AiryLab. 12 impasse de la Cour, 83560 Vinon sur Verdon

Rapport de mesure

Référence	2012-22001
Date	23/05/2012
Opérateur	FJ
Procédure de mesure	SC-DP
Haso	HA-4333
LIP	LI-1028
Objectif(s)	MOD32 6,4
Miroir	RS-530

Client	***
Type d'optique	Dall Dirkham corrigé
Fabricant	Orion Optics UK
Nom/modèle	ODK16
S/N	***

Longueur d'onde
473
543
635
805

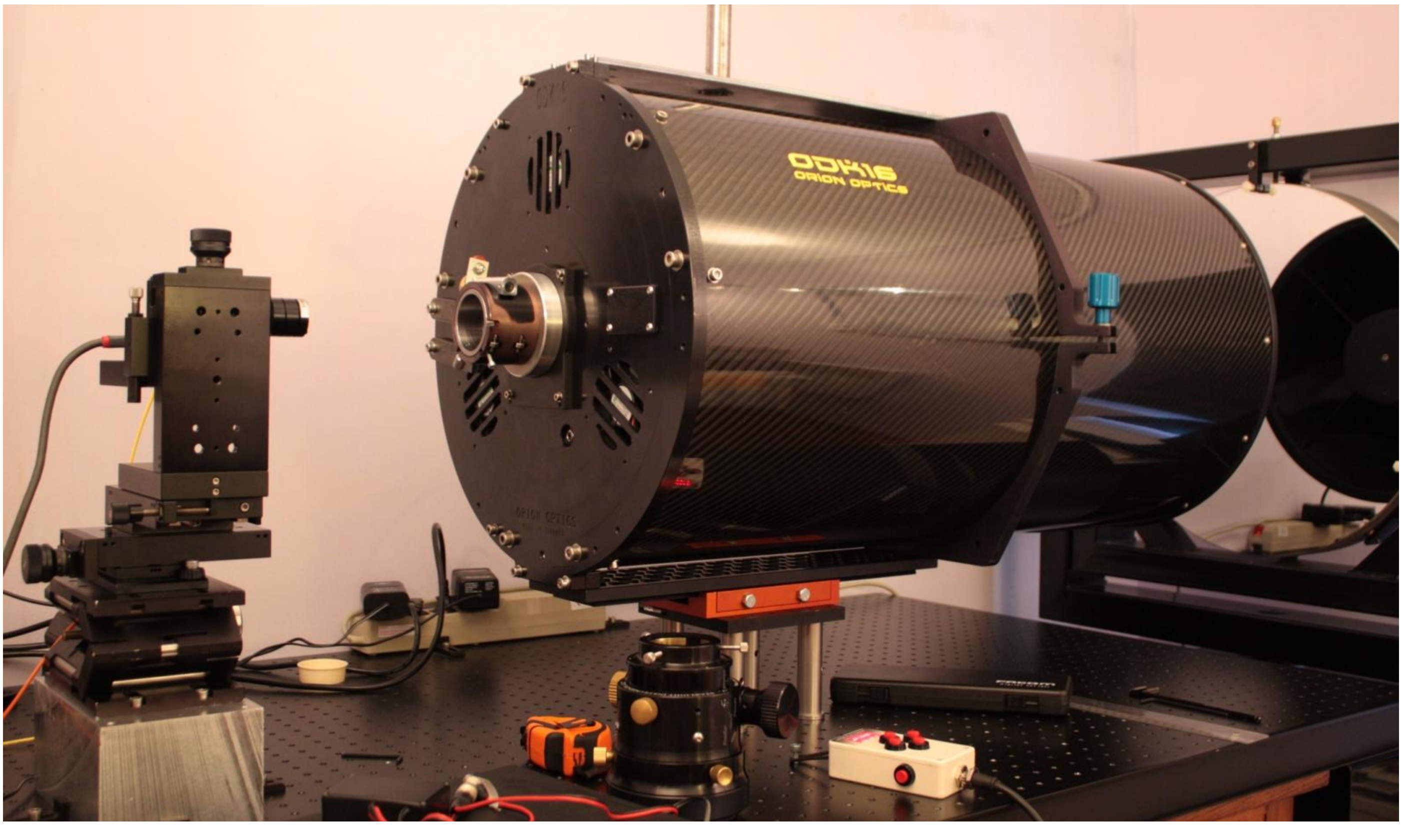
Termes d'aberration pris en compte dans les résultats	
Tilt X	
Tilt Y	
Focus	
Astig 0°	
Astig 45°	
Coma 0°	
Coma 90°	
Sphérique	

Incertitude PTV	9,86 / 5,45 nm
Incertitude RMS	0,6 / 0,54 nm
Interpolation	X2
Mode	Zonal + modal
référence	Oui
Mesures moyennées	200
Double passage	Oui
température	24°
Sous pupilles	-
Conjugaison de pupille	Oui

Essais réalisés	
Centrage sur l'axe(1)	RA
Mesure sur l'axe	Oui
Mesure chromatisme	Non
Mesure sur mécanique	Oui
Alignement optique (« collimation »)	Oui
Mesure dans le champ	Non
Courbure de champ	Non
Système correcteur	Non
Conjugaison	∞ Foyer

(1) : RR rétroréflexion laser HENE, RA réduction des aberrations de champ.

Sommaire



1 Theorical data

Focal length : 2720. Aperture : 400mm.

Aperture F number : 6,8

Diamètre théorique de la tâche de diffraction :

Focale	2720
Diamètre	400
Longueur d'onde	Taille PSF µm
635	10,54
543	9,01
473	7,85

Fréquences théoriques de coupure de la fonction de transfert de modulation (MTF) en cycles/mm

Focale	2720
Diamètre	400
Longueur d'onde	Coupure
635	231,59
543	270,83
473	310,91

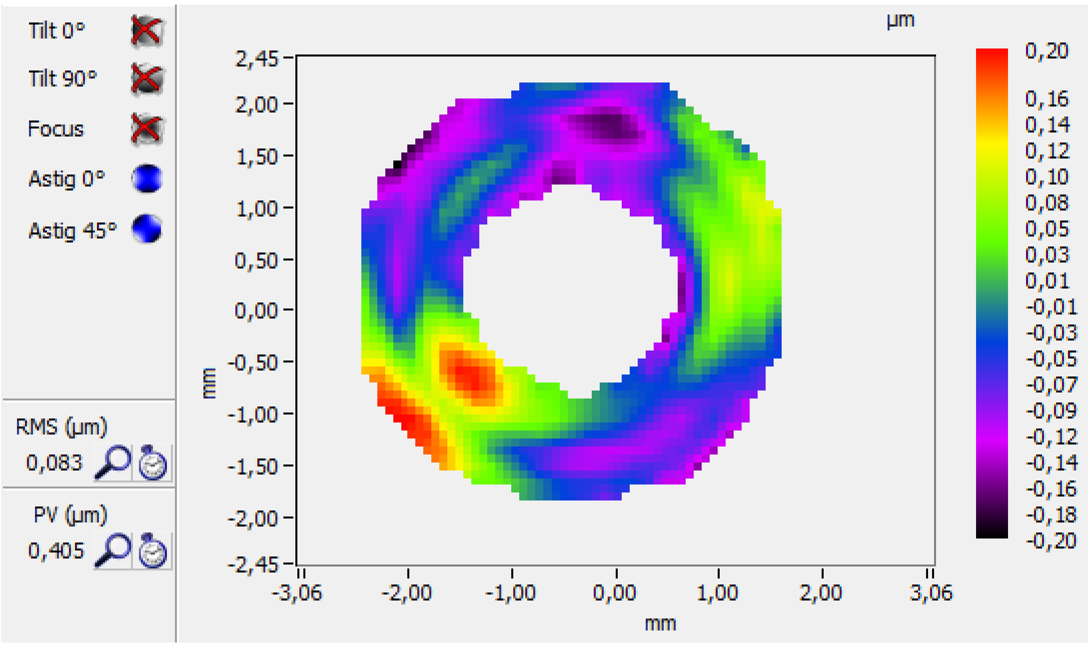
2 Manufacturer test result

Test performed at 632nm (HENE).
PTV : 96nm (L/6.5)
RMS : 15nm (L/41)

3 Measure at 261mm back focus distance, 635nm

Optical alignment by secondary mirror tilts X/Y.

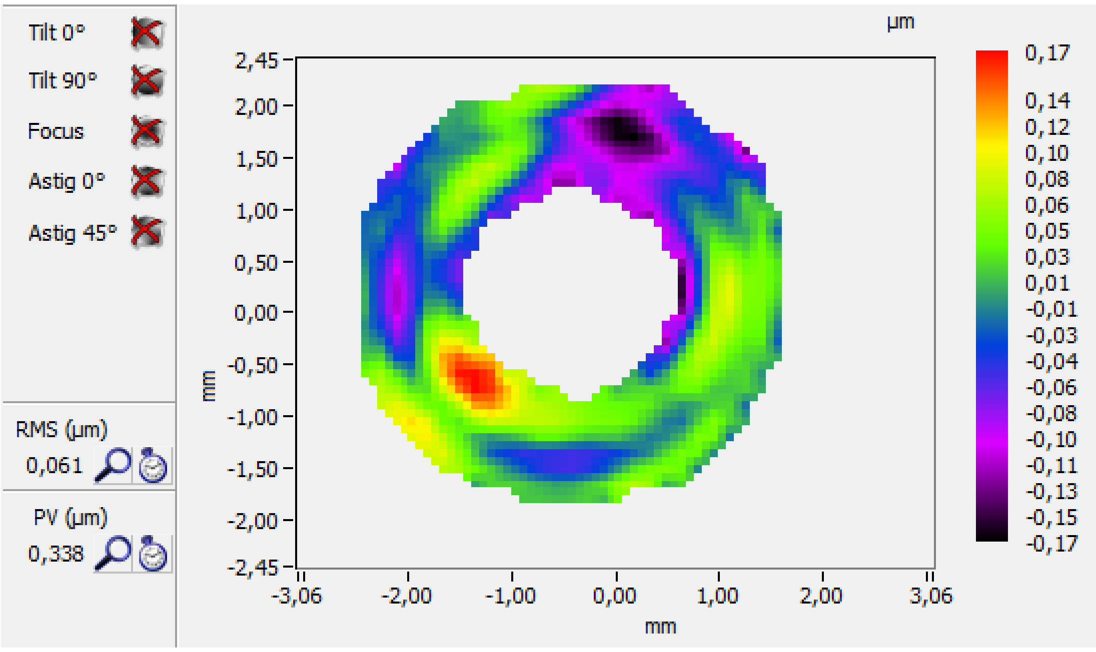
3.1 WFE



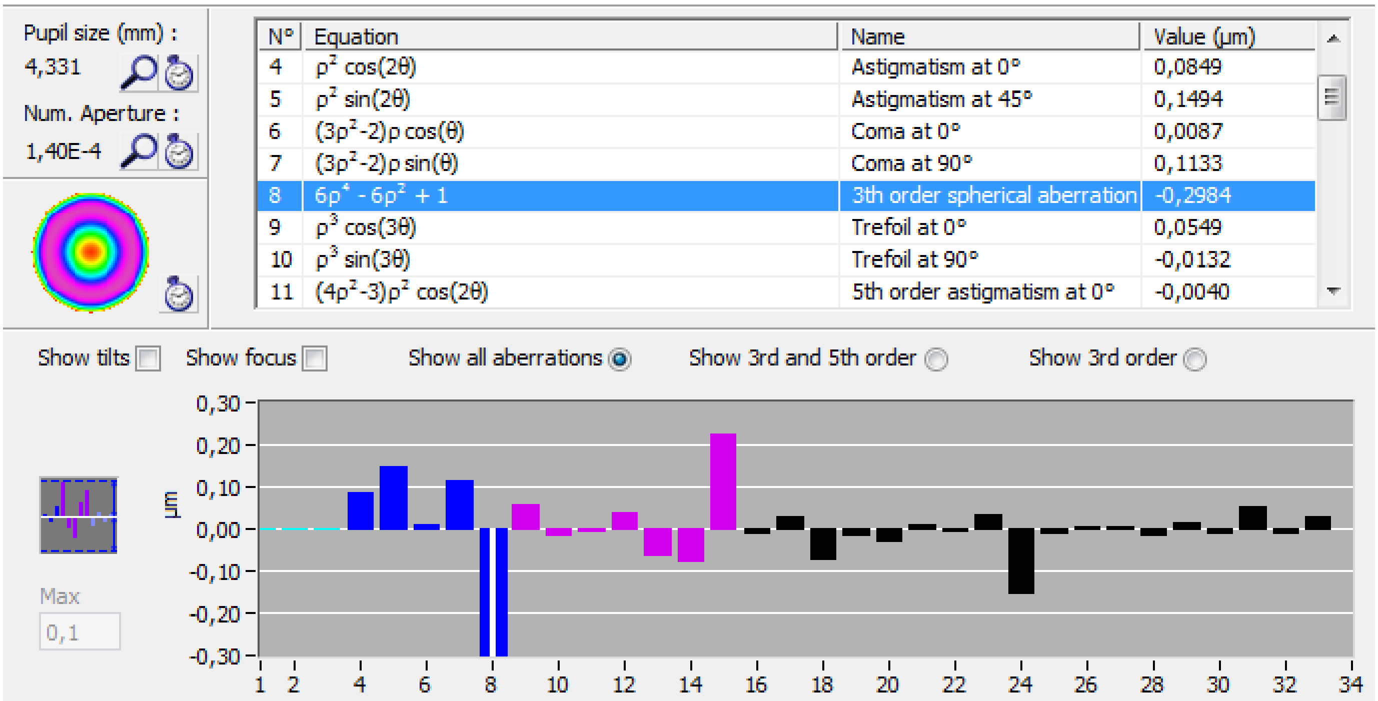
Note : the WFE shows a 3rd order astigmatism that may be due to the horizontal position that could deform the primary mirror (saddle). It is impossible to determine the real cause for this aberration.

Therefore in the rest of the analysis this 3rd order astigmatism is ignored.

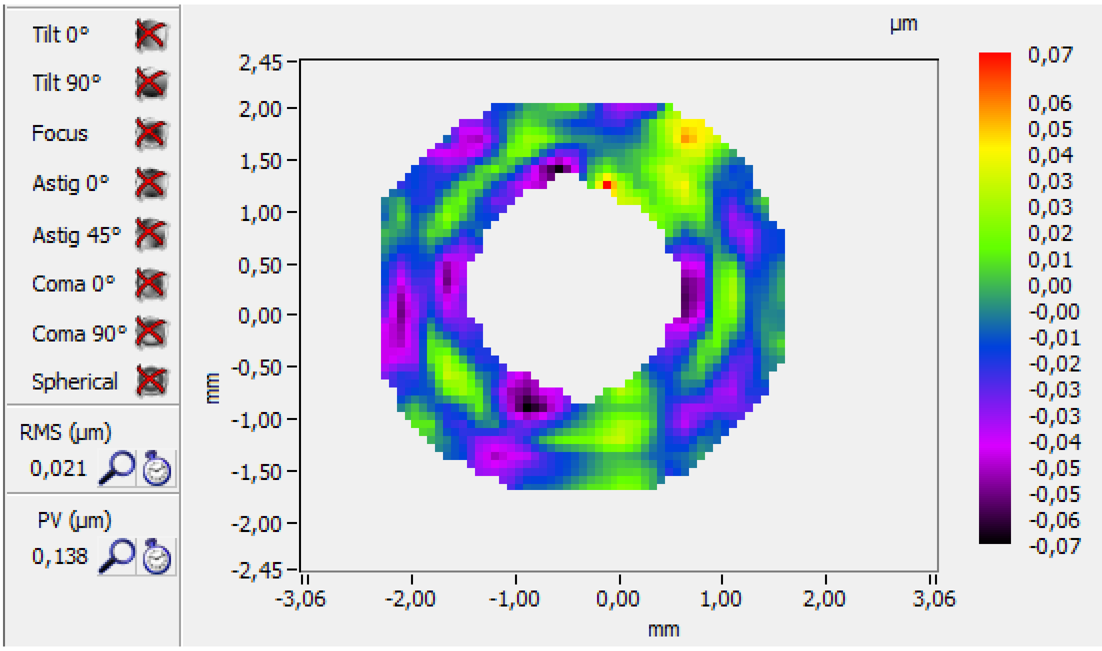
WFE without 3rd order Astigmatism :



The main contributor are the 3rd and 5rd order spherical aberration (Z8 and Z15) as show in the Zernike polynomial fit :



3.2 Residual WFE without 3/5/7 orders



This last WFE shows some typical round zone defects.

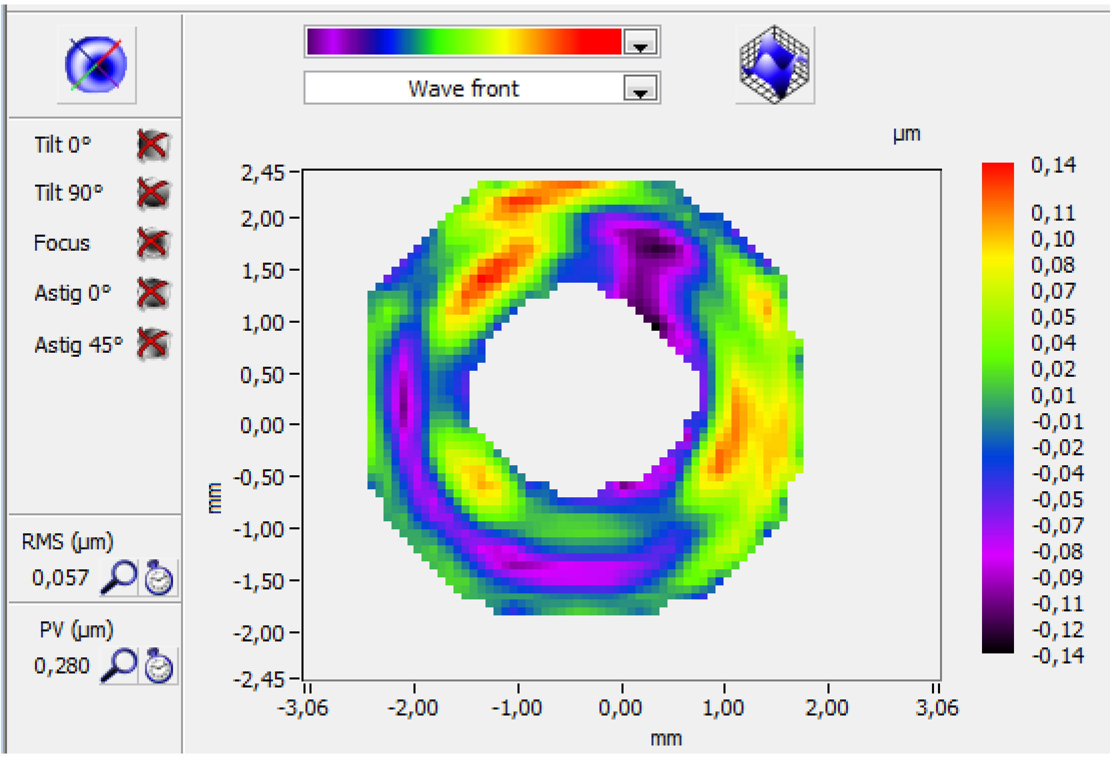
We can benchmark with the results Airylab usually gets depending on telescope type:

- Industrial telescope : 80 to 140nm
- Hand finished / High end product : 50 to 80nm
- High end refractor / ion beam or magneto-rheological grinding : 15 to 30nm

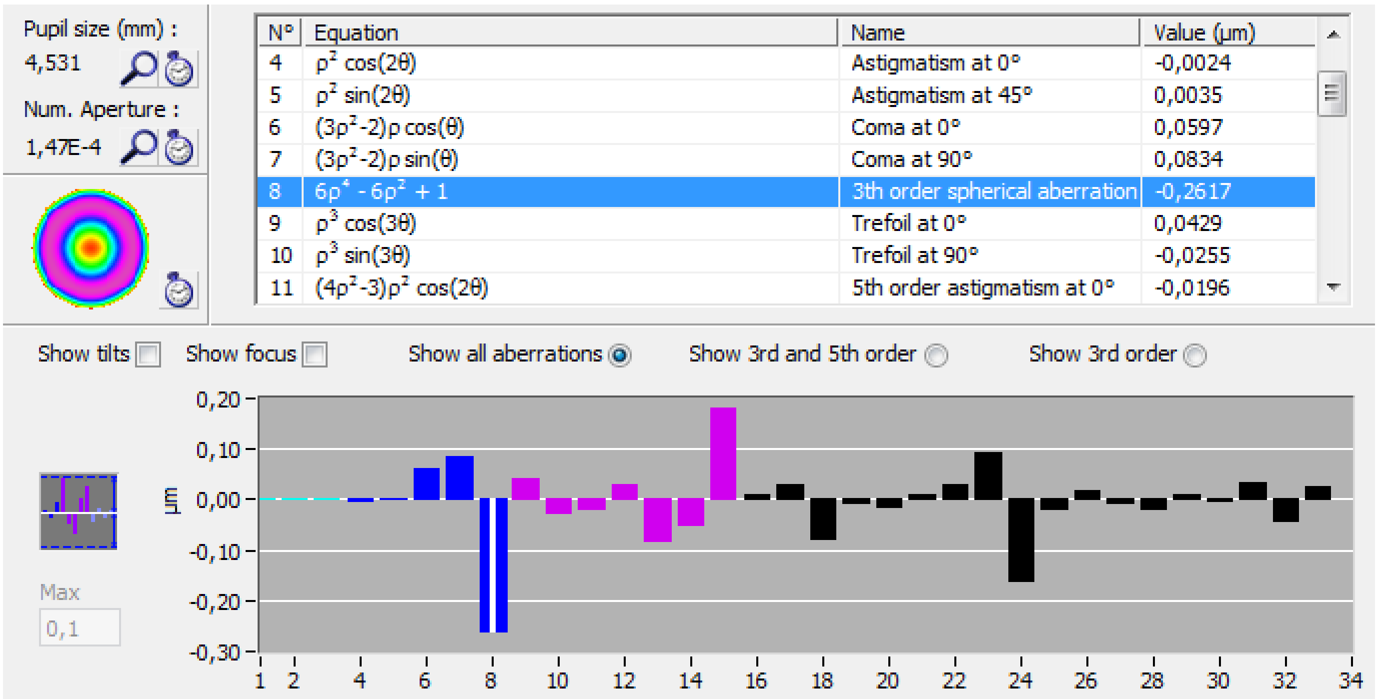
4 Measure at 248mm back focus distance, 635nm

We increase M2 - M1 distance to minimize the spherical aberration

4.1 WFE



4.2 Zernike polynomial fit



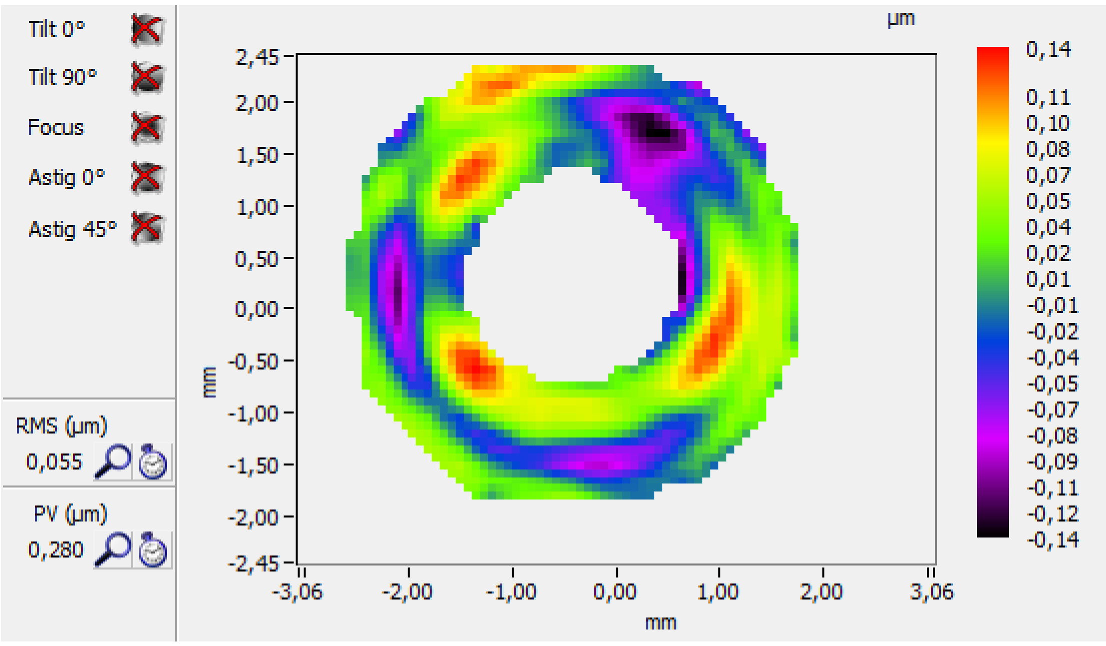
N°	Equation	Name	Value (µm)
4	$\rho^2 \cos(2\theta)$	Astigmatism at 0°	-0,0024
5	$\rho^2 \sin(2\theta)$	Astigmatism at 45°	0,0035
6	$(3\rho^2-2)\rho\cos(\theta)$	Coma at 0°	0,0597
7	$(3\rho^2-2)\rho\sin(\theta)$	Coma at 90°	0,0834
8	$6\rho^4 - 6\rho^2 + 1$	3th order spherical aberration	-0,2617
9	$\rho^3 \cos(3\theta)$	Trefoil at 0°	0,0429
10	$\rho^3 \sin(3\theta)$	Trefoil at 90°	-0,0255
11	$(4\rho^2-3)\rho^2 \cos(2\theta)$	5th order astigmatism at 0°	-0,0196

5 Measure at 233mm backfocus distance

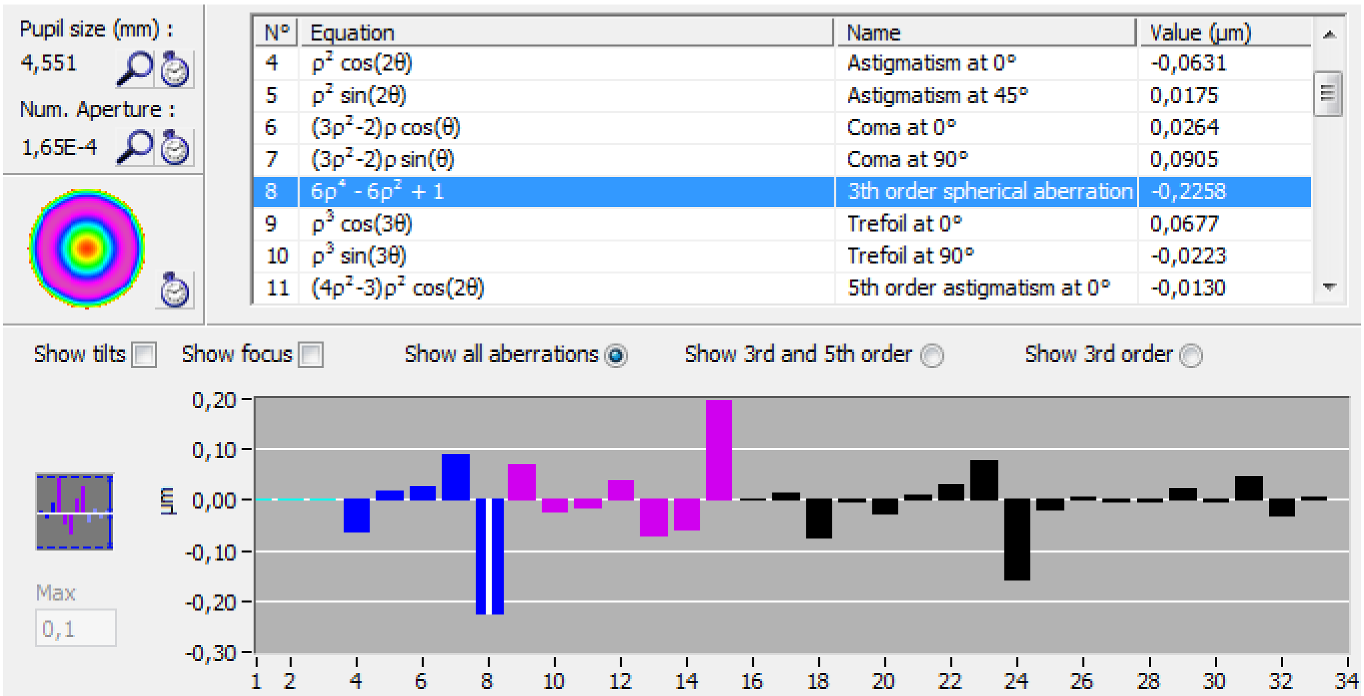
M1/M2 distance is further increased to the minimum back focus the end user can use with a binocular.

5.1 635nm (Red)

5.1.1 WFE

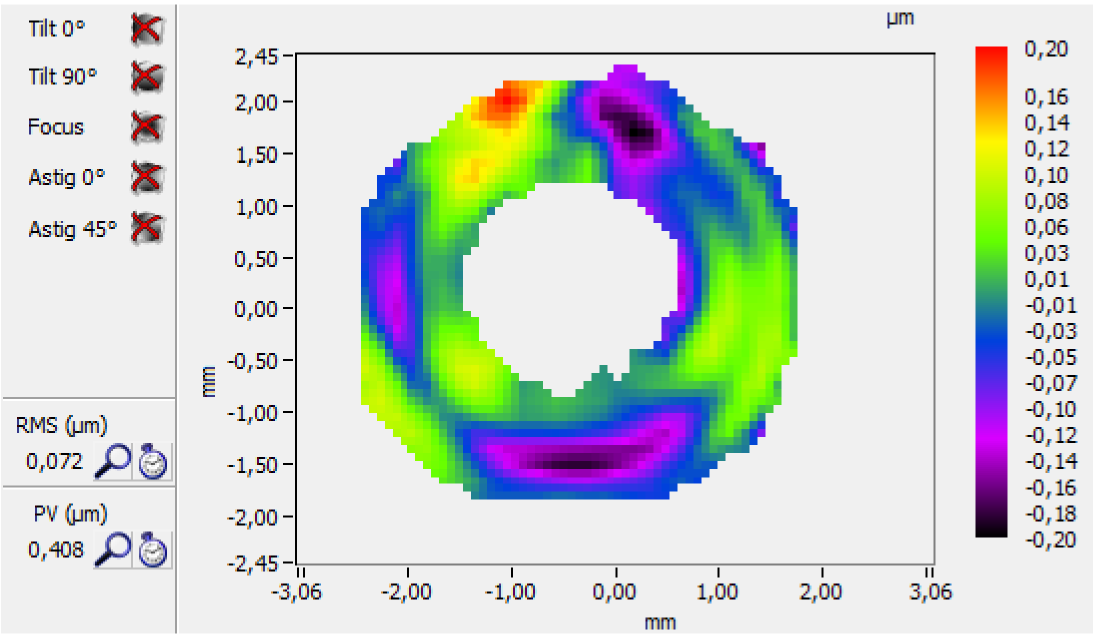


5.1.2 Zernike polynomial fit

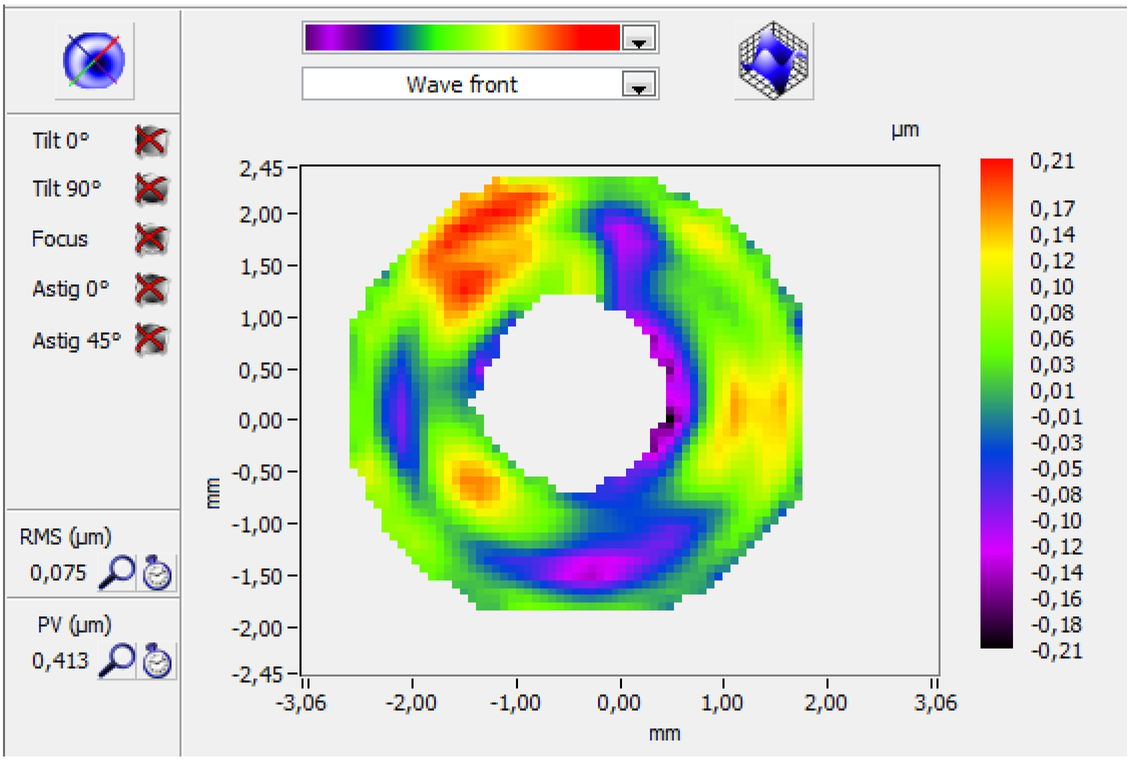


N°	Equation	Name	Value (µm)
4	$\rho^2 \cos(2\theta)$	Astigmatism at 0°	-0,0631
5	$\rho^2 \sin(2\theta)$	Astigmatism at 45°	0,0175
6	$(3\rho^2-2)\rho\cos(\theta)$	Coma at 0°	0,0264
7	$(3\rho^2-2)\rho\sin(\theta)$	Coma at 90°	0,0905
8	$6\rho^4 - 6\rho^2 + 1$	3th order spherical aberration	-0,2258
9	$\rho^3 \cos(3\theta)$	Trefoil at 0°	0,0677
10	$\rho^3 \sin(3\theta)$	Trefoil at 90°	-0,0223
11	$(4\rho^2-3)\rho^2 \cos(2\theta)$	5th order astigmatism at 0°	-0,0130

5.2 543nm (Green)



5.3 473nm (Blue)



6 Conclusion

The best result we obtained by increasing the M1/M2 distance to reduce the 3rd order spherical aberration is a wave front error of 280nm PTV and 55nm RMS.

Main contributors are

- **Astigmatism**. It is difficult to be sure of its origin (real surface error, M1 saddle deformation, mechanical constraint over M1 or M2, corrector lens constraint…).
- **3r^{d} and 5th order spherical aberration** due to a design implementation issue (bad working distance of a component or bad conic constant of the primary and/or secondary mirror). A part of the high order SA may come from the ring shaped zone error (see below)
- **Zones errors** ring shaped (probably due to the grinding process) with high PTV module

The 3rd order spherical aberration error evolution along the backfocus shows that it would be nulled for a value about 150mm. Nevertheless a high fifth order spherical aberration would still be present.