

# At-wavelength metrology report

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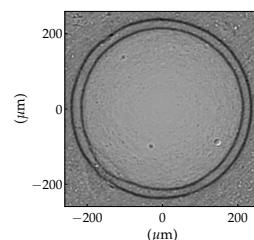
ESRF - The European Synchrotron

Grenoble, July 23, 2021.

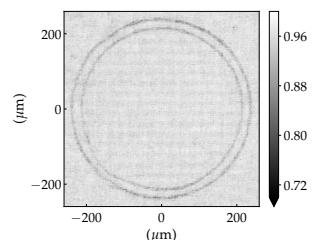
## 1. Lens summary

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: <b>ID01 lens 02</b>	
material:	Be
geometric aperture ( $\mu\text{m}$ ) h $\times$ v:	419.90 $\times$ 419.90
radius of curvature ( $\mu\text{m}$ ) h $\times$ v:	49.52 $\times$ 49.50
figure error ( $\mu\text{m}$ rms) for full aperture:	0.79
pixel size ( $\mu\text{m}$ )	0.64
experiment energy (keV):	17.0
beamline:	BM05
technique:	XSVT

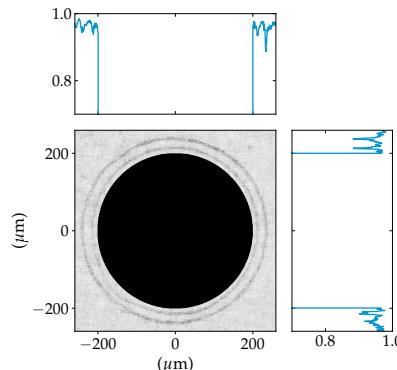


(a) radiography



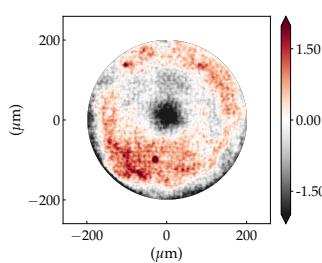
(b) cross-correlation peak

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

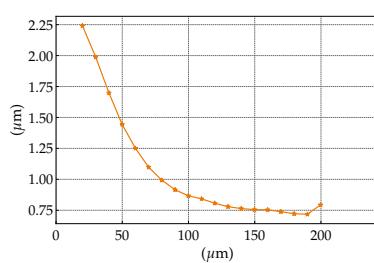


**Fig. 2.** In black: region of interest for metrological analysis.

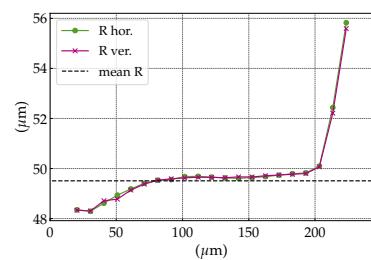
## 2. Thickness profile



(a) figure errors 2D distribution

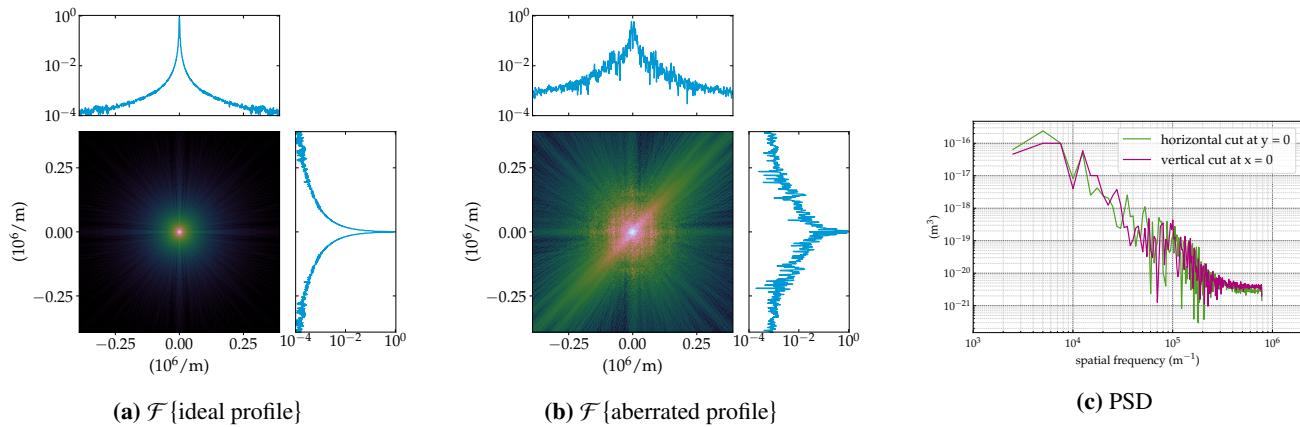


(b) figure errors vs. aperture size



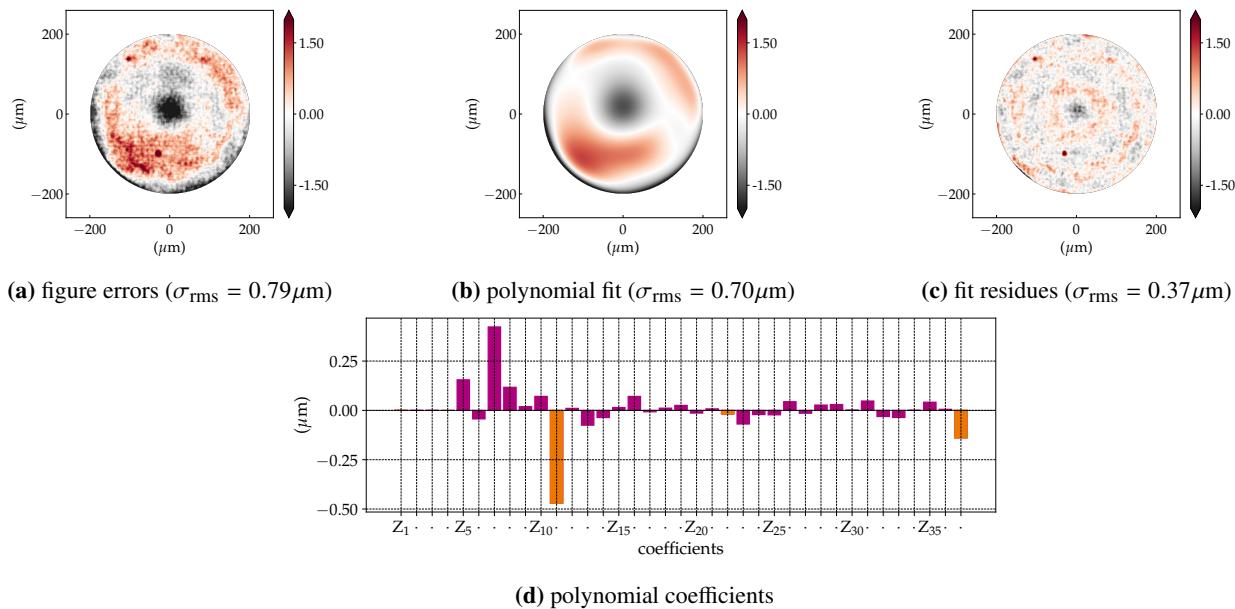
(c) R vs. aperture size

**Fig. 3.** (a) figure errors 2D distribution in  $\mu\text{m}$ , (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.

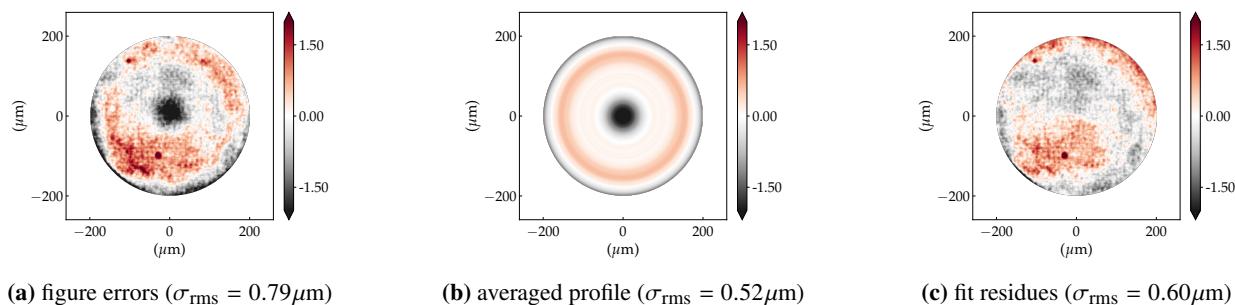


**Fig. 4.** Fourier transform of (a) an idealised aperture and (b) of the aberrated profile.  
(c) power spectrum density of orthogonal cuts at  $x = 0$  and  $y = 0$ .

### 3. Profile decomposition

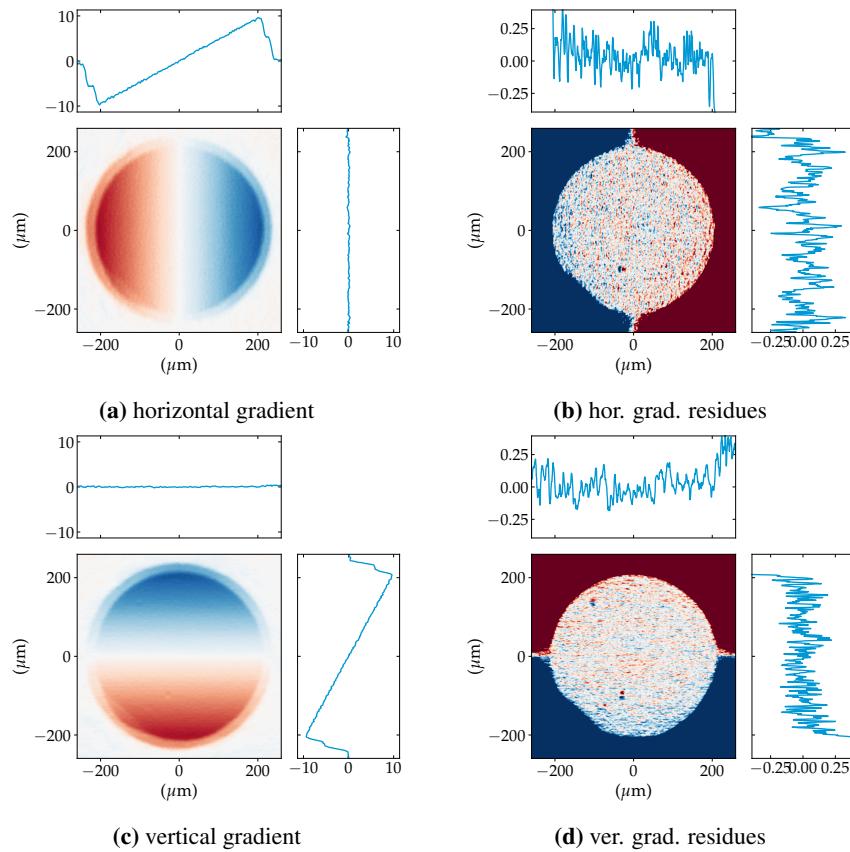


**Fig. 5.** Zernike polynomials decomposition for a circular aperture in  $\mu\text{m}$ . The profiles are related as: (a) figure errors = (b) polynomial fit + (c) residues; (d) coefficients in Noll notation - the orange bars indicate spherical aberrations.



**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  $\mu\text{m}$ .

#### 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  $\mu\text{rad}$ .

#### 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.

