



Risk mitigation for the ELT segments phasing

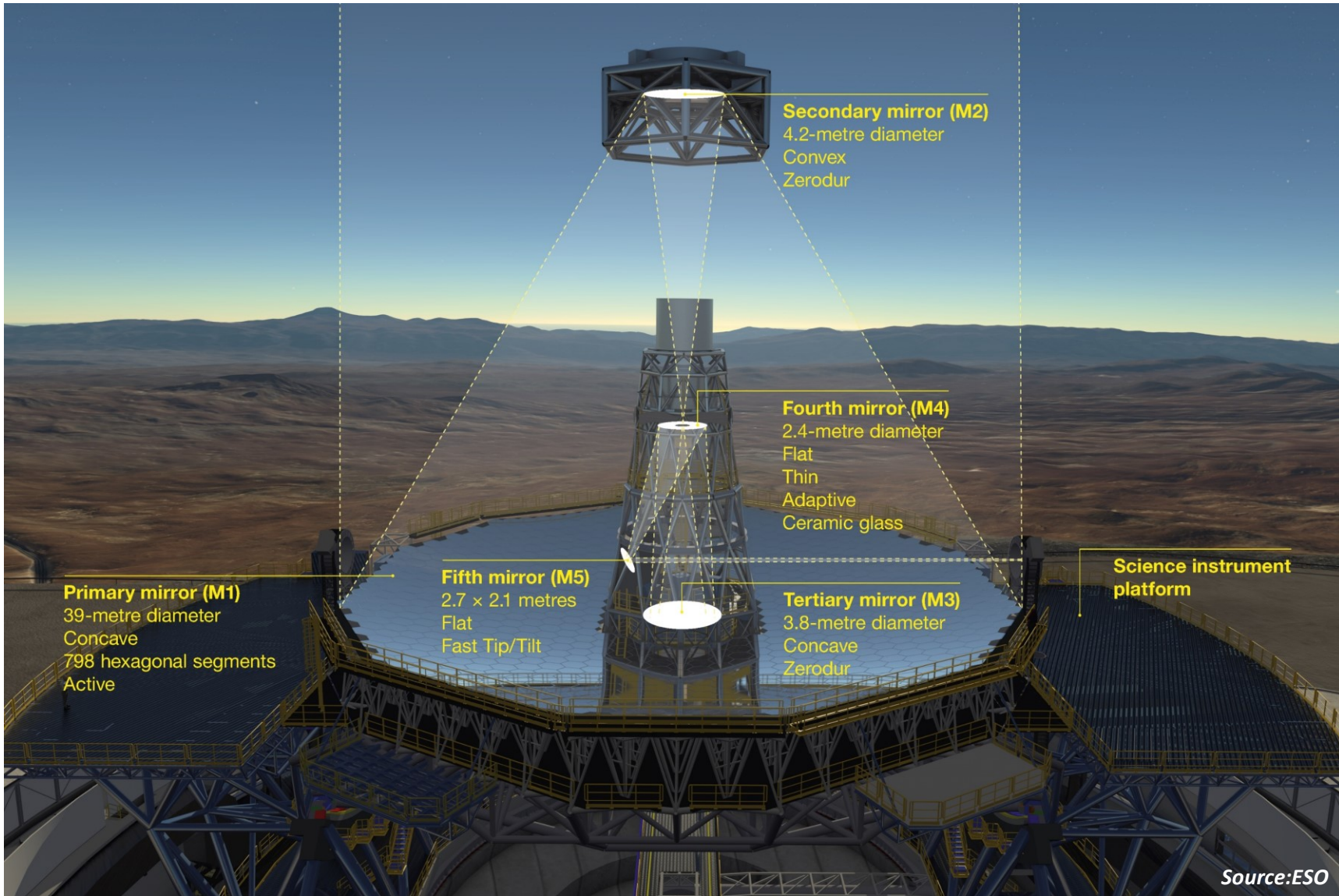
R&D SEMINAR

ANNE-LAURE CHEFFOT

EUROPEAN SOUTHERN OBSERVATORY / AIX MARSEILLE UNIVERSITY

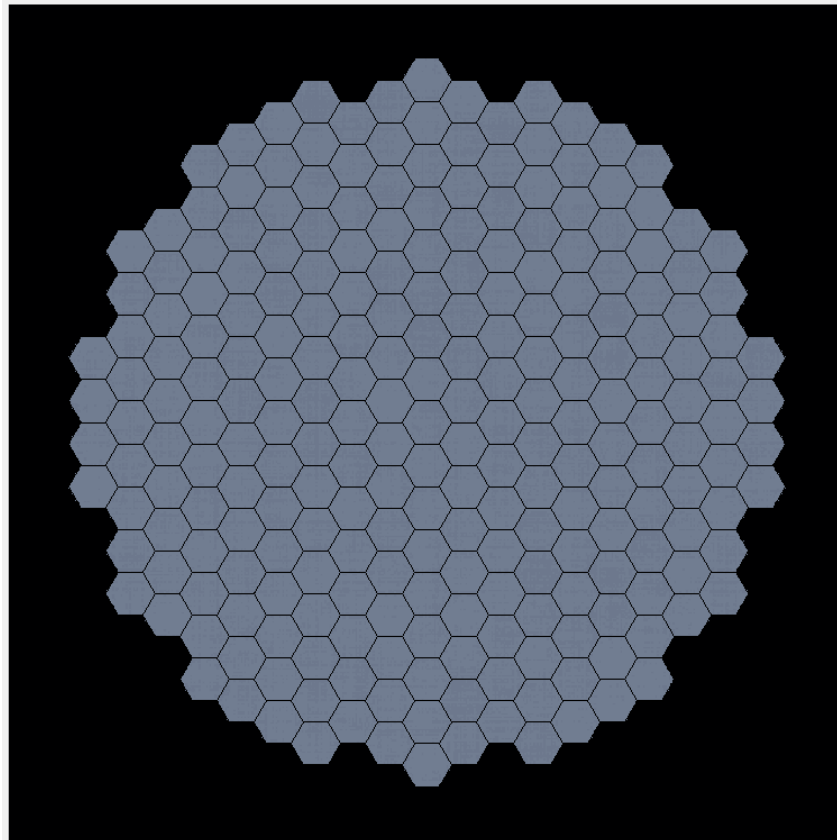


Source:ESO



Source:ESO

Primary mirror segmentation



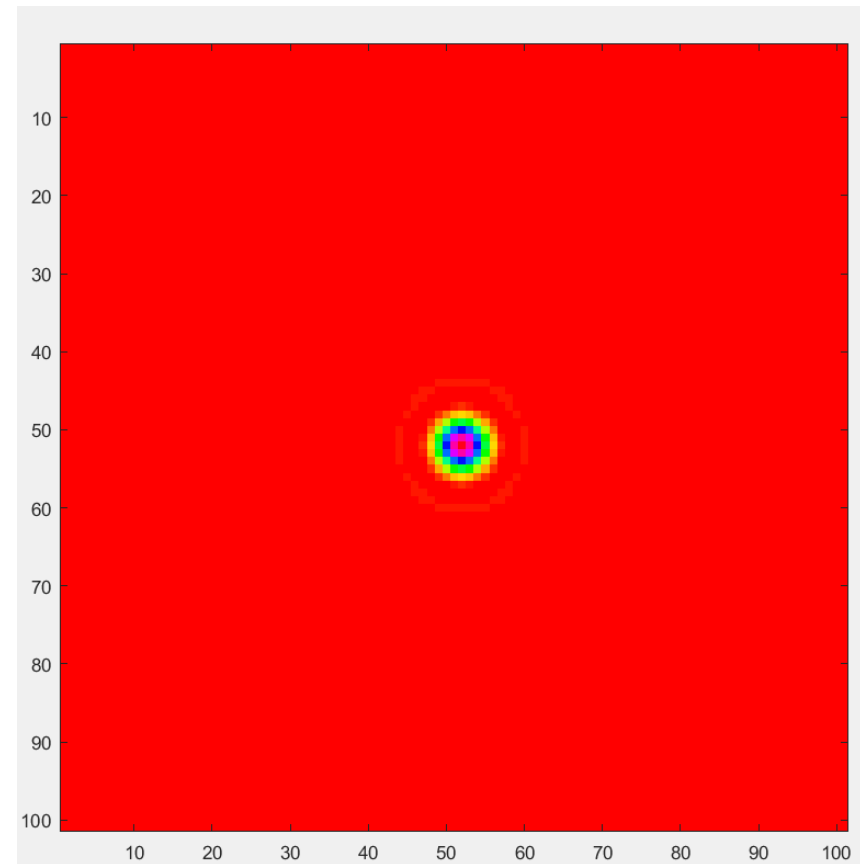
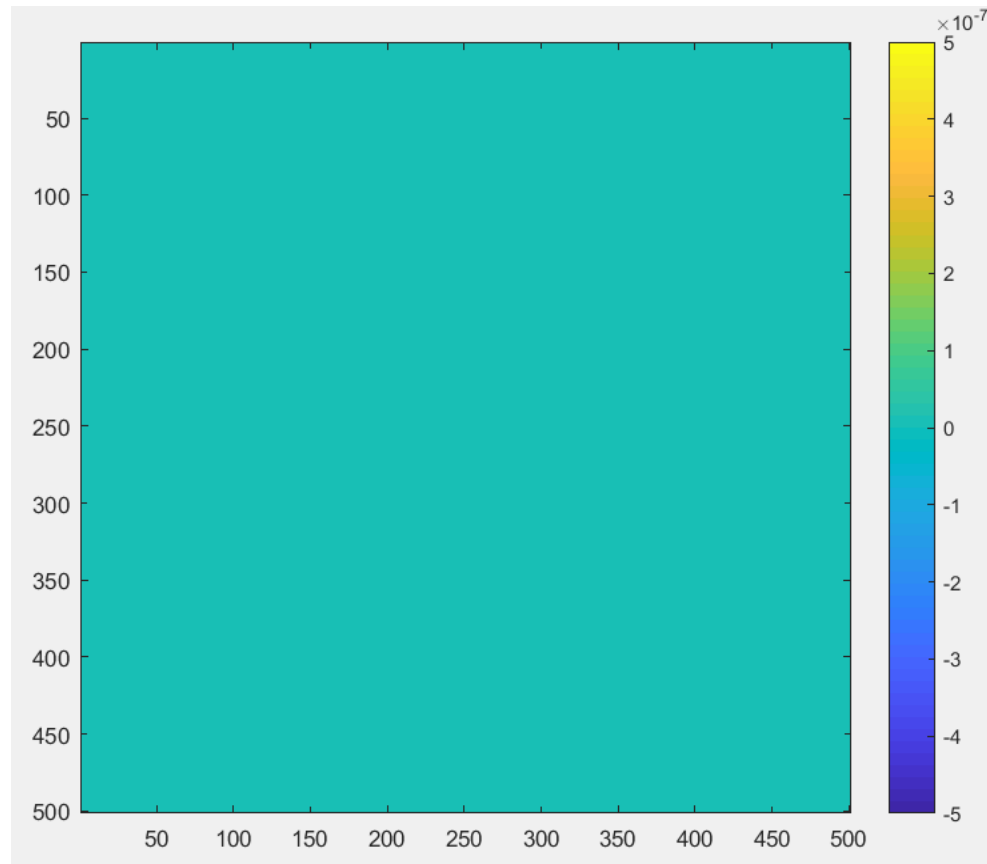
Critical numbers

- 39 meters diameter
- 798 segments
- 1.4m corner to corner
- 4mm gap between segments
- Controlled in Tip/Tilt Piston

And also...

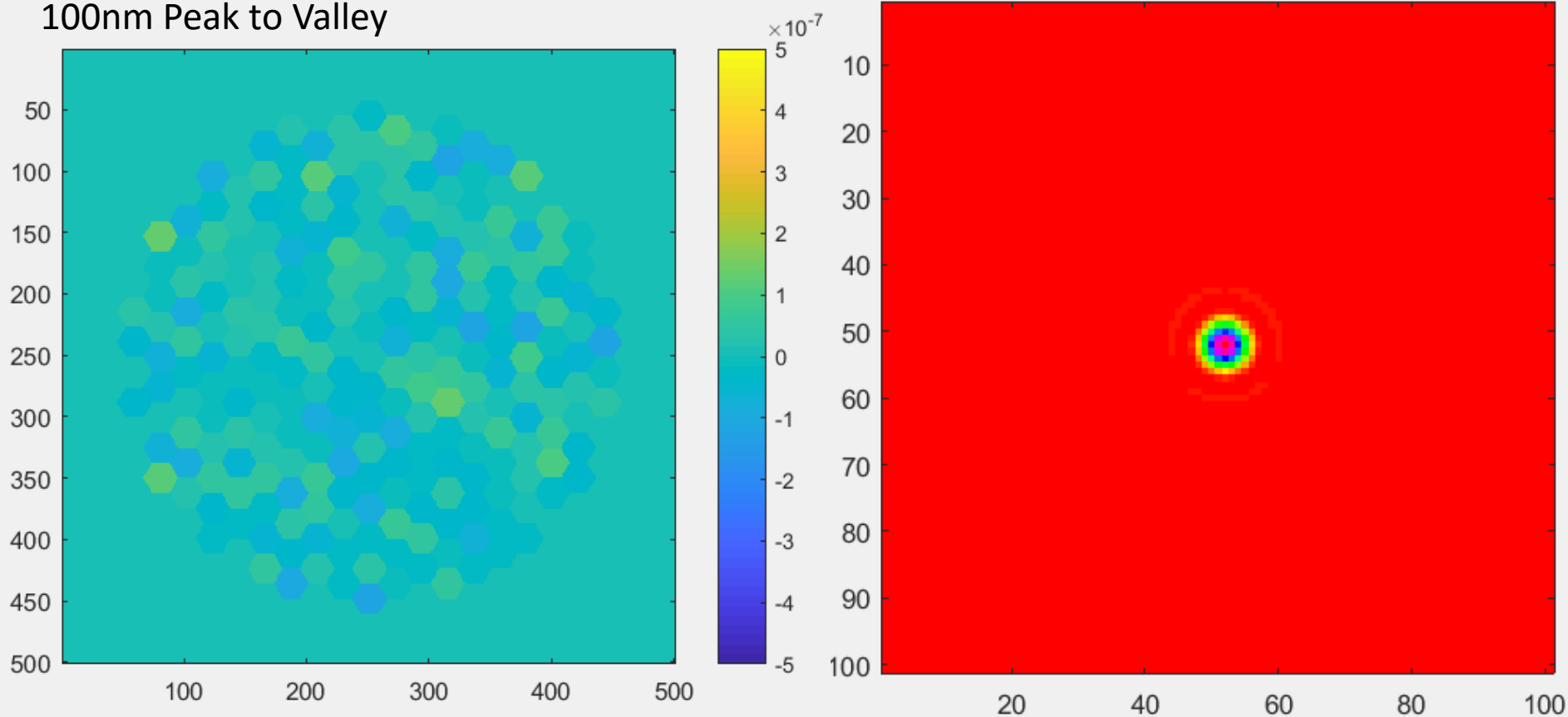
- > 7000 edge sensors
- > 7000 actuators

Perfect telescope



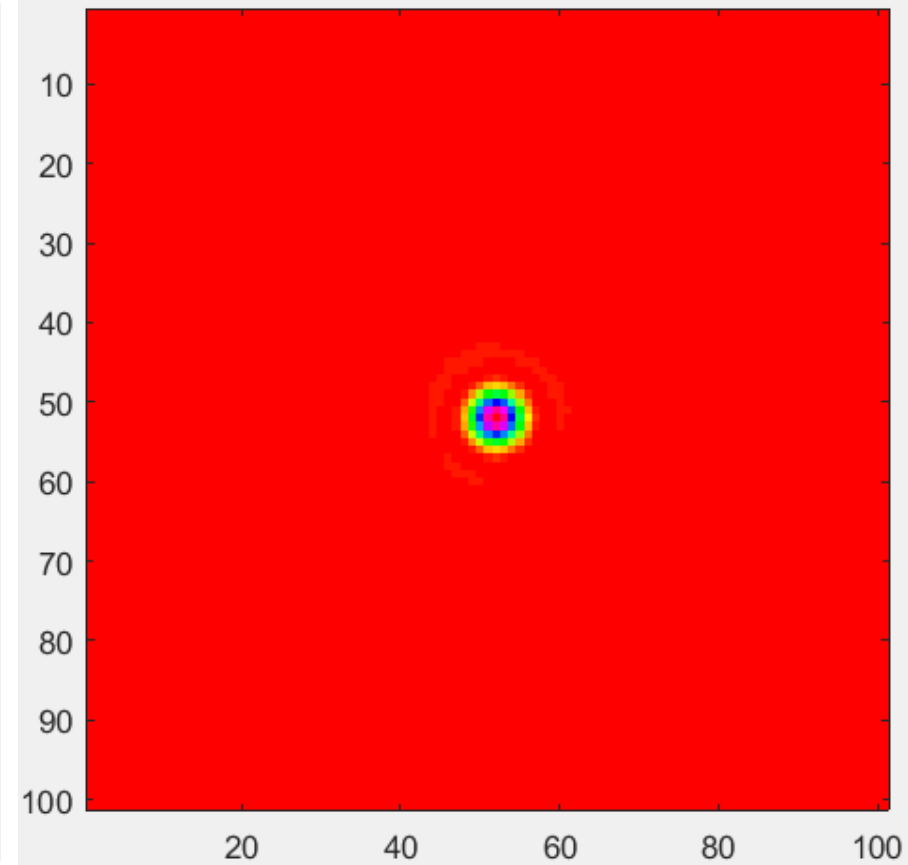
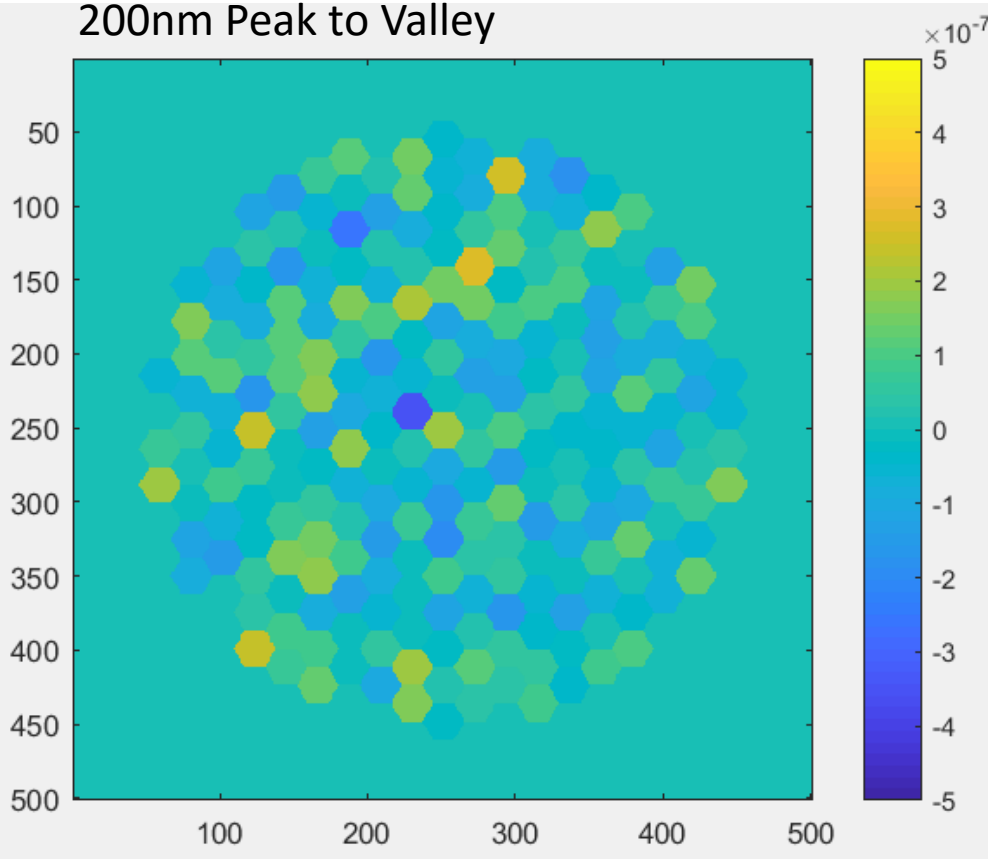
Not so perfect any more

100nm Peak to Valley



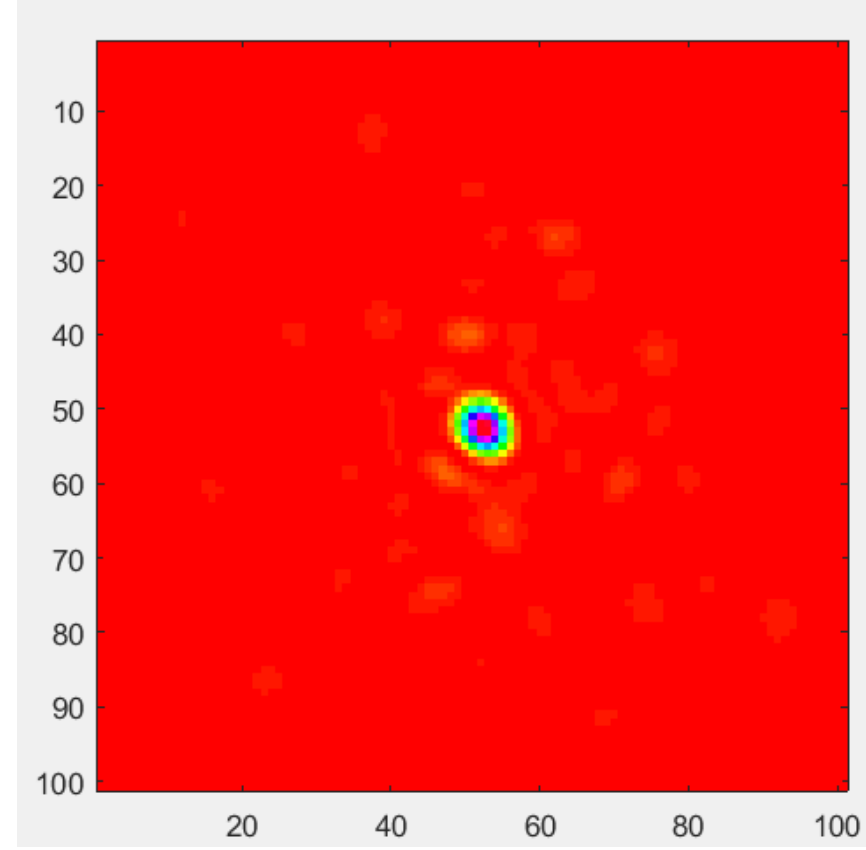
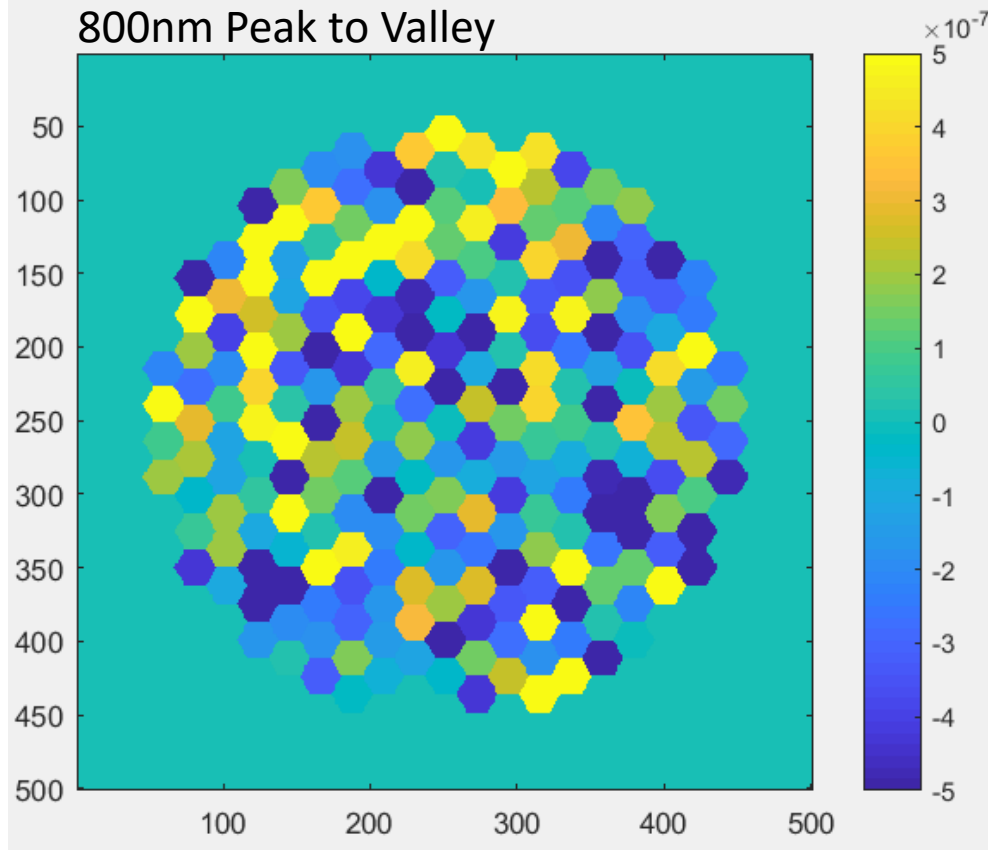
...

200nm Peak to Valley



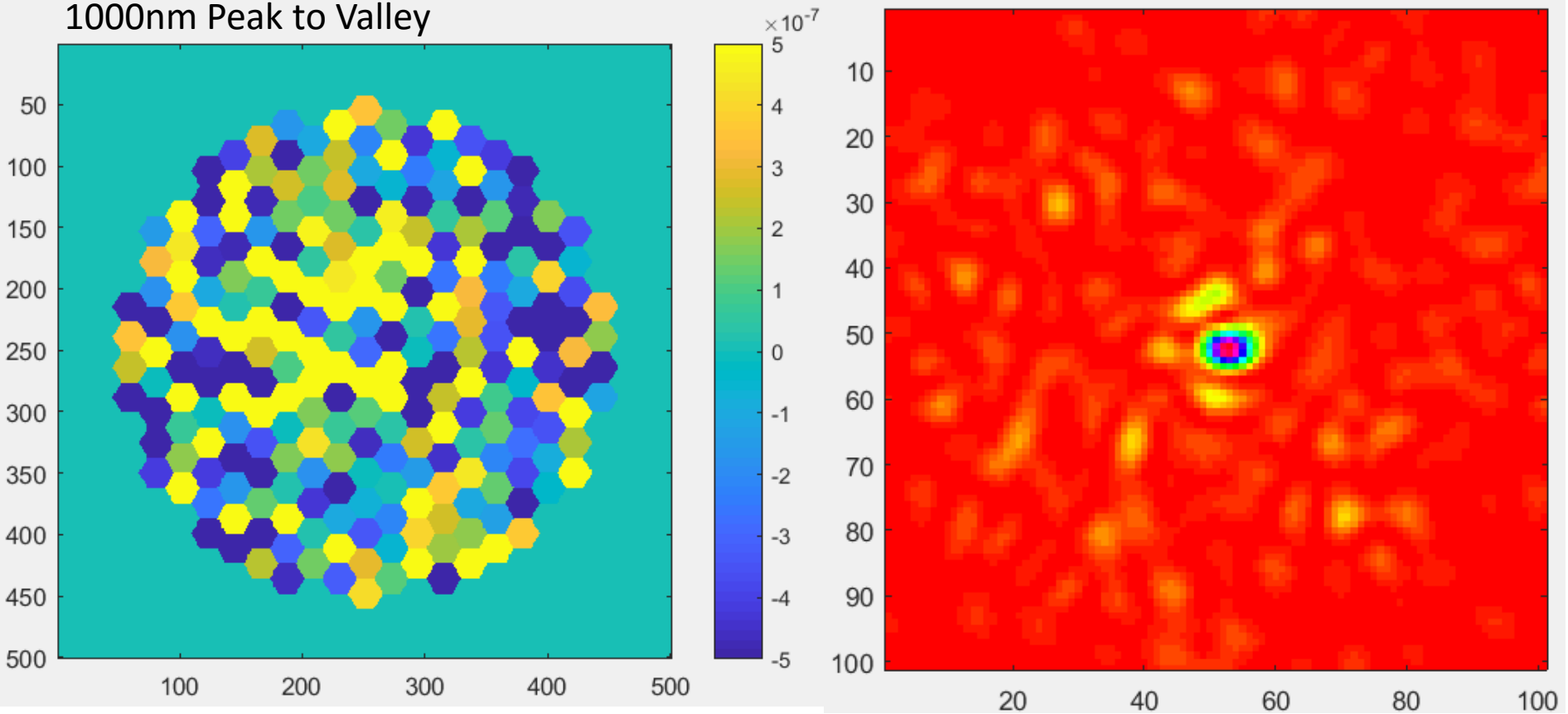
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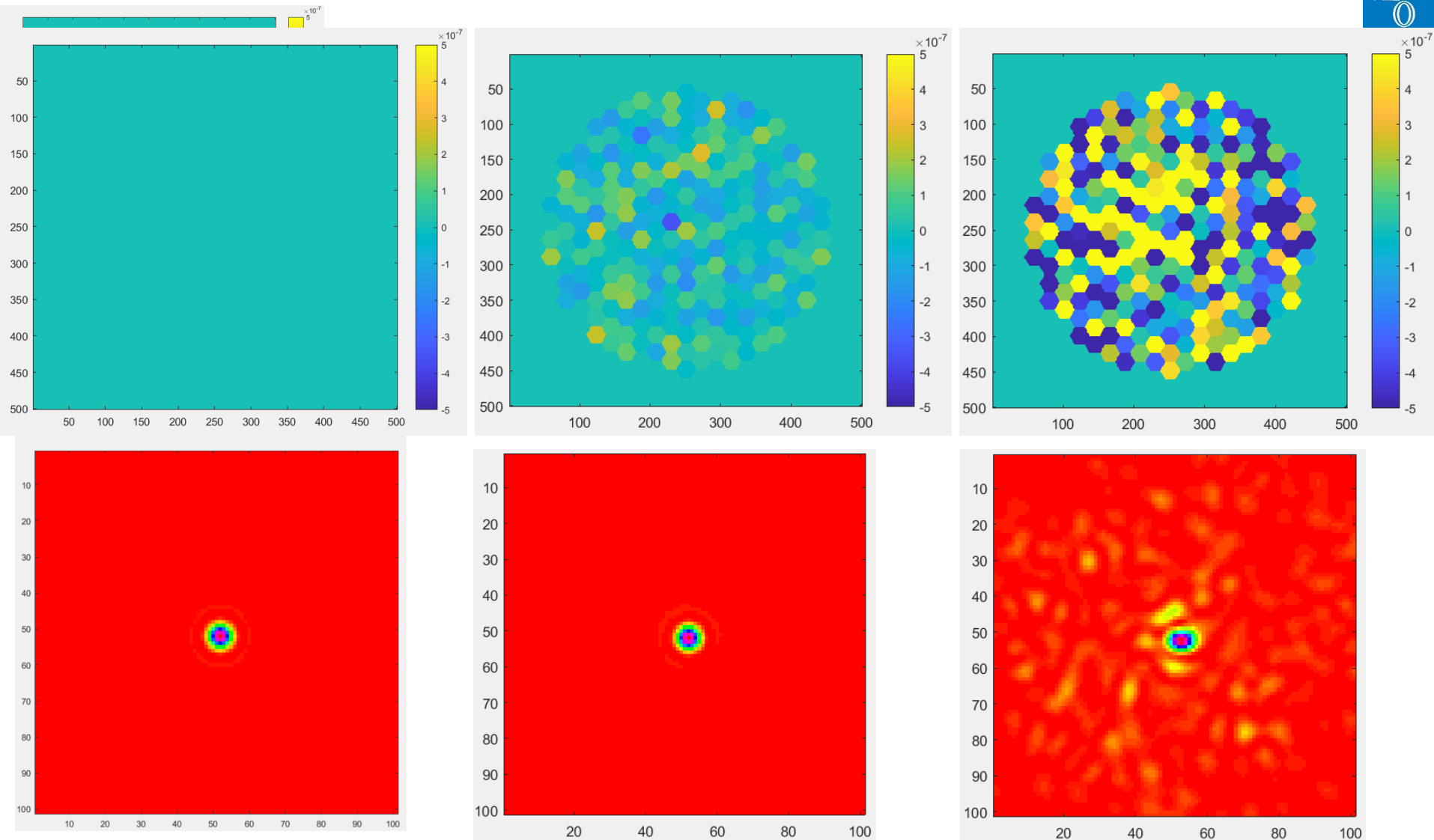
800nm Peak to Valley



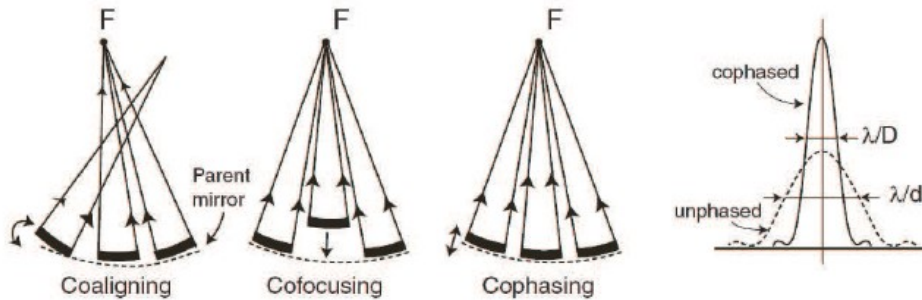
Completely banana

1000nm Peak to Valley

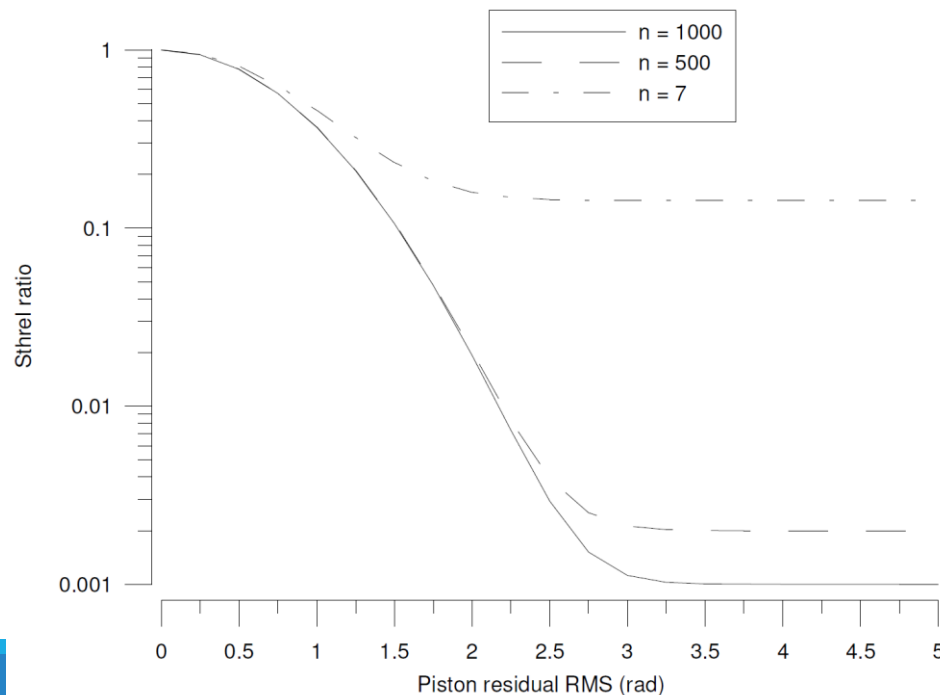




N=number of segments
 σ = residual RMS phasing error

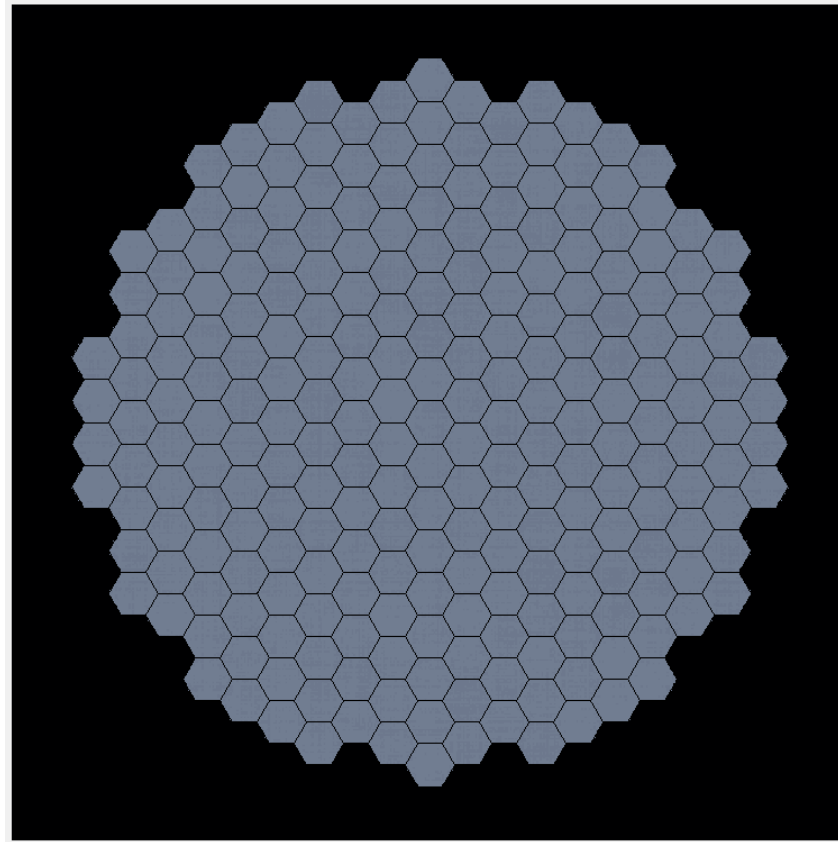


$$SR = \frac{1 + e^{-\sigma^2}(n - 1)}{n}$$



Source: Isabelle Surdej

Can you see something?



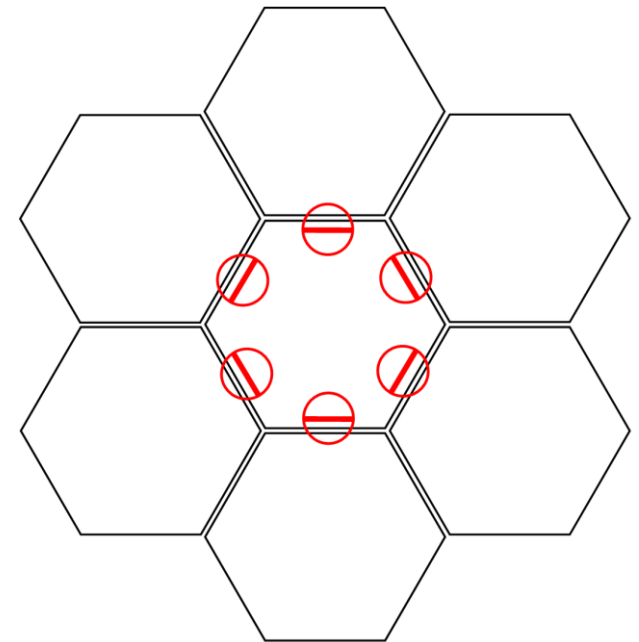
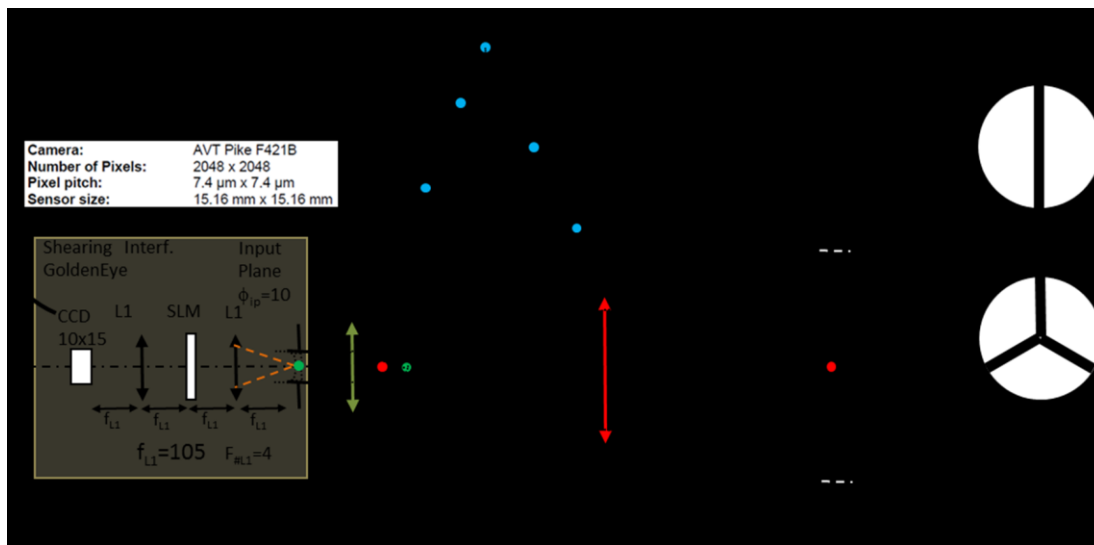
Challenge



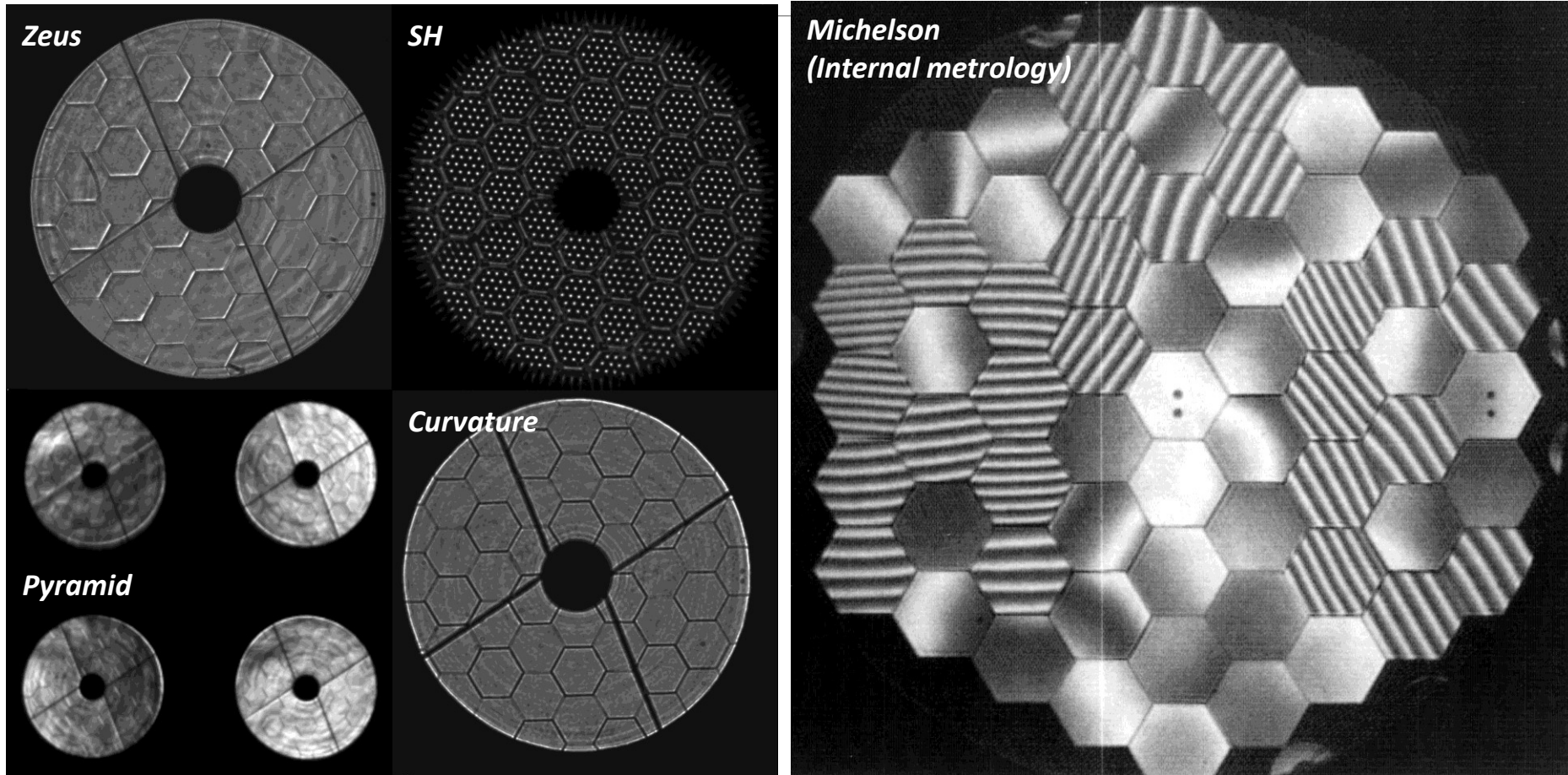
Solution



Look at it locally



Look at it globally



Active Phasing Experiment – ESO/VLT - 2009

Overview

Baseline for the ELT primary

- One phasing run on sky every two weeks using Shack-Hartmann
- Two freshly recoated segment re-installed on M1 per day

Risks

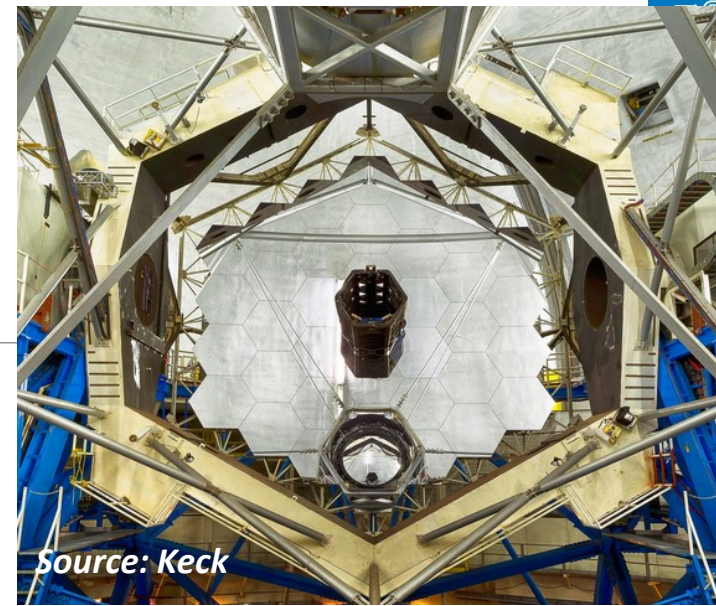
- High sensitivity to registration error (consequence of high segmentation)
- Degradation of the phasing over 2 weeks

Mitigation

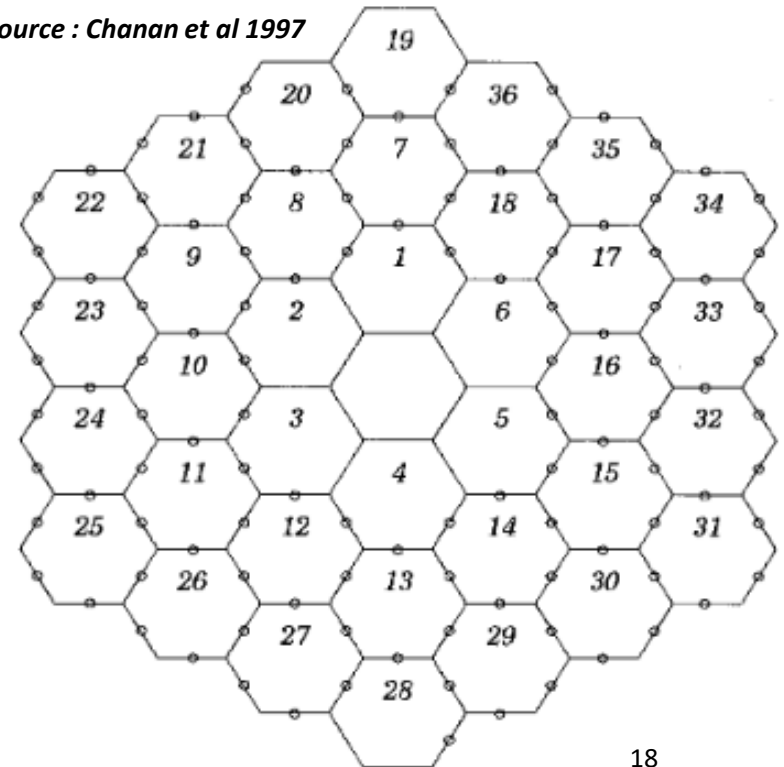
- Pupil plan phasing sensor to mitigate registration error
- Monitor the phasing during observation
- Phasing of one segment after replacement during sunny hours

Phasing Baseline: Keck approach

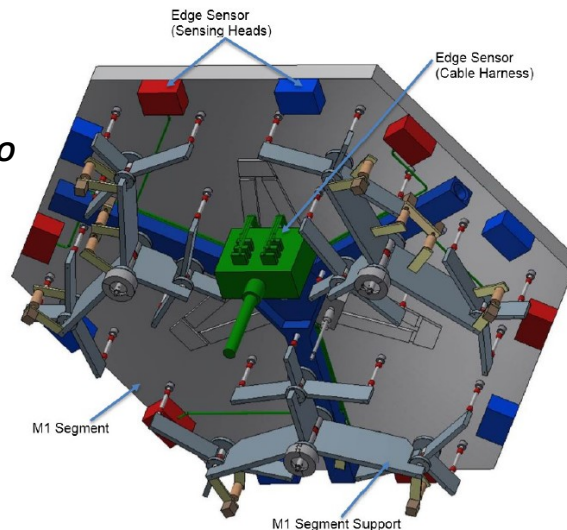
- Shack-Hartmann mask phasing sensor
- No phasing during observation:
→ high performance Edge sensor
- Maintenance



Source : Chanan et al 1997



Source : ESO



Risk assessment

Baseline

- Associated risk

One phasing run on sky every two weeks using Shack-Hartmann

- High sensitivity to registration error
- Degradation of the phasing

Baseline

- Associated risk

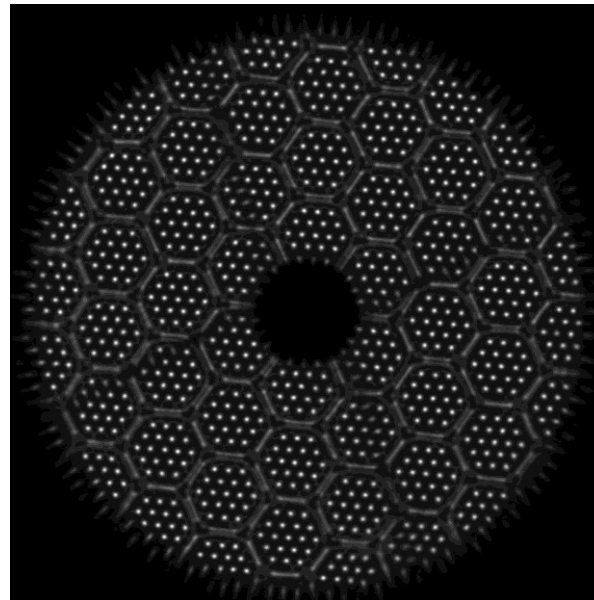
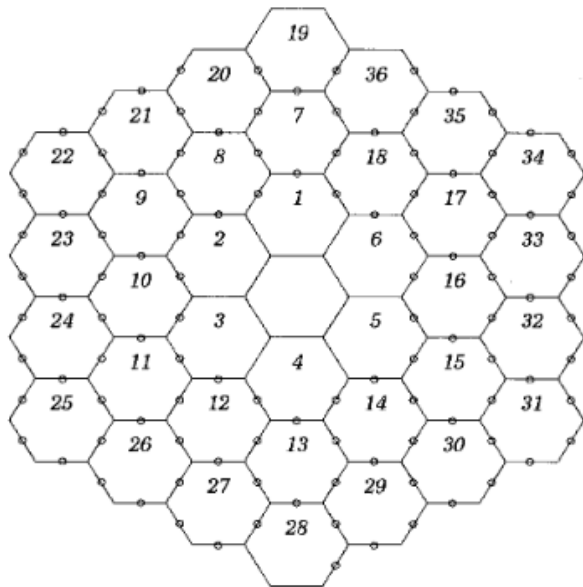
Two freshly recoated segment re-installed on M1 per day

- Degradation of the phasing

How to mitigate?

High sensitivity to registration error

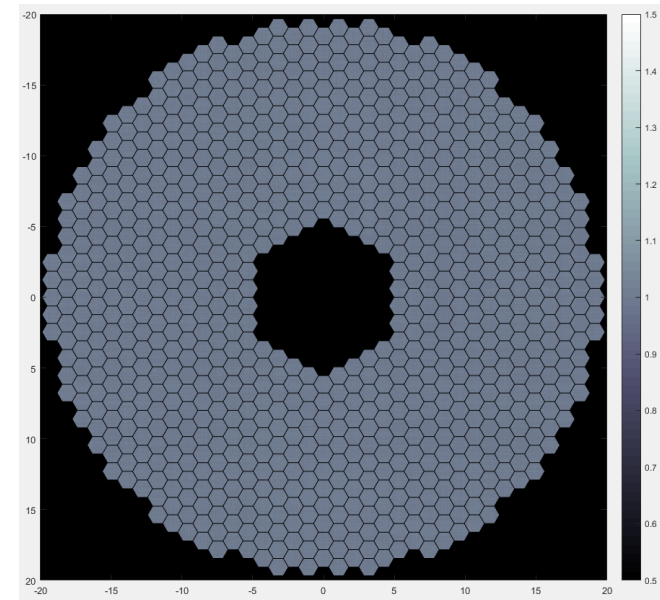
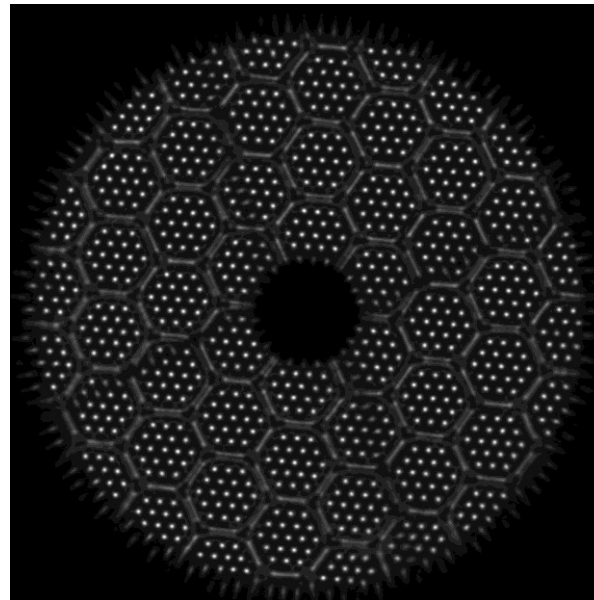
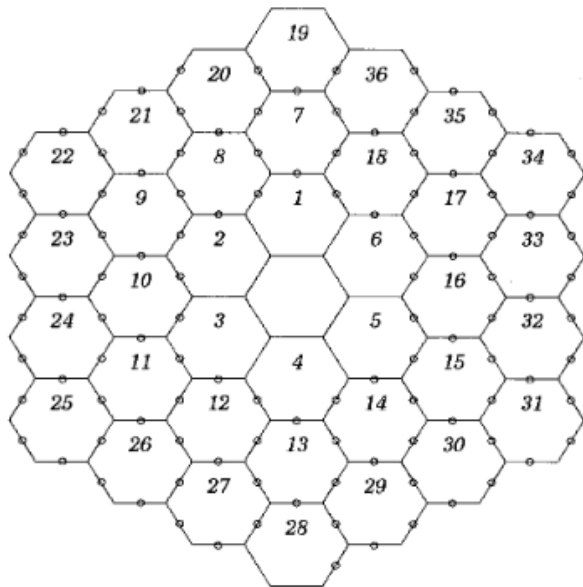
Registra...What?



Pupil plane phasing sensor to mitigate registration error

High sensitivity to registration error

Registra...What?

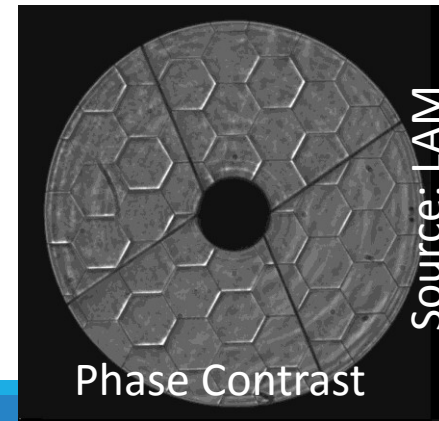
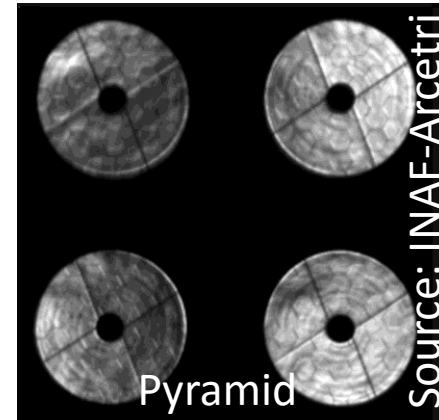
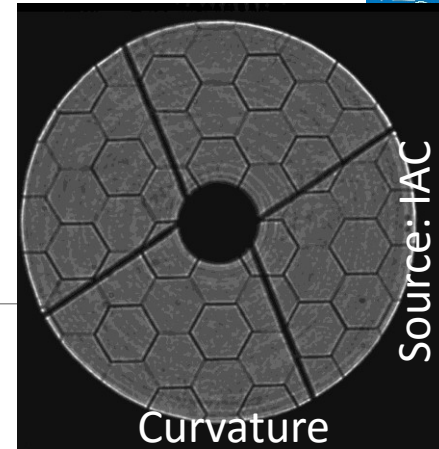
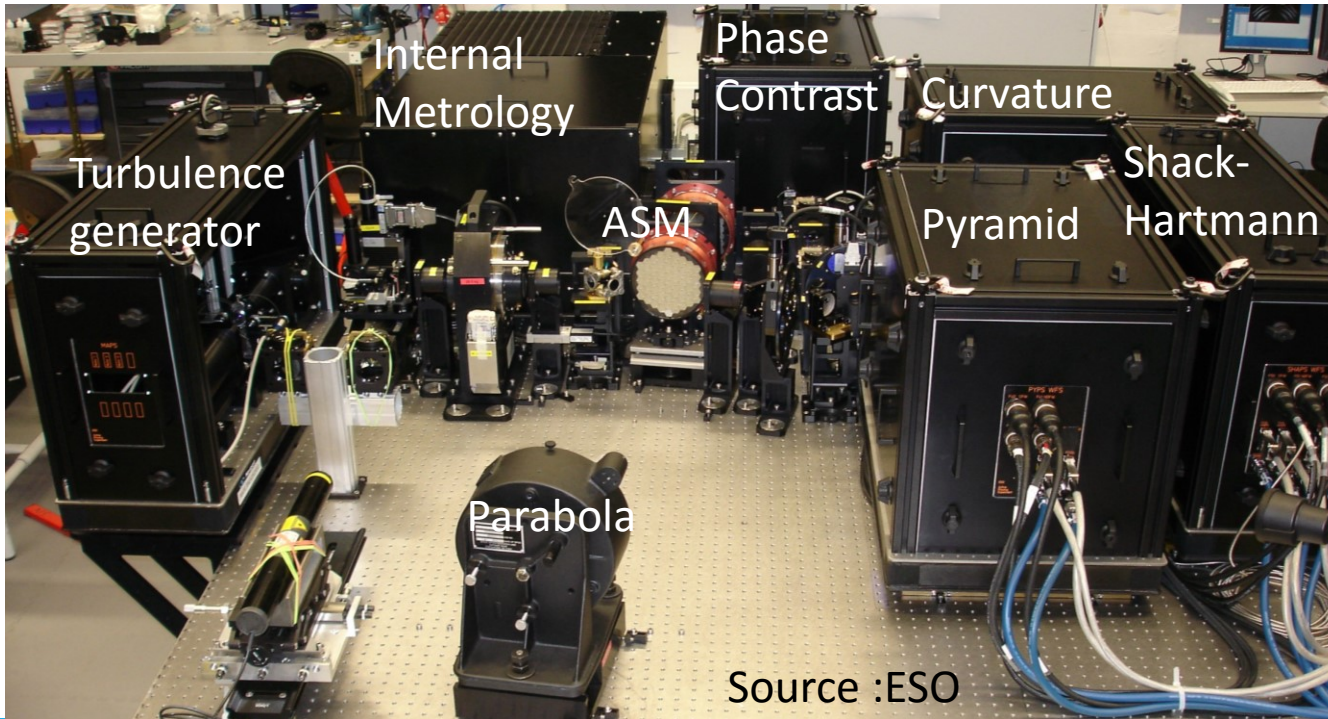


Pupil plane phasing sensor to mitigate registration error

High sensitivity to registration error

Active Phasing Experiment

- ASM :Active Segmented Mirror (61 Segment)

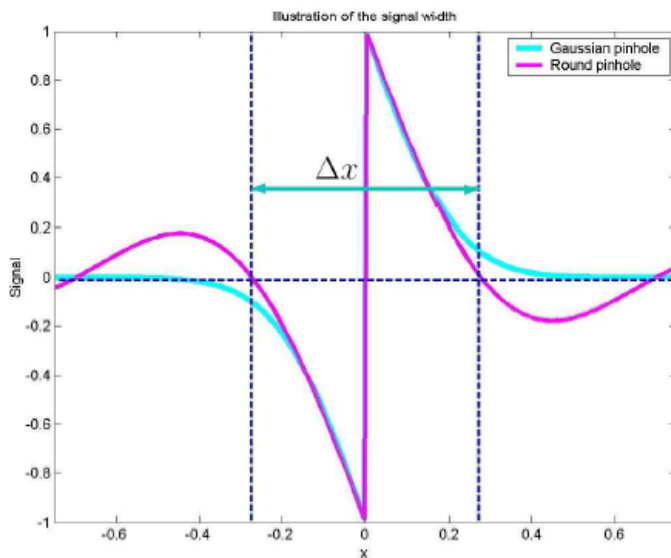
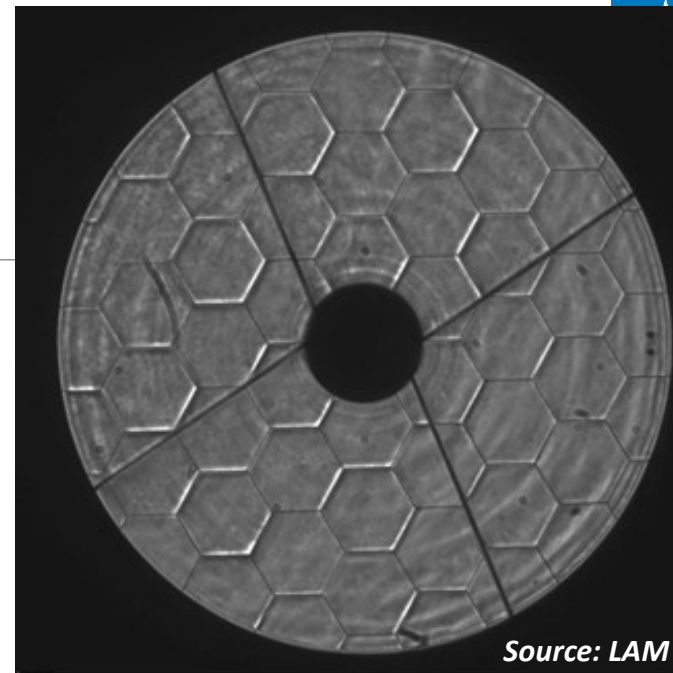


High sensitivity to registration error

Phase contrast sensor

- Zernike Unit Sensor (LAM)

Monitoring phasing during observation



Source: I.Surdej Thesis

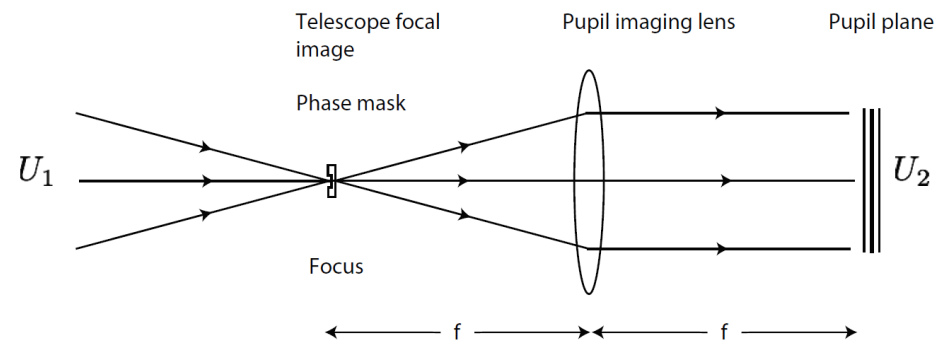


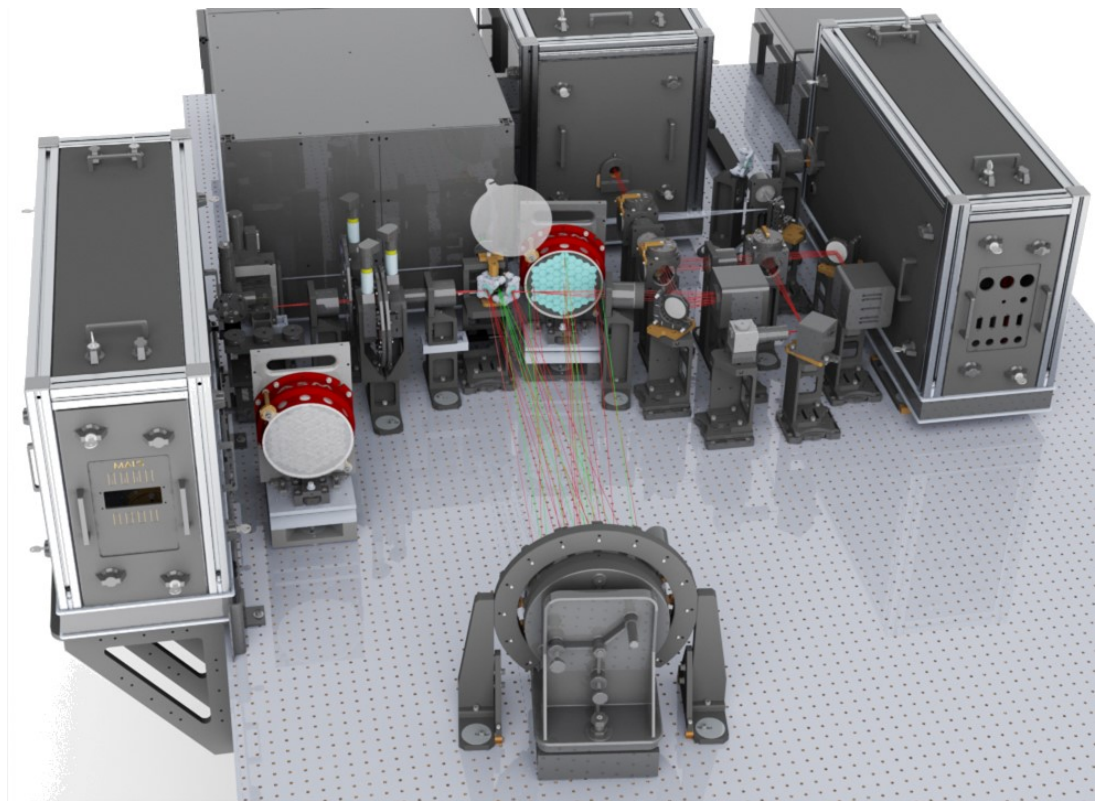
Figure 5.1: Zernike phasing sensor layout: After the filtering of the incoming wavefront U_1 by the phase mask (shown in detail in Fig. 5.2) in the focal plane, the pupil is re-imaged on the detector plane, U_2 , by a pupil re-imaging lens of focal length f .

Source: I.Surdej Thesis

Monitor the phasing during observations

Phasing the ELT with Adaptive optics Control Experiment (PEACE),

- Investigate cross-performance with AO
- ZEUS → wavelength scan to increase capture range?



Monitor the phasing during observations

Phasing the ELT with Adaptive optics Control Experiment (PEACE),

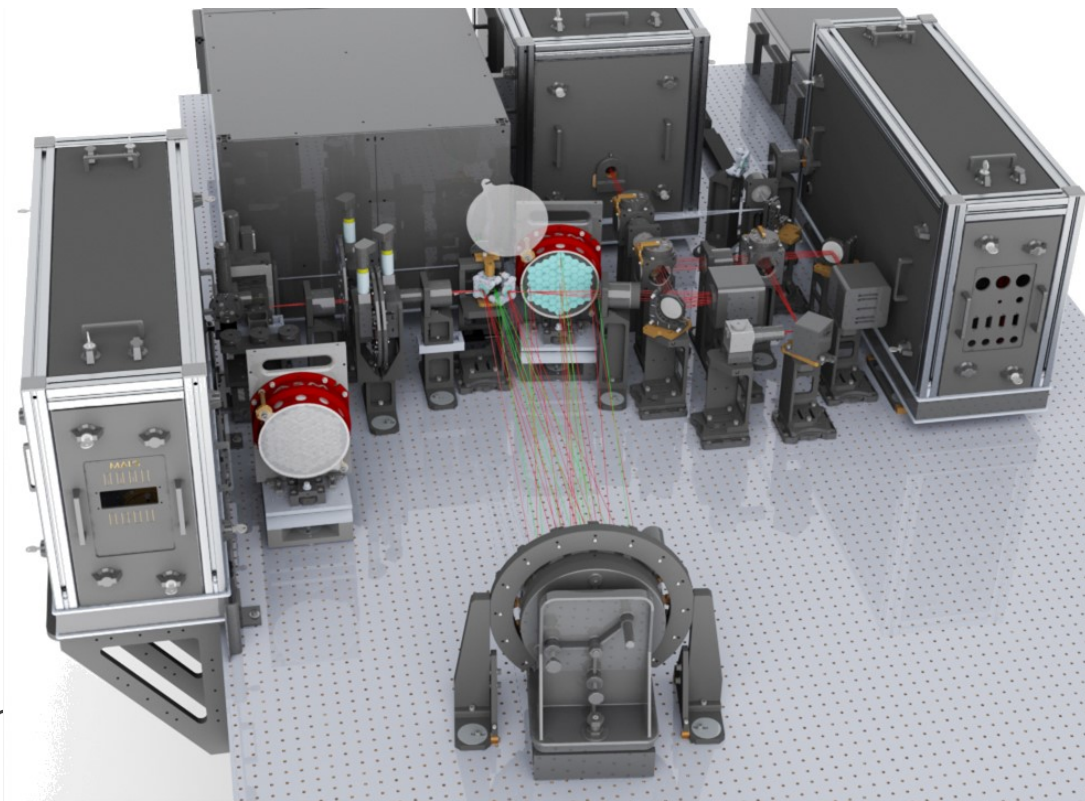
- Investigate cross-performance with AO
- ZEUS → wavelength scan to increase capture range?

On going refurbishment

- Metrology = Edge Sensor

Addition to fit ELT baseline

- ELT Spider
- Adaptive Optics Segmentator



Local phasing → phasing gun

Local phasing

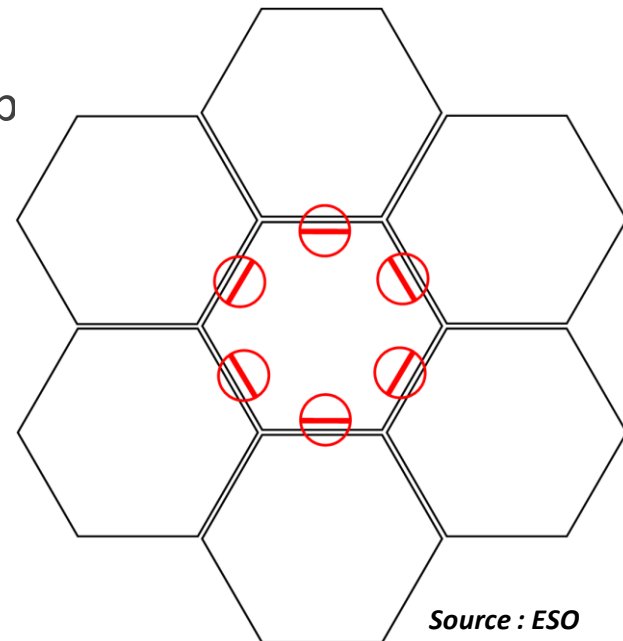
Two freshly recoated segment re-installed on M1 per day

Edge sensor: no phasing while observing

- Reference lost

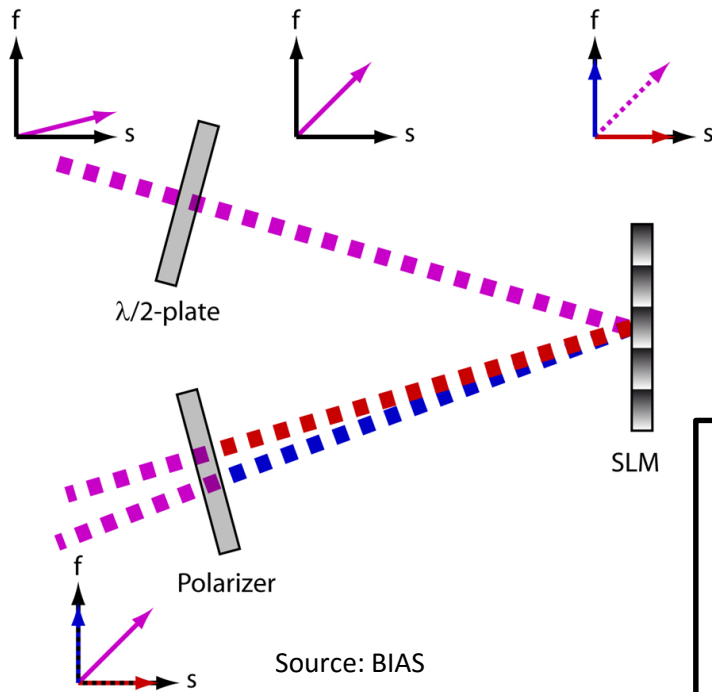
Day time phasing of one segment after rep

- Range $\pm 200\mu\text{m}$
- Precision $\sim 10\text{-}20\text{nm}$

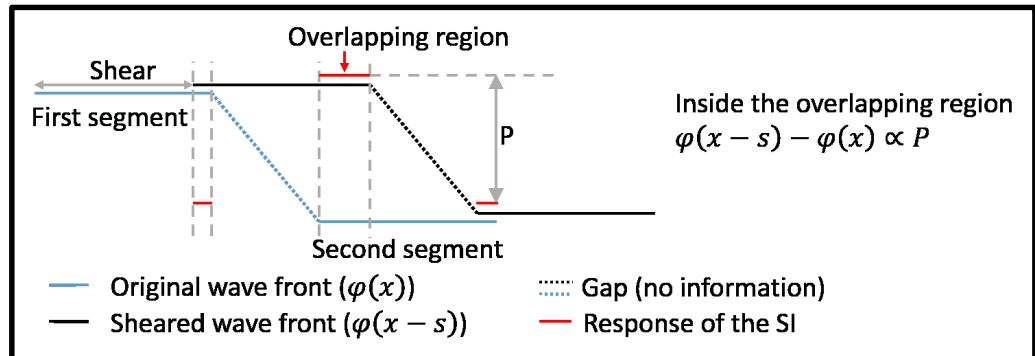
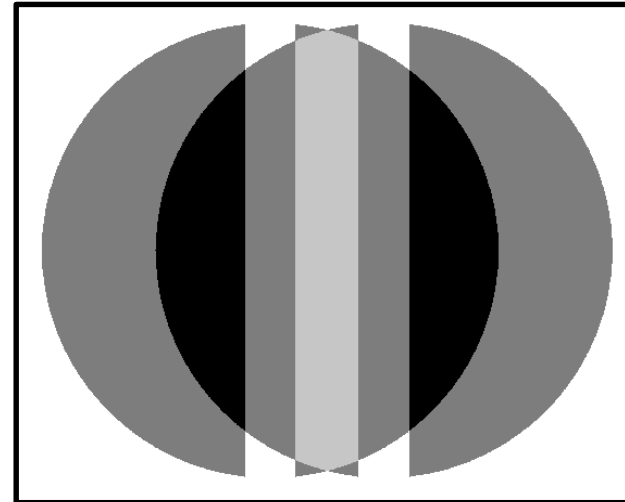


Source : ESO

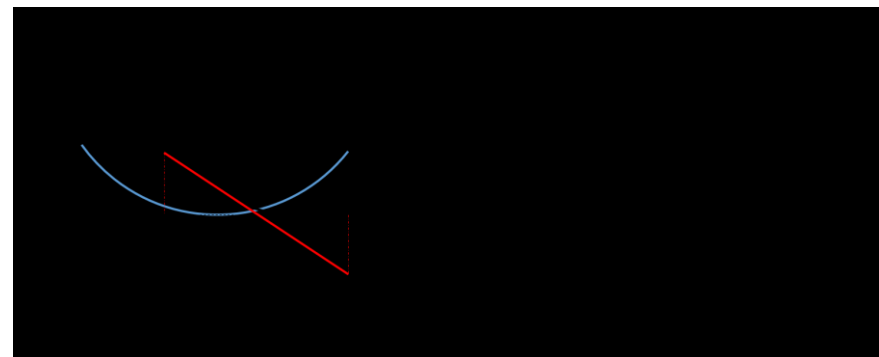
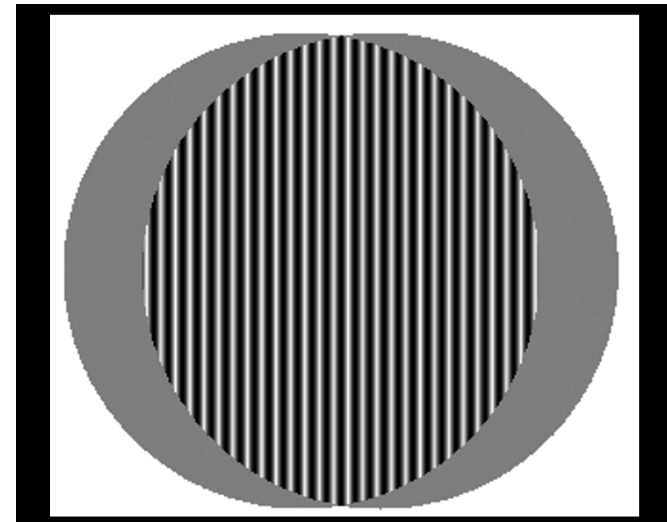
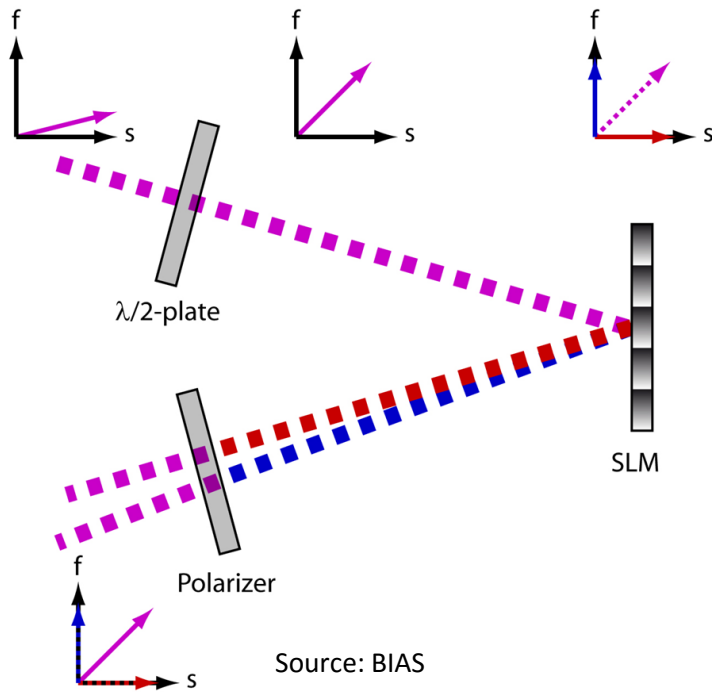
Multiwavelength Shearing Interferometer



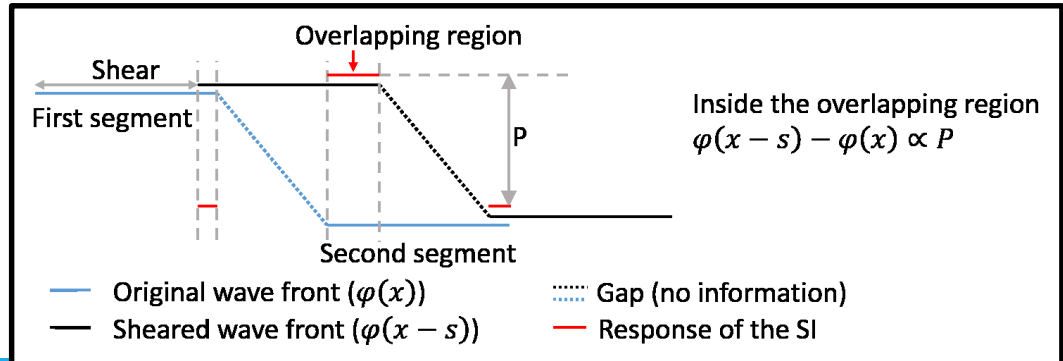
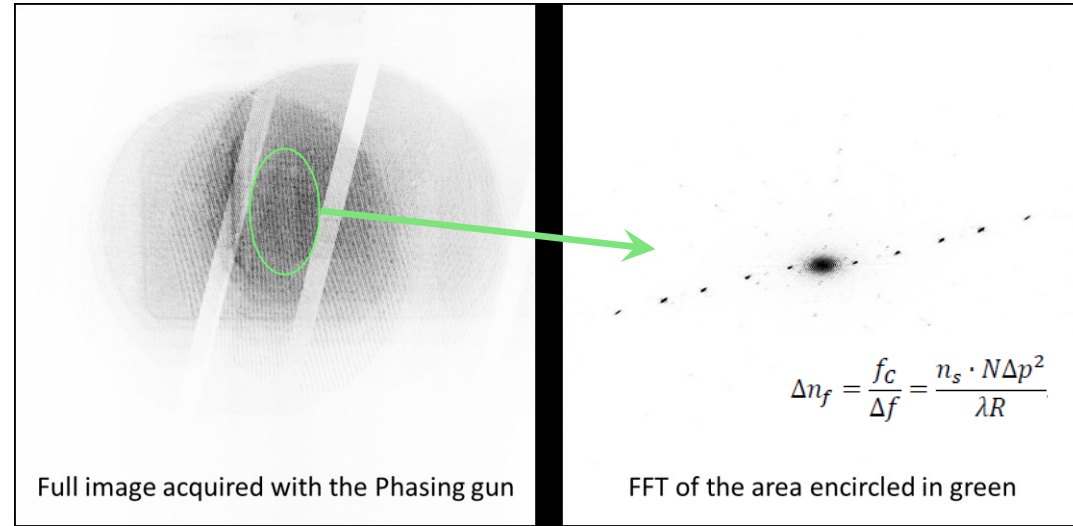
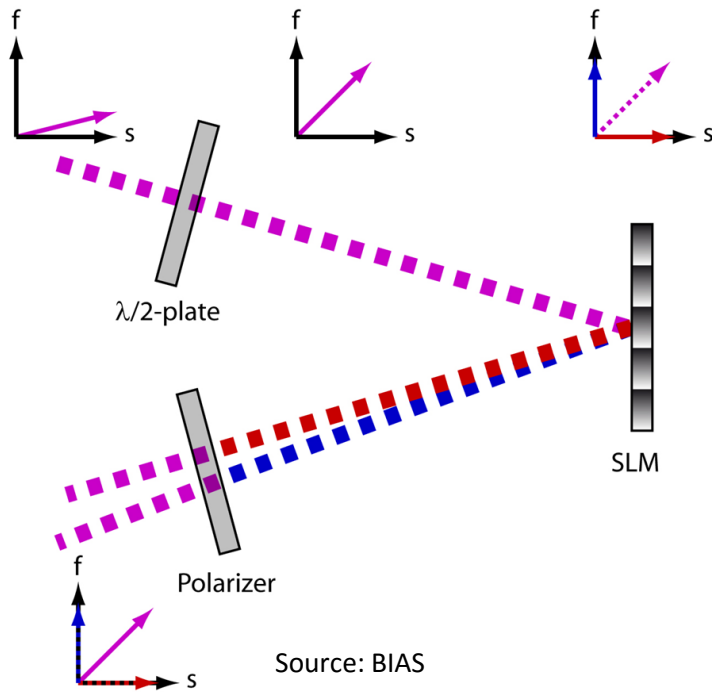
Source: BIAS



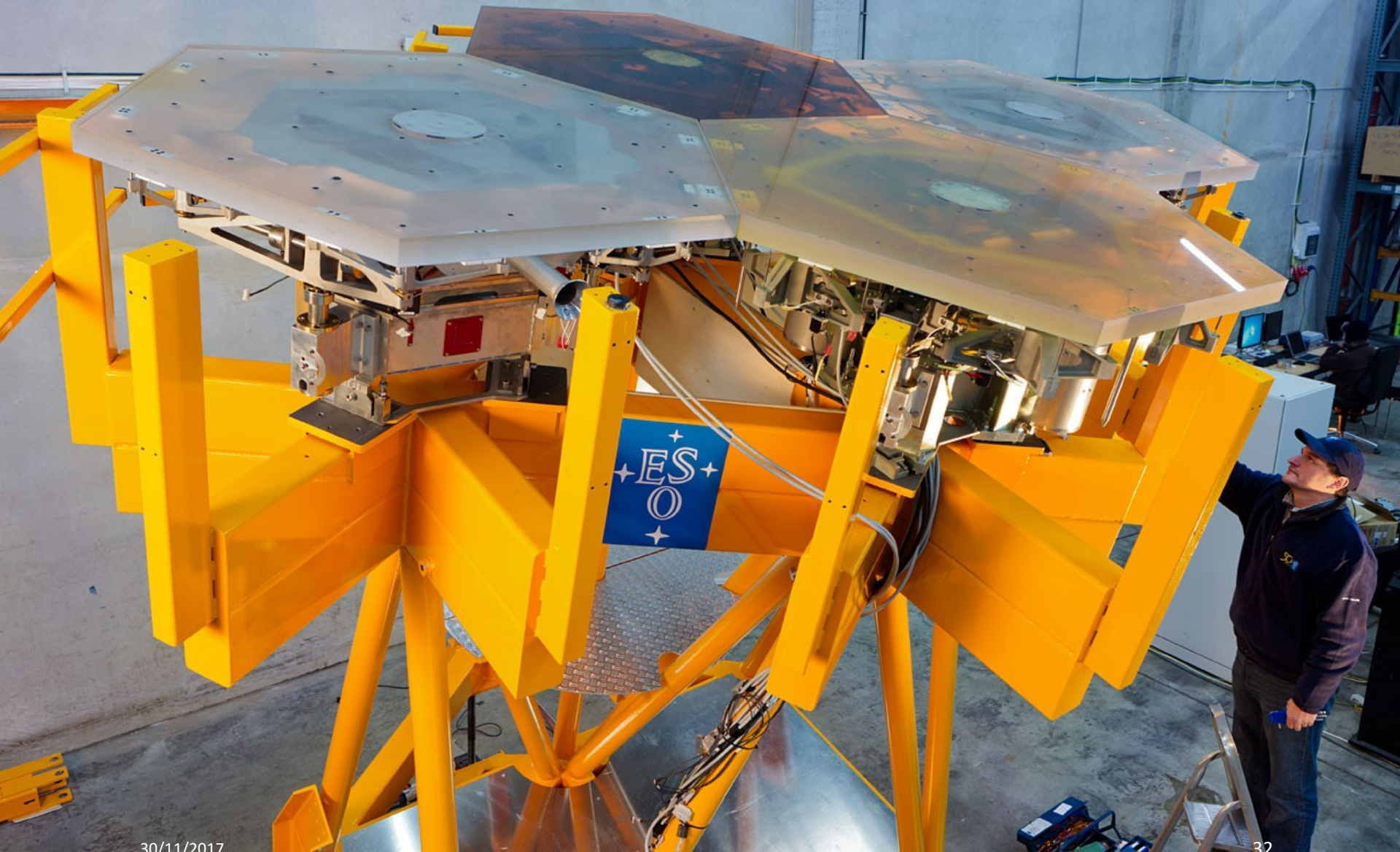
Multiwavelength Shearing Interferometer



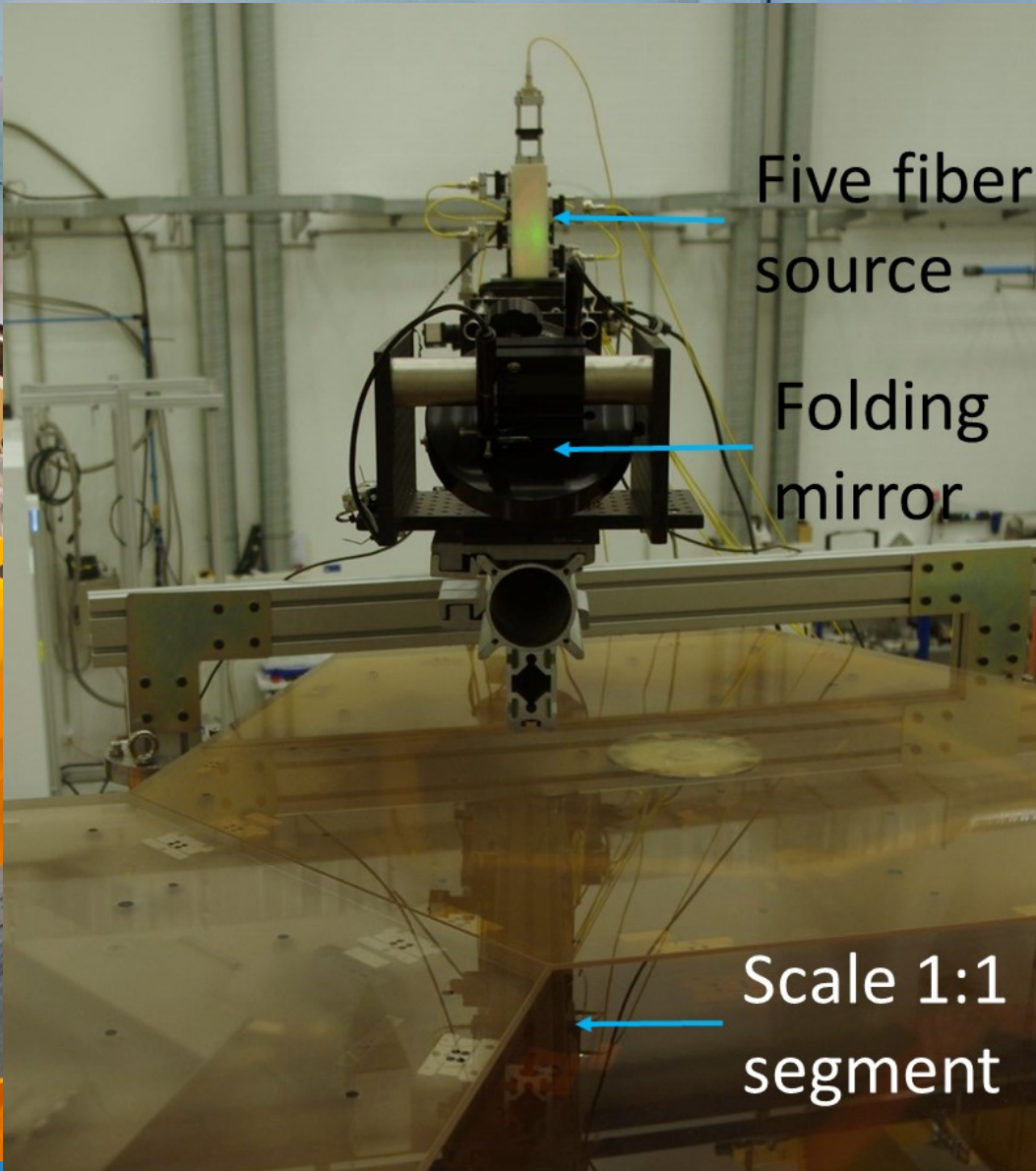
Multiwavelength Shearing Interferometer



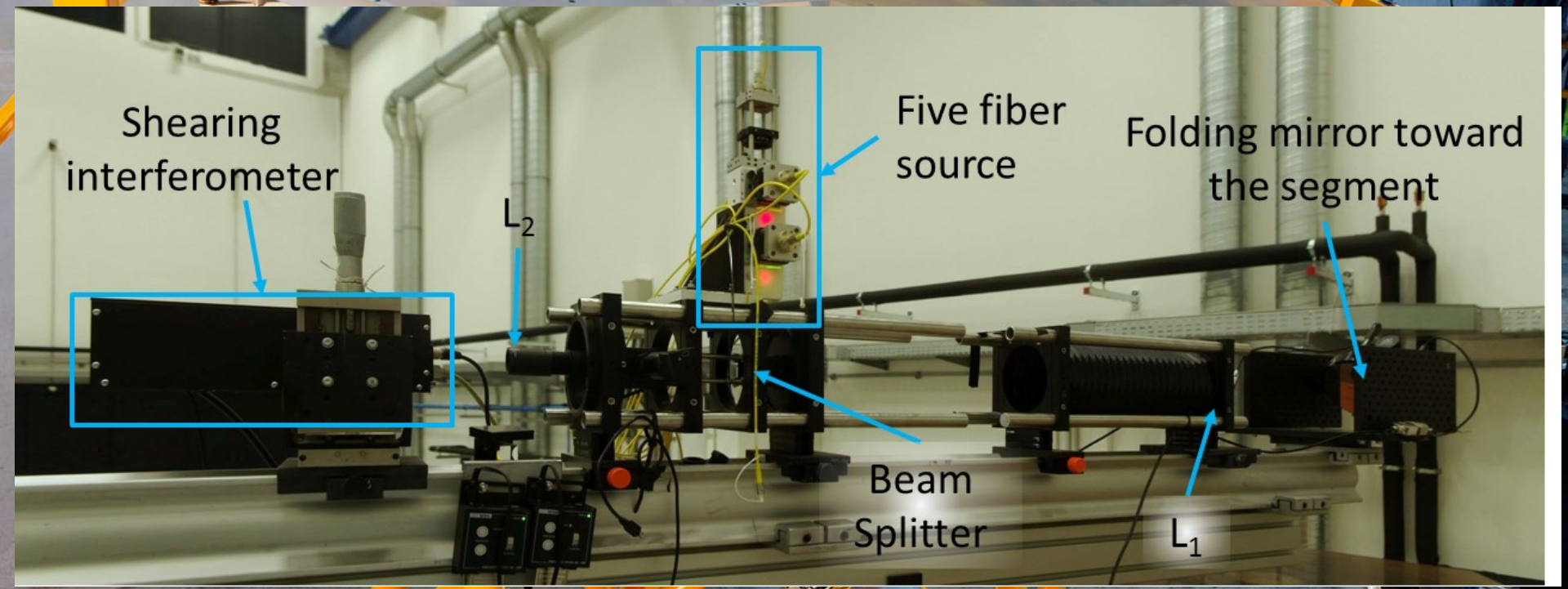
ELT M1 facility



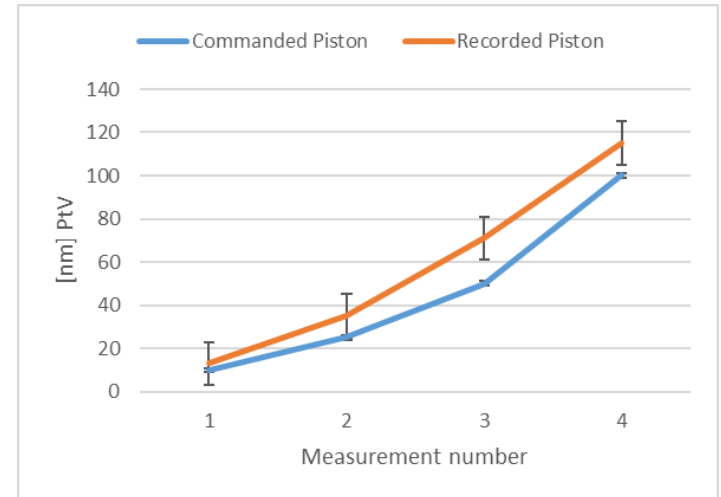
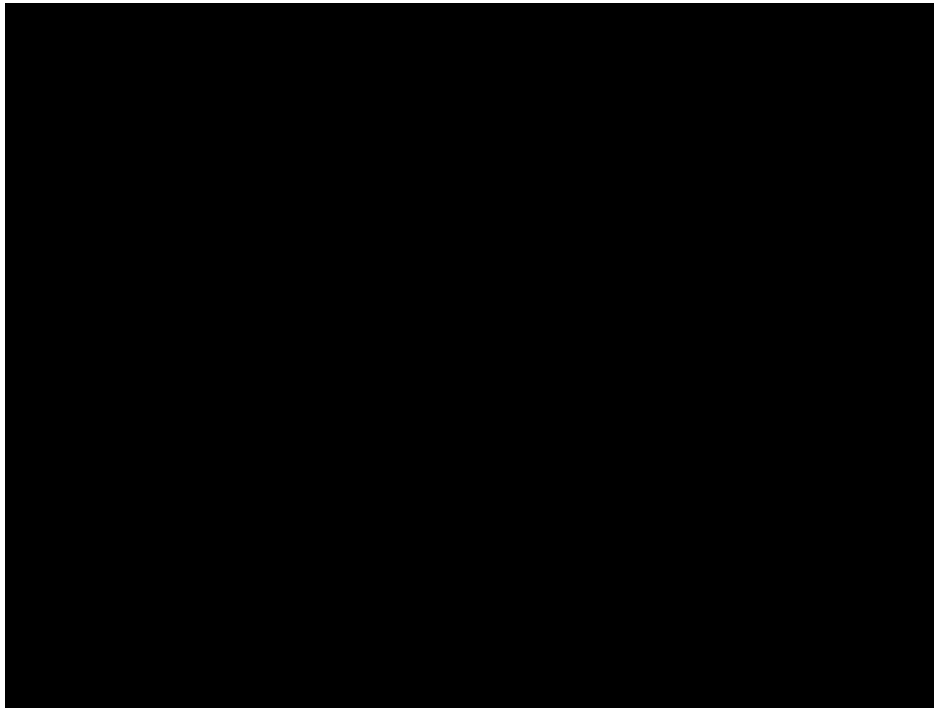
ELT M1 facility + Phasing gun



Multiwavelength Shearing Interferometer



Multiwavelength Shearing Interferometer



To be done:

- Repeatability
- Average of N measurements (dispersion)

Conclusion

On going & future work:

- PEACE refurbishment
 - AO cross performance
 - Zeus capture range increase -> wavelength scar

- Phasing gun
 - Miniaturisation
 - Dispersion characterisation

