Upgrade of the ESO Laser Guide Star Facility

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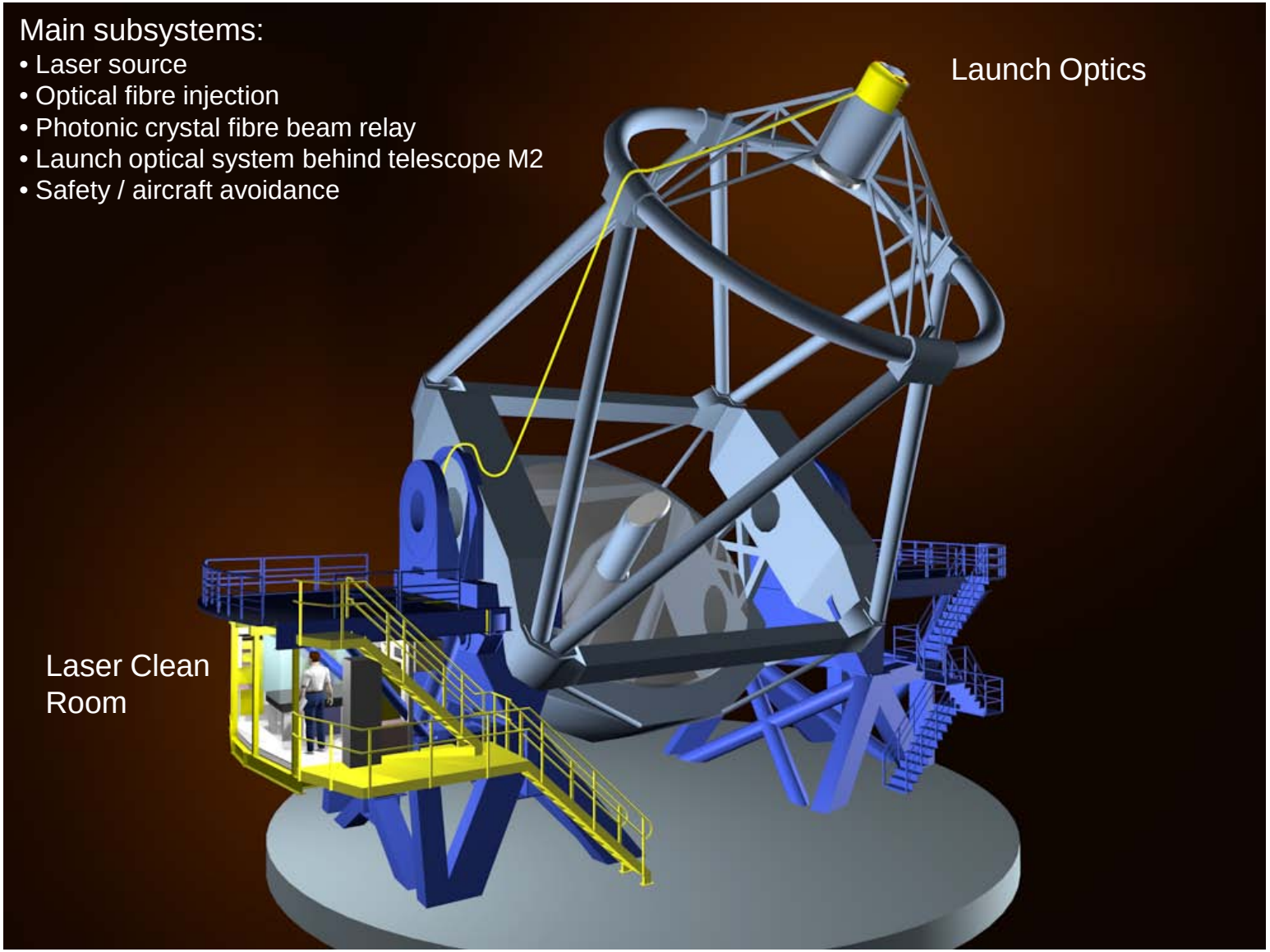
Introduction

- Laser Guide Star Facility Part of Unit Telescope 4 at Paranal Observatory. Installed in 2006
- Generates a single centre-launched sodium laser guide star for client AO instruments SINFONI and NACO
- Upgrade project (PARLA), new laser source subsystem for LGSF
- Goal to support Paranal operations, more flexible laser operation
- Laser based on patented Raman fibre laser technology
- Project Start / End: Nov 2011 – Feb 2013 (start of science operations)

Laser Guide Star Facility



System Requirements

Optical

- Power delivered to launch telescope (after relay fibre) >6 Watts (7W goal)
- Sodium D2a excitation only
- Broadened laser spectrum (110 MHz line spacing)

State Transitions

- Startup less than 60 mins / Shutdown less than 60 mins (goal 10 mins)
- Frequency Tune/Detune < 120s (goal 30s)
- IDLE to ON less than 30 mins

Lifetime/Availability:

- 3 year lifetime
- 12h operation per day average

Interfaces:

- Optical: BRSI fibre injection system. Beam quality and stability suitable for single mode fibre coupling.
- Mechanical: laser bench and electronics cabinets
- Electrical/Electronic: LGSF control and safety systems, normal and UPS power
- Cooling: existing stabilised coolant circuit

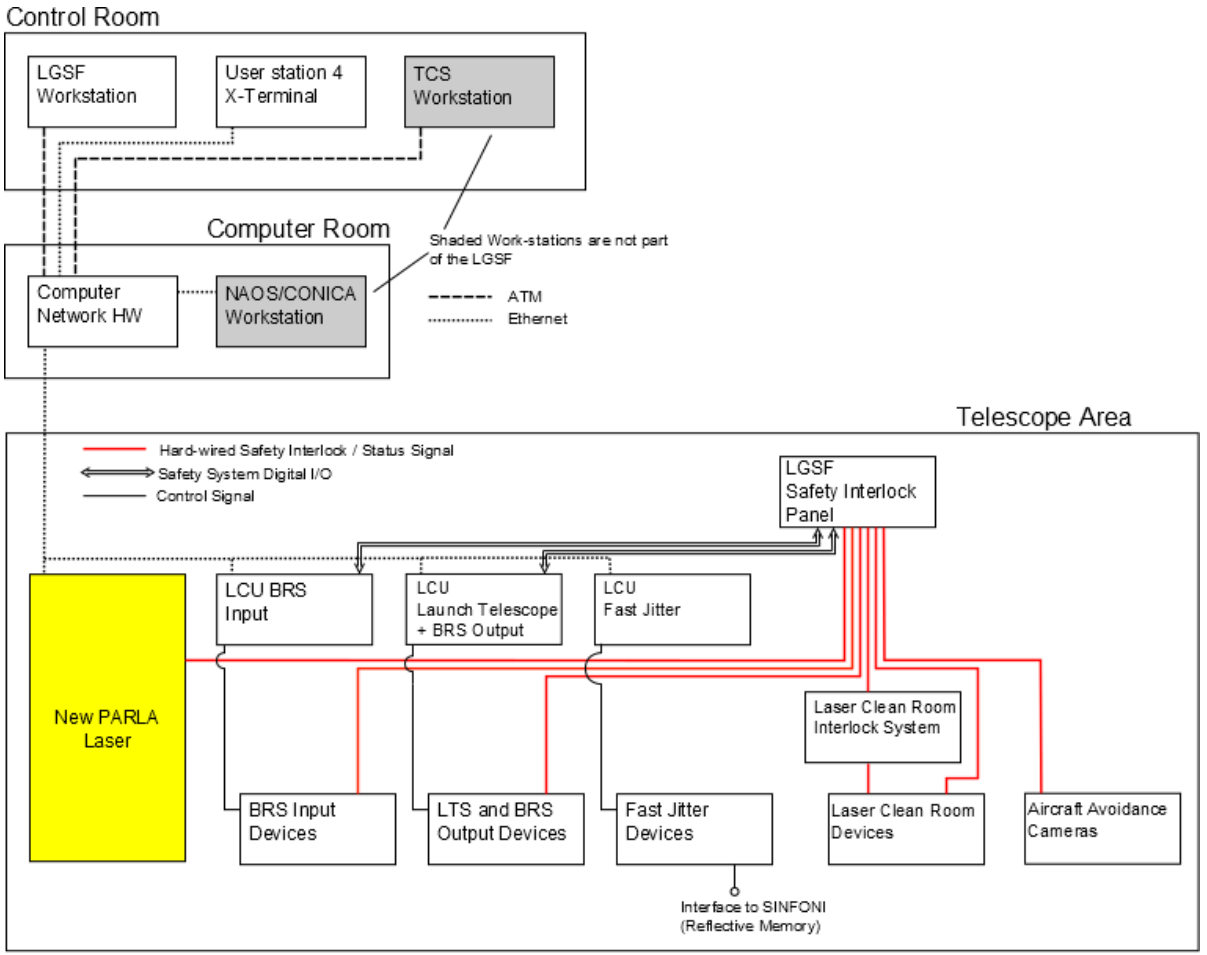
Environmental:

- Ambient temperature stability +/- 1C
- RH 5-15% typical, air pressure 700-800mBar typical
- Gravity invariant, clean room

Laser Guide Star Facility

Laser Guide Star Facility Control Architecture

- Workstation in Control Room
- 4 x Local Control Units (VME/VX Works Systems) in Telescope Area:
  - Laser LCU
  - BRS Fibre Injection LCU
  - Launch Telescope LCU
  - Fast Jitter LCU
- Safety Interlock System
- Laser LCU TCP/IP Interface with laser local control system



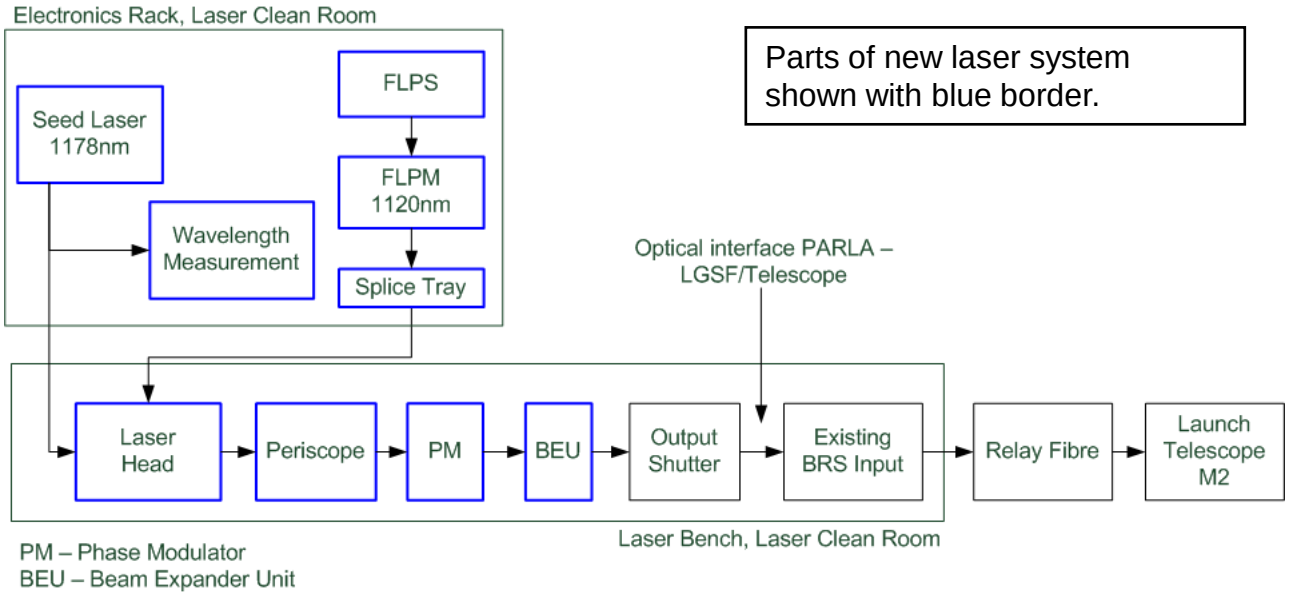
Main Optical Path

Electronics Cabinet:

- Seed Laser
- Pump Laser

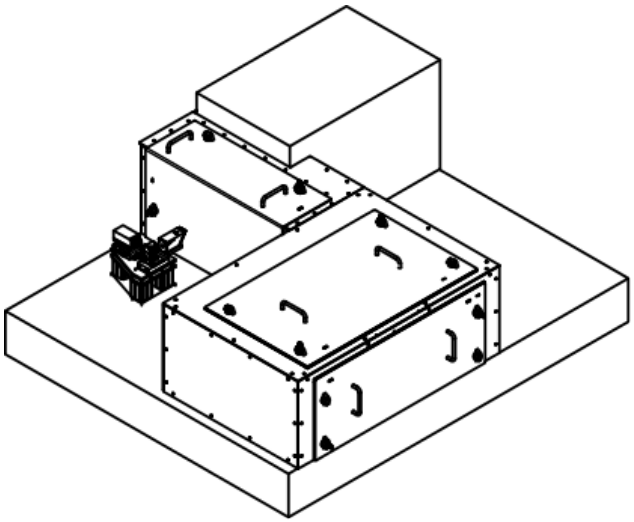
Laser Bench:

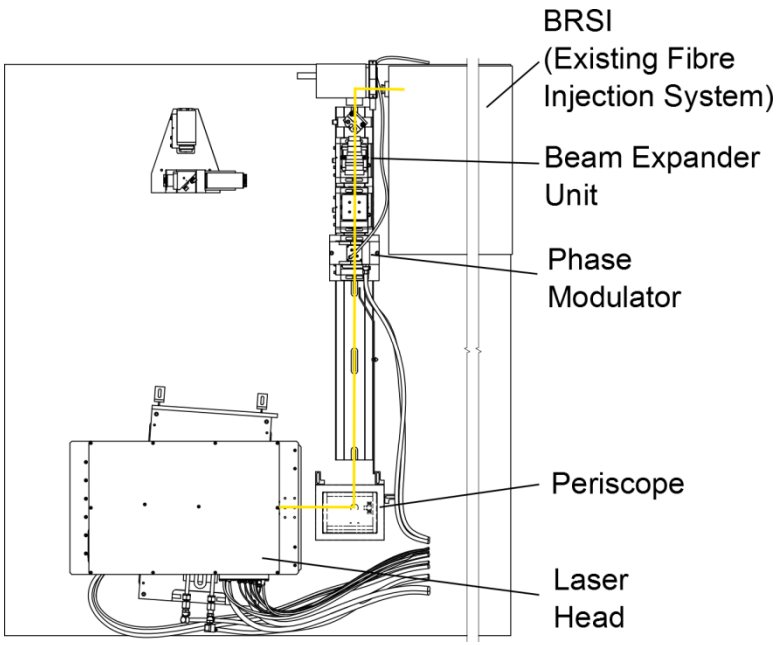
- Laser head
- Periscope
- Phase Modulator
- Beam Expander Unit



PARLA Bench Mechanical Layout

- Free Space Optics Mounted on Existing Optical Bench in Laser Clean Room
- Shown Below with and without Covers





Laser Tests (Europe)

Laser Stand Alone

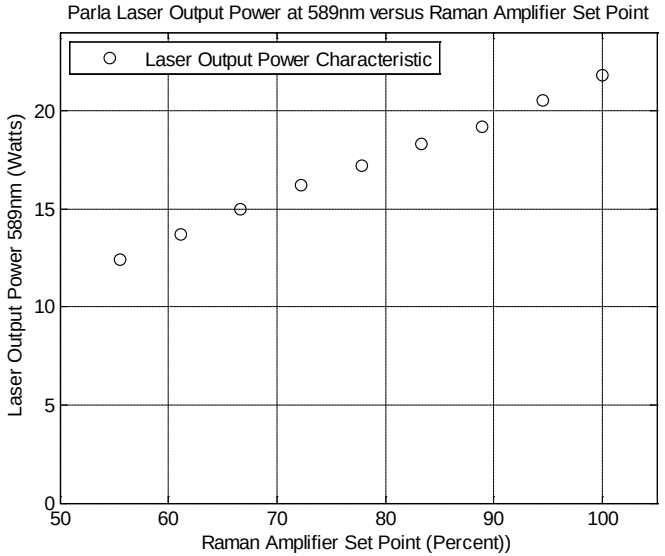
- Output power
- Beam pointing stability (transient)
- Beam quality
- Wavelength/wavelength stability
- Local control system

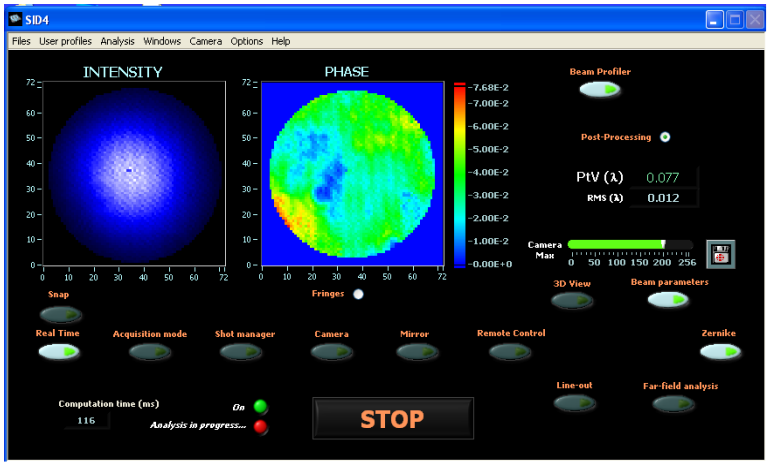
Laser + Beam Relay + Fibre Coupling

Soak Tests (12h runs)

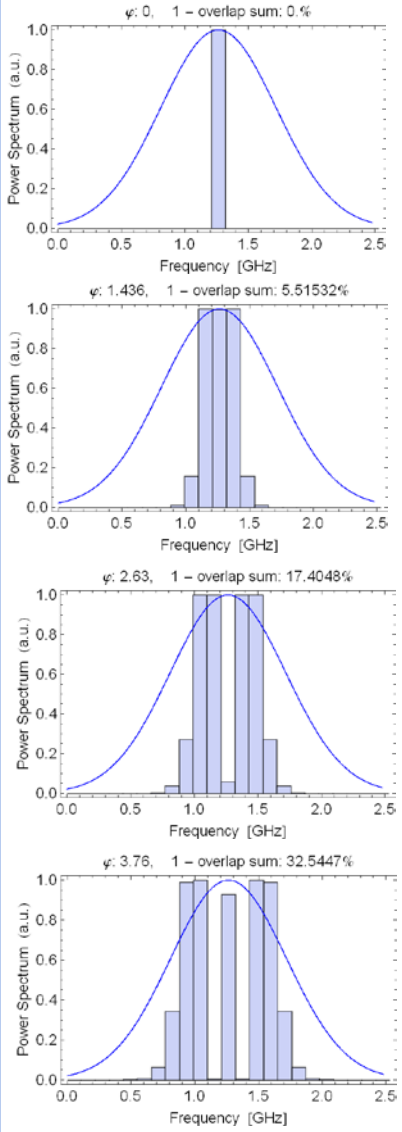
Software Tests (VLT SW Model)

- Control functionality
- State transitions
- Simulated observing cycles





Laser Spectral Optimisation



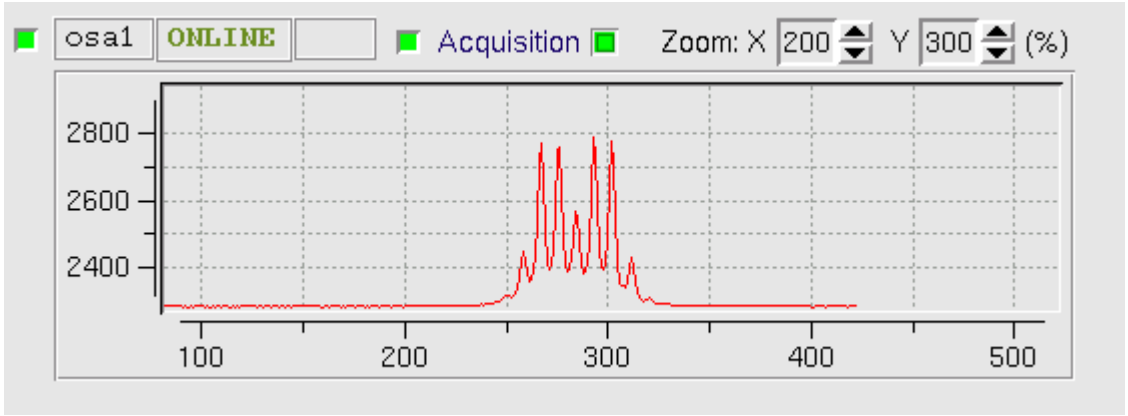
110MHz Phase modulator broadens the laser line

Overcome spectral power limitation in 27m PCF transport fibre

Figures on left show calculated line spectra for peak phase shifts of: 0, 1.44 (“3 lines”), 2.63 (“4 lines”), 3.76 (“5 lines”).

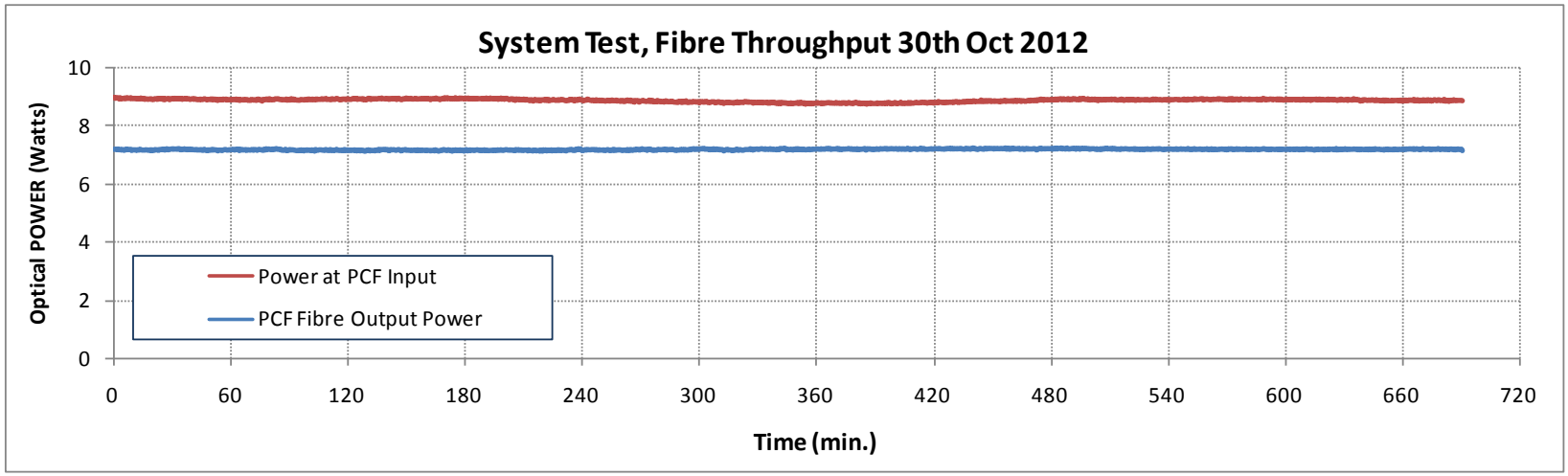
Solid curve shows overlap with sodium D2a line.

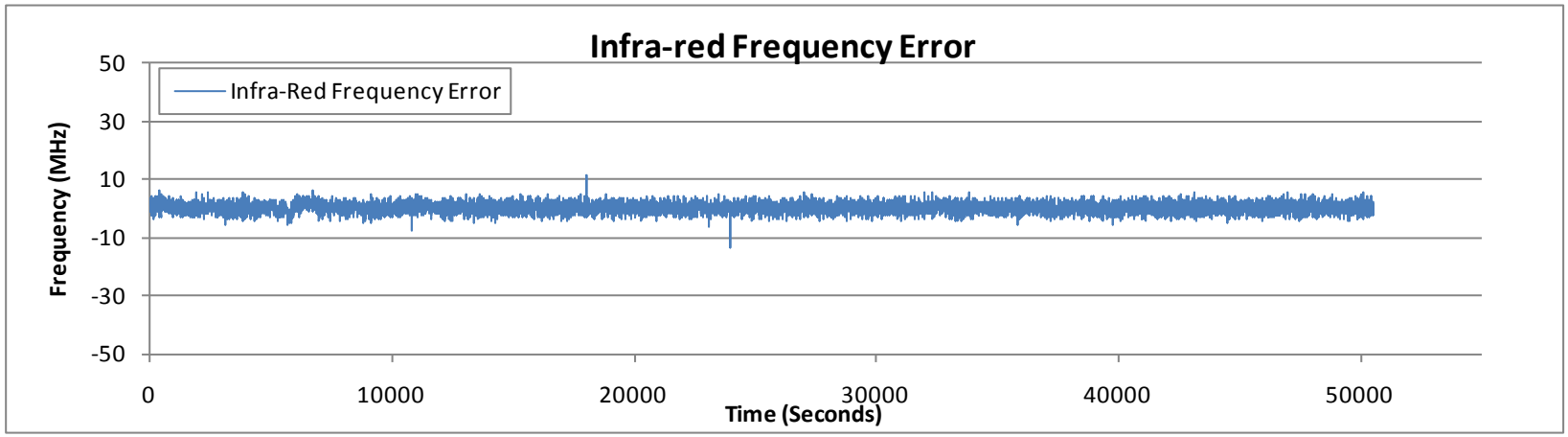
Below the measured spectrum of the beam in the installed system.



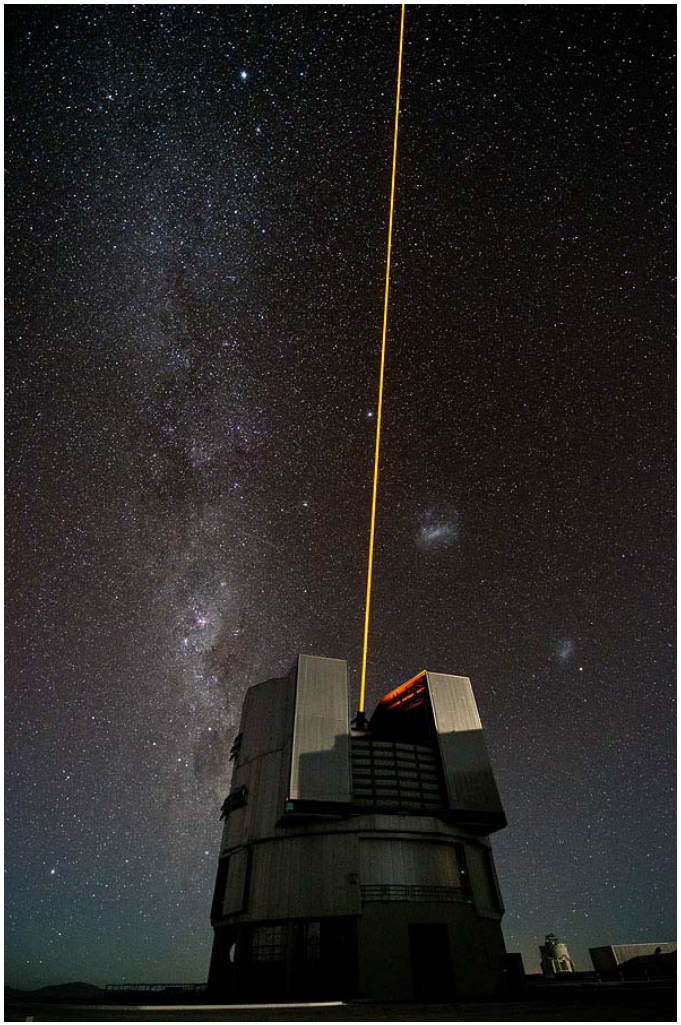
System Test Europe

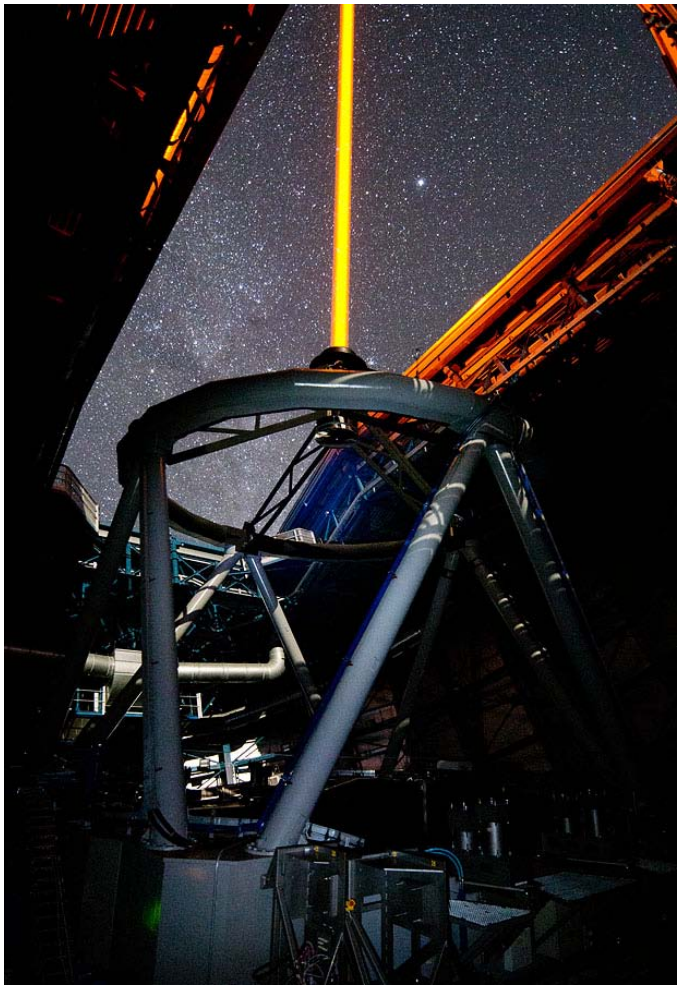
- AIV Europe
- Soak tests (12h)





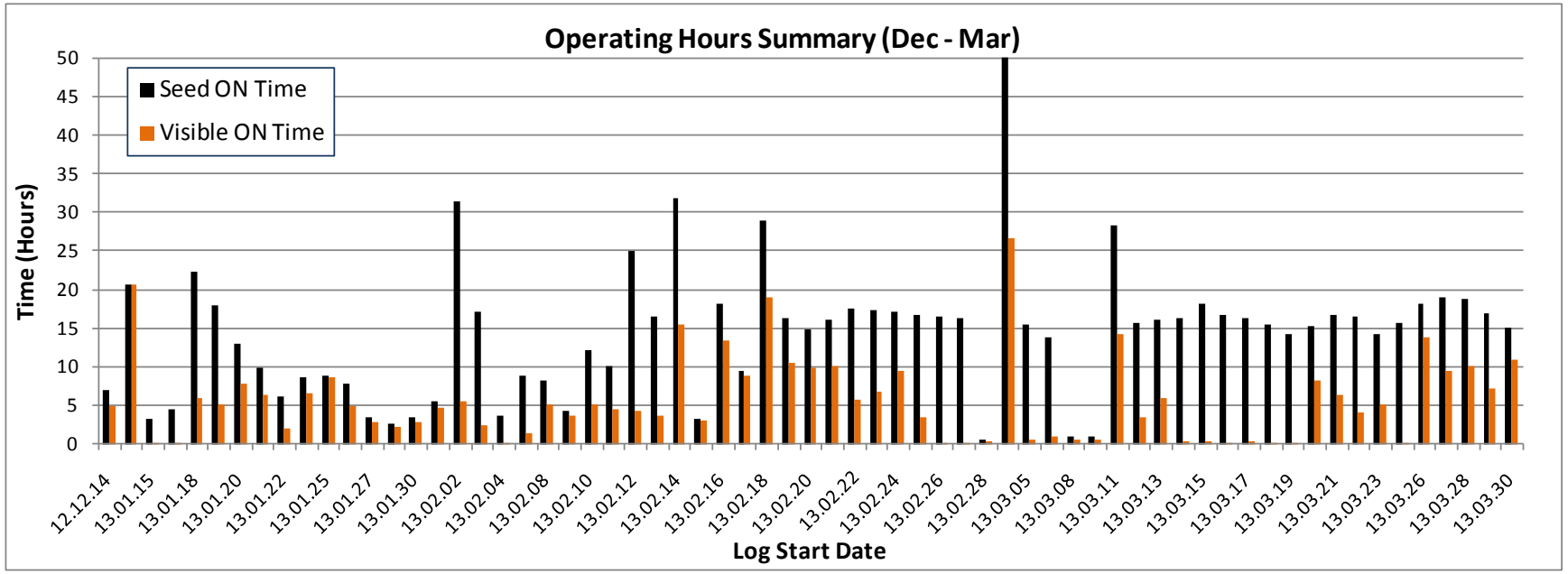
AIV, Commissioning (Chile)





Photos courtesy Gerd Hudepohl, ESO

AIV Chile, Commissioning



Reintegration:
Base Camp
Paranal (Dec)

Installation:
Laser Clean
Room UT4
(Jan-Feb)

Commissioning
(Feb)

Science Operation

Cumulative hours during this period:
Control System: 948
Seed: 943
Raman Amplifier: 394
Visible: 371

Commissioning Summary

Technical tests to re-commission LGSF with Telescope / Instruments SINFONI and NACO:

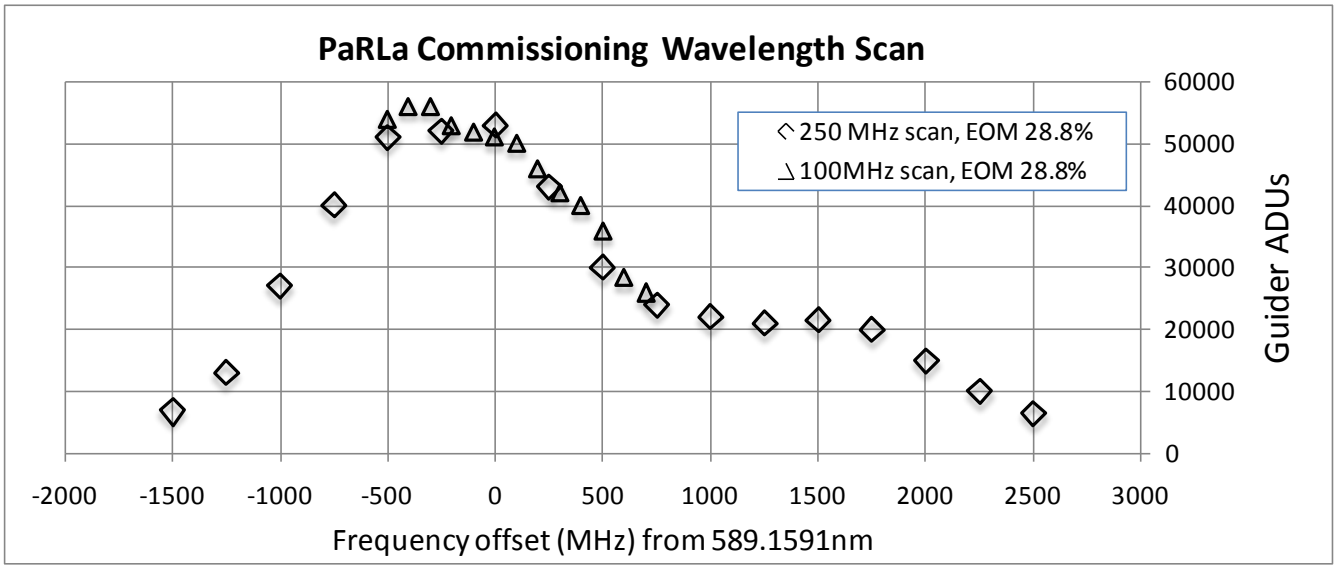
Task	Description
1	Sodium D2 Line Wavelength Scan
2	LGS vs Pointing
3	NACO and SINFONI dummy OB operation, testing the representative configurations of the instruments

Science verification, repeat a number of existing and previously published OBs to verify system performance:

Instr.	Object name	Description	Existing OB data
SINFONI	NGC3621	Bulgeless Galaxy with NC	083.B-0279(B)
	Centaurus A	AGN with central black hole	280.C-5005
	Haumea (TNO136108)	Solar system, trans-Neptunian object	087.C-0167(A)
NACO	Centaurus A	Active Galactic Nuclei	280.C-5005
	NGC 5139	Omega Cen.	60.A-9800(J)

Wavelength Scan on Sky

- Wavelength of laser tuned in steps through the sodium absorption line
- 250MHz steps + 100MHz steps near D2a peak
- LGS Brightness measured on telescope guider
- Convolution of broadened laser spectrum with sodium line
- Launched polarization is not controlled
- Power on sky approx 6.4 Watts during test



LGS Equivalent Magnitude, Strehl Table

Return flux measured at different telescope elevations, SINFONI.

Equivalent V-Magnitude 12

ALT Deg	Equivalent Magnitude
85.3	K-band
81.2	K-band
80.0	WFS eq. mv=11.98
65.0	WFS eq. mv=11.83
52.5	WFS eq. mv =11.9
44.7	WFS eq. mv=12.2

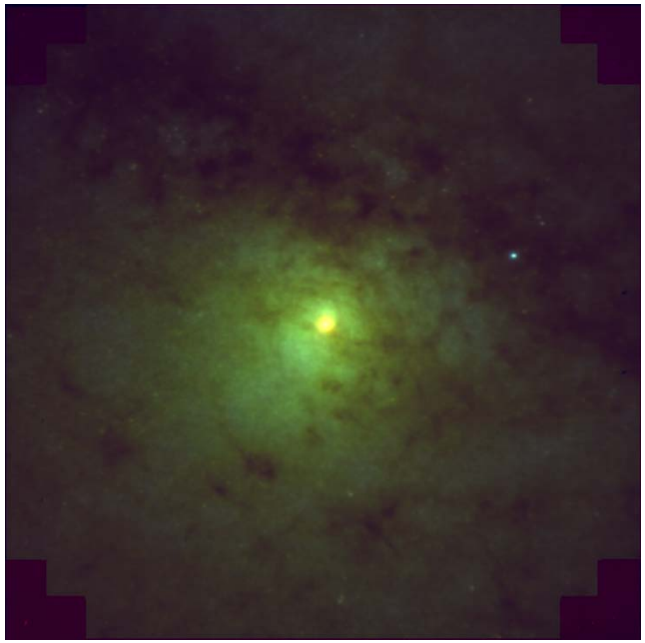
NACO

- NGS Strehl up to 63% at 2.17 microns, LGS Strehl measured up to 42% at 2.17 microns during commissioning (18th February)
- NACO can use 14x14 WFS around 80% of time
- Air Mass up to 1.8 and in twilight
- Seeing enhanced / high order only from 0.75” Seeing to 0.12” FWHM K Band

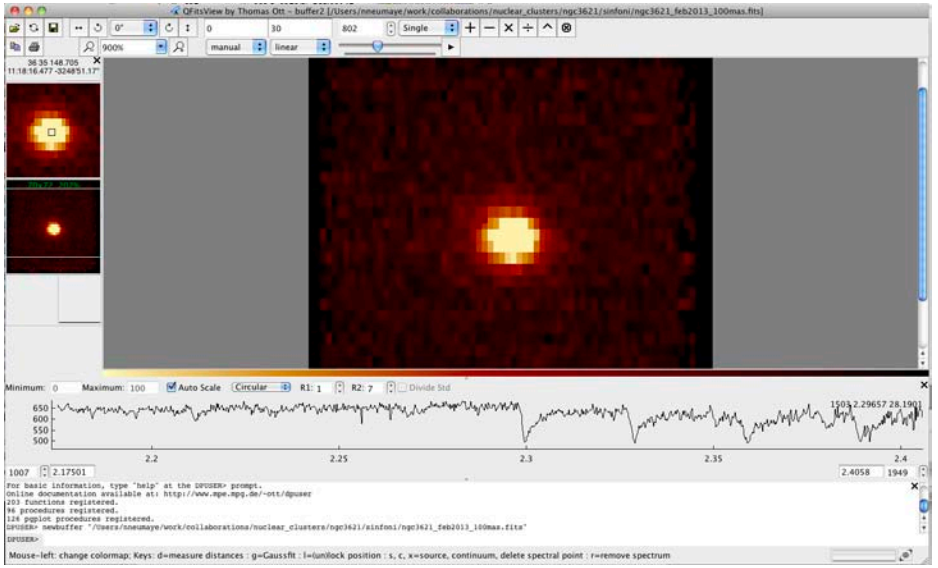
SINFONI

- K-Band Strehl up to around 35% measured with PARLA

Science Verification: NACO, SINFONI



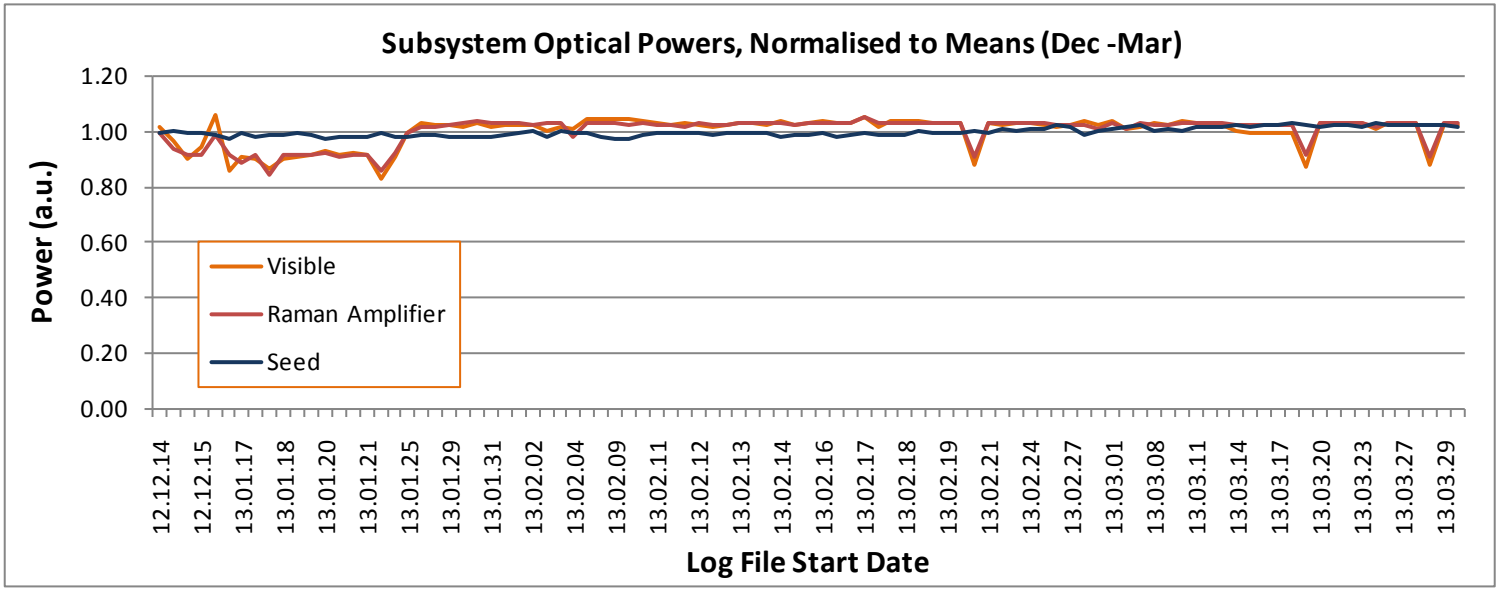
J,H,K band images composed in a single RGB picture, of the core of Centaurus A, a very active Radiogalaxy hosting a large Black Hole. NACO.



Reconstructed SINFONI image and spectra of the core of NGC3621. Bulgeless galaxy hosting a large black hole. CO absorption lines redward of 2.29 microns

Laser Performance Metrics (Dec-Mar)

- Long term follow-up
- Log files
- Define Performance Metrics
- Trends over time – months / years
- First experience with fibre laser in observatory operational environment



Conclusion

- Fibre laser commissioned in Paranal Laser Guide Star Facility
- Installed in laser clean room on VLT-UT4
- Goal to support Paranal operation e.g. more flexible observing with the laser
- Completed AIV and commissioning in February 2013
- LGS-AO science operation ongoing
- First Raman fibre laser at a major observing facility.
- System in operational environment gives valuable data for future systems such as AOF.

Acknowledgements: G. Hudepohl, N. Neumeyer, Y. Al Momany