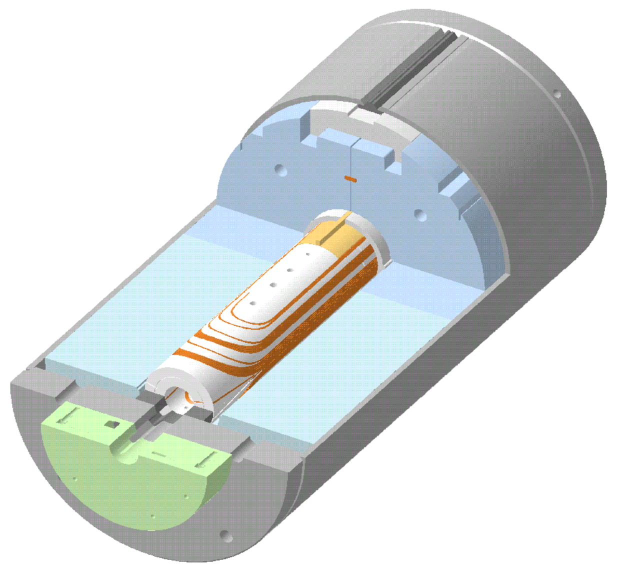
Nb$_3$Sn High Field Magnet R&D

Shell Type Dipoles Fabrication and Test



Shell type dipole magnet configuration

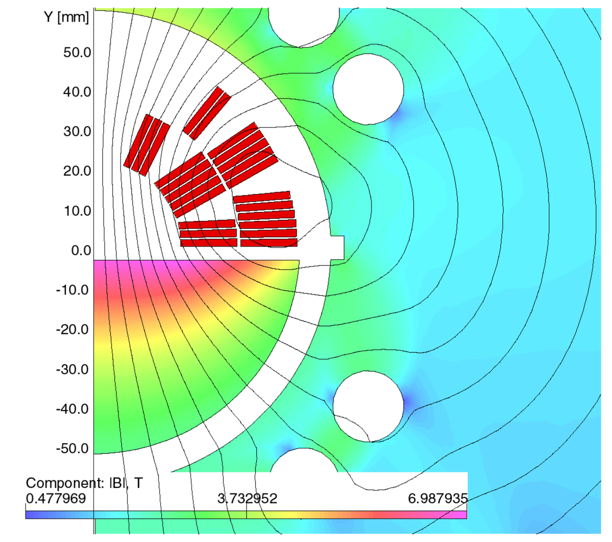
Three short dipoles (HFDA02-04) were fabricated and tested in FY2001-2002

Since last year we have focused on understanding and improving magnet quench performance.

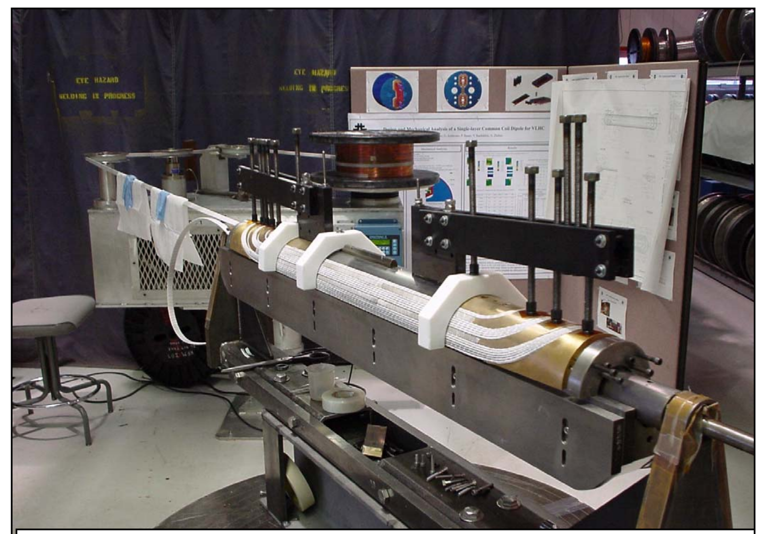
We study and optimize the Wind & React technology and quench performance issues using half-coils and a magnetic mirror (HFDM).

The main advantages of this approach are:

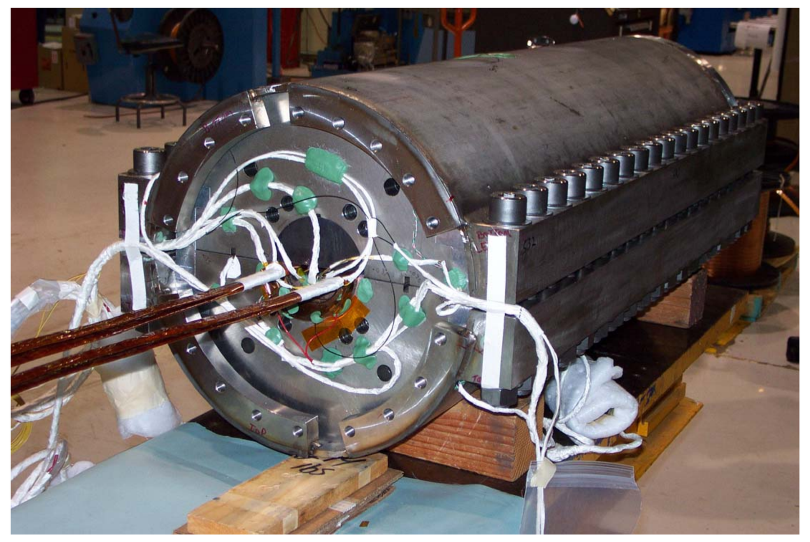
- The same mechanical structure and assembly procedure
- Advanced instrumentation
- Shorter turnaround time
- Lower cost



Mirror magnet magnetic field



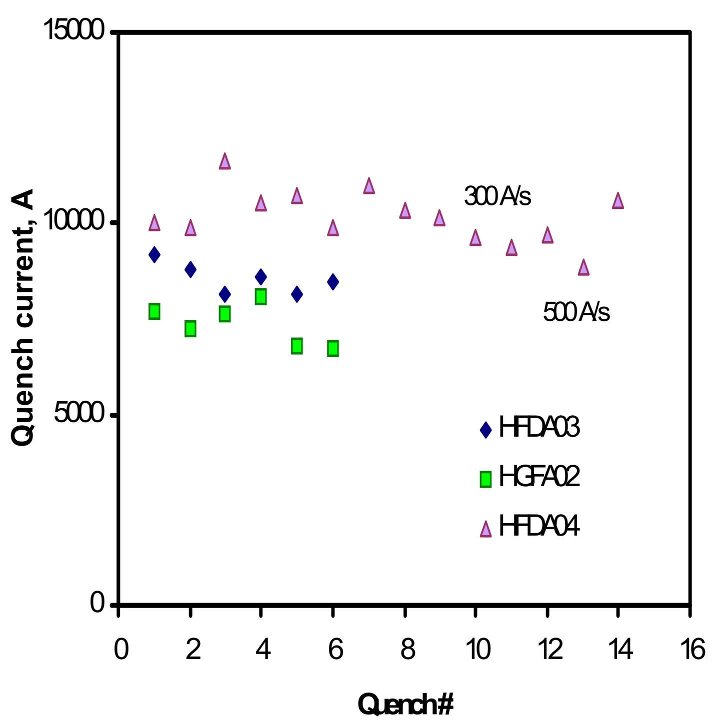
Half-coil winding



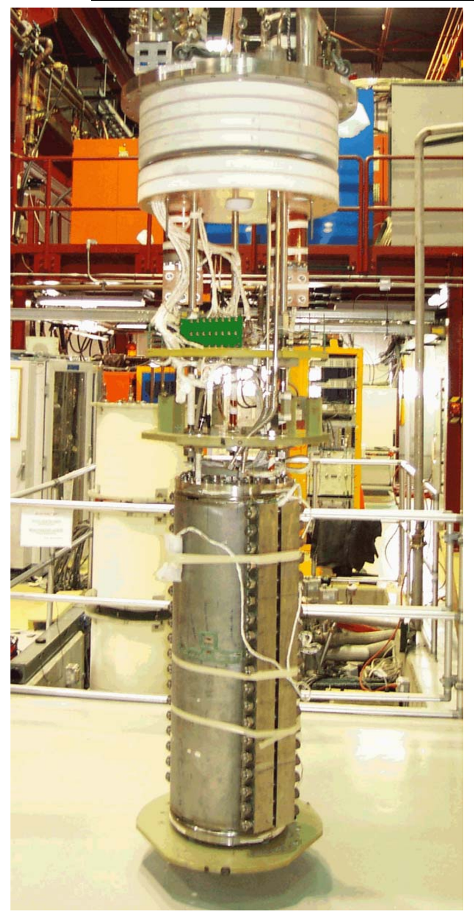
Mirror magnet complete assembly

Results achieved:

- Good, well understood field quality including geometrical harmonics and coil magnetization effects
- We developed and tested a simple and effective passive correction system to correct large coil magnetization effect in Nb$_3$Sn accelerator magnets

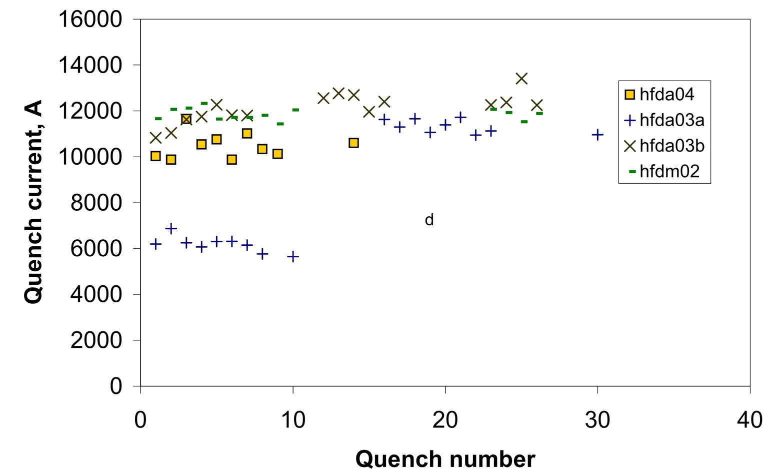


Quench history of shell type dipoles



Magnet prepared for testing

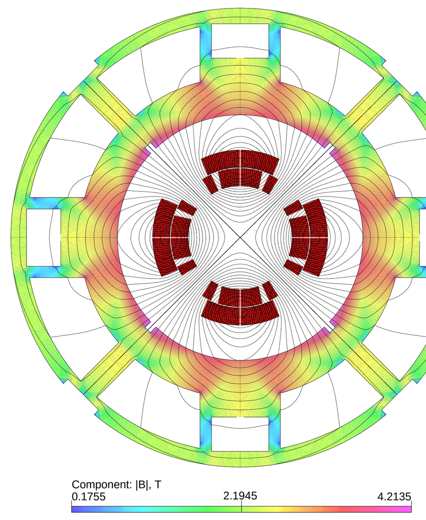
Quench location, quench propagation velocity, critical current and temperature margin measurements point out on the cable instability at low fields.



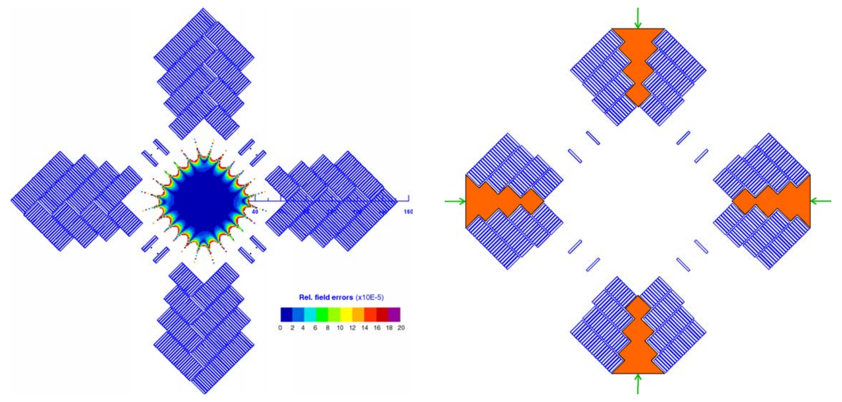
Mirror magnets quench history

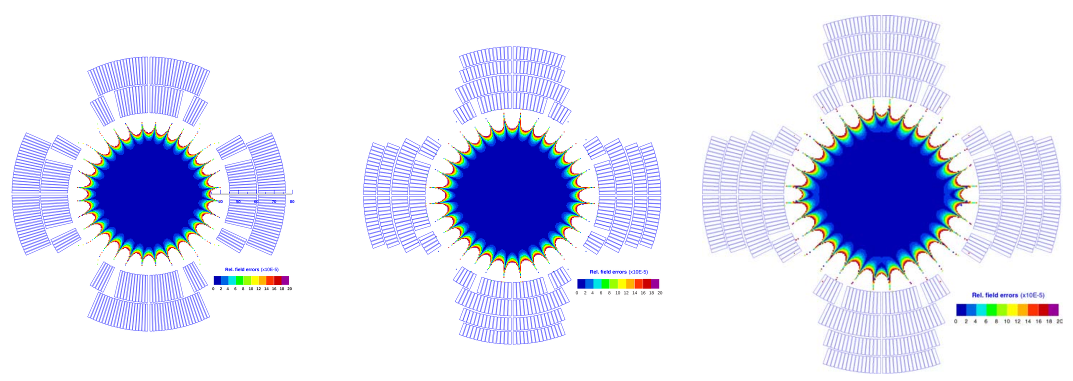
Quench current was only 50-60% of expected short sample current limit (B_{max}~6-7 T)

LARP Quadrupole R&D



- Fermilab is responsible for the development of new generation IR quads for the future LHC luminosity upgrade
- FY04 plan:
  - IRQ conceptual design studies and technology development
  - preparation to short model R&D
- Aperture limitation studies
- Analysis and comparison of block-type and shell-type quad designs





90-mm	100-mm	110-mm
N_{turns} = 144	228	248
S_{coil}, cm^2 = 48.1	59.3	84.9

The studies showed that 90-110-mm aperture quadrupole magnets using Nb$_3$Sn strands, expected to be available in the next few years, can provide the maximum field gradient of 250-260 T/m with an acceptable field quality.

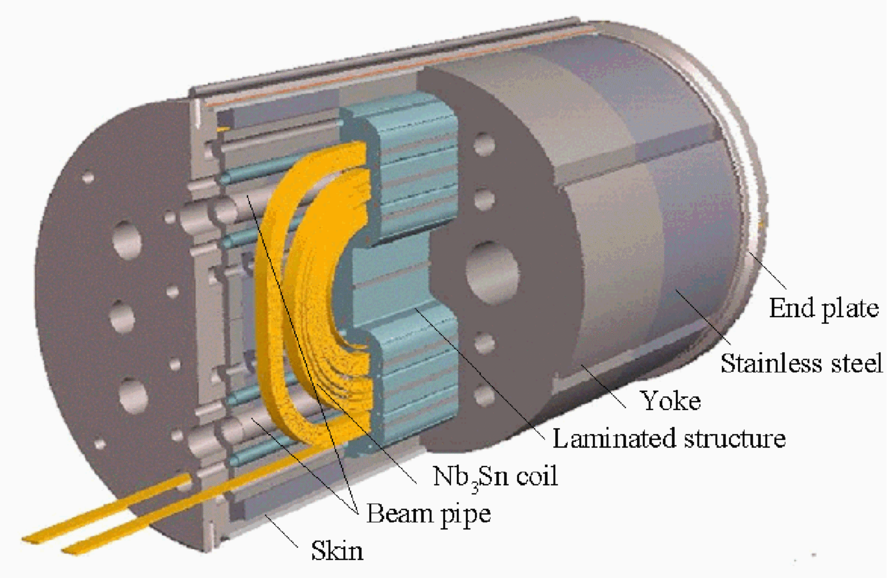
The cold yoke design have large holes for cooling that can be optimized for good field quality.

A warm yoke can be an interesting option for a single-bore magnet but rather challenging for double-bore design.

Peak temperatures during quench are acceptable for all the designs in spite of large stored energies.

The mechanical structure needs to be carefully optimized during R&D.

First Common Coil Magnet and Racetrack Coils. React & Wind Technology



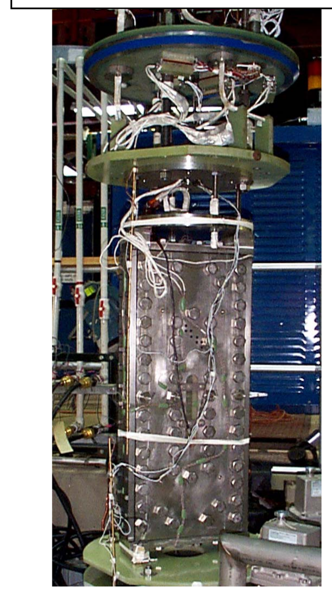
React-and-Wind Technology Common Coil Magnet

TABLE I
MAGNET PARAMETERS

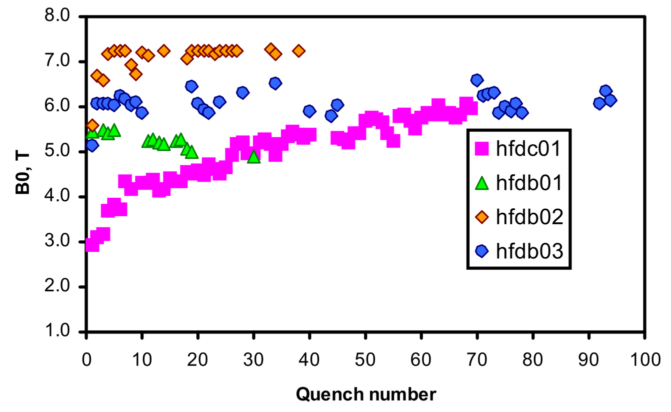
Parameter	Design value
Magnetic field, T	10
Current, kA	23.6
Aperture, mm	40
Aperture separation, mm	290
Iron yoke OD, mm	564
Stored energy @ 10 T, kJ/m	2 x 410
Inductance @ 10 T, mH/m	2 x 1.475
Magnet straight section length, m	0.4
Magnet yoke length, m	0.4
Superconductor	Nb$_3$Sn
Superconducting cable dimensions, mm^2	22.23 x 1.28
Number of strands	60
Strand diameter, mm	0.7

Collar laminations

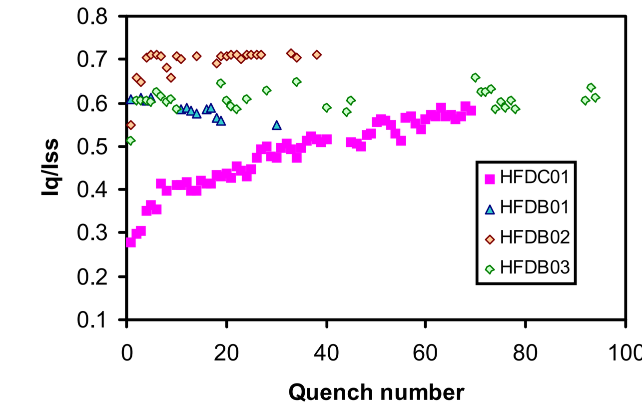
Coil block after impregnation



Racetrack assembly



Maximum field for CC magnet and Racetracks



Quench current / short sample current

Magnet cold mass assembly

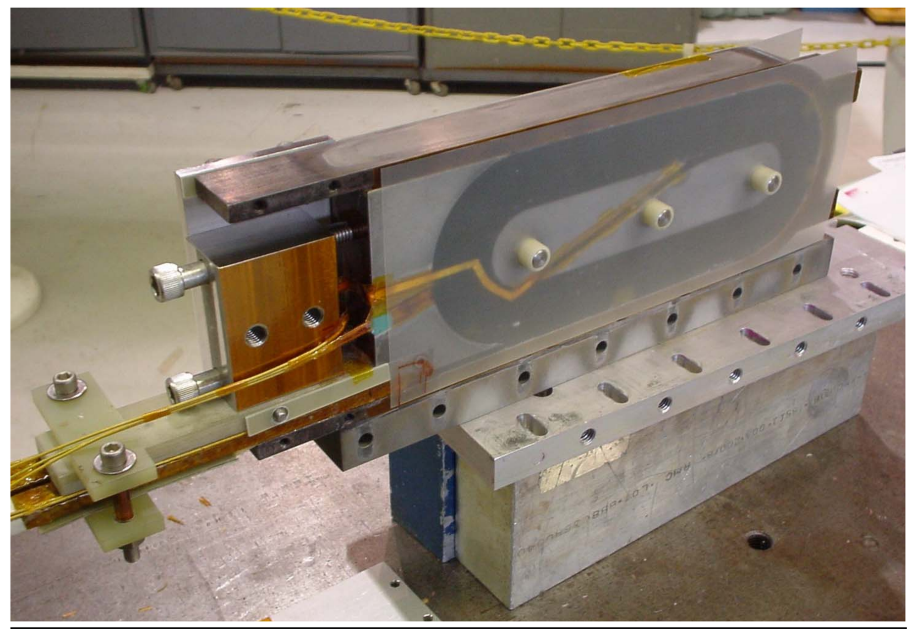
Maximum quench current reached for react & wind technology 60-70% of superconductor short sample current limit

Small Racetrack Fabrication and Test

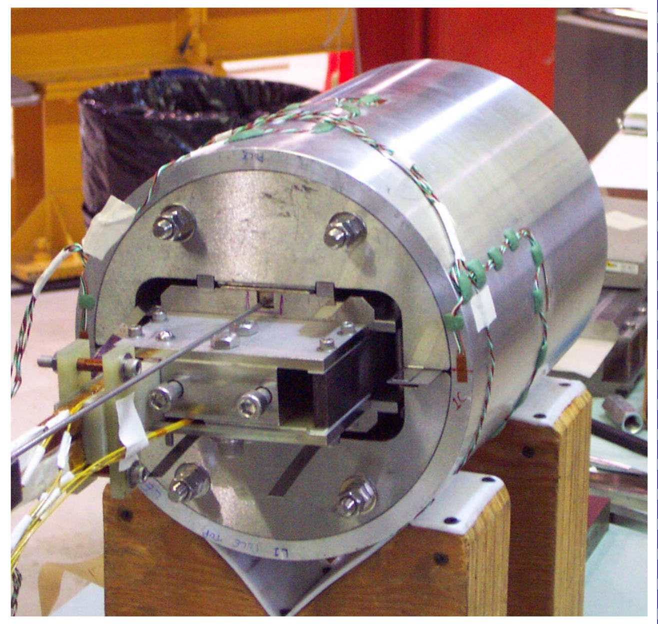
We testing cable using the technique developed at LBNL. The goals are:

- Test and optimize real full-size cables before using in magnets
- Use simple reliable mechanical structure to avoid test setup effects

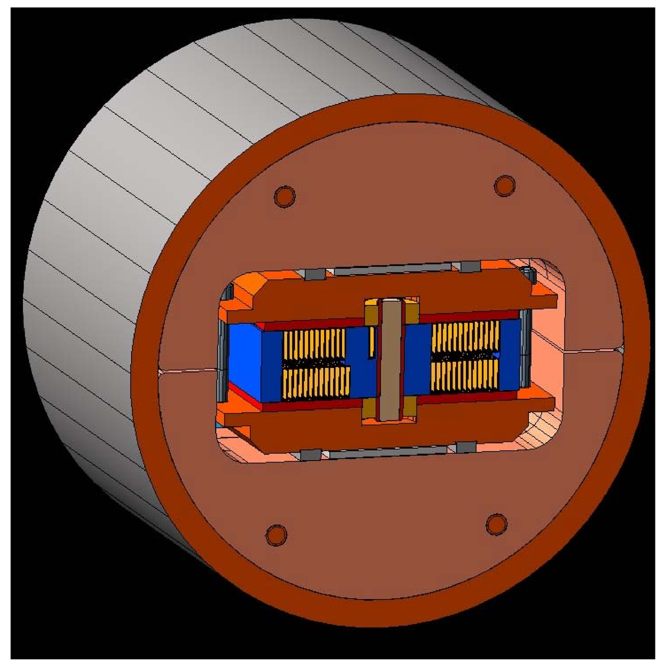
- 2 LBNL-type racetracks have been fabricated, test TBD with LBNL.
- 1st (PIT1.0) Fermilab racetrack: tested in January-March 2004
  - Racetrack SR01 reached the short sample limit @4.5K (see quench history)
- 2nd (MJR1.0) Fermilab racetrack: tests in April-May 2004.
- 3rd (PIT1.0) and 4th (RRP0.7) coils - tests in July-August 2004.



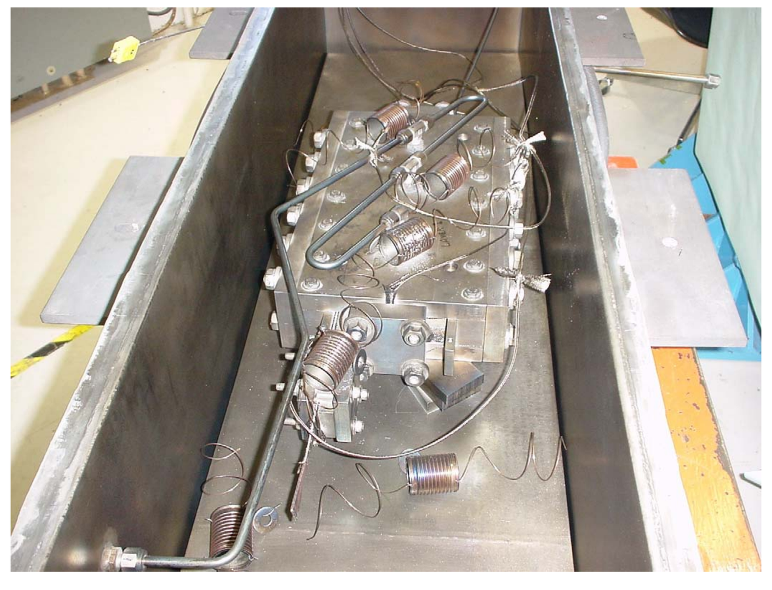
First FNAL Small Racetrack coil wound from PIT cable



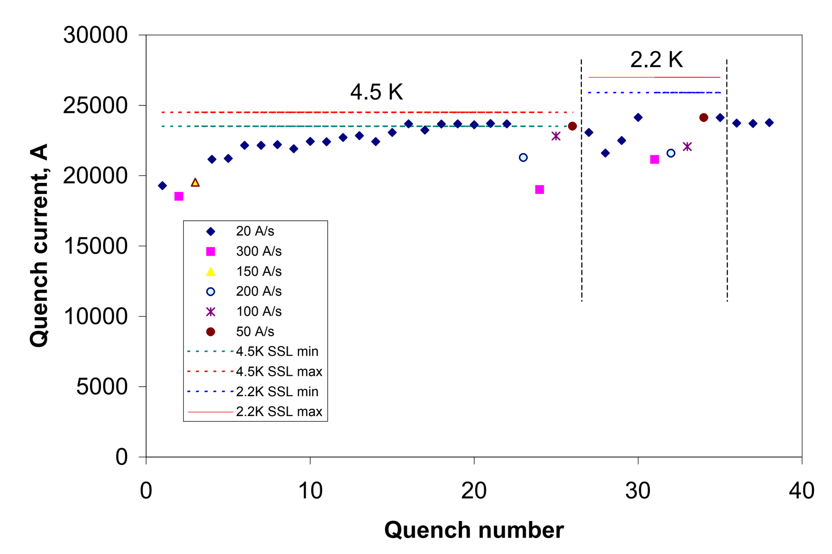
Small Racetrack cold mass assembly



Racetrack mechanical structure



Coil inside reaction fixture



Results of first FNAL Small Racetrack test

First FNAL Small Racetrack reached for wind & react technology 100% of superconductor short sample current limit !