MAGIC
Major Atmospheric
Gamma Imaging
Cerenkov Telescopes

FACULTY OF PHYSICS
AND APPLIED INFORMATICS
University of Lodz

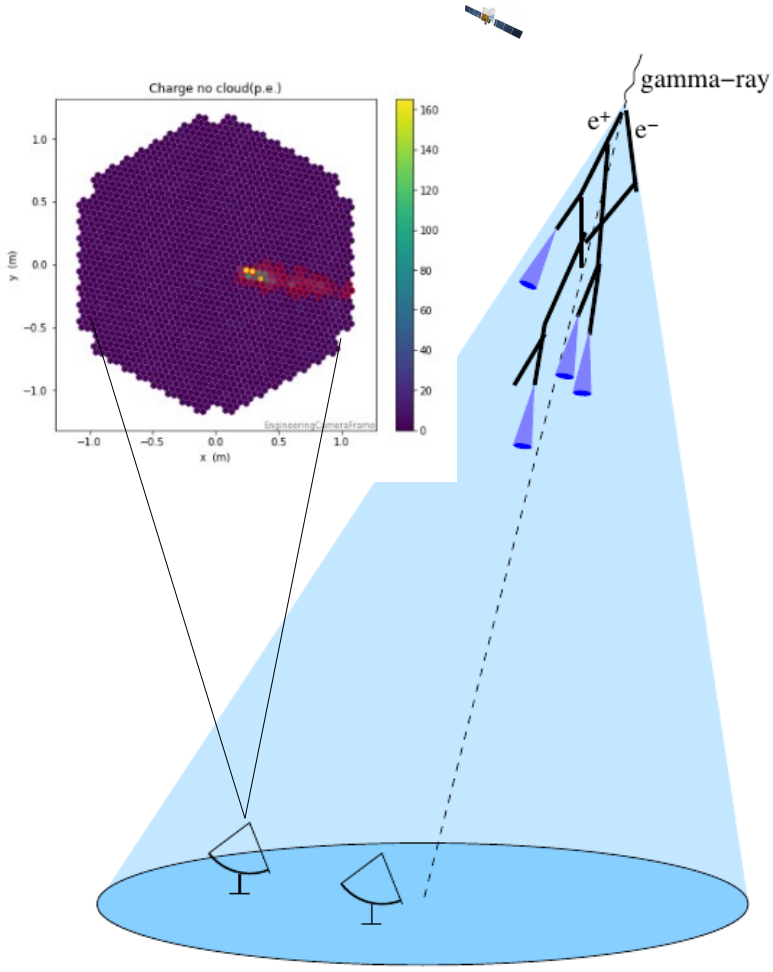
Science program of the MAGIC telescopes

J. Sitarek on behalf of the MAGIC Collaboration

2025.11.03, TeVPA, Valencia

Cherenkov light from air showers

- Gamma rays are absorbed in the atmosphere and cannot be observed directly on Earth
- Putting detectors in space we can gather gamma rays from only ~ 1m^2
- Extensive air shower induces production of Cherenkov light spread over area of ~100 000 m^2: indirect detection, but ground based and effective area is much larger than the size of the instrument



MAGIC telescopes

- Two 17-m diameter telescopes located at La Palma, Spain
- In operations for two decades
- Energy range: from a few tens of GeV to a few tens of TeV
- FoV ~3.5 deg
- Sensitivity
  - Long exposures: ~0.7% of the Crab Nebula flux above 300 GeV in 50 hr
  - Follow-up of transients: ~10% C.U. above 100 GeV in 1 hr
- Angular resolution ~0.1 deg
- Energy resolution ~15%

(still) the largest pair of operating IACTs – excellent low-energy performance

Physics with MAGIC

Galactic Science:
SNRs, PWNe, Novae,
Gal. Cent., Pulsars, ...

Extragalactic Science:
AGNs, starburst, ...

Transients and Multi-Messanger:
Follow up of GRBs,
GW, ν, FRB, ...

Fundamental Physics and Cosmology:
Probing Dark Matter,
LIV, EBL, IGMF, ...

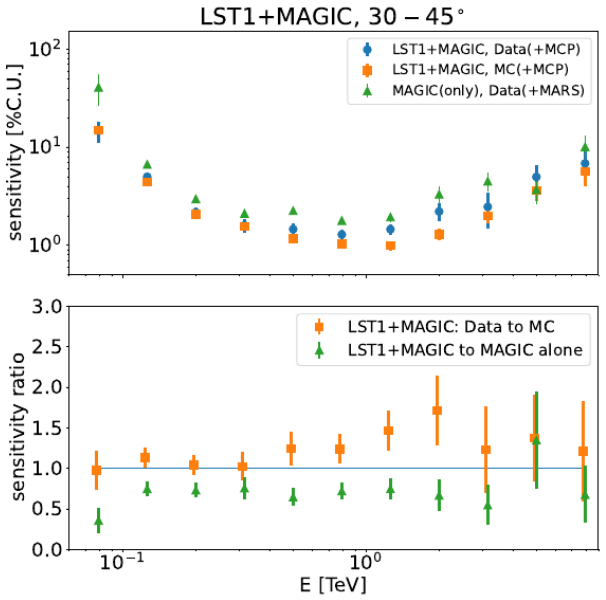
“Exotic applications”:
Cosmic Rays, Intensity Interferometry

One instrument, but multiple scientific targets
(sometimes even with the same data sets)

Going together with LST

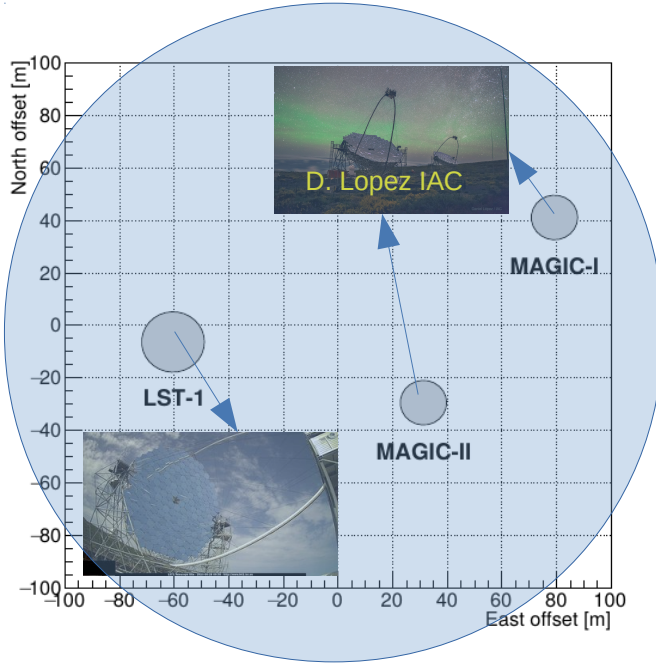
- Both MAGIC and LST-1 are located in the same site - same gamma-ray showers are seen by both instruments
- Joint observations allow detection of 30% (40%) lower flux than MAGIC-alone (LST-1-alone): detection of the same flux in two (nearly three) times shorter time.
- **MAGIC and LST-1 when combined have a better performance than working separately.**
- Already 1000 hrs taken jointly by both instruments

More details in the talk by E. Visentin



Abe et al. 2023, A&A 680, A66

Corr. Authors: A. Berti, F. Di Pierro, Y. Ohtani, JS, Y. Suda

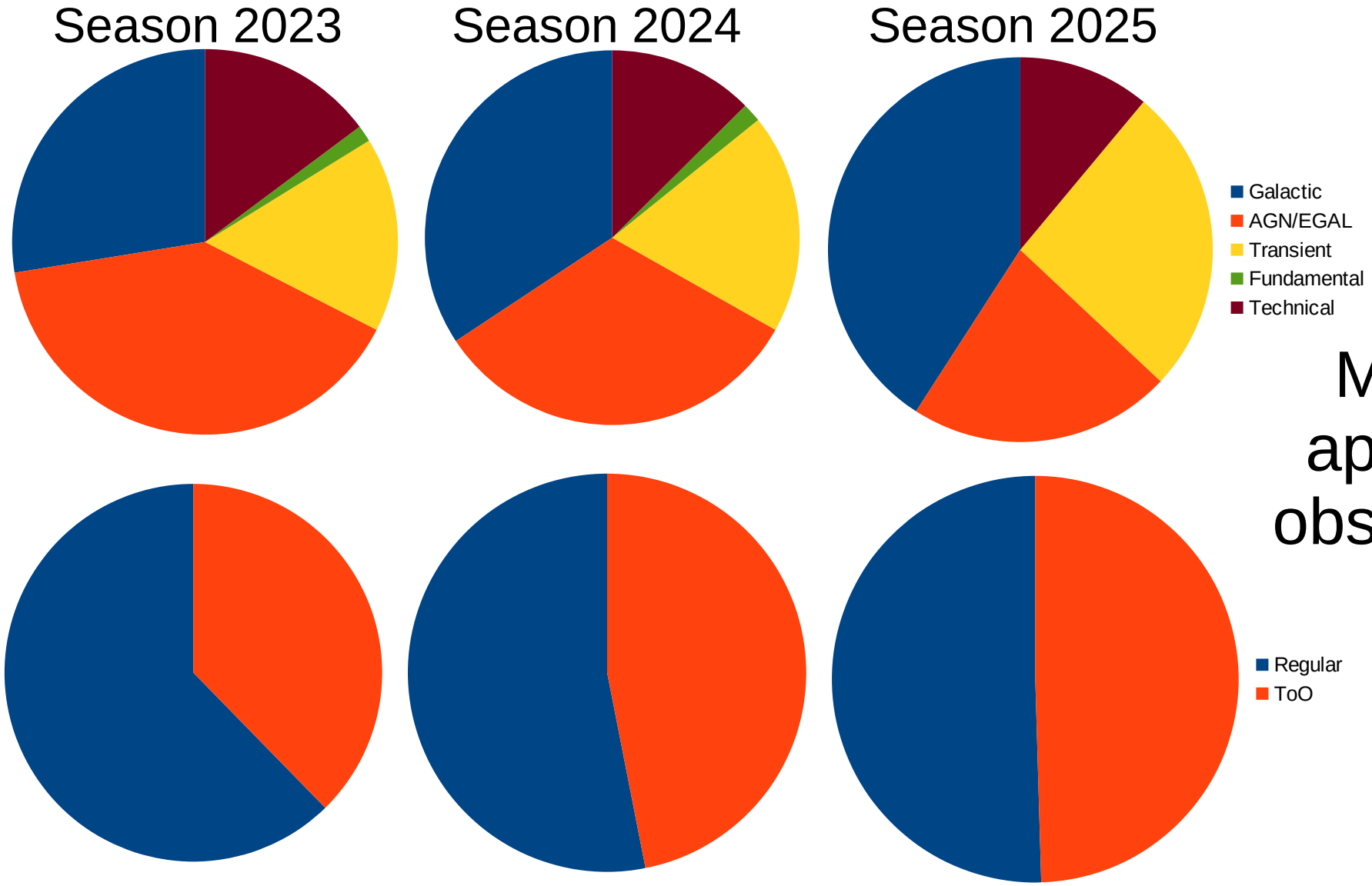


Typical shower light pool

Evolution of the science program

Pointing instrument with 1000(+300) hrs per year and two decades of observations already – important to use it most efficiently

- Increasing fraction of the ToO observations:
  - investigate the current transient events while CTAO is not yet operational
  - Participating in MWL and MM observation campaigns
- Increasing fraction of Galactic science proposals:
  - Input from LHAASO
  - Exploitation of joint observations with LST-1
- Fundamental physics is one of the pilars of the MAGIC scientific activity, however it is usually reusing data from other projects (like bright flares)



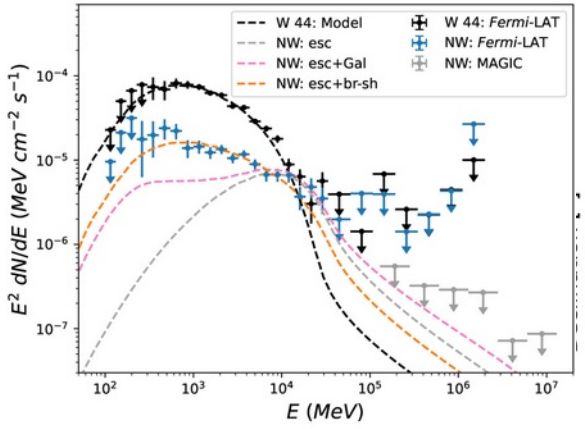
MAGIC approved observation time

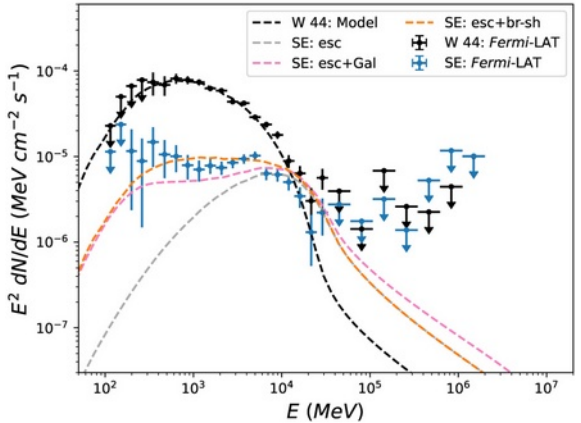
MAGIC results in this conference

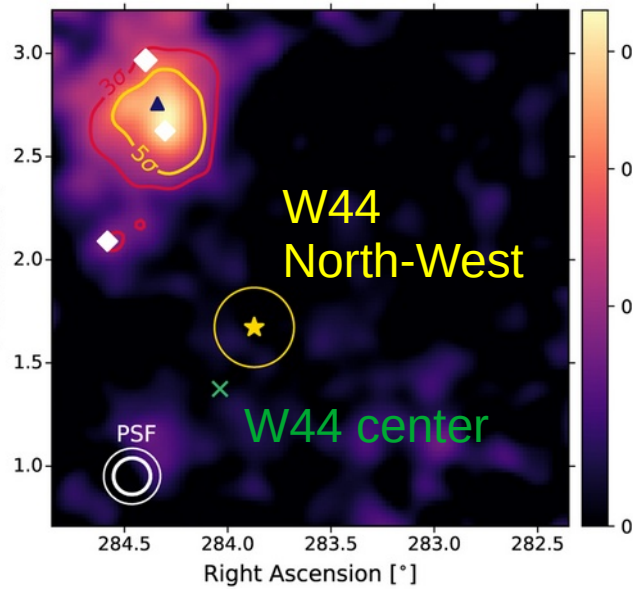
- AGN:
  - Giuseppe Silvestri - Twelve Years of Multiwavelength Monitoring of PG 1553+113: Evidence for a Two-Zone SSC Emission, **Wednesday, 16:45**
  - João Gabriel Giesbrecht Formiga Paiva - Investigation of the extreme activity of Mrk 501 in 2014 and of its intriguing TeV feature, **Wednesday, 17:30**
  - Mireia Nievas - The Most Distant VHE Quasar: Probing OP 313's power with LST-1 and MAGIC, **Monday, 17:15**
- Galactic sources:
  - Luis Barrios - Results of the long-term campaign on Cygnus X-3 with the MAGIC telescopes., **Wednesday, 14:30**
  - Giovanni Ceribella - Phase-dependent spectra of the Crab pulsar with the MAGIC telescopes, **Tuesday 17:00**
  - Andrea Simongini - VHE Supernovae: state of the art and latest observations with the CTAO LST-1 and MAGIC telescopes, **Thursday, 17:00**
- Fundamental and astroparticle physics:
  - Elia do Souto - Primordial black hole evaporation search with MAGIC, **Thursday, 18:00**,
  - Miguel Molero - Measurement of the Cosmic-Ray Proton Spectrum with MAGIC, **Wednesday, 16:45**
  - Salvatore Mangano - Discriminating Heavy Cosmic Rays at TeV Energies with MAGIC via Direct Cherenkov Emission, **Wednesday, 17:00**
  - Tomislav Terzic - First study of Lorentz invariance violation on a combined Cherenkov telescope data set, **Thursday 18:00**
- Transient and MM follow-ups:
  - Juan Jimenez - Follow-up of LVK O4 Gravitational Wave events, **Tuesday 14:45**
  - Davide Miceli - Testing the ubiquitous presence of very high energy emission in gamma-ray bursts with the MAGIC telescopes, **Tuesday, 15:45**
  - Elia do Souto - A new method for unbiased transient search in IACT archival, poster
- Technical:
  - Jarred Green - Classifying Waveform MAGIC Telescope Data Using Graph Neural Networks, **Thursday, 16:00**
  - Elisa Visentin - Analysis of joint MAGIC+LST-1 observations, **Monday 17:00**

Acceleration and escape of CR from SNR

- W44 is a middle-aged SNR embedded in a dense MC.
- GeV gamma-rays detected in NW and SE regions of W44 – can be interpreted as escaping CRs
- Modeled Fermi-LAT + MAGIC observations as the p-p emission of CRs escaping from W44 & Galactic CRs on ~ 10^4 M_{sun} MCs



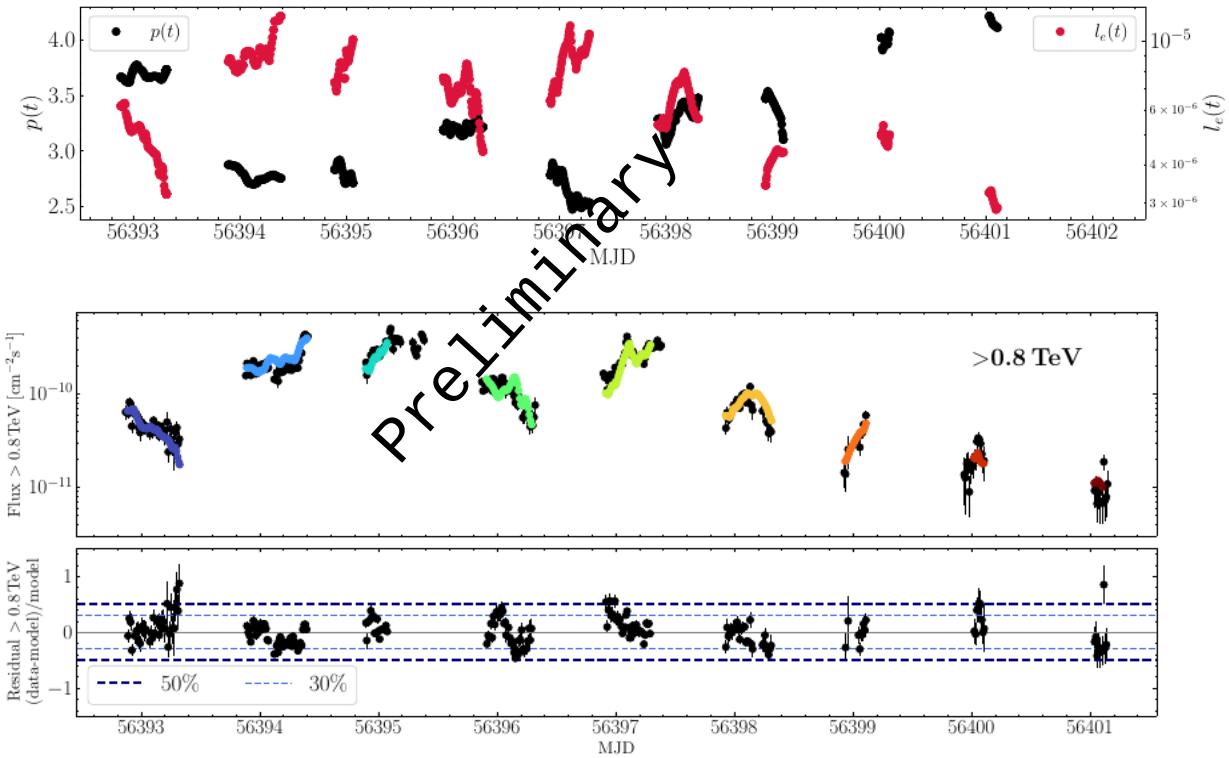




Abe et al. 2025, A&A, 693, A255
Corr. authors: A. Hahn, R. Di Tria, L. Di Venere, G. Morlino

Slicing AGN broadband emission in short time scales

- Simultaneous MWL SEDs of Mrk 421 during large flare resolved every 15 min.
- Describing the observations with time-dependent two-zone SSC model

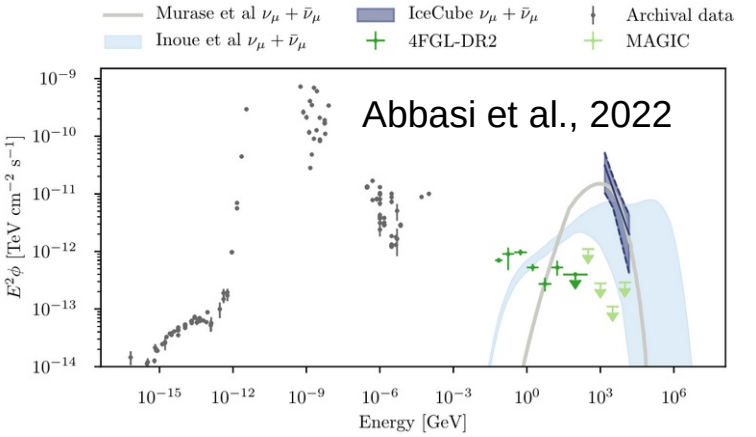


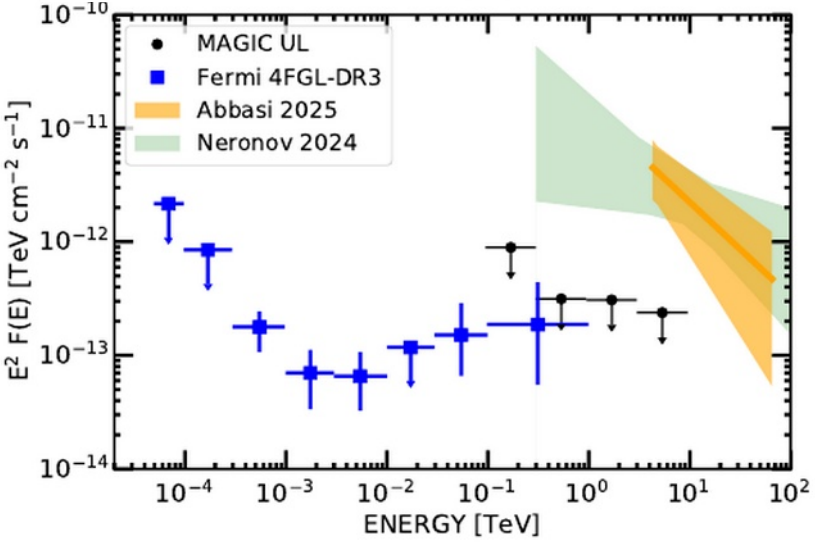
Abe et al. 2025, subm., arXiv:2509.08686

Corr. authors: A. Arbet-Engels, M. Polkas, M. Petropoulou, D. Paneque

Neutrino – gamma-ray connection

- In simple hadronic interaction models nu emission should be comparable to gamma one
- NGC 1068 – the only firmly detected TeV neutrino source has MAGIC limits which are in tension by an order of magnitude with this simple picture
- MAGIC observations of NGC 4151 (the second-best IceCube candidate) shows similarly strong constraints on the gamma-ray emission
- The image of strongly absorbed hadronic accelerations starts to form



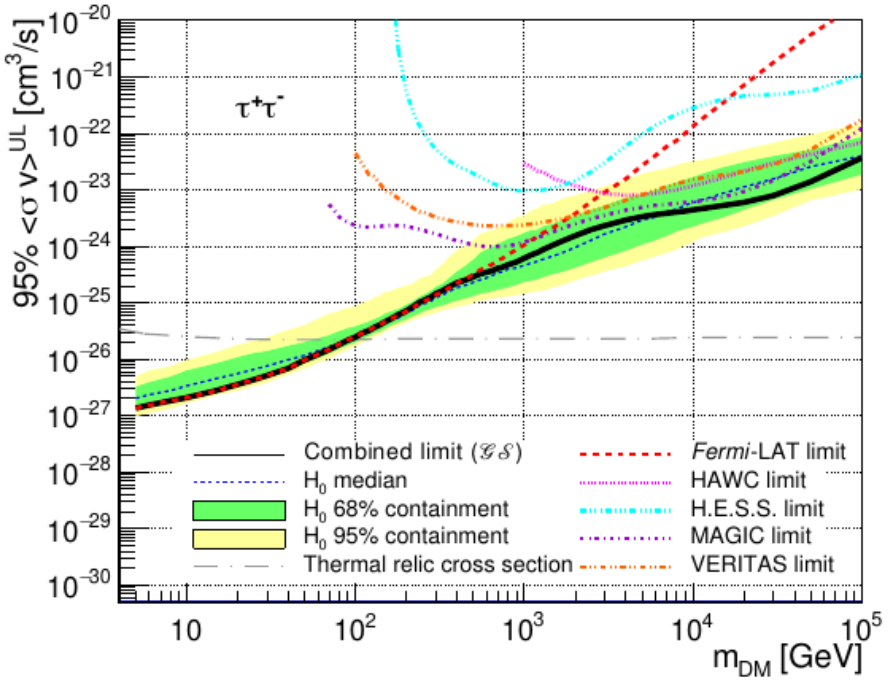


Abe et al. 2025, A&A, 702, A38

Corr. authors: A. Lamastra, S. Mangano, S. Menon, E. Peretti

Combined DM searches from dSph

- dSph are considered the purest targets for DM searches
- Combining multiple instruments for improving the limits: MAGIC(354 hrs) + VERITAS(216 hrs)+ H.E.S.S.(54 hrs) + Fermi-LAT (10 yr) + HAWC (3 yrs)



Abdollahi et al. 2025, JCAP

Corr. authors: C. Armand, E. Charles, M. di Mauro, C. Giuri, J. P. Harding, D. Kerszberg, T. Miener, E. Moulin, L. Oakes, V. Poireau, E. Pueschel, J. Rico, L. Rinchiuso, D. Salazar-Gallegos, K. Tollefson

Open science program of MAGIC

- MAGIC Collaboration allows external scientists to submit proposals for MAGIC observations
- High-level MAGIC data analysis is possible with open access tools (https://acme-magic-odas.sciencesconf.org/)
- Next observations cycle: April 2026 – mid April 2027
- Deadline for proposal submission: 23.01.2026
- Potential PIs are encouraged to get in contact with the MAGIC Physics Coordinator well before the deadline (until 7.01.2026) to help with technical details, inform about existing observations, ...
- Details of the call: https://magic.mpp.mpg.de/public/magicop/

- 40 hrs of MAGIC data has been released in DL3 format as part of the 1st MAGIC Open Data-Analysis School: https://zenodo.org/records/17064461
  (free to use for technical studies, scientific publications possible after approval of the MAGIC Collaborations)

Supported with ACME Transnational Access Programme

Summary

- Despite two decades of operations the telescopes are maintained in good condition and providing interesting scientific data
- Scientific program migrating to higher exploitation of ToO observations, and combined observations with LST-1
- **Check the latest MAGIC results on your favourite scientific topic in the dedicated talks/posters!**