

› MANUFACTURING AND INTEGRATION STATUS OF THE ELT LASER PROJECTION SYSTEM

Fred Kamphues, Max Baeten

L4AO – Marseille 22 June 2023

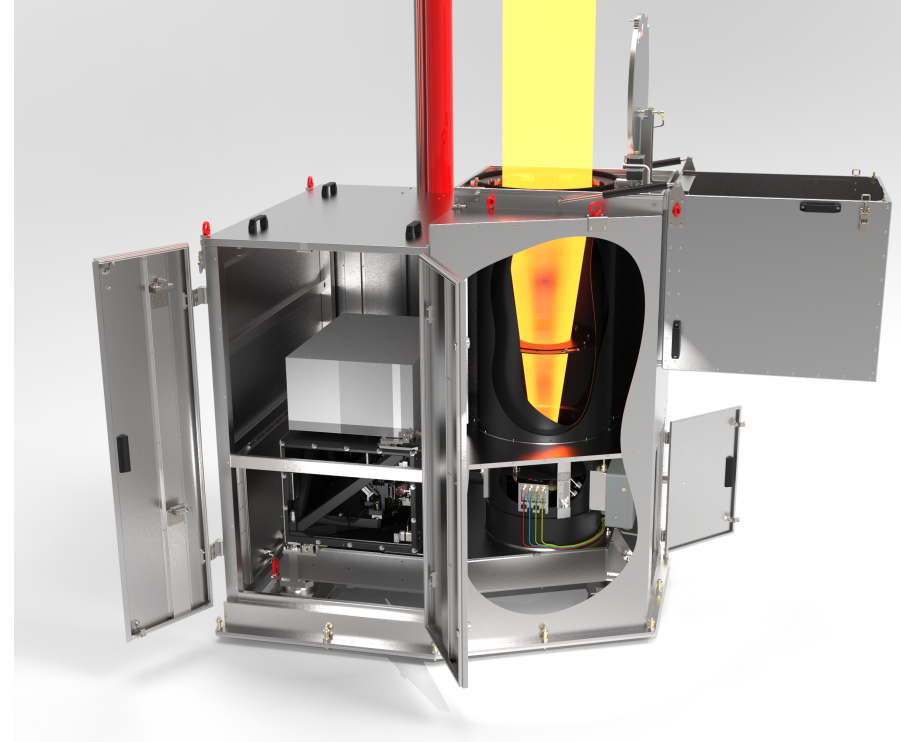
TNO innovation
for life

› 9 Laser Projection Systems

- › 3x VLTl (Gravity+)
- › 6x ELT

› Consortium:

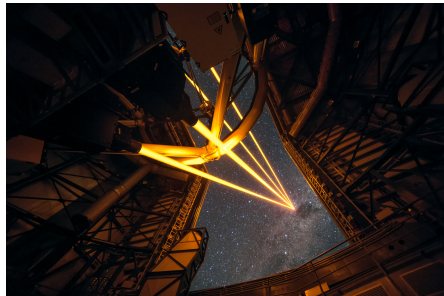
- › TNO: System design, integration & verification testing
- › Demcon: BCDS, electronics, cabling



› Optical Tube Assemblies (OTA) for VLT 4LGSF (delivered in 2012)

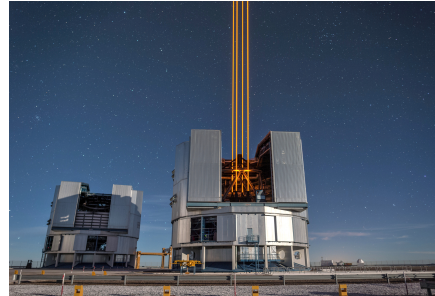
- › 20x Galilean beam expander with 15mm input, 300mm steerable output
- › 380mm aspherical L2
- › Fully a-thermalized optomechanical design
- › See also Proc. of SPIE Vol. 8447 84474N-2

Parameter	Requirement	Achieved
Transmitted wavefront error (excl focus and tilt)	< 50 nm rms	17-23 nm rms
Thermally induced defocus	< 0.2 waves PV	~ 0.15 waves PV
Pointing accuracy on-sky	< 0.3" (3σ)	< 0.2" (3σ)
Polarization extinction ratio (PER)	> 98%	> 99.5%
Throughput	> 95%	97.7%



VLT 4LGSF at
First Light in 2016

Credit: ESO/
F. Kamphues



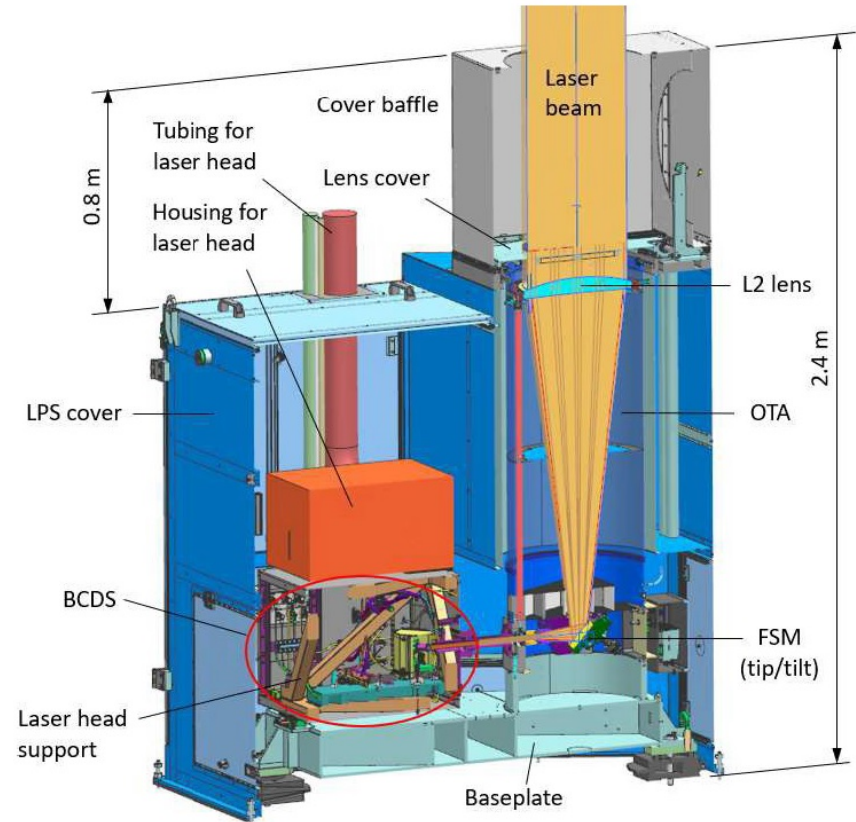
VLT 4LGSF OTA

› Laser Projection System (LPS), comprising

- › Beam Conditioning and Diagnostics System (BCDS)
- › Control Electronics and Drivers (LCER & LDER)
- › Electrical cabling
- › Optical Tube Assembly (OTA)
- › Cover Assembly
- › Baseplate

› Main characteristics

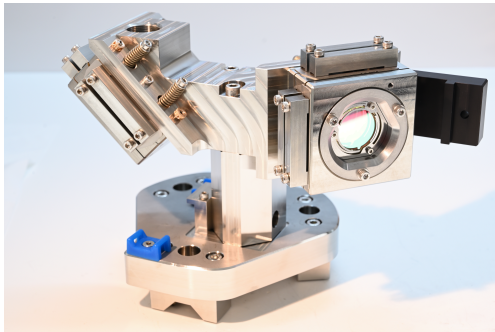
- › Suitable for laser power of up to 50W
- › FoV of 7' (half cone angle)
- › WFE < 65 nm rms
- › Defocus across FoV < 120 nm PV
- › Pointing resolution of 0,2" on sky
- › Absolute line of sight pointing error <10"
- › Relative pointing error <0.25" (120s interval)
- › Size: 2.4 x 1.7 x 1.4 m (height x length x width)



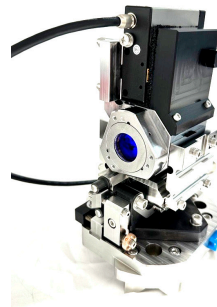
› Beam Conditioning and Diagnostics System (BCDS), comprising

- › Periscope (PER)
- › Beam Expander Unit (BEU), also used for focusing
- › Beam Propagation Shutter (BPS)
- › Jitter Loop Mirror (JLM)
- › Use optical design from VLT
- › Improved performance & reliability
- › Line Repleacable Units (LRUs) on kinematic mounts for easier maintenance
- › First system integration is ongoing
- › See also Proc. of SPIE Vol. 12185 121857K-1

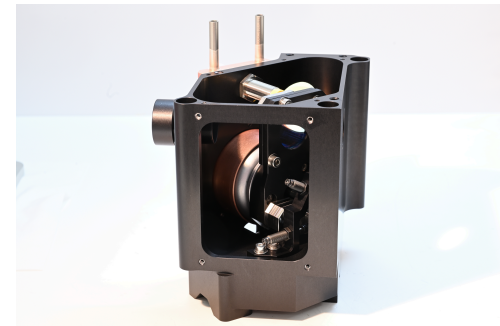
Parameter	Unit	Value
Central wavelength	nm	589.159
Laser beam magnification	-	3.6
Optical throughput	%	94.8
Degree of linear polarization	%	95.2
RMS wavefront error	nm	39.5
Focus adjustment range	λ PTV	± 5
Focus adjustment resolution	λ PTV	0.04
Pointing control range	μ rad	± 1000
Pointing control resolution	μ rad	0.08
Pointing control settling time (10%)	ms	0.48
Beam position stability (combined)	μ m	± 30
Beam pointing stability (combined)	μ rad	± 15



Periscope



Beam Expander Unit



Beam Propagation Shutter

› Control Electronics

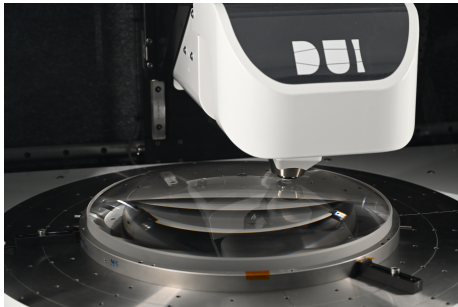
- › LPS Control Electronics Rack (LCER)
- › LPS Driver Electronics Rack (LDER)
- › Remote BCDS Cabinet (RBC)
- › Remote OTA Cabinet (ROC)
- › Beckhoff based design
- › Compatible with ESO control software (license will be granted by ESO for use at other observatories)
- › First system fully assembled and tested
- › Verification Testing in environmental chamber successfully completed



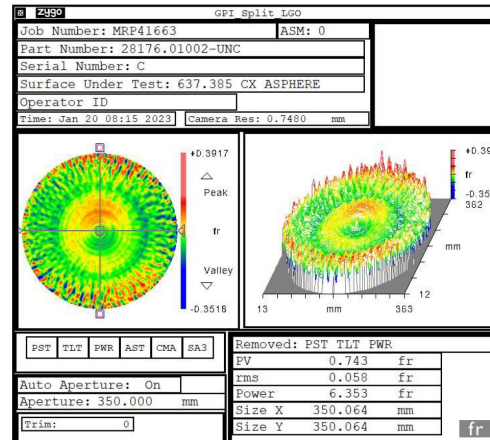
LDER and LCER testing at Demcon

› OTA, consisting of:

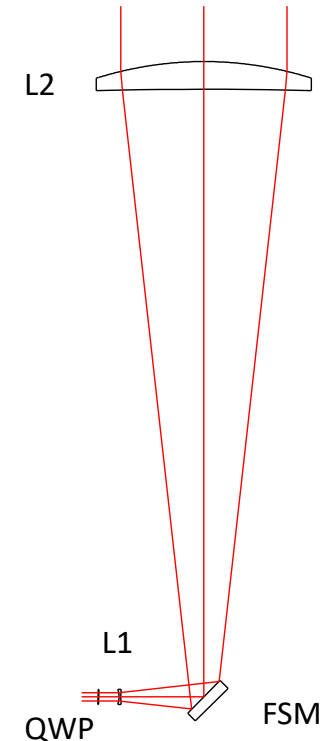
- › Quarter Wave Plate (QWP)
- › L1: negative lens
- › FSM: Field Selector Mechanism with flat steering mirror
- › L2: 380 mm NBK7 asphere (manufactured by Optimax), bonded in Titanium mount
- › Steel tube
- › Invar metering rods



L2 metrology at TNO



L2 s/n 03 acceptance test results at Optimax



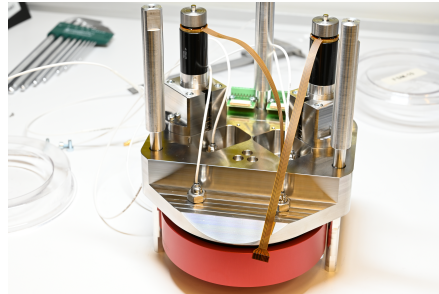
OTA optical design

› Field Selector Mechanism (FSM)

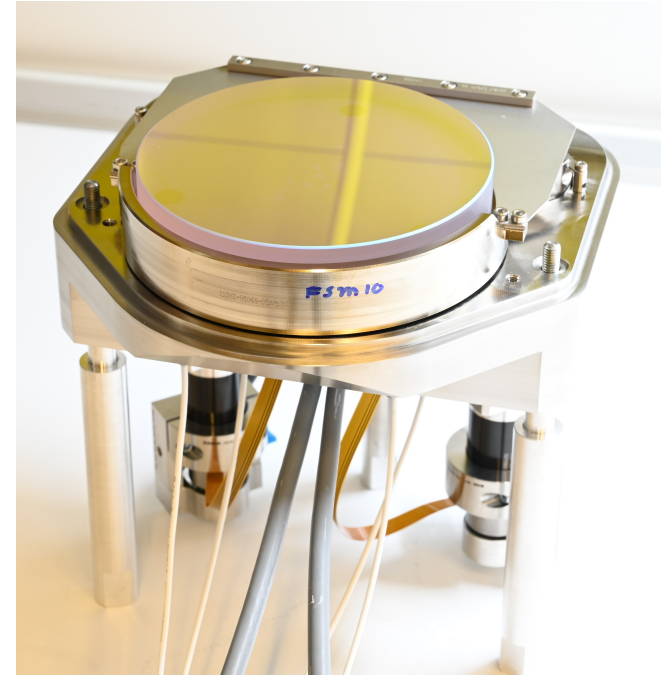
- › Large stroke tip/tilt mechanism (8.9 mrad)
- › Enhanced on-sky pointing range w.r.t. VLT (from 4.8 arcmin to 7.0 arcmin)
- › <0.2 arcsec on-sky pointing accuracy
- › In-house design by TNO (IP owned by TNO)
- › See also Proc. of SPIE Vol. 8125 812503-1



Actuator assembly



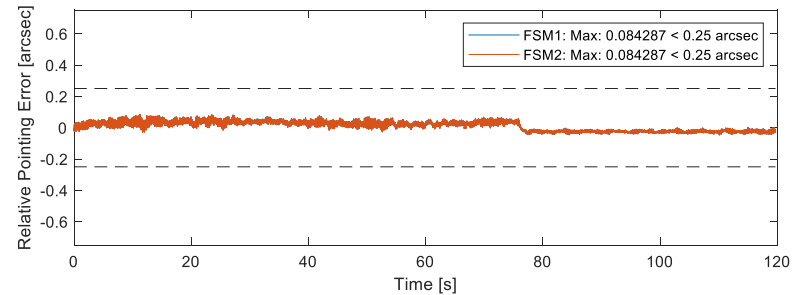
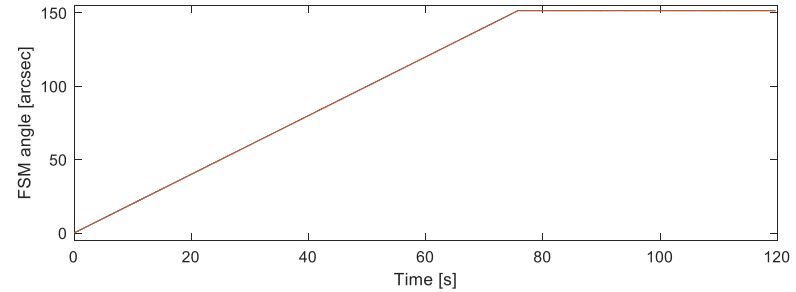
Actuator side of FSM



Fully Assembled FSM

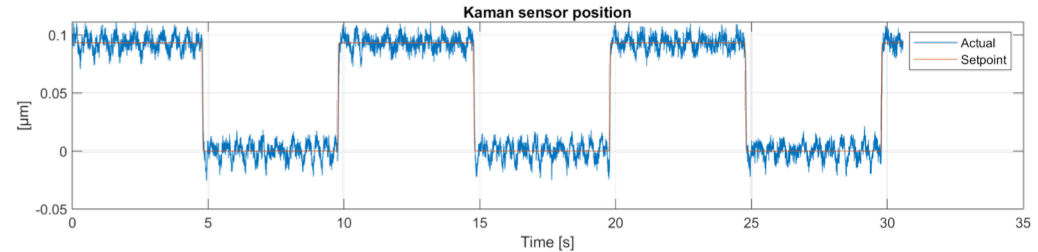
Static and fieldsteering

- › Max field steering velocity = 2"/s
- › RPE < 0.25" for 2min



Resolution

- › Resolution < 0.2"



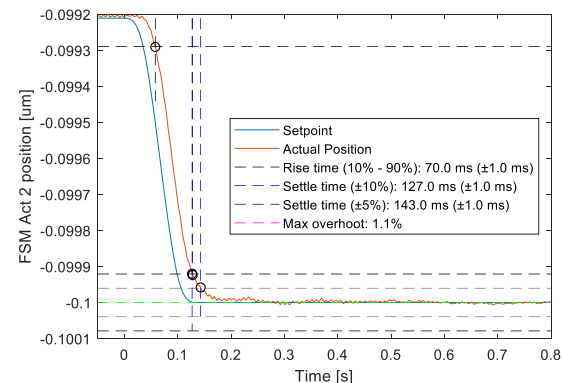
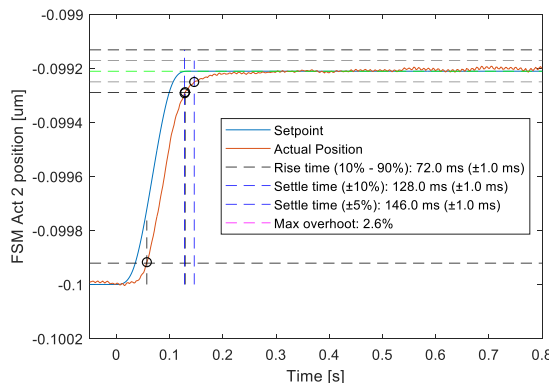
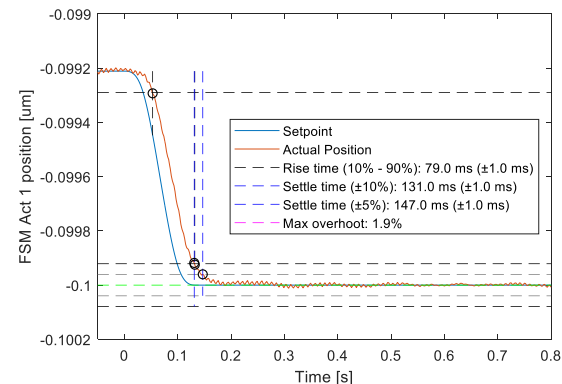
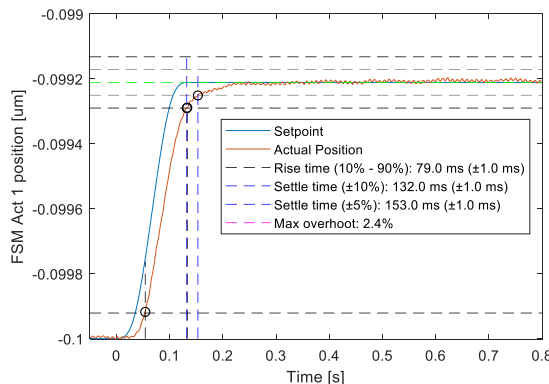
Step response

- › $0.8\mu\text{m}$ -> on sky angle 1.2arcsec
- › Speed = 25arcsec/s = slewing speed

- › Rise Time = 80ms ($< 120\text{ms}$)
- › Max Overshoot = 2.6% ($< 10\%$)
- › Settling time 10% = 130 ($< 200\text{ms}$)
- › Settling time 5% = 155 ($< 250\text{ms}$)

Next

- › Calibrate absolute angle of FSM



› **THANK YOU FOR YOUR
ATTENTION**

TNO innovation
for life