

RESULTS FROM THE HIGH ALTITUDE WATER CHERENKOV OBSERVATORY

Miguel Mostafá



College of Science
and Technology

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Multi-messenger Astroparticle Conference



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Jun 17 – 21, 2024



CRIS 2006



CRIS 2006



OUTLINE

(BRIEF) DESCRIPTION OF THE HAWC OBSERVATORY

SELECTED RECENT RESULTS

NEW TEV SOURCES

PEVATRON CANDIDATES

EXTENDED EMISSION REGIONS

SUMMARY & OUTLOOK

HAWC Observatory

HAWC operates day and night, providing a large field of view for the observation of the highest energy gamma rays.

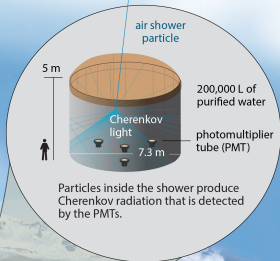


Pico de Orizaba
(5,626 m)

HAWC

Water Cherenkov tank

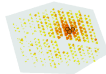
HAWC comprises an array of 300 tanks that record the particles created in gamma-ray and cosmic-ray showers.



Gamma rays vs cosmic rays

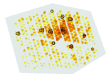
HAWC selects gamma rays from among a much more abundant background of cosmic rays.

gamma-ray shower



"hot" spots concentrate around the core

cosmic-ray shower



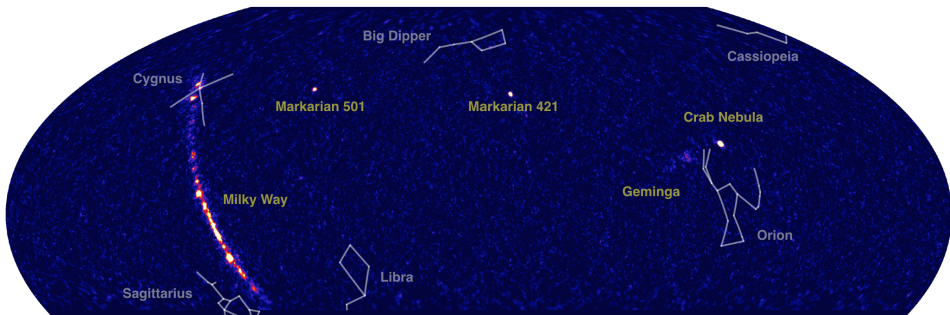
"hot" spots are more dispersed

HAWC is located at 4,100 m above sea level, covering an area of 20,000 m².

150 m

HAWC

- ▶ large instantaneous sky coverage
- ▶ long, uninterrupted observation periods

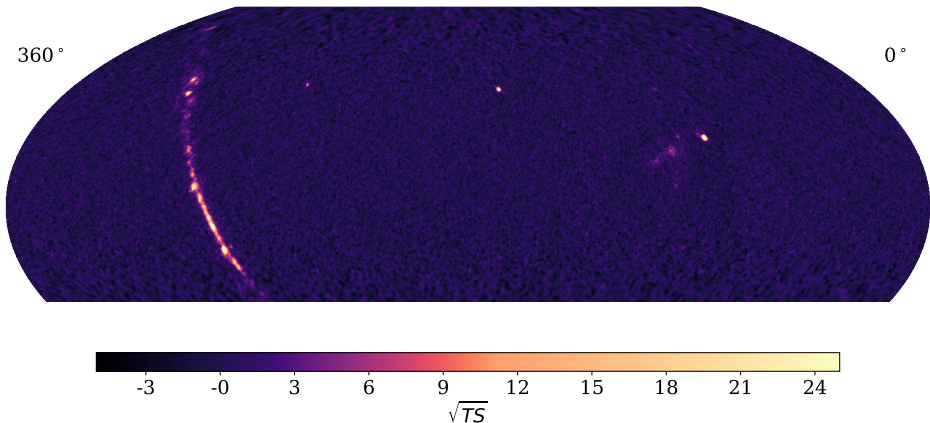


The HAWC Observatory: NIM **A1052** (2023) 168253

THE 3rd HAWC CATALOG OF VHE γ -RAY SOURCES

► Significance map (point-source hypothesis)

All-sky view; 0.0°; 1523 days

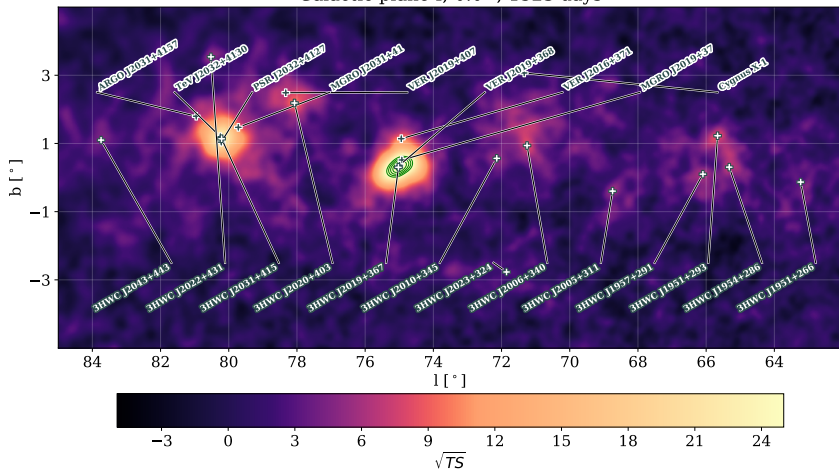


The 3HWC Catalog, HAWC Collaboration: *ApJ* **905** (2020) 76

THE 3rd HAWC CATALOG OF VHE γ -RAY SOURCES

► Significance map (point-source hypothesis)

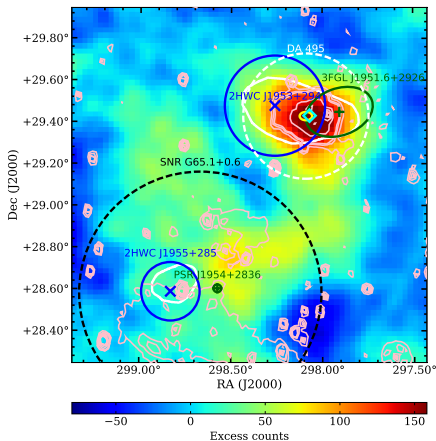
Galactic plane I; 0.0° ; 1523 days



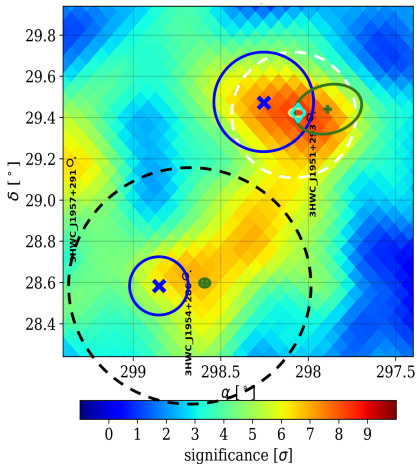
The 3HWC Catalog, HAWC Collaboration: *ApJ* 905 (2020) 76

NEW TEV γ -RAY SOURCES

► PWN DA 495 (2HWC J1953+2926)



VERITAS counts map

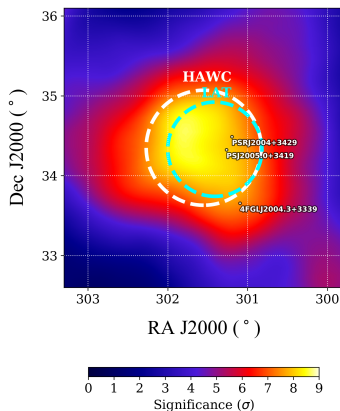


3HWC significance map

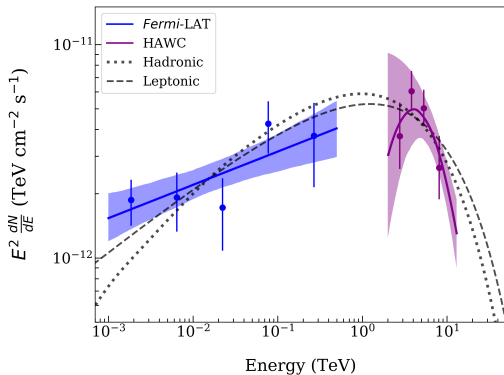
VERITAS+Fermi-LAT+HAWC: *ApJ* 866 (2018) 24

NEW TEV γ -RAY SOURCES

► 2HWC J2006+341



3HWC significance map

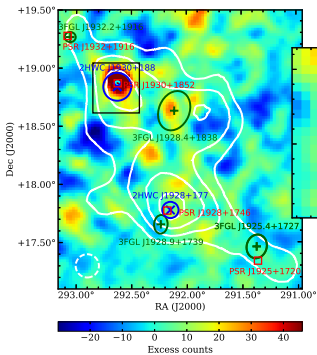


SED from HAWC and LAT data

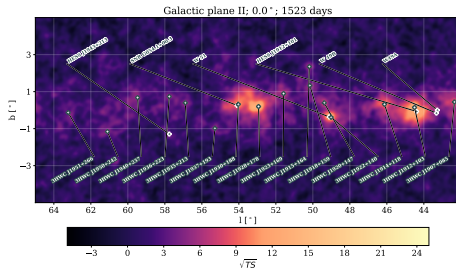
HAWC+Fermi-LAT detection of J2006: *ApJL* **903** (2020) L14

NEW TEV γ -RAY SOURCES

▶ SNR G54.1+0.3 (2HWC J1930+188)



VERITAS counts map

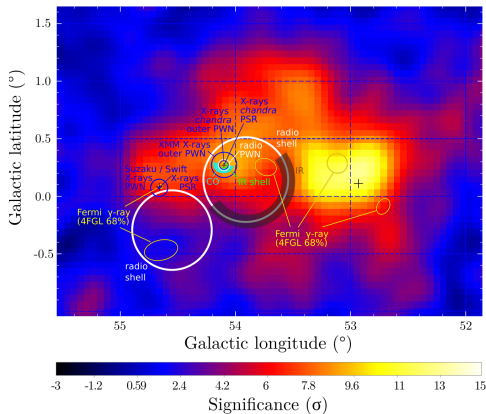


3HWC significance map

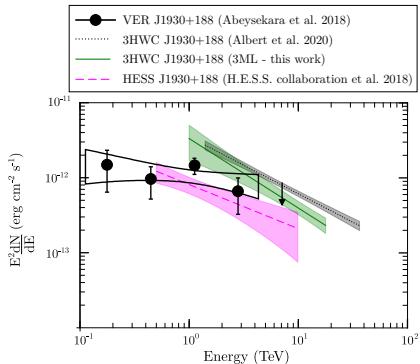
VERITAS+Fermi-LAT+HAWC: *ApJ* 866 (2018) 24

NEW TEV γ -RAY SOURCES

► 3HWC J1928+178 and HAWC J1932+192



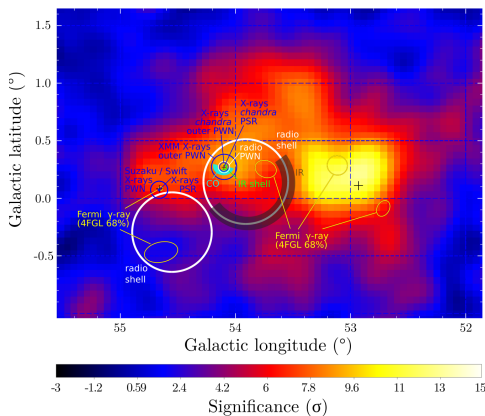
3HWC significance map



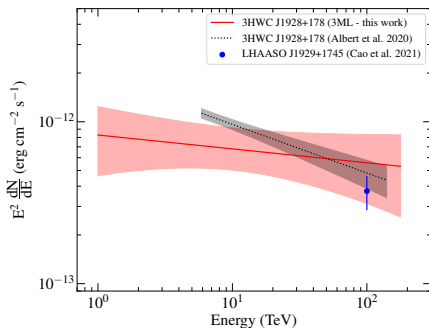
SED of 3HWC J1930+188

NEW TEV γ -RAY SOURCES

► 3HWC J1928+178 and HAWC J1932+192



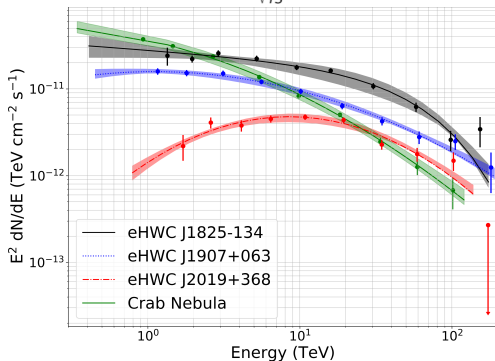
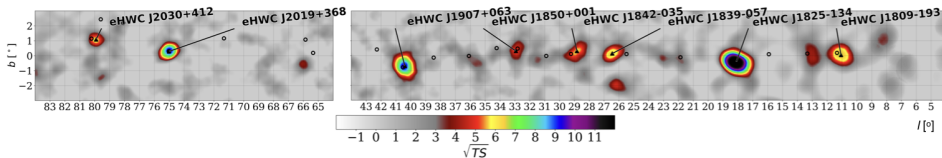
3HWC significance map



SED of 3HWC J1928+178

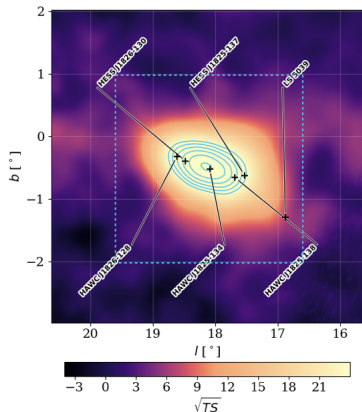
CATALOG OF γ -RAY SOURCES ABOVE 56 TeV

► Significance map ($E > 56$ TeV, 0.5° hypothesis)

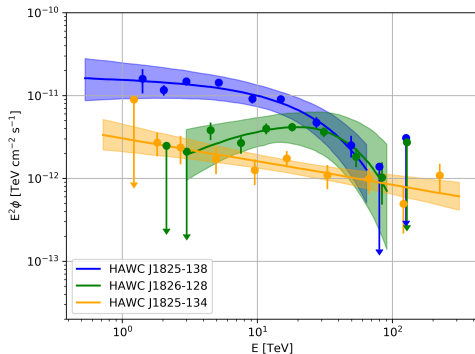


EVIDENCE OF 200 TeV γ RAYS

► eHWC J1825-134



Significance map

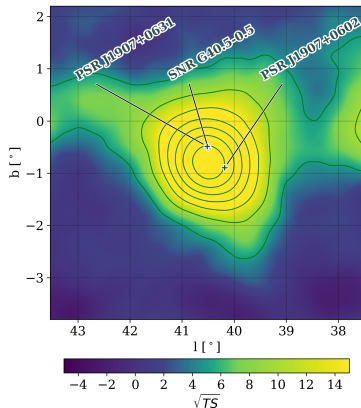


SED from HAWC data

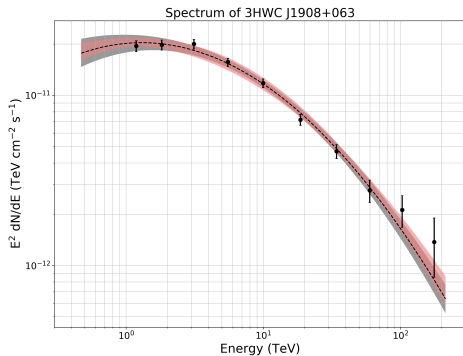
HAWC J1825-134, HAWC Collaboration: *ApJL* **907** (2021) L30

HE γ -RAY SPECTRA

► MGRO J1908+06



Significance map

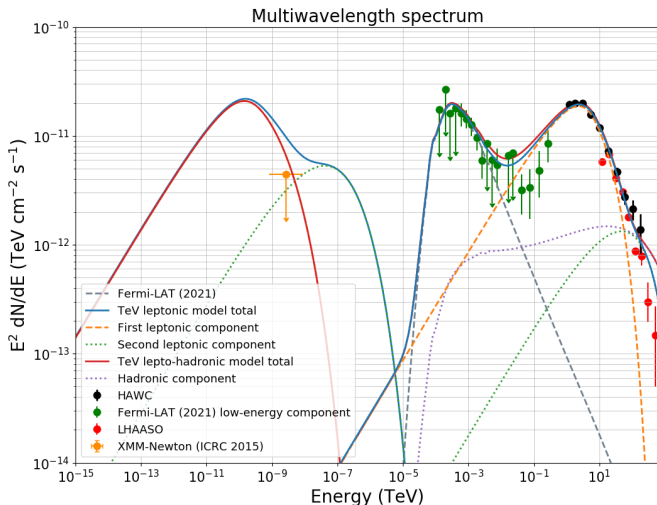


SED from HAWC data

MGRO J1908+06, HAWC Collaboration: *ApJ* **928** (2022) 116

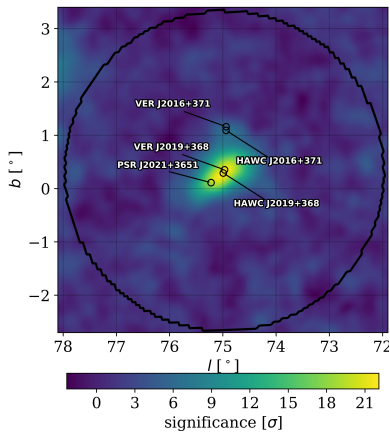
HE γ -RAY SPECTRA

► MGRO J1908+06

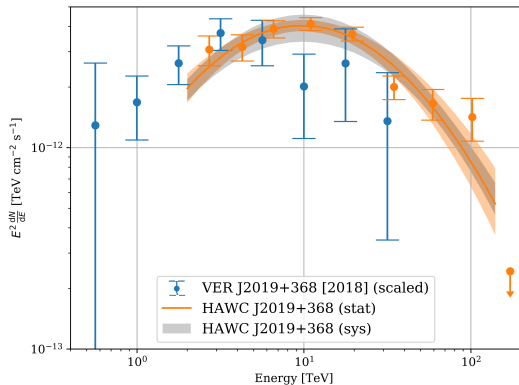
MGRO J1908+06, HAWC Collaboration: *ApJ* **928** (2022) 116

HE γ -RAY SPECTRA & MORPHOLOGY

► HWC J2019+368



Significance map

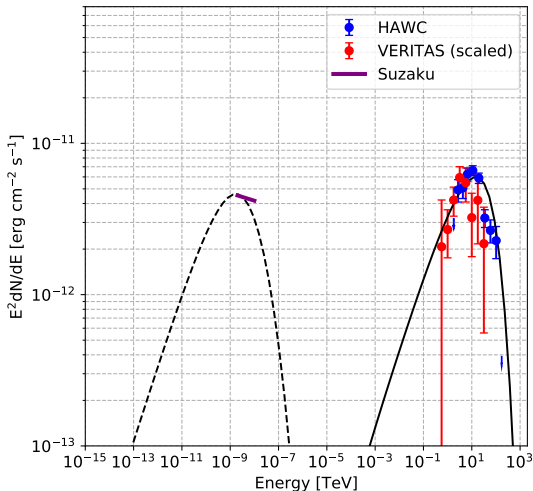


SED from HAWC data

HWC J2019+368, HAWC Collaboration: *ApJ* **911** (2021) 143

HE γ -RAY SPECTRA & MORPHOLOGY

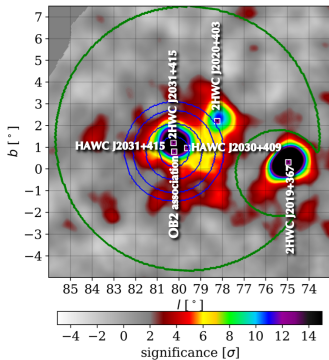
► HWC J2019+368



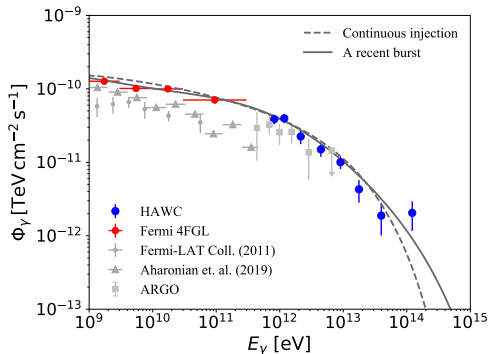
HWC J2019+368, HAWC Collaboration: *ApJ* **911** (2021) 143

VHE COSMIC-RAY ACCELERATORS

► Cygnus Cocoon



3HWC significance map

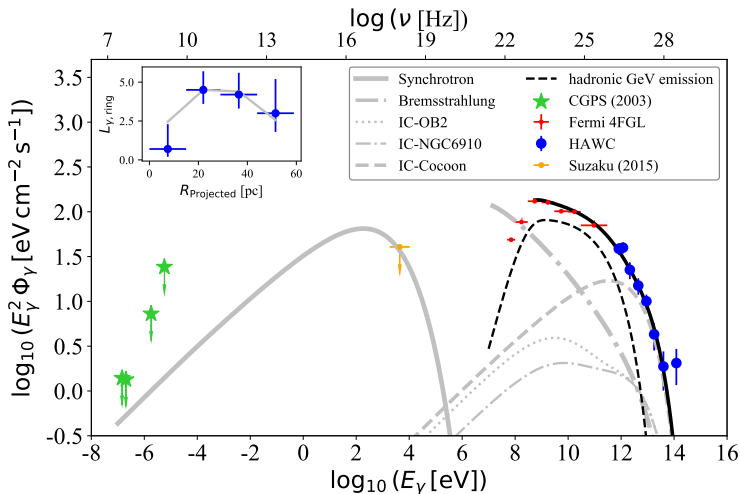


SED from HAWC and LAT data

Cygnus Cocoon, HAWC Collaboration: *Nat. Astro.* 5 (2021) 465

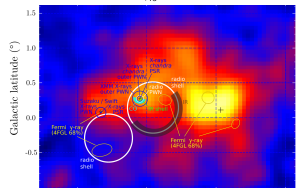
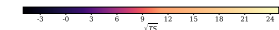
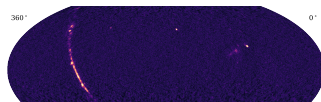
VHE COSMIC-RAY ACCELERATORS

► Cygnus Cocoon



SUMMARY & OUTLOOK

- ▶ HAWC catalog **public!**
New TeV sources
Pevatron candidates
- ▶ Other **science** contributions
Dark matter, CRs, solar physics,
particle physics,
multi-messenger studies,
diffuse emission, extended
regions, EBL, realtime alerts...
- ▶ Outrigger array **completed**
Enhanced sensitivity above
10 TeV



UPCOMING RESULTS (THAT YOU DON'T WANT TO MISS)

- ▶ Update on SS 433 (a.k.a. *HAWC observations of microquasars as powerful particle accelerators*)
- ▶ Exploring molecular clouds (a.k.a. *The Boomerang PWN and its SNR G106.3+2.7 viewed with HAWC*)
- ▶ Emission and morphology of the unassociated γ -ray source TeV J2032+4130
- ▶ Update on the cosmic-ray spectrum between 10 TeV and 1 PeV
- ▶ Observation of the Galactic Center beyond 100 TeV
- ▶ Multi-wavelength study of MGRO J1908 (HAWC, VERITAS, Fermi-LAT)
- ▶ Update on Geminga and Monogem and TeV Halo searches

An aerial photograph of a large, conical mountain, likely a volcano, with a forested base and a small rectangular field in the foreground. The mountain is the central focus, with its peak illuminated by a bright light source, possibly the sun. The surrounding landscape is a mix of brown and tan tones, suggesting a dry or semi-arid environment. The sky is a clear blue with some light clouds.

THANK YOU VERY MUCH!

Image courtesy of Philip Suárez Mauro

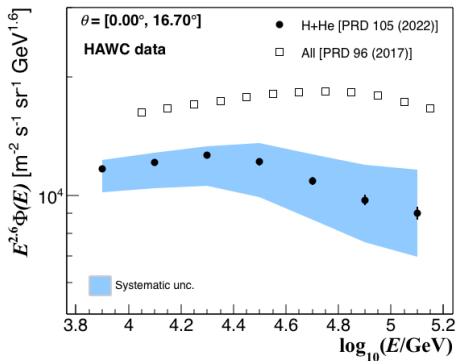
BACK-UP SLIDES

MOST RECENT HAWC PAPERS

- ▶ “Search for decaying dark matter in the Virgo cluster of galaxies with HAWC,” PRD **109** (2024) 043034
- ▶ “Galactic Gamma-Ray Diffuse Emission at TeV Energies with HAWC Data,” ApJ **961** (2024) 104
- ▶ “HAWC Study of the Very-high-energy γ -Ray Spectrum of HAWC J1844-034,” ApJ **954** (2023) 205
- ▶ “Discovery of Gamma Rays from the Quiescent Sun with HAWC,” PRL **131** (2023) 051201
- ▶ “HAWC Detection of a TeV Halo Candidate Surrounding a Radio-quiet Pulsar,” ApJL **944** (2023) L29
- ▶ “An optimized search for dark matter in the galactic halo with HAWC,” JCAP **12** (2023) 038
- ▶ “Searching for TeV Dark Matter in Irregular Dwarf Galaxies with HAWC Observatory,” ApJ **945** (2023) 25.
- ▶ “Search for Gamma-Ray and Neutrino Coincidences Using HAWC and ANTARES Data,” ApJ **944** (2023) 166.

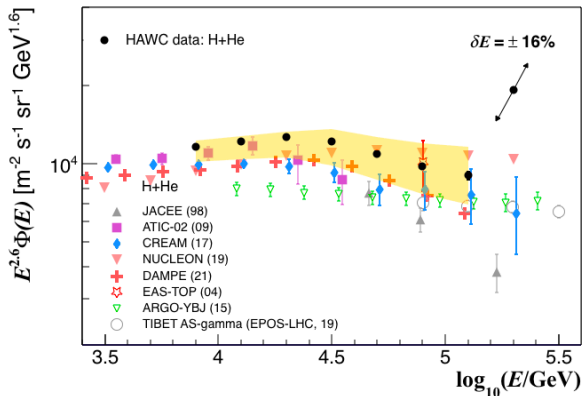
COSMIC RAY SPECTRUM

- ▶ H + He nuclei between 6 and 158 TeV



COSMIC RAY SPECTRUM

- ▶ H + He nuclei compared to other data



COSMIC RAY SPECTRUM

- ▶ all particle spectrum between 10 TeV and 1 PeV

