



Wir schaffen Wissen – heute für morgen

Paul Scherrer Institut

Yves Kayser

Wavefront metrology measurements at SACLA by means of
X-ray grating interferometry



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Riken Harima Institute: T. Katayama, M. Yabashi

- Grating based interferometry
 - Application domains
 - Working principle
- Single-shot metrology measurements at the SACLA hard X-FEL
 - Radius of curvature
 - Mirror and monochromator surface

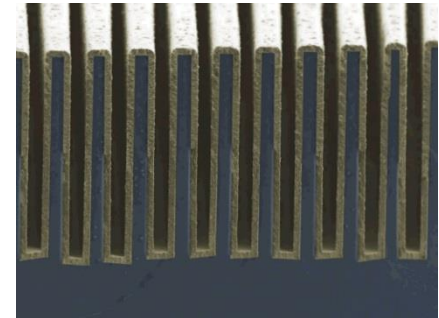
Grating interferometry at the PSI

Phase contrast imaging

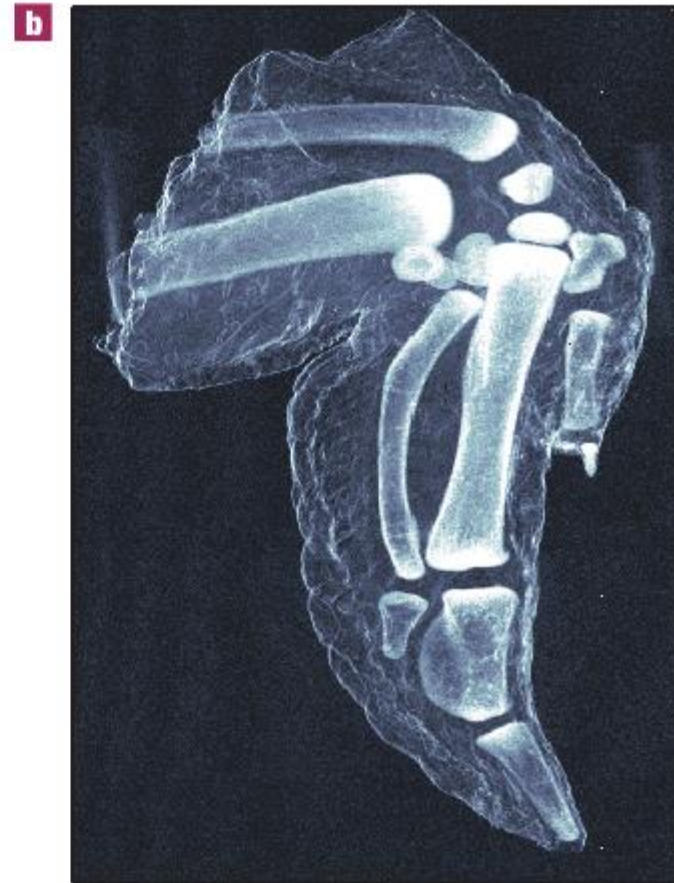
(synchrotron sources, x-ray tubes,
neutron sources)



X-ray metrology

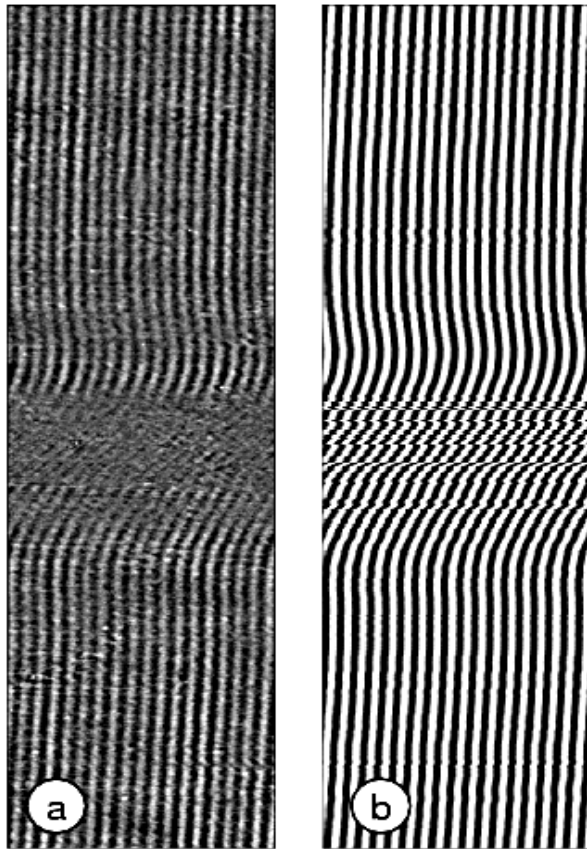


Applications of grating interferometry

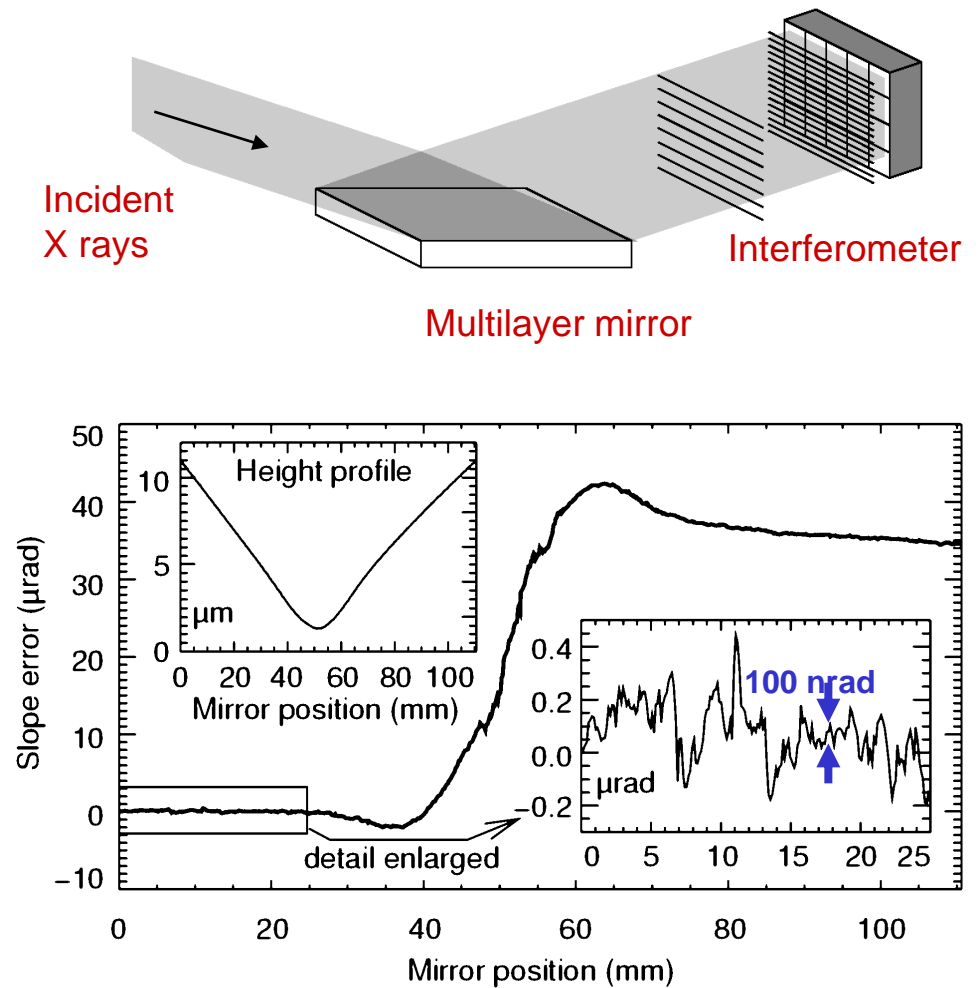


F. Pfeiffer, M. Bech, O. Bunk, P. Kraft, E. F. Eikenberry, Ch. Brönnimann, C. Grünzweig, and C. David,
Hard-X-ray dark-field imaging using a grating interferometer,
Nat. Mater. **7**, 134-137 (2008).

Metrology of X-ray optics

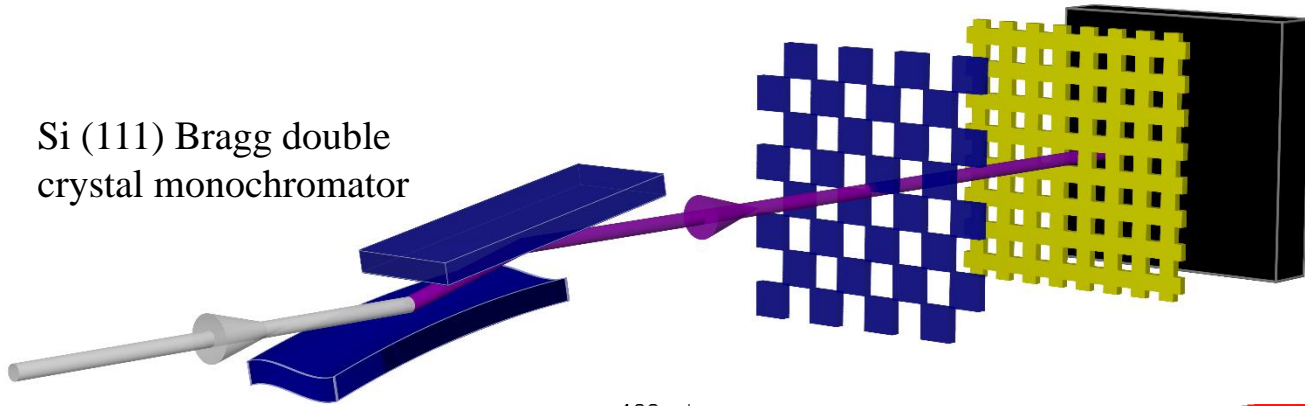


a) detected interferogram
b) analyze main Fourier component

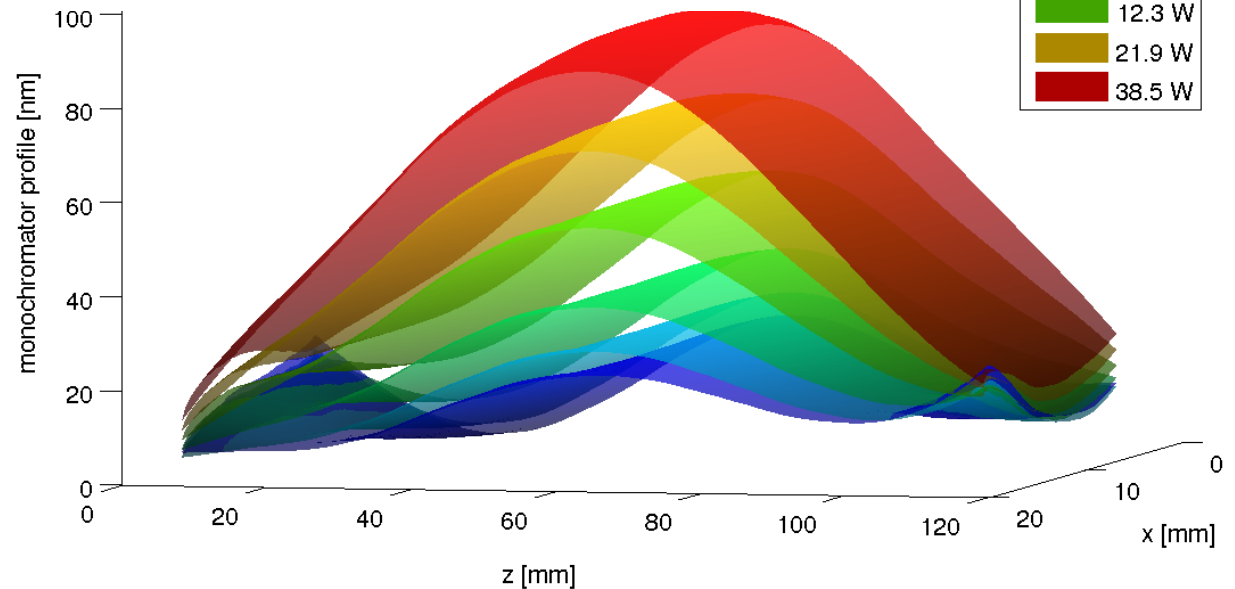
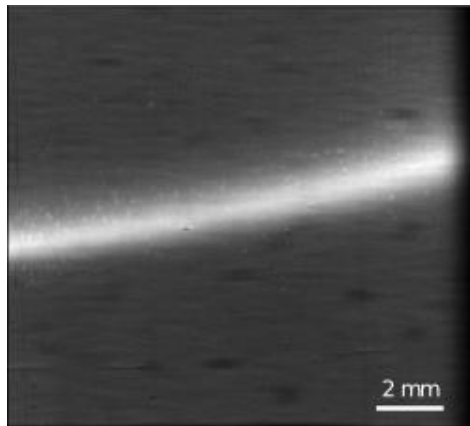


T. Weitkamp, B. Nöhammer, A. Diaz, C. David, and E. Ziegler,
X-ray wavefront analysis and optics characterization with a grating interferometer,
Appl. Phys. Lett. **86**, 054101 (2005).

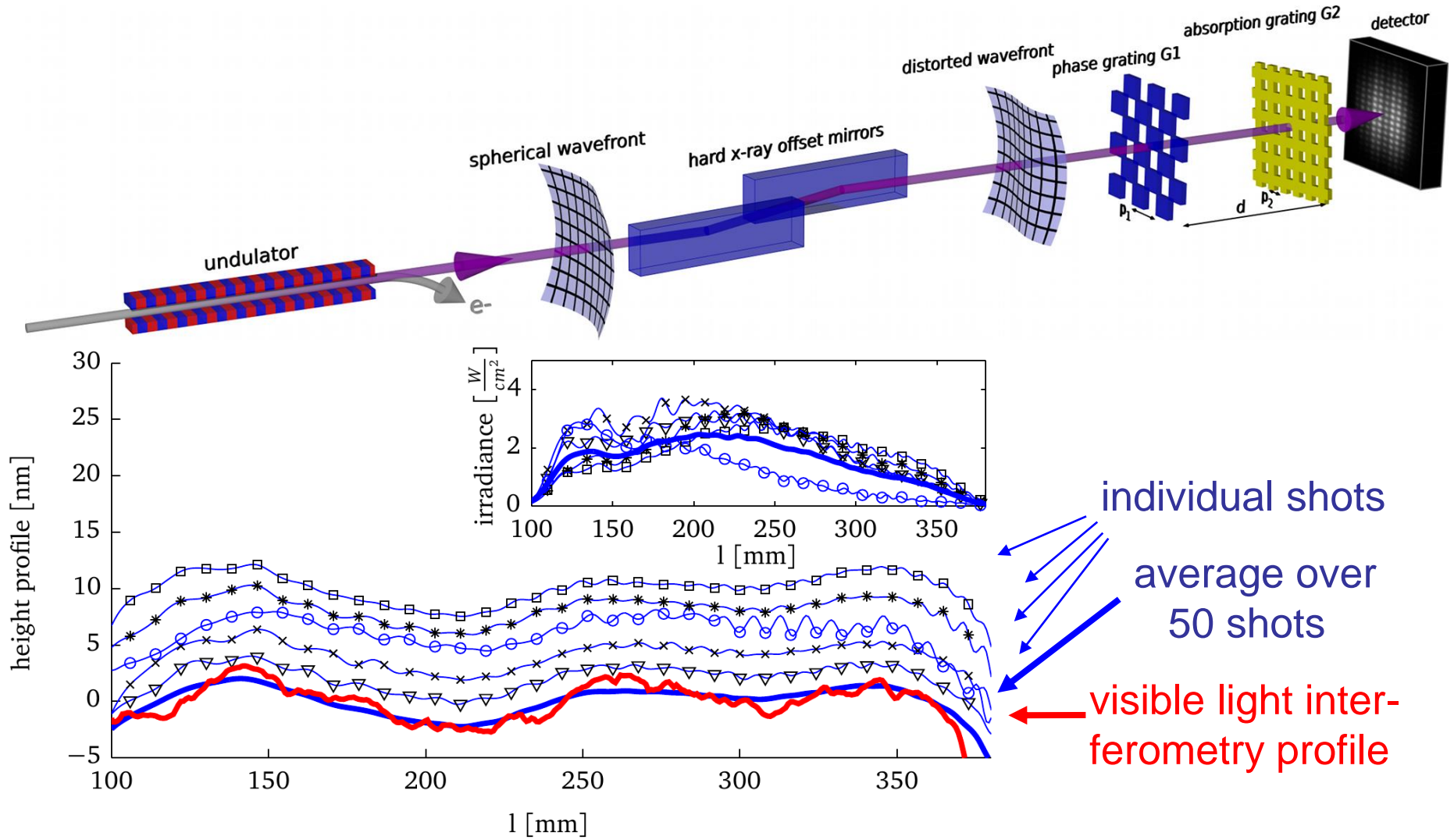
Si (111) Bragg double
crystal monochromator



2D grating interferometer

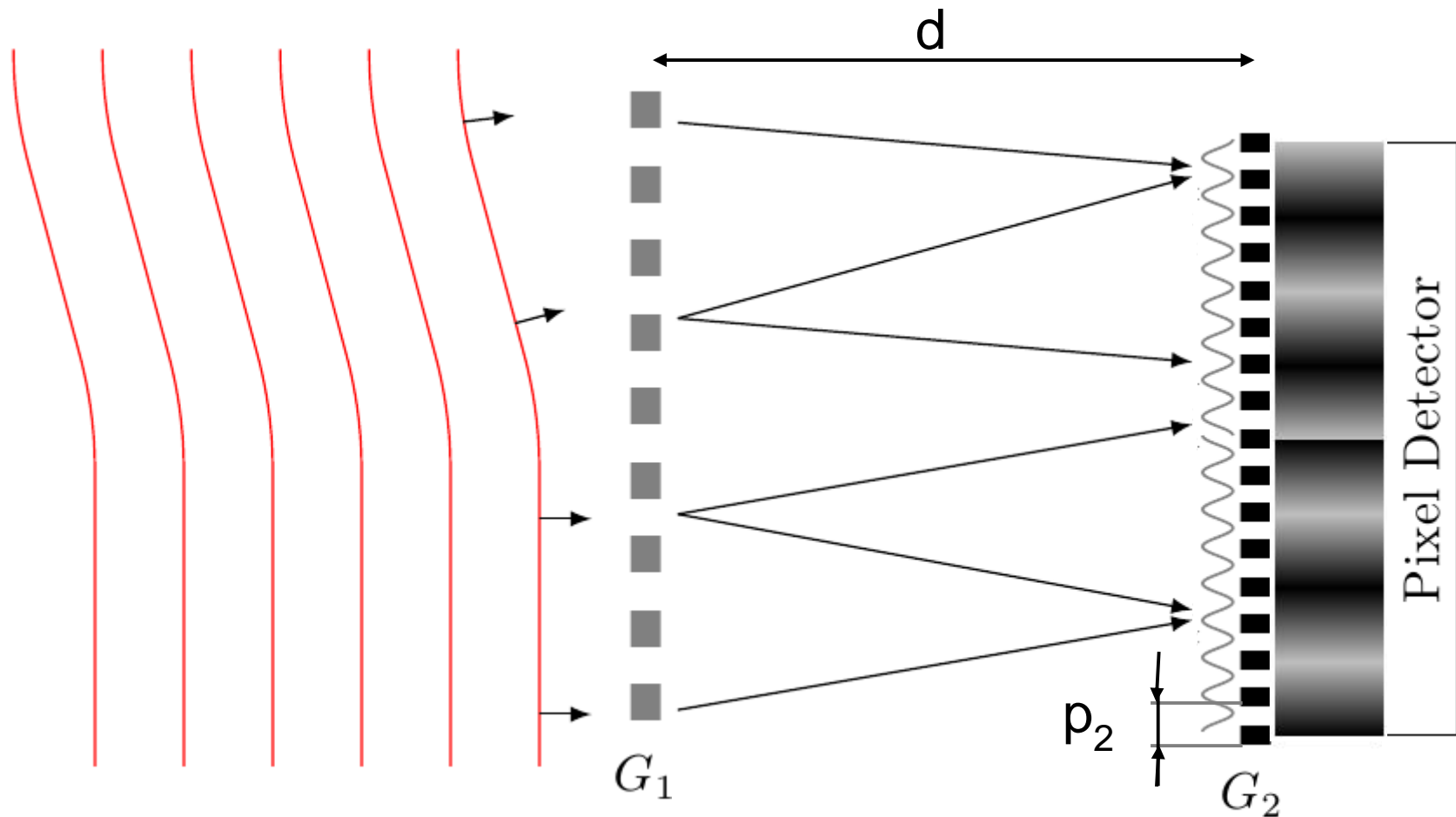


S. Rutishauser, A. Rack, T. Weitkamp, Y. Kayser, C. David and A. T. Macrander,
Heat bump on a monochromator crystal measured with X-ray grating interferometry,
J. Synchrotron. Rad. **20**, 300-305 (2013).



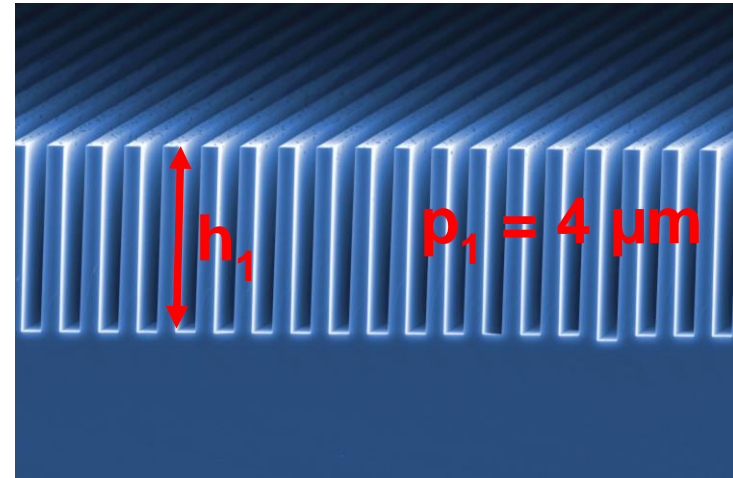
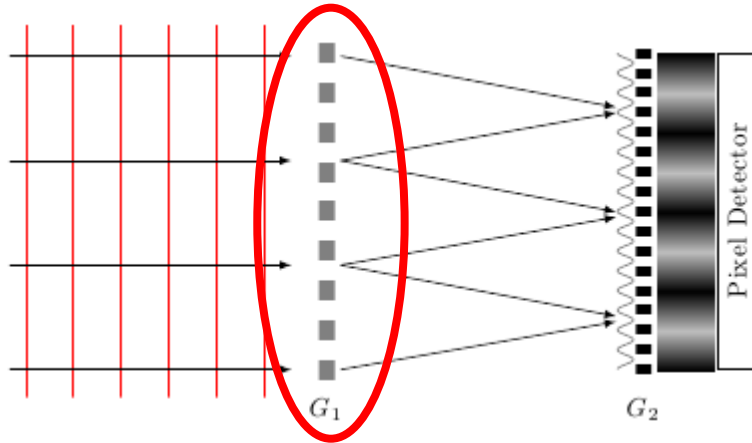
S. Rutishauser, L. Samoylova, J. Krzywinski, O. Bunk, J. Grünert, H. Sinn, M. Cammarata, D. M. Fritz, and C. David,
Exploring the wavefront of hard X-ray free electron laser radiation,
Nat. Commun. **3**, 947 (2012).

Hard X-ray grating interferometry



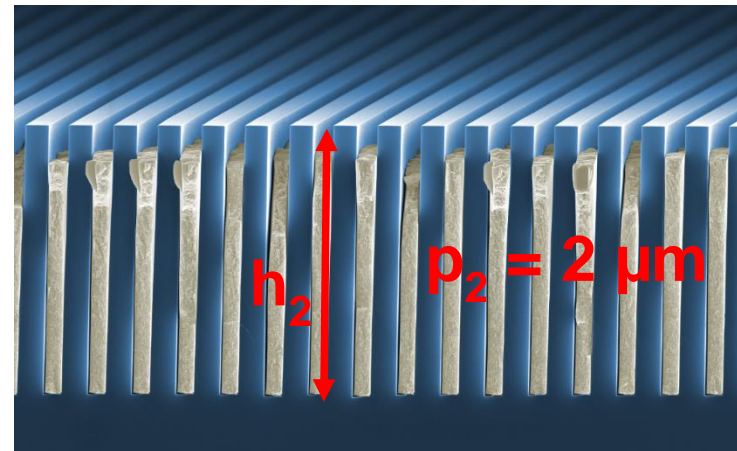
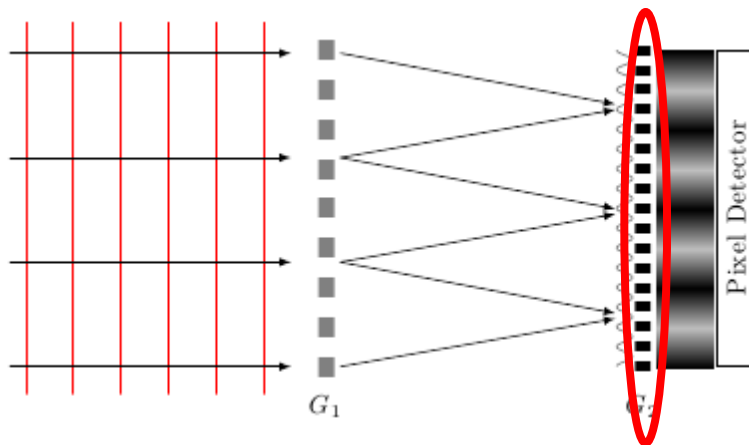
Sensitivity:
$$S \propto \frac{p_2}{d} = \frac{[\mu m]}{[m]} = [\mu rad] \xrightarrow{\text{detect } \frac{1}{100} \text{ fringe}} 10 nrad$$

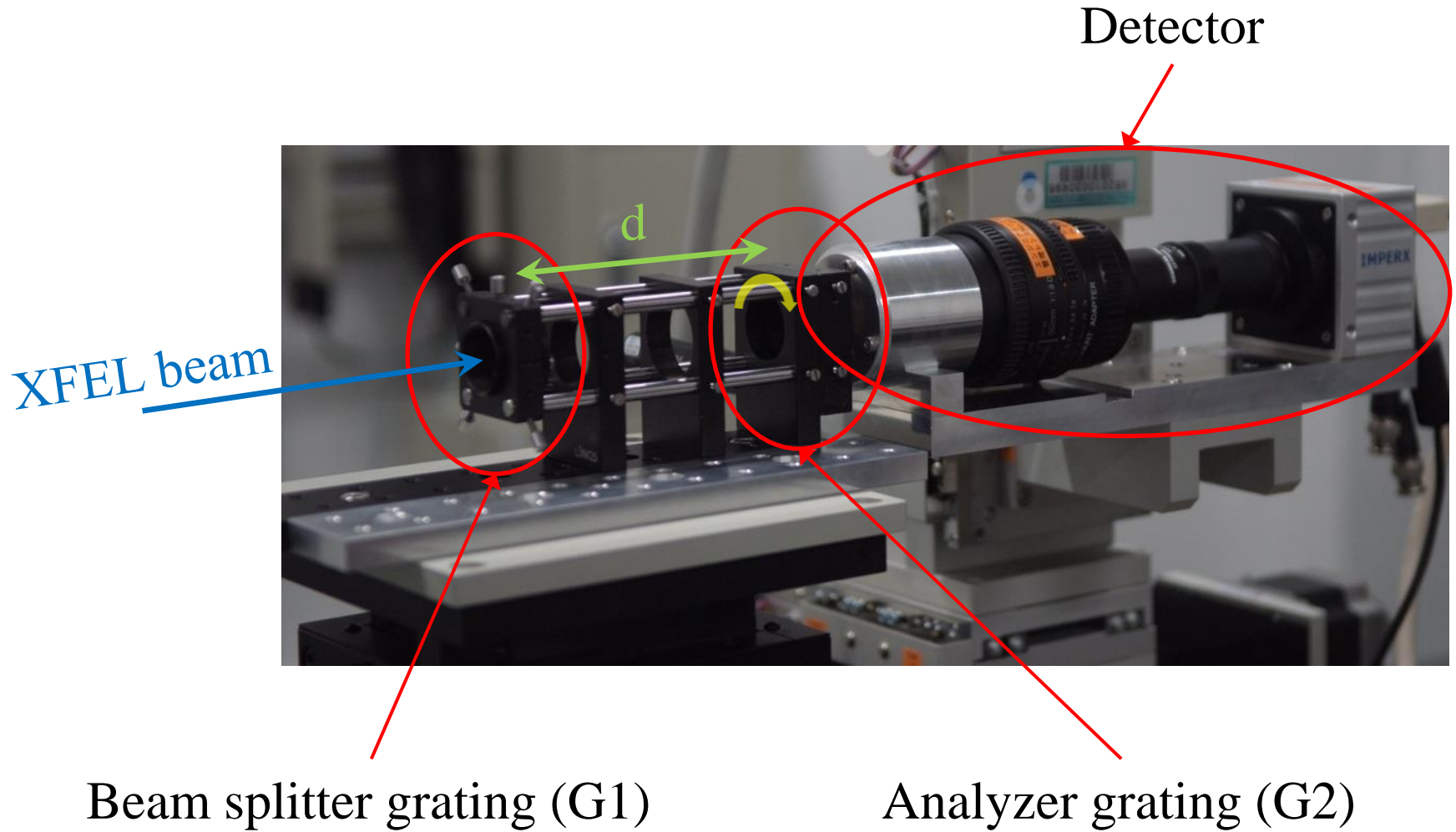
Beam splitter grating (G1)



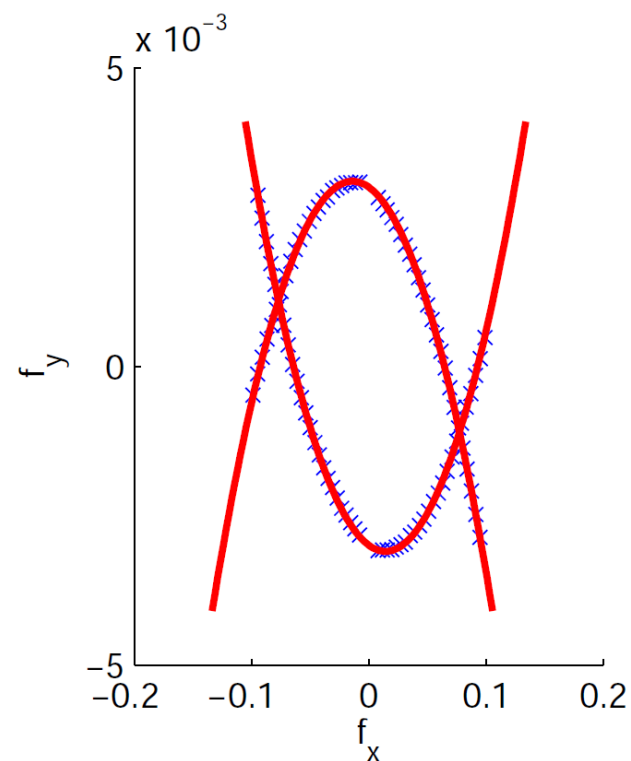
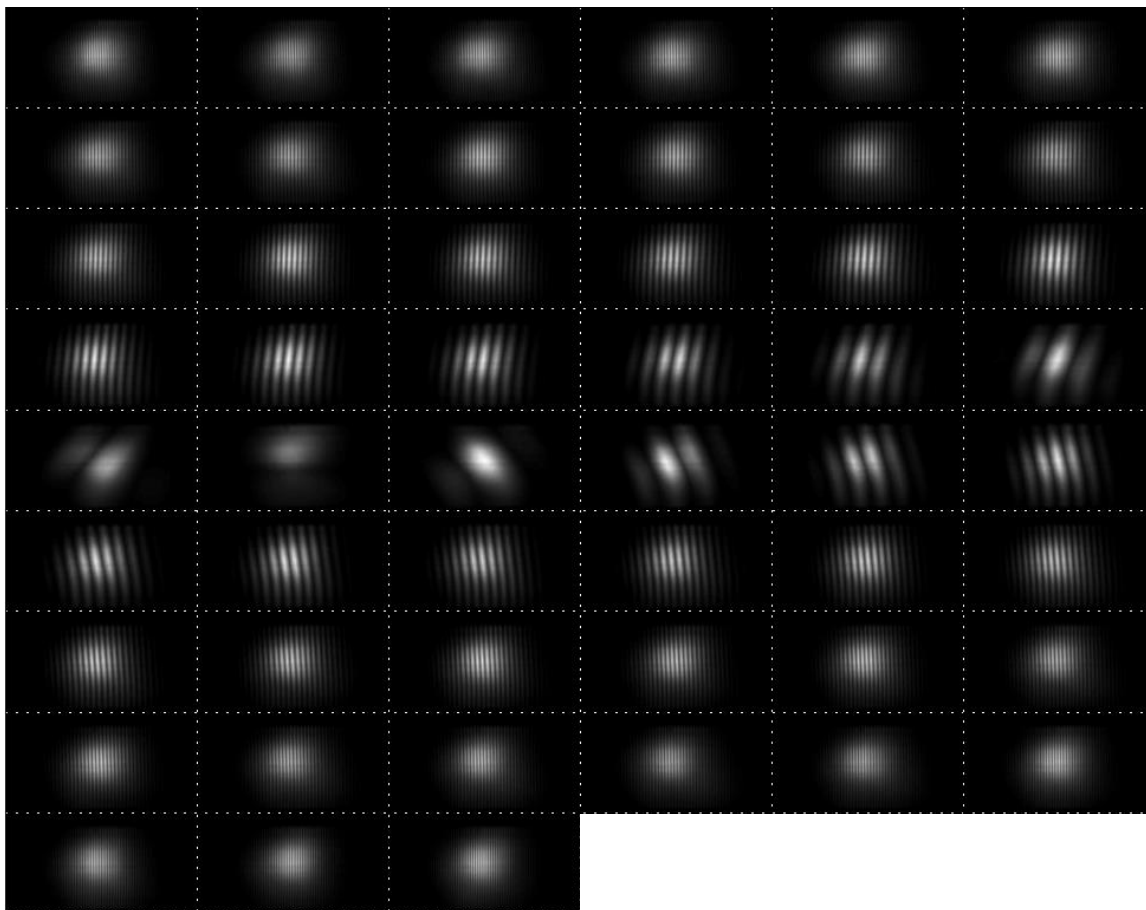
X-ray propagation direction
↓

Analyzer grating (G2)





Grating rotation scan

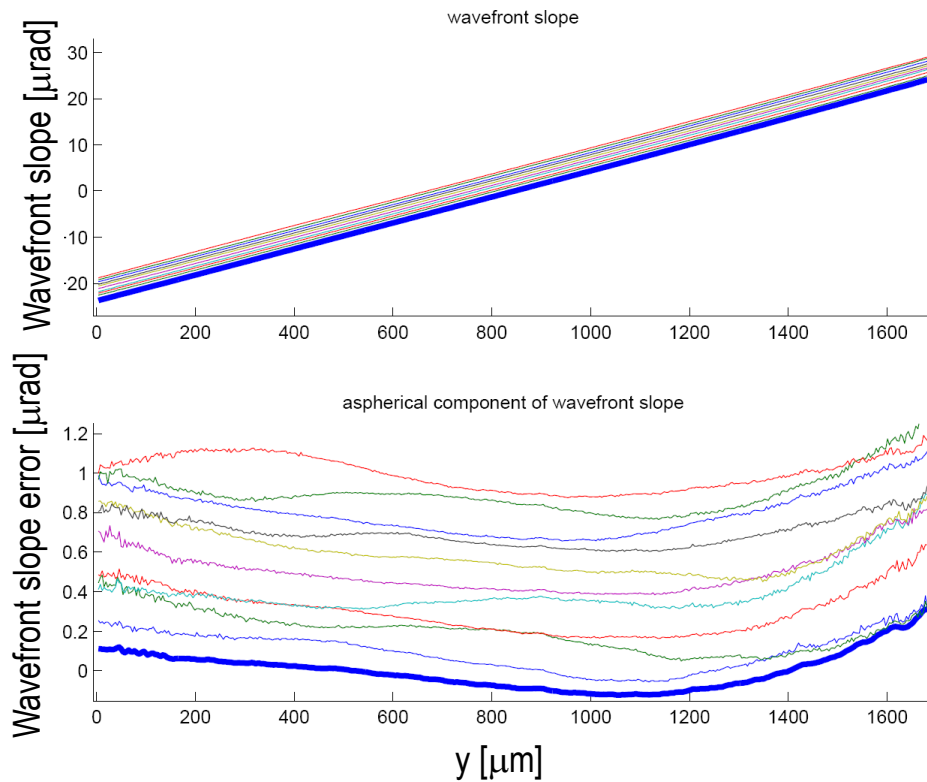
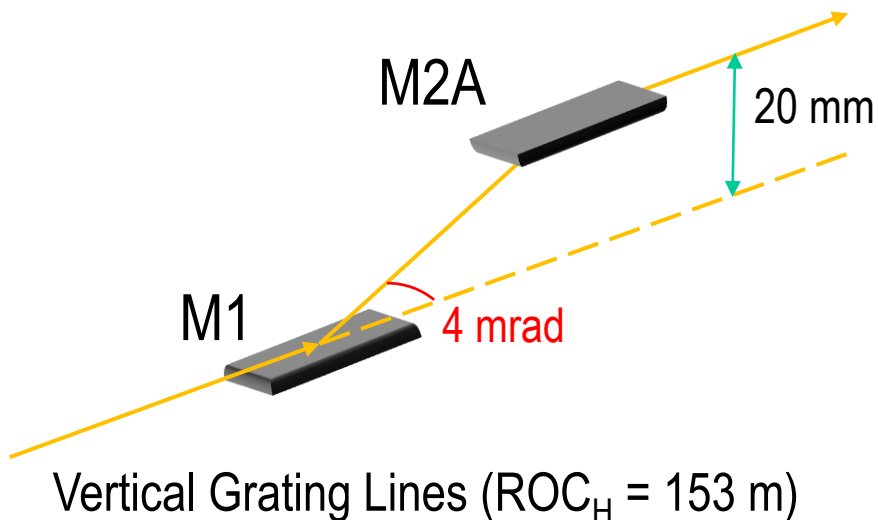


Angular Calibration

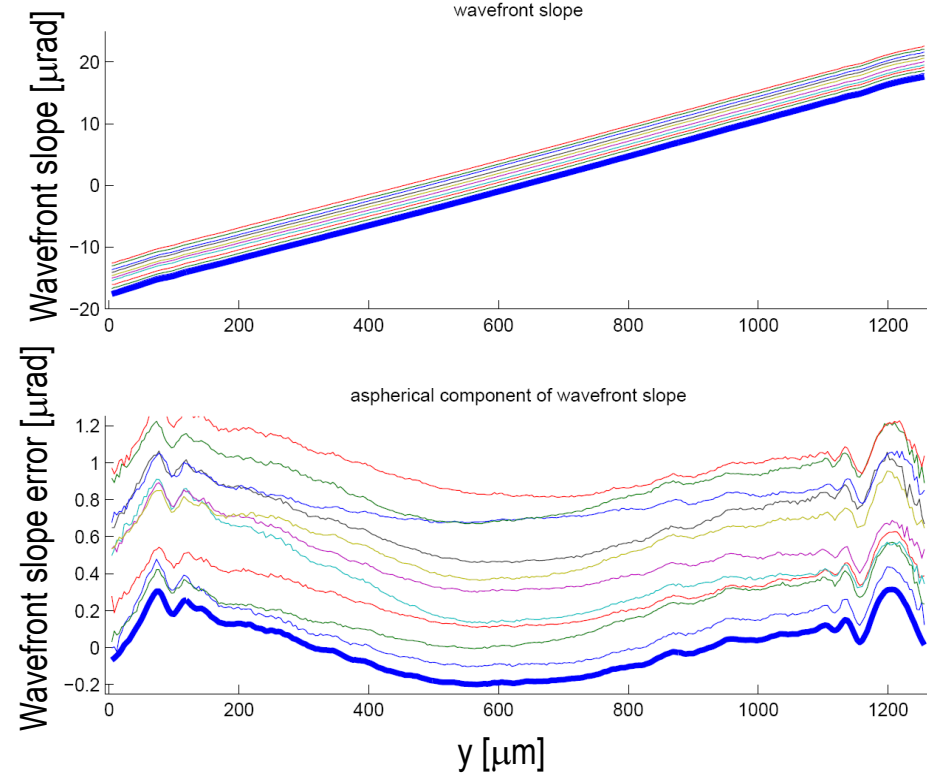
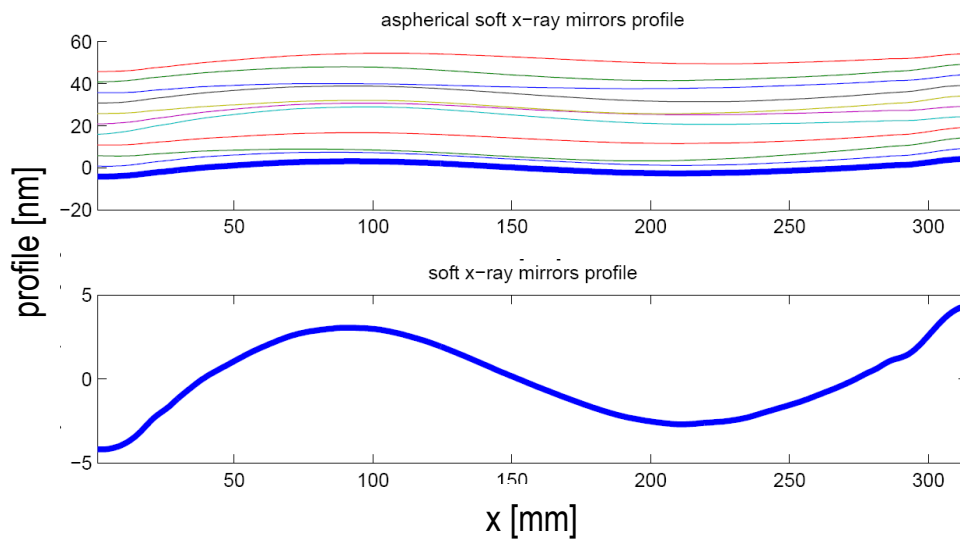
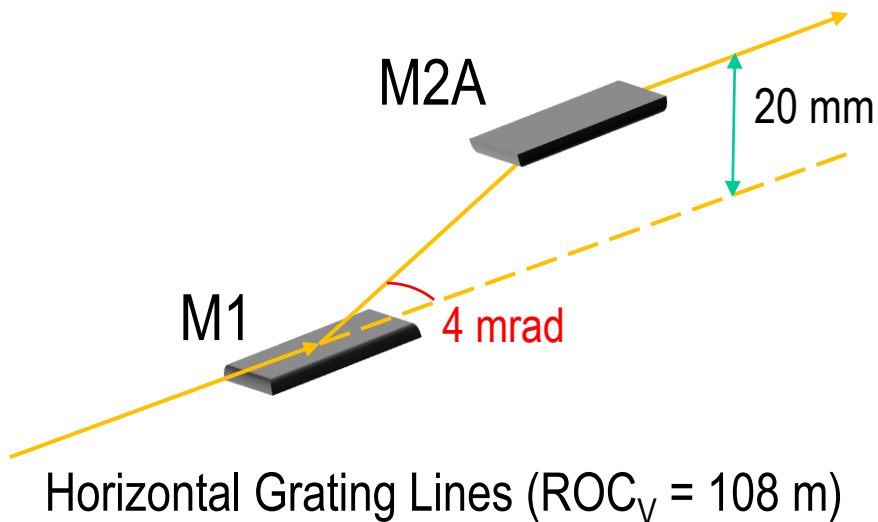
Radius of curvature (ROC)

H. Wang, K. Sawhney, S. Berujon, E. Ziegler, S. Rutishauser, and C. David,
X-ray wavefront characterization using a rotating shearing interferometer,
Opt. Express. **19**, 16550-16559 (2011).

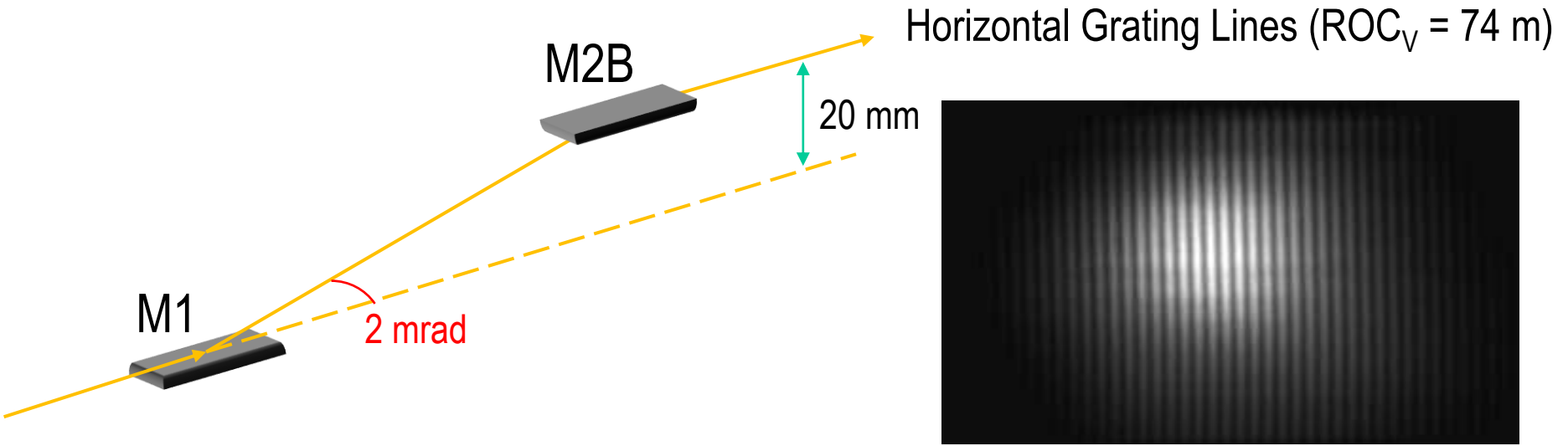
Results: Mirrors (M1 & M2A, $E_B = 7$ keV)



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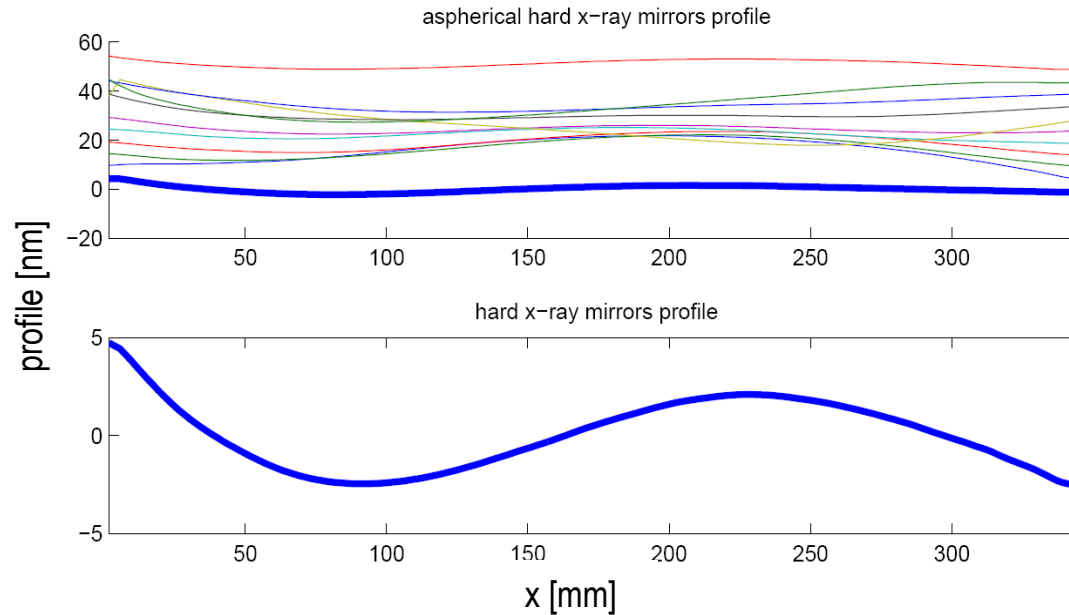
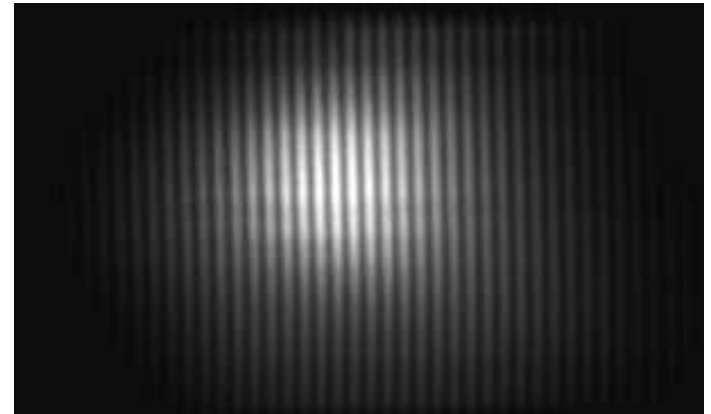
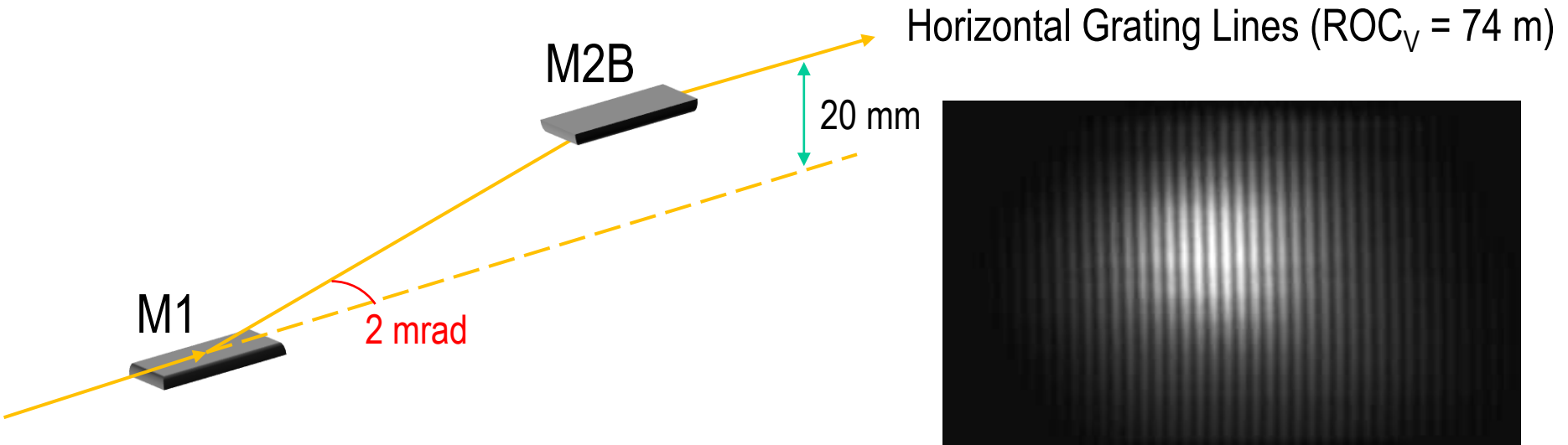
Results: Mirrors (M1 & M2B , $E_B = 12.4$ keV)

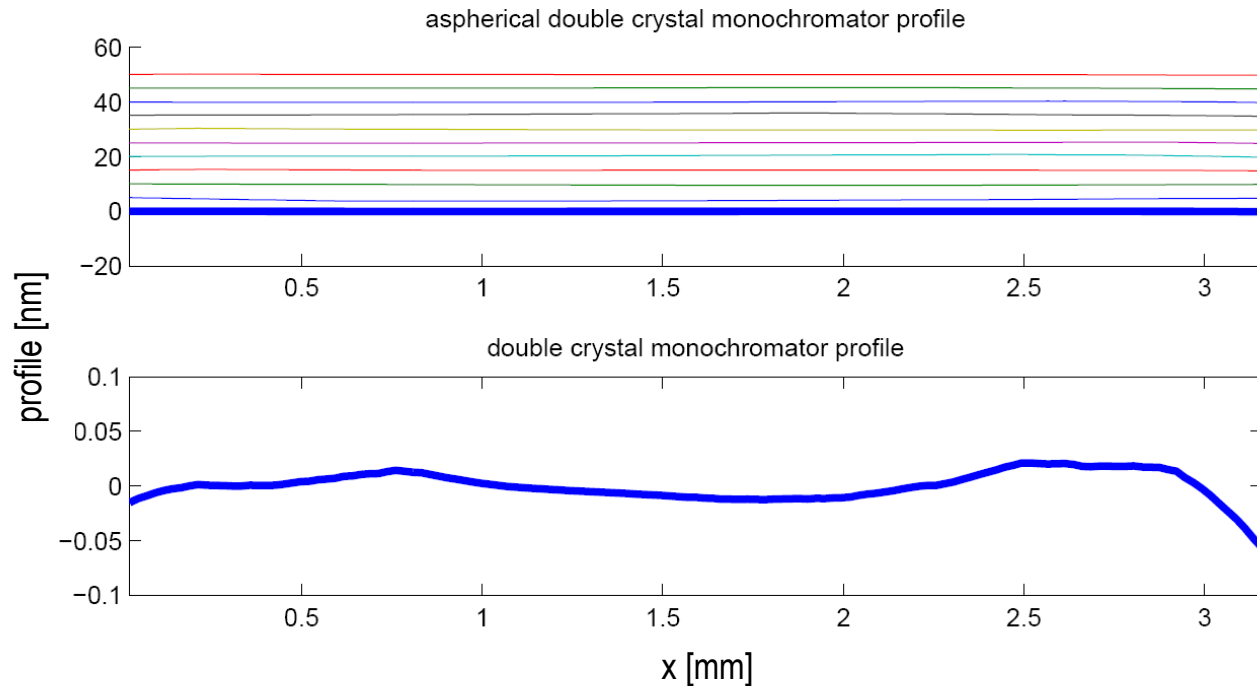
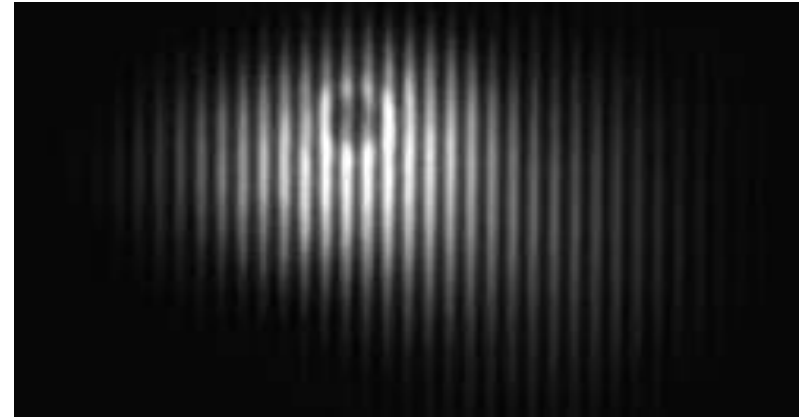
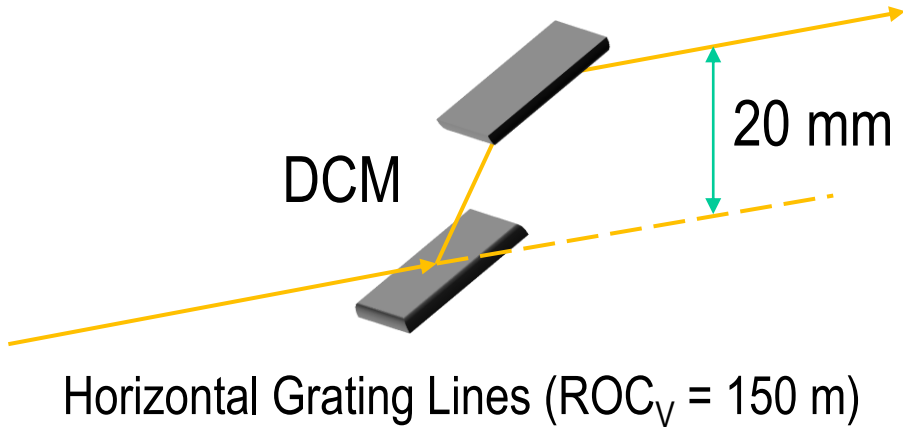


Vertical Grating Lines ($ROC_H = 153$ m)



Results: Mirrors (M1 & M2B , $E_B = 12.4 \text{ keV}$)





- In-situ at wavelength wavefront observations at the SACLA hard X-FEL source by means of grating interferometry
- Applied to metrology experiment aiming at spatially resolved wavefront measurements for optics testing
- Result: flat wavefront profiles & optical components of excellent quality

Thanks for your attention!

