

Activity 2101: MAORY2DM (€9,975,330)

Procurement of the 2nd deformable mirror for MORFEO, the adaptive optics module for ELT. Contract signed with ADOPTICA (MICROGATE + ADS) on 29/12/2023. Thin Shell accepted at REOSC (Paris) 03/03/2026, arrived at ADS 11/03/2026. Reference Body tested in South Korea, now traveling to ADS. Transfer of Ownership scheduled at ADS on **09 April 2026**



Key outcome: **16 additional GTO nights** on ELT for the entire INAF community

Activity 6501: BIH & Optical Lab (€337,000)

Upgrade of the MORFEO Bologna Integration Hall (BIH) and optical support laboratory with lifting tools and precision optics equipment: 5-ton forklift CPD50L1, three Genie scissor lifts (max height 11.78 m), TMC optical benches with Thorlabs & Newport opto-mechanical parts, MAT Taylor-Hobson micro-alignment telescope, FLIR cameras, 20MP Sony IMX183 monochrome cameras, environmental monitoring kit.

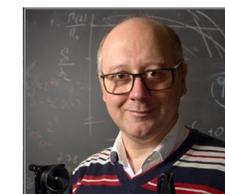


Activity 6502: Electronic Lab, Staff (€465,000)

High-end test, measurement and prototyping equipment for the electronics support laboratory: Tektronix MSO6B mixed-signal oscilloscope, Rigol DM3068 multimeter, Keysight U1252B portable multimeter, Siglent SPD3303X-E DC power supply, Tektronix AFG31252 function generator, Oxford Andor CB2 scientific camera with MUDPI interface (1608×1104 px, 74% QE, 500fps).



Researcher



Gabriele Umbriaco

PhD



Luca Rosignoli

PhD



Letizia Scaloni



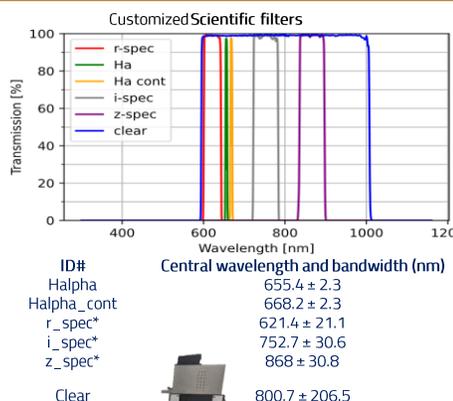
NirvanaVIS – Att. 2201

It is the upgrade of the existing instrument LINC-NIRVANA @LBT, Arizona, conceived to exploit the sensitivity correction (approx a factor 2) granted by LN wide-field GLAO in the visible regime (600-1000 nm), while leaving LN fully operative. The GLAO configuration, based on pyramid wavefront sensors, allows to search up to 12 natural guide stars in an annular FoV 2.8-6 arcmin diameter and correct with the 672 actuators LBT Adaptive Secondary Mirror. NirvanaVIS will provide on the SX side of the LN bench a FoV of 52" x 52" with uniform PSF across the field for speckle holography with a diffraction-limited PSF in Halpha. The design includes a Teledyne COSMOS 8K fast-frame CMOS, which presents a great opportunity but also technical challenges in data management and data reduction, providing a precursor for the next generation of telescopes.

Optical design

The **focal extender** is based on a positive-negative-positive lens design to achieve the required magnification in a relatively compact volume and have an almost telecentric beam on the detector. The **filter wheel** is placed between the second (L2) and third (L3) lens, where the optical beam footprint is smallest, to minimize the filter size.

Filter selection came from analysis of possible science-cases, simulations to determine the effect of bandwidth (due to ADC absence). 4° Aol comes from a trade-off between ghost analysis and filter performance.



AO-assisted speckle holography

- Short-exposure images to capture instantaneous atmospheric distortions
- GLAO to enhance image sharpness, reduce speckle number and increase their brightness and the coherence time, to provide a more uniformly corrected FoV for multiple bright calibrating stars used for PSF calibration, to enable more precise deconvolution
- Post-processing to reconstruct diffraction-limited images through Lucky imaging and via phase and amplitude retrieval techniques (Bispectrum analysis, holographic speckle imaging), using reference PSF estimation from AO telemetry

Workstations requirements

- 90 TB of storage space [Considering approx. 5 hours 128 MB (full frame 8120*8120 14bit images) at 18Hz for 2 observations nights]
- SSD NVMe with a writing speed >3GB/s
- RAM > 256GB
- Frame-grabber compatibility
- 10 hours max transfer rate of data (45 TB) to allow 2 nights consecutive observation on NVMe disks (transfer-rate to HDD not enough)
- Transfer of data from LBT to INAF-Padova → NVMe disks moved on twin Supermicro servers (one equipped with 6x 30.72 TB SSD, the second with 3 x 30.72 TB SSDs)
- Long-term data back-up on HDDs on NAS(140 Tb)



Scientific cases -High angular resolution

- Astrometric detection of nearby stellar companions.
- Dynamics and temporal evolution of stellar jets and outflows
- Populations, structure, and potential intermediate-mass black holes in globular cluster cores
- The densest regions in M31, M33 and local group galaxies
- Over-dense galaxy cores at intermediate redshift
- Stellar multiplicity in open clusters and its impact on the Initial Mass Function

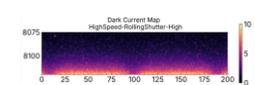
Current status & Next steps

- AIV: currently in OAPD laboratories: mechanics assembly is being finalized and the alignment of the optics has just started
- GLAO system: daytime GLAO tests at LBT installing a light-source into the retro-reflector structure
- NCPA correction strategy definition and implementation
- Definition of a review with LBT ahead of shipment
- Speckle imaging testing at Asiago with an Halpha filter and use of dedicated routines for PSF reconstruction
- Consolidation of data reduction pipeline and science cases
- Adaptation of the LN software to include the use of new hardware
- First light estimated in 2027

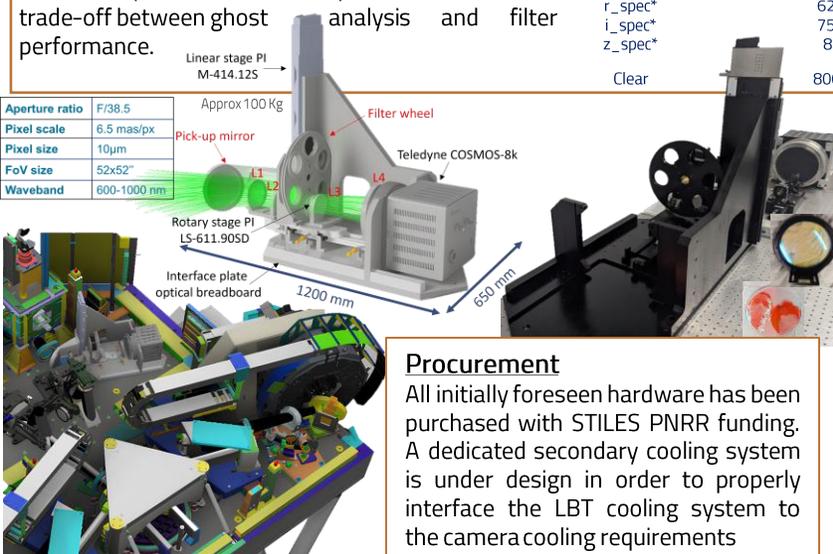
NirvanaVIS detector characterization

Main results:

- Bad pixels map
- Linearity (issues in low ADU regime as identified by Layden et al. 2025)
- Random telegraph Signal: not detected
- Dark current (pattern due to amplifier glow involving approx. 20-25 rows at the bottom): 0.12 ± 0.01 e-/s in central 8020x8020 pixels. Double when applying linearity corrections
- RON: temporal std across 1000 frames 1.60 ± 0.04 ADU; 1.63 ± 0.04 e-
- Gain: using the mean-variance method on full range, increasing exposure time



Camera was sent for repair, due to vacuum leak causing window condensation)



Procurement

All initially foreseen hardware has been purchased with STILES PNRR funding. A dedicated secondary cooling system is under design in order to properly interface the LBT cooling system to the camera cooling requirements



WP3301: AdvancedSW_PSF Simulations

Activity leader: Carmelo Arcidiacono (OAPD), DEC Amedeo Petrella (OAPD), Primo funzionario Laura Marongiu (OAPD)

Budget: 92.745,62 € Euro

The main objectives of Activity 3301 are:

- provide **high-performance computing resources** for the development of advanced algorithms
- support **adaptive optics simulations and PSF reconstruction**
- enable **machine learning applications** for astronomical data analysis
- support **large data processing workflows** related to ELT and SKA technologies.
- The infrastructure is designed to support both **software development and scientific analysis**.

The acquisition was performed through a **public procurement procedure** on the MEPA platform.

Main elements of the procedure:

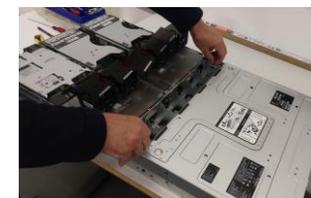
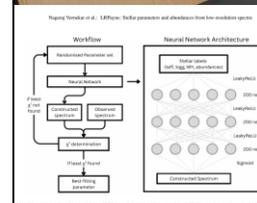
- Contracting Authority: INAF – Osservatorio Astronomico di Padova
- Procurement object: GPU server and scientific workstation
- Supplier: **Maticmind S.p.A.**
- Contract value: **76,021 € (excluding VAT)**

The acquired infrastructure consists of a **high-performance GPU server**, named **Aurora**, designed for scientific computing.

- Main components:
- HPE ProLiant DL385 server
- 2x96 core AMD EPYC processors
- 1.5 TB RAM system memory
- 20TB NVMe storage subsystem
- **2 x NVIDIA L40S GPUs**
- The system is optimized for:
- GPU-accelerated computing
- machine learning workloads
- high-throughput data processing

The system was delivered & installed at: INAF-Oss. Astronomico di Padova.

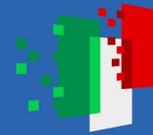
- the hardware delivered corresponds to the contractual specifications and was installed in Computer Room of the INAF-OAPD
 - the installation was performed correctly, with RHEL 9.0
 - the system is fully operational.
- The verification and acceptance were completed in **November 2024**.



The system is currently used for:

- scientific software development
- AI and machine learning experiments
- data analysis and simulation activities.

Refereed Publications:
Vernekar, N., Spina, L., Lucatello, S., Arcidiacono, C., Cortese, L., Simioni, M. and Balestra, A., "LR Payne: Stellar parameters and abundances from low-resolution spectra," *A&A* **706**, A217 (2026).



Activity 3331 (163.520,00 Eu)

Scope: upgrade computing and data storage infrastructure for upcoming (Italy-led) extra-galactic (radio continuum and HI) surveys exploiting MK-Band 5 receivers and MK+



Hiring: M. Brienza (TD)

Data processing pipelines (in collaboration with OA Cagliari):

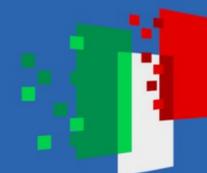
- **OXCAT (radio continuum) & CARACAL (HI)** - installed, tested and fine-tuned using computationally-heavy MK datasets:
 - ❑ Wide (23 deg²; 120h) radio continuum mosaic covering the Euclid Deep Field South (M. Brienza)
 - ❑ Wide (23 deg²; 120h) HI mosaic covering the Euclid Deep Field South (A. Bianchetti, F. Maccagni)
 - ❑ Two Deep (25h) HI pointings targeting NGC 3100 and NGC 3557 (F. Maccagni, I. Ruffa)

EDFS - Brienza+ in prep.

Procurement (A. Bosi; R. Poerio, G. Solinas, M. Tugnoli):

- **Computing multi-core Server:**
 - 2x32 cores & 2x512 GB RAM
 - 4x20 TB Hard disks (HDD) + 240 GB SSD
 - Hard Disk SSD 2.5" NVMe PCIe5 12.8TB 3DWPD
 - Hard Disk SSD 2.5" NVMe PCIe5 7.68TB 1DWPD
- **HD for 100 Gbit local network upgrade:**
 - N.1 Switch NVIDIA Spectrum SN2100
 - N.1 RACK installation kit for NVIDIA MELLANOX switch
 - N.1 NVIDIA MFA1A00-C020 AOC Cable Ethernet 100GbE QSFP 20mt
 - N.3 NVIDIA MCP1600-C002E30N DAC Cable Ethernet 100GbE QSFP28 2m
 - N.1 NVIDIA AI Enterprise Support Services Business Standard Support (3 years)
- **Tape Library** (procured by UniNA, Activity 3102)
 - Server + 20 Tapes (each 18 Tb or 45 Tb compressed)

All HW installed and now operational (IT IRA staff)



Pulsars in the Galactic Center with MeerKAT band 5B

Federico Abbate, Andrea Possenti

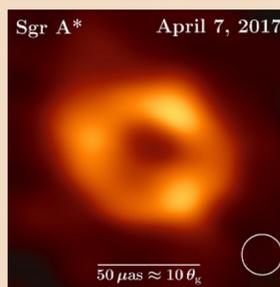
INAF - Osservatorio Astronomico di Cagliari, Via della Scienza 5, 09047, Selargius (CA)

The Galactic Center: Sgr A*

The Galactic Center is one of the most interesting environments to study for astronomers. It contains the most convincing evidence of the existence of black holes: Sgr A*.

Observations of the very tight orbit of the S-2 star (just 15 yr of orbital period) led to a precise estimate of the mass of Sgr A* of $\sim 4.3 \times 10^6 M_{\odot}$ (Gravity Coll. et al. 2022).

In 2022 the Event Horizon Telescope collaboration released an image (shown to the right) of the shadow cast by Sgr A* on the surrounding plasma predicted by General Relativity (GR) confirming its black hole nature (EHT coll. et al. 2022).

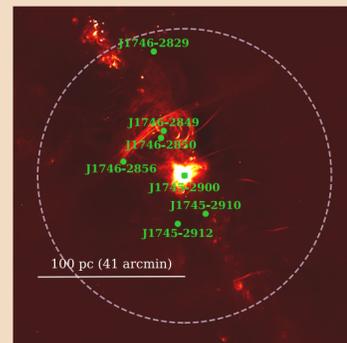


The known pulsars in the Galactic Center

The expected pulsar population in the central 100 pc is thought to be of a few thousands.

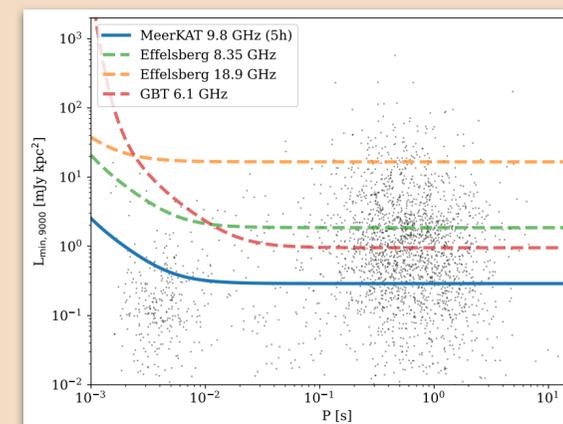
Currently there are only seven known pulsars within the central 100 pc of the Galaxy as shown in the image to the right. (Abbate et al. 2025)

The closest one to the center is J1745-2900, a magnetar located only 0.1 pc from Sgr A*. Unfortunately it is still too far to perform tests of gravity and its emission is highly irregular and hard to model.

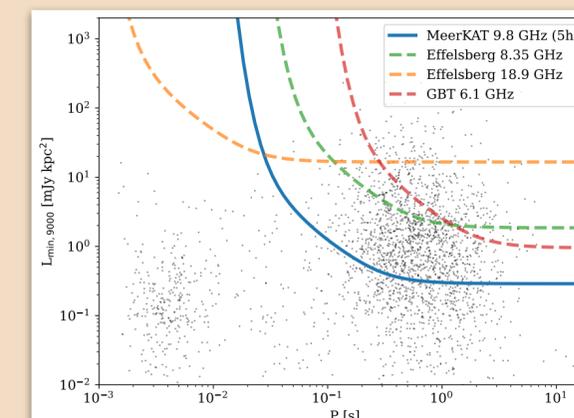


MeerKAT band 5B

The band 5B (8.3-15.4 GHz) receivers cover the ideal frequency range to search for pulsars around Sgr A*. MeerKAT is the radio telescope with the largest collecting area capable of observing the Galactic Center and its location in South Africa allows for very long tracks boosting the sensitivity for pulsars. It is the best telescope to use to perform these searches and will only be surpassed in the future by the SKA.



Sensitivity curves assuming the scattering is the same as what is observed for J1745-2900 (Eatough et al. 2021, Suresh et al. 2022)



Sensitivity curves assuming the scattering is the same as what is derived from the angular broadening of Sgr A* (Eatough et al. 2021, Suresh et al. 2022)

These plots show the sensitivity curves of a MeerKAT survey compared to the current best surveys for different scattering scenarios. The improvement in sensitivity limit allowed by MeerKAT goes from a factor of a few to one order of magnitude.

Pulsar in a relativistic orbit around Sgr A*

The discovery of a pulsar in orbit around Sgr A* would provide unprecedented and complementary information on the properties of the black hole.

If a pulsar in a 1 year orbit is found, it would be possible to measure, with extremely high precision, the mass (M), spin (S) and quadrupole mass moment (Q) of Sgr A*. It will allow for the first experimental tests of such GR predictions as (Liu et al. 2014):

Cosmic Censorship conjecture

$$\chi \equiv \frac{c}{G} \frac{S}{M^2} \leq 1$$

"no-hair" theorem

$$q \equiv \frac{c^4}{G^2} \frac{Q}{M^3} = -\chi^2$$

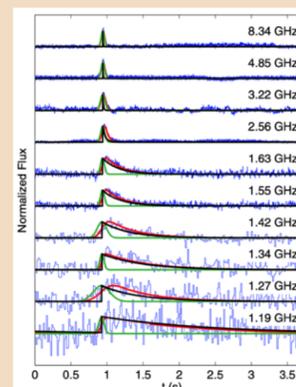
The importance of high frequency observations

The main reasons why so few pulsars are detected is the large distance and the scattering.

The scattering is a broadening of the pulse profile caused by multi-path propagation in the turbulent ionized medium. In the worst case the pulsation can become undetectable.

The scattering is highly frequency dependent. Going to higher frequencies reduces this effect. However, at higher frequencies the emission is weaker.

The best frequency range for detecting pulsars in the Galactic Center is 9-11 GHz.



Scattering profile of J1745-2900 (Spitler et al. 2014)

Potential discoveries

The percentage of pulsars that could be detected with a survey at MeerKAT using the band 5B is between 0.5 and 1 percent of the entire population. Given an expected population of a few hundreds of slow pulsars (Schodel et al. 2020) and a few thousands of faster millisecond pulsars (Abbate et al. 2018), we might detect 1 slow pulsar and a few tens of millisecond pulsars if the scattering scenario is favourable. Non-detections would start to be informative on the pulsar population present in the region.



Arcetri and Teramo Clusters: Developing SKA Controls

E.Giani^a, M.Canzari^b, C.Baffa^a, M.Di Carlo^b, G. Marotta^a, S. di Frischia^b

^aINAF Osservatorio Astronomico di Arcetri, Largo E.Fermi 5, Firenze, Italy;

^bINAF Osservatorio Astronomico d'Abruzzo, Via Mentore Maggini snc, Teramo, Italy



SKA Overview

The Square Kilometre Array (SKA) is a giant radio telescope project and will be the largest Radio Telescope ever built.

It will have two phases: a smaller one, SKA1 and the final SKA. It will be divided in two locations, South Africa (Mid) and Australia (Low).

SKA1 will consist of two networks of antennas:

- Low array, 1024 groups of 256 small antennas in phase 1
- Mid array, 197 large dish telescopes in phase 1

Phase 2 will make SKA 10 times larger!

4 main instruments:

- Low frequency array correlator and pulsar beam-former
- Mid frequency array correlator and pulsar beam-former
- Pulsar search machine
- Pulsar timing machine



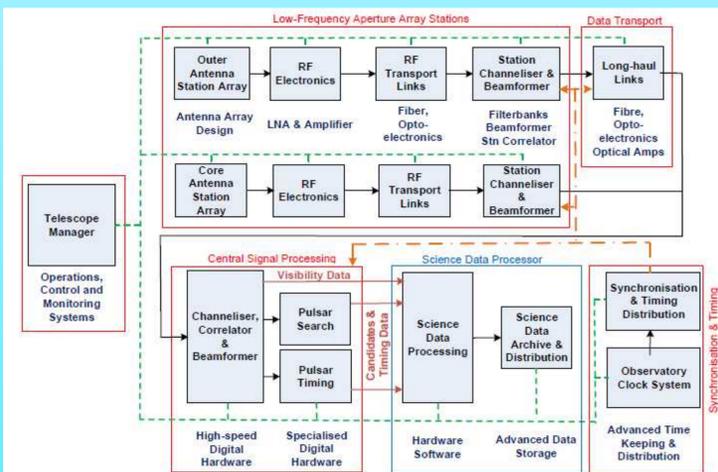
The Square Kilometre Array (SKA) project is an international effort to build the world's largest radio telescope, with eventually over a square kilometre of collecting area. The scale of SKA represents a major leap forward not only in scientific performance but also in the technologies involved. Every aspect of such an ambitious project requires outstanding results and the most advanced technological solutions.

The development and verification of the SKA control and telemetry system (LMC), which constitutes the true nervous system of the instrument, requires a complex infrastructure consisting of dozens of interacting servers. This infrastructure is implemented through a system of virtual machines orchestrated by a dedicated server (Kubernetes). INAF has been entrusted with the responsibility for a critical portion of this LMC system. In order to improve the efficiency and quality of the development activities, it is already necessary to deploy a computing system that significantly exceeds the resources available. <Some mentions of Taranta interface>.

To address that necessity a joint STILES work package proposal has been issued by Teramo and Arcetri INAF institutes, resulting in the activities **3401 and 3402**. The resulting clusters are full functional and instrumental to the development and verification of the SKA software.

The cluster reproduces the full technological stack of the SKA clusters used for software test. Integration and verification. The team operating the cluster is the same that developed the CSP.LMC and Taranta software packages, which together enable a complete integration workflow from a single simulated device up to the graphical user interface. The platform is also highly interoperable with other SKA software components, allowing the facility to operate as an isolated Integration and Test environment. Having a dedicated cluster provides a controlled platform where software can be validated, optimized, and stress-tested before deployment, significantly improving development efficiency and overall software reliability.

SKA1 MID Schematic Structure



SKA Structure

The telescope facilities for SKA1 have been defined as:

- SKA1_Low, a low-frequency aperture array to be built in Australia; and
- SKA1_Mid, a mid-frequency array of parabolic reflectors (dishes) to be built in South Africa.

In illustration on the left there is a schematic representation of the SKA1_Mid Telescope. From the Monitor and control prospective the two facilities will be handled in a similar manner, with differences only in minor details. In the following we will refer to SKA1_Mid. Data coming from Antennas are fed to the Central Signal Processor (CSP). CSP is in charge to collect, correlate, filter and analyse the observational data, according to the astronomical prescriptions for the current observation(s) coming from the Telescope Manager (TM). Processed data is then forwarded to the Science Data Processor for the final reduction and post-processing in order to obtain scientifically meaningful results.

For the "imaging mode" each pair of antennas in a sub-array is cross-correlated to produce full-polarization visibility spectra across the required bandwidth and number of channels. The visibilities are packaged and transmitted to the Science Data Processor (SDP) which produces high-quality continuum and/or spectral-line images.

In the "non-imaging mode" a sub-array can form a number of tied-array beams and process data for each beam independently:

- 1) SKA1_MID is able to form up to 1500 Pulsar Search beams based on the sum of selected antennas which are used to search for pulsars and fast transient sources. Similar functionality is supported by SKA1_Low for up to 500 beams.
- 2) Both SKA1_Mid and SKA1_Low can form up to 16 Pulsar Timing beams, each covering up full input bandwidth for the observing band, based on the sum of selected antennas which are used to very accurately measure deviations between observations of known pulsars and existing ephemeris.

SKA Central Signal Processor (CSP) MID version

The CSP_Mid comprises four design sub-elements

1. Correlator and Beamformer (CSP_Mid.CBF)
2. Pulsar Search (CSP_Mid.PSS)
3. Pulsar Timing (CSP_Mid.PST)
4. Local Monitor and Control (CSP_Mid.LMC).

CSP_Mid.CBF performs two basic functions, correlation and beam-forming. It calculates full-polarization cross-correlation spectra with ~64,000 channels for every pair of antennas. The maximum data rate to the SDP arises when all 197 antennas are used together. In this case is ~2.85 TBps.

The Pulsar Search Engine accepts up to 1500 different beams. The engine searches each beam for pulsars and transient sources over a range of dispersion measures (DM), accelerations, and periods. The resulting source candidates are sorted and transmitted to the SDP. Maximum data rate is of the order of 0.6TBps

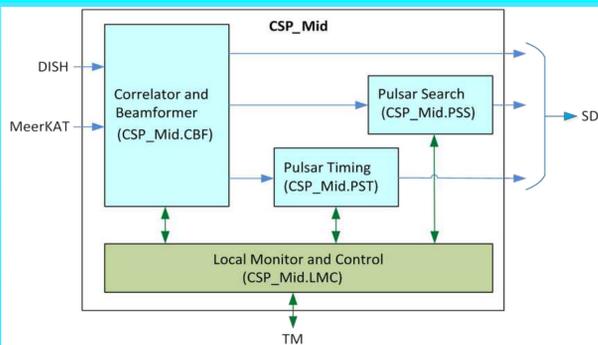
The Pulsar Timing Engine is able to time concurrently up to 16 known pulsars, each in a different Pulsar Timing beam produced by CSP_Mid.CBF.

The CSP_Mid Local Monitor and Control provides the gateway to the Telescope Manager (TM) to all CSP_Mid sub-elements. All configuration, control, and monitor messages for CSP_Mid flow through CSP_Mid.LMC.

Local Monitor and Control (LMC)

The main role of CSP.LMC is to provide a gateway to Telescope Manager, to make provision for TM to monitor and control CSP as a single entity, without being aware of the details of CSP implementation. The SKA control system is based on TANGO middleware and run inside a Kubernetes (K8s) cluster.

Following TANGO approach, the CSP element, CSP sub-elements and major components are defined as TANGO devices. With the inclusion of all components a fully deployed CSP.LMC and of all CSP component LMC can easily consists of thousands of Tango devices. The resulting requirements on the HW cluster is HUGE.



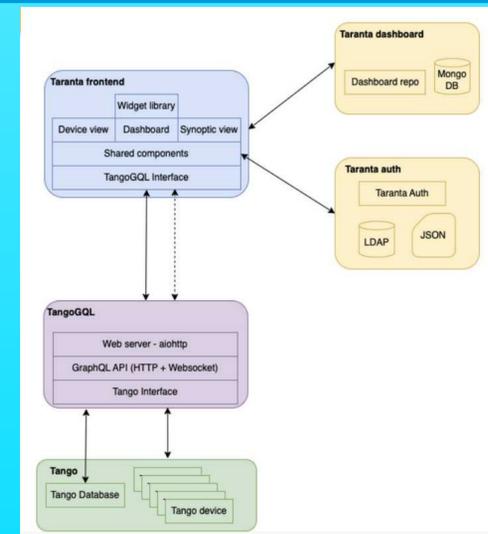
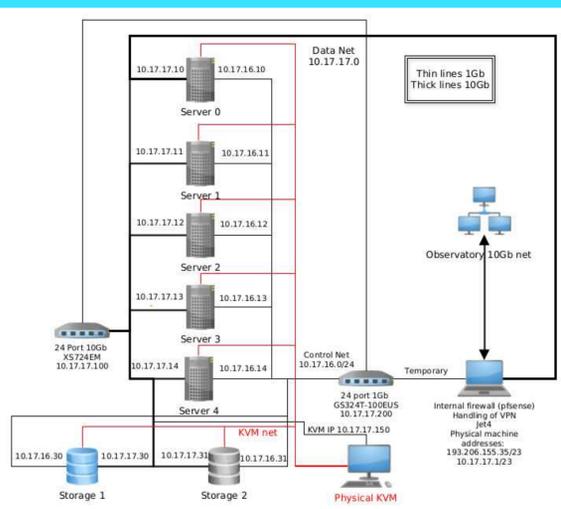
Future Development

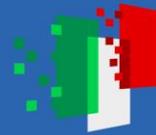
The cluster currently enables full software integration and validation in an independent environment before official release, providing a controlled platform to improve reliability and overall software quality. SKA GitLab pipeline integration is already established and extensively used in CSP.LMC software development to automate test execution, collect pipeline test artefacts, and support the subsequent statistical analysis aimed at failure classification and flakiness investigation. Another ongoing activity is the integration of the new SKA Alarm System Management (ASM), which is currently evolving from a prototype. The cluster provides a valuable environment for this work, as it allows flexible configurations and integration tests that are not possible on the standard SKA servers due to operational constraints. This flexibility is essential to overcome current prototype limitations and to implement the necessary workarounds during the development phase. In addition, one of the servers has recently been equipped with a GPU optimized for machine learning. The first planned application is the integration of machine learning techniques with the alarm system. Running the alarm infrastructure in a fully integrated environment, and coupling it with machine learning capabilities, enables precursor studies on advanced alarm management strategies, which are expected to play a crucial role in the future operational efficiency of SKA.

Taranta

Taranta is a web application that allows a user to:

- easily browse devices of a Tango server, inspect them and interact with them, all using web browser of choice.
- quickly develop and change interactive dashboards with widgets that allow you to monitor and interact with Tango devices. Once created, dashboards can be run, saved, and exported.
- a dashboard can be defined in a few minutes, with minimal knowledge of web technologies; you only need to know which devices you want to interact with and what attributes and commands they expose. run and interact with synoptic components





Control SW infrastructure @OACN

Activity 3404

Objectives

Upgrade of the Capodimonte TESTA (TElescopi e STRumenti per l'Astronomia) laboratory for the design and development of control electronics for ELT class instrumentation.

Activities

Procurement of GPU enabled computing resources. These are useful for the real time algorithms of the multi-conjugate adaptive optics (MCAO) control system. Hardware was delivered on January 3, 2024. As one of the first STILES purchases, this enabled us the immediate start of prototyping for the Morfeo Real-Time Computer (RTC).

These GPUs also facilitate the prototype of A.I. systems to support the engineering of ESO instruments, including a Retrieval-Augmented Generation (RAG) system designed to manage project documentation and internal knowledge base

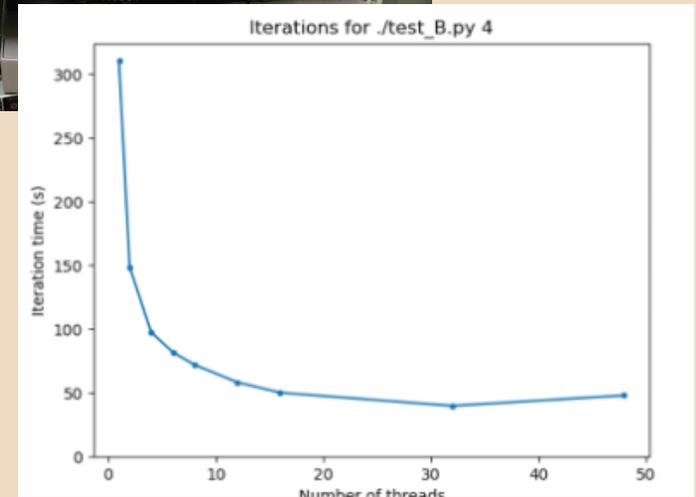
Procurement of other hardware and equipment:

- Hardware for prototyping control systems compliant with ESO ELT standards
- Laboratory equipment for electronic development
- High precision stages for prototyping of VIS/NIR instruments



Team

Giulio Capasso (lead.)
Mirko Colapietro
Sergio D'Orsi
Laurent Marty
Salvatore Savarese
Pietro Schipani



Acknowledgements

We wish to thank OACN administrative staff for their prompt support in bureaucracy tasks:
R. Aiello, A. Filidoro,
F. Manco, A. Perrotta

Control Software Infrastructure – WP3000 / Activity 3405 – INAF OA Padova

Baruffolo A., Salasnich B., Ricci D., Di Prospero C., Lampitelli S., Diretto D., Balestra A., Petrella A., Selvestrel D., Lessio L., Marongiu L., Filippone R., Panizzolo G., Carraro M.

AIM

Procure and install infrastructure to support Instrument Control Software (ICS) and Real Time Computer (RTC) development, in particular for MORFEO MCAO module for ELT.

WHAT

Hardware procured:

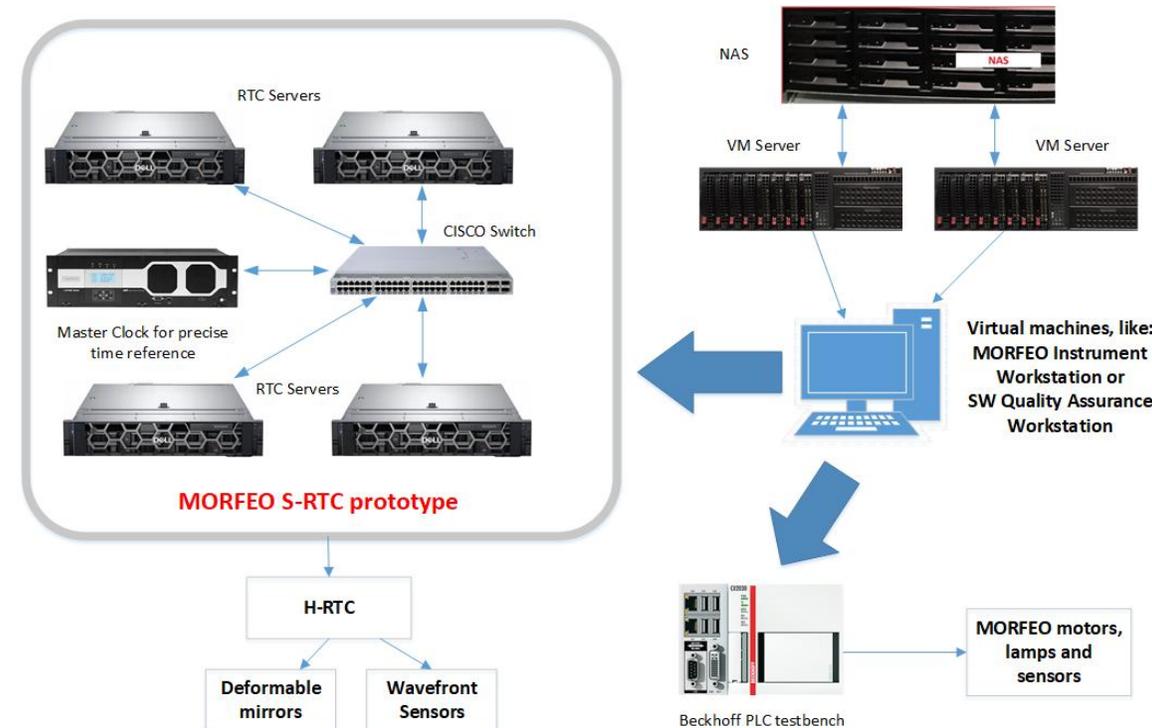
- ✓ A PLC-based, ELT standard compliant, test bench for prototyping of low-level control software (device drivers) for ELT ICSES.
- ✓ Two multi-CPU, multi-core servers with plenty of memory and local storage for provisioning of Virtual Machines to support development, high-level software prototyping and SW Quality Assurance activities.
- ✓ One NAS for storing simulated, test and telemetry data.
- ✓ Eight servers and a high-performance network switch dedicated to prototyping and development of MORFEO Soft-RTC. Two servers are equipped with NVIDIA GPUs to support computationally-intensive tasks.
- ✓ A Master clock for distribution over the network of precise time reference.
- ✓ All rack machines are installed in the OAPd computer room.

HOW

Total funding ~270 K€. Six procurement procedures activated and completed in mid 2025.

STATUS

The infrastructure is in active use to support prototyping, development, testing and quality control of ICSES (a.o.) for MORFEO, MAVIS, SHARK-NIR, SOXS instruments. Upgrades and expansions are planned to support evolving requirements.



Strengthening Laboratory Infrastructure at INAF - OATs

Antonio Sulich, Sofia Benedetti, Igor Coretti, Paolo Di Marcantonio, Giulia Manca, Nathan Neri

The INAF-OATs Instrumentation Control Group (ICG) has a long experience in the field of design, implementation and integration of software and control electronics for state-of-the-art astronomical instrumentation (both in the optical and radio domain). For this activity, the group uses a laboratory at the OATs that, however, was not yet equipped to adequately support long-term activities. This led to a criticality especially in the phases of transitions between projects, limiting the possibilities of keeping up with technological evolution and extending the design and development phases at the beginning of new projects.

In this context, the proposed activity aimed to fill this gap by enhancing the existing laboratory infrastructure along two main lines:

- equip the laboratory with a high precision time reference system and high-speed network (10G) based on ELT and SKA standards
- purchase hardware components for a template instrument (ELT compliant industrial PLCs, motors of various typology, piezo systems, sensors, GigE Vision cameras, cabinets) with metrology and verification instruments and handling devices.

A successful upgrade of the laboratory structure is of primary importance to foster existing and future national and international collaboration and to keep existing leadership roles, in particular for ESO CUBES, ESO FORSup and ESO ANDES instruments and SKA.



INAF OATs purchased a family of instruments from Meinberg Funkuhren GmbH & Co. KG, which are used to synchronize time and frequency signals in networks via satellite signals, to enhance its laboratory's instrumentation. Like all microSync systems, this model is also equipped with a network processor with firmware capable of supporting Network Time Protocol (NTP), Precision Time Protocol (PTP), and other monitoring protocols. The Grandmaster Clock was then connected to an antenna capable of receiving Global Navigation Satellite System (GNSS) signals from various satellites, thus providing more precise reception of time data. Purchasing also a Cisco C9300-24P-A switch, we were able to expand our connections and test their performance using an oscilloscope.



To provide our technical staff with high performance equipment, enhance prototyping capabilities, and improve testing performance at our facilities, we purchased two fully equipped Programmable Logic Controller (PLC) for the creation of control systems. The selected components are from the Siemens S7-1500 and Beckhoff CX-2043 series. They are both used in the astronomical equipment designed by our laboratory. In addition to the CPUs and many technologically different modules, we purchased some HMIs, motors and the Siemens TIA Portal development environment for the control system's hardware and software configuration.



We purchased a pantograph that allows us to improve the quality and precision of our work. Thanks to this tool, we can perform highly accurate cuts and engravings, reducing processing times and margins of error.

In particular, the pantograph has become essential for the production of connector plates for electrical panels. The ability to achieve precise shapes, consistent measurements, and clean finishes allows us to guarantee components perfectly compliant with required standards and respond more quickly to project needs.

Beyond this specific use, the versatility of the pantograph allows us to expand our activities, producing prototypes, small series, and customized work with a much greater degree of autonomy than before. The investment therefore translates not only into operational improvements, but also into increased efficiency and the workshop's capacity for innovation.



The lab also purchased a K1 Max 3D printer, a Falcon laser engraver, and a Creaform 3D scanner. These tools were acquired to enhance the lab's prototyping capabilities, enabling the independent and efficient design and production of small mechanical components. The introduction of this equipment will significantly improve precision and development speed, better supporting the observatory's research and maintenance activities.



Activity #4202 – OptSpectrLab (P.I.: Daniele Fulvio – INAF OACT)

daniele.fulvio@inaf.it

In trying to understand the origin of life, a promising scientific approach regards the possible role of substrates (e.g. minerals and clays, meteorites, and cosmic dust grains) which may have favored the formation of biomolecules starting from simpler species.

Thanks to the STILES project, we have upgraded the facilities present at INAF OACT to allow the UV-VIS-NIR and NIR-MIR analysis and characterization at high temperature (up to 900°C in vacuum) of minerals, clays, meteorites, and terrestrial analogs of astrophysical interest and to study their interactions with simple and complex organic molecules, *ex situ*, *in situ* and at high-T.

NIR-MIR module

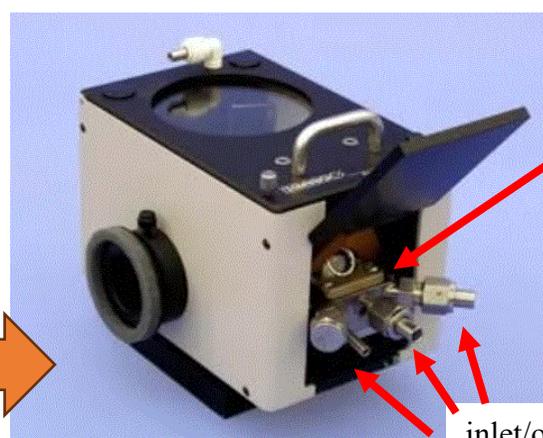
(high-T reaction chamber + Praying Mantis Accessory + pumping units)
to acquire *in situ* reflectance spectra at temperatures above room-T

UV-VIS-NIR fiber optic module

to acquire *ex situ* reflectance spectra of selected samples



Praying Mantis™ Diffuse Reflection Accessory

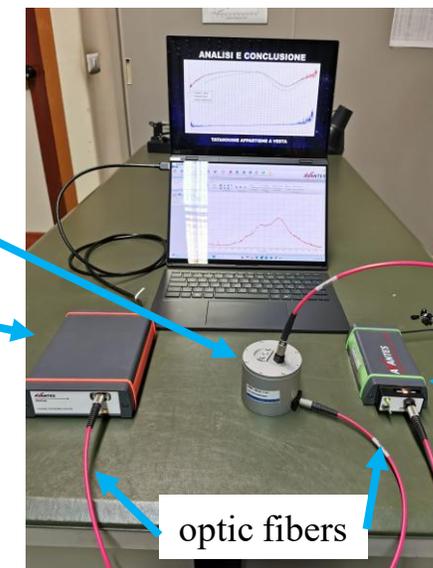


high-T reaction chamber

inlet/outlet ports (3) for evacuating and introducing selected gases

integrating sphere

detector

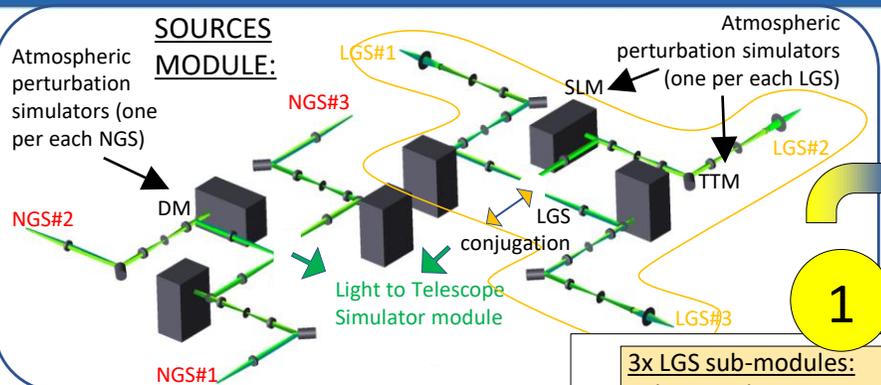


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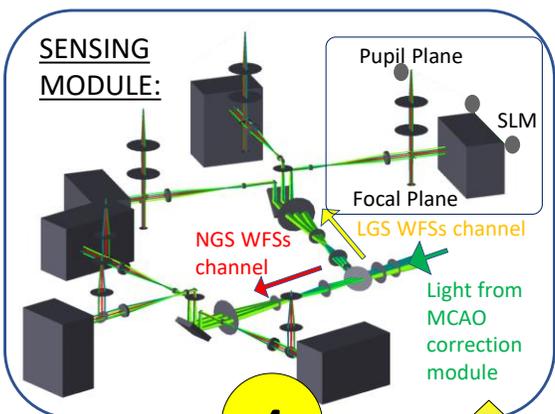
optic fibers

MATTO (Multi-conjugate Adaptive Techniques Test Optics)

A facility to test/compare MCAO techniques, mimicking very large and extremely large telescopes ranges.

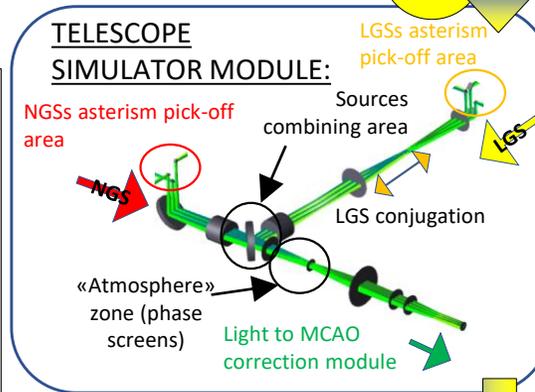


Telescope Simulator Module:
 - allows for varying source sub-modules' asterism
 - combines light from different sources
 - allows to vary LGS conjugation distance
 - mimics the geometry of the beams in the lower atmosphere
 - can mimic atm. aberr. (phase screens)

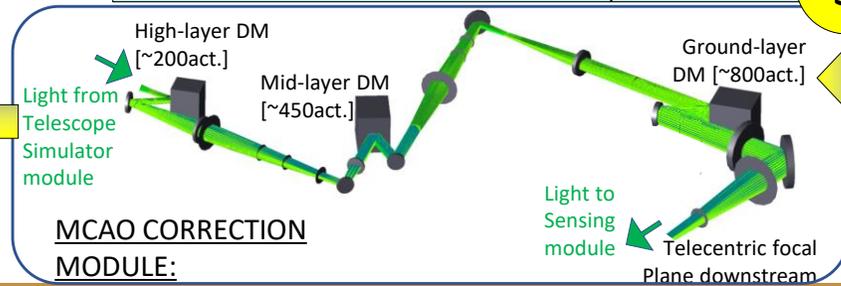


3x LGS sub-modules:
 - elongated source
 - @ finite distance
 - can mimic atm. aberr. (SLM+TTM)

3x NGS sub-modules:
 - unresolved source
 - @ infinite distance
 - can mimic atm. aberr. (DM)



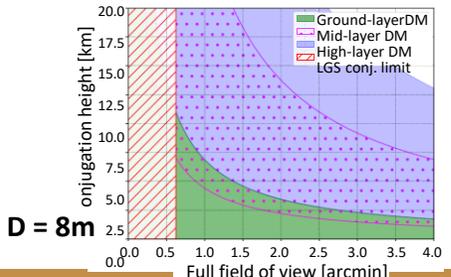
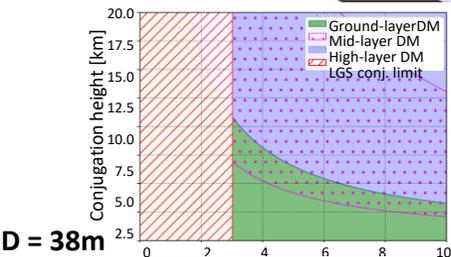
MCAO Correction Module:
 - simulates a variety of compensation schemes
 - 3 DMs with varying conjugation distance
 - Performance camera to evaluate closed loop merit function



Sensing Module:
 - simulates a variety of wavefront sensors
 - includes means to locally change focal plane phase
 - includes means to sense both in the pupil or in the focal plane

The control
 The RTC software will be based on the highly-modular DAO framework, developed at CfAI (Durham University).
MCAO loop:
 - 3 DMs (a total of about 1500 actuators)
 - up to 6 WFSs (slope computation, on CPUs, depending on the WFS to be simulated)
Sources module disturbances:
 - Up to 3 DMs + up to 3 SLMs

Flexibility ranges





STILES – Strategic Infrastructure for Advanced PCB Prototyping INAF – Cagliari Astronomical Observatory

Strategic Vision

- Development of an in-house advanced PCB manufacturing chain
- Optimization of prototyping time and costs
- Strengthening RF/microwave technological autonomy
- Enabling infrastructure for INAF and SRT instrumentation
- < 2 weeks from concept to validated prototype

Integrated PCB Production and Validation Line



**Laser Structuring
(Protolaser S4)**
High-resolution fine-
pitch patterning



**CNC Milling & Drilling
(Protomat S64)**
Accurate multilayer
machining



**Through-Hole
Metallization (Contac S4)**
Conductive via formation



**Multilayer Lamination
(Multipress S4)**
Pressing and consolidation
of multilayer PCB stacks



**SMD Assembly
(ProtoPrint S4)**
Solder paste printing



**SMD Assembly
(ProtoFlow S4)**
Reflow and soldering

Scientific Impact

- RF front-end prototyping
- Cryogenic control electronics
- IF modules and conversion systems
- Support for SRT instrumentation upgrades
- Reduction of industrial outsourcing
- Strengthening of internal INAF technological expertise
- Technology transfer and collaborative R&D with industry and academia

Transforming infrastructure investment into long-term technological capability for INAF instrumentation



New Laboratory @ INAF - OACN for Additive Manufacturing, Reverse Engineering and Metrology to support mechanical design – WP 5000/Activity 5601

Vincenzo De Caprio, Vincenzo Cianniello, Mina Sibalic

INAF - Osservatorio Astronomico di Capodimonte, Salita Moiarriello n. 16 - 80131 Napoli (NA)

PROTOTYPING FACILITY

The prototyping facility is made of three 3D printers covering 2 different technologies FDM (Fused Deposition Modeling) and SLA (Stereo Lithography Apparatus):

- The Stratasys F370CR printer, a FDM printer, with a 355 x 254 x 355 mm printing volume. It is characterized by a high precision and resolution and the low customization guarantee reliable results.
- The Ultimaker S7-Pro printer, still a FDM printer, with a comparable printing volume (330 x 240 x 300 mm). Is the quicker and most customizable printer, helping in making the first attempt prototypes with a satisfactory resolution.
- The Formlabs Form 3L, a SLA printer, with a printing volume of 335 x 200 x 320 mm. Thanks to a different technologies and the dedicated washing & post-curing cycle, was brought as alternative to the Stratasys to produces finalized pieces with an excellent surface finish.



METROLOGY FACILITY

The main metrology tools available at the laboratory are:

- Leica Absolute Tracker AT-500 + B-Probe Plus.
- Hexagon Absolute Arm 8320 + R55 Laser Scanner.

These tools (in the right image) will be used to support the metrology activities related to the test of combination of the mechanical mounting combined with the optics.



HOW IT WAS DONE

- ✓ Total funding ~330 K€.
- ✓ Three procurement procedures activated.
- ✓ Completed, up and running from the Q1 of 2024.

IN WHICH PROJECTS WE USE AND FIRST RESULTS

The new facility is an active supports to the innovative and multidisciplinary design activities.

For **MORFEO**:

- We have been started the first prototypes for one of the opto-mechanical mountings (produced in scale 1:20), using the two different technologies acquired.
- We made a mechanical shaft support for some electronic test.



For **MUAM** (Moon UV Albedo Measurement):

Project proposal (in the PNRR context Earth - Moon - Mars (EMM)) for a lunar albedometer.

- Four prototypes (for different optical elements) have been designed and “machined” using one of the new printing machine.

