ASTRI Mini-Array flying with Cygnus

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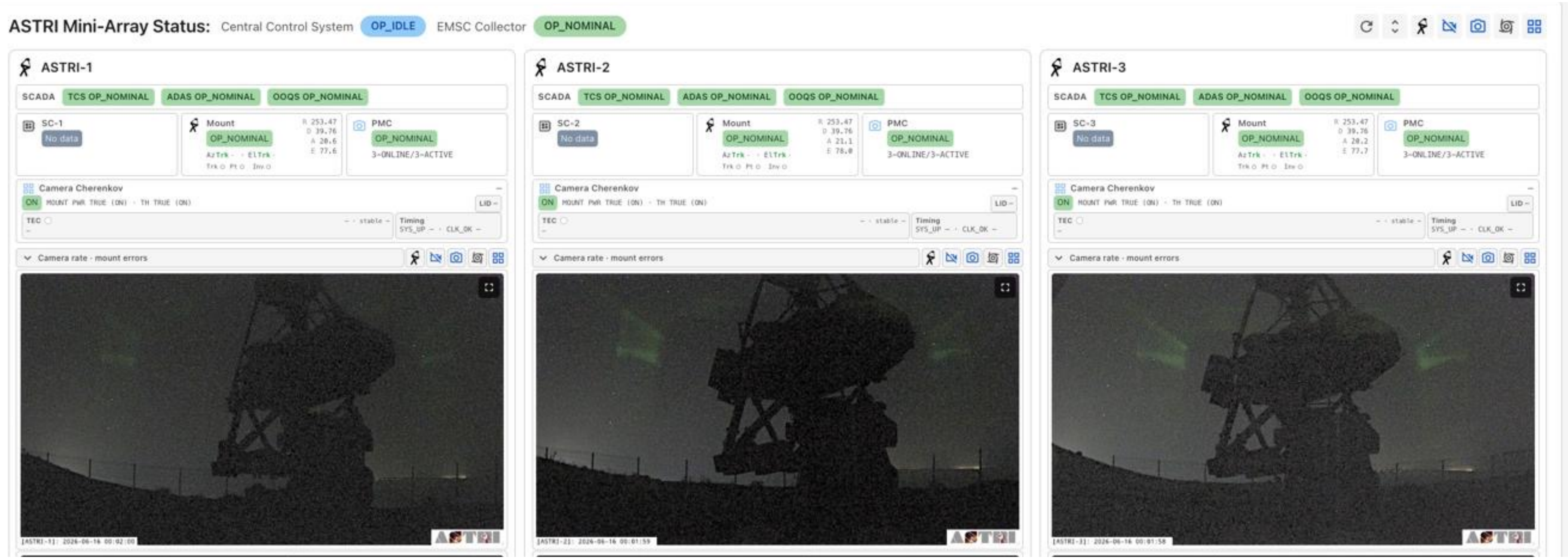
for the ASTRI Project

From 9 to 40: the SST Telescopes and Gamma-Ray Science with ASTRI and CTAO – 20/07/2026

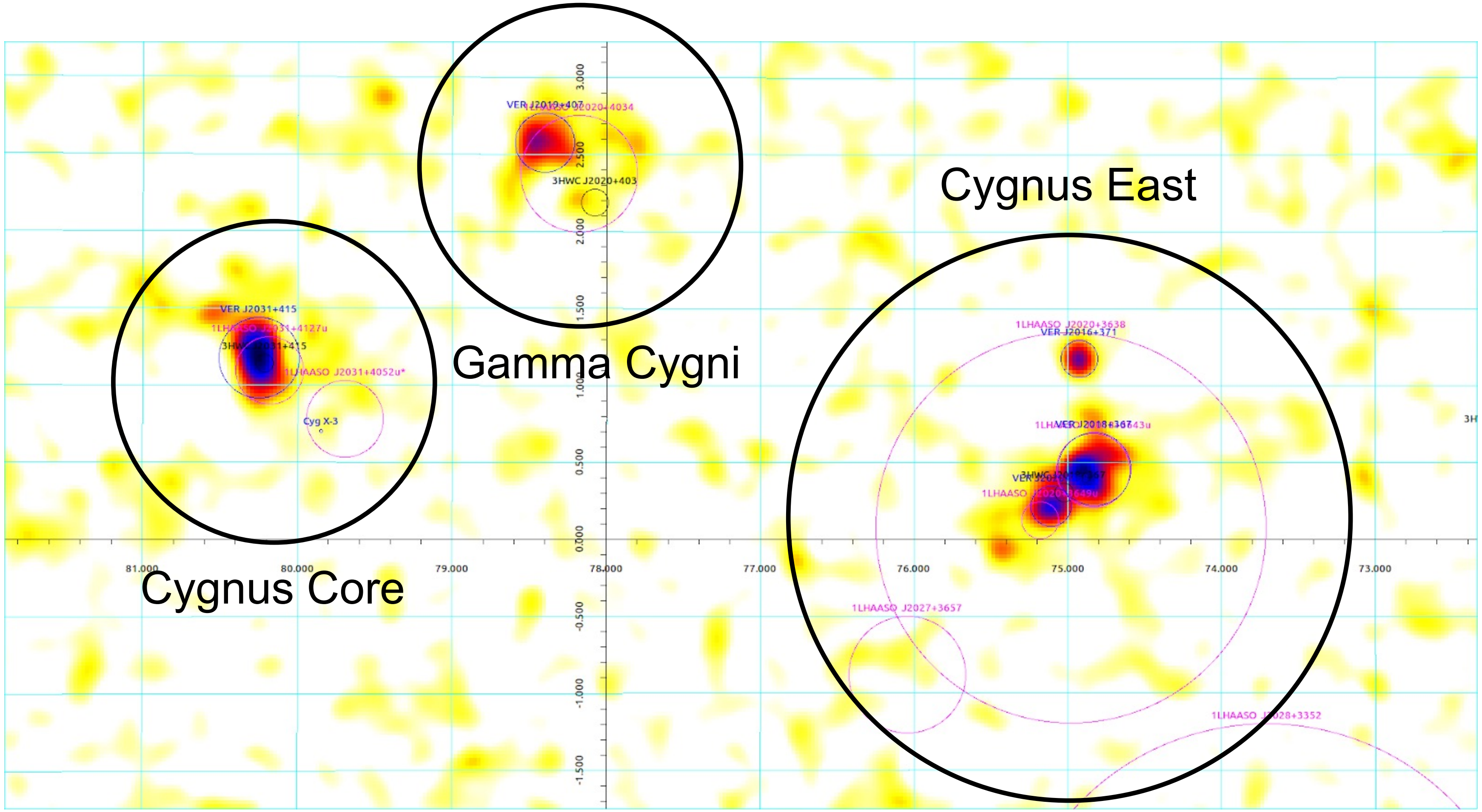
A NEW ERA FOR ASTRI

ASTRI enters a new phase with stereoscopic observations: ASTRI-1, ASTRI-2 and ASTRI-3 are now operating together!



The complex Cygnus region

Cygnus represents one of the most complex, rich and densely populated start-forming region!

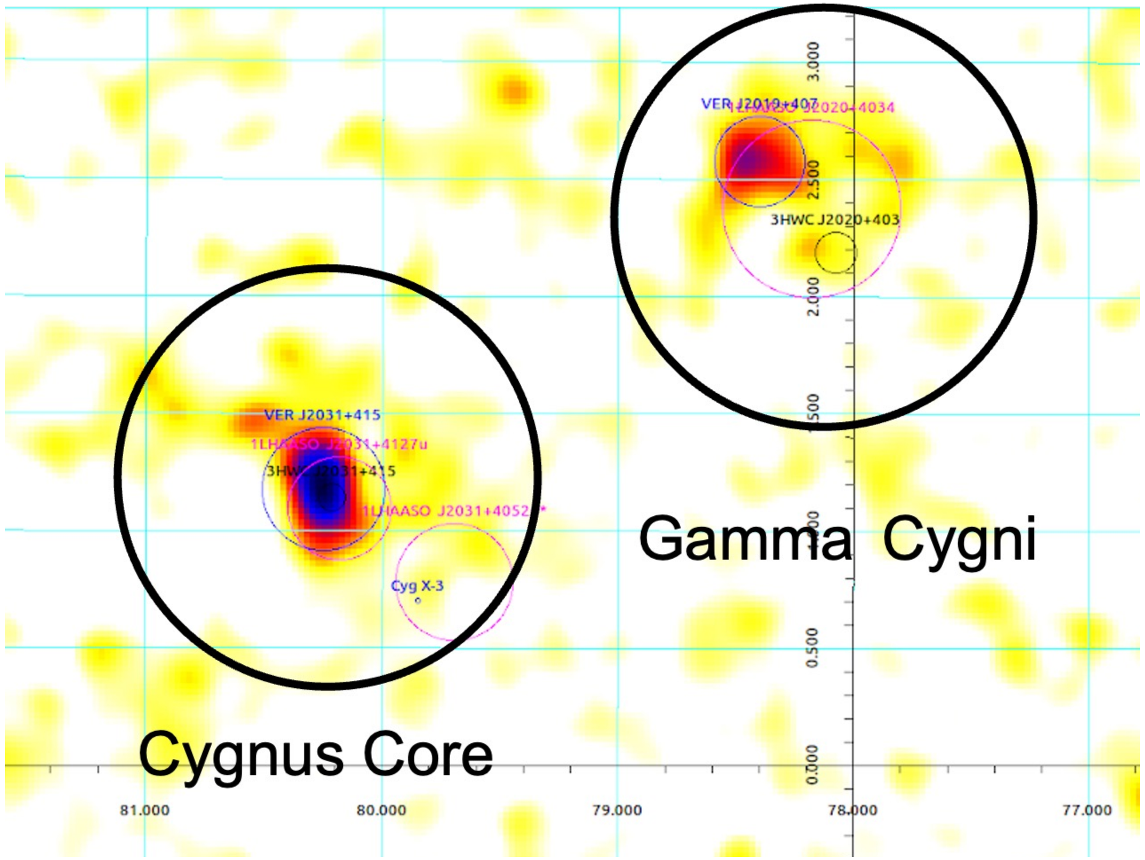


The complex Cygnus region

Cygnus represents one of the most complex, rich and densely populated start-forming region!

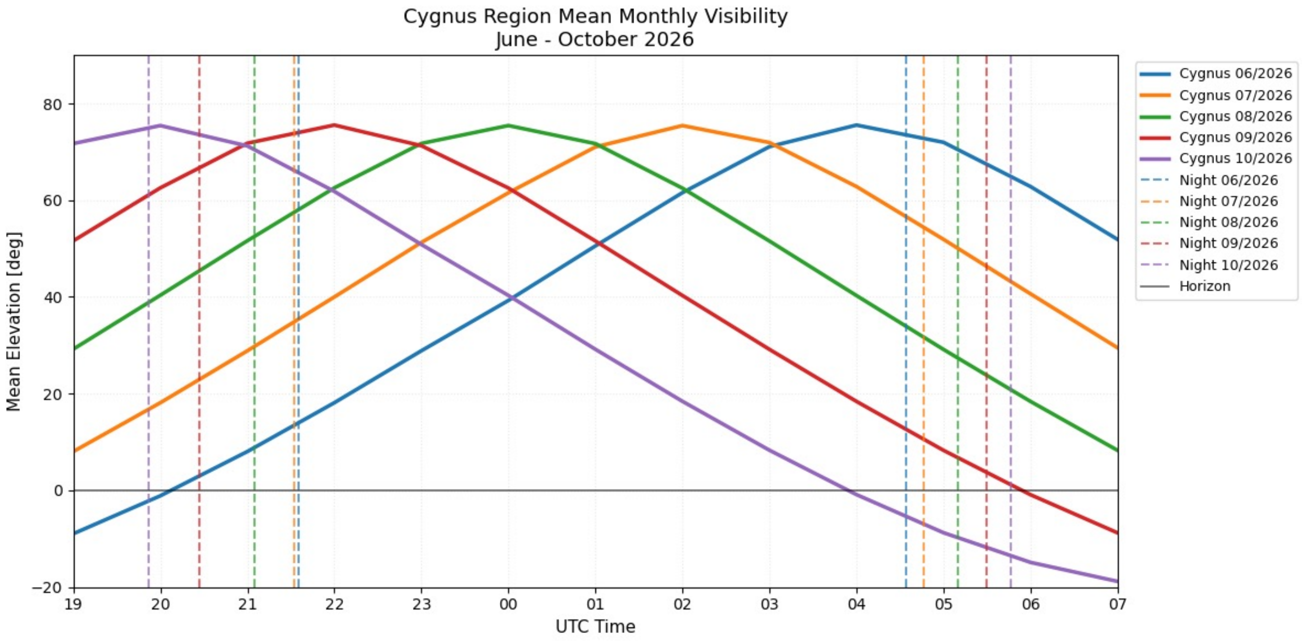
This summer we will focus on the observation of Cygnus core and Gamma Cygni region

- Cygnus OB2 : Massive young OB association
- Cygnus X3: high mass X-ray binary
- Gamma–Cygni region: supernova remnant and a pulsar (PSR 2021+4026)



Cygnus Visibility

- Cygnus is perfectly visible from June to October 2026.
- A total of 400 hours are available
- Included periods with moderate Moon
- ZA < 40°



	Jun	Jul	Aug	Sept	Oct	TOT
Cygnus	66h	96h	99h	86h	54h	401h

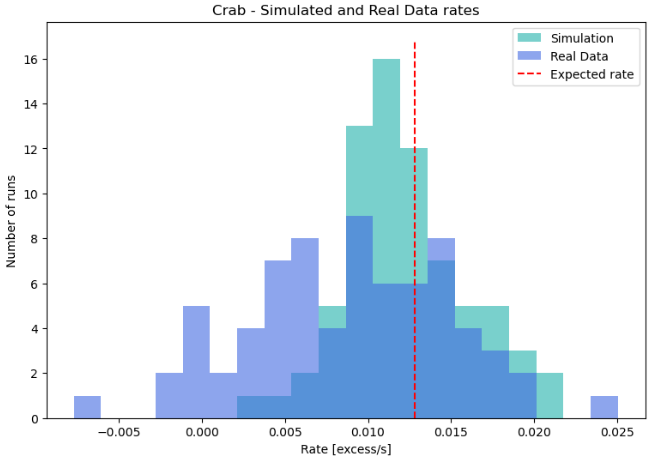
Objective

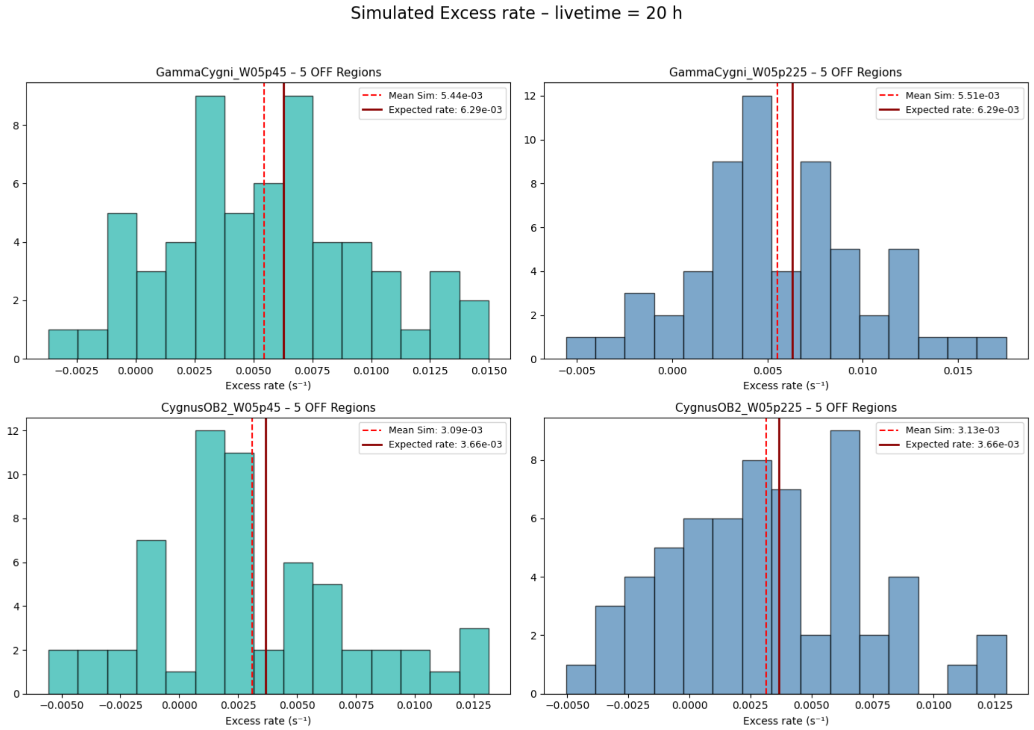
We wanted to be ready for the Cygnus observations

Realistic simulations of the Cygnus region are required:

- First observations in stereoscopic mode
- pointing strategy
- Analysis strategies for extended sources

Lesson learned from Crab data: general agreement but we saw a tail in the observed data respect to the simulations





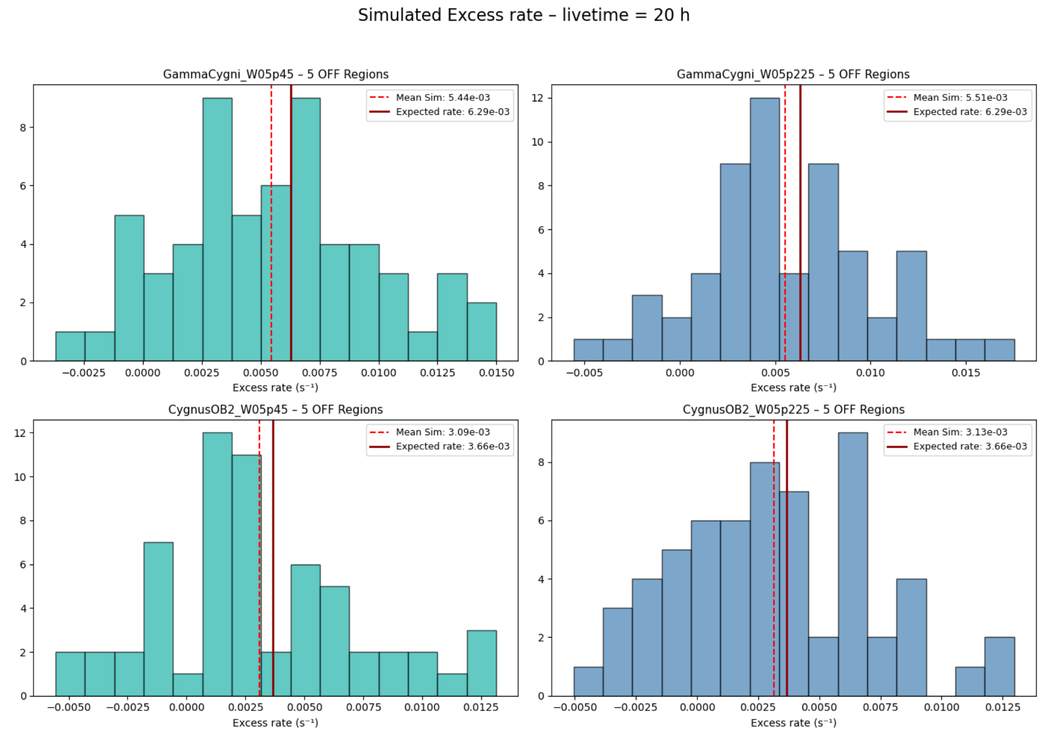
Simulated Cygnus excess rates based on the actual livetime of the Cygnus observations acquired in June–July

Objective

We wanted to be ready for the Cygnus observations

What do we need?

- Spectral and morphological models (1LHAASO & VERITAS catalogues)
- Background model



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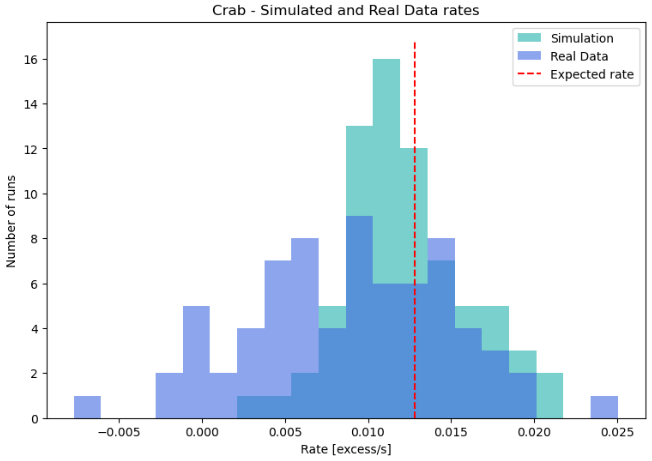
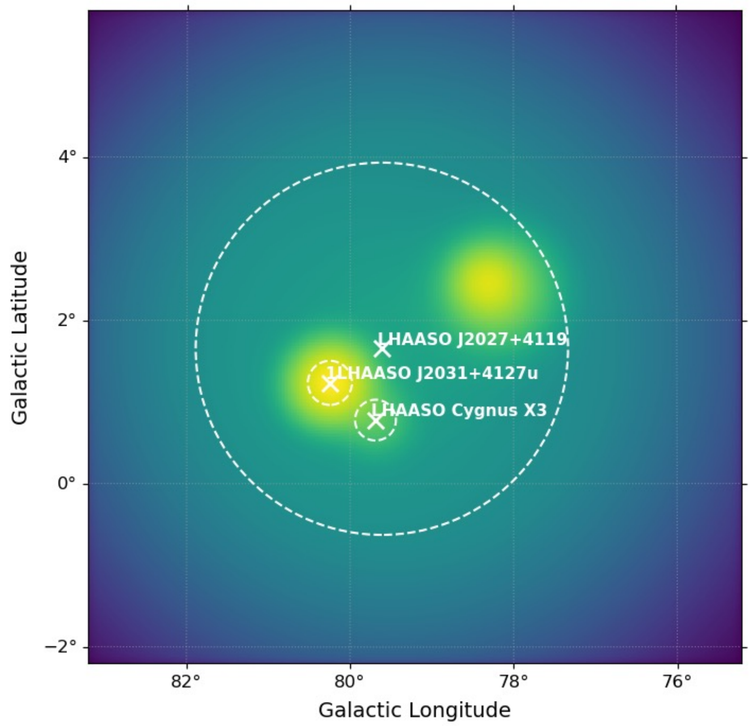
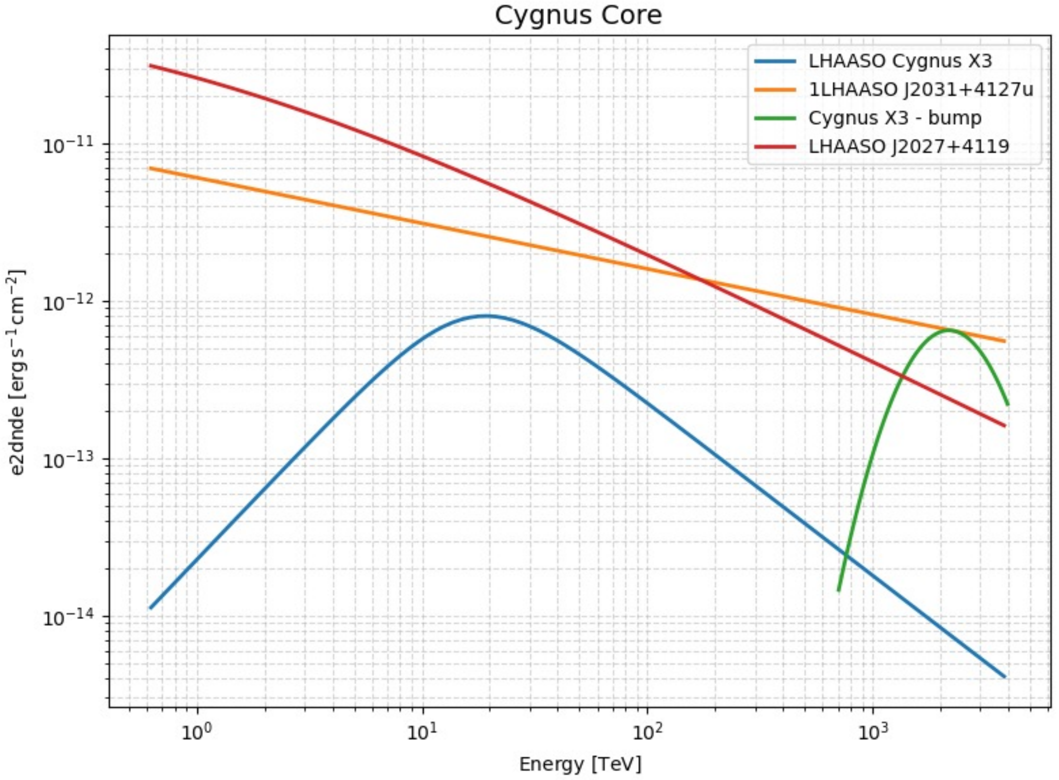


Simulated models – Cygnus core

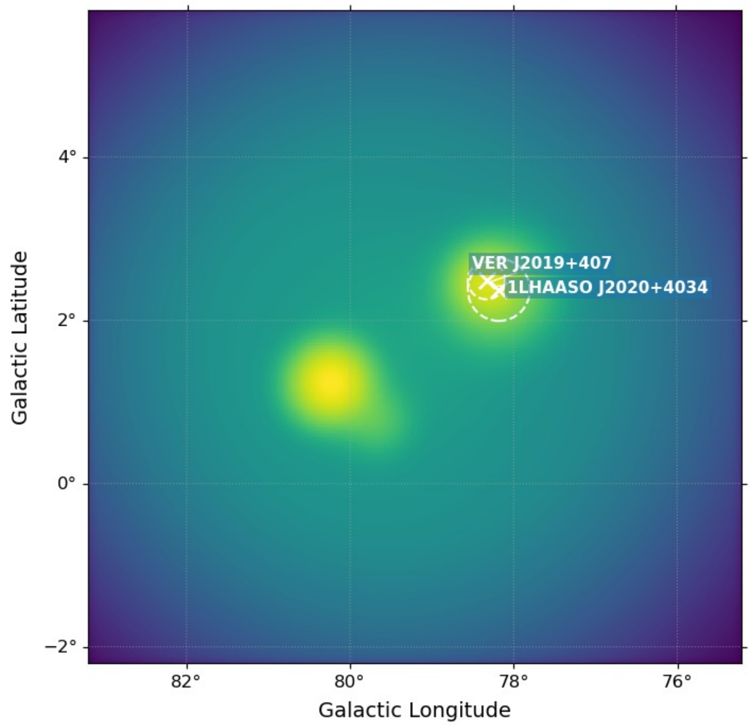
- Gaussian morphologies
- Spectral models: PowerLaw (1LHAASO J2031+4127u), SmoothBrokenPowerLaw (LHAASO Cygnus X3, LHAASO J2027+4119) and log-parabola (Cygnus X3-bump)

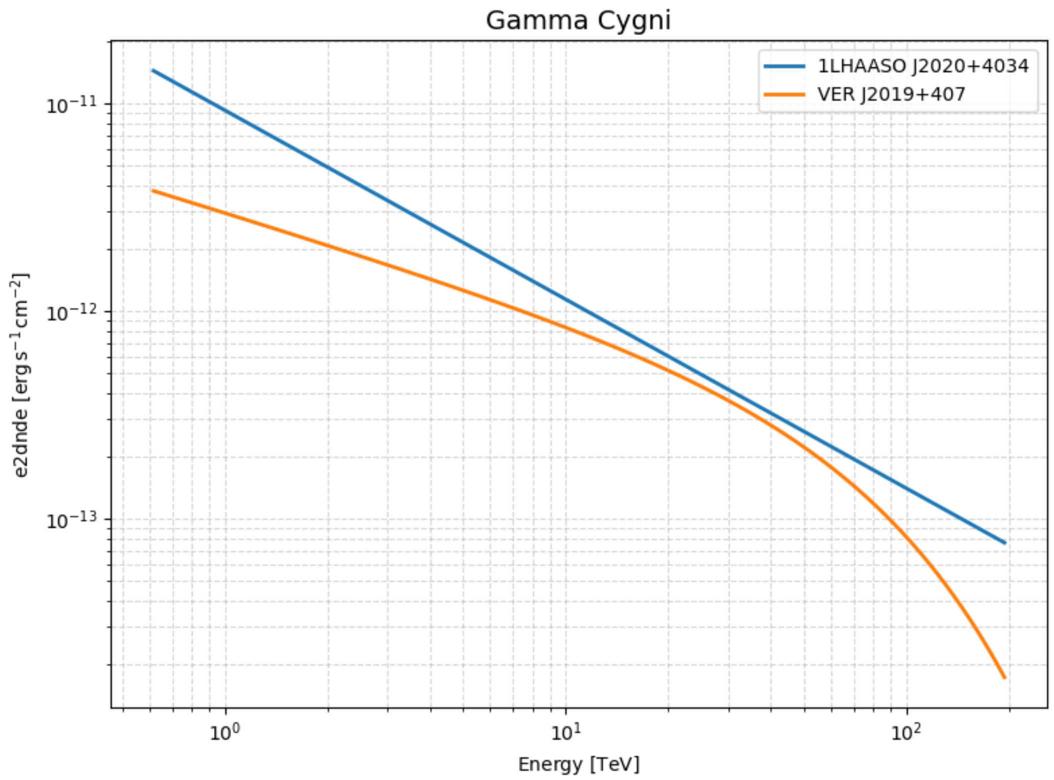




Simulated models – Gamma Cygni

- Gaussian morphologies
- Spectral models: PowerLaw (1LHAASO J2020+4034) and ExpCutoffPowerLaw (VER J2019+407)

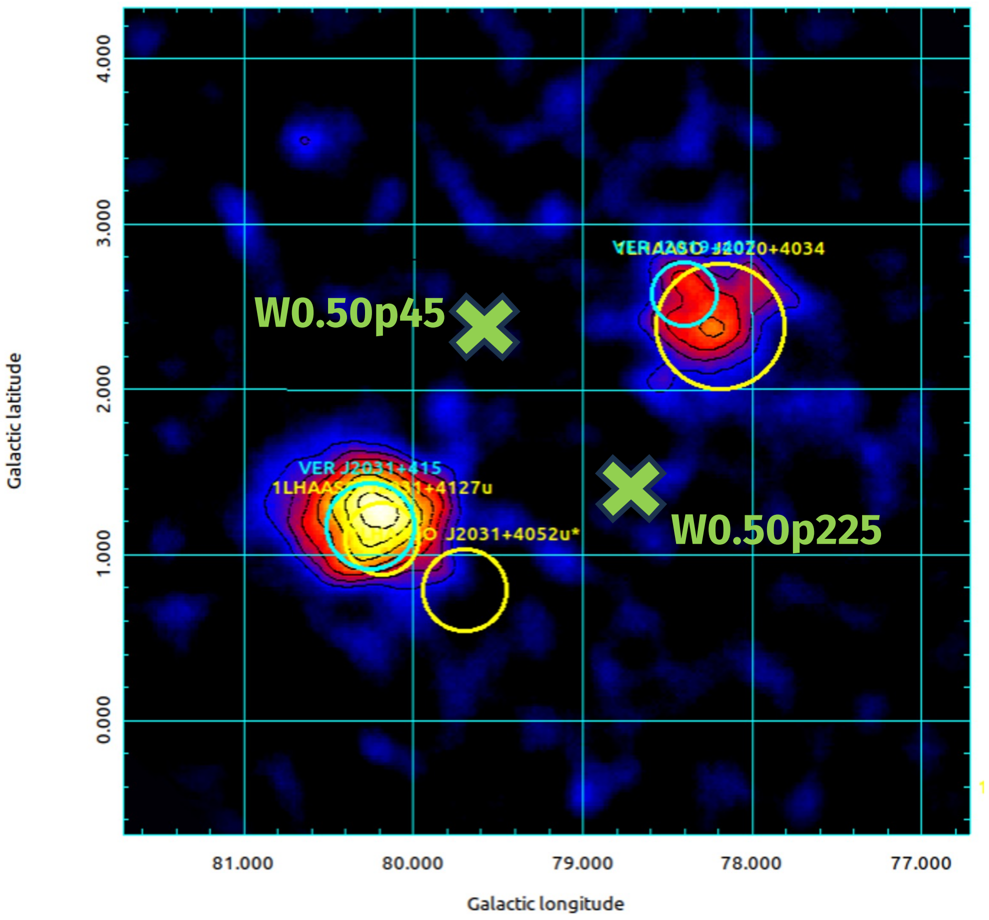




DATA CHALLENGE

First simulation (V0.1):

- Gammapy v2.0.1 (latest version)
- ASTRI IRF 3T (cc03->50h)
- 401 simulated runs
- Livetime = 1 h
- Wobble mode:
  - W0.50p45: (79.57°, 2.16°)
  - W0.50p225: (78.86°, 1.45°)
- BKG normalization: normal distribution between 1-2
- Energy range: (1, 250) TeV
- No diffuse component



Future simulations (V0.2):

- Introduce the diffuse component
- Background model extracted from real data
- IRF (cc11->90%)

DATA CHALLENGE

The idea is to implement a **blind** analysis approach:

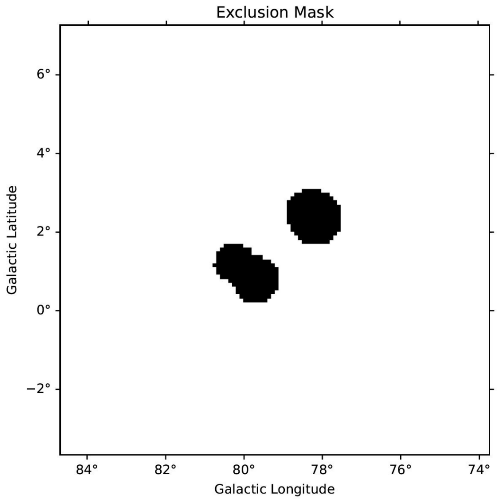
- Identify the **source models** and their associated **spectral properties**
- Reconstruct the **background model**

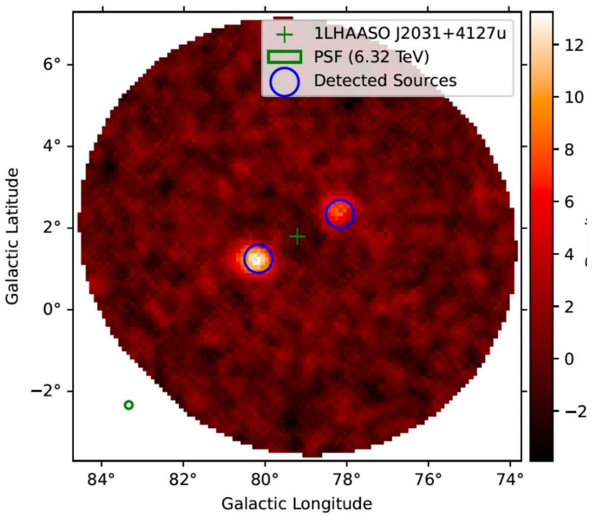
The data challenge has been shared on May 2026 with all the ASTRI team and is still open!

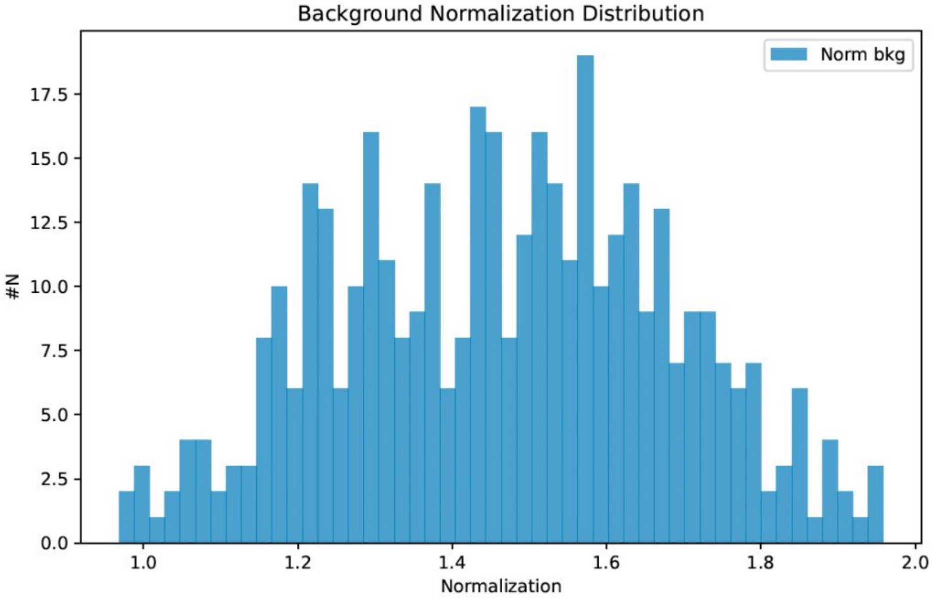
1° BLIND ANALYSIS (F. Pintore)

Steps of the analysis:

1. Source detection
   - applied an exclusion mask over central coordinates of known catalogue sources
   - FoV Background model





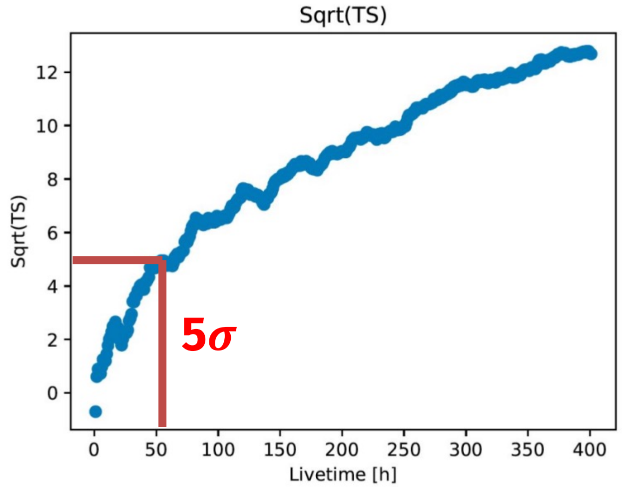


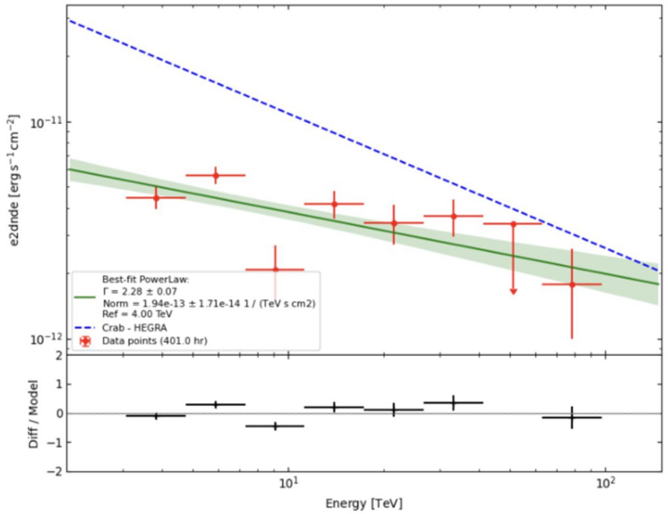
- Background found to be than 50% higher with respect to the IRF model. Perfectly match with the simulation!
- **Lesson learned: the energy range is crucial to estimate the background**. If the energy range is chosen to be outside a safe range, the background can be underestimated!

Source reconstruction - J2031

The spectral analysis was performed using two approches:

1. 1D analysis: perform an ON-OFF photometry
2. 3D analysis (best-performing): simultaneus fit of the morphology and the spectral shape of the sources

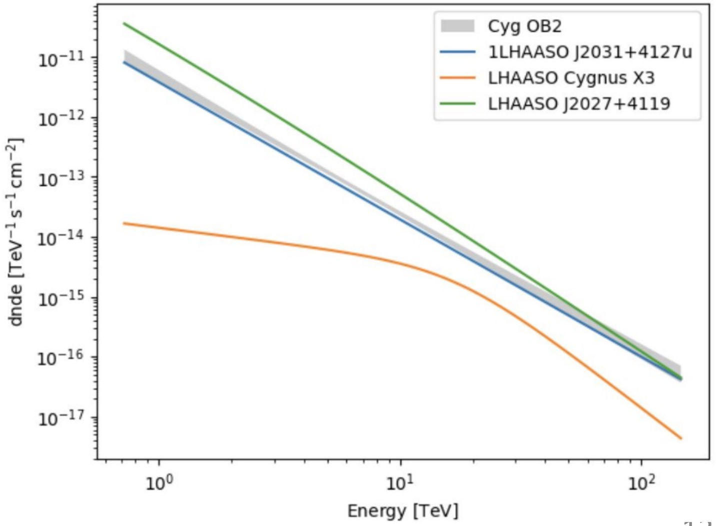




3D FIT:

- Energy range: 2-100 TeV
- Power Law model
- Gaussian morphology
- Estimated sigma: 0.30 ± 0.02

3D Analysis: Better agreement with the simulations



Source reconstruction – GAMMA CYGNI

The spectral analysis was performed using two approches:

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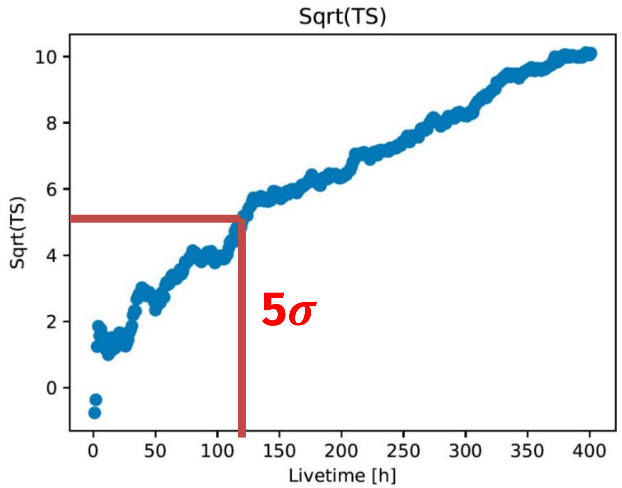
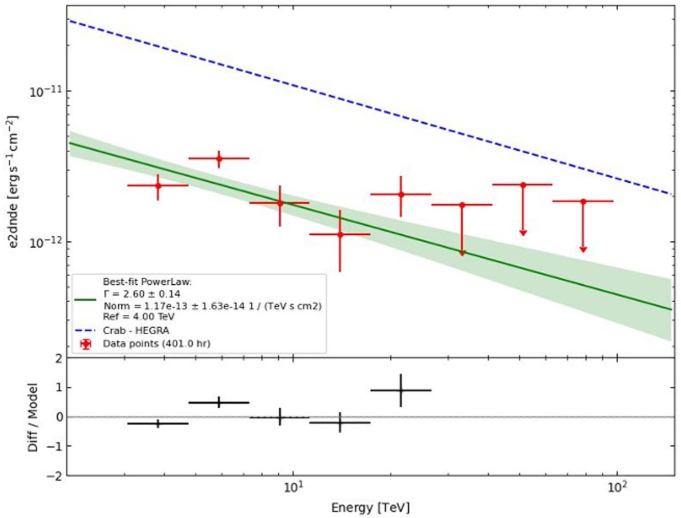
2. 3D analysis (best-performing): simultaneus fit of the morphology and the spectral shape of the sources

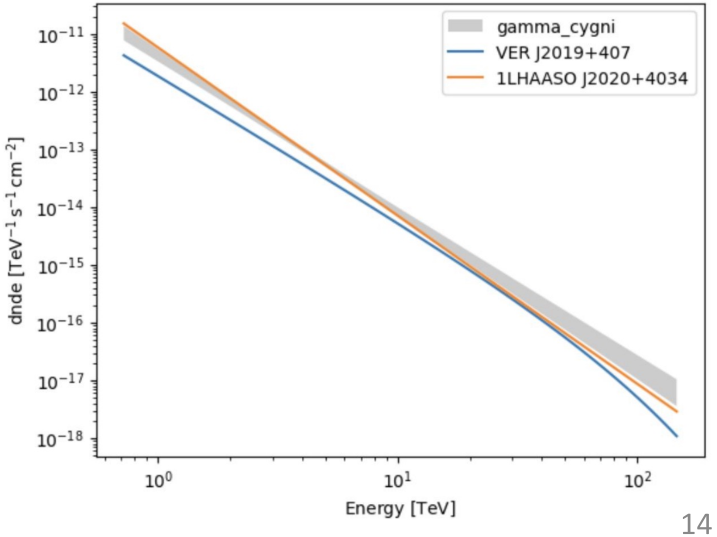




3D FIT:

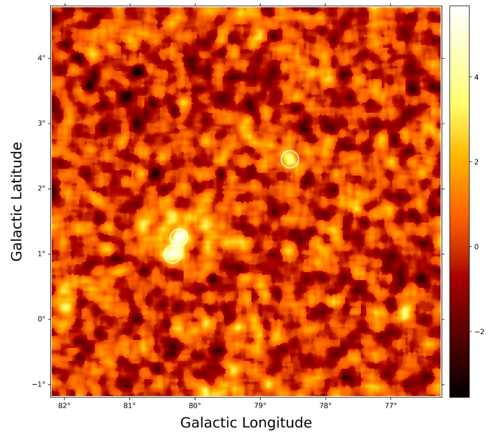
- Energy range: 2-100 TeV
- Power Law model
- Gaussian morphology
- Estimated sigma: 0.27 ± 0.03

3D Analysis: Better agreement with the simulations

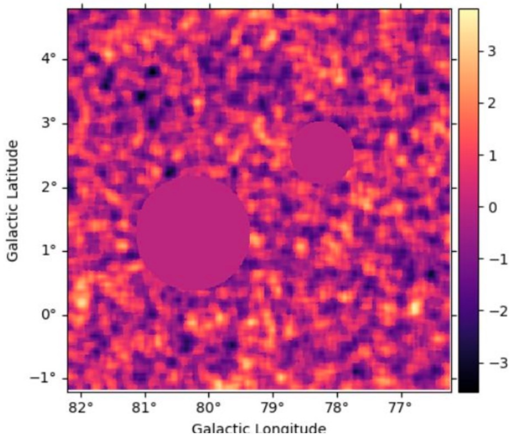


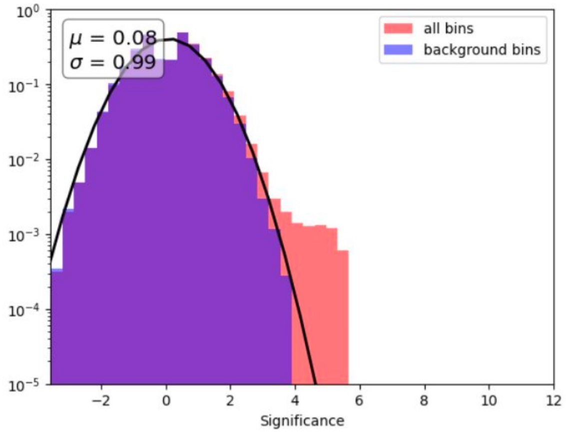
2° BLIND ANALYSIS (L. Jimenez)

3D Spectral Analysis (3–60 TeV) using the **BaccMod** tool to estimate the background model:

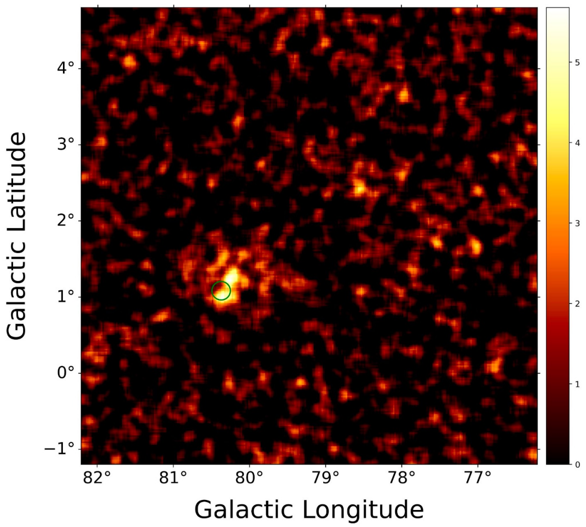


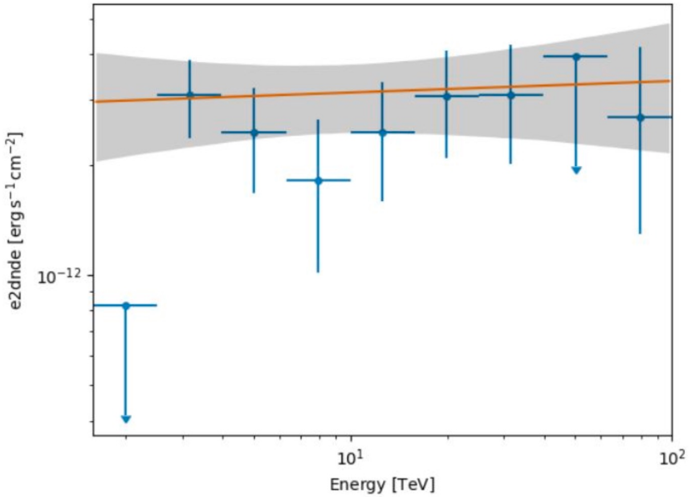
value	x	y	ra	dec
			deg	deg
float64	int64	int64	float64	float64
5.6724	93	109	308.18642	41.53461
5.6368	98	122	307.82729	41.60817
4.0222	183	182	305.21647	40.91626





- Diffuse component
- Fermi Coocon model





CONCLUSIONS

- A dedicated Cygnus Data Challenge was implemented to:
  - evaluate telescope performance,
  - optimize observational strategies,
  - identify the most effective analysis approach.
- Two indipendent 3D blind analysis with different approach have been performed
- On June 2026 started the shift with the observations of the Cygnus region and are still ongoing, and the first stereoscopic results are expected within the next few months.