PeVatrons with the ASTRI Mini-Array

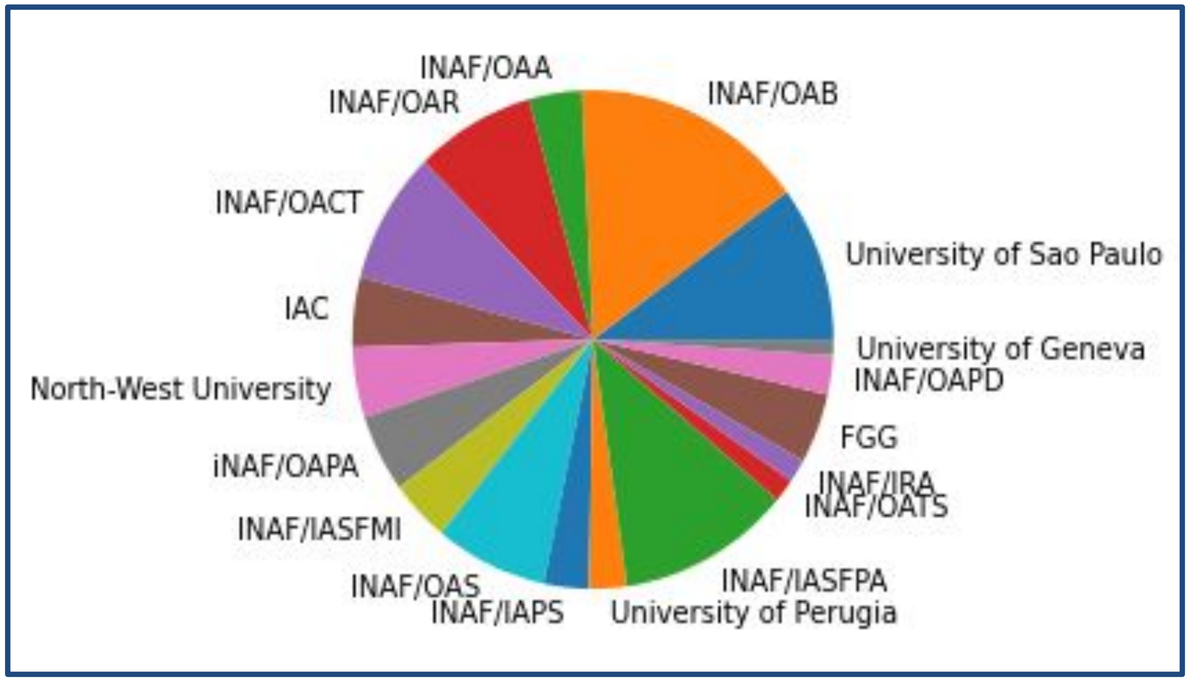
A.Giuliani (INAF / IASF Milano)

for the ASTRI Project

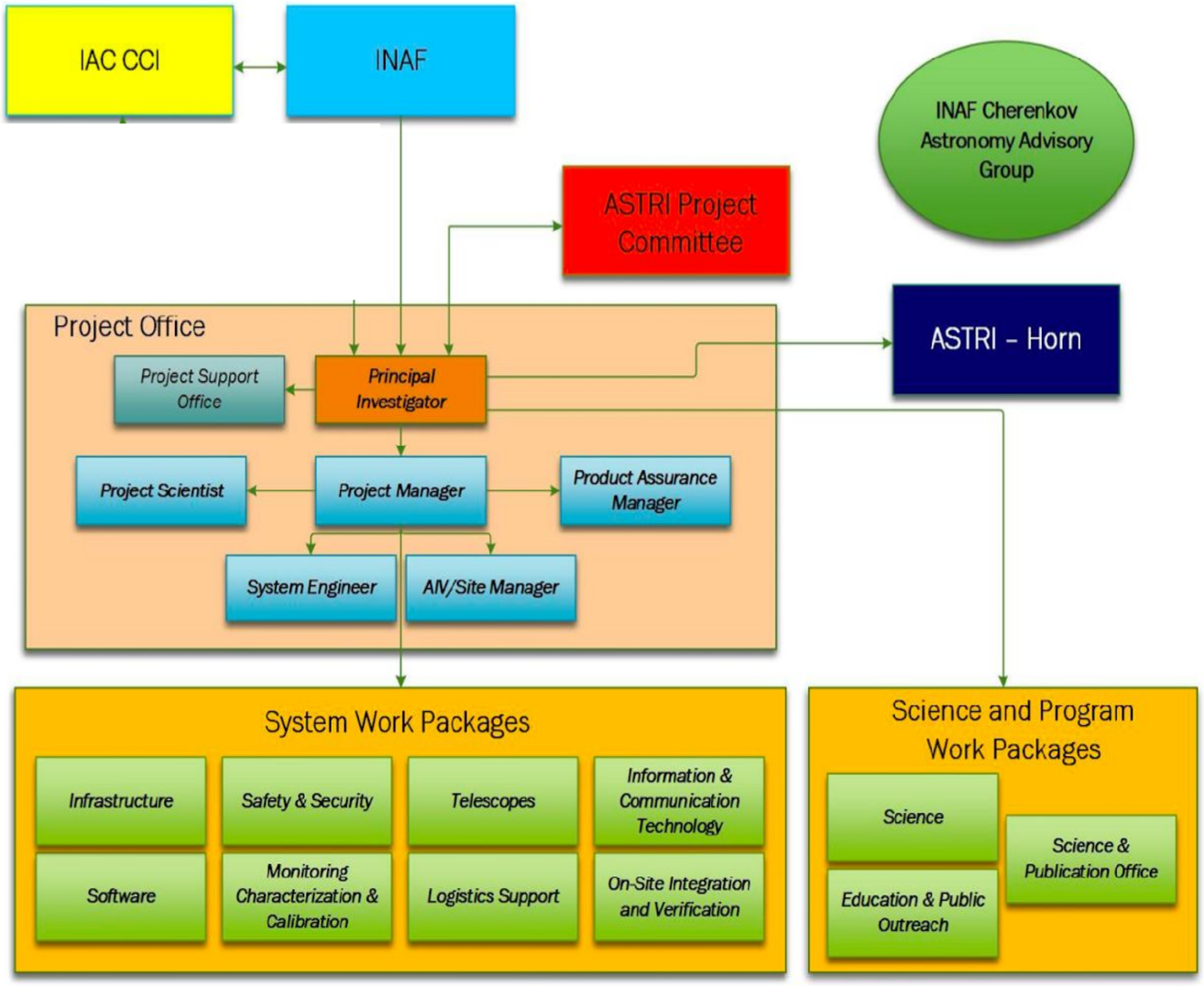
SNRs Symposium, Fuxian Lake, March 1st 2026

The ASTRI Mini-Array

- The ASTRI MA is an array of 9 Cherenkov telescopes of the 4 meters class under construction at the **Observatorio del Teide** in Tenerife (Spain)
- About **200 researchers** belonging to **INAF** institutes (IASF-MI, IASF-PA, OAS, OACT, OAB, OAPD, OAR, OAA, IAPS, OATS, OAPA) **Italian Universities** (Uni-PG, Uni-PD, Uni-CT, Uni-TS, Uni-GE, PoliMi), **INFN**, **Fundacion Galileo Galilei**, **IAC** (Spain), **University of Sao Paulo** (Brazil), **North-West University** (South Africa), **Université & Observatoire de Genève** (CH).
- End to end approach, from design/implementation of all HW/SW components to dissemination of final scientific products
- Unprecedented performance and wide FoV for observations at **multi-TeV energy scale**
- **Science Program** : 4 (Core) + 4 (Observatory)
- **Important synergies** with other Northern ground-based gamma-ray facilities (LHAASO, HAWC, MAGIC, VERITAS, CTAO-N)



ASTRI Mini-Array Project: organization



Principal Investigator: ***Giovanni Pareschi***

Program Manager: ***Salvo Scuderi***

Project Scientist: ***Andrea Giuliani***

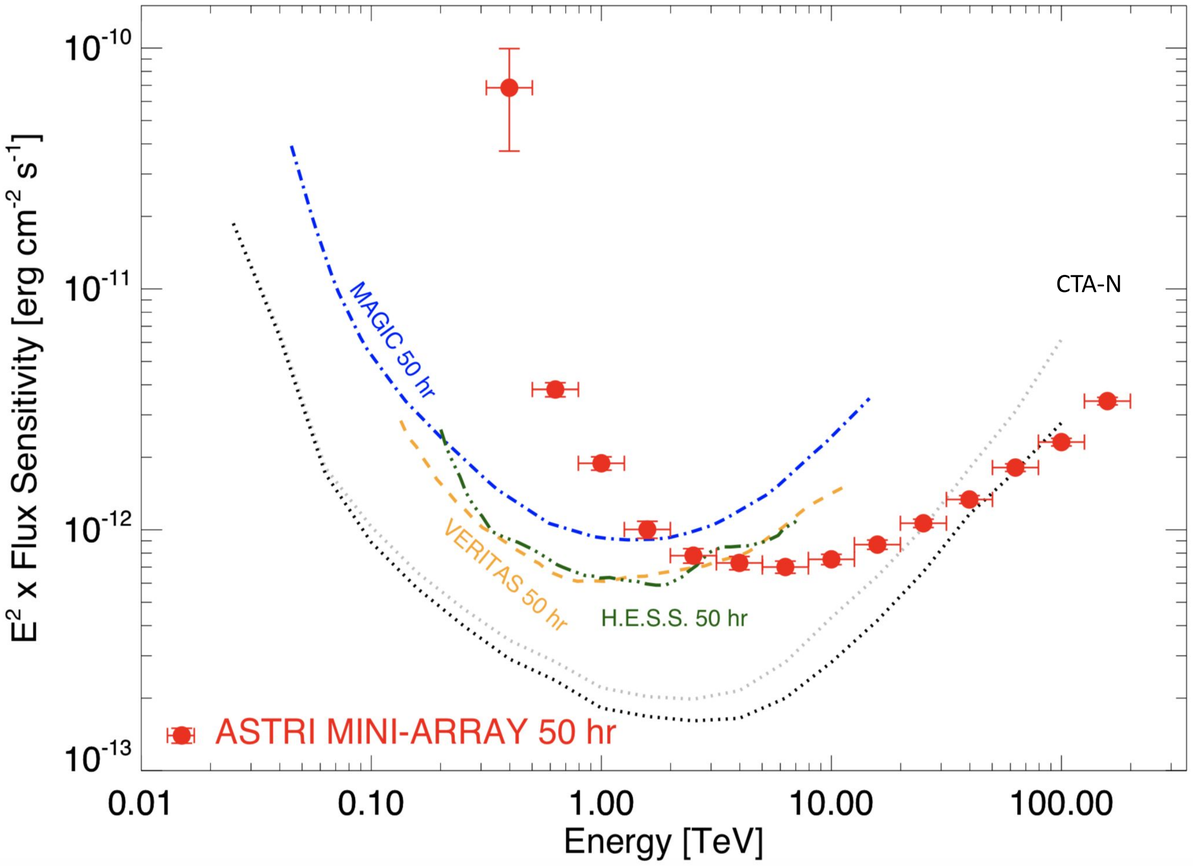
System Engineer: ***Gino Tosti***

User Groups Coordinator: ***Stefano Vercellone***

Proj. Committee Coordinator : ***Marco Tavani***

Scientific SW: ***Saverio Lombardi***

ASTRI Performance



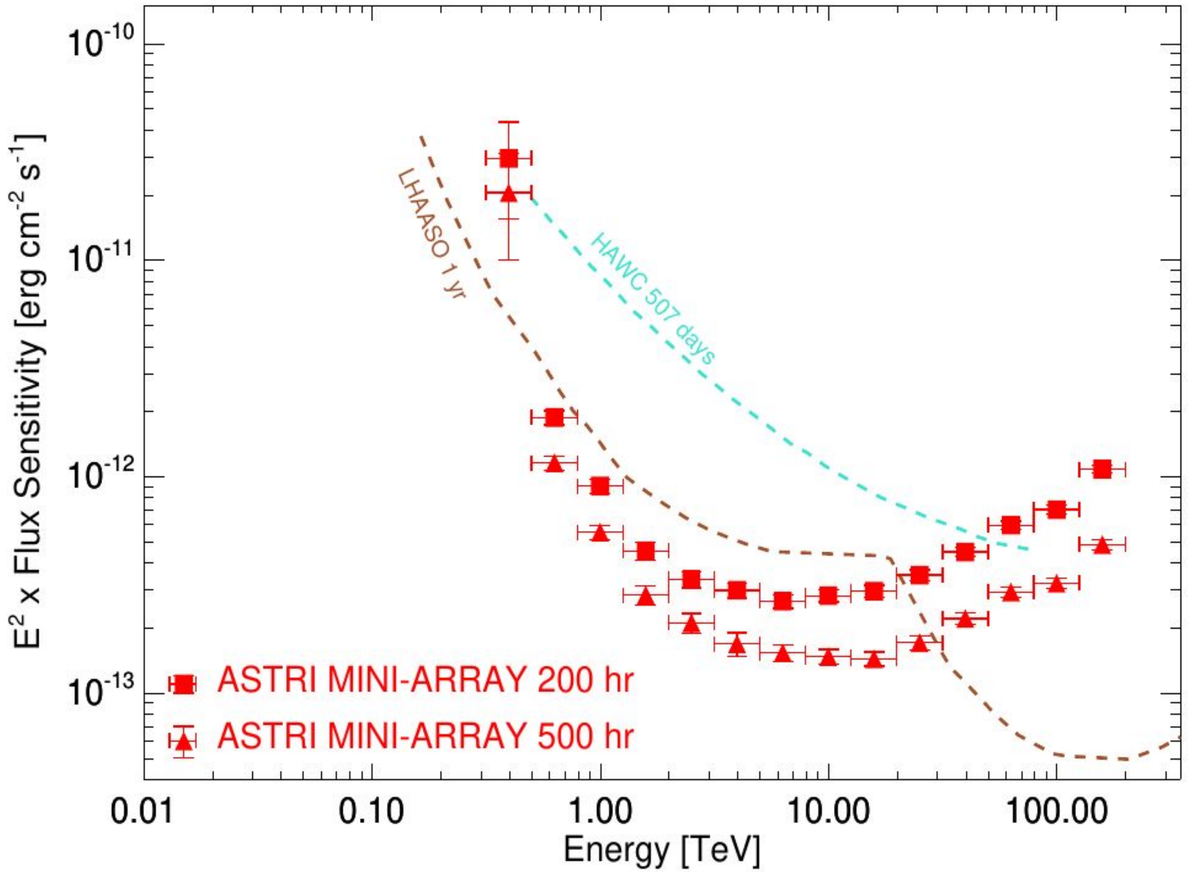
Expected performance

Sensitivity: better than that of current IACTs (E > a few TeV)

- Extend the spectra of already detected sources and/or measure cut-offs

Vercellone et al. JHEAP, 2022

ASTRI Performance



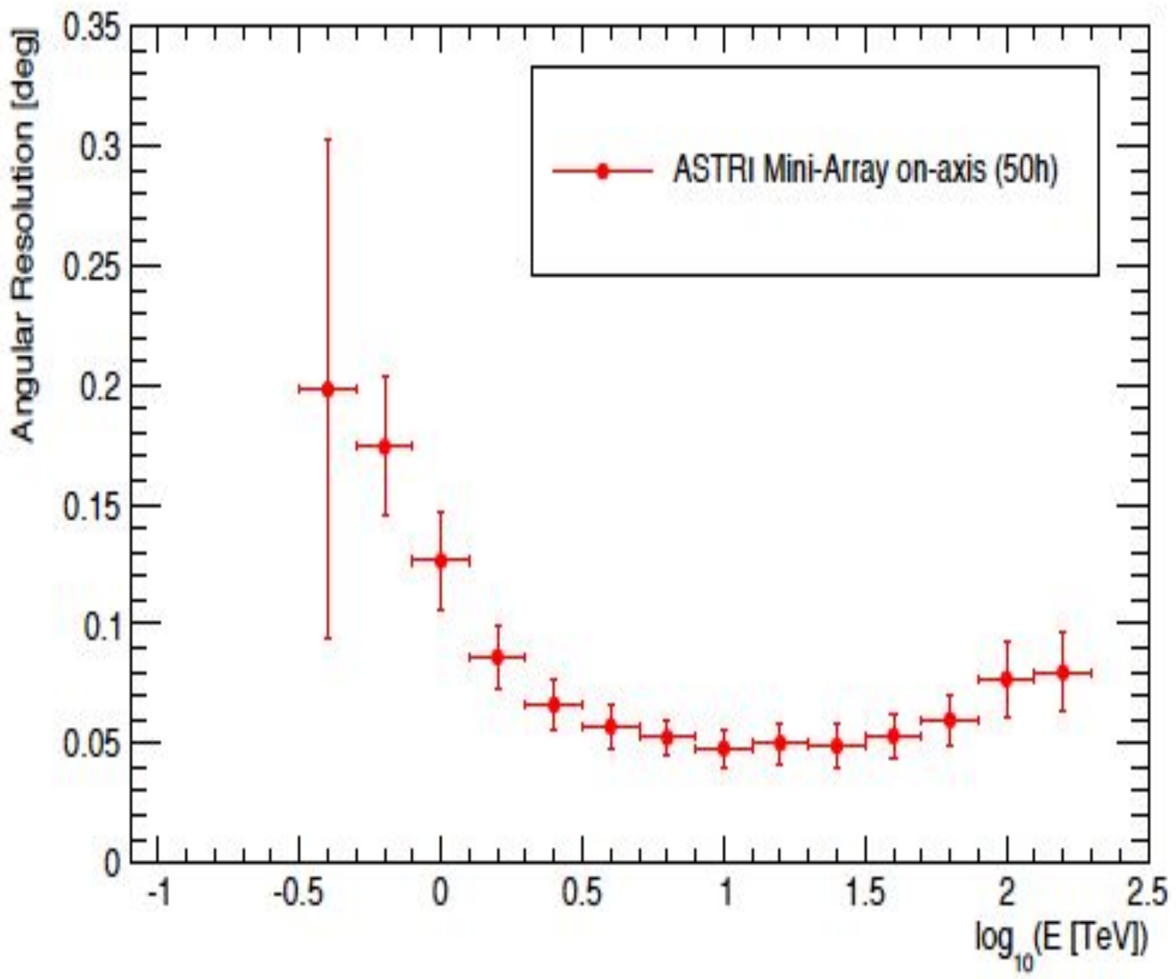
Expected performance

Sensitivity: better than that of current IACTs (E > a few TeV)

- Extend the spectra of already detected sources and/or measure cut-offs

Vercellone et al. JHEAP, 2022

ASTRI Performance



Expected performance

Sensitivity: better than that of current IACTs (E > a few TeV)

- Extend the spectra of already detected sources and/or measure cut-offs

Energy/Angular resolution: ~ 10% / ~ 3‘ (E > a few TeV)

- Characterize the morphology of extended sources at the highest VHE

Vercellone et al. JHEAP, 2022

ASTRI Science : overview

Origin of Cosmic Rays

- **PeVatrons**
- **CRs Acceleration and Propagation**
- **Pulsar Wind Nebulae and TeV Halos**

Fundamental Physics

- **Intergalactic fields**
- **Blazars**
- **LIV, ALP and DM**

Transient Follow-Up

Non gamma-ray science

The ASTRI Mini-Array of Cherenkov Telescopes at the Observatorio del Teide

JHEAP, 2022, 35, 52

ASTRI Mini-Array Core Science at the *Observatorio del Teide*

JHEAP, 2022, 35, 1

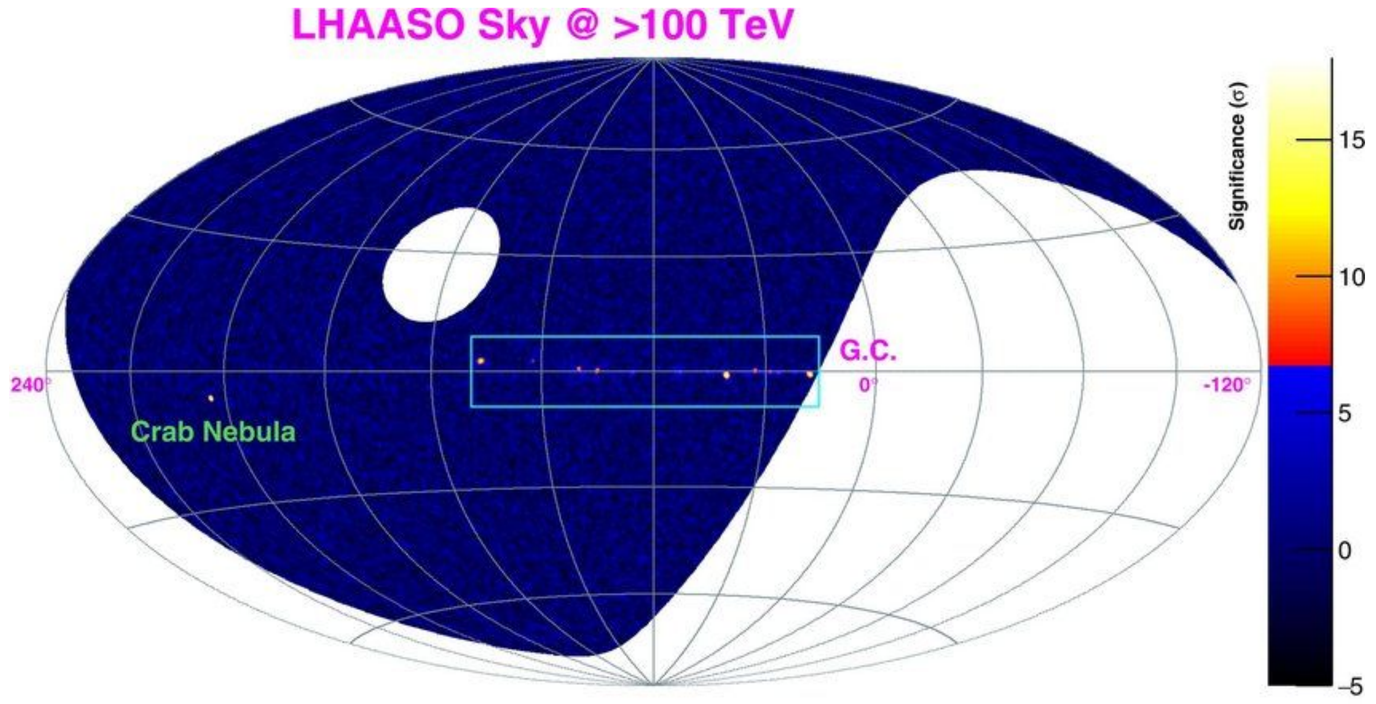
Galactic Observatory Science with the ASTRI Mini-Array at the *Observatorio del Teide*

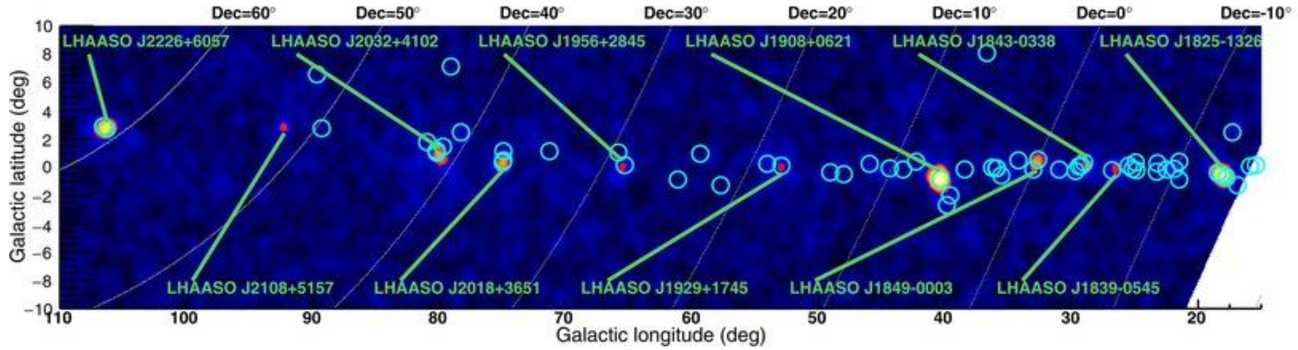
JHEAP, 2022, 35, 39

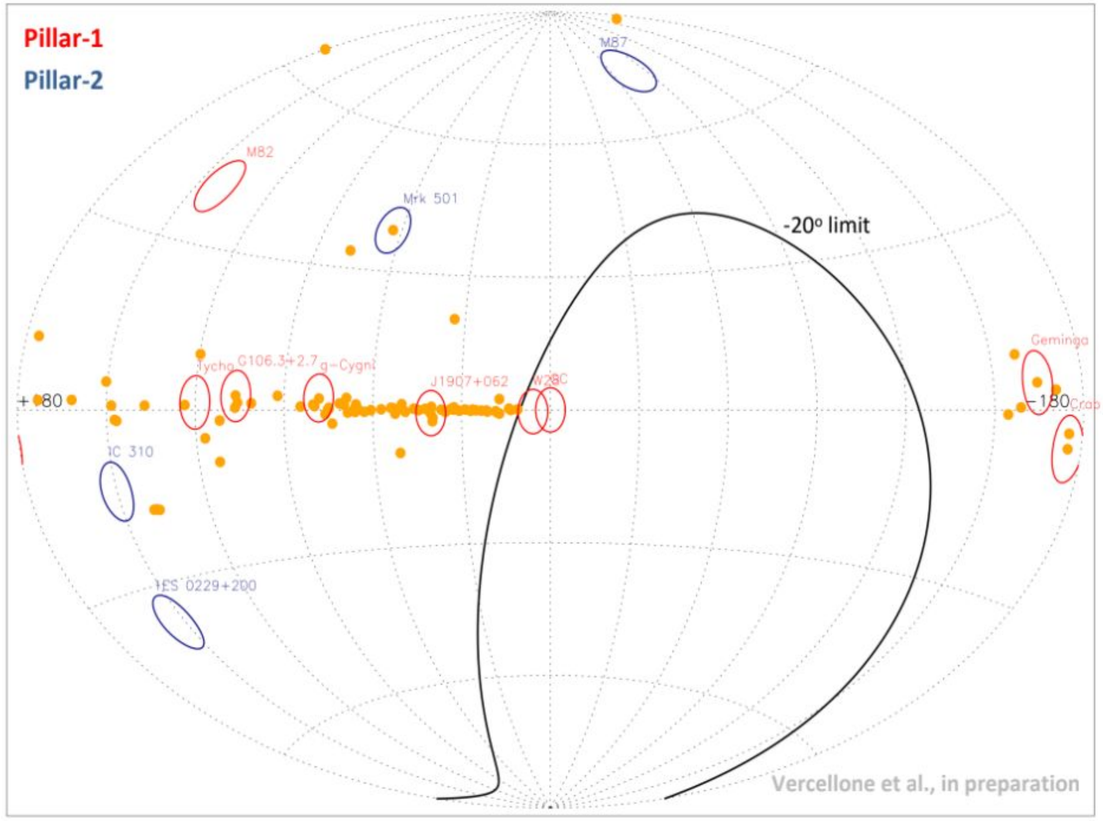
Extragalactic Observatory Science with the ASTRI Mini-Array at the *Observatorio del Teide*

JHEAP, 2022, 35, 91

ASTRI follow up of LHAASO Sources

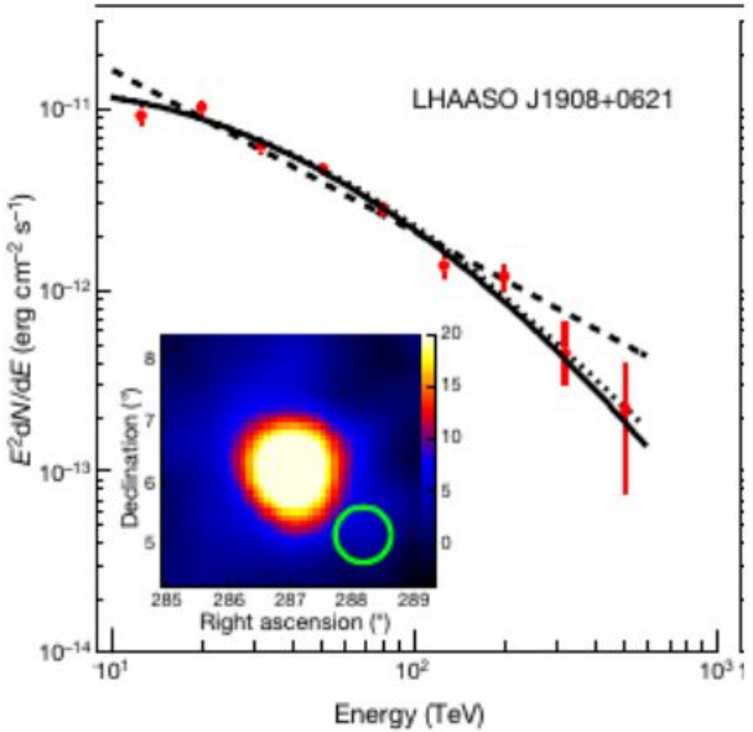






LHAASO Sources

LHAASO J1908+0621

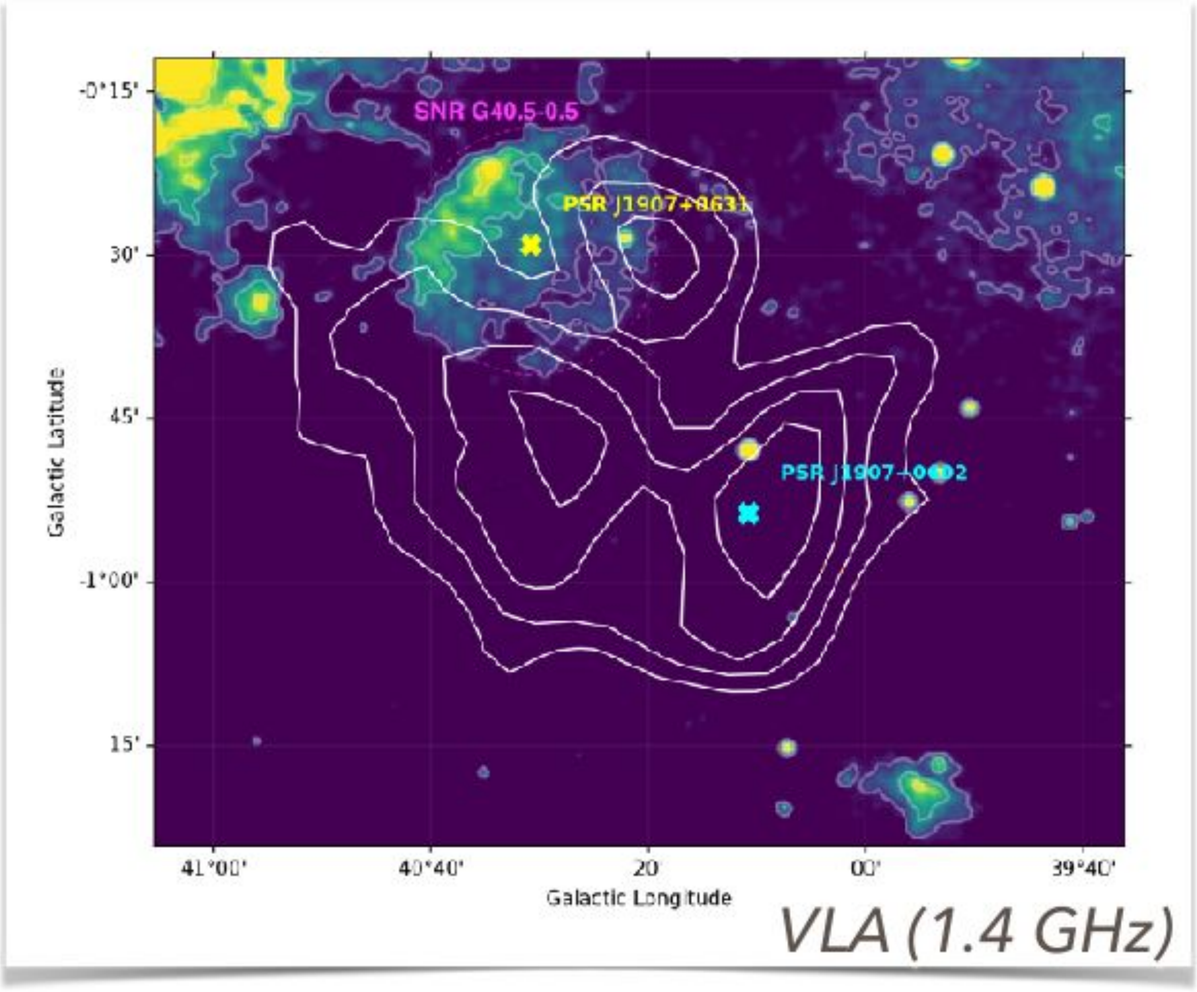


source	Number of on-source events	number of background events	exposure (hr)
LHAASO J0534+2202	67	5.5	2236.4
LHAASO J1825-1326	61	3.2	1149.3
LHAASO J1839-0545	26	4.2	1614.5
LHAASO J1843-0338	30	4.3	1715.4
LHAASO J1849-0003	36	4.8	1865.3
LHAASO J1908+0621	74	5.1	2058.0
LHAASO J1929+1745	29	5.8	2282.6
LHAASO J1956+2845	34	6.1	2461.5
LHAASO J2018+3651	42	6.3	2610.7
LHAASO J2032+4102	45	6.7	2648.2
LHAASO J2108+5157	30	6.4	2525.8
LHAASO J2226+6057	60	6.2	2401.3

Ultrahigh-energy photons up to 1.4 petaelectronvolts from 12 Î³-ray Galactic sources (LAHAASO coll.Â Nature, 2021)

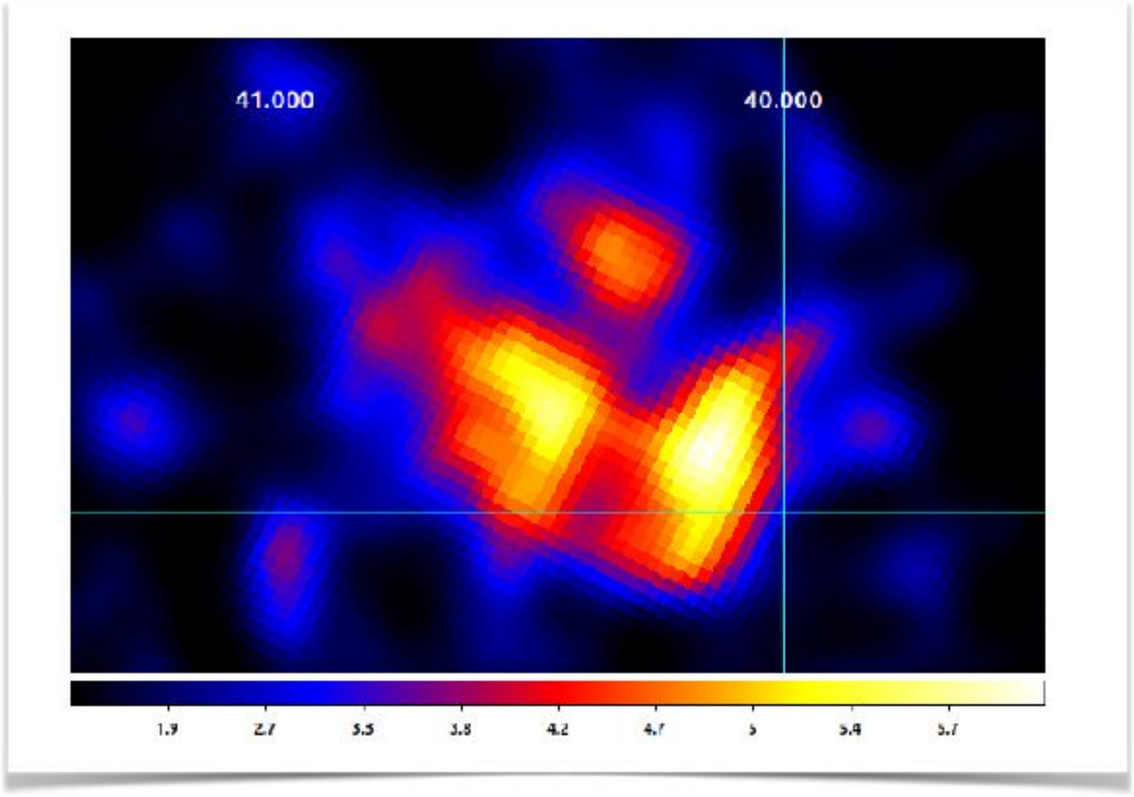
LHAASO J1908+0621

Source counterparts



VLA (1.4 GHz)

VERITAS (E>200 GeV)

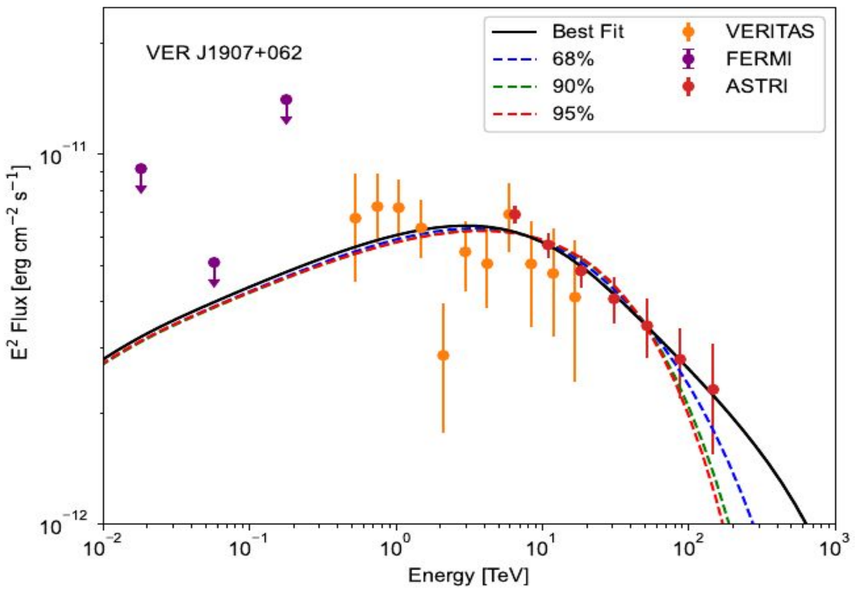


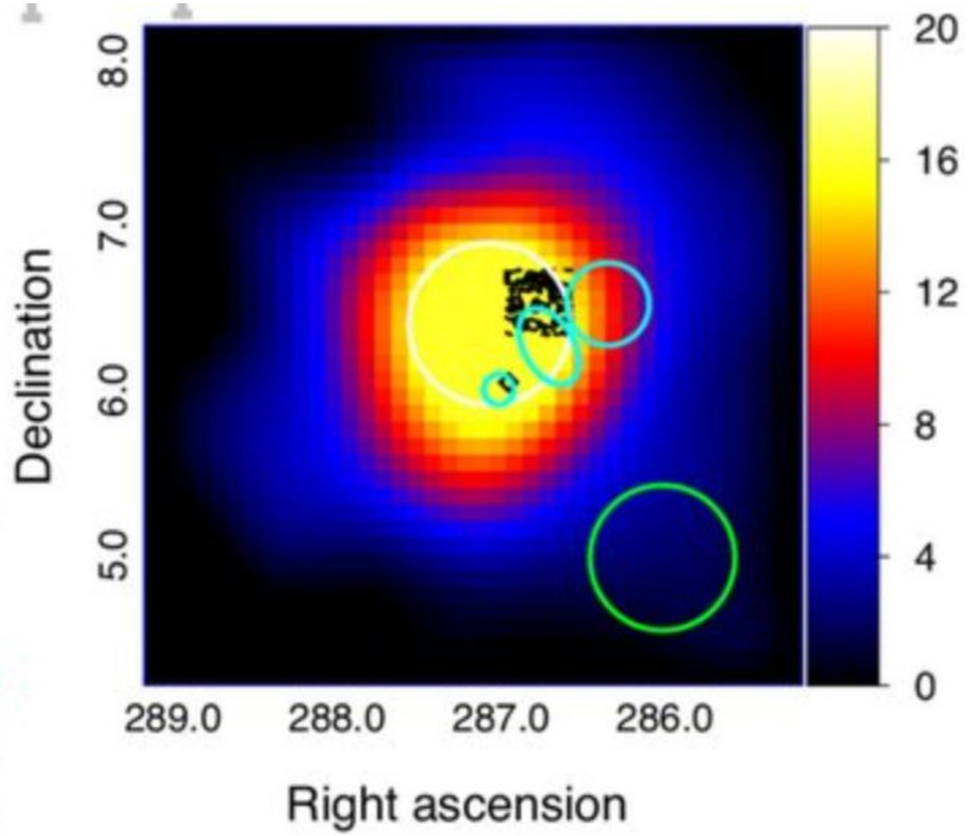
Follow up of LHAASO sources : the case of J1908+0621

ASTRI Mini-Array **200 hr simulation**

(up to E~200 TeV)

of **2HWC J1908+063**



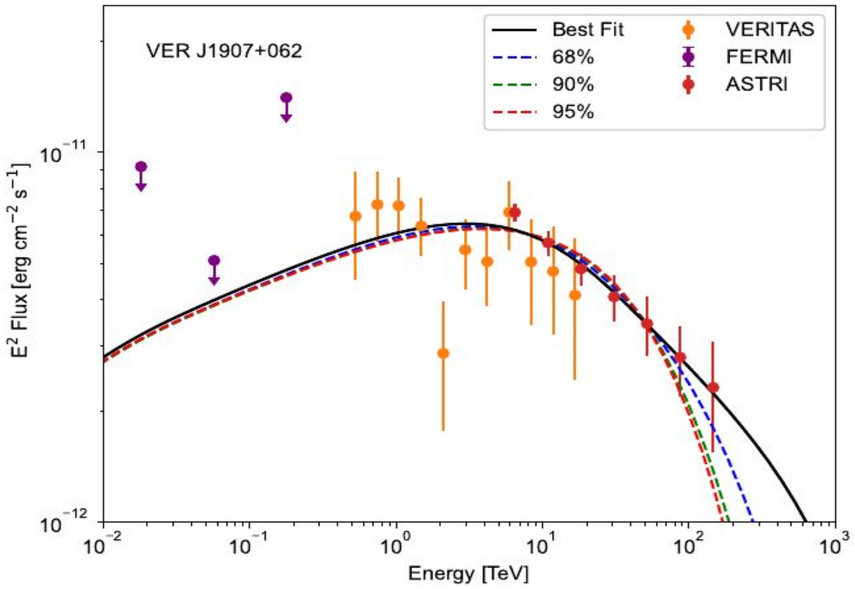


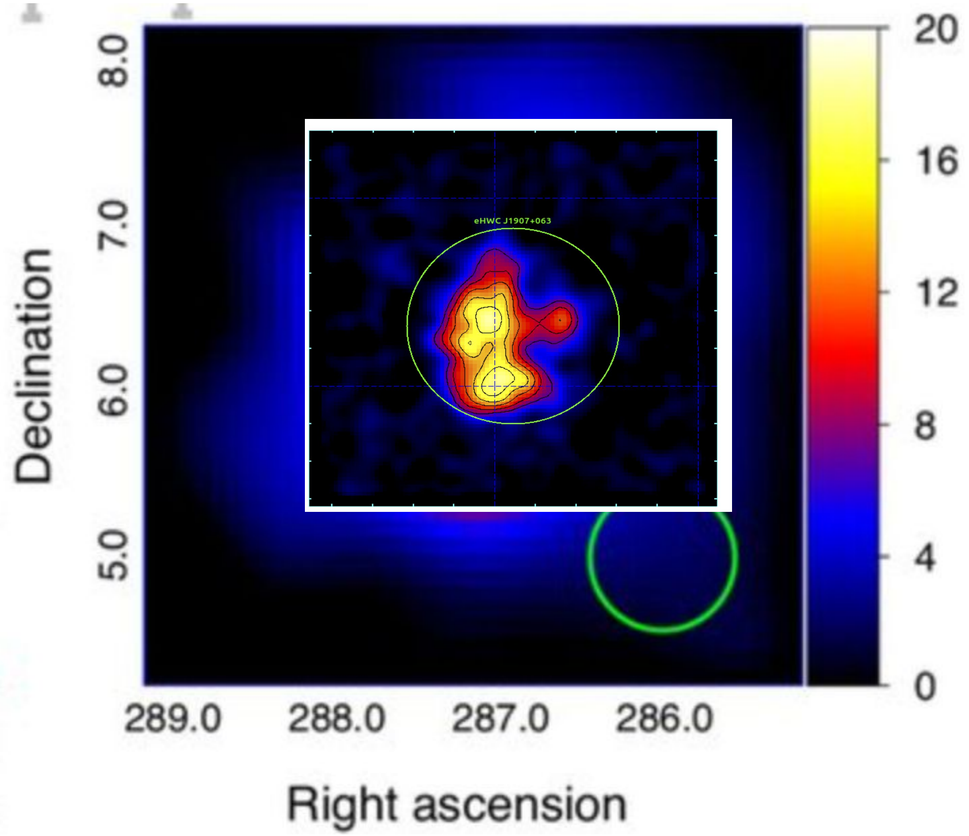
Follow up of LHAASO sources : the case of J1908+0621

ASTRI Mini-Array **200 hr simulation**

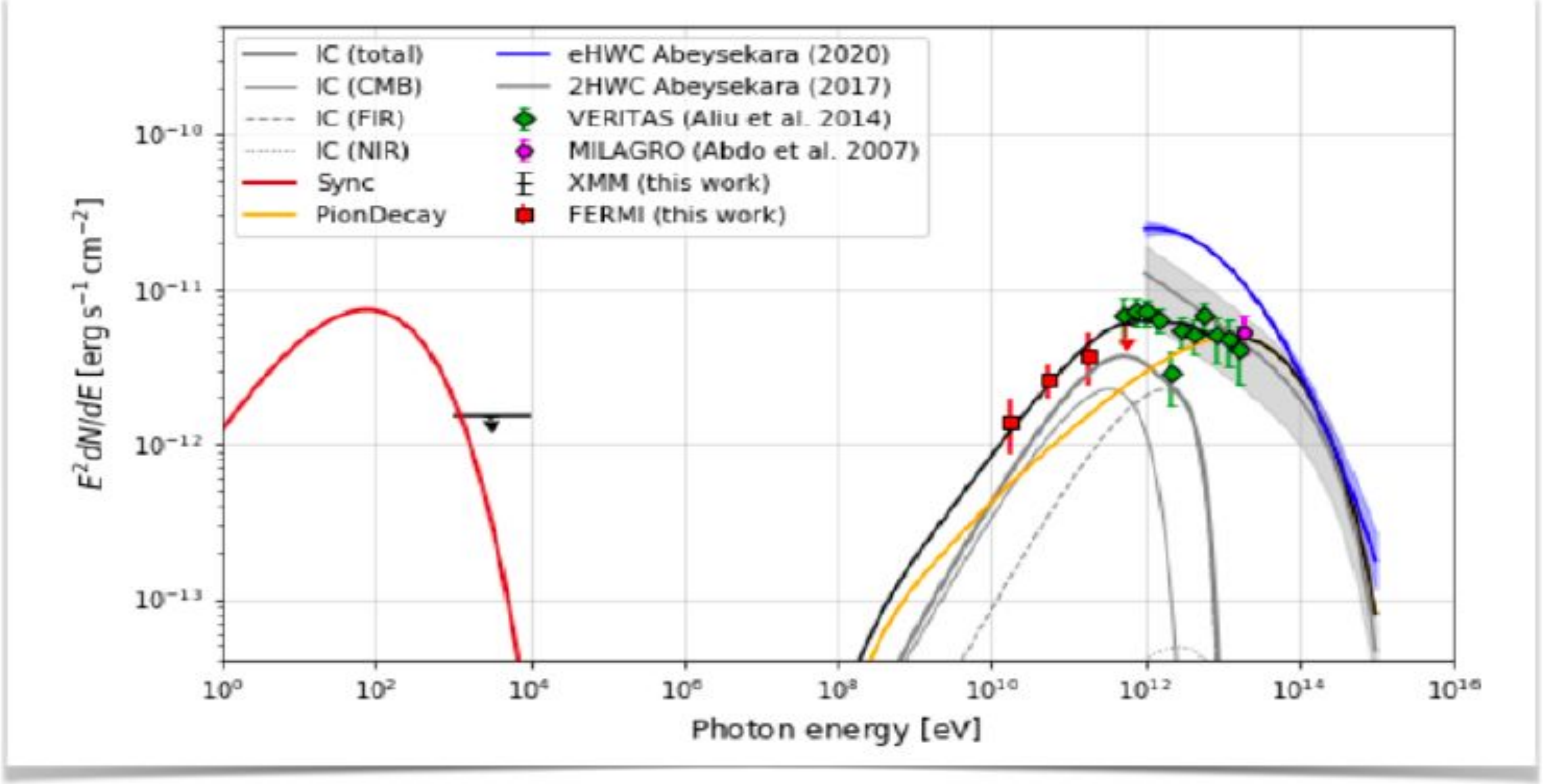
(up to E~200 TeV)

of **2HWC J1908+063**



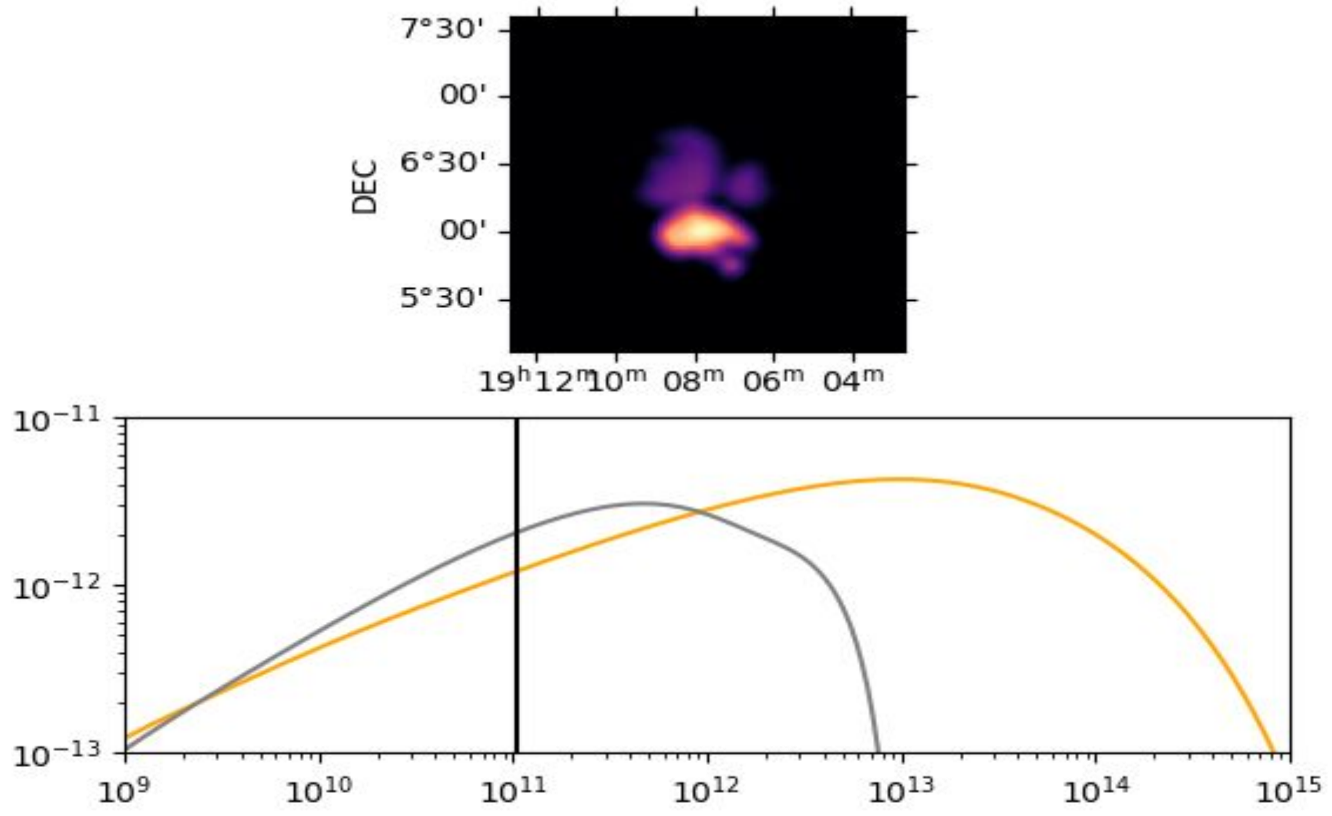


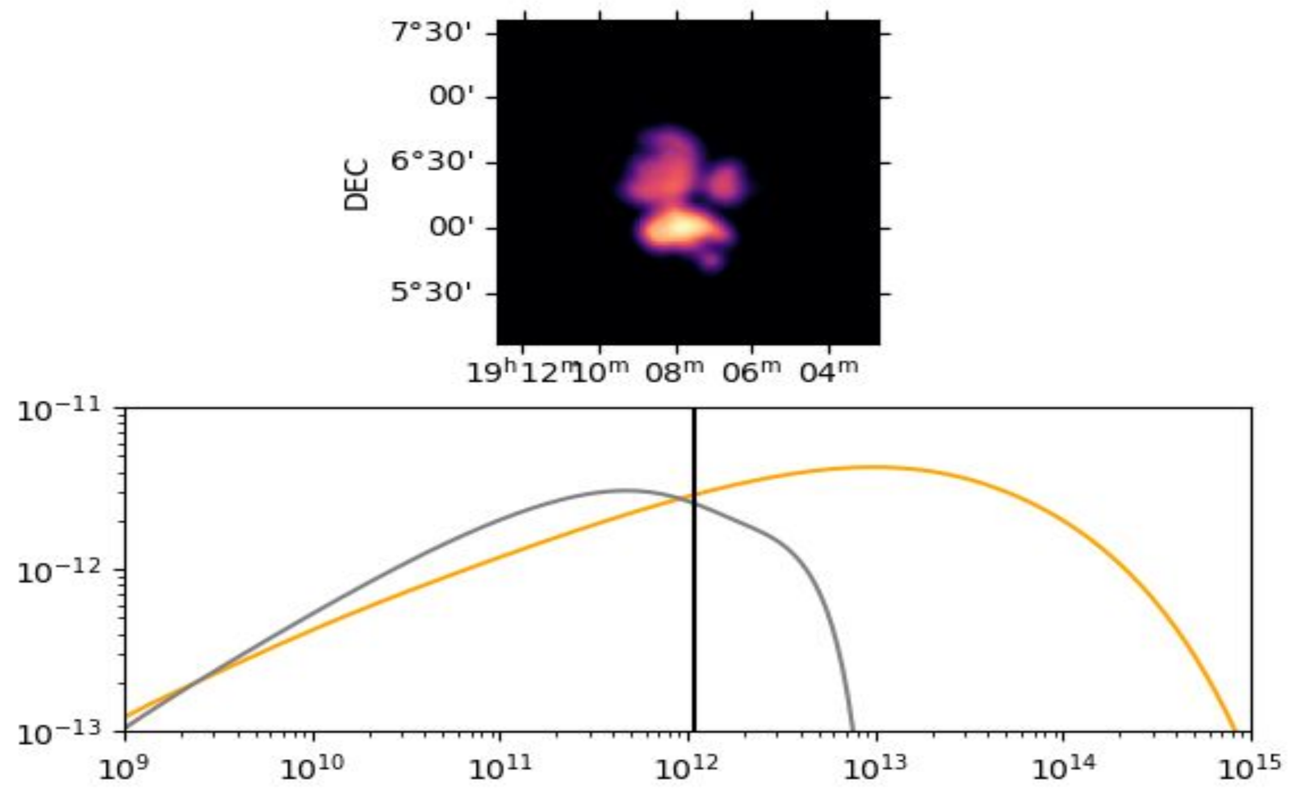
Follow up of LHAASO sources : the case of J1908+0621

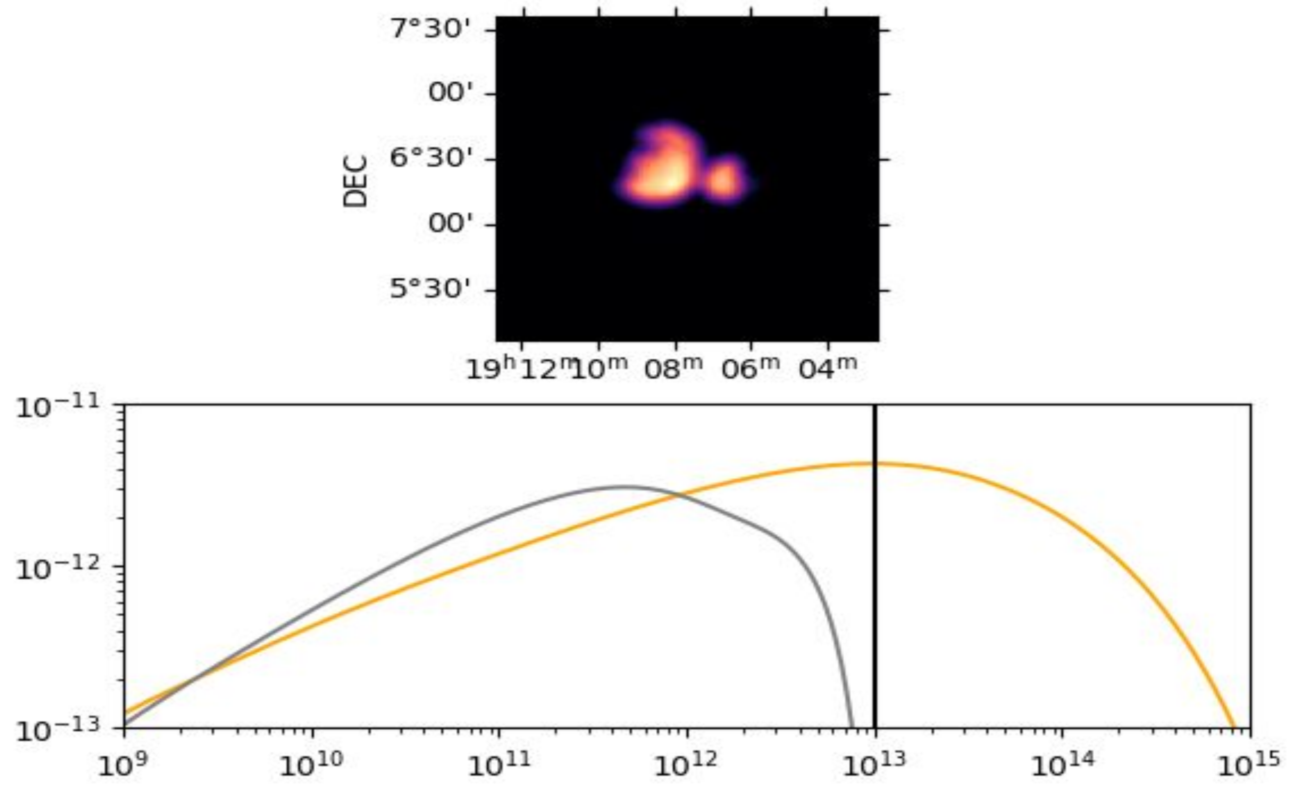


Model	Component	d (kpc)	Γ_1	Γ_2	W (erg)	E_0 (TeV)	E_b (TeV)	E_c (PeV)
1-zone	Leptonic	3	1.0 ± 0.4	2.6 ± 0.1	2×10^{47}	10	2.7 ± 0.7	7.1 ± 6.0
1-zone	Hadronic	3	1.0 ± 0.1	2.1 ± 0.1	7×10^{47}	30	2.8 ± 0.8	3.0 ± 0.9
1-zone	Hadronic	9	1.1 ± 0.2	2.1 ± 0.1	2×10^{49}	30	3.4 ± 1.2	1.9 ± 0.5
2-component	Leptonic	3	1.2	1.2	9×10^{46}	10	0.2	0.011
	Hadronic	3	1.6	2.0	4×10^{47}	30	200	>1
	Hadronic	9	1.6	2.0	1×10^{49}	30	200	>1

Crestan et al. MNRAS, 2021



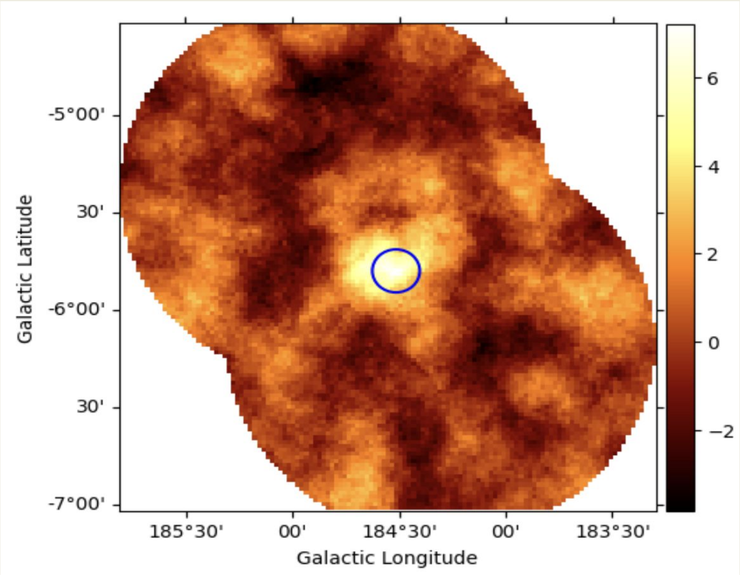




An Energy-dependent morphology (2 zone model)
can be **resolved by the ASTRI observations**

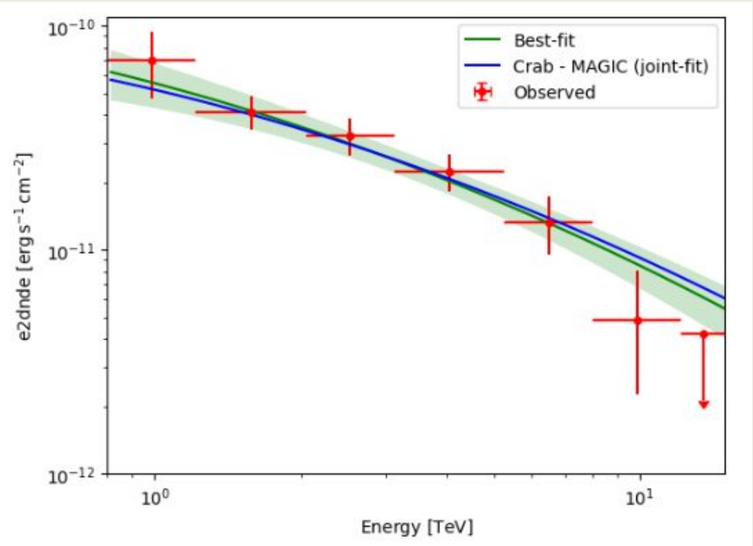
ASTRI HORN

ASTRI Horn Prototype of small telescopes, it was also a useful test bed for ASTRI-MA's data reduction and analysis software.



Crab Observations in 2022-2023

- Detection at ~7.2σ in ~22.6 hr
- 0.05° location accuracy
- Spectrum in 0.8-10 TeV energy range well modeled by a log-parabola



Leto et al., to be submitted

ASTRI Telescopes

The current ASTRI telescopes are an evolution of the ASTRI-Horn prototype telescope

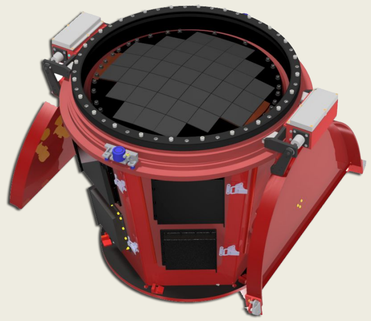
The electromechanical structure was optimized in terms of mass, functionality and maintainability (mass has been reduced by 30%).

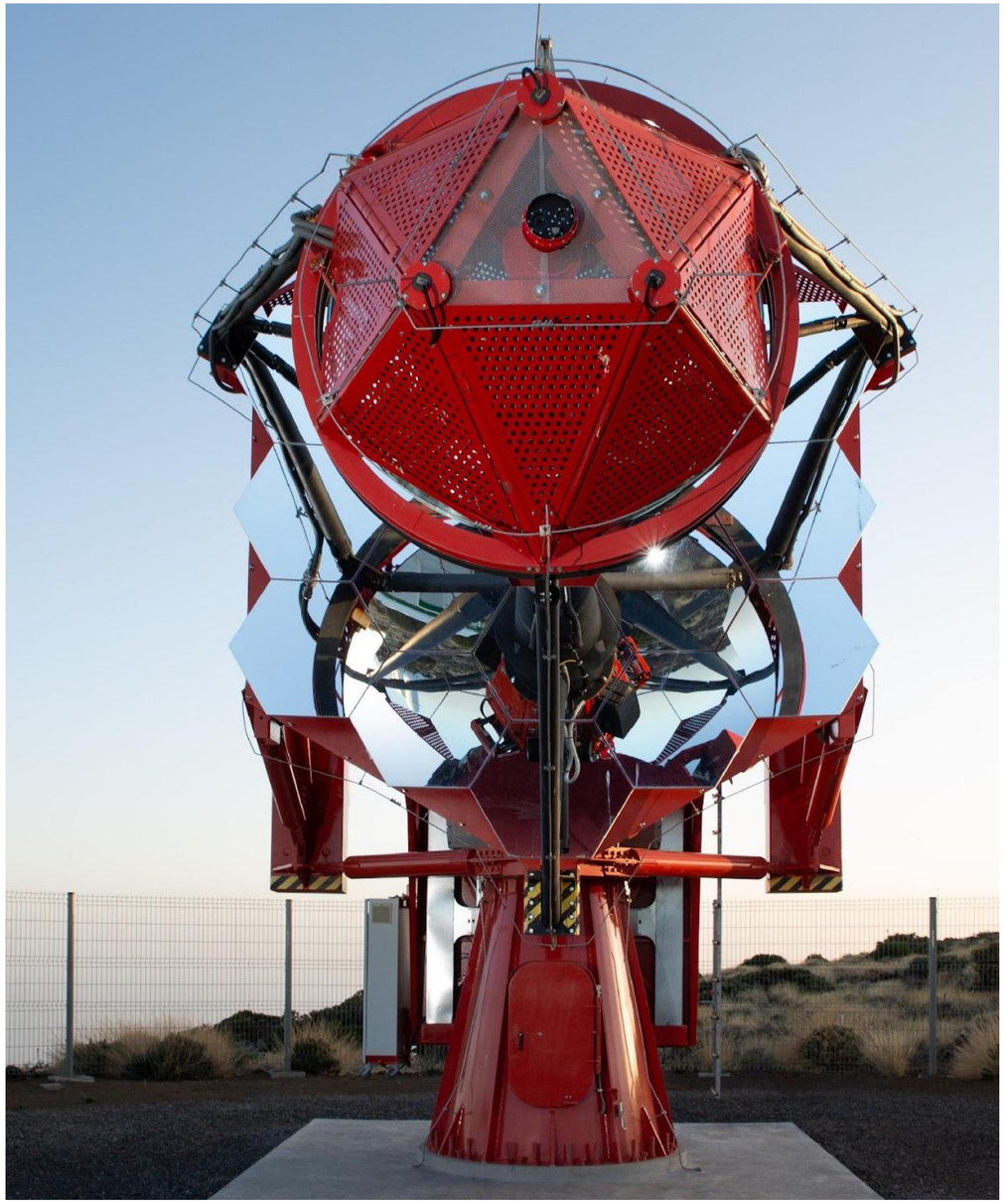
Dual-mirror optical layout (Schwarzschild-Couder)

- Wide FOV (~10)
- Optimal PSF across the entire FoV

ASTRI Silicon photomultipliers camera

- 37 (8x8) matrices are arranged to adapt to the curved focal plane of the telescope.
- Small pixel-size (0.19°)
- Work also with moonlight





ASTRI Mini-Array - Schedule

Summer 2021

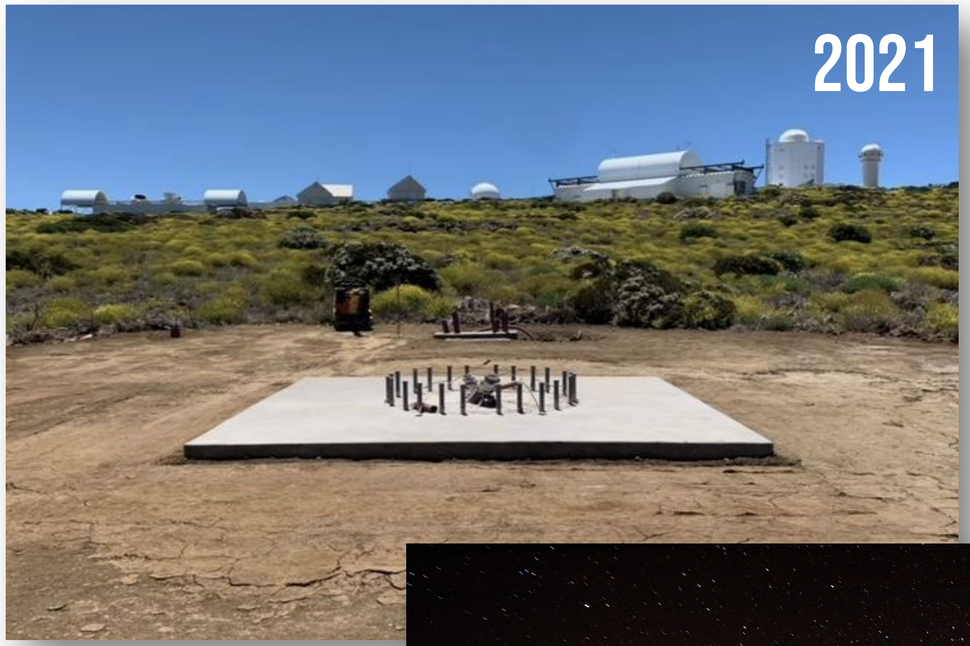
Site foundation

Autumn 2022

ASTRI 1 construction and calibration

"Mono" observations

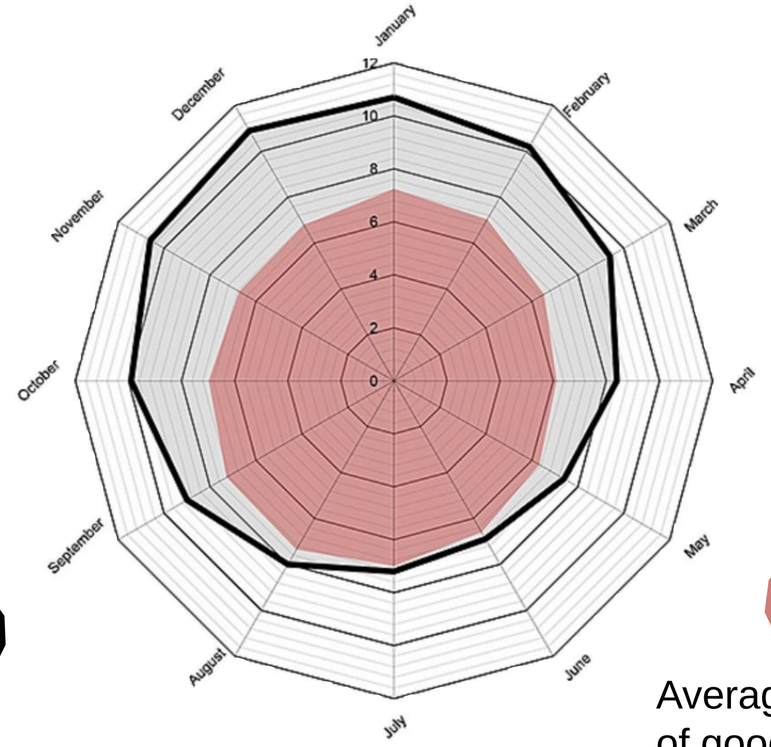
Autumn 2024



Teide Site

NSB : Lower humidity and low light pollution ensure a darker sky with less background brightness compared to Serra La Nave.

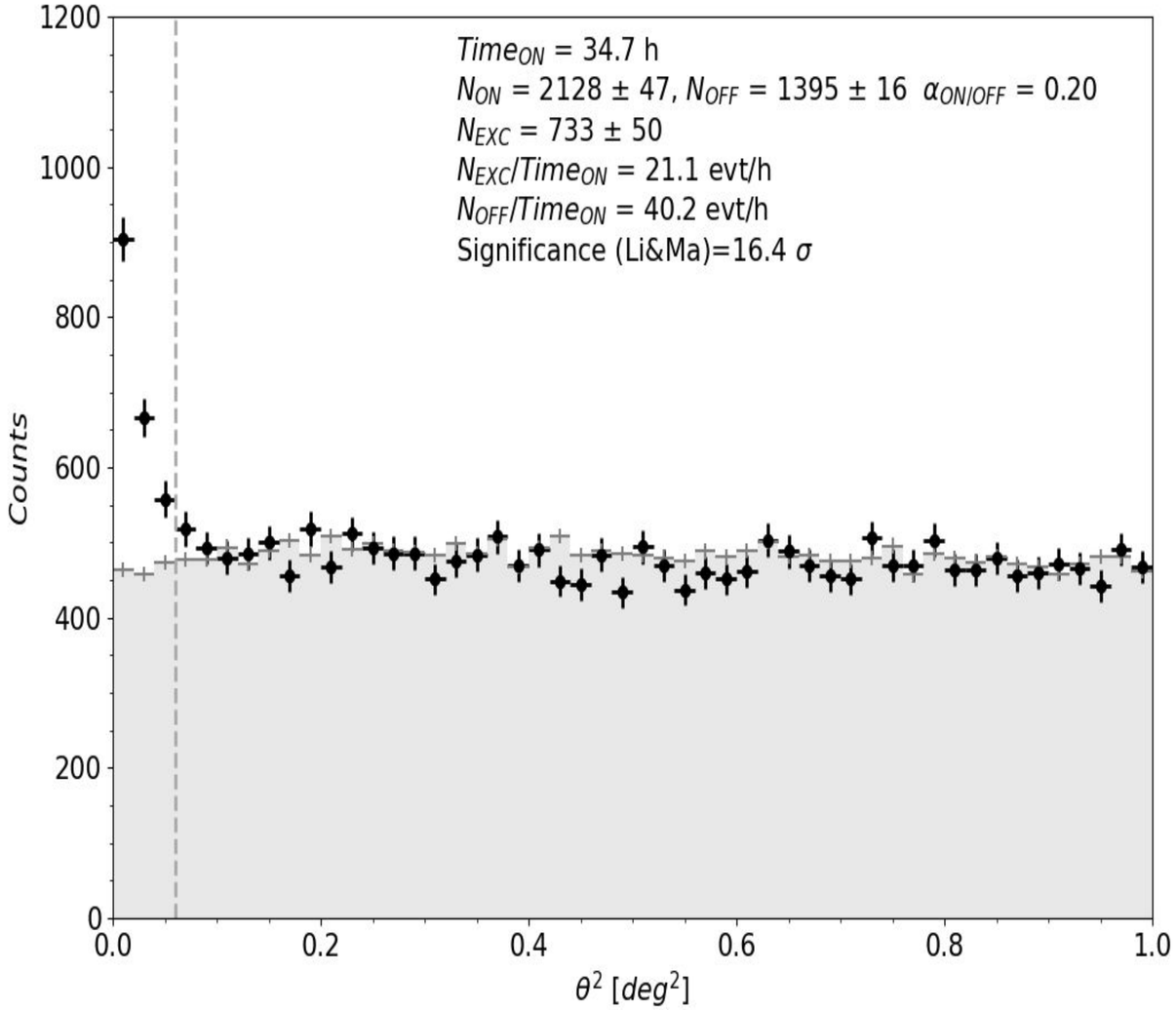
Minimal cloud coverage: Teide's high altitude keeps it above the inversion layer, reducing cloud interference



Nights hours

Average hours of good weather

Crab Nebula : november 2024 - february 2025



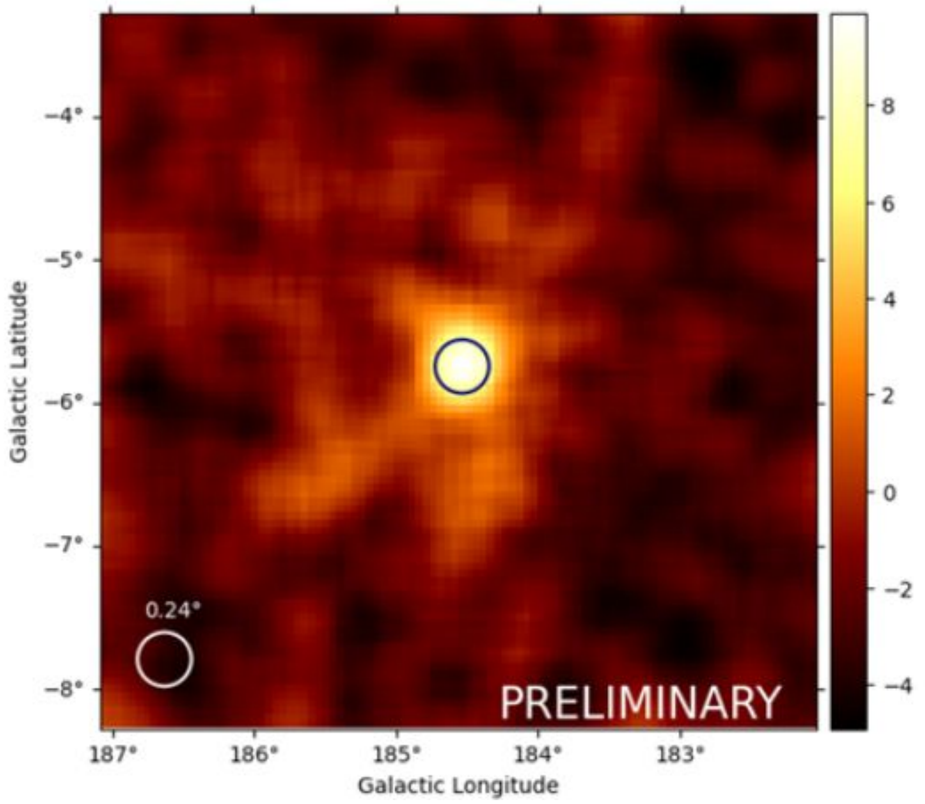
Crab: from 11/2024 to 02/2025

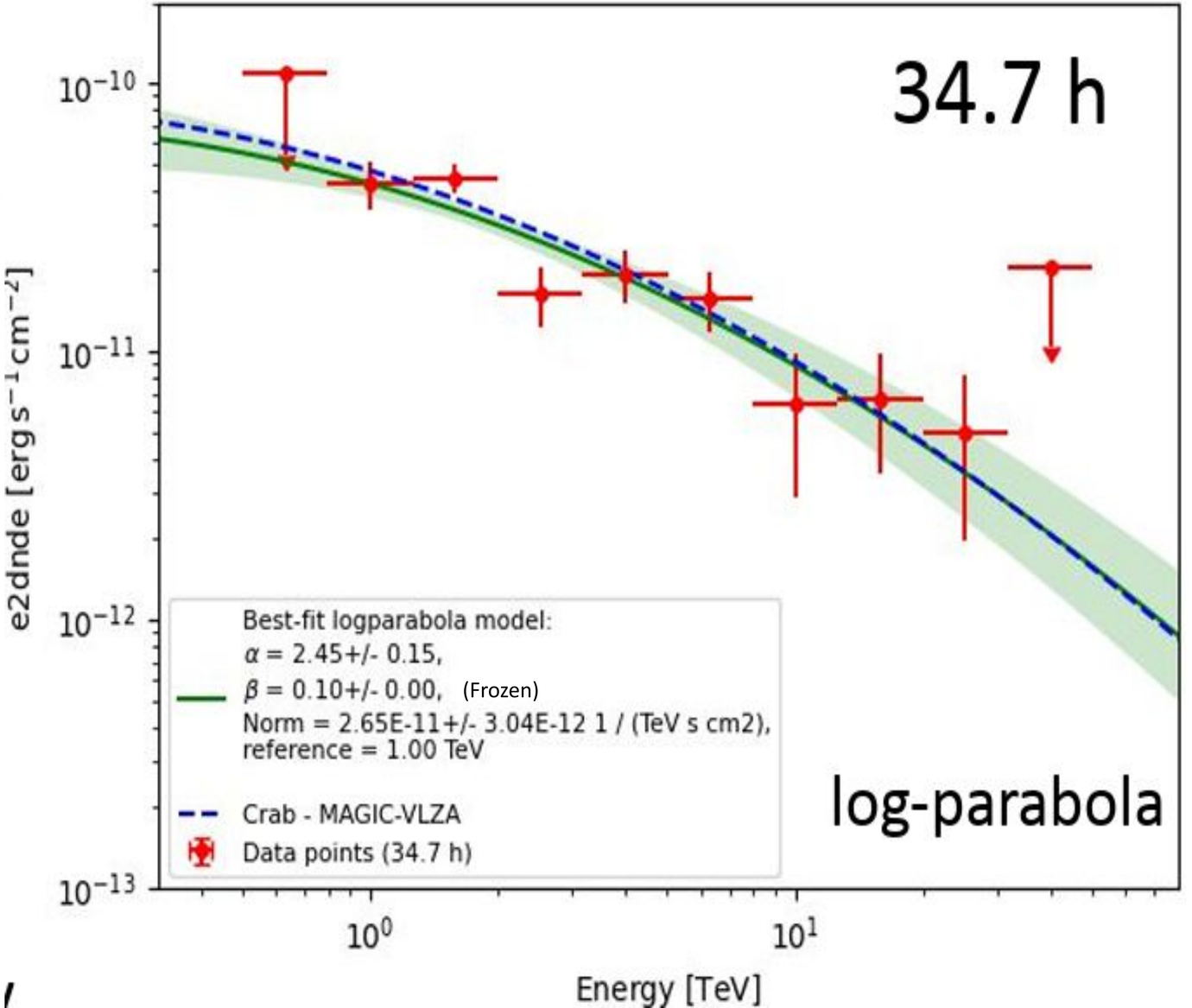
- Trigger Threshold = 7 pe
- Dark
- Offset: 0.5°
- Low ZD (< 30°)
- Subsample of selected good runs
- 34.7 h of total exposure time

ASTRI-1: Crab Spectrum

ASTRI Mini-Array

- RA/DEC = 83.65° , 22.05°
- 0.03°away from the position of Crab Nebula

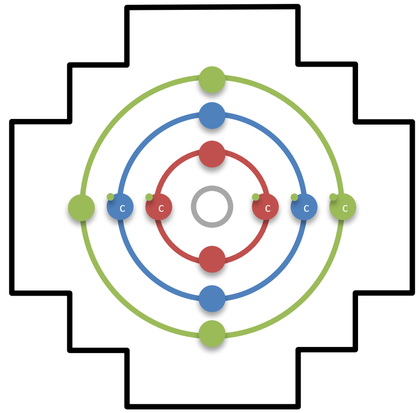




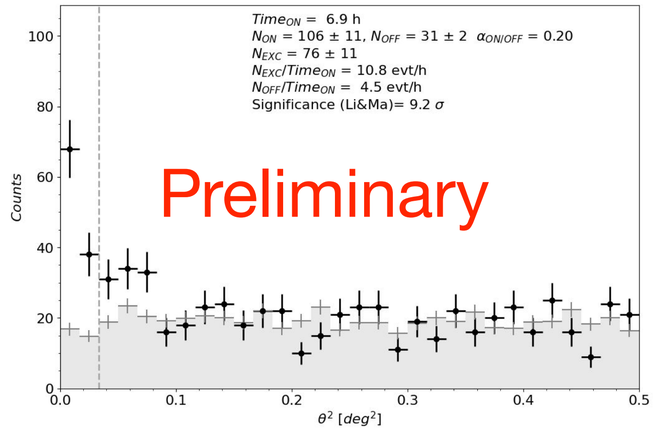
ASTRI-1 detection at increasing offsets

We got firm detection at increasing offset position

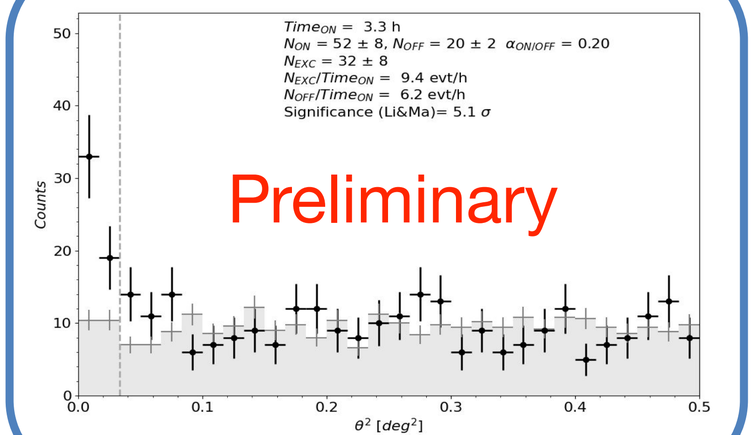
-> This is the indication that the camera's acceptance is quite flat up to an offset angle of 3.5°



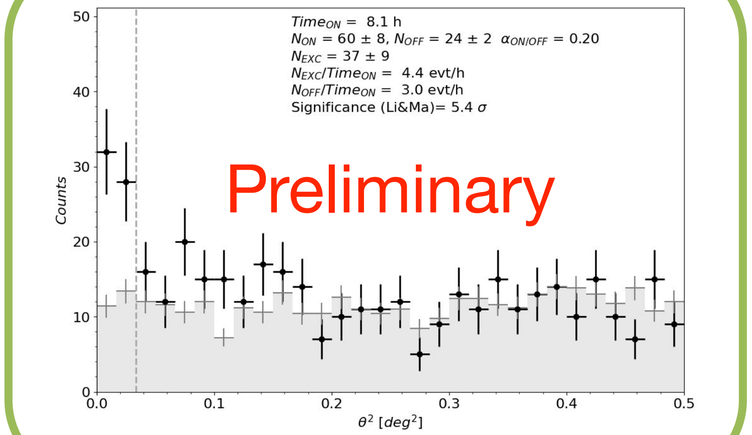
Offset 1.5°



Offset 2.5°

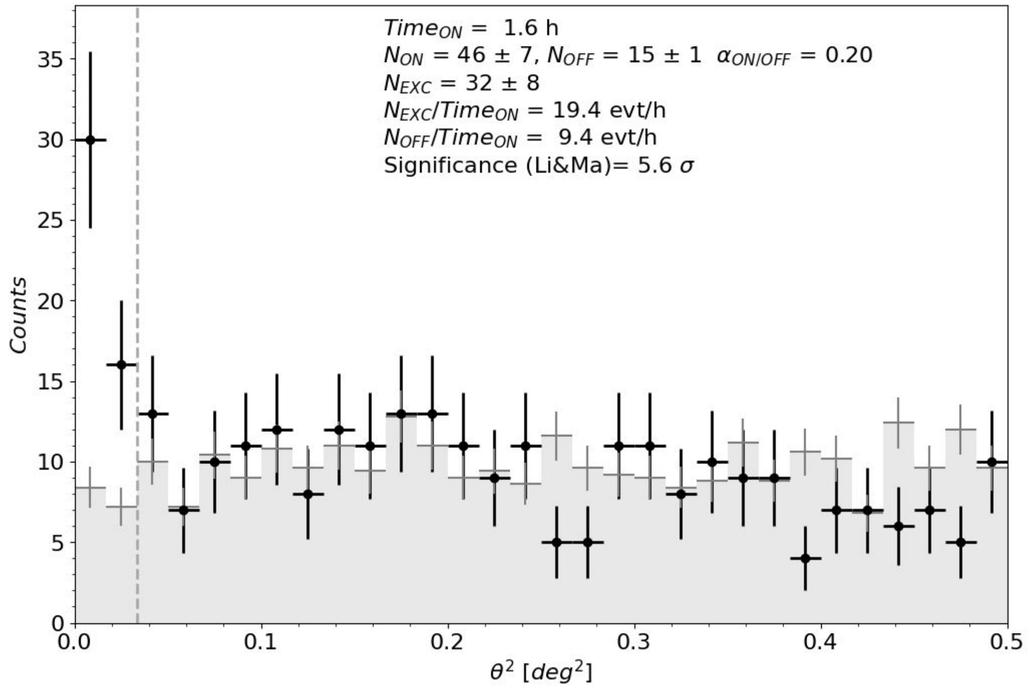


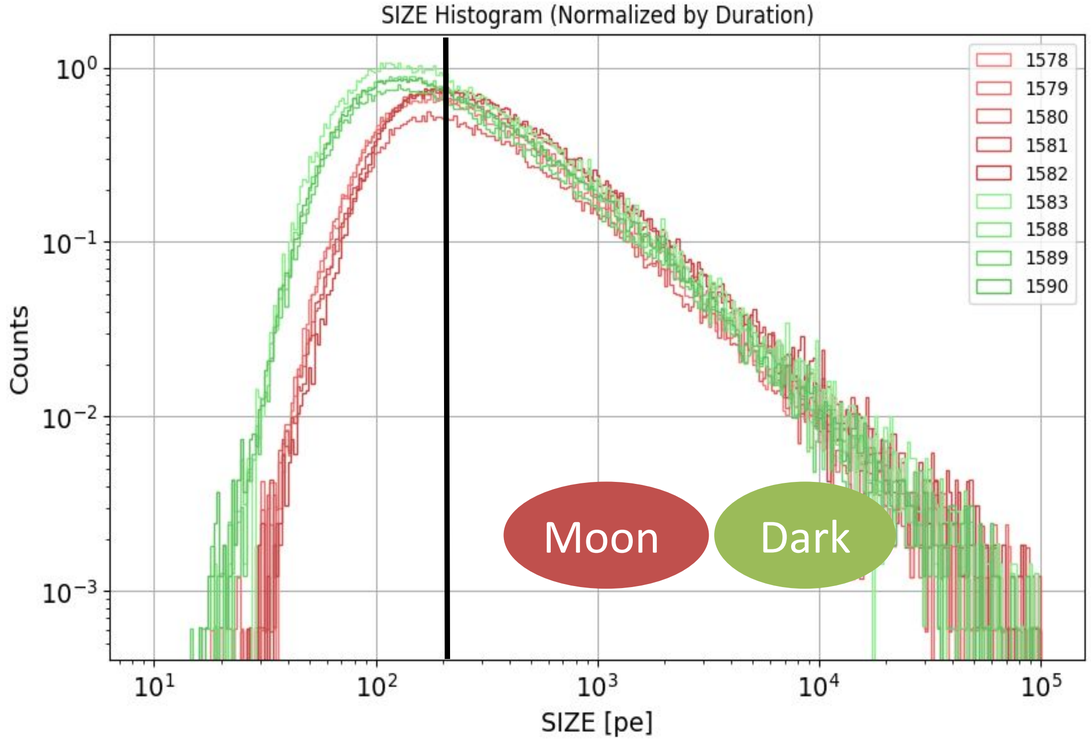
Offset 3.5°



Crestan et al., ICRC 2025,

ASTRI-1 detection with the Moon





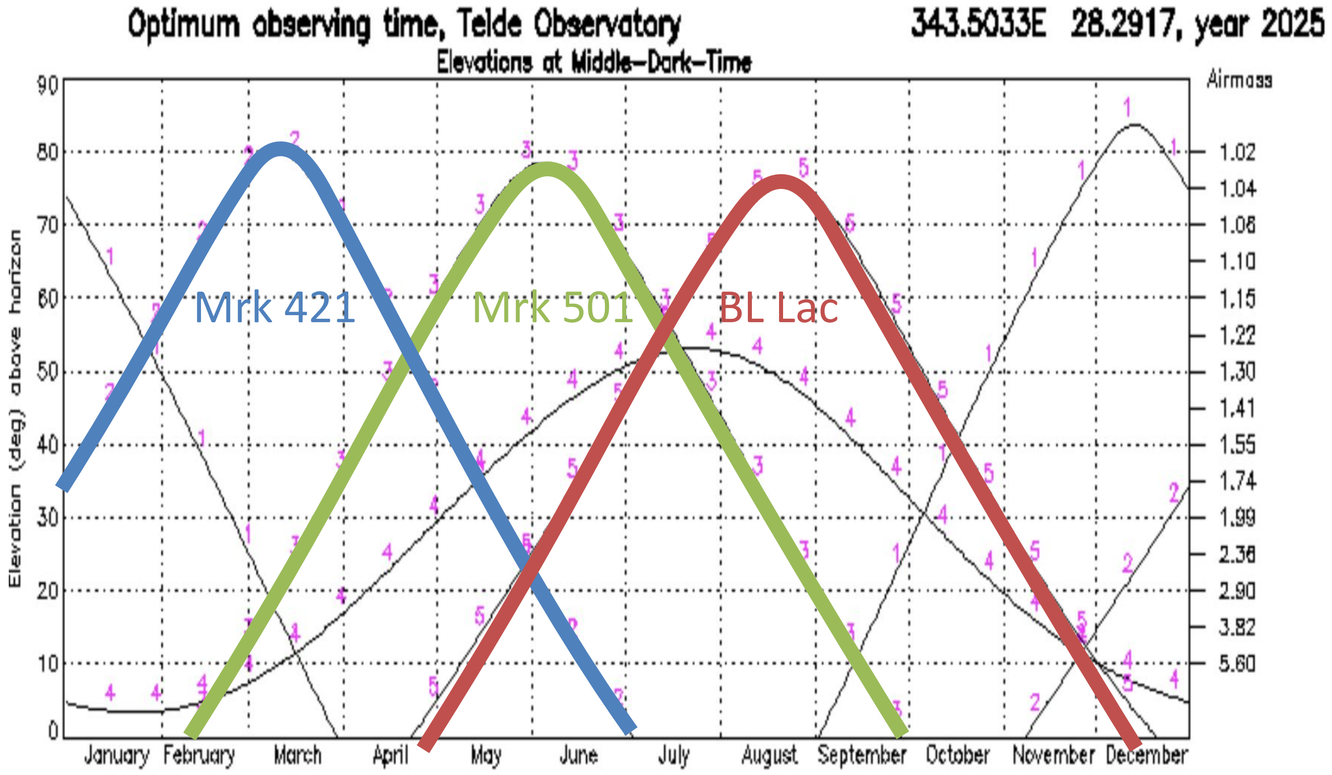
Crab runs taken during the first night:

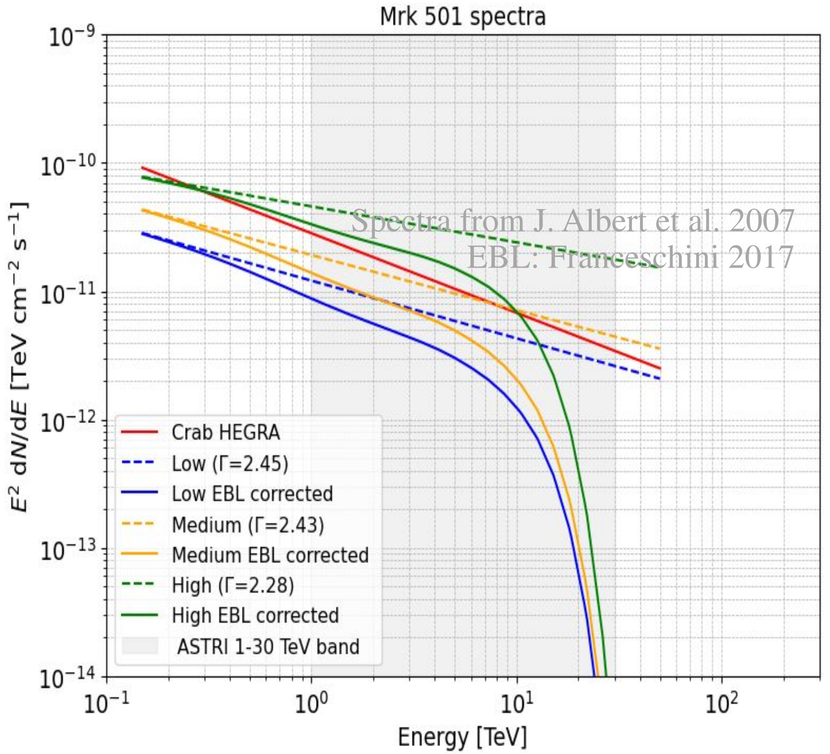
- 4 in moonlight condition
- Offset angle: 0.5°

Analysis :

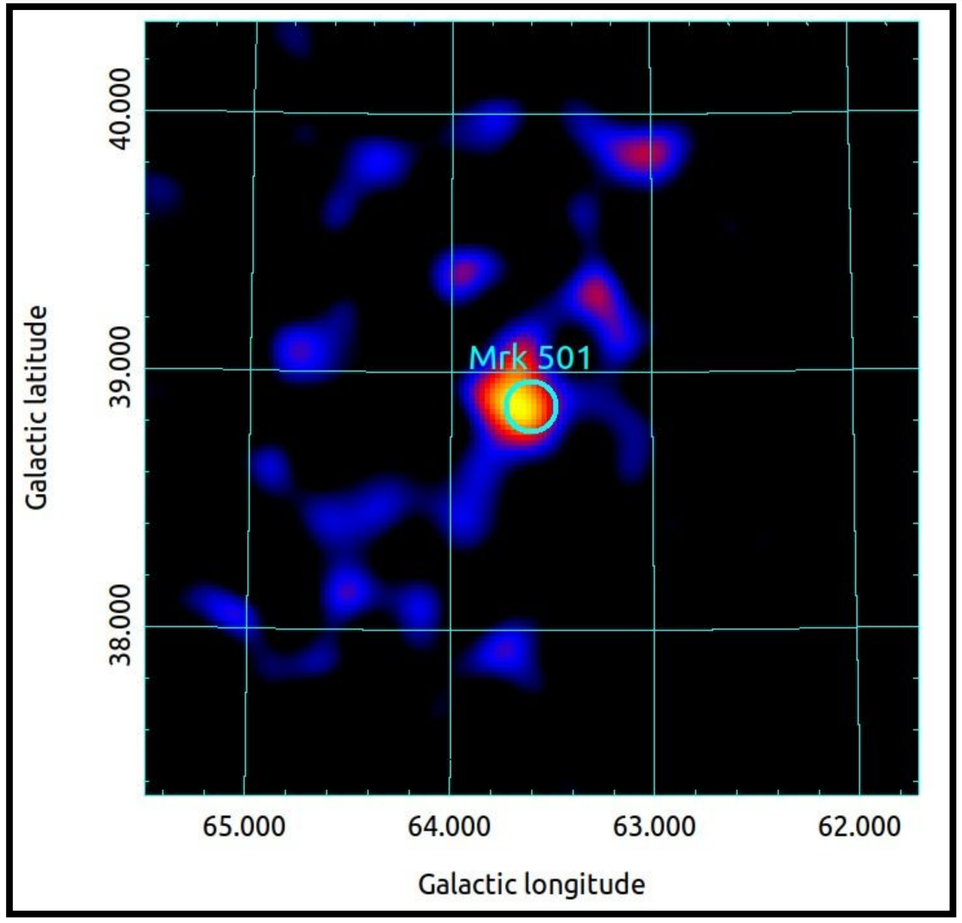
- Baseline analysis configuration
- Not-yet fine-tuned Monte Carlo simulation
- Applied cuts: Size>150 , Leakage=0, Numisland=1, ZD<30°, Gammaness>0.85, Th2<0.034 deg^2

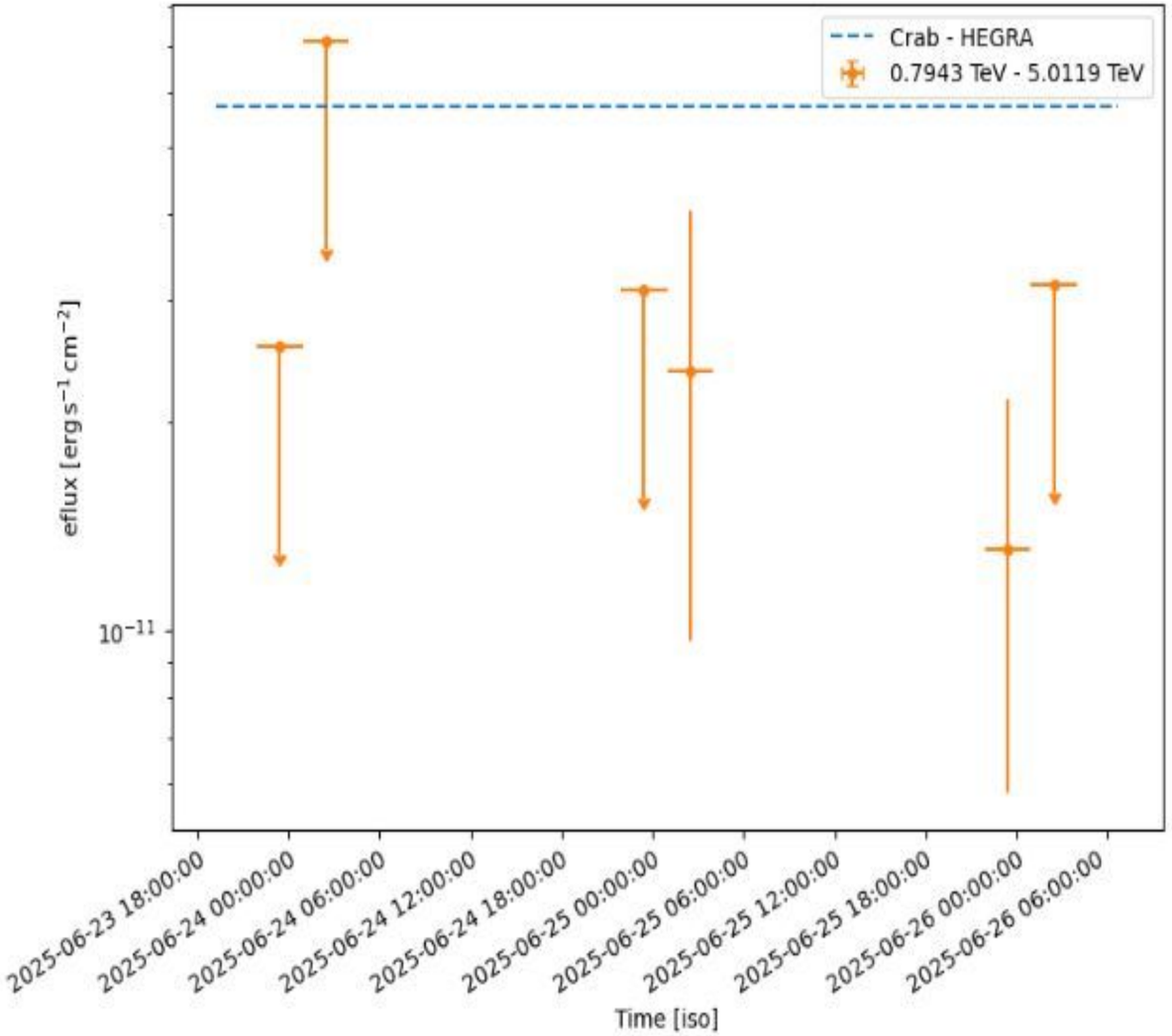
Not only Crab





Mrk 501 (June 2025)





Weak detection of Mrk501! (~ 0.5 Crab)

First source detected after the Crab with ASTRI-1.

[Previous | Next]

ASTRI-1 detection of enhanced very high-energy gamma-ray emission from Mrk 421 at TeV energies

ATel #17602; *S. Crestan (INAF/IASF Milano), C. Quartiroli (INAF/IASF Milano), A. Sunny (INAF/IAPS Roma), S. Lombardi (INAF/OAR Roma), F. Lucarelli (INAF/OAR Roma), F. Pintore (INAF/IASF Palermo), for the ASTRI Project*

on ***15 Jan 2026; 17:41 UT***

Credential Certification: Fabio Pintore (fabio.pintore@inaf.it)

Subjects: Gamma Ray, TeV, VHE, AGN, Blazar

Referred to by ATel #: 17622

The ASTRI-1 telescope has observed an increase in the very high-energy gamma-ray flux from the blazar Mrk 421 (z = 0.031). Observations were performed between 2026/01/15 - 2:00 UTC (MJD 61055.08) and 04:40 UTC (MJD 61055.20) for a total effective observation time of approximately 2.5 hr. A preliminary analysis of the collected data reveals a significant detection of 11 sigma. The detected gamma-ray flux between 0.8 and 5 TeV is estimated to be 2.3 +/- 0.3 (stat) Crab Units.

Related

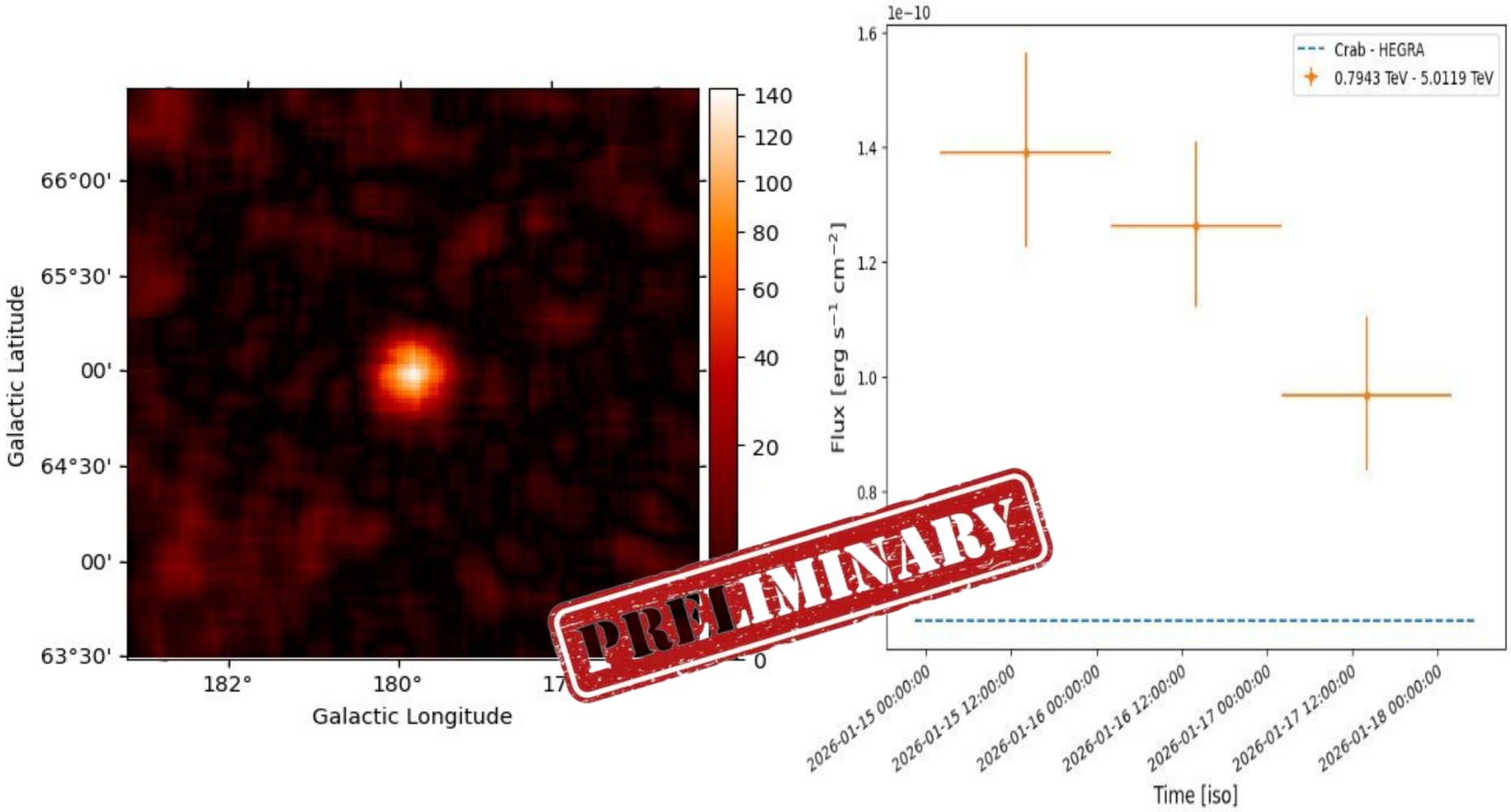
17622 Mrk 421: Upper limits from a neutrino search with IceCube
17602 ASTRI-1 detection of enhanced very high-energy gamma-ray emission from Mrk 421 at TeV energies
17597 SST-1M detection of increased very-high-energy gamma-ray activity of Mrk 421
17595 SVOM/ECLAIRs Detection of the Current Exceptional Very-High Energy Flare from Mrk 421
17594 An Exceptional Very-High-Energy Gamma-Ray Flare From Mrk 421 Observed with VERITAS
17535 LHAASO detection of Markarian 421 in a TeV-active state

Mrk 421

Mini-Array

Flare detection on January 14-16, 2026

A dedicated paper is in preparation



ASTRI Mini-Array - Schedule

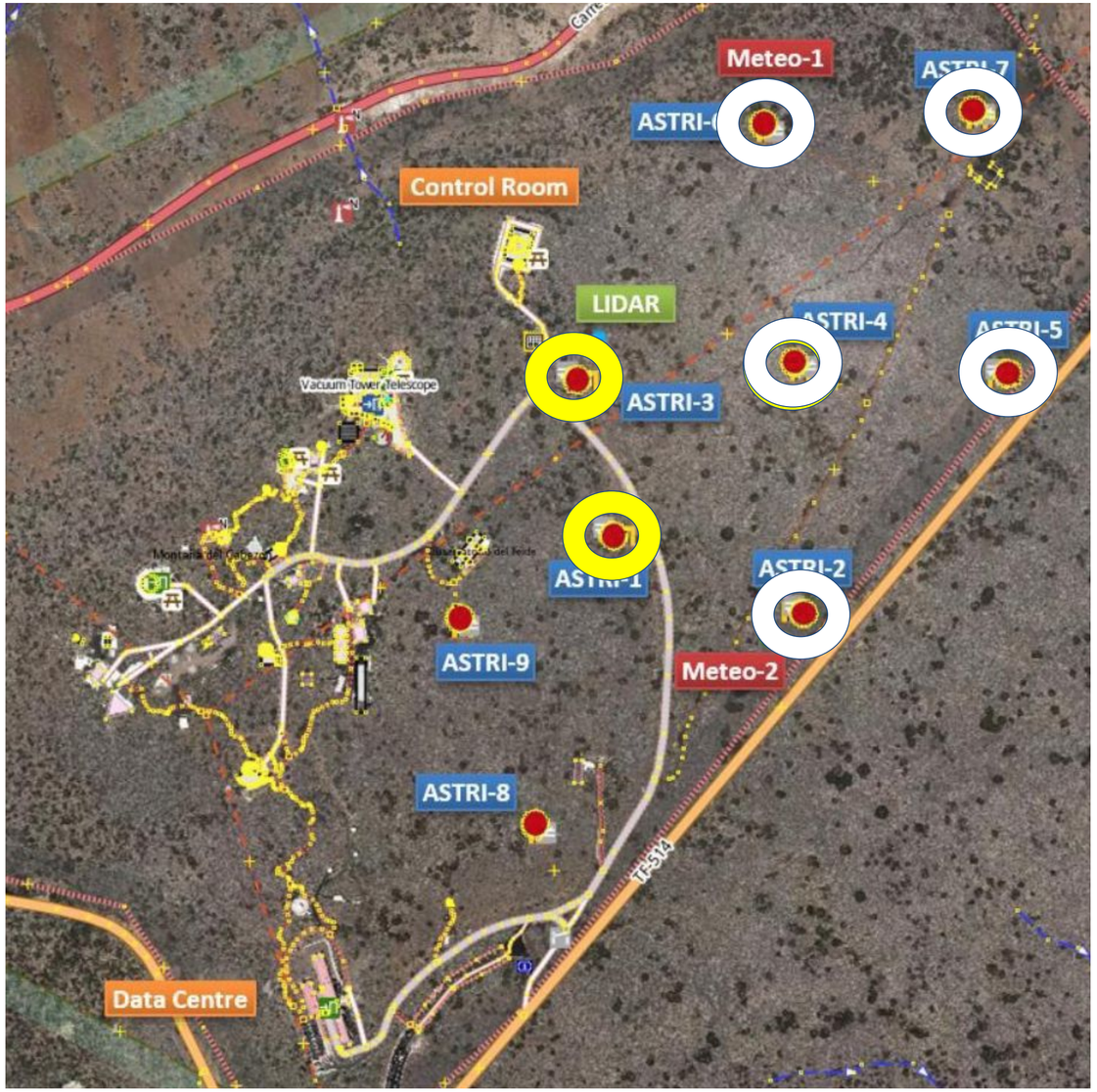
ASTRI 1 construction and calibration

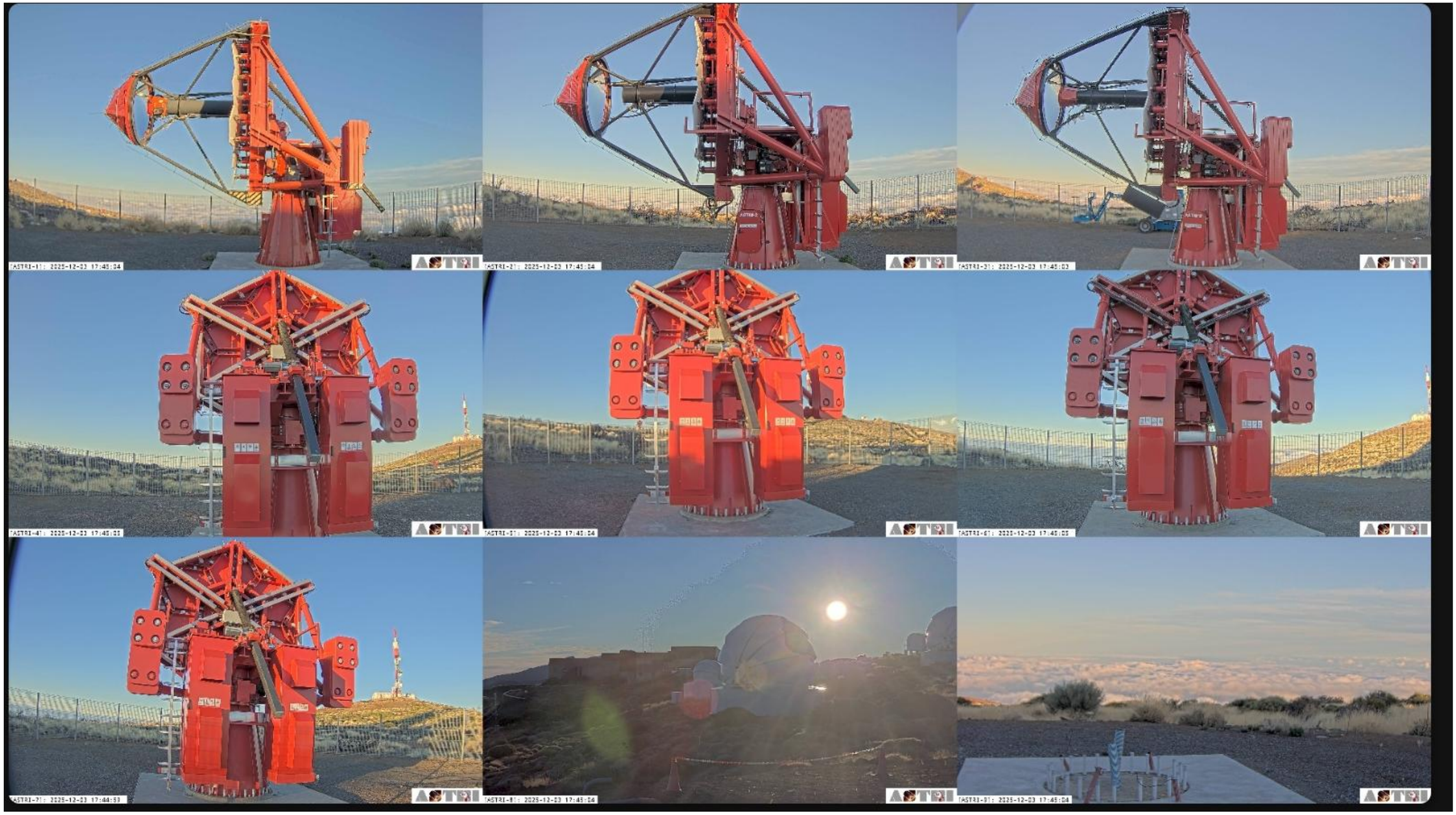
Autumn 2024

ASTRI-2T (+ 5 Tels.)

Autumn 2025

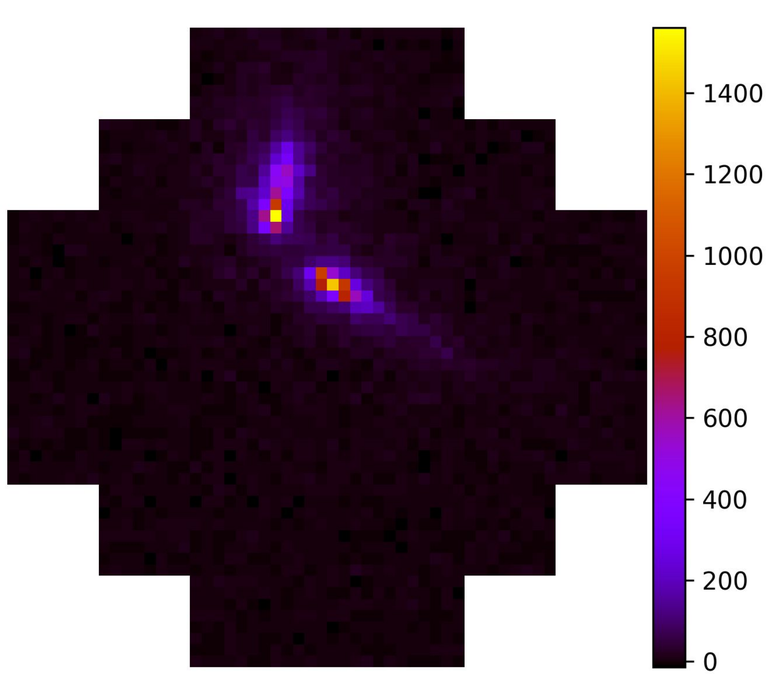
Stereoscopic observations

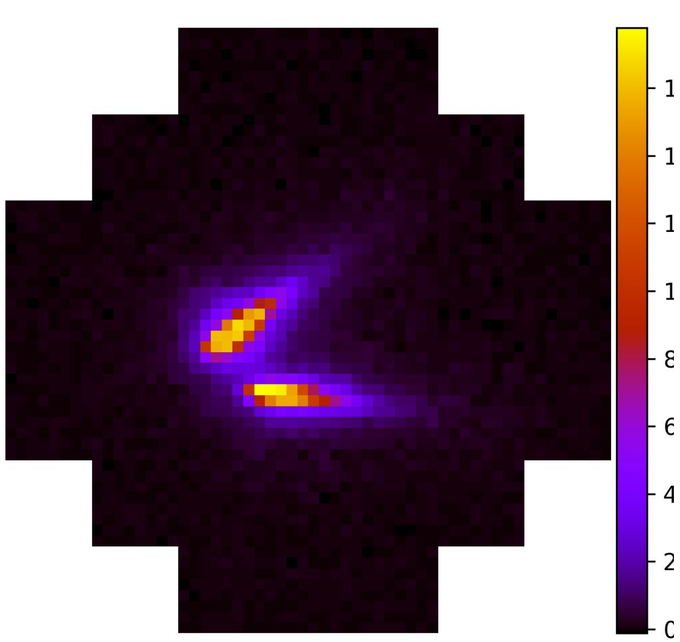


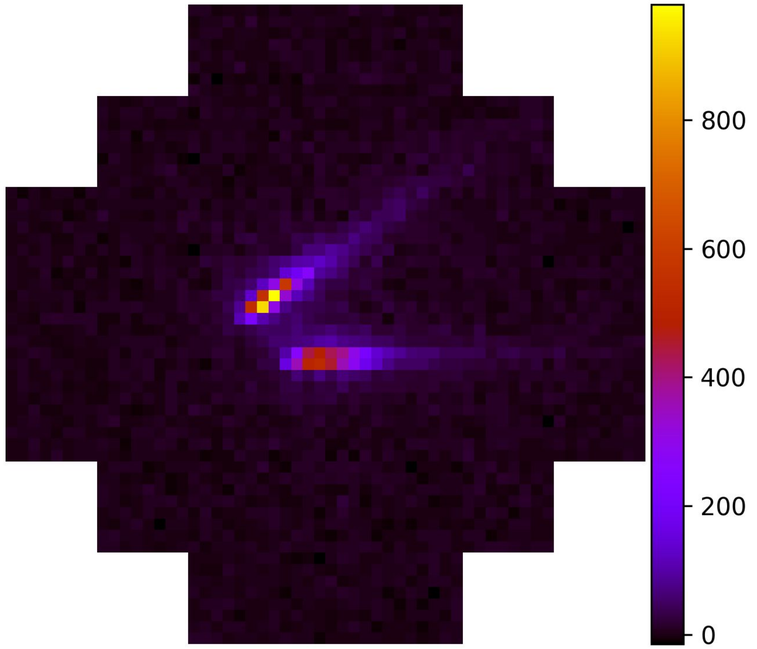


ASTRI-MA now

Stereo Events







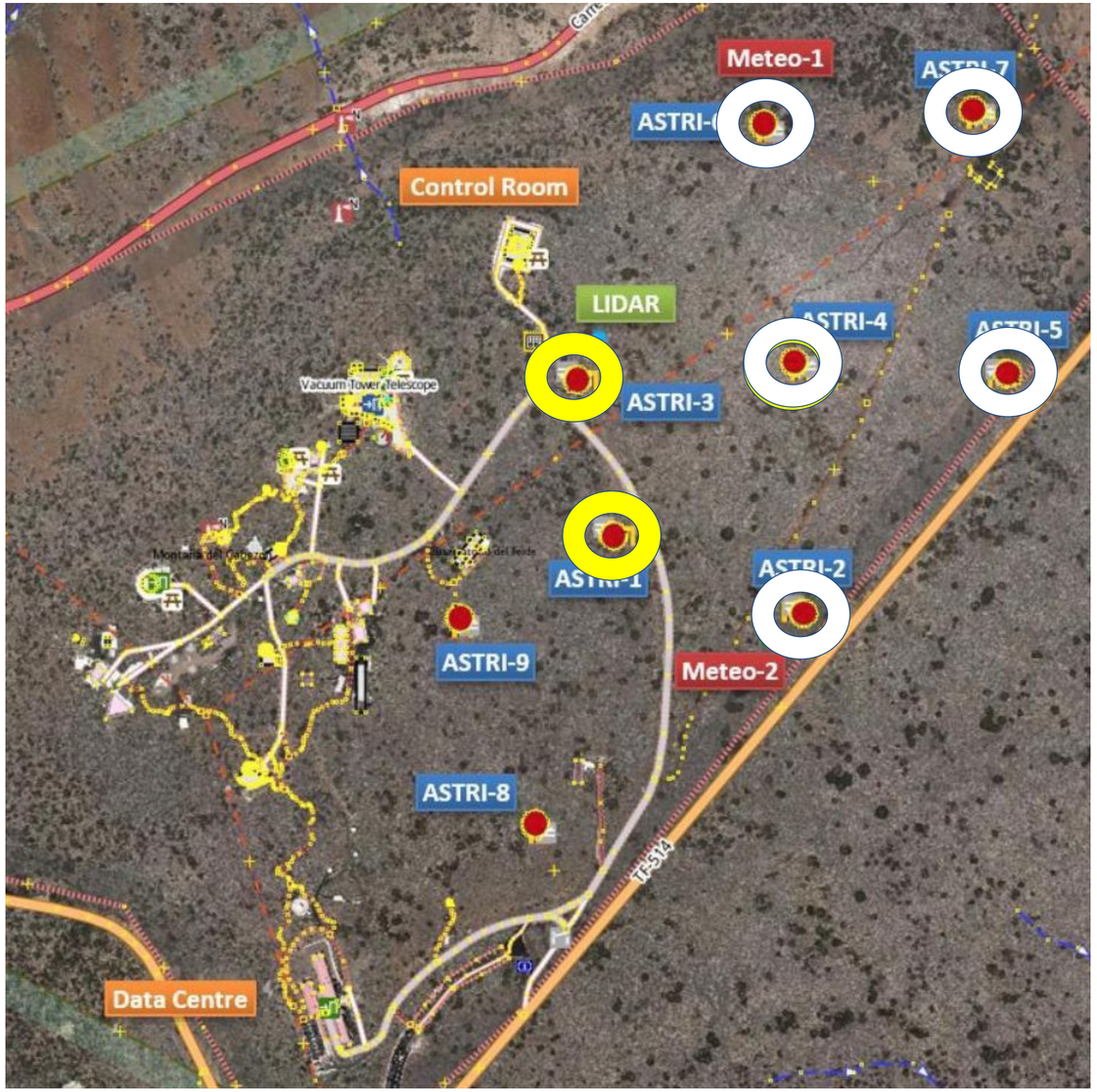
ASTRI Mini-Array - Schedule

ASTRI 1 construction and calibration

Autumn 2024

ASTRI-2T (+ 5 Tels.)

Autumn 2025



ASTRI Mini-Array - Schedule

ASTRI 1 construction and calibration

Autumn 2024

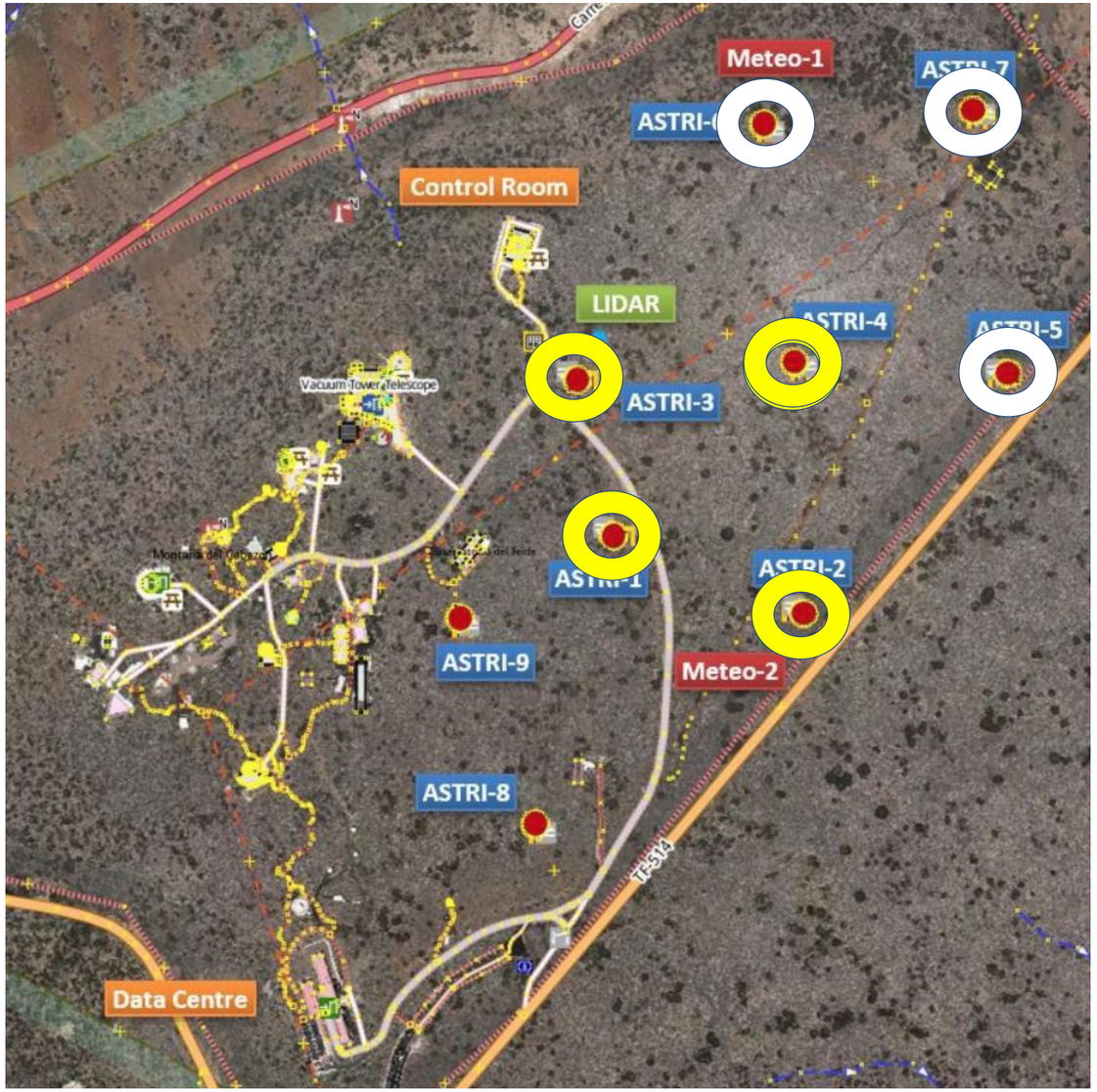
ASTRI-2T (+ 5 Tels.)

Autumn 2025

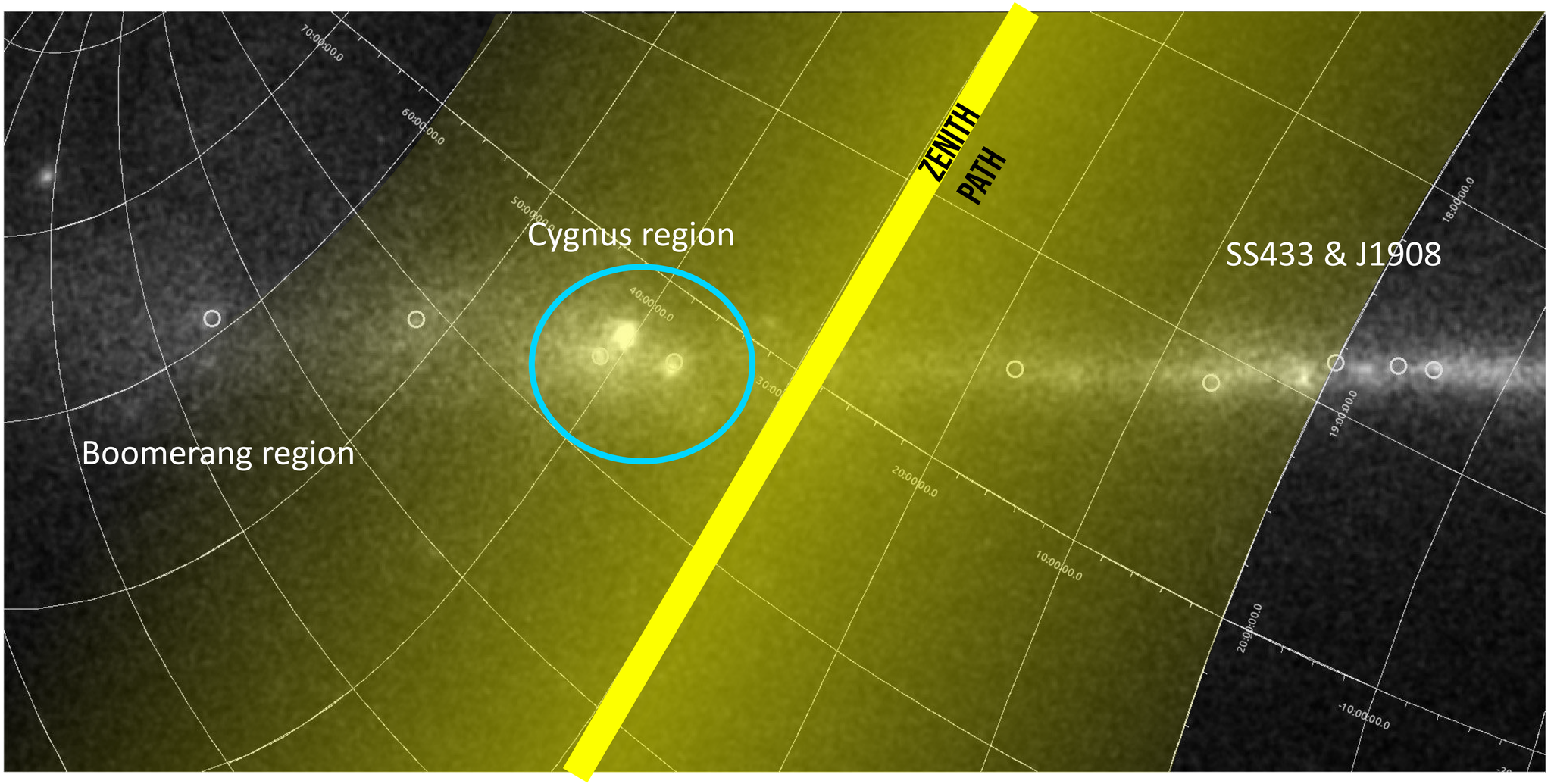
ASTRI-4T

Spring 2026

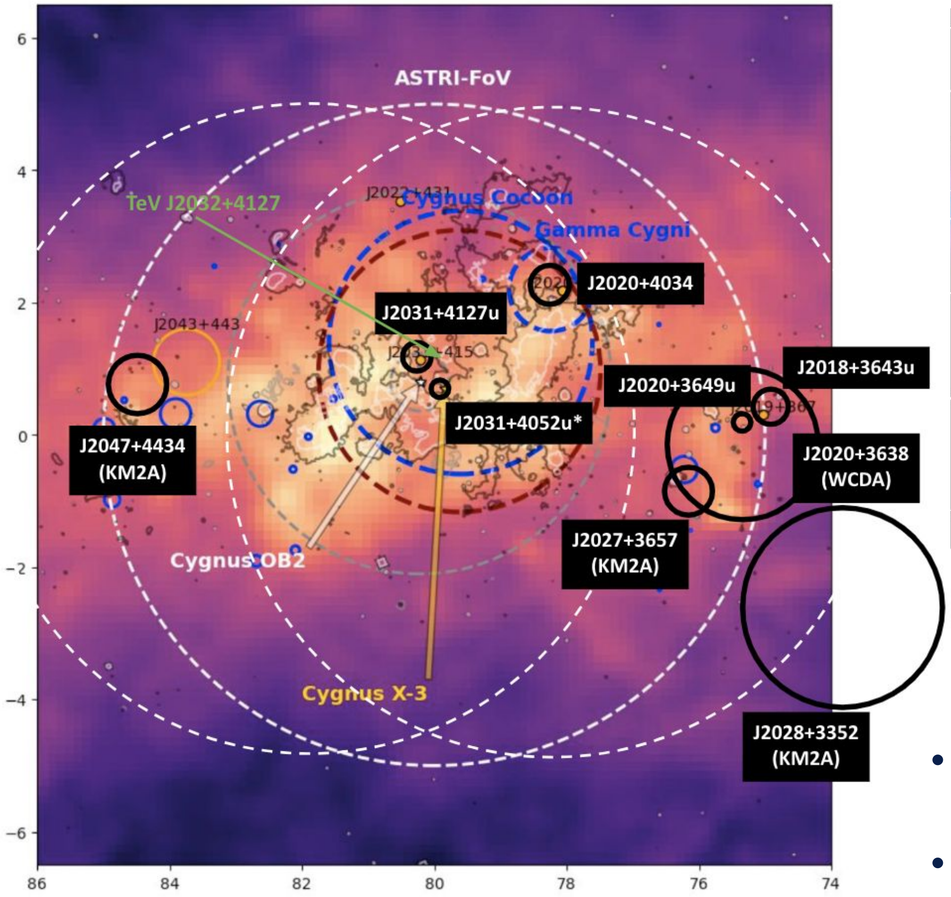
Early Science

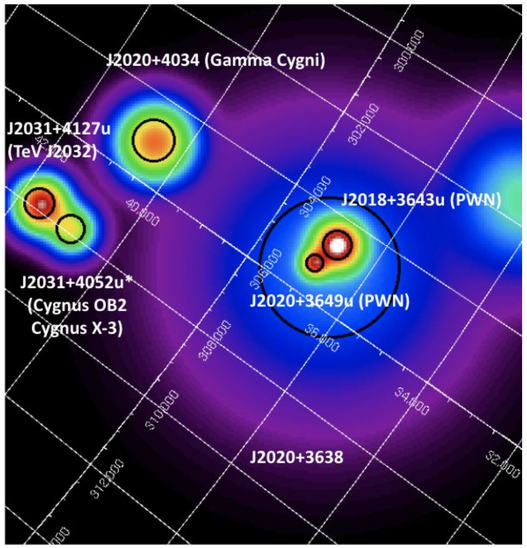


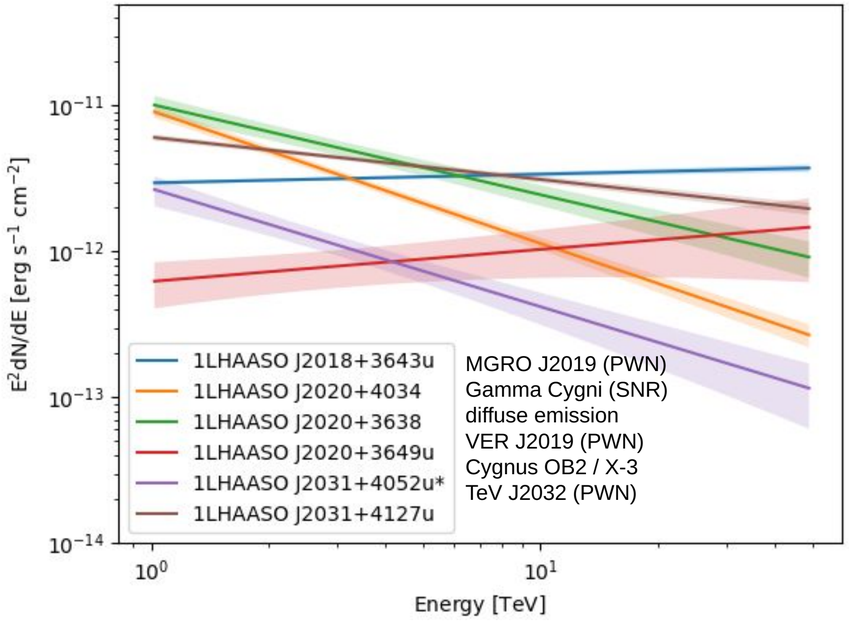
ASTRI Early Science



Cygnus Region



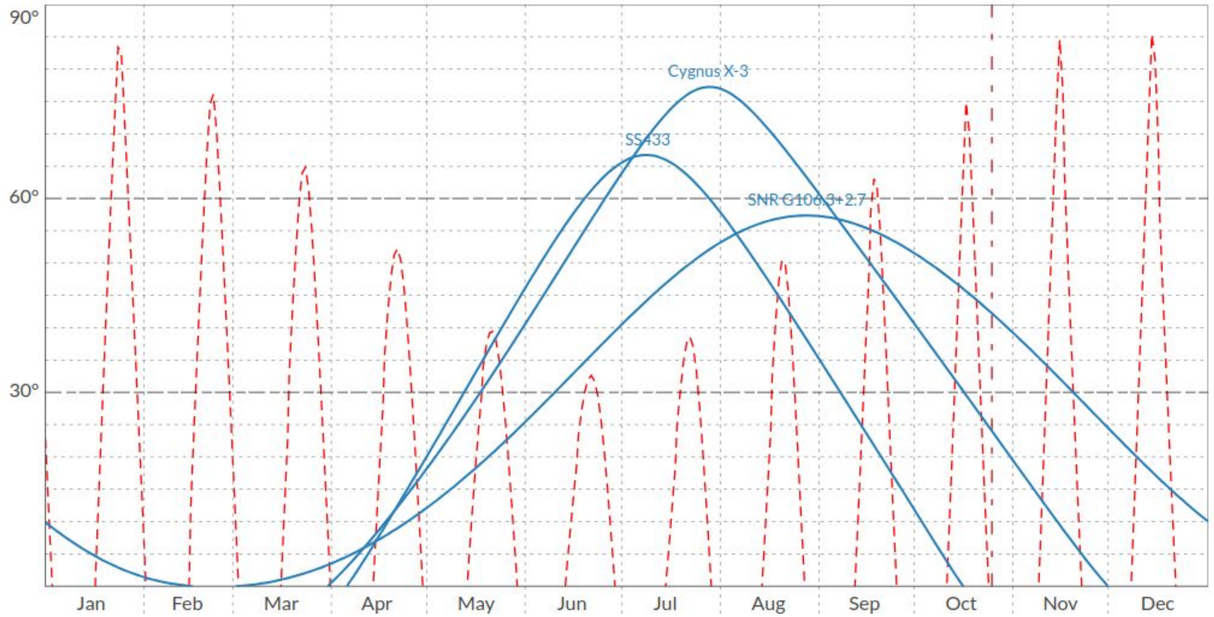




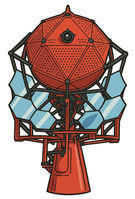
- SNRs:
  - Gamma Cygni (J2020+4034)
- PWNe:
  - TeV J2032+4130 (J2031+4127u)
  - MGRO J2019+37 (J2018+3643u)
  - VER J2019+368 (J2020+3649u)

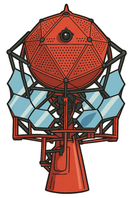
- YMSCs:
  - Cygnus OB2 (J2031+4052u*)
  - Berkeley 86 & 87
- MicroQ:
  - Cygnus X-3 (J2031+4052u*)
  - Cygnus X-1

ASTRI Early Science

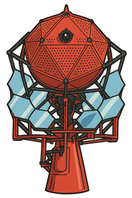


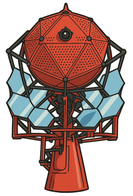
According to the current implementation schedule
4 out of 9 should be operational next spring





	Zenith angle	Jun	Jul	Aug	Sep	TOT
Cygnus	0–20 °	50 h	50 h	50 h	50 h	200 h





ASTRI Mini-Array - Schedule

ASTRI 1 construction and calibration

Autumn 2024

ASTRI-2T (+ 5 Tels.)

Autumn 2025

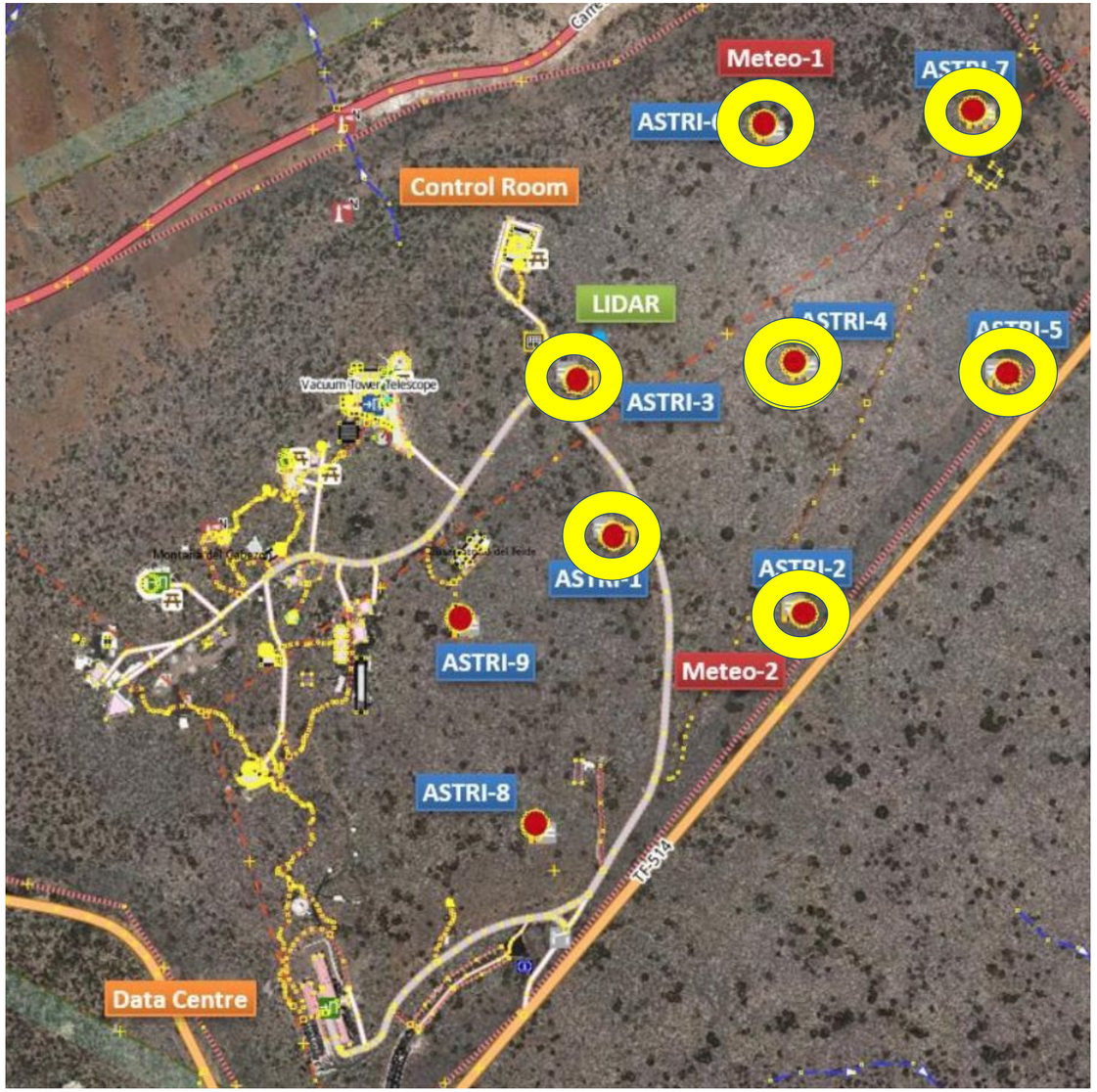
ASTRI-4T

Spring 2026

ASTRI-7T

End 2026

Start Pillar Science



ASTRI Mini-Array - Schedule

ASTRI 1 construction and calibration

Autumn 2024

ASTRI-2T (+ 5 Tels.)

Autumn 2025

ASTRI-4T

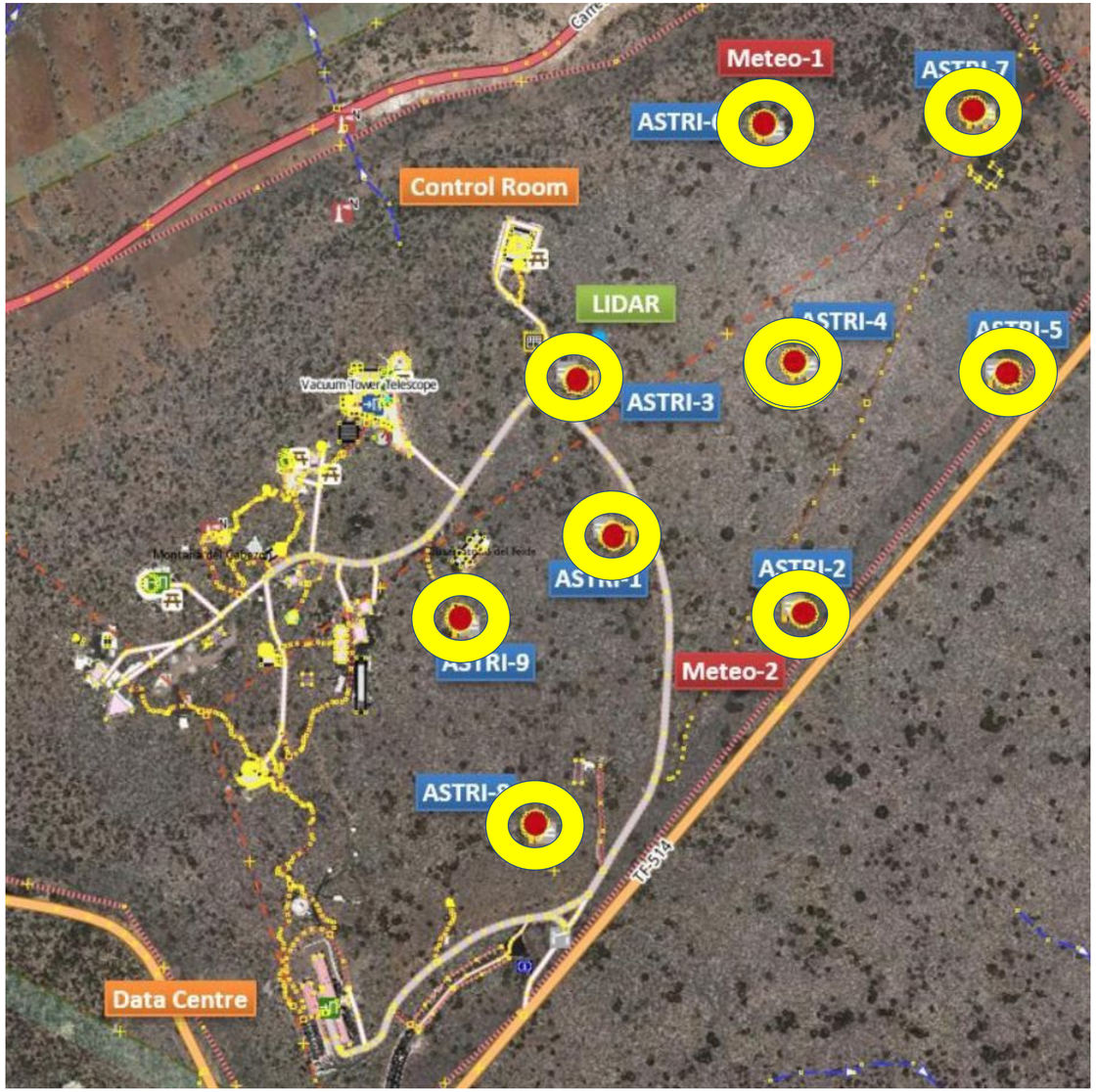
Spring 2026

ASTRI-7T

End 2026

ASTRI-9T

2027



Conclusions

- **We are ready to tackle the sheer volume of data that is about to arrive. You are all welcome to help with this challenge.**
- **The instrument performs as expected**
- **Detection of Crab , Mrk 501 and Mrk 421.**

Next Summer plans

- **The Early Science phase will begin next summer. The choice of a region of the sky on which to focus observations will already allow for the study of LHAASO sources (Cygnus?).**

More at :

- Astri web site : http://www.astri.inaf.it/
- On socials, search for ***ASTRIgamma*** (FB and Instagram)