Natural Star light pollution on the WFS images.

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TABLE OF CONTENTS

Change Record

Issue	Date	Section/ Paragraph Affected	Reasons / Remarks	Name
1.0	28.09.2010	all	created	M. Bonaglia

1 Scope

This technical note analyzes the effects of the background Natural Stars (NS) on the WFS images.

2 Applicable documents

No.	Title	Number & Issue
AD 1	http://bscw.mpe.mpg.de/bscw/bscw.cgi/d336362/wfs_v39.ZAR	
AD 2	ARGOS_FDR_015b_Wfs	

3 Introduction

The analysis has been carried out within Zemax, using the WFS optical project available on the BSCW (see AD 1). The ARGOS WFS module is described in detail in the AD 2.

The ARGOS LGS constellation is made of 3 Rayleigh beams. In the present analysis we considered only one of the 3 beams. The telescope is pointing at Zenith and the LGS beam coordinates are [2; 0] arcmin. The LGS is sensed by the Blue arm of the WFS.

4 NS footprint on LGS focal plane

The WFS Entrance Windows (EW) are placed in correspondence of the Rayleigh LGS focal plane. The distance between the NS and LGS focal planes is 1415mm. Figure 1 shows the footprint of a 2arcmin off-axis NGS on the EW.

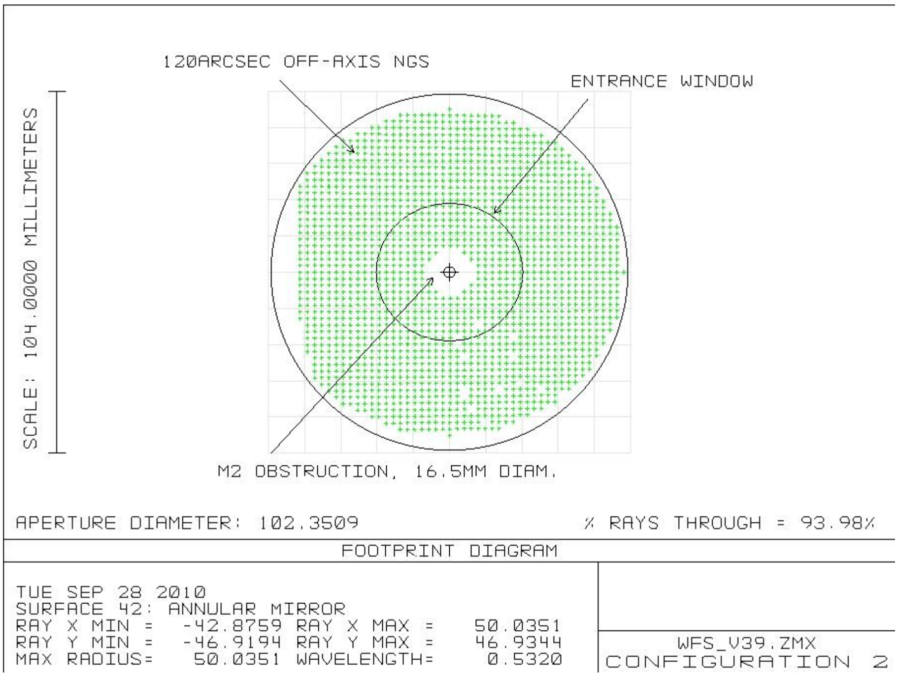

Figure 1. NGS footprint on the blue arm EW. The star coordinates are [2; 0] arcmin.

On the EW, the footprint diameter are 94mm (external) and 16.5mm (central obstruction). Because the plate scale of the f_{15} NGS beam is 0.6mm/arcsec, the "pollution field" that affects the WFS with NGS light is a circular corona of 2.6arcmin external diameter and 0.4arcmin internal diameter, centred on the LGS position. Each natural star in this field will eventually contribute to the WFS pollution.

5 Transmission of the NS to the WFS detector

The EW acts as a field stop for the WFS, the clear aperture of the thru-hole on the reflective first plate of this optical element is 3.1mm. This means that ~0.1% of the light of every star in the "pollution field" will enter the WFS and is totally transmitted up to the WFS detector (see Figure 4). No element in the WFS will vignet the "pollution beam", nor the Pockels cells will, because the incidence angles on the polarizer are within +/-0.8°, independently of the position of the star in the "pollution field".

Figure 2 shows that the "pollution beam" is spread on a small 8x8 pixel area of the detector, same size of a WFS subaperture. No appreciable variation is visible between a 1arcsec FWHM source and a DL one.

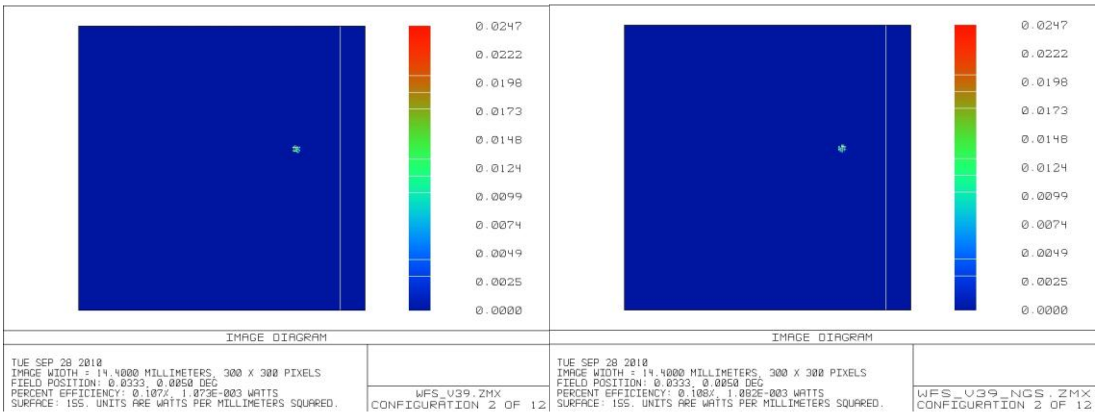

Figure 2. Two images of the NGS spot on the detector. The NGS coordinates are [2.0; 0.3]arcmin, the FWHM are 1arcsec (left) and 0.1arcsec (right). Almost 0.1% of the total NGS flux is imaged on 8x8 pixels on the CCD.

Figure 3 shows the detector area on which is imaged the star light coming from the FoV. For comparison the SH pattern of the blue LGS is showed. The envelope of the pollution field is a circular area of 5.3mm diameter at the bottom of the blue arm. Natural stars at 30arcsec distance fall on the same subaperture.

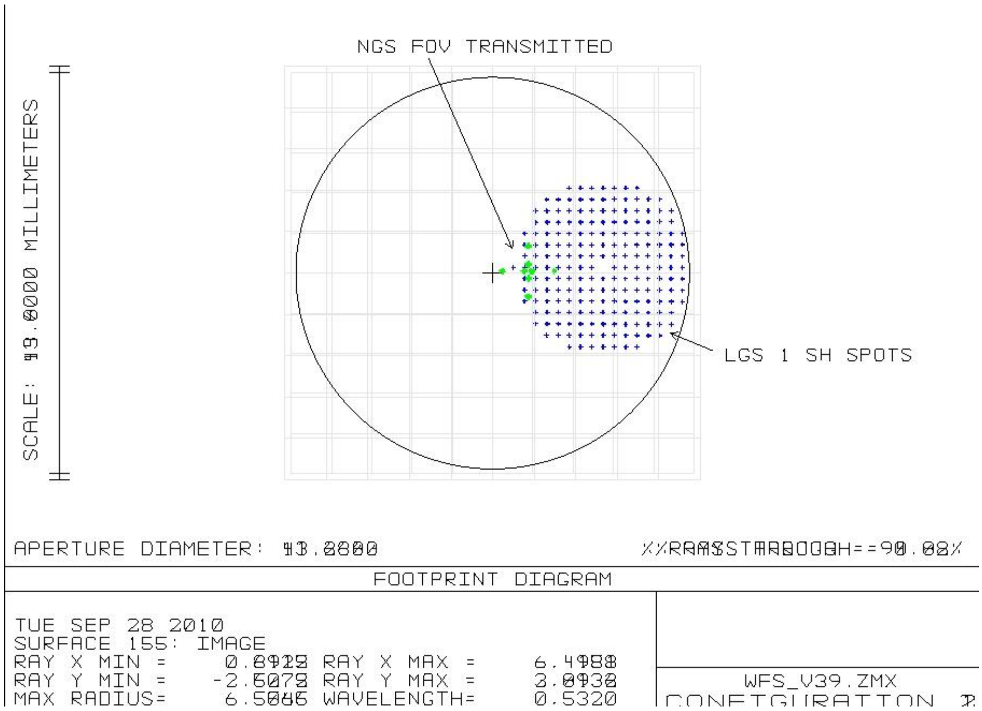

Figure 3. The green dots show the detector area affected by the light of stars in the FoV. The blue dots are the SH pattern of the LGS placed in [2.0; 0.0]arcmin.

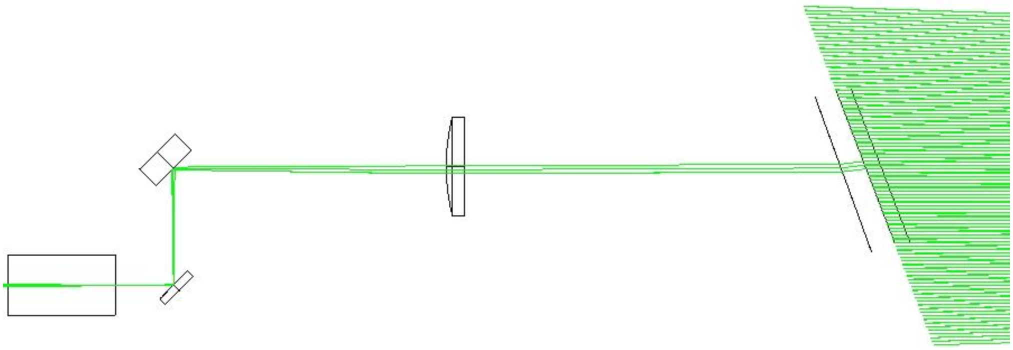

Figure 4. Transmission of the light from a NGS placed in [2.0; 0.3]arcmin . The incidence angles of the unpolarized NS light on the first element of the Pockels Cell are within +/-0.8°.

6 Conclusion

The LGS flux will be 1800photons/subap/ms. As a rough estimatation, we consider acceptable a NS pollution of 10% of the flux, corresponding to 200photons/subap/ms. This assumption has to be checked to quantify how much a single polluted subaperture will decrease the performance of the system.

As shown before, all the transmitted NS light will fall on a single subaperture.
Considering the 0.1% transmission factor at the EW and considering a telescope transmission efficiency of 0.4, a natural star flux of <500Mph/s on the telescope pupil is the maximum allowed limit.
Considering a transmission range of the optics (mainly due to the dichroic) between 400 and 600nm, such a flux will be given by a natural star of $m_V=8$.

Summarizing: compute the integrated natural flux for every patch of 30 arcsec in the 2.4arcmin "pollution field". If a patch flux is equivalent to $m_V < 8$ then the corresponding subaperture is polluted.

Based on the Bahcall-Soneira model the probability of finding an $m_V=8$ star in a 2.4arcmin field at b=30° is <0.1%.
We may want to consider the occurrence of scientific cases involving crowded fields.

Considering the results of this analysis, we may decide to provide anyhow the WFS with a band-pass filter to avoid the NS contamination of the WFS images. The filter can be implemented in different ways:

- With an auxiliary window at the very beginning of the WFS, in front of the split window and of patrol camera.
  Pro: it will be an easier to replace entrance window for the WFS and it will also filter the patrol-camera arm (even if not strictly needed)
  Con: 2 additional surfaces in the WFS. Custom filter is needed, coated on one side with AR-V coating, the other side with a bandpass filter.

- With a filter mounted on the filter wheel used to acquire the CCD dark.
  Pro: small size, commercial filter should fit. No modification to the mechanics.
  Con: 2 additional surfaces in the WFS. Patrol-camera not filtered.

- With a special coating on one of the custom optics that have to be produced (best candidate is the second lens of the collimator).
  Pro: No additional surfaces.
  Con: Patrol-camera not filtered, custom coating on a custom lens.

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