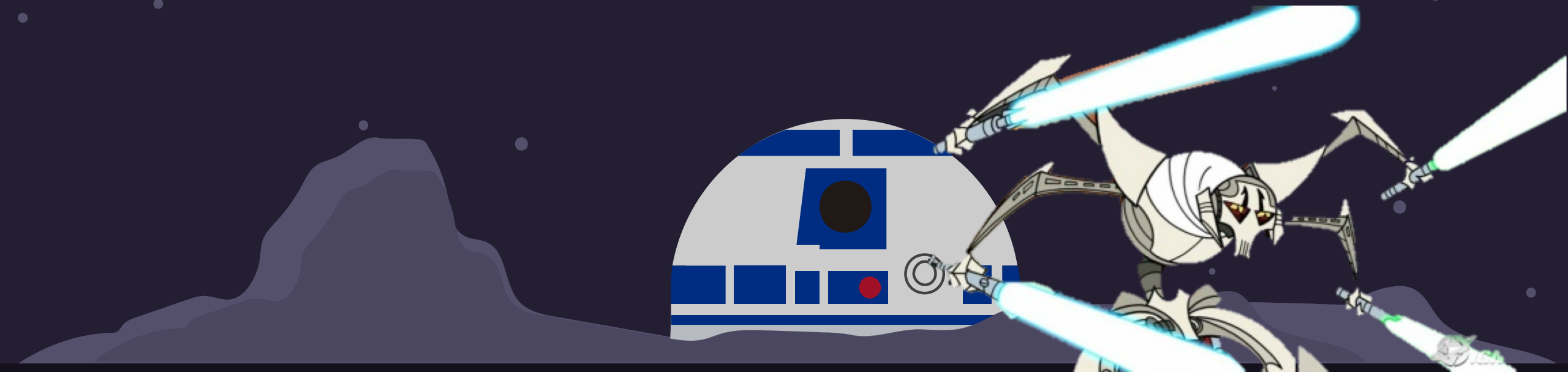
Splitting of LGS beams, a cheap solution to increase the number of LGSs

Pierre Haguenauer



See double

1. The diffractive optical element
2. Laboratory characterisation
3. Prototype and on-sky validation
4. Conclusions

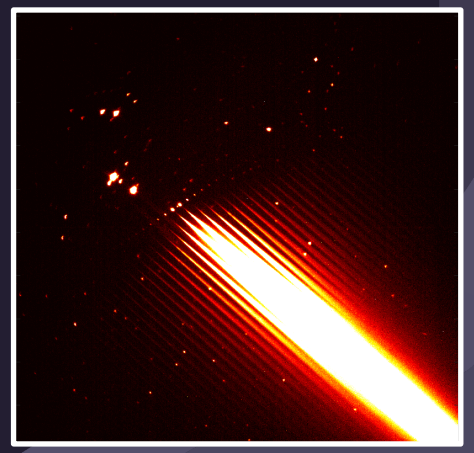
DOE

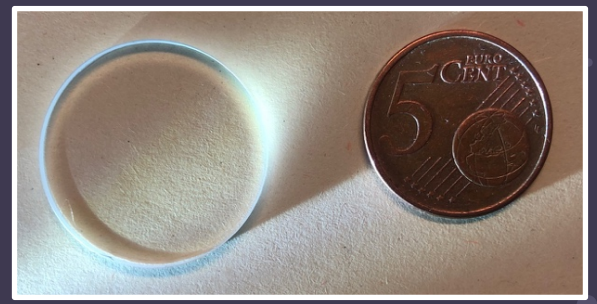
Diffractive Optical Element (DOE) procured from HOLO/OR. Made to specifications:

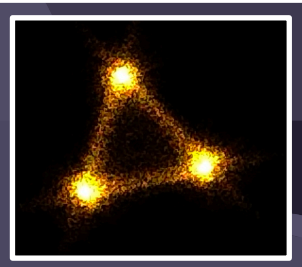
- Wavelength: 589 nm
- Number of spots: 2
- Separation: 0.0744 degrees at DOE exit / 13.4” on-sky
- High-efficiency version

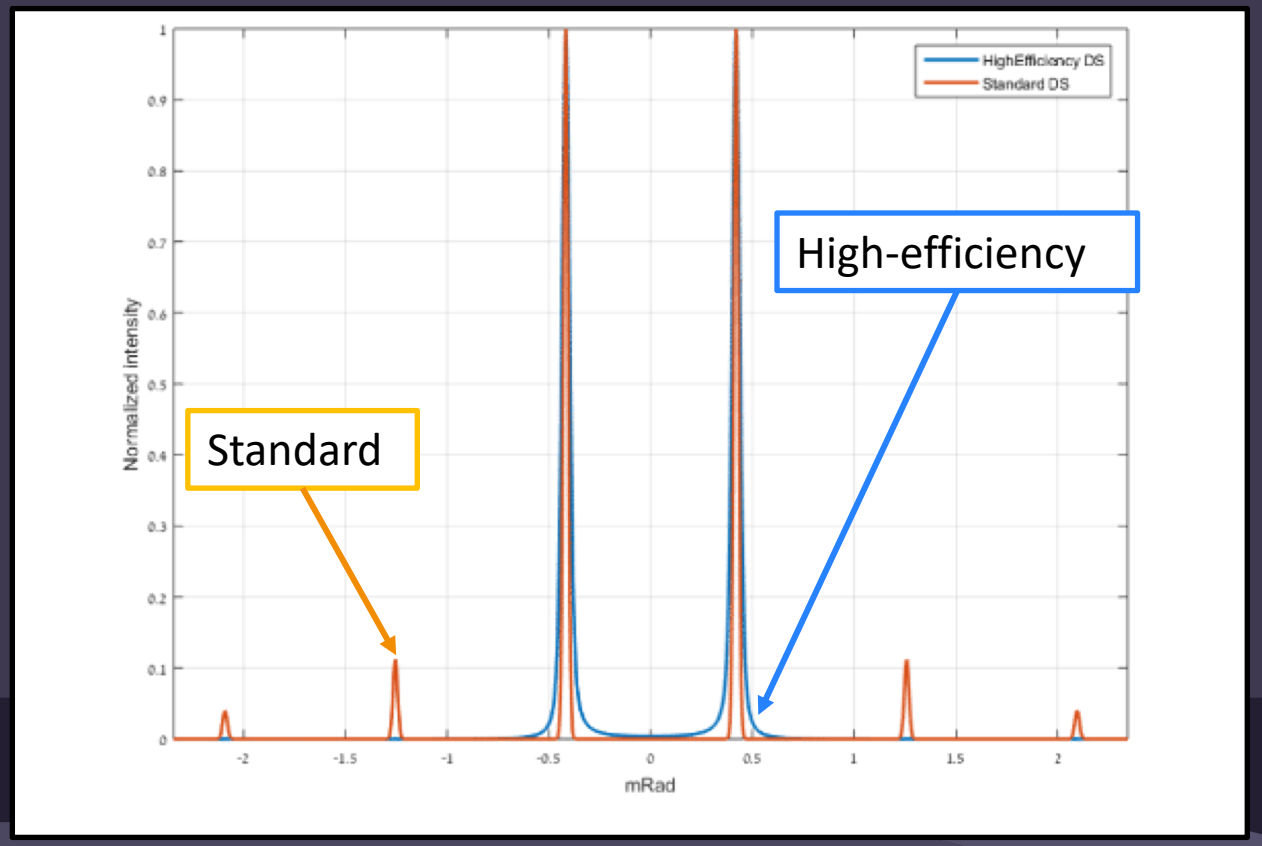
The minimum diameter at input must be at least three times the period of the DOE (depends on diffraction order, wavelength, angle at exit): 0.454 mm for our specifications.

Centring accuracy of +/- 0.5% of the input beam diameter needed to reach a 2% equality between output beams: +/- 75 microns here.







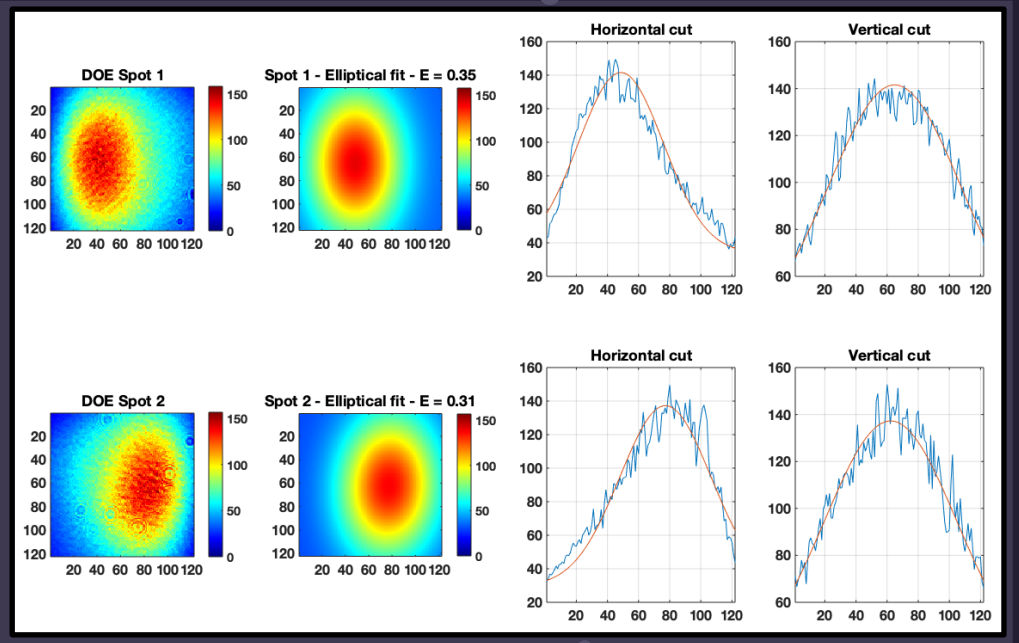


Lab Tests

Tested in laboratory for:

- Global transmission.
- Total power in the two exiting beams.
- Beams profiles.
- Polarisation.
- Wavefront quality.

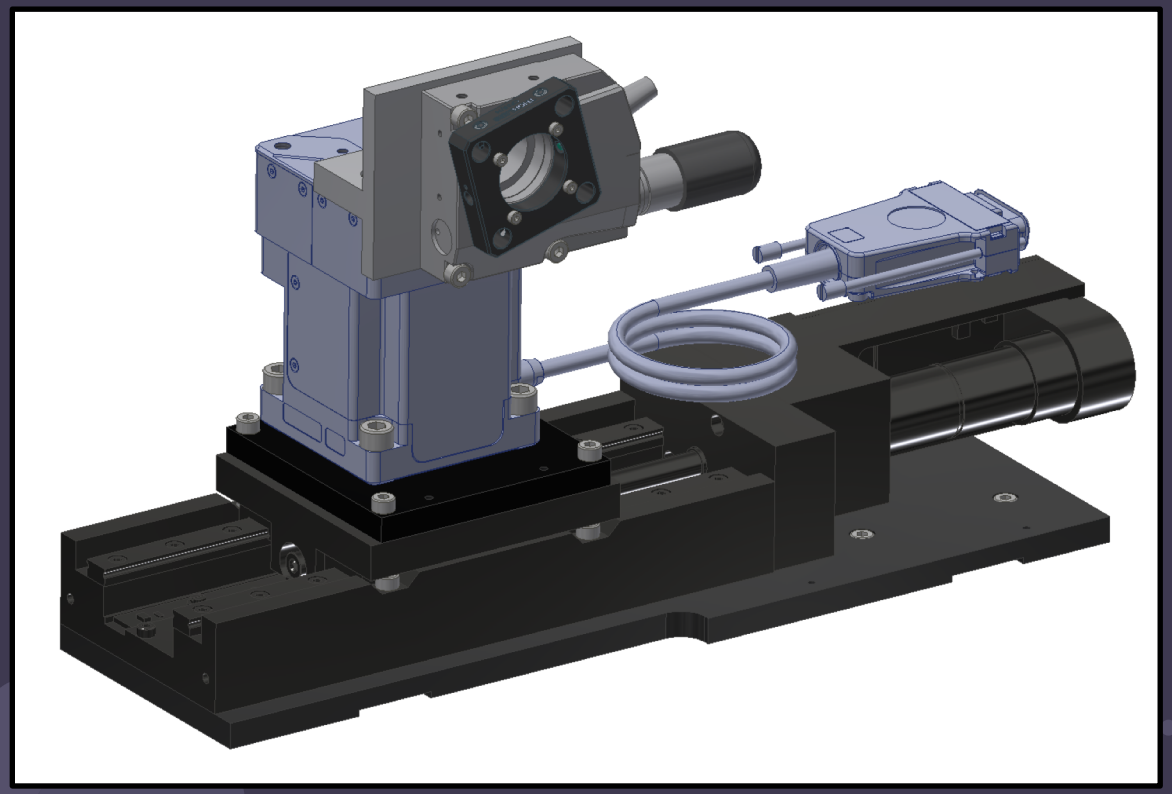
All validated and showing very good performances of the DOE.

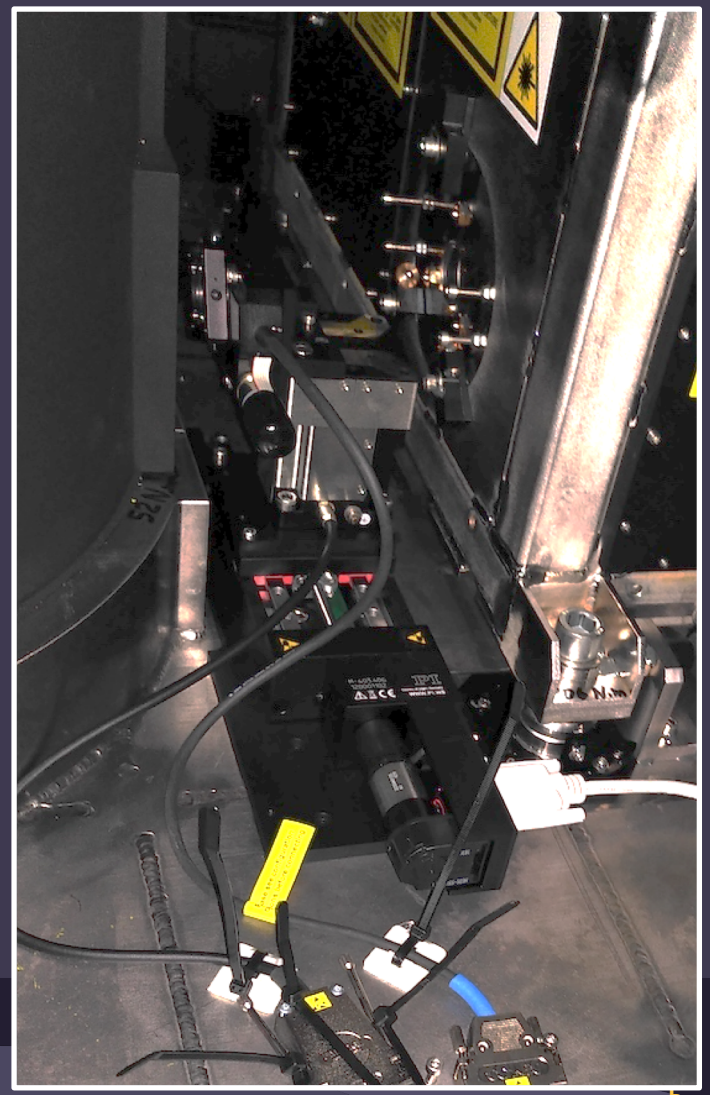


	Spec.	Lab	Sky
Transmission [%]	~ 100	98.1 ± 0.8	-
Efficiency [%]	97	95.6 ± 0.6	94
Uniformity [%]	< 1	< 0.5	<1
Polarisation	N/A	Output same as input	-
Ellipticity	N/A	0.33	No effect
WFE	N/A	λ/20 @ 589 nm	-
Separation [“]	13.4	-	13.38 ± 0.15

On-sky @ UT4

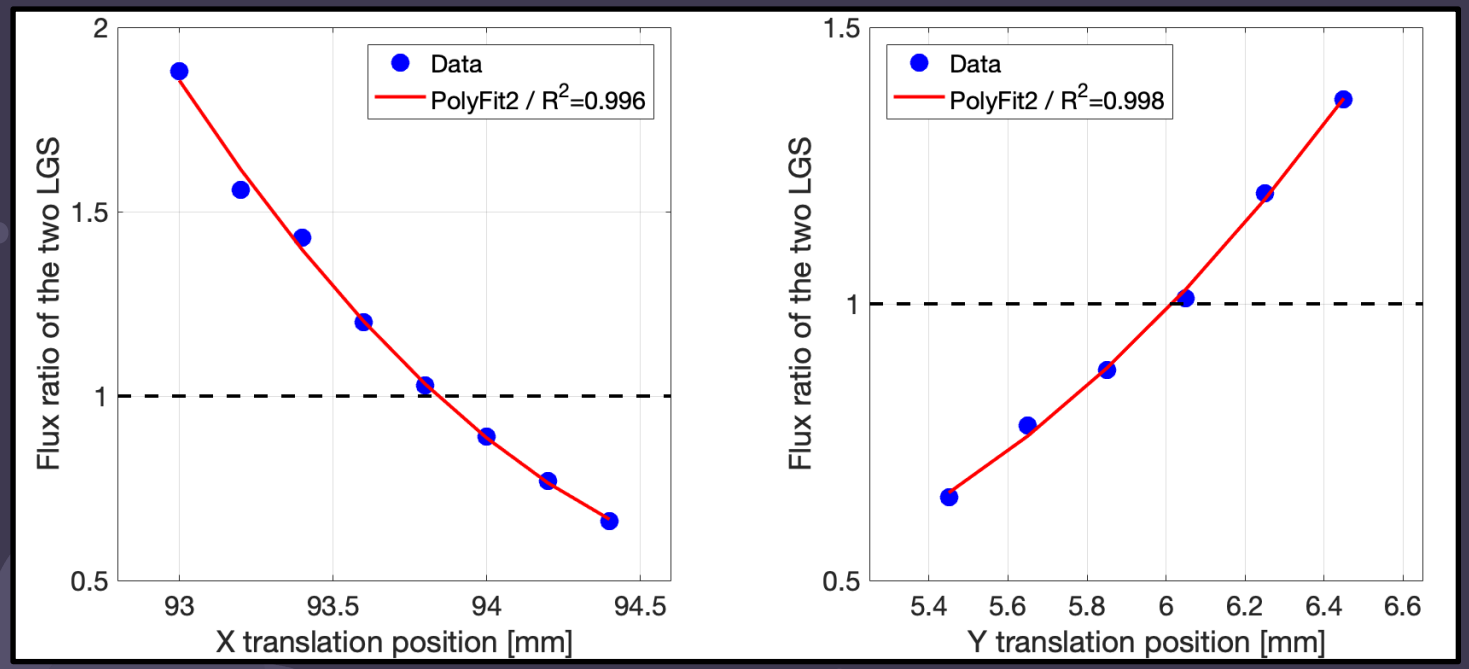
Prototype of LGS splitting implemented for on-sky testing on the UT4 telescope at Paranal.
Tested in November 2021.





On-sky @ UT4

- A very good uniformity between the flux of the split-LGS could be obtained by adjusting the centring of the DOE on the LGS beam.
- Visual pre-alignment in daytime.
- Precise centring on-sky.
- Very repeatable between the nights.



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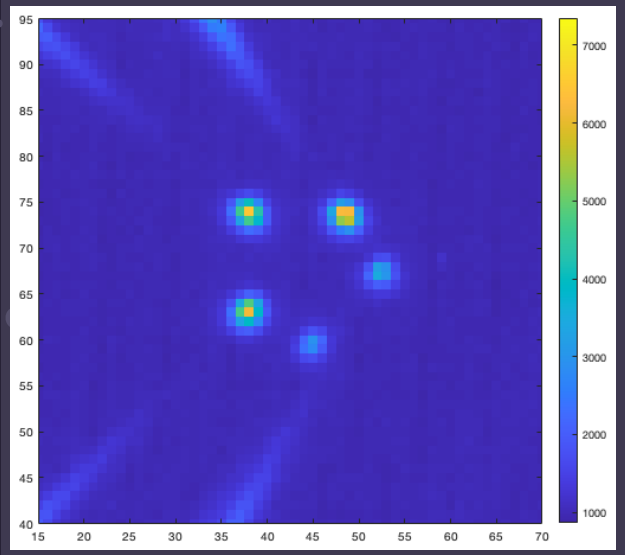
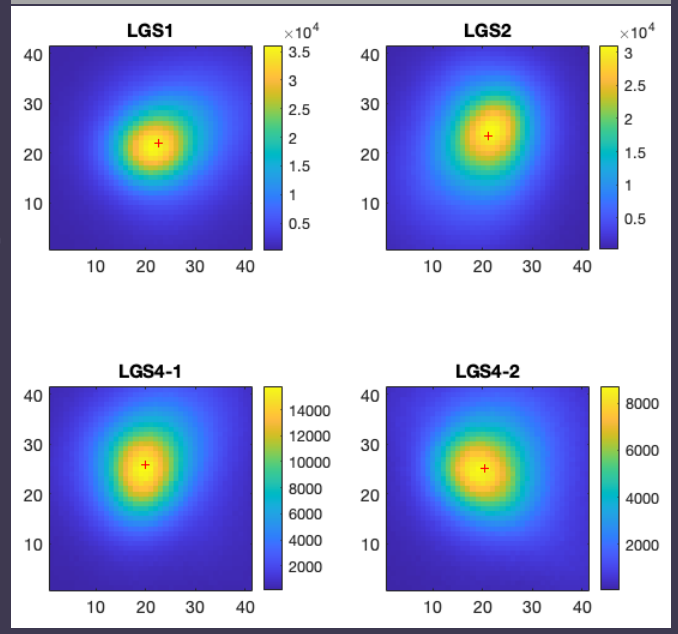
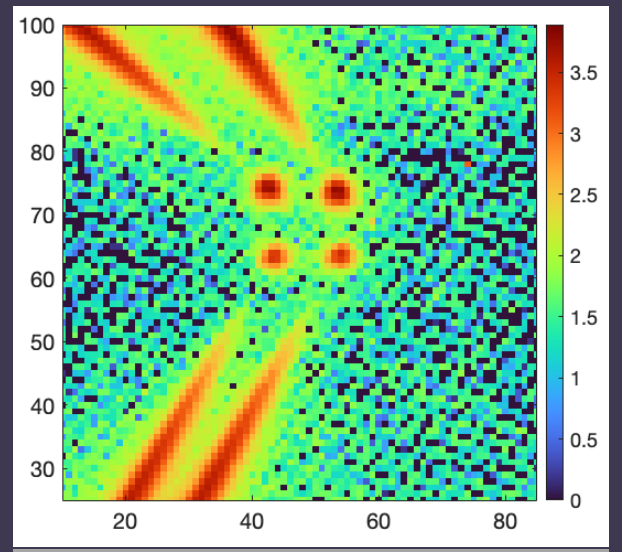


Separation measured on sky with a dedicated camera.
Other LGSs were also used for reference.

13.38” for 13.4” specified

The ellipticity measured in lab is not affecting the spot size on sky:
Same as non-split LGS.

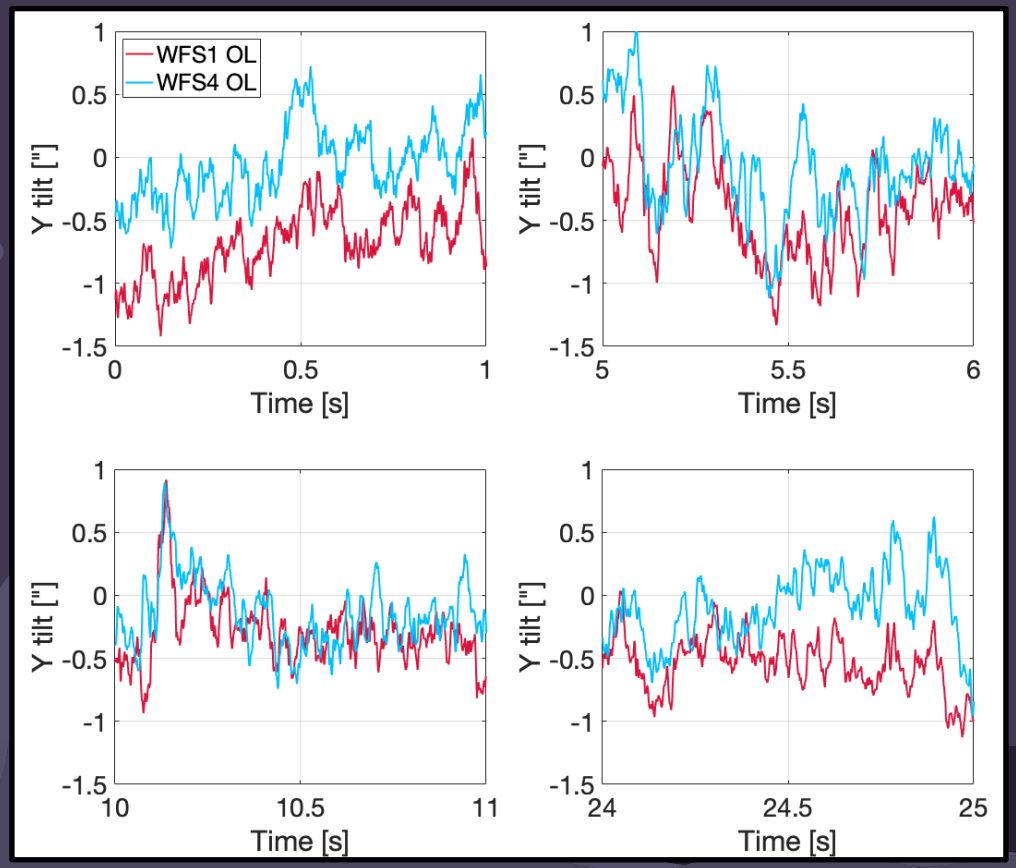


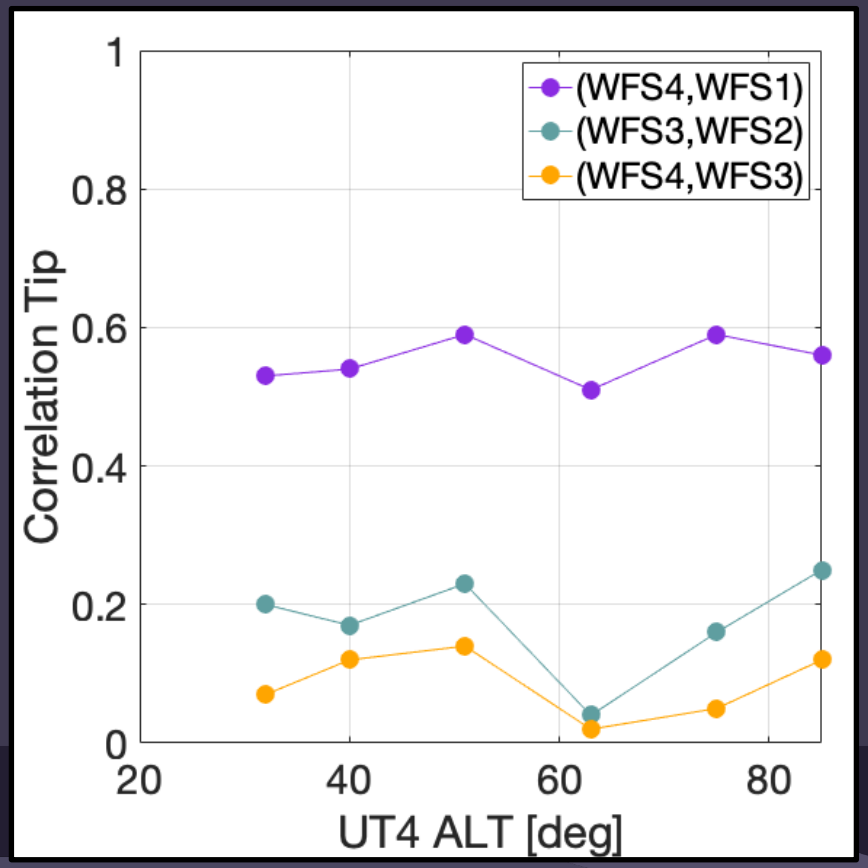


No side lobes can be seen down to 1% level

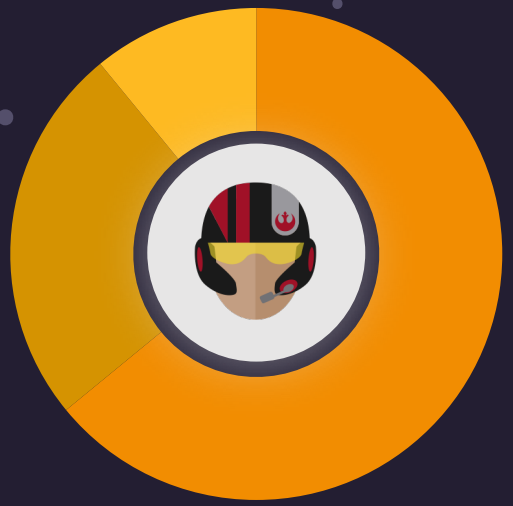
LGS jitter

- AOF-GALACSI WFSs used to measure tip-tilt between the split LGSs.
- Tip-tilt correlated mainly at low frequencies.
- The absolute value can get quite different during a time series.
- The correlation between the tip-tilt on the split LGS (WFS4 and WFS1) is always higher than between other pairs of LGSs. The split-LGSs path is almost common at launch when going through the turbulence manly located at ground (measured simultaneously with the AFO profiler).





Conclusions



A high-efficiency DOE, designed for a specific asterism need, has been characterized in laboratory and fulfilling the specifications:

- Transmission, efficiency, and uniformity are very good.
- The input linear polarisation is preserved.
- No ghost beam detected.
- Optical quality similar to standard optics.

A prototype has been successfully tested on-sky on UT4 with the AOF:

- Excellent match between the measured and specified separation.
- The ellipticity generated by the DOE has no impact on the spot size on sky.
- The tip and tilt of the two split-LGSs showed a higher correlation between 15Hz.

DOE is a simple solution to generate multiple laser guide stars from one single laser. Implementation is compact and with low complexity.

Thank you!

This is the double LGS way...