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Thomas Arnold, Axel Schindler

HZB Helmholtz Zentrum Berlin

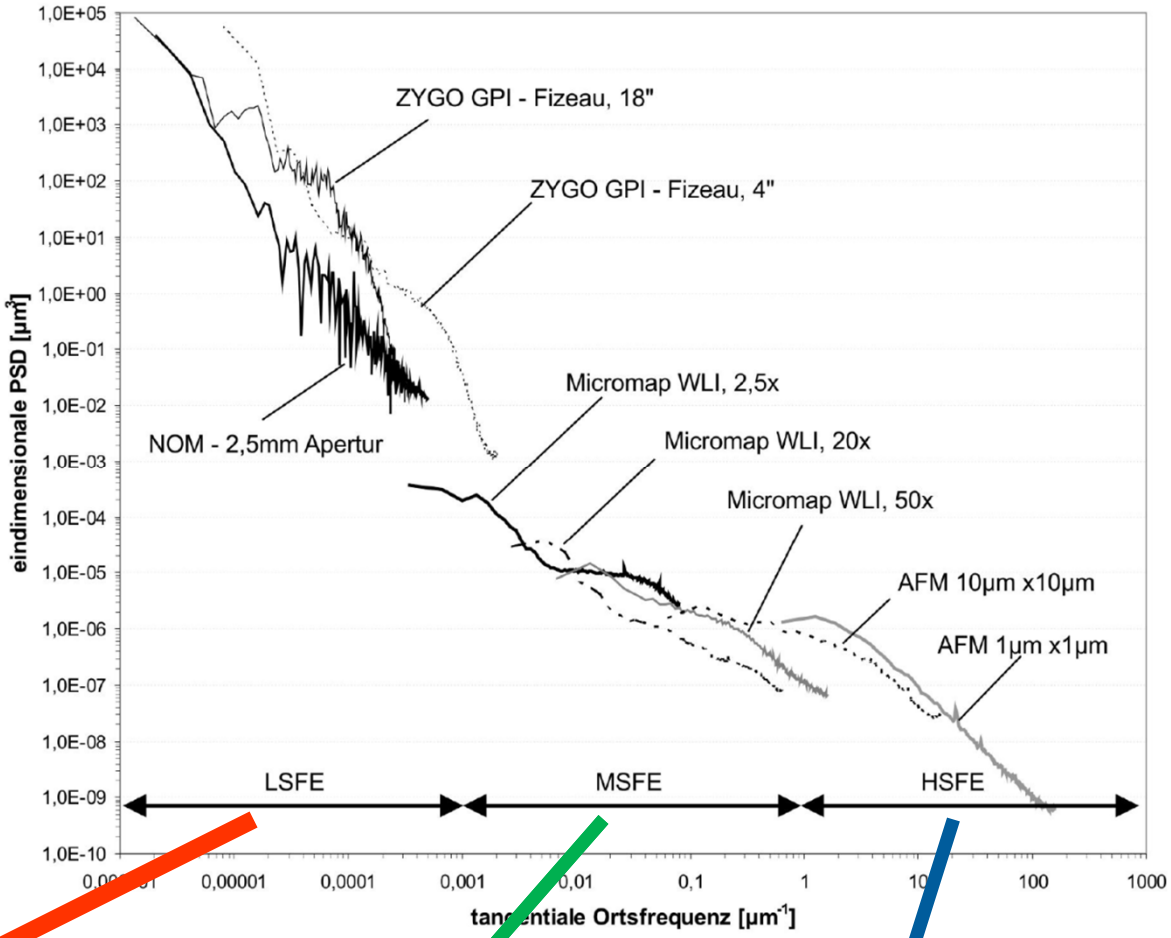
IOM

Investigations on the performance of autocollimator-based slope measuring profiler

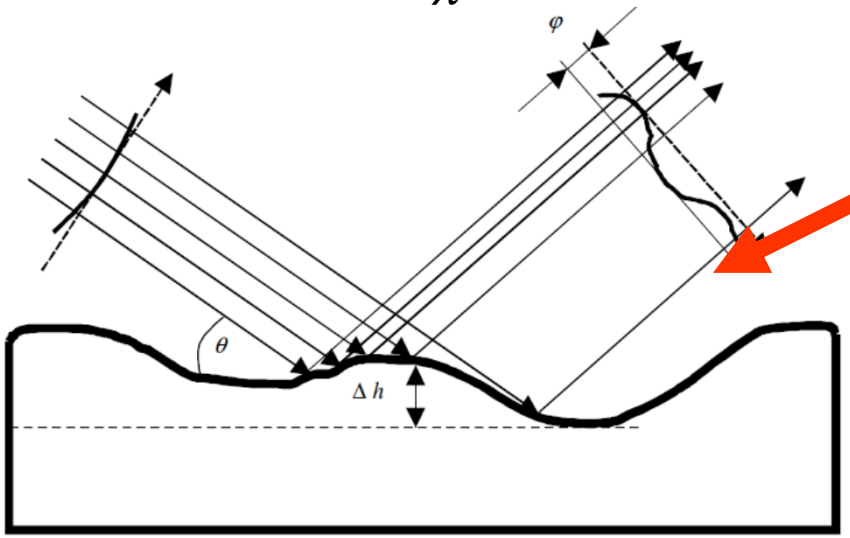
Outline:

- Introduction
- Latest results on metrology
- Performance test by use of a periodic and chirped sample

Mirror quality and beamline performance



$$\varphi = \frac{2\Delta h \sin\theta}{\lambda}$$



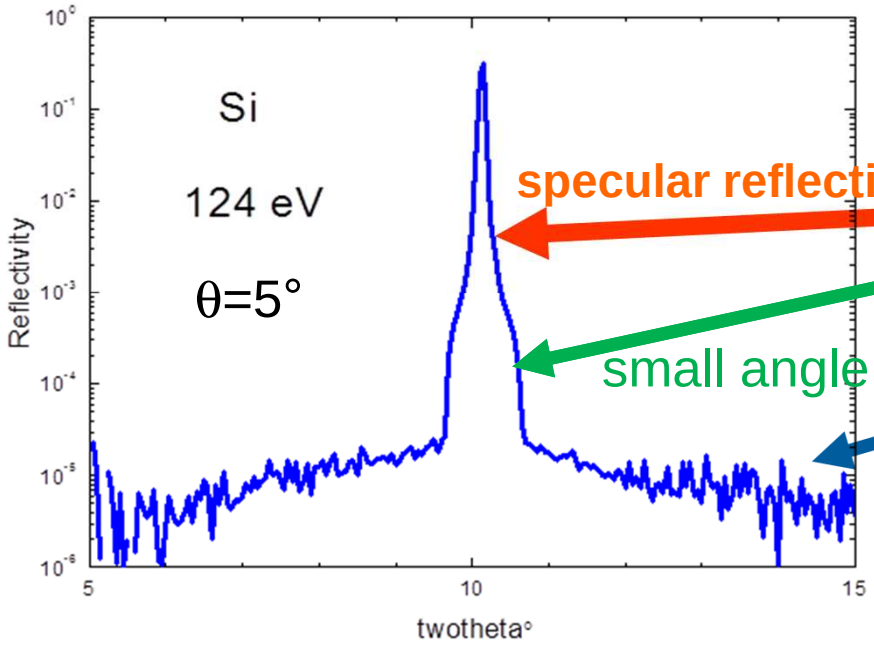
small angle scatter

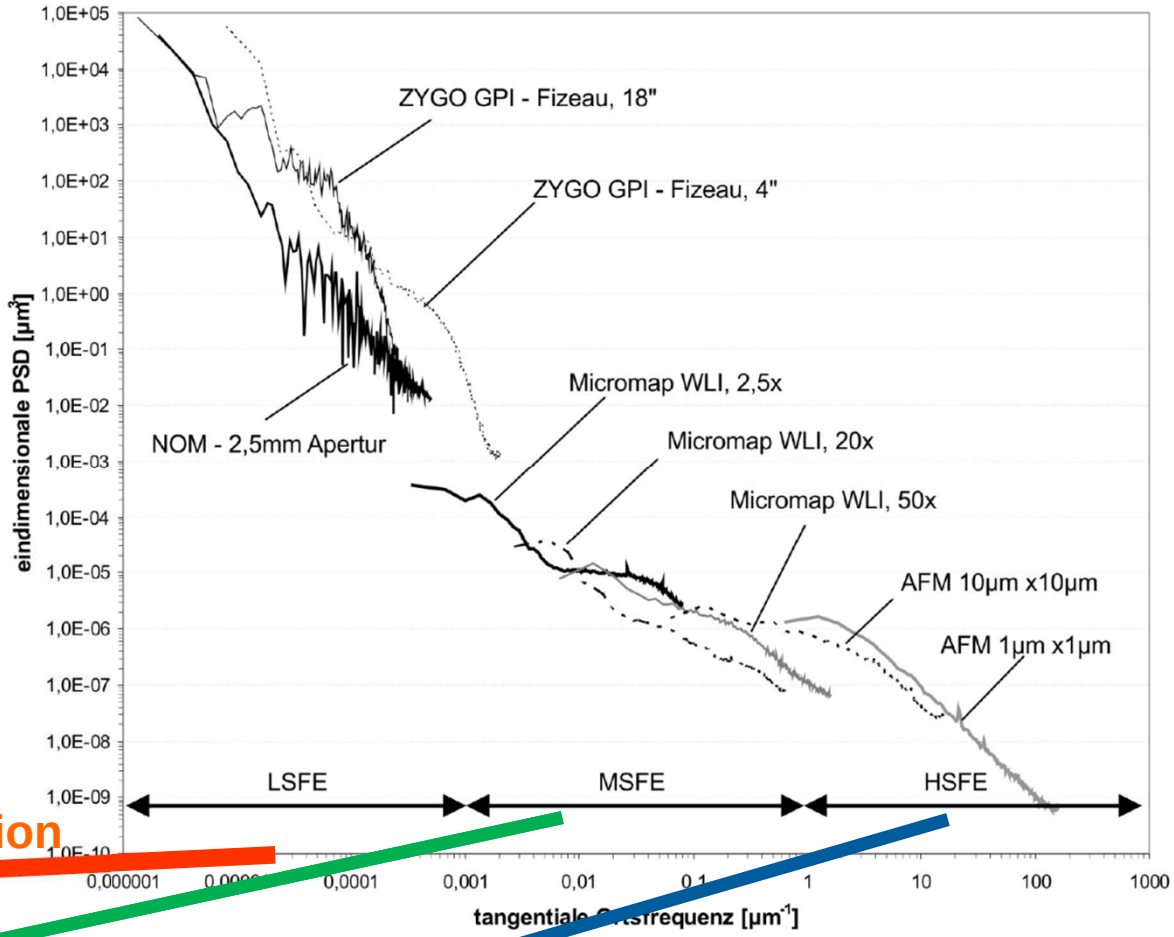
wide angle scatter

* See also: VDI/VDE-Richtlinie Röntgenoptik
IWXM 6. July 2012

Mirror quality and beamline performance

Thanks to Franz Schäfeers
and Silvio Kuenstner

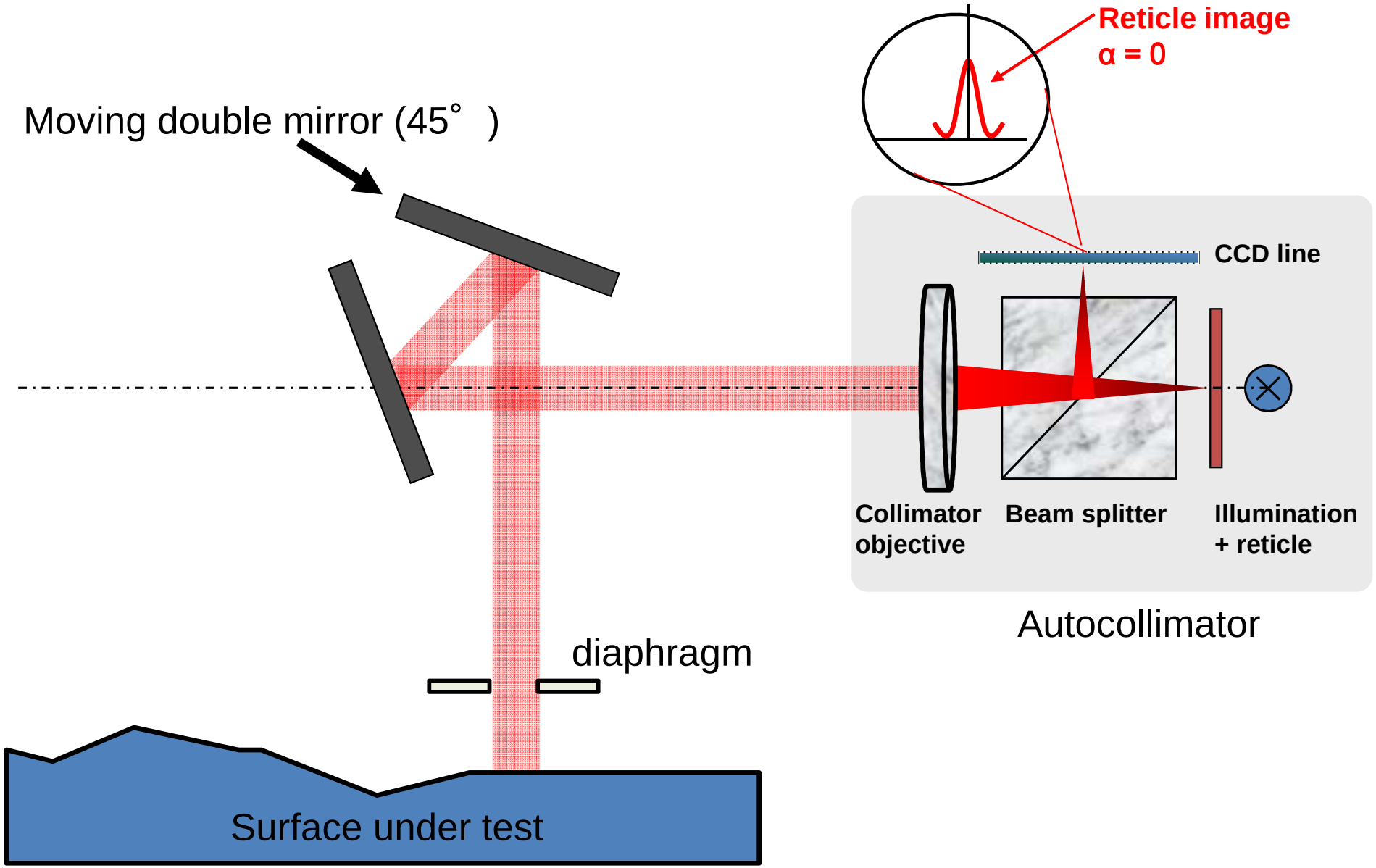




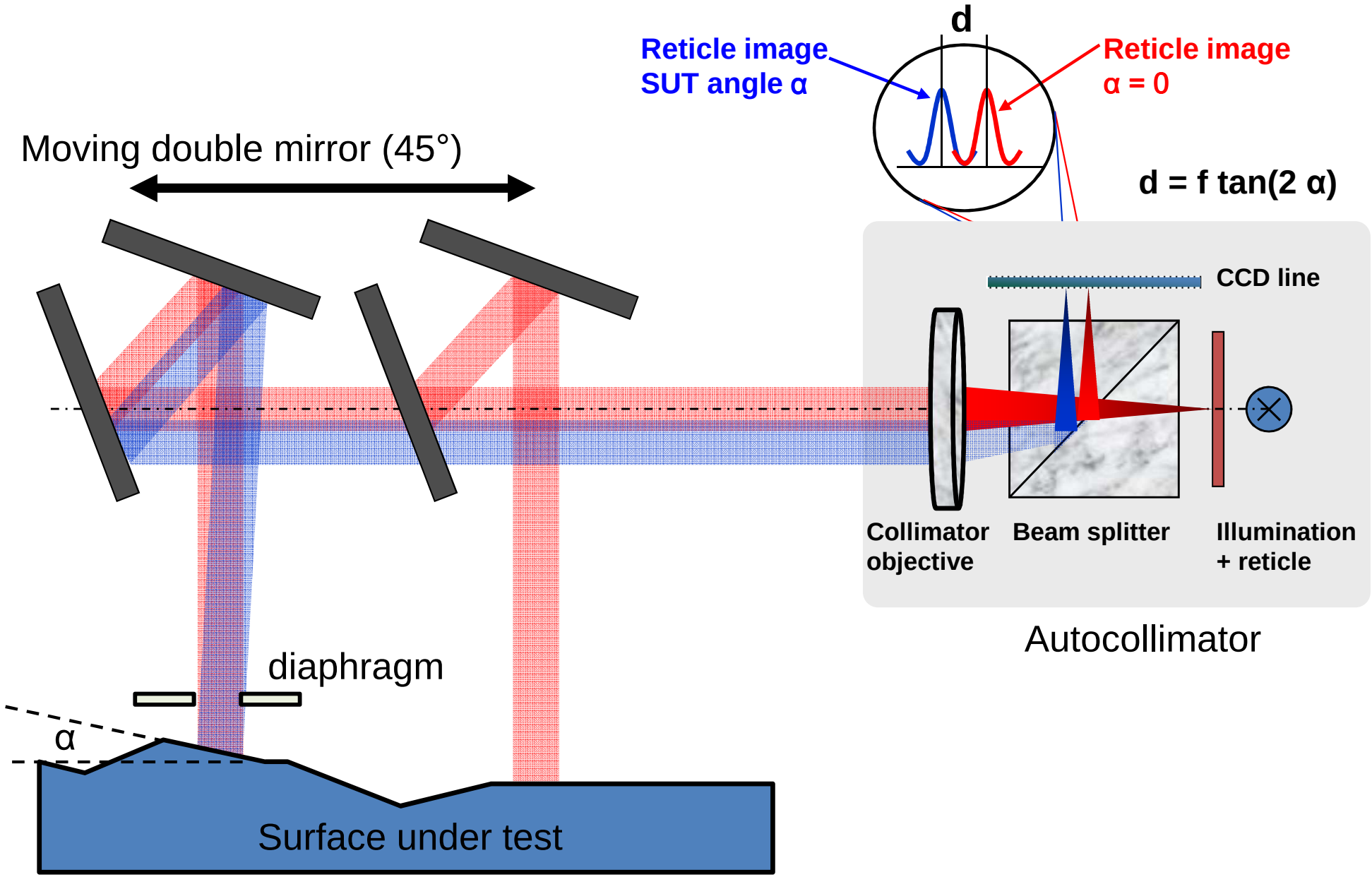
small angle scatter

wide angle scatter

Scanning Penta Prism – Set up



Scanning Penta Prism – Set up



F. Siewert, et al: „Characterization and Calibration of 2nd Generation Slope measuring Profiler“, NIMA 2009, doi:10.1016/j.nima.2009.12.033

Nanometer-Optical component measuring Machine - NOM

- max scan length: x = 1200 mm
  y = 298 mm
- Accuracy:
  < 20 nrad rms plane optics
  0.1 µrad rms curved optics
- Spatial resolution: 1 – 1200 mm
- Min Radius: R=1m (LTP)
  R=5m (AC)

Thermal isolation of the NOM by a double walled and thermal-bridge free housing - thermal stability is excellent.
In addition - low influence of air turbulence on the measurement

A plane elliptical focussing mirror for LCLS / CXI-Endstation – inspecting the mirror clamping

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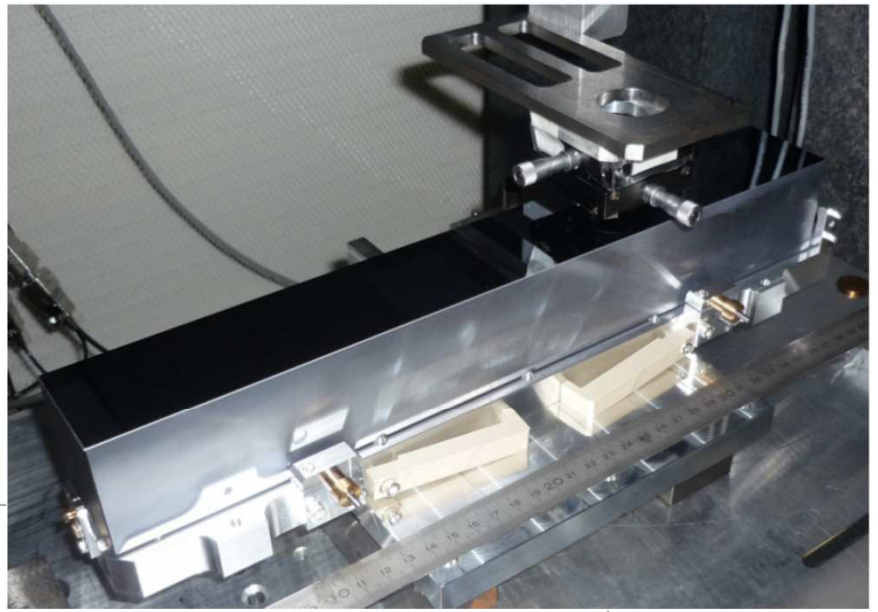
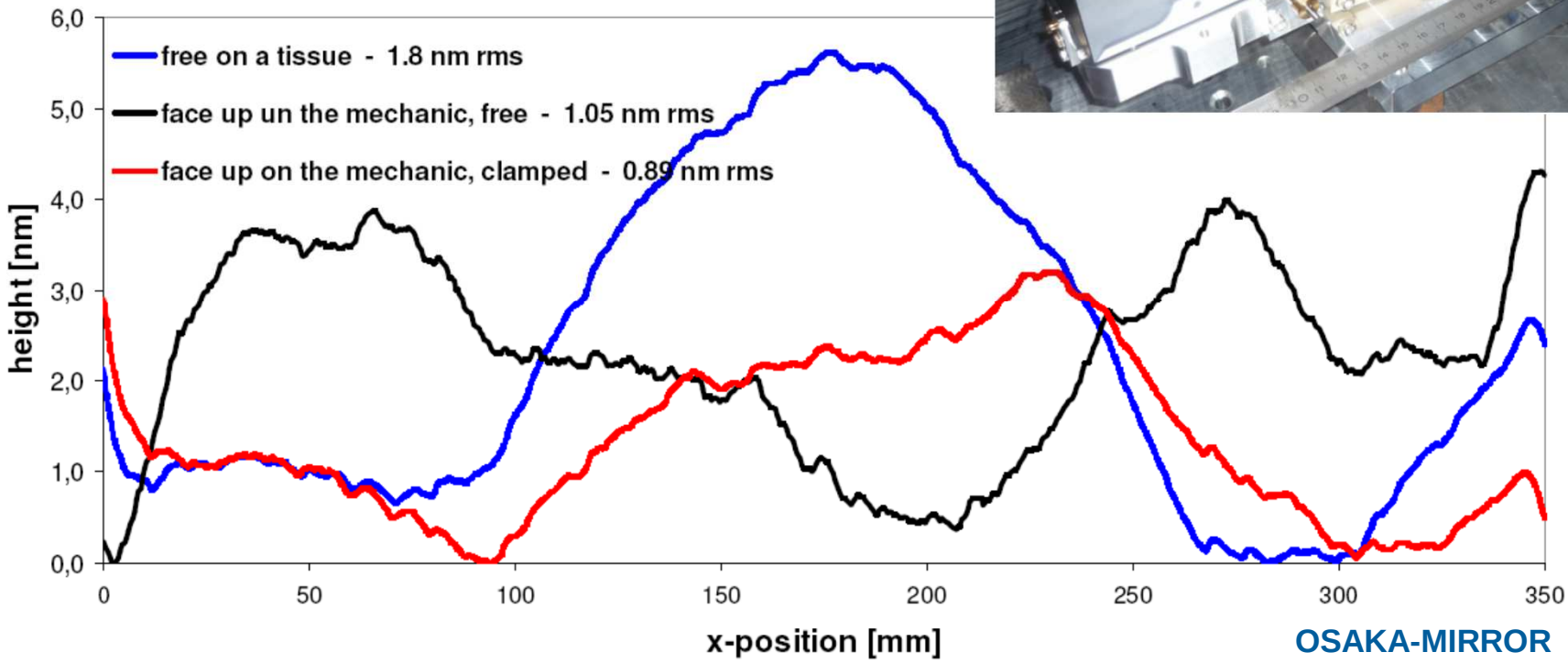
Size	:	370 × 50 × 50 mm^3
Source dist.	:	420 000 mm
Image dist.	:	8 300 mm
Incidence angle	:	3.59 mrad
Slope err. (mer)	:	0.061 µrad rms
Fig. error	:	0.89 nm rms / 3.5 nm PV
Roughness	:	≤ 0.2 nm rms





OSAKA-MIRROR

F. Siewert et al, *Optics Express Volume: 20 Issue: 4, 2012*
IWXM 6. July 2012

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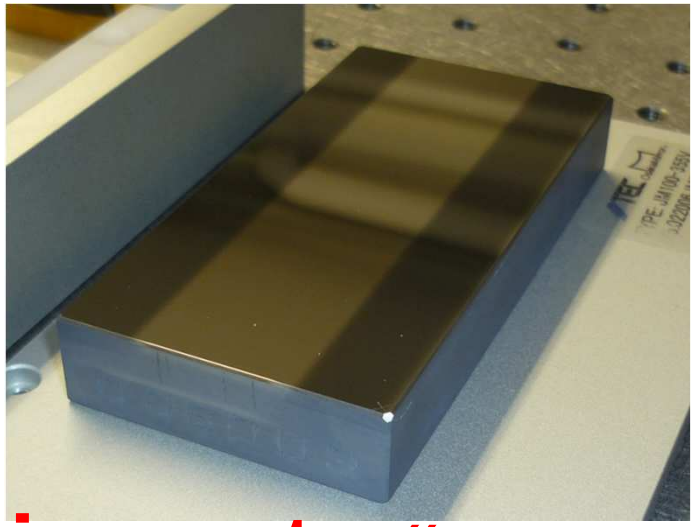
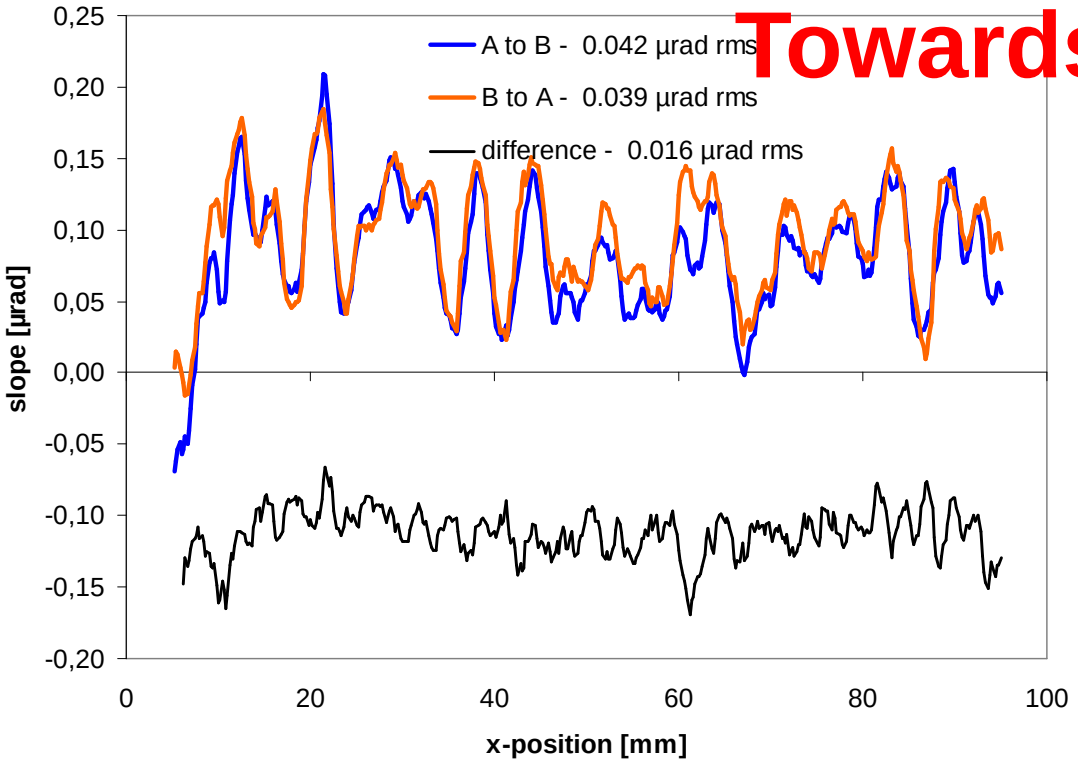
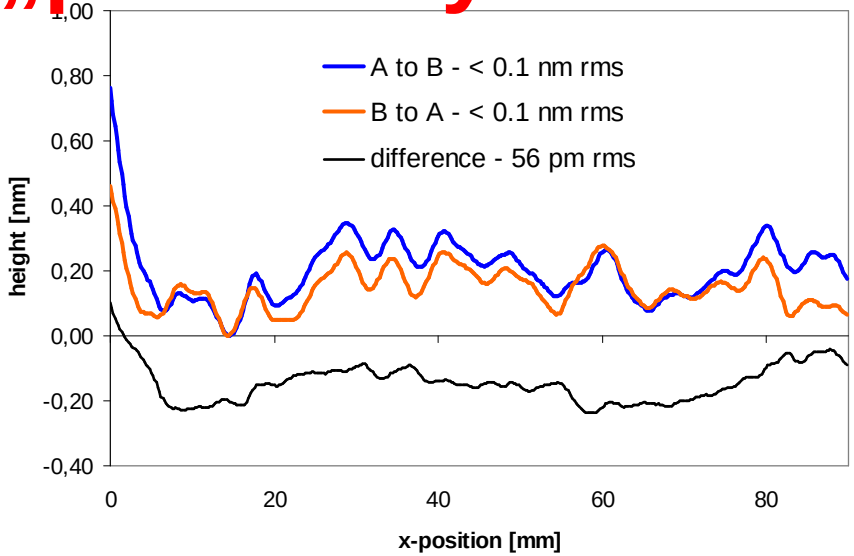
Size	:	100 × 50 × 20 mm³
Source dist.	:	93 595 mm
Image dist.	:	355 mm
Incidence angle	:	4.715 mrad
Slope err. (mer)	:	40 nrad rms
Fig. error	:	< 0.1 nm rms / 0.8 nm PV
Roughness	:	≤ 0.2 nm rms



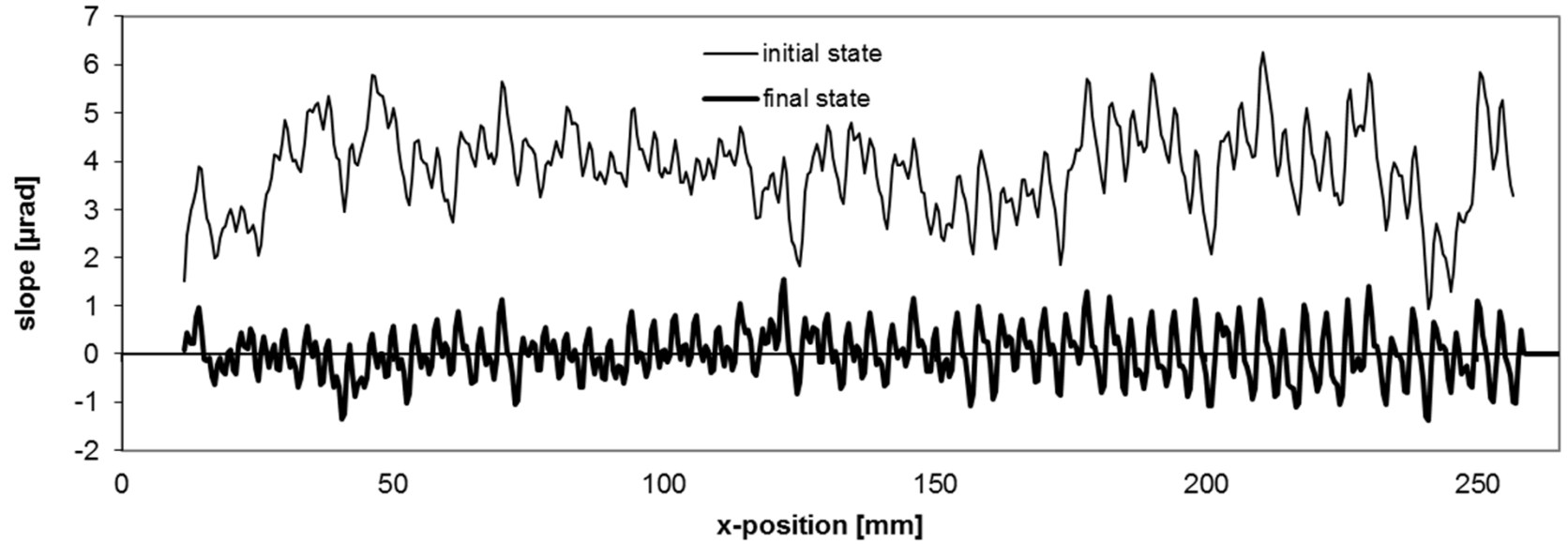
Towards „picometry“

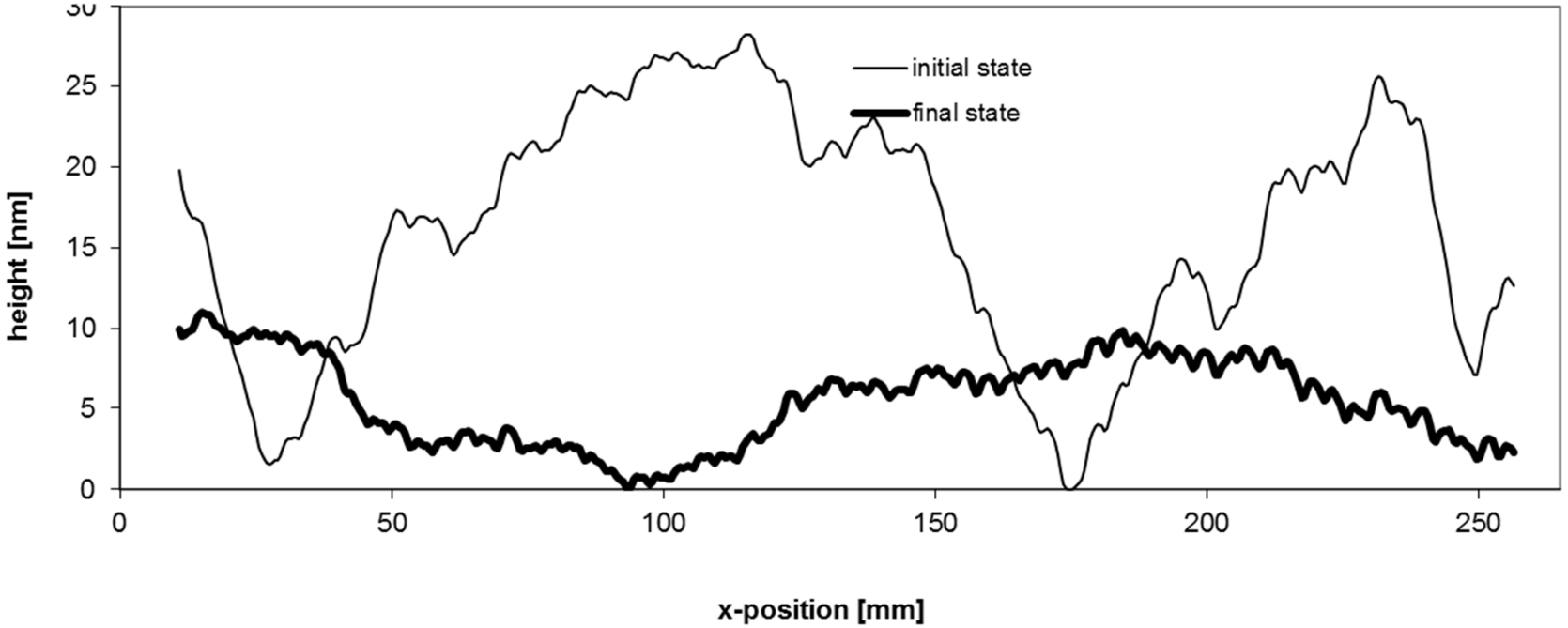




OSAKA-MIRROR

Residual slope / figure error – miror optimization by IBF





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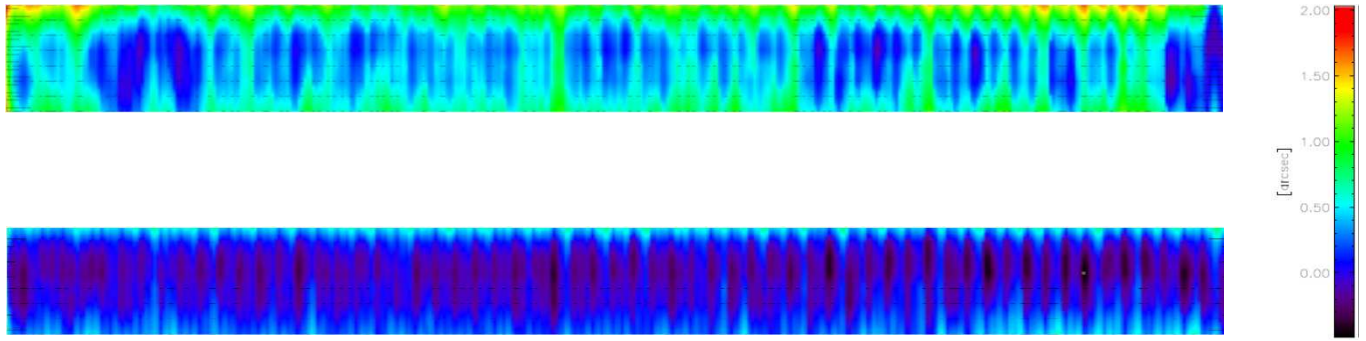
Maypping + IBF enables shape optimization of optical elements

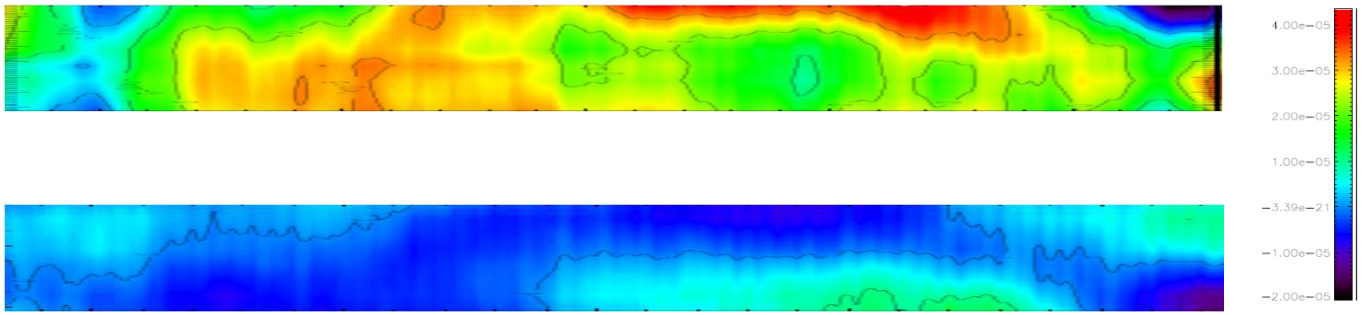
(Focusing mirror for UE48 at BESSY-II)



Res. slopes:

It. 3: 0.82 µrad rms

It. 4: 0.56 µrad rms



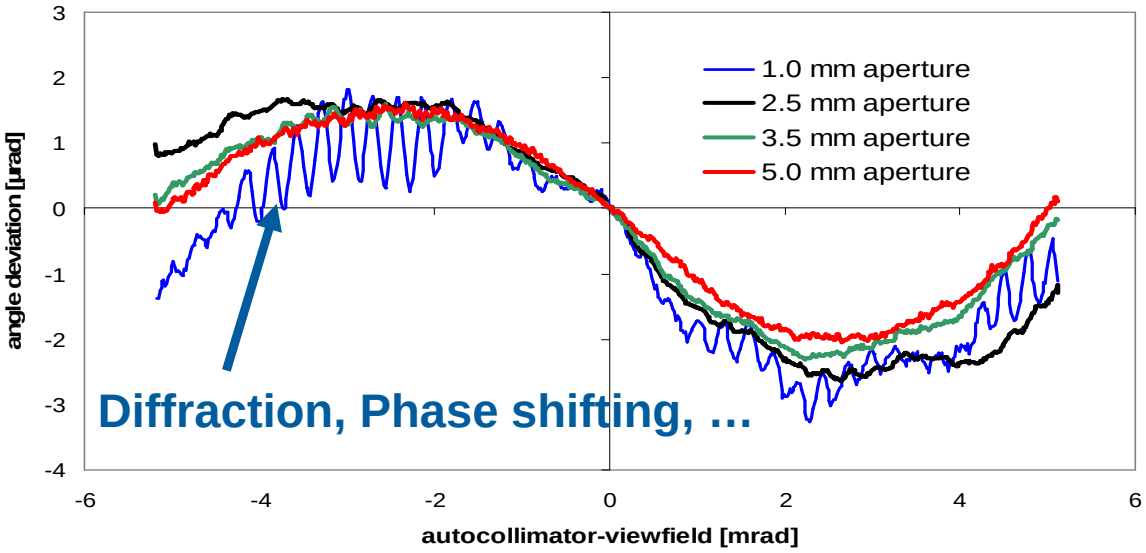
Height:

It. 3: 63 nm pv

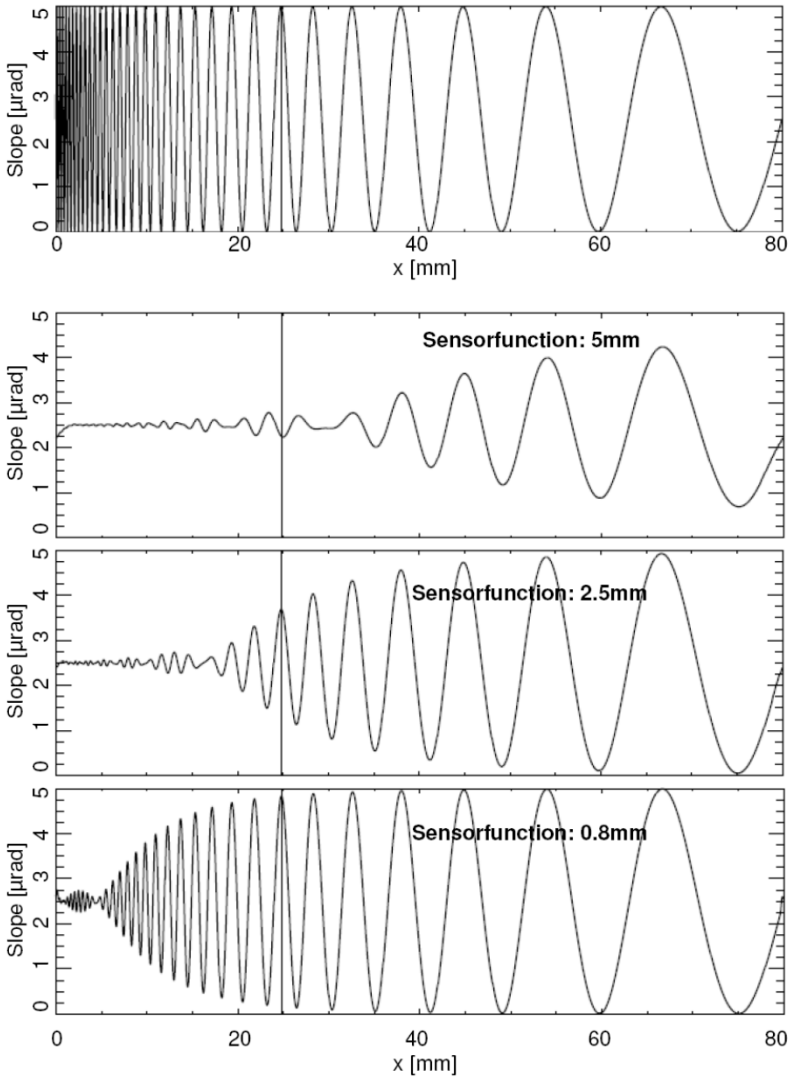
It. 4: 30 nm pv

H. Thiess et al.: „Fabrication of X-ray mirrors for synchrotron application “, Nucl. Instr. and Meth. A (2009), doi:10.1016/j.nima.2009.10.077

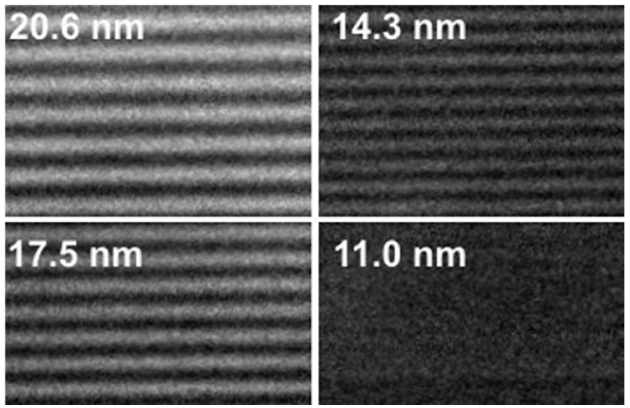
Characterization of AC-Sensor – Apertur Size Variation

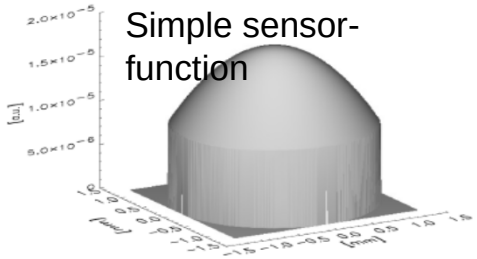


Simulation – spatial resolution



HZB-TXM resolved
lines and spaces: **14 nm**





G. Schneider, S. Rehbein and S. Werner: "*Volume Effects in Zone Plates*", Springer Series in Optical Sciences, Vol. 137, 137-171 (2008)

F. Siewert, et al: „Characterization and Calibration of 2nd Generation Slope measuring Profiler“, NIMA 2009, doi:10.1016/j.nima.2009.12.033

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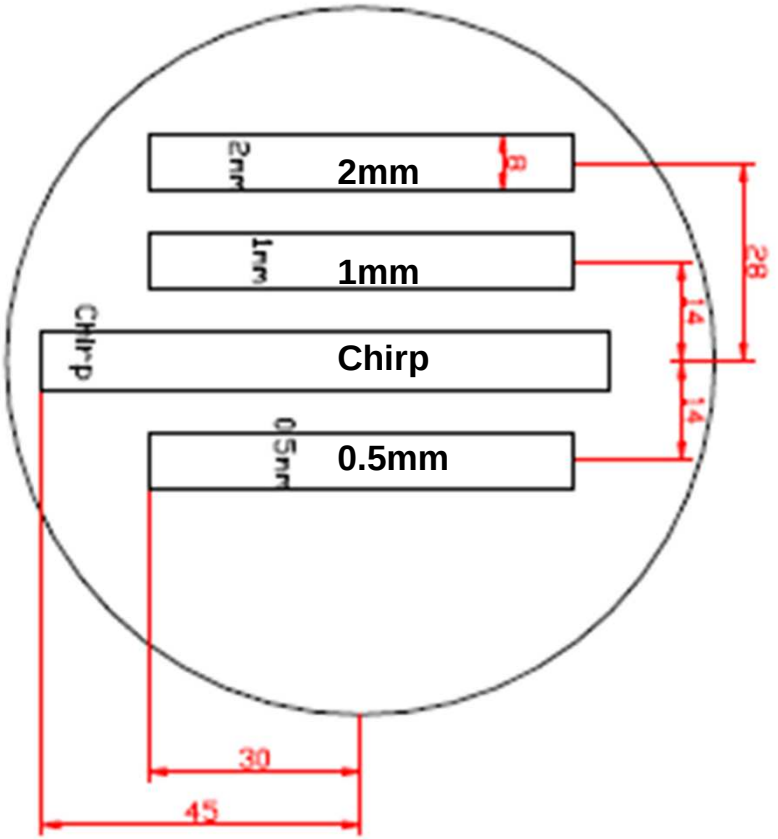
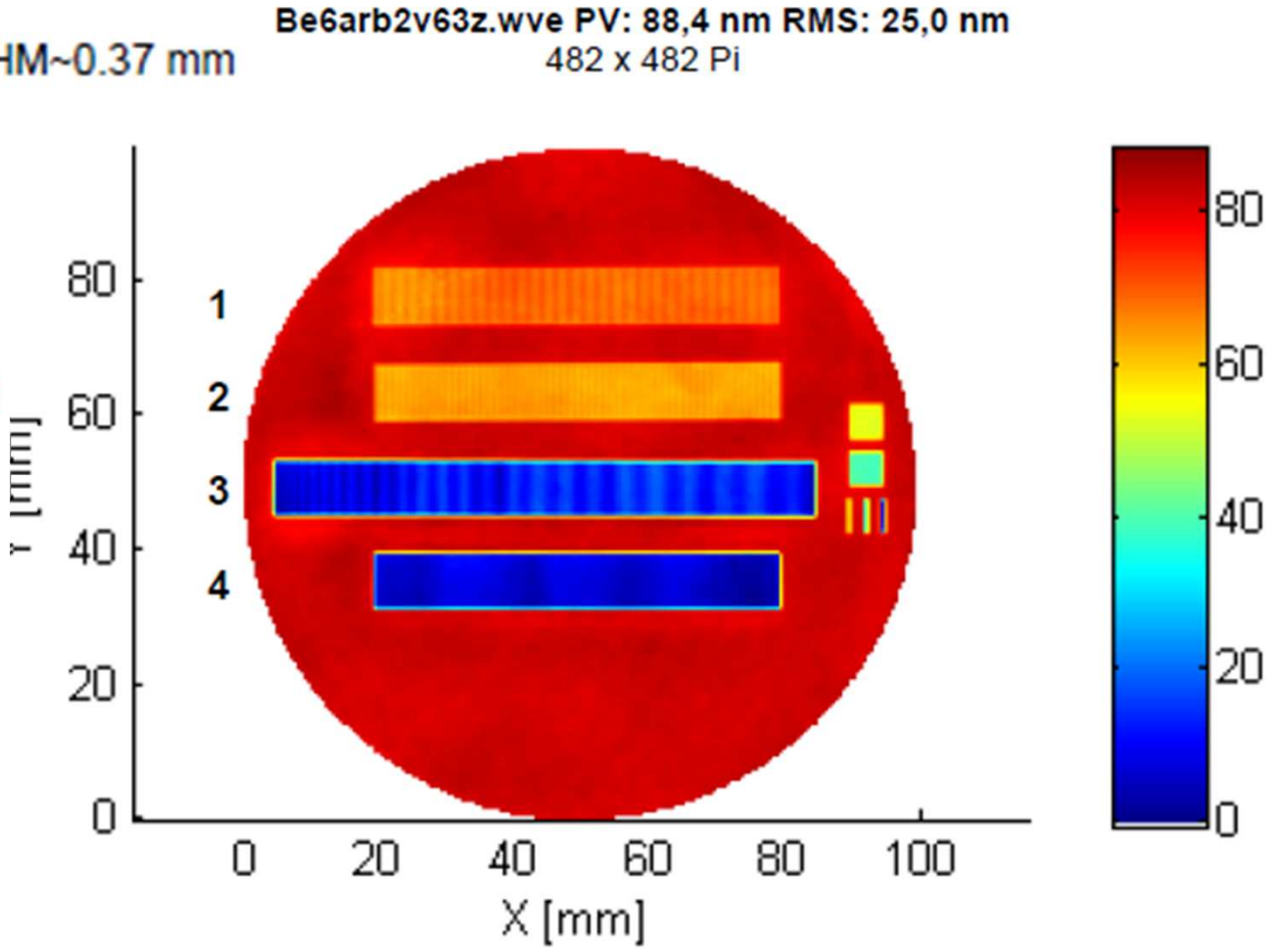
1. Plasma Jet Machining

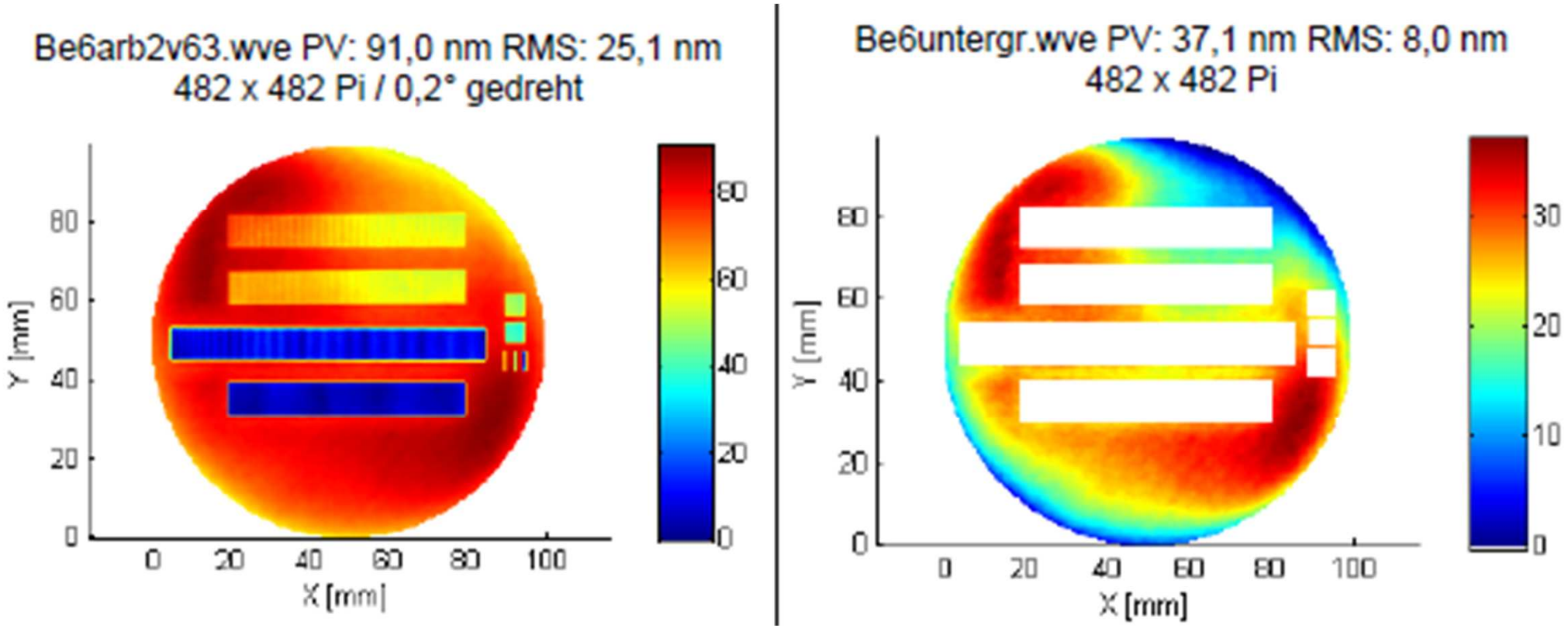
Tool: RF Plasmajet Rate~80nm/s, FWHM~0.37 mm





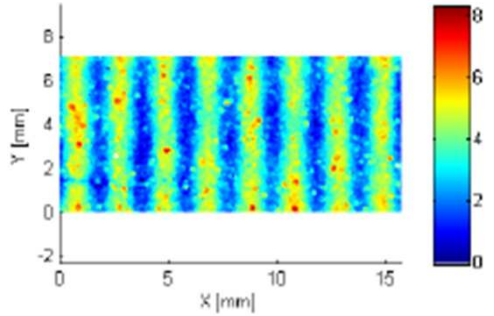
Chirp-Struktur:

```
Amp=2.5;
P=0.3+(0.04375.*sqrt(50*y));
z=Amp*cos(2*pi./P.*y)+Amp;
```

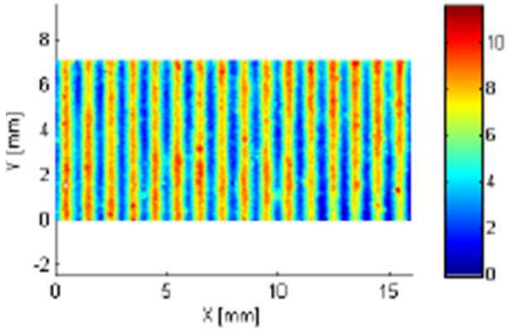

Be6arb2v63.wve PV: 91,0 nm RMS: 25,1 nm
482 x 482 Pi / 0,2° gedreht
Y [mm]
X [mm]
0
20
40
60
80
100
Be6untergr.wve PV: 37,1 nm RMS: 8,0 nm
482 x 482 Pi
Y [mm]
X [mm]
0
10
20
30

Sample with periodic and chirp profiles

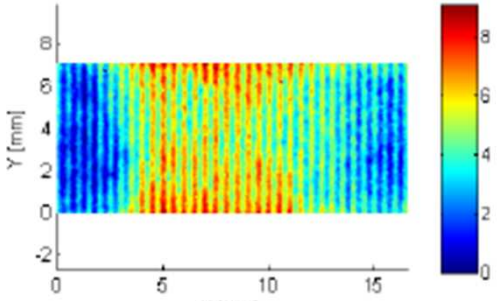
Be6g1ed.wve PV: 8,3 nm RMS: 1,3 nm
484 x 220 Pi



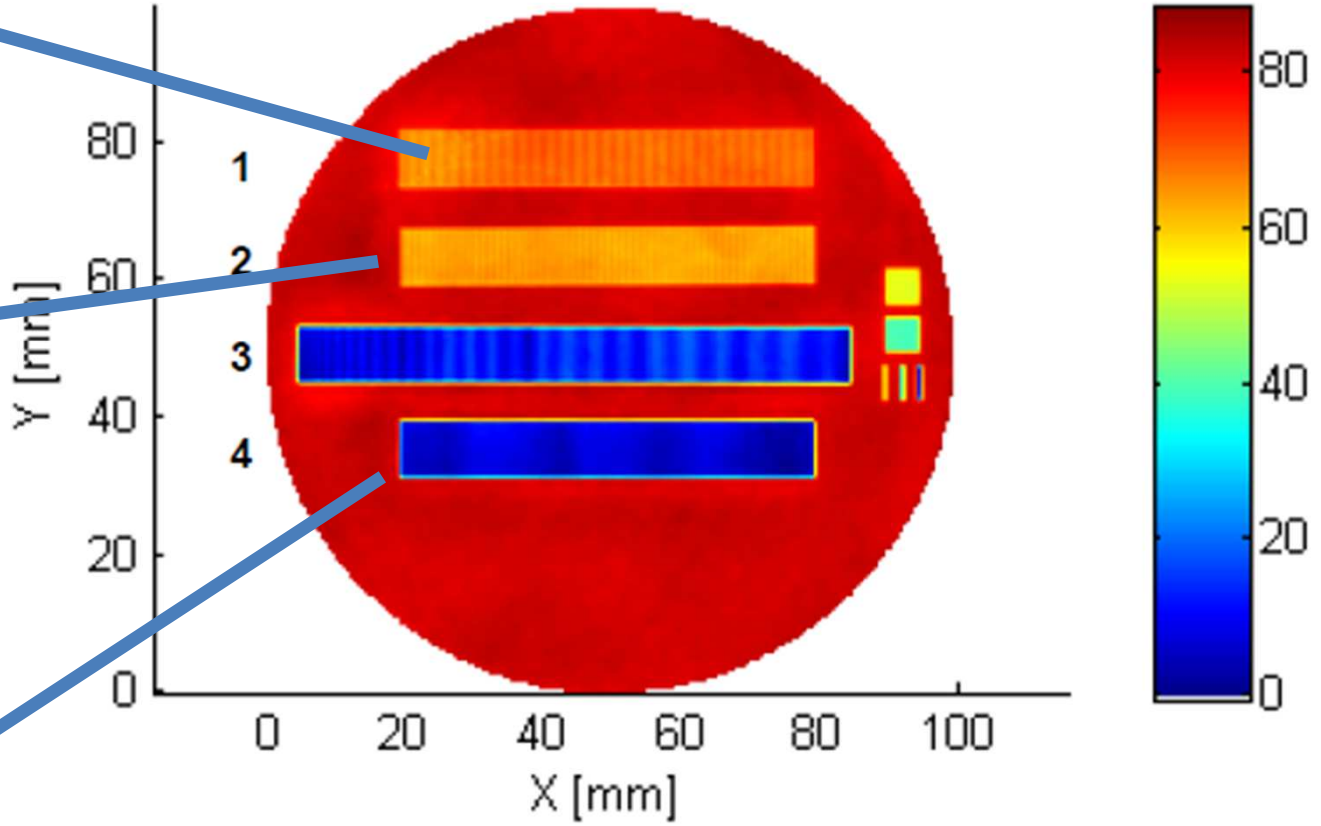
Be6g2ed.wve PV: 11,6 nm RMS: 2,3 nm
493 x 220 Pi



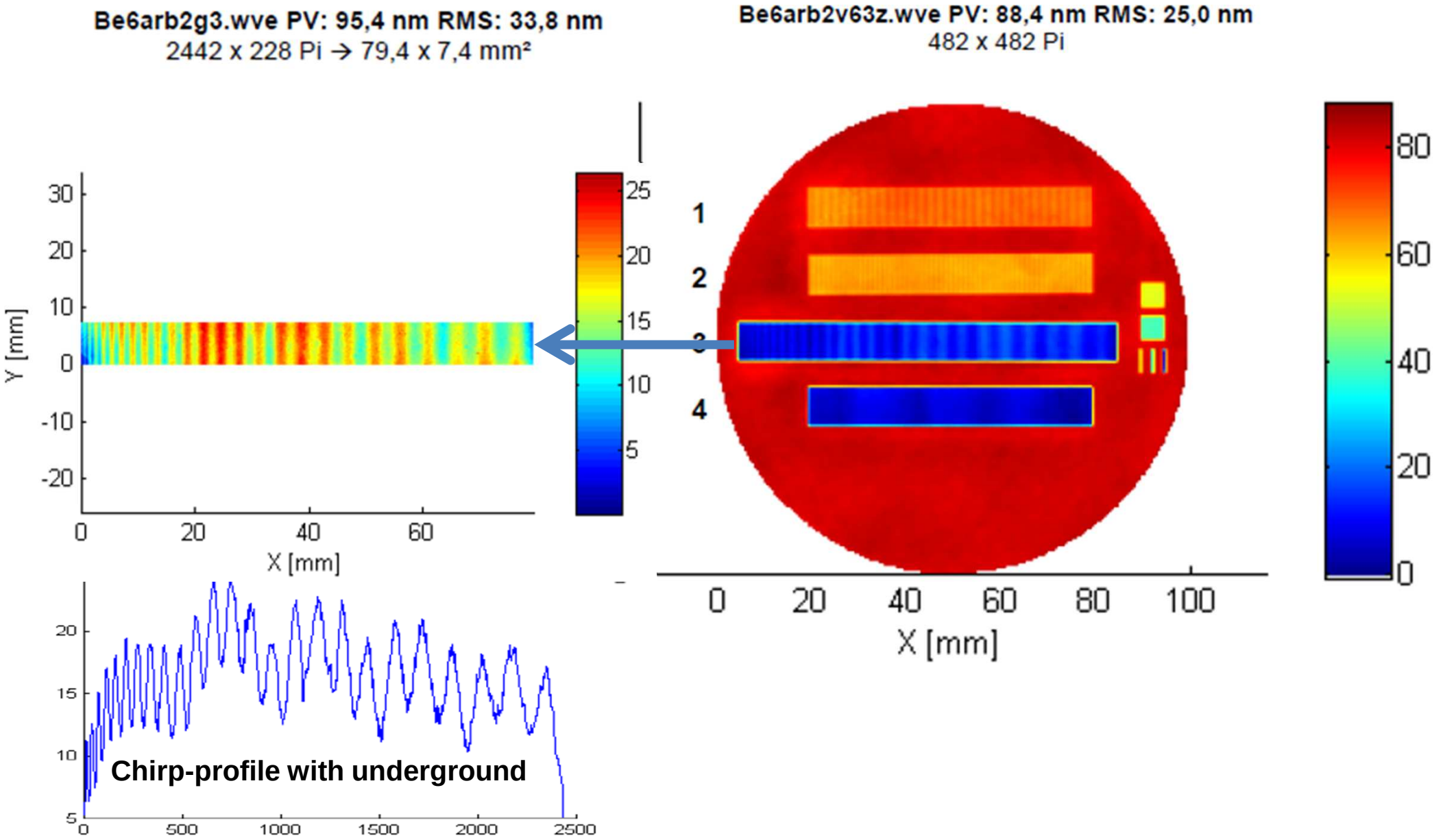
Be6g4ed.wve PV: 9,1 nm RMS: 1,7 nm
510 x 220 Pi



Be6arb2v63z.wve PV: 88,4 nm RMS: 25,0 nm
482 x 482 Pi

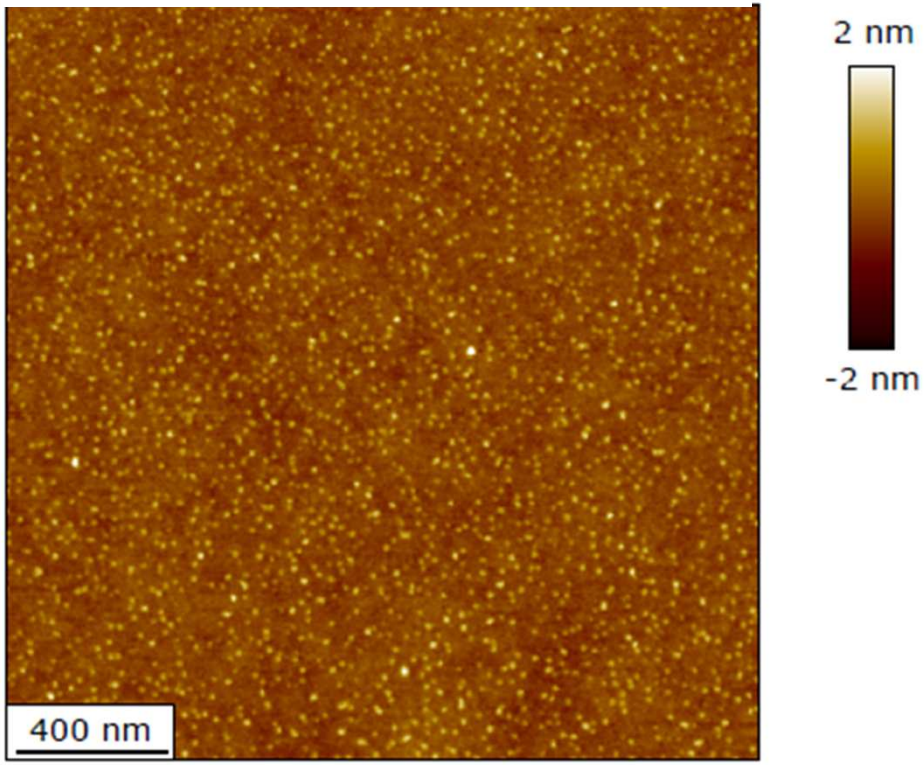


Sample with periodic and chirp profiles

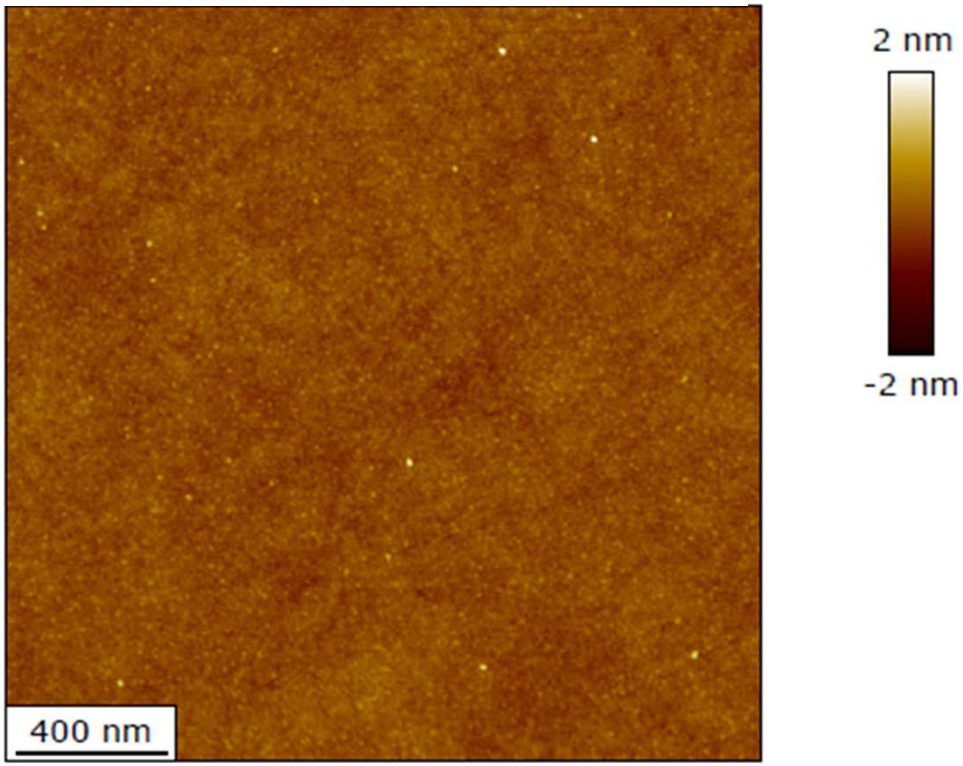


Microroughness after etching on the chirped section

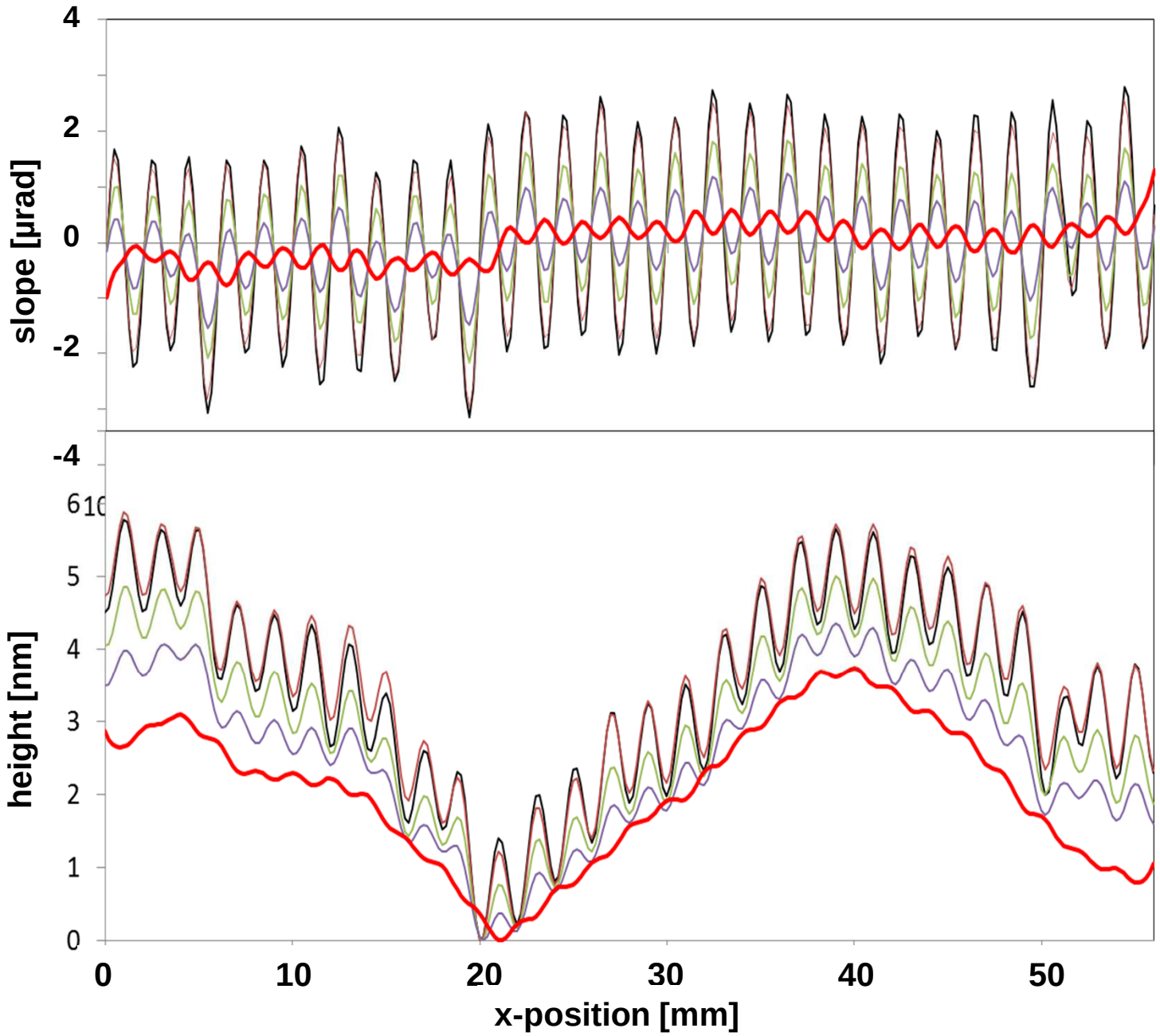
10mm from left edge, R_q = 0.26 nm



20mm from right edge, R_q = 0.17 nm



Section with 2mm period



NOM: 0.9 nm rms

ZYGO: 1.3 nm rms

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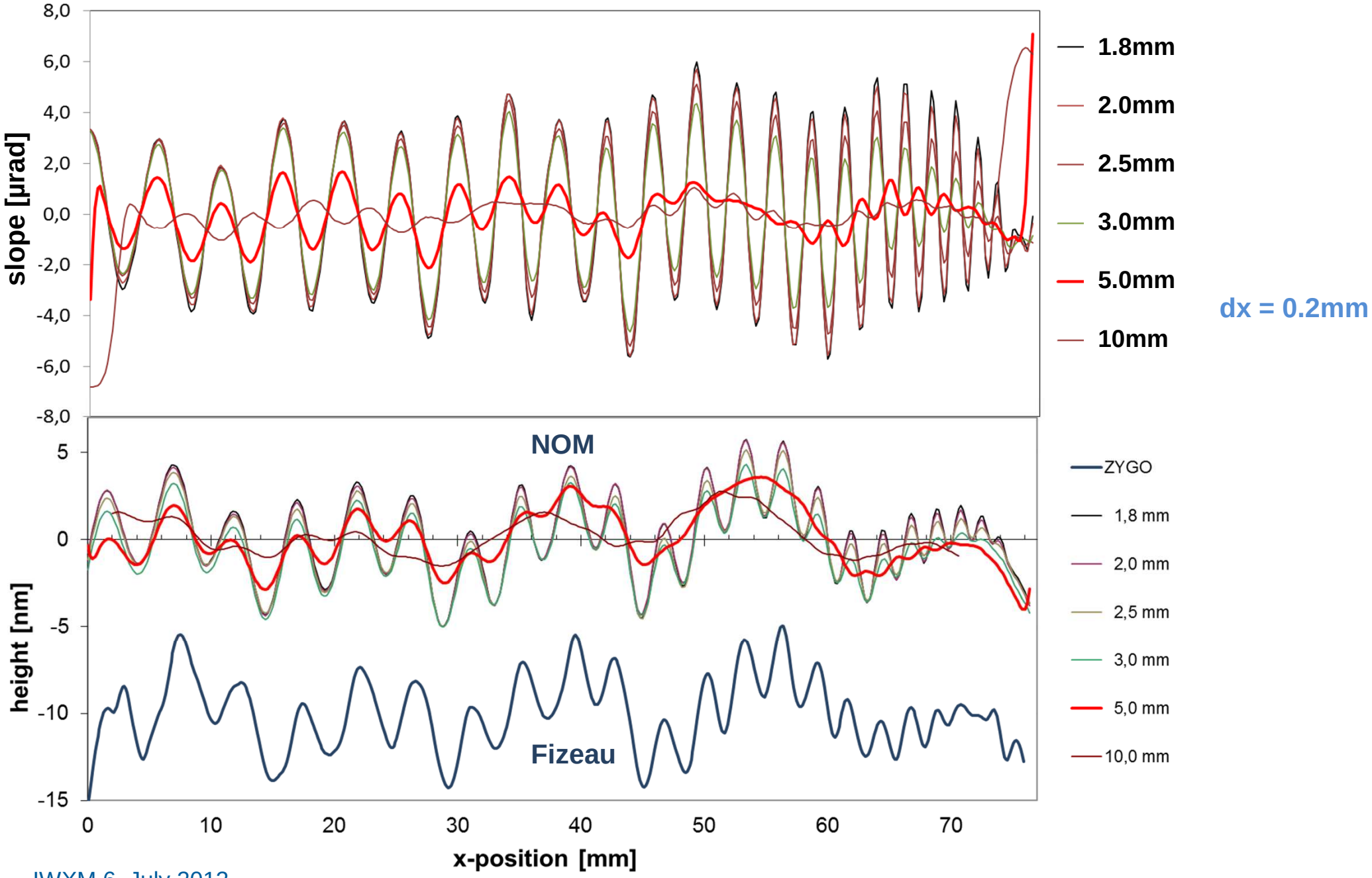
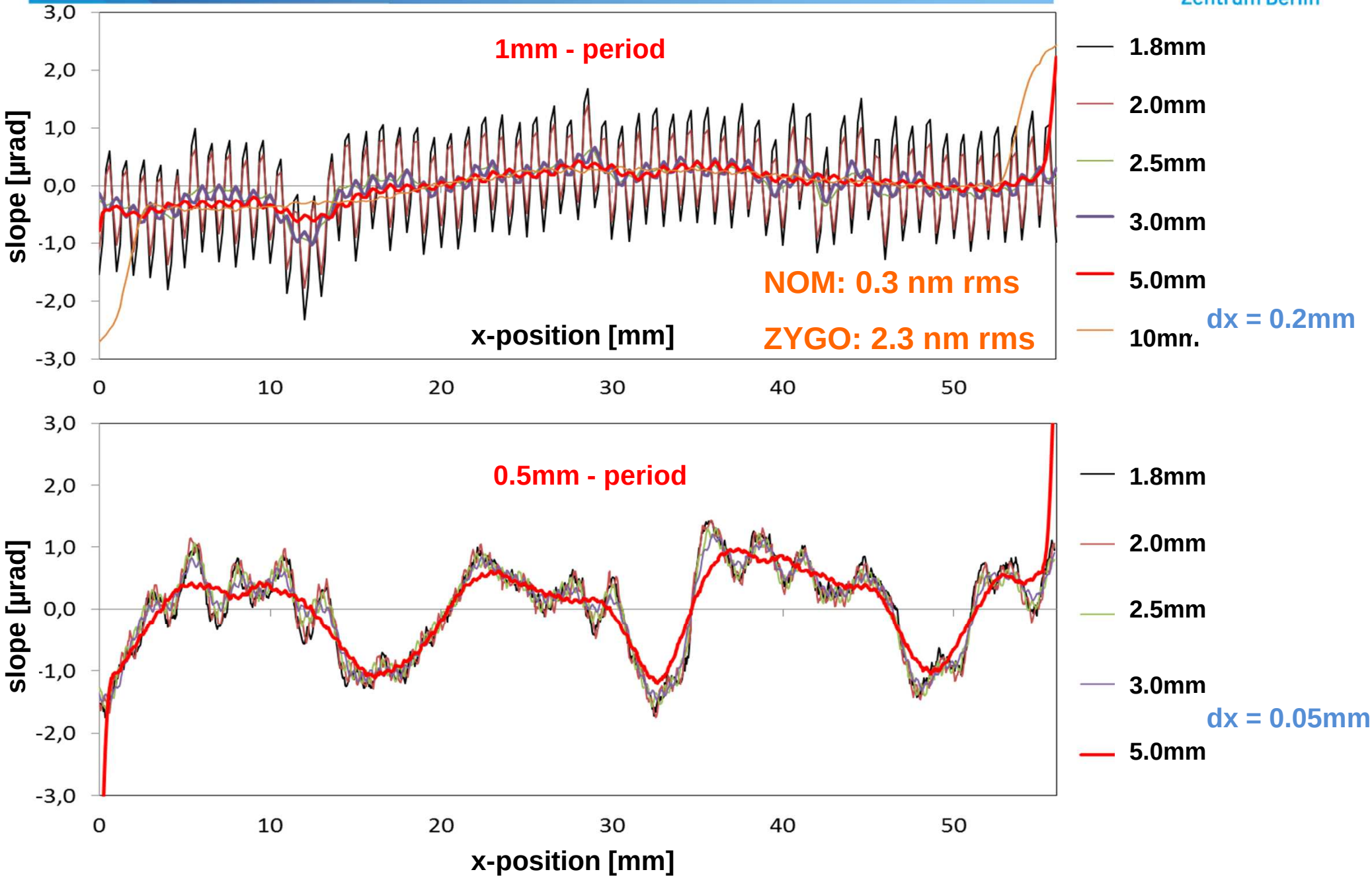
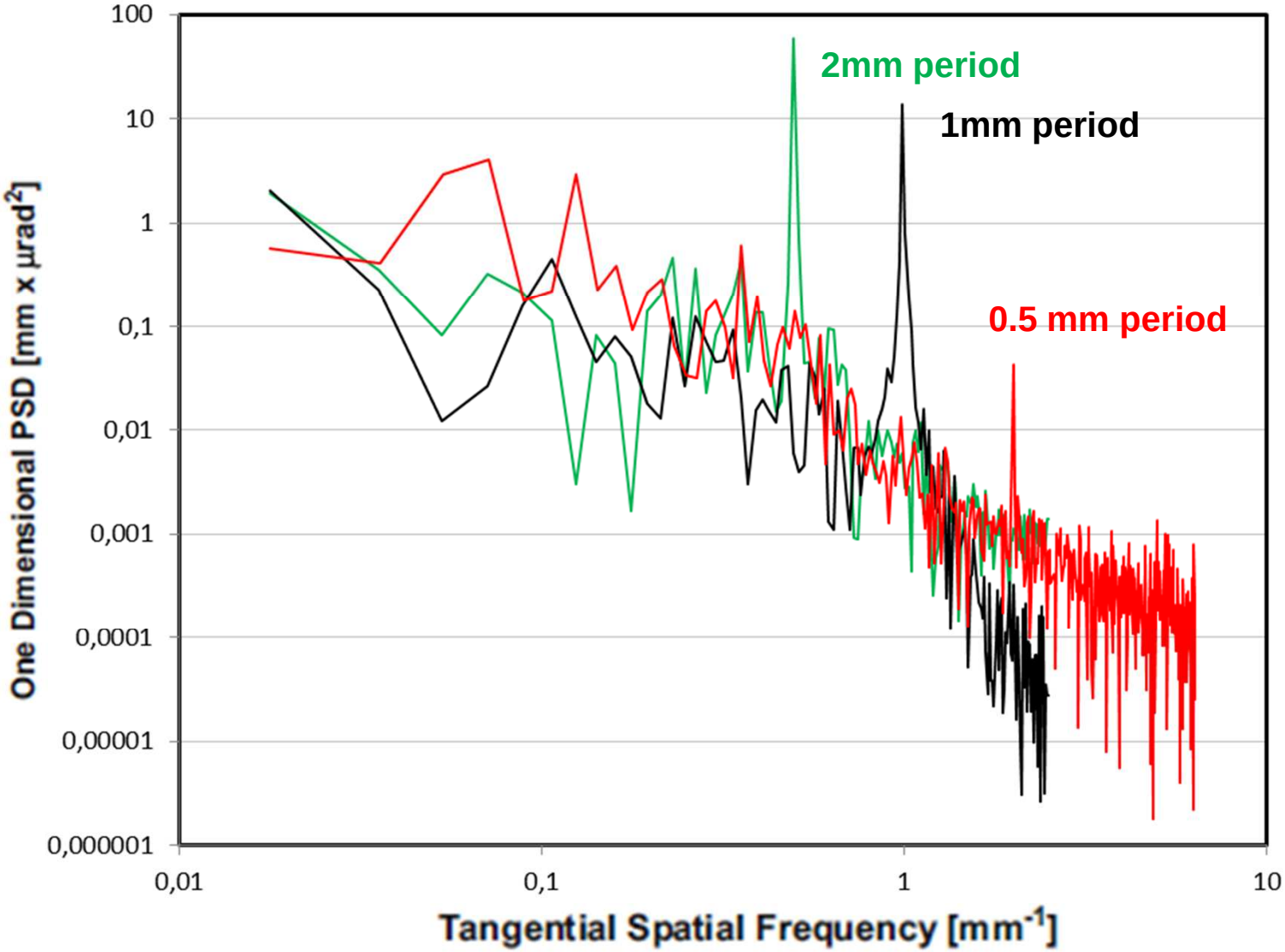


Section with 1mm and 0.5mm period



PSD for 1.8mm Diaphragm



- ultra precise mirrors with nm and sub-nm accuracy are available

- Ultra precise metrology is a key-technology to verify these achievements

- Dedicated mechanics and clamping strategy is essential
  for a shape preserving mount of optics

- Spatial periods of 1mm can be identified – but not with precise height resolution
- Special care is required to define the right combination of
  autocollimator and diaphragm-diameter: 2 - 2.5mm in case of BESSY-NOM
  depending on curvature of SUT

- This method can be applied in principle to all kind of slope measuring profiler

thanks to: G. Falkenberg, DESY

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H. Thiess, H. Lasser ZEISS

R. Signorato Bruker ASC GmbH

A. Ueda JTEC

Thank you for your attention