Aspheric multilayer optics for micron size sample illumination on synchrotron beamlines

Xenocs
Reflecting Future Technology

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Abstract

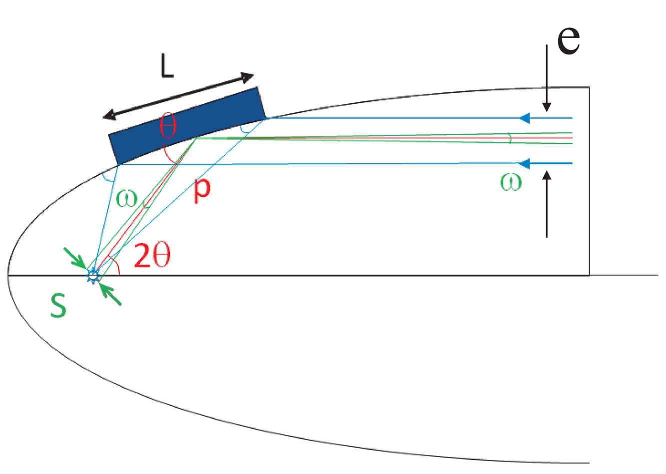
Multilayer coated optics are suited for micron size sample illumination. Within a compact size and coupled to monochromatic and collimated synchrotron radiation they generate a micron sized beam i.e. for microdiffraction application. The use of high quality **aspheric optics** strengthens these assets and provides easy, reliable and fast alignment procedure together with high stability and relatively long focal length. The type of optic described is based on a single reflection 3D paraboloïd design, having the capacity to capture a large parallel beam down to a focus of about 2µm. The net geometric gain measured up to now is about 500. The high reflectivity is **preserving the flux** and the long focal length is limiting the divergence, compatible with microdiffraction experiments. The **free space** available after the optic exit ranging between 9 and 21 cm at 8keV and 17.5keV respectively allows a variety of sample environments. The **ease of alignment** is due to the **compactness** of the optic, the acceptance of the multilayer coating and the high reflection angle. The low slope error and roughness render these optics particularly attractive to experiments that necessitate low background. With a broad size of the incoming beam and a single reflection geometry, **stable alignment** is therefore facilitated. This last feature offers new possibilities for flexible setups, with automatic insertion/removal capacities. Hence, combination of microdiffraction aside standard crystallography experiments could be developed.

The parabola

The theoritical size S of the focal spot obtained with a parabola-based optic depends on the divergence of the incoming beam.

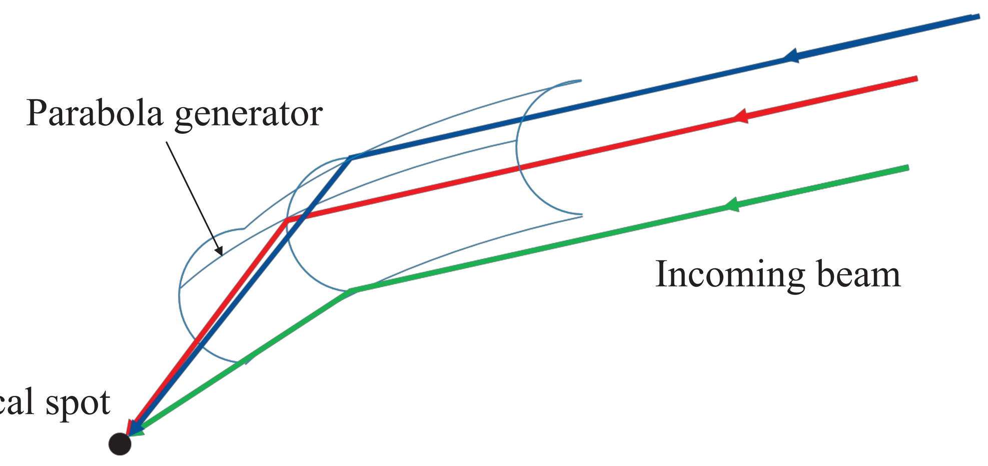
$S = p.\omega$

$e = L.\sin\theta$



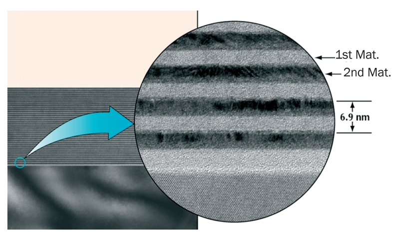
In practice, the aberrations of the mirror (shape, roughness) and the size of incoming beam are also limiting factors.

- Aspheric surfaces



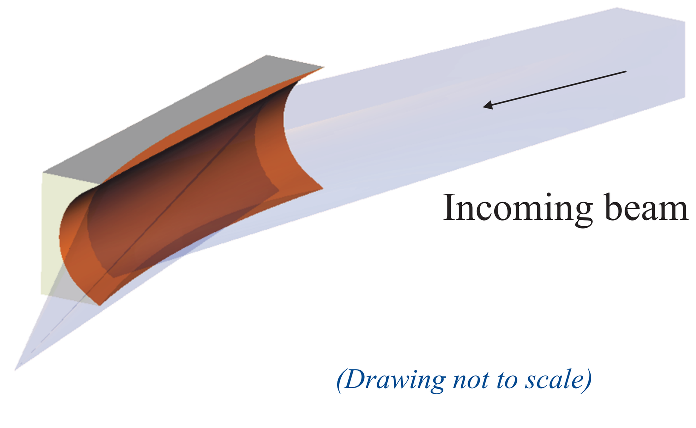
Small optic for high intensity and large collecting power

- X-ray multilayer coatings

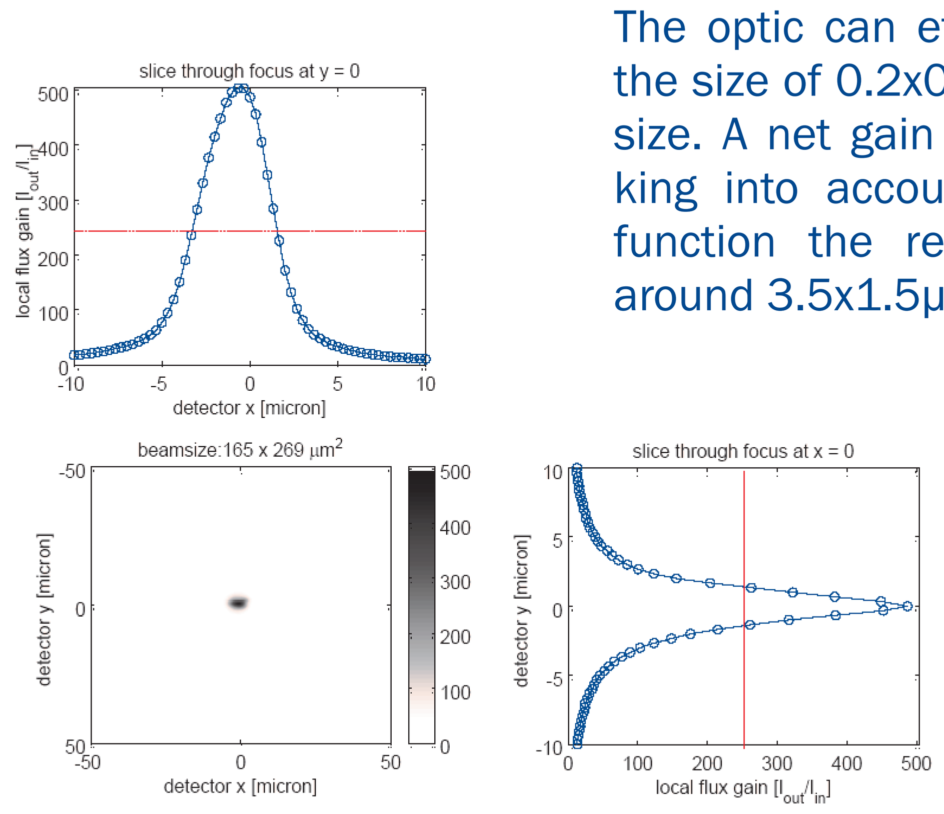


High reflectivity	>70%
High capture angle	1-2°
Tailored spectral range	up to 20keV
Large beam acceptance	1.5x1.5mm
Large working distance	9—21cm

- Fast insertion
  - Single reflection optics
  - Easy alignment (Bragg+tilt)
  - Compactness (L=6-8 cm) drives stability
  - Upstream divergent parasitic rejected



Results @ SLS/PSI

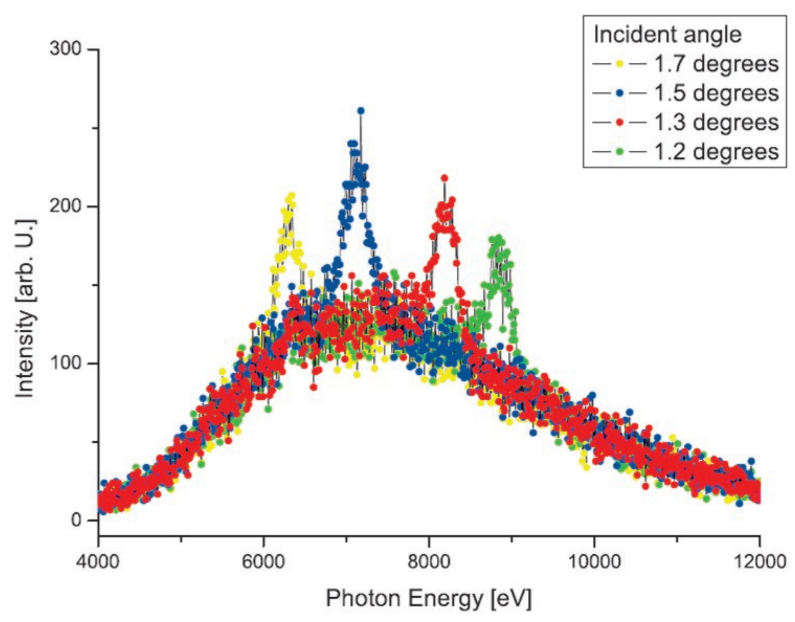


The optic can efficiently compress a beam of the size of 0.2x0.2mm² into a 4.5x2.5µm² spot size. A net gain of 500 was measured. By taking into account the detector point spread function the real beam size is somewhere around 3.5x1.5µm² for an energy of 8.05keV.

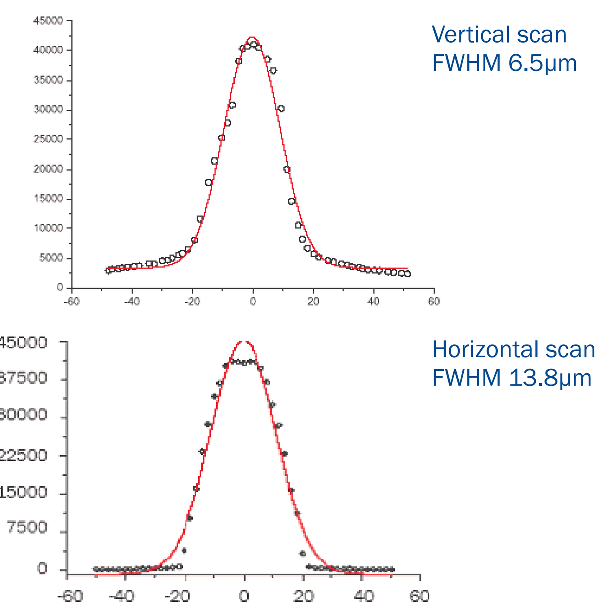
Data courtesy of Pr. F. Pfeiffer

Results @ University Göttingen

The same optic can be used for a broad energy range without significant loss of reflectivity but induces astigmatism. However, limited range of energy scan could be tolerated, i.e. around absorption edge.



Energy spectrum behind the Xenocs optic during alignment for different angles of incidence. The spectra were measured from air scattering 90 degrees with respect to the beam direction. The shown spectra are not corrected for air attenuation and the energy distribution of the bending magnet.

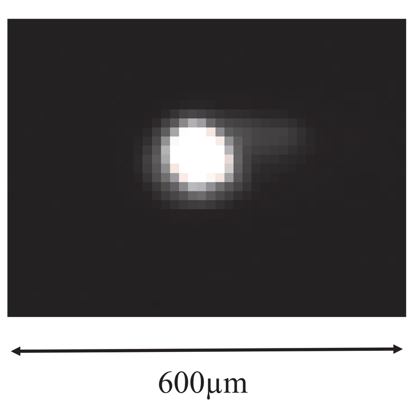


Pinhole scans through the focal spot of the INF-12 Cu FOX mirror measured 120mm behind optics integrating 7500eV-9000eV. With an incoming beam of 0.1x0.1mm, the gain is of 110.

Data courtesy of Pr. T. Salditt

Preliminary results @ EPFL/SNBL BM1 (ESRF)

Microdiffraction of high Z specimen or in complex environment may necessitate hard radiation, i.e. 17.4keV. By changing the shape of the substrate and the d_spacing of the multilayer, a mirror with ∞-25cm was designed. The preliminary test was performed at the BM01 @ SNBL/ESRF.



Incoming beam of HxV 0.4x0.6mm, with divergence of HxV 0.1x1mrad was used.
Being slightly out of focus of the optic, the image captured @ 21cm shows a 50x50µm spot. Data collected with an X-Ray eye with 11µm pixel size.
Expected future results of 30µm focal spot.

Aspheric optics

- Other type of geometry available

The control of the shape of the optic offers a wide variety of combination : Flat/parabola, Flat/Ellipse, Ellipsoid...

- X-ray beam delivery solutions

Low power/High brilliance micro-source are ideally coupled with optimised multilayer optic.

Applications currently covered :

- Protein Crystallography
- Small Molecule
- SAXS
- High Resolution
- High pressure diffraction
- Powder diffraction
- And many others ...

- **Xenocs single reflection optics enable to transform quasi parallel beam into a small focal spot, with a stable, preserved flux and with divergence compatible with microdiffraction**
- **Recent process improvement will deliver optimised spot and beam shapes**
- **Easy alignment through the single reflection design enables automatic insertion**

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