Investigating the origin of galactic cosmic rays with CTA and CTA+

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VHEgam Meeting – 15/01/2024, Bologna

Brief introduction

- **03/2023 – now:**
  RTDa (CTA+) at the University of Siena

- **11/2018 – 11/2022:**
  Ph.D. at the **Aix-Marseille Université/CPPM**
  on the search for **galactic PeVatrons** with the **CTA**

Scientific interests and research activity

- Thesis (Sup. F. Cassol, Co. Sup. H. Costantini):

  “Study of the PeVatron candidate SNR G106.3+2.7 and optimization of the CTA-North sensitivity at high energies”

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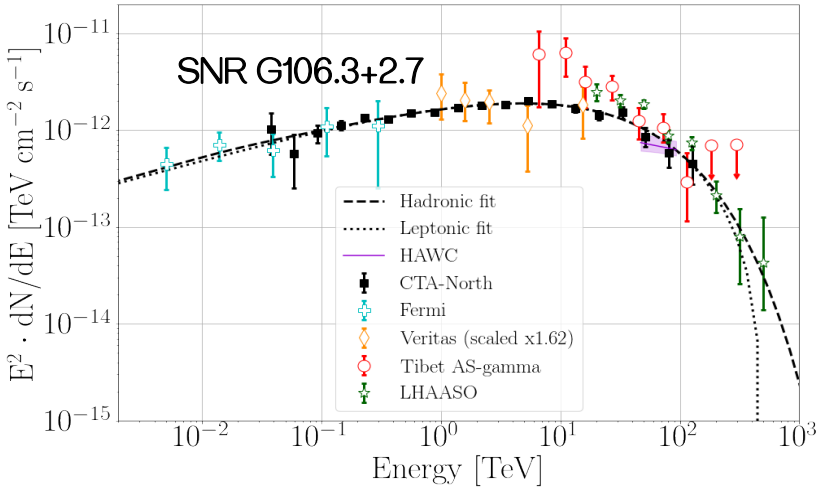

Verna et al. for the CTA Consortium, PoS, ICRC 2021

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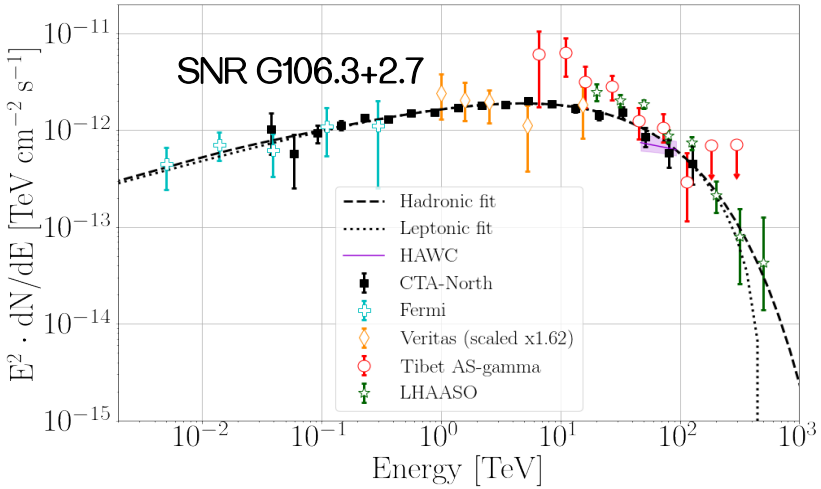

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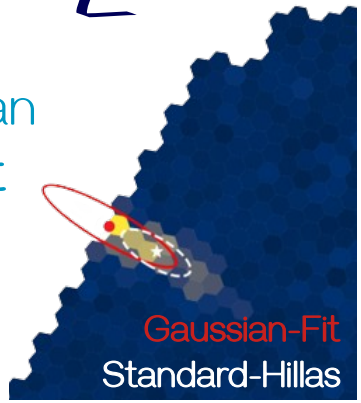
...by reconstructing **truncated images** with an alternative **Gaussian fit**



Verna et al. for the CTA Consortium, Il Nuovo Cimento, vol. 44 C (2021) n.104

Scientific interests and research activity

Beyond the SNR paradigm for the origin of galactic CRs:

➜ **Young Massive Stellar Clusters** (YMSCs) **and Star Forming Regions** (SFRs) as galactic CRs factories:

- **stellar winds** can supply the required energy for galactic CRs and provide a suitable environment for particle acceleration [1]
- a dozen YMSCs have been **associated to gamma-ray sources** such as Cygnus OB2 [2], Westerlund 1 and 2, 30 Doradus

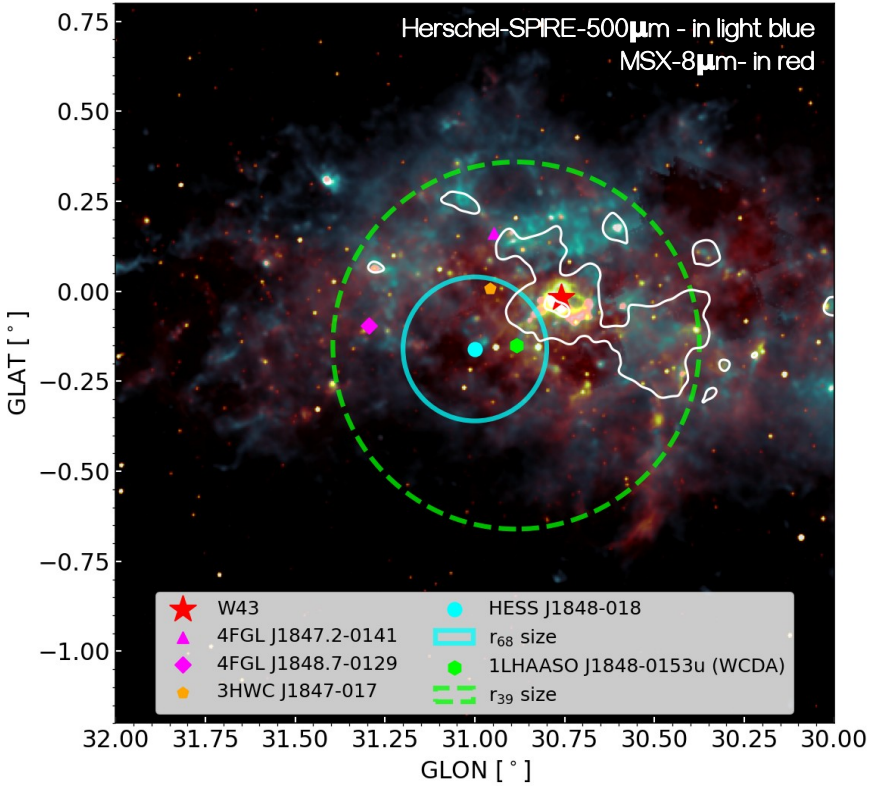
[1] Seo, J.. et al J. Korean Astron. Soc. 51, 37 48 (2018)
[2] LHAASO Collaboration 2023, arXiv:2310.10100

HESS J1848-018 observed by MAGIC (and LST-1)

- **Unidentified source of the H.E.S.S. GPS** possibly associated to the stellar cluster **W43** [5]
- **Recently detected by LHAASO** ($\sigma(E>100\,TeV)\sim 6$) [2]

- **MAGIC data** (from Cycle 15 - 2020) (8 hours)
- **MAGIC Proposal Cycle 19**

  (PI Sofia V.): 30h with possible **joint LST-1 observations**



[3] Abdalla H., et al., 2018, Astronomy Astrophysics, 612, A1
[4] Cao Z., et al., 2023 arXiv:2305.17030

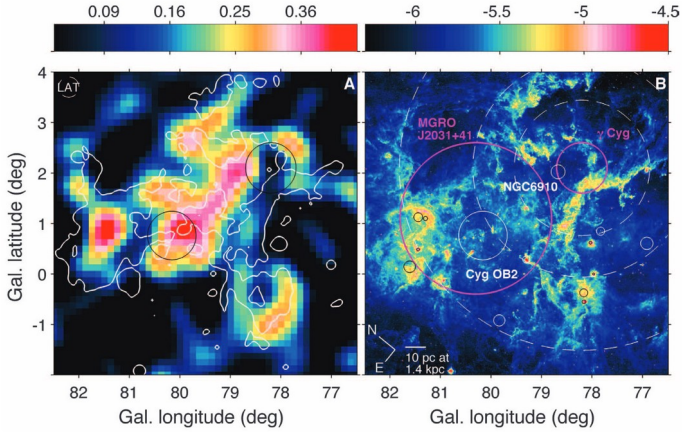
For LST-1 – Cycle 2

- **We do not plan to submit a proposal on HESS J1848-018** for LST-1 mono
- We plan to select **one (or more) interestig target for the next cycle**

- From the last LST Galactic WG call on Cycle 2 proposal [5]

  "LST view on the Cygnus-X region"

  (I. Vovk and M. Strzys)



Ackermann et al. Science 334, 1103 (2011)

[5] https://indico.cta-observatory.org/event/5293/

Conclusion and prospects

- **Scientific interests**: galactic CRs, PeVatrons with current focus on **YMSCs and SFRs**

- **MAGIC proposal on HESS J1848-018 (Cycle 19)** but **no LST-1 alone proposal for the current Cycle**
- **Interesting proposal on Cygnus-X for LST-1**: possibility to join the analysis group

- **Future proposal on stellar clusters for LST-1** (Cycle 3)
- **Simulation based studies for CTAO South and CTA+.** Possible targets: Arches and Quintuplet clusters near the Galactic Center, Vela molecular ridge [6]

[6] G. Peron et al., Nature Astronomy, 2024

Backup

Study of the PeVatron candidate SNR G106.3+2.7

SNR G106.3+2.7 + PSR J2229+6114

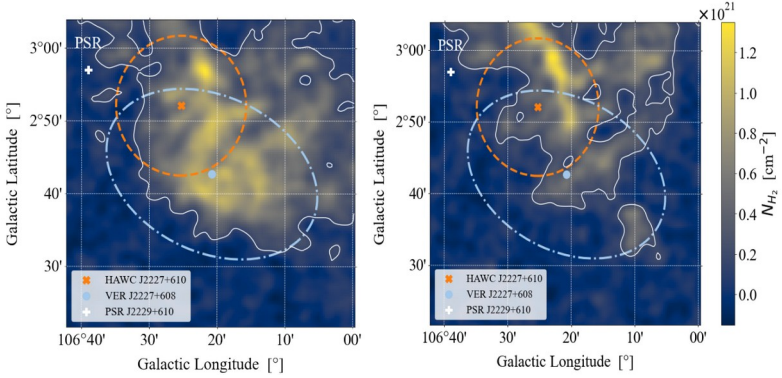
Gamma-ray source observed by:

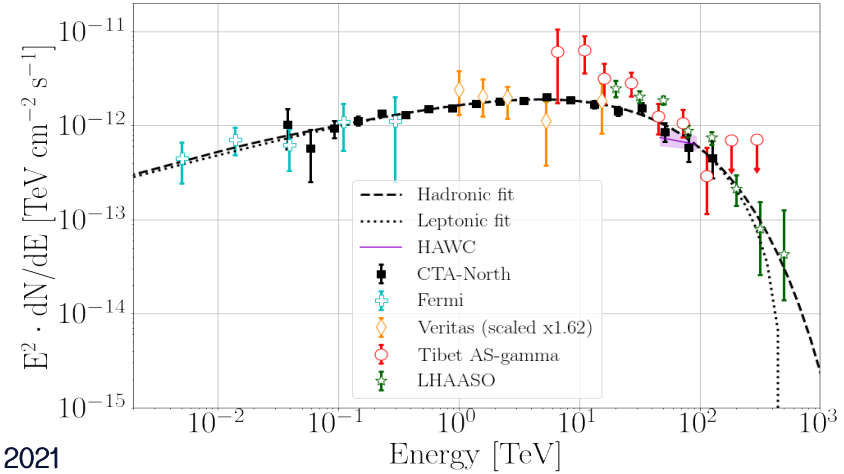
- Fermi-LAT
- VERITAS, MAGIC
- HAWC, Tibet AS-gamma, LHAASO

- **Simulated observation from CTA-North:**

  - **Morphology**: radio templates tracing molecular clouds (FCRAO survey)
  - **Spectrum**: Hadronic emission (Tibet AS-gamma model)

- 3D spectral and morphological **analysis** with **`gammapy`**





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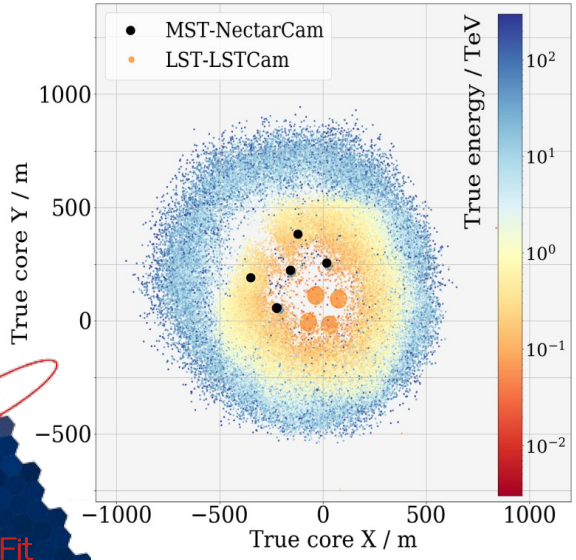
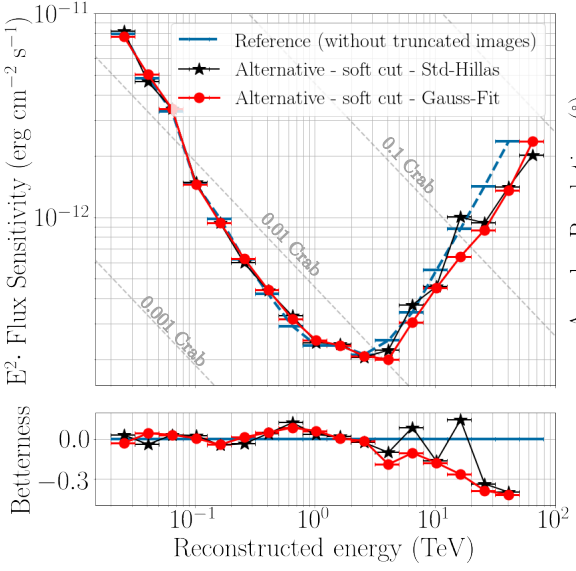
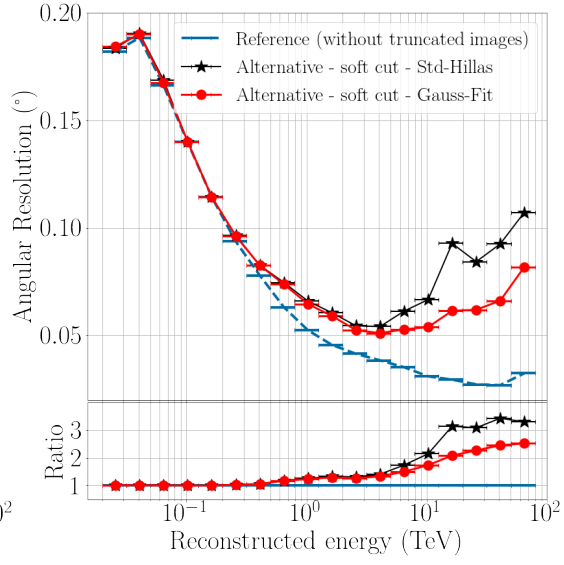
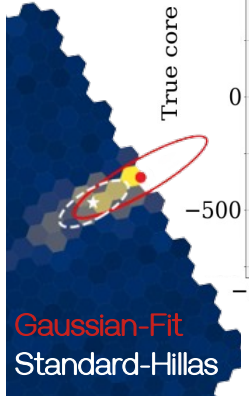
Optimization of the CTA-North sensitivity (E > 10 TeV)

- **CTA-North** site: 9 telescopes (5 MSTs, 4 LSTs)
- **Goal**: recover the **distant** and **energetic showers** seen with a large number of **truncated images**
- **Strategy**: Inclusion of **truncated images** in **`protopipe`** + **additional Gaussian Fit**
- Comparison between **Standard Hillas** and **Gaussian Fit** parameterization of truncated images









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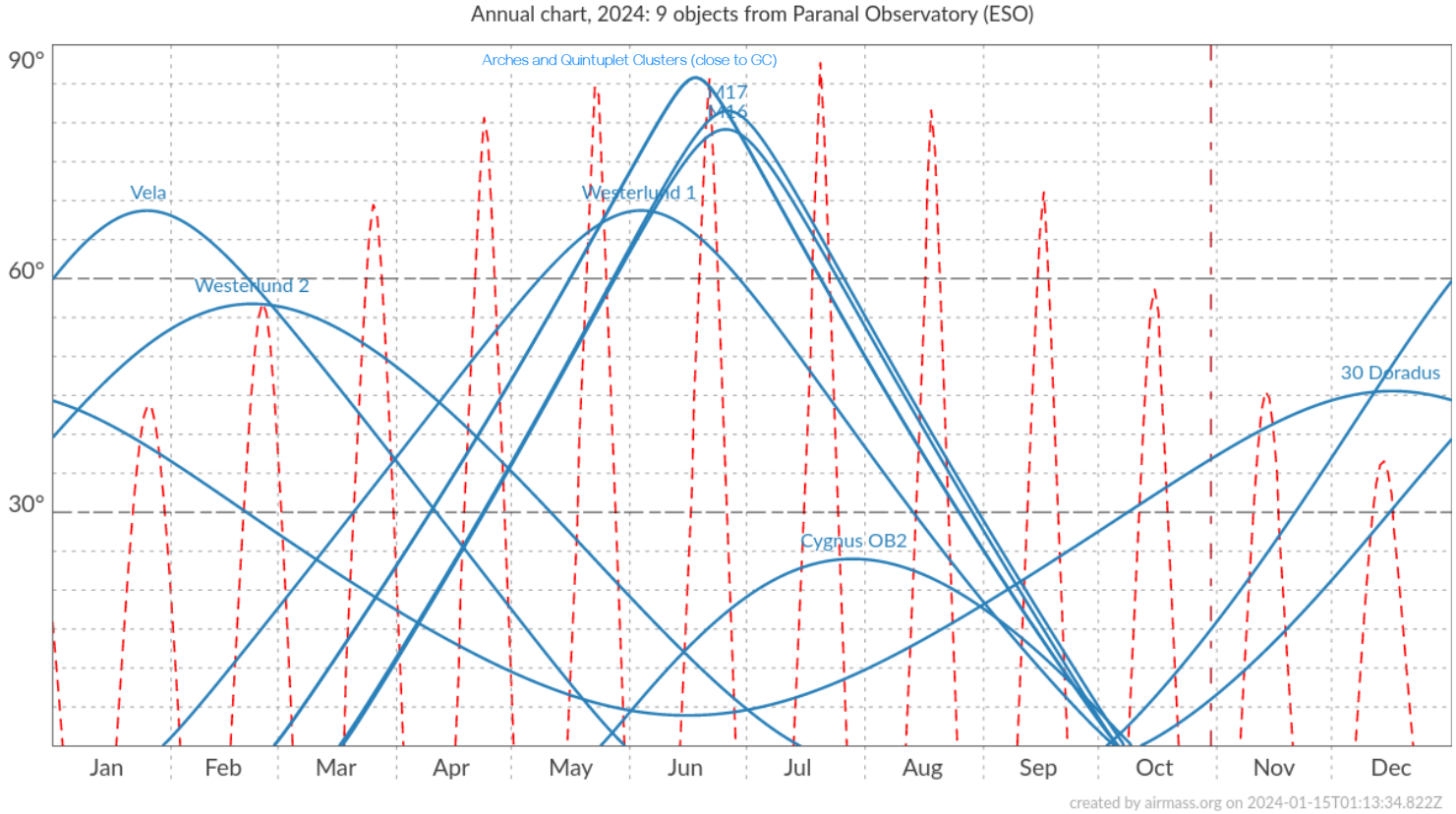
Visibility of some Stellar Clusters from CTAO South



Visibility of some Stellar Clusters from CTAO North