At-wavelength metrology report

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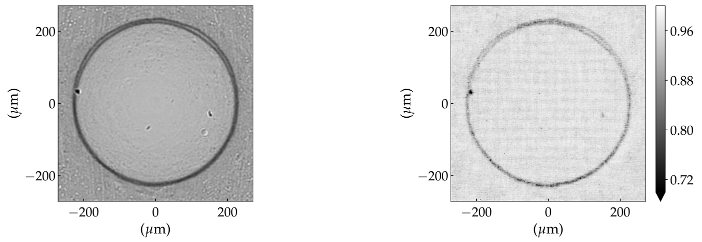
1. Lens summary

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:	**ID01 lens 03**
material:	Be
geometric aperture (μm) h × v:	442.91 × 442.91
radius of curvature (μm) h × v:	49.31 × 49.29
figure error (μm rms) for full aperture:	0.94
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.

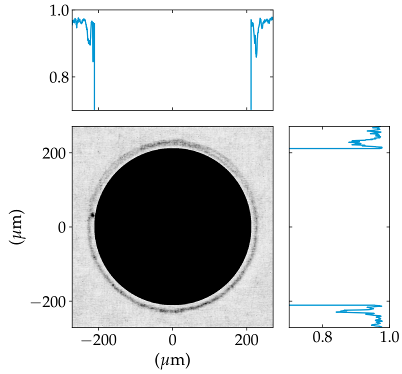
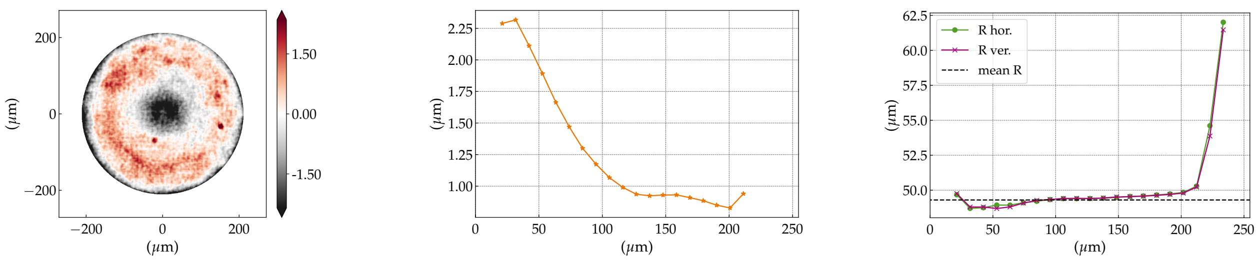


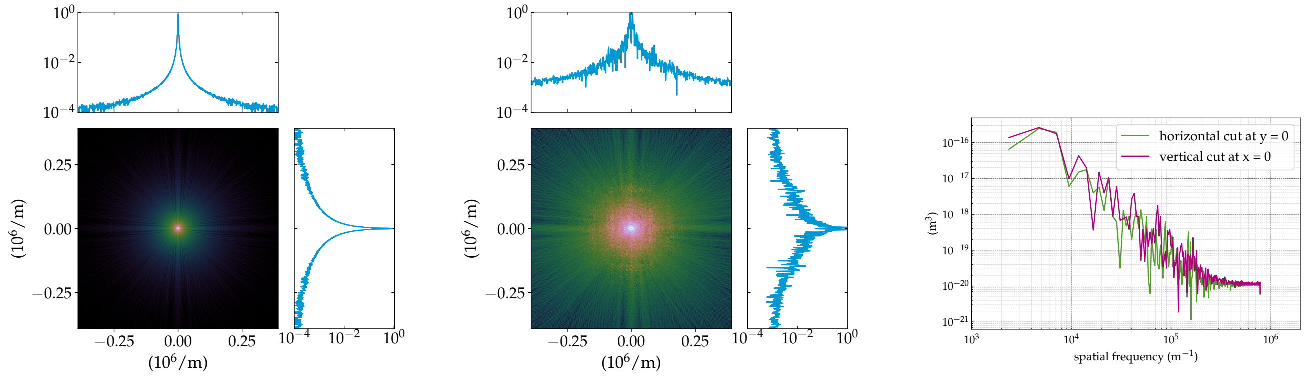
Fig. 2. In black: region of interest for metrologycal analysis.

2. Thickness profile



(a) figure errors 2D distribution **(b)** figure errors vs. aperture size **(c)** R vs. aperture size

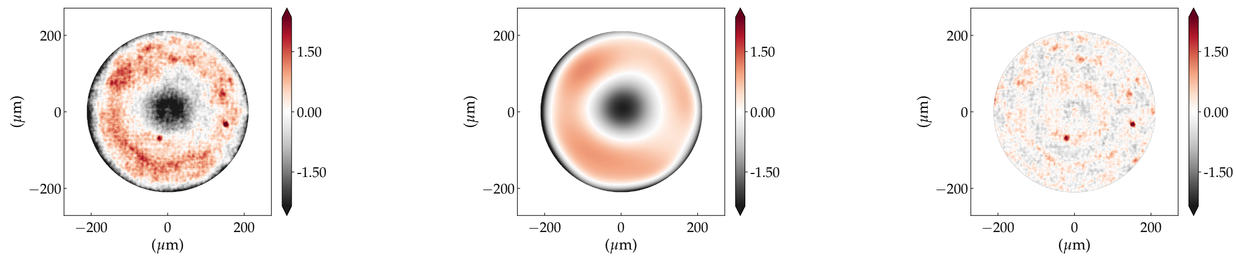
Fig. 3. (a) figure errors 2D distribution in μm, (b) figure error rms values as a function of the half aperture size and (c) and evolution of the radius of curvature as a function of the lens half-geometric aperture.



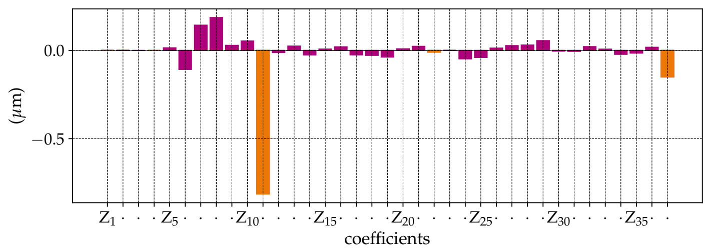
(a) $\mathcal{F}$ {ideal profile}   **(b)** $\mathcal{F}$ {aberrated profile}   **(c)** PSD

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

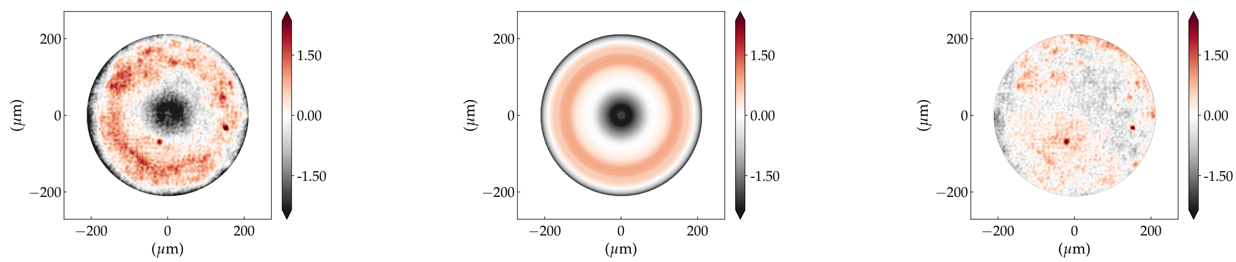


(a) figure errors (σ_{rms} = 0.94μm)   **(b)** polynomial fit (σ_{rms} = 0.87μm)   **(c)** fit residues (σ_{rms} = 0.33μm)



(d) polynomial coefficients

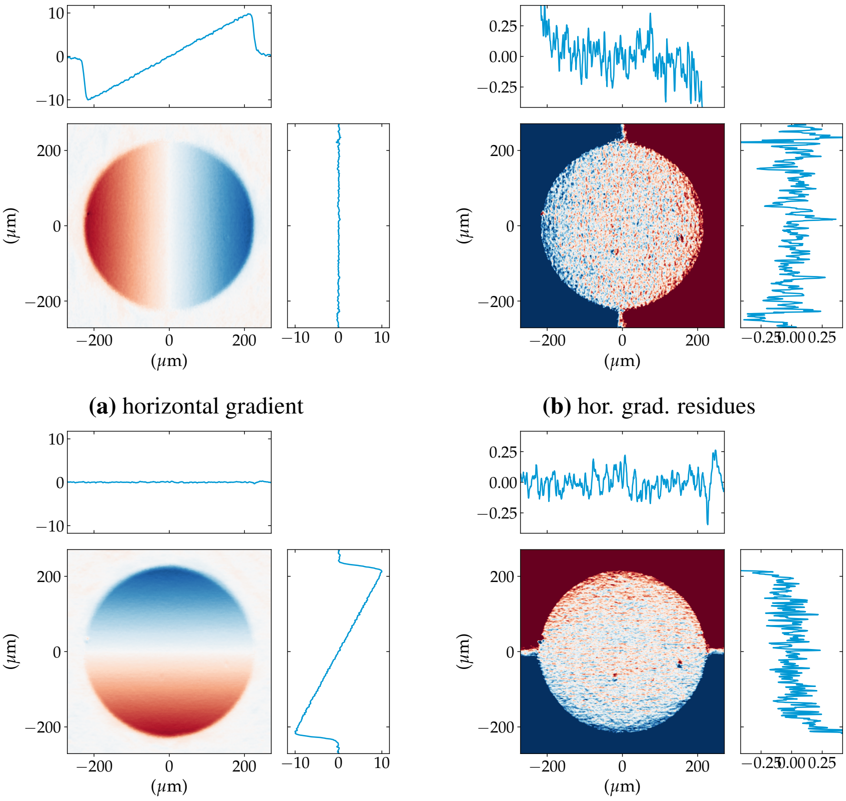
Fig. 5. Zernike polynomials decomposition for a circular aperture in μm. The profiles are related as: (a) figure errors = (b) polynomial fit + (c) residues; (d) coefficients in Noll notation - the orange bars indicate spherical aberrations.



(a) figure errors (σ_{rms} = 0.94μm)   **(b)** averaged profile (σ_{rms} = 0.83μm)   **(c)** fit residues (σ_{rms} = 0.43μm)

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.