2° Forum della Ricerca Sperimentale e Tecnologica

A Test Bench for LGS WFS Technology on an ELT-like Scenario

T. Gomes Machado, E. Portaluri, D. Greggio, S. Di Filippo, K. K. R. Santhakumari, M. Bergomi, F. Battaini, A. Ballone, R. Ragazzoni, C. Nesme, D. Malik, M. Dima, C. Arcidiacono, V. Viotto, M. Centrone, G. Umbriaco, L. Lessio, E. Carolo, S. Chinellato, J. Farinato, D. Magrin, L. Marafatto, D. Vassallo

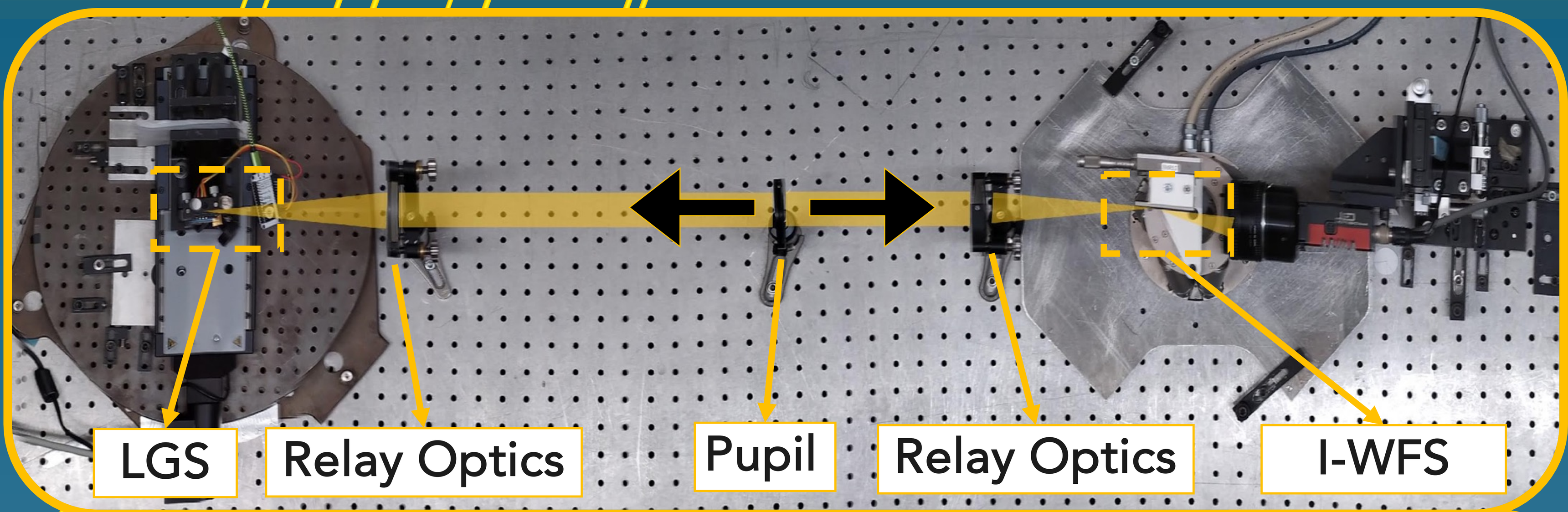
Introduction

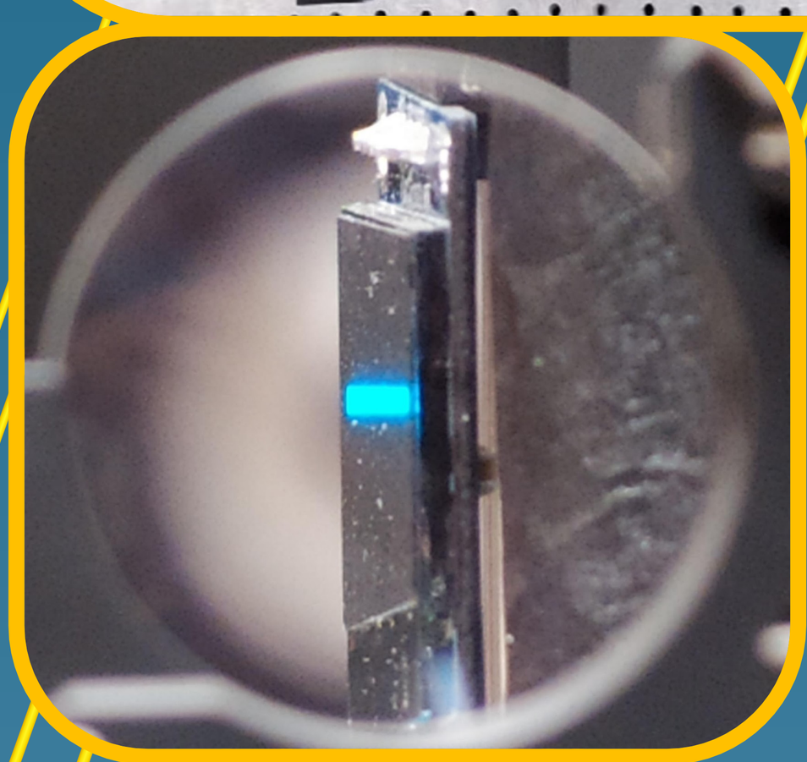
As the construction of Extremely Large Telescopes (ELTs) progresses, refining Adaptive Optics (AO) systems to maximize the benefits of Laser Guide Stars (LGS) is crucial. These telescopes will incorporate sodium LGS to enhance sky coverage for AO systems. New LGS technologies require accurate facilities that can replicate ELT-like conditions and simulate LGSs and the characteristics of the sodium layer. We present a test bench with such properties, developed at INAF-OAPd, and detail how currently it is being optimised to study the Ingot Wavefront Sensor (I-WFS).

Test Bench Characteristics

Simulate the LGS source on an ELT-like setup[1] keeping in mind:

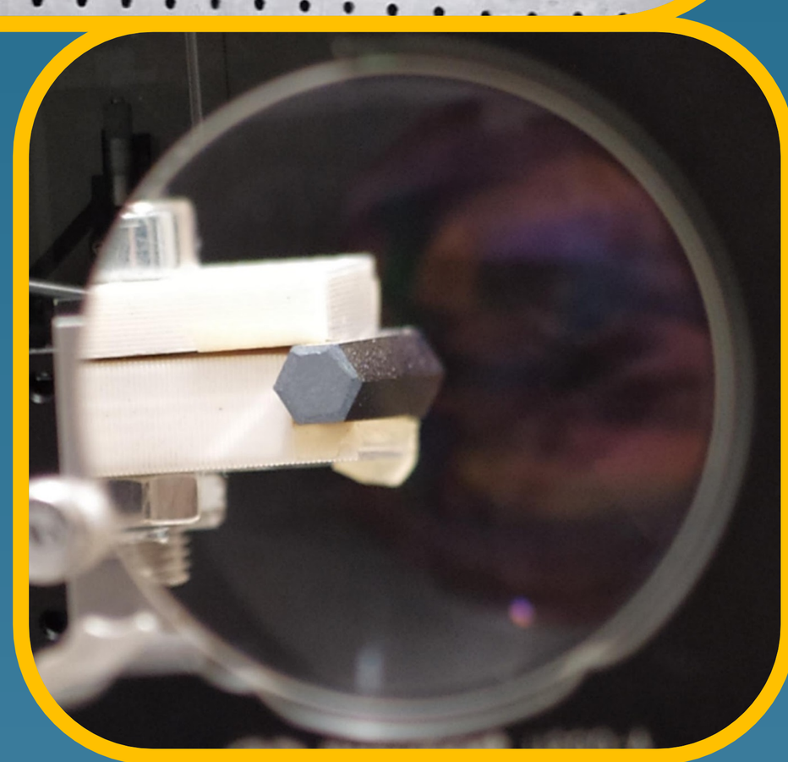
1. Sodium layer thickness, height, temporal and spatial variability
2. Ratio between LLT position and entrance pupil diameter
3. Telecentric image on WFS





OLED Screen (seen from pupil)

I-WFS (seen from pupil)



Future updates

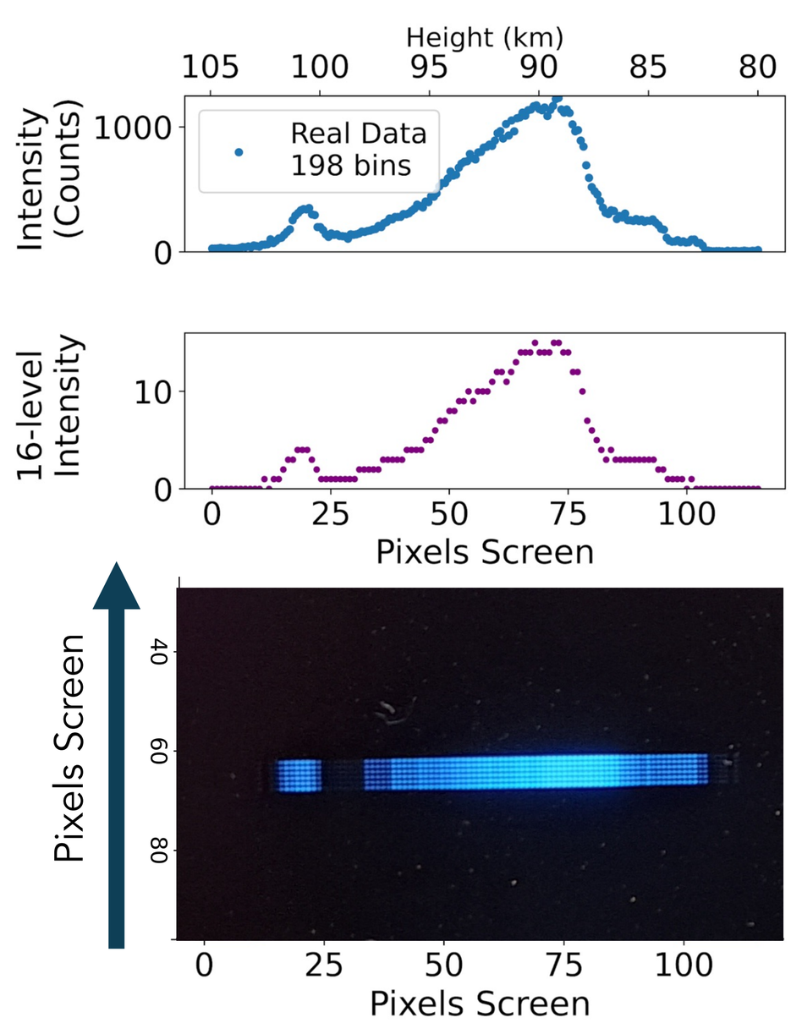
The project aims to meet the requirements of the LGS WFS module for the ELT+MORFEO[2] system.

Currently looking to **revise the optical bench design:**

1. Move from f/8 output to f/5 output.
2. Introduce a DM
3. Simultaneously test a SH WFS

OLED Technology to simulate the Sodium Layer

Using real sodium concentration data[3] as a function of height taken over several nights...

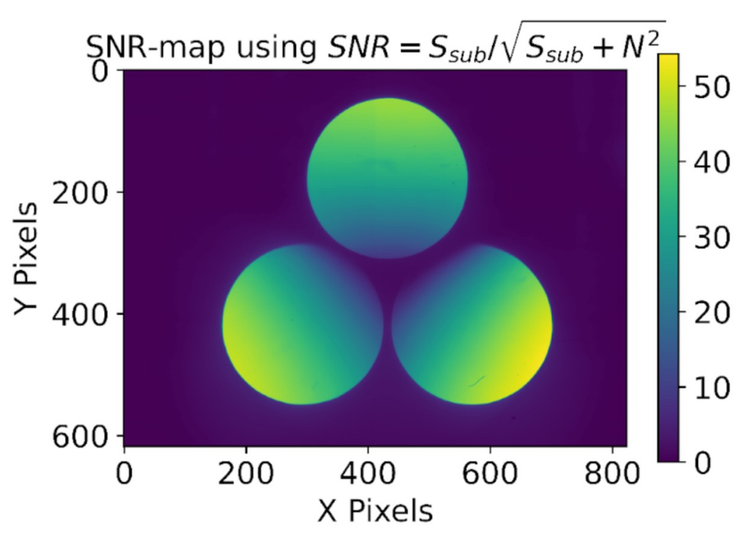


... we replicate the layer behaviour on a 16 level greyscale OLED screen

Scan the QR code to see our LGS changing!

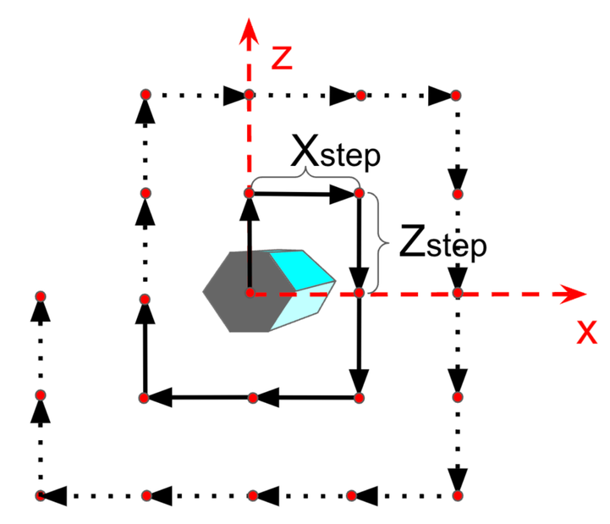
Alignment procedure

- Essential before wavefront sensing, uses information from the three pupils



- Iterative method with incremental movements in 6 d.o.f performed by an Hexapod.

- Alignment robustness tested with variable sodium profiles
- Additional search algorithm for extreme misalignments.

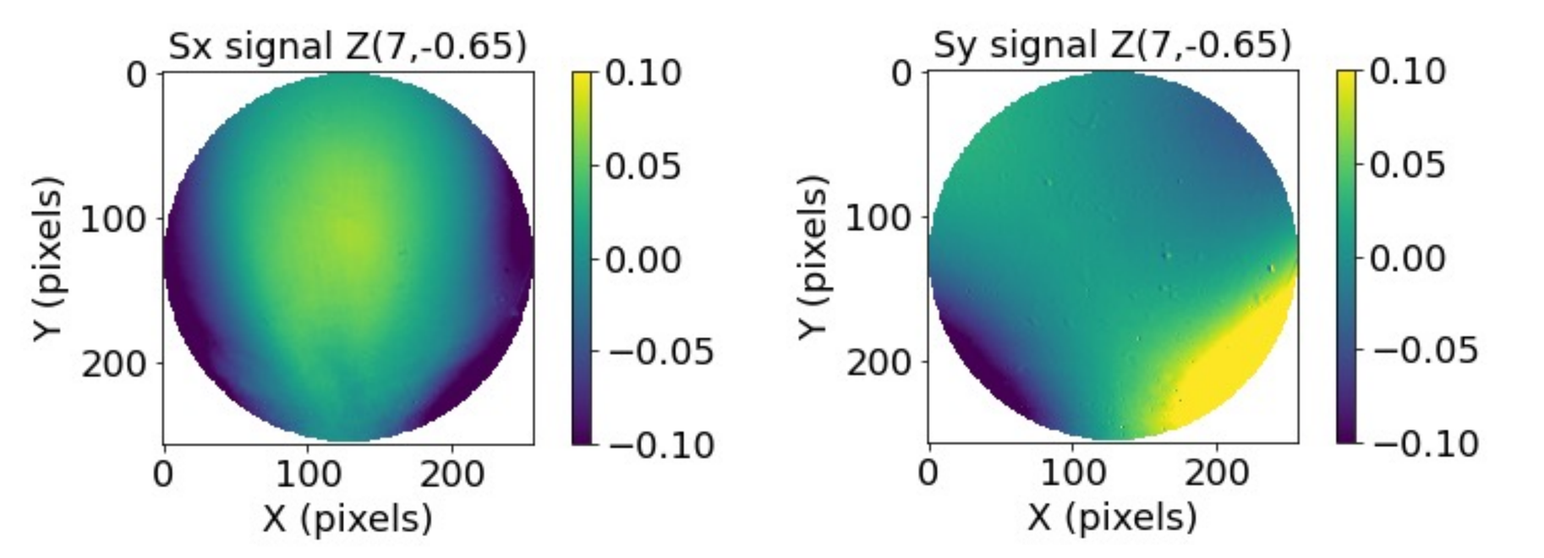


Deformable Lens

Dynamic Optics MAL Introduces low-order aberrations[4]

Used a 4D PhaseCam Interferometer to analyse its stability and characterize its flat configuration.

Tested the response of the I-WFS in the presence of four modes.



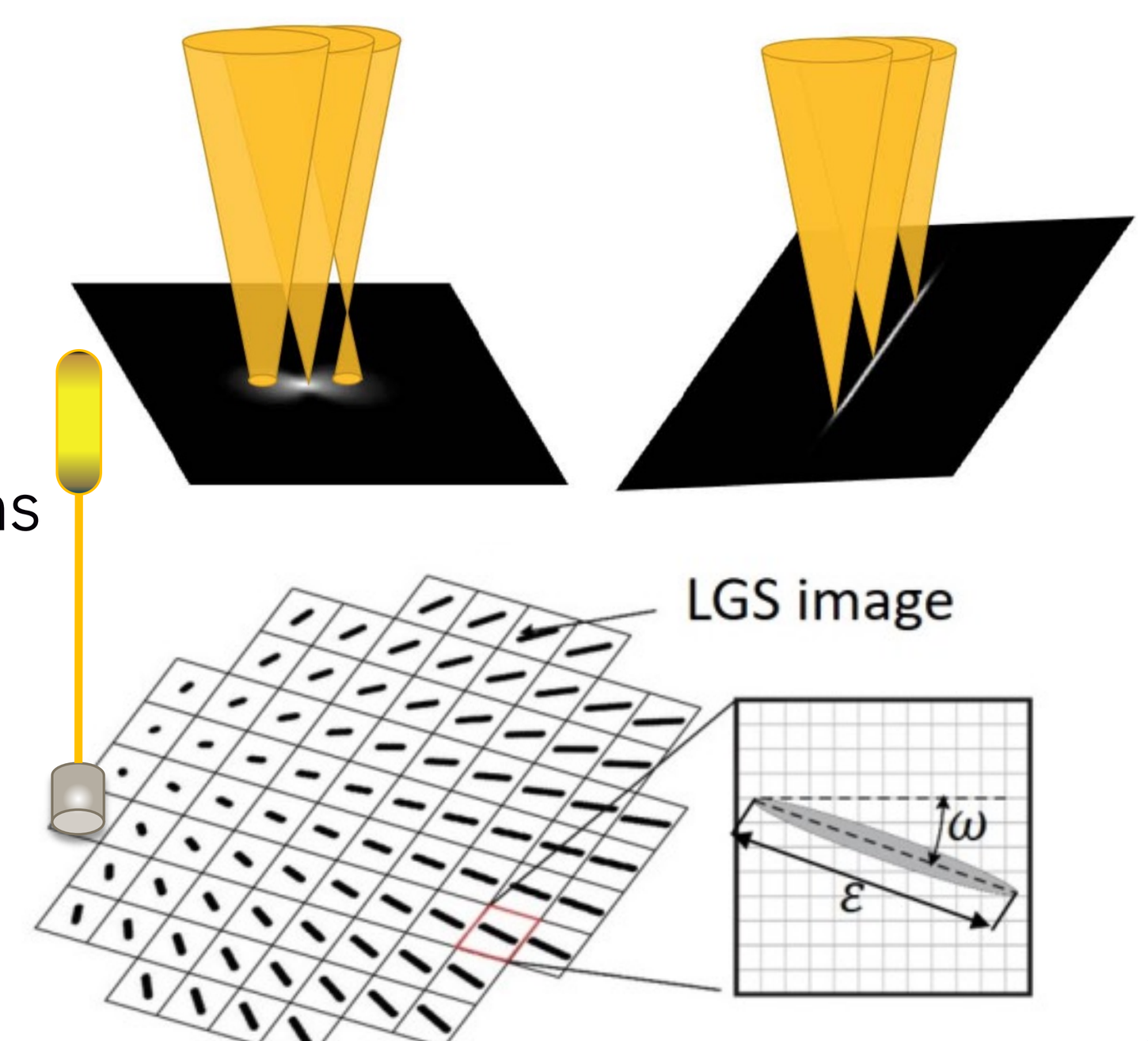
Signals measured when -0.65λ of Horizontal Coma are applied to the DL.

The bench design has been optimised to test the Ingot WFS.

What is the Ingot WFS?

LGS limitations can be addressed with the Ingot WFS

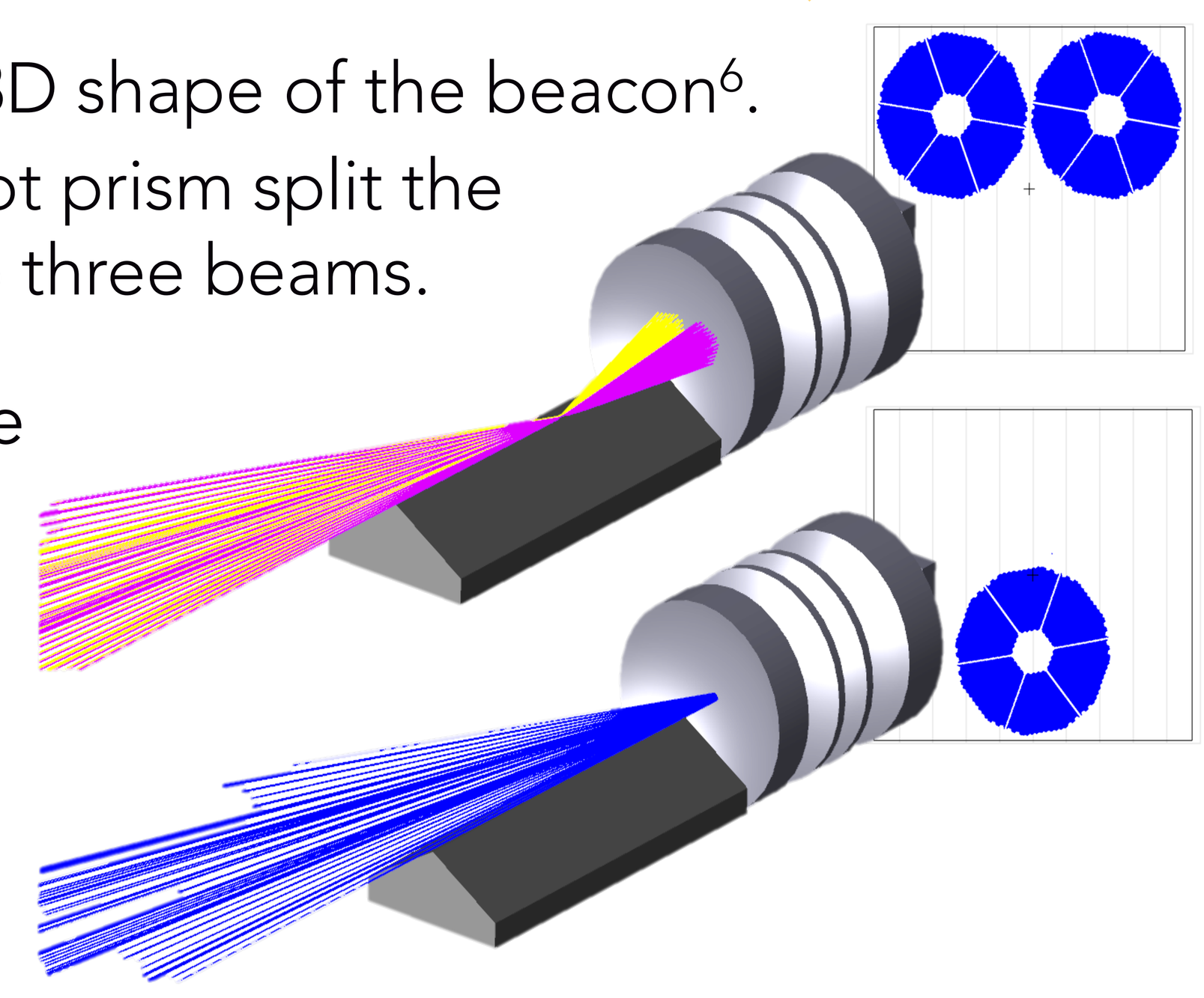
1. LGSs are NOT point-like sources.
2. LGSs focus on a 3D volume, not on a plane.
3. Spot elongation harms wavefront sensing[5]

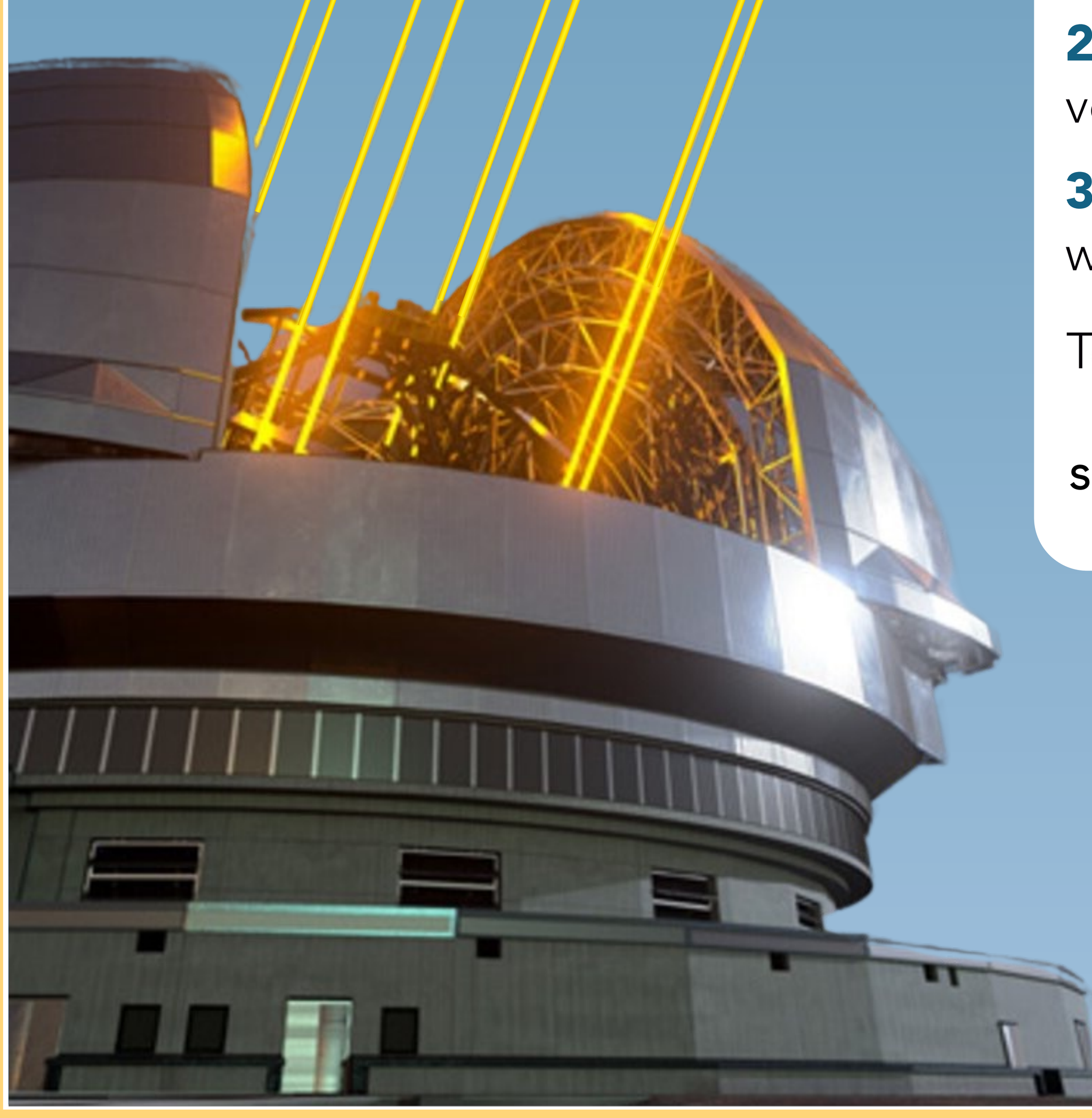


To optimise wavefront sensing, the WFS should be tailored to the LGS geometry.

This WFS matches the 3D shape of the beacon[6]. The surfaces of the ingot prism split the incoming LGS light into three beams.

Scan the QR code to see the Ingot working!





Future steps: Collaborations with the Laser Laboratory of INAF-Rome

Preparing for real **on-sky testing**

References

1) Di Filippo et al 2022, Adaptive Optics Systems VIII, SPIE
2) Busoni et al 2023, AO4ELT
3) Pfrommer et al 2010, Journal of the Optical Society of America
4) Bonora et al 2015, Optics Express
5) Ragazzoni et al 2017, AO4ELT5 Proceedings
6) Ragazzoni et al 2024, Astronomy & Astrophysics