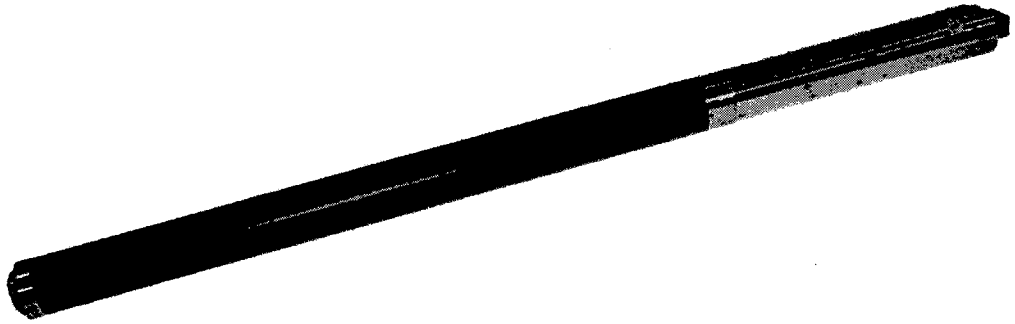
IMMW 12

A "badger" to calibrate the axis measurement of the main LHC quadrupoles (SSS)



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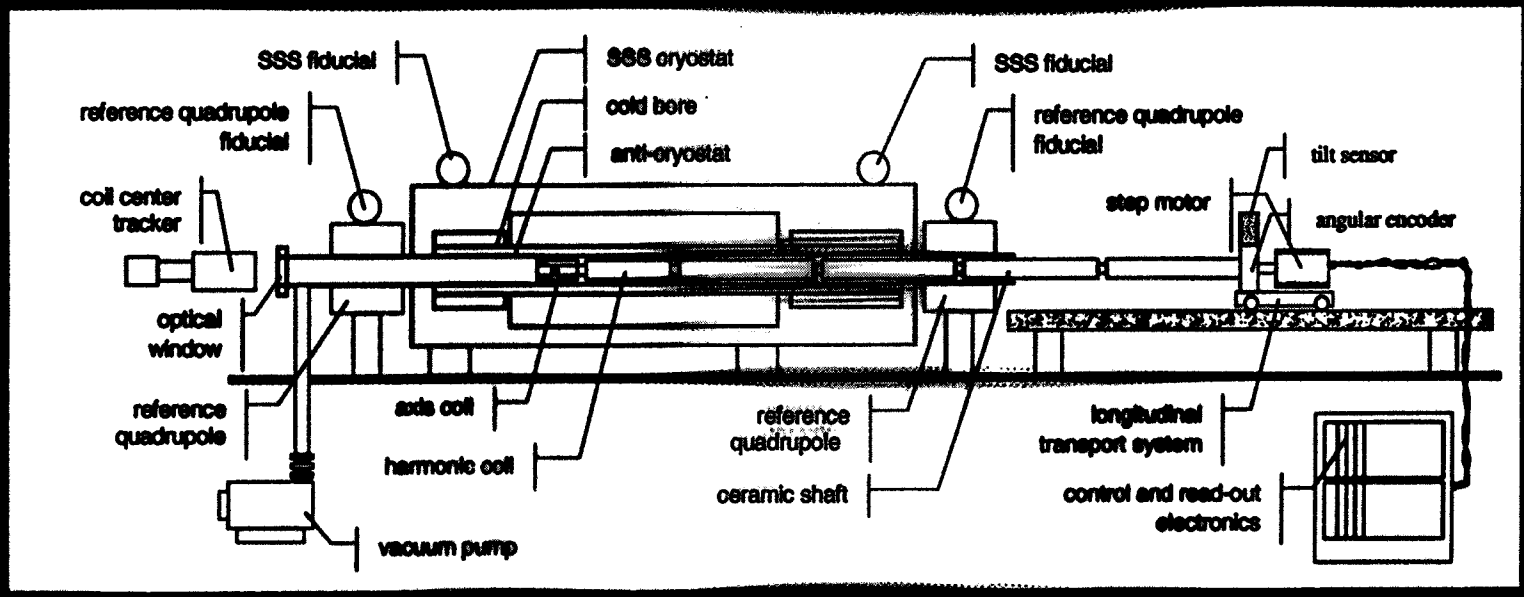
A "badger" to calibrate the axis measurement of the main LHC quadrupoles (SSS)

IMMW 12

Contents

- Introduction
- The "badger" bench
  - The measuring probe
  - The support bench
- Calibration procedure
- Conclusions

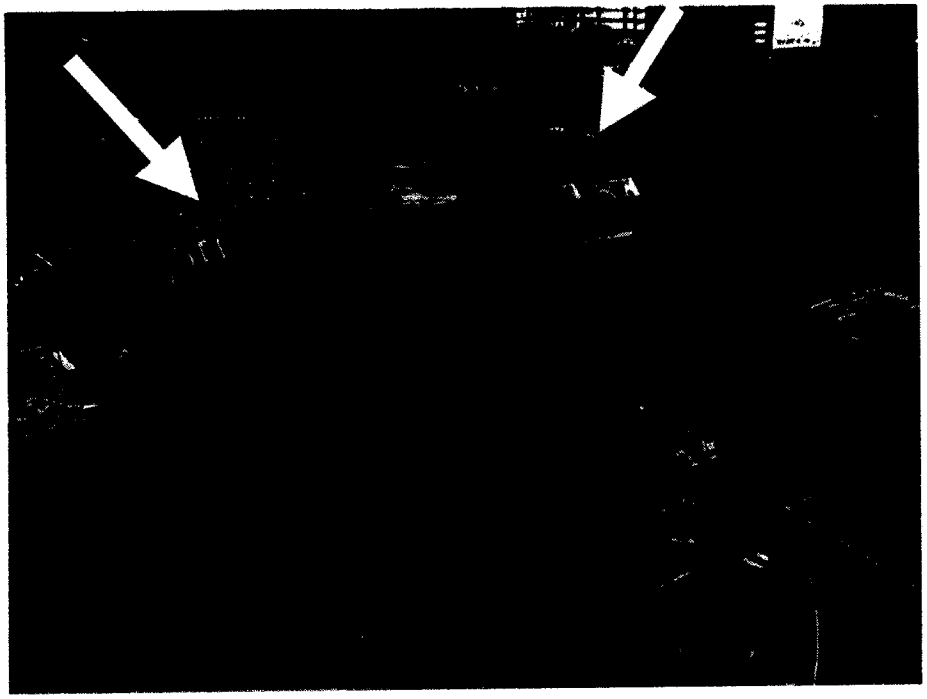
Measurement of [illegible] Alignment
(Automatic Scanner)



Schematic view of the [illegible] scanner [illegible] measurement on SSS's. The anti-cryostat [illegible] coil [illegible] is in front of the coil tracker is evacuated [illegible] in.

Introduction

- Two reference quadrupoles are part of the reference frame of the SSS axis measurement
- Well known, stable and periodically checked fiducialization is required



Introduction

- Accuracy requirements for the Measurement of Lattice Quadrupoles

Total budget (SSS cold measurements + ref quads calibration):

		Absolute	Random
Field direction	[mrad]	0.3	0.1
Magnetic center	[mm]	0.15	0.15

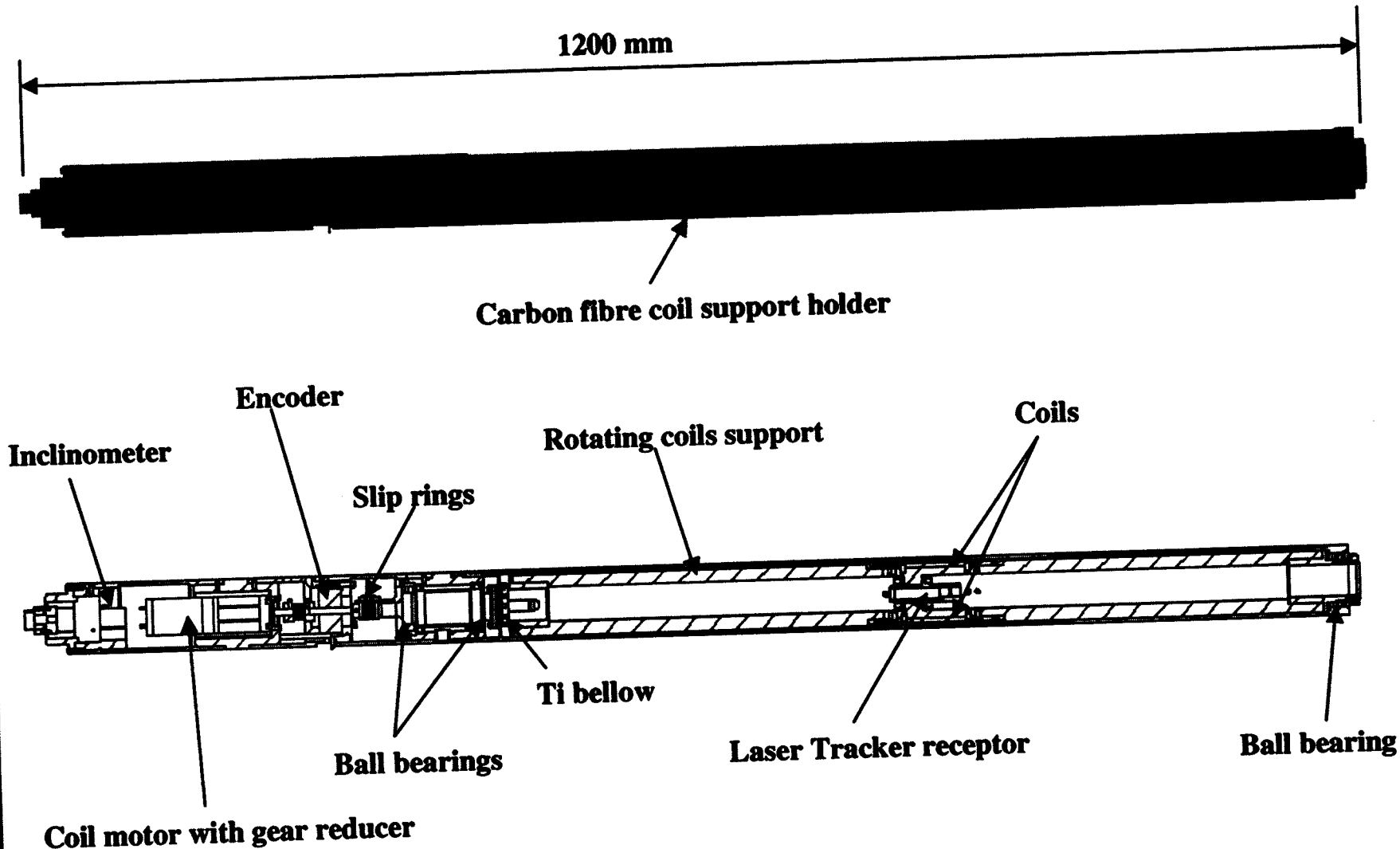
Assuming an equal contribution of those steps in the budget one can estimate roughly the **requirements to the "badger" system:**

Field direction	**[mrad]**	**0.2**	**0.07**
Magnetic center	**[mm]**	**0.1**	**0.1**

Main Features of the calibration bench

- The probe/support assembly features:
  - Four 100mm/150 turns tangential rotating coils for magnetic measurement placed on a fibre-reinforced epoxy hollow support
  - A laser tracker's target accurately positioned in the centre of the support . The laser tracker surveys the target inside the rotating coil in order to refer its axis of rotation to the magnet fiducials
  - Onboard inclinometer to refer the field direction to gravity
  - 200mm longitudinal displacement magnet support to place coil longitudinally on the same position with respect to magnet, at two orientation of the "badger"

The measuring probe (the "badger")



The measuring probe (the "badger")

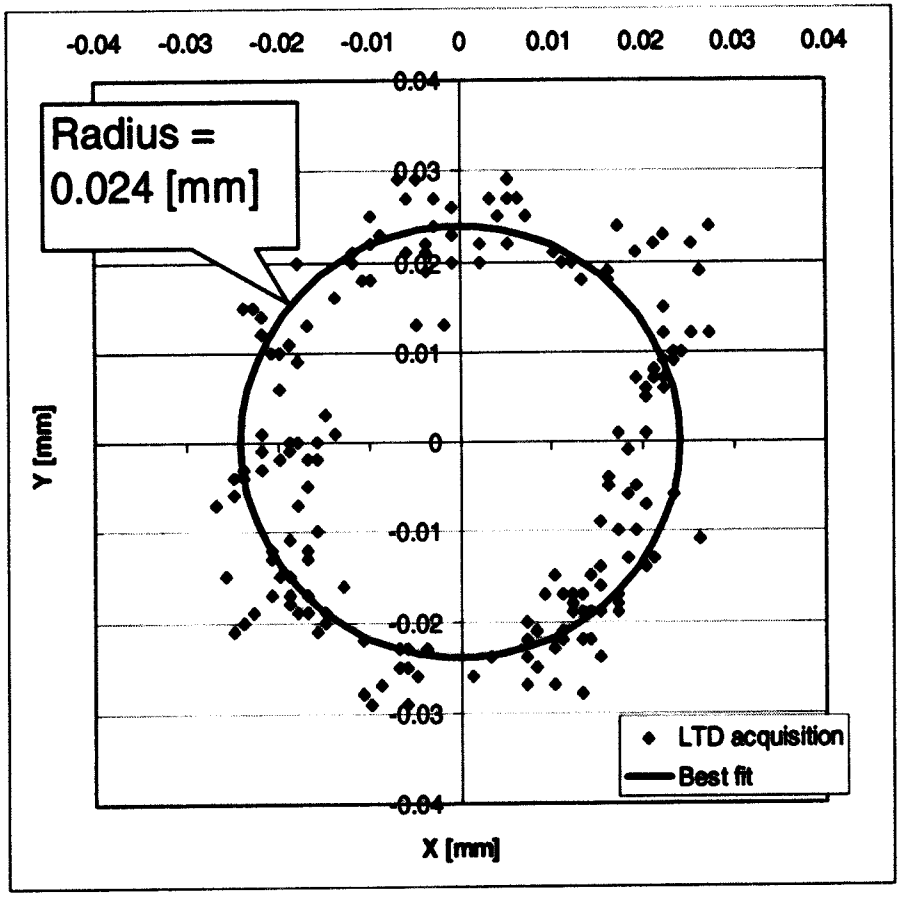
❑Main components

- Custom TBR target for Leica LTD500 3D measuring system
- DC Maxon motor with 72:1 gear reducer for coil rotation
- Litton 8 tracks slip rings for the coil signals
- Heidenhain 1024 pulses/turn rotating incremental angular encoder
- +/- 0.5° Spectron electrolytic inclinometer +/- 8.5 mrad range, 2 µrad resolution and better than 0.1mrad accuracy

The measuring probe (the "badger")

IMMW 12

Laser target wobble



The measuring probe (the "badger")

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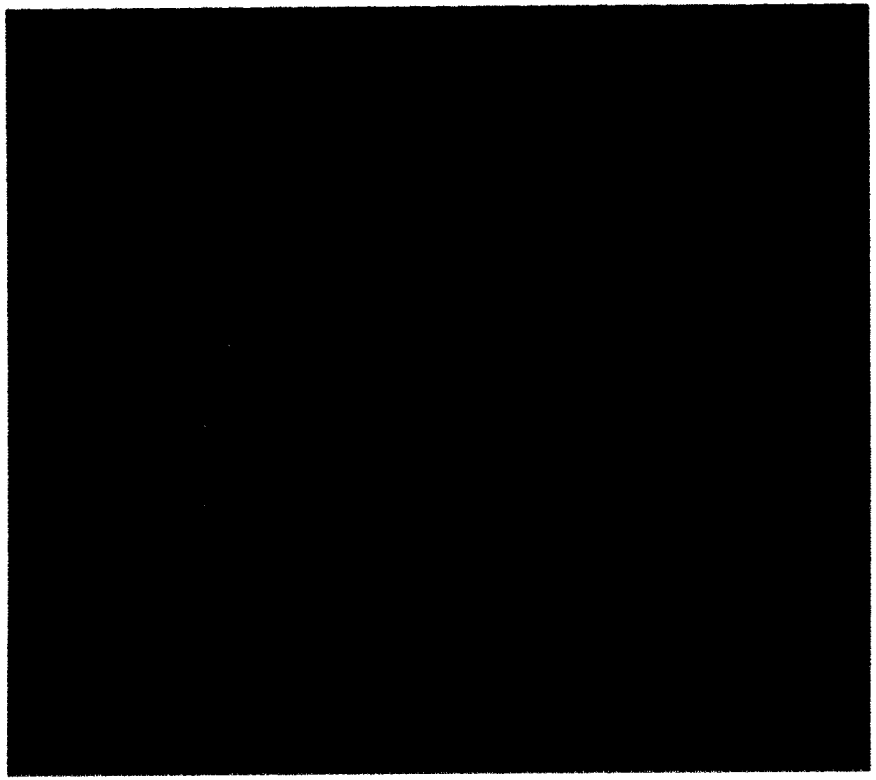
The laser reflector spot

The measuring probe (the "badger")

Leica TBR custom reflector



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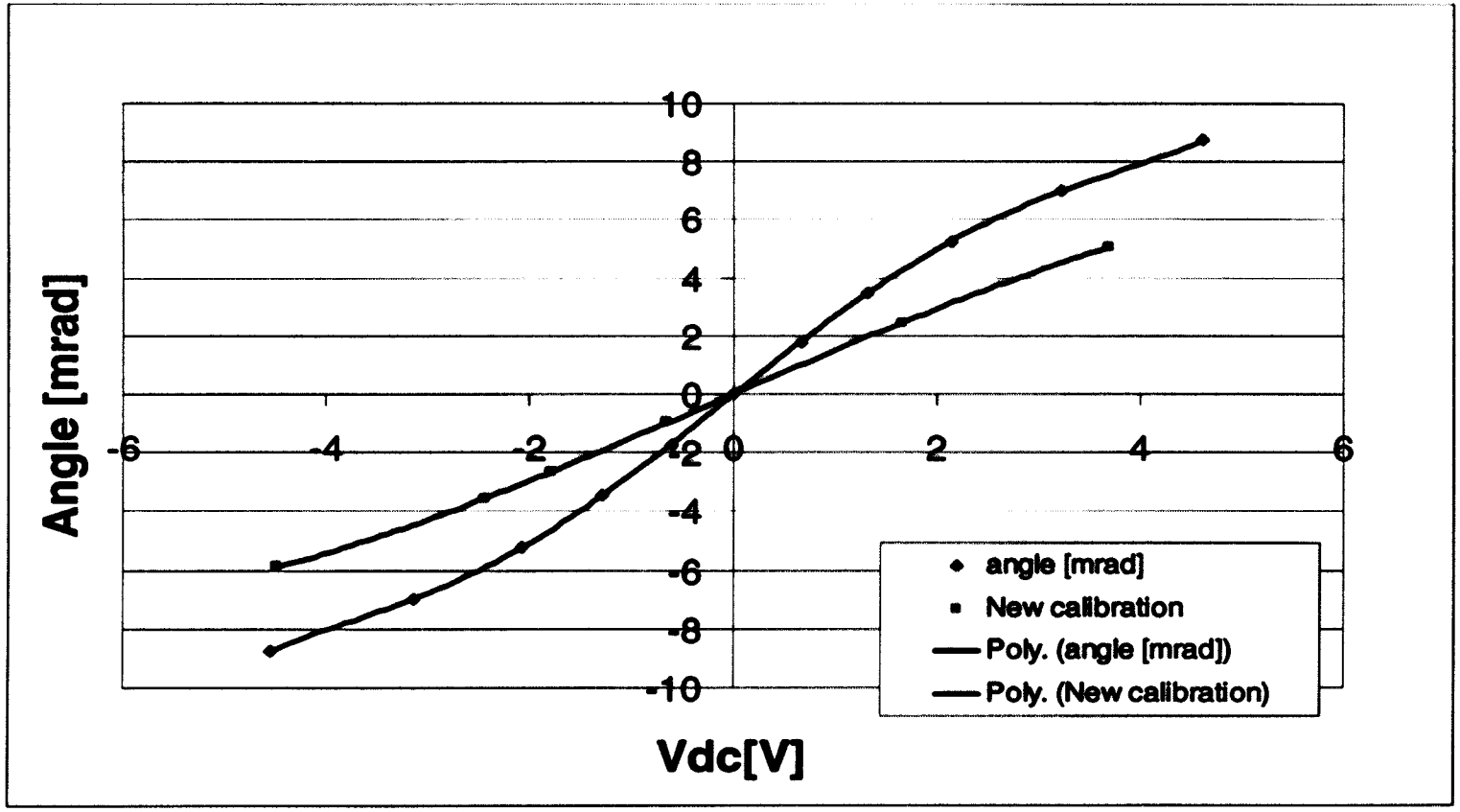
The measuring probe (the "badger")

Required inclinometer calibration due to insufficient manufacturer calibration

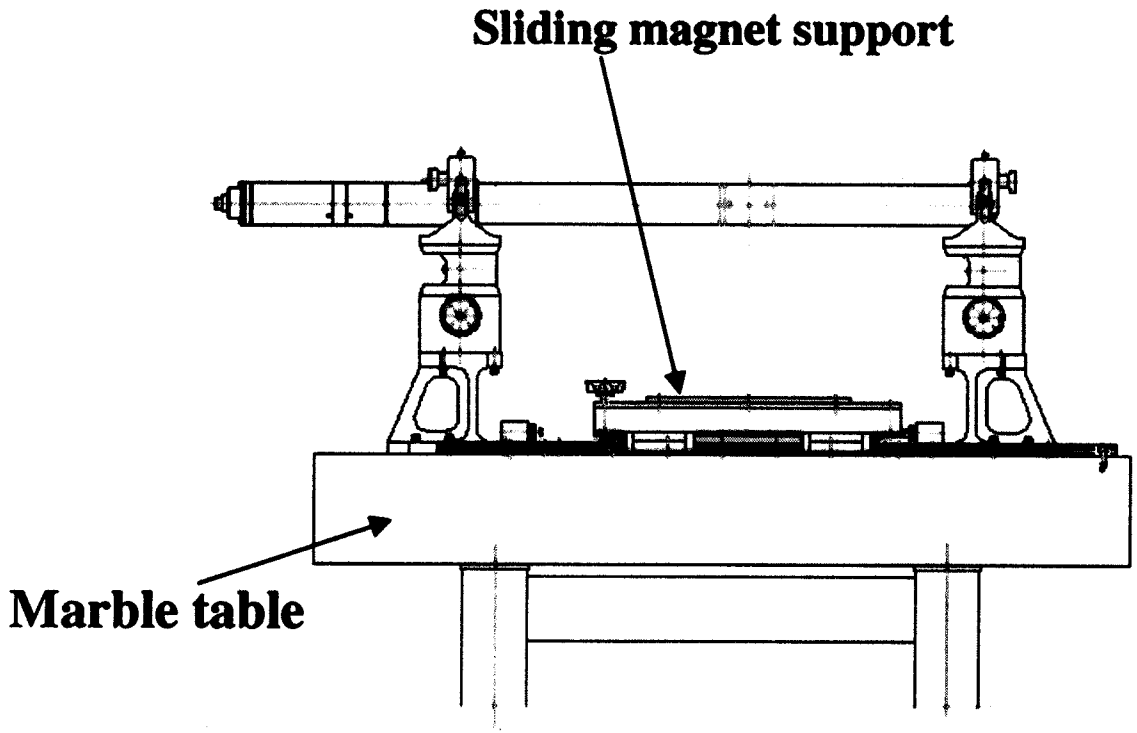


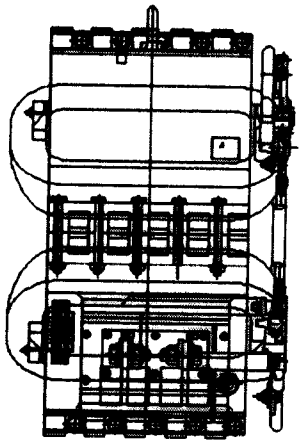
The measuring probe (the "badger")

IMMW 12

The AMP connector

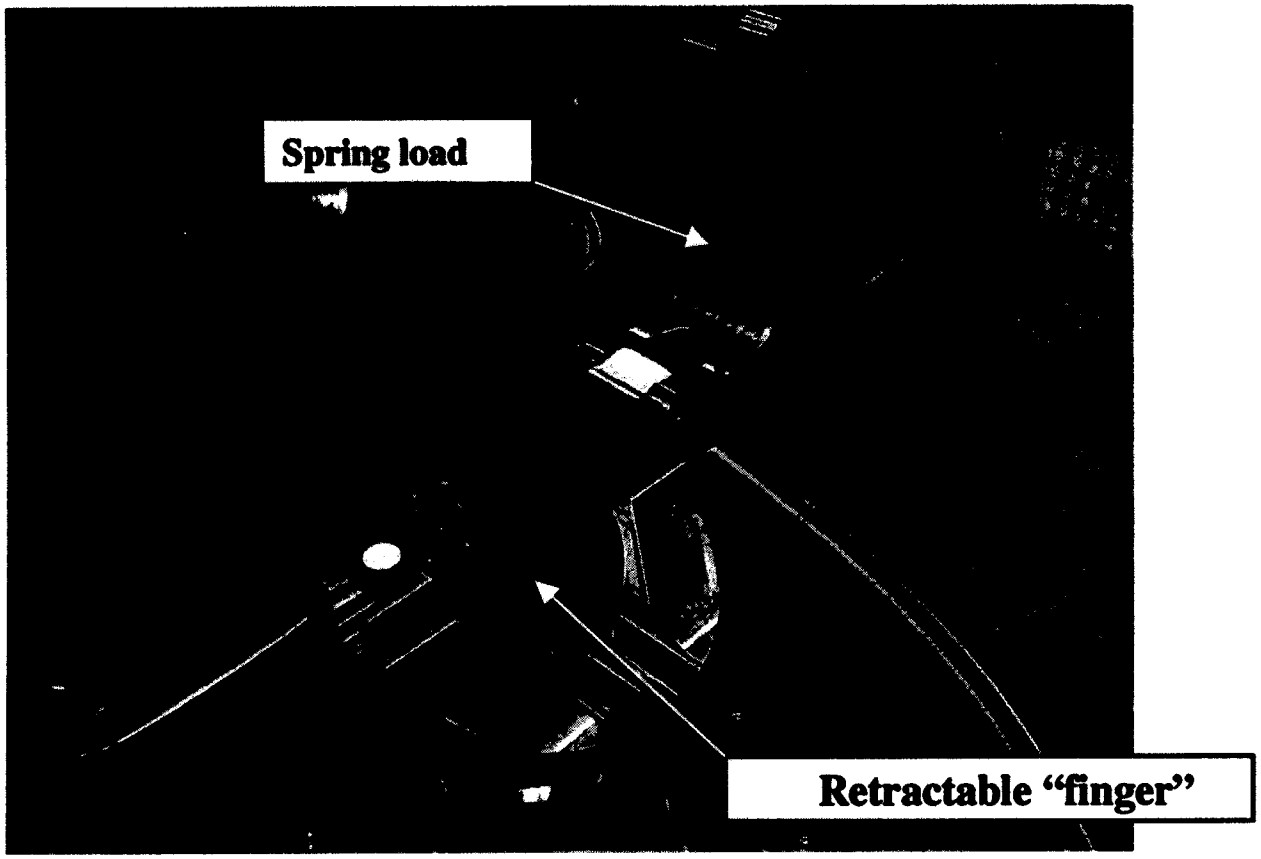
The support bench





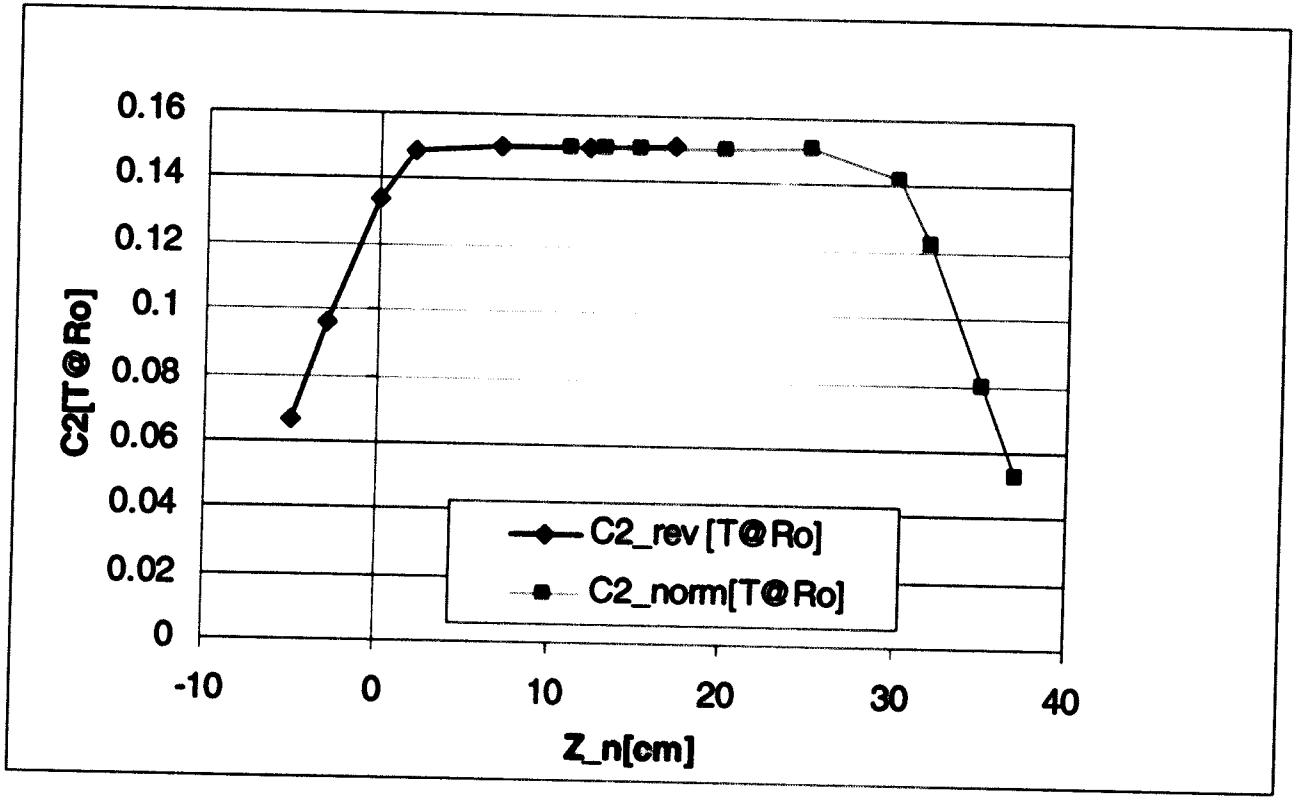
The support bench

Probe support



The support bench

Field as a function of longitudinal position



Calibration procedure

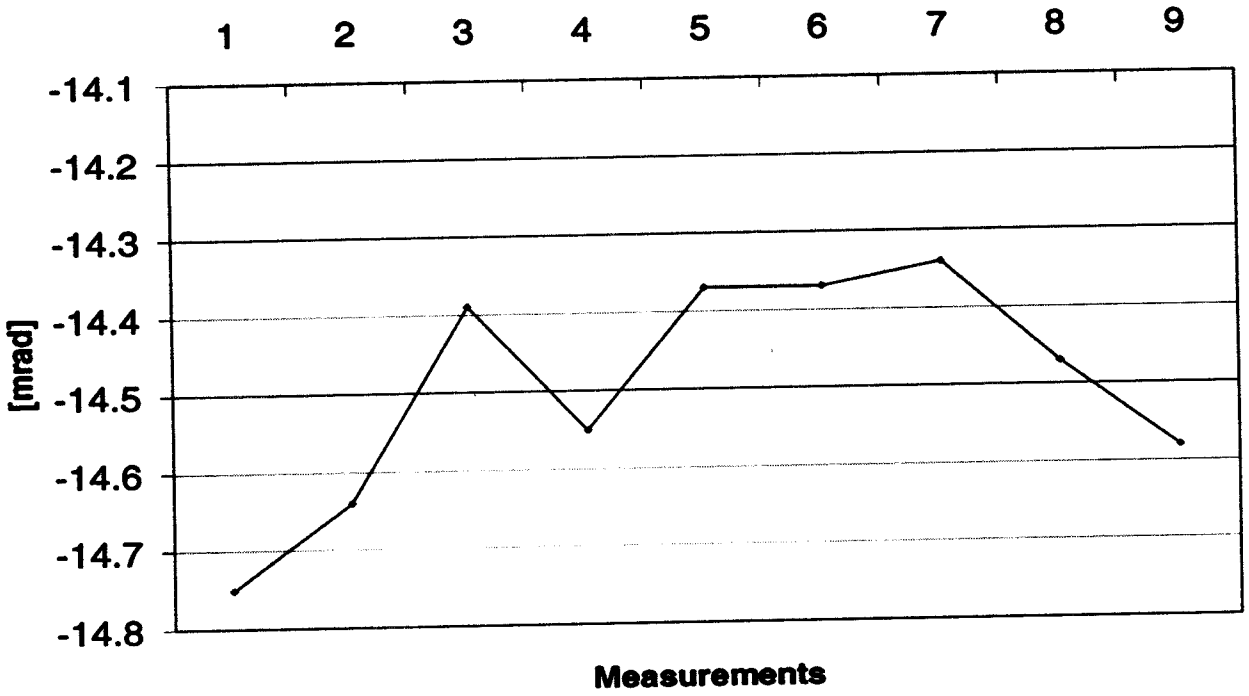
IMW 12

- Magnetic field measurement with the MMP acquisition program (see Maryline Gateau presentation):
  - Axis measurement
  - Roll angle (two positions of the "badger" turned over vertical axis)

- Survey of the coil centre and the magnet fiducials with the LTD500 laser tracker

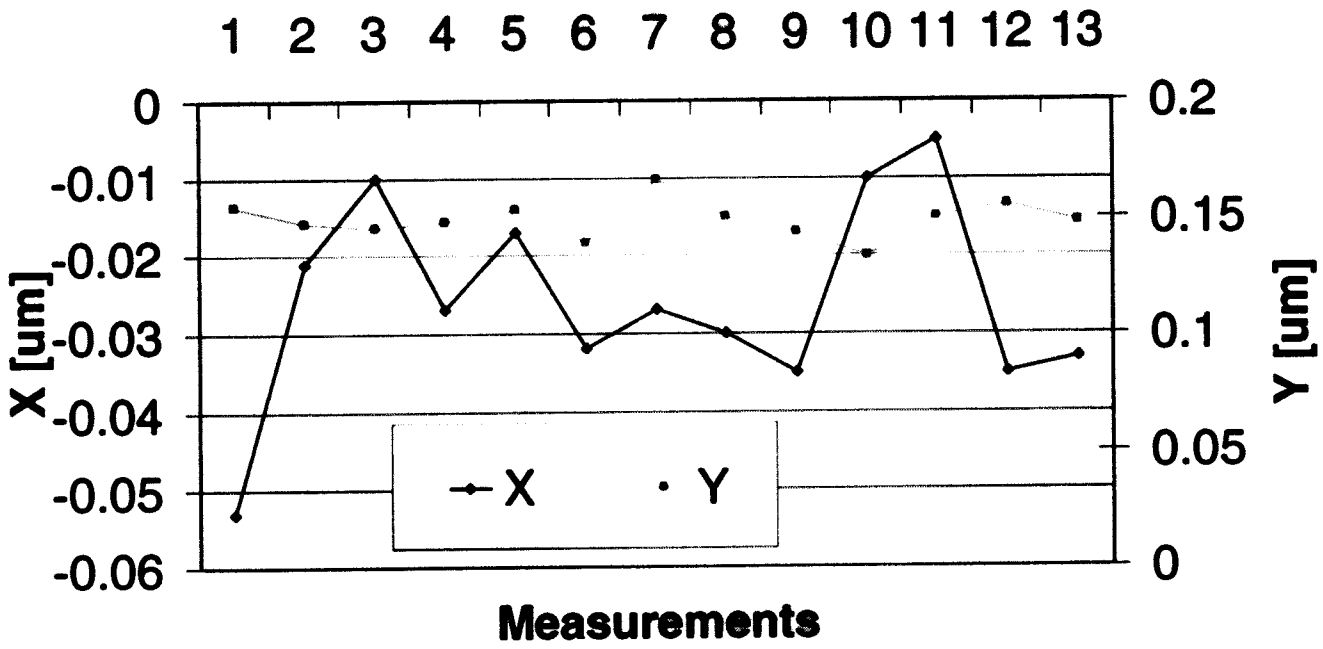
Calibration procedure

Reproducibility of the field angle calculated by MMP

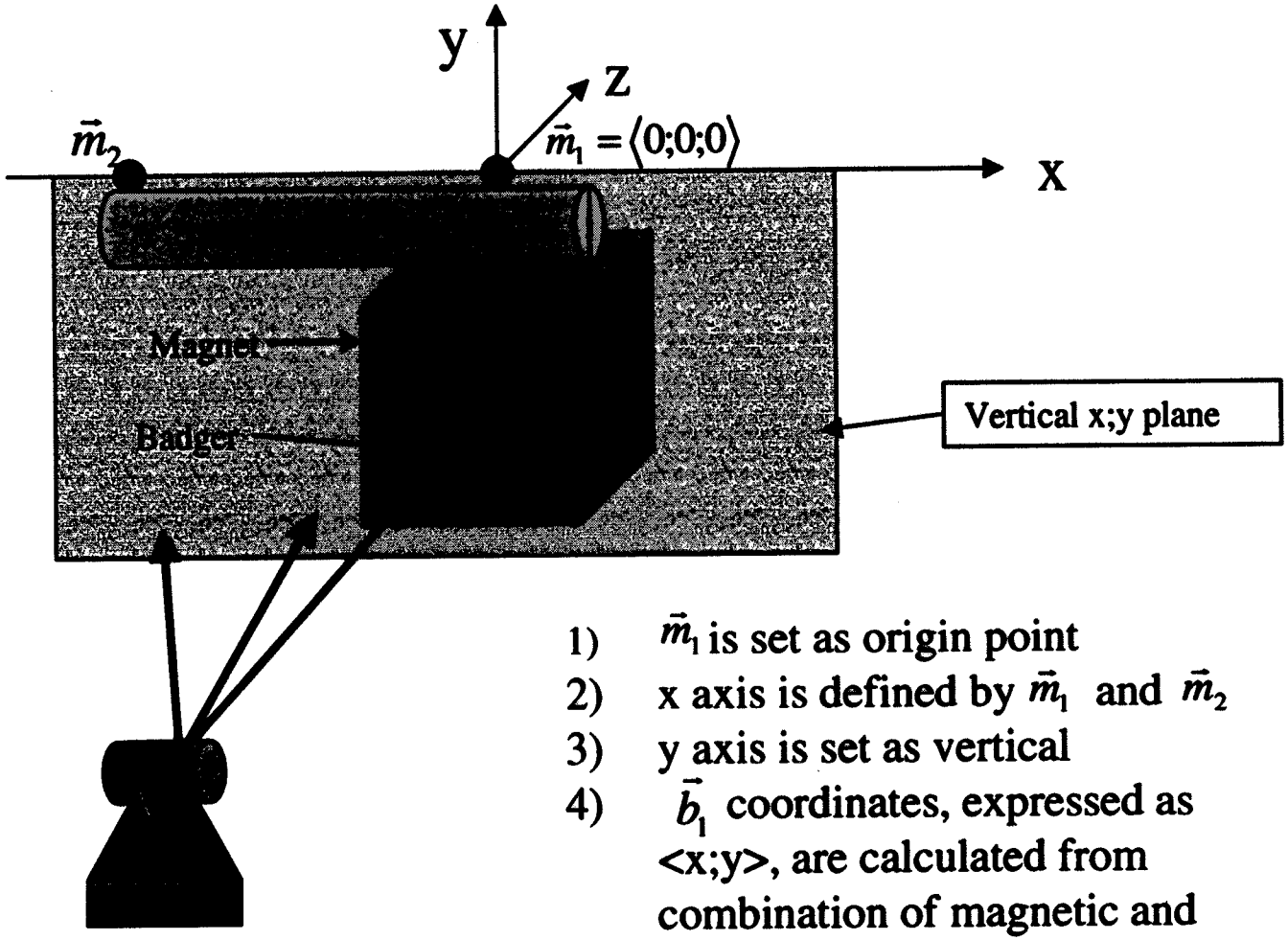


Calibration procedure

Reproducibility of magnetic axis measurement

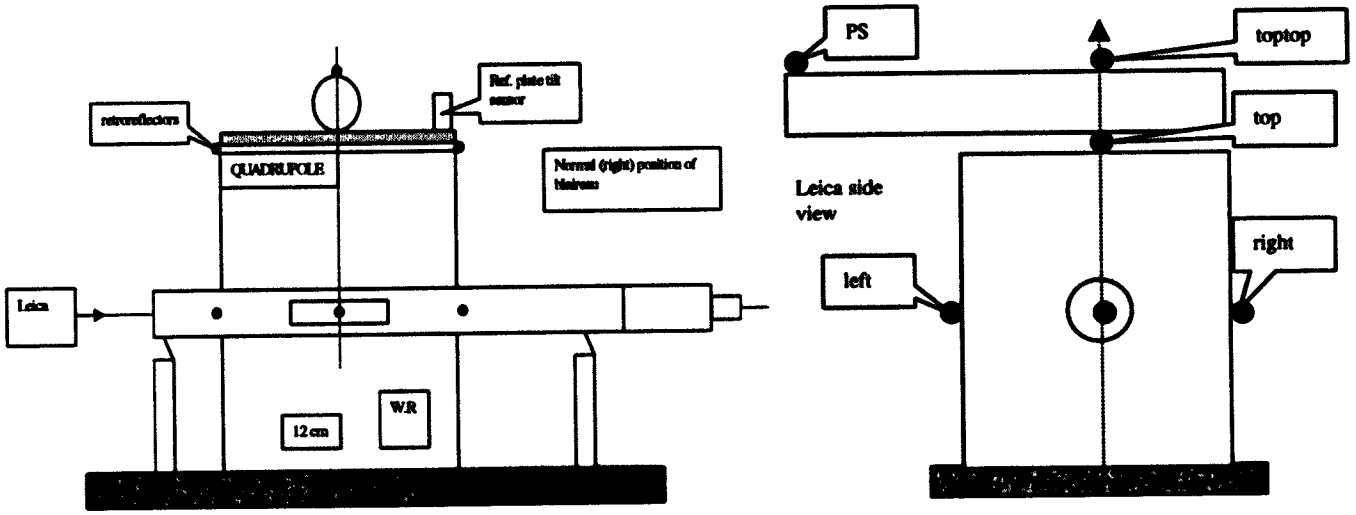


Calibration procedure: Laser Tracker survey



1) $\vec{m}_1$ is set as origin point
2) x axis is defined by $\vec{m}_1$ and $\vec{m}_2$
3) y axis is set as vertical
4) $\vec{b}_1$ coordinates, expressed as <x;y>, are calculated from combination of magnetic and survey measurements.

Calibration procedure: LTD targets location



- For fast cross-checking, 6 more targets are used on the iron yoke in order to check stability of the main fiducials with respect to the iron yoke

Conclusion

❑Systematic error:

•short term stability - reproducibility during one run of magnetic measurement

		Random	Status
Field direction	**[mrad]**	**~ 0.14**	**To be improved**
Magnetic center	**[mm]**	**0.02**	**Match the requirements**

•intermediate term stability - reproducibility from run to run ("badger" and magnet installation) **To be completed**

•long term stability - magnet transportation to the SSS test bench **To be completed**

❑Crosscheck measurement (with a Single Stretched Wire from FNAL, USA)

		Badger		SSW		Systematic error
		Abs	Stdev	Abs	Stdev	
Field direction	**[mrad]**	**-0.08**	**0.1**	**-0.06**	**0.07**	**0.020**
Magnetic center X	**[mm]**	**-0.081**	**0.034**	**-0.050**		**0.031**
Magnetic center Y	**[mm]**	**-479.315**	**0.034**	**-479.236**		**0.079**