Overview of Measurement Activities at BNL

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on behalf of

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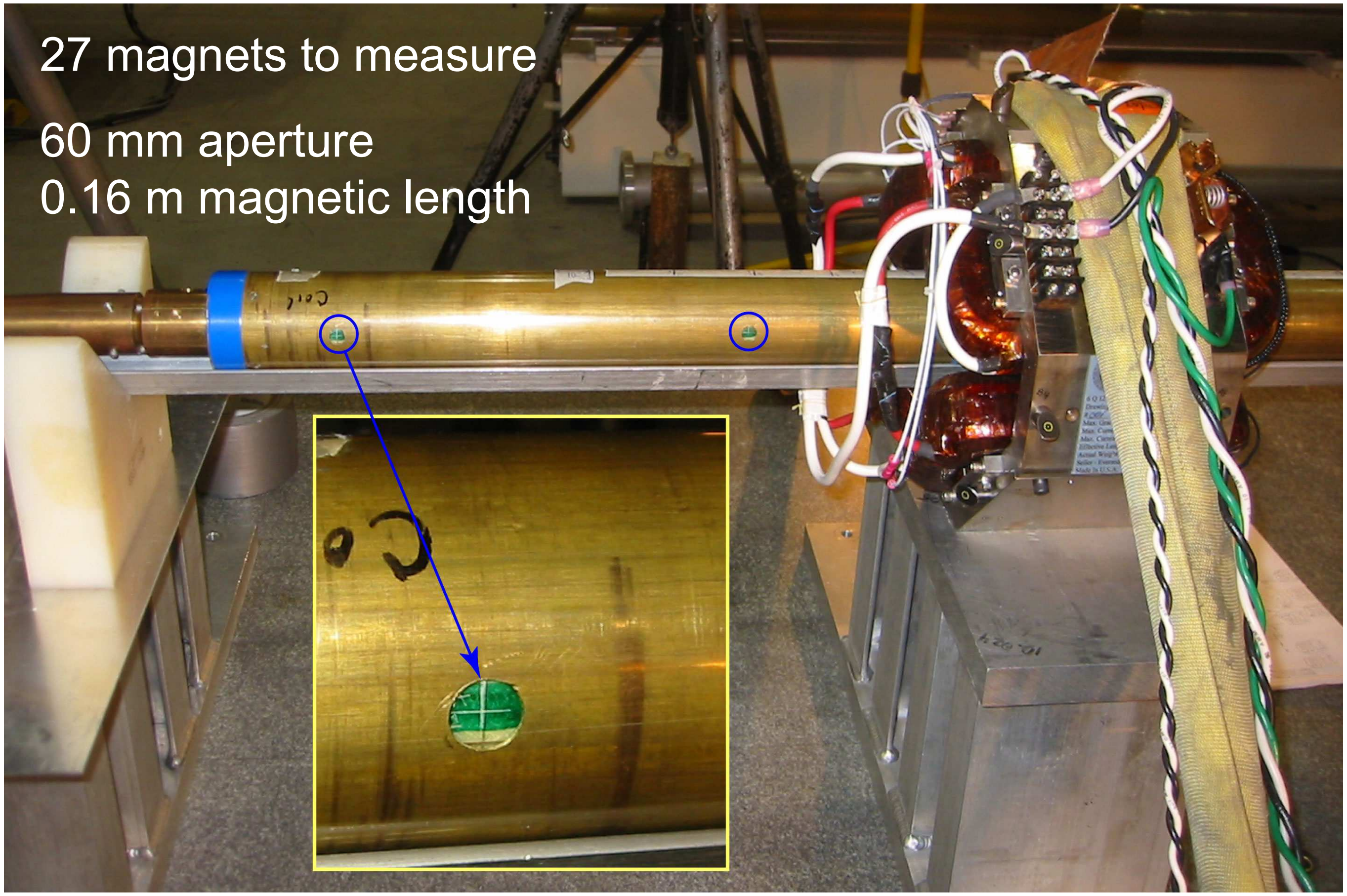
Introduction

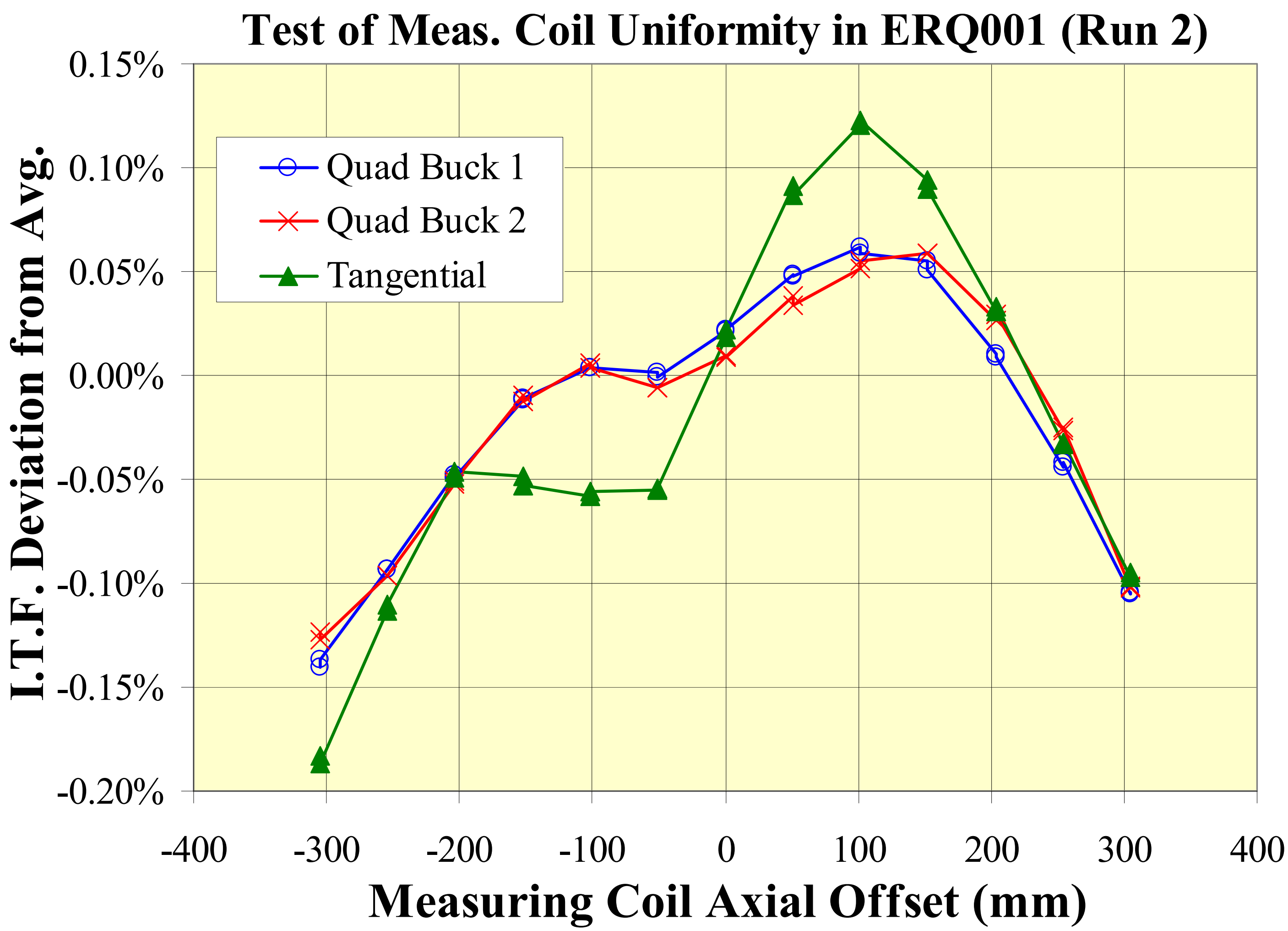
- In the past, the Superconducting Magnet Division at BNL has been actively engaged in designing, building and testing superconducting magnets for large projects (RHIC, LHC).
- We also completed successfully production testing of conventional magnets for the Spallation Neutron Source.
- No such large production measurements in the past two years.
- Ongoing activities:
  - Fast ramp measurements (GSI ✓, BioMed ✓, NSLS-II) (another talk at IMMW-15)
  - Measurements of quadrupoles and dipoles for ERL project at BNL.
  - Field quality measurements in Swiss Light Source magnets to understand field quality issues relevant to NSLS-II (integrated correctors, interference)
  - Vibrating wire alignment system R&D for NSLS-II (with Cornell).
  - Magnet vibration measurements for International Linear Collider (ILC).
  - Activities of NSLS group (superconducting undulator).

ERL Quadrupole: System Using A Mole



Mole has fiducials on the coil, and is accurately calibrated using dipole, quadrupole and sextupole fields.

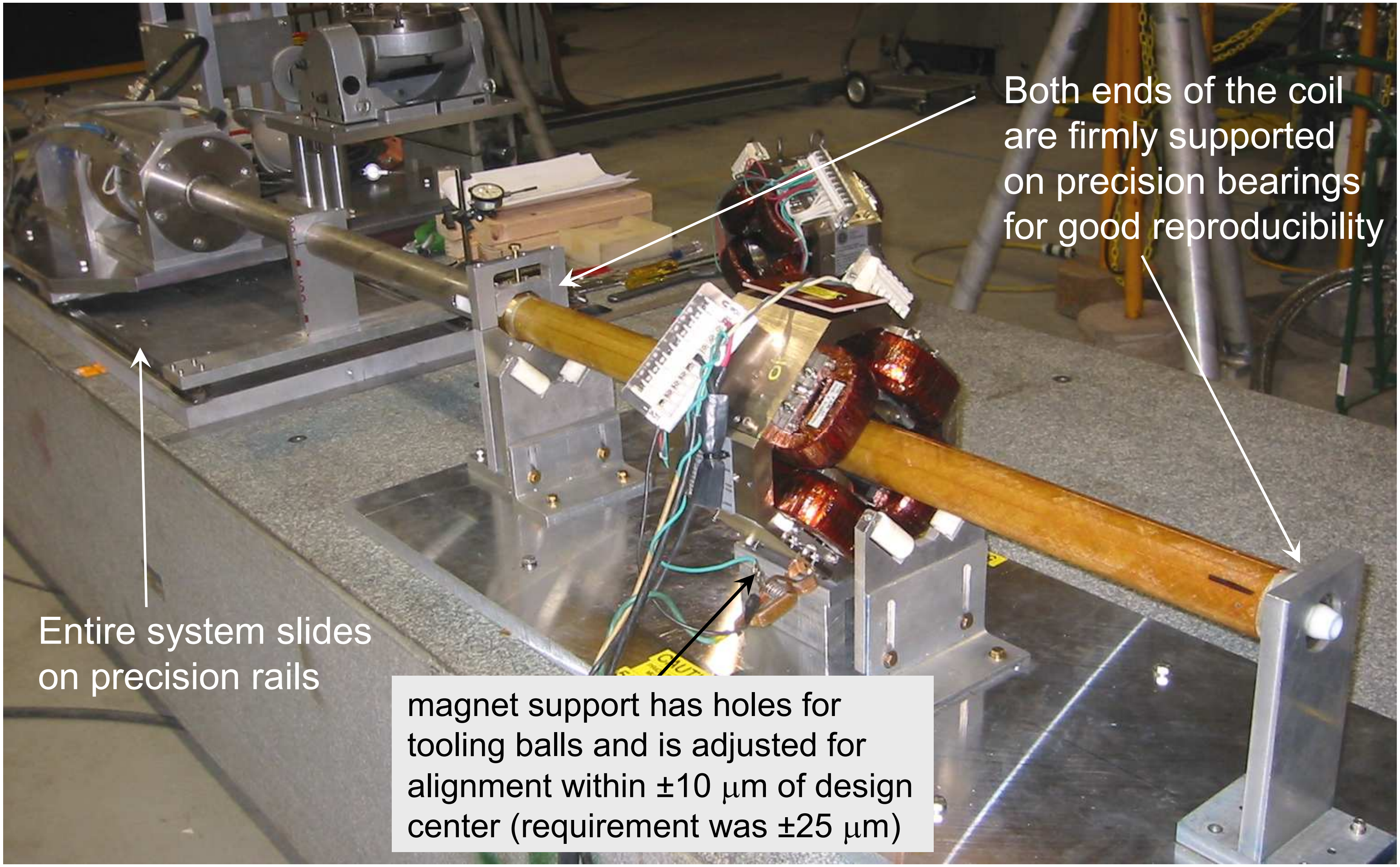
Drawback: Optical survey is slow and gives axis only within ±50 µm



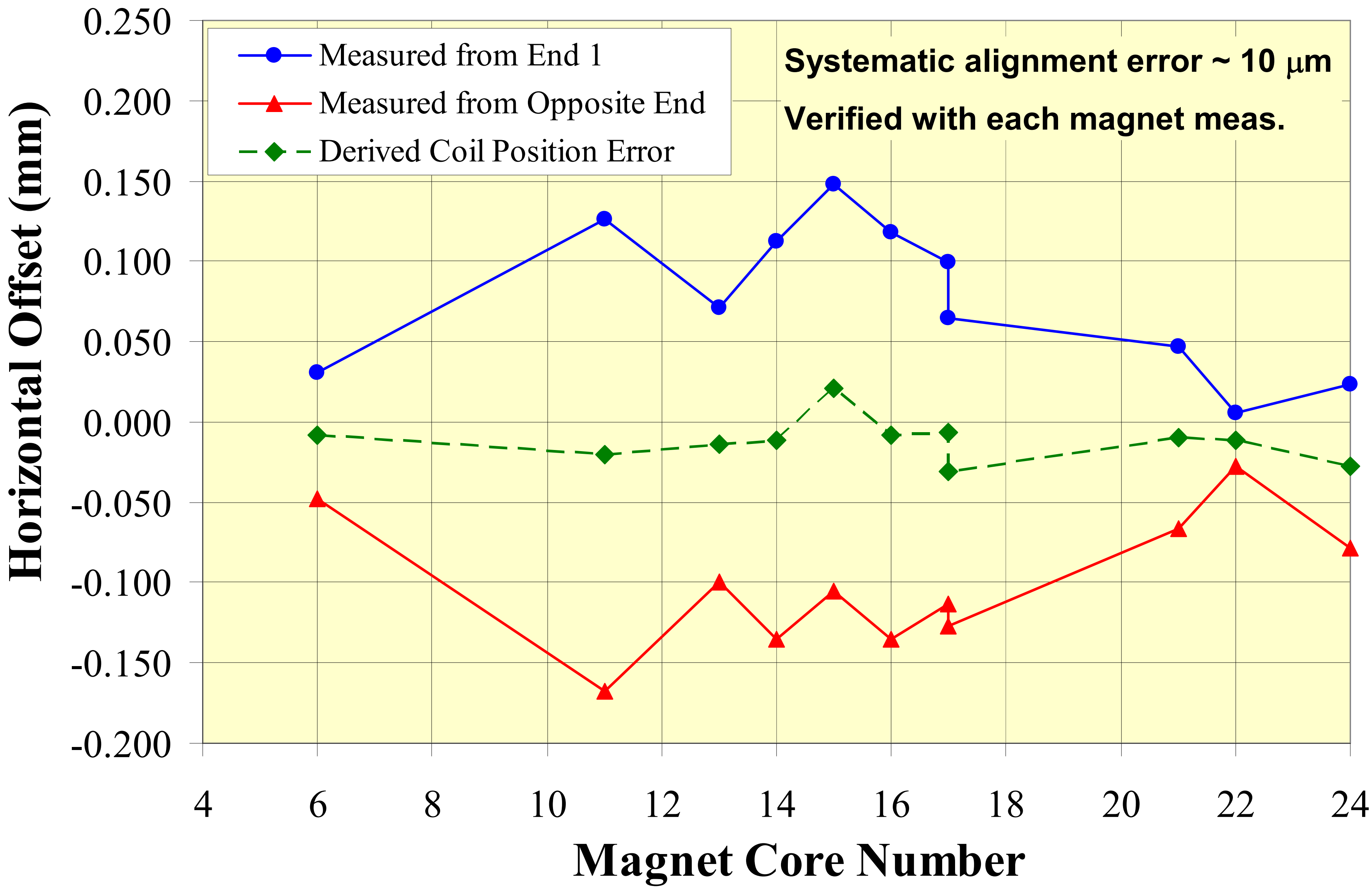
Measuring coil uniformity is an issue when coils are calibrated in a long magnet, but are used for measuring short magnets.

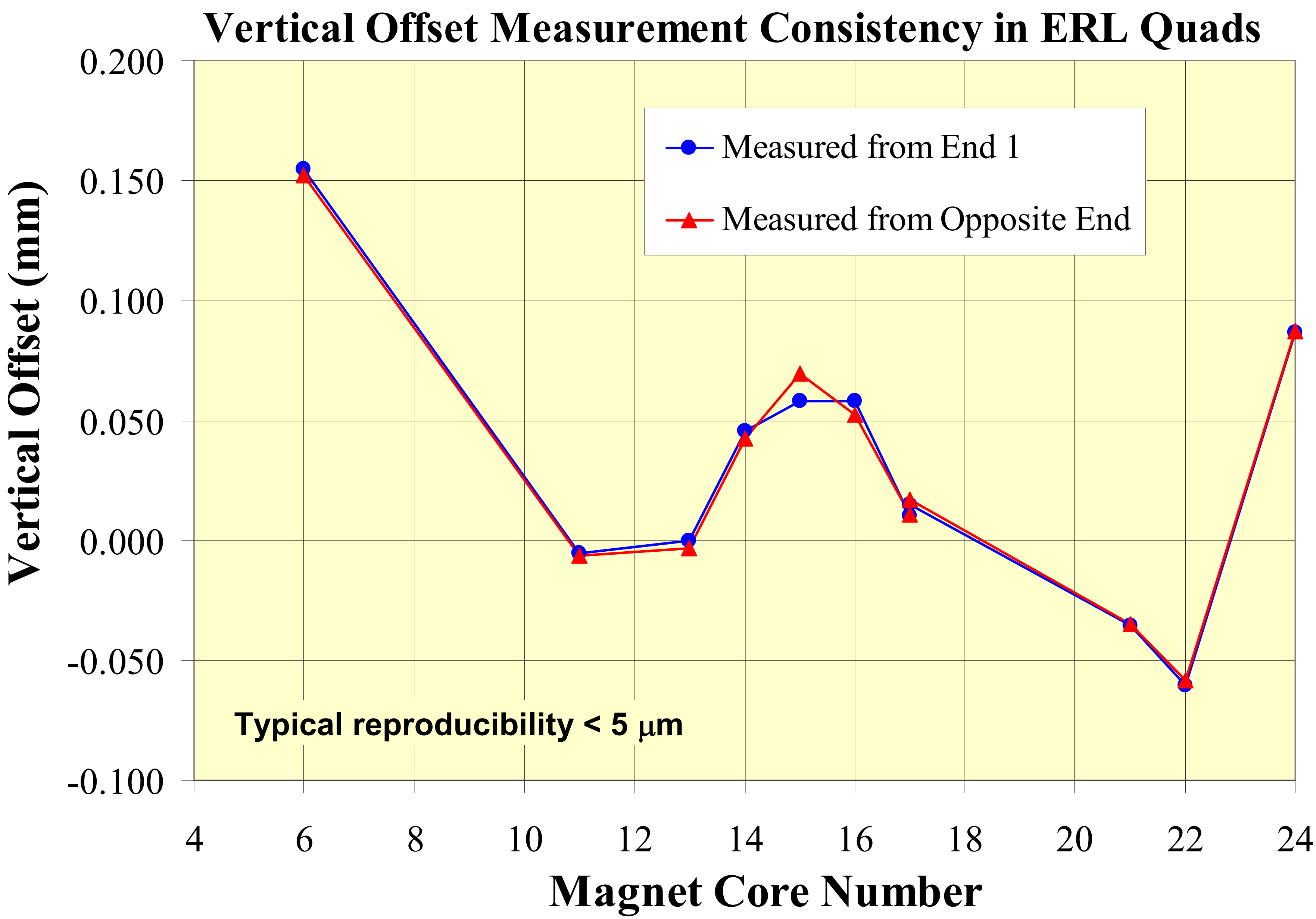
0.1% variation in integral transfer function corresponds to ±14 μm axial variations in the coil radius. Similar variation seen based on field angle.

ERL Quadrupole: External Drive System



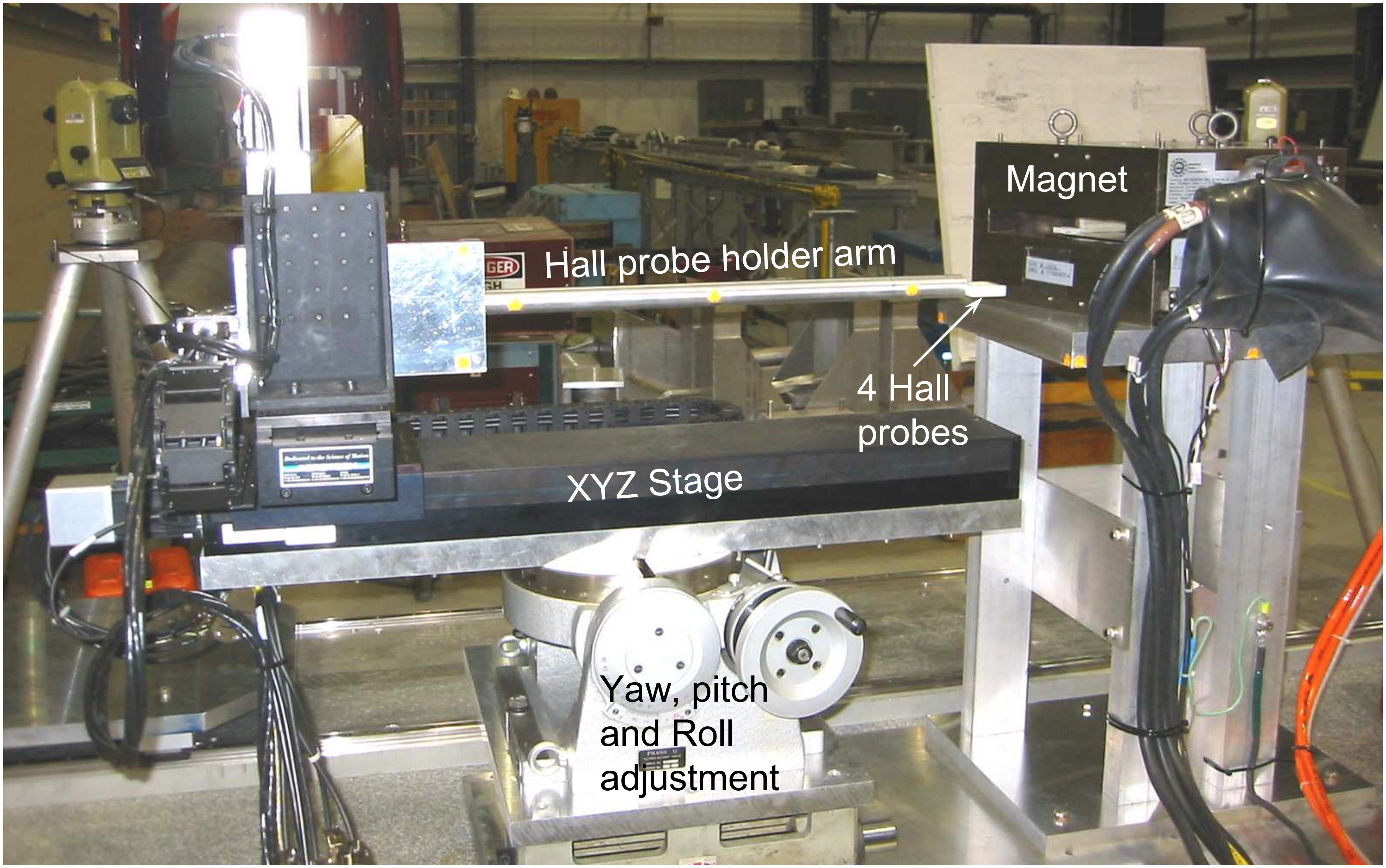
Horizontal Offset Measurements in ERL Quads



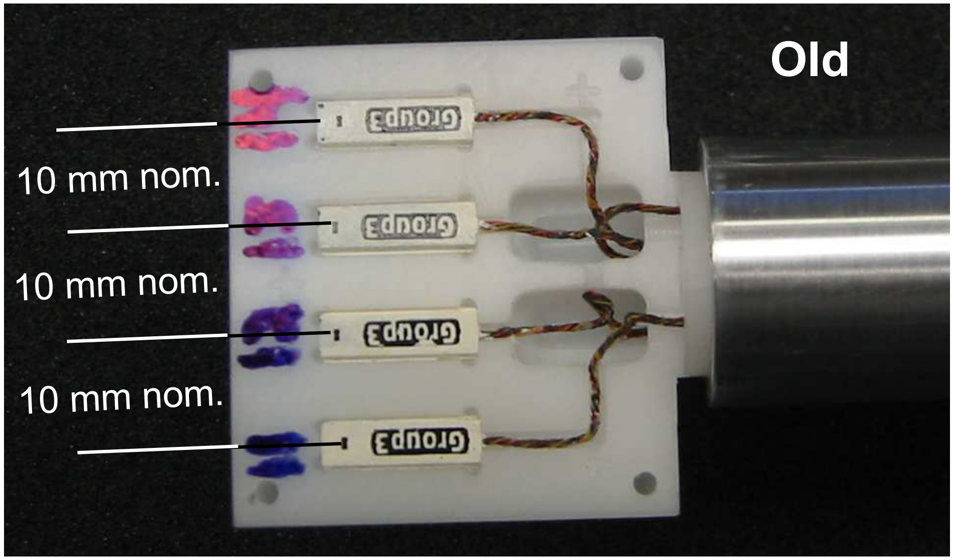


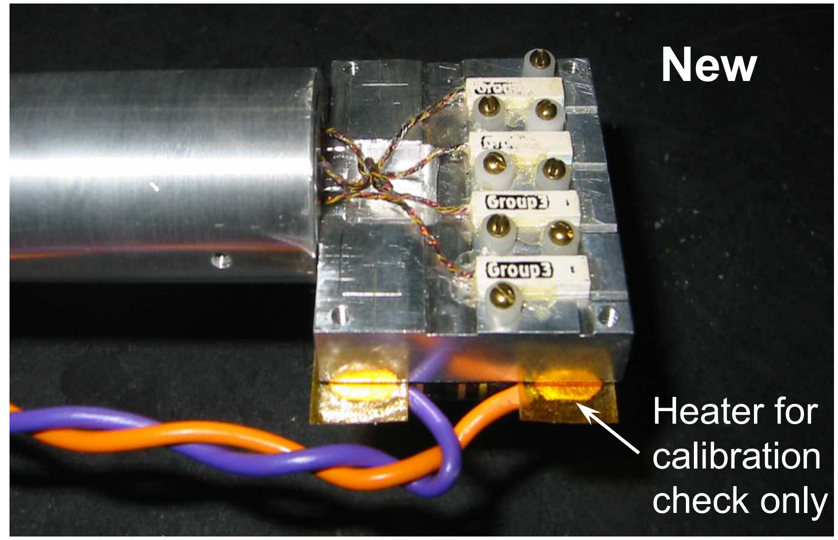
Vertical Offset Measurement Consistency in ERL Quads
0.200
0.150
0.100
0.050
0.000
-0.050
-0.100
Vertical Offset (mm)
Measured from End 1
Measured from Opposite End
Typical reproducibility < 5 μm
4
6
8
10
12
14
16
18
20
22
24
Magnet Core Number

ERL Dipole Measurement Setup



Hall probe Holder





Hall probes were mounted into grooves in a plastic holder.

Initial calibration showed departures from factory calibration.

The calibration changed further during measurements of the prototype, possibly due to changes in strain with temperature.

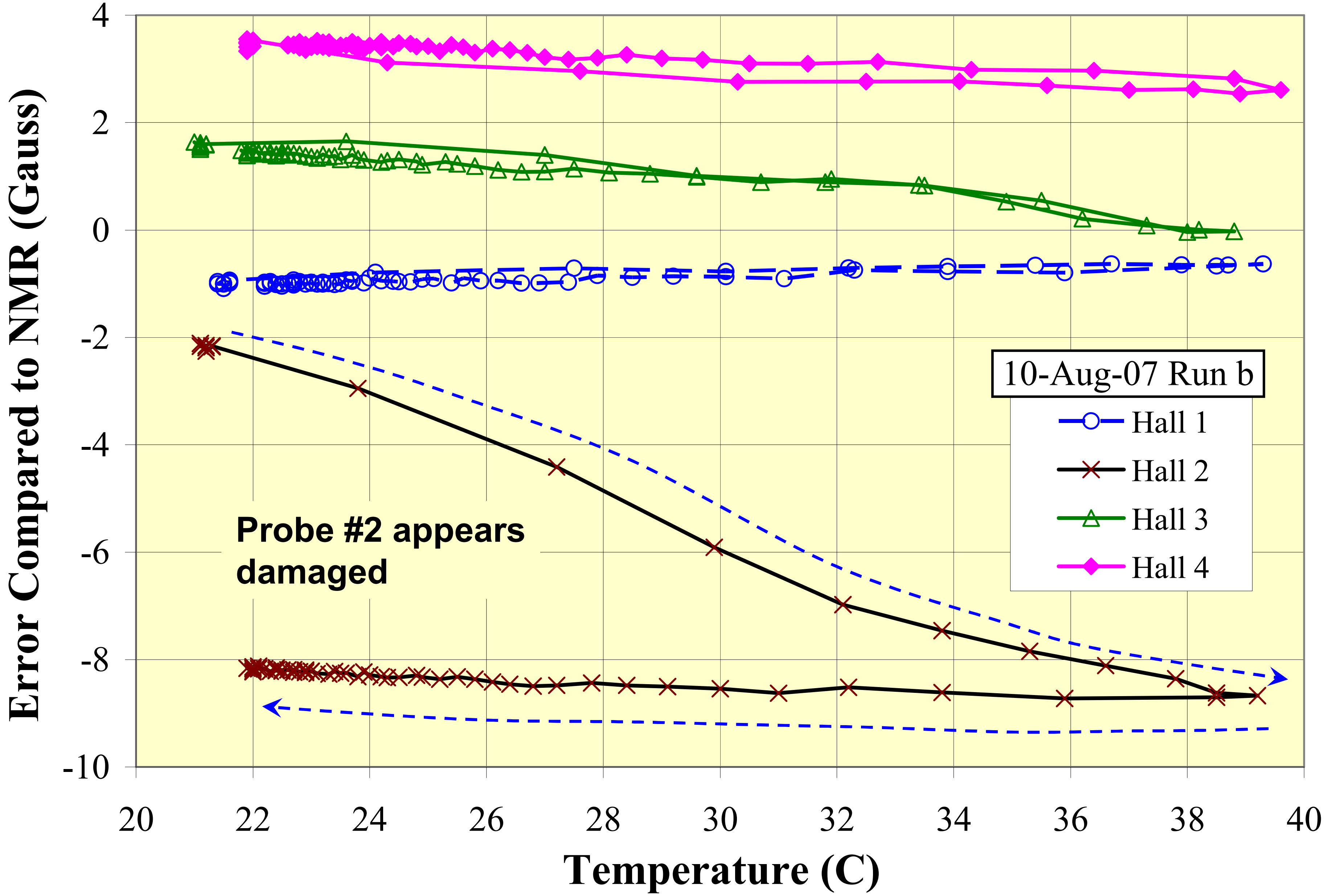
Made of Aluminum to minimize temperature gradients.

Probes mounted in a manner similar to a commercial holder to avoid strain.

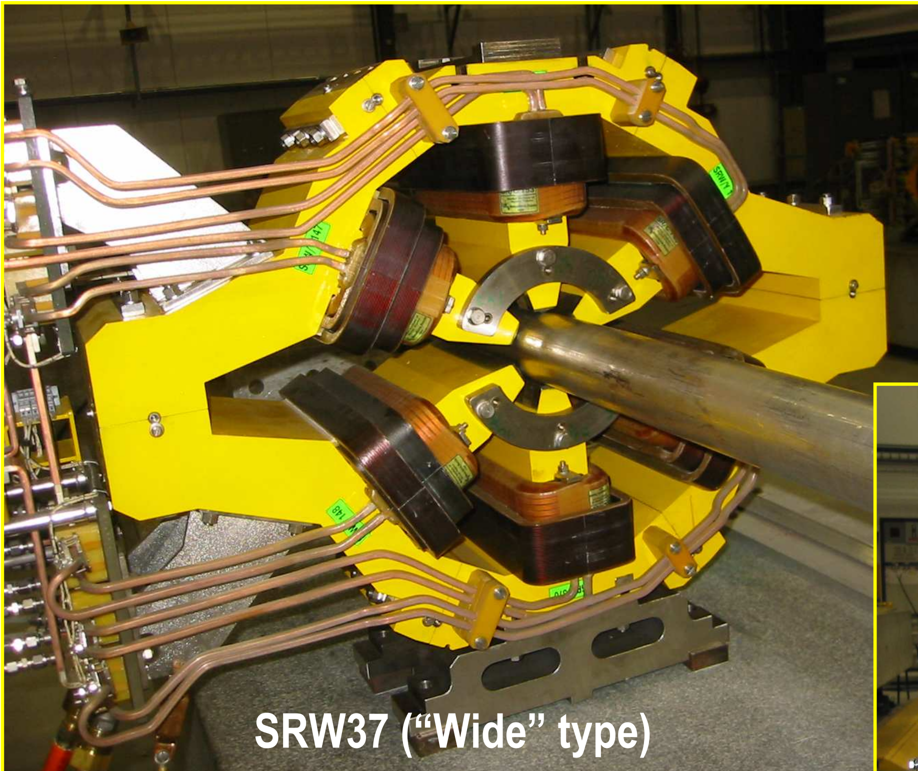
Calibration checked again in a reference dipole against NMR.

A temporary heater used to study stability with temperature.

Errors at 0.60 T Fixed Field Vs. Temperature



Sextupole Magnets Received from SLS

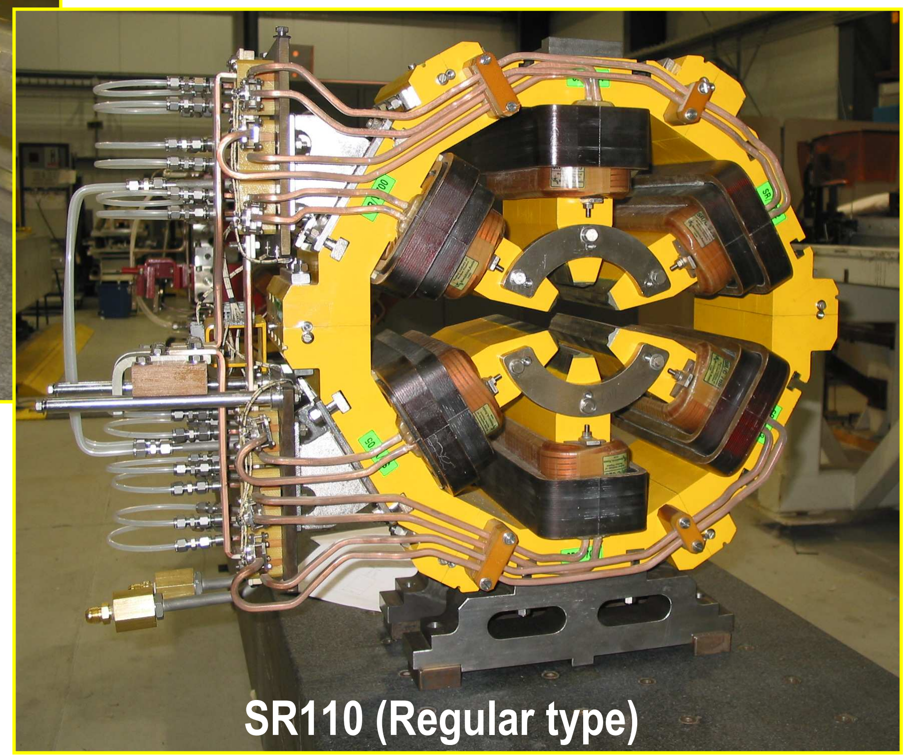


Magnet Details:
- 68 mm diameter bore
- 0.22 m magnetic length
- 140 A Maximum Current

At 138.3 A:

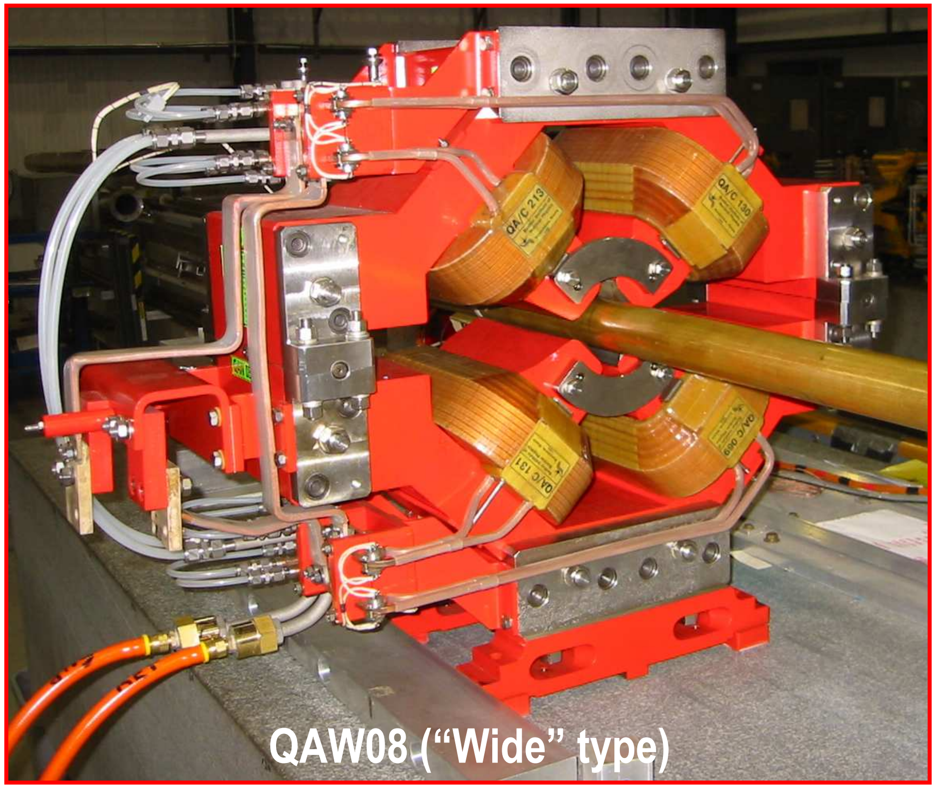
$$\int_{-\infty}^{\infty} \frac{d^2 B_y}{dx^2} dz = 160 \text{ T/m}$$

$$\frac{d^2 B_y}{dx^2} = 740 \text{ T/m}^2$$



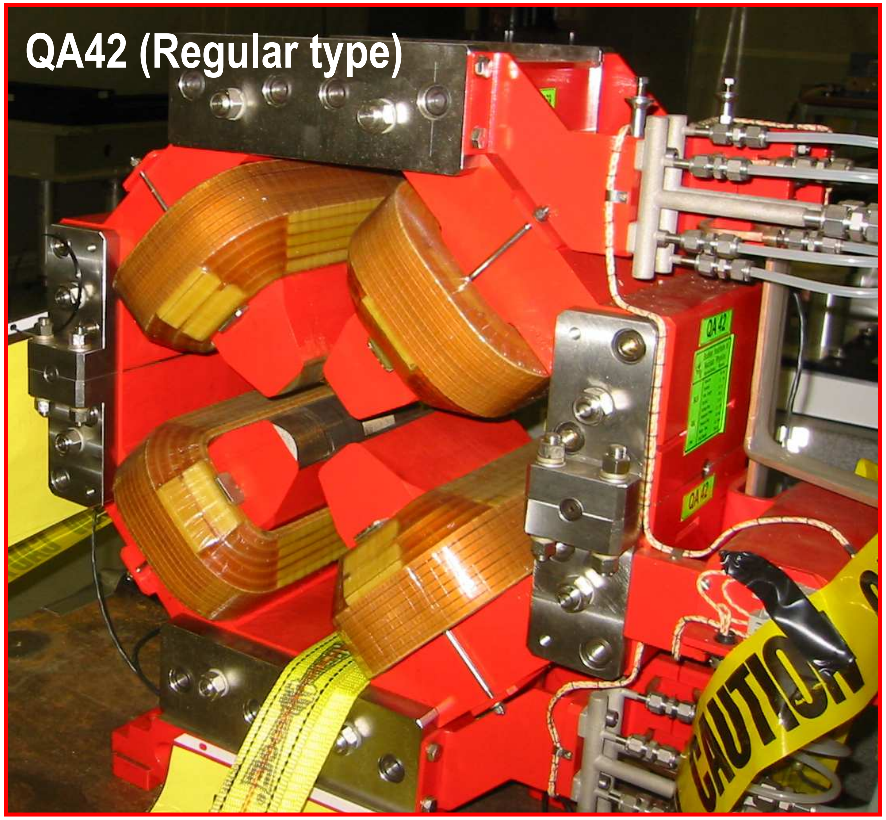
Measurement System Details:
- 5-winding rotating coil system
- 2.03 m long, 24.2 mm nom. diameter
- Rotates at 3.5 sec/rev.
- 128 points recorded per revolution

Quadrupole Magnets Received from SLS



At 120 A:

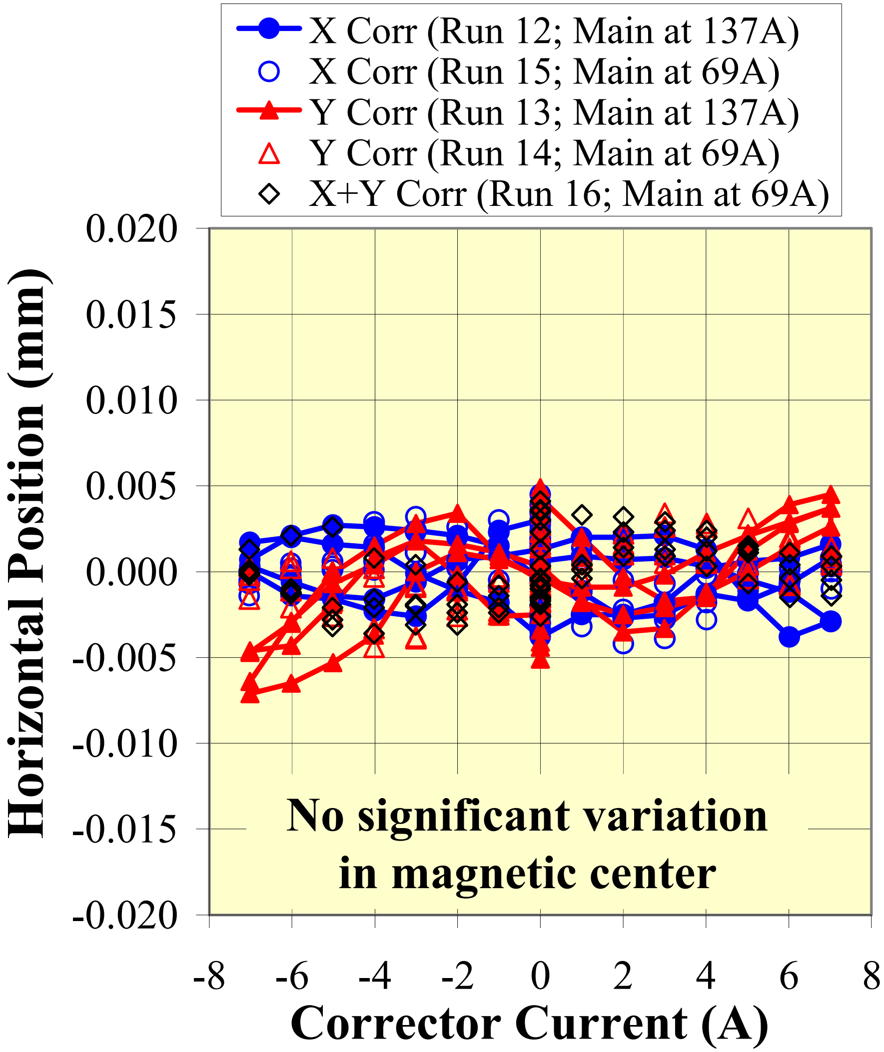
$$\int_{-\infty}^{\infty} \frac{dB_y}{dx} dz = 4.62\ \mathrm{T} \qquad \frac{dB_y}{dx} = 20.3\ \mathrm{T/m}$$



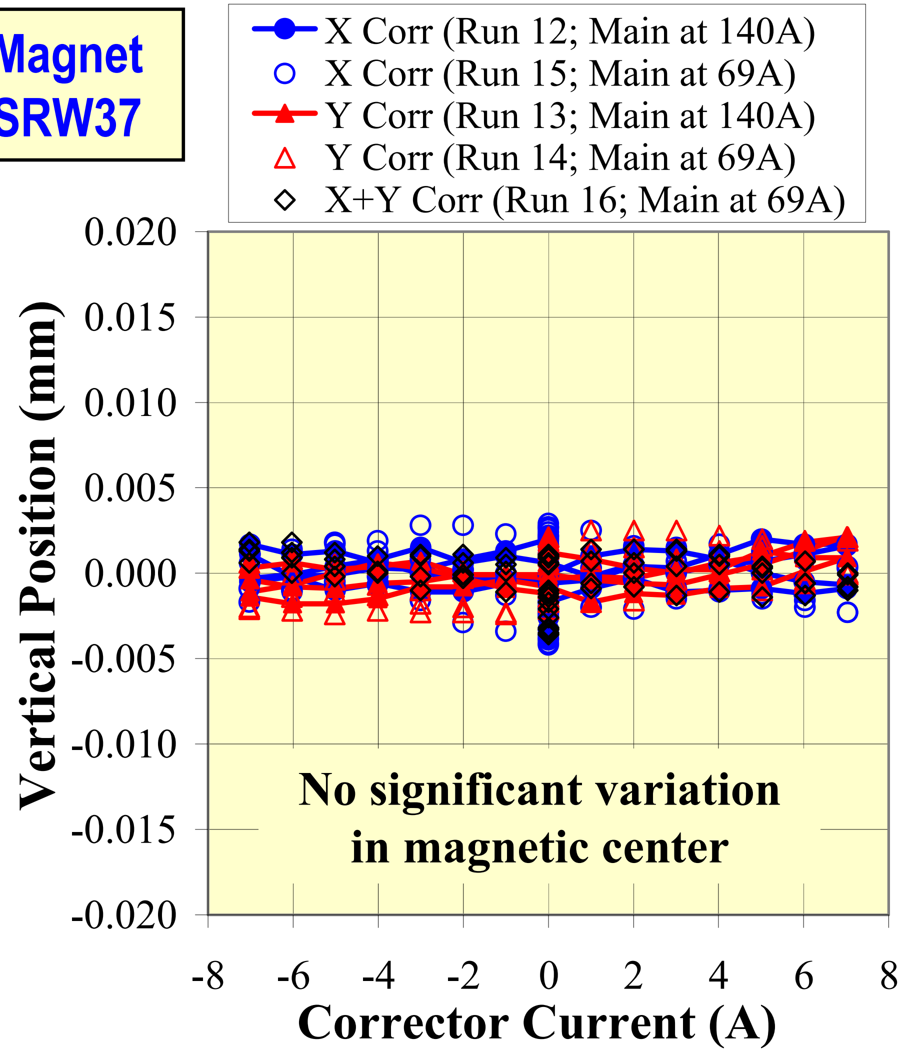
Magnet Details:

- 60 mm diameter bore
- 0.2 m magnetic length
- 120 A Maximum Current

Sextupole Center Vs. Dipole Corrector Excitation



Magnet SRW37

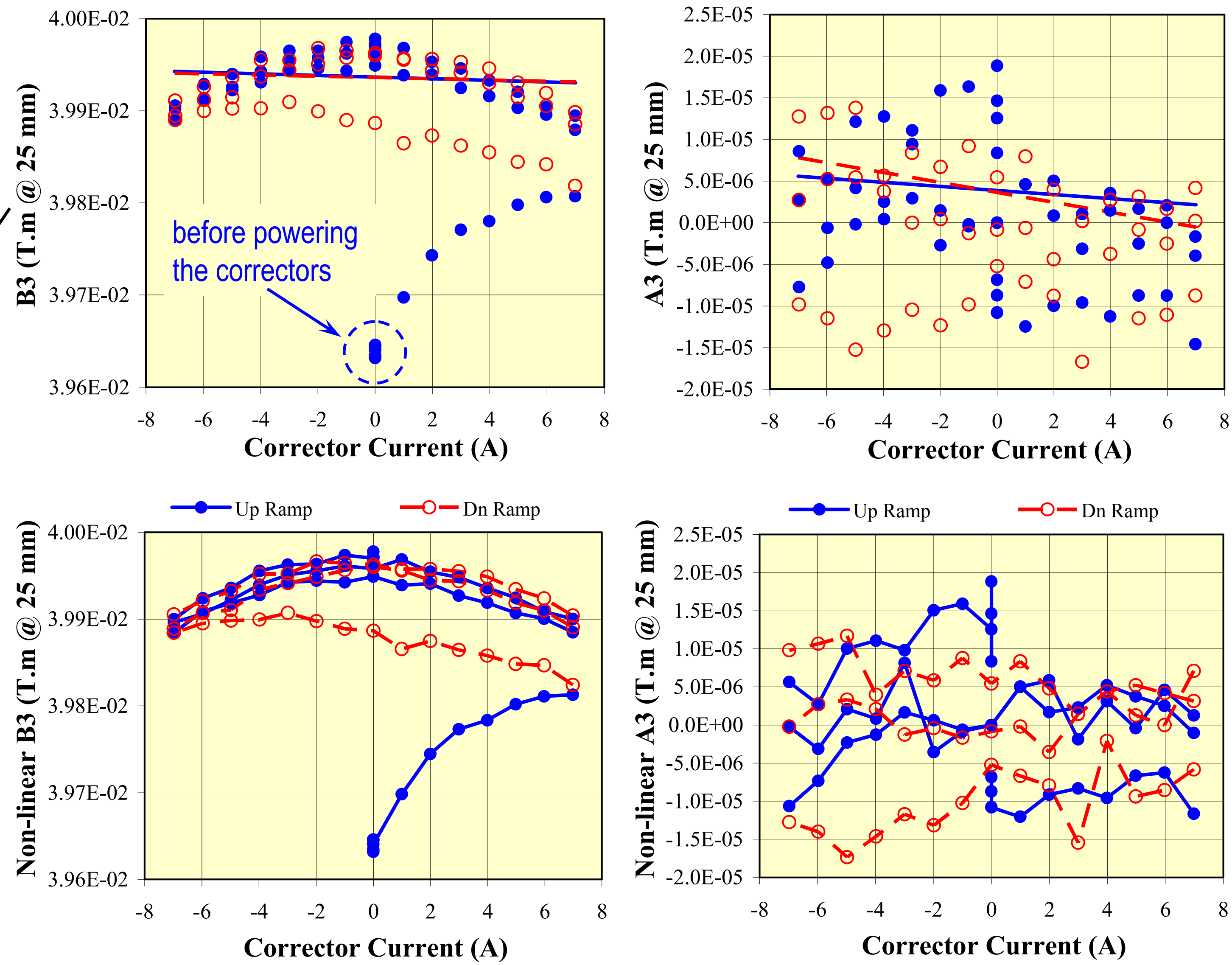


Sextupole Field Vs. Dipole Current (X & Y in series)

Magnet SR110

Background Sextupole current = 107.8 A

Term proportional to current is subtracted out, but this term is negligible in this case.



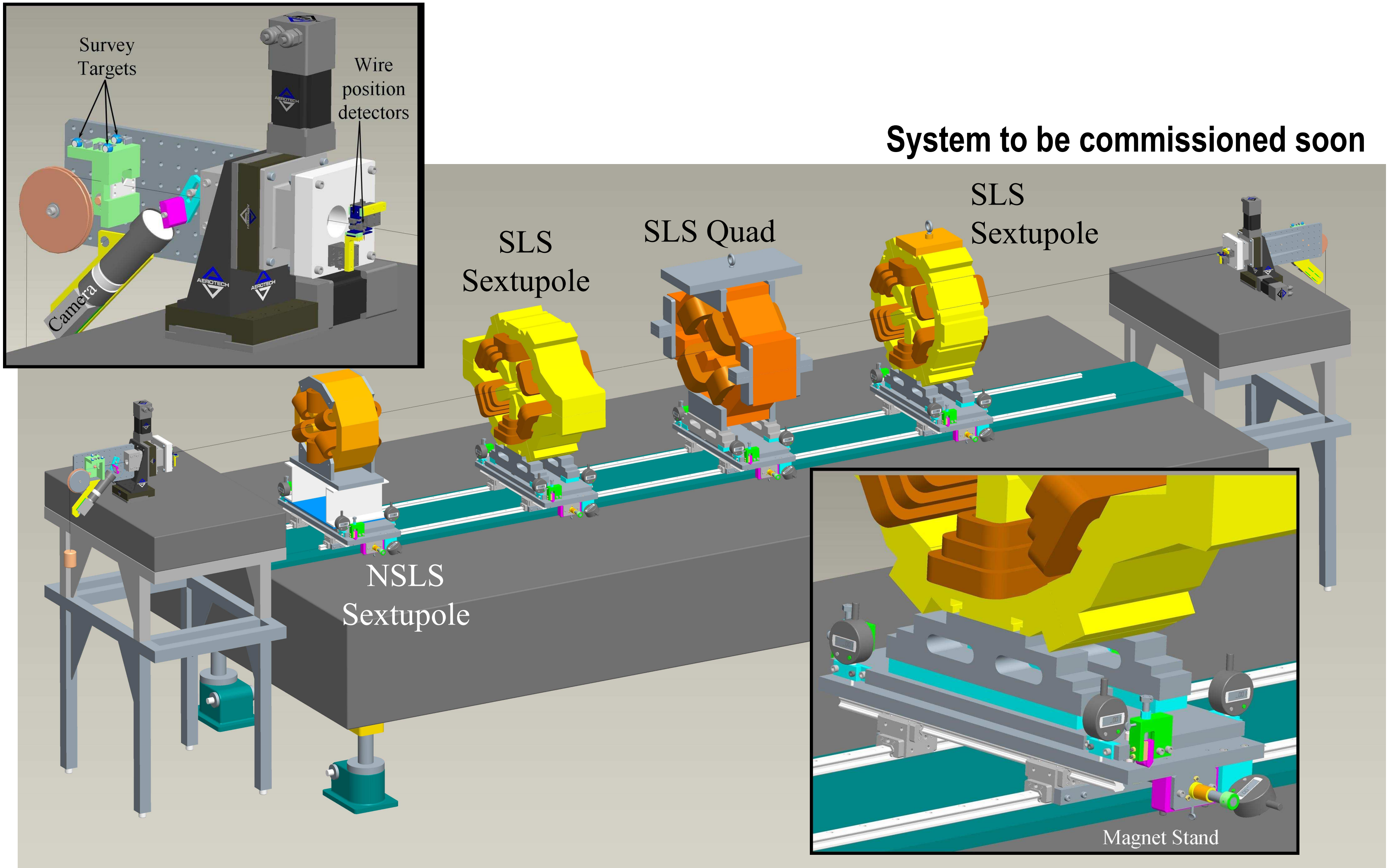
Effect of Neighboring Magnets on Field Quality

Easy to measure effect on the quadrupole field with unpowered sextupoles.

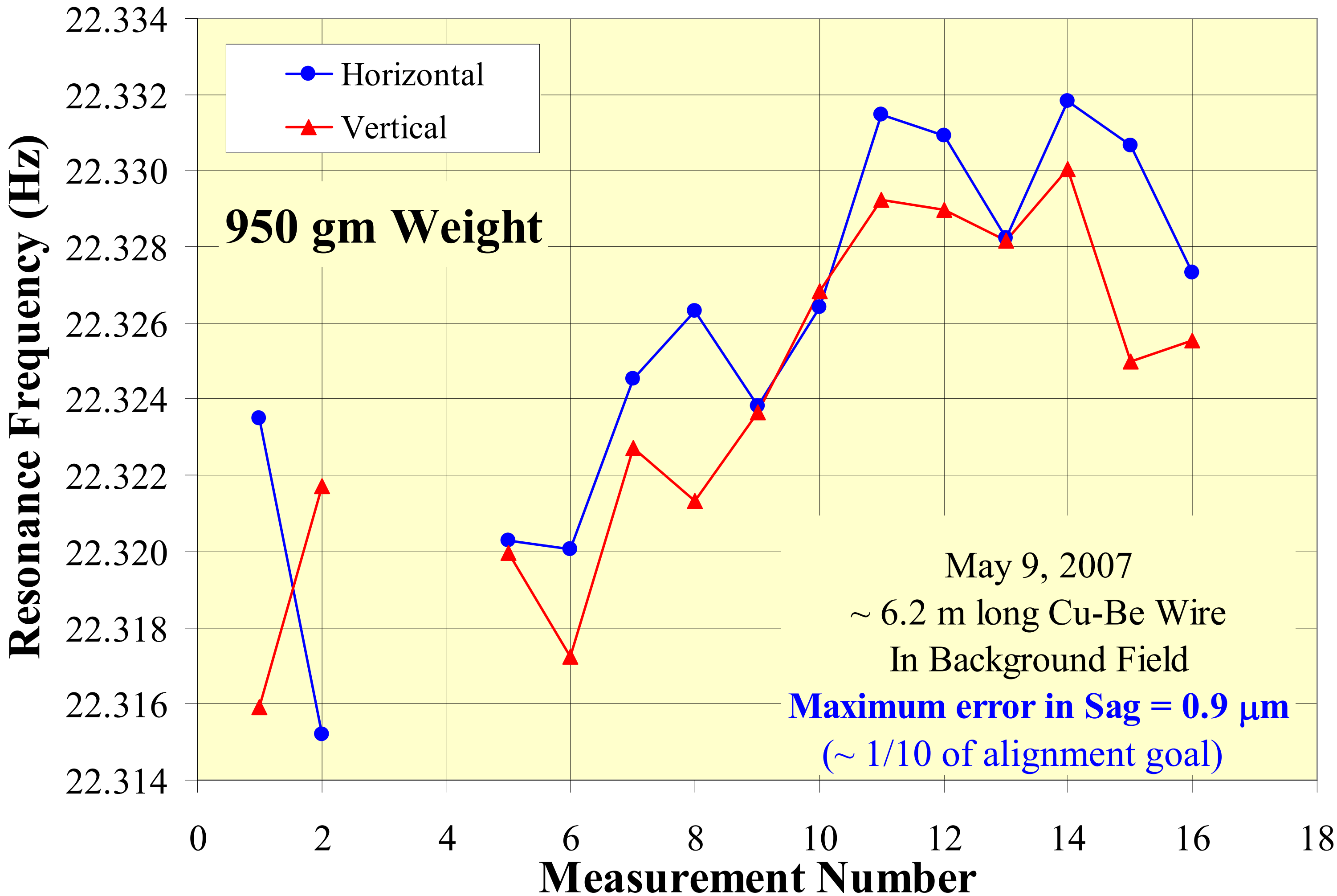
It is a challenge to make good measurements with the sextupoles powered – there are TWO equally strong field components ⇒ Bucking scheme does not work very well!

Vibrating Wire R&D

System to be commissioned soon



Resonant Frequency (or Sag) Stability



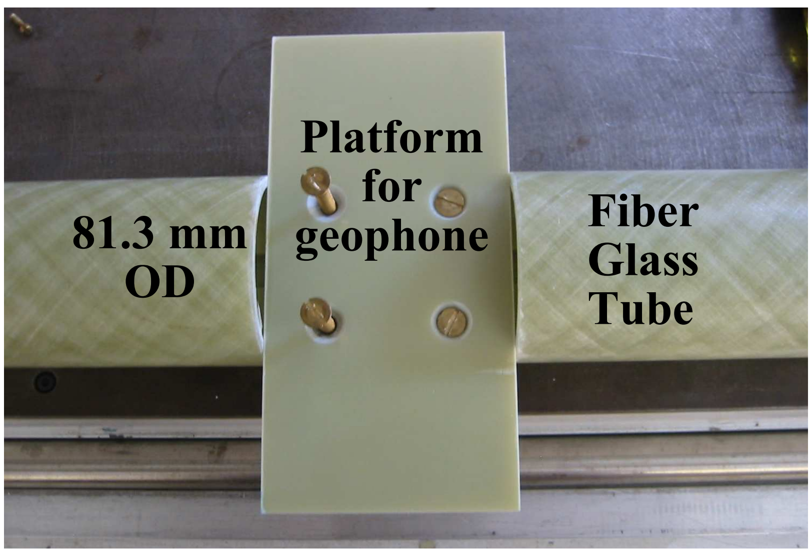
$$Sag = \frac{g}{32 f^2}$$

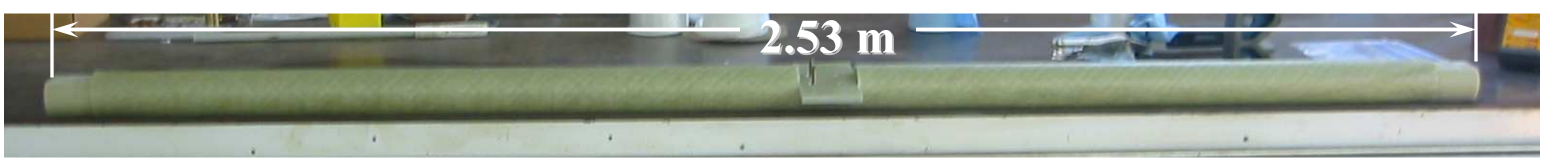
More on sag measurement in another talk at IMMW-15

Correction for large wire sag (500 to 600 microns for ~6.2 m length) is very important, which in turn requires a very precise measurement and good stability of the resonant frequency.

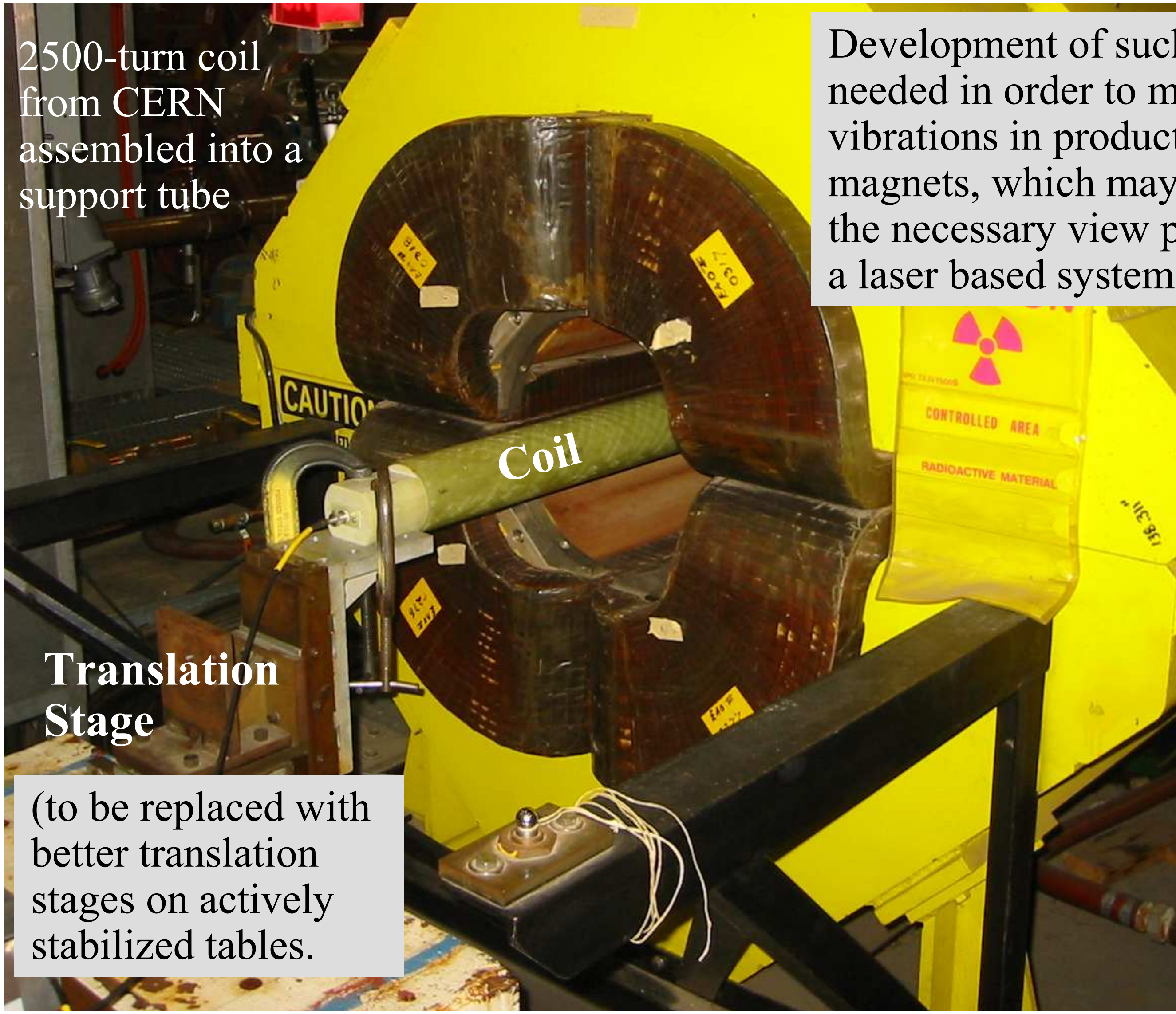
Vibration Pick-up Coil Assembly for ILC

2500-turn coil from CERN





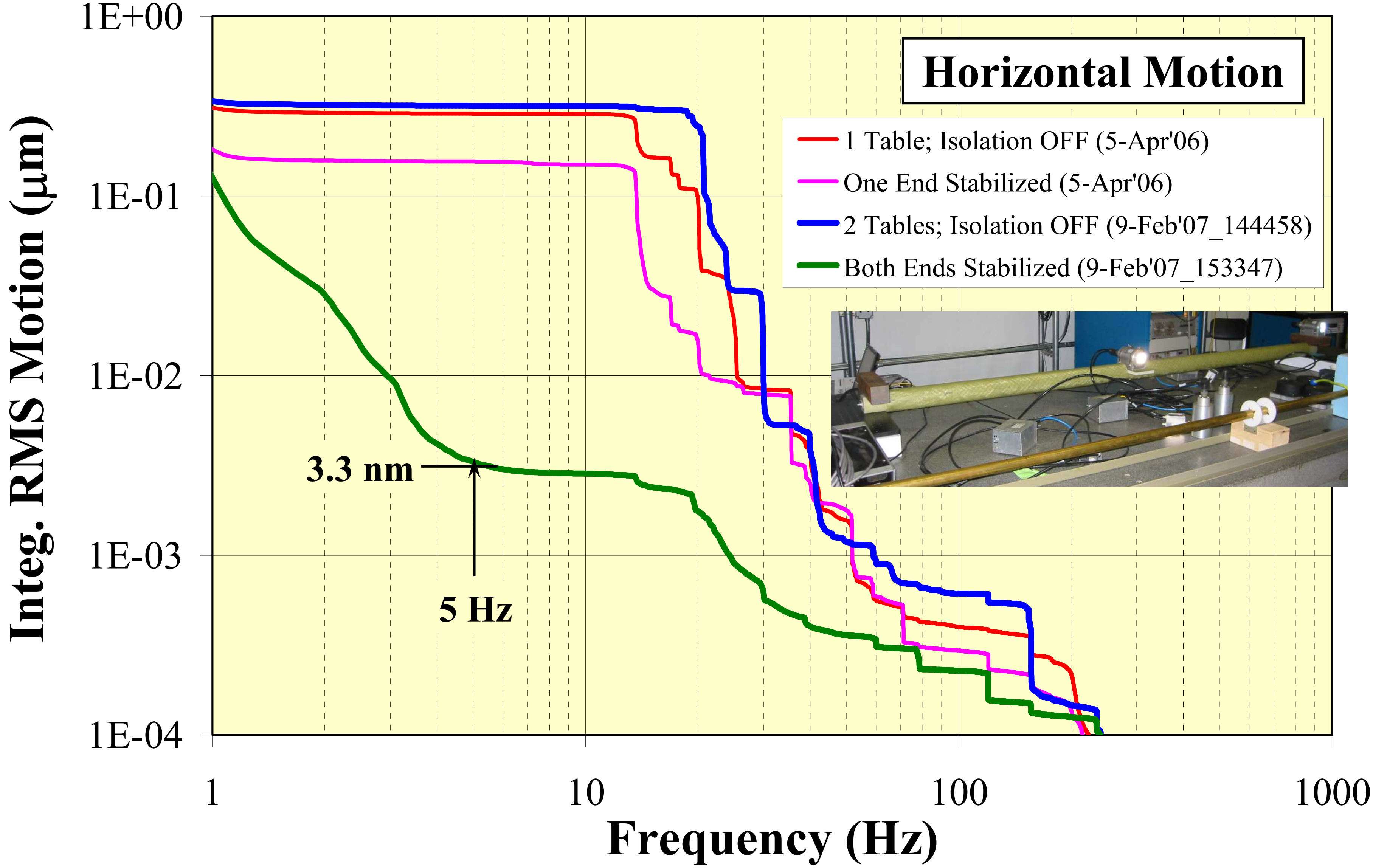
Pick-up Coil Setup in Room Temp. Quad



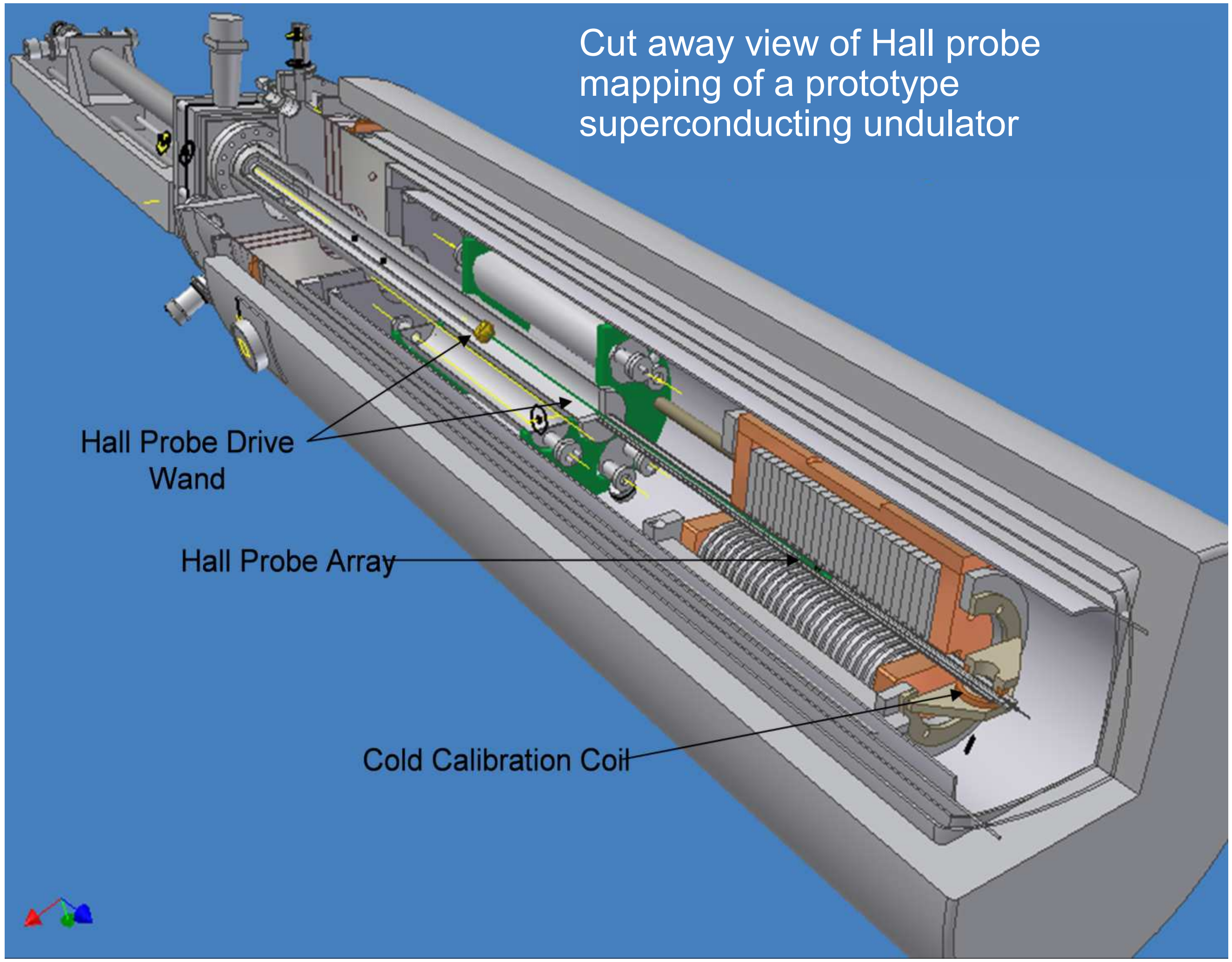
Development of such a coil is needed in order to measure vibrations in production magnets, which may not have the necessary view ports to use a laser based system.

(to be replaced with better translation stages on actively stabilized tables.

2500-Turn Coil Motion With & Without Stabilization



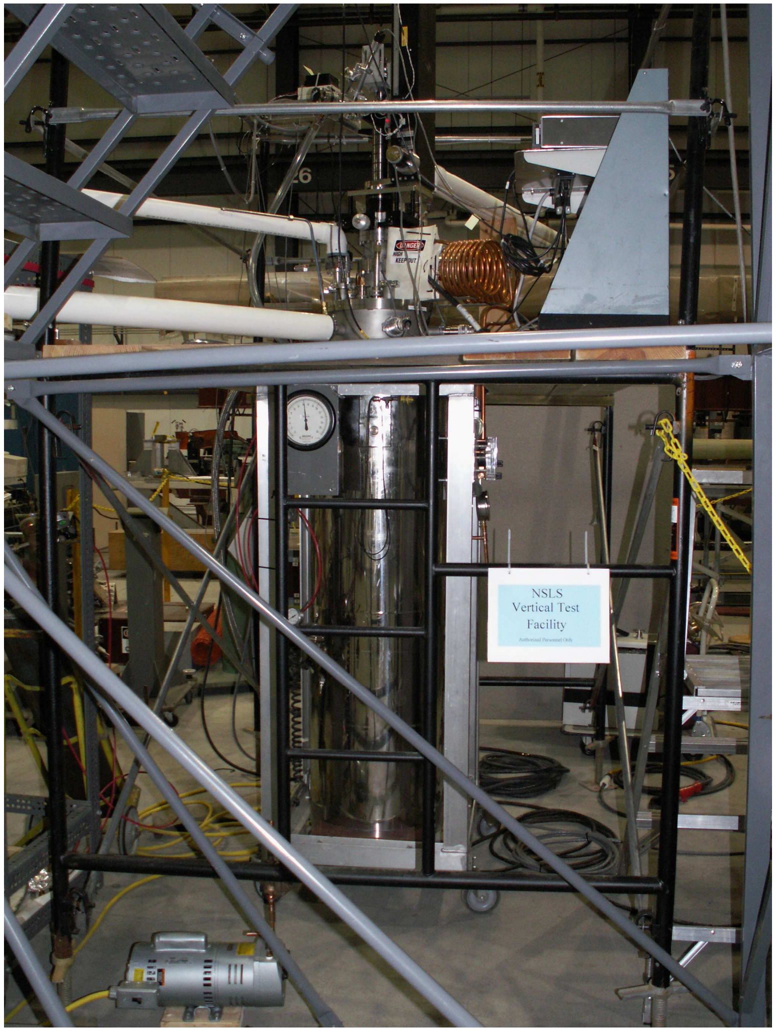
NSLS Vertical Test Facility



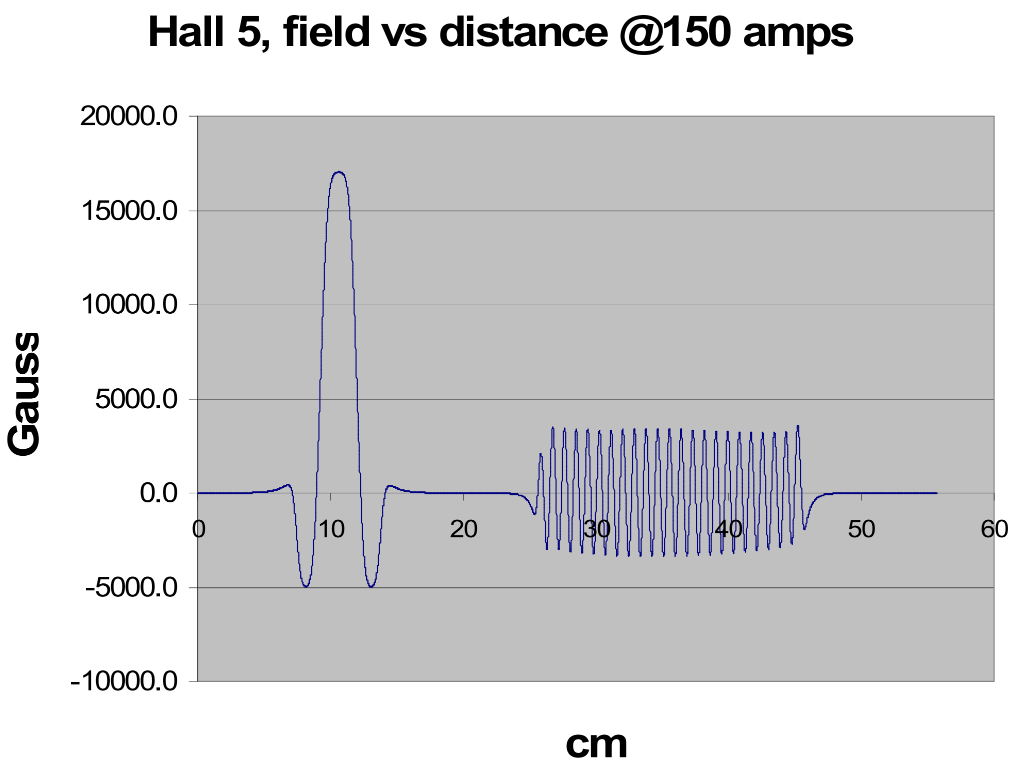
SCU Vertical Test Facility

- Magnetic & Calorimetric Measurement of Short (<0.4m) SCU Models
- Hall probe or Pulsed Wire
- In-situ Hall probe calibration by Helmholtz coil
- 3 LHe Calorimetry channels (Planned)
- Simulate up to 50W beam heat load in beamtube (Planned)
- Started Operation

NSLS Vertical Test Facility (Phase-I) in Operation



Latest measurement result of 8.8 mm SCU with a calibration magnet



Summary

- No large scale production measurements at the moment.
- ERL magnets are currently being measured – small quantities.
- A variety of specialized measurements have been made recently, such as fast ramp measurements and vibration measurements on cold masses with nm level resolution (not covered in this talk).
- Most measurement development activities at present are geared towards the needs of NSLS-II related measurements.
- A vibrating wire R&D system is expected to be commissioned very soon. (Collaboration with Alexander Temnykh, Cornell). The goal is to demonstrate capability to align quadrupoles and sextupoles to an accuracy of ~ ±10-15 μm.