The PETRA III Girder concept

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Girder concept

Accuracy requirements:

magnet to magnet on girder $\sigma = 50\mu m$

girder to girder $\sigma = 100\mu m$

both in lateral and height
Transfer measurement

Task: Transfer magnetic axis to target marks
Transfer measurement

- magnetic axis determined by $\sigma = 5\mu m$
- revolving SMR defines circle
- circle is measured by tracker
- center of circle better than $\sigma = 5\mu m$
- measurement to target marks with $\sigma = 20\mu m$

This gives us $\sigma = 21\mu m$ for transfer measurement
Alignment of magnets on girder
Alignment of magnets on girder

- CS of girder is oriented roughly to the mechanical structure of girder
- all magnets are aligned to this system by three rotations and translations
- movements done by DESY-standard elements (ballshaped screws & turnbuckles)
- accuracy comes from measurement ($\sigma = 20\mu m$) and from adjustment ($\sigma = 10\mu m$)

\[ \sigma = 22\mu m \] for alignment on girder
Intra-girder accuracy

Magnet to magnet accuracy results from
- transfer measurement accuracy
- alignment accuracy

\[ \sigma_{mm} = 30 \mu m \]

... but only if ideal conditions are met:
- climatized room
- good geometry
- precisely calibrated instruments, etc.

*can not be done in tunnel*
Transport

everything would be great ...
if it wouldn't be for the transport to the tunnel...
Transport

difference: before craning - after craning (targets on girder & magnets)
Overall accuracy

Let's assume we can get the shifts during transport to better than $\sigma = 40 \mu \text{m}$ ... that gives us...

$\sigma = 50 \mu \text{m}$

Pretty close...

recheck the numbers for transport with

- new (more inflexible) girder
- our own climatised hall
Summary

Girder bears no coordinate information

*Girder* is not aligned in the tunnel, but the „median straight line“ of the *magnets*

Transfer Measurement should be done directly on girder

Accuracy requirements are met, but will be hopefully improved with the final girder
Dynamic behavior

Contradicts with static requirements:

for best static stability connection between magnets and girder must be stiff

for least vibrations (from floor) in the magnets connection must be elastic
Modal analysis of girder system

Analysis on concrete stands & final stands
Measurement with accelerometers and impact hammer
Modal analysis of girder system

First eigenfrequency at 45Hz, Dipole loose
Modal analysis of girder system

Dipole loose
Modal analysis of girder system

Dipole fixed
Modal analysis of girder system

First eigenfrequency at 41Hz, Dipole fixed
Modal analysis of girder system

Dipole loose
Modal analysis of girder system

Dipole fixed
Summary

Modal analysis did help during the design of the girder.

3D visualisation is important to convince other people.

Analysis of Transfer Functions & Damping has still to be done.
DESY-HLS

DESY-HLS with ultrasonic measurement and in-situ calibration

\[ H_P = H_W + D_2 - D_1 \frac{OF - R_1}{R_2 - R_1} \]

unsatisfied with Krautkramer electronics

- complicated interface
- expensive
- but good accuracy
Build own electronics ...

Requirements:

- up to four probes per device
- communication via CAN-open
- use proven and tested measurement pot with KK probe
- automatic measurement with failure detection
- transfer only results per default, but transfer raw data on demand
- cost efficient
- standard 19” crate
- accuracy better 2µm for resulting height
Prototype

DESY-HLS test of electronics

HP, s(HP)=0.0010

moving average(HP,15), s(ma(HP))=0.0002

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Pricing

Accuracy on the μm-level

One channel: 716€
Two channel: 928€ (470€ / channel)
Four channels: 1352€ (350€ / channel)

plus 1,2k€ / channel for measurement pot and probe

This is a preliminary and non-commercial price!
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Thanks for your attention!