 *– User Demographic*

NMR Facility	Users	Male	Female	Prefer Not to Respond to Gender	Minority[1]	Non-Minority[1]	Prefer Not to Respond to Race	Users Pre-sent	Users Operating Remotely[2]	Users Sending Sample[3]	Off-Site Colla-borators[4]
Senior Personnel, U.S.	**94**	77	17	0	3	91	0	43	11	15	25
Senior Personnel, non-U.S.	**23**	22	1	0	1	22	0	2	4	2	15
Postdocs, U.S.	**27**	19	7	1	3	22	2	14	5	2	6
Postdocs, non-U.S.	**4**	2	2	0	0	2	2	1	0	0	3
Students, U.S.	**62**	34	28	0	6	50	6	35	6	3	18
Students, non-U.S.	**10**	9	1	0	1	9	0	3	2	2	3
Technician, U.S.	**6**	3	3	0	1	5	0	6	0	0	0
Technician, non-U.S.	**0**	0	0	0	0	0	0	0	0	0	0
Total:	**226**	**166**	**59**	**1**	**15**	**201**	**10**	**104**	**28**	**24**	**70**

[1]NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin
[2]"Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
[3]"Users Sending Sample" refers to users who send the sample to the facility and the experiment is conducted by in-house user support personnel. Users at UF, FSU, and LANL cannot be "sample senders" for facilities located on their campuses.
[4]"Off-Site Collaborators" are scientific or technical participants on the experiment; who will not be present, sending sample, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).
Note: Users using multiple facilities are counted in each facility listed.

Table 2 *– User Affiliation*

NMR Facility	Users	NHMFL-Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users[4]	National Lab Users[3,4]
Senior Personnel, U.S.	**94**	31	8	91	1	2
Senior Personnel, non-U.S.	**23**	2	0	18	1	4
Postdocs, U.S.	**27**	7	7	26	0	1
Postdocs, non-U.S.	**4**	0	0	3	0	1
Students, U.S.	**62**	18	16	62	0	0
Students, non-U.S.	**10**	1	0	9	1	0
Technician, U.S.	**6**	4	2	6	0	0
Technician, non-U.S.	**0**	0	0	0	0	0
Total:	**226**	**63**	**33**	**215**	**3**	**8**

[1]NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.
The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators".
[2]<u>In addition to</u> external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
[3]<u>In addition to</u> external users, users with primary affiliations at NHMFL/LANL are reported in this category.
[4]The total of university, industry, and national lab users will equal the total number of users.

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APPENDIX I – USER FACILITY STATISTICS

***Table 3** – Users by Discipline*

NMR Facility	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Senior Personnel, U.S.	**94**	6	16	18	7	47
Senior Personnel, non-.S.	**23**	0	7	1	1	14
Postdocs, U.S.	**27**	1	4	4	2	16
Postdocs, non-U.S.	**4**	0	1	2	0	1
Students, U.S.	**62**	1	11	16	3	31
Students, non-U.S.	**10**	0	6	0	0	4
Technician, U.S.	**6**	0	0	1	1	4
Technician, non-U.S.	**0**	0	0	0	0	0
Total:	**226**	**8**	**45**	**42**	**14**	**117**

***Table 4** – User Facility Operations*

NMR Facility	900	830	800NB	800MB	720	600	600WB	600WB2[2]	500	500 E[2]	Total Days Used /User Affil.	Percen-tage Used /User Affil.
	Number of Magnet Days[1]											
NHMFL-Affiliated	47	177	72	71	235	0	57	176	45	83	**963**	**29.00%**
Local	2	12	74	16	76	0	49	64	0	85	**378**	**11.38%**
U.S. University	127	139	86	207	54	136	64	58	168	19	**1,058**	**31.86%**
U.S. Govt. Lab.	39	0	0	0	0	0	0	0	0	0	**39**	**1.17%**
U.S. Industry	0	0	0	0	0	0	0	0	0	0	**0**	**0%**
Non-U.S.	134	40	8	69	0	250	18	1	0	13	**533**	**16.05%**
Test, Calibration, Set-up, Maintenance, Inst. Dev.	8	4	53	3	2	0	51	61	153	15	**350**	**10.54%**
Total:	**357**	**372**	**293**	**366**	**367**	**386**	**239**	**360**	**366**	**215**	**3,321**	**100%**

[1]*User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.*
[2]*These magnet systems are available for user 50% of the year. The remaining 50% is being used by in-house FSU faculties.*

***Table 5** – Operations by Discipline*

NMR Facility	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
	Number of Magnet Days[1]					
NHMFL-Affiliated	**963**	0	220	0	0	743
Local	**378**	0	34	85	0	259
U.S. University	**1,058**	0	319	73	0	666
U.S. Govt. Lab.	**39**	0	0	0	0	39
U.S. Industry	**0**	0	0	0	0	0
Non-U.S.	**533**	0	285	25	5	218
Test, Calibration, Set-up, Maintenance, Inst. Dev.	**350**	0	68	0	196	86
Total:	**3,321**	**0**	**926**	**183**	**201**	**2,011**

[1]*User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.*

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APPENDIX I – USER FACILITY STATISTICS

***Table 6** – User Program Experiment Pressure*

NMR Facility					
Experiment Requests Received	Experiment Requests Deferred from Prev. Year	Experiment Requests Granted	Experiment Requests Declined/Deferred	Experiment Requests Reviewed	Subscription Rate
472	31	424 (84%)	79 (16%)	503	119%

***Table 7** – New User PIs*[1]

First Name	Last Name	Organization
Leah	**Casabianca**	Clemson University
Yan	**Li**	Florida State University
Smita	**Mohanty**	Oklahoma State University
Leonard	**Mueller**	University of California, Riverside
A. Dean	**Sherry**	University of Texas Southwestern Medical Center
Hubert	**Yin**	University of Colorado Boulder
Total:		**6**

[1]*PI who received magnet time for the first time across all facilities*

***Table 8** – Research Proposals Profile with Magnet Time*

NMR Facility	Total	Minority[2]	Female[3]	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Number of Proposals	**63**	4	10	1	11	3	7	41

[1]*A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.*
[2]*The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.*
[3]*The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.*

***Table 9** – User Proposal*

This report lists all proposals that were allocated magnet time from January-December 2015 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users.
(S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Samuel Grant (S)	Florida State University & The National High Magnetic Field Laboratory	Chemical & Biomedical Engineering	National Science Foundation 0654118	Maintenance on the 500 MHz at Engineering School P02012	Magnets, Materials, Testing, Instrumentation	1	15.00
Lucio Frydman (S)	Weizmann Institute of Science	Dept. Chemical Physics	National Science Foundation OISE 1064075 Other - Fulbright Foundation Other - Feinberg Graduate School Other - Metaflux(EU-FP7) Other - Minerva Foundation	Ultrafast High Field Functional Magnetic Resonance Imaging and Spectroscopy P02112	Biology, Biochemistry, Biophysics	1	4.00
James Guest (S)	University of Miami	The Miami Project to Cure Paralysis	Other - The State of Florida Department of Health NHMFL User Collaboration Grants Program Other - The Miami Project to	Locomotor recovery threshold and Immune response associated to autologous	Biology, Biochemistry, Biophysics	1	11.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
			Cure Paralysis Clinical Trials Initiative	Schwann cell transplants intended for remyelination strategies after spinal cord injury (SCI). P08462			
Kwang Hun Lim (S)	East Carolina University	Chemistry	National Institutes of Health NINDS 1R15NS084138	Mechanistic studies of transthyretin misfolding and amyloid formation using solid-state NMR P08372	Biology, Biochemistry, Biophysics	12	73.00
Tim Cross (S)	Florida State University	NHMFL/Chemistry & Biochemistry	National Institutes of Health R01AI023007 Other - PI SRAD	Solid state NMR characterization of S31N M2 bound to novel adamantanes P08373	Biology, Biochemistry, Biophysics	25	146.00
Zhehong Gan (S)	Florida State University	NHMFL	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	development, testing, maintenance & repairs P08360	Magnets, Materials, Testing, Instrumentation	6	70.00
Rufina Alamo (S)	FAMU/FSU College of Engineering	Department of Chemical Eng.	Other - FSU	Characterization of Ethylene 1-alkene copolymers P08503	Engineering	1	1.00
Bo Chen (S)	University of Central Florida	Department of Physics	U.S. Army Air Force Office of Scientific Research FA9550-13-0150 Other - University of Central Florida Inhouse award	Structure and dynamics study of Rous Sarcoma Virus capsid assembly P02368	Biology, Biochemistry, Biophysics	7	53.00
Sungsool Wi (S)	NHMFL	NMR	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) NMR	Development and implementation of the state-of-the-art solid-state NMR pulse techniques 1) at ultrahigh magnetic fields and 2) for utilizing 14N overtone transition P02137	Chemistry, Geochemistry	11	68.00
Chulsung Bae (S)	Rensselaer Polytechnic Institute	Department of Chemistry & Chemical Biology	National Science Foundation CAREER 0747667 National Science Foundation 1308617 No other support (i.e. this experiment is entirely supported	Study of Water Dynamics in Superacidic Hydrocarbon Proton Exchange Membranes UsingSolid-State	Chemistry, Geochemistry	12	47.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
			by NHMFL users services via its core grant)	and Pulsed-Field Gradient NMR Spectroscopy P08440			
Yan-Yan Hu (S)	Florida State University	Chemistry & Biochemistry	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) Other - FSU National Science Foundation SusChEM 1508404 Department of Energy ARPA-E DE-AR0000492	High-temperature Solid-state NMR Studies of Ionic Conduction Mechanisms in Low-cost and Rare-earth-free Superior Fast Oxide-ion Conductor Sr3-3xNa3xSi3O9-1.5x P09504	Chemistry, Geochemistry	27	211.00
Tim Cross (S)	Florida State University	NHMFL/Chemistry & Biochemistry	National Institutes of Health P01AI074805 National Institutes of Health R01AI023007 National Institutes of Health 227000-520-015450 National Institutes of Health R01AI119178	Structure Study of the Full-length M2 Proton Channel in Membrane Bilayers P08302	Biology, Biochemistry, Biophysics	38	235.00
Hailong Chen (S)	Georgia Institute of Technology	School of Mechanical Engineering	U.S. Army CERDEC National Science Foundation FREEDM	battery MRI P07279	Magnets, Materials, Testing, Instrumentation	12	51.00
Fang Tian (S)	Penn State University	Biochemistry and Molecular Biology, Penn State Medical School	National Institutes of Health R01 GM105963 National Institutes of Health R01 GM1059630-02	Spherical Nanoparticle Supported Lipid Bilayers for the Study of Membrane Architecture P02428	Biology, Biochemistry, Biophysics	4	23.00
Christopher Jaroniec (S)	The Ohio State University	Chemistry & Biochemistry	National Institutes of Health R01GM094357 National Science Foundation 1243461	DARR 13C-13C correlation experiments of HuPrP23-144. P08324	Biology, Biochemistry, Biophysics	2	10.00
Elan Eisenmesser (S)	University of Colorado Health Sciences Center	Biochemistry & Molecular Genetics	National Institutes of Health 1R01GM096019-01A1	Determining the Conformational Changes within Active Enzyme-Substrate Systems on both Sides of the Reactions. P02387	Biology, Biochemistry, Biophysics	4	136.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Lucio Frydman (S)	Weizmann Institute of Science	Dept. Chemical Physics	Other - State of Florida Other - AHA 10GRNT3860040 Other - Israel Science Foundation 795/13 Other - Helen and Martin Kimmel Institute of Magnetic Resonance Other - Perlman Family Foundation	Relaxation Enhancements of unassigned brain metabolites resonances: new noninvasive stroke biomarkers assigned via in vivo 2D MRS P08345	Biology, Biochemistry, Biophysics	8	43.00
Thomas Budinger (S)	LBNL	Chair of the Department of BioEngineering	National Science Foundation DMR-0654118	Comparison of potassium, chlorine and sodium triple quantum signals from in vivo rat head at 21.1 T P07296	Biology, Biochemistry, Biophysics	6	23.00
Naresh Dalal (S)	Florida St. University	Chemistry	NHMFL User Collaboration Grants Program	High resolution MAS NMR study on ion dynamics in superionic conductor LiH2PO4 P02479	Condensed Matter Physics	9	39.00
Vladimir Ladizhansky (S)	University of Guelph	Physics	Other - Natural Sciences and Engineering Research Council of Canada	Solid-state NMR studies Protein-Lipid Interactions P08504	Biology, Biochemistry, Biophysics	1	4.00
Tim Cross (S)	Florida State University	NHMFL/Chemistry & Biochemistry	National Institutes of Health R01AI023007 Other - PI SRAD	Dynamics of M2 full length: Understanding the dynamics of the proton conductance and the gating mechanism of the full length M2 proton channel of Influenza A. P08486	Biology, Biochemistry, Biophysics	25	152.00
Tim Cross (S)	Florida State University	NHMFL/Chemistry & Biochemistry	National Institutes of Health 1PO1A1074805-01	Structural Characterization of FtsX P02213	Biology, Biochemistry, Biophysics	8	55.00
Zhehong Gan (S)	Florida State University	NHMFL	National Science Foundation 1104869	Development of high-field solid-state NMR methods P02217	Chemistry, Geochemistry	5	63.00
Songi Han (S)	University of California Santa Barbara	Department of Chemistry and Biochemistry	National Science Foundation 1443106	Characterization of surface accessible, catalytic, 27Al, 119Sn, and 17O species by DNP-enhanced NMR using targeted nitroxide spin	Chemistry, Geochemistry	9	41.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
				probes as reactant models P08470			
Tim Cross (S)	Florida State University	NHMFL/Chemistry & Biochemistry	National Institutes of Health P01AI074805	Structure Determination of LspA, an M. Tuberculosis Transmembrane Protein P08362	Biology, Biochemistry, Biophysics	37	189.00
Zhehong Gan (S)	Florida State University	NHMFL	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) Other - NSERC of Canada RGPIN 203308-11 National Science Foundation 1104869 National Science Foundation DMR-1505185	Development and applications of high-field solid-state NMR methods P08461	Magnets, Materials, Testing, Instrumentation	10	73.00
Joanna Long (S)	NHMFL/UF Mcknight Brain Institute	Biochemistry & Molecular Biology	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Characterizing DNP mechanisms at high magnetic fields to enable membrane protein NMR studies P07148	Biology, Biochemistry, Biophysics	7	38.00
Liliya Vugmeyster (S)	University of Colorado at Denver	Chemistry	National Institutes of Health R15 GM111681-01 National Institutes of Health P20GM103395	Dynamics of amyloid Abeta peptide by deuteron NMR P08439	Biology, Biochemistry, Biophysics	1	1.00
Hans Jakobsen (S)	University of Aarhus	Department of Chemistry	Other - Aarhus University Department of Chemistry	Dynamics in KMnO4 from low-temperature 17O VT MAS NMR at 21.1T: A collaboration between Aarhus University and NHMFL (FSU) P02233	Chemistry, Geochemistry	2	8.00
Robert Schurko (S)	University of Windsor	Chemistry	Other - NSERC, Canada Other - NSERC Discovery Grant Chemistry	Multinuclear SSNMR of Unreceptive Nuclides Using Adiabatic Pulses P02490	Chemistry, Geochemistry	4	17.00
Riqiang Fu (S)	NHMFL	NMR	National Institutes of Health P01AI174805 National Institutes of Health AI230007	Designing Solid State MAS NMR experiments to Differentiate Histidine Tautomeric States P07270	Biology, Biochemistry, Biophysics	7	31.00
Samuel Grant (S)	Florida State University &	Chemical & Biomedical	Other - American Heart Association	In vivo tracking of exogenous and labeled cell	Biology, Biochemistry, Biophysics	10	113.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
	The National High Magnetic Field Laboratory	Engineering	Grant-in-Aid	therapy to treat stroke: Cell migration & 23Na MRI P11442			
Armin Nagel (S)	German Cancer Research Center (DKFZ)	Medical Physics in Radiology	National Science Foundation DMR-0654118	39K MRI of rat brain at 21.1Tesla P07228	Magnets, Materials, Testing, Instrumentation	2	5.00
Yan Li (S)	Florida State University	Chemical and Biomedical Engineering	National Science Foundation BRIGE-1342192	MPIO Labeling of Cyogenically Preserved Neuroprogenitor Cells P11457	Engineering	1	91.00
Anant Paravastu (S)	FSU/FAMU College of Engineering	Chemical and Biomedical Engineering	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) DMR-1157490	Maintenance, Repairs, Testing on 500 MHz, Paravastu Magnet P02013	Magnets, Materials, Testing, Instrumentation	1	118.00
Myriam Cotten (S)	Hamilton College	Chemistry	National Science Foundation 0832571	Membrane Interaction and Atomic-Level Structures of Membrane-Active Peptides by 15N and 2H Solid-State NMR P02289	Biology, Biochemistry, Biophysics	11	45.00
Leah Casabianca (S)	Clemson University	Chemistry	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Hyperpolarization of Nano-Structured Materials P11434	Chemistry, Geochemistry	2	6.00
Chang Ryu (S)	Rensselaer Polytechnic Institute	Department of Chemistry & Chemical Biology	National Science Foundation 1308617	Investigation of the network structure of sustainable epoxy materials from vegetable oils P08441	Chemistry, Geochemistry	5	28.00
Leonard Mueller (S)	University of California, Riverside	Chemistry	National Institutes of Health GM097569	Chemically-Rich Structure and Dynamics in the Active Site of Tryptophan Synthase P11467	Biology, Biochemistry, Biophysics	2	14.00
Joanna Long (S)	NHMFL/UF Mcknight Brain Institute	Biochemistry & Molecular Biology	National Institutes of Health NIDCR R01DE021789 03	Structural studies of adhesion protein P1 of Streptococcus mutans and its formation of amyloid fibrils P07158	Biology, Biochemistry, Biophysics	3	63.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Victor Schepkin (S)	NHMFL	CIMAR	Other - Grant from FSU Council on Research& Creativity (CRC) FSU: Multidisciplinary Support Award 2013	Sodium-Diffusion MRI and Rodent Glioma Resistance to Therapy P02404	Biology, Biochemistry, Biophysics	1	3.00
Gianluigi Veglia (S)	University of Minnesota	BMBB	National Institutes of Health R01-AG026160 National Institutes of Health R01 GM064742	NMR Structural Analysis of Sarcoplasmic Reticulum Proteins in Membranes P11486	Biology, Biochemistry, Biophysics	5	43.00
Hubert Yin (S)	University of Colorado Boulder	Chemistry and Biochemistry	National Institutes of Health R01GM103843, R01GM101279	Human Toll-like Receptors Structure Determination by solid state NMR Spectroscopy P11501	Biology, Biochemistry, Biophysics	8	53.00
Gang Wu (S)	Queen's University	Chemistry	Other - NSERC of Canada	Characterization of a low-barrier hydrogen bond in nicotinic acid crystals P02432	Chemistry, Geochemistry	5	35.00
Michael Harrington (S)	Huntington Medical Research Institutes	Molecular Neurology	National Institutes of Health NINDS R01NS072497 National Institutes of Health NINDS R01NS-043295 Other - Huntington Medical Research Institute	Dysfunction Of Sodium Homeostasis In A Rat Migraine Model P02476	Biology, Biochemistry, Biophysics	7	29.00
Victor Schepkin (S)	NHMFL	CIMAR	Other - Friedrich Ebert Stiftung, Bonn, Germany	The development of the TQTPPI in vivo imaging of Na, K and Cl at 21.1 T using PV6 software P11487	Biology, Biochemistry, Biophysics	8	31.00
Lucio Frydman (S)	Weizmann Institute of Science	Dept. Chemical Physics	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	EPR and NMR Spectroscopy of Small Molecules in Low Viscosity Solvents P11492	Biology, Biochemistry, Biophysics	6	250.00
Robert Tycko (S)	The National Institutes of Health, NIDDK, LCP	Laboratory of Chemical Physics, NIDDK	National Institutes of Health NIDDK - Intramural Research Program DK075031 (Intramural Research Project Number) National Institutes of Health 1F12GM117604	Structural Study of Fibrils Formed by the Low-Complexity Domains of mRNA Binding Proteins P08483	Biology, Biochemistry, Biophysics	2	16.00

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NMR

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Conggang Li (S)	Wuhan Institute of Physics & Mathematics, Chinese Academy of Sciences	State Key Lab of Magnetic Resonance	Other - WIPM China NHMFL User Collaboration Grants Program Other - National Science Foundation of China 21173258 Other - National Science Foundation of China 21120102038 Other - National Science Foundation of China 21221064 Other - WIPM,wuhan China	Conformational study of synaptobrevin-2 in lipid bilayer using magic-angle spinning solid state NMR P12550	Biology, Biochemistry, Biophysics	9	75.00
Anant Paravastu (S)	FSU/FAMU College of Engineering	Chemical and Biomedical Engineering	National Science Foundation DMR-1055215	Molecular Structural Modeling Of Max8 Designer Peptide Nanofibers P12582	Biology, Biochemistry, Biophysics	1	77.00
Nate Traaseth (S)	New York University	Chemistry	National Institutes of Health R01AI108889 National Science Foundation MCB1506420	Structure of EmrE by Oriented Solid-State NMR Spectroscopy P13593	Biology, Biochemistry, Biophysics	1	3.00
Vladimir Ladizhansky (S)	University of Guelph	Physics	Other - Natural Sciences and Engineering Research Council of Canada Discovery Grant	Solid-state NMR studies of the effect of hydrophobic mismatch on the structure of polytopic membrane proteins P13602	Biology, Biochemistry, Biophysics	4	31.00
Tim Cross (S)	Florida State University	NHMFL/Chemistry & Biochemistry	National Institutes of Health R01AI023007 National Institutes of Health R01AI119178	Structural Characterization of the Full Length CrgA protein from the Tuberculosis Cell Division Apparatus P13604	Biology, Biochemistry, Biophysics	11	55.00
Stephen Melville (S)	Virginia Tech	Biological Sciences	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Determination of the conformation and geometry of bacterial pilin proteins in an artificial membrane P02219	Biology, Biochemistry, Biophysics	1	2.00
Smita Mohanty (S)	Oklahoma State University	Chemistry	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Structure & Function Studies of Proteins P13616	Biology, Biochemistry, Biophysics	4	64.00

APPENDIX I – USER FACILITY STATISTICS

NMR

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Alexander Nevzorov (S)	NC State University	Chemistry	Other - NCSU	Benchmarking intra-peptide distances with selectively labeled samples of Pf1 coat protein P13625	Biology, Biochemistry, Biophysics	2	15.00
Bradley Chmelka (S)	University of California, Santa Barbara	Department of Chemical Engineering	Other - U.S. Federal Highway Administration DTFH61-12-H-00003 National Science Foundation Division of Chemical, Bioengineering, Environmental, and Transport Systems CBET-1335694	Low-Gamma Quadrupolar Nuclei in Nanostructured Solids P13658	Engineering	1	9.00
Anant Paravastu (S)	FSU/FAMU College of Engineering	Chemical and Biomedical Engineering	National Institutes of Health NIA - National Institute on Aging R01AG045703 Other - Alzheimer's Association NIRG-10-173755 NHMFL User Collaboration Grants Program	Solid state NMR structural characterization of oligomeric ß-Amyloid (1-42) peptide P12581	Biology, Biochemistry, Biophysics	1	67.00
A. Dean Sherry (S)	University of Texas Southwestern Medical Center	Advanced Imaging Research Center	National Institutes of Health 5 R01 CA115531-09	Localized 31P NMR spectroscopy and (1H) APT imaging studies of brain glioma at 21.1 T P13596	Biology, Biochemistry, Biophysics	1	2.00
Tim Cross (S)	Florida State University	NHMFL/Chemistry & Biochemistry	National Institutes of Health 1PO1A1074805-01	Structural Characterization of ChiZ membrane protein P14693	Biology, Biochemistry, Biophysics	3	22.00
Douglas Kojetin (S)	The Scripps Research Institute - Scripps Florida	Molecular Therapeutics	National Institutes of Health NIDDK DK101871	NMR analysis of ligand binding to the nuclear receptor PPARG, a type 2 diabetes drug target P14736	Biology, Biochemistry, Biophysics	1	11.00
Zhehong Gan (S)	Florida State University	NHMFL	Other - NSERC of Canada	Quadrupolar nuclei NMR using 36 T Series Connected Hybrid Magnet P14747	Chemistry, Geochemistry	1	13.00
William Brey (S)	NHMFL	NMR	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Probe testing, development, maintenance, repairs P14828	Magnets, Materials, Testing, Instrumentation	1	1.00
Total Proposals:				**63**	**Total Experiments:**	**424**	**3,321**

AMRIS

APPENDIX I – USER FACILITY STATISTICS

AMRIS

AMRIS FACILITY

***Table 1** – User Demographic*

AMRIS Facility	Users	Male	Female	Prefer Not to Respond to Gender	Minority[1]	Non-Minority[1]	Prefer Not to Respond to Race	Users Present	Users Operating Remotely[2]	Users Sending Sample[3]	Off-Site Collaborators[4]
Senior Personnel, U.S.	**102**	74	28	0	9	93	0	63	2	37	0
Senior Personnel, non-U.S.	**14**	12	2	0	2	12	0	2	1	11	0
Postdocs, U.S.	**28**	18	10	0	5	23	0	21	0	7	0
Postdocs, non-U.S.	**3**	2	1	0	0	3	0	1	0	2	0
Students, U.S.	**92**	65	27	0	11	81	0	73	0	19	0
Students, non-U.S.	**4**	2	2	0	1	3	0	2	0	2	0
Technician, U.S.	**14**	10	4	0	1	13	0	13	0	1	0
Technician, non-U.S.	**0**	0	0	0	0	0	0	0	0	0	0
Total:	**257**	**183**	**74**	**0**	**29**	**228**	**0**	**175**	**3**	**79**	**0**

[1]NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin
[2]"Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
[3]"Users Sending Sample" refers to users who send the sample to the facility and the experiment is conducted by in-house user support personnel. Users at UF, FSU, and LANL cannot be "sample senders" for facilities located on their campuses.
[4]"Off-Site Collaborators" are scientific or technical participants on the experiment; who will not be present, sending sample, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).
Note: Users using multiple facilities are counted in each facility listed.

***Table 2** – User Affiliation*

AMRIS Facility	Users	NHMFL-Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users[4]	National Lab Users[3,4]
Senior Personnel, U.S.	**102**	16	50	92	2	8
Senior Personnel, non-U.S.	**14**	0	0	12	1	1
Postdocs, U.S.	**28**	3	17	27	0	1
Postdocs, non-U.S.	**3**	0	0	3	0	0
Students, U.S.	**92**	0	69	92	0	0
Students, non-U.S.	**4**	0	0	4	0	0
Technician, U.S.	**14**	5	9	14	0	0
Technician, non-U.S.	**0**	0	0	0	0	0
Total:	**257**	**24**	**145**	**244**	**3**	**10**

[1]NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site.
Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.
The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators".
[2]In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
[3]In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
[4]The total of university, industry, and national lab users will equal the total number of users.

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***Table 3** – Users by Discipline*

AMRIS Facility	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Senior Personnel, U.S.	**102**	0	22	6	2	72
Senior Personnel, non-.S.	**14**	0	2	1	0	11
Postdocs, U.S.	**28**	0	9	3	0	16
Postdocs, non-U.S.	**3**	0	2	0	0	1
Students, U.S.	**92**	0	36	9	1	46
Students, non-U.S.	**4**	0	1	0	0	3
Technician, U.S.	**14**	0	1	2	0	11
Technician, non-U.S.	**0**	0	0	0	0	0
Total:	**257**	**0**	**73**	**21**	**3**	**160**

***Table 4** – User Facility Operations*

AMRIS Facility	500 MHz NMR	600 MHz NMR warm bore	600 MHz cryo	600 MHz NMR	750 MHz whole body	4.7 T / 33 cm	11.1 T/ 40 cm	3T whole body	Total Days Used/ User Affil.	Percentage Used / User Affil.
	Number of Magnet Days[1]									
NHMFL-Affiliated	39.2	78.8	85.6	27.4	65.6	68.3	29.1	26.1	**420.0**	**29.2%**
Local	0	5.8	25.1	44.7	68.4	81.5	33.5	167.0	**426.1**	**29.6%**
U.S. University	30.0	63.5	5.1	39.1	79.3	30.0	2.8	0.0	**249.7**	**17.4%**
U.S. Govt. Lab.	0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	**0.3**	**0%**
U.S. Industry	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	**0%**
Non-U.S.	0	0.0	12.9	3.0	24.8	0.0	9.2	0.0	**49.8**	**3.5%**
Test, Calibration, Set-up, Maintenance, Inst. Dev.	6.7	14.5	11.5	36.3	27.2	50.3	123.4	22.9	**292.7**	**20.3%**
Total:	**75.9**	**162.5**	**140.2**	**150.4**	**265.2**	**230.4**	**198.0**	**216.1**	**1,438.7**	**100 %**

[1]User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.

***Table 5** – Operations by Discipline*

AMRIS Facility	Total Days[1] Allocated/ User Affil.	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
	Number of Magnet Days[1]					
NHMFL-Affiliated	**420**	0	0	0	103	317
Local	**426.1**	0	0.6	0	13	412.5
U.S. University	**249.7**	0	107.5	0	51.2	91
U.S. Govt. Lab.	**0.3**	0	0	0	0.3	0
U.S. Industry	**0**	0	0	0	0	0
Non-U.S.	**49.9**	0	24.8	0	9.6	15.5
Test, Calibration, Set-up, Maintenance, Inst. Dev.	**292.7**	0	0	0	290.8	1.9
Total:	**1,438.7**	**0**	**132.9**	**0**	**467.9**	**837.9**

[1]User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.

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***Table 6** – User Program Experiment Pressure*

AMRIS Facility					
Experiment Requests Received	Experiment Requests Deferred from Prev. Year	Experiment Requests Granted	Experiment Requests Declined/Deferred	Experiment Requests Reviewed	Subscription Rate
~2600	~250	2363 (~90%)	~250 (~10%)	~2600	~110%

***Table 7** – New User PIs*[1]

First Name	Last Name	Organization
Martin	**Aran**	Instituto Leloir
Maureen	**Keller-Wood**	University of Florida
Charles	**Guy**	University of Florida
Robert	**McKenna**	University of Florida
Frank	**Chapman**	University of Florida
Dieter	**Klatt**	University of Illinois Chicago
Matthew	**Merritt**	University of Florida
Debapriya	**Dutta**	University of Illinois
Total:		**8**

[1]PI who received magnet time for the first time across all facilities

***Table 8** – Research Proposals Profile with Magnet Time*

AMRIS Facility	Total	Minority[2]	Female[3]	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Number of Proposals	**35**	6	11	0	8	0	0	27

[1]A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
[2]The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
[3]The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

***Table 9** – User Proposal*

This report lists all proposals that were allocated magnet time from January-December 2015 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users.
(S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

PI	Organization	Department	Funding Source	Proposal Title	Proposal ID#	Proposal Discipline	Experi-ment Scheduled	# of Days Used
Coy Heldermon	University of Florida	Medicine	NSF	Characterization of brain morphology in Mucopolysaccharidosis Type IIIB affected mice using Magnetic Resonance Imaging	P01777	Biology	19	11.6
Rebecca Butcher	University of Florida	Chemistry	National	Identification of dauer pheromones from entomopathogenic nematodes	P01980	Biology	1	0.0
Matthew Erickson	University of Florida	AMRIS	NSF	Augmented Tune/Match Circuits for High Performance Dual Nuclear Transmission Line Resonators	P02196	Biology	1	0.3

AMRIS

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PI	Organization	Department	Funding Source	Proposal Title	Proposal ID#	Proposal Discipline	Experi-ment Scheduled	# of Days Used
Rebecca Butcher	University of Florida	Chemistry	National	Identification of novel pheromones from Caenorhabditis elegans using comparative metabolomics and multidimensional NMR spectroscopy	P02201	Biology	40	40.0
Marcus Bäumer	University of Bremen	Institute of Applied and Physical Chemistry	Internati onal	Diffusion of light gases in samaria aerogel catalysts by pulsed field gradient NMR	P02223	Chemistry	8	24.8
Ben Turner	Smithsonian Panama	Unknown	NSF	The stability and reactivity of organic matter in peat wetland ecosystems	P02293	Chemistry	45	14.2
Richard Magin	University of Illinois at Chicago	Bioengineer-ing	National	Evidence of Changes in Gray/White Matter Structure Following Thyroid Hormone Disruption with Propylthiouracil in Rat Brains Using Fractional Order Diffusion Tensor Imaging (fDTI) at 17.6 T (750 MHz)	P02319	Biology	1	4.0
Kelly Foote	University of Florida	Neurosur-gery	NSF	17.6T MR Microscopy of movement disorders as a guide for deep brain stimulation surgery	P02393	Biology	2	0.0
Ben Turner	Smithsonian Panama	Unknown	NSF	The stability and reactivity of organic matter in African tropical savanna	P02397	Chemistry	25	29.7
Joanna Long	University of Florida	Biochemistry & Molecular Biology	NIH	Structural studies of adhesion protein P1 of Streptococcus mutans and its formation of amyloid fibrils	P07158	Biology	5	12.6
Richard Briggs	Georgia State University	Physics and Astronomy	NSF	31P NMR of the P301L Mouse Model of Frontotemporal Dementia and AD	P07170	Biology	19	9.4
Ryan Lively	Georgia Institute of Technology	School of Chemical & Biomolecu-lar Engineering	NSF	Gas diffusion in ZIF/polymer hybrid membranes by pulsed field gradient NMR	P07227	Chemistry	6	18.8
Xin Qi	University of Florida	Medicinal Chemistry	National	Explore Novel Drugs To Target HIV RNA for AIDS Therapy	P07282	Chemistry	1	0.6
Terrence Deacon	University of California, Berkeley	Anthropol-ogy	National	MRI microscopy of human motor neurons	P07285	Biology	1	5.0
Chris Turck	Max Planck Institute of Psychiatry	Proteomics and Biomarkers	NIH	Metabolomic profiling of 13C-enriched mouse tissue using 1D and 2D NMR	P08322	Biology	2	3.0
Malisa Sarntinoranont	University of Florida	Mechanical & Aerospace Engineering	NSF	Characterizing Blood Brain Barrier Breakdown with Status Epilepticus Brain Injury	P08375	Biology	51	48.4
Andrew Judge	University of Florida	Phyiscal Therapy	NIH	Non-invasive evaluation of skeletal muscle size and mitochondrial oxidative capacity in a mouse model of cancer cachexia using MRI and 31P-MRS	P08408	Biology	9	7.6

AMRIS

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AMRIS

PI	Organization	Department	Funding Source	Proposal Title	Proposal ID#	Proposal Discipline	Experi-ment Scheduled	# of Days Used
Juan Beltran-Huarac	University of Puerto Rico	Physics	NSF	Postdoctoral Researcher	P08489	Chemistry	12	6.4
Lloyd Lumata	University of Texas at Dallas	Physics	National	The Effect of Glassing Matrix Deuteration on 13C Dynamic Nuclear Polarization at 5	P08501	Chemistry	34	9.9
Joanna Long	University of Florida	Biochemistry & Molecular Biology	NSF	New equipment/upgrades/troubleshooting on verticals	P09507	Biology	143	87.3
Joanna Long	University of Florida	Biochemistry & Molecular Biology	NSF	New equipment/upgrades/troubleshooting on horizontals	P09509	Biology	5	1.9
Joanna Long	University of Florida	Biochemistry & Molecular Biology	NSF	New user training	P09511	Biology	94	39.9
Joanna Long	University of Florida	Biochemistry & Molecular Biology	NSF	DNP initiative in 2013 renewal	P09512	Biology	9	2.6
Arthur Edison	University of Georgia	Genetics Franklin College	International	Metabolomics of hydrocarbon degrading bacteria from Antarctic environments	P11445	Biology	6	10.5
Robert McKenna	University of Florida	Biochemistry and Molecular Biology	National	Role of Carbonic Anhydrase IX in Cancer Metabolism	P11476	Biology	2	1.5
William Zeile	University of Florida	Biochemistry & Molecular Biology	NSF	High field magnetic resonance imaging and spectroscopy of brain lactate levels in vivo between normal and PKU rodents.	P11477	Biology	16	4.9
Frank Chapman	University of Florida	Fisheries & Aquatic Sciences	NSF	Anatomy of the Goliath Grouper Skull	P11478	Biology	4	3.6
Carrie Haskell-Luevano	University of Minnesota	Medicinal Chemistry	NIH	AGRP peptides	P11482	Biology	4	4.1
Ryan Lively	Georgia Institute of Technology	School of Chemical & Biomolecular Engineering	NSF	Relationship between single component and gas mixture diffusion in porous membranes and nanotubes by pulsed field gradient NMR	P11493	Chemistry	8	28.6
Glenn Walter	University of Florida	Physiology and Functional Genomics	National	Investigation of Microscopic Architecture of Skeletal Muscle in Healthy and Dystrophic Muscle	P11540	Biology	5	24.8
Dieter Klatt	University of Illinois at Chicago	Bioengineering	National	Development of a spin-echo EPI acquisition technique for MRE of the mouse brain	P12551	Biology	4	2.8
Matthew Merritt	University of Florida	Biochemistry and Molecular Biology	NIH	Investigation of Effects of Propionate on the Myocardial Energy Metabolism – Dynamic Nuclear Polarization and 13C Isotopomer Analysis	P12556	Biology	14	32.2
Ricardo Borges	Federal University of Rio de Janeiro	Instituto de Pesquisas de Produtos Naturais	NSF	Metabolic fingerprint of microalgae from different aquatic sources for full prospection of biodiesel production	P12593	Biology	7	2.0

APPENDIX I – USER FACILITY STATISTICS

PI	Organization	Department	Funding Source	Proposal Title	Proposal ID#	Proposal Discipline	Experi-ment Scheduled	# of Days Used
		Walter Mors						
Scott Prosser	University of Toronto	Chemistry and Biochemistry	Interna-tional	In vivo Detection and Quantification of Protein Clearance using 13C-filtered MRI and MRS	P14670	Biology	6	6.8
Arthur Edison	University of Georgia	Genetics Franklin College	NIH	Global Metabolomic Analysis of High-Risk Pregnancies	P14671	Biology	12	12.2
Total Proposals:				**35**	**Total Experiments:**		**621**	**512.0**

Note: *The majority of costs for instrument acquisition and user experiments within the AMRIS facility are paid through non-NSF sources; Tables 8 and 9 report on user projects for which NSF-funding was used to either pay for user time or for development of specific functionalities as described in their project reports. Total usage of instruments is reported in tables 4 and 5. Tracking of time is done through a calendar rather than individual experiment numbers to enable users needed flexibility in how they utilize their time for individual projects.*

APPENDIX I – USER FACILITY STATISTICS

EMR FACILITY

***Table 1** – User Demographic*

EMR Facility	Users	Male	Female	Prefer Not to Respond to Gender	Minority[1]	Non-Minority[1]	Prefer Not to Respond to Race	Users Present	Users Operating Remotely[2]	Users Sending Sample[3]	Off-Site Collaborators[4]
Senior Personnel, U.S.	**53**	46	3	4	1	47	5	25	0	18	10
Senior Personnel, non-U.S.	**48**	38	6	4	6	34	8	8	0	17	23
Postdocs, U.S.	**11**	7	2	2	0	9	2	10	0	1	0
Postdocs, non-U.S.	**5**	2	2	1	1	3	1	1	0	2	2
Students, U.S.	**29**	17	9	3	2	21	6	22	0	4	3
Students, non-U.S.	**10**	6	3	1	1	5	4	5	0	1	4
Technician, U.S.	**0**	0	0	0	0	0	0	0	0	0	0
Technician, non-U.S.	**1**	1	0	0	0	1	0	0	0	0	1
Total:	**157**	**117**	**25**	**15**	**11**	**120**	**26**	**71**	**0**	**43**	**43**

[1]NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin
[2]"Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
[3]"Users Sending Sample" refers to users who send the sample to the facility and the experiment is conducted by in-house user support personnel. Users at UF, FSU, and LANL cannot be "sample senders" for facilities located on their campuses.
[4]"Off-Site Collaborators" are scientific or technical participants on the experiment; who will not be present, sending sample, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).
***Note:** Users using multiple facilities are counted in each facility listed.*

***Table 2** – User Affiliation*

EMR Facility	Users	NHMFL-Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users[4]	National Lab Users[3,4]
Senior Personnel, U.S.	**53**	22	3	53	0	0
Senior Personnel, non-U.S.	**48**	2	0	43	0	5
Postdocs, U.S.	**11**	5	3	11	0	0
Postdocs, non-U.S.	**5**	0	0	4	0	1
Students, U.S.	**29**	10	9	29	0	0
Students, non-U.S.	**10**	0	0	10	0	0
Technician, U.S.	**0**	0	0	0	0	0
Technician, non-U.S.	**1**	0	0	1	0	0
Total:	**157**	**39**	**15**	**151**	**0**	**6**

[1]NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.
The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators".
[2]In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
[3]In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
[4]The total of university, industry, and national lab users will equal the total number of users.

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APPENDIX I – USER FACILITY STATISTICS

***Table 3** – Users by Discipline*

EMR Facility	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Senior Personnel, U.S.	**53**	14	25	1	1	12
Senior Personnel, non-.S.	**48**	9	29	1	2	7
Postdocs, U.S.	**11**	4	6	1	0	0
Postdocs, non-U.S.	**5**	1	4	0	0	0
Students, U.S.	**29**	9	16	1	1	2
Students, non-U.S.	**10**	3	6	0	0	1
Technician, U.S.	**0**	0	0	0	0	0
Technician, non-U.S.	**1**	0	1	0	0	0
Total:	**157**	**40**	**87**	**4**	**4**	**22**

***Table 4** – User Facility Operations*

EMR Facility	17T	12T	Mossbauer	Bruker	Total Days Used / User Affil.	Percentage Used / User Affil.
	Number of Magnet Days[1]					
NHMFL-Affiliated	32	42	41	0	**115**	**9.51%**
Local	40	29	36	8	**113**	**9.35%**
U.S. University	77	48	233	192	**550**	**45.49%**
U.S. Govt. Lab.	0	0	0	0	**0**	**0.00%**
U.S. Industry	0	0	0	0	**0**	**0.00%**
Non-U.S.	169	94	34	59	**356**	**29.45%**
Test, Calibration, Set-up, Maintenance, Inst. Dev.	20	1	46	8	**75**	**6.20%**
Total:	**338**	**214**	**390**	**267**	**1,209**	**100.00%**

[1]User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.

***Table 5** – Operations by Discipline*

EMR Facility	Total Days[1] Allocated / User Affil.	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
	Number of Magnet Days[1]					
NHMFL-Affiliated	**115**	50	46	0	14	5
Local	**113**	0	113	0	0	0
U.S. University	**550**	69	260	32	0	189
U.S. Govt. Lab.	**0**	0	0	0	0	0
U.S. Industry	**0**	0	0	0	0	0
Non-U.S.	**356**	144	142	0	36	34
Test, Calibration, Set-up, Maintenance, Inst. Dev.	**75**	0	0	0	75	0
Total:	**1,209**	**263**	**561**	**32**	**125**	**228**

[1]User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.

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Table 6 *– User Program Experiment Pressure*

EMR Facility					
Experiment Requests Received	Experiment Requests Deferred from Prev. Year	Experiment Requests Granted	Experiment Requests Declined/Deferred	Experiment Requests Reviewed	Subscription Rate
72	31	91 (88.34%)	12 (11.65%)	103	113%

Table 7 *– New User PIs*[1]

First Name	Last Name	Organization
Gerd	**Buntkowsky**	Technische Universität Darmstadt
Eugenio	**Coronado**	Instituto de Ciencia Molecular, Universidad de Valencia
Roberto	**De Guzman**	University of Kansas
Carole	**Duboc**	Univ. Grenoble Alpes
Evert	**Duin**	Auburn University
Wojciech	**Grochala**	Univ. Warsaw
Hill	**Harman**	University of California-Riverside
Hongjun	**Liang**	Texas Tech University Health Science Center
Fabio	**Matta**	University of South Carolina
David	**Norman**	University of Dundee
Sankar	**Rath**	Indian Institute of Technology Kanpur
Federico	**Spizzo**	University of Ferrara
Joris	**van Slageren**	Universität Stuttgart
Maria	**Vaz**	Federal Fluminense University
Zhenxing	**Wang**	Huazhong University of Science and Technology
Huajun	**Zhou**	University of Arkansas
Total:		**16**

[1]*PI who received magnet time for the first time across all facilities*

Table 8 *– Research Proposals Profile with Magnet Time*

EMR Facility	Total	Minority[2]	Female[3]	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Number of Proposals	**71**	3	5	19	34	1	5	12

[1]*A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.*
[2]*The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.*
[3]*The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.*

Table 9 *– User Proposal*

This report lists all proposals that were allocated magnet time from January-December 2015 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users.
(S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Johan van Tol (S)	Florida State University	CIMAR	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	High Frequency Pulsed EPR/ENDOR instrumentation testing P00082	Magnets, Materials, Testing, Instrumentation	1	2.00
Michael Shatruk (S)	Florida State University	Department of Chemistry	National Science Foundation 0955353	Study of Magnetic Ordering in AlFe2-xMnxB2 by Mössbauer Spectroscopy, P02021	Chemistry, Geochemistry	2	16.0

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Evgeny Dikarev (S)	University at Albany, SUNY	Department of Chemistry	National Science Foundation 1152441	Investigation of Low-Coordinate Fe(II) beta-Diketonates by High-Frequency EPR Spectroscopy P02022	Chemistry, Geochemistry	1	1.00
Sylvain Bertaina (S)	IM2NP - CNRS	Nanoscience	Other - CNRS	High Frequencies EPR in 1D organic (TMTTF)2X P02025	Condensed Matter Physics	1	11.0
Hans Jakobsen (S)	University of Aarhus	Department of Chemistry	Other - Aarhus University, Denmark Department of Chemistry	Dynamics in KMnO4 from low-temperature 17O VT MAS NMR at 21.1T: A collaboration between Aarhus University and NHMFL (FSU) P02233	Chemistry, Geochemistry	1	3.00
Danna Freedman (S)	Northwestern University	Chemistry	Other - Northwestern University Start-up Fund Chemistry	Systematic analysis of decoherence sources for spin-based quantum computation P02333	Chemistry, Geochemistry	1	42.0
Zhiqiang Li (S)	National High Magnetic Field Laboratory	DC Field CMS	NHMFL User Collaboration Grants Program DC field	Magneto-transport and Magneto-optical Study of Topological Insulators P02349	Condensed Matter Physics	1	22.0
Eun Sang Choi (S)	NHMFL	Physics Department	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Study of Magnetic Phase transitions and Multiferroicity of Triangular Lattice Antiferromagnets P02366	Condensed Matter Physics	1	4.00
Mircea Dinca (S)	Massachusetts Institute of Technology	Department of Chemistry	Department of Energy DE-SC0006937	Using 57Fe Mössbauer Spectroscopy and High-Field EPR to Establish the Electronic Structure of Fe Sites in Lacunary Zn4O Clusters of MOF-5 P02384	Chemistry, Geochemistry	1	11.0
Andrej Zorko (S)	"Jozef Stefan" Institute	Solid State Physics Department	Other - Slovenian Research Agency	Local ESR Insight into Geometrically Frustrated Antiferromagnets P02399	Condensed Matter Physics	1	24.0
Albert Stiegman (S)	FSU	Chemistry	National Science Foundation 0911080	Electron Spin Resonance (ESR) Studies of the Phillip's Ethylene Polymerization Catalyst. P02403	Chemistry, Geochemistry	1	3.00
Srinivasa Rao Singamaneni (P)	North Carolina State University	Materials Science and Engineering	Other - Home Institution	Temperature Dependent High Frequency EMR investigations on Nd1-xYxMnO3: Probing Competing Magnetic Interactions P02421	Condensed Matter Physics	1	12.0
Kwang Yong Choi (S)	Chung Ang University	Department of Physics	Other - Korea NRF	ESR Studies on Novel Quantum States of Matter P02423	Condensed Matter Physics	1	26.0
Richard Oakley (S)	University of Waterloo	Chemistry	Other - NSERC, Canada Discovery Grant - Individual, Richard Oakley	Magnetic Resonance in Antiferromagnetic Organic Radicals P02460	Condensed Matter Physics	1	12.
Naresh Dalal (S)	Florida St. University	Chemistry	Future Fuels Institute	High-field EPR and ENDOR Studies of Fossil-Fuel and	Chemistry, Geochemistry	1	7.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
				Related Materials P02481			
Andrew Ozarowski (S)	National High Magnetic Field Laboratory	EMR	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Calibration And Maintenance Of The Mössbauer And 17 T Epr Instruments P02498	Magnets, Materials, Testing, Instrumentation	3	67.0
Christine Thomas (S)	Brandeis University	Department of Chemistry	Department of Energy DE-SC0004019	Variable temperature and variable field 57Fe Mossbauer and high field EPR studies of Fe-containing homo- and heterobimetallic complexes P02508	Chemistry, Geochemistry	2	98.0
Jamie Manson (S)	Eastern Washington University	Chemistry and Biochemistry	National Science Foundation 1005825	High-field ESR of novel S=1 molecular and polymeric magnets P07136	Condensed Matter Physics	1	22.0
Ellis Reinherz (S)	Dana-Farber Cancer Institute	Medicine	Other - Bill and Melinda Gates Foundation	Structural analysis of HIV-1 MPER segment from clade C viruses using EPR P07139	Biology, Biochemistry, Biophysics	2	75.0
Panayotis Kyritsis (S)	University of Athens	Chemistry	Other - University of Athens Other - Empirikion Foundation, Greece	Electronic properties of (i) synthetic analogues of metalloproteins' active sites and (ii) single-ion molecular magnet metal complexes, probed by HFEPR spectroscopy. P07143	Chemistry, Geochemistry	2	6.00
Joshua Telser (S)	Roosevelt University	Chemistry	Department of Energy 86ER13511	High-frequency and -field EPR studies of complexes of Group 6 - 8 ions with unusual ligands P07145	Chemistry, Geochemistry	1	8.00
Raj Sharma (S)	Panjab University	Chemistry	Other - UGC, New Delhi, India F.No. 40-60/ 2011	Magnetic and EPR Properties of Supramolecular Copper (II) Complexes P07146	Chemistry, Geochemistry	1	14.0
Thomas Albrecht-Schmitt (S)	Florida State University	Chemistry and Biochemistry	Department of Energy Heavy Elements Chemistry	High Field and High Frequency EPR Study of Novel Heterobimetallics P07153	Magnets, Materials, Testing, Instrumentation	1	10.0
Euan Brechin (S)	UniVersity of Edinburgh	School of Chemistry	National Science Foundation CHE 0924374 Other - Engineering and Physical Sciences Research Council EP/H004106/1	EPR characterization of molecular magneto-structural correlations under pressure P07168	Condensed Matter Physics	1	10.0
Sergey Suchalkin (S)	SUNY at Stony Brook	Electrical and Computer Engineering	National Science Foundation DMR1160843	Magneto-spectroscopy of metamorphic InAsSb narrow band semiconductors P07180	Condensed Matter Physics	1	5.00
Dmitry Smirnov (S)	NHMFL	Instrumentation & Operations	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) DC Field / CMS	Magneto-optics of 2D semiconducting transiton metal dichalcogenides P07197	Condensed Matter Physics	2	14.0
Joan Cano (S)	Universita de Valencia	Instituto de Ciencia	Other - Universitat de Valencia	Building arrays from mononuclear single-molecule magnets based on Mn(III)	Chemistry, Geochemistry	2	9.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Sched-uled	# of Days Used
		Molecular		and other 3d transition metal ions. In pursuit of new phys-ics in spintronics. P07202			
Naresh Dalal (S)	Florida St. University	Chemistry	National Science Foundation DMR 0701482I Other - Florida State University Chemistry P07221 National Science Foundation 0701462	High Frequency EPR of Fe doped CdSe Quantum Dots P07221	Chemistry, Geo-chemistry	3	75.0
Adam Veige (S)	University of Florida	Chemistry	National Science Foundation 1265993	A square-planar high-spin Fe(II) center stabilized by a trianionic pincer-type ligand P07226	Chemistry, Geo-chemistry	2	15.0
Armando Pombeiro (S)	Instituto Superior Tecnico	Chemical Engineering	Other - The Foundation for Sci-ence and Technology (Portugal)	Magnetic Properties and EPR spectroscopy of High-Nuclear Copper complexes P07238	Chemistry, Geo-chemistry	1	2.00
Changlin Tian (S)	University of Science and Tech-nology of China	School of Life Science	Other - National Key Basic Science Research Plan-Protein Science, China	Structure characterization of transmembrane protein rhodanese YgaP by EPR P07240	Biology, Biochem-istry, Biophysics	1	7.00
Malgorzata Holynska (S)	Philipps University Marburg	Chemistry	Other - German Research Coun-cil (DFG) Other - Philipps University Mar-burg	New magnetic materials based on bridged manganese complexes P07291	Chemistry, Geo-chemistry	4	21.0
Christos Lampropou-los (S)	University of North Florida	Chemistry	Other - University of North Florida Chemistry Other - Research Corporation for Science Advancement Cottrell College Science Awards (CCSA) 22598	HFEPR investigations on (i) the anisotropy of magnetic clusters, and (ii) the quantum mechanical interactions between structural building units in polymers P08309	Chemistry, Geo-chemistry	1	1.00
Vladimir Osipov (S)	Ioffe Physi-cal-Technical Institute	Division of Solid State Electronics	No other support (i.e. this exper-iment is entirely supported by NHMFL users services via its core grant)	High-frequency EPR studies of spin-spin interaction between pi-electronic edge-localized spin states and molecular oxygen in defec-tive carbon onions P08312	Condensed Matter Physics	1	5.00
Mark Murrie (S)	University of Glasgow	Chemistry	National Science Foundation 1309463	Single-ion magnets with giant axial magnetic anisot-ropy P08335	Chemistry, Geo-chemistry	1	2.00
Jianfeng Cai (S)	University of South Florida	Department of Chemis-try	Other - University of South Florida New Researcher Grant	Multi-frequency EPR analy-sis of AApeptides with membranes P08354	Biology, Biochem-istry, Biophysics	1	32.0
Alex Angerhofer (S)	University of Florida	Department of Chemis-try	National Science Foundation 1213440	High-Field EPR of Oxalate Decarboxylase P08361	Biology, Biochem-istry, Biophysics	1	5.00
John Engen (S)	Northeast-ern Univer-sity	Chemistry	National Institutes of Health GM101135	Membrane interaction of ADP Ribosylation Factor-1 defined by multi-frequency EPR P08380	Biology, Biochem-istry, Biophysics	1	5.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Lloyd Lumata (S)	University of Texas at Dallas	Physics	Other - Department of Defense CDMRP Prostate Cancer Research Program W81XWH-14-1-0048	X- and W-band Electron Spin Resonance (ESR) relaxation properties of DNP free radical polarizing agents P08395	Chemistry, Geochemistry	1	12.0
Marius Andruh (S)	University of Bucharest	Chemistry	Other - University of Bucharest Department of Inorganic Chemistry	Using High-Field EPR to explore the electronic structure of heterometallic, 3d-4f complexes P08419	Chemistry, Geochemistry	2	10.0
Dmitry Smirnov (S)	NHMFL	Instrumentation & Operations	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Magneto-Raman spectroscopy of correlated electron systems P08432	Condensed Matter Physics	2	10.0
Rafal Grubba (P)	Gdansk University of Technology	Department of Inorganic Chemistry	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Phosphanylphosphido complexes of iron: synthesis, chemical and magnetic properties P08455	Chemistry, Geochemistry	1	8.00
Christoph Boehme (S)	University of Utah	Department of Physics and Astronomy	Department of Energy #DESC0000909	Pulsed electrically detected magnetic resonance experiments on organic light emitting diodes at high magnetic fields P08460	Condensed Matter Physics	2	25.0
Alberto Ghirri (S)	CNR-Istituto Nanoscienze	Centro S3	Other - Consiglio Nazionale delle Ricerche (Italy) Other - US AFOSR/AOARD Other - Italian Ministry of Research FIRB project	Study of decoherence and relaxation in single-crystals of molecular nanomagnets P08473	Condensed Matter Physics	1	3.00
Stanislav Groysman (S)	Wayne State University	Chemistry	National Science Foundation CHE-1349048	Using High-Field EPR to Explore Electronic Structures of Bis(aldimino)pyridine Nickel Complexes P08475	Chemistry, Geochemistry	2	10.0
Dmitry Smirnov (S)	NHMFL	Instrumentation & Operations	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Testing new magneto-optical probes and new magneto-spectroscopy techniques P09590	Magnets, Materials, Testing, Instrumentation	1	2.00
George Christou (S)	University of Florida	Chemistry	National Science Foundation CHE-000000	High Frequency EPR Spectroscopy on Single-Molecule Magnets P11440	Chemistry, Geochemistry	1	17.0
Federico Spizzo (S)	University of Ferrara	Dipartimento Di Fisica E Scienze Della Terra	Other - University of Ferrara Department of Physics and Earth Sciences Other - University of Ferrara, Italy	Mössbauer and HF EPR studies on Fe3O4 nanoparticles P11441	Condensed Matter Physics	2	42.0
Daniel R. Talham (S)	University of Florida	Chemistry	National Science Foundation 1005581	Investigating photomagnetism in CoFe2O4 using Mössbauer spectroscopy P11456	Chemistry, Geochemistry	1	22.0
Zhenxing Wang (S)	Huazhong University of Science and Technology	Wuhan National High Magnetic Field Center, China	Other - 2013CB922102 National Basic Research Program of China, Chemistry	High Field EPR Measurements on Cobalt Based Single Ion Magnets P11462	Chemistry, Geochemistry	4	35.0

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
R. Britt (S)	University of California Davis	Chemistry	National Science Foundation 1213699	High Field EPR on Cobalt Oxide Water Oxidation Electrocatalysts P11468	Chemistry, Geochemistry	1	4.00
Wojciech Grochala (S)	Univ. Warsaw	CENT	Other - NCN, Polish National Science Center UMO-2011/01/B/ST5/06673	HF-ESR Characteristics of Paramagnetic Ag(2+) Sites in Several Prototypical Fluoride Systems P11479	Condensed Matter Physics	1	9.00
Joris van Slageren (S)	Universität Stuttgart	Institut für Physikalische Chemie	Other - German Research Foundation DFG	Increasing coherence times in molecular quantum bits P11480	Chemistry, Geochemistry	1	5.00
Lucio Frydman (S)	Weizmann Institute of Science	Dept. Chemical Physics	National Science Foundation NSF MRI Project CHE-1229170	EPR and NMR Spectroscopy of Small Molecules in Low Viscosity Solvents P11492	Biology, Biochemistry, Biophysics	2	19.0
Roberto De Guzman (S)	University of Kansas	Molecular Biosciences	National Institutes of Health AI074856	EPR studies of protein-protein interactions in the assembly of bacterial nanoinjectors P12563	Biology, Biochemistry, Biophysics	1	12.0
Evert Duin (S)	Auburn University	Department of Chemistry and Biochemistry	National Science Foundation 1404059	Redox state and magnetic properties of paramagnetic species in IspH detected under steady-state conditions P12564	Biology, Biochemistry, Biophysics	1	46.0
Hongjun Liang (S)	Texas Tech University Health Science Center	Cell Physiology and Molecular Biophysics	National Science Foundation 1410825	Membrane Interaction of Virus-Mimicking Polymer Molecular Brushes Defined by Multi-Frequency EPR P12579	Biology, Biochemistry, Biophysics	1	19.0
Gerd Buntkowsky (S)	Technische Universität Darmstadt	Chemistry	Other - German Research Council (DFG) Bu-911-21-1	Highfield EPR Investigation of Nickel Superoxide Dismutase P13608	Biology, Biochemistry, Biophysics	1	8.00
Ziling Xue (S)	University of Tennessee	Chemistry	National Science Foundation CHE-1362548	Probing Molecular Magnetism by Infrared and Raman Spectroscopies in Magnetic Fields P13617	Chemistry, Geochemistry	1	9.00
Maria Vaz (S)	Federal Fluminense University	Chemistry	Other - Capes (Brasil)	EPR studies of heterospin systems P13643	Chemistry, Geochemistry	1	3.00
Huajun Zhou (S)	University of Arkansas	High Density Electronic Center	Other - High Density Electronic Center, University of Arkansas	Using advanced spectroscopic techniques to assess the electronic structure of iron-based [GdFe] heterometallic, polynuclear clusters P13657	Chemistry, Geochemistry	1	17.0
Fabio Matta (S)	University of South Carolina	Civil and Environmental Engineering	Other - Centre for Energy Advancement through Technological Innovation (CEATI) Transmission Line Asset Management (TLAM) Interest Group T143700-3260	Characterization of Surface Oxides from Weathering Steel Transmission Line Structures Via Mössbauer Spectroscopy P14667	Engineering	1	32.0
Sankar Rath (S)	Indian Institute of Technology Kan-	Chemistry	Other - Indian Institute of Technology, Kanpur Department of Chemistry	Investigation on a Series of μ-Hydroxo Dimanga-	Chemistry, Geochemistry	1	4.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experi-ments Sched-uled	# of Days Used
	pur			nese/iron(III)Porphyrin Dimers P14685			
Klaus-Peter Dinse (S)	Free Uni-versity Berlin	Physics	Other - Max Planck Society Institut for Chemical Energy Conversion	Use of High-Frequency EPR in Heterogenous Catalysis P14700	Chemistry, Geo-chemistry	3	15.0
Sylvain Bertaina (S)	IM2NP - CNRS	Nanoscience	Other - CNRS - PICS CoDyLow	Pulsed EPR in Mn2+-doped Perovskite-Like MOF DMZnF P14729	Condensed Matter Physics	1	2.00
Likai Song (S)	NHMFL	EMR	No other support (i.e. this exper-iment is entirely supported by NHMFL users services via its core grant)	Development of high-field and pulsed EPR methods in biological applications P14730	Biology, Biochem-istry, Biophysics	1	8.00
Carole Duboc (S)	Univ. Gre-noble Alpes	Molecular Chemistry	Other - French National Agency for Research ANR-09-JCJC-0087	Investigating the origin of the zero-field splitting in mononuclear MnIV com-plexes P14763	Chemistry, Geo-chemistry	1	2.00
David Norman (S)	University of Dundee	Nucleic Acid Struc-ture Re-search Group	Other - UK Engineering and Physical Sciences Research Council (EPSRC)	Long-range distance deter-mination of large protein complexes using high-field pulsed EPR P14790	Biology, Biochem-istry, Biophysics	1	3.00
Hill Harman (S)	University of Califor-nia-Riverside	Chemistry	Other - UCR UCR Center for Catalysis	High Field EPR and Möss-bauer Studies on High-Spin Iron Dinitrogen Complexes P14804	Chemistry, Geo-chemistry	2	52.0
Srinivasa Rao Singamaneni (P)	North Carolina State University	Materials Science and Engineering	U.S. Army	High frequency EMR and spin relaxation studies on laser induced graphene films P14809	Condensed Matter Physics	1	4.00
Eugenio Coronado (S)	Instituto de Ciencia Mo-lecular (IC-Mol), Univer-sidad de Valencia	Chemistry	National Science Foundation 1309463, 1157490 Other - Air Force Office of Scientifi Research (AFSOR) FA2386 13-1-4031 Other - Ministry of Economy and co petitiveness-Spanish National Resea Council - MAT-2014-56143-R, CTQ2014-52758-P, MDM-2015-05 Ramon y Cajal Fellowship Other - European Research Council SPINMOL, DECRESIM Other - Generalitat Valenciana (Reg al Government of Valencia) Promoteo & ISIC-Nano Programs o Excellence	Enhancement in coherence time using clock transitions in a Ho(III) molecular na-nomagnet P14813	Magnets, Materials, Testing, Instrumen-tation	1	36.0
Total Proposals:				**71**	**Total Experiments**	**97**	**1,209**

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ICR FACILITY

***Table 1** – User Demographic*

ICR Facility	Users	Male	Female	Prefer Not to Respond to Gender	Minority[1]	Non-Minority[1]	Prefer Not to Respond to Race	Users Pre-sent	Users Operating Remotely[2]	Users Sending Sample[3]	Off-Site Collabo-rators[4]
Senior Personnel, U.S.	**118**	72	24	22	7	84	27	43	0	29	46
Senior Personnel, non-U.S.	**27**	16	3	8	3	14	10	4	0	5	18
Postdocs, U.S.	**21**	6	11	4	0	17	4	14	0	3	4
Postdocs, non-U.S.	**1**	0	1	0	1	0	0	1	0	0	0
Students, U.S.	**59**	19	35	5	5	45	9	41	0	5	13
Students, non-U.S.	**3**	1	2	0	1	1	1	1	0	2	0
Technician, U.S.	**10**	8	1	1	0	9	1	4	0	3	3
Technician, non-U.S.	**0**	0	0	0	0	0	0	0	0	0	0
Total:	**239**	**122**	**77**	**40**	**17**	**170**	**52**	**108**	**0**	**47**	**84**

[1]NSF Minority status includes the following races: American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. The definition also includes Hispanic Ethnicity as a minority group. Minority status excludes Asian and White-Not of Hispanic Origin
[2]"Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
[3]"Users Sending Sample" refers to users who send the sample to the facility and the experiment is conducted by in-house user support personnel. Users at UF, FSU, and LANL cannot be "sample senders" for facilities located on their campuses.
[4]"Off-Site Collaborators" are scientific or technical participants on the experiment; who will not be present, sending sample, or operating the magnet system remotely; and who are not located on the campus of that facility (i.e., they are off-site).
***Note:** Users using multiple facilities are counted in each facility listed.*

***Table 2** – User Affiliation*

ICR Facility	Users	NHMFL-Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users[4]	National Lab Users[3,4]
Senior Personnel, U.S.	**118**	16	13	95	10	13
Senior Personnel, non-U.S.	**27**	0	0	14	10	3
Postdocs, U.S.	**21**	8	7	21	0	0
Postdocs, non-U.S.	**1**	1	0	1	0	0
Students, U.S.	**59**	8	14	58	1	0
Students, non-U.S.	**3**	0	0	3	0	0
Technician, U.S.	**10**	3	1	7	3	0
Technician, non-U.S.	**0**	0	0	0	0	0
Total:	**239**	**36**	**35**	**199**	**24**	**16**

[1]NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on our Web site/directory], even if they travel to another site. Local users are defined as any non-NHMFL-Affiliated researchers originating at any of the institutions in proximity to the MagLab sites (i.e. researchers at FSU, UF, FAMU, or LANL), even if they travel to another site.
The sum of NHMFL-Affiliated and Local users equals what was formerly referred to as "Internal Investigators".
[2]In addition to external users, all users with primary affiliations at FSU, UF, or FAMU are reported in this category, even if they are also NHMFL associates.
[3]In addition to external users, users with primary affiliations at NHMFL/LANL are reported in this category.
[4]The total of university, industry, and national lab users will equal the total number of users.

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***Table 3** – Users by Discipline*

ICR Facility	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Senior Personnel, U.S.	**118**	0	71	5	4	38
Senior Personnel, non-.S.	**27**	0	23	1	0	3
Postdocs, U.S.	**21**	0	17	0	0	4
Postdocs, non-U.S.	**1**	0	1	0	0	0
Students, U.S.	**59**	0	46	1	1	11
Students, non-U.S.	**3**	0	3	0	0	0
Technician, U.S.	**10**	0	7	2	1	0
Technician, non-U.S.	**0**	0	0	0	0	0
Total:	**239**	**0**	**168**	**9**	**6**	**56**

***Table 4** – User Facility Operations*

ICR Facility	21 T Hybrid	14.5 T Hybrid	9.4. T Passive	9.4. T Active	Total Days Used / User Affil.	Percentage Used / User Affil.
	Number of Magnet Days[1]					
NHMFL-Affiliated	8	41	91	0	**140**	**14.55%**
Local	0	24	19	13	**56**	**5.82%**
U.S. University	8	79	145	53	**285**	**29.63%**
U.S. Govt. Lab.	0	7	17	0	**24**	**2.49%**
U.S. Industry	0	8	29	0	**37**	**3.85%**
Non-U.S.	0	0	60	53	**113**	**11.75%**
Test, Calibration, Set-up, Maintenance, Inst. Dev.	60	155	29	63	**307**	**31.91%**
Total:	**76**	**314**	**390**	**182**	**962**	**100.00%**

[1]*User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.*

***Table 5** – Operations by Discipline*

ICR Facility	Total Days[1] Allocated / User Affil.	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
	Number of Magnet Days[1]					
NHMFL-Affiliated	**140**	0	89	0	8	43
Local	**56**	0	26	0	1	29
U.S. University	**285**	0	193	0	0	92
U.S. Govt. Lab.	**24**	0	14	3	0	7
U.S. Industry	**37**	0	28	0	0	9
Non-U.S.	**113**	0	112	0	1	0
Test, Calibration, Set-up, Maintenance, Inst. Dev.	**307**	0	6	0	252	49
Total:	**962**	**0**	**468**	**3**	**262**	**229**

[1]*User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.*

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***Table 6** – User Program Experiment Pressure*

ICR Facility					
Experiment Requests Received	Experiment Requests Deferred from Prev. Year	Experiment Requests Granted	Experiment Requests Declined/Deferred	Experiment Requests Reviewed	Subscription Rate
63	57	106 (88%)	14 (12%)	120	113%

***Table 7** – New User PIs[1]*

First Name	Last Name	Organization
Jeramie	**Adams**	Western Research Institute (University of Wyoming Research Corporation)
Lissa	**Anderson**	NHMFL
David	**Barnidge**	Mayo Clinic College of Medicine
Thomas	**Bianchi**	University of Florida
Thomas	**Borch**	Colorado State University
Martha	**Chacon**	Universidad Industrial de Santander
Robert	**Cook**	Louisiana State University
Orlando	**Coronell**	University of North Carolina at Chapel Hill
Hongchang	**Cui**	Florida State University
Juliana	**D'Andrilli**	Montana State University
A. Ligia	**Focsan**	Valdosta State University
Karen	**Frey**	Clark University
Pierre	**Giusti**	Total
Allen	**Goldstein**	University of California at Berkeley
Nikolas	**Hagemann**	University of Tuebingen
David	**Henry**	City of Tallahassee
Teddy	**Kim**	Vanton Research Laboratory
Elizabeth	**Kujawinski**	Woods Hole Oceanographic Institution
William	**Landing**	Florida State University
Young Jin	**Lee**	Iowa State University
Jenna	**Luek**	University of Maryland Center for Environmental Science
Paul	**Mann**	Northumbria University
Patricia	**Medeiros**	University of Georgia
Jonathan	**O'Donnell**	National Park Service
Susan	**Pedigo**	University of Mississippi
Phoebe	**Ray**	NHMFL
Xavi	**Ribas**	Universitat de Girona
Fernando	**Rosario-Ortiz**	University of Colorado
Jorge	**Ruiz**	Ecopetrol
Farid	**Salama**	NASA-Ames Research Center
Viji	**Sitther**	Morgan State University
Stephen	**Skrabal**	University of North Carolina Wilmington
Robert	**Spencer**	Florida State University
Robert	**Tomko**	Florida State University
Avner	**Vengosh**	Duke University
Jorien	**Vonk**	University of Utrecht
Kimberly	**Wickland**	U.S. Geological Survey
Si	**Wu**	University of Oklahoma
Total:		**38**

[1]*PI who received magnet time for the first time across all facilities.*

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***Table 8** – Research Proposals Profile with Magnet Time*

ICR Facility	Total	Minority[2]	Female[3]	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instrum.	Biology, Biochem. Biophys.
Number of Proposals	106	12	23	0	67	1	5	33

[1]A "proposal" may have associated with it a single experiment or a group of closely related experiments. A PI may have more than one proposal.
[2] The number of proposals satisfying one of the following two conditions: (a) the PI is a minority OR (b) the PI is a non-minority working at a minority-serving college or university AND the proposal includes minority participants.
[3] The number of proposals satisfying one of the following two conditions: (a) the PI is a female OR (b) the PI is a male working at a college or university for women AND the proposal includes female participants.

***Table 9** – User Proposal*

This report lists all proposals that were allocated magnet time from January-December 2015 on the reportable magnet system(s) identified in Annual Report Table 5. The PI is shown first in the list of users.
(S = Senior Personnel; P = Postdoc; G = Graduate Student; U = Undergraduate Student; T = Technician, programmer)

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Mary Lusk (G)	University of Florida	Soil and Water Science Dept.	Other - University of Florida Center for Landscape Conservation and Ecology	Ultrahigh resolution Fourier transform ion cyclotron resonance mass spectrometry to characterize the molecular composition of dissolved organic nitrogen in urban and nonurban streams P08348	Chemistry, Geochemistry	1	1.00
Omics LLC (S)	Omics, LLC	Omics	Other - Omics, LLC	OMICS P11443	Chemistry, Geochemistry	1	10.00
Teddy Kim (T)	Vanton Research Laboratory	Pharmaceutical Department	Other - Vanton Research Laborary, LLC	Zygophyllum Extraction P08480	Biology, Biochemistry, Biophysics	1	9.00
Nate Kaiser (S)	NHMFL	ICR	National Science Foundation CHE-1016942 National Science Foundation 1019193	21 Tesla Fourier Transform Ion Cyclotron Resonance Instrumentation design and development P01998	Magnets, Materials, Testing, Instrumentation	2	20.00
Nate Kaiser (S)	NHMFL	ICR	National Science Foundation CHE-1016942 National Science Foundation CHE-1019193	Repair and maintenance of FT ICR MS instruments .Hardware and Software Development Toward 21 Tesla : The Use of the 14.5 Tesla and 9.4 Tesla FT-ICR as a Test Bed for the Future P11453	Magnets, Materials, Testing, Instrumentation	1	126.00
Ryan Rodgers (S)	NHMFL	ICR	Future Fuels Institute	Comprehensive Simulation/Projection of Heavy Crude Oil Distillation and Detailed Molecular Composition Prediction by Direct-Infusion Fourier Transform Ion Cyclotron Mass Spectrometry. P02294	Chemistry, Geochemistry	1	14.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Matthew Tarr (S)	University of New Orleans	Department of Chemistry	National Science Foundation 1111525 National Science Foundation 1004869	High Resolution MS of Phototreated Crude Oil P02408	Chemistry, Geochemistry	1	3.00
Stephen Dalton (S)	University of Georgia	Department of Biochemistry and Molecular Biology	National Institutes of Health P01GM85354	Characterizing histone modification dynamics of human pluripotent stem cells during cell cycle transitions P02422	Biology, Biochemistry, Biophysics	1	1.00
Ryan Rodgers (S)	NHMFL	ICR	National Science Foundation DMR-11-57490	Characterization of Petroleum using Spectral Stitching by High Resolution FT-ICR MS P02452	Chemistry, Geochemistry	1	4.00
Jonathan Dennis (S)	Florida State University	Department of Biological Science	National Institutes of Health NIDA - National Institute on Drug Abuse R01 DA033775	Dynamic Changes in Histone Sequence Variants and Post-Translational Modifications During HIV activation P07166	Biology, Biochemistry, Biophysics	1	18.00
Chris Hendrickson (S)	NHMFL	Ion Cyclotron Resonance Program	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) ICR	Determination of Site-Specific Proteins Disulfide Bond Redox Potentials by Top Down FTICR Mass Spectrometry P07237	Biology, Biochemistry, Biophysics	1	9.00
Ryan Rodgers (S)	NHMFL	ICR	Future Fuels Institute	Continued Development of Novel Method for Isolation of Interfacial Material from Crude Oil P07265	Chemistry, Geochemistry	1	22.00
Ian MacDonald (S)	Florida State University	Dept of Oceanography	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	FT-ICR MS characterization of natural oil seep (Megaplume) from Gulf of Mexico. P08305	Chemistry, Geochemistry	1	3.00
Robert Nelson (S)	Woods Hole Oceanographic Institute	Dept Marine Chemistry and Geochemistry	Other - Deep-C Consortium SA 12-12, GoMRI-008	Reexamining the Exxon Valdez Oil Spill and the Effects of Cold Climate Weathering: Molecular Characterization by Fourier Transform Ion Cyclotron Resonance P08350	Magnets, Materials, Testing, Instrumentation	1	2.00
Manhoi Hur (T)	Iowa State University of Science and Technology	Genetics Development & Cell Biology-LAS	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Application of volcano plots for quantitative visualization and comparison of a set of two spectra obtained by high-resolution mass spectrometric analysis of crude oils, P08367	Chemistry, Geochemistry	1	1.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Yvonne N Fondufe-Mittendorf (S)	University of Kentucky	Department of Molecular & Cellular Biochemistry	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	The effect of arsenite-induced modifications on chromatin structural proteins in mediating gene expression P08371	Biology, Biochemistry, Biophysics	1	13.00
Ryan Rodgers (S)	NHMFL	ICR	Future Fuels Institute None	Correlation of mass spectral data to petroleum bulk properties P08456	Chemistry, Geochemistry	1	8.00
Heath Fleming (S)	HK Petroleum, LTD	Bulk Sales	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Characterization of Municipal Solid Waste Pyrolysis Oil by FT-ICR MS P08465	Chemistry, Geochemistry	1	15.00
Geoffrey Klein (S)	Christopher Newport University	Department of Molecular Biology and Chemistry	Other - ACS Petroleum Research Fund 50670-UR6, 2011 National Science Foundation GK-12 0841295, 2009	Access to the Ultra-High Resolution FT-ICR Mass Spectrometers at the NHMFL for Analysis of the Maltene Fractions of Three Different Crude Oils P08471	Chemistry, Geochemistry	1	4.00
Matthew Tarr (S)	University of New Orleans	Department of Chemistry	National Science Foundation CHE-1111525	Chromatographic Fractionation of Phototreated Crude Oil and Characterization by FT-ICR MS P11437	Chemistry, Geochemistry	1	2.00
Ryan Rodgers (S)	NHMFL	ICR	National Science Foundation DMR-11-57490 Other - Deep-C	Chromatographic Fractionation of a Standard Reference Material Weathered Macondo Crude Oil and Characterization by FT-ICR MS P11438	Chemistry, Geochemistry	1	4.00
Pierre Giusti (S)	Total	Research & Technology	Future Fuels Institute Total	Future Fuels Institute-Proprietary P11447	Chemistry, Geochemistry	1	18.00
Peter Slater (S)	ConocoPhillips Company	Research & Development & Shared Services	Future Fuels Institute ConocoPhillips	Future Fuels Institute-Proprietary P11449	Chemistry, Geochemistry	1	6.00
Rosana Cardoso (S)	Petrobras	Petrobras	Future Fuels Institute Petrobras	Future Fuels Institute-Proprietary Petrobras P11450	Chemistry, Geochemistry	1	7.00
Jorge Ruiz (S)	Ecopetrol	Analytical Research & Development	Future Fuels Institute Ecopetrol	Future Fuels Institute-Proprietary EcoPetrol P11452	Chemistry, Geochemistry	1	16.00
David Podgorski (S)	Future Fuels Institute	ICR	Future Fuels Institute	Quantitative Detection of Ring-Separated HPLC Fractions P11455	Chemistry, Geochemistry	1	3.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Elizabeth Stroupe (S)	Florida State University	BIOLOGICAL SCIENCE	National Science Foundation MES 1149763	HDX FT-ICR MS to Study the conformations of electron transfer complex in sulfite reductase P02385	Biology, Biochemistry, Biophysics	1	5.00
Chris Hendrickson (S)	NHMFL	Ion Cyclotron Resonance Program	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Method development for characterizing post-translational modifications of Histone H4 P08493	Biology, Biochemistry, Biophysics	1	44.00
Nur Gueneli (G)	The Australian National University	ANU College of Physical & Mathematical Sciences	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Characterization of the world's oldest (1.1 Ga) porphyrins P08490	Chemistry, Geochemistry	1	5.00
Dave Valentine (S)	University of California Santa Barbara	Department of Geological Sciences	Other - BP/Gulf of Mexico Research Initiative Deep-C Consortia	Molecular-Level Characterization Of Petroleum Seeps, Volcanoes, And Sediments From Santa Barbara Basin By Ft-ICR Mass Spectrometry P02304	Chemistry, Geochemistry	1	1.00
Alexandra Stenson (S)	University of South Alabama	Chemistry	Other - University of South Alabama Center for Environmental Resiliency	Investigation of Disinfection Byproducts formed by different NOM fractions P08352	Chemistry, Geochemistry	1	2.00
Nate Kaiser (S)	NHMFL	ICR	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Maintenance and Cleaning of the FT-ICR MS instrumentation P07172	Magnets, Materials, Testing, Instrumentation	1	89.00
Josep Poblet (S)	Universitat Rovira i Virgili	Departament de Quimica Fisica i Inorganic	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Study of encapsulation of clusters and metals in carbon cages by high resolution FT-ICR mass spectrometry P07175	Chemistry, Geochemistry	1	33.00
Josep Poblet (S)	Universitat Rovira i Virgili	Departament de Quimica Fisica i Inorganic	Other - Spanish Ministry of Science and Innovation	Trimetallic nitride endohedral metallofullerenes P07275	Chemistry, Geochemistry	1	43.00
Luis Echegoyen (S)	University of Texas at El Paso	Chemistry	National Science Foundation CHE-1408865	Identification of C70-based adducts for organic photovoltaics P09516	Biology, Biochemistry, Biophysics	1	11.00
Luis Echegoyen (S)	University of Texas at El Paso	Chemistry	National Science Foundation 1408865	Ru-C60 derivatives P09517	Biology, Biochemistry, Biophysics	1	3.00
Michael	Baker Hughes	Heavy Oil	Other - Baker	Characterizing the Compositional and	Chemistry, Geochemistry	1	1.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Shammai (S)	Oilfield Operations Inc	Research Projects	Hughes	Structural Changes in Crude Oil and Asphaltenes P08491			
David Crane (S)	CA Dept of Fish and Wildlife	Office of Spill Prevention and Response	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Characterization of Tar Balls Collected from Beaches in Central California and newly discovered Piedras Blancas Seep by FT-ICR MS P02410	Chemistry, Geochemistry	1	2.00
Kristina Håkansson (S)	University of Michigan	Department of Chemistry	National Science Foundation CHE-1152531 National Institutes of Health 1-R01-GM-107148-01-A1	ICR Program Proposal Kristina Håkansson, Department of Chemistry, University of Michigan P08478	Chemistry, Geochemistry	2	4.00
David Podgorski (S)	Future Fuels Institute	ICR	Other - BP/Gulf of Mexico Research Initiative (DEEP-C Consortium) Future Fuels Institute N/A National Science Foundation 1111525	Photochemical Changes of Macondo Crude Oil as a Function of Structure and Chemistry P11446	Chemistry, Geochemistry	1	10.00
Matthew Tarr (S)	University of New Orleans	Department of Chemistry	National Science Foundation CHE-1111525, DMR-1004869	High Resolution MS of Phototreated Crude Oil P08463	Chemistry, Geochemistry	1	1.00
Fernando Rosario-Ortiz (S)	University of Colorado	Environmental Engineering	Other - Water Research Foundation Tailored Collaboration Program Future Fuels Institute Department of Energy DE-SC0007144 Department of Energy DE-SC0012272	Characterization of organic nitrogen in wildfire impacted soils and water P11490	Chemistry, Geochemistry	1	4.00
Thomas Borch (S)	Colorado State University	Soil and Crop Science	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Effect of the composting process on the chemical nature of the biochar P11473	Biology, Biochemistry, Biophysics	1	3.00
Gheorghe Bota (S)	Institute for Corrosion and Multiphase Technology at	Chemical and Biomolecular Engineering	No other support (i.e. this experiment is entirely supported by NHMFL users	Identification of Corrosive Naphthenic Acids Characterization of Ketones Formed from	Chemistry, Geochemistry	1	20.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
	Ohio University		services via its core grant)	Ferrous Naphthenate Thermal Decomposition P07287			
Phoebe Ray (P)	NHMFL	ICR	National Science Foundation 1111525 National Science Foundation 1004869	High Resolution MS of Phototreated Crude Oil P11494	Biology, Biochemistry, Biophysics	1	8.00
Kenneth Roux (S)	Florida State University	Department of Biological Science	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Discovery of Nature of Cross-reactivity between Cashew and Pistachio 7S Proteins by HDX Mass Spectrometry P07267	Biology, Biochemistry, Biophysics	1	4.00
Alan Marshall (S)	NHMFL	ICR	National Science Foundation 11-57490	Microalgal Lipids Profiling by Liquid Chromatography Coupled with FT-ICR Mass Spectrometry P11466	Biology, Biochemistry, Biophysics	1	29.00
Stephen Skrabal (S)	University of North Carolina Wilmington	Chemistry & Biochemistry	National Science Foundation AGS - Atmospheric and Geospace Sciences 1003078 1440425 National Science Foundation OCE - Ocean Sciences 1154850 Future Fuels Institute	Characterization of Photoreleased Dissolved Organic Matter Released from Resuspended Sediments by Fourier Transform Ion Cyclotron Resonance Mass Spectrometry P12548	Biology, Biochemistry, Biophysics	1	2.00
Ryan Rodgers (S)	NHMFL	ICR	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Optimization of APCI for detection of crude oil saturate fraction by FT-ICR MS P08359	Chemistry, Geochemistry	1	4.00
Nicolas Young (S)	NHMFL	Ion Cyclotron Resonance Program	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Complementray Lys-N/Lys-C Digestion Combined With Ultrahigh Complementray Lys-N/Lys-C Digestion Combined With Ultrahigh Resolution Ft-Icr Ms And Ms/Ms For Peptide De Novo Sequencing P07176	Biology, Biochemistry, Biophysics	1	1.00
Min Guo (S)	The Scripps Research Institute - Florida	Department of Cancer Biology	Other - Sydney Kimmel Cancer Scholar Award	HDX FT-ICR MS to Study the conformations of tRNA synthetases P02118	Biology, Biochemistry, Biophysics	1	8.00
Robert Cook (S)	Louisiana State	Chemistry	National Science Foundation	ICR-MS analysis of chemically edited humic	Chemistry, Geochemistry	1	4.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
	University		CHE-1411547	acids P12561			
Robert Spencer (S)	Florida State University	Earth, Ocean & Atmospheric Science	National Science Foundation OCE - Division of Ocean Sciences 1464396 Future Fuels Institute	Calibration and application of vascular plant and aqueous microbial molecular signatures to examine transformations of dissolved organic matter in coastal waters P12542	Chemistry, Geochemistry	1	3.00
William Landing (S)	Florida State University	EOAS	National Science Foundation OCE-Division of Ocean Science 069000-520-034027	FT-ICR Characterization of Marine Siderophores P13601	Chemistry, Geochemistry	1	1.00
Thomas Manning (S)	Valdosta State University	Chemistry	Other - QEP-SACS Grant for supplies and field work	Bryostatin, the 763 m/z spectral feature P08368	Chemistry, Geochemistry	1	3.00
Si Wu (S)	University of Oklahoma	Chemistry and Biochemistry	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Deciphering the secrets of fungal secreted proteins P13603	Biology, Biochemistry, Biophysics	1	5.00
Isabelle Merdrignac (S)	IFP Energies nouvelles	Chemistry	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Relationship between structure and reactivity in hydrotreatment / hydroconversion of residues P08437	Biology, Biochemistry, Biophysics	1	2.00
Jeff Chanton (S)	Florida State University	Oceanography	Department of Energy DE-SC0007144 Department of Energy DE-SC0004632	Investigating dissolved organic matter decomposition pathways with depth along a natural permafrost thaw gradient in Northern Sweden P02435	Chemistry, Geochemistry	1	2.00
Louis Kaplan (S)	Stroud Water Research Center	Biogeochemistry Group	National Science Foundation Division of Environmental Biology 1120717	Negative Ion ESI FT-ICR MS of Water Stream Samples from White Clay Creek in Eastern, PA and Rio Tempisquito in the Cordillera de Guanacaste, Costa Rica P02443	Chemistry, Geochemistry	1	1.00
David Podgorski (S)	Future Fuels Institute	ICR	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Photochemically-Induced Weathering of Interfacial Material Isolated from Petroleum P08400	Chemistry, Geochemistry	1	18.00
Xavi Ribas (S)	Universitat de Girona	Institut de Química Computacional i Catàlisi (IQCC) i	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core	Catching Smaller Fullerenes by Supramolecular Nanocages P12562	Biology, Biochemistry, Biophysics	1	1.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
		Departament de Química	grant)				
Alan Marshall (S)	NHMFL	ICR	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Determination of Site-Specific Protein Disulfide Bond Redox Potentials by Top-Down FT-ICR Mass Spectrometry P12569	Biology, Biochemistry, Biophysics	1	12.00
Farid Salama (S)	NASA-Ames Research Center	Space Science & Astrobiology Division	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Laboratory Astrophysics: Investigation of Growth, Formation, and Destruction of Carbon-Based Cosmic Molecules under Conditions of Stellar Outflows P12577	Biology, Biochemistry, Biophysics	1	14.00
David Podgorski (S)	Future Fuels Institute	ICR	Future Fuels Institute	Research Experience for Undergraduates: The Fate of Petroleum-Derived Water-Soluble Organic Photoproducts in Marine Environments P13606	Chemistry, Geochemistry	1	6.00
Nikolas Hagemann (G)	University of Tuebingen	Center for Applied Geosciences, Geomicrobiology	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Investigating the composting process on the biochar at the molecular level P12573	Chemistry, Geochemistry	1	1.00
Thomas Bianchi (S)	University of Florida	Geological Sciences	Other - BP/The Gulf of Mexico Research Initiative SA12-09/GoMRI-006	Characterization of Oil-Derived Chromophoric Dissolved Organic Matter (CDOM) from Deep Waters of the Gulf of Mexico using Ultrahigh Resolution Mass Spectrometry P08495	Chemistry, Geochemistry	1	1.00
Luis Echegoyen (S)	University of Texas at El Paso	Chemistry	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Identification of New Uranium-based and Transition Metal Endohedral Fullerenes P12547	Chemistry, Geochemistry	1	11.00
Luis Echegoyen (S)	University of Texas at El Paso	Chemistry	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	[1,3]-Thiazine-[60]-Fulleropyrrolidinium salts: A new class of fullerene derivatives with potent HIV inhibition P12567	Biology, Biochemistry, Biophysics	1	6.00
Nate Kaiser (S)	NHMFL	ICR	National Science Foundation 1016942	Optimization of excitation, transfer, accumulation, and detection of petroleum by FT-ICR MS at 21T P11461	Magnets, Materials, Testing, Instrumentation	1	27.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
Hongchang Cui (S)	Florida State University	Department of Biological Science	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant) ICR	Mapping the Sites of O-GlcNAcylation and Phosphorylation in the CTD Domain of Arabidopsis Pol II by Top-Down MS/MS P11537	Biology, Biochemistry, Biophysics	1	1.00
Lissa Anderson (P)	NHMFL	ICR	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Top-Down Proteomics Method Development (fETD, CID, CAD) at 21 T P12571	Biology, Biochemistry, Biophysics	1	28.00
Héctor Koolen (G)	Woods Hole Oceanographic Institution	Department of Marine Chemistry and Geochemistry	Other - BP/The Gulf of Mexico Research Initiative to the Deep-C Consortium	Advanced characterization of oil residues on Texas beaches after Kirby oil spill P08469	Chemistry, Geochemistry	1	2.00
Orlando Coronell (S)	University of North Carolina at Chapel Hill	Environmental Sciences and Engineering	Other - Orica Watercare	Membrane Fouling by Water Pretreatment with MIEX Resin P08472	Chemistry, Geochemistry	1	1.00
Jeramie Adams (S)	Western Research Institute (University of Wyoming Research Corporation)	Transportation Technology	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Characterization of Crude Oil Interfacail Material P12592	Biology, Biochemistry, Biophysics	1	1.00
Amy McKenna (S)	NHMFL	ICR	Other - NHMFL REU program	Research Experience for Undergraduates: Solvent Extraction of Organic Compounds from Shale Rock Samples from the Bowland-Hodder formation in Lancashire England P13600	Chemistry, Geochemistry	1	2.00
Jonathan O'Donnell (S)	National Park Service	Arctic Network	Other - National Parks Service	Temperature sensitivity of DOM production and transformation across different organic soil types in Alaska's boreal region P14663	Chemistry, Geochemistry	1	6.00
Bing Li (S)	UT Southwestern	Medical Center	National Institutes of Health 1R01GM090077	Top-down Study of the Phosphorylation State of the CTD Domain of RNA Polymerase II P02240	Biology, Biochemistry, Biophysics	1	5.00
Aixin Hou (S)	Louisiana State University	Department of Environmental Sciences	Other - BP/Gulf of Mexico Research Initiative	Characterization of the BP petroleum residuals in the sediment of the Salt Marshes in the Northern Gulf of Mexico P02345	Chemistry, Geochemistry	1	2.00
Young Jin Lee	Iowa State	Chemistry	National Science	Negative Atmospheric Pressure Photoionization	Biology, Biochemistry,	1	4.00

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PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
(S)	University		Foundation Chemical Bioengineering #1438004	FT-ICR Analysis of Biofuels P14661	Biophysics		
Pamela Vaughan (S)	University of West Florida	Department of Chemistry	Other - Gulf of Mexico Research Initiative C-IMAGE II Consortium	FT-ICR MS Analysis of Weathered Surrogate Oil and Water Accommodated Fractions P14679	Chemistry, Geochemistry	1	2.00
Rafael Bruschweiler (S)	Ohio State University	CCIC	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	A Combined MS/NMR Strategy for New Metabolite Identification in Complex Mixtures P12560	Chemistry, Geochemistry	1	9.00
Karen Frey (S)	Clark University	Graduate School of Geography	National Science Foundation PLR - Division of Polar Programs 1107596	Seasonality of chromophoric dissolved organic matter and molecular composition in Arctic lakes along the North Slope of Alaska P14674	Chemistry, Geochemistry	1	3.00
Susan Pedigo (S)	University of Mississippi	Chemistry and Biochemistry	Other - Department of education GAANN P200A120046	Probing Cadherin Interactions by Hydrogen/Deuterium Exchange Mass Spectrometry P14681	Biology, Biochemistry, Biophysics	1	18.00
Elizabeth Kujawinski (S)	Woods Hole Oceanographic Institution	NA	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Marine Metabolomics at Ultrahigh Resolution P12568	Chemistry, Geochemistry	1	15.00
Min Guo (S)	The Scripps Research Institute - Florida	Department of Cancer Biology	Other - Sydney Kimmel Cancer Scholar Award	HDX FT-ICR MS to Study the conformations of tRNA synthetases P07229	Biology, Biochemistry, Biophysics	1	13.00
Kimberly Wickland (S)	U.S. Geological Survey	National Research Program	Other - U.S. Geological Survey	Understanding influences of land-use and seasonality on in-stream reactivity and transformations of DOM through ultrahigh resolution mass spectrometry P14703	Chemistry, Geochemistry	1	7.00
Allen Goldstein (S)	University of California at Berkeley	Environmental Science, Policy, and Management	Other - Energy Bioscience Institute	Application of Ultrahigh Resolution Fourier Transform Ion Cyclotron Resonance Mass Spectrometry to Characterize Petroleum Composition Transformations under Sulfate, Nitrate, and Perchlorate Reducing	Chemistry, Geochemistry	1	11.00

APPENDIX I – USER FACILITY STATISTICS

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
				Conditions P13661			
Robert Tomko (S)	Florida State University	Biomedical Sciences, College of Medicine	Other - FSU College of Medicine PI's start-up funds	Study Molecular Mechanisms of Proteasome Biogenesis by HDX P14688	Biology, Biochemistry, Biophysics	1	1.00
Thomas Borch (S)	Colorado State University	Soil and Crop Science	Other - USDA NIFA 2013-67019-21359	Impact of soil temperature on chemical fractionation of DOC at the mineral – water interface P14672	Chemistry, Geochemistry	1	1.00
Juliana D'Andrilli (S)	Montana State University	Center for Biofilm Engineering & Dept. of Land Resources and Environmental Sciences	National Science Foundation ANT - Antarctic Sciences 1141936	Characterization of Glacial Dissolved Organic Matter P14713	Chemistry, Geochemistry	1	1.00
Avner Vengosh (S)	Duke University	Nicholas School of Environment	National Science Foundation EAR-1441497	Geochemistry and environmental impact of produced waters from the Bakken Formation, North Dakota P13655	Chemistry, Geochemistry	1	1.00
David Henry (S)	City of Tallahassee	Underground Utilities - Water Resources Engineering	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Stormwater Dissolved Organic Matter : Characterization of Leon County Stormwater Lakes by Ultrahigh Resolution Fourier Transform Ion Cyclotron Mass Spectrometry P14725	Engineering	1	3.00
Christoph Aeppli (P)	Woods Hole Oceanographic Institute	Dept Marine Chemistry & Geochemistry	Other - BP/Gulf of Mexico Research Initiative Deep-C Consortia	Molecular level characterization for Carpinteria terrestrial tar pits by comprehensive GC X GC and FT-ICR MS P02314	Chemistry, Geochemistry	1	1.00
Jorien Vonk (S)	University of Utrecht	Earth Sciences/Geochemistry	Other - Netherlands Organization for Scientific Research Veni 863.12.00	Consequences of glacial retreat on meltwater fluxes, geomorphology and carbon release in Svalbard, Norway P14738	Chemistry, Geochemistry	1	1.00
Henderson Cleaves (S)	Institute for Advanced Study	Interdisciplinary Studies	Other - Tokyo Institute of Technology Earth-Life Science Institute	High Resolution Mass Spectrometric Sequence Analysis of Combinatorial Primitive Polyester Libraries P14718	Chemistry, Geochemistry	1	2.00
Viji Sitther (S)	Morgan State University	Biology	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	FT-ICR Analysis of Lipids Produced by Fremyella diplosiphon in Brackish Waters P14723	Chemistry, Geochemistry	1	3.00

APPENDIX I – USER FACILITY STATISTICS

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
A. Ligia Focsan (S)	Valdosta State University	Department of Chemistry	Department of Energy LDK DEFG02-86ER-13465	Investigate neutral radical formation in carotenoids by HDX P14662	Biology, Biochemistry, Biophysics	1	2.00
David Barnidge (S)	Mayo Clinic College of Medicine	Laboratory Medicine and Pathology	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Mass spectrometry analysis of monoclonal immunoglobulins in patients with plasma cell proliferative disorders P14665	Biology, Biochemistry, Biophysics	1	3.00
Martha Chacon (G)	Universidad Industrial de Santander	Analytical Chemistry Department	Other - Bicentenary Scholarship from the Colombian National Program for Ph.D. Studies	Characterization of Extrography Asphaltene subfractions by (+) APPI FT-ICR mass spectrometry P14799	Chemistry, Geochemistry	1	3.00
Patricia Medeiros (S)	University of Georgia	Marine Sciences	National Science Foundation OCE - Division of Ocean Sciences 1356010	Untargeted Characterization of Dissolved Organic Matter Transformations by Bacterioplankton P14726	Chemistry, Geochemistry	1	2.00
Jenna Luek (G)	University of Maryland Center for Environmental Science	Environmental Chemistry	No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)	Identification of halogenated organics in fracking wastewaters P14727	Chemistry, Geochemistry	1	1.00
Paul Mann (S)	Northumbria University	Geography	Other - Northumbria University	Dynamics of DOM composition and microbial function in streams: Investigating the influence of land-cover and permafrost loss across a sub-arctic landscape gradient P14739	Chemistry, Geochemistry	1	2.00
Dave Valentine (S)	University of California Santa Barbara	Department of Geological Sciences	Other - The BP Gulf of Mexico Research Initiative Deep-C	Distinguishing Oil Released from the 2015 Refugio Oil Spill from Natural Seepage in Santa Barbara Basin P12585	Chemistry, Geochemistry	1	4.00
Pamela Vaughan (S)	University of West Florida	Department of Chemistry	Other - Gulf of Mexico Research Consortia Deep-C	Development of Water Accommodated Fractions from MC252 Surrogate Oil:The role of photochemistry P02406	Chemistry, Geochemistry	1	1.00
Michael Freitas (S)	Ohio University Medical Center	Medical Center	National Institutes of Health 5 R01 CA107106 07	Top-down characterization of H1 phosphorylation isoforms P02204	Biology, Biochemistry, Biophysics	1	5.00
Jeff Chanton (S)	Florida State University	Oceanography	National Science Foundation 0628349	Characterization of Peatland DOM by FT-ICR MS P02016	Chemistry, Geochemistry	1	1.00

ICR

APPENDIX I – USER FACILITY STATISTICS

ICR

PI	Organization	Department	Funding Source(s)	Proposal Title & ID#	Proposal Discipline	Experiments Scheduled	# of Days Used
			Department of Energy DE-SC0007144 Department of Energy DE-SC0004632				
Total Proposals:				**106**	**Total Experiments:**	**108**	**962**

APPENDIX II
USER FACILITIES
OVERVIEW

APPENDIX II – USER FACILITIES OVERVIEW

Overall Statistics across All NHMFL User Facilities

Table A- *Instrument Operations*

User Facility	Total # days Instr. Operations[8]	# days to outside users at facility[9]	# days in-house (NHMFL Affiliated) research[10]	# days instrument development and maintenance (Combined)[11]	# days to awardee institution faculty (local)[12]
DC Field [1]	**1,703**	1,236	365	49	53
PF Field [2]	**603**	411	135	29	28
HBT [3]	**842**	606	133	103	0
NMR [4]	**3,321**	1,630	963	350	378
AMRIS [5]	**1,439**	300	420	293	426
EMR [6]	**1,209**	906	113	77	113
ICR [7]	**962**	459	140	307	56

[1] ***Note:*** *Since each resistive magnet requires two power supplies to run and the 45 T hybrid magnet requires three power supplies, there can be four resistive magnets + three superconducting magnets or the 45 T hybrid, two resistive magnets + three superconducting magnets operated in a given week. User Units are defined as magnet days. Users of water-cooled resistive or hybrid magnets can typically expect to receive enough energy for 7 hours a day of magnet usage so a magnet day is defined as 7 hours. Superconducting magnets are scheduled typically 24 hours a day. There is an annual four weeks shutdown in fall of powered DC resistive and hybrid magnets for infrastructure maintenance and a two weeks shutdown period for the university mandated holiday break.*
[2] *User Units are defined as magnet days. Magnets are scheduled typically 12 hours a day.*
[3, 4, 6, 7] *User Units are defined as magnet days. One magnet day is defined as 24 hours in superconducting magnets.*
[5] *User Units are defined as magnet days; time utilized is recorded to the nearest 15 minutes. Magnet-day definitions for AMRIS instruments: Verticals (500, 600s, & 750 MHz), 1 magnet day = 24 hours. Horizontals (4.7, 11.1, and 3T), 1 magnet day = 8 hours. This accounts for the difficulty in running animal or human studies overnight. Magnet days were calculated by adding the total number of real used for each instrument and dividing by 24 (vertical) or 8 (horizontal).* ***Note****: Due to the nature of the 4.7 T, 11 T and 3 T studies, almost all studies with external users were collaborative with UF investigators. In 2014 the 3T system was funded entirely off of non-NHMFL funds but is reported for historical purposes*
[8] *Total # days Instr. Operations = > total days allocated*
[9] *# days to outside users at facility => all U.S. University, U.S. Govt. Lab., U.S. Industry, Non-U.S. excluding NHMFL Affiliated and local and Test, Calibration, Set-up, Maintenance, Inst. Dev.*
[10] *# days in-house (NHMFL Affiliated) research => NHMFL Affiliated only*
[11] *# days instrument development and maintenance (Combined) => test, calibration, set-up, maintenance, inst. Dev.*
[12] *# days to awardee institution faculty (local) => local only*

Table B - *User Program Proposal Pressure by User Facility*

User Facility	# experiments received (requested and deferred)	# experiments reviewed	# days requested in reviewed experiments	# days allocated to outside users	# days allocated to awardee institution personnel (local)	Total # days allocated	% Subscription (# days requested / # days allocated)
DC Field	344	461	3,425	1,236	53	**1,703**	**201%**
PF Field	121	151	1,078	411	28	**603**	**179%**
HBT	13	15	982	606	0	**842**	**117%**
NMR	472	502	3,857	1,630	378	**3,321**	**116%**
AMRIS	2,600	2,600	1,583	300	426	**1,439**	**110%**
EMR	72	102	1,280	906	113	**1,209**	**106%**
ICR	63	119	962	459	56	**962**	**100%**

APPENDIX II – USER FACILITIES OVERVIEW

***Table C** - Funding Source of User's Research- Days allotted (counts)*

User Facility	NSF [including UCGP + No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)]	NIH	DOE	DOD (NASA, U.S. Army, U.S. Navy, U.S. Airforce)	NHMFL VSP	FFI	UF McKnight Brain Institute	Other (Enter the name of e.g. home institution or university; corporation; foundation; academy of science, society, etc.)				Sum (# of days)
								EPA	Interna-tional	National	Indus-try	
DC Field	746	5	366	84	18	0	0	5	309	138	32	**1,703**
PFF	283	0	177	0	0	0	0	0	61	82	0	**603**
HBT	408	0	328	0	0	0	0	0	0	106	0	**842**
NMR	1,287	1,288	1	58	0	0	0	0	160	527	0	**3,321**
AMRIS	536	486	0	22	0	0	45	0	42	293	15	**1,439**
EMR	426	17	151	21	0	0	0	0	302	286	7	**1,209**
ICR	651	31	7	0	0	0	0	0	81	72	120	**962**

***Table D** - Funding Source of User's Research- Fraction of Days allotted (percentage)*

User Facility	NSF [including UCGP + No other support (i.e. this experiment is entirely supported by NHMFL users services via its core grant)]	NIH	DOE	DOD (NASA, U.S. Army, U.S. Navy, U.S. Airforce)	NHMFL VSP	FFI	UF McKnight Brain Institute	Other (Enter the name of e.g. home institution or university; corporation; foundation; academy of science, society, etc.)				Sum (# of days)
								EPA	Interna-tional	National	Indus-try	
DC Field	44%	0%	21%	5%	1%	0%	0%	0%	18%	8%	2%	**1,703**
PFF	47%	0%	29%	0%	0%	0%	0%	0%	10%	14%	0%	**603**
HBT	48%	0%	39%	0%	0%	0%	0%	0%	0%	13%	0%	**842**
NMR	39%	39%	0%	2%	0%	0%	0%	0%	5%	16%	0%	**3,321**
AMRIS	37%	34%	0%	2%	0%	0%	3%	0%	3%	20%	1%	**1,439**
EMR	35%	1%	12%	2%	0%	0%	0%	0%	25%	24%	1%	**1,209**
ICR	68%	3%	1%	0%	0%	0%	0%	0%	8%	7%	12%	**962**

APPENDIX III
GEOGRAPHIC DISTRIBUTION

APPENDIX III – GEOGRAPHIC DISTRIBUTION

1. National Distribution

DC Field Facility

Senior Personnel, U.S.

Name	Organization	Country
Dmytro Abraimov (S/PI)	NHMFL	USA (FL)
Charles Agosta (S/PI)	Clark University	USA (MA)
James Analytis (S/PI)	University of California, Berkeley	USA (CA)
Hongwoo Baek (S)	NHMFL	USA (FL)
Kirk Baldwin (S)	Princeton University	USA (NJ)
Luis Balicas (S/PI)	NHMFL	USA (FL)
Cristian Batista (S)	LANL	USA (NM)
Eric Bauer (S/PI)	LANL	USA (NM)
Ryan Baumbach (S/PI)	NHMFL	USA (FL)
Christianne Beekman (S/PI)	FSU - NHMFL	USA (FL)
Gregory Belenky (S)	SUNY at Stony Brook	USA (NY)
Anand Bhattacharya (S/PI)	Argonne National Laboratory	USA (IL)
Greg Boebinger (S/PI)	NHMFL	USA (FL)
Scott Bole (S)	NHMFL	USA (FL)
Clifford Bowers (S/PI)	UF	USA (FL)
Ivan Bozovic (S/PI)	Brookhaven National Lab	USA (NY)
James Brooks (S/PI)	FSU	USA (FL)
Sergey L Bud'ko (S/PI)	Iowa State University	USA (IA)
Paul Cadden-Zimansky (S/PI)	Bard College	USA (NY)
Paul Canfield (S/PI)	Iowa State University	USA (IA)
Andrey Chabanov (S/PI)	University of Texas at San Antonio	USA (TX)
Joseph Checkelsky (S/PI)	MIT	USA (MA)
Yong Chen (S/PI)	Purdue University	USA (IN)
Sang Wook Cheong (S/PI)	Rutgers University	USA (NJ)
Luisa Chiesa (S/PI)	Tufts University	USA (MA)
Irinel Chiorescu (S/PI)	FSU - NHMFL	USA (FL)
Eun Sang Choi (S/PI)	NHMFL	USA (FL)
C. W. (Paul) Chu (S/PI)	University of Houston	USA (TX)
William Coniglio (S)	NHMFL-FSU	USA (FL)
Jason Cooley (S/PI)	Alloy Design and Development Team, MST-6	USA (NM)
Bryon Dalton (S/PI)	NHMFL	USA (FL)
Timir Datta (S/PI)	University of South Carolina	USA (SC)

APPENDIX III – GEOGRAPHIC DISTRIBUTION

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Lloyd Engel (S/PI)	NHMFL	USA (FL)
Ian Fisher (S/PI)	Stanford University	USA (CA)
Zachary Fisk (S/PI)	University of California Irvine	USA (CA)
Nathanael Fortune (S/PI)	Smith College	USA (MA)
Franz Freibert (S)	LANL	USA (NM)
James Gleeson (S/PI)	Kent State University	USA (OH)
Arno Godeke (S/PI)	NHMFL	USA (FL)
David Goldhaber-Gordon (S/PI)	Stanford University	USA (CA)
David Graf (S/PI)	FSU	USA (FL)
Martin Greven (S/PI)	University of Minnesota	USA (MN)
William Halperin (S/PI)	Northwestern University	USA (IL)
James Hamlin (S/PI)	UF	USA (FL)
Ke Han (S/PI)	NHMFL	USA (FL)
Scott Hannahs (S/PI)	NHMFL	USA (FL)
Neil Harrison (S/PI)	NHMFL - LANL	USA (NM)
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Eric Hellstrom (S)	NHMFL	USA (FL)
Erik Henriksen (S/PI)	Washington University in St. Louis	USA (MO)
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Stephen Hill (S/PI)	NHMFL	USA (FL)
David Hilton (S)	NHMFL	USA (FL)
David Hilton (S/PI)	University of Alabama-Birmingham	USA (AL)
James Hone (S/PI)	Columbia University	USA (NY)
Benjamin Hunt (S/PI)	Carnegie Mellon University	USA (PA)
Harold Hwang (S/PI)	Stanford University	USA (CA)
Marcelo Jaime (S/PI)	NHMFL - LANL	USA (NM)
Antal Jakli (S)	Kent State University	USA (OH)
Marc Janoschek (S/PI)	LANL	USA (NM)
Jan Jaroszynski (S/PI)	NHMFL	USA (FL)
Quanxi Jia (S)	Mpa-cint: center for integrated nanotechnologies	USA (NM)
Jianyi Jiang (S/PI)	NHMFL - ASC	USA (FL)
Zhigang Jiang (S/PI)	Georgia Institute of Technology	USA (GA)
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Junichiro Kono (S/PI)	Rice University	USA (TX)
Jurek Krzystek (S/PI)	NHMFL	USA (FL)
Philip Kuhns (S)	NHMFL	USA (FL)
Cagliyan Kurdak (S/PI)	University of Michigan	USA (MI)
Igor Kuskovsky (S/PI)	Queens College of CUNY	USA (NY)
David Larbalestier (S/PI)	NHMFL	USA (FL)
Chun Ning (Jeanie) Lau (S/PI)	University of California, Riverside	USA (CA)
Minhyea Lee (S/PI)	University of Colorado Boulder	USA (CO)
Lu Li (S/PI)	University of Michigan	USA (MA)
Zhiqiang Li (S/PI)	NHMFL	USA (FL)
Aimin Liu (S/PI)	Georgia State University	USA (GA)
Bernd Lorenz (S)	University of Houston	USA (TX)
Jun Lu (S/PI)	NHMFL	USA (FL)
Serge Luryi (S)	SUNY at Stony Brook	USA (NY)
Kin Fai Mak (S/PI)	Penn State University	USA (PA)
David Mandrus (S/PI)	University of Tennessee	USA (TN)
Michael Manfra (S)	Bell Labs	USA (NJ)
Efstratios Manousakis (S)	FSU	USA (FL)
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Brian Maple (S/PI)	Univ. of California at San Diego	USA (CA)
William Marshall (S)	NHMFL	USA (FL)
James McCusker (S/PI)	Michigan State University	USA (MI)
Ross McDonald (S/PI)	NHMFL - LANL	USA (NM)
Stephen McGill (S/PI)	NHMFL	USA (FL)
Tyrel McQueen (S/PI)	Johns Hopkins University	USA (MD)
Charles Mielke (S/PI)	NHMFL - LANL	USA (NM)
Albert Migliori (S/PI)	LANL	USA (NM)
Ireneusz Miotkowski (S)	Purdue University	USA (IN)
Jeremy Mitchell (S)	LANL	USA (NM)
Vesna Mitrovic (S/PI)	Brown University	USA (RI)
Sheena Murphy (S/PI)	University of Oklahoma	USA (OK)
Tim Murphy (S/PI)	NHMFL	USA (FL)
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Dmitry Smirnov (S/PI)	NHMFL	USA (FL)
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Susanne Stemmer (S/PI)	UC Santa Barbara	USA (CA)
Eden Steven (S/PI)	NHMFL	USA (FL)
Sergey Suchalkin (S/PI)	SUNY at Stony Brook	USA (NY)
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Makoto Takayasu (S/PI)	MIT	USA (MA)
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Danko van der Laan (S/PI)	National Institute of Standards and Technology	USA (CO)
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Kang Wang (S/PI)	UCLA	USA (CA)
Hubertus Weijers (S/PI)	NHMFL	USA (FL)
Jeremy Weiss (S)	NHMFL - ASC	USA (FL)
Ken West (S)	Princeton University	USA (NJ)
James Willit (S)	Argonne National Laboratory	USA (IL)
Jie Wu (S)	Brookhaven National Laboratory	USA (NY)
Aixia Xu (S)	University of Houston	USA (TX)
Xiaodong Xu (S/PI)	University of Washington	USA (WA)
Ziling Xue (S/PI)	University of Tennessee	USA (TN)
Peide Ye (S/PI)	Purdue University	USA (IN)
Ming Yin (S)	Benedict College	USA (SC)
Andrea Young (S/PI)	University of California	USA (CA)
Vivien Zapf (S/PI)	NHMFL - LANL	USA (NM)
Chenglin Zhang (S/PI)	University of Tennessee	USA (TN)
Haidong Zhou (S/PI)	University of Tennessee	USA (TN)
Jun Zhu (S/PI)	Penn State University	USA (PA)
Michael Zudov (S/PI)	University of Minnesota	USA (MN)
172 Users		

Postdocs, U.S.

Name	Organization	Country
Amal Al-Wahish (P)	University of Tennessee	USA (TN)
Biplob Barman (P)	University of Alabama at Birmingham	USA (AL)
Christopher Beedle (P/PI)	NHMFL	USA (NM)
Michael Bishop (P)	NHMFL	USA (FL)
Ernesto Bosque (P)	NHMFL	USA (FL)
Nicholas Breznay (P)	Lawrence Berkeley National Lab	USA (CA)
Xinghan Cai (P)	University of Washington	USA (WA)
Zhiguo Chen (P)	NHMFL	USA (FL)
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Deepu George (P)	Virginia Tech	USA (VA)
Audrey Grockowiak (P)	NHMFL	USA (FL)
Jeonghoon Ha (P)	NHMFL	USA (FL)
Zheng Han (P)	The City College of New York	USA (NY)
Anthony Hatke (P)	NHMFL - FSU	USA (FL)
Qinglin He (P)	UCLA	USA (CA)
Binhui Hu (P)	University of Maryland	USA (MD)
Jin Hu (P)	Tulane University	USA (LA)
Youngduck Kim (P)	Columbia University	USA (NY)
Andhika Kiswandhi (P)	University of Texas at Dallas	USA (TX)
Alexey Kovalev (P)	NHMFL	USA (FL)
Gil-Ho Lee (P)	Harvard University	USA (MA)
Joon Sue Lee (P)	Pennsylvania State University	USA (PA)
Gang Li (P)	University of Michigan	USA (MI)
Jia Li (P)	Columbia University	USA (NY)
Chi-Te Liang (P)	Stanford/NTU TaIwan	USA (CA)
Cunming Liu (P)	University of South Florida	USA (FL)
Minhao Liu (P)	Princeton University	USA (NJ)
Ruiyuan Liu (P)	Rice University	USA (TX)
Margherita Maiuri (P)	Princeton University	USA (NJ)
Catalin Martin (P/PI)	Ramapo College of New Jersey	USA (NJ)
Inanc Meric (P)	Columbia University	USA (NY)
Nihar Pradhan (P)	NHMFL	USA (FL)
Brad Ramshaw (P/PI)	NHMFL - LANL	USA (NM)
Sheng Ran (P)	UCSD	USA (CA)
Rebeca Ribeiro Palau (P)	Columbia University	USA (NY)
Javad Shabani (P)	University of California, Santa Barbara	USA (CA)
Sufei Shi (P)	UC Berkeley	USA (CA)
Zhenzhong Shi (P)	FSU	USA (FL)
Zhiwen Shi (P)	University of California, Berkeley	USA (CA)
Keshav Shrestha (P)	Idaho National Laboratory	USA (ID)
Takehito Suzuki (P)	MIT	USA (MA)
Komalavalli Thirunavukkuarasu (P)	NHMFL	USA (FL)
Jifa Tian (P)	Purdue University	USA (IN)
Paul Tobash (P)	LANL	USA (NM)
Takahisa Tokumoto (P)	University of Alabama at Birmingham	USA (AL)

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Ke Wang (P)	Harvard University	USA (MA)
Kefeng Wang (P)	University of Maryland College Park	USA (MD)
Shengyu Wang (P)	NHMFL	USA (FL)
Bo Wen (P)	Columbia University	USA (NY)
Hua Wen (P)	Penn State University	USA (PA)
Xiaoxiang Xi (P)	Penn State University	USA (PA)
Liang Yin (P/PI)	UF	USA (FL)
Guichuan Yu (P)	University of Minnesota	USA (MN)
Bin Zeng (P)	NHMFL	USA (FL)
61 Users		

Students, U.S.

Name	Organization	Country
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Naweem Anand (G)	UF	USA (FL)
Christopher Aoyama (G)	UF	USA (FL)
Ghidewon Arefe (G)	Columbia University	USA (NY)
Tomoya Asaba (G)	University of Michigan	USA (MI)
Paul Baity (G)	NHMFL	USA (FL)
Jesse Balgley (G)	Columbia University	USA (NY)
Kevin Barry (G)	FSU	USA (FL)
Shermane Benjamin (G)	FSU	USA (FL)
Andrew Bestwick (G)	Stanford University	USA (CA)
Rishi Bhandia (U)	Occidental College	USA (CA)
Lakshmi Bhaskaran (G)	FSU	USA (FL)
Daniel Brown (G/PI)	NHMFL	USA (FL)
Shayne Cairns (G)	University of Oklahoma	USA (OK)
Laura Casto (G)	University of Tennessee	USA (TN)
Pavan Kumar Challa (G)	Kent State University	USA (OH)
Ali Charkhesht (G)	Virginia Tech	USA (VA)
Shi Che (G)	University of California, Riverside	USA (CA)
Kuan-Wen Chen (G)	NHMFL - FSU	USA (FL)
Peng Chen (G)	NHMFL - ASC	USA (FL)
Shaowen Chen (G)	Columbia University	USA (NY)
Xunchi Chen (G)	Georgia Institute of Technology	USA (GA)
Zhuoyu Chen (G)	Stanford University	USA (CA)
Amanda Clune (G)	University of Tennessee	USA (TN)
Kankan Cong (G)	Rice University	USA (TX)
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Liping Deng (G/PI)	FSU	USA (FL)
Aravind Devarakonda (G)	MIT	USA (MA)
Prasenjit Dey (G)	University of South Florida	USA (FL)
Siddharth Dhomkar (G)	Queens College of CUNY	USA (NY)
Georgi Diankov (G)	Stanford University	USA (CA)
Eileen Dixon (G)	Michigan State University	USA (MI)
Lingjie Du (G)	Rice University	USA (TX)
Yuchen Du (G)	Purdue University	USA (IN)
Zhiling Dun (G)	University of Tennessee	USA (TN)
Yun Suk Eo (G)	University of Michigan	USA (MI)
Babak Fallahazad (G)	University of Texas at Austin	USA (TX)
Shiyu Fan (G)	University of Tennessee	USA (TN)
Yu Fan (G)	University of Michigan	USA (MI)
Carlos Forsythe (G)	Columbia University	USA (NY)
Andrew Gallagher (G)	FSU - NHMFL	USA (FL)
Tong Gao (G)	Princeton University	USA (NJ)
Yuanda Gao (G)	Columbia University	USA (NY)
Carlos Garcia (G)	FSU	USA (FL)
Nathaniel Gillgren (G)	UC Riverside	USA (CA)
Paula Giraldo Gallo (G)	Stanford University	USA (CA)
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Daniel Jackson (G)	UF	USA (FL)
Cody Jett (U)	University of Alabama at Birmingham	USA (AL)
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Jonathon Kemper (G/PI)	FSU	USA (FL)
Nikesh Koirala (G)	Rutgers University	USA (NJ)
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Yangmu Li (G)	University of Minnesota	USA (MN)
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Lucy Liang (U)	Smith College	USA (MA)
Tian Liang (G)	Princeton University	USA (NJ)
Jinyu Liu (G)	Tulane University	USA (LA)
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Yang Liu (G)	Princeton University	USA (NJ)
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Max Meynig (U)	Bard College	USA (NY)
Evgeny Mikheev (G)	University of California, Santa Barbara	USA (CA)
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Vikram Nagarajan (U)	University of Minnesota	USA (MN)
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Yanmeng Shi (G)	University of California, Riverside	USA (CA)
En-Min Shih (G)	Columbia University	USA (NY)
Borzoyeh Shojaei (G)	University of California Santa Barbara	USA (CA)
Peter Siegfried (G)	University of Colorado Boulder	USA (CO)
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Ross Terrell (G)	Georgia State University	USA (GA)
Kevin Tharratt (G)	Stanford	USA (CA)
Colin Tinsman (G)	University of Michigan	USA (MI)
John Tokarski (G)	UF	USA (FL)
Yevhen Tupikov (G)	Penn State University	USA (PA)
Derrick VanGennep (G)	UF	USA (FL)
Michael Veit (G)	Stanford University	USA (CA)
Lei Wang (G)	Columbia University	USA (NY)
Lei Wang (G)	University of South Carolina	USA (SC)
Wudi Wang (G)	Princeton University	USA (NJ)
Zefang Wang (G)	Penn State University	USA (PA)
Zhengjun Wang (G)	West Virginia University	USA (WV)
Mark Wartenbe (G/PI)	FSU	USA (FL)
Maya Weingrod Sandor (U)	Bard College	USA (NY)
Steven Wolgast (G)	University of Michigan	USA (MI)
Ryan Wood (G)	UF	USA (FL)
Rong Wu (G)	Queens College of CUNY	USA (NY)
Sanfeng Wu (G)	University of Washington	USA (WA)
Yizhou Xin (G)	Northwestern University	USA (IL)
Jun Xiong (G)	Princeton University	USA (NJ)
Yang Xu (G)	Purdue University	USA (IN)
Jeremy Yang (G)	Georgia Institute of Technology	USA (GA)
Mohamad Meqdad Yazdanpanah (G)	University of Maryland	USA (MD)
Linda Ye (G)	MIT	USA (MA)
Liyang Ye (G)	Fermi National Accelerator Laboratory and North Carolina State University	USA (IL)
Chongyue Yi (G)	FSU	USA (FL)
Jun Yin (G)	Columbia University	USA (NY)
Michael Yokosuk (G)	University of Tennessee	USA (TN)
Hyeok Yoon (G)	Stanford University	USA (CA)

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Wenlong Yu (G)	Georgia Institute of Technology	USA (GA)
Biwen Zhang (G)	FSU	USA (FL)
Qi Zhang (G)	Rice University	USA (TX)
Qiu Zhang (G)	NHMFL	USA (FL)
Xiaoxiao Zhang (G)	Columbia University	USA (NY)
Hong Zhou (G)	Purdue University	USA (IN)
Mengze Zhu (G)	Michigan State University	USA (MI)
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Technician, U.S.

Name	Organization	Country
Scott Maier (T)	NHMFL	USA (FL)
Dmitry Semenov (T/PI)	NHMFL	USA (FL)
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Pulsed Field Facility

Senior Personnel, U.S.

Name	Organization	Country
Moaz Altarawneh (S/PI)	NHMFL - LANL	USA (NM)
James Analytis (S/PI)	University of California, Berkeley	USA (CA)
Fedor Balakirev (S/PI)	NHMFL - LANL	USA (NM)
Luis Balicas (S/PI)	NHMFL	USA (FL)
Cristian Batista (S)	LANL	USA (NM)
Eric Bauer (S/PI)	LANL	USA (NM)
Ryan Baumbach (S/PI)	NHMFL	USA (FL)
Jonathan Betts (S/PI)	LANL	USA (NM)
Greg Boebinger (S/PI)	NHMFL	USA (FL)
Ivan Bozovic (S/PI)	Brookhaven National Lab	USA (NY)
Sergey L Bud'ko (S/PI)	Iowa State University	USA (IA)
Nicholas Butch (S/PI)	National Institute of Standards and Technology	USA (MD)
Paul Canfield (S/PI)	Iowa State University	USA (IA)
Gang Cao (S/PI)	University of Kentucky	USA (KY)
Sang Wook Cheong (S/PI)	Rutgers University	USA (NJ)
William Coniglio (S)	NHMFL-FSU	USA (FL)
Scott Crooker (S/PI)	LANL	USA (NM)
Nicholas Curro (S/PI)	University of California	USA (CA)
John DiTusa (S)	Louisiana State University	USA (LA)
Kirk Flippo (S/PI)	LANL	USA (NM)
Krzysztof Gofryk (S/PI)	Idaho National Laboratory	USA (ID)

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Richard Greene (S/PI)	University of Maryland	USA (MD)
Genda Gu (S)	Brookhaven National Lab	USA (NY)
Neil Harrison (S/PI)	NHMFL - LANL	USA (NM)
Zahid Hasan (S)	Princeton University	USA (NJ)
Eric Hellstrom (S)	NHMFL	USA (FL)
Pei-Chun Ho (S/PI)	California State University, Fresno	USA (CA)
Michael Hoch (S/PI)	NHMFL	USA (FL)
Eric Isaacs (S)	Argonne National Laboratory	USA (IL)
Marcelo Jaime (S/PI)	NHMFL - LANL	USA (NM)
Jason Jeffries (S)	Lawrence Livermore National Laboratory	USA (CA)
Jianyi Jiang (S/PI)	NHMFL - ASC	USA (FL)
Xianglin Ke (S/PI)	Michigan State University	USA (MI)
Junichiro Kono (S/PI)	Rice University	USA (TX)
Cagliyan Kurdak (S/PI)	University of Michigan	USA (MI)
Lu Li (S/PI)	University of Michigan	USA (MA)
Boris Maiorov (S/PI)	LANL	USA (NM)
Jamie Manson (S/PI)	Eastern Washington University	USA (WA)
Zhiqiang Mao (S/PI)	Tulane University	USA (LA)
Brian Maple (S/PI)	Univ. of California at San Diego	USA (CA)
Ross McDonald (S/PI)	NHMFL - LANL	USA (NM)
Charles Mielke (S/PI)	NHMFL - LANL	USA (NM)
John Mitchell (S/PI)	Argonne National Laboratory	USA (IL)
Emilia Morosan (S/PI)	Rice University	USA (TX)
Tim Murphy (S/PI)	NHMFL	USA (FL)
Janice Musfeldt (S/PI)	University of Tennessee, Knoxville	USA (TN)
Martin Nikolo (S/PI)	Saint Louis University	USA (MO)
N. Phuan Ong (S/PI)	Princeton University	USA (NJ)
Wei Pan (S/PI)	Sandia National Laboratories	USA (NM)
Ju-Hyun Park (S/PI)	NHMFL	USA (FL)
Dwight Rickel (S/PI)	NHMFL - LANL	USA (NM)
Scott Riggs (S/PI)	NHMFL	USA (FL)
James Rondinelli (S)	Northwestern University	USA (IL)
Filip Ronning (S/PI)	LANL	USA (NM)
Myron Salamon (S/PI)	University of Texas at Dallas	USA (IL)
John Schlueter (S/PI)	Argonne National Laboratory	USA (IL)
Arkady Shehter (S/PI)	NHMFL	USA (FL)
John Singleton (S/PI)	NHMFL - LANL	USA (NM)

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Haiyan Wang (S/PI)	Texas A&M University	USA (TX)
Jeremy Weiss (S)	NHMFL - ASC	USA (FL)
Jie Wu (S)	Brookhaven National Laboratory	USA (NY)
Anvar Zakhidov (S)	University of Texas at Dallas	USA (TX)
Vivien Zapf (S/PI)	NHMFL - LANL	USA (NM)
Rena Zieve (S/PI)	University of California, Davis	USA (CA)
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Postdocs, U.S.

Name	Organization	Country
Hirofumi Akamatsu (P)	Pennsylvania State University	USA (PA)
Nicholas Breznay (P)	Lawrence Berkeley National Lab	USA (CA)
Mun Chan (P/PI)	LANL	USA (NM)
Shalinee Chikara (P/PI)	NHMFL - LANL	USA (NM)
Jose Galvis Echeverri (P)	NHMFL	USA (FL)
Audrey Grockowiak (P)	NHMFL	USA (FL)
Tian-Heng Han (P/PI)	University of Chicago	USA (IL)
Jae Wook Kim (P)	Rutgers University	USA (NJ)
Gang Li (P)	University of Michigan	USA (MI)
Li Li (P)	unknown	USA (KY)
Catalin Martin (P/PI)	Ramapo College of New Jersey	USA (NJ)
Brad Ramshaw (P/PI)	NHMFL - LANL	USA (NM)
Keshav Shrestha (P)	Idaho National Laboratory	USA (ID)
Andreas Stier (P/PI)	LANL	USA (NM)
Franziska Weickert (P/PI)	LANL	USA (NM)
Jie Yong (P)	University of Maryland	USA (MD)
Bin Zeng (P)	NHMFL	USA (FL)
Zengwei Zhu (P/PI)	LANL	USA (NM)
18 Users		

Students, U.S.

Name	Organization	Country
Nasser Alidoust (G)	Princeton University	USA (NJ)
Tomoya Asaba (G)	University of Michigan	USA (MI)
Kuan-Wen Chen (G)	NHMFL - FSU	USA (FL)
Amanda Clune (G)	University of Tennessee	USA (TN)
Nicholas Cornell (G/PI)	University of Texas at Dallas	USA (TX)
John Crocker (G)	UC Davis	USA (CA)
Andrew Gallagher (G)	NHMFL - FSU	USA (FL)

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Joshua Higgins (G)	Center for Superconductivity Research	USA (TX)
Maximilian Hirschberger (G)	Princeton University	USA (NJ)
Tai Kong (G)	Iowa State University	USA (IA)
Oleksandr Korneta (G)	University of Kentucky	USA (KY)
Ben Lawson (G)	University of Michigan	USA (MI)
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Shiming Lei (G)	Pennsylvania State University	USA (PA)
I-LIn Liu (G)	University of Maryland	USA (MD)
Yongkang Luo (G/PI)	Princeton University	USA (NJ)
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Kimberly Modic (G/PI)	LANL	USA (NM)
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Tess Smidt (G)	University of California Berkeley	USA (CA)
Ryan Stillwell (G)	NHMFL	USA (FL)
Eteri Svanidze (G)	Rice University	USA (TX)
Yazhong Wang (G)	Rutgers	USA (NJ)
Mark Wartenbe (G/PI)	FSU	USA (FL)
Steven Wolgast (G)	University of Michigan	USA (MI)
Qiu Zhang (G)	NHMFL	USA (FL)
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Technician, U.S. - 0

High B/T Facility

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Name	Organization	Country
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Jian Huang (S/PI)	Wayne State University	USA (MI)
Michael Lilly (S)	Sandia National Labs	USA (NM)
Naoto Masuhara (S/PI)	UF	USA (FL)
Wei Pan (S/PI)	Sandia National Laboratories	USA (NM)
Loren Pfeiffer (S)	Princeton University	USA (NJ)

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Neil Sullivan (S)	UF	USA (FL)
Yasu Takano (S/PI)	UF	USA (FL)
Jian-Sheng Xia (S)	UF	USA (FL)
Haidong Zhou (S/PI)	University of Tennessee	USA (TN)
12 Users		

Postdocs, U.S.

Name	Organization	Country
Alessandro Serafin (P)	UF	USA (FL)
Liang Yin (P/PI)	UF	USA (FL)
2 Users		

Students, U.S.

Name	Organization	Country
Blaine Bush (G)	University of California at Davis	USA (CA)
Daniel Jackson (G)	UF	USA (FL)
Andrew Padgett (G)	UF	USA (FL)
Tracy Stevenson (U)	UF	USA (FL)
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NMR Facility

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Rufina Alamo (S/PI)	FAMU/FSU College of Engineering	USA (FL)
Rajendra Arora (S)	FAMU/FSU College of Engineering	USA (FL)
Chulsung Bae (S/PI)	Rensselaer Polytechnic Institute	USA (NY)
Jeanine Brady (S)	UF	USA (FL)
William Brey (S/PI)	NHMFL	USA (FL)
Thomas Budinger (S/PI)	LBNL	USA (CA)
David Busath (S/PI)	Brigham Young University	USA (UT)
Marc Caporini (S)	Bruker Biospin	USA (MA)
Leah Casabianca (S/PI)	Clemson University	USA (SC)
Srinivasan Chandrashekar (S/PI)	FAMU-FSU	USA (FL)
Eduard Chekmenev (S/PI)	Vanderbilt University	USA (TN)
Bo Chen (S/PI)	University of Central Florida	USA (FL)
Hailong Chen (S/PI)	Georgia Institute of Technology	USA (GA)
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Tim Cross (S/PI)	FSU	USA (FL)
Naresh Dalal (S/PI)	FSU	USA (FL)
Mark Davis (S/PI)	California Institute of Technology	USA (CA)
Arthur Edison (S/PI)	UF	USA (FL)
Elan Eisenmesser (S/PI)	University of Colorado Health Sciences Center	USA (CO)
Gail Fanucci (S/PI)	UF	USA (FL)
Riqiang Fu (S/PI)	NHMFL	USA (FL)
Zhehong Gan (S/PI)	FSU	USA (FL)
Petr Gor'kov (S/PI)	NHMFL	USA (FL)
Samuel Grant (S/PI)	NHMFL - FSU	USA (FL)
Clare Grey (S/PI)	State University of New York at Stony Brook	USA (NY)
Patrick Griffin (S)	The Scripps Research Institute—Scripps Florida	USA (FL)
James Guest (S/PI)	University of Miami	USA (FL)
Lisa Hall (S)	Ohio State University	USA (OH)
Daniel Hallinan (S)	FSU	USA (FL)
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David Hilton (S)	NHMFL	USA (FL)
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Nabanita Das (P)	University of Colorado-Boulder	USA (CO)
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Dylan Murray (P)	The National Institutes of Health	USA (MD)
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Andrea Santamaria (P)	University of Miami	USA (FL)
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Maxwell Zimmerman (G)	FSU	USA (FL)
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Amin	Manish	UF	USA	FL
Arbogast	Jannik	UF	USA	FL
Ashizawa	Tetsuo	UF	USA	FL
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Baligand	Celine	UF	USA	FL
Banan	Guita	UF	USA	FL
Barton	Elizabeth	UF	USA	FL
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Batra	Abhinandan	UF	USA	FL
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Bhatt	Avni	UF	USA	FL
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Bonnenman	Carsten	National Institutes of Health	USA	MD
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Edison	Art	UF	USA	FL
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Fanucci	Gail	UF	USA	FL
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Fernandez-Funez	Pedro	UF	USA	FL
Fizgerald	David	UF	USA	FL
Flint	Jeremy	UF	USA	FL
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Forder	John	UF	USA	FL
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Gregg	Anthony	UF	USA	FL
Gullet	Joseph	UF	USA	FL
Guo	Yi	UF	USA	FL
Guy	Charles	UF	USA	FL
Hagelin-Weaver	Helena	UF	USA	FL
Hahn	Dan	UF	USA	FL
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Hanson	Andrew	UF	USA	FL
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Heldermon	Coy	UF	USA	FL
Hey	Matthew	UF	USA	FL
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Kasinadhuni	Aditya	UF	USA	FL
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Lee-McMullen	Brittany	UF	USA	FL
Levy	Charles	Veterans Affairs	USA	FL
Li	Hong	Rush University	USA	IL
Liang	X	UF	USA	FL
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Lilleskov	Erik	Northern Research Station	USA	MI
Lim	Woo Taek	UF	USA	FL
Liu	Zhanglong	UF	USA	FL
Lively	Ryan	Georgia Institute of Technology	USA	GA
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Lott	Donovan	UF	USA	FL
Ludden	Kaylee	UF	USA	FL
Luesch	Hendrik	UF	USA	FL
Lukjan	Suzanne	Troy University	USA	AL
Lumata	Lloyd	University of Texas Dallas	USA	TX
Luo	Danmeng	UF	USA	FL
Ma	Jingfeng	UF	USA	FL
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Mareci	Thomas	UF	USA	FL
Martin	Glenroy	University of Tampa	USA	FL
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McNally	Elizabeth	University of Illinois Chicago	USA	IL
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Notterpek	Lucia	UF	USA	FL
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Okun	Michael	UF	USA	FL
Pasternak	Ofer	HarVeterans Affairs University	USA	MA
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Penman	Christy	UF	USA	FL
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Plant	Daniel	UF	USA	FL
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Powers	Cathy	UF	USA	FL
Prather	Robert	UF	USA	FL
Qi	Xin	UF	USA	FL
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Tari	Ana	UF	USA	FL
Tate	J	University of Alabama	USA	AL
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Thapa	Bibek	University of Puerto Rico	USA	PR
Tisher	Craig	UF	USA	FL
Tokarski III	John	UF	USA	FL
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Evert Duin (S/PI)	Auburn University	USA (AL)
John Engen (S/PI)	Northeastern University	USA (MA)
Danna Freedman (S/PI)	Northwestern University	USA (IL)
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Stephen Hill (S/PI)	NHMFL	USA (FL)
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Tobin Marks (S)	Northwestern University	USA (IL)
Alan Marshall (S/PI)	NHMFL	USA (FL)
Fabio Matta (S/PI)	University of South Carolina	USA (SC)
Amy McKenna (S/PI)	NHMFL	USA (FL)
Andrew Ozarowski (S/PI)	NHMFL	USA (FL)
Ellis Reinherz (S/PI)	Dana-Farber Cancer Institute	USA (MA)
Ryan Rodgers (S/PI)	NHMFL	USA (FL)
Michael Shatruk (S/PI)	FSU	USA (FL)
Dmitry Smirnov (S/PI)	NHMFL	USA (FL)
Likai Song (S/PI)	NHMFL	USA (FL)
Albert Stiegman (S/PI)	FSU	USA (FL)
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Sungsool Wi (S/PI)	NHMFL	USA (FL)
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Haidong Zhou (S/PI)	University of Tennessee	USA (TN)
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Thierry Dubroca (P)	NHMFL	USA (FL)
Ivan Hung (P)	NHMFL	USA (FL)
Jin Jung Kweon (P)	NHMFL	USA (FL)
Adrian Lita (P)	FSU	USA (FL)
Hans Malissa (P)	University of Utah	USA (UT)
Vasanth Ramachandran (P)	FSU	USA (FL)
Srinivasa Rao Singamaneni (P/PI)	North Carolina State University	USA (NC)
Sebastian Stoian (P)	NHFML FSU	USA (FL)
Komalavalli Thirunavukkuarasu (P)	NHMFL	USA (FL)
Joe Zadrozny (P)	Northwestern University	USA (IL)
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Adewale Akinfaderin (G)	FSU	USA (FL)
Matthew Barragan (G)	University of South Carolina	USA (SC)
Livia Batista Lopes Escobar (G)	FSU	USA (FL)
Shermane Benjamin (G)	FSU	USA (FL)
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George Aiken (S/PI)	U.S. Geological Survey	USA (CO)
Jonathan Amster (S/PI)	University of Georgia	USA (GA)
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Dennis Phillips (S)	University of Georgia	USA (GA)
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Huimin Zhang (S)	Merck Research Laboratories, Merck & Co., Inc	USA (NJ)
Lichao Zhang (S)	University of Virginia	USA (VA)
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Postdocs, U.S.

Name	Organization	Country
Christoph Aeppli (P/PI)	Woods Hole Oceanographic Institute	USA (MA)
Lissa Anderson (P/PI)	NHMFL	USA (FL)
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Jackie Jarvis (P/PI)	NHMFL	USA (FL)
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Kyle Noble (P)	FSU	USA (FL)
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Emma Spencer (P)	FSU	USA (FL)
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Nicholas Ward (P)	UF	USA (FL)
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Shelby Boyd (U)	University of South Alabama	USA (AL)
Taylor Brown (U)	University of South Alabama	USA (AL)
Brandon Buchel (U)	University of South Alabama	USA (AL)
David Buck (G)	University of Texas at El Paso	USA (TX)
Maira Cerón (G)	University of Texas at El Paso	USA (TX)
Tong Chen (G)	NHMFL	USA (FL)
Amy Clingenpeel (G)	FSU	USA (FL)
Xibei Dang (G)	Ion Cyclotron Resonance	USA (FL)
Ellen Daugherty (G)	Colorado State University	USA (CO)
Samantha Davila (G)	University of Mississippi	USA (MS)
Joshua Driver (G)	University of Georgia	USA (GA)
Pengfei Fang (G)	The Scripps Research Institute	USA (FL)
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Raaj Ghosal (U)	University of South Alabama	USA (AL)
Wendi Hale (G)	University of Michigan	USA (MI)
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Carolyn Hutchinson (G)	Iowa State University	USA (IA)
Kevin Ileka (G)	University of Michigan	USA (MI)
Tao Jiang (G)	University of Michigan	USA (MI)
Tingting Jiang (G)	ICR	USA (FL)
Caroline Johansen (G)	FSU	USA (FL)
Joshua Johnson (U)	Gardner-Webb University	USA (NC)
Panitan Jutaporn (G)	University of North Carolina at Chapel Hill	USA (NC)
Héctor Koolen (G/PI)	Woods Hole Oceanographic Institution	USA (MA)
Logan Krajewski (G)	NHMFL and FSU	USA (FL)
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Misty Mangiacapre (G)	University of North Carolina Wilmington	USA (NC)
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Malak Missilmani (G)	FSU	USA (FL)
Genevieve Mullen (U)	University of South Alabama	USA (AL)
Jeremy Nowak (G)	UC-Berkeley	USA (CA)
Sydney Plummer (U)	Valdosta State University	USA. (GA)
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Danisha Rivera-Nazario (G)	University of Texas at El Paso	USA (TX)
Melissa Rizor (U)	Christopher Newport University	USA (VA)
Nikole Roland (U)	Gardner-Webb University	USA (NC)
Alysha Sheets (U)	FSU	USA (FL)
Michael Shields (G)	UF	USA (FL)
Alan Shomo (G)	FSU	USA (FL)
Brian Spetman (G)	FSU	USA (FL)
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Jie Lu (T/PI)	NHMFL	USA (FL)
Jonathan Putman (T)	FSU	USA (FL)
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Alimamy Bangura (S/PI)	Max Planck Institute for Solid State Physics	Germany
Doug Bonn (S/PI)	University of British Columbia	Canada
David Cardwell (S/PI)	University of Cambridge	UK
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Shinji Kawasaki (S)	Okayama University	Japan
Naoki Kikugawa (S/PI)	National Institute for Materials Science	Japan
Jun Sung Kim (S/PI)	POSTECH	Korea
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Vadim Grinenko (P)	IFW Dresden	Germany
Toni Helm (P)	MaxPlanck Institute for chemical physics in solids	Germany
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Min Park (G)	Graduate School of Convergence Science and Technology, Seoul National University	Republic of Korea
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Fangyuan Yang (G)	Fudan University	China
Kyongjun Yoo (G)	Seoul National University	Korea
Feifei Yuan (G)	IFW Dresden	Germany
Xiang Yuan (G)	Fudan University	China
Cheng Zhang (G)	Fudan University	China
Po Zhang (G)	Peking University	China
51 Users		

Technician, Non-U.S.

Name	Organization	Country
Tony Dennis (T)	University of Cambridge	UK
Simon Fortier (T)	Université de Sherbrooke	Canada
2 Users		

Pulsed Field Facility
Senior Personnel, non-U.S.

Name	Organization	Country
Michael Baenitz (S/PI)	Max Planck Institute for chemical physics of Solids	Germany
Geetha Balakrishnan (S/PI)	University of Warwick, Coventry	UK
Doug Bonn (S/PI)	University of British Columbia	Canada
Radu Coldea (S)	University of Oxford	UK
James Day (S)	University of British Columbia	Canada
Takao Ebihara (S/PI)	Shizuoka University	Japan
Paul Goddard (S/PI)	Warwick University	UK
Jean-Christophe Griveau (S)	Institute for Transuranium Elements	Germany
Walter Hardy (S)	University of British Columbia	Canada
Shuang Jia (S/PI)	Peking University (Non-U.S. University)	China
Naoki Kikugawa (S/PI)	National Institute for Materials Science	Japan
Yoshiharu Krockenberger (S)	NTT Basic Research Laboratories	Japan
Ruixing Liang (S)	University of British Columbia	Canada
Gil Lonzarich (S/PI)	Cambridge University	UK
Eun Deok Mun (S/PI)	Simon Frazer University	Canada

APPENDIX III – GEOGRAPHIC DISTRIBUTION

Name	Organization	Country
Guillaume Radtke (S)	Université Pierre et Marie Curie	France
Gwenaelle Rousse (S/PI)	UPMC	France
Marcus Schmidt (S)	MPG	Germany
Suchitra Sebastian (S/PI)	Cambridge University	UK
Raivo Stern (S/PI)	NICPB	Estonia
Stefan Sullow (S/PI)	TU Braunschweig	Germany
Hidekazu Tanaka (S/PI)	Tokyo Institute of Technology	Japan
Alexander Tsirlin (S/PI)	National Institute of Chemical Physics and Biophysics	Estonia
Huiqiu Yuan (S/PI)	Zhejiang University	China
24 Users		

Postdocs, Non-U.S.

Name	Organization	Country
Monica Ciomaga Hatnean (P)	University of Warwick	UK
Toni Helm (P)	Max Planck Institute for Chemical Physics of Solids	Germany
Nobuyuki Kurita (P)	Tokyo Institute of Technology	Japan
Mayukh Majumder (P)	Max Planck Institute for Chemical Physics of Solids	Germany
4 Users		

Students, Non-U.S.

Name	Organization	Country
William Blackmore (G)	University of Warwick	UK
Jamie Brambleby (G)	University of Warwick	UK
Yu Hsu (G)	University of Cambridge	UK
Lin Jiao (G)	Zhejiang University	China
Masato Koike (G)	Tokyo Institute of Technology	Japan
Hong Lu (G)	Peking University	China
Philip Moll (G/PI)	ETH Zurich	Switzerland
Meiling Sun (G)	Collège de France	France
Beng Tan (G)	University of Cambridge	UK
Zeji Wang (G)	Peking University	China
Zongfa Weng (G)	Zhejiang University	China
Chenglong Zhang (G)	Peking University	China
12 Users		

Technician, Non-U.S. - 0

APPENDIX III – GEOGRAPHIC DISTRIBUTION

High B/T Facility

Senior Personnel, non-U.S.

Name	Organization	Country
Guillaume Gervais (S/PI)	McGill University	Canada
1 Users		

Postdocs, Non-U.S. - 0

Students, Non-U.S.

Name	Organization	Country
Simon Bilodeau (G)	McGill University	Canada
Dominique Laroche (G)	McGill University	Canada
2 Users		

Technician, Non-U.S. - 0

NMR Facility

Senior Personnel, non-U.S.

Name	Organization	Country
Lia Addadi (S)	Weizmann Institute of Science	Israel
Jean-Paul Amoureux (S/PI)	Université des Sciences et Technologies de Lille	France
Henrik Bildsoe (S)	Aarhus University	Denmark
Michael Brorson (S)	Haldor Topsoe	Denmark
Leonid Brown (S)	University of Guelph	Canada
Jean-Nicolas Dumez (S)	Centre National de la Recherche Scientifique (CNRS)	France
Lucio Frydman (S/PI)	Weizmann Institute of Science	Israel
Yuval Golan (S)	Ben Gurion University of the Negev	Israel
Hans Jakobsen (S/PI)	University of Aarhus	Denmark
Svend Knak Jensen (S)	Aarhus University	Denmark
Antonios Kolocouris (S)	National and Kapodistrian University of Athens	Greece
Mark Ladd (S)	German Cancer Research Center (DKFZ)	Germany
Vladimir Ladizhansky (S/PI)	University of Guelph	Canada
Conggang Li (S/PI)	Wuhan Institute of Physics & Mathematics, Chinese Academy of Sciences	China
Armin Nagel (S/PI)	German Cancer Research Center (DKFZ)	Germany
Tangi Roussel (S)	Weizmann Institute of Science	Israel

APPENDIX III – GEOGRAPHIC DISTRIBUTION

Name	Organization	Country
Lothar Schad (S)	Heidelberg University	Germany
Robert Schurko (S/PI)	University of Windsor	Canada
Noam Shemesh (S)	Champalimaud Neuroscience Programme, Champalimaud Centre for the Unknown	Portugal
Jorgen Skibsted (S)	Aarhus University	Denmark
Reiner Umathum (S)	German Cancer Research Center (DKFZ)	Germany
Steve Weiner (S)	Weizmann Institute of Science	Israel
Gang Wu (S/PI)	Queen's University	Canada
23 Users		

Postdocs, Non-U.S.

Name	Organization	Country
Xianqi Kong (P)	Queen's University	Canada
Manuela Rosler (P)	German Cancer Research Center (DKFZ)	Germany
Laura Santonja-Blasco (P)	Polytechnic University of Valencia	Spain
Sebastian Sart (P)	CNRS, Ecole Polytechnique	France
4 Users		

Students, Non-U.S.

Name	Organization	Country
David Bolton (G)	University of Guelph	Canada
James De Santis (U)	University of Windsor	Canada
Yuwei Ge (G)	Wuhan Institute of Physics and Mathematics, the Chinese Academy of Sciences	China
David Hirsh (G)	University of Windsor	Canada
Michael Jaroszewicz (G)	University of Windsor	Canada
Andrew Namespetra (U)	University of Windsor	Canada
Andreas Neubauer (G)	Heidelberg University	Germany
Anthony Sandre (U)	University of Windsor	Canada
Stanislav Veinberg (G)	University of Windsor	Canada
Meaghan Ward (G)	University of Guelph	Canada
10 Users		

Technician, Non-U.S. - 0

APPENDIX III – GEOGRAPHIC DISTRIBUTION

AMRIS Facility

Senior Personnel, non U.S. Users

Last Name	First Name	Organization	Country
Alvares	Rohan	University of Toronto	Canada
Aran	Martin	Instituto Leloir	Argentina
Baumer	Marcus	Bremen University	Germany
Cheesman	Alex	James Cook University	Australia
Cheng	Tian	Ecole Polytechnique FŽdŽrale de Lausanne	Switzerland
Comment	Arnaud	Ecole Polytechnique FŽdŽrale de Lausanne	Switzerland
Grover	Samantha	La Trobe University	Australia
Hansen	Brian	Aarhus University	Denmark
Hasabnis	Advait	University of Toronto	Canada
Heumann	Hermann	Silantes GmbH	Germany
Klink	Miriam	Bremen University	Germany
MacCormack	W	Instituto Antartico Argentino	Chile
MacDonald	Peter	University of Toronto	Canada
Mathur	Sunita	University of Toronto	Canada
Prosser	R. Scott	University of Toronto	Canada
Shaw	Christopher	University of British Columbia	Canada
Sheth	Snaha	University of British Columbia	Canada
Torto	Baldwin	International Centre of Insect Physiology and Ecology (ICIPE)-African Insect Science for Food and Health	Kenya
Turck	Chris	Max Planck Institute of Psychiatry	Germany
Turner	Ben	Smithsonian	Panama
Uy	Mylene	Mindanao State University-Iligan Institute of Technology	Philippines
21 Users			

EMR Facility

Senior Personnel, non-U.S.

Name	Organization	Country
Marco Affronte (S/PI)	CNR	Italy
Marius Andruh (S/PI)	University of Bucharest	Romania
Fabrice Bert (S)	Laboratoire de Physique des Solides	France
Sylvain Bertaina (S/PI)	IM2NP - CNRS	France

APPENDIX III – GEOGRAPHIC DISTRIBUTION

Name	Organization	Country
Henrik Bildsoe (S)	Aarhus University	Denmark
Euan Brechin (S/PI)	University of Edinburgh	UK
Gerd Buntkowsky (S/PI)	Technische Universität Darmstadt	Germany
Joan Cano (S/PI)	Universita de Valencia	Spain
Isabel Castro (S)	Universitat de València	Spain
Kwang Yong Choi (S/PI)	Chung Ang University	South Korea
Eugenio Coronado (S/PI)	Instituto de Ciencia Molecular (ICMol), Universidad de Valencia	Spain
Klaus-Peter Dinse (S/PI)	Free University Berlin	Germany
Carole Duboc (S/PI)	University Grenoble Alpes	France
Toshiaki Enoki (S)	Tokyo Institute of Technology	Japan
Lucio Frydman (S/PI)	Weizmann Institute of Science	Israel
Alberto Ghirri (S/PI)	CNR-Istituto Nanoscienze	Italy
Wojciech Grochala (S/PI)	Univ. Warsaw	Poland
Malgorzata Holynska (S/PI)	Philipps University Marburg	Germany
Hans Jakobsen (S/PI)	University of Aarhus	Denmark
Svend Knak Jensen (S)	Aarhus University	Denmark
Julia Jezierska (S/PI)	University of Wroclaw	Poland
Miguel Julve (S)	Universitat de Valencia	Spain
Maria Korabik (S)	University of Wroclaw	Poland
Panayotis Kyritsis (S/PI)	University of Athens	Greece
Francesc Lloret (S)	Universitat de València	Spain
Zoran Mazej (S)	Jozef Stefan Institute	Slovenia
Philippe Mendels (S)	Laboratoire de Physique des Solides	France
Mark Murrie (S/PI)	University of Glasgow	UK
David Norman (S/PI)	University of Dundee	UK
Richard Oakley (S/PI)	University of Waterloo	Canada
Vladimir Osipov (S/PI)	Ioffe Physical-Technical Institute	Russia
Emilio Pardo (S)	Universitat de València	Spain
Paul Plieger (S)	Massey University/ University of New Zealand	New Zealand
Armando Pombeiro (S/PI)	Instituto Superior Tecnico	Portugal
Sankar Rath (S/PI)	Indian Institute of Technology Kanpur	India
Robert Schloegl (S)	Max Planck Society	Germany
Reinhard Schomaecker (S)	Technical University Berlin	Germany
Alexander Shames (S)	Ben-Gurion University of the Negev	Israel
Raj Sharma (S/PI)	Panjab University	India

APPENDIX III – GEOGRAPHIC DISTRIBUTION

Name	Organization	Country
Jorgen Skibsted (S)	Aarhus University	Denmark
Federico Spizzo (S/PI)	University of Ferrara	Italy
Kazuyuki Takai (S)	Hosei University	Japan
Changlin Tian (S/PI)	University of Science and Technology of China	China
Joris van Slageren (S/PI)	Universität Stuttgart	Germany
Maria Vaz (S/PI)	Federal Fluminense University	Brazil
Zhenxing Wang (S/PI)	Huazhong University of Science and Technology	China
Andrej Zorko (S/PI)	"Jozef Stefan" Institute	Slovenia
Sergei Zvyagin (S/PI)	Dresden High Magnetic Field Laboratory	Germany
48 Users		

Postdocs, Non-U.S.

Name	Organization	Country
Alina Dinca (P)	University of Bucharest	Romania
Rafal Grubba (P/PI)	Gdansk University of Technology	Poland
Katie Marriott (P)	University of Glasgow	Scotland
Alexey Ponomaryov (P/PI)	Hemholtz-Zentrum Dresden-Rossendorf	Germany
Daniel Tietze (P)	Technische Universität Darmstadt	Germany
5 Users		

Students, Non-U.S.

Name	Organization	Country
Katharina Bader (G)	University of Stuttgart	Germany
Claudio Bonizzoni (G)	Università of Modena and Reggio Emilia	Modena
Kasturi Chaudhuri (G)	Indian Institute of Technology Kanpur	India
Charles-Emmanuel Dutoit (G)	IM2NP - CNRS	France
Firoz Khan (G)	Indian Institute of Technology Kanpur	India
Su-Heon Lee (G)	Chung-Ang University	Republic of Korea
Dejan Premuzic (G)	Philipps University Marburg	Germany
Debangsu Sil (G)	Indian Institute of Technology Kanpur	India
Michael Stevens (G)	University of Dundee	UK
Julia Vallejo (G)	Universitat de València	Spain
10 Users		

APPENDIX III – GEOGRAPHIC DISTRIBUTION

Technician, Non-U.S.

Name	Organization	Country
Clemens Pietzonka (T)	Philipps University Marburg	Germany
1 Users		

ICR Facility

Senior Personnel, non-U.S.

Name	Organization	Country
Laura Abella (S)	Universitat Rovira i Virgil	Spain
Flávio Albuquerque (S)	PETROBRAS R&D Center, Cidade Universitária	Brazil
Chris Boreham (S)	Geoscience Australia	Australia
Jochen Brocks (S)	The Australian National University	Australia
Rosana Cardoso (S/PI)	Petrobras	Brazil
Benny Chefetz (S)	The Hebrew University of Jerusalem	Israel
Yu Chen (S)	Shaanxi Cancer hospital	China
Peter DiMaggio (S)	Imperial College London	UK
Christopher Ewels (S)	Universite de Nantes	France
Pierre Giusti (S/PI)	Total	France
Jason Icerman (S)	COT	UK
Gaelle Jousset (S)	Total	France
Andreas Kappler (S)	University of Tuebingen	Germany
Sunghoon Kim (S)	Seoul National University	Korea
Caroline Mangote (S)	Total	France
Paul Mann (S/PI)	Northumbria University	England
Isabelle Merdrignac (S/PI)	IFP Energies nouvelles	France
Paul Monks (S)	University of Leicester	UK
Yusuke Nishiyama (S)	JEOL Ltd.	Japan
Naohiko Ohkouchi (S)	Japan Agency for Marine Earth Science & Technology (JAMSTEC)	Japan
Josep Poblet (S/PI)	Universitat Rovira i Virgili	Spain
Xavi Ribas (S/PI)	Universitat de Girona	Catalonia-Spain
Antonio Rodriguez-Fortea (S)	Universitat Rovira i Virgili	Spain
Jorge Ruiz (S/PI)	Ecopetrol	Colombia
Hisanori Shinohara (S)	Nagoya University	Japan
Jorien Vonk (S/PI)	University of Utrecht	The Netherlands
Wilfried Weiss (S)	IFPEN	France
27 Users		

APPENDIX III – GEOGRAPHIC DISTRIBUTION

Postdocs, Non-U.S.

Name	Organization	Country
Cristina García-Simón (P)	Institut de Qui´mica Computacional i Cata`lisi and Departament de Qui´mica,	Spain
1 Users		

Students, Non-U.S.

Name	Organization	Country
Martha Chacon (G/PI)	Universidad Industrial de Santander	Colombia
Nur Gueneli (G/PI)	The Australian National University	Australia
Nikolas Hagemann (G/PI)	University of Tuebingen	Germany
3 Users		

Technician, Non-U.S. – 0

APPENDIX IV
PERSONNEL

APPENDIX IV - PERSONNEL

SENIOR PERSONNEL AT FSU, UF & LANL (228)

Name	Position Title
100 - Management and Administration	
Cordi, Thomas	Assistant Lab Director, Business Administration
Davidson, Michael	Research Faculty I
Greene, Laura	Chief Scientist
Rea, Clyde	Assistant Director, Business & Financial / Auxiliary Services
Zhu, Lei	Assistant Professor
300 - DC Instrumentation	
Hannahs, Scott	Research Faculty III
400 - Magnet Science & Technology	
Bird, Mark	Research Faculty III, Director, Magnet Science & Technology
Crooks, Roy	Visiting Assistant Scholar / Scientist
Dixon, Iain	Research Faculty III
Gavrilin, Andrey	Research Faculty III
Godeke, Arno	Research Faculty II
Guo, Wei	Professor
Han, Ke	Research Faculty III
Hilton, David	Research Faculty I
Kalu, Peter	Professor
Lu, Jun	Research Faculty II
Markiewicz, William	Research Faculty III
Marshall, William	Sr Research Associate
Min, Na	Visiting Associate Scholar / Scientist
Painter, Thomas	Sr Research Associate
Takada, Suguru	Visiting Associate Scholar / Scientist
Toth, Jack	Research Faculty III
Van Sciver, Steven	Professor
Walsh, Robert	Sr Research Associate
Weijers, Hubertus	Research Faculty II
Xin, Yan	Research Faculty II
Yuan, Jinhui	Visiting Associate Scholar / Scientist
Zavion, Sheryl	Sr Research Associate (MS&T Operations Manager)
500 - Condensed Matter Science	
Albrecht-Schmitt, Thomas	Professor
Baek, Hongwoo	Research Faculty I
Balicas, Luis	Research Faculty III
Baumbach, Ryan	Research Faculty I
Beekman, Christianne	Assistant Professor

APPENDIX IV - PERSONNEL

Bonesteel, Nicholas	Professor
Cao, Jianming	Professor
Chiorescu, Irinel	Professor
Choi, Eun Sang	Research Faculty II
Coniglio, William	Research Faculty I
Dalal, Naresh	Professor
Dobrosavljevic, Vladimir	Professor
Engel, Lloyd	Research Faculty III
Fajer, Piotr	Professor
Gao, Hanwei	Assistant Professor
Gor'kov, Lev	Professor
Graf, David	Research Faculty I
Hill, Stephen	Professor/EMR Director
Hoch, Michael	Visiting Scientist/Researcher
Huang, Chen	Assistant Professor
Jaroszynski, Jan	Research Faculty II
Knappenberger, Kenneth	Assistant Professor
Kovalev, Alexey	Assistant In Research
Krzystek, Jerzy	Research Faculty III
Kuhns, Philip	Research Faculty III
Li, Zhiqiang	Research Faculty I
Ma, Biwu	Associate Professor
Manousakis, Efstratios	Professor
McGill, Stephen	Research Faculty II
Mendoza-Cortes, Jose	Assistant Professor
Murphy, Timothy	Director, DC Field Facility
Oates, William	Assistant Professor
Ozarowski, Andrzej	Research Faculty II
Park, Jin Gyu	Professor
Park, Ju-Hyun	Research Faculty II
Popovic, Dragana	Research Faculty III
Ramakrishnan, Subramanian	Associate Professor
Reiff, William	Visiting Associate Scholar / Scientist
Reyes, Arneil	Research Faculty III
Riggs, Scott	Research Faculty I
Rikvold, Per	Professor
Schlottmann, Pedro	Professor
Schlueter, John	Visiting Scientist/Researcher
Schneemeyer, Lynn	Visiting Associate in
Shatruk, Mykhailo	Assistant Professor

APPENDIX IV - PERSONNEL

Siegrist, Theo	Professor
Smirnov, Dmitry	Research Faculty III
Smith, Julia	Research Faculty I
Song, Likai	Research Faculty I
Suslov, Alexey	Research Faculty III
Telotte, John	Associate Professor
Thirunavukkuarasu, Komalavalli	Visiting Associate in Research
Tozer, Stanley	Research Faculty III
Vafek, Oskar	Associate Professor
van Tol, Johan	Research Faculty III
Whalen, Jeffrey	Research Faculty I
Yang, Kun	Professor
Yu, Zhibin	Assistant Professor
Zhang, Mei	Associate Professor
Zhou, Haidong	Adjunct Assistant Scholar/Scientist
600 - LANL	
Balakirev, Fedor	Staff Member
Betts, Jonathan	Director of Operations
Chan, Mun Keat	Staff Member
Crooker, Scott	Staff Member
Harrison, Neil	Staff Member
Hinrichs, Mark	Electrical Engineer
Jaime, Marcelo	Staff Member
Maiorov, Boris	Staff Member
McDonald, Ross	Deputy Director, Pulsed Field Facility
Mielke, Charles	Director, Pulsed Field Facility at LANL and Deputy Group Leader
Migliori, Albert	Staff Member and LANL Fellow
Nguyen, Doan	Director of Pulsed Field Facility Magnet Science and Technology
Ramshaw, Brad	Staff Member
Singleton, John	Staff Member and LANL Fellow
Zapf, Vivien	Director of Pulsed Field Facility User Program
700 - CIMAR	
Alamo, Rufina	Professor
Arora, Rajendra	Professor
Blakney, Gregory	Research Faculty II
Brey, William	Research Faculty III
Corilo, Yuri	Research Faculty I, Director of Informatics Research & Modeling
Cross, Timothy	Professor
Dunk, Paul	Research Faculty I
Frydman, Lucio	Scholar / Scientist

APPENDIX IV - PERSONNEL

Fu, Riqiang	Research Faculty III
Gan, Zhehong	Research Faculty III
Gor'kov, Peter	Sr Research Associate
Grant, Samuel	Associate Professor
Hallinan, Daniel	Assistant Professor
Hendrickson, Christopher	Research Faculty III/Director of ICR User Program
Houpt, Thomas	Professor
Hu, Yanyan	Assistant Professor
Hung, Ivan	Assistant in Research
Jakobsen, Hans	Visiting Professor
Kaiser, Nathan	Research Faculty I
Kim, Chul	Visiting Scientist/Researcher
Kim, Jeong-su	Associate Professor
Lalli, Priscila	Visiting Research Faculty I
Levenson, Cathy	Professor
Litvak, Elizaveta	Visiting Faculty
Litvak, Ilya	Assistant In Research
Lobodin, Vladislav	Research Faculty I
Lu, Jie	Assistant in Research
Marshall, Alan	Professor, Chief Scientist for Ion Cyclotron Resonance (ICR) and Robert O. Lawton Distinguished Professor of Chemistry
McKenna, Amy	Research Faculty II
Paravastu, Anant	Assistant Professor
Podgorski, David	Research Faculty I
Qin, Huajun	Associate in Research
Rodgers, Ryan	Research Faculty III
Rosenberg, Jens	Visiting Research Faculty I
Rowland, Steven	Visiting Research Faculty I
Schepkin, Victor	Research Faculty II
Shekar, Srinivasan	Research Faculty I
Smith, Donald	Research Faculty I
Wi, Sungsool	Research Faculty II
Zhou, Huan-Xiang	Associate Professor
800 - UF	
Abernathy, Cammy	Professor, Materials Science & Engineering, Dean, College of Engineering
Andraka, Bohdan	Associate Research Professor
Angerhofer, Alexander	Professor, Chemistry
Ashizawa, Tetsuo	Melvin Greer Professor and Chairman, Department of Neurology, Executive Director McKnight Brain Institute

APPENDIX IV - PERSONNEL

Biswas, Amlan	Associate Professor of Physics
Blackband, Stephen	Professor, Neuroscience
Bowers, Clifford	Associate Professor, Chemistry
Brey, Wallace	Professor Emeritus, Chemistry
Butcher, Rebecca	Assistant Professor
Cheng, Hai Ping	Professor of Physics
Christou, George	Drago Professor
Douglas, Elliot	Associate Professor, Materials Science & Engineering
Eyler, John	Professor Emeritus, Chemistry
Fanucci, Gail	Associate Professor
Febo, Marcelo	Assistant Professor
Fitzsimmons, Jeffrey	Professor, Radiology
Forder, John	Associate Professor of Radiology
Hagen, Stephen	Professor
Hahn, Daniel	Associate Professor
Hamlin, James	Assistant Professor
Hebard, Arthur	Distinguished Professor of Physics
Hershfield, Selman	Professor
Hirschfeld, Peter	Professor
Huan, Chao	Assistant Scholar / Scientist
Ihas, Gary	Professor Emeritus
Ingersent, Kevin	Chair of UF Physics Department & Professor, Chair, UF Physics Dept.
Kumar, Pradeep	Professor
Labbe, Greg	Senior Engineer, Cryogenics Facility
Lai, Song	Professor of Radiation Oncology and Neurology, Director, CTSI Human Imaging Core McKnight Brain Institute
Lee, Yoonseok	Professor
Long, Joanna	Associate Professor, NHMFL Director of AMRIS
Luesch, Hendrik	Associate Professor
Mareci, Thomas	Professor
Maslov, Dmitrii	Professor
Masuhara, Naoto	Senior Engineer, Microkelvin Laboratory
Meisel, Mark	Professor
Merritt, Matthew	Associate Professor
Murray, Leslie	Assistant Professor
Muttalib, Khandker	Professor
Pearton, Stephen	Distinguished Professor, Alumni Professor of Materials Science & Engineering
Polfer, Nicolas	Assistant Professor

APPENDIX IV - PERSONNEL

Rinzler, Andrew	Professor
Stanton, Christopher	Professor
Stewart, Gregory	Professor
Sullivan, Neil	Professor, Director of High B/T Facility
Takano, Yasumasa	Professor
Talham, Daniel	Professor
Tanner, David	Distinguished Professor of Physics
Vaillancourt, David	Associate Professor
Vandenborne, Krista	Professor
Vasenkov, Sergey	Associate Professor
Walter, Glenn	Associate Professor
Xia, Jian-Sheng	Associate Scientist
Zeng, Huadong	Specialist, Animal MRI/S Applications
1100 - ASC	
Abraimov, Dmytro	Research Faculty II
Gibson, Murray	Visiting Scientist/Researcher
Griffin, Van	Senior Research Associate
Hahn, Seungyong	Professor
Hellstrom, Eric	Professor
Jiang, Jianyi	Research Faculty II
Kametani, Fumitake	Research Faculty II
Kim, Youngjae	Research Faculty 1
Larbalestier, David	Chief Materials Scientist, Director, Applied Superconductivity Center
Lee, Peter	Research Faculty III
Pamidi, Sastry	Associate Professor, Electrical & Computing Engineering; Associate Director, Center for Advanced Power Systems
Polyanskii, Anatolii	Research Faculty II
Starch, William	Senior Research Associate
Tarantini, Chiara	Research Faculty I
Trociewitz, Ulf	Research Faculty II
1200 - Director's Office	
Boebinger, Gregory	Director/Professor, Professor of Physics
Hughes, Roxanne	Research Faculty I, Director, Center for Integrating Research and Learning
Palm, Eric	Deputy Lab Director
Roberts, Kristin	Director of Public Affairs
1300 - Geochemistry	
Chanton, Jeff	Professor
Cooper, William	Professor
Froelich, Philip	Scientist

APPENDIX IV - PERSONNEL

Humayun, Munir	Professor
Landing, William	Professor
Morton, Peter	Visiting Assistant
Odom, Leroy	Professor
Owens, Jeremy	Assistant Professor
Salters, Vincent	Professor, Director, Geochemistry
Spencer, Robert	Assistant Professor
Wang, Yang	Professor
Young, Seth	Assistant Professor
Total Employees: 228	

POSTDOCTORAL ASSOCIATES AT FSU, UF & LANL (58)

Name	Position Title
400 - Magnet Science & Technology	
Niu, Rongmei	Postdoctoral Associate
Vanderlaan, Mark	Postdoctoral Associate
500 - Condensed Matter Science	
Besara, Tiglet	Postdoctoral Associate
Chakraborty, Shantanu	Postdoctoral Associate
Dubroca, Thierry	Postdoctoral Associate
Galvis Echeverri, Jose	Postdoctoral Associate
Giraldo Gallo, Paula	Postdoctoral Associate
Gong, Shoushu	Postdoctoral Associate
Grockowiak, Audrey	Postdoctoral Associate
Ha, Jeonghoon	Postdoctoral Research Associate
Hatke, Anthony	Postdoctoral Associate
Jiang, Qinglong	Postdoctoral Associate
Kweon, Jin Jung	Postdoctoral Associate
Lanata, Nicola	Postdoctoral Associate
Li, JunQiang	Postdoctoral Associate
Louis, Golda	Postdoctoral Associate
McKay, Johannes	Postdoctoral Associate
Pradhan, Nihar	Postdoctoral Associate
Pramudya, Yohanes	Postdoctoral Associate
Saraswat, Garima	Postdoctoral Associate
Shi, Zhenzhong	Postdoctoral Associate
Shimura, Yasuyuki	Visiting Scientist/Researcher
Steven, Eden	Postdoctoral Associate
Stoian, Sebastian	Postdoctoral Associate
Sur, Shouvik	Postdoctoral Associate

APPENDIX IV - PERSONNEL

Vellore Winfred, Joseph Sundar Raaj	Postdoctoral Associate
Wang, Shengyu	Postdoctoral Associate
Wildeboer, Julia	Postdoctoral Associate
600 - LANL	
Beedle, Christopher	Postdoctoral Associate
Chikara, Shalinee	Postdoctoral Associate
Modic, Kimberly	Postdoctoral Associate
Stier, Andreas	Postdoc Research Associate
Winter, Laurel	Postdoctoral Associate
Yang, Luyi	Postdoctoral Associate
700 - CIMAR	
Anderson, Lissa	Postdoctoral Associate
Chen, Huan	Postdoctoral Associate
Dai, Jian	Postdoctoral Associate
DeHart, Caroline	Postdoctoral Associate
Hooker, Jerris	Postdoctoral Associate
Mooney, Victoria	Postdoctoral Associate
Morris, Deborah	Postdoctoral Associate
Mulet Gas, Marc	Postdoctoral Associate
Murray, Dylan	Postdoctoral Associate
Ramaswamy, Vijaykumar	Postdoctoral Associate
Ray, Phoebe	Postdoctoral Associate
Smith, Pieter	Postdoctoral Associate
Tang, Tzu-chun	Postdoctoral Associate
Wang, Xiaoling	Postdoctoral Associate
800 - UF	
Serafin, Alessandro	Postdoctoral Associate
1100 - ASC	
Balachandran, Shreyas	Postdoctoral Associate
Bosque, Ernesto	Postdoctoral Research Associate
Constantinescu, Anca-Monia	Postdoctoral Associate
Kim, Kwang Lok	Postdoctoral Associate
1300 - Geochemistry	
Guillemette, Francois	Postdoctoral Associate
Mayer, Bernhard	Postdoctoral Associate
Perrot, Vincent	Postdoctoral Associate
Waeselmann, Naemi	Postdoctoral Associate
Wyatt, Neil	Postdoctoral Associate
Total Employees: 58	

APPENDIX IV - PERSONNEL

OTHER PROFESSIONALS AT FSU, UF & LANL (88)

Name	Position Title
100 - Management and Administration	
Barron, John	Maintenance Mechanic
Clark, Eric	Application Developer/Designer
Greenlee, Reshaye	Senior Financial Specialist
Kynoch, John	Assistant Director
McCrory, Marcia	Budget Analyst
McEachern, Judy	Assistant Director, Business Systems
Mook, Bradley	Budget Analyst
Perkins, Robert	Technician
Wackes, Christina	Administrative Specialist
Wood, Marshall	Facilities Electrical Supervisor
300 - DC Instrumentation	
Barrios, Matthew	Research Engineer
Berhalter, James	Technology Specialist
Billings, Jonathan	Scientific Research Specialist
Boenig, Heinrich	Engineer
Brooks, Erica	Technology Specialist
Dalton, Bryon	Scientific Research Specialist
Jensen, Peter	Network Administrator
Jones, Glover	Scientific Research Specialist
Maier, Scott	Scientific Research Specialist
Powell, James	Research Engineer
Rubes, Edward	Scientific Research Specialist
Schwartz, Robert	Scientific Research Specialist
Schwerin, John	Technology Specialist
Semenov, Dmitry	Scientific Research Specialist
Stiers, Eric	Research Engineer
Williams, Vaughan	Research Engineer
400 - Magnet Science & Technology	
Adkins, Todd	Research Engineer
Bole, Scott	Research Engineer
Cantrell, Kurtis	Research Engineer
Goddard, Robert	Scientific Research Specialist
Gundlach, Scott	Research Engineer
Jarvis, Brent	Research Engineer
Johnson, Zachary	Research Engineer
Lucia, Joseph	Technical/Research Designer
Marks, Emsley	Research Engineer

APPENDIX IV - PERSONNEL

McRae, Dustin	Research Engineer
Mellow, Amy	Administrative Specialist
Miller, George	Research Engineer
Noyes, Patrick	Associate in Research
O'Reilly, James	Research Engineer
Richardson, Donald	Research Engineer
Sheppard, William	Research Engineer
Stanton, Robert	Research Engineer
Su, Yi-Feng	Research Specialist
Toplosky, Vince	Scientific Research Specialist
Viouchkov, Youri	Research Engineer
Voran, Adam	Research Engineer
White, James	Research Engineer
500 - Condensed Matter Science	
Batista Lopes Escobar, Livia	Visiting Scientist/Researcher
Feng, Weibo	Research Assistant
Javed, Arshad	Grants Compliance Analyst
Jurado, Gabriel	Research Assistant
Knox, Javon	Research Assistant
Li, Le	Visiting Scientist/Researcher
Luallen, Renee	Program Coordinator
Shehter, Arkady	Visiting Research Faculty I
Trociewitz, Bianca	Research Engineer
700 - CIMAR	
Beu, Steven	Visiting Scientist/Researcher
Bickett, Karol	Administrative Specialist
Clingenpeel, Amy	Research Assistant
Garcia Simon, Cristina	Visiting Scientist/Researcher
Hodges, Kurt	Coordinator, Animal Welfare Compliance
Kitchen, Jason	NMR Engineer
McIntosh, Daniel	Scientific Research Specialist
Quinn, John	Research Engineer
Ranner, Steven	Research Engineer
Schiano, Jeffrey	Visiting Scientist/Researcher
Wright, Anna	Research Assistant
800 - UF	
Elumalai, Malathy	RF Engineer
Jenkins, Kelly	RF Coil Engineer
Nicholson, Tammy	Certified Radiology Technology Mgr. (3T Imaging Applications)
Plant, Daniel	Coordinator

APPENDIX IV - PERSONNEL

Rocca, James	Senior Chemist & NMR Applications Specialist
1100 - ASC	
Linville, Connie	Administrative Specialist
1200 - Director's Office	
Bilenky, Stephen	Videographer
Brown, Alfie	Industrial Safety & Health Eng
Coyne, Kristen	Media Specialist
McNiel, Caroline	Media Specialist
Richerson, Lezlee	Administrative Specialist
Roberson, Bettina	Assistant Director, Administrative Services, Human Resources
Roberts, Kari	Program Coordinator
Rodman, Christopher	Industrial Safety & Health Eng.
Sanchez, Jose	Program Coordinator
Tabtimtong, Nilubon	Media Specialist
Toth, Anke	Program Coordinator
Villa, Carlos	Outreach Coordinator
1300 - Geochemistry	
Sachi-Kocher, Afi	Scientific Research Specialist
White, Gary	Scientific Research Specialist
Total Employees: 88	

GRADUATE STUDENTS AT FSU, UF & LANL (159)

Name	Position Title
400 - Magnet Science & Technology	
Brown, Daniel	Graduate Research Assistant
Dhuley, Ram	Graduate Research Assistant
Gao, Jian	Graduate Research Assistant
Gordon, Renee	Research Assistant
Mastracci, Brian	Graduate Research Assistant
Scott, Valesha	Graduate Research Assistant
Stubbs, Devin	Graduate Research Assistant
Wray, Andrew	Graduate Research Assistant
500 - Condensed Matter Science	
Abhyankar, Nandita	Research Assistant
Akinfaderin, Adewale Abiodun	Graduate Research Assistant
Bade, Sri Ganesh Rohit	Graduate Research Assistant
Bahadur, Divya	Graduate Research Assistant
Baity, Paul	Graduate Research Assistant
Barry, Kevin	Graduate Research Assistant

APPENDIX IV - PERSONNEL

Benjamin, Shermane	Graduate Research Assistant
Bindra, Jasleen Kaur	Graduate Research Assistant
Cary, Samantha	Graduate Research Assistant
Chappell, Greta	Graduate Research Assistant
Chen, Kuan-Wen	Graduate Research Assistant
Das, Suvadip	Graduate Research Assistant
Dong, Lianyang	Graduate Research Assistant
Freeman, Matthew	Graduate Research Assistant
Gallagher, Andrew	Graduate Research Assistant
Garcia, Carlos	Graduate Research Assistant
Geske, Thomas	Graduate Research Assistant
Ghosh, Soham	Graduate Research Assistant
Gorfien, Matthew	Graduate Research Assistant
Greer, Samuel	Graduate Research Assistant
Hammel, Emily	Graduate Research Assistant
Hayati, Zahra	Graduate Research Assistant
Holleman, Joshua	Graduate Research Assistant
Hu, Tianqi	Graduate Research Assistant
Jiang, Yuxuan	Research Assistant
Komijani, Dorsa	Graduate Research Assistant
Lai, You	Graduate Research Assistant
Lakshmi Bhaskaran, FNU	Graduate Research Assistant
Lan, Wangwei	Graduate Research Assistant
Lee, Minseong	Graduate Research Assistant
Lee, Tsung-Han	Graduate Research Assistant
Lewin, Sylvia	Research Assistant
Li, Dong	Graduate Research Assistant
Lian, Xiujun	Graduate Research Assistant
Liou, Shiuan-Fan	Graduate Research Assistant
Liu, Mengtian	Graduate Research Assistant
Lu, Zhengguang	Graduate Research Assistant
Ludwig, Jonathan	Graduate Research Assistant
Marbey, Jonathan	Graduate Research Assistant
Memaran, Shahriar	Graduate Research Assistant
Mendez, Joshua	Graduate Research Assistant
Mendoza, Luis Enrique	Graduate Research Assistant
Moon, Seongphill	Graduate Research Assistant
Muhammed, Faheem	Graduate Research Assistant
Nelson, William	Graduate Research Assistant
Neu, Jennifer	Graduate Research Assistant

APPENDIX IV - PERSONNEL

Pavanjeet Kaur, FNU	Graduate Research Assistant
Pouranvari, Mohammad	Graduate Research Assistant
Rahmani, Hamidreza	Graduate Research Assistant
Ramirez, Daniel	Graduate Research Assistant
Rhodes, Daniel	Graduate Research Assistant
Riner, Lauren	Research Assistant
Seidler, Kevin	Graduate Research Assistant
Shafieizadeh, Zahra	Graduate Research Assistant
Shan, Xin	Graduate Research Assistant
Siddique, Sabrina	Graduate Research Assistant
Silver, Mark	Graduate Research Assistant
Smith, Adam	Visiting Scientist/Researcher
Stanley, Lily	Graduate Research Assistant
Suarez, Daniel	Research Assistant
Szymanski, Thiago	Graduate Research Assistant
Tang, Shao	Graduate Research Assistant
Tran Hoang, Phong	Graduate Research Assistant
Vakil, Parth	Research Assistant
Wang, Ying	Graduate Research Assistant
Williams, Damon	Graduate Research Assistant
Wilson, Douglas	Graduate Research Assistant
Yue, Guang	Graduate Research Assistant
Zabalo, Aidan	Graduate Research Assistant
Zeuch, Daniel	Graduate Research Assistant
Zhang, Biwen	Graduate Research Assistant
Zhang, Qiu	Graduate Research Assistant
Zhang, Shengzhi	Graduate Research Assistant
Zheng, Wenkai	Graduate Research Assistant
Zhou, Chenkun	Graduate Research Assistant
Zhou, Qiong	Graduate Research Assistant
600 - LANL	
Martinez, Nicholas	Graduate Research Assistant
700 - CIMAR	
Abad, Nastaren	Graduate Research Assistant
Amouzandeh, Ghoncheh	Graduate Research Assistant
Beasley, Rebecca	Graduate Research Assistant
Cain, Uriel	Undergraduate Research Assistant
Chacon, Martha	Visiting Researcher
Chen, Xuejian	Graduate Research Assistant
Chien, Po-Hsiu	Graduate Research Assistant

APPENDIX IV - PERSONNEL

Dang, Xibei	Graduate Research Assistant
Darkazalli, Ali	Graduate Research Assistant
Escobar Bravo, Cristian	Graduate Research Assistant
Ge, Yuwei	Research Assistant
He, Lidong	Graduate Research Assistant
Hike, David	Graduate Research Assistant
Jiang, Tingting	Graduate Research Assistant
Krajewski, Logan	Graduate Research Assistant
Li, Xiang	Graduate Research Assistant
Liu, Peilu	Graduate Research Assistant
Muniz, Jose	Graduate Research Assistant
Oparaji, Onyekachi	Graduate Research Assistant
Ould Ismail, Abdol Aziz	Graduate Research Assistant
Paulino, Joana	Graduate Research Assistant
Putman, Jonathan	Graduate Research Assistant
Rose, Alyssa	Graduate Research Assistant
Shin, Yiseul	Graduate Research Assistant
Tao, Yeqing	Graduate Research Assistant
Wi, Leejoo	Graduate Research Assistant
Yang, Guang	Graduate Research Assistant
Yin, Hao	Graduate Research Assistant
Yuan, Xuegang	Graduate Research Assistant
Zheng, Jin	Graduate Research Assistant
1100 - ASC	
Bhattarai, Kabindra	Graduate Research Assistant
Brown, Michael	Graduate Research Assistant
Chen, Peng	Graduate Research Assistant
Chetri, Santosh	Graduate Research Assistant
Collantes, Yesusa	Graduate Research Assistant
Collins, Justin	Graduate Research Assistant
Davis, Daniel	Graduate Research Assistant
Hu, Xinbo	Graduate Research Assistant
Matras, Maxime	Graduate Research Assistant
Oz, Yavuz	Graduate Research Assistant
Pan, Yanjun	Graduate Student
Sanabria, Carlos	Graduate Research Assistant
Segal, Christopher	Graduate Research Assistant
Singh Bal, Harman	Graduate Research Assistant
Thompson, Christie	Laboratory Assistant
1200 - Director's Office	

APPENDIX IV - PERSONNEL

Moir, Camilla	Graduate Research Assistant
Wartenbe, Mark	Graduate Research Assistant
1300 - Geochemistry	
Aljahdali, Mohammed	Graduate Research Assistant
Bosman, Samantha	Graduate Research Assistant
Bowman, Chelsie	Research Assistant
Dial, Angela	Graduate Research Assistant
Ebling, Alina	Graduate Research Assistant
Fish, Brandon	Graduate Research Assistant
Fowler, Gary	Graduate Research Assistant
Harper, Alexandra	Graduate Research Assistant
Henrick, Stevie	Graduate Research Assistant
Hodgkins, Suzanne	Graduate Research Assistant
Imhoff, Johanna	Graduate Research Assistant
Johnston, Sarah	Graduate Research Assistant
Kellerman, Anne	Graduate Research Assistant
Kleinberg, Andrew	Graduate Research Assistant
Kozik, Nevin	Graduate Research Assistant
Liu, Jin	Graduate Research Assistant
Luzius, Casey	Graduate Research Assistant
Malinowski, Christopher	Graduate Research Assistant
Mandeville, Justin	Graduate Research Assistant
Mickle, Alejandra	Graduate Research Assistant
Olsen, Lauren	Research Assistant
Perison, Elizabeth	Graduate Research Assistant
Rogers, Kelsey	Graduate Research Assistant
Roy, Rupsa	Graduate Research Assistant
Stacklyn, Shannon	Graduate Research Assistant
Wu, Xiujie	Graduate Research Assistant
Yang, Shuying	Graduate Research Assistant
Total Employees: 159	

APPENDIX IV - PERSONNEL

UNDERGRADUATE STUDENTS AT FSU, UF & LANL (69)

Name	Position Title
100 - Management and Administration	
Campbell, Caleigh	Programmer
400 - Magnet Science & Technology	
Arroyo, Erick	Technician
Chauncey, Gunnar	Engineering Technician
Correa Castanheira, Barbara	Research Assistant
Hallstrom, Benjamin	Technician
Kolb-Bond, Dylan	Laboratory Assistant / Technician
Levin, Talya	Undergraduate Research Assistant
Sheppard, Greg	Technician
500 - Condensed Matter Science	
Bartholomew, Hannah	Research Assistant
Brown, Jhanielle	Research Assistant
Burke, Jamie	Laboratory Assistant / Technician
Catt, Sarah	Research Assistant
Cherrier-Vickers, Samuel	Research Assistant
Chown, Amanda	Research Assistant
Chu, Winston	Research Assistant
Crothers, Stephen	Laboratory Assistant / Technician
deTorres, Fernando	Laboratory Assistant / Technician
Estry, Amelia	Laboratory Assistant / Technician
Falb, Nathaniel	Research Assistant
Gordon, Andrew	Research Assistant
Gutalj, Stanko	Research Assistant
Haney, Bobby	Research Assistant
Hoadley, Megan	Research Assistant
Jarrett, Jeremy	Laboratory Assistant / Technician
Kiros, Hana	Research Assistant
Krehl, Jessey	Laboratory Assistant / Technician
Lacey Jr, Jeffrey	Research Assistant
Landrum, Reef	Research Assistant
Lein, Mckayla	Research Assistant
Newsome, Melissa	Research Assistant
Normand, Caroline	Research Assistant
Paz, Daniel	Research Assistant
Rodenbach, Linsey	Laboratory Assistant / Technician
Ross, Samuel	Research Assistant
Saff, David	Research Assistant

APPENDIX IV - PERSONNEL

Silver, Justin	Research Assistant
Simon, Federico	Research Assistant
Swanson, Samuel	Research Assistant
Velasquez, Ever	Research Assistant
Voss, Ryan	Research Assistant
Wallace, Scott	Research Assistant
Washington, Herbert	Research Assistant
Williams, Alan	Laboratory Assistant / Technician
Yannakopoulos, Anna	Laboratory Assistant / Technician
600 - LANL	
Schneider, Kim	Undergraduate Student
700 - CIMAR	
Bartges, Tessa	Undergraduate Research Assistant
Davenport, Nicholas	Undergraduate Research Assistant
Jones, Jillian	Undergraduate Research Assistant
Jones, Natalie	Graduate Research Assistant
Kurteva, Denitsa	Undergraduate Research Assistant
Perron, Rebecca	Undergraduate Research Assistant
1100 - ASC	
Alicea, Ryan	Laboratory Assistant-Level 2
Chew, Brandon	Laboratory Assistant - Level 3
DiEmmanuele, Justin	Laboratory Assistant-Level 1
Mathis, Charles	Laboratory Assistant-Level 2
Mauch, William	Laboratory Assistant-Level 1
Miller, Steven	Laboratory Assistant-Level 2
Nwodu, Arriana	Laboratory Assistant- Level 2
Radcliff, Kyle	Laboratory Assistant-Level 1
Wawrzyniak, Justin	Laboratory Assistant- Level 1
1300 - Geochemistry	
Holland, Alisia	Research Assistant
Leverone, Randy	Undergraduate Research Assistant
Patneaude, Alyssa	Undergraduate Research Assistant
Silver, Adam	Undergraduate Research Assistant
Sobrito, Sophia	Undergraduate Research Assistant
Summers, Brent	Research Assistant
Sutton, John	Undergraduate Research Assistant
Weisend, Rachel	Undergraduate Research Assistant
Westberry, Shelby	Undergraduate Research Assistant
Total Employees: 69	

APPENDIX IV - PERSONNEL

SUPPORT STAFF – TECHNICAL/MANAGERIAL AT FSU, UF & LANL (81)

Name	Position Title
100 - Management and Administration	
Allbaugh, Tony	Skilled Trades Worker
Avant, Michael	Electrician
Blinderman, Adam	Programmer
Braverman, Kenneth	Research Assistant
Childs, John	Graphic Artist
Cone, Raymond	Mechanical Assistant
Coyne, Sean	Facilities Engineer
Eck, Christopher	Maintenance Support Worker
Finn, Sarita	Web Designer/Programmer
Gamble, Kevin	Facilities Superintendent
Hahn, David	Web Designer/Programmer
John, Kevin	Graphic Artist
Johnson, Steve	Maintenance Mechanic
Kirschner, Matthew	Systems Programmer
Lewis, Raymond	Scientific & Research Technician
Ludlow, Richard	Graphic Artist
Nixon, Willie	Scientific & Research Technician
Oxendine, Christopher	Scientific & Research Technician
Phinazee, Billy	Maintenance Mechanic
Ransom, Tammy	Maintenance Superintendent
Shreve, Rodney	Industrial Engineer
Stevens, Dustin	Mechanical Trades Technician
Walker, Tory	Technical Writer
Wilson, Korey	Microscopist
Young, Aaron	Engineer Technician
300 - DC Instrumentation	
Brehm, William	Technician/Research Designer
Carrier, Robert	Technical/Research Designer
Flowers, Gregory	Programmer
Freeman, Daniel	Technical/Research Designer
Gonzalez, Brian	Web Designer/Programmer
Gordon, Larry	Scientific Research Specialist
Hicks, Michael	Technical/Research Designer
Hill, Scott	Technical/Research Designer
Oliff, Morgan	Technical/Research Designer
Petty, Joseph	Technical/Research Designer

APPENDIX IV - PERSONNEL

Piotrowski, Joel	Technical/Research Designer
Pullum, Bobby	Scientific & Research Technician
Scott, Philip Cole	Computer Support Technician
Sloan, David	Technician/Research Designer
Smith, Dylan	Technical Support Analyst
Szelong, Dustin	Technology Specialist
Torres Camacho, Jesus	Technical/Research Designer
400 - Magnet Science & Technology	
Deterding, Justin	Research Engineer
Helms, Randy	Technical Research/Designer
McDaniel, Kolby	Intern
McGuire, David	Research Engineer
Ostrander, Josh	High School Intern
Ray, Christopher	Technical/Research Designer
Windham, Carl	Research Assistant
500 - Condensed Matter Science	
Culliton, Kagan	Laboratory Assistant / Technician
Hannahs, Maia	Research Assistant
Luca, William	Laboratory Assistant / Technician
Wackes, Elisabet	Laboratory Assistant / Technician
Yuan, Shaojie	Research Assistant
600 - LANL	
Coulter, Yates	Head of Generator Operations
Gordon, Michael	Research Technologist
Lucero, Jason	Research Technician
Martin, Jeff	Controls Specialist
Michel, James	Research Technician
Pacheco, Michael	Research and Development Technologist
Roybal, Darrell	Research Technician
Sattler, Dave	Designer
Teshima, Hazuki	Research Technician
Vigil, Billy	Research & Development Technologist
700 - CIMAR	
Blue, Ashley	Technical/Research Designer
Bonaventura, Nash	Laboratory Assistant / Technician
Bonninghausen, Russell	Technician
Desilets, Richard	Technical/Research Designer
Farley, Marcus	Research Assistant
Henricks, Henry	Laboratory Assistant / Technician
800 - UF	

APPENDIX IV - PERSONNEL

Graham, John	Senior Engineering Technician, Cryogenics
Slade, Joshua	Engineering Technician
Swiers, Christi	MRI Technologist
Webb, Elizabeth	Coordinator, Research Programs / Services
1100 - ASC	
English, Charles	Research Engineer
Francis, Ashleigh	Research Engineer
Kim, Seokho	Visiting Scientist/Researcher
1300 - Geochemistry	
Barnwell, Jacob	Research Assistant
Groszos, Angela	Laboratory Assistant / Technician
Langford, Lauren	Research Assistant
Zateslo, Theodore	Senior Engineer
Total Employees: 81	

SUPPORT STAFF – SECRETARIAL/ CLERICAL AT FSU, UF & LANL (33)

Name	Position Title
100 - Management and Administration	
Anderson, Shelby	Program Assistant
Burton, Gwendolyn	UBA Accounting Associate
Cherisol, Luc	Accounting Representative
Cobb, Damaris	Program Associate, Purchasing
Hacker, Miranda	Office Administrator
Hermance, Scott	Campus Service Assistant
Hicks, Cheryln	UBA Accounting Associate
Hill, Philip	Campus Services Assistant
Joiner, Karen	Admin Support Assistant
Lang, Angelena	Procurement Associate
Paschal, Melanie	Procurement Associate
Reynolds, Joshua	Budget Assistant/Clerk
Roberts, Christopher	Campus Services Assistant
Sapronetti, Andrew	Administrative Support Specialist
Stafford, Holly	Administrative Support Assistant
400 - Magnet Science & Technology	
Maddox, James	Program Associate
Mon, Ei	Admin Clerk
Seibert, Ben	Intern
500 - Condensed Matter Science	
Qureshi, Aisha	Administrative Assistant

APPENDIX IV - PERSONNEL

600 - LANL	
Gallegos, Julie	Program Administrator
Willow, Angeline	Administrative Assistant
700 - CIMAR	
Desilets, Mary	Administrative Support Assistant
Jemmott, Krista	Program Associate
Mozolic, Kimberly	Program Associate
800 - UF	
Colson, Marcia Tessie	Program Assistant
Fuhr, Angela	Office Manager
Mesa, Denise	NHMFL Administrative Assistant
1100 - ASC	
Hall, Charlotte	Admin Support Assistant
1200 - Director's Office	
Davis, Colleen	Safety Coordinator
Fitch, Morgan	Administrative Assistant
Hancock, Felicia	Program Associate
Patel, Nilay	Volunteer
Tabtimtong, Melissa	Intern
Total Employees: 33	

APPENDIX IV - PERSONNEL

Parameter / Category	Senior Personnel	Postdoc	Other Professional	Graduate Student	Undergraduate Student	Support Staff - Technical/ Managerial	Support Staff - Secretarial/ Clerical	Total	%
Gender									
Male	199	38	62	97	40	69	9	**514**	**71.80%**
Female	29	20	26	62	29	12	24	**202**	**28.20%**
Race									
White	169	32	75	78	63	71	23	**511**	**71.40%**
Male	149	21	54	49	36	61	6	376	52.50%
Female	20	11	21	29	27	10	17	135	18.90%
Black or African American	1	1	6	11	4	6	4	**33**	**4.60%**
Male	1	1	4	7	2	5	1	21	2.90%
Female	0	0	2	4	2	1	3	12	1.70%
Native Hawaiian or Pacific Islander	0	0	1	0	1	0	0	**2**	**0.30%**
Male	0	0	1	0	1	0	0	2	0.30%
Female	0	0	0	0	0	0	0	0	0.00%
Asian	58	24	6	70	1	3	4	**166**	**23.20%**
Male	49	16	3	41	1	2	1	113	15.80%
Female	9	8	3	29	0	1	3	53	7.40%
American Indian or Alaska Native	0	1	0	0	0	1	2	**4**	**0.60%**
Male	0	0	0	0	0	1	1	2	0.30%
Female	0	1	0	0	0	0	1	2	0.30%
Ethnicity									
Hispanic or Latino	6	5	3	14	4	6	2	**40**	**5.60%**
Male	5	4	3	10	2	6	0	30	4.20%
Female	1	1	0	4	2	0	2	10	1.40%
Not Hispanic or Latino	222	53	85	145	65	75	31	**676**	**94.40%**
Male	194	34	59	87	38	63	9	484	67.60%
Female	28	19	26	58	27	12	22	192	26.80%
Does this person have a disability?									
Yes	1	1	0	4	2	1	0	**9**	**1.30%**
Male	1	1	0	4	2	1	0	9	1.30%
Female	0	0	0	0	0	0	0	0	0.00%
No	227	57	88	155	67	80	33	**707**	**98.70%**
Male	198	37	62	93	38	68	9	505	70.50%
Female	29	20	26	62	29	12	24	202	28.20%
Total:	**228**	**58**	**88**	**159**	**69**	**81**	**33**	**716**	**100.00%**
%:	**31.80%**	**8.10%**	**12.30%**	**22.20%**	**9.60%**	**11.30%**	**4.60%**	**100.00%**	

APPENDIX V
POSTDOCTORAL MENTORING PLAN

APPENDIX V – POSTDOCTORAL MENTORING PLAN

National High Magnetic Field Laboratory
Postdoctoral Mentoring Plan

The goal of the Postdoctoral Mentoring Plan at the National High Magnetic Field Laboratory (NHMFL) is to provide NHMFL postdoctoral associates with a complete skill set that addresses the modern challenges of a career in science, technology, engineering and mathematics (STEM). A key component of the plan is full immersion in the interdisciplinary culture of the NHMFL and in the surrounding communities of one of the NHMFL's three partner institutions - the Florida State University (FSU), the University of Florida (UF), and Los Alamos National Laboratory (LANL). The Center for Integrating Research and Learning (CIRL) housed within the NHMFL will facilitate this Postdoctoral Mentoring Plan.

Currently, NHMFL postdoctoral researchers are required by their supervisors and research groups to participate in the preparation of publications, and to make presentations at group meetings and conferences. Postdoctoral researchers are also required to play active roles in STEM-strengthening programs, such as the NHMFL Diversity Plan, Outreach efforts, and formal educational or mentoring programs (e.g. the Research Experiences for Undergraduates program, the Research Experiences for Teachers program, and other CIRL outreach programs, through which they can provide significant STEM mentorship to students, early career scientists and the teachers of the next generation of scientists). Finally, NHMFL postdoctoral associates are required to provide service to the laboratory through participation in the NHMFL Annual Open House or other events designed specifically to translate and communicate research in the NHMFL user community to members of the general public.

The key components of the Postdoctoral Mentoring Plan are:

- **Orientation.** Orientations for all new employees including postdocs are held quarterly. At which time, new employees will meet with the NHMFL Director and the Human Resources Director who can address questions they may have related to their new position and the lab. Orientation materials, including a "Welcome to the MagLab" document are available online to augment the face-to-face orientation. The postdocs at the lab have developed an additional orientation booklet that speaks to the unique issues postdocs face. Orientation includes an overview of: the three sites of the NHMFL, the breadth of scientific research in the NHMFL user program, particularly interdisciplinary research, and practical institutional information (including but not limited to performance expectations, salary information, the ordering and delivery of materials, as well as information about local housing, schools, health care resources, and links to special interest groups at the local partner institution).
- **Professional Development.** Professional development classes, workshops, and online materials will cover grant writing, ethical conduct of research, organizing data, writing manuscripts, giving effective scientific presentations, mentoring other scientists and communicating scientific research to non-scientists. Workshops will be facilitated by CIRL and involve faculty from the NHMFL sites, the FSU Career Center, National Postdoc Associations, and Industry partners.
- **Career Counseling.** Sometimes postdoctoral associates may have career questions that their assigned mentor cannot speak to (e.g. careers in industry, networking opportunities for underrepresented minority students). Therefore, the NHMFL Postdoctoral Mentoring Plan includes a list of additional volunteer mentors who are willing to answer questions that postdoctoral associates may have. Postdoctoral associates may choose to contact volunteers from this list if they feel they need additional advice not exclusively from their direct supervisor. Possible forms of advice include: providing guidance, encouragement, and information on opportunities for networking, contributed and invited talks, and travel funds to attend conferences, including the NHMFL's Dependent Care Travel Grant Program [https://nationalmaglab.org/user-resources/funding-opportunities].
- **Assessment.** Assessment will be conducted by CIRL through the analysis of annual evaluation surveys to determine topics of interest to postdoctoral researchers and to ensure that postdoctoral researchers' mentoring needs are being met.