

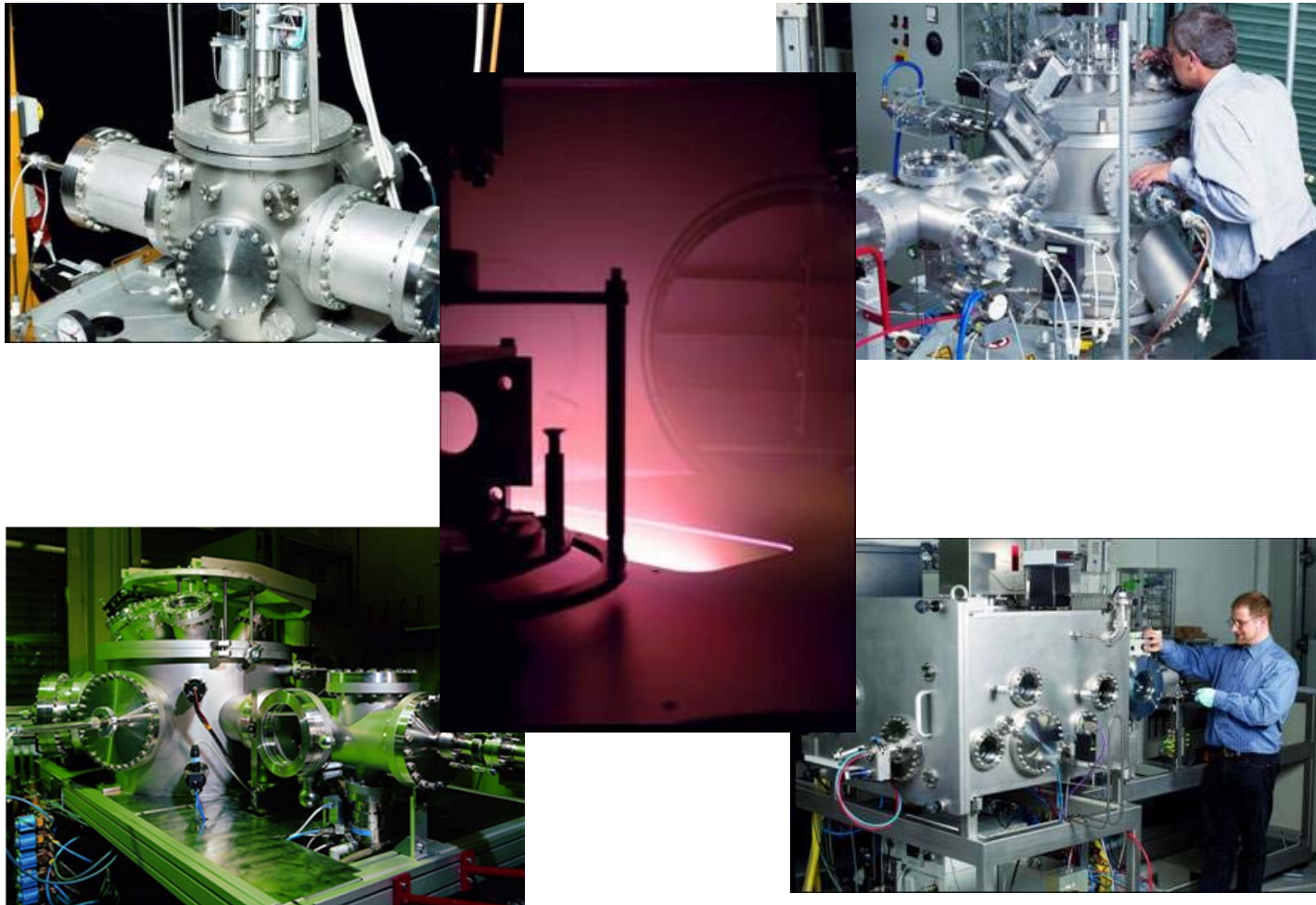
Thin film based optical elements for analytical X-ray applications

APPEC Technology Forum 2017



Jörg Wiesmann – Managing Director

Incoatec: Innovative Coating Technologies



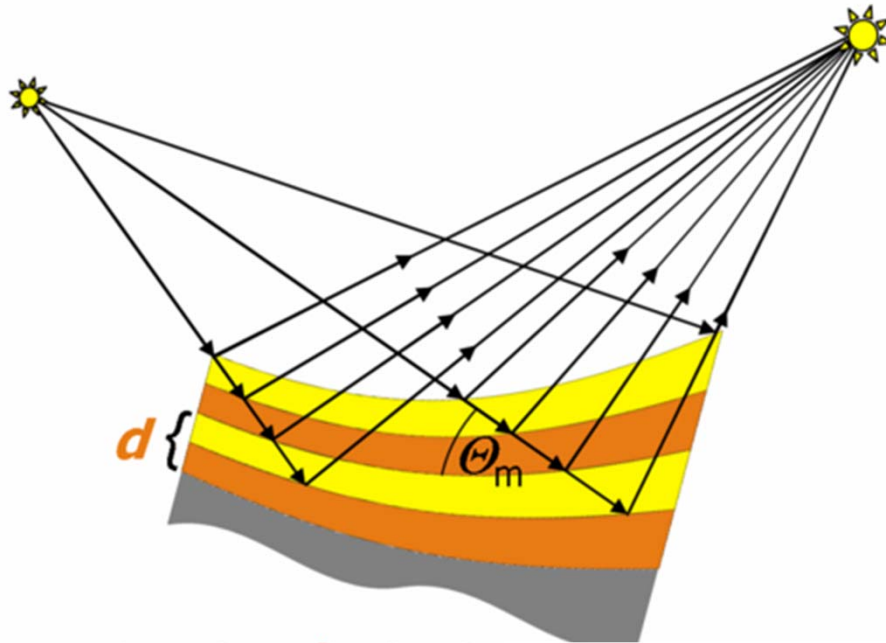


- Founded 2002 as joint venture with Bruker AXS, located in Geesthacht (near Hamburg)
- Located in the GITZ, new 4.100 sqm building
- Production & development of X-ray optics and microfocus sources
- Equipment for home-lab instruments and synchrotron beamlines



X-ray Optics

Key know-how: Multilayer X-ray Optics



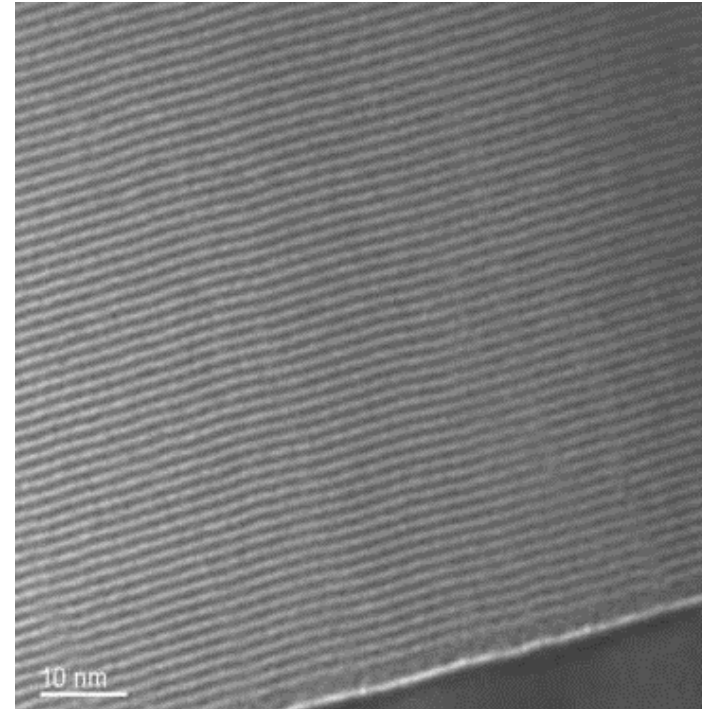
$$m \cdot \lambda = 2 \cdot d \cdot \sin \Theta$$

$$d = 2 - 6 \text{ nm}$$

$$\theta_m \approx 1.0^\circ \text{ (Cu-K}_\alpha, 8 \text{ keV)}$$

$$\theta_m \approx 0.5^\circ \text{ (Mo-K}_\alpha, 17.5 \text{ keV)}$$

Multilayers act as Bragg reflector



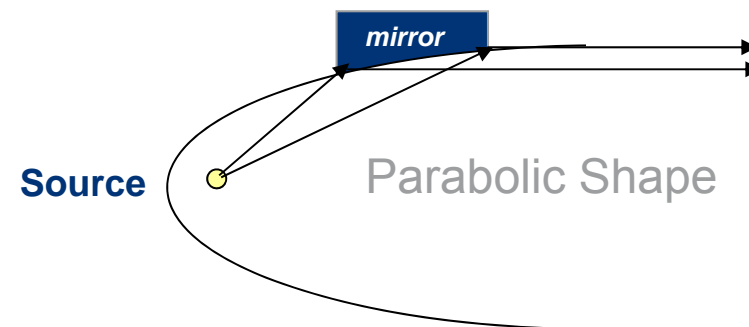
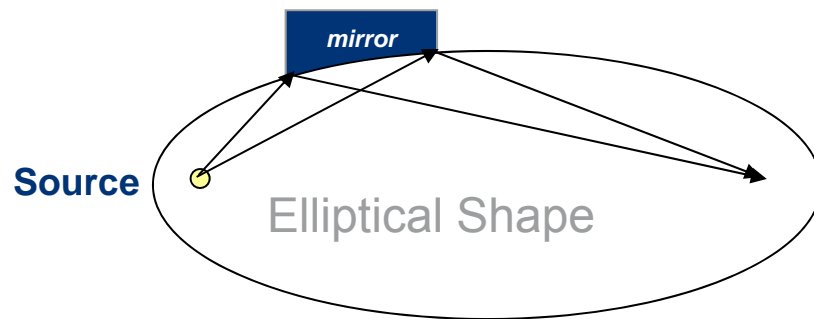
W/C Multilayer (TEM, Uni Kiel, Prof. Jäger)

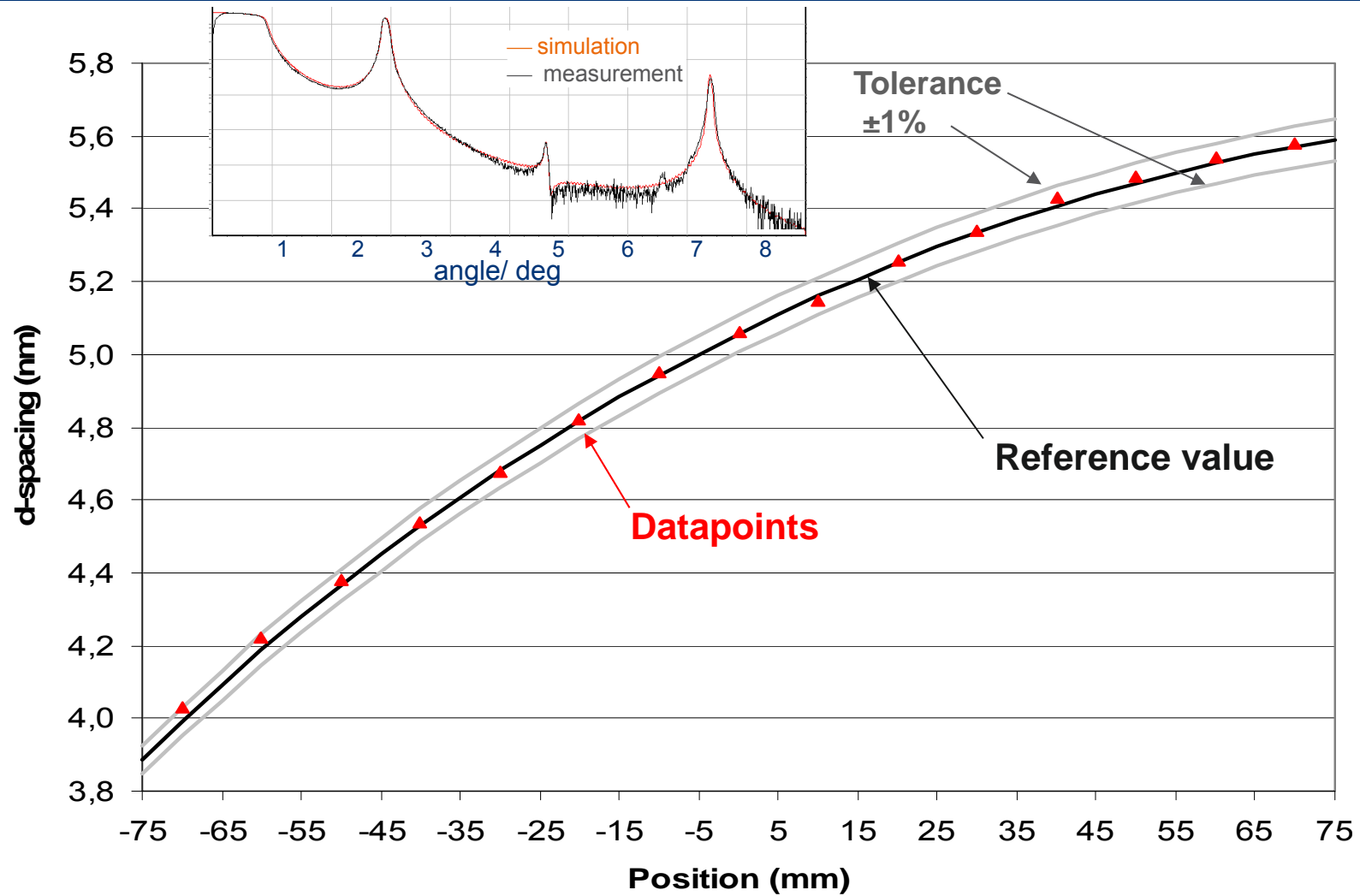
~ 100 layer pairs

Interface roughness < 10%

Tolerance in d spacing better +/- 1 %

2-dim beam shaping: Montel Optics

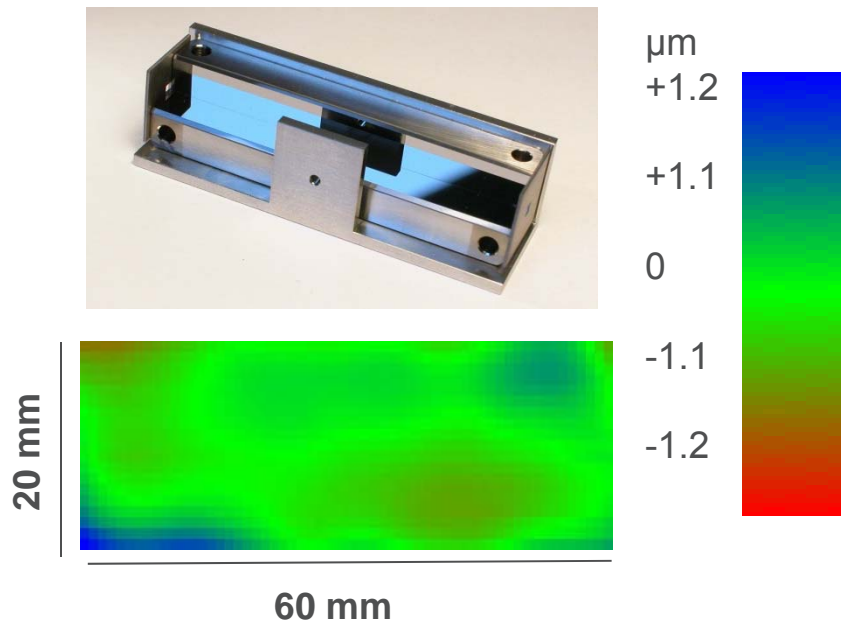




d-spacing accuracy within the tolerance of 1%

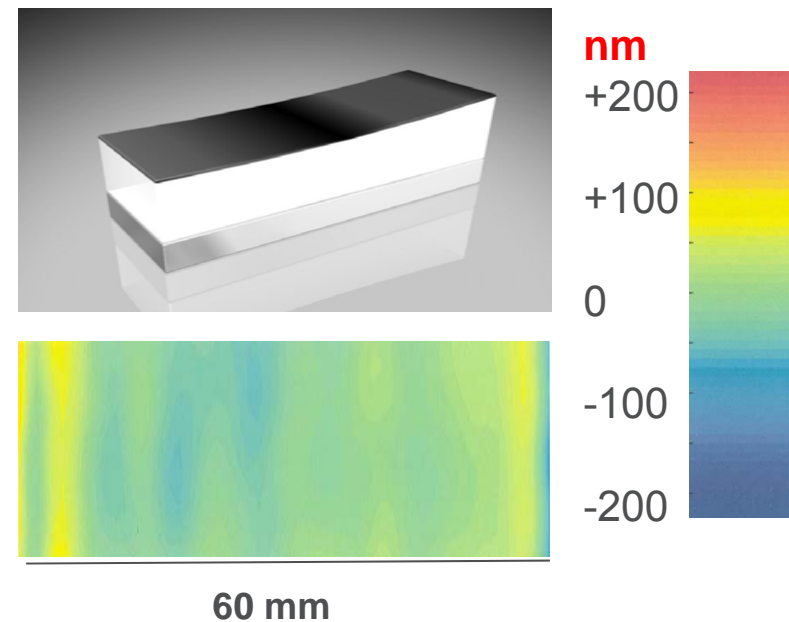
The beginning of it all: quality of substrates

Bent Si Wafer



- Shape errors up to $\pm 1.2 \mu\text{m}$
- Figure errors typically $< 10 \text{ arcsec rms}$

Prefigured Substrate



- Shape errors up to $\pm 100 \text{ nm}$
- Figure errors typically $< 2 \text{ arcsec rms}$

New Synchrotron type 3rd generation Montel realized for Bruker / Excillum Metaljet!

$$1 \text{ arcsec} = 0.0048 \text{ mrad} = 0.00028^\circ$$

- To be combined with synchrotron, X-ray laser, plasma or metal jet sources
- Optics for typical energies available (4..25 keV; Ga, In, Cu, ...; lower E on request)
- Collimating and focusing
- Standard optics for Bruker
- Specials: delivery time 8 to 12 (!) months
- high price due to high substrate costs (up to 80.000 EUR)



Our profile as thin film company



Simulation of layer and mirror properties

Flexible, on customer request

Substrate characterization

Shape / slope error / roughness

Magnetron sputtering for

extremely precise coatings

large area coatings

gradients / stripes / monolayer / multilayer

We produce the mirrors custom-made!

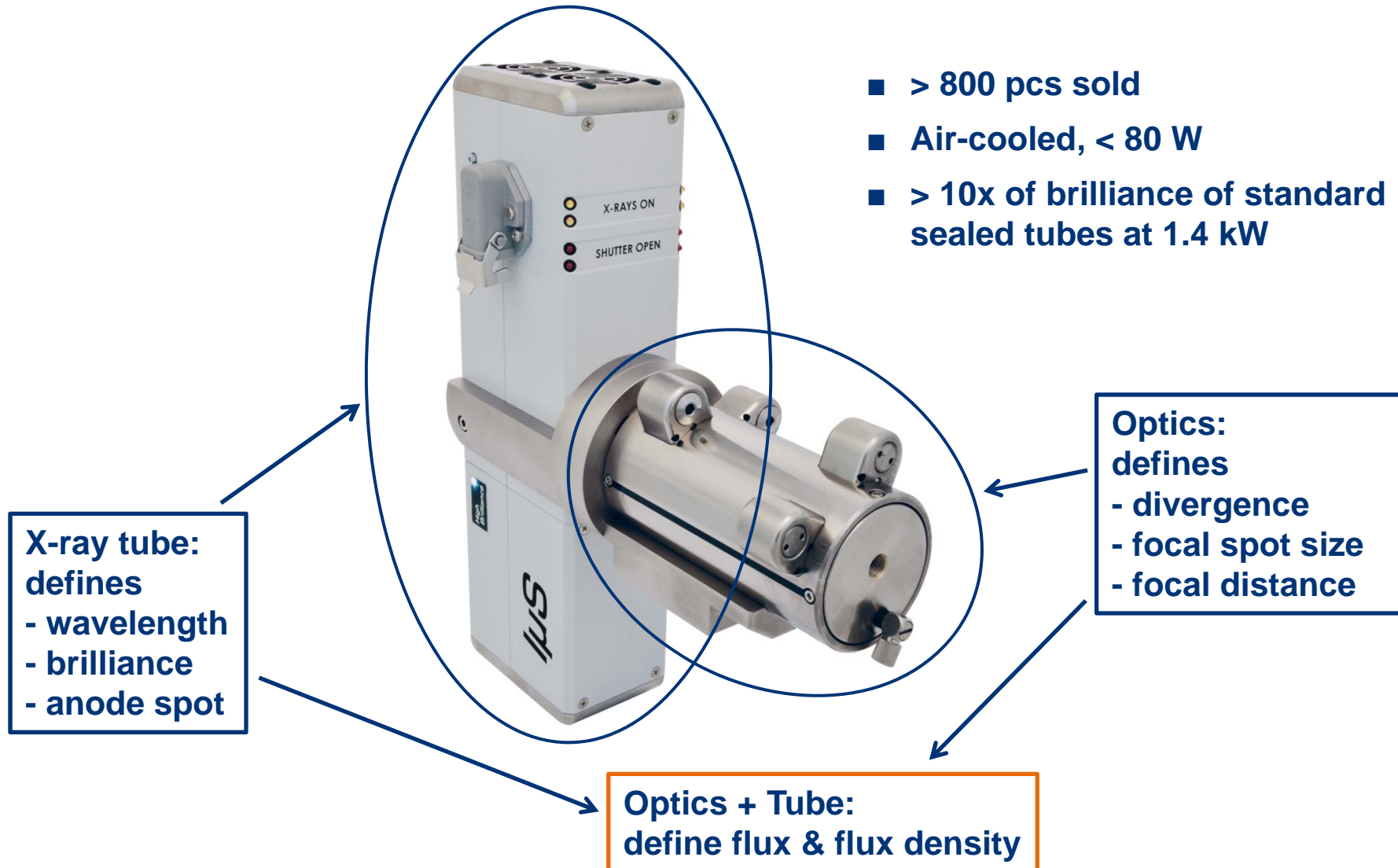
Flexible “in-house” manufacturing for various wavelengths and applications

But we offer much more!



Microfocus Source I μ S

The market & technology leader: μ S





State of the art lab instruments for X-ray Crystallography



Bruker AXS *D8 Quest & Venture*

What is special about a tube optimized for diffraction?

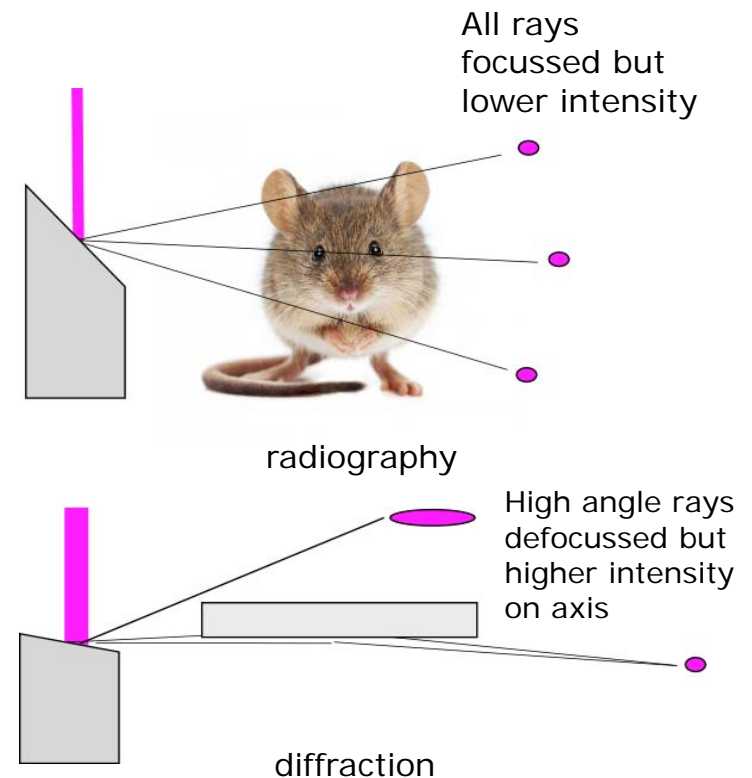
μ S 3.0 achieves higher intensity by going to low take-off angle

All other microfocus tubes on the market were designed primarily for radiography (medical or NDT)

- They therefore feature high take off angles in order to *preserve resolution over a wide field of view*

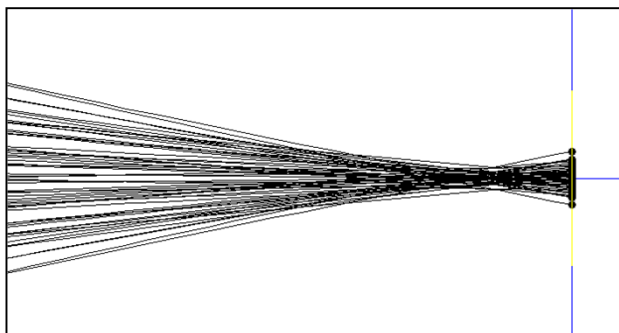
In diffraction we do not need a wide field of view, we only need to produce an intense beam of X-rays

- *An elongated electron beam focus on a low-take-off-angle anode produces higher intensity*
- *Ray bundles at large angles are defocussed but we don't care*

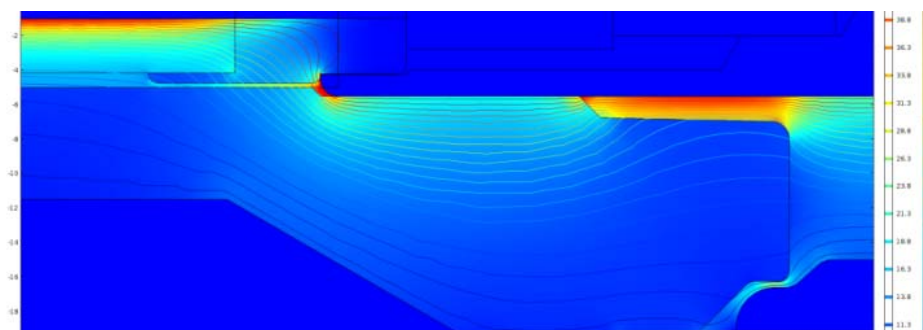


NEW:

We design and develop customiized X-ray tubes for X-ray analytical applications

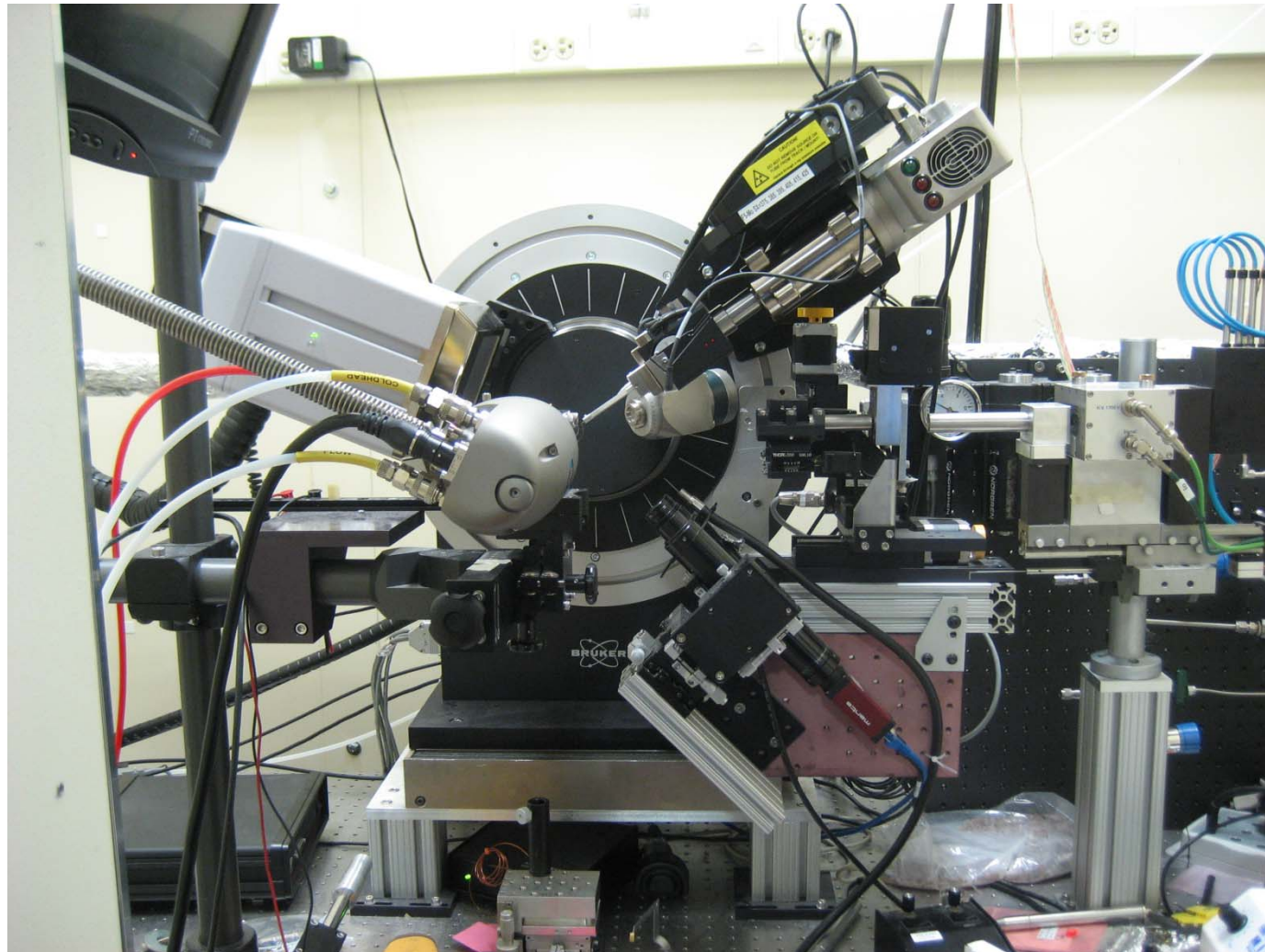


Ray tracing of electrons



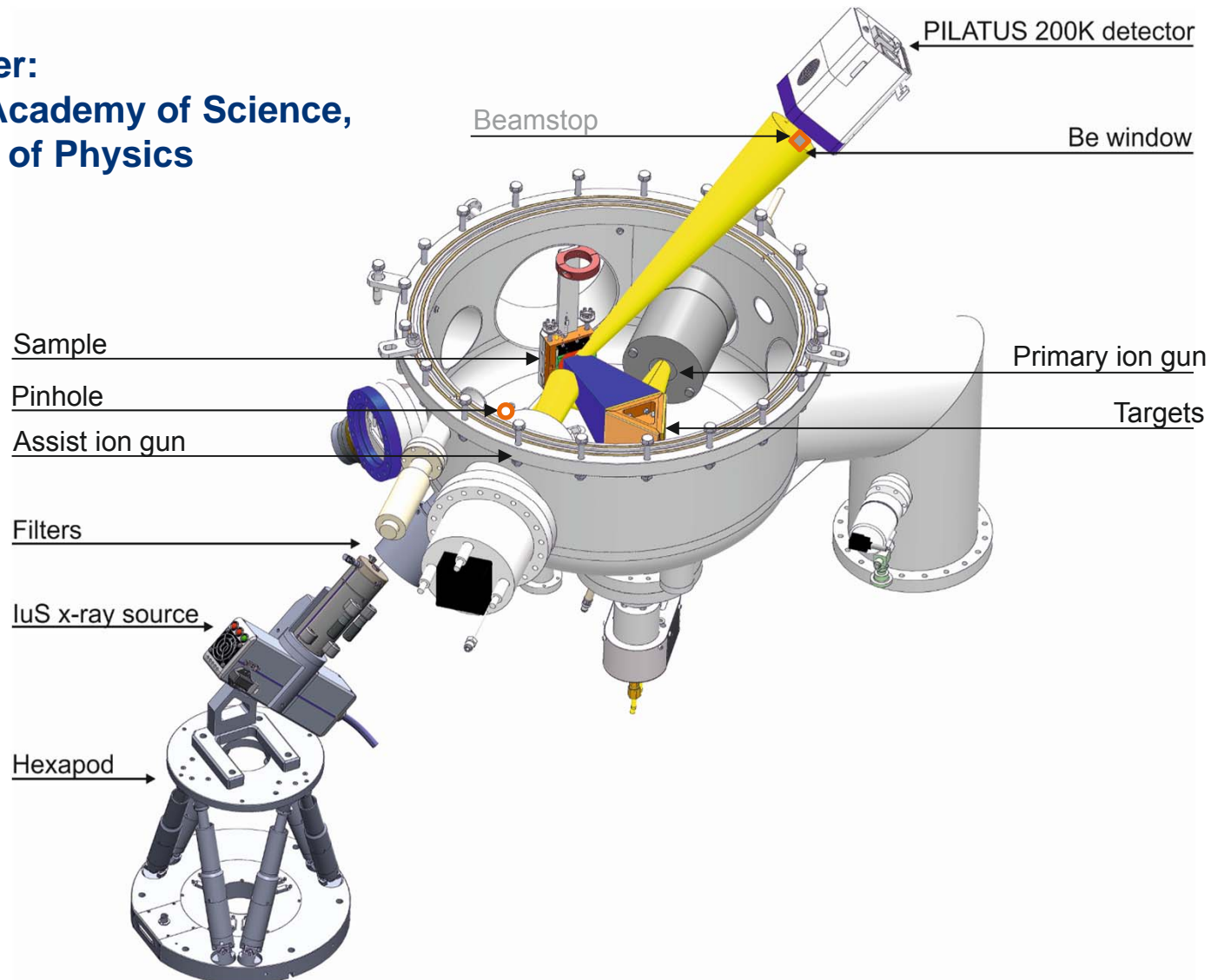
Calculation of heat flow (FEM)

Special Solutions with $\text{I}\mu\text{S}$ - ALS in Berkeley: Mo $\text{I}\mu\text{S}$ + Synchrotron Beam



Experimental setup – DIBS with in-situ GISAXS option

Customer:
Slovak Academy of Science,
Institute of Physics



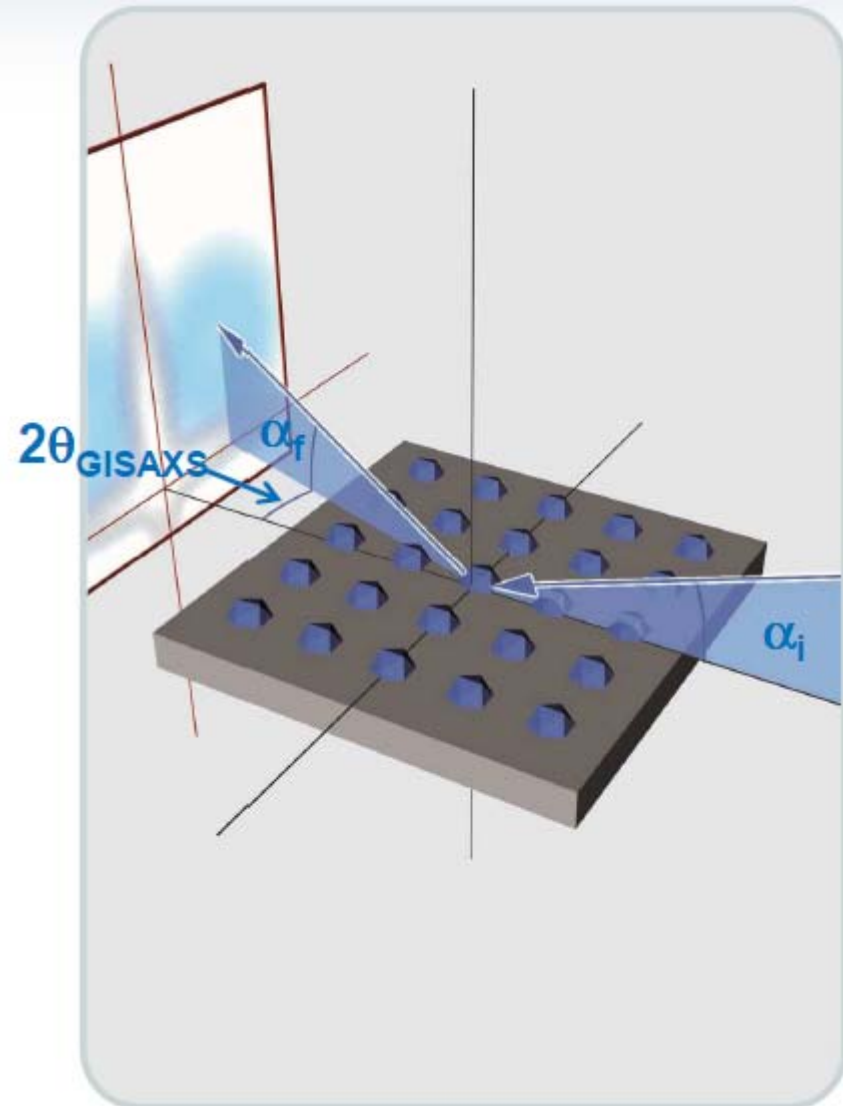
Background: GISAXS

Grazing Incidence SAXS

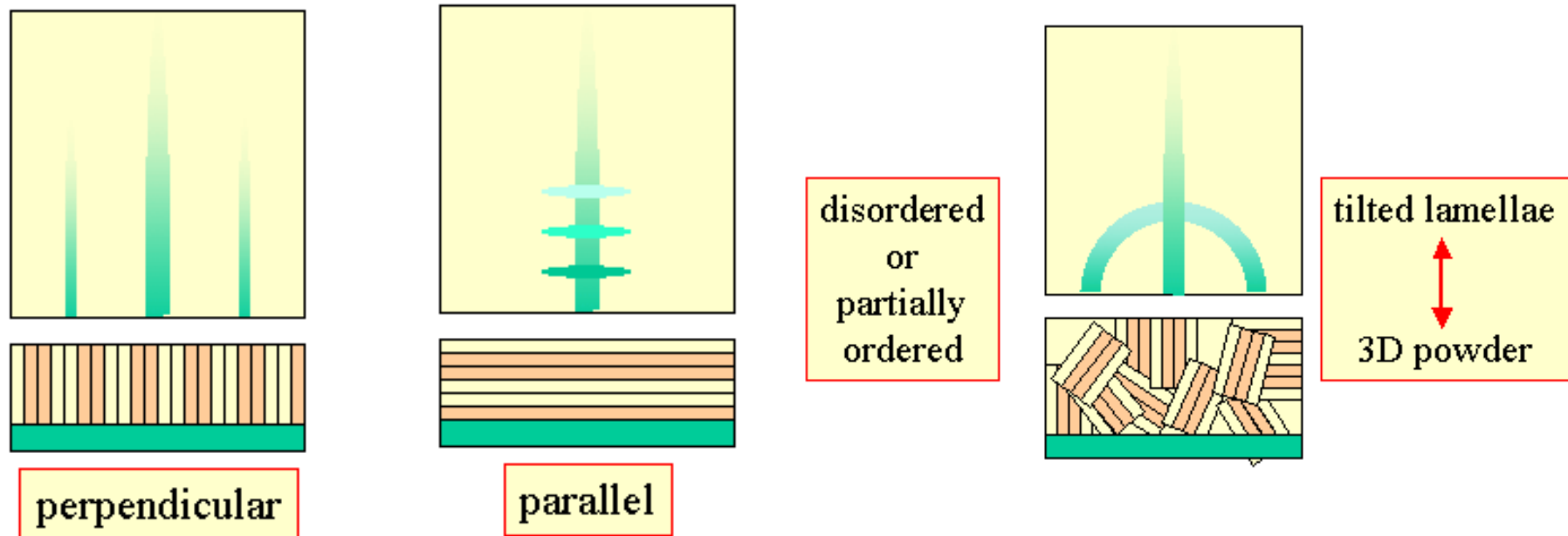
Measures diffuse scattering in reflection geometry at grazing incident (α_i) and exident (α_f) angles

Diffuse scattering contains information about surface and subsurface structure

- Island dimensions
- 3-D arrangements
- Roughness
- Pore diameter
- ...

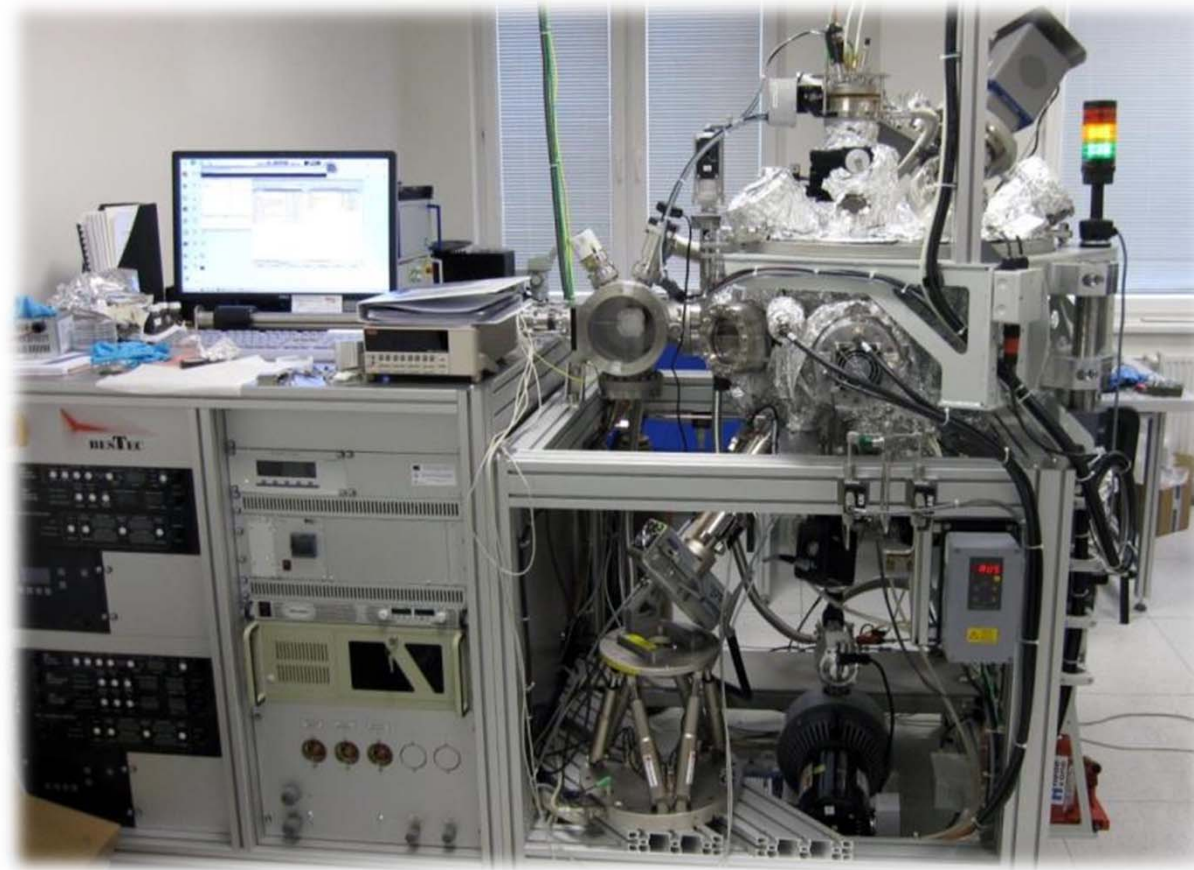


Grazing-incidence small-angle X-ray scattering (GISAXS)



<http://staff.chess.cornell.edu/~smilgies/gisaxs/GISAXS.php>

Special Solution for In-situ GISAXS



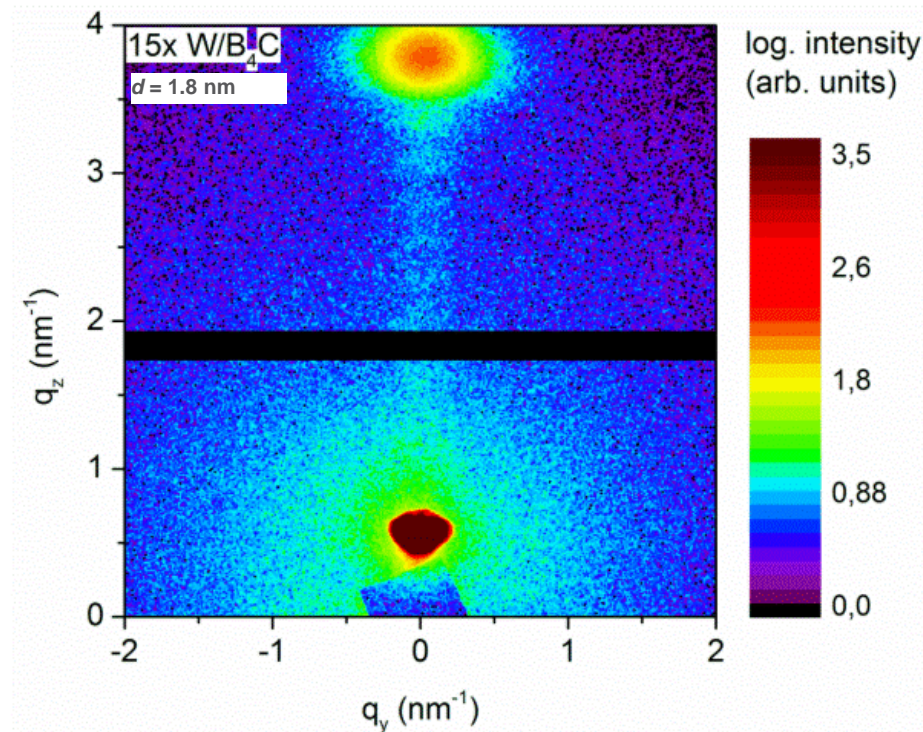
**Adaptation of Cu-I μ S to ion beam deposition UHV chamber,
plus Dectris 2D detector**

Special Solution for In-situ GISAXS



On-line hexapod alignment incl.
collision detection & radiation safety

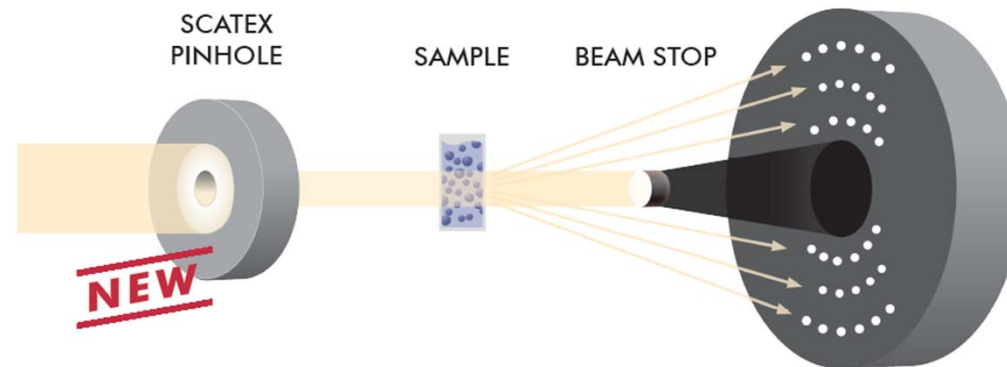
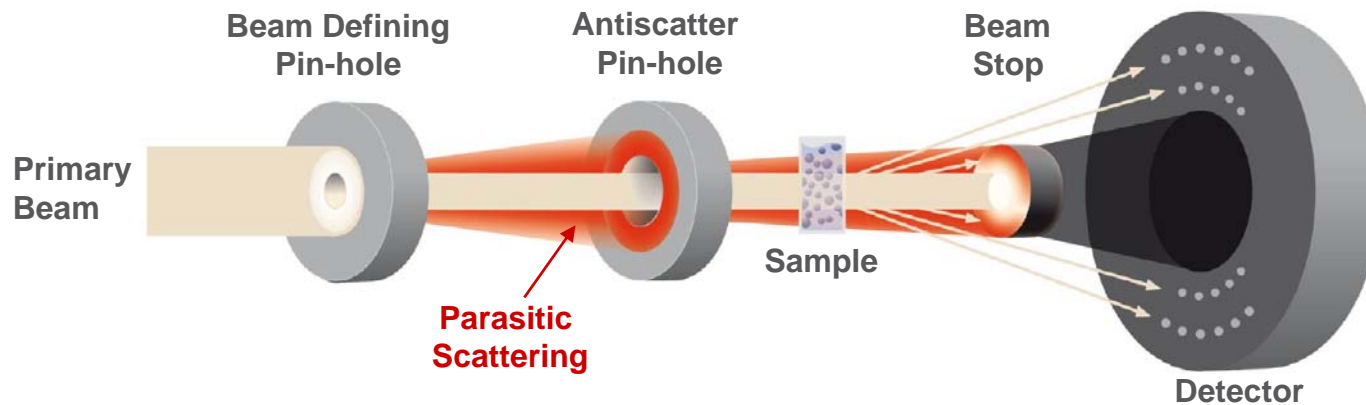
Only 8 s Exposure Time !



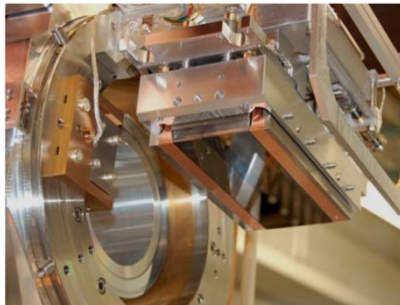
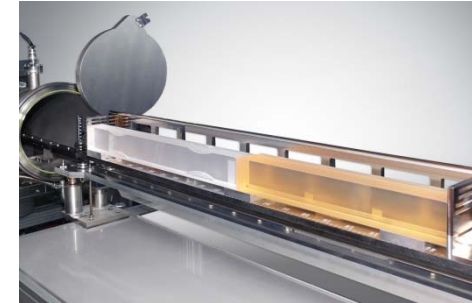
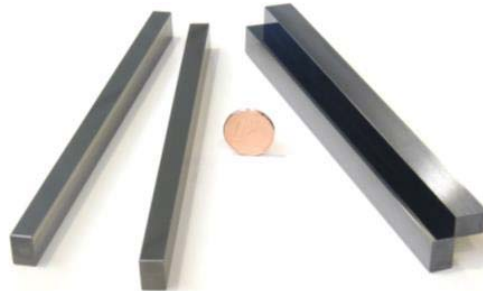
Reciprocal space map of 15 periods W/B₄C multilayer

In-situ GISAXS monitoring of ultrashort period W/B₄C multilayer x-ray mirror growth,
Martin Hodas, Peter Siffalovic et al., *Proc. SPIE* 9588 (August 26, 2015); doi:10.1117/12.2187999

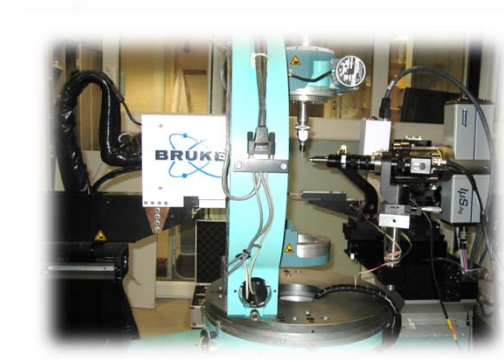
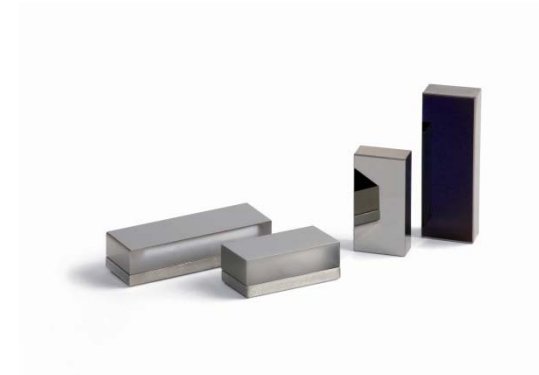
SCATEX: new scatterless pinholes



Your Partner for X-Ray Optics, Scatter-Less Pinholes and Microfocus Sources



- X-ray Optics
- X-ray Tubes
- Microfocus Sources
- Scatterless Pinholes
- Synchrotron Optics



Incoatec – Your partner for X-ray optics and microfocus sources

- Key know-how: Multilayer Optics & X-ray Tubes
- Scatterless pinhole SCATEX
- Microfocus Source μ S

We are ready for new solutions!



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