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LASER ZENTRUM HANNOVER e.V.

EUV Source Collectors: Characterization of Performance and Lifetime using a Full Size EUV Collector Reflectometer

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Outline

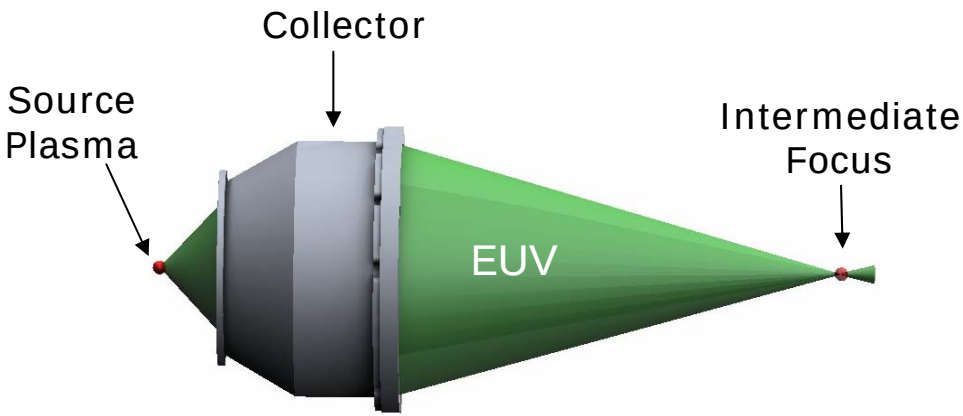
- Introduction

- Concept of EUV source collector reflectometer
- EUV metrology source
- Schwarzschild objective
- Reflectometer hardware & results

- Conclusion

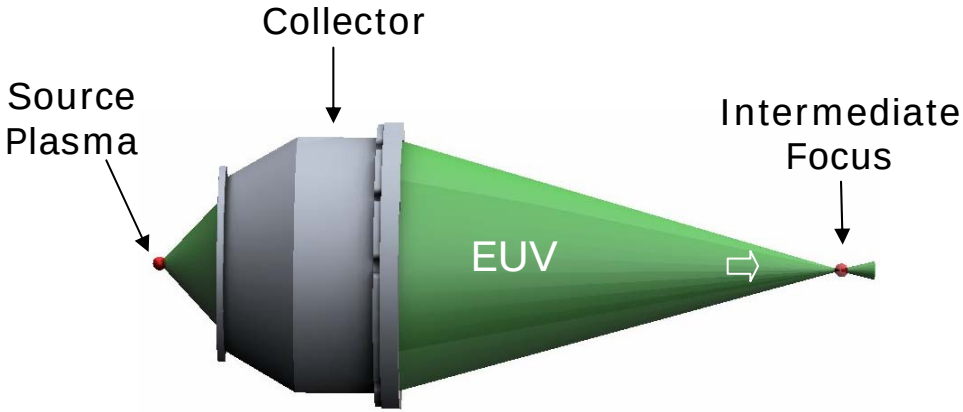
EUV Source Collector Optics

- Wolter-Shell Type 1 nested reflecting mirrors
- Source side:
  collection angle up to 2 sr
  (up to NA 0.73 = 47°)
- Intermediate focus side:
  up to 0.24 sr
  (up to NA 0.28 = 16°)



Reflectometer Concept

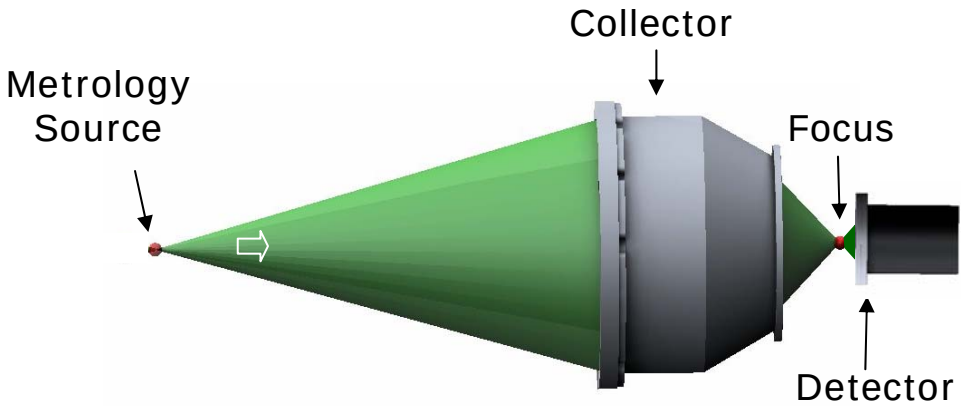
Orientation in
high power Xenon source



Little space for spectral filtering, beam shaping etc.

➔ Inverse orientation
in metrology stand

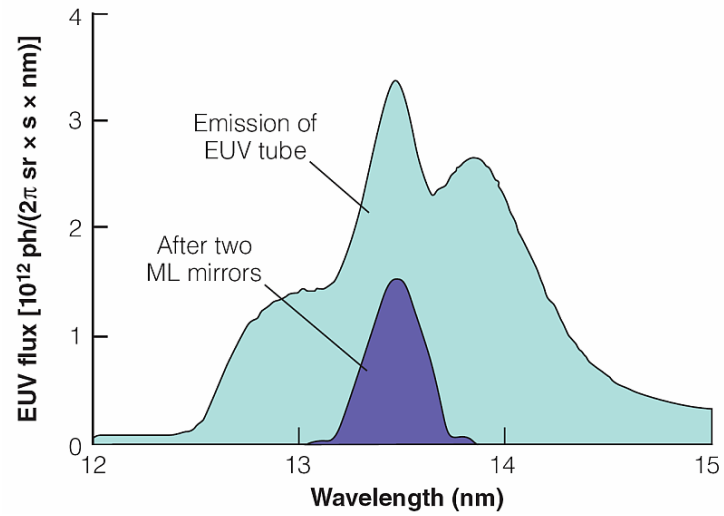
suggested by XTREME



Metrology Source

- EUV-tube (sem|20): modified µ-focus X-Ray tube
- Uses Si $L_{2,3}$ emission at 13.5 nm
- compact, stable, debris-free

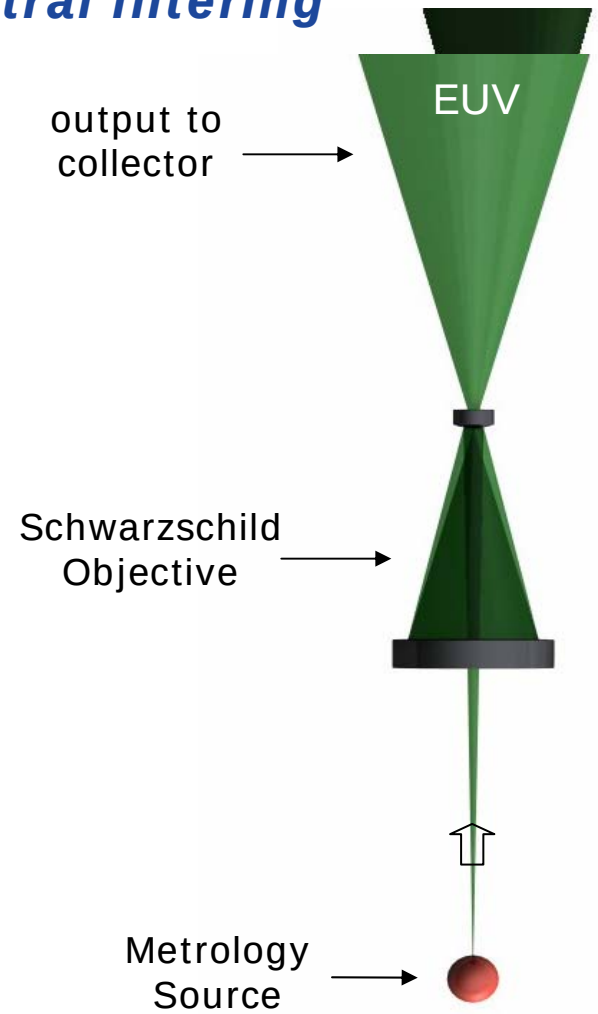
- EUV power 30µW 2πsr
- spot size down to 20µm dia. possible



Schwarzschild Objective

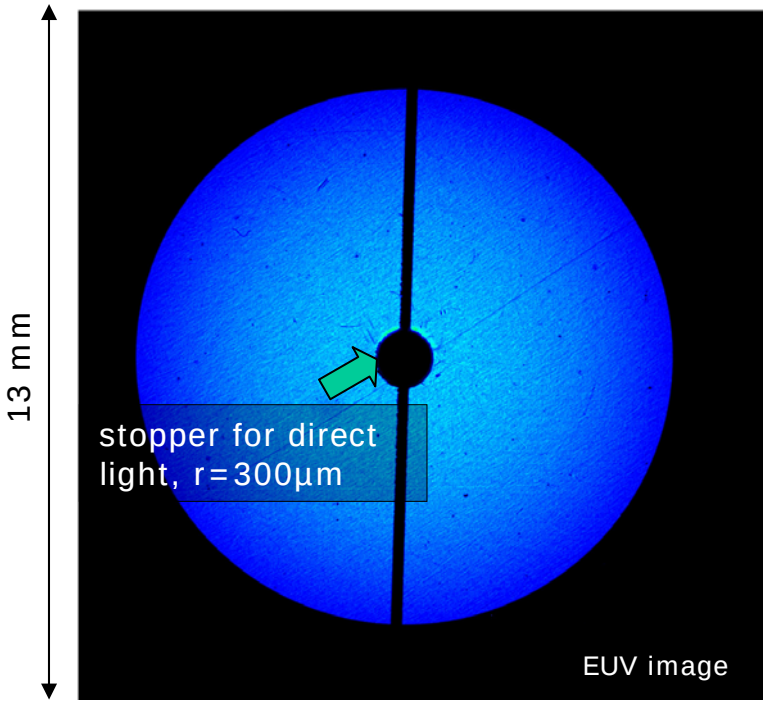
for beam shaping and spectral filtering

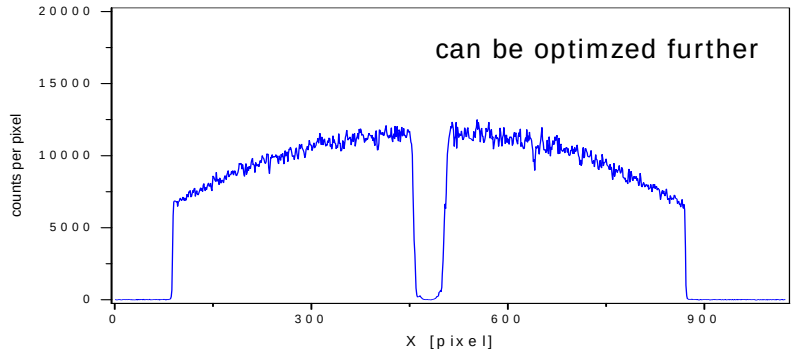
- Mo/Si multilayer mirrors
- Input numerical aperture up to NA 0.01 (0.57°, $3 \cdot 10^{-4}$ sr)
- Output numerical aperture up to NA 0.28 (16°, 0.24sr)
- Focus on mirror surface
- Demagnification x 28



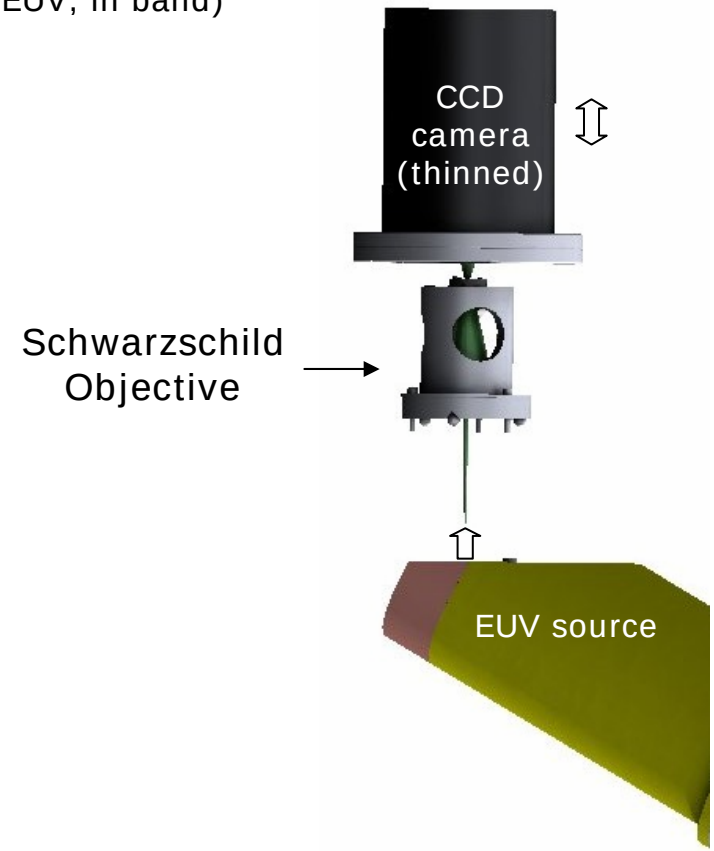
Fraunhofer Institut Angewandte Optik und Feinmechanik

I_0-Measurement Behind Objective
(in Front of Collector)





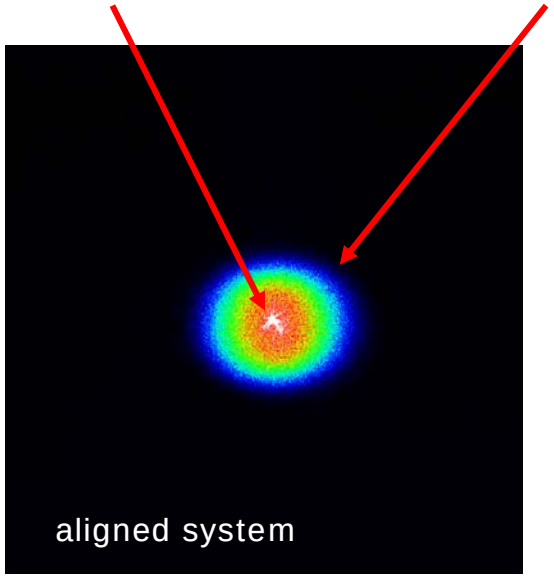
- CCD camera about 20 mm behind focus
- total power in image after objective and filters: 30-50 pW (EUV, in band)

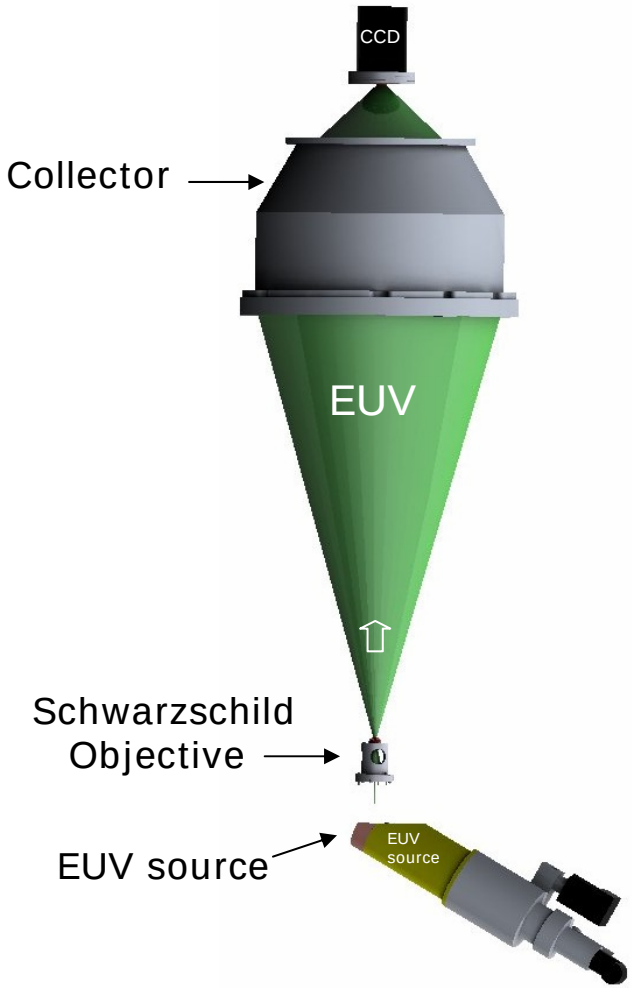


Before Collector Measurement: Adjustment Verification

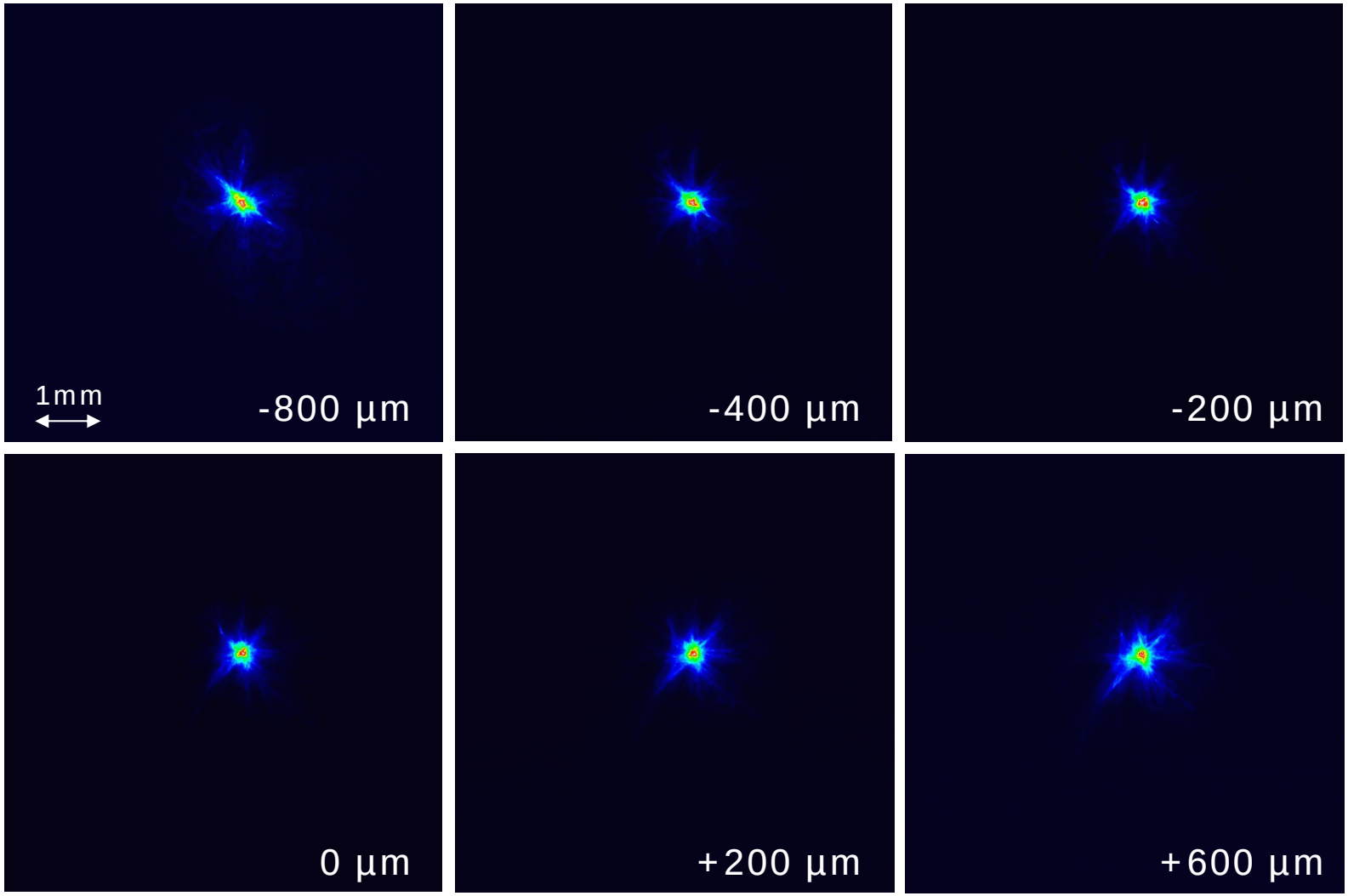
- CCD-camera behind collector

- adjustment verification:
  collector focus + direct light on CCD



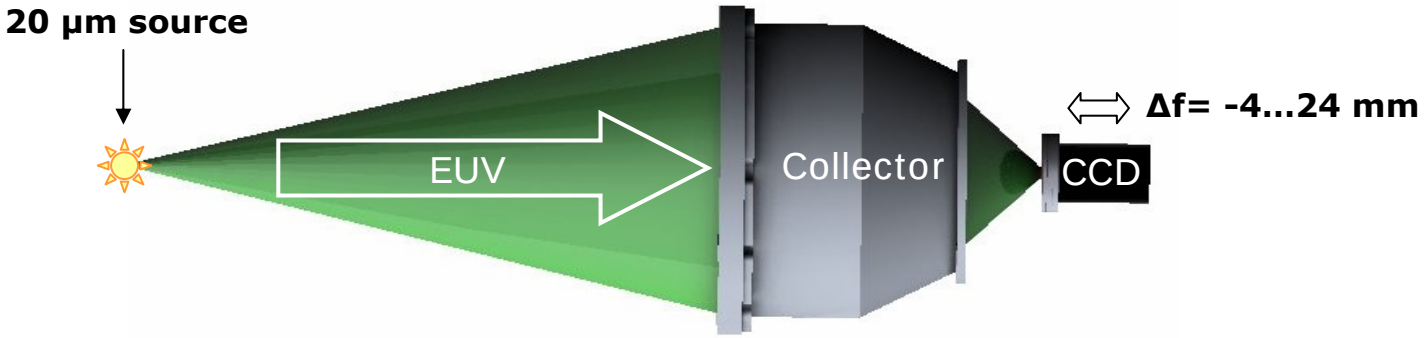


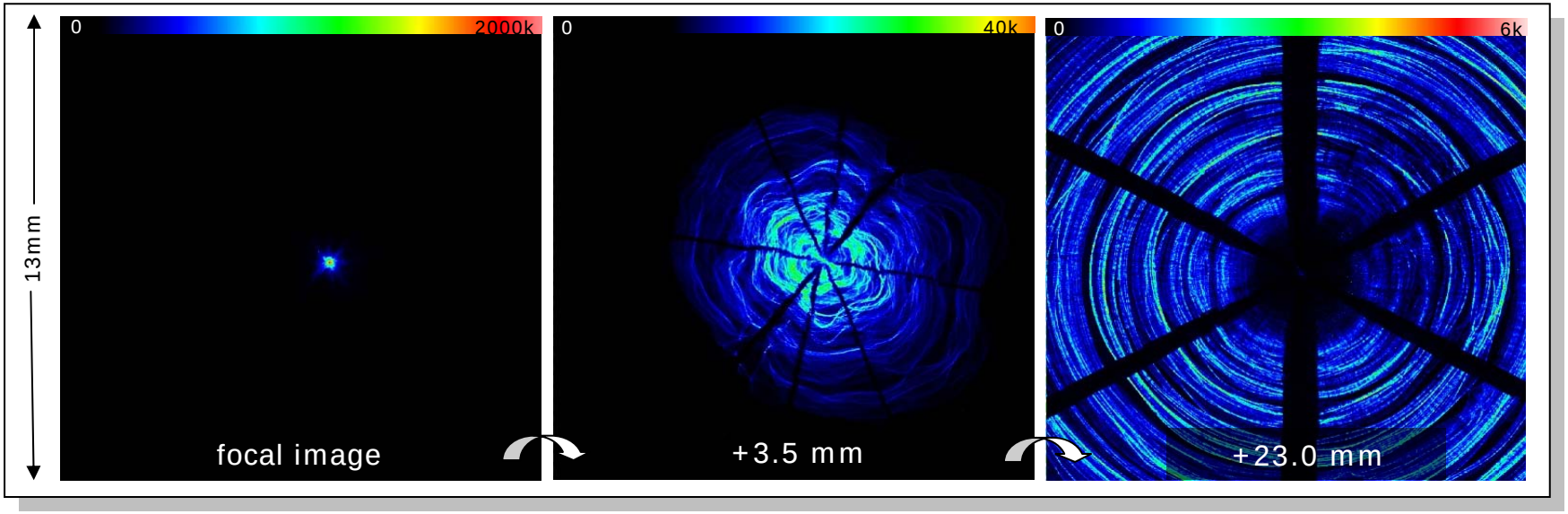
Focal Images



Test Collector Images: Focus to „Extra Focus“

- Point-like source, inverse configuration
- High spatial resolution of the reflectometer enables accurate metrology



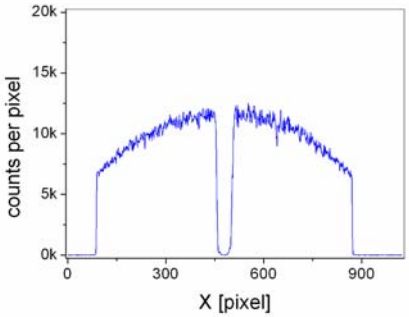


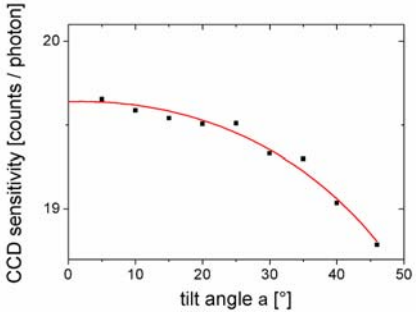
Collection Efficiency

- collection efficiency = I / I0 · c

  c = correction factor considers:

  - angular intensity distribution
  - CCD camera angular sensitivity (measured at synchrotron Bessy II, PTB)
  - numerical aperture correction
  - inverse geometry (ray tracing calculations)





- **reflectometer accuracy better than 1.5%**

Collection Efficiency

Collector	Coating	Calculated	Measured
Single-shell	Gold	2.34%	2.37%
Dual-shell	PVD Ru	9.0%	7.8-8.1%
Full-configuration	PVD Ru	17.1%	16.4-17%

Summary

- First full-size laboratory EUV collector reflectometer
- >8 different collectors tested
- >25 Collector measurements
- Metrology source: EUV-tube
- Measurement of focal spot size, collection efficiency, optical quality, lifetime and ageing,…

Collector reflectometer for XTREME technologies

Acknowledgements

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