Magnetic Field Stability Measurements

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23Oct07

Measurement Needs

- ILC quad center stability
  - In addition to alignment of quad to external fiducials
  - Center should remain stable – need to measure this to a micron or better (?!)

- Stray fields
  - Measure at the level of μT as function of frequency

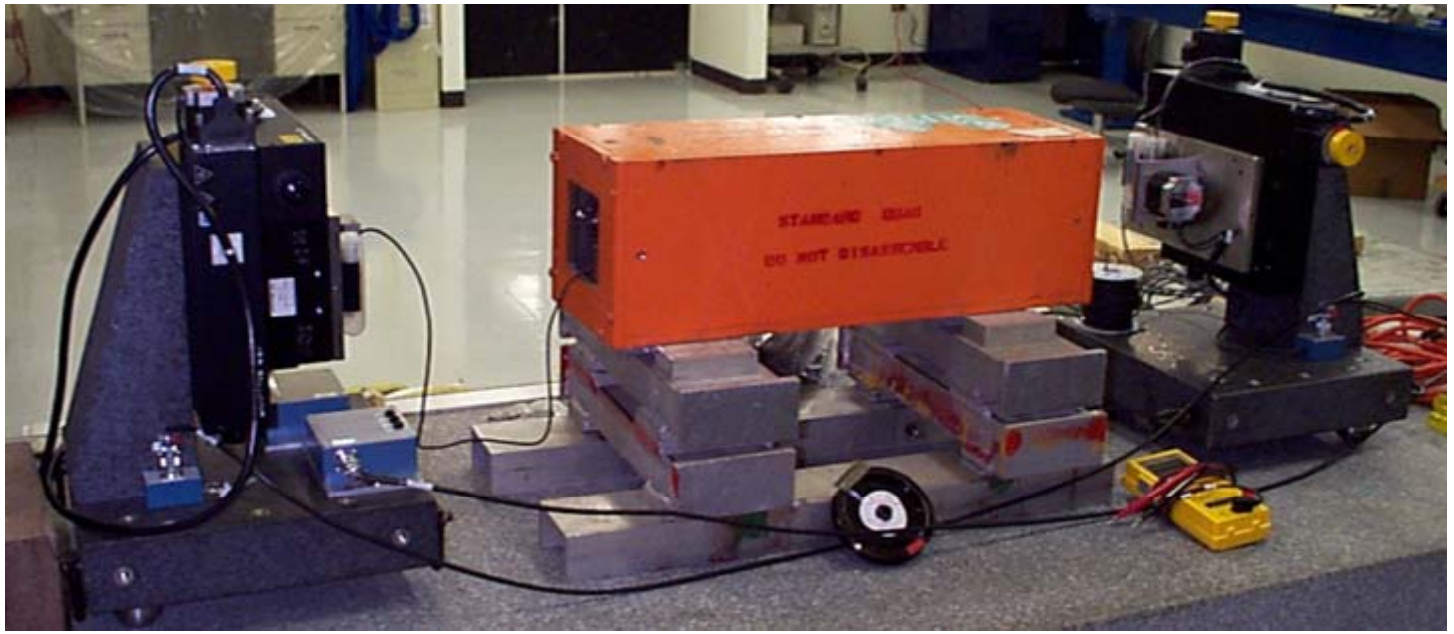
Standard Techniques

(Things we've tried...)

- Single Stretched Wire (SSW)
  - Measure change in flux during precision motion of single wire
- Multi-turn fixed coil
  - Measure flux changes during change in fields during ramping or because of vibration, etc.

ICL Quad center stability

Horizontal Measurements with SSW

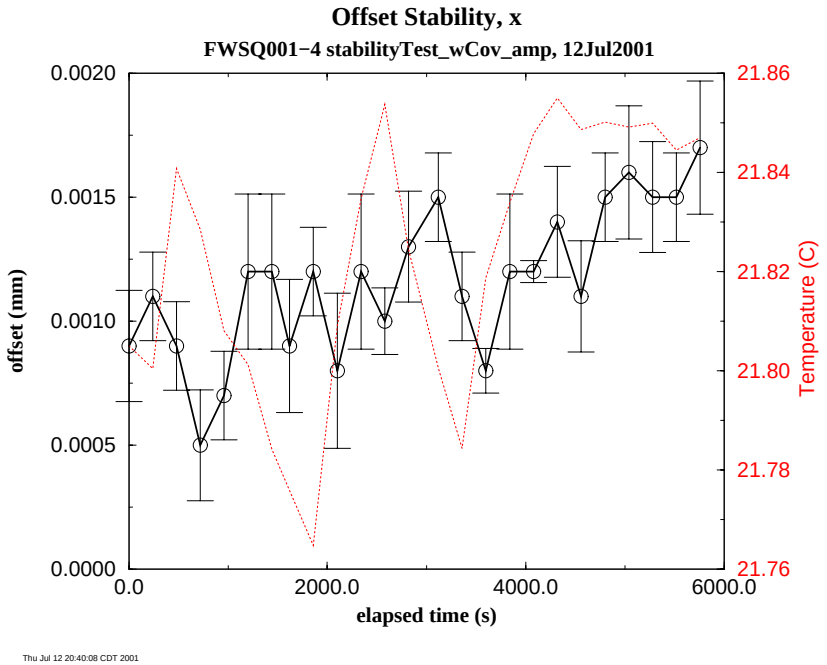


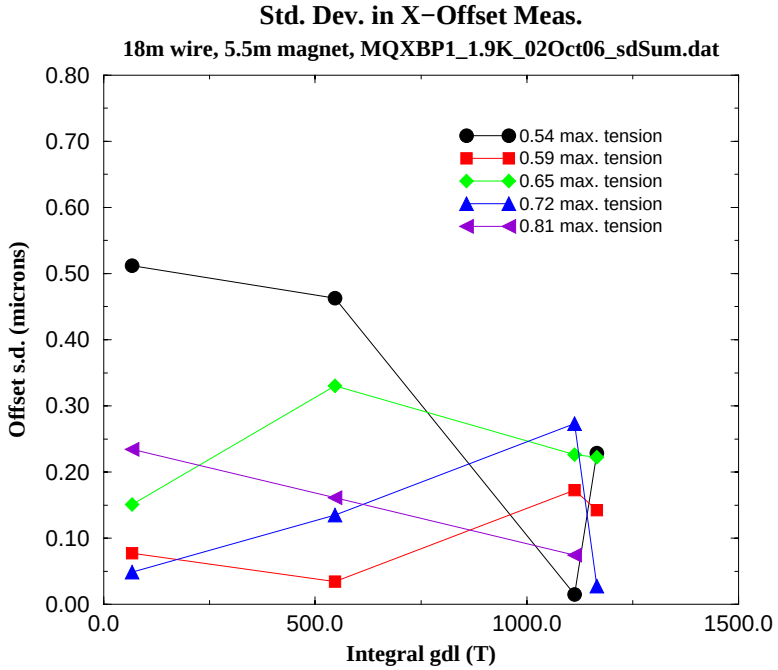
Stages have 1 micron accuracy encoders, 0.1 micron resolution, 0.5 micron repeatability. Laser tracker fiducials on stages are calibrated to position of wire ends and can easily transfer alignment axis to magnet.

Center Stability Measurements with SSW

Center stability measurement on
NLC quad 0.4m prototype(1m wire length).
Aperture 12.5mm, gdl ~30Tm/m ,
wire step +/- 5mm

SSW resolving changes at the 0.5μm level.





X-center measurements on LHC 5.5m quad (18m wire), ~67Tm/m (lowest gdl), wire step +/- 10mm

s.d. ~0.25 microns
independent of tension
or signal strength –
likely positioning or
vibration limitation

SSW Center Stability Measurements for ILC Quad

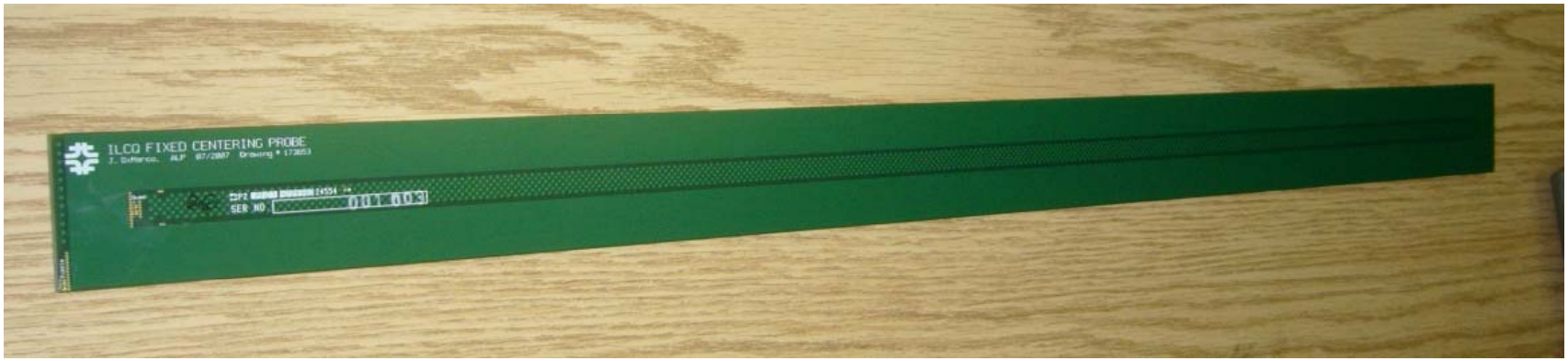
To improve SSW resolution

- Electrical improvements
  - Upgrade integrator
  - Use of low-noise amplifiers
  - Electronics temperature stabilization - better control of non-linear drifts.
- Precision of stage motion
  - Better stages can be purchased to improve repeatability by a factor ~5.
  - Effects of vibrations and thermal effects could be gauged and addressed
- Environmental enclosures/isolation

Explore other SSW methods

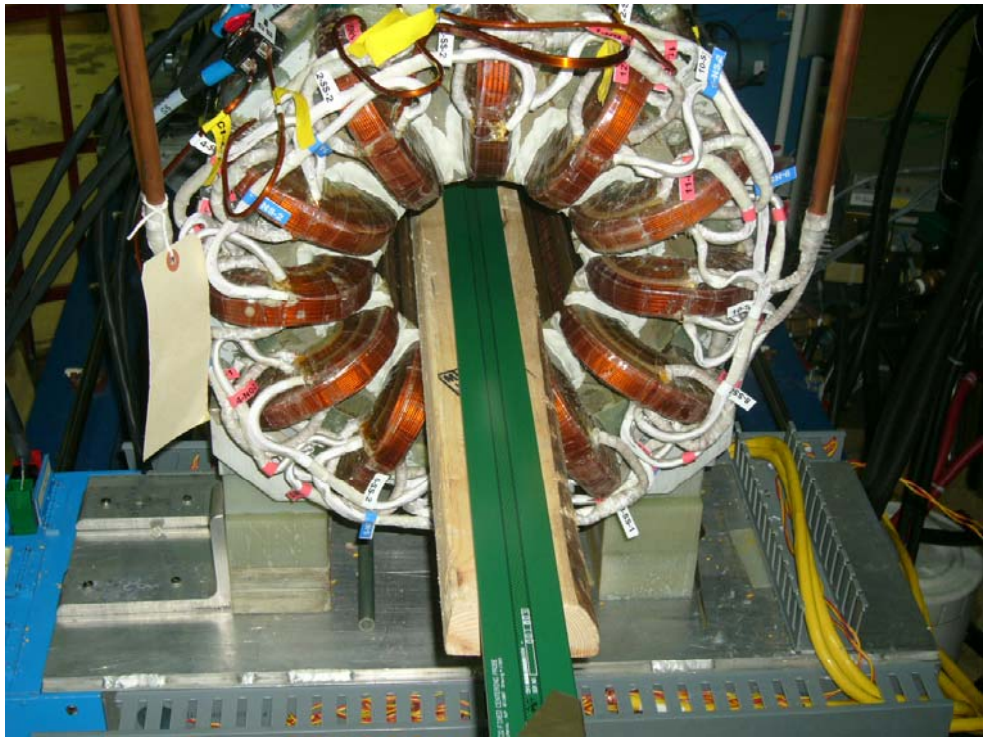
- e.g. try using 'vibrating wire' for monitoring center
  - Set wire to quadrupole center using SSW
  - Apply AC current on wire at resonant frequency
  - Monitor zero position optically

Center stability with fixed coil probe



- 28 Layer circuit board design
  1152 turns of 'dipole sensitive' winding
  48 turns of 'quad sensitive' winding
- Measure quad and dipole change during ramp to determine and monitor center offset of probe wrt magnet.
- Used vertically or horizontally

- Could attach vibration measurement instrumentation
- Mount probe on supports which isolate it from vibrations
- Other environmental control (?) (temperatures, ...)



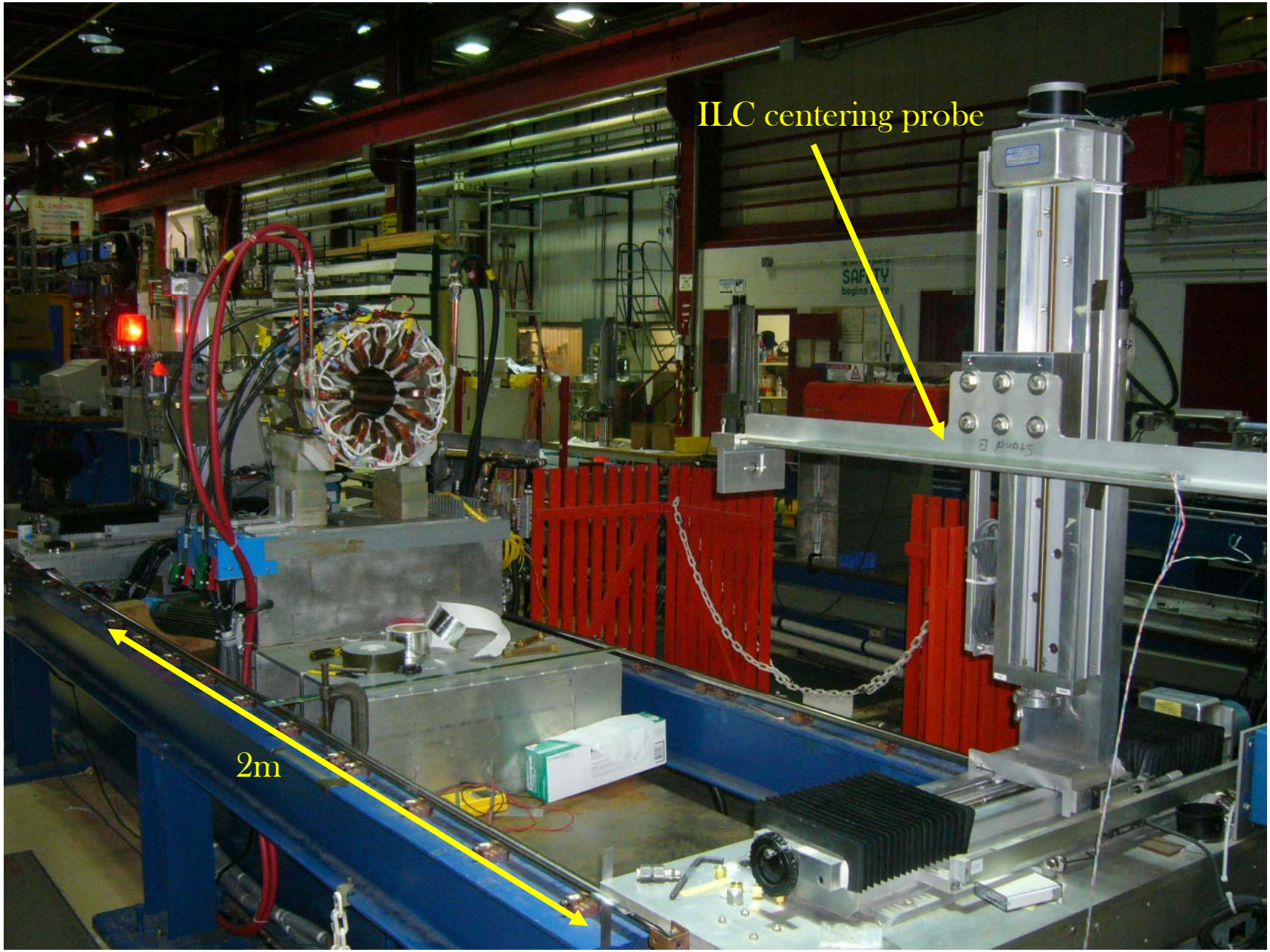
Tested probe using quadrupole correction element of BMA magnet:
Integrated field 0.1Tm/m at 50A.

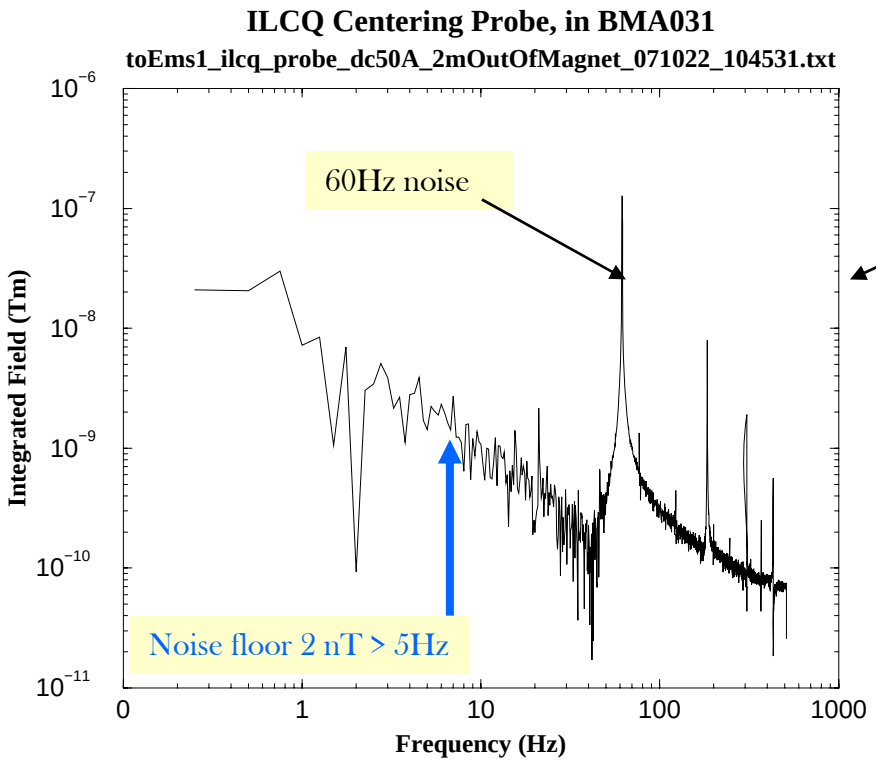
Based on tests, expect better than 0.1μm resolution with ILC quad

Stray field measurements

- Have also used the multi-turn fixed coil for these measurements
- Tested the centering probe sensitivity to stray fields by placing it 2m outside the 0.1Tm/m field of the corrector magnet.
- Measured fields seen on probe with 50A DC on magnet, 15Hz AC cycle on magnet

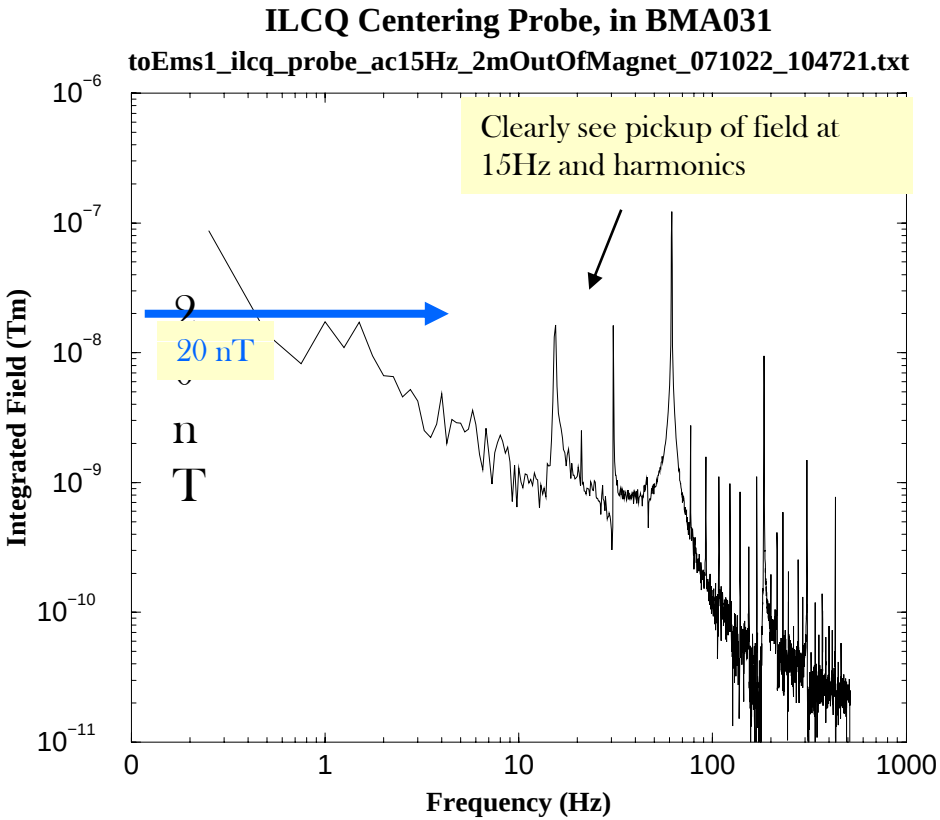
Stray Field Test with ILCQ Centering Probe





50A DC on magnet

Stray field test with probe 2m outside magnet



AC booster waveform on magnet

Stray field measurements

- Improvement in technique similar to that for center stability (vibration isolation and monitoring, environmental control, etc., ...)

Summary

Field stability internal and external to magnet systems are stringent and require careful measurement.

Seem to be attainable with some improvements in standard equipment and techniques.