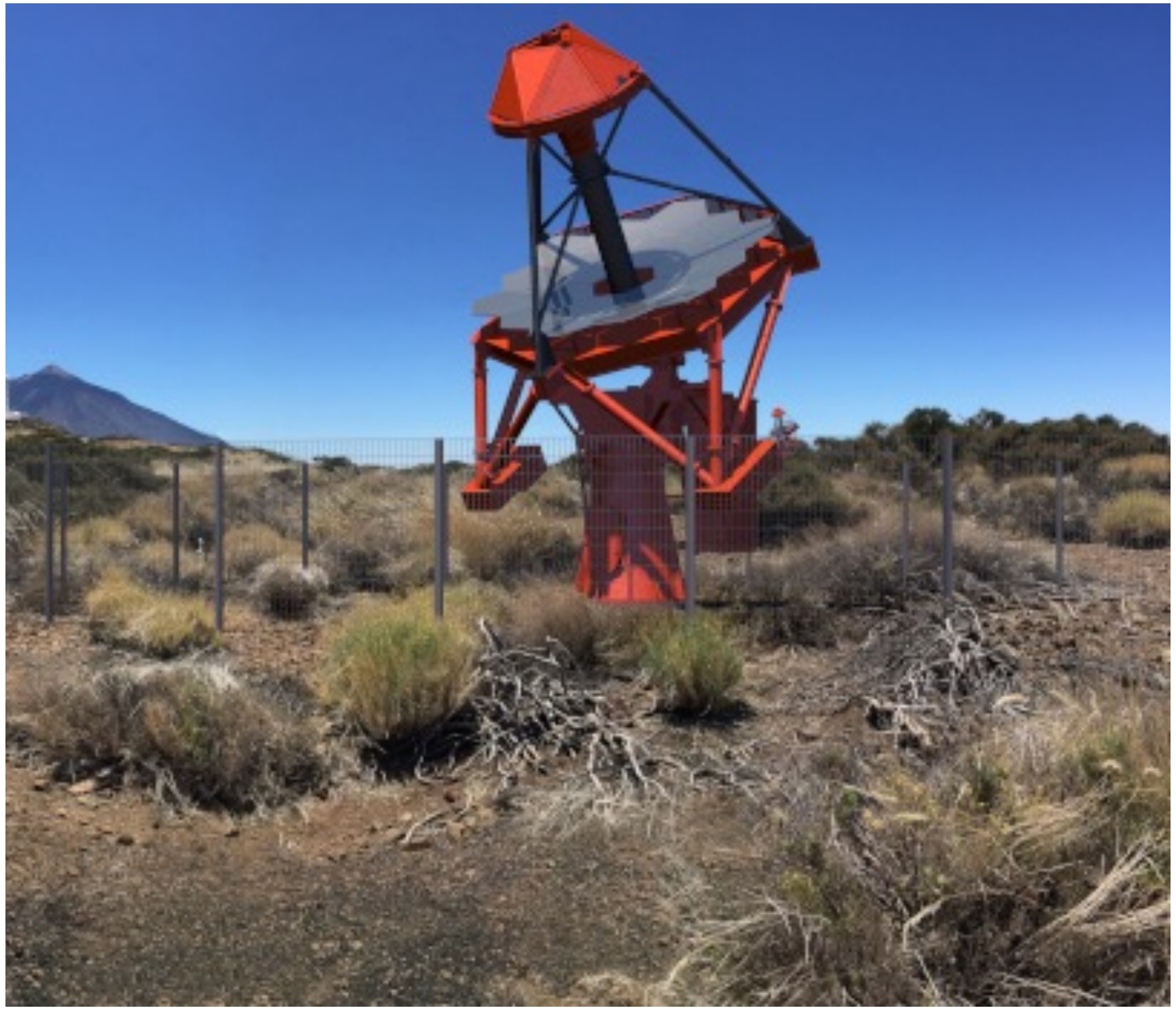
The ASTRI mini-array

Giovanni Pareschi – L. Angelo Antonelli
INAF
for the ASTRI Project

Outline

- The ASTRI project from the ASTRI-Horn prototype to the mini-Array
- The ASTRI Mini-Array project
- Operation concepts
- Technical description of the system
- ASTRI Mini-Array status



The ASTRI Mini-Array Project

The ASTRI Mini-Array is a project whose purpose is to construct, deploy and operate an array of 9 Cherenkov telescopes of the 4 meters class at the Observatorio del Teide in Tenerife (Spain) in collaboration with IAC.

More than 150 researchers belonging to

- INAF institutes (IASF-MI, IASF-PA, OAS, OACT, OAB, OAPD, OAR)
- Italian Universities (Uni-PG, Uni-PD, Uni-CT, Uni-GE, PoliMi) & INFN
- Fundacion Galileo Galilei
- International institutions (IAC - Spain, University of Sao Paulo – Brazil, North-West University – South Africa, IAC – Spain, Université / Observatoire de Geneve - CH).

Italian and foreign industrial companies are involved in the ASTRI Mini-Array project with important industrial return.

The ASTRI Project

ASTRI-Horn Prototype

INAF-led Project funded by Italian Ministry of Research

End-to-end prototype installed and operational on Mount Etna volcano (Sicily, Italy)

First detection of a gamma-ray source (Crab Nebula) above 5σ **with a dual-mirror, Schwarzschild-Couder Chrenkov telescope** (Lombardi et al., 2020)

Array of 9 ASTRI telescopes

INAF-led Project with international partners: Univ. of Sao Paulo/FPESP (Brazil), North-West Univ. (S. Africa), IAC (Spain), FGG, ASI/SSDC, Univ. of Padova, Perugia and INFN

Being deployed at the *Observatorio del Teide* (Spain) in collaboration with IAC and FGG-INAF.

First 4 years → *Core Science*, following 4 → *Observatory Science.* **Science operation → 2024**

ASTRI - Astrofisica con Specchi a Tecnologia Replicante Italiana

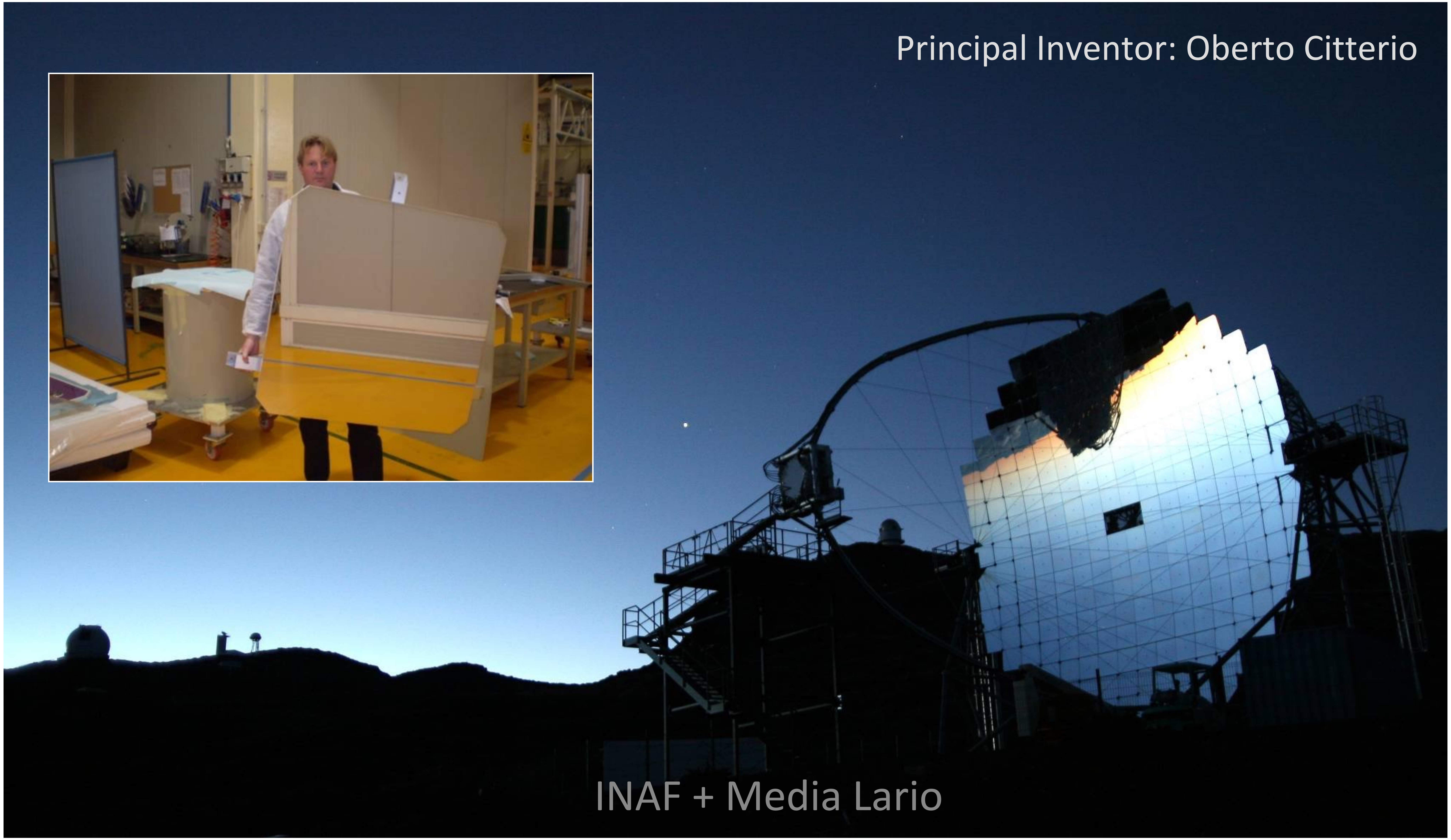
Astrophysics with Mirrors via Italian Replication Technology

(No mirrors, no party!)

Name given by Nanni Bignami

Adventure started with MAGIC II (2006)

ASTRI Mini-Array



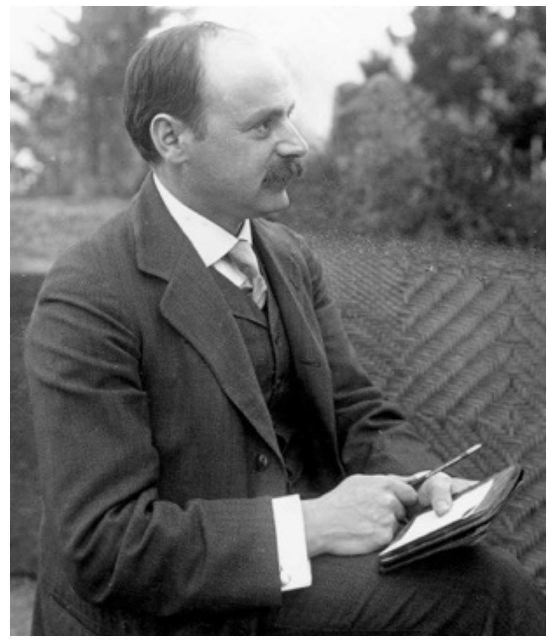
The Schwarzschild Aplanatic Telescope

1905: Karl Schwarzschild solved the Seidel 's equations for **spherical** aberration and **coma** finding a relation between parameters capable to make a telescope **aplanatic**. *(Couder 1926 ➔ also correction of* ***astigmatism*** *with curved focal plane)*

"For any geometry, 2 aspheric mirrors allow the correction of SI and SII to give an aplanatic telescope"

Vladimir Vassiliev, UCLA

Schwarzschild telescope



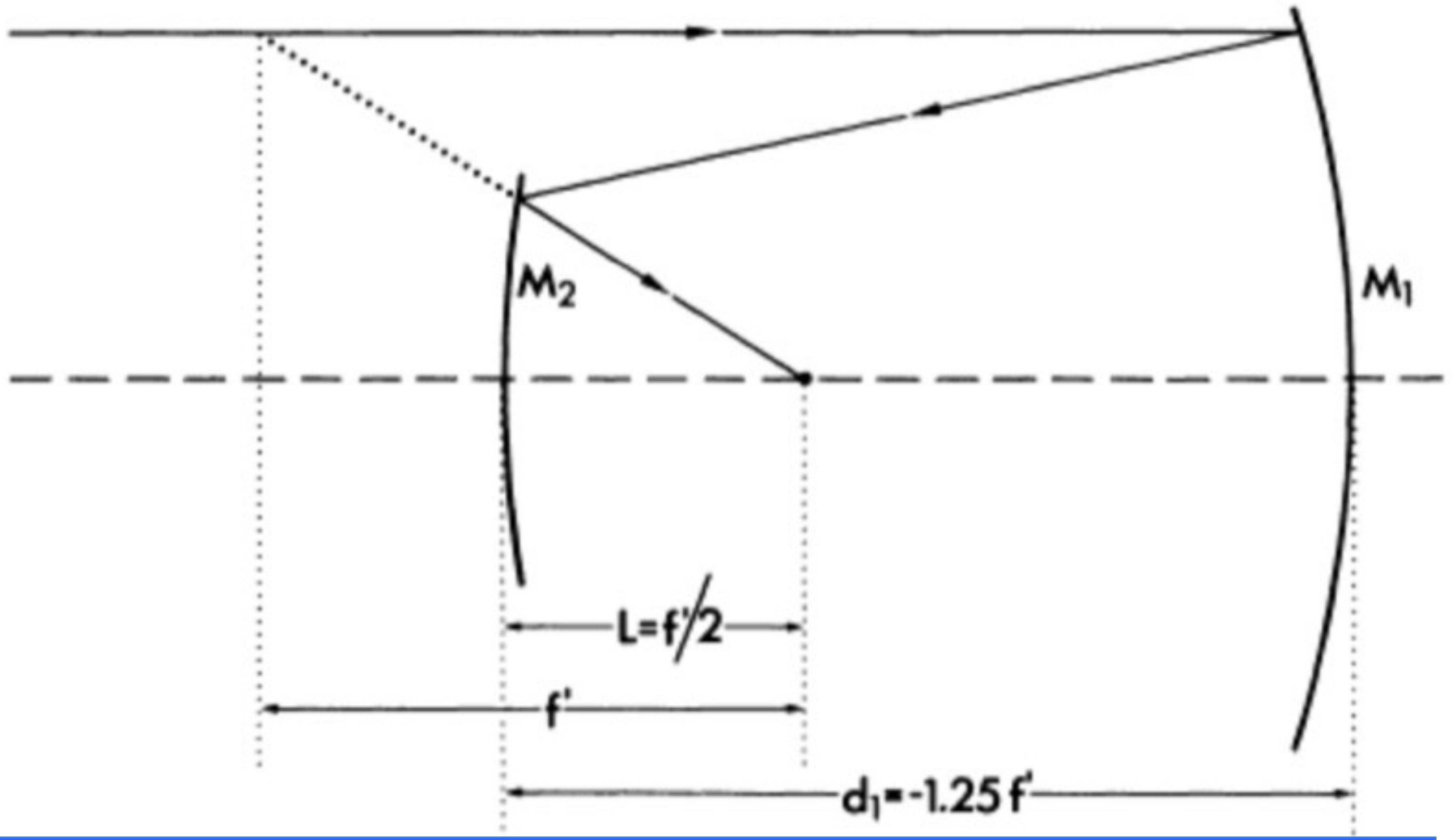
KS: f/3.0

b_{S1}= -13.5 (Hyperbola)

b_{S2}= 1.963 (Spheroid)

FoV:2.8 deg

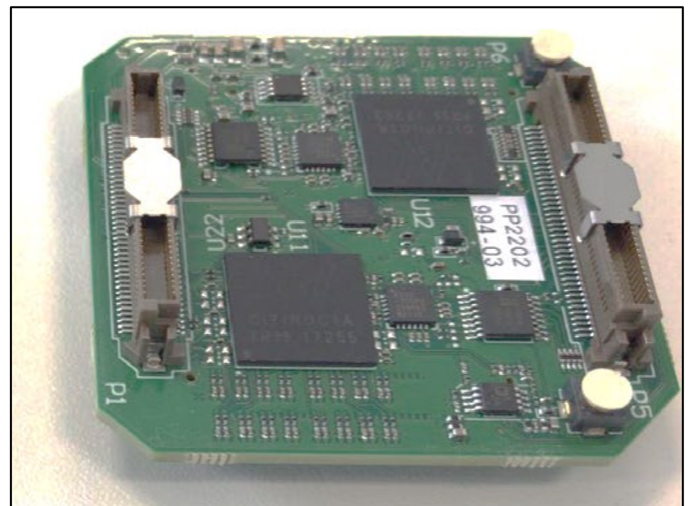
RMS_{edge}~12''



Technology challenge: Aspherical Optics manufacturing + large secondary mirror

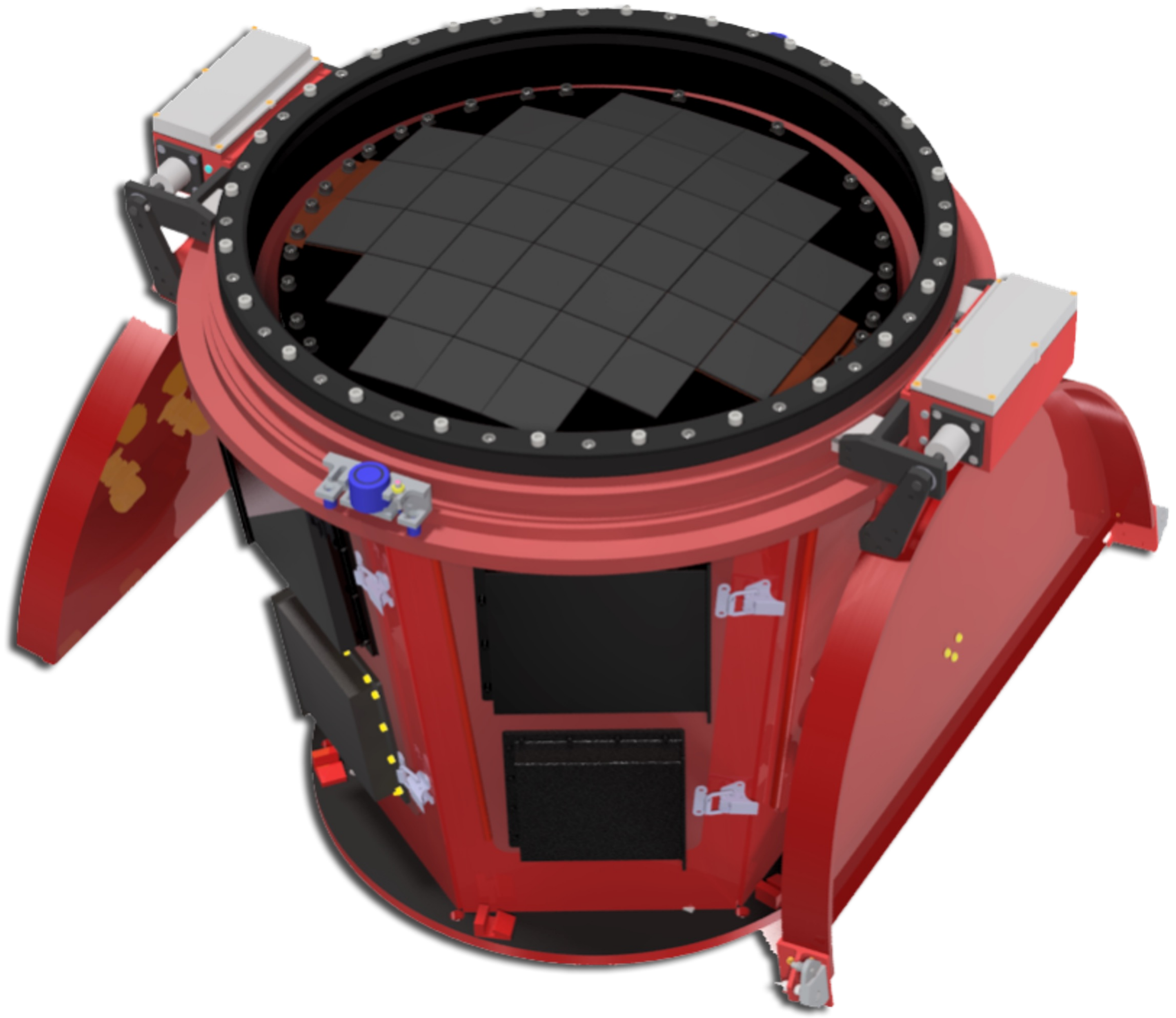
The ASTRI Camera

SiPM matrices


ASIC board

- The SiPM produced by Hamamatsu photonics (7x7 mm^2) grouped in matrices of 8x8 pixels
- 37 matrices are arranged to adapt to the curved focal plane of the telescope.
- innovative electronics for peak detection (CITIROC ASICS, WEEROC-INAF) ⇒ small amount of data
- Interferential filter as front window (Romeo et al. (2018) and Catalano et al. (2018)) that allows to reduce the contribution from the night sky background at wavelengths greater than 550 nm where the sensitivity of SiPM detector is still high.

FIELD OF VIEW OF 10.5 Deg IN DIAMETER



CAEN Tools for Discovery

EIE GROUP

HAMAMATSU PHOTON IS OUR BUSINESS

ASTRI Mini-Array


24 September 2014

The ASTRI-Horn results

ASTRI Mini-Array

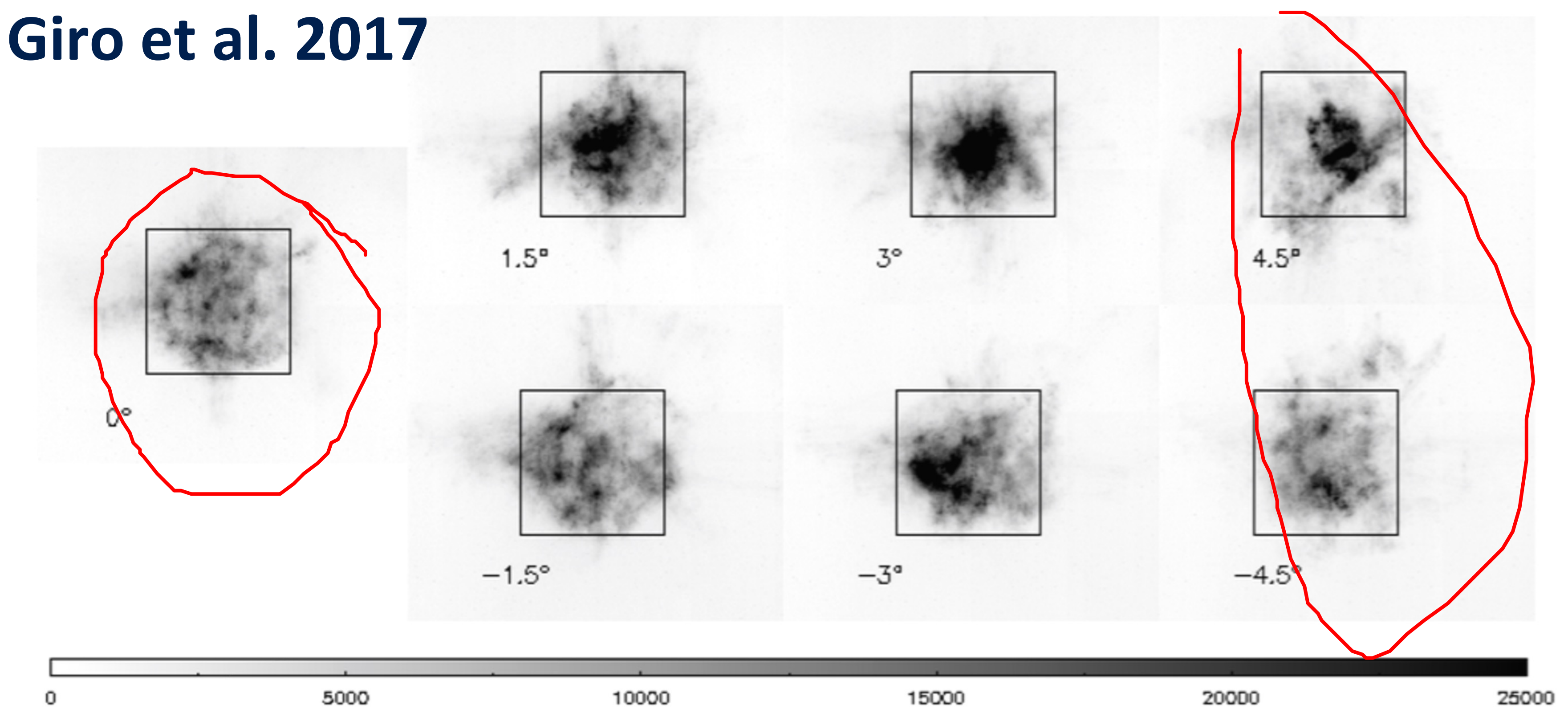
A&A 608, A86 (2017)
DOI: 10.1051/0004-6361/201731602

Astronomy & Astrophysics

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]

Giro et al. 2017

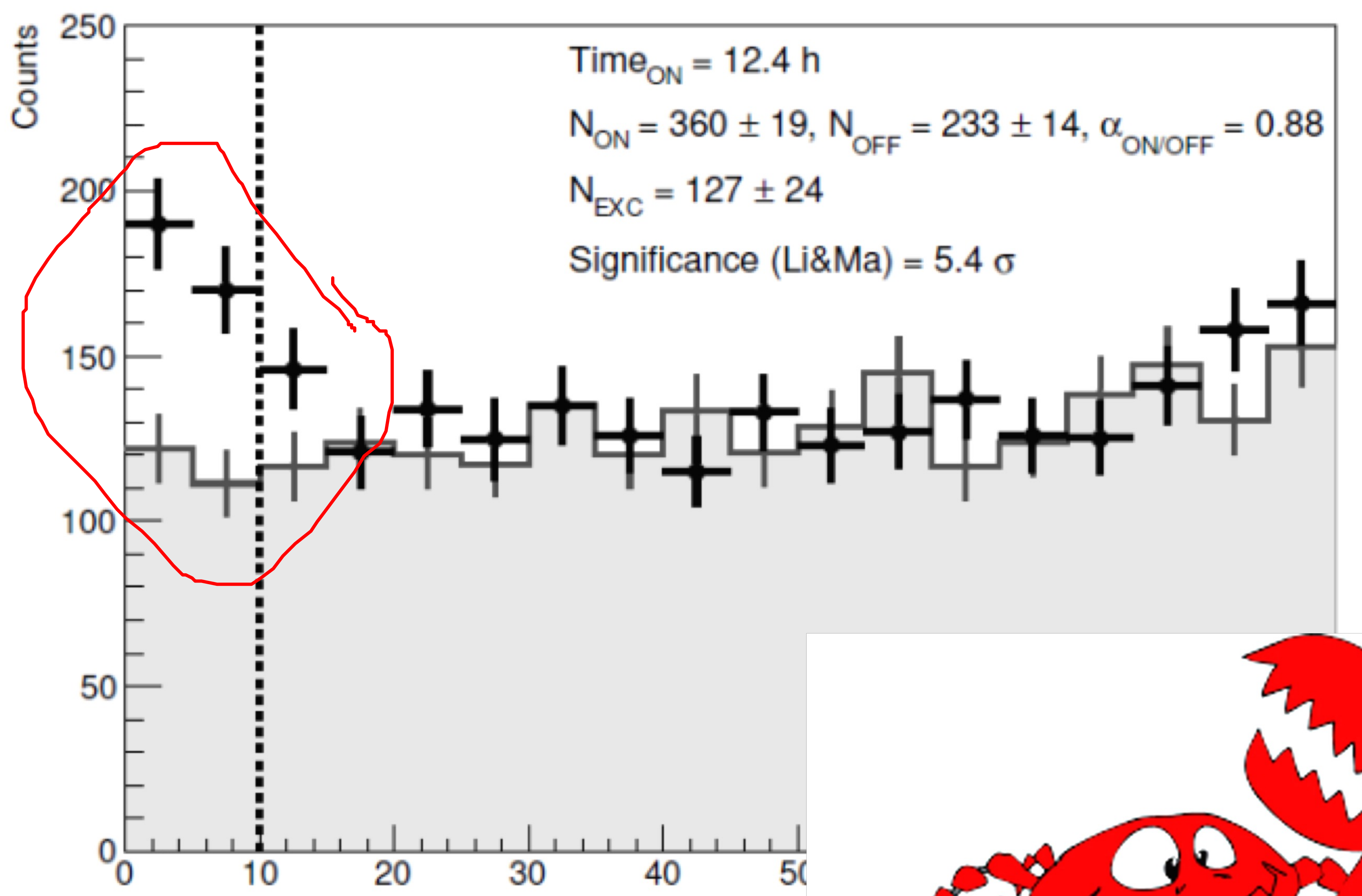


A&A 634, A22 (2020)
https://doi.org/10.1051/0004-6361/201936791

Astronomy & Astrophysics

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

S. Lombardi[1,2,⋆], O. Catalano[3,⋆], S. Scuderi[4,⋆], L. A. Antonelli[1,2], G. Pareschi[5], E. Antolini[6], L. Arrabito[7], G. Bellassai[8], K. Bernlöhr[9], C. Bigongiari[1], B. Biondo[3], G. Bonanno[8], G. Bonnoli[5], G. M. Böttcher[10], J. Bregeon[11], P. Bruno[8], R. Canestrari[3], M. Capalbi[3], P. Caraveo[4], P. Conconi[5], V. Conforti[12], G. Contino[3], G. Cusumano[3], E. M. de Gouveia Dal Pino[13], A. Distefano[4], G. Farisato[14], C. Fermino[13], M. Fiorini[4], A. Frigo[14], S. Gallozzi[1], C. Gargano[3], S. Garozzo[8], F. Gianotti[12], S. Giarrusso[3], R. Gimenes[13], E. Giro[14], A. Grillo[8], D. Impiombato[3], S. Incorvaia[4], N. La Palombara[4], V. La Parola[3], G. La Rosa[3], G. Leto[8], F. Lucarelli[1,2], M. C. Maccarone[3], D. Marano[8], E. Martinetti[8], A. Micciché[8], R. Millul[5], T. Mineo[3], G. Nicotra[15], G. Occhipinti[8], I. Pagano[8], M. Perri[1,2], G. Romeo[8], F. Russo[3], F. Russo[12], B. Sacco[3], P. Sangiorgi[3], F. G. Saturni[1], A. Segreto[3], G. Sironi[5], G. Sottile[3], A. Stamerra[1], L. Stringhetti[4], G. Tagliaferri[5], M. Tavani[16], V. Testa[1], M. C. Timpanaro[8], G. Toso[4], G. Tosti[17], M. Trifoglio[12], G. Umana[8], S. Vercellone[5], R. Zanmar Sanchez[8], C. Arcaro[14], A. Bulgarelli[12], M. Cardillo[16], E. Cascone[18], A. Costa[8], A. D'Aì[3], F. D'Ammando[12], M. Del Santo[3], V. Fioretti[12], A. Lamastra[1], S. Mereghetti[4], F. Pintore[4], G. Rodeghiero[14], P. Romano[5], J. Schwarz[5], E. Sciacca[8], F. R. Vitello[8], and A. Wolter[5]



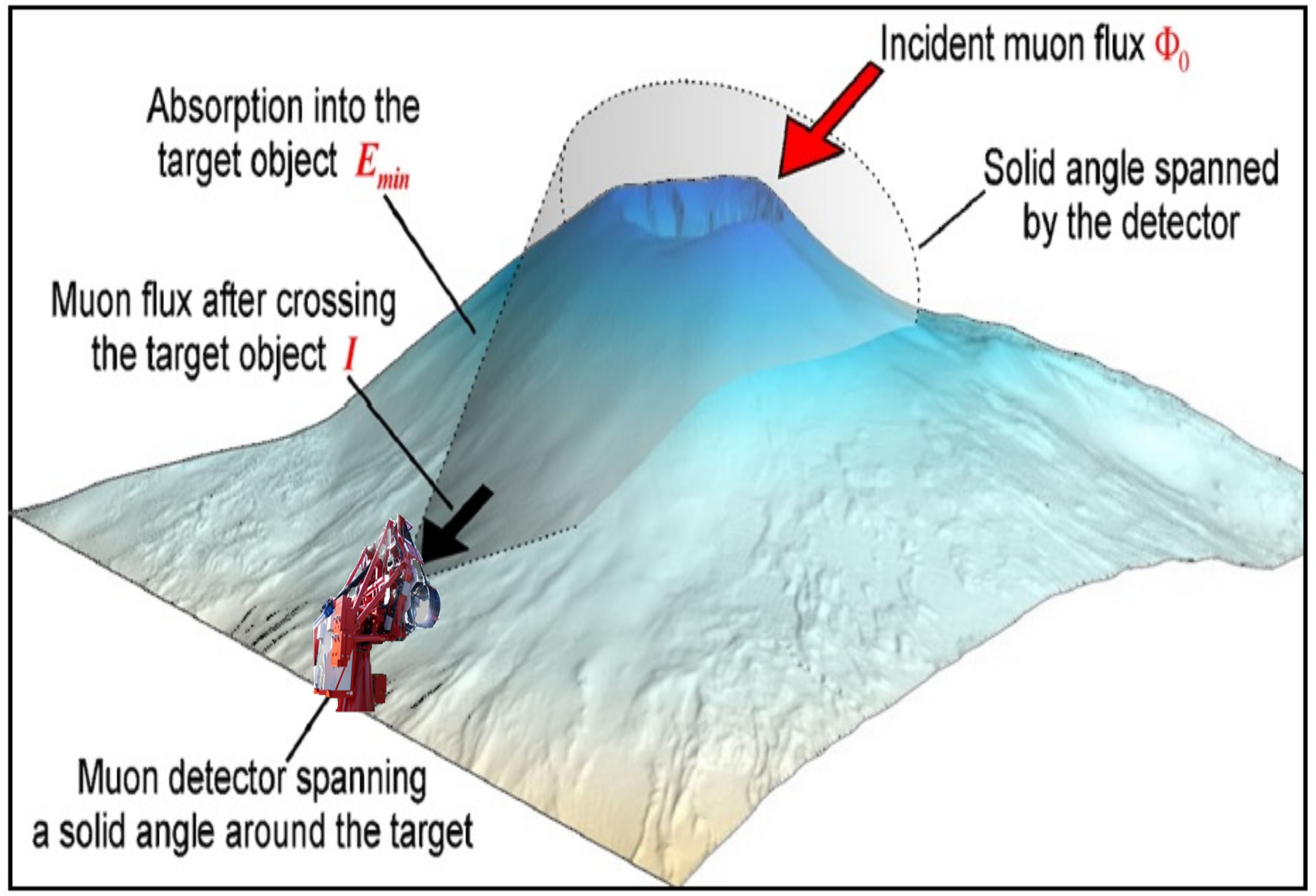
Lombardi et al. 2020

"Muongraphy" with ASTRI-Horn

ASTRI Mini-Array

The feasibility of muography is currently being investigated with ASTRI Horn exploiting the fortunate coincidence of the proximity of the telescope to the ETNA volcano.

The quantitative understanding of the inner structure of a massive target, as a volcano, is a key-point to monitor the stages of the volcano activity, to forecast the eruptive style and mitigate volcanic hazards.

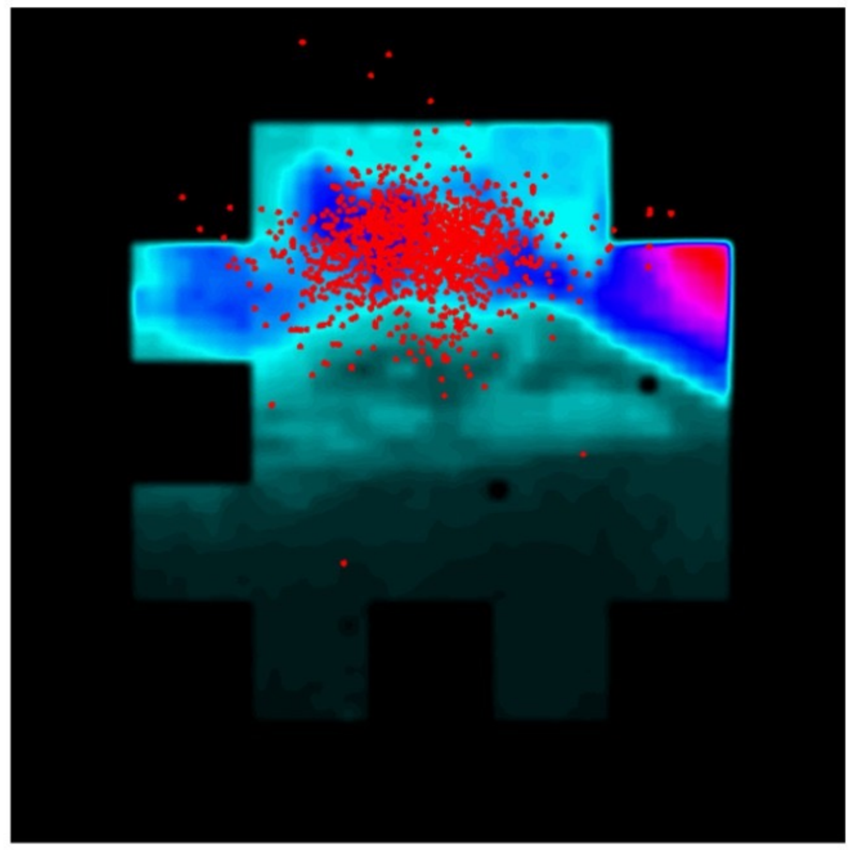


Fracastoro observatory - Serra la Nave (Monte Etna) : Altitude 1735 m a.s.l.
Longitude: +14° 58'4'' : Latitude +37°41'5''

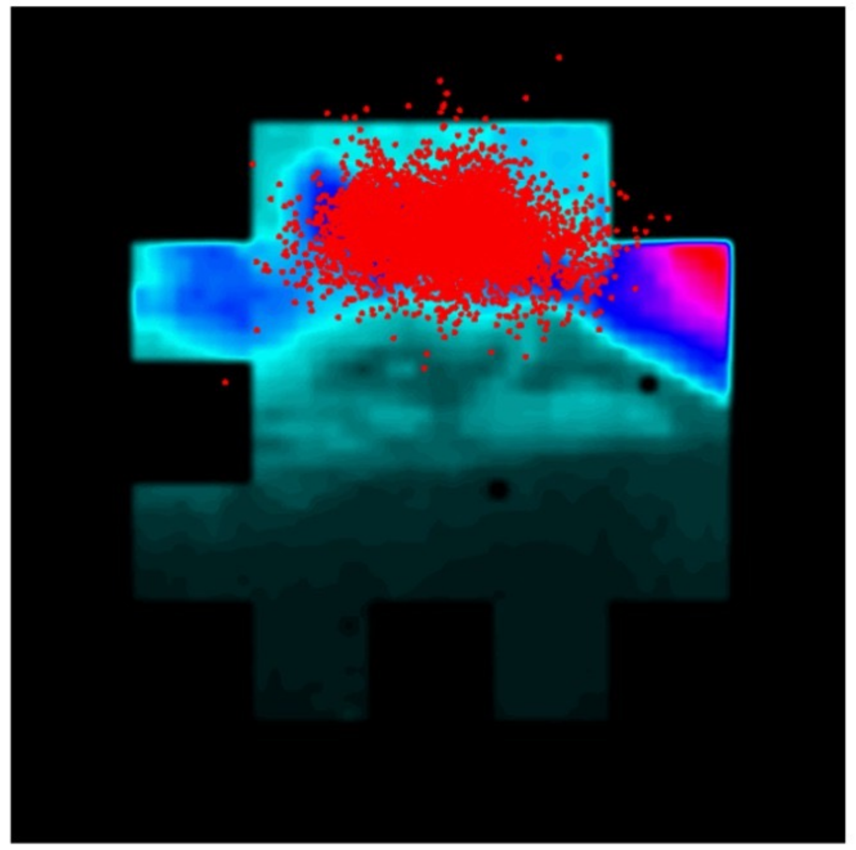
"Muongraphy" with ASTRI-Horn

Mini-Array

DICEMBRE VS OTTOBRE

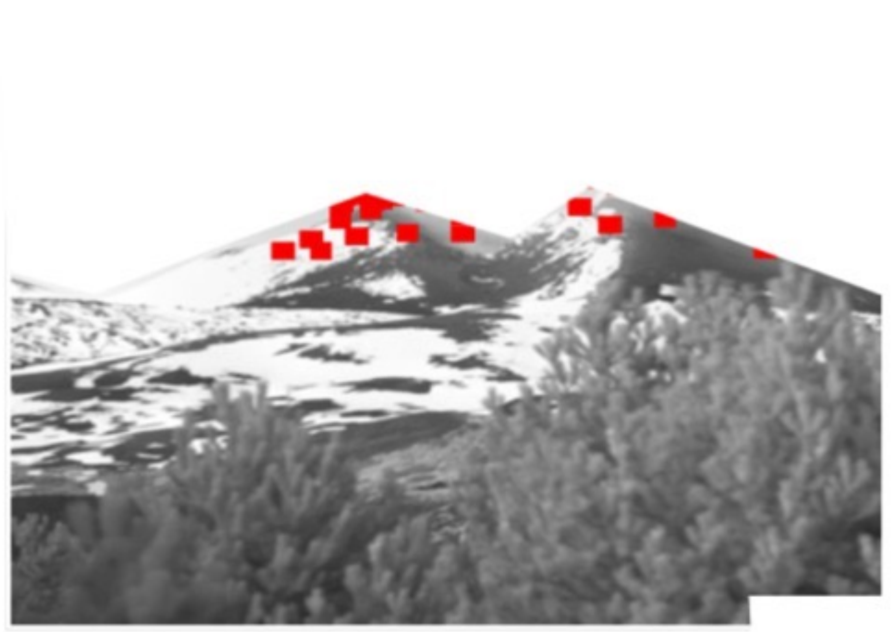


22 DICEMBRE 2022
120 minuti



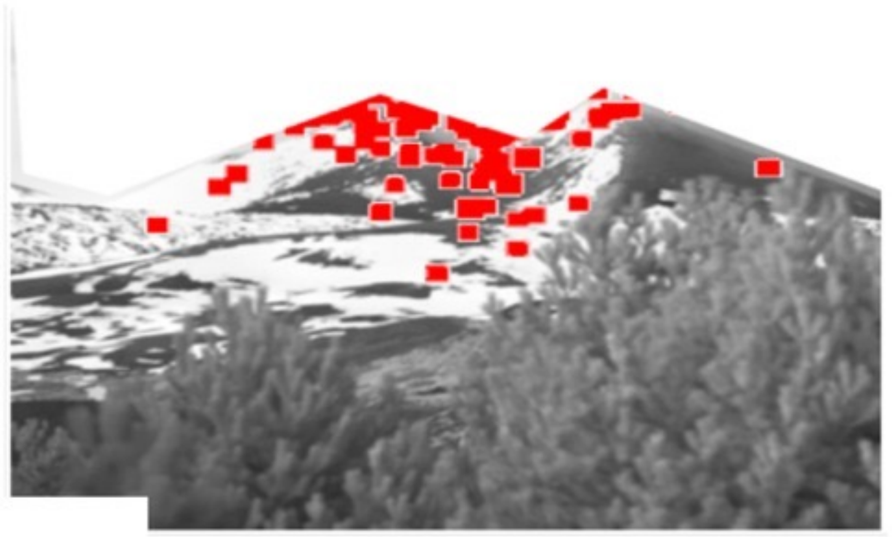
25 OTTOBRE 2022
160 minuti

ID 2770 – 2771 - 2772
VOLCANO 21 OCTOBER 2022



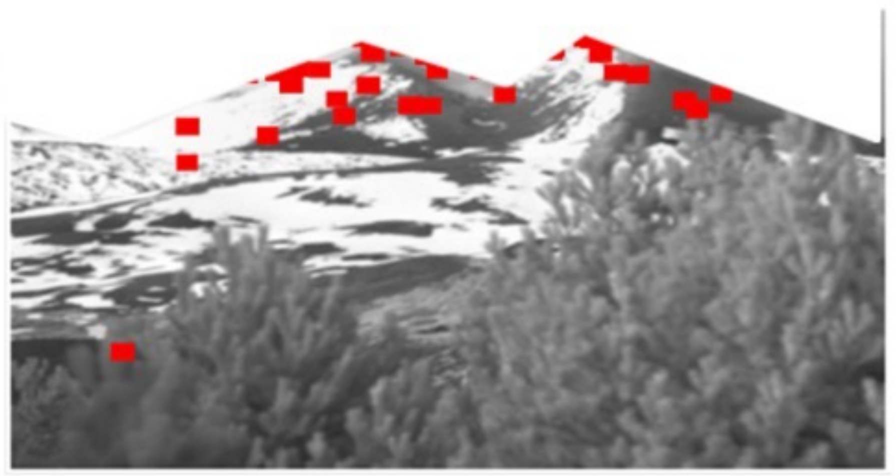
Open sky muons are masked

ID 3027 – 3028 - 3029
VOLCANO 22 DECEMBER 2022



(NB: Piccola Eruzione – Dicembre 2022, sull'altro versant

VOLCANO 20 FEBRUARY 2023



ID 3173 – 3175 - 3206

PRELIMINARY

The ASTRI mini-array @Teide: the adventure starting!

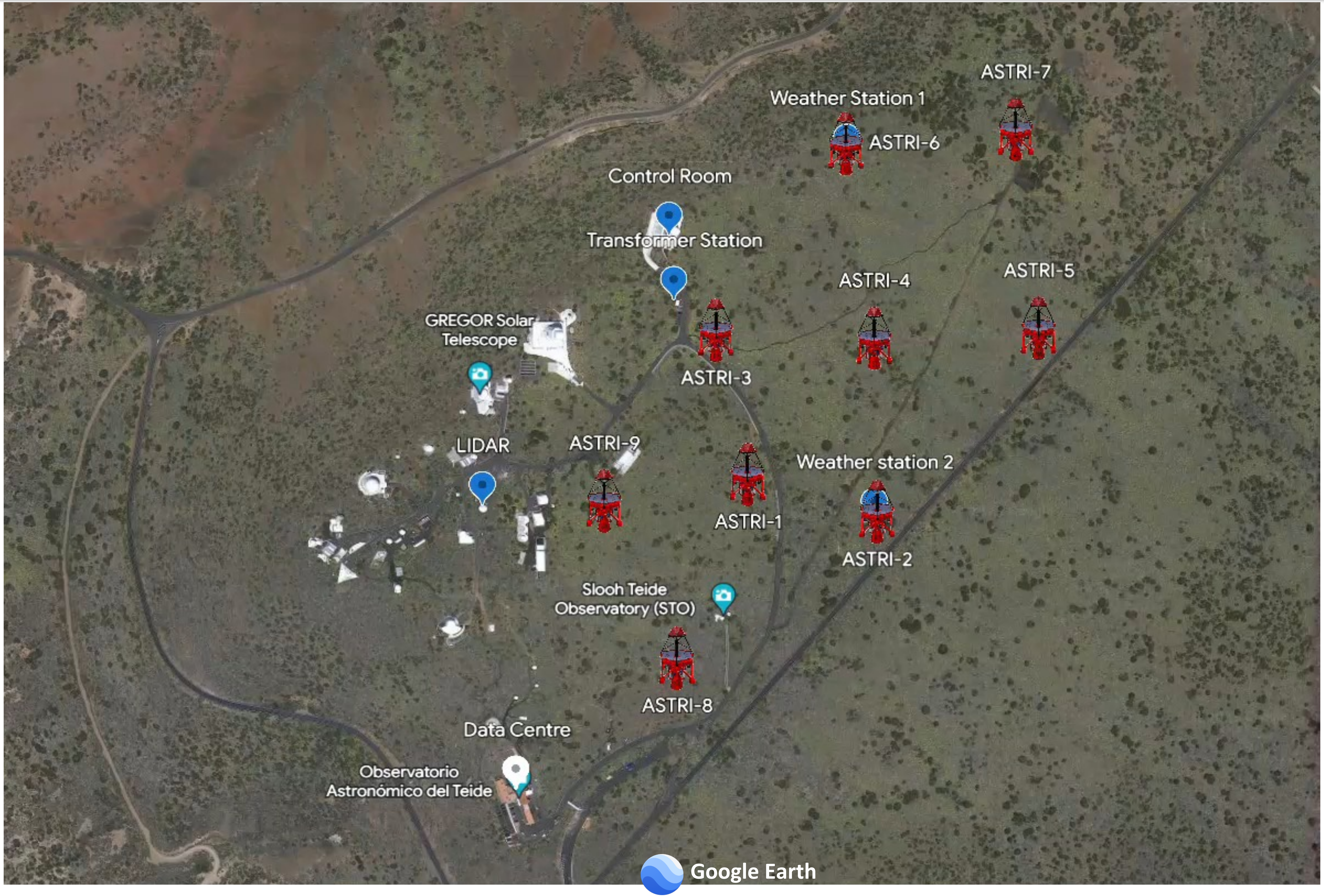
12 June 2019

ASTRI: a new pathfinder of the arrays of Cherenkov telescopes

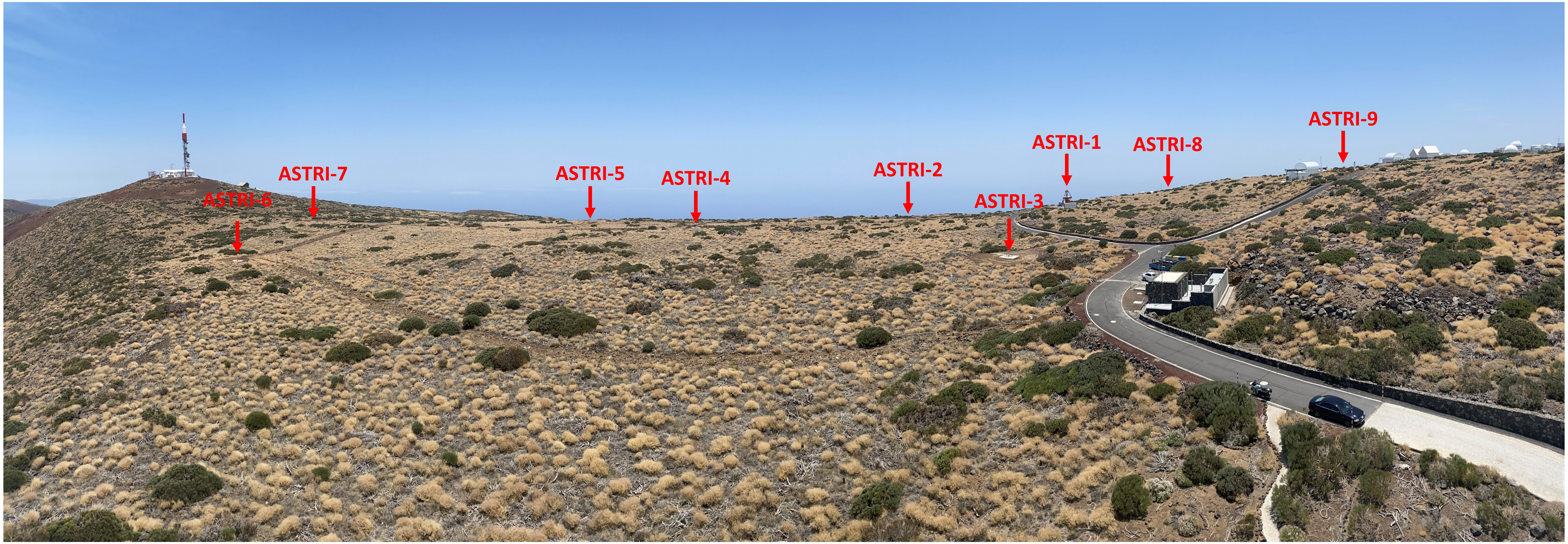
On June 12nd 2019, in La Laguna (Tenerife, Spain) Prof. Nichi D'Amico, President of the Italian National Institute for Astrophysics (INAF), and Prof. Rafael Rebolo Lopez, Director of the Instituto de Astrofisica de Canaries, signed a Record of Understanding to enter a detailed negotiation on a technical and programmatic basis aimed to install and operate the ASTRI Mini-Array at the Observatorio del Teide

INAF and IAC Representatives on the Teide Observatory site

The ASTRI Mini-Array @ the Teide observatory



The ASTRI Mini-Array @ Teide Observatory



View from Themis Telescope

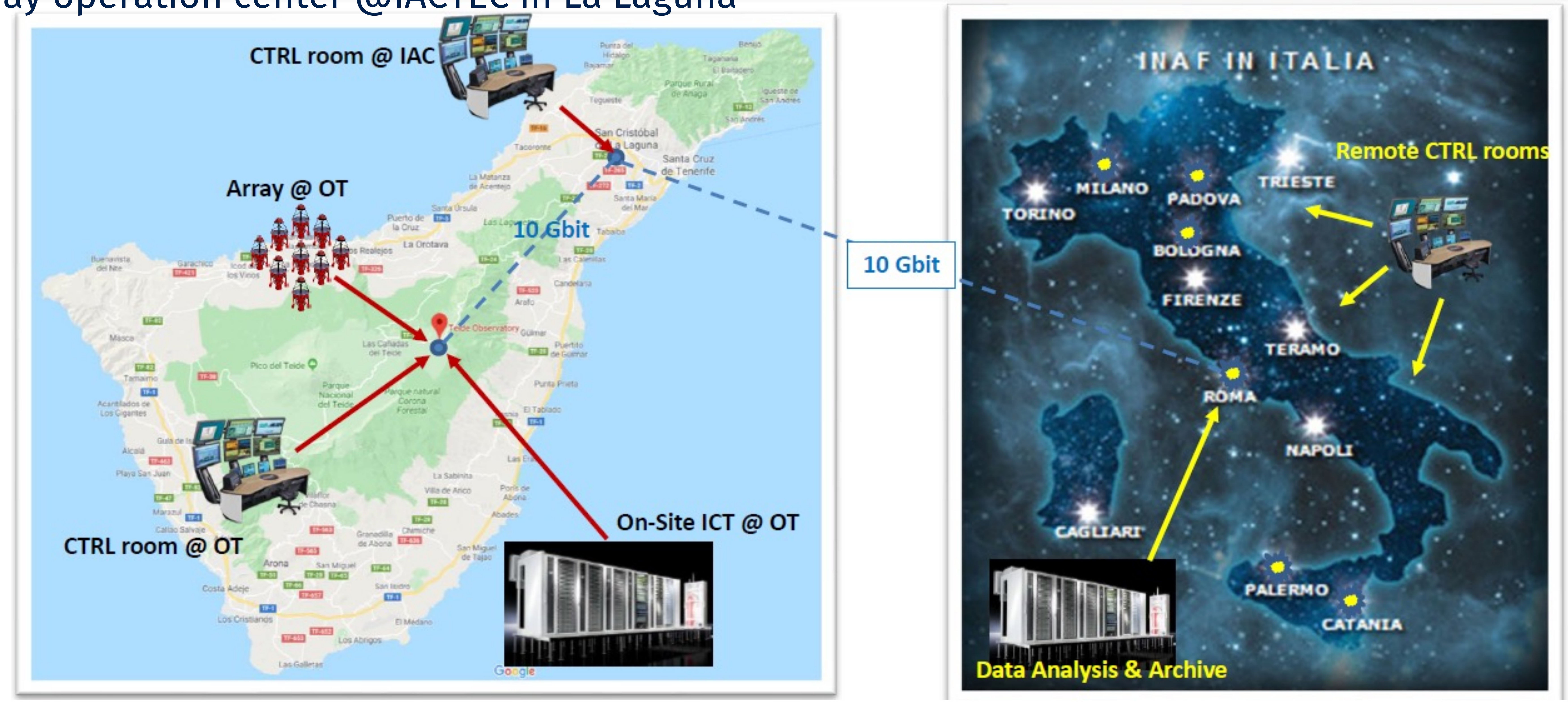
The ASTRI Mini-Array locations

The ASTRI Mini-Array in Tenerife

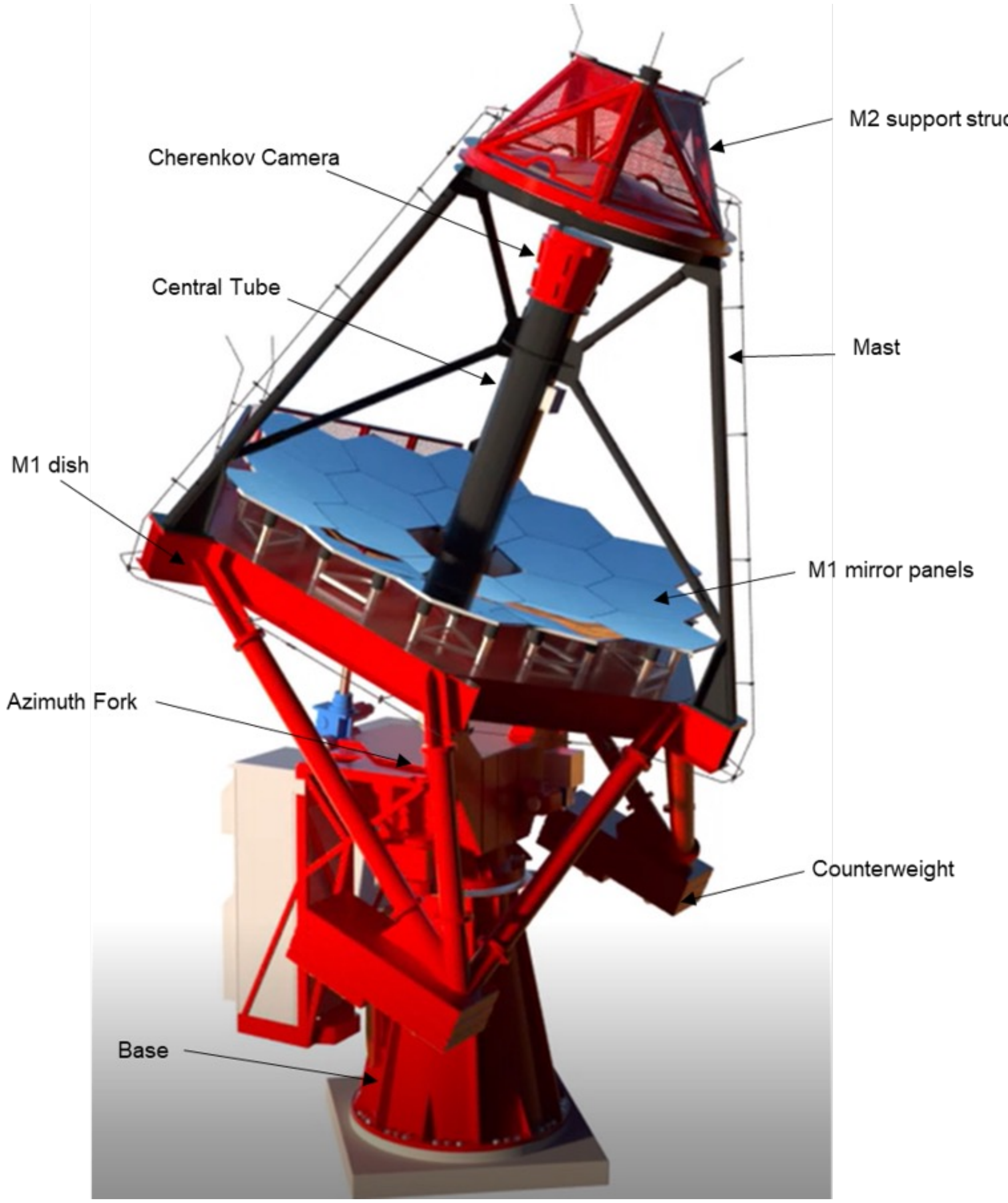
- Telescope Array & auxiliaries (Observatorio del Teide - OT)
- Local Control Room @THEMIS building (OT)
- On site Data Centre @IAC Residencia (OT)
- Array operation center @IACTEC in La Laguna

The ASTRI Mini-Array in Italy

- Data Centre in Rome
- Remote Array operation centers



ASTRI Mini-Array telescopes in a nutshell



- **Opto-mechanics (EIE, MLT, Flabeg, ZAOT)**
  - Alt-azimuthal mount
  - Modified Schwarzschild-Couder configuration
  - Primary Mirror: 4.3 m (18 segments)
  - Secondary Mirror: 1.8 m (monolithic)
  - F-number: 0.5
  - Average effective area > 5.0 m^2
  - Optical PSF $\leq$ 0.19 deg
  - Post calibration pointing precision $\leq$ 7 arcsec
- **Cherenkov Camera (CAEN, EIE, NI, Hamamatsu, Weeroc)**
  - Front-end electronics based on CITIROC-1A ASIC
  - SiPM sensors: 7x7 mm (series LV3 – 75 μm pixel size)
  - 2368 pixels (37 matrices of 8x8 pixels)
  - Filter Window with dielectric coating
  - Angular pixel size: 0.19 deg
  - Field of View: 10.5 deg

The ASTRI Mini-Array – Performance

Mini-Array

	ASTRI Mini-Array	MAGIC	VERITAS	H.E.S.S.	HAWC	LHAASO
Location	28° 18′ 04″ N	28° 45′ 22″ N	31° 40′ 30″ N	23° 16′ 18″ S	18° 59′ 41″ N	29° 21′ 31″ N
	16° 30′ 38″ W	17° 53′ 30″ W	110° 57′ 7.8″ W	16° 30′ 00″ E	97° 18′ 27″ W	100° 08′ 15″ E
Altitude [m]	2,390	2,396	1,268	1,800	4,100	4,410
FoV	~ 10°	~ 3.5°	~ 3.5°	~ 5°	2 sr	2 sr
Angular Res.	0.05° (30 TeV)	0.07° (1 TeV)	0.07° (1 TeV)	0.06° (1 TeV)	0.15°[(a)] (10 TeV)	(0.24–0.32)°[(b)] (100 TeV)
Energy Res.	12% (10 TeV)	16% (1 TeV)	17% (1 TeV)	15% (1 TeV)	30% (10 TeV)	(13–36)% (100 TeV)[(b)]
Energy Range	(0.3-200) TeV	(0.05-20) TeV	(0.08-30) TeV	(0.02-30) TeV[(c)]	(0.1-100) TeV	(0.1-1,000) TeV

Sensitivity: better than current IACTs (E ≳ 3 TeV)

Extended spectrum and cut-off constraints

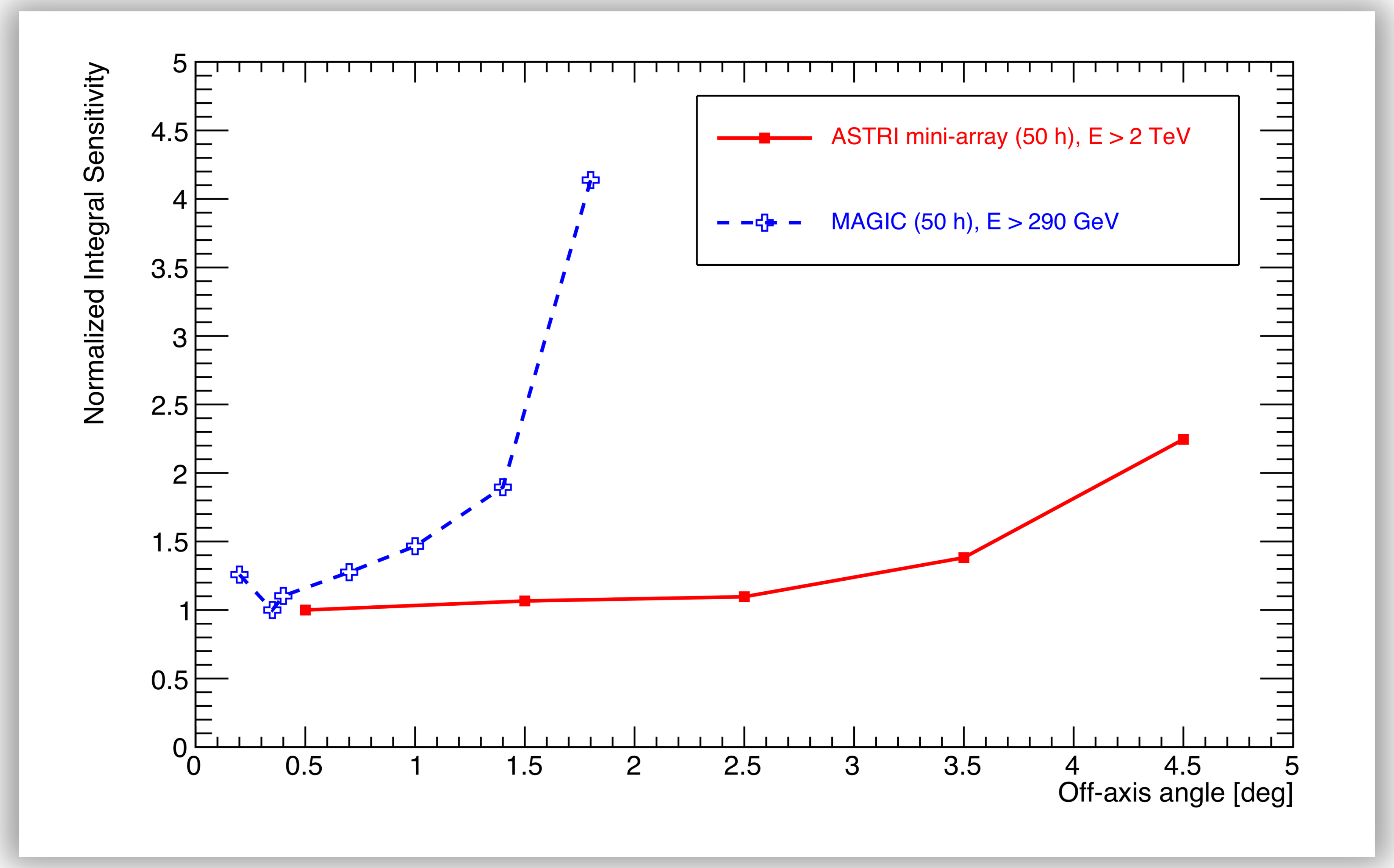
Energy/Angular resolution: ~10% / ~0.05° (E =10 TeV)

Identify and characterize extended sources morphology

10.5° field of view with homogeneous off-axis performance

Multi-target fields, surveys, and extended sources

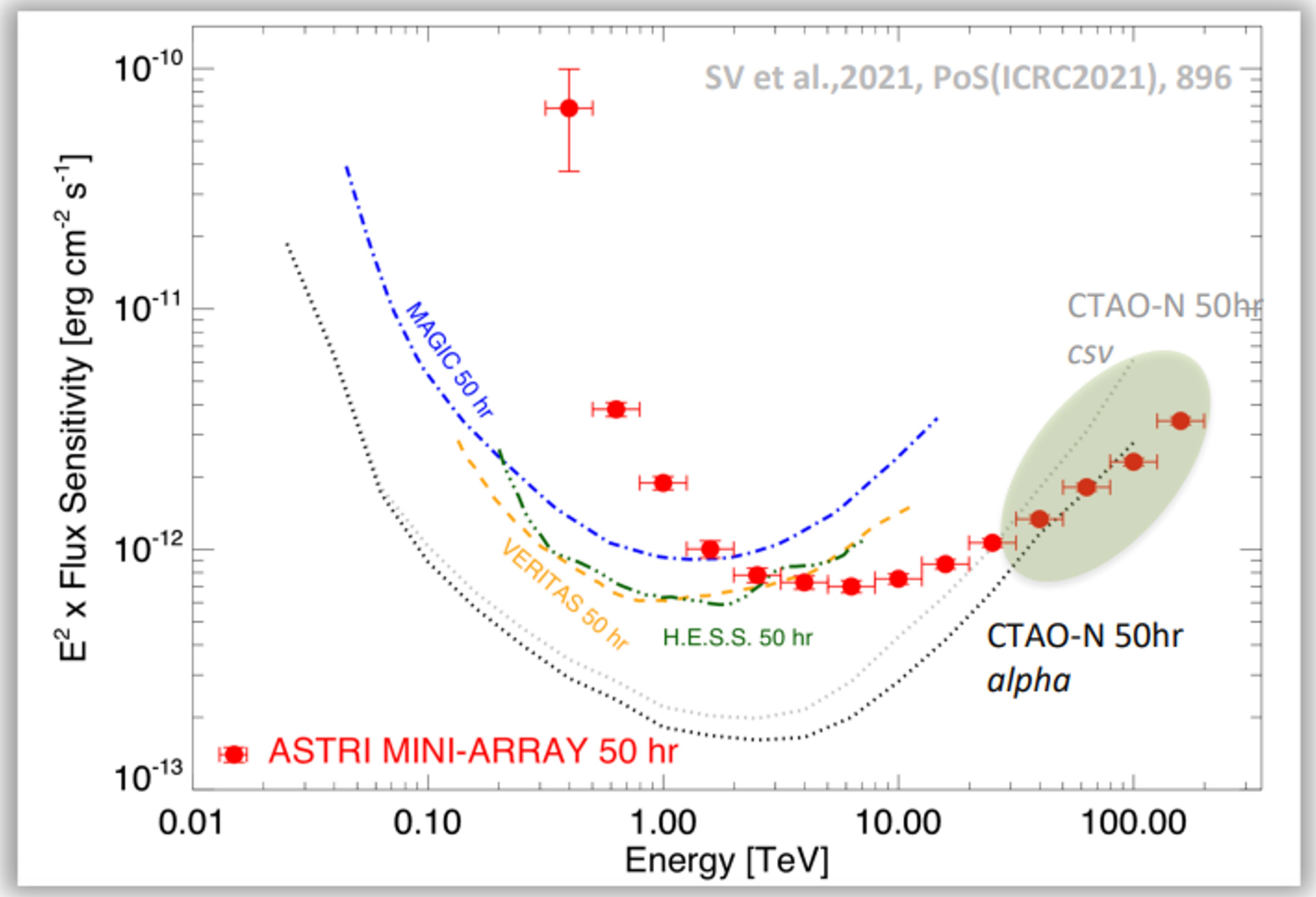
Enhanced chance for serendipitous discoveries

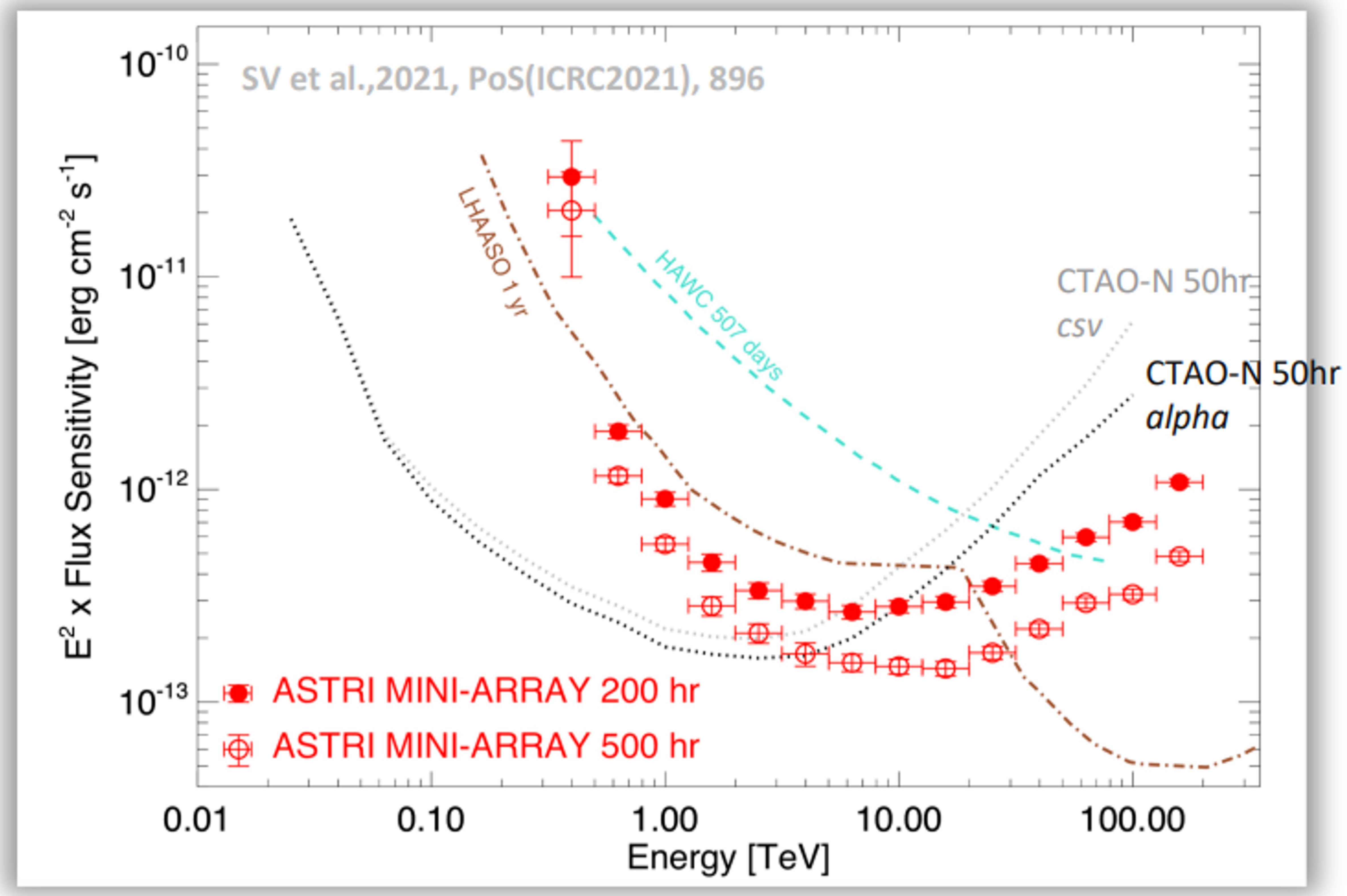


Vercellone et al., 2022

The ASTRI Mini-Array – Performance

- We extend current IACTs **differential sensitivity up to several tens of TeV and beyond**
- Investigate possible spectral features at VHE, such as the presence of **spectral cut-offs** or the detection of emission at several tens of TeV expected from **Galactic PeVatrons**





The ASTRI White Book

ASTRI Mini-Array

Astrophysics
Volume 35, August 2022, Pages 52-68

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

S. Scuderi [a], A. Giuliani [a], G. Pareschi [b], G. Tosti [c], O. Catalano [f], E. Amato [p], L.A. Antonelli [h], J. Becerra Gonzàles [m], G. Bellassai [d], C. Bigongiari [h, u], B. Biondo [f], M. Böttcher [n], G. Bonanno [d], G. Bonnoli [b], P. Bruno [d], A. Bulgarelli [e], R. Canestrari [f], M. Capalbi [f], P. Caraveo [a], M. Cardillo [k], V. Conforti [e], G. Contino [f], M. Corpora [f], A. Costa [d], G. Cusumano [f], A. D'Aì [f], E. de Gouveia Dal Pino [l], R. Della Ceca [b], E. Escribano Rodriguez [o], D. Falceta-Gonçalves [s], C. Fermino [l], M. Fiori [j, g], V. Fioretti [e], M. Fiorini [a], S. Gallozzi [h], C. Gargano [f], S. Garozzo [d], S. Germani [c], A. Ghedina [o], F. Gianotti [e], S. Giarrusso [f], R. Gimenes [f, l], V. Giordano [d], A. Grillo [d], C. Grivel Gelly [o], D. Impiombato [f], F. Incardona [d], S. Incorvaia [a], S. Iovenitti [b], A. La Barbera [f], N. La Palombara [a], V. La Parola [f], A. Lamastra [h], L. Lessio [g], G. Leto [d], F. Lo Gerfo [f], M. Lodi [o], S. Lombardi [h, u], F. Longo [r], F. Lucarelli [h, u], M.C. Maccarone [f], D. Marano [d], E. Martinetti [d], S. Mereghetti [a], A. Micciché [d], R. Millul [b], T. Mineo [f], D. Mollica [f], G. Morlino [q], A. Morselli [i], G. Naletto [j, g], G. Nicotra [t], A. Pagliaro [f], N. Parmiggiani [e], G. Piano [k], F. Pintore [f], E. Poretti [o], B. Olmi [q], G. Rodeghiero [e], G. Rodriguez Fernandez [i], P. Romano [b], G. Romeo [d], F. Russo [e], P. Sangiorgi [f], F.G. Saturni [h], J.H. Schwarz [b], E. Sciacca [d], G. Sironi [b], G. Sottile [f], A. Stamerra [h], G. Tagliaferri [b], V. Testa [h], G. Uman…

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[b] INAF, OA Brera, Via Bre…
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[d] INAF, OA Catania, Via S…

Journal of High Energy Astrophysics
Volume 35, August 2022, Pages 1-42

ASTRI Mini-Array core science at the *Observatorio del Teide*

S. Vercellone [a], C. Bigongiari [b], A. Burtovoi [c], M. Cardillo [d], O. Catalano [e], A. Franceschini [f], S. Lombardi [b, g], L. Nava [a], F. Pintore [e], A. Stamerra [b], F. Tavecchio [a], L. Zampieri [h], R. Alves Batista [i], E. Amato [c, j], L.A. Antonelli [b, g], C. Arcaro [h, k], J. Becerra González [l, m], G. Bonnoli [a], M. Böttcher [k], G. Brunetti [n], A.A. Compagnino [e], S. Crestan [o, p], A. D'Aì [e], M. Fiori [h, f], G. Galanti [o], A. Giuliani [o], E.M. de Gouveia Dal Pino [q], J.G. Green [b], A. Lamastra [b, g], M. Landoni [a], F. Lucarelli [b, g], G. Morlino [c], B. Olmi [r, c], E. Peretti [s], G. Piano [d], G. Ponti [a, t], E. Poretti [a, u], P. Romano [a], F.G. Saturni [b…], … Tutone [b], G. Umana [v], J.A. Acosta-Pulido [l, m], P. Barai [q], A. Bonanno [v], G. Bonann… …ano [e], M. Del Santo [e], M.V. del Va… …ani [x, y], R.J. García-López [l, m], A. G… …enitti [a], A. La Barbera [e], N. La Palo… …, M.C. Maccarone [e], S. Mereghett… …ghi [a], J.C. Rodríguez-Ramírez [q], G. … …, G. Tosti [x, y], M. Vázquez Acosta [l]…

Journal of High Energy Astrophysics
Volume 35, August 2022, Pages 91-111

Extragalactic observatory science with the ASTRI mini-array at the *Observatorio del Teide*

F.G. Saturni [a, b], C.H.E. Arcaro [c, d, e, f], B. Balmaverde [g], J. Becerra González [h, i], A. Caccianiga [j], M. Capalbi [k], A. Lamastra [a], S. Lombardi [a, b], F. Lucarelli [a, b], R. Alves Batista [l], L.A. Antonelli [a, b], E.M. de Gouveia Dal Pino [m], R. Della Ceca [j], J.G. Green [a, b, n], A. Pagliaro [k], C. Righi [o], F. Tavecchio [o], S. Vercellone [o], A. Wolter [j], E. Amato [p], C. Bigongiari [a, b], M. Böttcher [d], G. Brunetti [q], P. Bruno [r], A. Bulgarelli [s], M. Cardillo [t], V. Conforti [s], A. Costa [r], G. Cusumano [k], V. Fioretti [s], S. Germani [u], A. Ghedina [v], F. Gianotti [s], V. Giordano [r], A. Giuliani [w], F. Incardona [r], A. La Barbera [k], G. Leto [r], F. Longo [x, y], G. Morlino [p], B. Olmi [z], N. Parmiggiani [s], P. Romano [o], G. Romeo [r], A. Stamerra [a], G. Tagliaferri [o], V. Testa [a], G. Tosti [j, u], P.A. Caraveo [w], G. Pareschi [o]

Journal of High Energy Astrophysics
Volume 35, August 2022, Pages 139-175

Galactic observatory science with the ASTRI Mini-Array at the *Observatorio del Teide*

A. D'Aì [a], E. Amato [b], A. Burtovoi [b], A.A. Compagnino [a], M. Fiori [c], A. Giuliani [d], N. La Palombara [d], A. Paizis [d], G. Piano [e], F.G. Saturni [f, g], A. Tutone [a, h], A. Belfiore [d], M. Cardillo [e], S. Crestan [d], G. Cusumano [a], M. Della Valle [i, j], M. Del Santo [a], A. La Barbera [a], V. La Parola [a], S. Lombardi [f, g], S. Mereghetti [d], G. Morlino [b], F. Pintore [a], P. Romano [k], S. Vercellone [k], A. Antonelli [f], C. Arcaro [l], C. Bigongiari [f, g], M. Böettcher [m], P. Bruno [n], A. Bulgarelli [o], V. Conforti [o], A. Costa [n], E. de Gouveia Dal Pino [p], V. Fioretti [o], S. Germani [q], A. Ghedina [r], F. Gianotti [o], V. Giordano [n], F. Incardona [n], G. Leto [n], F. Longo [s, t], A. López Oramas [u], F. Lucarelli [f, g], B. Olmi [v], A. Pagliaro [a], N. Parmiggiani [o], G. Romeo [n], A. Stamerra [f], V. Testa [f], G. Tosti [o, q], G. Umana [n], L. Zampieri [e], P. Caraveo [d], G. Pareschi [k]

ASTRI IRF on Zenodo

«ASTRI Project. (2022). ASTRI Mini-Array Instrument Response Functions (Prod2, v1.0)» https://zenodo.org/record/6827882#.YtFCjZNBx60 - DoI: 10.5281/zenodo.6827882

“Pillar” Sources *(just an example)*

Mini-Array

from Vercellone et al.

Pillar 1
Origin of CRs

- **PeVatrons**
- **CRs Propagation**
- **Pulsar Wind Nebulae**

Pillar 2
Cosmology and Fund. Physics

Name	Type
Tycho Snr	SNR
Gal. Center	Diffuse
VER J1907	SNR+PWN
G106.3+2.7	SNR
γ-Cygni	SNR
W28	SNR/MC
M82	Starburst
Crab	PWN
Geminga	PWN
IC 310	Radio gal
M87	Radio gal
Mkn 501	Blazar
1ES 0229+200	Blazar

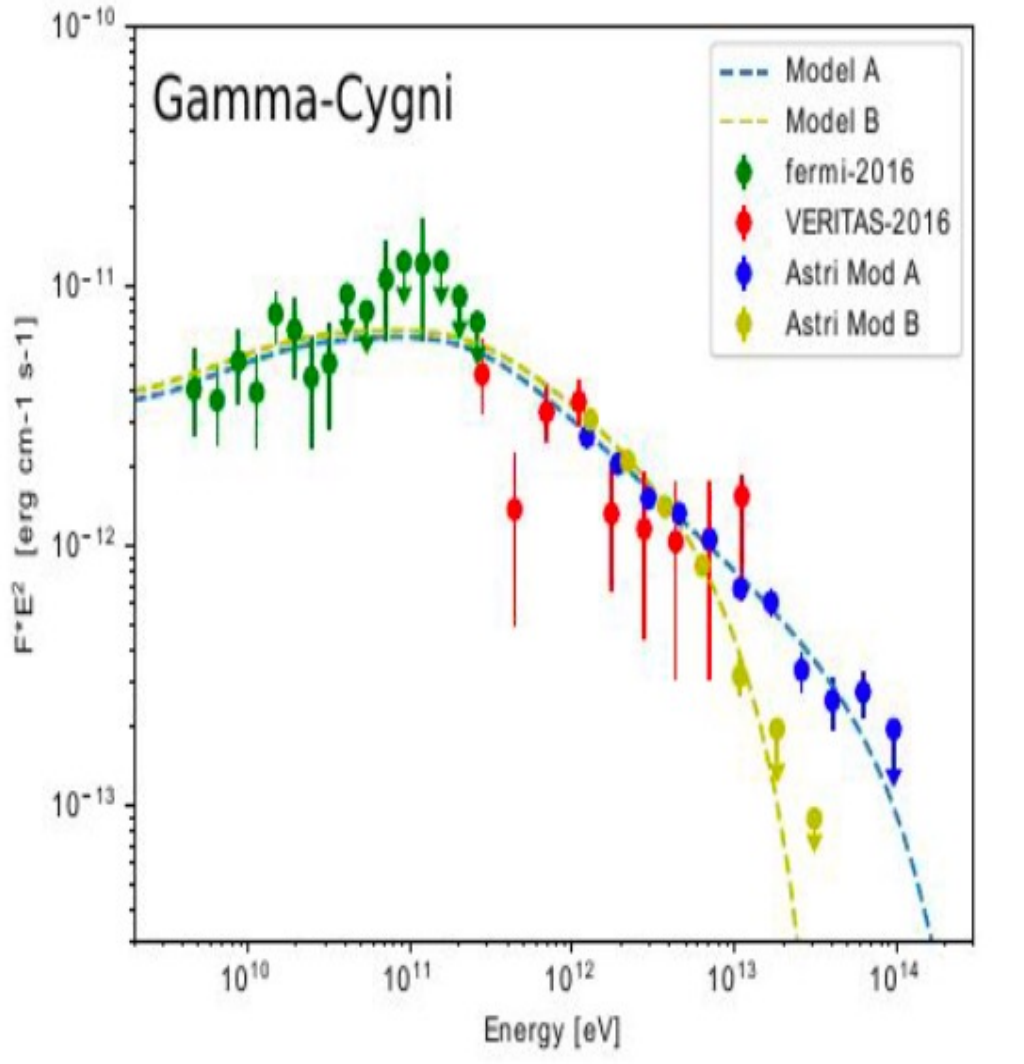
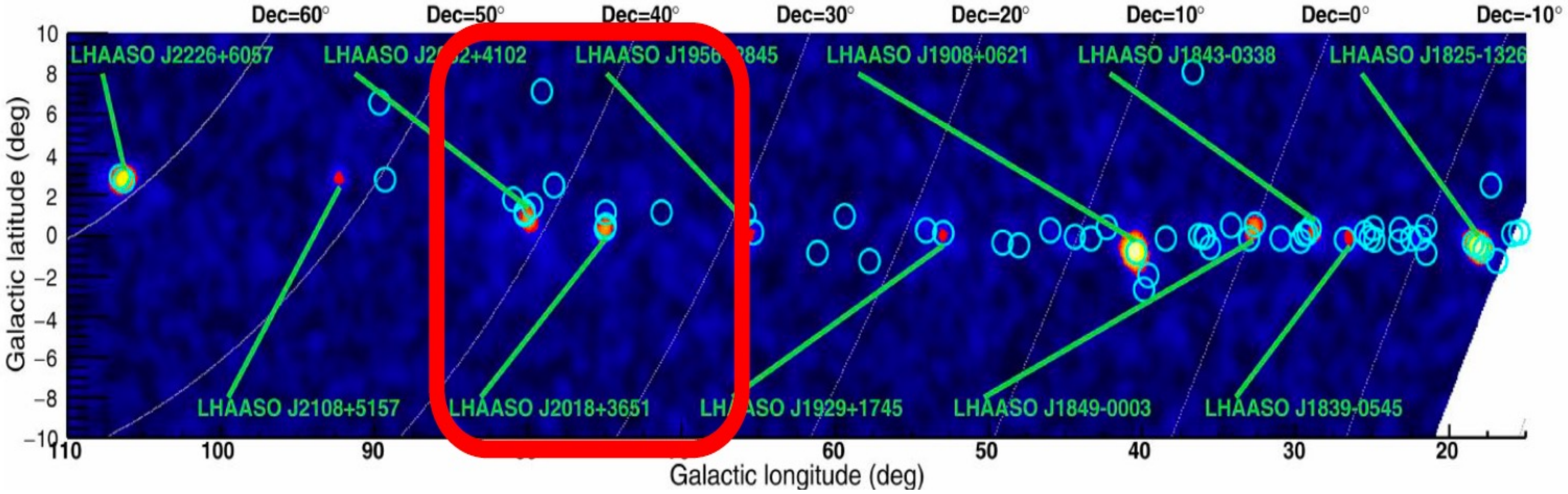


Figure 15: γ-ray spectrum of γ-Cygni. Data are from Fermi-LAT and VERITAS while theoretical models A and B (described in the text) are showed with dashed curves. Blue and yellow dots show the ASTRI Mini-Array simulations for model A and B, respectively, for 500 hr of exposure.

LHAASO Sources : Cygnus Region

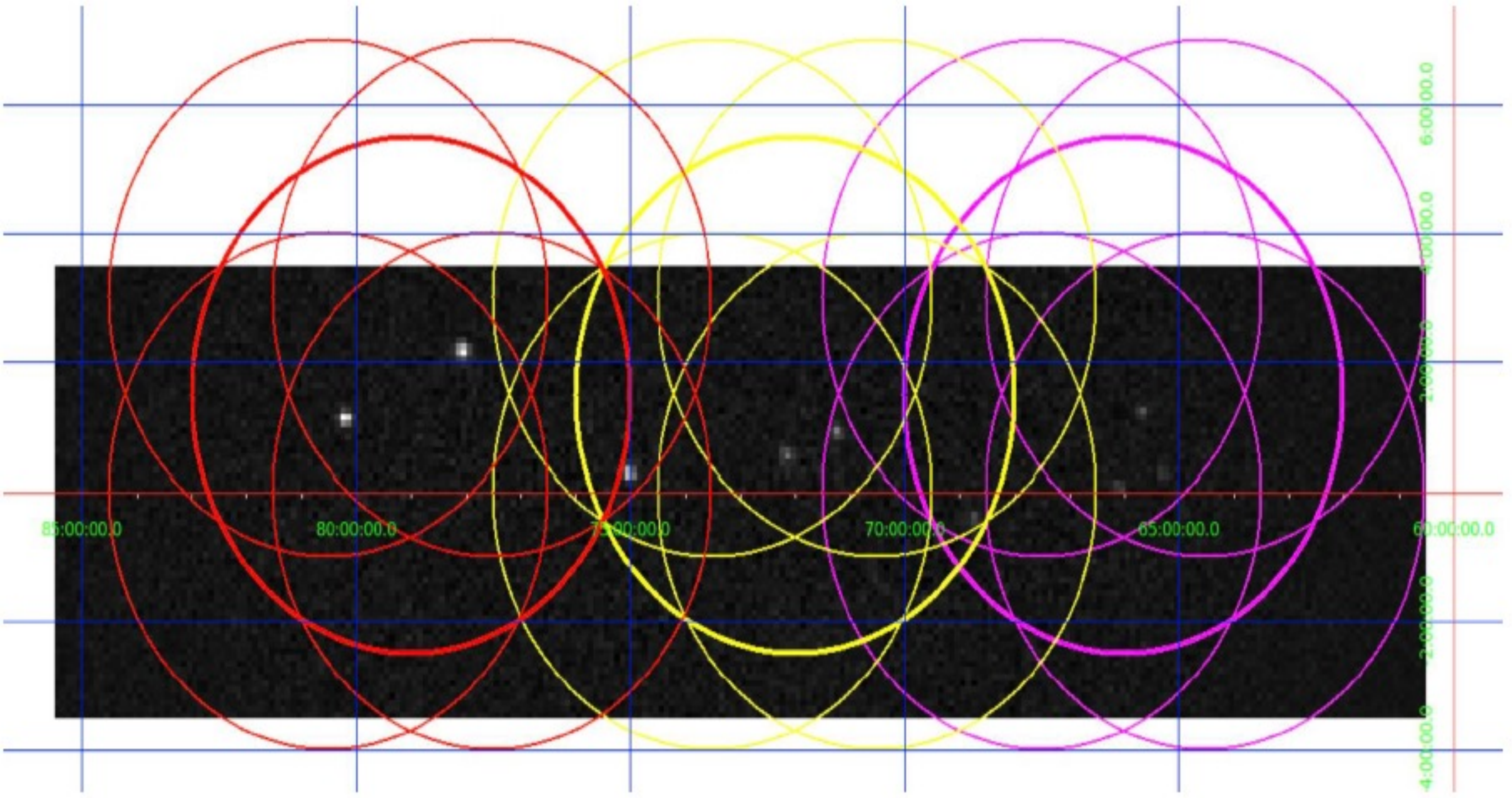
Source name	RA (°)	dec. (°)	Significance above 100 TeV (×σ)	E_{max} (PeV)	Flux at 100 TeV (CU)
LHAASO J0534+2202	83.55	22.05	17.8	0.88 ± 0.11	1.00(0.14)
LHAASO J1825-1326	276.45	−13.45	16.4	0.42 ± 0.16	3.57(0.52)
LHAASO J1839-0545	279.95	−5.75	7.7	0.21 ± 0.05	0.70(0.18)
LHAASO J1843-0338	280.75	−3.65	8.5	$0.26_{-0.10}^{+0.16}$	0.73(0.17)
LHAASO J1849-0003	282.35	−0.05	10.4	0.35 ± 0.07	0.74(0.15)
LHAASO J1908+0621	287.05	6.35	17.2	0.44 ± 0.05	1.36(0.18)
LHAASO J1929+1745	292.25	17.75	7.4	$0.71_{-0.07}^{+0.16}$	0.38(0.09)
LHAASO J1956+2845	299.05	28.75	7.4	0.42 ± 0.03	0.41(0.09)
LHAASO J2018+3651	304.75	36.85	10.4	0.27 ± 0.02	0.50(0.10)
LHAASO J2032+4102	308.05	41.05	10.5	1.42 ± 0.13	0.54(0.10)
LHAASO J2108+5157	317.15	51.95	8.3	0.43 ± 0.05	0.38(0.09)
LHAASO J2226+6057	336.75	60.95	13.6	0.57 ± 0.19	1.05(0.16)

Celestial coordinates (RA, dec.); statistical significance of detection above 100 TeV (calculated using a point-like template for the Crab Nebula and LHAASO J2108+5157 and 0.3° extension templates for the other sources); the corresponding differential photon fluxes at 100 TeV; and detected highest photon energies. Errors are estimated as the boundary values of the area that contains ±34.14% of events with respect to the most probable value of the event distribution. In most cases, the distribution is a Gaussian and the error is 1σ.



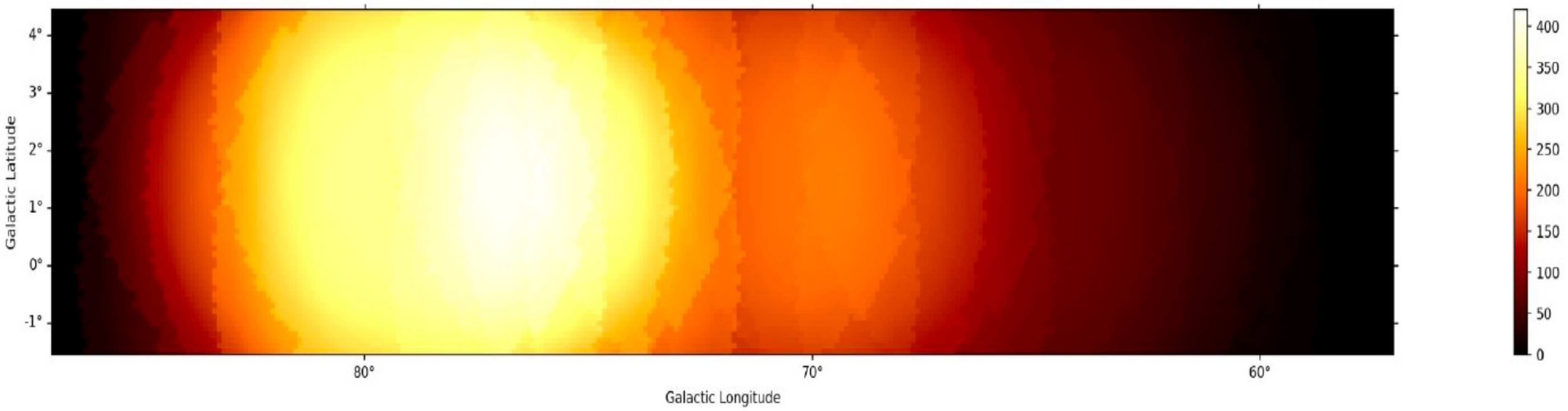
Cao et al., 2021

The data challenge of the Cygnus region

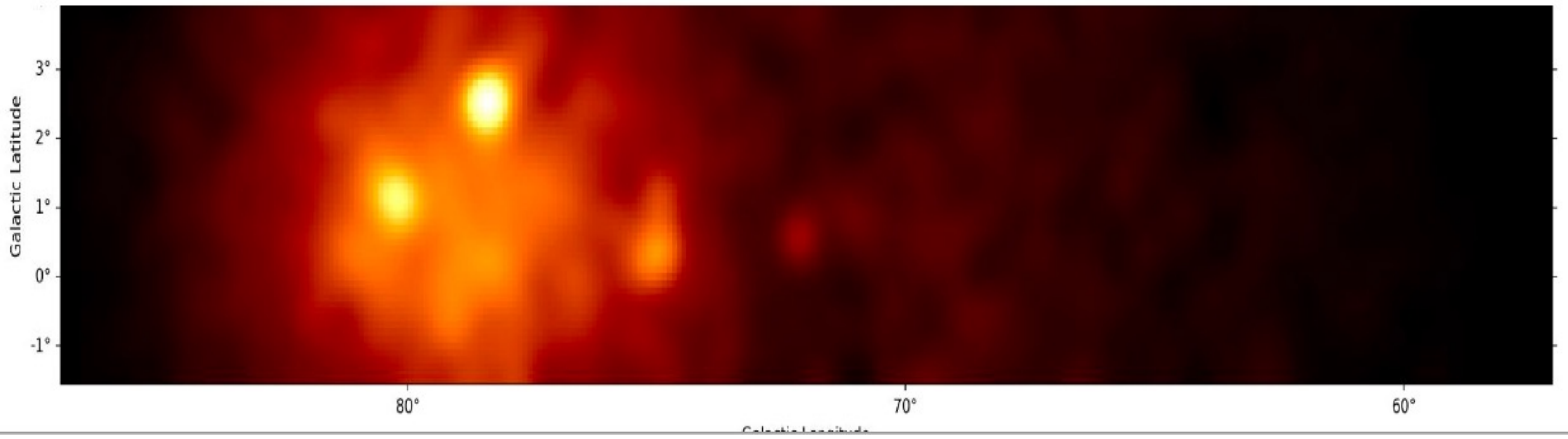


We simulated a survey of the Cygnus region, adopting 15 pointing positions along the Galactic longitude in the [60-85 deg] range.

All the known sources (eg from 3rd HAWC catalogue + LHAASO) and the Galactic diffuse component (from Gaggiero et al.) were simulated.

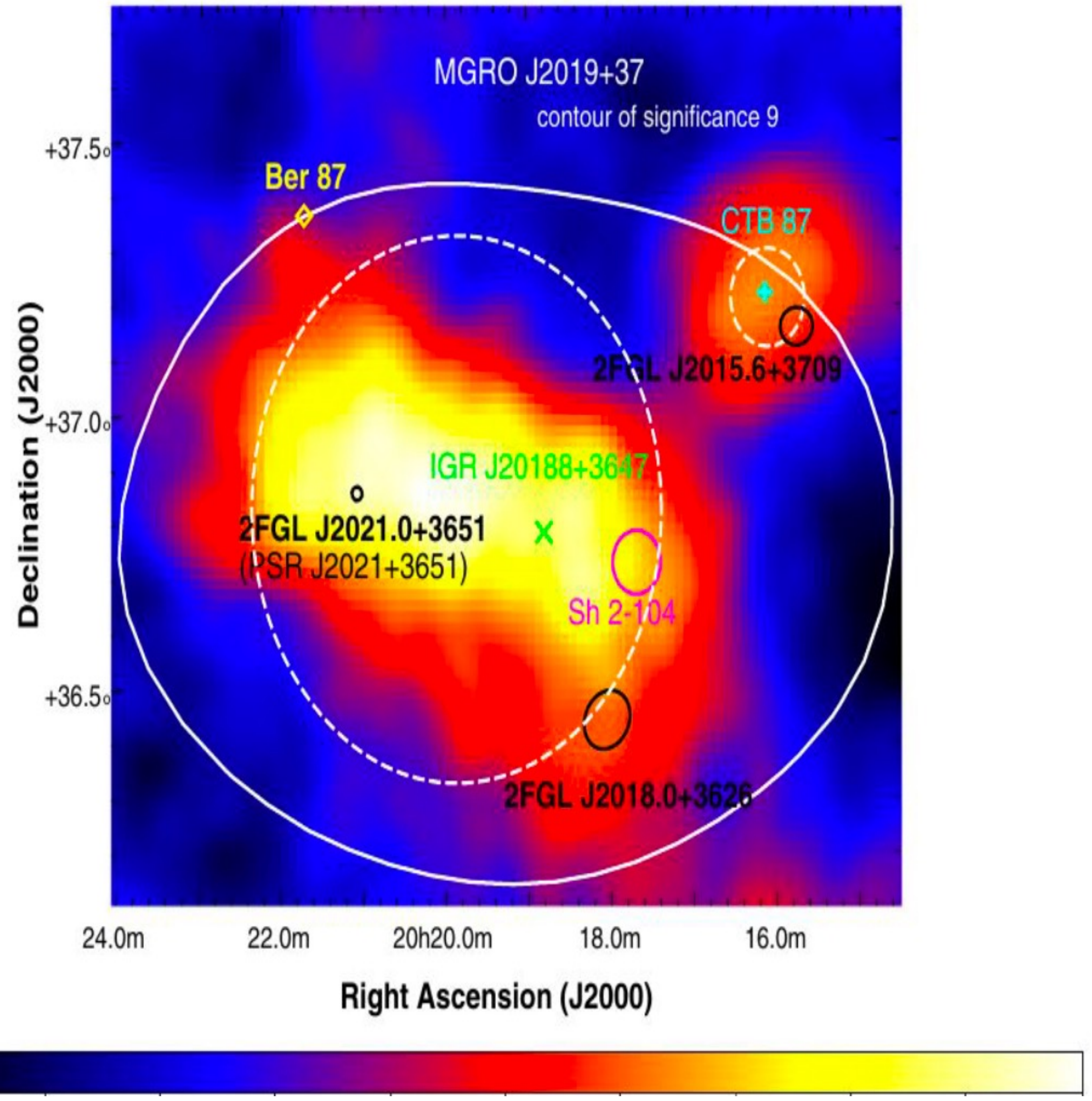


Background map of the region,
brightness indicates regions of higher ***exposure***



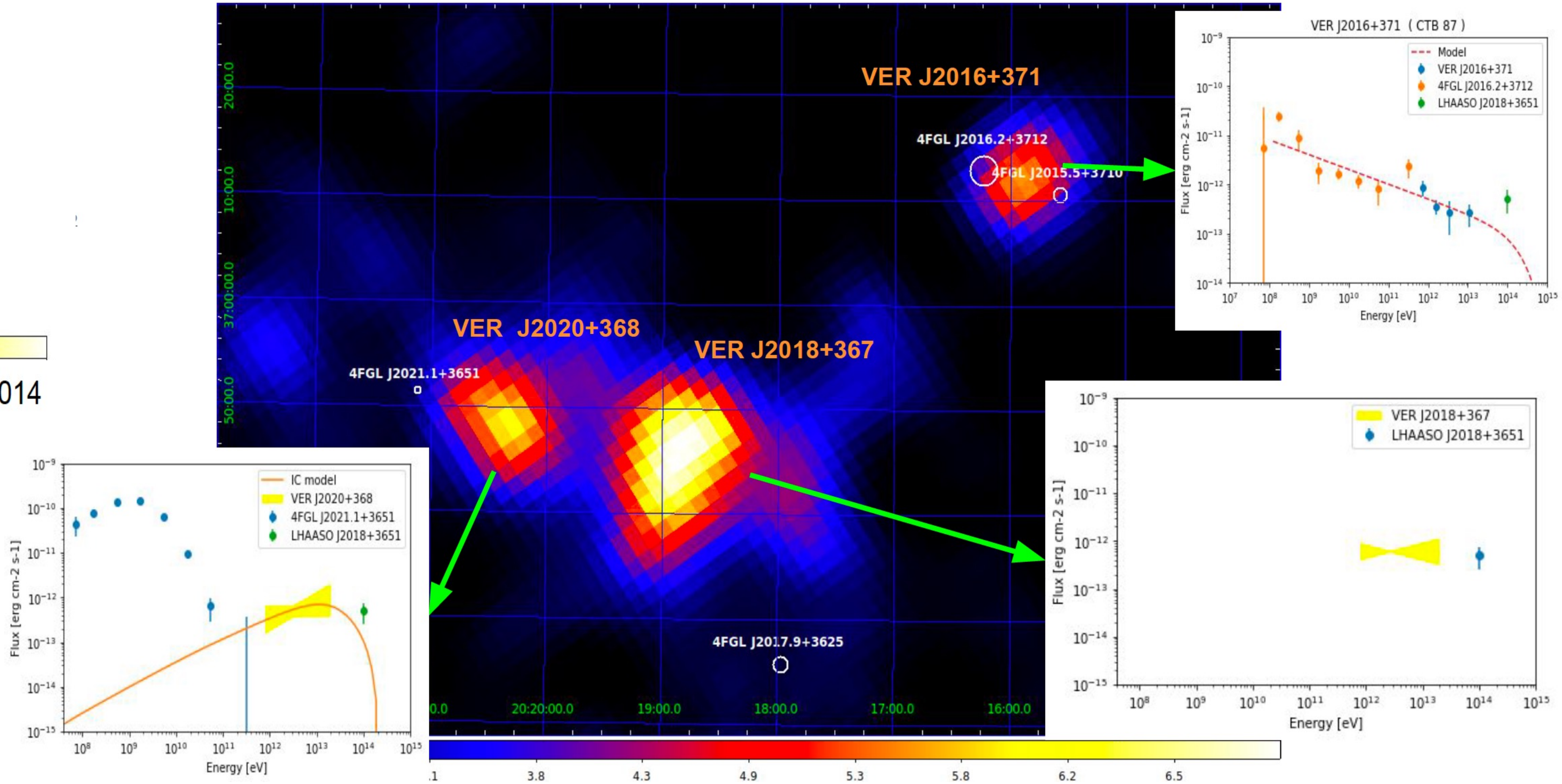
Excess map of the region,
brighter points indicate ***source or diffuse emission***

Cygnus/J2018+3651 region



From : The Astrophysical Journal, 788:78 (10pp), 2014

VERITAS Cygnus Region Survey - Abeysekara et al. 2018



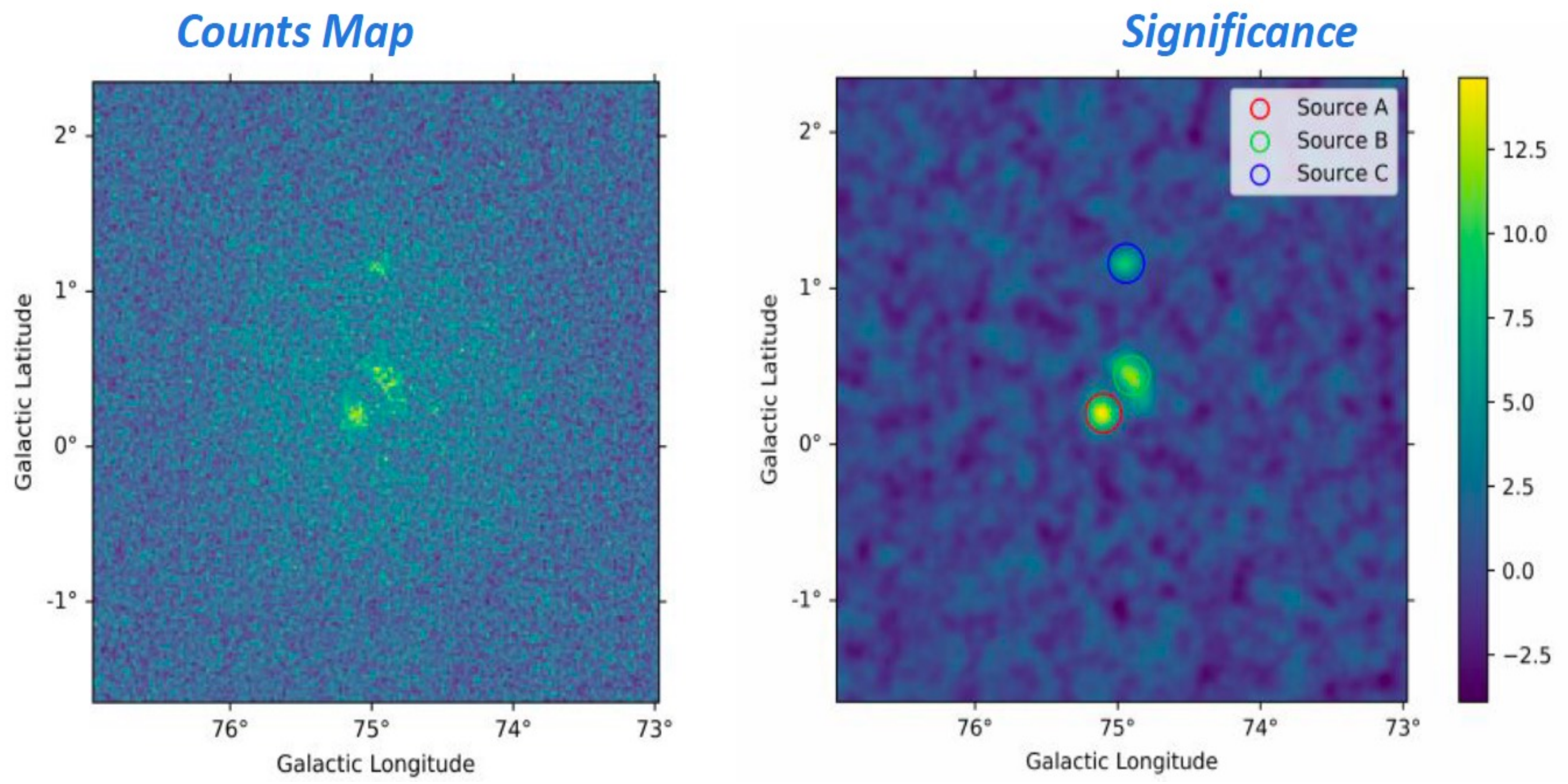
LHAASO J2018+3651 with ASTRI-MA

Mini-Array

ASTRI M.A. observations

Exposure : 200 hrs

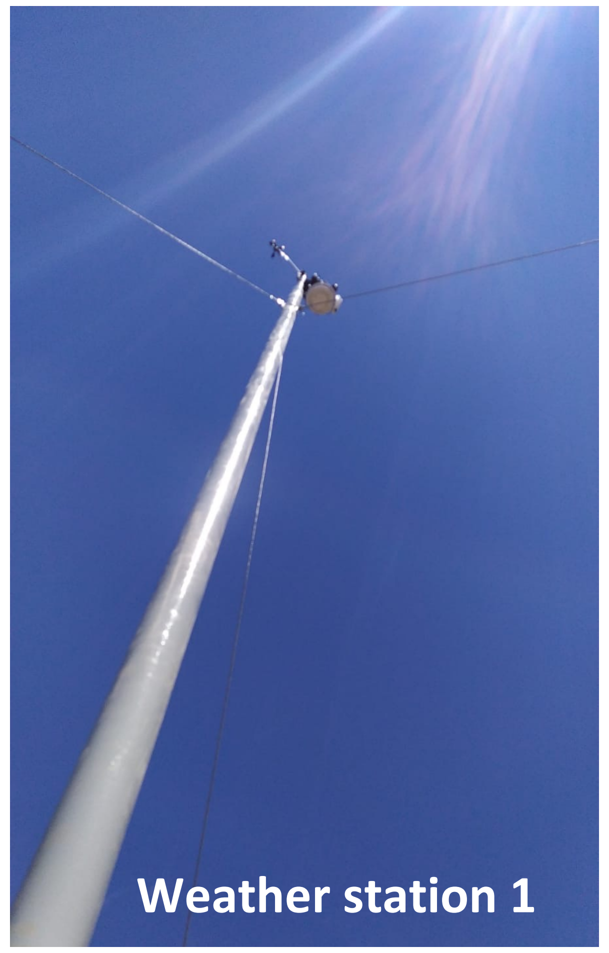
Spectral Parameters			
Name	N_0	Γ	λ
Source A	$(4.6\pm0.4)\times10^{-15}$	1.8 ± 0.04	0.01 ± 0.004
Source B	$(3.9\pm0.6)\times10^{-15}$	1.8 ± 0.06	0.004 ± 0.002
Source C	$(9.0\pm0.3)\times10^{-16}$	2.5 ± 0.09	-
Spatial Parameters			
Name	l	b	σ
Source A	75.11 ± 0.02	0.2 ± 0.008	0.056 ± 0.005
Source B	74.89 ± 0.02	0.44 ± 0.009	0.04 ± 0.003
Source C	74.95 ± 0.01	1.18 ± 0.009	0.02 ± 0.008



PRELIMINARY

Source	l	b	TS
	deg	deg	
Source A	305.09	36.80	214
Source B	304.70	36.77	147
Source C	303.99	37.21	90

The ASTRI Mini-Array @ the Teide observatory

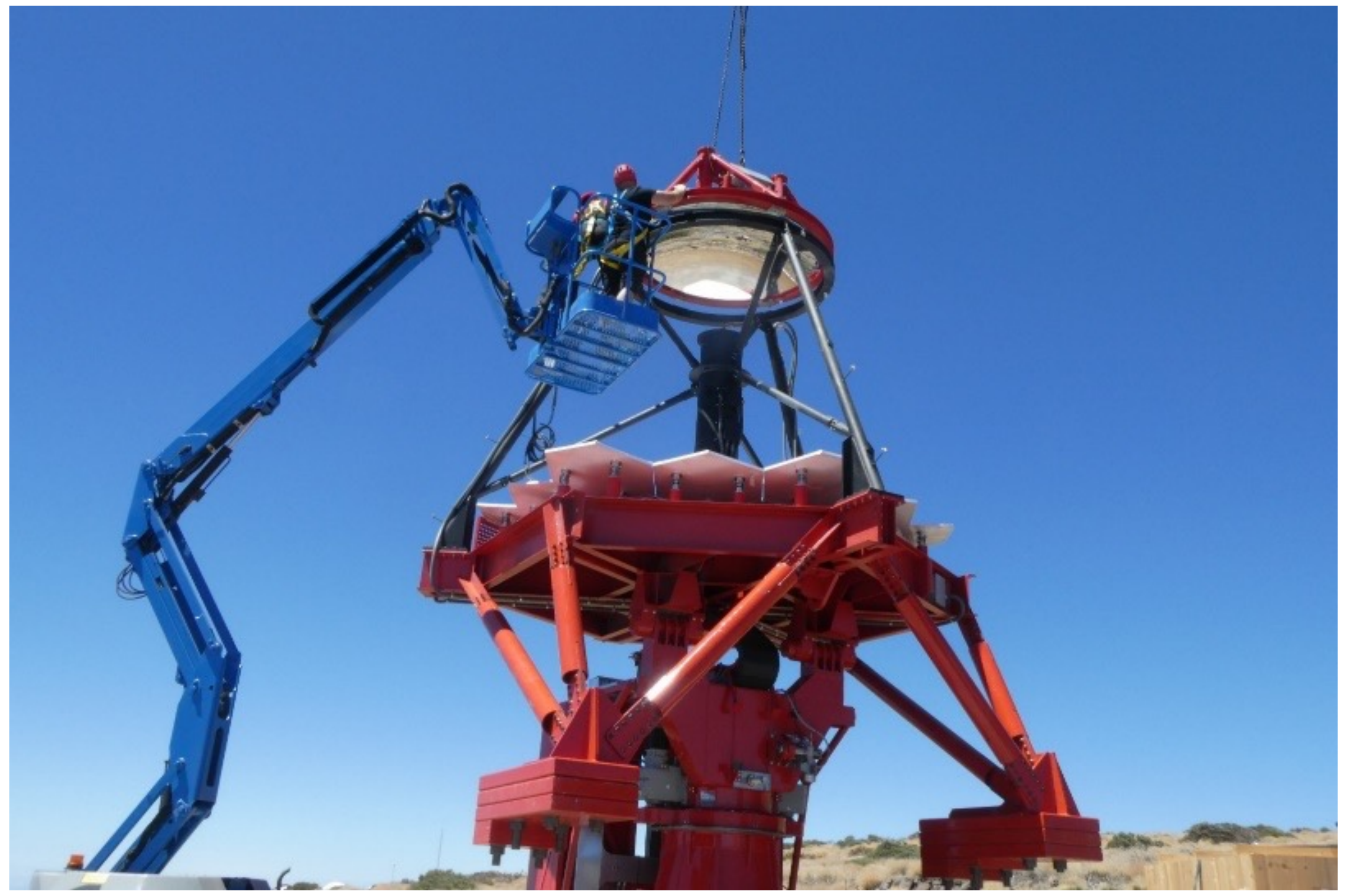


Infrastructure

Infrastructure delivery:
18th of November 2022

ASTRI-1 on site integration

Mini-Array



Telescope integration takes 3-4 weeks (working days) including:

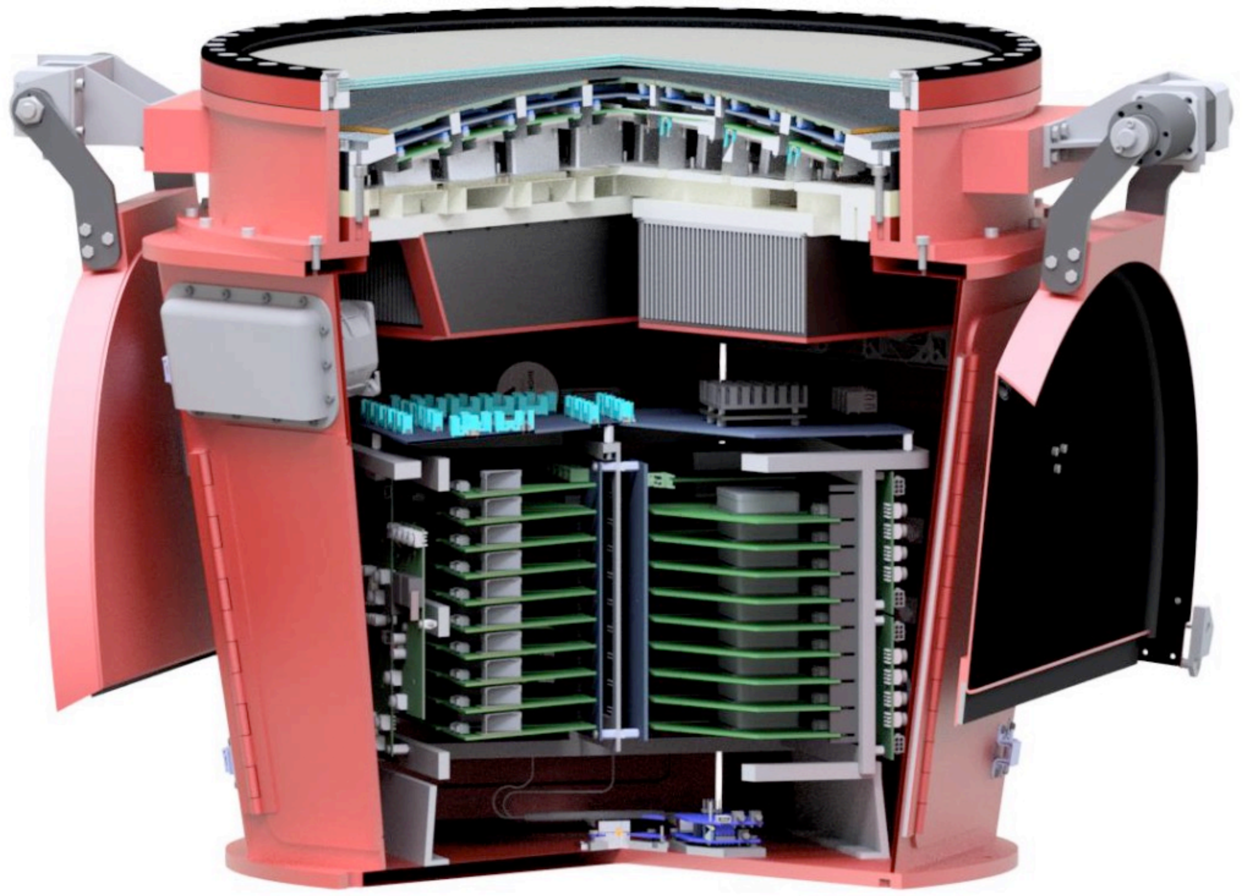
- **Base grouting 2-3 days**
- **M1 panels integration 2 days**
- **M2 mirror integration 2 days**

Acceptance at the end of January 2023

Cherenkov Cameras

Contract for the production of 11 cameras

- 1 engineering camera for qualification
- 9 cameras
- 1 spare camera



CAEN Tools for Discovery

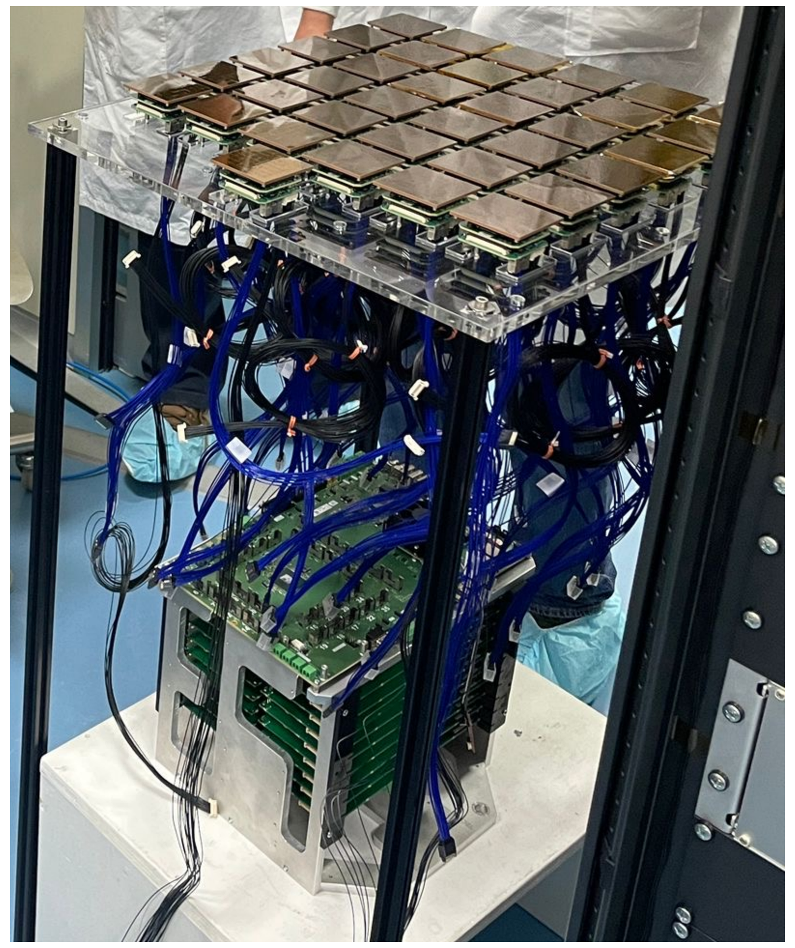
NI Nuclear Instruments

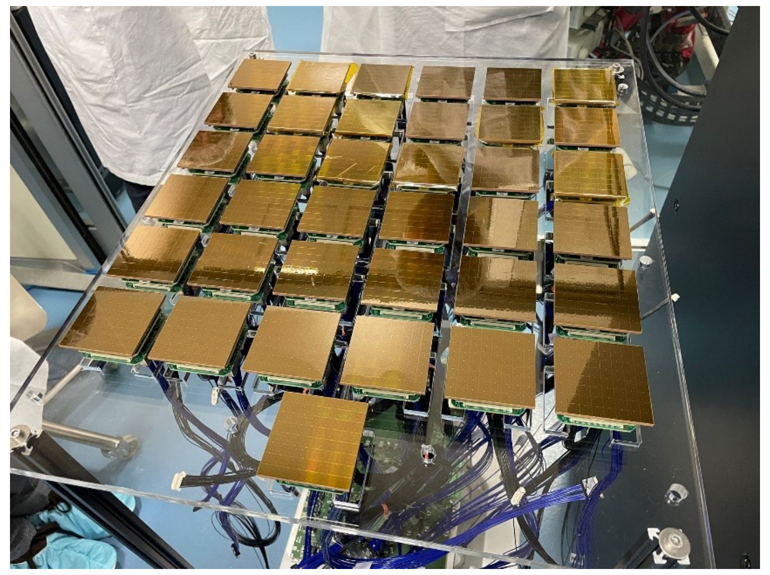
EIE GROUP

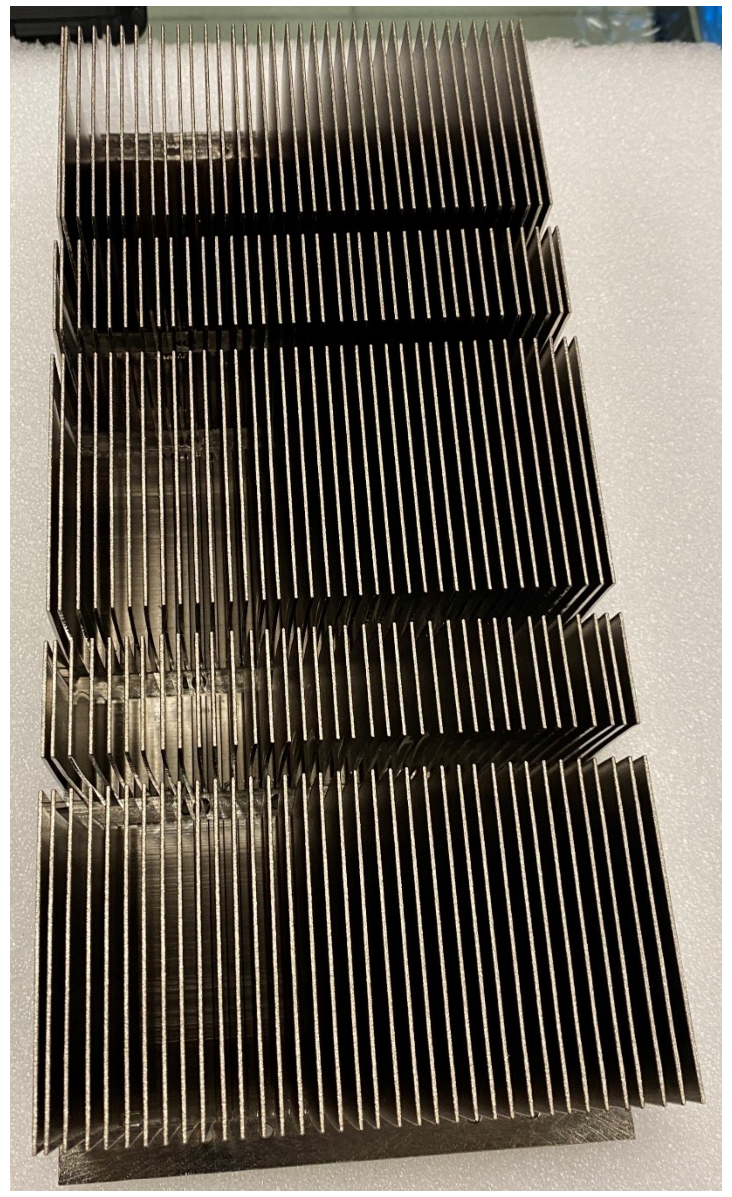
weeroc

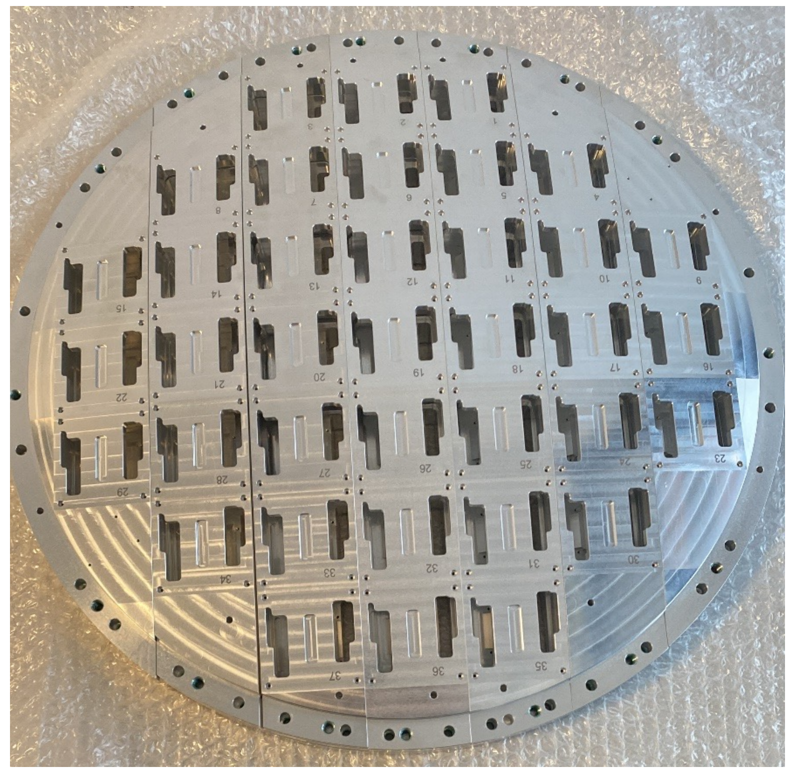
HAMAMATSU PHOTON IS OUR BUSINESS

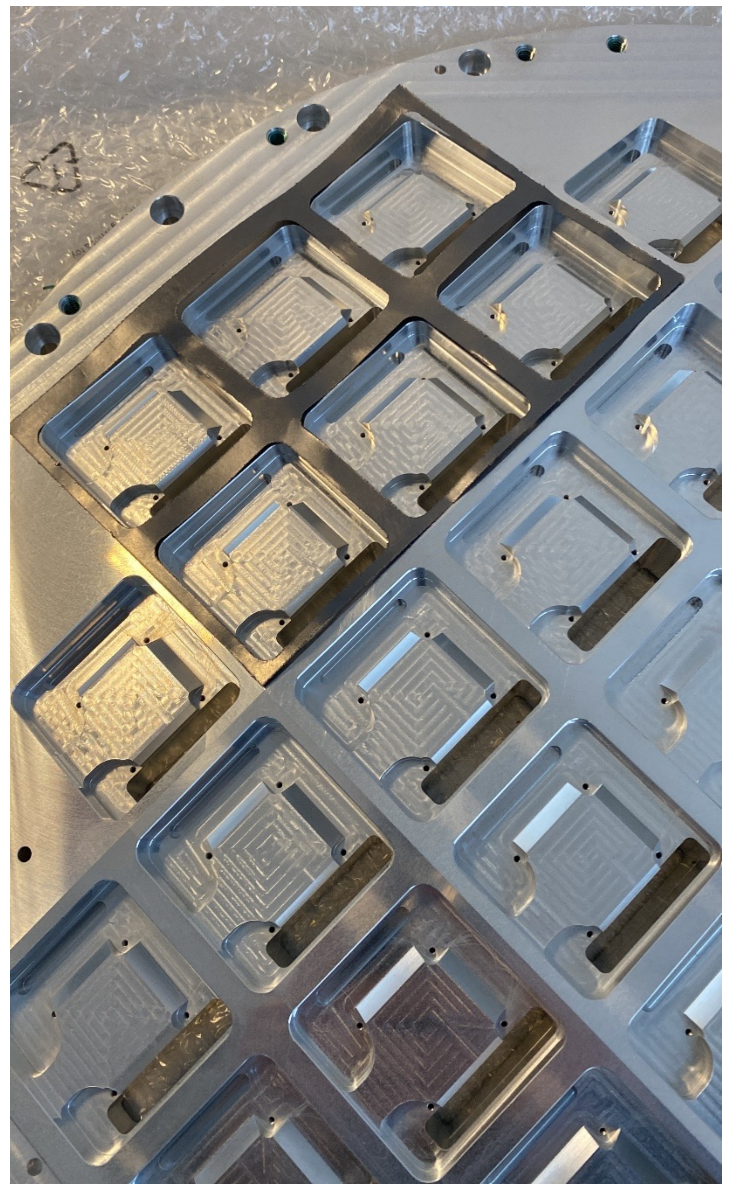
Production and test of engineering camera ongoing





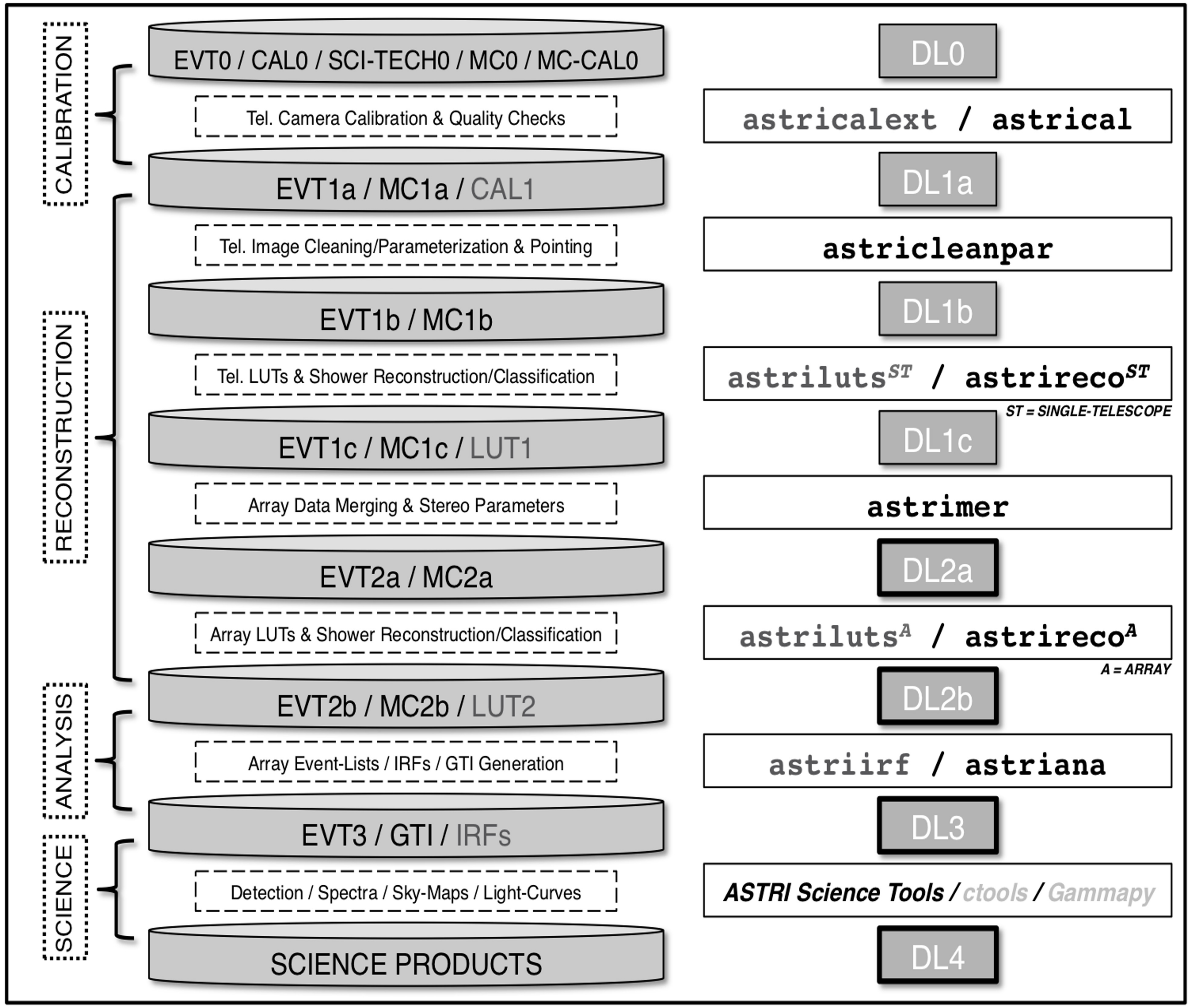






The ASTRI Data Handling

Proc. SPIE, 10707, 107070R (2018)



ASTRI Data Handling:

- ~15 involved people from different INAF institutes
- **End-to-End approach, focus on both ASTRI prototype on-site activities and ASTRI Mini-Array**

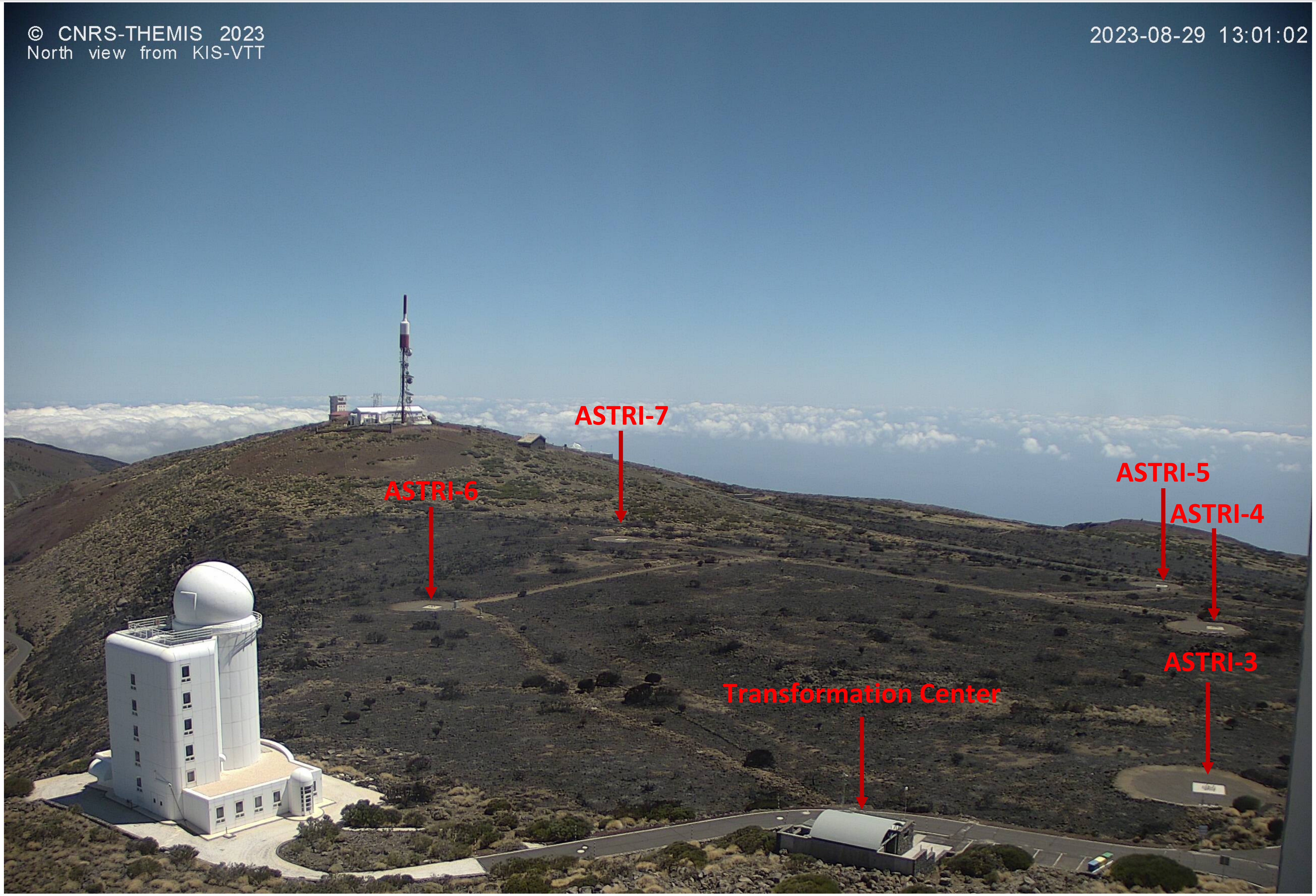
ASTRI Data Handling main activities:

- on-site/off-site **archives and pipelines**
- MC simulations (for real data reduction and performance assessment)
- Prototype data reduction for commissioning/validation phases
- Mini-array IRFs production for CTA pre-production science studies
- Science tools (*ctools* and *Gammapy*) utilization and testing
- Real Time Analysis for ASTRI prototype

View from VTT

ASTRI-1

View from VTT



ASTRI Mini-Array implementation timeline

Timeline based on current available information

- Teide infrastructure almost complete -> Contract is going to be closed
- ASTRI-1 telescope site acceptance review in January 2023
- ASTRI-8 & ASTRI-9 telescopes procurement ongoing

  → Shipping to Tenerife by the end of 2023
- First Cherenkov camera (engineering camera)

  → ready for lab test – Oct 2023

  → first Cherenkov light at the site Spring 2024
- First three telescopes (ASTRI-1, 8, 9) complete with cameras → winter 24
- Second batch of telescopes will start to arrive @ spring of 2024
- ASTRI Mini-Array ready for commissioning in 2025
- Scientific observations with the full array start at the end of 2025

Photo credits: Tommaso Marchiori (EIE group)

Tomaso Belloni (1962 – 2023)

http://www.tomasobelloni.it/