Testing a 20 cm Diameter Open Reflector

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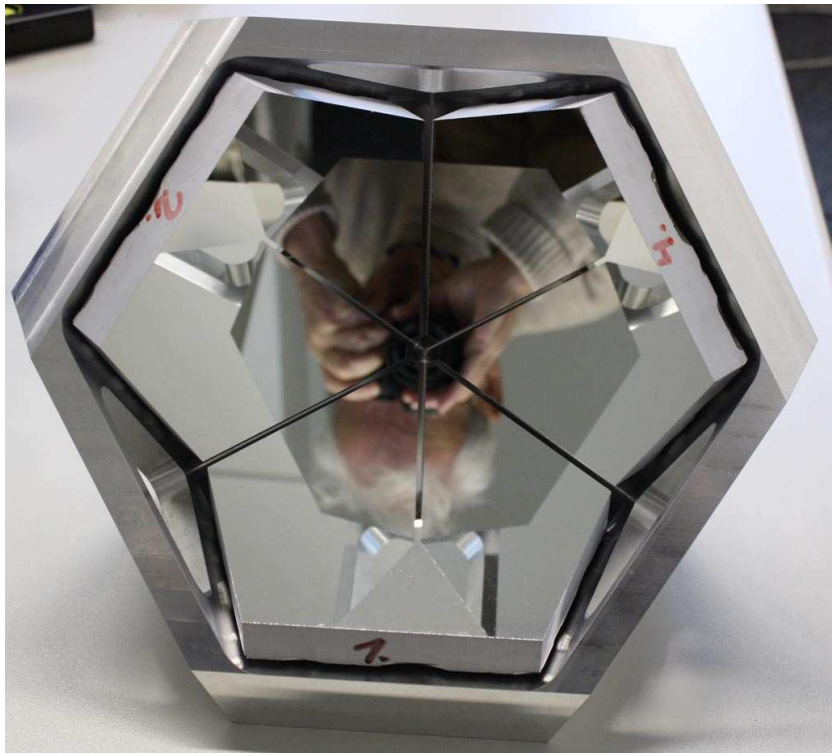

GFZ Helmholtz Centre Potsdam

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STI

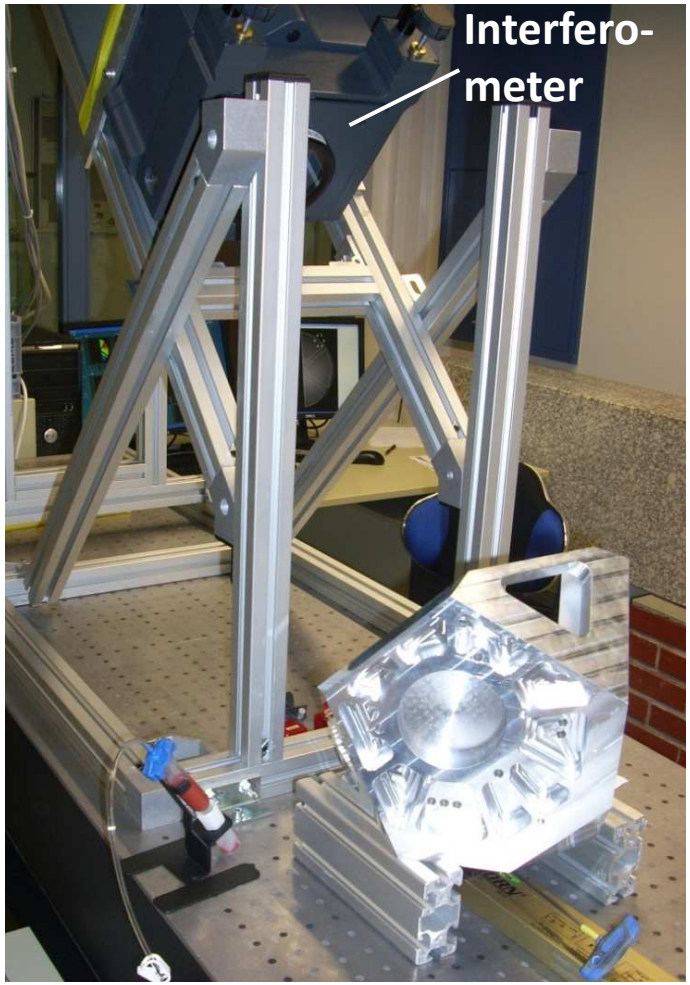
Introduction

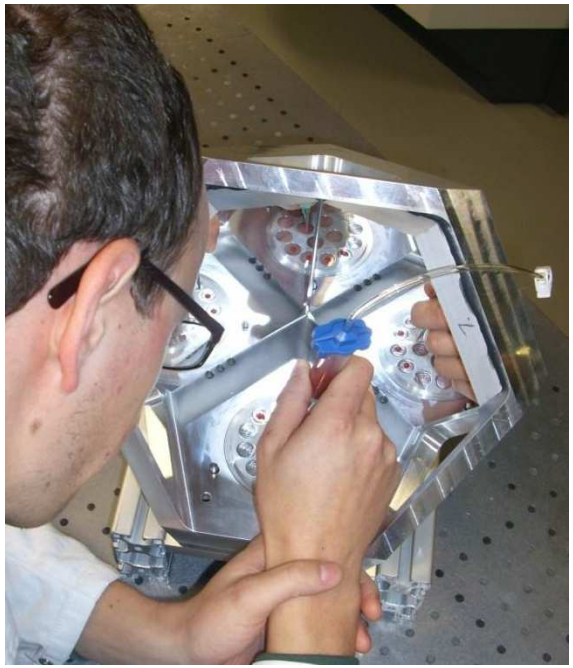
- A lab model of a triple mirror open reflector with about 20 cm diameter has been developed jointly by FHD, STI and GFZ *)
- Objective was the selection of the overall concept and the demonstration of the feasibility of the manufacturing/assembly accuracy
  - A „monolithic“ base structure was selected
  - Mirrors are individually and independently glued to this structure
  - An accuracy of better 0.2 arcsec for the mirror alignment was established as target
- All test measurements have been performed at ambient temperature and include:

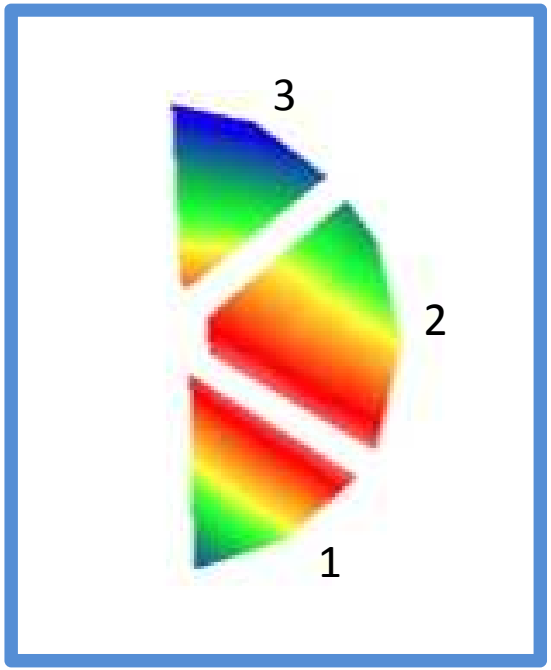
  - real time interferometry during mirror assembly at FHD
  - measuring the far field using the facility of Einstein Tower Potsdam
  - Interferometry using the 16 inch ZYGO of the Helmholtz Centre Berlin

*) co-funded by Federal Ministry of Economics and Technology

Assembling the Reflector under Fizeau Interferometer – 3 Flats





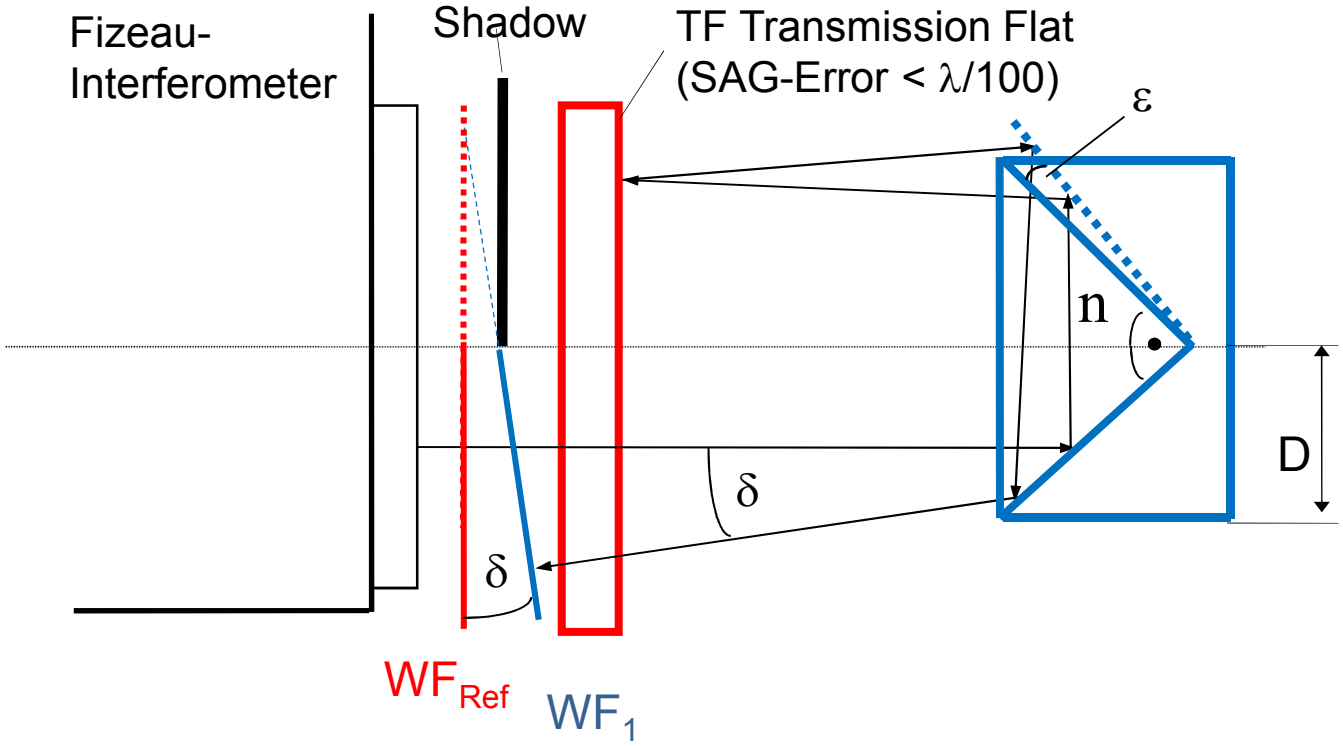


Ang Err 1-2	Ang Err 2-3	Ang Err 3-1
0,32 arcsec	**2,35 arcsec**	**0,13 arcsec**

Measurement Uncertainty (systematic and random error) < 0,054 arcsec
According to GUM; k=2 (1-α = 95%)

Assembling:
Interferometer under 45°

Principle Measurement of Reflector by Interferometry



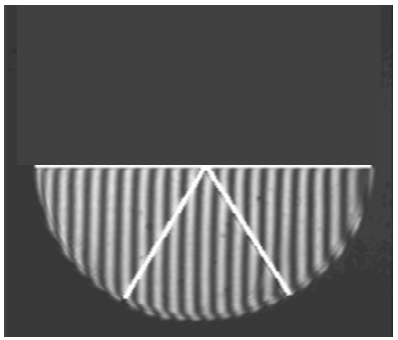
Wavefront error (double pass):

$$\delta = 4 \cdot \varepsilon \cdot n = \frac{k \cdot \lambda}{D}$$

Error of prism angle:

$$\hat{\varepsilon} = \frac{k \cdot \lambda}{4 \cdot D \cdot n}$$

Visualised wavefront:



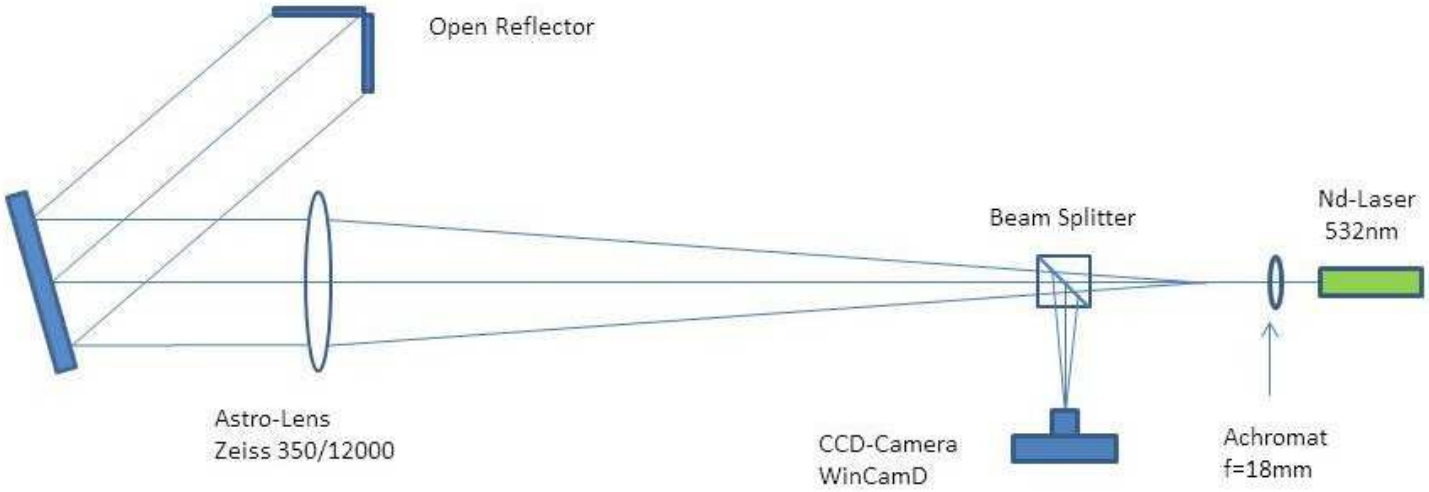
Computed phase-shifted wavefront:

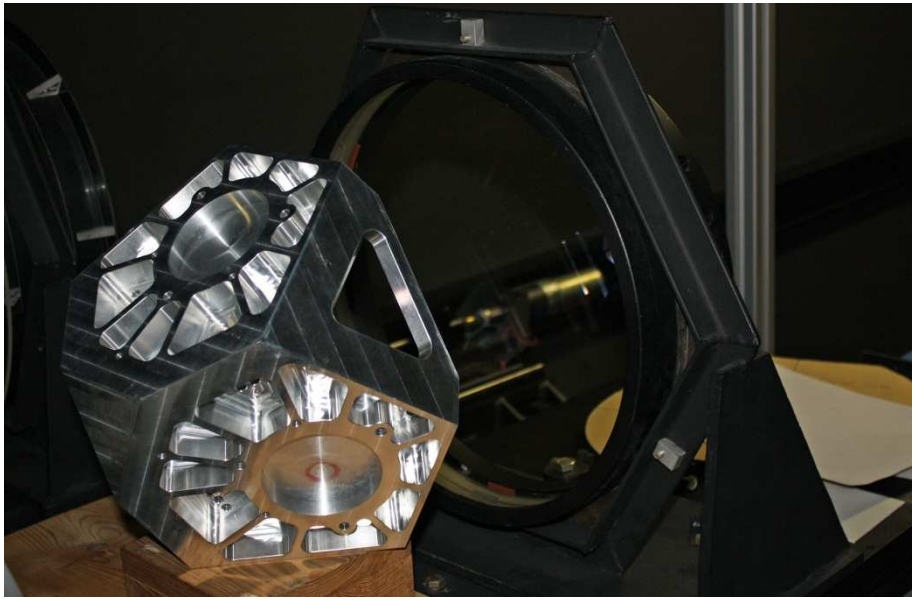
Computed angle Error/arcsec

Random Error (n=20)	< 0,02
Systematic Error SAG < λ/100	< 0,05
Sum Error*	**< 0,054**

*) GUM; k=2 (1-α = 95%)

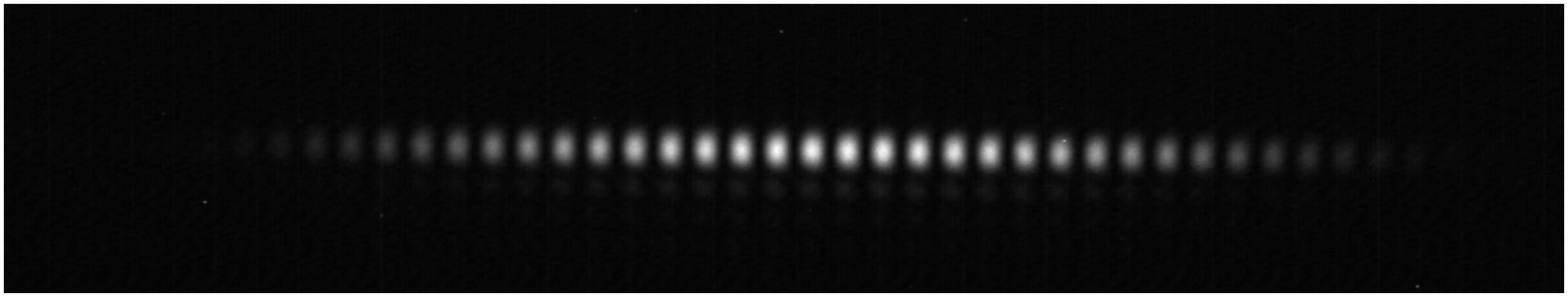
The Far Field Test Setup

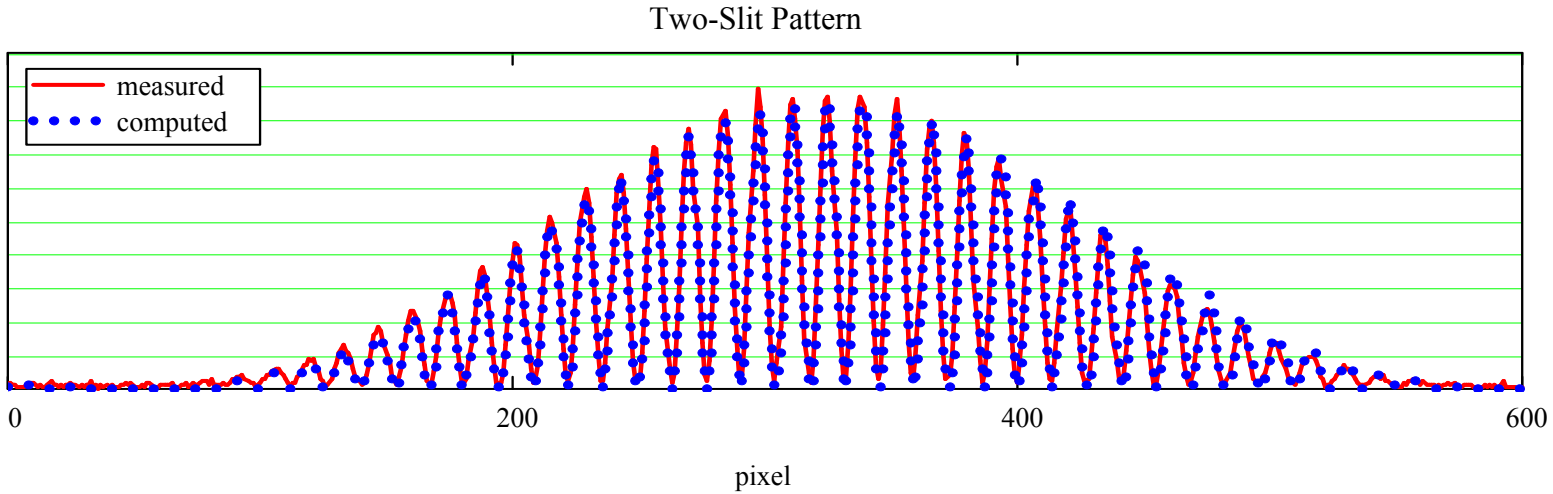




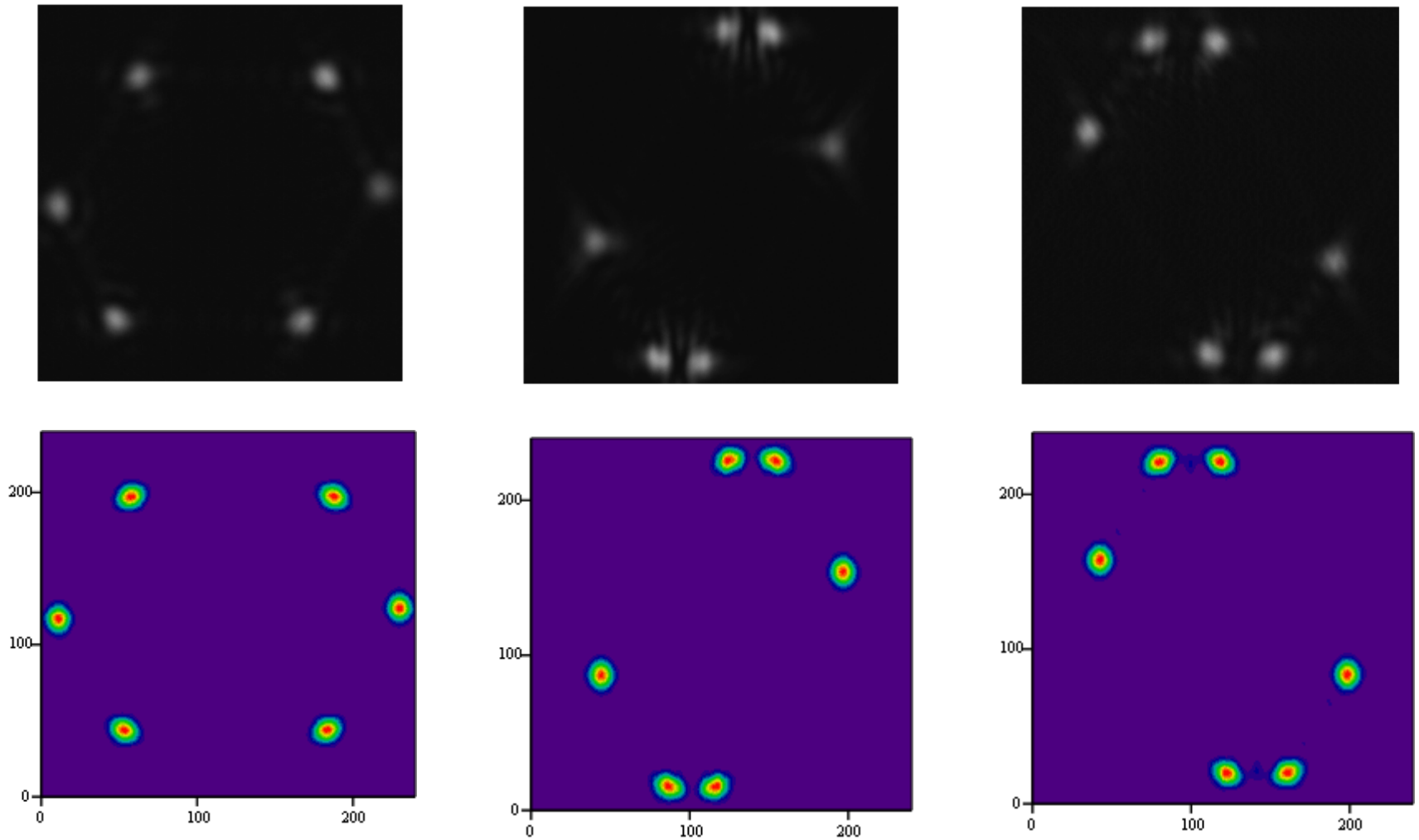
Calibration of the angular scale in the focal plane using the two-slit diffraction pattern
slit spacing: 100 mm, width of individual slits: 5 mm

Result: 1 pixel = 0.080” (WinCamD with 4.65µm pixel spacing)





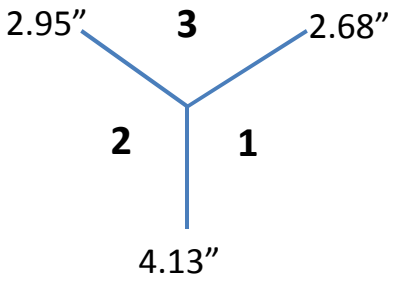
Observed and computed far field patterns (fullscale 120x120 µrad)



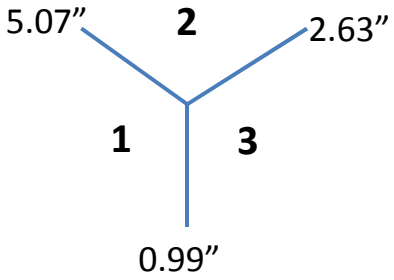
Results for upper mirror horizontal

Blue lines: edges. Bold numbers: mirror No.

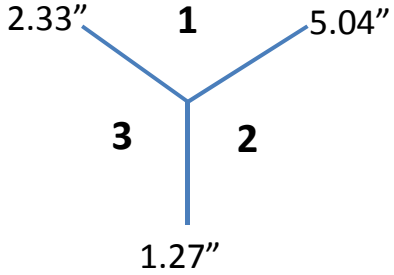
Angle offsets in arc sec



S = 9.76

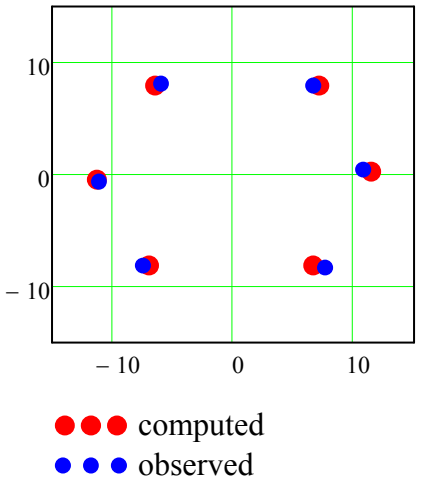


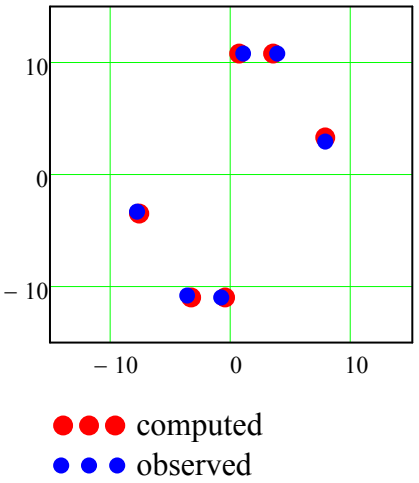
S = 8.69

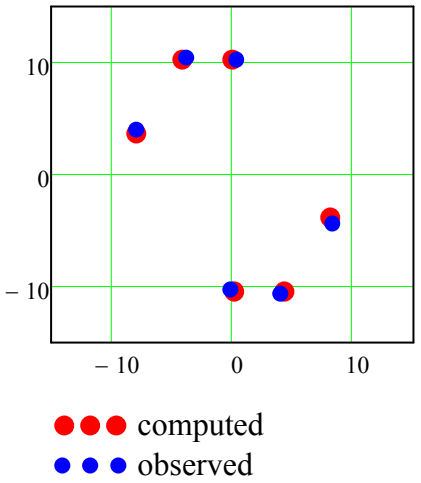


S = 8.64

Observed and computed spot location:

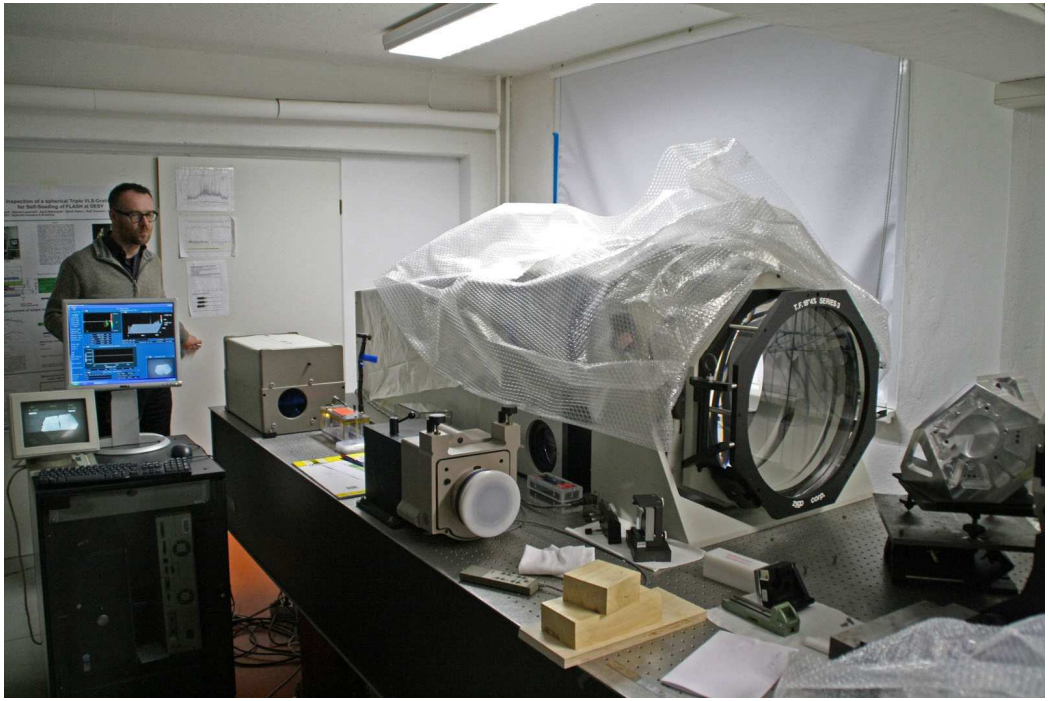






Verification of the Measurements using a 16 inch ZYGO Interferometer (Optical Lab. of the Berlin Synchroton BESSY II)

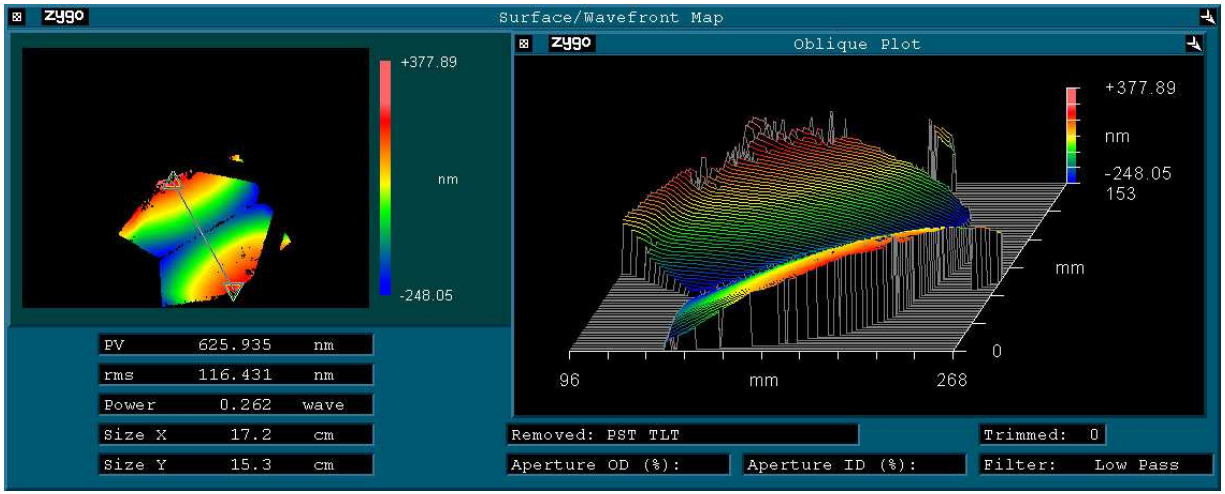
Measurement of the offset angles by the observation of interference patterns from two-mirror reflection

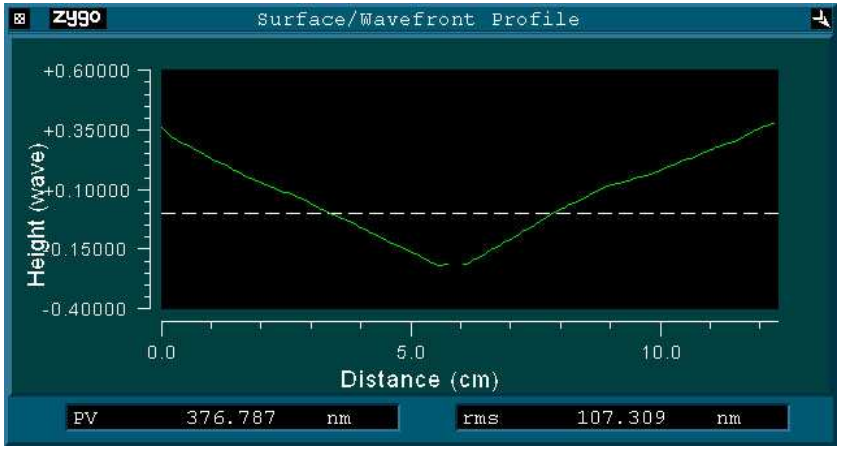


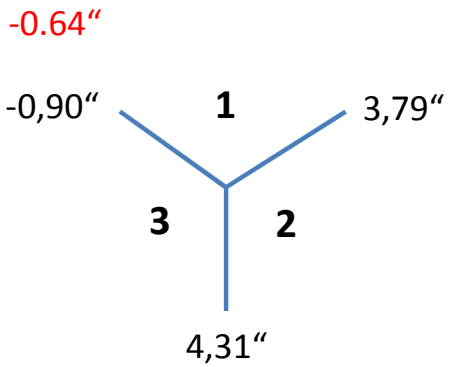
Offset Angle Test Example: Mirrors 1 and 4

Red: ZYGO interferometer

Black: result from last far field measurement (13.1.2012 Einstein-Tower)







Summary and Future Plans

- A breadboard model of the 20 cm diam. open reflector has been developed
- The assembling technology including continuous interferometric measurement during assembly is nearing the required precision of 0.2“
- 1 g deformation effects on the triple mirror assembly are observed however
  - Far field and interferometric tests show significant elastic change of the offset angles under different orientations
  - also long term drifts up to 1 arcsec have been observed
- Temperature stability at lower than lab temperatures is to be improved

→ As a first step a modified cementing will be applied to minimize elastic effects in the joining material

→ In a second step materials with higher elastic modulus and better conductivity will have to be applied

→ In a third step a new triple mirror assembly will have to be manufactured