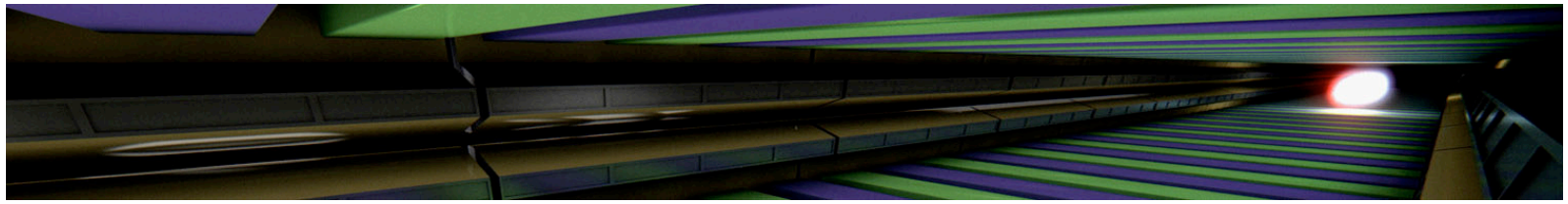
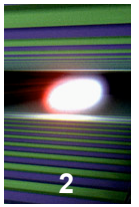


Status of Undulator Systems January 2009

Joachim Pflüger XFEL / DESY

European XFEL

Overview



- R& D Activities
  - Pre-Series Prototype Mechanics
  - Phase Shifter
  - Magnetic Measurements, XFEL Measurement Room
  - Tunnel Temperature Stabilization
- In Kind Contributions to WP71
- Time Schedule

R & D Actitivities

5m Pre-Series Prototype Design

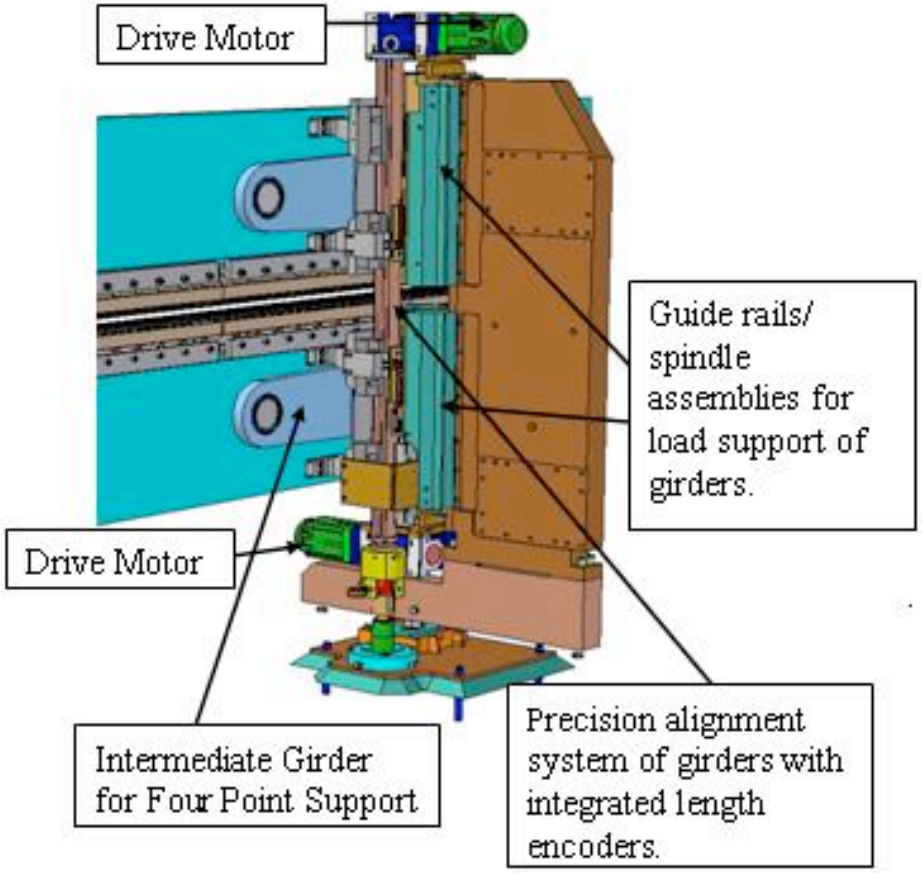
Reviewed Design 2008 for Pre-Series Prototypes

Motto simpler, better, cheaper

Includes:

- Relaxed Tolerances: Girder Material AlMg
  Y. Li, B. Faatz, J. Pflueger, Phys. Rev. ST-AB 1,100701 (2008)
- Simplified Girder Guiding → cheaper AND better
- Low Friction spherical Support Unit of Girder
- Smaller and cheaper Spindles
- Direct Measurement of Gap

Old: Girder Guiding using separate Guide Rail

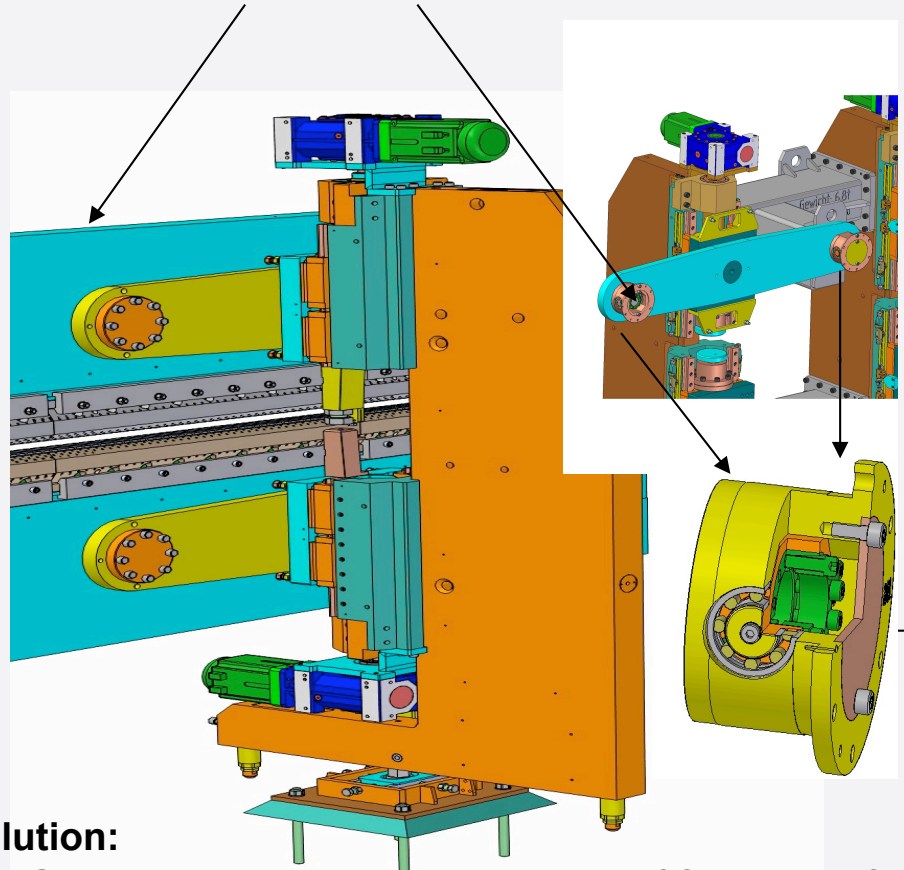


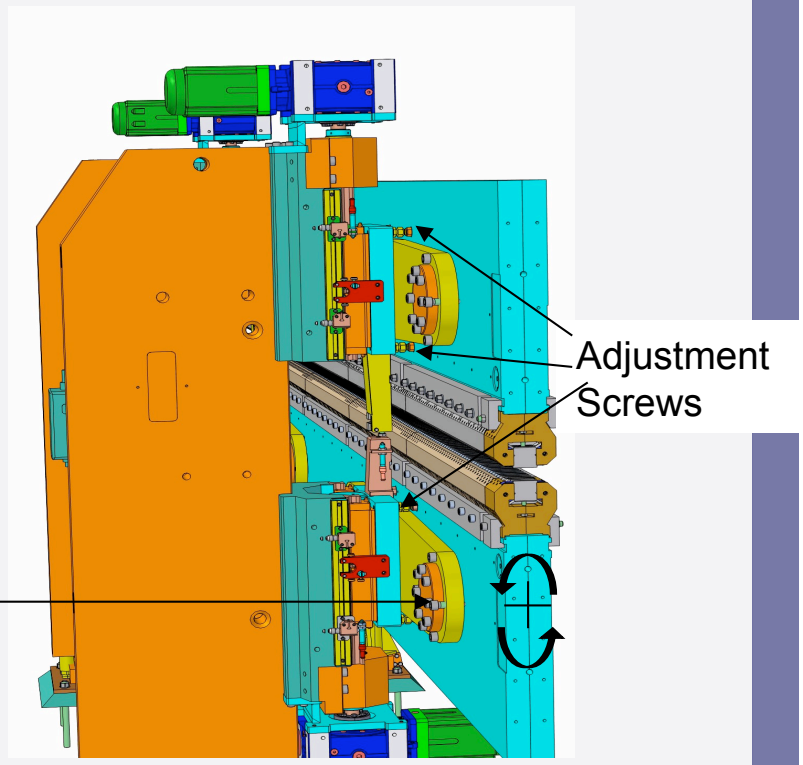
Strict separation between:

- **Load support (Load ↔ deformation)**
- **Force free girder guiding (precision)**

New: Girder guiding by Support

Problem: The old intermediate girder deforms und magnetic forces. Girders deflect by 500μrad each





Solution:

- **Girders have a rotational degree of freedom of low friction**
- **Alignment through the support guide way, adjustable via screws**
- **Girder Tilt ≈ ≤ ± 100 μrad → more accurate and cheaper**

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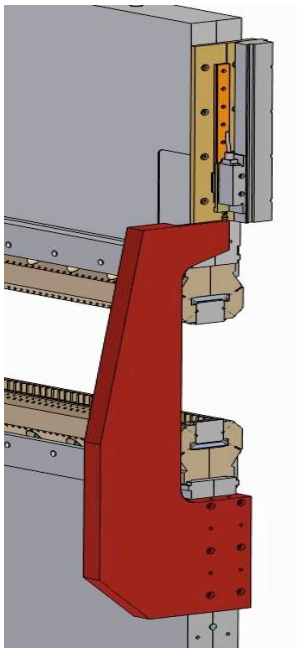
Direct Measurement of Gap



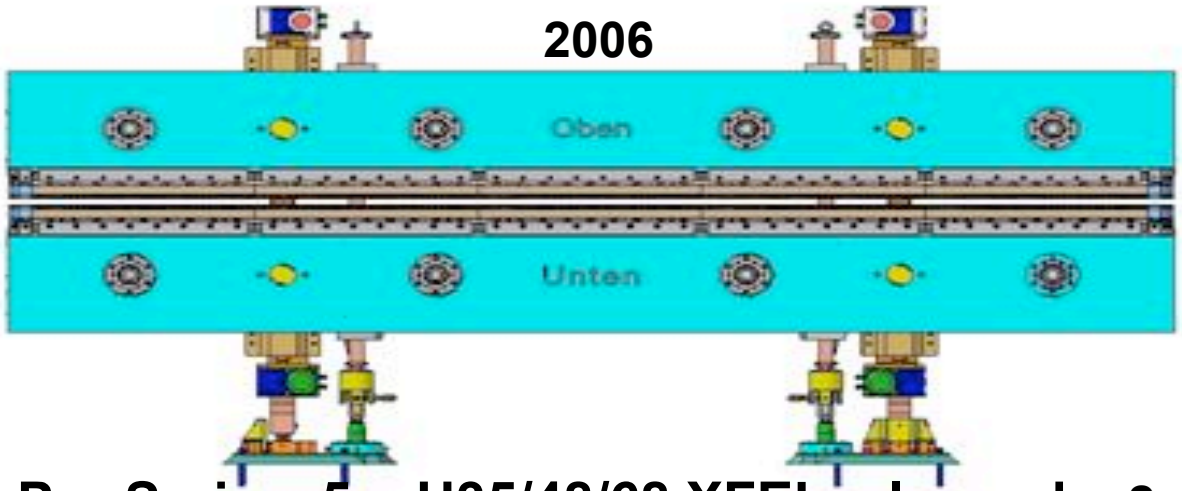
Required Accuracy ± 1μm

Problem: Forces of Measurement

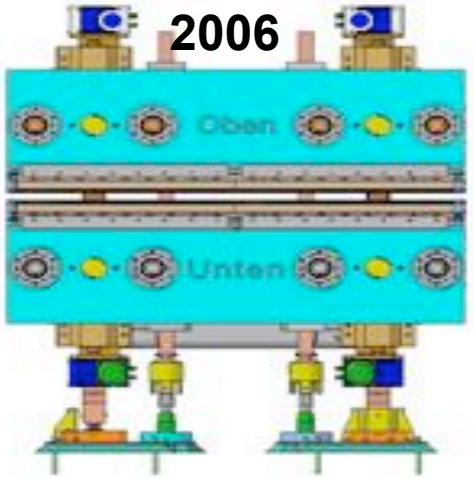
Best Result at present: ± 1μm

Prototyping Experience (Dec 08)

1. Generation 5m U29 Petra III /XFEL 2006

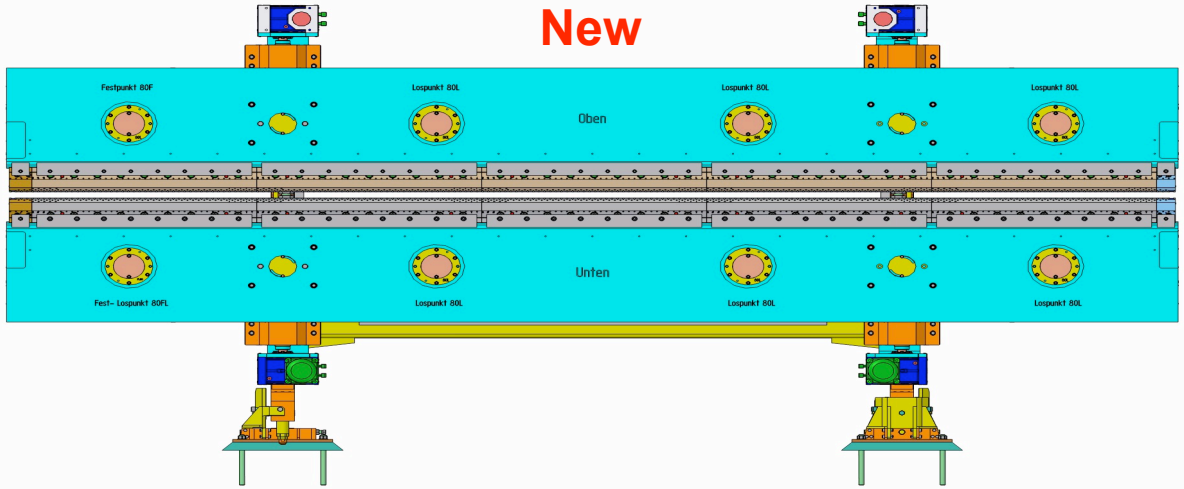


2m U29 PETRA III 2006

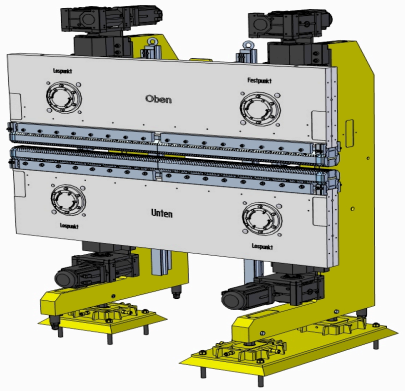


Pre-Series 5m U35/48/68 XFEL, planned

New



2. Generation 2 m U32 PETRA III 2007-Present



Phase Shifter

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中國科學院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

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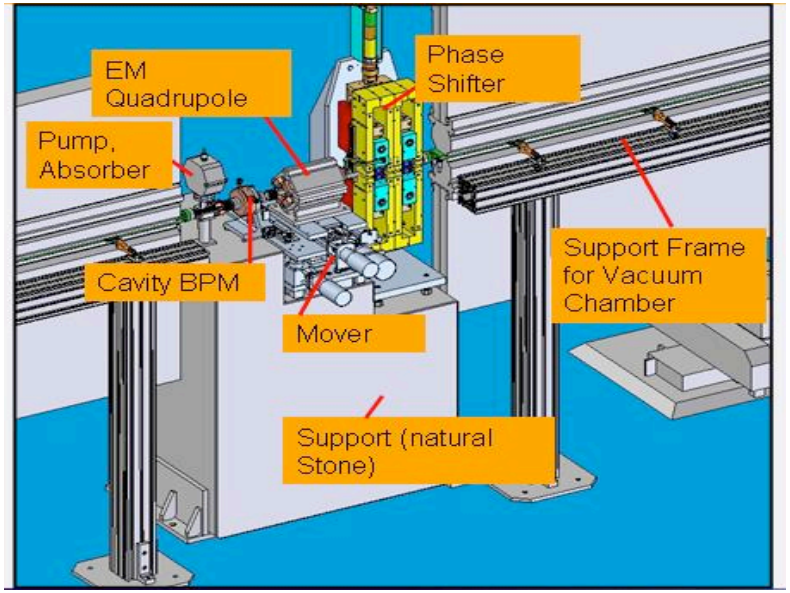
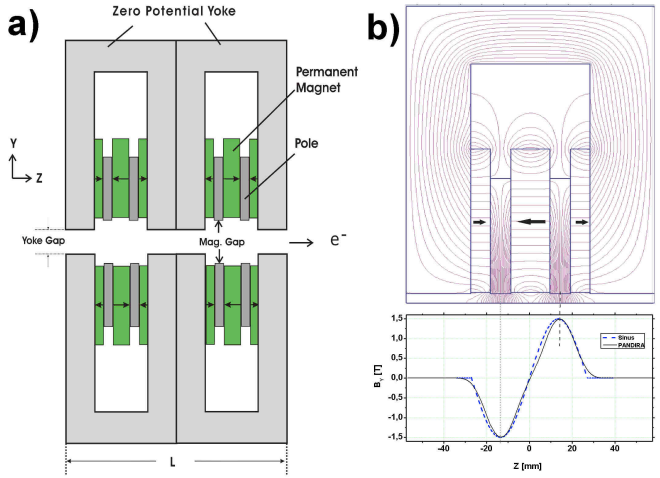
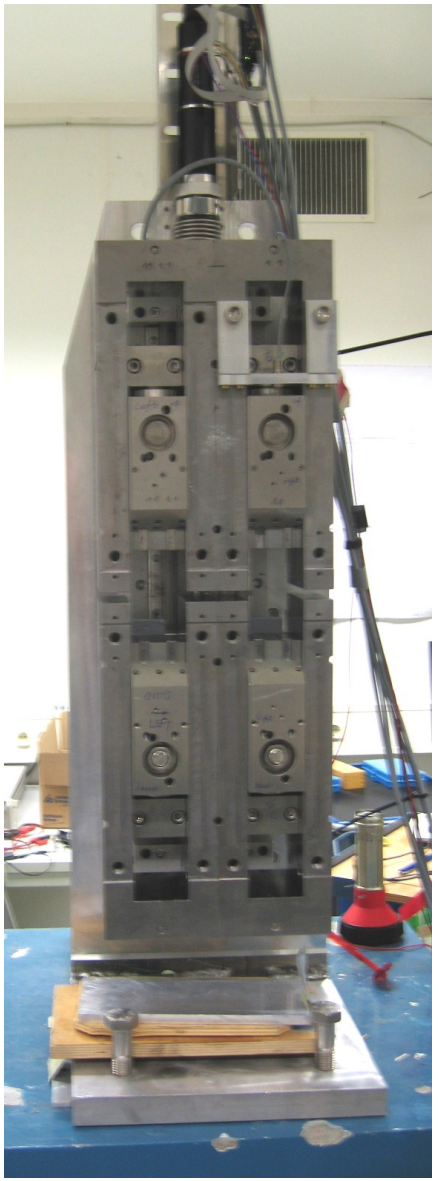
Phase Shifter: General







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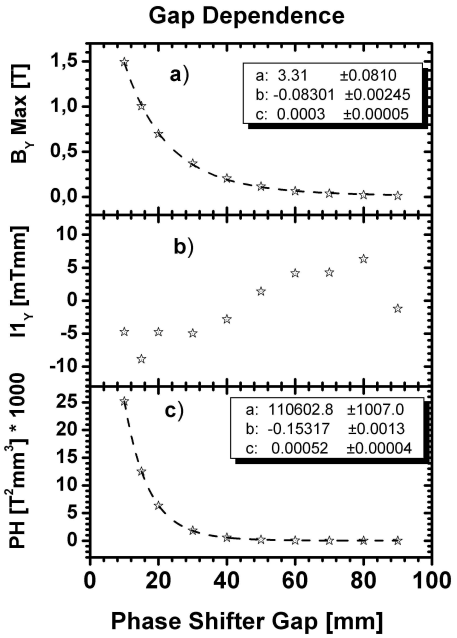
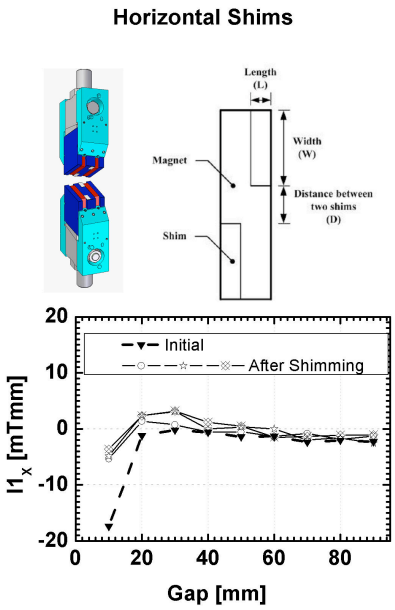
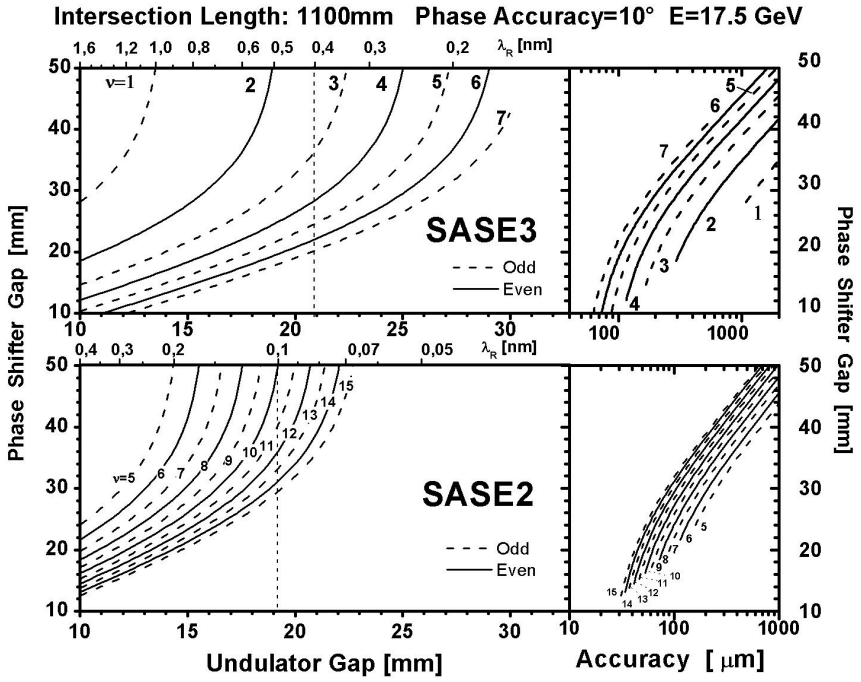
Phase Shifter: Final Results

$$PI(g_P) = \left(\frac{mc}{e}\right)^2 \left(\frac{\lambda_U \left(1 + 0.5K_U^2(g_U)\right)}{2\pi \; n} \nu \; \pi - L\right) = \left(\frac{mc}{e}\right)^2 (\lambda_R \gamma^2 \nu \quad - L) \geq 0$$







Vertical Field

Huihua Lu, Jian Zhuang, Motuo Wang, IHEP

Horizontal Field

Phase Tuning Curves

J. Pflüger

New Magnetic Lab, Magnetic Measurements

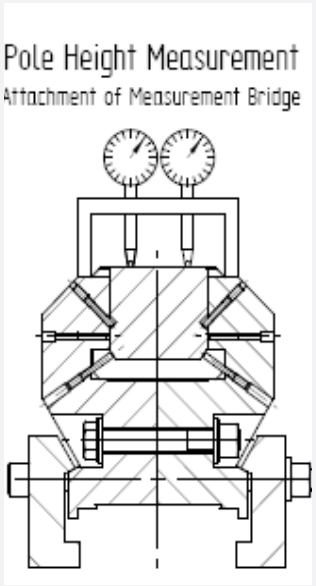
Magnetic Measurements, New Magnetic Lab

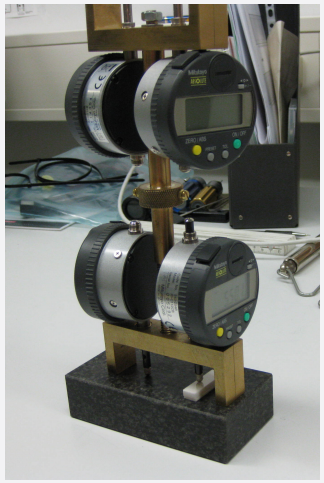
Progress in 2008

- Magnetic Measurements
  - Pole Height and Tilt Tuning is working fine, routinely used
  - Magnet Measurement Techniques needed for XFEL is available
- New Magnetic Lab
  - Lab operational
  - Temperature Specs fulfilled
  - Control Software working
  - In Use for PETRA III Devices

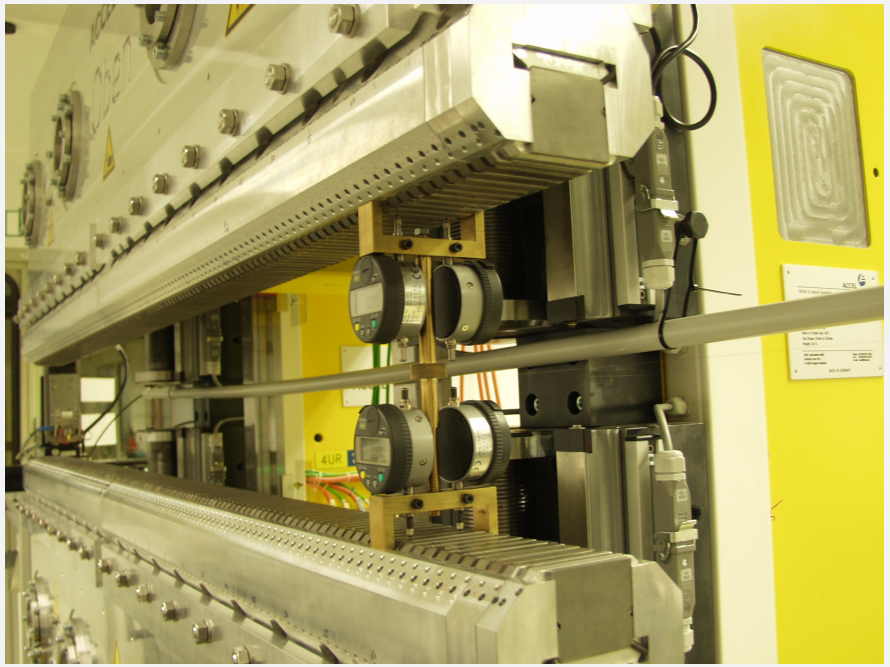
Pole Height Adjustment using μm Dial Gauges

Measurement Bridge





Double Bridge in Use



Reading Accuracy: ±1μm

Requirement: ±5μm

Direct view
Simple, easy to use
preferred Method

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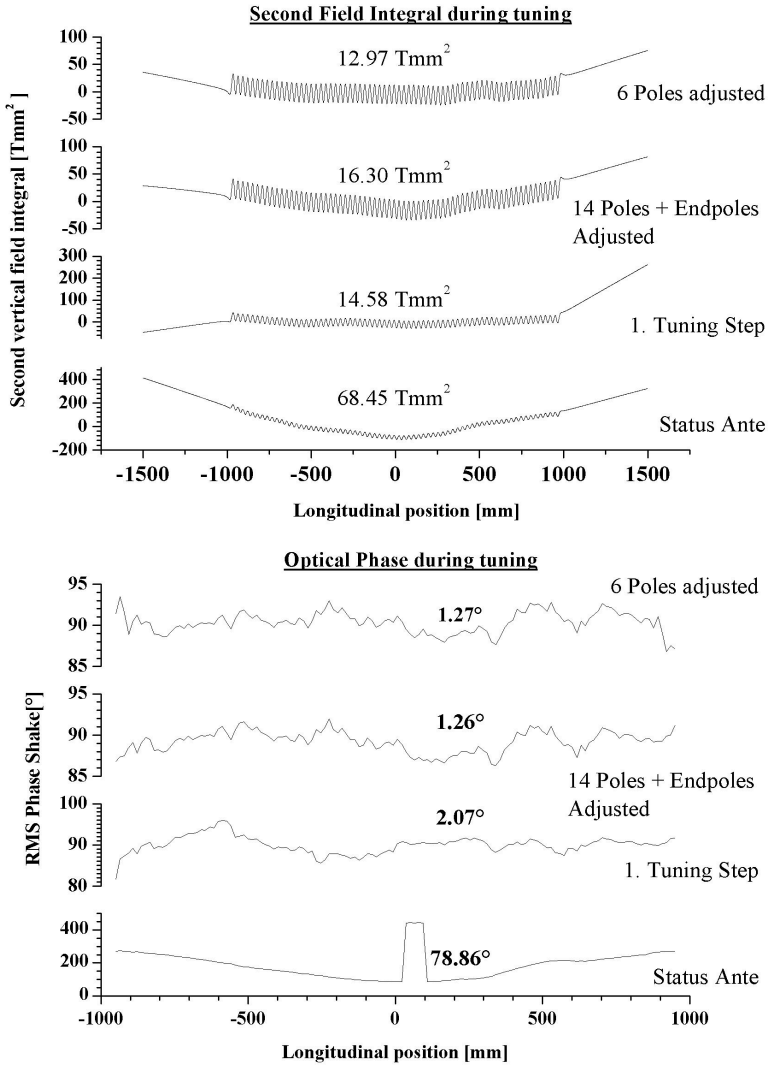
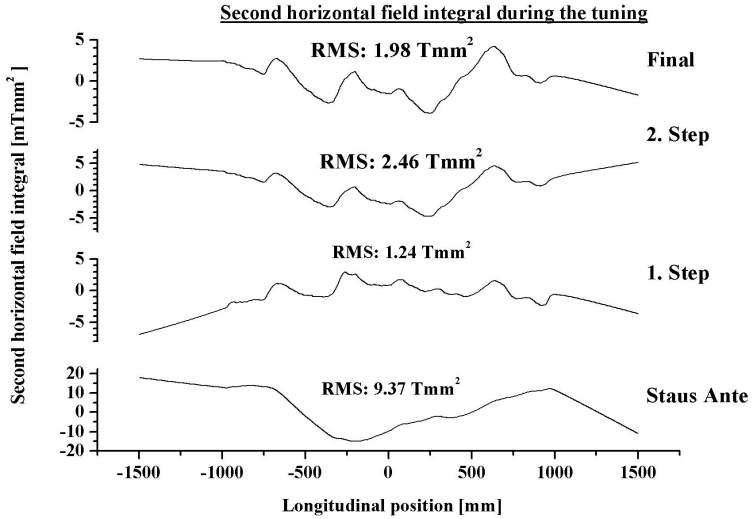
Field Measurements Results New Lab



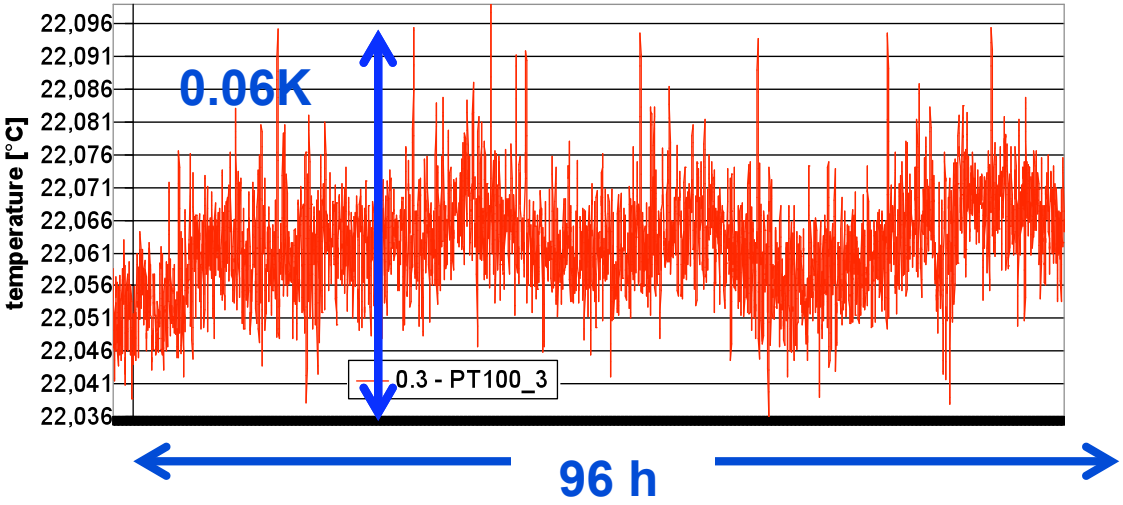


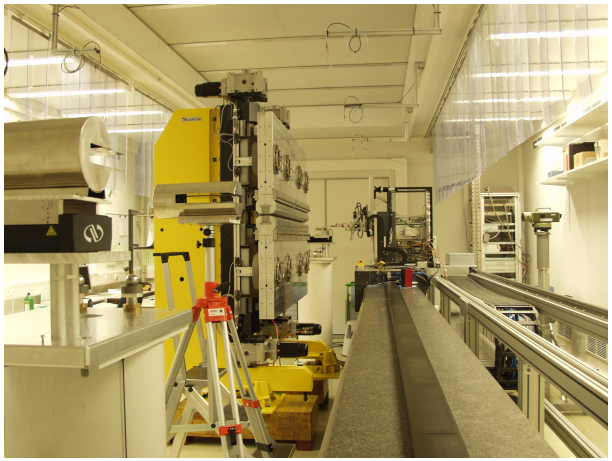
U. Englisch

European XFEL

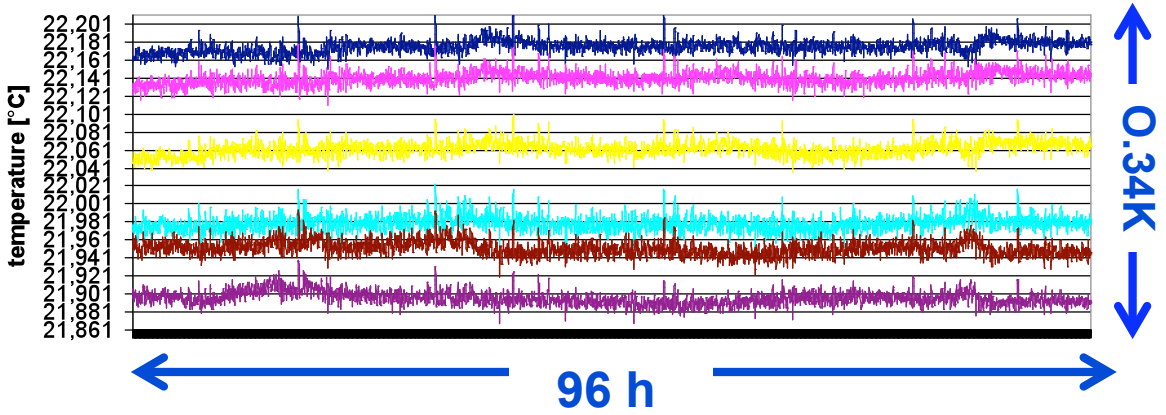
XFEL Magnetic Lab with 0.1°C Stability (C. Schulz)

Temporal Temperature Stability





Local Temperature Stability



Tunnel Temperature Stabilization

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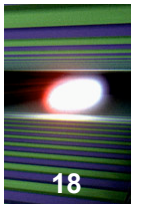
Tunnel Temperature Stabilization



- Reduced Tolerances on Air Conditioning
  Y. Li, B. Faatz, J. Pflueger, Phys. Rev. ST-AB 1,100701 (2008)
  - Requirement of ± 0.1°C Variation over whole Systems is relaxed to ± 0.1-0.2°C over ONE undulator Cell
  - Temperature Deviation is compensated with Gap Adjustment
- Old concept was very expensive
- Study of alternative Concepts, using longitudinal Air Flow (C. Schulz)
- Heat Transport properties in the Tunnels are important:
  - Marl, Glacial Till no water convection: Good Insulator
  - Sand and Gravel with Water Convection: Poor Insulator
- Measurements in the HERA to get Information

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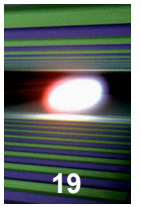
Objectives of HERA Measurements



- HERA Tunnel as an example of the XFEL tunnels
  - Temperature ≈20°C, Tunnel is still maintained (Heated)
  - Ground Water: Ost-Rechts Sand: Süd-Rechts
- Thermal Situation the HERA Tunnel
  - Equilibrium Soil Temperatures 5m around Tunnel with / without Ground Water
  - Thermal Response to Changes in Heat Load – shut off
- Impact on Design of XFEL Air Conditioning System
  - Cooling and/or Heating required? How much?
  - Dehumidifiers needed?
  - Design of Air Conditioning System
  - Impact on Cost

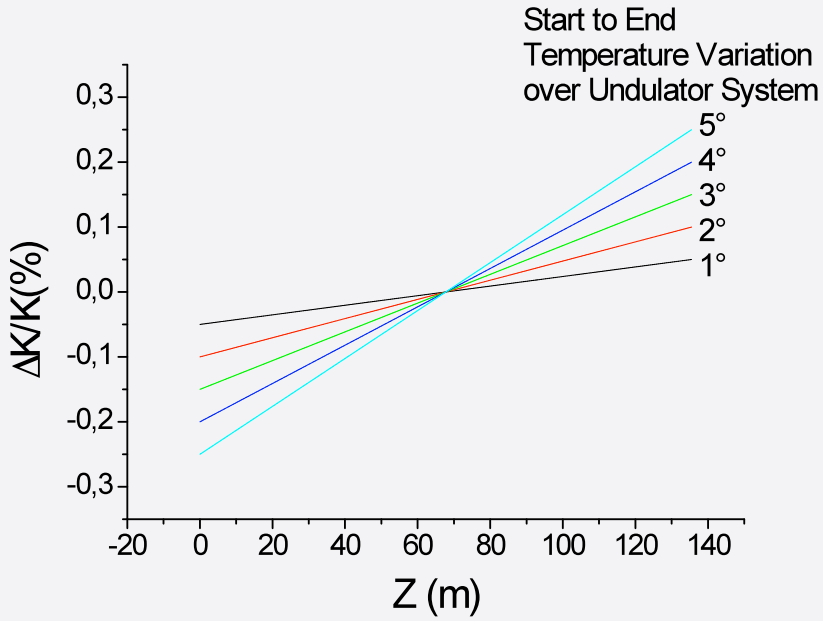
Temperature Stability

Li, Faatz, Pflueger

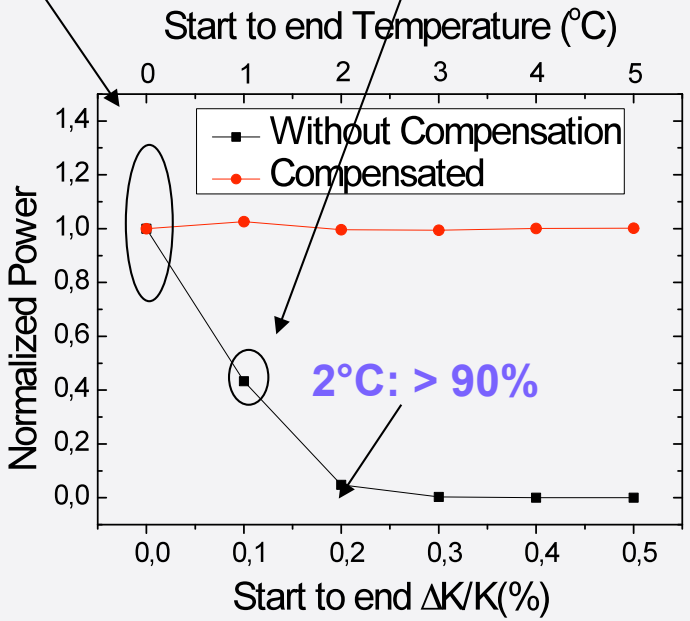
- ρ requires temperature stability < 0.1°C
- Constant Gradient, i.e. K changes linearly over system length

$$\eta_{NdFeB} = 1 \times 10^{-3} / °K$$

0.1°C Temperature variation equivalent to ρ



1°C temperature variation Power degradation > 50%



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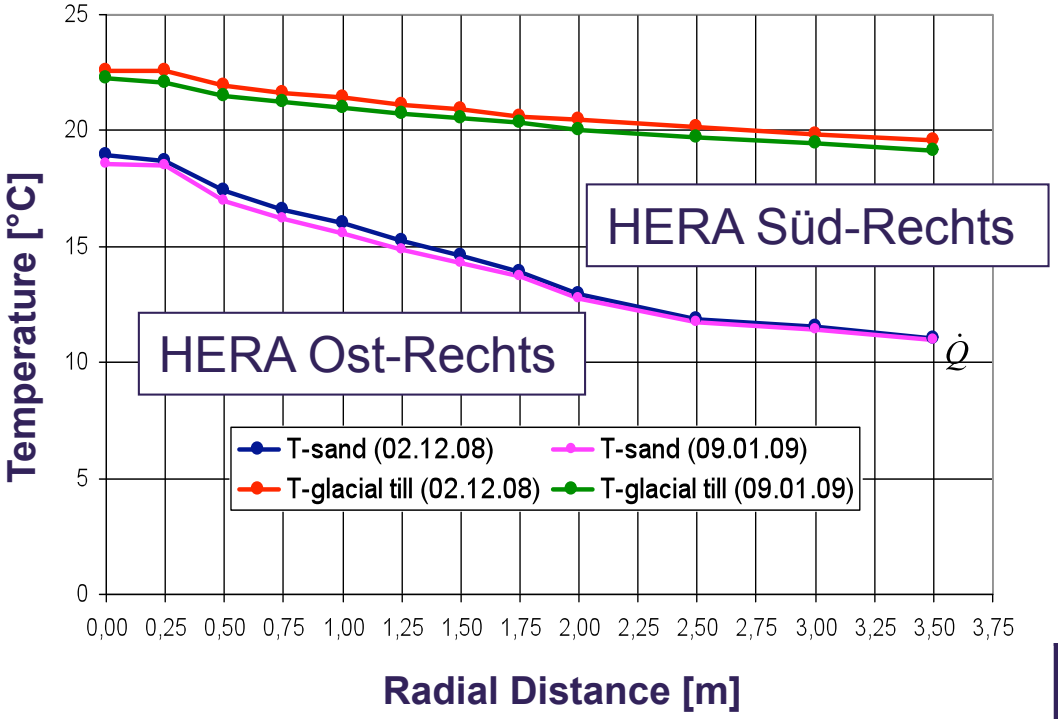
First HERA Results (C. Schulz & Uni Stuttgart)

Soil Temperature 0-3.5m Outside the HERA Tunnel

Start 2.12.08 Tunnel Temperature: 22-23°C



$$Q = \frac{\lambda}{d} A \Delta T$$

***Q** : Heat Flux*

λ: Heat Conductivity 2.3 W/mK for Concrete

d: Thickness of Concrete 0.3m

A: Area = 16.7 m^2 per m Tunnel

ΔT : Temperature Difference

	ΔT [K]	***Q* [W/m]**
Süd-Rechts	0.5	64
Ost Rechts	3.0	380

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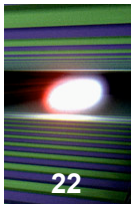
Time Line of HERA Measurements



- Measurements until End of Feb 09
- Data Evaluation until End of April
- Definition of the Air Conditioning Concept until Nov 09
- Detailed Design Aug 2011

In Kind Contributions

European XFEL

CIEMAT Madrid

Design and Production of Components for 92 Intersections:

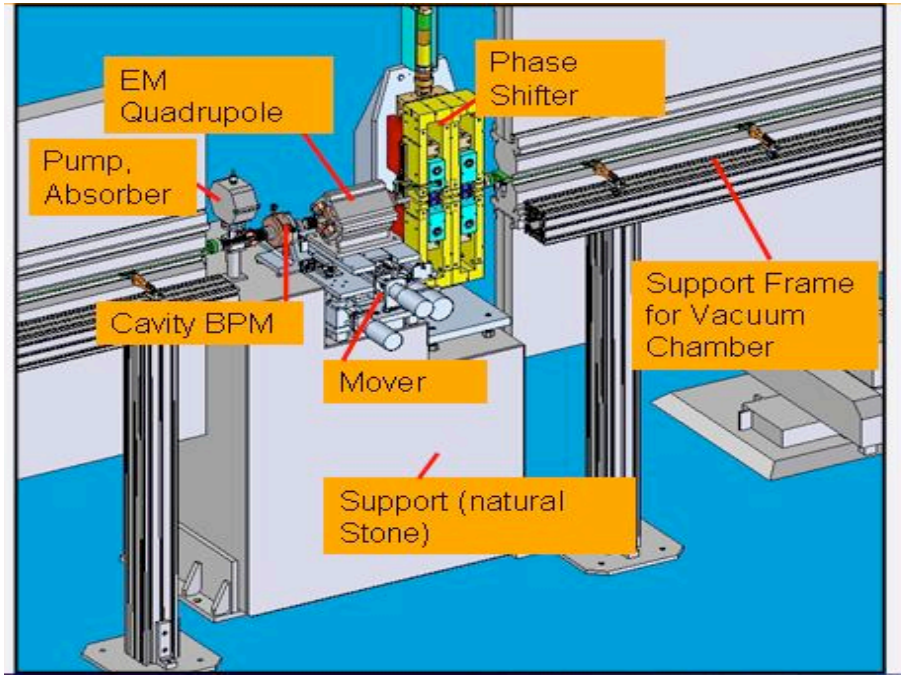
Phase Shifters, Quadrupole Movers, Support Bases

Option:

System Resonsibility for Complete Intersection Sub-Assemblies

Status: Approved by Spanish Side

Waiting for XFEL GmbH



European XFEL

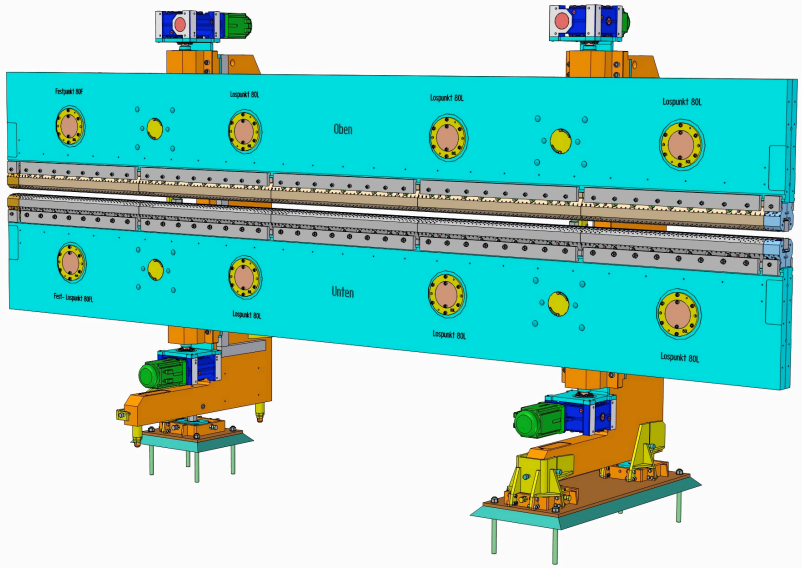
CELLS Barcelona

Production Management of the SASE3 Standard Undulator Segments

- Production of 21 XFEL Standard Mechanics and SASE3 Magnet Structures:
  Tendering, Project Management, Quality Management…..
- Magnetic Tests and Tuning @XFEL, Commissioning

Status: Approved by Spanish Side

Waiting for XFEL GmbH



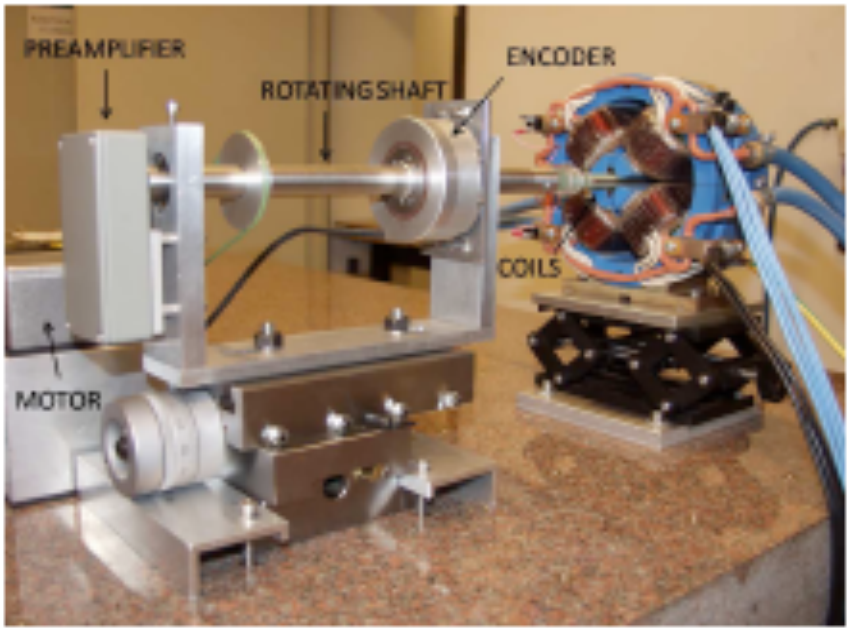
XFEL Standard Segment

Manne Siegbahn Lab, Stockholm

Development and Implementation of a Precision Method to measure Qudrupole Properties in the Undulator Intersections

Approved by Swedish Side

Waiting for XFEL GmbH



Test Setup with FLASH TQG July 08

Time Schedule

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Time Schedule