Gamma-Ray Astrophysics at IPARCOS-GAE

IPARCOS Scientific Advisory Board: Bi-Annual Review 2026

IPARCOS

UNIVERSIDAD COMPLUTENSE MADRID

GAE Overview

Group Snapshot

- **Group Name & Principal Investigator (PI):** High Energy Physics (*Grupo de Altas Energías*), Marcos López-Moya
- **Current Size:** 8 Staff, 7 PhD students and 1 project manager (shared with GUAIX).
- **Key Personnel Changes:** 3 PhD students joined, 2 Postdocs left and 2 PhD students finished and left the group.
- **Education:** participating on BSc in ***Physics*** (*Structure of Matter* subjects) and MSc in ***Astrophysics***, ***Electronics, Theoretical*** and ***Biomedical*** Phyisics

Key Performance Indicators

- **High-Impact Publications:** 77 peer-reviewed papers (most in Q1 Journals), both by Individuals and in International Collaborations
- **Funding Secured:** 250 k€ (Ministry of Science -Proof of Concept-), 1 Industrial PhD grant.
- **Training:** 2 PhD theses defended.

GAE Overview

Top Scientific Highlights

- **Search for periodic variability in γ-ray blazars Using *Fermi*-LAT.** P. Peñil et al, Monthly Notices of the Royal Astronomical Society 541 (2025) 2955
- **Combined dark matter search towards dwarf spheroidal galaxies with *Fermi*-LAT, HAWC, H.E.S.S., MAGIC, and VERITAS**, Journal of Cosmology and Astroparticle Physics JCAP03(2026)035

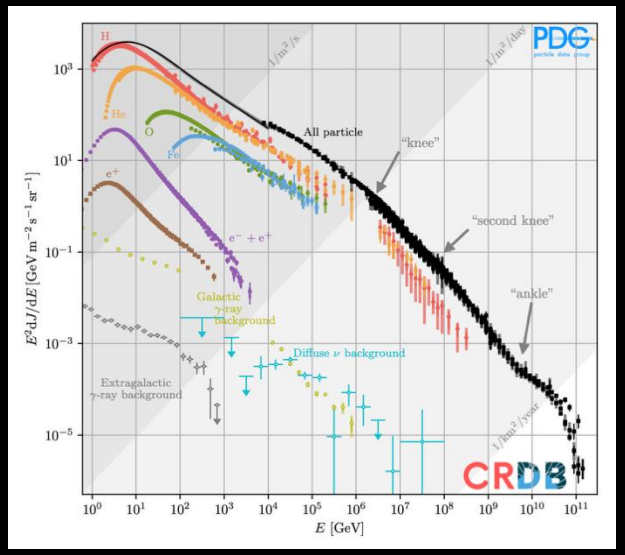
Leadership, Internationalization & Impact

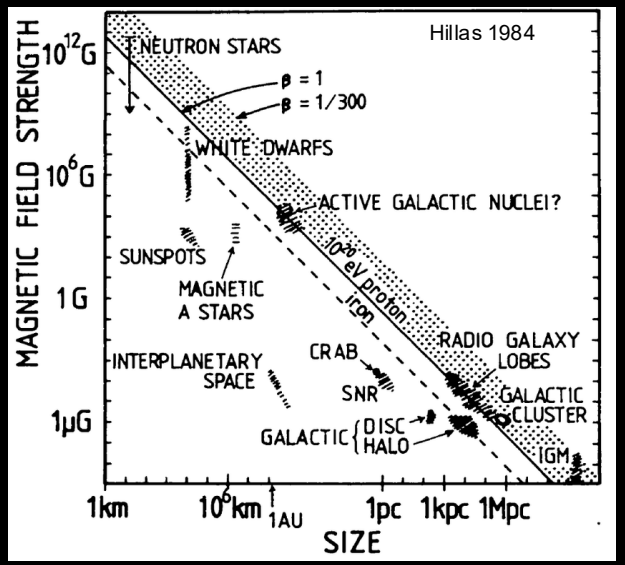
- **Contribution to Research Infrastructure:** MAGIC, Cherenkov Telescope Array Observatory (CTAO LST & MST cameras, CTAO Software)
- **Major Roles:** Responsibles of Onsite analysis @ MAGIC and LST-1. Trigger & Clock convener at CTAO NectarCAM-MST, two members in MAGIC and LST-1 Speakers and Publications Offices
- **Tech. Transfer / Outreach:** software package *CTLearn for AI-based CTAO reconstruction*, patent submitted on a *Uncorrelated random pulse generator based on a SiPM*

The Horizon

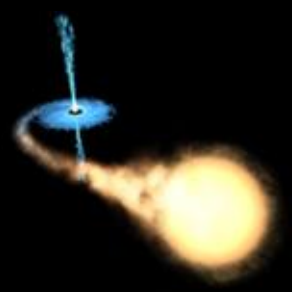
- **Next Big Milestone:** Commissioning of CTAO LSTs and MSTN-1 cameras

Scientific interests

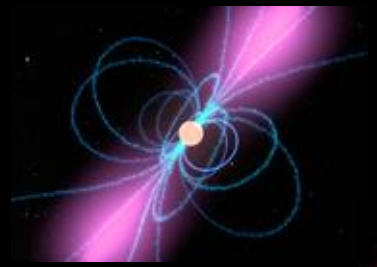




Gamma-Ray Astrophysics



Gamma-ray Binaries

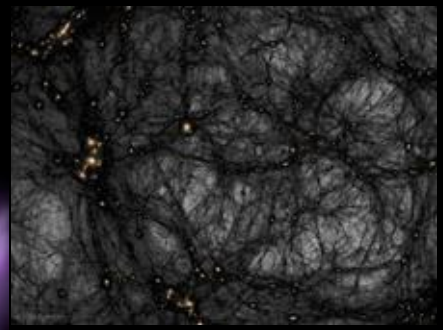


Pulsars

Gamma-ray Bursts

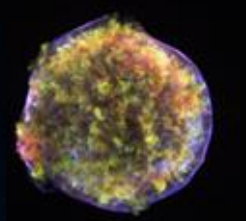
Compact-object mergers

Fundamental physics



Dark Matter searches
Lorentz Invariance
Cosmology

Pulsar Wind Nebulae



Supernova Remnants

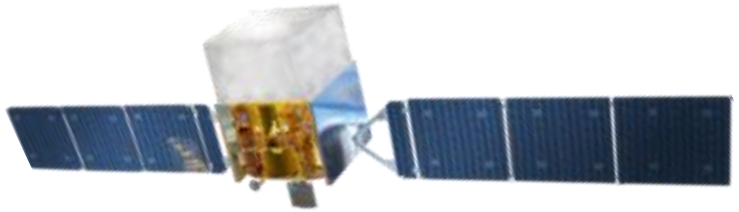
Starburst Galaxies

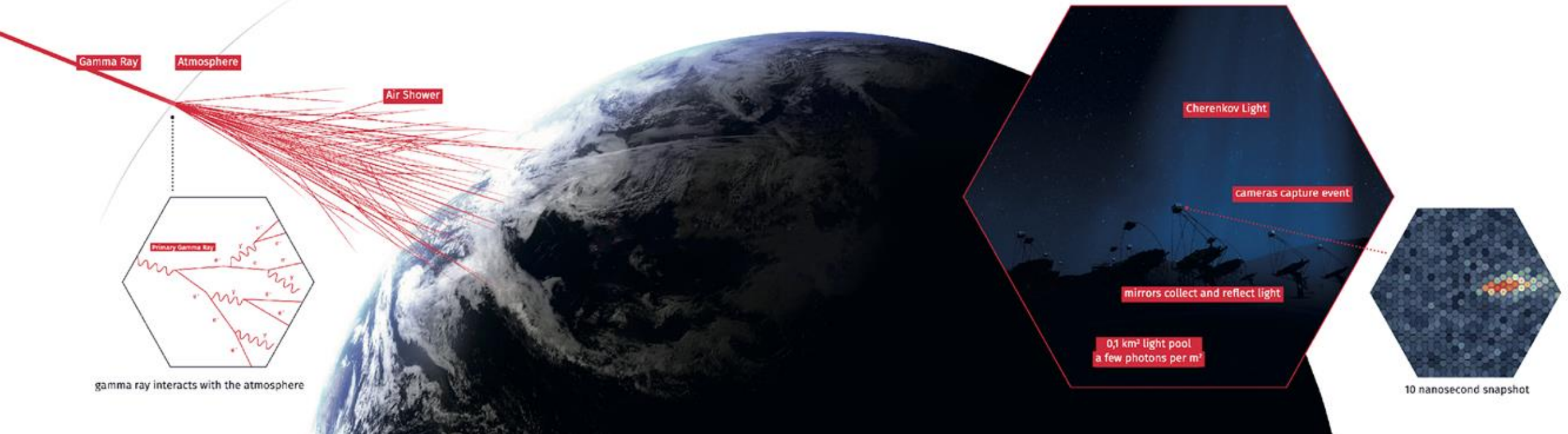
Active Galactic Nuclei

Gamma-Ray Telescopes

Present

Near future

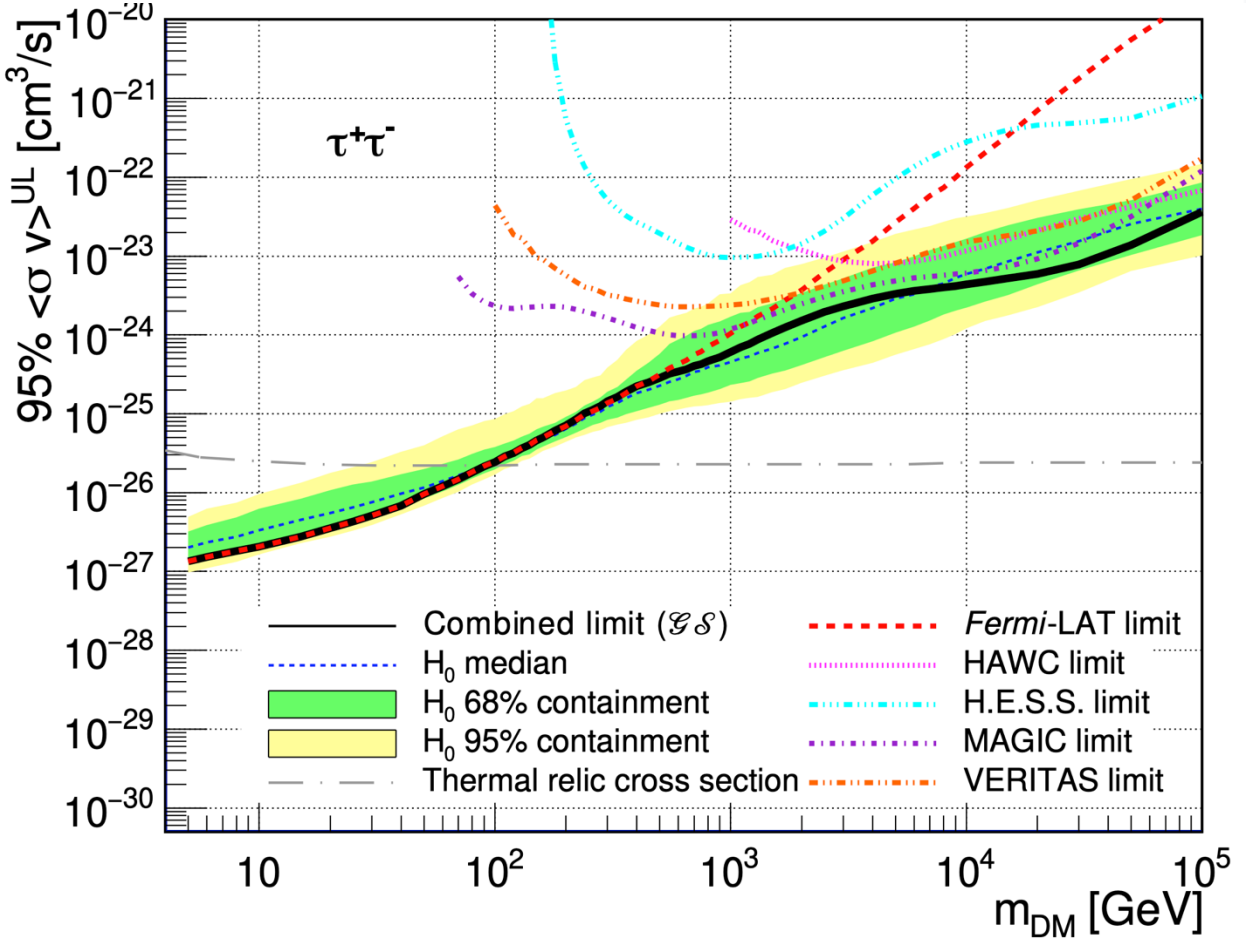




Dark Matter Searches

Combined search in dwarf spheroidal galaxies for branon dark matter annihilation signatures with the MAGIC telescopes

- **Four-target global joint likelihood analysis**
- **Most contraining limits to date for branon DM above 1 TeV**
- **Synergistic project between IPARCOS theoreticians and experimentalists**



IPARCOS-GAE leadership

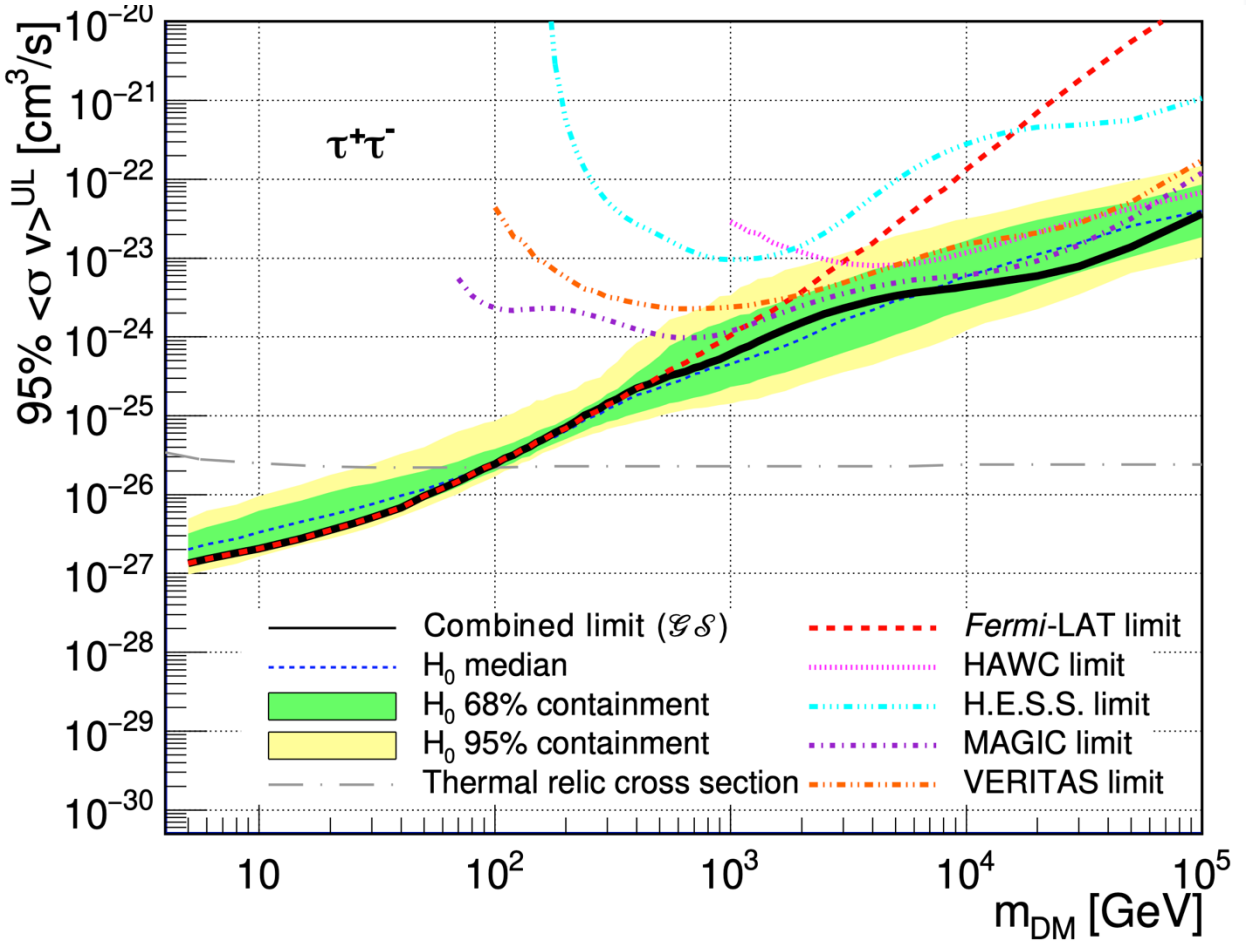
- **Tjark Miener (former PhD student) as corresponding author**

JCAP03(2025)020

Dark Matter Searches

Combined dark matter search towards dwarf spheroidal galaxies with *Fermi*-LAT, HAWC, H.E.S.S., MAGIC, and VERITAS

- **Five-instrument global joint likelihood analysis**
- **2-3 times more constraining upper limits on $\langle \sigma v \rangle$ than the individual results**
- **Wide mass range spanning from 5 GeV to 100 TeV**
- **Legacy results until CTAO comes full online**



IPARCOS-GAE leadership

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JCAP03(2026)035

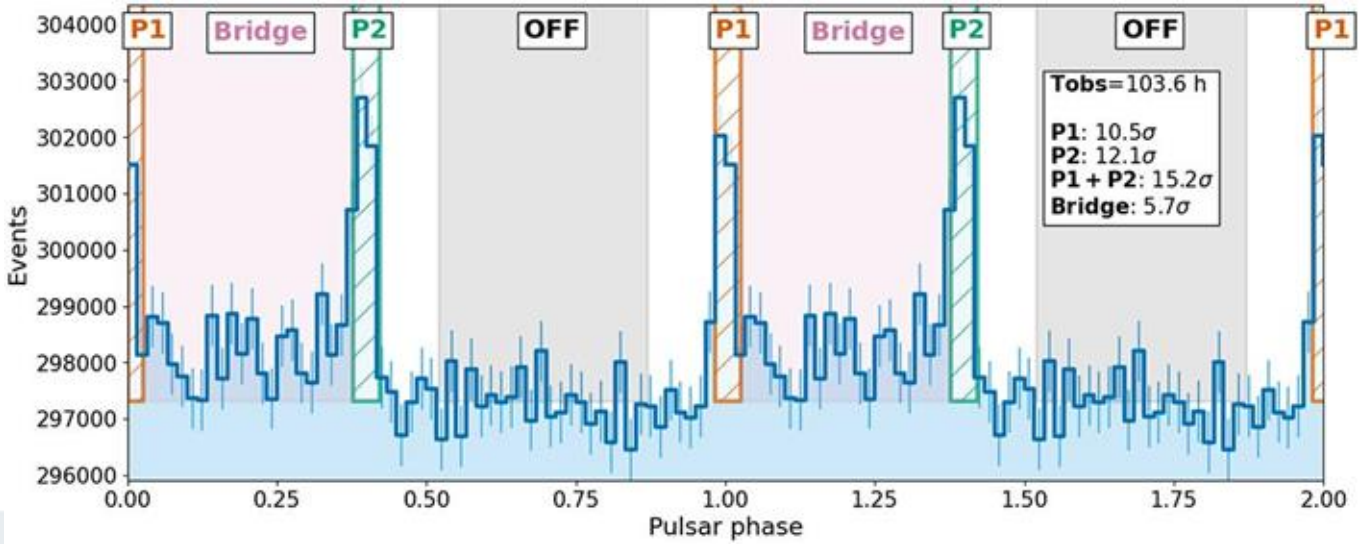
Pulsars: Crab

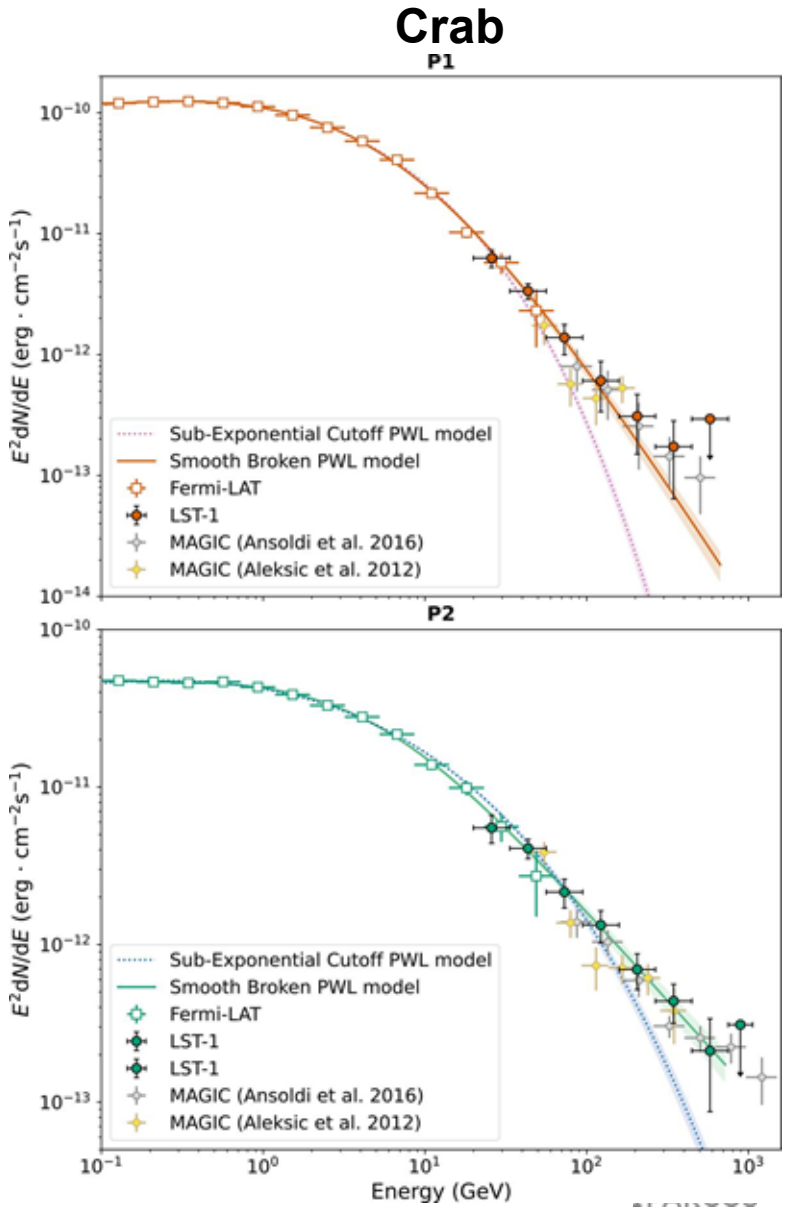
IPARCOS-GAE leadership in pulsar studies

- LST-1 has detected Crab and Geminga pulsars.
- Proves LST potential at the lowest energies.
- **GAE members are corresponding authors of both papers!**

Crab Detection (A&A, A167, 690, 2024)

- Most precise measurement so far at tens of GeV.
- Detailed study of the pulse morphology versus energy.
- Excellent overlap with Fermi-LAT data.





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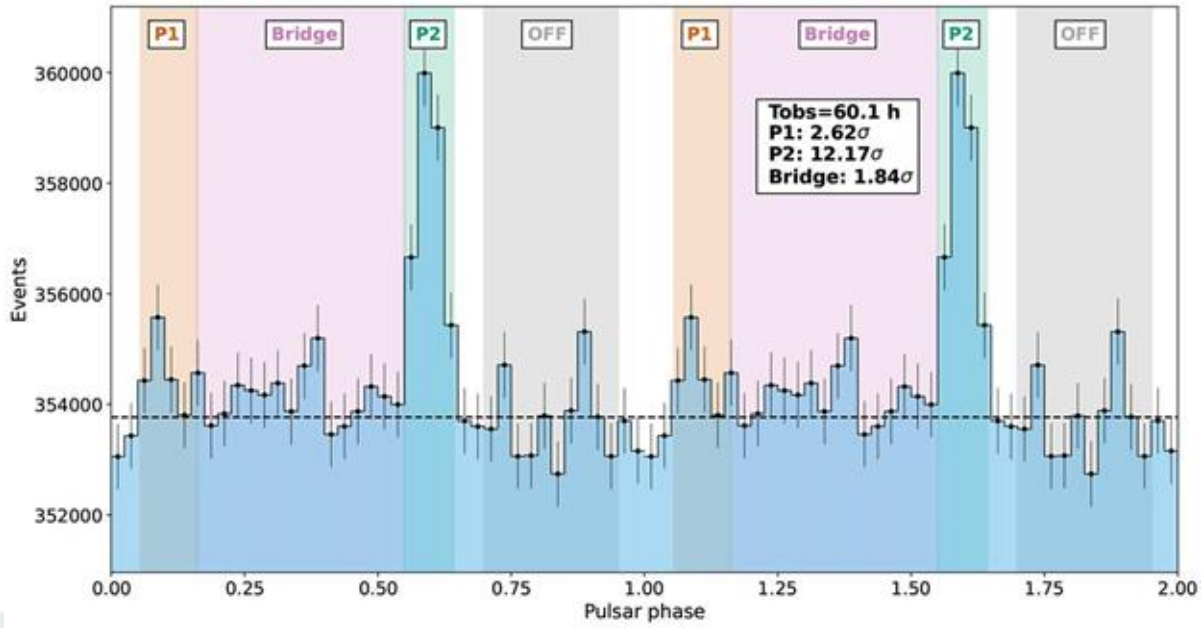
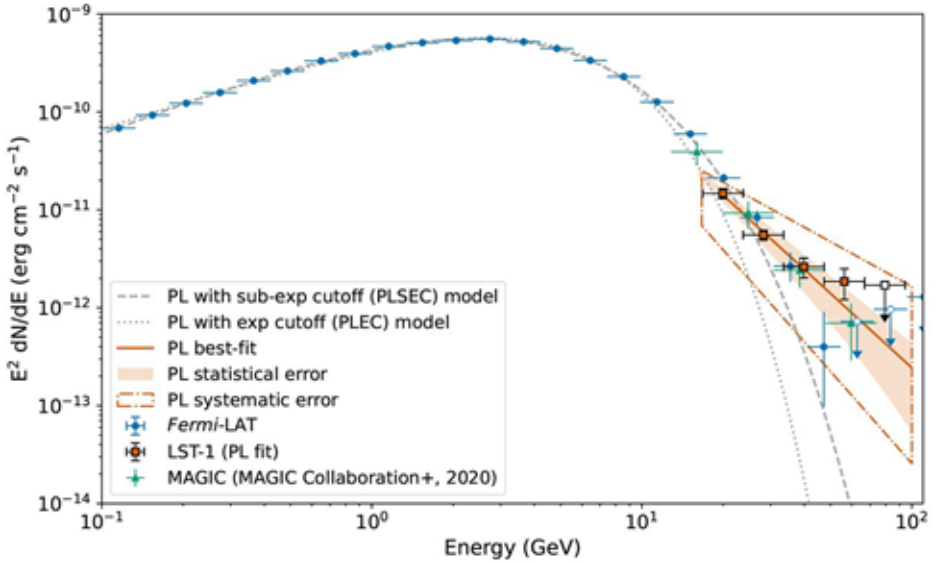
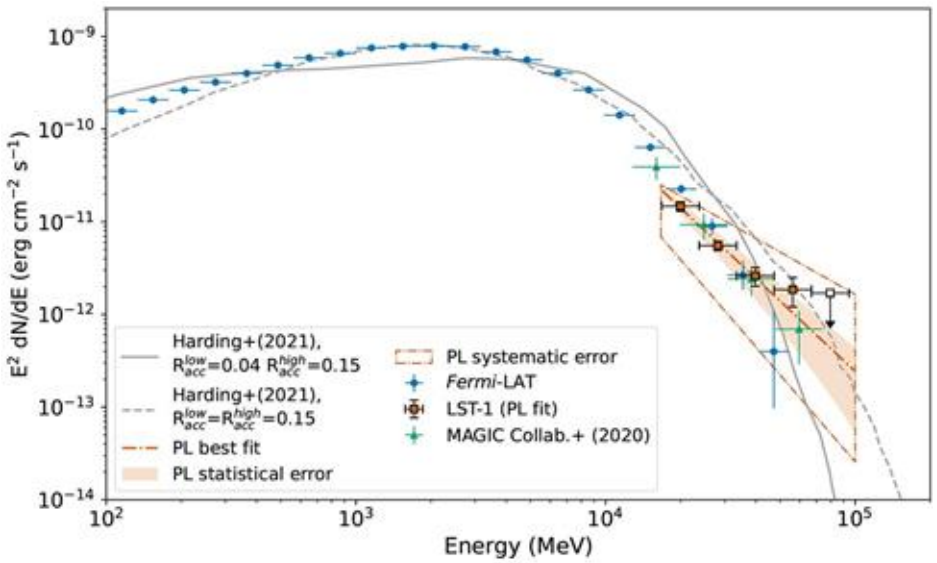
Geminga Detection (A&A, A283, 698, 2025)

- Detected in **20 h** (MAGIC needed ~80 h).

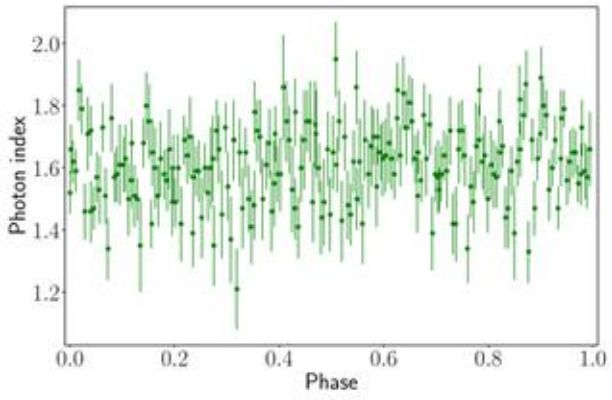


Geminga

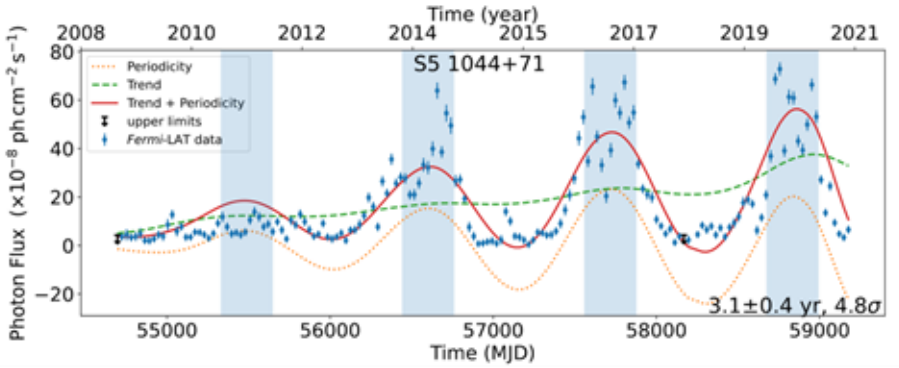




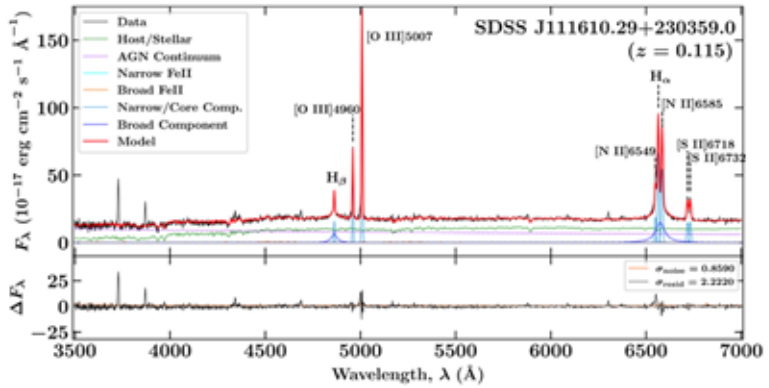
Active Galactic Nuclei



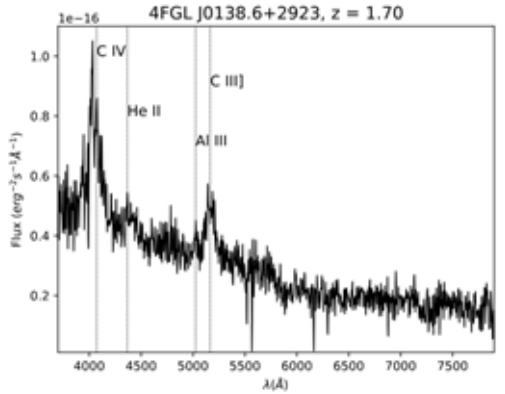
Spectral Studies in Blazars: Identified two emitting regions in the jets of PG 1553-133 and PKS 2155-304, proposing the "Geometric Masking" scenario (10+ papers, incl. Láinez+ 25, Banerjee+ 25, Madero & Domínguez 26, etc).



Blazar Periodicity: Systematic studies of quasi-periodic oscillations and statistical methods detected hints of a decade-long period in PG 1553-133 (10+ papers, incl. Peñil+ 24, Rico+ 25, Peñil+ 26, etc.).

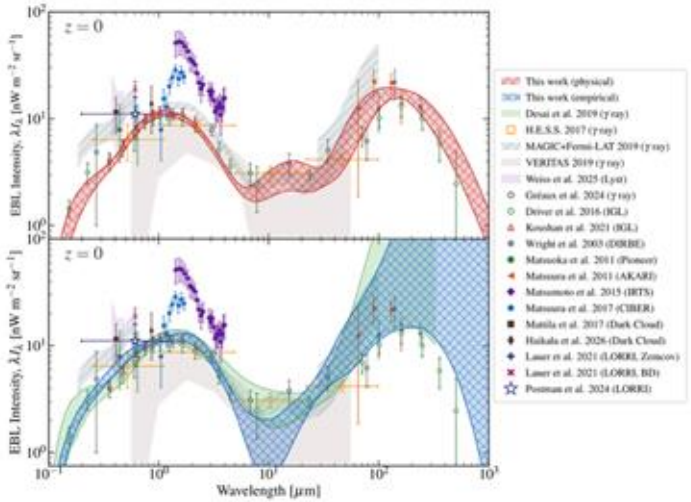


NLSy1 & Radio Galaxies: Compiled the largest NLSy1 galaxy catalog, finding potential Mpc-scale jets in low-mass galaxies (Paliya+ 24a, 24b, 25).

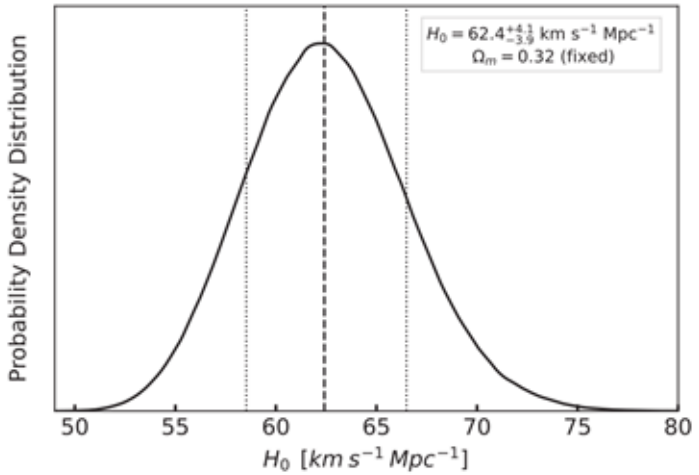


Redshift Observational Campaigns: Derived redshifts using a combination of spectroscopy and photometry, with supplementary studies using gamma-ray attenuation (Domínguez+ 24, Alvarez-Crespo+ 25,

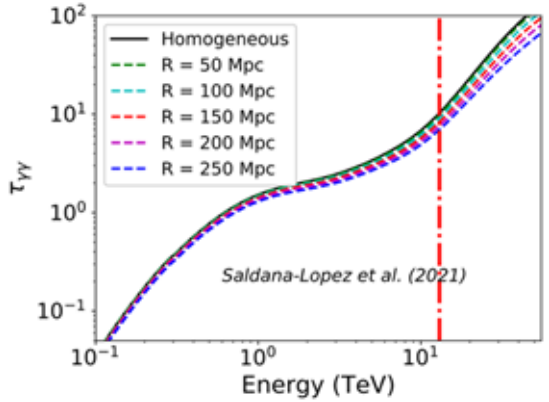
Extragalactic Background Light



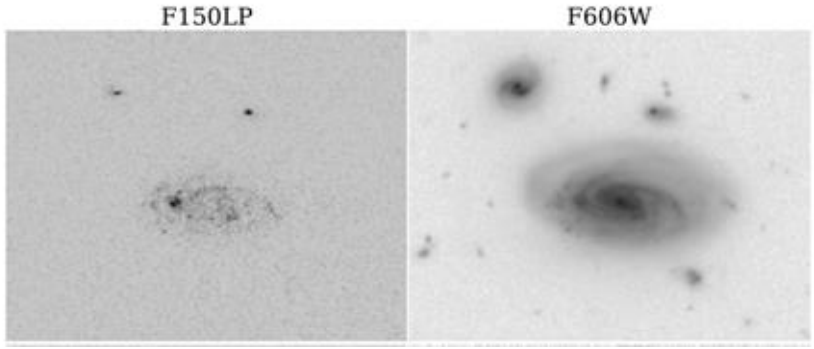
Extragalactic Background Light: Studied using updated gamma-ray attenuation data from Fermi-LAT and IACTs (Banerjee+ 26, Baxter+ 26).



Hubble Constant: Derived H0 from gamma-ray attenuation data (Domínguez+ 24).



Cosmic Transparency: Investigated the dependence of the universe's transparency to gamma-rays on large-scale structures (Hassan+ 25).



Far-UV Surveys: Compiled a far-UV catalog using Hubble Space Telescope (HST) observations (Kavei+ 26).

Conclusions

- Person-power did not significantly change with respect to 2024
- Funding level conserved (national plan), but also applied to alternative funding sources (EU, cooperation in IA, …)
- Keep leading first-class publications on:
  - Dark matter searches
  - Pulsars
  - Active galactic nuclei & Extragalactic background light