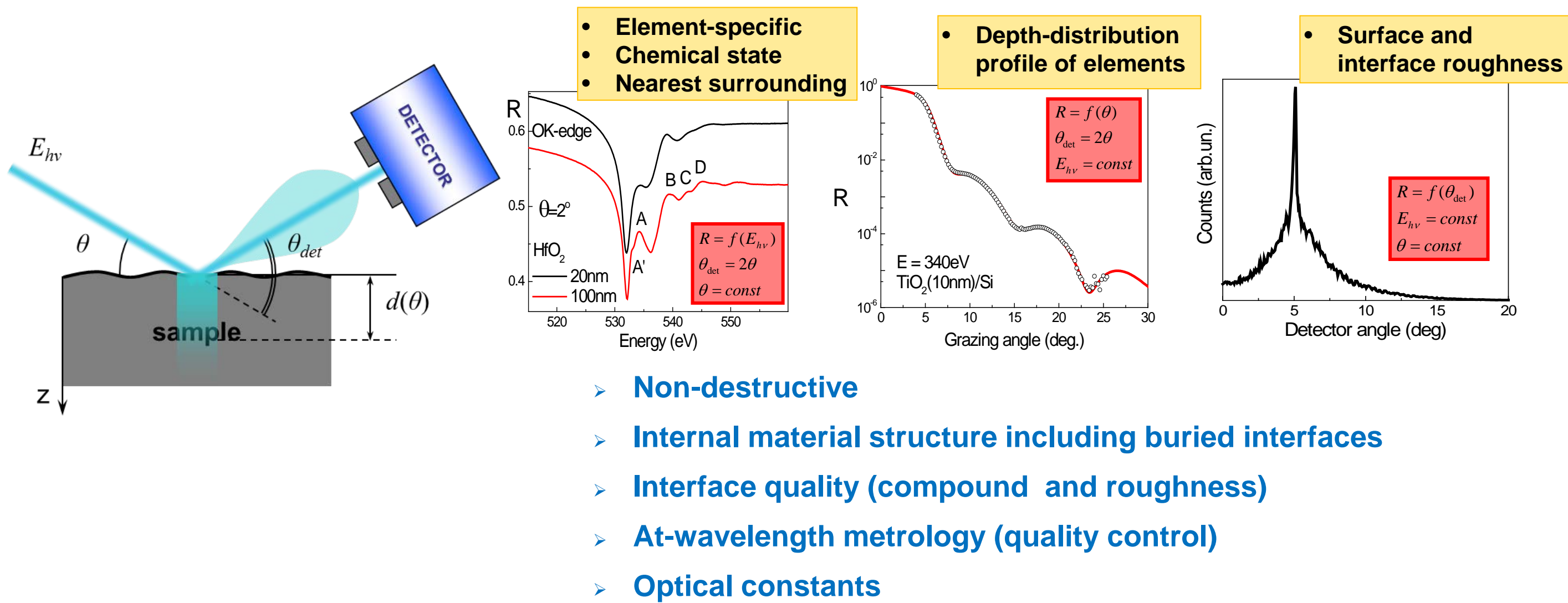


The At-Wavelength Metrology facility for UV- and XUV reflection and diffraction optics

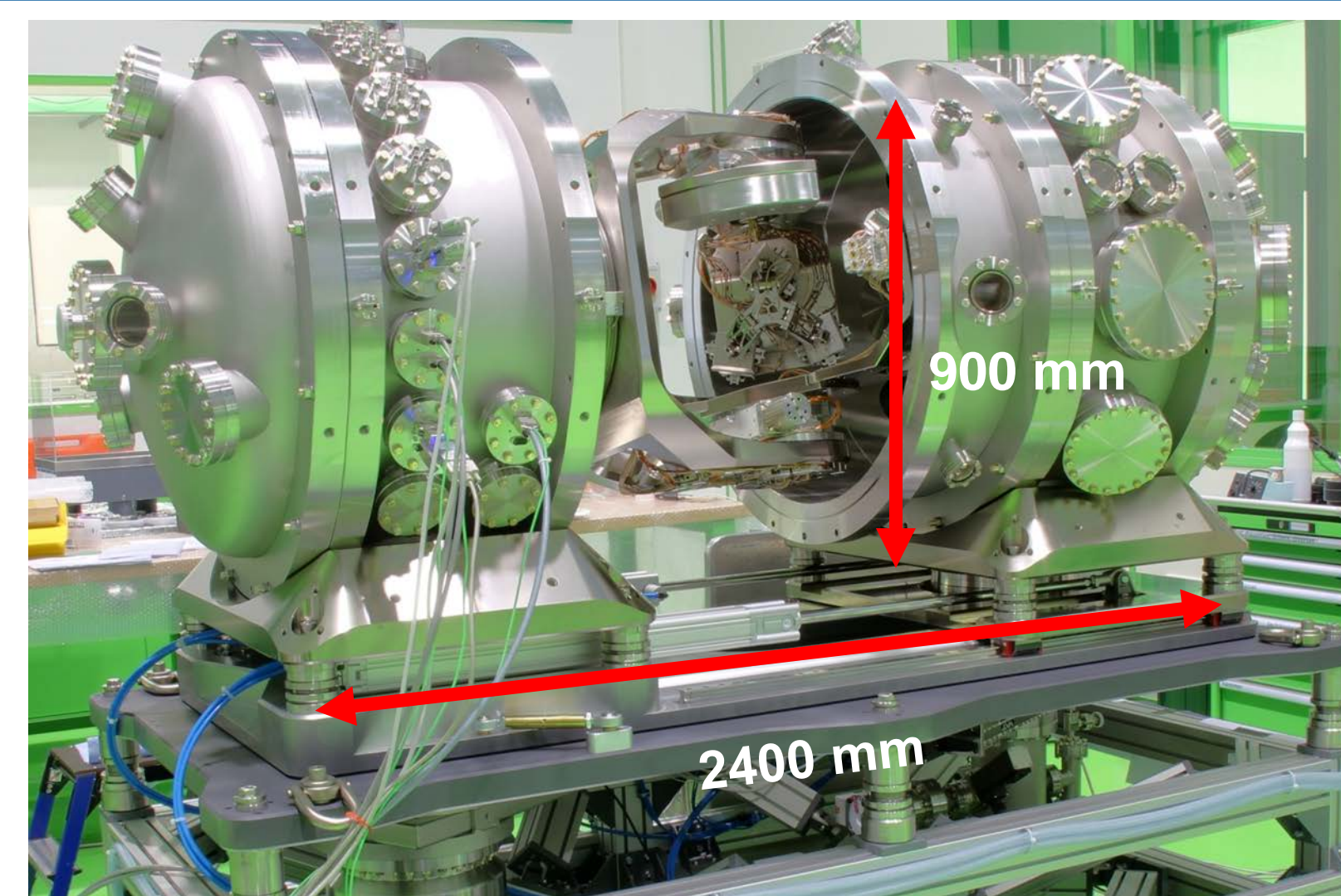
F. Schäfers, F. Eggenstein, F. Senf, A. Sokolov
Institute for Nanometre Optics and Technology / BESSY II

Research with Reflectometry

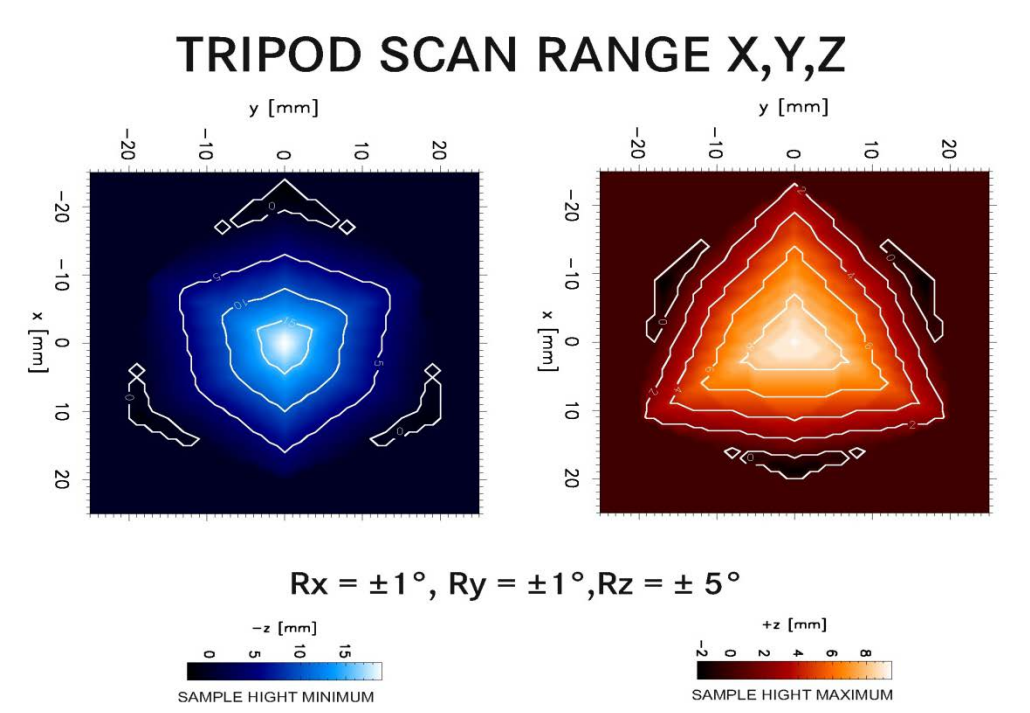
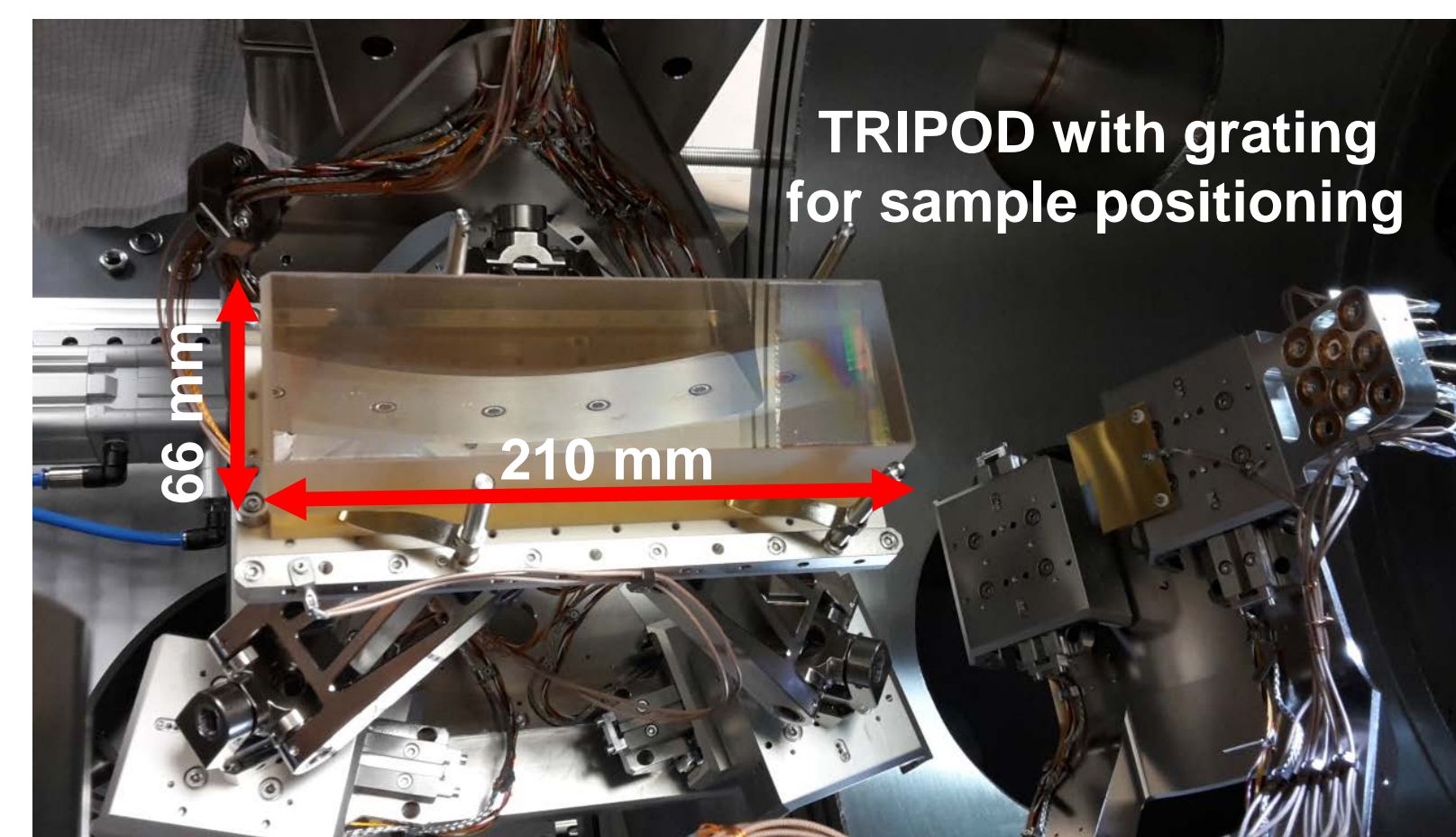
Reflectometry - a powerful technique



11-axes UHV-Reflectometer



- Clean room surrounding
- UHV-tube volume 2 m³
- Chamber weight 2.1 tons
- 2000 l/s Turbomolecular pump
- LN₂ cold trap, Ti-Suppl. Pump
- Base pressure <5x10⁻⁹ mbar
- Pneumatic drive for chamber opening
- Renishaw encoders at all axes
- Measurements of R_s and R_p
- Samples electrically isolated
- Sample weight: 4 kg
- Sample size: 300 x 60 x 60 mm³
- Load-lock in preparation



Axis	Hardware	Range	Pos. accuracy
Azimuth angle Φ	HUBER 430	-180° - 180°	3.6"
Sample angle θ	HUBER 411	-90° - 270°	3.6"
Detector angle 2θ	HUBER 411	-180° - 180°	3.6"
Detector off-plane (2 axes)	Ceramic motors	-25 mm - 25 mm (-4° - 4°)	50 nm
Sample Adjustment Tx, Ty, Tz	Ceramic motors	-20 mm - 20 mm (not simul.)	500 nm
Sample Adjustment Rx, Ry, Rz	Ceramic motors	-10° - 10° (not simul.)	1"

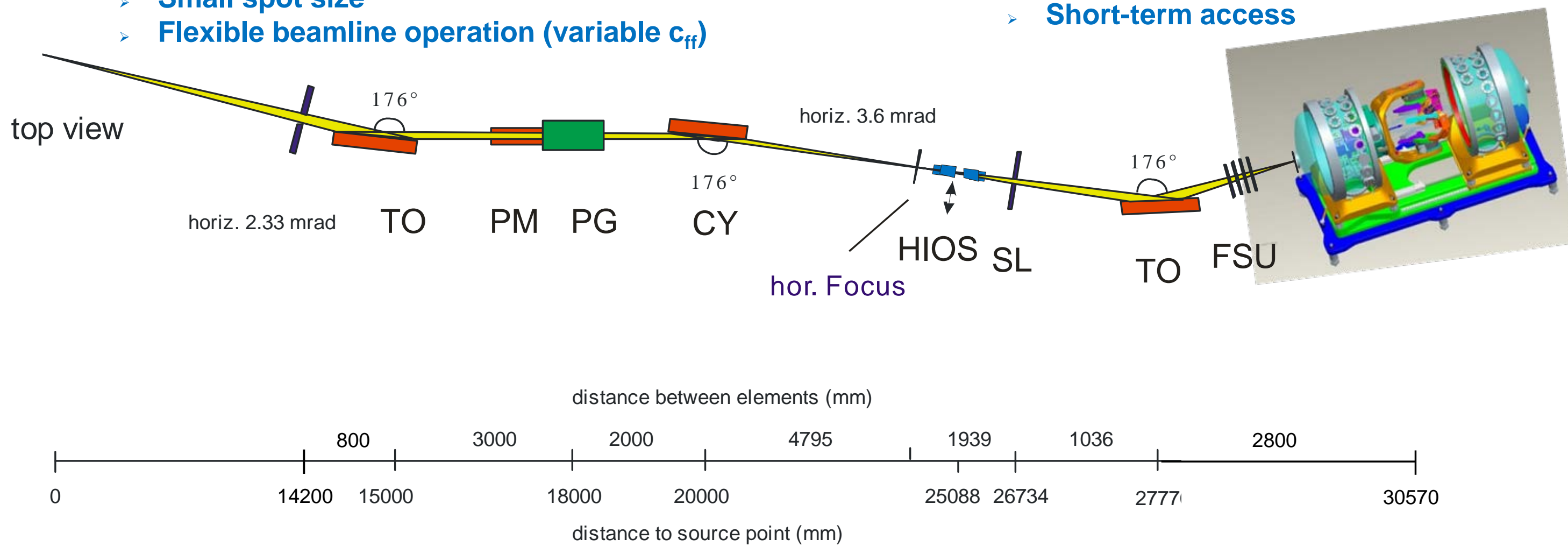
Optics Beamline

Collimated c-PGM

- 10 - 2000 eV
- Moderate resolution 5.000 (@400 eV)
- Polarization linear / elliptical
- Higher order suppression
- Low divergence
- Small spot size
- Flexible beamline operation (variable c₁₁)

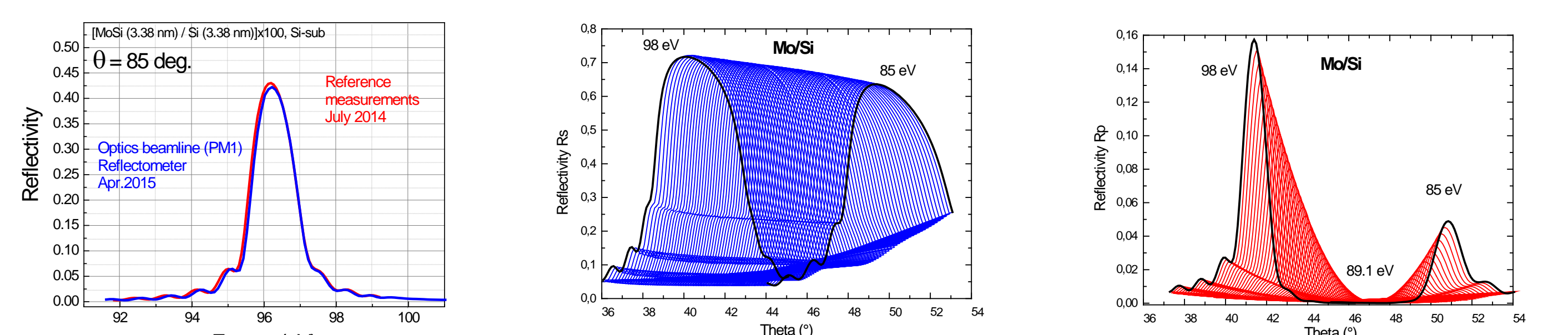
Reflectometry

- At-wavelength metrology
- Quality control
- In-house R&D
- User operation
- Short-term access

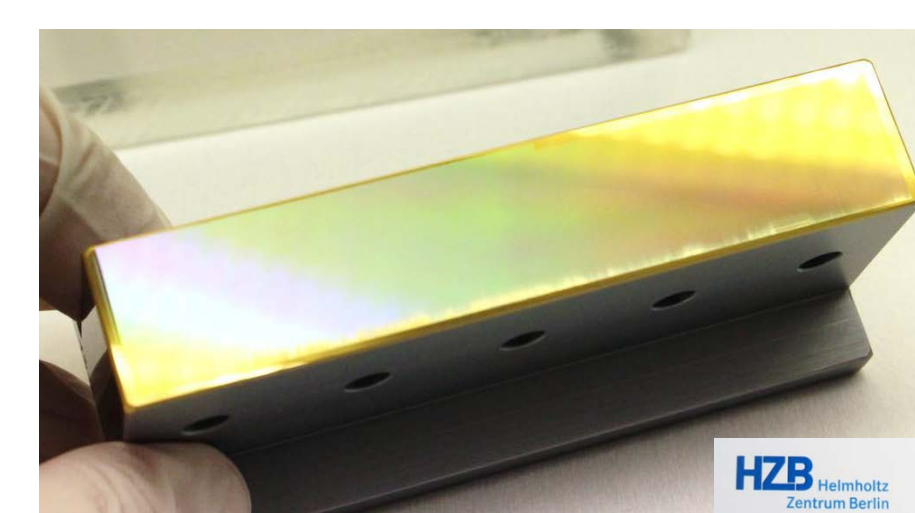


At-Wavelength Metrology

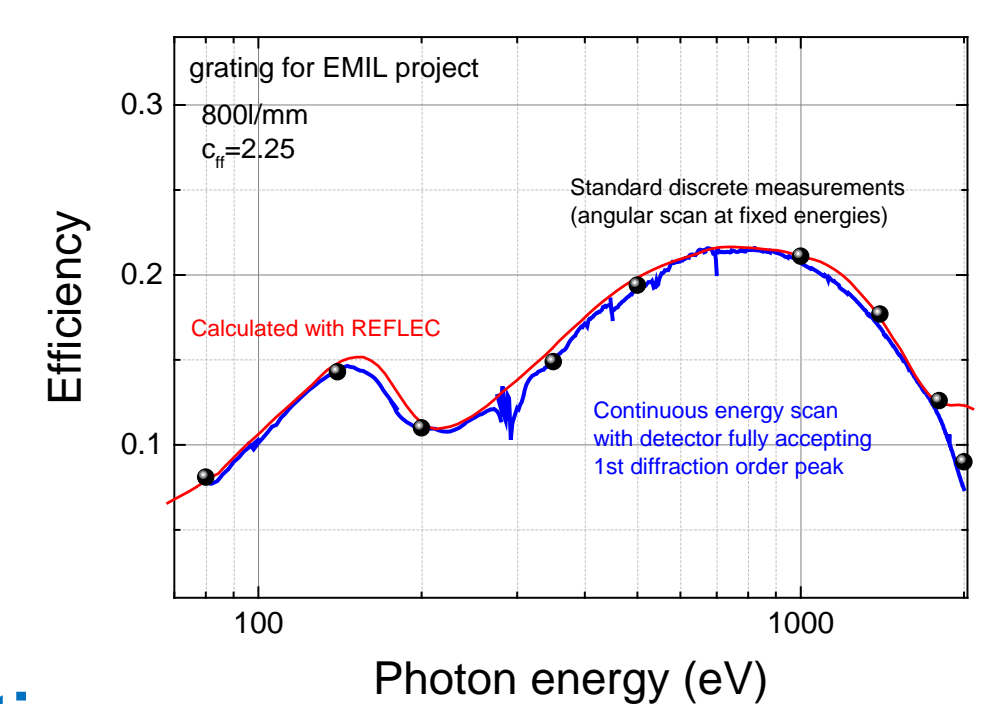
Metrology on Multilayers



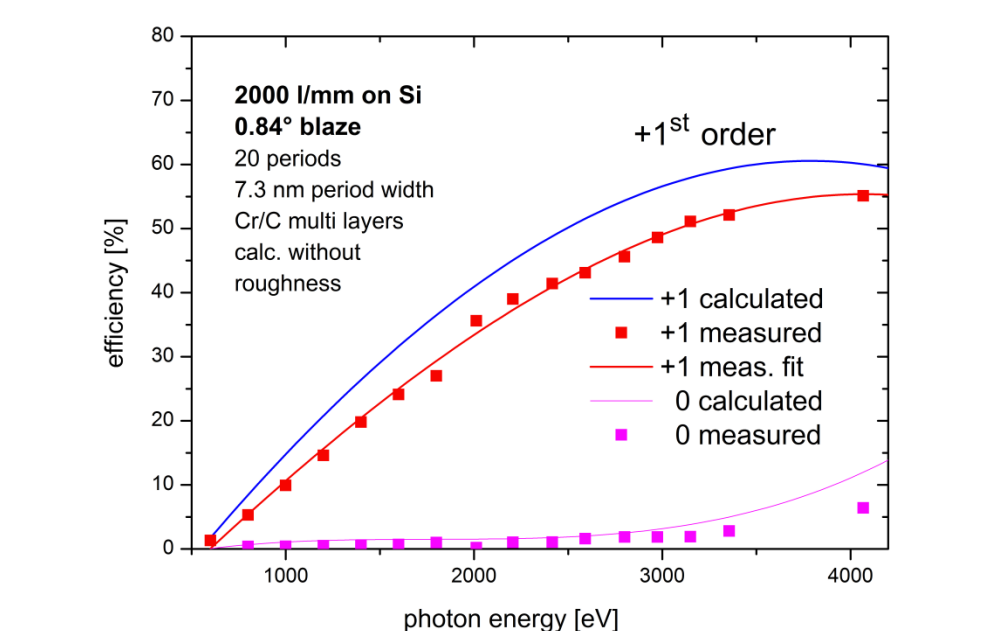
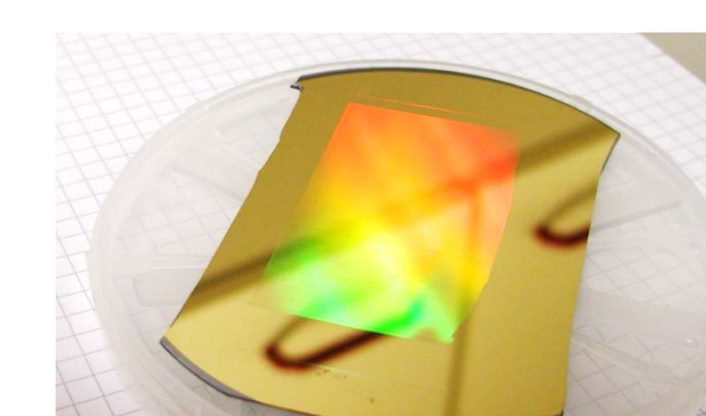
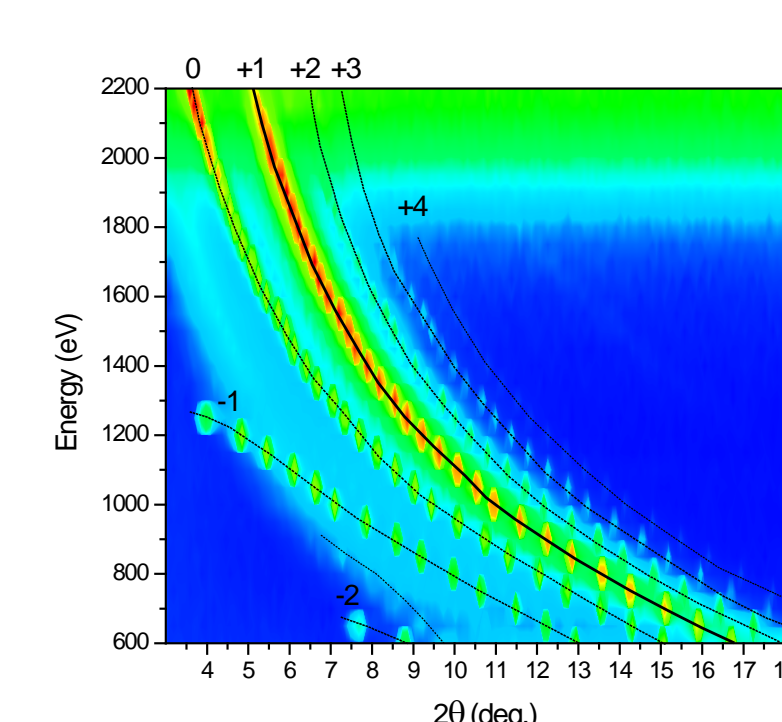
Metrology on blazed gratings



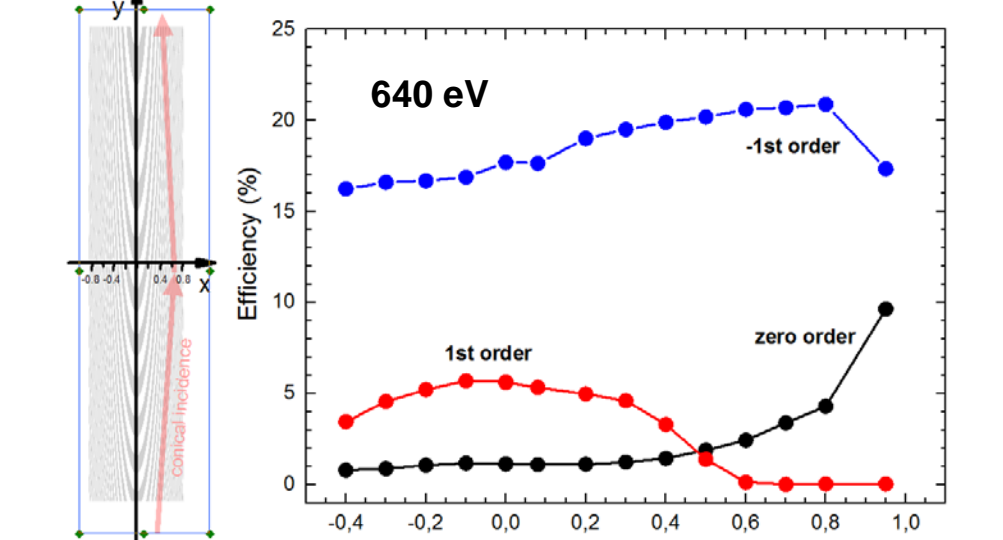
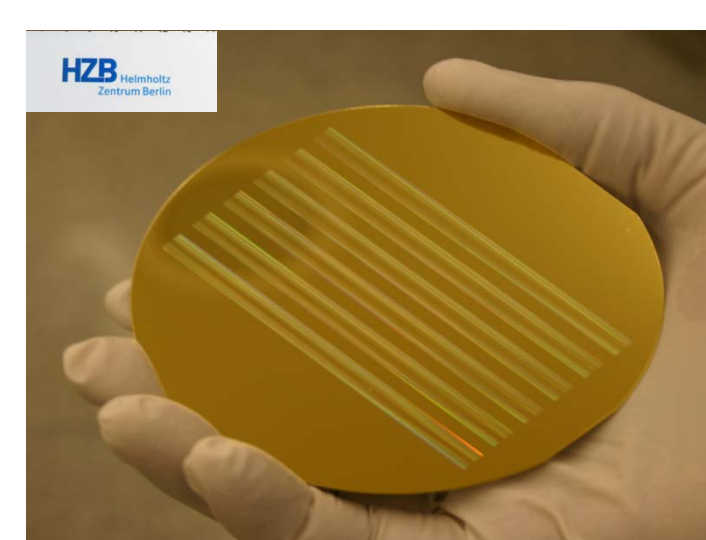
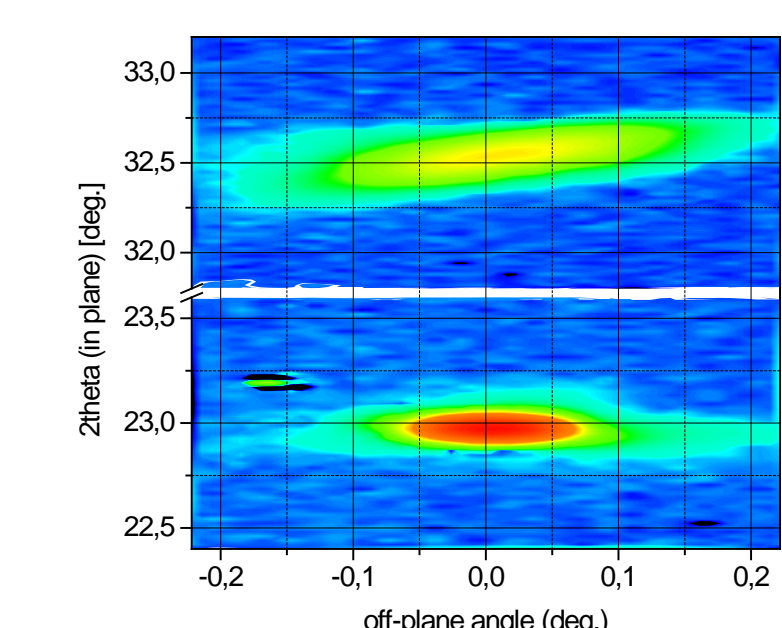
- Grating for EML@BESSY-II
- 800 l/mm
- blaze angle: 0.91°
- antiblaze: 174°
- Au (30 nm)
- roughness 0.22 nm



Metrology on blazed multilayer gratings

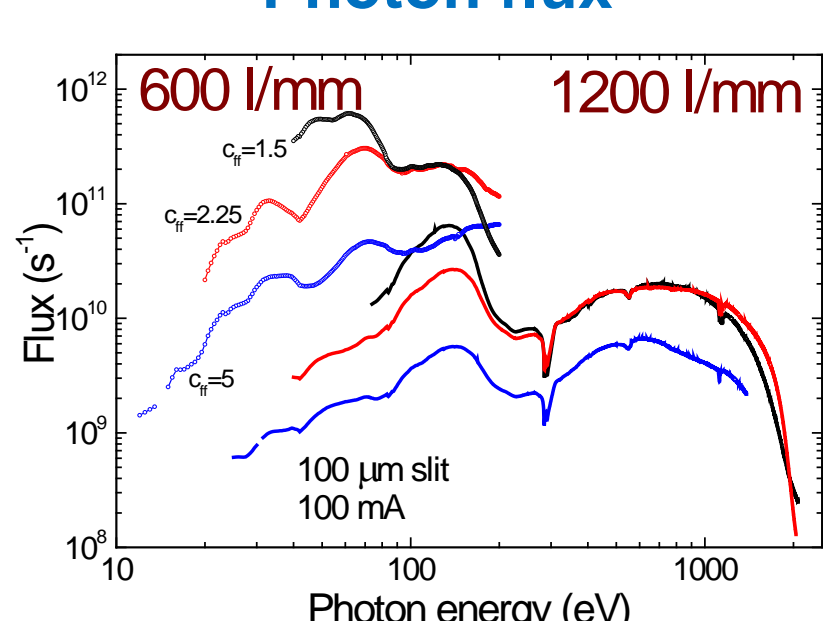


Metrology on Reflection Zone Plates

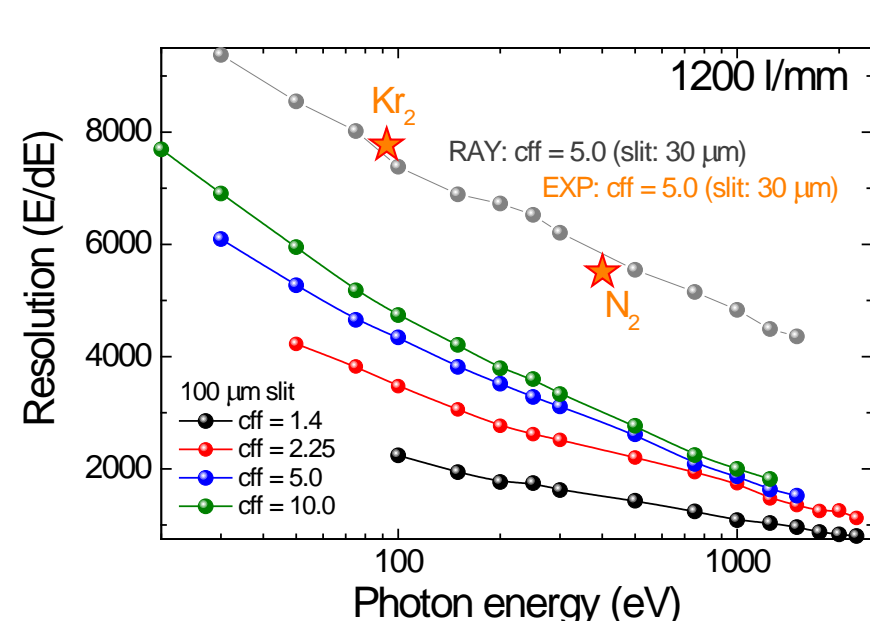


Performance

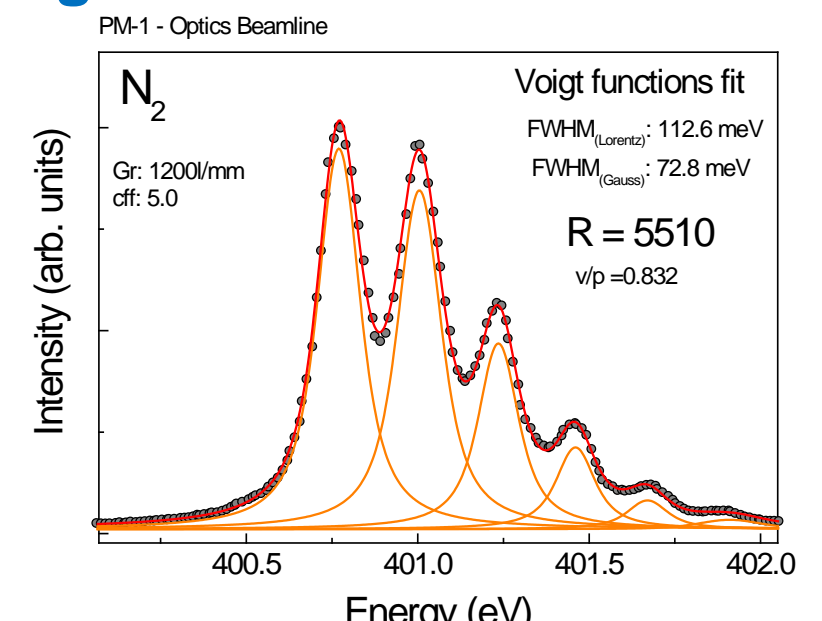
Photon flux



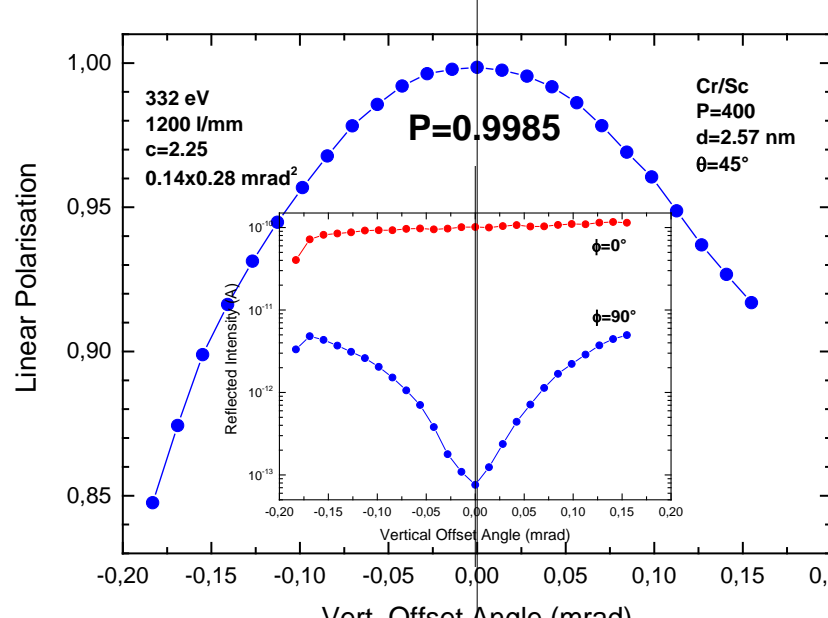
Beamline



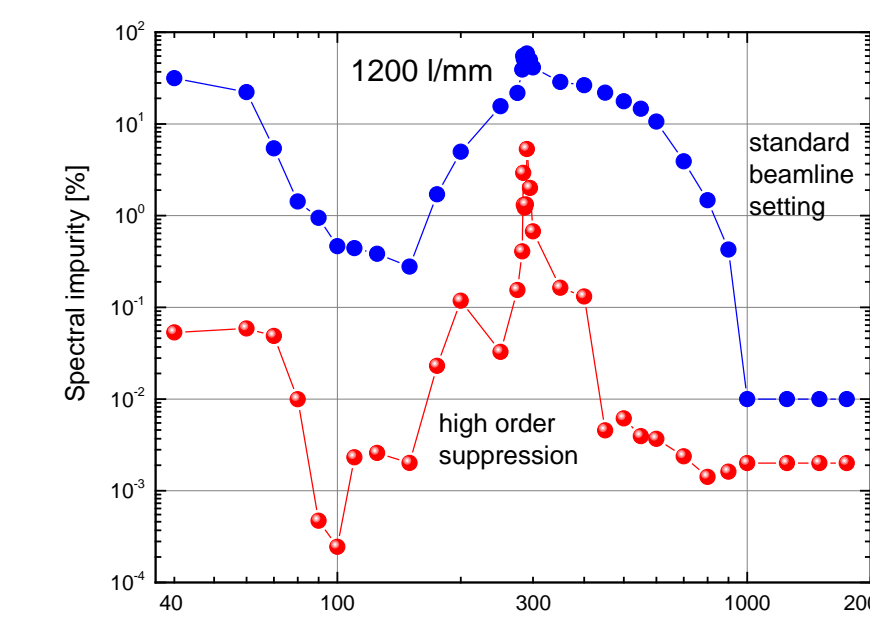
Resolving Power



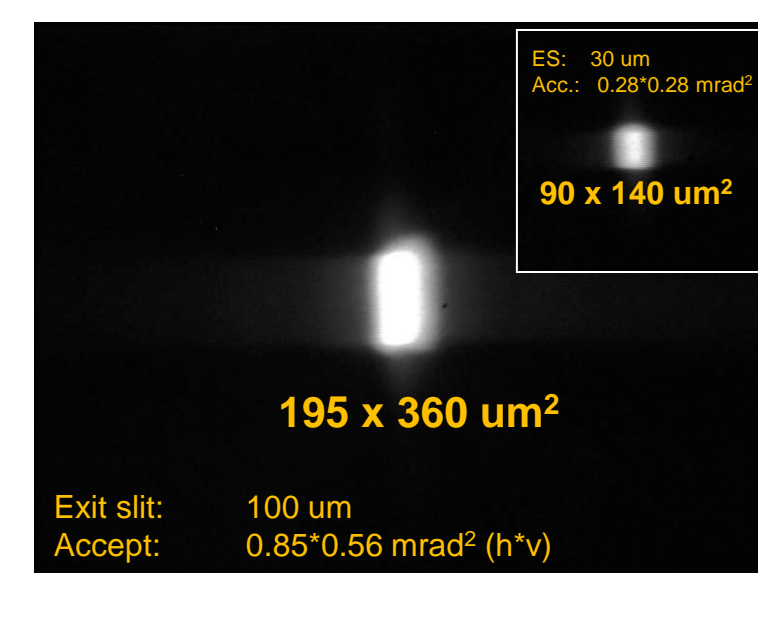
Polarisation



Spectral impurity

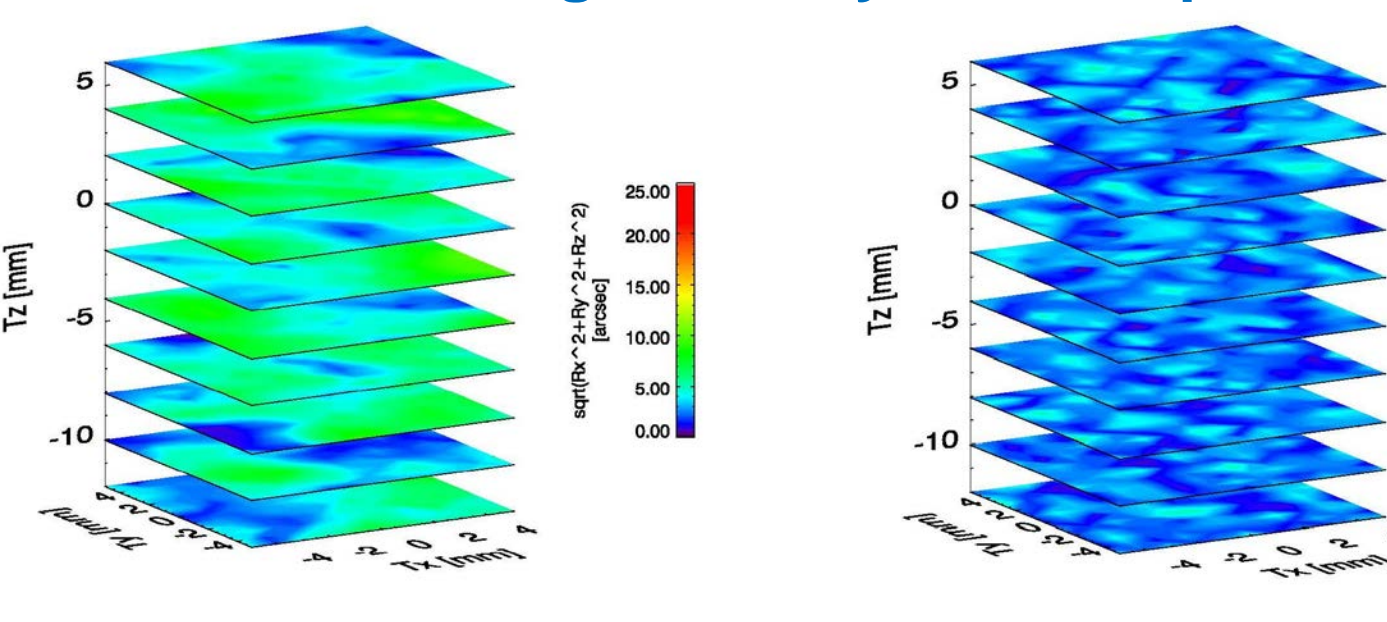


Focus Size

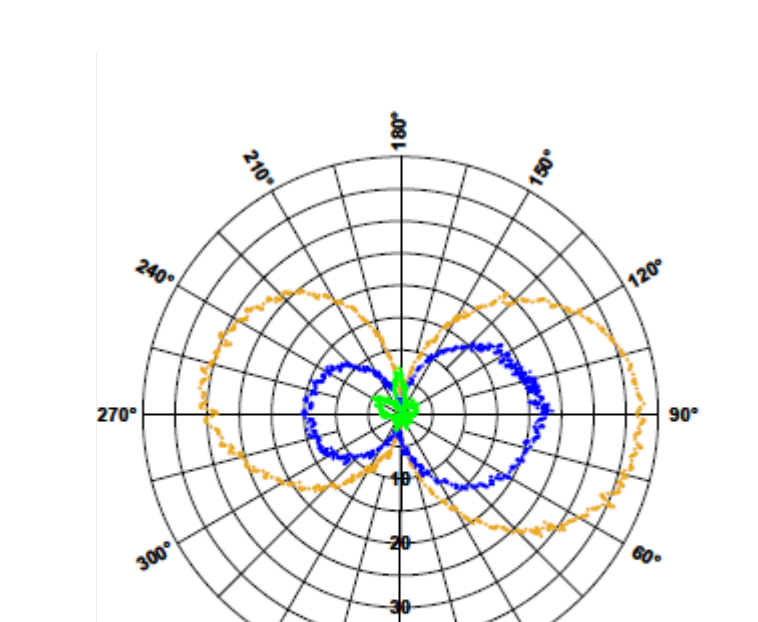


Reflectometer

Positioning accuracy of the Tripod



Autocollimation of Φ -stage



Axis 1	Axis 2	Tilt (°)	Distance (mm)
θ	20	179.979°	0.014
θ	Φ	90.025°	0.049
20	Φ	89.994°	0.057

Sample pointing stability: 50 μ m / 0.025°

Conclusions

- At-Wavelength metrology: powerful, indispensable tool for development, characterization and final control of UV/XUV optical elements
- At-Wavelength performance cannot be obtained by any other method
- HZB grating fabrication facility is well established now
- Attractive UV/XUV experimental beamline setup at BESSY-II operational
- Metrology on large-scale samples with versatile 11-axes UHV-reflectometer operational
- Ellipsometry, polarimetry possible with elliptically polarised bending magnet radiation
- Short-term access at 24 h / 7 d operation
- Open for user operation

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 [9] F. Senf et al., Highly efficient blazed grating with multilayer coating for tender X-ray energies, Optics Express 24(12), 13220-13230 (2016)