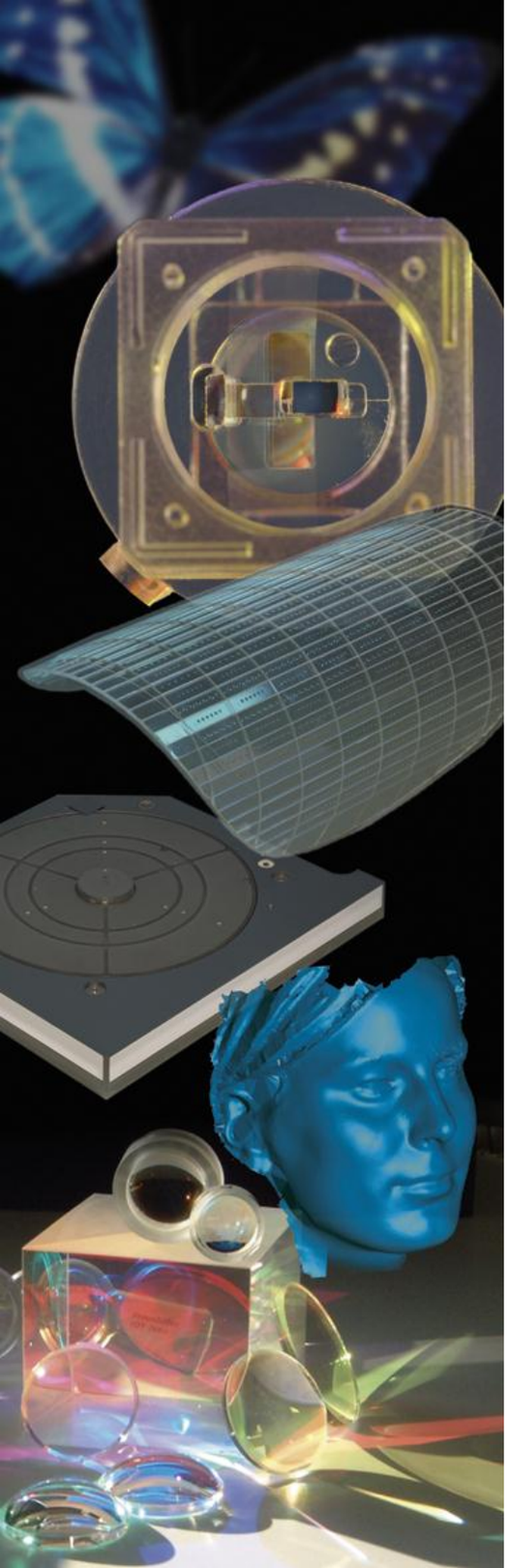
Solutions with light –
meet challenges and offer opportunities



Optical performance of 5.5 sr LPP multilayer collectors

2011 International Symposium on EUV Lithography

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- Introduction
- Characterization of LPP collector substrates
- Multilayer coating of LPP collectors
- Summary and acknowledgement

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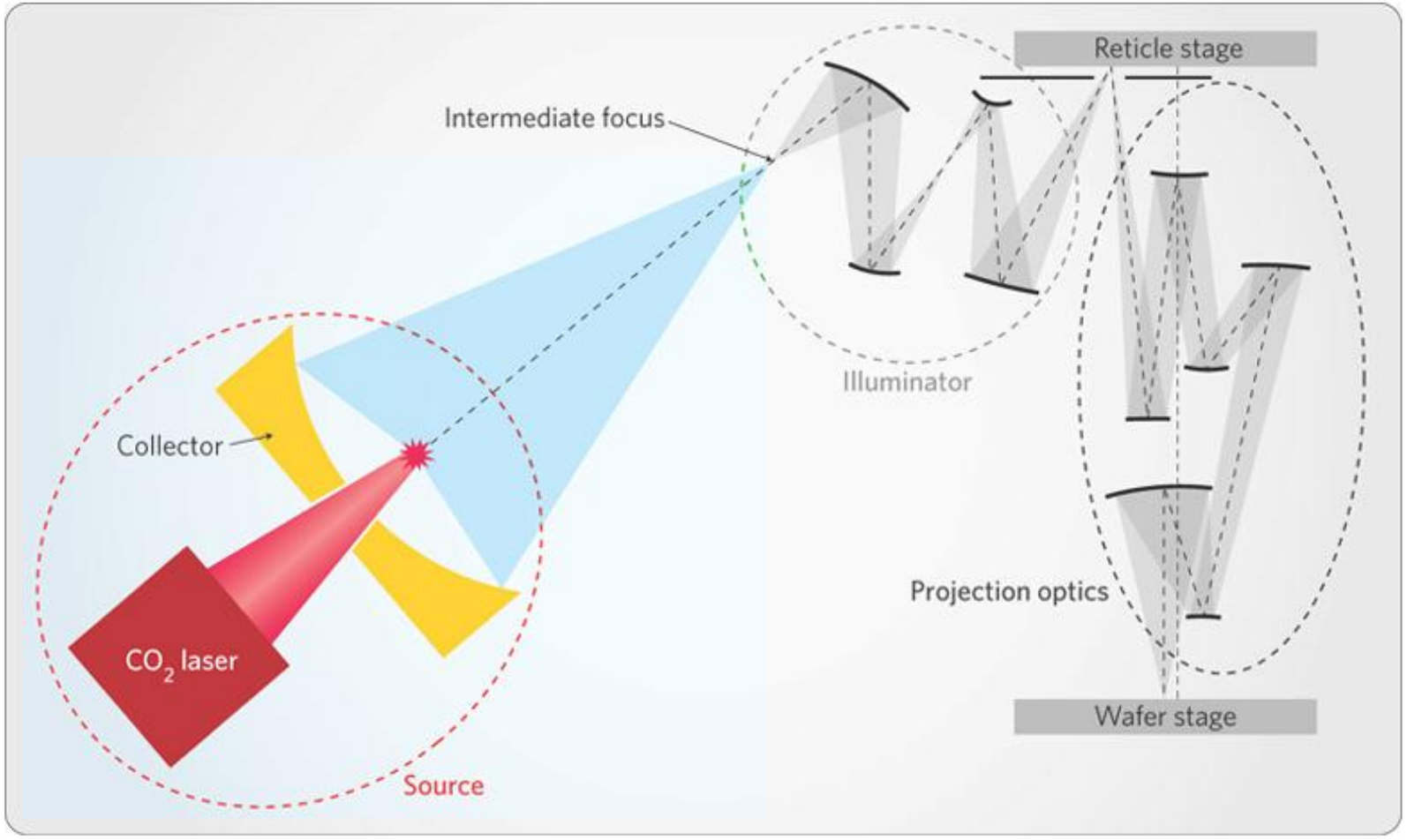
Coating and characterization of LPP collector optics



[*Nature Photonics* **4**, 24-26 (2010)]

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LPP collector coating challenges

R > 65 %

λ = (13.5 ± 0.03) nm

→ Δd = 0.015 nm = 15 pm

- Diameter: > 660 mm
- Lens sag: > 150 mm
- Tilt: > 45 deg
- Weight: > 40 kg

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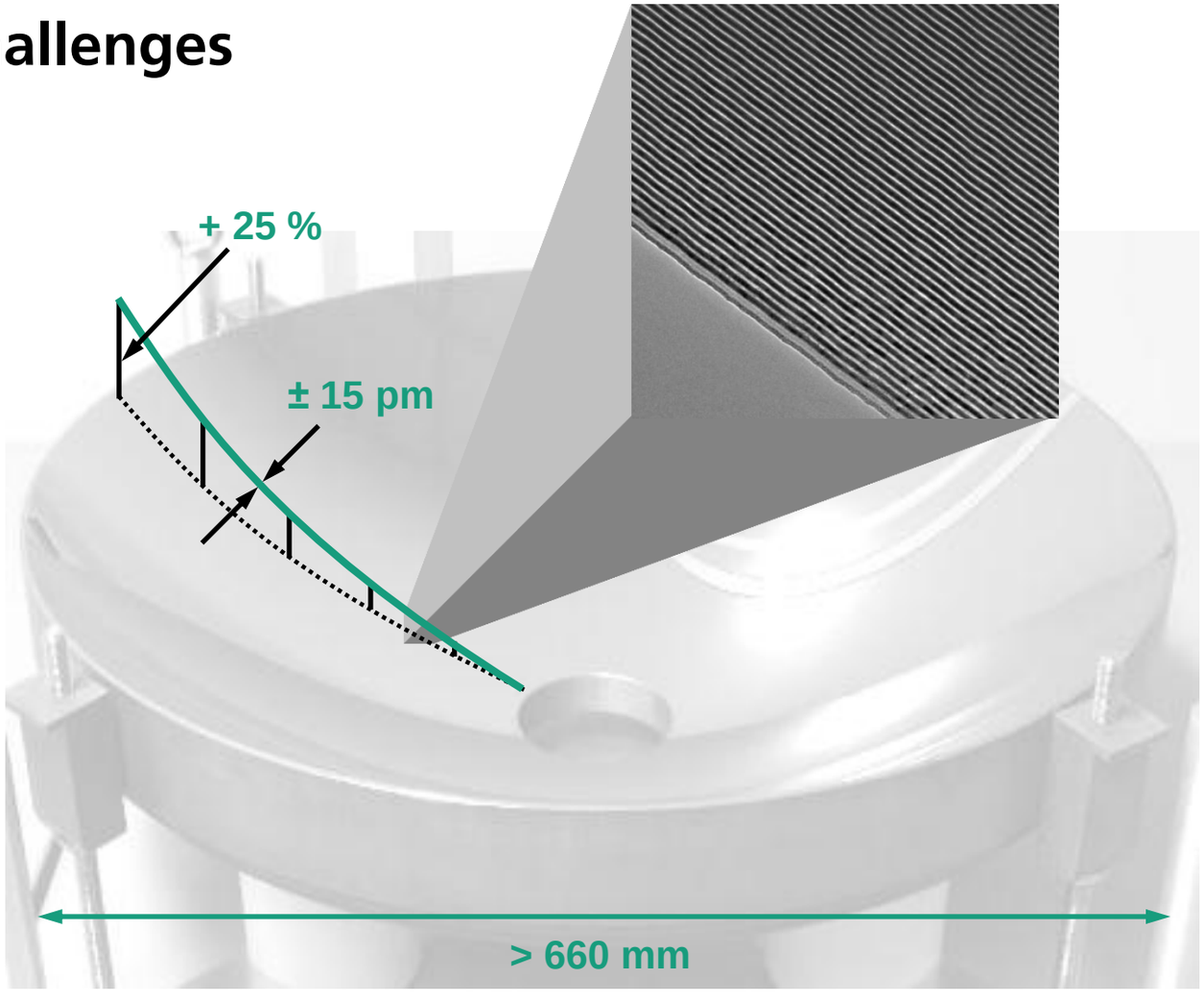

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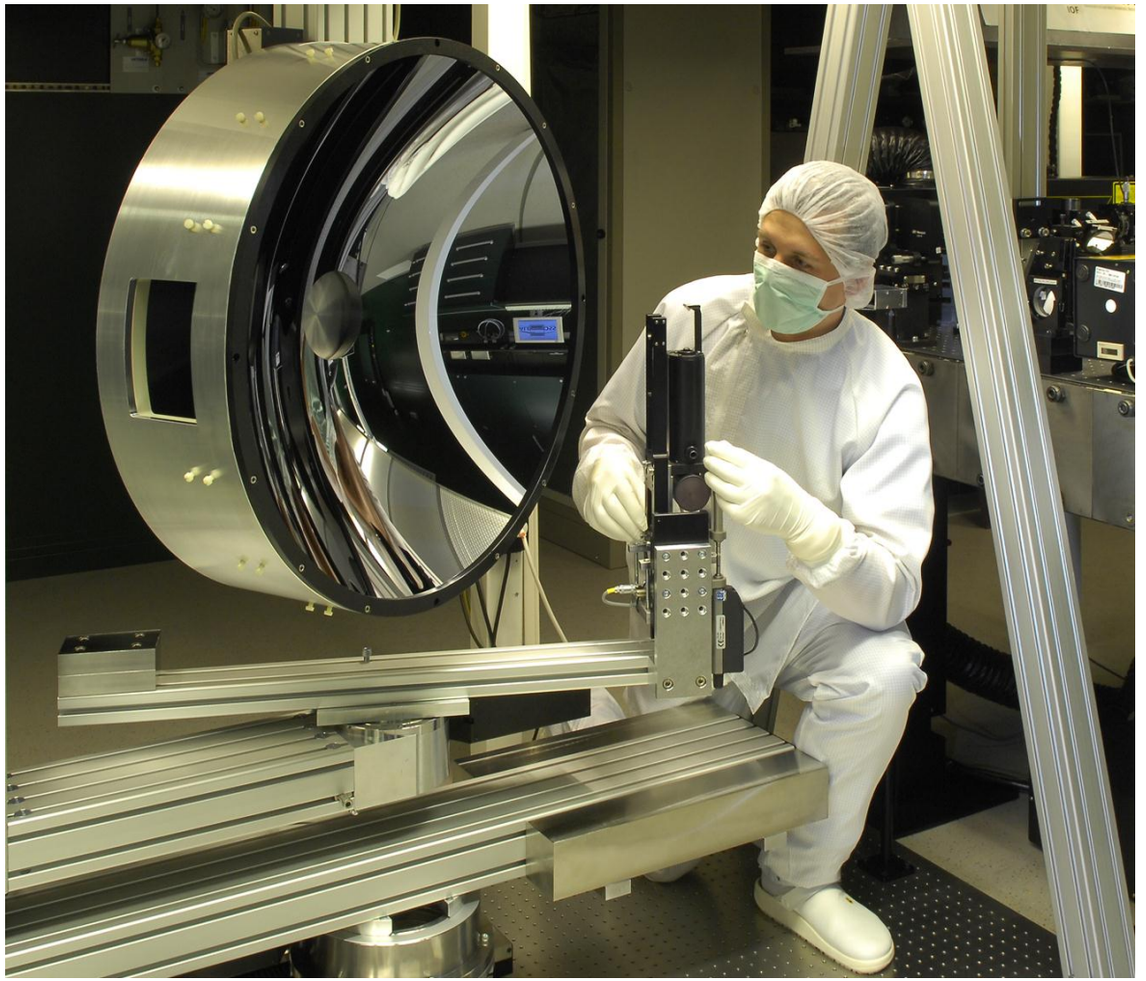
Surface characterization of EUV collector substrates

- No reliable roughness data available so far:
  - complex geometry
  - roughness < 0.2 nm
- Development of new surface characterization based on light scattering
- Light scattering:
  - fast
  - non-contact
  - comprehensive
  - high sensitivity



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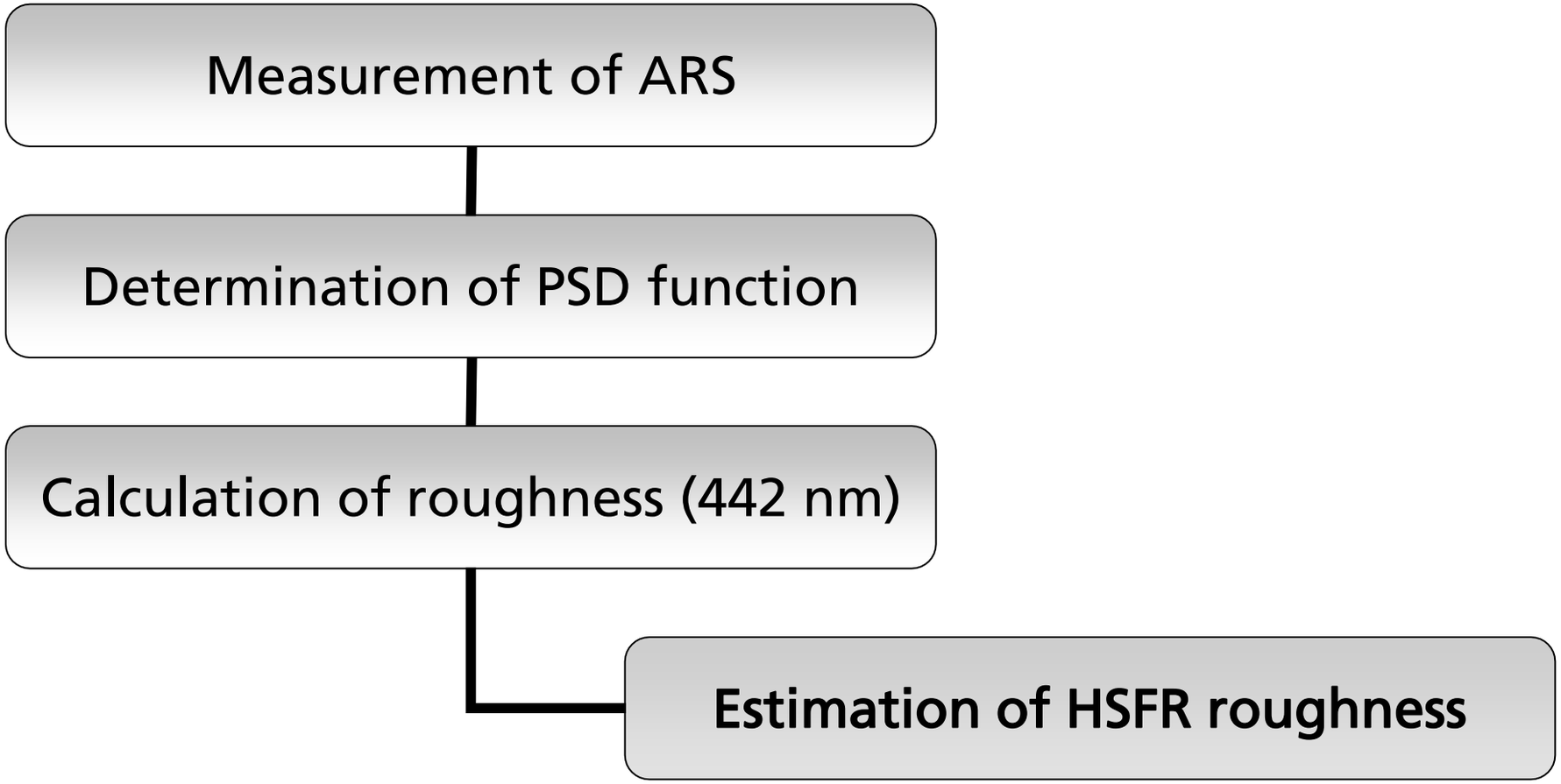
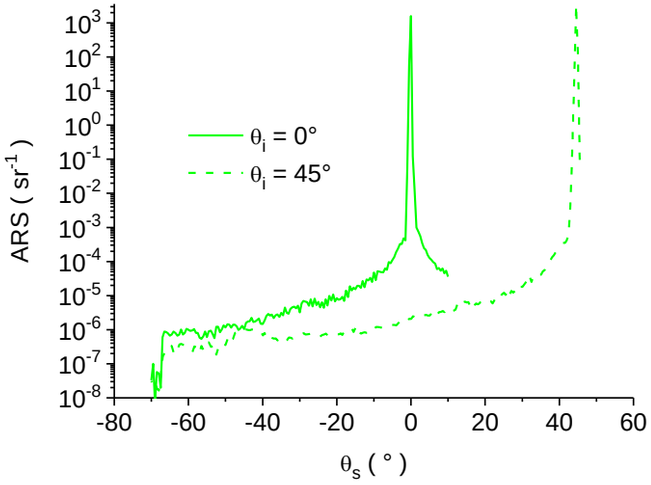
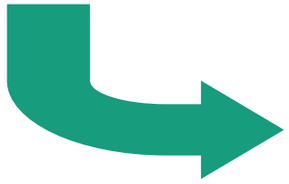
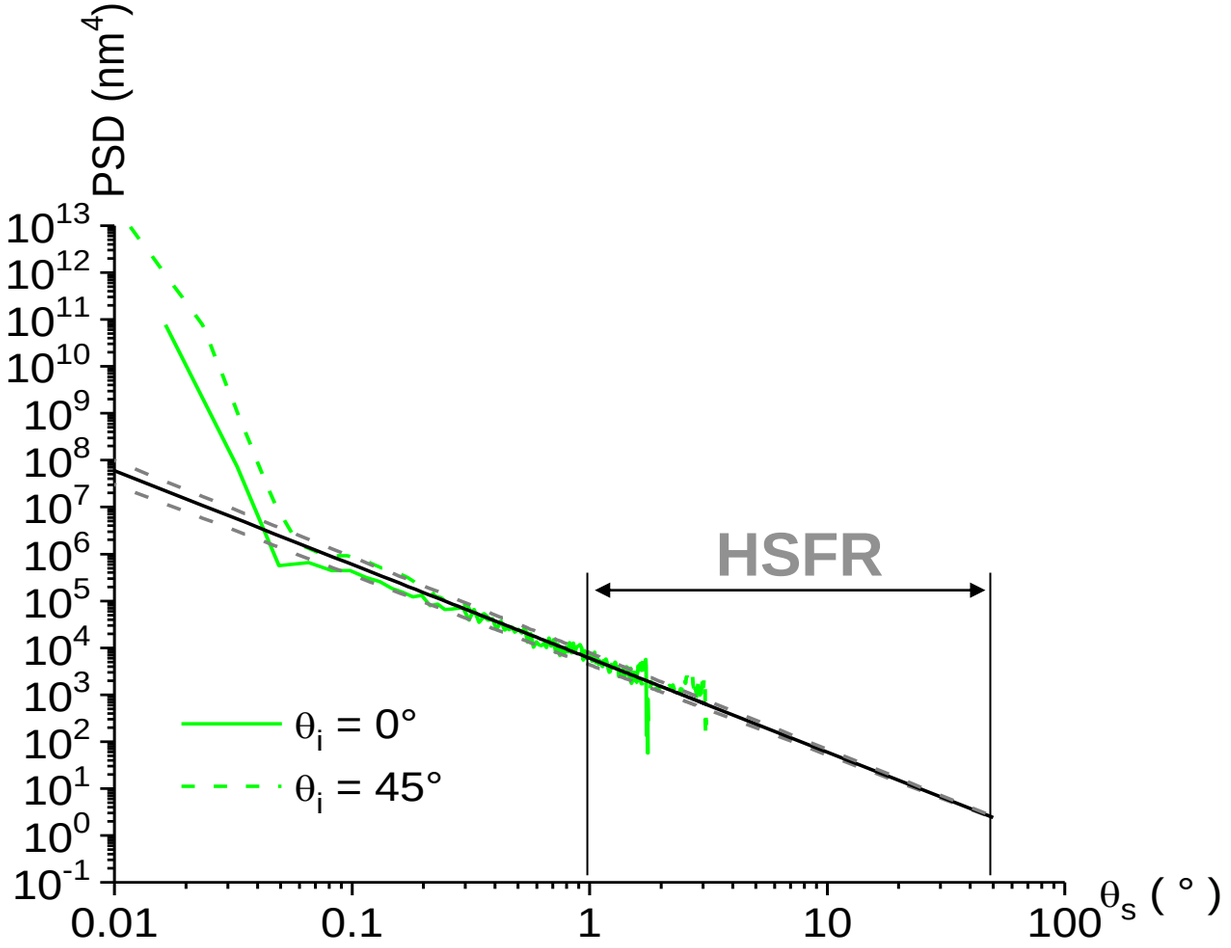
Surface characterization of EUV collector substrates



Measurement of ARS and determination of PSD function

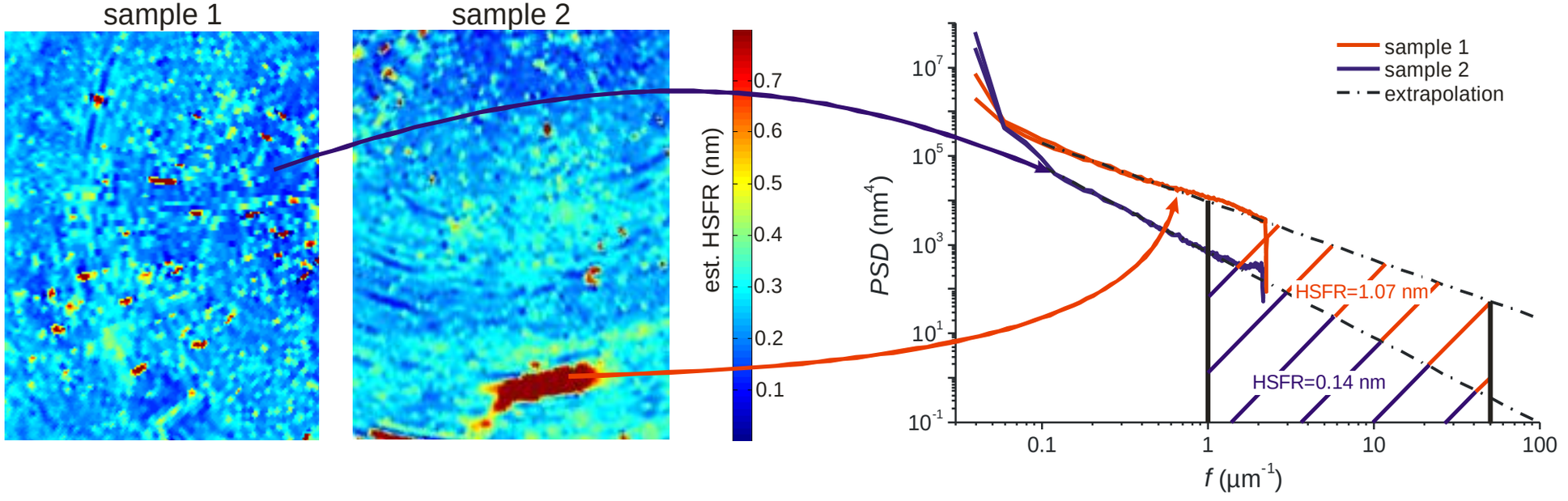






HSFR mapping retrieved from ARS measurements

PSD analysis



→ **Perfect fractal behavior at smooth and rough areas**

→ **Prediction of performance at 13.5 nm based on detailed roughness information (PSD, HSFR)**

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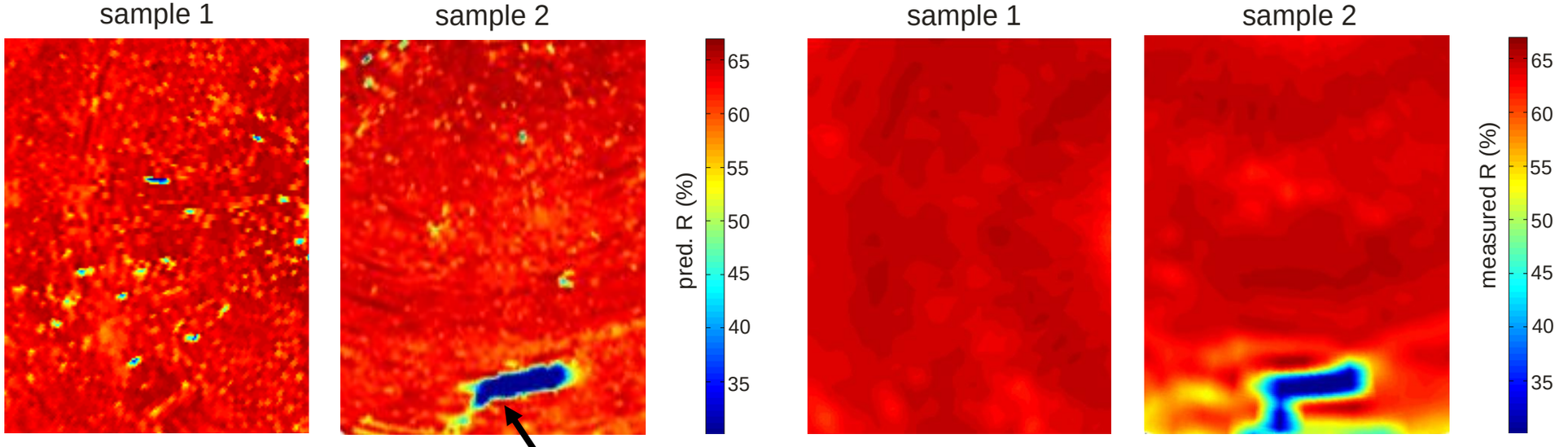
Prediction based on roughness data obtained from scattering (before coating)

Reflectance measurements at PTB, Berlin (after coating)

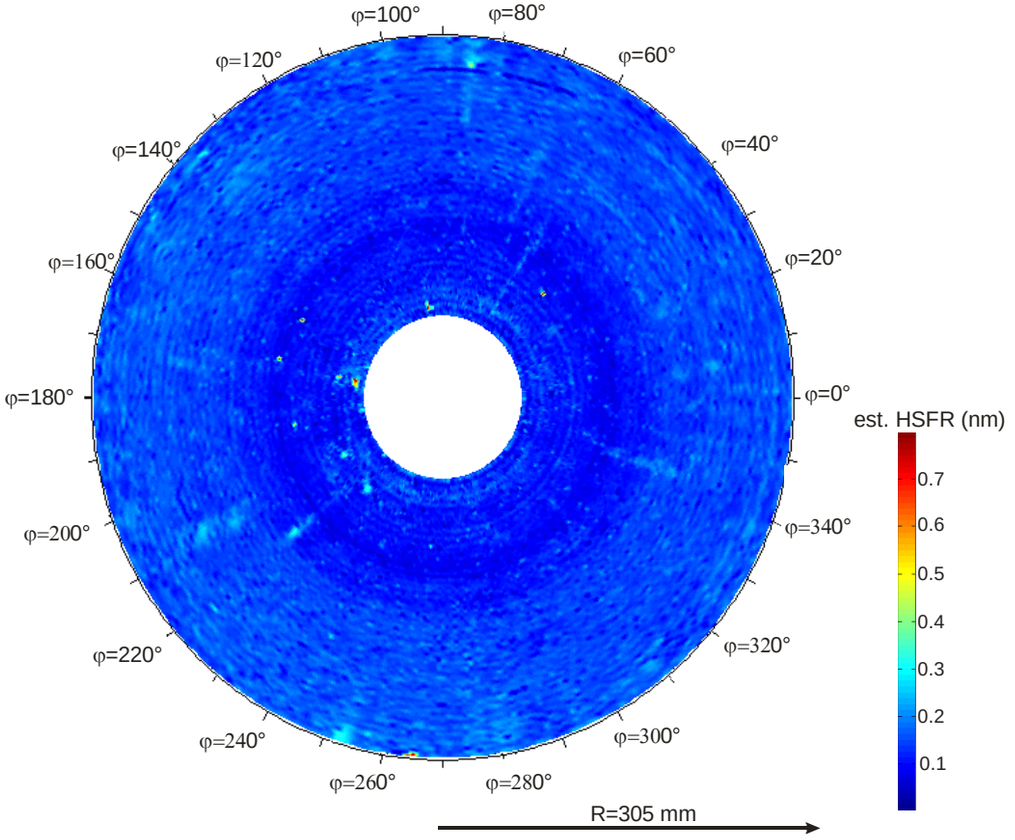


Reflectance drop > 45 %

→ **Good correlation between predicted and experimental data**

→ **Accuracy of average predicted reflectance: ΔR < 1%**

Optical performance of 5.5 sr LPP multilayer collectors



- **Fast data acquisition: mapping of entire sample surface (100% characterization)**
- **High sensitivity to roughness (average HSFR = 0.1 nm)**

→Thorough characterization of collector substrate before coating

→Check for homogeneity and defects

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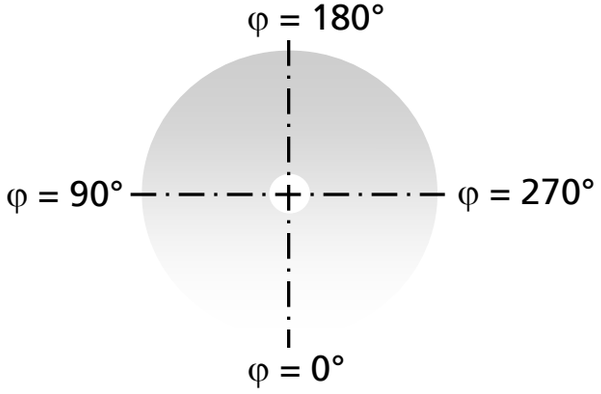
NESSY – ‚New' EUV Sputtering System

Design and realization of an EUV sputtering system

Conception:

- magnetron sputtering of rotating and fast spinning substrates **up to Ø 665 mm**
- four deposition targets
- deposition of graded multilayers on curved substrates

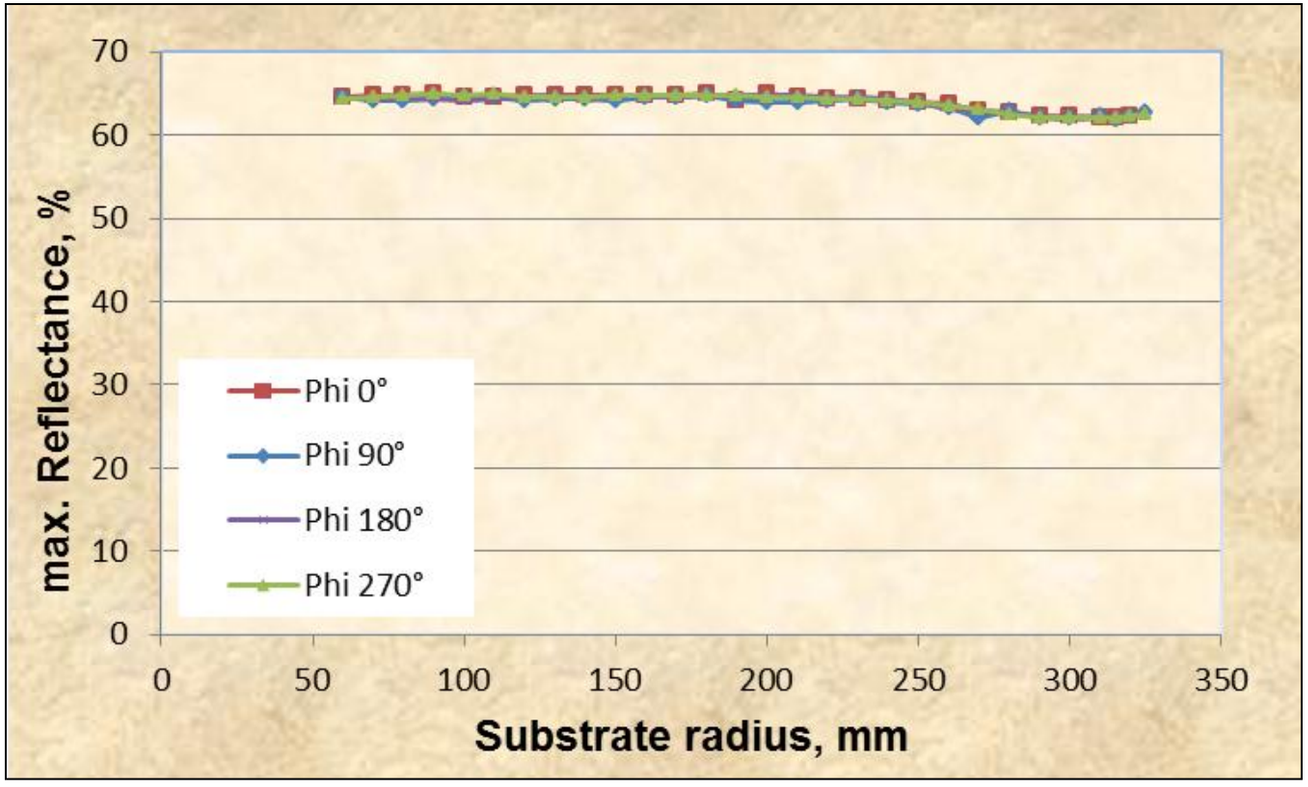
Reflectivity of LPP collector mirror



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

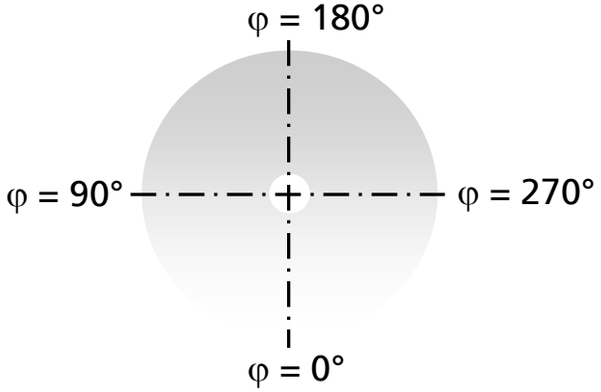
R ~ 65% @ r < 240 mm

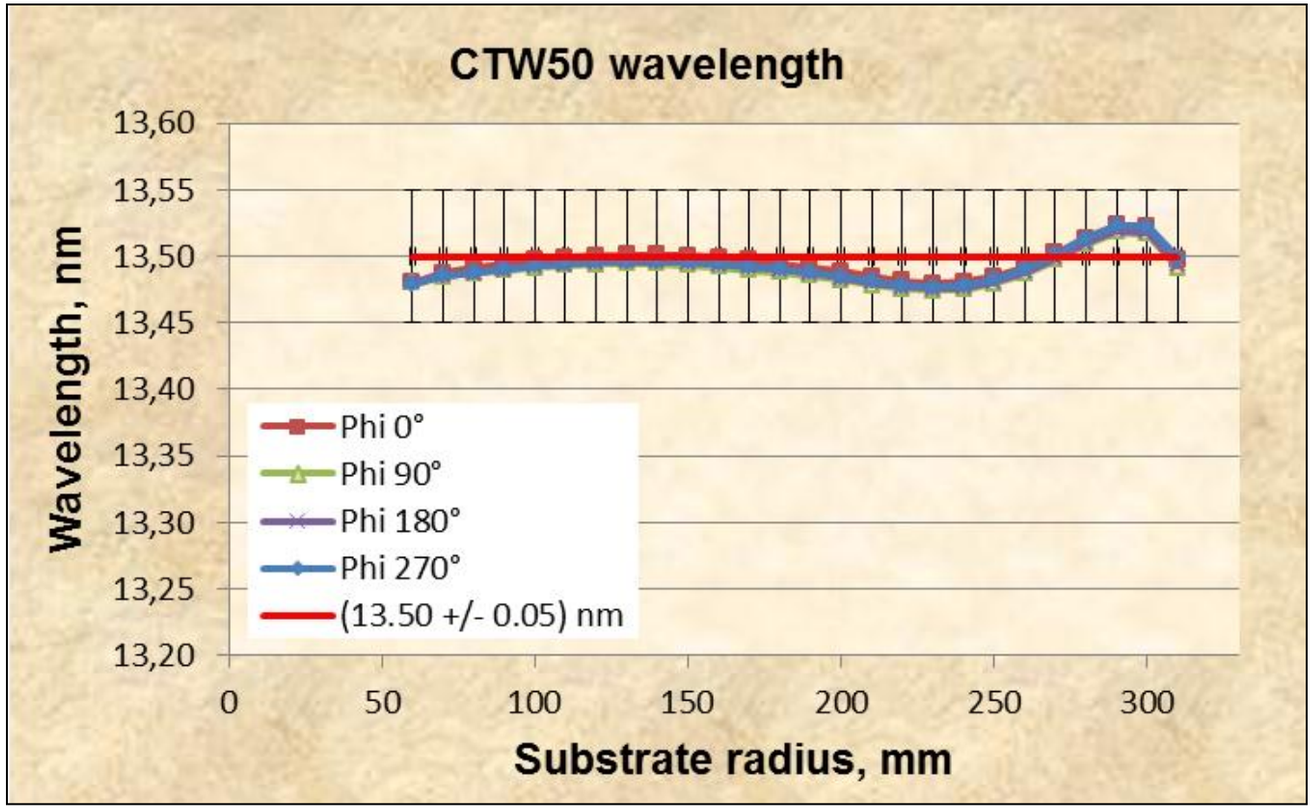
R ~ 62% @ r = 250 … 320 mm



Measurements: PTB Berlin

Reflectivity of LPP collector mirror





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

$\lambda = (13.50 \pm 0.03)$ nm

Measurements: PTB Berlin

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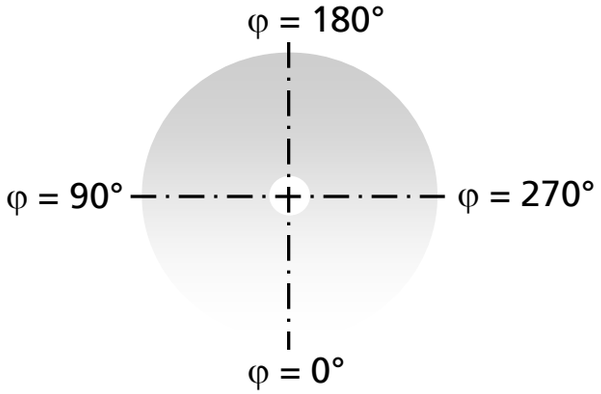
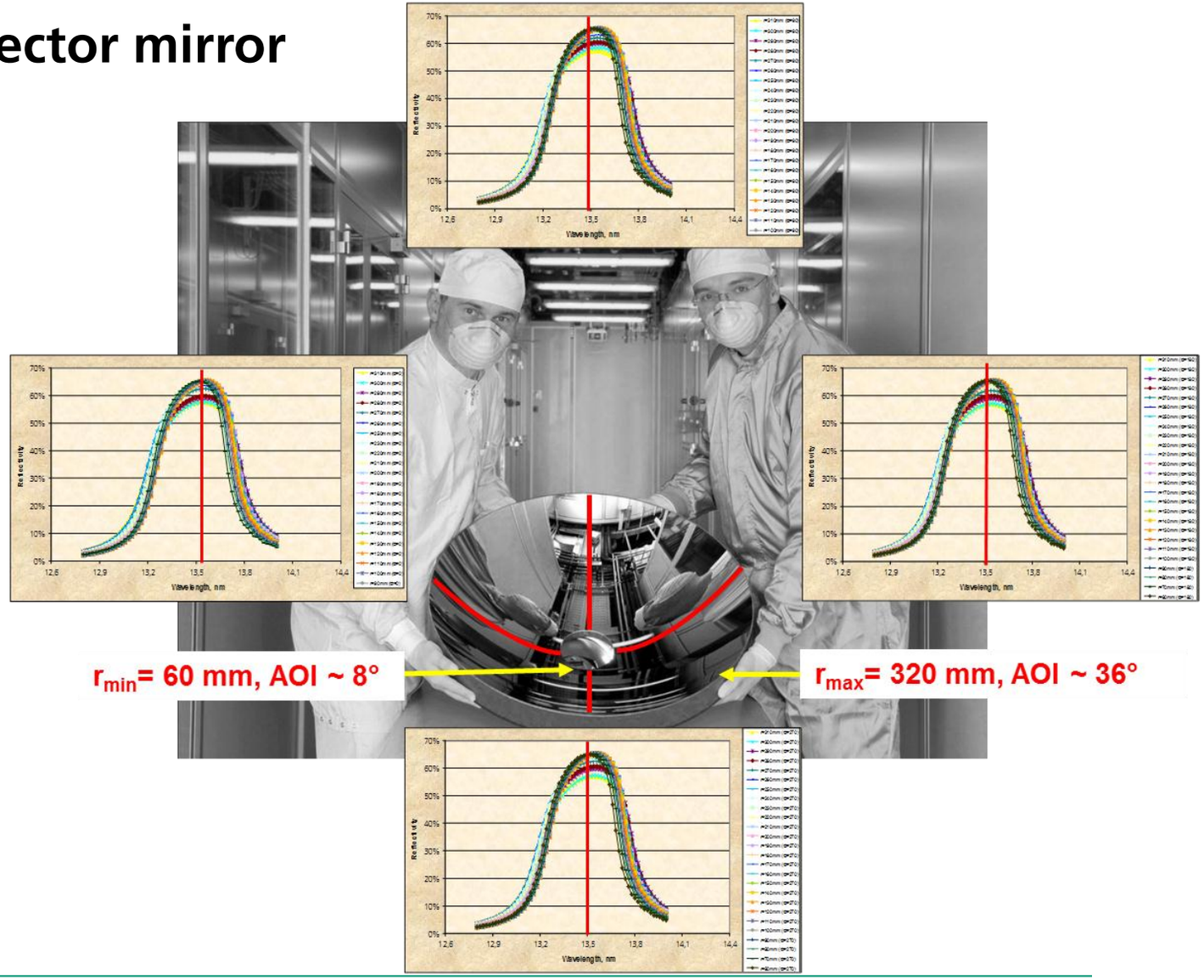
Reflectivity of LPP collector mirror



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

108 measurement curves

Measurements: PTB Berlin



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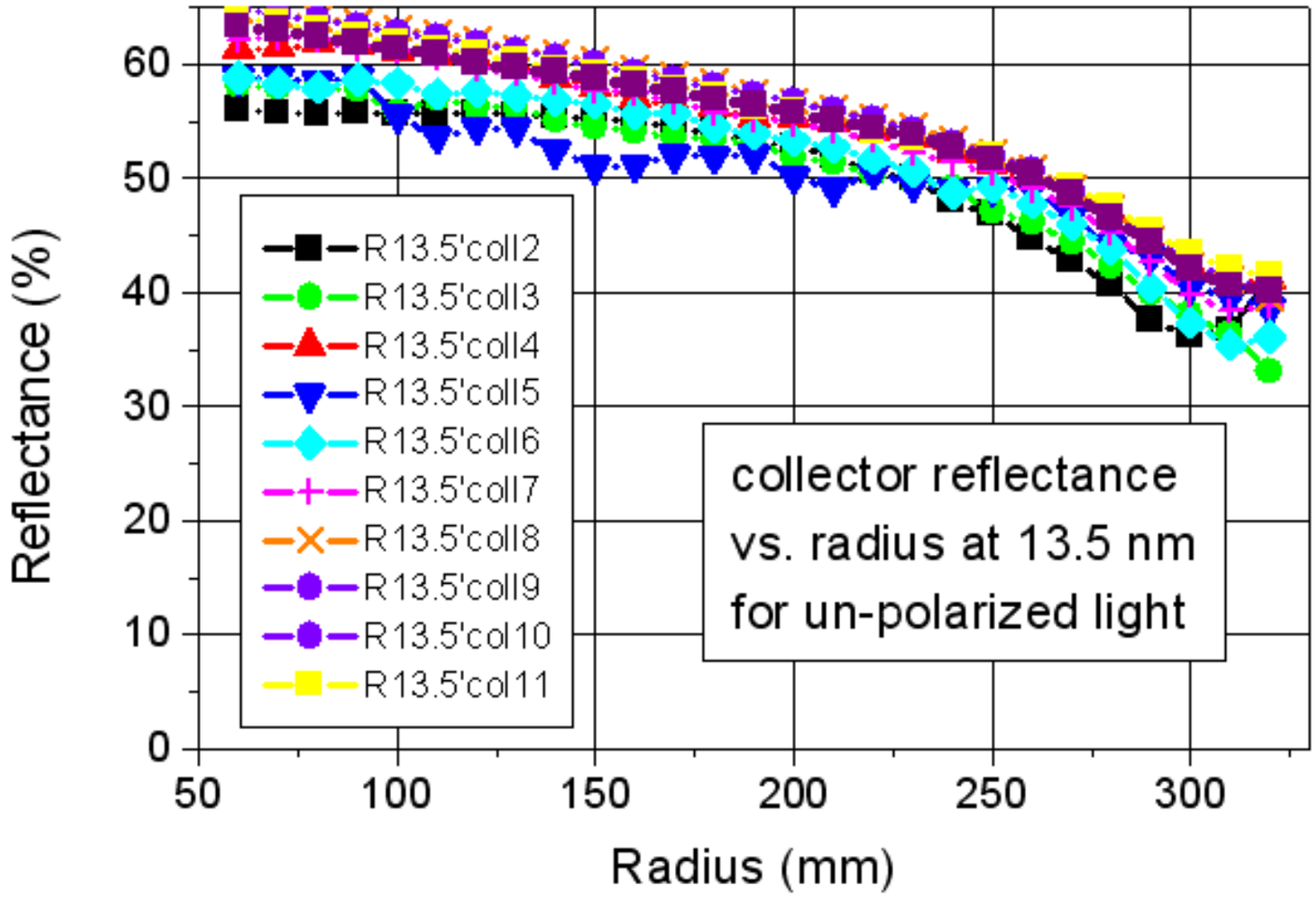
Reflectivity of LPP collector mirrors … climbing the learning curve



52.2 % average area-weighed reflectance reached at 13.5 nm

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Summary

- Characterization of EUV collector optics:
  - light scattering technique for HSFR substrate characterization

- Multilayer coating of EUV collector optics:
  - R > 65 % and d-spacing accuracy of $\Delta d < 15$ pm
    on world's largest EUV multilayer mirror (Ø > 660 mm)

Acknowledgements

- **Cymer for LPP source development:**
  Norbert Böwering, Kevin Cumming, Bruno La Fontaine, David Brandt, Igor Fomenkov, Alex Ershov, Kay Hoffmann and many others

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Thank you!