

OAS Bologna Laboratories

G. Morgante (OAS Bologna)

on behalf of the OAS Labs Staff Service

CSN5 Forum della ricerca sperimentale e tecnologica in INAF

Jun 22nd - 24th 2022

OAS Bologna Labs

- ❑ Long heritage of experimental activities @ OAS (TeSRE, IASF Bo, OABo)
- ❑ Mainly focussed on supporting high energy & IR/mm astrophysics from space, balloon and ground
- ❑ OAS labs organization is based, as much as possible, on a *flexible structure* that can be (re)arranged depending on the projects needs/evolution
 - Equipment maintenance
- ❑ Three major experimental facility categories:
 - Shared facilities
 - Specific to projects or bands
 - Loiano observational station
- ❑ ***OAS Labs keywords***: detectors, optics, calibrators, electronics, cryogenics, EGSE, SW

Clean room

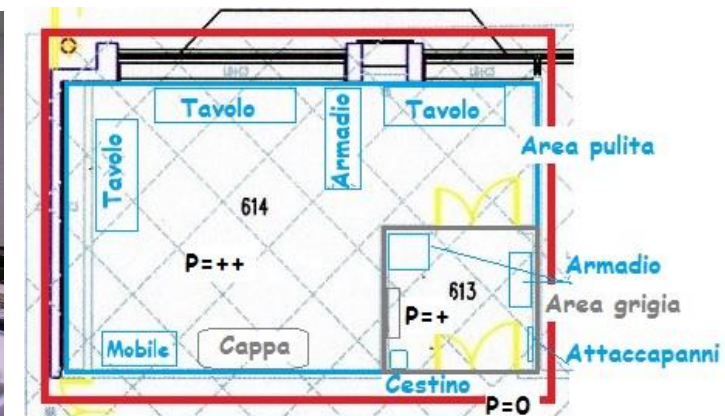
- ❑ **ISO 7** (1:10000 class) controlled pressure **Clean Room**
- ❑ Specifically designed for assembly/calibration activities of detectors or other sensitive equipment
- ❑ Can be organized as chemical/mechanical/electronics lab
- ❑ It is equipped with:
 - Climatic chamber
 - Laminar flow chamber (down to 1:1000 class)
 - Ultrasonic cleaner
- ❑ Upgraded in 2016 and 2017 (energy saving refurbishment), since 2000 has supported many qualification tests of sensitive instrumentation of projects like Integral, Agile, Planck-LFI, Euclid-NISP, ARIEL, Alma and others



CARATTERISTICHE TECNICHE:

- Capacità utile: **224 lt**
- » Dimensioni interne: 600x535x700 (LxPxH) mm
 - » Dimensioni esterne: 850x1460x1563 H mm
 - » Campo di temperatura: -40/+180°C
 - » Velocità di variazione della temperatura (valori medi):
 - in salita: 3,9°C/min. da -40°C a +180°C
 - in discesa: 2,5°C/min. da +180°C a -40°C
 - » Campo di umidità relativa: dal 10% al 98%
 - » Campo del punto di rugiada: +2/+94°C
 - » Controllo con μ PLC

Volume 614	150mc
Area grigia (locale 613)	4.5mq
Volume 613	16mc
Aria esterna (Rinnovi) (750mc/h)	5v/h
Temperatura	23
Umidità	50%
Persone	1/10mq
Mandata UTA 8 terminali di immissione (7+1)	4860 mc/h
Ripresa UTA 8 bocchette di ripresa (7+1)	4250 mc/h
Ricircoli totali nominali (R) portata di aria entrante/volume camera bianca	32



Resp.: F. Schiavone, L. Terenzi

Banca radioisotopi

- ❑ A set of sealed radioactive sources are maintained at OAS for the calibration and testing of high energy telescopes and detectors
- ❑ Due to safety related issues the storage and handling of these sources are rigidly disciplined by a specific legislation
- ❑ The use of such sources is allowed only in dedicated controlled labs and by authorized operators

Restanti sorgenti radioattive sigillate di taratura detenute presso INAF-OAS				
Codice interno INAF	Radionuclide	Data riferimento certificato	Attività (kBq)	
			Iniziale	Attuale
1	²⁴¹ Am	31/12/1982	4,07E+02	3,83E+02
2	⁶⁰ Co	31/12/1982	2,00E+03	1,36E+01
3	²⁴¹ Am	01/05/1984	3,70E+02	3,49E+02
4	¹³⁷ Cs	15/10/1984	3,50E+03	1,53E+03
5	¹³⁷ Cs	30/11/1984	3,70E+02	1,62E+02
6	⁵⁵ Fe	30/05/1985	7,40E+05	9,25E+01
7	¹³³ Ba	11/05/1990	8,48E+02	1,13E+02
8	²² Na	01/07/1992	3,76E+03	1,92E+00
16	¹⁰⁹ Cd	15/06/2004	1,11E+05	1,11E+01
17	¹⁰⁹ Cd	17/10/2017	1,11E+05	1,91E+04
18	⁵⁷ Co	22/02/2018	7,40E+04	5,45E+03



When not in use the sources are stored in a safe chamber with the following characteristics:

- 20 cm concrete room walls/ceiling/floor
- metallic door (350 kg) with 4mm thick Pb shield

Resp.: F. Schiavone, N. Auricchio, E. Virgili

The EGSE LAB carries out activities related to the integration and testing of instrument Workstations (IWS)

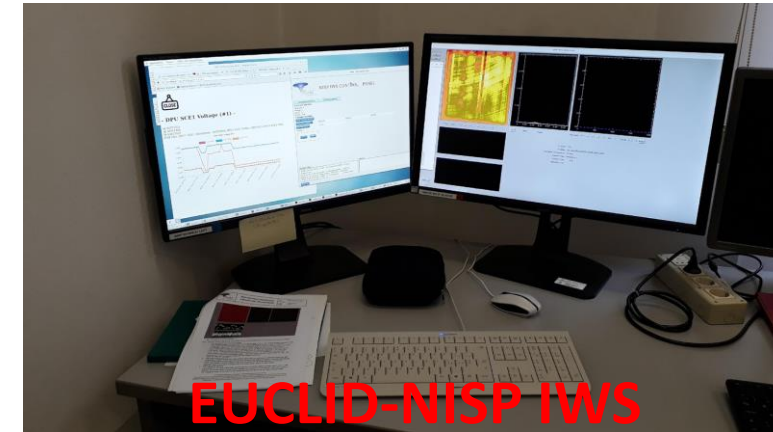
- ❑ The Instrument Workstation and the Scientific Workstation are part of the EGSE and are dedicated to the acquisition, control and visualization of the scientific data of the Satellite or Telescope
- ❑ Since 1990 we have developed IWSs for several missions. The last two IWSs we have developed are those for EUCLID NISP and that for ASTRI, shown in the figures
- ❑ The data acquired by the IWS are transmitted to the OAS Data Center where they are available to Engineers and Scientists who analyze them in near real time in order to evaluate the progress of the tests of scientific instruments

LAB Facilities and Activities:

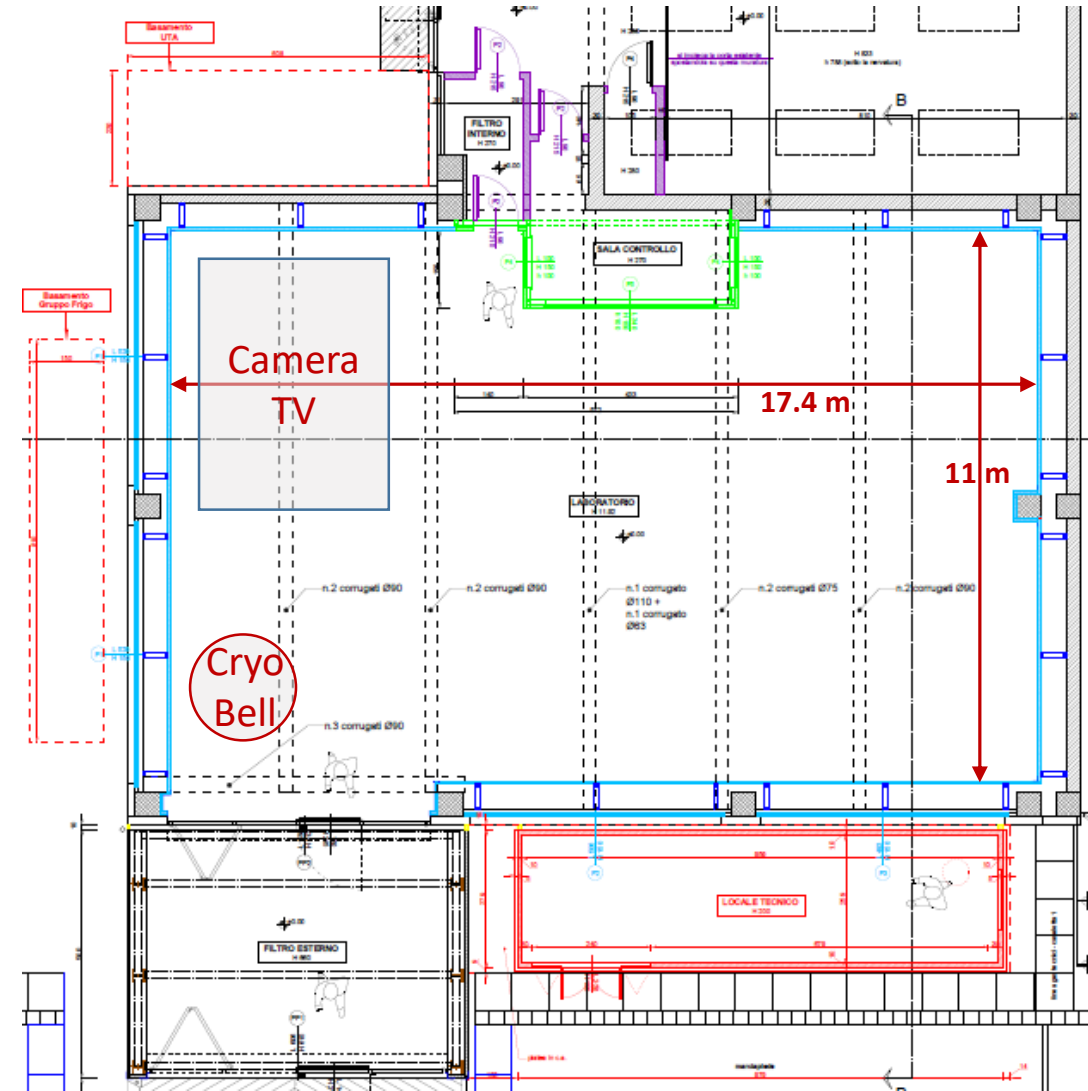
- ❑ The laboratory provides the spaces, power supply under UPS, dedicated high-speed network and always-on air conditioning with local regulation
- ❑ **Activities carried out:**
 - Configuration of servers and workstations dedicated to EGSE of satellites or ground experiments
 - Use of Workstation remotely or locally for Software development and testing
 - Integration of server and Workstation with each other or with Back End Electronic (BEE) interface cards

PEOPLE:

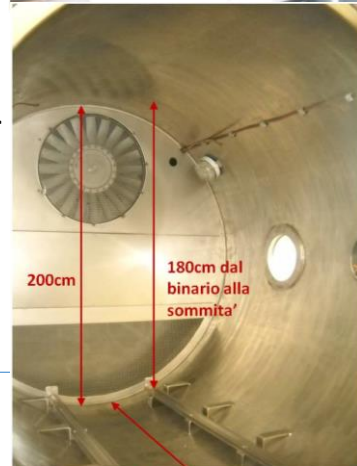
- ❑ **Fulvio Gianotti:** LAB Responsible and ICT-infra OAS Manager
- ❑ **Vito Conforti:** ASTRI Mini-Array QA Manager and Data Acquisition responsible OAS
- ❑ **Enrico Franceschi:** NISP EGSE manager, NISP IDT, NISP IOT, NISP PO - OAS
- ❑ **Valerio Pastore:** Data Acquisition Engineer - OAS



Main assembly hall



- ❑ **Large dims integration lab** (17.4m × 11m × 12 m)
- ❑ Presently under refurbishment to improve:
 - cleanliness (up/near to ISO 8 level, TBC)
 - environmental condition stability control (T, P, humidity)
 - airflow control
 - support equipment (liquid cooling and technical gases)
- ❑ **3.2t** overhead crane (hook height 10.2 m)
- ❑ Two thirds of the lab will be reserved to the MAORY/ MORFEO project for system AIV (see later)
- ❑ One third will host the two main facilities:
 - the **Thermal-Vacuum chamber**
 - approx 6 m³ internal volume, horizontal cylinder with D = 2 m and H = 2 m
 - T cycle between -60°C and + 100 °C
 - P cycle between 1 mbar and 1 bar
 - the **Cryo Bell** (see next slide)



Cryogenic facilities @ OAS

☐ Three main cryo-chambers:

■ **Blue Barrel** (samples cycling, properties measurement, sensors calibration)

- cold stage 360mm diameter, 300 mm height
- 2-stage cooler (1.5W@4K and 35W@50 K)

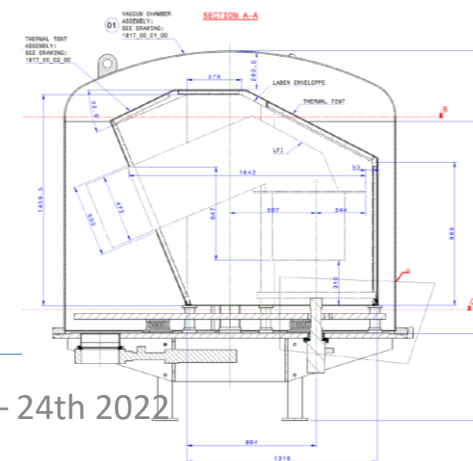
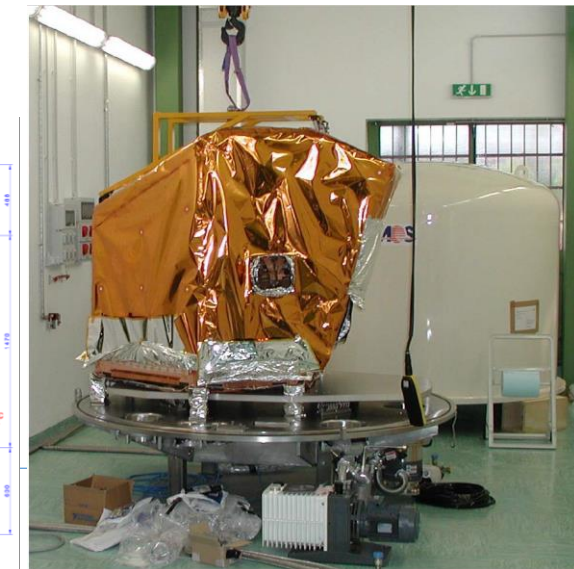
■ **Big Coffin** (cryogenic instruments characterization and calibration)

- About 2m x 1m x 0.5m volume
- Two 2-stage coolers (1.5W@4K and 35W@50 K, 12W@20K and 30W@65K)

■ **Cryo Bell** (currently being upgraded for Ariel M1 test campaign)

- About 2 m diameter, 2 m height
- One 20K cooler lifting 25W, two 80K coolers each lifting 190W
- Optical window to test/measure optical instrumentation at cryogenic temperature

☐ A set of more than 30 cryogenic thermistors, and readout system allowing 36 high accuracy temperature monitoring channels and 8 T control loops



Cryowaves LAB



Cryowaves
è Bologna

INAF - OAS Area
della Ricerca di
Bologna

☐ Instrumentation

- approx 210 m², 1t overhead crane, 3D printer for prototyping
- 5 cryocooler compressor lines, RF instrumentation up to 116 GHz (expandable), optical bench
- cryo-facilities: Big Coffin (instrument testing), Blue Barrel (material & component testing)

☐ Activities

- Integration, characterization and testing of microwave/mm instrumentation at cryogenic T
- Materials testing and measurement in the 4K - 300K range
- AIV activities for complex systems
- System engineering approach to activities and testing
- Experimental support to the System Engineering activities

☐ Main projects in progress

- **ALMA band 2**: Prototyping and production of the receiver (in a dedicated cryostat)
- **LSPE/Strip**: System integration and testing (in a dedicated cryostat) + Telescope SE
- **ARIEL**: thermal treatments and optical characterization at cryogenic T of the primary mirror
- **TMS**: design and test campaign of the 4K reference cold-load
- Design, development and characterization of microwave/mm calibrators

F. Cuttaia (OAS)
A. Derosa (OAS)
S. Mariotti (IRA)
G. Morgante (OAS)
M. Sandri (OAS)
S. Ricciardi (OAS)
L. Terenzi (OAS)
F. Villa (OAS)

MAORY/MORFEO

❑ People involved (locally):

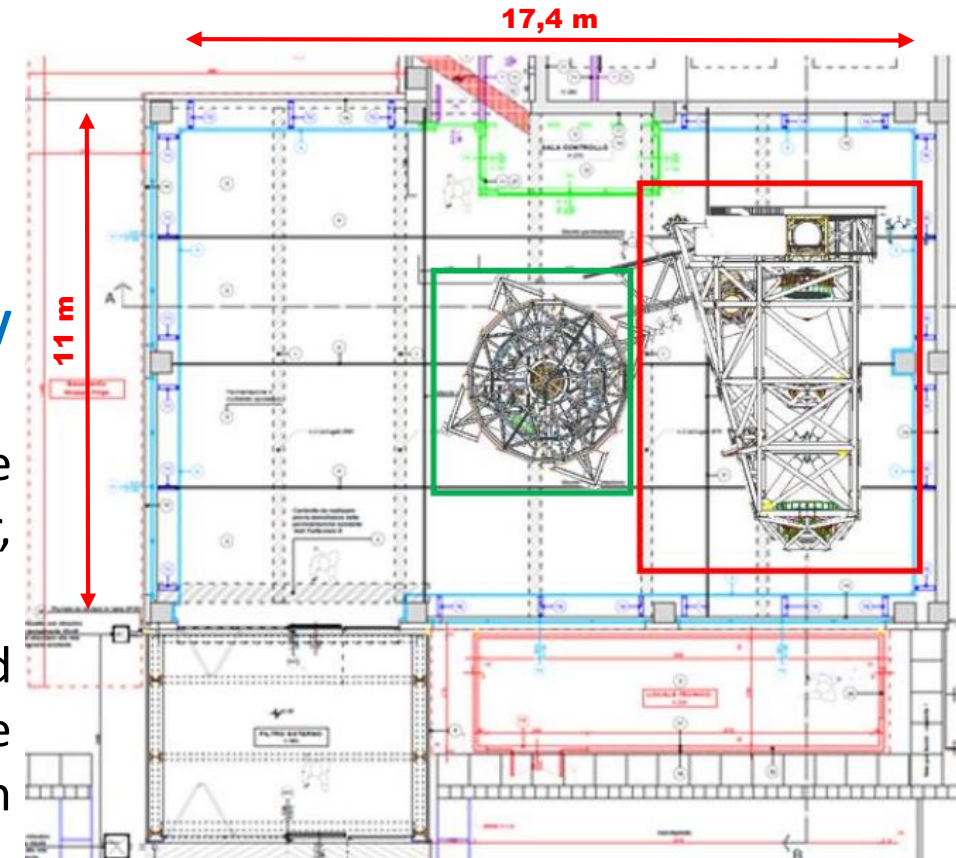
Paolo Ciliegi, Italo Foppiani, Gabriele Rodeghiero, Ugo Di Giammatteo, Alessandro Tacchini, Fulvio Gianotti (OAS), Giuseppe Cosentino (UNIBO-DIFA)

❑ The **MAORY/MORFEO** project will exploit the **Main Assembly Hall Lab** for system AIV activities (approx. two thirds of the hall)

❑ The overhead crane, part of the facility equipment, will be supplemented with extra handling equipment as cherry picker, scissor lift and manual cranes

❑ In the same framework **two laboratories**, one for **optical** and one for **electronic** activities, are being set up to support the integration of **large optical instruments**, as MAORY/MORFEO, in the main assembly hall:

- both labs are equipped with general purpose instrumentation as optical bench(es), laser(s), illuminators, optics, oscilloscopes, power supplies, etc. to integrate or to test the integrity of components and subsystems
- main expertise of local people: optical & NIR detector characterization and controller development; optical system design, integration and verification



Opto-electronic infrastructure for ground-based and space-borne instrumentation development and testing

Description

- About 50 m² area divided into two adjacent rooms on ground floor
- One room serves as optical laboratory, one room as electronics laboratory
- Currently not suited for AIT activities requiring qualified clean environment (for these ones, the OAS clean room is needed)
- Planned upgrade of lab and equipment on PNRR funds, if proposal successful

Equipment and instrumentation

- Optical bench, optical and mechanical components for prototyping, optical alignment tools
- Measurement instrumentation (laser interferometer, thermal imaging camera, oscilloscope, spectrum analyser, etc.)
- Support instrumentation (waveform generator, power supplies, etc.)

Activities

- Development of **instrumentation and technologies for visible, infrared and ultraviolet wavelengths**
- Development of **adaptive optics instrumentation and technologies**
- **AIT** of opto-electro-mechanical devices and systems

Main projects

SPHERE+ (upgrade of SPHERE on ESO's VLT)

- Adaptive optics module AIT
- MedRes spectrograph AIT

Ariel (ESA Cosmic Vision Mission)

- testing of development models of telescope M1

Cassini Telescope @Loiano

- AIT of instrumentation for Space Surveillance and Tracking

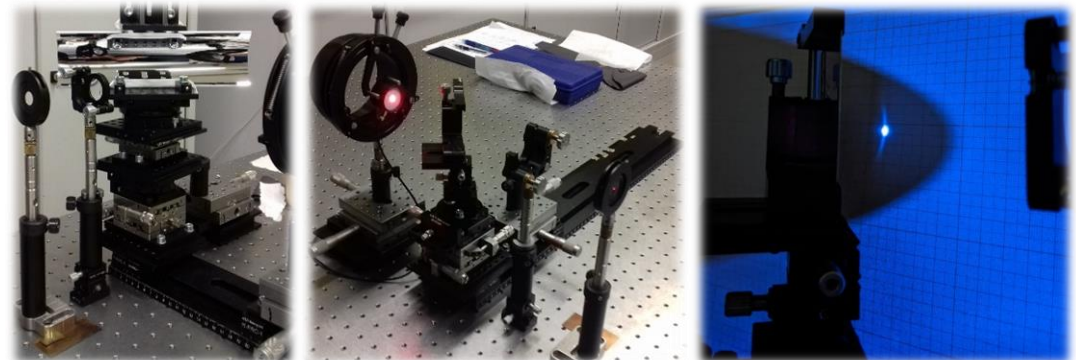
Ultra Violet Germicidal Irradiation (CoViD19, disinfection in space environments, etc.)

- Testing of materials, development of prototypes

OAS personnel

Emiliano Diolaiti
Fausto Cortecchia
Adriano De Rosa
Matteo Lombini
Giuseppe Malaguti
Gianluca Morgante
Filomena Schiavone
Laura Schreiber
Luca Terenzi

Setups for testing UV-reflecting materials

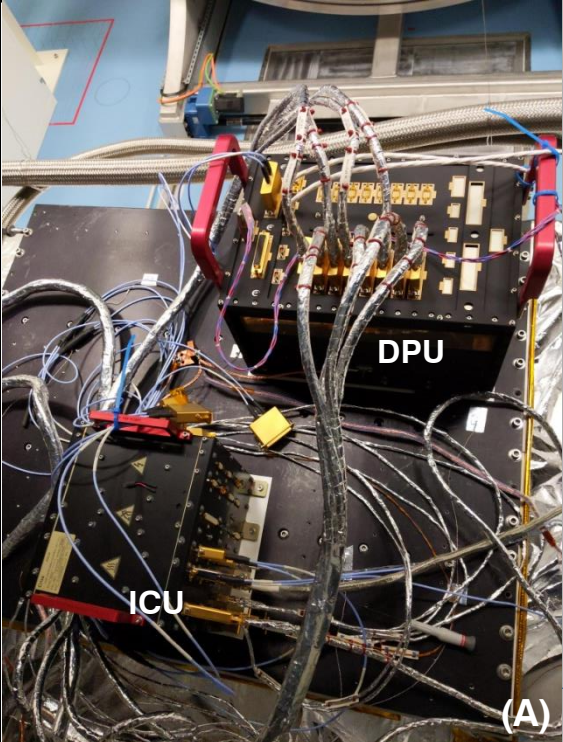
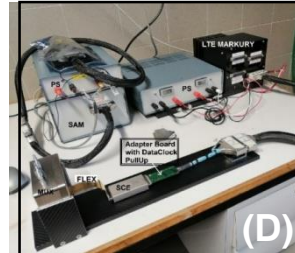
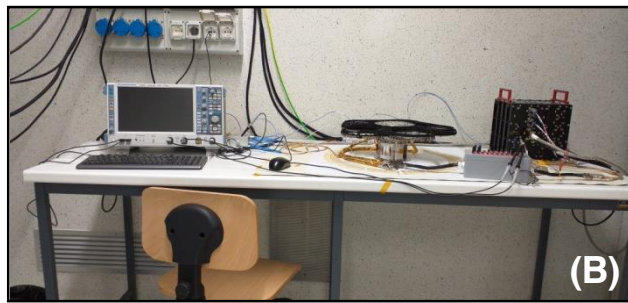




Euclid's Near Infrared Spectro-Photometer on-board application SW maintenance laboratory

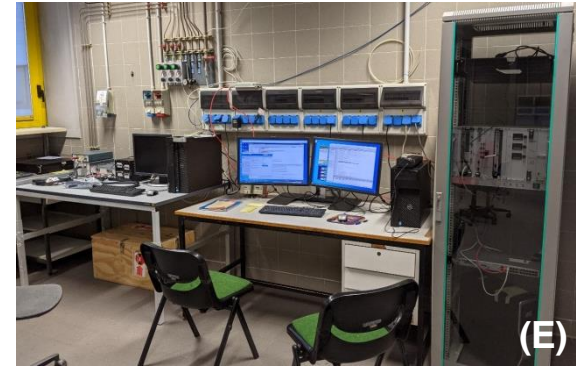
Instrumentation:

- ❑ NISP Engineering Qualification Models (EQM): Instrument Control Unit & Data Processing Unit **(A)**, Filter Wheel, Grism Wheel Assemblies, Calibration Unit **(B)**, 1/2 focal plane – flight-like front-end electronics (8xSIDE CAR ASICs) **(C)**
- ❑ Flight-like infrared sensors (H2RG) with a dedicated cryogenic setup (to be refurbished)
- ❑ Stand-alone ASICs readout systems **(D)**, and ICU test equipment
- ❑ DPU-ASW development ambient (RTOS) **(E)**
- ❑ Ambient for software engineering (ECSS standard): Unit Tests & Static tests **(E)**
- ❑ Electrical Ground Support Equipment (EGSE):
 - SCOE (Special Check Out Equipment) for satellite simulation and payload interfacing **(F)**
 - CCS (Central Checkout System) for commanding, monitoring and control **(G)**
 - IWS (Instrument WorkStation) for quick look, storing and offline analysis of data products **(H)**



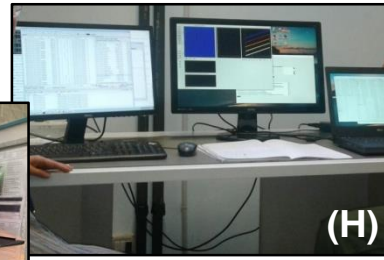
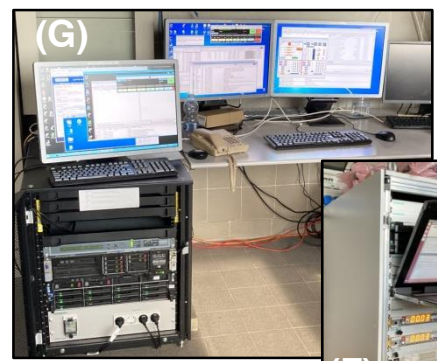
Activities:

- ❑ *Support*
 - analysis of science outcome related to the instrument operability
 - real-time operations interfaced with MOC through the IWS
 - interface between the warm electronics and the detector system
 - management of the NISP on-board operations
 - NISP survey group
- ❑ *Maintenance*
 - DPU-ASW and ICU-ASW
 - NISP's instrument operative concept
 - NISP thermal model (G. Morgante)
 - EGSE SW and setup
- ❑ *Outreach*



NISP Project Leadership:

- PI E. Medinaceli, NI-DPU-ASW manager, NI-IDT - OAS
- S. Ligori, NI-ICU-ASW manager, NI-IDT - OATo
- F. Gianotti, NI-IWS manager - OAS
- E. Franceschi, NI-EGSE manager, NI-IDT - OAS
- P. Battaglia, NISP operation manager, NI-IDT - OAS
- N. Auricchio, NISP warm unit Product Assurance manager - OAS



Expertise in the following activities:

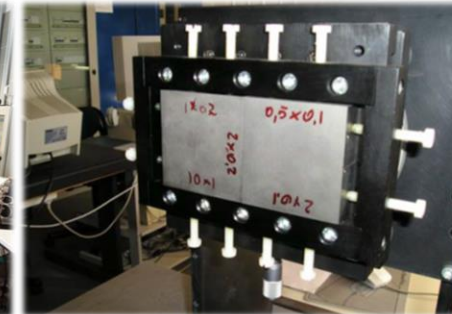
- INAF-OAS has more than 20y experience in design, development, assembly, integration, testing, calibration and characterization of semiconductor detectors (CdTe/CdZnTe) at room temperature and related front-end/readout electronics for X/gamma ray spectroscopy, imaging and polarimetry in astrophysics and medical applications. In addition to Quick Look, SW tools to analyse the detector performance and simulations

Latest projects:

- High performance 3D Cadmium-Zinc-Telluride spectro-imager for X and gamma-ray applications (3CaTS) by INFN: INFN-PV, OAS BO, IMEM/CNR, UNIPA
- 3D-CZT Module for spectroscopic imaging, timing and polarimetry in hard X-/soft gamma-rays satellite mission (3DCaTM) by ASI/INAF: OAS BO, IASF-PA, IMEM/CNR, UNIPA
- Increase of the Technological Readiness Level for the realization of hard X-/soft Gamma-ray Laue optics (TRILL) by ASI/INAF: OAS BO, IASF-PA, UNIFE, IMEM/CNR
- H2020-AHEAD 2020/ASTENA study: OAS BO, IASF-PA, UNIFE, IMEM/CNR, DTU, CEA
- H2020-HEMERA and ASI support: BADG3R payload (3DCaTM complement then, the same team)

Educational activity:

- “Test and calibration of hard X-ray detectors”, part of the Astrophysics Laboratory Course, Department of Physics and Astronomy, University of Bologna
- “Astrofisica alle alte energie: test di rivelatori per raggi X duri”, part of the Physics of Matter Laboratory Course, Department of Physics and Astronomy, University of Bologna
- PON – ORIENTAMENTO FORMATIVO E RI-ORIENTAMENTO: "Scuola Estiva di Astrofisica su RAGGI X e RAGGI COSMICI”



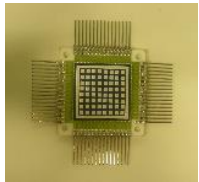
Lab for semiconductor detector characterization

Instrumentation:

- several measurement chains, some equipped with micrometric movement systems with multiple axes and rotation of the detection system, which can be irradiated by finely collimated radioactive sources (^{241}Am , ^{109}Cd , ^{57}Co , ^{133}Ba , ^{137}Cs), and aligned with it, to perform spectroscopic scanning of the sample to be tested.
- standard instrumentation for nuclear physics measurements (High speed digitizer, Spectroscopic preamplifier, digital oscilloscope, power supply, MCA, etc.)

INAF People: N. Auricchio, E. Caroli, J. Stephen, F. Schiavone, A. Basili, S. Silvestri, S. Del Sordo, A. Segreto, C. Gargano, L. Abbene, F. Principato, A. Buttacavoli

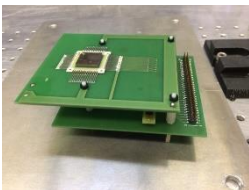
Compton spectro-imager based on 2 CdTe pixelated detectors when used as a Compton polarimeter



Single detector

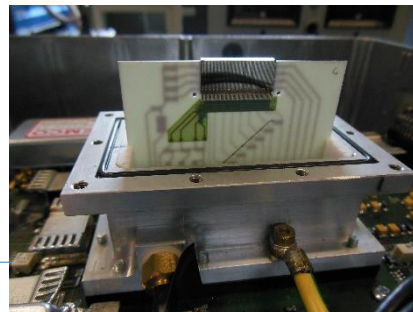


Test campaign at ESRF (Grenoble) to evaluate the tracker polarimetric performance

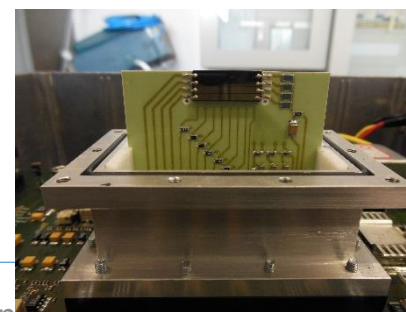


2 layers

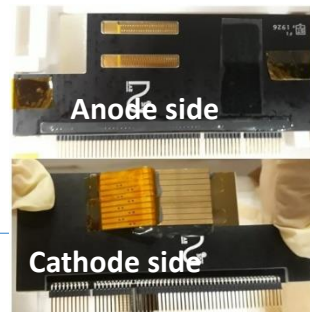
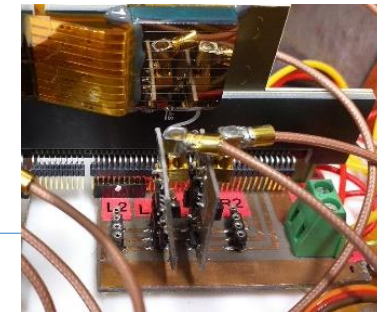
3D CZT detector (12 channels read by ASIC)
Anode side



Cathode side



3D CZT detector (24 channels)



Collaboration

Scientific Institutions:

- OAS Bologna, INAF, Bologna, Italy
- Dept. of Physics and Earth Science, University of Ferrara, Italy
- IMEM, CNR, Parma, Italy
- IASF-Palermo, INAF, Palermo, Italy
- INFN Sez. Pavia, Pavia, Italy
- DiFC/University of Palermo, Palermo, Italy
- CEA/Saclay, Paris, France
- DTU Space, Lingby, Denmark
- LIP, Coimbra, Portugal
- Physics & Astronomy Dpt., Sacramento, CA, USA

Industries:

- TAS I-Milan and Turin, Italy
- Due2Lab S.r.l., Scandiano (RE), Italy
- 3D Plus, France

LABORATORIO GAMMA

LABORATORIES AND FACILITIES FOR HIGH ENERGY INSTRUMENTATION VERIFICATION, CHARACTERISATION AND CALIBRATION

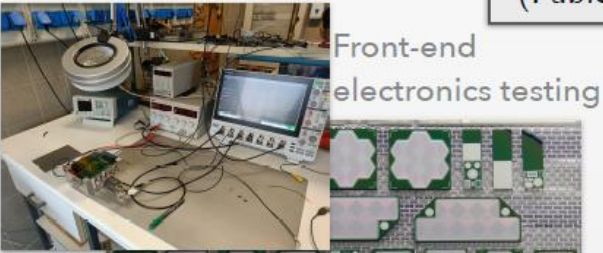
Spaces
INAF/OAS
Area della Ricerca
IV floor
Rooms 605, 608, 612, (614)

People
Riccardo Campana
Enrico Virgilli
Ezequiel Marchesini
Claudio Labanti
(Fabio Fuschino)

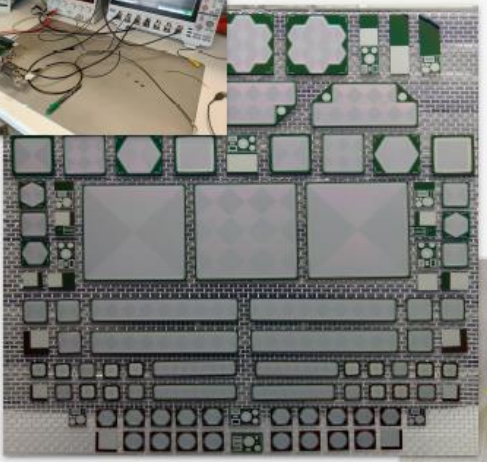
Heritage
Balloon-borne experiments
INTEGRAL/PICsIT
AGILE/MCAL
R&D for X and gamma-ray
instrumentation

Current projects
HERMES
GammaFLASH
eXTP
PixDD
THESEUS

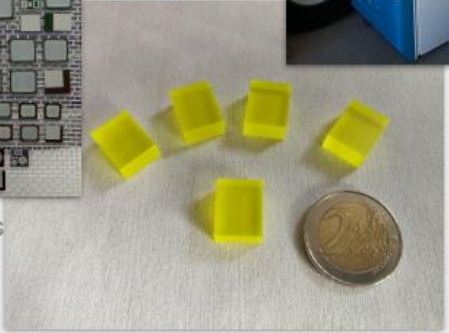
Instrumentation
Several workbenches
Soldering stations
Test equipments for instrument I/F
Vacuum pump (10^{-3} bar)
Radioactive calibration sources
X-ray tubes
Microscopes
2 climatic chambers
Mechanical tools
3D printer
Chemical bench+hood



Front-end electronics testing



Silicon Drift Detectors



Scintillators

CC testing (-30° , $+70^{\circ}$, $\sim 1 \text{ m}^3$)



Instrument integration and testing

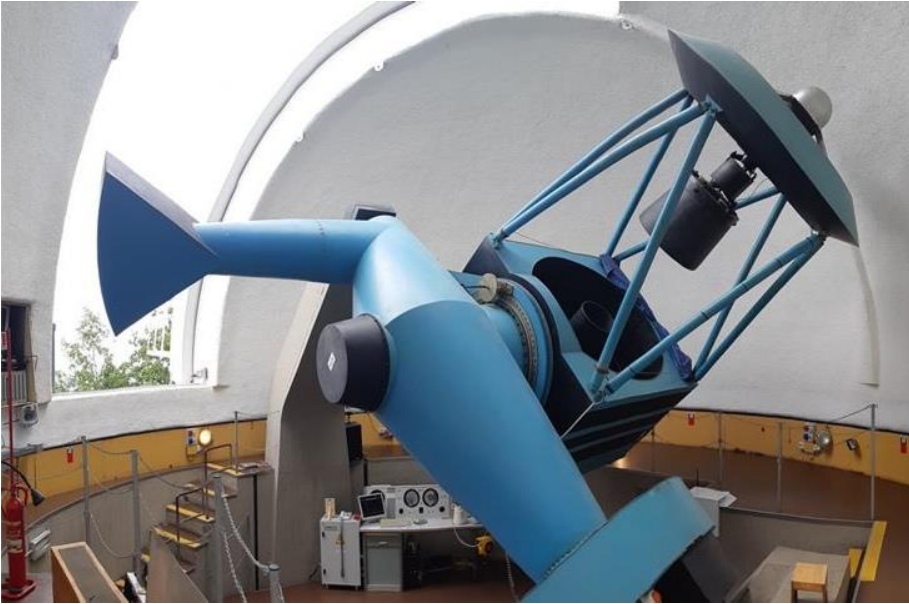


Mechanical tooling and 3D prototyping



Calibration of high-energy detectors

Telescopio “Cassini” a Loiano - 152cm



ACTIVITES:

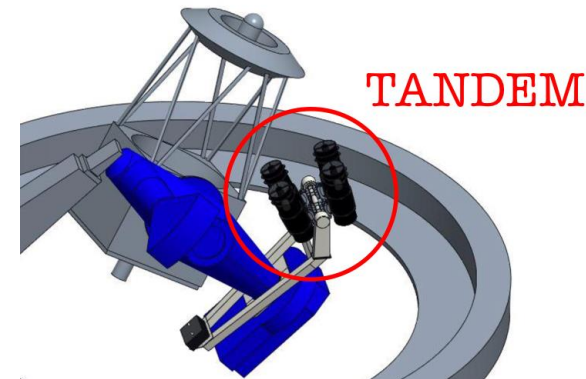
- ❑ Space Situational Awareness → *primary mission*:
 - satellites and space debris tracking
 - NEO search and classification
 - Loiano Team + Buzzoni (PI), Diolaiti, Cortecchia, Lombini, Schreiber, Rossetti (DIFA-UniBo)
- ❑ Technical and logistic support to scientific programs proposed by OAS users

COMPETENZE:

- ❑ Electronic and mechanical management/maintenance of the telescope and related instrumentation

INSTRUMENTATION UNDER DEVELOPMENT (for SSA):

- ❑ **TANDEM**: piggy-back cluster of 4 telescopes x 35cm, flexible configuration, very wide field (up to $20^\circ \times 20^\circ$) → *tender in progress*
- ❑ **SuperFOSC**: focal length reducer, multi-purpose instrument for Cassegrain focus, finalized to recover the full FoV of the Cassini optics ($1^\circ \times 1^\circ$) → *design in progress*



❑ TEAM

- Coordinator: Stirpe (Bologna)
- Other scientists: Carbognani, Galletti (Loiano)
- Technical support: Bruni, De Blasi, Gualandi (Loiano), Di Luca (Bologna)