LGS SPLITTING

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MAVIS QUICK SHEET

MCAO-Assisted Visible Imager & Spectrograph

http://mavis-ao.org/mavis/

- May 2018: VAOI/MAVIS Call for proposal from ESO
- Sep 2018: MAVIS Proposal submitted by consortium
- Nov 2018: Proposal successful
- 01 Feb 2019: Kick off meeting
- 1 May 2020: End of phase A

What is MAVIS?

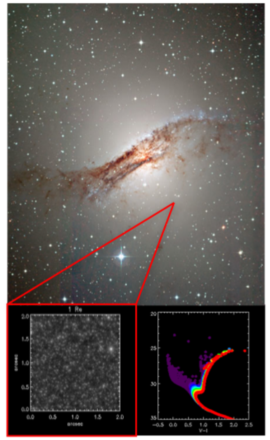
MAVIS (MCAO-Assisted Visible Imager & Spectrograph) is a proposed instrument for ESO's VLT Adaptive Optics Facility that will provide near-diffraction limited image quality over a large field of view using Multi-Conjugate Adaptive Optics. MAVIS is an Australian-European project.
More information at http://mavis-ao.org/mavis.

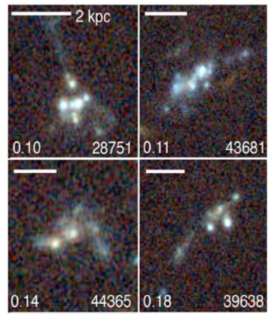
Science with MAVIS

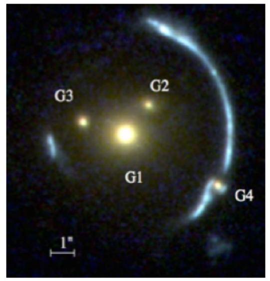
- Star formation histories of the local volume through resolved stellar populations
- Local group internal dynamics via proper motions and crowded field spectroscopy
- Resolving star formation clumps to high redshift
- Dark matter substructure via lensing
- Monitoring solar system bodies

Strawman MAVIS Requirements

Field of view	30”x30”
Angular resolution	FWHM ~ 20mas at V band
Wavelength coverage	VRI, extended to UBz
Strehl ratio	15% at V under median seeing conditions
Sky coverage	> 50% at Galactic Poles
Imager	~ 7mas pixel size. Broad and narrow band filters. Tuneable filters - to be explored
Spectrograph	Fibre + Starbug concepts to be explored: Highly multiplexed point-source capabilities Multiplexed compact IFUs (0.5” FoV) and larger FoV IFUs. R=5,000-10,000. Alternatively, 3”x3” image slicer IFU with 25mas spaxels.



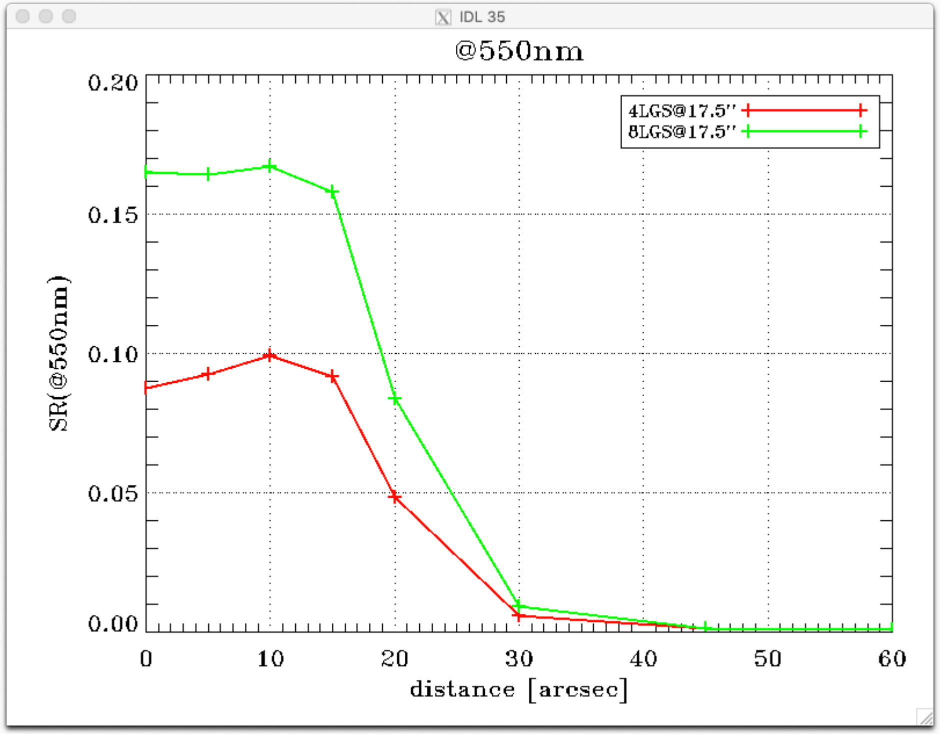




Number of LGS

- AO simulations showed that at least 6 (current simulations goes to 8) LGSs are needed to reach the performances over the FoV.
- Adding 2 (or 4) lasers on UT4 center piece will be very challenging in terms of space and weight (if even feasible).
- Cost issue: price of each additional laser is >1MEuros (laser + launch telescope + implementation).

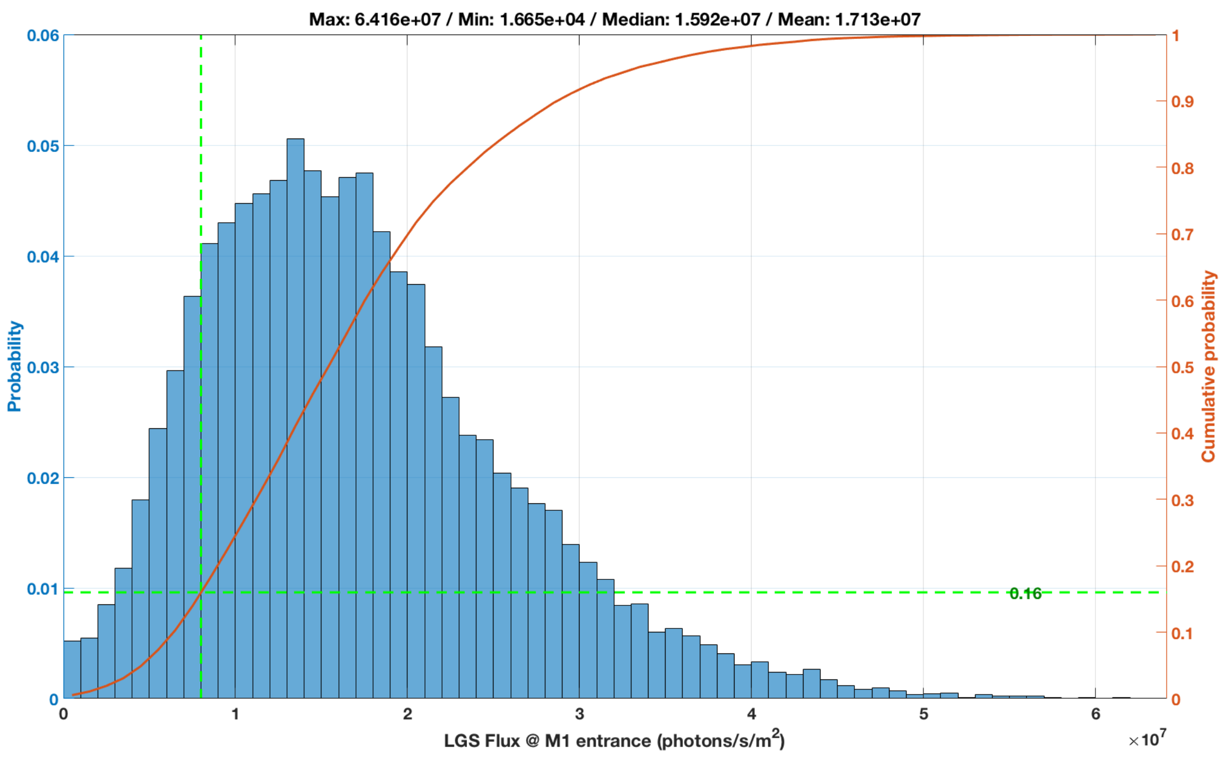
- Experience in AOF operation showed that the LGS WFS of GRAAL and GALACSI are never short in photons.
  - ☞ Can we split the GSLs in two?
  - ☞ Will the flux be enough?
  - ☞ Can we implement a splitting in 4LGSF?



Simulation done by Guido Agapito

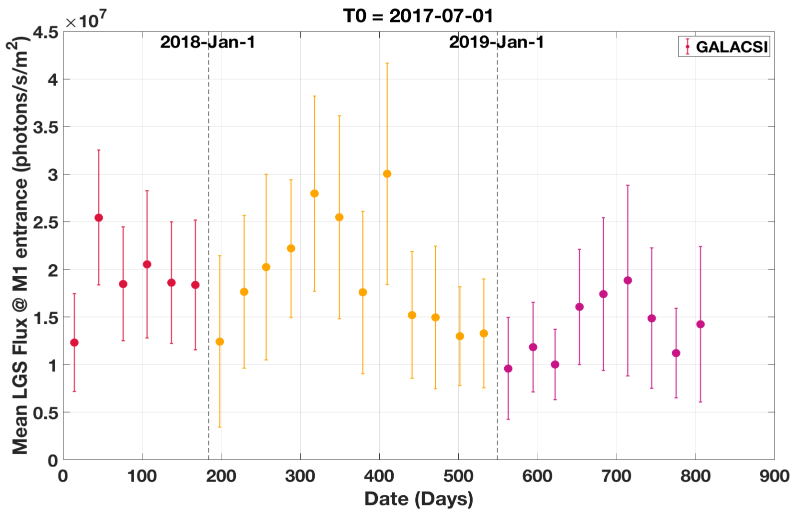
AOF LGS flux return

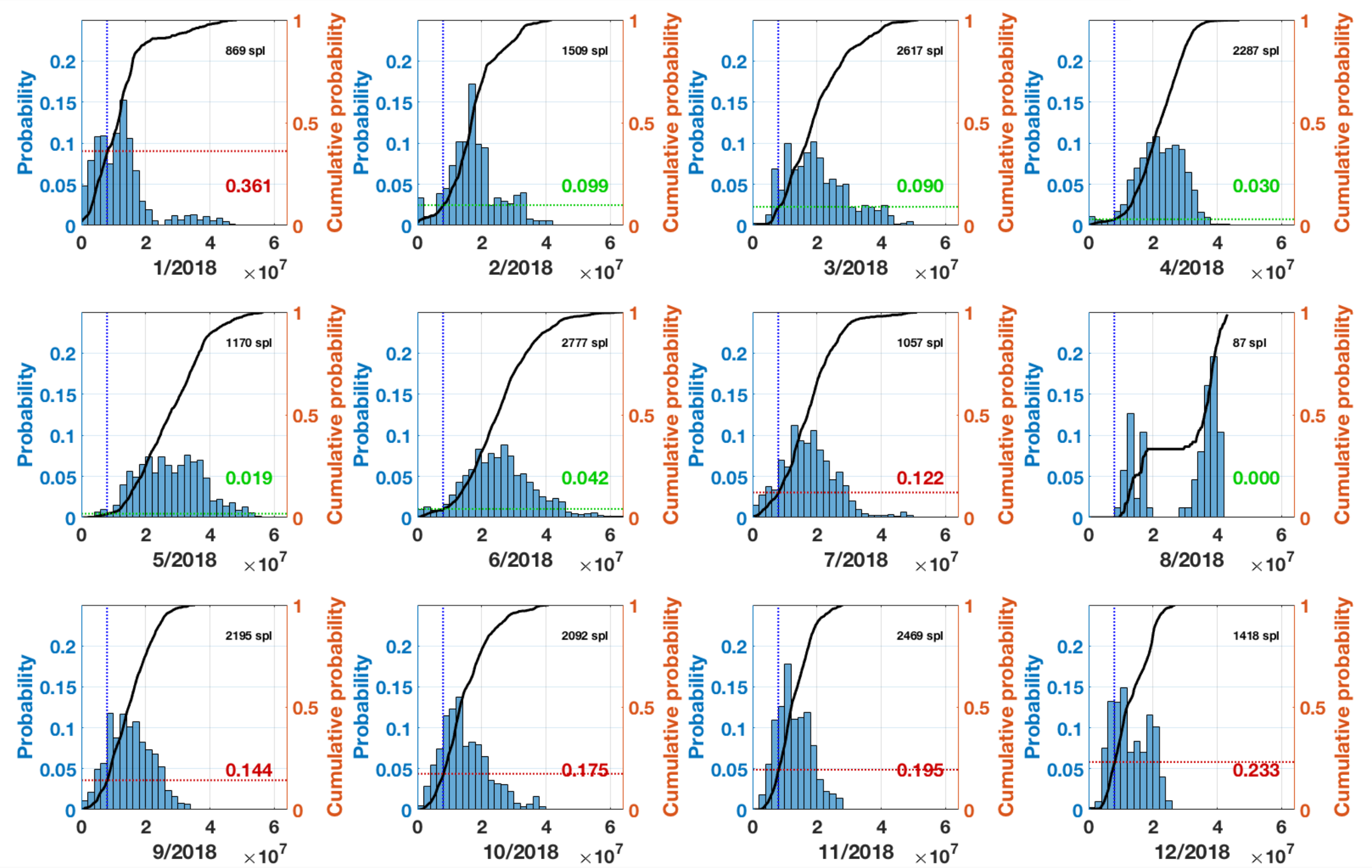
- Flux in GALACSI WFS is logged automatically during operation.
- Not filtered from atmosphere transmission (value not available at Paranal).
- Two years of operations give a good statistics (atmosphere, Na density).
- Considering a 0.4 transmission (MAVIS+UT4), 20 cm sub-apertures, a 1kHz sampling:
  - 62 photons/sub-aperture/frame in the pessimistic case (8×10^6 ph/s/m^2)
  - 128 photons/sub-aperture/frame in the nominal case (1.6×10^7 ph/s/m^2)



AOF LGS FLUX RETURN

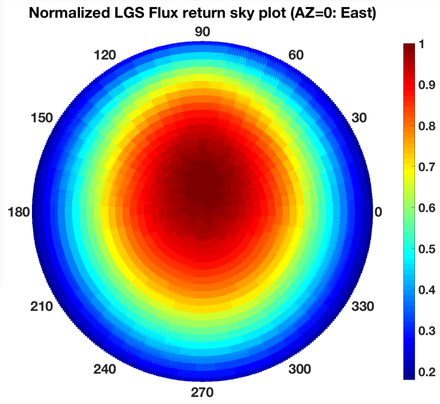
- But Na layer density variations have a seasonal (winter is better) and yearly impact (2019 seems lower than 2018).

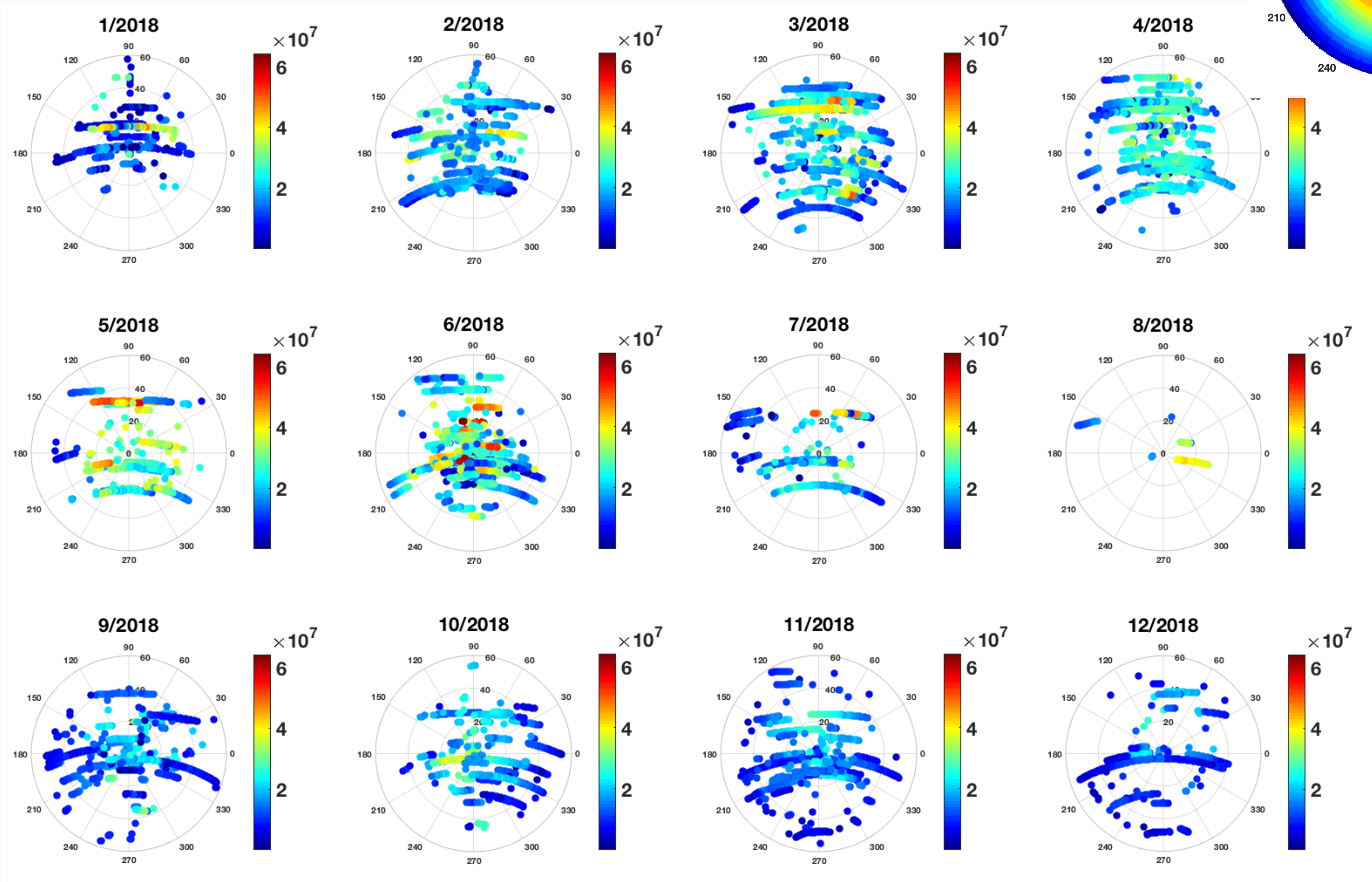




AOF LGS flux return

- Lower flux return in summer months is not a pointing bias.





AOF GSL FLUX INCREASE?

- AOF GSL are currently set at 22W launched power.
- GSL can be pushed to 27W.
- Should not have an impact on GSL lifetime.
- Still needs discussion/contract with Toptica to remove 22W limitation.

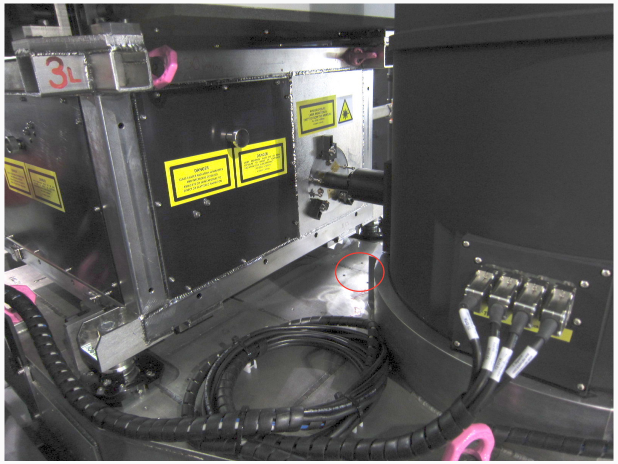
➢ **~ 22.5% increase is already possible.**

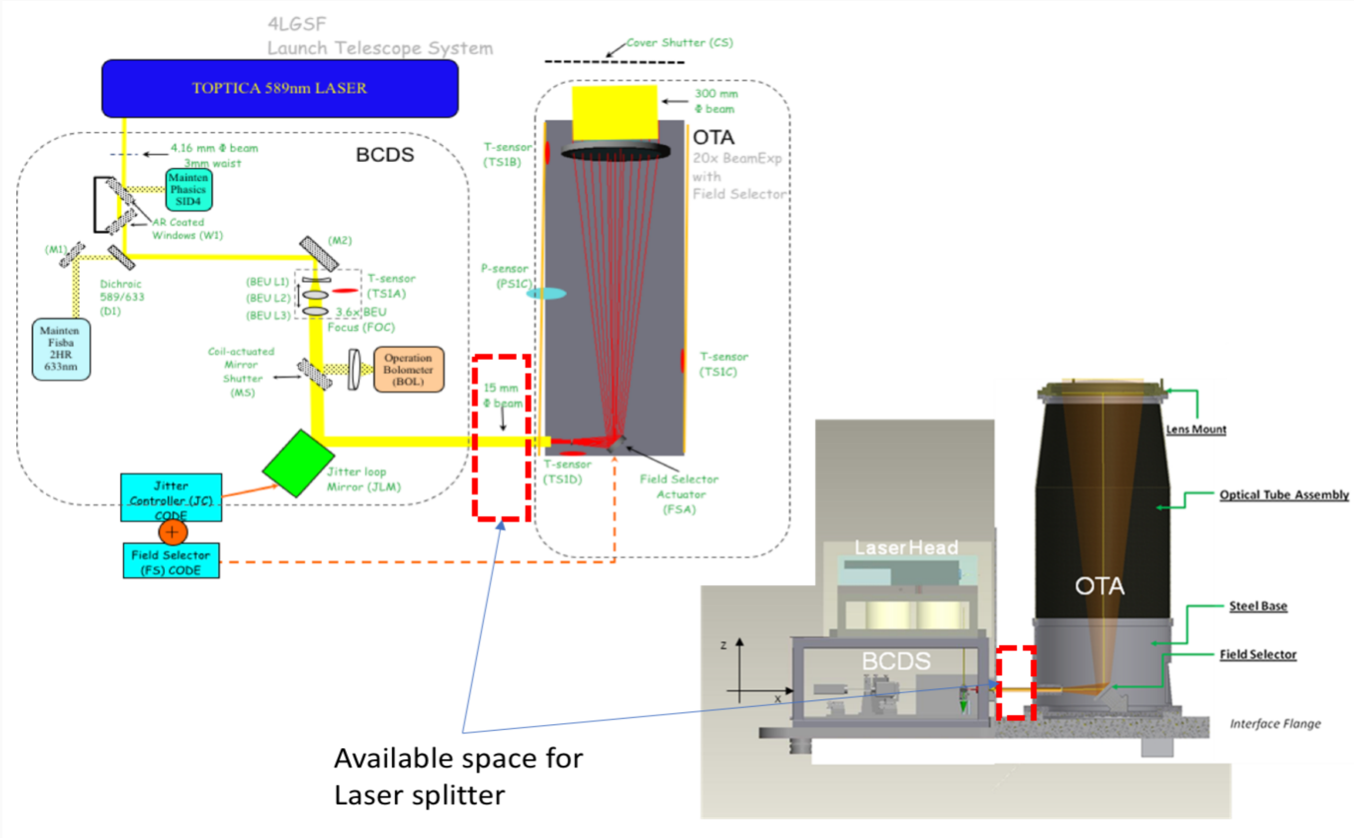
- Can the existing GSL be upgraded to more power?
  - How much power?
  - Can this be done with limited impact/change on current system.
- Prototype of 50W laser exists, but:
  - Important redesign
  - Cost unknown

➢ **Process started at ESO to discuss this with Toptica.**

GSL SPLITTING

- Trade-off on solutions concluded that only a static splitting, i.e. the 2 LGS are created at the same time, is viable.
- Possible technical solutions: Wollaston prism, wedged beam-splitter, diffractive optical element (DOE).
- DOE is the most promising one.
- Implementation in 4LGSF is feasible: opto-mechanics, electronics, control.





ON-SKY DEMONSTRATION

- ESO Wendelstein LGS Unit (WLGSU) installed at the Observatorio del Roque de los Muchachos was used for this test.
- WLGSU uses the same technologies as those implemented on UT4. The laser power output was 17.5W (single beam, before splitting).

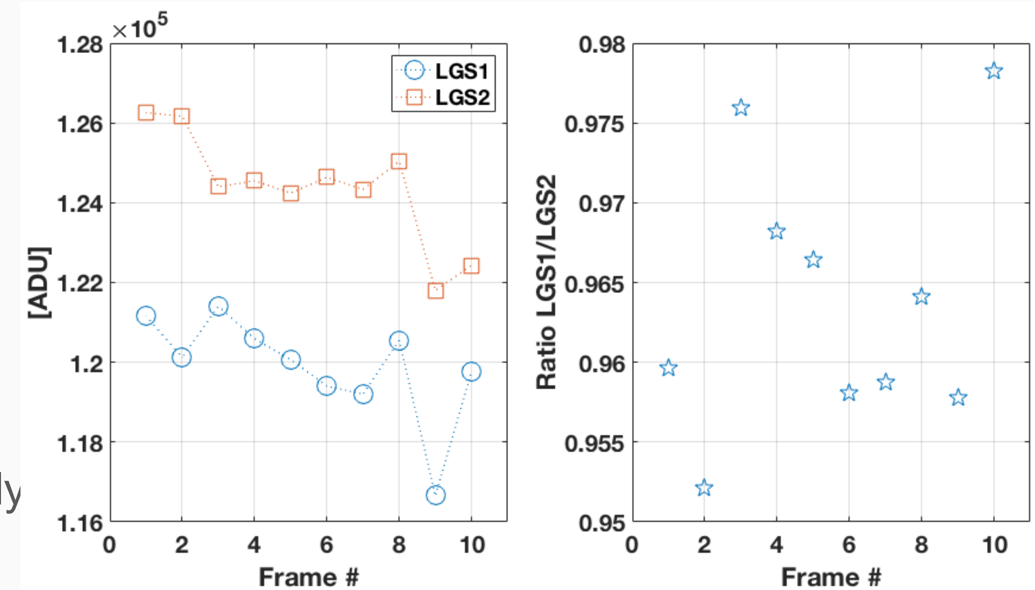
- Same launch telescope design has the 4LGSF launch telescopes,
- A 16” Meade receiver telescope (Rx) equipped with a PCO Edge 5.5 CMOS camera, placed about 8m from the LGS launch telescope was used to image the LGS and NGS.

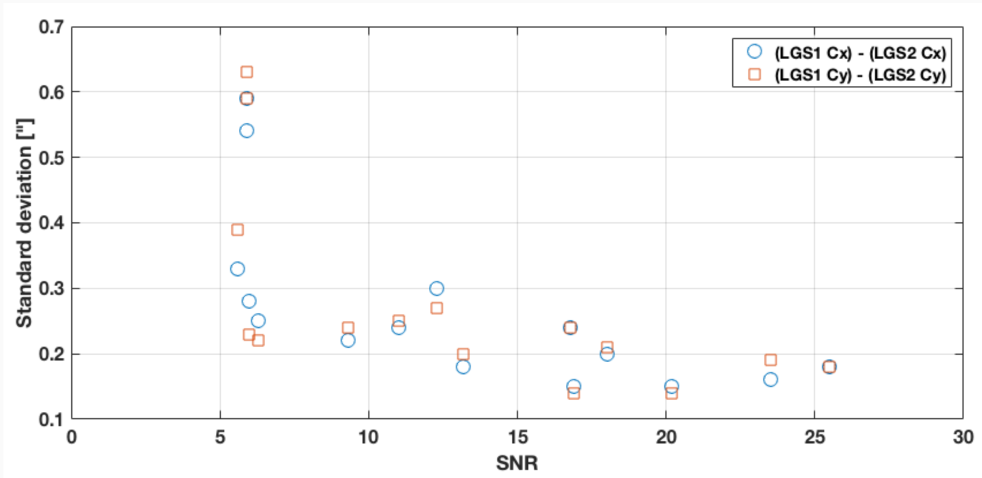
Diffractive Optical Element: DOE

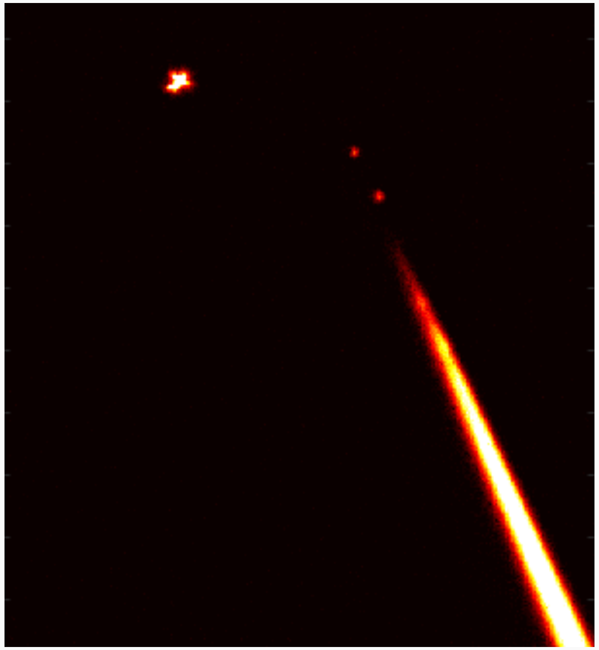
- The diffractive optical element (DOE) has been procured from “Laser Components”.
- Off-the-shelves DOE.
- The main characteristics are:
    - Wavelength: 589 nm
    - Size / Clear Aperture: 25.4 / 22.9 mm
    - Thickness: 3 mm
    - Number of spots: 2
    - Separation Angle: 0.10 degree, giving 18” on-sky
    - Transmission: close to 100%
    - Efficiency: 79%
    - Uniformity: <1%

ON-SKY DEMONSTRATION

- Two orientations of the separation tested.
- Measurements done:
  - Separation: 16.8+/-0.07”; calibration of plate scale?
  - Photometry: 0.96+/-0.03; Good
  - Differential tip-tilt: 0.2”; most probably no need for separate TT control.







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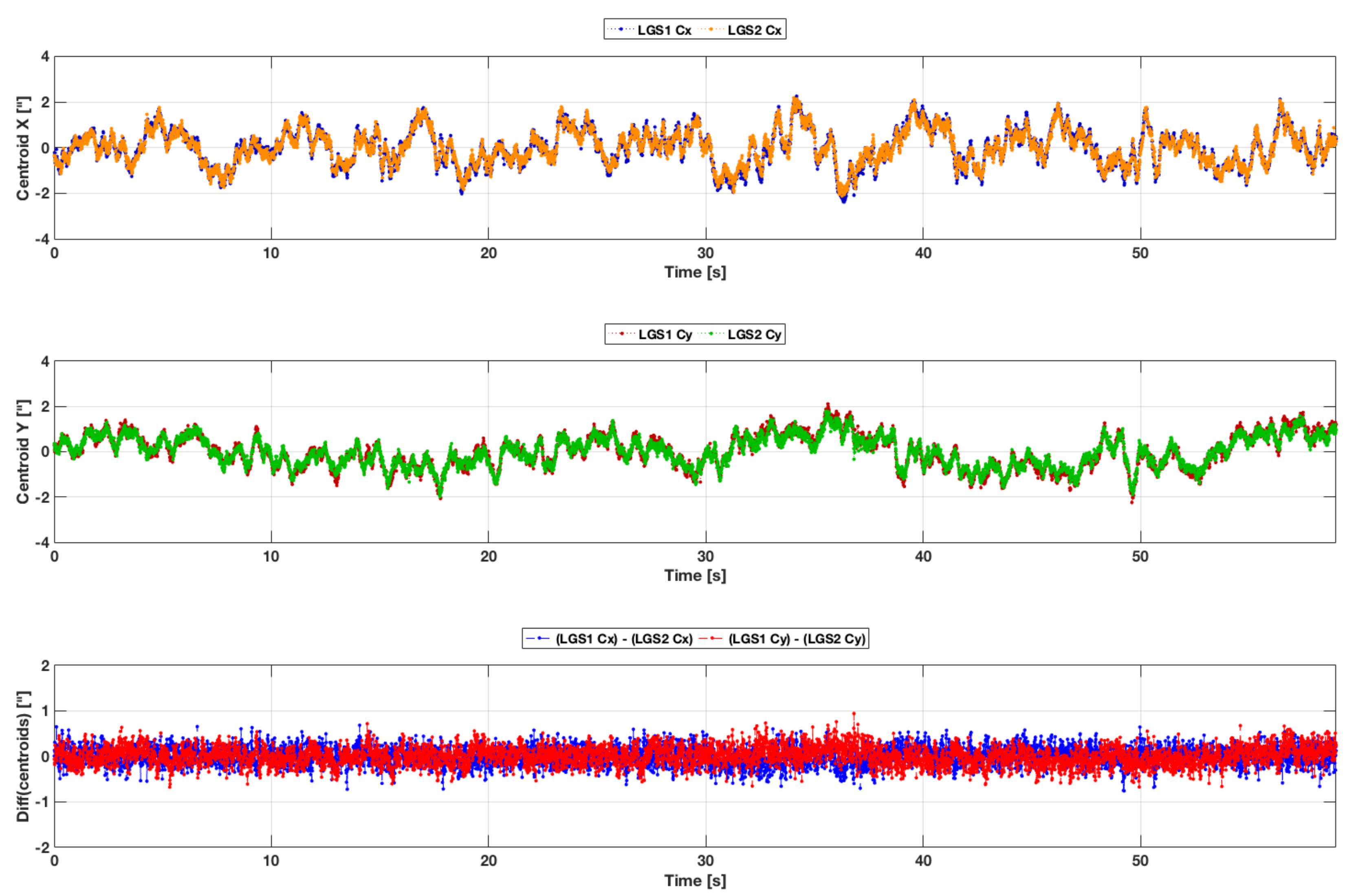
TIP-TILT TIME SEQUENCE

- Recording at 100Hz

	STD(x) [arcsec]	STD(y) [arcsec]
LGS1 WCoG	0.74	0.67
LGS2 WCoG	0.70	0.60
LGS1-LGS2 WCoG	0.19	0.20



NEXT STEPS

- Laboratory characterization ongoing:
  - Laser re-integration completed
  - Planned measurements:
    - Beams separation
    - Beams shape
    - Efficiency
    - Polarization
- Implementation test and validation on UT4:
  - Technical time request filled for Paranal Period 105 (April-October 2020): early April requested.
  - Design transparent for other UT4 instruments.
  - Goals:
    - Develop and test the implementation of the DOE inside one of the lasers of UT4.
    - Measure on-sky the efficiency.
    - Measure the separation of the two LGS for different altitudes of pointing.
    - Measure the spot size for the two LGS.
    - Inject simultaneously each of the two generated LGS in two WFS of GALACSI (feasibility has been checked) and measure the flux levels, spot sizes and differential tip-tilt. GALACSI WFS design similar to MAVIS.

CONCLUSIONS

- We demonstrated the feasibility of splitting a GSL using the WLGSU at La Palma.
- The two LGS intensities on-sky are ~equal (within the experimental measurement error).
- The separation measured on-sky with the off-the-shelves DOE was 16.75” (limited by test setup calibration).
- We could measure differential tip-tilt between the two LGS up to 199Hz.
- The application of the DOE to adaptive optics in each unit of the 4LGSF is feasible without worrying for the differential tilt between the two LGS, by just operating the LGSU jitter mirror compensating the average coherent motion of the two LGS.
- Laboratory tests will be done to measure: beam quality, exact DOE beam separation at 589nm, throughput.
- Real on-site test and validation on UT4 is planned.

LET'S GET CRAZY AND HAVE NO LIMITS 🤪