Tecnologie informatiche @OAS Bologna

V. Fioretti, L. Baroncelli, V. Conforti, F. Gianotti, L. Nicastro, N. Parmiggiani, L. Schreiber

CSN5 Forum della Ricerca Sperimentale e Tecnologica in INAF – 23 Giugno 2022 Bologna
Sessione **Tecnologie informatiche**

La ricerca informatica in OAS

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Ricercatore OAS

Data Acquisition systems

ICT Data centers

Astro Database Web-tools

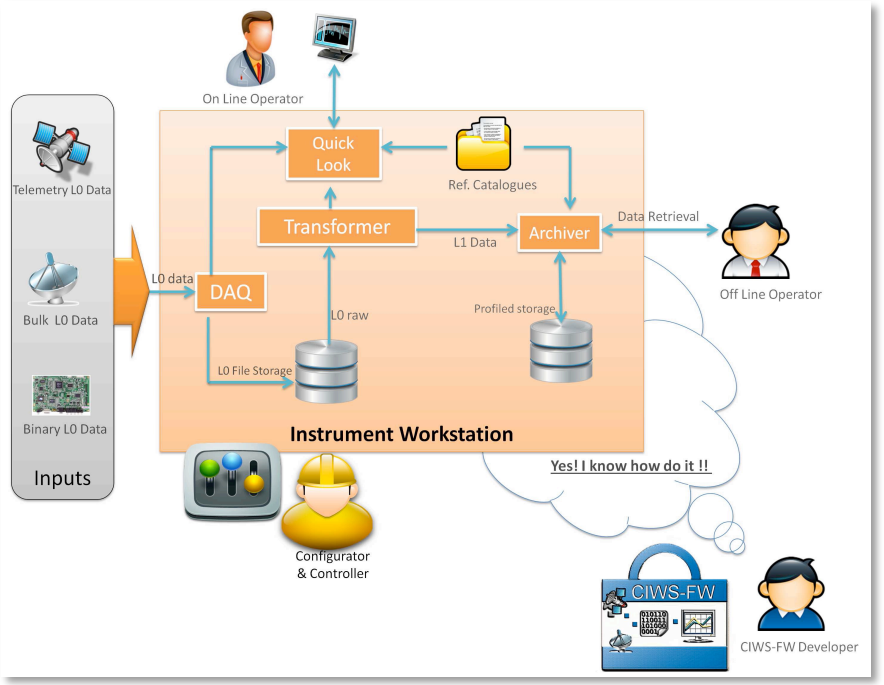
Deep learning

Adaptive optics analysis

Geant4 simulations

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 propely 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.



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****.*

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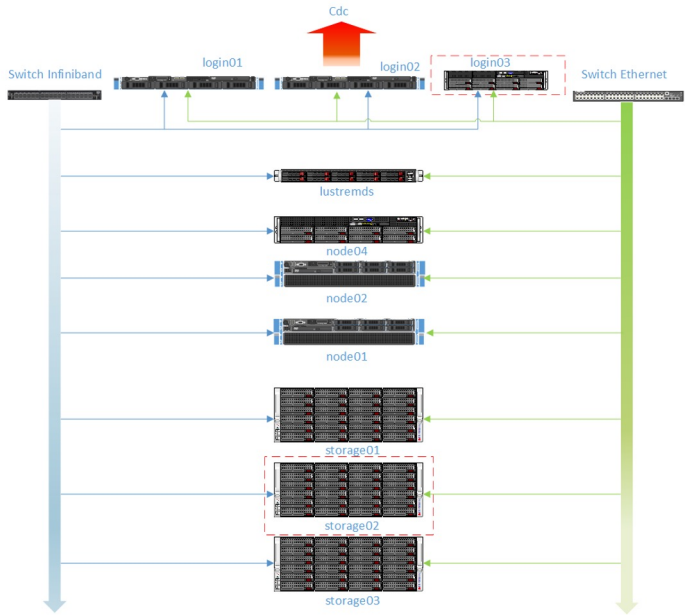
ICT infrastructure @ OAS

In OAS we have acquired an important experience in the Design, Construction and Management of important IT infrastructures dedicated to astrophysics, this experience is divided into:

- **Creation of an institute data center**
- **Creation of On-Site ICT Infrastructures**

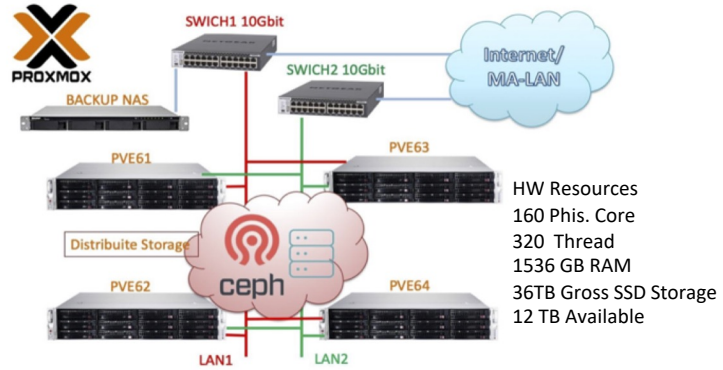


OAS Cluster

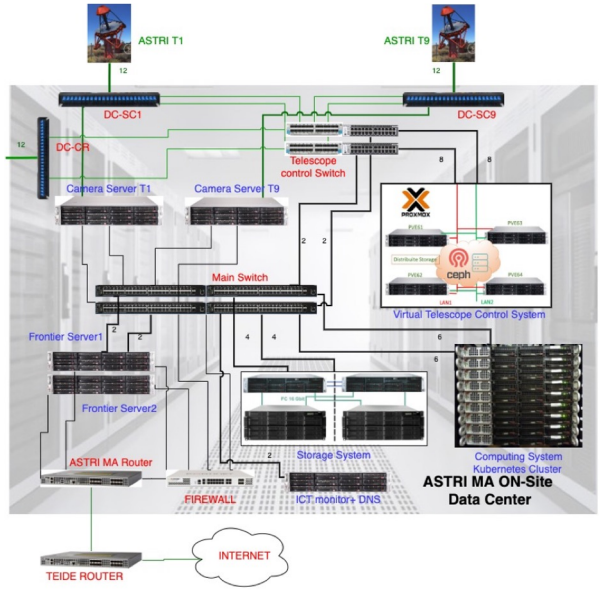
The OAS Compute Cluster consists of 3 login nodes and 3 batch and iterative compute nodes and is based on the FileSytem LUSTER file.

OAS Data Center

The OAS Data Center consists of 8 racks, fast network up to 10Gbit / s, UPS, Generator and redundant connection system. This is suitable for hosting the institute's computing cluster, services such as Media INAF, EDU-INAF and suitable for hosting the servers of important projects such as ASTRI, EUCLID.
The Computing Center also hosts the IT infrastructures of CTAO -Project Office.



HW Resources
160 Phis. Core
320 Thread
1536 GB RAM
36TB Gross SSD Storage
12 TB Available



ASTRI-MA On-Site ICT

The most important On-Site structure is the one for ASTRI-MA which will soon be installed in the Teide Observatory and which consists of all the subsystems to Control the Telescopes, Acquire Scientific Data and transfer them to Italy

ProxMox Virtual System

An important infrastructure Designed in OAS is the ProxMox Virtualization system shown in the figure which is used in the Data Center, but also in ASTRI-MA and by CTA

Core team: F. Gianotti, A. Tacchini, A. De Rosa, M. Bottura

Contacts: Fulvio Gianotti (fulvio.gianotti@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**

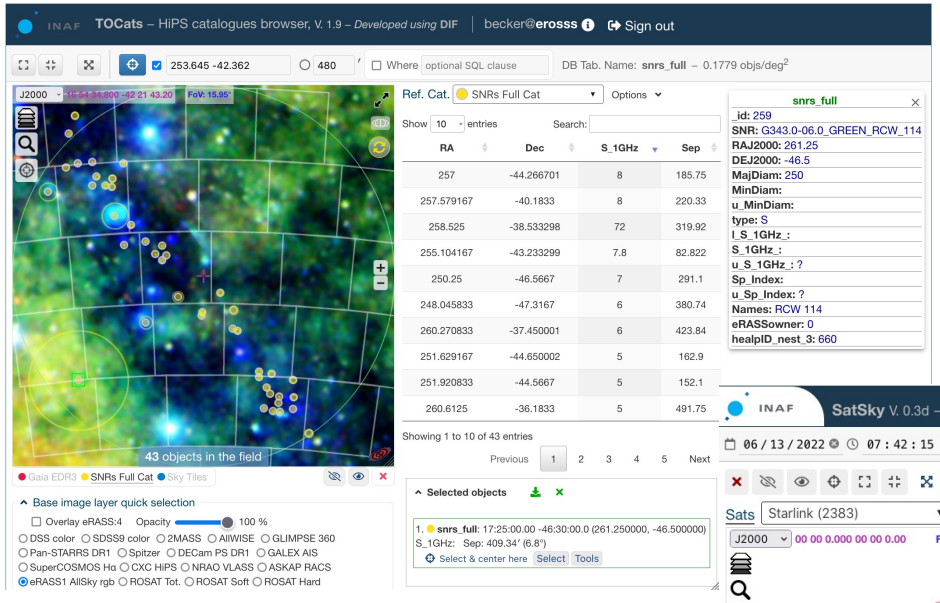
Main ingredients involved:

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

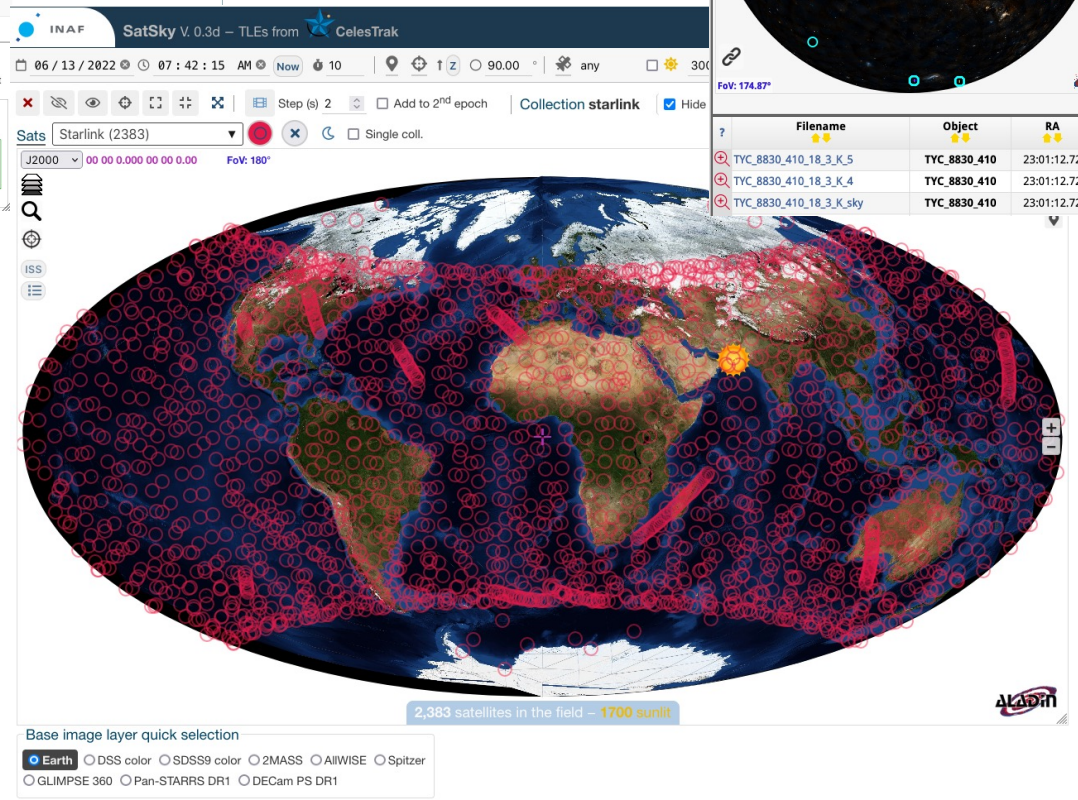
Main JS packages: *AladinLite, JS9, amCharts*

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

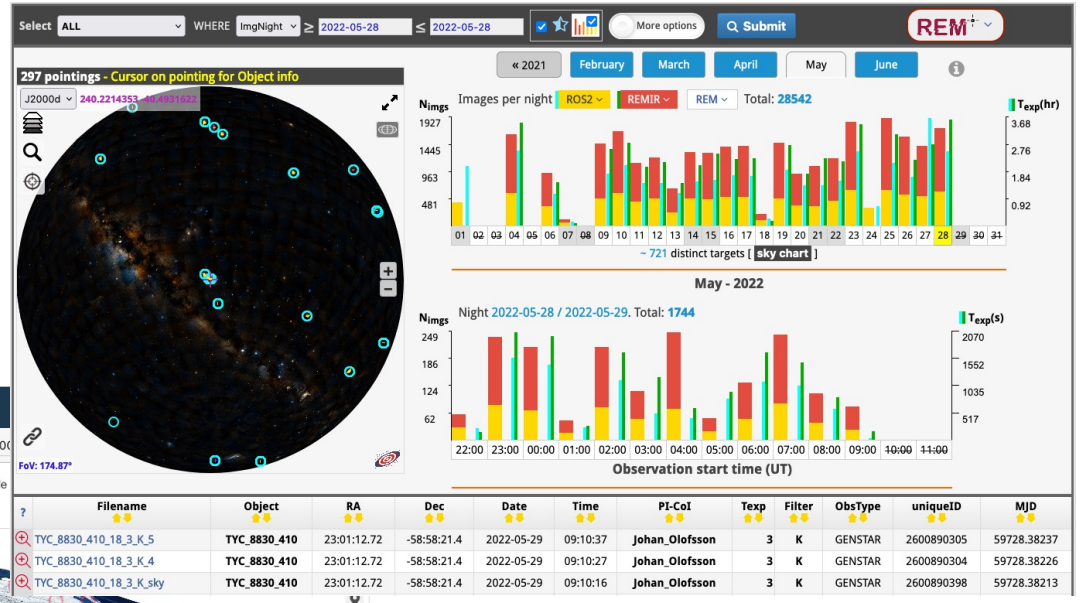
AstroDBs & Web tools



TOCats



SatSky



REMDB

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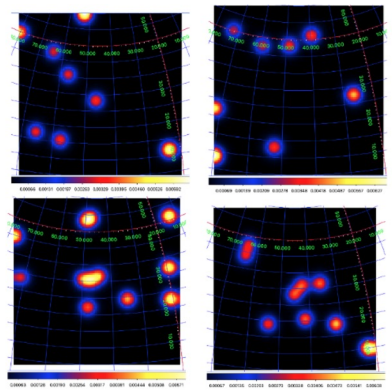
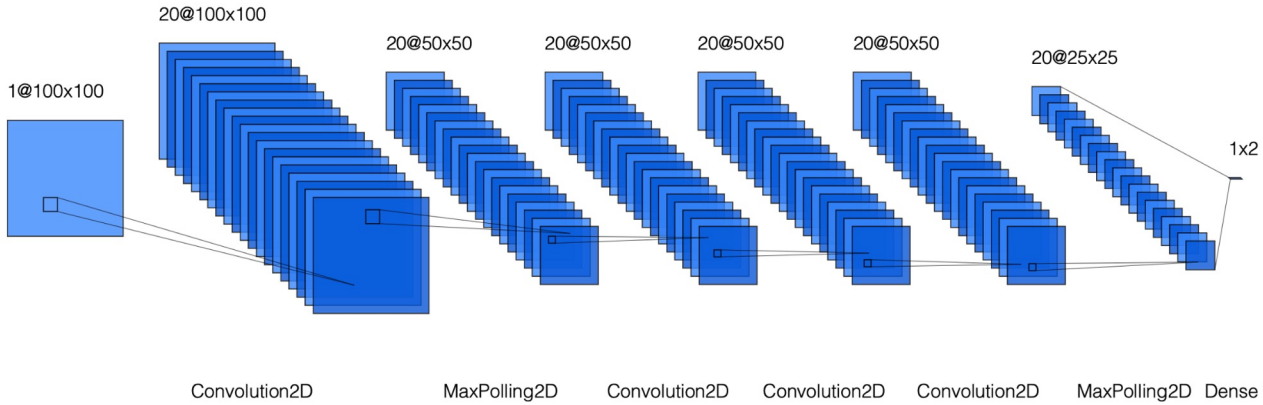
Deep Learning Research Activity

- 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:

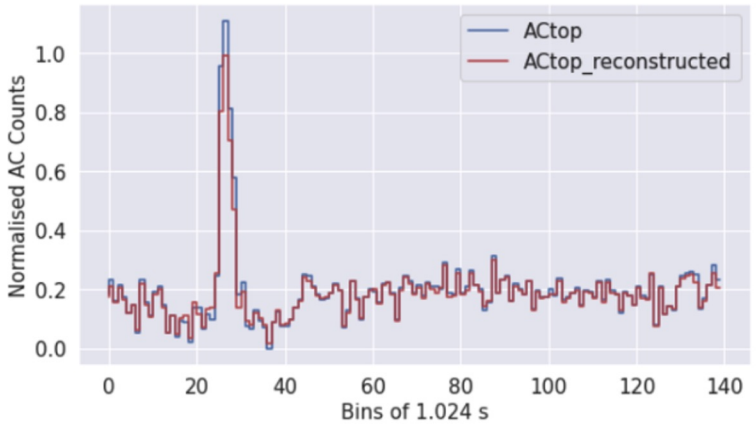
Parmiggiani N., Bulgarelli A., Fioretti V. et al. A Deep Learning Method for AGILE/GRID Gamma-ray Bursts detection, Astrophysical Journal, Volume 914, Issue 1, id.67, 12 pp (2021)

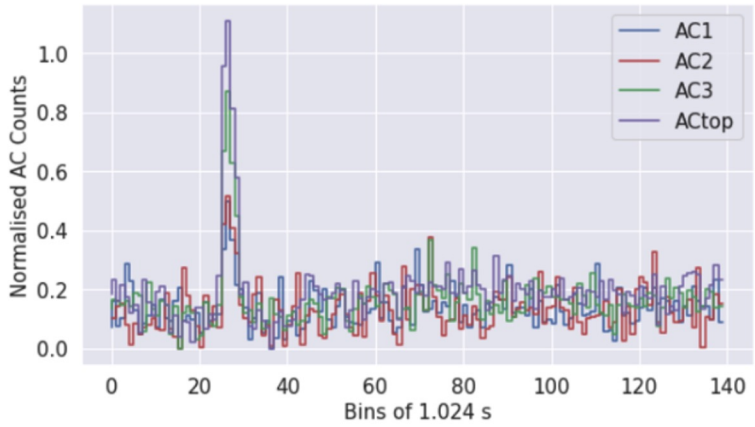
Parmiggiani, N., Italian National Prize for Artificial Intelligence and Big Data research, WMF and IFAB 2021. Media INAF

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

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:

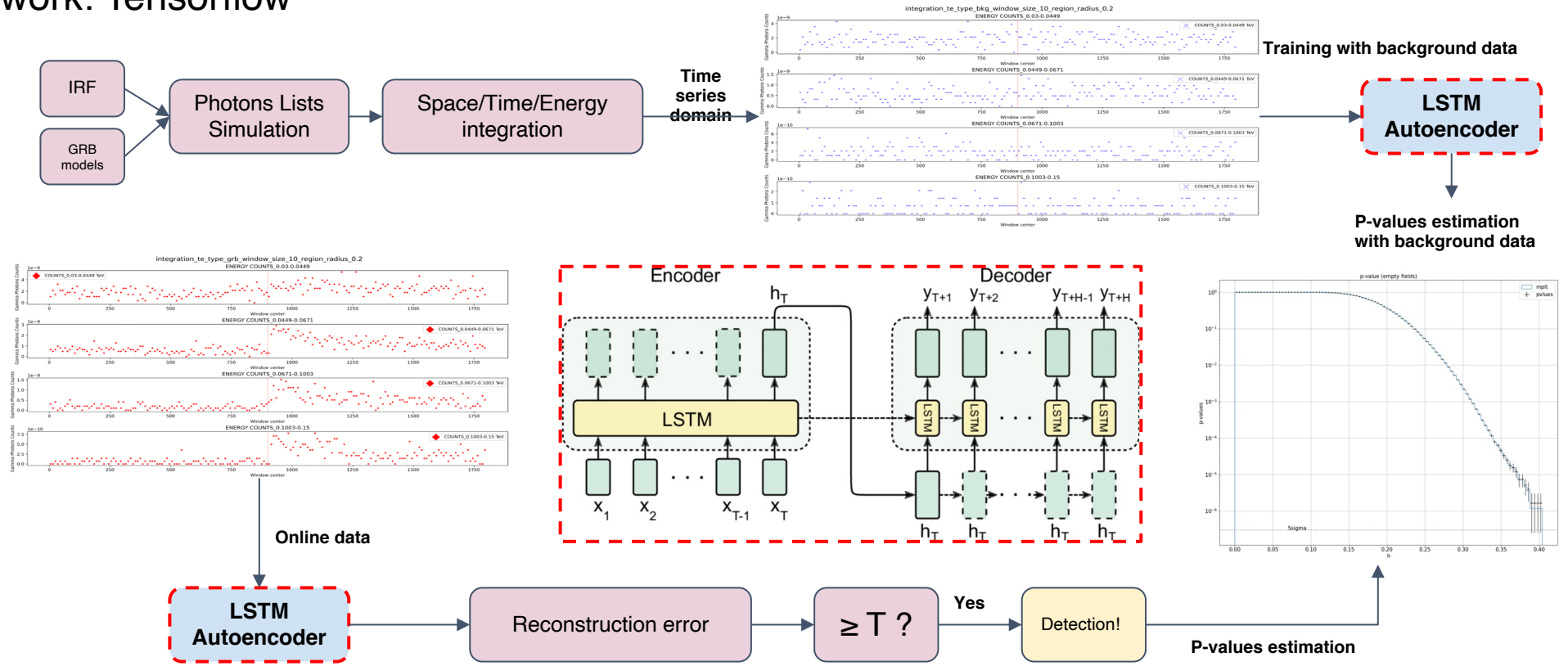
Parmiggiani, N., A. Bulgarelli et al., "Preliminary Results of a Deep Learning Anomaly Detection Method to Identify Gamma-Ray Bursts in the AGILE Anticoincidence System" ADASS 2021.

- The paper for **ApJ** is in preparation with additional demonstrations and results.

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)

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

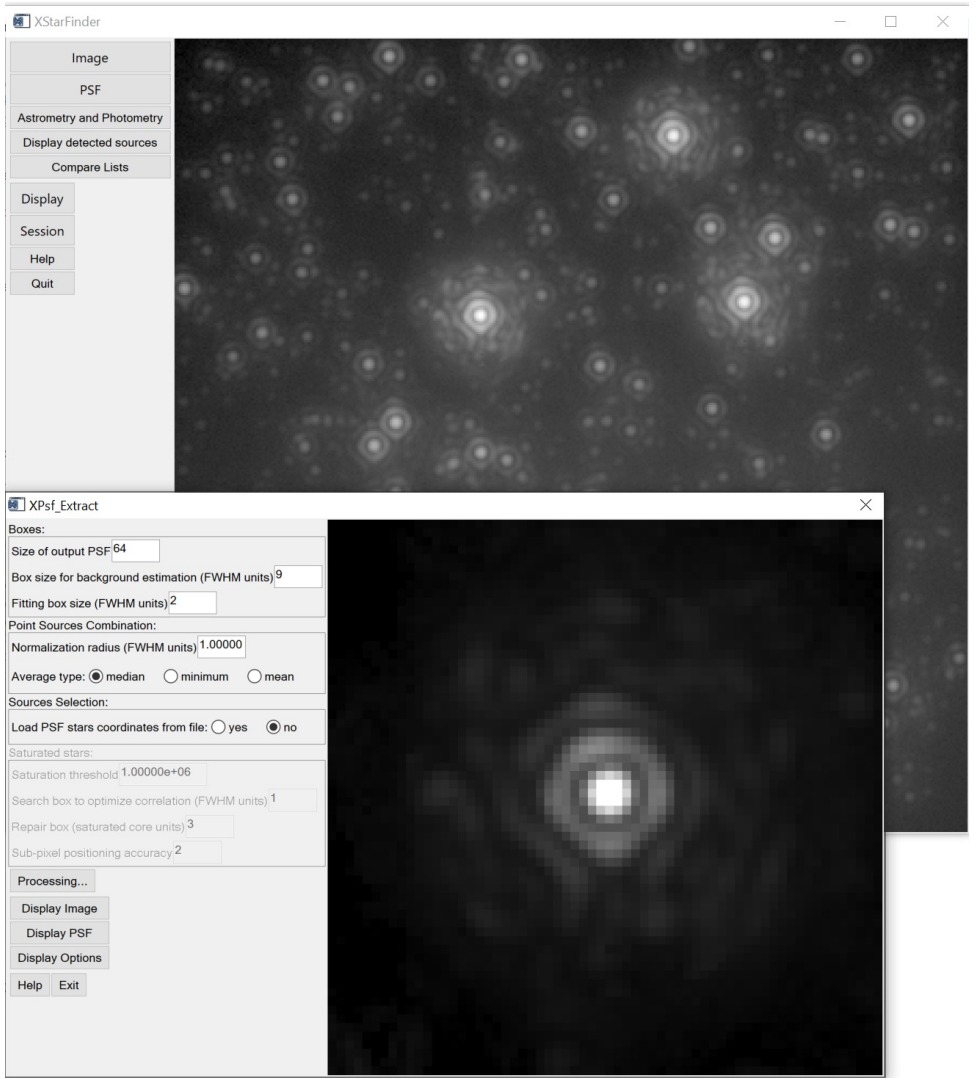
Starfinder is a public domain IDL® code
https://www.ict.inaf.it/gitlab/laura.schreiber/starfinder2

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)

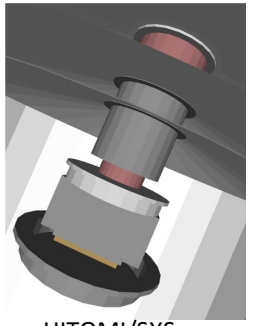
Geant4 simulations of ground experiments and space missions

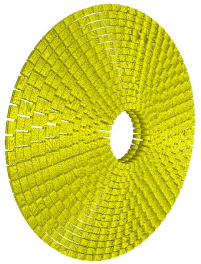
Geant4 is an open-source toolkit library for Monte Carlo particle transport simulations at high energies (from few eV). Based on C++, it allows to build a 3D mass model of the instrumentation and simulate the transport of particles through matter, with a variety of physics interaction libraries to choose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

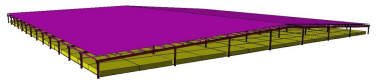
INAF OAS has become a center of reference for the development of **Geant4-based frameworks and applications**:

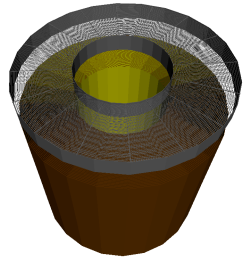
- BoGEMMS (Bologna Geant4 Multi-Mission Simulator), Geant4-based framework for the development of configurable and astronomy-oriented simulations
- Geant4 physics validation and implementation of new models, X-ray and Gamma-ray background simulation, instrument response definition, shielding optimisation 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, …

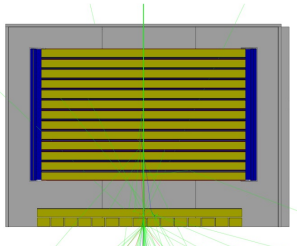
See afternoon poster session “Science Data Segment” on Thursday 23

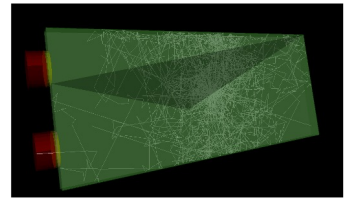

HITOMI/SXS


ATHENA/SPO


ARGO-YBJ


XMM-Newton mirror


AGILE/GRID


COSI/ACS

Latest publications:

- V. Fioretti et al., “Design and characterization of a prototype proton response matrix for the XMM-Newton mission, Proc. SPIE, 118221F, 2021
- V. Fioretti et al., “AGILESim: Monte Carlo Simulation of the AGILE Gamma-Ray Telescope”, ApJ, 896, 61, 2020

Contacts: Valentina Fioretti (valentina.fioretti@inaf.it)

Questions? Collaborations? Contact us!

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