# Ultrafast Functional and Diffusion Magnetic Resonance Imaging

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## Introduction

The high-field 21.1 T MRI/NMR system at the National High Magnetic Field Lab (NHMFL) provides the highest sensitivity available for *in vivo* functional magnetic resonance imaging (fMRI) and diffusion weighted imaging (DWI) studies. We have recently implemented a suite of ultrafast single-shot spatially encoded (SPEN) imaging sequences on the 21.1T imaging platform, and have begun *in vivo* fMRI and DWI pilot studies at the NHMFL. The SPEN imaging sequences provide an advantage over standard echo planar imaging sequences due to their relative immunity to high field susceptibility and phase-encode ghosting artifacts. Our steady-state SPEN imaging protocols offer a novel means for recording functional contrast in high-field applications.

## Experimental

Spatially encoded diffusion weighted imaging sequences were implemented on Paravision 5.1 on the NHMFL Bruker Avance III spectrometer operating at 21.1T. Echo-planar imaging (EPI) based sequences utilize a frequency swept pulse played in the presence of a spatial encoding gradient with a 180° slice selective shaped pulse placed within the diffusion weighted imaging module (**Figure 1a**). Post-processing was carried out on Matlab and consisted of realignment and shearing of positive and negative EPI readouts, and application of super-resolution reconstruction that yields a final <200 µm pixel resolution (**Figure 1b**).

## Results and Discussion

Initial results obtained on the 21.1T NHMFL imaging platform demonstrate that the SPEN pulse sequences are performing well, and the high-magnetic field advantage is providing unprecedented signal-to-noise in these experiments. With these positive results in mind, we are now carrying out diffusion imaging studies with *in vivo* rat stroke models utilizing contrast agent perfusions including gadolinium and dysprosium chelates, super-paramagnetic iron oxides (SPIO), and SPIO labeled therapeutic stem cells. Moreover when combined with fMRI paradigms these SPEN DWI experiments can probe diffusion contrasts that are emergent during the hemodynamic response.

## Conclusions

Our collaboration with the Grant Lab combines SPEN pulse sequences, the NHMFL high-field MRI platform, and *in vivo* rat stroke models currently being evaluated at the NHMFL. Ultimately, combined SPEN fMRI and DWI studies will provide us with robust protocols with which to evaluate functional hemodynamic response in an *in vivo* model that has immediate implications for diagnosis and detection of motor-sensory impairment following stroke-related ischemia.

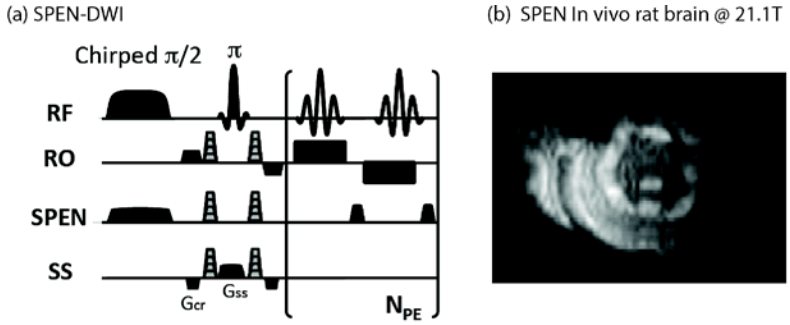


**Figure 1.** SPEN Imaging at 21.1T. A novel means for acquiring artifact-free functional and diffusion images at ultra-high field.

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