S.I.D OAS

Fulvio Gianotti, Alessandro Tacchini – for S.I.D. OAS

Introduction and Outline

What the SID is responsible for:

- Network Infrastructure
- Hardware and Software Services managed by SID
- IT Systems for Administration
- OAS-Battiferro Data Center
- OAS-CNR Data Center
  - Infrastructure
  - Network
  - Services
  - Critical Issue
- HPC Cluster
- Computing Research hosted at OAS

Network Infrastructure and Printers

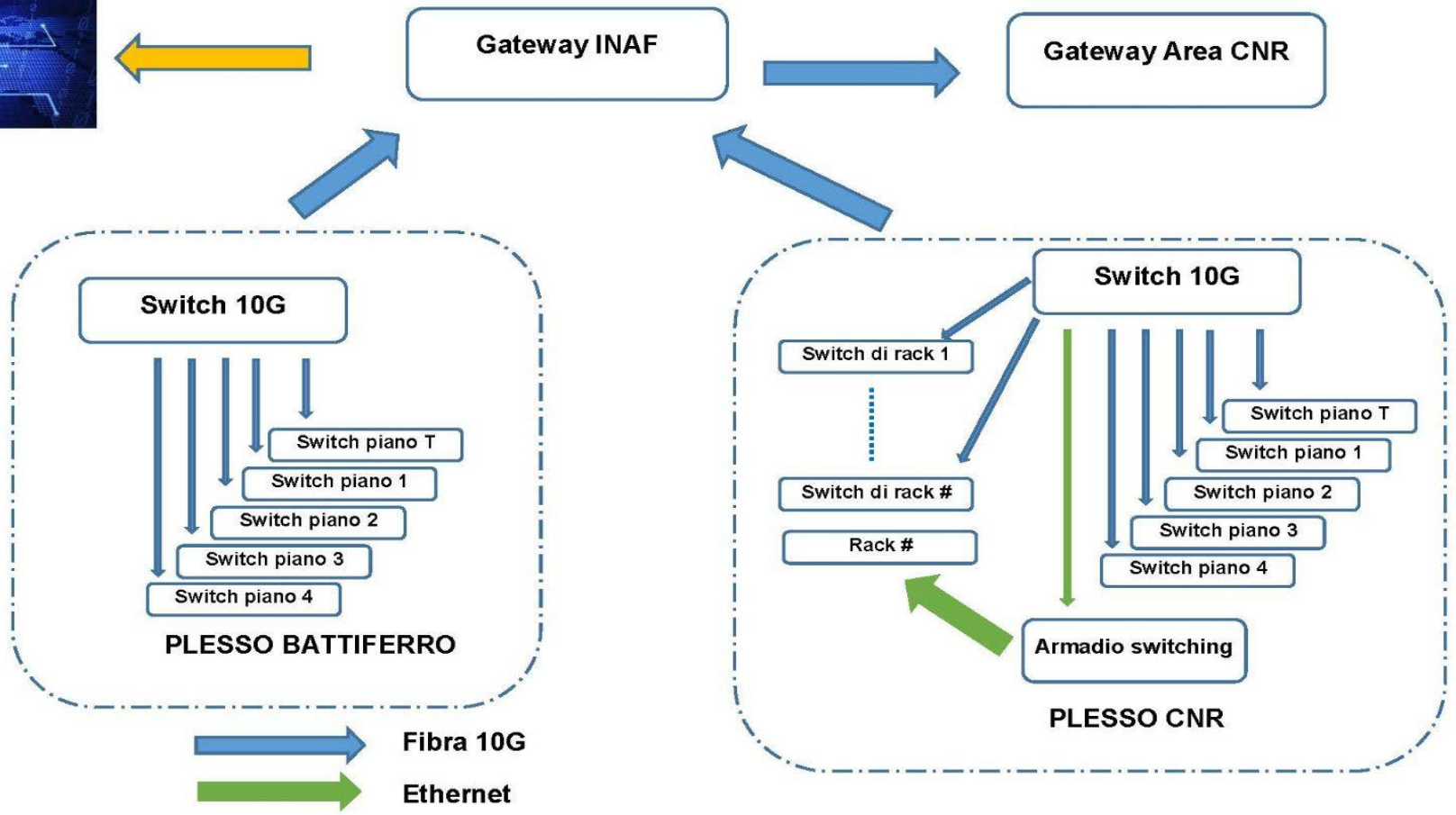
Network infrastructure refers to everything needed to allow communication between servers, PCs, and printers, both with each other and with the internet.

- Two infrastructures on separate physical sites, a single structure SID. How is it harmonized?
  - On a physical level, nothing changes; each site continues to require all skills.
  - Coordination (purchase planning, license management) and support to the administration are shared.
- At the Battiferro site, the network is next-generation, with switches located on each floor and connected via 10 Gb/s fiber optics to the central hub and the router.
- In 2024, the CNR site was also equipped with floor switches and 10 Gb/s riser cables.
- The Wi-Fi network is implemented with floor access points, at least two per floor to ensure optimal coverage of all areas.
- A centralized control server (Unifi by Ubiquiti) manages the network.
- The Battiferro site has a VoIP telephone network, while the CNR site is still using an analog network (the switch to VoIP is planned for 2025).
- There is an institutional printing system with multifunction printers, one per floor, under a rental contract (Convenzione aquistinretepa).

Network Infrastructure

- The CNR site hosts several computer and technology laboratories on the 4th floor:
  - A laboratory dedicated to supporting space activities (currently Euclid-NISP);
  - An EGSE (Electrical Ground Support Equipment) integration laboratory;
  - A gamma physics and electronics laboratory;
  - A solid-state physics laboratory;
  - An electronics laboratory;
  - An educational prototyping laboratory.
- There is also a Cryowaves laboratory on the ground floor, networked similarly to the 4th floor.
- Currently, laboratories are connected to the data center at 10 Gb/s via a floor switch. An upgrade to 100 Gb/s is under consideration.
- A high-bandwidth connection with the data center provides powerful servers for laboratory activities in a more suitable environment (cooling, UPS).

Network Infrastructure Scheme



Hardware and Software Services managed by SID

- Monitoring of hardware and software of the network, devices and main services at the Battiferro and CNR sites using Observium software.
- User support for astronomical software and more.
- Management of licenses, both INAF and OAS level.
- Management of the VoIP telephone switchboard at the Battiferro site for OAS and CTA.
- Management of local users and OAS mailing lists in Gsuite.
- Management of the image archive from the G.D. Cassini telescope in Loiano.

IT Systems for Administration

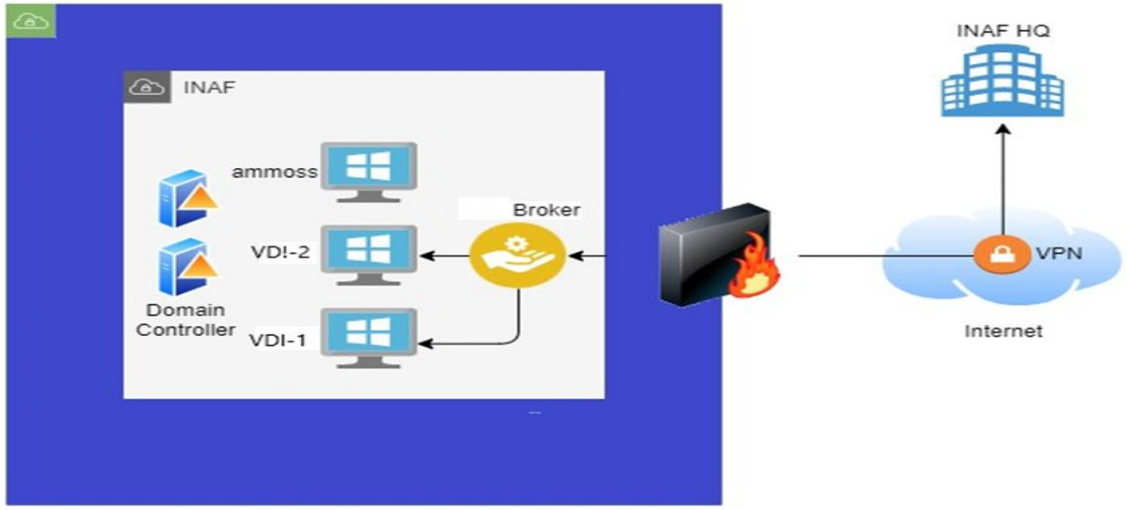
The configuration of the “virtual desktops” for OAS administration (in operation since mid-2014 for OABO) has been changed due to objective needs and management difficulties:

- The need to purchase new servers in order to upgrade to the latest versions of the VMware hypervisor (a VSphere 5.5 no longer supported in terms of security updates or customer support) and, consequently, to the new versions of VMware Horizon for VDI management;
- the inability to satisfactorily handle all the software management issues involved;
- complying with AGID directives to consolidate services and reduce the number of data centers in public administration.

After market research, the choice fell on ARUBA, which offered a good balance between cost and services, as well as the advantage of hosting the system, and therefore the data, on Italian territory, transitioning from a “local” system to a “Private Cloud.

IT Systems for Administration

The requested solution, depicted below, consists of two Microsoft servers that provide VDIs through “Remote Desktop” with access balanced by a broker, a (duplicated) domain controller, a server for data management, a firewall protecting the entire data center, and a secure connection to users’ PCs (VPN with dual authentication via user-password-token). The entire solution is based on VMware virtualization.



IT Systems for Administration

The system contains the necessary resources for the administration, which can access it whether at the workplace, from home (home working), or from any other location outside of their usual workplace (smart working). From this perspective, nothing has changed for the user.

The capacity of the centralized servers designated for user sessions can be dynamically expanded based on the desired user base, which may vary during the contract period to enable more efficient management of the operating system and any application updates. Currently, **10 sessions** have been requested.

The internet connectivity has sufficient bandwidth to handle all 10 sessions simultaneously, and the entire infrastructure is managed by the service provider up to the operating system layer and VDI platform management.

The entire data center is protected by backups to minimize service disruptions in case of data loss and/or disaster recovery. **The system has been in production since November 2022.**

Ruolo	OS	Qtà	CPU (GHz)	RAM (GB)	Disco (GB)
Terminal VDI	Windows Server	2	8	32	250
ammoss	Windows Server	1	4	4	470
Domain Controller	Windows Server	2	2	4	300
VDI Broker	Windows Server	1	2	4	150
Firewall Appliance	FortiOS	1	1	2	20
TOTALE		**7**	**27**	**82**	**1440**

Data Center Battiferro

The Data Center at the Battiferro site has the following functions:

- Central hub for network connections and Internet access
- Hosts (or hosted) the virtualization system for the administration
- Hosts network services
- Hosts servers and workstations for projects. The server and workstation hosting service is a very important function and includes:
  - Providing space for installation on dedicated racks or tables with KVM
  - Providing power supply through UPS
  - Providing the necessary cooling for the premises

This is a very important service because many of these devices cannot be housed in regular offices.
The hosting service is also one of the main services for the Data Center at the CNR site.
For the hosted servers and workstations, support is offered for purchase, installation, and networking, as well as an upgrade service for the operating system and installed software.

OAS-CNR Data Center

The OAS Data Center is approximately (6x7.5) 45 square meters and hosts 7 Racks with approximately 80 servers, plus 1 Rack for network equipment.

The Data Center is equipped with:

- Redundant cooling with free cooling function
- UPS and Generator for a maximum power of about 50 KW
- 10Gbit/s ethernet network infrastructure for server connections, 1Gbit/s with offices and 10Gbit/s Internet

The Data Center hosts:

- Network Services, DNS, LDAP, VPN, NAT, DHCP, RADIUS,
- Virtualization system based on ProxMox
- HPC Cluster
- Server and Workstation Hosting Service for Missions and Projects. ASTRI-CTA, CTA-RTA, AGILE, PLANK, REM, GAIA, GRAPPA, INTEGRAL, XMM, CHANDRA, EUCLID etc..
- The Media-INAF and EDU INAF Servers.
- The CTA-PO Calculation Center (being finalized).

Electrical Installations

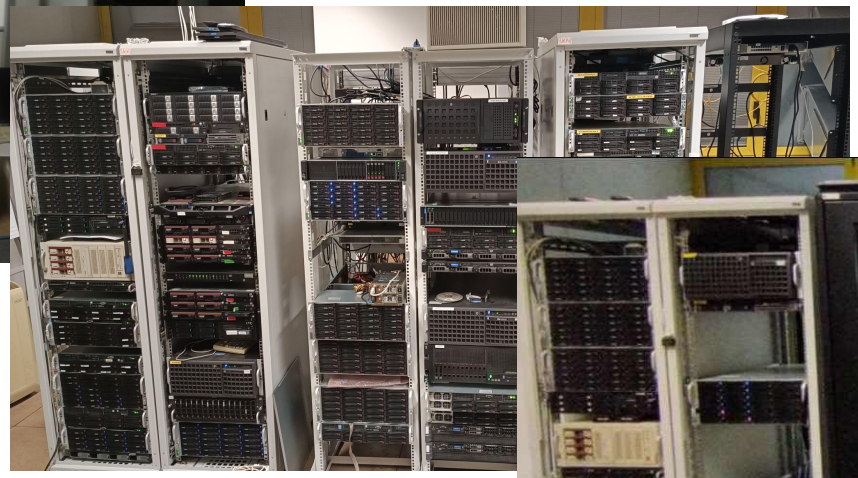
- In recent years, we have made significant interventions in the electrical systems:
  - Replaced line switching switches from ENEL to diesel generator
  - Replaced UPS batteries
  - Replaced UPS capacitors and fans
  - Regular renewal of the maintenance contract
- We have 60 KVA of three-phase electrical power fully backed up by UPS.
- The UPS has about ten minutes of autonomy before the generator kicks in.
- The UPS is under a two-year maintenance contract.

- The racks have a dedicated electrical panel with emergency circuit breakers that limit maximum power consumption and mitigate the effects of short circuits.
- Each rack is powered by three phases, so it has three dedicated breakers in the panel.
- The servers have redundant power supplies.
- This ensures continuity of service even in the event of maintenance or partial failure of electrical lines.

Cooling System

- Emerson system with 2 air conditioners like the one on the left, capable of operating in free cooling mode, which uses cold winter air and allows for over 50% savings on electricity for cooling in a year.
- At the top is the traditional chilled water system integrated with general cooling, used as redundancy.

Continuous Development of the CNR Data Center

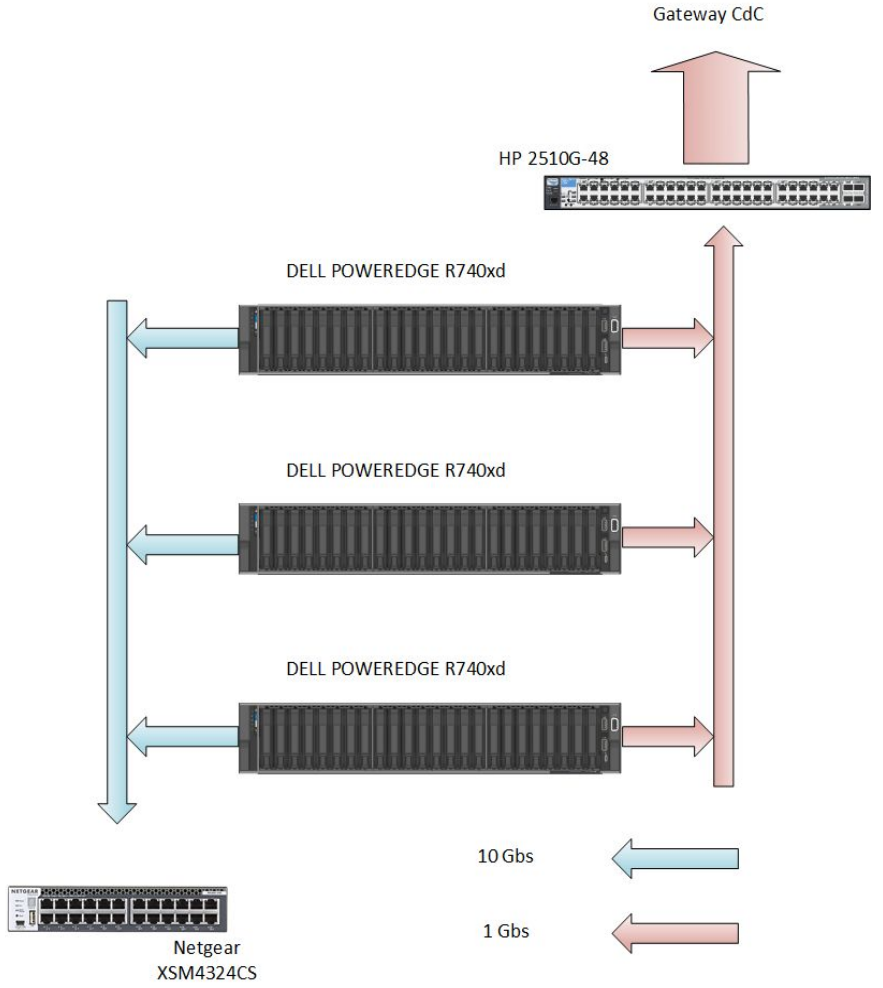


Data Center in 2024

Data Center in 2018

Services

- We have implemented a new virtualization system capable of hosting all OAS services as well as small workstations for data processing (virtual workstations).
- The virtualization system used is ProxMox, which is very reliable and free, and is used in many research centers and projects.
- We conducted a training course to manage it effectively.
- A technical report is available that describes this infrastructure.
- Proxmox+CEPH and a dedicated full backup system (PBS).



Cluster - LUSTRE

- The cluster has been completely redesigned (Derosa, Gianotti, Tacchini) utilizing a new file system (LUSTRE) and migrating the head nodes and computing systems to a more recent Linux distribution (RedHat 8), which is capable of running all the programs necessary for our institute's research.
- The hardware and software migration, which lasted several months, was carried out without ever stopping the computing system, allowing everyone to continue working except during the final two weeks of system transition.

Cluster Numbers

Users:

- **The mailing list cluster.oas@inaf.it contains 31 email contacts, who are regular users of the cluster, although there are more accounts than users subscribed to the mailing list.**

Computing capacity:

- **Interactive computing: 128 cores, of which 96 are of the latest generation, with 722 GB of RAM. Multi-user graphical access (ThinLinc) is also provided for interactive computing.**
- **Batch computing with Slurm queues: 84 Core (168 thread) Intel and 256GB RAM**

192 Core (288 thread) Core AMD EPYC 7413 2 TB RAM

Storage:

- **File System for HOME directory: 15TB**
- **File System LUSTRE dedicated to computing: 133TB**
- **File System DATA for processing results: 22TB**
- **File System dedicated to software: 20TB**
- **Backup: 73GB All filesystems are backed up except for the computing filesystem.**

Network:

- **10Gbit/s Ethernet for cluster control on**
- **10Gbit/s Ethernet for computing and data**

Software:

- **All the main scientific SW used in OAS are installed and we proceed continuously to update and add those that are necessary.**

The OAS Cluster does not have a power comparable to the large Commercial and Research Clusters, but being tailored to the needs of OAS members, it responds well to the needs of the institute and can serve as a Training Ship to then be able to access larger structures if necessary.

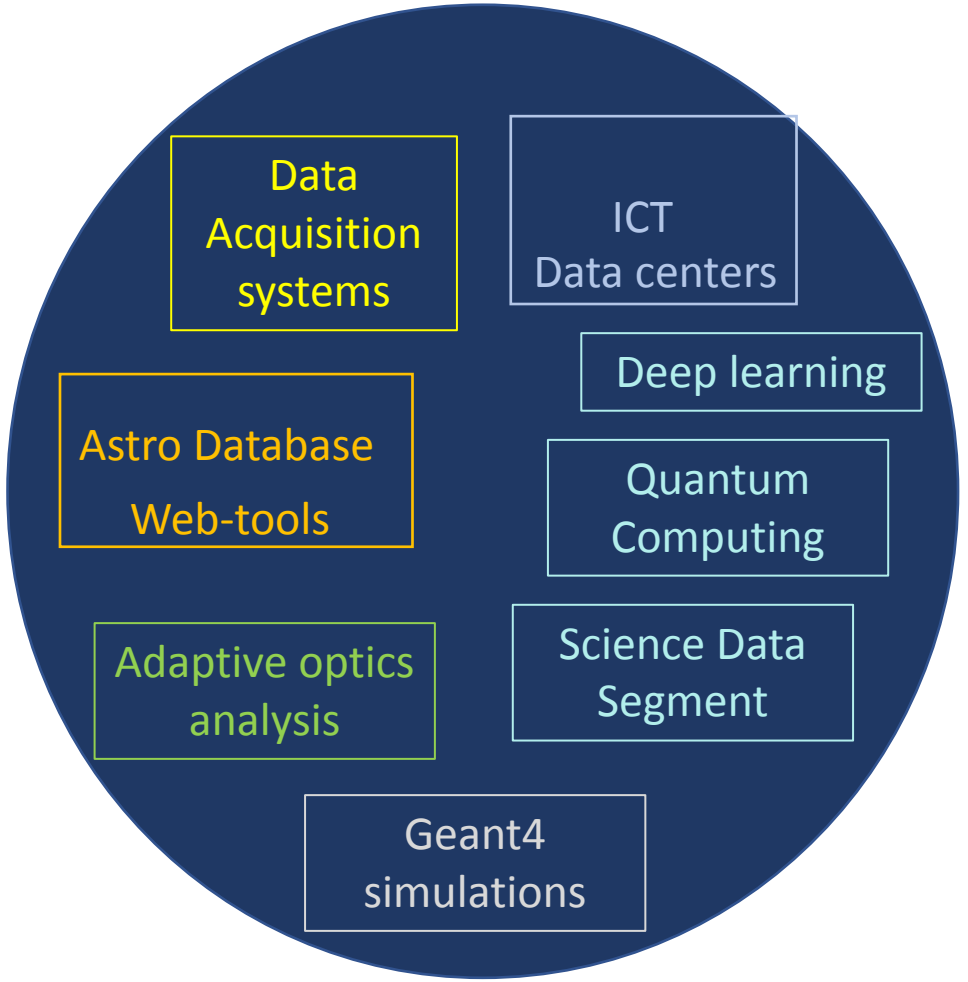
Cluster - Critical Issues and Development

- Lack of personnel, particularly CTER (only one person remains).
- Manage the deployment of scientific software on the cluster.
- We are identifying key individuals who can oversee various scientific software related to the different research areas that use the cluster as a computing tool.
- We have also identified some people who will assist us with the hardware of the data center in case of emergencies or during peak workload times.
- Continuous updates of hardware and software.

  (modules ➡ Container)

Computing research in OAS

A very important function of the CNR Datacenter is also to host the computers of Projects and Missions. In fact, OAS is rich in activities that require IT support in the sectors outlined on the side, which will be described in the following slides.



Computing research in OAS

- ASTRI TECHNOLOGICAL ACTIVITIES @OAS
- ASTRI-MA PROXMOX TEST BED @OAS
- LAB EGSE @ OAS
- DATA ACQUISITION SYSTEMS FOR SPACE AND GROUND TELESCOPES
- ASTRODBS & WEB TOOLS
- DEEP LEARNING RESEARCH ACTIVITY
- STARFINDER
- GEANT4 SIMULATIONS OF GROUND EXPERIMENTS AND SPACE MISSIONS
- ASTRI MINI-ARRAY: SCADA
- TELESCOPE CONTROL SYSTEM: TCS
- QUANTUM COMPUTING
- CTA OBSERVATORY SCIENCE ALERT GENERATION SYSTEM
- ARIEL INSTRUMENT OPERATION AND SCIENCE DATA CENTER
- EUCLID SPACE MISSION
- EUCLID NISP INSTRUMENT OPERATION
- AGILE: CONTRIBUTIONS TO GROUND SEGMENT
- ASTRI MINI-ARRAY: OBSERVATION QUALITY SYSTEM AND AUTOMATED SCIENCE PRODUCT GENERATION
- COSI: CONTRIBUTIONS TO GROUND SEGMENT

ASTRI Technological activities @OAS

- ASTRI Mini-Array
  - ASTRI software Deputy Software coordinator (A. Bulgarelli)
  - Responsibility of SCADA (A. Bulgarelli)
    - SCADA people: F. Russo, V. Conforti, N. Parmiggiani, V. Fioretti, L. Baroncelli, V. Pastore
  - Responsibility and development of the SCADA subsystems:
    - Telescope Control System (F. Russo)
    - On-Line Observation Quality System (N. Parmiggiani)
    - Array Data Acquisition System (V. Conforti)
  - **Responsible of the on-site ICT (F. Gianotti)**
  - Integration and deployment test bed (F. Gianotti, V. Conforti)
  - Software engineering activities and members of the software engineering team
  - Release Manager (V. Conforti)
  - Software Quality Assurance (V. Conforti)
  - Requirement, Architecture, Interfaces (A. Bulgarelli)
  - Interface Manager (A. Bulgarelli)
  - Responsibility of software in the ASTRI Data Center
    - Automated scientific analysis pipeline (N. Parmiggiani)
    - Cherenkov Camera Preprocessing (V. Conforti)

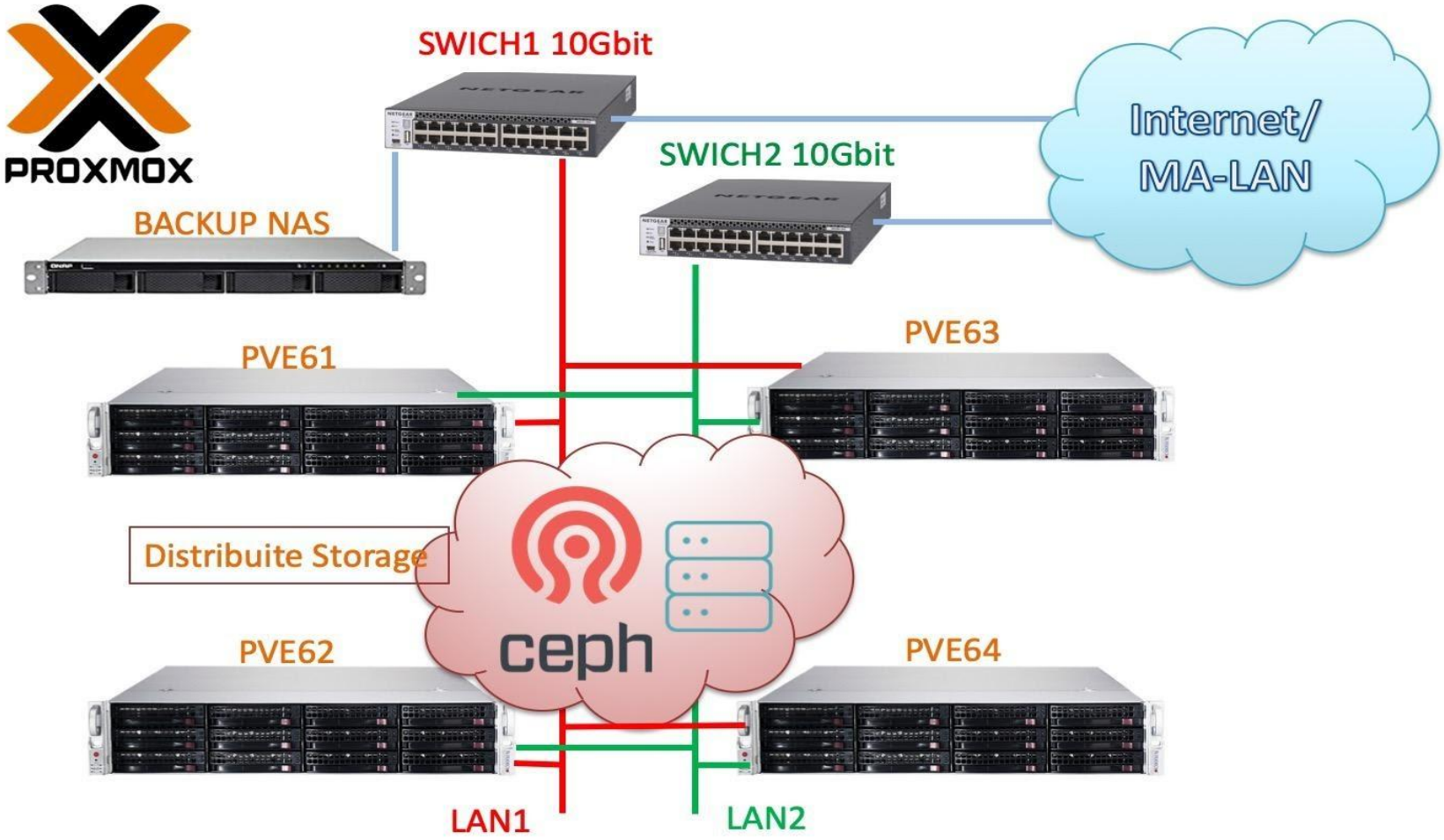
ASTRI-MA ProxMox Test Bed @OAS

With only 4 Hypervisor servers and 2x10Gbit switches we are able to virtualize what will be needed for the ASTRI Mini Array SW development, integration and test.

HW Resources:

- 160 Phis. Core
- 320 Thread
- 1 TB RAM
- 48TB SSD Storage Gross

This System was presented in INAF ICT Workshop Milan 2019

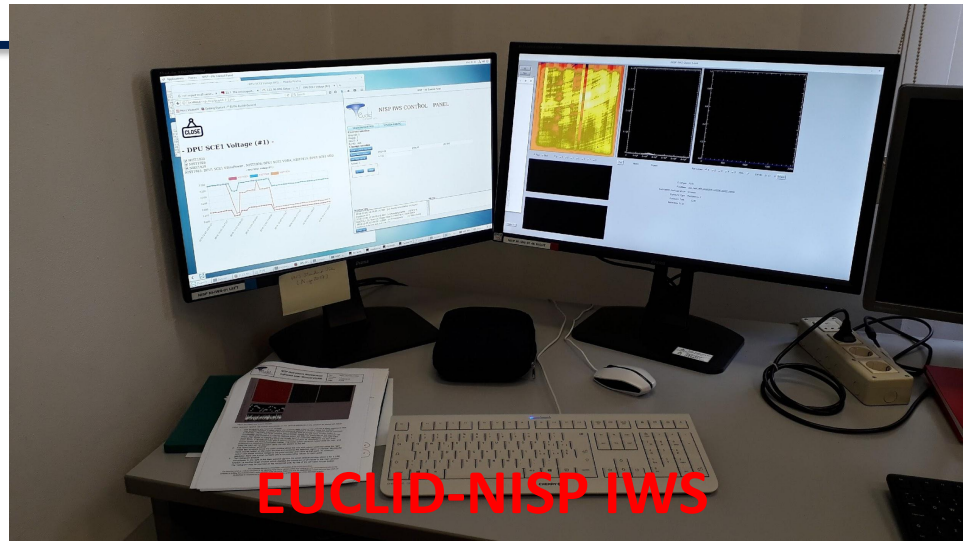


https://indico.ict.inaf.it/event/795/contributions/5131/#preview:5592

LAB EGSE @ OAS

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.

The activities that take place are:

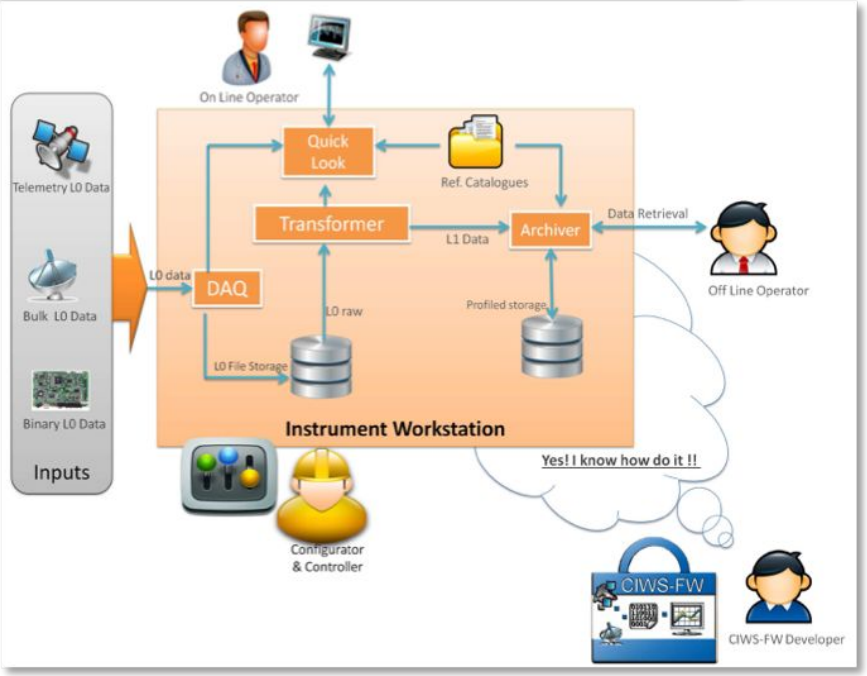
- Configuration of servers and workstations dedicated to EGSE of Satellites or ground experiments.
- Use of Workstation remotely or locally for Software development and testing.
- Integration of server and Workstation with each other or with Back End Electronic (BEE) electronic interface cards

PEOPLE:

- **Fulvio Gianotti:** LAB Responsible
- **Vito Conforti:**
- **Enrico Franceschi:**
- **Valerio Pastore**

Data acquisition systems for space and ground telescopes

- In 2012 CIWS-FW (Customizable Instrument Workstation System – Framework) was implemented to provide a common and standard solution for the **storage, processing and quick look at the data acquired from scientific instruments for astrophysics**.
- The CIWS-FW core includes software developed by team members for previous experiments and provides new components and tools that improve the software reusability, configurability and extensibility attributes.
- The Instrument Workstation for the **Euclid NISP**, the ASTRI-Horn Data AcQuisition System (DAQ) and the **ASTRI Mini-Array** Array Data Acquisition System (ADAS) exploit the CIWS-FW.
- We are working to improve performance and capabilities of CIWS-FW through «ricerca di base» funding in order to properly support the challenges of future ground projects and space missions. In addition a proposal for an INAF Techno grant has been submitted in order to include also the Back End Electronics to the CIWS-FW.



main phases: development, AIV, operations, maintenance

The core team of CIWS-FW: ***Vito Conforti****, Massimo Trifoglio,* ***Andrea Bulgarelli****,* ***Fulvio Gianotti****,* ***Enrico Franceschi****,* ***Luciano Nicastro****,* ***Mauro Dadina****, Ricky Smart, Roberto Morbidelli, Marco Frailis, Stefano Sartor, Andrea Zacchei, Marcello Lodi, Roberto Cirami, Fabio Pasian,* ***V. Fioretti****,* ***V. Pastore****.*

Contacts: Vito Conforti (vito.conforti@inaf.it)

AstroDBs & Web tools

- DIF / SID – *sky pixelisation*: https://github.com/lnicastro/DIF – https://github.com/lnicastro/SID
- SatSky – *satellites tracking*: https://sats.oas.inaf.it/ – https://github.com/lnicastro/SatSkyMap
- DBs in astronomy course: https://ross2.oas.inaf.it/wp/imprs18/
- **TOCats** – *Catalogues*: https://cats.oas.inaf.it/ – https://catsweb.oas.inaf.it/
- REMDB / GRAWITA – *Images*: http://ross.oas.inaf.it/REMDB/ – https://grawita.inaf.it/VSTbrowse/
- QSFIT / QUBRICS / GUCDS – *Spectra*:
  - https://qsfit.inaf.it/ – https://github.com/lnicastro/GFitViewer.jl a GFit web tool - https://gucds.inaf.it/

***TOCats* main collaboration with OATO**

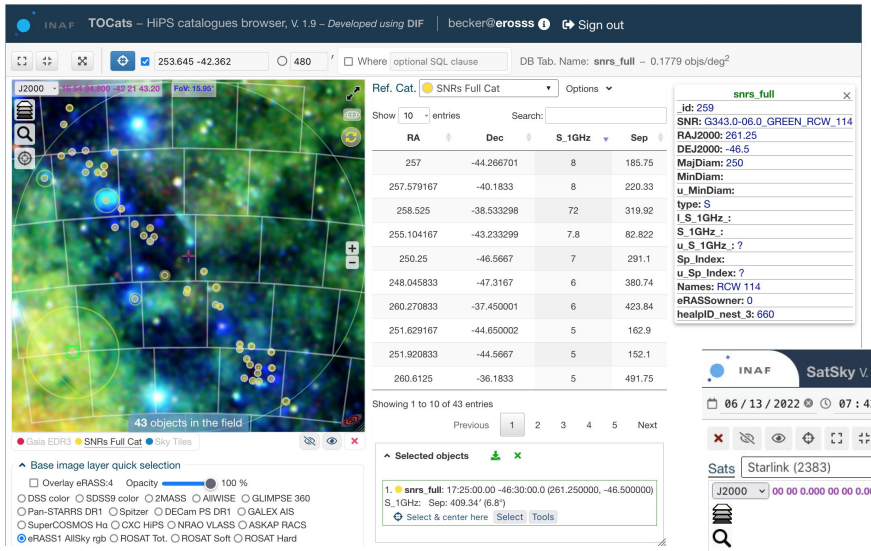
Main ingredients involved:

- DB server ⇒ MySQL/MariaDB
- Web server ⇒ Apache
- Language ⇒ HTML5, CSS3, PHP, JavaScript – JQuery

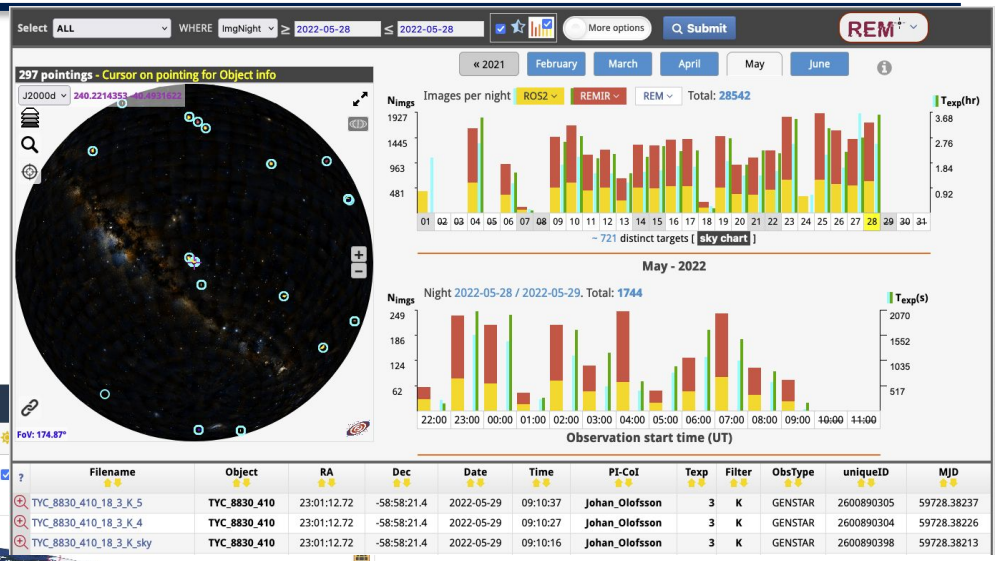
Main JS packages: *AladinLite, JS9, amCharts*

Contacts: Luciano Nicastro (luciano.nicastro@inaf.it)

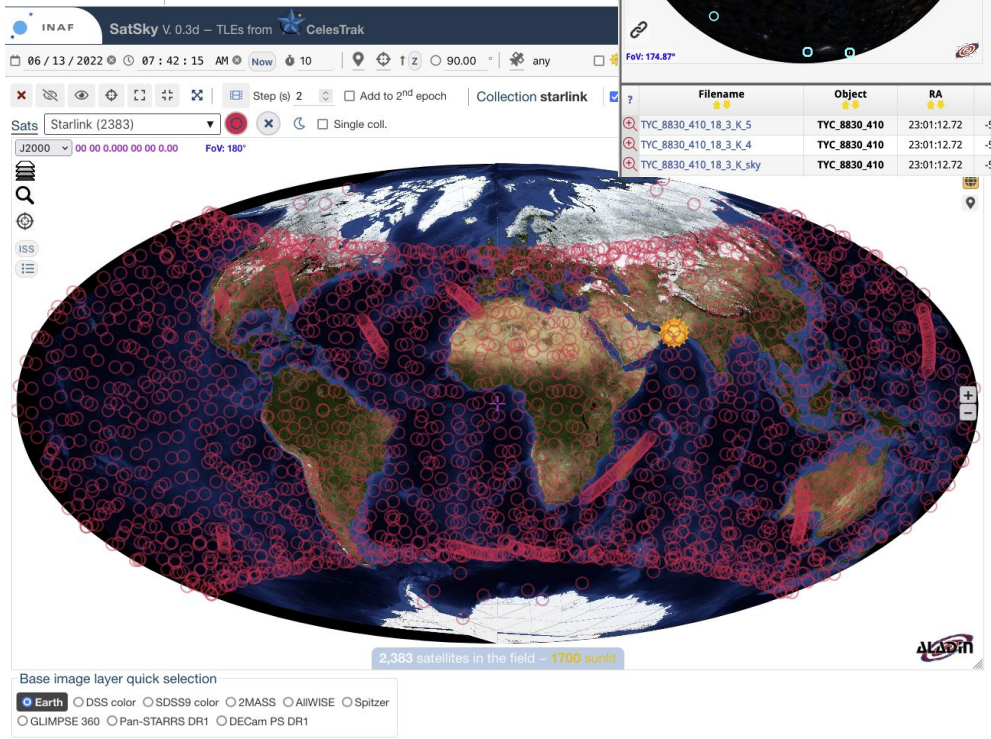
AstroDBs & Web tools



TOCats



REMDB



SatSky

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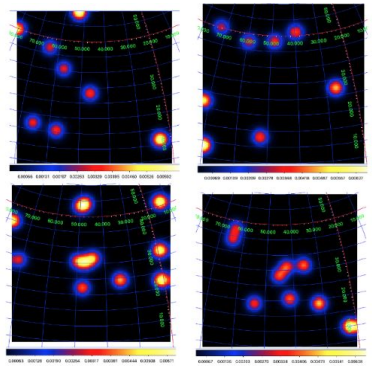
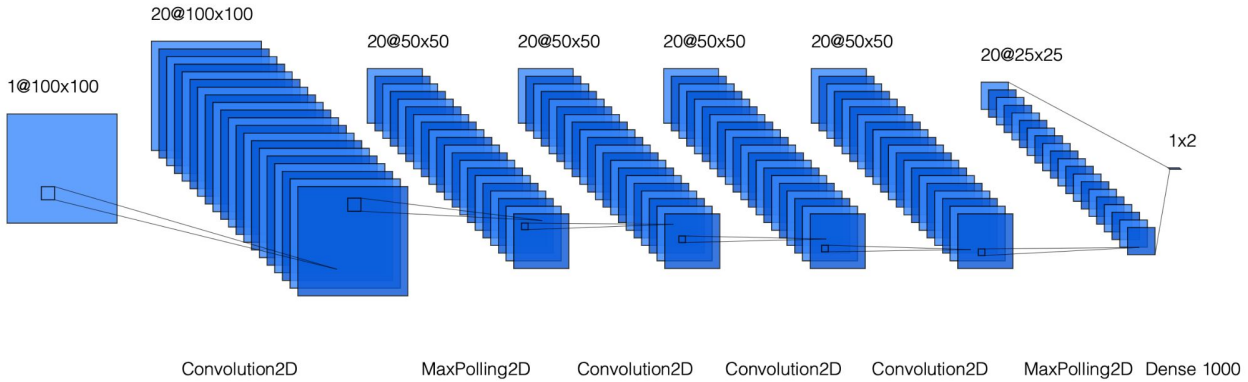
Deep Learning Research Activity

- This research aims to apply Machine Learning and in particular the Deep Learning technologies to analyse the data acquired by the AGILE detectors (**time series and sky maps**).
- Frameworks: Keras and Tensorflow
- GPUs: Nvidia Tesla (from k80 to V100)
- The first application was to develop a Deep Learning model to detect GRBs inside the AGILE/GRID counts maps when an external science alert is received.





- Publications and awards:

Parmiggiani N., Bulgarelli A., Fioretti V. et al. A Deep Learning Method for AGILE/GRID Gamma-ray Bursts detection, Astrophysical Journal, Volume 914, Issue 1, id.67, 12 pp (2021)

Parmiggiani, N., Italian National Prize for Artificial Intelligence and Big Data research, WMF and IFAB 2021. Media INAF

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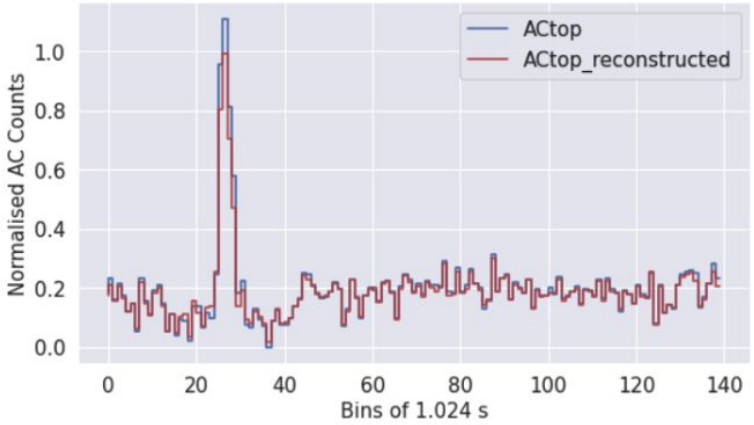
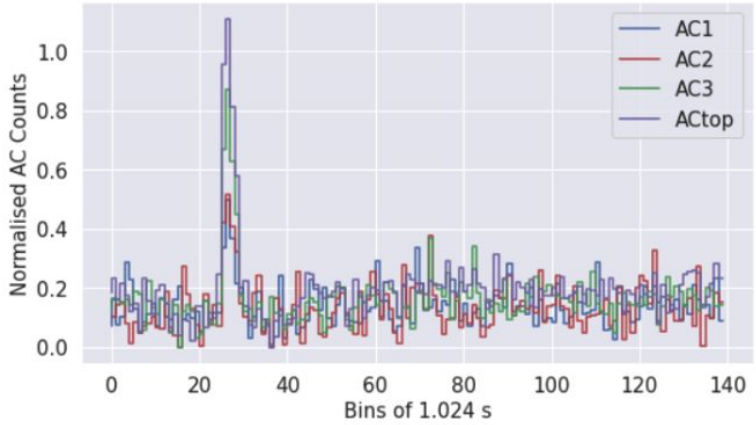
Deep Learning Research Activity

- Now we are developing a Deep Learning anomaly detection model to detect GRBs in the AGILE Anticoincidence System ratemeters





- Future applications: **AGILE real-time analysis pipelines**, **Cherenkov Telescope Array,** or the **COSI space mission**.

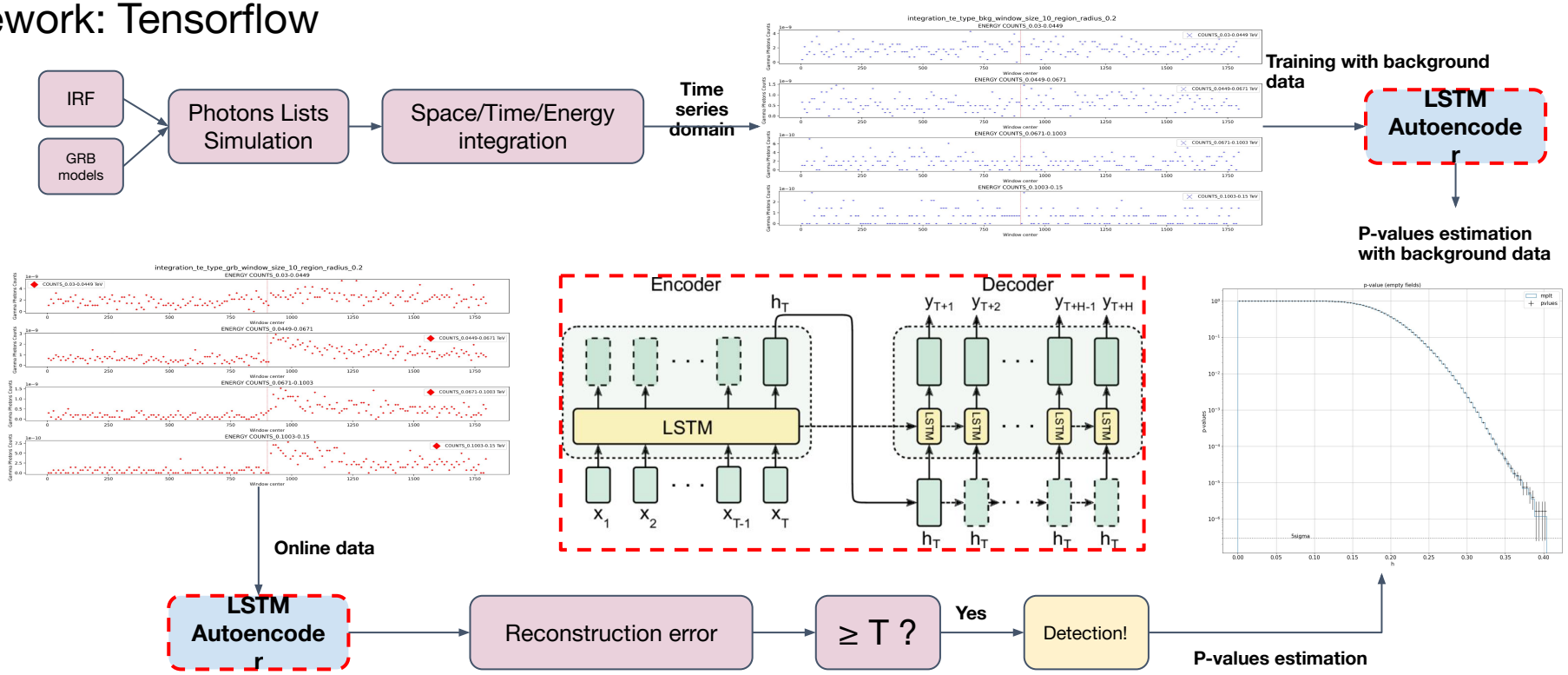
- Publications:

- Parmiggiani, N., A. Bulgarelli et al. “A deep learning anomaly detection method to identify Gamma-ray bursts in the ratemeters of the AGILE anti-coincidence system”, Astrophysical Journal, Volume 945, 2023.
- Parmiggiani, N., A. Bulgarelli et al., “Preliminary Results of a Deep Learning Anomaly Detection Method to Identify Gamma-Ray Bursts in the AGILE Anticoincidence System” ADASS 2021.

Contacts: Nicolò Parmiggiani (nicolo.parmiggiani@inaf.it), Andrea Bulgarelli (andrea.bulgarelli@inaf.it)

Deep Learning Research Activity

- Design and development of an online anomaly detection system for science alert generation, based on deep learning, in the context of the CTA Observatory.
- Framework: Tensorflow



Contacts: Leonardo Baroncelli (leonardo.baroncelli@inaf.it), Andrea Bulgarelli (andrea.bulgarelli@inaf.it)

STARFINDER

Software for **deep analysis of stellar fields, designed for Adaptive Optics (AO) well-sampled images, characterized by complex and highly structured Point Spread Function (PSF)**

Numerical PSF extracted directly from the image, to take into account the actual structure of the instrumental response and the atmospheric effects. An external user-defined PSF may also be loaded

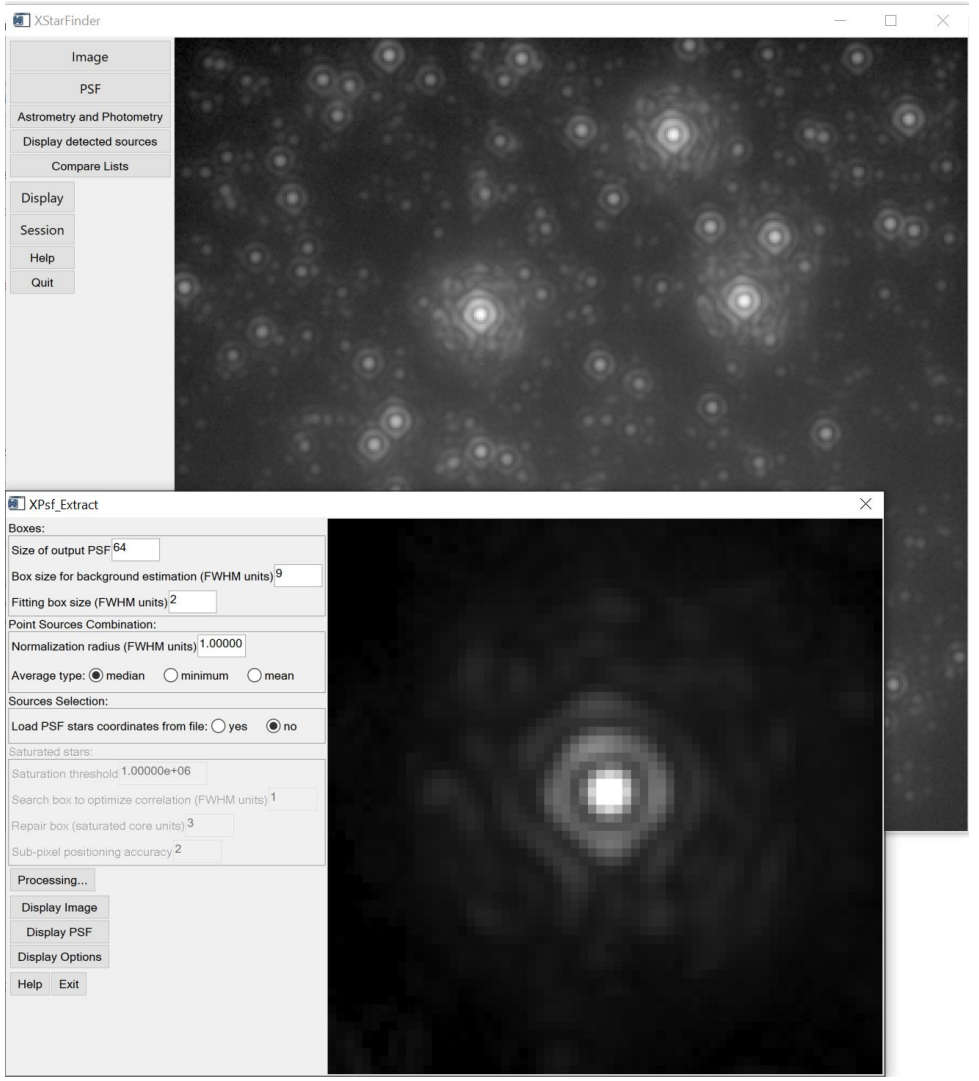
Starfinder is a public domain IDL® code
https://www.ict.inaf.it/gitlab/laura.schreiber/starfinder2

Self-contained widget-based application, provided with tools for data visualization and analysis

Widely used in AO community but also for space telescope data

On-going and future developments

- Method for spatially variable PSF (already in progress)
- Code translation to Python™



Main References:
[1] Diolaiti et al. 2000, A&A Sup, v.147, p.335-346
[2] Schreiber et al. 2020, Proc SPIE 114480H

Contacts: Laura Schreiber (laura.schreiber@inaf.it)

Geant4 simulations of ground experiments and space missions

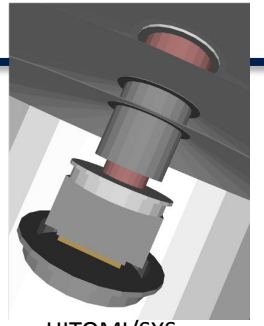
Geant4 is an open-source toolkit library for Monte Carlo particle transport simulations at high energies (from few eV). Based on C++, it allows to build a 3D mass model of the instrumentation and simulate the transport of particles through matter, with a variety of physics interaction libraries to choose from.

INAF OAS has become a center of reference for the development of **Geant4-based frameworks and applications**:

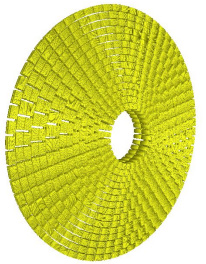
- BoGEMMS (Bologna Geant4 Multi-Mission Simulator), Geant4-based framework for the development of configurable and astronomy-oriented simulations
- Geant4 physics validation and implementation of new models, X-ray and Gamma-ray background simulation, instrument response definition, shielding optimisation and performance characterisation of high energy missions and instruments
- Participation in the ESA funded CTP projects AREMBES and EXACRAD, EU funded AHEAD2020 projects
- Simulation of Simbol-X, NHXM, ARGO-YBJ, FAMU, STACEX, XMM-Newton, ATHENA, ASTROGAM, COSI, AGILE, HITOMI, HERMES, eXTP, THESEUS, …

Latest publications:

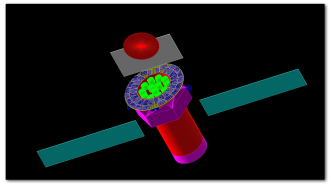
- V. Fioretti et al., Proc. SPIE, 118221F, 2021
- R. Campana et al., Proc. SPIE, 114448P, 2020



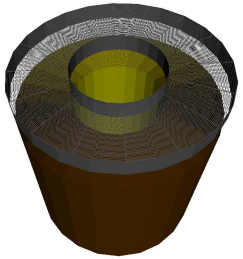
HITOMI/SXS



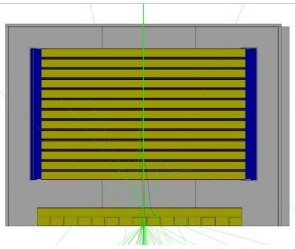
ATHENA/SPO



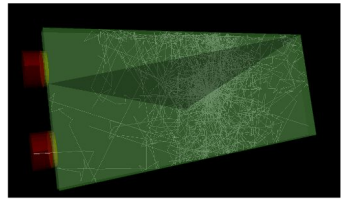
eXTP



XMM-Newton mirror



AGILE/GRID

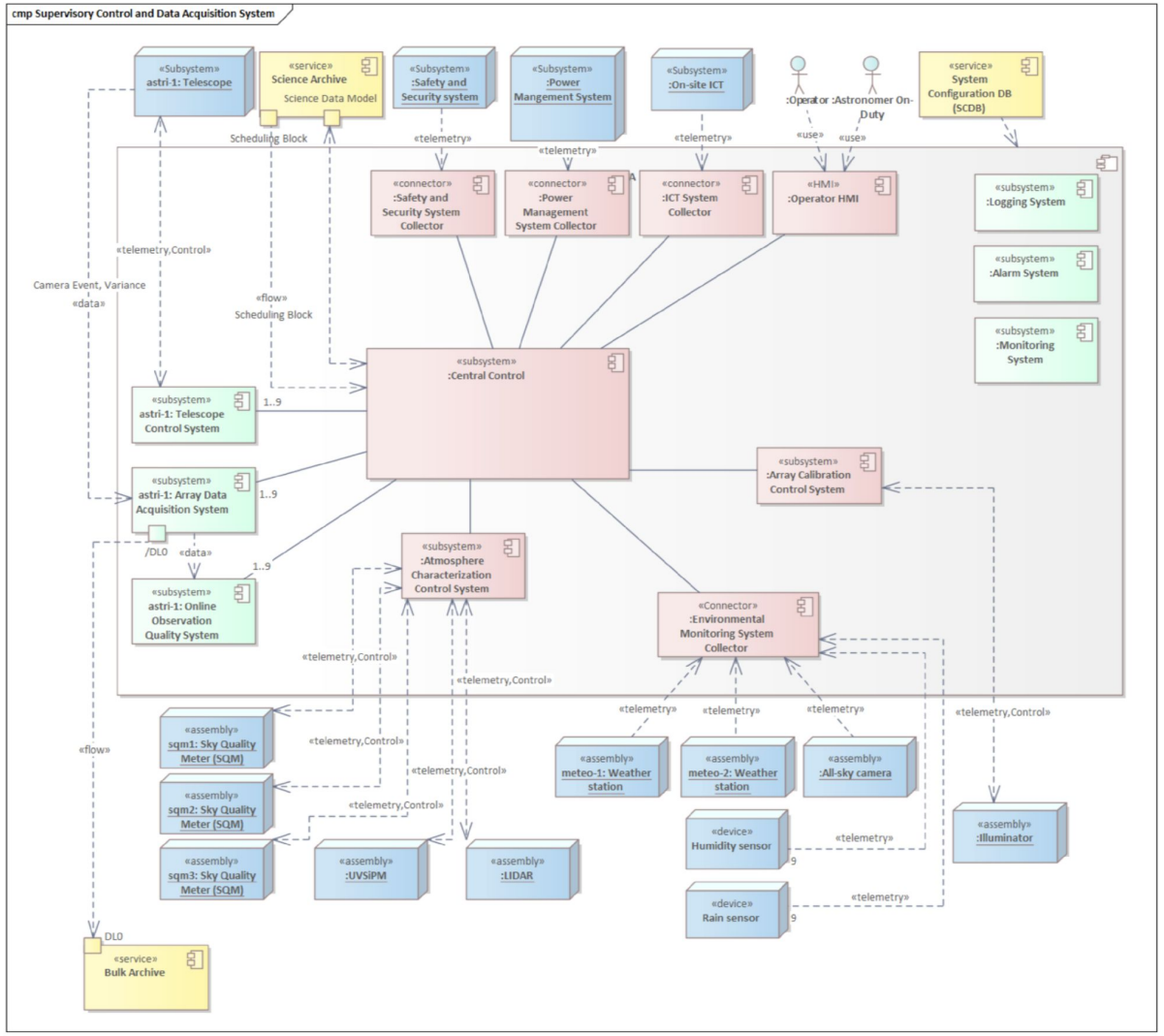


COSI/ACS

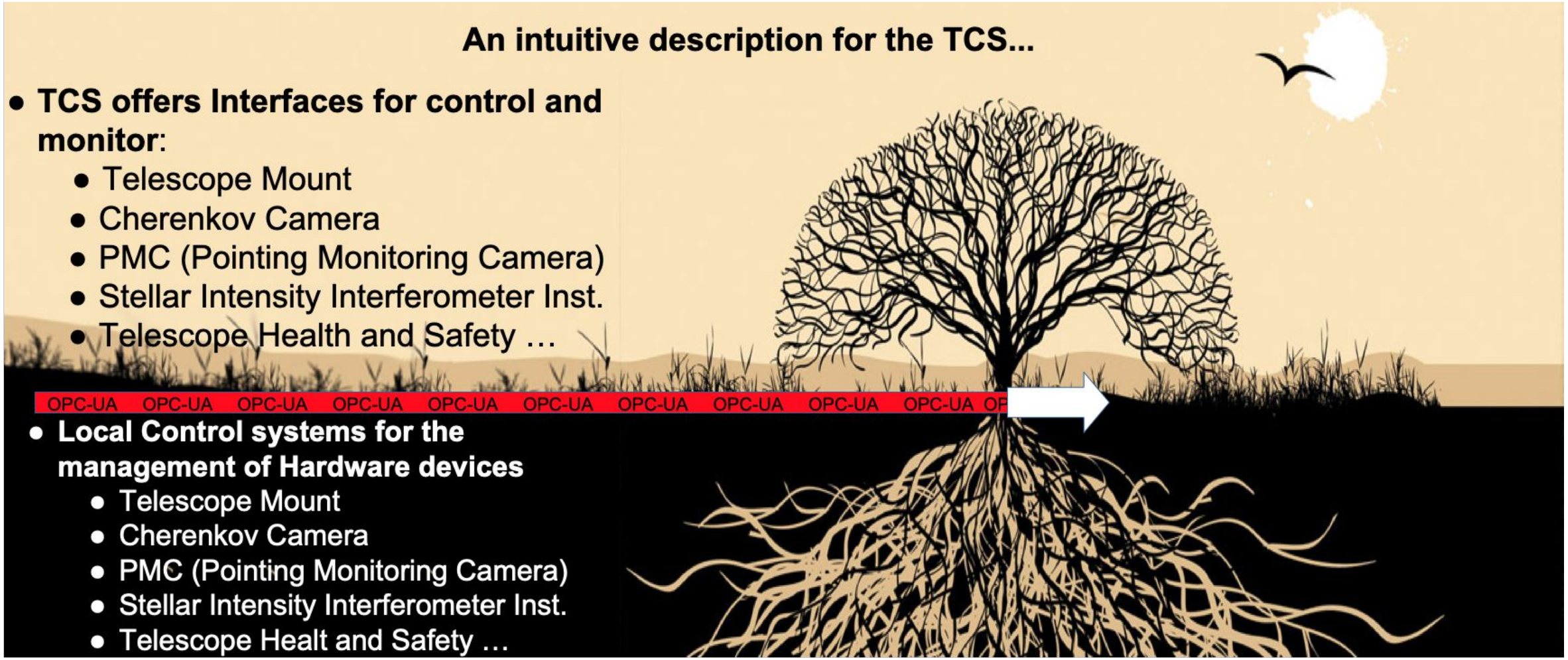
Contacts: Valentina Fioretti (valentina.fioretti@inaf.it), Riccardo Campana (riccardo.campana.inaf.it), Andrea Bulgarelli (andrea.bulgarelli@inaf.it)

ASTRI Mini-Array: SCADA

The Supervisory Control and Data Acquisition (SCADA) is an on-site software system controlling all the operations carried out at the MA site.
is a distributed software system based on Alma Common Software (ACS) that shall manage start-up, shutdown, configure, supervise and control of all site assemblies and subsystems.
SCADA is responsible for the execution of the observations and shall normally perform the operations in an automated way but is supervised by the Operator located in one of the ASTRI Control rooms.
SCADA collects monitoring points; manage alarms raised by any assembly; check the health status of all systems and acquire scientific data.
SCADA shall collect scientific data provided by the scientific instruments, logging, monitoring points, and alarms provided by the ASTRI MA assemblies, and provide online observation quality information to the Operator in order to assess the quality of data during the acquisition.

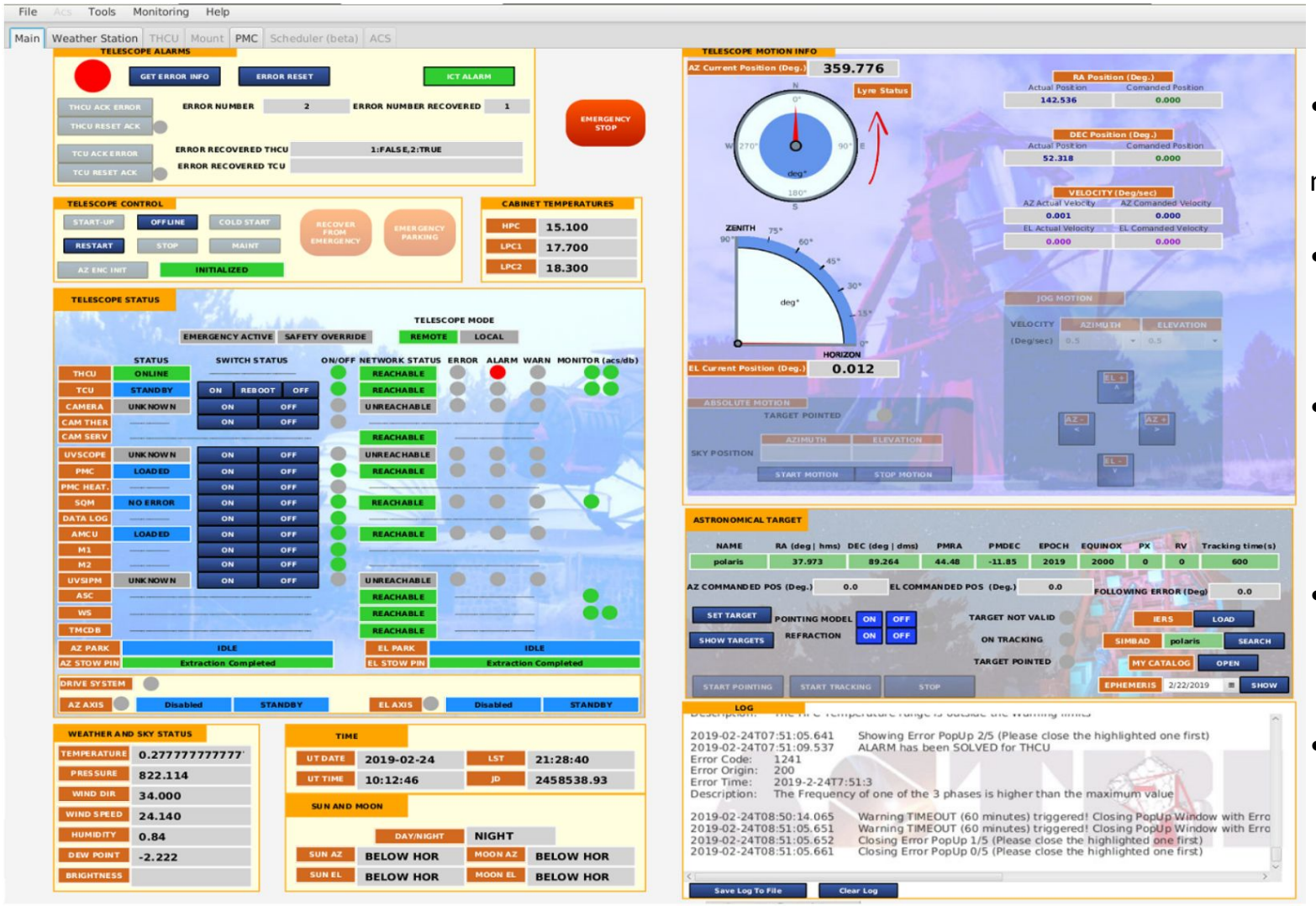


Telescope Control System: TCS



Contacts: Federico Russo

Telescope Control System: TCS



MAIN GUI FUNCTIONALITIES

- TELESCOPE CONTROL Window:
  - o Offers commands to change the telescope state machine (Start-up, parking and switch off procedure).
- TELESCOPE ALARM Window :
  - o Gives detailed information about the telescope current errors.
- TELESCOPE STATUS Window :
  - o Monitors the status of the devices on-board the telescope, theirs networks, Errors and Alarms.
  - o Commands the switch for on/off of the devices.
- TELESCOPE MOTION INFO window:
  - o Monitoring AZ and EL motion parameters.
  - o Commands Absolute and Jog Motions.
- ASTRONOMICAL TARGET window:
  - o Sets all the information required to point or track the current astronomical target.
  - o Monitors the tracking information (AZ/EL commanded positions, Following error etc.).
  - o Starts embedded tools to access astronomical catalogs (both from local data and from internet).

Telescope Control System: TCS

Development of software for embedded systems.

- real-time data acquisition on Red-Pitaya platforms (CPU+FPGA)
- quick-look

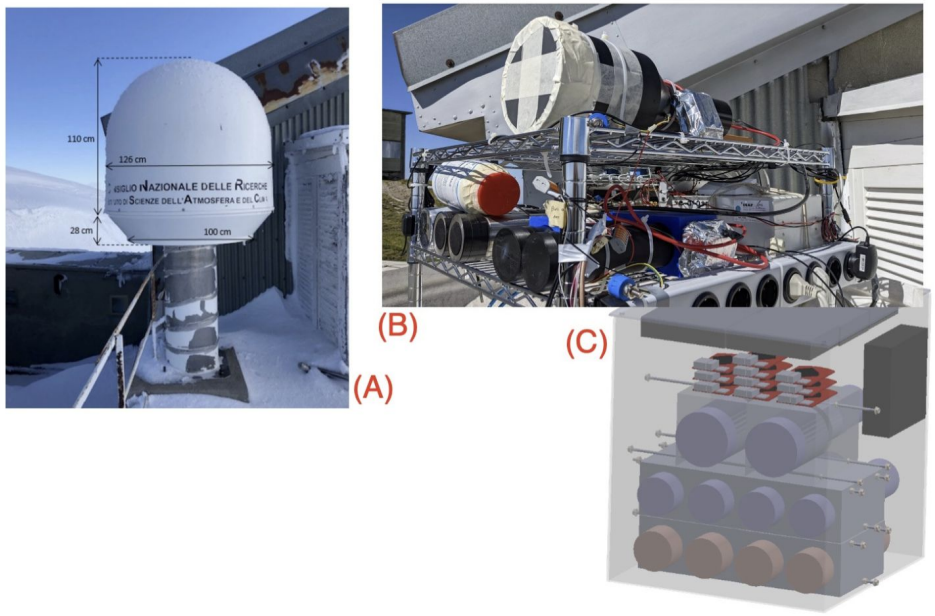
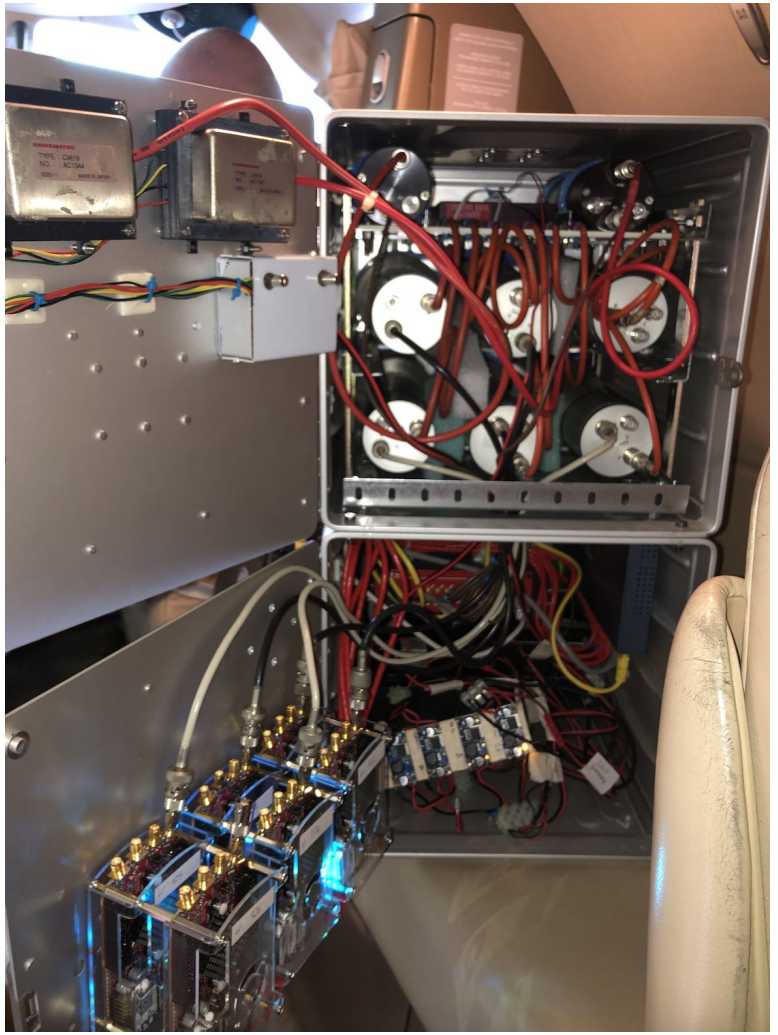


Figure 1. The Gamma-Flash experiment. (A) The dome where the detectors are placed. (B) Detail of the terrestrial setup, with five γ-ray detectors and three neutron detectors. (C) A model of the Gamma-Flash airborne payload on aircraft flying near the thunderstorm to collect information from a nearby position.



Contacts: Andrea Bulgarelli, A. Aboudan, E. Virgilli

Quantum Computing

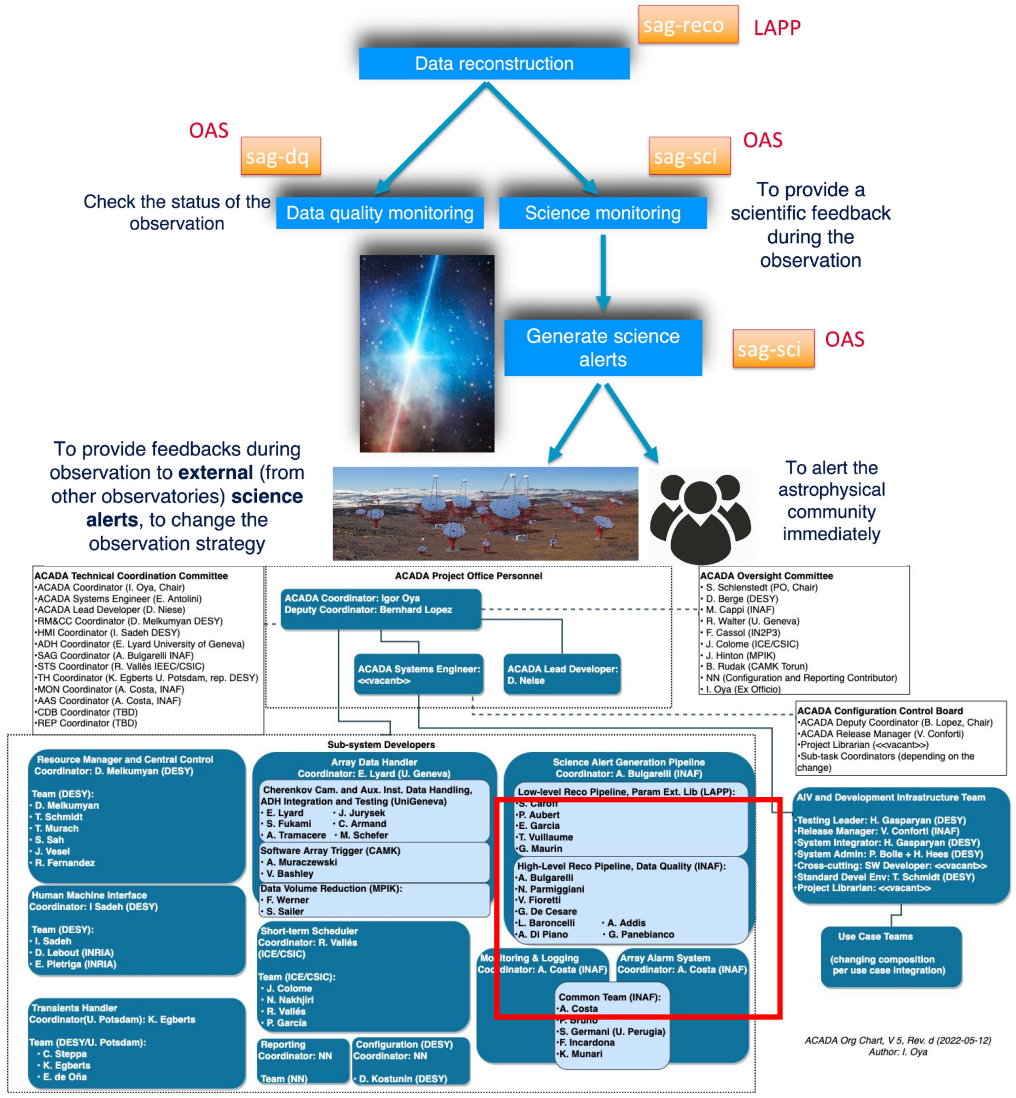
- Activities with ICSC/SPOKE 10
- Quantum machine learning
  - A Master student in Artificial Intelligence is working for his thesis on the implementation of a Quantum Deep Neural network based on Convolutional Neural Network to analyze the time-series acquired by the AGILE detectors.
  - This is a feasibility study to understand how quantum computing can be applied to already existing DL models and the improvements in term of performances that can be obtained.

Contacts: Andrea Bulgarelli, N. Parmiggiani

CTA OBSERVATORY SCIENCE ALERT GENERATION SYSTEM

- A **CTA Observatory/Array Control and Data Acquisition (ACADA)** work-package: **on-site** with the telescopes.
- On-line scientific analyses, **during the observation**. Input data rate: 5 GB/s
- The SAG must be capable of **issuing candidate science alerts with a latency of 20s** since data becomes available to ACADA.
- The ACADA/SAG is a key system in the context of **multi-messenger** and **multi-wavelength** astronomy.
- **AGILE heritage.**
- **Key expertise: HPC, Big Data, Deep Learning, software management**

People involved: A. Bulgarelli (responsible), N. Parmiggiani, V. Fioretti, G. De Cesare, L. Baroncelli, A. Di Piano, G. Panebianco



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ARIEL INSTRUMENT OPERATION AND SCIENCE DATA CENTER

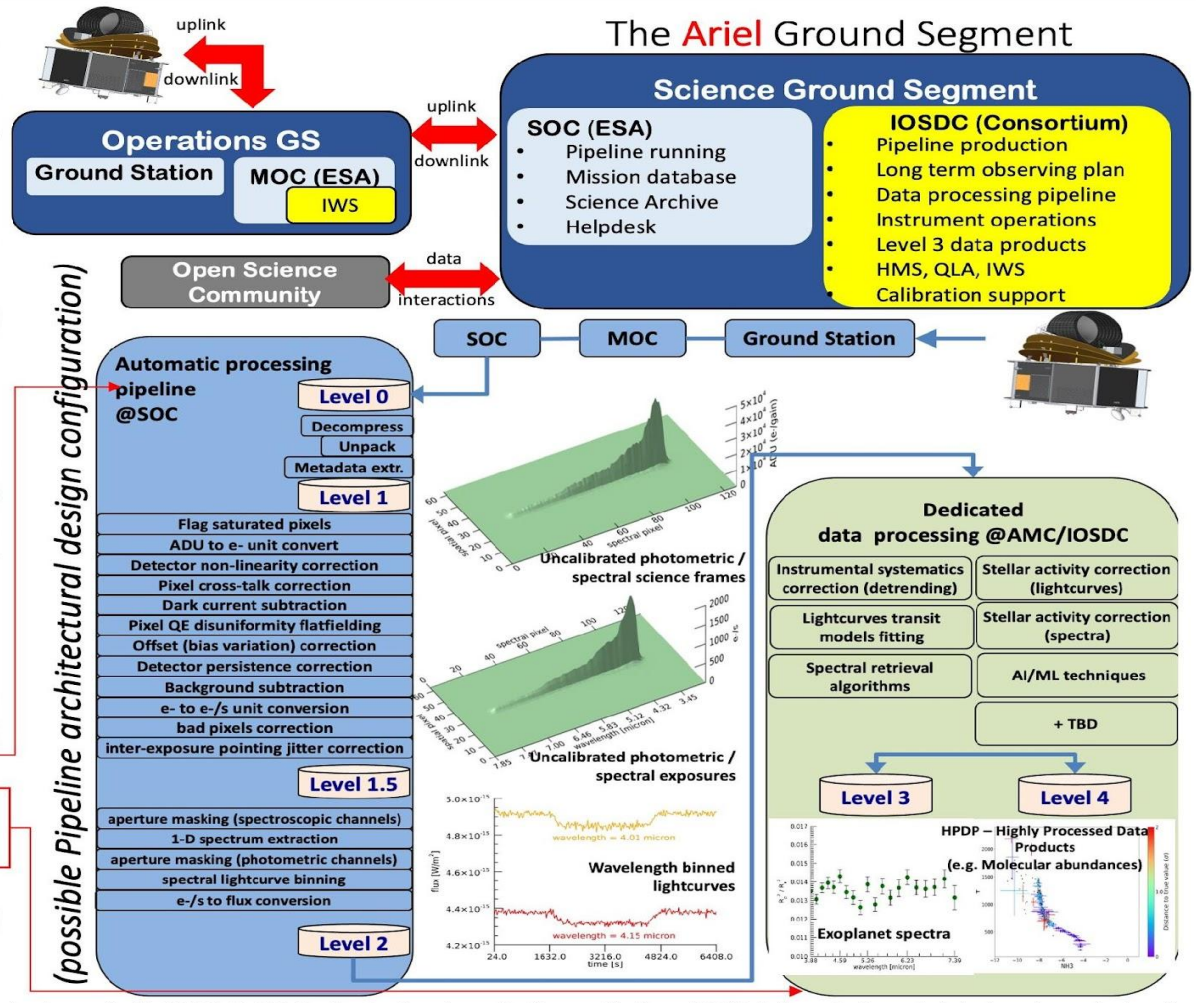
Ariel (Atmospheric Remote-sensing Infrared Exoplanet Large-survey), ESA Cosmic Vision M4 mission, will study composition, formation and evolution of exoplanets and their atmospheres, by surveying a diverse sample of ~1000 exoplanets, simultaneously in visible and infrared.

INAF roles in **Ariel** include: two CoPIs, Systems Teams and Science WG members, and the co-responsibility (jointly with RAL UK) of the **Instrument Operations and Science Data Centre** (**IOSDC**) within the Mission **Ground Segment** (GS).

Ariel GS is formed by the Operations Ground Segment (Ground Stations + MOC) and the **SGS - Science Ground Segment**. SGS is composed of the Science Operation Centre (SOC, c/o ESA), and **IOSDC**, under Consortium responsibility.

IOSDC key tasks and responsibilities include:

- **Data processing Pipeline** (running @SOC) for the production of **L1** (photometric/spectral images) and **L2** (target lightcurves),
- **L3** (exoplanets spectra) and **>L3** (Highly Processed Data Products, e.g. molecular abundances),
- **Long Term Observation Planning Tools**,
- **Health Monitoring Systems**, **Instrument WorkStation** and **Quick Look Analysis** tools,
- **Operations** and **Calibration** support.



(ASI support via Accordo N. 2021-5-HH.0 «Partecipazione italiana alla fase B2/C della missione Ariel» is acknowledged)

People involved: G. Malaguti (Co-PI), N. Auricchio, F. Cortecchia, E. Diolaiti, M. Lombini, G. Morgante, F. Schiavone, L. Schreiber, L. Terenzi

EUCLID SPACE MISSION

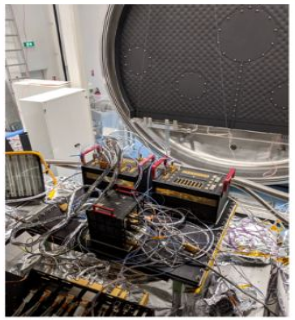
EUCLID SPACE MISSION

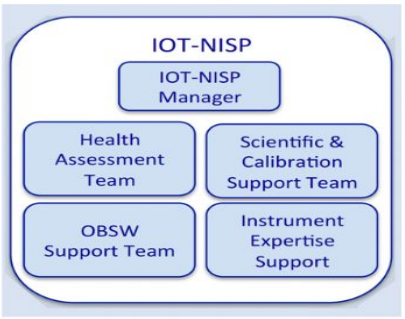
Euclid – Near Infrared Spectro-Photometer Instrument

- Euclid main science drive – dark matter and dark energy
- One of the two scientific instruments (together with a Visible imager)
- NISP main science goal – redshift determination of ~25 million galaxy spectra

- The data acquisition is governed by the Data Processing Unit (x2) running the Application Software (DPU-ASW) hangling the NI-Focal Plane interface, on-board data processing and transmission to the satellite mass memory.
- The Bologna is responsible of the DPU-ASW including maintenance and monitoring during operations. A laboratory equipped with the EQM models of the complete NISP instrument is located at Bologna.
- The ASW implements the ECSS standard using a RTOS (VxWorks5.1), is a multi-task preemptive scheduling algorithm.

- The Bologna team was on charge of the EGSE infrastructure used during the NISP warm electronics (DPU and Instrument Control Unit) tests. The CCS + SCOE equipments are part of the software maintenance setup.
- The Bologna team coordinates the NISP instrument operations during nominal operations – lunch foresee for 7th July 2023.



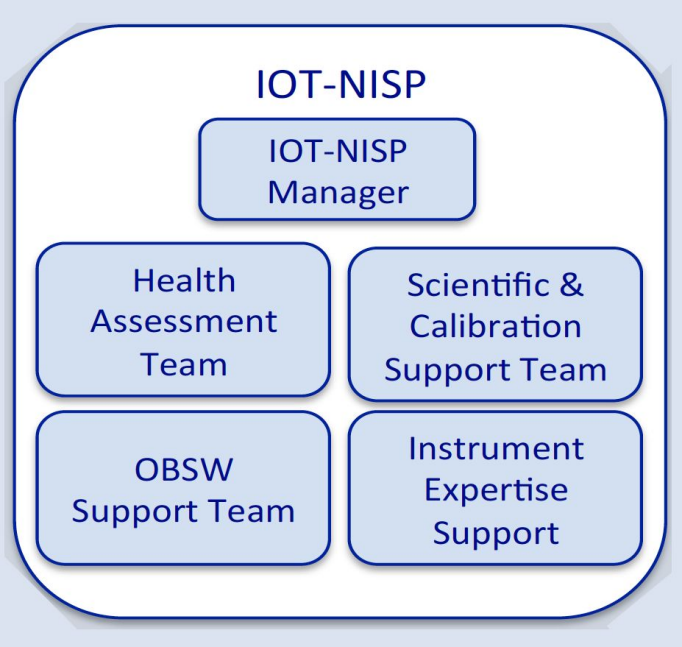


- Paola Battaglia NISP IOT Manager
- Natalia Auricchio NISP IOT member
- Ruben Farinelli NISP IOT/IDT member
- Enrico Franceschi NISP EGSE Manager
- Fulvio Gianotti NISP IOT member
- Eduardo Medinaceli NISP DPU-ASW Manager

EUCLID NISP INSTRUMENT OPERATION

- NISP (Near Infrared Spectrometer and Photometer) is a spectrophotometer (detectors cooled down to 100K).
- It is located in the focal plane of the ESA-Euclid telescope, together with a visual imager (VIS).
- Euclid scientific goal: to measure the expansion history of the Universe and the growth rate of cosmic structures (dark matter, dark energy).

The **Instrument Operation Team** (IOT) is an Euclid Consortium group that belongs to the Science Ground Segment (SGS).



- Paola Battaglia NISP IOT Manager
- Natalia Auricchio NISP IOT member
- Ruben Farinelli NISP IOT member
- Enrico Franceschi NISP IOT member
- Fulvio Gianotti NISP IOT member
- Eduardo Medinaceli NISP IOT member
- Massimo Trifoglio NISP IOT member

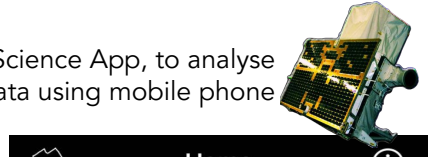
- The IOT is the connection point between EC SGS and Science Operation Center (led by ESA).
- **IOT NISP**:

1. is in charge of instrument maintenance and monitoring
2. will support SGS in the development of instrument operational modes

People involved: P. Battaglia (NISP IOT Manager), N. Auricchio, R. Farinelli, E. Franceschi, F. Gianotti, E. Medinaceli, M. Trifoglio

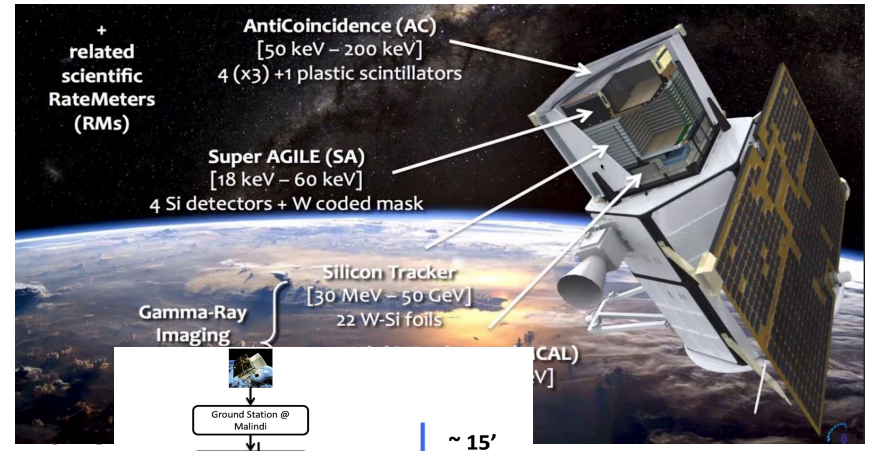
AGILE: CONTRIBUTIONS TO GROUND SEGMENT

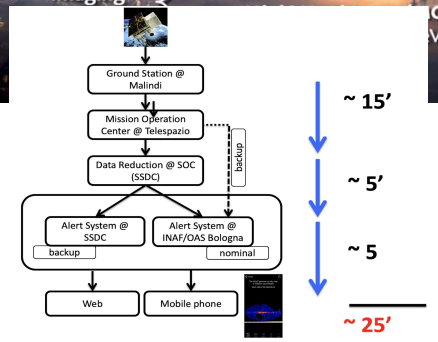
AGILEScience App, to analyse science data using mobile phone

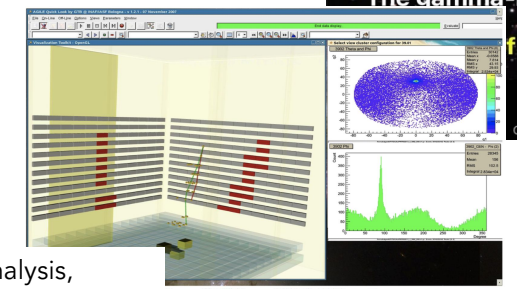


AGILE is fully operational, nominal status. **Contributions to ASI/SSDC Science Ground Segment**:

- AIV software
- AGILE P/L Health Monitoring System
- Telemetry Preprocessing System (from telemetry to FITS file)
- P/L Monte Carlo simulations
- New AGILE/GRID reconstruction techniques
- AGILE Science Tools with INAF/IASF Milano
- AGILEScience App
- Agilepy
- **AGILE Real-Time Analysis** @ OAS, backup chain @ ASI/SSDC: first scientific results are within 25 minutes from data downlink.
  - Since the beginning, the monitoring of the gamma-ray sky with a rapid and efficient alert system led the publication of
  - 204 Astronomer Telegram and 247 GCNs circulars.
  - AGILE follow-up of all GW events resulted in 96 GW-AGILE type GCNs.
  - From May 2019 automatic GCN notices on MCAL: more than 70 automated notices have been sent to the GCN network about GRBs without human intervention.
  - Many lessons learned after 15 years of operations.

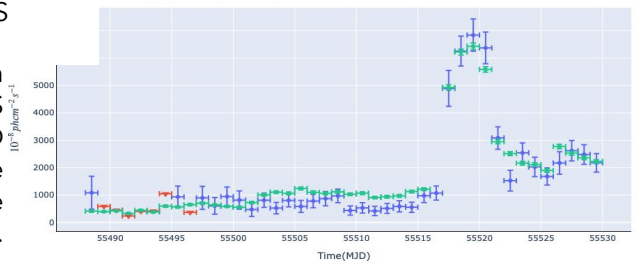






AGILE ground segment and real-time analysis, distributed between ASI/SSDC and INAF/OAS Bologna

Agilepy is an open-source Python package developed at INAF/OAS Bologna to analyse AGILE/GRID data built on top of the command-line version of the AGILE/GRID Science Tools.



People involved: A. Bulgarelli (responsible), M. Trifoglio, F. Gianotti, N. Parmiggiani, A. Addis, L. Baroncelli, V. Fioretti, A. De Rosa

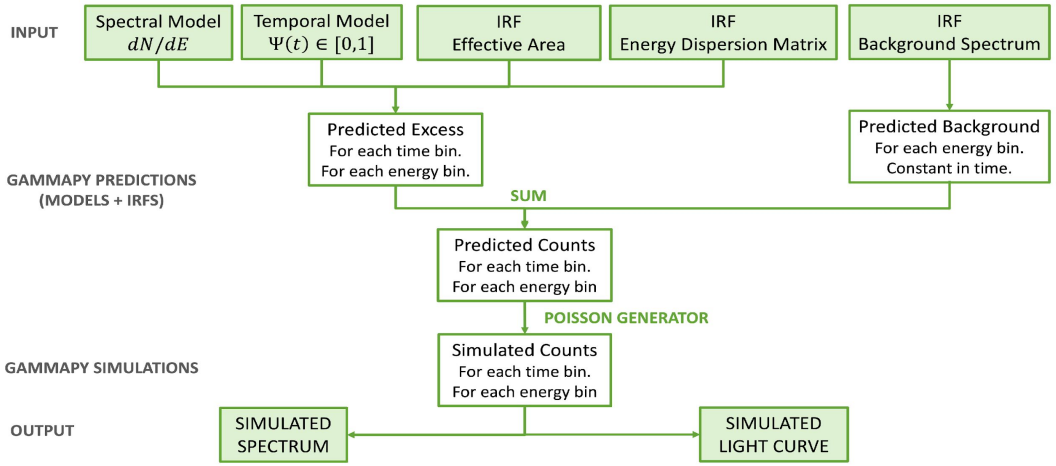
ASTRI MINI-ARRAY: OBSERVATION QUALITY SYSTEM AND AUTOMATED SCIENCE PRODUCT GENERATION

- The **On-Line Observation Quality System** is part of the ASTRI Mini-Array **on-site** SCADA software:
  - **execute data quality checks on the data acquired in real-time** by the Cherenkov camera and intensity interferometry instruments deployed in the nine ASTRI Mini-Array telescopes.
  - **high data rate** generated by the instruments (up to 4.5 GB/s for the intensity interferometry observations) and the Cherenkov event rate of 1000 Hz.
- The **Automated Science Product Generation Pipeline** of the ASTRI Mini-Array will be deployed in the **off-site data centre** in Rome **to execute automated scientific analysis**. It is part of the Data Processing System that manages the automated analyses starting from the raw data received from the Array Data Acquisition system on-site, to execute
  - **short-term analysis**: executed automatically as soon as the event list is received (~ 20 min since data acquisition)
  - **long-term analysis**: executed without time constraints and based on the best available calibration factors.

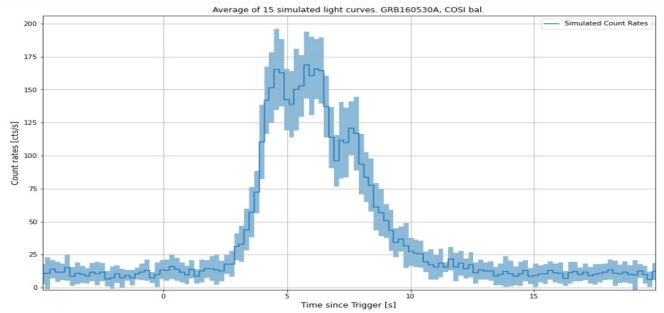
People involved: N. Parmiggiani (responsible), L. Baroncelli

COSI: CONTRIBUTIONS TO GROUND SEGMENT

- **COSI:** selected by NASA for the SMEX program. Launch: September 2025. The MeV band: a bridge between the thermal and non-thermal Universe.
- INAF/OAS involvement:
  - Data pipeline
  - P/L simulations
- **Development of a simulation tools for transients: light curve generator**
  - Create a random GRB light curve, and polarization distribution according to different models, starting from e.g. GBM catalogues, determine spectral and temporal model distributions for short and long GRBs.
  - Include other transients: SGRs, AGN, solar flares, and other relevant transients.
  - Sub-project: light curve generation using neural networks such as VAEs, GANs, LSTM / RNNs to create new random light curves with similar properties than the real ones.



Workflow for light curve generation



Light curve simulation of a GBM GRB using COSI instrument response functions

People involved: G. Panebianco, A. Bulgarelli, V. Fioretti, A. Di Piano, N. Parmiggiani, A. Ciabattoni

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THE END