Status of PCMAG fieldmapping analysis

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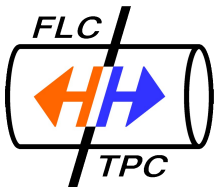
DESY FLC TPC



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  - offset measurement and probe quality
  - raw fieldmap
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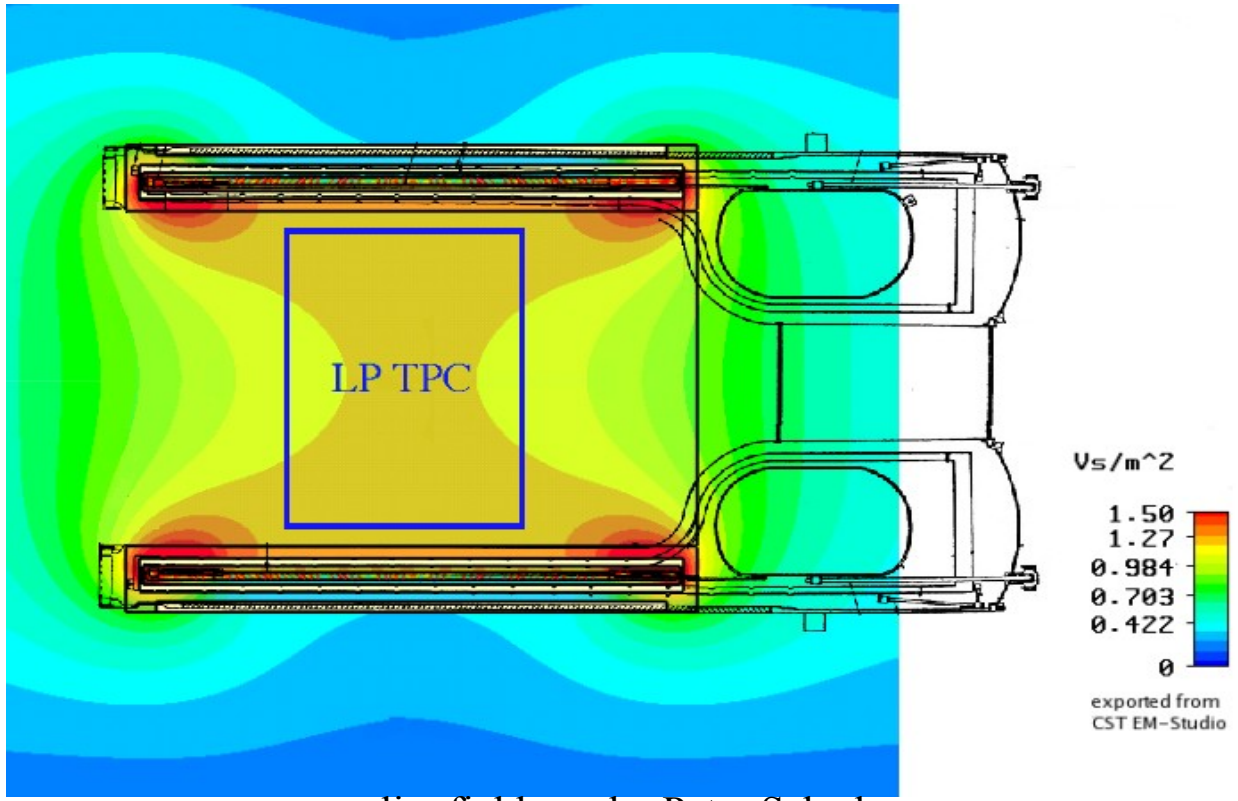
- things to do...

This is still work in progress and very preliminary!!!

Aims of the project

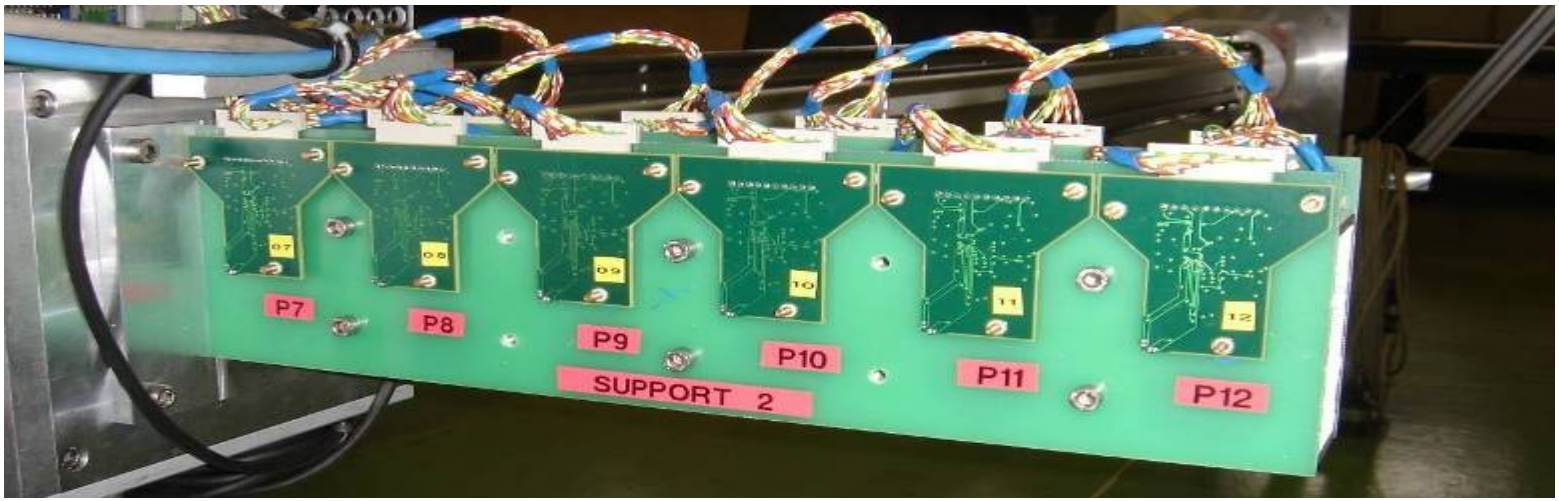
- provide a fieldmap for the PCMAG superconducting magnet installed at DESY, which will host the Large Prototype (LP) of the LCTPC
- the needed accuracy is determined by the needed track resolution in the TPC. The aim was set for a few Gauss (10^{-4} T)
- as the LP will be moved along the PCMAG axis it is important to deal with the inhomo-geneous parts of the magnetic field



earlier fieldmap by Peter Schade

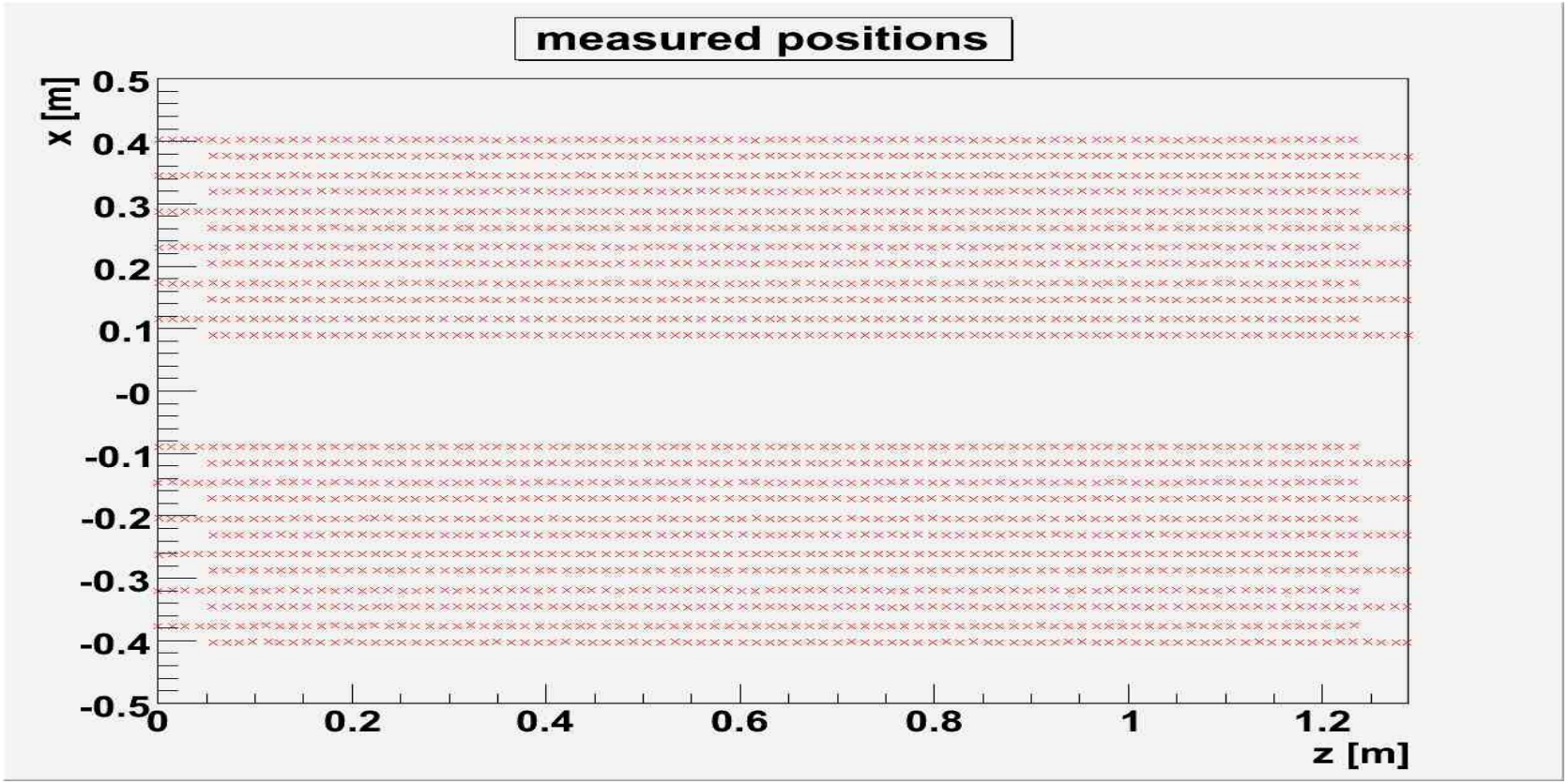
What data do we have?

- 24 probes on 2 arms at 12 different r positions
- 89 z positions with steps of 14 mm
- 12 probes mounted on the front and 12 on the back of the arms with an offset of 56 mm in z direction. Overlap from position 4 on.
- angular positions of 0° to 180° in steps of 5°
- angular positions of 180° to 360° in steps of 15° for cross checking of the two arms
- measured more than 100 000 points @ 1 T



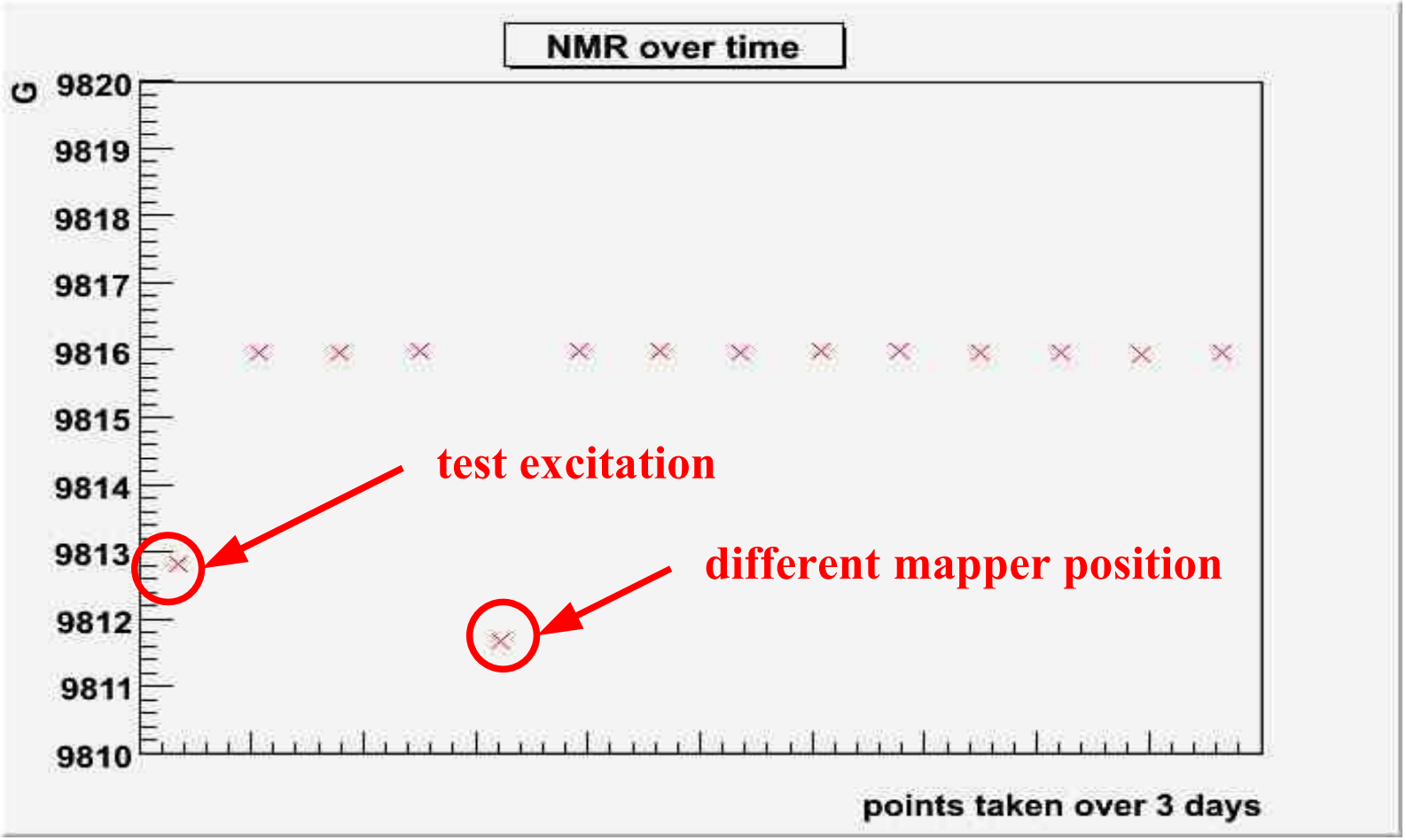
What additional data do we have?

- reference data from a NMR probe in the center of the bench over all 3 days of the mapping effort
- 2 z scans @ 0 T for offset measurements at 0° and 90°
- data from the 2 permanent probes installed on the front and the back of PCMAG for refference use during later magnet operation



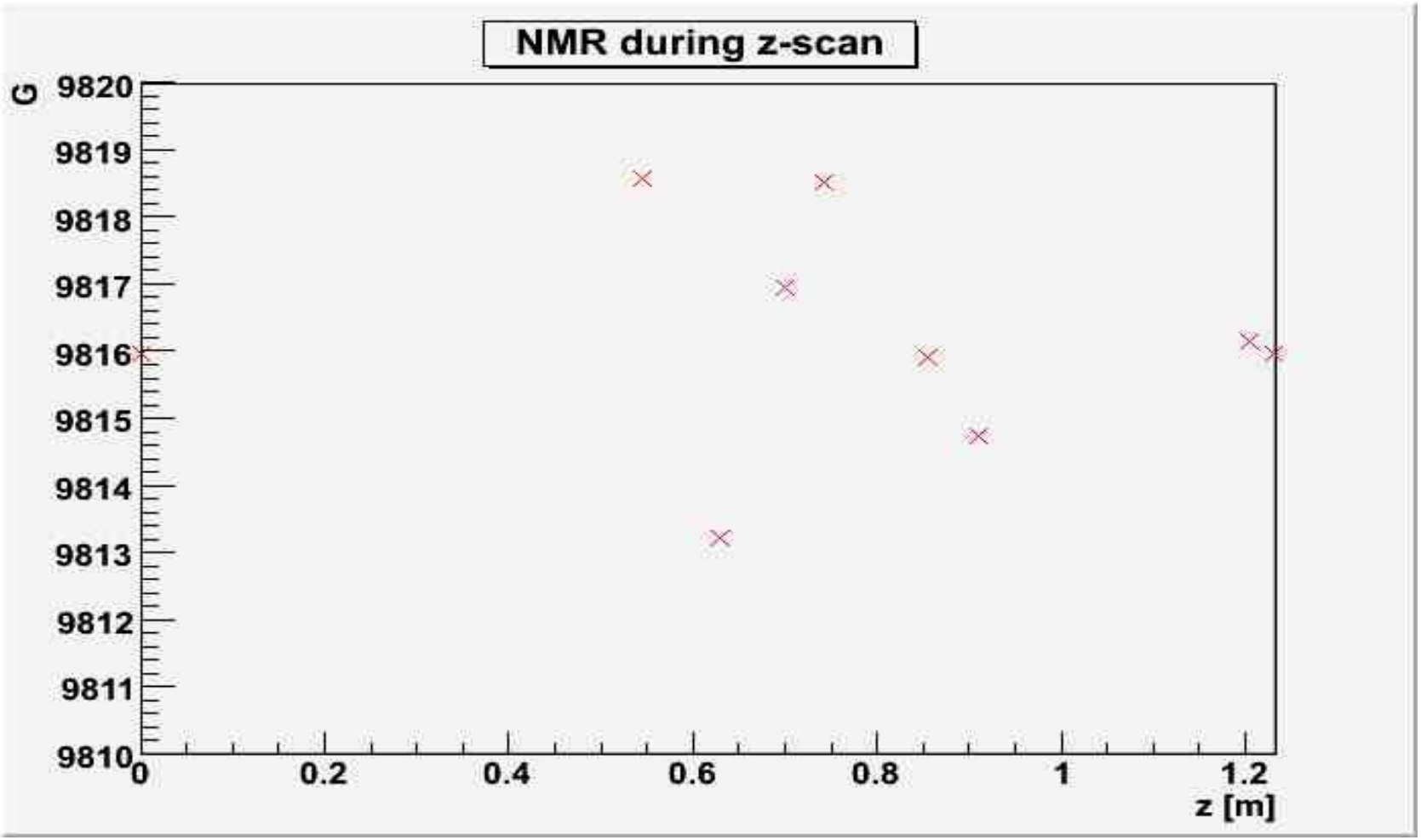
Reference measurements and magnet stability

- reference measurements with the NMR show the extremely high stability of the magnet during operation
- a measurement during test excitation, one day before the mapping began, shows high reproduceability of the field



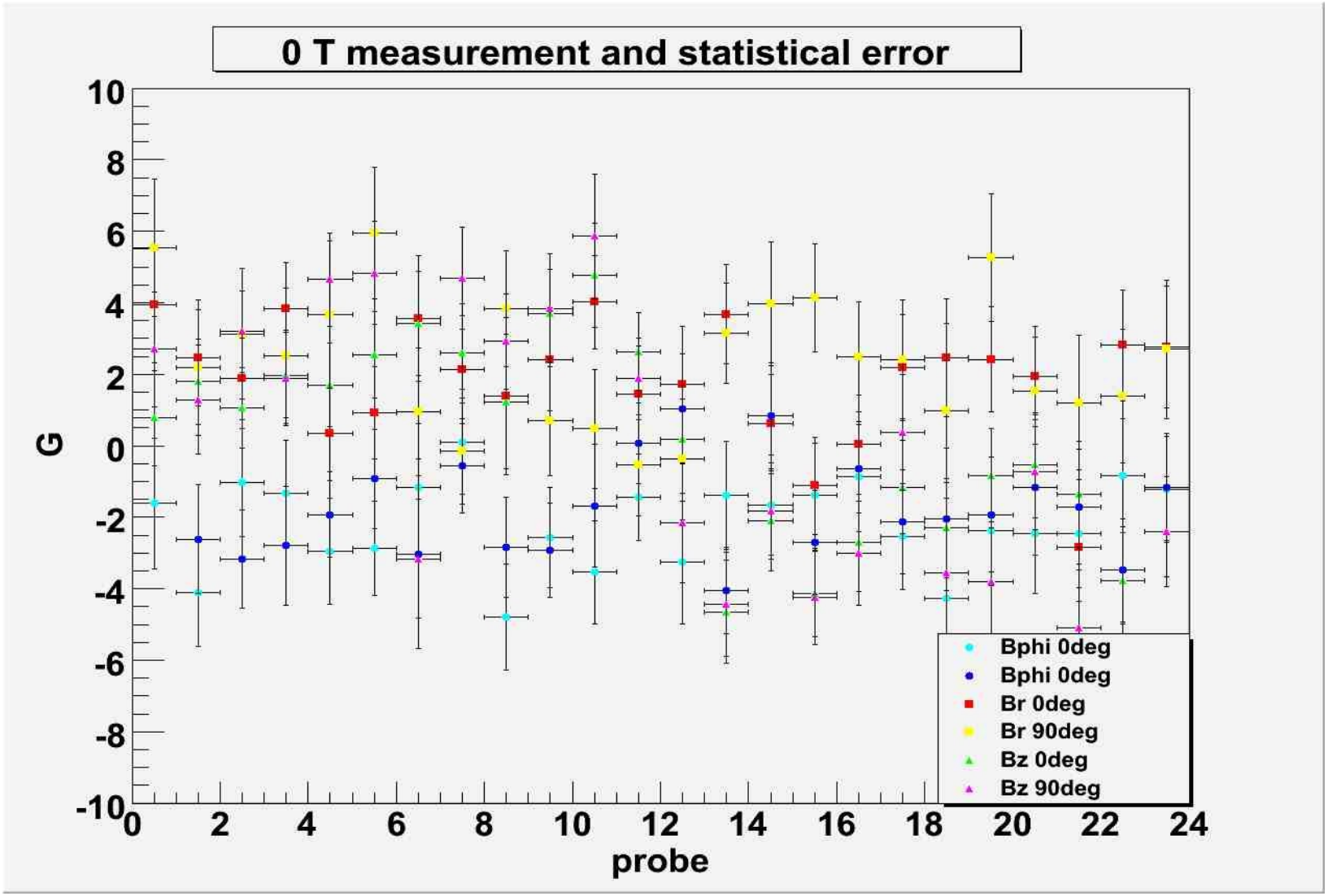
Reference measurements and magnet stability

- NMR measurements at different z positions of the mapping machine show the effect of the ferromagnetic components
- there is no effect seen until now for the innermost probes



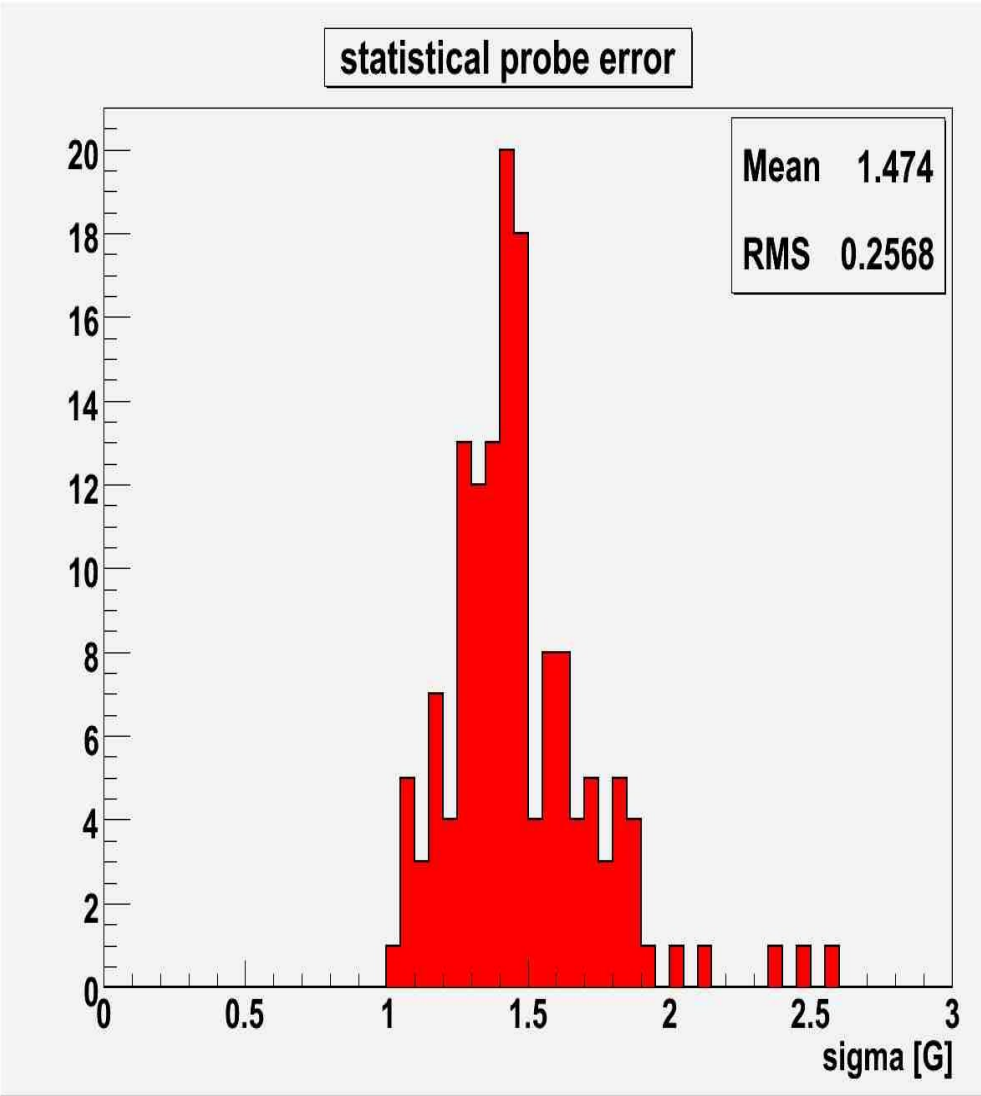
Offset measurements and probe quality

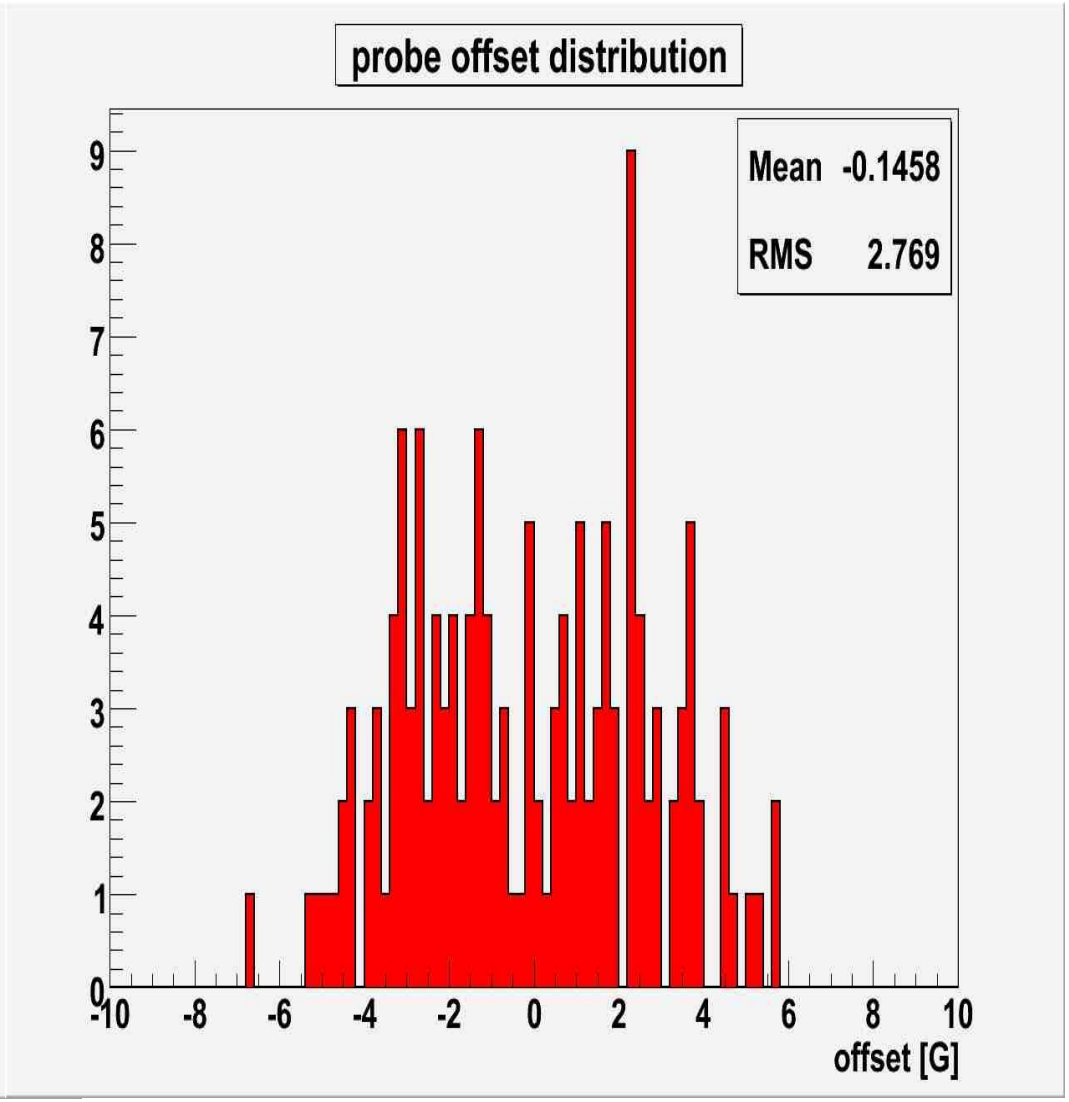
- the 2 data sets taken @ 0 T can be used as an estimation of the probe error, which is below 2 G



Offset measurements and probe quality

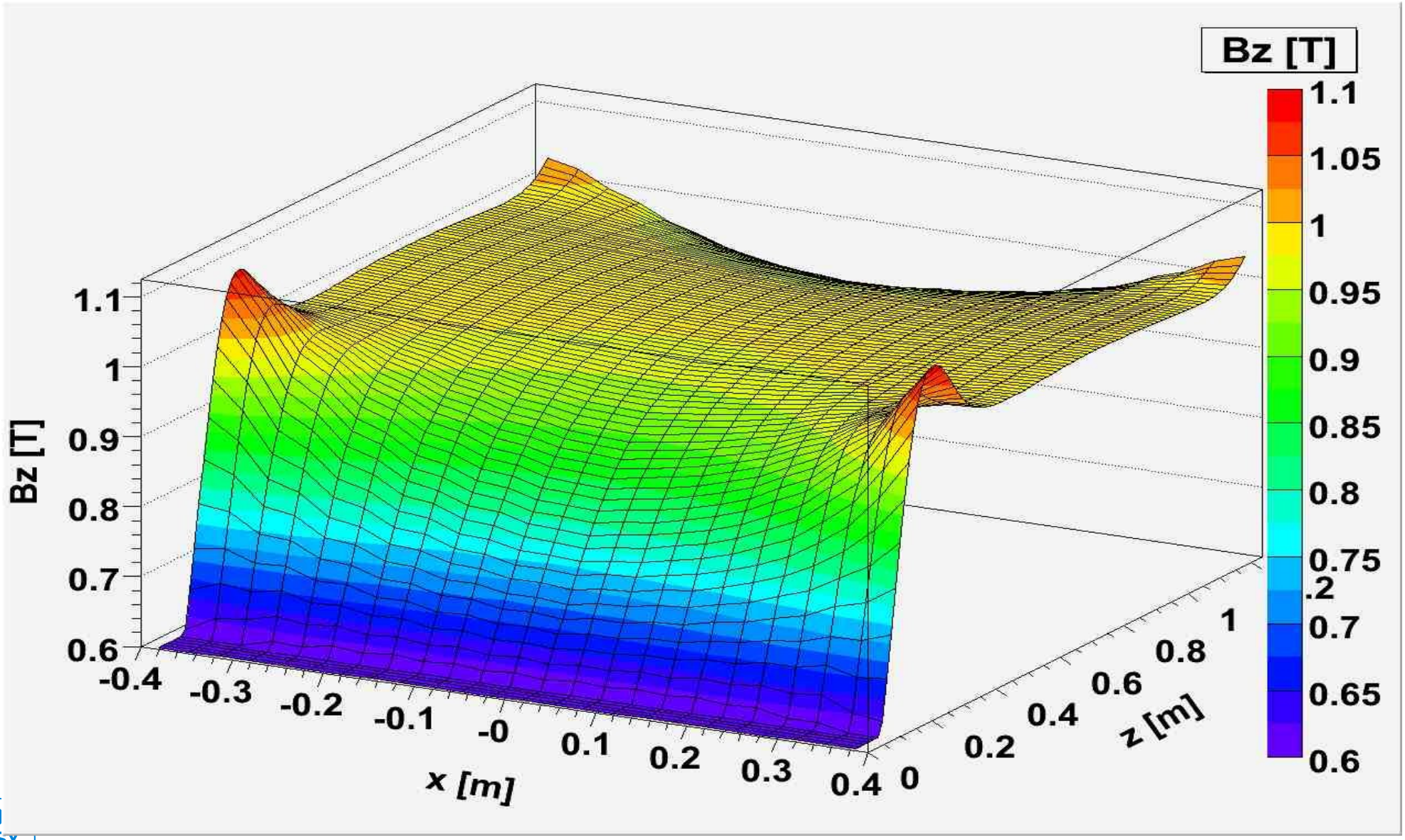
- its also necessary to correct the individual probes for the offset, since its magnitude is of the order of desired accuracy





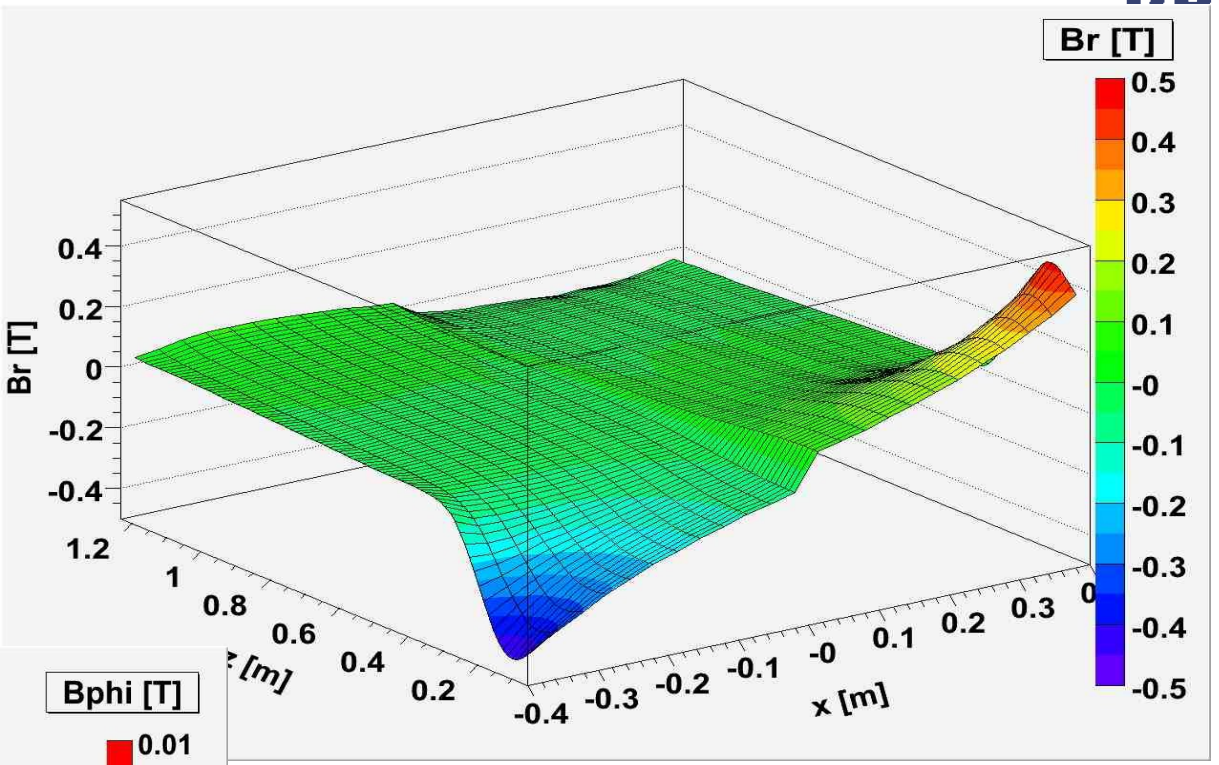
Raw fieldmap

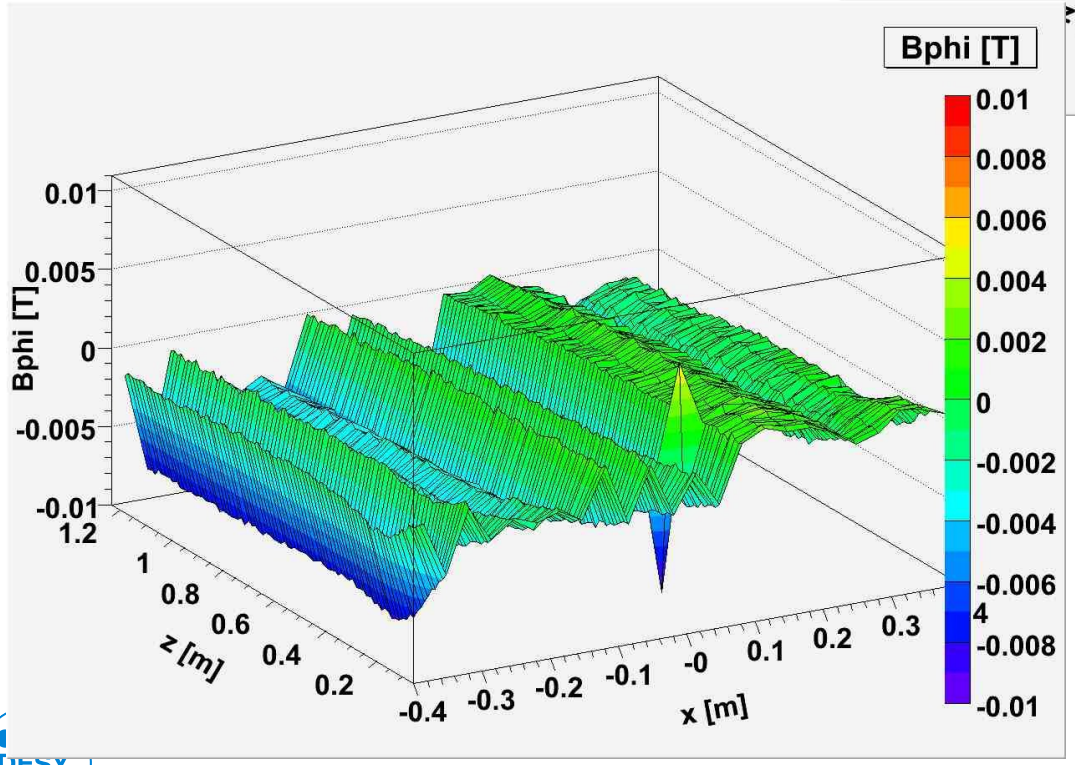
- a raw fieldmap without any corrections applied



Raw fieldmap

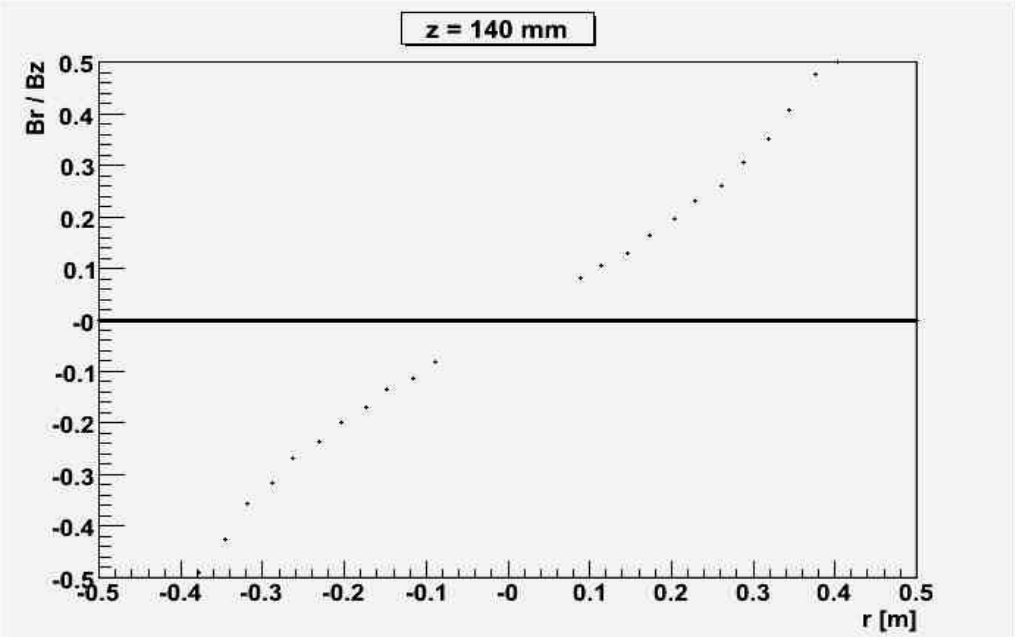
- gap in the data leads to jump in this visualization (no real effect)

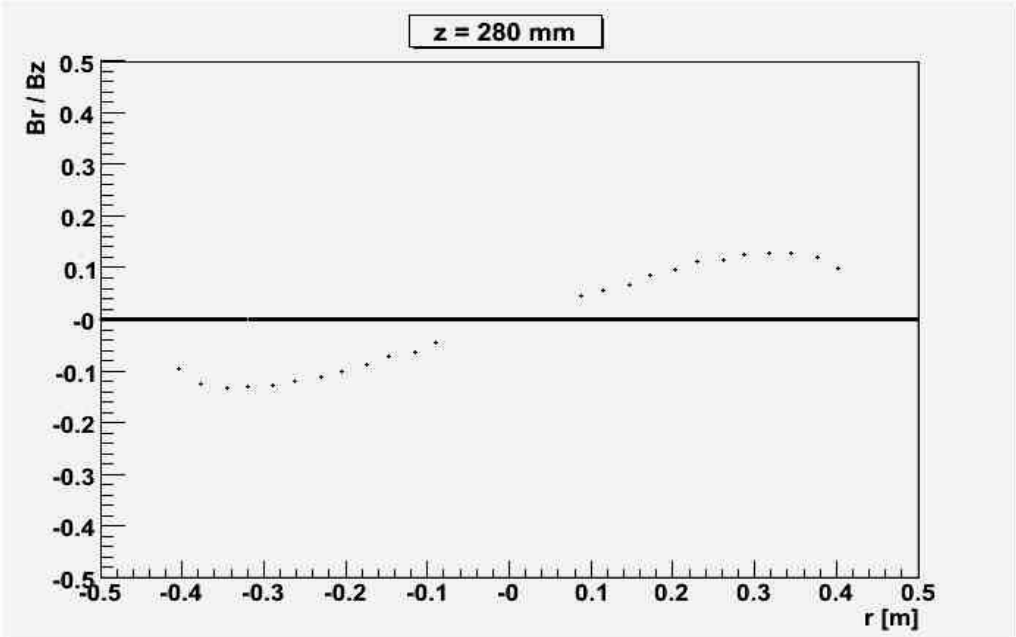


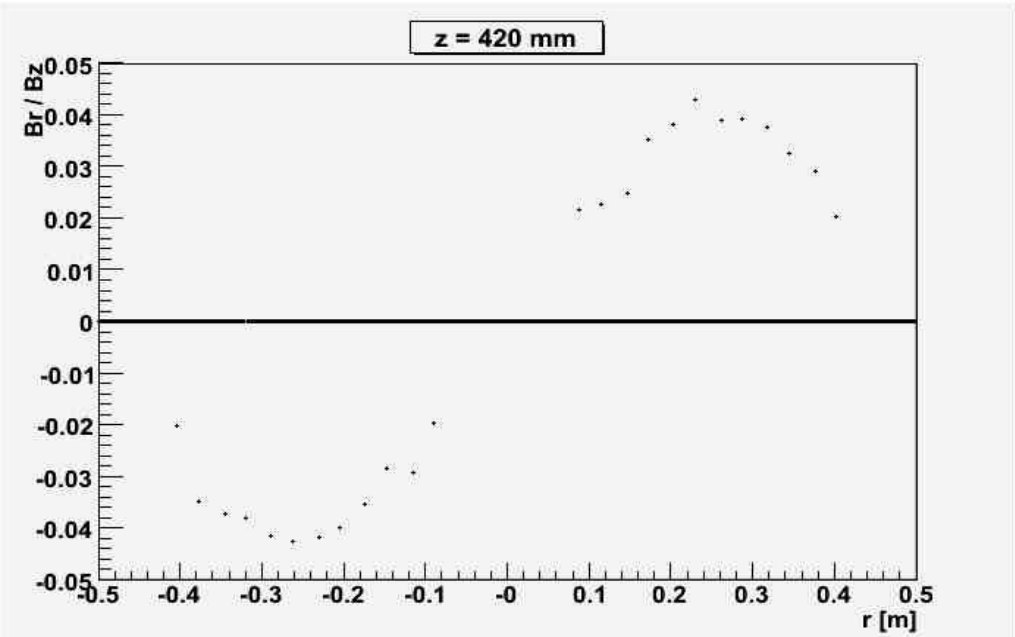


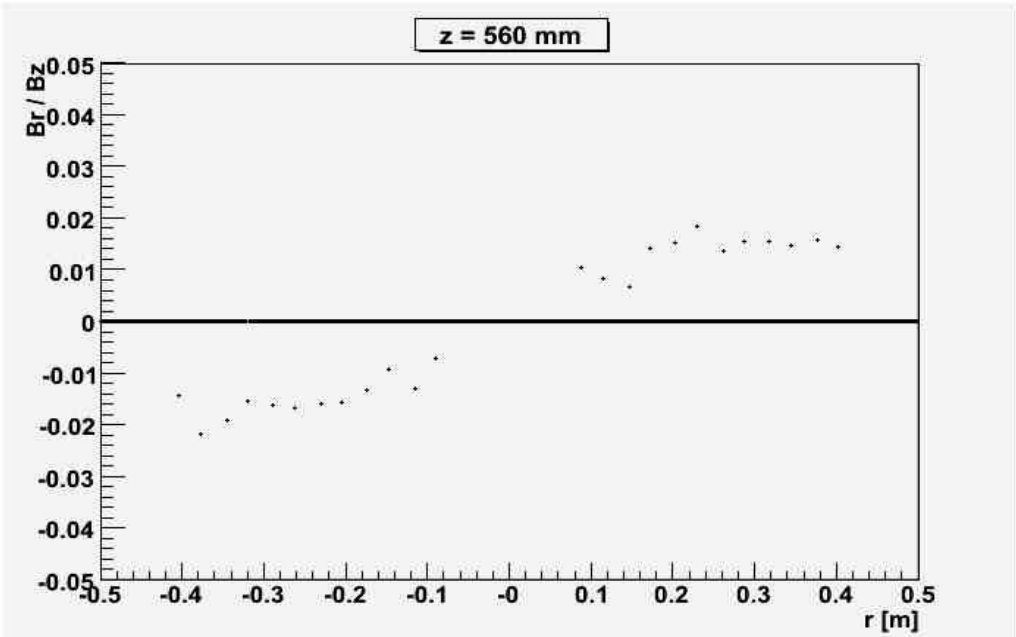
- Bphi is dominated by systematic effects
  - shift of probes
  - tilting of the cards
  - shift and tilting of the bench

Field homogeneity



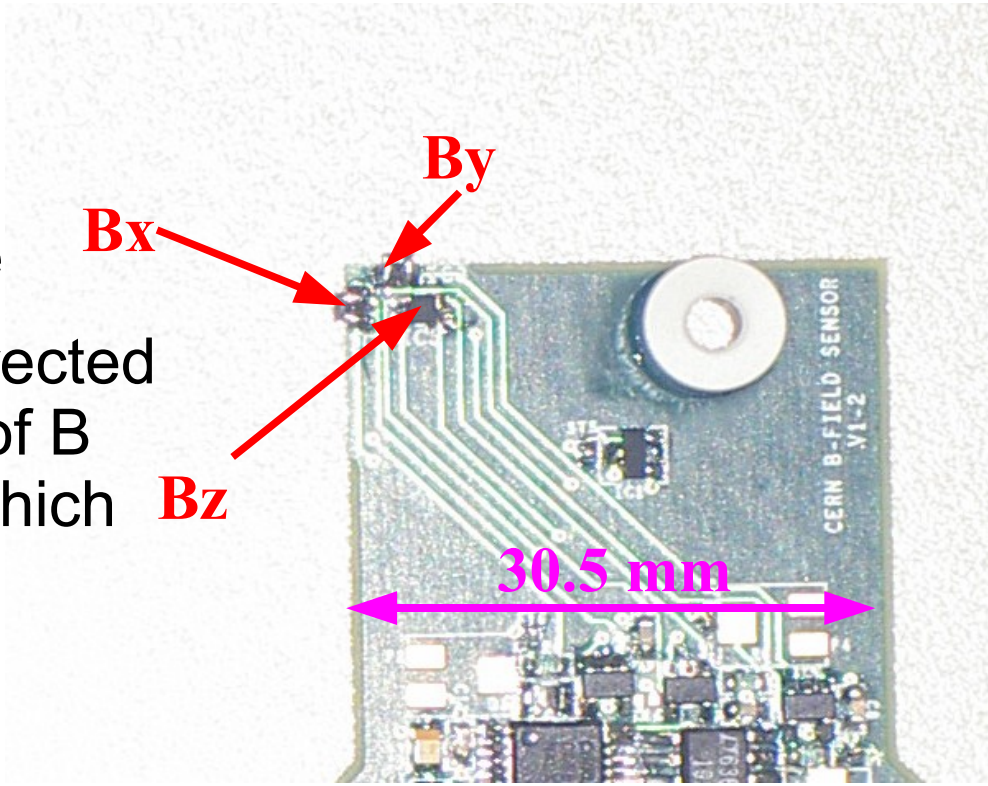






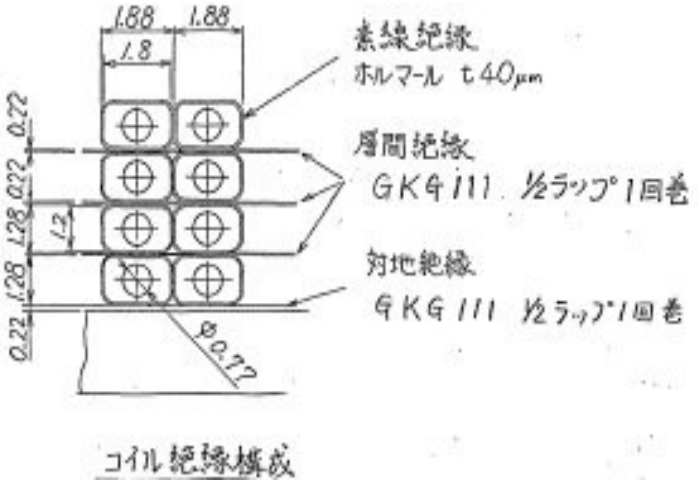
Corrections on probe positions

- during probe callibration the three probes per card are treated as if they were located at the center of mass. This is fine for homogeneous fields but leads to problems in the inhomogeneous parts of the field
- for a shift of 2 mm estimations of the field gradient lead to a shift in B of 1.4 G in the center and more than 10 G at the end of the magnet.
- tilts and shifts in the card mounting can also lead to an effect of the same magnitude
- this can be effect can be corrected by fitting the phi component of B in the homogeneous parts, which should always be zero

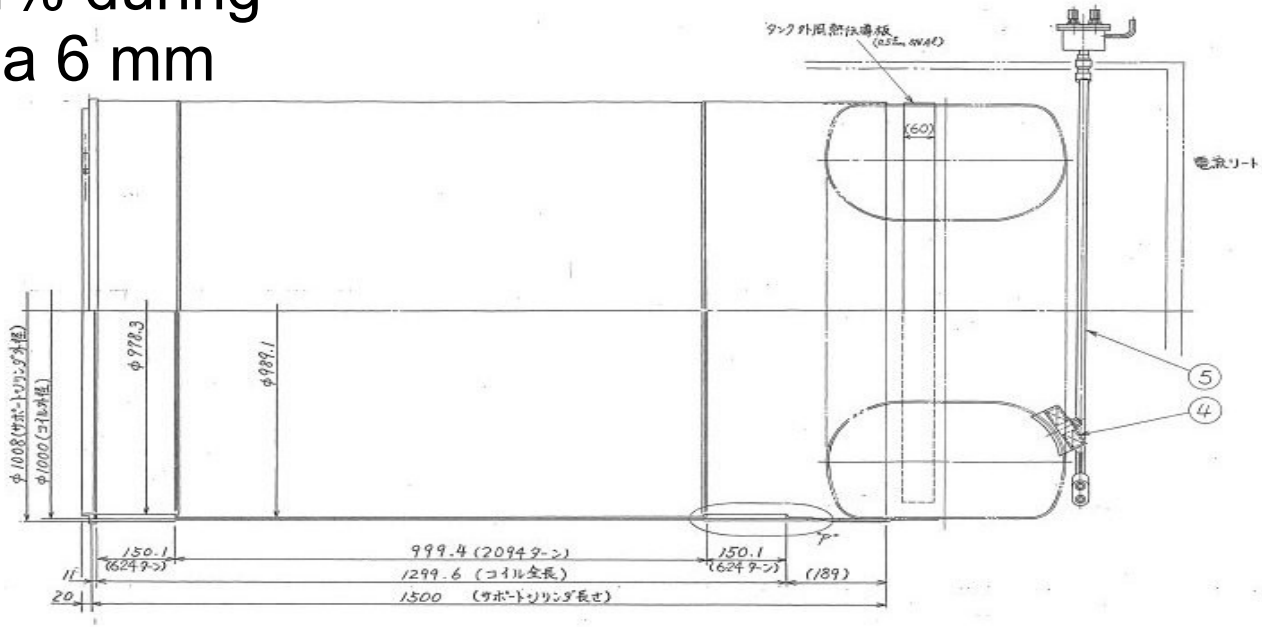


A fieldmodel for PCMAG

- since this magnet has no iron the simplest approach is evaluating Biot-Savart law for single current loops at a given point for all windings and then adding up the field
- coil parameters are ambiguous
- according to Akira Yamamoto the coil gets shorter by 0.4% during cooling, that results in a 6 mm change of length. The radius stays aproximately the same

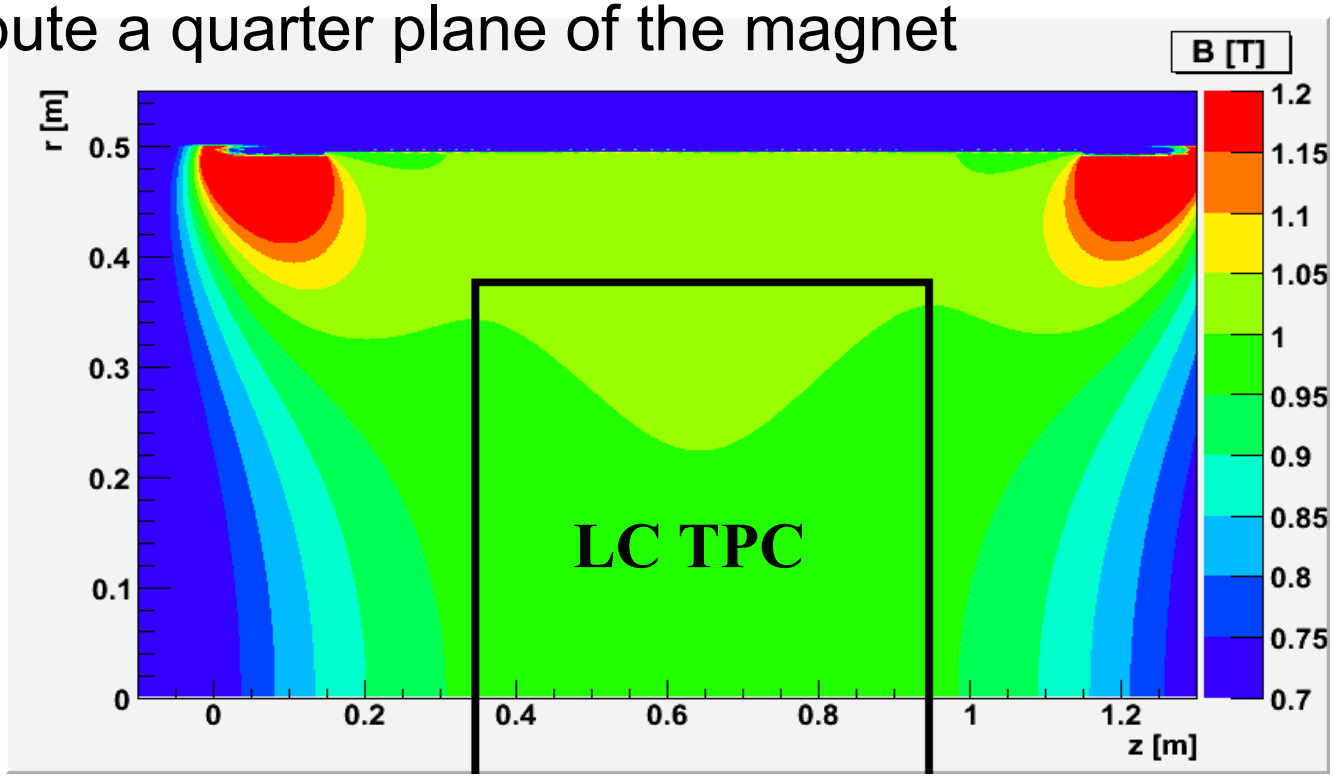


コイル絶縁構成



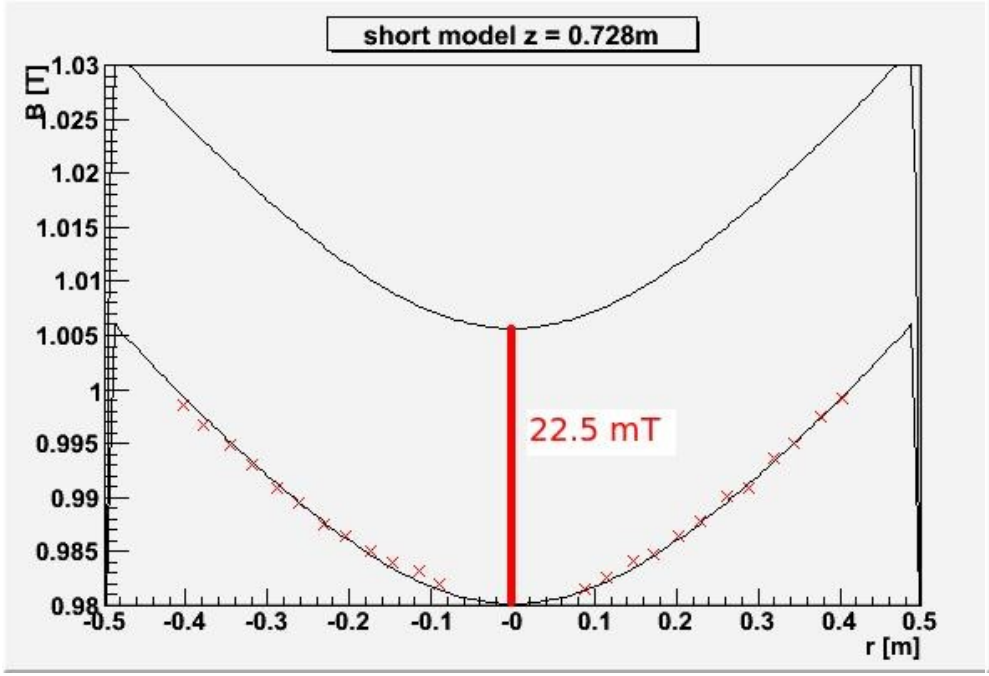
A fieldmodel for PCMAG

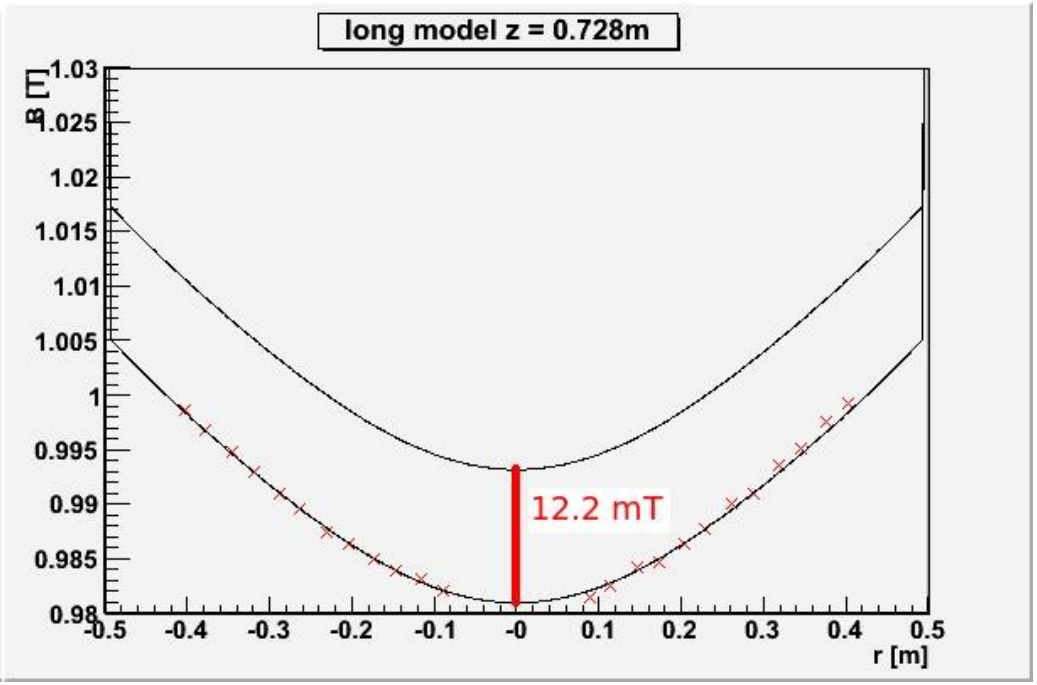
- solution
  - create two model fieldmaps, a small and a big one
  - interpolate in between
  - fit with data to get real coil parameters
- for now modell uses maximum radial symmetry, so you only need to compute a quarter plane of the magnet



Compare model and data

- depending on coil parameters (especially radius) there is an offset field between model and data
  - maybe real fields which have to be included
  - more likely the current has to be scaled to fit the data
  - maybe current loss of 1 – 2 % at switch to 'permanent mode'





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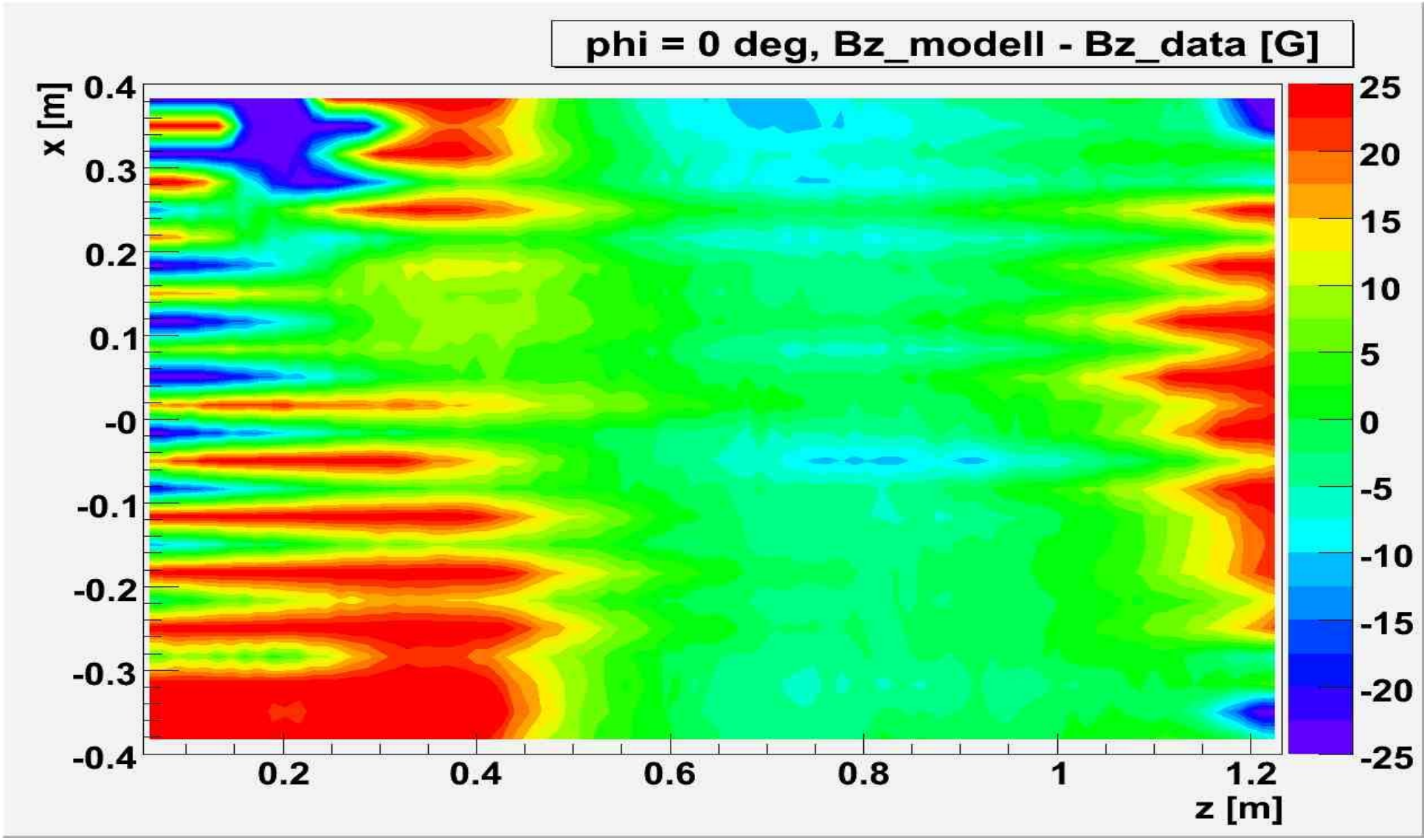

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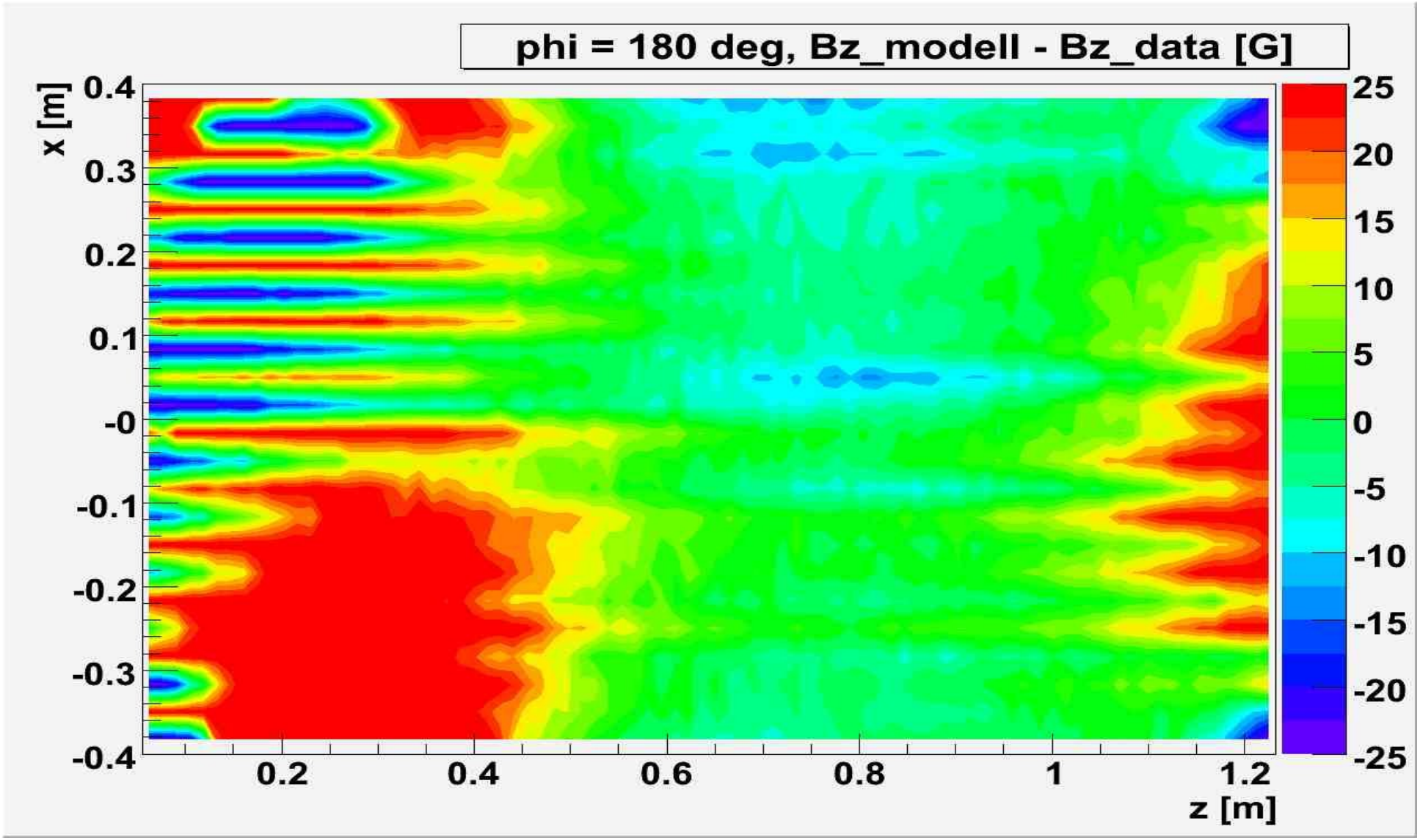

Compare model and data

- the comparison of model and raw fieldmap already shows which effects are important
  - the bench is not perfectly alingned with the axis of the magnet
  - shift in probe positions leads to stepping effect in field since shifts are in opposite directions for cards mounted on front and back of measurement arms
- all these effects are especially important for the inhomogeneous parts of the magnet and grow with field gradient

Things to do...

- correct for actual probe position
  - different positions for each field component on the card
  - include eventual tilting of the cards
- align model and data
  - geomatrical fit the coil parameters
  - include rotation of the bench
  - correct for the offset field (scale down current)

Conclusion

- NMR data shows the high stability of the magnet
- statistical uncertainty of each probe is below 2 G
- final map still needs a lot of systematic corrections
- a crude fieldmap is already available