ALIGNMENT & FIDUCIALISATION

2nd October 2001

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Five Talks :

- Marco Buzio (Dipole Alignment measurements @ CERN) – CERN
- Guy Deferne ('Badger' for axis measurement of quadrupoles) – CERN
- Fabien Patru (Corrector magnets in industry) – CERN
- Juan J.Garcia Perez (Axis measurements in industry) – CERN
- Zack Wolf (SPEAR III gradient dipoles) – SLAC

DIPOLE ALIGNMENT

- Field angle precision required ≈ 0.5 mrad. (1 σ errors achieved ≈ 2x to 5x better). Need to watch systematics. Randoms are not a problem.
- Field angle sensitive to vertical displacement of the center, but only a very small effect.
- Most magnets only measured warm for alignment ⇒ warm-cold correlation needed.
- QCD to determine dipole axis (proposed at SSC, studied extensively at BNL, used for RHIC dipoles) ⇒ Need to study higher harmonics.
- Dipole axis in the two apertures track.
- Open questions :
  Warm-cold correlation in QCD
  Cross-talk effect betw. apertures (Yet another reason to use higher harmonics!)

BADGER

- Four 100mm/150 turns tangential coils
- Laser tracker target at center of coil
- Gravity sensor for field angle relative to gravity. (0.5° range too narrow. Another sensor with larger range present ?)
- 'Badger' turned around to cancel systematic error in the field angle. (The same technique was used at BNL for critical insertion region dipoles).
- Laser target wobble < 25μm ⇒ IMPRESSIVE !
- Cannot rely on vendor's calibration for gravity sensors.
- Good agreement with single stretched wire data (0.020 mrad for field angle, < 80μm for axis).

CORRECTOR MAGNETS IN INDUSTRY

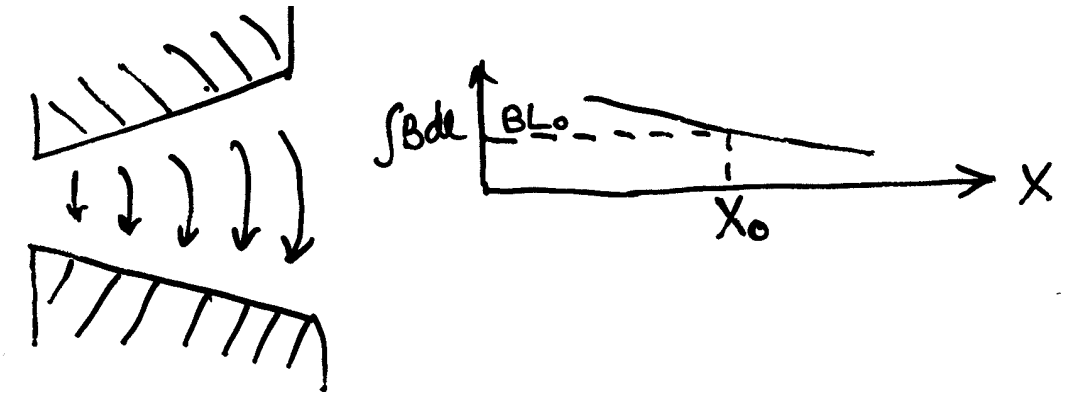
- More than 3500 correctors of various types.
- Vertical measuring bench
- Magnets mounted precisely using pins or keys.
- Transfer function, harmonics, axis, angle
- Bench calibrated by rotating the magnet 180°, as well as magnet turned end to end.
- (Should be done periodically to maintain calibration).
- 15 more benches to do so.

AXIS MEASUREMENT DEVICE IN INDUSTRY

- Two versions : Mechanical & Optical (IMMW11)
- Non-rotating ; set of 4 coils (tangential)
- Four LEDs + retroreflector to locate coil center WRT beam tube.
- Diffuse reflection of LEDs in beam tube (used to locate the beam tube ?)
- 25Hz excitation of the magnet
- Negligible frequency dependence for 10Hz<f<50Hz
- Extensive calibration routine carried out. (Most parts should not need recalibration)
- Designed to measure magnet axis W.R.T. beam tube, rather than fiducials ⇒ Specific LHC requirement.
- Any vendors trained yet ?

FIDUCIALISATION OF THE SPEAR III GRADIENT DIPOLE MAGNETS

- 'Reference' pole surfaces on either end of the magnet to set height, roll, pitch, yaw.
- 'Unconventional' definition of 'axis' due to tapered poles :



- Well characterized errors in the fixtures
- Axis determined by moving a stretched wire
- Helpful feedback to operators for aligning magnet to reference poles
- Non rotating coil package for measuring field quality :
  - Single wire for n=1 (dipole term)
  - Single loop for n=2 (quadrupole term)
  - Two loops separated in x for n = 3,4,…

  (More complex than using rotating coils. An example of clever adaptation of existing equipment to fulfill measurement needs.).