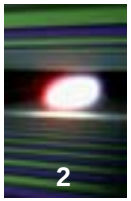
Ambient field Influence on the 5m long XFEL Undulator Segments

U. Englisch, A. Liebram, J. Pflueger
European XFEL GmbH, Germany

DESY

HELMHOLTZ ASSOCIATION

Contents of the Talk



1. XFEL laboratory and XFEL insertion devices
2. Motivation and characterization of the external Helmholtz Coils
3. Influence of an ambient field onto XFEL prototype undulators
4. Explaination model
5. Conclusions

The XFEL laboratory

Further devices:

Temperature control system: stability +/- 0.1°C

External Helmholtz Coils

collects the output voltage coming from the gaussmeter and the integrator

probe for measuring
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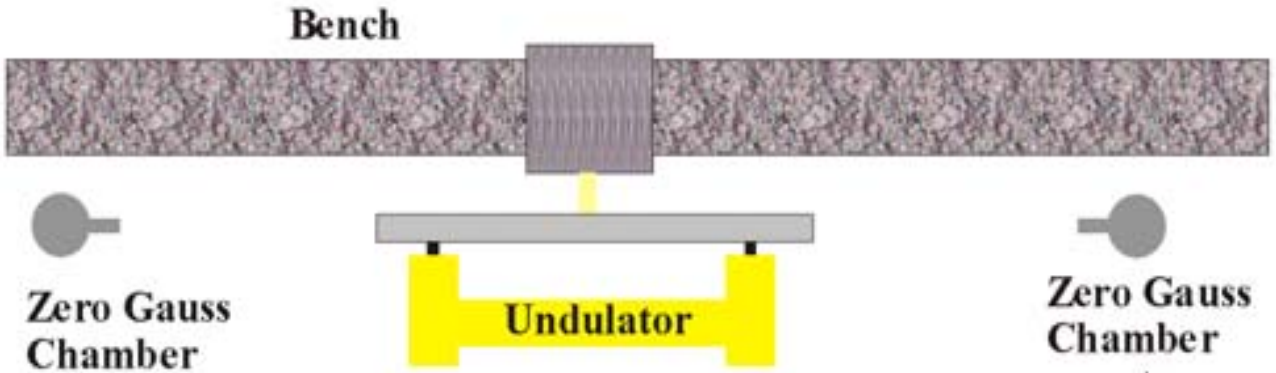
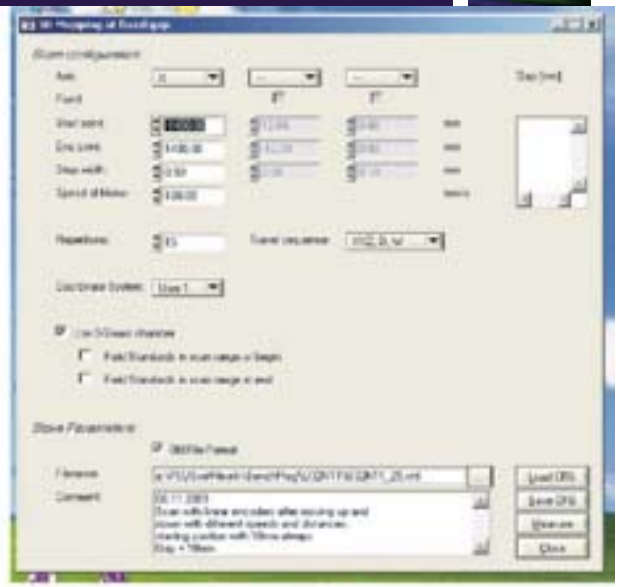
Set up for magnet field measurements





End of scan:
measuring of electronic offsets for hall sensor and coil

Start of scan:
Adjust electronic drift of integrator
measuring of electronic offsets for hall sensor and coil

Electronic offsets:
hall sensor: average of values in zero gauss chamber
coil: calculation of slope between values in right and left zero gauss chamber ⟶ able to calculate drift values for very point in the spectrum

⟩ will be subtracted from spectrum ↓

voltages will be converted into magnetic field using the calibration curves

- earth field is not subtracted for both components

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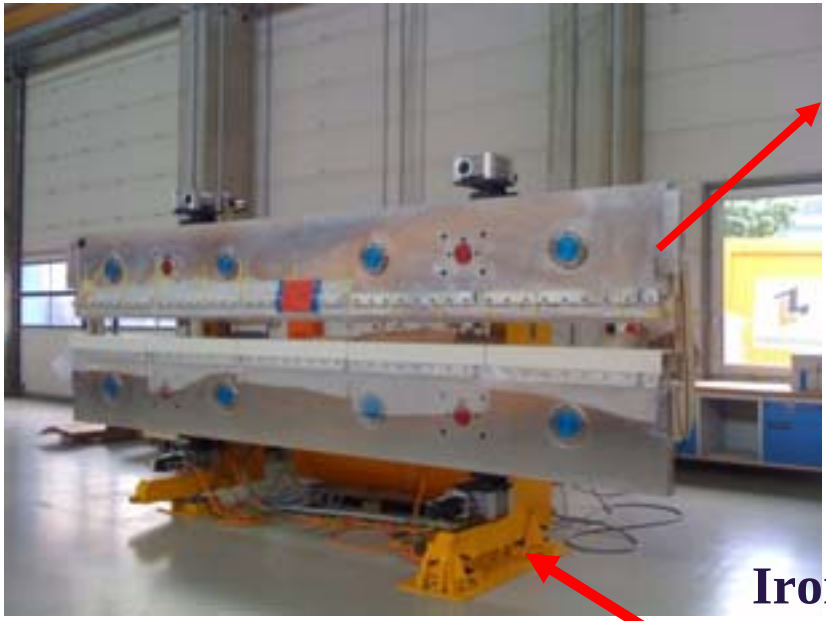
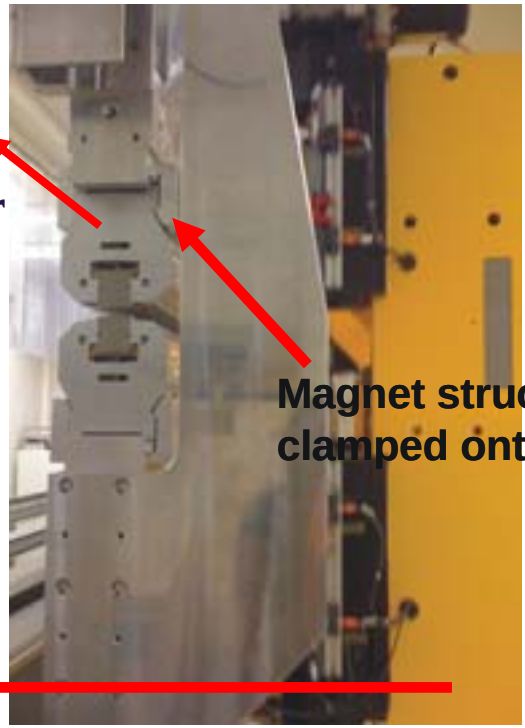
XFEL insertion devices: Hybrid Structure



Material of girders and magnet holder AlMg



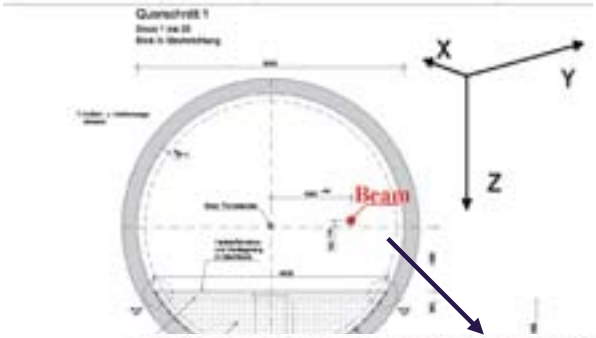
Magnet structure, clamped onto girder

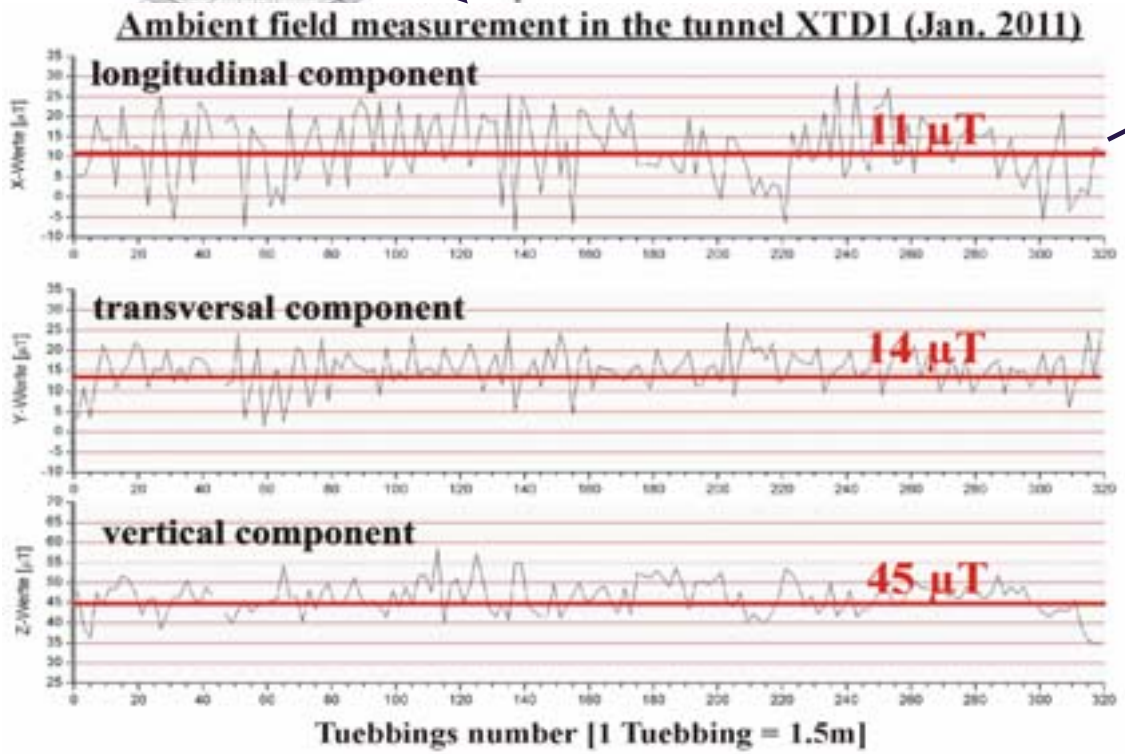
Iron Support Frame

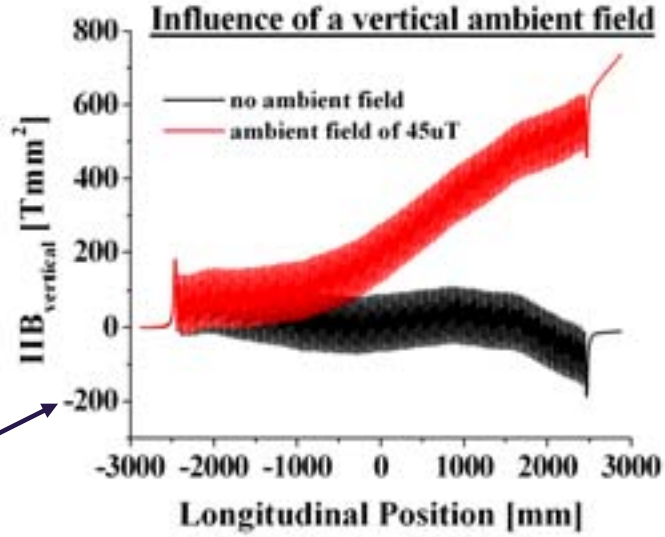
- **Requirements**
  - Temperature insensitive
  - Magnetic forces up to 160kN

- **Concept** (ZM1, since Sept.04)
  - 4-fold girder support
  - Decoupling of guiding and load support
  - 4-axis drive

Motivation for External Helmholtz Coils



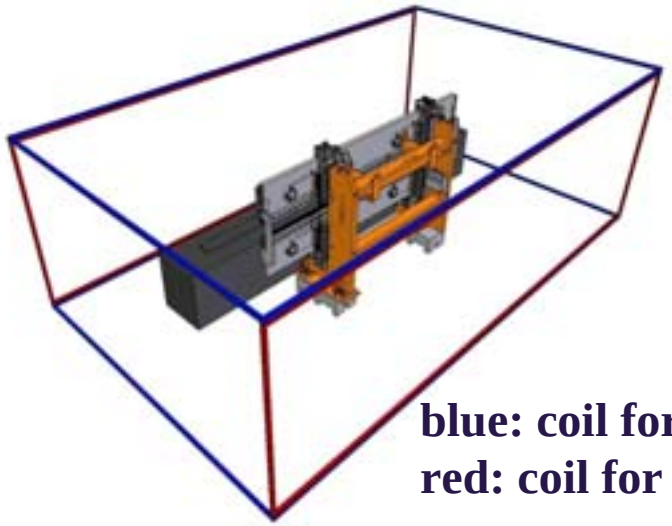




- Different ambient fields in tunnels as compared to Lab
- Adjustment of arbitrary transverse field using External Helmholtz Coils

Setup of external Helmholtz Coils

drawn by M.Roehling



blue: coil for vertical field
red: coil for horizontal field

- coils are placed in corners of the walls of the lab
- +/- 60A bipolar constant current supplies

Power supplies

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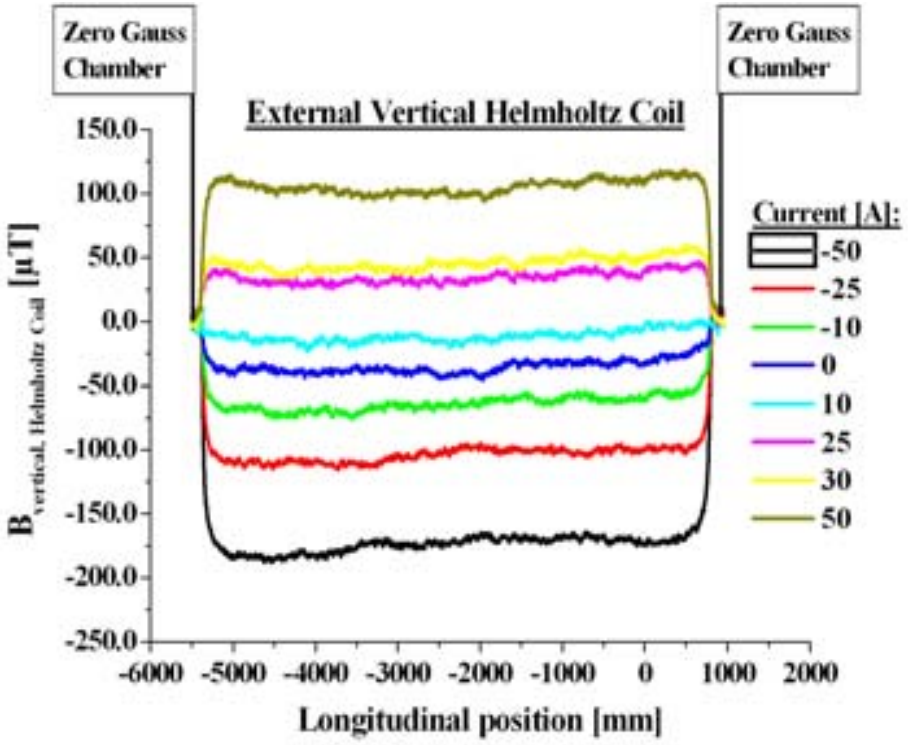
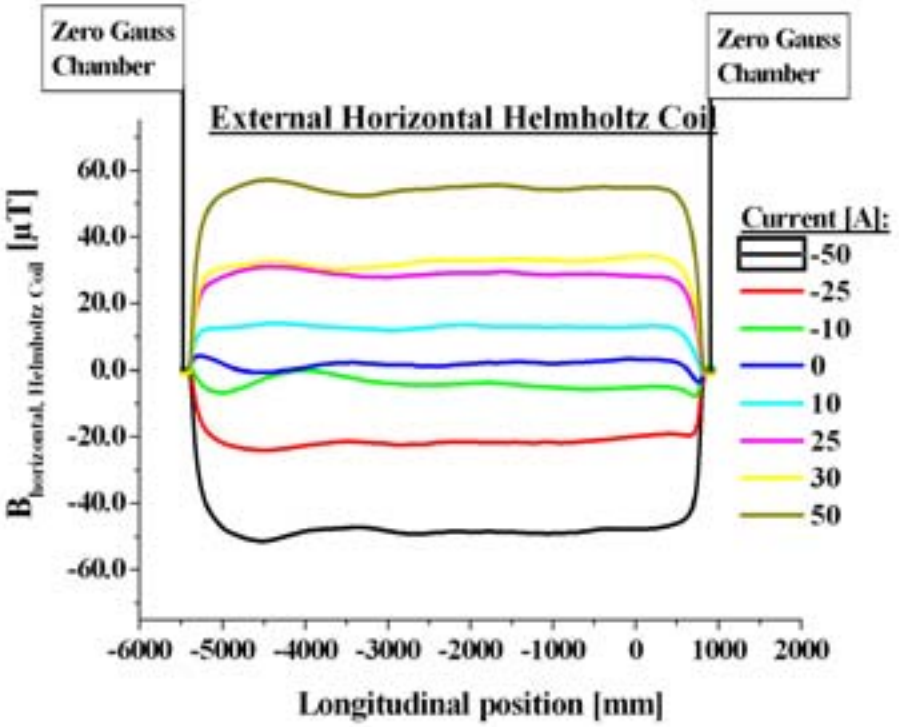
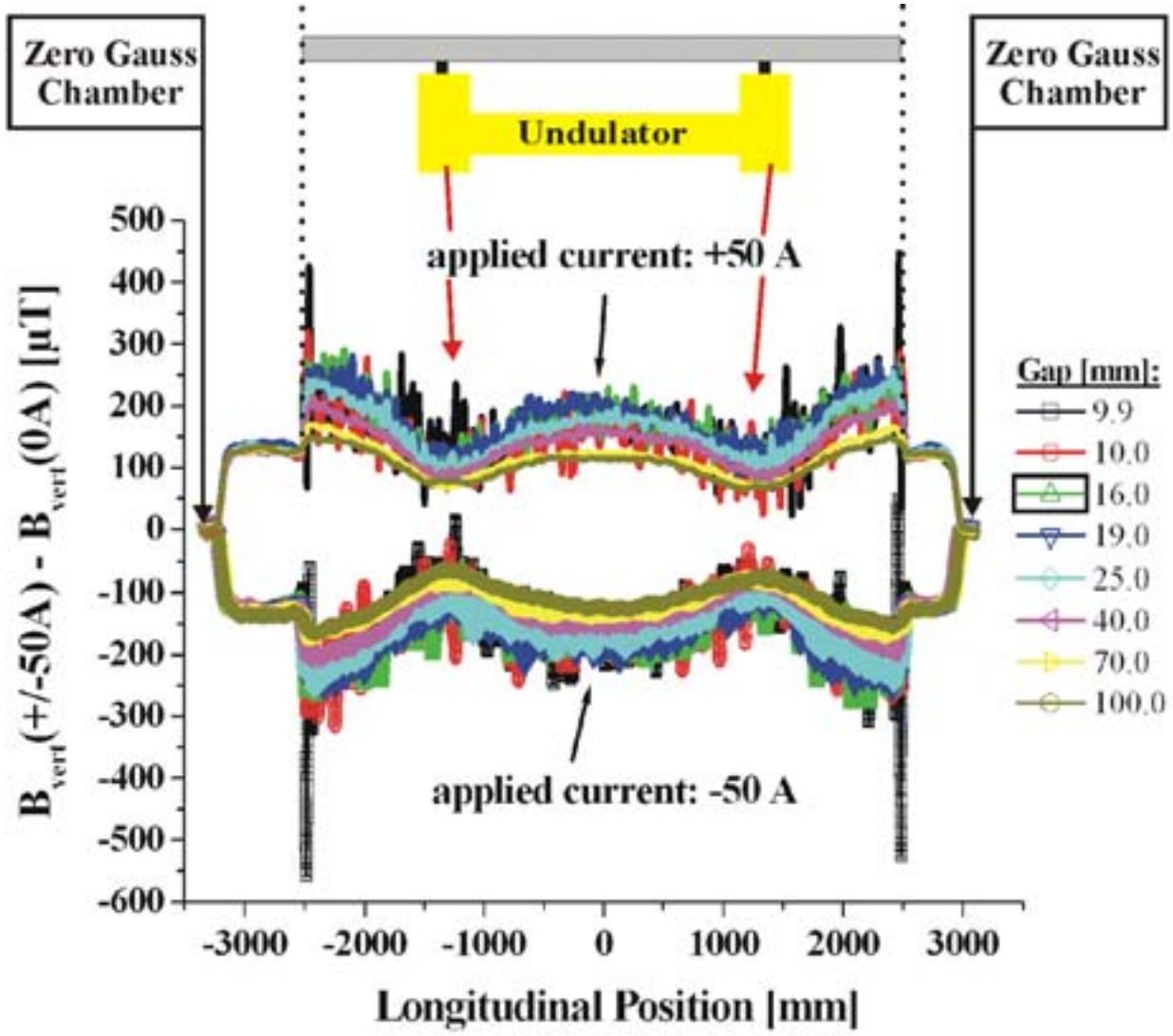
Properties of the External Helmholtz Coils

- characterization in the predefined scan range **without insertion device**
- Can do much more than earth field in Hamburg (7-8 µT / -35µT)
- good field homogeneity in scan range





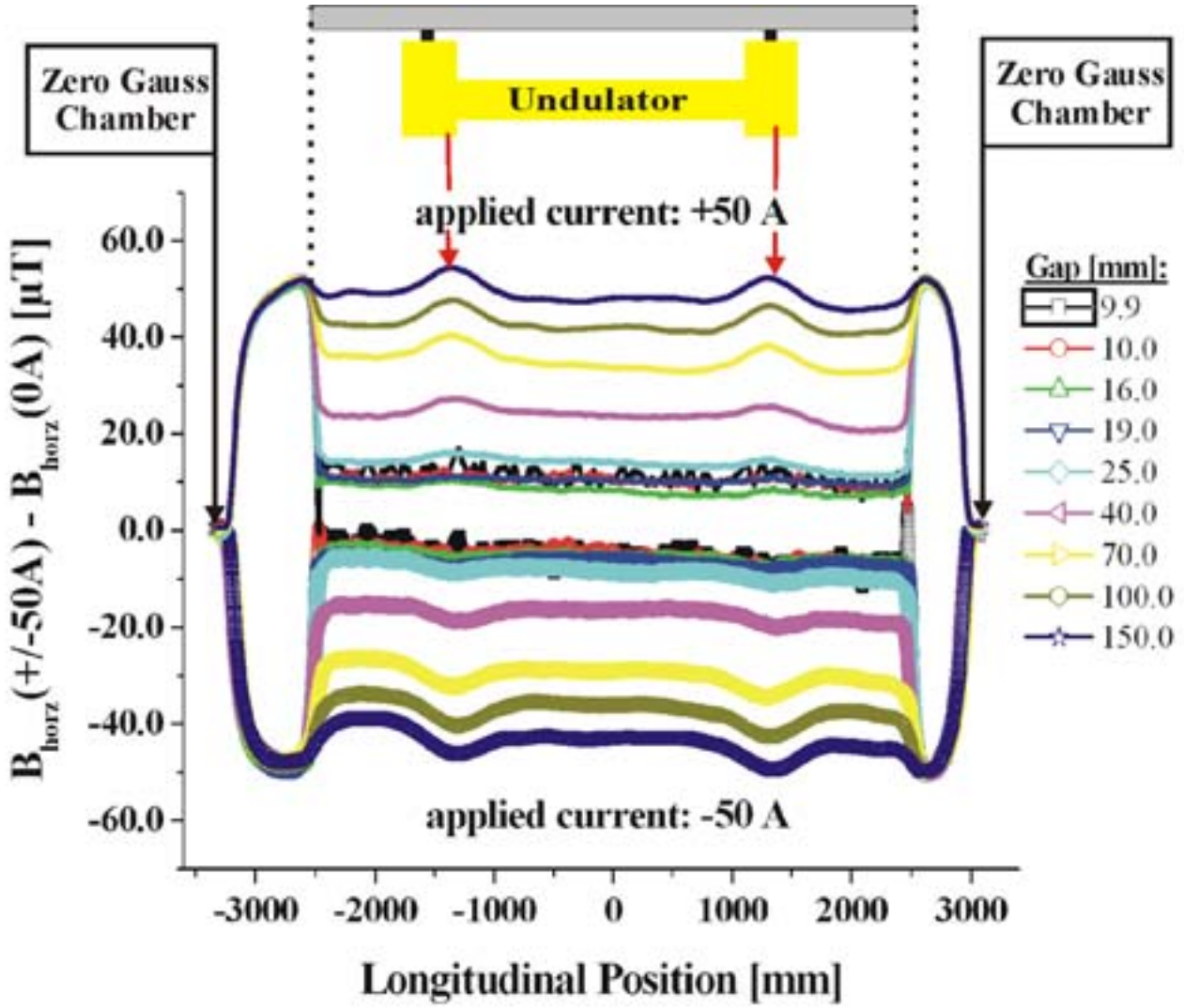
Vertical ambient field influence onto a XFEL undulator (Prototype U48)



Vertical field:

- Scan from zero gauss at start to zero gauss chamber at end
- Difference spectrum: B_{vert} (+/- 50A) - B_{vert}(0A)
- amplification factor shows longitudinal dependency max. value: 1.4 – 1.6
- field decreases strongly at C-support
- low gap dependence

Horizontal ambient field influence onto a XFEL undulator (Prototype U48)

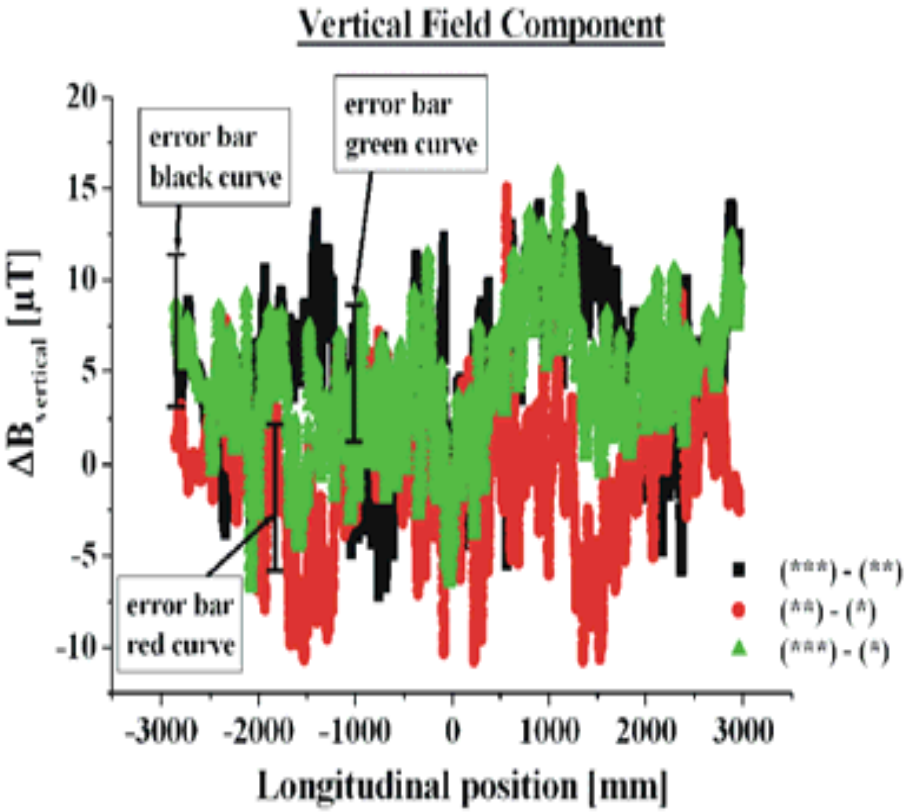


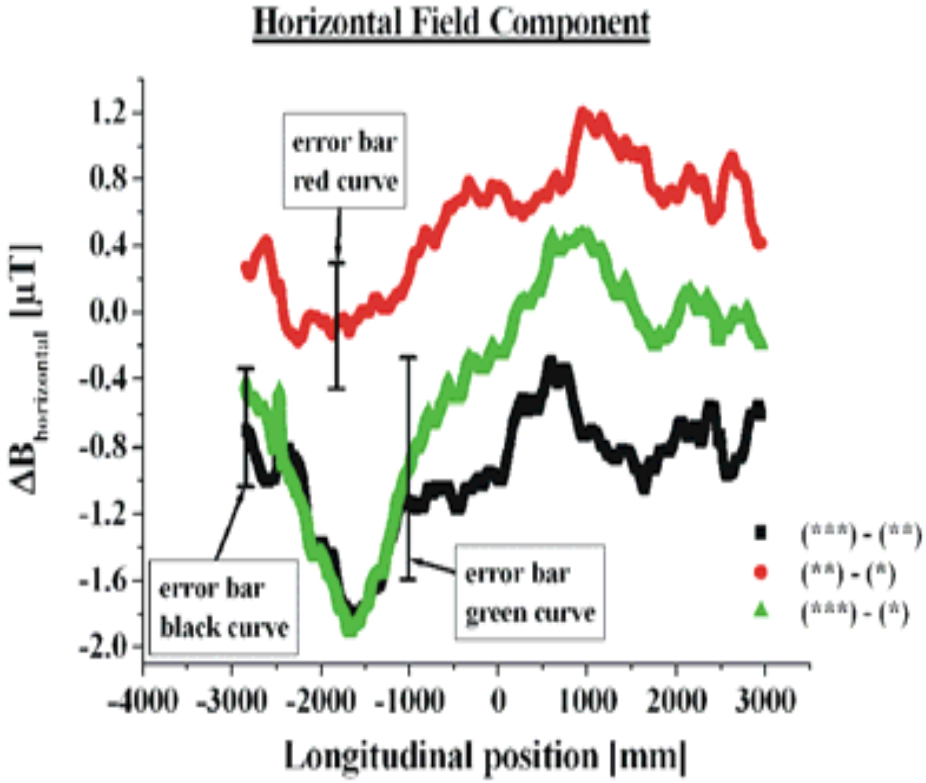
Horizontal field:

- Scan from zero gauss at start to zero gauss chamber at end
- Difference spectrum: B_{horz} (+/- 50A) - B_{horz}(0A)
- vanishes for low gap
- rises up if gap will be opened –> gap dependent shielding
- at C-Support horizontal field is increased in contrast to the vertical field

Hysteresis Effect for Prototype U48

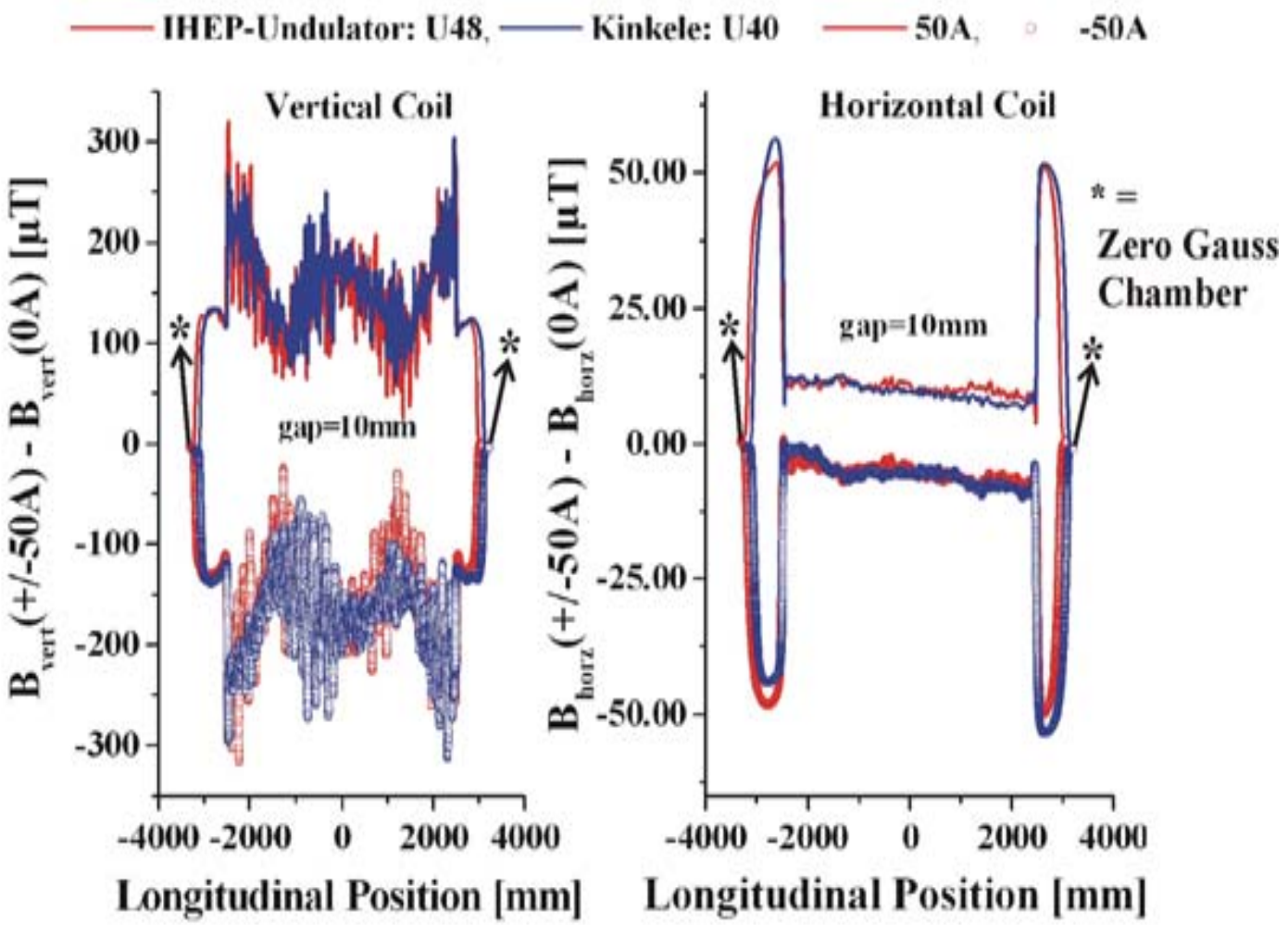
Current Cycle: 0A (*) –> 50A –> 0A (**) –> -50A –> 0A (***)





- within the error bars hysteresis effect can be neglected

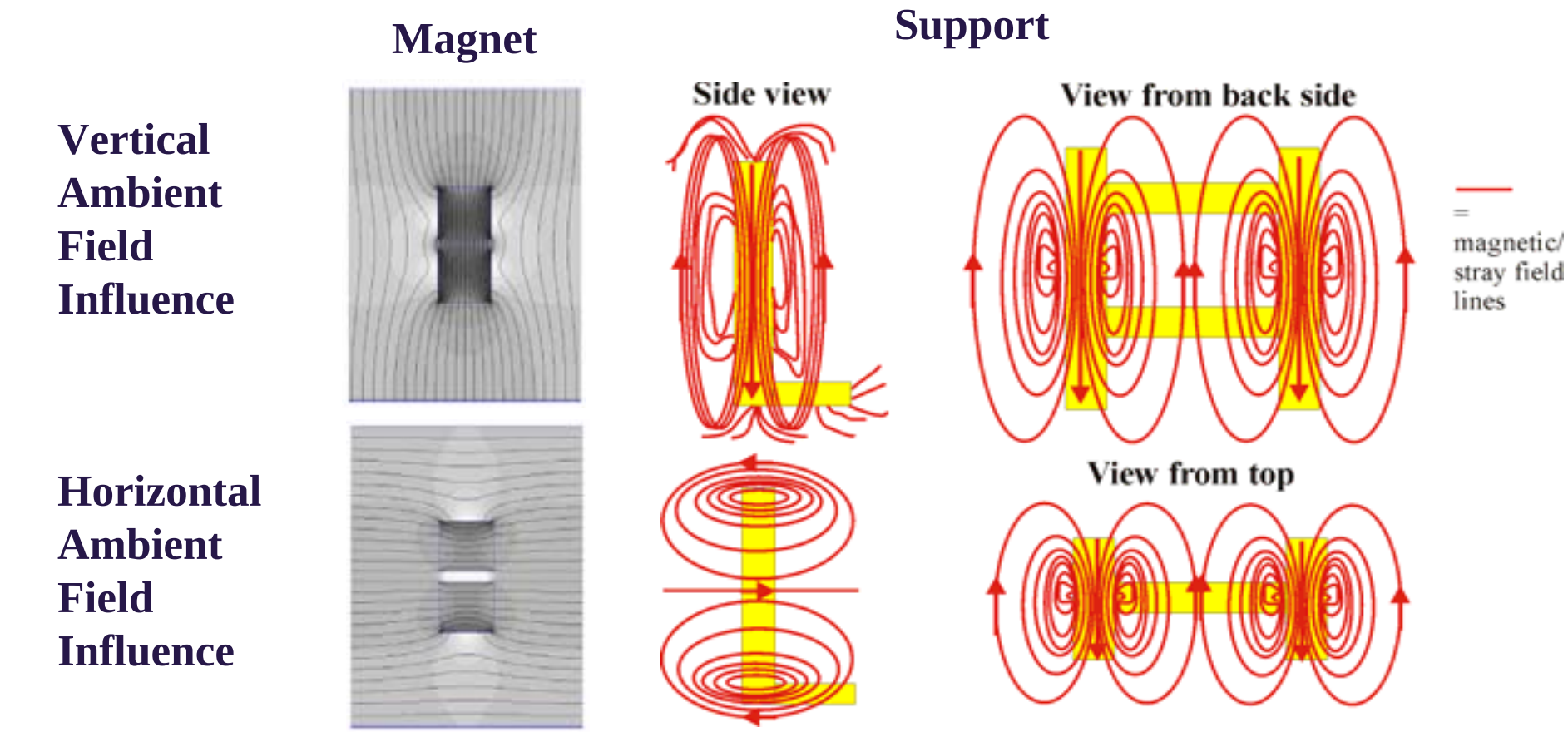
Comparison between Prototype (U48) and Pre-Series Model (U40)



- Check if the undulators coming from different companies show same behaviour
- Very recent measurements
- Same behaviour of the support with respect the ambient field application

Explaination Model

- taken into account ambient field behaviour in magnet and support structure
- magnetic structure: vertical ambient field enhanced, horizontal ambient field shielded
- support frame: behaves like a bar magnet



Conclusions

- accuracy for magnetic measurements
  vertical field component: down to 30uT on the poles
  horizontal field component: 8-10uT on the poles
- built-in external helmholtz coils allow application of an ambient field much more than the earth field in Hamburg
  vertical field component: -175uT – 125uT
  horizontal field component: -63uT – 51uT
- high homogeneity of applied ambient field in our scan range
- vertical ambient field is amplified if the influence of the C-support can be neglected –> amplification factor varies with longitudinal position
- horizontal ambient field vanishes almost for low gap and rises up to higher gap
- C-supports diminishes the vertical ambient field but amplify the horizontal field
- hysteresis effect can be neglected