2° Forum della Ricerca Sperimentale e Tecnologica

Padova: Laboratory facilities in INAF and interferometric laboratory in DFA

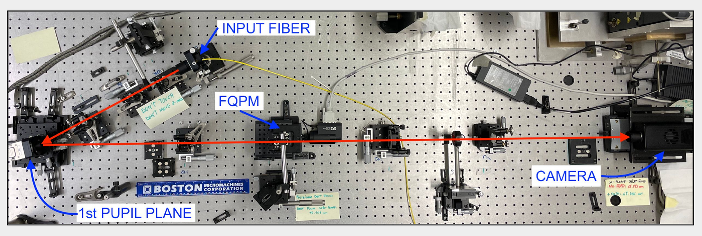
*Carolo Elena, Gabriele Umbriaco and the Instrumentation and Adaptive Optive Group in INAF-OAPd***

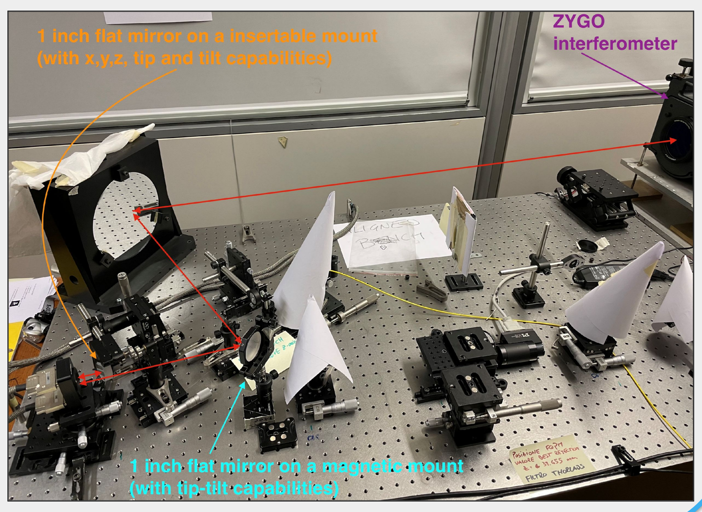
INAF-OAPd and UNIPD-DFA

CORONAGRAPHIC TEST BENCH FOR SHARK-NIR

This set-up is a test bench implemented to investigate the causes and the possible solutions for the poor, not expected, performance of the Four-quadrant phase mask (FQPM) reached on sky by SHARK-NIR. SHARK-NIR is an INAF-OAPd PI instrument designed and aligned in INAF-OAPd labs, and now mounted on the Large Binocular Telescope (LBT). It is now operative and in the Early Science phase. The instrument is dedicated to the infrared bands Y, J and H and it is equipped with several coronagraphic masks (Farinato et al. 2014).

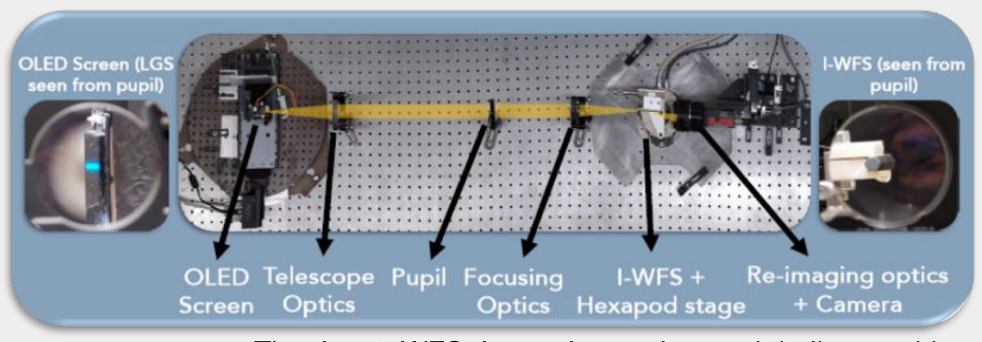
The FQPM is characterized by a four-quadrant pattern with the two adjacent quadrants providing a π phase shift in order to produce destructive interference with the stellar light. The FQPM is placed at the first focal plane (coronagraphic plane) while a Lyot stop is located at the second pupil plane of the instrument. This test bench has been realized in order to replicate exactly the optical properties of the FQPM of SHARK-NIR and with the additional possibility to analyze the optical quality of the beam on the coronagraphic plane.





THE INGOT WAVEFRONT SENSOR LAB

This laboratory bench is used to test the feasibility and gain of the Ingot Wavefront Sensor (I-WFS), by developing an automatic procedure to align the system and assessing its sensitivity. The main components are: 1) an OLED screen, which reproduces the expected intensity profile of a Laser Guide Star (LGS) fired by the ELT launcher, and 2) the hexagonal pipe that represents the ingot prism and can be moved by 3) an hexapod. More components are/will be added to run more tests (e.g. a deformable lens/mirror to reproduce first order aberrations).



The Ingot WFS is an innovative and indispensable pupil plane wavefront sensor, proposed by Ragazzoni et al. (2017) and refined by the AO Group @INAF-Padova (see Portaluri et al. 2022 for a description of the project). It is based on the idea of optimizing the match between the elongated source, which is fired from the side of the primary mirror and can be considered like "a cigar in the sky", and the optical surface used to sense it, shaped like an ingot prism. In fact, it consists of a combination of refractive and reflective surfaces arranged onto a complex prismatic shape that extends in three dimensions (Ragazzoni et al. 2024).

See the dedicated poster of T. S. Gomes Machado.

TESTING AND INSPECTION LAB

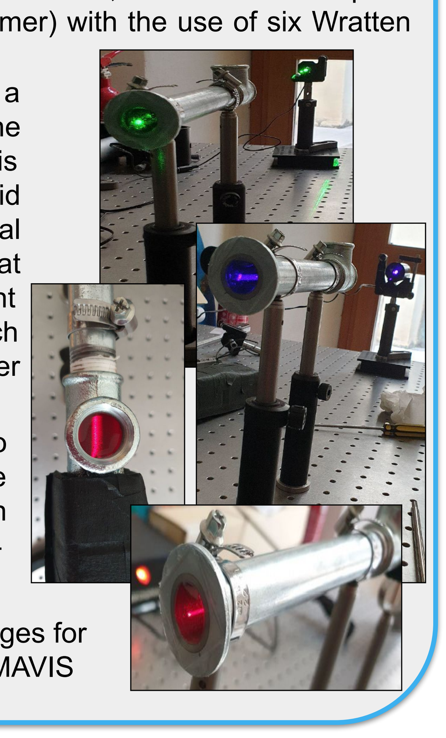
Set-up created to measure the refractive index of a liquid. It exploits the fact that the size of the image of an object is proportional to the index itself.

An object of known size (a graduated cylinder) is used immersed in the liquid whose index is to be known, which produces an image of the object. Photos are taken with a camera (I used a CANON 5d EOS) and the size of the image is measured from these: the ratio between this size and the real one provides an estimate of the liquid index.

The Fluids image shows this process applied to distilled water, and to fluorine liquids FC-72 (perfluorohexane) and Novec7200 (fluorine polymer) with the use of six Wratten filters to obtain the variation of n in the visible spectrum.

The set-up for measuring the absorption coefficient of a liquid; this parameter allows you to quantify the transparency in the visible. A light source (a laser) is used whose light passes through a sample of liquid (enclosed in a tube sealed at the ends with BK7 optical windows) and then hits, downstream, a detector that measures the light power. To improve measurement accuracy, we chose to use two identical tubes, which differ only in length (one is 1 m, the other 20 cm) in order to carry out a differential measurement.

From the ratio between the logarithm of the ratio between the measured powers and the difference in the lengths of the tubes, an estimate of the absorption coefficient is obtained. To characterize it in the visible, 4 lasers were used: 405, 532, 543 and 633 nm.



On this bench several optics, sources, motorized stages for different projects as SHARK-NIR, SOXS, MATTO, MAVIS were and will be inspected and tested.

#3 OPTO-MECH LABS

#1 CRANE LAB FOR AIV INTEGRATION

#1 CLEAN ROOM

#2 3D-PRINTERS

#1 INTERFEROMETRIC LAB

#1 LAB OF MULTI CONJUGATE AO

#1 ELECTRONIC LAB

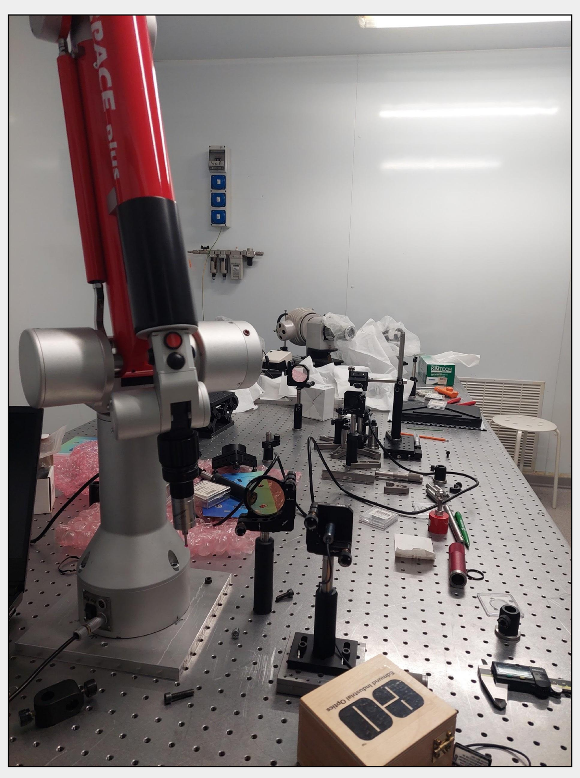
#1 MECHANICAL WORKSHOP

Location: Vicolo dell'Osservatorio 5, Padova

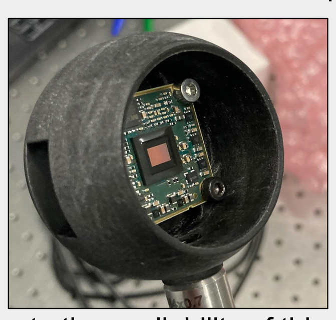
Location: Vicolo dell'Osservatorio 3, Padova

CLEAN ROOM (ISO 5, 2.5x3mt)

We developed a new optomechanical tool to quickly align an optical beam to a reference mechanic. In the alignment of the SOXS Common Path we used a referenced sensor to align the master laser beam to the mechanical structure of the subsystem. Based on that experience we conceptualized and prototyped a new effective tool for alignment.

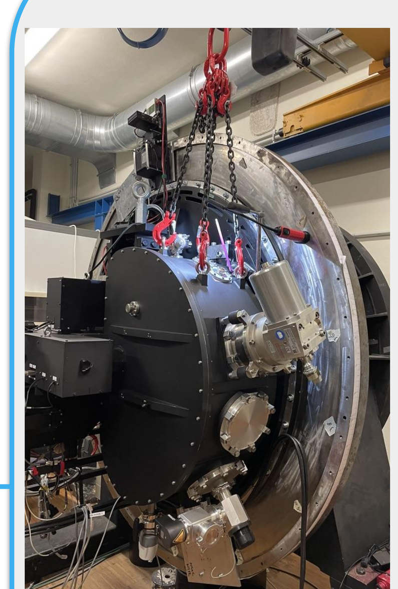


A sphere is 3D printed, to host a small bare-board cmos with the sensor plane passing through the center of the sphere. This tool used in combination with a portable coordinate-measuring machine (pCMM) allows for a quick alignment of a laser collimated narrow beam or a converging beam on an optical bench as in 3D space.



Owing to the availability of this room, compatible with ISO 5 standards, it was possible to align the SHARK-NIR optical bench and test some of the SOXS subsystems.

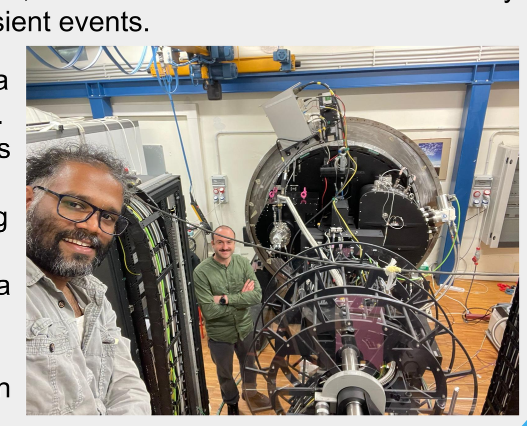
AIV INTEGRATION LAB WITH CRANE (1 ton, 5.50x8mt)



SOXS (Son Of X-Shooter) is a single object spectrograph offering simultaneous spectral coverage in UV-VIS (350-850nm) and NIR (800-2000nm) with an average R ~ 4500 for an 1" slit. It can also perform photometry in 360-970nm (ugVrizY) (3.5'x3.5', 0.2"/pixel). SOXS will be mounted on the Nasmyth platform of the 3.58m ESO NTT at the La Silla Observatory.

SOXS consists of three scientific arms (UV-VIS Spectrograph, NIR Spectrograph and Acquisition & Imaging Camera), each of which is connected by the Common Path sub-system to the NTT, and the Calibration Unit. It will be one of the few spectrographs on a dedicated telescope with a significant amount of observing time to characterize astrophysical transients. It is based on the concept of X-Shooter at the VLT but, unlike its "father", the SOXS science case is heavily focused on transient events.

- The sub-system Common Path AIVT is a contribution of INAF-Padova among things.
- The full SOXS system integration is ongoing in INAF-Padova laboratory now.
- We are starting the PAE in the coming months.
- Expected to ship the instrument to La Silla by the end of the year.
- AIVT @ La Silla in Jan 2025.
- Commissioning anticipated to start in March 2025.

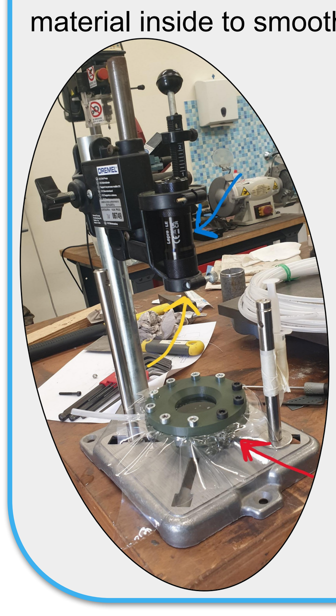


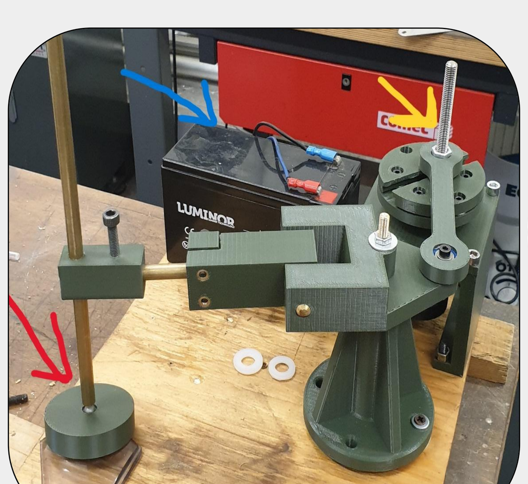
3D PRINTERS STRATAsys F170 & J55

Machine assembled to coat a 3D printed lens. The coating is made with a layer of VeroClear resin to make the surface of the lens shiny. It is carried out by pressing the lens (yellow arrow) on a drop of resin placed on an elastic and well-stretched membrane. A UV lamp (blue arrow) polymerizes the resin in a few seconds, making it adhere to the lens. The heat released by the polymerization reaction is absorbed by the water, enclosed in a tank at the bottom (red arrow).

Machine assembled from 3D printed components (the dark green tool) and designed to carry out a polishing operation on 3D printed lenses.

The battery (blue arrow) powers a motor which rotates a wheel (yellow arrow). Thanks to a connecting rod, the rotary motion is transferred to a pad at the end (red arrow) which can move describing a small arc of circumference. The skate has abrasive material inside to smooth the lens on which it slides.

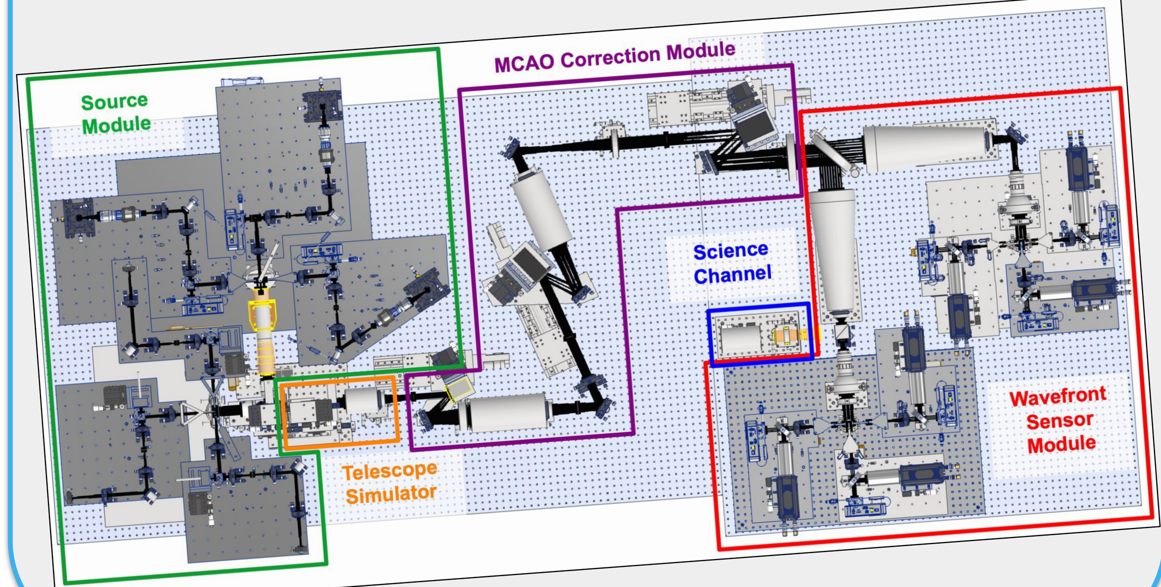




Washers of 5 mm diameter in various thicknesses printed with the 3D printer

MULTI CONJUGATE AO LAB

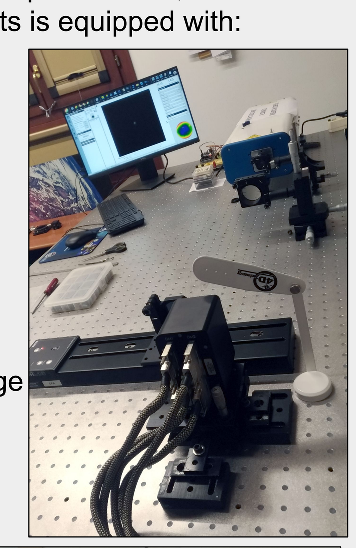
The Multi-conjugate Adaptive Techniques Test Optics (MATTO) bench will serve as an international facility for innovative wide-field adaptive optics techniques. The opto-mechanical design has been optimized to simulate the current and future largest telescopes, with a broad range of diameters (4-40m) and fields of view (0.5-10 arcmin). The bench is based on a modular design, so that it can be easily modified or upgraded in the future, to cope with not-yet-identified new AO techniques and WF sensing approaches. Practically speaking, the design is based as much as possible on existing off-the-shelf components to reduce cost and delivery time, providing at the same time a good optical quality in all the channels. An opto-mechanical view of the bench is displayed in the figure below. **See the dedicated poster of S. Di Filippo.**

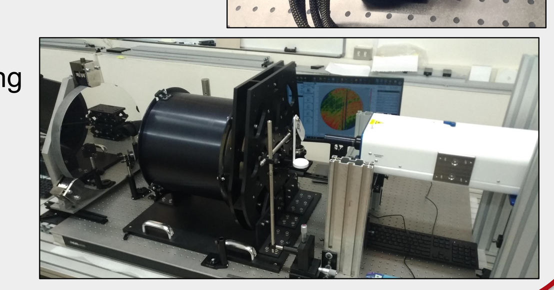


INTERFEROMETRIC LAB

The Department of Physics and Astronomy "G. Galilei" (DFA) is in the context of highly competitive international research and is launching the project titled "Physics of the Universe", founded by Dipartimenti di Eccellenza MUR 2018-2022. The DFA established new laboratories for the development of optics and sensors necessary for experiments and observations, both ground-based and space-based, in which the Department is involved. The new lab of interferometric tests is equipped with:

- Optical bench 2000x1000x300mm +wheels +PDU+Passive air leveling vibration isolators
- Diverger lens EFL80 mm λ/10
- Custom Beam expander
- Achromatic Beam expander 5x & 10x
- 2x AOL1816 Deformable lens 18 actuators Clear Aperture 16mm (Dynamic Optics srl)
- SH-wavefront sensor
- Reference flat and spherical λ/20
- Thorlabs LTS300C 300mm motorized translation stage
- PLICO software control station
  A framework for Adaptive Optics laboratory experiments, instruments control under Python
  doi://10.13009/AO4ELT7-2023-042
- 4D 4Sight Focus software control
- Lab temperature & humidity monitoring
- All under remote control





***the Instrumentation and Adaptive Optive Group in INAF-OAPd**:

Alessandro Ballone, Bartolomeo Bottazzi Baldi, Carmelo Arcidiacono, Cesar Nesme, Daniele Vassallo, Davide Greggio, Demetrio Magrin, Dheeraj Malik, Elena Carolo, Elisa Portaluri, Federico Battaini, Gabriele Umbriaco, Jacopo Farinato, Kalyan Radhakrishnan, Luca Marafatto, Luigi Lessio, Marco Dima, Maria Bergomi, Oleksandra Rebrysh, Paolo Cerpelloni, Roberto Ragazzoni, Silvio Di Rosa, Simone Di Filippo, Simonetta Chinellato, Tania S. Gomes Machado, Valentina Viotto

Contact: elena.carolo@inaf.it, gabriele.umbriaco@inaf.it