



Technological master thesis proposals @ INAF-OAS

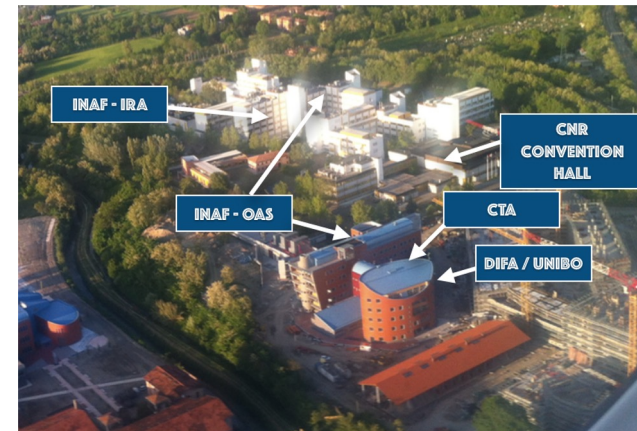
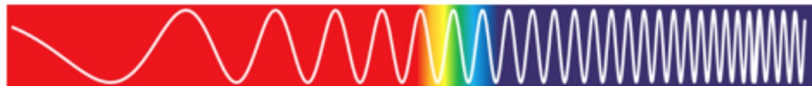
5 February 2024

**Gabriele RODEGHIERO (INAF/OAS) on behalf of
Raggruppamento Scientifico Tecnologie Avanzate e Strumentazione
(TAS) dell' OSSERVATORIO DI ASTROFISICA E SCIENZA DELLO SPAZIO
(INAF-OAS) di Bologna.**

INAF OAS Bologna is a leading institute in many space science and ground-based research facilities and participates in several instrumentation activities with a broad heritage in the experimental astrophysics and project management.

Main fields of research:

- Telescope instrumentation for microwave, infrared, optical & UV, X & gamma-ray
- Space missions & technologies
- Astro-informatics
- Outreach and education activities



The following thesis proposals do not include all the INAF OAS instrumentation projects, get in contact with us for more info!

Hard X-/gamma-ray astrophysics laboratory

OAS-BO

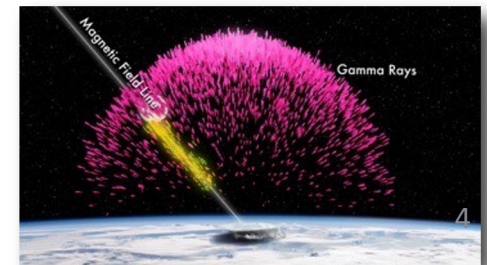
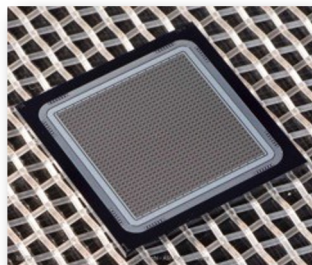
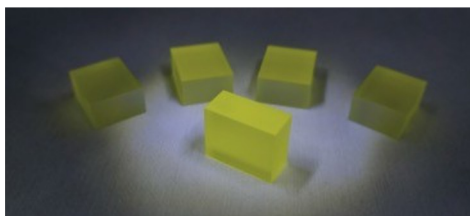
Gamma Lab OAS-BO



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Enrico Virgilli (enrico.virgilli@inaf.it)

DIFA contact: **Christian Vignali** (cristian.vignali@unibo.it)

- **HERMES Pathfinder:** Nano-satellites X & gamma rays for GRB and space-time probing. One satellite launched in December 2023, launch of the other 6 nano-satellites by end 2024. Energy resolution, timing, integration and calibration of flight models, Monte Carlo simulations, design of new detectors.
- **Study and characterization of X & gamma ray detectors.** Development of data acquisition systems and electronics for **LEM-X** (high energy sky monitoring on the lunar surface). Test equipment for the **eXTP** mission prototype. **SWIPE:** development of a X-ray Compton polarimeter.



Gamma Lab OAS-BO



- **GAMMA-FLASH**

Operate a gamma-ray detector already installed on a jet (Cessna Citation Mustang) to detect Terrestrial Gamma Ray Flashes generated by lightning discharges in the upper atmosphere, and subsequently process and analyze the acquired data.

- **THESEUS ESA M7 mission candidate**

Design and qualification of detector and readout electronics for the X and Gamma-ray Imager and Spectrometer (XGIS) onboard of the THESEUS ESA candidate mission for the study of the GRBs in X and gamma rays, thesis in collaboration with the Politecnico di Milano and Università di Pavia.

- **ASTENA**

Study of the mission concept ASTENA to focus gamma-rays (Laue lenses)

- **GLOSS – Gamma-ray Laue Optics and Solid State detectors**

Optical elements for Laue lenses and CdTe crystals are transported to the International Space Station for the purpose of evaluating their aging under particle exposure and thermal cycling.

- **AGO – Adjustable Gamma-ray Optics**

Fabrication of a prototype Laue lens consisting of 9 focusing crystals each equipped with an actuator. For the first time an adjustable gamma-ray optics is realized, similarly to active/adaptive systems used in optics.

Euclid

NISP Instrument Development & Operations Team

INAF - OAS Bologna

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Euclid NISP

Near Infrared Spectrometer and Photometer Instrument Development & Operations Team



Students will have the **opportunity** to:

- **Interact** with scientists engaged in the **new generation of space telescopes**
- Directly work with **NISP raw data** acquired during the **first operations of Euclid**
- **Develop new algorithms** in support to the **NISP instrument maintenance**

- ❖ Scientific Data Calibration → data reduction pipelines
- ❖ Instrument Health Check → instrument telemetry analysis
- ❖ Detector Systematics Characterization → cosmic rays interaction



Since **2009**, INAF-OAS has taken part in the development, test and verification of NISP, the **near infrared instrument** onboard **Euclid**.

In **July 2023** Euclid was launched, NISP was commissioned, and the **nominal operations** have just started.

Currently, the INAF-OAS Team is responsible of:

- Support to **NISP in-flight calibration**
- Monitoring of **NISP instrument health check**
- Maintenance of **NISP DPU on-board software**
- Management of **NISP in-flight operations**

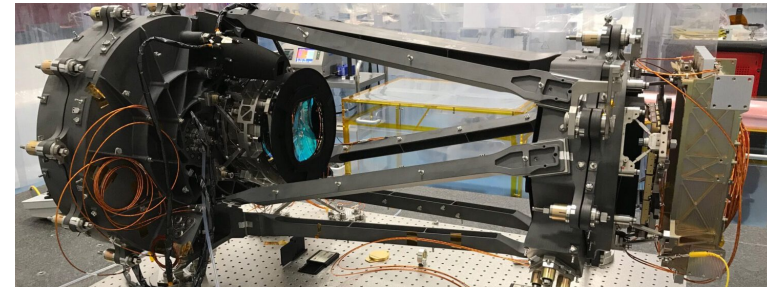


Thesis projects

STRONGLY RECOMMENDED IF YOU ARE INTERESTED IN SPACE MISSIONS PROJECTS!

Euclid's Near Infrared Spectro-Photometer INSTRUMENT HEALTH CHECK monitoring

Students will perform the monitoring of the performances, and the health check of the NISP instrument, by developing end-to-end tools to evaluate the instrument performances.

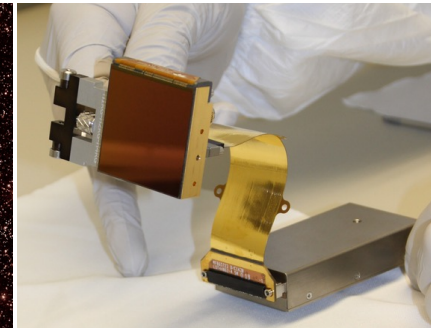
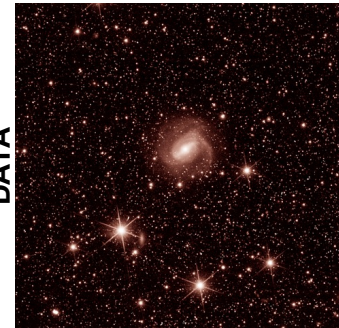


INSTRUMENT

PHOTO and SPECTRO performances of NISP through the analysis of the first Euclid's data

Students will analyze raw data within the Science Ground Segment framework, focusing on the link between the NISP detectors' instrumental effects and the scientific requirement of the mission.

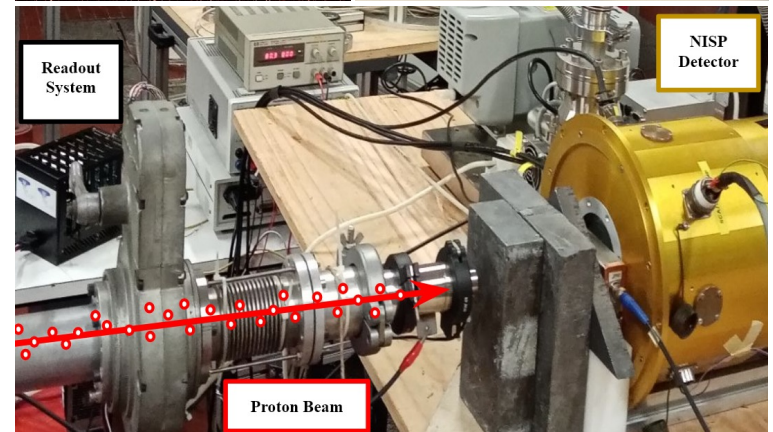
DATA



DETECTOR

CONDOR: a particle physics experiment to study the COSMIC RAY - like signal on NISP detectors

Students will develop ad-hoc analysis tools to study the signal of cosmic ray-like particles (proton beam) hitting on NISP detectors, aiming at optimize the cosmic ray rejection algorithm currently applied by NISP calibration pipelines.



Proton Beam

EXPERIMENTAL PHYSICS

OPTICAL & NEAR INFRARED ASTRONOMY



Optical & NIR OAS-BO



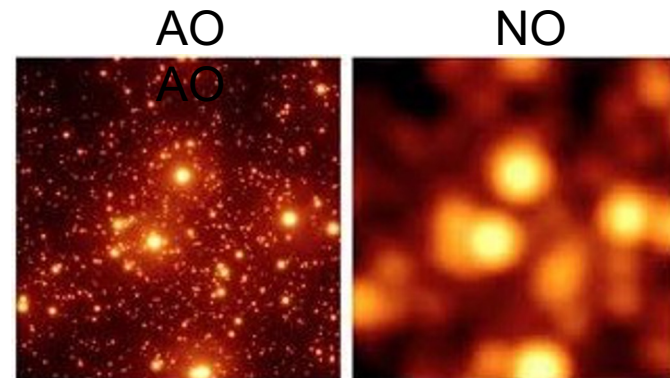
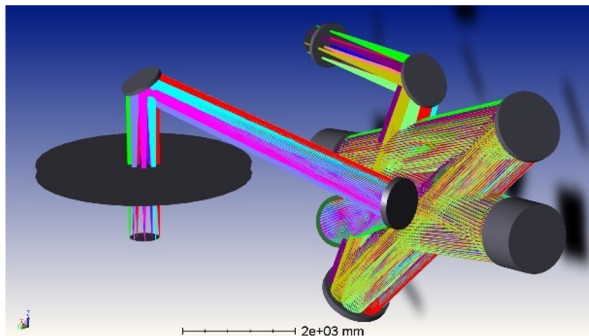
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[Paolo Ciliegi \(paolo.ciliegi@inaf.it\)](mailto:paolo.ciliegi@inaf.it)

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[Gabriele Umbriaco \(gabriele.umbriaco@unibo.it\)](mailto:gabriele.umbriaco@unibo.it)

- **Your gateway to Chile & ESO:** MORFEO is a first-generation ELT adaptive optics instrument that compensates for the distortions of the Earth's atmospheric turbulence. MORFEO will be **integrated and tested in Bologna** (lab @ CNR Area) before its shipping to Chile.
- Hands-on experience with optical instrumentation, performance analysis, alignment strategy studies, system engineering, verification and validation of large optics.



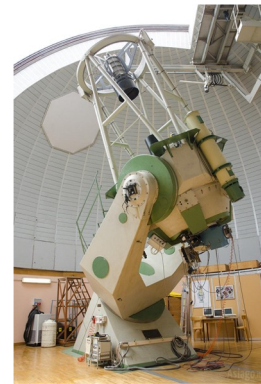
Optical & NIR OAS-BO



- The Vera C. Observatory is a US flagship project to deploy a 10yr deep survey of the southern sky with a 8.4m wide field telescope. You will get involved in the analysis of the **integration, testing & commissioning data** of the telescope optics and their modeling with ray tracing software (Zemax-OpticStudio).



- **On-sky performance testing** of a low-order wavefront sensing Donut technique with Copernico 182cm telescope at the Asiago Observatory. You shall characterize the optical aberrations of the telescope beam and compare the performance of this technique with other **wavefront sensing techniques** as Shack-Hartmann and Pyramid wavefront sensors.



- Optical design, manufacturing & test of a near-infrared camera equipped with a **fast tip-tilt mirror** for atmospheric image motion stabilization for the Campo Imperatore Observatory. Experience you can gain: **optical design, control algorithm, optical testing & alignment** of astronomical instruments.



Simulations of high energy missions and experiments

Geant4 simulations for the design of X-ray and Gamma-ray space telescopes



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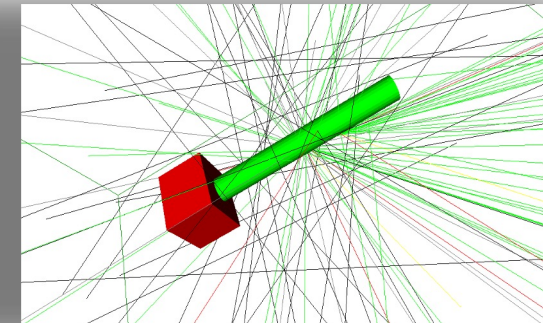
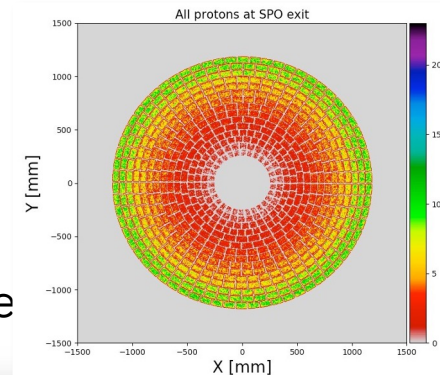
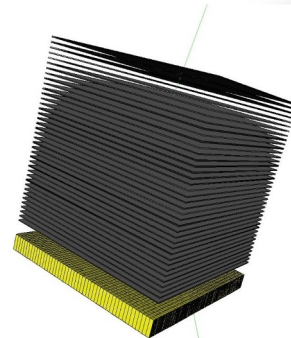
Geant4 is a toolkit library for the development of particle transport codes and it is the tool of reference of space agencies (e.g. NASA, ESA) and research institutes for the simulation of high energy space missions.

Projects:

- Design of the shielding system of the ESA ATHENA X-ray telescope
- new concepts for gamma-ray detection in the MeV regime (e.g. NASA COSI)

Master thesis goals:

- Learning Geant4-based simulations
- Contributing to the mission design



Cherenkov Telescope Array

Thesis proposals with CTA



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- **Topic: “Optimization strategies and algorithms for identification of gamma-ray transients with the CTA Real-Time Analysis”**
- **Topic: “Machine Learning algorithms for identification of gamma-ray transients for CTA and AGILE**

General objectives: the candidate will deal with several aspects of **data analysis** in general and with **CTA’s transient sky**. In particular:

gamma-ray

- » Learning gamma-ray data analysis with many tools
 - » Strategies for transient identification with the real-time analysis (development of new algorithms)
 - » Simulation of the gamma-ray sky
 - » Observational strategy of transients for CTA
 - » Development of a deep learning/neural network for the identification of transient emission of the selected science use case.
- A focus on possible scientific topics with OAS colleagues on AGNs, Gamma-ray binaries, Neutrino events, GRBs, gravitational waves

Education, dissemination & communication of science

Scientific citizenship and creative learning in Astrophysics



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Marcella Brusa (marcella.brusa@unibo.it)

INAF with Game Science Research Center and in collaboration with Unibo are carrying on a series of project on **education** (practices and research), **dissemination and communication of science**. In this framework we propose two possible thesis:

Narratives in Science: a role-playing Game about Space and Astronomical ideas

To build a democratic society, it is necessary to democratize knowledge, in primis science and technology that profoundly shapes our world but are often perceived as an elitarian and too challenging topic. In this work, we propose to **design a role-playing game adventure as an educational tool**. **Space, Astronomy, and Astrophysics** are "special places" because intrinsically trigger fascination and wonder even in non-experts, especially in children, teens, and young adults. The target audience and the theme will be defined together with the expected results. It will also be possible to conduct a brief campaign and its evaluation regarding the participants' engagement and perception of Science (Astrophysics).

Artifacts in Astronomy and Astrophysics: objects that changed the paradigm.

With constructionism (1980), S. Papert, mathematician, epistemologist, and pedagogist introduces the concept of **artifacts**: **objects or devices that facilitate learning**. They must be imagined, discussed, constructed, shown, examined, and admired as tools to investigate reality. As a community, scientists build giant and incredible artifacts such as satellites or beautiful telescopes to obtain data and challenge ourselves and our "learning community" with the interpretation and construction of new knowledge. In this work, the candidate will **review some interesting astrophysical artifacts that challenged the structure of knowledge of the time by building new paradigms**.

LABORATORIO CRYOWAVES

LABORATORIO DI MICROONDE, TECNOLOGIE
MILLIMETRICHE, CRIOGENIA



Cryowaves
è Bologna

Laboratorio CRYOWAVES



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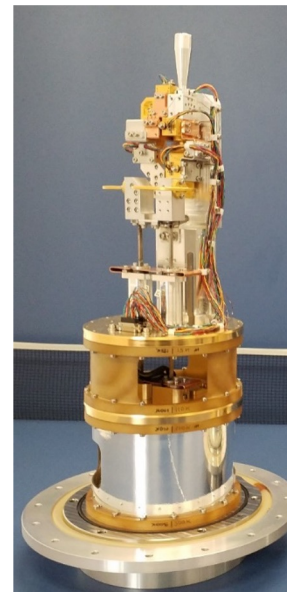
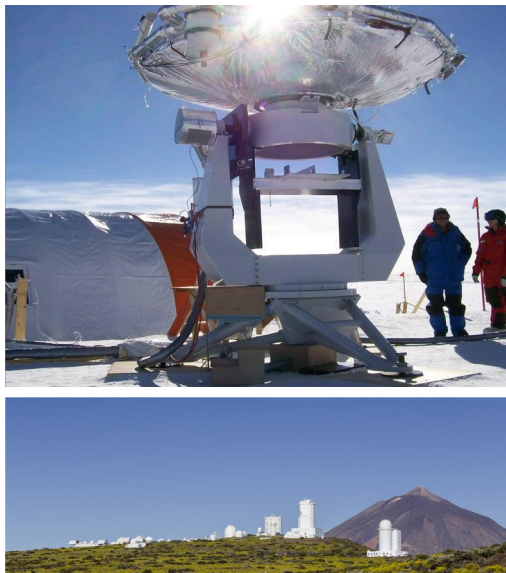
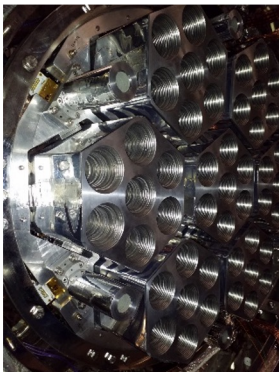
Fabrizio Villa (fabrizio.villa@inaf.it)

DIFA contact:

Leonardo Testi (leonardo.testi@unibo.it)

Potential activities you can get involved:

- Design, integration, verification of microwave & mm cryogenic receivers for spacecraft, balloons and ground-based observatories
- Study of microwave optics (antenna reflectors and focal plane antennas)
- Cryogenics & material characterization
- Operations and data analysis.



ONGOING PROJECTS

- ❖ ALMA BAND 2 (Atacama)
- ❖ Ariel (Space – L2)
- ❖ LSPE-STRIP (Tenerife)
- ❖ LiteBird (Space - L2)
- ❖ TMS- 4KCL (Tenerife)
- ❖ SOLARIS (Antartica)

Thesis proposals @CRYOWAVES



Assembly, integration and verification of the microwave cryogenic calibrator for the LSPE-Strip instrument (francesco.cuttaia@inaf.it)

laboratory activities functional to the integration, verification and implementation of the cryogenic calibrator, characterization tests of the Strip instrument (compatible with the project timetable).

Implementation of a microwave noise source for the LSPE-Strip Low noise polarimeters: assembly, integration, verification and validation (francesco.cuttaia@inaf.it)

implementation of the calibration source, in its integration with the instrument as well as in the verification during the system tests in Bologna. Possible implementation and verification @ Tenerife.

Development of a prototype receiver for SOLARIS telescopes (francesco.cuttaia@inaf.it, fabrizio.villa@inaf.it)

laboratory and simulations activities functional to the development of the receiver for Solar observations from Antarctica and from Italy (Testa Grigia, Milano)

Alignment and performance evaluation of LSPE-STRIP Telescope (fabrizio.villa@inaf.it)

Study of alignment methods for the STRIP telescope. Possible hardware implementation of the technique.

Structural and thermoelastic effects of the LSPE-STRIP Telescope (fabrizio.villa@inaf.it)

Evaluation of the detector response on the sky, taking into account the reflector and mount deformation of the telescope (GRASP simulations)

Performance Verification and optimization of the STRIP-LSPE instrument (francesco.cuttaia@inaf.it)

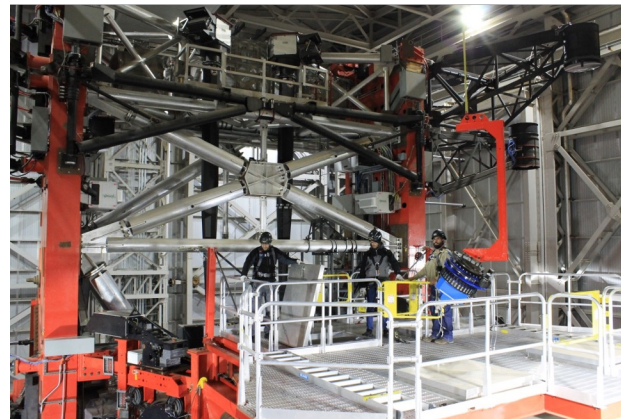
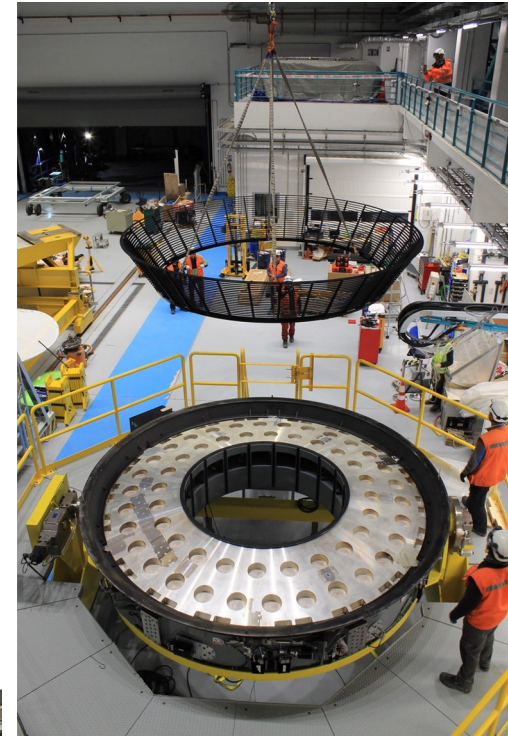
laboratory activities, programming, data analysis, for the ongoing system tests of the Strip-LSPE instrument.

Cryogenic test of the M1 mirror of the Ariel mission's telescope: simulations, setup, implementation and data analysis.

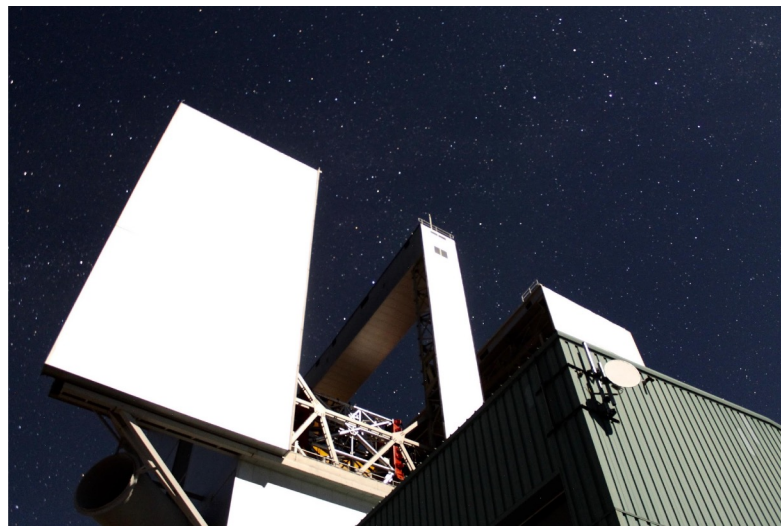
gianluca.morgante@inaf.it

OAS cryofacility preparation and test setup - Thermal analysis of the M1; cryogenic tests to qualify the optics; Test results data analysis (thermal and optical)

The beauty of building instruments people, adventures & fun



The beauty of building instruments people, adventures & fun



More information



<https://www.oas.inaf.it/it/alta-formazione/proposte-di-tesi/>

https://docs.google.com/spreadsheets/d/1Tj_qF13xfceoMtA6-vVU4TJo6caumhxkxwShtJZpKXQ/edit#gid=0

Thanks for your attention!