Laser Guide Star Systems
ESO 4LGSF and Technology R&D

Domenico Bonaccini Calia

European Southern Observatory

- VLT Adaptive Optics Facility and the 4LGSF
- Technology Development: Laser Systems R&D

MPIA Heidelberg, 03.02.2017

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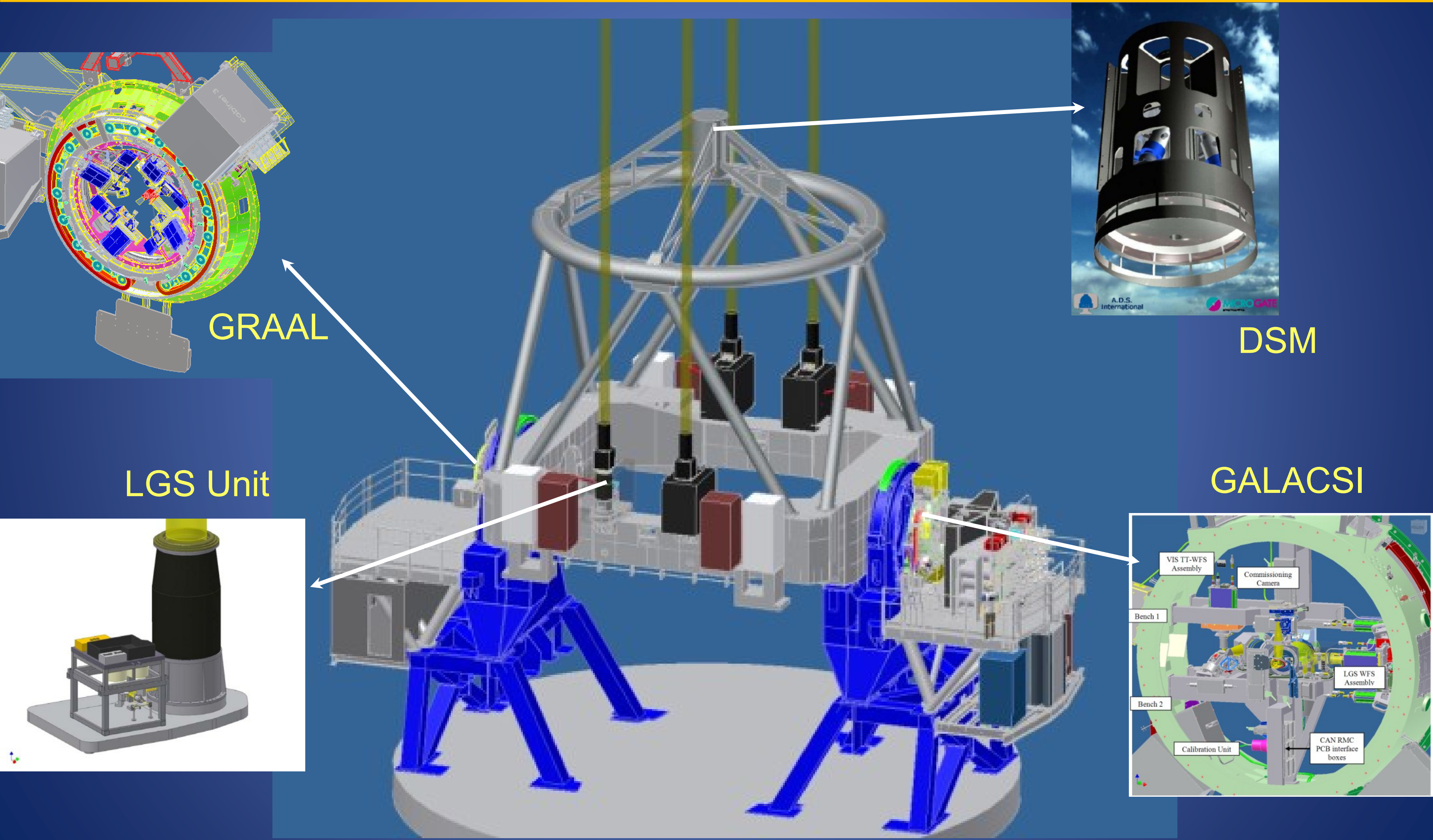
ESO 4LGSF

D.Bonaccini Calia, W.Hackenberg, M.Comin, C.Dupuy., F.Gago, I.Guidolin, R.Guzman, R.Holzlohner, S.Huber, L.Kern, S.McLay, D.Popovic, M.Quattri, J.Quentin, S.Lewis, T.Pfrommer, R.Arsenault, P-Y Madec, J.A.Abad, G.Fischer, J-P Kirchbauer, P.Duhoux, M.Enderlein, J-F Pirard, J.Beltran, J-L Alvarez, D.Del Valle, J.C.Palacio, D.P.Wei

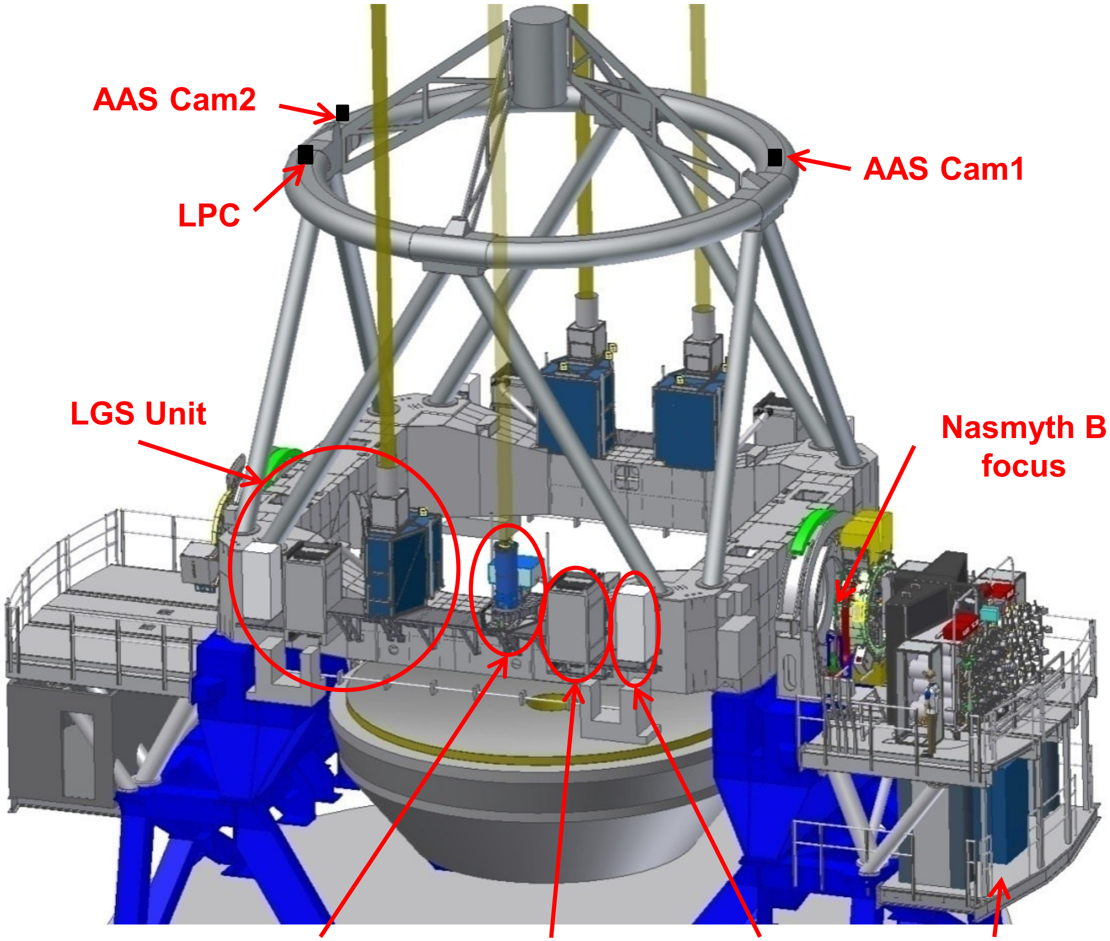
- AOF and 4LGSF Overview
- 4LGSF Top Level Requirements
- LGSU1 Integration and Commissioning step
- 4LGSF Integration
- 4LGSF Standalone Commissioning

AOF main subsystems

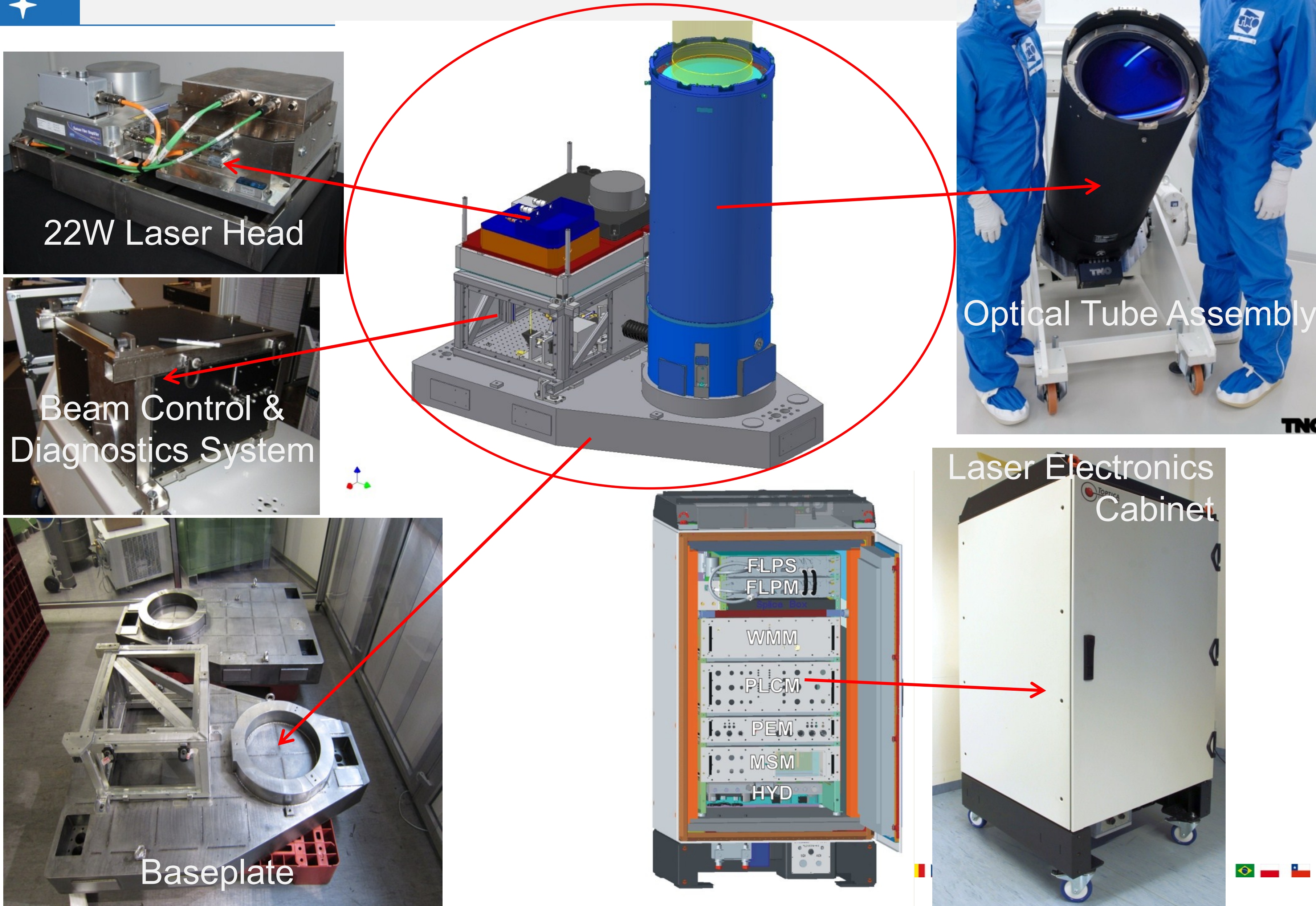


4LGSF Modular Design

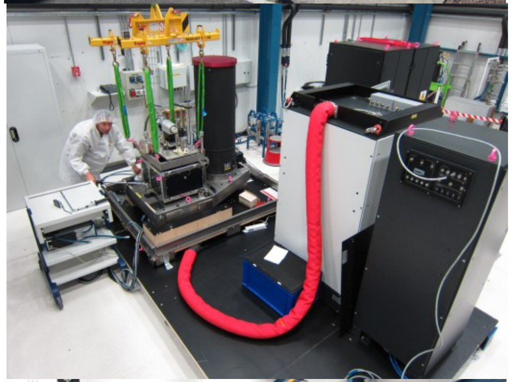
- 4x LGS Unit (UT4 Centerpiece)
  - Laser Cabinet (Toptica/MPBC)
  - Laser Head (Toptica/MPBC)
  - Launch Telescope (TNO)
  - BCDS (ESO)
  - LGSU Control Electronic Cabinet (ESO)
- LCU cabinet (under Nasmyth B)
- Safety and Housekeeping System (under Nasmyth B)
- Toptica Heat Exchanger (under nasmyth B)
- Aircraft Avoidance Cameras (UT4 Top Ring) shared between LGSF and 4LGSF
- Laser Pointing Camera (UT4 Top Ring)

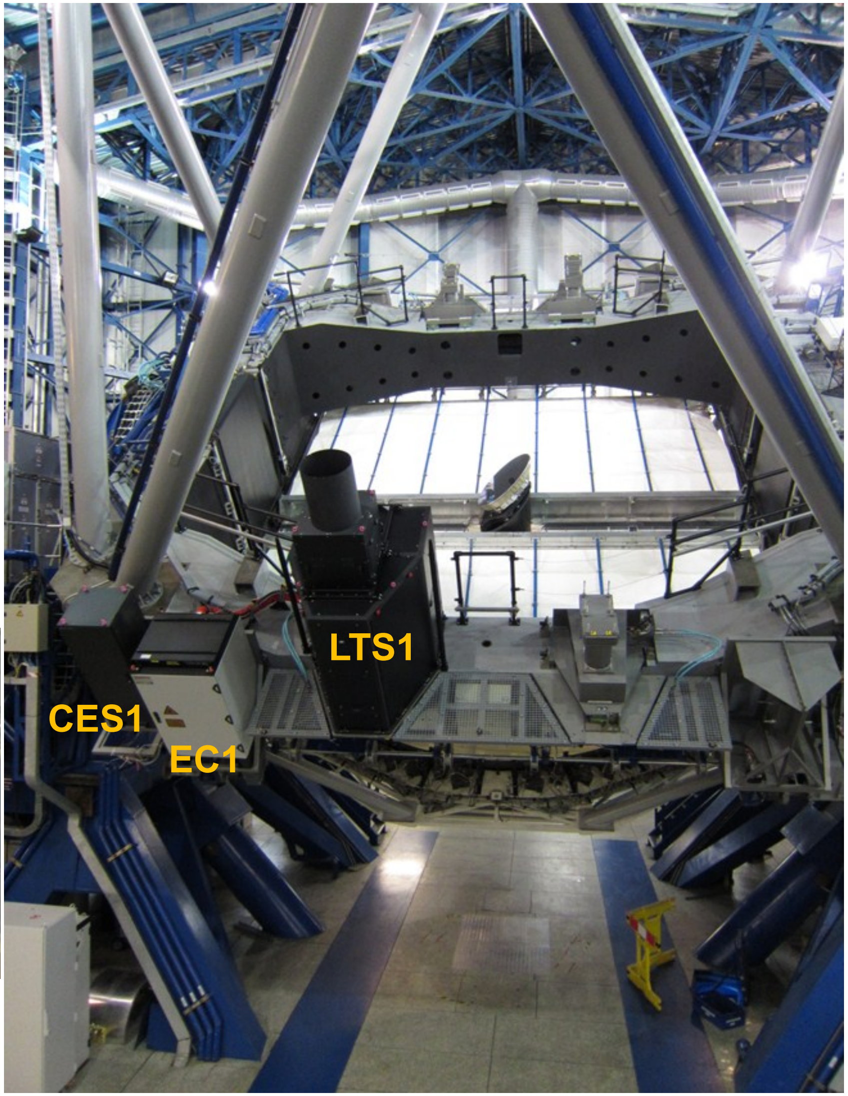


LGS-Unit


22W Laser Head
Beam Control & Diagnostics System
Baseplate
Optical Tube Assembly
TNO
Laser Electronics Cabinet
FLPS
FLPM
WMM
PLCM
PEM
MSM
HYD

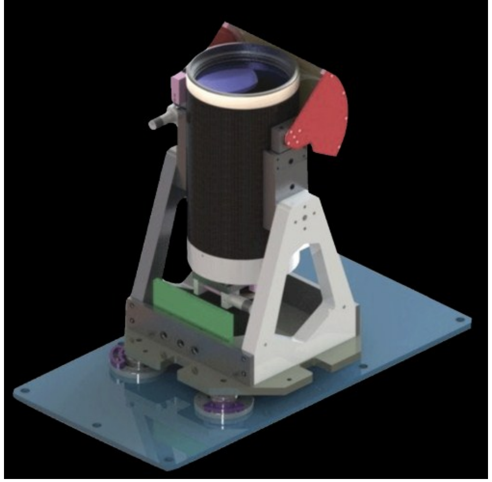
LGSU #1





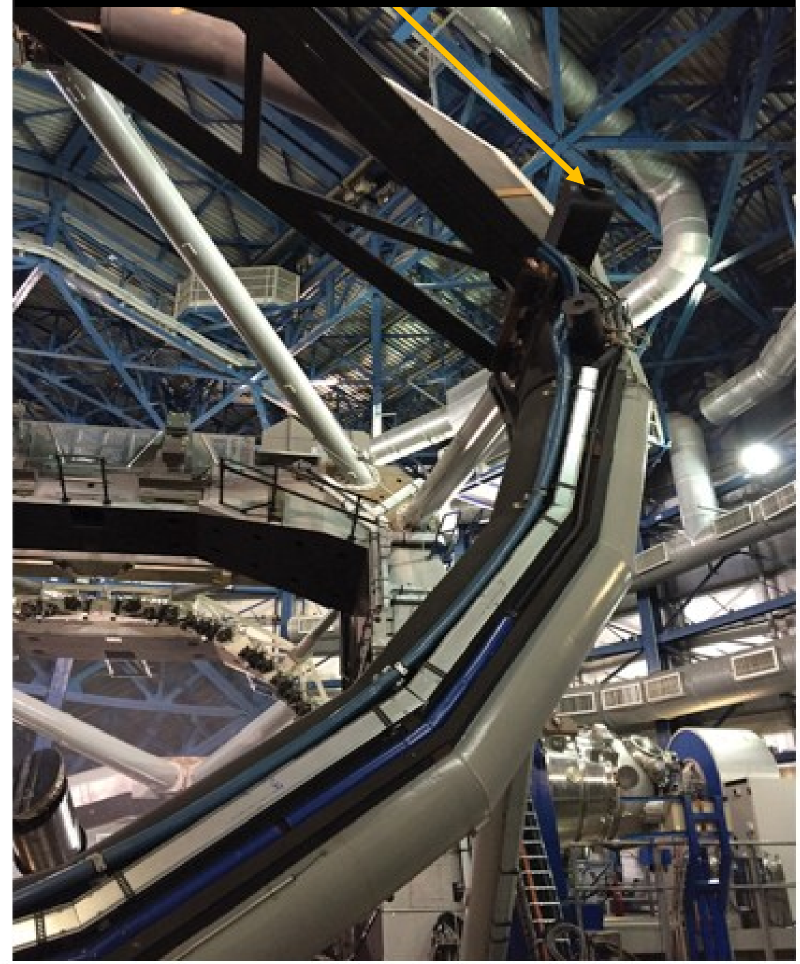
Laser Pointing Camera

- Essential tool, all along the Commissioning (Pointing models, PM verifications, focus loops check, return flux) and in Operation.
- With LPC we will be able to automatically record photometry and PM corrections, when in AODRIVEN mode, during operations
- 8-14km scattering measurement/monitoring on-line (cirrus)
- Photometry calibration check. Accuracy 0.1 mag.
- Private p2p LAN for remote maintenance, outside UT4 network



LPC: Linux Smartcamera on LAN

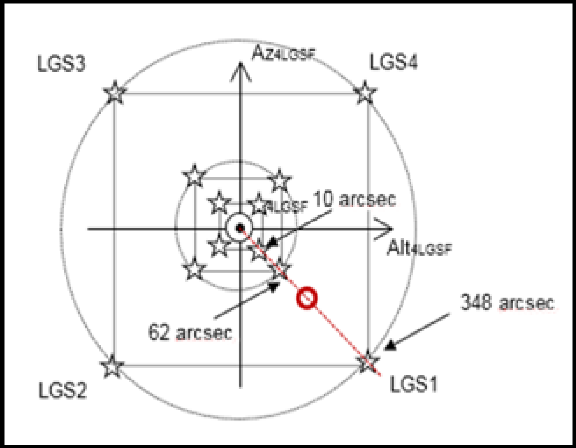
- Absolute coordinate astrometry
- Offsets of LGS while UT4 cycles
- LGS Photometry
- LGS FHWM and cirrus monitor



See LPC on SPIE Vol 9909 (2016)

4LGSF: Main Requirements from AO

- LGS Return Flux (TLR7): $\geq 7.7 \times 10^6$ photons/s/m^2 at the ground, pointing at zenith, with Sodium column density = $4 \times 10^{13}\ m^{-2}$
- LGS Spot Size (TLR 8): with 0.6” NGS fwhm, the short axis of the LGS fwhm shall be ≤ 1” at UT4 ALT 60˚, short exposure;
- Pointing Range (TLR 9): Radial pointing: from 0 arcsec to 6 arcmin with respect to VLT optical axis, square geometry asterism
- Open Loop Pointing Accuracy: Radial 2.5”



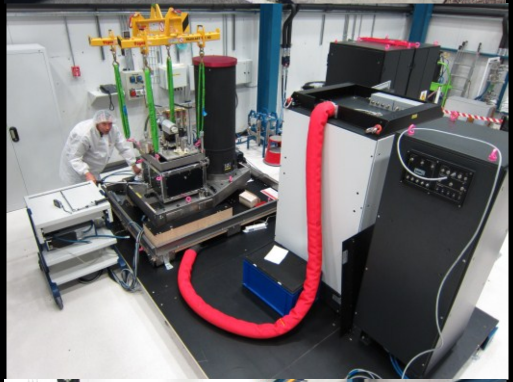
4LGSF Integration, Commissioning: stepped approach

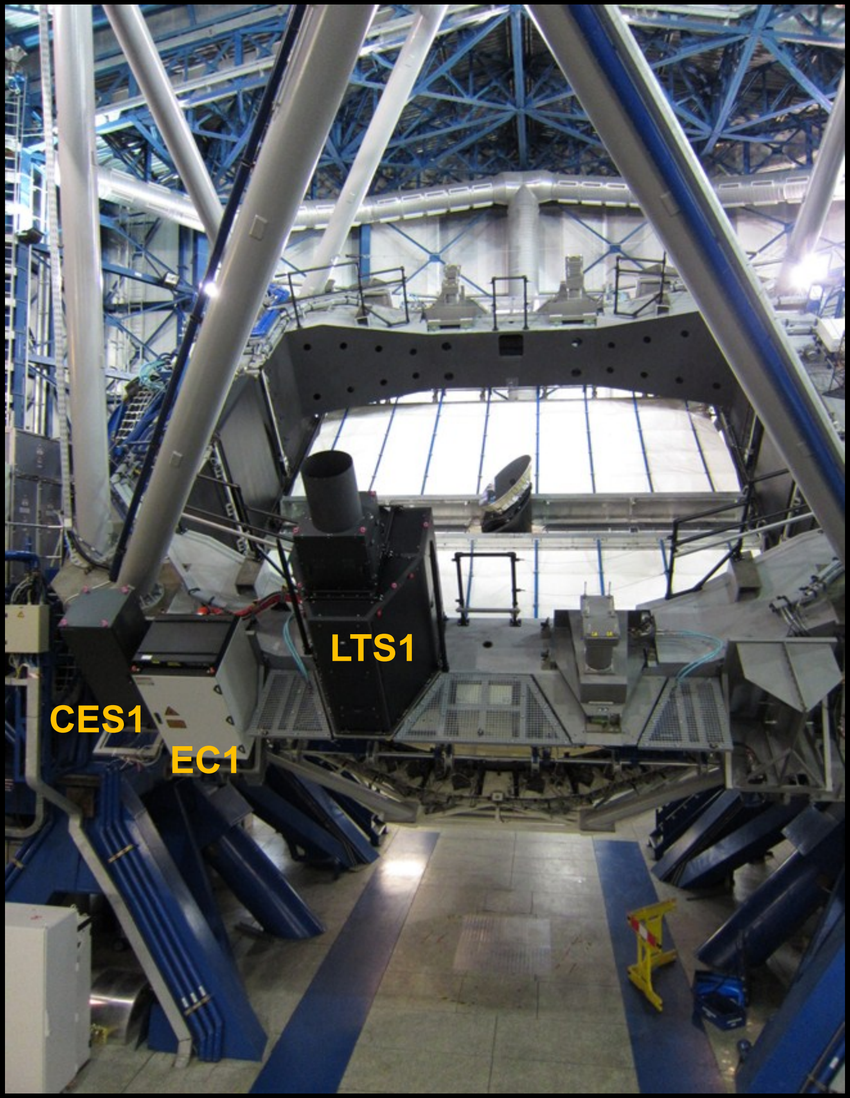
- LGSU1 on VLT-UT4 integrated in Feb-Mar 2015
- Commissioned LGSU1 in 2Q15. With GRAAL 3Q15
- The team includes ESO and Toptica+MPBC staff
- From the LGSU1 commissioning, implemented changes in the LGSU2-4 back at HQ in Garching

- Full 4LGSF reintegration at base camp first, test that everything works (Jan 2016)
- Permission to Install on UT4: Feb 2016
- Daytime verification on UT4: Mar 2016
- First calibrations on Sky: Mar 2016
- Full Commissioning Nights:

26 April-4 May, 15June-21 June

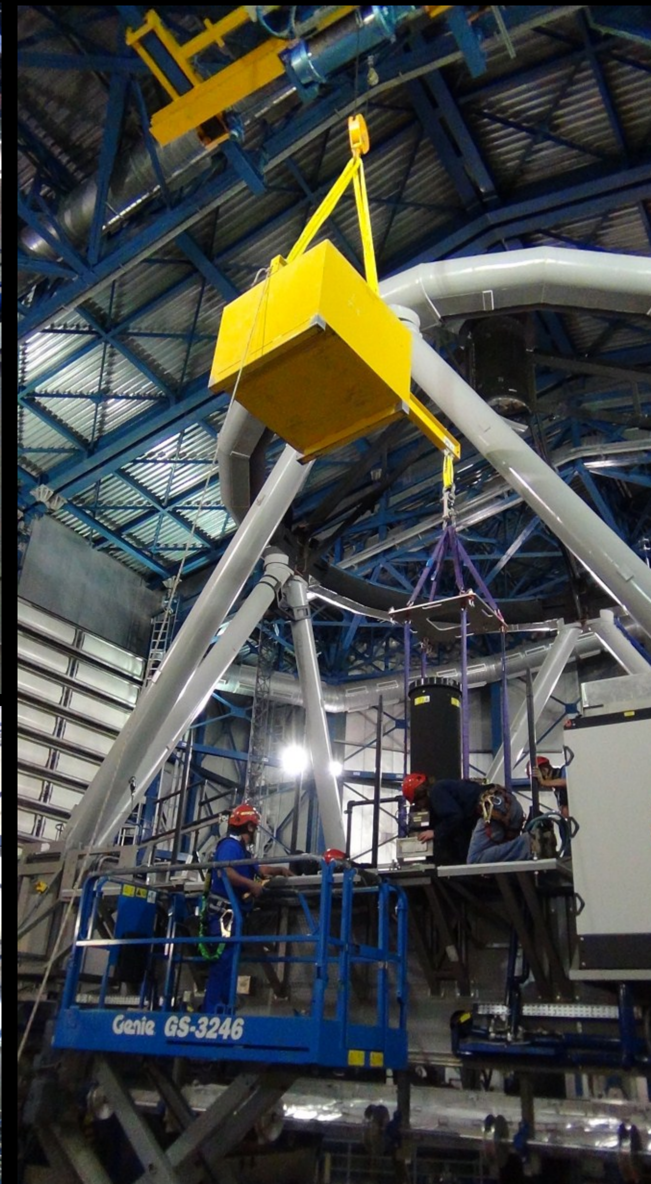
ESO 4LGSF: Integration in the VLT

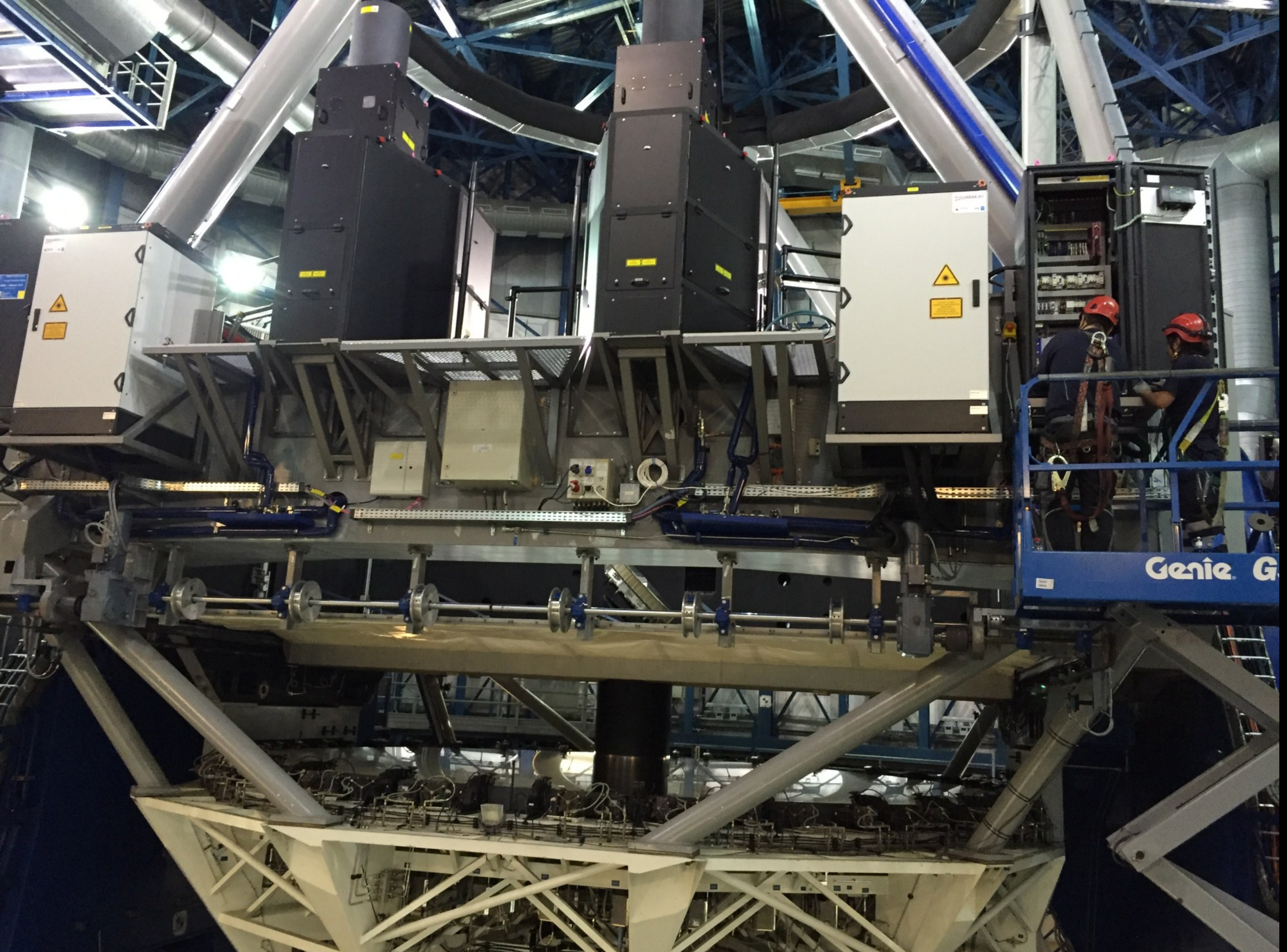




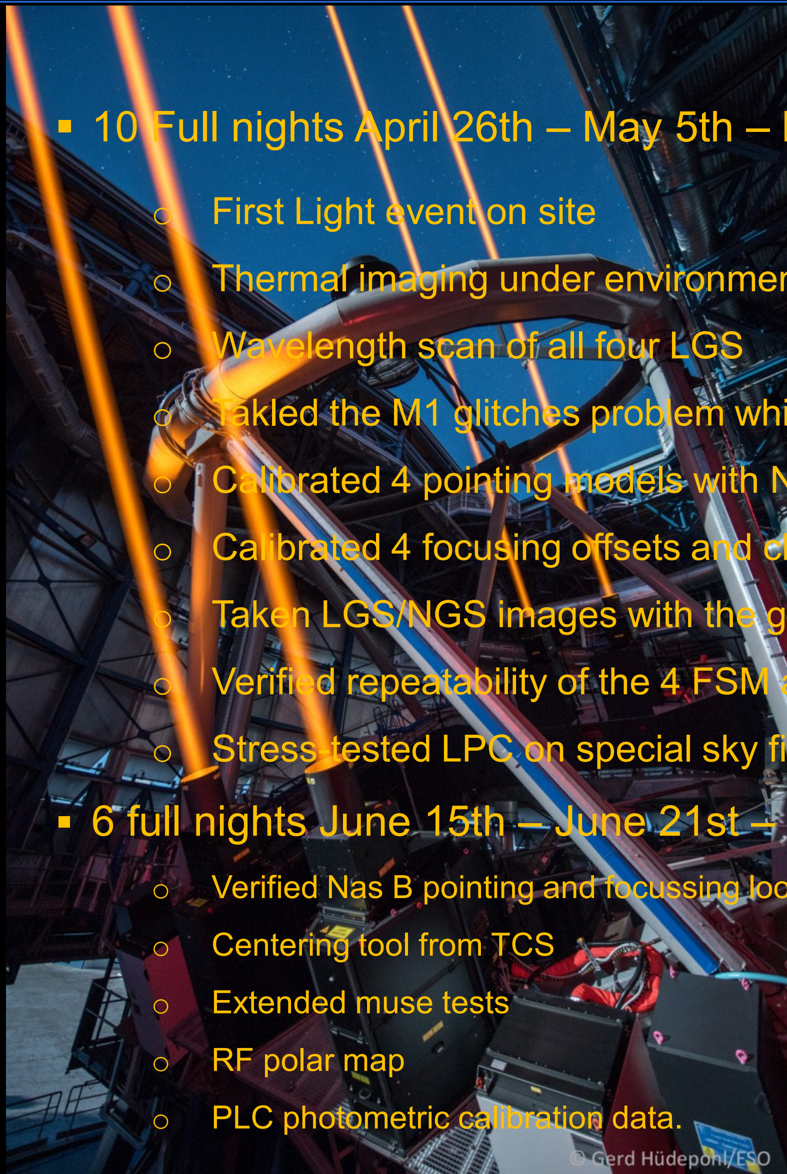
ESO 4LGSF: Integration in the VLT

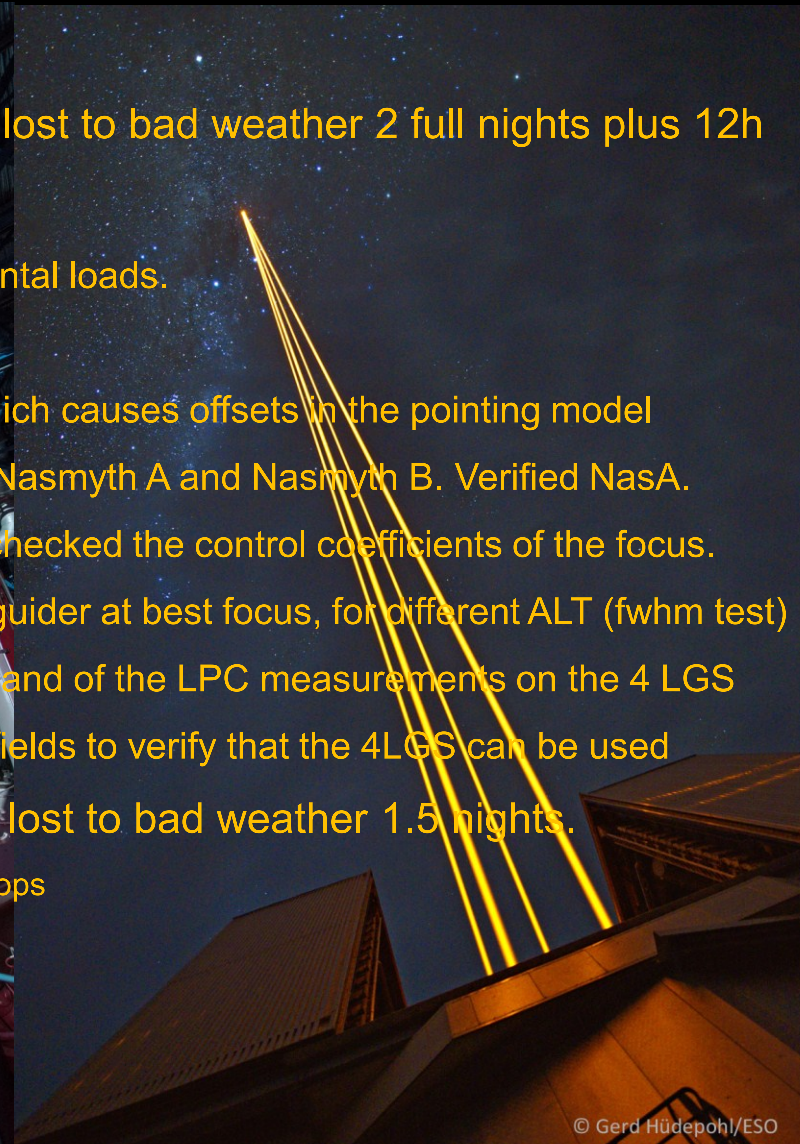
- UT4 structure prepared
- 10 days UT4 Full Access
- Intense team activities




Genie

4LGSF Commissioning and on-sky results





- 10 Full nights April 26th – May 5th – lost to bad weather 2 full nights plus 12h
  - First Light event on site
  - Thermal imaging under environmental loads.
  - Wavelength scan of all four LGS
  - Takled the M1 glitches problem which causes offsets in the pointing model
  - Calibrated 4 pointing models with Nasmyth A and Nasmyth B. Verified NasA.
  - Calibrated 4 focusing offsets and checked the control coefficients of the focus.
  - Taken LGS/NGS images with the guider at best focus, for different ALT (fwhm test)
  - Verified repeatability of the 4 FSM and of the LPC measurements on the 4 LGS
  - Stress-tested LPC on special sky fields to verify that the 4LGS can be used
- 6 full nights June 15th – June 21st – lost to bad weather 1.5 nights.
  - Verified Nas B pointing and focussing loops
  - Centering tool from TCS
  - Extended muse tests
  - RF polar map
  - PLC photometric calibration data.

On Sky wavelength calibration

- Performed the LUs wavemeter calibrations
- Assigned set wavelength to the seed WL control and measured the RF
- Lasers are tuned OK.

LGSU3

Emission wl (nm)	Delta (MHz)	seed wl (nm) in vacuum	ADU Intensity (10 sec exp)	Dark ADU	Flux	Relative flux
589.16	-400	1178.32	3900	1890	2010	0.264126150
589.159969	-375	1178.31994	4100	1890	2210	0.290407359
589.159679	-250	1178.31936	6500	1890	4610	0.605781866
589.15939	-125	1178.31878	8900	1890	7010	0.921156373
589.15910	0	1178.3182	9500	1890	7610	1.000000000
589.158811	125	1178.31762	8400	1890	6510	0.855453351
589.158521	250	1178.31704	5900	1890	4010	0.526938239
589.158232	375	1178.31646	3900	1890	2010	0.264126150
589.157942	500	1178.31588	3100	1890	1210	0.159001314

LGSU2

Emission wl (nm)	Delta (MHz)	seed wl (nm) in vacuum	ADU Intensity (10 sec exp)	Dark ADU	Flux	Relative flux
589.16	-400	1178.32	3300	1890	1410	0.198312236
589.159969	-375	1178.31994	3500	1890	1610	0.226441632
589.159679	-250	1178.31936	5350	1890	3460	0.486638537
589.15939	-125	1178.31878	7650	1890	5760	0.810126582
589.15910	0	1178.3182	9000	1890	7110	1.000000000
589.158811	125	1178.31762	8750	1890	6860	0.964838256
589.158521	250	1178.31704	6650	1890	4760	0.669479606
589.158232	375	1178.31646	4520	1890	2630	0.369901547
589.157942	500	1178.31588	3320	1890	1430	0.201125176

LGSU4 Mean Dark 1800

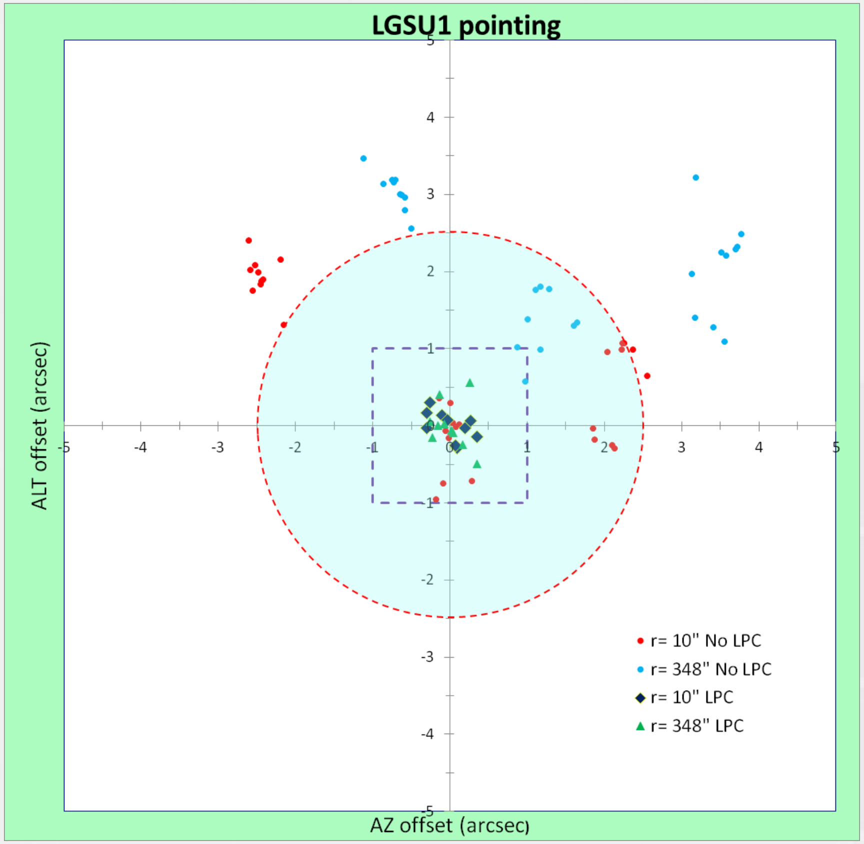
Emission wl (nm)	Delta (MHz)	seed wl (nm) in vacuum	ADU Intensity (Mean)	Dark ADU	Flux (ADU)	Relative flux
589.16	-350	1178.32000	2850	1800	1050	0.218750
589.15968	-250	1178.31936	4020	1800	2220	0.462500
589.15939	-125	1178.31878	5500	1800	3700	0.770833
589.1591	0	1178.3182	6600	1800	4800	1.000000
589.15881	125	1178.31762	5680	1800	3880	0.808333
589.15852	250	1178.31704	4300	1800	2500	0.520833
589.15823	375	1178.31646	3150	1800	1350	0.281250
589.157942	500	1178.31588	2500	1800	700	0.145833

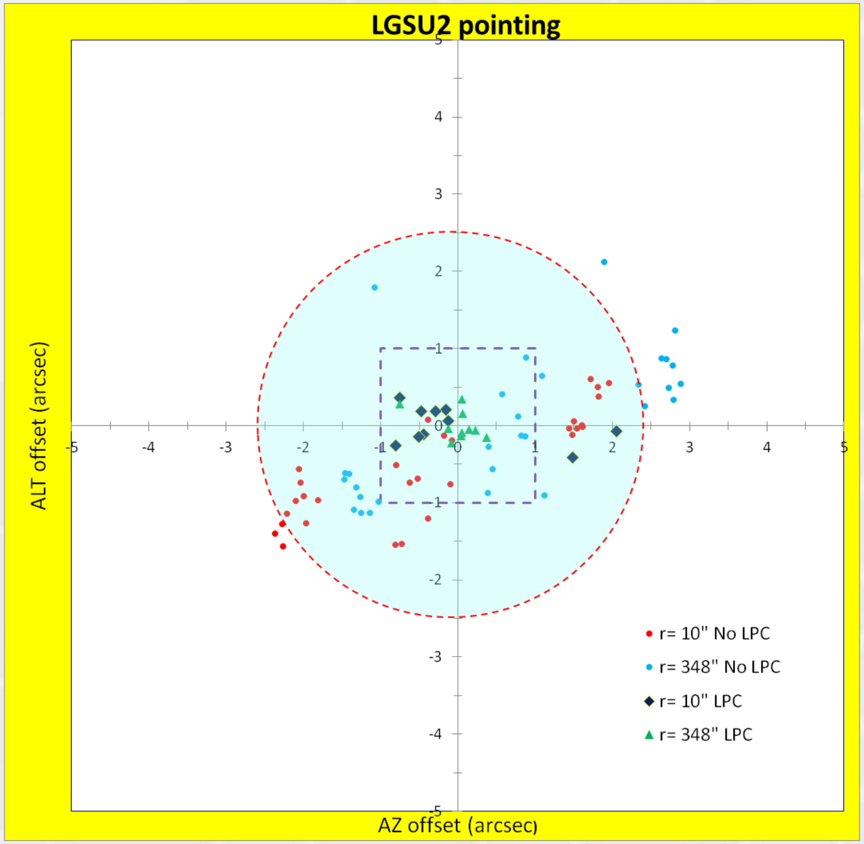
LGSU1

Emission wl (nm)	Delta (MHz)	seed wl (nm) in vacuum	ADU Intensity (10 sec exp)	Dark ADU	Flux	Relative flux
589.16	-400	1178.32	2900	1890	1010	0.179715302
589.159969	-375	1178.31994	2970	1890	1080	0.192170819
589.159679	-250	1178.31936	4340	1890	2450	0.435943060
589.15939	-125	1178.31878	6210	1890	4320	0.768683274
589.15910	0	1178.3182	7510	1890	5620	1.000000000
589.158811	125	1178.31762	7150	1890	5260	0.935943060
589.158521	250	1178.31704	6100	1890	4210	0.749110320
589.158232	375	1178.31646	4320	1890	2430	0.432384342
589.157942	500	1178.31588	3230	1890	1340	0.238434164

Open Loop Pointing

- LGS Open loop pointing: explored ALT range 30-85 deg, NasA , 3 asterisms
  LPC needed to meet OL pointing requirement. M1 glitches.
- In Spec with LPC : r< 2.5”

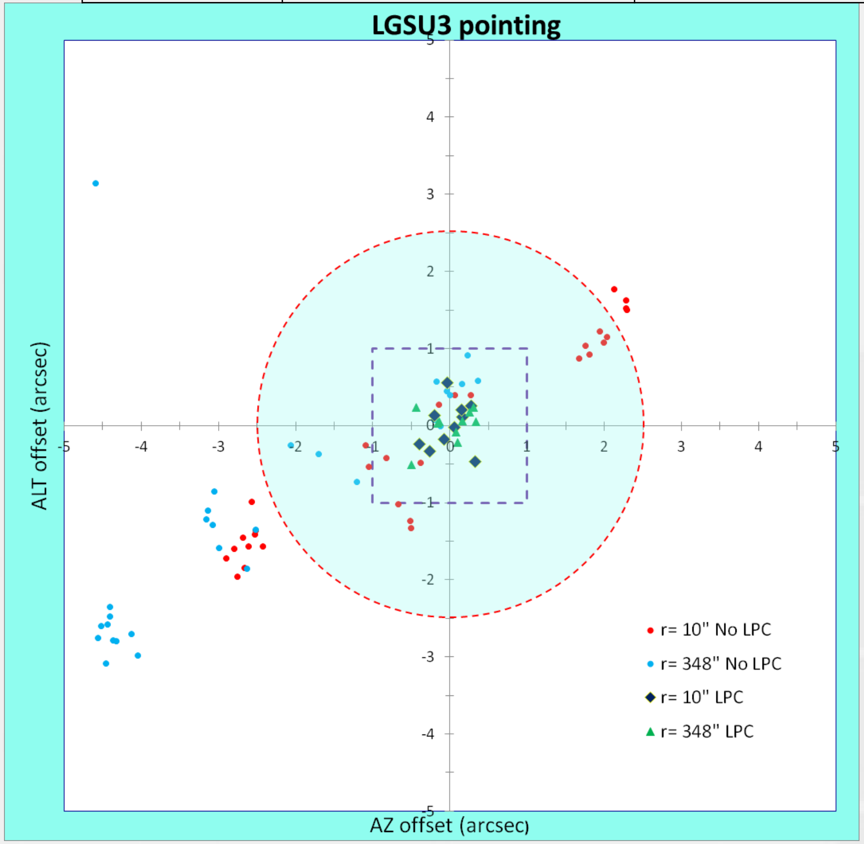


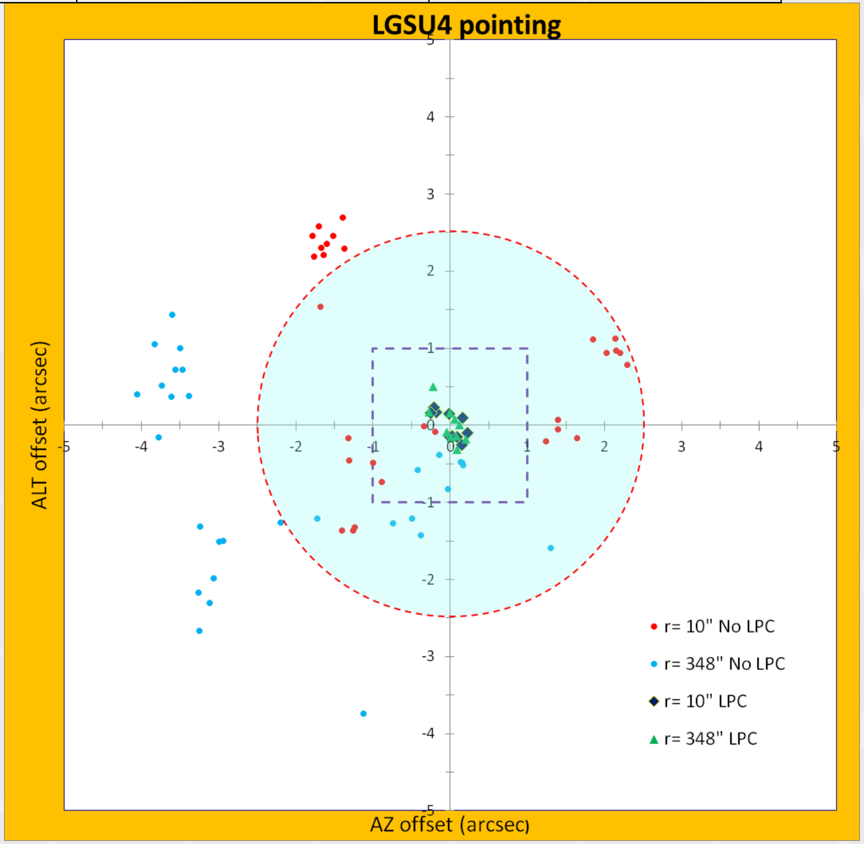


Open Loop Pointing (2)

- Repeatability LPC measurements (rms):

Asterism	LGSU1 rms		LGSU2 rms		LGSU3 rms		LGSU4 rms	
	ALT (")	AZ (")	ALT (")	AZ (")	ALT (")	AZ (")	ALT (")	AZ (")
10"	0.19	0.22	0.26	0.23	0.33	0.25	0.18	0.16
62"	0.28	0.31	0.26	0.32	0.32	0.36	0.13	0.27
348"	0.32	0.22	0.20	0.32	0.24	0.32	0.25	0.16





Open Loop Pointing (3)

- M1 glitches, 4” steps. Now we are sure. Problem handled by procedures: OK with LPC
- Large PM offsets can be created by the M1 glitch during operations

LGSU1		LGSU2		LGSU3		LGSU4	
ALT (")	AZ (")	ALT (")	AZ (")	ALT (")	AZ (")	ALT (")	AZ (")
5.4	8.7	5.9	7.2	7.4	6.8	4.2	7.3
-24.3	-8.8	-23.2	-9.2	-25.3	-7.7	-22.7	-8.8
-7.6	-6.1	-9.9	-4.4	-11.5	-5.1	-6.7	-4.0

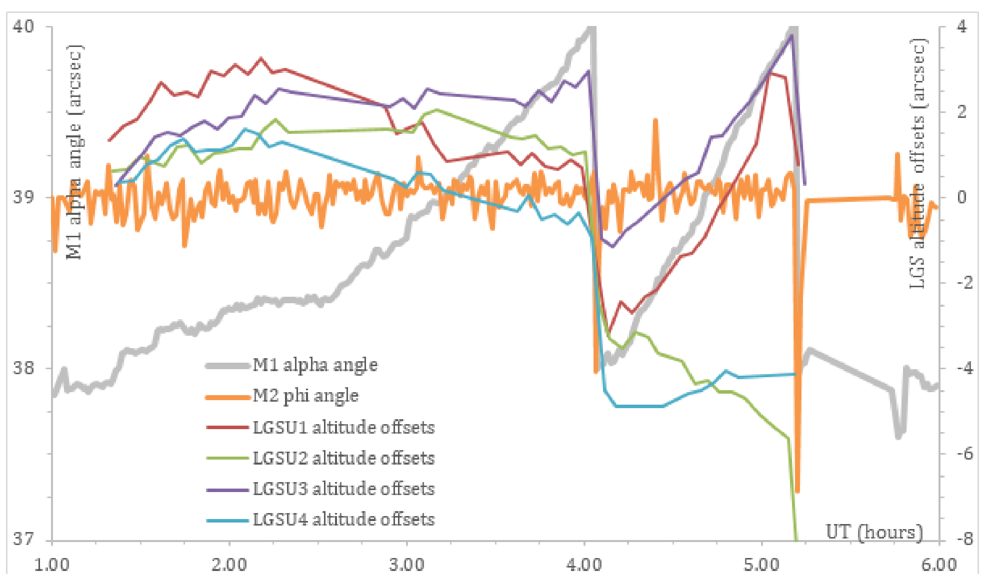
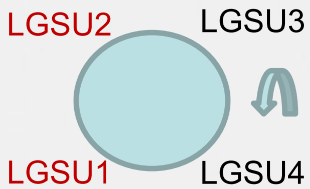
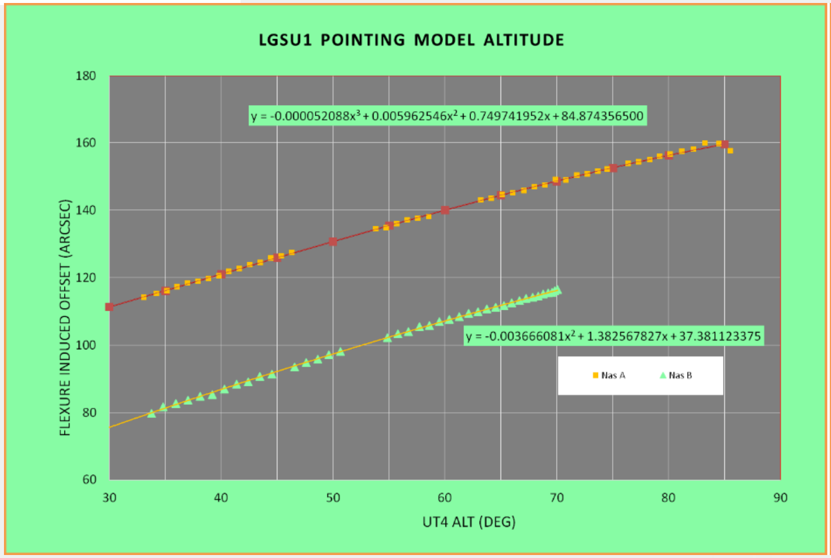
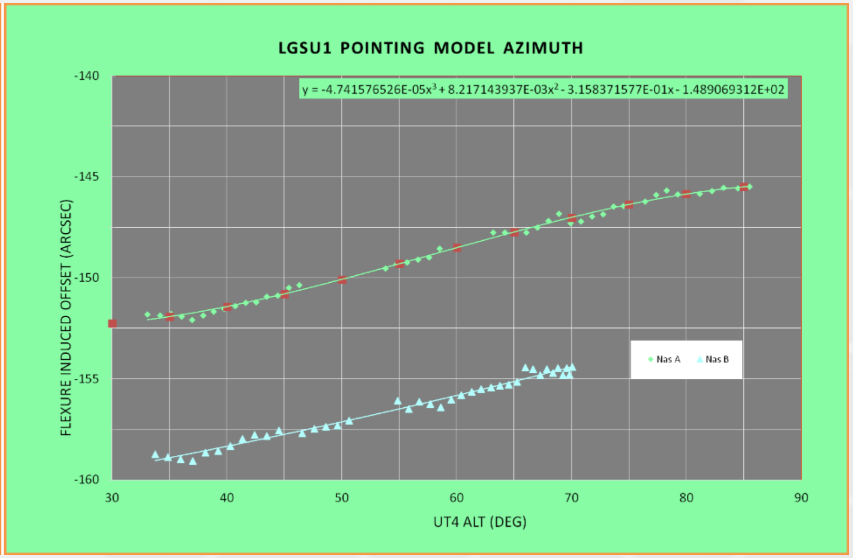


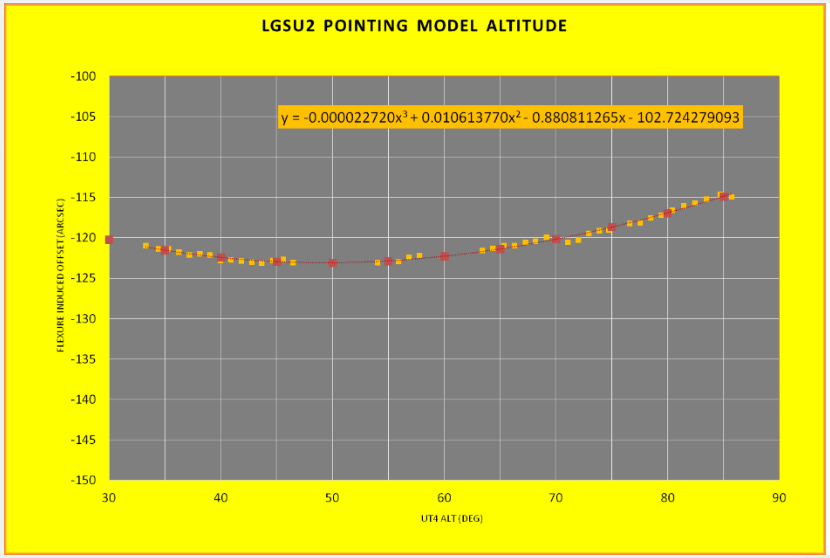
Figure 3: LPC altitude offsets, M1 alpha angle and M2 phi angle vs time – night from April 28th to 29th – M1 alpha angle is associated to the left vertical axis – all other parameters are associated to the right one

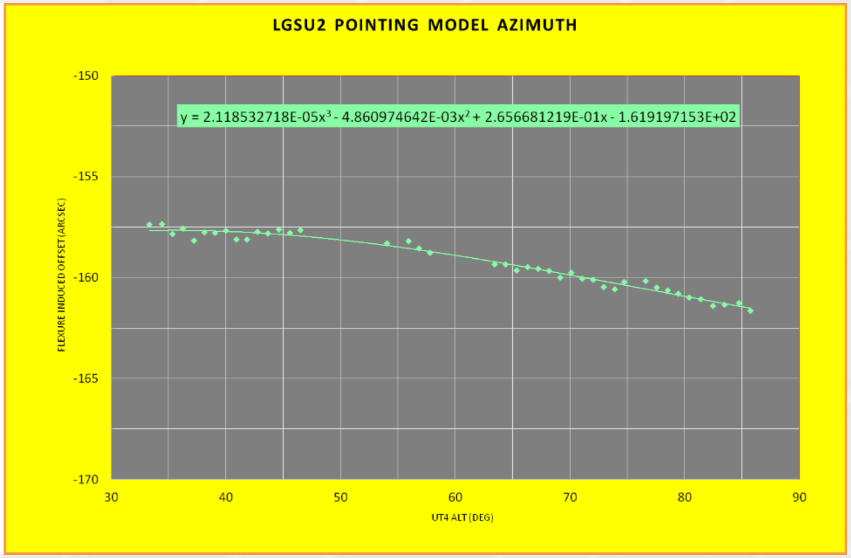
Pointing Models









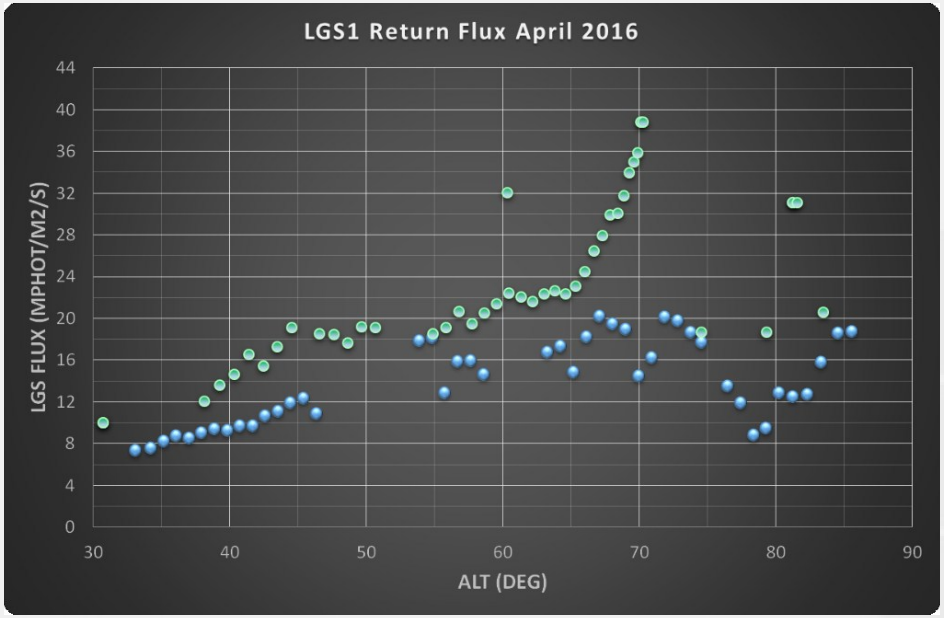


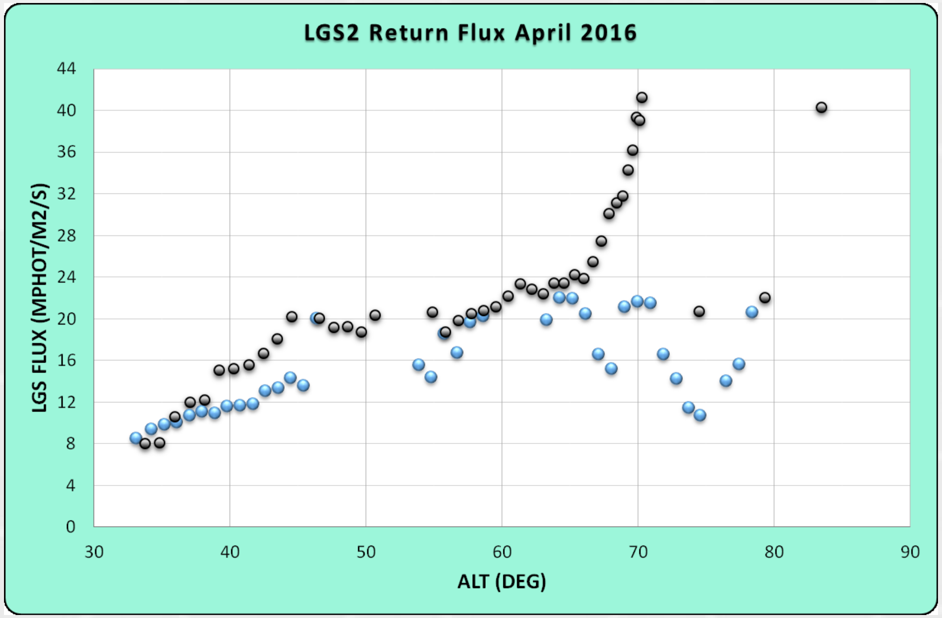
Summary Open Loop Pointing

- With the support of the LPC, open loop pointing is in spec
- We have verified that LPC can operate also at extreme fields (cluster, empty fields, extended objects in the background). Eta-Car exception.
- The pointing models are different between the lower and the upper LGSUs
- Difference between the Nas A and Nas B pointing models (UT4-M3 flexures)
- The UT4-M1 glitches affecting the PM can be overcome by procedures with LPC

LGS Return Flux

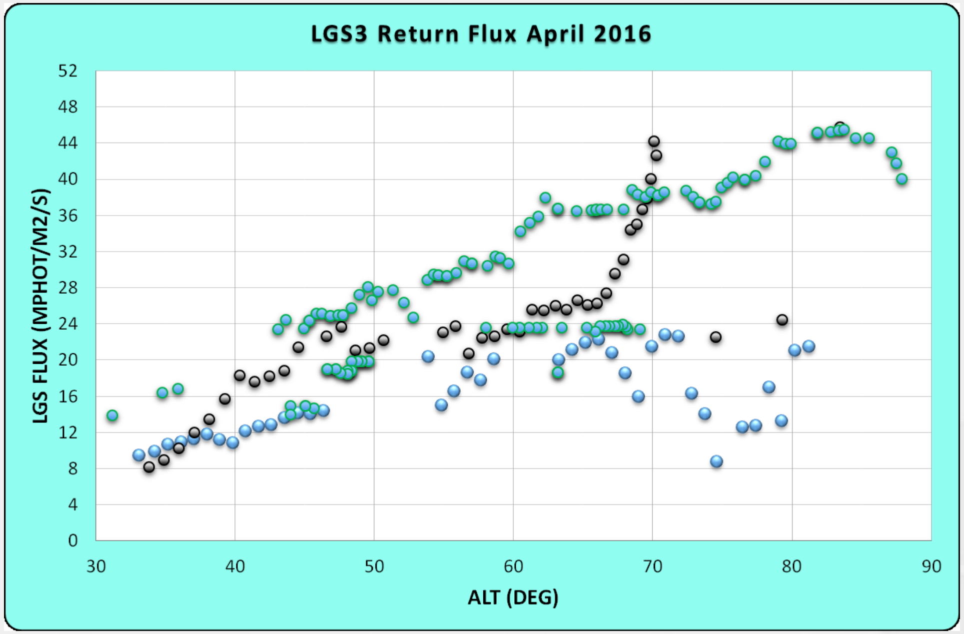
- TLR 7: LGS Return Flux in specification (7.7 Mphot/m^2/s at Zenith, Na $4x10^{13}$ /m^2)
- Always in spec. Sodium abundance has changed a lot during the runs
- Photometry calculation under review, do not expect big changes of the results

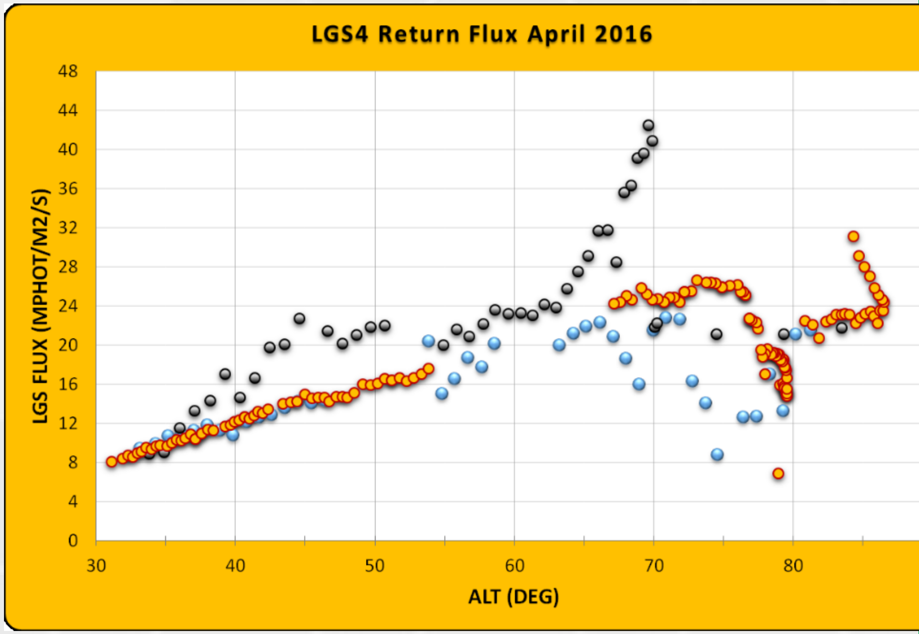




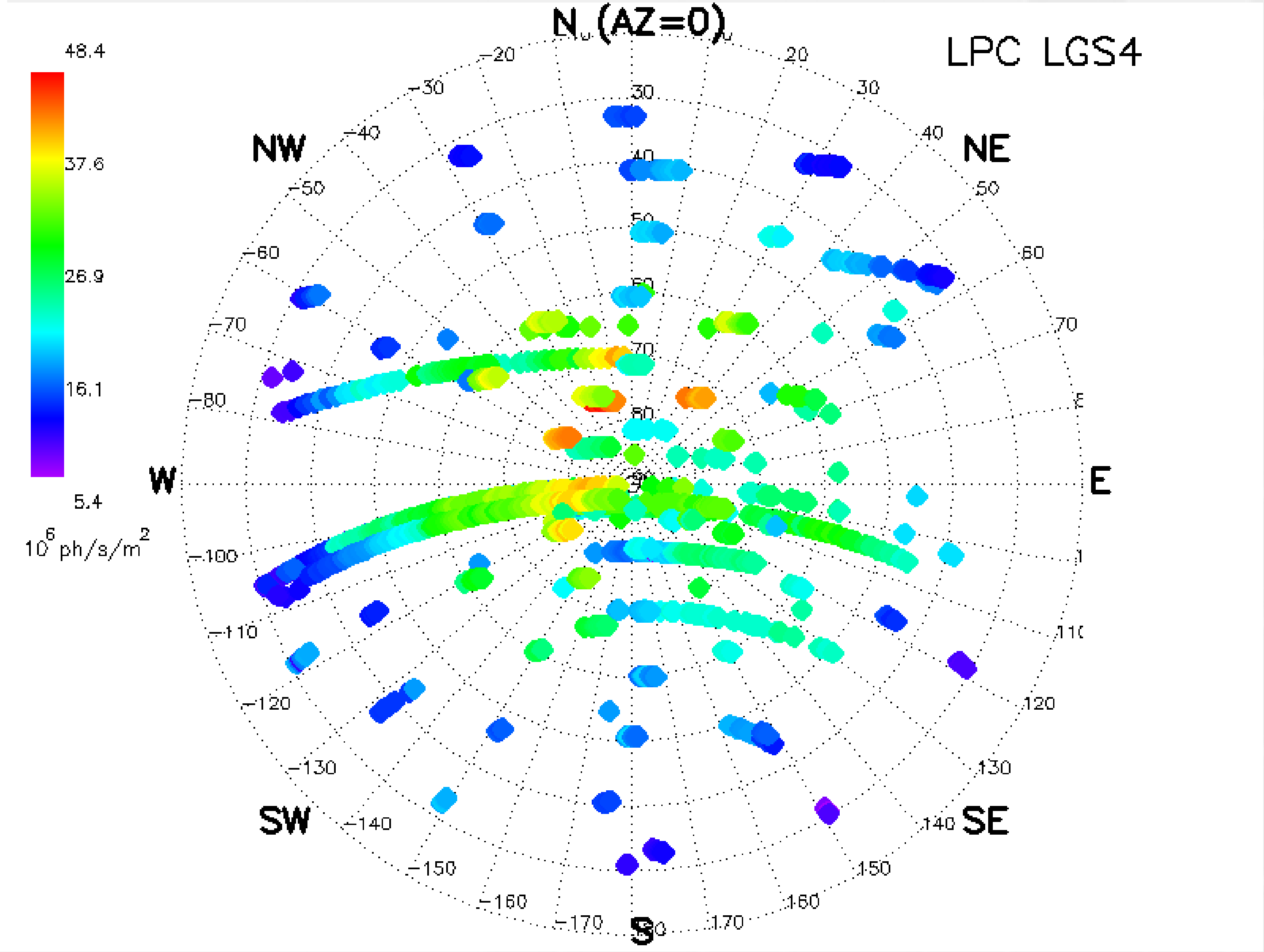
LGS Return Flux (2)

- Data will be placed on polar plots to see also the AZ dependence





Paranal LGS Return Flux (April and June runs)



LGS FWHM

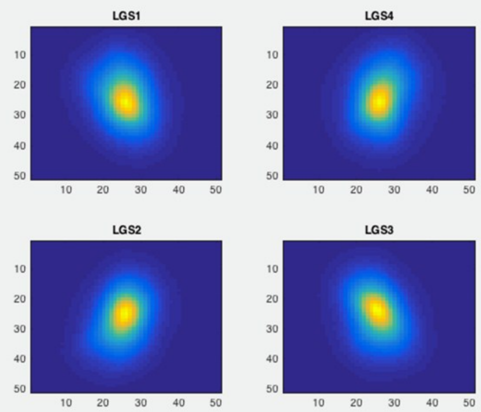
- TLR8 - for seeing 0.6”: LGS 1.0” ; for 1” seeing, LGS fwhm = 1.35

ALT	LGSU1				
	LGS		NGS	Ratio	Mesosphere
	fwhm S	fwhm L	fwhm	lgs/ngs fwhm	spot size
83	**0.94**	**1.54**	**0.59**	1.59	0.67
79	1.09	1.65	0.60	1.82	0.77
73	1.21	1.94	0.48	2.53	0.86
68	1.13	1.68	0.66	1.70	0.80
51	1.11	1.47	0.76	1.47	0.79
38	1.21	1.50	0.61	1.96	0.85

LGSU2				
LGS		NGS	Ratio	Mesosphere
fwhm S	fwhm L	fwhm	lgs/ngs fwhm	spot size
0.85	**1.48**	**0.59**	1.45	0.60
1.07	1.57	0.47	2.26	0.75
0.98	1.50	0.46	2.15	0.70
0.96	1.47	0.51	1.87	0.68
1.06	1.46	0.54	1.97	0.75
0.93	1.28	0.65	1.44	0.66

ALT	LGSU3				
	LGS		NGS	Ratio	Mesosphere
	fwhm S	fwhm L	fwhm	lgs/ngs fwhm	spot size
83	**0.97**	**1.54**	**0.38**	2.51	0.68
79	0.96	1.53	0.46	2.09	0.68
73	0.93	1.53	0.48	1.93	0.66
68	1.06	1.48	0.42	2.50	0.75
51	0.90	1.29	0.47	1.92	0.64
38	1.01	1.43	0.53	1.92	0.72

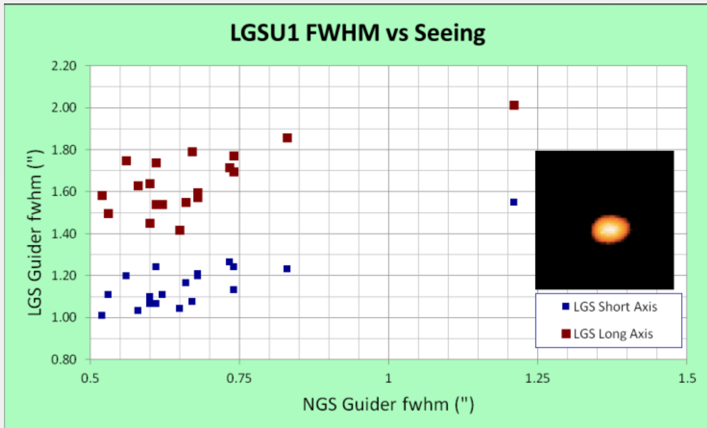
LGSU4				
LGS		NGS	Ratio	Mesosphere
fwhm S	fwhm L	fwhm	lgs/ngs fwhm	spot size
0.94	**1.57**	**0.38**	2.46	0.67
1.20	1.59	0.58	2.07	0.85
1.10	1.53	0.48	2.29	0.78
0.95	1.45	0.42	2.25	0.67
0.85	1.38	0.53	1.60	0.60
1.04	1.39	0.45	2.31	0.73

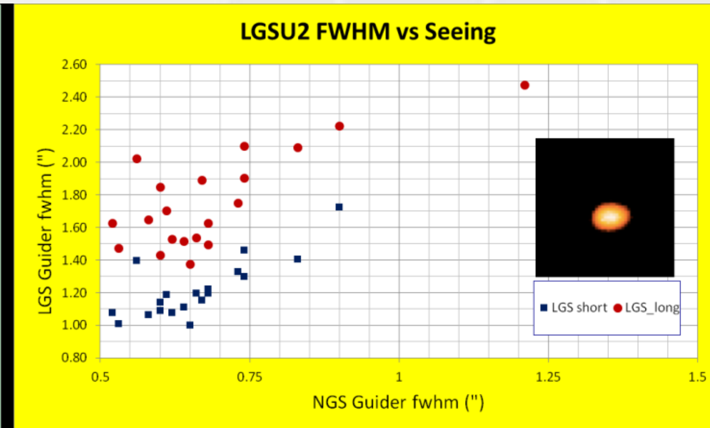


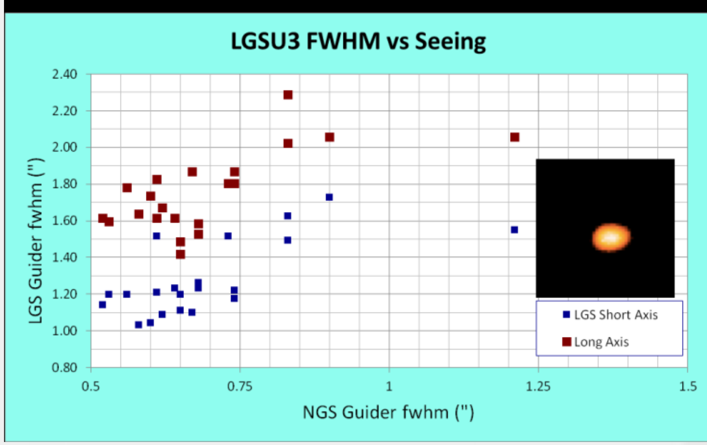
- LGS focus optimized on guider
- 10 measurements averaged
- NGS and LGS exposure time 0.2s
- OK, in spec. Matches Ron‘s simulations

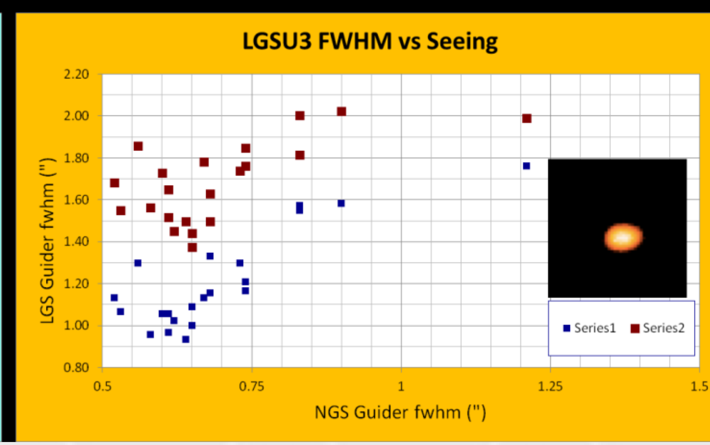
LGS FWHM

		fwhmx (px)	fwhmy (px)	fwhmx ("")	fwhmy ("")	NGS fwhm ("")	BEU	ALT	AZ
SPEC POSITION	LGS1	13.7	8.8	1.507	**0.968**	**0.57**	-5194	ALT 63	AZ 154
with TCS	LGS2	15.1	9.5	1.661	**1.045**		66313		
Optimization	LGS3	14.6	9.8	1.606	**1.078**		34300		
	LGS4	15.1	10	1.661	**1.1**		41459		



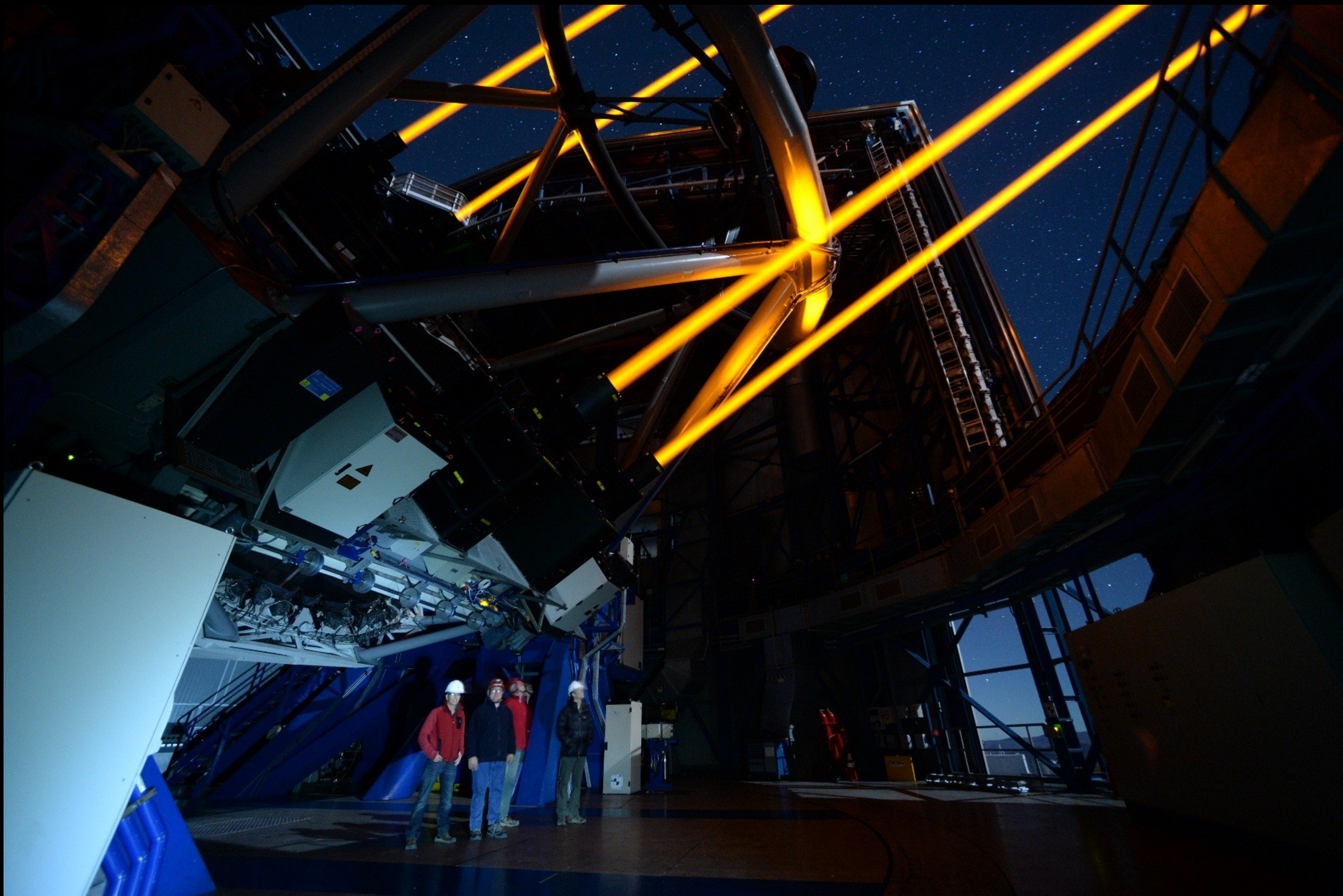






Summary Main Commissioning Results

- Wavelength calibration of the lasers: OK
- Nigthtime cooling and surface Temp: OK, passed.
- AAS handling between 4LGSF/LGSF OK. Check on mask loading to be implemented
- LGS pointing: within ALT range 30-85 deg, NasA, NasB <2.5” radius in spec
- LPC properly working also in very empty fields, galaxy backgrounds, clusters and galaxies. Only very bright, extended objects created difficulty if close to one LGS.
- LGSF Fwhm in specification 0.6” seeing at 30 deg Zenith.
- LGS Return Flux in specification [range 7-21 Mphot/m^2/s (>45 Mphot/m^2/s one night !)]



MPIA Heidelberg 2017

Laser Guide Star Systems R&D: experiments toward future LGS-AO systems

ESO: D.Bonaccini Calia, I.Guidolin, T.Pfrommer, R.Holzlöhner, , S.Lewis, W.Hackenberg, E.Marchetti. P-Y Madec

IAC: M.Reyes Garcia Talavera, I.Montilla

GTC: G.Lombardi

INAF-OAR + Arcetri: M.Centrone, S.Esposito, E.Pinna

LESIA Obs. Paris: G.Rousset, E.Gendron, L.Bardou, F.Vidal, T.Buey

Durham University: T. Morris, A.Badsen, J.Osborne

LZT: P.Hickson

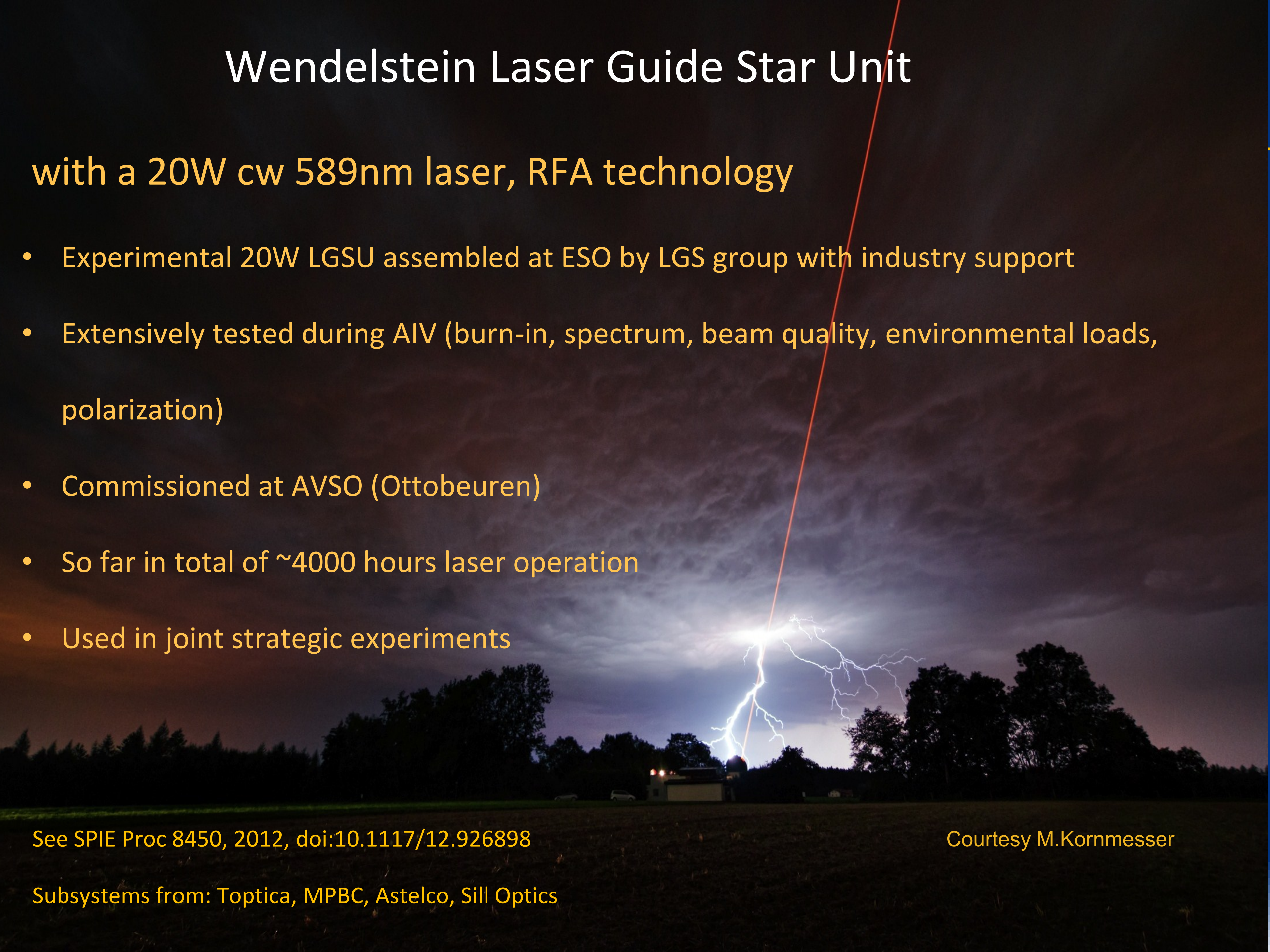
MPE: S.Rabien

The ESO 'Wendelstein' transportable laser guide star is an experimental unit used for field experiments on LGS Systems R&D, together with the ESO community

The 20W CW, 589nm laser is based on the RFA technology, also present in the AOF/4LGSF Toptica laser

- WLGSU
- Experiments done
- Experiments ongoing
- Outlook and planned future experiments

Daniel López / IAC



Wendelstein Laser Guide Star Unit

with a 20W cw 589nm laser, RFA technology

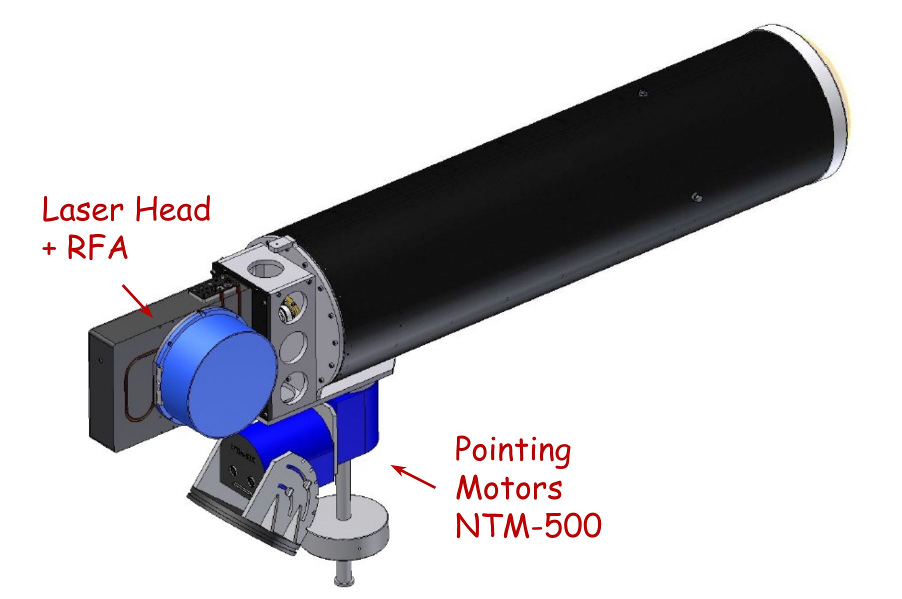
- Experimental 20W LGSU assembled at ESO by LGS group with industry support
- Extensively tested during AIV (burn-in, spectrum, beam quality, environmental loads, polarization)
- Commissioned at AVSO (Ottobeuren)
- So far in total of ~4000 hours laser operation
- Used in joint strategic experiments

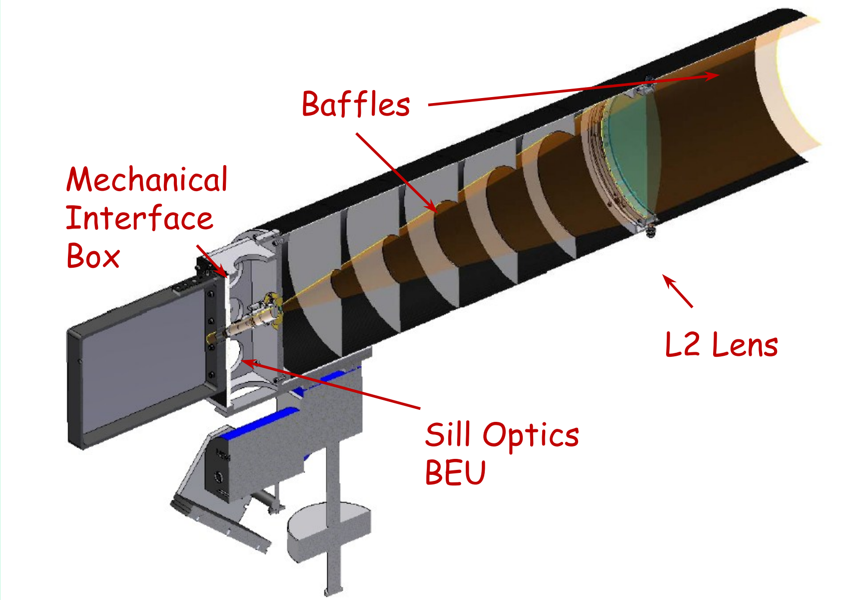
See SPIE Proc 8450, 2012, doi:10.1117/12.926898

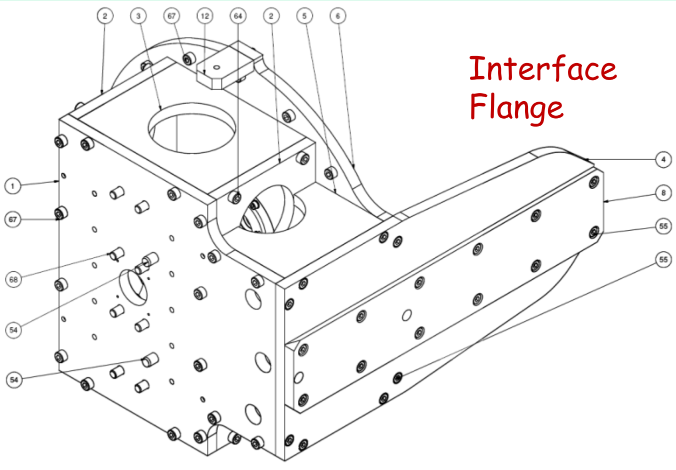
Courtesy M.Kornmesser

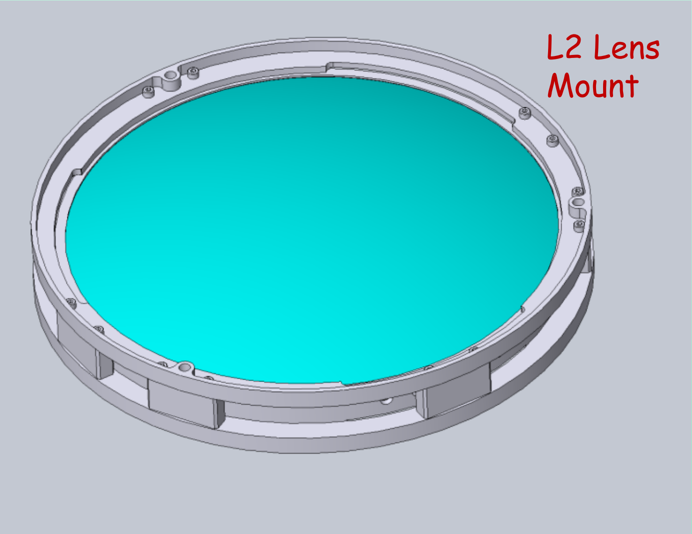
Subsystems from: Toptica, MPBC, Astelco, Sill Optics

Launch Telescope: Astelco on OTA

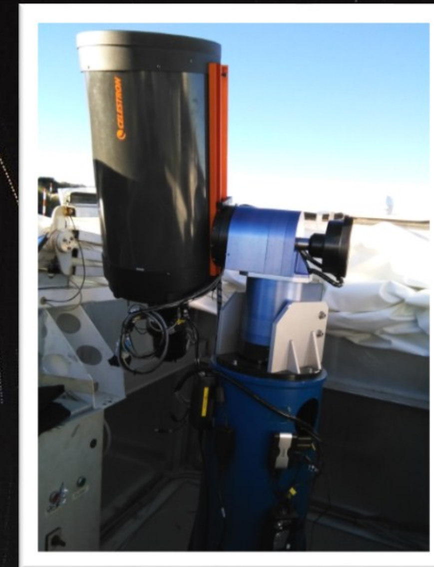






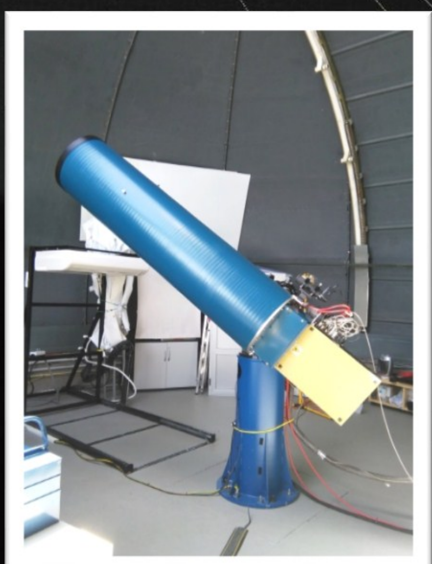


WLGSU

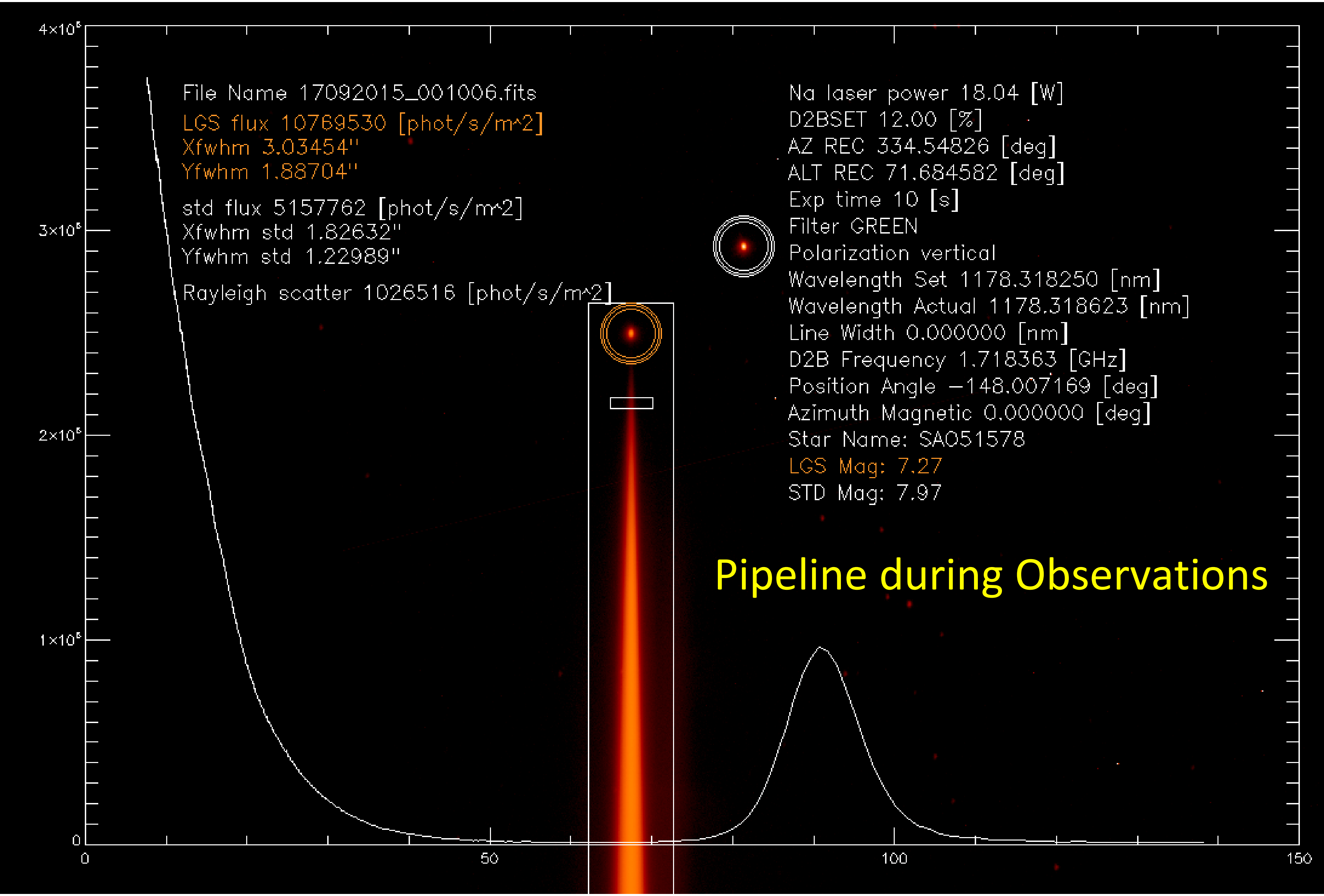


Find OPTIMAL LASER FORMAT vs ALT,AZ. Find RF
Vary laser parameters

- Linewidth (6-32 MHz)
- Polarization (lin ver,hor,+45,-45, circular)
- D2b intensity (0–30%)
- Power at 589nm (2.5–20 W)
- D2b frequency (1673–1753 MHz)



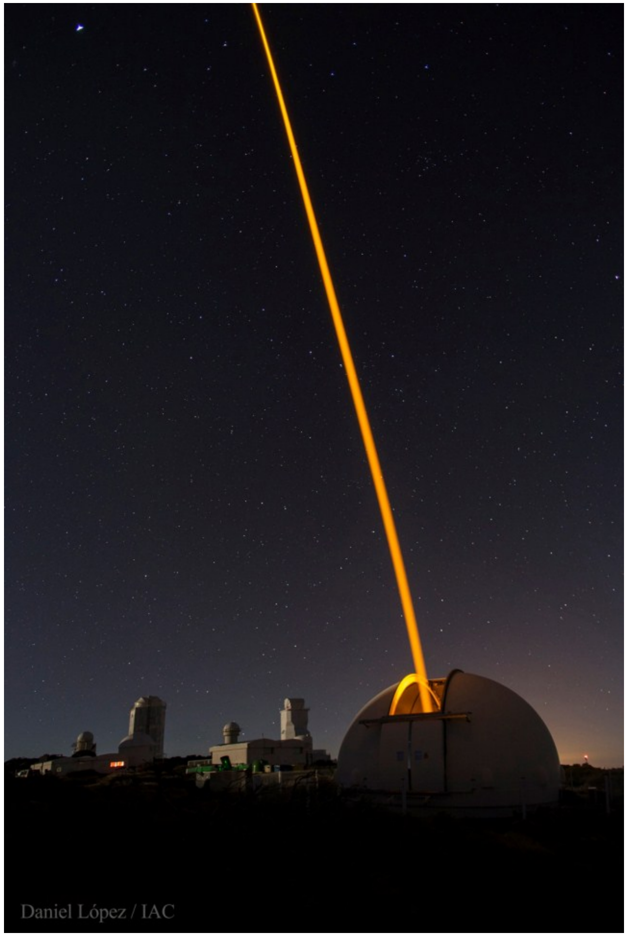
- LT 350mm diameter
- LGS Pointing error: ±2”
- Rx 40cm, with SBIG XT10
- OB observing blocks
- Data Pipeline

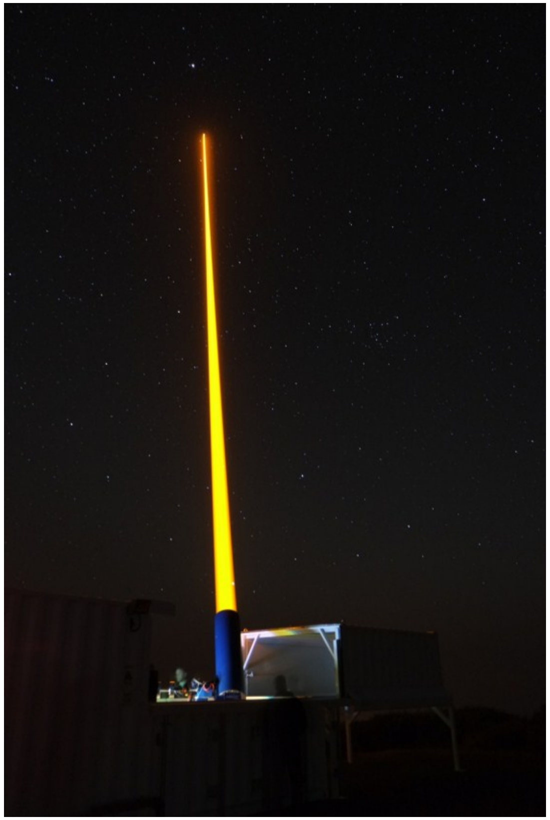

File Name 17092015_001006.fits
LGS flux 10769530 [phot/s/m^2]
Xfwhm 3.03454"
Yfwhm 1.88704"
std flux 5157762 [phot/s/m^2]
Xfwhm std 1.82632"
Yfwhm std 1.22989"
Rayleigh scatter 1026516 [phot/s/m^2]
Na laser power 18.04 [W]
D2BSET 12.00 [%]
AZ REC 334.54826 [deg]
ALT REC 71.684582 [deg]
Exp time 10 [s]
Filter GREEN
Polarization vertical
Wavelength Set 1178.318250 [nm]
Wavelength Actual 1178.318623 [nm]
Line Width 0.000000 [nm]
D2B Frequency 1.718363 [GHz]
Position Angle −148.007169 [deg]
Azimuth Magnetic 0.000000 [deg]
Star Name: SAO51578
LGS Mag: 7.27
STD Mag: 7.97
Pipeline during Observations
4×10⁵
3×10⁵
2×10⁵
1×10⁵
0
0
50
100
150

WLGSU on the Canary Islands

Roque de los Muchachos, WHT 2016-2021

Observatorio de El Teide 2015-16





Now WLGSU is at ORM WHT

Rationale and tests chosen

R&D on LGS-AO technologies, toward mature LGS-AO systems for our telescopes

1. Can we derive online from each LGS of the EELT the corresponding sodium profile, at 0.5Hz rate?
2. Which is the best laser format for the LGS return flux ? (Holzlöhner et al. , 2010, Bonaccini et al 2016)
3. Is the 22W Toptica laser meeting also the EELT LGS RF specifications ? (7.6Mph/s/m2 at Zenith)
4. LGS-AO for the EELT: field test of adaptive optics with a ‘cigar’ LGS (2016-2017)
5. LGS-AO for the visible on 8m: field tests using a Pyramid WFS and pulsed lasers for spot tracking

- Unique situation in Europe, expertise and know-how distributed
- Sinergies, resources and efforts combined from different member states institutes: ESO, IAC/GTC (ES), INAF (I), Durham Univ (UK), LESIA (F), MPE (D).
- Tests done at the LZT and then at the Canary Islands observatories, OT and ORM

Derivation of Sodium Profile from MHz modulation of CW laser
(LZT, ESO)

Astronomy & Astrophysics manuscript no. Butler Lidar — February 2, 2008
(DOI: will be inserted by hand later)

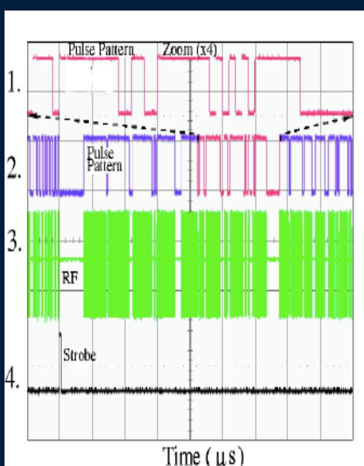
Measuring the Absolute Height and Profile of the Mesospheric Sodium Layer using a Continuous Wave Laser

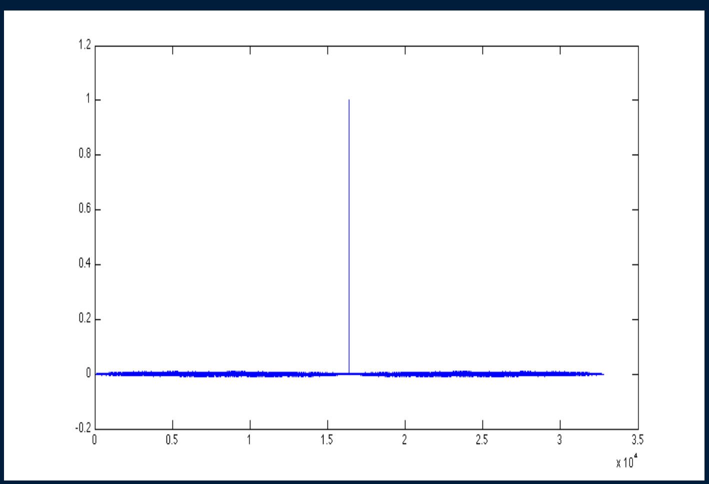
D. J. Butler[1], R. I. Davies[2], R. M. Redfern[3], N. Ageorges[4], and H. Fews[3*]

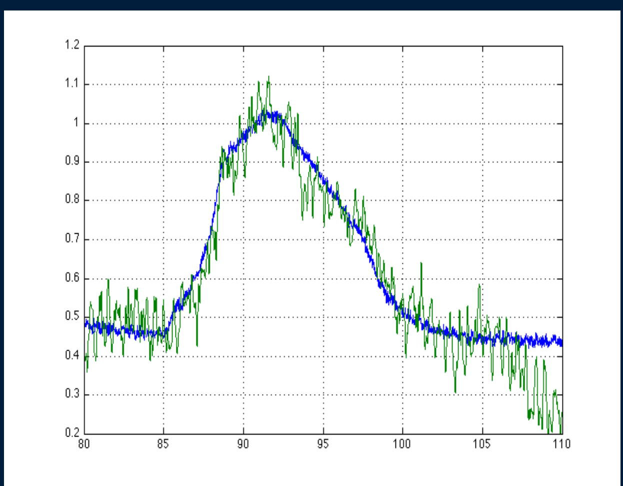
CONSTRUCTION OF BINARY ALMOST PERFECT SEQUENCES BASED ON EXTENDED CYCLIC DIFFERENCE SETS

P.K.S. Wah (wah@nari.ee.ethz.ch)
Communication Technology Laboratory, ETH Zentrum, 8092 Zurich

Amplitude Modulate with prbs → Record CW Lidar data with LZT → X-corr pbrs with data → Extract CW Lidar profile → Compare with LZT Lidar



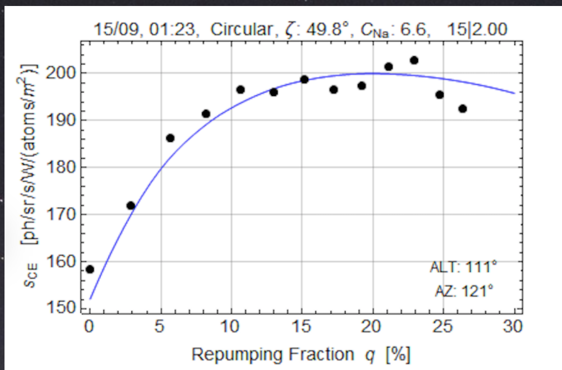


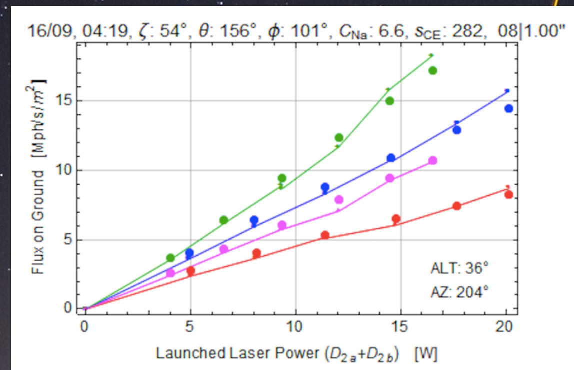


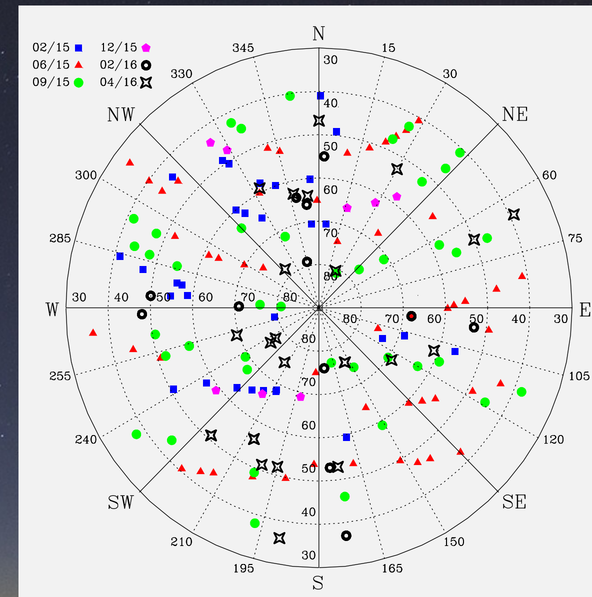
TEST DONE - DATA BEING REDUCED

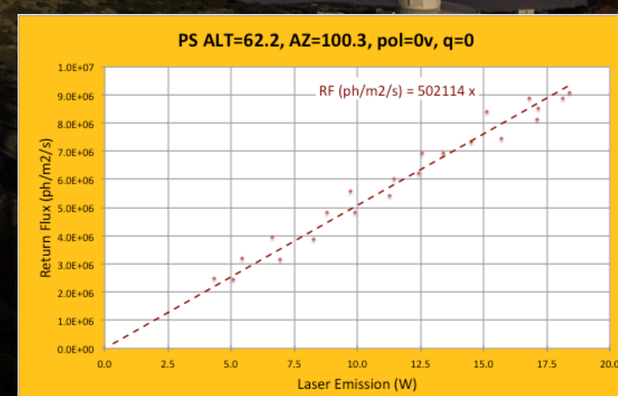
Best Laser Format ? (ESO, IAC/GTC, INAF)

RF Observations at OT - LGS Photometry







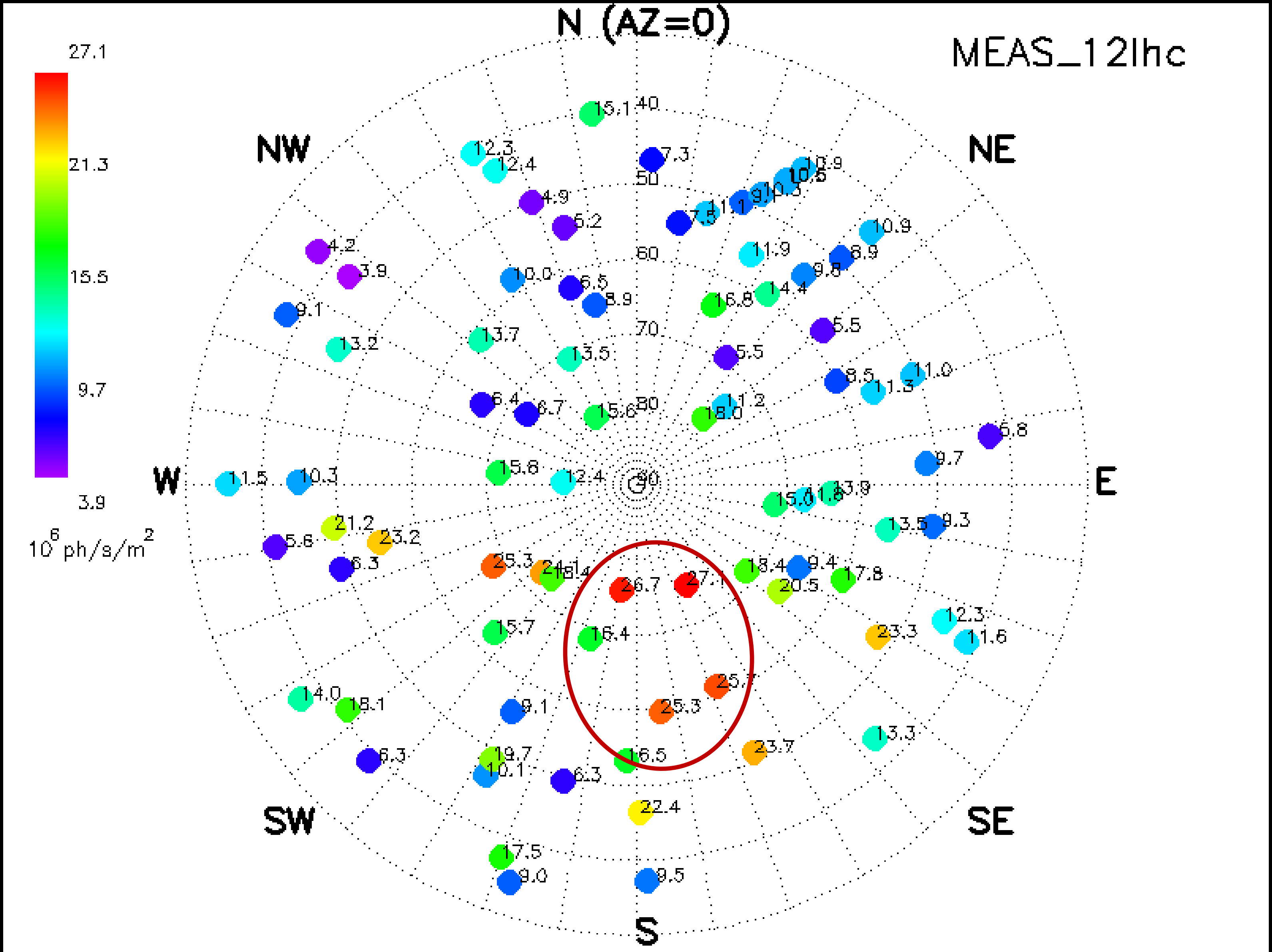


Acquire LGS Photometry
Use OB observing blocks
Use Data Pipeline

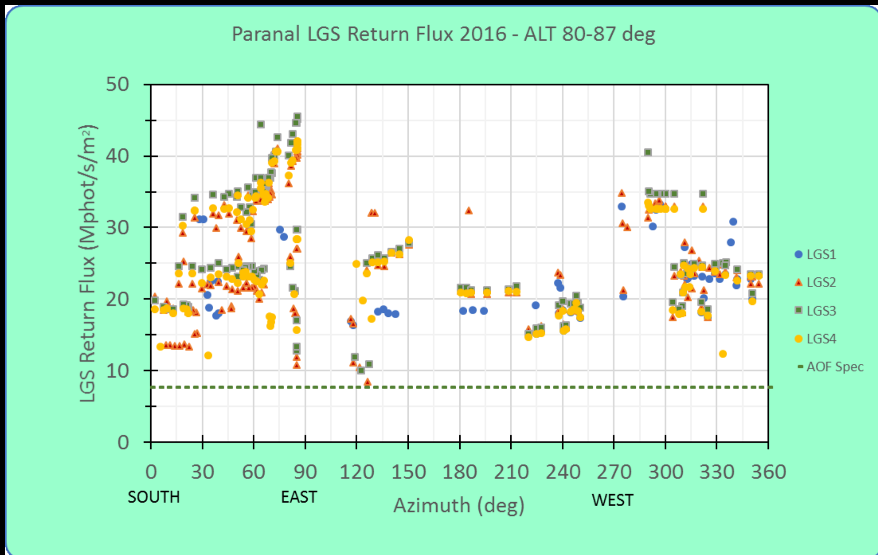
Done, ESO internal report pending

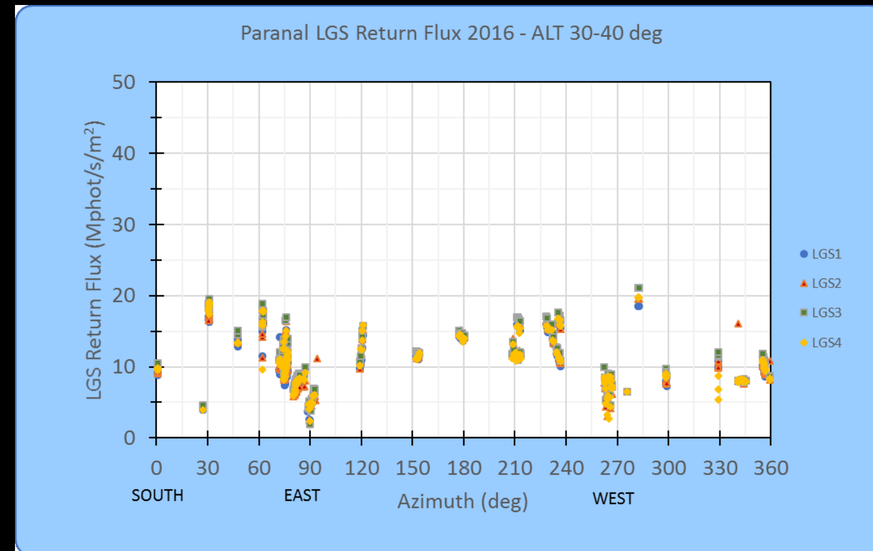
Model results from Holzlöhner et al. (A&A, 2010)

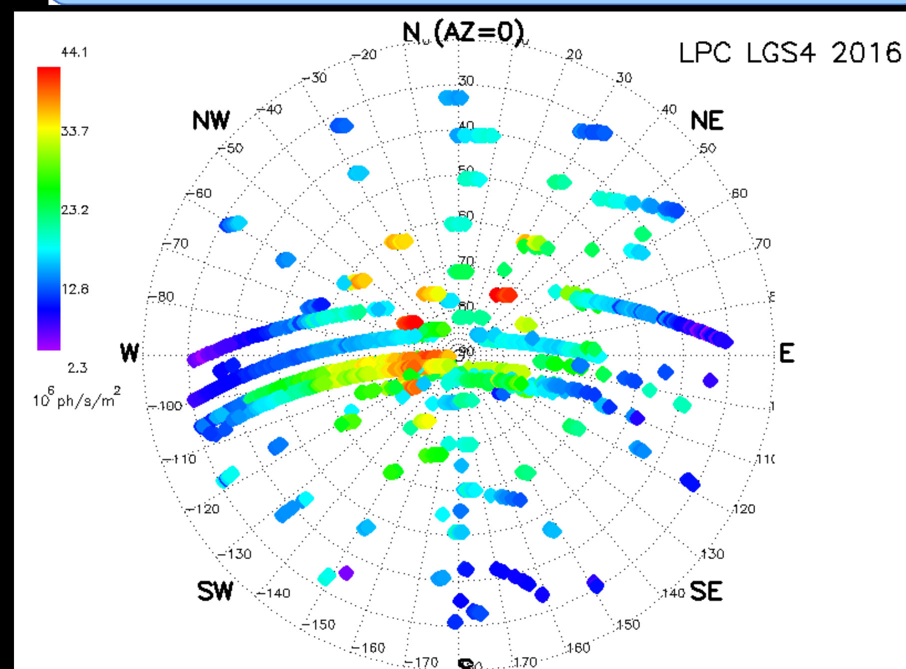
OT Measured Return Fluxes - Done



VLT Measured Return Fluxes (Commissioning April-Dec 2016)







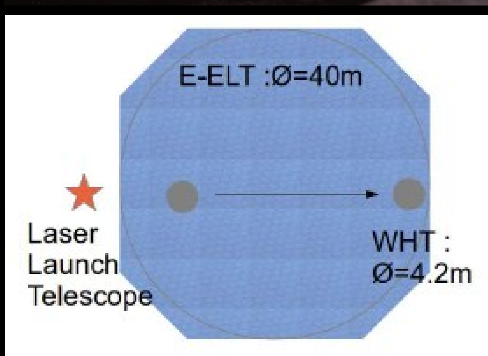
- Toptica 22W laser on 4LGSF/AOF
- Seasonal sodium variation included
- Sodium abundance can vary by factor 5
- Altitude variation of return flux, ~3
- Paranal measurements with only one laser format (D_{2b} 10%, circular polarization)

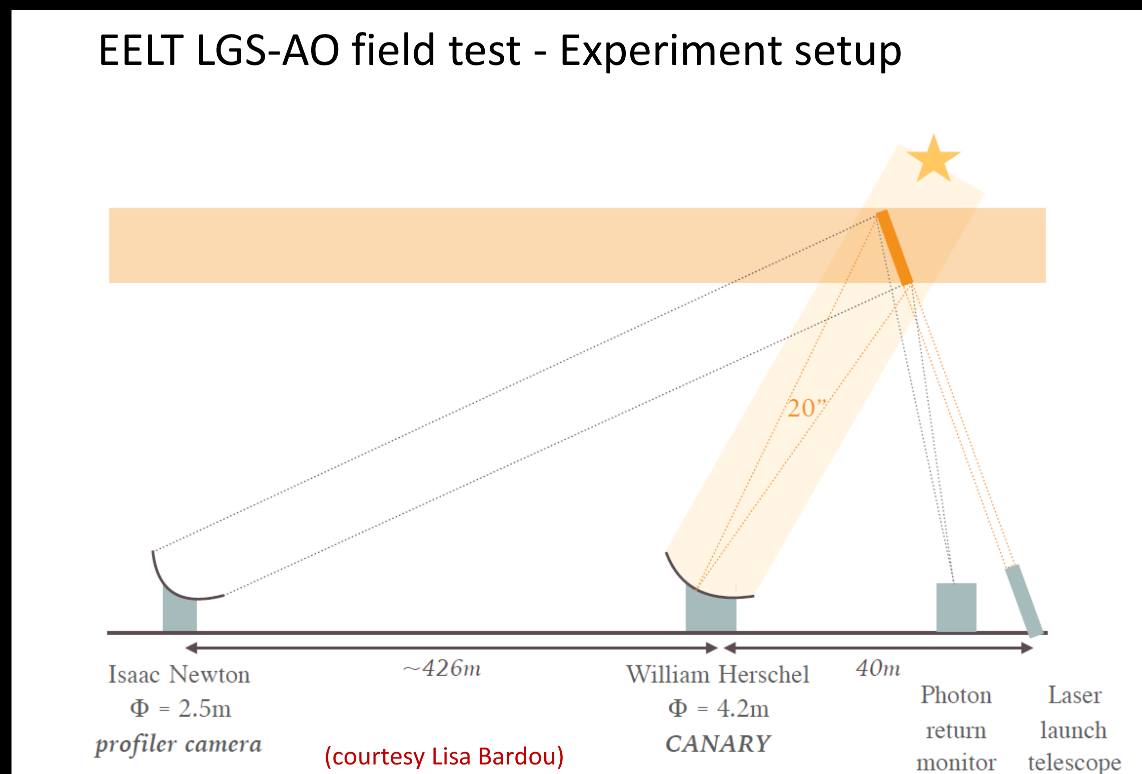
LGS-AO with 20W CW laser, EELT elongated LGS – ONGOING

Canary phase D + WLGSU (Durham, Lesia, ESO, IAC, INAF)

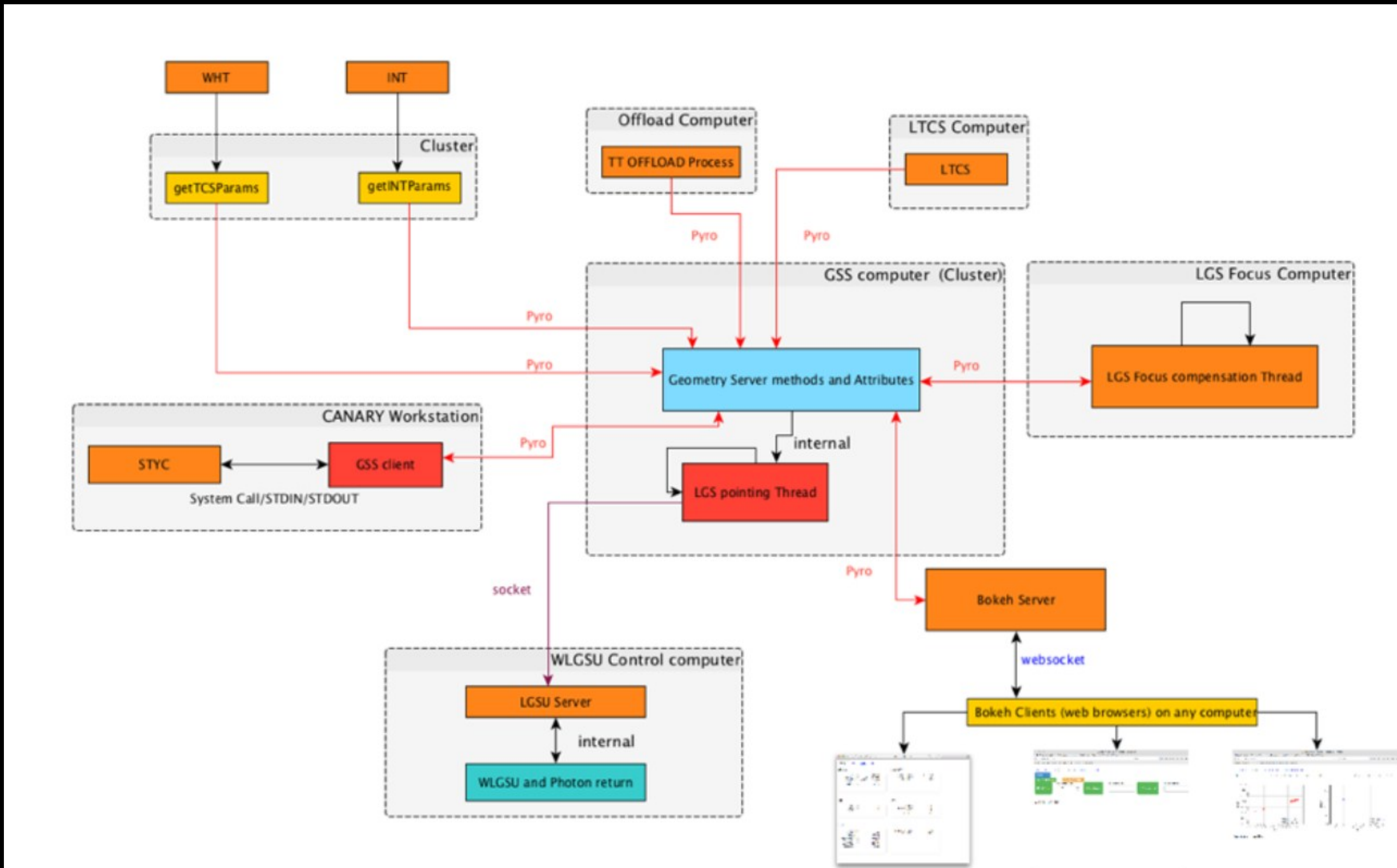
Effect of Sodium variability and spot elongation on Wavefront reconstruction

- Performance of LGS-WFS with elongated LGS and real sodium layer
- Record simultaneously NGS and LGS WFS data, 150Hz.
- Open loop and Closed loop. LGS and NGS superimposed.
- Use Na profile measured at 150 Hz to remove sodium height variability
- Vary LGS cigar elongation by changing pointing directions
- Turbulence profile from 3 WFS on NGS asterism.

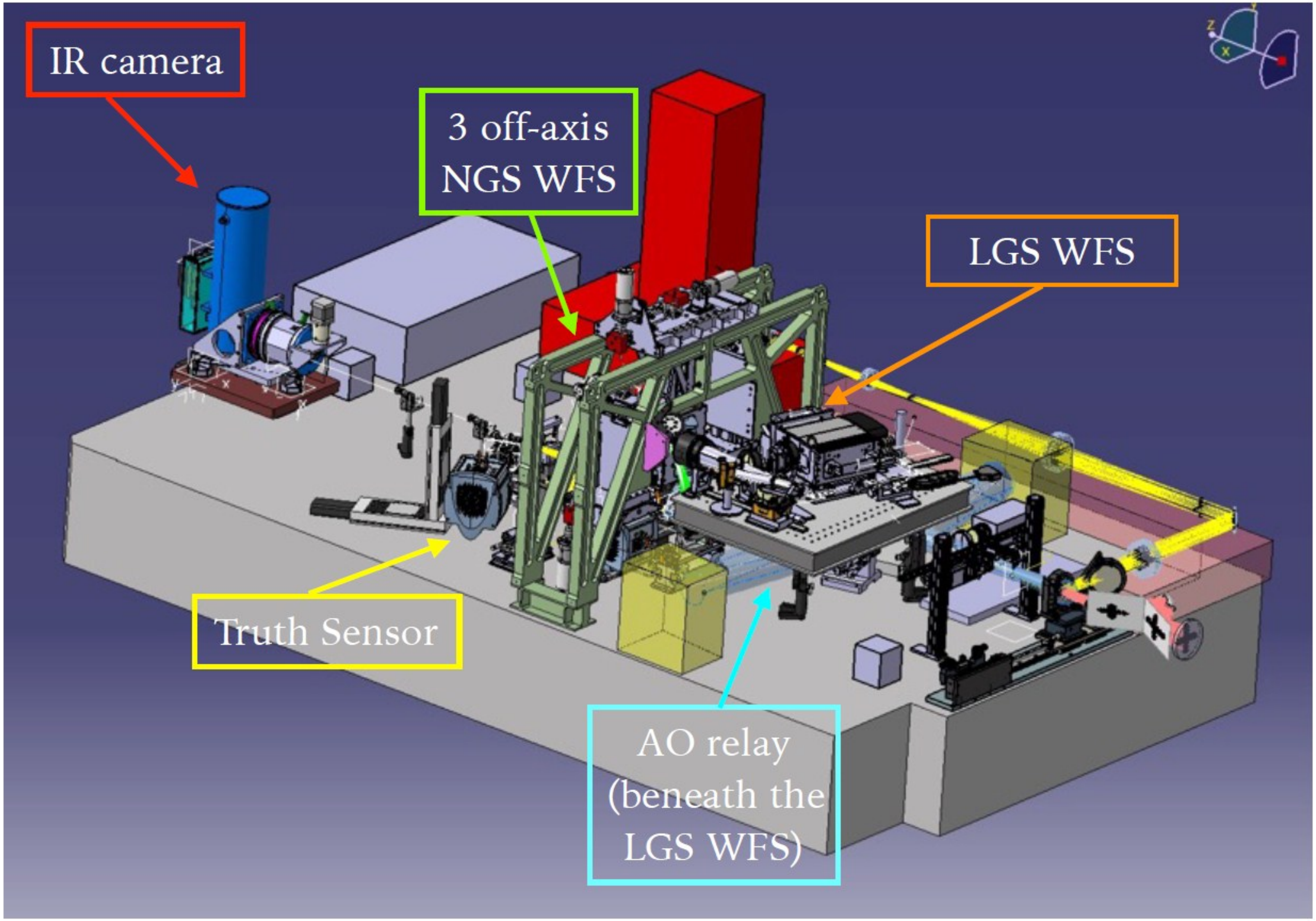




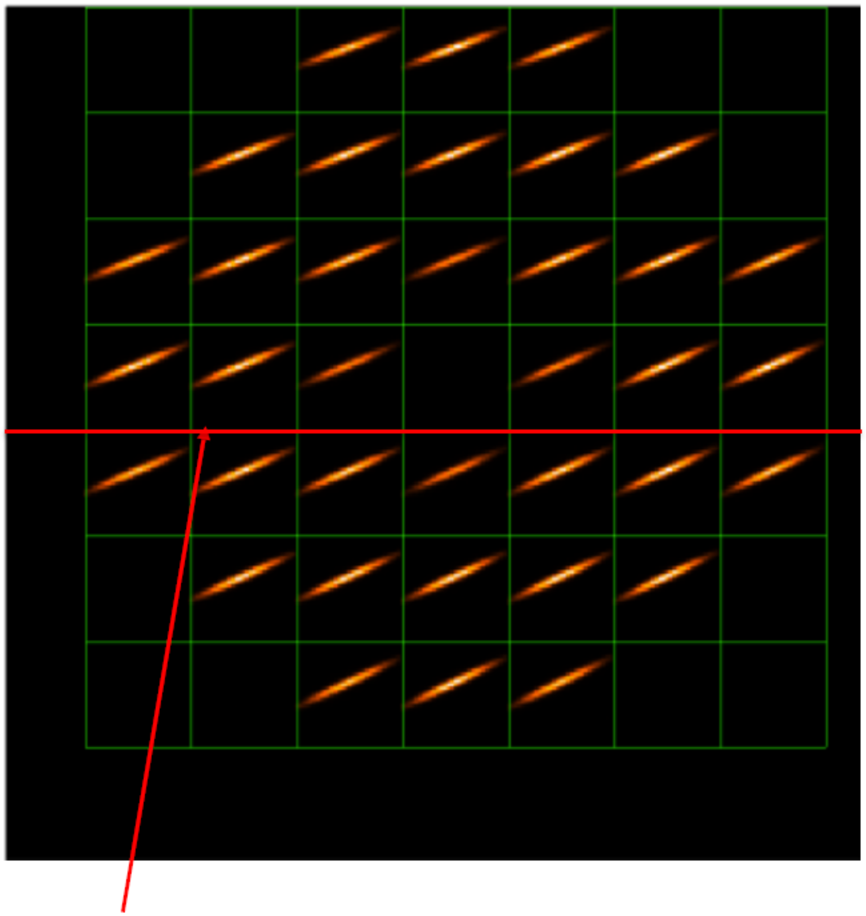
GEOMETRY SERVER, to point all telescopes together, store data, LTCS



CANARY BENCH



Canary LGS WFS



2 dead lines

- Camera: OCAM
  - 240x240 pixels
  - RON < 0.2e⁻ rms/pixels
- WFS :
  - 7x7 subapertures
  - 30x30 pixels/subaperture
  - 0.65" pixel FOV
  - FOV :19.5"
  - Field stop : 39"

Phase D Observing Blocks

Good Seeing (17th September 2016)

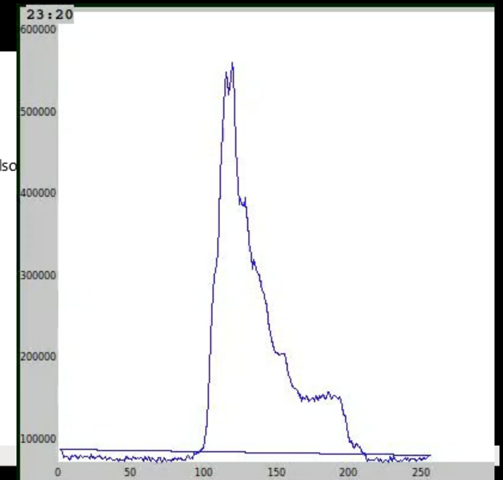
Each dataset contains a number of 10s bursts of pixel and WFS slope data from all WFSs. Sodium profiles from the INT are also grabbed and if the AO loop is engaged, IR (H-band) images should also be recorded.

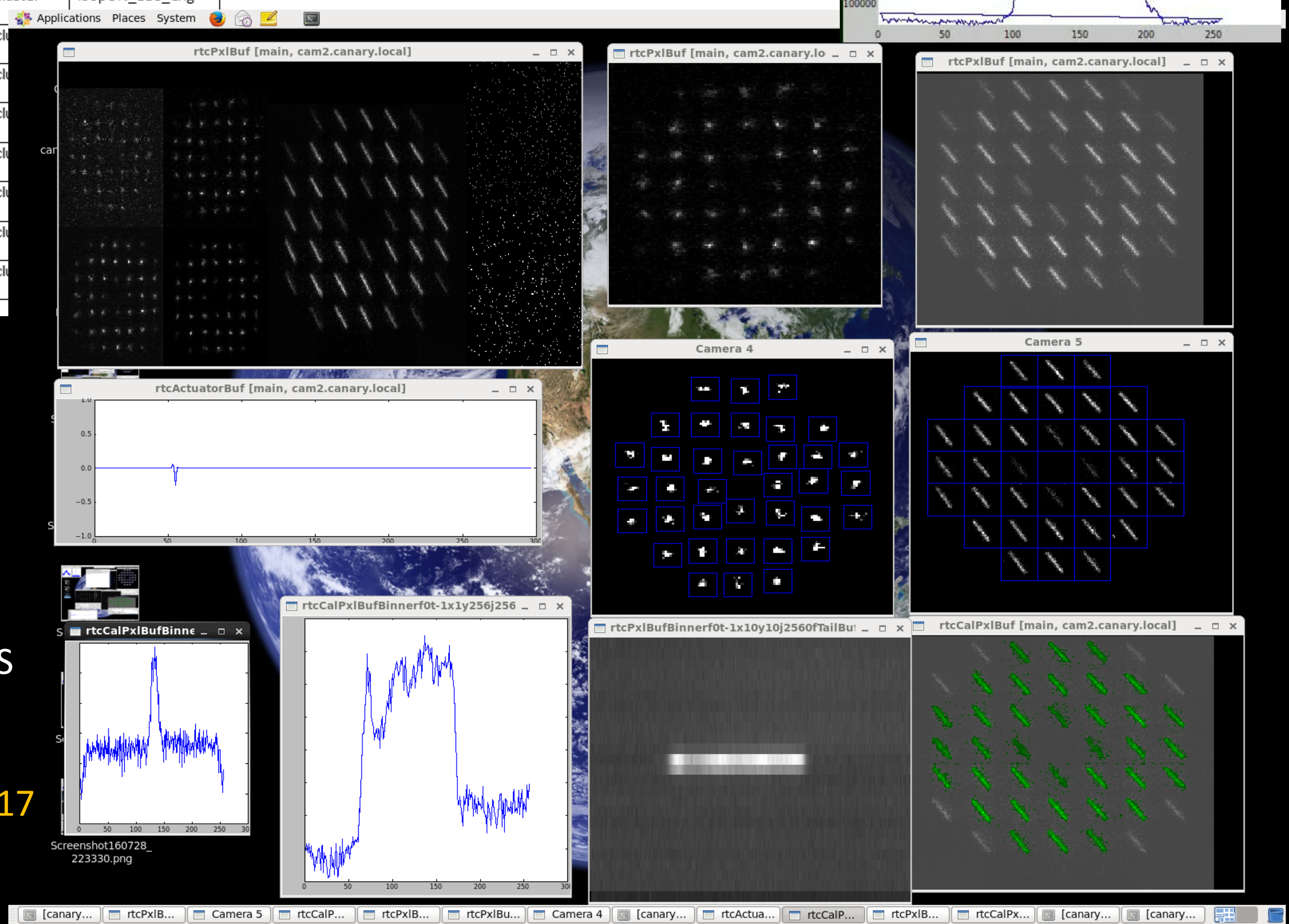
NOTE: The tomographic dataset taken at the beginning of the OB does not include pixel data.

Description	File Prefix	File suffix
Tomographic dataset (10000 frames)	datatomo	No specific suffix
5 x All loops open	datacluster	loopOFF_all_open
5 x Closed loop on Truth Sensor (DM gain 0.2, TT gain 0.2, LSM gain 0.2)	datacluster	loopON_TS_eng
Take reference slopes on LGS WFS with TS loop closed	refslopes	No specific suffix
5 x Closed loop on LGS WFS with NGS tip/tilt/focus (DM gain 0.2, TT gain 0.2, LSM gain 0.2)	datacluster	loopON_LGS_eng
5 x All loops open	datacl	
5 x Bzz NGS TT modulated (amplitude 0.3V with 20 frames open loop)	datacl	
5 x All loops open	datacl	
5 x Closed loop on Truth Sensor (NGS TT loop only with a gain of 0.2)	datacl	
5 x All loops open	datacl	
5 x Bzz NGS TT modulated (amplitude 0.3V with 20 frames open loop)	datacl	
5 x All loops open	datacl	

2x tt mirrors, 1DM, 4 NGS WFS, 1 LGS WFS

All data saved (slopes, pixels, commands) including calibrations





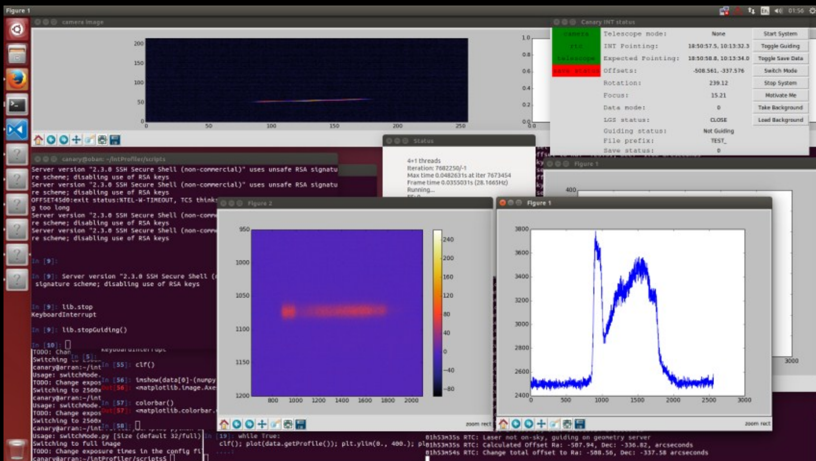
- Data processing starts
- INAF-OAR helps
- 4Tb from 4 nights
- Open loop data for all
- Marchetti: truncation of LGS
- DBC: LGS Tilt

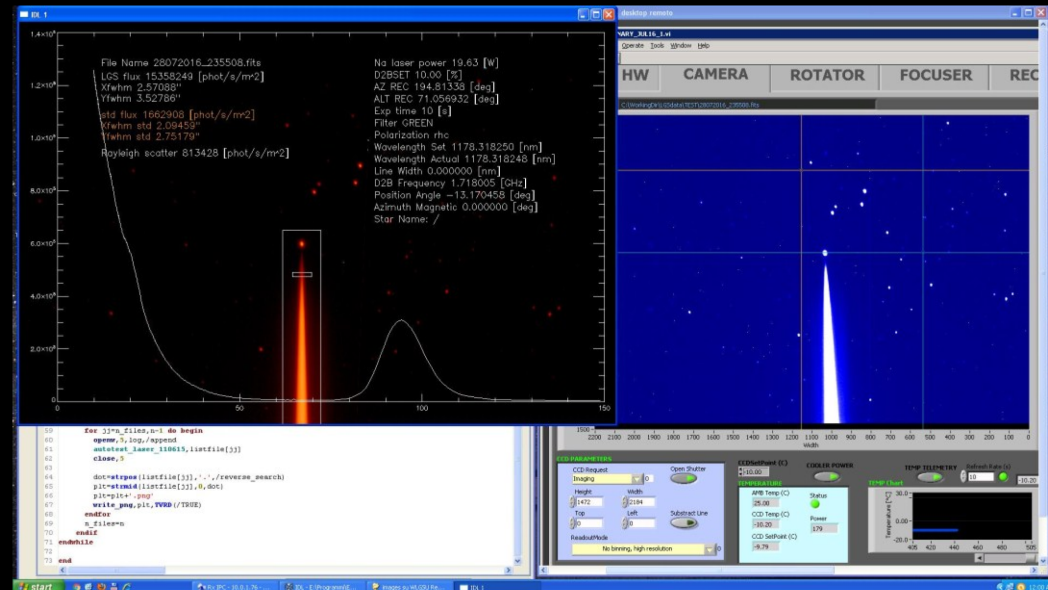
Next run 1-6 June 2017 + 3Q17

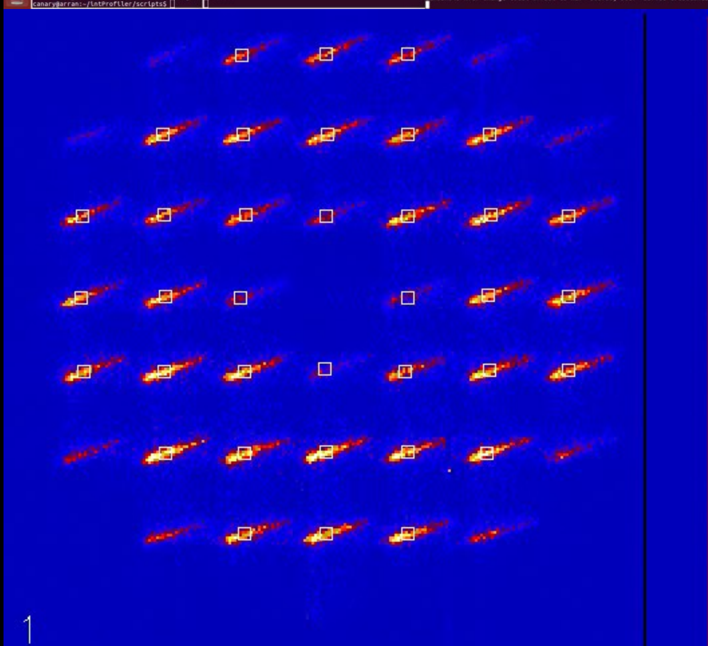
First paper published Mon.Not.RAS (Jan 2017):

On sky demonstration matched filters for wavefront measurements using ELT-scale Elongated LGS

https://doi.org/10.1093/mnras/stx062







- Open loop data useful for simulations input, open access
- Closed loop with CoG, matched filter, X-correlation
- X-corr seems to give best results, but it depends on…
- Achieved H-band Strehl 0.28 with 0.8“ seeing

Next:
LGS-AO for the visible on 8m: field tests using a Pyramid WFS and pulsed lasers for spot tracking (2018-2021)

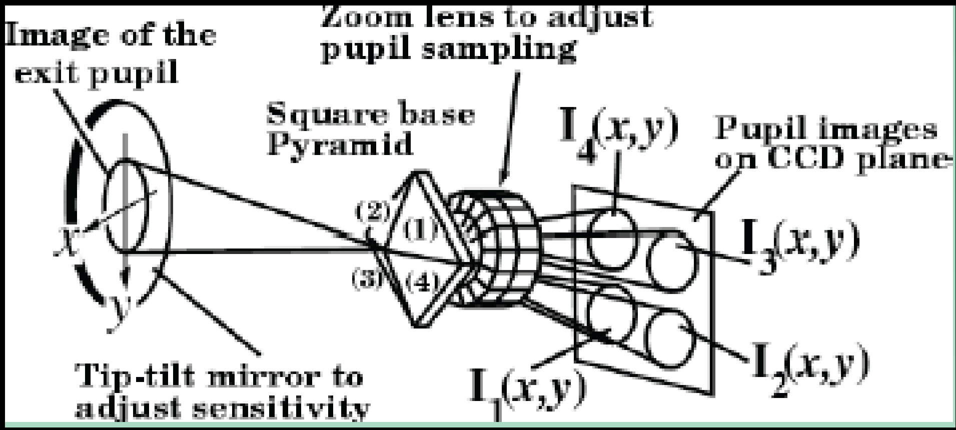
Canary + WLGSU (Durham, Lesia, ESO, IAC, INAF, MPE)

Progressive test of 4 strategic technologies for future LGS-AO systems.
Elimination of the LGS spot elongation.
Each institute responsible for ist own subsystem, to be installed at the WHT or WLGSU

Experiment Coordination: ESO and Durham

- Uplink laser beam correction to shrink the LGS (Durham, IAC, INAF) in 2018
- Use of pulsed lasers for spot tracking (ESO, modification of the WLGSU laser) in 2019
- Downlink dynamic refocusing (MPE) in 2019
- Pyramid WFS on LGS (INAF, LESIA) in 2020-2021

Activity kick-off: Feb 21st 2017



Vielen Dank! - Thank you!
Let's work together - Science first!