Joint-instrument analyses with Gammapy

Tim Unbehaun – HEAMM workshop
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PHYSICS

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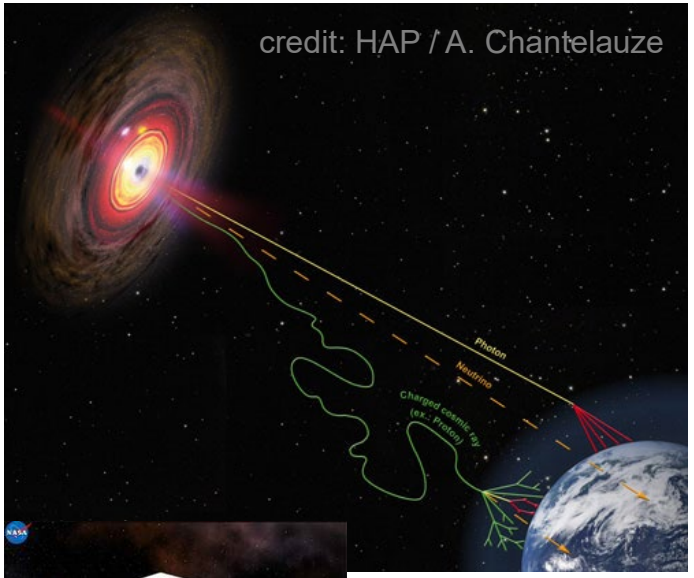
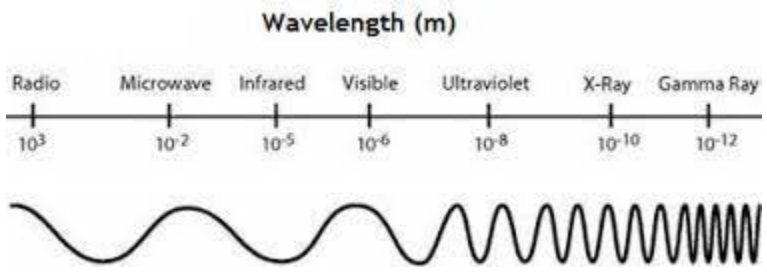
Last Time

- Presented joint instrument analyses using Gammapy
- Fermi-LAT + H.E.S.S. data to measure the spectrum and extension of the Crab nebula
- KM3NeT + CTA (simulated) data to investigate the combined sensitivity to the particle production mechanism

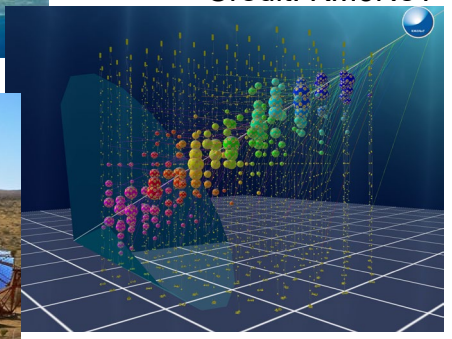



Credit: NASA / Aurore Simonnet



credit: labman.phys.utk.edu

Credit: KM3NeT



Credit: HESS Collaboration

3D analyses with Gammapy

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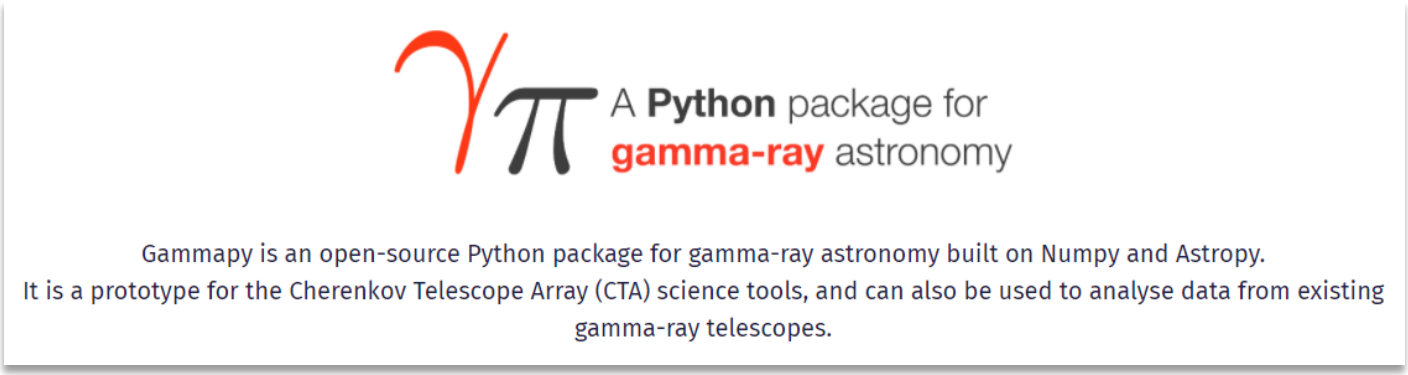
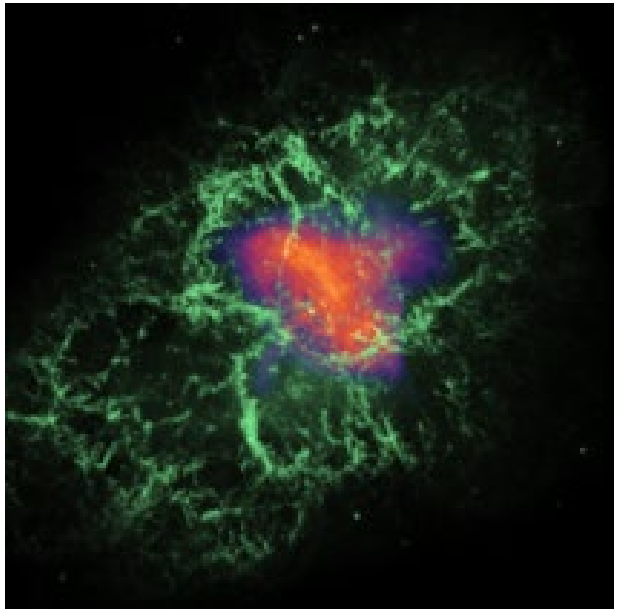


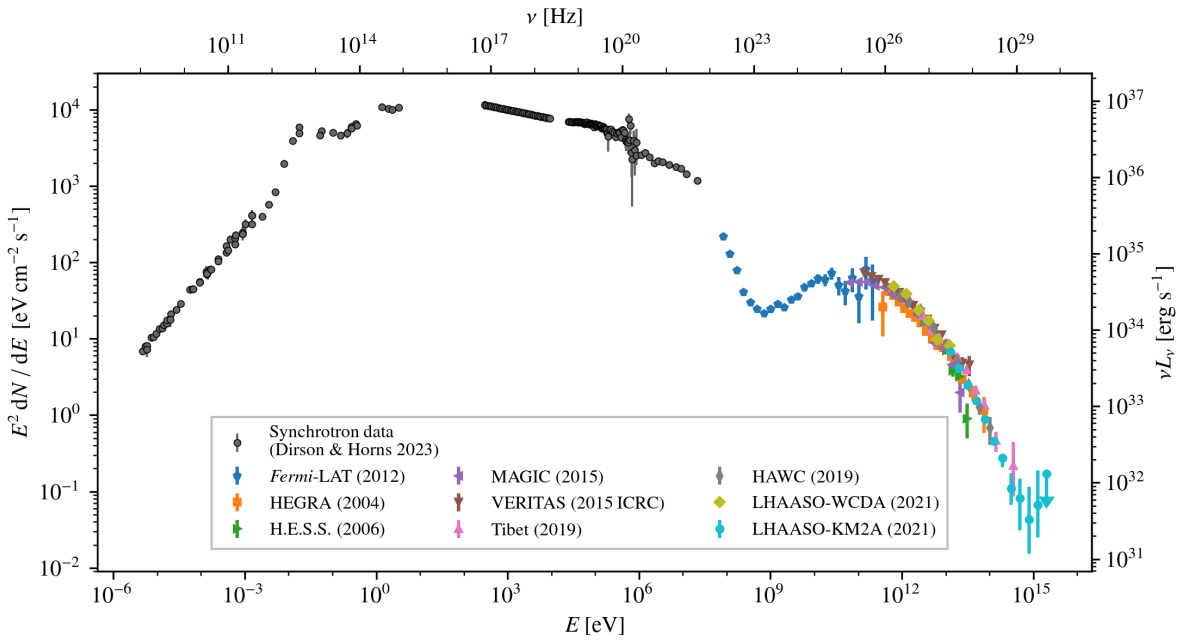
- Binned likelihood analysis in 3D (2 spatial, 1 energy)
- Combination of different data sets at likelihood level
  → can fit same physical model to data from different instruments
- Requirement: instrument data (DL3) in common format
  → can also include i.e neutrino data,
  although package is designed for γ-ray data analysis

Combined Fermi + HESS analysis on the Crab nebula



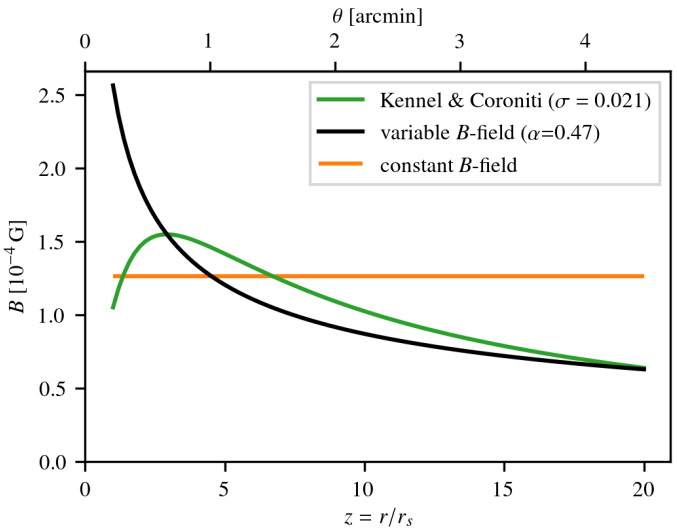
H.E.S.S.

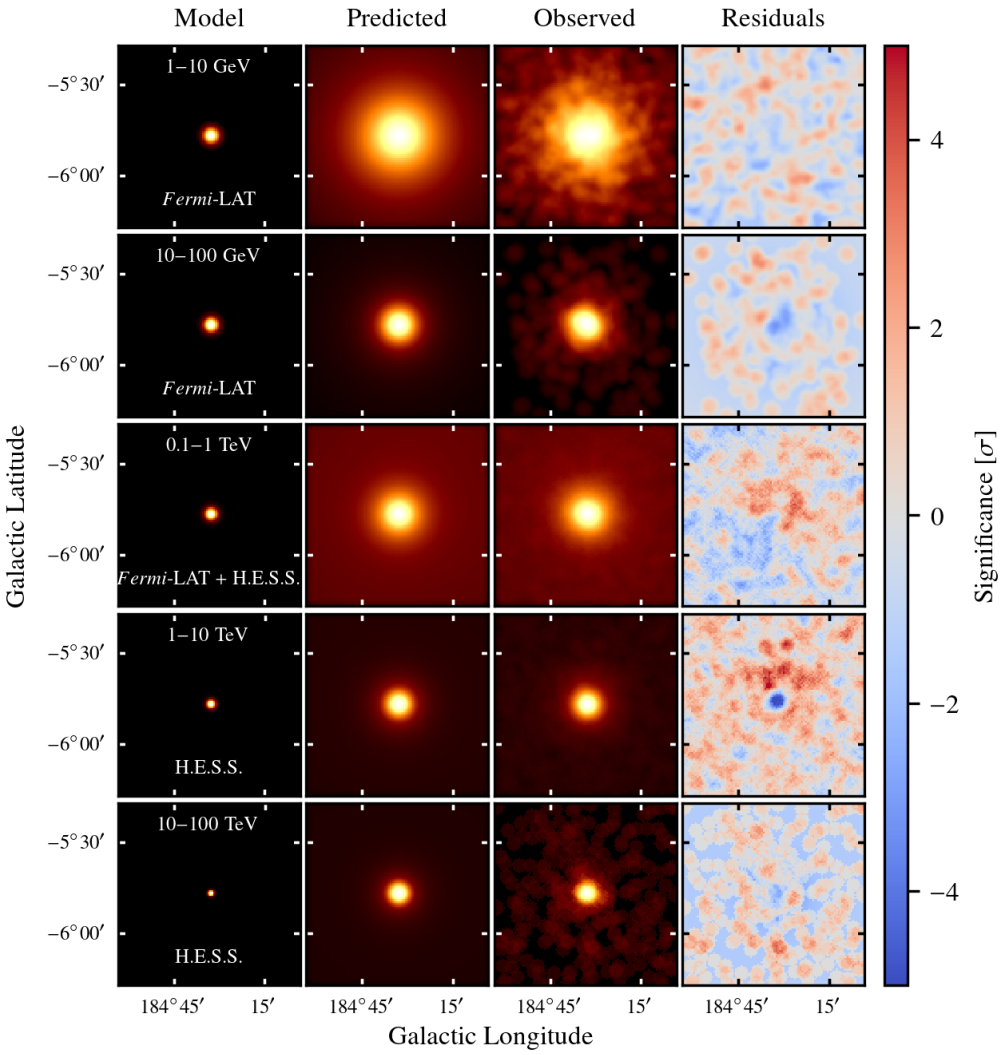
Fermi Gamma-ray Space Telescope



Fermi + HESS on the Crab

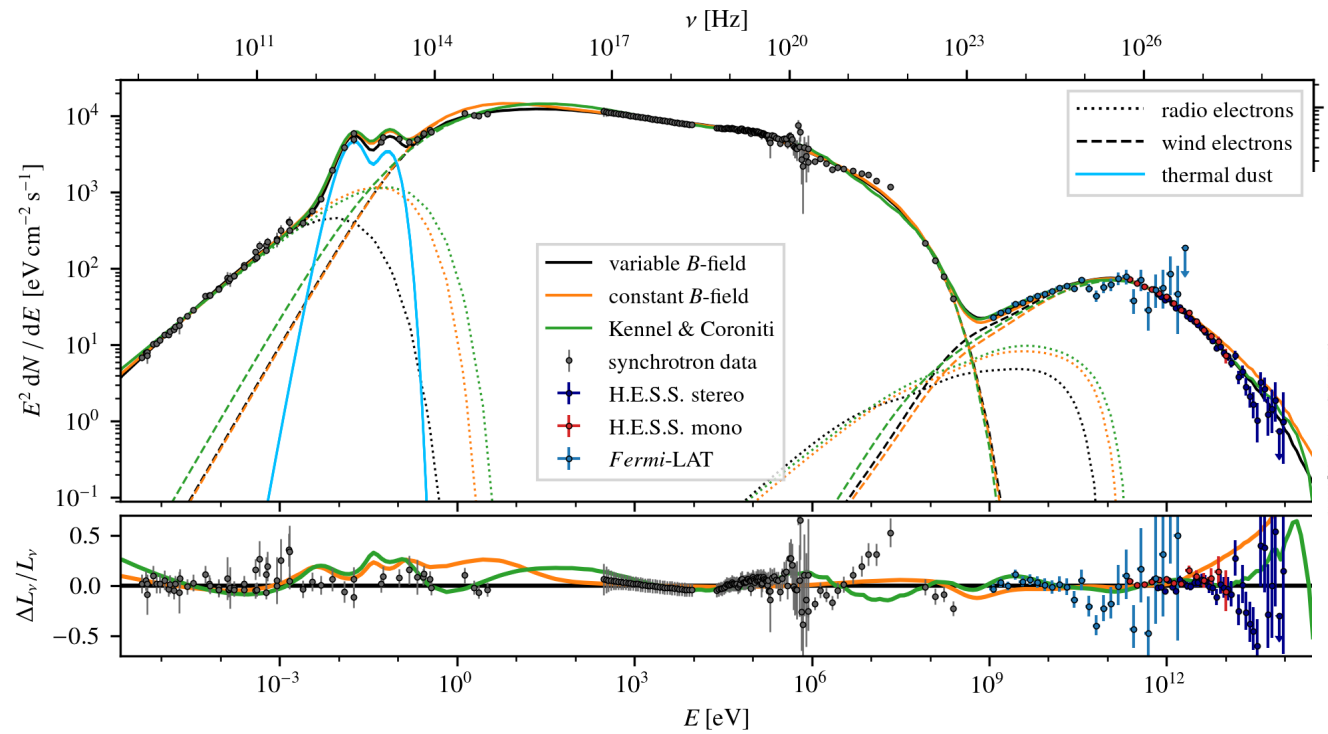
- Tested 3 phenomenological synchrotron self-Compton models with different B-field profiles
- Forward folding of the model prediction using the respective IRFs of each instrument
- Minimizing the combined likelihood with respect to the binned counts

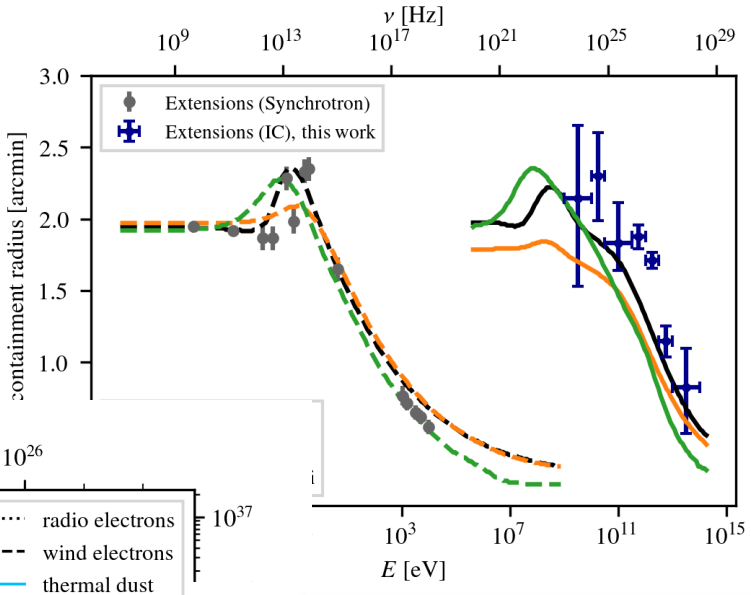


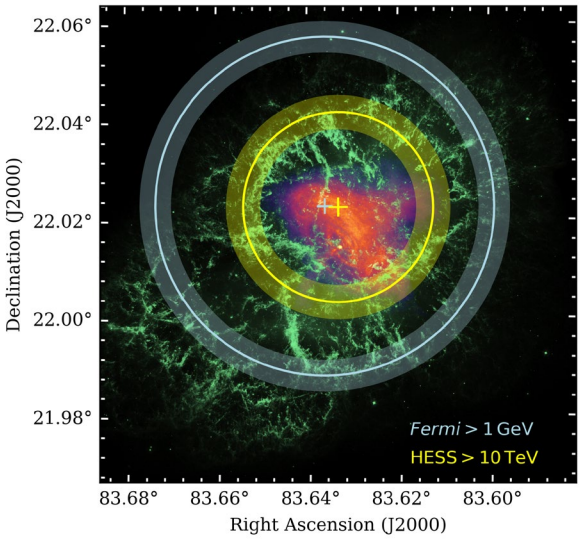


Fermi + HESS on the Crab

- Paper accepted by the journal and published on arXiv
  https://arxiv.org/abs/2403.12608





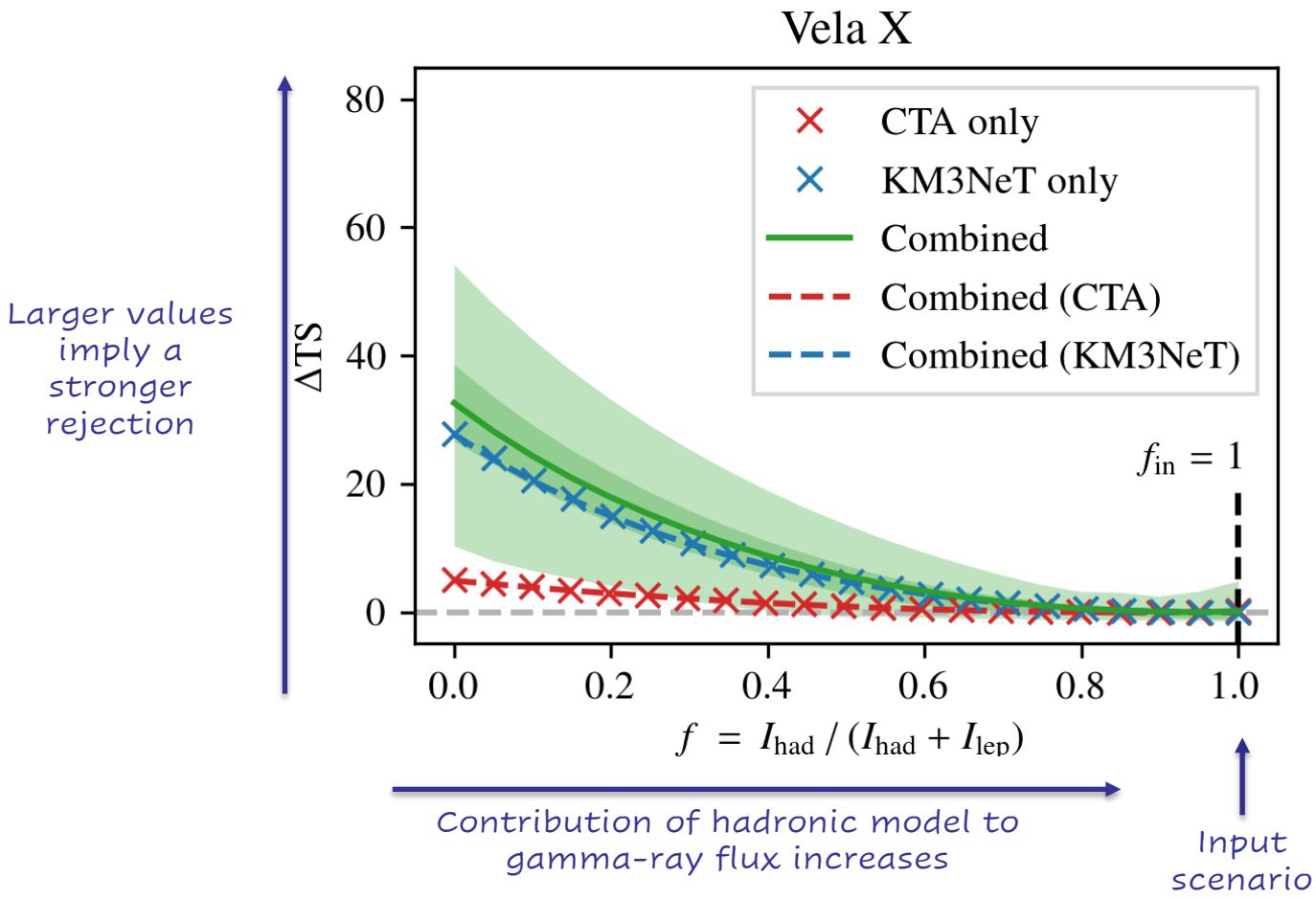


Combined CTA + KM3NeT analysis

“Are there Galactic gamma-ray sources for which the combined analysis of data from KM3NeT and CTA would help us to discriminate between hadronic and leptonic emission scenarios?“

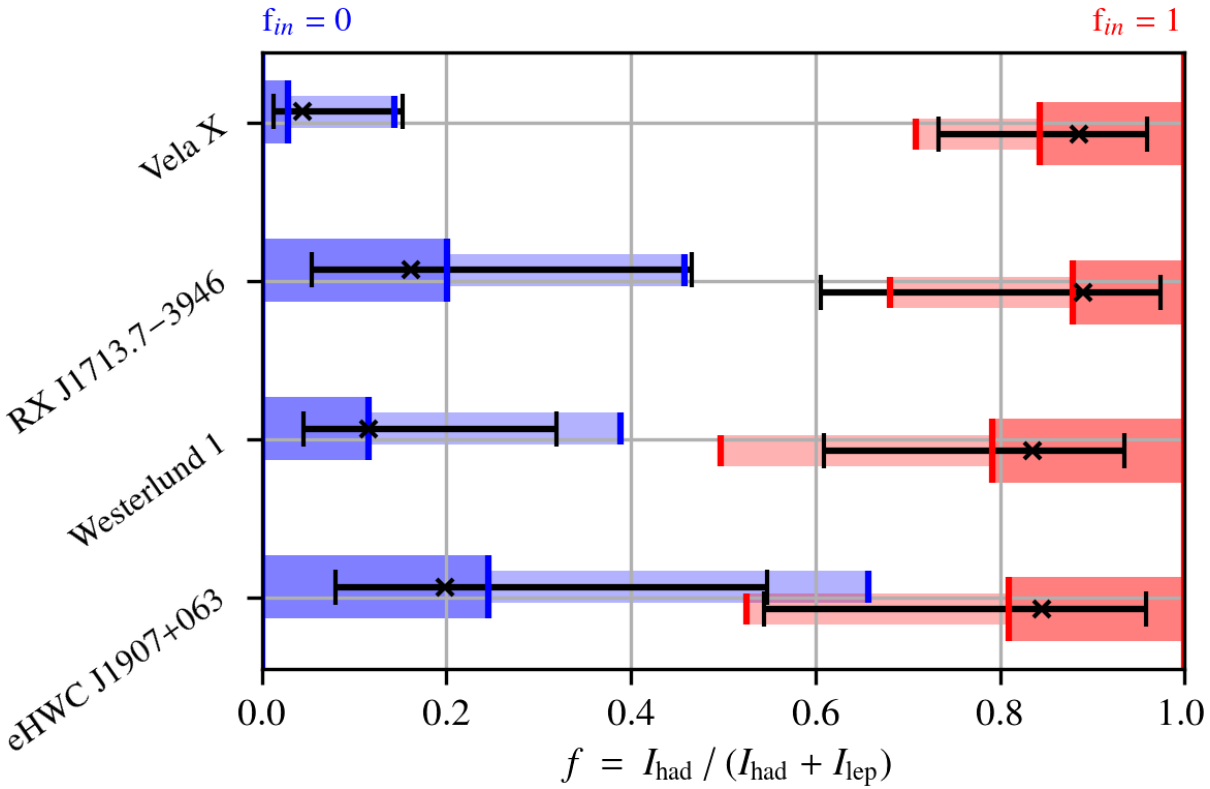
Limits on the hadronic contribution

- Perform *likelihood-profile* scans of the hadronic contribution *f*



Limits on the hadronic contribution

- Distribution of the best-fit values together with the average uncertainty
- Paper accepted and published: https://arxiv.org/abs/2309.03007

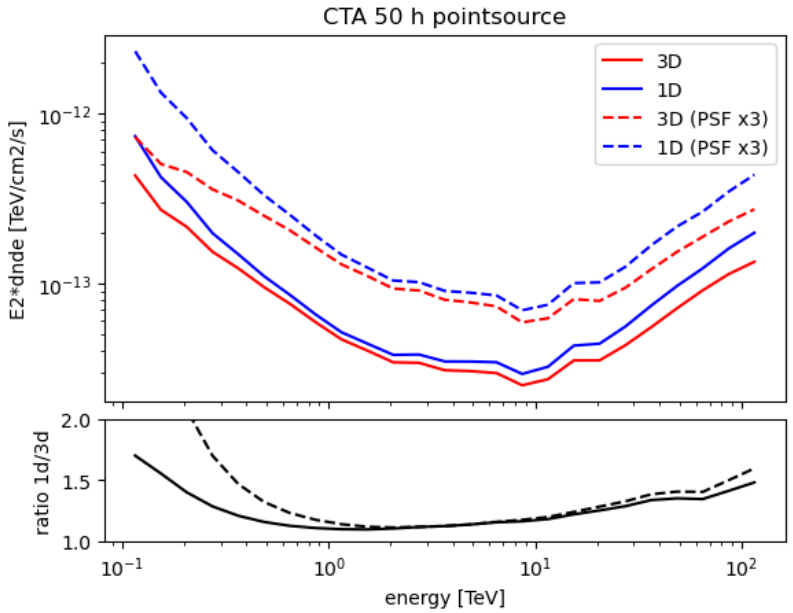


Current and future work

- Attempting to systematically evaluate benefits and systematics when analyzing and combining data from different instruments in different ways
  → All within the framework of Gammapy
  → Sensitivity estimates for different quantities (detection, flux, extension, …)
  → Comparing different analysis techniques (3D, 1D, Flux points, priors, …)
  → Different systematic uncertainties on IRFs, background, energy scale, …

- When is it beneficial to combine the data and when are systematics dominating (asymmetry of source with different pointing uncertainties)

- How can one model systematics and constrain them



Thanks for your attention!

Bundesministerium
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