The ASTRI Mini-Array: Overview and first results

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TeV Particle Astrophysics (TeVPA)
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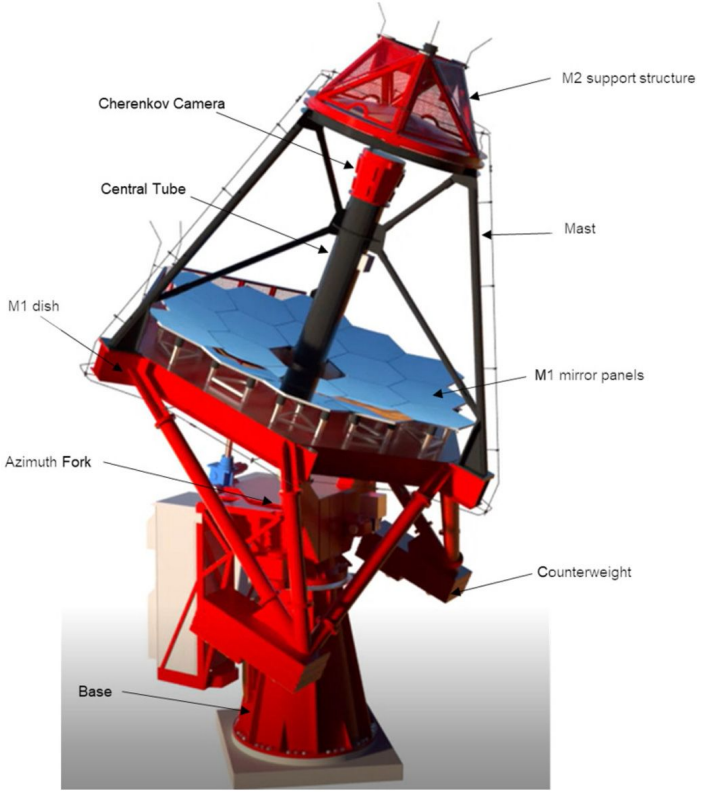
The ASTRI Mini-Array

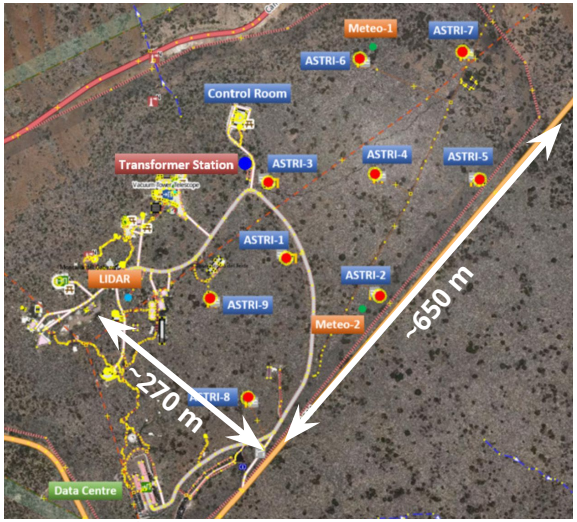
- ASTRI is an array of 9 Cherenkov telescopes under construction at the **Observatorio del Teide (OT)**.
- Project led by **INAF**, with more than **150 researchers** from institutions in 5 different countries.
- The telescopes have a diameter of **4.3 m** and a **dual-mirror** (modified Schwarzschild-Couder) optical layout. Vassiliev+07
  - Wide field of view (FoV ~ 10º) and good off-axis performance.

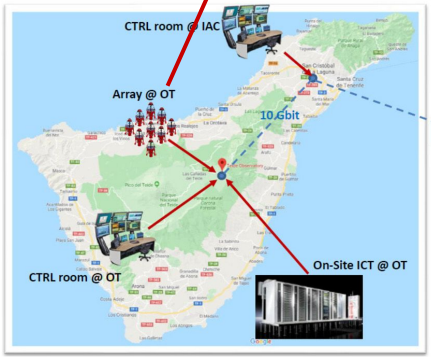


Scuderi+2022

The ASTRI site and layout

- ASTRI is located at the Observatorio del Teide in Tenerife, Spain, at an **altitude of 2360 m**.
- The telescopes cover a wide area of around **650m × 270m,** with a median telescope separation of **~160 m**.
  - Chosen based on MC simulations and existing infrastructure.
- Both **onsite and remote** control rooms are available.
- Data are initially stored in an onsite data center and later transferred to the offsite data center at INAF-OAR (Rome).

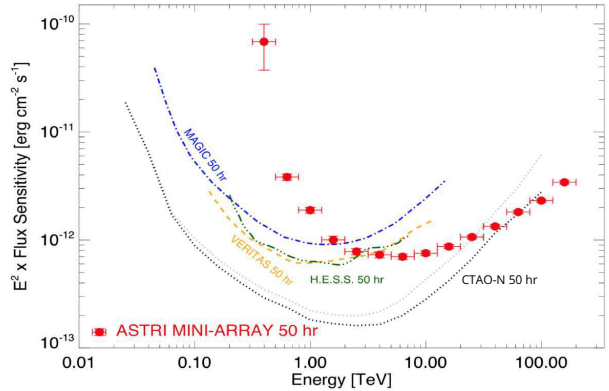




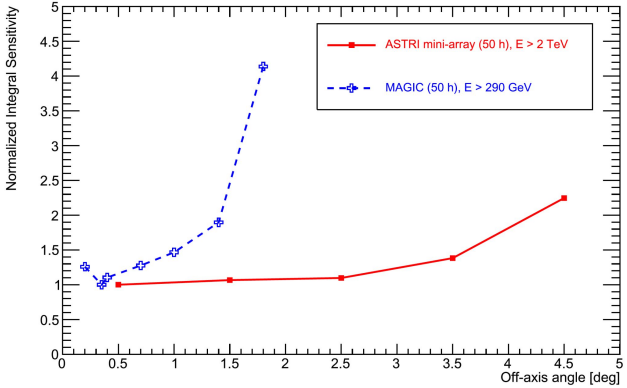
10 Gbit

Expected performance

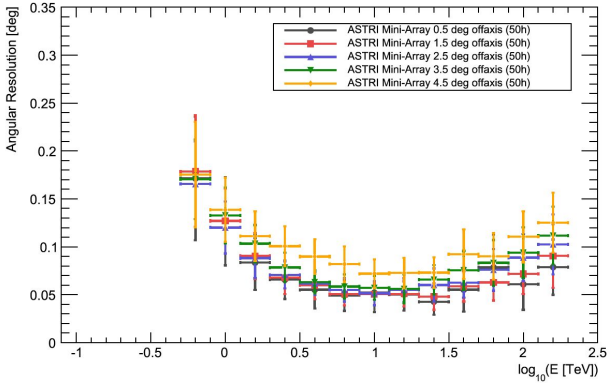
Performance study based on MC simulations of the full ASTRI array



Better sensitivity than current instruments for energies above ~3 TeV.



Wide FoV with homogenous acceptance up to ~3.5°.



Angular resolution of ~0.05° for energies above a few TeV. Stable up to ~3.5° offsets.

Vercellone+2022

Timeline and current status

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Summer 2021

Site foundation

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Summer 2021 — Site foundation

Autumn 2022 — ASTRI-1 construction

Autumn 2024 — **Start of ASTRI-1 observations**

Timeline and current status

- **Summer 2021** — Site foundation
- **Autumn 2022** — ASTRI-1 construction
- **Autumn 2024** — **Start of ASTRI-1 observations**
- **Spring 2025** — ASTRI 2–7 construction
- **Autumn 2025** — **Start of ASTRI-3 observations**

Present

- **Autumn 2026** — Full array expected

Science cases

- **Cosmic-ray origins:**
  - PeVatrons
  - Particle propagation and escape
  - Pulsar wind nebulae and TeV halos
- **Fundamental physics:**
  - Infrared EBL constraints
  - Intergalactic magnetic fields
  - Lorentz invariance violation, axion-like particles, dark matter searches
- Transients events (Gamma-ray bursts, flares,...) → **See talk by A. Carosi**
- Non gamma-ray astronomy (Direct cosmic-ray measurement, intensity interferometry)

Scuderi+2022, Vercellone+2022, D'Aì+2022, Saturni+2022

Science cases

90 sources, 43 of them detected **above 100 TeV**

The First LHAASO Catalog of Gamma-Ray Sources

Zhen Cao[1,2,3], F. Aharonian[4,5], Q. An[6,7], Axikegu[8], Y. X. Bai[1,3], Y. W. Bao[9], D. Bastieri[10], X. J. Bi[1,2,3], Y. J. Bi[1,3], J. T. Cai[10], Q. Cao[11], W. Y. Cao[7], Zhe Cao[6,7], J. Chang[12], J. F. Chang[1,3,6], A. M. Chen[13], E. S. Chen[1,2,3], Liang Chen[14], Lin Chen[8], Long Chen[8], M. J. Chen[1,3], M. L. Chen[1,3,6], Q. H. Chen[8], S. H. Chen[1,2,3], S. Z. Chen[1,3], T. L. Chen[15], Y. Chen[9], N. Cheng[1,3], Y. D. Cheng[1,3], M. Y. Cui[12], S. W. Cui[11], X. H. Cui[16], Y. D. Cui[17], B. Z. Dai[18], H. L. Dai[1,3,6], Z. G. Dai[7], Danzengluobu[15], D. della Volpe[19], X. Q. Dong[1,2,3], K. K. Duan[12], J. H. Fan[10], Y. Z. Fan[12], J. Fang[18], K. Fang[1,3], C. F. Feng[20], L. Feng[12], S. H. Feng[1,3], X. T. Feng[20], Y. L. Feng[15], S. Gabici[21], B. Gao[1,3], C. D. Gao[20], L. Q. Gao[1,2,3], Q. Gao[15], W. Gao[1,3], W. K. Gao[1,2,3], M. M. Ge[18], L. S. Geng[1,3], G. Giacinti[13], G. H. Gong[22], Q. B. Gou[1,3], M. H. Gu[1,3,6], F. L. Guo[14], X. L. Guo[8], Y. Q. Guo[1,3], Y. Y. Guo[12], Y. A. Han[23], H. H. He[1,2,3], H. N. He[12], J. Y. He[12], X. B. He[17], Y. He[8], M. Heller[19], Y. K. Hor[17], B. W. Hou[1,2,3], C. Hou[1,3], X. Hou[24], H. B. Hu[1,2,3], Q. Hu[7,12], S. C. Hu[1,3,25], D. H. Huang[8], T. Q. Huang[1,3], W. J. Huang[17], X. T. Huang[20], X. Y. Huang[12], Y. Huang[1,2,3], Z. C. Huang[8], X. L. Ji[1,3,6], H. Y. Jia[8], K. Jia[20], K. Jiang[6,7], X. W. Jiang[1,3], Z. J. Jiang[18], M. Jin[8], M. M. Kang[26], T. Ke[1,3], D. Kuleshov[27], K. Kurinov[27], B. B. Li[11], Cheng Li[6,7], Cong Li[1,3], D. Li[1,2,3], F. Li[1,3,6], H. B. Li[1,3], H. C. Li[1,3], H. Y. Li[7,12], J. Li[7,12], Jian Li[7], Jie Li[1,3,6], K. Li[1,3], W. L. Li[20], W. L. Li[13], X. R. Li[1,3], Xin Li[6,7], Y. Z. Li[1,2,3], Zhe Li[1,3], Zhuo Li[28], E. W. Liang[29], Y. F. Liang[29], S. J. Lin[17], B. Liu[7], C. Liu[1,3], D. Liu[20], H. Liu[8], H. D. Liu[23], J. Liu[1,3], J. L. Liu[1,3], J. Y. Liu[1,3], M. Y. Liu[15], R. Y. Liu[9], S. M. Liu[8], W. Liu[1,3], Y. Liu[10], Y. N. Liu[22], R. Lu[18], Q. Luo[17], H. K. Lv[1,3], B. Q. Ma[28], L. L. Ma[1,3], X. H. Ma[1,3], J. R. Mao[24], Z. Min[1,3], W. Mitthumsiri[30], H. J. Mu[23], Y. C. Nan[1,3], A. Neronov[21], Z. W. Ou[17], B. Y. Pang[8], P. Pattarakijwanich[30], Z. Y. Pei[10], M. Y. Qi[1,3], Y. Q. Qi[11], B. Q. Qiao[1,3], J. J. Qin[7], D. Ruffolo[30], A. Sáiz[30], D. Semikoz[21], C. Y. Shao[17], L. Shao[11], O. Shchegolev[27,31], X. D. Sheng[1,3], F. W. Shu[32], H. C. Song[28], Yu. V. Stenkin[27,31], V. Stepanov[27], Y. Su[12], Q. N. Sun[8], X. N. Sun[29], Z. B. Sun[33], P. H. T. Tam[17], Q. W. Tang[32], Z. B. Tang[6,7], W. W. Tian[2,16], C. Wang[33], C. B. Wang[8], G. W. Wang[7], H. G. Wang[10], H. H. Wang[17], J. C. Wang[24], K. Wang[9], L. P. Wang[20], L. Y. Wang[1,3], P. H. Wang[8], R. Wang[20], W. Wang[17], X. G. Wang[29], X. Y. Wang[9], Y. Wang[8], Y. D. Wang[1,3], Y. J. Wang[1,3], Z. H. Wang[26], Z. X. Wang[18], Zhen Wang[13], Zheng Wang[1,3,6], D. M. Wei[12], J. J. Wei[12], Y. J. Wei[1,2,3], T. Wen[18], C. Y. Wu[1,3], H. R. Wu[1,3], S. Wu[1,3], X. F. Wu[12], Y. S. Wu[7], S. Q. Xi[1,3], J. Xia[7,12], J. J. Xia[8], G. M. Xiang[2,14], D. X. Xiao[11], G. Xiao[1,3], G. G. Xin[1,3], Y. L. Xin[8], Y. Xing[14], Z. Xiong[1,2,3], D. L. Xu[13], R. F. Xu[1,2,3], R. X. Xu[28], W. L. Xu[26], L. Xue[20], D. H. Yan[18], J. Z. Yan[12], T. Yan[1,3], C. W. Yang[26], F. Yang[11], F. F. Yang[1,3,6], H. W. Yang[17], J. Y. Yang[17], L. L. Yang[17], M. J. Yang[1,3], R. Z. Yang[7], S. B. Yang[18], Y. H. Yao[26], Z. G. Yao[1,3], Y. M. Ye[22], L. Q. Yin[1,3], N. Yin[20], X. H. You[1,3], Z. Y. You[1,3], Y. H. Yu[7], Q. Yuan[12], H. Yue[1,2,3], H. D. Zeng[12], T. X. Zeng[1,3,6], W. Zeng[18], M. Zha[1,3], B. B. Zhang[9], F. Zhang[8], H. M. Zhang[9], H. Y. Zhang[1,3], J. L. Zhang[16], L. X. Zhang[10], Li Zhang[18], P. F. Zhang[18], P. P. Zhang[7,12], R. Zhang[7,12], S. B. Zhang[2,16], S. R. Zhang[11], S. S. Zhang[1,3], X. Zhang[9], X. P. Zhang[1,3], Y. F. Zhang[8], Yi Zhang[1,12], Yong Zhang[1,3], B. Zhao[8], J. Zhao[1,3], L. Zhao[6,7], L. Z. Zhao[11], S. P. Zhao[12,20], F. Zheng[33], B. Zhou[1,3], H. Zhou[13], J. N. Zhou[14], M. Zhou[32], P. Zhou[9], R. Zhou[26], X. X. Zhou[8], C. G. Zhu[20], F. R. Zhu[8], H. Zhu[16], K. J. Zhu[1,2,3,6], and X. Zuo[1,3]

(The LHAASO Collaboration)

Cao+2024

- **Cosmic-ray origins:**
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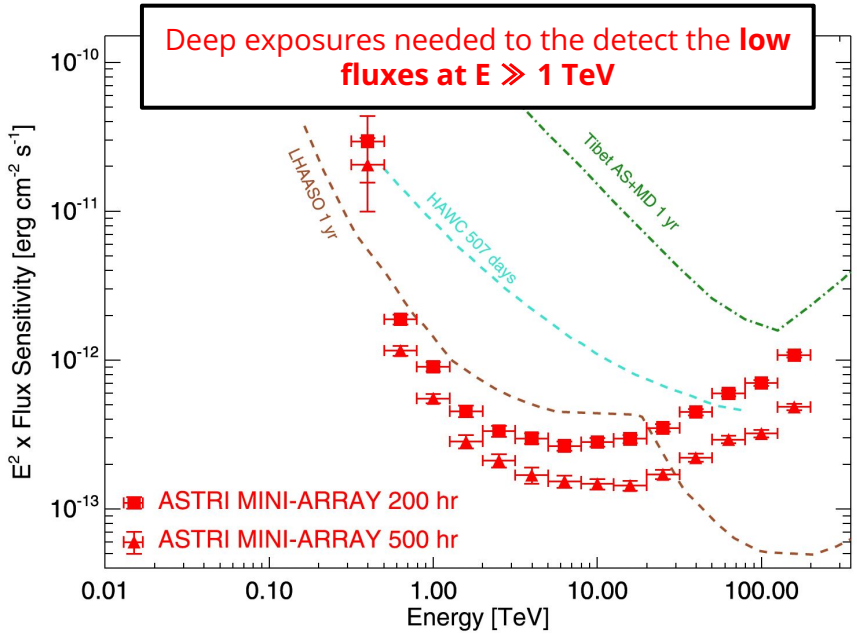
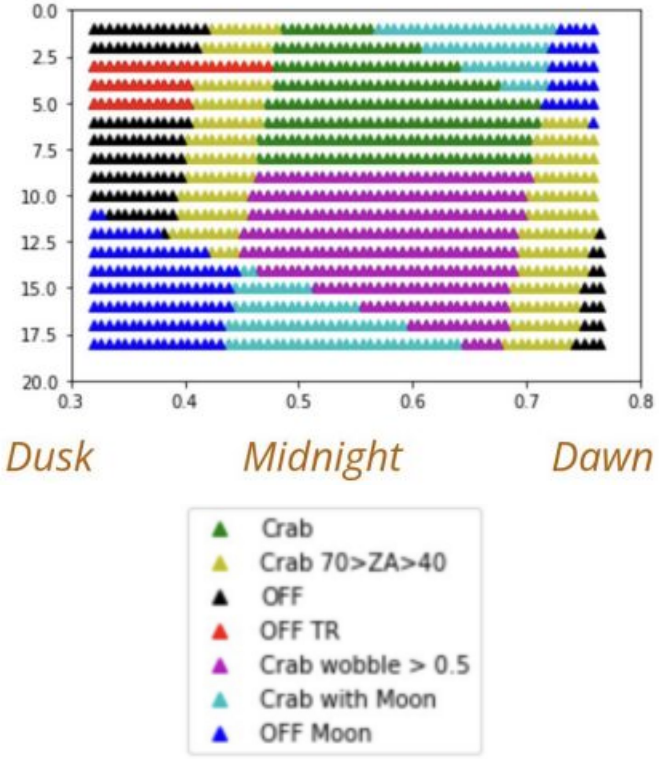


Scuderi+2022, Vercellone+2022, D'Aì+2022, Saturni+2022

ASTRI-1: Observations

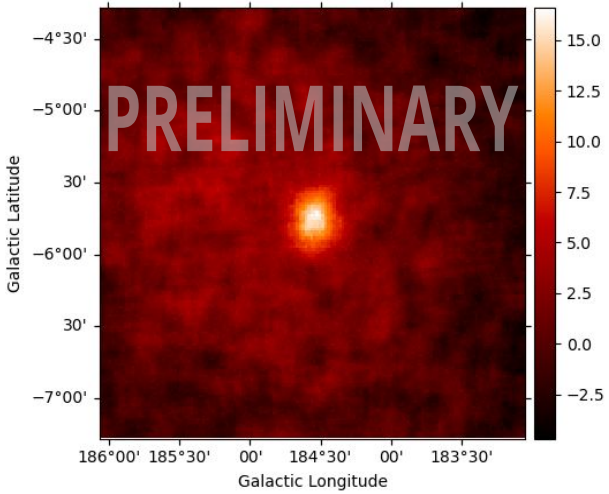
- ASTRI-1 operations started in **November 2024**.
- More than **400h of data** have been collected up to now:
  - Scientific data: **Crab Nebula**, Mrk501, BLLac, Perseus
  - Technical data including fixed OFF pointings.
- Observations were conducted in different trigger and offset configurations (0.5° – 4.5°).
- Very little time lost due to technical problems.
  - **Operational efficiency of ~90%** (without accounting for weather).

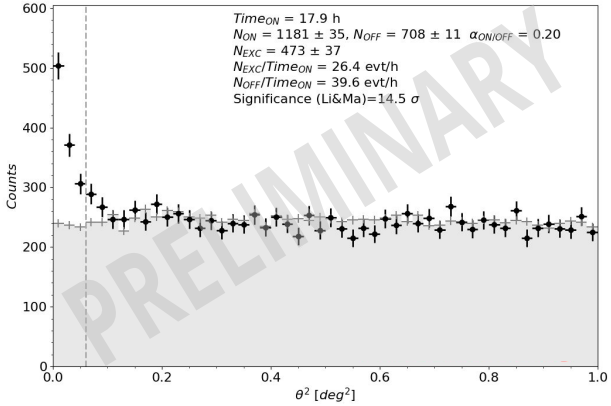
First ASTRI-1 shift



ASTRI-1: Preliminary results

- The preliminary results shown here are for **17.9h** of **Crab Nebula data** taken between 11/2024 and 02/2025, with
  - offset of 0.5°
  - zenith angle below 30°
  - no moon
  - quality cuts applied
- A clear **14.5σ detection** is obtained.
- The spectrum is compatible with the one obtained by HEGRA (and other IACTs) up to 20 TeV. Aharonian+00





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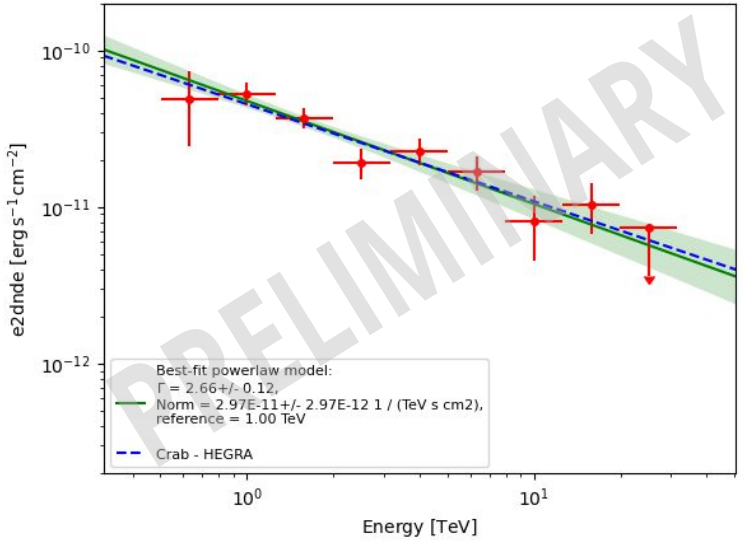

Summary

- The ASTRI Mini-Array is an array of 9 Cherenkov telescopes at the OT.
  - Expected completion date by late 2026.
- Two telescopes are already operational and taking data.
- The array will provide good energy and angular resolution over a wide FoV for energies well above 1 TeV.
  - Large exposures needed due to the low fluxes.
  - Complementary to LHAASO. Synergies with CTAO-North.
- Preliminary results with ASTRI-1 reproduce well the Crab spectrum.
- Stereo results with 2+ telescopes coming shortly!

THANK YOU FOR YOUR ATTENTION

Edgar Molina
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on behalf of the ASTRI Project

TeV Particle Astrophysics (TeVPA)
Valencia, 3 – 7 November 2025

Cofinanciado por la Unión Europea

Backup

Data analysis (not fully optimized yet)

A-SciSoft

- L0 calibration:
  - Standard procedure
  - Cleaning/Parameterization: relative cleaning 4.0-2.0
- L1 reconstruction:
  - Quality cuts: SIZE > 50, LEAKAGE < 0.1, NUMISLAND < 2
  - Pointlike-srcindep approach (random forest for g/h, energy and arrival direction)
  - Pointing and source position calculation from astrometry of VARIANCE data (without PMC information)
- L2 reconstruction:
  - No additional Random Forests
- L3 event list and IRF generation.
- L4–L5: Analysis with **Gammapy**

ASTRI-1: Preliminary results