Effects of differential movements between WFS and Calibration Unit

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Change Record

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1 Scope

This document analizes the aberration introduced by a differential movement between the calibration unit and the WFS. This feature is expected to happen when the environmental conditions change slightly between the calibration and observing time.

2 Applicable documents

No.	Title	Number & Issue
AD 1	ARGOS_FDR_015b_WFS.pdf	
AD 2	ARGOS_FDR_017c_CalOptics.pdf	

3 Introduction

The ARGOS calibration unit is composed by a fast lens that projects three optical fibers directly in the prime focus and onto M2, reproducing the LGS spots in the primary focal plane as sketched in Figure 1. All chromatic aberrations are traced perfectly because a monochromatic light source with the same wavelength as the laser beacons is used. More information on the Calibration Unit system can be found in AD2.

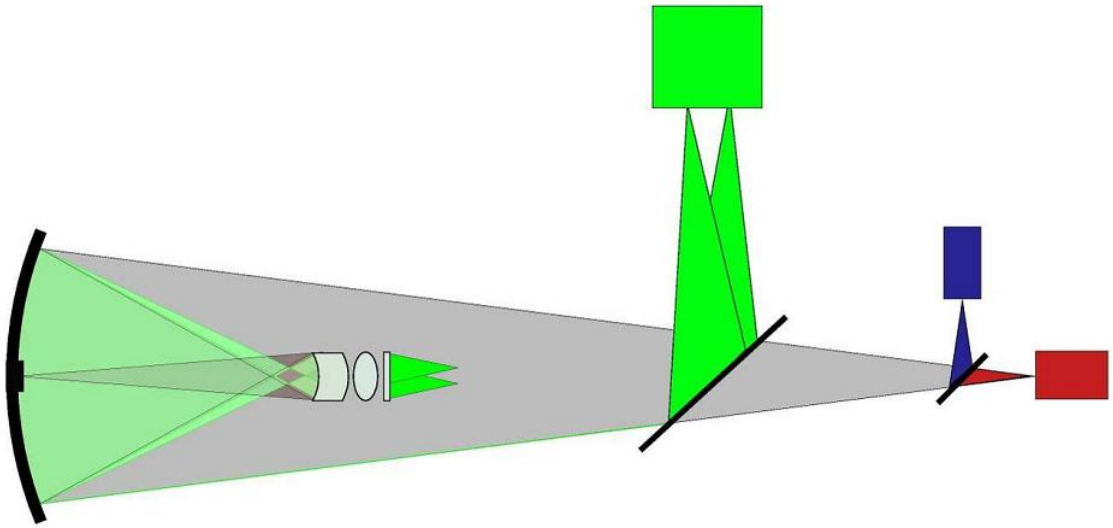

Figure 1. Sketch of the light path and scheme of the calibration method including calibration unit and WFS.

A dedicated swing arm will be constructed to insert the optics into the prime focus volume when needed. After placing the optics below the ASM, the ASM hexapod will be used to do the precise alignment of M2 with respect to the calibration unit optics.

OBJ	Standard		Infinity	Infinity		Infinity		0.000000
1	Atmospheric		Infinity	0.000000		4126.197510		0.000000
2*	Standard	PRIMARIO	-1.920000E+004	-9600.000000	MIRROR	4204.000000	U	-1.000000
3	Standard	F1	Infinity	-1063.700000		0.058748		0.000000
STO*	Standard	SECONDARIO	1974.264540	8413.700000	MIRROR	455.500000	U	-0.732802

Figure 2. Zemax project of the first two mirrors of LBT.

Light coming form a natural source is focussed by the primary mirror of LBT 1063.7mm under M2 (see Figure 2), while a source at 12km distance is focussed at 1055.25mm under M2. To calibrate the ARGOS WFS the hexapod of M2 will be moved to put the mirror at 1055.25mm distance from the calibration unit focus.

The WFS unit is placed aside the LUCIFER focal station, by using a combination of a dichroic plate and a flat folding mirror. The entrance windows of the WFS are placed on the focal plane of a 12km atitude source, at 15218.35mm distance from M2.

4 Differential aberration analisys

To analize the aberration introduced by a differential movement between the calibration unit and the WFS we used a simplified model of the telescope. The model includes only the secondary mirror of LBT and an on-axis point-like source placed in the prime focus of a 12km altitude LGS (see Figure 3).

	Surf:Type	Comment	Radius	Thickness		Glass	Semi-Diameter		Conic
OBJ	Standard	CAL UNIT FOCUS	Infinity	1055.250000			0.000000		0.000000
STO*	Zernike Stan..	M2	-1974.247000	0.000000		MIRROR	455.400000	U	-0.732802
2	Standard	M2 to WFS	Infinity	-1.521835E+004	V		436.063000		0.000000
IMA	Standard	WFS FOCUS	Infinity	-			1.904034		0.000000

Figure 3. Zemax project used to analyze the differential aberrations.

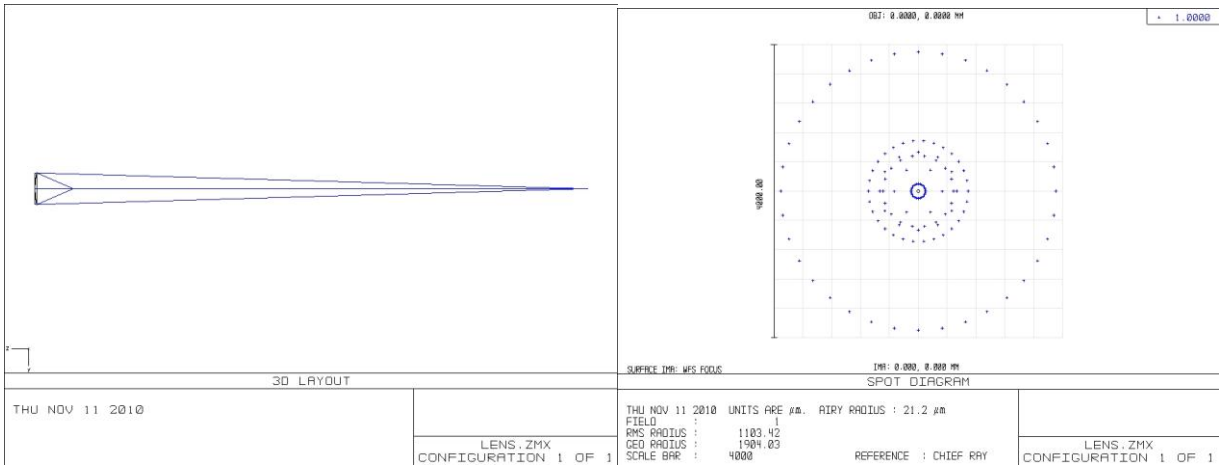

Figure 4. Left: drawning of the setup used to evaluate the aberration introduced by the differential movement of the WFS and calibration unit. Right: spot pattern on the focal plane where the WFS is placed.

We retrieved the focal plane of the 12km altitude source minimizing the rms of the wf error. On this plane the WFS entrance windows will be placed. Values reported in Figure 3 reprensent the nominal position for the elements.
Figure 4 shows a sketch of the setup and the spot pattern on the WFS focal plane. The Zernike coefficients measured on the WFS focal plane are reported in Table 1. All values are expressed in wavelengths (λ=1μm).

We applied a shift in the WFS nominal position of 10mm, consistent with the expected variation of reciprocal position between the WFS and Calibration Unit with a temperature variation of 40°C. We then reoptimized the M2 position to compensate for such a displacement (see Figure 1).
The aberrations measured on the WFS focal plane, expressed in Zernike coefficients, are reported in Table 1. M2 has been moved by 50μm towards the Calibration Unit to compensate for the WFS displacement. The variation in the Zernike coefficients is below 1%.

	Surf:Type	Comment	Radius	Thickness	
OBJ	Standard	CAL UNIT FOCUS	Infinity	1055.250000	
1	Standard	CAL UNIT shift	Infinity	0.000000	
2	Coordinate B..	M2 comp		-0.048917	V
STO*	Zernike Stan..	M2	-1974.247000	0.000000	
4	Coordinate B..	M2 comp		0.048917	T
5	Standard	M2 to WFS	Infinity	-1.521835E+004	
6	Standard	WFS shift	Infinity	-10.000000	
IMA	Standard	WFS FOCUS	Infinity	-	

Figure 5. Zemax project showing the positions of the elements when a 10mm displacement is applied to the WFS.

The same analisys has been done shifting the Calibration Unit by 4mm towards M2 and reoptimizing the mirror position to compensate for it (see Figure 6). Again the aberrations measured in the WFS focal plane are reported in Table 1. It is necessary to move M2 almost by the same amount to compensate (~3.99mm), but the differential aberration introduced are less than 1%.

	Surf:Type	Comment	Radius	Thickness	
OBJ	Standard	CAL UNIT FOCUS	Infinity	1055.250000	
1	Standard	CAL UNIT shift	Infinity	-4.000000	
2	Coordinate B..	M2 comp		3.980992	V
STO*	Zernike Stan..	M2	-1974.247000	0.000000	
4	Coordinate B..	M2 comp		-3.980992	T
5	Standard	M2 to WFS	Infinity	-1.521835E+004	
6	Standard	WFS shift	Infinity	0.000000	
IMA	Standard	WFS FOCUS	Infinity	-	

Figure 6. Zemax project showing the positions of the elements when a 4mm displacement is applied to the Calibration Unit.

Table 1. Resume of the aberrations measured on the WFS focal plane before and after a 10mm differential movement is applied.

Z	Nominal value [λ]	10mm WFS dispacement [λ]	4mm Cal. Unit displacement [λ]
1	-4.935	-4.924	-4.907
4	0.047	0.070	0.069
11	2.101	2.113	2.106

5 Effects on the NGS WFS

The compensation with M2 hexapod of the differential movement between the Calibration Unit and the WFS can inject aberrations in the NGS WFS located at the netural star focal plane.
We measured this effect providing our simple Zemax model with an on-axis source, located in the central obstruction of M2. As showed in Figure 1 the light from the fiber is reflected by an elliptic mirror that has

the first focus coincident with the fiber itself and the second one coincident with the primary focus of LBT. The elliptic mirror center is placed 32.42mm under the primary focal plane (see). The optical specifications for the elliptic mirror have been taken from AD2.

	Surf:Type	Comment	Radius	Thickness		Glass	Semi-Diameter		Conic
OBJ	Standard	CAL UNIT FOCUS	Infinity	-1063.700000			0.000000		0.000000
1	Standard		Infinity	-32.419424			13.474552		0.000000
2*	Standard	ELLIPTIC MIRROR	63.000000	0.000000		MIRROR	50.800000	U	-0.885000
3	Standard		Infinity	32.419424	P		14.551521		0.000000
4	Standard		Infinity	1063.700000	P		4.405487E-003		0.000000
5	Standard	CAL UNIT shift	Infinity	0.000000			0.000000		0.000000
6	Coordinate B..	M2 comp		0.000000		-	0.000000		
STO*	Zernike Stan..	M2	-1974.247000	0.000000		MIRROR	455.400000	U	-0.732802
8	Coordinate B..	M2 comp		0.000000	T	-	0.000000		
9	Standard	M2 to WFS	Infinity	-1.521936E+004			0.000000		0.000000
10	Standard	WFS shift	Infinity	0.000000			0.000000		0.000000
11	Standard		Infinity	-1.371369E+004			455.546728		0.000000
IMA	Standard	WFS FOCUS	Infinity	-			7.125102E-003		0.000000

Figure 7. Zemax project used to evaluate the aberrations injected into the NGS WFS while compensating differential movements with M2.

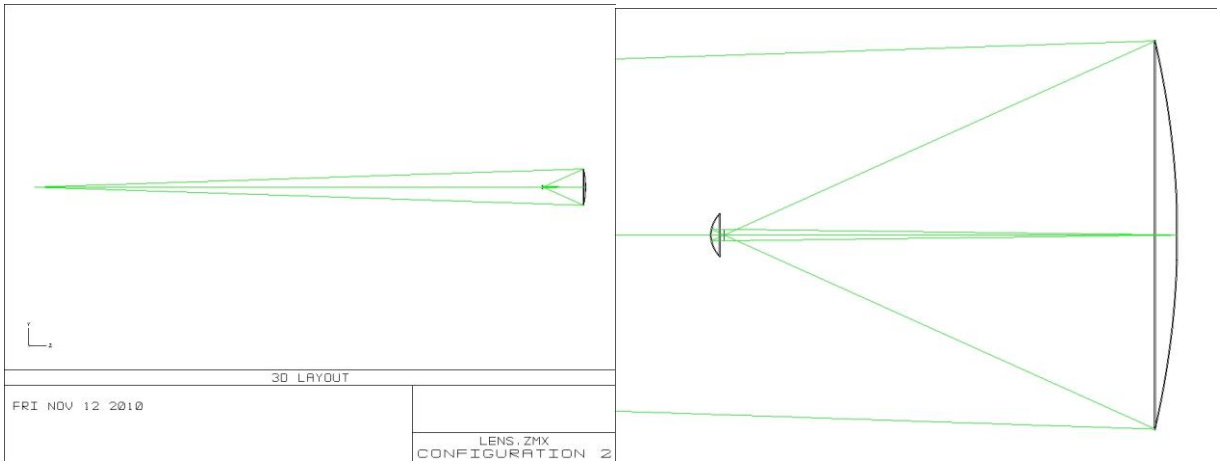

Figure 8. Drawning of the optical setup. Right: particular of the 2 mirrors system.

Figure 9. Spot patterns on the natural star focal plane. Left: when all optics are in their nominal position as indicated in Figure 7. Right: when a 50um shift on M2 has been applied to compensate for a 10mm differential movement between the ARGOS WFS and the Calibration Unit.

The effects of a 50µm shift on the M2 position have been evaluated measuring the aberrations on the NGS focal plane. This shift is sufficent to compensate for a 10mm differential movement between the ARGOS WFS and Calibration Unit. The results are reported in Table 2. All measures are expressed in units of wavelength that is monochromatic and equal to 1µm. It is visible from Table 2 that the aberration injected into the NGS WFS are negligible.

Table 2. Resume of the aberrations injected on the NGS WFS while compensating with M2 the differential movement between the ARGOS WFS and Calibration Unit.

Z	Nominal value [λ]	50µm M2 shift [λ]
1	0.020	-0.012
4	-3.9e-7	4.8e-7
11	-0.009	0.005

6 Conclusions

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