The National High
Magnetic Field Laboratory

2012 Annual Report





2012 Annual Report

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2012 ANNUAL REPORT

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ABOVE
Two budding scientists from the middle school mentorship program display parts of their project in the lab. *Turn to page 61 (Chapter 5) to learn about our other outreach efforts.*

CHAPTER 1

The Year in Review

2012: Another successful year of growth

by Gregory Boebinger, MagLab Director

ABOVE LANL celebration after the successful 100 T experiment.

There were two major highlights at the MagLab this year. The greatest achievement of 2012 occurred on March 22, when the MagLab's Los Alamos Pulsed Field Facility reached its goal of conducting a 100 T nondestructive experiment. The six successful experiments garnered user data on quantum-phase transitions and new ultra high-field magnetic states, Fermi-surface determinations and topologically protected states of matter.

In July, the National Science Board and the National Science Foundation awarded the MagLab its five-year renewal grant, which covers the operation of the MagLab user program from 2013-2017.

Expanding User Community

In 2012, 1,352 users from all over the world enjoyed access to magnet time at the lab's seven facilities at three sites, the largest number on record. Also in 2012, 72 first-time principal investigators requested magnet time and 25 grad students wrote their doctorates using MagLab data.

The MagLab's users generated 415 research reports — a near-record high that reflects the sustained strength of our user community and the important role played by high magnetic fields in rapidly expanding areas of research.

Pioneering Research Publications

- **May:** Working with MagLab scientist **Stephen McGill**, grad student **Tim Noe** and principal investigator **Junichiro Kono** of Rice, both users, published *Nature Physics* work on the superflorescence that solid-state materials are capable of producing under special conditions. Noe spent weeks at the MagLab, the only facility with the right combination of gear to carry out such an experiment.

- **July:** User **Paul Dunk**, grad student of Nobel winner **Harry Kroto**, published *Nature Communications* work on the self-assembly of carbon networks. Obtained using ICR magnets, the findings should have important implications for carbon nanotechnology and provide insight into the origin of space fullerenes, which are found throughout the universe.

- **September:** A collaboration between a user, Gainesville's High B/T Facility and the Los Alamos Pulsed Field Facility netted a *Nature* paper that specifically tested the leading theory of what happens to a quantum system when it is subject to disorder that can break the system into pieces that are no longer in phase with each other.

The 415 research reports represented 18 categories, including magnet science and technology, materials science, condensed matter physics, chemistry and the life sciences.

Twenty percent of the research activities (80 reports) were published in 2012, many in prominent journals. Additionally, 21 reports were accepted for publication;

ABOVE Attendees of the week-long Theory Winter School event, held January 9–12, 2012, converse with one another after a presentation.

41 were submitted for publication; and 157 have manuscripts in preparation.

Funding & Collaborations

The majority of research projects were funded by the U.S. National Science Foundation, the U.S. Department of Energy, and the U.S. National Institutes of Health. Other funding organizations included: NASA, U.S. Department of Defense, U.S. Air Force Office of Scientific Research, U.S. Army, U.S. Navy, and numerous universities. Research was also supported by science federations, ministries, and universities in countries around the world including: Brazil, Canada, China, Denmark, France, Germany, Israel, Japan, Poland, Russia, Slovakia, South Korea, and the United Kingdom.

Grants

- The Magnet Lab User Collaboration Grants Program supported 48 of the 415 research activities. The UCGP program encourages collaborations among internal and external investigators, promotes bold but risky efforts and provides initial seed money for new faculty and enhancements of experimental techniques.

- MagLab researchers **Steve Hill** and **Steve McGill** were each awarded NSF Major Research Instrumentation grants in August, totaling almost $3 million, to build EMR instrumentation and optics equipment for the split magnet in our DC user program, respectively.

- The NHMFL/UF continued to build a strong relationship with Claflin College, an HBCU in Orangeburg, SC. MagLab Professor **Art Edison** participated in two grant proposals from Claflin, hosted one African American undergraduate student from Claflin in his lab for summer research, invited two female scientists from Claflin to present their research in a workshop organized at UF and sent samples to Claflin for analysis by the Claflin students.

Partnerships

New partnerships were created with Bethune-Cookman University and Tallahassee Community College STEM Stars and STEM Initiative, resulting in three minority participants in the MagLab's REU program. In addition, a Native American student was accepted at LANL as a REU student. He had applied to the REU program as a direct result of MagLab recruiting at the 2011 meeting of the American Indian Science and Engineering Society.

Workshops

- **January:** The Magnet Lab hosted its first Winter School. This theory school featured 11 instructors from institutions nationwide and hosted 52 early-career theorists to learn about computational techniques in condensed matter physics. Students traveled from Turkey, Spain, Brazil, Serbia and France, as well as from around the U.S. to attend.

- **May:** The MagLab's fourth User Summer School provided both lectures and hands-on experience to visiting early-career experimentalists.

- **November:** The MagLab held its first dedicated energy workshop, *Energy@MagLab*, with presentations on better crude oil distillation, understanding catalysts, and creating more efficient fuel cells and energy storage devices.

MagLab Management

- **May: Roxanne Hughes**, a specialist in why women choose STEM fields, was selected as the director of the Center for Integrating Research and Learning.

- **June: Lucio Frydman** of Israel's Weizmann Institute was hired as the lab's chief scientist in chemistry and biology. An NMR user, Frydman is the developer of multiple quantum magic angle spinning, a technique that provides the increased sharpness needed for scientists to draw more accurate conclusions from their experiments.

- **September:** Physicist and longtime MagLab veteran **Eric Palm** was selected as the lab's deputy director. He had most recently been the chair of the DC User Facility.

ABOVE Art Edison and Roxanne Hughes.

ABOVE Lucio Frydman and Eric Palm.

Noteworthy Personal Achievements

- The User Committee elected **Ian Fisher** as its new chair, **Nicholas Curro** as its vice chair for DC/Pulsed/High B/T, and **Robert Schurko** as its vice chair for NMR/MRI/ICR/EMR.

- Two MagLab scholar scientists, **Dragana Popović** and **Luis Balicas**, were elected to be 2012 Fellows of the American Physical Society. Dragana's citation was "for experimental studies of glassy behavior in s trongly correlated systems near the metal-insulator transition" and Luis' citation was "for experimental studies of unconventional superconductors, heavy fermion materials, and frustrated magnetic systems." In addition, a MagLab-affiliated professor, **Rufina Alamo**, was also elected as a 2012 APS Fellow "for her use of well-characterized materials and performance of carefully designed experiments to address structure-property relationships in polyolefins."

- Two Maglab scholar scientists, **Scott Hannahs** and **Lloyd Engel**, were honored with 2012 Distinguished University Scholar awards by Florida State University. The award recognizes outstanding performance by nontenured or nontenure-seeking Florida State employees who have longstanding track records of research and/or creative activity at the university and occupy more senior levels in their respective positions.

- **September:** MagLab alum **Jennifer Stern** was a key member of the Mars Curiosity team that made news around the world.

Educational Outreach

The MagLab hosted two workshops on Mentoring and Networking for FSU women faculty in STEM fields. On average, three NHMFL female faculty members participated in each workshop. The August workshop was also attended by six female NHMFL postdocs, as part of the collaborative initiative between the Center for Integrating Research and Learning (CIRL) and Diversity Program for postdoctoral mentoring.

The MagLab created a "MagLab Fellowship" that provides $3,000/year for two years to a strong female or minority first-year graduate student in physics. In 2012, fellowships were awarded to two female incoming first-year graduate students in physics. These students attended the first postdoctoral and graduate student mentoring session held at the Magnet Lab.

With 20 different programs, CIRL continued its broad, highly successful outreach efforts, including expanding its Research Experiences for Teachers program to the LANL campus.

CIRL Achievements

- CIRL hosted 18 Research Experiences for Undergraduates students who spent eight weeks conducting hands-on research and learning the basics of basic research.

- CIRL hosted 11 Research Experiences for Teachers participants this year, for the teachers charged with engaging a new generation of kids in science. For the first time, two RET internships took place at LANL. Emphasis in this program is to mentor teachers at Title 1 schools.

- CIRL staff conducted outreach to over 10,000 K-12 students and more than 300 teachers in local counties and the state of Florida during the 2012 year.

- The MagLab through CIRL hosted a formal internship program for high school and college students beginning in the summer of 2012. Eleven students participated in the summer program in 2012 and four participated in the fall. These students are partnered with a scientist at the lab on a regular basis throughout the semester.

- Eight Science Café hosts gave informal talks on topics ranging from ants to oil spills.

- **February:** MagLab annual Open House offered opportunities for 4,700 community members of all ages to connect with the lab.

ABOVE Dragana Popović, Luis Balicas and Rufina Alamo were all recently named fellows of the American Physical Society (APS) for their exceptional contributions to physics.

ABOVE STEM Star and Tallahassee Community College student Jessica Saintibert characterized HIV lipids using EPR spectroscopy during her participation in the 2012 Research Experiences for Undergraduate (REU) program.

- **July:** The MagLab hosted 32 middle and high school girls for SciGirls, an immersive summer science camp designed to engage young women directly in scientific thinking.

- The MagLab hosted 36 middle school students in the MagLab Summer Camp, an immersive summer science camp designed to engage young men and women in scientific thinking.

- The MagLab education website reached over 900,000 visitors from across the world each year.

- The MagLab also substantially grew its social media outreach: Among more than 330 tweets in 2012 was the live feed from the MagLab/LANL of the 100 tesla pulse!

CHAPTER 2

Users Program

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 chapter, each facility presents information about its research capabilities, developments, plans, productivity, and efforts to build the user community during 2012.

The Magnet Lab was extremely pleased to welcome requests for magnet time from 72 new principal investigators in 2012: 14 in the DC Field Facility; 10 in the Pulsed Field; 14 in NMR-MRI@FSU; 11 in NMR-MRI@UF (AMRIS); 3 in EMR; and 20 in ICR. Most new PIs received magnet time during the year; a few were scheduled for 2013 (see Appendix A, for further information).

User proposals for magnet time are submitted online (https://users.magnet.fsu.edu/) and reviewed in accordance with the NHMFL User Proposal Policy (https://users.magnet.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. The facility directors may seek additional external or staff-written reviews on a proposal-by-proposal basis to ensure a comprehensive and high quality review process. 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.

Some "frequently-asked-for" lab-wide user statistics are presented in the **Tables 1 and 2** (see **Appendix A** for details). **Tables 3 and 4** present information on 2012 research reports and peer-reviewed publications (see also **Chapter 9**).

TABLE 1

Magnet Lab User Profile[1] *for 2012*

	Total	Women	Minority	NHMFL Affiliated Users[2]	Local Users[2]	University Users, U.S.[3,5]	Industry Users, U.S.[5]	National Lab Users, U.S.[4,5]	Non-U.S. Users[5]
Senior Investigators	730	88	36	146	95	434	21	85	190
Postdocs	170	31	7	33	50	98	1	28	43
Students	409	104	32	47	114	308	0	9	92
Technicians	43	12	5	15	15	30	2	2	9
TOTAL USERS	**1352**	**235**	**80**	**241**	**274**	**870**	**24**	**124**	**334**

1. The laboratory reports seven user facilities (DC Field, Pulsed Field, High B/T, NMR, AMRIS, ICR, EMR). A user is a member of a research group that is allocated magnet time. The user does not have to be "on site" for the experiment. Consequently, 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.
2. NHMFL-Affiliated users are defined as anyone in the lab's personnel system [i.e. on 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".
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. Four columns of users (university, industry, national lab, non-U.S.) will equal the Total Number of Users.

TABLE 2

Magnet Lab Facility Usage Profile *for 2012*

	Number of Magnet Days[1] Allocated	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Materials, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL-Affiliated[2]	3258.38	510.20	640.36	422.59	390.23	1295
Local[2]	1855.35	652.35	346	0	0	857
U.S. University	2485.78	1281.16	214.36	3	50.46	936.8
U.S. Govt. Lab.	369.35	340.28	13	0	3.07	13
U.S. Industry	70.98	3.98	65	0	2	0
Non-U.S.	1229.96	809.64	298.32	7	29	86
Test, Calibration, Set-up, Maintenance[3]	835.04	0	200	0	61.04	574
TOTAL	**10104.84**	**3597.61**	**1777.04**	**432.59**	**535.8**	**3761.8**

1. 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, Los Alamos, 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).
2. Use by NHMFL-Affiliated and Local users as defined in Table 1, footnote 2.

TABLE 3

2012 Research Reports *by Facility*

At the end of each year, Magnet Lab users and faculty at FSU, UF and LANL submit brief abstracts of their experiments, research and scholarly endeavors. All reports are available online at: http://www.magnet.fsu.edu/usershub/publications/researchreportsonline.aspx

Facility	Number of Reports
DC Field Facility	129
Pulsed Field Facility	56
High B/T Facility	8
NMR-MRI@FSU	68
NMR-MRI@UF (AMRIS)	56
EMR Facility	42
ICR Facility	21
MagLab Departments & Related Groups	
Applied Superconductivity Center	8
Condensed Matter Theory /Experiment (FSU)	14
Magnet Science & Technology	8
UF Physics	5
TOTAL REPORTS	**415**

TABLE 4

2012 Publications *by Facility*

Throughout the year, and particularly at year-end, Magnet Lab users and faculty at FSU, UF and LANL report their peer-reviewed publications and other products for the year. See **Chapter 9 – Products** of this document for further information or visit the website, http://www.magnet.fsu.edu/search/publications/search.aspx, to search the database.

Facility	Number of Publications
DC Field Facility	81
Pulsed Field Facility	31
High B/T Facility	11
NMR-MRI@FSU	42
NMR-MRI@UF (AMRIS)	60
EMR Facility	47
ICR Facility	24
MagLab Departments & Related Groups	
Applied Superconductivity Center	15
Condensed Matter Theory /Experiment (FSU)	59
Magnet Science & Technology	20
Physics @ UF	18
Center for Integrating Research & Learning	2

NOTE: Publications may be counted 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 involved both user/experimentalists and theorists. **As mentioned in Chapter 9, 368 distinct publications were reported to the laboratory for 2012.**

DC Field Facility

The DC Field Facility in Tallahassee continues to serve its large and diverse user community by providing continuously variable magnetic fields in a range and quality unmatched in the world.

2012 statistics on DC Field Facility users, proposals, and magnet usage are presented in Appendix A.

The DC Field user community is made up of undergraduate students, graduate students, postdocs, 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 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, postdocs and senior investigators who come to the DC Field Facility to perform their research results in a continuous mix of scientific ideas and state-of-the-art techniques that are passed both to and from users.

Facility Developments

A number of improvements were made in 2012 to the DC Field Facility that either improved existing measurement techniques or created new possibilities for measurements that pushed forward the leading edge of the lab's measurement capabilities. The first of these is the outfitting of the 25 T Split Helix magnet with a unique top loading cryostat coupled with a custom designed, U-shaped optical table and cryostat vibration isolation system that decouples the entire measurement apparatus (including the cryostat) from any vibration generated by the magnet or ambient frequencies present in the floor of the cell. The cryostat allows users to cover the temperature range from 4 K to 300 K and take full advantage of the unique optical geometry provided by the Split Helix magnet. Several users ran in this system in the latter part of 2012 with excellent preliminary results. **Figure 1** shows a photo of the magnet, cryostat, and optical tables, as well as results from Hailin Wang's group from the University of Oregon investigating trion resonances in CdTe quantum wells.

The new **top loading cryogenic system for the 45 T Hybrid** which was delivered in December 2011 was tested, outfitted, installed, and in use in 2012. This system has a ^{3}He cryostat and a variable temperature cryostat with interchangeable probes which allow users to perform experiments in the temperature range: 0.3

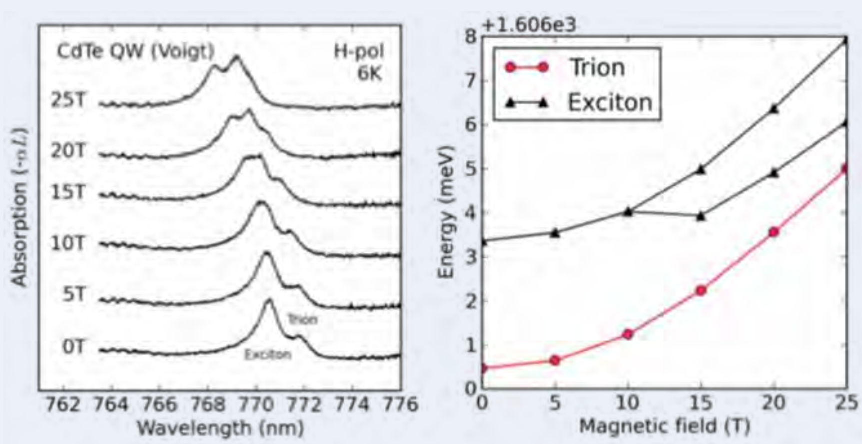

FIGURE 1. A) Photo of the 25 T Split Helix magnet with cryostat and optical tables. **B)** Absorbtion spectra of the CdTe QW show trion oscillator strength diminishes at high magnetic field, **C)** Binding energies of excitons and trions as a function of magnetic field.

K<T<70 K and 1.5 K<T<300 K. The user interface for mounting samples is identical to the 35 T top loading cryogenic system which enables experiments to be easily moved from the 35 T magnet to the 45 T Hybrid. Since it is a top loading cryostat sample changes by the user are straightforward and relatively fast. The top loading design also allows for construction of dedicated probes for measurement techniques that would not be possible through modification of existing probe hardware and it gives the lab the flexibility to integrate emergent measurement techniques.

A **technique for measuring photocurrent and photoluminescence in micron sized samples** in the optics 17.5 T superconducting magnet has been developed. This is an important capability since it is often the case that large (square mm) samples of a material may not be possible to synthesize. The probe and sample holder include an imaging system that allow the user to find their sample on the stage and once it is located it has sufficient precision to scan the focused laser spot across the sample.

The final piece of our multi-year liquid helium liquefaction and recovery system upgrade was delivered and installed in 2012. A custom **Linde Helium Gas purifier** is now in operation. This allows us to recover and clean He gas that is contaminated to 10,000 PPM level and can operate continuously at 18 g/s flowrate of recovered gas. This gas is purified to the 1 PPM level suitable for liquefaction by our turbine liquefiers. The importance of this completed system cannot be overstated given the importance of liquid helium to the MagLab's operation and the cost increases and supply restrictions that have occurred worldwide. This purifier and associated storage capacity allows us to recover a very high percentage of helium gas at a high rate. This means that recovered gas can be purified at the rate it is boiled off when transferring into large magnet systems, ensuring that we do not exceed our impure gas storage capabilities and vent He gas to the atmosphere.

Two small **high pressure piston cylinder cells (PCC)** have been designed, built, and tested. These cells were specifically developed to make them safe and easy to use for MagLab researchers whose experiments call for high pressures in the magnets and cryogenic systems available at NHMFL. These pressure cell designs make it much easier for users to learn how to load and prepare a pressure cell and change pressure between magnet shifts. The larger cell has sample space that is 3 mm in diameter with a usable height of 2.5 mm at the maximum pressure of 18 kbar. This "double clamped" design (with two open ends) makes this cell quite easy to use. It is able to rotate ±15° in the superconducting magnet SCM1 and rotate fully

DC Field Facility Magnet Systems

Florida Bitter and Hybrid Magnets Field, Bore, (Homogeneity)	Power (MW)	Supported Research
45 T, 32 mm, (25 ppm/mm)	29.3	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	19.2	
31 T, 32 mm to 50 mm[1]	18.4	
29 T, 32 mm (~5 ppm/mm)[2]	18.3	
20 T, 195 mm	20.0	
25 T, 52 mm, (1 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 – 2 K	Magneto-optics – ultra-violet through far infrared; Magnetization; Specific heat; Transport – DC to microwaves; Magneto-striction; 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, 47mm[3]	4 K – 300 K	
10 T, 34 mm, (50 ppm/cm)[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.

in SCM2. It can also be fixed on a non-rotating probe used in the resistive magnet top loading cryostats. Twelve leads can be brought into the high pressure volume. The smaller cell has a sample space that is 2 mm in diameter with a usable height of 1.0 mm. It has a maximum pressure at low temperatures of 15 kbar and is small enough to rotate in in the portable dilution refrigerator that can be installed in our resistive magnets. Approximately four leads can be brought into this cell. Being a single ended thick wall test tube design, this cell requires a much higher level of skill. Four probe resistivity, Hall effect, NMR, coil magnetometry, and TDO studies are feasible. The pressure cells are intended for use at fixed temperatures as the pressure can change during cooling.

Facility Plans

Work to exploit and e**nhance the scientific possibilities of the Split Helix magnet** will continue in 2013 with the award of a three-year, $900,000, NSF, Major Research Instrumentation proposal to PIs Steve McGill (NHMFL) and Madalina Furis (University of Vermont) for the development of a unique ultrafast magneto-optical spectroscopy system for the 25 T Split Helix magnet. This will enable multi-dimensional femtosecond spectroscopy, studies in the terahertz region of the spectrum and magnetic circular dichroism imaging at high magnetic fields. In addition plans will be finalized for the construction of a platform to provide better access to the top of the cryostat, provide shielding from scattered beams and protection for the optical tables surrounding the magnet.

The recently installed Linde L280 turbine liquefier will be connected to the 45 T Hybrid magnet in 2013 and replace the two vintage PSI piston liquefiers that are currently performing that task. This connection will be made through the **Cryogenic Central Distribution Box (CDB)** that is due to be installed in late summer. The CDB is essentially a manifold that allows the connection of the liquefier to multiple points. The CDB will allow the L280 to provide liquid helium and 80 K cooling loops for the 45 T hybrid, series connected hybrid, and produce liquid helium for the entire facility. The helium recovery piping in the DC magnet building and magnet cells will also be upgraded as well.

Upgrades will continue to the **resistive magnet power supplies** with the purchase of filter inductors and replacement 6 and 12 pulse transformers to push the noise level on the DC current supplied to the magnets to an even lower level. This has been an ongoing project that is being done in a modular fashion so as to minimize facility downtime for the users.

Science Productivity

Two examples of the DC Field Facility's productivity — "Symmetry Breaking in Graphene" and "First Superfluorescence in a Solid" — are given on the following pages in this section.

Progress on STEM and Building User Community

The DC Field Facility continued to be oversubscribed in 2012 as can be seen the usage tables in Appendix A. In spite of this oversubscription, the DC facility has continued to make bringing new investigators into the MagLab a priority. We are continuing our efforts to reach out wherever possible in order to expand our user program and enable principal investigators from backgrounds that are under-represented in the scientific community. In particular, the NHMFL sponsored a booth at the APS March Meeting and also the annual meeting of the National Society of Black Physicists / National Society of Hispanic Physicists to advertise our capabilities and opportunities.

In 2012 the DC Field Facility continued to attract new researchers. **Appendix A, Table 8** shows that **we received proposals requesting magnet time from 14 new PIs**: 7 received magnet time in 2012; 6 will receive time in 2013; and one is under review/to be scheduled. This is in addition to the 25 new PI's which we reported last year and 21 in 2010. These new PI's came from institutions as varied as Technical University of Dresden (GER), IBM (USA), University of Chicago, and Ohio State University. Of these new users one was female.

The DC Field Facility also hosted the **2012 MagLab Users Summer School** that attracted 24 graduate student and postdoc attendees. The summer school is a five-day series of lectures and practical exercises developed and put on by the MagLab scientific staff from the three sites. It has proven to be a great way to pass on 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 2013.

Symmetry Breaking in Graphene

USERS A.F. Young, C.R. Dean, L. Wang, H. Ren, P. Cadden-Zimansky, J. Hone, K.L. Shepard and P. Kim (Columbia University); K. Watanabe and T. Taniguchi (National Institute for Materials Science, Japan)

Graphene continues to be a material of intense interest in the condensed matter physics community and this is reflected in magnet time proposals from our users. Phillip Kim's research group from Columbia investigated **symmetry breaking in graphene** in the 35 T resistive magnet located in cell 12. In graphene these broken symmetry states are manifested as additional integer quantum hall states that appear outside the typical sequence where the QHE is only observed at filling factors n=4(N+1/2) **Figure 2a**. By using a rotating sample stage developed for the top loading cryogenic system they were able to classify the broken symmetry states through their spin polarization. In this work it was found that graphene becomes either a spin ferromagnet or a variety of density wave (**Figure 2b**). The underlying SU(4) symmetry is shown by the unusual absence of a n=5/3 fractional quantum hall state (**Figure 2c**).

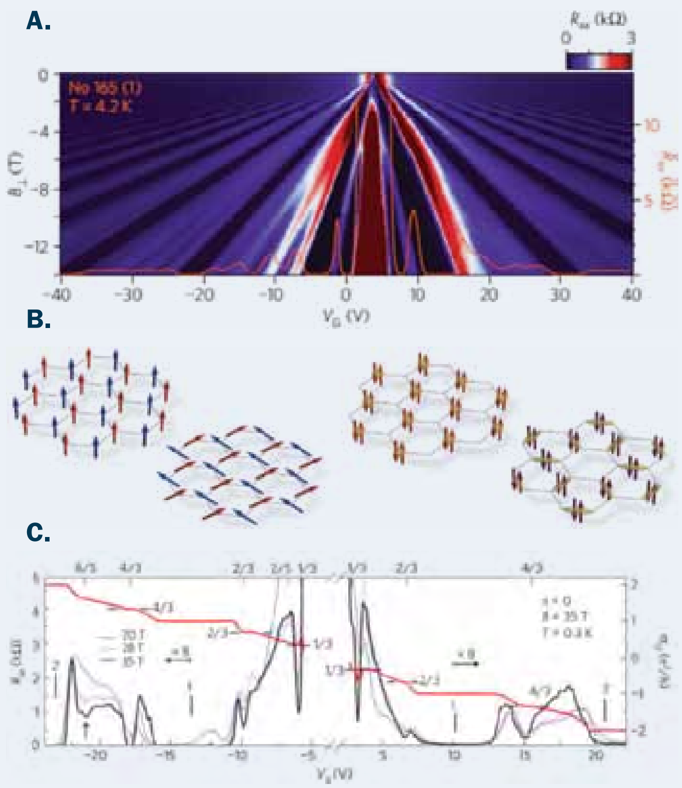

FIGURE 2. A) B) & C)

FACILITIES

35 T resistive magnet

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First Superfluorescence in a Solid

USERS G. Timothy Noe II, Ji-Hee Kim and Junichiro Kono (Rice University); Jinho Lee and David H. Reitze (University of Florida); Yongrui Wang, Aleksander K. Wójcik and Alexey A. Belyanin (Texas A&M University); Stephen A. McGill (NHMFL)

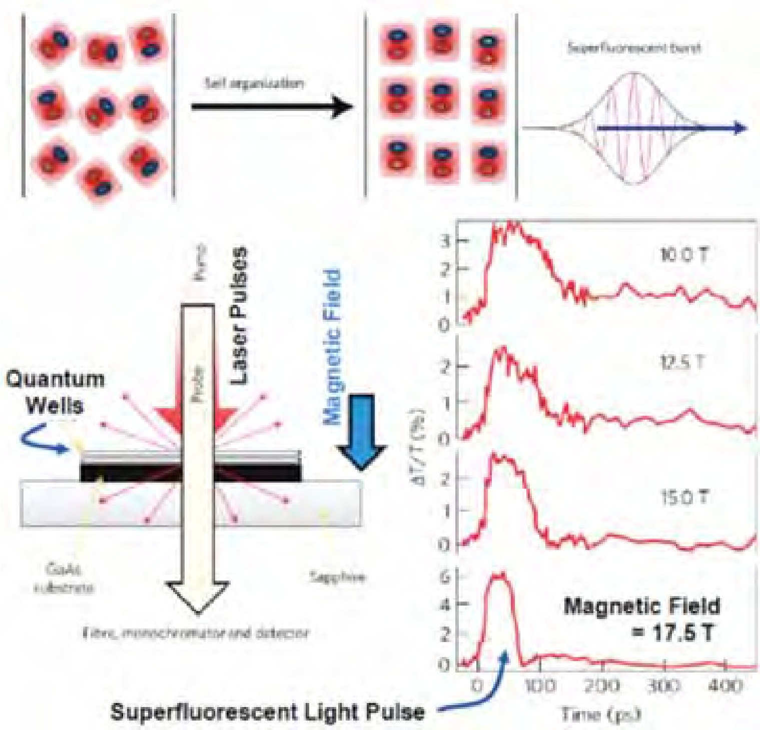

FIGURE 3. Random electron-hole pairs created by the light pulse (left) soon self-organize to generate a superfluorescent outgoing light pulse (right).

A groundbreaking experiment at the Magnet Lab in 2012 resulted in the **first observation of superfluoresence in a solid.** Superfluoresence is the spontaneous emission of electromagnetic radiation from a collection of excited atoms. Superfluorescence in the solid studied here occurs when the semiconductor containing a stack of two-dimensional quantum wells is placed in a very strong magnetic field (up to 17.5 T) at very low temperatures (5 K). The light pulse creates many electron-hole pairs in each quantum well that self-organize in the strong magnetic fields and low temperatures (**Figure 3**). These electron-hole pairs act very much like excited atoms that build up in the material until they spontaneously combine to produce the emitted light. This feat was accomplished by shining an extremely brief pulse of light on the layered semiconductor resulting in light of a different frequency being emitted 30 picoseconds later. This realization of superfluoresence in a solid with the observed unprecendented controllability raises the possibility of tunable sources of coherent pulses.

FACILITIES

Dedicated Optics Magnet "SCM-3"

REFERENCES

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Pulsed Field Facility

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) along with two other world class user programs: The Center for Integrated Nano Technology (CINT) and the Los Alamos Neutron Science Center (LANSCE).

2012 statistics on Pulsed Field Facility users, proposals, and magnet usage are presented in Appendix A.

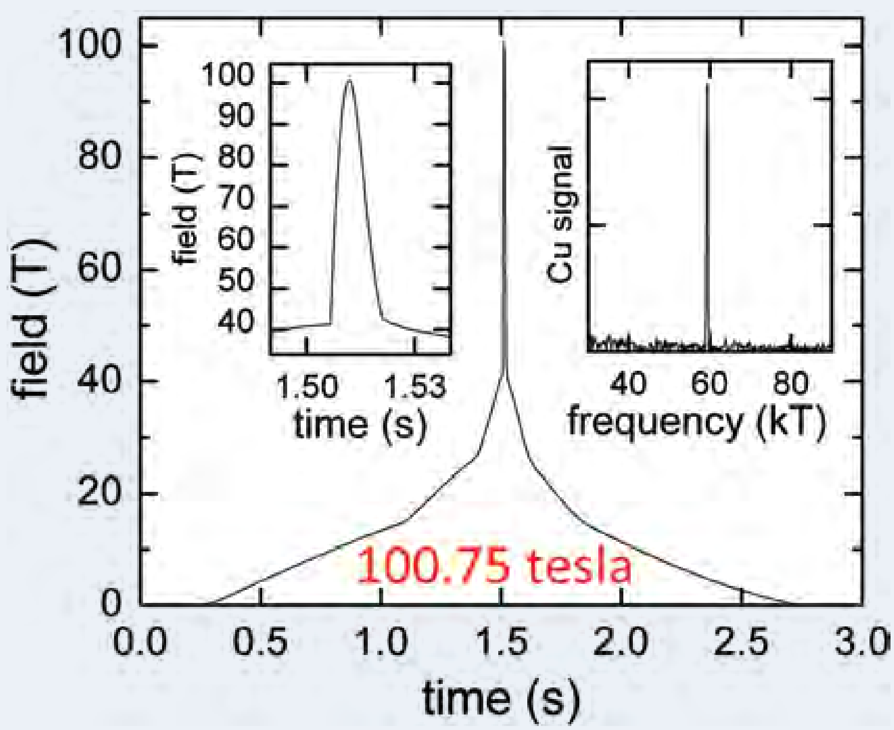

FIGURE 4. On March 22, 2012 the NHMFL broke the megagauss barrier, with a 100.75 tesla pulse. The world record for magnetic field intensity for a non-destructive pulsed magnet was confirmed via magneto quantum oscillations in poly-crystalline copper. This marks the first nondestructive generation of magnetic fields in excess of 100 T as a research tool.

The NHMFL-PFF utilizes LANL- and U.S. 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 possible 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 and computer controlled, 6-position 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 users program, which accommodates approximately 150 different users each year.

The LANL/DOE-owned 1.4GW generator is unique in the world and provides users with the highest non-destructive magnetic fields available.

Facility Developments

In 2012 the Pulsed Field facility continued on with efforts to reach 100 tesla. This 15-year effort culminated in the facility setting the world record for a non-destructive pulsed magnet of 100.75 tesla on March 22, 2012 (**Figure 4**).

This effort utilized the 1.4 GW generator to drive the outsert coil to 42 tesla with a capacitor driven insert coil designed and built in house at the Pulsed Field Facility providing the remainder of the 100.75 tesla field. This tremendous effort engaged all of the facilities staff, and we look forward to a sustainable 100 tesla science program in the future.

The second 10mm bore insert is now installed and available for user science with fields of 92 tesla being routinely delivered; 95 tesla shots being available for exceptional science based cases.

New in-house designs for the 65 tesla short pulse magnets have been rolled out in 2012 allowing us to reduce the cool down time between shots and maintain the magnet reliability.

Facility Plans

- Installation of the Linde helium liquefier and associated helium gas storage is well underway and should be complete in 2013.
- Winding of the third generation of 100T multishot outsert coils will begin in 2013.
- Development of the next generation short pulse magnets utilizing **Los Alamos[CF] cooling technology.**

Science Productivity

To date, 31 peer reviewed publications and 21 presentations and posters have been reported for 2012; 1 Ph.D. thesis and one masters dissertation have also been reported.

Two examples of the Pulsed Field Facility's productivity are given on the following pages in this section.

Progress on STEM and building the user community

The NHMFL-PFF provided magnet time for 126 distinct experiments in 2012 with 51 unique PI's. **Ten (10) requests for magnet time were received from new PIs**; 8 received magnet time in 2012 and 2 are scheduled for 2013.

Several students from underrepresented groups were involved in the program this year providing mutual benefits to the students and the PFF mentors.

Travel support may be granted to the new users, which has been helpful in growing the new user base considering the relatively remote location of the PFF in Los Alamos.

The staff members of the PFF continue to make considerable efforts toward outreach. In 2012 the fourth summer school was organized by Albert Migliori and Eric Palm. Held at the DC facility in Tallahassee, the school helped new users and students understand the complexity of conducting experiments in all of the NHMFL facilities with both lectures and hands on experiences. Many scientists from the NHMFL-PFF gave their time to teach at this important effort.

In 2012, the NHMFL-PFF hosted facility tours for over 400 people.

Pulsed Field Facility Magnet Systems

Capacitor Bank Driven Magnets — Field (T), Duration, Bore (mm)	Supported Research
Cell 1. 65 T Short Pulse, 25 msec, 15 mm Ultra low noise	Magneto-optics (IR through UV), magnetization, and magneto-transport from 350 mK to 300 K. Pressure from 10 kbar typical, up to 100 kbar. GHz conductivity, MHz conductivity, Pulse Echo Ultra-sound spectroscopy. IR & FIR transmission in the Single Turn Magnet. Specific heat capability in 60 T Long Pulse. Dilatometry up to 95T.
Cell 2. 65 T Short Pulse, 25 msec, 15 mm Rapid cool design	
Cell 3. 65 T Short Pulse, 25 msec, 15 mm Ultra low noise	
Cell 4. 65 T Short Pulse, 25 msec, 15 mm Rapid cool design	
Cell 294. Development test cell	
60 T Long Pulse Magnet, ~3 sec, 32 mm	
95T Multi-Shot, 10 msec, 10 mm / 85T Multi-Shot, 10 msec, 15 mm	
Single Turn (to 240 T so far), 0.06 msec, 10 mm	

Superconducting Magnets — Field (T), Bore (mm)	Supported Research
20 T magnet, 52 mm bore	Same as pulsed fields, plus thermal-expansion, specific heat, and 20 mK to 600 K temperatures. Heat Capacity, THz Resistivity, Heat Capacity, Magnetometry.
15/17 T magnet, 52 mm	
14 T-PPMS magnet	

Unprecedented Fermi Surface Spectral Resolution in the Underdoped High T_c Superconductor $YBa_2Cu_3o_{6+X}$ at 100 T

USERS N. Harrison, C.H. Mielke (LANL), S.E. Sebastian, G.G. Lonzarich (Cavendish Lab., Cambridge Univ., UK), R.-X. Liang, D.A. Bonn, W.N. Hardy (Univ. British Columbia, Canada)

In signal processing, an increase in the time interval over which a signal is sampled leads to an increase in the amount of information that can be extracted within a given frequency bandwidth. The same principle also applies to the measurement of magnetic quantum oscillations in metals as a function of the reciprocal magnetic field. An increase in the range in reciprocal magnetic field over which quantum oscillations are measured (obtained by extending measurements to both lower and higher magnetic fields) leads to an increase in spectral information that can be extracted regarding the Fermi surface geometry.

The recent achievement of magnetic fields exceeding 100 tesla provided the ideal opportunity to increase the resolution and precision with which the Fermi surface of the underdoped high T_c superconductor $YBa_2Cu_3O_{6+x}$ can be measured, enabling us to achieve substantial progress in our understanding of the origin of the small Fermi surface pockets[1].

A key distinguishing feature of the quantum oscillation waveform in underdoped $YBa_2Cu_3O_{6+x}$ is the beat pattern giving rise to nodes (at which the amplitude is suppressed) at 1/B=0.033 and 0.022 T-1. A Fourier transform of the oscillations reveals the beat pattern in the dominant amplitude quantum oscillation frequency (of 534 T) to be caused by the presence of two smaller amplitude frequencies that are separated from the main frequency peak by +-90 T. The values of the frequencies obtained in the Fourier transform are further confirmed by performing sinusoidal fits to the quantum oscillation data.

Rather than corresponding to three individual sections of Fermi surface, the observed distribution of frequencies in which a central peak is equally flanked by two adjacent peaks of similar amplitude can be shown to be the simple consequence of quasiparticles tunneling between two concentric Fermi surface orbits that differ slightly in size[2]. Such an observation is expected for a bilayer Fermi surface that is split into separate bonding and antibonding cross-sections by the presences of a direct coupling between the layers. A simple model that includes the effect of the tunneling is shown to provide an explanation for both the frequency distribution and the magnetic field-dependent quantum oscillation amplitude and beat pattern.

FACILITIES

100 T Pulsed Magnet

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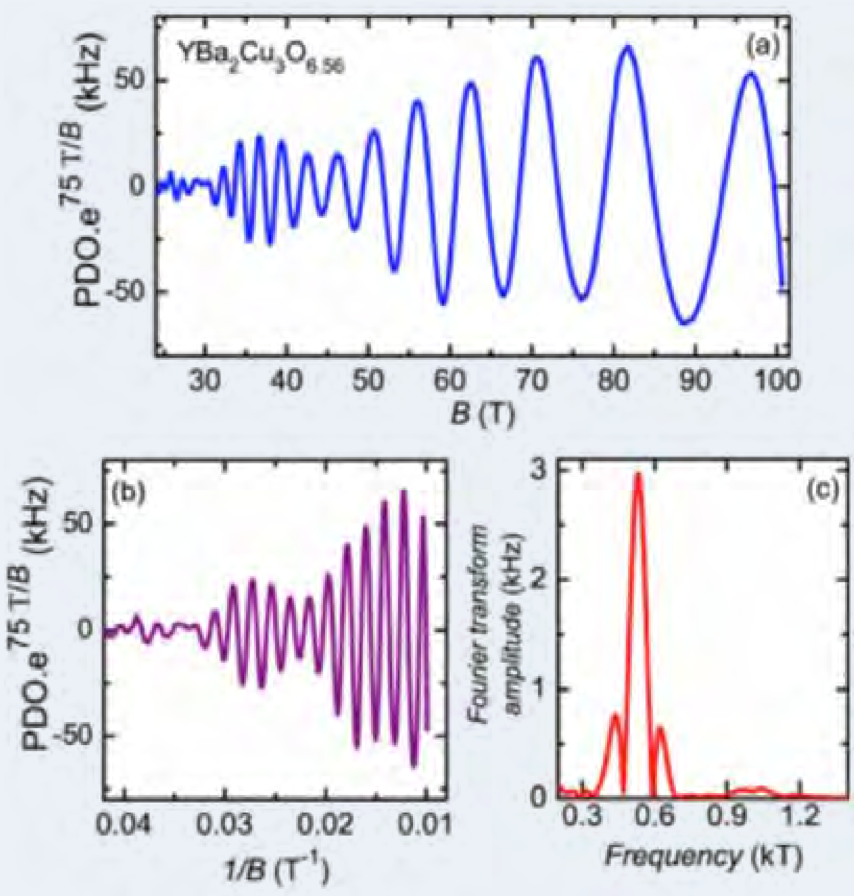

FIGURE 5. Quantum oscillations in $YBa_2Cu_3O_{6+x}$ obtained using the contactless conductivity technique shown versus magnetic field (**A**) and reciprocal magnetic field (**B**). **C)** A Fourier transform in which a Blackman window has been applied to the data.

Magnetostriction and Magnetic Texture to 100.75 Tesla in Frustrated $SrCu_2(BO_3)_2$

USERS M. Jaime (LANL, NHMFL), R. Daou (MPI, CPfS), S. Crooker (LANL, NHMFL), F. Weickert (LANL, CMMS), A. Uchida (LANL, NHMFL), A. Feiguin (Univ. of Wyoming, Physics), C. Batista (LANL, T4), H.A. Dabkowska (McMaster, Physics), B.D. Gaulin (McMaster, Physics)

Strong geometrical frustration in magnets leads to exotic states such as spin liquids, spin supersolids, and complex magnetic textures. $SrCu_2(BO3)_2$, a spin-1/2 Heisenberg antiferromagnet in the archetypical Shastry–Sutherland lattice, exhibits a rich spectrum of magnetization plateaus and stripe-like magnetic textures in applied fields. The structure of these plateaus is still highly controversial due to the intrinsic complexity associated with frustration and competing length scales. We discover magnetic textures in $SrCu_2(BO_3)_2$ via magnetostriction and magnetocaloric measurements in fields up to 100.75 T. In addition to observing low-field fine structure with unprecedented microstrain resolution, the data also reveal lattice responses at 73.6 T and at 82 T that we attribute, using a controlled density matrix renormalization group approach, to an unanticipated 2/5 plateau and to the long-predicted 1/2 plateau[1].

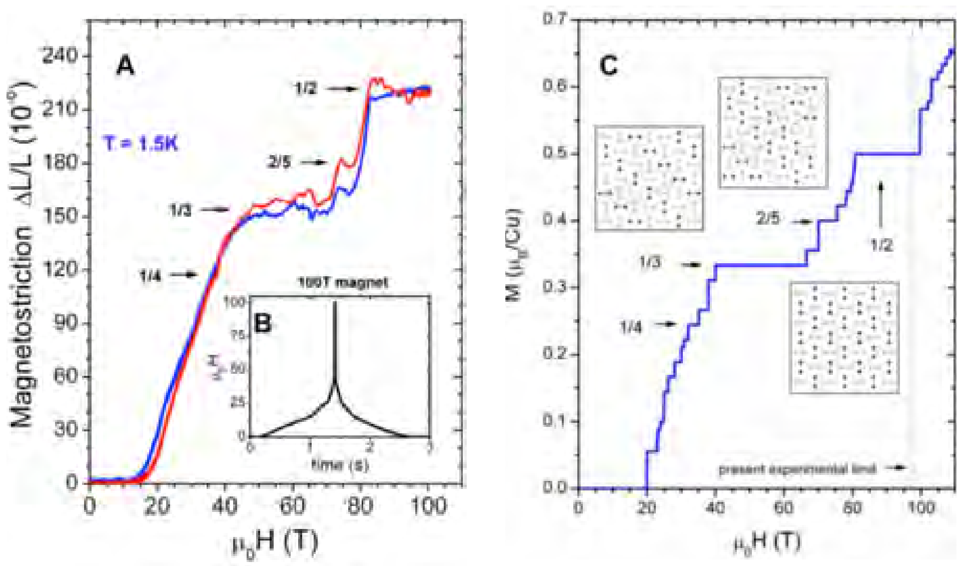

FIGURE 6. A) Magnetostriction vs. magnetic field for L//H//c-axis measured in a 100T (red and blue) pulsed magnet. Data taken during field upsweep (red) and downsweep (blue) are included. Two new features at 73.6T and 82.4T in the high field data are attributed to the onset of the 2/5 and 1/2 magnetization plateaus. This sample was measured while held in place solely by the optical fiber used for magnetostriction. **B)** Field profile of the 100T repetitively pulsed magnet at the National High Magnetic Field Laboratory. **C)** Normalized magnetization vs. field calculated using a density matrix renormalization group technique in a 4 x 30 site lattice for J0=78K and J1/J0=0.62 showing that the most stable magnetization plateaus occur at 1/3, 2/5 and 1/2 of magnetization saturation. Inset: Solid circles represent Cu2+ dimers occupied by spin triplet states. Open symbols are spin singlet states, organized in the 1/3, 2/5 and 1/2 states.

FACILITIES

100 T Pulsed Magnet

REFERENCES

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High B/T Facility

The High B/T Facility provides users with access to a unique combination of high magnetic fields (up to 16 T) and ultra-low temperatures (down to 0.04 mK) simultaneously.

2012 statistics on High B/T Facility users, proposals, and magnet usage are presented in Appendix A.

Two nuclear demagnetization stages are available, one using $PrNi_5$ to provide high cooling power down to 0.4 mK and a second using a Cu nuclear refrigerator capable of reaching 0.07 mK. In addition a fast turn-around 10 mK-10 T facility is available for testing experimental probes and sample properties prior to using the nuclear refrigerators. The nuclear refrigerators are housed in high quality electromagnetic shielded rooms in the University of Florida Microkelvin Laboratory and provide the ultra-quiet environments needed for high sensitivity measurements at very low temperatures.

Equipment is available to carry out measurements of magnetic and electric susceptibilities, ultrasound propagation, nuclear magnetic resonance, and transport studies at sub-millikelvin temperatures.

Facility Developments

In order to probe the electro-magnetic interactions in organic quantum magnets high precision ultra-low temperature capacitance bridges have been developed. This new capability has revealed the existence of new magneto-electric effects following the introduction of disorder in magnetic systems that display Bose-Einstein condensation of magnetic excitations.

Facility Plans

In collaboration with a new faculty member of the High B/T Facility, **James Hamlin**, new capabilities are being developed for studies at high pressures and at low temperatures. This new capability will meet user requests to extend the available parameter space at low temperatures to moderately high pressures (2-3 GPa), to explore the density dependence of the ordered states of novel magnetic systems such as low dimensional frustrated magnets and new classes of superconductors such as the pnictides.

Science Productivity

The High B/T facility reported 11 peer reviewed publications for 2012, including 6 significant publications, and there were 8 research reports for a total of 6 independent experiments in 2012. Three examples of exceptional science are included on the following pages in this section.

High B/T Facility Magnet Systems

Superconducting Magnets	Refrigerator	Supported Research
Bay 3, Microkelvin Laboratory 15.5 T at 4 K (16.5 T at 1.2 K) 2.5 cm DSV experimental space	$PrNi_5$ nuclear refrigerator 0.4 mK, 10 nW cooling power	Magnetic and electric susceptibility measurements, NMR to 1000 MHz, transport, Hall effect studies
Bay 2, Microkelvin Laboratory 8 T at 4 K (10 T at 1.2 K) 3.25 cm DSV experimental space	Cu nuclear refrigerator 0.07 mK, 1 nW cooling power (lowest attained temperature 0.04 mK)	Magnetic and electric susceptibility, NMR/NQR to 1000 MHz, transport, fQHE, dHVA studies, ultrasound absorption
Williamson Hall Annex 10 T, 2.5 cm DSV experimental space	Dilution refrigerator 10 mK	Fast-turn-around facility for testing samples

Quantum Spin Ice: Pyrochlore Quantum Magnet $Tb_2Ti_2O_7$ at Ultra-low Temperatures

USERS Q.J. Li, X.F. Sun (Hefei National Lab. & Chinese Academy of Sciences, China); L. Yin, J.S. Xia, Y. Takano (UF)

The pyrochlore lattice of the Tb3+ ions forms corner sharing tetrahedra, resulting in a highly frustrated spin system that is a good candidate for novel ground states at low temperatures. The observed dependence of the susceptibility on magnetic field and temperature reveal the existence of three phases as shown in **Figure 7**. Phase I, previously unobserved for this material, is believed to be a quantum spin ice and phase II a quantum kagome ice. These are new states of matter arising from frustrated effective spin interactions emerging from classically non-frustrated ones owing to quantum fluctuations. The nature of phase III is not completely understood. Long relaxation times and frequency dependent susceptibilities are observed in phase I [1].

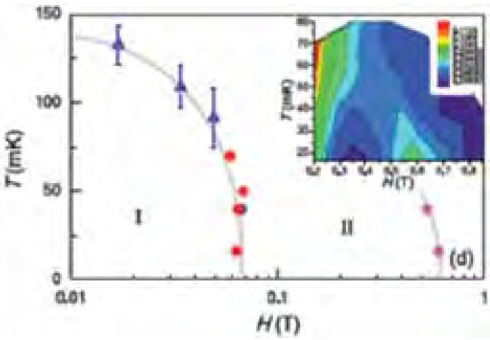

FIGURE 7. The low temperature phase diagram of the pyrochlore $Tb_2Ti_2O_7$ deduced from measurements of the AC magnetic susceptibility in Bay 3 of the UF Microkelvin Laboratory.

Investigation of Dirty Quantum Magnets — The Quest for the Bose Glass State

USERS L. Yin (UF, Physics), J.S. Xia (UF, Physics), V.S. Zapf (LANL), A. Paduan-Filho (Universidade de Sao Paulo), T. Roscilde (Ecole Normale Supérieure de Lyon), R. Yu (Rice University)

The AC magnetic susceptibility of a site diluted quantum magnet, dicholor-tetrakis-thiourea-nickel (DTN) was investigated as a function of applied field at very low temperatures (down to 1 mK). Pure DTN undergoes a Bose-Einstein condensation with critical fields of H_{c1} ~ 2 T and H_{c2} ~ 12 T. The goal of studying the doped material is determine if the BEC transition is lost if the amount of disorder introduced is sufficient, and if one can observe the long sought Bose Glass state.

For the bond-diluted quantum magnet $Ni_{0.85}Cd_{0.15}Cl_2$-$4SC(NH_2)_2$ studied down to 1mK and for magnetic fields up to 15 T a crossover temperature T_{cr} = 100~200 mK is observed below which, the critical fields H_c obey the scaling relation $|H_c(T) - H_c(0)| \sim T^{\alpha}$, with a novel and universal scaling exponent α ~ 0.9. This value is in agreement with numerical results from a theoretical model for the effects of the introduction of disorder in a Bose Einstein condensate. The results provide strong evidence of the existence of a Bose glass phase in $NiCl_{1.85}Br_{0.15}$-$4SC(NH_2)_2$, and they display a quantitative signature of the transition between a Bose glass and a Bose Einstein condensate[2].

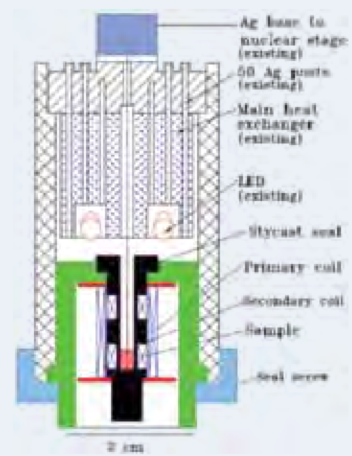

FIGURE 8. High sensitivity AC magnetic susceptometer.

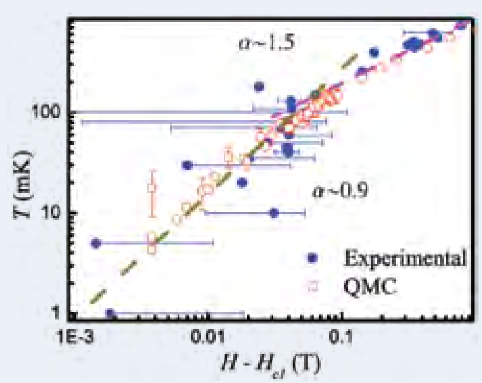

FIGURE 9. Scaling of the critical temperatures for Cd-doped DTN at the lower critical field H_{c1} with the distance from *T* = 0 critical fields, exhibiting a crossover between various exponents.

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Structural Ladders with Tunable Spins: Metal Monophosphonates $M\{(2\text{-}C_5H_4NO)CH_2PO_3\}(H_2O)_2$ (M = Co, Ni, Mn)

USERS Ting-Hai Yang and Li-Min Zheng (Nanjing University, China); Song Gao (Peking University, China); Elizabeth Knowles, Daniel Pajerowski, and Mark Meisel (UF, Physics), Jian-sheng Xia and Liang Yin (UF, Physics & NHMFL-High B/T Facility)

There is intense interest in simple low-dimensional arrangements (such as chains and ladders) of anti-ferromagnetically coupled spins that can serve as test beds for simple theoretical models of new magnetic states where geometrical frustration and quantum fluctuations can lead to new states. Metal monophosphates form a particular class of spin ladders for which the effective spin value can be tuned while maintaining a double-chain structure in which the $M_2(\mu\text{-}O)_2$ dimers are connected by O-P-O bridges (**Figure 10**).

Low magnetic field (less than 7 Tesla) and high temperature (greater than 2 K) magnetic susceptibility studies performed with a commercial magnetometer were extended to high fields (up to 10 T) and low temperatures (down to 50 milliKelvin) for M = Co, Ni, and Mn. The results of the AC susceptibility measurements (**Figure 11**) allowed the users to identify the dominant magnetic interactions as nearest-neighbor antiferromagnetic superexchange, leading to magnetic dimers for the Co and Ni compounds, with weaker dimer-dimer interactions present. On the other hand, the magnetic interactions of the Mn system are significantly weaker, so a definitive description of the magnetism in this compound is not resolved by the extremes of magnetic field and temperature used. A full discussion of results and analyses has been published[1].

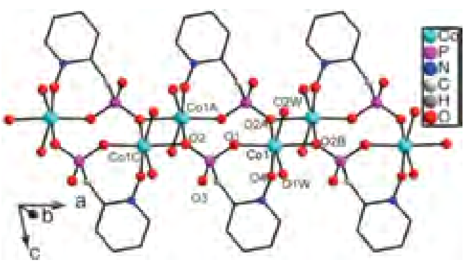

FIGURE 10. Structure of Co- monophosphonate, which is isostructural with the Ni and Mn analogues.

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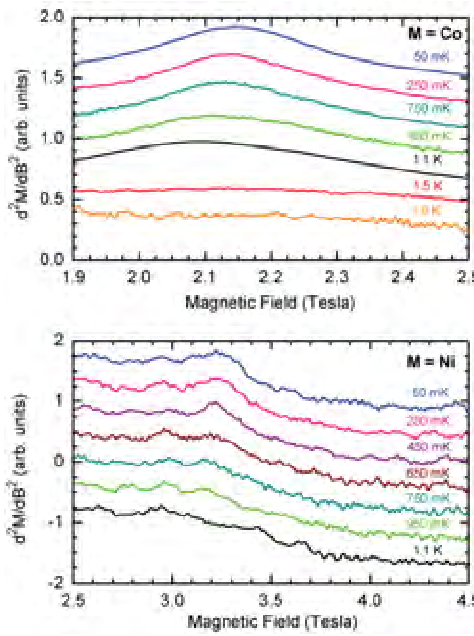

FIGURE 11. Isothermal responses of (d^2M/dB^2) for M = Co (top panel) and Ni (bottom panel). In each panel, the data indicate the presence of temperature-dependent features that possess no hysteresis with respect to the direction of the field sweep. These features are associated with the field-induced transition from the antiferromagnetically coupled dimer state to the spin-polarized state.

Progress on STEM and Building the User Community

Faculty and staff members of the High B/T Facility offered several tours of the low temperature facility to student and teacher groups in 2012. Among others, these tours included: (1) a dedicated UF program for K-8 teachers titled "Enhance Science Content for K-8" as part of the UF-Futures Program, (2) four sessions of talks and laboratory visits for 4th graders as part of the Newberry Elementary School Science Day titled "Stand Back and Try Science", (3) a tour of the REU students for both NHMFL-REU students and UF-Physics-REU students, and (4) a tour dedicated to senior undergraduates from the UF chemistry department. In addition High B/T Facility faculty supervised summer research for three REU students in the summer of 2012, of which one was from an underrepresented group.

A collaborative agreement with the Low Temperature Physics Group at the **Korean Advanced Institute of Science and Technology** (KAIST) was reached under the direction of Prof. **Yoon Lee** of the UF Microkelvin Laboratory and Prof. **Hyoungsoon Choi** of KAIST for the development of materials for use in nuclear adiabatic demagnetization refrigerators. Prof. Choi is a recently hired faculty member at KAIST, who is an expert in quantum fluids and solids. Prof. Lee will visit KAIST in 2013 as part of the collaboration.

FIGURE 12. Professor Meisel introduces Sante Fe Community College students to the NHMFL High B/T Facility in Bay 3 of the UF Microkelvin Laboratory.

NMR-MRI Facility at FSU

The NMR and MRI User Program in Tallahassee offers user scientists access to the highest magnetic fields along with the latest NMR techniques and probe technology.

2012 statistics on NMR-MRI at FSU users, proposals, and magnet usage are presented in Appendix A.

NMR-MRI Facility at FSU Magnet Systems

NMR Frequency	Field (T)	Bore (mm)	Homogeneity	Measurements
1.7 GHZ	40	32	10 PPM	Solid State NMR
1066 MHZ	25	52	1 PPM	Solid State / Solution NMR
900 MHZ	21.1	105	1 PPB	Solid State NMR, MRI
830 MHZ	19.6	31	100 PPB	Solid State NMR
800 MHZ	18.7	63	1 PPB	Solid State NMR
800 MHZ	18.7	52	1 PPB	Solution NMR, Cryoprobe
720 MHZ	16.9	52	1 PPB	Solid State / Solution NMR
600 MHZ	14	89	1 PPB	MRI and Solid State NMR
600 MHZ	14	89	1 PPB	Solid State NMR
600 MHZ	14	52	1 PPB	Solution NMR
500 MHZ	11.75	89	1 PPB	Solid State NMR
500 MHZ	11.75	89	1 PPB	NMR Microscopy
400 MHZ	9.4	89	1 PPB	Solid State NMR
300 MHZ	7	52	1 PPB	Instrument Development
300 MHZ	7	89	1 PPB	Solid State NMR

Our flagship 900 MHz ultra-wide bore spectrometer is the world's highest field instrument for *in vivo* imaging and also offers leading capabilities in materials and biological solid state NMR. Lower field instruments offer users additional unique capabilities in solution NMR and solid state NMR as well as opportunities for additional experiment time. Our technology efforts continue to be focused on the development of innovative probes for triple resonance solid state, high field *in vivo* imaging and very high mass sensitivity solution NMR probes. Efforts are also underway to develop rf probes and associated NMR instrumentation that will be needed for a ground-breaking new powered magnet, the 36 T series connected hybrid, which will have record-setting capabilities for NMR.

Facility Developments and Plans

2012 was a very productive year for the NMR/MRI Program in Tallahassee. **Bill Brey** was Acting Director for the first two-thirds of the year and now continues on as Associate Director. **Tim Cross** was on sabbatical for much of the year. In early 2012 **Lucio Frydman** was hired part-time to be Chief Scientist for Chemistry/Biology. His enthusiasm for higher fields, higher resolution and sensitivity in NMR and MRI is boundless. Two new scholar scientists have also been hired, **Srinivasan Chandrashekar** ("Shekar") with a strong interest in advancing Li^+ battery technology and **Sungsool Wi** from Virginia Tech with interests in polymers used for water purification. Both have interests in a broad range of NMR, MRI, and DNP activities.

With the 5-year renewal came strong support for a multidisciplinary DNP program that spans AMRIS, EMR, and the NMR program. Dissolution DNP is to be established in Gainesville. Overhauser DNP for small molecules and MAS bio-solids DNP are to be established in Tallahassee. In the meantime the program has taken delivery of a 63 mm 800 MHz magnet, a gift from the University of Minnesota for the cost of extracting the magnet from a subterranean facility and shipping it to Tallahassee, where it has now been reassembled, energized, and shimmed. A new Bruker console is on its way and **Peter Gor'kov** and colleagues are designing solid state NMR probes and a VT system for the magnet. In the meantime, to address the high demand for biological solid state NMR spectroscopy, the 720 MHz narrow bore has been converted for oriented sample NMR and now has higher sensitivity than the WB600. As a result more WB600 time is available for MAS spectroscopy. To compensate for the lost solution NMR time on the 720, the Magnet Lab has coupled with the Department of Chemistry and Biochemistry to provide Magnet Lab users access to the 700 MHz system with a cryo probe in the department.

Almost all of our external solution NMR spectroscopists operate remotely. Indeed an increasing number of our biological ssNMR users also operate the instruments remotely including the UWB 900. The development of remote access is a high priority for the facility as an important cost-saving feature for our users in an age of limited research dollars.

Science Productivity

Work at the NMR-MRI Facility in Tallahassee led to 68 annual research reports and 42 peer-reviewed publications in 2012. These publications appeared in high-impact journals such as *Nature Materials* (1), *Journal of the American Chemical Society* (5), *Angewante Chemie* (1) and *ACS Nano* (1), as well as in more specialized publications such as *Journal of Magnetic Resonance* (7), *PLoS Biology* (1), and *Analytical Chemistry* (1). Four examples of the NMR-MRI Facility at FSU's productivity are given on the following pages in this section.

Progress on STEM and Building the User Community

The NMR-MRI Facility in Tallahassee had 216 users during 2012: 45 were female and 15 were minorities. Of the 117 senior investigators in 2012, 35 were new to the NHMFL, of which **14 were new principal investigators** leading research projects. To attract new users and projects we continue to add new capabilities such as the 63 mm bore 800 MHz magnet from the University of Minnesota.

Order–Disorder Transitions Govern Kinetic Cooperativity and Allostery of Monomeric Human Glucokinase

USERS Mioara Larion, Lei Bruschweiler-Li, Brian G. Miller and Rafael Brüschweiler (FSU, Chemistry & Biochemistry); Roberto Kopke Salinas (University of São Paulo, Institute of Chemistry)

Miller and **Brüschweiler** (FSU Chemistry and Biochemistry) in collaboration with **Salinas** (Univ. of São Paulo) have proposed an unexpected solution for a long standing question in biochemistry. Glucokinase is a key metabolic enzyme that regulates the rate at which insulin is secreted through a cooperative kinetic response to increasing glucose concentrations. Through solution NMR spectroscopy of the this large enzyme an intrinsically disordered domain (a theme in our highlights) becomes structured in the presence of glucose leading to enhanced activation of the enzyme (**Figure 13**).

FACILITIES

Bruker Avance III spectrometer operating at 800 MHz proton field and equipped with a TCI cryogenic probe.

REFERENCES

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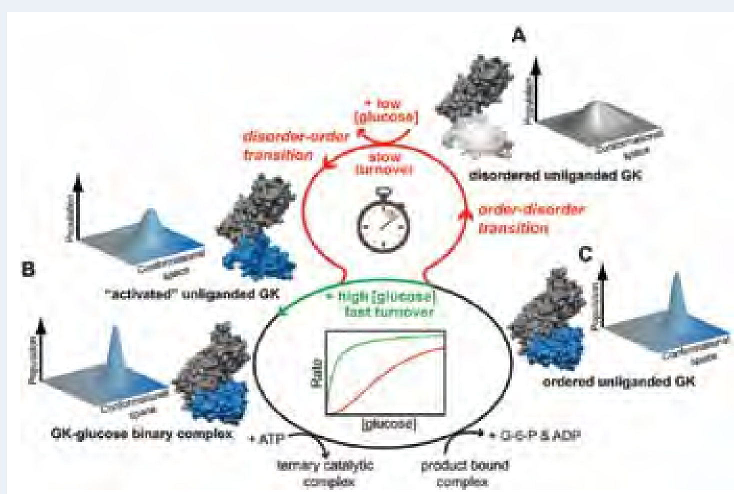

FIGURE 13. Mechanism of glucokinase cooperativity.

Lower Aggregation States of the β-amyloid

USERS Terrone L. Rosenberry (Mayo Clinic); Anant Paravastu and Maxwell Zimmerman (FSU, Chemical Engineering); William Tay (Mayo Clinic, College of Medicine), Danting Huang, Ashley Cormier and Sarah Leonard (FSU College of Engineering); Xiaodong Pang (FSU, Institute of Molecular Biophysics)

Exciting structural work has been reported for β-amyloid fibrils in the recent literature. However, it is now thought that lower aggregation states of the β-amyloid may play a more significant role in disease pathology. **Paravastu** (FSU, Chemical Engineering) in collaboration with researchers at the Mayo Clinic have isolated structurally homogeneous samples of oligomers of the 42 amino acid residue β-amyloid and showed significant structural differences compared with the fibrils of the same peptide using ^{13}C-^{13}C dipolar recoupling experiments (**Figure 14**).

FACILITIES
500 MHz, 89 mm bore, 11.7T

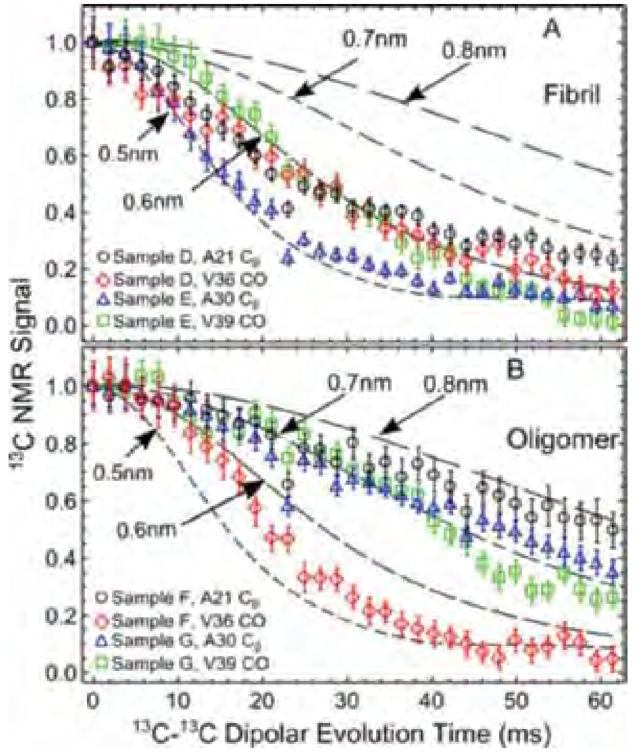

FIGURE 14. The ^{13}C homonuclear recoupling data for fibrils and oligomers of β-amyloid.

Solid-State NMR Structural and Dynamics Studies of HIV-1 Protein Assemblies

USERS Tatyana Polenova, Yun Han, Christopher Suiter and Guangjin Hou (University Delaware, Chemistry & Biochemistry); Bill Brey, Zhehong Gan and Ivan Hung (NHMFL)

Polenova (Univ. of Delaware) has been working with **Gor'kov** and **Brey** on the development of triple resonance MAS capabilities for the 900. In **Figure 15** Polenova shows spectra of assemblies of the HIV-1 viral capsid CA protein and capsid-spacer peptide 1 (CA-SP1). The SP1 tail is unstructured and increasingly such domains are associated with important functions. The assemblies show excellent spectral resolution, and detailed structural and dynamic characterizations are underway.

FACILITY
21 T 900 MHz Ultra Wide Bore magnet

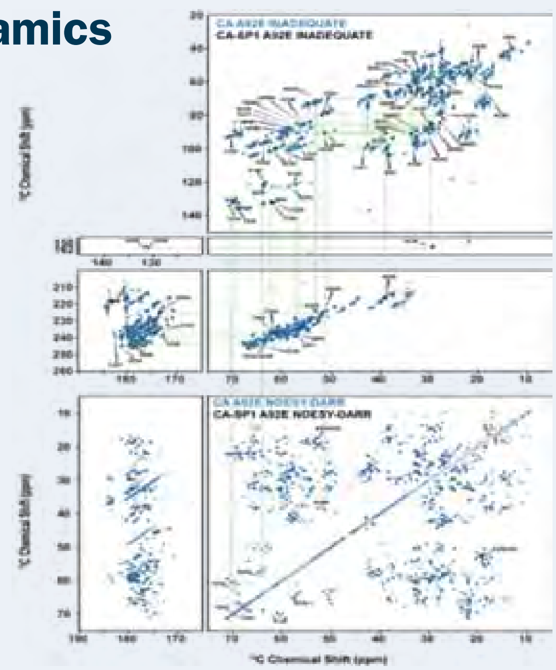

FIGURE 15. 2D homonuclear dipolar and scalar based correlation spectra.

High-Resolution MRI Probe for STRAFI Studies of Solid Materials

USERS Joel A. Tang and Sneha Dugar (NHMFL, FSU); Guiming Zhong and Yong Yang (Xiamen University); Jason A. Kitchen and Riqiang Fu (NHMFL)

Fu (NHMFL) has teamed up with **Y. Yang** at Xiamen University to obtain high resolution images of a battery phantom by Stray Field Imaging (STRAFI) (**Figure 16**). This approach takes advantage of the 50T/m gradient in the 830 MHz NMR magnet that occurs about 20 cm below the center of the field. The present results which made the cover story of JMR showed an image with 15 µm resolution. The presence of metal disks did not affect the image profile showing the possibility of studying batteries in situ with STRAFI.

FACILITIES

19.6 T Narrow Bore NMR magnet

REFERENCES

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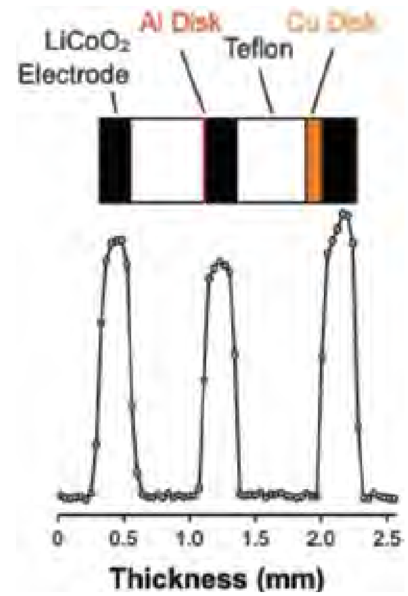

FIGURE 16. 1D STRAFI profile of a battery phantom.

NMR-MRI Facility at UF (AMRIS)

The NMR and MRI user facilities at the University of Florida, commonly referred to as AMRIS (the Advanced Magnetic Resonance Imaging and Spectroscopy facility), support nuclear magnetic resonance studies of chemicals, biomolecular systems, tissues, small animals, large animals, and humans.

2012 statistics on NMR-MRI at UF users, proposals, and magnet usage are presented in Appendix A.

We currently offer eight systems with different magnetic fields and configurations to users for magnetic resonance experiments. AMRIS has eight professional staff members to assist users, maintain instrumentation, build new coils and probes, and help with administration.

Several of the AMRIS instruments offer users unique capabilities: the 750 MHz wide bore provides outstanding high-field microimaging for excised tissues and live mice; the 11.1 T horizontal MRI is the largest field strength magnet in the world with a 400 mm bore; the 600 MHz 1-mm HTS cryoprobe is the most mass-sensitive NMR probe in the world and is ideal for natural products; the 3 T human whole body has 32 channels for rapid parallel imaging and is the only whole body instrument in the state of Florida dedicated to research. These systems support a broad range of users from natural product identification to solid-state membrane protein NMR to cardiac studies in animals and humans to tracking stem cells and gene therapy *in vivo* to functional MRI in humans.

Facility Developments

With funding from an NIH shared instrumentation grant and the NHMFL, in 2012 we installed two new consoles and gradients for our two oldest instruments, the 500 MHz solution/solid state NMR and 600 MHz solution/solid state NMR and MRI spectrometers. This equipment replaced 12-15 year old RF technology; users immediately enjoyed the enhanced sensitivity and ease of use on both these instruments. They have enabled us to streamline changes in modality (solids NMR vs. solution NMR vs. magnetic resonance imaging) and increased the breadth of experimental configurations we can offer to users.

In 2012, we began two exciting new initiatives in the AMRIS facility. The first is to upgrade the capabilities of the 750 MHz instrument. With funds from the NHMFL, both to AMRIS and through a User Collaboration Grants Program (UCGP)

NMR-MRI Facility at UF Magnet Systems

^{1}H Frequency	Field (T)	Bore (mm)	Homogeneity	Measurements
750 MHZ	17.6	89	1 PPB	Solution/solid state NMR & MRI
600 MHZ	14	52	1 PPB	Solution/solid state NMR & MRI
600 MHZ	14	52	1 PPB	1-mm HTS cryoprobe
600 MHZ	14	54	1 PPB	5-mm cryoprobe
500 MHZ	11.7	52	1 PPB	Solution/solid state NMR
470 MHZ	11.1	400 (290 mm useable bore)	0.1 PPM	MRI and NMR of animals
200 MHZ	4.7	330	0.1 PPM	MRI and NMR of animals
130 MHZ	3	900 (600 mm useable bore)	0.1 PPM	Whole body MRI and NMR of humans and large animals

award to **Tom Mareci**, we purchased a new console and gradients to replace our existing instrumentation, much of which dates back to the initial installation of this instrument in 2001. The UCGP award is especially focused on developing enhanced capabilities for *in vivo* imaging on both mice and rats, building on expertise gained by the NHMFL staff in developing MRI capabilities on the UWB 900 in the NMR/MRI facility. The new console is scheduled for delivery in May, 2013, and the new *in vivo* imaging probe will be assembled and tested during the summer of 2013.

The second new initiative is to develop a polarizer to enable *in vivo* spectroscopy of insensitive nuclei, such as ^{13}C and ^{15}N. This is part of the dynamic nuclear polarization (DNP) initiative outlined in our renewal proposal to the NSF for the NHMFL awarded this year; this is a cooperative effort of the EMR, NMR-MRI at FSU, and AMRIS facilities to develop DNP-enhanced technology to enable *in vivo* spectroscopy, solution NMR, and solid state NMR experiments on sensitivity-limited samples.

Another major development for AMRIS was the addition of a next generation 1.5 mm HTS probe for natural products and metabolomics optimized for both ^{1}H and ^{13}C detection, developed by **Art Edison** and **Bill Brey** in collaboration with Agilent, Inc., to the user program. This probe is installed on the 600 MHz NMR spectrometer that was added to the AMRIS user program in fall 2010 and many users are already benefiting from its enhanced sensitivity, especially for ^{13}C-detected experiments. New microimaging coils ranging in size from 50-100 µm, developed by **Steve Blackband** in collaboration with Bruker Biospin, Inc., for ultra high resolution microimaging have also led to the growth of our user program into new areas.

Finally, we partnered with the NIH-funded Clinical and Translational Science Institute at the University of Florida to recruit a new faculty member to head up our human imaging efforts. **Song Lai** joined us in June as the head of the human imaging core and a faculty member in the department of Radiation Oncology. Through his efforts we are building a program complementary to the NHMFL user program which supports users pursuing biomedical research through NIH funding mechanisms.

Facility Plans

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 particularly excited by the research that will be enabled by the DNP initiative. The new dissolution DNP instrumentation which will be completed in the AMRIS facility in 2013 can enable ≥10,000x increases in the nuclear polarization and NMR signal. The polarized sample can then be rapidly injected into animals for *in vivo* imaging and spectroscopy of metabolites. Initially it will support studies on our 4.7 T MRI systems, with plans to expand to the 11 T MRI and 600 MHz NMR systems.

Science Productivity

The AMRIS facility users reported 60 peer-reviewed publications and 7 theses for 2012. Two examples of the NMR-MRI Facility at UF's productivity are given on the following pages in this chapter.

Progress on STEM and Building the User Community

Art Edison organized a metabolomics workshop at the University of Florida from June 4-7, 2012, featuring 17 speakers, including 12 outside of UF and 2 international leaders. We had 46 registrants, including 11 from institutions outside of UF. Art Edison and **Joanna Long** both gave "Science Café" presentations on their research, Dr. Edison in Thomasville, GA, and Dr. Long in Tallahassee, FL. These were public lectures with about 30-40 people from the community, including youth and adults. **Sergey Vasenkov** gave an overview of the unique PFG NMR technique combining advantages of high field (17.6 T) and high gradients (30 T/m) for studies of gas transport in porous materials and ionic liquids to a group of high school teachers and students from the Gainesville area on January 30, 2012, as part of the 48th Annual Florida Junior Science, Engineering and Humanities Symposium (JSEHS). **Art Edison** received a Fulbright Specialist grant to teach NMR, metabolomics, and natural products to students at the National University of Buenos Aires (FAUBA) from October 30, 2012 to November 28, 2012. During the visit, he taught a formal course and also gave 6 seminars at various universities and institutes, including seminars highlighting the NHMFL and introducing students and faculty to the external user program.

We are continuing to build a strong relationship with Claflin University, with **Dr. Edison** hosting two African American undergraduate students in his lab during the summer. **Dr. Arezue Bourujerdi**, an Assistant Professor at Claflin, gave a lecture at the UF metabolomics workshop and her postdoc, **Dr. Miki Watanabe**, also presented at the workshop.

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 20-30 of these participants working on projects at any given time.

Nematode Chemical Ecology

USERS Art Edison (UF), Frank Schroeder (Cornell University), Paul Sternberg (CALTECH), Peter Teal (USDA), *et al.*

Nematodes are the most abundant animal on earth, and parasitize virtually every animal and plant. The small soil nematode *Caenorhabditis elegans* is one of the best studied animals. *C. elegans* utilizes an extensive chemical "language" that allows individuals to communicate and regulates basic behaviors such as feeding, mating, and population density control. We still know very little about how the components work together and how the chemical signals are regulated. Because of the chemical ecology progress, some receptors and other gene products that transducer signals into behavior are now being discovered.

We previously discovered the mating pheromone for *C. elegans* and showed that it is a mixture of small molecule ascarosides that overlap with the known dauer pheromones, which regulate developmental arrest. There are now at least 150 known pheromones in various forms (wild-type and several different mutants) of *C. elegans*, and many different species of nematodes use the same signals. We recently discovered the mating pheromones in a related species of nematode, *Panagrellus redivivus*, a free-living species with females and males that is distantly related to *C. elegans*, which has hermaphrodites and males. In *P. redivivus*, the females attract the males and the males attract the females.

We discovered both attractants and showed that they are both ascarosides that differ significantly and that are only expressed in the opposite gender, as expected. Moreover, we took two approaches, traditional activity-guided fractionation and targeted metabolomics and found the same compounds. This information may one day provide important new clues for the biological control of other nematode parasites of plants or animals (**Figure 17**).

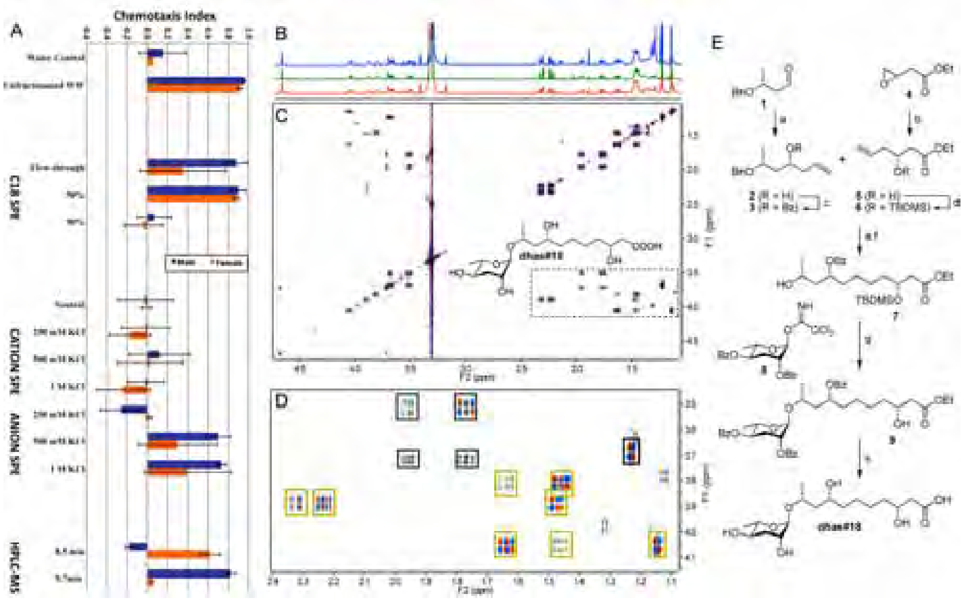

FIGURE 17.[2] Identification of ascr#1 and dhas#18 as sex pheromones in *P. redivivus*. **A)** Activity-guided fractionation of *P. redivivus* WW. **B)** ^{1}H NMR spectra of isolated natural dhas#18 (red), synthetic dhas#18 (green), and a mixture of natural and synthetic samples (blue). **C)** dqf-COSY spectrum of isolated dhas#18. **D)** Section of the dqf-COSY spectrum in C showing cross-peaks diagnostic of the ascarylose ring (black boxes) and the highly functionalized side chain (yellow boxes). **E)** Synthesis of dhas#18. a, 1. $TiCl_4$, 2. allylSn(PPh_3); b, vinylmagnesium bromide, Me_2S-CuBr, tetrahydrofuran (THF); c, BzCl, pyridine; d, t-butyldimethylsilyl chloride (TBDMSCl), imidazole, dichloromethane (DCM); e, Grubbs II, 1,4-benzochinone, DCM; f, H_2, Pd/C, EtOH; g, trimethylsilyl triflate (TMSOTf), DCM; h, aqueous LiOH, THF, dioxane.

FACILITIES

NMR data was collected using 600 MHz NMR spectrometers in the AMRIS facility and cryoprobes.

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3. Kaplan, F.; Alborn, H.T.; von Reuss, S.H.; Ajredini, R.; Ali, J.G.; Akyazi, F.; Stelin¬ski, L.L.; Edison, A.S.; Schroeder, F.C.; Teal, P.E., *Interspecific nematode signals regulate dispersal behavior*, PLOS One **7**(6) e38735 (2012).
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Magnetic Resonance Characterization of Enzyme-inhibitor Interactions

USERS Ian deVera, Xi (Rochelle) Huang, Mandy Blackburn, Mike Veloro, Ben Dunn, and Gail Fanucci (UF); Carlos Simmerling (Stony Brook University)

Human immunodeficiency virus type 1 protease (HIV-1 PR) is an essential enzyme for HIV maturation and undergoes conformational exchange upon ligand binding. Prolonged exposure of HIV/AIDS patients to protease inhibitors (PIs) often result in drug resistance because of drug pressure selected mutations in the HIV genome that lead to amino acid changes in the HIV-1 protease (HIV-1 PR) and weaker binding with PIs. This work focuses on characterizing changes in protease dynamics as a result of these mutations and how they relate to changes in inhibitor effectiveness. Pulsed EPR, specifically site-directed spin-labeling (SDSL) double electron-electron resonance (DEER) spectroscopy, is used to observe the ligand-induced conformational shift of inactive HIV-1 PR at cryogenic temperatures, and solution NMR spectroscopy is used to examine protein-ligand interactions in solution under more physiologically relevant conditions. Inhibitors are titrated in and changes in protein backbone chemical shifts and peak intensities are monitored via ^{1}H-^{15}N-HSQC spectra. This method enables the approximation of inhibitor residence time and binding strength at room temperature; giving a relative estimate of the ligand exchange dynamics.The HSQC titration data support the results of EPR and suggest that pulsed EPR can be used to accurately characterize micromolar to sub-micromolar range protein-inhibitor interactions in conformationally flexible enzyme systems such as D25N inactive HIV-1 PR (**Figures 18, 19 & 20**).

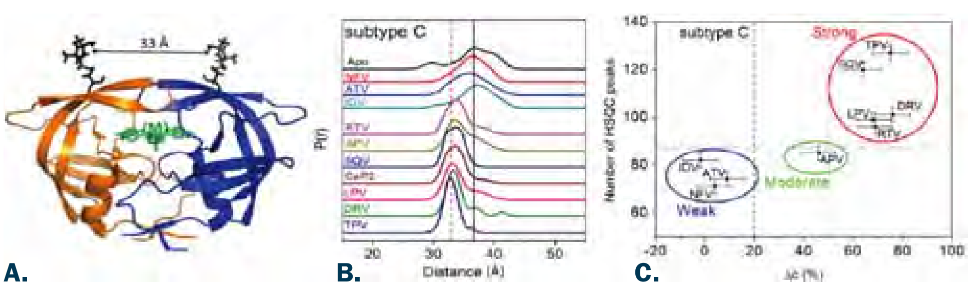
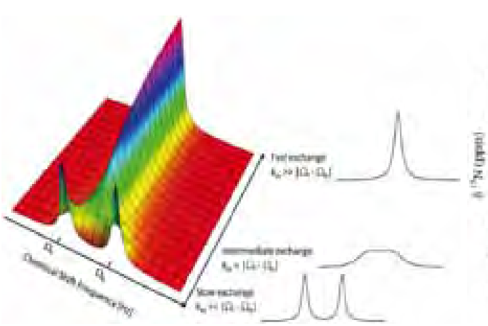


FIGURE 18. A) Ribbon diagram of HIV-1 PR, distance between the two spin label is measured by the EPR. **B)** Distance distribution profiles for HIV-1 PR with inhibitors. **C)** Comparison of number of ^{1}H-^{15}N HSQC resonances to changes in fractional occupancy, *Δc*, induced by inhibitor binding.



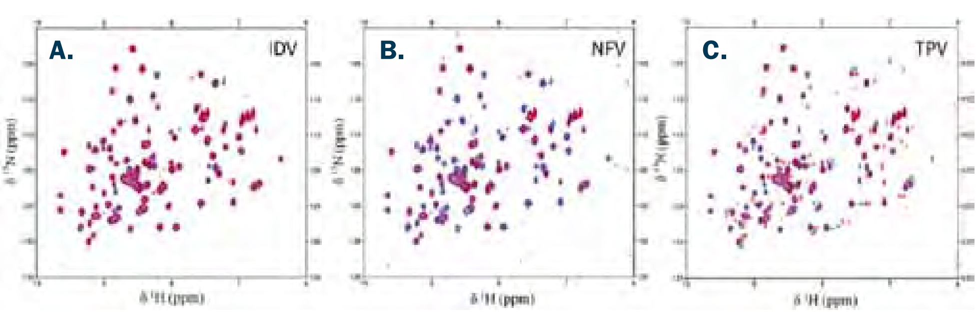


FIGURE 19. (Left) Simulated 1D NMR spectra of a two-site chemical exchange process.
FIGURE 20. (Right) Select ^{1}H–^{15}N HSQC spectra of HIV-1 PR in the apo (red) state and bound to 1:1 inhibitor: protein (blue). **A)** Fast exchange. **B)** Intermediate exchange. **C)** Slow exchange.

FACILITIES

EPR data was collected using a Bruker EleXsys E580 spectrometer equipped with an ER 4118X-MD-5 dielectric ring resonator. NMR data was collected using a 600 MHz NMR spectrometer in the AMRIS facility and a 700 MHz NMR spectrometer in the NMR/MRI facility.

REFERENCES

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2. Huang, X.; de Vera, I.M.S.; Veloro, A.M.; Blackburn, M.E.; Kear, J.L.; Carter, J.D.; Rocca, J.R.; Simmerling, C.; Dunn, B.M.; Fanucci, G.E., *Inhibitor-induced conformational shifts and ligand exchange dynamics for HIV-1 protease measured by pulsed EPR and NMR spectroscopy*. J Phys Chem B **16**(49):14235-44 (2012).

Electron Magnetic Resonance Facility

The Electron Magnetic Resonance (EMR) facilities at the NHMFL offer users several home built, high field and high frequency instruments providing continuous frequency coverage from 10 GHz to ~1 THz, with additional frequencies available up to 2.5 THz using a molecular gas laser.

2012 statistics on EMR users, proposals, and magnet usage are presented in Appendix A.

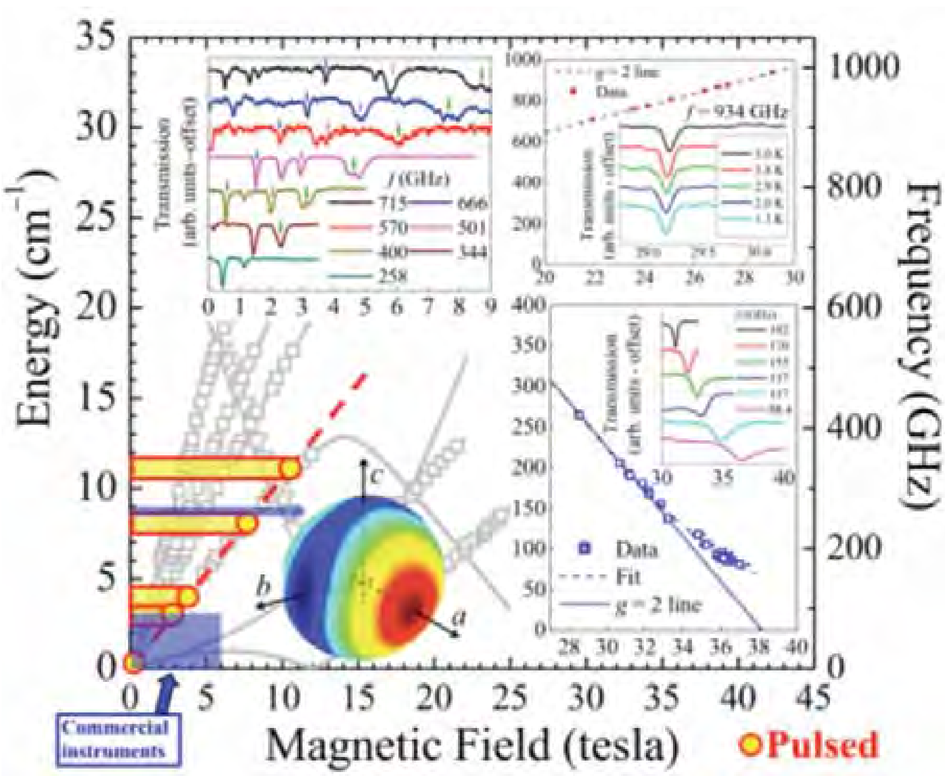


FIGURE 21. Frequency-field parameter space available for high-field EPR at the NHMFL. Blue regions represent commercial instruments. The red-dashed line represents the standard 28 GHz/tesla ESR paradigm for nearly-free electron spins. Users of the facilities in Tallahassee typically require measurements spanning the entire parameter space in the figure, as demonstrated with the examples. Recent upgrades have extended capabilities beyond the light gray data (tetrahedral Co^{II}) in the bottom left-hand portion of the figure. Upper left – low-field, high-frequency EPR for a $[Co^{II}]_4$ single-molecule magnet; upper right – high-field, high-frequency EPR for a Cu^{II} $S = ½$ quantum antiferromagnet; lower right – high-field, low-frequency inter-spin state transitions observed for a Mn^{V} $S = 1$ quantum anti-ferromagnet; lower middle – complete map of the g-tensor of a Cu^{II} species under pressure. Pulsed high-field EPR capabilities are also available, including the world's highest frequency pulsed spectrometer (336 GHz, 12.5 T).

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 magnet (see **Figure 21**). Some of the probes can be configured with resonant cavities, providing enhanced sensitivity as well as options for in-situ rotation of samples in the magnetic field. Quasi-optical (QO) reflection spectrometers are also available in combination with dedicated high-resolution 12/17 T superconducting magnet systems; a simple QO spectrometer has also been developed for use in the resistive magnets (up to 45 T). EMR staff members can assist users in the DC field facility using broadband tunable homodyne and heterodyne spectrometers.

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 delivered in 2012; this instrument will become available to users later in 2013 (see below). A commercial Bruker Elexsys 680 operating at 94 GHz is also available upon request. The combination of c.w. and pulsed instruments may be used for a large range of applications, including the study of optical conductivity, cyclotron resonance, paramagnetic impurities, molecular clusters, antiferromagnetic and ferromagnetic compounds and thin films, optically excited paramagnetic states, radicals, catalysts, model complexes and other biologically relevant species, etc.

2012 Highlights: Events, Personnel and New Instruments/Projects

Workshops and conferences

The EMR group hosted the inaugural Magnetostructural Correlations Workshop in Tallahassee in April 2012. The event attracted 45 participants from six countries (France, Scotland, England, Germany, Canada and the US). Aside from two tutorials by NHMFL staff, and two seminars by distinguished visitors, the remaining 21 talks were given by graduate students and postdocs; they were each given 50 minutes, but asked to prepare 30 minute talks so as to leave lots of time for

FIGURE 22. TOP Collage of photos taken at the Magnetostructural Correlations workshop (cover of program shown top left). **BOTTOM** US-MMM participants in the EMR lab.

discussion (see **Figure 22**).

The group was also involved in the inaugural Florida State University (FSU) Undergraduate School on Magnetism and Magnetic Materials (US-MMM – Chaired by Michael Shatruk, FSU, Chemistry). This event, which included lectures and practicals that focused on various topics in magnetism, was attended by 13 undergraduates selected from a diverse pool of US applicants (see **Figure 22**, lower picture).

The EMR Director, **Stephen Hill**, co-Chaired the 13th International Conference on Molecule-based Magnets (ICMM), held in Orlando, Florida, October 7-11, 2012. Student participation was a major goal of this event, which began with a full day of free tutorials prior to the main conference; ~100 students/postdocs attended the tutorials. Meanwhile, fifty students received significant financial support (free accommodations and waived registration) towards attendance at ICMM. In the end, 140 students/postdocs attended out of a total of 300 participants. Of these, 19 were selected to give short oral presentations at the main conference, for which there were no parallel sessions. This proved to be extremely popular among both the students and senior participants.

Dynamic Nuclear Polarization (DNP)

Stephen Hill and **Hans van Tol** teamed up with the NMR group (**Bill Brey**, **Joanna Long** and Chief Scientist for Chemistry and Biology, **Lucio Frydman**) to develop a joint research program focused on the development of high-field/ frequency Dynamic Nuclear Polarization (DNP). As part of this effort, the National Science Foundation funded a separate $1.35M MRI project (with $250k State cash match) to develop a high-power, gyrotron-based 395 GHz/600 MHz DNP instrument targeted at small molecules in organic solutions. A separate 395 GHz/600 MHz solids DNP effort is also under way, with support from the MagLab and the State of Florida. These joint EMR/DNP efforts represent a major new initiative that was laid out in the five-year renewal proposal to the NSF. Several new postdoc positions and a new staff position will help to support this multi-year effort.

HiPER

In August 2012, the 94 GHz HiPER spectrometer was delivered to the EMR lab from St. Andrews University in Scotland. The NHMFL system currently operates at low powers (<250 mW). However, an upgrade to 1 kW is planned within the next 18 months, which will enable $\pi/2$ pulses for $S = ½$ 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 changed 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 also offers excellent sensitivity.

HiPER will initially operate at low powers (2013 and much of 2014). An order has been placed for the high-power amplifier that should lead to full functionality in late 2014. Longer term plans involve extending capabilities to ~240 GHz. HiPER will be made available to users for c.w. and low-power pulsed measurements in September 2013. A workshop is planned for winter 2013/14 in order to inform users of this new capability, and to grow a user program around HiPER.

Mössbauer Lab

A zero-field instrument capable of working over the temperature range from 1.4 K to 300 K has been available since 2008. A superconducting 8 T magnet was acquired in 2012 and is being tested now as a part of a second, independent Mössbauer system. The magnet is specially designed for Mössbauer spectroscopy and is equipped with a bucking coil to reduce the magnetic field at the site of the gamma source below 100 Gauss. Both the old and the new instrument operate on ^{57}Fe nuclei. Mössbauer spectroscopy in magnetic field allows determination of the nuclear g parameters, the sign of the quadrupole splitting, etc. Data collected at the Mössbauer lab were used in 4 papers in 2012, of which 2 were published in the *Journal of the American Chemical Society*. A Mössbauer specialist was hired as a postdoctoral fellow at the end of 2012 (see below).

Crow postdoctoral fellow

Sebastian Stoian (PhD from Carnegie Mellon University, followed by postdoc positions at MIT and Carnegie Mellon) joined the EMR group in 2012. His position is funded through the NHMFL Crow Postdoctoral Fellowship Program. Sebastian has extensive experience in Mössbauer spectroscopy and will work with **Andrew Ozarowski** as demand for this user facility increases. Sebastian will also assist EMR users.

Plans for 2013

HiPER Workshop

In response to recommendations from the most recent users meeting, a workshop is planned for the winter of 2013/14 that will focus on the technical capabilities and potential applications of the new HiPER spectrometer. The workshop will feature scientific presentations from experts, as well as hands-on demonstrations. Existing and new users will be invited to participate, particularly graduate students and postdocs. The workshop will be extensively advertised during 2013.

SEMRC

The NHMFL EMR and NMR programs will host the Southeastern Magnetic Resonance Conference (SEMRC) in October 2013.

Acquisition of high-power microwave sources

Two major pieces of hardware will be delivered to the EMR program in 2013; a 1 kW 94 GHz amplifier with 1 GHz bandwidth has been ordered and will be delivered for integration with HiPER in 2014 (see above); and a 395 GHz, 50 W gyrotron source is in the process of being ordered for the DNP project.

EMR engineer

Approval has been given for the EMR program to advertise for a permanent staff engineer. This person will assist the EMR scientists and students/postdocs in the development of new instrumentation, probes, sample-holders, etc., particularly as required for the new DNP initiative and as part of the effort to expand operations in the DC facility (Series Connected Hybrid and Split Resistive magnets).

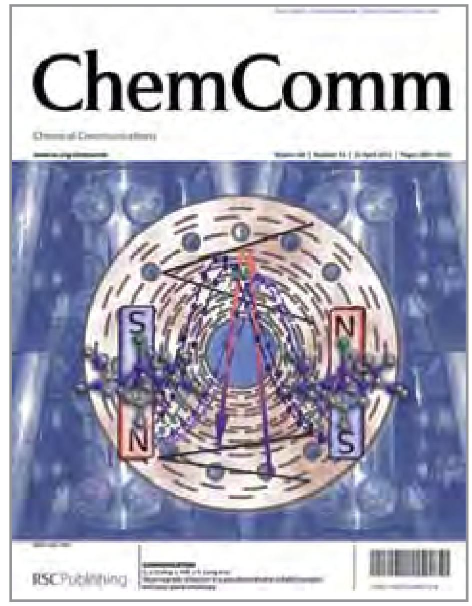
EMR/DNP postdoc(s)

The EMR group is currently advertising for up to two postdocs to assist with DNP development. We anticipate filling these positions in the first half of 2013.

Science Productivity

In 2012 a large number of research groups and projects were accommodated by the EMR group, resulting in the submission of 49 research reports; seven of these were submitted to the DC field facility, representing a marked increase over previous years. In addition, 47 peer-reviewed journal articles were reported by our users, up from 38 in 2011, as well as numerous presentations at conferences.

Many publications appeared in high-impact journals including: Nature (1); *Angewandte Chemie* (1); *Journal of the American Chemical Society* (6); *Physical Review Letters* (1); *Chemical Communications* (1), featured on the cover of the journal; *Nano* and *Nano. Lett.* (3); *Inorganic Chemistry* (12); *Biochemistry* (2); *Physical Review B* (4); and *Dalton Transactions in Chemistry* (2). Projects spanned a range of disciplines from applied materials research to studies of proteins. Three recent examples are given on the following pages.



ABOVE MagLab research is featured on the cover of *Chemical Communications*, issue 33 (2012).

Progress on STEM and Building the User Community

The EMR Facility had 109 users in 2012, 16% of whom were women and 5% were minority. It received proposals from 3 new principal investigators, 2 of whom have received magnet time; the other proposal is under review.

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. In addition, members of the EMR group made aggressive efforts to advertise the facility at international workshops and conferences. These efforts included attending conferences outside of their own immediate research areas. The group also organized several workshops and symposia and provided financial support in the form of student travel grants for the two main EPR conferences in the US. The group intends to continue this series of student workshops in the coming years as a means of outreach to the international EPR community. Finally, the EMR group has participated in several outreach activities, including the mentorship of summer REU students, RETs and local high-school interns.

Understanding Nanoscale Magnetization Dynamics via High-Field EPR

USERS X. Feng, J. Zadrozny, N.A. Piro and J. R. Long (UC Berkeley), T.D. Harris (Northwestern University), J. Liu (NHMFL and UF), C.J. Chang (LBNL and UC Berkeley), S. Hill (NHMFL and FSU)

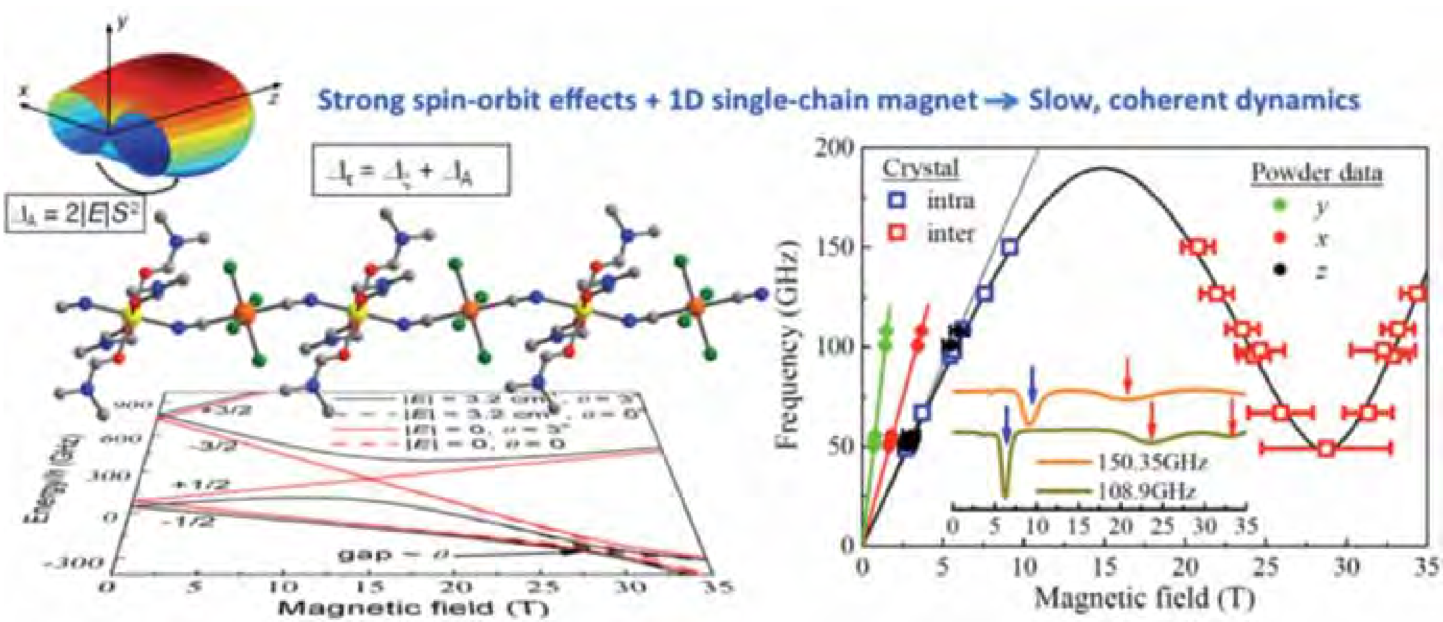


FIGURE 23. High-field EPR data for the Re^{IV} building block used in the chain shown at left[1].

Molecules that exhibit slow magnetic relaxation upon removal from a polarizing magnetic field, referred to as single-molecule magnets (SMMs), have received considerable attention owing to their potential utility in applications such as spin-based information storage. The slow relaxation in SMMs normally arises from the action of an easy-axis magnetic anisotropy, quantified by a negative axial zero-field splitting parameter, D, on a high-spin ground state, S.

Two separate EPR studies carried out in the DC field facility by students from UC Berkeley have identified compounds that undergo slow relaxation, even though the relevant magnetic ions possess easy-plane-type anisotropy ($D > 0$)[1,2]. A theoretical model was developed to account for this behavior in the study involving a $Mn^{II}Re^{IV}$ chain (shown right). Indeed, fundamentally new mechanisms seem to underpin the observed slow relaxation in both cases, suggesting new strategies for designing SMMs.

FACILITIES

EMR and DC Field Facilities

ACKNOWLEDGEMENTS

This work was supported by the Department of Energy (LBNL) and the National Science Foundation (CHE1111900 and DMR0804408), and the NHMFL (NSF DMR 0654118 and the State of Florida).

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1. Xiaowen Feng, Junjie Liu, T. David Harris, Stephen Hill and Jeffrey R. Long, *Slow Magnetic Relaxation Induced by Large Transverse Zero-Field Splitting in a $Mn^{II}Re^{IV}(CN)_2$ Single-Chain Magnet*, J. Am. Chem. Soc. **134**, 7521–7529 (2012).
2. Joseph M. Zadrozny, Junjie Liu, Nicholas A. Piro, Christopher J. Chang, Stephen Hill, and Jeffrey R. Long, *Slow magnetic relaxation in a pseudotetrahedral cobalt(II) complex with easy-plane anisotropy*, Chem. Comm. **48**, 3927-3929 (2012) – featured on the cover of the journal (see previous page).

Polarization of Nuclear Spins in a Silicon Transistor with Small Electrical Currents

USERS C.C. Lo and J. Bokor (LBNL and UC Berkeley); C.D. Weis and T. Schenkel (LBNL); J. van Tol (NHMFL)

The quantum magnetic moments of electrons and atomic nuclei (electron and nuclear spins) are attractive candidates as building blocks (qubits) for a solid-state quantum computer. Electron and nuclear spins of dopants like phosphorus in silicon can maintain their quantum states for a relatively long time, and various quantum computing schemes have been suggested based on dopants in silicon. One of the requirements for a quantum computer is to be able to initialize the constituent qubits. It has already been shown that this can be achieved with light excitation or microwave irradiation. In the experiments at the NHMFL it has now been shown that this initialization can be achieved in a magnetic field purely electrically, which is of crucial importance for possible nanoscale devices as it enables addressing of individual qubits.

The devices that were studied are silicon field effect transistors (FETs), doped with phosphorus. These donors have a nuclear spin I=1/2 and, at low temperatures, and a localized electron spin with S=1/2. The conduction in these FETs is due to the electrons at the interface of the silicon and the insulating layer that separates the silicon from the gate electrode. The number of electrons at this interface (referred to as a 2D electron gas, as the electrons are confined to a plane at the interface) can be tuned by the voltage on the gate electrode.

By irradiating the silicon FET with microwaves of the exact energy corresponding to the energy difference of the spin states of the electrons (336 GHz at 12 Tesla), the population distribution within the quantized levels can be changed, which can be measured as a change in the current through the FET. Because the electrons in the 2D electron gas are weakly coupled to the electrons trapped at nearby phosphorus atoms in the silicon, microwave induced transitions of electron spins on the phosphorus can also be measured as changes in the current through the FET. A typical spectrum of the current as a function of the magnetic field consists of three lines: a broad line due to the spins in the 2D electron gas; and two narrower lines from the phosphorus impurities (there are two lines due to the 'hyperfine' interaction with the nuclear spin of the phosphorus, and they correspond to the centers with the nuclear spin either up or down). The relative intensity of the two lines then gives a measure of the relative population of the nuclear spin states, which corresponds to the nuclear spin polarization.

By carefully measuring the relative intensity of these two lines as a function of the gate electrode voltage and current through the FET, we have shown that the phosphorus nuclear spin can be flipped either up or down ('polarized' or 'anti-polarized') by the current through the FET. This provides an important stepping-stone for devices that use the phosphorus nuclear spins for quantum information processing.

FACILITIES

12.5 T magnet

ACKNOWLEDGEMENTS

This work was supported by the U.S. National Security Agency (100000080295) and by the U.S. Department of Energy (DE-AC02-05CH11231, LBNL), and the NHMFL (NSF DMR-0654118 and the State of Florida). Technical support by the UC Berkeley Microlab staff during device fabrication is gratefully acknowledged.

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1. C. C. Lo, C. D. Weis, J. van Tol, J. Bokor, and T. Schenkel, All-Electrical Nuclear Spin Polarization of Donors in Silicon, Physical Review Letters **110**, 057601 (2013).

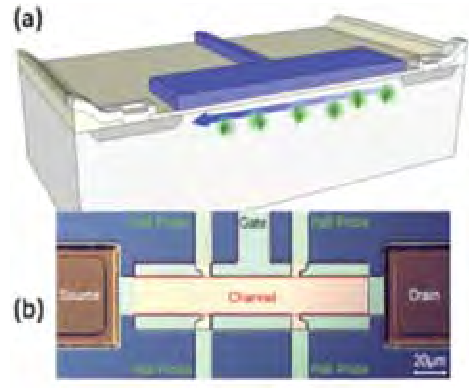

FIGURE 24. A) Schematic view of silicon Field Effect Transistor (FET). The electrons move in the 2D electron layer between the source and drain contacts, and interact with the nearby electron and nuclear spins of the phosphorus dopants. **B)** Top view of actual device. The resistance is measured in a Hall Probe configuration.

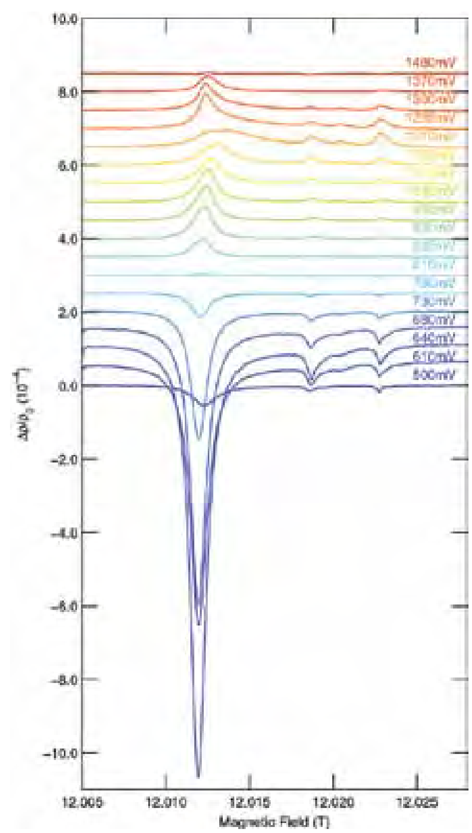

FIGURE 25. The electrically detected ESR signal at 336 GHz as a function of the gate voltage. The changes in the signals from peaks to dips are due to quantization of the electron orbitals (quantum Hall effect).

HFEPR Characterization of a Planar Three-coordinate Vanadium(II) Complex

USERS B.L. Tran, B. Pinter, A.J. Nichols, F.T. Konopka, R. Thompson, C.-H. Chen, M.-H. Baik, D.J. Mindiola (Indiana U.); J. Krzystek and A. Ozarowski (NHMFL); J. Telser (Roosevelt U.); K. Mayer (U. Erlangen-Nürnberg, Germany)

Transition metal ions are known to be efficient catalysts in a variety of chemical reactions. In particular, there has been a continuous interest in efficient catalysts in the industrial production of chemicals such as ammonia and ammonia-derived fertilizers, and in understanding the atmospheric nitrogen cycle. The reported project was directed towards the synthesis and characterization of low-coordination number, low oxidation state vanadium molecular complexes that react with atmospheric nitrogen (N_2) analogously to the more familiar molybdenum-based catalysts. The work is of fundamental importance in catalysis, but is also of biological relevance: a vanadium-containing nitrogenase enzyme (V-N_2ase) is known to exist, yet little is understood about its properties. This project will thus help in biotechnology applications.

The first ever three-coordinate V(II) complex, [(nacnac)V(ODiiP)] (1), where nacnac is a β-diketiminate ligand, and ODiiP is a phenoxide, was synthesized by the Mindiola group and characterized by high-frequency and -field electron paramagnetic resonance (HFEPR) (**Figure 26**), demonstrating its spin $S = 3/2$ ground state. This complex reacts with N_2 to give an N_2-bridged vanadium(III) dimer, with an overall diamagnetic, spin $S = 0$ ground state, but with an $S = 1$ excited state observed at higher temperatures. These results provide valuable information for the further development of vanadium(II) systems for catalysis.

FACILITIES

EMR homodyne transmission spectrometer, 15/17 T magnet

ACKNOWLEDGEMENTS

This work was supported by the Department of Energy (Grant No. DE-FG02-07ER15893), the German DFG, and the NHMFL (NSF-DMR-0654118 and the State of Florida).

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1. B. L. Tran, B. Pinter, A. J. Nichols, F. T. Konopka, R. Thompson, C.-H. Chen, J. Krzystek, A. Ozarowski, J. Telser, M.-H. Baik, K. Mayer, and D. J. Mindiola, *A Planar Three-Coordinate Vanadium(III) Complex and the Study of Terminal Vanadium Nitrides from N_2: A Kinetic or Thermodynamic Impediment to N-N Bond Cleavage?*, J. Am. Chem. Soc. **134**, 13035-13045 (2012).

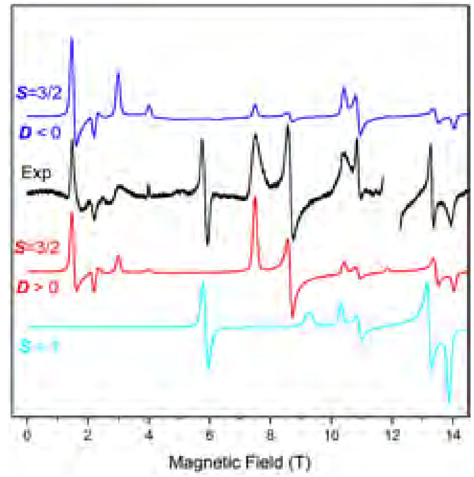

FIGURE 26. HFEPR spectrum of a polycrystalline sample of 1 recorded at 10 K and 328.8 GHz (black trace) with the V(IV) impurity resonance at 12 T left out. Simulations for 1 are provided employing the spin Hamiltonian parameters given in the reference below (blue trace, $D < 0$; red trace, $D > 0$). The cyan trace is a simulation of the (unwanted) V(III) oxidation product also showing up in the experimental spectrum, using: $S = 1$, $g_{iso} = 1.93$, $D = -2.62$ cm^{-1}, $E = 0.186$ cm^{-1}.

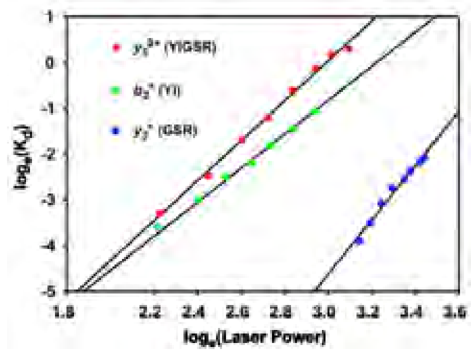

FIGURE 27. Log-log plot of dissociation constant vs. laser power for each of three precursor peptide ions. The slope yields activation energy.

Ion Cyclotron Resonance Facility

During 2012, 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 six staff scientists who support instrumentation, software, biological applications, petrochemical and environmental applications, and user services as well as a machinist, technician, and several rotating postdocs who are available to collaborate and/or assist with projects.

2012 statistics on ICR users, proposals, and magnet usage are presented in Appendix A.

ICR Facility Magnet Systems

Field (T)	Bore (mm)	Homogeneity	Measurements
14.5	104	1 PPM	ESI, AP/LIAD-CI, APPI, Thermospray Ionization, DART FT-ICR
9.4	220	1 PPM	ESI, AP/LIAD-CI, APCI, APPI, Thermospray, DART, DAPPI FT-ICR
9.4	155	1 PPM	FD, LD FT-ICR
7	155	1 PPM	EI, CI FT-ICR

Facility Developments

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. Addition of new reagents enhances liquid chromatographic separation for intact proteins and increases the charge states of proteins up to 78 kDa (*Anal. Chem.*, **82**, 7515-7519 (2010). Mass resolving power > 200,000 at m/z 400 is achieved at one scan per second, which is ideal for LC-MS (*Int. J. Mass Spectrom.*, **305**, 116-119 (2011)) and facilitates automated data reduction for H/D exchange experiments (*J. Am. Soc. Mass Spectrom.*, **21**, 550-558 (2010)). Robotic sample handling allows unattended or remote operation. An additional pumping stage has been added to improve resolution of small molecules. Simultaneous infrared multiphoton (IRMPD) and electron capture dissociation (ECD) are under development.

The 9.4 T, 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. A redesign to the custom-built mass spectrometer coupled to the 9.4 T, 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

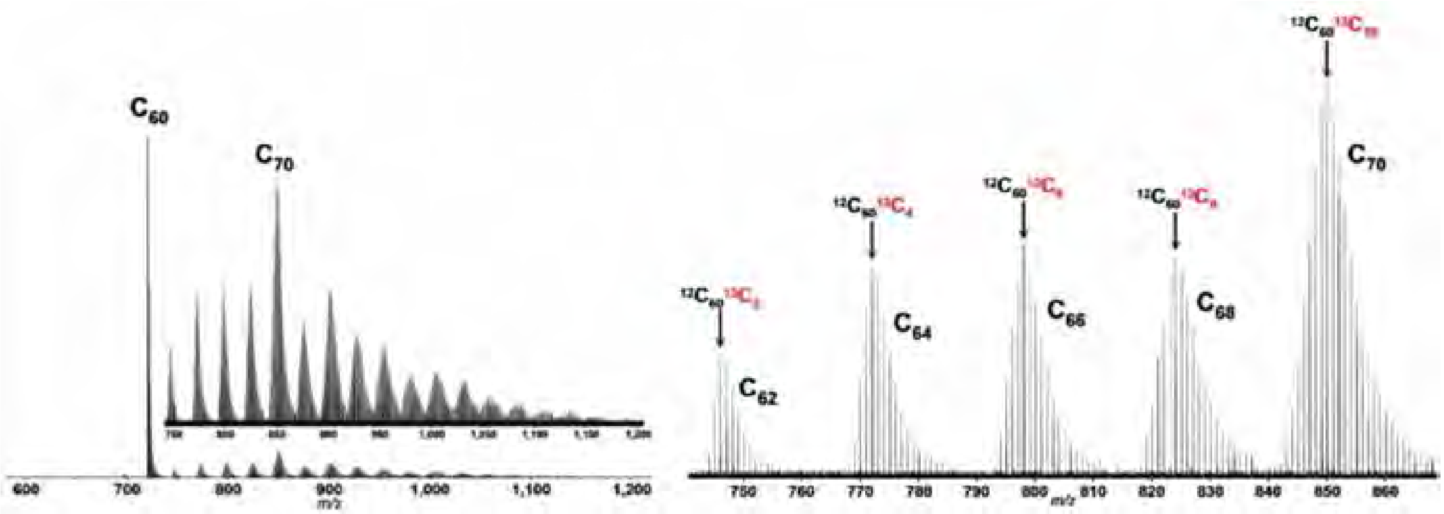

FIGURE 28. Results of exposure of C_{60} to ^{13}C-enriched carbon vapor. **LEFT:** Positive ions generated from a target comprised of amorphous ^{13}C (99% atom ^{13}C) target mixed with C_{60} under the same conditions as in the C_{60}-graphite experiment, with mass scale expansion of C_{60} illustrating the occurrence of atom exchange events. **RIGHT:** C_{62}-C_{70} mass region expanded to show growth of C_{60} to larger fullerenes by successive ^{13}C ingestion events.

at the ICR cell. The ICR cell, electrical vacuum feed throughs, and cabling have been improved to reduce the detection circuit capacitance (and improve detection sensitivity) 2-fold (*Anal. Chem.* **85**, 265-272 (2013)). When applied to compositionally complex organic mixtures such as dissolved organic matter (*Anal. Chem.*, **84**, 5085-5090 (2012)) and petroleum (*Energy Fuels*, **26**, 2256-2268 (2012)), mass spectrometer performance improves significantly, because those mixtures are replete with mass "splits" that are readily separated and identified by FT-ICR MS. 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 (*Anal. Chem.*, **75**, 3256-3262 (2003)). Available dissociation techniques include collision-induced (CID), infrared multiphoton-induced (IRMPD) (*J. Am. Soc. Mass Spectrom.*, **23**, 644-654 (2012)) (**Figure 27**), and electron capture-induced (ECD). Development and design of an Atmospheric Pressure Laser-Induced Acoustic Desorption Chemical Ionization (AP/LIAD-CI) source enables facile and independent optimization of analyte desorption, ionization, and sampling events, and can be coupled to any mass analyzer with an atmospheric pressure interface (*Anal. Chem.* **84**, 7131-7137 (2012)). Baseline resolution for an intact 147.7 kDa monoclonal antibody set a world record for unit mass resolution and facilitates future characterization of large biomolecules by FT-ICR MS. Adduct dissociation, optimization of detected total ion number, and optimization of ICR cell parameters result in long ICR transient lifetime (up to 20s) and magnitude-mode resolving power ~ 420,000 at *m/z* 593 for the 57+ charge state, the highest mass for which baseline unit mass resolution had been achieved (*Anal. Chem.*, **83**, 8391-8395 (2011)).

The 9.4 and 7 T actively shielded FT-ICR instruments are available for analysis of complex nonpolar mixtures and instrumentation development. The 9.4 T magnet is currently used for field desorption (*Anal. Chem.*, **80**, 7379-7382 (2008)) 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)) (**Figure 27**).

Science Productivity

ICR facility users published 24 peer-reviewed journal articles in 2012. Several significant topics and highlights of science productivity begin on the next page.

Progress on STEM and Building the User Community

The ICR program had received 20 proposals from new principal investigators in 2012, 18 of whom received magnet time in 2012 and two are under review/ to be scheduled. The ICR program also enhanced its undergraduate research and outreach program for 4 undergraduate scientists, (two female, and two minority). The ICR program in 2012 supported the attendance of scholar-scientists, postdoctoral associates, graduate, undergraduate and high school students at numerous national conferences to present current results.

The ICR facility co-chaired the 13th International Conference on Petroleum Phase Behavior and Fouling (2012) Conference, with more than 200 industrial and academic participants (43 graduate students), and awarded five student awards to encourage student participation.

Science Productivity

Automated broadband phase correction of FT-ICR data can in principle produce and absorption-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 complex organic mixtures such as petroleum and coal (*Fuel.*, **95**, 35-49 (2012)). Phase correction applied to complex petroleum fractions facilitates resolution and identification of ionic species that differ in mass by roughly the mass of an electron (*J. Mass Spectrom.*, **46**, 337-343 (2011)), and provides accurate elemental composition assignment to establish compositional boundaries for fossil hydrocarbons (*Anal. Chem.* **84**, 3410-3416 (2012)).

Baseline Correction of Absorption-mode Fourier Transform Ion Cyclotron Resonance Mass Spectra

USERS Xian, F.; Corilo, Y.E.; Hendrickson, C.L. and Marshall, A.G. (NHMFL – ICR Program)

Development of a fast, robust, and automated algorithm that flattens the absorption-mode spectral baseline by defining baseline data minima, followed by linear interpolation to generate a complete baseline, followed by boxcar smoothing, and baseline subtraction increases the number of detected peaks for petroleum and proteins[1].

FACILITIES

9.4 T ICR Magnet

REFERENCES

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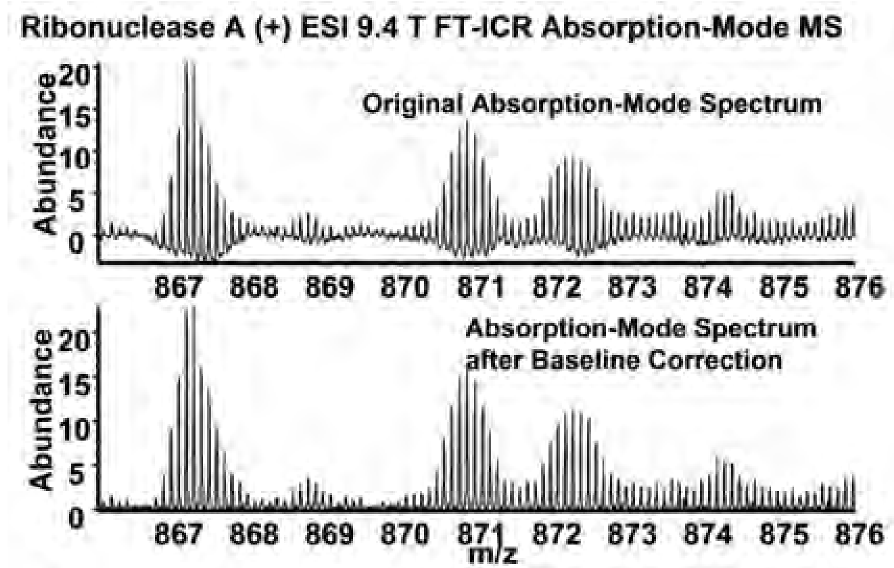

FIGURE 29. RNase A positive ESI FT-ICR absorption-mode mass spectral segments, demonstrating the performance of the baseline corrected algorithm.

Implementation of an electrically compensated Fourier transform ion cyclotron resonance cell for the 9.4 T instrument enables separation and identification of isobaric species in complex natural organic petroleum mixtures, and preserves ion cloud coherences for longer transient duration by a factor of 2 (*Anal. Chem.*, **83**, 6907-6910 (2011)). The improved performance of the compensated ICR cell provides more symmetric peak shape and better mass accuracy through tunable compensation electrodes, critical for optimal performance. FT-ICR MS typically uses an *m/z*-independent excitation magnitude to excite all ions to the same cyclotron radius, so that the detected signal magnitude is directly proportional to the relative ion abundance. However, deleterious space charge interaction between ion clouds is maximized for clouds of equal radius. To minimize ion cloud interactions, imposition of an *m/z*-dependent ion radius distribution (30-45% of the maximum cell radius) results in a 3-fold increase in mass spectral dynamic range for complex organic mixtures (*Anal. Chem.* **85**, 265-272 (2013)).

Development of novel ionization techniques such as Atmospheric Pressure Laser-Induced Acoustic Desorption Chemical Ionization (AP/LIAD-CI) decouples analyte desorption from subsequent ionization and enables rapid and independent optimization and generates analyte ions that are efficiently thermalized by collisions with atmospheric gases, thereby reducing fragmentation. Modification of the carrier/reagent gas for AP/LIAD-CI with O_2 reports the first molecular-level characterization of saturated hydrocarbons. Nonthermal sample vaporization with subsequent chemical ionization generates abundant ion signals for straight-chain, branched, and cycloalkanes with minimal or no fragmentation, and yields $[M-H]^+$ as the dominant molecular ionic species (*Anal. Chem.* **84**, 7131-7137 (2012))

Tertiary and quaternary structure can also be probed. Automated hydrogen/deuterium exchange improved by depletion of heavy isotopes ($^{13}C/^{15}N$) for protein subunits of a complex can greatly simplify the mass spectrum, increase the signal-to-noise ratio of depleted fragment ions, and remove the ambiguity in assignment of *m/z* values to the correct isomeric species. However, automated data reduction algorithms extract the deuteration level for individual peptides, but do not exploit additional information arising from fragment overlaps that result from proteolysis. Implementation of an algorithm that determines discrete rate constant values to each of the amide hydrogens in overlapped fragments improves sequence resolution, often to a single amino acid residue (*J. Am. Soc. Mass Spectrom.*, **23**, 1202-1208 (2012)). Details of biomolecular conformation and surface contact between molecules in a noncovalent complex can be deduced. However, water in the reversed-phase liquid chromatography mobile phase leads to back-exchange, resulting in incorrect identification of fast exchanging hydrogens as unexchanged hydrogens. Replacement of up to 40% of the water in the LC mobile phase by polar modifiers that lack exchangeable hydrogens significantly reduces back-exchange. Online-LC micro-ESI FT-ICR MS resolves overlapped proteolytic peptide isotopic distributions, allowing for quantitative determination of the extent of back-exchange (*J. Am. Soc. Mass Spectrom.* 23, 699-707 (2012))

Identification of new diagnostic and prognostic biomarkers for patients with breast cancer remains critical to increase life expectancy. A change in the glycosylation on a glycoprotein often causes a change in the function of that glycoprotein, and is correlated with cancer formation. Glycoproteins showing differences in glycosylation were examined by 2-dimensional gel electrophoresis with double staining and identified by reversed-phase nano-liquid chromatography coupled with a hybrid linear quadrupole ion trap/FT-ICR mass spectrometer, and results

Nano-LC FT-ICR Mass Spectrometry for Top-Down Proteomics: Routine Baseline Unit Mass Resolution of Cell-Derived Proteins up to 72 kDa

USERS Tipton, J.D. (NHMFL-ICR Program, FSU & Northwestern University, Molecular Biosciences); Tran, J.C., Catherman, A.D., Ahlf, D.R., Durbin, K.R., Lee, J.E., Kellie, J.F., Kelleher, N.L. (Northwestern University, Molecular Biosciences); Hendrickson, C.L. (NHMFL-ICR Program) and Marshall, A.G. (NHMFL-ICR Program, FSU, Chemistry & Biochemistry)

Current high-throughput top-down proteomic platforms provide routine identification of proteins less that 25 kDa with 4-D separations. However, advances in separation science have allowed increased number of proteins to be identified when combined with nanoliquid chromatography (nLC) prior to mass spectrometry (MS) analysis, to enable baseline resolution of proteins from a whole cell lysate up to 72 kDa on a nano-LC chromatographic time scale[1] (**Figure 30**).

FACILITIES

14.5 T ICR Magnet

REFERENCES

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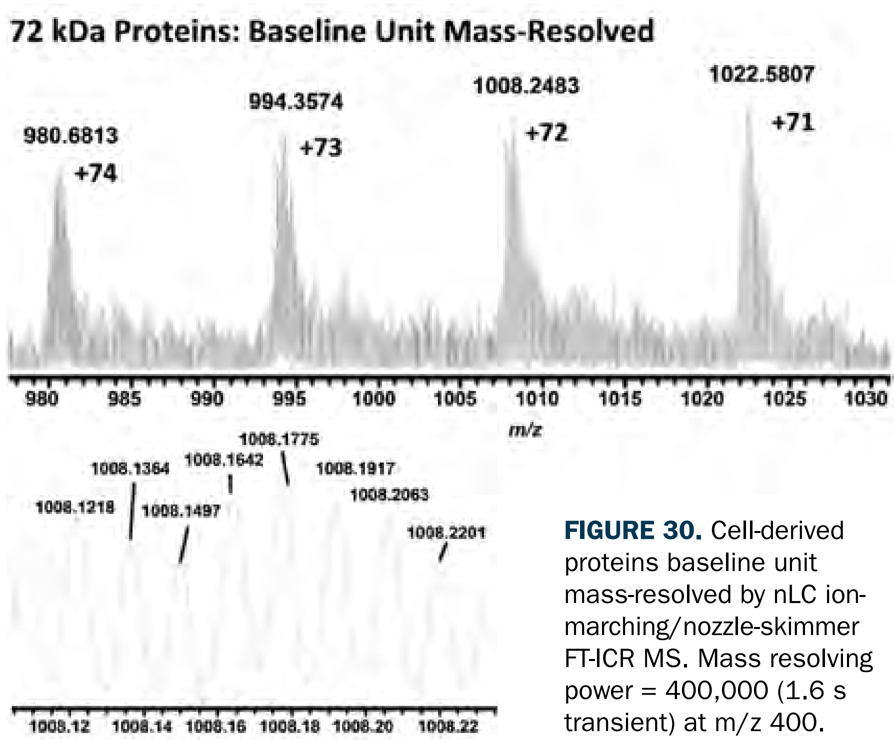

FIGURE 30. Cell-derived proteins baseline unit mass-resolved by nLC ion-marching/nozzle-skimmer FT-ICR MS. Mass resolving power = 400,000 (1.6 s transient) at m/z 400.

showed the presence of a possible glycosylation difference in alpha-1-antitrypsin, a potential tumor-derived biomarker for breast cancer progression (*J. Cancer*, **3**, 269-284 (2012)).

The 7, 9.4, and 14.5 T instruments are primed for immediate impact in **environmental, petrochemical, and forensic analysis**, where previously intractably complex mixtures are common. The field of "petroleomics" has been developed largely due to the unique ability of high-field FT-ICR mass spectrometry to resolve and identify all of the components in petroleum samples. A comprehensive review article catalogues recent advances in high resolution mass spectrometry (*Anal. Chem.*, **84**, 708-719 (2012)). Further, fossil fuel samples can be analyzed and components resolved without chromatographic separation. Selective ionization of acidic crude oil components, such as naphthenic acids, by negative-ion electrospray ionization combined with tandem mass spectrometry (collision-induced dissociation (CID) and infrared multiphoton dissociation (IRMPD) provides detailed identification and structural characterization of acids isolated from naphthenate deposits (*Int. J. Mass Spectrom.*, **300**, 149-157 (2011)). Selective ionization of nitrogen compounds in dissolved organic matter (DOM) from aquatic systems by APPI combined with FT-ICR MS demonstrates significant signal-to-noise increase for nitrogen species relative to conventional electrospray ionization (*Anal. Chem.*, **84**, 5085-5090 (2012)).

Biofuel characterization has established the polar lipid profile of fatty acids, glycolipids, phospholipids, and betained lipids for Nannochloropsis oculata, a green algae highly prized for its oil suitable for biodiesel production. The first application of on-line liquid chromatography-mass spectrometry (LC-MS) characterization of algae polar lipids provides highly accurate mass measurement and resolves monoisotopic peaks from interfering components for unique determination of lipid elemental compositions (*Energy Fuels*, **25**, 4770-4775 (2011)).

Characterization of Pine Pellet and Peanut Hull Pyrolysis Bio-Oils by Negative-Ion Electrospray Ionization FT-ICR Mass Spectrometry

USERS J.M. Jarvis (FSU), A.M. McKenna (NHMFL), R.N. Hilten and K.D. Das (University of Georgia), R.P. Rodgers and A.G. Marshall (FSU & NHMFL-ICR Program)

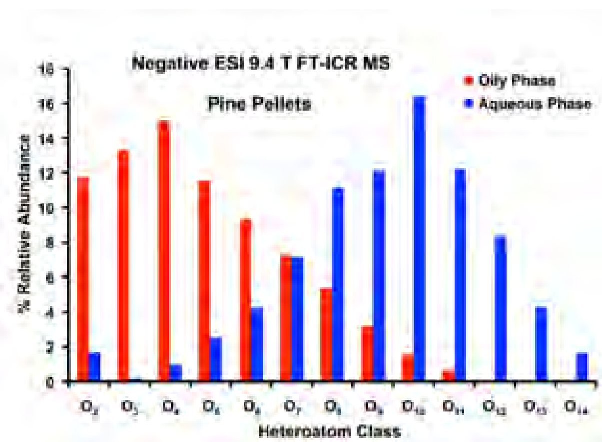

FIGURE 31. Heteroatom class distribution for the pine pellet oily (red) and aqueous (blue) phases derived from negative ESI 9.4 T FT-ICR mass spectra. The most abundant class in the oily phase contains 4 oxygens whereas the most abundant class in the aqueous phase contains 10 oxygens. Only classes with greater than 1% relative abundance in either phase are shown.

Pyrolysis of solid biomass (pine pellets and peanut hulls) generates a hydrocarbon-rich bi-phasic (aqueous and organic) bio-oil. Characterization of each phase by negative-ion ESI FT-ICR MS reveals that bio-oils are dominated by O_x species, with few oxygens per molecule for the oily phase and many more oxygens per molecule for the aqueous phase, corresponding to water-solubility[1] (**Figure 31**).

FACILITIES

9.4T FT-ICR Mass Spectrometer

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CHAPTER 3

Magnets & Materials

Setting a world-record 100.8 tesla in a non-destructive magnet at the Pulsed Field Facility at LANL was just one major achievement for the magnets and materials groups of the Magnet Lab. This chapter describes advancements in **Resistive Magnets & Materials**, including sections on pulsed magnets, DC magnets, and high-strength materials; **HTS Magnets & Materials**, including progress on the 32 T magnet, REBCO R&D coils targeting NMR applications, REBCO conductor properties, Bi2212 conductors, Bi2212 R&D coils, Fe-based superconductors; and **LTS Magnets & Materials**, including sections on CICC magnets, strand-level Nb_3Sn optimization, deconstruction of SULTAN-tested ITER CICCs, ITER wire characterization and ITER CS structure.

In March 2012 the MagLab broke the 100 T barrier with a non-destructive magnet for the first time, setting a world record of 100.8 +/- 0.1 tesla. This milestone is the product of more than 15 years of effort that has involved development of numerous new technologies at the NHMFL. The magnet system and the success of the endeavor involved a close collaboration between the NSF-funded NHMFL and the DOE-BES program at Los Alamos National Laboratory. The outer coil section of the 100 T magnet utilizes a large generator system (1.43 GW) modified to provide high current transient pulses (up to 600 MJ per pulse). The innermost coil closely resembles a conventional pulsed magnet that is powered by a 2.6 MJ capacitor bank. Several of the technological advances were introduced and demonstrated in lower-field pulsed magnets prior to being employed in the 100 T, and many have been disseminated throughout the pulsed magnet community. Hence, these new technologies have already enabled hundreds (perhaps thousands) of magnet pulses in the 65 – 85 T range worldwide over the past 10 or more years. Revolutionary technologies developed as part of this project include: better Cu-Nb and Cu/Al_2O_3 nanocomposite wires with higher strength and larger sizes than those previously available, nickel-based (MP35 N) nanocomposite reinforcement materials with 44% higher strength than previously available, a new metal/organic zylon/MP35N microcomposite reinforcement system, incorporation of fatigue assessment into pulsed magnet design, nested-coil design concepts and improved layer-to-layer transitions. The 100 T pulsed magnet has enabled high magnetic field research in unprecedented physical conditions and precision. The distributed mechanical loads realized in the 100 T magnet validate the concept and provide a path forward for higher maximum fields.

In March 2013 (just before going to press) the MagLab tested the prototype of the innermost coil of the 32 T all-superconducting magnet presently under development. This coil uses the same superconducting tape, insulation, joints, protection system, winding technology, clamping technology and has the same inner and outer diameters as the real innermost coil of the 32 T magnet. While several previous REBCO coils have been tested, this was the first to incorporate all these features. The next major milestone on this project is to test a prototype of the outer REBCO coil later this year. Successful completion of these two milestones will allow us to proceed with winding and stacking of the two REBCO coils that form the 17 T HTS section of the 32 T magnet that will then be mated to the outer Nb_3Sn and Nb-Ti coils being developed by Oxford Instruments. We expect the 32 T superconducting magnet to be operational in 2015.

FIGURE 1. Technician James Michel of the NHMFL-PFF at LANL assembles a coil for the pulsed magnet user program.

A major breakthrough in superconducting wire technology was made in late fall 2012 by developing a new process to enable round wire, multifilament $Bi_2Sr_2CaCu_2O_{8-x}$ (Bi-2212) to achieve whole-wire conductor current densities of over 600

A/mm² at 20 T and 4.2 K. By contrast REBCO coated conductors have about 400 A/mm² or less depending, on the amount of needed protection copper and the best Nb_3Sn is about 250 A/mm², heading to zero at about 25 T due to its proximity to the upper critical field. This development, made on industrially produced wires, is the culmination of two years of extensive investigation of the current limiting mechanisms in Bi-2212, which identified gas bubbles formed by agglomeration of the residual gas within the filament pack as being the dominant obstacle to current flow within the superconducting filaments. Application of external pressure of 10-100 bar prevents dedensification of the filaments and greatly enhances their connectivity, raising the current density of coil length wires about 6 times. The process was proved out in a small coil containing about 35 m of wire processed under 10 bar. It achieved 33.8 T when tested in a background of 31.2 T and operated at a winding current density of 190 A/mm² at 33.8 T. This new conductor for the first time allows an HTS conductor to compete on the favored turf of low temperature Nb-based superconductors, round wire and multifilament. It is anticipated to be of special interest to accelerator magnets that use Rutherford cables made of round wires and to high homogeneity magnets where small magnetization currents are desirable. This work was led from the MagLab but also involved substantial collaborations within the High Energy Physics labs at Brookhaven, CERN, Fermilab, and Lawrence Berkeley Laboratory.

A central feature of the MagLab's mission is the provision of unique high-performance magnet systems for our users that exploit the latest materials and magnet design developments. During 2012 we made significant progress on all fronts. In addition to the highlights above, we completed improvements to the 25 T split resistive magnet, wound most of the CICC coil for the Series-Connected Hybrid magnet, made significant steps in developing and characterizing materials suitable for use as conductors or structural reinforcement, and developed technologies suitable for future generations of NMR magnets. As we move forward, the balance of development of new magnet systems with development of new technology to keep us at the forefront is of critical importance. Collaborations with other leading industrial, academic, and government groups that develop these new magnet technologies is built in to many of these thrusts.

FIGURE 2. The prototype of the innermost coil of the 32 T all-superconducting magnet is raised prior to being installed in the dewar and tested.

Resistive Magnets & Materials

Pulsed Magnets

A challenging mission of MagLab's Pulsed Field Facility (PFF) at Los Alamos is to develop and operate pulsed magnet systems, enabling scientific research in the highest magnetic fields. In March, 2012, the PFF broke the *100-T barrier, setting a world record of 100.75 T for a non-destructive magnet!* This significant milestone of the MagLab has been pursued for more than 15 years. To achieve that goal, the generator operation was optimized to drive the outsert magnet to create a 41.4-T base-plateau field and the capacitor-bank-driven insert magnet produced a 59.35-T magnetic field on the top of the background field. The insert magnet was finally retired in August 2012 after serving 20 months for users and delivering a total of 140 pulses with 62 full-field shots (> 80 T). A duplicate 10-mm-bore insert magnet was installed in September 2012 and is currently in service for users of the ultra-high field science program. An upgraded outsert magnet has been built at our industrial partner, Everson Tesla INC. Two spare coils, 5 and 6 of the outsert magnet, were completed in 2012 as planned. Other spare coils of the upgraded outsert magnet are planned to be completed in the near future.

This year, numerous improvements have been tested and implemented in the design of our 65 T magnets. As an example, a new cooling technique was developed to create more robust magnets with significantly shorter cooling time. The cooling time for a full-field pulse was reduced to about 40 minutes, compared to 2 hours cooling time of the original design (300% improvement in productivity). This technique will be implemented in the new insert of the 100 T magnet to enable higher productivity. Four 65 T magnet assemblies have been delivered in 2012 to ensure enough magnet time for users of the short-pulse science program. In collaboration with our colleagues at MST-6 (LANL), we built wire-drawing equipment that allows us to reshape our high-strength magnet wires over long lengths. The test results on AL-60 wires indicated that the drawing processes did not degrade the mechanical

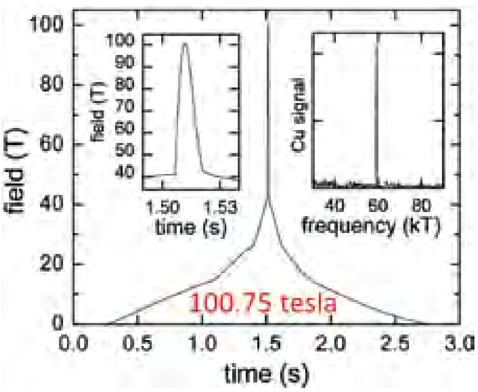

FIGURE 3. Magnetic field profile for a 100-T pulse (magnetic field calibrations were made by detecting De Haas-van Alphen oscillations in poly-crystalline copper).

and electrical properties of the wires. This accomplishment gave us more flexibility and reduced the cost to reshape the as-received conductors into the desired wires for our high-field magnets.

DC Magnets

Split 25 T Magnet

In 2011, the NHMFL completed the novel split magnet providing a *world record 25T magnetic field* (vs. 18 T available elsewhere) along with uniquely large mid-plane ports for scattering (four ports providing a total of 0.5 steradians of solid angle). This magnet system not only represents a unique facility worldwide for photon scattering at high magnetic field, but also is the first demonstration of a new magnet technology, the split Florida-Helix (*U.S. patent no. 7,609,139*) that required more sophisticated 3-dimensional finite-element multi-physics analysis than has previously been used in resistive magnets along with the development of new manufacturing technology. It is also the first 28 MW resistive magnet to be installed at the MagLab. While the magnet has served six separate user groups reliably conducting science during 9 weeks of magnet time while consuming 2460 MWHrs of electricity, many improvements have been made to the system since its original installation. To maximize the performance of the newly designed and fabricated user cryostat (fully operational since June 2012), the 70mm ID bore tube has been extended by ~200mm. Additional modifications to the magnet have been made to the Helixes, the wheel and various other parts to improve the alignment of the coils and the anticipated reliability. In June of 2012 a complete *A/B-Spare* coil set was completed which allows us to now operate routinely at the full 25T.

Conical Bore Resistive Insert for Neutron Scattering

In 2012, the MagLab finished the design of a novel resistive insert for the Series-Connected Hybrid (SCH) magnet to be delivered and installed at the Helmholtz Zentrum Berlin (HZB) in Germany. This magnet design includes a *unique bore with 30 degree opening angle at world record 25 T central field (US patent no. 7,825,760)*. The effective conical bore is created by stamping disks with different inner diameters and stacking them to form a series of steps. This approach is required due to the discrete cooling rings in the disks and results in current-density and stress concentrations at each step which require more sophisticated 3-dimensional analysis than is typically performed in dc resistive magnets. Fabrication of the coils is commencing with delivery intended for early 2013.

Resistive Shims

The MagLab is presently building two SCH magnets. The second will be installed in the DC Field Facility and is intended to provide a unique combination of 36 T with inhomogeneity of only 1 ppm over a 10-mm diameter spherical volume. This magnet will require resistive shims to be incorporated into the bore-tube of the resistive magnet. The technology for these shims is being proven via prototypes that are tested in the 25 T, 10 ppm Keck magnet presently operational in the DC Field Facility. In 2012 we implemented improved mapping techniques and tested the first prototype of such resistive shims that successfully demonstrating *world record 5.6 ppm at 25 T*. In parallel, concentrated efforts have been made to examine the sensitivity of the inhomogeneity of both the Keck coils and the SCH coils due to manufacturing tolerances via both modeling of mis-aligned coils and analysis of the field-map data from previously built high-homogeneity magnets. This has resulted in finalized conservative specifications for the resistive shims required for the SCH to reach 1 ppm at 36 T. In light of this analysis, it was determined that there is need for development of a 2nd generation resistive shim prototype with considerably raised capabilities. In December 2012, the design of this second resistive shim set for the Keck magnet was completed. We intend to build it and test it in the coming year.

Resistive Maintenance

To support smooth operation of the resistive user program, the NHMFL has completed fabrication and assembly of 9 resistive spare coils as part of the routine 2012 maintenance program. In addition,

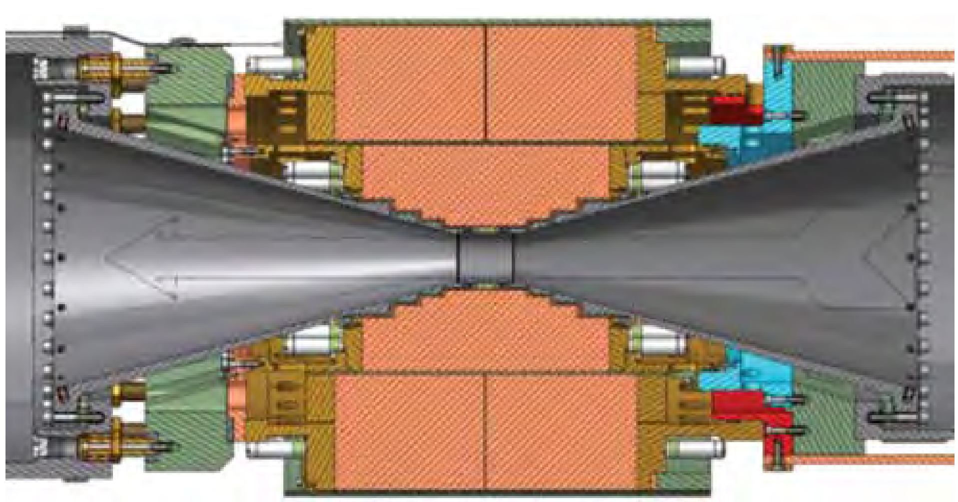

FIGURE 4. 3D Model of the conical bore resistive insert for the Helmholtz Zentrum Berlin (HZB) Series-Connected Hybrid.

in March 2012, the inner coils of the Keck magnet were replaced, re-aligned, and re-calibrated.

High-Strength Materials

The high-strength material program continues to play an important role in building high field user magnets and in contributing to the scientific activities in the MagLab. We have been collaborating with our vendors and with other institutes in order to develop high strength materials and fabrication approaches for new generations of magnets. We have also studied the relationship among fabrication, microstructure, and properties of magnet materials with the aim of ensuring the safe and reliable performance of high-field magnets. This section outlines our activities in characterizing and developing high strength normal conductors, structural materials and insulation for high-field magnets.

Conductors

Presently, the conductors that can achieve the highest mechanical strength are still the metal-metal composites. One of these is Cu-24wt%Ag sheet, which is used in Florida-Bitter magnets. These conductors are fabricated by solidification, cold deformation and heat treatment. During the first part of the solidification process of these materials, certain Cu dendrites,

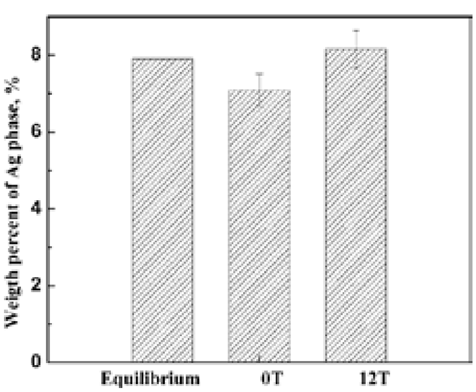

FIGURE 5. The weight percent of Ag in Cu dendrites of Cu-25 %Ag alloys solidified with and without a 12-T high magnetic field. For comparison, the equilibrium solid solubility or maximum solubility of Ag at the eutectic temperature is shown. It is interesting to notice that the Ag content for 12 T sample is higher than that for equilibrium.

which contain a small amount (<10%) of Ag, form a coarse structure. These dendrites have lower strength than the eutectic Cu-Ag laminates that are formed later in the process[1]. In collaboration with Northeastern University in China, we have started work on the impact of a high magnetic field on the microstructure of solidified Cu-Ag composites. Our preliminary experimental results show that an applied magnetic field enriches the average Ag content in Cu dendrites, as shown in **Figure 5**. This enriched Ag content can strengthen Cu dendrites and possibly strengthen the overall composite significantly[2].

In addition to solidification, we also studied the impact of cold-deformation and heat-treatment on properties of Cu-Ag conductors[3]. Presently, these conductors are ordered in sheet-metal form with a specified minimum strength of 850 MPa. We are working with Tanaka Kikinzoku Group of Japan to develop conductors for future magnets with a minimum strength beyond 900 MPa.

Cu-Nb and Cu+Al_2O_3 are two types of composite conductors being used for pulsed magnets. The strengthening components of these conductors are either Nb ribbons or nanosized Al_2O_3 particles. We have been studying these systems for more than 10 years to understand how fabrication processes affect the size and distribution of these ribbons or particles. Refined size improves the performance of the conductors in pulsed magnets[1, 4]. These conductors cycle from elastic compression into the plastic tensile range that forces the Cu matrix to flow between the refined ribbons or particles. Consequently, fatigue properties must be studied, understood and controlled. Our tests were performed in both stress- and strain-controlled modes to simulate various operating conditions experienced by conductors in pulsed magnets[5]. The development and characterization of high strength conductors have played an essential role in developing our recently commissioned 100 T pulsed magnet. Fatigue data collected since commissioning is being used to determine the operating parameters for future use.

In 2012, we began work on Ag+Ni composite sheets. We found that a 31.2-T magnetic field can delay coarsening of the microstructure during the annealing, resulting in greater hardness than that of materials annealed without magnetic field[6].

Structural materials

MP35N (35wt%Co-35wt%Ni-20wt%Cr-10wt%Mo) is a high Young's modulus (>220 GPa) reinforcement alloy. Researchers in the MagLab have been collaborating with H.C. Stark for many years and developed the heat-treatment and cold-rolling schedule that enabled this material to reach an unprecedented level of strength (2300 MPa) that enabled it to be included in the inner coil of the 100 T magnet that was successfully tested last year. Since then, additional material has been fabricated and tested that is being used to construct spare coils for the 100 T system.

While pulsed magnets operate at ~77 K, we are now seeking to apply this material in superconducting systems operating at ~4 K. In 2012 the tensile strength of cold-rolled and aged MP35N was determined to exceed 2400 MPa at liquid helium temperature for strip made via the MagLab's optimized fabrication methods[7]. Magnetization was also measured and determined to be predominately paramagnetic with permeability of 1.0009±0.0002 (similar to wrought 316 LN). Consequently, this material has a potential for use in both low-temperature and high-temperature superconducting magnets.

The MagLab's 45 T Hybrid magnet is not only the highest field dc magnet in the world, it is also the magnet using Nb_3Sn Cable-In-Conduit Conductor (CICC) that has operated for the longest time. The conduit material used in it is a modified 316LN austenitic stainless steel developed at the MagLab that has subsequently been adopted by ITER and the Series-Connected Hybrid magnets in Tallahassee, Berlin and, in 2012, Nijmegen, The Netherlands. While we continue to improve the properties of modified stainless steels we are now working with Ni-based Haynes alloys for use in these conduits as they have similar thermal contraction as the Nb_3Sn wires resulting in less thermal contraction and higher critical current. Work in the past year indicates that it may be possible to wind a CICC coil using "soft", unreacted Haynes conduit and then age the conduit at the same time the wire is being reacted resulting in potentially 20% higher strength in the conduit while having roughly twice the critical current density in the wire due to the reduced thermal strain mis-match[8].

Insulation

In recent years we have developed a sol-gel dip process for making Al_2O_3–SiO_2 coatings of ~5 µm thickness. These coatings have a room-temperature dc dielectric strength of 40 MV/m[9]. This process has low cost and high throughput and produces a thin electrical insulation with excellent thermal, dielectric, and mechanical properties. In 2012 this technology was scaled up to a reel-to-reel system capable of handling tapes up to 1 km long. This technology will be used for the construction of our new 32 T all superconducting magnets.

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High Temperature Superconductor Magnets & Materials

32 T Magnet

The 32 T project is a ground-breaking effort to build a 32 T all-superconducting magnet operating at 4 K with REBCO coated-conductor high-field coils. Specifications include a 32 mm cold bore with a field uniformity of 500 ppm in a 1 cm diameter spherical volume. When completed, this magnet will be made available as a user magnet at the MagLab. Additional planned equipment includes a dilution refrigerator capable of reaching 20 mK. No existing superconducting user magnet anywhere exceeds 23.5 T, so a successful project would represent an unprecedented leap in available magnetic field strength for scientific users.

The REBCO High Temperature Superconductor part of this magnet consists of two coils and requires the development and rigorous testing of new technology, particularly on assembly techniques and quench protection. Development of quench protection technology started early in the project, resulting in a patented approach. Active quench heaters will initiate sufficiently large normal zones in the REBCO coils to widely distribute the stored energy and prevent hot-spots. Based on the experience of previous test coils we have arrived at the heater design shown in **Figure 6**, which will be tested in the upcoming inner prototype coil test. A schematic showing the relative size of the test coils, prototype coils, and the 32 T design is shown in **Figure 7**.

A modular approach was selected for the coil windings considering the limited conductor lengths that are commercially available and for risk management, as modules can more easily be reworked or replaced than entire coils. This results in a relatively large number of parts and elements that have to fit together tightly to be mechanically robust, placing a high demand on the flatness of the modules and

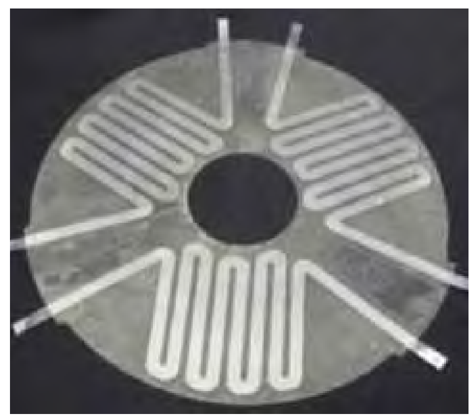

FIGURE 6. Quench protection heater consisting of stainless steel foils between thin epoxy-fiberglass sheets.

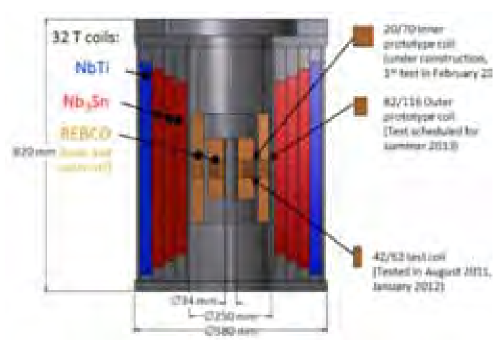

FIGURE 7. Conceptual design of the 32 T magnet, with the relative size of the test coils and prototype coils superimposed.

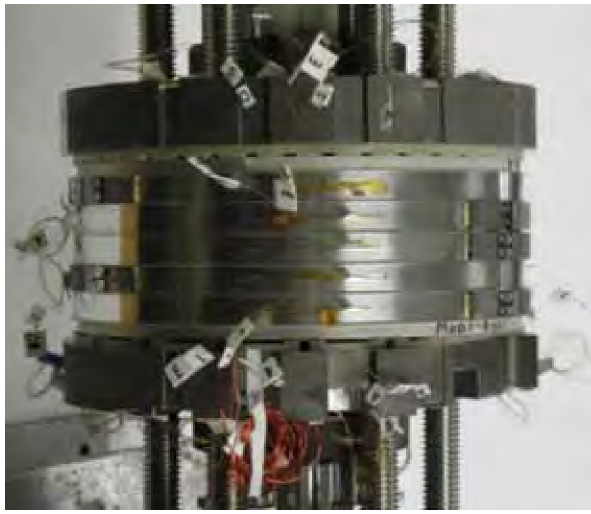

FIGURE 8. (Left) Fully assembled model coil using plastic disks to represent the REBCO inner prototype coil.
FIGURE 9. (Right) Actual REBCO inner prototype coil during assembly.

assembly procedures. In a project of this complexity, it is important to ensure that assembly steps like soldering joints, terminals, applying pre-compression, installing the quench heater circuit etc. can all be completed correctly the first time and in an efficient sequence without interfering with one another. To this end, a dimensionally-correct model coil was built (**Figure 8**) using plastic disks to represent the pancake-coils wound from REBCO. It was used to fine-tune details of the real coil and develop and practice detailed procedures. A prototype of the inner REBCO coil, very similar to the final design but with only 6 modules instead of 20, has been assembled and is in final preparation for testing (**Figure 9**). The protocol for testing in the 20 T Large Bore resistive magnet in Cell 4 will allow all known critical aspects of the 32 T design to be tested at or above design levels.

Much time and effort have been spent over the past years on analyzing a wide range of characteristics of commercially available REBCO tape. Feedback of the insights to the vendors has allowed us to steer the development of the conductors somewhat and has led to the availability of a more magnet-suitable conductor. Until a few years ago, the development of REBCO conductor was almost exclusively guided by utility applications (power transmission cables, etc.), not magnets. Industry standards for conductor specifications, particularly characterization of the current carrying capability at 77 K and self-field, could not meet the needs of the 32 T project for lack of correlation between 77 K and 4 K high-field properties. Also, the high demand on the flatness of modules and the minimum acceptable radial thermal conductivity of the windings require tight tolerances on the conductor width and thickness. A collaborative effort and changes in the prospective vendors' production lines were required to arrive at a conductor specification that at least one vendor (SuperPower) could meet and will meet the project needs as well. To our knowledge, this is the first REBCO conductor specification with a critical current specification at 4 K, which is something we hope will become an industry standard.

The Low Temperature Superconductor (LTS) part of the 32 T magnet is challenging too, with a magnetic field and bore size (15 T in 250 mm) that are right at the edge of the envelope of what has previously been achieved in 4.2 K magnets. Oxford Instruments Ltd. (OI) was awarded the contract to supply the LTS coils and a cryostat. As the HTS and LTS coils interact during operation and especially during quench, an integrated HTS-LTS analysis of quench behavior is required, to ensure that the separate HTS and LTS quench protection schemes are compatible. A collaborative effort is underway and results will be discussed during the design reviews.

The detailed design for the prototype of the outer REBCO coil is underway. Once built, the outer prototype will be tested in combination with the inner prototype, using the 45 T Hybrid magnet's superconducting outsert at 10 to 11 T as a test bed. Following a design review, the final REBCO coils will be built and integrated with the 15 T LTS magnet. Barring unforeseen delays, operation to 32 T is foreseen by mid-2015.

REBCO R&D Coils Targeting NMR Applications

$REBa_2Cu_3O_{7-x}$ (REBCO) coated conductors have substantially improved as a number of successful record coil attempts carried out by several research groups have shown[1, 2]. Being essentially a highly-aspected single filament conductor, REBCO coated conductors develop significant screening currents that are induced by the radial field components in tape-wound coils that affect their field profile. For high-homogeneity magnets, it is necessary to quantify field-distortions and correct for these. We developed an analytical model to compare to experimental data with the goal of predicting field-profiles in future coated-conductor coils. A layer-wound test coil was built and its field-profile was mapped using an array of Hall sensors, **Figure 10**. Four 3-axis calibrated Hall sensors were placed at various radii on a bar mounted on a spindle, actuated by a stepper motor. This sensor array then mapped the distance between the field center and the end of the coil. Using a critical-current distribution first developed by Brandt and Indenbom[3] that takes screening-currents into account, an analytical model was developed to predict the field-profiles in realistic coated-conductor wound coils. The analytical model is based on the summation of field contributions of single-wire loops using Biot-Savart's law. Additionally a functional dependence for the field field-angle dependence of the critical-current was developed and both the current-distribution across the tape width as well as the current field-angle dependence were applied in the whole model[4]. The experiments revealed that the field-profiles affected by screening currents in the coil

SUPERPOWER "M3-894-2 MS"
1192.68-1322.68m

CONDUCTOR STATS
Width - 4.02 mm
Thickness - 0.096 mm
Insulation - Shrink tube
Thickness init. - 12.7 µm

COIL STATS
ID - 84 mm
OD - 88.2 mm
Height - 128 mm
Layers - 14
Turns/Layer - 29
Turns Total - 406
Cond. Length - 110 m
Joints - none
Coil Constant - 3.3 mT/A
Inductance - 7 mH
Homogeneity - (10 mm DSV) - 1981 ppm

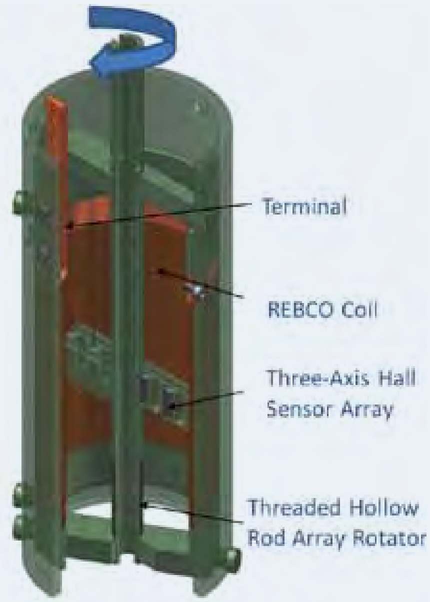

FIGURE 10. Coil specifications and schematic view of the coil instrumented with the Hall sensor array.

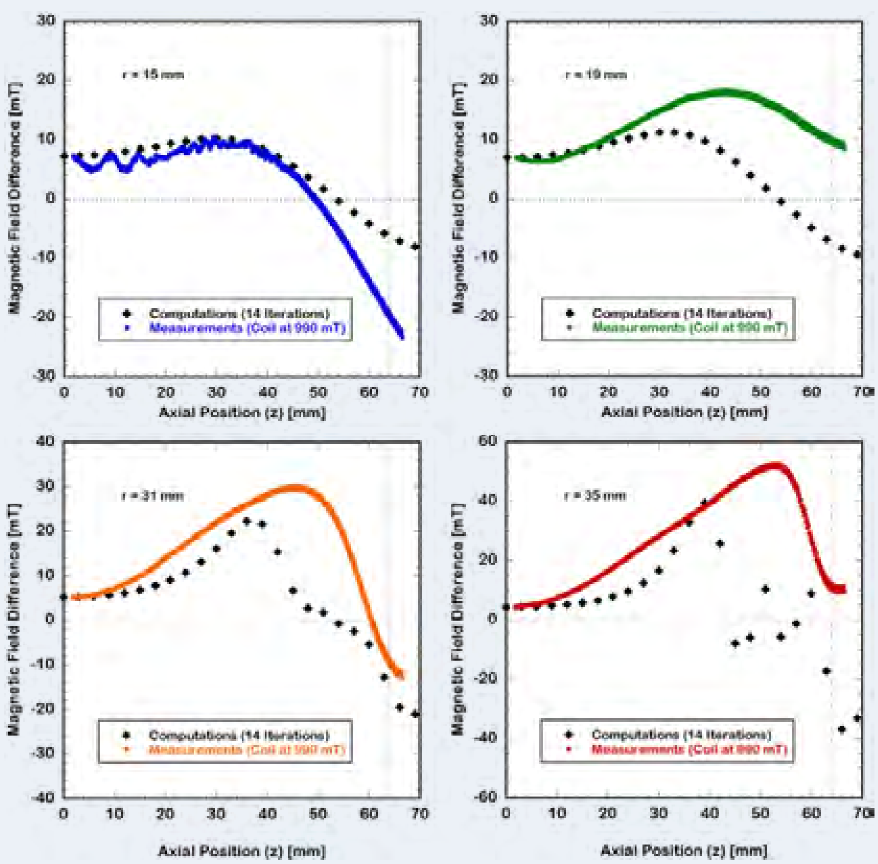

FIGURE 11. Comparison of the magnetic field difference vs. axial position of the measured (solid lines) and theoretically derived data (dotted lines).

windings are moderate. **Figure 11** shows the magnetic field differences between the experimental data as well as the screening current affected model data and data for an identical magnet without screening-currents. Our analytical model qualitatively reproduces the measured data, but we hope to refine our model by more analysis and measurement so as to develop design guidelines for the winding of superconducting coils with high field homogeneity using (RE)BCO coated conductors.

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REBCO Conductor Properties

REBCO coated conductors (CCs) have been developed principally for large-scale applications for electric power applications at elevated temperatures, especially in liquid nitrogen (LN_2) at 77 K. However, the high field applications of interest to the MagLab will be at liquid helium (LHe) temperatures rather than 77 K or even 30 K. Although REBCO CCs are commercially available, tape production is still in many respects in a pilot-plant development phase. The NHMFL performs extensive studies of the conductor by many different techniques with the goal of supporting the design, engineering, and fabrication of the 32 T all superconducting user magnet and various R&D conductor and magnet activities, including application to high field NMR coils. These studies include angular critical current transport investigations of I_c at 4.2-77 K at fields as high as 31 T, microscopic studies of the morphology of vortex pinning (i.e. critical current enhancing) defects and current blocking defects that degrade properties, extensive studies of conductor dimensions, strength, delamination, contact resistance, quality of copper, plating, and magneto-optical studies of supercurrent uniformity. Of course, it would be very good to have full low temperature characteristic for all approximately 10 km of conductor needed for the 32 T magnet fabrication, but this is not feasible. However, all test methods in LHe are presently destructive, because the conductor must be cut into short samples. In particular, in-line transport I_c testing is impossible, because of the very high $I_c > 1$ kA in typical, 4 mm wide CC, to mention just one among many other problems. Thus, the testing in LHe temperatures must be somehow limited to short samples taken from the ends of long lengths, while these lengths are characterized end-to-end in LN_2, where continuous I_c tests are possible. Commercially available instruments infer I_c indirectly from magnetization. Another approach is to measure I_c directly. Such a LN_2 setup has been successfully developed in collaboration with LANL. The instrument is capable of delivering a large amount of data on small regions in an automated manner. It can measure $I_c(x)$ vs. position on the tape with magnetic field in different configuration with better than 2 cm resolution. It can measure also I_c vs. angle and magnetic field. **Figure 12** clearly shows various types of I_c fluctuations along different conductors from current production.

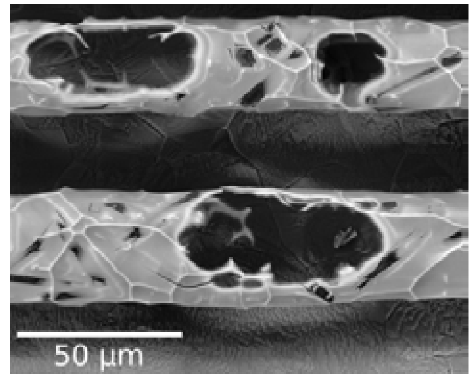

FIGURE 13. Gas bubbles that form in the melt step of HT in individual 2212 filaments.

Bi-2212 Conductor

In 2012 we had a major breakthrough that significantly increased the overall conductor current density J_E in Bi-2212 ($Bi_2Sr_2CaCu_2O_8$) round wire. The major current-blocking defect in Bi-2212 wires was found to be gas bubbles (**Figure 13**), not high angle grain boundaries. In 2011 we used mechanical deformation (Cold-Isostatic Pressing and swaging) to eliminate the bubbles, which significantly increased J_c[1]. In 2012 we used overpressure (OP) processing to eliminate the bubbles, achieving J_E of over 725 A/mm^2 (4.2 K, 20 T), values higher even that recent coated conductors being used for construction of the 32 T magnet. Our earlier mechanical deformation process was applicable only to samples a few cm long, but the new OP process can be used to fabricate high-field magnets (see coil section).

OP processing, which we originally developed for Bi-2223 conductors, is a variant of hot isostatic pressing (HIP). We heat treat the Bi-2212 wire under a high pressure Ar/O_2 mixture, the Ar compressing the Bi-2212 wire, eliminating the bubbles, while the O_2 partial pressure sets the thermodynamic conditions needed to form the 2212 superconductor. **Figure 14** shows that J_E increases with increasing OP pressure and appears to saturate at about 100 bar, at which point the 2212 filament density is close to 100%.

Figure 15 shows J_E as a function of applied field for several superconducting wires that could potentially be used for high-field magnets. An aggressive target for high-field magnets is $J_E \geq 500$ A/mm^2. Remarkably our OP processed wires achieve this target at 4.2 K, 30 T. The inset shows J_c for the non-Ag portion of the wire for these 2212 wires.

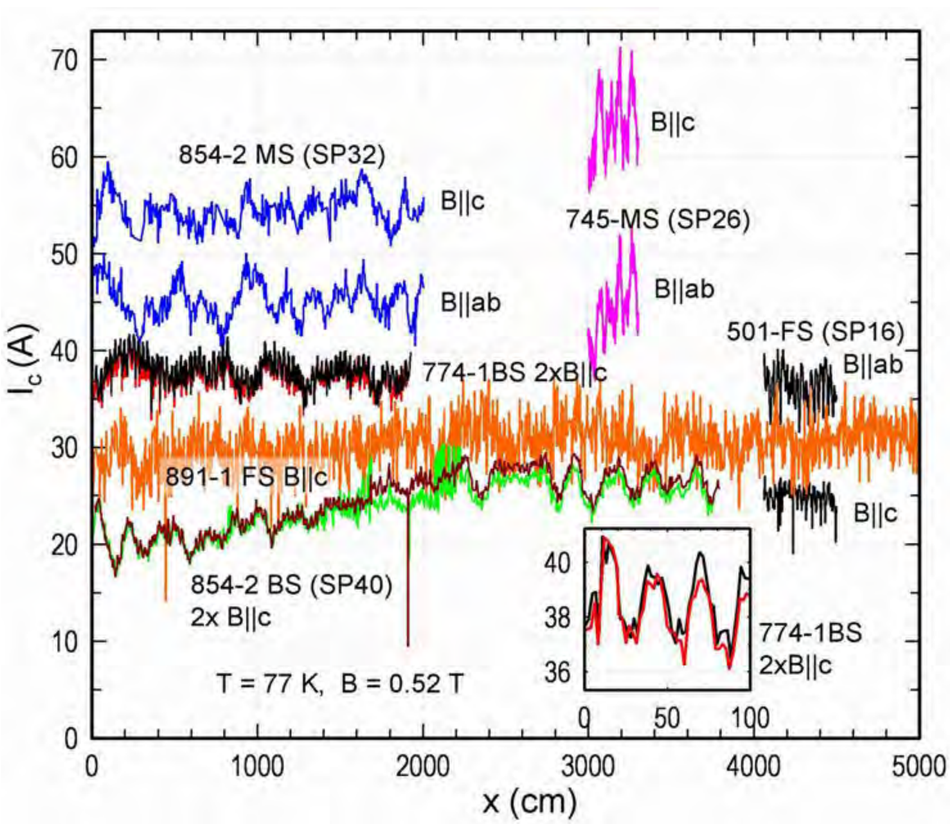

FIGURE 12. I_c vs. position for several different coated conductors. I_c was measured for either B||c and B||ab, or twice in the B||c configuration. Inset shows a reproducible periodicity observed in some conductors. The instrument can measure I_c with a resolution of ~2 cm on 100 m lengths.

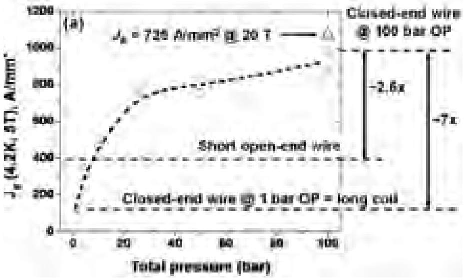

FIGURE 14. A. J_E - OP pressure plot. J_E for a 100 bar OP wire is ~2.5x higher than for the best open-end short sample and ~7x higher than for a long length coil would have when processed at 1 bar total pressure. A data point is shown for CIPping and swaging (810 A/mm² at 5 T at 1 bar, for which the pressure is applied before the heat treatment.)

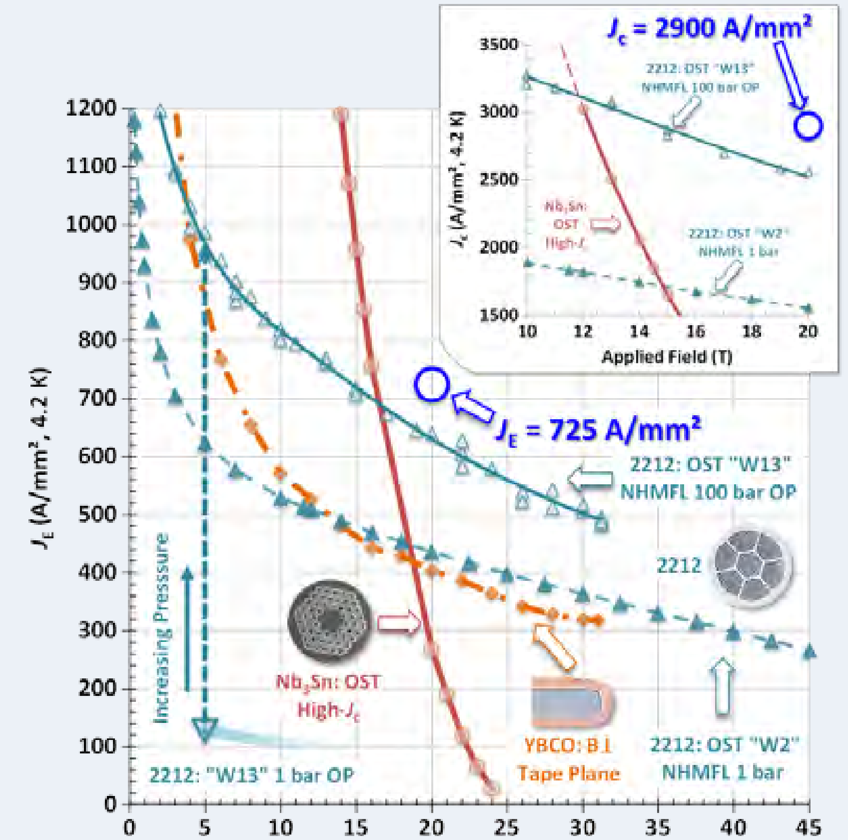

FIGURE 15. J_E - field plot for several superconductors, including Nb_3Sn, YBCO CC tape with B⊥ab, a 2212 wire (W2) that was measured to 45 T in 2005, a 2212 wire (W13) OP processed at 100 bar that was measured to 31 T, and an extrapolated data point at 20 T (J_E = 725 A/mm²) for our champion 100 bar OP sample that was measured at 5 T.

Bi-2212 R&D Coils

Bi-2212 is the only High Temperature Superconductor (HTS) available in round wire form. However, relatively low critical current densities and thick and chemically incompatible insulations[1] have long made it only marginally attractive for high field magnet applications. Recent progress in the understanding of Bi-2212 wire processing has led to an almost 6 fold increase in the long length critical current density[2] to now 500 A/mm² at 30 T, by using an overpressure heat treatment that densifies the wire during heat treatment. In addition, a newly developed, commercial, 15 μm thick TiO_2-based insulation has become available that is 10 times thinner than the current alumino-silicate or silica braided insulations provided by the conductor manufacturers. To test whether this would enable a significantly enhanced coil current-density, a small test coil was wound using Bi-2212 round wire insulated with this new TiO_2-based insulation. It was also the first coil made using the OP process described above, but reaction was made in a system limited to a total pressure of 10 bar. After heat-treatment the coil was epoxy-impregnated and instrumented for low-temperature, in-field measurements in the 31.2 T Bitter magnet. The coil generated an additional magnetic field of 2.6 T for a total of 33.8 T at a helium bath-temperature of 1.8 K, corresponding to a winding current density of 187 A/mm² at quench, i.e. a conductor engineering current density of about 225 A/mm². Though the coil was safely quenched multiple times for different ramp rates, the coil was always limited by the performance of the terminals. Due to space restrictions of the currently available over-pressure furnace, the coil was heat-treated with its terminals reaching into the inhomogeneous zone of the furnace, yielding lower transport performance. Nevertheless, the transport properties of the coil showed a more than two-fold increase of winding current density over previous coils. The performance of this coil, reacted only at 10 bar, achieved about half the conductor current density of the best 100 bar OP short sample measured so far (**Figure 17**), a comparison that clearly demonstrates that Bi-2212 round wire shows great potential for becoming a truly viable competitor to REBCO coated conductors for high magnetic field applications such as NMR where an electromagnetically isotropic conductor with minimal screening currents is highly preferred to highly aspected conductors and hybrid magnets in the 50 – 60 T range and magnets for high energy physics accelerators, where a wire that can be easily cabled is required.

References –
Bi2212 Conductor & Coils

1. M. Dalban-Canassy, *et al.*, Supercond. Sci. and Technol., **25** (11), 115015 (Nov. 2012).
2. J. Jiang, *et al.*, Supercond. Sci. Technol., **24** (8), 082001 (Aug. 2011).

FIGURE 16. Bi-2212 layer wound coil mounted on the probe. The coil specifications are: 71.2 mm long, 14.3 mm ID, 36 mm OD, ~30 m total conductor length.

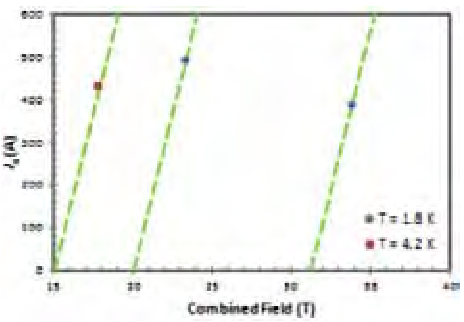

FIGURE 17. Quench current *vs.* field relationship of the 10 bar processed Bi-2212 coil for different cryogenic bath temperatures. 1.8 K testing provides more reliable performance data for magnets tested in the 32.2 T Bitter magnet because the cryostat is small and gaseous He bubbles formed in the vicinity of the current junctions do not easily dissipate except in superfluid He.

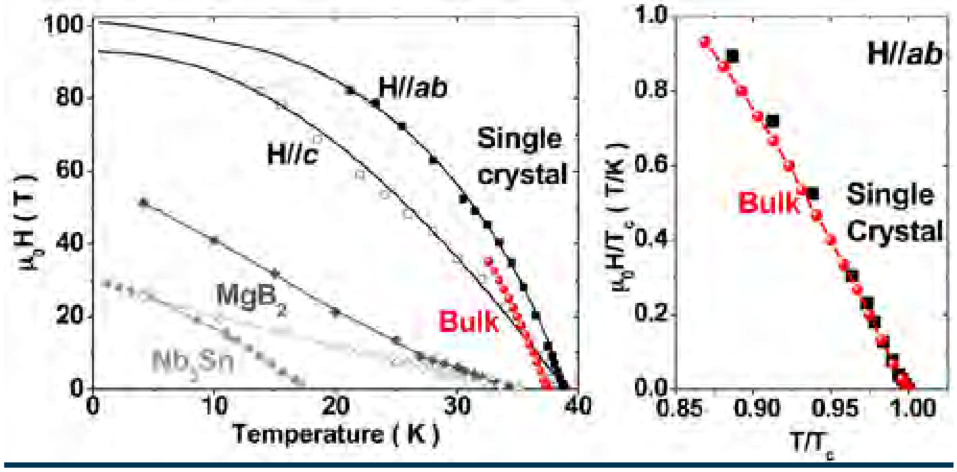

FIGURE 18. Upper critical field as a function of temperature. **LEFT:** for Ba-122 bulk compared to an optimally doped single crystal, a Nb_3Sn wire, and a textured MgB_2 thin film with H applied parallel (closed symbols) and orthogonal (open symbols) to its surface. **RIGHT:** Hc_2 and temperature normalized by T_c to show close agreement between bulk polycrystal and single crystal with H//ab. (From reference 1.)

Iron-Based Superconductors

We are constantly in pursuit of new materials with properties relevant for applications. In 2008, several families of iron-based superconductors were discovered with upper critical fields above 80 T and single-crystal critical-current densities of well over 1 $MAcm^{-2}$ (SF, 4.2 K). In 2012, we succeeded in synthesizing bulk $(Ba_{0.6}K_{0.4})Fe_2As_2$ with high upper critical-fields (see **Figure 18**) and processing it into round mono-core wires with critical current densities over 0.1 $MAcm^{-2}$ (SF, 4.2 K)[1]. This J_c value was more than an order of magnitude higher than any previous bulk sample or wire. It resulted from applying the lessons of current-limiting in earlier samples, both thin film bicrystals and bulk samples and applied new synthesis methods to make a very fine-grain (~100 nm) and clean grain boundary structure. While J_c is still about 5 times smaller than is needed for applications, this break-through suggests that the weak-link behavior of grain boundaries in these high temperature superconductors may be mitigated by clever processing. In addition, we have continued to investigate the pinning properties of $BaFe_{1-x}Co_xAs_2$ thin films with artificial and self-assembled vortex pinning-centers[2]. We found that in addition to accepting a very high density of pins (15-20 vol.%) without T_c suppression, it was possible to engineer the material to have a nearly isotropic $J_c > 0.1$ $MAcm^{-2}$ at 20 T and global pinning force density F_p of ~50 GN/m^3. Both the ability to transmit high current in untextured bulk material, and the ability to accept a large volume fraction of pins (which leads to high $H_{irr}(T)$ enhancements and improved J_c at high fields) is what sets these materials apart from the cuprates.

References – Iron-Based Superconductors

1. J.D. Weiss, C. Tarantini, J. Jiang, F. Kametani, A.A. Polyanskii, D.C. Larbalestier, and E.E. Hellstrom, Nature Materials, **11** (8), 682–685 (May 2012).
2. C. Tarantini, S. Lee, F. Kametani, J. Jiang, J. Weiss, J. Jaroszynski, C. Folkman, E. Hellstrom, C. Eom, and D. Larbalestier, Physical Review B, **86** (21) (Dec. 2012).

Low Temperature Superconductor Magnets & Materials

FIGURE 19. (Left) Winding of the FSU outsert CICC coil.
FIGURE 20. (Right)Fabrication of a splice joint pair for the HZB outsert CICC coil.

CICC Magnets

The NHMFL presently is engaged in three cable-in-conduit conductor (CICC) magnet projects. Two are the development of the Series-Connected Hybrid (SCH) magnets for the Helmholtz Zentrum Berlin (HZB) and FSU that were initiated a few years ago. International recognition was gained with the progress and quality demonstrated in those projects which helped bring forth a third new magnet project that started in 2012. It is the development of the superconducting Nb_3Sn CICC coil for a 45 T Hybrid magnet for the High Field Magnet Lab at Radboud University Nijmegen in The Netherlands.

The winding of the FSU coil is nearing completion. Only one length of conductor (of 5) remains to be wound. This will complete the final four of eighteen layers. The coil winding is shown in **Figure 19**. After winding of the coil, a significant amount of critical work remains. The next steps are to form the leads into their final position and build the splice and termination joints. Once completed the Nb_3Sn reaction heat-treatment is performed. Vacuum-process impregnation with epoxy follows and then the fabrication is completed with the assembly of the cold mass. The outsert coil for the HZB has completed many of these activities. The lead and joint fabrication (**Figure 20**) was done in the fall and the reaction heat-treatment was just recently completed. The coil is now being prepared for the epoxy impregnation.

Other systems are coming together for the FSU SCH.

- The HTS BSCCO tapes for the binary leads have been ordered and are expected in early 2013. In addition, the manufacturing designs for the upper lead stack (77 K – room temperature) are finished and the lower lead stack (4.5 K – 77 K) will be done in the first quarter of 2013. **Figure 21** shows the binary leads design.
- The cryogenic distribution box was delivered to the lab, as shown in **Figure 22**. This will link the new helium liquefier with the 45 T Hybrid and the FSU SCH magnet.
- The magnet cell has been outfitted with the rear section of the platform, current breakers, and resistive magnet cooling water plumbing.
- The iron shield to restrict the fringe field has been ordered.
- An order to fabricate the SCH cryostat and magnet housing was awarded to Criotec Impianti who also successfully fabricated the cryostat for the HZB SCH.

Strand-Level Nb_3Sn Optimization

The Applied Superconductivity Center at the NHMFL, supported by the DOE, works closely with the U.S. High Energy Physics (HEP) community to identify and push the limits of performance of high-J_c Nb_3Sn strand by providing a detailed understanding of the many variables that determine strand properties. In 2012 a formal agreement was reached with CERN to extend our HEP collaborations to Europe, providing access to the latest generation of HEP power-in-tube (PIT) strands. This extended collaboration has allowed us to compare RRP® and PIT strands for:

- Specific heat C_p up to 16 T, to evaluate the T_c-distribution and superfluid density, both at 0 T and in-field at 16 T and to obtain the fraction of A15 and Nb diffusion barrier (DB) in the conductor. An example is shown in **Figure 23(a)**, where an advanced PIT wire has been given two optimized reaction Heat-Treatments (HT) at CERN to obtain the maximum J_c (12 T, 4.2 K) with RRR > 100: 1) a two-stage HT, 120h/620°C+120h/640°C; 2) a single HT, 280h/625°C. The normalized electronic specific heat, C_e, reveals only small differences. The only visible difference is in the Nb jump at 9 K that is slightly smaller in the two-stage HT case, indicating a greater reaction of the Nb DB to Nb_3Sn. The T_c-distribution f(T_c), in the inset of **Figure 23(a)**, shows that the majority of the A15 phase has a T_c over 17 K but a marked peak structure is observed suggesting distinct layers with different compositions.
- Weak field (~mT) SQUID magnetometry to get the temperature dependent shielding of the lower T_c shells of the A15 phase or the Nb DB.
- Vibrating Sample Magnetometry (VSM) up to 14 T, to magnetically determine

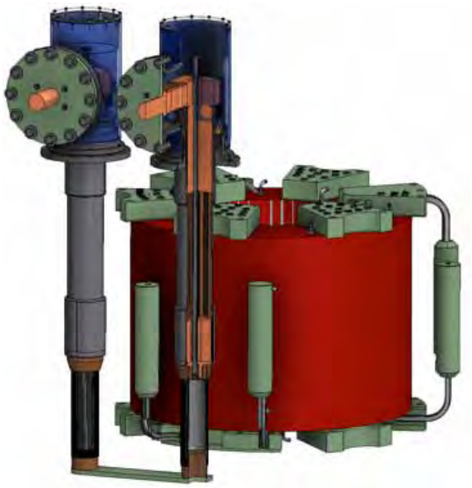

FIGURE 21. (Left) Binary HTS/resistive leads for the FSU SCH shown with the superconducting solenoid.

FIGURE 22. (Right) Installation of the cryogenic distribution box into the high-bay of Cell 16.

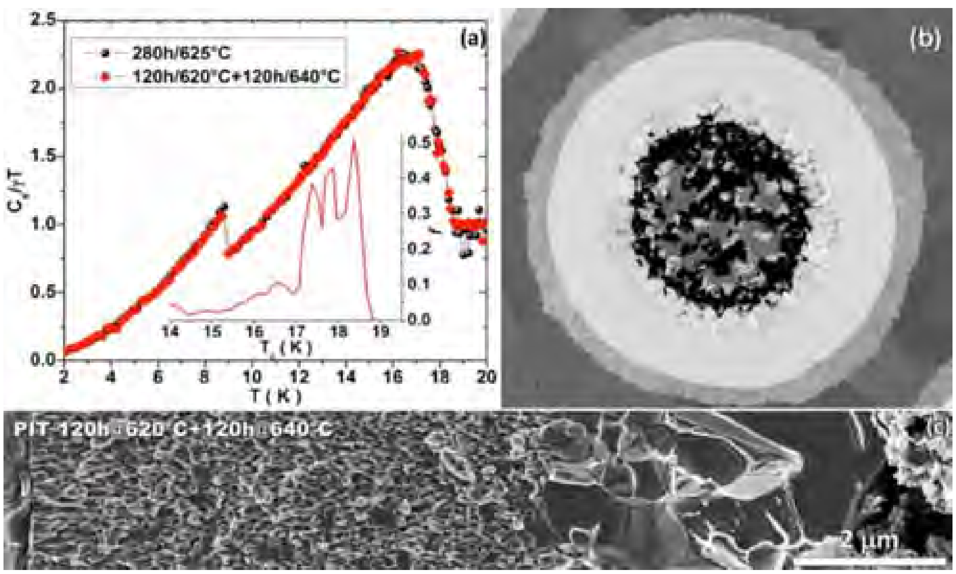

FIGURE 23. A comparison of a PIT wire given two different optimized reaction heat treatments at CERN: **A.** Normalized electronic specific heat at 0 T showing two main transitions at ~9 K, related to the Nb7.5Ta barrier, and at ~18 K, related to the A15 phase; in the inset, the T_c-distribution of the two-stage HT sample shows multiple peaks in the high T_c region. **B.** FESEM BEI cross-sectional view of a PIT filament and **C.** FESEM fractograph showing variation on Nb_3Sn grain morphology across the A15 layer.

J_c, the bulk pinning force F_p, and the irreversibility field H_{Irr} and to compare them with transport I_c data taken at BNL or CERN.

- FESEM, to determine the fraction of A15 lying within the DB, the small to large grain A15 ratio in the case of PIT, the A15 grain size and grain shape distribution and any radial variation of properties from the low-Sn to the high-Sn side of the layer, and the DB thickness and uniformity including possible DB breakage. An example of FESEM images are shown in **Figure 23**. **Figure 23(b)** represents a filament in which residual core, large and small grain layers and Nb diffusion barrier are clearly recognizable. The FESEM fractograph in **Figure 23(c)** reveals the different grain size and density across the A15 layer, so important for the J_c performance.
- FESEM-EDS to determine the composition variation across the A15 layer.

A major advance in our analytical capabilities has been the acquisition of a state-of-the-art Cs-probe corrected analytical TEM/STEM (JEM-ARM200cF) with a very complete suite of imaging and analytical detectors, and this has allowed us for the first time to show inhomogeneous distributions of Ti and Cu at grain boundaries of Ti-doped Nb_3Sn. These results may help explain differences observed in the mechanical properties of Ti and Ta-doped strands[1] and may eventually lead to improvements in strain tolerance in Nb_3Sn strand and, combined with our extensive measurements on RRP® and PIT strands, the specific pinning force of the GBs, Q_{GB}, and ultimately the limits of Nb_3Sn strand performance.

Reference – Strand-Level Nb_3Sn Optimization

1. N. Cheggour, L. Goodrich, T. Stauffer, J. Splett, X. Lu, A. Ghosh, and G. Ambrosio, "Influence of Ti and Ta doping on the irreversible strain limit of ternary Nb_3Sn superconducting wires made by the restacked-rod process," *Superconductor Science and Technology*, **23**, 052002 (2010).

Deconstruction of SULTAN-tested ITER CICCs

CICCs for ITER are tested in the SULTAN facility at the Paul Scherrer Institut in Switzerland to qualify new strands and cable designs for the high-field CS (Central Solenoid) and TF (Toroidal Field) coils that confine and control the plasma; these tests have until recently shown degradation in performance with cyclic field loading and periodic WUCD (warm-up\cool-down) cycles. Determining the source of this degradation is of great interest. The Applied Superconductivity Center has been tasked by the ITER Organization (IO) and US-ITER to disassemble and perform a detailed metallographic post-mortem of several key TF and CS CICCs after SULTAN test, to quantitatively evaluate the condition of the superconducting cable after testing.

The United States is responsible for the CS coils for ITER and initial CS CICCs failed ITER qualification, resulting in redesigns of the cable configuration; three SULTAN CS samples with new and baseline configurations have been deconstructed and analyzed to this date. **Table 1** shows basic descriptions of the CS samples under disassembly and analysis at NHMFL.

In addition to high resolution digital analysis of full cable cross-sections we extract short lengths of strand (~ 15 mm in length) from representative regions of the cable (high field tested region, low field regions, high and low pressure sides of the cable, sub-cable locations) as well as examine strands with different levels of cabling deformation.

In 2012 the first three tested CS CICCs in **Table 1** were disassembled, analyzed and compared. **Figure 24** shows a longitudinal cross section of a strand extracted from the High Field Zone (HFZ), with the filament fractures highlighted as blue dots. With the crack locations identified by position we can quantify the distribution and density of cracks in the strand and compare them with cracks produced under controlled conditions by collaborators at the University of Twente. Both the CSIO-1 legs and the CSJA-2 cables show significant levels of filament fracture in strands in the HFZ after SULTAN testing (no cracking is observed in the Low Field Zone). Cracks are only observed in strands with some level of curvature and the distribution is similar to that observed under TARSIS bend testing at the University of Twente.

We work closely with IO and US-ITER and we provide rapid feedback to the cable designers to aid in the interpretation of the SULTAN test results.

ITER Wire Characterization

The ITER experimental fusion reactor is a multibillion dollar international collaborative effort to study the feasibility of fusion as a long-term energy source for the world. The United States is one of seven participants of the ITER program. A key component of ITER is the superconducting magnet system which needs 500 tons of Nb_3Sn wires. Historically, the annual worldwide production of Nb_3Sn has been ~15 tons. Therefore the quality verification testing of the production wires was very important to the ITER project in year 2012.

The MagLab participated in the ITER Nb_3Sn and Nb-Ti wire benchmarking tests starting in 2009[1, 2]. In 2012, we were awarded a two-year, $1.3 M contract by US-ITER (under the management of the Department of Energy) for testing Nb_3Sn wires used for ITER toroidal field (TF) magnets, and investigating the effect of the heat treatment schedule variation on the critical properties of ITER Nb_3Sn wires.

During the course of the Nb_3Sn testing project, we have hired engineers and technicians, established testing protocols and procedures, installed a new 15/17 T superconducting magnet, and installed heat treatment systems. After experiencing some technical difficulties, we are now meeting the ITER demands in high quantity while maintaining high quality standards.

This work will have many very positive long term impacts. Through this work, we are establishing an international reputation as the superconducting materials testing reference lab in the United States. We have trained/educated young engineers and students who can be easily transferred to work on other MagLab superconducting magnet projects. In addition, the equipment procured in this project will significantly enhance the capability of our material testing laboratory. The equipment

FIGURE 24. Longitudinal cross-section of a High Field Zone (HFZ) strand extracted from the Low-Pressure (LP) side of the CSIO1-2 SULTAN leg. The locations of cracks are shown in blue.

TABLE 1

Basic Characteristics of the Samples Deconstructed

Sample	Strand Type	Triplet Configuration	Projects Funded	Void Fraction	Strand Producer
CSIO 1-1	1.5:1 OST Internal Sn (IT)	3 superconducting strands	Baseline	33%	OST (D)
CSIO 1-2	1:1 OST IT	2 superconducting + 1 Cu strand	Baseline	33%	OST (D)
CSJA 2	1:1 Jastec Bronze of 3rd generation	2 superconducting + 1 Cu strand	Baseline	33%	JAS
CSIO 2-1	1:1 OST IT	2 superconducting + 1 Cu strand	Short	32.4%	OST (D)

can serve other MagLab projects such as the series-connected hybrid and the 32 T all-superconducting magnet projects. We anticipate submitting a proposal for other testing in coming months.

References – ITER Wire Characterization

1. M.C. Jewell, T. Boutboul, L. Oberli, F. Liu, Y. Wu, A. Vostner, T. Isono, Y. Takahashi, S.-H. Park, A. Shikov, A. Vorobieva, N. Martovetsky, K. Seo, D. Bessette, and A. Devred, *"World-wide benchmarking of ITER strand test facilities,"* IEEE Transactions on Applied Superconductivity, **20**, 1500 (2010).
2. I. Pong; M.C. Jewell; B. Bordini; L. Oberli; S. Liu; F. Long; T. Boutboul; P. Readman; S.-H. Park; P.-Y. Park; V. Pantsyrny; V. Tronza; N. Martovetsky; J. Lu and A. Devred, *Worldwide Benchmarking of ITER Internal Tin Nb_3Sn and NbTi Strands Test Facilities*, IEEE Trans. Appl. Supercond., **22** (3), 4802606 (2012).

ITER CS Structure

CICC Technology for the ITER Central Solenoid (CS) and Toroidal Field (TF) Coils requires research to qualify the 4 K mechanical properties of the conduit and its insulation. Personnel and equipment have been developed at the MagLab that has allowed the US-ITER team to tap a unique and efficient engineering support group. Austenitic steels used for the conduit are required to have yield strengths of 1000 MPa and endurance to withstand 60,000 fatigue cycles at 4 K. The CS conduit is evaluated using fracture mechanics test to confirm the toughness is greater than 150 MPa$\sqrt{m}$ at 4 K and to measure the fatigue-crack growth-rate at 4 K. Conduit research conducted includes simulated conduit production steps such as cold forming and reaction heat treatments, followed up with microstructural and physical property characterization (grain structure, fractography, thermal expansion/conductivity etc.). Conduit weld tests require special attention to details and features that could influence conduit fatigue and fracture performance.

The CICCs are electrically insulated with a glass-fiber reinforced/kapton/epoxy system that must perform over the lifetime of the magnets. To assess physical and mechanical properties of the CS modules, tests on prototype samples (4 x 4 arrays made with insulated conduit lengths) were performed. The large (250 mm^3) CICC model samples were fatigue tested and inspected to evaluate the insulation system performance. Thermal expansion and elastic modulus of the composite specimens was measured for design purposes.

CHAPTER 4

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. The 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
- **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 MagLab 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 Magnet Lab cannot fund clinical studies.

Sixteen (17) UCGP solicitations have now been completed with a total of 488 pre-proposals being submitted for review. Of the 488 proposals, 255 were selected to advance to the second phase of review, and 111 were funded (22.75% of the total number of submitted proposals).

TABLE 1

UCGP Proposal Solicitation Results *for 2012*

Research Area	Pre-Proposals Submitted	Pre-Proposals Proceeding to Full Proposal	Projects Funded
Condensed Matter Science	3	3	2
Biological & Chemical Sciences	10	8	2
Magnet & Magnet Materials Technology	1	1	0
TOTAL	**14**	**12**	**4**

2012 Solicitation & 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. Since 2001, the proposal submission and two-stage proposal review process has been handled by means of a web-based system.

Of the 14 pre-proposals received, the committee recommended that 12 pre-proposals be moved to the full proposal stage. Of the 12 full proposals, 4 grants were awarded. A breakdown of the review results is presented in **Tables 1 and 2**.

2013 Solicitation

The 2013 Solicitation Announcement should be released on about May 15, 2013. Awards will be announced by the end of the year.

Results Reporting

To assess the success of the UCGP, reports were requested in December 2012 on grants issued from the solicitations held in the years 2007 through 2011 that had start dates respectively near the beginnings of years 2008 through 2012. At the time of the reporting, some of these grants were in progress, and some had been completed. For this "retrospective" reporting, principal investigators (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, 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.

Tables 3 and 4 summarize the results. The success of the program is evident from the wide-ranging enhancements produced and from the production of peer-reviewed publications, many in high impact journals. These include 1 article in *Nature*, 1 in *Nature Materials*, 1 in *Nature Structural & Molecular Biology*, 6 in *Physical Review Letters*, and 2 in the *Journal of the American Chemical Society*. A significant positive impact on education is also evident from the reporting, since almost all grants were reported to have supported one or more students, at least partially or through supplies.

TABLE 2

UCGP Funded Projects *from 2012 Solicitation*

Principal Investigator	NHMFL Institution	Project Title	Funding
James Hamlin	UF	*In situ* Pressure Variation at Low Temperatures	$199,060
Dmitry Smirnov	NHMFL	High-field Raman Spectroscopy of Advanced Electronic Systems	$216,200
Stephen Hill	NHMFL	Integration of a Microwave Resonator and Diamond-Anvil Pressure Clamp for High-Field Cavity Perturbation Studies	$189,024
William Brey	NHMFL	High Temperature Superconductive NMR Probe for Metabolic Flux Studies in Single Animals	$200,710

TABLE 3

Facility Enhancements *Reported from 2007-2011 UCGP Solicitations*

Enhancement and available date	Users *
Free space Raman measurement capability to 10 T (4/10)	3
Ball bonder (1/10)	1
EPR field standard using lines of the H-atom entrapped in octa-isobutyl-silsesquioxane (4/10)	1
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 measurements in pulsed field (3/12)	4
500 MHz solid state NMR system and MAS probe on existing 600 MHz (10/10)	2
Force magnetometers for unprecedented low T, high B (9/12)	3
Stray field gradient imaging NMR probe (11/12)	1
Dielectric based cylindrical waveguide structure for the 900 UWB magnet (12/11)	2
Low temperature HEMT-based NMR preamp for High B/T facility (5/08)	1
Probe and coils for *in vivo* NMR with 900 MHz and 600 MHz magnets (1/09)	4
900 MHz high B1 homogeneity dielectric resonator for NMR (5/09)	1
Quadrupolar Carr-Purcell Meiboom-Gill sequence for resistive magnets (8/08)	1
Triple resonance “low E” probe 600 MHz (3/10) and 900 MHz (10/11)	2
NMR pulse sequence for improved broadband sideband separation, resolution enhancement (10/08)	1
High field magneto-optics for magneto-Raman or sensitive PL spectroscopy (11/10)	4
High resolution visible spectrometer with LN2 cooled CCD (8/09)	5

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

TABLE 4

Publications Reported *2007-2011 UCGP Solicitations*

Applied Physics Letters	2
Applied Superconductivity	2
Chemical Science	2
European Biophysics Journal	1
Inorganic Chemistry	1
Institute of Physics Conference Series	8
Journal of Crystal Growth	1
Journal of Low Temperature Physics	5
Journal of Membrane Science	2
Journal of the American Chemical Society	2
Journal of Materials Chemistry	1
Journal of Magnetic Resonance	7
Chinese Journal of Magnetic Resonance	1
Journal Physical Chemistry Letters	1
Journal of Physical Condensed Matter	1
Langmuir	1
Magnetic Resonance Imaging	1
Magnetic Resonance in Medicine	2
Materials Science Forum	1
Nature Materials	1
Nature	1
Nature Structural & Molecular Biology	1
Neuro Image	3
Superconductor Science and Technology	1
Neurology	1
Physical Review B	10
Physical Review Letters	6
Physica C	1
Biomacromolecules	1
RSC Advances	1

Publications (including accepted for publication) as of December 2012, reported from UCGP grants.

CHAPTER 5

The Center for Integrating Research & Learning

The Center for Integrating Research & Learning (CIRL) reaches over 10,000 K-12 students and more than 200 teachers per year through a variety of outreach activities that include classroom outreach, hands-on extended programs (e.g. internships and camps), Research Experiences for Teachers programs, and web-based activities.

CIRL also runs the Research Experience for Undergraduate program and the postdoctoral/graduate student mentoring program for the lab. Our mission — to expand scientific literacy and to encourage interest in the pursuit of scientific studies among educators and students of all ages — has become more specifically targeted to encourage students, particularly those from underrepresented groups, to pursue STEM career paths. While this has always been a goal of CIRL programming, increasing the number of students entering the STEM pipeline has become a national imperative and one that is a mandate for informal science education. **Table 1** shows statistical highlights for our educational and public outreach programs.

As part of all of these programs, CIRL graduate students under the direction of **Roxanne Hughes**, Director of the Center for Integrating Research and Learning, conduct annual evaluations and research projects on all of the programming (**Table 2**).

New Evaluation/Research Initiatives in 2012

In response to the 2011 NSF site visit report, CIRL incorporated a formal assessment plan (**Table 3**) during 2012 and will use the results of this assessment to improve 2013 programming. The assessment plan for REU, as well as our other programs, includes: goals for the program, metrics for those goals, and action plans in response to feedback relating to the level of success in reaching those goals.

Plans for 2013 Assessment:

- Pre- and post-surveys and annual tracking for interns.
- Annual tracking for graduate students and postdocs
- Development of a validated survey instrument for publication and future use for secondary school and undergraduate programs

Presentations, Publications & Awards

CIRL's research staff published a number of studies at national conferences and in peer-reviewed journals in 2012. CIRL continues to maintain a strong research agenda that allows it to add to the literature on informal science education. This knowledge gained from the research agenda allows CIRL to be a leader in Informal Science Education.

Presentations

R. Hughes. (2012, January). *Trajectories of Science Identity Formation*. Paper presented at the Annual Meeting of the Association of Science Teacher Education, Clearwater, FL.

R. Hughes. (2012, January). *Liberatory Science Education in a Single Sex and a Coeducational Setting*. Paper presented at the Annual Meeting of the Association of Science Teacher Education, Clearwater, FL.

Publications

Hughes, R., Molyneaux, K., & Dixon, P. (2012). The role of scientist mentors on teachers' perceptions of the community of science during a summer research experience. *Research in Science Education Journal*. 42(5), 915-941.

Awards and Recognition from National and International Organizations

Roxanne Hughes, *Nominee for the Research on Women and Education Dissertation Award*: The Research on Women and Education Dissertation Committee Award nominated Hughes' dissertation as one of the finalist for the 2012 Dissertation Award.

Roxanne Hughes, *Recognition of Merit (Top 5 Finalist) for the PDK International Outstanding Doctoral Dissertation Award*. The PDK International committee selected Hughes' dissertation as a finalist based on: the dissertation's representation of sound scholarship and the strength of the knowledge presented and the conclusions drawn for the improvement of education.

Research Results

CIRL research – as well as leading science education researchers – indicates that reaching underrepresented minorities as early as elementary school and then providing continuous exposure to STEM research and careers, significantly increases their persistence in STEM fields. CIRL helps students who participate in our programming at each of the crucial stages of their STEM career trajectories: middle school, high school, undergraduate, and graduate school.

The results of the research and evaluation that CIRL conducts demonstrates that our hands-on opportunities for students – internships, camps, and research experiences – provide the in-depth exposure that students need to maintain interest in STEM and develop positive attitudes toward and perceptions of STEM careers and profes-

TABLE 1

CIRL Educational & Public Outreach Programs

K-12 STUDENTS

- **Classroom Outreach** – over 10,000 students per year
- **High School Internships** – average 8-10 interns per semester
- **Middle School Mentoring** (School of Arts & Sciences) – since 2003 over 137 students, 60% Females, 10% Minorities
- **Middle School Summer Camps**, since 2006 over 350 students reached: 82% female, 24% African American, 6% Hispanic, .6% Native American
- **ERC-FREEDM Young Scholars** – (High School students)
- **Web Activities** – Facebook, Twitter, Blogs

K-12 TEACHERS

- **Classroom Outreach** – over 200 classrooms per year
- **Mag Lab Educators Club** – over 150 members
- **Teacher Workshops** – 1-2 school districts per year
- **Research Experiences for Teachers** – (~15 teachers per summer) 225 teachers have participated since 1998 reaching more than 1,000 students K-12 annually
- **Social Media/Web**
- **Leadership in teacher organizations** – BLAST (North Florida and South Georgia organization that promotes science instruction)

PUBLIC/COMMUNITY

- **Barnes and Nobles** – monthly
- **Senior Center** – four times per year
- **Science Café** – monthly opportunity for scientists to present research in informal setting, reaching ~ 50 participants per outreach
- **Tours of the MagLab**
- **Social Media/Web**
- **Leadership in community organizations** – Community Classroom Consortium; Afterschool Network

UNDERGRADUATE & BEYOND

- **Research Experiences for Undergraduates** – Since 1999, 274 students have participated (~20 per year), representing institutions located in over 40 states. 44% female (122), 10% from HBCUs (28), 16% African American (42), 16% Hispanic (43), 2% Native American (6).
- **Graduate Student/Postdoc mentoring sessions** – presentation and writing help, social activities, etc.
- **Outreach** – Provide opportunities for undergraduate and graduate students and others to conduct outreach with K-12 students and teachers and public.

sionals. One of our prominent evaluation projects – the REU Tracking Project – has been conducted by **Brandon Nzekwe** since 2008. Brandon has been tracking former REUs who participated in the program since 1999. CIRL has academic and professional information on 197 participants from 1999 – 2012 (69 are currently working in STEM fields (47.9%); 50 are currently working on doctoral degrees (34.7%); 19 are c urrently working on master's degrees (13.2%); 6 are currently working in non-STEM fields (4.2%); 12 came to FSU for the graduate degree and 5 went to UF. Brandon is currently working with the Office of Undergraduate Research at FSU to develop a survey to measure the effects of research experiences for all undergraduate students. Brandon has also developed a survey instrument that other REU programs across the country are using to study the effects of their respective REU programs.

Outreach

The goal of CIRL's programs is to increase the representation of underrepresented groups including women, African Americans, Hispanics, and Native Americans. Our programs are aimed towards students and teachers from Title I schools and students/teachers who may not have access to the quality science outreach that we provide. Part of our efforts for the next award period (2013-2017) is to increase the role of LANL and UF. To prepare for this during 2012 (our transition year), both **Roxanne Hughes** and **Jose Sanchez** visited LANL to improve the connections between outreach in Tallahassee and LANL. Roxanne Hughes also visited UF to hear their suggestions as to how the relationship between UF and FSU as it relates to outreach can be improved.

CIRL's outreach alone demonstrates how dedicated we are to outreach to Title I schools. **Figure 1** demonstrates that CIRL provides at least half of its outreach to Title I schools (shown in dark blue) each year.

Linking the Outreach Conducted by the Three Locations – 2012 Transition Year

It is the MagLab's goal that by 2013, CIRL staff will develop outreach plans with LANL scientists to strengthen their outreach to Native American populations and with UF scientists/postdocs/graduate

TABLE 2

CIRL Program Evaluations

Outreach	Form of Evaluation	CIRL Staff
Classroom outreach	· Post-survey sent after classroom outreach conducted – formative assessment	Smriti Jangra
RET/REU/ Summer camps	· Pre- and post-survey taken on first and final day of program to assess self-efficacy in STEM (and for teachers in teaching STEM); · Attitudes toward STEM and STEM careers; perceptions of STEM and STEM careers; · Annual tracking survey (where are they now) to measure STEM career persistence.	Roxanne Hughes Brandon Nzekwe Smriti Jangra
Graduate Student/ Postdoc Mentoring	· Surveys given at opening session to determine academic sessions of interest; · Each session will present a post-survey to participants to conduct a formative assessment to improve future planning; · Annual tracking survey (where are they now) to measure STEM career persistence.	Brandon Nzekwe
NHMFL Winter Theory School and NHMFL Users Summer School	· Pre-survey measuring expectations; · Post survey measuring evaluations of program; · Annual tracking survey (where are they now) to measure STEM career persistence.	Roxanne Hughes Brandon Nzekwe

students to strengthen their outreach to underrepresented groups. Already, CIRL's outreach coordinator, **Carlos Villa**, has provided UF graduate students with outreach materials and necessary information to work in local schools.

CIRL is also working with the MagLab Technology Specialists to make it easier for scientists to report their outreach efforts. This new reporting system, which should be completed by December 2012, will then keep all of this outreach information in a database so that it can easily be reported to NSF by year, department, and location.

CIRL is working with the MagLab Technology Specialists to create live video sessions during our monthly postdoc/graduate student mentoring sessions, so that LANL and UF postdocs and graduate students can be a part of these sessions.

Postdoc/Graduate Student Mentoring Plan

The Postdoctoral/Graduate Student Mentoring Plan was initiated by CIRL and the MagLab in the fall of 2012. To begin this initiative, CIRL conducted an orientation session inviting NHMFL postdocs and graduate students from FSU and UF to come to the lab for face-to-face orientation opportunities. The orientation included an overview of the Magnet Lab, the interdisciplinary nature of the diverse groups at the lab, the science conducted at the lab by different groups, practical institutional information (getting paid, ordering materials, who to speak to about practical matters of resources, expectations, etc.), as well as information about housing, schools, health care resources, resolving problems and issues specific to the lab or university-wide, links to groups on campus. All of this information is also available on the MagLab website and separated based on its applications to graduate students, postdocs, and faculty.

Of the 53 postdocs at FSU and the 158 graduate students, 13 postdocs attended and 18 graduate students (including 9 graduate students from UF). During this first session we surveyed participants to determine the types of academic sessions they would like to attend. We will create six sessions per year that will cover: presenting at conferences, writing CVs, library resources, and job presentations, etc. In 2012 CIRL held two additional sessions. On November 14, a representative from the FSU Office of Research presented to 33 attendees about the FSU grants database that allows FSU-affiliated students, faculty, and postdocs to search for grant opportunities and to find collaborators. On December 5, the final postdoc/graduate student session for 2012 was held, during which Luis Balicas presented to the attendees about publishing research in top tier journals.

The overall goals of the postdoc/graduate student mentoring sessions are:

- To support postdocs and graduate students at the Lab. Each session we conduct surveys that ask participants to identify what sessions they would like to see.
- To facilitate the mentoring goals of Magnet Lab scientists and the NHMFL strategic plan (**Appendix G**). The director of CIRL works with NHMFL scientists to make sure the planned sessions meet the goals of the lab.
- To coordinate with diversity efforts at the lab, utilizing best practices for recruiting and retaining members of underrepresented groups. By collecting current contact information, CIRL and the lab are able to notify students/postdocs at all three sites about upcoming conferences, career opportunities, networking opportunities, and outreach opportunities (including presentations at conferences for underrepresented groups).

In 2013, we will begin to incorporate group mentoring sessions – once a semester – that will place a MagLab scientist with a group of postdocs or graduate students. The scientists can answer questions about career trajectories.

Classroom Outreach — Title 1 Schools

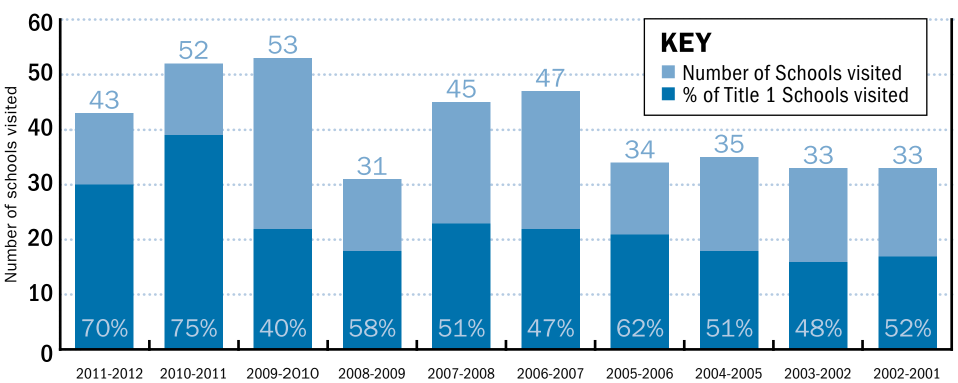

FIGURE 1. Outreach to Title 1 schools. For the 2011-2012 school year, CIRL visited a total of 43 schools, 70% of which were Title 1 schools.

TABLE 3

CIRL Formal Assessment Plan *(In response to NSF Site Visit report)*

1. Identify goals of the program in collaboration with MagLab scientists.

CIRL staff revisited and then formalized the goals for all of our programs. These are currently on the Education webpage as well as in our CIRL documents on the Mag Lab server.

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2. Make sure that the goals are clear and that measurable objectives are set.

REU Program Goals

Research Experiences for Undergraduates (REU) is an eight week program that matches highly qualified undergraduates in the STEM fields with scientists at the Magnet Lab's three sites (Florida State University, Los Alamos National Laboratory and the University of Florida). Through the REU program, undergraduate STEM majors are exposed to authentic scientific research that involves high magnetic fields, superconductivity, optical microscopy, materials characterization, geochemistry and numerous other STEM related topics pursued by scientists at the Magnet Lab.

The program goals are to:

- Increase the number of underrepresented groups in STEM fields
- Enable undergraduate student collaboration with mentors at all three sites
- To enable undergraduates to gain experience in developing and presenting quality final projects based on their summer experience

We can measure these by:

- Tracking increases in our minority participation
- Tracking increases in REUs at UF and LANL
- Utilizing the results of mentor surveys and focus group questions to determine how well students do with their projects and what they think of the process of developing and presenting research projects.

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3. Pre- and post-surveys will be administered to students (as is currently being done) and a post-survey will be sent to all mentors.

A post-survey was sent to all mentors for 2012 REU and RET. The questionnaire used in this evaluation was created from qualitative data gathered from Magnet Lab mentors in 2009. There were 22 Magnet Lab affiliate scientists that participated as mentors for the 2012 REU and/or RET program(s), and we received 14 completed questionnaires giving us 63.6% response rate. Of the 22 scientists, 6 mentored RETs and 17 mentored REUs (note: 4 scientists mentored multiple participants during the summer 2012). The gender, distribution of the 2012 REU/RET mentors was 90.9% male and 9.1% female. Participants' race/ethnicity distribution was 22.7% Asian and 77.3% White non-Hispanic; 13.6 also indicated that they were foreign nationals. On average, our mentors had 21.3 years of experience working in their scientific field ranging from 3 to 41 years; an average of 12.2 of those years were in affiliation with the Magnet Lab ranging from 1 to 21 years.

On average, Magnet Lab scientists had 5.7 years of experience working with REU participants. These mentors were asked several attitudinal questions regarding what they believe their role as a REU mentor encompassed, and what they should provide REU participants with during their research experience.

When mentors were asked what they believed their role as a REU mentor encompassed:
90.9% said to expose students to how scientists think
81.8% said to help students persist in the sciences
72.7% said to incorporate students into the lab culture
63.6% said to help build students' self-confidence
63.6% said to promote the pursuit of graduate-level research
63.6% said to prepare students for graduate school
54.5% said to allow students to contribute to current research
45.5% said to recruit potential graduate students
45.5% said to train students for more demanding research
27.3% said to reinforce classroom instruction

When mentors were asked what they should provide REU participants with during their research experience:
100% chose scientific content knowledge
81.8% chose career guidance
72.7% chose personal advice
72.7% chose advanced materials
63.6% chose academic guidance
18.2% chose social activities

The majority (73%) of REU mentors indicated that they preferred that their REU mentee(s) either work individually or with graduate students on a single project during their Magnet Lab REU program experience.

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4. CIRL will conduct a mentor workshop to clarify expectations and goals and to provide mentoring strategies and tips for those who wish to work with REU/RET.

This mentor workshop will be incorporated next year (2013). It currently is done on an informal basis since most of our mentors have participated in the program before and only one or two are new. In 2013, the Director of the REU program (Jose Sanchez) will incorporate mentoring sessions for REU students on the following issues: applying to graduate school, writing cover letters and resumes for graduate school, and writing for scientific publication.

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5. Focus groups of students and mentors will be conducted during and after the REU program.

Focus groups were conducted. The results of the focus groups helped CIRL to identify needs for the students and mentors. First, students would prefer to work in pairs so that they can learn from each other. Second, students would like to have presentations on career and graduate school. Both of these will be incorporated in 2013.

CIRL Formal Assessment Plan *(continued)*

6. Data will be distributed in Mag Lab Reports and in the Annual Report.

This table serves as CIRL's presentation of the evaluation.

REU 2012 Assessment Results

The current results from all REU (n=114 since 1999 with the 2012 participants added in) participants indicate the following results.

Participants were asked a number of questions regarding what they learned from their REU experience(s) (note: some participants chose more than one response) (n=114):

- 67.5% indicated that you have to have patience with research.
- 64.9% indicated that they had the ability to be a competent researcher.
- 43.9% indicated that they had what it takes to be a successful graduate student.
- 41.2% indicated that they would like to do similar research as a career.
- 36.0% indicated that they wanted to go for a PhD.
- 34.2% indicated that they liked research better than they expected that they would.
- 34.2% indicated that they learned better time management skills.
- 20.2% indicated that they wanted to go for a Masters.
- 13.2% indicated that they learned about a career that they never knew existed.
- 7.0% indicated that they did not have the patience for research.
- 4.4% indicated that research was not for them.

Former REU participants also were asked to evaluate their mentor and their overall experience; 86.8% of participants indicated that their primary mentor was above average or better (n=68), 92.1% of participants indicated that their participation in the Magnet Lab REU met or exceeded their expectations (n=68), and 95.6% indicated that they were moderately to very satisfied with their Magnet Lab REU experience (n=114).

CIRL has always conducted pre/post surveys, observations, and interviews with its summer camp participants. We are currently initiating an annual survey for Camp participants and RET participants that will be sent out each May and hope to achieve the same results as the REU tracker.

The assessment will be conducted on an annual basis to determine where each of the graduate students/postdocs are in their career trajectory and what role the MagLab had on said trajectories. CIRL already has postdocs/graduate students complete surveys to help tailor sessions.

Other CIRL Programs

The Middle School Mentorship program run by **Carlos Villa** is a partnership between the Magnet Lab and the School of Arts and Sciences. Since 2003, over 137 students have participated in this semester long internship where students are paired with scientists at the lab: 60% of these students are female and 10% are African American, Hispanic, or Native American. In 2012, eleven students and seven scientists from the lab participated.

Summer Programs

CIRL's summer programs include three middle school camps, two of which are funded (fully or partially) through partnerships. The ERC Renewable Energy Camp, run by **Brandon Nzekwe**, is a one-week camp for Title I middle school students that is the fully supported through FSU/NHMFL's partnership with the ERC-FREEDM grant. ERC also funds a 5-week Young Scholars program for high school students from Title I schools that is run through CIRL (also by **Brandon Nzekwe**). The SciGirls summer camps are two weeks and are supported partially through a partnership with WFSU (**Roxanne Hughes**). In 2012, the Magnet Lab Camp (**Carlos Villa**) was increased to two one-week camps allowing 36 students to attend (14 females, 5 Hispanic, 6 African American, 1 Native American, 9 from Title I schools). The SciGirls camps reached 32 middle and high school girls (10 African American, 1 Hispanic, 1 Native American, and 2 from Title I schools). The ERC FREEDM Renewable Energy Camp one-week middle school camp included 18 middle school students all from Title I schools (6 female, 8 African American). The 5-week ERC FREEDM Young Scholars program included 7 high school students, 6 of whom came from a Title I school (3 female, 5 African American, 1 Hispanic).

In 2012, CIRL, represented by **Jose Sanchez**, partnered with the Panhandle Area Educational Consortium (PAEC) to host and facilitate a nano-technology workshop for high school students. 36 high school students participated from three counties in Florida (Wakulla, Liberty, and Gadsden): 64% of these students came from Title I schools; 50% were female, of the 18, 10 were African American, 1 was Pacific Islander; of the 18 boys, 4 were African American, 1 Asian. Since 2006 our summer programs have reached over 350 students: 82% female; 24% African American, 6% Hispanic, and .6% Native American.

During the summer of 2012, CIRL ran the summer internship program at the lab. Eleven students (high school and college) and 10 scientists participated. The demographics for the students were 3 women (1 Asian American, 1 White, and 1 African American) and 9 men (2 Hispanic, 2 Asian, 1 African American, 1 not reported, 3 White). The MagLab scientists who participated were: **Afi Sachi Kocher, Greg Boebinger, Vincent Salters, Maitri Warusawithana, Yang Wang, Jianyi Jaing, Jingping Chen, Denis Markiewicz, Hyunok Park,** and **Andrzej Ozarowski**.

TABLE 4

2012 Research Experiences for Teachers *11 Participants*

RET Participant	School	Research Area	Mentor
Jeffrey Davis (LANL)	Turquoise Trail Charter School, Santa Fe, NM	Pulse Magnet Research	Ross McDonald
Mohamed Elgazzar	Celebration School, Celebration, FL	Molecular Beam Epitaxy Related to CRT (Cathode Ray Tube) Design	Maitri Warusawithana
Andrea Felix (LANL)	E.J. Martinez Elementary School, Santa Fe, NM	Pulse Magnet Research	Ross McDonald
Dana Fields	James Rickards High, Tallahassee, FL	Analysis of Martian Meteorites	Munir Humayun
Mark Hall	Northeast Middle School, Clarksville, TN	Determining Accuracy Using EBD (Electron Backscatter Diffraction)	Bob Goddard
Larry Hoffeditz	Port St. Lucie High, Port St. Lucie, FL	Molecular Beam Epitaxy Related to CRT (Cathode Ray Tube) Design	Maitri Warusawithana
Gwendolyn Jefferson	Wilmer Amina Carter High, Rialto, CA	Analysis of Martian Meteorites	Munir Humayun
Kim Perez	Chaires Elementary School, Tallahassee, FL	Density of Bi-2212 Filaments Using Image Analysis	Eric Hellstrom
Linda Pike	Jupiter Middle School of Technology, Jupiter, FL	Density of Bi-2212 Filaments Using Image Analysis	Eric Hellstrom
Marcelle Savoy	Pigeon Forge High, Pigeon Forge, TN	Ultrafast Imaging the Dynamics of Warm Dense Matter	Jim Cao
Faith Shiver	E.R. Jerger Elementary, Thomasville, GA	Determining Accuracy Using EBD (Electron Backscatter Diffraction)	Bob Goddard

K-12 Teacher Programs

Since 1998, CIRL has run an RET program for K-12 teachers. Over 225 teachers have participated reaching more than 1,000 K-12 students annually. Since 2001, 30% of these teachers have come from Title I schools. In 2012, eleven teachers participated in the RET program (7 female; 1 African American, five of whom came from Title I schools), mentored by six Magnet Lab scientists (**Table 4**).

In addition to RET, CIRL conducts teacher workshops for local schools and districts. In 2012 CIRL staff (**Jose Sanchez** and **Carlos Villa**) partnered with a local Florida school district (Wakulla) to conduct workshops with all of the science elementary school teachers in that district (50+ teachers). CIRL also created a monthly newsletter and an email list known as the MagLab Educators Club. The email newsletter highlights activities and opportunities for teachers at CIRL, the MagLab, and locally/nationally. There are currently more than 150 members. CIRL also maintains a presence on Twitter, Facebook, and the web for teachers.

Undergraduate and Beyond

The successful REU program is run by **Jose Sanchez.** The MagLab has run an REU program since 1999, and since that time, 274 students have participated (44% have been female (122); 10% come from HBCUs (28); 16% African American (42); 16% Hispanic (43); 2% Native American (6). In 2012, 153 students applied and 18 were accepted (**Table 5**). Seventeen scientists from all three sites worked with these REU participants.

TABLE 5

2012 Research Experiences for Undergraduates *18 Participants*

REU Participant	School	Research Area	Mentor
Arielle Adams	University of West Florida	Study of Magnetic Exchange Interaction in DTANQ Radical Dimers Using Electron Paramagnetic Resonance	Stephen Hill
Thomas Badman	Syracuse University	Modular Multichannel Measurement Apparatus for 100 T Pulsed Magnet and Critical Current Measurement	Charles Mielke
Daniel Braga	Florida State University	Metal-organic Frameworks for Magnetism and Multiferroic Behavior	Vivien Zapf
Keiko Cooley	Claflin University	Quantification of ^{13}C Labeled Compounds Within a Mixture of Natural Abundance and Labeled Compounds	Art Edison
Lorenzo Dumacas	The College of Wooster	Magnetic Field Distribution Calculation via Iterated Circular Current Loops	Andrey Gavrilin
Holly Fitzgibbon	Carnegie Mellon University	Quality Testing of Nb_3Sn Superconducting Strands in ITER Cables	Peter Lee
Rebecca Hallock	Florida State University	Femto-Second Laser Pump and Probe Technique and the Two-Temperature Model: Developing a Simulation of Electron-Phonon Heat Exchange	Jim Cao
Heath Hartley	Florida State University	Simulation of an 8 T Niobium-Titanium Superconducting Magnet	Denis Markiewicz
Marcus Jones	Morehouse College	Magneto-Optical Spectroscopy of Large Area Graphene: UV Investigation of Saddle-Point Excitons	Steve McGill
Vicktoria McDonald	Fort Valley State University	Live Cell Imaging of Fluorescent Proteins: An Advanced Tool for Cell Biology	Mike Davidson
Justin Mincey	Bethune-Cookman University	Analysis of F1F0-ATPase d-subunit using NMR	Art Edison
Jose Moreno-Quilmes	University of Puerto Rico - Mayaguez	*In-situ* Calorimetry Analysis of Mechanically Induced Self-sustaining Reactions for the Development of Pnictide Superconductors	Eric Hellstrom
Jessica Saintibert	Tallahassee Community College	Fluidity and Polarity of HIV Virion Mimic Membranes Defined by EPR Spin-labeling Methods	Likai Song
Juan Sanchez	Dartmouth College	A Simple, Efficient Method for Extraction of Water-Soluble Organics from Petroleum Characterized by Atmospheric Pressure Photoionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometry	David Podgorski
Lorena Sanchez	Florida State University	Organic Field Effect Transistor with Silk Dielectric Layer	Theo Siegrist
Kedrick Vaughans	University of Alabama	Removing Native Oxide from Silicon Substrate for Perovskite Oxide Crystal Growth	Maitri Wasusawithana
Jasmin Wilson	Tallahassee Community College	Where is the Missing Nb in the Earth?	Vincent Salters
Andrew Wray	Florida State University	Digital Image Correlation for Measurement of In-Plane Deformation with Vic-3D	Bob Walsh

CHAPTER 6

Diversity Program

The Magnet Lab has a goal to become a nationally recognized leader for its STEM diversity programs and the diversity of its scientific, technical and engineering staff, much the same way it is already recognized for its education and outreach programs. Since the adoption of the formal Diversity Action Plan (DAP) in 2004, the Magnet Lab has launched activities and efforts to increase the participation of underrepresented groups in science, engineering and mathematics.

The Diversity Action Plan, which is available online at http://magnet.fsu.edu/about/howwework/diversity/plan.html, was last updated in 2011. It includes lists of action items by which the Magnet Lab plans, implements, and assesses its Diversity activities. The DAP also appears in this document as **Appendix D** and as part of the Strategic Plan (**Appendix G**). In 2012, the Lab conducted the following activities that focused on five main areas.

Building diversity permanence into the NHMFL scientific population

- One or more members of the Magnet Lab Diversity Committee were included in some of the STEM-related search committees to increase awareness and knowledge of the diversity issues.

- Some positions were advertised in venues that target women and minorities, in particular in the Association for Women in Science and National Society of Black Physicists.

- In collaboration with "The Alliance for the Advancement of Florida's Academic Women in Chemistry and Engineering" (AAFAWCE), an NSF ADVANCE-PAID grant, the NHMFL Diversity Committee held two training sessions on "Faculty Recruitment for Excellence and Diversity" (FRED), one in March and another one in November, with a total of 24 faculty attending for the first time. The total number of NHMFL faculty who have attended FRED is 65. The November attendees included also two NHMFL female postdocs. The presenter was AAFAWCE-FSU PI Prof. Penny Gilmer. A FRED webpage has been created on the NHMFL diversity website. The FRED webpage (http://magnet.fsu.edu/about/howwework/diversity/fred.html) includes slides from the FRED presentation and a list of original research articles that are cited in FRED. Where available, links to the publications are provided. Summaries of all articles, prepared by the CIRL director, have been also posted.

- The Diversity Committee developed a Director's Letter to Search Committee Chairs, which includes guidelines for search committees based on best practices for increasing the recruitment of members of underrepresented groups.

- AAFAWCE organized six workshops on Mentoring and Networking for FSU women faculty in STEM fields, one approximately every couple of months. Two of the workshops were held at the Magnet Lab. On the average, three NHMFL female faculty participated in each workshop. The sixth workshop in a series consisted of FRED training in November. The Lab Director participated in two of the workshops as a mentor. The August workshop was also attended by six female NHMFL postdocs, as part of the collaborative initiative between CIRL and Diversity Program for postdoctoral mentoring.

- The Dependent Care Travel Grant Program (DCTGP) gave awards to two women and two men. DCTGP assists researchers with primary dependent care responsibilities to defray the additional cost of professional travel associated with dependent care.

Developing and cultivating individually crafted early career opportunities for members of underrepresented groups at the undergraduate level and above

- The NHMFL/UF continued to build a strong relationship with Claflin College, an HBCU in Orangeburg, SC. The relationship was initiated by a 2009 CO-WIN lecture. In 2012, Art Edison participated in two grant proposals from Claflin, hosted one African American undergraduate student from Claflin in his lab for summer research, invited two female scientists from Claflin to present their research in a workshop organized at UF, and sent samples to Claflin for analysis by the Claflin students.

- New partnerships were created with Bethune-Cookman University and Tallahassee Community College STEM Stars and STEM Initiative, resulting in three minority REU participants. In addition, a Native American student was accepted at LANL as a REU student. He had applied to the REU program as a direct result of CO-WIN recruiting at the 2011 meeting of the American Indian Science and Engineering Society.

- CIRL staff recruited students for REU and internships at the NOAA Education and Science Forum on FAMU campus, at which 4 HBCUs participated. Travel support was provided to one of the graduate students at the Lab to visit Morehouse in Atlanta, a traditionally African American College, for the Hopps Scholar Symposium in the interest of recruiting students. The student and CIRL staff passed out brochures for the REU as well as graduate programs at FSU/NHMFL. NHMFL REU program was also advertised at the Society for Advancing Chicanos and Native Americans in Science (SACNAS) conference in Seattle, and at the Florida Undergraduate Research Symposium.

- CIRL initiated rolling acceptance for the REU program to ensure diverse participants, resulting in 15 underrepresented out of 18 accepted students to the program. 8 students were female. Four of the participants came from HBCUs, and one was from a Hispanic Serving Institution. The Diversity Program provided funding for one REU student.
- Travel support was provided to a female graduate student to present her research results at a professional conference.
- The NHMFL created a "MagLab Fellowship", which provides $3,000/year for two years to a strong female or minority first-year graduate student in physics. In 2012, fellowships were awarded to two female incoming first-year graduate students in physics. These students were invited to, and attended, the first postdoctoral and graduate student mentoring session held at the Magnet Lab.
- The NHMFL Diversity Program provided partial support to staff scientists to enable the hiring of three postdoctoral researchers, four graduate students, and two undergraduate year-round researchers. All of these early career scientists were from underrepresented groups and none would have been able to be hired without the additional support.
- The NHMFL funds were provided to FAMU researchers for 25 hours of time on the FSU Chemistry Department NMR facility.
- Two female scientists were invited to give colloquia at LANL.
- A Lab tour was given to undergraduate students from FSU Women in Math, Science and Engineering (WIMSE).
- CIRL, in collaboration with FSU Physics Dept. and Tallahassee Community College, worked to write up a two-page pre-proposal for a NASA grant that would help undergraduate students persist in STEM fields.
- CIRL and Diversity Program representatives attended meetings with FSU Dean of the Graduate School to discuss a proposal for the Alliances for Graduate Education and the Professoriate (AGEP) grant.

Aiming educational outreach for K-12 and the general public to broad and diverse groups

- NHMFL scientists spoke at the Florida Youth Leadership Forum Mentors' Luncheon. The Able Trust sponsored this event that had nearly 100 young people in attendance, all with a disability. Ability First (an organization that supports students with disabilities) high school student was accepted for internship in summer 2012.
- During the summer of 2012, a total of 11 students participated in the high school internships run through CIRL: 3 Females (1 African American), 8 males (1 African American, 2 Hispanic). The NHMFL Diversity Program provided support to one female high school student for a year-round internship.
- Outreach was provided to Title I or underserved schools via College Reach-Out Program, 21st Century Learning Community After-School Program, Partners in Excellence Program, Grandparents as Parents Program, Family Fair Event (Florida Department of Education), science demonstrations, career and science fairs, Lab tours, and a contract with the Panhandle Area Educational Consortium (PAEC). E.g. CIRL hosted and facilitated the PAEC Nanotechnology workshop for high school students from June 11-14. Out of 36 students who participated, 64% came from Title I schools and 50% were female. Of the 18 boys, 4 were minority; of the 18 girls, 11 were minority.
- Outreach by LANL scientists included science demonstrations in a local, traditionally Native American elementary school, and in a high school that serves a large Hispanic and Native American community.
- CIRL submitted an Innovative Technology Experiences for Students and Teachers (ITEST) grant proposal to NSF that would create 16 summer camps and 12 after school programs for underrepresented students in middle schools across the Florida Panhandle (approximately 1000 students per year).
- SciGirls summer camp, a joint activity with WFSU, offered 9 full scholarships to scholarship requests (these ranged from single parent households, graduate students, and grandmothers raising children). Out of 9 female students receiving scholarships, 8 were minority. In this two-week-long summer camp for middle and high school girls, 32 girls participated (11 African American, 1 Hispanic and 1 Native American), and over 10 alumnae participated as camp counselors.
- The Magnet Lab Summer camps had 19 of 36 middle school students registered as underrepresented. Preference was given to applicants from Title I schools for summer camp acceptance.
- The School of Arts & Sciences middle school mentorship was held in the spring semester. Out of 11 students who participated, 7 were females.
- In ERC FREEDM Summer Camp, a joint program between the NHMFL, the Center for Advanced Power Systems (CAPS), and a broader consortium that includes NC State University, 18 middle school students attended. The demographics for the camp were: 8 African Americans; 6 Asian Americans; 6 females.
- In ERC FREEDM Young Scholars program for high school students from

title I schools, there were 7 students in attendance: 3 females and 4 males. (5 African Americans; 1 Hispanic; 1 Asian American).

- CIRL staff participated in the USA Science and Engineering Festival in Washington, DC, to encourage high school students to pursue STEM pathways, and in National Girls Collaborative Project Conference in Washington, D.C., to identify programs and initiatives for encouraging women and girls in science.

- The six-week RET program hosted 11 teachers, 2 of whom were placed at LANL. Seven of the participants were women, 1 participant was African American. Three of the teachers were from Title I schools. The estimated annual number of students reached by these teachers is 800.

- Four teachers participated in the ERC FREEDM RET program. Two out of 4 were from Title I schools. It is estimated that these teachers annually reach over 400 students.

- Spanish language translations of outreach materials for the website were completed. The materials include the first Spanish language translation of an educational activity book targeted for Elementary students, but available to the general public (http://www.magnet.fsu.edu/education/students/activities/activitybook.html).

- Science Café series was continued to translate science to the general public. New speakers were recruited to represent women in science and minorities in science.

- CIRL and Public Affairs directors met with representatives from CPALMS (an organization that is part of the Learning Systems Institute at FSU). They load lesson plans that include video interviews with experts and practitioners for Florida teachers that align with Florida state standards. This will allow the Magnet Lab scientists to reach a broader population including underrepresented minorities throughout the state of Florida.

- Public Affairs facilitated a blog on the NHMFL website for a female, Hispanic REU student and a blog for a female, African American RET participant.

- 100 T pulse attempt was covered live via Twitter, allowing for NSF and general public participation in real time. Joint effort with LANL netted more than 4 million media impressions and widespread coverage in youth-oriented online media. The CIRL director also joined Twitter, to increase the amount of science education news and updates that is sent to the NHMFL Twitter followers.

- Public Affairs secured wide media coverage for the NHMFL's Annual Open House, utilizing radio, network television news, Facebook, Twitter, local Head Start programs, schools, and African-American churches. Open House was attended by 4,796 visitors, with an estimated 15-18% minority attendance. 1,175 pounds of food were collected for Second Harvest, a charitable organization.

Maintaining awareness among NHMFL staff and user programs that Diversity Matters

- The Diversity Committee held regular, quarterly meetings. A SharePoint site ("Diversity Portal") was established for the Diversity Committee to facilitate meeting planning and information exchange.

- Three members of the Diversity Committee, including the Diversity Program and CIRL directors, attended the Workshop on Ethnic Diversity in Materials Science and Engineering in Arlington, VA.

- The annual meeting of the Diversity Advisory Committee was held in December.

- The NHMFL diversity website was kept up to date and expanded. Some current articles of interest were sent via email to the entire NHMFL mailing list.

- The NHMFL demographic statistics were maintained on a monthly basis. The national statistics for STEM fields were compiled by the CIRL director.

- A lab-wide meeting in April, led by the NHMFL director, covered the topic of Diversity in hiring, and how the Lab needs to amplify efforts not only to meet, but exceed, the national averages. A PowerPoint presentation was used to illustrate Diversity hiring trends of race and gender in the scientific fields across several decades. The need to overcome stereotypical and, possibly, discriminatory thinking in the hiring process was also raised. The FRED training sessions were again strongly encouraged for faculty and clearly stated as an upcoming requirement in the future for those on hiring committees.

- All actions were catalogued in a Diversity Tracker, which was updated on a regular (quarterly) basis. This report was discussed at the meetings of the NHMFL Executive Committee. The Mid-Year Diversity Report was also prepared.

Maintaining frequent external guidance and review of NHMFL diversity issues

- D. Popović, the NHMFL Diversity Program Director, gave a presentation on "Expanding Diversity Initiatives at FSU, LANL and UF" at the meeting of the NHMFL External Advisory Committee.

- D. Popović attended a series of meetings of the FSU President's Diversity and Inclusion Council, and of its Recruitment and Retention subcommittee, chaired by the FSU Provost. D. Popović completed four online Diversity Training courses, as required of all members of the Diversity and Inclusion Council. Following her suggestion, FSU created the new Diversity and Inclusion Council's BlackBoard site. This site will allow the council and subcommittees to access diversity and inclusion topics, facilitate collaboration, engage in communication with one another in a manner that will assist them with moving their initiative forward.

- Three newly elected members of the User Advisory Committee for the DC, Pulsed and High B/T Facilities include one female. Their terms start in January 2013. They will replace three (two male, one female) outgoing members.

CHAPTER 7

Industrial Partners & Collaborations

Magnet Lab researchers and staff develop partnerships and collaborations with the private sector, federal agencies, and institutions and international organizations, resulting in a wide variety of magnet-related technologies and advancing other projects that bring technologies closer to the marketplace. Engaging in such research and development activities is part of the National Science Foundation's charge to the Magnet Lab.

Magnets, Magnet Technologies and Materials for Magnets

Advanced Conductor Technologies, Boulder, CO

MagLab contact: Huub Weijers, MS&T

The Applied Superconductivity Center and the Magnet Science and Technology division of the Magnet Lab are collaborating with Advanced Conductor Technologies on the development and testing of Coated Conductor Stranded Cable (CCSC), using multi-layer 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 resulted in the first measurements ever of HTS cables at low temperature and high magnetic field (4 K and 20 T in Cell 4).

Advanced Magnet Lab, Inc., Palm Bay, FL

MagLab contact: Tom Painter, MS&T

Engineers from the NHMFL are collaborating with Advanced Magnet Lab, Inc. to produce the innovative field-correction shims required to decrease spatial and temporal field disturbances in the Series-Connected Hybrid (SCH). Advanced Magnet Lab has provided the precision fabrication processes required to produce these innovative shims for the first-of-a-kind SCH magnet system that will produce 1 ppm field homogeneity at 36 T.

Danfoss Turbocor Inc., Tallahassee, FL

MagLab contact: Ke Han, MS&T

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 started a joint research project on selection, characterization, and development of permanent magnet materials for high performance and environmentally friendly compressors.

Faculty of Material Science and Engineering, Kunming University of Science and Technology, China

Magnet Lab contact: Ke Han, MS&T

The collaboration between the Kunming University and the Magnet Lab is related to the magnetic field impact on phase transformation in steels. A professor from Kunming University was in the Maglab as a visiting scientist for one year to do the research. The collaboration is a continuous effort.

Helmholtz Zentrum Berlin, Berlin, Germany

MagLab contact: Mark D. Bird, MS&T

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 present record field for such a configuration is 17 T. Five external design reviews have been held with an international committee of reviewers. Fabrication of the magnet is underway: The superconducting strand has been delivered and cabled and jacketed, the cryostat has been fabricated, winding of the superconducting coil is complete, joints have been fabricated, reaction of the coil to form the superconductor is complete, impregnation of the CICC coil is underway, design of the resistive insert coils is complete and fabrication of them is starting. In the summer of 2013 the cold-mass should ship to Italy where the cryostat will be assembled around it prior to transport to Berlin.

High Performance Magnetics (HPM), Tallahassee, FL

MagLab contact: Bob Walsh, MS&T

This start-up company is a spin-off from the Magnet Lab's Magnet Science & Technology Division and is involved in the USDOE ITER program. The Cable-in-Conduit-Conductor (CICC) technology, used successfully in the NHMFL High Field DC Hybrid magnets, is being advanced at HPM with the development of a state-of-the-art CICC jacketing production line. The jacketing process requires advance weld techniques that alter critical mechanical properties of the conduit. HPM has contracted with the Magnet Lab to additionally process the welds and to perform 4 K qualification tests.

Industrial Research Limited, Lower Hutt, New Zealand

MagLab contact: Huub Weijers, MS&T

The Applied Superconductivity Center and the Magnet Science and Technology division of the Magnet Lab 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.

Institute of Metal Research, Chinese Academy of Sciences, Shenyang, China

MagLab contact: Ke Han, MS&T

The collaboration between the Institute of Metal Research and the Magnet Lab is related to the characterization of stainless steels and other structural materials for high field magnets. The materials are mainly stainless steel 316LN and maraging steels with high mechanical strength.

International Thermonuclear Experimental Reactor (ITER), US-ITER Project Office, Oak Ridge, TN

MagLab contact: Bob Walsh, MS&T

The United States is part of an international collaboration to construct and operate ITER, a full-scale experimental device designed to demonstrate the feasibility of the production of fusion energy. The Magnet Lab's Magnet Science and Technology division is assisting in the research and development of large superconducting magnets and components for the enormous Fusion Reactor Tokamak. Engineers in MS&T are collaborating on magnet design topics such as stress analysis, component tests, and materials characterization.

Key Laboratory of Electromagnetic Processing of Materials, Northeastern University, Shenyang, China

MagLab contact: Ke Han, MS&T

The collaboration between the Northeastern University and the Magnet Lab is related to the magnetic field impact on fabrication of high strength conductors. A professor from Northeastern University was in the Maglab as a visiting scientist for one year to do the research. The collaboration is a continuous effort and another professor will be in the Maglab in 2013. A MagLab scientist will visit Northeastern University.

Lawrence Berkeley Laboratory, Accelerator and Fusion Research, Berkeley, CA

MagLab contact: Huub Weijers, MS&T

The Applied Superconductivity Center and the Magnet Science and Technology division of the Magnet Lab 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.

University of Science and Technology Beijing, Department of Materials Science and Engineering, Beijing, China

MagLab contact: Ke Han, MS&T

The collaboration between the University of Science and Technology Beijing and the Magnet Lab is related to the thermodynamic calculations of the multi-elements and multiphase systems. Currently, efforts are focused on understanding interstitial elements impact on the precipitation in steels for high field magnets.

Ion Cyclotron Resonance

Pfizer, Andover, MA

MagLab Contact: Alan Marshall, ICR

This collaboration is with Jason C. Rouse, who directs mass spectrometry research and development at Pfizer Andover. Current research focuses on identifying and locating the sites of post translational chemical modifications of antibodies by top-down proteomics (i.e., direct analysis of intact gas-phase antibody molecules).

Scripps Research Institute

MagLab Contact: Nicolas Young, ICR

Current collaborations include principal investigators at Scripps La Jolla (Paul Schimmel, Xiang-Lei Yang) and Scripps Florida (Ming Guo). The common thread is 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.

Sierra Analytics, Modesto, CA

MagLab contact: Greg Blakney, ICR

The lab's ICR research team maintains a licensing agreement with Sierra, a company that provides mass spectrometry software to petroleum companies. The software contains high level algorithms for identification of thousands of compounds in petroleum mass spectra, obtained through the lab's pioneering Fourier transform ICR technique development. Lab researchers and Sierra Analytics continue to share updated information, enabling both to stay atop the petroleomics field.

University of Texas Medical Branch at Galveston

MagLab Contact: Nicolas Young, ICR

The ICR Program collaborates with Professors 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 is matrix-assisted laser desorption/ionization mass spectral imaging and FT-ICR mapping of lipid alterations in spinal cord injury.

Woods Hole Oceanographic Institute, Woods Hole, MA

MagLab Contact: Ryan Rodgers, ICR

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/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.

Nuclear Magnetic Resonance

Agilent Technologies, Life Sciences/ Chemical Analysis Division, Santa Clara, CA
MagLab contacts: William Brey, NMR and Art Edison, AMRIS

Investigators from Magnet Lab facilities at UF and FSU collaborate with technical staff at Agilent on an NIH-funded project to develop improved superconductive cryogenic probes for solution NMR.

Bruker Biospin Corp., Billerica, MA
MagLab contact: Peter Gor'kov, NMR

The Magnet Lab'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.

Revolution NMR, LLC, Fort Collins, CO
MagLab contact: Peter Gor'kov, NMR

Revolution NMR has licensed from FSU the Low-E probe technology developed at the Magnet Lab in order to fabricate static NMR probes for biological (protein) samples. Additionally, the Magnet Lab's NMR instrumentation program and Revolution NMR collaborate on the development of stators for magic angle spinning NMR.

Université des Sciences et Technologies de Lille, Lille, France
MagLab contact: Peter Gor'kov, NMR

The Magnet Lab completed a contract to develop a specialized RF probe for solid-state MAS NMR of low-gamma nuclei. The instrument has sensitivity exceeding those of commercial probes and is used by the research group of Professor Jean-Paul Amoureux.

Education

CPALMS – Collaborate, Plan, Align, Learn, Motivate, and Share
MagLab Contact: Roxanne Hughes, Educational Programs

CPALMS is part of the Florida Center for Research in STEM and is the state of Florida's platform for educators to Collaborate, Plan, Align, Learn, Motivate, and Share through online lesson plans and activities. The Center for Integrating Research & Learning (CIRL) has partnered with CPALMS to facilitate scientist interviews as part of their video accessories for lessons. Carlos Villa also works closely with CPALMS to discuss the role of informal STEM outreach.

Columbia University RET Program
MagLab contact: Jose Sanchez, Educational Programs

The Center for Integrating Research & Learning continues its collaboration with other institutions that conduct educational outreach with teachers. Through the Research Experiences for Teachers (RET) Network, the Center maintains a national presence among other laboratories, centers, and universities that conduct RET and other teacher enhancement programs. Current projects include participating in a research project with Columbia University that will compare various RET programs from across the country.

Community Classroom Consortium, Tallahassee, FL
MagLab Contacts: Roxanne Hughes, Educational Programs or Kristen Coyne, Public Affairs

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.

Florida Afterschool Network, Tallahassee, FL
MagLab Contact: Roxanne Hughes, Educational Programs

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-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.

Florida State University, College of Education, Tallahassee, FL
MagLab Contact: Roxanne Hughes, Educational Programs

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.

Future Physicists of Florida
MagLab Contact: Roxanne Hughes, Educational Programs

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.

North Carolina State University, Raleigh, NC
MagLab Contact: Roxanne Hughes, Educational Programs

In partnership with the Center for Advanced Power Systems and the FAMU-FSU College of Engineering, the Center for Integrating Research & Learning supports ERC FREEDM educational and assessment activities. Working with The Science House and the ERC FREEDM Center at North Carolina State University, CIRL facilitates the pre-college education program through summer camps, Young Scholars high school internship programs, and Research Experiences for Teachers. In addition, one full-time graduate student coordinates assessment at all locations participating in the FREEDM grant.

Panhandle Area Educational Consortium (PAEC)
MagLab Contact: Roxanne Hughes, Educational Programs

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.

Thomas University, Thomasville, GA
MagLab Contact: Roxanne Hughes, Educational Programs

CIRL has worked closely with faculty from Thomas University – a small university in Thomasville, GA – to help them develop a Science Café and a summer camp similar to our SciGirls summer camp. We initially helped plan their Science Cafés, now they have a faculty member who does this. In the summer of 2012, three teachers from Thomas County worked closely with our SciGirls program to observe and eventually create their own camp.

WFSU-TV, Tallahassee, FL
MagLab contact: Roxanne Hughes, Educational Programs

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 Magnet Lab 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.

Optical Microscopy

89 North, Burlington, VT
MagLab contact: Mike Davidson, Optical Microscopy

Scientists at the Magnet Lab 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.

Agilent Technologies, Santa Clara, CA
MagLab contact: Mike Davidson, Optical Microscopy

Agilent Technologies is entering the imaging arena with a new "Monolithic" laser combiner featuring acousto-optic-tunable filter (AOTF) control. The Magnet Lab is collaborating with Agilent to prototype the laser system for use in super-resolution imaging.

Allele Biotech, San Diego, CA
MagLab contact: Mike Davidson, Optical Microscopy

Allele is a manufacturer and distributor of fluorescent protein constructs made by Robert Campbell and Nathan Shaner. The Magnet Lab is collaborating with Allele to develop fusion vectors of selected fluorescent proteins.

Andor-Tech, Belfast, Ireland
MagLab contact: Mike Davidson, Optical Microscopy

Andor-Tech is an imaging specialist involved with development of CCD camera systems designed to produce images at extremely low light levels. The Magnet Lab 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.

B&B Microscopes, Pittsburgh, PA
MagLab contact: Mike Davidson, Optical Microscopy

Scientists in the Optical Microscopy facility at the Magnet Lab 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.

Bioptechs, Butler, PA
MagLab contact: Mike Davidson, Optical Microscopy

The Magnet Lab 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.

Chroma, Rockingham, VT
MagLab contact: Mike Davidson, Optical Microscopy

A major supplier of Interference filters for fluorescence microscopy and spectroscopy applications, Chroma is collaborating with the Magnet Lab to build educational tutorials targeted at fluorescence microscopy. Working in conjunction with Nikon, engineers from Chroma and scientists from the Magnet Lab are examining the characteristics of a variety of filter combinations.

The Cooke Corp., Romulus, MI
MagLab contact: Mike Davidson, Optical Microscopy

Scientists at the Magnet Lab 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.

CoolLed Ltd., Andover, Hampshire, United Kingdom
MagLab contact: Mike Davidson, Optical Microscopy

Scientists at the Magnet Lab 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.

Covance Research Products, Berkeley, CA
MagLab contact: Mike Davidson, Optical Microscopy

Covance is a biopharmaceutical company involved with research and diagnostic antibody production. Magnet Lab 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.

Diagnostic Instruments, Sterling Heights, MI
MagLab contact: Mike Davidson, Optical Microscopy

Scientists at the Magnet Lab 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.

Evrogen, Moscow, Russia
MagLab contact: Mike Davidson, Optical Microscopy

Evrogen is a manufacturer and distributor of fluorescent protein constructs made by Dmitriy Chudakov and Vladislav Verkhusha. The Magnet Lab is collaborating with Evrogen to develop fusion vectors of selected fluorescent proteins.

EXFO, Mississauga, Ontario, Canada
MagLab contact: Mike Davidson, Optical Microscopy

The Magnet Lab 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.

Hamamatsu Photonics, Bridgewater, NJ
MagLab contact: Mike Davidson, Optical Microscopy

Scientists at the Magnet Lab 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.

Linkam, Surrey, United Kingdom
MagLab contact: Mike Davidson, Optical Microscopy

Scientists at the Magnet Lab 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.

Lumencor Inc., Beaverton, OR
MagLab contact: Mike Davidson, Optical Microscopy

The Magnet Lab is collaborating with Lumencor 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.

MBL International, Woburn, MA
MagLab contact: Mike Davidson, Optical Microscopy

Scientists at the Magnet Lab 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.

Media Cybernetics, Silver Spring, MD
MagLab contact: Mike Davidson, Optical Microscopy

Programmers at the Magnet Lab 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.

Molecular Probes/Invitrogen, Eugene, OR
MagLab contact: Mike Davidson, Optical Microscopy

A major supplier of fluorophores for confocal and wide-field microscopy, Molecular Probes is collaborating with the Magnet Lab to develop educational tutorials on the use of fluorescent probes in optical microscopy.

Nikon USA, Melville, NY
MagLab contact: Mike Davidson, Optical Microscopy

The Magnet Lab 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 Magnet Lab is field-testing new Nikon equipment and developing new methods of fluorescence microscopy.

Olympus America, Melville, NY
MagLab contact: Mike Davidson, Optical Microscopy

The Magnet Lab 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 Magnet Lab in Tallahassee. This activity will involve biologists at the Magnet Lab and will feature Total Internal Reflection Fluorescence microscopy.

Olympus Corp., Tokyo, Japan
MagLab contact: Mike Davidson, Optical Microscopy

Investigators at the Magnet Lab 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.

Omega Optical, Brattleboro, VT
MagLab contact: Mike Davidson, Optical Microscopy

The Magnet Lab is involved in a collaboration with Omega to develop interactive tutorials targeted at education in fluorescence filter combinations for optical microscopy. Engineers at Omega work with Magnet Lab microscopists to write review articles about interference filter fabrication and the interrelationships between various filter characteristics and fluorophore excitation and emission.

Photometrics (Roper Scientific Inc.), Tucson, AZ
MagLab contact: Mike Davidson, Optical Microscopy

The microscopy research team at the Magnet Lab 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.

Prior Scientific Inc., Rockland, MA
MagLab contact: Mike Davidson, Optical Microscopy

Prior is a major manufacturer of illumination sources and filter wheels for fluorescence microscopy. The Magnet Lab team is collaborating with Prior to develop new illumination sources and mechanical stages for all forms of microscopy.

Qimaging, Burnaby, British Columbia, Canada
MagLab contact: Mike Davidson, Optical Microscopy

High-resolution optical imaging is the focus of the Magnet Lab 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.

Semrock, Rochester, NY
MagLab contact: Mike Davidson, Optical Microscopy

The Magnet Lab 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 Magnet Lab microscopists to write review articles about interference filter fabrication and the interrelationships between various filter characteristics and fluorophore excitation and emission. In addition, Magnet Lab scientists produce images of living cells with Semrock filter combinations.

Sutter Instrument, Novato, CA
MagLab contact: Mike Davidson, Optical Microscopy

The Magnet Lab 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.

Zeiss Micro Imaging, Thornwood, NY
MagLab contact: Mike Davidson, Optical Microscopy

The Optical Microscopy group at the Magnet Lab 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.

CHAPTER 8

Conferences and Workshops

Theory Winter School
January 9-13, 2012 · Tallahassee, FL

The MagLab held its first Theory Winter School this year, with lectures focusing on Computational Approaches for Electronic/Magnetic Materials, a subject of great relevance for the budding Materials Synthesis and Characterization Program, currently under rapid development at the Magnet Lab.

Ten leading experts in this active and exciting area of research presented two tutorial lectures each during this five-day program. These lectures covered a comprehensive overview of the most advanced computational and theoretical strategies, stressing pros and cons of each method, and explaining its advantages and limitations for a given family of materials and compounds. In addition, each afternoon a breakout session offered junior participants the opportunity for hands-on experience with select computational tools, and also for direct exchange of ideas with lecturers and each other.

Magnetostructural Correlations Workshop
April 23-26, 2012 · Tallahassee, FL

The workshop focused on the magnetic properties of materials and how these properties are affected by chemical structure. This multidisciplinary workshop brought together materials, physics, and chemistry researchers in a talk and discussion format designed to broaden their understanding of the spectroscopic techniques and approaches to problem solving. The program mainly featured talks presented by graduate students and postdocs.

User Summer School
May 14-18, 2012 · Tallahassee, FL

The fourth annual User Summer School once again introduced early-career users and potential users to the MagLab's infrastructure, experimental options, and support staff. User Summer School focuses on helping attendees develop skills useful in both the home laboratory and in user facilities worldwide. MagLab User Summer School is designed to provide a "technique toolkit " for early career scientists that includes: noise types and theory, noise suppression techniques, transport techniques, magnetometry, heat capacity measurements, magneto-optics, infrared and terahertz spectroscopy, ultrasound spectroscopy, high-pressure methods, NMR techniques for chemistry, biology and condensed matter, electron paramagnetic resonance, cryogenic techniques, measurements at ultra-low temperatures, and the nuts and bolts of data acquisition.

UF Metabolomics Workshop
June 4-7, 2012 · Gainesville, FL

Sponsored by the UF Clinical and Translational Science Institute (CTSI) and the MagLab, the 2012 UF Metabolomics Workshop was held at the UF Health Science Center in Gainesville, Florida. The four-day workshop covered basic intro to nuclear magnetic resonance (NMR), mass spectrometry (MS) and statistical analysis, MatLab workshop by Mathworks and a demonstration of using Matlab for metabolomics. In addition, there were special sessions on dynamic nuclear polarization (DNP) for in-cell and animal metabolomics using NMR, advanced MS methods of imaging and isotopic ratio outlier analysis (IROA) for global analysis, tours/workshops of NMR and MS facili-

ties, as well as a Matlab demonstration and hands-on teaching lab, and a mini-symposium of metabolomics seminars that demonstrated applications of many of the techniques covered in the workshop.

13th International Conference on Petrophase Behavior and Fouling
June 10-14, 2012 • St. Petersburg Beach, FL

The 13th International Conference on Petroleum Phase Behavior and Fouling was organized jointly by Nalco Energy Services and the MagLab. The venue for the conference was the Loews Don CeSar Hotel, member of the National Register of Historic Hotels of America. The conference included oral presentations and poster sessions. An exhibition of scientific equipment was held during the conference. Presentations ranged from Heavy Oils and Extra Heavy Oils, Asphaltenes and Petroleum Macromolecules, Naphthenates and Naphthenic Acids, Sulfur Speciation, Wax Thermodynamics and Deposition, Physics and Chemistry of Petroleum-Water Emulsions, Mechanisms and Mitigation of Fouling in Production and Refining.

ICMM: The 13th Annual Conference on Molecule-based Magnets
October 7-11, 2012 • Orlando, FL

The International Conference on Molecule-based Magnets (ICMM) is the largest international conference on the research field of "Molecular Magnetism". This meeting focused on the magnetism of molecules and molecular-based materials, i.e. the design, synthesis, and evaluation of artificial spin systems composed of organic radicals, transition metal complexes, and composite materials. This "field" of research has grown tremendously over the past two decades and is an enormously interdisciplinary endeavor. In keeping with tradition, this meeting covered a diverse range of topics including (but not limited to): synthesis of magnetic molecules and materials; magnetic properties of organic radicals, coordination complexes, metal-radical systems; nanomagnetism; multi-property magnetic materials; and theoretical approaches.

Energy@MagLab Workshop
November 7-8, 2012 • Tallahassee, FL

This workshop was concentrated on the overlap between MagLab facilities and the world's research needs in energy. The two-day workshop featured plenary talks covering leading energy frontier research. Poster sessions featured high-magnetic-field research techniques that address energy research needs. In recognition of the growing portfolio of energy-related user research at the MagLab, one of the four major science drivers in the MagLab's vibrant, interdisciplinary User Program is Energy and Environment. The Energy@MagLab workshop was designed to build awareness and increase the effectiveness of high-magnetic-field research to address energy frontier research needs for petroleum production, catalysts, batteries, and fuel cells. The workshop featured talks by energy researchers from universities, national laboratories, and the private sector. Poster sessions focused on presenting high-magnetic-field research techniques relevant to energy research.

CHAPTER 9

Products of MagLab Users & Faculty

The laboratory continued its strong record of publishing, with 368 articles appearing in peer-reviewed scientific and engineering journals in 2012. The full listing, along with citations for over 325 presentations, is available on the Magnet Lab's Web site: http://www.magnet.fsu.edu/search/publications/search.aspx.

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, and the Center for Integrating Research & Learning. 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.

Journal names appearing in red and bold are deemed by the laboratory as significant journals. Of the 368 publications, 228 (62%) 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.

DC Field Facility Publications (81)

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Internet Disseminations (3)

Schepkin, V.D.; Calixto-Bejarano, F.; Gor'kov, P.L.; Brey, W.W.; Morgan, T.; Ozambela, M.; Gower-Winter, S. and Levenson, C.W., *Tumor resistance and in vivo sodium MR imaging at 21.1 T*, http://www.magnet.fsu.edu/mediacenter/publications/reports/mlr/2012/mlr192_web.pdf, (2012)

Schepkin, V.D.; Elumalai, M.; Kitchen, J.A.; Gor'kov, P.L. and Brey, W.W., *In vivo chlorine magnetic resonance imaging of rat brain at 21.1 T*, http://www.magnet.fsu.edu/mediacenter/publications/reports/mlr/2012/mlr_191_web.pdf, (2012)

Yakunin, M.V.; Suslov, A.V.; Podgornykh, S.M.; Dvoretsky, S.A. and Mikhailov N.N., *Effects of Spin Polarization in the HgTe Quantum Well*, http://arxiv.org/abs/1211.4983, (2012)

Patents & Other Products (3)

Chen, J.; Han, K.; Kalu, P. and Markiewicz, W., *"Patent: Aluminum Oxide Particle Strengthened Niobium-Tin Superconducting Composite Wire"*, U.S. Patent No. 8,176,620, dated May 15, 2012 (2012)

Marshall, A.G.; Juyal, P. and Rodgers, R., *"Patent: Electrospray Ionization Mass Spectrometry Methodology"*, U.S. Patent No. 8,110,797, dated 2/7/2012 (2012)

Singleton, J.; Ardavan, H. and Ardavan, A., *"Apparatus and method for phase fronts based on superluminal polarization current"*, U.S. 2012-02-28 Patent: 8,125,385 (2012)

Awards, Honors & Services (26)

Alamo, R. (Rufina), American Physical Society Fellow (2012)

Balicas, L. (Luis), American Physical Society Fellow (2012)

Cao, J. (Jianming), FSU Council on Research and Creativity Planning Grant (2012)

Chen, P. (Peng), 1st Place Poster Award, Applied Superconductivity Conference (2012)

Dalal, N.S. (Naresh), 2012-2013 Robert O. Lawton Distinguished Professor, Florida State University (2012)

Das, N. (Nabanita), International Society of Neurochemistry Fellowship (2012)

Das, N. (Nabanita), Sigma Aldrich Student Sponsorship Award (2012)

Edison, A.S. (Arthur), 2012-2015 University of Florida Research Foundation Professorship (2012-2015)

Engel, L. (Lloyd), Distinguished University Scholar, Florida State University (2012)

Hannahs, S.T. (Scott), Distinguished University Scholar, Florida State University (2012)

Hughes, R. (Roxanne), Recognition of Merit (Top 5 Finalist) for the PDK International Outstanding Doctoral Dissertation Award (2012)

Knappenberger, K.L. Jr. (Kenneth), NSF Career Award (2012)

Kynoch, J. (John), Prudential-Davis Productivity Award, Florida State University (2012)

Kynoch, J.; Marks, E. and Bole, S., Prudential-Davis Productivity Award (2012)

Lee, P. (Peter), Elected Senior Member IEEE (2012-present)

Marshall, A. (Alan), 2012 American Chemical Society New York Section William H. Nichols Medal (2012)

Marshall, A. (Alan), 2012 Association of Biomolecular Resource Facilities Award (2012)

Marshall, A. (Alan), 2012 Society of Analytical Chemists of Pittsburgh Analytical Chemistry Award (2012)

Matras, M. (Maxime), 1st Place Poster Award, Applied Superconductivity Conference (2012)

Miao, Y., Student Travel Award to attend the Joint 2012 Southeastern Magnetic Resonance Conference/SERMACS Symposia (2012)

Popovic, D. (Dragana), American Physical Society Fellow (2012)

Pucci, J. (John), Review Panel Member, Argonne SPX Cryogenic Plant Specification Review (2012)

Singleton, J.; Schmidt, A.C.; Dye, R.C. and Marksteiner, Q., Federal Laboratories Consortium Mid-Central Regional Award for Excellence in Technology (2012)

Tremaine, D.M., Student Travel Grant - VM Goldschmidt Conference (2012-present)

Weiss, J. (Jeremy), 1st Place Poster Award, Applied Superconductivity Conference (2012)

Zhu, L. (Lei), FSU Council on Research and Creativity Planning Grant (2012)

Ph.D. Dissertations (25)

Twenty-five (25) Ph.Ds were reported for 2012: 15 were awarded to users / students at FSU or UF; 10 were awarded to users at other academic institutions.

Ph.Ds. awarded to users/students at FSU or UF (15):

Besara, T. (Tiglet), *"NMR Near Ferroelectric, Magnetic and Quantum Phase Transitions"*, Florida State University, Chemistry, advisors: Dalal, N.S. (Naresh) and Reyes, A.P. (Arneil) (2012)

Bewernitz, M.A., *"A Liquid Condensed Phase (LCP) of Calcium Carbonate and its Relevance to the Polymer-Induced Liquid-Precursor (PILP) Process: Fundamentals and Applications"*, University of Florida, Engineering, advisor: Gower, L. (Laurie) (2012)

Carter, J.D. (Jeffrey David), *"Characterization of the Mobile Loops in GM2 Activator Protein and the Flap Region of HIV-1 Protease via Electron Paramagnetic Resonance Spectroscopy"*, University of Florida, Chemistry, advisor: Fanucci, G.E. (Gail) (2012)

Chandra, S., *"Detection and Characterization of Retinal Disruption in Mice using High Angular Resolution Diffusion Microscopy (HARDM)"*, University of Florida, Biochemistry, advisor: Blackband, S.J. (2012)

Cormier, A.R. (Ashley), *"Solid State NMR Structural Analysis of the RADA16-I Designer Self-Assembling Peptide"*, Florida State University, Chemical and Biomedical Engineering, advisor: Paravastu, A.K. (Anant) (2012)

de Vera, I. (Ian), *"Insights into the Mechanisms of HIV-1 Protease Drug Resistance from Pulsed Electron Paramagnetic Resonance and Nuclear Magnetic Resonance Spectroscopy"*, University of Florida, Chemistry, advisor: Fanucci, G.E. (Gail) (2012)

Dunk, P.W. (Paul), *"Growth and Formation of Nanocarbon: Fullerenes, Metallofullerenes, and Heterofullerenes"*, Florida State University, Chemistry and Biochemistry, advisor: Kroto, H.W. (Harold) (2012)

Green, E. (Elizabeth), *"Magnetic Field Dependent Properties of the Spin-Peiels chain in the Organic Conductore Per2Pt[mnt]2"*, Florida State University, Physics, advisors: Brooks, J.S. (James) and Reyes, A.P. (Arneil) (2012)

Heon-Lee, C., *"Exploration of Magnetic Resonance Microscopy: From Cellular Structures to Subcellular Structures"*, University of Florida, Biochemistry, advisor: Blackband, S.J. (2012)

Hwang, J., *"Magnetoelectric and Multiferroic Properties in Layered 3D Transition Metal Oxides"*, Florida State University, Physics, advisor: Choi, E.S. (2012)

Kim, Y. (Younghee), *"Magneto-Raman Spectroscopy of Graphene and Graphite: Probing electronic structure and electron-phonon interaction"*, Florida State University, Physics, advisor: Smirnov, D. (Dmitry) (2012)

Nzekwe, B. (Brandon), *"Occupational Role-identity Salience and Science Career Attitudes: A comparison of undergraduate science majors participating in research programs"*, Florida State University, Educational Psychology and Learning Systems, advisor: Losh, S.C. (Susan Carol) (2012)

Shi, X. (Xiaoyan), *"Magnetotransport Properties in Underdoped High Tc Superconductors"*, Florida State University, Physics, advisor: Popovic, D. (Dragana) (2012)

Xian, F. (Feng), *"Broadband Phase Correction of Fourier Transform Ion Cyclotron Resonance Mass Spectra"*, Florida State University, Chemistry & Biochemistry, advisor: Marshall, A.G. (Alan) (2012)

Ye, W., *"Efficient Sampling Geometries for Diffusion Propagator Reconstruction"*, University of Florida, Biochemistry, advisor: Blackband, S.J. (2012)

Ph.Ds awarded by other academic institutions to external users/students (10):

Arevalo-Hidalgo, A.G., *"Silicoaluminophosphate Nanoporous Materials for Carbon Dioxide Adsorption at Low Concentration"*, University of Puerto Rico - Mayaguez, Chemical Engineering, advisor: Hernandez-Maldonado, A.J. (Arturo) (2012)

Brinzari, T.V., *"Electron-phonon and magneto-elastic coupling in molecule-based materials"*, University of Tennessee, Chemistry, advisor: Musfeldt, J.L. (Janice) (2012)

Choi, A., *"Magneto Resistance of One-Dimensional Polymer Nanofibers"*, Seoul National University, Physics and Astronomy, advisor: Park, Y.W. (Yung Woo) (2012)

Ji, Y. (Yu), *"NMR Studies of Quantum Gases Confined in Mesoporous Materials"*, University of Florda, Physics, advisor: Sullivan, N.S. (2012)

Knez, I. (Ivan), *"Transport Properties of Topological Phases in Broken Gap InAs/GaSb Based Quantum Wells"*, Rice University, Physics and Astronomy, advisor: Du, R.R. (Rui-Rui) (2012)

Lima, M.A., *"Heparins and their Derivatives: Quality Control and Relation Between Structure and Function"*, Federal University of Sao Paulo, Biochemistry, advisor: Nader, H.B. (Helena Bonciani) (2012)

Liu, M. (Minhou), *"Transport Study on MBE-Grown Topological Insulator Thin Films"*, Tsinghua University, Physics, advisor: Wang, Y. (Yayu) (2012)

Sun, Q.-C., *"Charge, Bonding, and Spin-phonon Coupling in Nanomaterials"*, University of Tenenssee, Chemistry, advisor: Musfeldt, J. L. (Janice) (2012)

Susner, M. (Michael), *"Influences of Crystalline Anisotropy, Doping, Porosity, and Connectivity on the Critical Current Densities of Superconducting Magnesium Diboride Bulks, Wires, and Thin Films"*, The Ohio State University, Materials Science, advisor: Sumption, M.D. (Mike) (2012)

Velasco Jr., J. (Jairo), *"3>2 >1: Investigation of Single Particle and Many Body Physics in Dual-Gated 1,2,3 Layers of Graphene"*, University of California, Riverside, Physics, advisor: Lau, C.N. (Chun Ning (Jeanie)) (2012)

Master Theses (3)

Ayaka, H. (Higashiguchi), *"Low-Temperature Physical Properties of Genuine Organic Triangular Spin Antiferromagnets"*, Osaka Prefecture University, Physical Science, advisor: Hosokoshi, Y. (Yuko) (2012)

Schmidt-Zweifel, A.C. (Andrea), *"Terrestrial and Extraterrestrial Radiation Sources That Move Faster Than Light"*, University of New Mexico, Mathematics, advisors: Singleton, J. (John) and Embid, P. (Pedro) (2012)

Walsh, J.K, *"Cellular Responses to Osmotic Perturbation: A High-Field ^{1}H and ^{23}Na Magnetic Resonance Microscopy Study"*, Florida State University, Chemical & Biomedical Engineering, advisor: Grant, S.C. (2012)

CHAPTER 10

Management & Administration

The Florida State University, the University of Florida and Los Alamos National Laboratory (with user programs at each location) jointly operate the National High Magnetic Field Laboratory for the National Science Foundation 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.

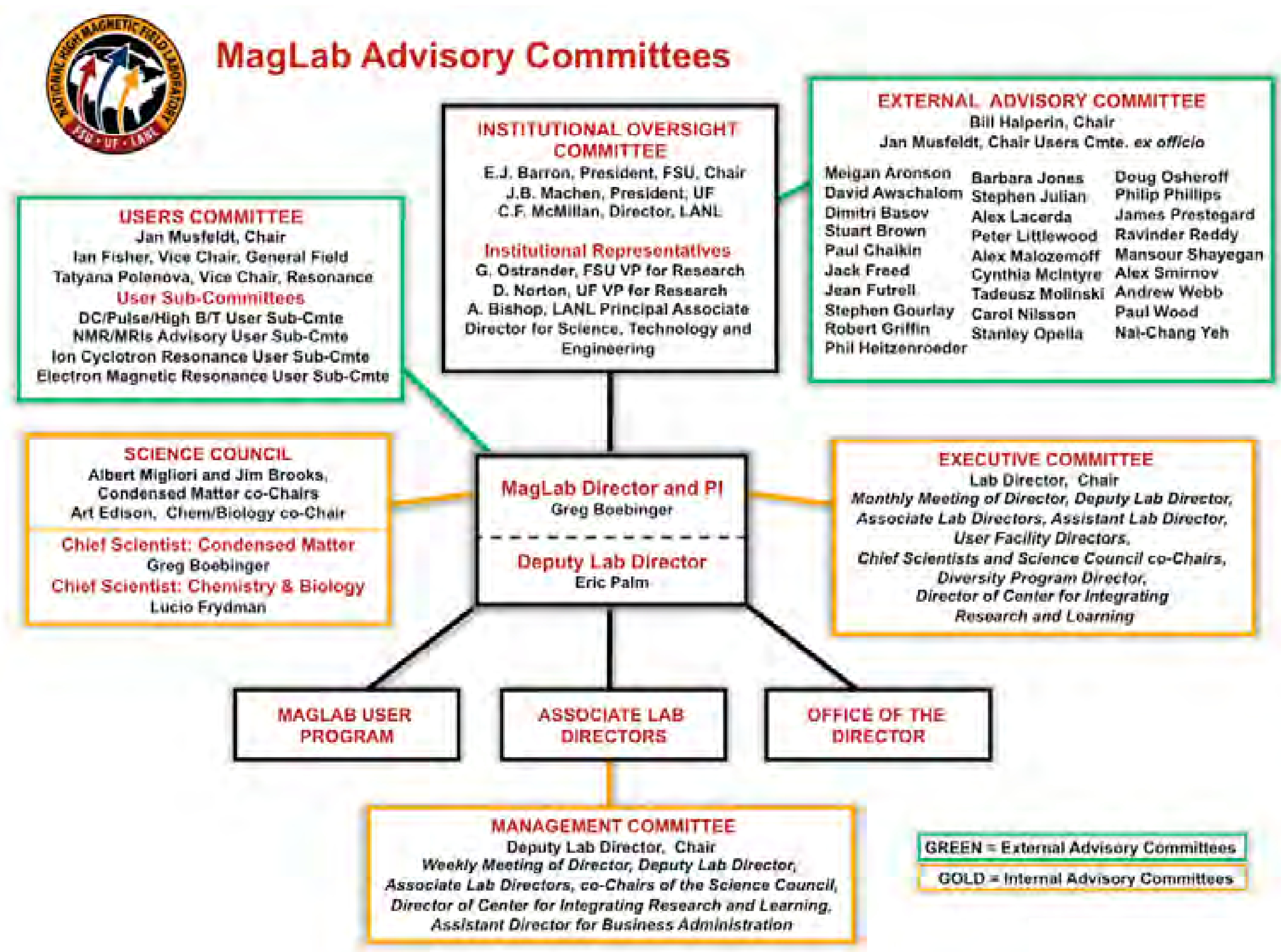

FIGURE 1. Organizational chart of the MagLab, showing internal and external advisory committees.

Management

Early in 2012, the NHMFL and FSU commissioned two external consultants to study the organizational structure of the MagLab. As a result of this study, the MagLab's organizational structure has been changed to better address succession planning among MagLab upper management. The structure of the MagLab is shown in **Figure 1** and **Figure 2**. The first figure shows the external oversight and advisory committees, as well as the three internal committees that provide guidance to NHMFL leadership. The second figure shows the internal, operational structure of the laboratory.

Greg Boebinger is the director of the MagLab and PI of the cooperative agreement. The newly created position of deputy laboratory director is filled by Eric Palm. Together the director and deputy 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 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 labwide issues as well as program-specific issues.

Several key management positions were filled in 2012. **Roxanne Hughes**, a specialist in why women choose STEM fields, became the lab's director of the Center for Integrating Research and Learning. "Roxanne is considered by the physics education community to be one of the leaders in learning how to open doors for young women to more broadly participate in the physics and engineering professions," said

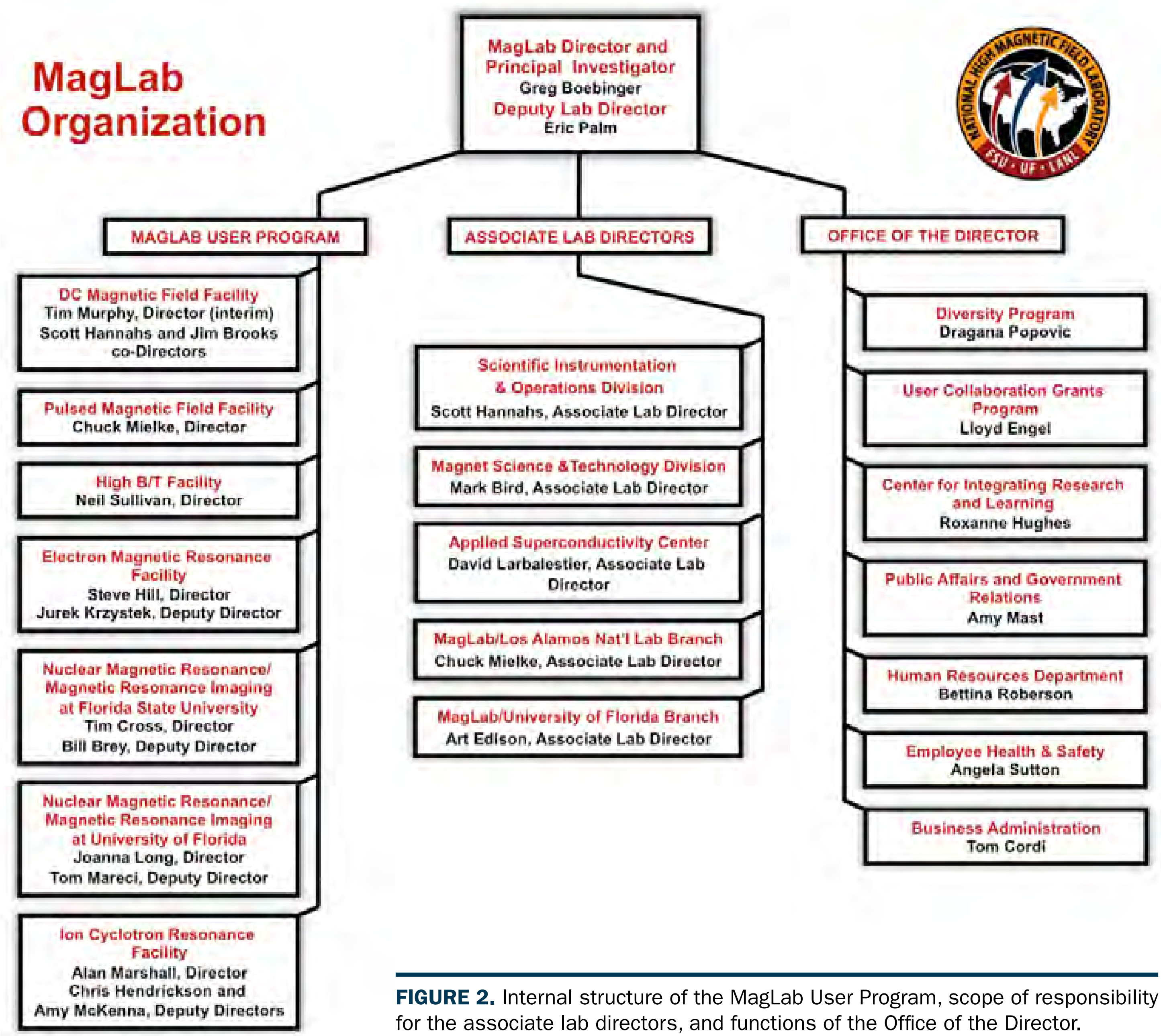

FIGURE 2. Internal structure of the MagLab User Program, scope of responsibility for the associate lab directors, and functions of the Office of the Director.

User Committee Members

DC / Pulsed / High B/T Advisory Committee
Kenneth Burch, University of Toronto
Nicholas Curro*, University of California Davis
Ian Fisher*, Stanford University
Jeanie Lau, University of California, Riverside
Janice Musfeldt*, University of Tennessee-Knoxville
Cedomir Petrovic, Brookhaven National Lab
Oliver Portugall, Laboratoire National des Champs Magnétiques Intenses
Makariy Tanatar, US DOE The Ames Laboratory

EMR Advisory Committee
Christoph Boehme, University of Utah
David Britt, University of California, Davis
Gavin Morley, University of Warwick
Stefan Stoll, University of Washington
Joshua Telser*, Roosevelt University
Sergei Zvyagin, Dresden High Magnetic Field Lab (HLD)

ICR Advisory Committee
I. Jonathan Amster, University of Georgia
Steve Beu, S. C. Beu Consulting
Michael Greig, Pfizer Global R&D – La Jolla
David C. Muddiman, North Carolina State University
Alexandra Stenson*, University of S. Alabama
Evan Williams, University of California

NMR/MRIs Advisory Committee
Dmitri Artemov, Johns Hopkins University
Ari Borthakur, University of Pennsylvania
Joanna Collingwood, University of Warwick
Linda Columbus, University of Virginia
Myriam Cotten, Hamilton College
Michael Harrington, Huntington Medical Research Institutes
Conggang Li, Wuhan Institute of Physics & Mathematics, Chinese Academy of Sciences
Manish Mehta, Oberlin College
Tatyana Polenova*, University of Delaware
Scott Prosser*, University of Toronto
Marek Pruski, Ames Laboratory and Iowa State University
Mark Rance, University of Cincinnati
Rob Schurko*, University of Windsor
Fang Tian, Penn State University
Ivan Tkac, University of Minnesota

**Member of Users Executive Committee*

External Advisory Committee Members

William P. Halperin, External Advisory Committee Chair, Northwestern University
Jan Musfeldt, User Committee Chair (*ex officio* member of EAC), University of Tennessee-Knoxville

Magnet Technology & Materials Subcommittee
Stephen Gourlay, Lawrence Berkeley National Lab
Phil Heitzenroeder, Princeton University
Alexis Malozemoff, American Superconductor Corp.

Biology & Chemistry Subcommittee
Jack Freed, Cornell University
Jean Futrell, Battelle, Pacific Northwest National Lab
Robert Griffin, MIT
Tadeusz F. Molinski, UC-San Diego
Carol Nilsson, University of Texas Medical Branch
Stanley Opella, UC-San Diego
James Prestegard, The University of Georgia
Ravinder Reddy, University of Pennsylvania
Alex Smirnov, North Carolina State University
Andrew Webb, Leiden University Medical Center
Paul L. Wood, Lincoln Memorial University

Condensed Matter Subcommittee
Meigan Aronson, Brookhaven National Laboratory
David Awschalom, UC-Santa Barbara
Dimitri Basov, UC-San Diego
Stuart Brown, UC-Los Angeles
Paul Chaikin, New York University
Barbara A. Jones, IBM Almaden Research Center
Stephen Julian, University of Toronto
Alex Lacerda, Los Alamos National Laboratory
Peter Littlewood, Argonne National Laboratory
Cynthia Roberta McIntyre, Council on Competitiveness
Douglas D. Osheroff, Stanford University
Philip W. Phillips, University of Illinois-Urbana Champaign
Mansour Shayegan, Princeton University
Nai-Chang Yeh, California Institute of Technology

Paul Cottle, an FSU physics professor.

Lucio Frydman of Israel's Weizmann Institute was hired as the lab's chief scientist in chemistry and biology. An NMR user, Frydman is the developer of multiple quantum magic angle spinning, a technique that provides the increased sharpness needed for scientists to draw more accurate conclusions from their experiments. He has also pioneered the development of "ultrafast" methods, capable of reducing the duration of multidimensional spectra and images by orders of magnitude.

Physicist and longtime MagLab veteran **Eric Palm** was selected as the lab's deputy director. He had most recently been the director of the DC User Facility.

Tom Cordi is the lab's new assistant director for business administration, overseeing its budget, finance and business systems.

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: Albert Migliori (co-chair), Jim Brooks (co-chair), Art Edison (co-chair), Gail Fanucci, Zhehong Gan, Lev Gor'kov, Stephen Hill, Jurek Krzystek, David Larbalestier, Dragana Popović, Ryan Rodgers, Theo Siegrist, Glenn Walter and Huub Weijers.

Two external committees meet regularly to provide critical advice on important issues. 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. 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. These committees and their 2012 meetings are further described below.

Users Committee

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. Since the DC, Pulsed and High B/T facilities primarily deal with condensed matter physics, there is a single subcommittee representing the three user facilities. Likewise, the NMR facilities at UF and FSU have a single, combined subcommittee. 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/Pulsed/High B/T Advisory Committee, the EMR Advisory Subcommittee, the NMR/MRI Advisory Committee, and the representative from the ICR Advisory Committee met November 8-10 in Tallahassee to discuss the state of the laboratory and provide feedback to the NSF and MagLab management.

The full report from this meeting can be found at http://www.magnet.fsu.edu/usershub/userscommittee/documents/2012UserCommitteeReport_final.pdf and also in **Appendix B** of this annual report. The executive summary from this committee meeting is reprinted at right.

External Advisory Committee

The External Advisory Committee met August 7-8, 2012, in Tallahassee and provided a report directly to Eric Barron, president of FSU; J. Bernard Machen, president of UF; and Charles F. McMillan, director of Los Alamos National Laboratory. 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 expected recompetition in coming years.

Safety

The MagLab's mission includes the provision of a safe and healthful working environment for all employees, visitors and users. The Safety Department directs a comprehensive set of safety programs directly related to the specific needs and operations of the laboratory. Great care, expertise and coordination are used to develop these programs in an effort to ensure the safest possible conditions for faculty, staff, users and visitors.

The MagLab maintains an active Safety Committee that includes the MagLab's upper management and members from 11 departments across the laboratory, the two full-time members of the MagLab's Safety Department and a representative from Florida State University Environmental, Health and Safety Department. Members of the Safety Committee review safety procedures, safety performance and propagate the MagLab's commitment to safety throughout the lab. The Safety Committee supports group safety meetings for MagLab departments and partners with faculty, administration and research supervisory personnel to promote safe work practices, ensure personnel are properly trained and provide safe equipment and facilities for staff, students and visitors.

Safety personnel and members of the Safety Committee conduct formal lab inspections every spring and fall for each of the MagLab's laboratories. These twice-annual lab inspections identify any unsafe conditions in the lab, using a comprehensive checklist that includes chemical, electrical, compressed gas, magnetic field and housekeeping hazards. We require lab personnel to be present during the spring inspections to receive annual area-specific safety training from

2012 NHMFL Users Committee Report, Executive Summary *(Reprint)*

First and foremost, the User Committee commends the NHMFL for their tremendous technical and scientific advances and achievements during the last year, including the achievement of science at 100 T, and for continuing to provide users with access to world-leading facilities. We also congratulate the lab for their successful renewal, and extend to them the thanks and appreciation of the wide user community for the substantial effort that this achievement required from everyone in the lab.

The lab continues to be well-managed, resulting in the availability of excellent facilities for a broad and growing community of users. The dedication and quality of management, scientific scholars and technical staff is impressive, and is a cornerstone of the lab's success. The recent promotion of the head of the DC program presents an opportunity to continue this strong tradition with the appointment of a new leader, and the committee was encouraged to hear that the lab will work closely with the User Committee, the External Advisory Committee and the resident scholar scientists in the associated search process.

Within the realm of the DC/Pulsed Field/High B/T facilities, the committee was pleased to hear about the opening of an additional bay in the High B/T facility, the transition of the 25 T split coil magnet to user operations (and the associated successful MRI proposal), the new top-loading cryostats, the upgrades to the helium purifier, liquefier and eventual distribution box, and the progress towards the 32 T all-superconducting magnet. Recognizing that budgets are tight, the committee still encourages the lab to vigorously pursue the realization of a 41 T 28 MW resistive magnet as a high priority, to the extent that this is possible within the given constraints. Such a magnet would provide two facilities for research in DC fields above 40 T, and ensure the continued vitality of the DC program if the hybrid magnet failed for any extended period of time. From the user perspective, availability of additional user time would of course be very welcome, and we comment below on the various proposals for weekend operations that were presented. The committee suggests seeking additional input from the broader user community in order to ensure that any investment in this direction is optimally matched to user needs, in particular with regard to the specific demand for weekend operations, and the way that user time is configured for such operations. The DC program is a core program of the NHMFL, and the committee felt that extended access should be pursued simultaneous with the development of new magnet facilities. Nevertheless, the general feeling was that development and implementation of the new 41 T magnet would on the whole benefit the user community more than increasing access to the existing resistive magnets, although ideally both actions should be pursued in tandem.

Within the magnetic resonance program, the committee was pleased with the development of new technologies over the last year, including the addition of an 800 MHz spectrometer with a new Bruker console, the 900 MHz imaging spectrometer, and the development of specialized NMR probes. The committee commends the lab for the hiring of a number of excellent quality scientific staff, as well as the partial appointment of L. Frydman. Concern was expressed over the impact of potential budget cuts to the NMR program, and over the need for an uninterruptable power supply for the 21T ICR system, both of which are discussed in greater detail below.

Finally, we commend the lab for continuing to run their highly successful summer school. We urge the lab to continue hosting this superb event, which acts to draw new users to the lab, advertise the range of available experiments and facilities, and educate students from a broad range of backgrounds.

the Safety Department. Beginning in 2010, the fall inspection became "snap" inspections, with inspectors showing up in each laboratory unannounced in order to gauge daily compliance with safety practices. Lab inspection reports are submitted to the PI/ supervisor of each lab and corrective actions are implemented for any infractions. **Figure 3** shows that the number of infraction findings has halved and the number of laboratories scoring 100 percent has doubled over the past five years.

In addition to our internal inspections, the MagLab hosts inspections from the following external agencies: State Fire Marshall, Florida Department of Environmental Protection, Federal Aviation Administration, and Department of Homeland Security. We respond to all recommendations from the Fire Marshall to further improve fire safety at the lab. The MagLab received no violations from any of the other external agencies during the inspections listed in **Table 1**.

MagLab safety personnel regularly facilitate safety tours for the Tallahassee Fire Department to educate first-response personnel on potential hazards at the lab. We also coordinate periodic reviews from the Florida State University Police Department to evaluate lab security. The FSU Biological Safety and Radiation Safety divisions of the FSU Environmental Health and Safety Department support and assist the lab in maintaining compliance in these areas.

The MagLab is pleased that its recordable injury rate (1.0 per 100 employees in 2011 and 0.4 per 100 employees in 2012) remains lower than the national averages from the U.S. Department of Labor for both "Scientific Research and Development" institutions (1.1 in 2011) as well as for "Colleges and Universities" (2.6 in 2011). In the wake of a serious safety accident in November 2012, the laboratory is implementing Integrated Safety Management in 2013. ISM will be summarized in the 2013 annual report.

Personnel and Staffing

As of December 31, 2012, six hundred forty-seven (647) people worked for or were affiliated with the Magnet Lab at its three sites in 2012 compared to 634 in 2011. Of that number, senior personnel represent the largest group at 32%,

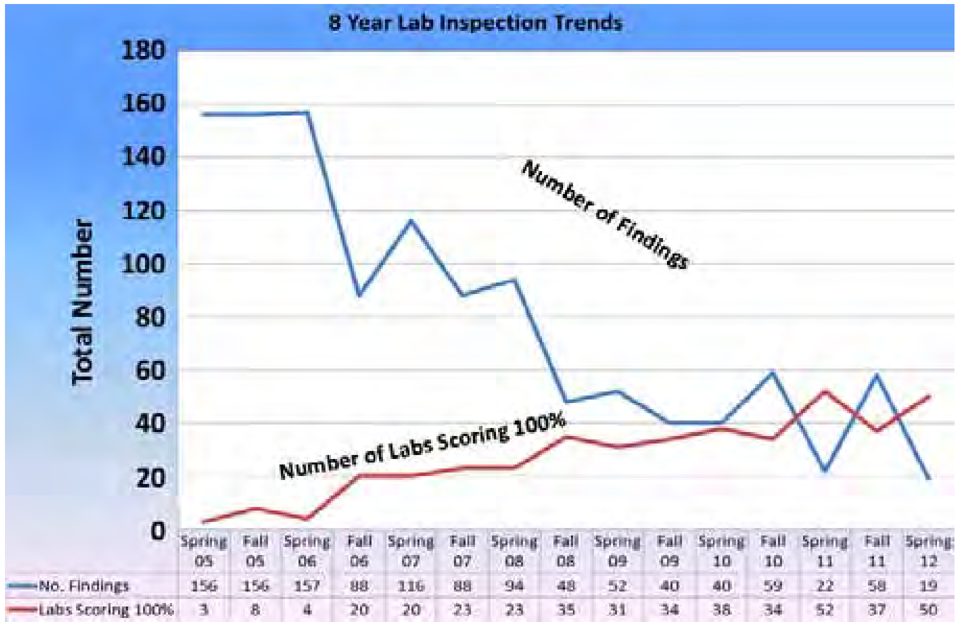

FIGURE 3. The overall downward trend in the number of findings and upward trend in the number of labs scoring 100% are both moving in the proper directions. In order to better measure "everyday" safety performance of our laboratories, the fall inspections have been "snap" (*i.e.* unannounced) inspections since 2010.

MagLab Staffing

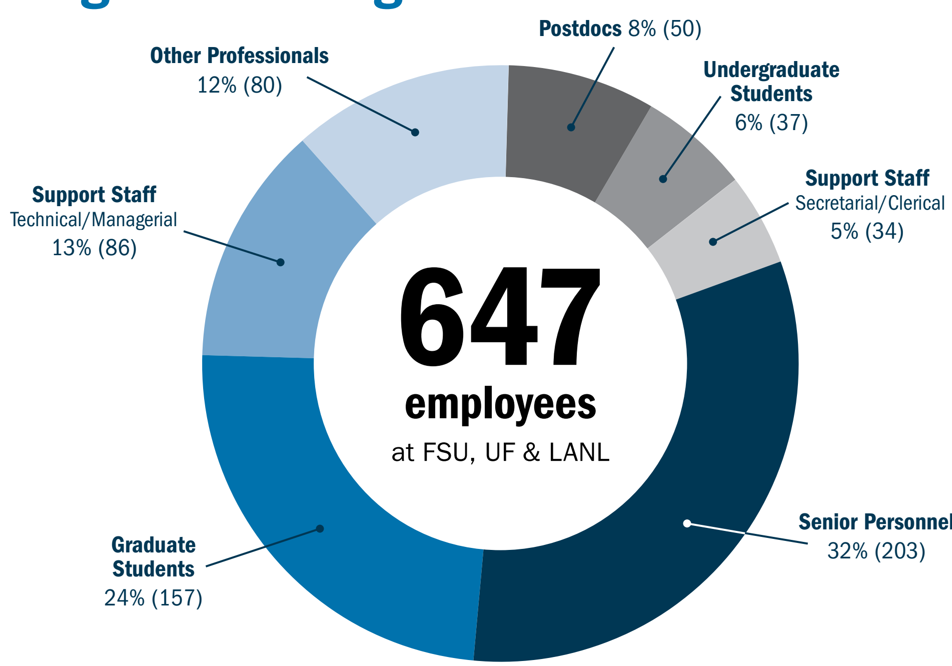

FIGURE 4. MagLab Staffing. Includes NHMFL employees paid by the NSF Core Grant or State of Florida funding, plus all affiliated professors, postdoctoral researchers and graduate students. Distribution by NSF Classification as of Jan. 3, 2013.

TABLE 1

Recent Inspections of the NHMFL *by external safety and security agencies*

External Agency	Frequency	Last Inspection Dates
State Fire Marshall	annually	12/2011, 11/2010
Florida Department of Environmental Protection		
Waste Water Division	annually	4/2012, 12/2010
Hazardous Waste Division	biennial	3/2012, 5/2010
Federal Aviation Administration	periodically	6/2010
Department of Homeland Security	periodically	6/2012

TABLE 2

NHMFL NSF 5-Year Budget *with indirect cost distributed to programs*

Division/Program	2008-2012 5-Year NSF Summary	% of Budget
Director's Office	6,012,871	3.96%
Associate Director/Management & Administration	11,950,521	7.88%
DC Field Facility	17,182,127	11.32%
Magnet Science & Technology	19,812,903	13.06%
Condensed Matter Science	7,209,844	4.75%
CIMAR – NMR	4,898,153	3.23%
CIMAR – ICR	7,320,824	4.83%
CIMAR – EMR	2,184,060	1.44%
CIRL & REU	1,695,550	1.12%
ASC	7,599,416	5.01%
Electricity & Gases	25,795,385	17.00%
LANL	28,618,765	18.86%
UF - High B/T	1,903,359	1.25%
UF- AMRIS	4,103,177	2.70%
Diversity	474,617	0.31%
UCGP	4,963,428	3.27%
TOTAL NSF COOPERATIVE AGREEMENT	**$151,725,000**	**100.00%**

1 FY 2008 included award of $26,500,000 plus supplement of $1,250,000 for a total award of $27,750,000.
2 FY 2009 included award of $22,525,000 plus August 2010 supplement of $3,975,000 for a total award of $26,500,000.Supplement ARRA funding of $5,000,000 is not included in the financial data reported in this budget section.
3 FY 2010 included award of $26,500,000 plus supplement of $6,500,000 for a total award of $33,000,000.
4 FY 2011 included award of $26,675,000 plus an advance of $5,000,000 received in Sept 2010 for a total award of $31,675,000.
5 FY 2012 included award of $26,800,000 plus an advance of $6,000,000 received in Sept 2011 for a total award of $32,800,000.
6 The National Science Foundation (National Science Board) approved funding of up to $162,000,000 for 2008-2012.
7 UCGP (User Collaboration Grants Program) for FSU/NHMFL, LANL and UF reported as one line item.

followed by graduate students at 24% and support staff technical/managerial at 13%. The total distribution by NSF classification appears in **Figure 4**.

Budget

The National High Magnetic Field Laboratory operates with funding provided by federal, state, institutional and industry sources. In addition, the Magnet Lab faculty and staff have been very successful in securing individual research funding for specific areas of research from a variety of sources, including federal and private sectors. Although the lab receives funding from numerous sources, the National Science Foundation is its primary funding source for operations.

NSF Facilities Budget

The National Science Foundation Division/Directorate approved the National High Magnetic Field Laboratory's facilities renewal award on December 12, 2007 with an effective date of January 1, 2008. **Table 2** provides a view of the total 5-year award. **Table 3** presents the annual NSF budgets for the 5-year award period. **Table 4** summarizes the Magnet Lab's budget position as of December 31, 2012. The negative budget balance represents carry-forward funds (deferred spending from 2011) spent in 2012.

Matching Commitment

The NSF award includes a matching commitment by the State of Florida through FSU, which is 10 percent of the annual award. In addition, the State of Florida also provides institutional funds to

TABLE 3

NHMFL NSF Budget by Program *with indirect cost separated from programs*

Division / Program	2008	2009	2010	2011	2012	Total Budget
Director's Office	578,614	-453,866	2,051,017	1,342,496	1,344,050	4,862,311
Associate Director/Management & Administration	1,554,740	1,676,171	1,688,772	1,592,194	1,688,637	8,200,514
DC Field Facility	2,286,768	2,168,960	2,180,666	2,417,219	2,567,123	11,620,736
Magnet Science & Technology	2,340,153	2,250,915	2,653,109	2,732,504	3,576,072	13,552,753
Condensed Matter Science	500,894	953,785	974,190	1,094,806	1,219,643	4,743,318
CIMAR - NMR	587,040	623,469	650,256	659,574	856,037	3,376,376
CIMAR - ICR	961,673	1,053,252	1,119,366	989,849	1,039,409	5,163,549
CIMAR - EMR	131,519	133,475	998,930	222,401	261,871	1,748,196
CIRL & REU	187,807	216,087	258,735	288,607	333,137	1,284,373
ASC	447,101	490,014	1,233,965	1,257,050	1,805,425	5,233,555
Electricity & Gases	5,791,897	4,779,676	4,918,789	3,834,130	3,830,735	23,155,227
LANL	2,895,534	3,065,568	3,218,243	6,213,942	5,000,000	20,393,287
UF - High B/T	212,483	273,940	272,036	447,372	387,372	1,593,203
UF- AMRIS	500,159	562,705	556,443	1,038,689	838,689	3,496,685
Diversity	64,073	64,001	64,642	62,997	67,669	323,382
User Collaboration Grant Program	897,225	911,400	1,208,143	1,296,660	650,000	4,963,428
Indirect Cost	7,812,320	7,730,448	8,952,698	6,184,510	7,334,131	38,014,107
TOTAL	**$27,750,000**	**$26,500,000**	**$33,000,000**	**$31,675,000**	**$32,800,000**	**$151,725,000**

1 FY 2008 included award of $26,500,000 plus supplement of $1,250,000 for a total award of $27,750,000.
2 FY 2009 included award of $22,525,000 plus supplement of $3,975,000 for a total award of $26,500,000.
Supplement ARRA funding of $5,000,000 is not included in the financial data reported in this budget section.
3 FY 2010 included award of $26,500,000 plus supplement of $6,500,000 for a total award of $33,000,000.
4 FY 2011 included award of $26,675,000 plus an advance of $5,000,000 received in Sept 2010 for a total award of $31,675,000.
5 FY 2012 included award of $26,800,000 plus an advance of $6,000,000 received in Sept 2011 for a total award of $32,800,000.
6 The National Science Foundation (National Science Board) approved funding of up to $162,000,000 for 2008-2012.
7 UCGP (User Collaboration Grants Program) for FSU/NHMFL, LANL and UF reported as one line item.

the laboratory above the NSF matching requirement. The Magnet Lab utilizes these additional state resources as cost-sharing funds for other funding opportunities, as well as supporting other NSF activities. **Table 5** presents the State of Florida matching requirements and contribution provided through FSU.

American Recovery and Reinvestment Act (ARRA) Funding

The MagLab received a $5 million ARRA award from the NSF in 2009. Cumulative underfunding of the five-year NSF award led to the deferment of equipment replacement, preventive maintenance, and other projects. Receipt of ARRA funds provided the MagLab with the flexibility for reinstating many of the deferred items.

A **helium liquefier system**, with refrigeration, has been purchased, installed, commissioned, and is fully operational. Once operational, there was a dramatic increase in the recovery rates of helium that resulted in a significant cost savings. This system is an essential component of the lab's operation of superconducting magnets and scientific research, and most importantly allows the lab to maintain a state-of-the-art facility for users.

Equipment purchases at the Los Alamos National Laboratory (LANL) included $1 million to purchase and install emergency replacement parts for the 60T and 100T Long Pulse Magnet Systems. Without these replacement parts, a magnet failure would require immediate suspension of the NHMFL Pulsed Field User Facility. A cryostat was purchased, installed, and is now fully operational. Low loss cryostats were decreasing the consumption of liquid helium for magnet systems in the Pulsed Field User Facility. The new cryostat has significantly improved the efficiency that is required to offset the increasing costs of liquid helium.

The Advance Magnetic Resonance Imaging and Spectroscopy (AMRIS) Program at the University of Florida was provided $200,000 to purchase upgrades for imaging and spectroscopy consoles. Frequent breakdowns of the equipment over 10 years old were negatively impacting the NHMFL AMRIS User Facility. However, commercial NMR instrument manufacturers have made great strides in digital technology over the last decade. By modernizing the AMRIS consoles, gains in sensitivity, dynamics range, and pulse sequence programming have resulted. These upgrades were necessary to support cutting-edge imaging and *in vivo* spectroscopy experiments that are required by MagLab external users.

TABLE 4

NSF Budget and Expenses *for Fiscal Year 2012*

Expense Classification	Budget	Spent & Encumbered	Balance 12/31/2012
Salaries and Fringe	8,856,147	9,208,876	(352,729)
Subawards	6,331,061	6,652,708	(321,647)
Capital Equipment	8,696,176	5,039,654	3,656,523
Other Direct cost	1,582,485	6,723,713	(5,141,228)
SUBTOTAL	**25,465,869**	**27,624,950**	**(2,159,081)**
Indirect	7,334,131	7,100,489	233,642
TOTAL	**$32,800,000**	**$34,725,439**	**($1,925,439)**
Program Income	0	0	0

TABLE 5

State of Florida Matching and Contribution *Fiscal Year 2012/2013*

	State Matching	State Contribution	Total State Funding
State of Florida Recurring Funds Cost-Sharing	3,280,000	8,939,037	12,219,037
Indirect Cost (52%)	1,705,600	4,648,299	6,353,899
TOTAL	**$4,985,600**	**$13,587,336**	**$18,572,936**

APPENDIX A

User Facility Statistics

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.

Note: 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.

DC Field Facility User Statistics

Users, Requests and Operations: January 16, 2012 to January 20, 2013

TABLE 1

DC Field Facility User Demographics *for 2012*

	Users	Female	Minority[1]	Users Present[3,7]	Users Operating Remotely[4,7]	Users Sending Sample[5,7]	Off-Site Collaborators[6,7]
Senior Investigators, U.S.	152	14	4	101	0	6	45
Senior Investigators, non-U.S.	81	6	3	39	0	6	36
Postdocs, U.S.	41	5	0	36	0	4	1
Postdocs, non-U.S.	12	3	1	7	0	0	5
Students[2], U.S.	136	22	8	119	0	4	13
Students[2], non-U.S.	44	5	2	35	0	1	8
Technician, U.S.	2	0	1	2	0	0	0
Technician, non-U.S.	1	0	0	0	0	0	1
TOTAL	**469**	**55**	**19**	**339**	**0**	**21**	**109**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 "Students" generally refers to graduate students, but may include a few undergraduate students.
3 "Users Present" includes users physically present in the MagLab user facility during the experiment AND any MagLab-Affiliated or Local users on the experiment.
4 "Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
5 "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.
6 "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).
7 The total of Users Present + Users Operating Remotely + Users Sending Sample + and Off-Site Collaborators will equal the total number of users.

TABLE 2

DC Field Facility User Affiliations *for 2012*

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	152	51	8	127	1	24
Senior Investigators, non-U.S.	81	0	0	55	0	26
Postdocs, U.S.	41	10	9	30	1	10
Postdocs, non-U.S.	12	1	0	9	0	3
Students, U.S.	136	17	23	132	0	4
Students, non-U.S.	44	0	0	40	0	4
Technician, U.S.	2	2	0	2	0	0
Technician, non-U.S.	1	0	0	1	0	0
TOTAL	**469**	**81**	**40**	**396**	**2**	**71**

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".
Note for Annual Reporting: Due to programming limitations and the dynamic nature of information in this system, Local Users may include a few NHMFL-Affiliated users who left during the year and whose records have not yet been updated.
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

DC Field Facility Users by Discipline *for 2012*

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	152	112	16	11	12	1
Senior Investigators, non-U.S.	81	71	5	2	1	2
Postdocs, U.S.	41	36	2	1	1	1
Postdocs, non-U.S.	12	10	1	1	0	0
Students, U.S.	136	101	14	13	7	1
Students, non-U.S.	44	39	3	1	1	0
Technician, U.S.	2	1	0	0	1	0
Technician, non-U.S.	1	0	0	1	0	0
TOTAL	**469**	**370**	**41**	**30**	**23**	**5**

TABLE 4

DC Field Facility Experimental Requests[1] for Magnet Time *for 2012*

Weeks Requested	Weeks Granted	Weeks Declined
383	277 (63.97%)	156 (36.03%)

1 Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

DC Field Facility Research Proposals[1] Profile *with magnet time*

	Number of Proposals
Condensed Matter Physics	116
Chemistry, Geochemistry	9
Engineering	4
Magnets, Materials, Testing, Instruments	15
Biology, Biochemistry, Biophysics	2
TOTAL	**146**

	Number of Proposals
Minority [2]	3
Female [3]	17

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 6

DC Field Facility Operations Statistics *Number of magnet days[1]*

	Resistive & Hybrid Magnets	Superconducting Magnets	Total Days Allocated /User Affil.	Percentage Allocated /User Affil.
NHMFL-Affiliated[2]	148.38	199.00	347.38	23.89%
Local[2]	16.35	72.00	88.35	6.08%
U.S. University	284.78	308.00	592.78	40.77%
U.S. Govt. Lab.	60.35	35.00	95.35	6.56%
U.S. Industry	3.98	0.00	3.98	0.27%
Non-U.S.	223.96	100.00	323.96	22.28%
Test, Calibration, Set-up, Maintenance	2.04	0.00	2.04	0.14%
TOTAL	**739.84**	**714.00**	**1453.84**	**100.00%**

1 User Units are defined as magnet days. For the DC Field Facility, one magnet day is defined as 7 hours in a water-cooled resistive or hybrid magnet . Using this definition, a typical 24-hour day in the DC Field Facility contains three or four “magnet days” . For experiments in the superconducting magnets, one “magnet day” is defined as 24 hours of use.

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 usage equals what was formerly referred to as usage by “Internal Investigators”.

TABLE 7

DC Field Facility Operations by Discipline *Number of magnet days[1]*

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL-Affiliated[2]	347.38	272.19	10.36	8.59	56.23	0.00
Local[2]	88.35	81.35	7.00	0.00	0.00	0.00
U.S. University	592.78	540.16	37.36	0.00	12.46	2.80
U.S. Govt. Lab.	95.35	92.27	0.00	0.00	3.07	0.00
U.S. Industry	3.98	3.98	0.00	0.00	0.00	0.00
Non-U.S.	323.96	298.64	18.32	7.00	0.00	0.00
Test, Calibration, Set-up, Maintenance	2.04	0.00	0.00	0.00	2.04	0.00
TOTAL	**1453.84**	**1288.60**	**73.05**	**15.59**	**73.80**	**2.80**

1 User Units are defined as magnet days. For the DC Field Facility, one magnet day is defined as 7 hours in a water-cooled resistive or hybrid magnet . Using this definition, a typical 24-hour day in the DC Field Facility contains three or four “magnet days” . For experiments in the superconducting magnets, one “magnet day” is defined as 24 hours of use.

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 usage equals what was formerly referred to as usage by “Internal Investigators.”

TABLE 8

DC Field Facility New User PIs[1] *(14)*

Name	Organization	Proposal	Year of Magnet Time
Feng, Yejun	Argonne National Laboratory	P02036	2012
Kuehne, Hannes	Technical University of Dresden	P02038	2012
Obukhov, Sergey	The Ioffe Physical Technical Institute of the Russian Academy of Sciences	P02043	TBD
Rosenbaum, Tom	University of Chicago	P02044	2012
Yang, Fengyuan	The Ohio State University	P02046	2012
Qu, Dongxia	Lawrence Livermore National Lab	P02052	2012
Herrmannsdoerfer, Thomas	Helmholtz-Zentrum Dresden-Rossendorf	P02053	Scheduled 2013
Padilla, Willie	Boston College	P02062	Scheduled 2012
Avouris, Phaedon	IBM T. J. Watson Research Center	P02079	2012
Yin, Liang	University of Florida	P02114	2012
Tian, Mingliang	Hefei Institute for Physical Science	P02162	2013
Palmstrom, Chris	UC Santa Barbara	P02254	2013
Mason, Nadya	University of Illinois	P02255	Scheduled 2013
Selvamanickam, Venkat	University of Houston	P02261	Scheduled 2013

1 This table lists users serving as a principal investigator for the first time, and whose proposal was submitted during this year. It also shows the year in which magnet time was received. TBD stands for To Be Determined, indicating it has not yet been allotted magnet time.

Pulsed Field Facility User Statistics

Users, Requests and Operations: January 1, 2012 to December 31, 2012

TABLE 1

Pulsed Field Facility User Demographics *for 2012*

	Users	Female	Minority[1]	Users Present[3,7]	Users Operating Remotely[4,7]	Users Sending Sample[5,7]	Off-Site Collaborators[6,7]
Senior Investigators, U.S.	75	3	5	41	0	13	21
Senior Investigators, non-U.S.	24	5	2	8	0	5	11
Postdocs, U.S.	22	2	1	17	0	4	1
Postdocs, non-U.S.	2	0	0	2	0	0	0
Students[2], U.S.	18	3	1	13	0	2	3
Students[2], non-U.S.	7	1	0	4	0	1	2
Technician, U.S.	1	1	0	1	0	0	0
Technician, non-U.S.	0	0	0	0	0	0	0
TOTAL	**149**	**15**	**9**	**86**	**0**	**25**	**38**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 "Students" generally refers to graduate students, but may include a few undergraduate students.
3 "Users Present" includes users physically present in the MagLab user facility during the experiment AND any MagLab-Affiliated or Local users on the experiment.
4 "Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
5 "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.
6 "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).
7 The total of Users Present + Users Operating Remotely + Users Sending Sample + and Off-Site Collaborators will equal the total number of users.

TABLE 2

Pulsed Field Facility User Affiliations *for 2012*

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	75	22	15	33	0	42
Senior Investigators, non-U.S.	24	0	0	19	1	4
Postdocs, U.S.	22	4	9	12	0	10
Postdocs, non-U.S.	2	0	0	0	0	2
Students, U.S.	18	4	1	14	0	4
Students, non-U.S.	7	0	0	6	0	1
Technician, U.S.	1	0	0	0	0	1
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**149**	**30**	**25**	**84**	**1**	**64**

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".
Note for Annual Reporting: Due to programming limitations and the dynamic nature of information in this system, Local Users may include a few NHMFL-Affiliated users who left during the year and whose records have not yet been updated.
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

Pulsed Field Facility Users by Discipline *for 2012*

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	75	65	4	1	3	2
Senior Investigators, non-U.S.	24	24	0	0	0	0
Postdocs, U.S.	22	20	2	0	0	0
Postdocs, non-U.S.	2	2	0	0	0	0
Students, U.S.	18	16	2	0	0	0
Students, non-U.S.	7	7	0	0	0	0
Technician, U.S.	1	1	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**149**	**135**	**8**	**1**	**3**	**2**

TABLE 4

Pulsed Field Facility Experimental Requests[1] for Magnet Time *for 2012*

Experiment Requests	Requests Granted	Requests Declined
140	110 (67.90%)	52 (32.10%)

1 Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

Pulsed Field Facility Research Proposals[1] Profile *with magnet time*

	Number of Proposals
Condensed Matter Physics	56
Chemistry, Geochemistry	1
Engineering	0
Magnets, Materials, Testing, Instruments	7
Biology, Biochemistry, Biophysics	0
TOTAL	**64**

	Number of Proposals
Minority [2]	5
Female [3]	10

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 6

Pulsed Field Facility Operations Statistics *Number of magnet days[1]*

	Super-Cond.	Short Pulse	Mid Pulse	Long Pulse	100 T	Single Turn	Total Days Allocated /User Affil.	Percentage Allocated /User Affil.
NHMFL-Affiliated[2]	108.00	123.00	0.00	23.00	23.00	0.00	277.00	21.73%
Local[2]	122.00	100.00	0.00	0.00	1.00	0.00	223.00	17.49%
U.S. University	279.00	164.00	0.00	17.00	5.00	0.00	465.00	36.47%
U.S. Govt. Lab.	18.00	20.00	0.00	5.00	0.00	13.00	56.00	4.39%
U.S. Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00%
Non-U.S.	65.00	154.00	0.00	11.00	19.00	5.00	254.00	19.92%
Test, Calibration, Set-up, Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00%
TOTAL	**592.00**	**561.00**	**0.00**	**56.00**	**48.00**	**18.00**	**1275.00**	**100.00%**

1 User Units are defined as magnet days. For the Pulsed Field Facility, one magnet day is defined as 12 hours in any pulsed magnet system. For experiments in the superconducting magnets, one "magnet day" is defined as 24 hours of use.

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.

TABLE 7

Pulsed Field Facility Operations by Discipline *Number of magnet days[1]*

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL-Affiliated[2]	277.00	226.00	0.00	0.00	51.00	0.00
Local[2]	223.00	223.00	0.00	0.00	0.00	0.00
U.S. University	465.00	427.00	14.00	0.00	24.00	0.00
U.S. Govt. Lab.	56.00	56.00	0.00	0.00	0.00	0.00
U.S. Industry	0.00	0.00	0.00	0.00	0.00	0.00
Non-U.S.	254.00	235.00	0.00	0.00	19.00	0.00
Test, Calibration, Set-up, Maintenance	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**1275.00**	**1167.00**	**14.00**	**0.00**	**94.00**	**0.00**

1 User Units are defined as magnet days. For the Pulsed Field Facility, one magnet day is defined as 12 hours in any pulsed magnet system . For experiments in the superconducting magnets, one "magnet day" is defined as 24 hours of use.

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 usage equals what was formerly referred to as usage by "Internal Investigators".

TABLE 8

Pulsed Field Facility New User PIs[1] *(10)*

Name	Organization	Proposal	Year of Magnet Time
Iwasa, Yoshihiro	The University of Tokyo	P02011	2012
Li, Lu	University of Michigan	P02065	2012
Mascarenhas, Angelo	National Renewable Energy Lab	P02078	2012
Fitzsimmons, Michael	Los Alamos National Laboratory	P02091	2012
Lau, Chun Ning (Jeanie)	University of California, Riverside	P02113	2012
Wang, Junfeng	Wuhan National High Magnetic Field Center	P02129	2012
Tanner, David	University of Florida	P02134	2012
Greven, Martin	University of Minnesota	P02193	Scheduled 2013
Seshadri, Ram	UCSB	P02195	Scheduled 2013
Leighton, Chris	University of Minnesota	P02206	2012

1 This table lists users serving as a principal investigator for the first time, and whose proposal was submitted during this year. It also shows the year in which magnet time was received. TBD stands for To Be Determined, indicating it has not yet been allotted magnet time.

High B/T Facility User Statistics

Users, Requests and Operations: January 1, 2012 to December 31, 2012

TABLE 1

High B/T Facility User Demographics *for 2012*

	Users	Female	Minority[1]	Users Present[3,7]	Users Operating Remotely[4,7]	Users Sending Sample[5,7]	Off-Site Collaborators[6,7]
Senior Investigators, U.S.	18	1	0	9	0	8	1
Senior Investigators, non-U.S.	5	0	1	0	0	2	3
Postdocs, U.S.	6	1	0	5	0	0	1
Postdocs, non-U.S.	0	0	0	0	0	0	0
Students[2], U.S.	3	1	1	3	0	0	0
Students[2], non-U.S.	1	1	0	1	0	0	0
Technician, U.S.	0	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0	0
TOTAL	**33**	**4**	**2**	**18**	**0**	**10**	**5**

1 Minority status <u>includes</u> American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status <u>excludes</u> Asian and White-Not of Hispanic Origin.
2 "Students" generally refers to graduate students, but may include a few undergraduate students.
3 "Users Present" includes users physically present in the MagLab user facility during the experiment AND any MagLab-Affiliated or Local users on the experiment.
4 "Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
5 "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.
6 "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).
7 The total of Users Present + Users Operating Remotely + Users Sending Sample + and Off-Site Collaborators will equal the total number of users.

TABLE 2

High B/T Facility User Affiliations *for 2012*

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	18	6	2	13	0	5
Senior Investigators, non-U.S.	5	0	0	4	0	1
Postdocs, U.S.	6	2	3	3	0	3
Postdocs, non-U.S.	0	0	0	0	0	0
Students, U.S.	3	0	3	3	0	0
Students, non-U.S.	1	0	0	1	0	0
Technician, U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**33**	**8**	**8**	**24**	**0**	**9**

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".
Note for Annual Reporting: Due to programming limitations and the dynamic nature of information in this system, Local Users may include a few NHMFL-Affiliated users who left during the year and whose records have not yet been updated.
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

High B/T Facility Users by Discipline *for 2012*

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	18	15	1	2	0	0
Senior Investigators, non-U.S.	5	4	1	0	0	0
Postdocs, U.S.	6	6	0	0	0	0
Postdocs, non-U.S.	0	0	0	0	0	0
Students, U.S.	3	3	0	0	0	0
Students, non-U.S.	1	1	0	0	0	0
Technician, U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**33**	**29**	**2**	**2**	**0**	**0**

TABLE 4

High B/T Facility Experimental Requests[1] for Magnet Time *for 2012*

Experiment Requests	Requests Granted	Requests Declined
13	13 (72.22%)	5 (27.78%)

1 Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

High B/T Facility Research Proposals[1] Profile *with magnet time*

	Number of Proposals
Condensed Matter Physics	9
Chemistry, Geochemistry	0
Engineering	0
Magnets, Materials, Testing, Instruments	0
Biology, Biochemistry, Biophysics	0
TOTAL	**9**

	Number of Proposals
Minority [2]	0
Female [3]	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 6

High B/T Facility Operations Statistics *Number of magnet days[1]*

	16 T Bay 3	8 T Bay 2	10 T Williamson Hall	4 T Williamson Hall	Total Days Allocated /User Affil.	Percentage Allocated /User Affil.
NHMFL-Affiliated[2]	0.00	0.00	0.00	0.00	0.00	0.00%
Local[2]	343.00	0.00	0.00	0.00	343.00	33.01%
U.S. University	102.00	0.00	136.00	0.00	238.00	22.91%
U.S. Govt. Lab.	0.00	179.00	0.00	0.00	179.00	17.23%
U.S. Industry	0.00	0.00	0.00	0.00	0.00	0.00%
Non-U.S.	231.00	0.00	0.00	0.00	231.00	22.23%
Test, Calibration, Set-up, Maintenance	0.00	48.00	0.00	0.00	48.00	4.62%
TOTAL	**676.00**	**227.00**	**136.00**	**0.00**	**1039.00**	**100.00%**

1 User Units are defined as magnet days. For the High B/T Facility, one magnet day is defined 24 hours in the superconducting magnets.
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 usage equals what was formerly referred to as usage by "Internal Investigators".

TABLE 7

High B/T Facility Operations by Discipline *Number of magnet days[1]*

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL-Affiliated[2]	0.00	0.00	0.00	0.00	0.00	0.00
Local[2]	343.00	343.00	0.00	0.00	0.00	0.00
U.S. University	238.00	238.00	0.00	0.00	0.00	0.00
U.S. Govt. Lab.	179.00	179.00	0.00	0.00	0.00	0.00
U.S. Industry	0.00	0.00	0.00	0.00	0.00	0.00
Non-U.S.	231.00	231.00	0.00	0.00	0.00	0.00
Test, Calibration, Set-up, Maintenance	48.00	0.00	0.00	0.00	48.00	0.00
TOTAL	**1039.00**	**991.00**	**0.00**	**0.00**	**48.00**	**0.00**

1 User Units are defined as magnet days. For the High B/T Facility, one magnet day is defined 24 hours in the superconducting magnets.
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 usage equals what was formerly referred to as usage by "Internal Investigators".

TABLE 8

High B/T Facility New User PIs[1] *(0)*

Name	Organization	Proposal	Year of Magnet Time

1 This table lists users serving as a principal investigator for the first time, and whose proposal was submitted during this year. It also shows the year in which magnet time was received. TBD stands for To Be Determined, indicating it has not yet been allotted magnet time.

NMR-MRI @ FSU Facility User Statistics

Users, Requests and Operations: January 1, 2012 to December 31, 2012

TABLE 1

NMR-MRI @ FSU Facility User Demographics *for 2012*

	Users	Female	Minority[1]	Users Present[3,7]	Users Operating Remotely[4,7]	Users Sending Sample[5,7]	Off-Site Collaborators[6,7]
Senior Investigators, U.S.	96	17	5	48	5	15	28
Senior Investigators, non-U.S.	21	3	2	3	1	5	12
Postdocs, U.S.	21	2	0	13	3	0	5
Postdocs, non-U.S.	4	0	0	0	3	0	1
Students[2], U.S.	62	20	6	50	4	2	6
Students[2], non-U.S.	6	0	1	0	0	0	6
Technician, U.S.	6	3	1	6	0	0	0
Technician, non-U.S.	0	0	0	0	0	0	0
TOTAL	**216**	**45**	**15**	**120**	**16**	**22**	**58**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 "Students" generally refers to graduate students, but may include a few undergraduate students.
3 "Users Present" includes users physically present in the MagLab user facility during the experiment AND any MagLab-Affiliated or Local users on the experiment.
4 "Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
5 "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.
6 "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).
7 The total of Users Present + Users Operating Remotely + Users Sending Sample + and Off-Site Collaborators will equal the total number of users.

TABLE 2

NMR-MRI @ FSU Facility User Affiliations *for 2012*

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	96	25	15	87	9	0
Senior Investigators, non-U.S.	21	2	0	18	1	2
Postdocs, U.S.	21	5	6	21	0	0
Postdocs, non-U.S.	4	0	0	4	0	0
Students, U.S.	62	15	23	62	0	0
Students, non-U.S.	6	0	0	5	0	1
Technician, U.S.	6	5	1	6	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**216**	**52**	**45**	**203**	**10**	**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".
Note for Annual Reporting: Due to programming limitations and the dynamic nature of information in this system, Local Users may include a few NHMFL-Affiliated users who left during the year and whose records have not yet been updated.
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

NMR-MRI @ FSU Facility Users by Discipline *for 2012*

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	96	3	18	14	6	55
Senior Investigators, non-U.S.	21	0	10	2	0	9
Postdocs, U.S.	21	0	2	2	0	17
Postdocs, non-U.S.	4	0	1	0	0	3
Students, U.S.	62	0	4	19	2	37
Students, non-U.S.	6	0	4	0	0	2
Technician, U.S.	6	0	0	1	1	4
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**216**	**3**	**39**	**38**	**9**	**127**

TABLE 4

NMR-MRI @ FSU Facility Experimental Requests[1] for Magnet Time *for 2012*

Days Requested	Days Granted	Days Declined
2701	2994 (83.33%)	599 (16.67%)

1 Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

NMR-MRI @ FSU Facility Research Proposals[1] Profile *with magnet time*

	Number of Proposals
Condensed Matter Physics	2
Chemistry, Geochemistry	21
Engineering	4
Magnets, Materials, Testing, Instruments	5
Biology, Biochemistry, Biophysics	44
TOTAL	**76**

	Number of Proposals
Minority [2]	7
Female [3]	9

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 6

NMR-MRI @ FSU Facility Operations Statistics *Number of magnet days[1]*

	900	830	800	720	600	600 WB	600 WB2	500	500E	Total Days Allocated /User Affil.	Percentage Allocated /User Affil.
NHMFL-Affiliated[2]	101.00	117.00	343.00	29.00	14.00	9.00	80.00	364.00	257.00	1314.00	43.89%
Local[2]	84.00	36.00	1.00	100.00	1.00	290.00	207.00	0.00	24.00	743.00	24.82%
U.S. University	117.00	48.00	0.00	226.00	263.00	51.00	69.00	0.00	0.00	774.00	25.85%
U.S. Govt. Lab.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00%
U.S. Industry	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.07%
Non-U.S.	49.00	101.00	0.00	0.00	0.00	0.00	11.00	0.00	0.00	161.00	5.38%
Test, Calibration, Set-up, Maintenance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00%
TOTAL	**353.00**	**302.00**	**344.00**	**355.00**	**278.00**	**350.00**	**367.00**	**364.00**	**281.00**	**2994.00**	**100.00%**

1 User Units are defined as magnet days. For the NMR Facility in Tallahassee, one magnet day is 24 hours in the superconducting magnets.
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 usage equals what was formerly referred to as usage by "Internal Investigators."

TABLE 7

NMR-MRI @ FSU Facility Operations by Discipline *Number of magnet days[1]*

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL-Affiliated[2]	1314.00	0.00	270.00	364.00	99.00	581.00
Local[2]	743.00	0.00	31.00	0.00	0.00	712.00
U.S. University	774.00	30.00	21.00	3.00	14.00	706.00
U.S. Govt. Lab.	0.00	0.00	0.00	0.00	0.00	0.00
U.S. Industry	2.00	0.00	0.00	0.00	2.00	0.00
Non-U.S.	161.00	0.00	105.00	0.00	0.00	56.00
Test, Calibration, Set-up, Maintenance	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**2994.00**	**30.00**	**427.00**	**367.00**	**115.00**	**2055.00**

1 User Units are defined as magnet days. For the NMR Facility in Tallahassee, one magnet day is 24 hours in the superconducting magnets.
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 usage equals what was formerly referred to as usage by "Internal Investigators".

TABLE 8

NMR-MRI @ FSU Facility New User PIs[1] *(14)*

Name	Organization	Proposal	Year of Magnet Time
Leeper, Thomas	University of Akron	P01985	2012
Veglia, Gianluigi	University of Minnesota	P01990	2012
Traaseth, Nate	New York University	P02009	2012
Frydman, Lucio	Weizmann Institute of Science	P02015	2012
Manning, Thomas	Valdosta State University	P02031	2012
Thompson, Lynmarie	University of Massachusetts Amherst	P02032	2012
Kern, Dorothee	HHMI/Brandeis University	P02085	2012
Ladizhansky, Vladimir	University of Guelph	P02088	2012
Wi, Sungsool	NHMFL	P02137	2012
Chandrashekar, Srinivasan	NHMFL	P02140	2012
Doty, David	Doty Scientific, Inc	P02209	2012
Miller, Brian	Florida State University	P02216	TBD
Melville, Stephen	Virginia Tech	P02219	2012
Rainey, Jan	Dalhousie University	P02277	2013

1 This table lists users serving as a principal investigator for the first time, and whose proposal was submitted during this year. It also shows the year in which magnet time was received. TBD stands for To Be Determined, indicating it has not yet been allotted magnet time.

NMR-MRI @ UF (AMRIS) Facility User Statistics

Users, Requests and Operations: January 1, 2012 to December 31, 2012

TABLE 1

NMR-MRI @ UF (AMRIS) Facility User Demographics *for 2012*

	Users	Female	Minority[1]	Users Present[3,7]	Users Operating Remotely[4,7]	Users Sending Sample[5,7]	Off-Site Collaborators[6,7]
Senior Investigators, U.S.	92	16	5	55	6	31	NA
Senior Investigators, non-U.S.	15	4	2	7	4	4	NA
Postdocs, U.S.	16	6	2	9	3	4	NA
Postdocs, non-U.S.	16	4	0	10	2	4	NA
Students[2], U.S.	50	19	7	31	0	19	NA
Students[2], non-U.S.	24	6	1	16	2	6	NA
Technician, U.S.	23	5	1	13	1	9	NA
Technician, non-U.S.	8	2	1	4	2	2	NA
TOTAL	**244**	**62**	**19**	**145**	**20**	**79**	**NA**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 "Students" generally refers to graduate students, but may include a few undergraduate students.
3 "Users Present" includes users physically present in the MagLab user facility during the experiment AND any MagLab-Affiliated or Local users on the experiment.
4 "Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
5 "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.
6 "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).
7 The total of Users Present + Users Operating Remotely + Users Sending Sample + and Off-Site Collaborators will equal the total number of users.

TABLE 2

NMR-MRI @ UF (AMRIS) Facility User Affiliations *for 2012*

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	92	16	39	83	1	8
Senior Investigators, non-U.S.	15	2	5	15	0	0
Postdocs, U.S.	16	1	9	12	0	4
Postdocs, non-U.S.	16	3	7	16	0	0
Students, U.S.	50	0	32	50	0	0
Students, non-U.S.	24	0	15	23	1	0
Technician, U.S.	23	5	12	20	2	1
Technician, non-U.S.	8	2	2	7	1	0
TOTAL	**244**	**29**	**121**	**226**	**5**	**13**

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".
Note for Annual Reporting: Due to programming limitations and the dynamic nature of information in this system, Local Users may include a few NHMFL-Affiliated users who left during the year and whose records have not yet been updated.
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

NMR-MRI @ UF (AMRIS) Facility Users by Discipline *for 2012*

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	92	0	12	5	1	74
Senior Investigators, non-U.S.	15	0	2	0	0	13
Postdocs, U.S.	16	0	2	1	1	12
Postdocs, non-U.S.	16	0	3	0	0	13
Students, U.S.	50	0	6	3	1	40
Students, non-U.S.	24	0	6	0	0	18
Technician, U.S.	23	0	2	4	0	17
Technician, non-U.S.	8	0	3	5	0	0
TOTAL	**244**	**0**	**36**	**18**	**3**	**187**

TABLE 4

NMR-MRI @ UF (AMRIS) Facility Experimental Requests[1] for Magnet Time

Experiment Requests	Requests Granted	Requests Declined
>1800	1488	>300

1 Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

NMR-MRI @ UF (AMRIS) Facility Research Proposals[1] Profile *with magnet time*

	Number of Proposals
Condensed Matter Physics	0
Chemistry, Geochemistry	6
Engineering	6
Magnets, Materials, Testing, Instruments	0
Biology, Biochemistry, Biophysics	82
TOTAL	**94**

	Number of Proposals
Minority [2]	4
Female [3]	9

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 project 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 project includes female participants.

TABLE 6

NMR-MRI @ UF (AMRIS) Facility Operations Statistics *Number of magnet days[1]*

	500 MHz NMR	600 MHz NMR /MRI	600 MHz Cryo	600 MHZ Cryo 2	750 MHz WB	4.7 T /33 CM	11.1 T /40 CM	3T Whole Body	Total Days Allocated /User Affil.	Percentage Allocated /User Affil.
NHMFL-Affiliated[2]	9	228	39	64	144	106	104	60	753	40%
Local[2]	0	1	1	2	6	38	41	53	142	8%
U.S. University	0	3	43	0	87	0	0	0	133	7%
U.S. Govt. Lab.	0	0	6	0	0	0	4	12	22	1%
U.S. Industry	0	0	0	0	0	0	0	0	0	0
Non-U.S.	35	0	2	0	0	0	0	0	37	2%
Development[3]	48	37	88	73	73	26	54	1	401	22%
Test, Calibration, Set-up, Maintenance[4]	70	70	34	70	34	37	40	18	373	20%
TOTAL	**162**	**339**	**213**	**209**	**344**	**207**	**243**	**144**	**1861**	**100%**

1 User Units are defined as magnet days. Magnet-day definitions for AMRIS instruments:
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). This accounts for the difficulty in running animal or human studies overnight. With additional staffing, the 11.1 T system went to an 8 hour/ 7day a week schedule in 2010. There is an annual 7 day holiday shutdown at UF so total days are based on a 51 week calendar. Magnet days were calculated by adding the total number of real hours used for each instrument and dividing by 24 (vertical) or 8 (horizontal).
In 2012, the 500 MHz and 600 MHz NMR/MRI consoles were upgraded leading to an increase in time for Test, Calibration, Set-up, Maintenance. A significant delay in the delivery of critical components for the new 500 console led to a decrease in magnet days on the 500 compared to other years.

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.

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 usage equals what was formerly referred to as usage by "Internal Investigators". **Note:** All of the use in this category was paid by individual investigator grants and not the NHMFL.

3 Development was used for several purposes, primarily for establishing new capabilities such as building and testing coils, implementing new pulse sequences, and developing new protocols. For merging with other NHMFL user tables, Development data will be added to Test, Calibration, Set-up, Maintenance.

4 In 2012, the 500 MHz and 600 MHz NMR/MRI consoles were upgraded leading to an increase in time for Test, Calibration, Set-up, Maintenance. A significant delay in the delivery of critical components for the new 500 console led to a decrease in magnet days on the 500 compared to other years. A new HTS probe was also installed and tested on the 600 MHz cryo2 instrument.

TABLE 7

NMR-MRI @ UF (AMRIS) Facility Operations by Discipline *Number of magnet days*[1]

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL-Affiliated[2]	753	0	50	50	0	653
Local[2]	142	0	12	0	0	130
U.S. University	133	0	13	0	0	120
U.S. Govt. Lab.	22	0	11	0	0	11
U.S. Industry	0	0	0	0	0	0
Non-U.S.	37	0	7	0	0	30
Development[3]	401	0	100	0	0	301
Test, Calibration, Set-up, Maintenance[4]	373	0	100	0	0	273
TOTAL	**1861**	**0**	**293**	**50**	**0**	**1518**

1 User Units are defined as magnet days. Magnet-day definitions for AMRIS instruments:
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). This accounts for the difficulty in running animal or human studies overnight. With additional staffing, the 11.1 T system went to an 8 hour/ 7day a week schedule in 2010. There is an annual 7 day holiday shutdown at UF so total days are based on a 51 week calendar. Magnet days were calculated by adding the total number of real hours used for each instrument and dividing by 24 (vertical) or 8 (horizontal).
In 2012, the 500 MHz and 600 MHz NMR/MRI consoles were upgraded leading to an increase in time for Test, Calibration, Set-up, Maintenance. A significant delay in the delivery of critical components for the new 500 console led to a decrease in magnet days on the 500 compared to other years.

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.

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 usage equals what was formerly referred to as usage by “Internal Investigators”.
Note: All of the use in this category was paid by individual investigator grants and not the NHMFL.

3 Development was used for several purposes, primarily for establishing new capabilities such as building and testing coils, implementing new pulse sequences, and developing new protocols. For merging with other NHMFL user tables, Development data will be added to Test, Calibration, Set-up, Maintenance.

4 In 2012, the 500 MHz and 600 MHz NMR/MRI consoles were upgraded leading to an increase in time for Test, Calibration, Set-up, Maintenance. A significant delay in the delivery of critical components for the new 500 console led to a decrease in magnet days on the 500 compared to other years. A new HTS probe was also installed and tested on the 600 MHz cryo2 instrument.

TABLE 8

NMR-MRI @ UF (AMRIS) Facility New User PIs[1] *(11)*

Name	Organization	Proposal	Year of Magnet Time
Butcher, Rebecca	University of Florida	P01980	2012
Prosser, Scott	University of Toronto	P01956	2013
Frank, Larry	University of California San Diego	P01926	2012
Dixon, Warren	University of Florida	P02110	2012
Fisher, Aron	University of Pennsylvania	P02120	2012
Broderson, Craig	University of Florida	P02164	2012
Schmelz, Eric	USDA	P02207	2012
Tari, Ana	University of Florida	P02221	2012
Baumer, Marcus	University of Bremen	P02223	2012
Liu, Ting	Beijing Academy of Agricultural and Forestry Science	P02225	2012
Erickson, Matthew	VA Hospital	P02196	2013

1 This table lists users serving as a principal investigator for the first time, and whose proposal was submitted during this year. It also shows the year in which magnet time was received. TBD stands for To Be Determined, indicating it has not yet been allotted magnet time.

Electron Magnetic Resonance Facility User Statistics

Users, Requests and Operations: January 1, 2012 to December 31, 2012

TABLE 1

EMR Facility User Demographics *for 2012*

	Users	Female	Minority[1]	Users Present[3,7]	Users Operating Remotely[4,7]	Users Sending Sample[5,7]	Off-Site Collaborators[6,7]
Senior Investigators, U.S.	40	1	1	16	0	7	17
Senior Investigators, non-U.S.	27	3	2	7	0	7	13
Postdocs, U.S.	7	1	0	5	0	1	1
Postdocs, non-U.S.	6	2	0	5	0	1	0
Students[2], U.S.	23	7	2	17	0	0	6
Students[2], non-U.S.	6	3	0	2	0	0	4
Technician, U.S.	0	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0	0
TOTAL	**109**	**17**	**5**	**52**	**0**	**16**	**41**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 "Students" generally refers to graduate students, but may include a few undergraduate students.
3 "Users Present" includes users physically present in the MagLab user facility during the experiment AND any MagLab-Affiliated or Local users on the experiment.
4 "Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
5 "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.
6 "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).
7 The total of Users Present + Users Operating Remotely + Users Sending Sample + and Off-Site Collaborators will equal the total number of users.

TABLE 2

EMR Facility User Affiliations *for 2012*

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users[4]	National Lab Users[3,4]
Senior Investigators, U.S.	40	12	3	39	0	1
Senior Investigators, non-U.S.	27	0	0	25	0	2
Postdocs, U.S.	7	3	1	7	0	0
Postdocs, non-U.S.	6	0	0	6	0	0
Students, U.S.	23	3	8	22	0	1
Students, non-U.S.	6	0	0	6	0	0
Technician, U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**109**	**18**	**12**	**105**	**0**	**4**

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".
Note for Annual Reporting: Due to programming limitations and the dynamic nature of information in this system, Local Users may include a few NHMFL-Affiliated users who left during the year and whose records have not yet been updated.
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

EMR Facility Users by Discipline *for 2012*

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	40	13	17	1	0	9
Senior Investigators, non-U.S.	27	9	16	1	1	0
Postdocs, U.S.	7	3	3	0	0	1
Postdocs, non-U.S.	6	2	1	0	2	1
Students, U.S.	23	5	10	4	1	3
Students, non-U.S.	6	0	6	0	0	0
Technician, U.S.	0	0	0	0	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**109**	**32**	**53**	**6**	**4**	**14**

TABLE 4

EMR Facility Experimental Requests[1] for Magnet Time *for 2012*

Experiment Requests	Requests Granted	Requests Declined
32	42 (77.78%)	12 (22.22%)

1 Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

EMR Facility Research Proposals[1] Profile *with magnet time*

	Number of Proposals
Condensed Matter Physics	12
Chemistry, Geochemistry	22
Engineering	0
Magnets, Materials, Testing, Instruments	1
Biology, Biochemistry, Biophysics	4
TOTAL	**39**

	Number of Proposals
Minority [2]	2
Female [3]	2

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 6

EMR Facility Operations Statistics *Number of magnet days[1]*

	17 T	12 T	Mossbauer	Total Days Allocated /User Affil.	Percentage Allocated /User Affil.
NHMFL-Affiliated[2]	7.00	25.00	119.00	151.00	28.65%
Local[2]	20.00	26.00	0.00	46.00	8.73%
U.S. University	63.00	39.00	31.00	133.00	25.24%
U.S. Govt. Lab.	0.00	13.00	0.00	13.00	2.47%
U.S. Industry	0.00	0.00	0.00	0.00	0.00%
Non-U.S.	80.00	48.00	56.00	184.00	34.91%
Test, Calibration, Set-up, Maintenance	0.00	0.00	0.00	0.00	0.00%
TOTAL	**170.00**	**151.00**	**206.00**	**527.00**	**100.00%**

1 User Units are defined as magnet days. For the EMR Facility, one magnet day is defined as 24 hours in superconducting magnets.
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 usage equals what was formerly referred to as usage by "Internal Investigators".

TABLE 7

EMR Facility Operations by Discipline *Number of magnet days[1]*

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL-Affiliated[2]	151.00	12.00	125.00	0.00	0.00	14.00
Local[2]	46.00	5.00	36.00	0.00	0.00	5.00
U.S. University	133.00	46.00	67.00	0.00	0.00	20.00
U.S. Govt. Lab.	13.00	13.00	0.00	0.00	0.00	0.00
U.S. Industry	0.00	0.00	0.00	0.00	0.00	0.00
Non-U.S.	184.00	45.00	129.00	0.00	10.00	0.00
Test, Calibration, Set-up, Maintenance	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	**527.00**	**121.00**	**357.00**	**0.00**	**10.00**	**39.00**

1 User Units are defined as magnet days. For the EMR Facility, one magnet day is defined as 24 hours in superconducting magnets.
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 usage equals what was formerly referred to as usage by "Internal Investigators".

TABLE 8

EMR Facility New User PIs[1] *(3)*

Name	Organization	Proposal	Year of Magnet Time
Tovar, John	Johns Hopkins University	P01888	TBD
Bienkiewicz, Ewa	Florida State University	P01982	2012
Ritter, Tobias	Harvard	P02024	2011

1 This table lists users serving as a principal investigator for the first time, and whose proposal was submitted during this year. It also shows the year in which magnet time was received. TBD stands for To Be Determined, indicating it has not yet been allotted magnet time.

Ion Cyclotron Resonance Facility User Statistics

Users, Requests and Operations: January 1, 2012 to December 31, 2012

TABLE 1

ICR Facility User Demographics *for 2012*

	Users	Female	Minority[1]	Users Present[3,7]	Users Operating Remotely[4,7]	Users Sending Sample[5,7]	Off-Site Collaborators[6,7]
Senior Investigators, U.S.	67	12	2	22	0	31	14
Senior Investigators, non-U.S.	17	3	2	4	0	5	8
Postdocs, U.S.	14	5	2	11	0	2	1
Postdocs, non-U.S.	3	0	1	1	0	0	2
Students[2], U.S.	25	14	3	21	0	2	2
Students[2], non-U.S.	4	2	0	0	0	4	0
Technician, U.S.	2	1	1	1	0	0	1
Technician, non-U.S.	0	0	0	0	0	0	0
TOTAL	**132**	**37**	**11**	**60**	**0**	**44**	**28**

1 Minority status includes American Indian, Alaska Native, Black or African American, Hispanic, Native Hawaiian or other Pacific Islander. Minority status excludes Asian and White-Not of Hispanic Origin.
2 "Students" generally refers to graduate students, but may include a few undergraduate students.
3 "Users Present" includes users physically present in the MagLab user facility during the experiment AND any MagLab-Affiliated or Local users on the experiment.
4 "Users Operating Remotely" refers to users who operate the magnet system from a remote location. Remote operations are not currently available in all facilities.
5 "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.
6 "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).
7 The total of Users Present + Users Operating Remotely + Users Sending Sample + and Off-Site Collaborators will equal the total number of users.

TABLE 2

ICR Facility User Affiliations *for 2012*

	Users	NHMFL Affiliated Users[1]	Local Users[1]	University Users[2,4]	Industry Users [4]	National Lab Users [3,4]
Senior Investigators, U.S.	67	10	8	52	10	5
Senior Investigators, non-U.S.	17	0	0	13	1	3
Postdocs, U.S.	14	4	6	13	0	1
Postdocs, non-U.S.	3	0	0	0	0	3
Students, U.S.	25	8	9	25	0	0
Students, non-U.S.	4	0	0	4	0	0
Technician, U.S.	2	1	0	2	0	0
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**132**	**23**	**23**	**109**	**11**	**12**

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".
Note for Annual Reporting: Due to programming limitations and the dynamic nature of information in this system, Local Users may include a few NHMFL-Affiliated users who left during the year and whose records have not yet been updated.
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

ICR Facility Users by Discipline *for 2012*

	Users	Condensed Matter Physics	Chemistry, Geochemistry	Engineering	Magnets, Matls., Testing, Instruments	Biology, Biochemistry, Biophysics
Senior Investigators, U.S.	67	0	35	0	1	31
Senior Investigators, non-U.S.	17	0	13	0	0	4
Postdocs, U.S.	14	0	7	0	1	6
Postdocs, non-U.S.	3	0	3	0	0	0
Students, U.S.	25	0	13	0	2	10
Students, non-U.S.	4	0	3	0	0	1
Technician, U.S.	2	0	1	0	0	1
Technician, non-U.S.	0	0	0	0	0	0
TOTAL	**132**	**0**	**75**	**0**	**4**	**53**

TABLE 4

ICR Facility Experimental Requests[1] for Magnet Time *for 2012*

Days Requested	Days Granted	Days Declined
73	82 (85.42%)	14 (14.58%)

1 Due to operational differences, experimental requests for magnet time are measured differently among facilities. A request for NMR magnet time is measured in the number of days requested. A request for DC Field magnet time is measured in weeks. In the PFF, High B/T, EMR, and ICR facilities, the number of requests is equal to the number of experiments. For any given year, the time (or requests) granted and the time (or requests) declined may not equal the total number of requests. This is because (1) magnet time may be granted to experiments submitted in a prior year and/or (2) in NMR and DC Field facilities, the days or weeks granted may be more (as in the case of a user getting exceptional results) or less than what was requested due to operational limitations.

TABLE 5

ICR Facility Research Proposals[1] Profile *with magnet time*

	Number of Proposals
Condensed Matter Physics	0
Chemistry, Geochemistry	49
Engineering	0
Magnets, Materials, Testing, Instruments	7
Biology, Biochemistry, Biophysics	17
TOTAL	**73**

	Number of Proposals
Minority [2]	3
Female [3]	13

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 6

ICR Facility Operations Statistics *Number of magnet days[1]*

	14.5 T Hybrid	9.4 T Passive	9.4 T Active	Total Days Allocated /User Affil.	Percentage Allocated /User Affil.
NHMFL-Affiliated[2]	210.00	201.00	5.00	416.00	43.56%
Local[2]	10.00	40.00	220.00	270.00	28.27%
U.S. University	70.00	67.00	13.00	150.00	15.71%
U.S. Govt. Lab.	0.00	4.00	0.00	4.00	0.42%
U.S. Industry	1.00	64.00	0.00	65.00	6.81%
Non-U.S.	1.00	26.00	12.00	39.00	4.08%
Test, Calibration, Set-up, Maintenance	6.00	5.00	0.00	11.00	1.15%
TOTAL	**298.00**	**407.00**	**250.00**	**955.00**	**100.00%**

1 For the ICR Facility, one magnet day is defined as 24 hours of use.
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 usage equals what was formerly referred to as usage by "Internal Investigators."

TABLE 7

ICR Facility Operations by Discipline *Number of magnet days[1]*

	Total Days[1] Allocated /User Affil.	Condensed Matter Physics	Chemistry, Geochem.	Engineering	Magnets, Matls, Testing, Instruments	Biology, Biochemistry, Biophysics
NHMFL-Affiliated[2]	416.00	0.00	185.00	0.00	184.00	47.00
Local[2]	270.00	0.00	260.00	0.00	0.00	10.00
U.S. University	150.00	0.00	62.00	0.00	0.00	88.00
U.S. Govt. Lab.	4.00	0.00	2.00	0.00	0.00	2.00
U.S. Industry	65.00	0.00	65.00	0.00	0.00	0.00
Non-U.S.	39.00	0.00	39.00	0.00	0.00	0.00
Test, Calibration, Set-up, Maintenance	11.00	0.00	0.00	0.00	11.00	0.00
TOTAL	**955.00**	**0.00**	**613.00**	**0.00**	**195.00**	**147.00**

1 For the ICR Facility, one magnet day is defined as 24 hours of use.
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 usage equals what was formerly referred to as usage by "Internal Investigators".

TABLE 8

ICR Facility New User PIs[1] *(20)*

Name	Organization	Proposal	Year of Magnet Time
Williams, Henry	Florida Agricultural & Mechanical University	P01964	2012
Perminova, Irina	Lomonosov Moscow State University	P01992	2012
Schaefer, Mathias	University Cologne	P02003	2012
Van Stipdonk, Michael	Lawrence University	P02064	2012
Gray, Murray	University of Alberta	P02080	2012
Mosher, Jennifer	Stroud Water Research Center	P02099	2012
Cleaves, Henderson	Blue Marble Space Institute of Science	P02101	2012
Klein, Geoffrey	Christopher Newport University	P02117	2012
Cohen, Samuel	University of Nebraska	P02119	2012
Dass, Amala	University of Mississippi	P02130	2012
Watts, Michael	FAMU-FSU College of Engineering	P02136	TBD
Johnson, Mark	Yale University	P02144	2012
Rastinejad, Fraydoon	Sanford-Burnham Medical Research Institute	P02166	2012
Trakselis, Micheal	University of Pittsburgh	P02202	2013
Freitas, Michael	Ohio University Medical Center	P02204	2012
Suzuki, Teruo	Japan Petroleum Energy Center	P02212	2012
Bobier, Dwight	Calfrac Well Services Ltd.	P02214	2012
Marto, Jarrod	Harvard Medical School	P02215	2012
Johs, Alexander	Oak Ridge National Laboratory	P02218	2012
Zhou, Zhigao	Old Dominion University	P02286	TBD

1 This table lists users serving as a principal investigator for the first time, and whose proposal was submitted during this year. It also shows the year in which magnet time was received. TBD stands for To Be Determined, indicating it has not yet been allotted magnet time.

APPENDIX B

Users Committee Report

(Reprint on the 2012 Users Committee Meeting Report)

The User Committee thanks the NHMFL director, management, scientific staff and administrative assistants for their time, energy and hospitality in hosting the recent User Committee meeting, and for their responsiveness to the Committee's requests for dynamic modification of the schedule during the meeting. We also thank the National Science Foundation, the State of Florida, Florida State University, the University of Florida, and Los Alamos National Laboratory for their continuing generous, long-term support of the Lab.

Report on the 2012 NHMFL User Advisory Committee meeting held in Tallahassee from Thursday, Nov. 8 – Saturday, Nov. 10, 2012

Chair: Ian Fisher, Department of Applied Physics, Stanford University.
DC/Pulsed/High B/T Vice-Chair: Nicholas Curro, Department of Physics, UC Davis
NMR/MRI/ICR/EMR Vice-Chair: Robert Schurko, Departments of Chemistry and Biochemistry, University of Windsor

User committee members for 2013:
I. Jonathan Amster (University of Georgia); Dmitri Artemov (Johns Hopkins University); Steve Beu (S. C. Beu Consulting); Christoph Boehme (University of Utah); Ari Borthakur (University of Pennsylvania); David Britt (UC Davis); Kenneth Burch (University of Toronto); Joanna Collingwood (University of Warwick); Linda Columbus (University of Virginia); Myriam Cotton (Hamilton College); Nicholas Curro (University of California Davis); Ian Fisher (Stanford University); Roy Goodrich (George Washington University); Michael Greig (Pfizer Global R&D); Michael Harrington (Huntington Medical Research Institutes); Jeanie Lau (UC Riverside); Conggang Li (Wuhan Institute of Physics & Mathematics); Manish Mehta (Oberlin College); Gavin Morley (University of Warwick); David C. Muddiman (North Carolina State University); Janice Musfeldt (University of Tennessee-Knoxville); Cedomir Petrovic (Brookhaven National Laboratory); Tatyana Polenova (University of Delaware); Oliver Portugall (Laboratoire National des Champs Magnétiques Intenses); Scott Prosser (University of Toronto); Marek Pruski (Ames Laboratory); Mark Rance (University of Cincinnati); Rob Schurko (University of Windsor); Alexandra Stenson (University of South Alabama); Stefan Stoll (University of Washington); Makariy Tanatar (Ameslab); Joshua Telser (Roosevelt University); Fang Tian (Penn State University); Ivan Tkac (University of Minnesota); Evan Williams (UC Berkeley); Sergei Zvyagin (Dresden High Magnetic Field Laboratory).

Committee members who served in 2012, and are now retiring:
Paul Goddard (Oxford); Vesna Mitrovic (Brown University); John Schlueter (Argonne National Laboratory).
(Thank you for your service!)

Executive Summary

First and foremost, the User Committee commends the NHMFL for their tremendous technical and scientific advances and achievements during the last year, including the achievement of science at 100 T, and for continuing to provide users with access to world-leading facilities. We also congratulate the lab for their successful renewal, and extend to them the thanks and appreciation of the wide user community for the substantial effort that this achievement required from everyone in the lab.

The lab continues to be well-managed, resulting in the availability of excellent facilities for a broad and growing community of users. The dedication and quality of management, scientific scholars and technical staff is impressive, and is a cornerstone of the lab's success. The recent promotion of the head of the DC program presents an opportunity to continue this strong tradition with the appointment of a new leader, and the committee was encouraged to hear that the lab will work closely with the User Committee, the External Advisory Committee and the resident scholar scientists in the associated search process.

Within the realm of the DC/Pulsed Field/High B/T facilities, the committee was pleased to hear about the opening of an additional bay in the High B/T facility, the transition of the 25 T split coil magnet to user operations (and the associated successful MRI proposal), the new top-loading cryostats, the upgrades to the helium purifier, liquefier and eventual distribution box, and the progress towards the 32 T all-superconducting magnet. Recognizing that budgets are tight, the committee still encourages the lab to vigorously pursue the realization of a 41 T 28 MW resistive magnet as a high priority, to the extent that this is possible within the given constraints. Such a magnet would provide two facilities for research in DC fields above 40 T, and ensure the continued vitality of the DC program if the hybrid magnet failed for any extended period of time. From the user perspective, availability of additional user time would of course be very welcome, and we comment below on the various proposals for weekend operations that were presented. The committee suggests seeking additional input from the broader user community in order to ensure that any investment in this direction is optimally matched to user needs, in particular with regard to the specific demand for weekend operations, and the way that user time is configured for such operations. The DC program is a core program of the NHMFL, and the committee felt that extended access should be pursued simultaneous with the development of new magnet facilities. Nevertheless, the general feeling was that development and implementation of the new 41 T magnet would on the whole benefit the user community more than increasing access to the existing resistive magnets, although ideally both actions should be pursued in tandem.

Within the magnetic resonance program, the committee was pleased with the development of new technologies over the last year, including the addition of an 800 MHz spectrometer with a new Bruker console, the 900 MHz imaging spectrometer, and the development of specialized NMR probes. The committee commends the lab for the hiring of a number of excellent quality scientific staff, as well as the partial appointment of L. Frydman. Concern was expressed over the impact of potential budget cuts to the NMR program, and over the need for an uninterruptable power supply for the 21T ICR system, both of which are discussed in greater detail below.

Finally, we commend the lab for continuing to run their highly successful summer school. We urge the lab to continue hosting this superb event, which acts to draw new users to the lab, advertise the range of available experiments and facilities, and educate students from a broad range of backgrounds.

Report on DC–Pulsed Field–High B/T facilities:

Contributors to the DC-Pulsed Field – High B/T report

The committee comprises…

- Kenneth Burch (Univ. of Toronto),
- Nicholas Curro (UC Davis),
- Ian Fisher (Stanford Univ.),
- Paul Goddard (Oxford Univ.),
- Roy Goodrich (George Washington Univ.),
- Jeanie Lau (UC Riverside),
- Vesna Mitrovic (Brown Univ.),
- Janice Musfeldt (UT Knoxville),
- Cedomir Petrovic (Brookhaven Nat'l Lab),
- Oliver Portugall (Laboratoire National des Champs Magnétiques Intenses, CNRS),
- John Schlueter (Argonne Nat'l Lab),
- and Makariy Tanatar (Ames Lab).

1. Management

The committee thanks the Director and management for discussing in depth the new organization chart. The promotion of the previous head of the DC program presents an opportunity to consider the leadership roles that might be associated with such a position. The smooth running of such extensive user facilities demands the full time attention of a dedicated manager. This job has been very ably performed in recent years to the considerable benefit of the user community, and we thank Eric Palm for his tireless and dedicated service in that role. Considering the new organization chart, it is apparent that all of the other, admittedly smaller, user programs at either FSU or UF are associated with a faculty level head – i.e. a scientist of international stature whose role is to help shape/defend/advocate intellectual themes represented within their program and mentor associated scholar scientists. While acknowledging that the DC program covers broad intellectual ground, nevertheless, the Committee recommends that the lab consider ways to attract a faculty level senior

Condensed Matter Physics scientist to *head* the program, coupled to a dedicated manager whose role is to smoothly *administer* the program. This leadership role has historically been ably assumed by the current Director, but as the lab has grown, and the tasks associated with directing the lab have grown in proportion, it seems timely to at least consider whether such a faculty level leadership position (akin to a Chief Scientific Officer in the realm of condensed matter physics) might be beneficial to the long term vision and vitality of the program. We encourage the lab to include members of the User Committee, the External Advisory Committee and local scholar scientists in the discussion and any eventual search process.

2. DC facilities

The committee was pleased to see that the split coil magnet has successfully passed all of the preliminary tests and is now regularly employed by users to explore new science. This represents a tremendous technological advance, and is already enabling new science. The next step for this system is to implement the motor assembly to rotate the magnet by ninety degrees.

A significant advance during the past year is the liquefier upgrade, including a helium purifier. These advances improve the cryogenic operations, and will reduce the overall costs of operation.

The committee was impressed by, and pleased with, the plan to design and build a new 41T/ 28 MW DC system. This technological advance is possible because of improvements in the power supplies. It would provide users with a second DC system operating above 40 T, and of course a valuable backup should the hybrid ever fail. Ideally this would not mean removing a working 35T/20MW system, but rather adding a new magnet to the suite of DC systems available to users.

The committee discussed the various options to increase the magnet time available to users, and the consensus was that option II as presented at the User Meeting (i.e. full weekend operations, with two users) would offer the best compromise. This schedule would provide an option for users to perform short term experiments, and could also increase the access of the staff scientists/ scholars to the high field magnets for testing/calibration of equipment. (These tests are often necessary but usually undertaken during external user visits.) Since additional staff are necessary to run the magnets during these weekend shifts, it is more efficient to run full weekend operations (option II) than half (option I, with just one user), although the power costs would of course be higher. The committee nevertheless suggests that the lab first determines the user demand for 2-day weekend experiments before making the necessary investments in human resources. Are there a sufficient number of users who could perform their experiments in a shorter, more intense, two day period? Should we consider allowing proposals for experiments lasting 7 days rather than 5 days? The user committee could help by surveying the broader user community if this would be helpful.

Although the user committee would like to see both the implementation of more high field magnets as well as an increase in user time, it is clear that there are clear budget constraints and we feel that the management has taken a wise approach to both approaches. In particular, we commend the plans to balance new magnets with developing new/better/advanced experimental probes that users can use, guided by input from the science council and the user committee.

As a final comment, the users continue to like flextime. Having a fixed energy budget is working well, and users feel comfortable with and understand the procedures to request additional MWhrs when the completion of successful experiments demands it. In short, this system is working well, and we like it.

3. High B/T facility

The high B/T facility is well-managed, operates efficiently, and continues to generate/enable top quality science. The committee was pleased to hear about the opening of another bay, effectively expanding operations for users. Even so, the committee notes that waiting times are very long for well rated proposals to finally receive magnet time, and we encourage the lab to further push to open Bay 1 to full user access (which has so far been reserved for internal users), and to hire the necessary staff scientist to make this possible, within funding constraints.

4. Pulsed Field facility

First and foremost, the user committee congratulates the lab on its recent highly-visible success in achieving 100 T and the associated high-profile science that has emerged already. The facility is well-managed, and enables key science that cannot be done anywhere else. The user committee was, however, concerned about the potential issues facing the pulsed field facility in terms of the availability of materials for the magnet components for replacement parts. These challenges could pose a problem for the user community, and we are glad to see that the management is actively working on potential solutions with sufficient foresight. The committee was presented with several longer term goals to bring new magnets up to full user support, including the "100 * 100" T magnet (i.e. 100 shots at 100 T), a "shorter" pulse magnet, and the 300 T single turn. Noting that each of these magnets presents its own unique challenges for performing experiments, we recommend that the Scientific Council play an active role in establishing the relative priority of these different projects based on scientific drivers and projected user-base.

Report on the Magnetic Resonance Division

I. Nuclear Magnetic Resonance

Contributors to the NMR section of this report:

- Robert W. Schurko (Univ. of Windsor, UC co-chair, MR division)
- Tatyana Polenova (Univ. of Delaware, past UC co-chair, MR division)
- Marek Pruski (Ames Lab, Iowa State Univ.)
- Richard L. Magin (Univ. of Illinois at Chicago)
- Manish Mehta (Oberlin College)
- Fang Tian (Penn State)
- Michael Harrington (Huntington Medical Research Institute)

1. Overview

The NMR Users' Committee is pleased with progress made at the NHMFL over the past year in terms of development of new technologies, fundamental and applied research, and broader impact, as indicated by the large number of high quality publications. Of particular note is the impact of Prof. Lucio Frydman in the role of chief scientist, the acceleration of the DNP NMR program, and the hiring of three new staff scientists. The user base has slightly expanded from last year, and a diverse array of research areas are currently being supported, including chemistry, biochemistry and materials science, with target research areas in energy, biostructural characterization, metabolomics and magnetic resonance imaging. Major concerns of the Committee include the potential impact of budget cuts on the NMR facilities, and the wider effect that this may have on the many external users (see below), and the need for continued support for equipment, infrastructure and staff to serve the large user community. Overall, the future of the high-field NMR laboratories and programs appears to be very bright, especially in terms of making enormous impacts in technology development for NMR experimentation, and expanded application of these technologies across many disciplines.

2. Personnel

The 25% appointment of Prof. Frydman has been a tremendous success. During his short tenure as NHMFL chief scientist, he has played a very positive role in many of the developments outlined in this report. The committee applauds his leadership in the successful NSF-MRI proposal for a DNP instrument. This project is a prime example of how Dr. Frydman has energized the DNP initiative and has hit the ground running at the NHMFL. That the award was used to leverage funds from the State of Florida is also noteworthy (this was a smart, intentional step to avoid any deleterious effects on the user programs by potentially diverting funds away from it, and consistent with User Committee recommendations from last year). Another beneficial byproduct of his appointment has been a new collaborative relationship with the Weizmann Institute. In addition, three staff scientists have been hired in the last year (Malathy Elumalai, Sungsool Wi and Srinivasan Shekar). Wi and Shekar are Ph.D.-level scientists who bring complementary expertise to their respective areas. The Committee also applauds the excellence of these candidates, as well as the gender and ethnic diversity they represent. We note that the management at the NHMFL has been proactive in responding to issues raised regarding diversity in the NSF site visit panel report. The Committee encourages the management at the NHMFL to sustain their attention to diversity in their hiring for the internal staff. The diversity within the external user community is also noteworthy.

The management and staffing structure at the NHMFL are lean and horizontal. The leanness of the personnel configuration is impressive, and it should be sustained. The Committee encourages the NHMFL to maintain its high performance-to-personnel quotient.

The addition of new instruments (see below) to the already extensive complement will expand the current capabilities – one that is sure to have a positive impact on the external users. Concomitant with the expansion, though, will be a need for additional staffing to help make optimum use of those resources for the external user community. The Committee anticipates future pressure on staffing that will accompany the addition of new capabilities, and thus encourages the management to take steps to address the staffing needs as they arise.

3. Infrastructure

The following significant changes in infrastructure are noted:

- The committee is pleased to see the addition of an 800 MHz (63 mm) spectrometer (donated by the University of Minnesota) with a new Bruker console (cost $625 K) for solid state NMR.
- Also of importance is the reallocation of the 720 MHz instrument to novel applications for oriented samples, membrane proteins, etc.
- The repurposing of older spectrometers and/or magnets shows that the facility is conscious of funding limitations, and willing to drive innovation and user capabilities by wise equipment and infrastructure acquisitions.
- The committee praises efforts of leveraging of funds from multiple resources to upgrade several instruments and to add a new 700 MHz spectrometer (50% time).
- The committee is in favor of the continued development and use of remotely operated spectrometers, which reduces travel costs and gives user more options to collect data.
- We would like to point out that as more instruments are acquired and repurposed, it is possible that more staffing would be required down the road, in order to maintain a strong portfolio of expertise in all areas (solids, in vivo, DNP, etc.).
- Real efforts have been made to reach out to industry partners including Bruker, Agilent and Revolution NMR to promote common interests and synergies, to avoid duplicated efforts and directions, and focus limited resources on unique methodological and technological developments. Strategically, the committee feels that this is the best practice, and should be continued in the future.
- The committee also notes that technologies developed at

NHMFL have (e.g., low E probe technology) and will become available commercially, to the benefit of the NMR and scientific communities at large.

4. Technological Accomplishments & Future Directions

4.1 HTS Probes

The NMR instrumentation division continues to lead in the development of specialized NMR probes using high temperature superconductors (HTS). Strong collaborations with the major manufacturers (Bruker, Agilent, MR) involve first and second generation probe technology (single and dual nuclei, e.g., ^{13}C-^{1}H). Recent results were presented at the 2012 ENC meeting in Miami, FL. Such advances in mass sensitivity and SNR demonstrate synergy and impact for both NHMFL users and for the emergence of new commercial HTS probe technology.

4.2 900 MHz Imaging Spectrometer

The 900 MHz MR-system is operational and has undergone technical upgrades to improve its capabilities and performance (new frequency lock, double tuned ^{1}H-^{13}C birdcage RF coil, additional shielding). These provide frequency drift compensation for NMR experiments and a new multi-frequency capability for animal imaging studies. One interesting feature of the new probe designs in the exchange of "plug-in" capacitors, which allows single probes to be easily modified for different uses. Another is the migration of high frequency (900 MHz) probe – and animal cradles – designs to the 750 MHz system in Gainesville.

4.3 Magnetic Resonance Imaging Probes

The 900 MHz live animal imaging probe, with surface and volume coils, provides users applications unavailable elsewhere, with dielectric resonator and waveguide technology for ultrahigh field MRI a highly promising and exciting direction in the Lab. There are also double-resonance head coils for ^{1}H-^{23}Na and ^{1}H-^{13}C, and ^{35}Cl imaged physiological events *in vivo* at 21 T and cellular imaging with detail similar to light microscopy. Transferring technology from 900 MHz (Tallahassee) to 750 MHz (Gainesville) expands the user access for high field *in vivo* imaging, illustrated by microimaging diffusivity with 10 μm isotropic resolution.

4.4 Series Connected Hybrid

The 36 T series connected hybrid (40 mm bore, 1 ppm field inhomogeneity) is moving toward operational status (2015). A number of innovations (improved stability, induction field regulation, water-cooled shims) that promise to extend high field performance are incorporated into the new design.

5. Dynamic Nuclear Polarization

The development of DNP capabilities is a major step in terms of advancement of science and technology, and this separate section addresses several keys points.

The Committee is very pleased with the planned development of DNP capabilities included in the 2013-2017 Technology Initiatives. This plan recognizes the great potential of DNP in enhancing NMR's sensitivity and the need of further foundational research in this area. The DNP effect was predicted theoretically, demonstrated experimentally and brought to recent prominence in the American universities by A. W. Overhauser, C. P. Slichter and R. G. Griffin, among others. However, the United States currently lags behind Europe in this area in view of significant investments made recently in Germany, Switzerland, France and the Netherlands. Indeed, the DNP workshop, co-organized jointly by PNNL and the Ames Laboratory in December of 2011, highlighted the pressing demand for user access to DNP instrumentation in the United States and the need for further development of DNP instrumentation and methodology.

The reports presented during the User Committee's Meeting highlighted the fact that NHMFL is very well positioned to develop state-of-the-art DNP NMR capabilities. Lucio Frydman is one of the leading experts in the area of hyperpolarization enhancements, and outstanding expertise in cryogen technology, magnet design, MHz and GHz radiation sources, and probe technology exist in the Laboratory.

Three DNP initiatives are proposed in key areas of DNP NMR: (1) shuttled DNP NMR, performed at very low temperature (~1 K) capable of achieving sensitivity enhancement factor $\varepsilon > 10{,}000$, (2) DNP MAS NMR for solids, with targeted temperature range 80-100 K and $30 < \varepsilon < 200$, and (3) (3) DNP-enhanced solution NMR at room temperature and higher, referred to as Overhauser DNP, with $100 < \varepsilon < 300$. Future development of high-field DNP instrumentation, polarizing agents and methodology may push these sensitivity gains even higher. The Committee strongly recommends that these three key areas of DNP NMR spectroscopy be pursued.

The Committee finds the idea of using one gyrotron source to serve both the Overhauser DNP and MAS DNP to be a clever and cost-effective way of developing a versatile user program. We agree with the EAC recommendation for acquisition of a sweepable wide bore 600 MHz magnet as being an optimum choice for MAS DNP. We are very pleased that most of the funds required for the purchase of the gyrotron and the Overhauser DNP instrument were obtained through the NSF-MRI Program, and trust that any outstanding costs, if needed, will be backed out by the laboratory. Recognizing that the laboratory's resources are limited, we recommend that the following initiatives be given the highest priority: (1) acquisition of the abovementioned 600 MHz magnet and all accessories associated with the beam splitter, and (2) development of low-E high power/80-100 K DNP MAS probe and the necessary cryogenic system, which will be a valuable resource for many users with interest in studying a wide range of low-gamma nuclei in materials science, catalysis and other areas.

6. Science: Diversity of Projects and Disciplines

The Committee notes the excellent diversity of projects/disciplines that relies upon the continued development of new MR technologies. These include:

• Development of DNP technologies for a wide range of applica-

tions in biochemistry and materials chemistry.
- Targeted research areas in new materials for energy storage.
- Inorganic chemistry and biosolids NMR research, which relies on the availability of low-G and low-E enhanced-design MAS probes whose sensitivity and resolution exceeds current commercial probes.
- The imaging and microscopy programs are truly innovative and represent transformative science. The range of systems under analysis ranges from live animals to individual cells, in the latter case the resolution limit is unsurpassed in any other facility worldwide.
- Metabolomics and solution NMR of mixtures continues to be a promising research area.
- Emphasis should be placed upon developing application areas for emerging ultrahigh field magnet technologies (i.e., SCH and HTS systems).

The Committee also notes that the record of peer-reviewed publications is excellent, both in quality and number of papers.

7. Prioritized List of Recommendations

7.1 Synopsis

The committee is generally satisfied with how things are running in terms of NMR-related programs at the NHMFL. We are, however, concerned about the impact of the severe budget cuts on the NMR area, especially the Users' Program and new DNP NMR initiative. We would like to make the following recommendations and comments:

7.2. General management (recommendations from 2010 are still pertinent):

The committee strongly recommends that the following recommendations be carried out:
- Systematic infrastructure support, including maintenance and upgrades of existing equipment, along with support for mid- to ultra-high field strength magnetic resonance spectrometers.
- We recommend continued cooperation and collaboration between the NMR and EMR divisions, which will be crucial for the success of the DNP initiative.
- We advise management to continue to purchase and repurpose NMR spectrometers for a variety of innovative uses. The examples discussed above are good examples of funding-conscious management and scientific teams that are driving innovation while keeping costs down.
- Managers should initiate activities such as outreach programs, advertisements, regular web site updates, email lists, etc. to continue to attract the best users for the ultra-high field NMR systems (see *User base* issues below).
- The committee notes the success of the current collaboration between AMRIS and NHMFL staff in MRI areas, such as DNP, and would like to encourage joint technology developments that have both fundamental and potential clinical significance.

7.3 Budget:

In reviewing the previous budget and proposed cuts for NMR activities, the committee makes the following recommendations:
- It is crucial that the funding be maintained at or close to previous levels for *the NMR and MRI User Experiments*. Cutting this cornerstone of the NMR/MRI budget line by 38% will have adversely negative effects on internal and collaborative research programs.
- Given the success in getting the *DNP NMR program* off the ground (with the combined efforts of Profs. Frydman and Long), we feel it would be unwise to cut this budget line by 77%. The DNP line should be funded in full, perhaps by a combination of state and federal funding. The budget cut would reduce the ability of the NHMFL scientists to compete with burgeoning DNP facilities in Europe, which have benefitted from strong government support. This line item is also very important in terms of collaborations between the NMR and EMR groups – the expertise at the NHMFL and among the users will afford technological developments that are simply not possible anywhere else in the world.
- Given the previous success and ongoing advances in the development and application of l*ow E NMR probes and MRI probes for the 900 MHz* NMR spectrometer, at the NHMFL, we feel that this funding should only be cut by 50% (as opposed to the proposed 77%), so as not to completely hamstring this research area.
- There has been much success in the development of *HTS probes*. The budget line requesting funds for the HTS users program can be absorbed in the *NMR and MRI User Experiments budget*.

7.4 User base and administrative issues:

A major concern is that the user base for the NHMFL NMR facilities (which has been steady in terms of numbers) will be challenging to increase substantially due to limited resources (mostly in terms of staff scientists/scholars to assist new and current users).
- The majority of NMR spectrometers are oversubscribed in terms of users – this is especially apparent for the 600 MHz and 900 MHz instruments in Tallahassee, showing the value of these instruments to scientists around the world. The repurposing of several instruments for novel uses (see above), and the acquisition of new instruments, may alleviate some of this strain.
- In light of the current and incoming scientists, and their wide range of expertise, new users of ultra-high field NMR spectrometers, in vivo high-field NMR techniques and DNP NMR should be actively recruited. The committee notes that it is the strong recruitment practices that have built a diverse user base which has enabled the development of many successful collaborations.
- The continued support for infrastructure, new spectrometers, development of new MR hardware and probes, repurposing of old spectrometers, along with the hiring and retention of scientific/technical personnel, are crucial for the continued development of a strong user base.

Electron Magnetic Resonance

Attendees:

User Committee:
Christoph Boehme, Gavin Morley (in part, by Skype), Stefan Stoll, Josh Telser (Chair), Sergei Zvyagin
Other:
Sandra Stenson (U. South Alabama, ICR User)
FSU/NHMFL:
Steve Hill, Jurek Krzystek, Andrew Ozarowski, Likai Song, Hans van Tol, Sebastian Stoian (in part)
UF: Alex Angerhofer

General

The EMR program at the NHMFL with its outstanding instrumentation and staff is world leading. The user committee is enthusiastic and congratulates it on this continuing extraordinary success. Most impressive is the EMR program's high scientific productivity (10% of the overall NHMFL output; 39 papers already in 2012), relative to its very small share of the NHMFL budget.

HiPER

The committee is impressed by the progress with the recently installed HiPER spectrometer. The committee urges that funding for a 1.3kW high-power amplifier be obtained. Such an amplifier will be critical in leveraging HiPER for high-field biostructural studies (spin labeling, DEER). This will provide capabilities that are unique in the U.S. and will expand the EMR user base significantly. A workshop on the use of HiPER is planned for Spring 2014 to introduce the spectrometer to the wider user community.

Electron Magnetic Resonance

The committee is supportive of proposed, relatively simple hardware improvements in the pulsed and SC systems. Access is also an important issue. Although EMR facilities are booked at or near capacity (e.g., the SC system is booked solidly for the rest of 2012), no concerns were raised about user access. The proposal review process and magnet time allocation is smooth. However, due to this heavy utilization, any downtimes are potentially damaging. Therefore, the committee hopes that sufficient funds are provided to cover routine repair and maintenance.

DC Field

The committee is also supportive of EMR users taking advantage of the NHMFL's remarkable capabilities in resistive and hybrid magnets. EPR experiments are being done in the Keck, 31 T, and 35 T resistive magnets, and the 45 T hybrid. Therefore, EMR users share the concerns of other DC Field users regarding competition for magnet time on these oversubscribed systems. The EMR users join with others in urging that technological, staffing, and other measures be taken to ensure maximum DC magnet time availability. The committee is also very excited about the coming (2 – 3 years) low-power Series-Connected Hybrid (SCH) magnets, which will offer high-resolution – crucial for many EMR applications.

Funding

The committee is impressed with Hill's success in obtaining external funding, which helps keep the lab on its trajectory of technological advance and high scientific impact. The committee urges the EMR staff scientists to similarly leverage core function by seeking external funding, especially in conjunction with collaborative projects with EMR users.

Technology

The committee is strongly supportive of continued development of very high field EPR (using the SCH) in close collaboration with the DC facility and of DNP development, with the NMR facility.

Administrative

A broader issue that EMR users share with other users is the evolving management structure of NHMFL. There should not be an increase in unneeded layers of management; a direct line of communication should be maintained between the NHMFL Director and Deputy Director and the user programs. Such communication is crucial for maintaining and pushing a clear, strong and coherent scientific vision for the lab.

Recommendations (in Priority Order)

- Continue support for the operation and improvement of pulsed and CW EPR spectrometers at NHMFL/FSU (and supporting instrumentation such as FDMRS and magnetic Mössbauer) for the large number and wide scientific range of users. This includes ensuring that there is sufficient budgeting for routine maintenance and repairs.
- Continue the progress with bringing HiPER online. This includes support for hardware (most importantly a high-power amplifier) that is needed to make this pulsed high-field/frequency EMR spectrometer a unique user facility.
- Hire a technical support staff person for the EMR facility who would work on instrument development.
- Obtain dedicated machinist support, which would be in conjunction with the above design-oriented position.
- Support the DC facility by contributing to the development and EPR applications of its existing magnets and the future high-resolution, low power SCH magnets. Making continued, and wider, use of the other DC facilities for EPR experiments.
- Support the DC facility in the hiring of a top-level condensed matter scientist (physicist, chemist, materials scientist, or engineer) as an FSU faculty member to lead the DC facility and provide direction in this core mission of the NMHFL that is also crucial for EMR, with its extensive research in materials areas.
- Support the NMR facility in the development of a DNP spectrometer.
- Encouraging the EMR staff scientists to seek external funding that comes to NHMFL, rather than simply providing support letters for external users' grant proposals.
- Supporting X-/Q-band EPR at UF for regional users.

Ion Cyclotron Resonance

During 2012 Overall User Committee Meeting in Tallahassee, FL, Dr. Alan Marshall gave the User Committee an overview of recent improvements to instrument design that have led to significant enhancement in virtually all parameters of relevance in FT-ICR MS: sensitivity, resolution, mass accuracy, and dynamic range within individual mass spectra. These improvements, achieved through innovations in cell design, ion ejection (from the accumulation region to the ICR cell) and detection mode (collecting in absorption mode) are providing enhancements to existing instruments that are, in some cases, equivalent to doubling the magnetic field. The User Community is truly impressed with these enhancements and some of us have already obtained data that were previously unobtainable (e.g., improvements in sensitivity have allowed the isolation of individual isobars from extremely complex mixtures at sufficient signal abundance to collect tandem MS spectra where previously, on the same instrument, this experiment was unsuccessful).

Dr. Marshall also updated the User Committee on the progress of the 21 T instrument: building expansion to house the new instrument is almost completed, instrument delivery appears to be on schedule (the cryostat has already been built), and the 14.5 T is slated for use as a test-bed for the new instrument. Dr. Marshall indicated that observations from the 14.5 T instrument are already being used to optimize mass spectrometer design for the 21 T instrument. For instance, improvements in overcoming the large fringe field, which has proven somewhat problematic on the 14.5 T in the past, will be incorporated into the new design. The Users' Committee was also enthusiastic about the availability of three different ionization sources on the 21 T instrument.

However, Dr. Marshall indicated one significant concern in relation to the 21 T instrument; as of right now, no line item exists in the NSF grant that funded this instrument for an uninterruptable power supply. The latter is an important layer of protection for such a significant investment. Power outages are rather common, especially in Florida, and can significantly impact instrument lifetime and availability to users. Dr. Marshall mentioned that he has approached the program officer for the NSF grant (independent of the NHMFL core grant) that funded acquisition of the instrument for permission to use remaining funds in that grant to purchase an uninterruptable power supply. The User Community strongly supports this initiative and the purchase of the uninterruptable power supply.

The hiring of Dr. Young as the Biological Applications director to fill the position left vacant by the departure of Dr. Emmett was also announced. The User Community looks forward to a reinvigoration of the user base in this area in response to Dr. Young's appointment. To help with this task, the User Community continues to recommend the hiring of a designated bioinformatics specialist. Currently, the plan is to approach Dr. Yuri Corilo, an informatics expert currently helping with informatics for petroleomics and environmental projects. However, Dr. Corilo is a post-doc in the ICR facility and thus will not be able to provide the necessary continuity in software design, maintenance, and upgrades that is necessary for a world leading user facility.

The User Community continues to be impressed by the ICR facility's ability to attract external funding and collaborators from Industry. The collaborations, especially in the area of petroleomics, have not only led to a closer connection between scientific research and industry but also, in part, been responsible for laying the groundwork in petroleomics research which is proving invaluable against the backdrop of recent oil spill disasters. The recent oil spill in the Gulf of Mexico, especially, demonstrates the far-reaching broader impacts of petroleomics research and expertise accrued at the NHMFL. The User Community considers the NHMFL ICR Facility's inclusion in the Deep C consortium as a natural fit and expects far-reaching insight and important improvement in spill remediation to derive from this collaboration.

Overall, the User Community acknowledges that the ICR program continues to maintain a world-leading role in high field FT-ICR mass spectrometry and complex mixture analysis. The user community is also satisfied with user support, the proposal review process the NHMFL has control over (one user in the recent user survey (8% of responders) objected to the process itself because of concerns with sharing ideas with competitors)), and the availability of user time. We are particularly appreciative that the vast majority of instrument time is allotted to external users and welcome the inclusion of a significant number of new users each year. The User Committee is also pleased with the NHMFL's responsiveness to user input and diversity of research projects.

Targeted needs for the ICR Program

- **Uninterruptable Power Supply** - Power outages are a very real and relatively common problem (compared to other types of complete shutdowns of instrumentation). Therefore, the committee strongly supports the ICR facilities request for permission from NSF to purchase an uninterruptable power supply for the 21 T instrument from the funds remaining in the original 21 T equipment grant.
- The committee looks forward to the availability of the data processing software (MIDAS) compatible with Windows 7.
- **Bioinformatics specialist:** Although we commend the facility's resourcefulness in using in-house talents to fulfill their bioinformatics needs, we recommend that a designated bioinformatics specialist be hired to provide the needed data processing capabilities.

APPENDIX C

Personnel

The MagLab comprises 692 people at FSU, UF, and LANL, who are paid by the NSF core grant, State of Florida funding, individual investigator awards, as well as home institutions and other sources. The demographic distribution is presented below, followed by 10 departmental lists of personnel by NSF classification. All information in this appendix is as of March 28, 2013.

MagLab Faculty & Staff Demographic Report *as of March 28, 2013*

Parameter/ Department	Management & Administration	DC Instru-mentation	MS&T	CM Science & EMR	LANL	CIMAR (NMR & ICR)	UF	ASC	Director's Office	Geo-chemistry	TOTAL	%
Senior Personnel	4	2	21	51	15	37	53	14	3	10	210	30.3%
Postdoc	0	0	2	21	9	11	1	5	1	4	54	7.8%
Other Professional	9	16	22	8	0	5	5	1	10	2	78	11.3%
Graduate Student	1	0	12	60	3	50	0	13	6	24	169	24.4%
Undergraduate Student	1	0	5	18	2	8	0	13	0	4	51	7.4%
Support Staff - Tech./Mgr.	38	17	11	4	12	7	2	1	1	2	95	13.7%
Support Staff - Sec./Clerical	14	0	2	0	2	3	4	3	6	1	35	5.1%
Gender												
Male	41	34	64	131	37	84	52	41	12	24	520	75.1%
Female	26	1	11	31	6	37	13	9	15	23	172	24.9%
Race												
White	52	32	57	102	35	72	53	37	21	35	496	71.7%
Black or African American	11	3	3	4	0	2	0	2	4	2	31	4.5%
Native Hawaiian or Pacific Islander	1	0	0	0	0	0	0	0	0	0	1	0.1%
Asian	3	0	14	56	7	47	12	11	1	10	161	23.3%
American Indian or Alaska Native	0	0	1	0	1	0	0	0	1	0	3	0.4%
Ethnicity												
Hispanic or Latino	2	0	1	2	9	7	1	3	2	1	28	4.0%
Not Hispanic or Latino	65	35	74	160	34	114	64	47	25	46	664	96.0%

Management & Administration Faculty & Staff (67)

1 - Senior Personnel
Cordi, Thomas – Assistant Lab Director, Business Administration
Davidson, Michael – Assistant Scholar / Scientist
Rea, Clyde – Assistant Director, Business & Financial / Auxiliary Services
Zhu, Lei – Assistant Professor

3 - Other Professional
Brooks, Richard – Facilities Superintendent
Clark, Eric – Application Developer/Designer
Jiang, Tiehu – Assistant in Research
Kynoch, John – Assistant Director
McCrory, Marcia – Budget Analyst
McEachern, Judy – Assistant Director, Business Systems
Payne, Jimmy – Scientific Research Specialist
Thomas, Carey – Budget Analyst
Wood, Marshall – Facilities Electrical Supervisor

4 - Graduate Student
Wilson, Korey – Microscopist

5 - Undergraduate Student
Guan, Suzhe – Accounting Clerk

6 - Support Staff - Technical/Managerial
Allbaugh, Tony – Skilled Trades Worker
Allen, John – Laboratory Assistant / Technician
Andrews, David – Maintenance Mechanic
Baird, Michelle – Microscopist
Bozik, James – Web Designer/Programmer
Braverman, Kenneth – Research Assistant
Brown, Alfie – Engineering Technician
Childs, John – Graphic Artist
Cone, Raymond – Skilled Trades Worker
Cook, James – Maintenance Mechanic
Coulliette, Steven – Maintenance Mechanic
Coyne, Sean – Facilities Engineer
Cranfill, Paula – Microscopist
DiGirolamo, Jade – Laboratory Assistant / Technician
Eck, Christopher – Maintenance Support Worker
Finn, Sarita – Web Designer/Programmer
Gamble, Kevin – Research Assistant
Greenlee, Reshaye – Accounting Specialist
Hahn, David – Web Designer/Programmer
Hendrickson, Kayla – Microscopist
Howe, Elizabeth – Microscopist
John, Kevin – Graphic Artist
Johnson, Steve – Maintenance Mechanic
Kirschner, Matthew – Programmer
Labaddan, Rosel – Microscopist
Lewis, Raymond – Scientific & Research Technician
Ludlow, Richard – Graphic Artist
Malik, Cathy – Microscopist
Nixon, Willie – Scientific & Research Technician
Oxendine, Christopher – Scientific & Research Technician
Paul, Randy – Maintenance Superintendent
Phinazee, Billy – Maintenance Mechanic
Piper, Zachary – Programmer
Robinson, Paul – Maintenance Support Worker
Sell, Brittney – Microscopist
Steenerson, Christopher – Graphic Artist
Yevtich, Deborah – Laboratory Assistant / Technician
Young, Aaron – Engineer Technician

7 - Support Staff - Secretarial/Clerical
Burton, Gwendolyn – UBA Accounting Associate
Cobb, Damaris – Program Associate, Purchasing
Fagg, Deborah – Accounting Associate
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
Mayfield, Melody – Admin Support Assistant
Paschal, Melanie – Procurement Associate
Roberts, Christopher – Shipping/Receiving Clerk
Sheffield, Mildred – Clerk
Stafford, Holly – Administrative Support Assistant

DC Instrumentation Faculty & Staff (35)

1 - Senior Personnel
Hannahs, Scott – Dir, DC Facilities and Instrumentation
Murphy, Timothy – Research Associate, Interim Director, DC User Program

3 - Other Professional
Berhalter, James – Technology Specialist
Billings, Jonathan – Scientific Research Specialist
Boenig, Heinrich – Engineer
Bonninghausen, Russell – Research Engineer
Dalton, Bryon – Scientific Research Specialist
Jensen, Peter – Network Administrator
Jones, Glover – Scientific Research Specialist
Maier, Scott – Scientific Research Specialist
Pouliotte, Matthew – Technology Specialist
Powell, James – Research Engineer
Pucci, John – Research Engineer

Rubes, Edward – Scientific Research Specialist
Schwartz, Robert – Scientific Research Specialist
Schwerin, John – Technology Specialist
Semenov, Dmitry – Scientific Research Specialist
Williams, Vaughan – Research Engineer

6 - Support Staff - Technical/Managerial

Allen, Brian – Programmer
Brehm, William – Technician/Research Designer
Carrier, Robert – Technical/Research Designer
Coker, Alexander – Programmer
DeGraff, Tim – Research Assistant
Freeman, Daniel – Technical/Research Designer
Gordon, Larry – Scientific Research Specialist
Hicks, Michael – Technical/Research Designer
Oliff, Morgan – Technical/Research Designer
Petty, Joseph – Technical/Research Designer
Piotrowski, Joel – Technical/Research Designer
Pullum, Bobby – Scientific & Research Technician
Sloan, David – Technician/Research Designer
Smith, Dylan – Technical Support Analyst
Stiers, Eric – Technical/Research Designer
Szelong, Dustin – Technology Specialist
Trociewitz, Bianca – Scientific Research Specialist

MS&T Faculty & Staff (75)

1 - Senior Personnel

Bai, Hongyu – Assistant Scholar / Scientist
Bird, Mark – Scholar / Scientist, Director, Magnet Science & Technology
Crooks, Roy – Visiting Assistant Scholar / Scientist
Dixon, Iain – Research Associate
Gavrilin, Andrey – Scholar / Scientist
Guo, Wei – Professor
Han, Ke – Scholar / Scientist
Hilton, David – Assistant Scholar / Scientist
Kalu, Peter – Professor
Lu, Jun – Assistant Scholar / Scientist
Markiewicz, William – Scholar / Scientist
Marshall, William – Research Associate
Painter, Thomas – Research Associate
Tan, Xiaohua – Visiting Assistant Scholar / Scientist
Toth, Jack – Scholar / Scientist
Van Sciver, Steven – Professor
Walsh, Robert – Research Associate
Weijers, Hubertus – Associate Scholar / Scientist
Xin, Yan – Associate Scholar / Scientist
Zavion, Sheryl – Program Director
Zuo, Xiaowei – Visiting Assistant Scholar / Scientist

2 - Postdoc

Chagovets, Tymofiy – Postdoctoral Associate
Niu, Rongmei – Postdoctoral Associate

3 - Other Professional

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 – Welder/Technician
Marks, Emsley – Research Engineer
Mellow, Amy – Adminstrative Specialist
Miller, George – Research Engineer
Napier, Sarah – Research Assistant
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

4 - Graduate Student

Allampalli, Surya Prakash – Graduate Research Assistant
Bosque, Ernesto – Graduate Research Assistant
Brown, Daniel – Graduate Research Assistant
Carter, Richard – Research Assistant
Deng, Liping – Research Assistant
Dhuley, Ram – Graduate Research Assistant
Gao, Jian – Graduate Research Assistant
Gordon, Renee – Research Assistant
Harwood, Parker – Graduate Research Assistant
Hurd, Joseph – Graduate Research Assistant
Scott, Valesha – Graduate Research Assistant
Vanderlaan, Mark – Graduate Research Assistant

5 - Undergraduate Student

Arroyo, Erick – Technician
Baker, Daniel – Technician
Dellinger, Kegan – Laboratory Assistant / Technician
Hartley, Heath – Engineering Technician
McRae, Dustin – Engineering Technician

6 - Support Staff - Technical/Managerial

Brown, Hunter – Technician
Carter, Steven – Technician
Deterding, Justin – Research Engineer
English, Charles – Research Engineer
Helms, Randy – Technician
Hill, Scott – Technician

Hollett, Donald – Research Grant Coordinator
McGuire, David – Research Engineer
Ray, Christopher – Technical/Research Designer
Walsh, Nicole – Technician
Windham, Carl – Research Assistant

7 - Support Staff - Secretarial/Clerical
Dong, Xiaohan – Administrative Finance Analysis
Maddox, James – Program Associate

Condensed Matter Science @ FSU Faculty & Staff (138)

1 - Senior Personnel
Albrecht-Schmitt, Thomas – Professor
Balicas, Luis – Scholar / Scientist
Bonesteel, Nicholas – Professor
Brooks, James – Professor
Cao, Jianming – Associate Professor
Chiorescu, Irinel – Professor
Choi, Eun Sang – Associate Scholar / Scientist
Dobrosavljevic, Vladimir – Professor
Engel, Lloyd – Scholar / Scientist
Gilmer, Penny – Adjunct Professor
Gor’kov, Lev – Professor
Graf, David – Assistant Scholar / Scientist
Hoch, Michael – Visiting Scientist/Researcher
Jaroszynski, Jan – Assistant Scholar / Scientist
Knappenberger, Kenneth – Assistant Professor
Kovalev, Alexey – Assistant in Materials Instrumentation
Kuhns, Philip – Scholar / Scientist
Li, Zhiqiang – Assistant Scholar / Scientist
Manousakis, Efstratios – Professor
McGill, Stephen – Assistant Scholar / Scientist
Moulton, William – Professor
Oates, William – Assistant Professor
Park, Ju-Hyun – Assistant Scholar / Scientist
Popovic, Dragana – Scholar / Scientist
Ramakrishnan, Subramanian – Associate Professor
Reyes, Arneil – Scholar / Scientist
Rikvold, Per – Professor
Schlottmann, Pedro – Professor
Schneemeyer, Lynn – Visiting Associate in
Shatruk, Mykhailo – Assistant Professor
Siegrist, Theo – Professor
Smirnov, Dmitry – Associate Scholar / Scientist
Suslov, Alexey – Associate Scholar / Scientist
Telotte, John – Associate Professor
Tozer, Stanley – Scholar / Scientist
Vafek, Oskar – Assistant Professor
Warusawithana, Maitri – Assistant Professor
Whalen, Jeffrey – Assistant Scholar / Scientist
Winger, Ian – Associate in
Yang, Kun – Associate Professor
Zhang, Mei – Associate Professor
Zhou, Haidong – Visiting Scientist/Researcher

2 - Postdoc
Besara, Tiglet – Postdoctoral Associate
Chen, Zhiguo – Postdoctoral Associate
Coniglio, William – Postdoctoral Associate
Constantinescu, Anca-Monia – Postdoctoral Associate
Cvetkovic, Vladimir – Postdoctoral Associate
Goswami, Pallab – Postdoctoral Associate
Hatke, Anthony – Postdoctoral Associate
Lai, Hsin-Hua – Postdoctoral Associate
Lin, Ping – Postdoctoral Associate
Moon, Byoung Hee – Postdoctoral Associate
Park, Jin Gyu – Postdoctoral Associate
Poumirol, Jean-Marie – Postdoctoral Associate
Pradhan, Nihar – Postdoctoral Associate
Roy, Bitan – Postdoctoral Associate
Throckmorton, Robert – Postdoctoral Associate
Tokumoto, Takahisa – Postdoctoral Associate
Wang, Liran – Postdoctoral Associate
Zeng, Bin – Postdoctoral Associate

3 - Other Professional
Hedick, Katherine – Media Specialist
Javed, Arshad – Grants Compliance Analyst
Kim, Younghee – Research Assistant
Steven, Eden – Research Assistant
Sun, Liang – Visiting Scientist/Researcher
Toth, Anke – Program Coordinator
Wood, Ryan – Visiting Scientist/Researcher

4 - Graduate Student
Baity, Paul – Graduate Research Assistant
Benjamin, Shermane – Graduate Research Assistant
Brodeur, Gary – Graduate Research Assistant
Chakraborty, Shantanu – Graduate Research Assistant
Cherian, Judy – Graduate Research Assistant
Cipri, Robert – Graduate Research Assistant
Clayton II, Charles – Graduate Research Assistant
Coulter, John – Graduate Research Assistant
Daniel, Alden – Graduate Research Assistant
Das, Suvadip – Graduate Research Assistant
Dong, Lianyang – Graduate Research Assistant
Ellanson, Garrett – Graduate Research Assistant
Feng, Weibo – Graduate Research Assistant
Ghosh, Soham – Graduate Research Assistant
Javan Mard, Hossein – Graduate Research Assistant
Kiswandhi, Andhika – Graduate Research Assistant
Kreth, Phillip – Graduate Research Assistant
Lai, You – Graduate Research Assistant
Lee, Minseong – Graduate Research Assistant
Li, Dong – Graduate Research Assistant

Liu, Teng – Graduate Research Assistant
Lovett, Jonathan – Graduate Research Assistant
Ludwig, Jonathan – Graduate Research Assistant
Lundberg, Matthew – Graduate Research Assistant
Magill, Brenden – Graduate Research Assistant
Mahmoudian, Samiyeh – Graduate Research Assistant
Martens, Mathew – Graduate Research Assistant
Moench, Michael – Research Assistant
Murray, James – Graduate Research Assistant
Pouranvari, Mohammad – Graduate Research Assistant
Pramudya, Yohanes – Graduate Research Assistant
Ramirez, Daniel – Graduate Research Assistant
Redmon, Carissa – Graduate Research Assistant
Rhodes, Daniel – Graduate Research Assistant
Riner, Lauren – Research Assistant
Stillwell, Ryan – Graduate Research Assistant
Sun, Jifeng – Graduate Research Assistant
Tang, Shao – Graduate Research Assistant
Trayner, Sarah – Graduate Research Assistant
Wang, Luyang – Graduate Research Assistant
Wilson, Cory – Graduate Research Assistant
Winter, Laurel – Graduate Research Assistant
Xiao, Zhiwei – Graduate Research Assistant
Yuan, Shaojie – Graduate Research Assistant
Yue, Guang – Graduate Research Assistant
Zeuch, Daniel – Graduate Research Assistant
Zhang, Qiu – Graduate Research Assistant
Zhang, Yuhui – Graduate Research Assistant
Zhou, Jun – Graduate Research Assistant

5 - Undergraduate Student
Bernheisel, Ashley – Laboratory Assistant / Technician
Bernstein, Michael – Laboratory Assistant / Technician
Cullen, Abigail – Laboratory Assistant / Technician
Ellis, Andrew – Research Assistant
Eveland, Stephanie – Research Assistant
Gray, Matthew – Research Assistant
Hwang, Christine – Research Assistant
Jarrett, Jeremy – Laboratory Assistant / Technician
Jensen, Justin – Research Assistant
Jhun, Bukyoung – Research Assistant
Johansen, Cody – Research Assistant
Mckay, Zara – Research Assistant
Porter, Amber – Research Assistant
Sanchez, Lorena – Research Assistant
Serniak, Kyle – Research Assistant
Trujillo Jr, Francisco – Research Assistant
Van Gennep, Derrick – Laboratory Assistant / Technician
Velasquez, Ever – Research Assistant

6 - Support Staff - Technical/Managerial
deTorres, Fernando – Laboratory Assistant / Technician
Foster, Chase – Technician
Kuhne, Hannes – Researcher
Sunshine, Anica – Laboratory Assistant / Technician

EMR Faculty & Staff (24)

1 - Senior Personnel
Dalal, Naresh – Professor
Fajer, Piotr – Professor
Hill, Stephen – Professor/EMR Director
Krzystek, Jerzy – Scholar / Scientist
Ozarowski, Andrzej – Assistant Scholar / Scientist
Reiff, William – Visiting Associate Scholar / Scientist
Song, Likai – Assistant Scholar / Scientist
Tsai, Hui-Lien – Visiting Scientist/Researcher
van Tol, Johan – Scholar / Scientist

2 - Postdoc
Beedle, Christopher – Postdoctoral Associate
Stoian, Sebastian – Postdoctoral Associate
Thirunavukkuarasu, Komalavalli – Postdoctoral Associate

3 - Other Professional
Ling, Shenglong – Research Assistant

4 - Graduate Student
Barrett, Ryan – Graduate Research Assistant
Christian, Jonathan – Graduate Research Assistant
Kinyon, Jared – Graduate Research Assistant
Lakshmi Bhaskaran, FNU – Graduate Research Assistant
Muhandis, Muhandis – Graduate Research Assistant
Pavanjeet Kaur, FNU – Graduate Research Assistant
Simmons, Danielle – Graduate Research Assistant
Stanley, Lily – Graduate Research Assistant
Wang, JingFang – Graduate Research Assistant
Wang, Xi – Graduate Research Assistant
Winter, Stephen – Graduate Research Assistant

Pulsed Field Facility (LANL) Faculty & Staff (43)

1 - Senior Personnel
Balakirev, Fedor – Staff Member
Betts, Jonathan – Technical Staff Member
Crooker, Scott – Staff Member
Harrison, Neil – Staff Member
Hinrichs, Mark – Electrical Engineer
Hundley, Mike – CMMS Group Leader
Jaime, Marcelo – Staff Member
McDonald, Ross – Staff Member
Mielke, Charles – Director, Pulsed Field Facility at LANL and Deputy Group Leader
Migliori, Albert – Staff Member and LANL Fellow

Nguyen, Doan – Magnet Scientist
Rickel, Dwight – Staff Member
Sims, James – Staff Member
Singleton, John – Staff Member and LANL Fellow
Zapf, Vivien – Staff Member

2 - Postdoc
Jain, Prashant – Postdoctoral Associate
Kim, Jae Wook – Postdoctoral Research Associate
Li, Yan – Postdoctoral Fellow
Mun, Eun-Deok – Postdoctoral Research Associate
Ramshaw, Brad – Postdoctoral Research Associate
Rice, Bill – Postdoctoral Research Associate
Shehter, Arkady – Postdoctoral Research Associate
Zhang, Zoucheng – Postdoctoral Research Associate
Zhu, Zengwei – Postdoctoral Research Associate

4 - Graduate Student
Martinez, Nicholas – Graduate Research Assistant
Modic, Kimberly – Graduate Student
Topping, Craig – Graduate Student

5 - Undergraduate Student
Schneider, Kim – Undergraduate Student
Vigil, Anthony – Undergraduate Student

6 - Support Staff - Technical/Managerial
Coulter, Yates – Research Technologist
Gordon, Michael – Research Technologist
Lucero, Jason – Research Technician
Martin, Jeff – Controls Specialist
Michel, James – Research Technician
Pacheco, Michael – Research & Development Technologist
Redman, Simon – High School Student
Roybal, Darrell – Research Technician
Salazar, Andrew – Facilities Coordinator
Sattler, Dave – Designer
Tomei, Tony – Lab Associate
Vigil, Billy – Research & Development Technologist

7 - Support Staff - Secretarial/Clerical
Gallegos, Julie – Program Administrator
Willow, Angeline – Administrative Assistant

CIMAR: NMR-MRI @ FSU Faculty & Staff (79)

1 - Senior Personnel
Alamo, Rufina – Professor
Arora, Rajendra – Professor
Brey, William – Scholar / Scientist
Bruschweiler, Rafael – Professor, Associate Director for Biophysics
Bruschweiler-Li, Lei – Assistant Scholar / Scientist
Cross, Timothy – Professor
Frydman, Lucio – Scholar / Scientist
Fu, Riqiang – Scholar / Scientist
Gaffney, Betty – Professor of Biology
Gan, Zhehong – Scholar / Scientist
Gor'kov, Peter – Research Associate
Grant, Samuel – Assistant Professor
Hallinan, Daniel – Assistant Professor
Houpt, Thomas – Professor
Hung, Ivan – Assistant in
Jakobsen, Hans – Visiting Professor
Kim, Jeong-su – Assistant Professor
Li, Dawei – Assistant Scholar / Scientist
Paravastu, Anant – Assistant Professor
Qin, Huajun – Assistant in Research
Schepkin, Victor – Associate Scholar / Scientist
Shekar, Srinivasan – Assistant Scholar / Scientist
Shetty, Kiran – Associate in Research
Smith, James – Professor
Wi, Sungsool – Associate Scholar / Scientist
Zhang, Fengli – Assistant Scholar / Scientist
Zhou, Huan-Xiang – Associate Professor

2 - Postdoc
Dai, Jian – Postdoctoral Associate
Hooker, Jerris – Postdoctoral Associate
Kweon, Jin Jung – Postdoctoral Associate
Larion, Mioara – Postdoctoral Associate
Rosenberg, Jens – Postdoctoral Associate
Zeng, Danyun – Postdoctoral Associate

3 - Other Professional
Kitchen, Jason – NMR Engineer

4 - Graduate Student
Abrahams, Carl – Graduate Research Assistant
Bingol, Ahmet – Graduate Research Assistant
Bradshaw, Miles – Research Assistant
Brown, Jason – Graduate Research Assistant
Chattopadhyay, Soumi – Graduate Research Assistant
Das, Nabanita – Graduate Research Assistant
Dugar, Sneha – Graduate Research Assistant
Ekanayake, E – Graduate Research Assistant
Escobar, Cristian – Graduate Research Assistant
Griffin, James (Jay) – Graduate Research Assistant
Holland, Stephen – Graduate Research Assistant
Huang, Danting – Graduate Research Assistant
Hudson, Benjamin – Graduate Research Assistant
Khamoui, Andy – Graduate Research Assistant
Kimbrough, Adam – Graduate Research Assistant
Lee, Sang-rok – Graduate Research Assistant
Leonard, Sarah – Graduate Research Assistant
Longo, Liam – Graduate Research Assistant

Meng, Dan – Graduate Research Assistant
Miao, Yimin – Graduate Research Assistant
Mudela, Sai Kaushik – Graduate Research Assistant
Muniz, Jose – Graduate Research Assistant
Murray, Dylan – Graduate Research Assistant
Oparaji, Onyekachi – Graduate Research Assistant
Paulino, Joana – Graduate Research Assistant
Ramaswamy, Vijaykumar – Graduate Research Assistant
Sagaram, Smriti – Graduate Research Assistant
Sahanggamu, Paula – Graduate Research Assistant
Shellikeri, Annadanesh – Graduate Research Assistant
Worden, Matthew – Graduate Research Assistant
Wright, Anna – Graduate Research Assistant
Wu, Xianfang – Graduate Research Assistant
Yang, Guang – Graduate Research Assistant
Zimmerman, Maxwell – Graduate Research Assistant

5 - Undergraduate Student

Chin, Adam – Research Assistant
Chrzanowski, Grace – Research Assistant
Horne, Johnny – Research Assistant
Skamangas, Nickolas – Research Assistant
Summerill, Corinne – Research Assistant

6 - Support Staff - Technical/Managerial

Blue, Ashley – Technical/Research Designer
Calixto-Bejarano, Fabian – Lab Assistant/Technician
Cassell, Jennifer – Laboratory Assistant / Technician
Desilets, Richard – Technical/Research Designer
Utermohle, John – Laboratory Assistant / Technician

7 - Support Staff - Secretarial/Clerical

Mozolic, Kimberly – Administrative Support Assistant

CIMAR: ICR Faculty & Staff (40)

1 - Senior Personnel

Blakney, Gregory – Associate Scholar / Scientist
Eberlim de Corilo, Yuri – Visiting Assistant Scholar / Scientist
Kaiser, Nathan – Assistant Scholar / Scientist
Lobodin, Vladislav – Visiting Assistant Scholar / Scientist
Lu, Jie – Assistant in Research
Marshall, Alan – Professor, ICR Program Director
McKenna, Amy – Assistant Scholar / Scientist
Podgorski, David – Visiting Assistant Scholar / Scientist
Rodgers, Ryan – Scholar / Scientist
Young, Nicolas – Assistant Scholar / Scientist

2 - Postdoc

Bythell, Benjamin – Postdoctoral Associate
Chen, Huan – Postdoctoral Associate
Chen, Yu – Postdoctoral Associate
He, Huan – Postdoctoral Associate
Lalli, Priscila – Postdoctoral Associate

3 - Other Professional

Beu, Steven – Visiting Scientist/Researcher
McIntosh, Daniel – Scientific Research Specialist
Quinn, John – Research Engineer

4 - Graduate Student

Beasley, Rebecca – Graduate Research Assistant
Chen, Tong – Graduate Research Assistant
Clingenpeel, Amy – Graduate Research Assistant
Dang, Xibei – Graduate Research Assistant
Dunk, Paul – Graduate Research Assistant
Jarvis, Jacqueline – Graduate Research Assistant
Krajewski, Logan – Graduate Research Assistant
Lewis, Adam – Graduate Research Assistant
Mao, Yuan – Graduate Research Assistant
Rowland, Steven – Graduate Research Assistant
Ruddy, Brian – Graduate Research Assistant
Shomo, Alan – Graduate Research Assistant
Tao, Yeqing – Graduate Research Assistant
Tingting, Jiang – Graduate Research Assistant
Valeja, Santosh – Graduate Research Assistant
Zhang, Qian – Graduate Research Assistant

5 - Undergraduate Student

Bartges, Tessa – Undergraduate Intern
Fitzsimmons, Jade – Research Assistant
Pierce, Daniel – Undergraduate Intern

6 - Support Staff - Technical/Managerial

Atolia, Esha – Research Assistant
Hendrickson, Christopher – Researcher

7 - Support Staff - Secretarial/Clerical

Davis, Colleen – Program Associate

CIMAR: Administration (2)

3 - Other Professional

Bickett, Karol – Administrative Specialist

7 - Support Staff - Secretarial/Clerical

Desilets, Mary – Administrative Support Assistant

UF Faculty & Staff (65)

1 - Senior Personnel
Abernathy, Cammy – Professor, Materials Science & Engineering, Dean, College of Engineering
Andraka, Bohdan – Associate Scientist in Physics
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
Edison, Arthur – Professor, Biochemistry & Molecular Biology, NHMFL Director for Chemistry & Biology
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
Hamlin, James – Assistant Professor
Hebard, Arthur – Distinguished Professor of Physics
Hershfield, Selman – Professor
Hirschfeld, Peter – Professor
Ingersent, Kevin – Professor, Associate 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
Muttalib, Khandker – Professor
Pearton, Stephen – Distinguished Professor, Alumni Professor of Materials Science & Engineering
Polfer, Nicolas – Assistant Professor
Rinzler, Andrew – Professor
Simpson, Nicholas – Research Associate Professor, Medicine
Stanton, Christopher – Professor
Stewart, Gregory – Professor
Sullivan, Neil – Professor, Director of High B/T Facility
Takano, Yasumasa – Professor
Talham, Daniel – Professor and Chair, Chemistry
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
Yin, Liang – Assistant Scientist
Zeng, Huadong – Specialist, Animal MRI/S Applications

2 - Postdoc
Serafin, Alessandro – Postdoctoral Associate

3 - Other Professional
Elumalai, Malathy – RF Engineer
Jenkins, Kelly – RF Coil Engineer
Nicholson, Tammy – Certified Radiology Technology Mgr. (3T Imaging Applications)
Plant, Daniel – Coordinator
Rocca, James – Senior Chemist & NMR Applications Specialist

6 - Support Staff - Technical/Managerial
Graham, John – Senior Engineering Technician, Cryogenics
Slade, Joshua – Engineering Technician

7 - Support Staff - Secretarial/Clerical
Lambert, Angela – Office Manager
Latimer, Darlene – Program Assistant
Mesa, Denise – NHMFL Administrative Assistant
Nichola, Kristin – Program Assistant, Condensed Matter Theory Program

Applied Superconductivity Center (50)

1 - Senior Personnel
Abraimov, Dmytro – Assistant Scholar / Scientist
Griffin, Van – Associate In Research
Hellstrom, Eric – Professor
Jiang, Jianyi – Assistant Scholar / Scientist
Kametani, Fumitake – Assistant Scholar / Scientist
Larbalestier, David – Chief Materials Scientist, Director, Applied Superconductivity Center
Lee, Peter – Scholar / Scientist
Liang, Zhiyong – Associate Professor
Otto, Alexander – Visiting Scientist
Pamidi, Sastry – Assistant Scholar / Scientist
Polyanskii, Anatolii – Associate Scholar / Scientist
Starch, William – Associate in Research
Tarantini, Chiara – Assistant Scholar / Scientist
Trociewitz, Ulf – Associate Scholar / Scientist

2 - Postdoc
Craig, Natanette – Postdoctoral Associate
Dalban-Canassy, Matthieu – Postdoctoral Associate
Kandel, Hom – Postdoctoral Associate
Sinclair, John – Postdoctoral Research Associate
Sung, Zu Hawn – Postdoctoral Associate

3 - Other Professional
Linville, Connie – Administrative Specialist

4 - Graduate Student
Brown, Michael – Graduate Research Assistant
Chen, Peng – Graduate Research Assistant
Collins, Justin – Graduate Research Assistant
Davis, Daniel – Research Assistant
Hesselink, Bram – Visiting Research Assistant
Hu, Xinbo – Graduate Research Assistant
Li, Pei – Graduate Research Assistant
Matras, Maxime – Graduate Research Assistant
Sanabria, Carlos – Graduate Research Assistant
Segal, Christopher – Graduate Research Assistant
Stangl, Alexander – Visiting Research Assistant
Weiss, Jeremy – Graduate Research Assistant
Whittington, Andrew – Graduate Research Assistant

5 - Undergraduate Student
Blum, Timothy – Laboratory Assistant-level 2
Canuto, Daniel – Laboratory Assistant-Level 2
Chew, Brandon – Laboratory Asst.-level 2
Craft, Joseph – Laboratory Assistant-Level 1
Diaz, Jesse – Laboratory Assistant-Level 2
Dillman, Markus – Laboratory Assistant Level 2
Francis, Ashleigh – Laboratory Assistant-Level 2
Gavin, Jennifer – Laboratory Assistant-Level 2
Hainsey, Benjamin – Laboratory Assistant-Level 2
Mankin, Alexander – Laboratory Assistant-Level 1
McCallister, Jeremiah – Lab Assistant Level 1
Miller, Sondra – Laboratory Assistant- Level 2
Nabulsi, Wael – Laboratory Assistant-Level 1

6 - Support Staff - Technical/Managerial
Santos, Michael – Research Assistant

7 - Support Staff - Secretarial/Clerical
Hall, Charlotte – Admin Support Assistant
Hobbs, Alice – Clerk
Pan, Yanjun – Office Assistant

Director's Office (27)

1 - Senior Personnel
Boebinger, Gregory – Director/Professor, Professor of Physics
Hughes, Roxanne – Assistant Scholar/Scientist, Director, Center for Integrating Research and Learning
Palm, Eric – Deputy Lab Director

2 - Postdoc
Grockowiak, Audrey – Postdoctoral Associate

3 - Other Professional
Coyne, Kristen – Media Specialist
DeBoer, Diana – Administrative Specialist
Laufenberg, Kathleen – Media Specialist
Roberson, Bettina – Assistant Director, Administrative Services
Rodman, Christopher – Industrial Safety & Health Eng.
Sanchez, Jose – Associate in Research
Sutton, Angela – Assistant Director, Environmental, Health, Safety and Security
Tabtimtong, Nilubon – Media Specialist
Vernon, Lizette – Media Specialist
Villa, Carlos – Training Specialist

4 - Graduate Student
Jangra, Smriti – Graduate Research Assistant
Kemper, Jonathon – Graduate Research Assistant
Moir, Camilla – Graduate Research Assistant
Nzekwe, Brandon – Graduate Research Assistant
Stegen, Zachary – Graduate Research Assistant
Wartenbe, Mark – Graduate Research Assistant

6 - Support Staff - Technical/Managerial
Ward, Briana – Safety Technician

7 - Support Staff - Secretarial/Clerical
Barfield, David – Clerk
Bowley, Chealsye – Intern
Hancock, Felicia – Program Associate
Jensen, William – Clerk
Owens, Nancy – Administrative Support Assistant
Sapronetti, Andrew – Administrative Support Specialist

Geochemistry (47)

1 - Senior Personnel
Chanton, Jeff – Professor
Cooper, William – Professor
Froelich, Philip – Professor
Hsieh, Ping – Professor
Humayun, Munir – Associate Professor

Landing, William – Professor
Odom, Leroy – Professor
Salters, Vincent – Professor, Director, Geochemistry
Wang, Yang – Professor
Xu, Yingfeng – Visiting Assistant in Research

2 - Postdoc

Buck, Clifton – Postdoctoral Associate
Morton, Pete – Postdoctoral Associate
Perrot, Vincent – Postdoctoral Associate
Shelley, Rachel – Postdoctoral Associate

3 - Other Professional

Sachi-Kocher, Afi – Scientific Research Specialist
White, Gary – Scientific Research Specialist

4 - Graduate Student

Aljahdali, Mohammed – Graduate Research Assistant
Avery, Aaron – Research Assistant
Bosman, Samantha – Graduate Research Assistant
Ciner, Burcu – Graduate Research Assistant
Dial, Angela – Graduate Research Assistant
Ebling, Alina – Graduate Research Assistant
Eller, Virginia – Technician
Harper, Alexandra – Graduate Research Assistant
Hodgkins, Suzanne – Graduate Research Assistant
Krishnamurthy, Nishanth – Graduate Research Assistant
Landing, Alexandra – Laboratory Assistant / Technician
Li, Dong – Graduate Research Assistant
Mauney, Michael – Graduate Research Assistant
Mickle, Alejandra – Graduate Research Assistant
Morris, Rachel – Graduate Research Assistant
Rogers, Kelsey – Graduate Research Assistant
Roy, Rupsa – Graduate Research Assistant
Stapleton, Brian – Graduate Research Assistant
Tazaz, Amanda – Graduate Research Assistant
Tremaine, Darrel – Graduate Research Assistant
Trusty, Debra – Graduate Research Assistant
Wallace, Thomas – Laboratory Assistant / Technician
Wang, Zong – Graduate Research Assistant
Yang, Shuying – Graduate Research Assistant

5 - Undergraduate Student

Medwell, Melody – Research Assistant
Stacklyn, Shannon – Research Assistant
Walker, James – Undergraduate Research Assistant
Williams, Jeffrey – Research Assistant

6 - Support Staff - Technical/Managerial

Langford, Lauren – Research Assistant
Zateslo, Theodore – Senior Engineer

7 - Support Staff - Secretarial/Clerical

Hancock, Ashley – Office Assistant

APPENDIX D

Plan for Broadening Participation

(Reprint of NHMFL Renewal Proposal 2013-2017, Appendix 1, submitted 8/31/2011)

Vision

The National High Magnetic Field Laboratory (NHMFL) reaffirms its commitment to diversity in the facility workplace at all levels, from undergraduates to faculty, technicians, professional staff, and leadership positions. Diversity is fundamental to the laboratory's core scientific, R&D, and educational missions and responds to a critical national issue – the retention of a strong and diverse scientific and engineering workforce. The diversity of our employees is vital to maintaining the laboratory's preeminent worldwide status as a national user facility dedicated to ultra-high magnetic field research. The laboratory also fully recognizes that diversity in the workforce is essential to the United States as it responds to the challenges facing the nation and the world.

Mission Statement

The NHMFL, in cooperation with its three partner institutions – The Florida State University (FSU), the University of Florida (UF), and Los Alamos National Lab (LANL), is fully committed to achieving National Science Foundation (NSF) objectives to promote new opportunities for members of underrepresented groups in science, engineering, and mathematics. NHMFL management recognizes the need to establish a policy for expanding and maintaining a diverse and inclusive organization to ensure a broad pool of highly qualified candidates and to retain the critical and high-performance skills needed to operate the laboratory. It is also committed to providing an enriching environment for undergraduate and graduate students to explore research opportunities and to encourage them to remain committed to securing the highest degree possible. The NHMFL recognizes that early exposure to the importance of science, engineering, and math as academic and career paths among K-12 students and teachers is a very effective strategy for generating the workforce of the future. The NHMFL educational outreach programs, with their particular focus on broadening diversity, will continue outreach to these targeted constituencies.

Strategic Planning

The NHMFL Diversity Committee is composed of members of the faculty and staff from all three partner institutions: FSU, UF, and LANL. This nine-member committee meets quarterly by teleconference and is charged to help coordinate and implement recommendations coming from NHMFL personnel, the National Science Foundation, and the Diversity Advisory Committee (DAC).

The Diversity Advisory Committee, composed of individuals with experience in diversity enhancement programs, advises the NHMFL's leadership and Diversity Committee members on opportunities to promote diversity in hiring and outreach programs. The DAC also ensures that NHMFL diversity activities are aligned with university initiatives to attract, develop, and retain diverse talent at all levels [http://www.diversity.fsu.edu/PDF/2011plansummary.pdf] by partnering with the FSU Office of Diversity and Equal Opportunity. The DAC is chaired by the NHMFL Director and includes the chair of the NHMFL Diversity Committee to provide coordination and support to the NHMFL Diversity Advisory Committee. The NHMFL Human Resources Manager serves as an ex-officio member of both committees. He or she supports hiring and outreach programs by providing a single point of contact at the NHMFL for interactions with programs at the laboratory's partner institutions - FSU, UF and LANL.

The Diversity Advisory Committee convenes at least once a year to review benchmarks, the NHMFL Diversity Action Plan, the NHMFL Annual Report, the NHMFL User Committee Report, and the NSF Site Visit Report. The DAC then advises the Director of the NHMFL and other appropriate NHMFL personnel on opportunities to enrich its diversity and inclusion efforts. The NHMFL Diversity Action Plan, written in 2004 and updated in 2007, was updated again in 2011 to reflect recommendations from the DAC. *Organized in logical order, the Diversity Action Plan includes bullet lists of action items by which the NHMFL plans, implements, and assesses its Diversity activities.*

Diversity Action Plan

The NHMFL has a goal to become a nationally-recognized leader for its STEM diversity programs and the diversity of its scientific, technical and engineering(STEM) staff. The Diversity Action Plan was first developed in 2004 and updated in 2007 and 2011. The Diversity Action Plan includes ongoing activities proven to be successful and incorporates new ideas to be implemented during next grant period:

NHMFL Diversity Action Plan

The NHMFL Diversity Program is focused on explicit actions. These actions are catalogued in a Diversity Tracker, the highlights of which are incorporated into an annual NHMFL Diversity Report submitted to the NSF, representatives of the NHMFL's partner institutions, the NHMFL Executive Committee, Diversity Advisory Committee and Users Committee. Each action in the plan is tagged by one or more category: Leadership, Strategic Planning, Human Resources (HR) Focus, Results, and Statistics/Analysis.

ACTION 1: Building diversity permanence into the NHMFL scientific population

- **[Results]** Continue to ensure that at least one member from the NHMFL Diversity Committee actively serves on each NHMFL Search Committee to increase awareness and knowledge of diversity issues within every search committee.

- **[Leadership; HR Focus]** Continue to train NHMFL managers and search committees using Faculty Recruitment for Excellence and Diversity (FRED) classes, which are based on materials from the STRIDE program at the University of Michigan [http://sitemaker.umich.edu/advance/home] and other successful programs. FRED is required attendance for any scientist to serve on a scientific search committee.

- **[Leadership; Results]** Continue to advertise in venues that reach women and minorities (special subgroups of professional organizations, focused conferences and workshops, etc.), e.g., Society for Advancement of Chicanos and Native Americans in Science (SACNAS), Association for Women in Science (AWIS), National Society of Black Physicists (NSBP).

- **[Leadership; Results]** Develop written bylaws for a scientific search process to specify the search committee composition, describe and adopt "open" searches and candidate evaluation tools, as well as other strategies based on STRIDE and other successful programs. The goal is to ensure that more than one female and/or minority candidate are invited to visit the NHMFL as a finalist candidate for each search, as this disproportionately increases the likelihood that a woman and/or minority scientist will be hired.

- **[Statistics/Analysis]** Continue to require each search committee to summarize specific efforts to recruit scientific staff from underrepresented groups.

- **[Statistics/Analysis]** Maintain new hires at a rate above the present level of diversity at the NHMFL, particularly for senior hires into permanent scientific positions. Continue to track progress using the three-year running averages of diversity statistics to provide annual concrete feedback while minimizing statistical fluctuations in this assessment.

- **[HR Focus]** Provide an environment for success of NHMFL new hires from underrepresented groups by providing mentors, opportunities to network within and beyond the NHMFL. Organize new Faculty Mentorship Workshops, based on STRIDE and other similar programs, to train mentors.

- **[HR Focus]** Promote retention of staff members in underrepresented groups by monitoring and cultivating progress at all career stages, including not only formal performance appraisals but also informal reviews among mentors and attention to maintaining a receptive and responsive workplace environment at the NHMFL. Organize new workshops on Women and Leadership in the Sciences and Engineering, based on STRIDE and other similar programs.

- **[HR Focus]** Continue to promote family-friendly policies, such as the recently launched the Dependent Care Travel Grant Program [http://www.magnet.fsu.edu/usershub/funding/travel.html].

ACTION 2: Developing and cultivating individually-crafted early career opportunities for members of underrepresented groups at the undergraduate level and above

- **[Leadership]** Continue to establish and cultivate relationships with historically black, Hispanic and female universities through the NHMFL CO-WIN (College Outreach-Workforce Initiative) program of exchanging scientific visits.

- **[Leadership; Results]** Continue to invite identified individuals to apply to the NHMFL's REU, postdoc and Visiting Scientist programs, including those positions reserved for underrepresented groups.

- **[HR Focus]** Continue to provide financial support for summer research collaborations and seek year-round collaborations with scientists from underrepresented groups, including supporting proposals originated by these scientists.

- **[Leadership; Results]** Continue to actively recruit members of underrepresented groups at all times, not only when there are predetermined searches. Maintain and cultivate relationships with potential candidates over many years.

- **[Leadership; Results]** Continue to network to discover unforeseen opportunities to hire, including offering invited talks to female and minority faculty to visit the NHMFL and establish connections with NHMFL scientists.

ACTION 3: Aiming educational outreach for K-12 and the general public to broad and diverse groups

- **[Leadership]** Continue to aim NHMFL education and outreach to a diverse and large population of young students and the general public, to teach the importance of science as a career to the individual and the nation.

- **[Leadership]** Continue to broadly advertise the NHMFL's Annual Open House, as well as its REU and RET programs and assess the diversity of the group benefiting from each of these programs.

- **[Leadership]** Continue to aim NHMFL education and outreach to the general public and government officials, to present scientific research as an engine for economic growth and national prosperity.

ACTION 4: Maintaining awareness among NHMFL staff and user programs that Diversity Matters

- **[Strategic Planning; HR Focus]** Understand the national importance of increasing the diversity of the STEM (Science, Technology, Engineering and Mathematics) population throughout the United States, by having active Diversity Advisory and Diversity Committees, periodic labwide informational meetings, FRED and other workshops, and permanent diversity resources on the NHMFL website.

- **[Strategic Planning; Statistics/Analysis]** Understand NHMFL diversity in the national context, including the monitoring of progress through the maintenance of NHMFL and national statistics on diversity.

- **[Strategic Planning; Statistics/Analysis]**
  Continue to document evidence of success and ongoing improvement that will be available for presentation during the NSF Site Visit. This report is discussed at the meetings of the NHMFL Executive Committee and forms a part of the *NHMFL Annual Report* and the *Mid-Year Diversity Report*. The *NHMFL Annual Report* is submitted to the NSF annually and is a primary document given to external review committees. The report focuses on measurable objectives, e.g., increases in participation of underrepresented students in NHMFL programs, in NHMFL research papers with authors from underrepresented groups, in scientific collaborations with scientists from underrepresented groups, the NHMFL demographics, etc.

ACTION 5: Maintaining frequent external guidance and review of NHMFL diversity issues

- **[Strategic Planning; Results]** Continue to incorporate diversity presentations and discussions into meetings of the NHMFL User Committee, the NHMFL External Advisory Committee and at NSF Site Visits.

- **[Results]** Ensure that the Diversity Committee, the Diversity Advisory Committee, and the NHMFL External Advisory Committee include a diverse membership, as well as university, regional and national leaders working to improve diversity in the scientific workforce of the future.

- **[Results]** Continue to seek to increase the diversity of the NHMFL's User Committee, whose membership is determined by vote of the user community, through active recruiting of a diverse slate of candidates.

Assessment

[Results] The NSF and NSF external site visit committees will review the NHMFL Diversity Action Plan and its progress in implementing its goals.

APPENDIX E

Postdoctoral Mentoring Plan

(Reprint of NHMFL Renewal Proposal 2013-2017, Appendix 2, submitted 8/31/2011)

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. 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).

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 Action Plan, the Research Experiences for Undergraduates program and the Research Experiences for Teachers program, through which they can provide significant STEM mentorship to early career scientists and the teachers of the next generation 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.

In addition to these activities, the following new initiatives are proposed for postdoctoral associates in this NHMFL renewal proposal:

Orientation

Orientation materials, including a "Welcome to the MagLab" document will be made available online to augment face-to-face orientation and best accommodate the different individual start dates of NHMFL postdoctoral associates. Orientation will include 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, reporting time and getting paid, 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). The orientation will be organized by the NHMFL's Center for Integrating Research & Learning (CIRL) and facilitated by Public Affairs, Management and Administration personnel and NHMFL scientists.

Training

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 subject matter experts such as librarians from the FSU Dirac Science and Engineering Libraries to provide guidance on effective use of internet and library resources.

Career Counseling

Each postdoctoral associate will be assigned a scientific mentor other than their direct supervisor. The mentor will provide 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 [http://www.magnet.fsu.edu/usershub/funding/travel.html].

Assessment

Assessment will be conducted by CIRL through entry and exit surveys, informal interviews conducted during employment at the lab, and tracking after leaving the laboratory. Assessment results will be presented to NHMFL faculty to improve their postdoctoral mentorship skills.

APPENDIX F

Data Management Plan

(Reprint of NHMFL Renewal Proposal 2013-2017, Appendix 3, submitted 8/31/2011)

The National High Magnetic Field Laboratory (NHMFL) user facilities serve a multi- and inter-disciplinary scientific research community. Users of NHMFL facilities are expected to promptly analyze and submit their data for publication, with authorship that accurately reflects the contributions of those involved, and including all scientific findings from experiments performed at the NHMFL.

The NHMFL Data Management Plan accommodates the specific environments and natures of data generated at each of its six user facilities: DC Magnets, Pulsed Magnets, High B/T, Ion Cyclotron Resonance, Electron Magnetic Resonance, and the Nuclear Magnetic Resonance/Magnetic Resonance Imaging (NMR/MRI) User Facilities located at three campuses: Florida State University, University of Florida and Los Alamos National Laboratory. The data management policy is driven by the needs of our user community and the standards of the relevant funding agencies. The policy is reviewed annually to stay current with user demands and changes in technology.

Data Types

NHMFL user 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, a visiting user's laptop, 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.

All samples are considered to be under the control of the Principal Investigator (PI) and conforming to the requirements and standards under which the sample was generated. The NHMFL is able to temporarily store samples for experimenters at an NHMFL user facility as one of the services provided to the PI during an experimental project or for a period of time up to one year after the completion of an experiment. User samples are ultimately either returned to the PI or discarded with approval from the PI.

Data Standards

Standards for data vary 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-vendor-specified binary formats or custom file formats developed by NHMFL personnel. The ICR facility also stores data in an NHMFL-defined format as it develops new experimental protocols. 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. Data for the NMR/MRI imaging 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, lap top files, or other media at the option of the PI. Management of the meta data associated with standard data files is exclusively the purview of the PI.

Data Access Policies

The laboratory will ensure that the NHMFL Data Management and Sharing Policy continues to be aligned with the policy applied to NSF single investigator grants, as the NHMFL user community consists primarily of researchers supported by traditional single investigator grants.

The control of raw data files and rights to the data are retained by the PI for the experiment. The PI has full control of the use of the data, including its publication in the refereed literature. The PI is responsible for adhering to the policies and procedures of their funding agency.

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 PI of the project.

Data will be archived on CDs or other similarly permanent media and provided to the user. User data can be further transferred to any portable drive or computer deemed appropriate by the user. Users my request data transfer consistent local facility administration policies, e.g. via a hard copy, secure FTP or standard network protocols for copying files over a TCP-based network.

Data Re-use Policies

The NHMFL requires all NHMFL 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.

Data will not be reused nor any data-mining operations performed on past user data without permission of the PI. Once data are collected and provided to the user, it is solely the property of the PI. Any reuse of the data by the PI external to NHMFL is strictly at their discretion.

APPENDIX G

2013-2017 Strategic Plan

(A reprint of the Strategic Plan dated October 11, 2011)

The MagLab strategic plan outlines eight institutional mission imperatives that describe our fundamental ongoing responsibilities as a national laboratory. Each imperative is followed by a prioritized set of supporting actions that the MagLab will undertake on behalf of its user program. Our plan also lays out a set of science drivers and technical frontiers — those opportunities that the MagLab and its user program intend to build out from and across existing programs and research activities. Together, the imperatives, science drivers and technical frontiers explain our highest-priority ongoing efforts and our aspirations for program development & enhancement. This is a five-year plan extracted from the 2013-2017 renewal proposal submitted to the NSF in August 2011. It includes some activities that extend beyond the five-year horizon.

This plan is not a comprehensive overview of the many valued activities conducted within the MagLab and its user program. Rather, it is intended as a concise, high-level explanation of institutional direction and priorities for growth. More detailed descriptions of the full sweep of MagLab activities can be found in the MagLab *Annual Report*, MagLab Science Highlights, and the MagLab periodicals: *MagLab Reports* and *Flux* magazine.

Vision

The MagLab will remain the most interdisciplinary and most scientifically productive magnet lab in the world.

Mission Imperatives

1. Promote magnet-related research to serve an interdisciplinary scientific user community spanning materials science, condensed matter physics, magnet technology, chemistry, and biology.
2. Provide unique high-magnetic-field facilities through a competitive and transparent proposal review process.
3. Advance magnet and magnet-related technology via high-risk, high-reward projects
4. Partner with universities, other national laboratories and industry to enhance national competitiveness in magnet and related technologies.
5. Serve the NSF as a prominent example of its successful stewardship of large research facilities
6. Serve as a successful model as:
  - **a.** a multi-site national laboratory
  - **b.** a collaboration among our three partner institutions: Florida State University (FSU), the University of Florida (UF) and Los Alamos National Laboratory (LANL)
  - **c.** a partnership of the federal and state government
  - **d.** a partnership of the National Science Foundation and the Department of Energy

7. Support science and technology education in the United States.
8. Increase diversity in the science, technology, engineering and mathematics workforce of today and tomorrow

By the Numbers: An Introduction to the MagLab User Program

User Programs

- **3 campuses:** FSU (headquarters, largest facility), UF, and Los Alamos National Laboratory (LANL)

- **1 High Magnetic Field User Program** built around six unique high magnetic-field facilities:

– Steady-State (DC) Resistive Electromagnets: physics and some

chemistry, located at FSU
– Pulsed Electromagnets: physics and some chemistry, located at LANL.
– Ultra-Low Temperatures in Magnetic Fields: physics, located at UF.
– Nuclear Magnetic Resonance and Magnetic Resonance Imaging (NMR/MRI): chemistry, biochemistry and materials research at FSU and UF.
– Electron Magnetic Resonance: interdisciplinary (physics, chemistry, biology) located at FSU.
– Ion Cyclotron Resonance (ICR): chemistry, located at FSU.

• > 7000 days of magnet time provided annually by our six user facilities.

• ~1100 visiting scientists annually, with access to magnets provided free on a competitive basis.

• ~220 new users annually, i.e. ~20% of our visiting scientists are first-time users each year.

• ~425 refereed publications annually, including annual totals of ~40 *Physical Review Letters*, 4 or 5 *Proceedings of the National Academy of Sciences*, and ~15 total in *Science* and *Nature*.

• ~300 Ph.D. students and ~150 postdocs acquire critically important data at the MagLab annually.

Budget and Staffing

• Annual budget of ~$50M, including
– ~$33M NSF ($31.5M from Division of Materials Research, $1.5M from Chemistry)
– ~$8.5M State of Florida, largely in salary of user support scientists and magnet engineers
– ~$8.5M Other sources, including other Federal grants for magnet projects and instrumentation, as well as the Helmholtz Zentrum Berlin (HZB) Series Connected Hybrid magnet project

• ~400 MagLab employees and ~200 affiliated faculty and researchers.

• ~$4.5M annual electricity bill and $1M annual cost of liquid helium and nitrogen.

Capital Investments

• More than $100M in magnets supporting unique scientific capabilities:
– $15M 45T Hybrid Magnet (FSU), Guinness world record for continuous magnetic field
– $12M 36T High-Homogeneity (1ppm) Magnet (FSU), to be completed in 2012
– $ 4M 25T Split Magnet (FSU), vertical-field magnet ‘split’ at the equator to allow easy access for light-scattering experiments, with a (horizontal-field) ‘rotation’ insert planned for precision two-axis rotation experiments.
– $16M 900 MHz NMR Magnet - world’s largest bore (105 mm), providing the highest magnetic field for MRI in vivo studies of mice (21.1T, roughly twice the field available elsewhere)
– $15M NMR and MRI Magnet Facilities (UF and FSU) over and above the 900MHz magnet above.
– $20M ICR Magnet Facility (FSU), including the recent award to purchase a 21T ICR Magnet
– $10M 60T Long-Pulse Magnet (LANL)- Highest field for controlled-shape, seconds-long pulse
– $15M 100T Multi-shot Magnet Project (LANL), presently delivering 85T pulses in accordance with the magnet development plan – Achieved 97.4T, highest field ever for a non-destructive magnet
– $ 5M Single-turn Magnet System (LANL), destructive microsecond pulses exceeding 200T.

Education and Outreach

• ~60 Ph.D. degrees awarded annually containing MagLab data

• ~15 Masters degrees awarded annually containing MagLab data

• ~ 20 Research Experience for Undergraduates (REU students) annually

• ~ 15 Research Experience for Teachers (RET visitors) annually

• >10,000 K-12 students reached annually via tours & classroom visits

• ~5,000 Annual Open House visitors to interact with ~75 hands-on exhibits

User Program Science Drivers

The specific MagLab research directions are ultimately determined by the most meritorious peer-reviewed proposals submitted by users. Input from the COHMAG report, the MagLab’s user community, and advisory committees identifies the four most promising science drivers for the coming decade:

• **Quantum Matter**, the broadly challenging manifestations of quantum phenomena in materials, including • low-dimensional metals like graphene, where magnetic fields quench the kinetic energy to isolate correlation effects; • cuprate and Fe-based superconductivity, which despite many differences, both occur in proximity to magnetism; and • quantum phase transitions such as Bose-Einstein condensation in spin systems, where the density of spins is tuned by the applied magnetic field;

• **Spin Coherence and Spin Control**, the detection and manipulation of electron and nuclear spins, including • molecular magnets, where high fields enable study of systems with strong electron spin-orbit coupling; • quantum magnetism, which requires a very wide range of EPR frequencies; • spintronics and quantum computing, each requiring high fields and EPR frequencies; • high frequency pulsed EPR to resolve nanosecond dynamics; • highest-sensitivity NMR probes for both solution and solid-state NMR; • new contrast agents for single cell MRI; • novel NMR data processing; and high-magnetic-field dynamic nuclear polarization, which draws on MagLab EMR and NMR expertise.

- ***In Vitro* to *In Vivo***, the structure and dynamics of the molecular components of life using high magnetic fields for • structural studies of large heterogeneous membrane proteins using NMR; • hydrogen/deuterium exchange to probe molecular complex dynamics using ICR, • high frequency pulsed EPR to measure distance and dynamics in macromolecules; • large zero-field energy level splitting of metal ions in biological molecules using high-frequency EPR • organic radicals important to physiological processes using high-field EPR; • cellular MRI of individual neurons and subcellular structures; • the assay of hundreds to thousands of small molecule metabolites using highest-field NMR and ICR; and • in vivo biochemistry and physiology measurements of nuclei in living animals;

- **Energy and Environment**, the increase in user research at five of the MagLab's six user facilities that spans organic chemistry, solid-state physical chemistry, and materials physics at interfaces has required high magnetic fields where, for example • economic and environmental issues of energy production via molecular-level assaying of crude oil and candidate future fuels such as pine mulch and algae are revealed via the ICR sensitivity and resolution at the MagLab that launched the petroleomics research field; catalysis and the 'interface problem', where the highest magnetic fields change energy bands and local energy states sufficiently to provide reversible, quantitative tuning of nanostructured interfacial thermodynamics and kinetics • energy storage in batteries and chemicals, where the highest-sensitivity EMR and NMR determine local environment, location, and functionality.

Technical Goals Resulting from the Science Drivers

The science drivers have determined the priorities for new initiatives and magnet technology articulated in this section. The highest priority technical goals are:

- **Increase Peak Magnetic Fields**, the primary demand of the user community and the primary enabler of the Science Drivers, by leveraging major investments by the MagLab's partner institutions, including:
  - Develop 28MW magnets to take advantage of the $7.5M State-of-Florida funded 56MW DC Magnet power supply upgrade at Florida State University,
  - Steadily increase from 85 T to 100 T the peak field delivered to the Pulsed Magnet Users as experience is gained in the operation, the performance, and the experimental challenges of the 100 T Multi-Shot Magnet.
  - Launch a user program that accesses the 200T microsecond-duration pulsed magnetic fields enabled by $4.2M LANL-funded infrastructure.
  - Commission new $1.2M superconducting magnet at the High B/T facilities at the University of Florida.

- **Increase User Magnet Time** in response to the growing user demand evidenced by User Committee surveys and magnet oversubscription rates.

- **Further develop EMR, NMR and MRI capabilities** by investing in probes, gradient coils, upgraded electronics and new consoles.

- **Further develop cross-disciplinary utilization of MagLab facilities**, including for example the use of:
  - the ultra-wide-bore 900 MHz magnet for temperature-dependent materials research of multi-ferroics and other quantum matter,
  - MagLab MRI capabilities for in-situ profiling of lithium and hydrogen in batteries and fuel cells, and
  - starting 2015, the 36T/1ppm-homogeneity Series Connected Hybrid to advance solid-state NMR to 1.5 GHz and multi-disciplinary Electron Magnetic Resonance to 1 terahertz.

- **Per the COHMAG report, continue to develop MagLab high-Tc superconducting (HTS) materials and magnet technologies** to significantly advance the peak fields achievable from superconducting magnets.

- **Continue to develop MagLab superconducting Cable-in-Conduit Conductor (CICC) technology** for both Nb-based and HTS superconducting applications.

Education, Diversity & Outreach Goals

- Establish the MagLab's programs as national leaders in informal science education, and STEM diversity, including K-12 outreach in Florida and New Mexico, REU and RET programs, SciGirls summer camps, and two periodicals, *Flux* for the general public and *Mag Lab Reports* for scientists.

- Continued mentorships to young scientists from underrepresented groups, tailored to strengthen and advance each individual's career aspirations. This is a very high priority reflected by the roughly $200K/yr budget devoted to support the MagLab Diversity Action Plan.

- Continue the MagLab summer school for graduate students and postdocs to learn experimental techniques of importance to high magnetic field research. The one-week curriculum will include basic electronics, noise suppression, and grounding techniques, as well as the details of NHMFL measurement techniques such as transport, magnetization, specific heat, and nuclear magnetic resonance.

- Establish a MagLab Winter Theory School to augment the MagLab Summer School. The theory school will host a half-dozen leading theorists to present a week-long series of lectures on topics in condensed matter physics and materials science relevant to high-magnetic-field research.

Science-Enabling Technical Frontiers

The MagLab has world-leading magnet technology and unique capabilities to further advance a wide variety of technologies relevant next generation magnet and magnet materials. *With the first priority listed first*, MagLab technical priorities are:

- **Series Connected Hybrid** – a pioneering MagLab magnet technology utilizing superconducting and resistive coils connected electrically in series. The system allows for multiple resistive insert coils to be positioned in the bore of a common superconducting outer coil.
  - to realize 36T fields of unprecedented homogeneity (1ppm) for powered magnets. This insert coil is under construction.
  - to realize 40T fields using only 14MW of power, half the amount required for an all-resistive magnet. Plans for this insert coil are under development.

- **28MW DC Magnets**, first developing a 41T/32mm magnet and then a 37T/50mm magnet, exploiting the capabilities of the new 56MW DC Power Supply to increase user DC magnetic fields by ~18%, the largest increase in 20 years and a two-fold increase in 40T fields worldwide.

- **Develop high-field dynamic nuclear polarization (DNP)** using existing MagLab strengths - NMR probes, high-frequency EMR, and NMR/MRI technique development – to enhance solid-state NMR and detection of critical biological molecules in living organisms, including in vivo metabolism and physiology.

- **Continue to define the technical roadmaps** and provide impetus to the eventual realization of all three of the COHMAG challenge magnets: the 30T NMR magnet, 60T Hybrid Magnet, and 100T/1sec Pulsed Magnet. Each of these magnets depends upon the development of new materials prior to the development of magnet construction proposals.

- **Terahertz Light to the MagLab Magnets** – continue to develop the scientific community for 'BigLight', a unique THIR (terahertz to infrared) light source separate from but synergistic with the MagLab.

- **Magnets for Competing Magnet Labs** Four of the world's five leading magnet labs use MagLab Florida-Bitter technology. The MagLab will continue to assist and collaborate with other magnet labs in both magnet technology and experimental techniques, in particular:
  - EuroMagNET, the unified European magnet laboratory: Grenoble and Nijmegen (DC magnetic fields), and Toulouse and Dresden (pulsed magnetic fields)
  - Magnet Labs in Japan: Kashiwa (pulsed magnetic fields)
  - Magnet Labs in China: Hefei (DC magnetic fields) and Wuhan (pulsed magnetic fields)

- **Magnets to the Neutrons** – design and construct a 20T DC magnet for the neutron source at the HZB (Berlin, Germany); continue discussions with the Spallation Neutron Source at Oak Ridge National Laboratory

- **Magnets to the X-rays** – develop plans with the Advanced Light Source at Argonne National Lab for either pulsed or DC magnetic fields.

Strategic Plan Performance Metrics

The MagLab publishes an *Annual Report* that showcases the programs and activities at the MagLab and includes the metrics used by MagLab management, the MagLab External Advisory Committee, the MagLab User Committee and the NSF Site Visit committees to evaluate the MagLab's performance. Each *Annual Report* includes:

- The Year in Review, written by the Director
- Science & Engineering Highlights
- Reports and statistics from the lab's user facilities
- Summaries from the magnet engineering and materials groups
- Summaries of management, administration, education, and diversity programs
- Results of the User Collaboration Grants Program
- Summaries of MagLab industrial partnerships and collaborations
- Lists of publications, presentations, theses and other activities.

The MagLab receives expert evaluation of its scientific program by other scientists, including but not limited to reports by the MagLab External Advisory Committee, the MagLab User Committee and the NSF Site Visit Committees. Numerical metrics that characterize the MagLab's performance are reported in the *Annual Report* including:

- MagLab User Committee's survey of user satisfaction with:
  - Equipment availability
  - Equipment performance
  - MagLab scientist assistance
  - MagLab administrative assistance
  - MagLab training and safety procedures
  - MagLab user proposal submission and evaluation process

- MagLab User Profile report containing the breakdown of the total number of MagLab users by:
  - Senior investigators, postdocs, students and technicians
  - Gender and minority status
  - Affiliation of users: NHMFL, university, industry, national lab, or overseas.
  - Facility utilized: DC, Pulsed, High B/T, NMR/MRI, EMR & ICR.

- MagLab Facility Usage Profile report containing the breakdown of magnet days allocated by scientific discipline, affiliation of users, and facility utilized.

- User Collaboration Grants Program (UCGP) report, including:
  - Number of proposals received
  - Proposal acceptance rates
  - Usage of facility enhancements reported from UCGP solicitations
  - Publications reported from UCGP solicitations

- Education Program report that includes the number of participants in:
  - Research Experiences for Teachers
  - Research Experiences for Undergraduates
  - Middle School Mentorships
  - High School Mentorships
  - MagLab classroom outreach and laboratory tours.

- Science and Research Productivity statistics, including:
  - Publications in Peer-Reviewed Journals
  - Publications in Prominent Peer-Reviewed Journals, such as *Nature*, *Science*, *the Proceedings of the National Academy of Sciences*, and prominent, discipline-specific journals such as *Physical Review Letters* and *Journal of the American Chemical Society*.
  - Ph.D. degrees awarded
  - Masters' degrees awarded

Annual Reports are posted on the MagLab website, www.magnet.fsu.edu at http://www.magnet.fsu.edu/mediacenter/publications/annualreport.aspx.

Diversity Action Plan

The MagLab fully recognizes that diversity in the nation's workforce will be essential as it responds to the challenges facing the nation and the world. The reach and scope of the MagLab provides wonderful opportunities to increase diversity in science, technology, engineering, and mathematics. While our user community and staff are truly international, they do not reflect the diversity of the nation's own population. The MagLab's Center for Integrating Research and Learning (CIRL) has excellent and acclaimed programs for outreach to K-12 students, undergraduates, K-12 teachers, and the general public. The MagLab Diversity Action Plan, written in 2004 and most recently updated in 2010, complements CIRL and builds one-on-one relationships with undergraduates and early career scientists who could benefit from increased mentoring, networking, and research experience. *Organized in logical order, the plan includes bullet lists of action items by which we plan, implement and assess our Diversity activities.*

Diversity and Inclusion Action Plan

Vision

The NHMFL reaffirms its commitment to diversity in the facility workplace from undergraduates to faculty to technicians to professional staff. Diversity is fundamental to the laboratory's core scientific, R&D, and educational missions and response to a critical national issue-the retention of a strong and diverse scientific and engineering workforce. The diversity of our employees is vital to maintaining the laboratory's preeminent worldwide status as a national user facility dedicated to ultra-high magnetic field research. The laboratory also fully recognizes that diversity in the workforce for the future will be essential to the United States as it responds to the challenges facing the nation and the world.

Mission Statement

The NHMFL, in cooperation with FSU, UF, and LANL, is fully committed to achieving National Science Foundation objectives to promote new opportunities for underrepresented groups in science, engineering, and mathematics. NHMFL management recognizes the need to establish a policy for expanding and maintaining a diverse and inclusive organization to ensure a broad pool of highly qualified candidates and to retain the critical and high-performance skills needed to operate the laboratory. It is also committed to providing an enriching environment for undergraduate and graduate students to explore research opportunities and to encourage them to remain committed to securing the highest degree possible. The NHMFL recognizes that early exposure to the importance of science, engineering, and math as academic and career paths among K-12 students and teachers is a very effective strategy for generating the workforce of the future. The NHMFL educational outreach programs will continue its outreach to these targeted constituencies.

Action Plan

The NHMFL has a goal to become a nationally-recognized leader in the diversity of its scientific, technical and engineering (STEM) staff, much as its other education and outreach programs are presently recognized as national leaders.

ACTION 1: Build diversity permanence into the NHMFL scientific population

- **[Results]** Ensure that at least one member from the NHMFL Diversity Committee actively serves on each NHMFL Search Committee to increase awareness and knowledge of diversity issues within every search committee.

- **[Leadership; HR Focus]** Train NHMFL managers and search committees using materials from the STRIDE program at the University of Michigan [http://sitemaker.umich.edu/advance/stride] and other successful programs.

- **[Leadership; Results]** Advertise in venues that reach women and minorities (special subgroups of professional organizations, focused conferences and workshops, etc.), e.g., Society for Advancement of Chicanos and Native Americans in Science (SACNAS), Association for Women in Science (AWIS), National Society of Black Physicists (NSBP).

- **[Leadership; Results]** Ensure that at least one female and/or minority candidate is invited to visit the NHMFL as a finalist candidate for each search, as this disproportionately increases the likelihood that a woman and/or minority scientist will be hired.

- **[Statistics and Analysis]** Require each search committee to summarize specific efforts to recruit scientific staff from underrepresented groups.

- **[Statistics and Analysis]** Maintain new hires at a rate above the present level of diversity at the NHMFL, particularly for senior hires into permanent scientific positions. Track progress using the three-year running averages of diversity statistics to provide annual concrete feedback while minimizing statistical fluctuations in this assessment.

- **[HR Focus]** Provide an environment for success of NHMFL new hires from underrepresented groups by providing mentors, opportunities to network within and beyond the NHMFL.

- **[HR Focus]** Promote retention of staff members in underrepresented groups by monitoring and cultivating progress at all career stages, including not only formal performance appraisals but also informal reviews among mentors and attention to maintaining a receptive and responsive workplace environment at the NHMFL.

ACTION 2: Develop and cultivate individually-crafted early career opportunities for members of underrepresented groups at the undergraduate level and above

- **[Leadership]** Establish meaningful relationships with historically black, Hispanic and female universities through the NHMFL CO-WIN (College Outreach-Workforce Initiative) program of exchanging scientific visits.

- **[Leadership; Results]** Invite identified individuals to apply to the NHMFL's REU, postdoc and Visiting Scientist programs, including those positions reserved for underrepresented groups.

- **[HR Focus]** Provide financial support for summer research collaborations and seek year-round collaborations with scientists from underrepresented groups, including supporting proposal originated by these scientists.

- **[Leadership; Results]** Actively recruit members of underrepresented groups at all times, not only when there are predetermined searches. Maintain and cultivate relationships with potential candidates over many years.

- **[Leadership; Results]** Network to discover unforeseen opportunities to hire, including offering invited talks to female and minority faculty to visit the NHMFL and establish connections with NHMFL scientists.

ACTION 3: Aim educational outreach for K-12 and the general public to broad and diverse groups

- **[Leadership]** Aim NHMFL education and outreach to a diverse and large population of young students and the general public, to teach the importance of science as a career to the individual and the nation.

- **[Leadership]** Broadly advertise the NHMFL's Annual Open House, as well as its REU and RET programs and assess the diversity of the group benefiting from each of these programs.

- **[Leadership]** Aim NHMFL education and outreach to the general public and government officials, to present scientific research as an engine for economic growth and national prosperity.

ACTION 4: Maintain awareness among NHMFL staff and user programs that Diversity Matters

- **[Strategic Planning]** Understand the national importance of increasing the diversity of the STEM (Science, Technology, Engineering and Mathematics) population throughout the United States.

- **[Strategic Planning]** Develop explicit criteria to convey the importance of diversity, including an active Diversity Committee, periodic labwide informational meetings and permanent diversity resources on the NHMFL website.

- **[Strategic Planning; Statistics & Analysis]** Understand NHMFL diversity in the national context, including the monitoring of progress through the maintenance of NHMFL and national statistics on diversity.

ACTION 5: Maintain frequent external guidance and review of NHMFL diversity issues

- **[Strategic Planning; Results]** Incorporate diversity presentations and discussions into meetings of the NHMFL Executive Committee, NHMFL User Committee, the NHMFL External Advisory Committee and at NSF Site Visits.

- **[Results]** Ensure that the Diversity Committee, Diversity Advisory Committee and NHMFL External Advisory Committee include a diverse membership, as well as university, regional and national leaders working to improve diversity in the scientific workforce of the future.

- **[Results]** Seek to increase the diversity of the NHMFL's User Committee, whose membership is determined by vote of the user community, through active recruiting of a diverse slate of candidates.

Assessment

[Results] The NSF and NSF external site visit committees will review the NHMFL Diversity and Inclusion Action Plan and its progress in implementing its goals.

2013-2017 Strategic Plan in Historical Perspective

- **September 1990** Original NSF award to FSU to establish and operate the MagLab through 1995

- **Five year awards typically:** The 2001-2005 award was extended to 2007 to delay the next renewal proposal submission until the release of the National Academy COHMAG report and the acclimation of the MagLab Director in the position that he started in April 2004.

- **National Academy of Sciences 2005 'COHMAG' Report** by Committee on Opportunities in High Magnetic Field Science endorses the NHMFL in run-up to 2008-2012 proposal submission:
  - "high magnetic field science and technology are thriving in the United States"
  - "the prospects are bright for future gains from high-field research"
  - "high-field magnet science is intrinsically multidisciplinary,"
  - *"NHMFL has successfully fulfilled the need for high-field magnets for about a decade, and its activities have done much to foster the leadership position that the United States currently enjoys in many areas of magnetic science and technology"*
  - "single most important recommendation [is that] the United States should maintain a national laboratory that gives its scientific community access to magnets operating at the highest possible fields."

- **2007 NSF Site Visit Review of MagLab's 2008-2012 Renewal Proposal:** The Executive Summary of the Site Visit Committee Report reads in part: "By virtue of its size, prominence and excellence, the NHMFL plays a critically important role for the scientific training of a future generation of scientists, for its outreach programs to educate young students and the public, for increasing the diversity of our scientific workforce, and for the overall vitality and health of the national scientific enterprise. **It is truly a jewel in the crown of US science."**

- **2007 National Science Board** endorses increase to $162M funding level for MagLab 2008-2012 NSF Grant.

- **2011 Update of MagLab Strategic Plan** in preparation for the 2013-2017 MagLab Renewal Proposal

- **2012 Release of 2013-2017 MagLab Strategic Plan**

Process for Developing the 2013-2017 Strategic Plan

The MagLab Strategic Plan articulates the five to fifteen year vision for the laboratory. The Strategic Plan is updated every five years during the development of the five-year NSF proposal that provides the MagLab's core funding. The process for developing the MagLab Strategic Plan begins at roughly the midpoint of a five-year funding cycle. For example, development of the 2008-2012 Strategic Plan was begun in mid-2005. Many stakeholders contribute to the development of the Strategic Plan, including MagLab scientists and staff; members of the MagLab External Advisory Committee, MagLab User Committee, and MagLab user community at large; and participants in the NSF Site Visits. Wide involvement in MagLab planning is essential because the activities described in the Strategic Plan are carried out in conjunction with numerous partners in the broader university and scientific community.

Key steps in the development of the 2013-2017 Strategic Plan include:

- Summer 2010: Articulation, discussion and refinement of draft science drivers and draft technical goals with MagLab External Advisory Committee.

- Autumn 2010: Articulation, discussion and further refinement of draft science drivers and draft technical goals with MagLab User Committee and solicitation of two-page white papers on opportunities for MagLab research, instrumentation, technology, outreach and education goals for the 2013-2025 timeframe.

- Late 2010: Articulation and discussion of draft science drivers and draft technical goals with NSF Site Visit Committee and NSF Program Managers.

- Early 2011: Posting of Science Drivers and white papers for 2013-2017 Strategic Plan on website available to members of the MagLab community, including all MagLab staff, affiliates and users. Continued solicitation of input including new white papers.

- Early 2011: Teleconferences with User Committee members and External Advisory Committee members to discuss opportunities articulated in white papers and refine definition and scope of each Science Driver.

- Spring 2011: Refinement and condensation of white papers. Finalize definition and scope of each Science Driver in response to white papers.

- Late Summer 2011: Incorporate all input into the structure of the Strategic Plan: Vision; Mission Imperatives; Science Drivers; Technical Goals resulting from the Science Drivers; Education, Diversity and Outreach Goals; and Science-Enabling Technical Frontiers.

- Autumn 2011: Present draft 2013-2017 Strategic Plan to MagLab User Committee.

- Late 2011: Present near final draft 2013-2017 Strategic Plan to NSF Site Visit Committee and NSF Program Managers.

- Early 2012: MagLab Executive Committee releases 2013-2017 Strategic Plan.

APPENDIX H

1030 Forms

NHMFL 2008-2012 NSF

Statement of Budget, Expensed and Total Residual Funds

NSF Facilities Award

		BUDGET 2008-2012	As of December 31, 2012 EXPENSED 2008-2012	RESIDUAL FUNDS
A-C. TOTAL SALARIES, WAGES AND FRINGE BENEFITS		39,356,638	39,179,338	177,300
D. TOTAL EQUIPMENT		14,998,155	13,228,910	1,769,245
E. TRAVEL	1. DOMESTIC	969,819	948,013	21,806
	2. FOREIGN	319,914	316,299	3,615
F. PARTICIPANT SUPPORT				
	1. STIPENDS	234,019		
	2. TRAVEL	12,000		
	3. SUBSISTENCE	18,000		
	4. OTHER	207,769		
TOTAL PARTICIPANT COSTS		471,788	444,044	27,744
G. OTHER DIRECT COSTS				
1. MATERIALS AND SUPPLIES		14,812,598	14,741,623	70,975
2. PUBLICATION/DOCUMENTATION/DISSEMINATION		-	-	-
3. CONSULTANT SERVICES		-	-	-
4. COMPUTER SERVICES		-	-	-
5. SUBAWARDS		37,006,611	36,461,879	544,732
6. OTHER		14,743,223	14,606,330	136,893
TOTAL OTHER DIRECT COSTS		66,562,432	65,809,832	752,600
H. TOTAL DIRECT COSTS (A THROUGH G)		122,678,746	119,926,436	2,752,310
I. INDIRECT COSTS (F&A) (SPECIFY RATE AND BASE)				
	Rate: %	52%	52%	
TOTAL INDIRECT COSTS (F&A)		29,046,254	28,750,566	295,688
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)		**151,725,000**	**148,677,002**	**3,047,998**

[1]Includes deferred User Collaboration Grant Program awards to be reissued after approval of no cost extension.

[2]Includes subaward balances to be invoiced and paid within 90 days of award end date.

SUMMARY PROPOSAL BUDGET

ORGANIZATION	FOR NSF USE ONLY		
Florida State University (NHMFL) January - December 2013	PROPOSAL NO.	DURATION	
		Proposed	Granted
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Gregory S. Boebinger	AWARD NO.		

	NSF-Funded Person-months			Funds Requested By Proposer
	CAL	ACAD	SUMR	
A. (39) TOTAL SENIOR PERSONNEL (1-6)	300.71	0.00	0.00	2,299,148
B. OTHER PERSONNEL				
1. (10) POSTDOCTORAL ASSOCIATES	110.77	0.00	0.00	494,486
2. (67) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	680.91	0.00	0.00	3,239,756
3. (6) GRADUATE STUDENTS				120,567
4. (11) UNDERGRADUATE STUDENTS				159,318
5. (16) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				463,201
6. ( ) OTHER Temporary				0
TOTAL SALARIES AND WAGES (A + B)				6,776,476
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				1,913,819
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				8,690,295
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)				2,176,124
E. TRAVEL 1. DOMESTIC (INCL. CAN, MEX & U.S. POSSE				270,189
2. FOREIGN				30,122
F. PARTICIPANT SUPPORT				
1. STIPENDS	133,200			
2. TRAVEL	9,000			
3. SUBSISTENCE	15,000			
4. OTHER	2,158			
TOTAL NUMBER OF PARTICIPANTS (22) TOTAL PARTICIPANT COSTS				159,358
G. OTHER DIRECT COSTS				
1. MATERIALS AND SUPPLIES				3,301,008
2. PUBLICATION/DOCUMENTATION/DISSEMINATION				0
3. CONSULTANT SERVICES				0
4. COMPUTER SERVICES				0
5. SUBAWARDS				8,027,493
6. OTHER				2,523,772
TOTAL OTHER DIRECT COSTS				13,852,273
H. TOTAL DIRECT COSTS (A THROUGH G)				25,178,361
I. INDIRECT COSTS (F&A) (SPECIFY RATE AND BASE) Rate: 52% Base: $12,391,614				
TOTAL INDIRECT COSTS (F&A)				6,443,639
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				31,622,000

Summarized from NSF Form 1030

APPENDIX I

Publications & Activities Index

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