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Los Alamos
NATIONAL LABORATORY
EST. 1943

Pulsed High Magnetic Fields for Neutron Scattering Science

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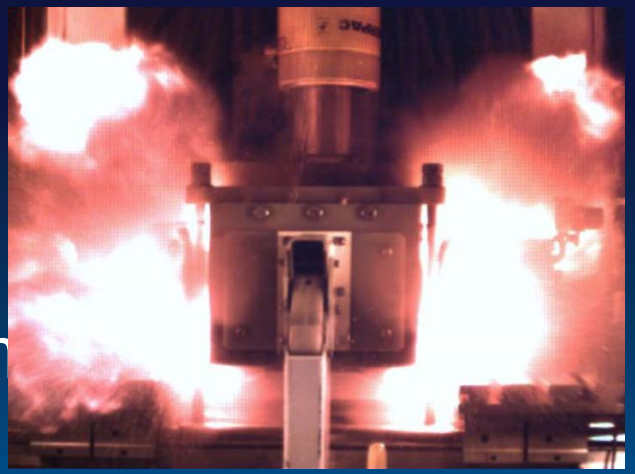
NATIONAL HIGH MAGNETIC FIELD LAB

State-of-the-art at NHMFL-PFF

- Pulsed Magnet Capabilities
  - 100 Tesla Multi-shot
  - 300 Tesla Single Turn
  - 60 Tesla Controlled Waveform
  - 65 Tesla milli-second
- Instrumentation
  - Liquid Helium-3 temperatures (~350 mK base)
  - Magnetization, resistivity, optical transmission, optical spectroscopy, dilation, specific heat, pulsed echo ultrasound, contactless conductivity, etc.



170 T shot (Single Turn @ NHMFL)

Pulsed Magnet Basics

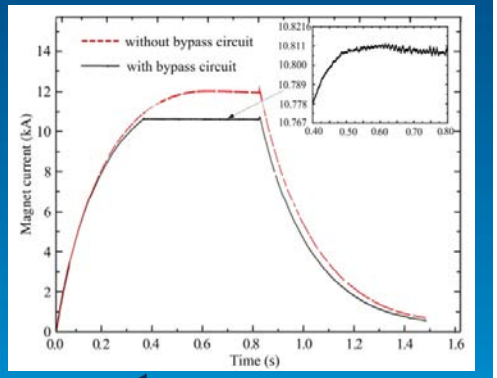
- Management of stress and heat
  - 100T has pressures ~3-4GPa
  - Wire UTS ~1.4 GPa at best (CuNb)
  - Conductivity ~60-70% IACS
  - T max < 450 K (insulation degradation)
  - All NHMFL-PFF Magnet are internally reinforced
- Rise times
  - Vary from 2 usec to 1 sec (most 10 mSec)
  - Sample heating -> mm to um sized samples
  - Slower is better

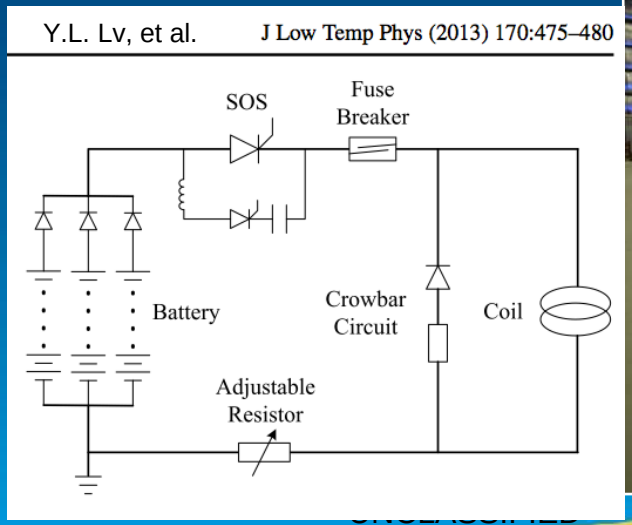
Pulsed Power Supply Basics

- Capacitor banks
  - Most common pulsed power supply
  - Common Energy scale is MJ
    - Nojiri style is 30 kJ
    - 50 MJ at Dresden
    - 14 MJ at Toulouse
    - 15 MJ at Wuhan
  - Voltage ranges typically 10-20 kV
  - Peak current ~ 100 kA

Pulsed Power Supplies cont.

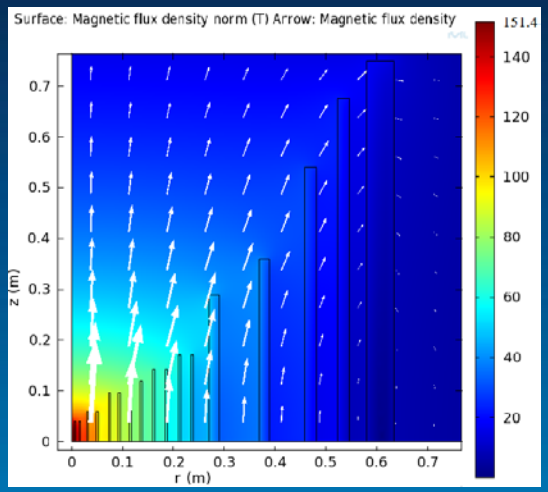
- Generator based inertial storage system
  - Large energy (600 - 2000 MJ at NHMFL)
  - Advantage is that the flow of energy can be stopped
  - Most complex maintenance
- Battery based systems
  - Wuhan has just installed a ~1000 cell system
    - Powers a 30 T coil with a 500 msec pulse
  - Lower peak currents
  - Difficult to stop
  - Scalable



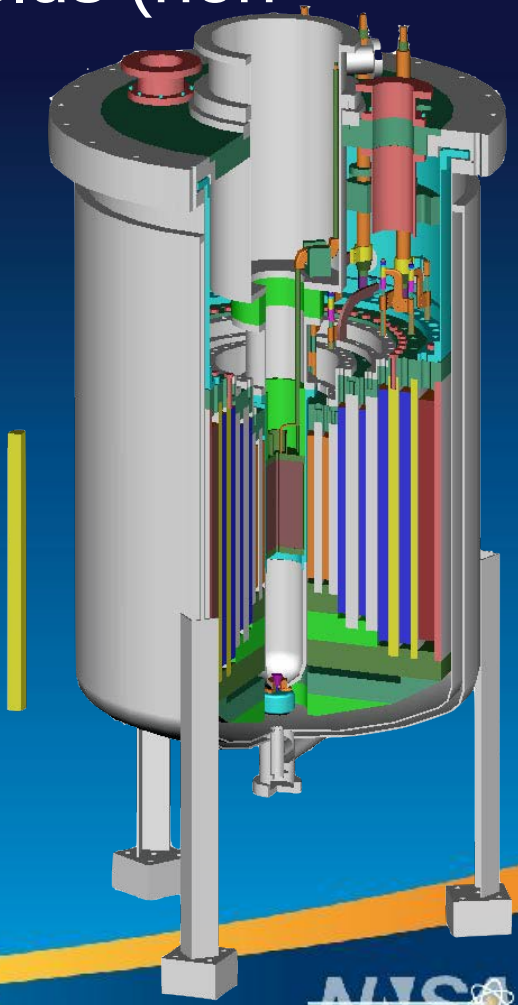


NHMFL's 100 T magnet

- Largest system, World Record fields (non-destructive)
- 240 MJ needed for a shot



150T with 50T outsert:
Magnetic energy: 690 MJ
Maximum outsert power: ~ 1500 MW



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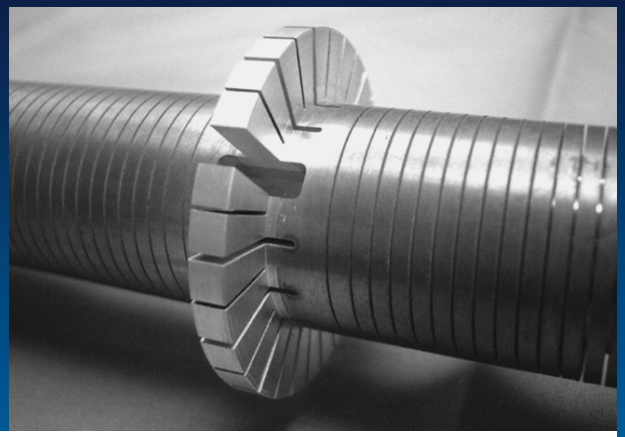
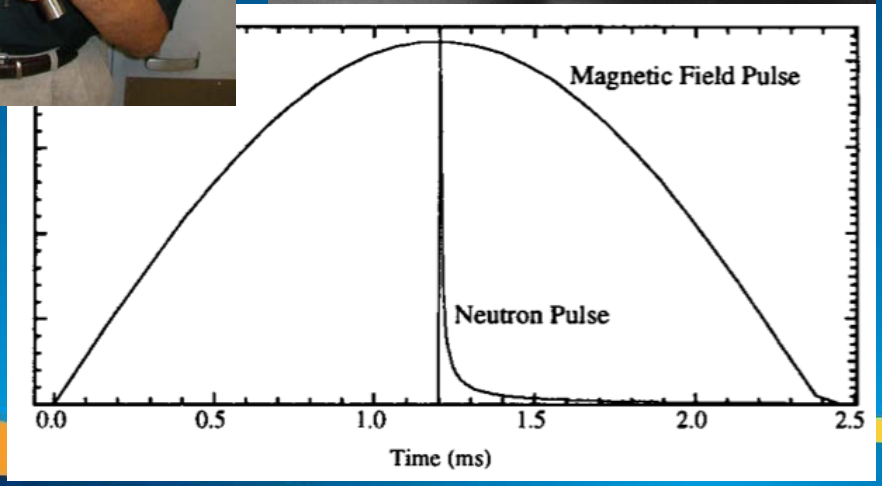
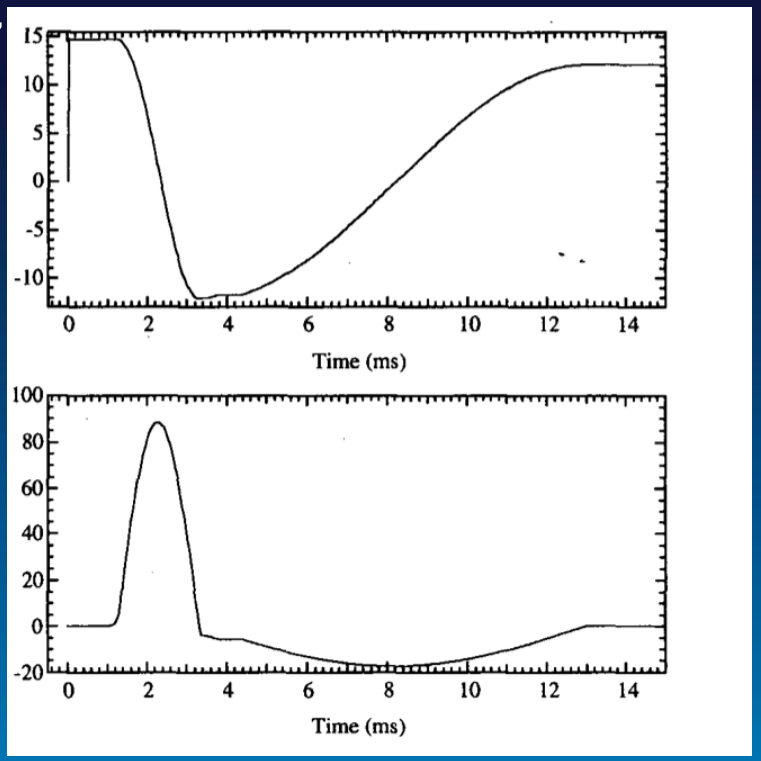
Pulsed Magnet for Neutron Scattering

- NHMFL-LANSCE project ca. 1997



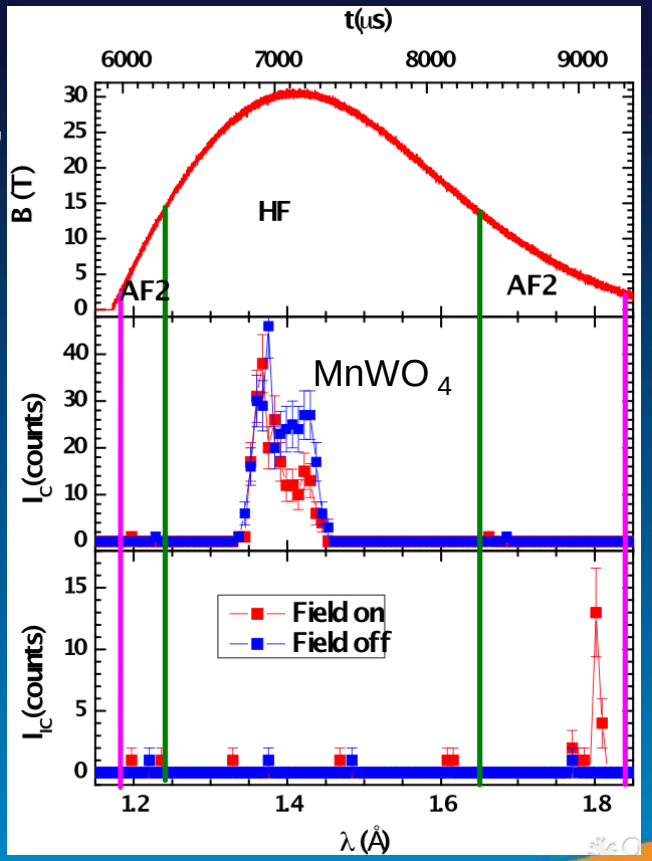




- M. Bird et al., IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY, VOL. 16, NO. 2, JUNE 2006.
- H. Boenig et al., Digest of Technical Papers. 12th IEEE International Conference Vol. 1 (1999).

“Nojiri” magnets

- Very cost effective
  - Rep rate is 5-30 minutes
  - Demonstrated “proof of principle”



http://neutrons.ornl.gov/conf/nobugs2010/Monday%20afternoon/NOBUGS32_Kohl.pdf

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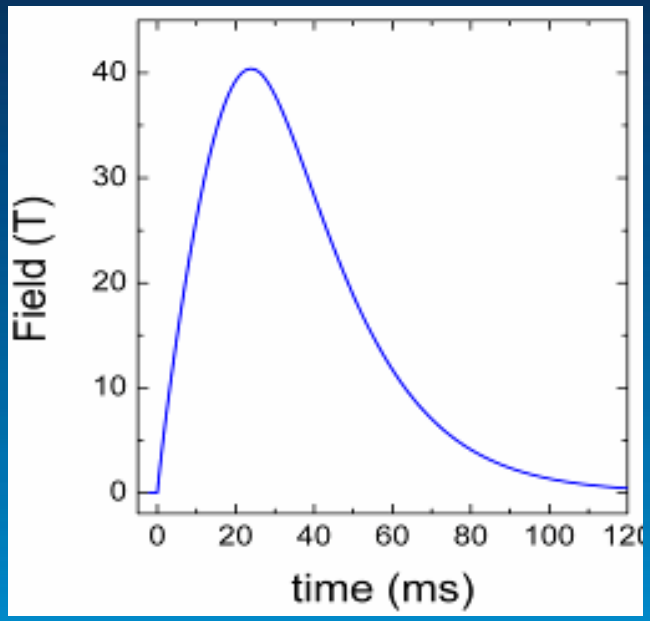
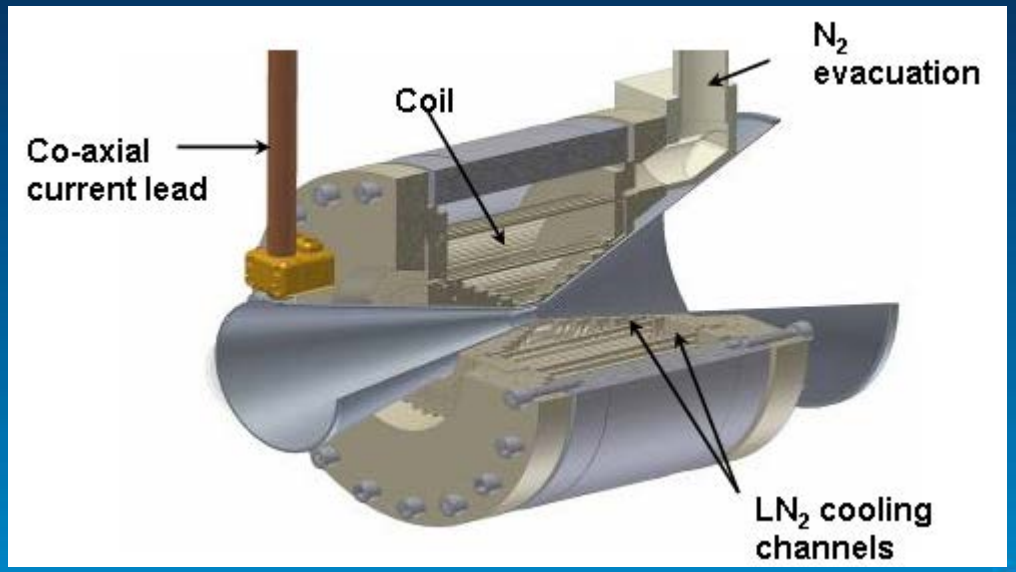
40 T Polyhelix design in Grenoble

- LN2 cooled design
  - 1 MJ capacitor bank
  - 7 minute rep time

PRO: Simple magnet design
CON: Complex cryostat





*M. Bird, private communication

Summary

- Pulsed Magnets are an economical tool for high magnetic field experiments
  - 1000 shot magnets are feasible (40 T range)
  - 10^7 shot magnets are very challenging
- Repetitive systems are feasible but expensive
  - A 30 T 1-2 second repetition rate system was designed but not fully realized at LANL
  - Power consumption will be of order 150 kW
- Signal Collection must take place in ~1/100 of pulse
  - What is feasible for neutron detectors?