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

Rapport de mesure

Référence	2012-19001
Date	02/05/2012
Opérateur	FJ
Procédure de mesure	SC-DP
Haso	HA-4333
LIP	LI-1028
Objectif(s)	MOD32-4 / 6,4
Miroir	RS-530

Client	xxx
Type d'optique	Dall Dirkham corrigé
Fabricant	Orion Optics UK
Nom/modèle	ODK20
S/N	xxx

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 Données théoriques

Focale : 3400mm. Pupille annoncée : 500mm.

Nombre d'ouverture : 6,8

Diamètre théorique de la tâche de diffraction :

Focale	3400
Diamètre	500
Longueur d'onde	Taille PSF µm
635	10,54
543	9,01
473	7,85

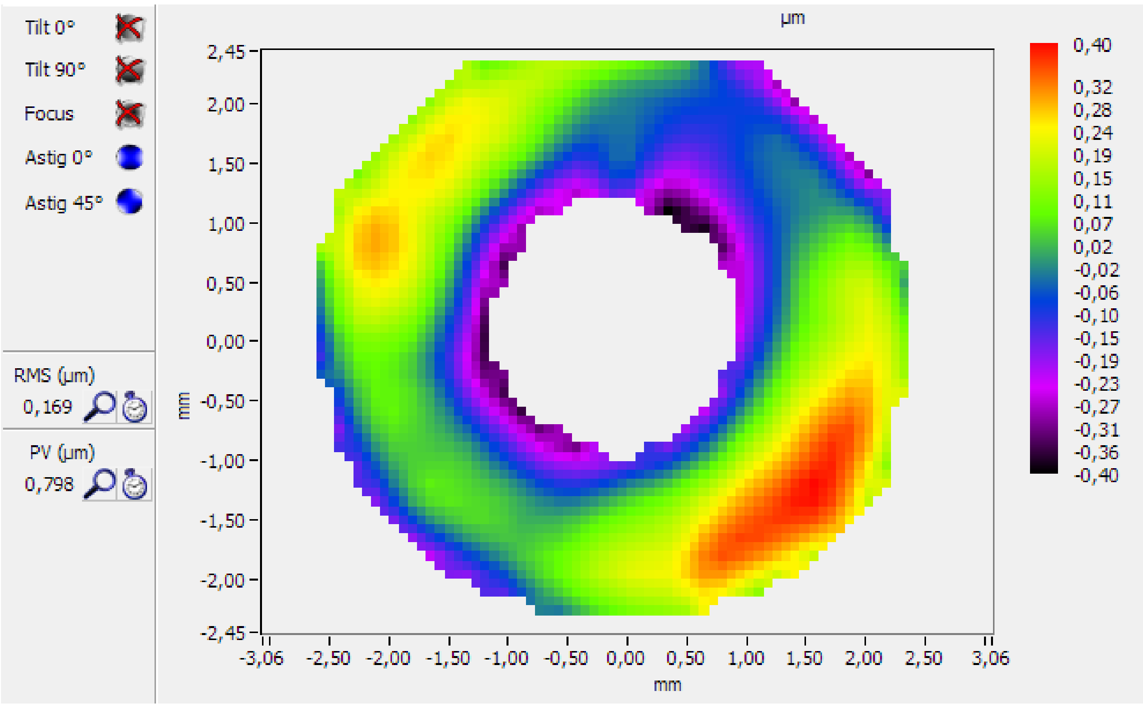
Fréquences théoriques de coupure de la fonction de transfert de modulation (MTF) en cycles/mm

Focale	3400
Diamètre	500
Longueur d'onde	Coupure
635	231,59
543	270,83
473	310,91

2 Measure at 186mm backfocus distance, 635nm

Optical alignment by secondary mirror tilt X/Y.

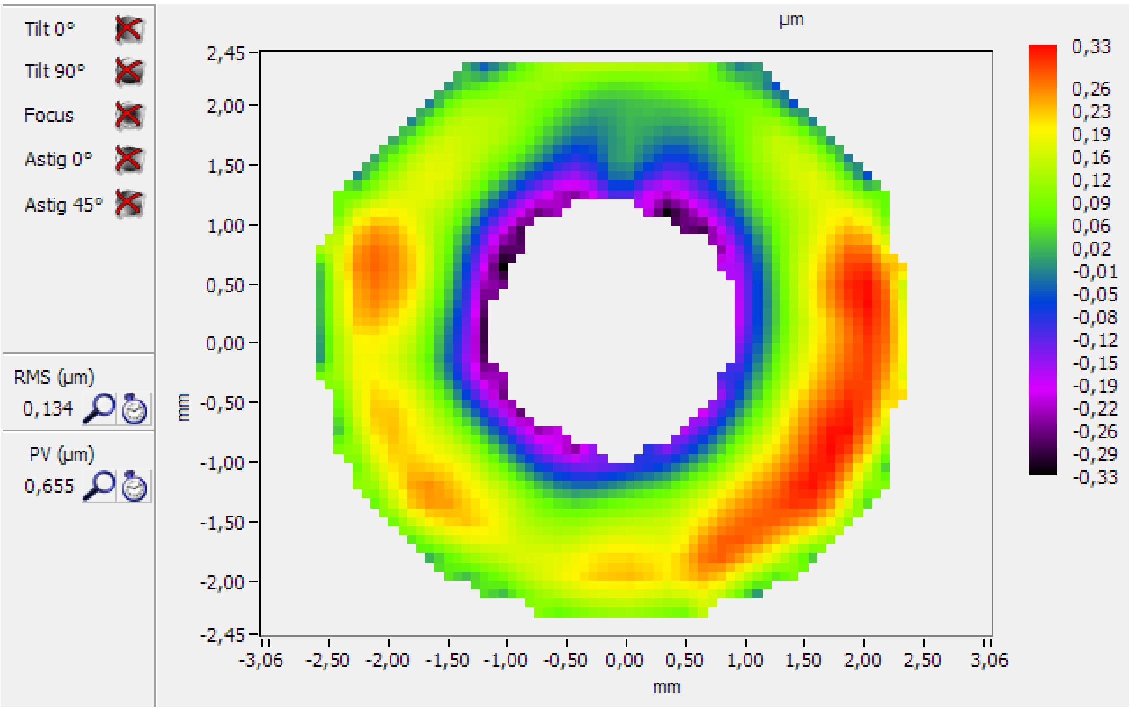
2.1 WFE



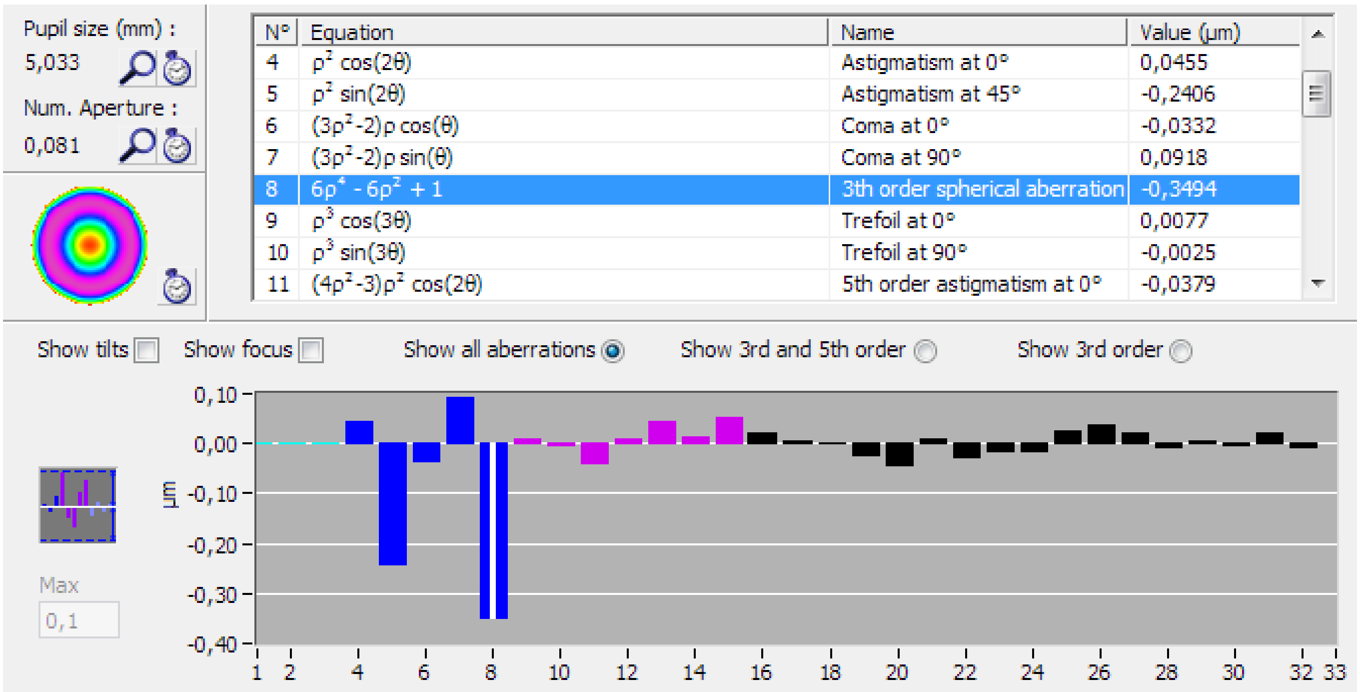
Note : the WFE shows a strong 3rd order astigmatism that <u>may be</u> due to the horizontal position that could deform the primary mirror (saddle).

<u>Therefore in the rest of the analysis this 3rd order astigmatism is ignored.</u>

WFE without 3rd order Astigmatism :

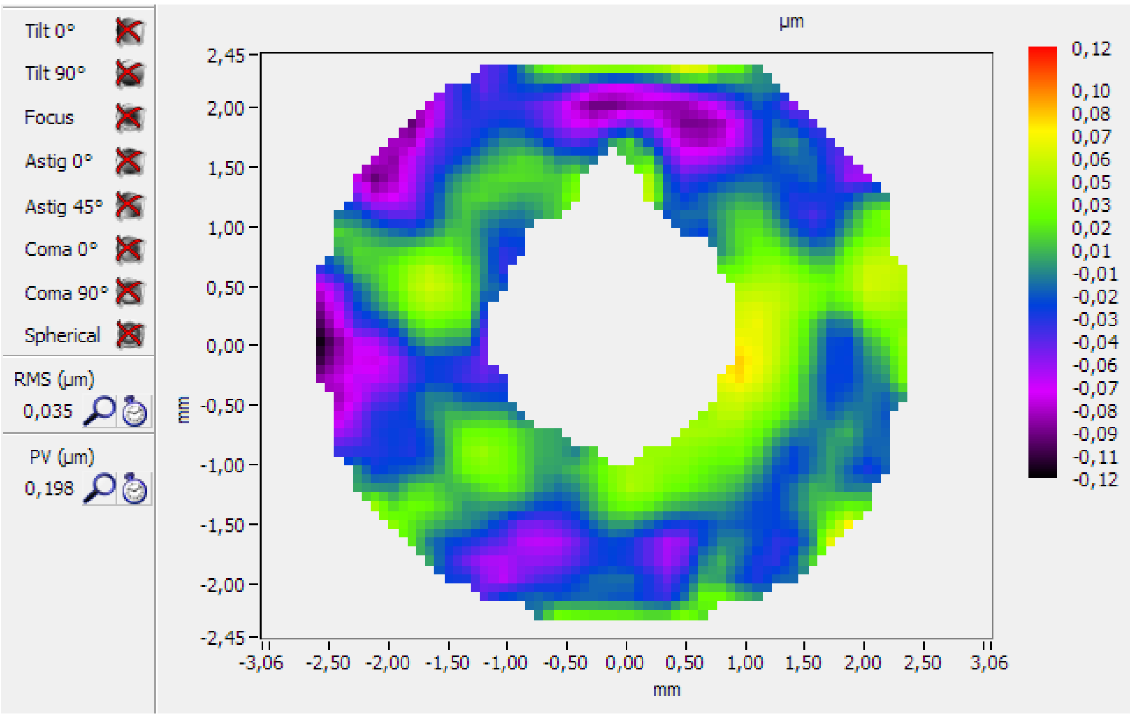


The main contributor is the 3rd order spherical aberration as show in the Zernike polynomial fit :

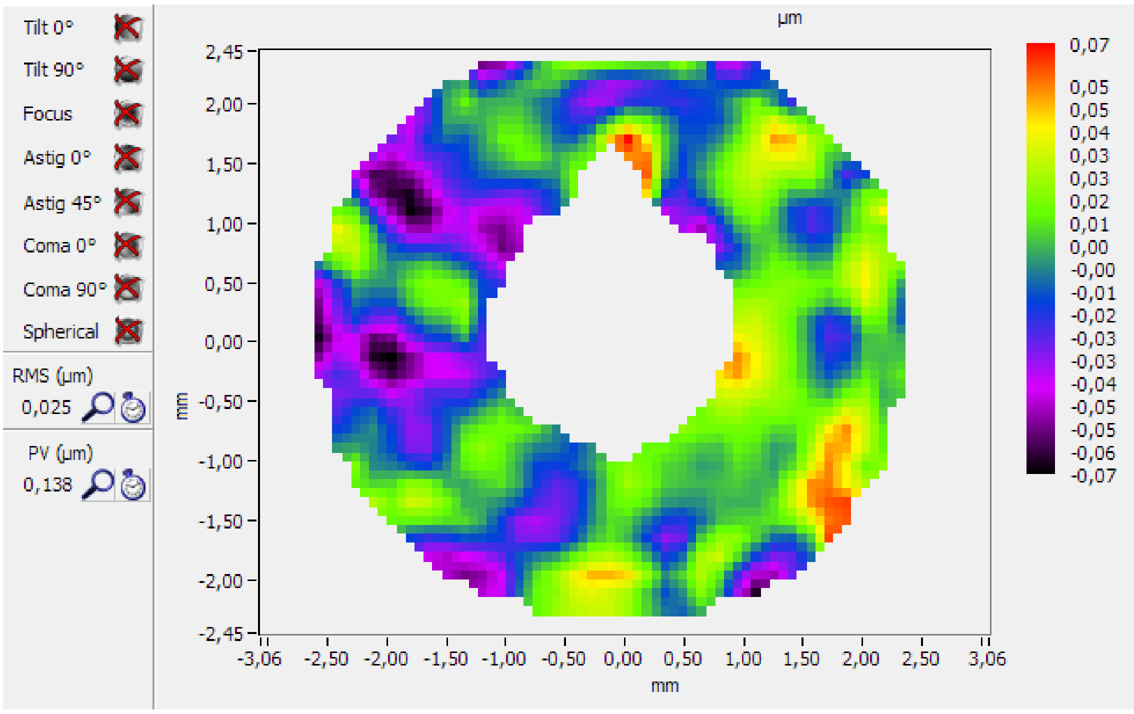


N°	Equation	Name	Value (µm)
4	$\rho^2 \cos(2\theta)$	Astigmatism at 0°	0,0455
5	$\rho^2 \sin(2\theta)$	Astigmatism at 45°	-0,2406
6	$(3\rho^2-2)\rho\cos(\theta)$	Coma at 0°	-0,0332
7	$(3\rho^2-2)\rho\sin(\theta)$	Coma at 90°	0,0918
8	$6\rho^4 - 6\rho^2 + 1$	3th order spherical aberration	-0,3494
9	$\rho^3 \cos(3\theta)$	Trefoil at 0°	0,0077
10	$\rho^3 \sin(3\theta)$	Trefoil at 90°	-0,0025
11	$(4\rho^2-3)\rho^2 \cos(2\theta)$	5th order astigmatism at 0°	-0,0379

2.2 WFE without 3rd order terms



2.3 Residual WFE without 3/5/7 orders



This last WFE shows some zone defects.

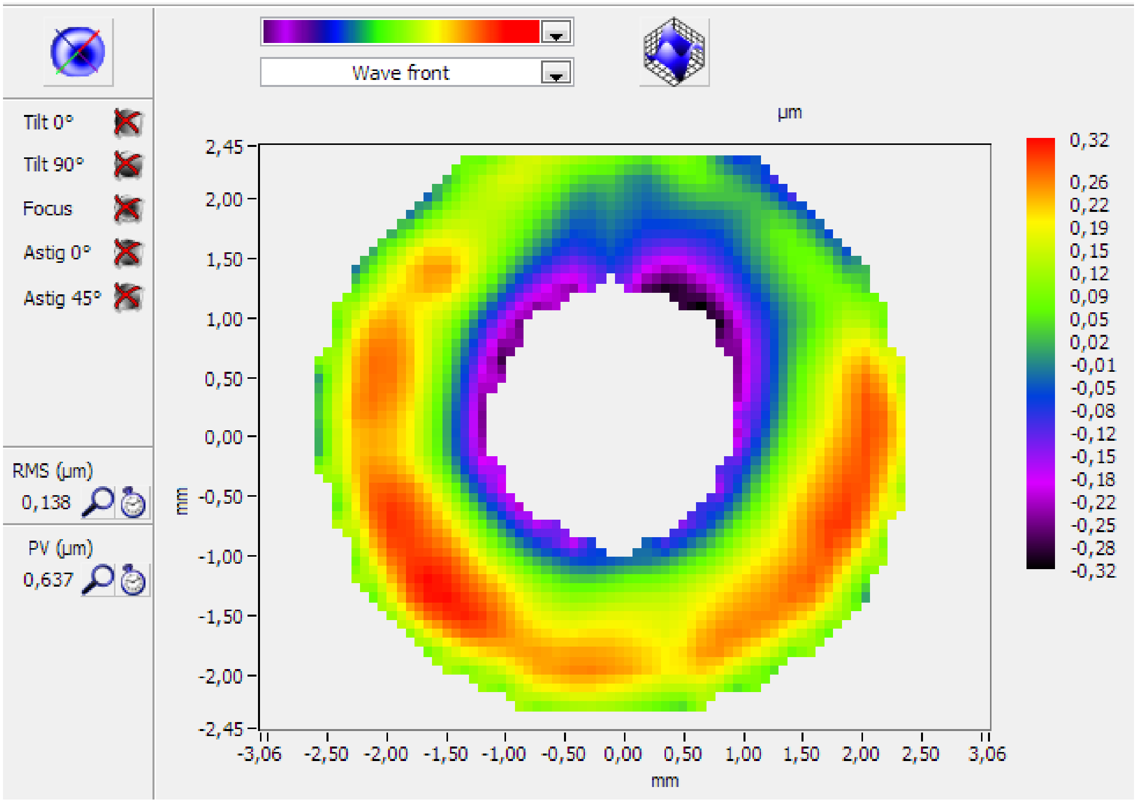
We can benchmark with the results Airylab usually gets depending on telescope type :

- 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

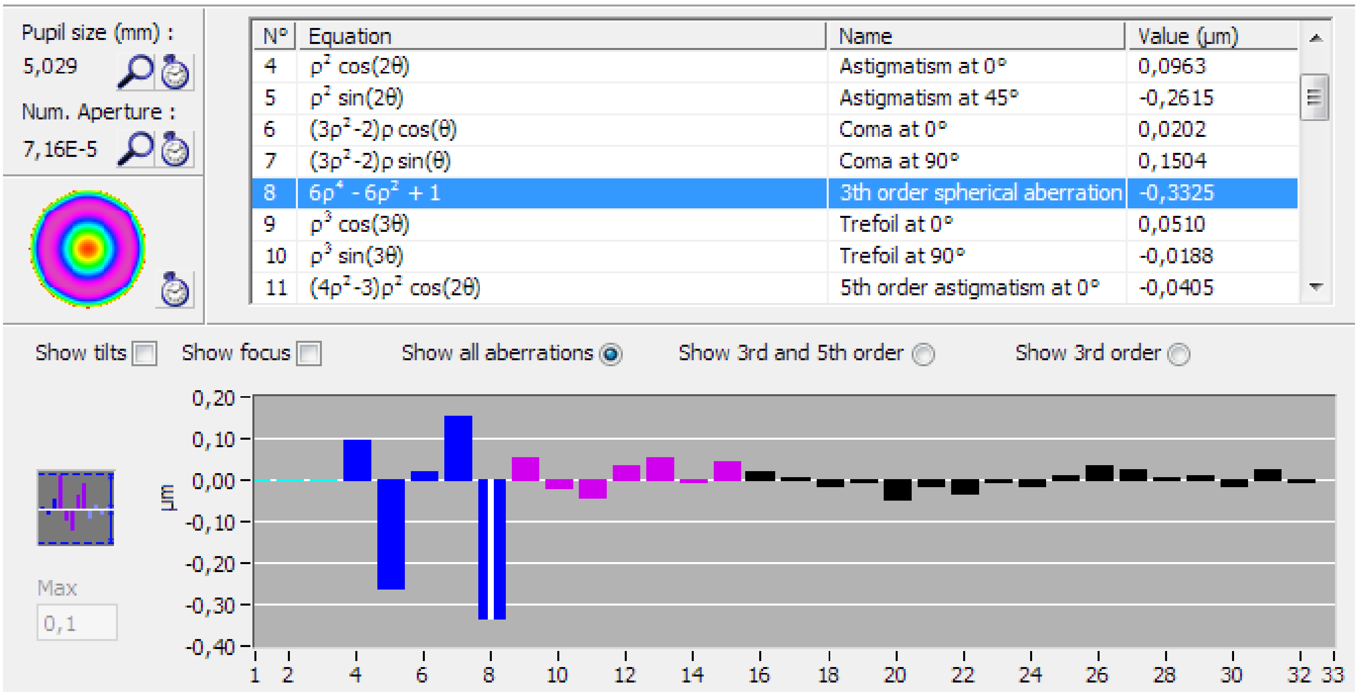
3 Measure at 183mm backfocus distance, 635nm

After a contact with the supplier Orion Optics we reduced the backfocus distance by increasing the M1/M2 distance.

3.1 WFE



3.2 Zernike polynomial fit

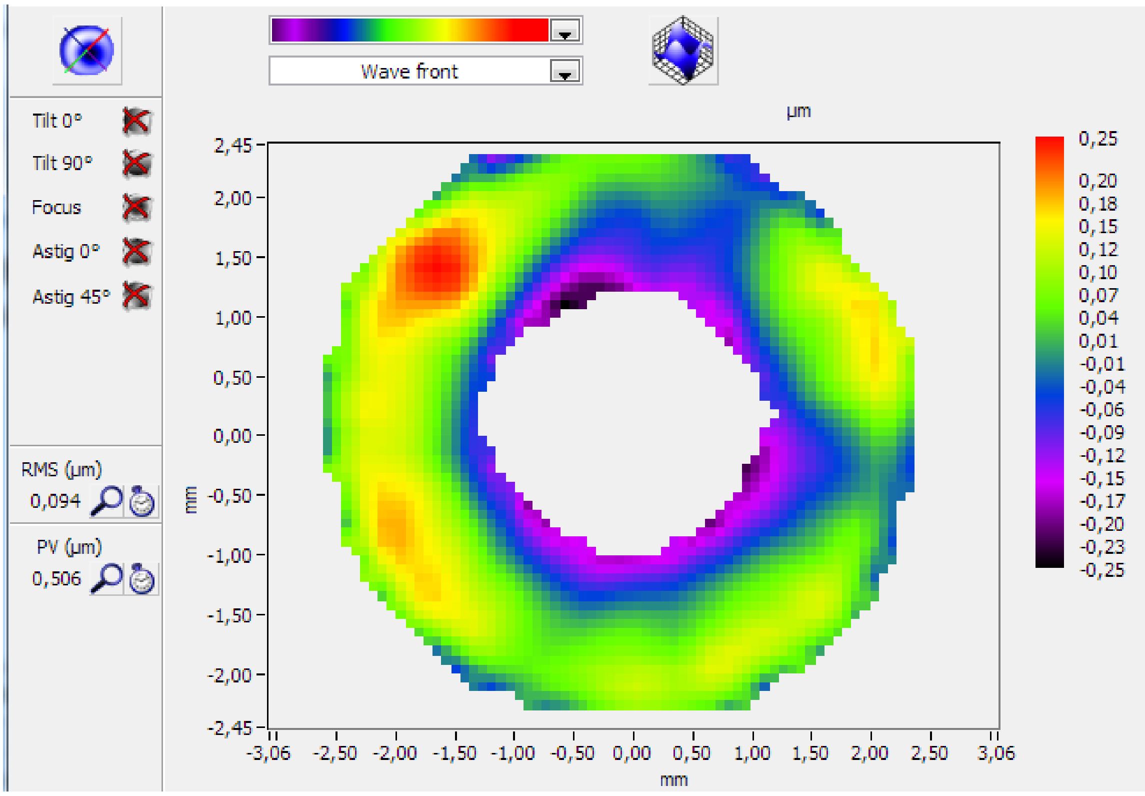


N°	Equation	Name	Value (µm)
4	$\rho^2 \cos(2\theta)$	Astigmatism at 0°	0,0963
5	$\rho^2 \sin(2\theta)$	Astigmatism at 45°	-0,2615
6	$(3\rho^2-2)\rho \cos(\theta)$	Coma at 0°	0,0202
7	$(3\rho^2-2)\rho \sin(\theta)$	Coma at 90°	0,1504
8	$6\rho^4 - 6\rho^2 + 1$	3th order spherical aberration	-0,3325
9	$\rho^3 \cos(3\theta)$	Trefoil at 0°	0,0510
10	$\rho^3 \sin(3\theta)$	Trefoil at 90°	-0,0188
11	$(4\rho^2-3)\rho^2 \cos(2\theta)$	5th order astigmatism at 0°	-0,0405

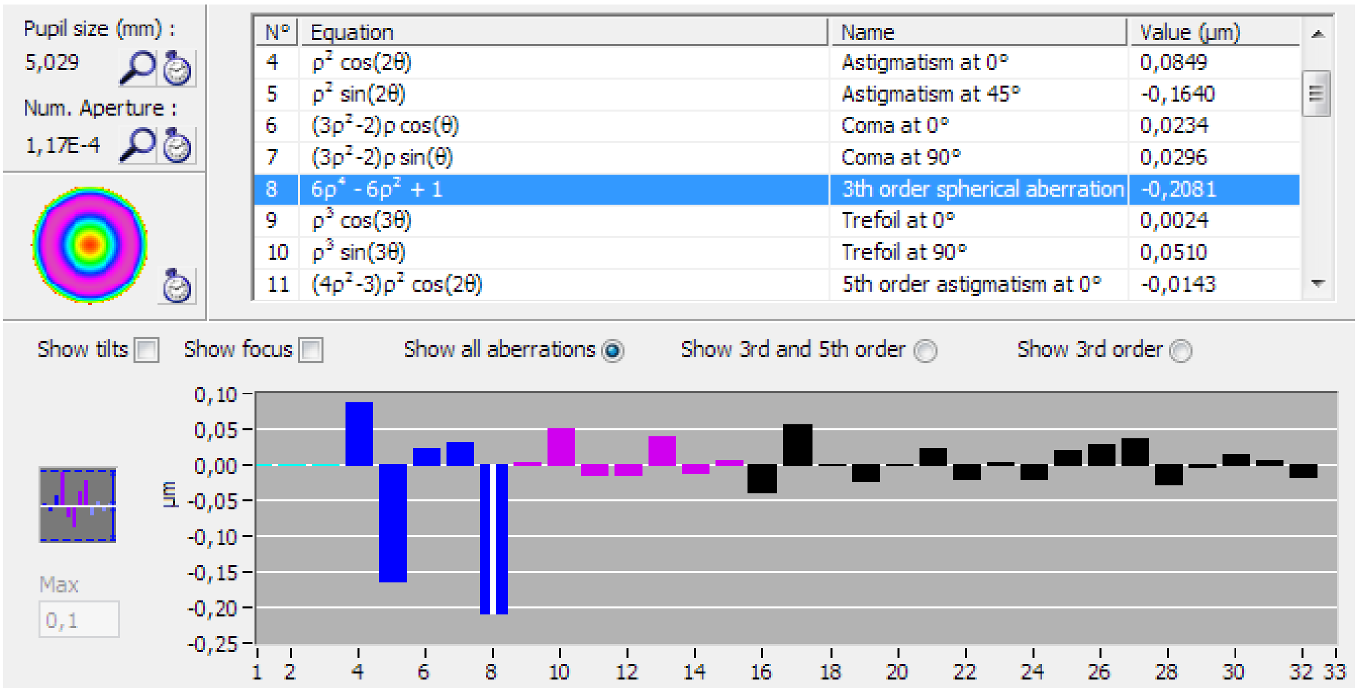
4 Measure at 164mm backfocus distance, 635nm

M1/M2 distance is further increased by changing carbon tube position in their plugs (approx 2,5mm) in order to reduce the SA.

4.1 WFE



4.2 Zernike polynomial fit



N°	Equation	Name	Value (µm)
4	$\rho^2 \cos(2\theta)$	Astigmatism at 0°	0,0849
5	$\rho^2 \sin(2\theta)$	Astigmatism at 45°	-0,1640
6	$(3\rho^2-2)\rho \cos(\theta)$	Coma at 0°	0,0234
7	$(3\rho^2-2)\rho \sin(\theta)$	Coma at 90°	0,0296
8	$6\rho^4 - 6\rho^2 + 1$	3th order spherical aberration	-0,2081
9	$\rho^3 \cos(3\theta)$	Trefoil at 0°	0,0024
10	$\rho^3 \sin(3\theta)$	Trefoil at 90°	0,0510
11	$(4\rho^2-3)\rho^2 \cos(2\theta)$	5th order astigmatism at 0°	-0,0143

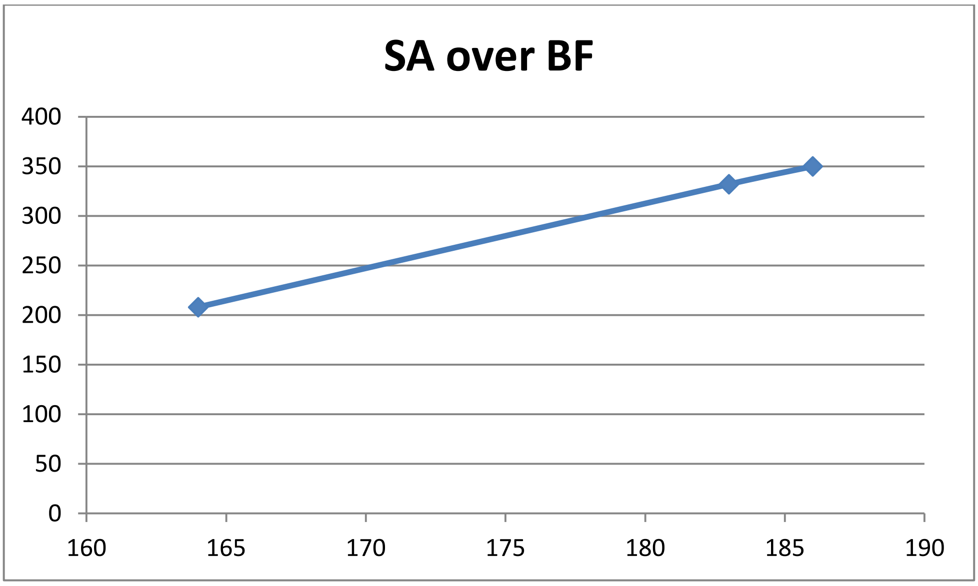
5 Conclusion

The best result we obtained by increasing the M1/M2 distance to reduce the 3rd order spherical aberration is a wave front error of 506nm PTV and 94nm RMS.
This result is far below the minimal quality expected from a 500mm telescope that would be about 200nm PTV (L/2,75 at 550nm).

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…).
- 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).
- Zones errors with high module

The spherical aberration error evolution along the backfocus shows that it would be nulled about 130mm. This value is to close from the metal back to handle an advanced imaging train.



Solving the SA issue may decrease the error to acceptable level if the solution doesn't hinder the field correction.