ATHERMAL LASER LAUNCH TELESCOPES

VLT 4LGSF OPTICAL TUBE ASSEMBLIES

TNO innovation for life

TNO HAS DEVELOPED THE LASER LAUNCH TELESCOPES FOR THE ESO VLT FOUR LASER GUIDE STAR FACILITY (4LGSF). THE 4LGSF IS PART OF THE NEW ESO ADAPTIVE OPTICS FACILITY (AOF) ON UNIT TELESCOPE 4 (UT4). THE 4LGSF WILL DEPLOY FOUR MODULAR SODIUM LGS UNITS AT THE UT4 CENTREPIECE.

Fully assembled OTA

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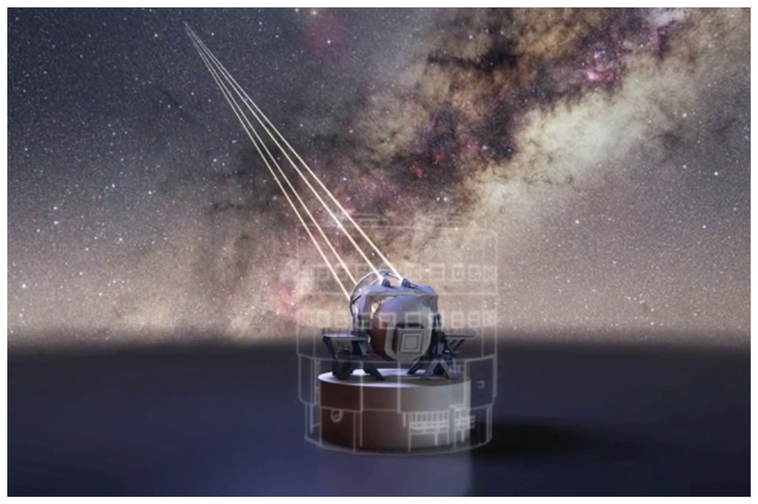
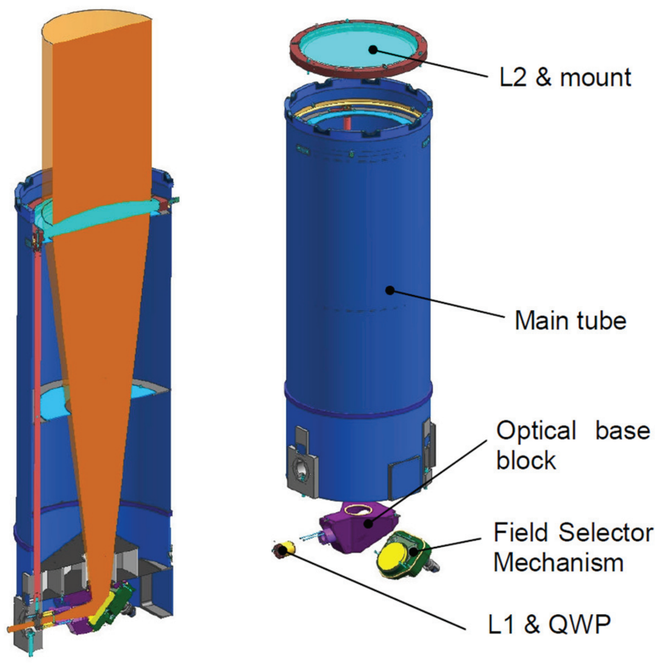


Artist impression of the VLT 4LGSF (© ESO)

VLT 4LGSF OTA

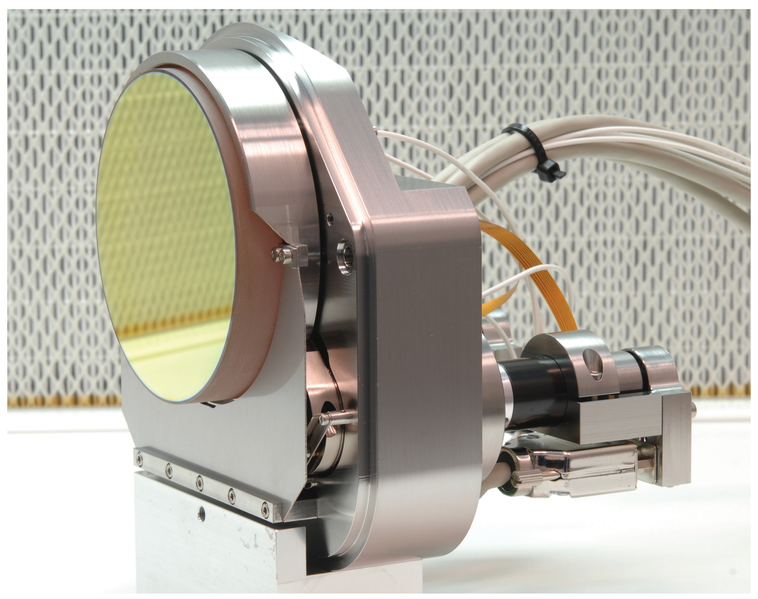
The 4 LGSF consists of a high power 25 W CW 589 nm laser, a Beam Conditioning and Diagnostics System (BCDS) and an Optical Tube Assembly (OTA). OTA is a 20x Galilean beam expander, with a 15 mm input beam and a steerable 300 mm collimated output beam. OTA employs four optical elements, a Quarter Wave Plate, a small double concave L1 lens, a Field Selector Mirror and a highly aspherical 380 mm L2 lens. The design is passively athermalized over a large temperature range as well as under the influence of thermal gradients.



OTA design

FIELD SELECTOR MECHANISM

To achieve 4.8 arcmin radius field of view on-sky, the FSM has to tilt up to ±6.1 mrad, in combination with less than 1.5 μrad RMS absolute accuracy. The maximum settling time for a 1 arcsec step on-sky is 0.2 sec. The FSM design consists of a Zerodur mirror, bonded to a membrane spring and strut combination to allow only tip and tilt. Since the range is too large for piezos, two (self-locking) spindle drives actuate the mirror, using a stiffness based transmission to increase resolution. Absolute accuracy is achieved with two differential inductive sensor pairs.



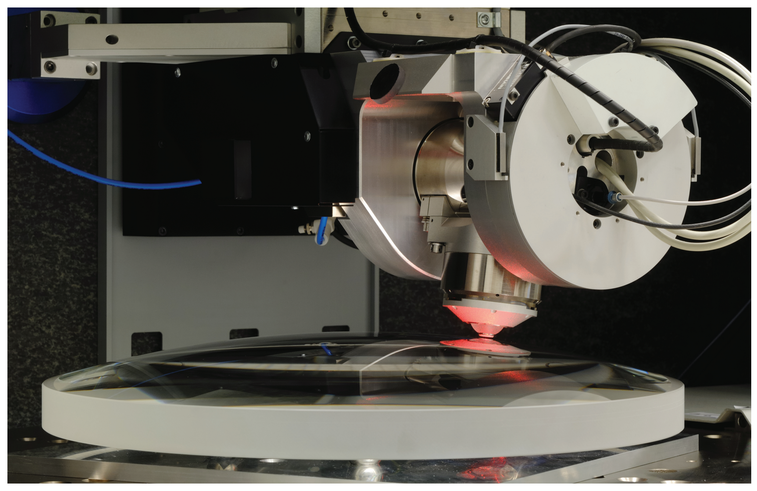
Field Selector Mechanism

OPTICAL MANUFACTURING AND METROLOGY

The L2 has a convex aspherical side with a radius of 637.381 mm and a conic constant of -0.447, resulting in a departure from the best-fit-sphere of 320 μm.
The convex aspherical surface of the L2 is particularly difficult to measure. Usually this is done by assembling and aligning the system, measure its transmitted wavefront, remove the lens and correct the errors in several iterations. The TNO NANOMEFOS machine allows for measuring the surface form directly, making the production much more flexible and efficient. Its characteristics are:

- Universal (from flat to freeform, convex to concave)
- Large measurement volume (Ø500 x 100 mm)
- High accuracy (30 nm, 2σ)
- Non-contact
- Fast (minutes)

TNO designed a custom 589 nm coating and applied it using its coating facility, resulting in a measured reflectivity of less than 0.2% for both sides.



Metrology of L2 with NANOMEFOS

OTA PERFORMANCE

The required wavefront quality of OTA is <50 nm rms. The output beam is steerable with an on-sky field-of-view radius of 4.8 arcmin. The combination of large FOV and small WFE led to the use of an aspherical L2 lens. The allowed defocus under operational conditions (0-15°C, 0.7°C/hr gradient) is only 0.2 waves. The thermal behaviour of the system has been analyzed by combining optical, lumped mass and FE analyses. Extensive thermal and high power laser testing has shown the system performs as required.

	Requirement	Measured performance
Transmitted Wavefront Error (WFE)	< 50 nm RMS	< 25 nm RMS over entire operational range (0 – 15 °C and 0 – 60 ° tilt)
Thermally induced defocus (0.7 °C/hr for 8 hours)	< 0.2 waves (118 nm)	~90 nm
On sky pointing accuracy	< 0.3” (3σ) over ±4.8’ range	< 0.1” (3σ) over ±4.8’ range
polarization extinction ratio (PER)	>97%	99.7 %
Throughput	> 95%	97.7%