# Technologies for the phasing of segmented pupil optical telescopes

MARIA BAZZICALUPO
NATIONAL INTEREST PHD IN TECHNOLOGIES FOR FUNDAMENTAL RESEARCH IN PHYSICS AND ASTROPHYSICS

CURRICULUM: RIVELATORI, LASER E OTTICA
HOSTING RESEARCH CENTRE: INAF OSSERVATORIO ASTROFISICO DI ARCETRI

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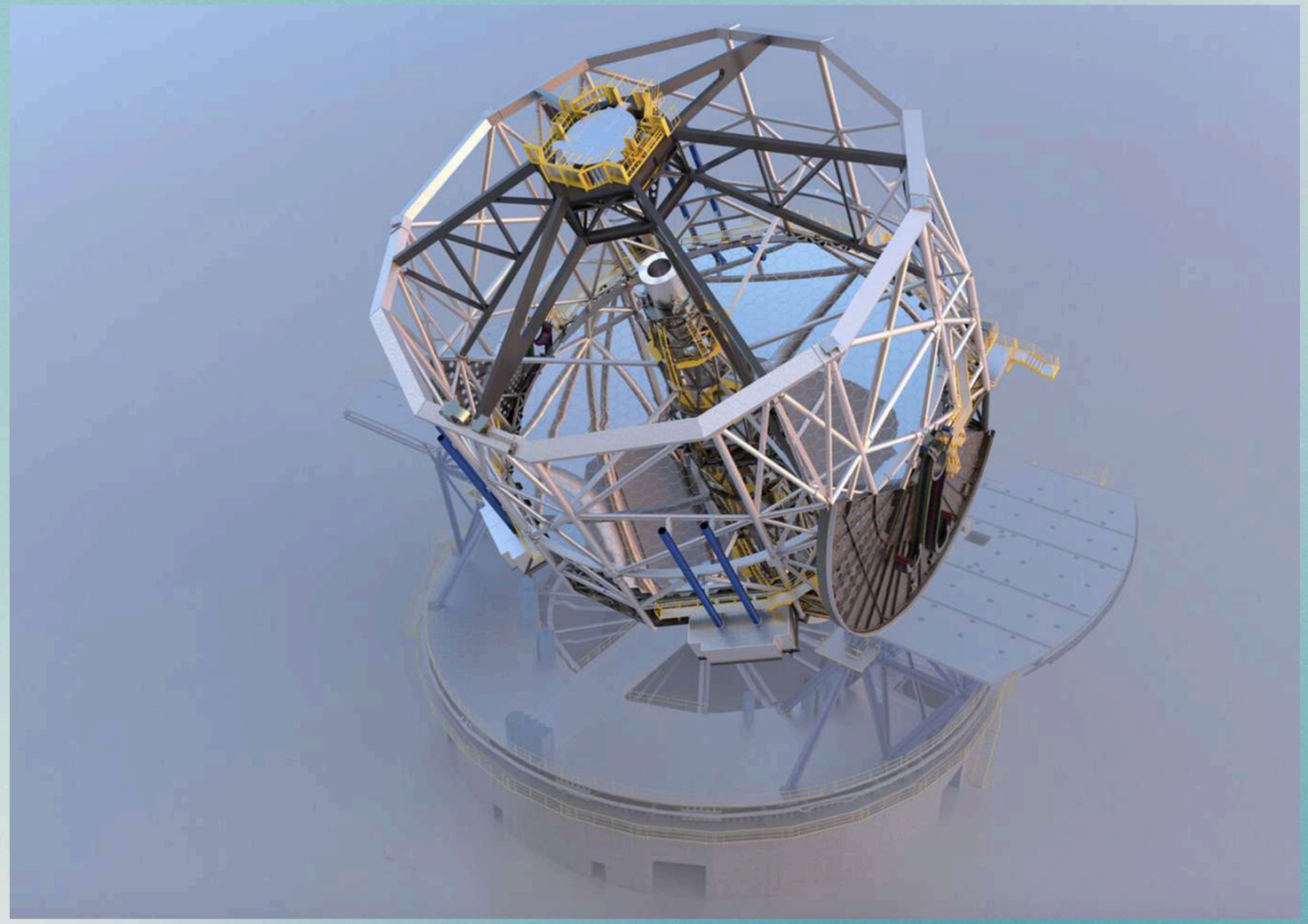
## Topics covered

# ELT

The Extremely Large Telescope is the largest ground-based telescope ever designed, with a primary mirror diameter of 39 meters.



The secondary mirror of ELT is supported by six legged 50cm-wide spider. These legs **break the spatial continuity of the incoming wave-front.**

The six segments of the pupil may become further discontinuous from each other due to atmospheric turbulence, low wind effects, and thermo-mechanical drift of the deformable mirror.

It is therefore necessary to measure these differential pistons in order to **reconstruct the full wave-front.**

# MORFEO

Morfeo, the Multiconjugate adaptive Optics Relay For ELT Observation , will deliver multiconjugate adaptive optics (MCAO) correction to the ELT.
MORFEO will help compensate for the distortion of light caused by turbulence in the Earth's atmosphere which makes astronomical images blurry, but will not make observations itself; it be an adaptive Optics system that will enable other instruments to take exceptional images.

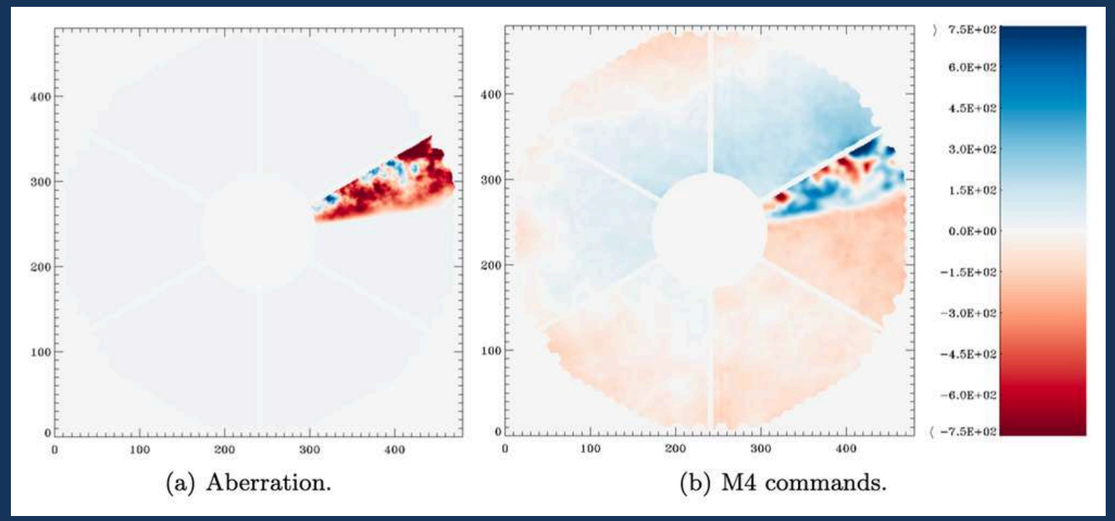
BUT **We cannot reconstract the differential pistons with the tipical wavefront sensor (WFS).**

This because the fragmentation of the pupil in six disjoint segments has a separation larger than the typical Fried parameter.
The Pupil fragmentation can then be a major issue for MORFEO that is equipped with Shack Hartmann (SH) WFSs that are slope sensors not able to measure phase jumps across the spiders of the ELT since the distance between the sectors is larger than the atmospheric coherence length.

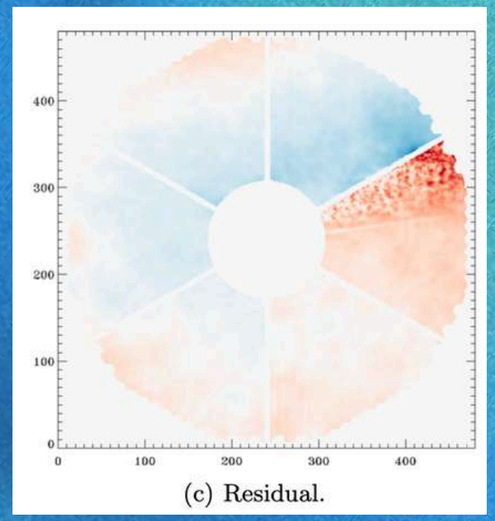
# The appropriate sensor

Using an appropriate sensor to detect this aberration is crucial to avoid compromising imaging quality and the expected scientific performance.

Low Wind Effect simulation on ELT:




(a) Aberration. (b) M4 commands.



(c) Residual.

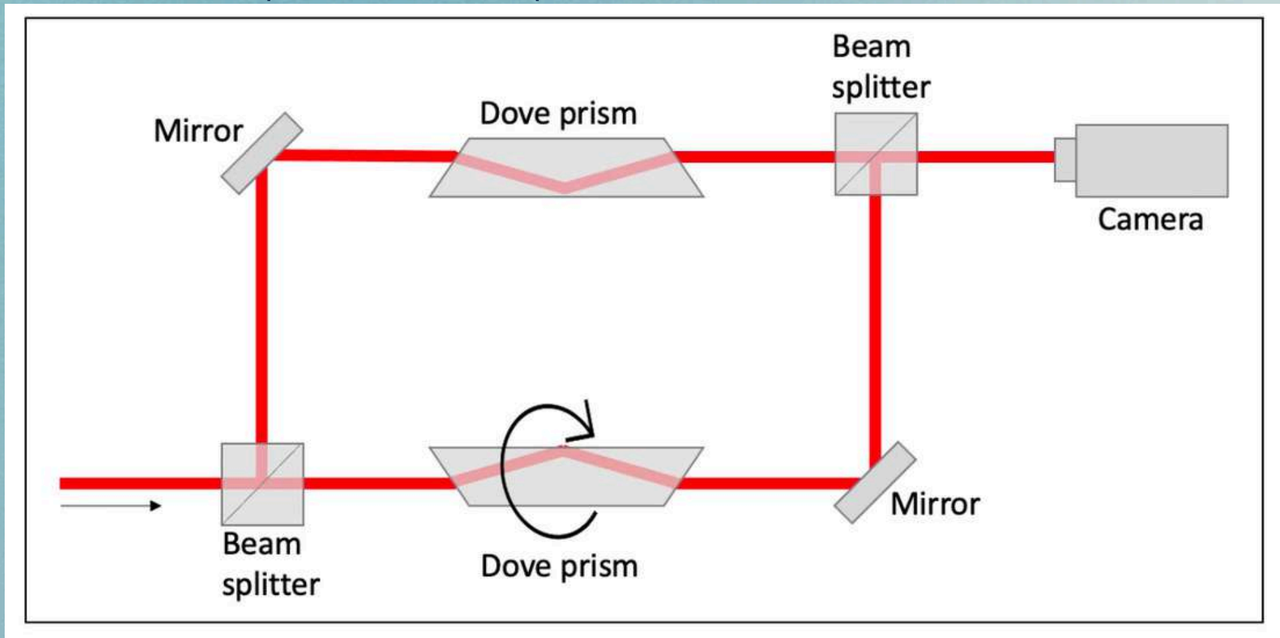
A modulated pyramid, that is one of the best optical WFS, to tackle the aberration results in a strong degradation of the imaging quality and compromises the scientific expected performance.

# CiaoCiao WFS

Rotational shearing interferometer to sense phase differences between the pupil sectors.

Considering the rotational symmetry of the ELT pupil, a rotational shearing interferometer can be used to generate interference between two pupil sectors divided by a spider, enabling the detection of phase differences between adjacent sectors.

Simplifed setup of the CiaoCiao WFS:



# Phase difference between overlapping sectors:

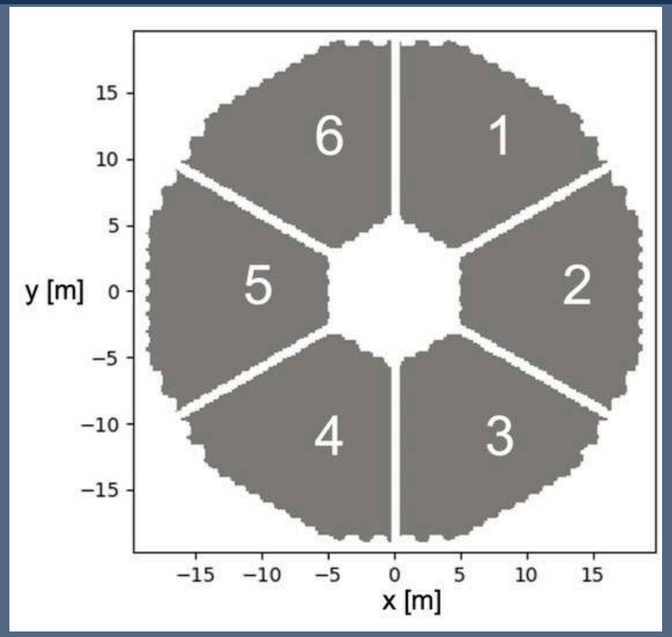



IMAGE OF THE PUPIL

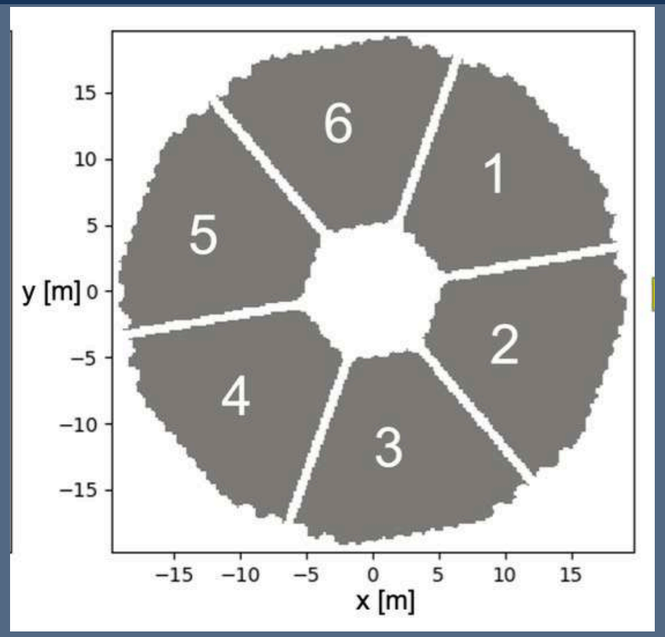
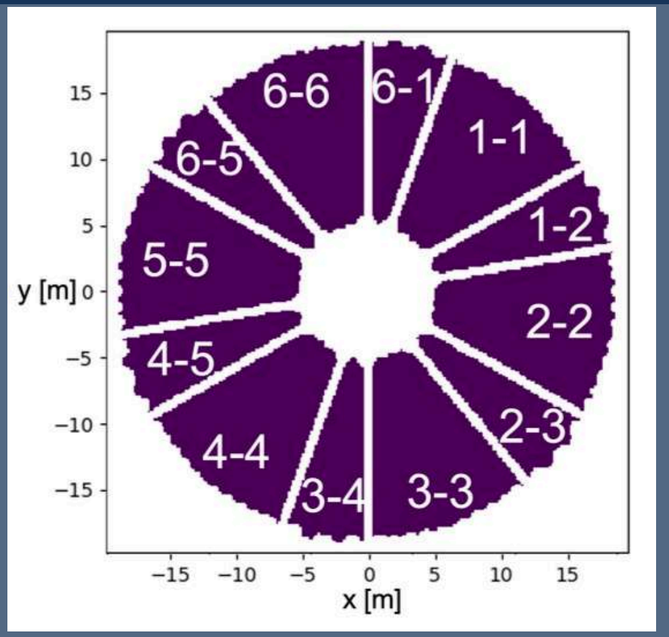
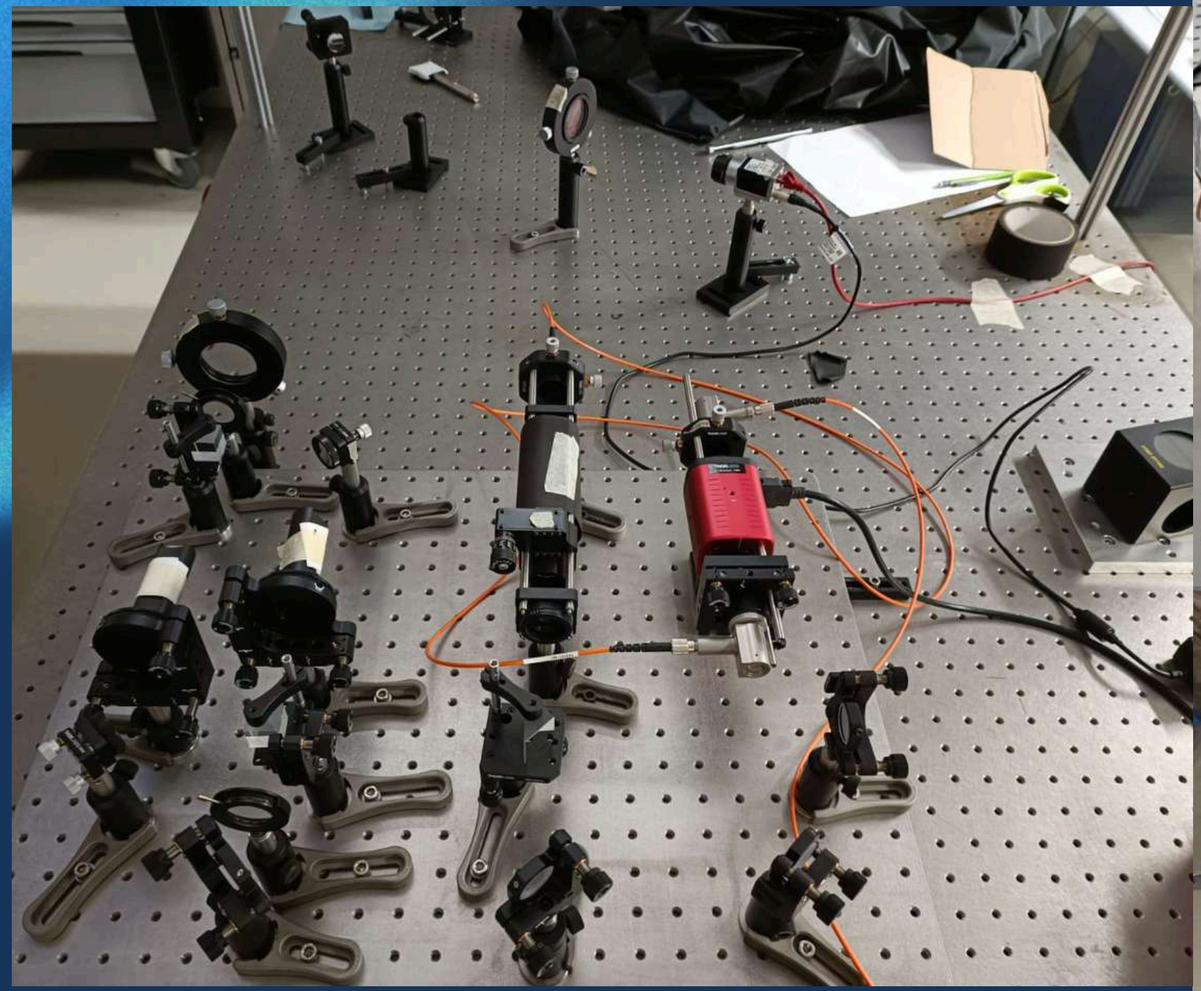


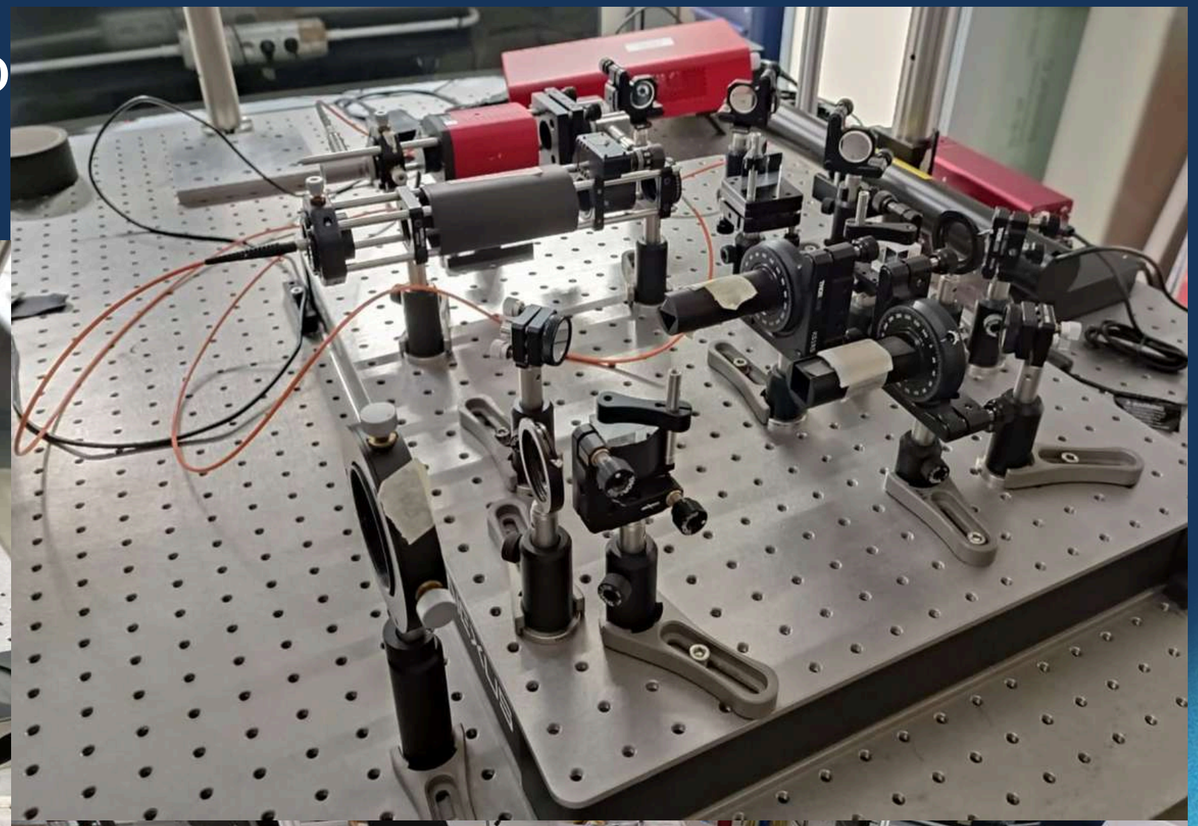

IMAGE OF THE PUPIL ROTATED BY 20°

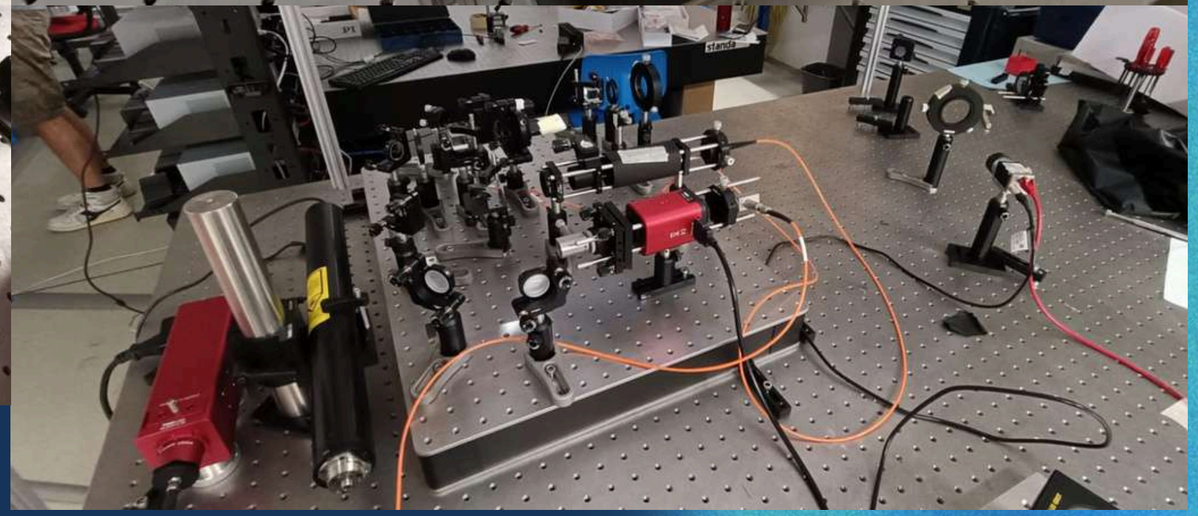



OVERLAPPING SECTORS AFTER INTERFERENCE

# The Current Optical Bench Setup in the Laboratory







# The courses, exams, and schools completed and those I will take during the 1st academic year

Courses and Exams:

- Fundamentals of system engineering and project management for large scientific projects, Prof. Xompero Marco Prof. Runa Antonio Briguglio Pellegrino ✓
- Adaptive Optics for Astronomy, Prof. Arcidiacono Carmelo ✓
- Deep Networks & Structured Learning, Prof. Basili Roberto ✓
- Ottica adattiva per l'astrofisica, Prof. Busoni Lorenzo Prof. Esposito Simone ✓
- Radio and optical interferometry, Prof. Fabrizio Massi Prof. Giovanni Comoretto

Schools:

- The ORP International school Observing with Adaptive Optics that will take place at Observatoire de Haute Provence in France from 29th September to 4th October 2024

# Courses, activities, and schools planned for the 2nd year

- The 2025 NEON Observing school will take place in Spain at the The Hispanic Astronomical Center in Andalusia (CAHA), also known as the Calar Alto Observatory, on 2 - 14 February 2024.
- some soft skills courses
- Laboratory activities to study and observe with empirical evidence the theory and characteristics of the CIAOCIAO WFS
- development of a data analysis software
- I will be spending a period abroad starting from January, but the destination is yet to be determined

**Proposed PhD Thesis Title:** Sensing phase discontinuities on ELT segmented pupil with a rotational shearing interferometer

# Grazie!