MINISTERO DELL' ISTRUZIONE, DELL'UNIVERSITÀ E DELLA RICERCA

INAF ISTITUTO NAZIONALE DI ASTROFISICA

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Preliminary results of the ASTRI-Horn observing campaigns

Silvia Crestan,
S. Lombardi, A. Giuliani, S.Germani, S. Iovenitti, T. Mineo, G.Contino and many others
for the ASTRI Project

8th Heidelberg International Symposium - Milan - 04/09/2024

ASTRI-Horn project

ASTROFISICA CON SPECCHI A TECNOLOGIA REPLICANTE ITALIANA

ASTRI was born as a “flagship project” funded by the Italian Ministry of University and Research to deploy an innovative end-to-end prototype of 4-m class wide-field telescopes and a mini-array of telescopes based on new technology aiming to gamma ray TeV energy range (1-100 TeV)

The ASTRI prototype was inaugurated in 2014 and dedicated to Guido Horn D’Arturo

ASTRI-Horn telescope

- Dual-mirror optical layout
  - First time for Cherenkov telescopes
  - Schwarzschild-Couder optical design
  - Optimal PSF across the entire FoV
- Silicon photo-multipliers camera
  - Small pixel-size (0.19°)
  - Can work during moonlight condition
- Wide FoV (10°)
  - Important for surveys and multi-target fields
  - Important for extended sources
  - Serendipity sources
- Expected performance
  - Energy threshold $\sim$ 2 TeV
  - Energy resolution < 25%
  - Angular resolution < 0.2°
  - Sensitivity $\sim$ 1 Crab @5σ in few hours

First results

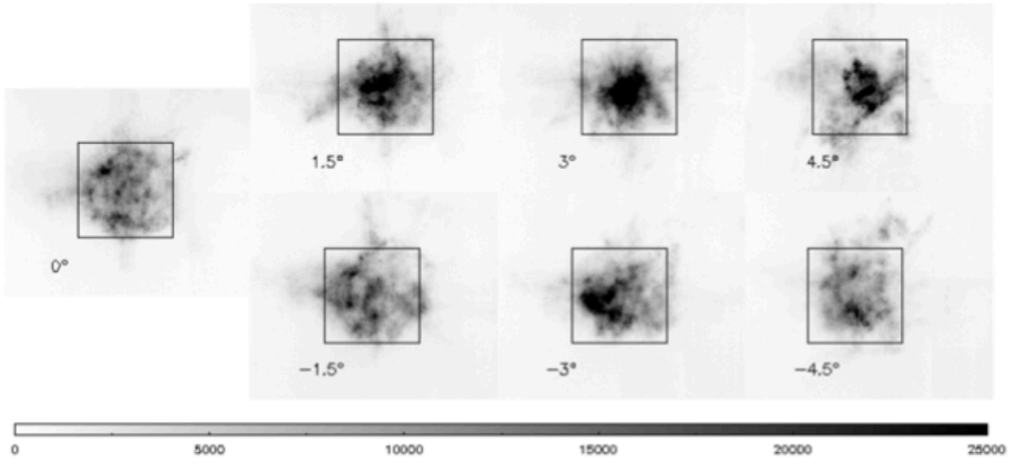
A&A 608, A86 (2017)
DOI: 10.1051/0004-6361/201731602

Astronomy & Astrophysics

2016

First optical validation of a Schwarzschild Couder telescope: the ASTRI SST-2M Cherenkov telescope

E. Giro[1,2], R. Canestrari[2], G. Sironi[2], E. Antolini[3], P. Conconi[2], C. E. Fermino[4], C. Gargano[5], G. Rodeghiero[1,6], F. Russo[7], S. Scuderi[8], G. Tosti[3], V. Vassiliev[9], and G. Pareschi[2]



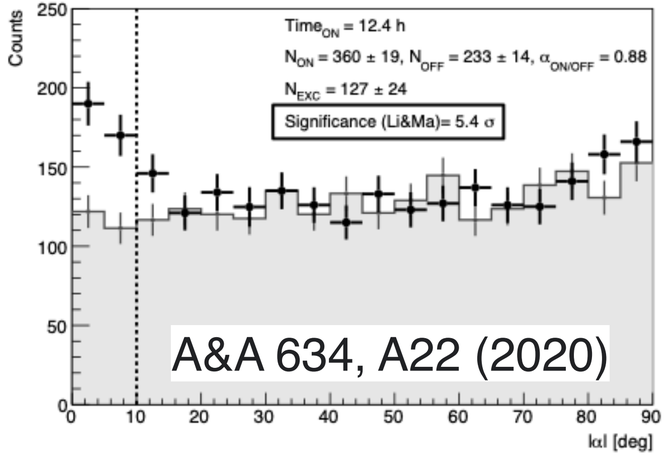
Astronomy & Astrophysics manuscript no. letter

2018

LETTER TO THE EDITOR

First detection of the Crab Nebula at TeV energies with a Cherenkov telescope in dual-mirror Schwarzschild-Couder configuration: the ASTRI-Horn telescope

S. Lombardi[1,2,⋆], O. Catalano[3,⋆], S. Scuderi[4,⋆], L. A. Antonelli[1,2,⋆], and G. Pareschi[5,⋆] et al.

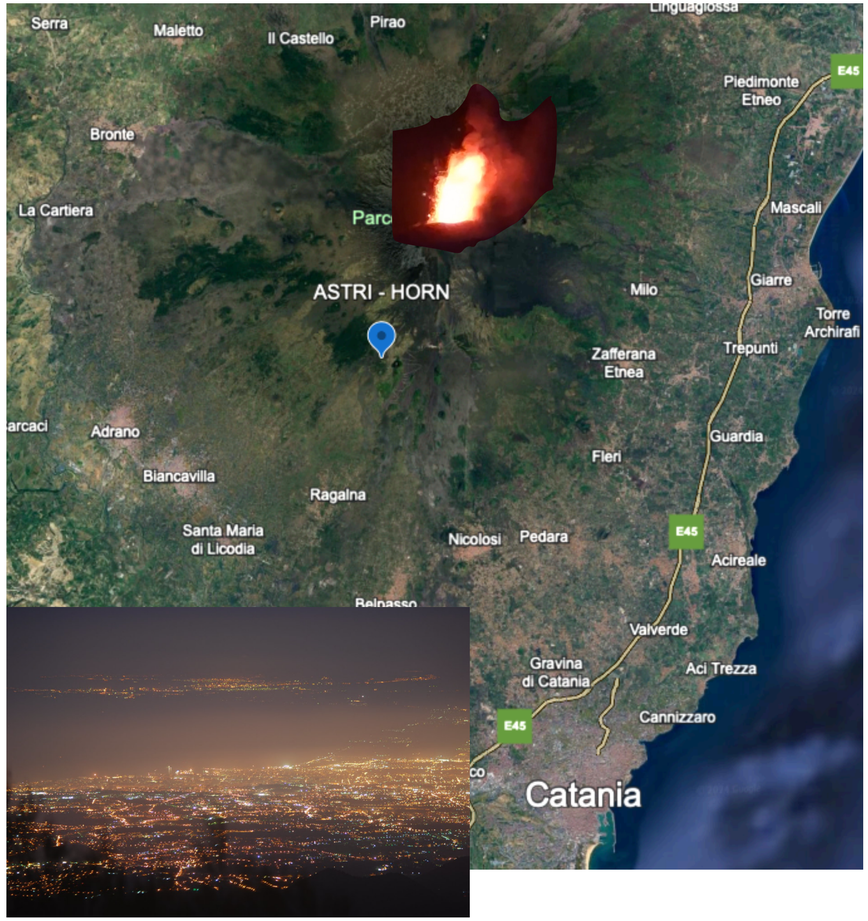


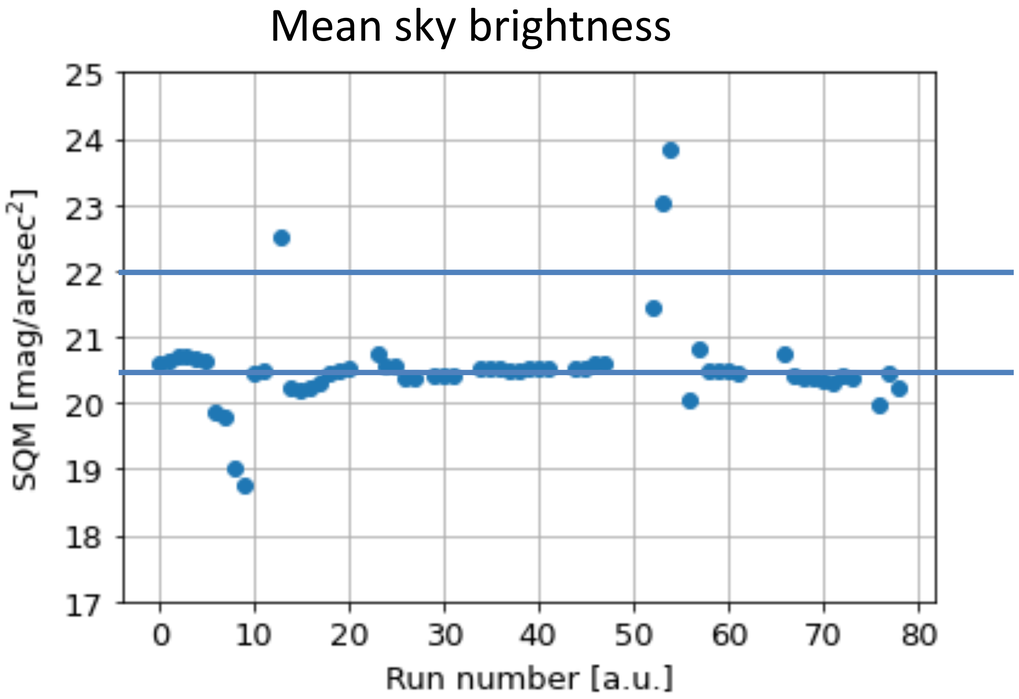
2020: full validation

ASTRI-Horn site

Mini-Array

Serra la Nave is a rather challenging site…





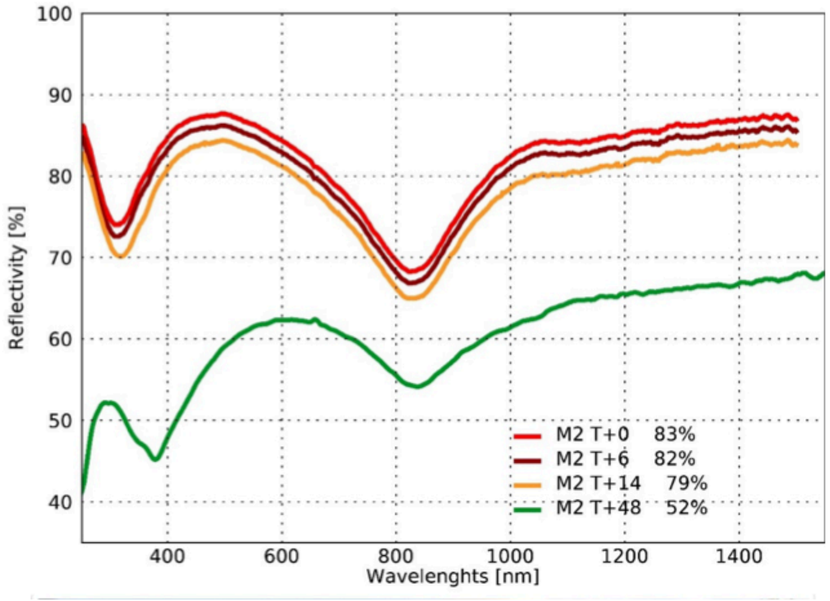
…but it is not so bad

ASTRI-Horn site

ASTRI-Horn operates in a very harsh environment due to the Etna aggressive atmosphere.

It is aging faster than expected

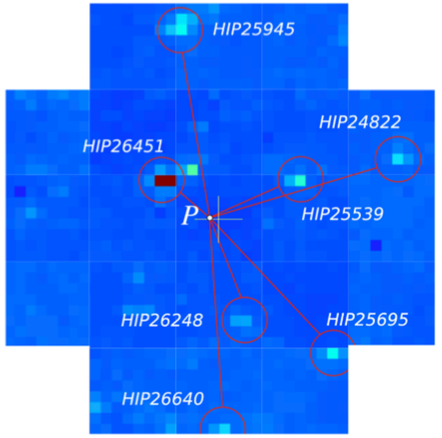
Astri-Horn M2



ASTRI-Horn upgrading

During 2020-2022 the telescope has undergone an extensive refurbishment. Almost all systems were verified and refurbished:

- Both mirrors were replaced with more effective ones
- The camera electronics was improved. The acquisition rate was increased, as well as the capability to acquire data under moderate night sky background conditions.
- Deep review of the camera and telescope control software
- Data reduction and analysis pipeline (***A-SciSoft***) has been updated and various auxiliary inputs and tools were implemented in the pipeline, e.g. tools for telescope calibration and Variance data astrometry (see Simone Iovenitti's Talk).



See Leto et al. (2023 - https://pos.sissa.it/444/729/pdf)

2022-2024 Observations

Mini-Array

Scientific observation

Gamma ray sources	2022-2023	2023-2024
Crab ON (high zenith)	16 h	
Crab OFF	13 h	16 h
Crab Wobble	34 h	54 h
MrK_501	18 h	34 h
SNR G106.7	45 h	
…		

Volcano	60 h

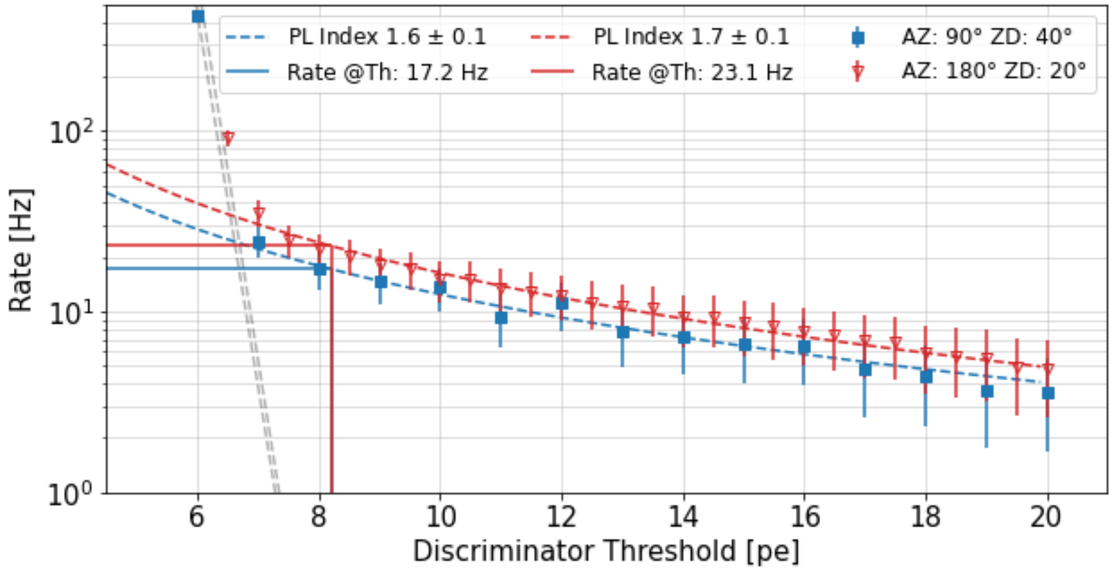
Test and calibration

Calibrations
Threshold scan
Closed LIDs Muons
BKG characterization
Acquisition with moon
…

~ 200 h

Crab 2022-2023

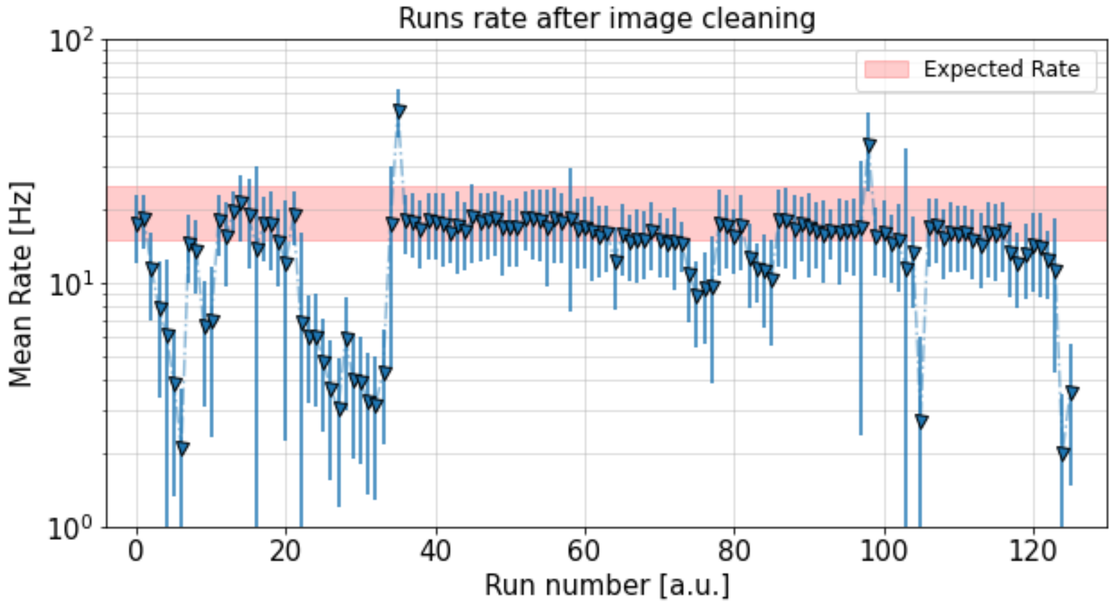
Threshold Scan at the beginning of observation



Discriminator threshold set to 8.2 pe

$$\frac{S}{N}(@8.2\ \text{pe}) \simeq 10^{-3}$$

CRAB Wobble pointing and control OFF-Crab pointing



2/3 of the runs have the expected rate ($\sim$ 30 h)

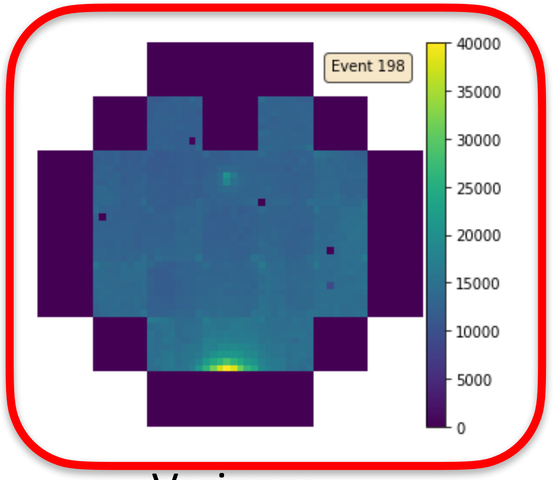
$\sim$ 20 h of Crab observation (preliminary data selection)

$\sim$ **10 h** of OFF-Crab observation (preliminary data selection)

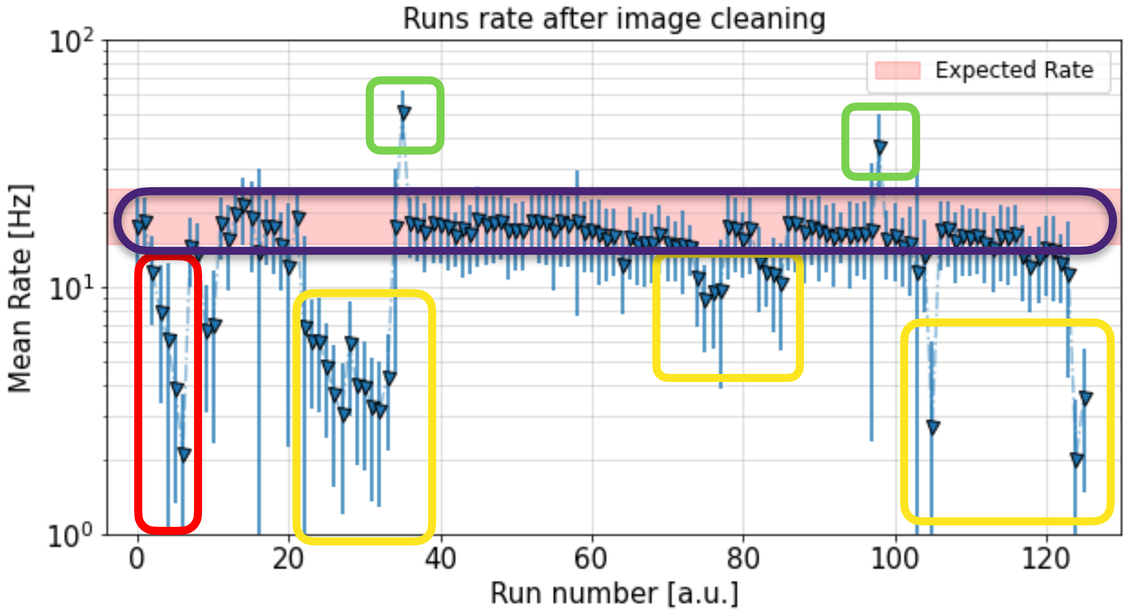
CRAB 2022-2023

Mini-Array

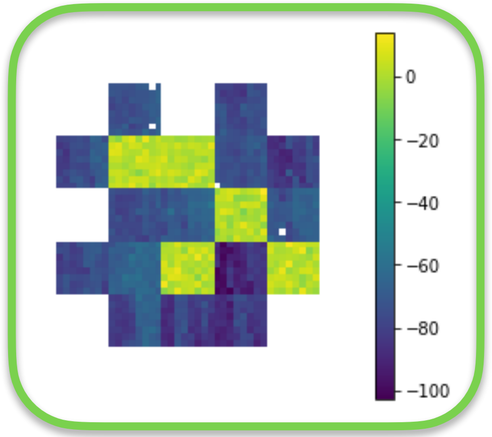
Mars in the FOV



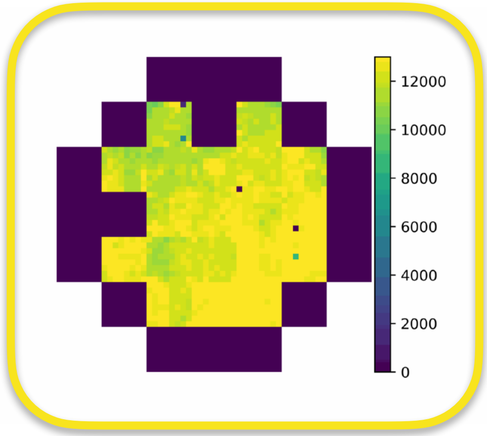
Variance



Electronic issues

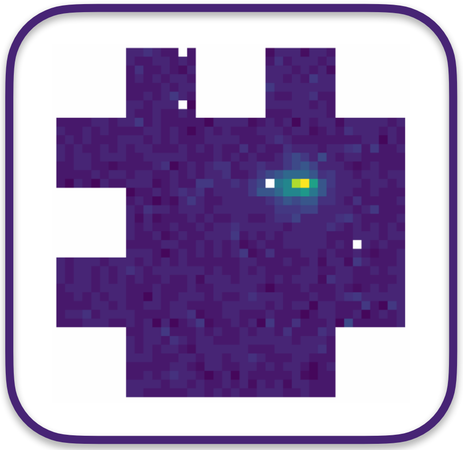


Passing clouds

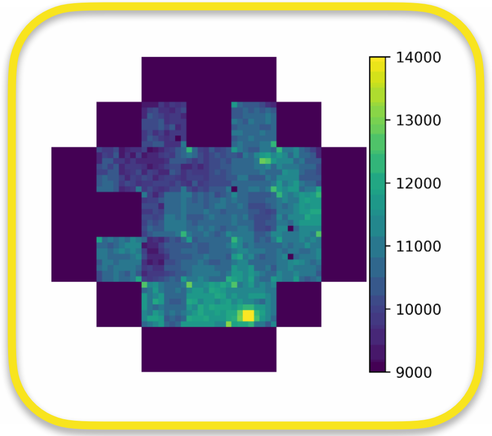


Variance

2 PDMs (out of 21) disconnected (for electronics reasons)

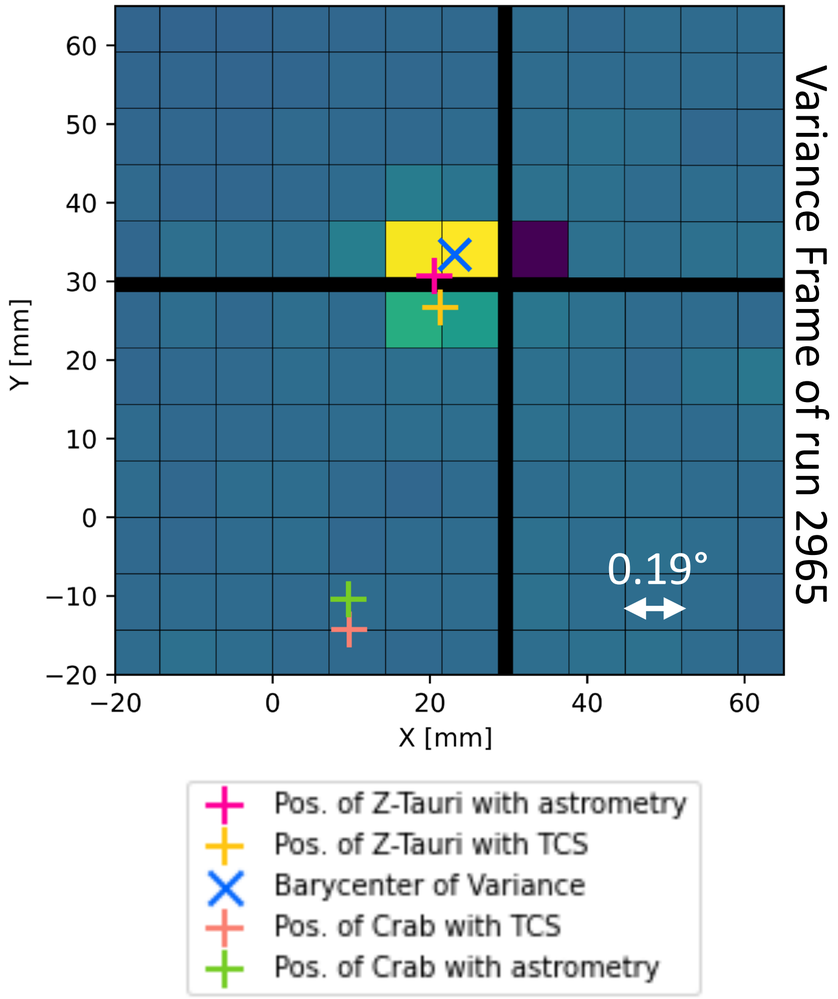


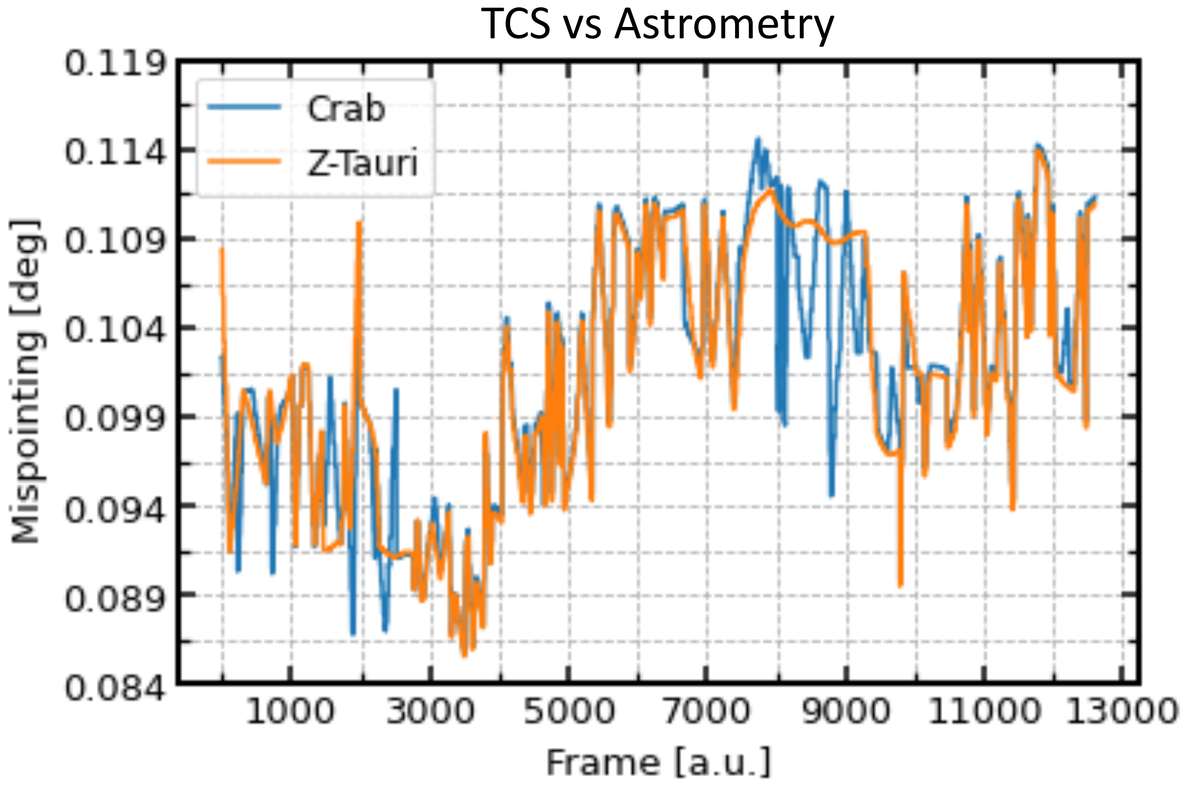
Smoke coming from the volcano



Variance

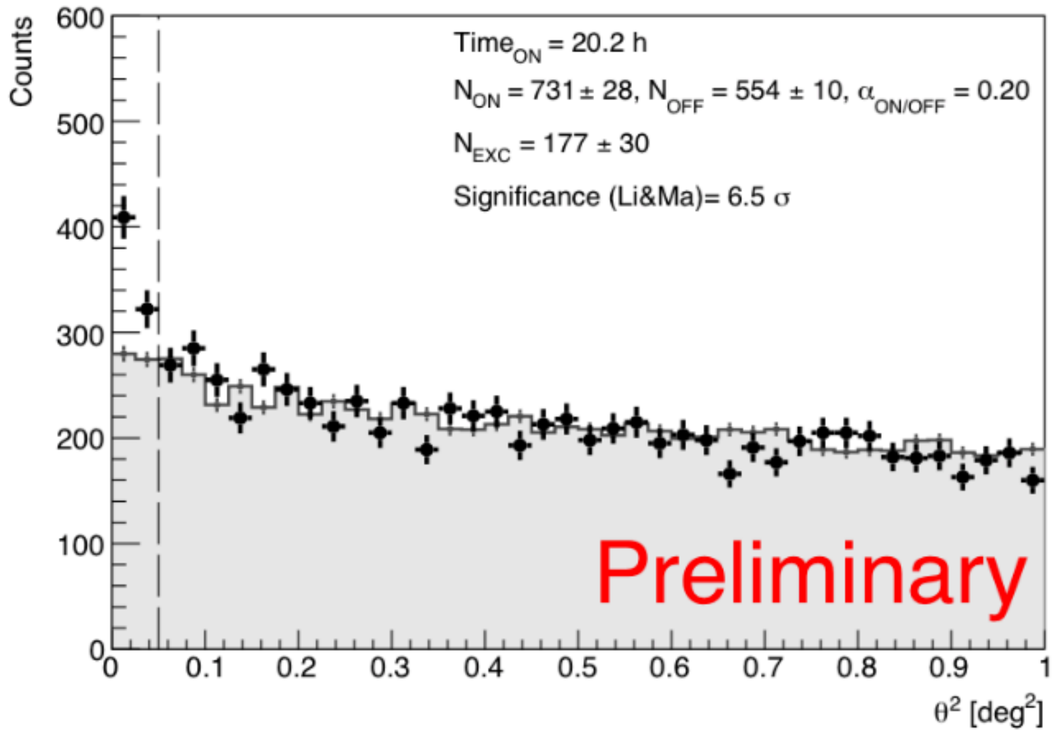
Pointing accuracy

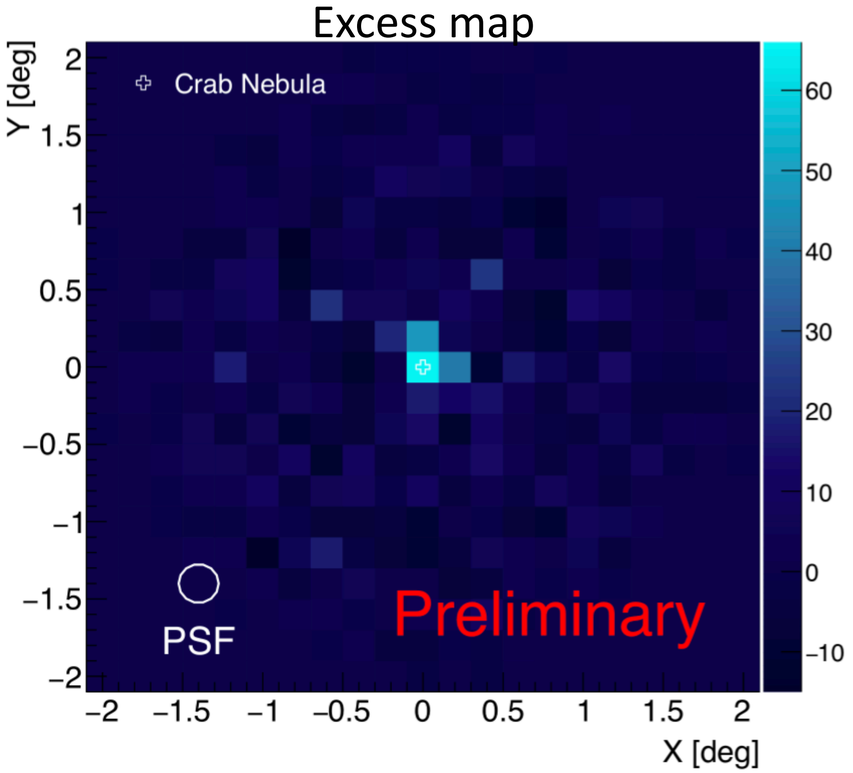




Pointing accuracy ~ 0.1 deg. -> within the pixel size (0.19°)

Crab 2022-2023



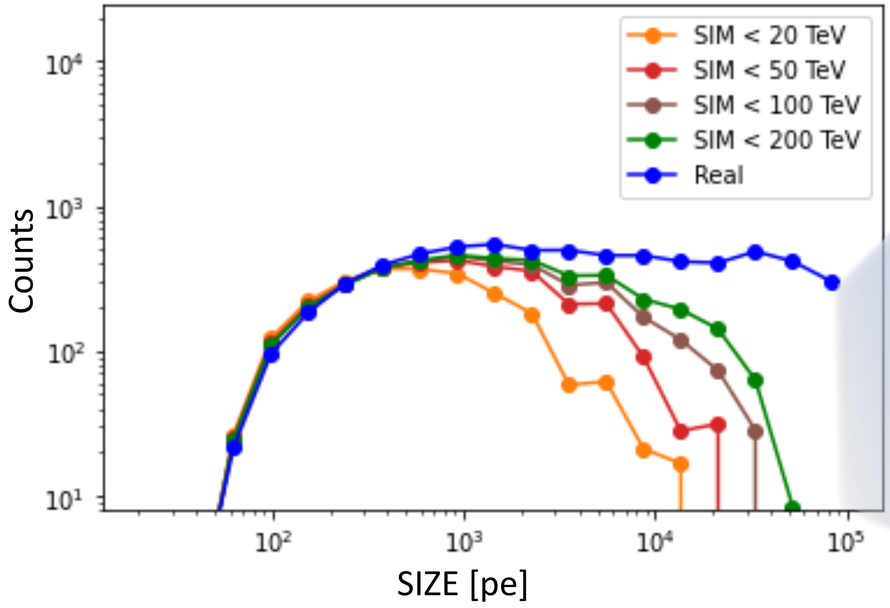


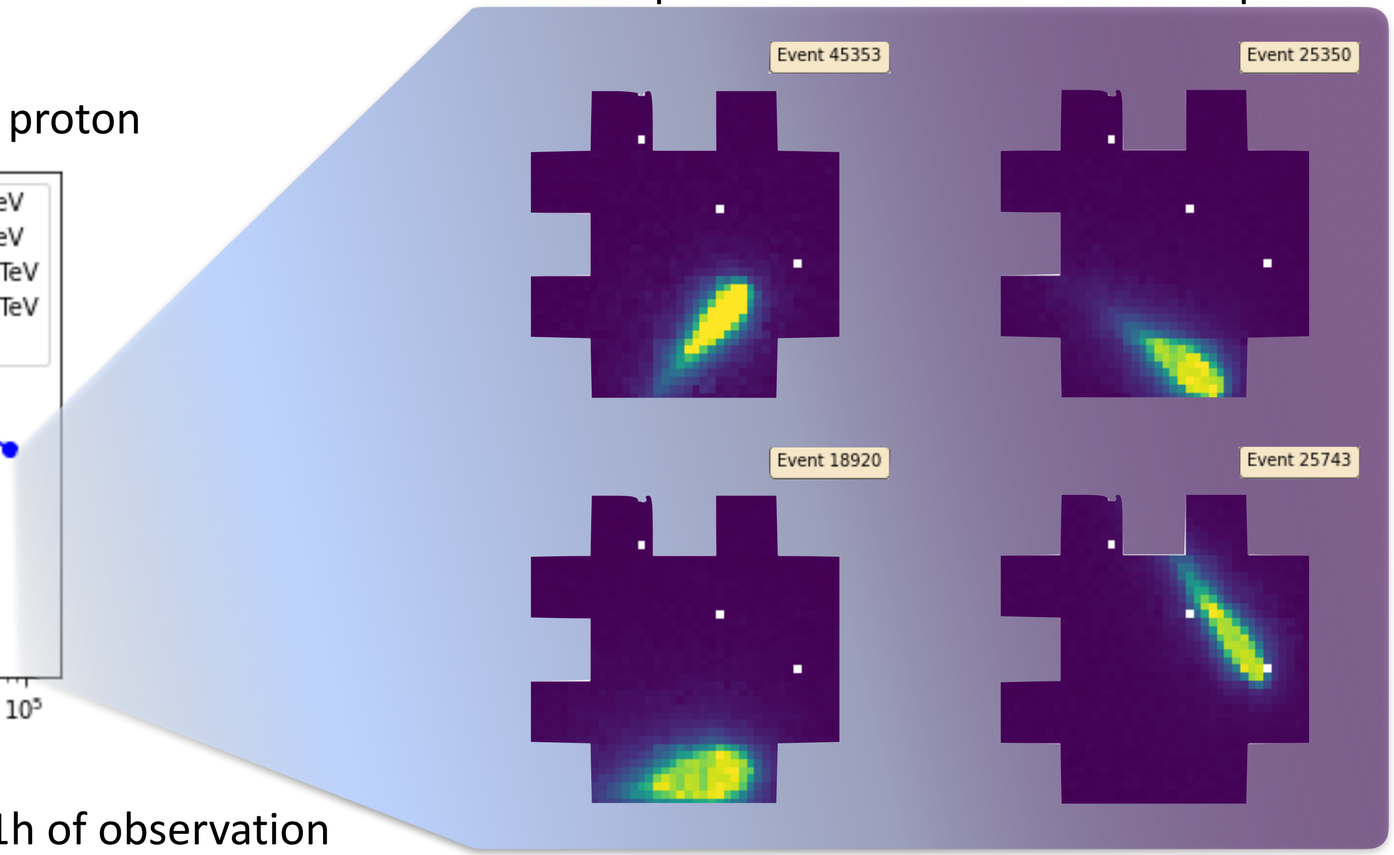
There is still significant room for improvement, especially in the fine-tuning of the simulations and on the data selection.
Higher level analysis (flux estimation, spectrum, light curve, counts map etc..) are still on going.

Cosmic rays

Examples of events with Size > 1e5 pe

1h Real data events compared with MC proton

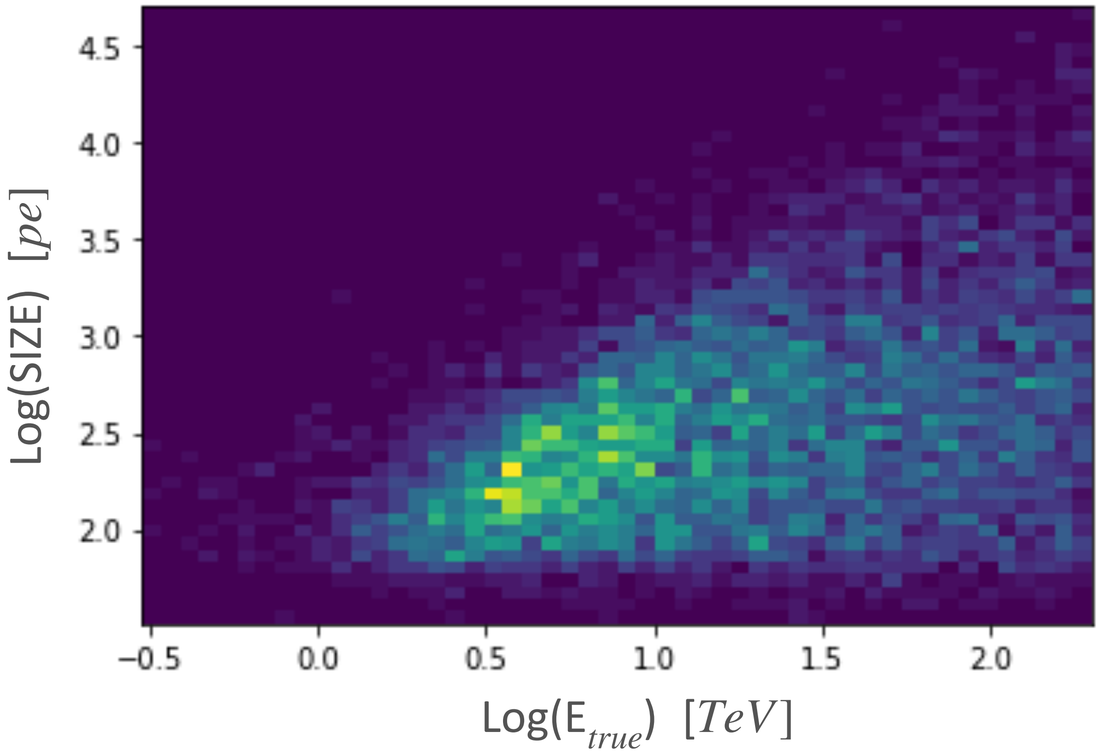




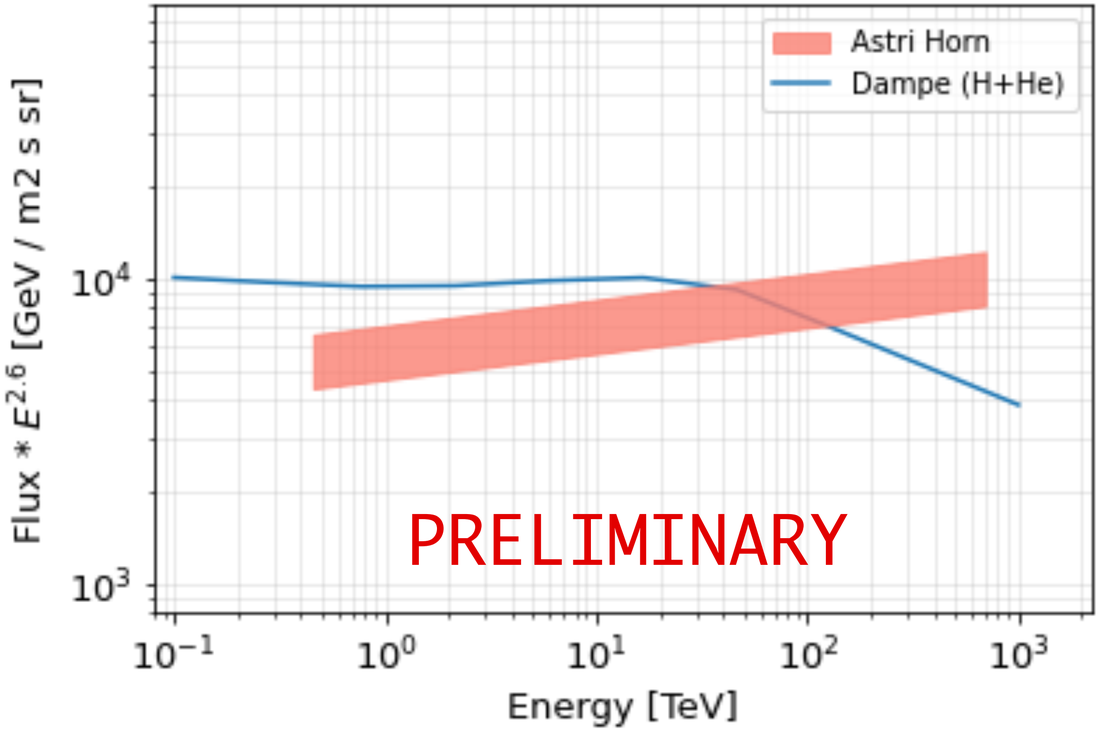
We observe CR up to hundreds of TeV in 1h of observation

Cosmic rays

Size dispersion matrix

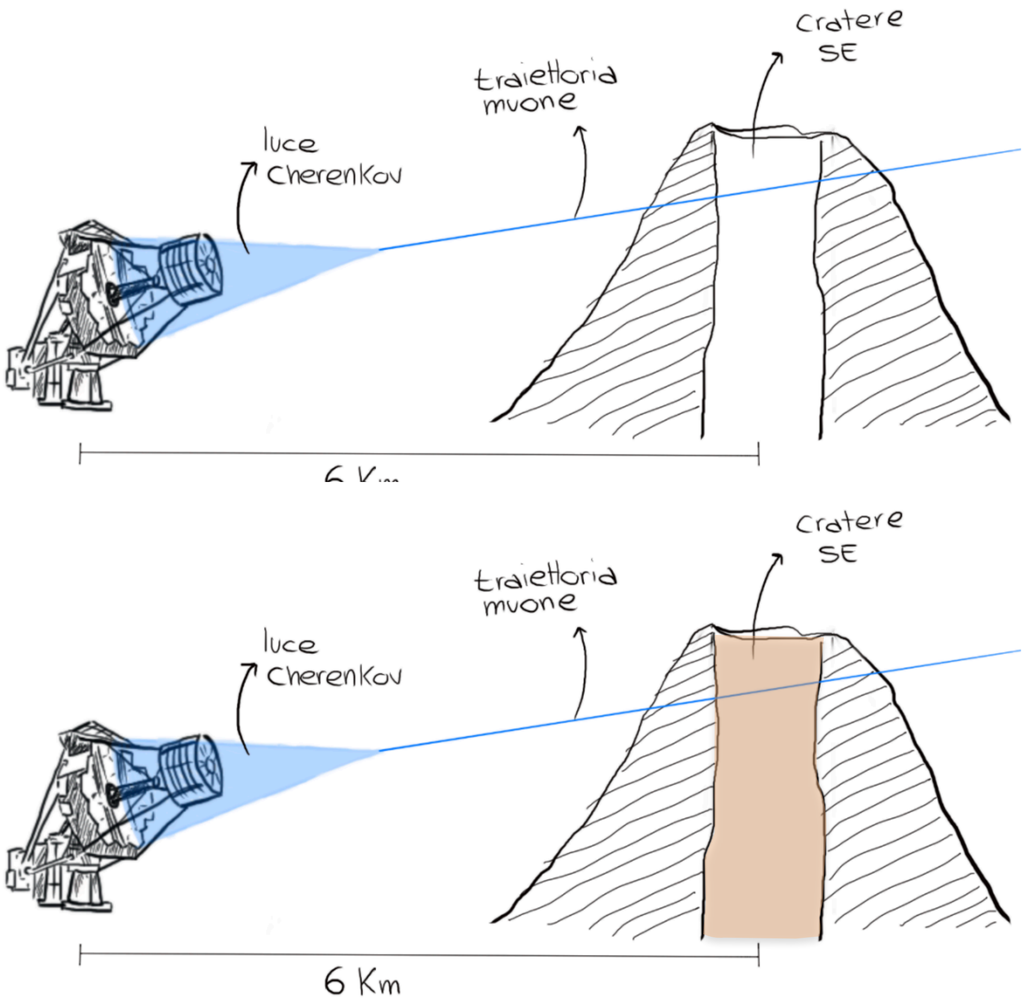


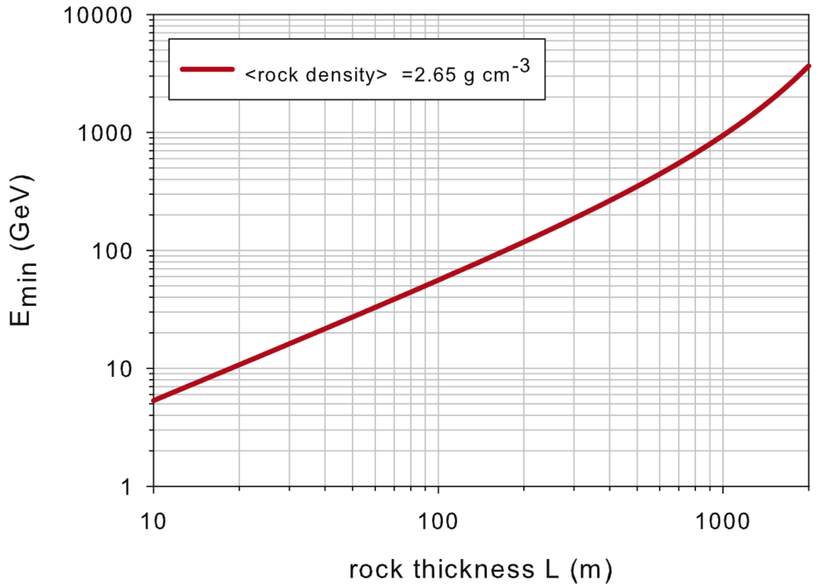
Good agreement with DAMPE data.

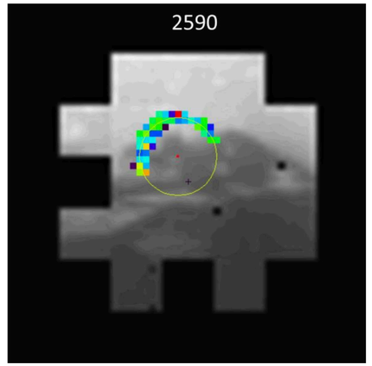


We plan to extend our simulation to perform more refine spectral analysis.

Etna muons radiography







By measuring the differential attenuation of the muon flux crossing a volcano, the density distribution of its interior can be determined.

Conclusion

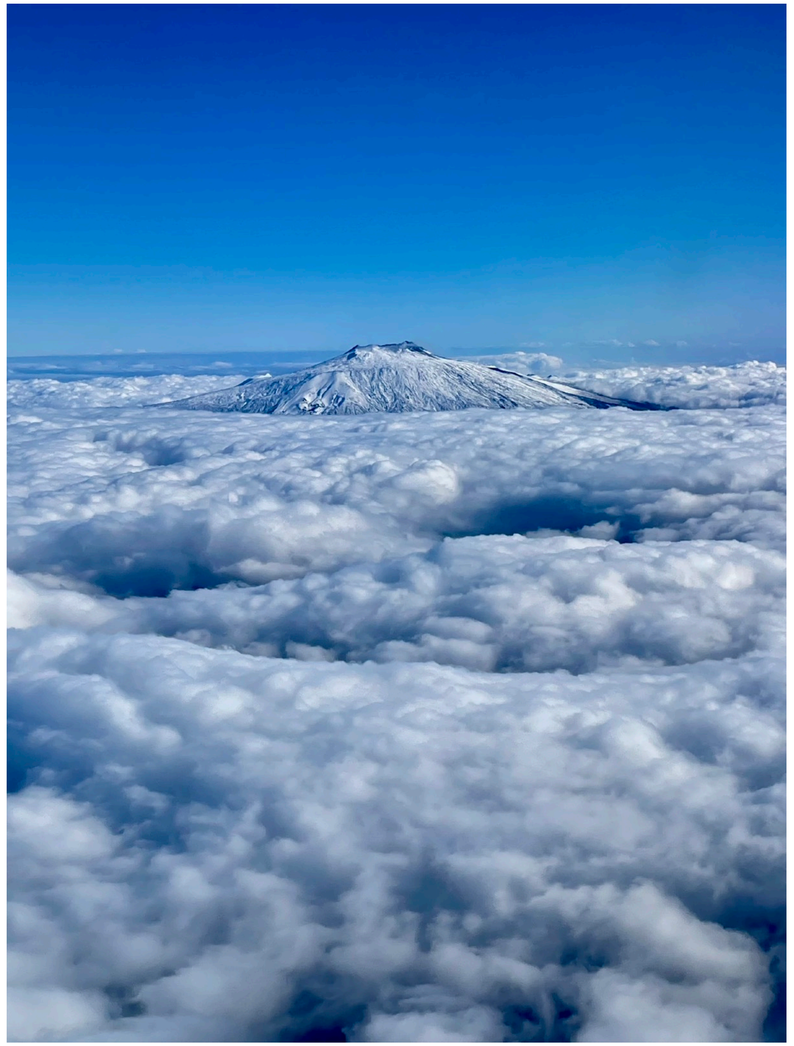
The ASTRI-Horn prototype after the refurbishment and maintenance intervention is fully operational. The scientific validation is ongoing

We have shown that ASTRI-HORN can be used for various tasks, not just gamma-ray detection, but also for studying cosmic rays and the volcano

More analyses and activities can be done with the data taken during this years.

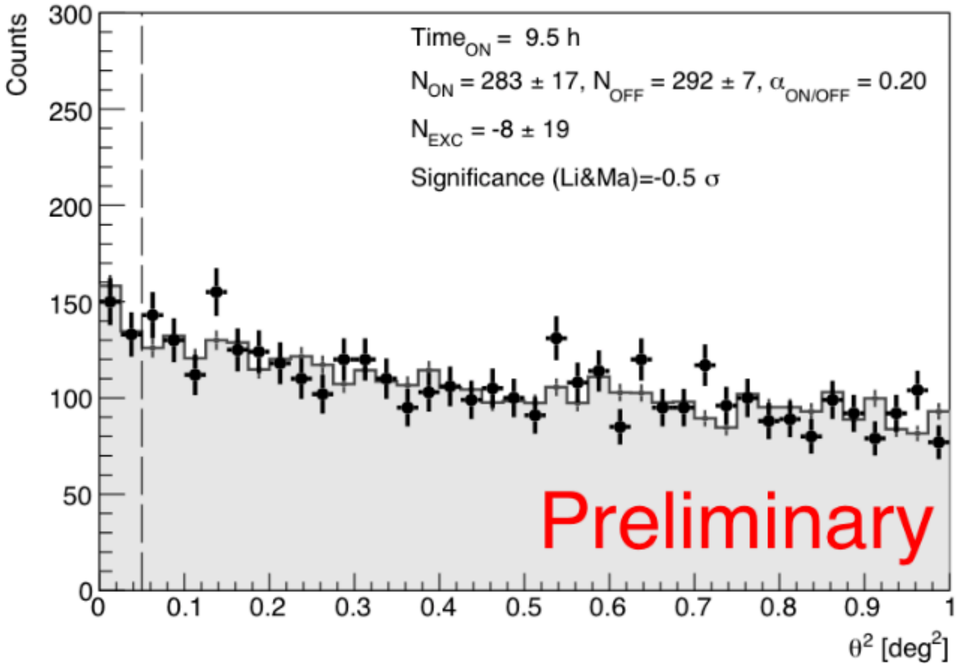
The experience gained with ASTRI-Horn is proving invaluable for ongoing operations at the Mini-Array.

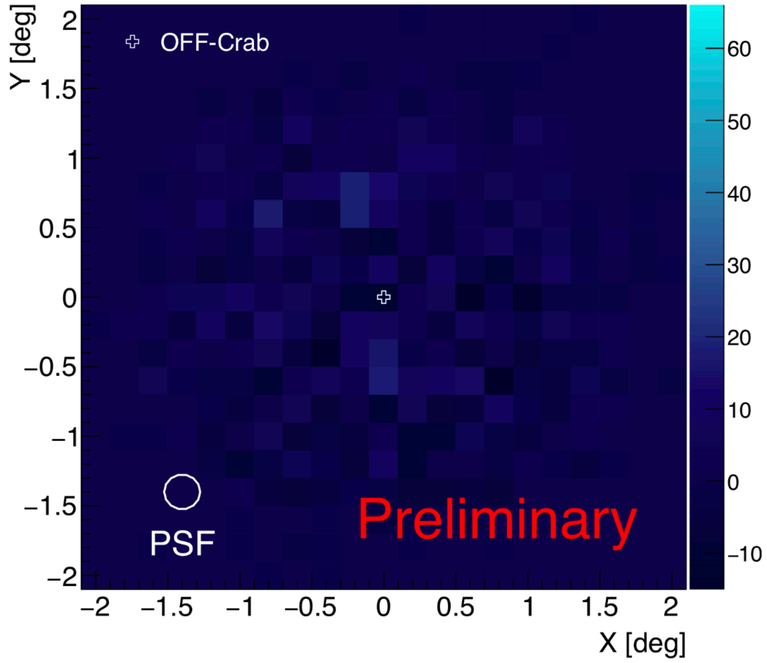
We are just seeing the tip of the volcano!



Back-up slide

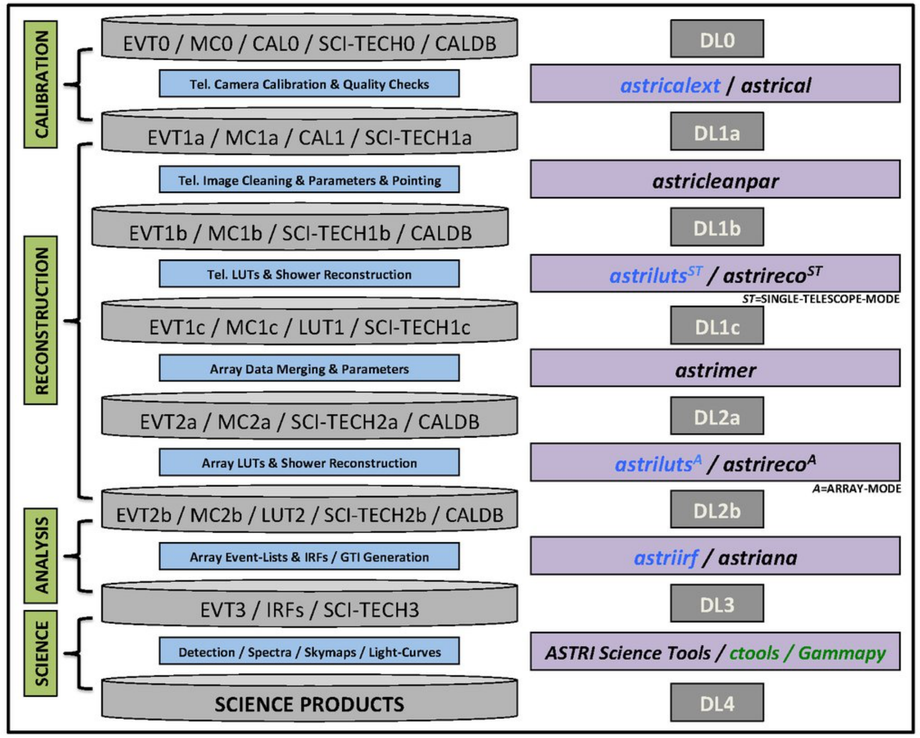
OFF CRAB pointing





Software upgrading

A-SciSoft is a dedicated software package for data reconstruction and scientific analysis. The software perform data reduction from DL0 data to scientific products. It is developed and tested with the ASTRI-Horn prototype.



Integrated auxiliary input

Variance astrometry
Scitech0 (telescope drive, weather)
Sky quality meter

Added tools