CTAO | LST COLLABORATION

Galactic Science results with the LST-1

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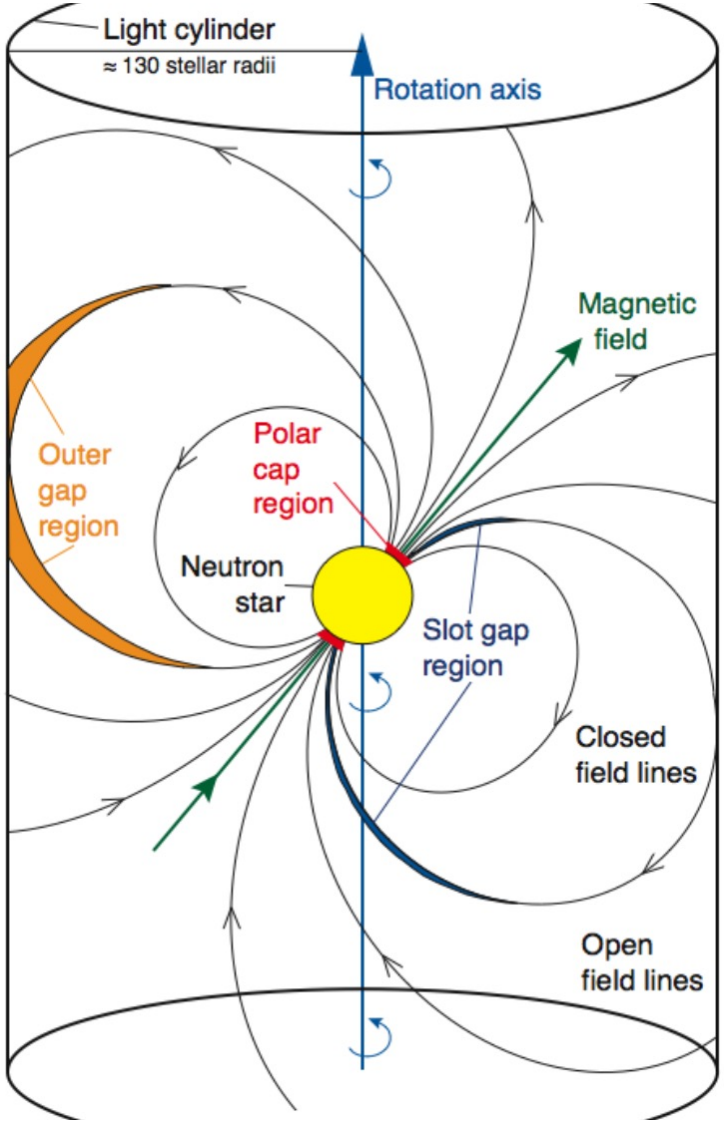
Overview

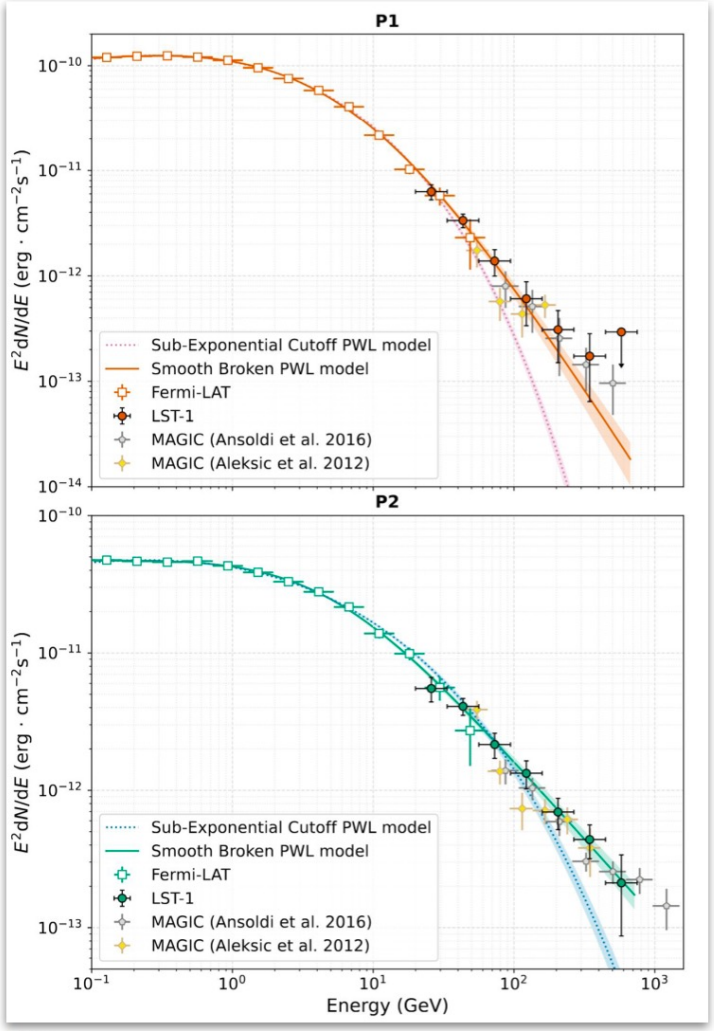
- Pulsars
  Crab Pulsar [A&A, 690, A167 (2024)]
  Geminga Pulsar
- Unidentified source
  LHAASO J2108+5157 [A&A 673, A75 (2023)]
- Galactic center
- Nova
  RS Ophiuchi [submitted to A&A]

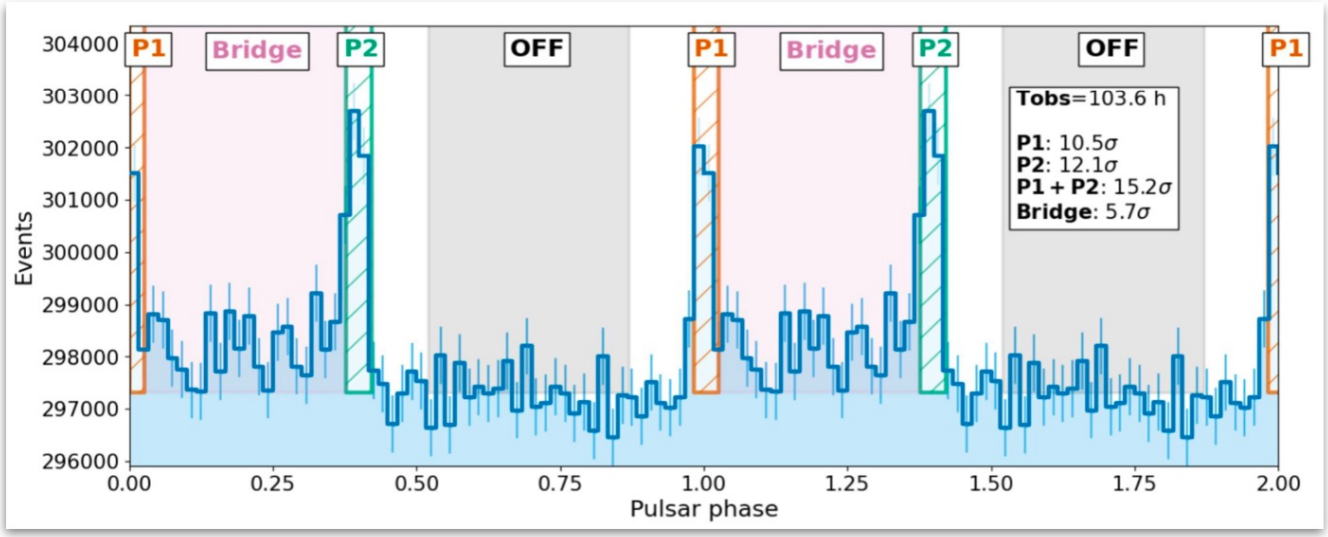
Pulsars

- Almost 340 pulsars detected at high energies.
  (Third *Fermi*-LAT Catalog of Gamma-ray Pulsars)
- Only three detected and very high energies.
  Crab, Vela and Geminga pulsar: pulsed emission detected by H.E.S.S., MAGIC and VERITAS up to TeV.
  → Challenge for current curvature radiation models.
  → Polar cap as emission region excluded.
- Emission mechanism at very high energies?



Crab pulsar



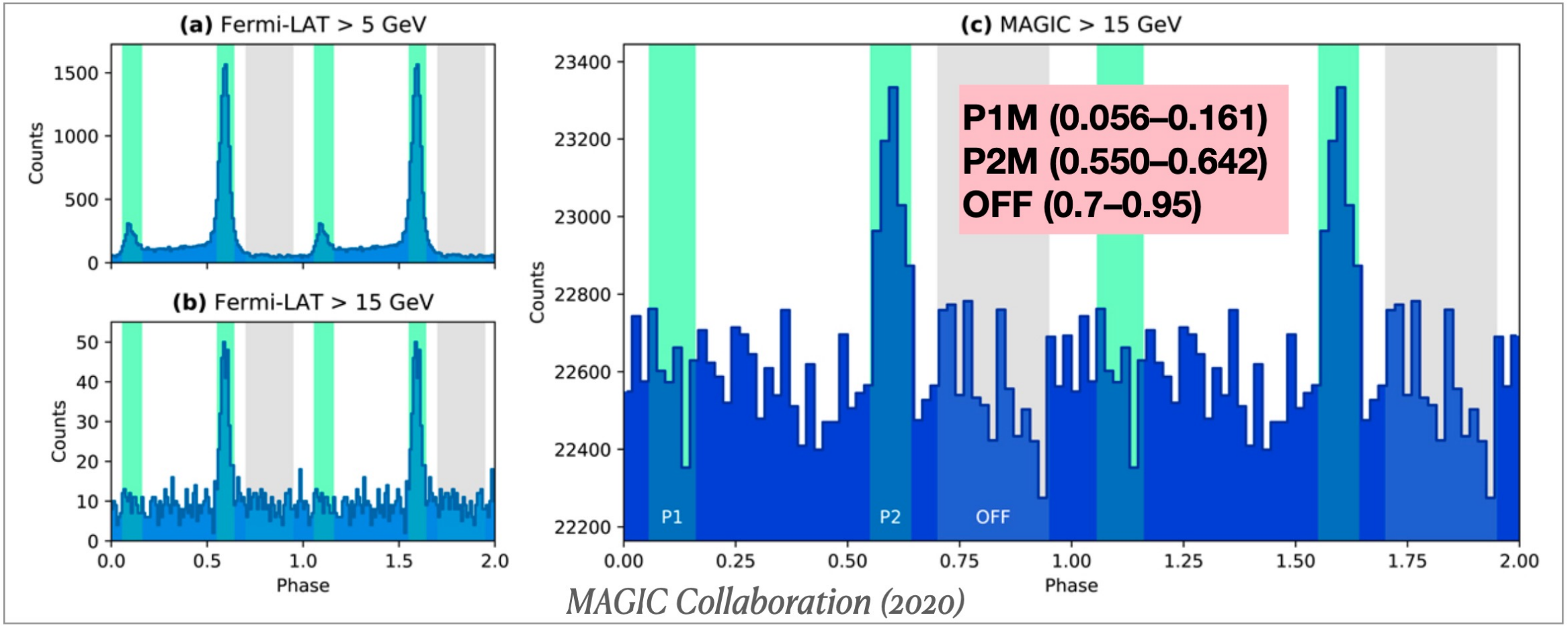


A detailed study of the very-high-energy Crab pulsar emission with the LST-1
A&A, 690, A167 (2024)

Detection of Crab Pulsar:

- Source physics + telescope performances (threshold, cross-calibration, energy resolution…)
- Clear detection of P1 and P2 → **Ethr down to ~20 GeV**
- Smooth transition between *Fermi*-LAT and LST-1

Geminga pulsar (PSR J0633+1746)



- P1 & Bridge are detected at 5 GeV, but Undetected above 15 GeV

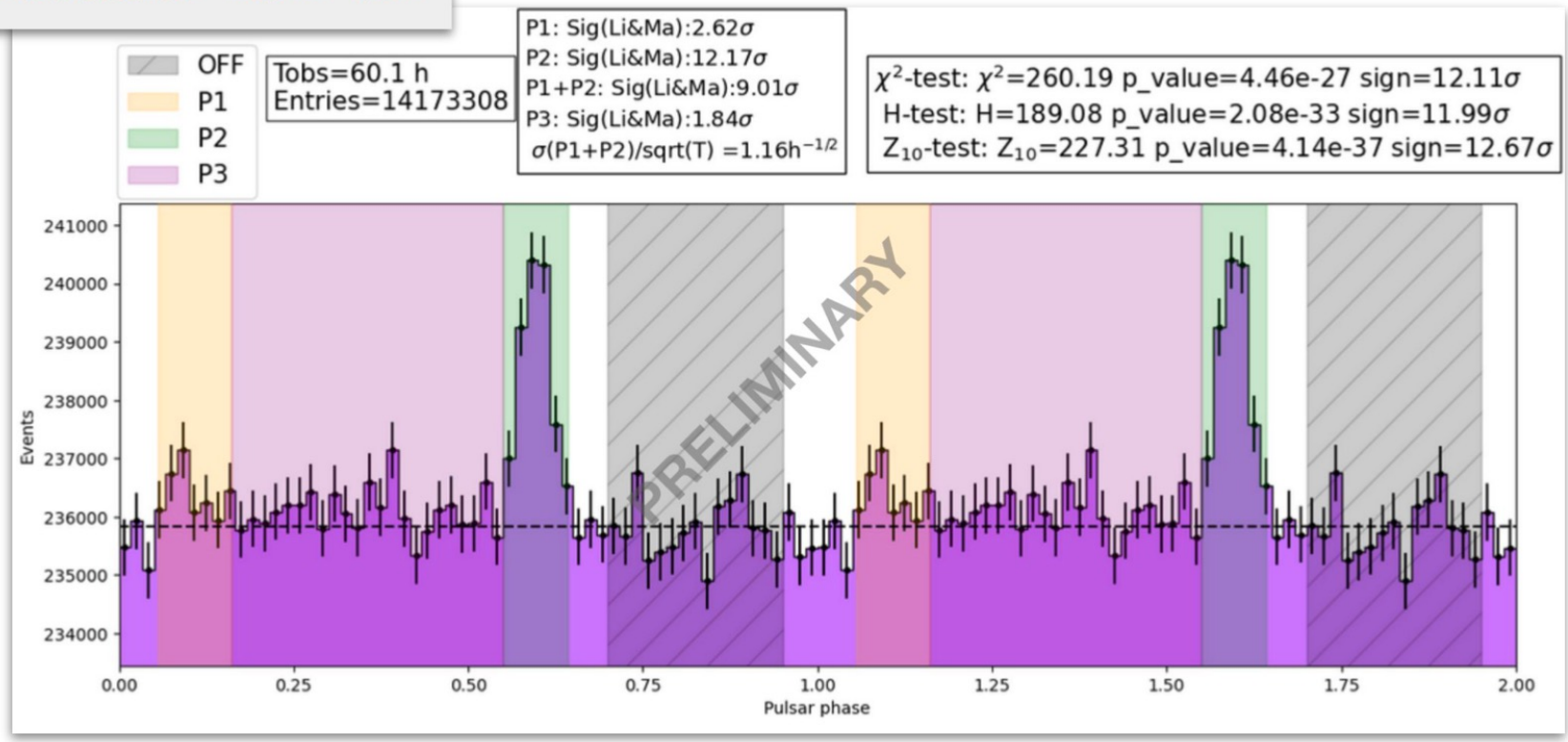
Geminga pulsar (PSR J0633+1746)

- Performance at lower energies confirmed by the detection of Geminga (PSR J0633+1746)

- Being a soft spectrum source, the detection of Geminga confirms the good performance in the 15-30 GeV band, one of the main scientific drivers of LST
- MAGIC: 6.3σ after 80 hours for P2
  (MAGIC coll., A&A 643 (2020) L14)
- Spectral analysis ongoing. >~200h to achieve the detection of P1

Detected at ~12σ in ~60h

from Yeung+@gamma24



Pulsar summary

Crab pulsar

- Energy dependecy of the peaks.
  P2 more significant at VHE than P1.
- Bridge emission visible.
  Spectra for all regions computed.
- Smooth transition between *Fermi*/LAT and LST-1 data that points
  → Emission being produced by a single population of electrons.
- Acceleration region still unclear.

Geminga pulsar

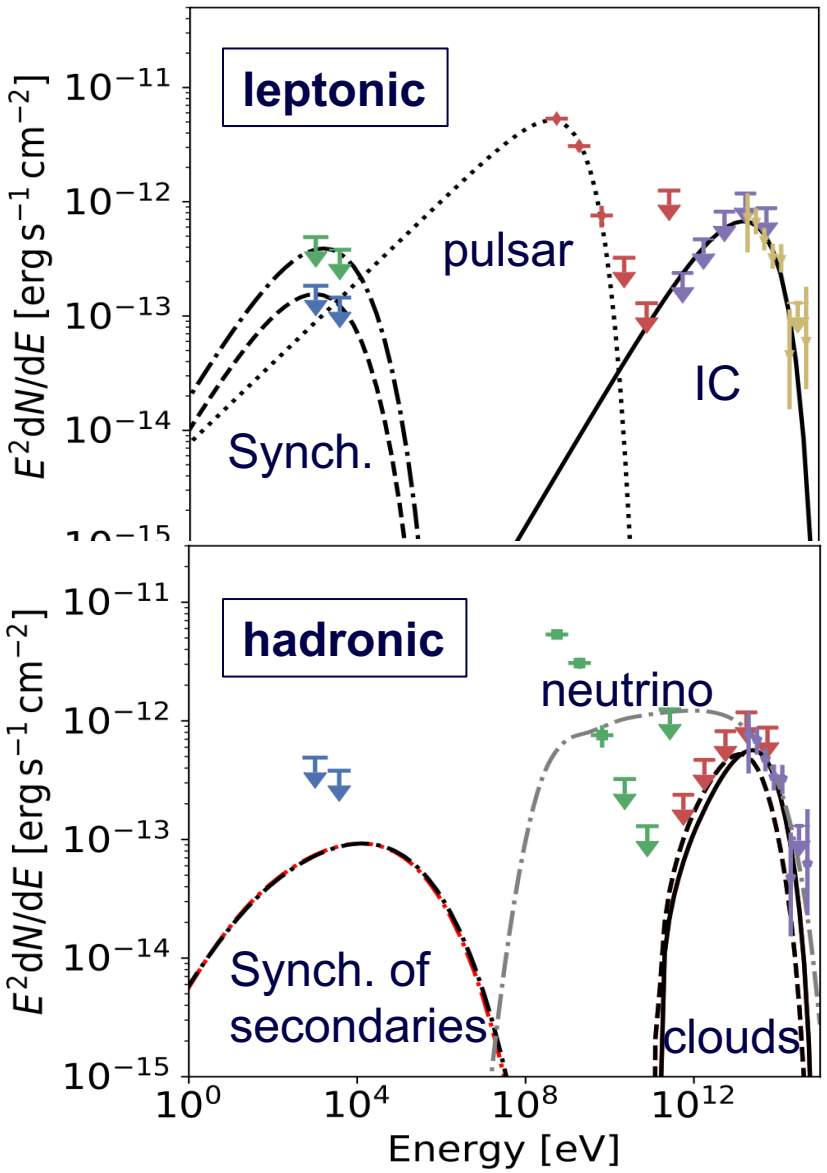
- Hints for P1 and bridge emission thanks to low energy threshold of LST-1.
  For detection more sensitive instrument (4 LSTs) needed.
- More pulsar detections to come specially with more LSTs.

LHAASO J2108+5157

Unidentified source

- First gamma-ray source directly discovered in the ultra-high energy (UHE) band (~100 TeV)
- ~91 hours observations with LST-1.
- No X-ray nor VHE counterpart (3.7σ in the few TeV band) → constraining upper limits achieved.
- Future CTAO observatory or deeper X-ray observation → distinguish PWN and TeV-halo hypotheses
- Interesting candidate for future neutrino experiments of sufficient sensitivity.

Abe, S., et al.: A&A 673, A75 (2023)



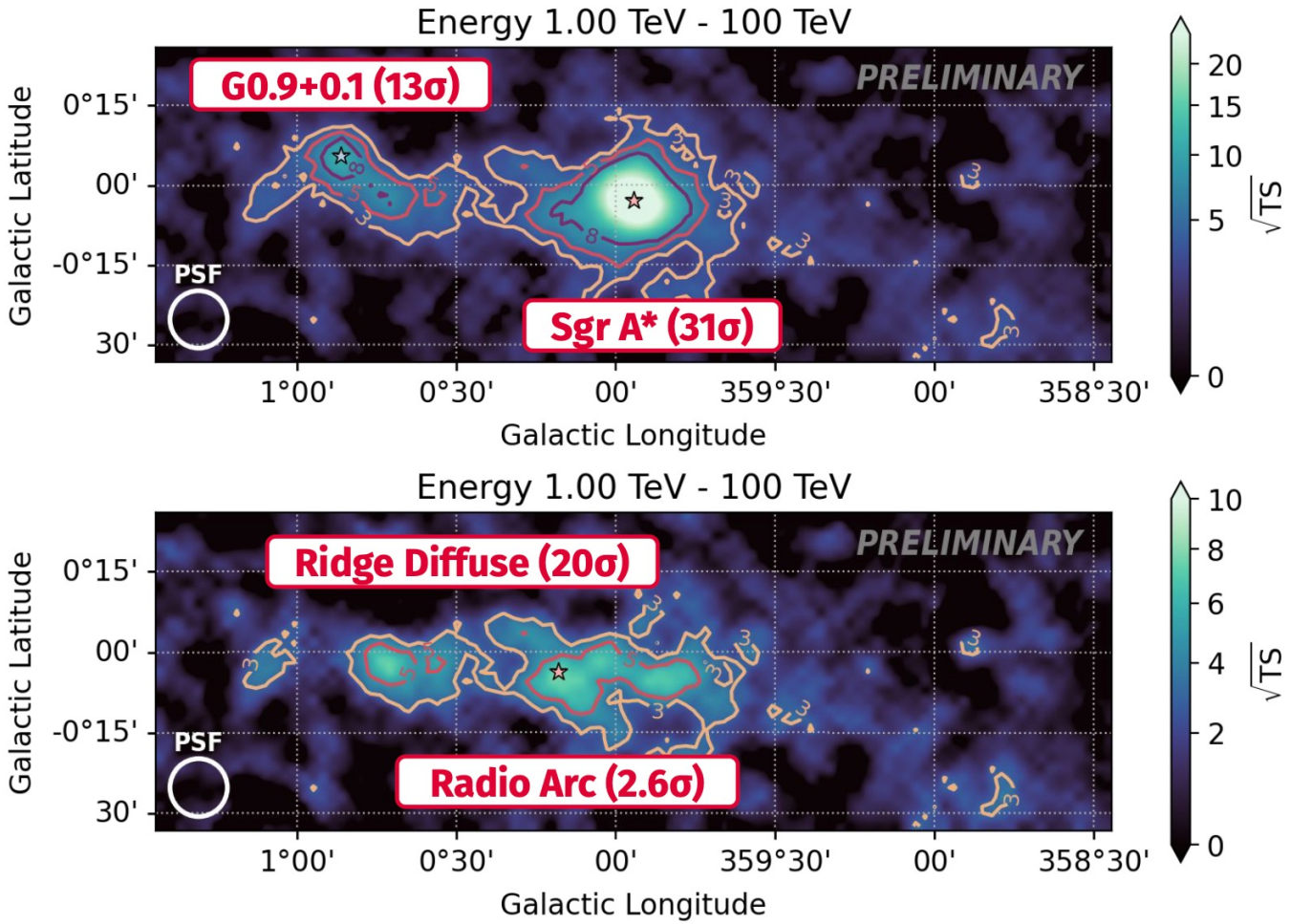
Galactic Center

- 39 hours taken at high zenith angles (Zd > 58 deg) .
- Spatially-resolved spectral fit with *gammapy*.

Source	Spatial	Spectral
Sgr A*	Point-like (Gaussian)	Power Law with Exp. Cutoff
G0.9+0.1	Point-like (Gaussian)	Power Law
Arc	Point-like (Gaussian)	Power Law
Ridge Diffuse	Template	Power Law with Exp. Cutoff

TS Map

Sgr A* & G0.9+0.1 subtracted



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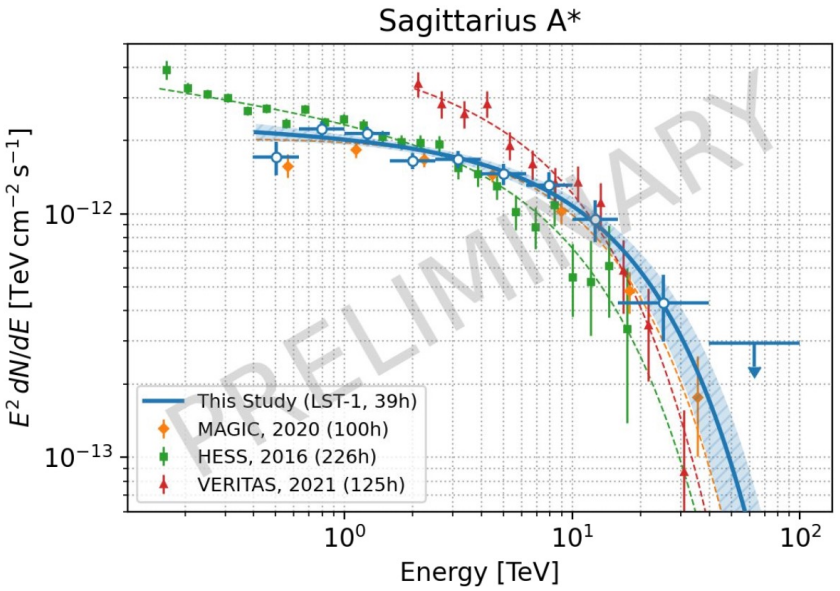
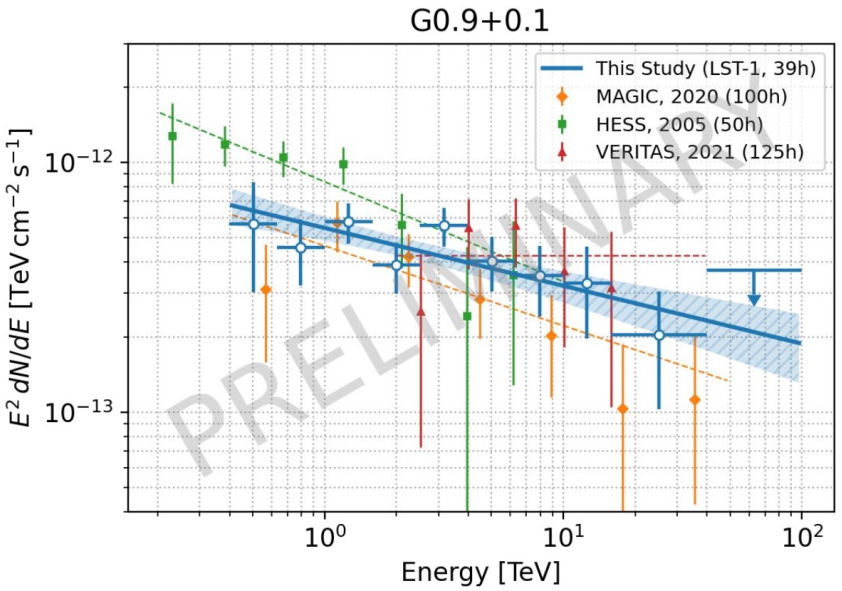
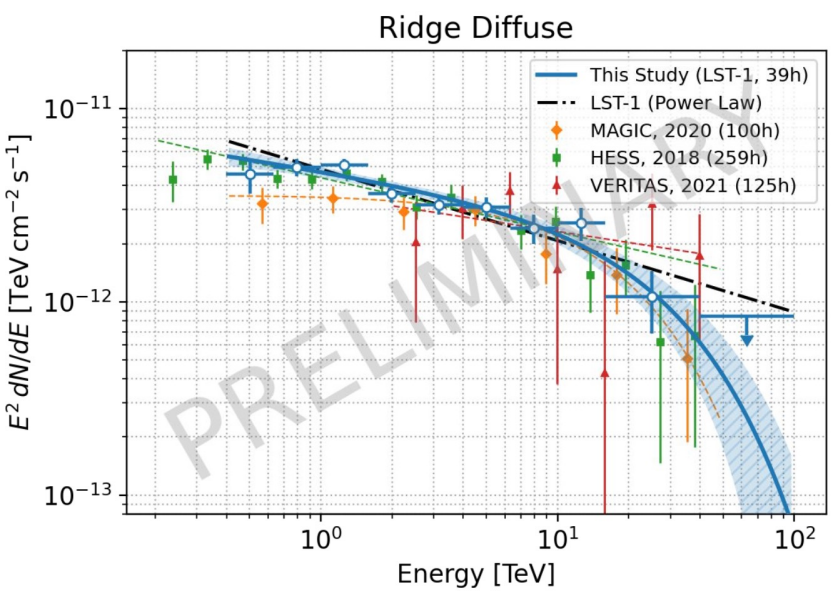




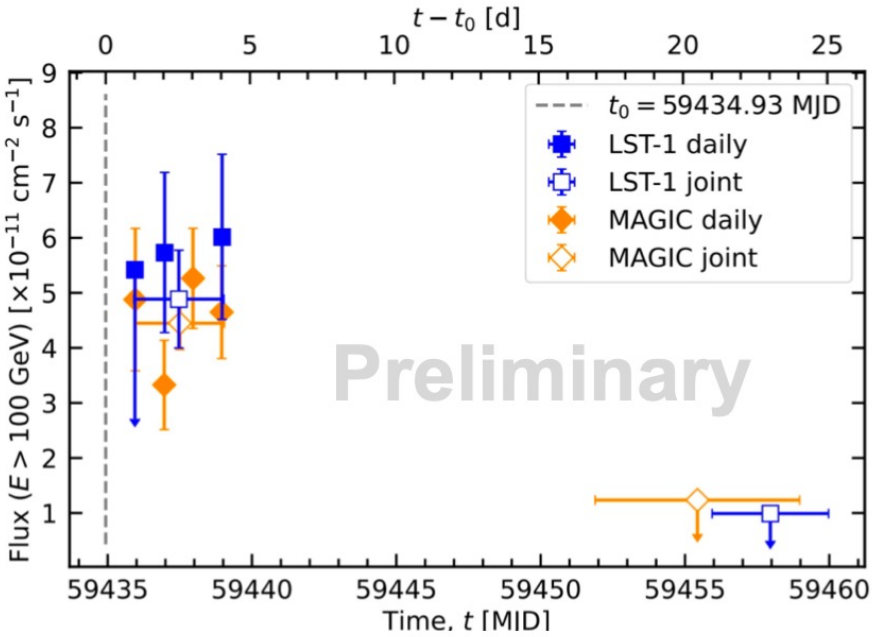


- LST-1 results consistent with prior studies.
- Cutoff not been seen in G0.9+0.1, despite the 4.8σ cutoff significance for Sgr A*.

Total diffuse emision favors cutoff at 29 TeV with 2.8σ, consistent with MAGIC results.

RS Ophiuchi Nova

Novae are thermonuclear explosions caused by accumulation of material from donor star on a surface of a white dwarf (WD)



Observation day	Γ	ϕ_0 [10^{-10} TeV^{-1} cm^{-2} s^{-1}]
Day 1	-4.2 ± 0.3	3.3 ± 1.3
Day 2	-3.65 ± 0.13	5.9 ± 1.0
Day 4	-3.50 ± 0.15	5.9 ± 1.1
Day 1, 2 and 4	-3.73 ± 0.10	5.2 ± 0.7

Preliminary

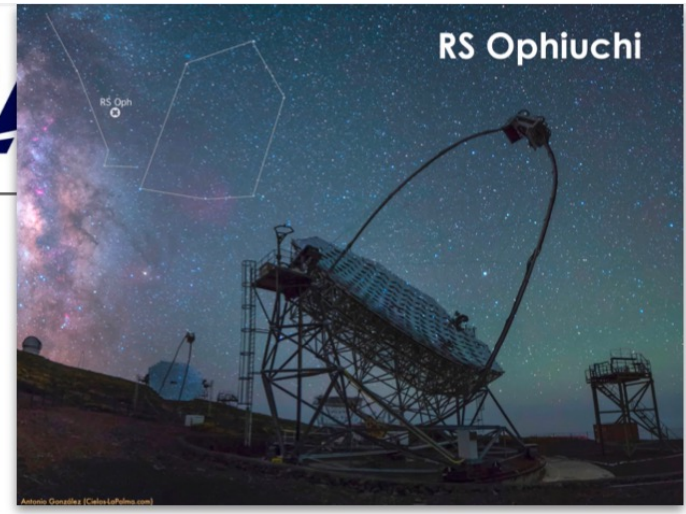
- System **is not** disrupted after the nova event -> cycle restarts
  - Most novae detected only once:
  - Outburst once every (hundreds of) thousand years
- Some novae show repeated outbursts within few years/human lifetime: recurrent novae (RN)
  - 10 known RN in the Galaxy with repetition rate <100 y
  - For a symbiotic nova to be RN, the WD must be massive (≥1.1 $M_\odot$) (if $M > 1.44\ M_\odot \rightarrow$ Sn Ia)

RS Oph is a recurrent symbiotic nova which displays major outbursts every 14.7 years

Observed and detected on August 2021

Novae established as a new type of VHE emitters

RS Ophiuchi Nova



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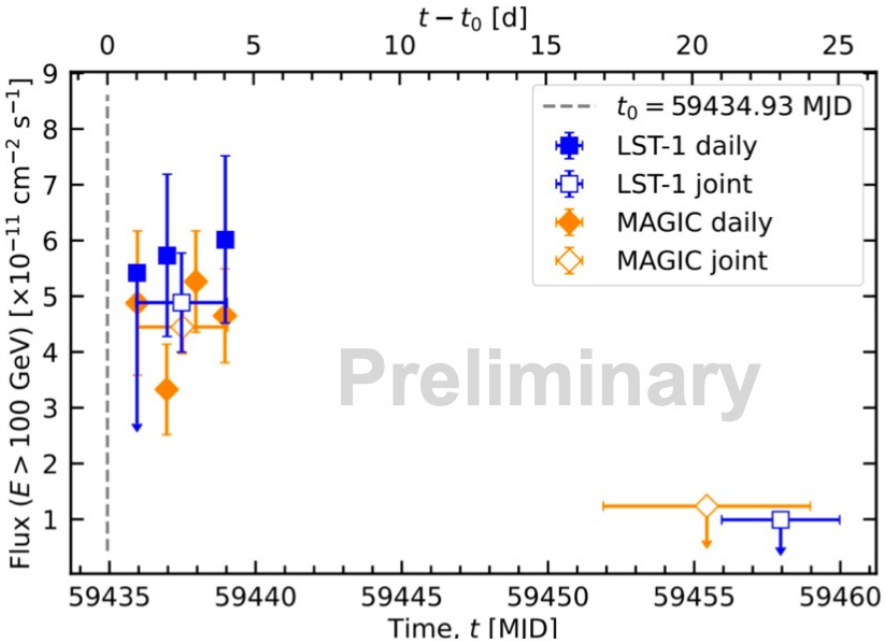

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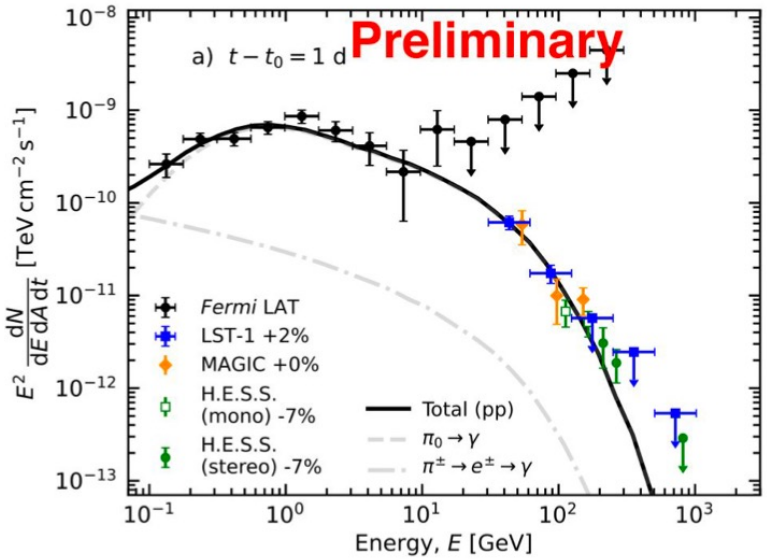
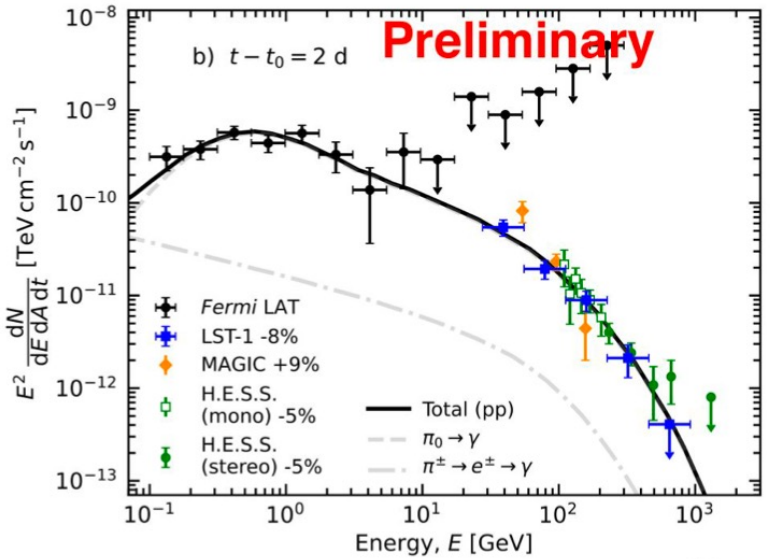
Preliminary

- Evidence for a spectral hardening as novae evolves and increase in cutoff energy
- Hadronic model preferred

paper in internal review phase





Summary

- Advantage of very low threshold.
  Closing gap of Fermi-LAT and Cherenkov telescopes.
  Detection of new pulsar population at VHE possible.
- LST provides observational constraints useful for testing theoretical frameworks.
  Unidentified sources.
- Galactic center observations possible through wide field of view.
  Higher significance of the ridge diffuse emission component & G0.9+0.1 than MAGIC with less than half of the observation time.

Summary & Outlook

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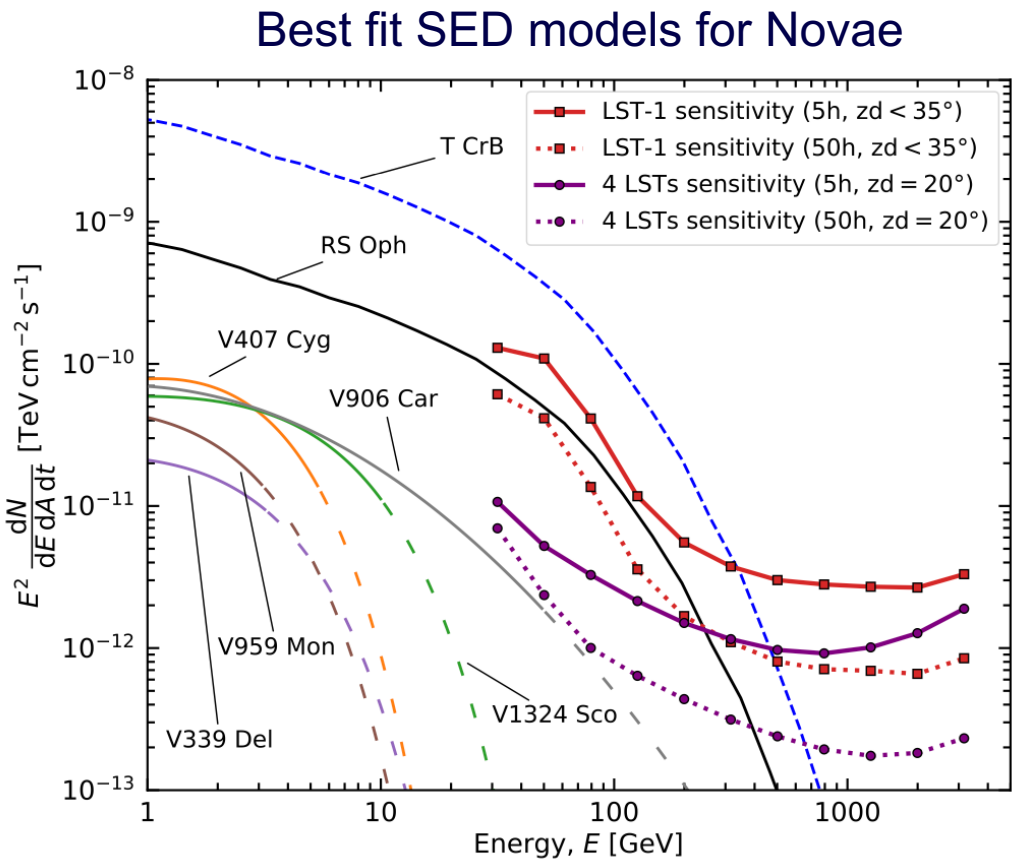

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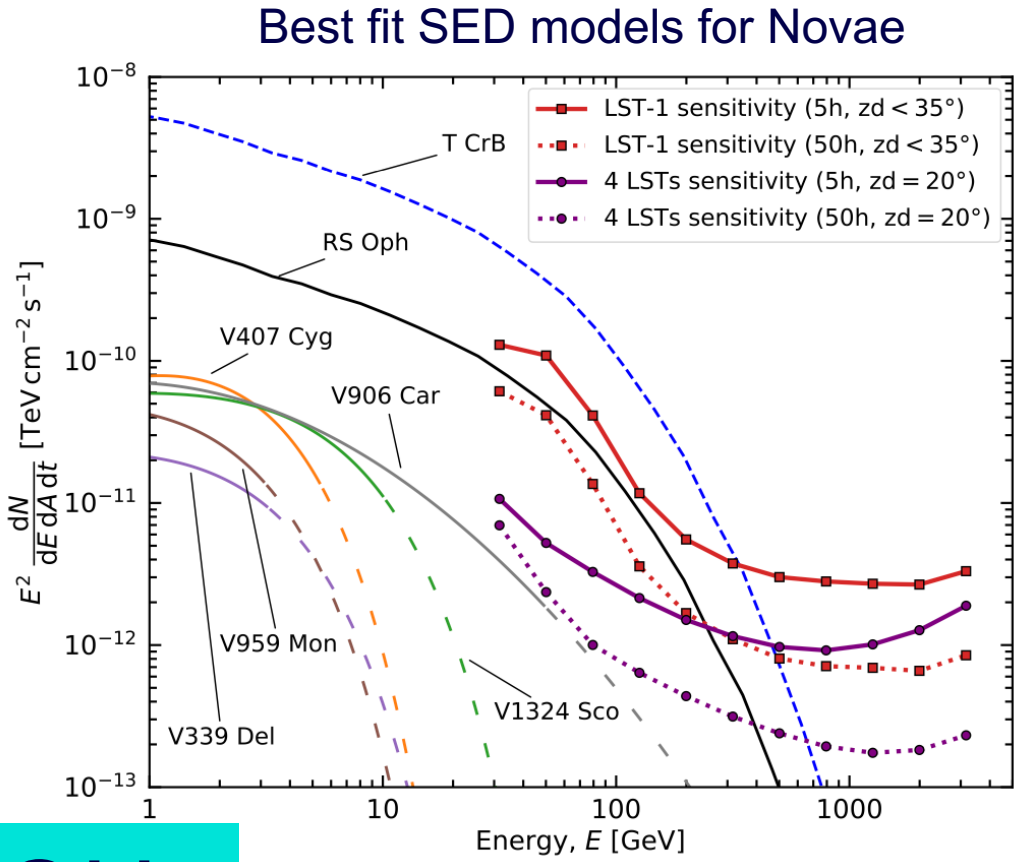

THANK YOU