Detection prospects of extended sources with ASTRI, CTAO, and LHAASO

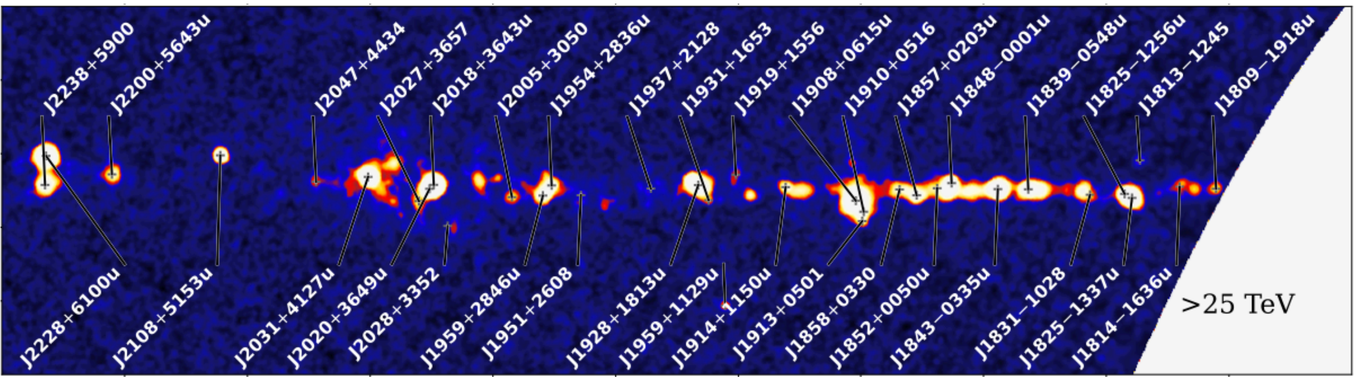
Silvia Celli & Giada Peron, (A&A, in press.) arXiv:2403.03731

8th Heidelberg International Symposium on High Energy Gamma Ray Astronomy - Milano 04.09.2024

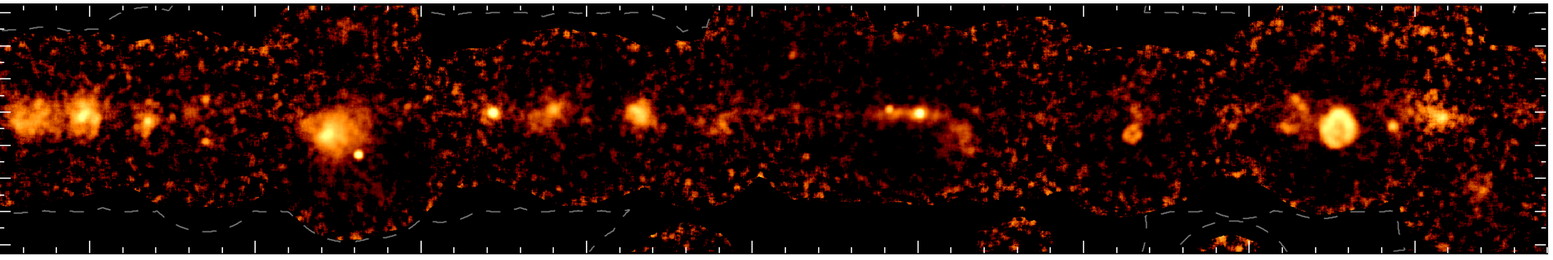
Motivations

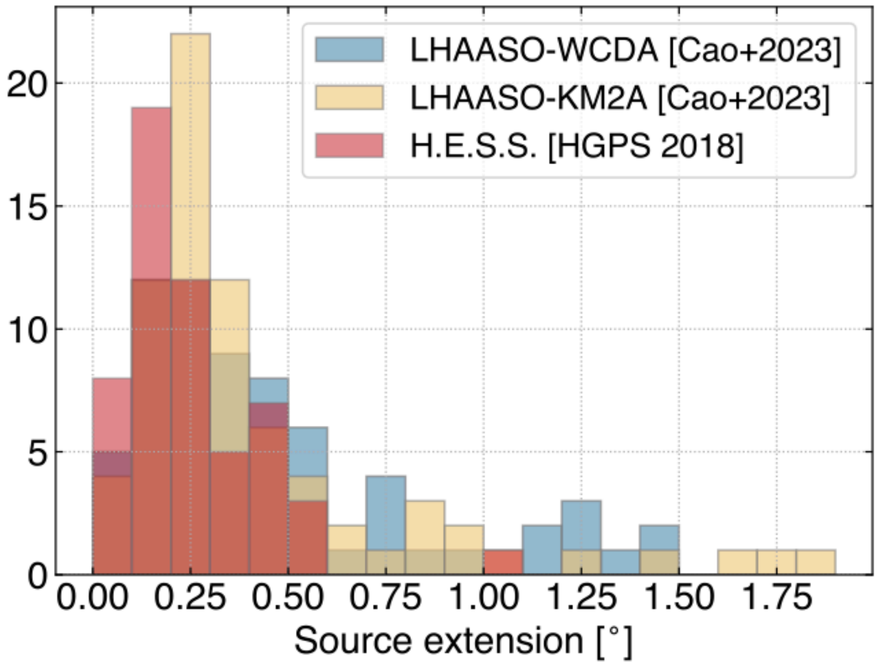
- Most of VHE sources are **extended** and/or **unidentified**

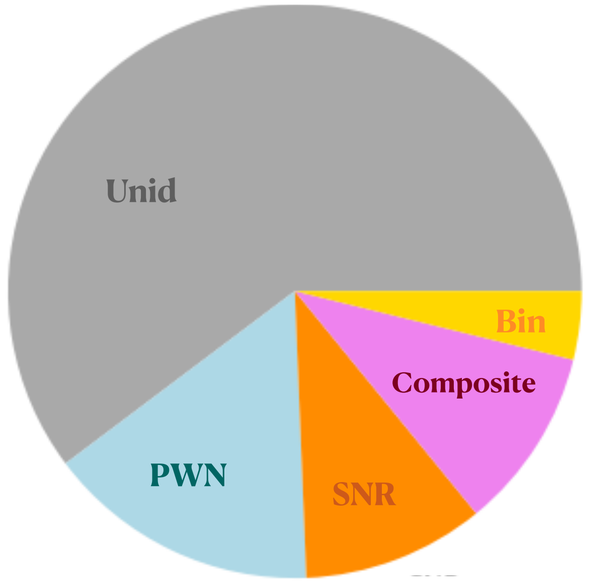
1LHAASO-KM2A



H.E.S.S. HGPS



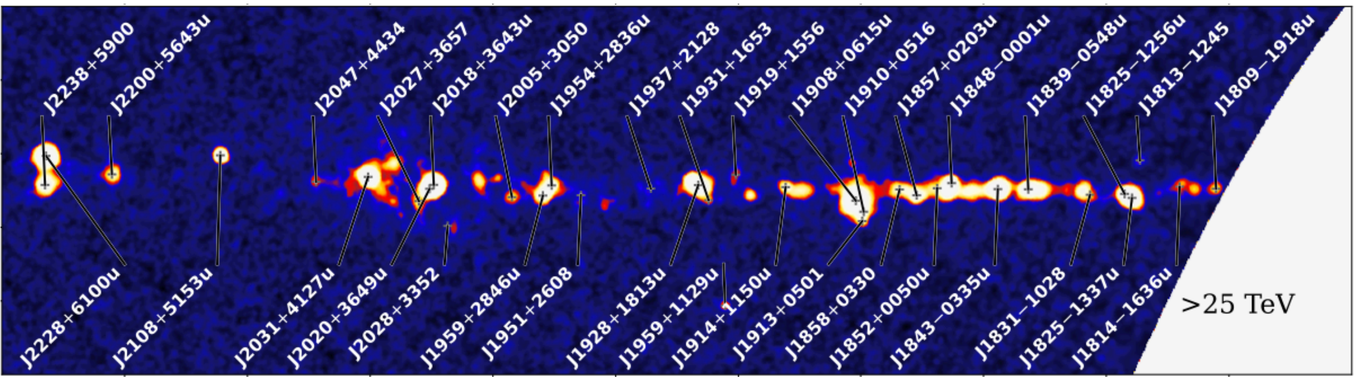




Motivations

- Most of VHE sources are **extended** and/or **unidentified**

1LHAASO-KM2A



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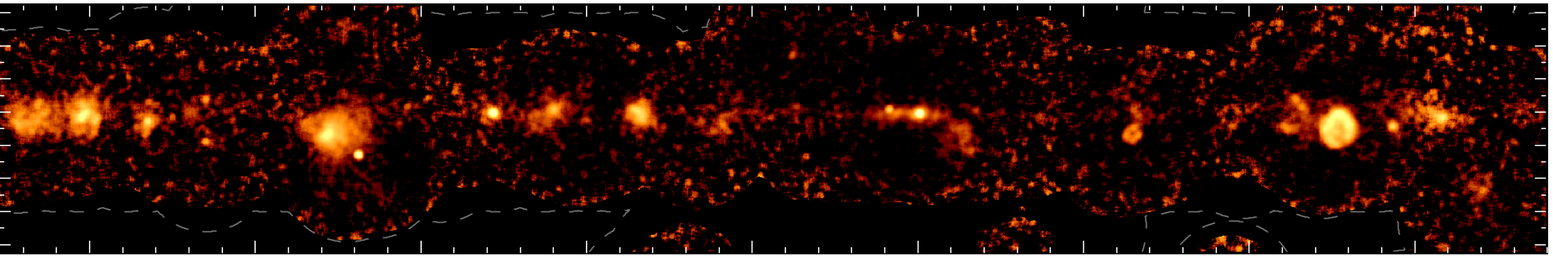
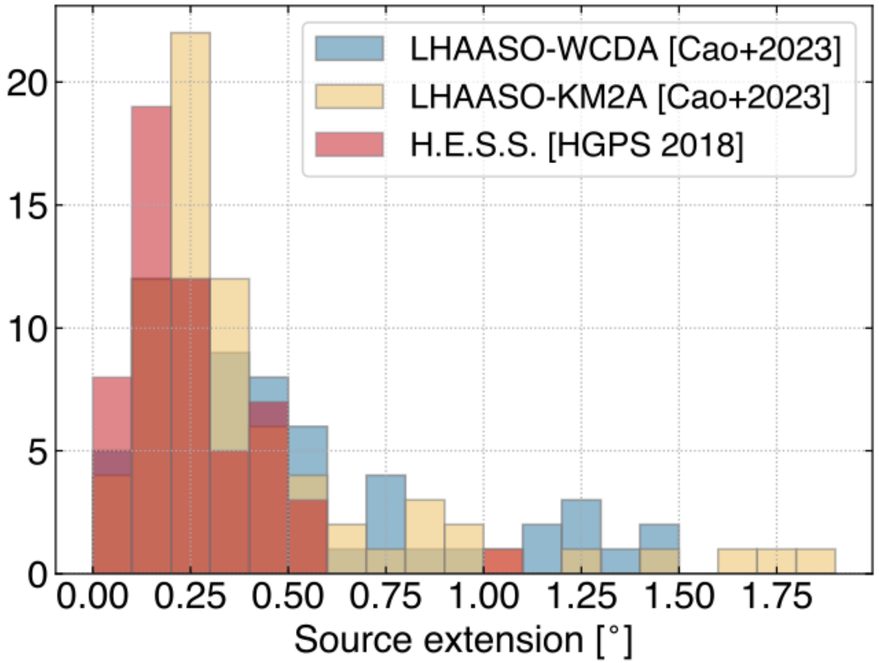
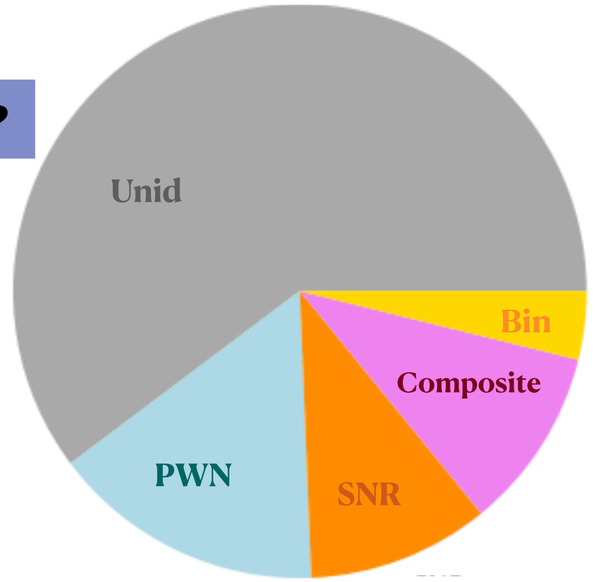




What can we do with next generation of IACTs?



Instruments capability (IRFs)

EAS detectors ⟵ **IACT arrays**

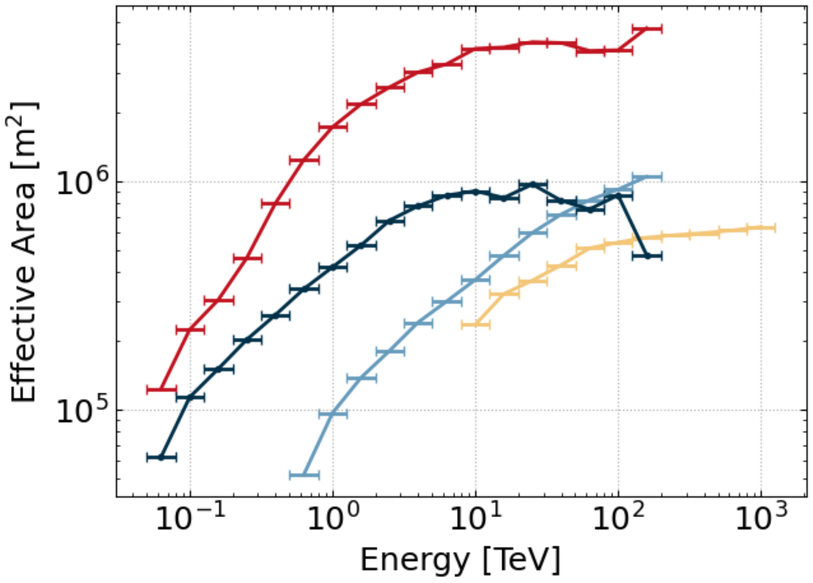
Field of view
Maximum energy
High duty cycle

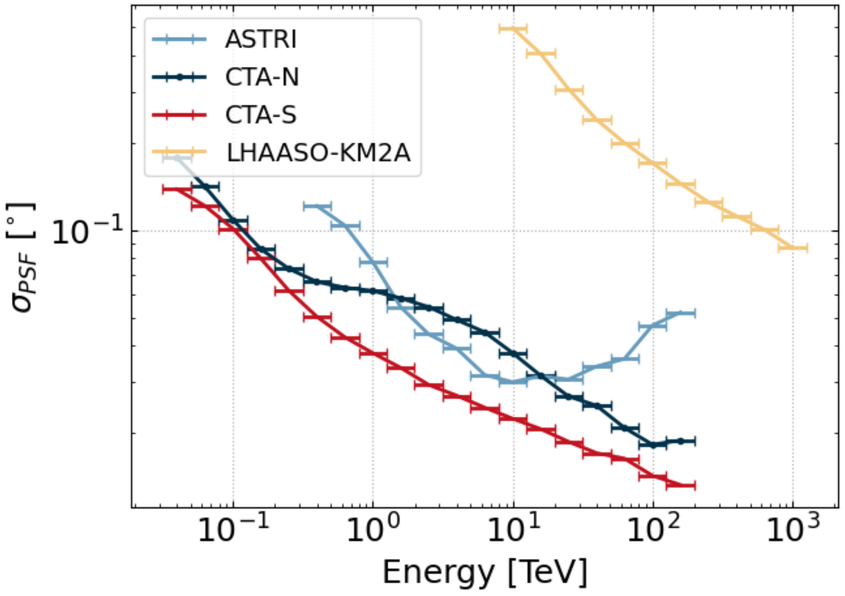
Surveyed the Sky at high energy detecting many PeVatron

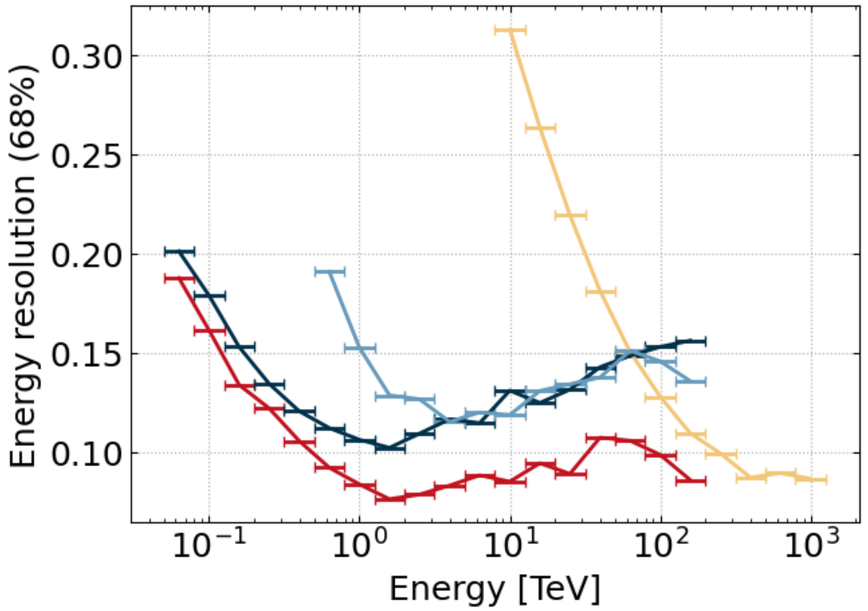
What can we do with next generation of IACTs?

Angular resolution
Energy resolution

Clarify emission mechanism, morphology, spectral feature, better **identification** and **characterization** of sources







Celli & Peron, A&A (in press.) 2024

Identifying the PeVatrons

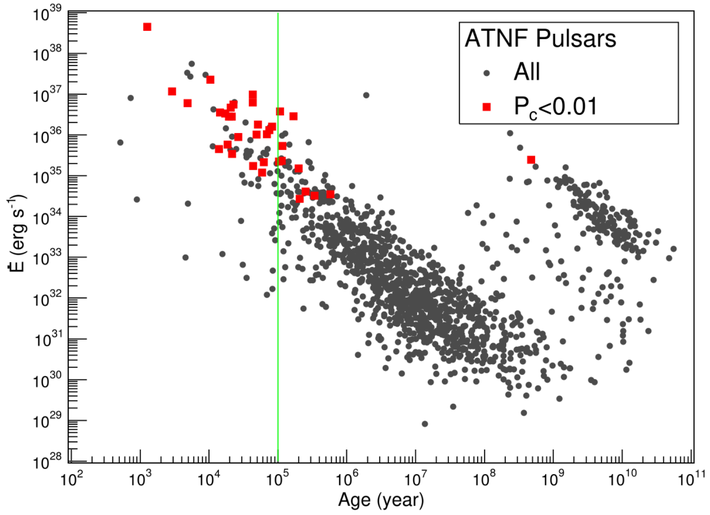
1st LHAASO source catalog Cao et al. 2024

44 Ultra high energy sources (>100 TeV)

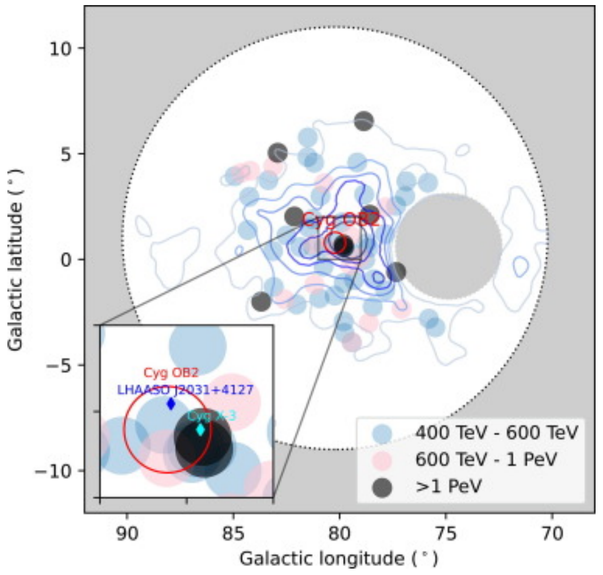
Confirmed PeVatron in the Galaxy, but..

- Soft spectrum (any break or cutoff?)
- No clear identification
- Not clear the emission mechanism: hadronic or leptonic

Unclear if they are enough to explain PeV CRs at Earth

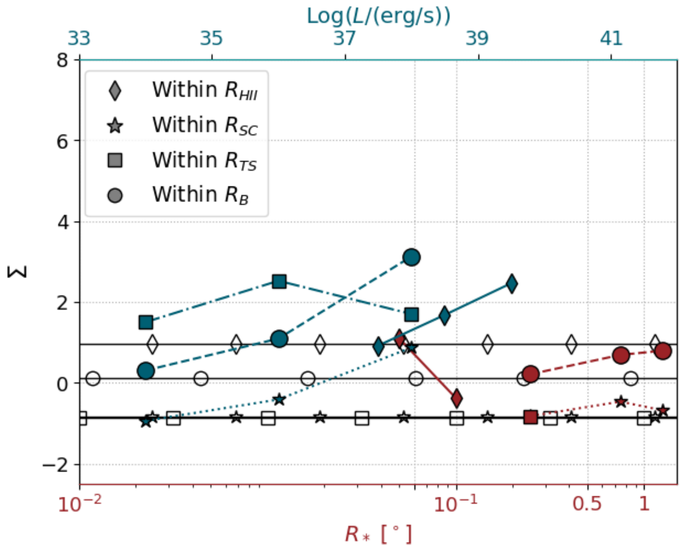


High degree of spatial coincidence with pulsars
Cao et al. 2024, (confirmed by Olmi et al. In prep.)



From **HAWC** and **LHAASO** : only clear hadronic PeVatron in the direction of **Cygnus OB2**

Low significance (Σ) of **association** with Gaia SCs and HII regions and very high energy sources
Peron et al. ApJL (in press.) 2024



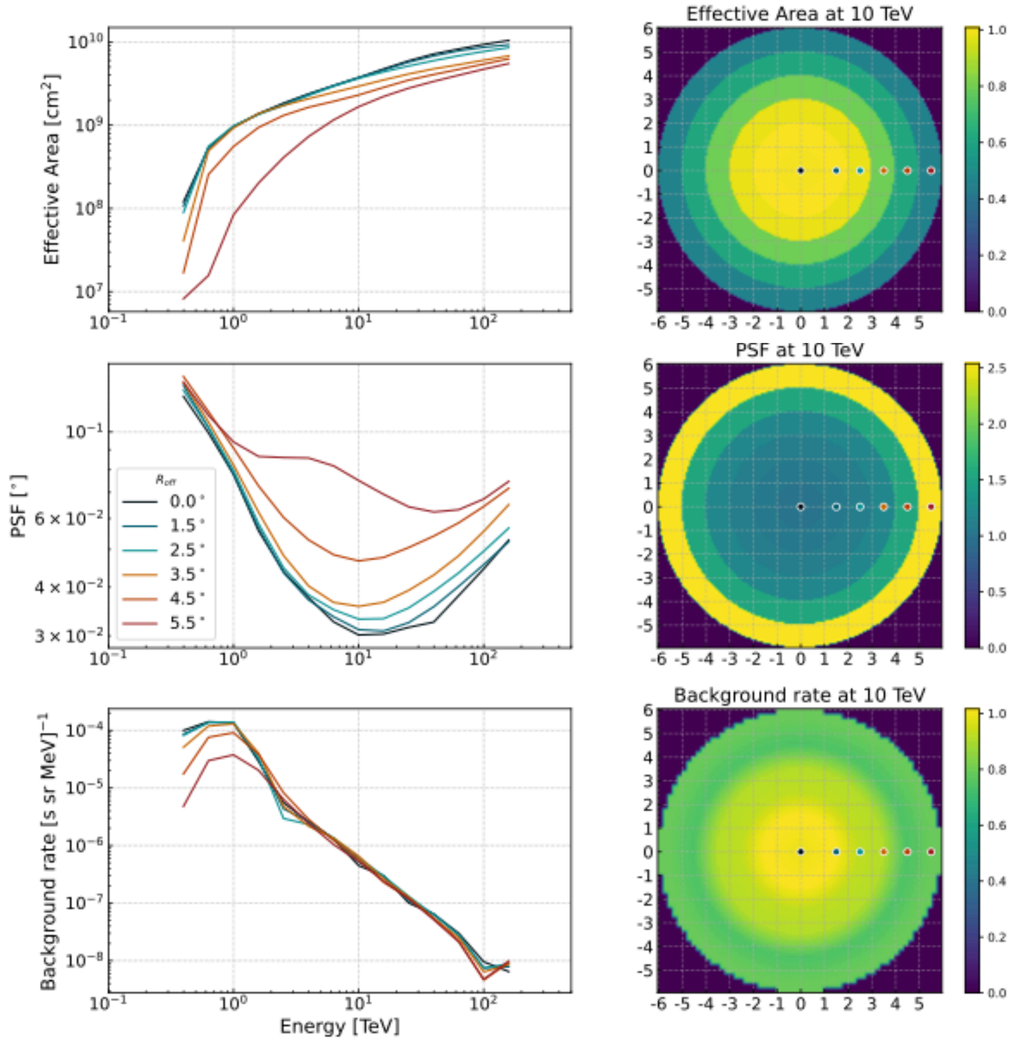
Instruments capability : Sensitivity

Need to account for extension

We considered the Crab spectrum and imposed the following condition on the number of **signal (S)** and **background (B)** events;

- $S > 10$
- $\frac{S}{\sqrt{B}} > 5$
- $S > 0.05B$

S and B are computed over the area of the source, considering that the IRFs varies with energy and along the FoV.



ASTRI

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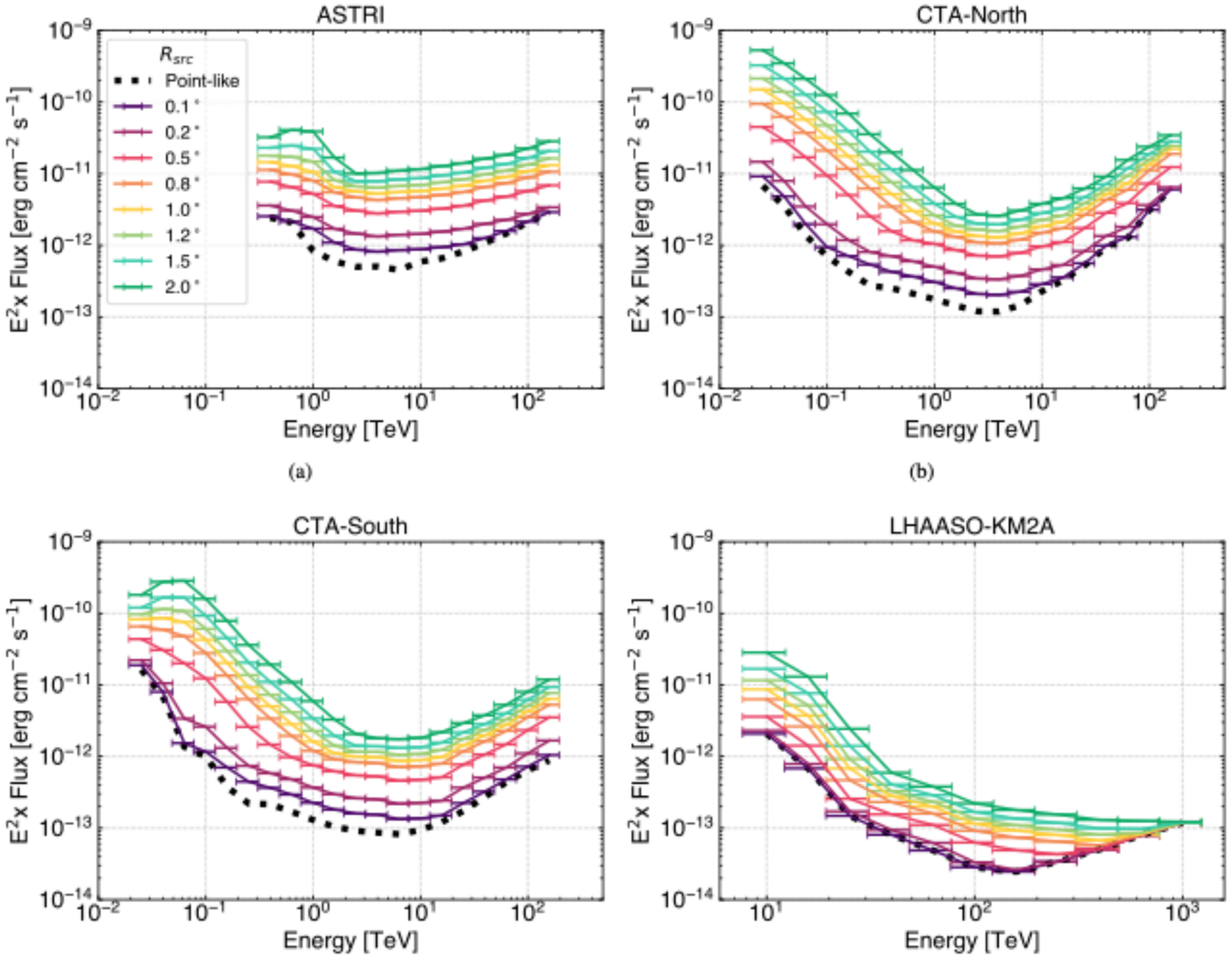
Instruments capability : Sensitivity



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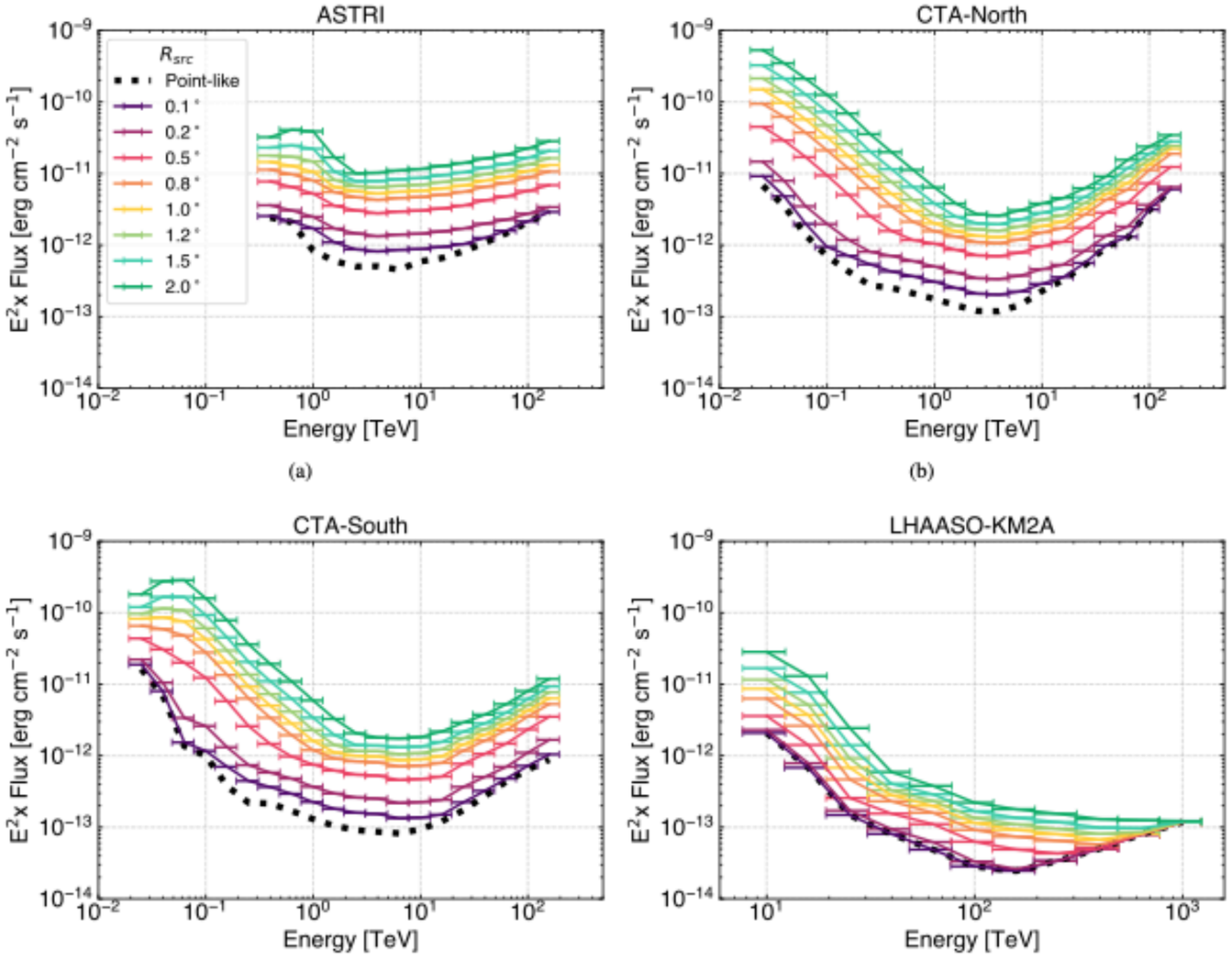
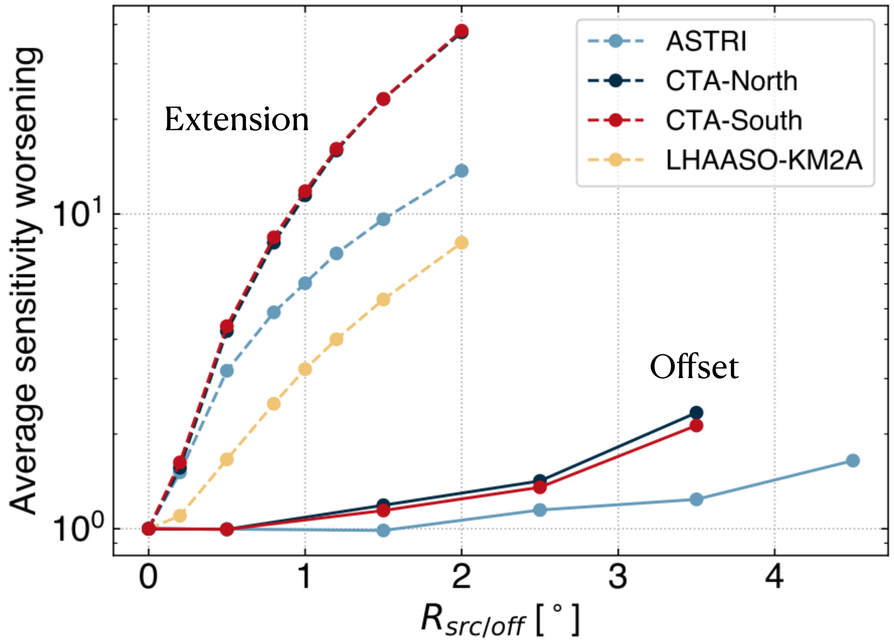
Instruments capability : Sensitivity





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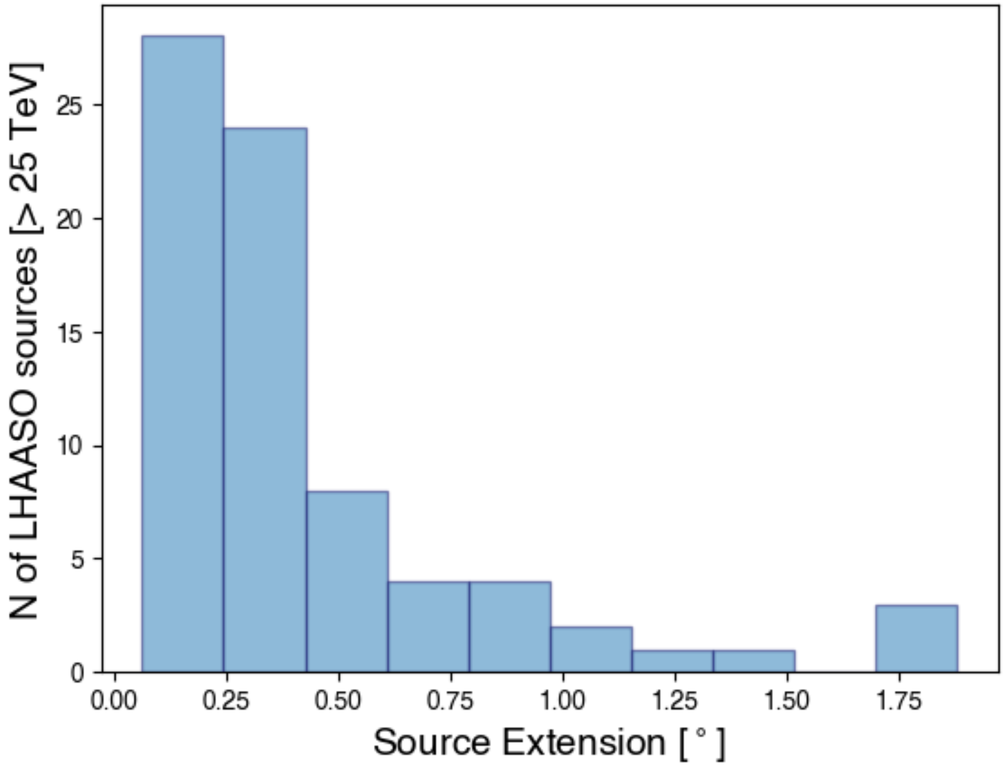
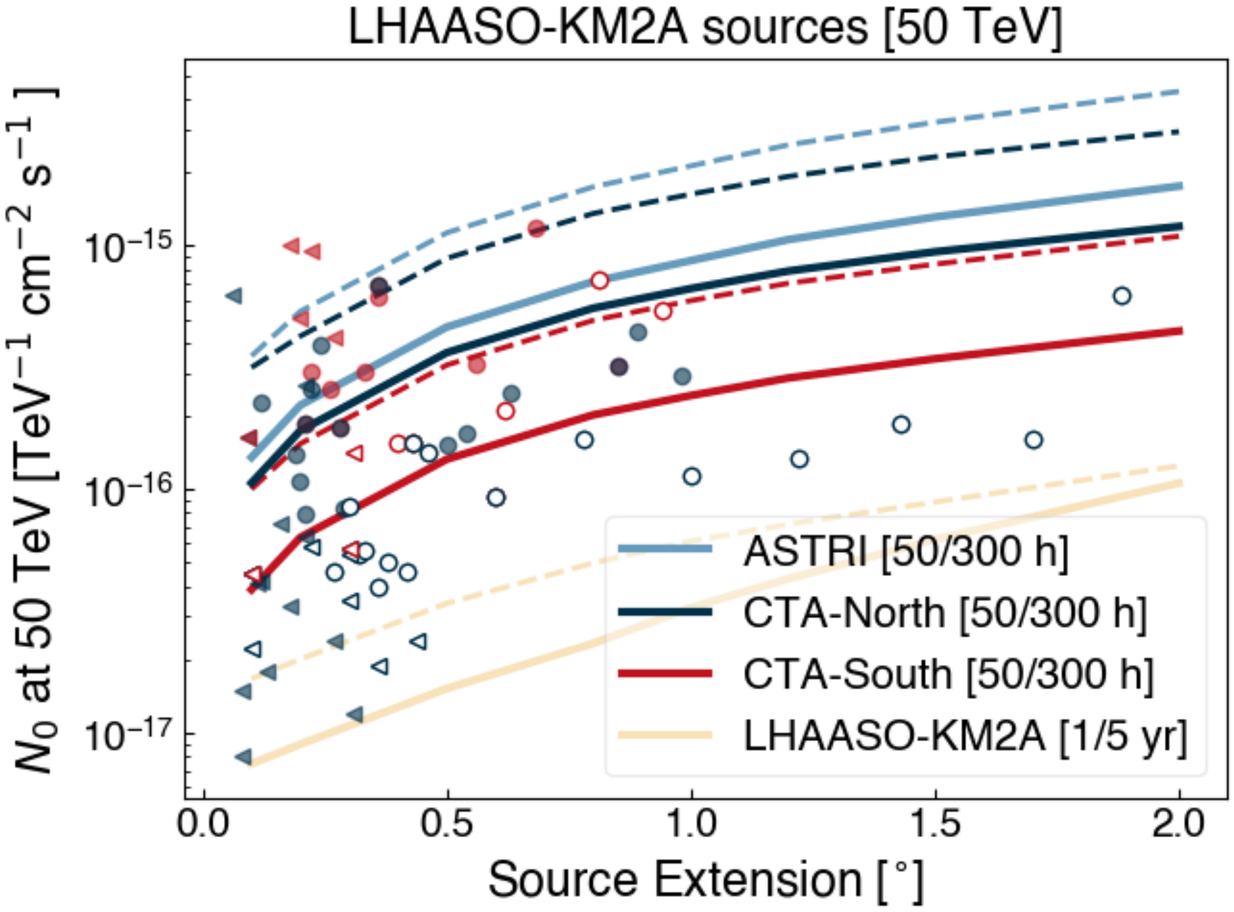
Instruments capability : for PeVatron investigation

@ 50 TeV





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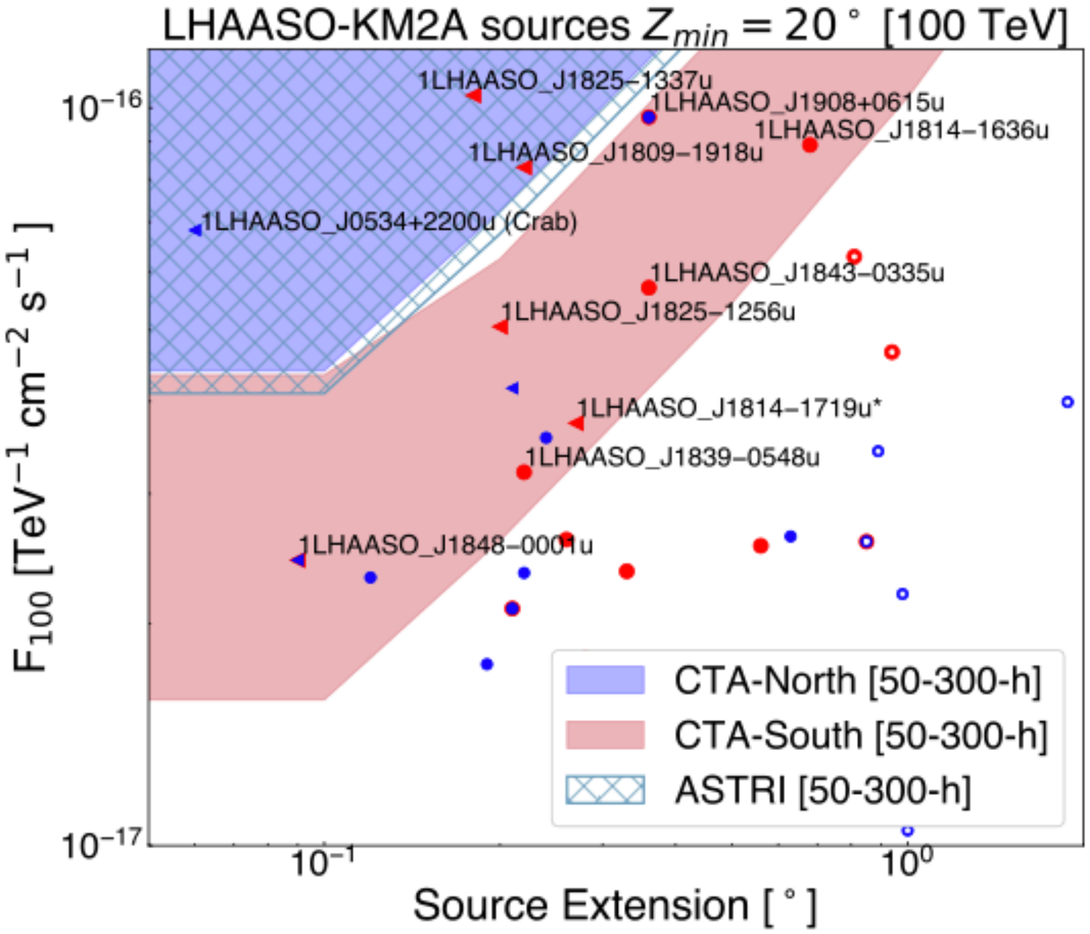
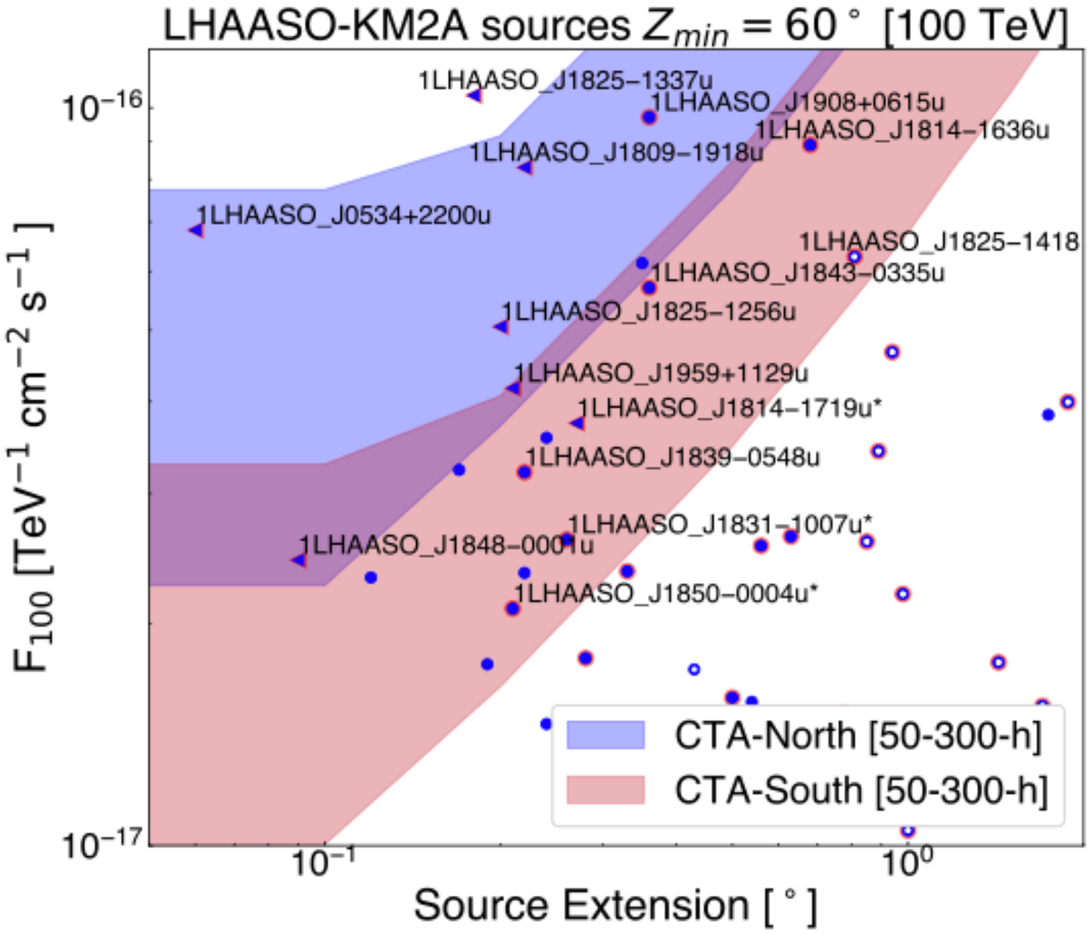
Instruments capability : for PeVatron investigation

@ 100 TeV





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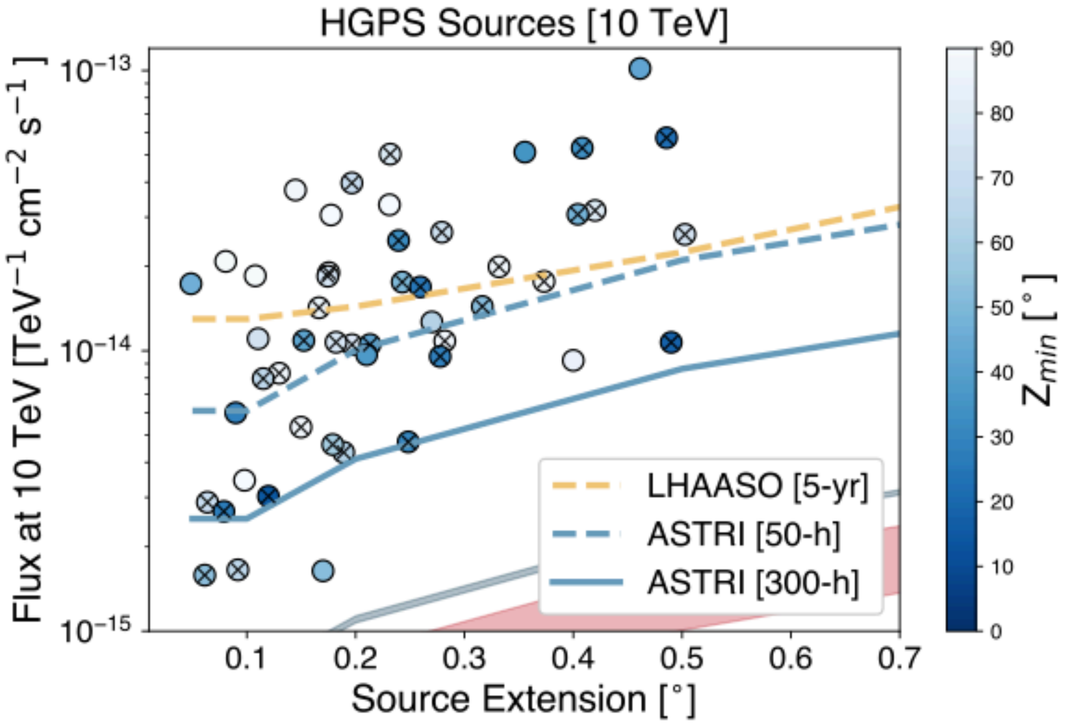
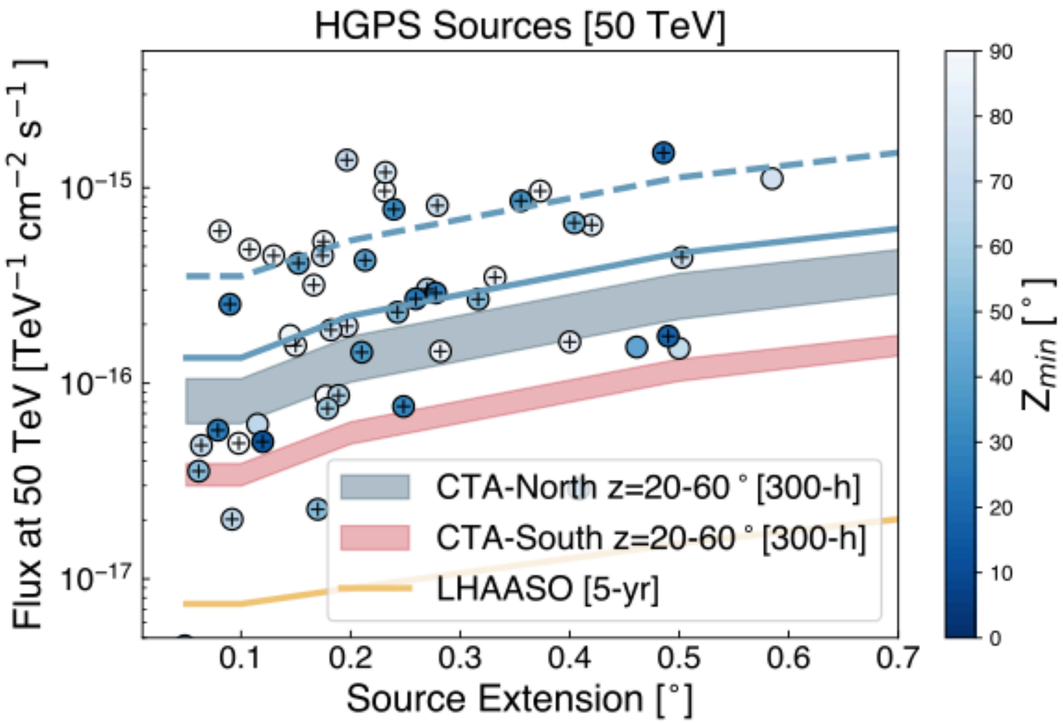
Instruments capability : for source identification





x = unidentified sources

+ = no cutoff

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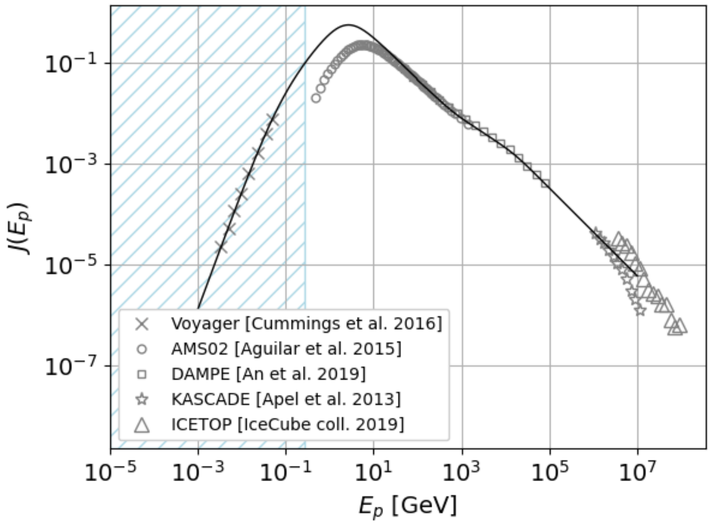
Instruments capability : molecular clouds in the MW

Molecular clouds emit gamma-rays as result of CR interaction

Only a few cases reported at VHE due to low surface brightness



$$\alpha_\gamma \sim \alpha_{CR} + 0.1$$

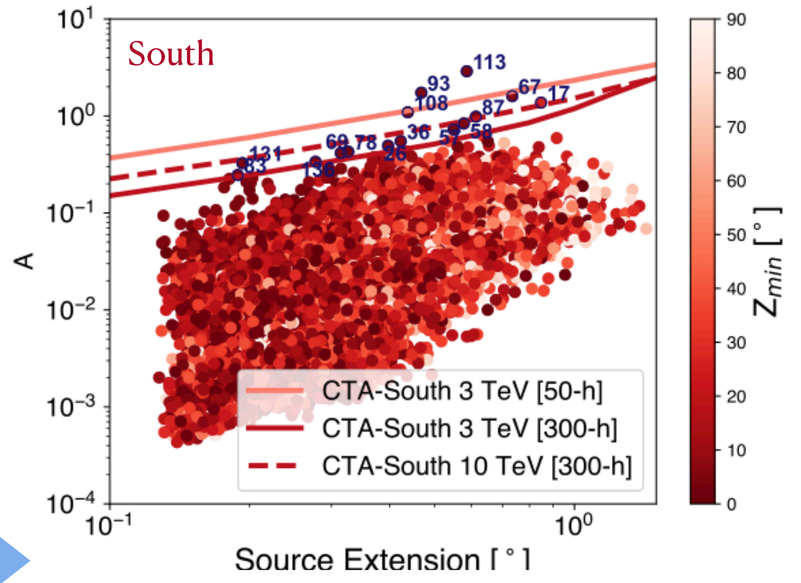
$$E_\gamma \sim 0.1 E_{CR}$$

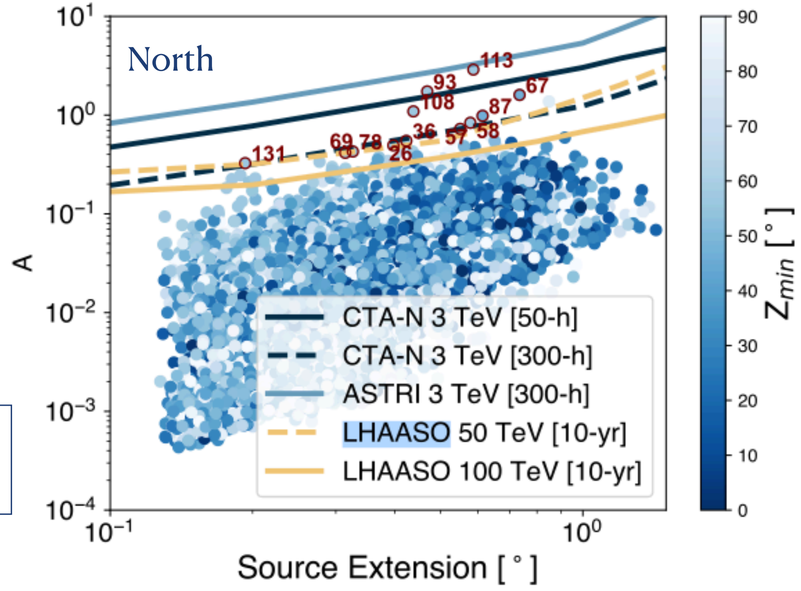
$$F_\gamma^{MC} = A \times \varphi_{gamma}$$

Cloud density — CR flux

The MC is visible if

$$A > \frac{Sensitivity(E_\gamma)}{\varphi(E_\gamma)}$$





A few clouds are in reach for CTA-S
Due to their location, even LHAASO need a longer exposure

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Summary

Next-generation IACTs will have improved performance at very high energies, allowing the characterization of VHE sources including PeVatrons and a few molecular clouds, improving in:

i) Detection (for clouds and new sources)

ii) Source identification

iii) Morphology

iv) Spectral feature

v) Emission mechanism

Despite the suppression in sensitivity due to source extension, many candidate source already emerges for follow-up studies.