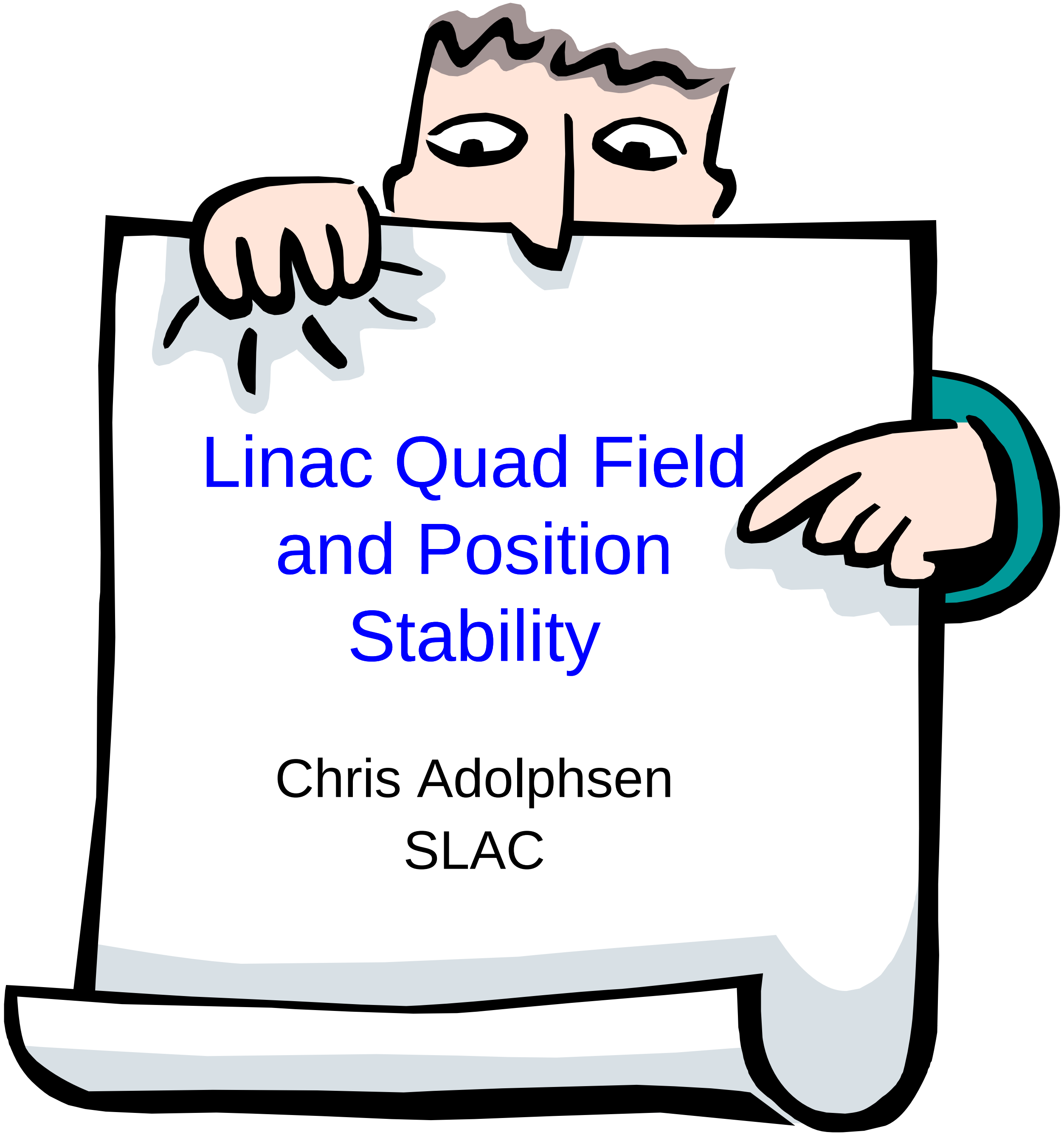


Linac Quad Field and Position Stability

Chris Adolphsen
SLAC

TDR Quad Layout

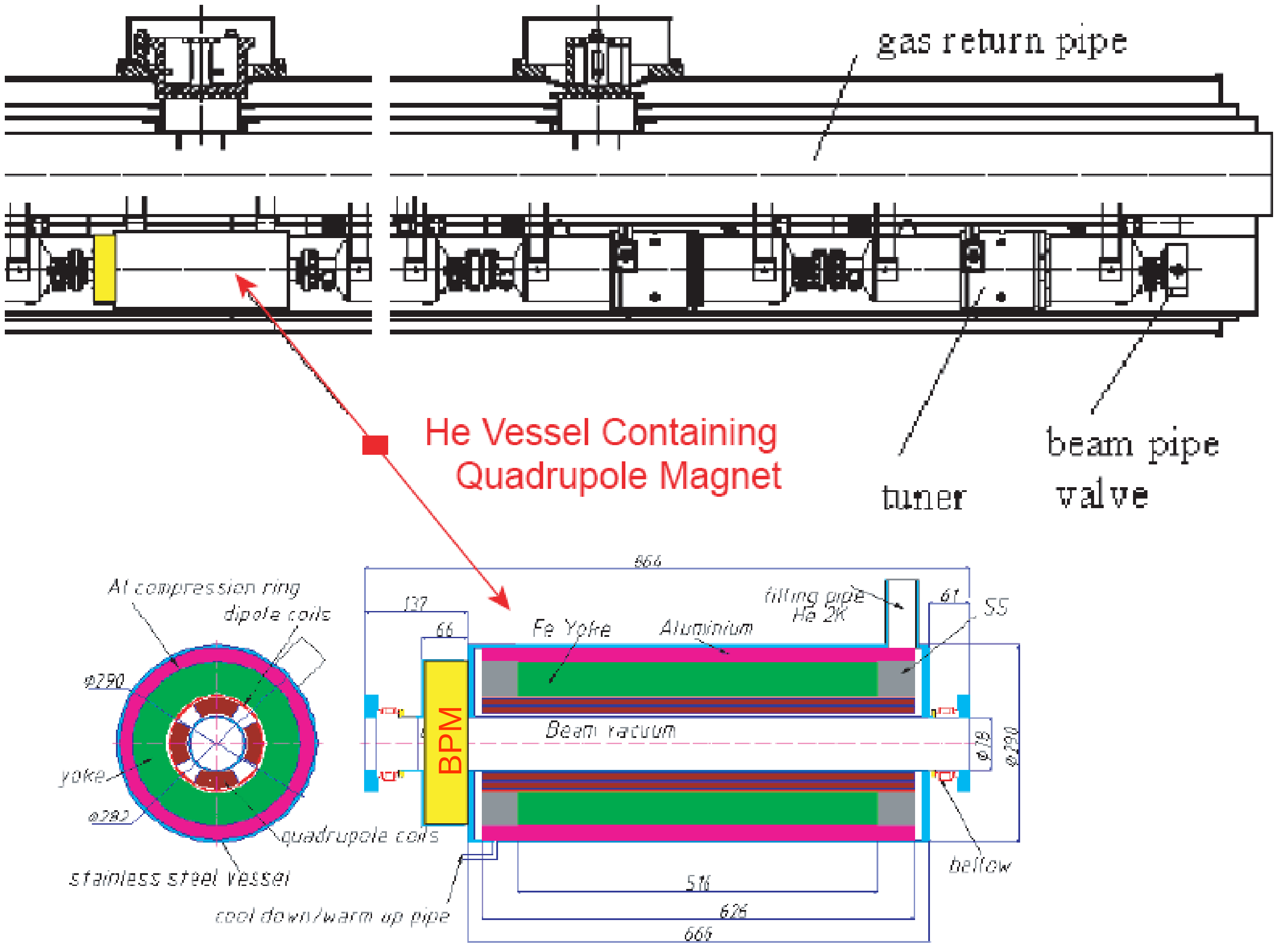


Figure 3.2.12: *Cross-section and longitudinal cut of superconducting magnet package.*

TDR Quad Specs

- **Quadrupole Coil - Cos(2Phi)**
  - Inner Coil Radius = 45 mm — Coil Total Length = 626 mm
  - Nominal Gradient = 60 T/m — Max Field At Conductor = 3.6 T
  - Operating Temperature 2 K — Nominal Current = 100 A
  - Inductance = 3.2 H
- **Dipole Coils, Vert./Horiz. (Cos, Single Layer)**
  - Inner Coil Radius = 67 mm — Coil Total Length = 626 mm
  - Max Field on Axis = 0.074 T — Max Current = 40 A
  - Inductance/Coil = 29 mH
- **Field Quality (at 30 mm radius)**
  - Skew Quadrupole < 3*10−4
  - Higher Harmonics Of Quadrupole < 10−3
  - Alignment Error (Angle) < 0.1 mrad rms

Quad Field and Position Requirements

- Fast Motion (Vibration)
  - Require uncorrelated vertical motion > ~ 1 Hz to be < 100 nm
  - Many measurements being done – data look close to meeting spec.
- Slow Motion (Drift)
  - For dispersion control, want quad to stay stable relative to it neighbors at few micron level, day to day
  - Although slow ground motion is large, it is correlated on over long distance range which makes its net effect small.
  - No data on local day-to-day motion of quad in a cryostat.
- Change of Field Center with Change in Field Strength
  - For quad shunting technique to be effective in finding the alignment between the quad and the attached bpm, quad center must not move by more than a few microns with a 20% change in field strength
  - No data for prototype ILC quads.

Quad Vibration

- Why is Ground Motion a Concern for the ILC:

  It will move the quadrupole magnets, which will steer the beams and cause them to miss at the IP: $\rightarrow\leftarrow$

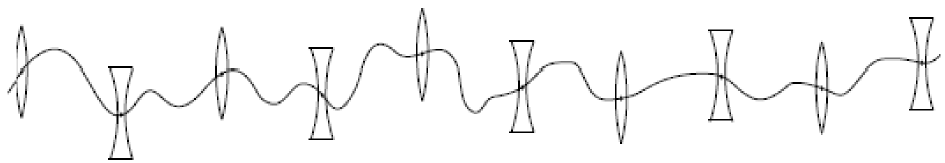
- Temporal Scale of Problem:

  Motion $\lesssim$ 0.1 Hz heavily suppressed by trajectory feedback loops.

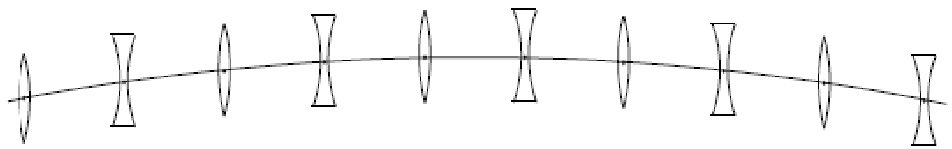
  Motion $\gtrsim$ 10 Hz generally not significant.

- Spatial Scale of Problem:

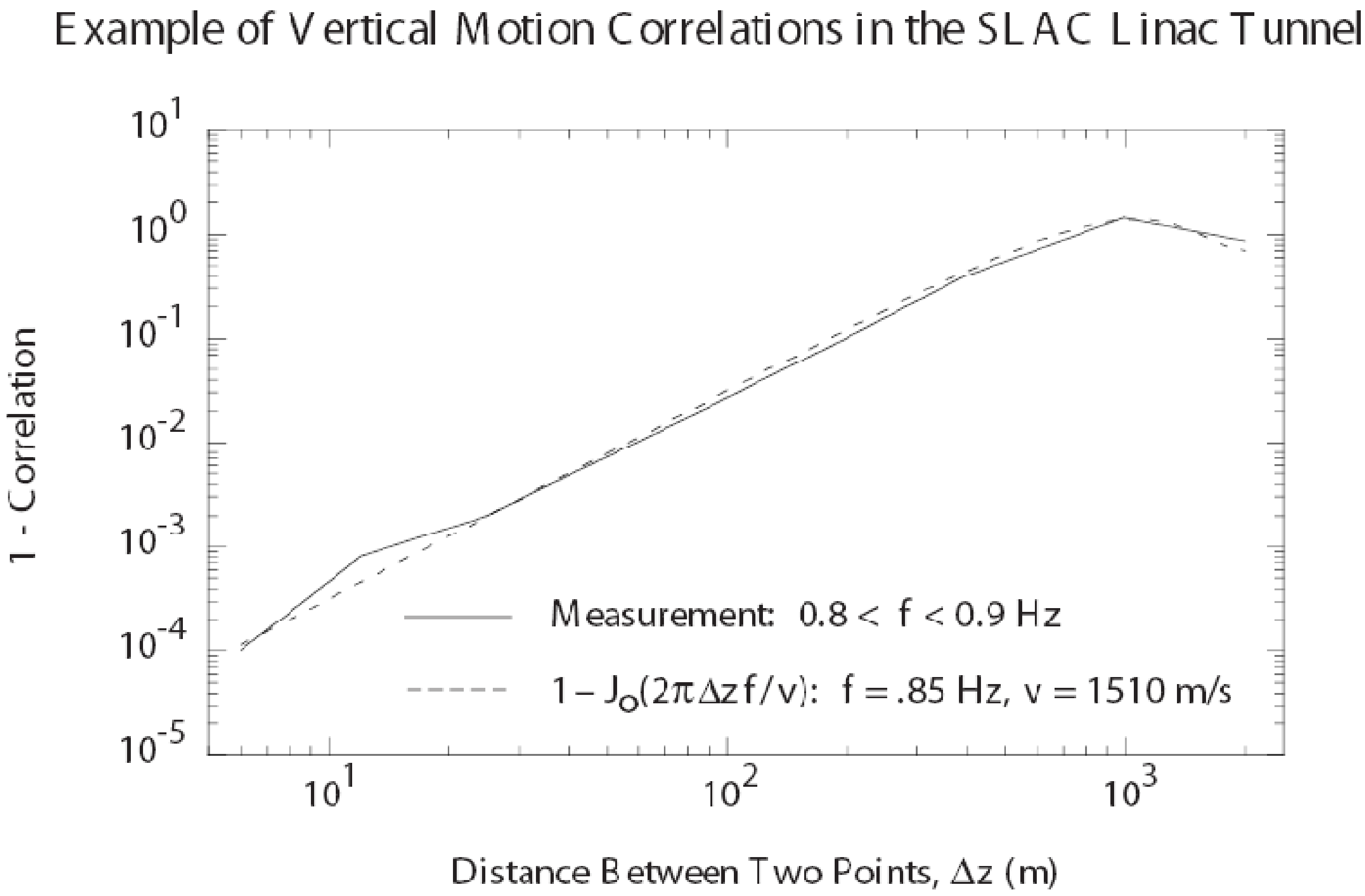
  More sensitive to uncorrelated motion,



  than to motion correlated over distances >> betatron wavelength:



Correlation of Motion



Amplification & Additional Motion

Do not want support system to amplify or add to quad motion.

Recent measurements of DESY M6 show some amplification due to cryostat supports, and some additional high freq motion.

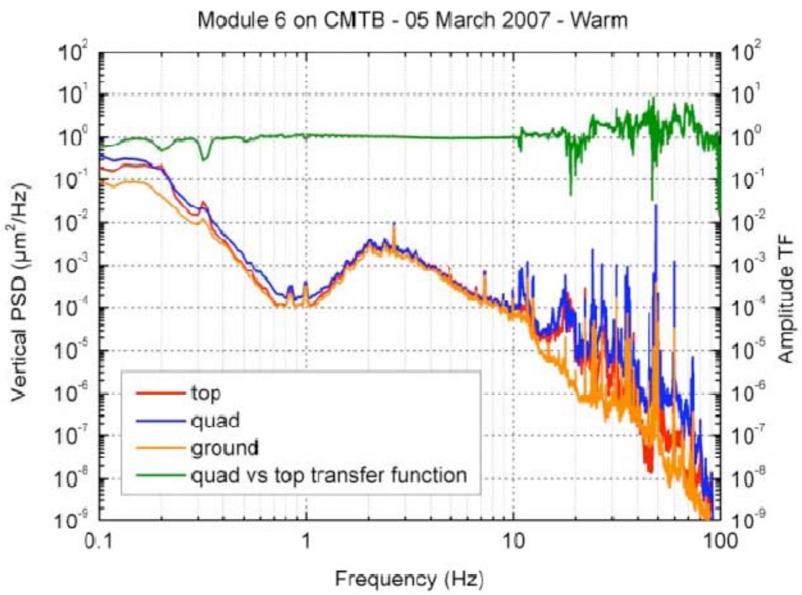


Figure 4. Room temperature PSD spectra measured simultaneously on the CMTB floor, on top of the vacuum vessel and on the quadrupole, quad vs vessel top transfer function is also shown.

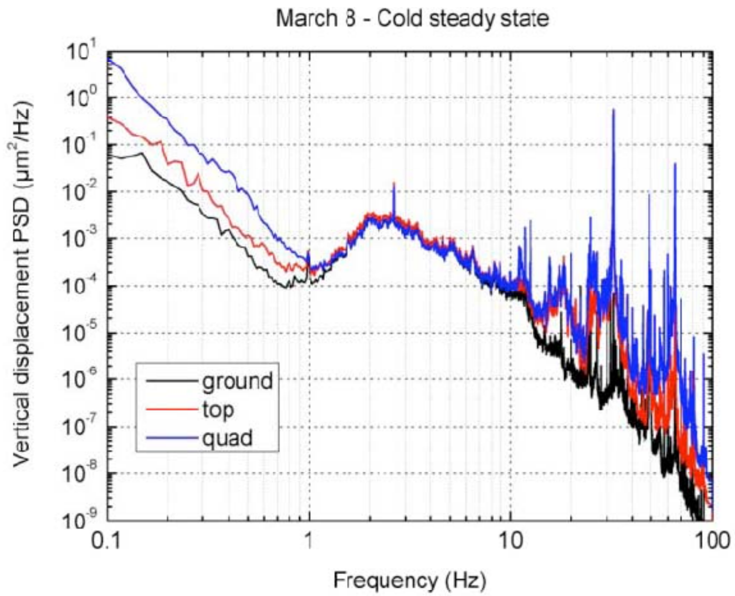
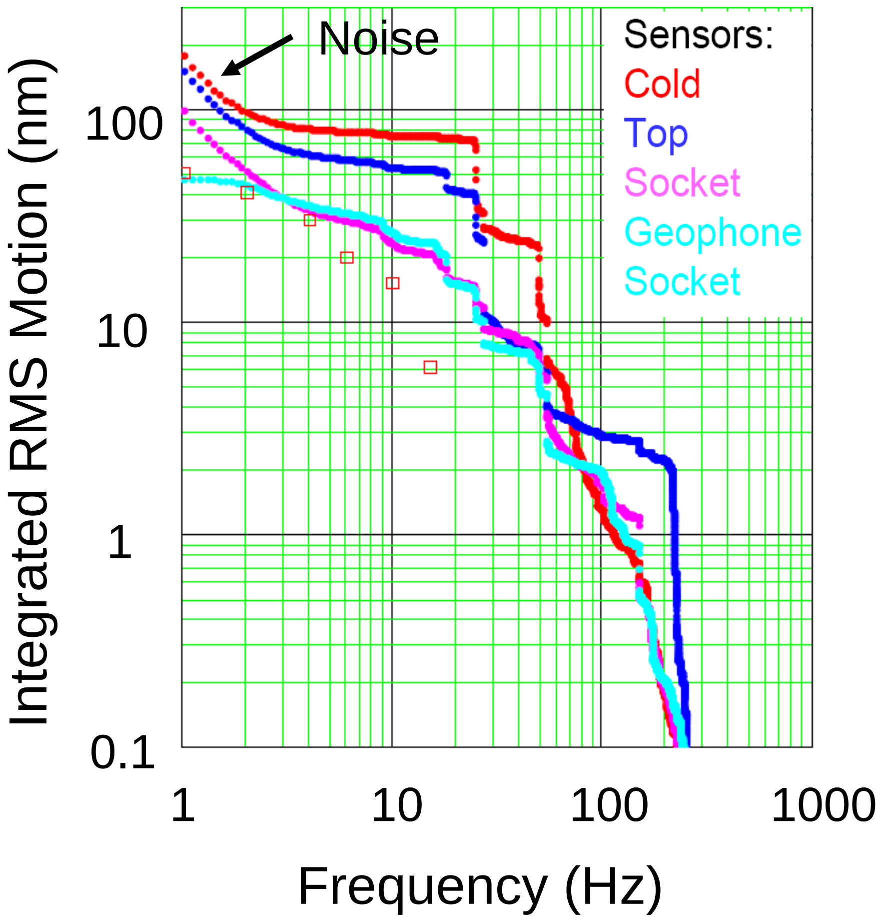
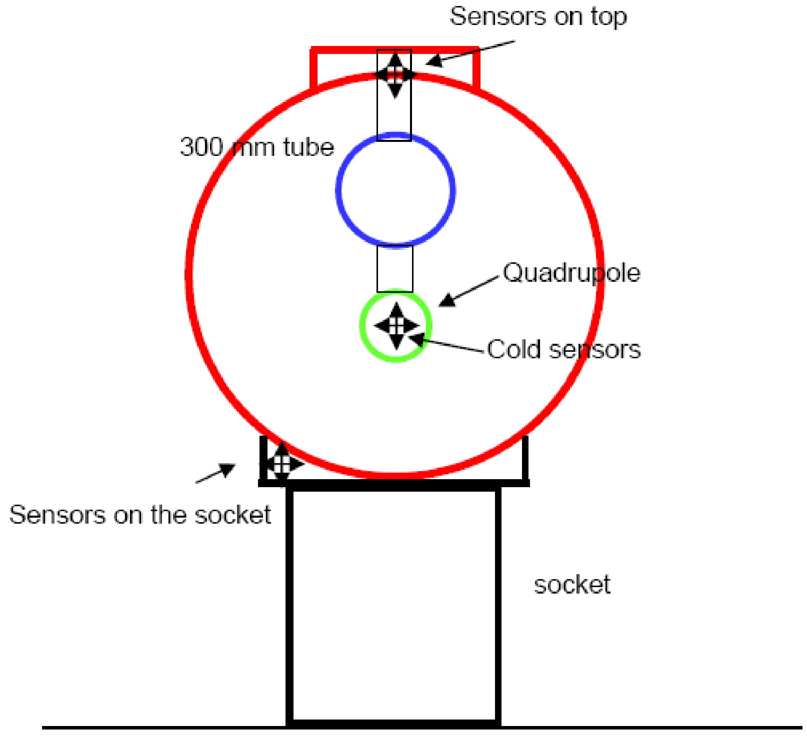


Figure 5: PSDs of ground, vessel top and quadrupole in cold steady state with RF off, measured just after reaching the cold stable conditions at the end of the 11th cooldown.

Earlier Vertical Quad Motion Measurements at TTF

(ILC Goal: < 100 nm for f > ~ 1 Hz)



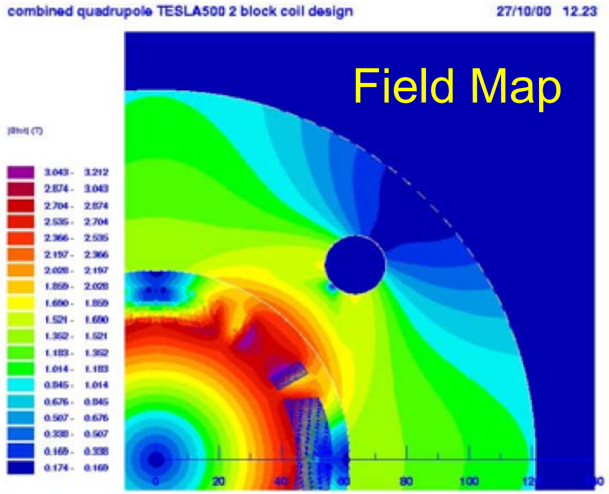


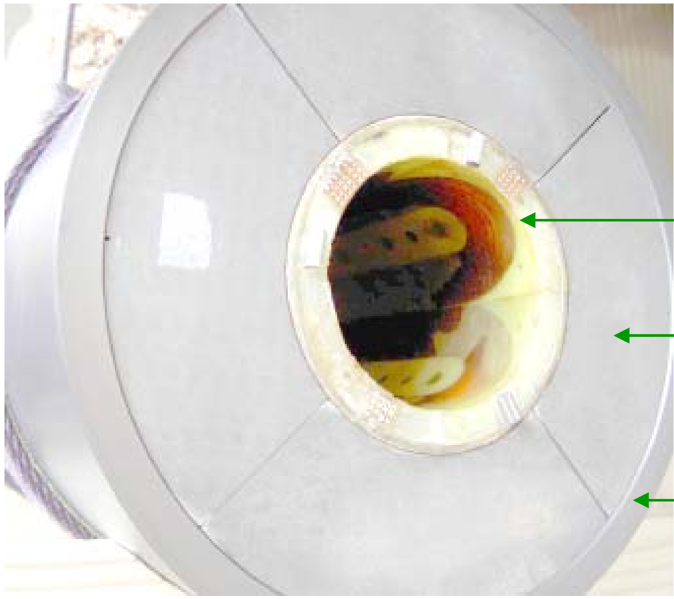
Motion of Quad Center -vs- Field Strength

CIEMAT

Cos(2Φ) SC Quad

(~ 0.7 m long)



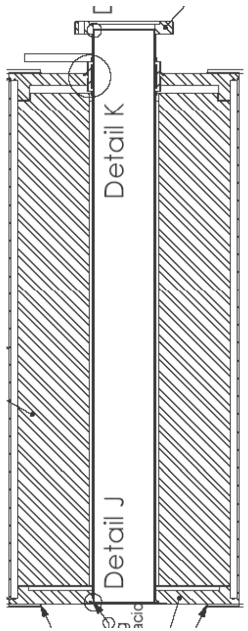


He Vessel

SC Coils

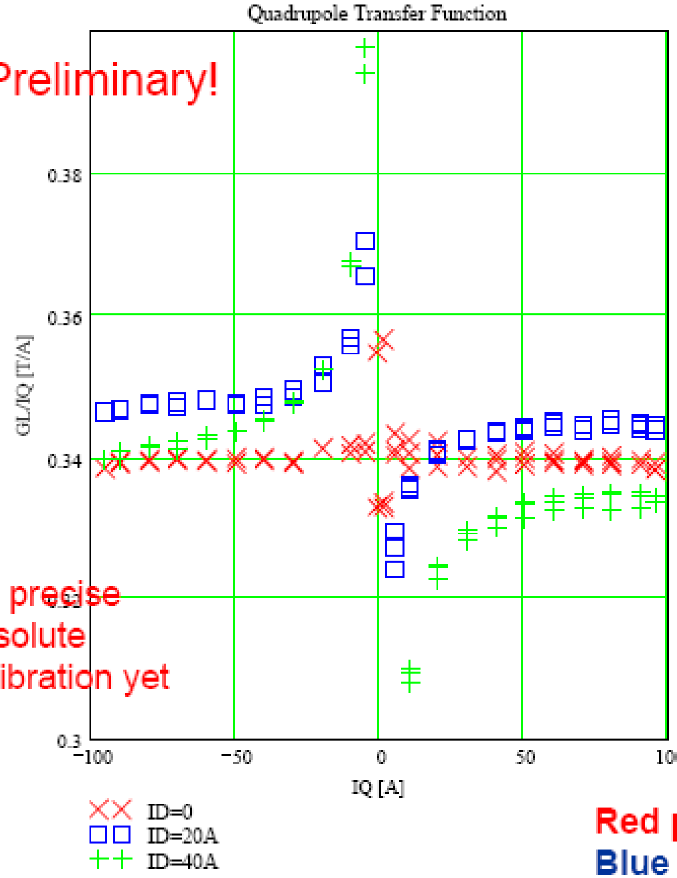
Iron Yoke Block

Al Cylinder

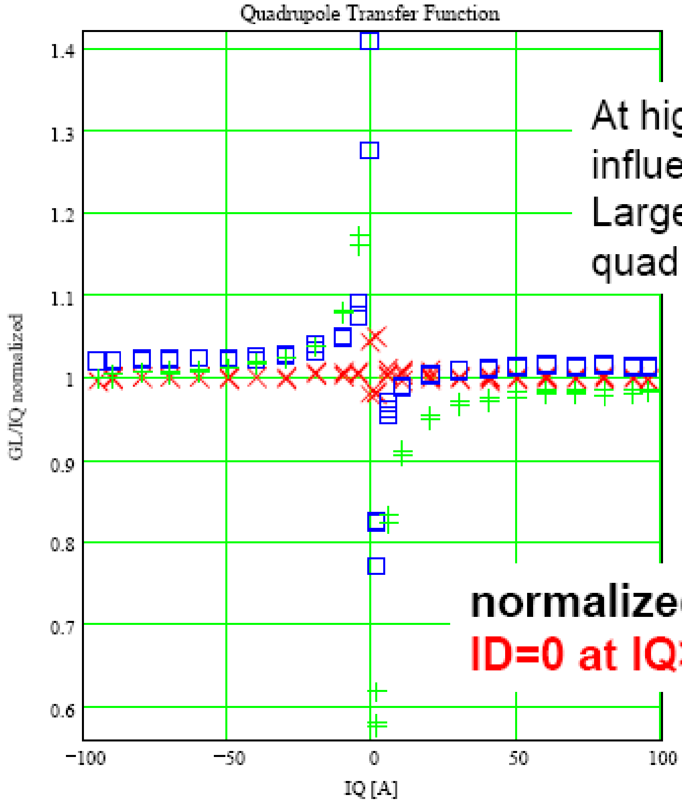


Quadrupole Transfer Function on up- and down-ramp of IQ for ID=0,20,40A

Preliminary!



No precise absolute calibration yet

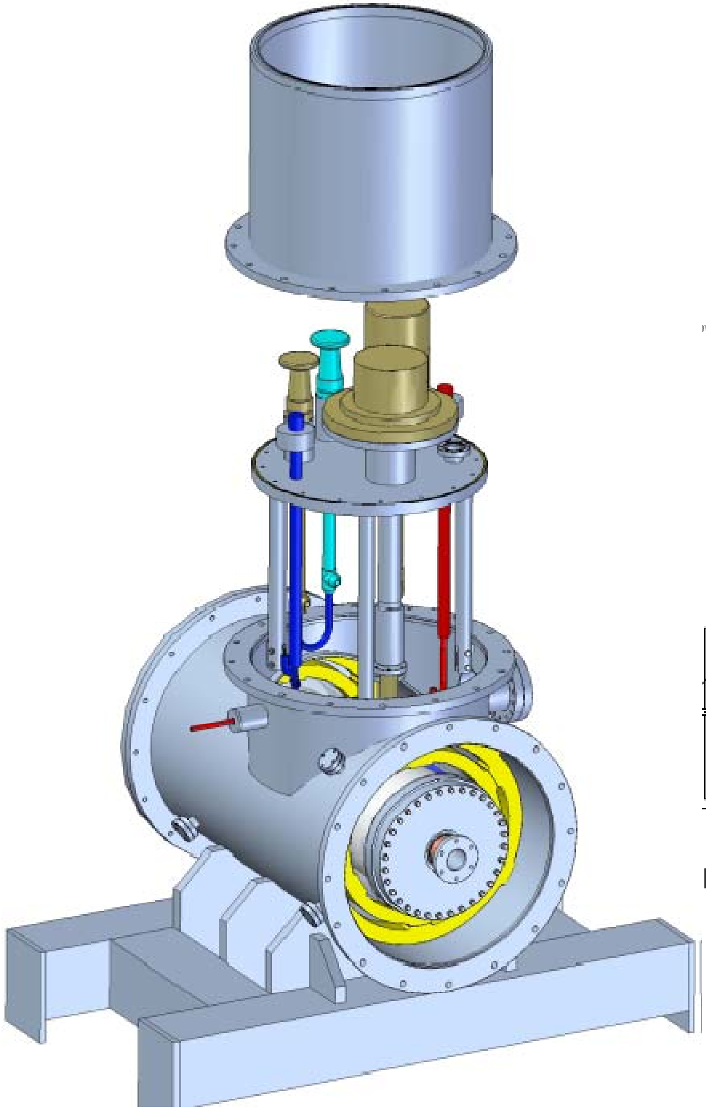


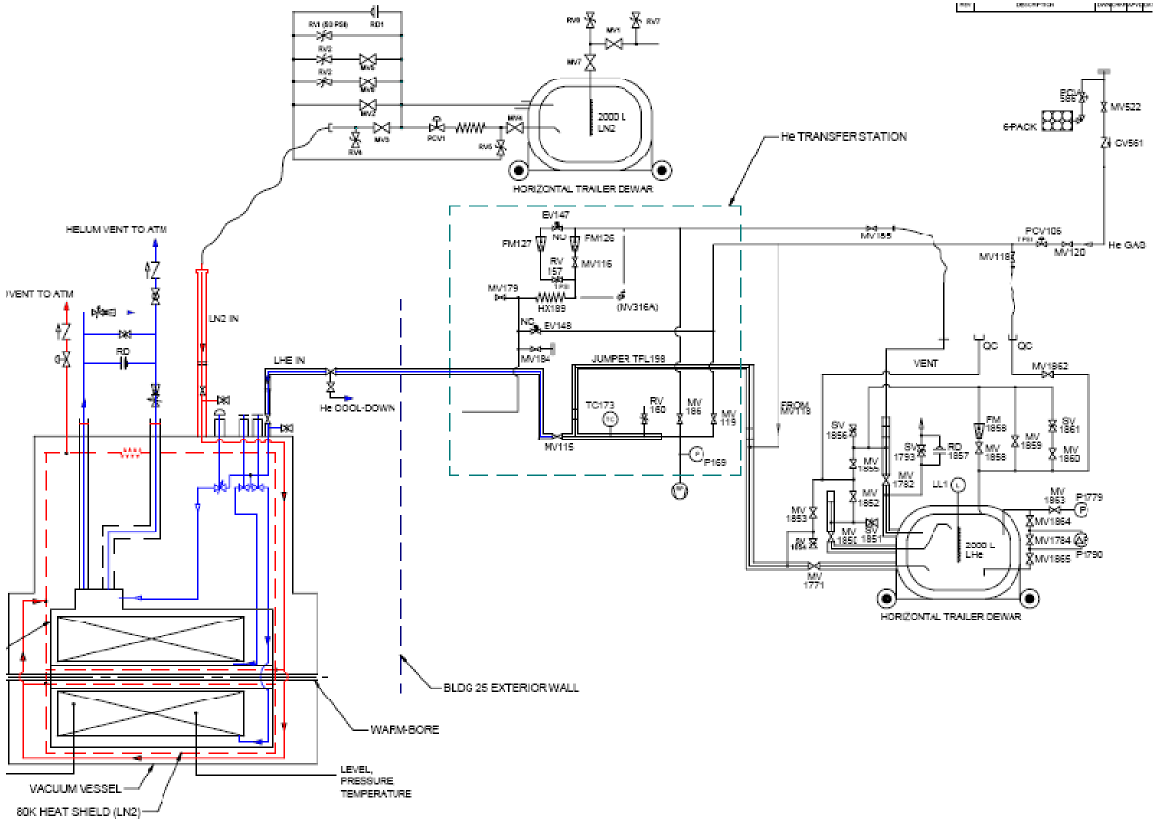
At high quad current influence small
Large effects at low quad currents

normalized at
ID=0 at IQ>60A

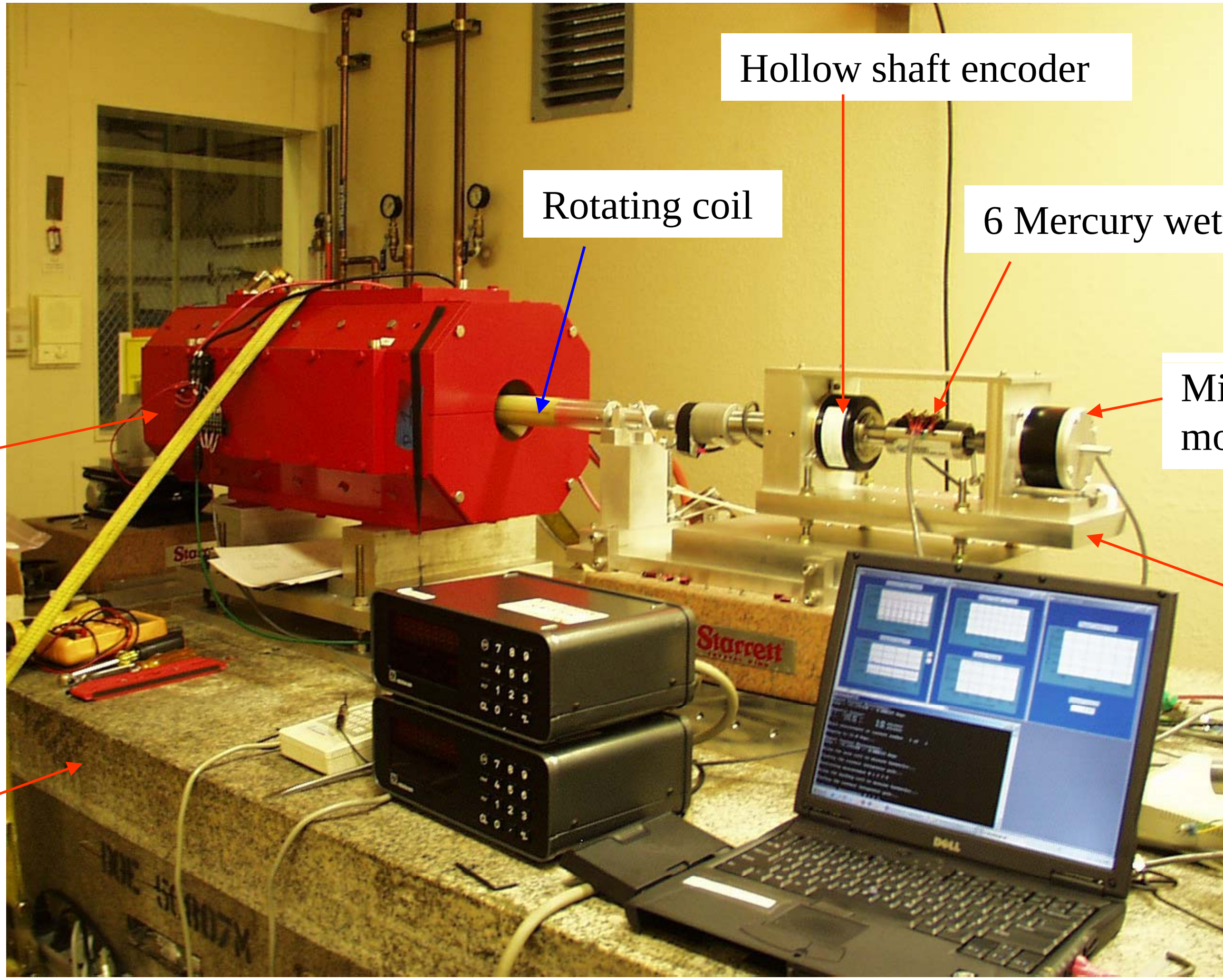
Red points: ID=0A
Blue Points: ID=20A
Green Points: ID=40A

Cryostat and Cryogenic System

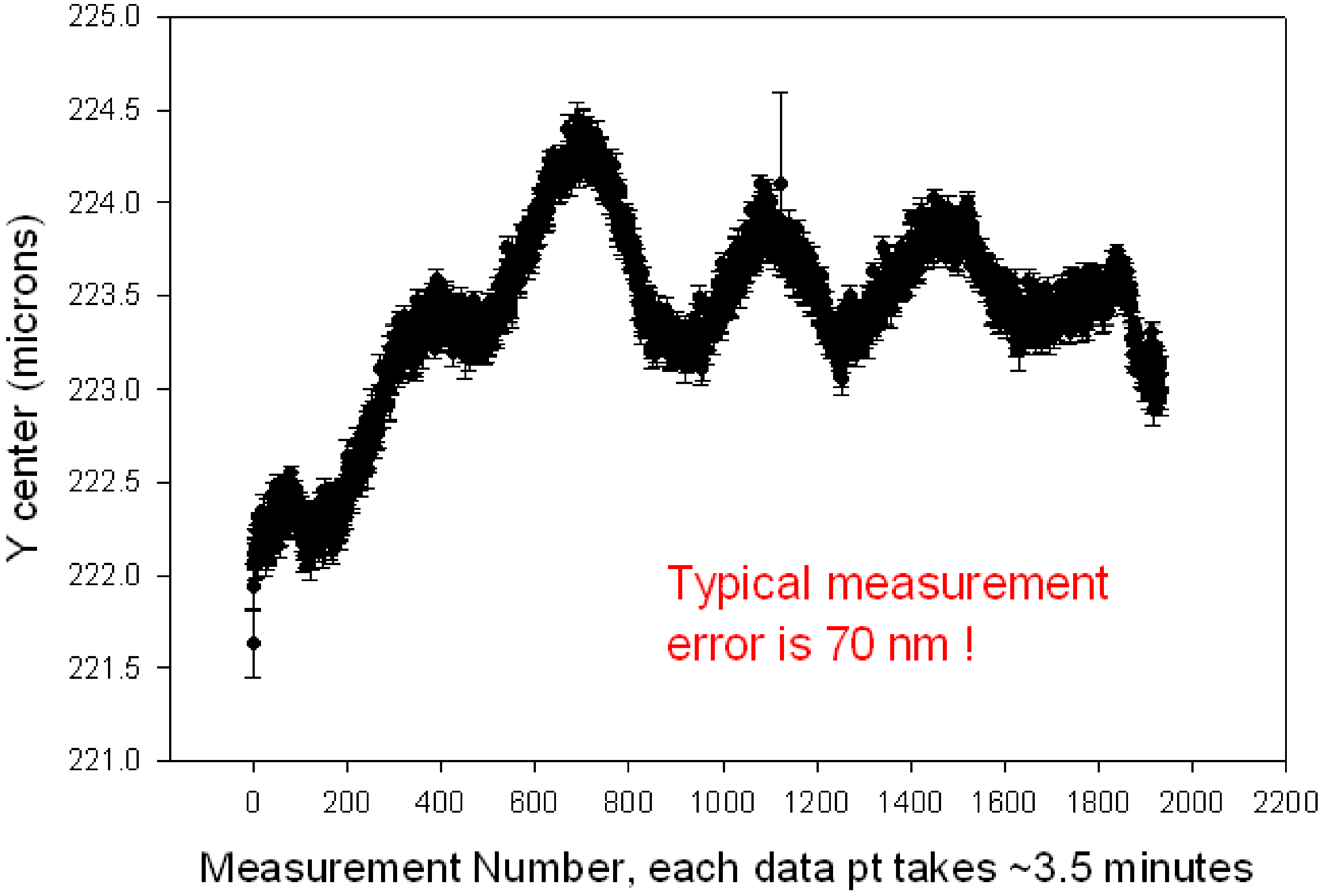




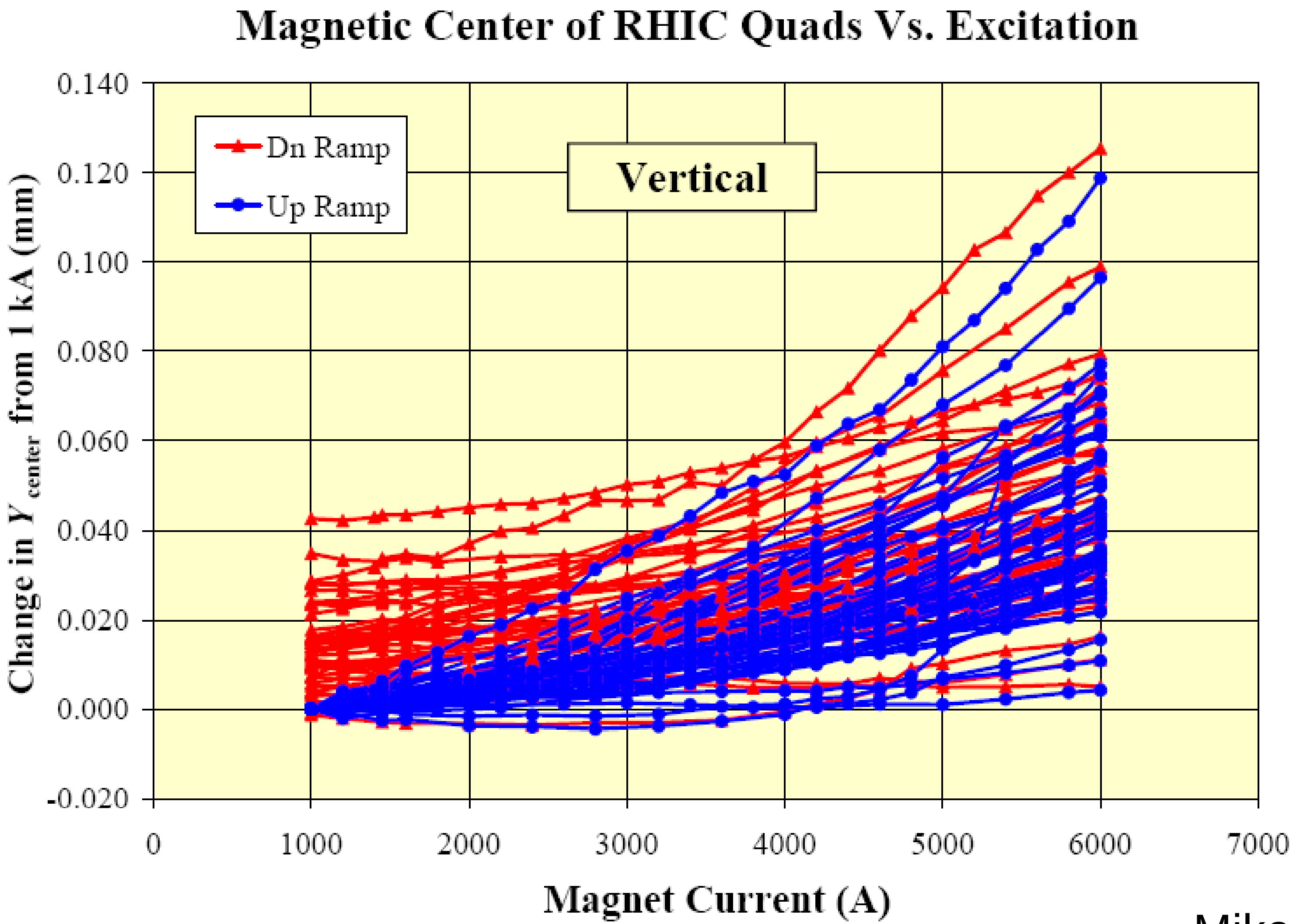
New Rotating Coil Set-up Designed For Measuring Large Bore Quads



Normal-Conducting Quad Center Stability Data Taken Over Five D



Magnetic Center Movement in RHIC SC Quads



Mike Harrison

From XFEL quad studies, it appears one can achieve 60 T/m in a 35 mm radius superferric quad (i.e., 35 T/m * 56 mm ~ 60 T/m * 35 mm)

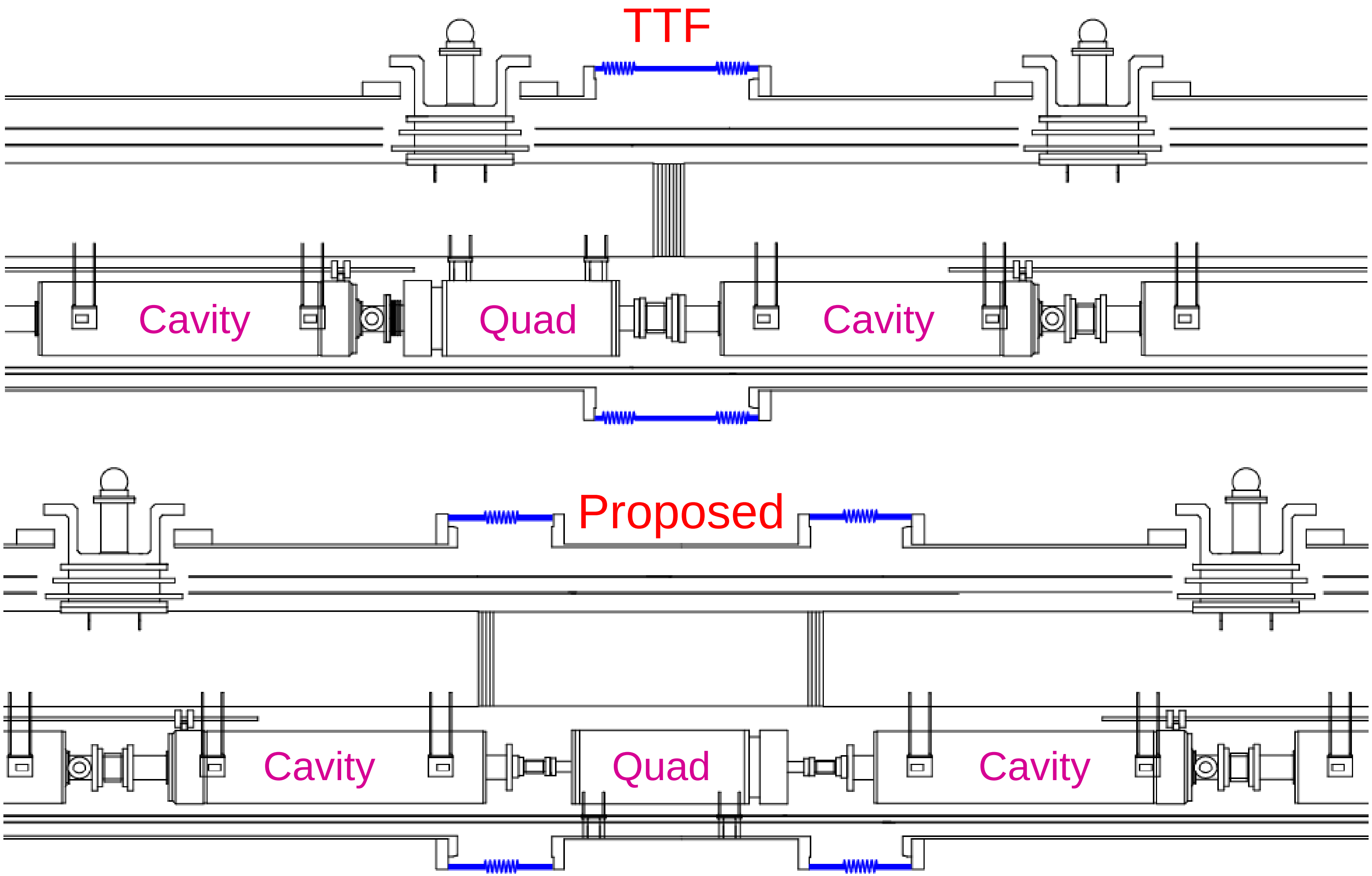
The magnetic center in such a iron-dominated quad may be more stable than in coil-dominated design

Design criteria of XFEL Magnets

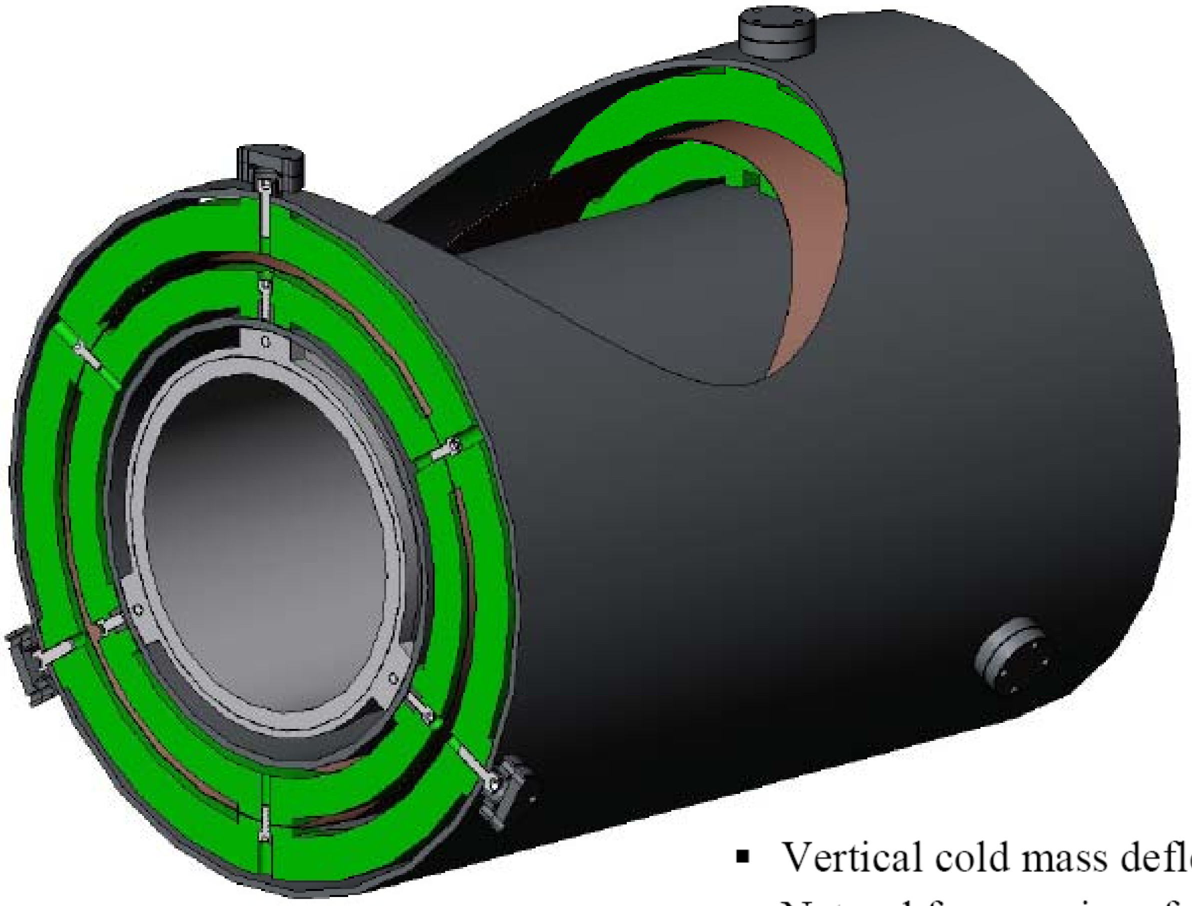
Requirements

	Quadrupole	Inner dipole	Outer dipole
Strength	5.6 T	0.006 T·m	0.006 T·m
Current	50 A	50 A	50 A
Temperature	2 K	2 K	2 K
Aperture	112 mm	100 mm	105 mm
Field quality	$\|b_6\| < 10$ units	-	-
Gradient/Field	35 T/m	0.04 T	0.04 T
Length	200 mm	250 mm	250 mm
Operation	DC	DC	DC

Quad/BPM Layout to Decouple Quad from GRP to Eliminate Possible Long-Term Motion



He Vessel Support in the Cryostat



- Vertical cold mass deflection <0.001" due to self-weight.
- Natural frequencies of cold mass and support structure:
  - First axial resonance ~72 Hz
  - First lateral resonance ~129 Hz
- Conduction heat loads through the G-10 supports:
  - 3.6 W to 80 K (each support)
  - 0.8 W to 4.5 K (each support)