The PETRA III Girder concept

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Girder concept

Accuracy requirements:

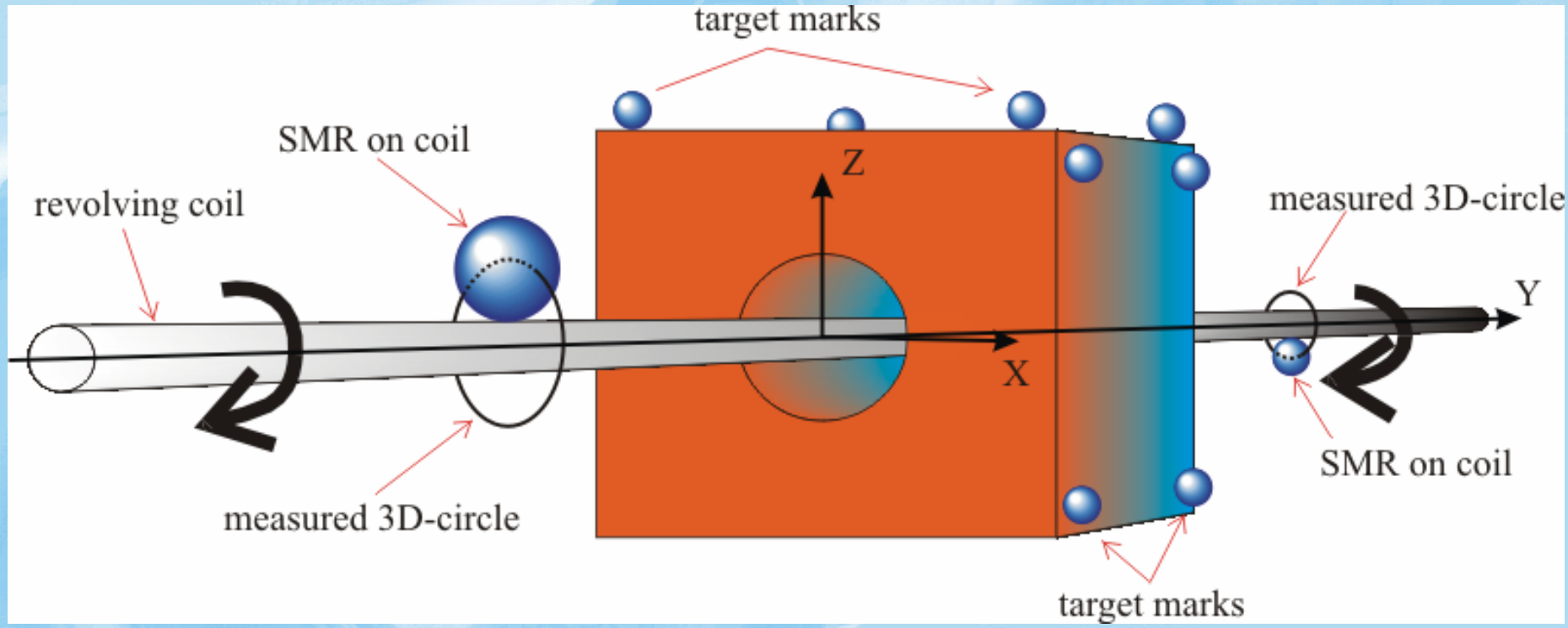
magnet to magnet on girder σ = 50μm

girder to girder σ = 100μm

both in lateral and height

Transfer measurement

Task: Transfer magnetic axis to target marks

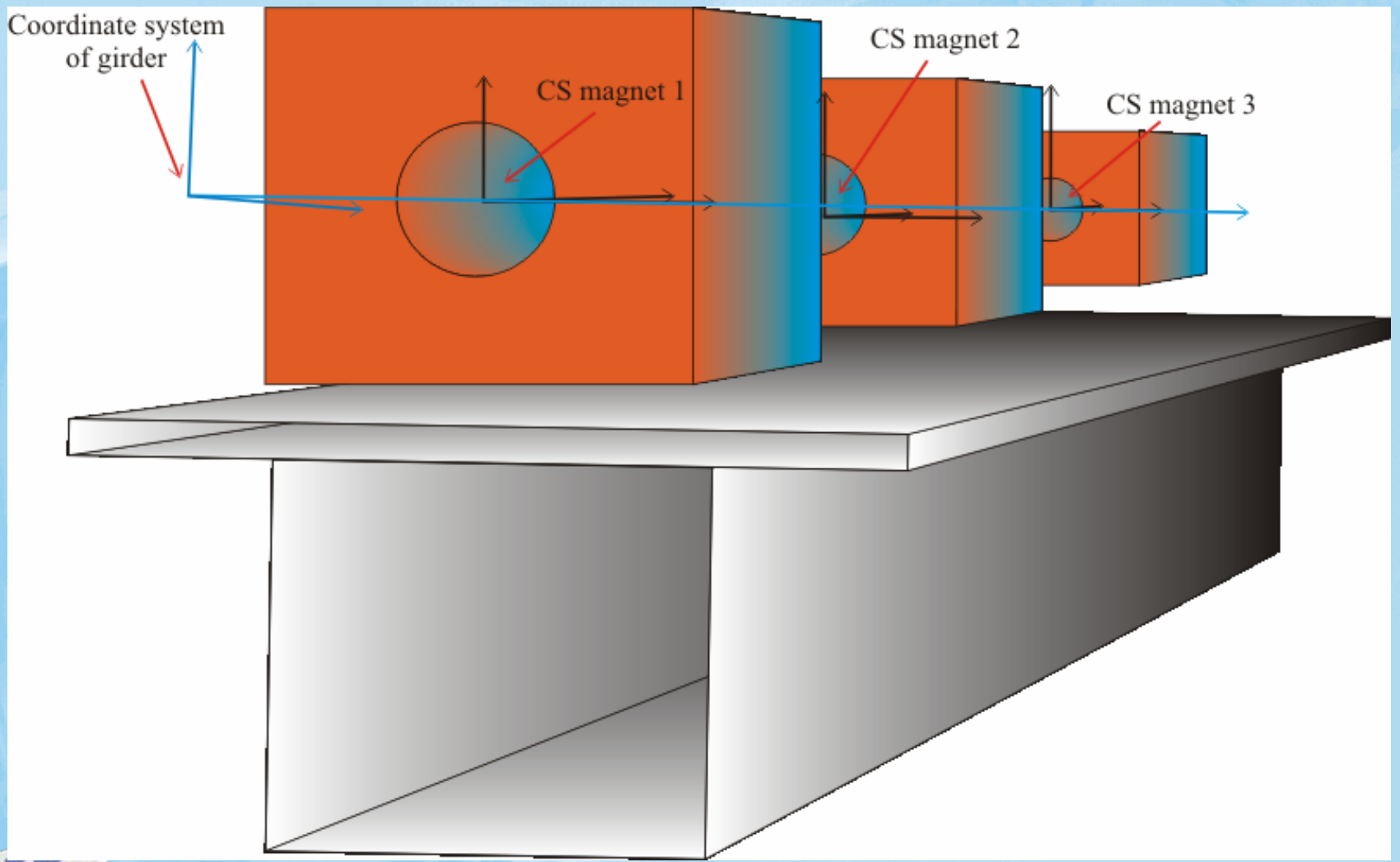


Transfer measurement

- magnetic axis determined by σ = 5μm
- revolving SMR defines circle
- circle is measured by tracker
- center of circle better than σ = 5μm
- measurement to target marks with σ = 20μm

gives us σ = 21μm 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 (σ = 20μm) and from adjustment (σ = 10μm)

gives us σ = 22μm 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

→ can **not** be done in tunnel

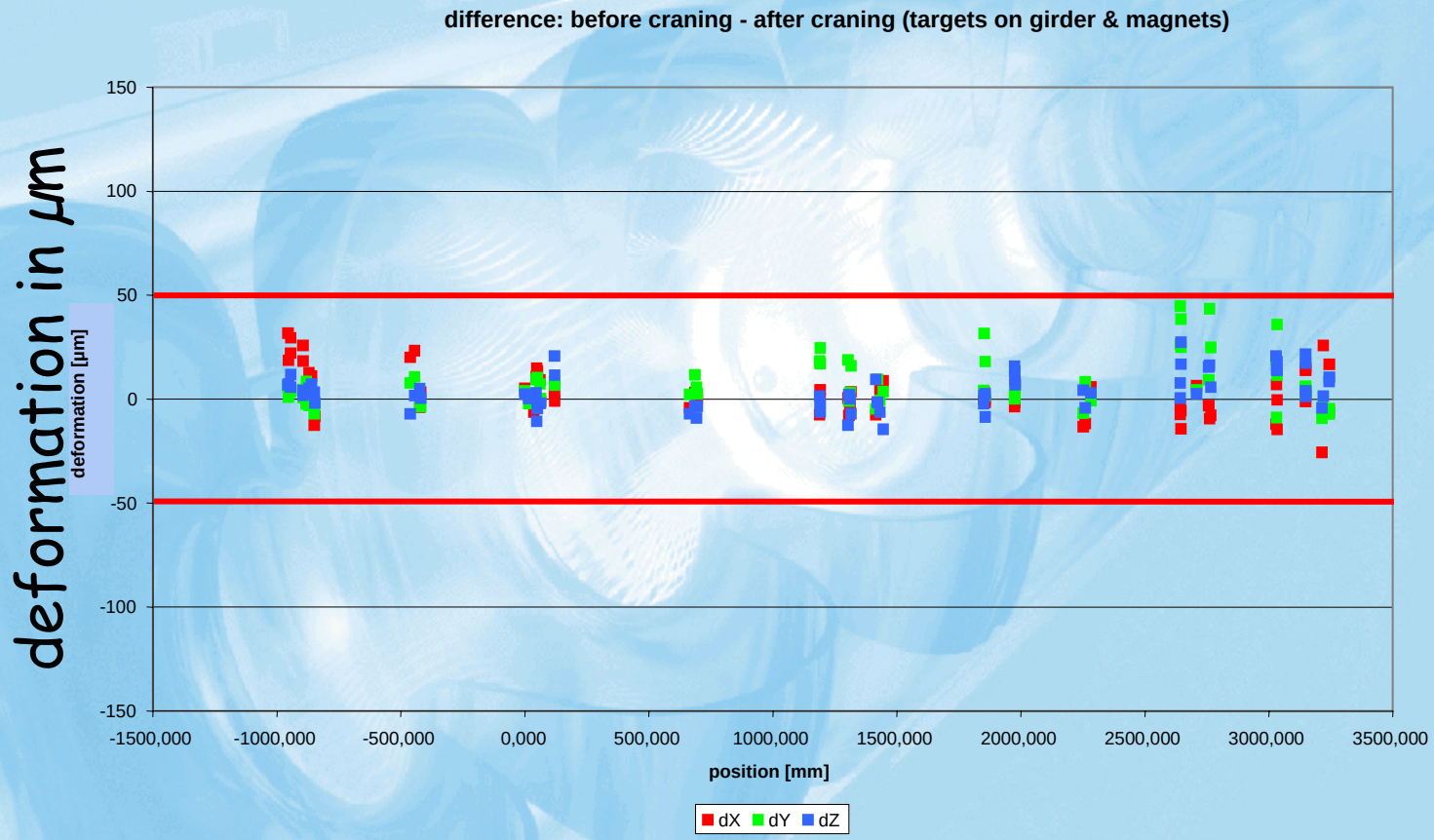
- precisely calibrated instruments, etc.

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)
deformation in µm
deformation [µm]
150
100
50
0
-50
-100
-150
-1500,000
-1000,000
-500,000
0,000
500,000
1000,000
1500,000
2000,000
2500,000
3000,000
3500,000
position [mm]
dX
dY
dZ

Overall accuracy

Let's assume we can get the shifts during transport to better than σ = 40μm …

that gives us…

$$\sigma = 50\mu m$$

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

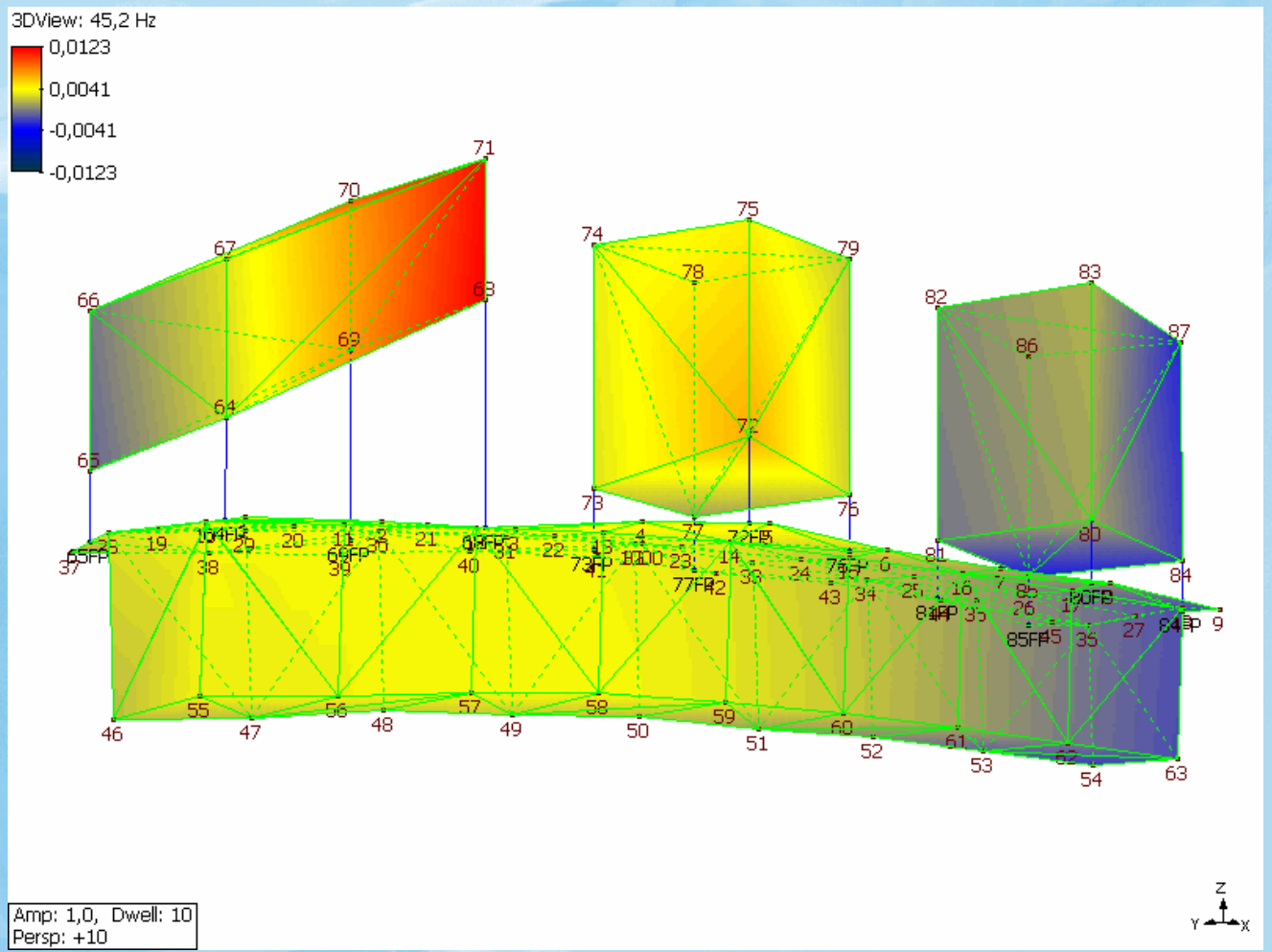
Modal analysis of girder system

Analysis on concrete stands & final stands

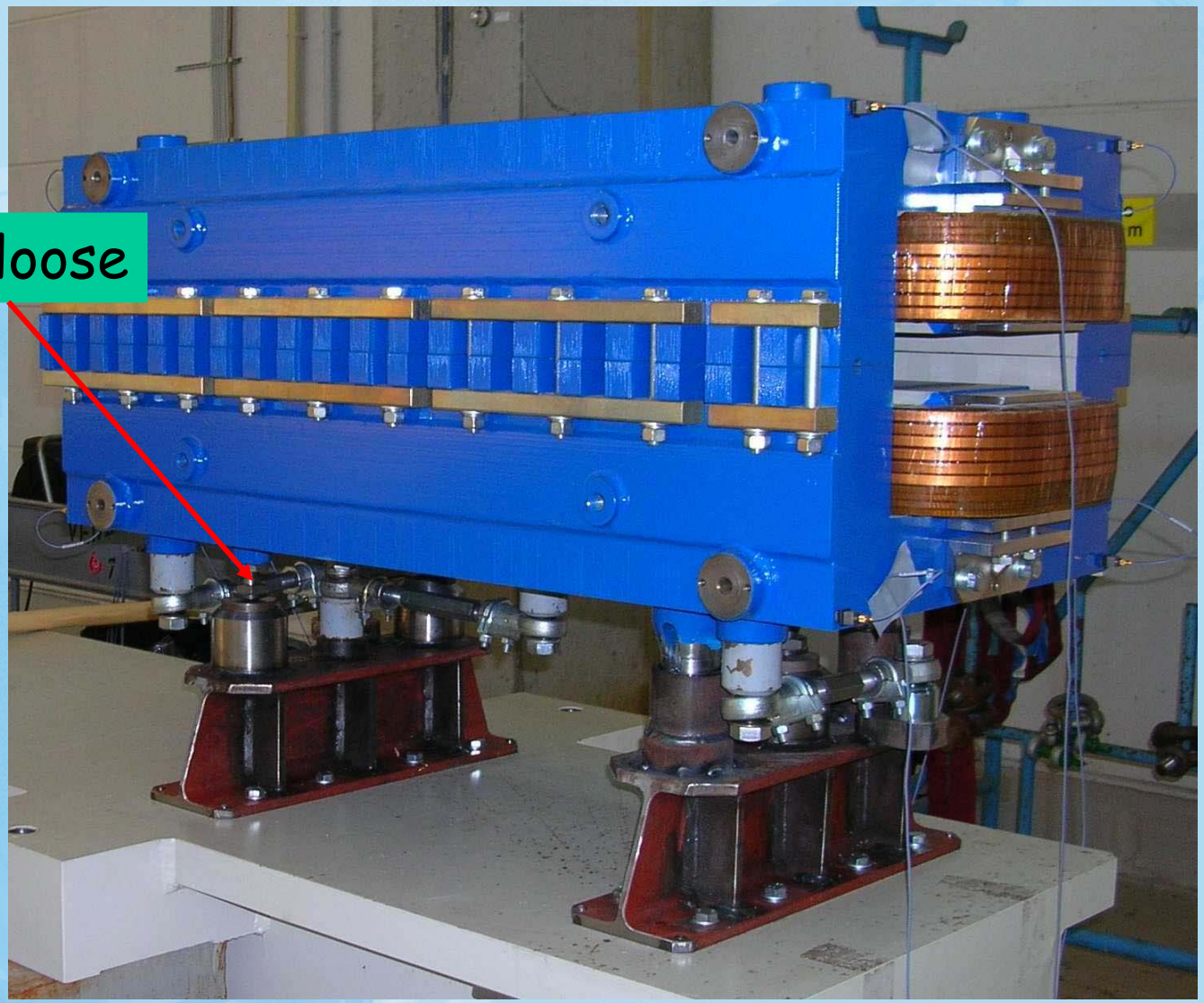
Measurement with accelerometers and impact hammer

Modal analysis of girder system

First eigenfrequency at 45Hz, Dipole loose



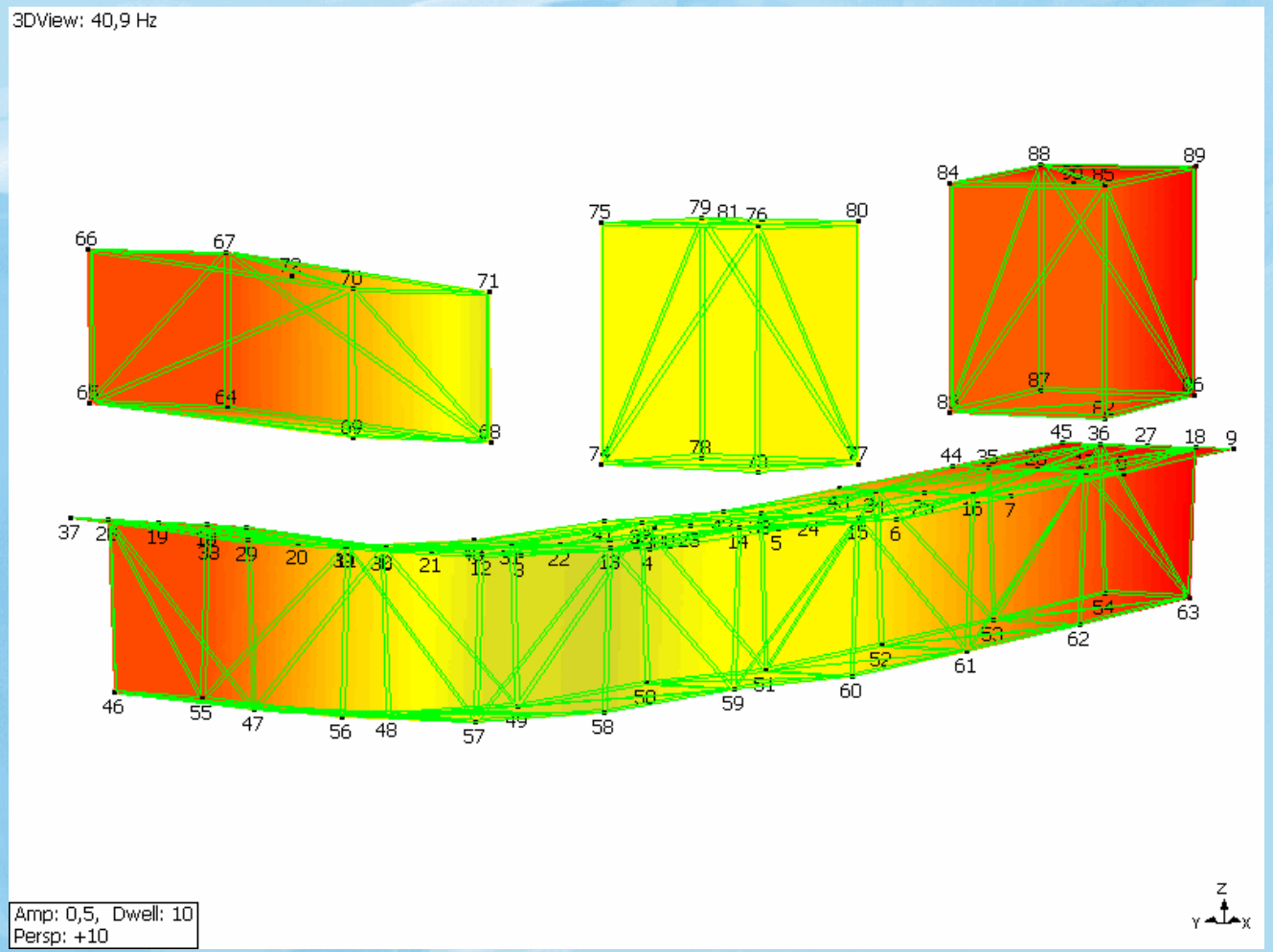
Modal analysis of girder system



Modal analysis of girder system

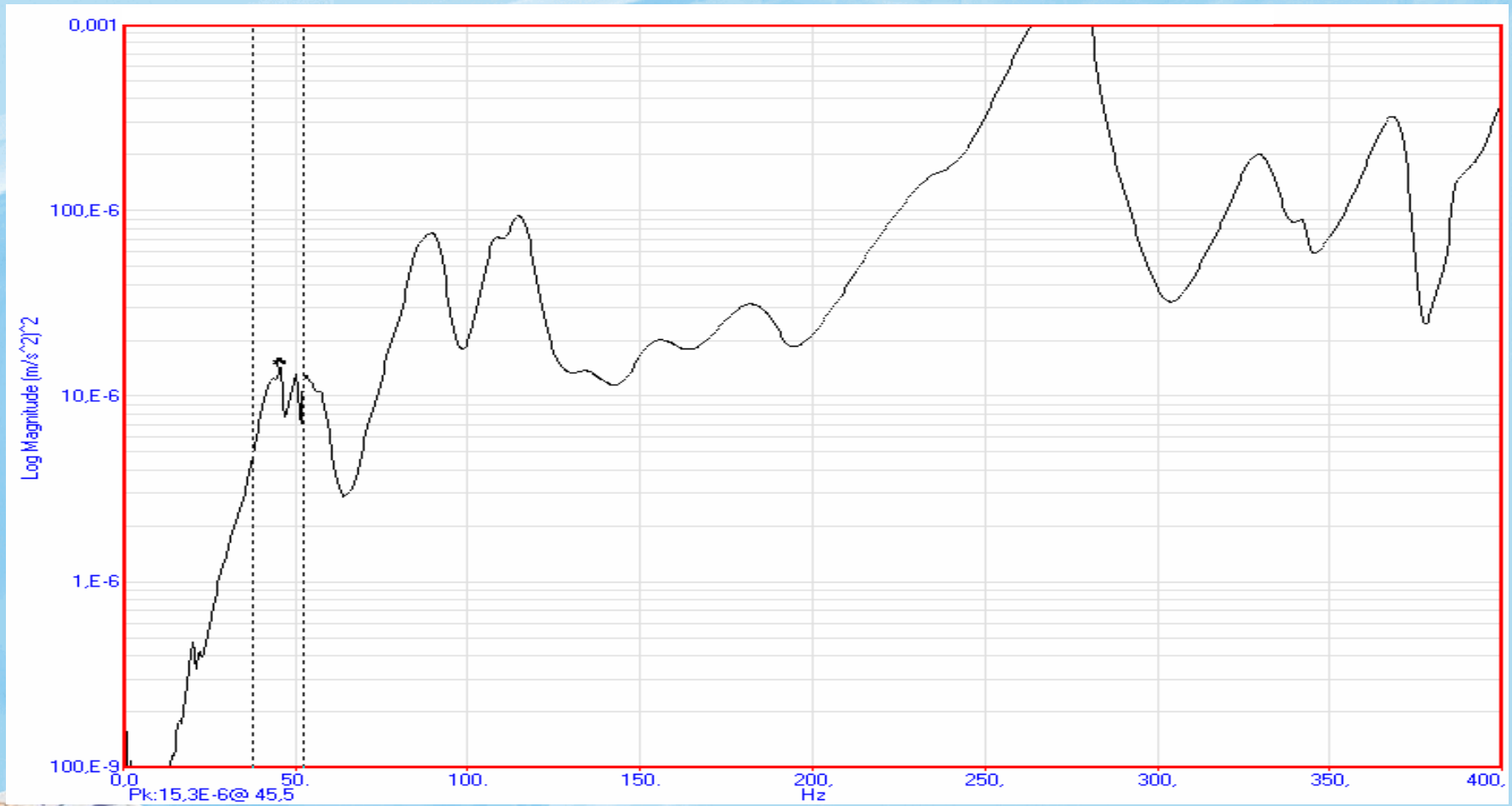
Modal analysis of girder system

First eigenfrequency at 41Hz, Dipole fixed



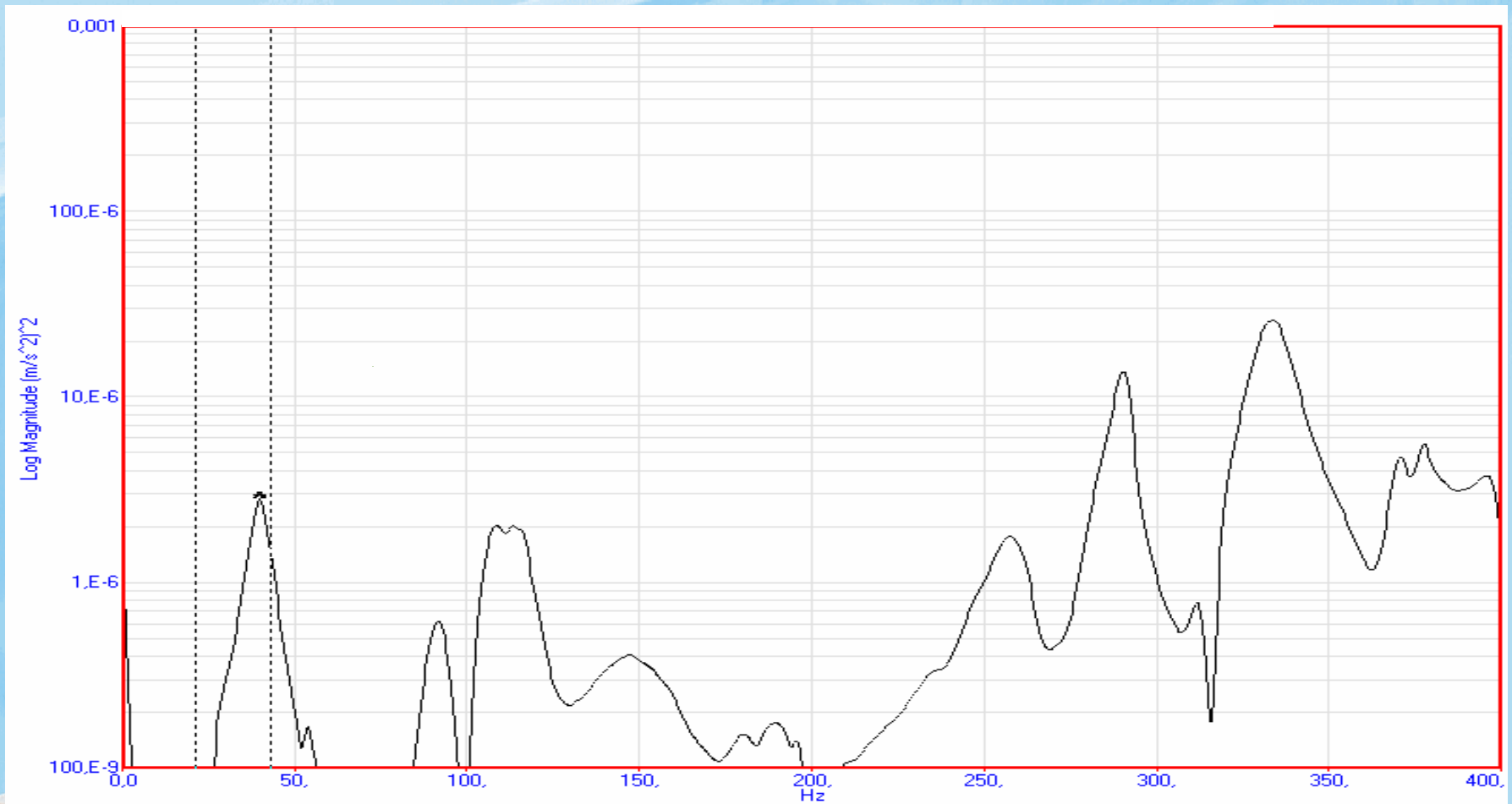
Modal analysis of girder system

Dipole loose



Modal analysis of girder system

Dipole fixed



Summary

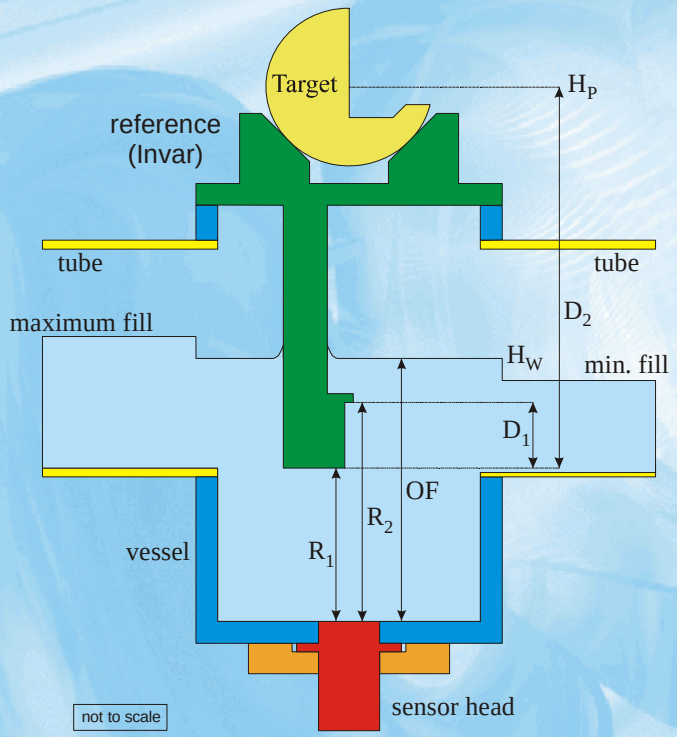
Modal analysis did help during the design of the girder

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

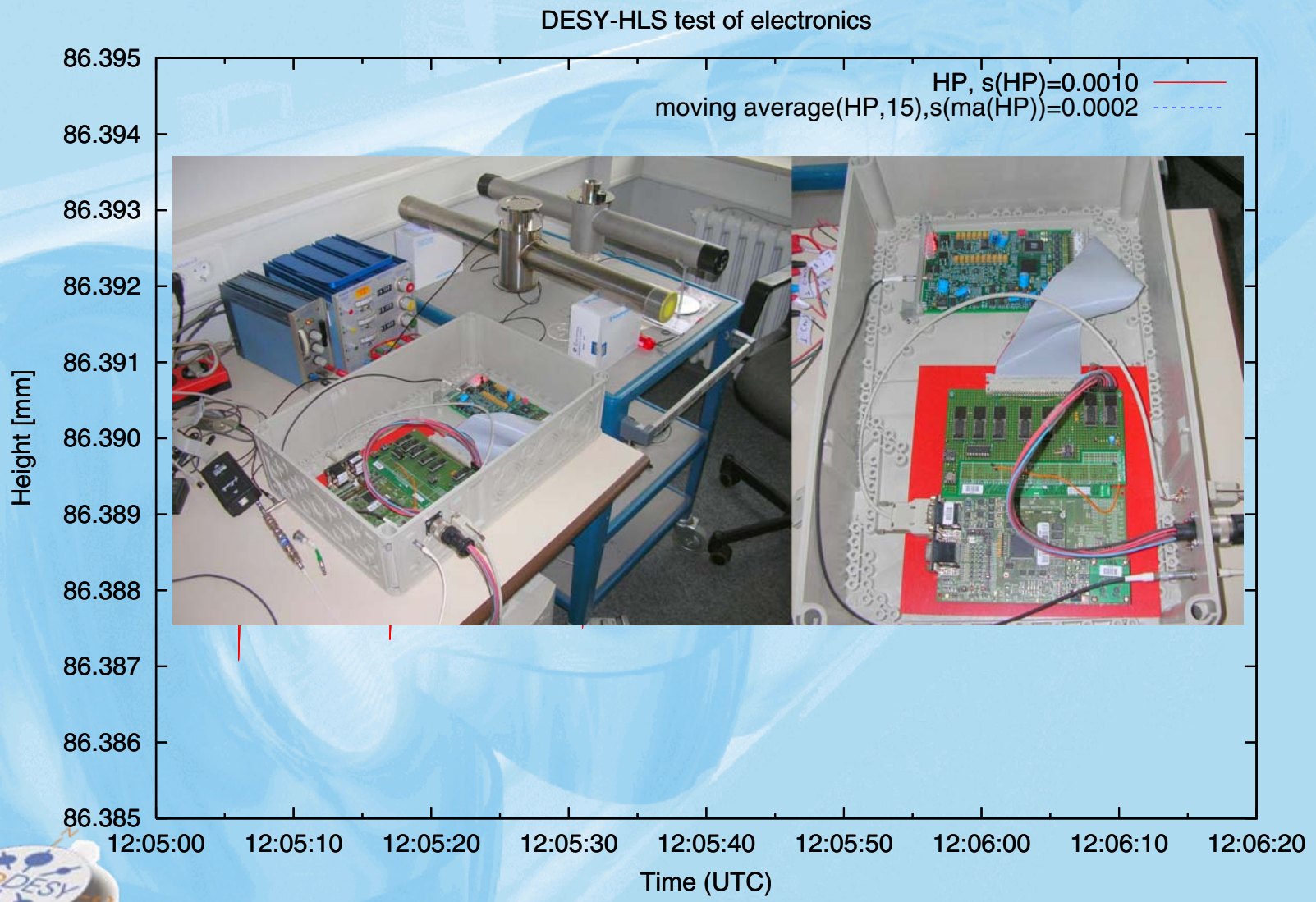
- complicated interface
- expensive
- but good accuracy

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
Height [mm]
86.395
86.394
86.393
86.392
86.391
86.390
86.389
86.388
86.387
86.386
86.385
12:05:00
12:05:10
12:05:20
12:05:30
12:05:40
12:05:50
12:06:00
12:06:10
12:06:20
Time (UTC)

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-comercial price!

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Thanks
for your attention!