

# Condensed Matter NMR User Facility at NHMFL

**Low Temperature Wideline NMR** - probes electronic interactions in Condensed Matter Systems via electron-nuclear hyperfine coupling.

## Magnets

- 25T 52mm bore, 1 ppm/mm resistive (Cell 6) 31T 32mm bore, 3 ppm/mm resistive (Cell 2), Optics (Cell 3)
- 45T hybrid, 32 mm bore, 25ppm/mm (Cell 15)
- 12T 39mm, 40ppm/cm field-sweepable superconducting
- 15T 40mm, 4ppm/cm field-sweepable superconducting
- 17T 40mm, 10ppm/cm , sweepable superconducting
- 18T 25mm, 100ppm, SC dil-fridge equipped (SCM1)

## Spectrometers and probes

- Five MagRes2000 homemade portable homodyne quadrature-detected console 2MHz-2GHz system, 100 MS/s, Labview interface, 25ns pulse widths, up to 600W
- Four High Field Probes – >500 MHz, 1.6-350K vacuum sealed, ~micron to 10mm sample dia , single and dual axis goniometry, optical access, high pressure, stepper motor bottom tuning, simultaneous transport and NMR
- Q=1 probe, top tuning for ultrawide frequency sweeps

## Cryogenics

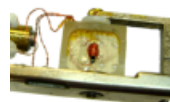
- 4 Adjustable flow VT cryostats- 1.4 to 325K, fast cooldown, for 31mm bucket dewars
- $^3\text{He}$  sorption 350mK Janis cryostat
- 20-300mK Oxford Dilution Fridge (SCM1)



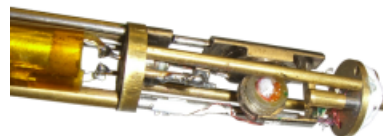
**Standard  
Goniometer**



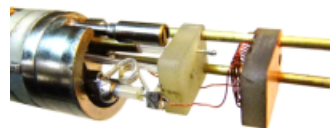
**Dual axis Rotator**



**Resistively Detected NMR  
(Simultaneous transport)**



**milliKelvin  
Dilution Fridge**



**Optical pumping  
OPNMR**



**Uniaxial stress**

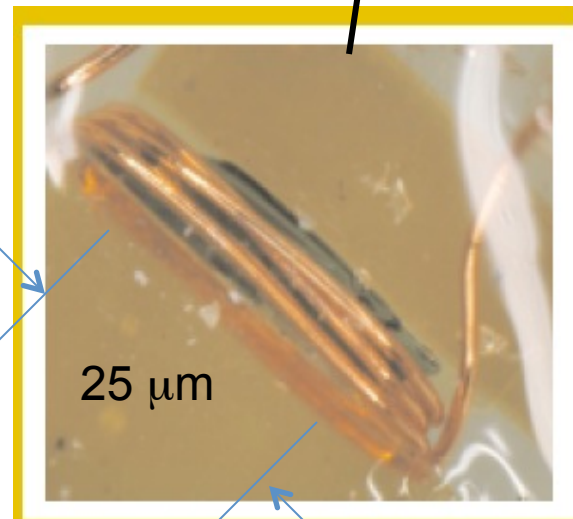
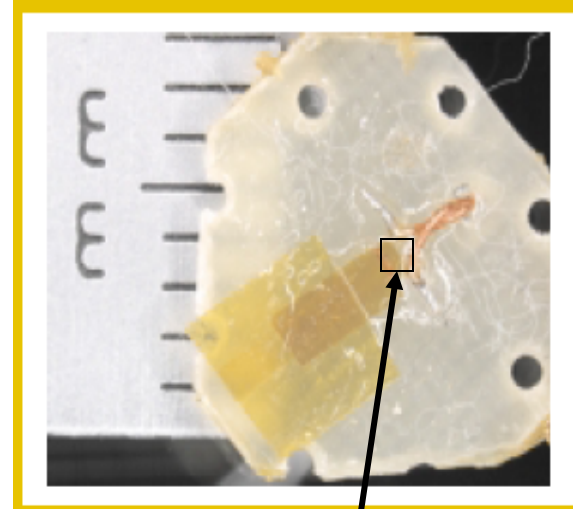
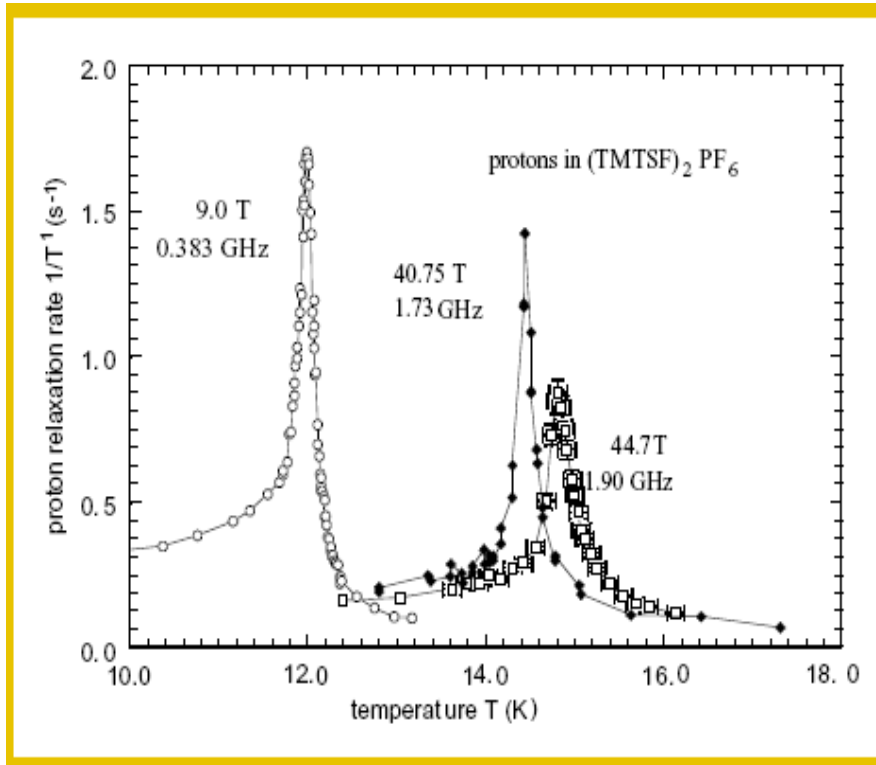


**Pulse  
Fields**



**High  
Pressure**

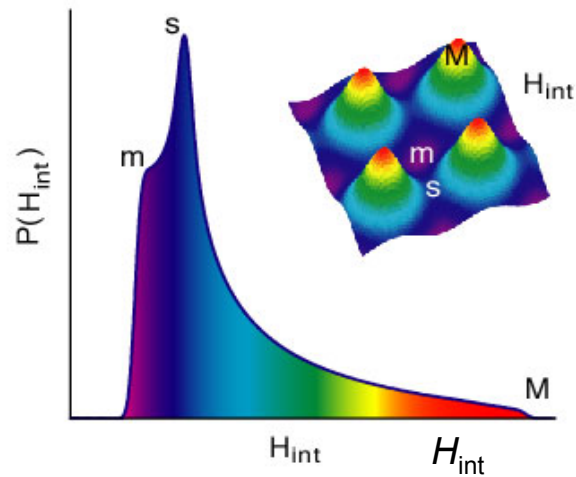
# World's Highest NMR Frequency 1.90GHz (44.7T protons) - microcoils



Critical Fluctuations in Quasi-1D  
SDW  $(\text{TMTSF})_2\text{PF}_6$

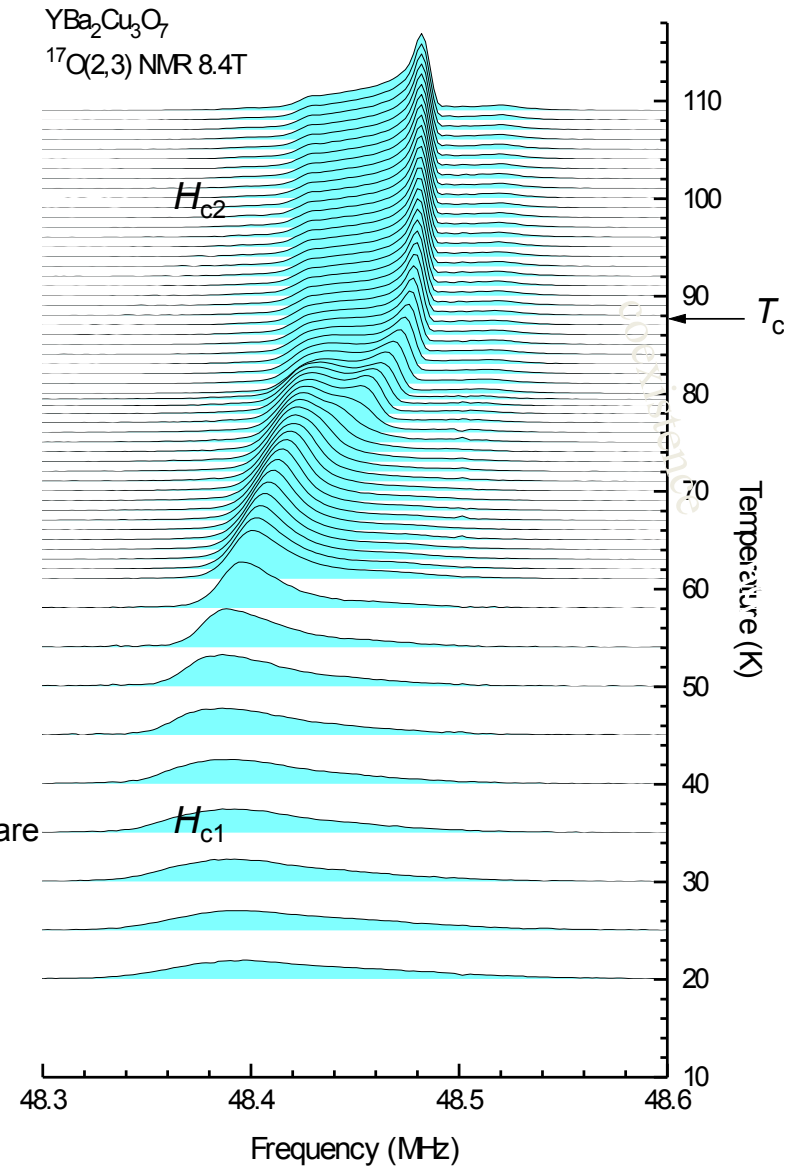
Clark et al., Int. J. of Mod. Physics B16,3252 (2002).

# NMR in HTSC: Field Map and Vortex Image

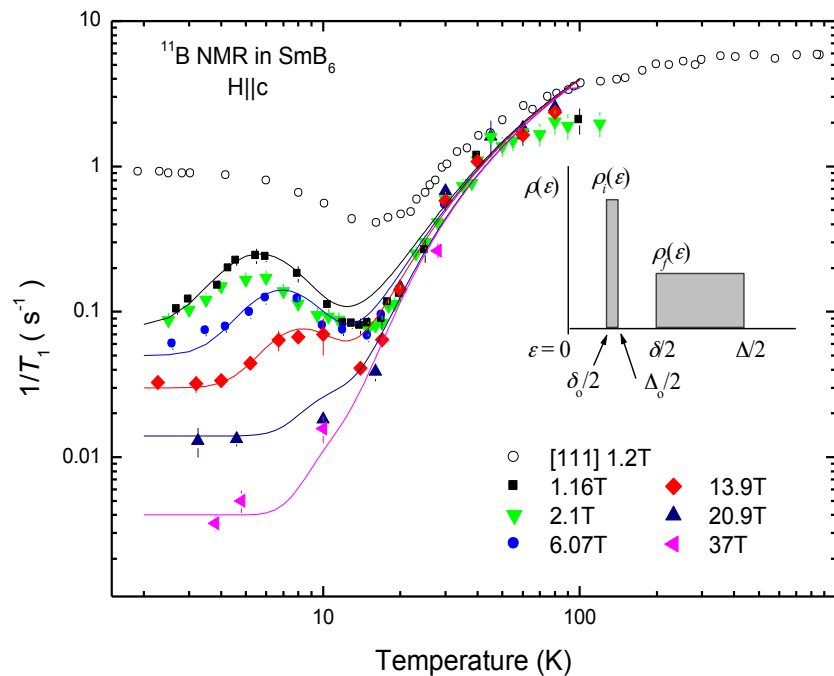


The real space internal magnetic field profile and the corresponding field distribution function,  $P(H_{int})$ , for a square vortex lattice in a superconductor as seen by NMR.

Reyes et al., PRB 55, R14737(1997)

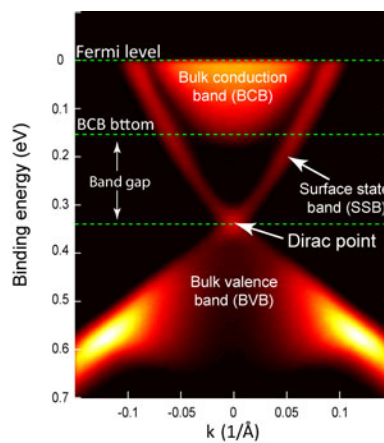


# Topological Kondo Insulator $\text{SmB}_6$

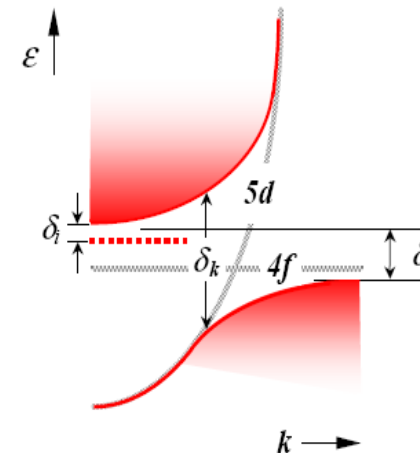


## $^{11}\text{B}$ Field dependent relaxation and model density of states

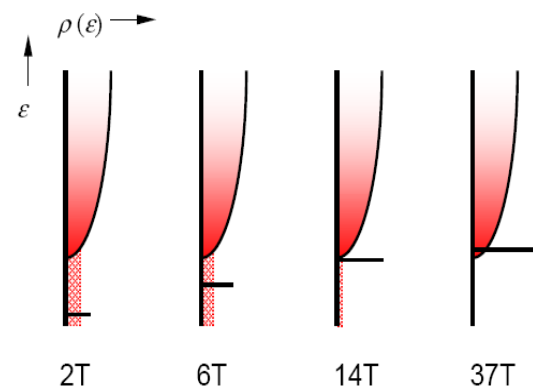
T. Caldwell, A. P. Reyes, W. G. Moulton, P. L. Kuhns, M. J. R. Hoch, P. Schlottmann, and Z. Fisk, Phys Rev B 75, 075106 (2007).



TI band structure



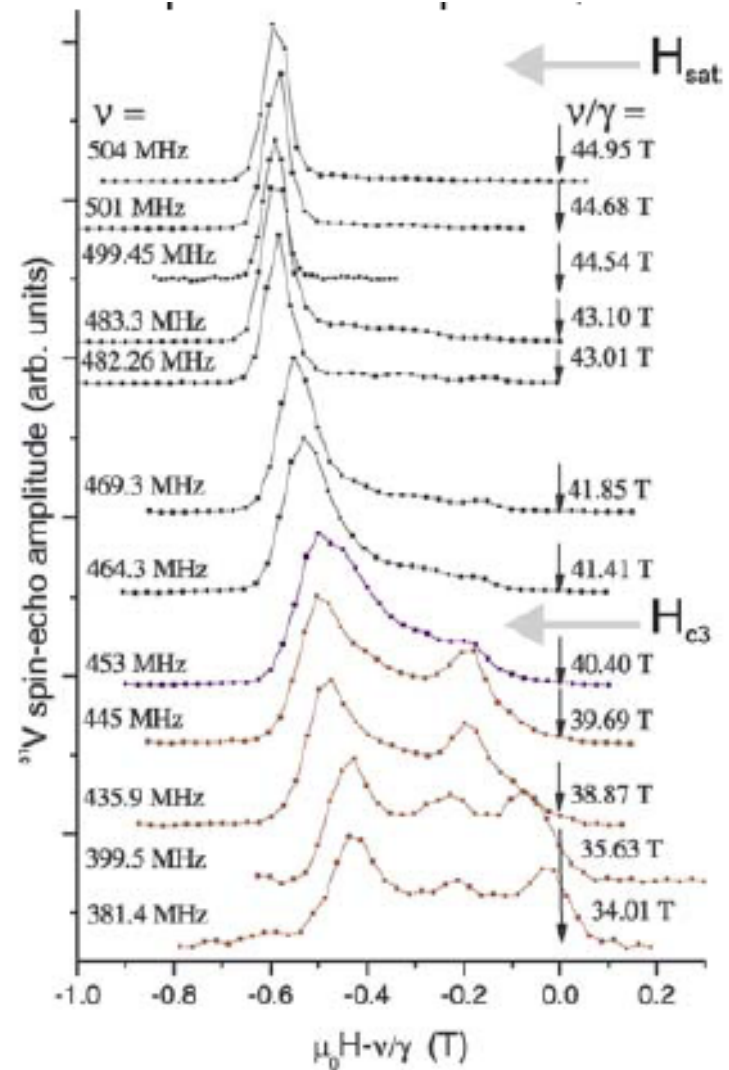
Hybridization gap



In-gap states and field suppression of gap

# Spin-Nematic Phase in Frustrated AF $\text{LiCuVO}_4$ (New state of matter)

- Spin-nematic - new exotic state of matter
- Similar to liquid crystals
- Rotational symmetry, no LR spin order
- Results of competition between AF and FM interaction
- Magnon pairs undergo BEC above  $T_c \sim 40\text{T}$ .
- NMR shows narrowing of line where all magnons line up with field



Buettgen et al. (2013)