ESRF	**Experiment title:** Characterization of point-focusing prism-array x-ray lens	**Experiment number:** MI-941
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Shifts: 9	**Local contact(s):** Luca Peverini	*Received at ESRF:*

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Report:

The purpose of this experiment was to evaluate a new refractive lens for x-ray energies between 20 and 50 keV. The lens is a generalized prism array [1] with cylindrical symmetry allowing for point focusing.

Measurements were done on three samples, referred to as lens 1, lens 2 and lens 3. The samples were irradiated with a monochromatic beam and using the FReLoN CCD camera as detector. Each lens was aligned with the beam using rotation stages and the lens-to-detector distance as well as the beam energy were scanned to find the configuration producing the highest gain in intensity. Fig. 1 shows the measurement resulting in the highest gain.

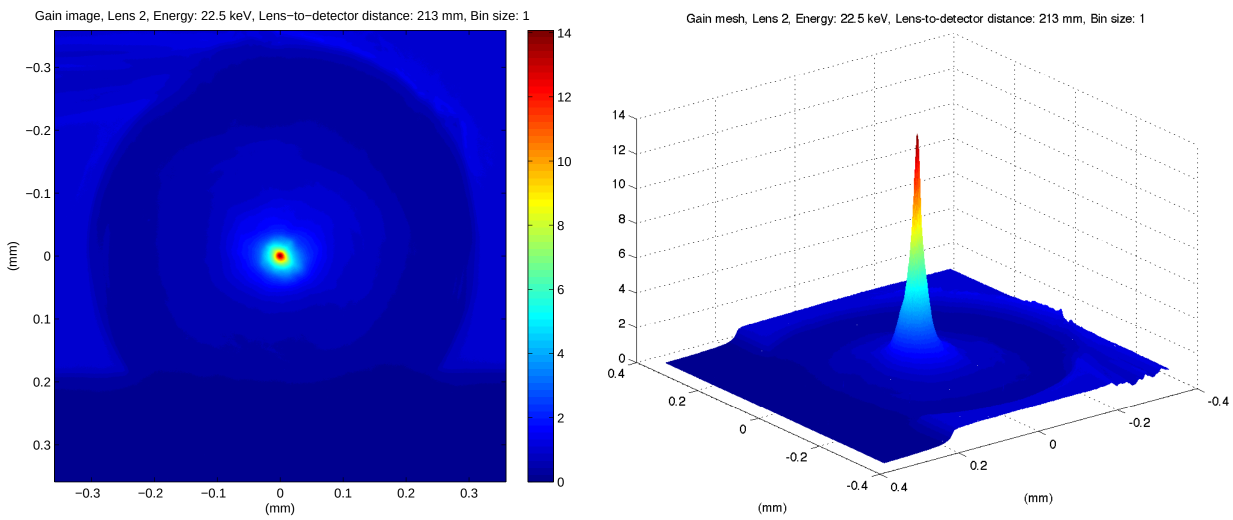

Figure 1. Gain image (left) and mesh (right) for lens 2 measured at 22.5 keV and lens-to-detector distance of 213 mm. This was the configuration with the highest gain and which lies close to the designed parameters, 23 keV and 221 mm.

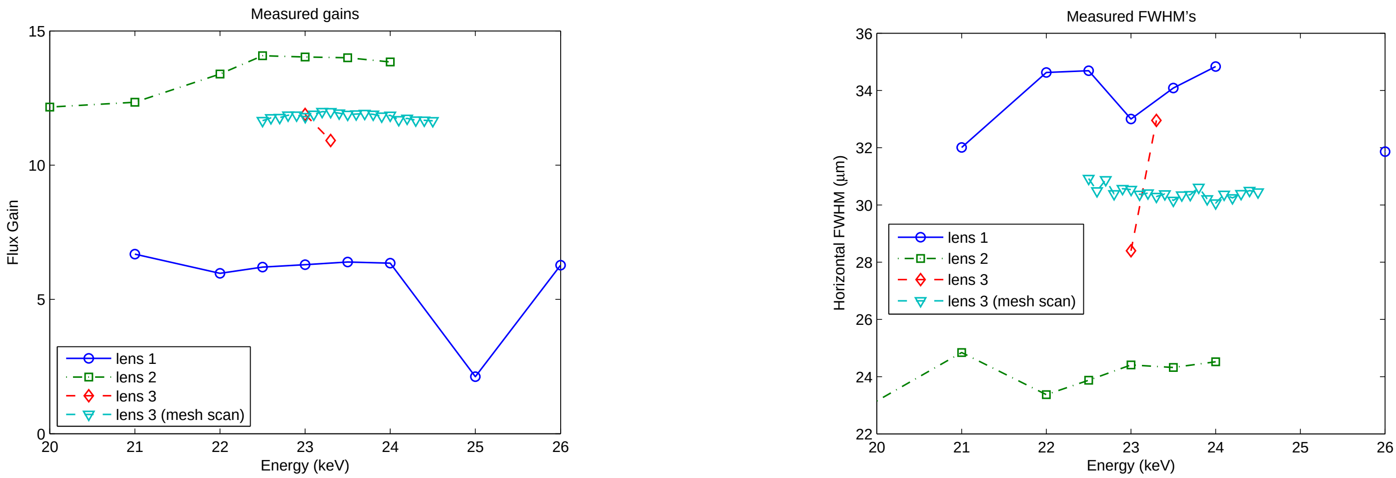

Figure 2. Measured gains and FWHM at different energies. Measurement were done at the lens-to-detector distance giving the maximum gain.

Fig. 2 summarises the measurements for all three samples. The best performing lens, lens 2, has a maximum gain of 14.1 and a spot size FWHM of 23 μm. While the energy dependence is weak the peaks lie around the design energy of 23 keV, at least for lens 2 and 3. Lens 1 works less well and deformation of this lens is clearly visible which explains the lower performance.

The results were also likely affected by the limited resolution of the FReLoN camera. The camera point spread function (PSF) was estimated using the intensity image of a slanted knife edge at close proximity to the camera, resulting in an estimated camera PSF FWHM of 2.3 μm. Deconvolving the measurements with the camera PSF suggests a gain 32.5 and FWHM of 11-12 μm for lens 2.

References

[1] B. Cederström, C. Ribbing and M. Lundqvist, "Generalized prism-array lenses for hard X-rays", *J. Sync. Rad*, vol 12 (3), pp. 340-344, 2005

The following paper stem from another experiment performed during the beam time:

Abstract

We present an experimental and theoretical evaluation of an x-ray energy filter based on the chromatic properties of a prism-array lens (PAL). It is intended for small-scale applications such as medical imaging. The PAL approximates a Fresnel lens and allows for high efficiency compared to filters based on ordinary refractive lenses, however at the cost of a lower energy resolution. Geometrical optics was found to provide a good approximation for the performance of a flawless lens, but a field-propagation model was used for quantitative predictions. The model predicted a 0.29 ΔE/E energy resolution and an intensity gain of 6.5 for a silicon PAL at 23.5 keV. Measurements with an x-ray tube showed good agreement with the model in energy resolution and peak energy, but a blurred focal line contributed to a 29% gain reduction. We believe the blurring to be caused mainly by lens imperfections, in particular at the periphery of the lens.

Fredenberg, E., Cederström, B., Nillius, P., Ribbing, C., Karlsson, S. and Danielsson, M., "A low-absorption x-ray energy filter for small-scale applications", *Optics Express*, Vol. 17, No. 14, 2009