IMMW12 Grenoble Oct 2001

Final Version of Magnetic axis measurement device in Industry

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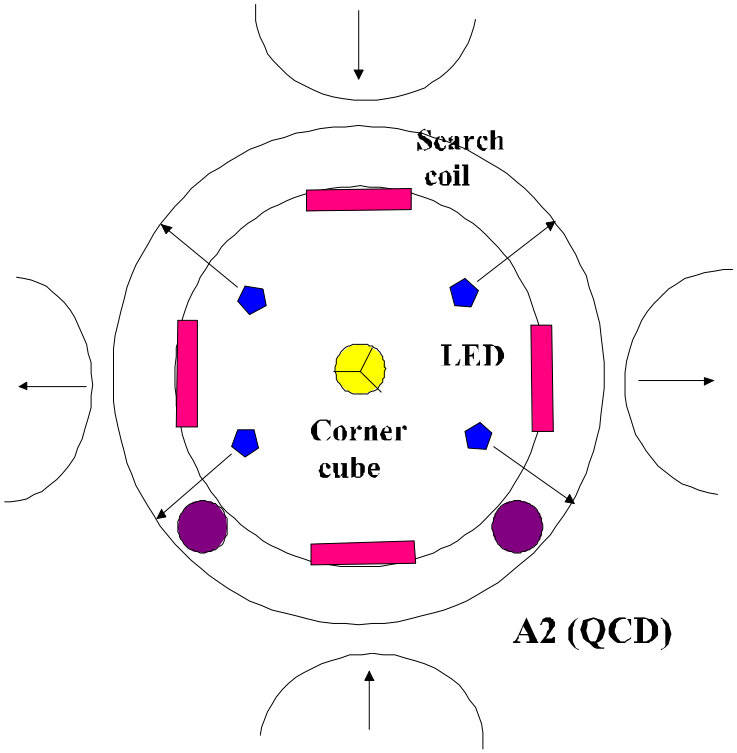
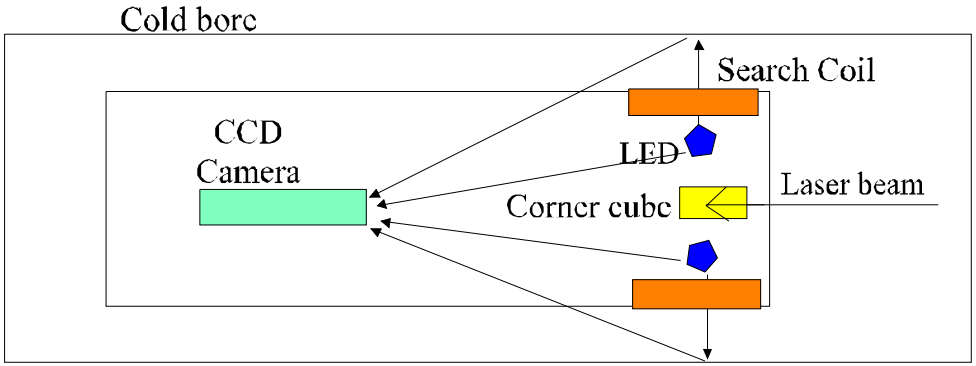
Overview

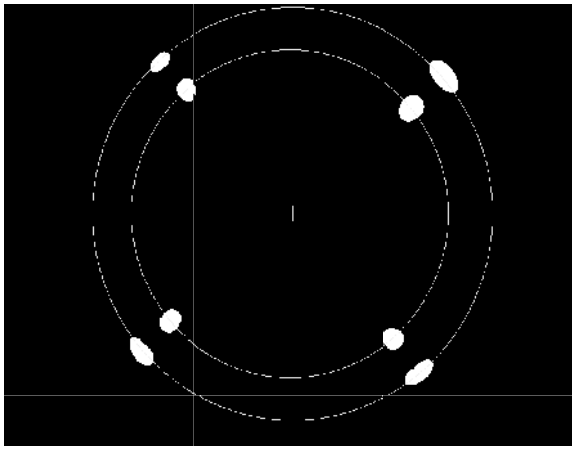
- Measurement Principle
- Instruments + LTD
- Mole positioning system & measurement
- Mechanical and Magnetic axis measurement
- Calibration system & method
- Optical mole Performance
- Axis measurements performance
- Results from prototypes and preseries
- Conclusions

Measurement principle

- Measure the offset between cold bore tube axis (geometry for assembling) and magnet axis (QCD for dipole)
  - LTD retroreflector for X,Y, Z in space (Leica measurement) => **cold bore axis**
  - 4 * 100 mm fixed tangential coils => local magnetic offset w.r.t. old bore axis
  - 0.5 Amps AC current at 25 Hz for synchronous detection of induced current
  - Cold bore position w.r.t. mole: mechanical autocentring or LED's measure (cold bore diameter and its centre)



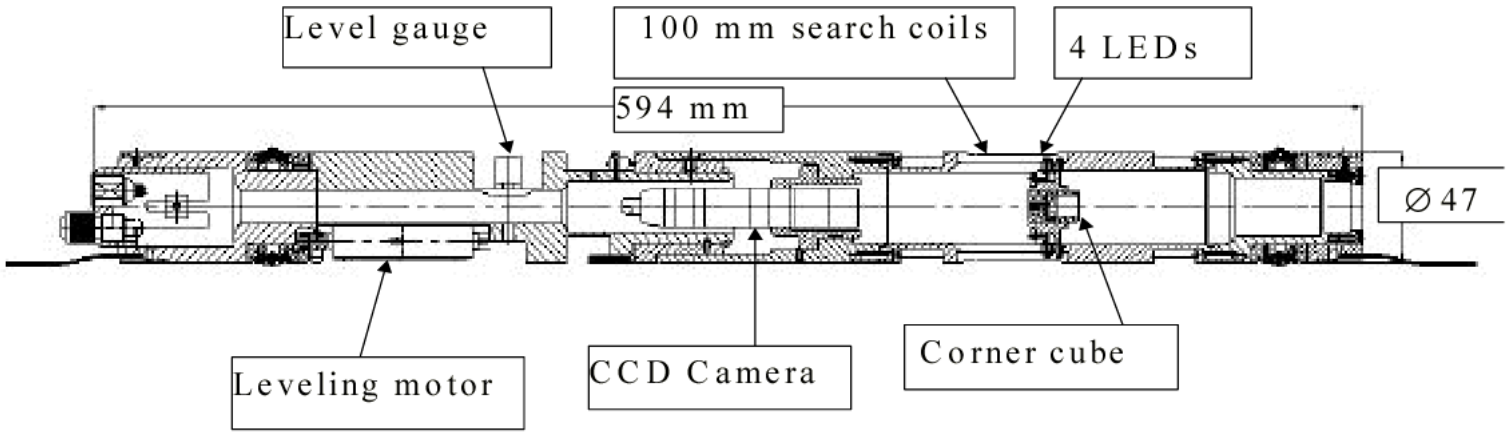




Instruments

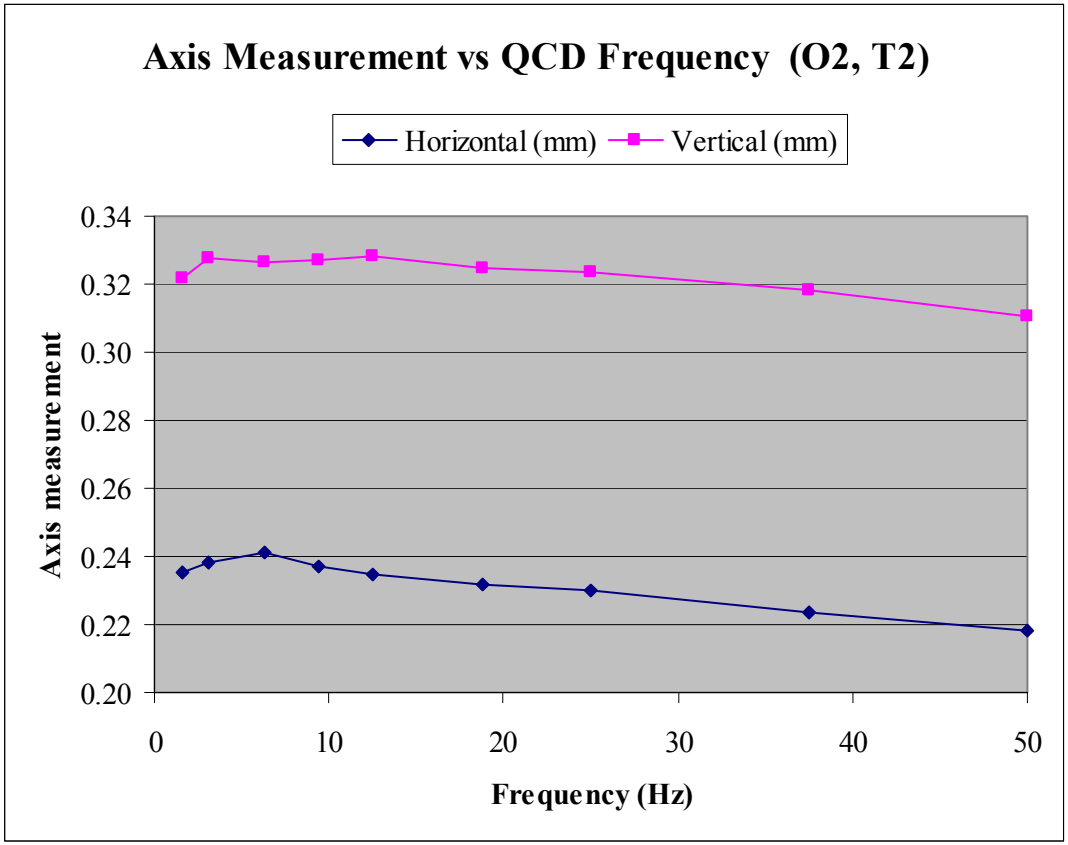
- 2 mole versions (global mechanic & global optic)
  - global mechanic, auto centring and ballast for level
  - global optic, LED's and motorised levelling
- LTD 500 Leica for 3D mole position measurement
- Synchronous detection electronics and positioning (angular and longitudinal) motors
- Software: AXYZ™ and Labview™

Optic Mole

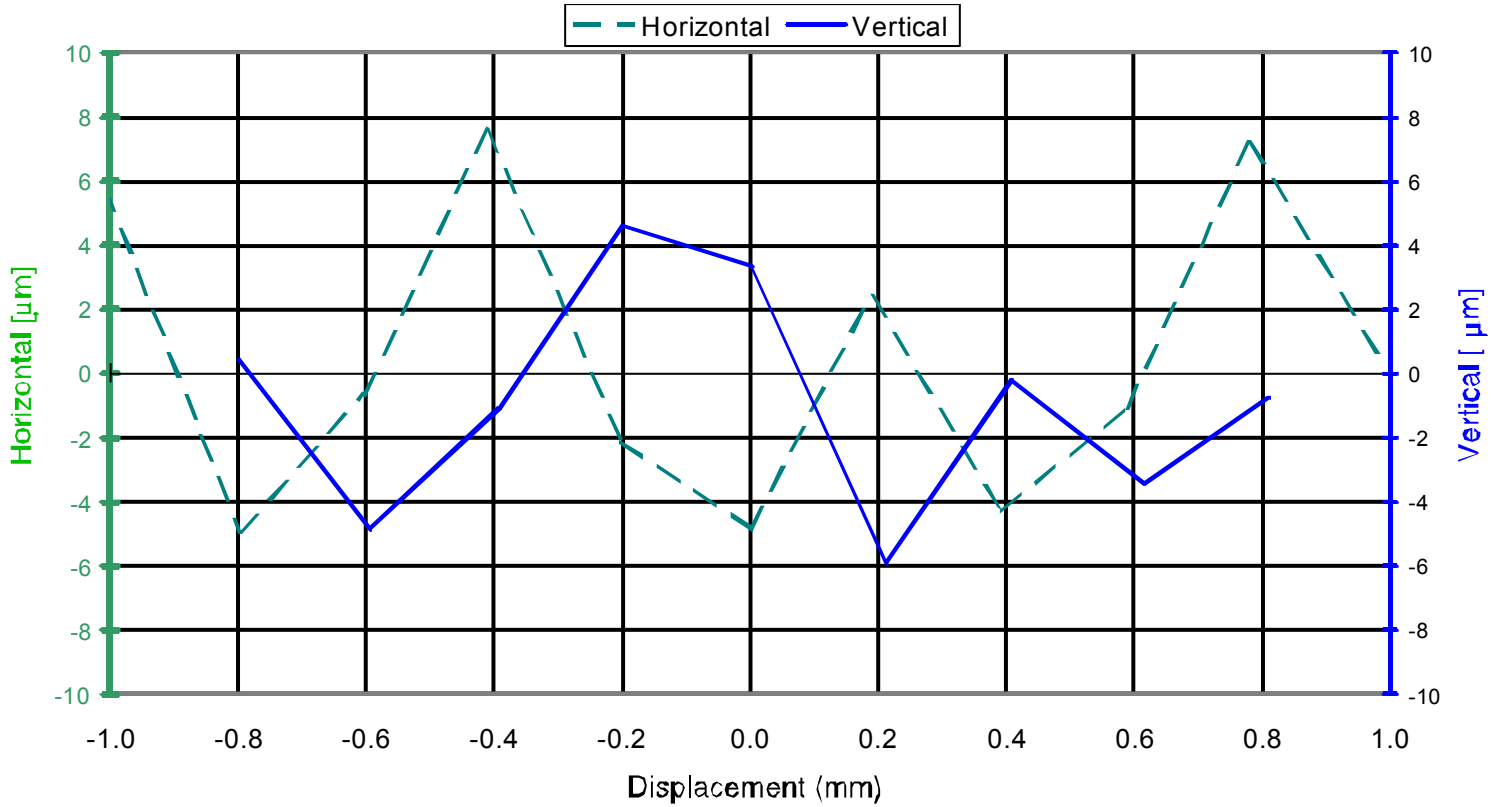

Level gauge
100 mm search coils
4 LEDs
594 mm
Ø 47
Leveling motor
CCD Camera
Corner cube

Sensitivity & Frequency check

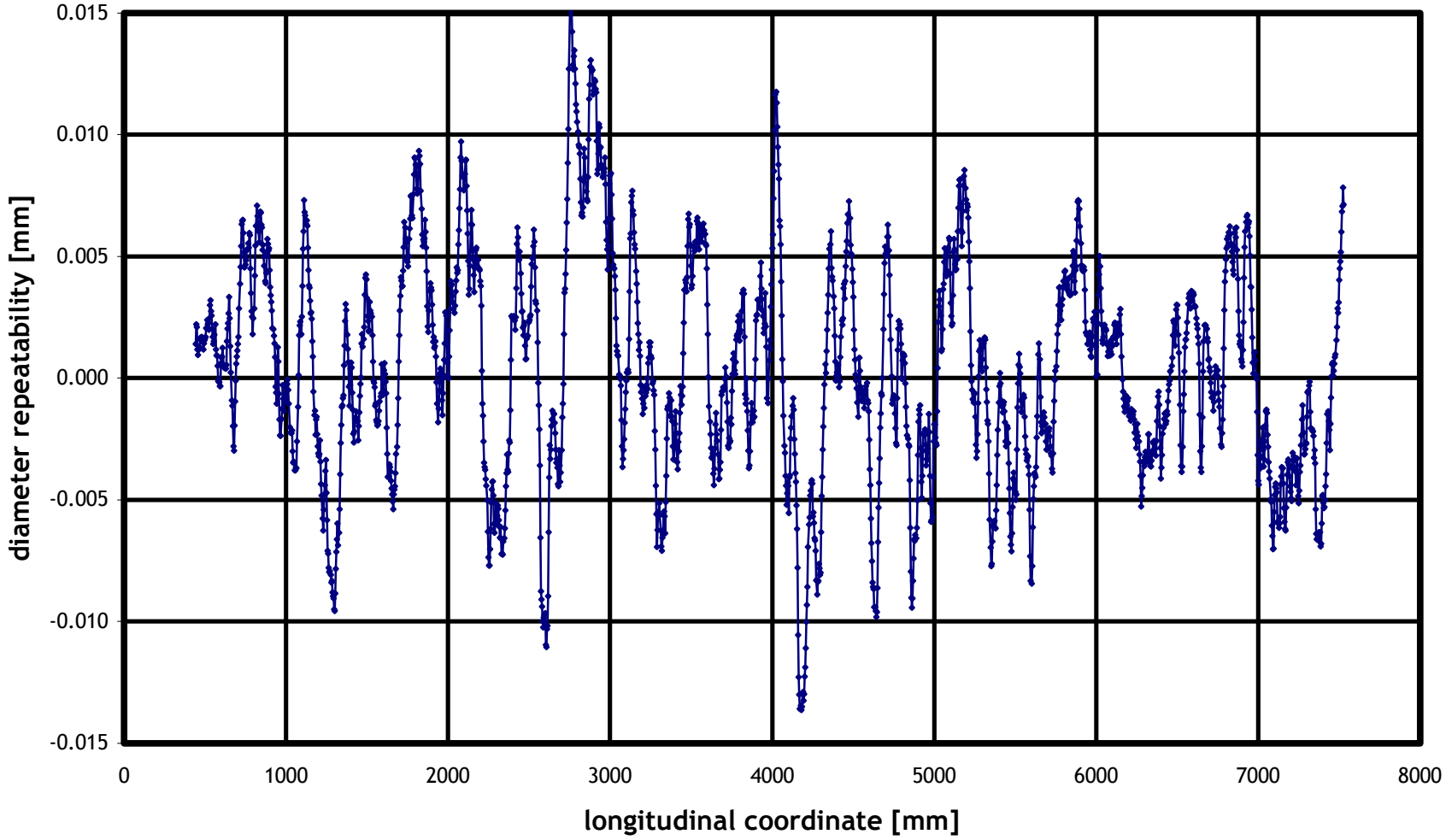
Coil Voltage (mV)	Input Current (mA)	Field at r=17 mm (T)	Sensitivity (µm)
37	100	3.10-4	<1
3.7	10	3.10-5	2
0.37	1	3.10-6	10



Sextupole calibration residuals



Repeatability of diameter measurement



Calibration method

We aim to have the three key centres, namely:

–Reflector centre

–Centre of gravity of search coils

–Cold bore tube centre (Centring of mechanical mole fingers or Centring of LED's)

well aligned, starting with the best mechanical precision from fabrication, but there are limits to that. In reality we have offsets between these centres. So we try to measure them. For that we use the following ingredients:

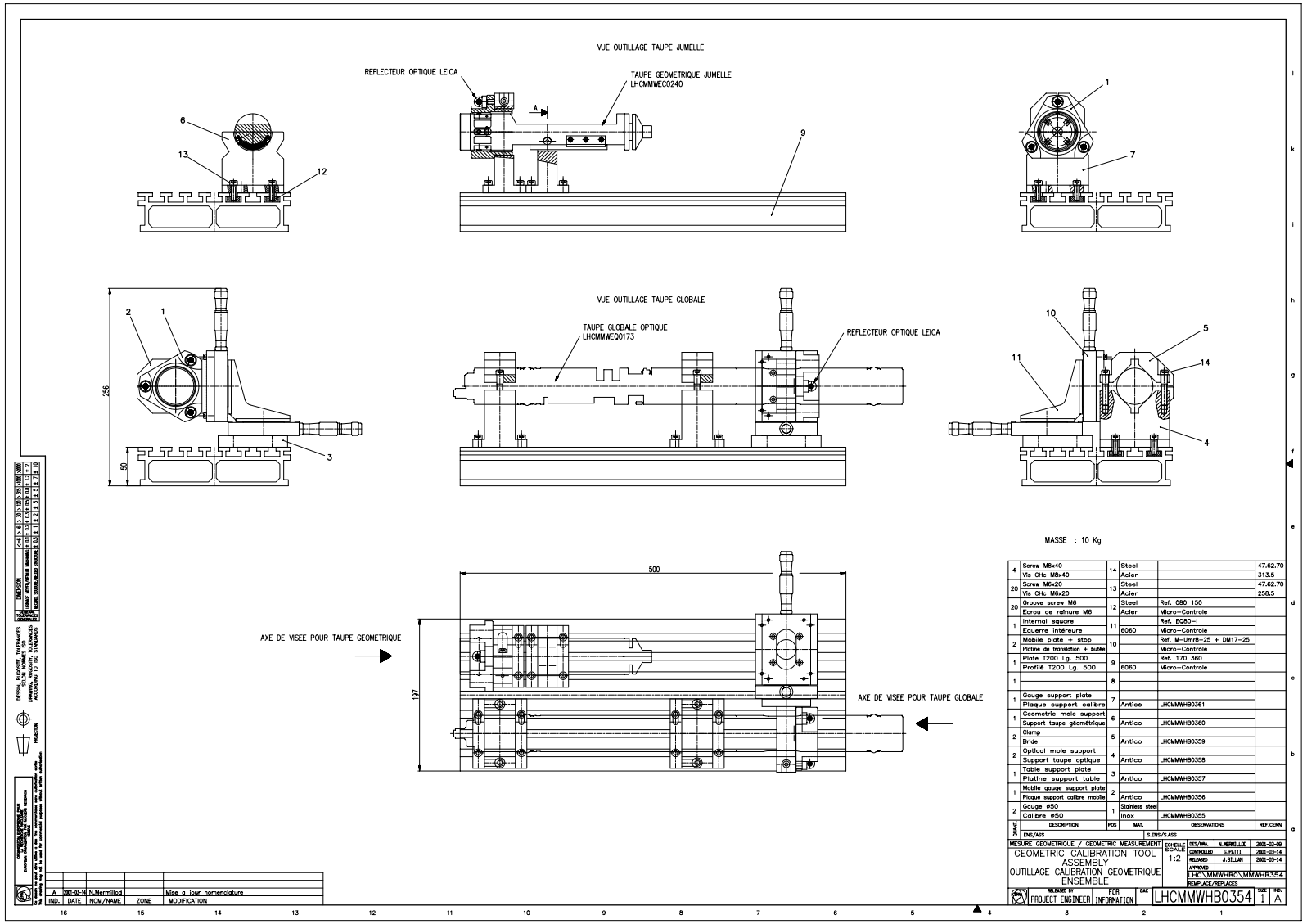
–turning by 180° in a 50 mm ➢ calibrated tubes

–turning by 180° in a calibrated quadrupole

–displacing transversally the mole inside a 50 mm ➢ tube to calibrate the LED's behaviour

–special device to calibrate the mechanical mole fingers

Calibration bench



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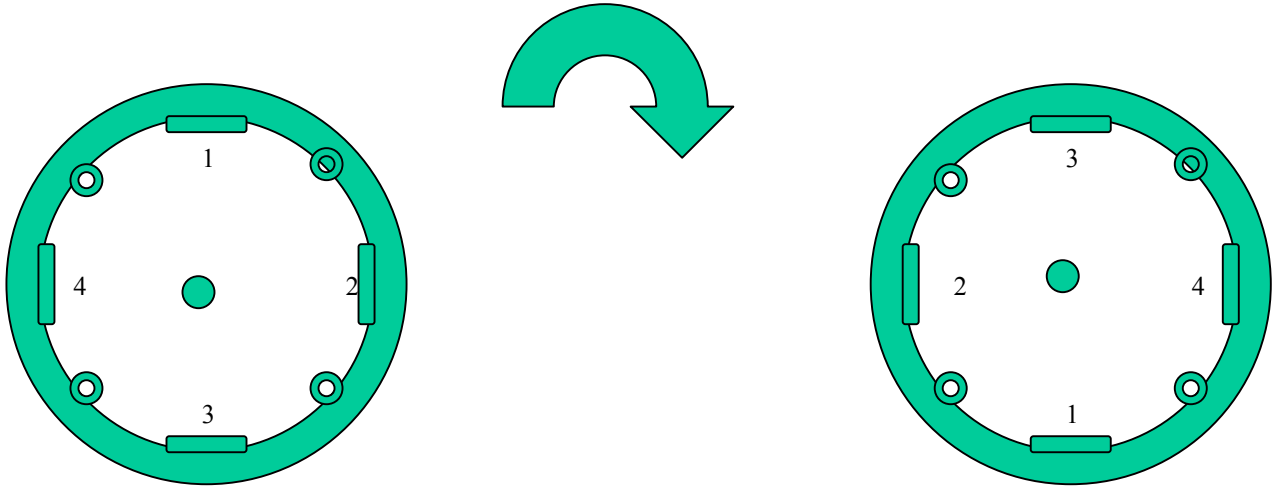
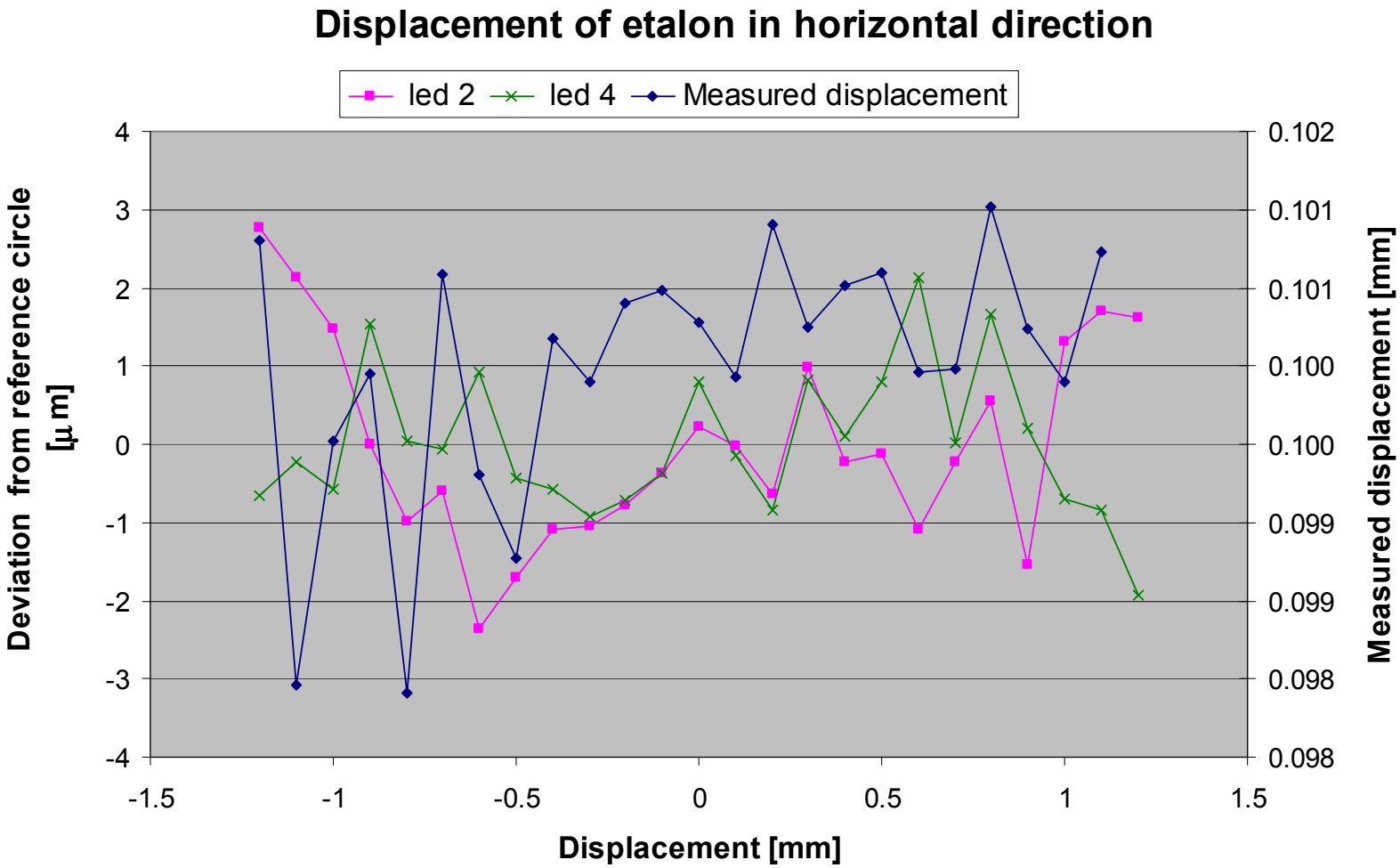
Calibration method

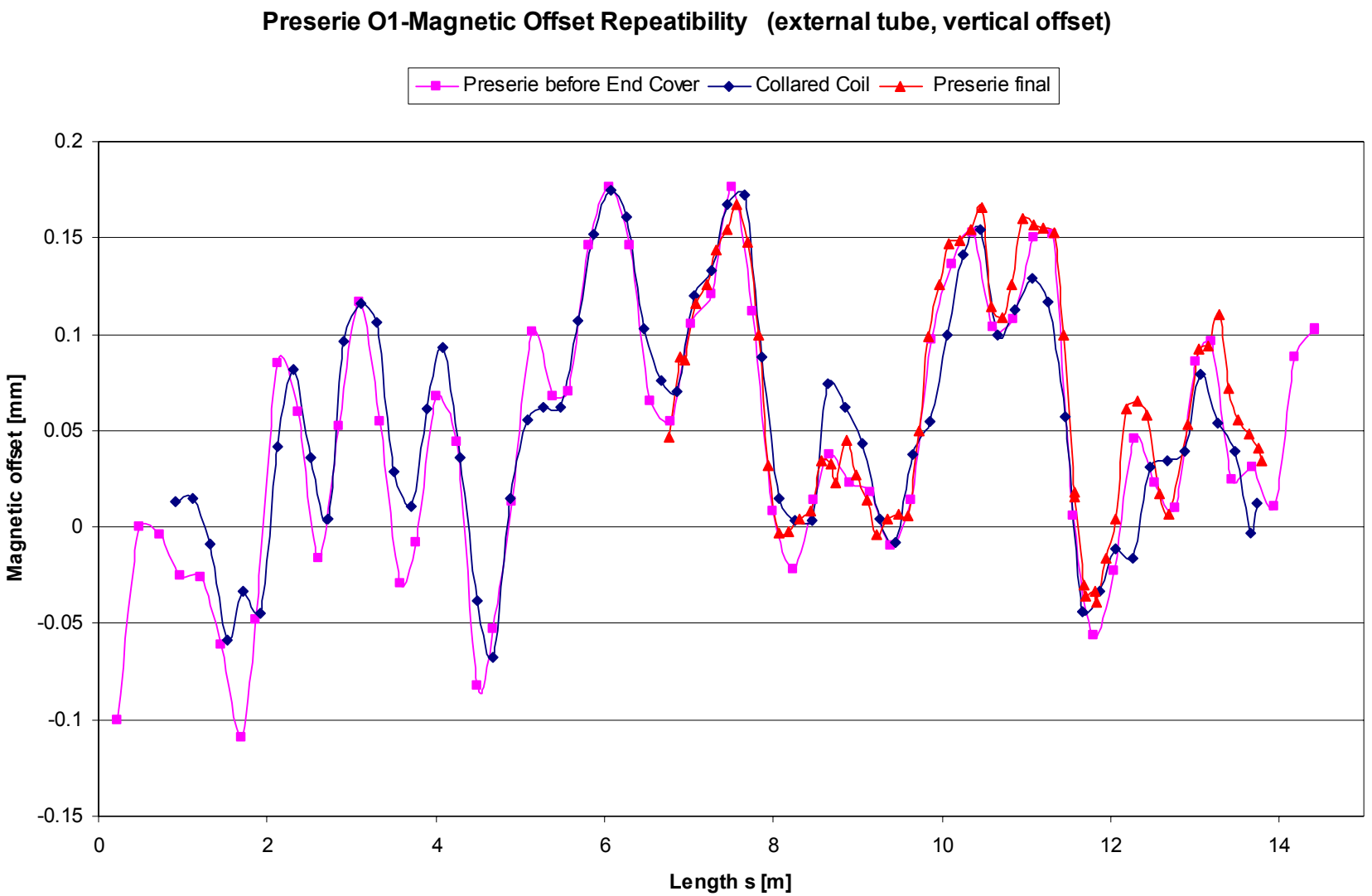
180 º rotations



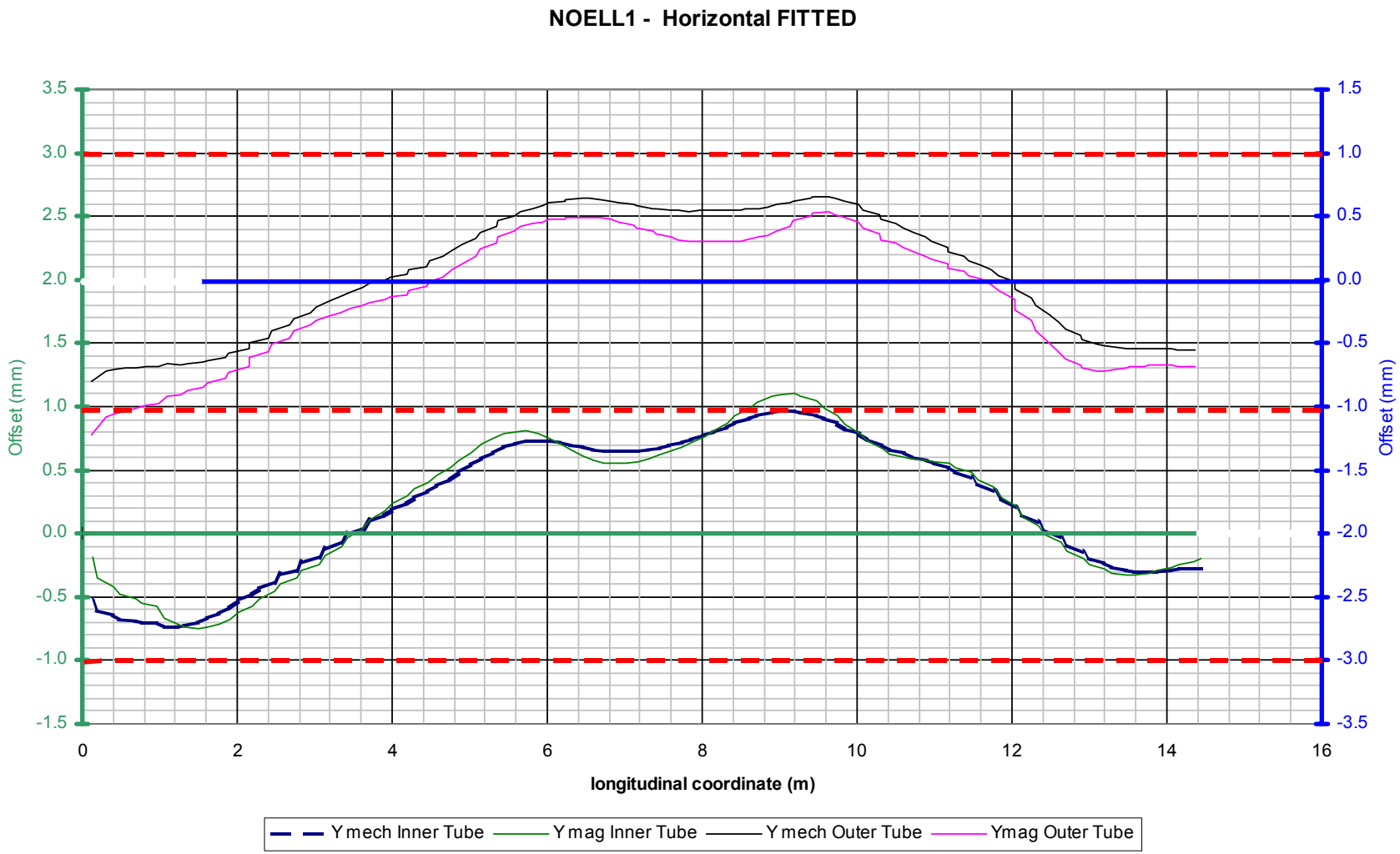
Optical Mole (Calibration)



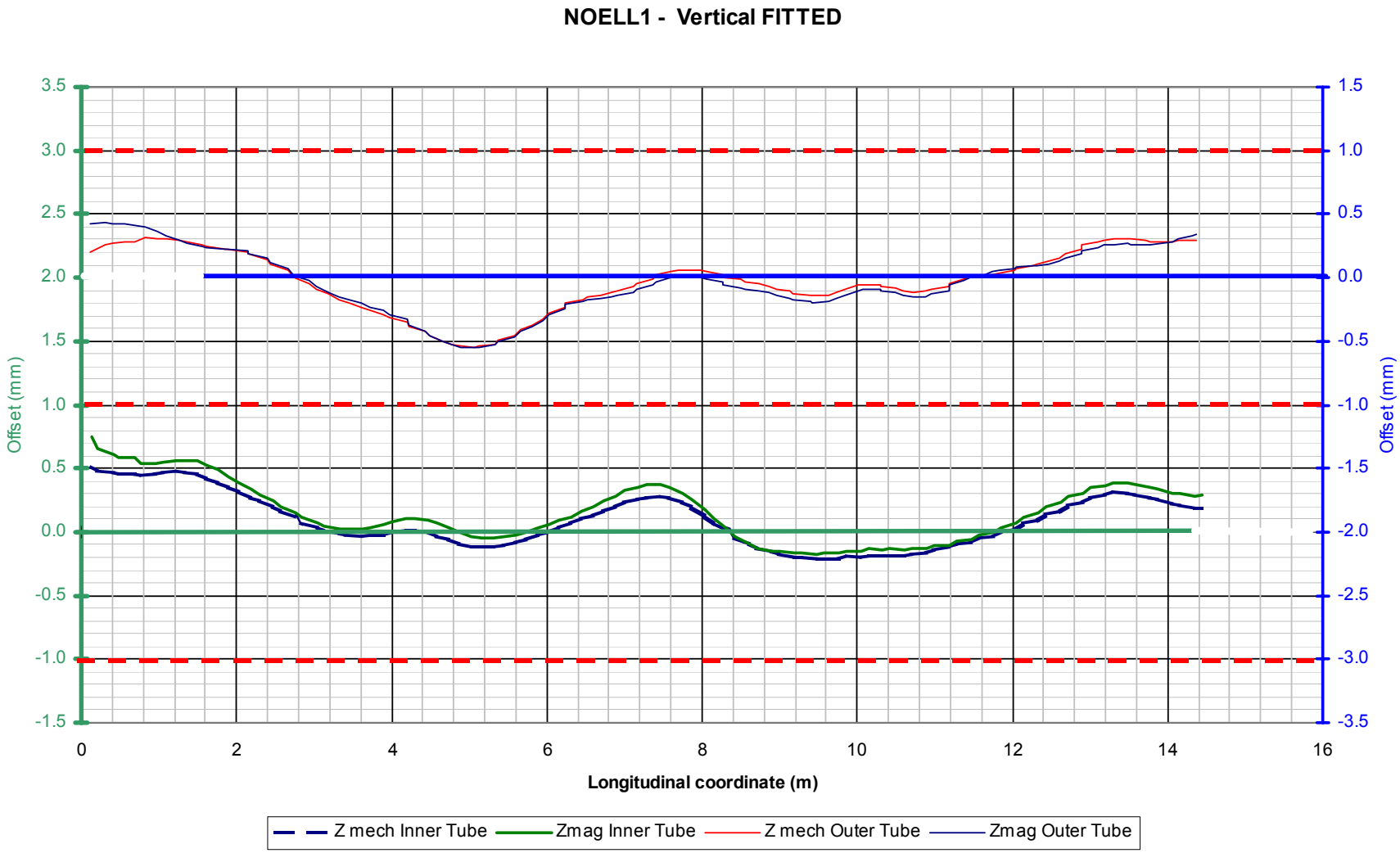
Magnet Axis measurements



Magnet Axis measurements



Magnet Axis measurements



Results from prototypes and preseries

Magnet	Mechanical-Magnetic Axis[mm]							
	Internal Tube				External Tube			
	horizontal		vertical		horizontal		vertical	
	mean	σ	mean	σ	mean	σ	mean	σ
MBP2A2	-0.09	0.03	0.02	0.02	0.05	0.03	0.08	0.03
MBP2O1	-0.25	0.06	-0.01	0.02	-0.20	0.07	-0.01	0.03
MBP2O2	0.04	0.03	0.06	0.03	-0.02	0.06	0.06	0.06
PSO1	-0.16	0.05	0.07	0.03	-0.20	0.04	0.05	0.02
Global	0.12	0.05	-0.04	0.02	0.09	0.06	-0.04	0.04

Conclusions

- We can measure the Magnetic axis of dipoles and correctors of LHC magnet with good accuracy, 0.03 mm in a very short time in parallel with the Mechanical axis measurements
- The Optical mole gives the diameter measurement
- The calibration bench and method are ready
- The results show a good agreement between both Magnetic and Mechanical axis