Combining Magnet and Neutron Pulses at SNS

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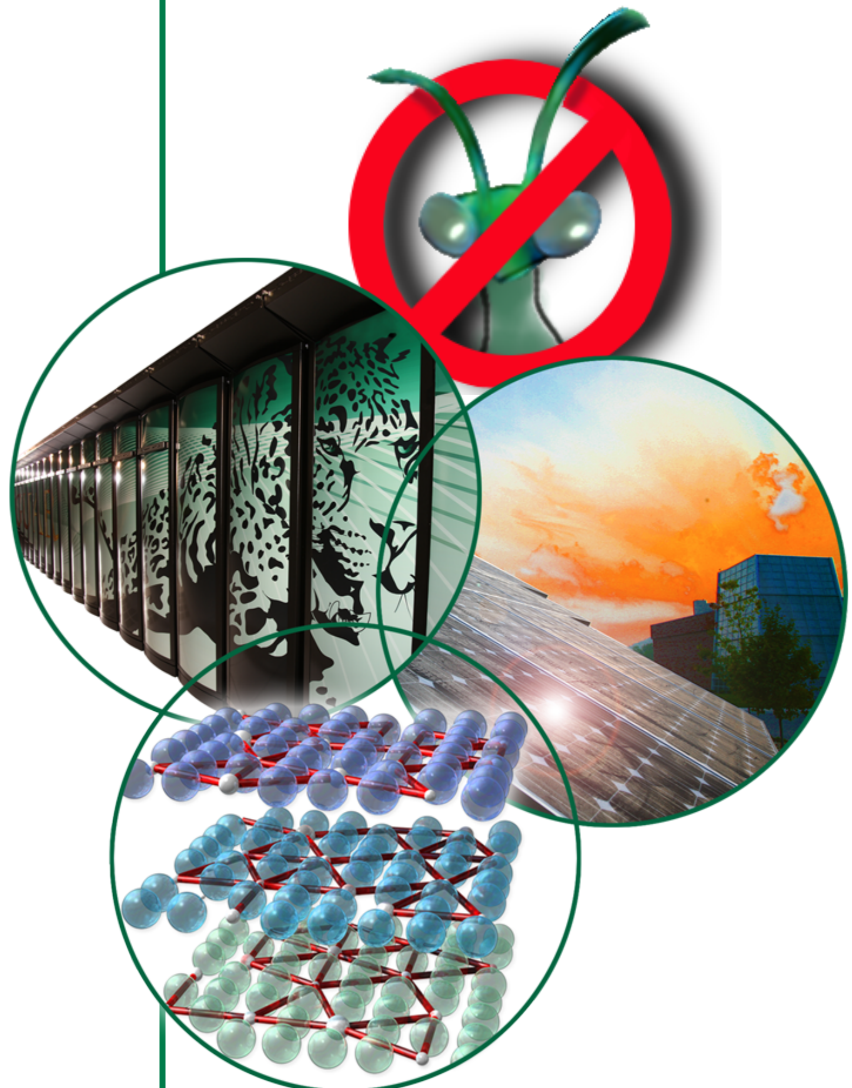

October 11, 2010
NOBUGS 2010
Gatlinburg, TN

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
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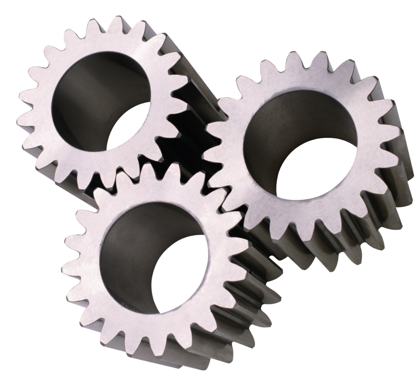
Motivation

- **Explore Magnetic and Atomic Structure under Large Magnetic Field Activation and Decay…**
  - **Use Large Magnetic Fields, Reduce Heat Produced**
    - **At 30T: can pulse magnet for ~2ms, only mV of cooling**
    - **Alternative: run steady state with 16 MW of cooling power!**
- **Analysis Requires More than "Filtering" Pulses**
  - ***Correlate & Synchronize* ~ Neutron / Magnet Pulses**

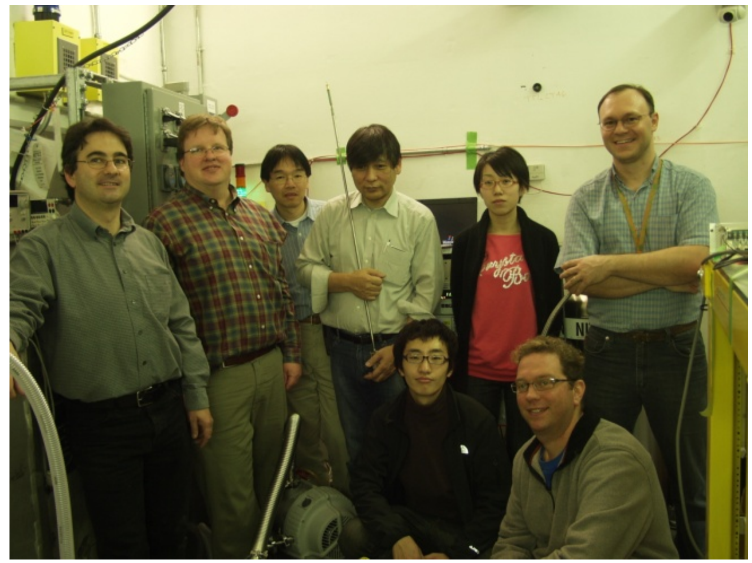
Outline:

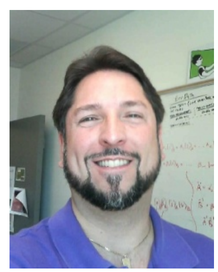
- **The People and the Equipment**
- **Software Architecture Solution**
- **Proof of Principle / Results**



Acknowledgements

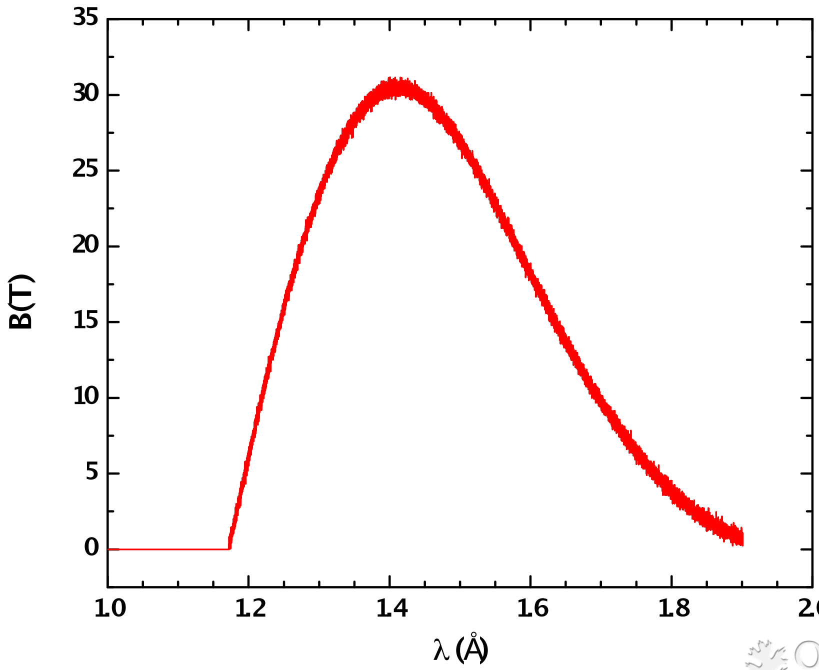
- Pulsed Magnet and $MnWO_4$ – H. Nojiri, B. Gaulin, L. Santodonato, K. Ross, M. Matsuda, K. Okada, M. Yasui, J. Carlo, P. Peterson, J. Kohl, A. Parizzi





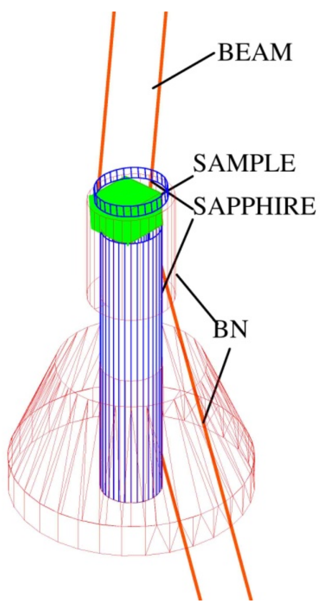
The Magnet

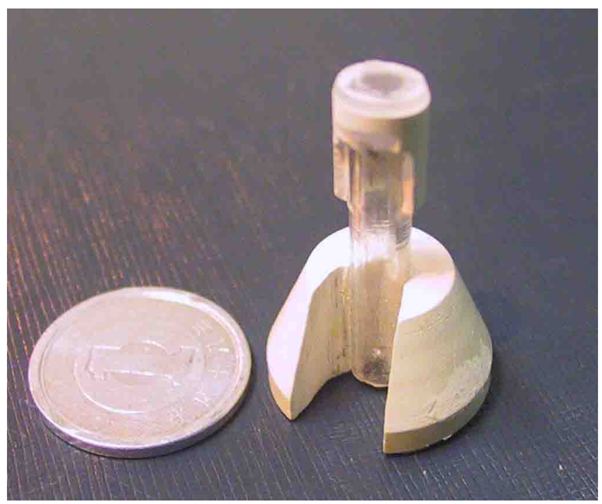
- Insert to orange cryostat
- Can apply up to 30 T on a sample
- Synced to timing signal just like a chopper (with “delay”…)
- 1 pulse every 2-3 minutes depending on peak field
- 14 degrees of scattering angle



Magnet and Mounting

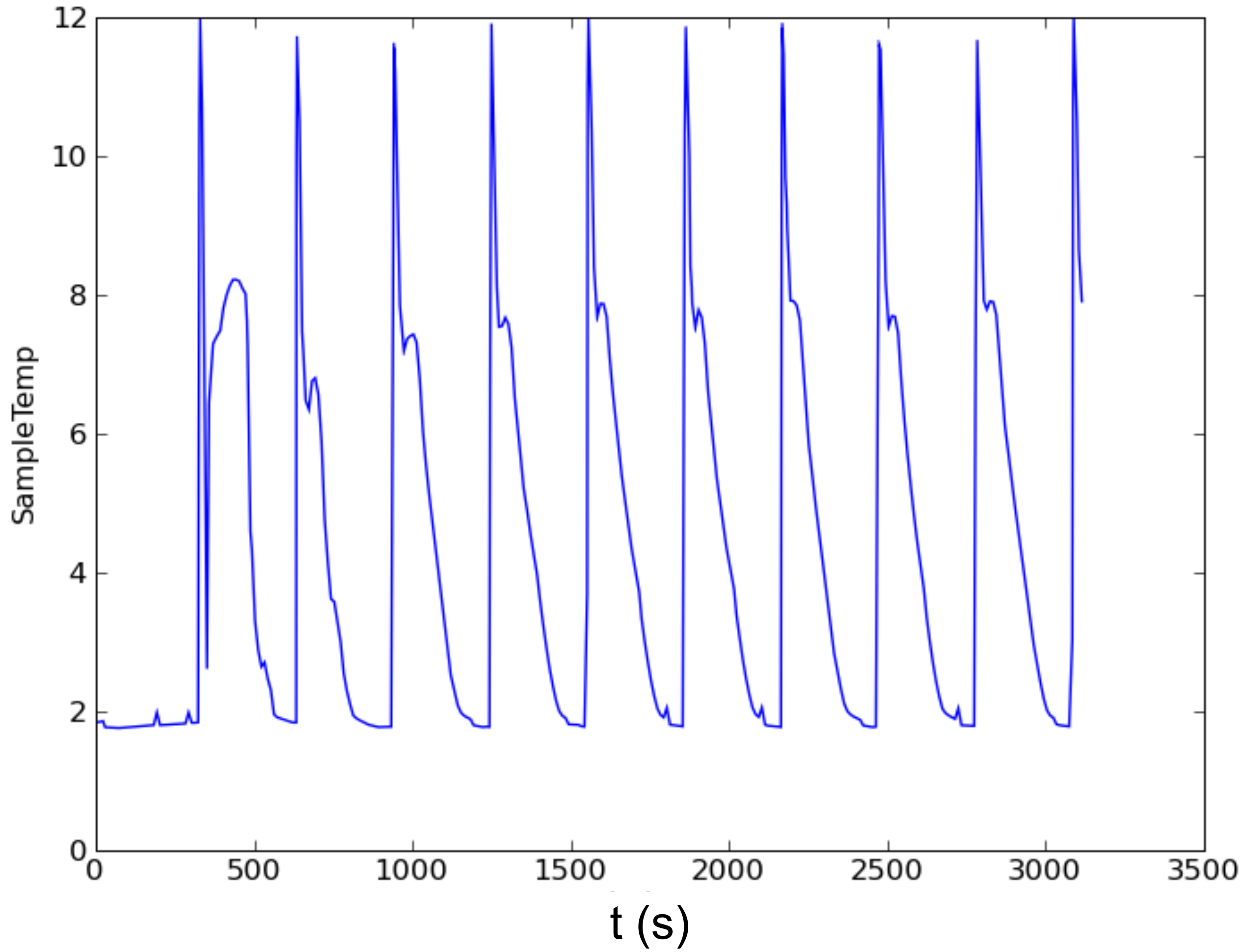
- **Sample well shielded**





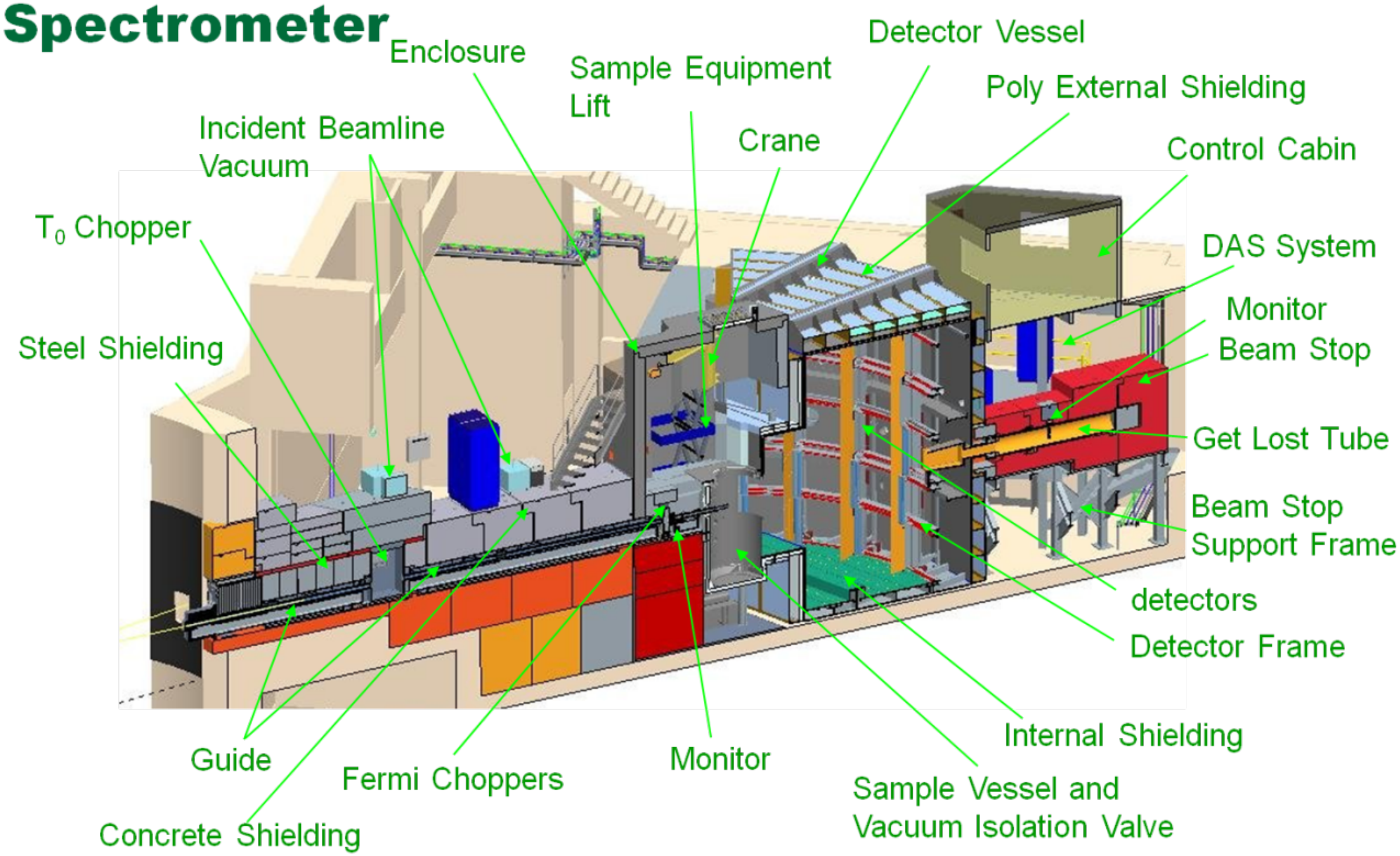
Magnet Must Be Cool

- Field pulse accompanied by Temperature pulse



The Instrument

SEQUOIA – High Resolution Chopper Spectrometer



Analysis Challenges

- Validating Magnet Pulses
  - Variations in activation / timing for magnet hardware
    - Sometimes the magnet doesn't fire, or fires way too late…
    - Moderately uniform; fortunately it's measurable…! ☺
  - User provides optional inputs to manually filter pulses
    - Set "Min / Max Magnet Delay" (filter pulses outside range)
    - Manually Mark Specific "Bad Magnet Pulses" (by index)

Analysis Challenges (cont.)

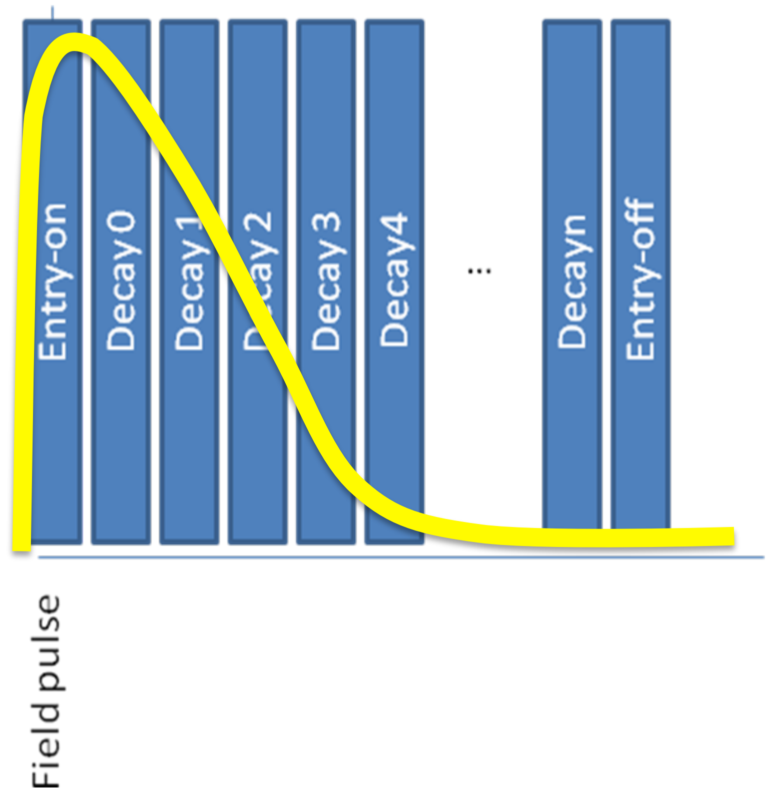
- Correlating Magnet Pulses with Neutron Pulses
  - Both Time Stamps from Same Synchronized Time Channel; Magnet Delays can Shift Correlation by Whole Pulse Width!
    - User specifies Microsecond “Time Offset” for Shifting Magnet Pulses
    - User specifies “Pulse Offset” (*Index)* for Shifting (simple & good!)
- Tachyon Problem, Negative Shift == “Future Knowledge”
  - Fortunately, Post-Mortem File-Based Analysis (for now…!)
  - Still, Can’t “Roll Back” Already-Processed Event Stream…
    - Read *Whole* Magnet Pulse List into Memory, See Whole “Time Track”
    - Keep Running “Last / Next” Magnet References… (yuk)

Analysis Challenges (cont.)

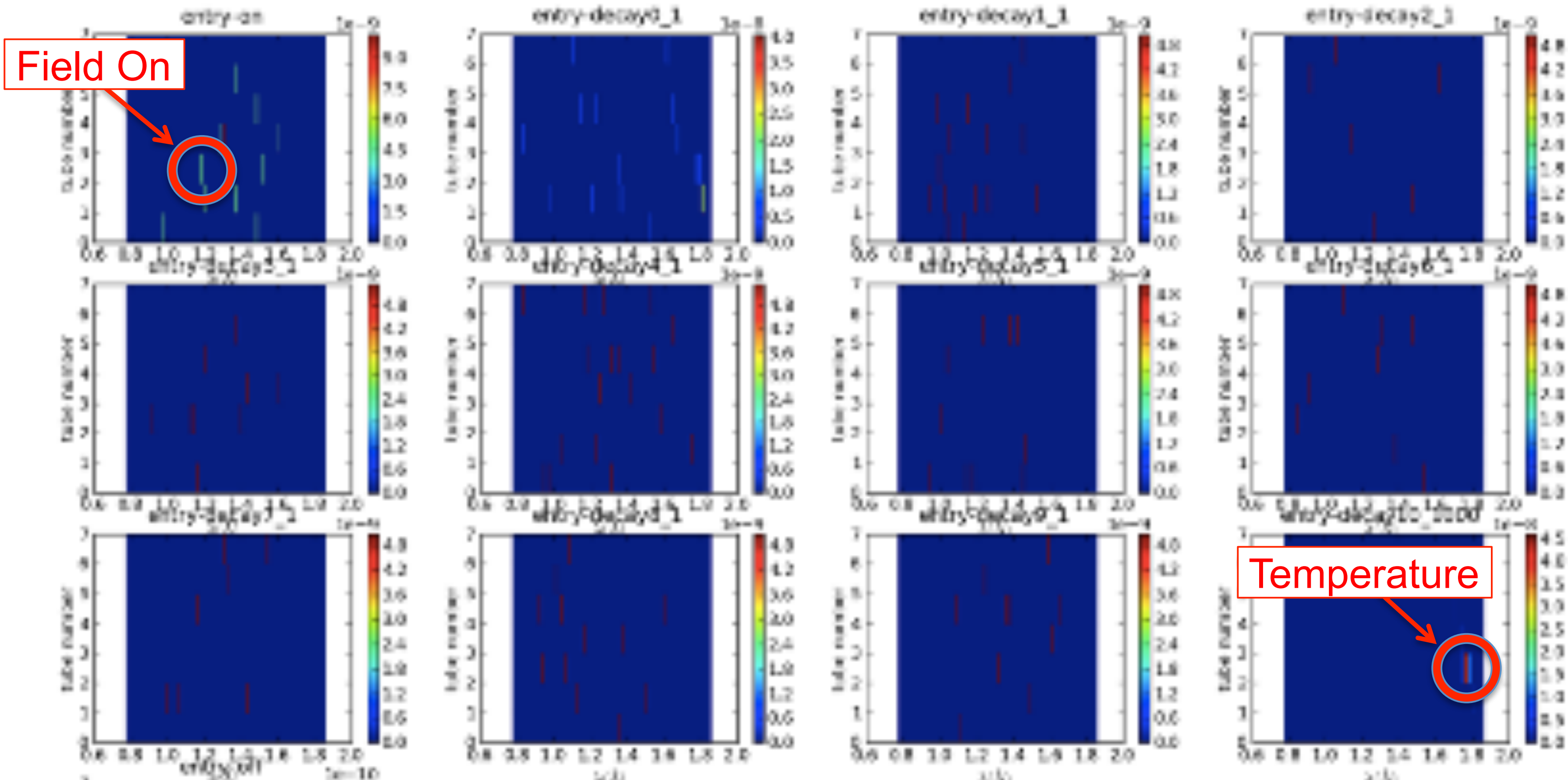
- Variable Number of Histogram States…
  - Normally "fixed", but part of analysis is Characterizing Nature and Impact / Duration of Magnet Decay…
    - User specifies Multiple Variable-Length "Decay Pulse" Periods…
    - Track Overlapping Magnet Pulses, Amidst Decay States… (ewww…)

Data Reduction

- **Histogram the field pulses starting in the "Entry-On" state, with several sets of subsequent frames for Decay$_n$ states, and everything else in the "Entry-Off" state.**



Magnet State Histograms



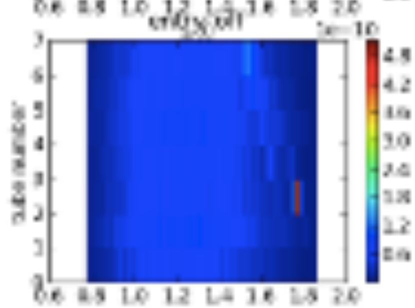
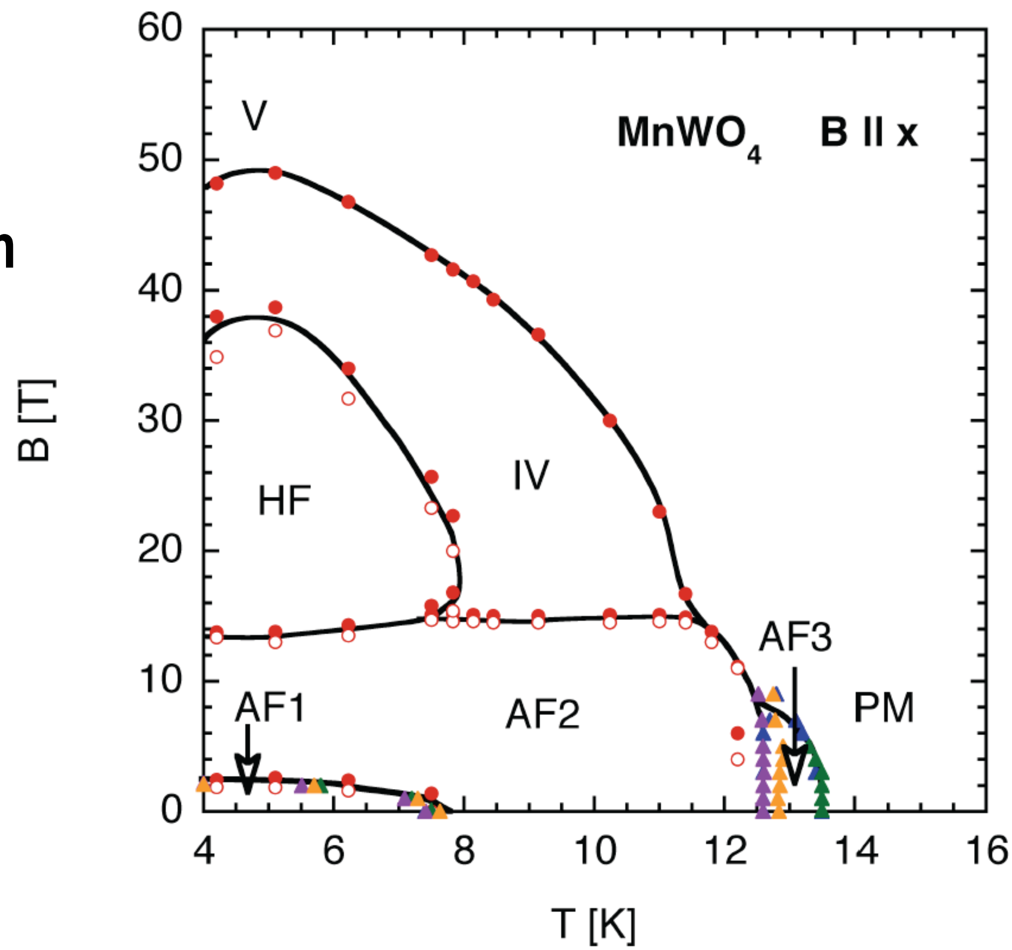


Figure: Bank 94 for Run 2349 histogrammed as described. The data are integrated over pixels 50-70 along the tubes. Notice the peak in the Field-On frame; the next histogram where this peak is observed is the entry-decay10_1000 histogram, a temperature-dependent excursion.

The Sample

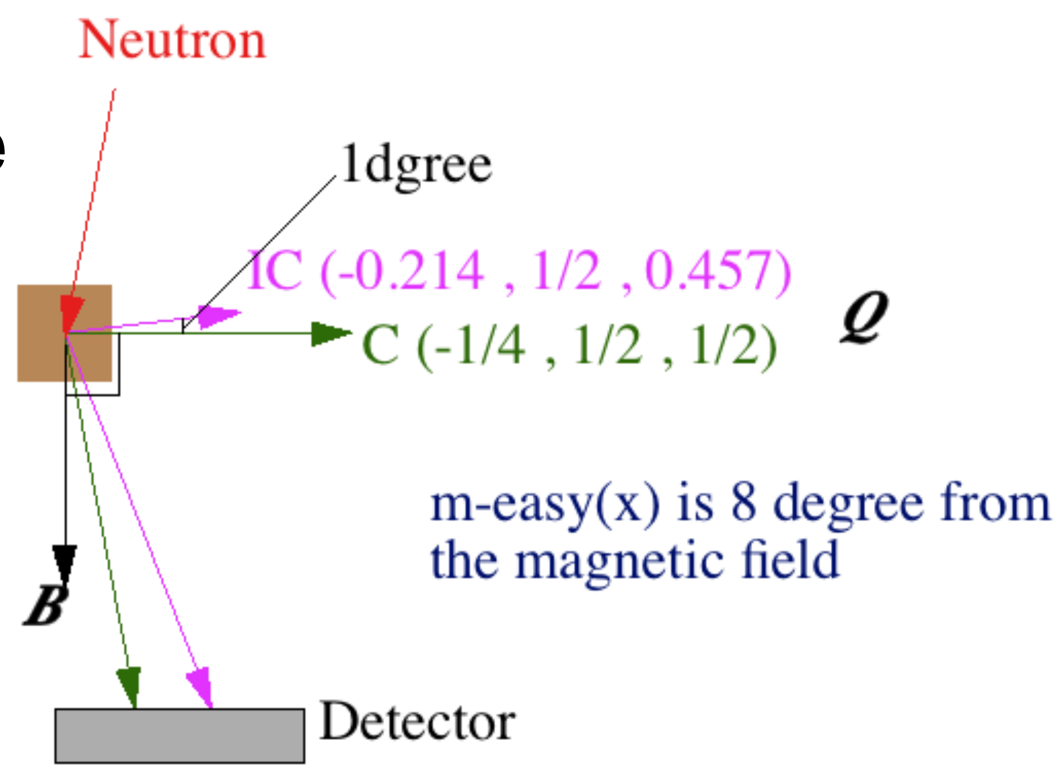
- $MnWO_4$ is ideal
  - MultiFerroic
  - Rich H, T phase diagram
  - AF1 is commensurate spiral
  - AF2 is incommensurate spiral
  - HF is another commensurate state
  - IV is another ??? state
  - G. Lautenschläger et al. PRB **48**, 6087 (1993)



H. Mitamura *et al*. J. Phys: Conf. **150**, 042126 (2009)

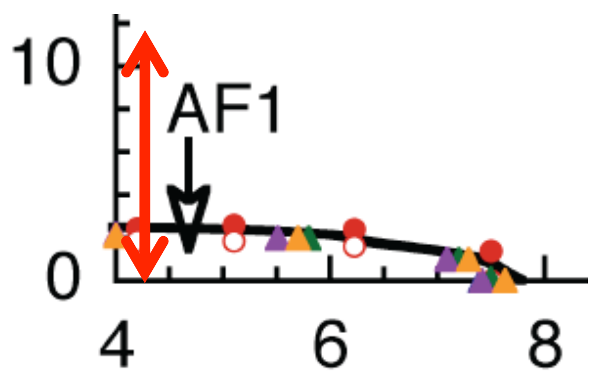
Crystal Alignment

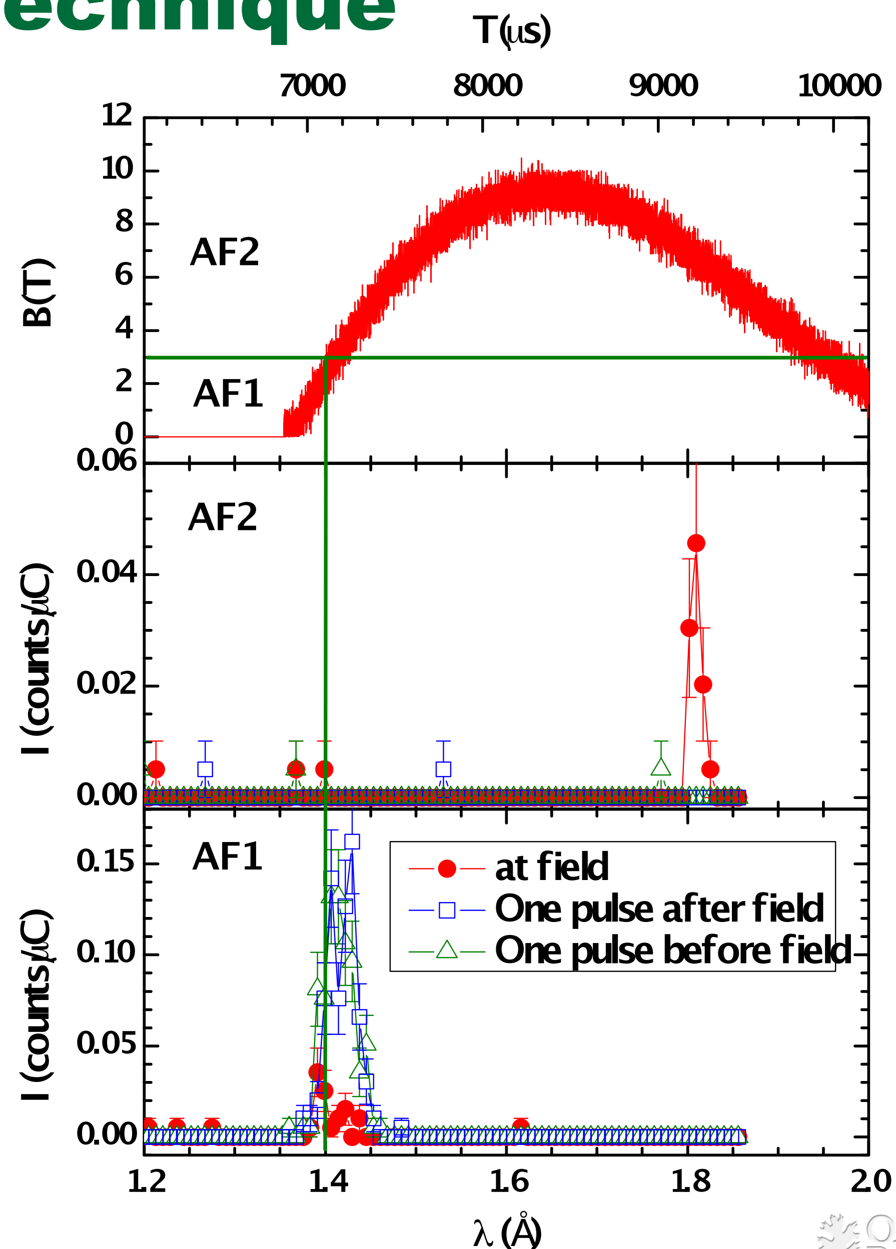
- The d-spacing change between commensurate and incommensurate peaks is small.
- With TOF diffraction, both can be measured with single orientation



Demonstration of Technique

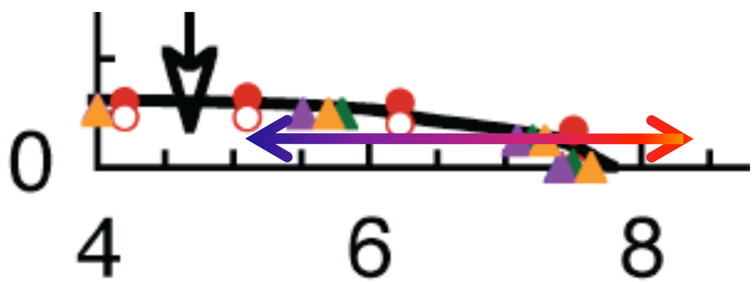
- **Phase magnet pulse for both peaks**
- **Peak is for 20 pulses**
- **Observation in a single tube**
- **T=2K**

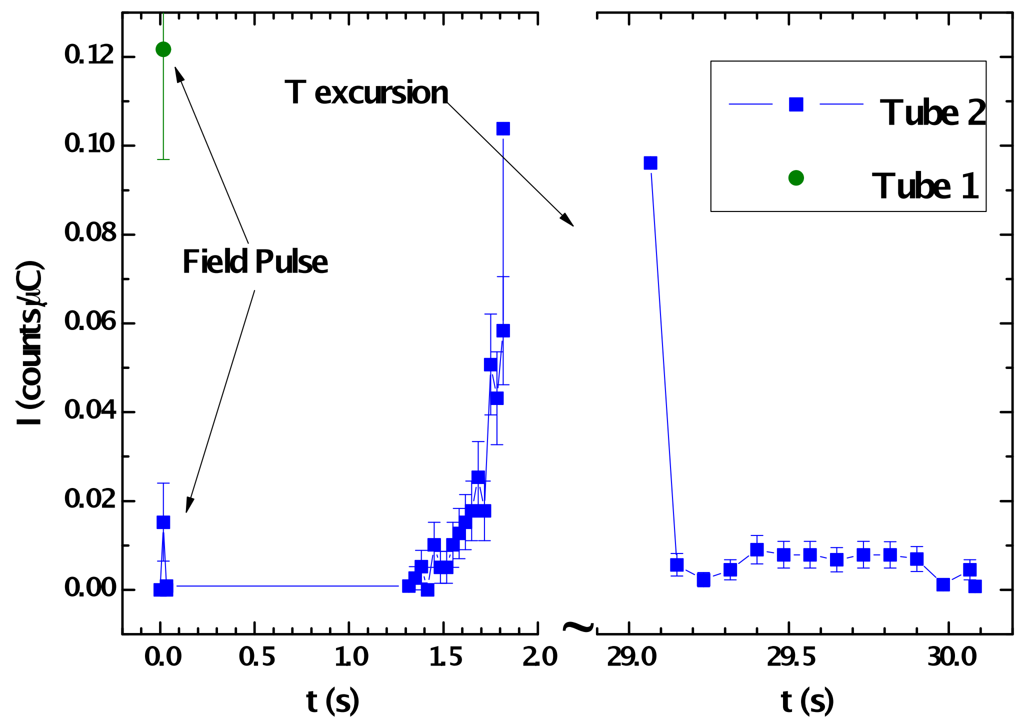




Different Field and Temperature Behavior

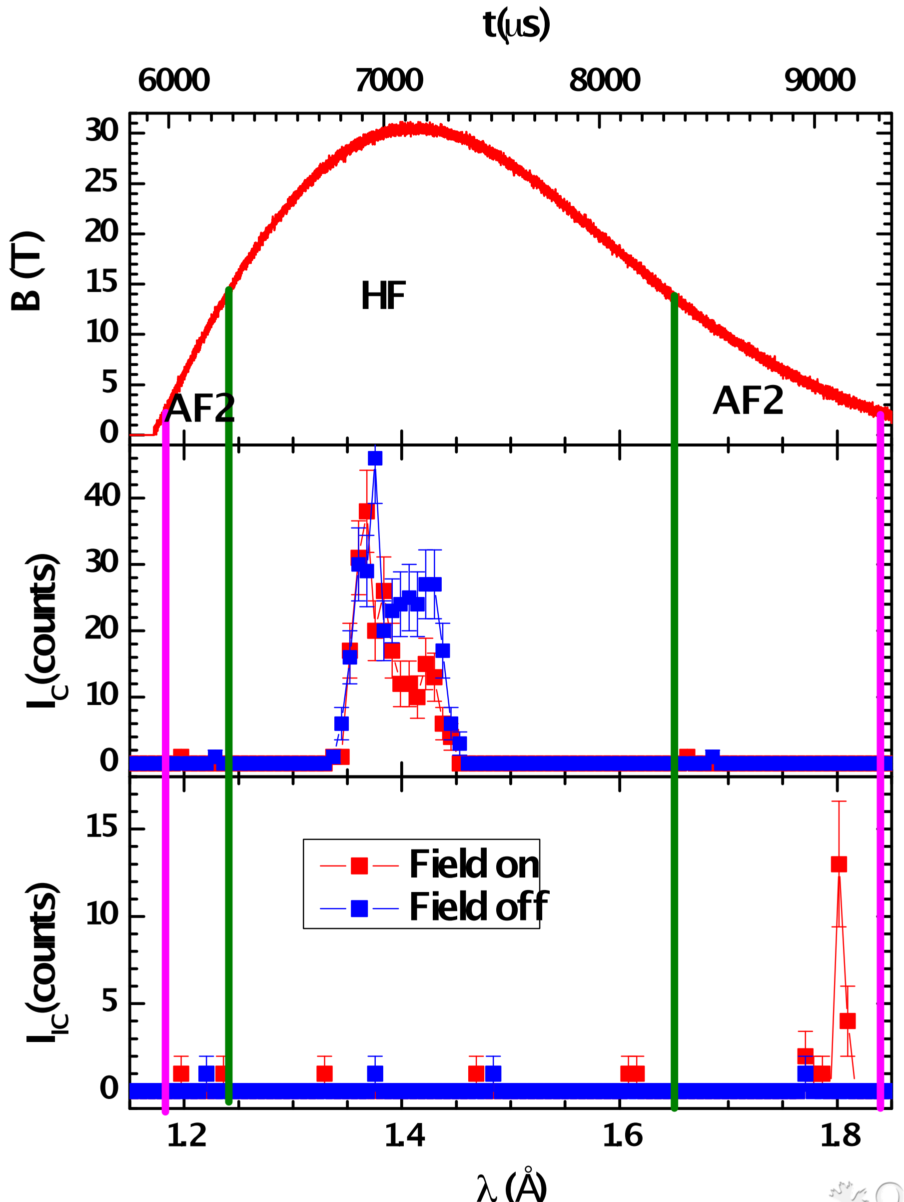
- Observation of field dependent behavior only in field pulse
- T dependent behavior occurs more than 1 second (60 frames) later and lasts for ~ 30 s

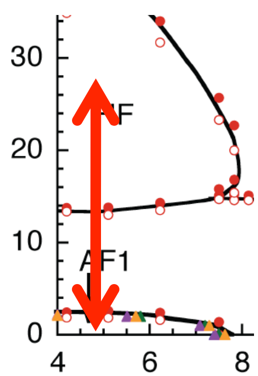




High Field Measurement

- Phase magnet pulse for Commensurate peak at 30 T
- Peak is for 30 pulses
- Sum over two tubes and pixels 50-70
- T = 2 K
- Peak shifts in HF phase





Summary & Future Work...

- Pulsed Magnet Worked!
  - Verified previously observed features in low field
  - Observed Bragg peak changes at 30T in the HF phase
  - More analysis is under way

- Future Plans:
  - Integrate with "Pump Probe" Project on VULCAN (LDRD)
    - Generalize the Correlation of Forcing Functions with Neutron Pulses…
      - Standardize Data Formats for Magnet with Others (Temperature, Pressure, etc)
  - Extend Magnet Processing to Live Data Processing (LDP)
    - Need means of Broadcasting Live Magnet Pulse Information…
      - (What to do about "Tachyons" in this case…! :-o)