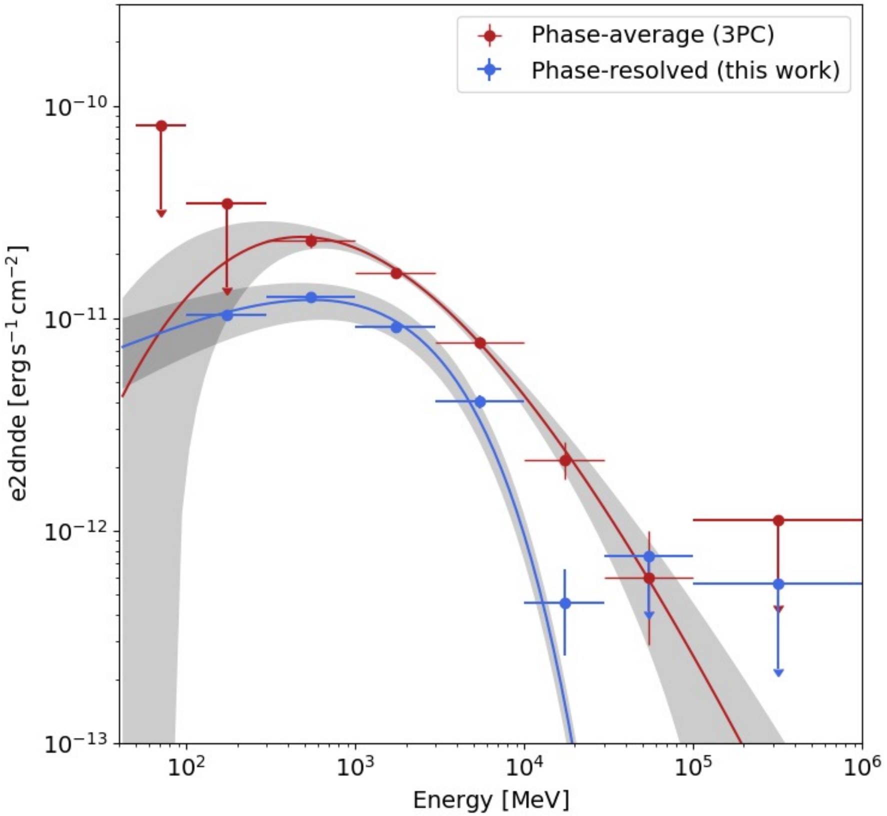
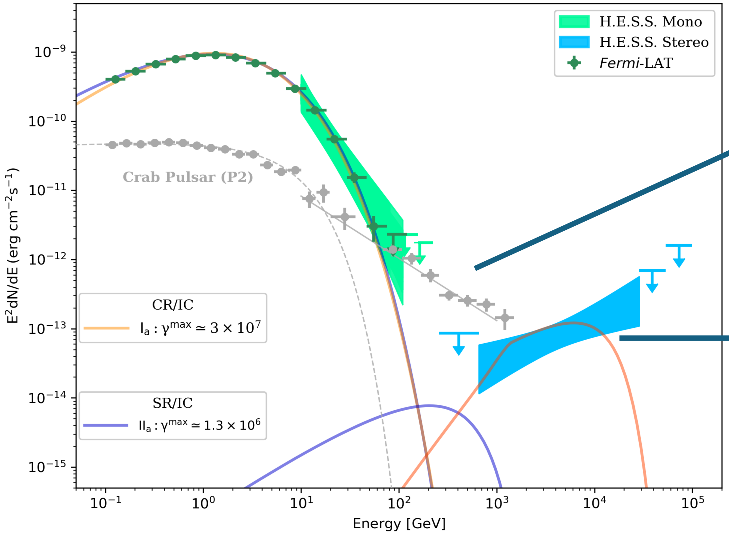
SEEKING VHE PULSAR CANDIDATES FOR CTA OBSERVATORY IN THE *FERMI*-LAT 3RD PULSAR CATALOG

Maxime Regeard & Arache Djannati-Ataï for the CTA Consortium
APC – Université Paris-Cité, CNRS, Paris, France.

The importance of phase-resolved SED: PSR J1833-1034



Phase-averaged versus phase-resolved SED of PSR J1833-1034.



Crab-like vs Vela-like

Crab GeV extension

Vela Inverse Compton

Caveats of SED extrapolation for Crab-like pulsars

- Overestimating emission @energies > 100 GeV in crowded regions

Prediction of the Inverse Compton emission

- the peak energy of the GeV bump : handle on the maximum particle energies for Inverse Compton (IC)
- IC luminosity /GeV luminosity can vary by orders of magnitude
  - Depends on :IC target density and interaction geometry, etc

Very-High-Energy gamma-ray pulsars with the LST-1

Speaker: **Giulia Brunelli** (University of Bologna & INAF-OAS Bologna)

Two pulsars detected by the prototype of CTAO's Large-Sized Telescope (LST-1)

Crab pulsar

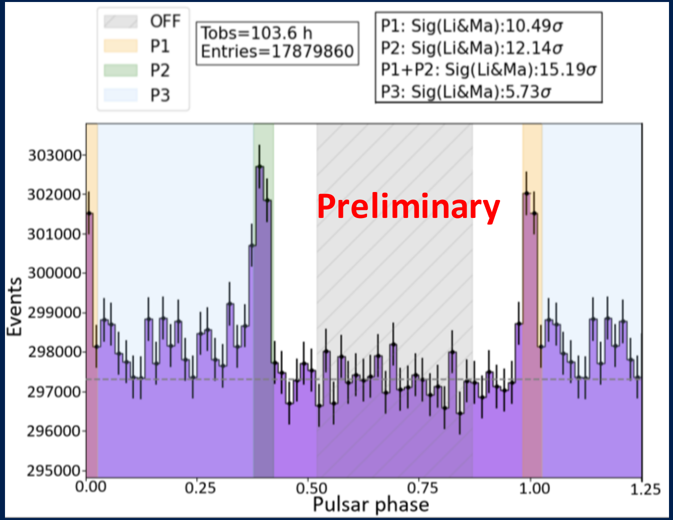


Fig 1: Preliminary phaseogram of the Crab pulsar obtained after the analysis of the 103 hours of good-quality data at Zd<50°.

Geminga pulsar

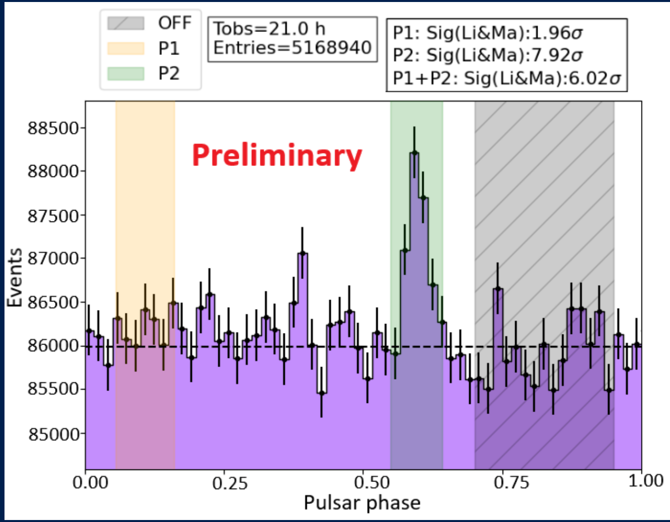


Fig 2: Preliminary phaseogram of the Geminga pulsar obtained after the analysis of the 21 hours of good-quality data at Zd<25°.

Excellent performance of the LST-1 at tens of GeV → crucial instrument to study gamma-ray pulsars

Spider Systems: Stellar arachnology at the highest energies

Rocha, L.S.[1], Santos, E.M.[1], dos Anjos, R.C.[2]
[1]**University of São Paulo**, [2]**Federal University of Paraná**

PROPERTIES

- Millisecond pulsars (P < 15 ms)
- Short orbits (orbital period P < 1 day)
- Presence of pulse eclipses (radio and sometimes gamma-ray)
- Low mass companion:
  - BWs: << 0.1 $M_\odot$
  - RBs: 0.1 – 0.5 $M_\odot$

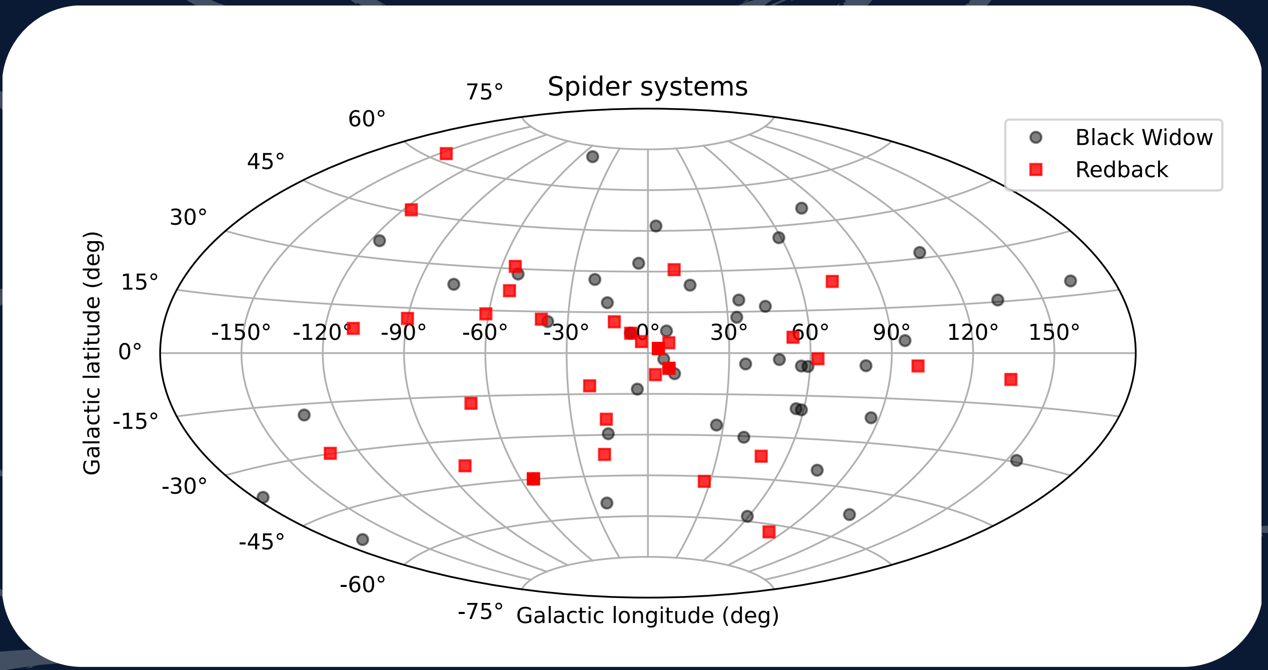
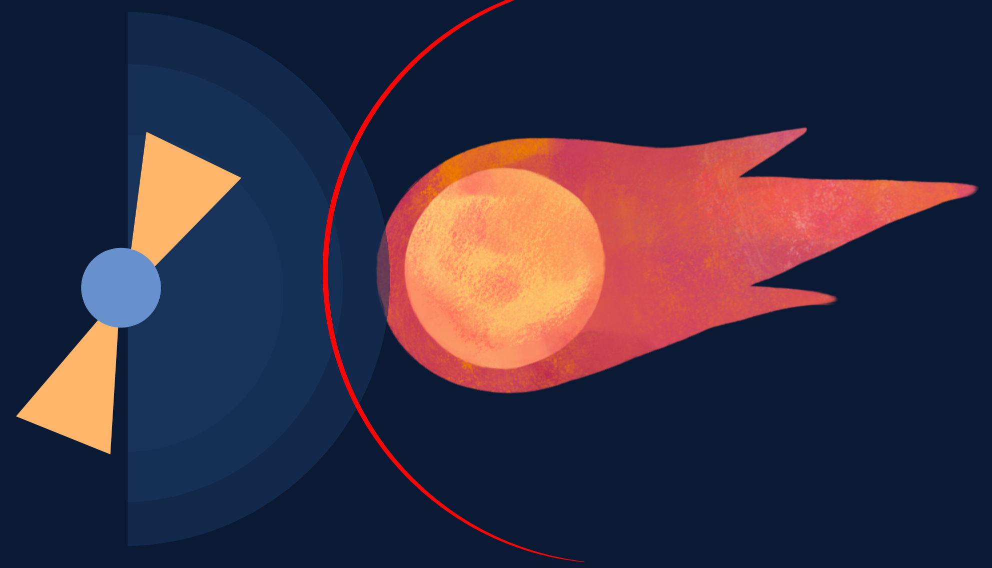


Figure 1. Sky map of confirmed and candidate spider systems in galactic coordinates.

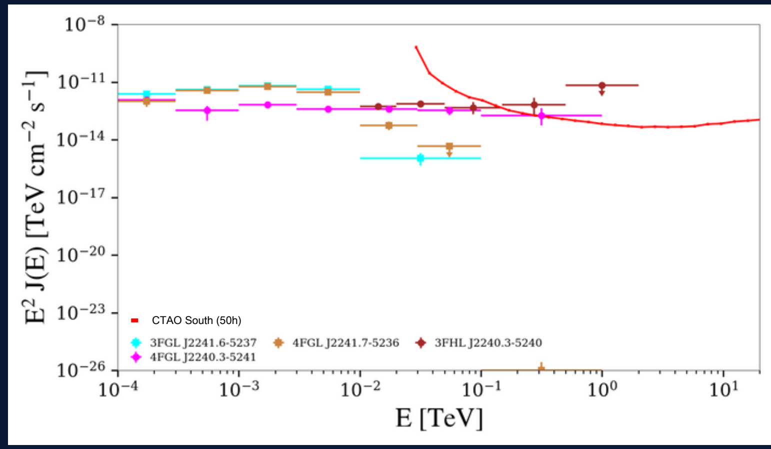
MOTIVATION

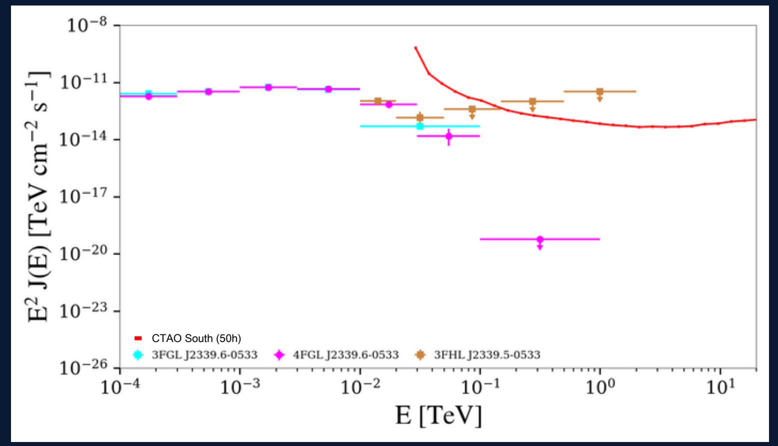
The pulsar wind interaction with the companion wind might form a intrabinary shock, a promising region to accelerate particles as well as emit gamma-rays in the TeV range.



PROSPECTS

- Radiative model (van der Merwe *et al.*, 2020):
  - X-rays and soft gamma-ray: *syncrothron* radiation;
  - hard gamma-rays: *inverse Compton* (IC)
- Spider systems with hot or flaring companions may be promising targets for the Cherenkov Telescope Array (CTA) Obersvatory.
- Our analysis follows as:
  - Select a region of interest (ROI) around each system
    - Extract flux points from available observations
    - Perform a MCMC sampling over a set of spectral models (power-law, log-parabola, etc.)
    - Model comparion methods to select the most likely model
    - 1D ON/OFF analysis to simulate observations (the best-fit model is injected in this step)
- Pin-down the best CTA targets





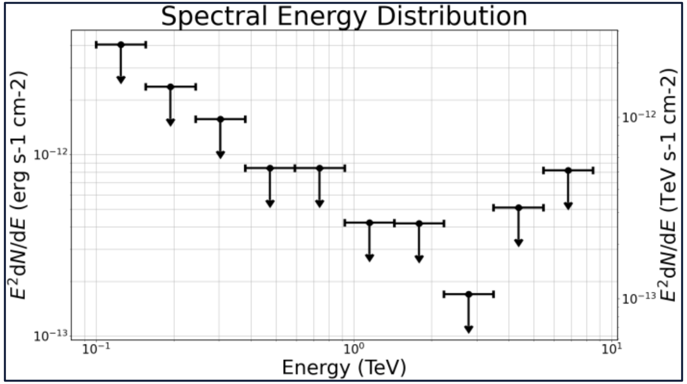
Acknowledgments:
FAPESP, CAPES, IFUSP, UFPR, cta

Very High-Energy Gamma-ray observations of the Galactic magnetar SGR 1935+2154 with the CTAO Large-Sized Telescope prototype

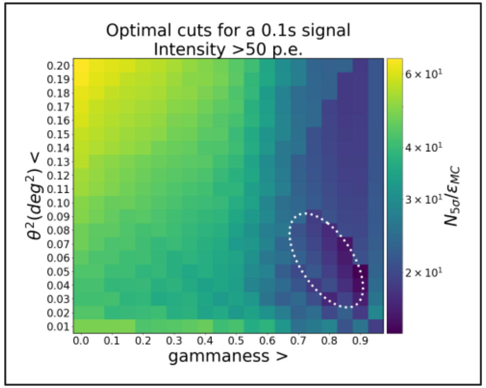
Speaker: G. Panebianco

- Galactic Magnetar, 2 types of emission:
  - Persistent (few keV)
  - Transient, short bursts at keV–MeV
- SGR 1935+2154: 1st evidence for **FRB-magnetar connection**
- LST-1 observations: ≈38h (≈25h good)
- **Simultaneous to 9 burst alerts** reported by X-gamma satellites

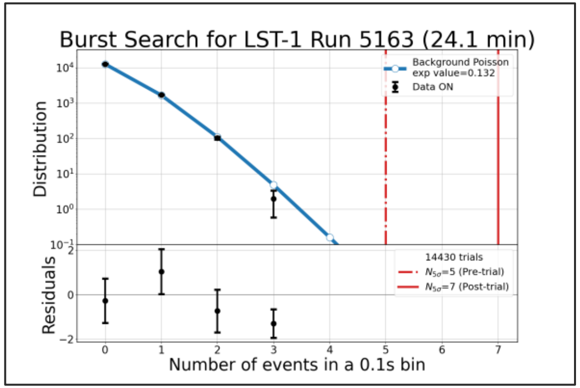
- Stacked spectral analysis -> Upper Limits (ULs) persistent emission (**Fig.1**)



- Short time scale analysis -> Cuts optimized to detect 0.1s signal above Poisson background (**Fig.2**)



- Flux ULs around Time of Alerts (≈ no background):
  - $1.3 \cdot 10^{-8}$ s^{-1} cm^{-2} (over 0.1 s)
  - $2.6 \cdot 10^{-9}$ s^{-1} cm^{-2} (stacked)
- Search for non-simultaneous bursts -> No detection (**Fig. 3**)



Analysis of the possible detection of the pulsar wind nebulae of four pulsars

MULTIMESSENGER ASTROPHYSICS
COSMIC RAYS - COMPACT OBJECTS - RELATIVISTIC ENVIRONMENTS
@ THE INSTITUTE OF SPACE SCIENCES (ICE, CSIC)

Aims

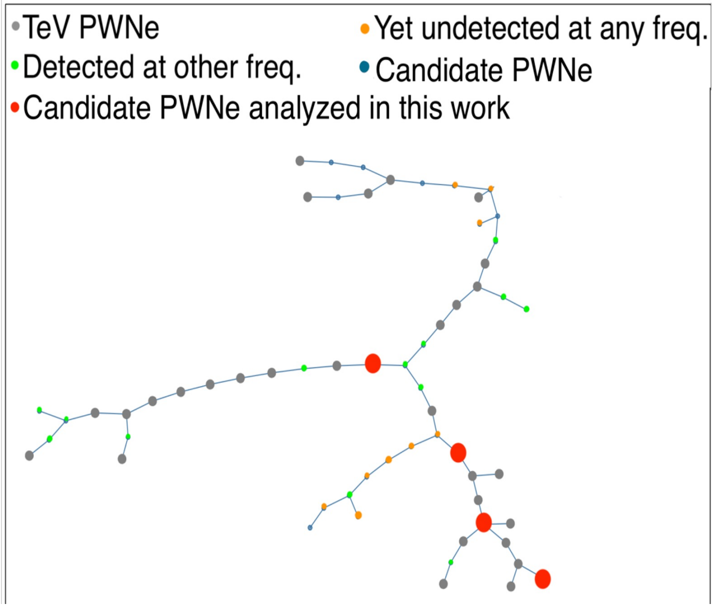
- Discover possible detectable PWNe
- Test to what extent the pulsar tree groups detectable PWNe despite it considering only pulsars’ intrinsic properties.

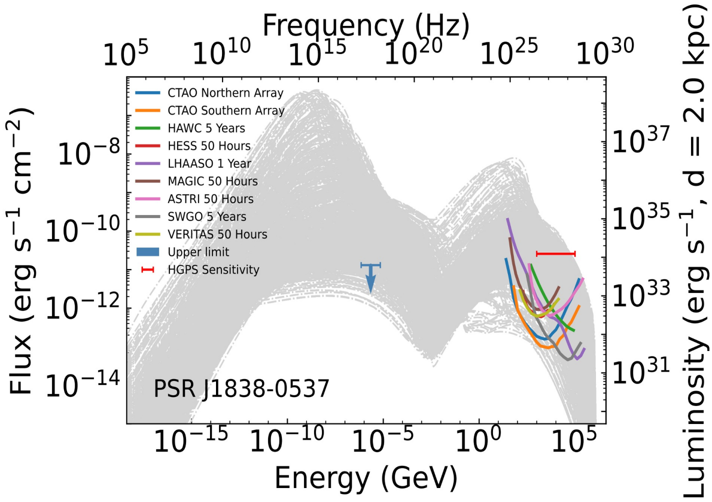
Method

- Select four pulsars as candidates for TeV PWNe based on their positions in the pulsar tree.
- Predicte possible spectral energy distributions (SEDs) of the PWNe of the four pulsars via our detailed time-dependent, leptonic model.

Results

- Estimate the likelihood of detection for the four candidates.
- In doing so, we provide context for analyzing the advantages and caveats of the pulsar tree position as a marker for properties.





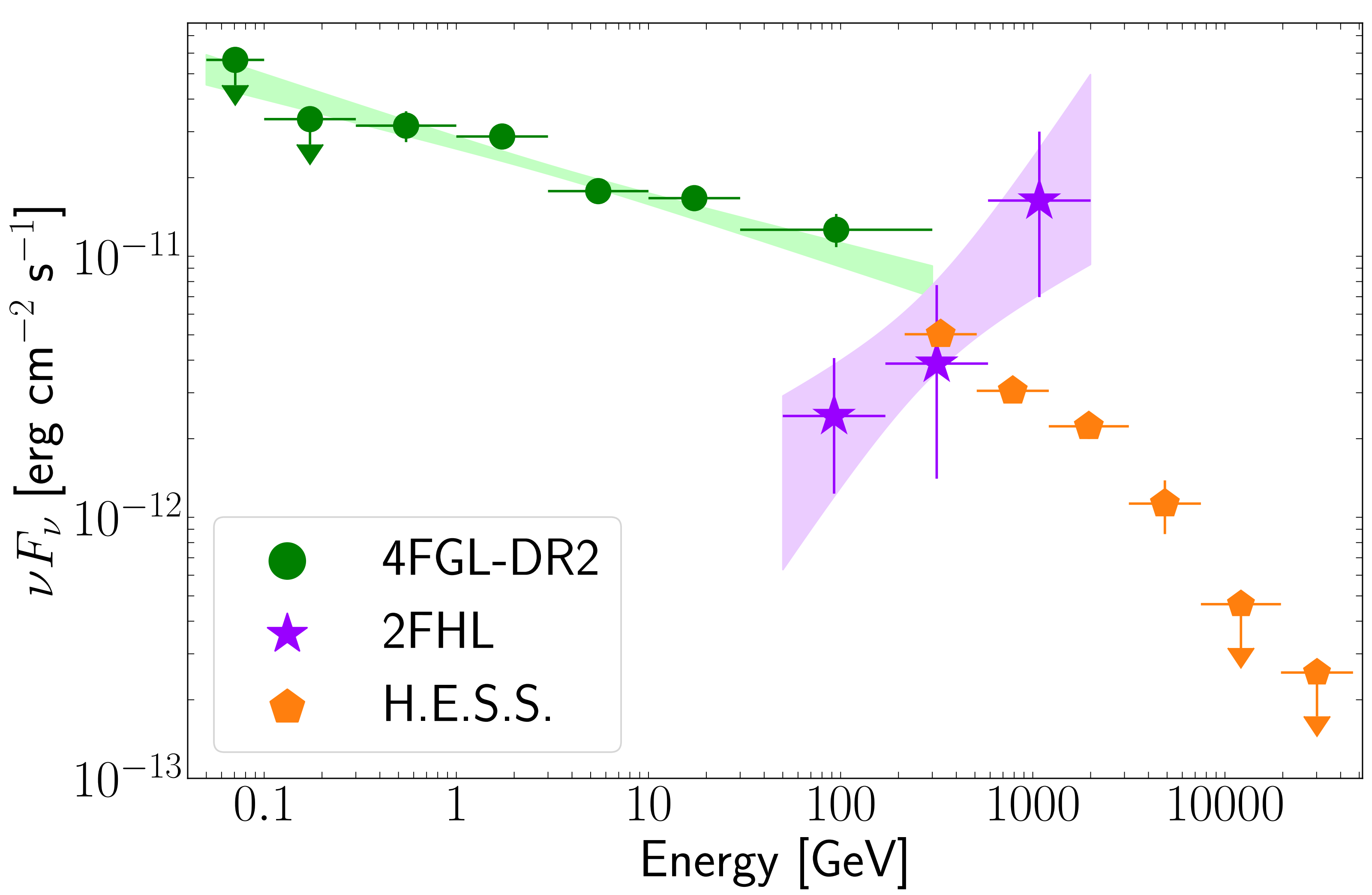
ICREA CSIC IEEC
Wei Zhang

Finanziato dall'Unione europea
NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA
INAF
ISTITUTO NAZIONALE DI ASTROFISICA

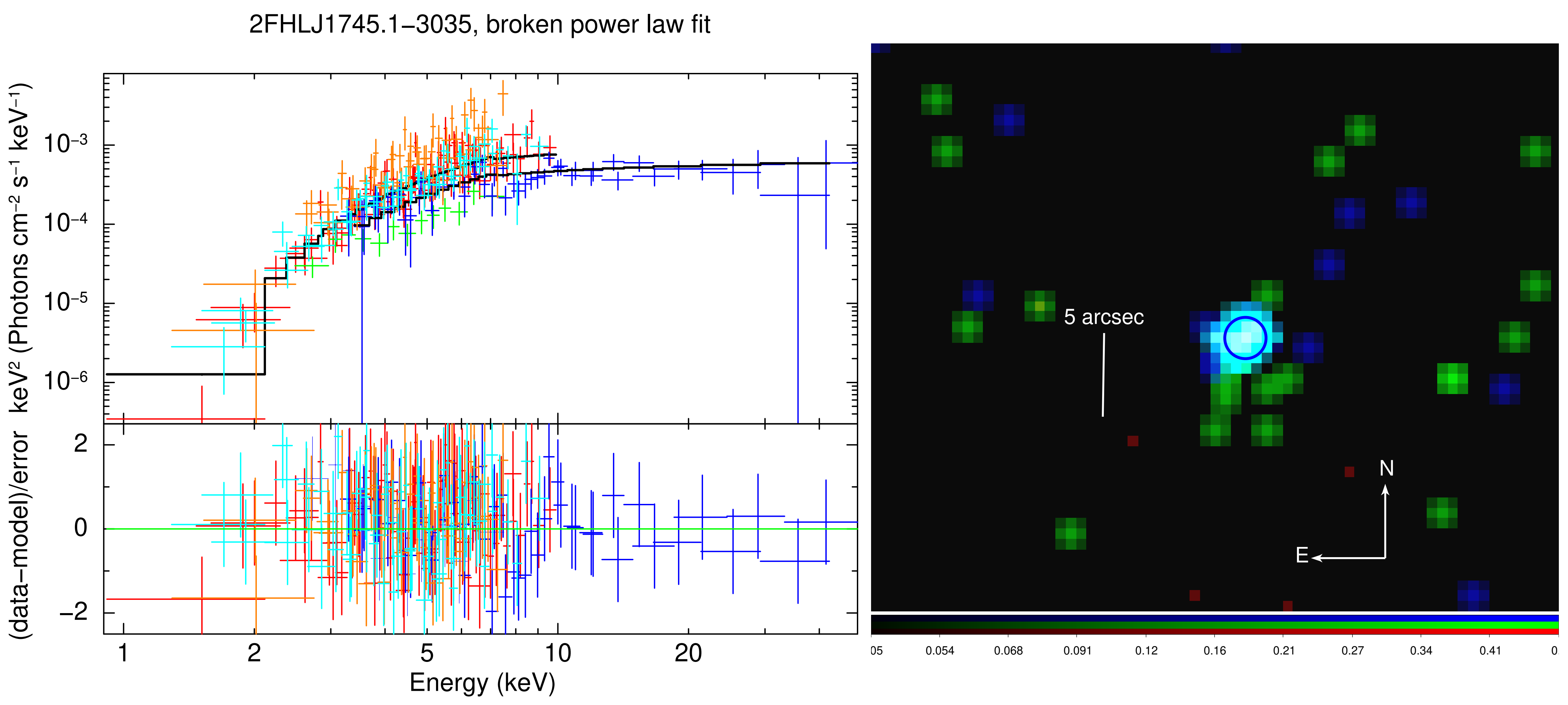
2FHLJ1745.1-3035: A Newly Discovered, Powerful Pulsar Wind Nebula Candidate

Very hard emitter (Gamma=1.2, Emax~1 TeV) detected by Fermi-LAT in the Galactic Plane. Unassociated, and not linked to nearby, softer 4FGL+H.E.S.S. source of unknown origin.

X-ray follow-up campaign (XMM-Newton, Chandra, NuSTAR): very hard spectrum in the X-rays as well, compact, but spatially resolved by Chandra (harder at center, softer in the outskirts: pulsar + PWN?)



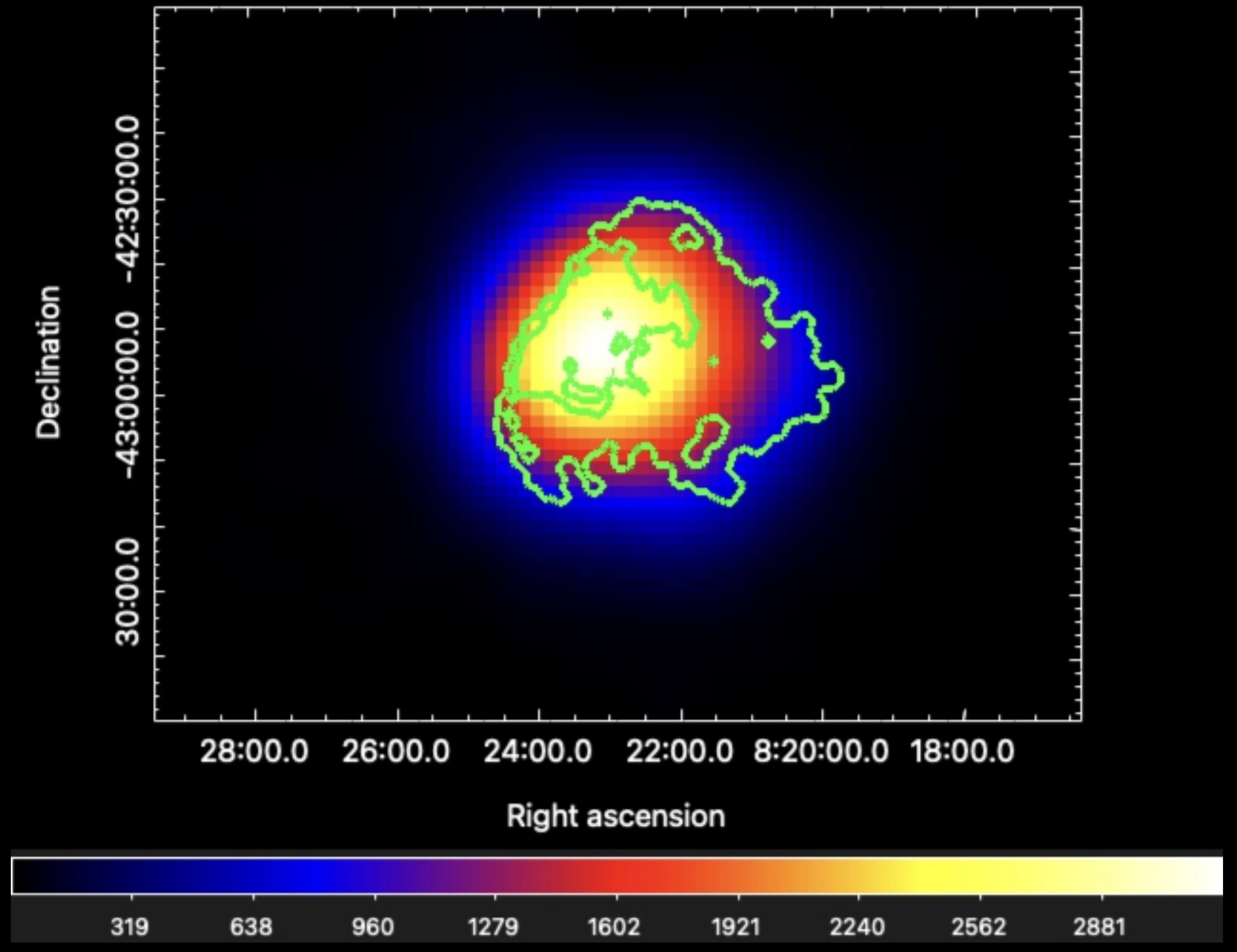
X-ray + SED Modelling: candidate compact, young (possibly youngest, age<1,000 years!) PWN. Ideal CTA follow-up target!

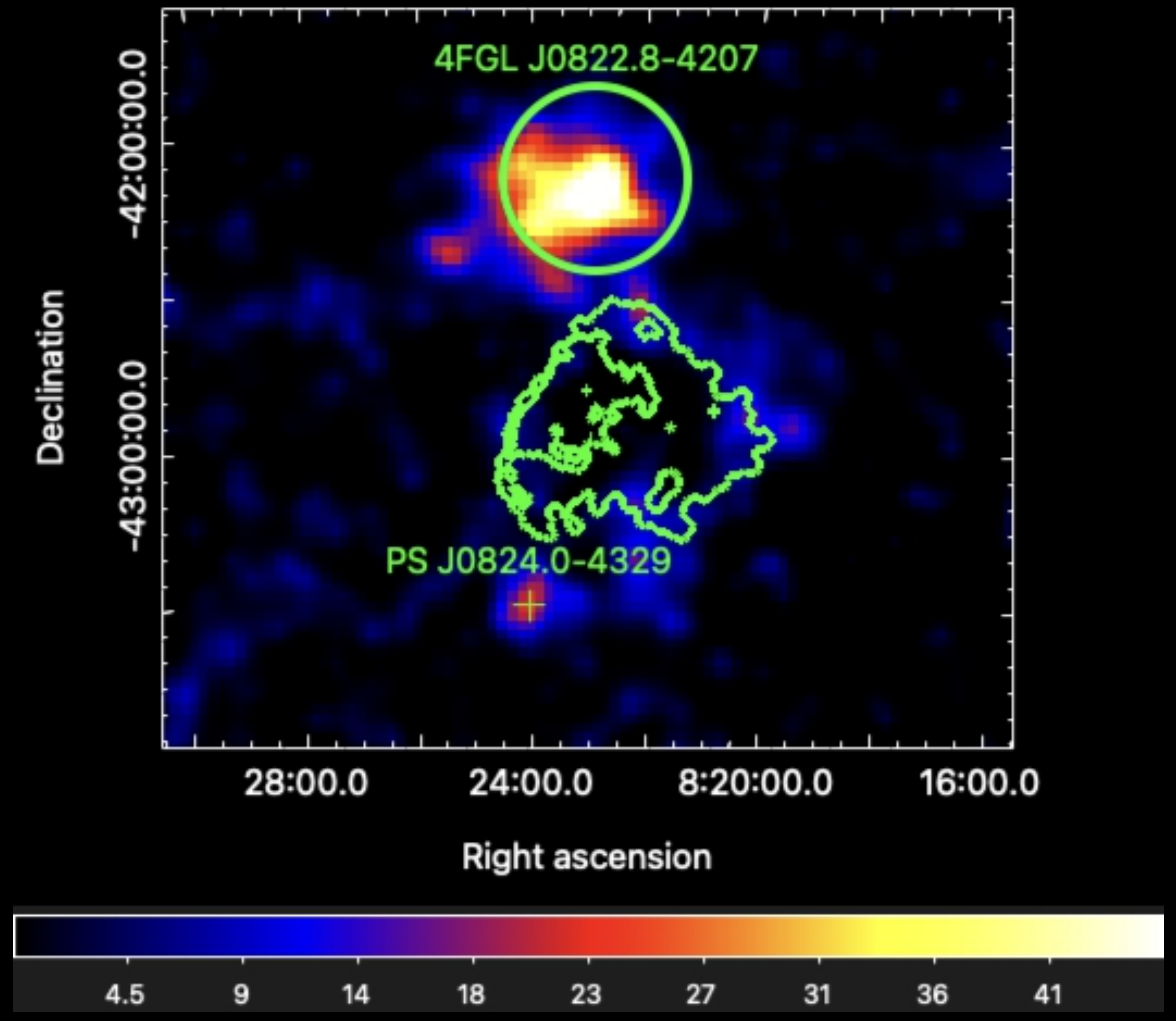


Gamma-ray emission from Puppis A with Fermi-LAT telescope: evidence for proton acceleration

1. Asymmetric gamma-ray emission:

   - Bright East side, interacting with a molecular cloud.
     Spectrum: Log Parabola. Radiative shock? Reaccelerated CRs (Uchiyama et al 2010)?
   - Fainter West side, interacting with an atomic cloud.
     Power Law. Non-radiative shock? DSA?





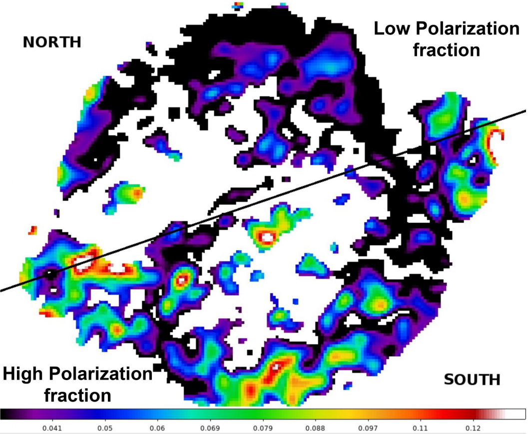
2. Two bright gamma-ray excesses out of the remnant:

- North: coincident with dense medium, extended, hard spectrum (w = 7.3 eV/cm3, SNR-escaping CR)
- South: coincident with dense medium, point-like, hard spectrum (w = 6.4 eV/cm^3, SNR-escaping CR)

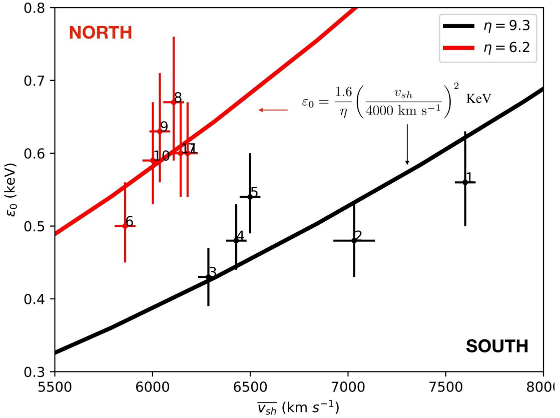
Roberta Giuffrida, Marianne Lemoine Goumard, Marco Miceli, Stefano Gabici, Hidetoshi Sano, Maki Aruga, Martin Mayer, Yasuo Fukui
on behalf of the Fermi-LAT collaboration

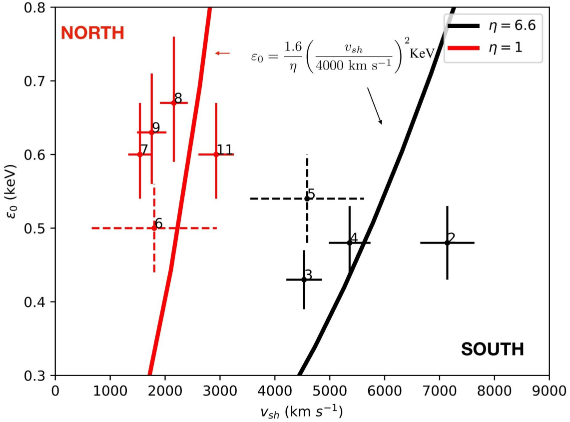
The Effects of Dense Medium on The Electron Acceleration in Kepler's SNR: A Multiwavelength Exploration

Radio Polarization Fraction

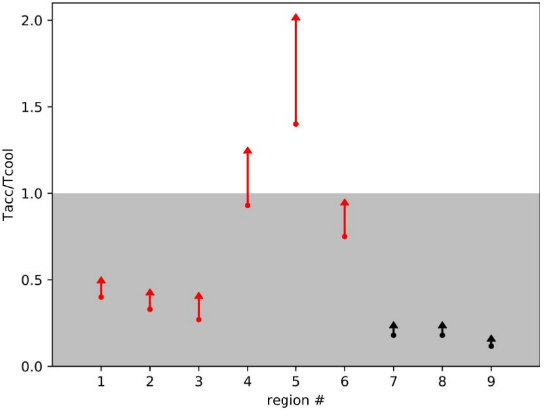


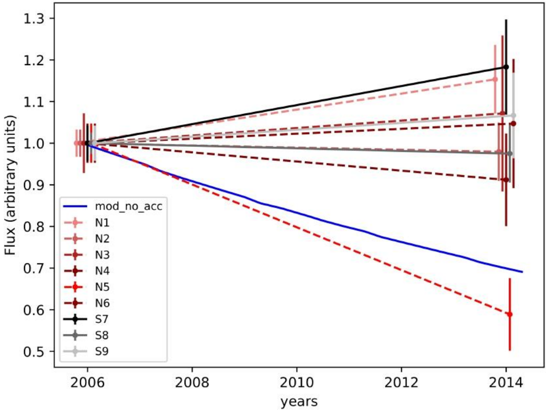
X-ray: XMM-Newton and NuSTAR



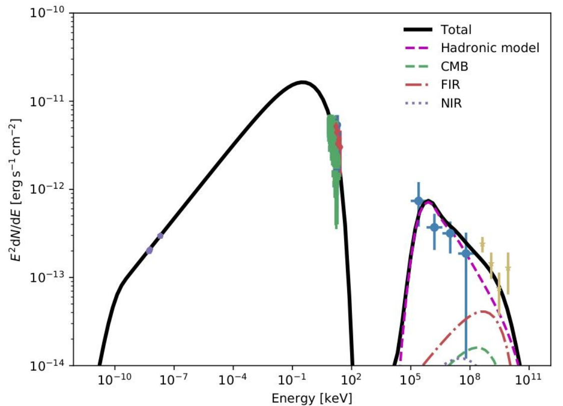


X-ray: two epochs Chandra





Spectral Energy Distribution



On the origin of HE CRs from Colliding Wind Binaries in SFRs: numerical simulations and particle acceleration

Falceta-Gonçalves, Diego
Kowal, Grzegorz; Abraham, Zulema & Banchetti, Gislaine

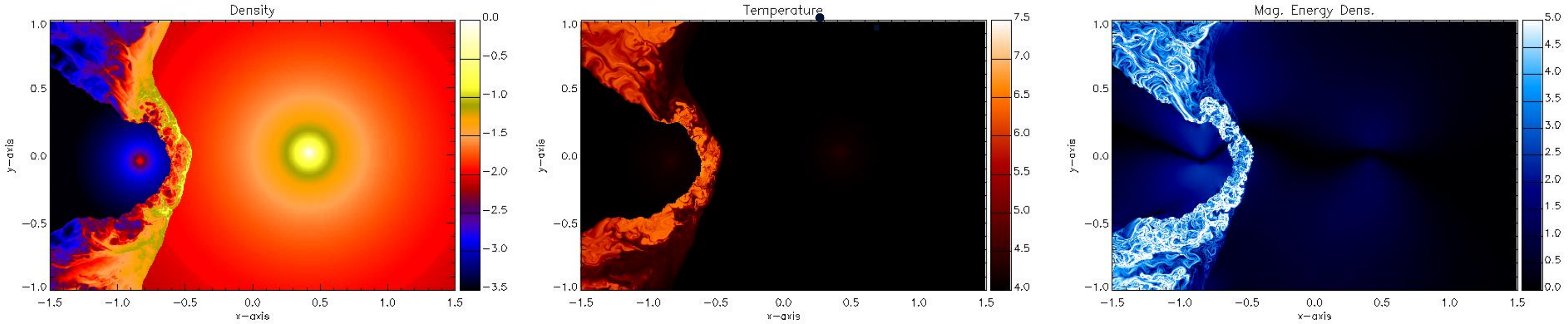
Universidade de São Paulo – School of Arts, Sciences & Humanities
São Paulo - Brazil

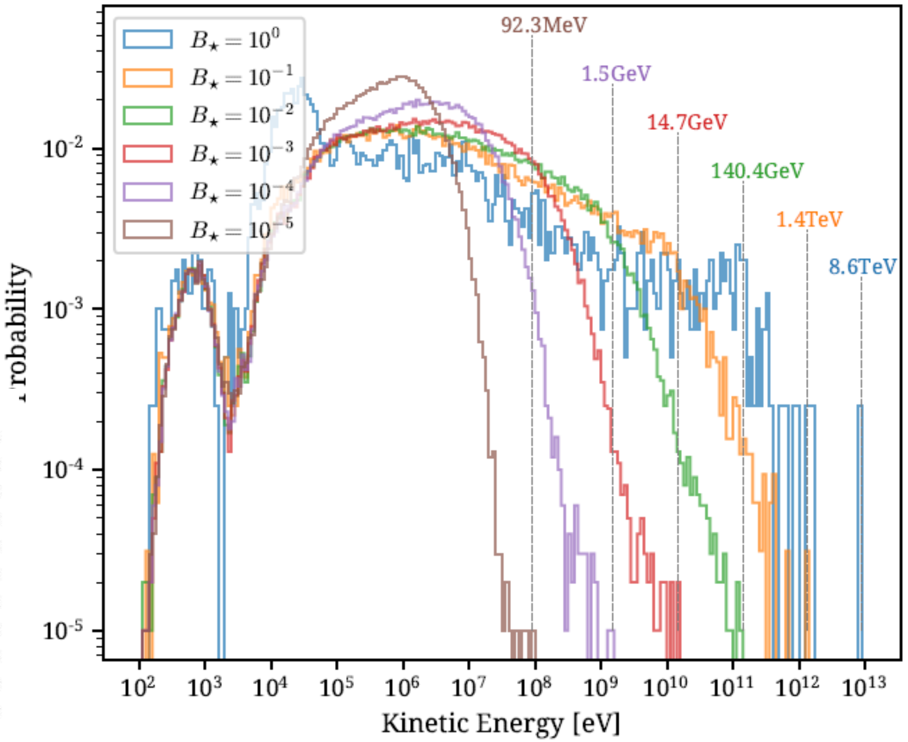
Motivation

- **Massive stars are mostly formed in binary/multiple systems (>50-70%).**
- **dM/dt ~ 10^{-7} - 10^{-4} M_{sun}/yr and wind speeds u ~ 700 – 4000 km/s.**
- **synchrotron emission, which indicates intense magnetization as well as high energy particles.**

Results

- **We use a Passive Particle Trajectory Integration method on top of the MHD.**
- **Our results showed that CWBs are efficient in accelerating particles in the > TeV energy range, confirming HESS and FERMI observations of Eta Carinae.**

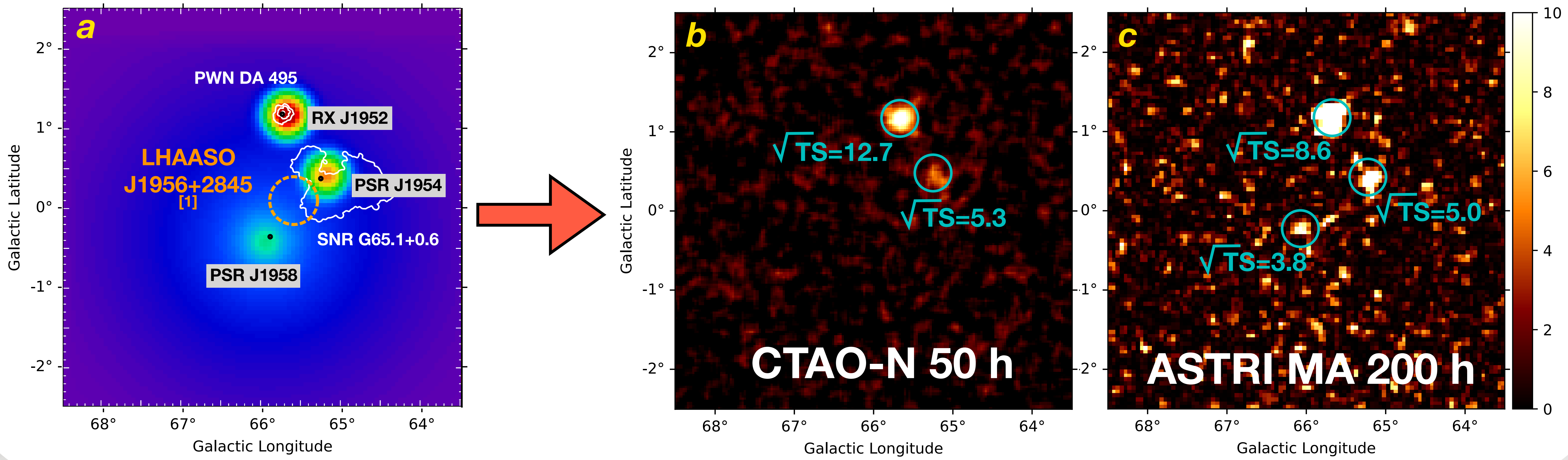




Multiwavelength characterization of the region around LHAASO J1956+2845

Michela Rigoselli[1], Silvia Crestan[1], Alberto Bonollo[1,2,3], Andrea Giuliani[1], Sandro Mereghetti[1]
for the ASTRI Project [http://www.astri.inaf.it/en/library/]

[1] INAF IASF-Milano
[2] University of Trento,
[3] IUSS-Pavia



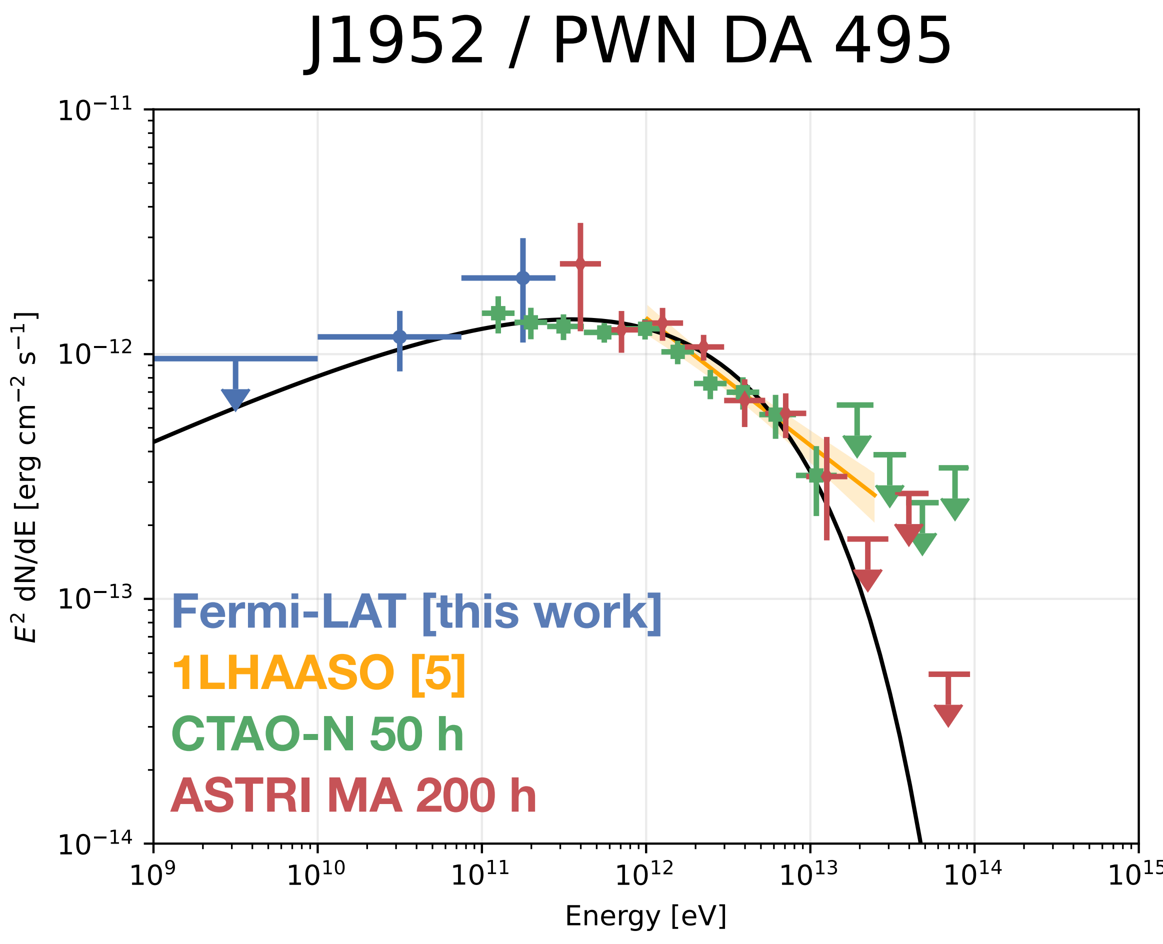
INPUT MODEL

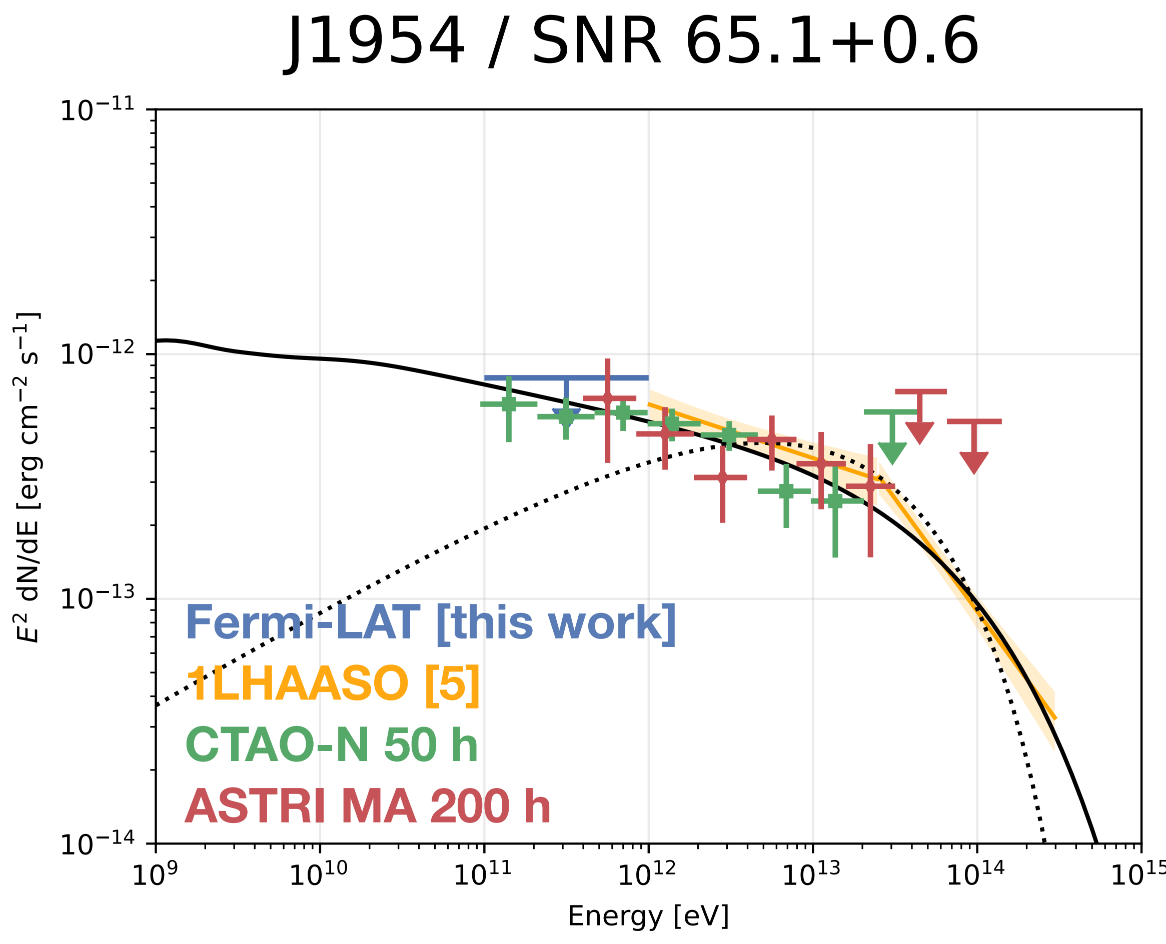
from our analysis of Fermi-LAT data [2]
and the study of multiwavelength emission [3,4,5]:

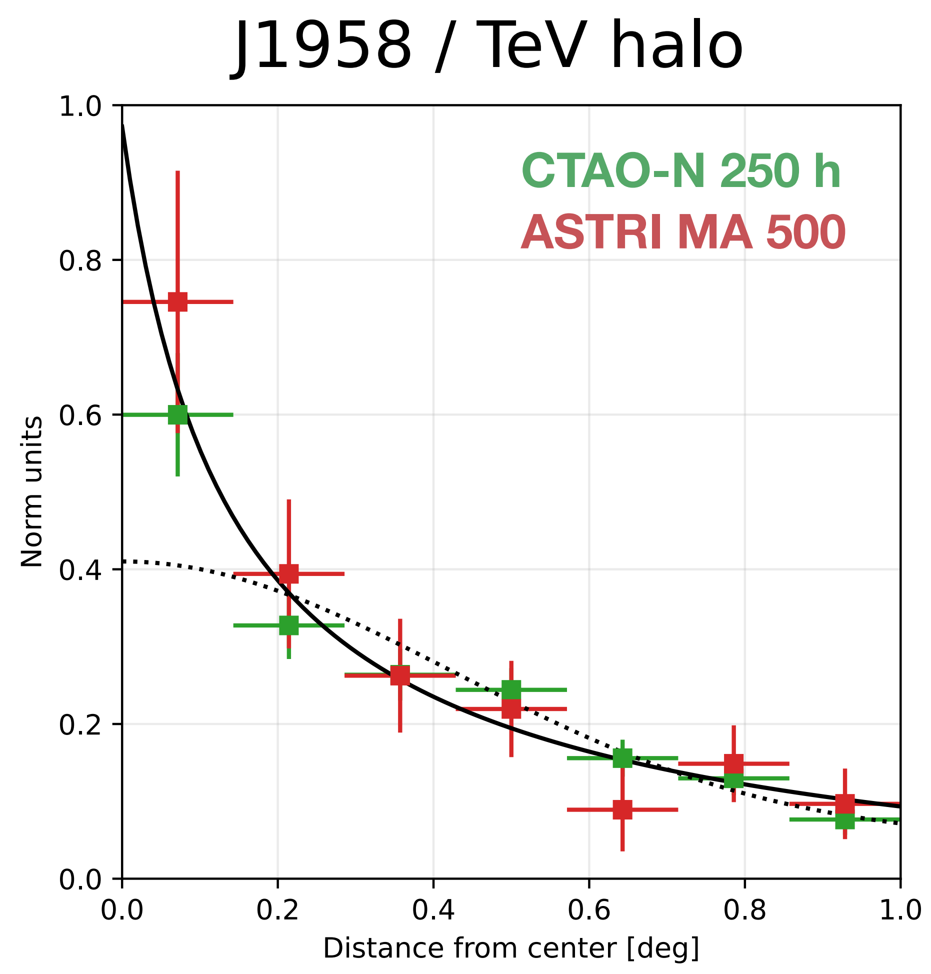
- **J1952 —> PWN DA 495**: Leptonic emission (α=2.4, E_c=16 TeV, B=6.7 μG)
  Gaussian morphology (σ=0.12°, [5])
- **J1954 —> SNR G65.1+0.6:** Hadronic emission (α=2.2, E_c=1 PeV)
  Gaussian morphology (σ=0.12°, [5])
- **J1958 —> TeV Halo:** Leptonic emission (α=2.3, E_c=250 TeV, B=5 μG)
  Diffusion-model morphology (θ_d=1°, [6])

RESULTS

of Fermi-LAT data [2], LHAASO spectra [5] and our simulated CTAO-North [7] and ASTRI Mini-Array [8] data:



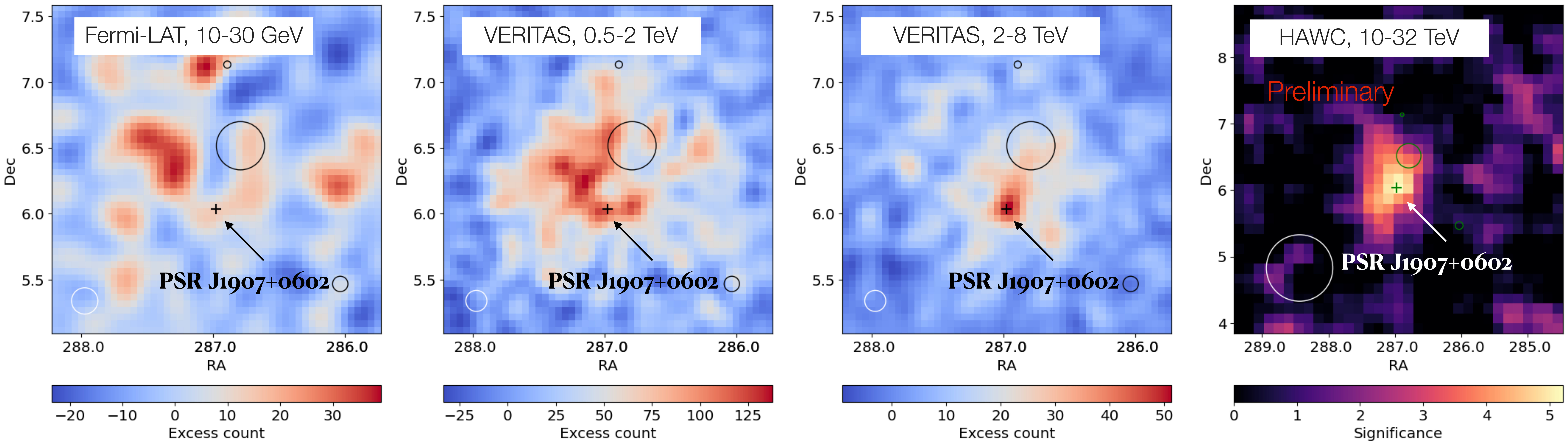




1. Cao et al. 2021, Nature, 594, 33
2. https://fermi.gsfc.nasa.gov/ssc/data/access/
3. Gao et al. 2011, A&A, 529, A159
4. Coerver et al. 2019, ApJ, 878, 126
5. Cao et al. 2024, ApJSS, 271, 25
6. Abeysekara et al. 2017, Science, 358, 911
7. *Science with the Cherenkov Telescope Array*, 2019
8. Scuderi et al., 2022, JHEAP, 35, 52

Investigating the leptonic PeVatron: MGRO J1908+06, with Fermi-LAT, VERITAS, and HAWC

Ruo-Yu Shang, Jordan Eagle, Sara Coutiño De León, Sajan Kumar

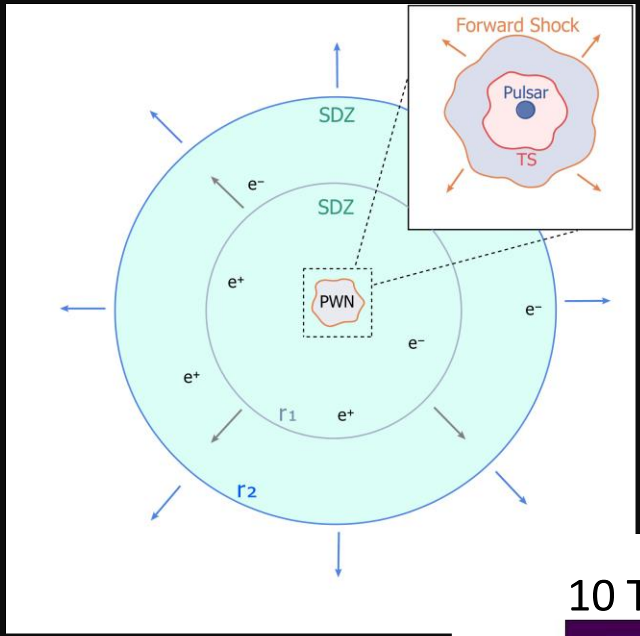


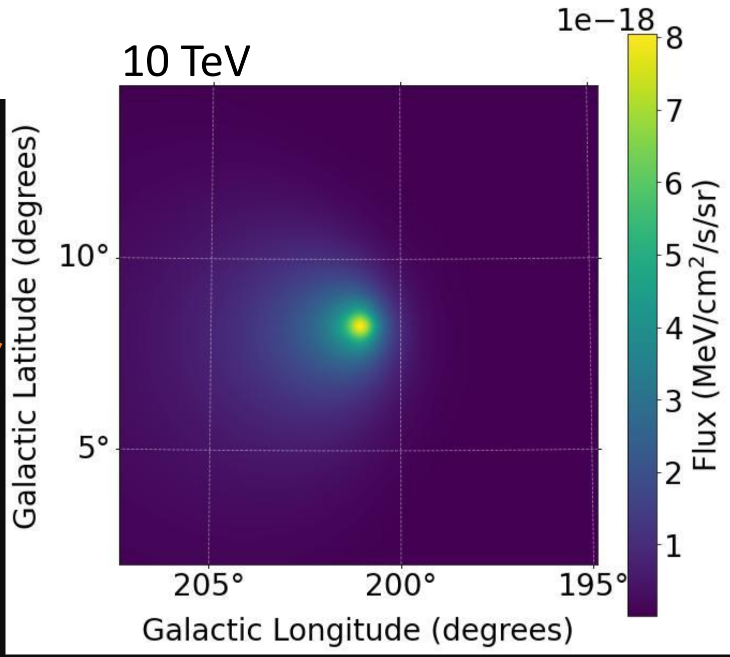
Watch the PWN evolution with multi-wavelength γ-ray data: low-energy γ rays reveal the relic nebula, while the high-energy γ rays show the recent image of the nebula. Analysis uses γ-ray morphology and spectrum to study PWN physics parameters.

Multi-messenger Modeling of the Monogem Pulsar Halo

Youyou Li
with Shin'ichiro Ando, Oscar Macias, and Jacco Vink

CTAO Symposium
15-18, April 2024





Realist modeling of multi-wavelength + CRs!

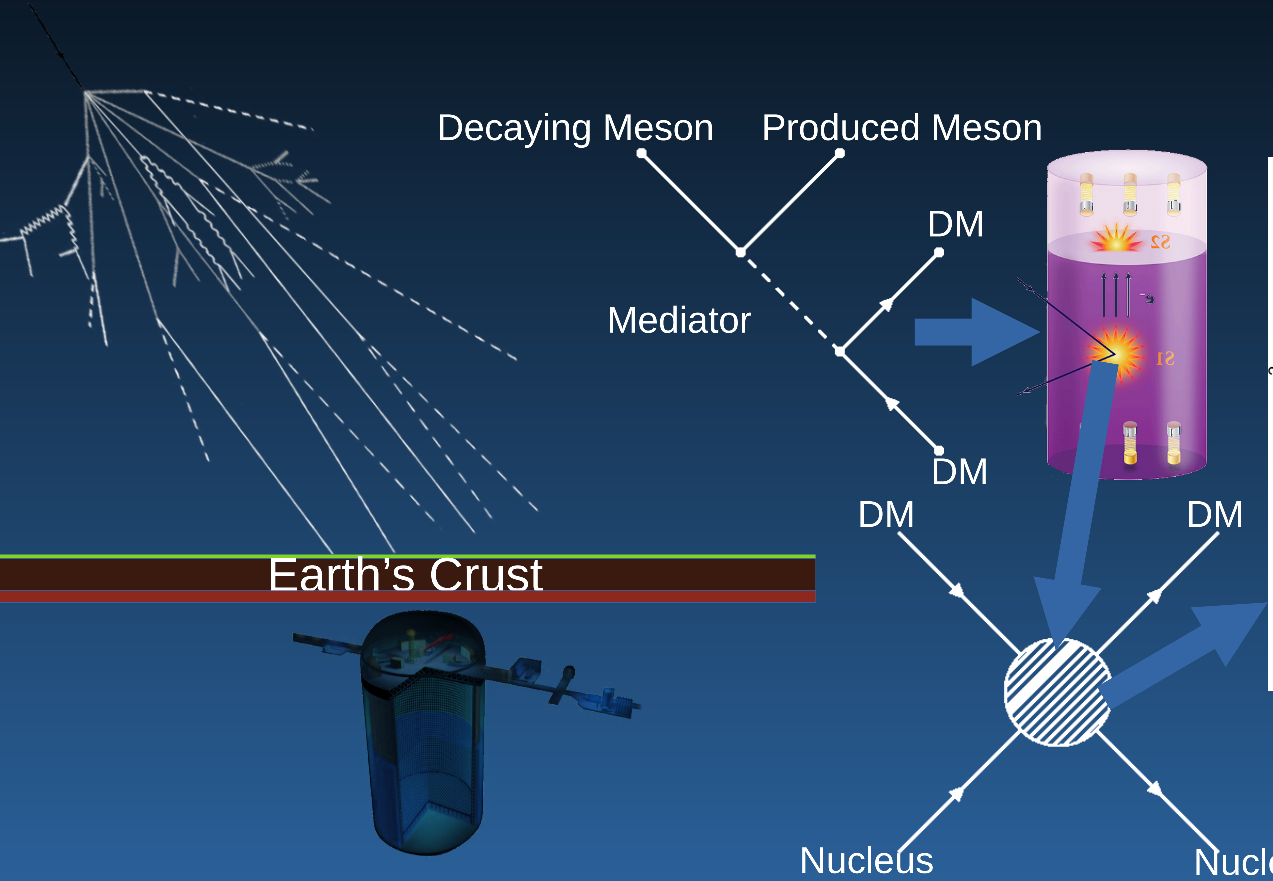
Predictions for future observations!

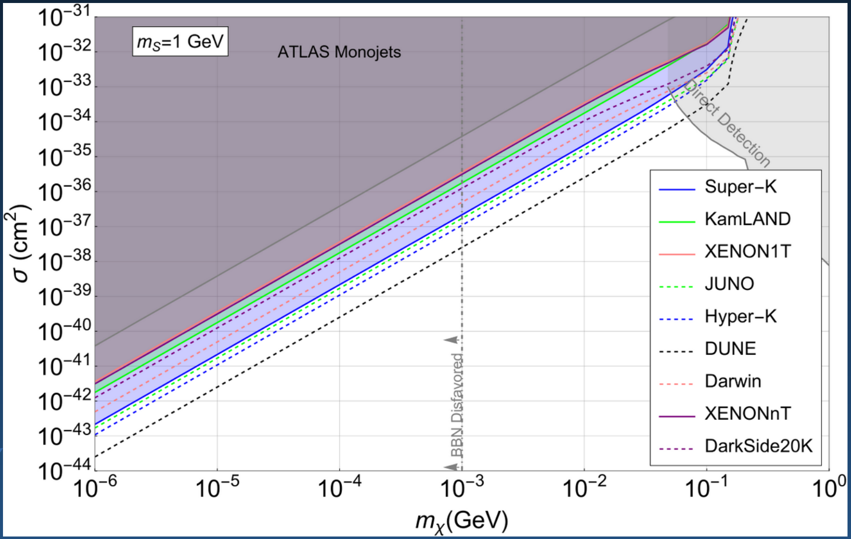
University of Amsterdam

GRAPPA
GRavitation AstroParticle Physics Amsterdam

Atmospheric Sub-GeV Dark Matter at Neutrino Detectors

Francesco Xotta, Filippo Sala, Silvia Pascoli
francesco.xotta@ung.si





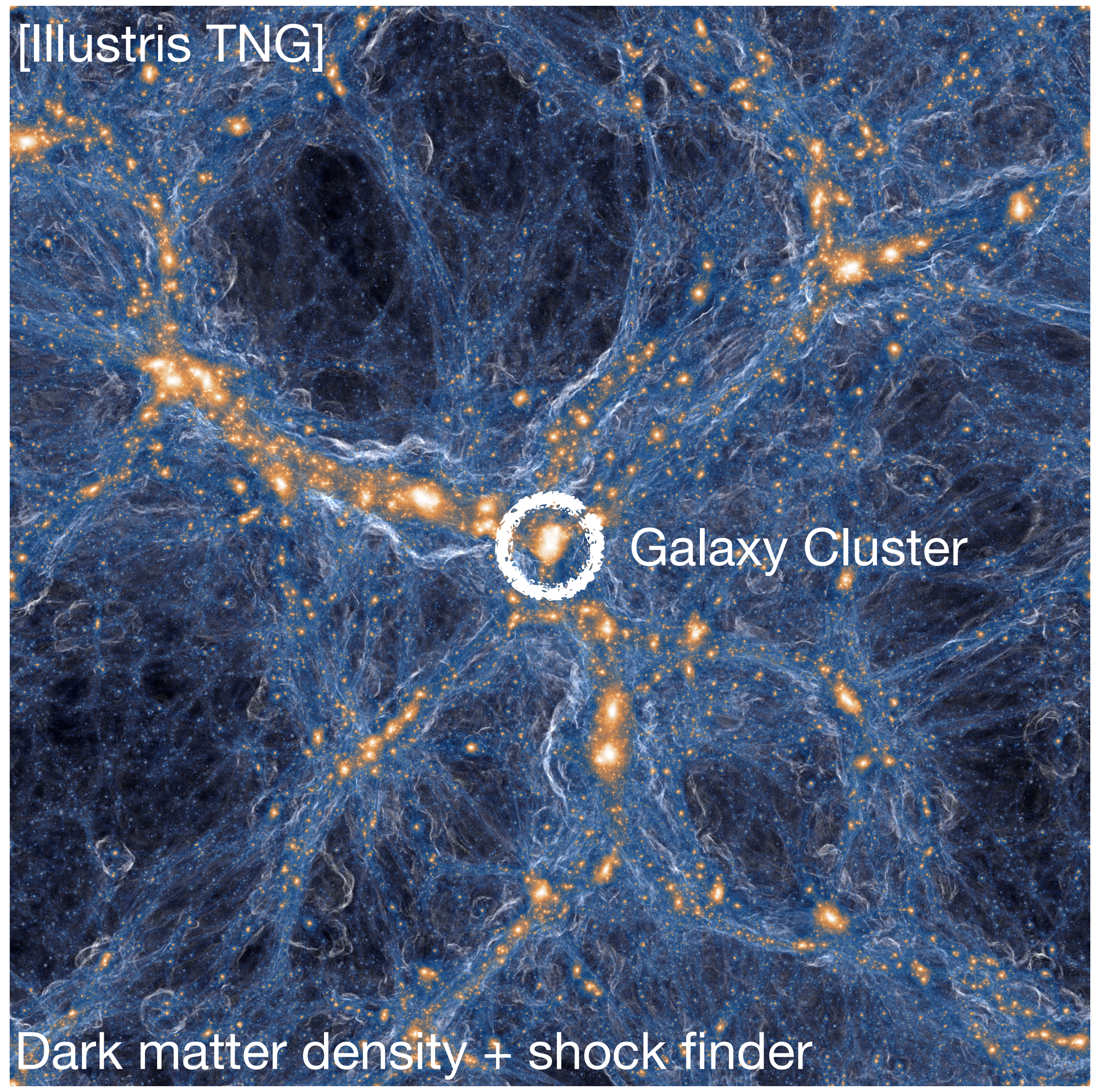
Dark Matter γ-ray searches in Galaxy Clusters with CTA: status & prospects

Judit Pérez-Romero (judit.perez@ung.si)
CTA Cons. 23 [2309.03712]

Poster

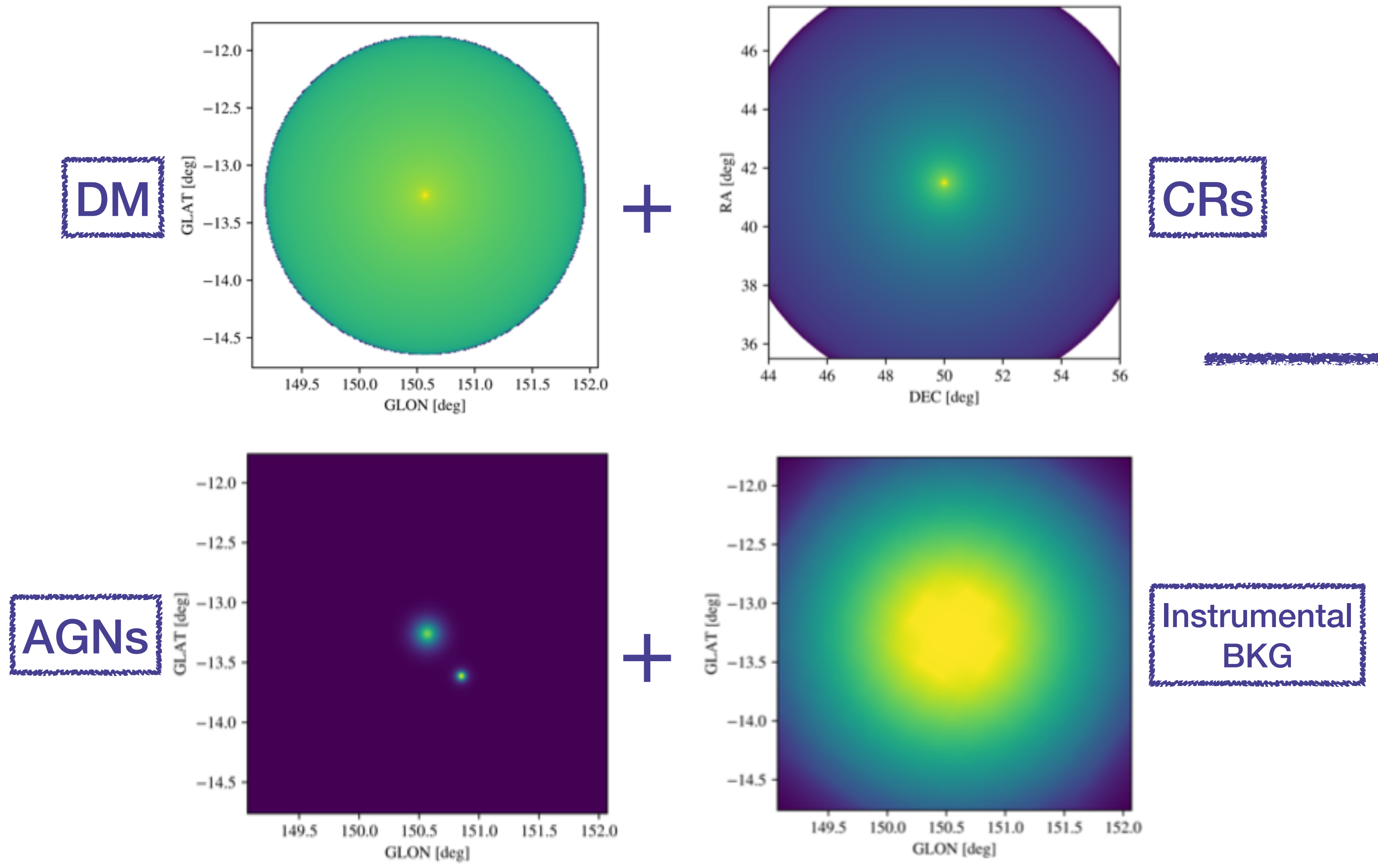
Paper

- Different gravitational evidences hint to the existence of Dark Matter (DM), a massive component of the Universe responsible for shaping the cosmic structures
- In denser regions, DM particles can annihilate/decay, producing γ-ray emission



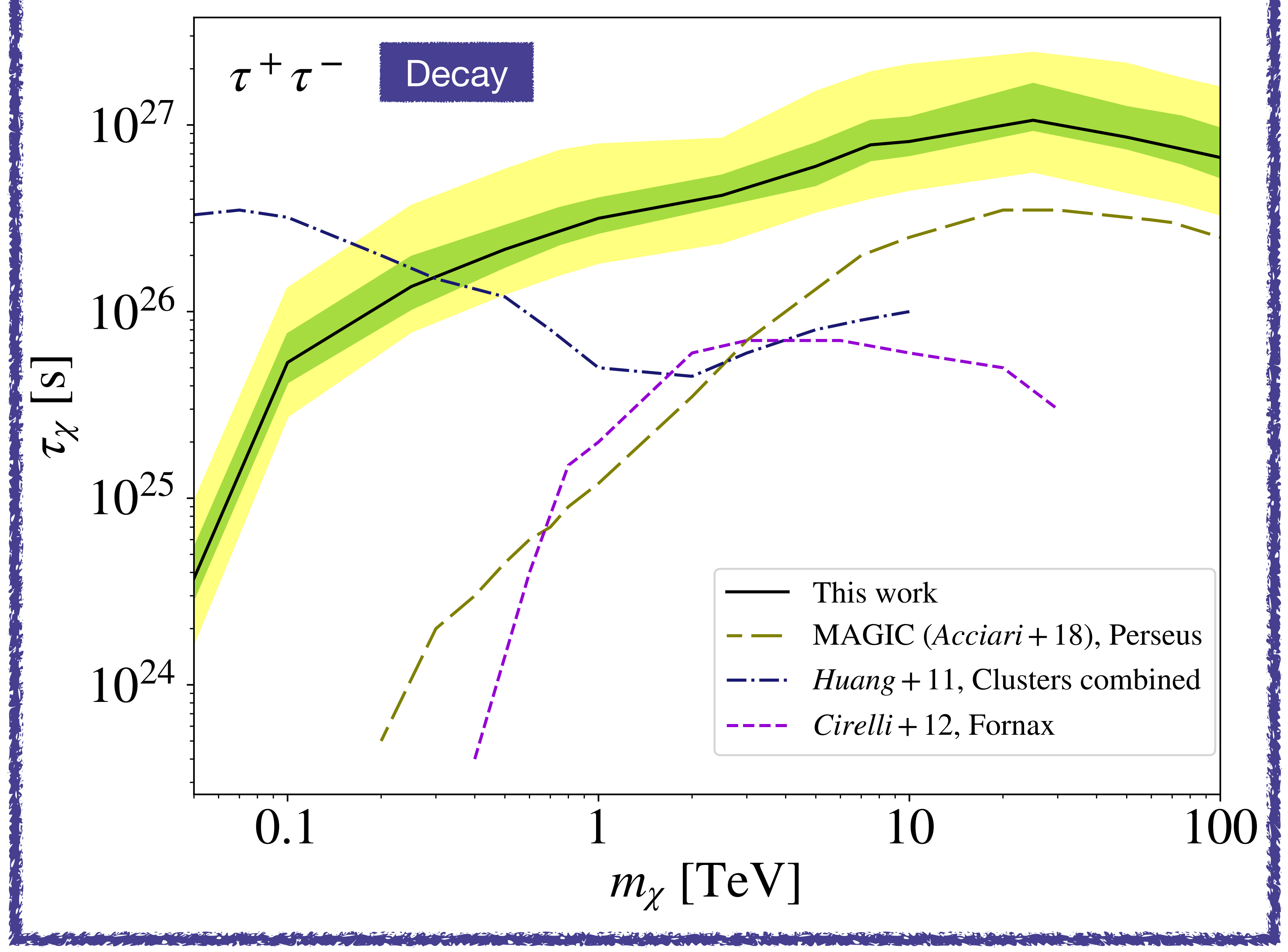
Galaxy Clusters are extremely massive, DM dominated objects
Perfect for γ-ray DM searches

- The Cherenkov Telescope Array (CTA) is the future of high-energy γ-ray astronomy (one order of magnitude improvement in sensitivity respect current IACTs)
- State-of-the-art model of DM density profile including the contribution of substructures
- Template fitting analysis including all γ-ray emissions in the region



CTA will observe the Perseus Galaxy Cluster
CTA has superb capabilities to test the TeV range for WIMP DM models

- Constraints for the DM parameters for the 300h of planned observations of Perseus cluster



Most constraining 95% C.L. limits for decaying DM in the literature

Galactic Centre Dark Matter Searches with SWGO

The Southern Wide-field Gamma-ray Observatory

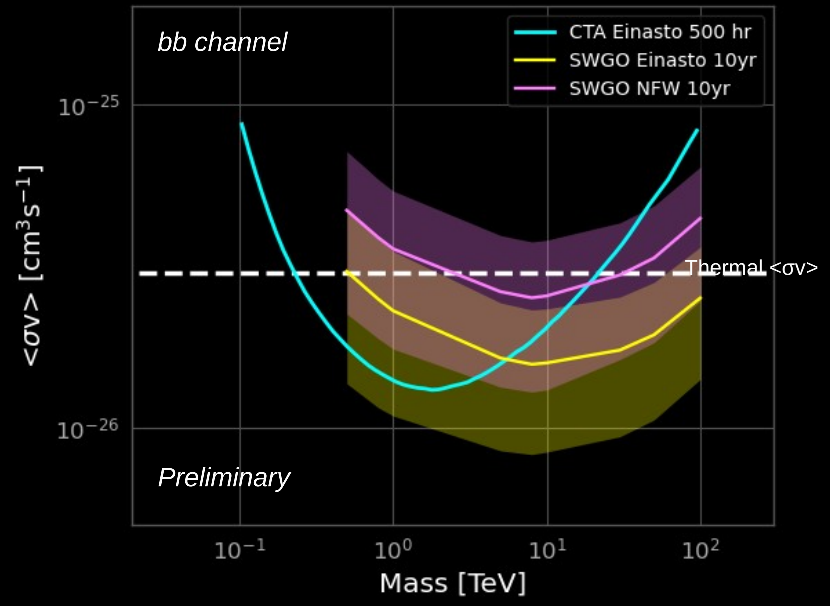
J. Djuvsland, H. X. Ren, A. Albert, M. Andrade, J. Serna, A. Viana and J. A. Hinton for the SWGO Collaboration

Estimated WIMP sensitivity for SWGO

(future gamma ray observatory in South America)

for observations of the Galactic Centre:

→ Sensitivity below thermal relic cross section for *O*(10 TeV) WIMP masses



Expected exclusion limits for WIMP annihilation at 95% C.L. for 10 years of SWGO operation compared to expectations for CTA [JCAP01(2021)057].

UNIVERSITY OF BERGEN

MAX-PLANCK-INSTITUT FÜR KERNPHYSIK HEIDELBERG

Funded by The Research Council of Norway
Project no. 301718

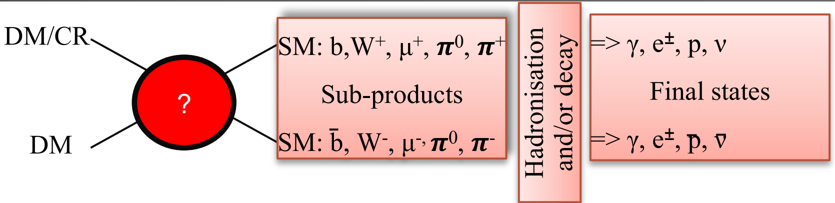
Searching for keV to PeV DM with the SWGO

Aion Viana[1], M. Andrade[1], V. de Souza[1], J. Fagiani[1], V.P. Gonçalves[3], E. Moulin[2], S. Miranda[1], I. Reis[1], C. Siqueira[1] for the SWGO Collaboration
[1]Instituto de Física de São Carlos, Univ. de São Paulo, São Carlos SP, Brazil
[2]Irfu, CEA Saclay, Université Paris-Saclay, Gif-sur-Yvette, France
[3]Institute of Physics and Mathematics, Federal University of Pelotas, Pelotas-RS, Brazil

CTAO Science Symposium
15-18 April Bologna, Italy

Supported by: FAPESP CNPq APOEMA

➢ **If DM** is a particle that **couples** non-gravitationally **to Standard Model particles,** its interaction can lead to observable signatures, in particular to gamma-rays.



The Southern Wide-field Gamma-ray Observatory
[arXiv:1902.08429]

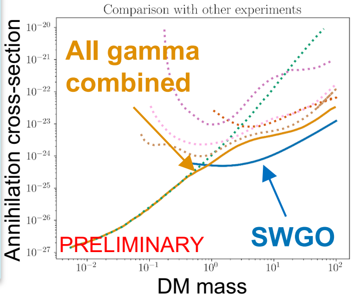
- Wide-angle gamma-ray observatory to be built in South America
- Covering the energy range of 100s of GeV up to the PeV scale
- Significant sensitivity improvement over current generation
- Various detector concepts under study

➢ SWGO will have a **rich Dark Matter program**
➢ **Complementary to CTA** in the Southern hemisphere

DARK MATTER SEARCHES IN DWARF GALAXIES

➢ 14 galaxies combined annihilation sensitivity

SWGO dSph: improvement of an order of magnitude from current, and more sensitive than CTA for dSph searches in TeV range

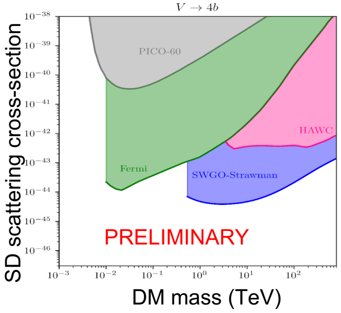


[arXiv:2309.10102]

DARK MATTER SEARCHES IN THE SUN

➢ Sensitivity to DM **SD scattering cross-section up to PeV masses**

SWGO Sun: improvement of up to two orders of magnitude from current detectors



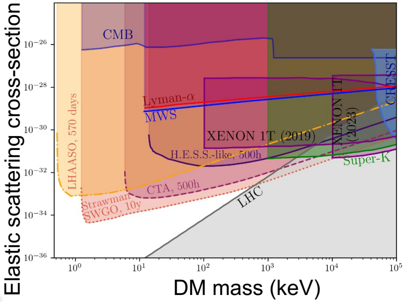
[under internal review]

COSMIC-RAY SCATTERING ON SUB-GEV DARK MATTER

➢ Sensitivity to **scattering cross-section** of sub-GeV DM particles

Constraints to currently unexplored parameter space, unavailable to other experiments;

SWGO sub-GeV DM: most sensitive prospects, better than LHAASO due to GC



[arXiv:2403.09343]

Search for the evaporation of primordial black holes with H.E.S.S.

Primordial Black Holes (PBH)

- Black Holes evaporate over time due to thermal emission (Hawking temperature).
- Speculative $10^{15} g$ PBHs would be evaporating now.
- TeV photons are emitted in the last hours before total evaporation.
- Signal: point-like signal during a short time-window

  ($\Delta t \simeq$ a few seconds).

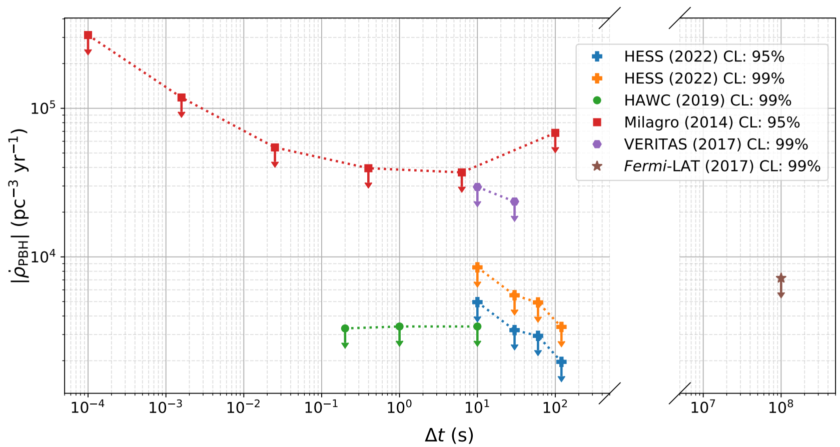
Search with H.E.S.S.

- 4816 hours from H.E.S.S. I phase (2004 $\rightarrow$ 2012).
- Search window: $\Delta\theta = 0.14^o$ (space),
  $\Delta t = 10, 30, 60, 120$ s (time).
- Statistical background found by "scrambling" the

  arrival time of photons.

Results

- No excess signal over background found for any value of Δt.
- Most constraining 95% CL upper limit on the PBH burst rate is $\dot{\rho}_{\mathrm{PBH}} < 2000\mathrm{pc}^3\mathrm{yr}^1$.
- Comparable to HAWC and Fermi-LAT constraints



Upper limits on the evaporation rate of PBHs $\dot{\rho}_{PBH}$ as a function of Δt.

Publication

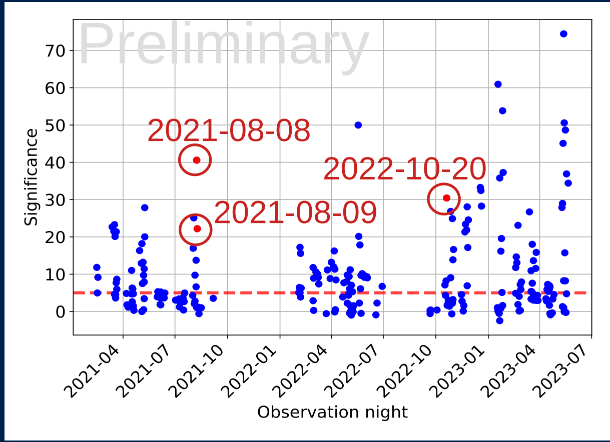
F.A Aharonian et al, H.E.S.S. collaboration, Journal of Cosmology and Astroparticle Physics, *vol. 2023, no. 4 (2023), doi:10.1088/1475-7516/2023/04/040*

Lorentz invariance violation search with the CTAO Large-Sized Telescope

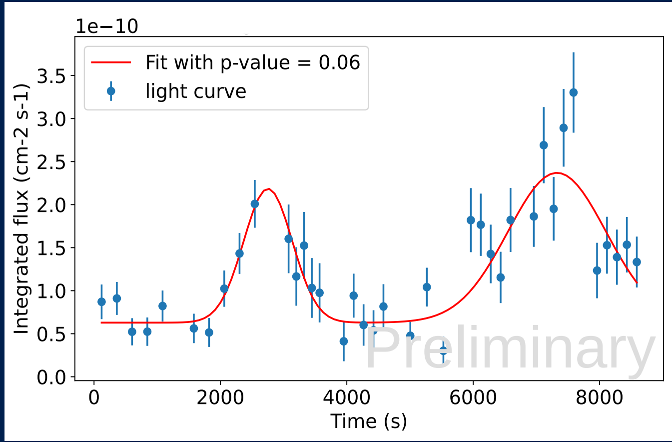
Speaker: Cyann Plard

- Extraction of a limit on the quantum gravity energy E_{QG} from γ-rays time delays
- A systematic study of all AGN data from LST-1

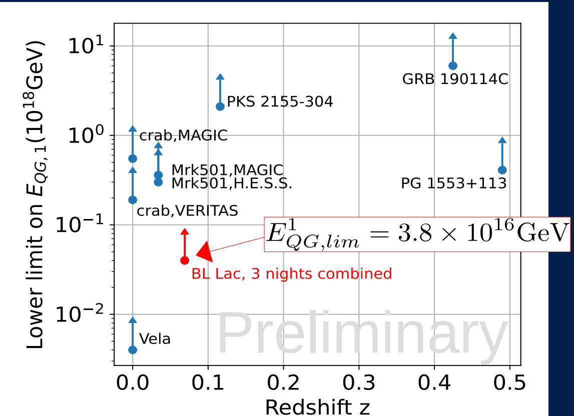
Significance of observation nights



Variability pattern of a lightcurve



Extracted limit on E_{QG}



Bolmont et al., 2022

Lorentz invariance violation searches and intrinsic effects with the Cherenkov Telescope Array: A feasibility study for flaring blazars

cherenkov telescope array

A. Rosales de León, J. Bolmont, H. Sol

Would CTA be able to detect intrinsic or LIV time delays from flaring blazars?

TIME-DEPENDENT AGN MODELING

- Based on Mrk 421 bright TeV flare of Feb, 2010.
- One-zone SSC model parameterization.
- ~5.5 h evolution of the flare.
- Output: SED snapshots with different values of injected LIV delays.

LIV injection:

- 1st order correction to the dispersion relation:

$$E^2 \simeq p^2c^2 \times \left[1 \pm \sum_{n=1}^{\infty} \left(\frac{E}{E_{QG}}\right)^n\right]$$

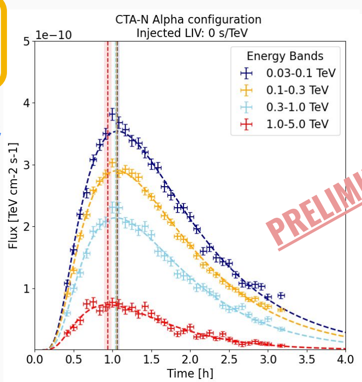
- Linear dependency of time lags with energy.
- Test subluminal and superluminal LIV effects: Injected LIV time delays: ±400, ±200 s/TeV.

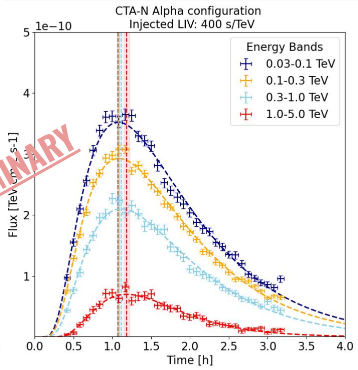
SIMULATIONS: CTA-AGN-VAR PIPELINE

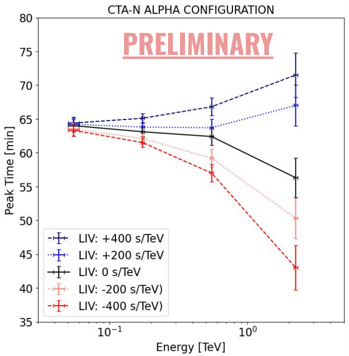
- Alpha and Omega configuration arrays.
- Prod5 v0.1 IRFs
- Fit an analytical spectral model: Power Law + Exp Cut-Off
- Output: Reconstructed light curves from simulations on different energy bands.
- Light curves are fitted using a Fast Rise Exponential Decay (FRED) function.

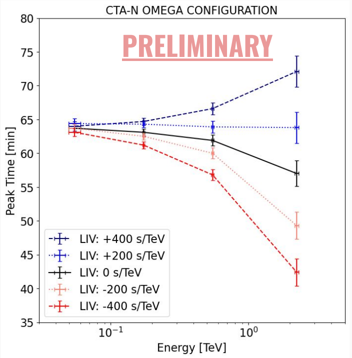
RESULTS

- Look for time delays between light curves at different energy bands.
- Check for the significance of the intrinsic and LIV time delays.
- Check for hysteresis patterns using Hardness-Intensity Diagrams (HID)









cnrs SORBONNE UNIVERSITÉ LPNHE PARIS l'Observatoire de Paris