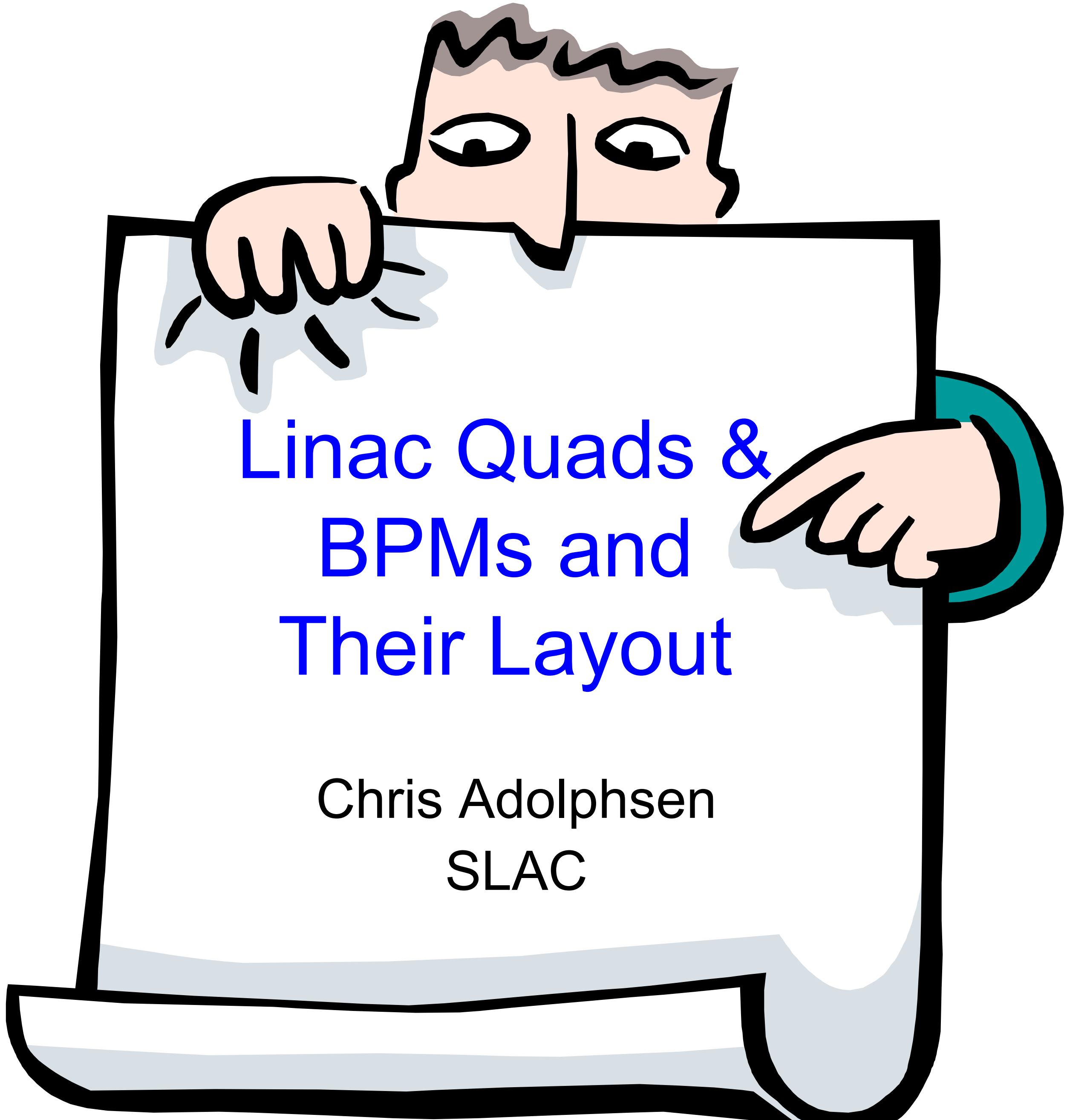


Linac Quads & BPMs and Their Layout

Chris Adolphsen
SLAC

TDR Quad Layout

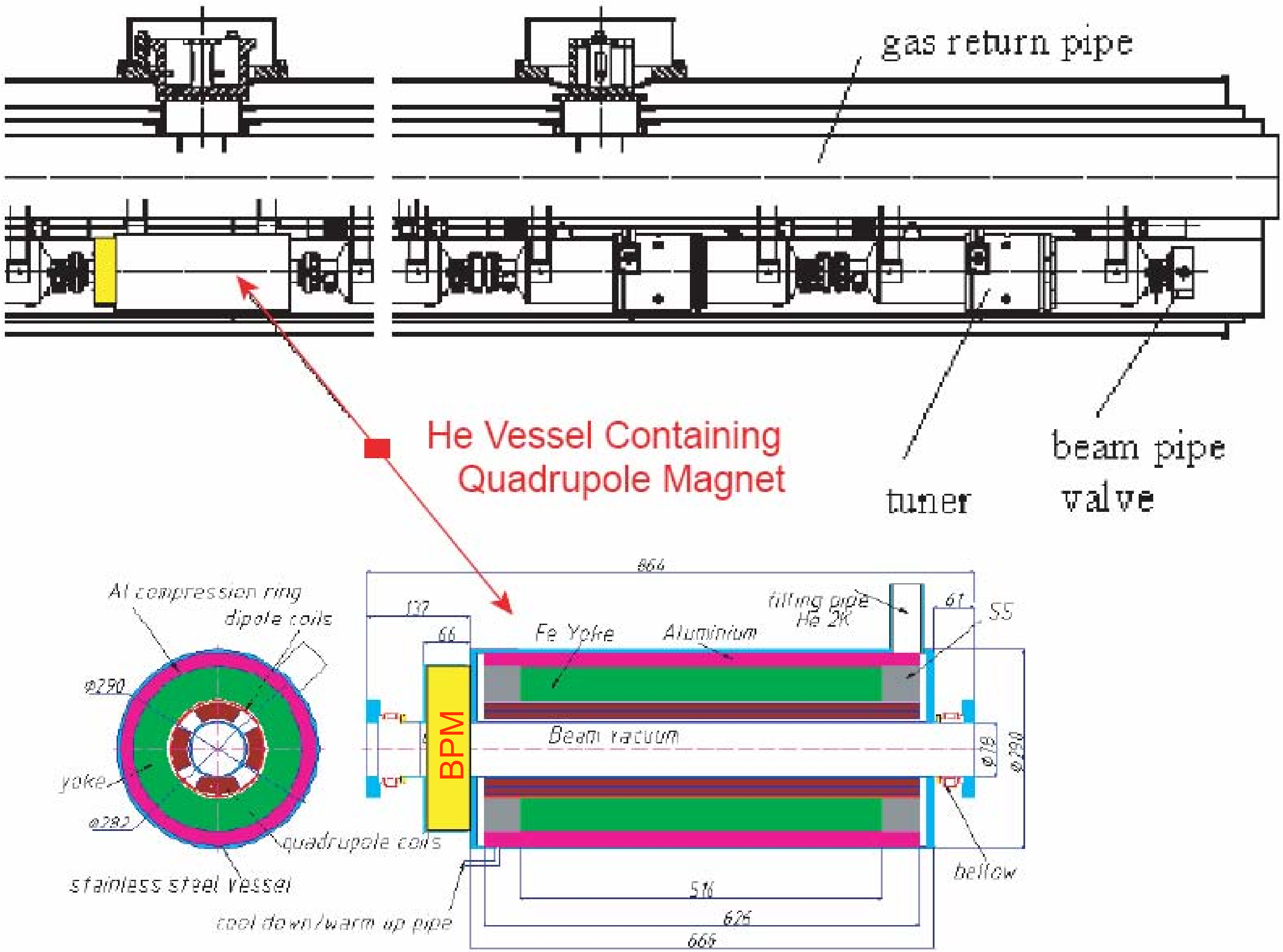


Figure 3.2.12: *Cross-section and longitudinal cut of superconducting magnet package.*

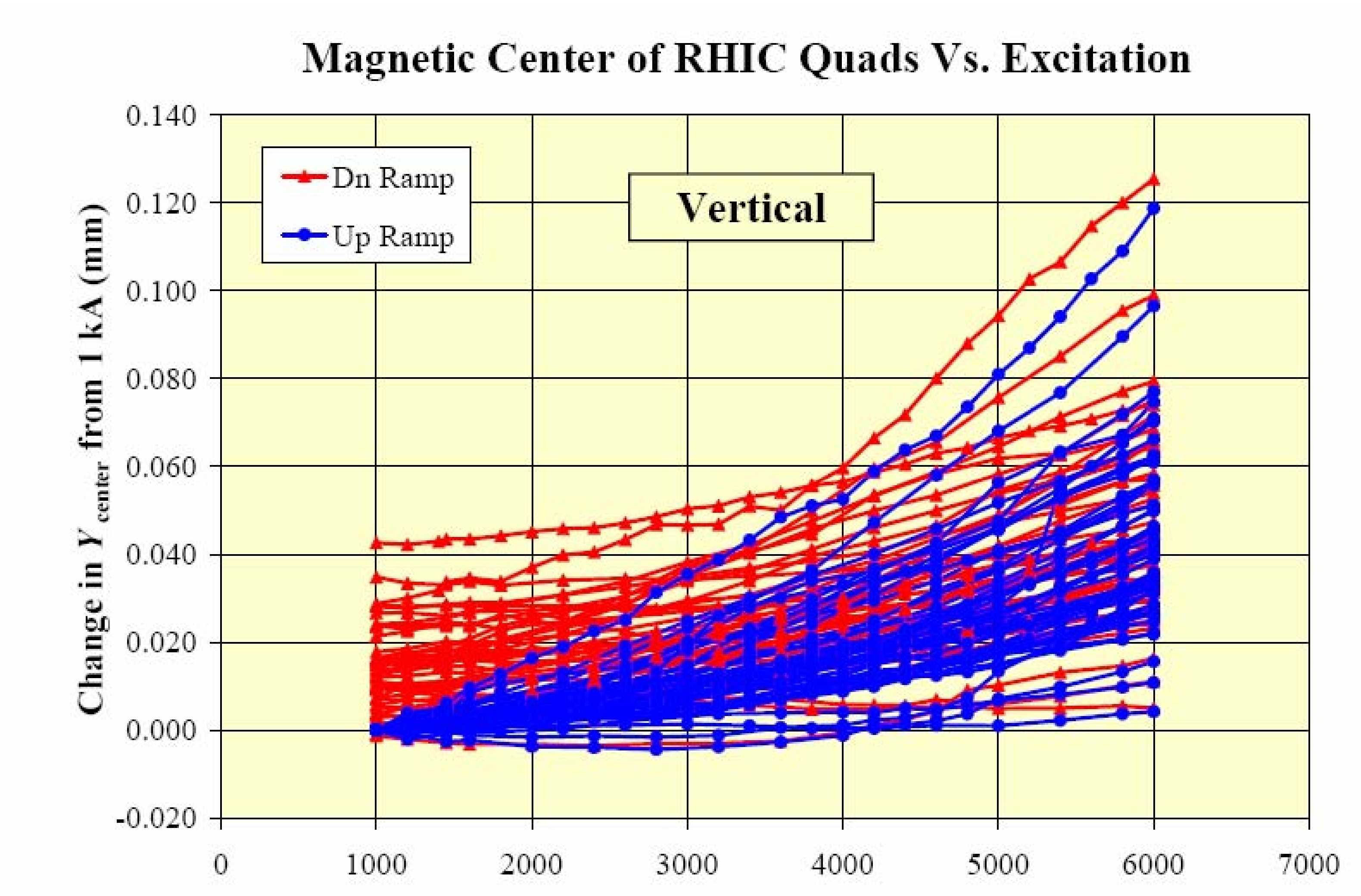
TDR Quad Specs

- **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

Linac SC Quad/BPM Evaluation Program

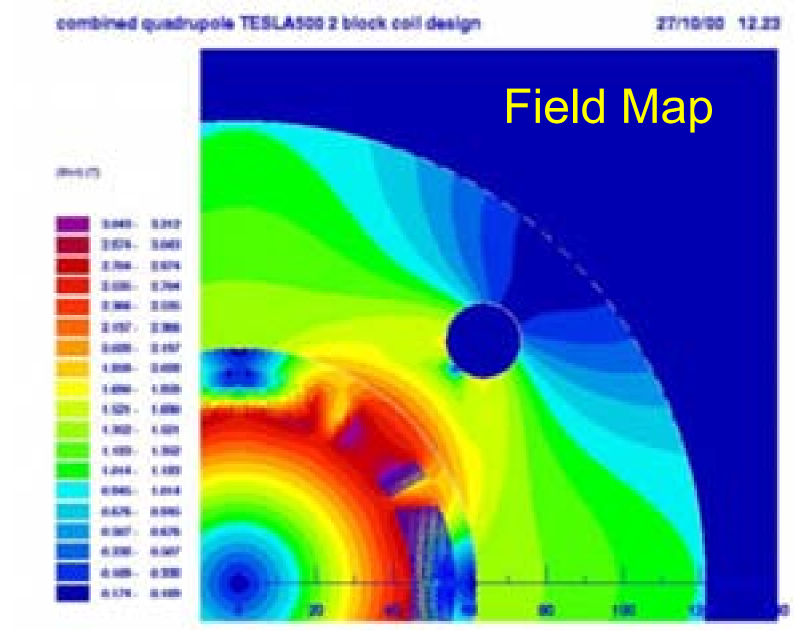
- Goal: Demonstrate Quad/BPM performance required for ILC beam-based alignment:
  - Verify < ~ 5 micron movement of Quad magnetic center with field change.
  - Show ~ 1 micron BPM resolution and < ~ 5 micron Quad-to-BPM stability with a compact, 35 mm aperture rf cavity BPM.
- For this program, we plan to
  - Acquire the ILC prototype Quad built by CIEMAT in Spain and build a warm-bore cryostat for it at SLAC.
  - Do quad center stability tests with a rotating coil at the SLAC Magnetic Measurements Lab.
  - Develop linac rf cavity BPMs and test with beam at ESA.
  - Integrate Quad and BPMs for a beam-based quad shunting test.
- Status
  - Quad nearly finished and cryostat and coil engineering underway – expect first magnet test in 2/06.
  - BPM design complete – test with beam in 2006.

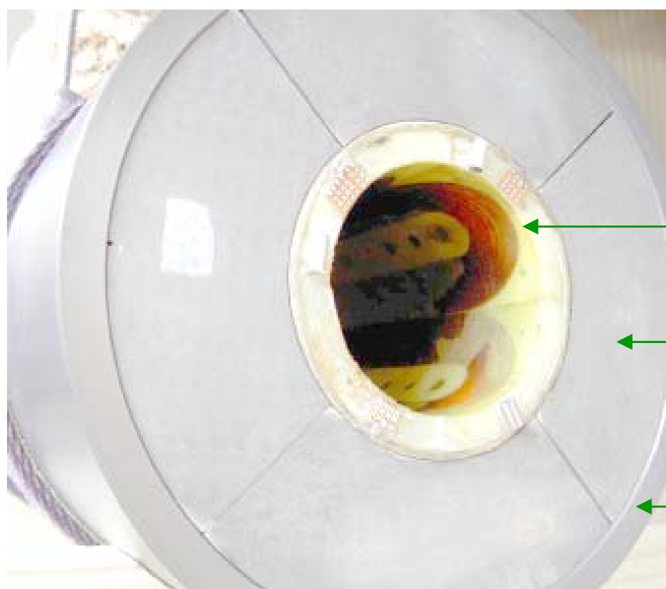
Magnetic Center Movement in RHIC SC Quads



Mike Harrison

CIEMAT
Cos(2Φ) SC Quad
(~ 0.7 m long)



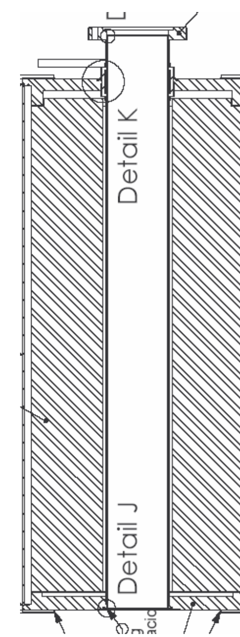


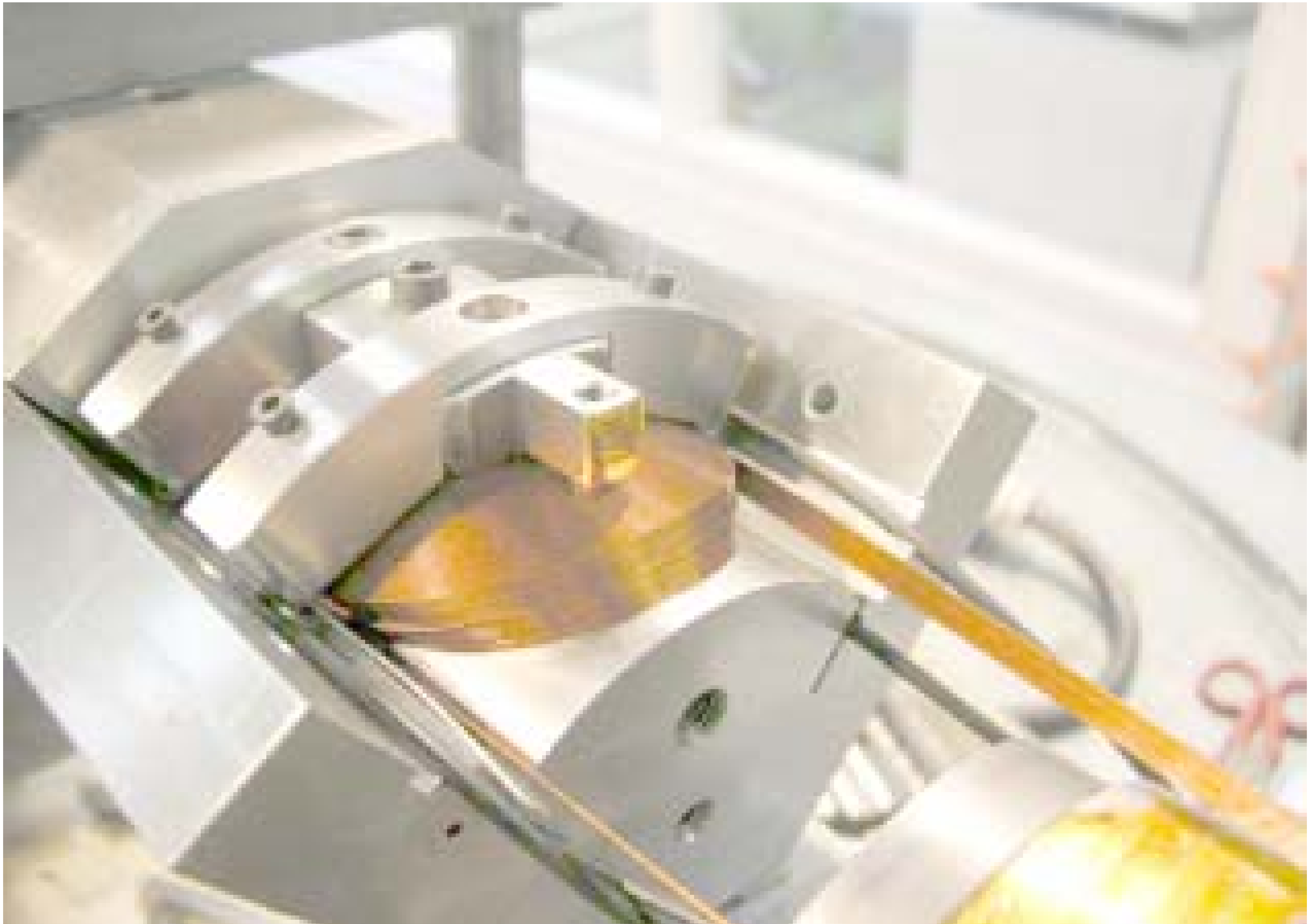
He Vessel

SC Coils

Iron Yoke Block

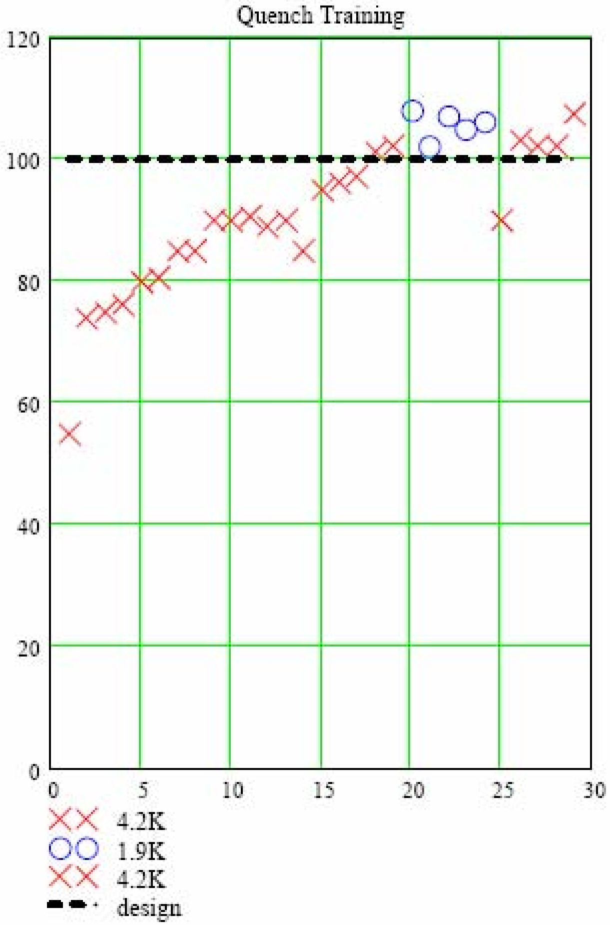
Al Cylinder





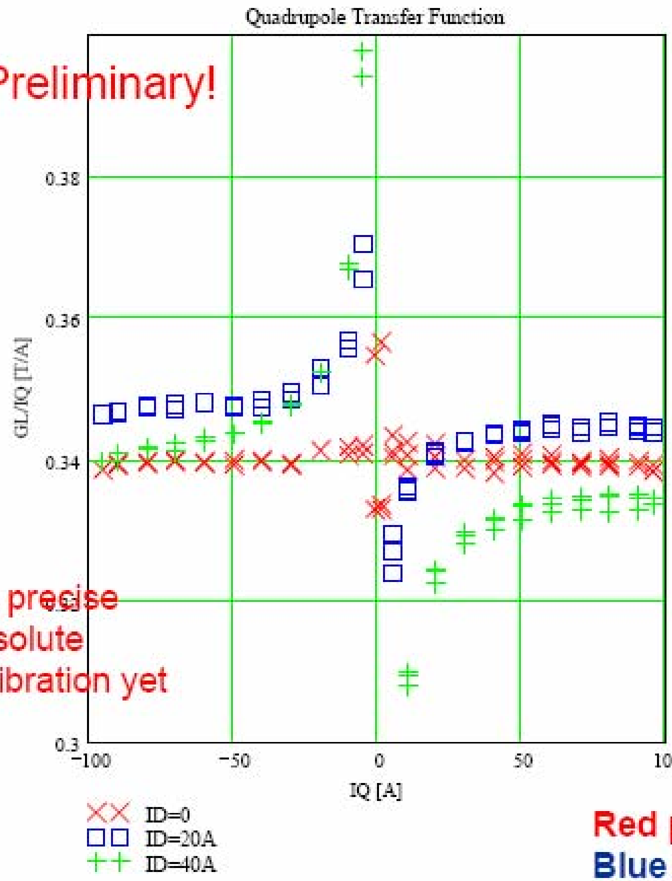
Quadrupole Quench Tests

- Magnet at 4.2K, red cross and 1.9K, blue circle
- The quadrupole reached 100A after about 17 training steps (should reach much more, Critical current at 4.2 is about 156A)
- CIEMAT nearly sure this behavior is due to low pre-stress
- Similar experience at CERN LHC
- Magnet now back at CIEMA
  - and modifications to increase the pre-stress is presently being done
- Re-measurement soon at DESY

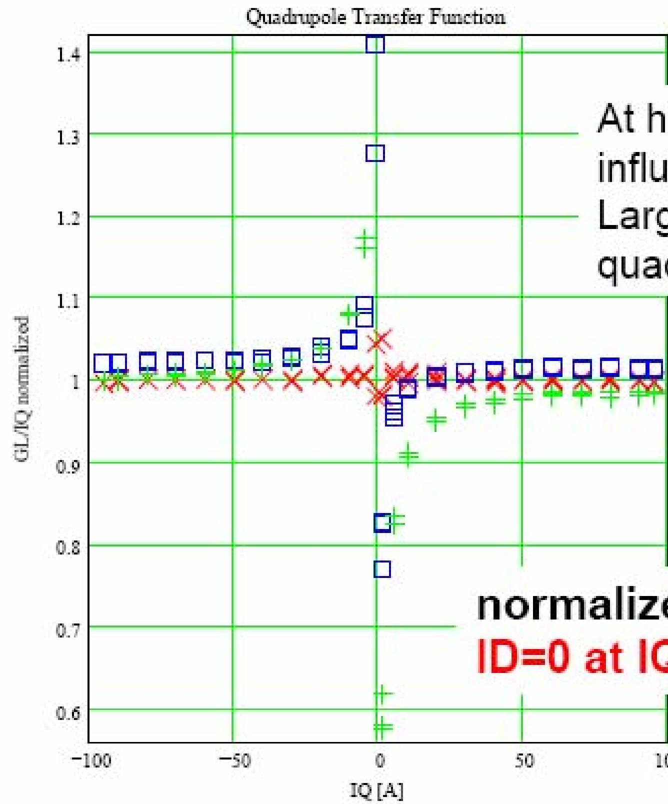


Quadrupole Transfer Function on up- and down-ramp of IQ for ID=0,20,40A

Preliminary!



No precise absolute calibration yet



At high quad current influence small

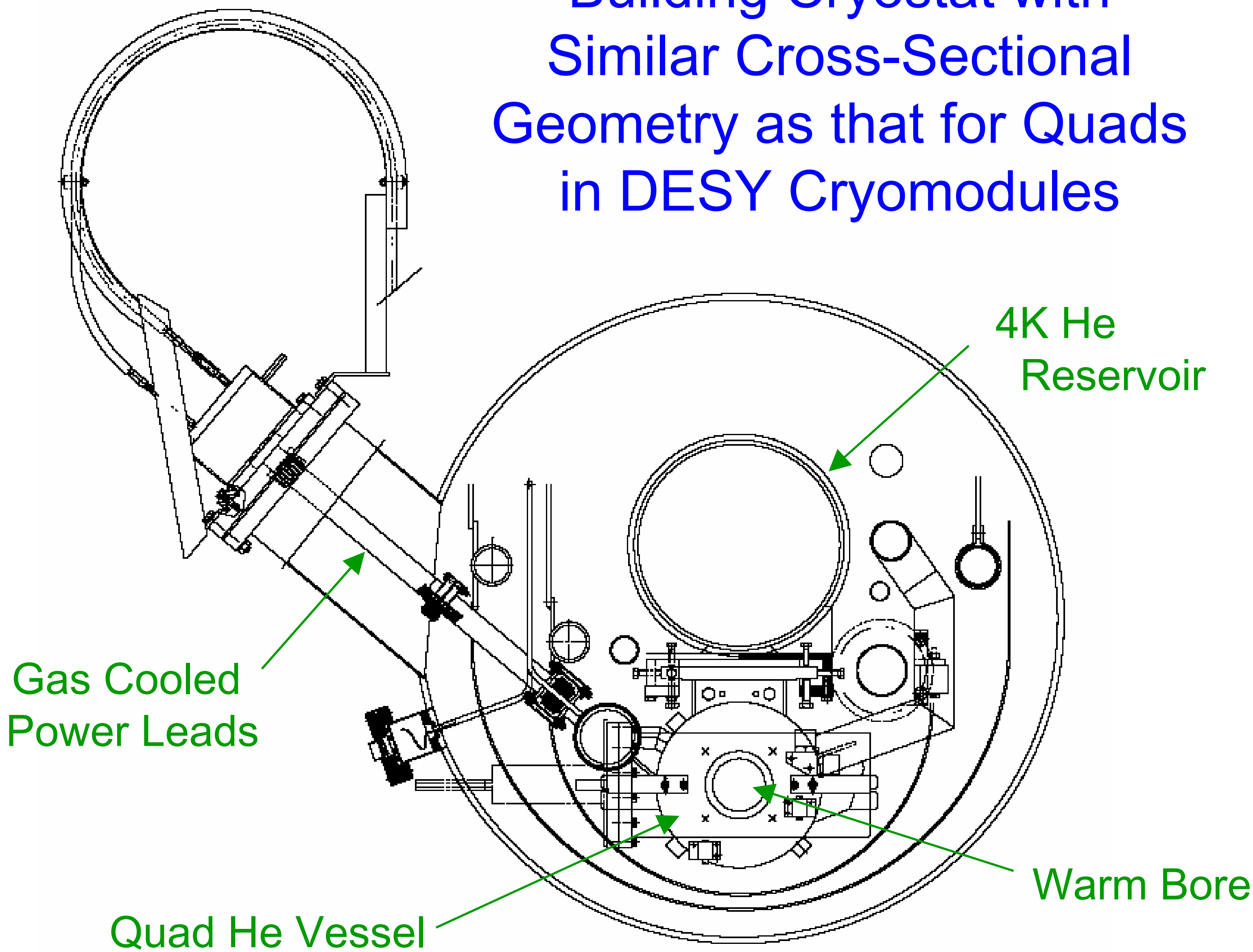
Large effects at low quad currents

normalized at
ID=0 at IQ>60A

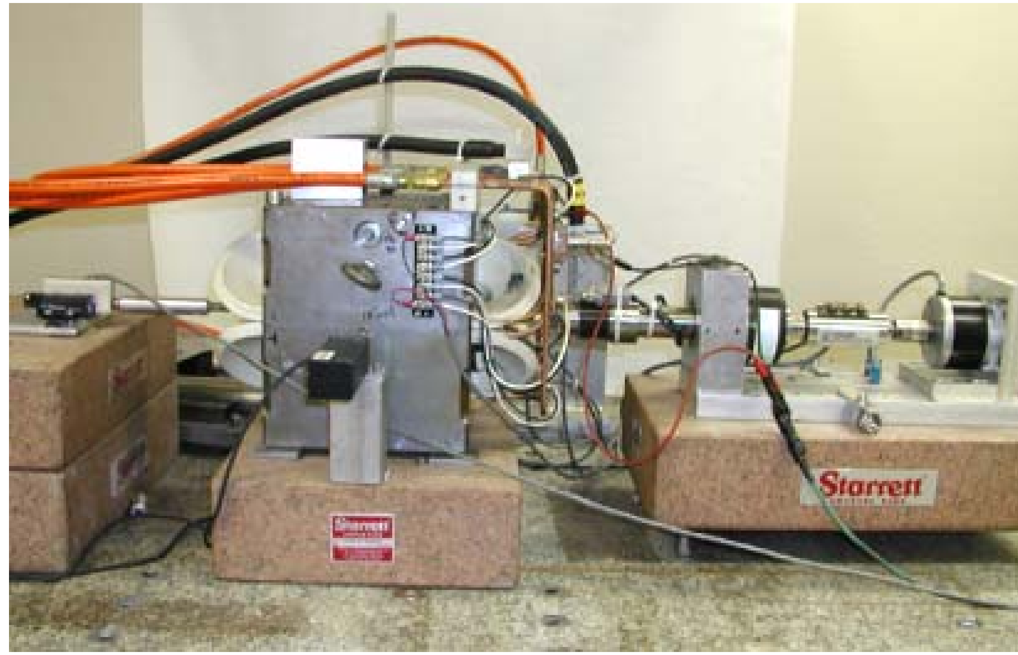
Red points: ID=0A
Blue Points: ID=20A
Green Points: ID=40A

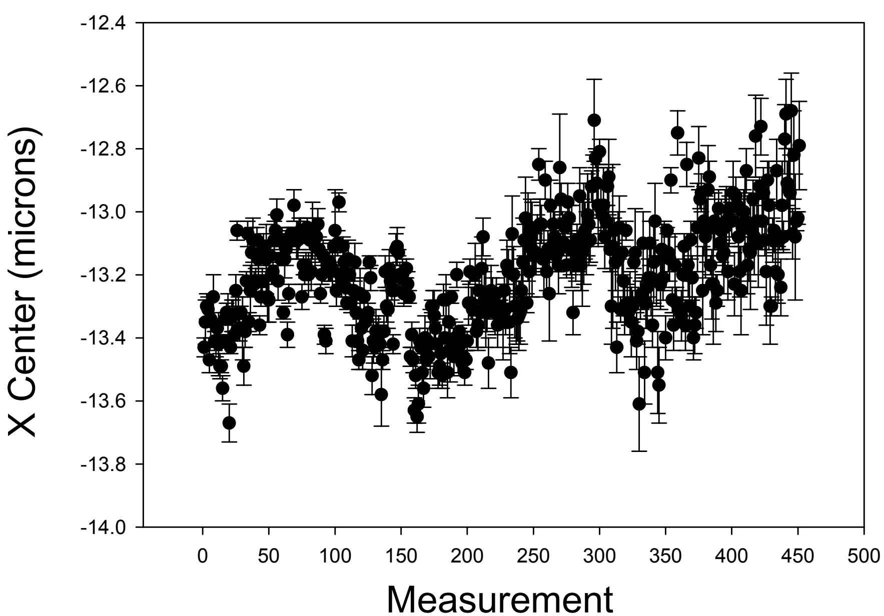
Ciemat CEDEX DESY

Building Cryostat with Similar Cross-Sectional Geometry as that for Quads in DESY Cryomodules



For Magnetic Center Measurements, Adapt Apparatus Developed for NLC NC Quads

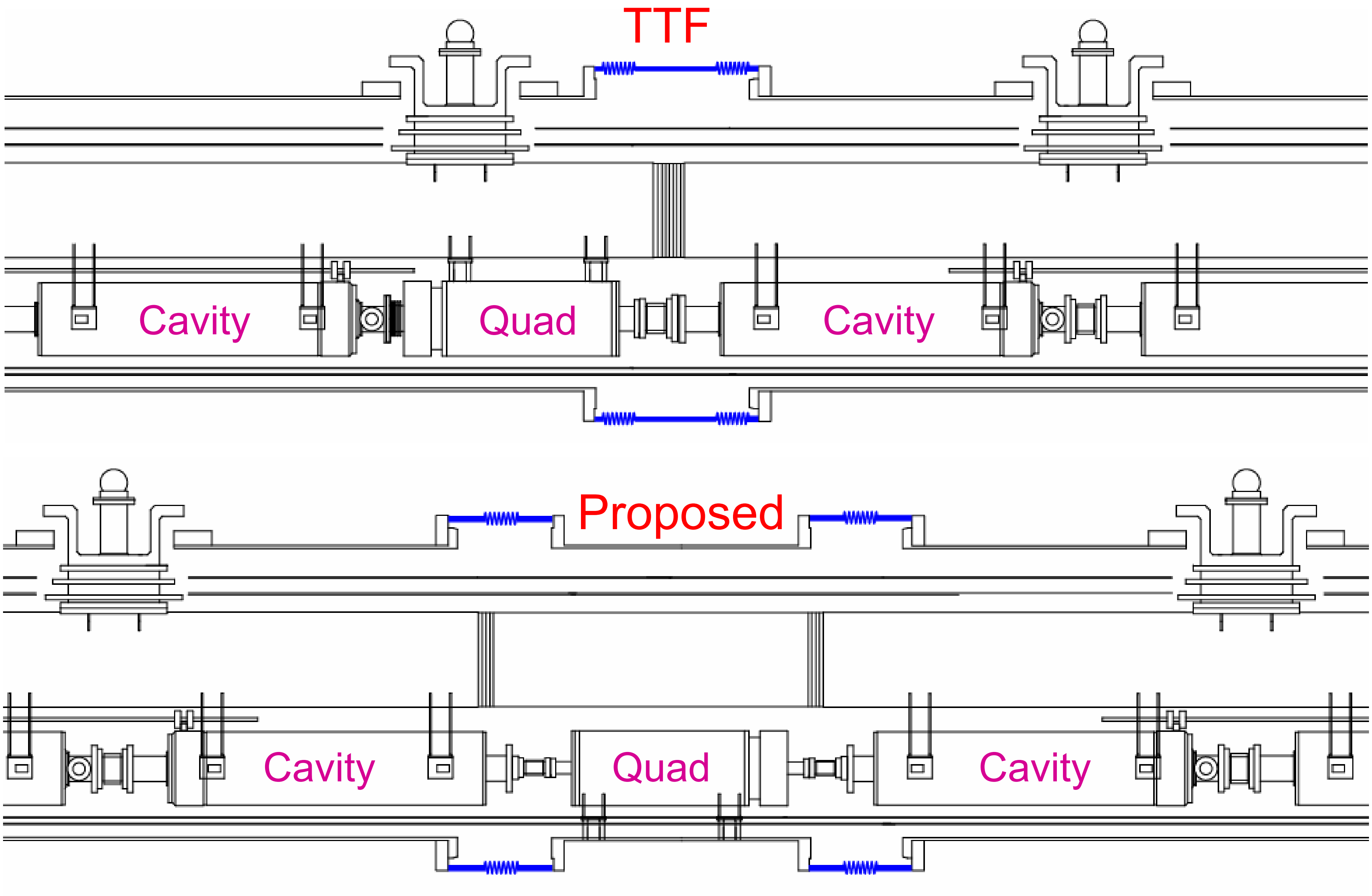




Series of measurements (8 minutes each) of a 25 cm long NLC prototype quad - shows that sub-micron resolution is possible and systematics are controllable.

Currently designing longer, wider coil for SC Quad test – will qualify it first with a NC Quad.

Quad/BPM Layout



Proposed Layout

- Put the quad, bpm and other instrumentation in a separate cryo-section that is optimized for stability.
- Reduce the pipe radius in this section to ~ 35 mm – this increases the short-range wakefield by ~10% on average, but allows
  - Higher resolution bpms
  - Use of superferric quads, which are less expensive and likely more stable
- Instead of using correctors magnet, which may change the quad strength, support the cryo-sections on movers.
  - Would need to put the cryomodules on movers anyway if want to center the beams in the cavities (the beam will follow an essentially straight line after beam-based quad alignment).

TTF Superferric Quad

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

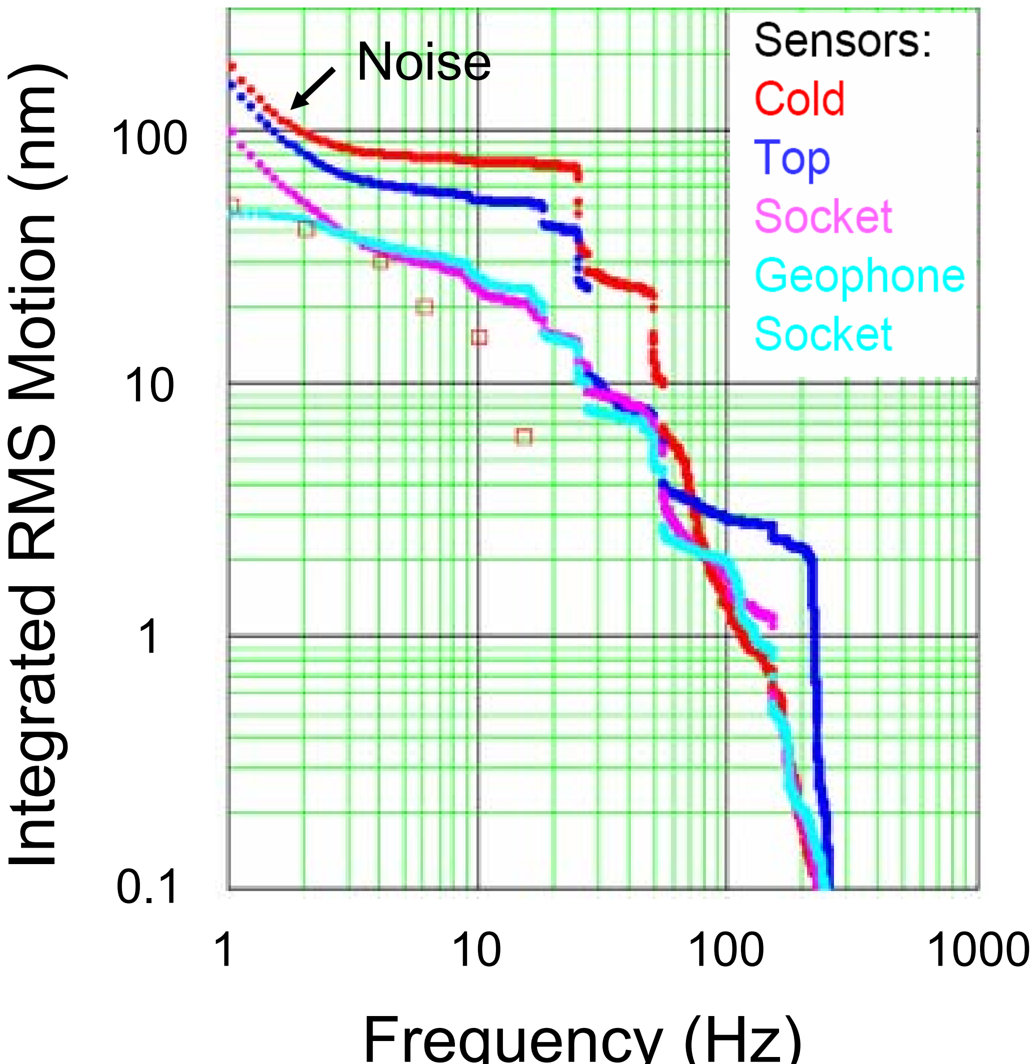
Design criteria of XFEL Magnets

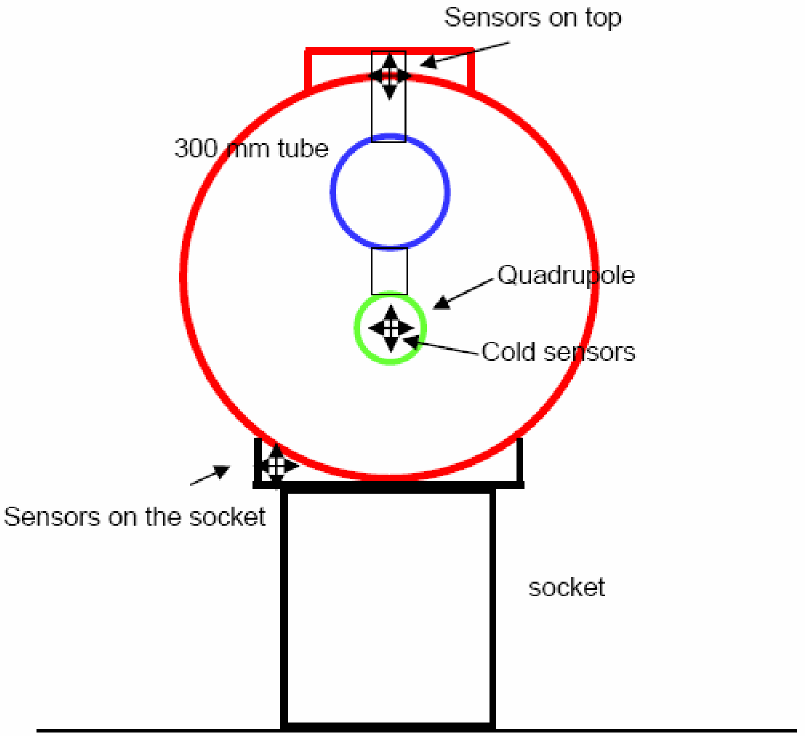
Requirements

	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	$\lvert b_6 \rvert < 10$ units	-	-
Gradient/Field	35 T/m	0.04 T	0.04 T
Length	200 mm	250 mm	250 mm
Operation	DC	DC	DC

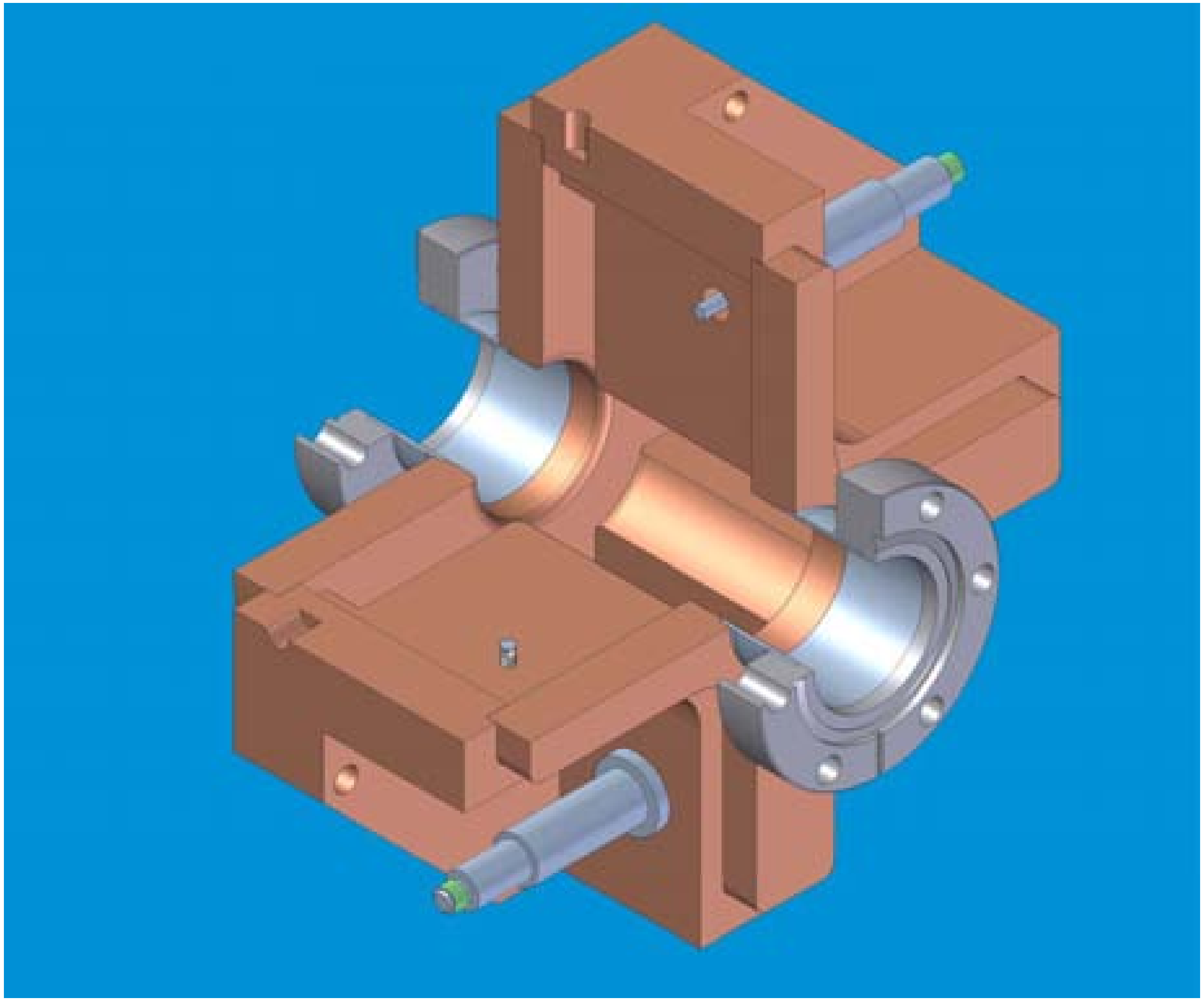
Vertical Quad Vibration at TTF

(ILC Goal: < 100 nm for f > 0.5 Hz ?)





S-Band BPM Design
(36 mm ID, 126 mm OD)



BPM Signal Size

- With:

  $Z = 50$ cable impedance (Ohm)

  $\omega = 2*pi*2.856e9$ signal freq (1/sec)

  $Q = 500$ loaded Q (unitless)

  $k = 0.62e-3$ loss factor in V/C/nm^2 from Z. Li

  $q = 1e10*1.6e-19$ bunch charge (Coulomb)

  The peak signal voltage with Q << Qo is

  $$V = \mathrm{sqrt}\,(\, q^2 * Z * \omega * k \,/\, Q \,)$$

  $= 1.7$ mV per μm of beam offset

- Note that the Q of 500 ($\omega/2Q$ = 56 ns) will allow clean (exp(-337/56) = ¼ %) bunch-to-bunch signal separation.

Layout of S-band BPMs for Testing in ESA at SLAC