At-wavelength metrology report

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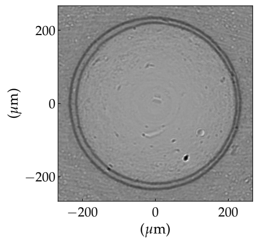
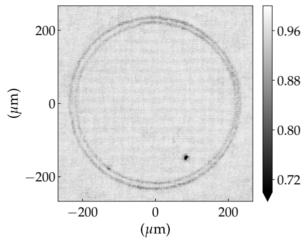
1. Lens summary

This report presents the data obtained from at-wavelength metrology at the ESRF as described in [1,2]. Below, a table summarising the lens and measurement main parameters. A detailed presentation of the results follows suit.

lens tag:	**Be pink beam**
material:	Be
geometric aperture (μm) h × v:	435.24 × 435.24
radius of curvature (μm) h × v:	49.72 × 49.70
figure error (μm rms) for full aperture:	0.77
pixel size (μm)	0.64
experiment energy (keV):	17.0
beamline:	BM05
technique:	XSVT



(a) radiography



(b) cross-correlation peak

Fig. 1. (a) radiography and (b) normalised cross-correlation peak map where values close to 1 indicate good template matching.

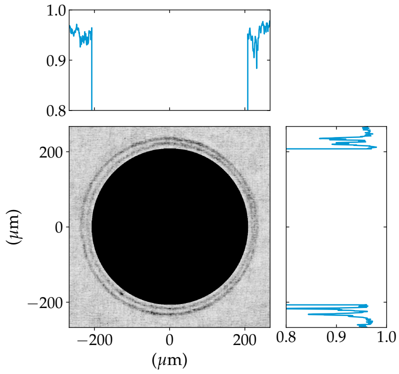
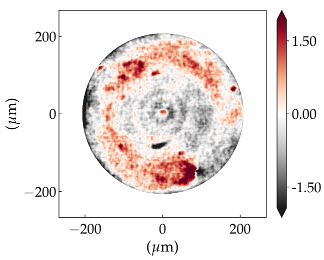
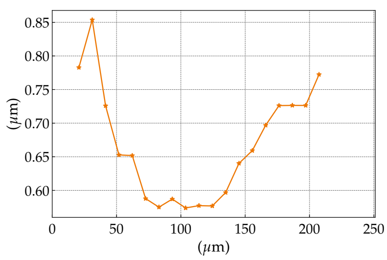


Fig. 2. In black: region of interest for metrologycal analysis.

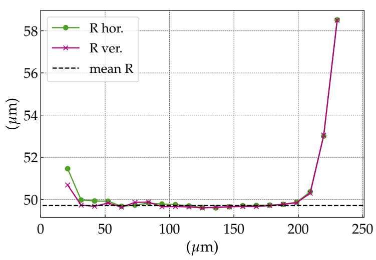
2. Thickness profile



(a) figure errors 2D distribution

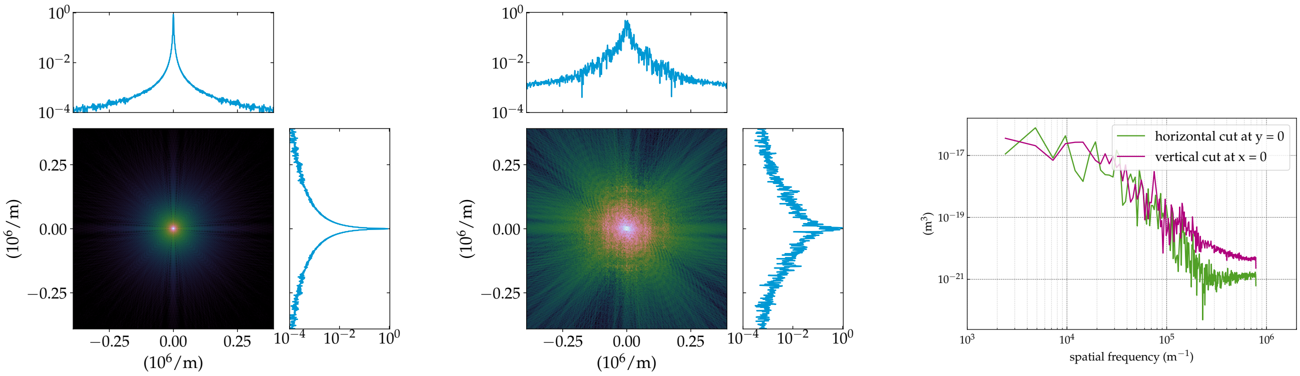


(b) figure errors vs. aperture size



(c) R vs. aperture size

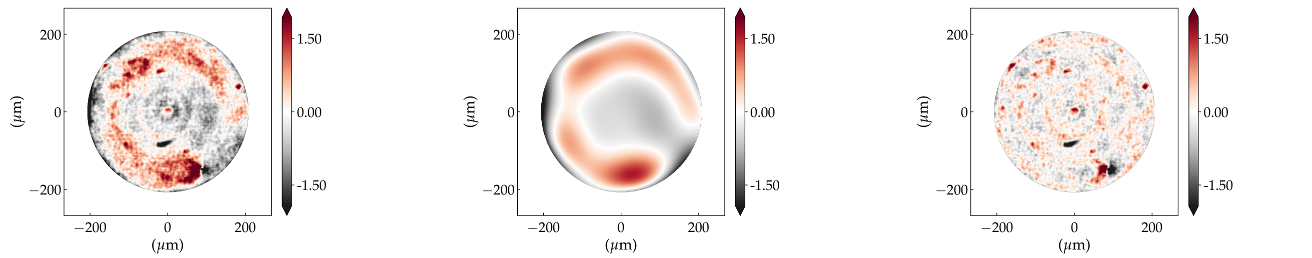
Fig. 3. (a) figure errors 2D distribution in μm, (b) figure error rms values as a function of the half aperture size and (c) and evolution of the radius of curvature as a function of the lens half-geometric aperture.



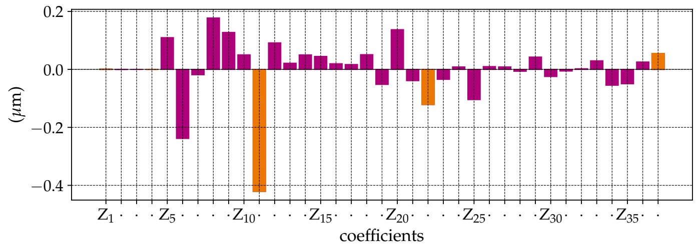
(a) $\mathcal{F}$ {ideal profile} **(b)** $\mathcal{F}$ {aberrated profile} **(c)** PSD

Fig. 4. Fourier transform of (a) an idealised aperture and (b) of the aberrated profile. (c) power spectrum density of orthogonal cuts at x = 0 and y = 0.

3. Profile decomposition

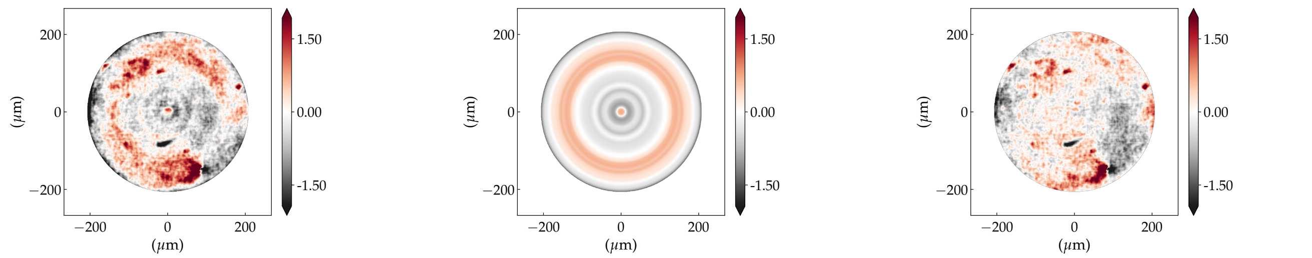


(a) figure errors ($\sigma_{\text{rms}} = 0.77\mu$m) **(b)** polynomial fit ($\sigma_{\text{rms}} = 0.61\mu$m) **(c)** fit residues ($\sigma_{\text{rms}} = 0.47\mu$m)



(d) polynomial coefficients

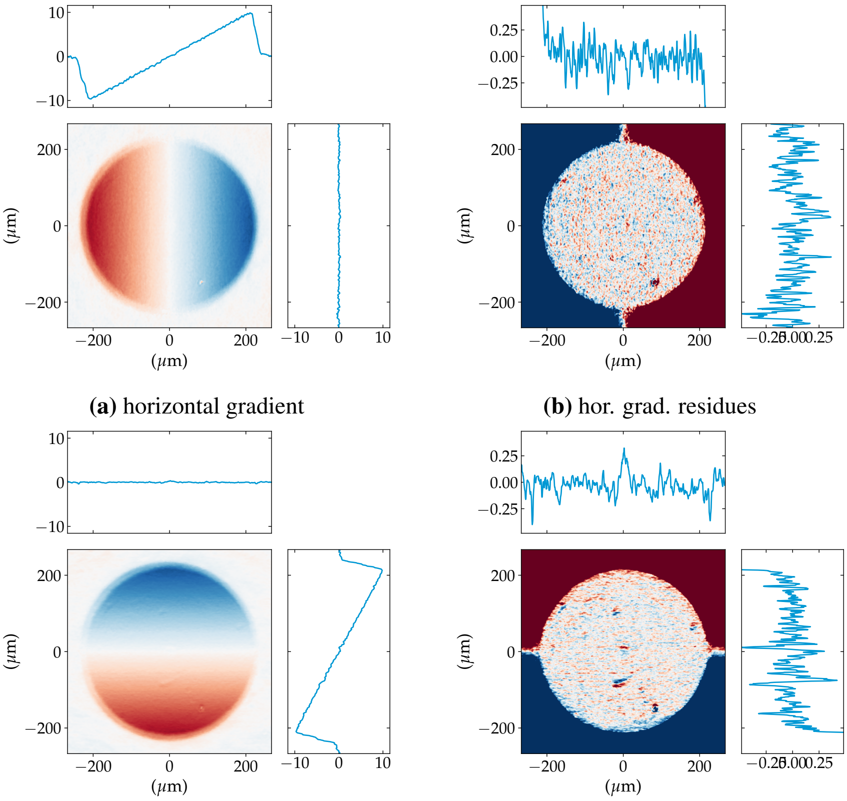
Fig. 5. Zernike polynomials decomposition for a circular aperture in μm. The profiles are related as: (a) figure errors = (b) polynomial fit + (c) residues; (d) coefficients in Noll notation - the orange bars indicate spherical aberrations.



(a) figure errors ($\sigma_{\text{rms}} = 0.77\mu$m) **(b)** averaged profile ($\sigma_{\text{rms}} = 0.46\mu$m) **(c)** fit residues ($\sigma_{\text{rms}} = 0.62\mu$m)

Fig. 6. From the figure errors in (a) it is possible to calculate the (b) *correctable profile* as defined in [3,4]. The residues of this fit are shown in (c). Valuer are in μm.

4. Gradients & gradient residues



(a) horizontal gradient

(b) hor. grad. residues

(c) vertical gradient

(d) ver. grad. residues

Fig. 7. Horizontal (a) gradient and (b) gradient residues after the removal of the linear term. Vertical (c) gradient and (d) gradient residues. Values are in μrad.

References

[1] Berujon, S. et al. (2020). "X-ray optics and beam characterization using random modulation: theory". J. of Synchrotron Rad., **27**(2), 284.
[2] Berujon, S. et al. (2020). "X-ray optics and beam characterization using random modulation: experiments". J. of Synchrotron Rad., **27**(2), 293.
[3] Sawhney, K. et al. (2016). "Compensation of X-ray mirror shape-errors using refractive optics". Appl. Phys. Lett., **109**(5), 051904.
[4] Seiboth, F. et al. (2020). "Hard X-ray wavefront correction via refractive phase plates made by additive and subtractive fabrication techniques". J. of Synchrotron Rad., **27**(5), 27.