
Enhanced lifetime and optical performance of the NXE:3100 LPP collector mirrors

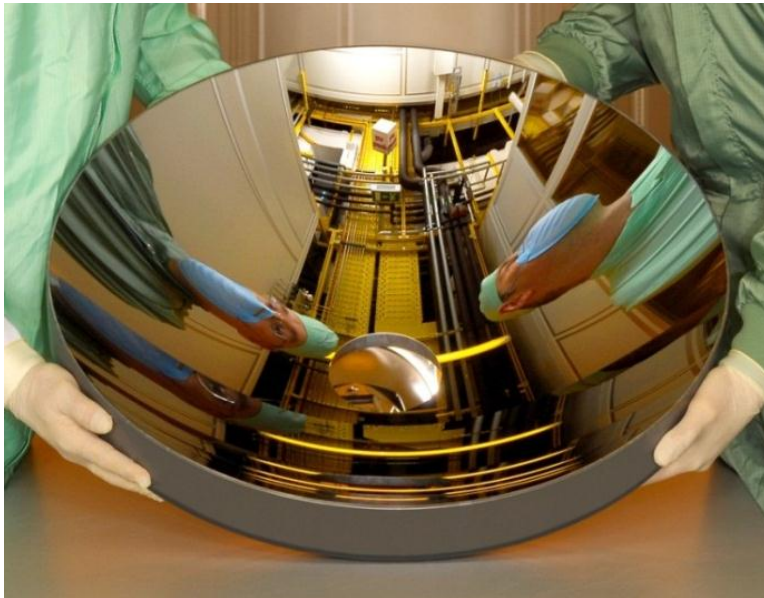
2012 International Symposium on EUV Lithography

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Contents

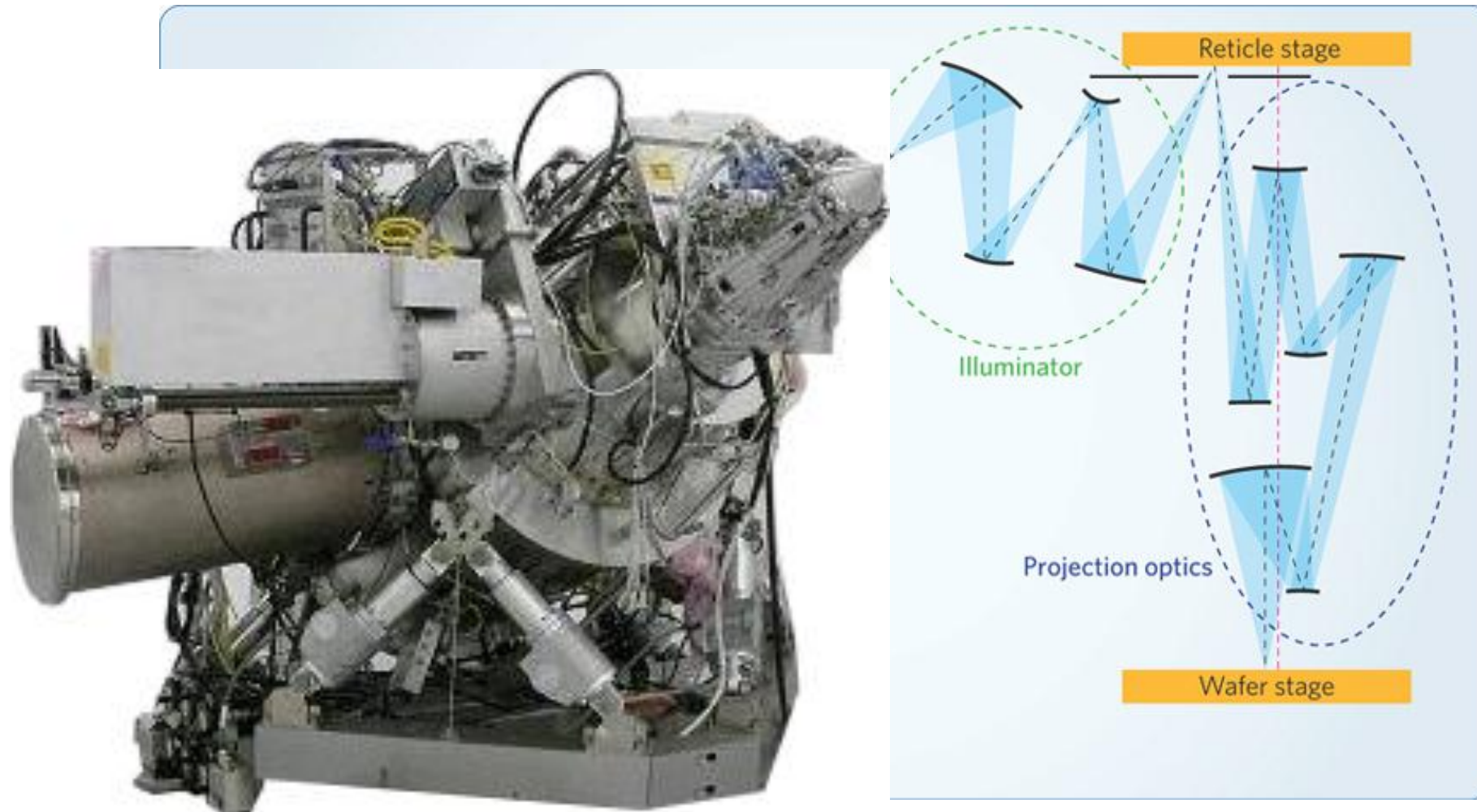
- Introduction
- Update on EUV coating infrastructure @ Fraunhofer IOF
- Optical performance and collector lifetime
- Summary and acknowledgement

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Coating and characterization of LPP collector optics



[*Nature Photonics* 4, 24-26 (2010), www.cymer.com]

LPP collector coating challenges

$R > 65 \%$

$\lambda = (13.5 \pm 0.03) \text{ nm}$

→ $\Delta d = 0.015 \text{ nm} = 15 \text{ pm}$

- Diameter: $> 660 \text{ mm}$
- Lens sag: $> 150 \text{ mm}$
- Tilt: $> 45 \text{ deg}$
- Weight: $> 40 \text{ kg}$



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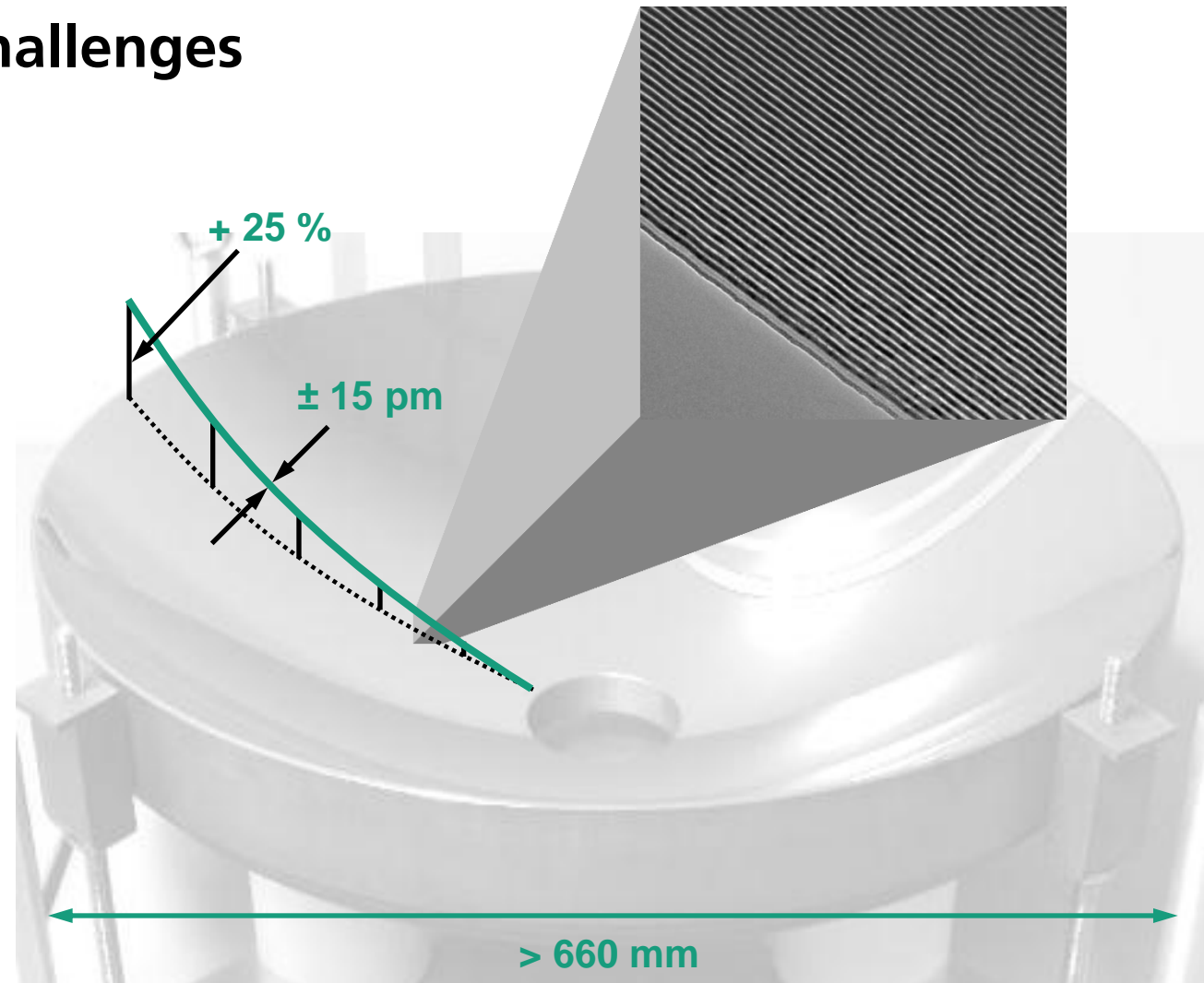
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NESSY I

- Substrate size:
up to \varnothing 450 mm
- four deposition targets
- deposition of graded multilayers on curved substrates
- Installation: 2003
- Application: EUV optics



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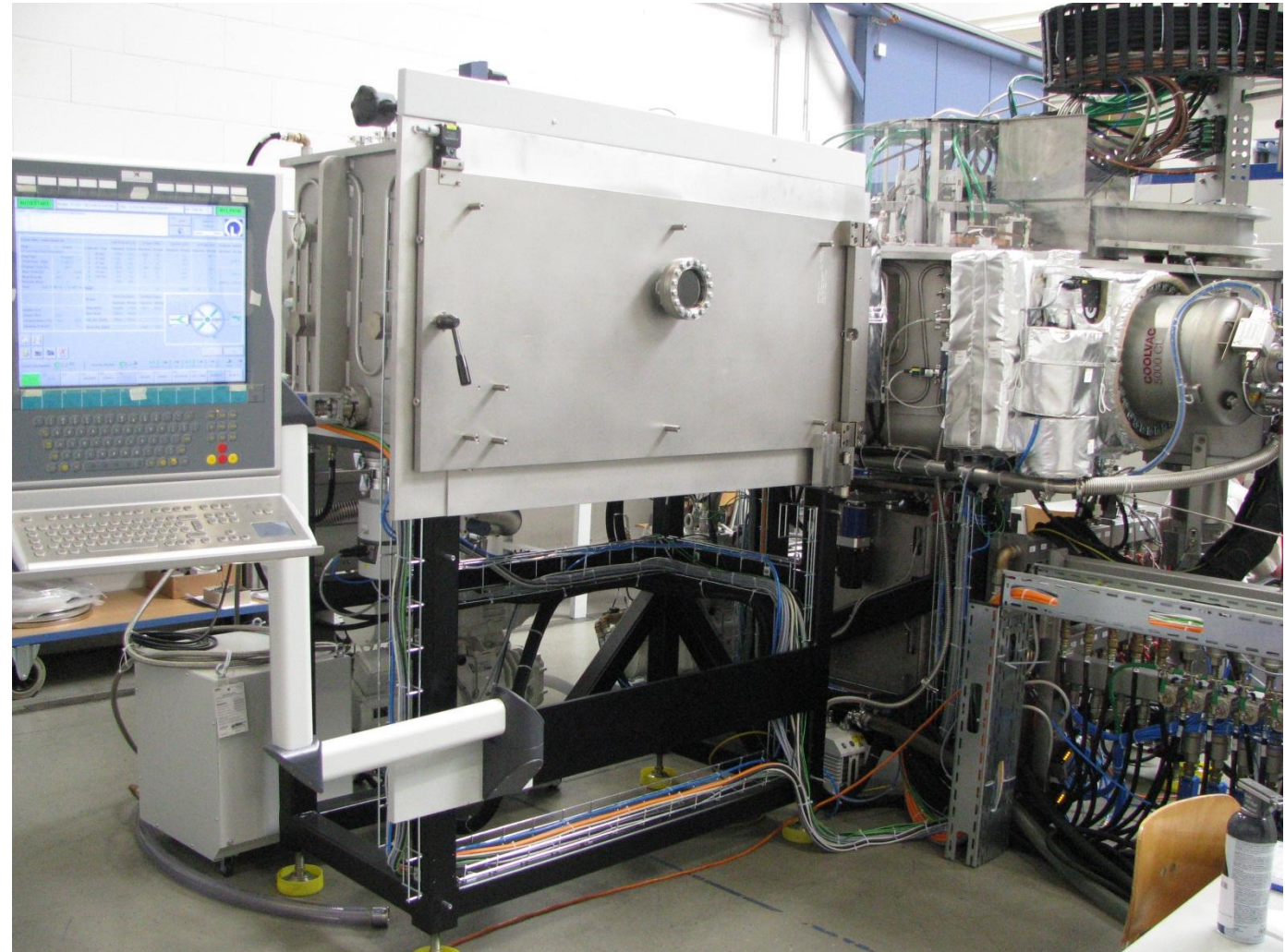
NESSY II

- Substrate size:
up to \varnothing 700 mm
- six deposition targets
- deposition of graded multilayers on curved substrates
- Installation: 2009
- Application: collectors



NESSY III – delivery to IOF: September 25, 2012

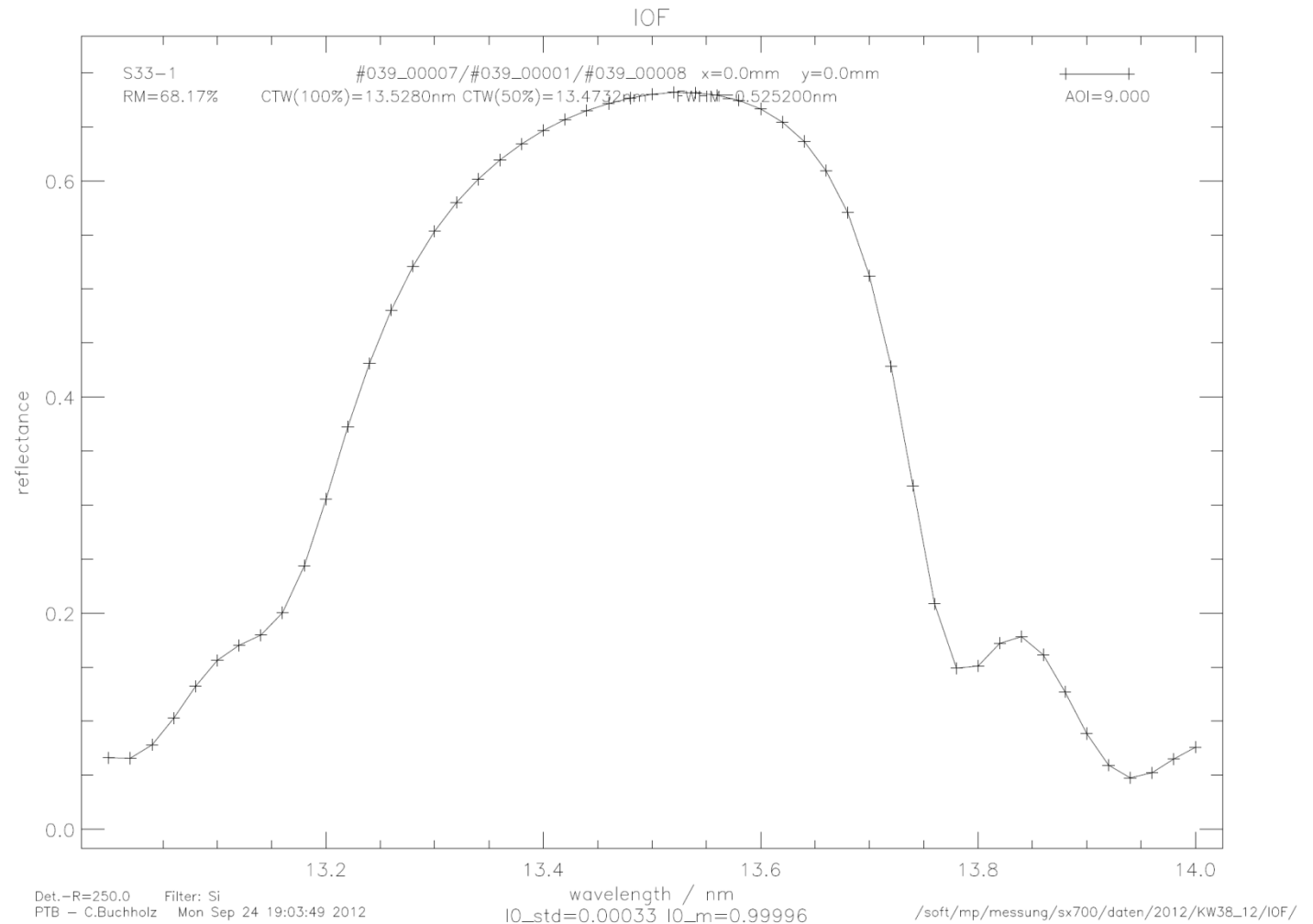
- Substrate size:
up to Ø 200 mm
- six deposition targets
- deposition of graded
multilayers on curved
substrates
- Installation: Sept. 2012
- Application: EUVL R&D



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NESSY III – first EUV reflectance results

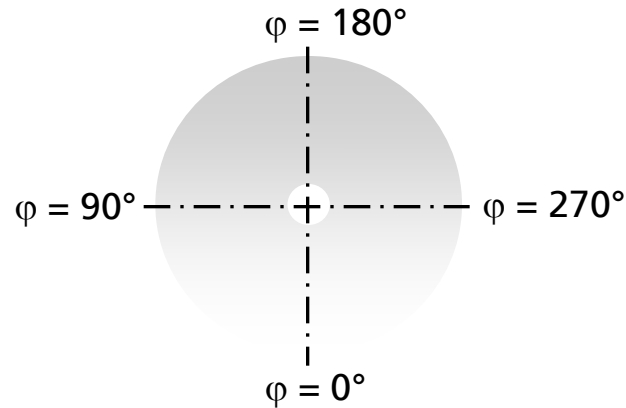
- Very first Mo/Si multilayer
- Reflectance: **R = 68.2 %**
- Peak: **$\lambda = 13.53 \text{ nm}$**
- Center: **$\lambda = 13.47 \text{ nm}$**
- FWHM: **0.525 nm**



Contents

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Reflectivity (s-pol.) of LPP collector mirror



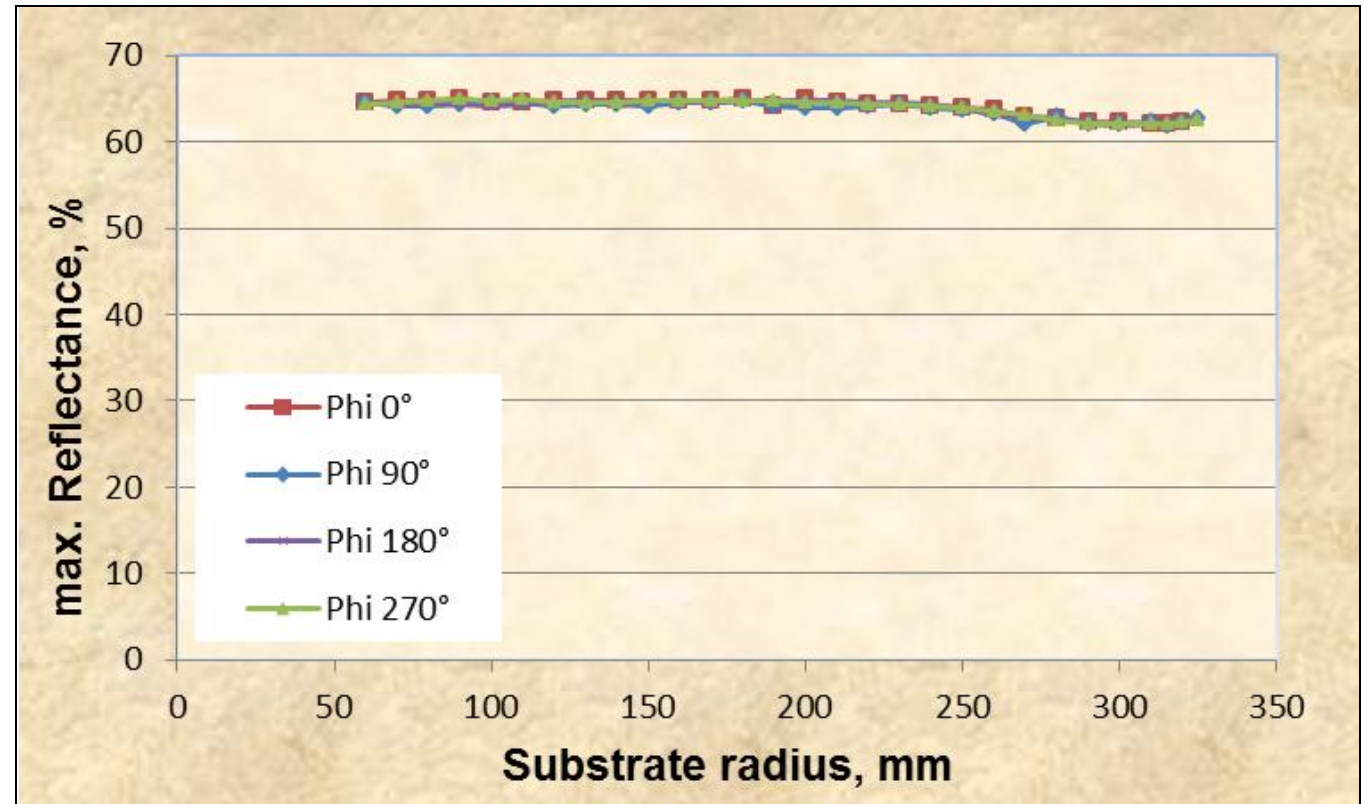
Maximum reflectance along
four lines within clear
aperture of collector mirror:

R = 65% ... 63 %

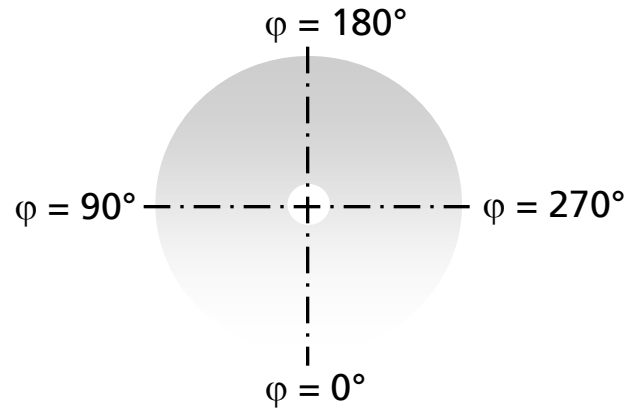
CHAMPION DATA:

R = 67 % ... 65 %

Measurements: PTB Berlin



Wavelength of LPP collector mirror



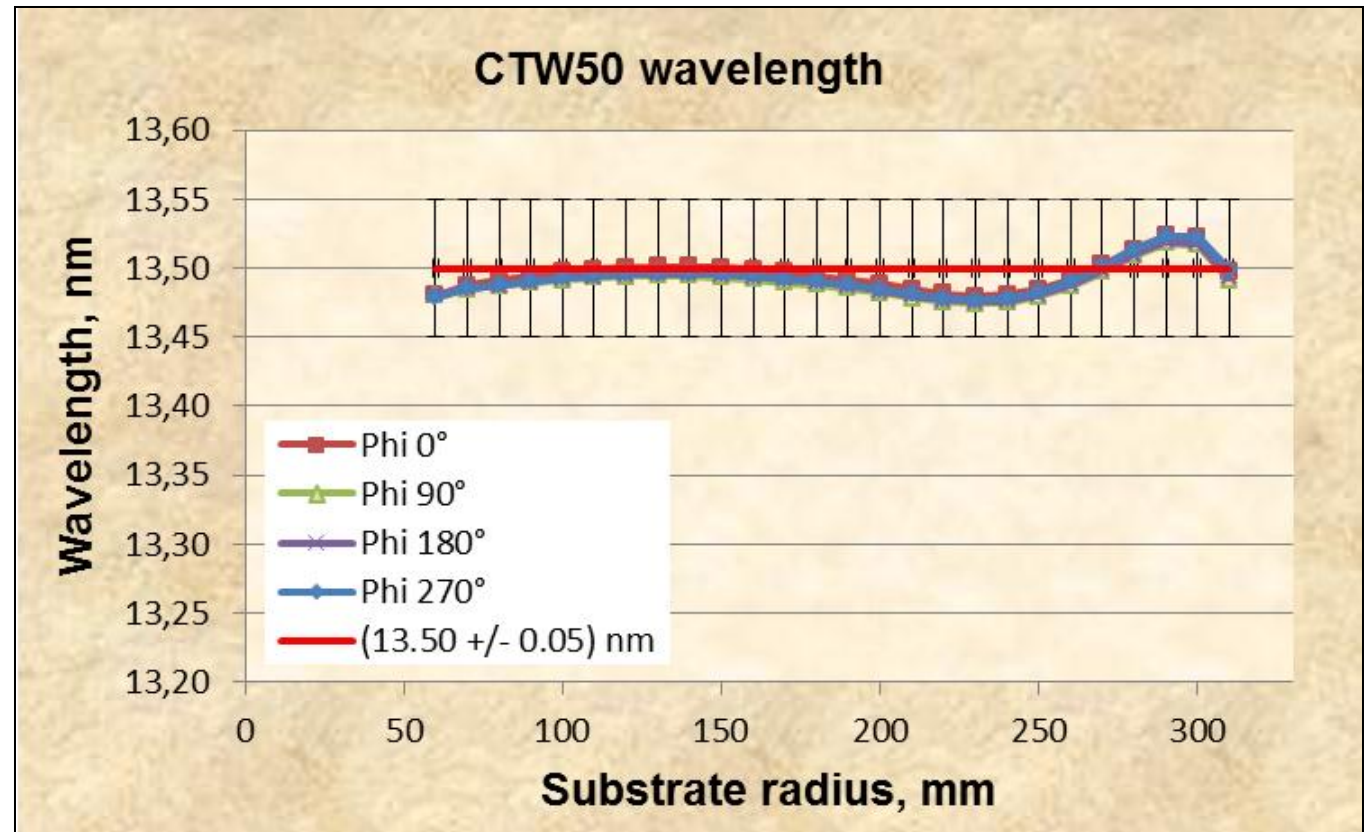
Center wavelength along
four lines within clear
aperture of collector mirror:

$$\lambda = (13.50 \pm 0.03) \text{ nm}$$

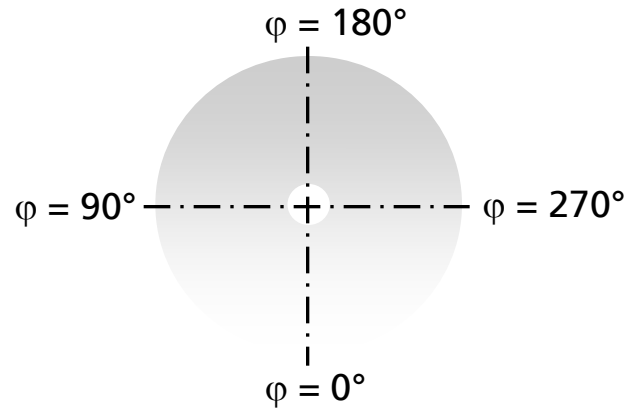
CHAMPION DATA:

$$\lambda = (13.500 \pm 0.015) \text{ nm}$$

Measurements: PTB Berlin



Wavelength of LPP collector mirror



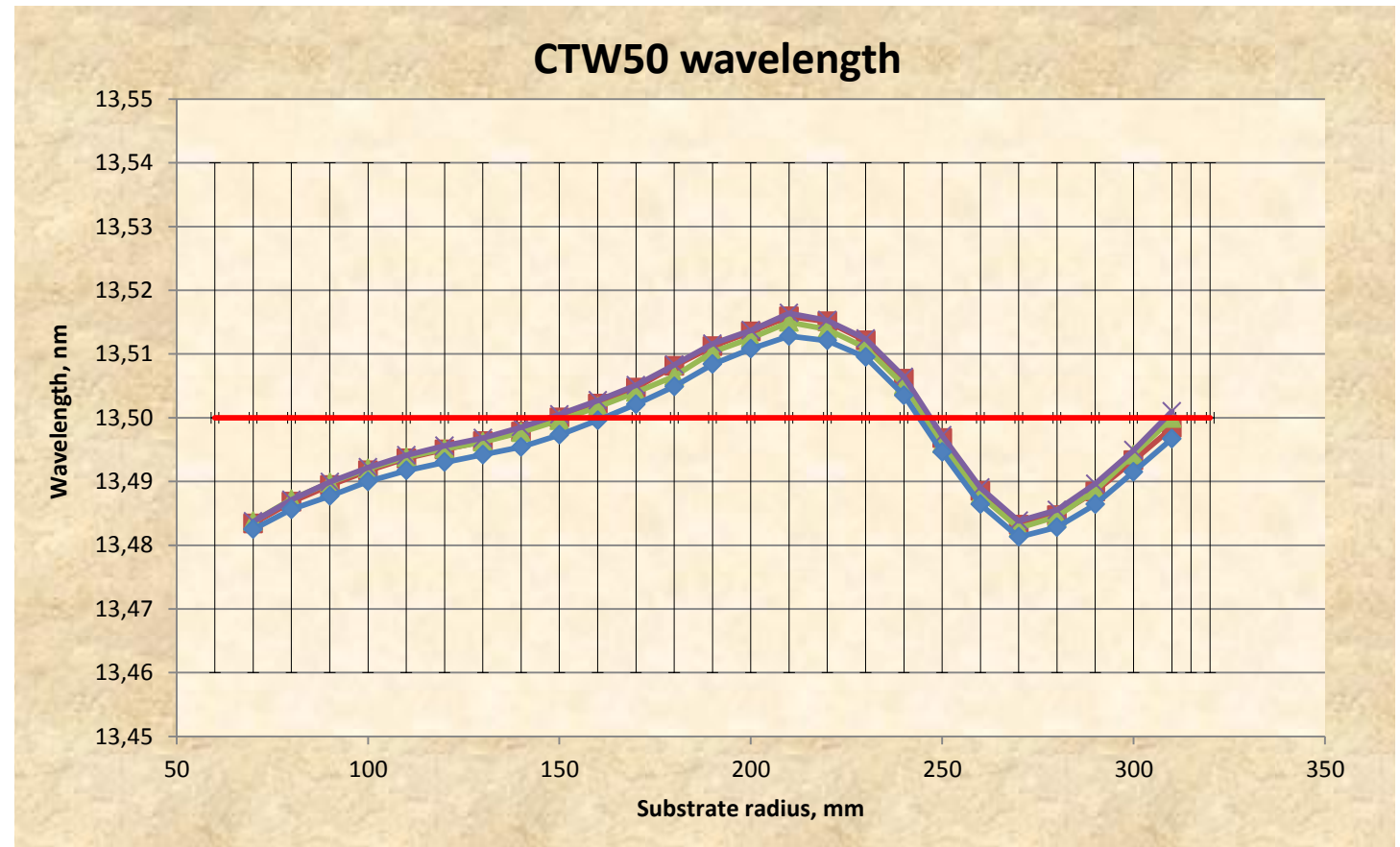
Center wavelength along
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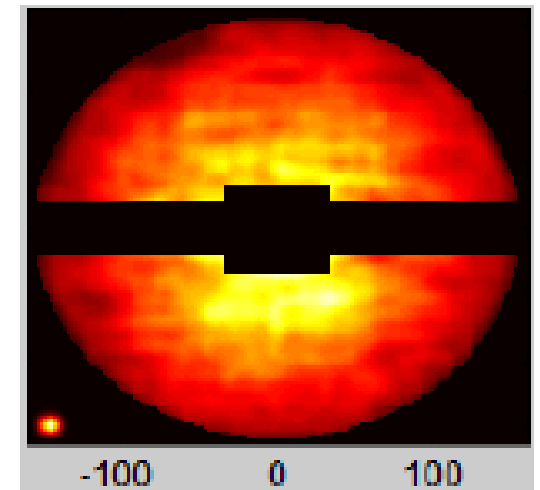
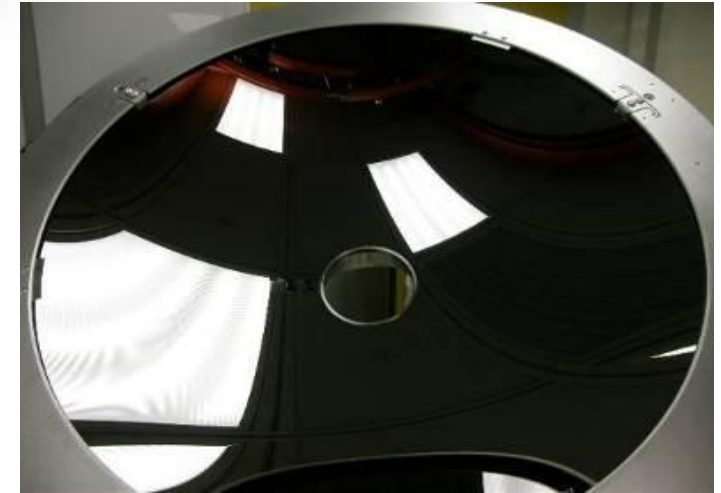
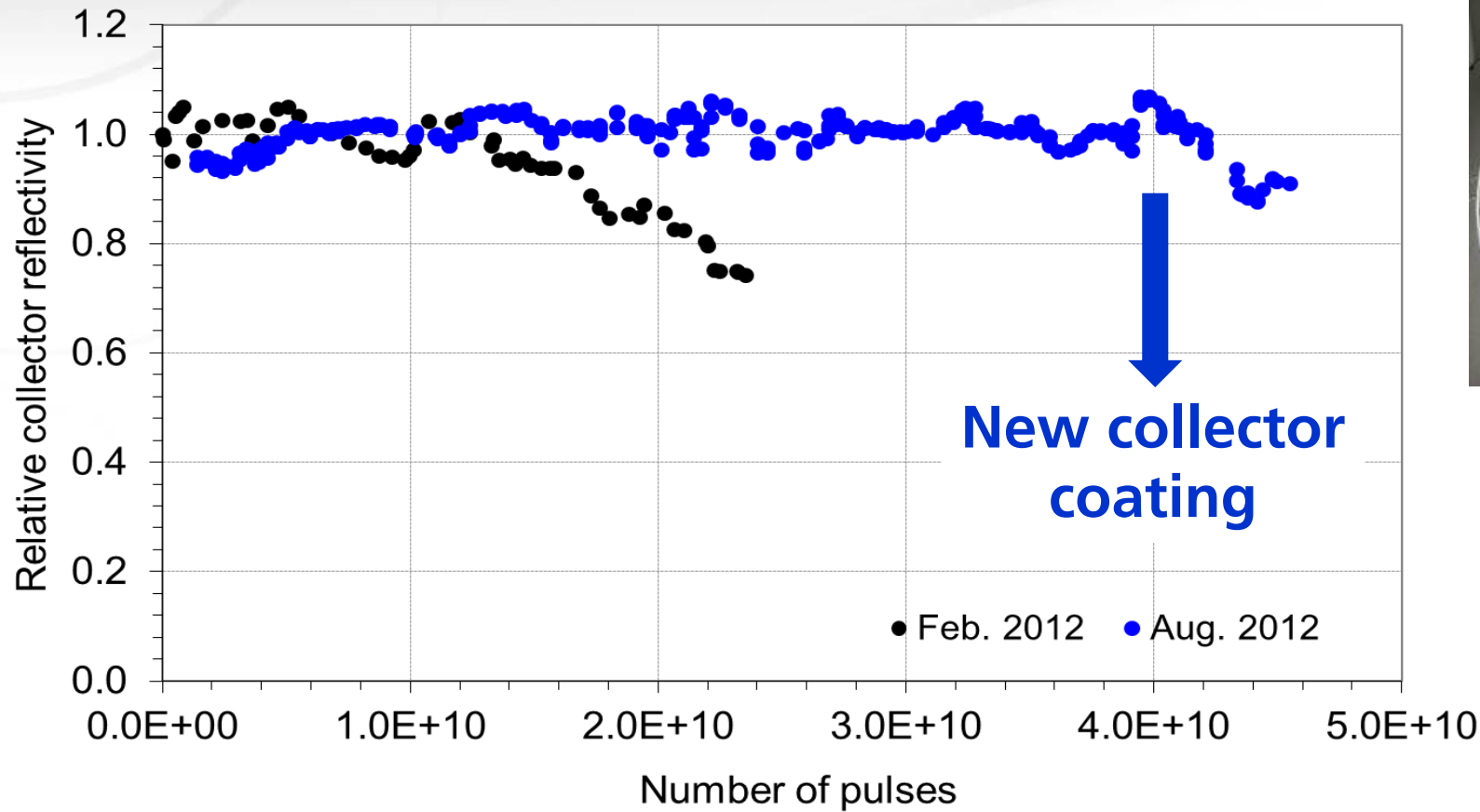
CHAMPION DATA:

$$\lambda = (13.500 \pm 0.015) \text{ nm}$$

Measurements: PTB Berlin



Improved Collector Lifetime in the Field >45 X 10⁹ Pulses at Original Reflectivity



**No change visible in far field image after
45 X 10⁹ pulses with a new coating**

EUV Image at
45 Billion Pulses

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Summary

- Collector lifetime: 45 Billion pulses with new collector coating
- 2011 EUVL Symposium champion data now routinely achieved:
 - R = 65 % ... 63 % and d-spacing accuracy of $\Delta d < 25 \dots 15$ pm routinely achieved on LPP EUV multilayer mirror ($\emptyset > 660$ mm)
 - R = 67 % ... 65 % and d-spacing accuracy of $\Delta d < 7$ pm champion data achieved on LPP EUV multilayer mirror ($\emptyset > 660$ mm)
- Collector refurbishment: EUV reflectance 90 % recovered

Acknowledgements

- **EUV source development team @ Cymer:**
David Brandt, Igor Fomenkov, Silvia De Dea, and many others
- **EUV reflectivity measurement team @ PTB Berlin:**
Frank Scholze, Christian Laubis, Christian Buchholz, Annett Barboutis, Martin Biel, Benjamin Dubreau, Jana Puls, Christian Stadelhoff
- **EUV collector team @ Fraunhofer IOF:**
Christoph Damm, Andreas Gebhardt, Tobias Herffurth, Robert Jende, Johannes Paul Jobst, Thomas Müller, Viatcheslav Nesterenko, Michael Scheler, Thomas Peschel, Stefan Risse, Sebastian Scheiding, Steffen Schulze, Ronald Schmidt, Mark Schürmann, Uwe Zeitner, and many others

Thank you!

