

At-wavelength metrology report

Dr. Rafael Celestre, Dr. Thomas Roth

rafael.celestre@esrf.eu

tel: +33 4 38 88 19 89

X-ray Optics Group

Instrumentation Services & Development Division

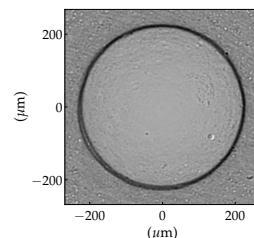
ESRF - The European Synchrotron

Grenoble, July 23, 2021.

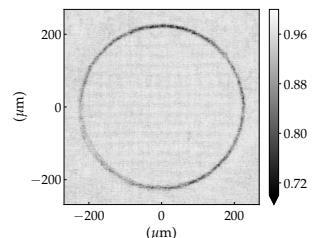
1. Lens summary

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 04	
material:	Be
geometric aperture (μm) h × v:	437.79 × 437.79
radius of curvature (μm) h × v:	49.44 × 49.48
figure error (μm rms) for full aperture:	1.31
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.

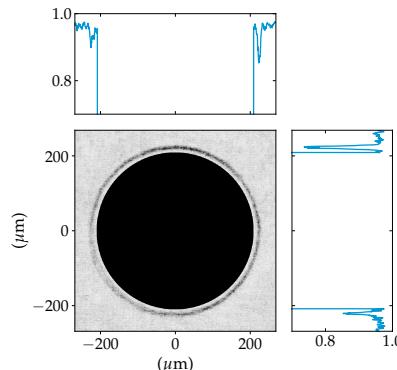
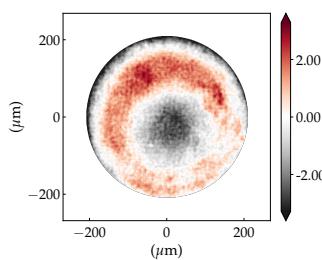
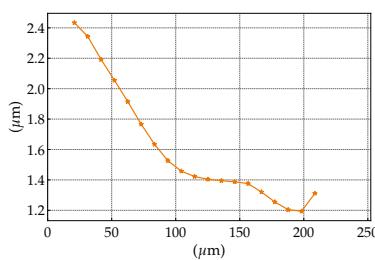


Fig. 2. In black: region of interest for metrological analysis.

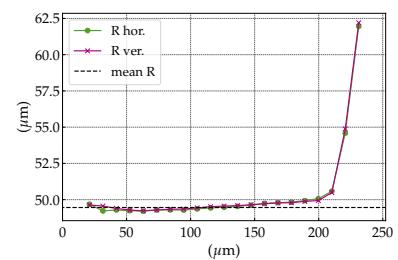
2. Thickness profile



(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) evolution of the radius of curvature as a function of the lens half-geometric aperture.

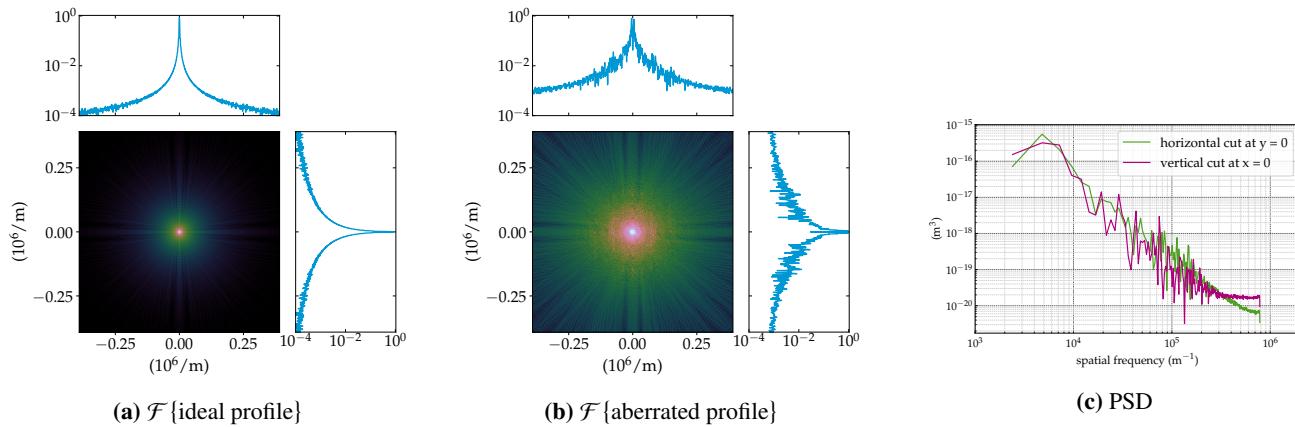


Fig. 4. Fourier transform of (a) an idealised aperture and (b) of the aberrated profile.
(c) power spectrum density of orthogonal cuts at $x = 0$ and $y = 0$.

3. Profile decomposition

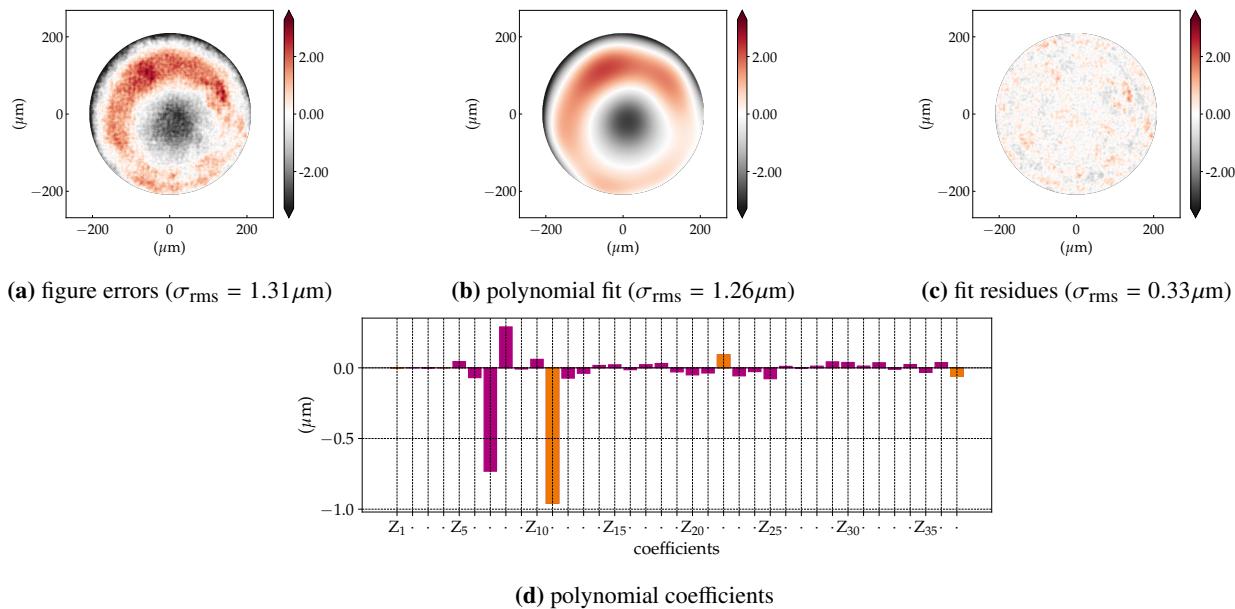


Fig. 5. Zernike polynomials decomposition for a circular aperture in μm . The profiles are related as: (a) figure errors = (b) polynomial fit + (c) residues; (d) coefficients in Noll notation - the orange bars indicate spherical aberrations.

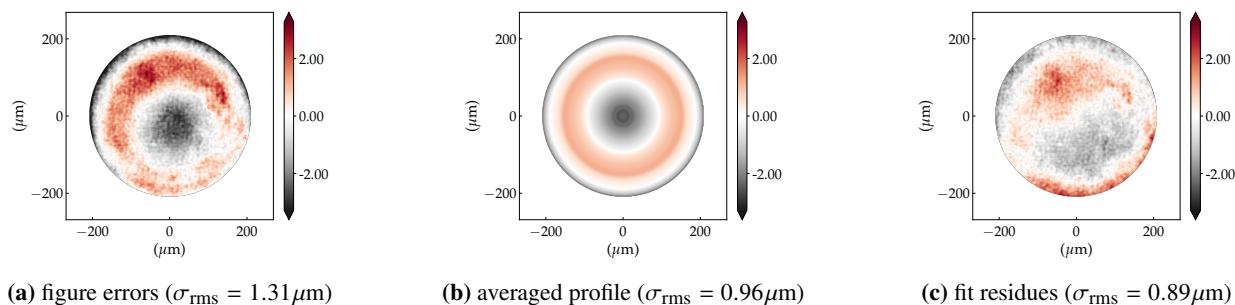


Fig. 6. From the figure errors in (a) it is possible to calculate the (b) *correctable profile* as defined in [3,4]. The residues of this fit are shown in (c). Values are in μm .

4. Gradients & gradient residues

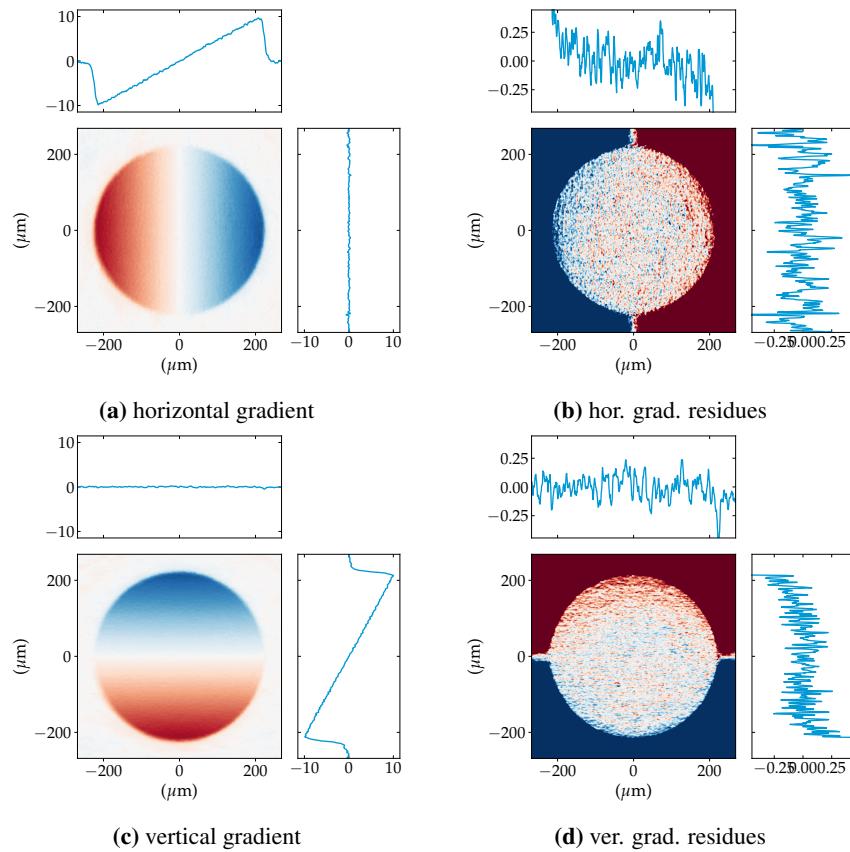


Fig. 7. Horizontal (a) gradient and (b) gradient residues after the removal of the linear term. Vertical (c) gradient and (d) gradient residues. Values are in μrad .

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.

