

THE HIGH ALTITUDE WATER CHERENKOV OBSERVATORY

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and Engineering

The Multimessenger Sky at Extreme Energies
From Sources to Fundamental Physics

Trieste, Italy

Sep 7 – 11, 2026



OUTLINE

THE HAWC OBSERVATORY

NEW TeV SOURCES

2HWC J1953+294

2HWC J2006+341

2HWC J1930+188

3HWC J1928+178

PeVATRON CANDIDATES

eHWC J1825-134

MGRO J1908+06

HWC J2019+368

EXTENDED EMISSION REGIONS

Cygnus Cocoon

MICROQUASARS

SS 433

LS 5039

V4641 SGR

CONCLUSIONS & OUTLOOK



HAWC Observatory

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



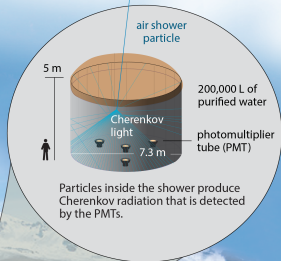
Pico de Orizaba
(5,626 m)

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

HAWC

Water Cherenkov tank

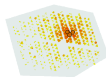
HAWC comprises an array of 300 tanks that record the particles created in gamma-ray and cosmic-ray showers.



Gamma rays vs cosmic rays

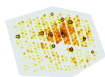
HAWC selects gamma rays from among a much more abundant background of cosmic rays.

gamma-ray shower



"hot" spots concentrate around the core

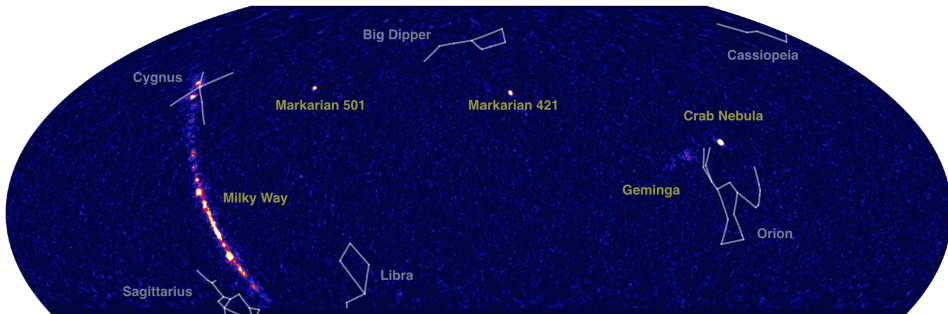
cosmic-ray shower



"hot" spots are more dispersed

HAWC

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

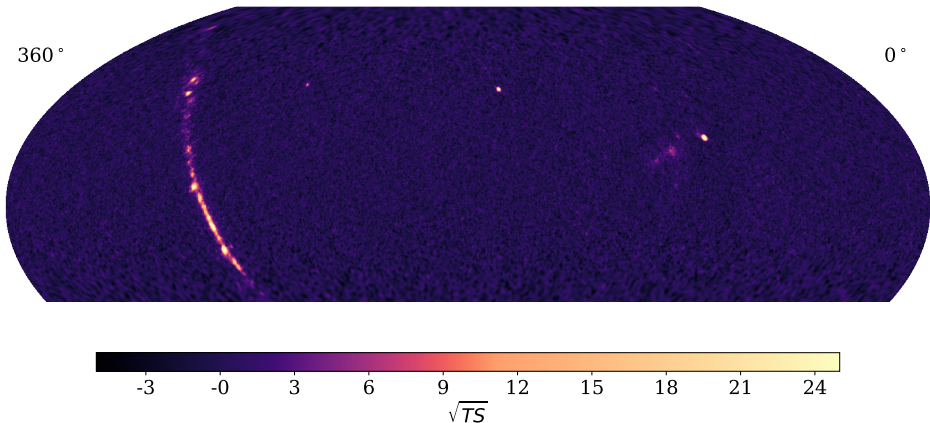


The HAWC Observatory: NIM **A1052** (2023) 168253

THE 3rd HAWC CATALOG OF VHE γ -RAY SOURCES

► Significance map (point-source hypothesis)

All-sky view; 0.0° ; 1523 days

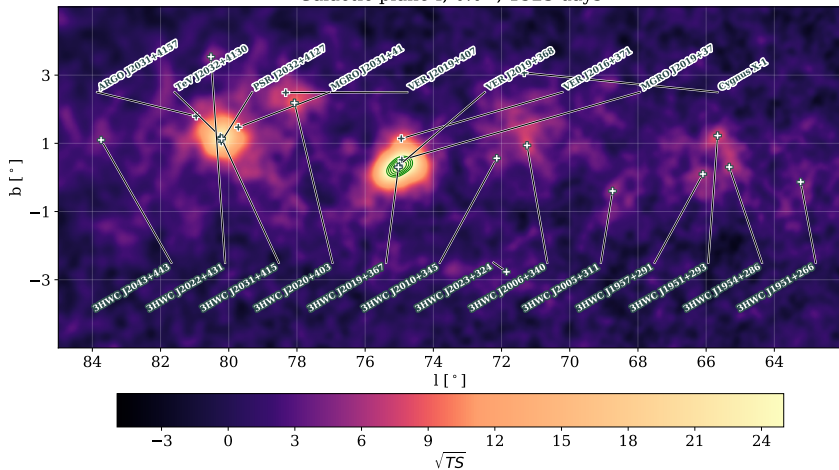


The 3HWC Catalog, HAWC Collaboration: *ApJ* **905** (2020) 76

THE 3rd HAWC CATALOG OF VHE γ -RAY SOURCES

► Significance map (point-source hypothesis)

Galactic plane I; 0.0°; 1523 days

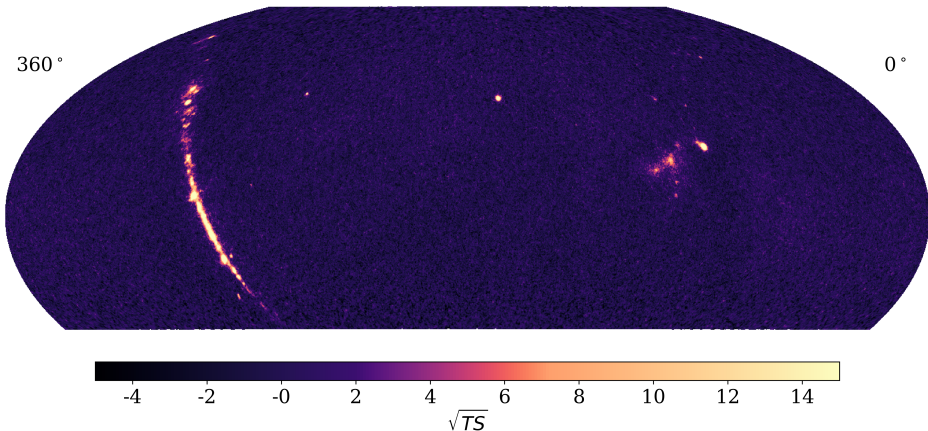


The 3HWC Catalog, HAWC Collaboration: *ApJ* **905** (2020) 76

THE 4th HAWC CATALOG OF VHE γ -RAY SOURCES

- Significance map (point-source hypothesis)

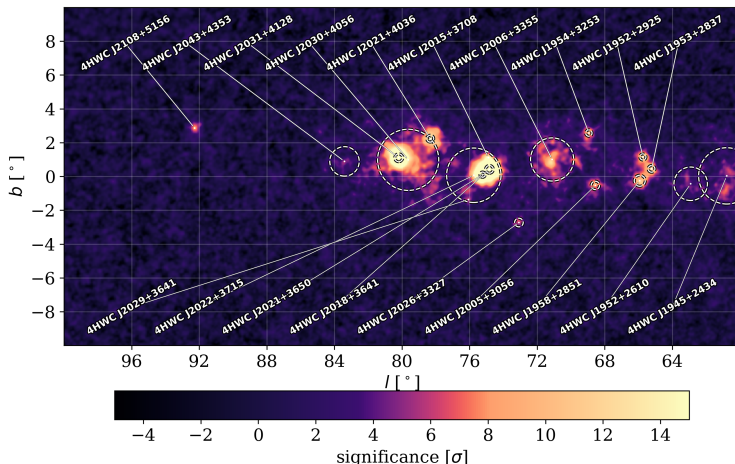
All sky; 2726 days



THE 4th HAWC CATALOG OF VHE γ -RAY SOURCES

► Significance map (point-source hypothesis)

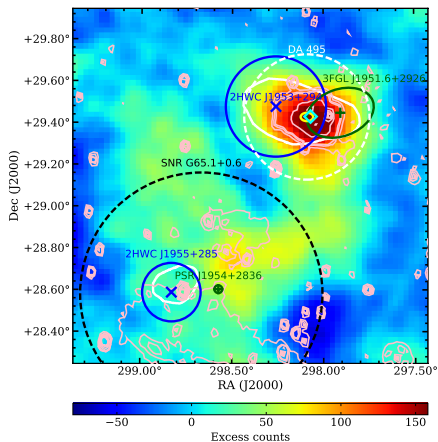
Galactic Plane I; 2726 days



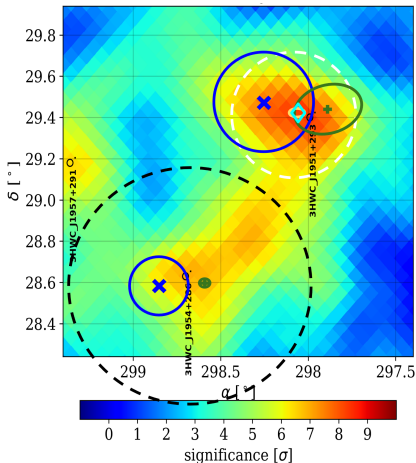
The 4HWC Catalog, HAWC Collaboration: submitted to *ApJ*

NEW TEV γ -RAY SOURCES

► PWN DA 495 (2HWC J1953+294)



VERITAS counts map

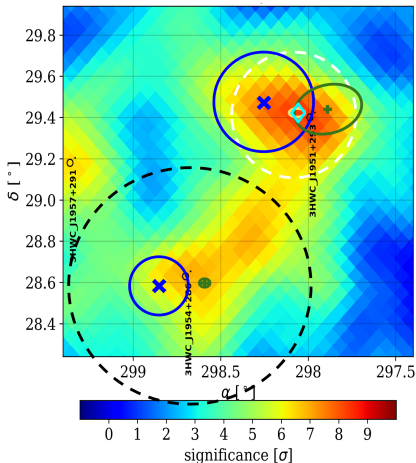
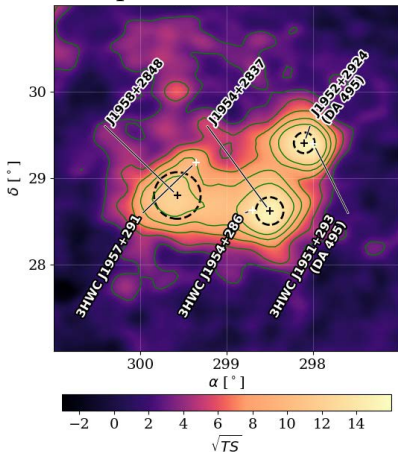


3HWC significance map

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

NEW TEV γ -RAY SOURCES

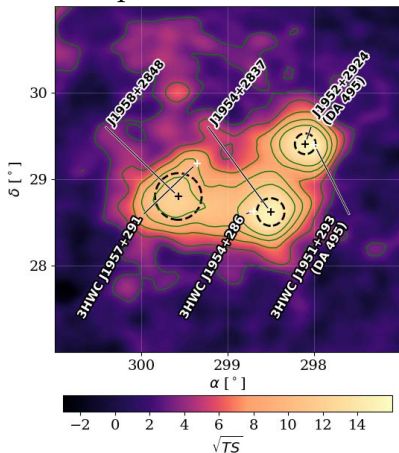
► Update on the PWN DA 495 region



HAWC Collaboration: submitted to *ApJ*

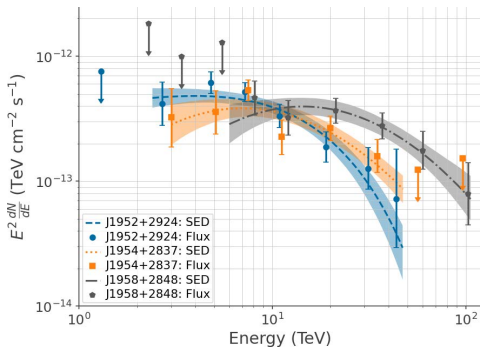
NEW TEV γ -RAY SOURCES

► Update on the PWN DA 495 region



HAWC data map (3071 d)

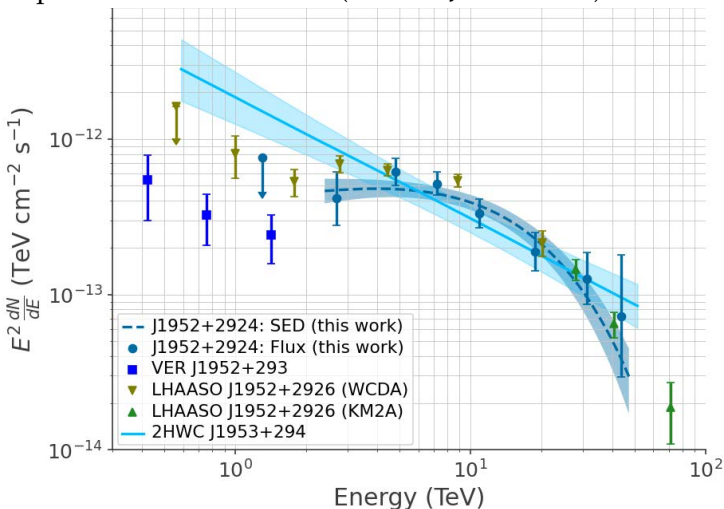
HAWC Collaboration: submitted to *ApJ*



SED for the three sources

NEW TEV γ -RAY SOURCES

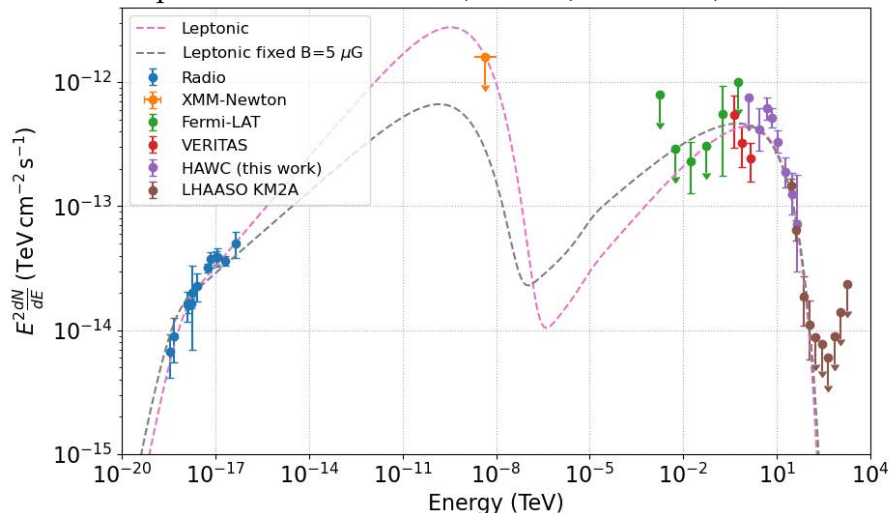
► Update on PWN DA 495 (HAWC J1952+2924)



HAWC Collaboration: submitted to *ApJ*

NEW TEV γ -RAY SOURCES

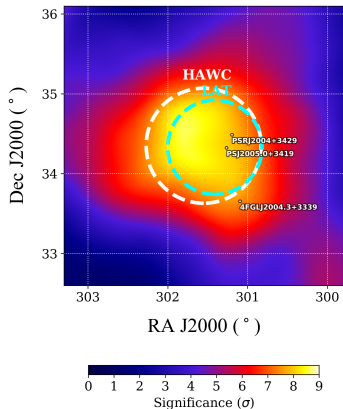
► Update on PWN DA 495 (HAWC J1952+2924)



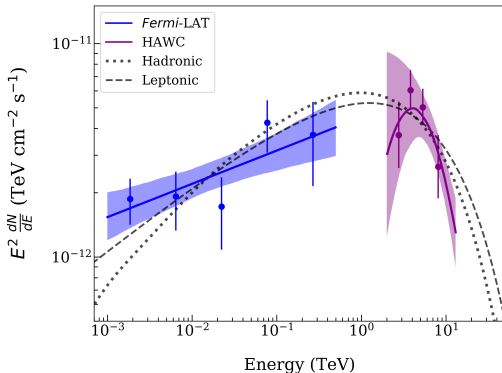
HAWC Collaboration: submitted to *ApJ*

NEW TEV γ -RAY SOURCES

► 2HWC J2006+341



3HWC significance map

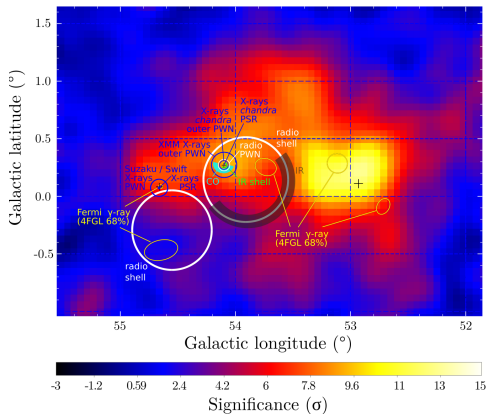


SED from HAWC and LAT data

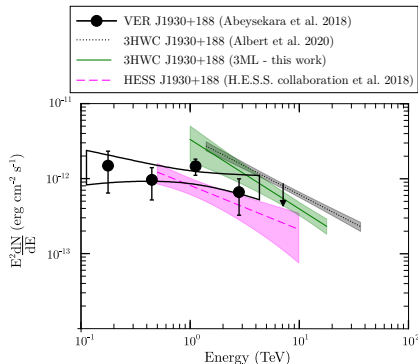
HAWC+Fermi-LAT detection of J2006: *ApJL* **903** (2020) L14

NEW TEV γ -RAY SOURCES

► 3HWC J1928+178 and HAWC J1932+192



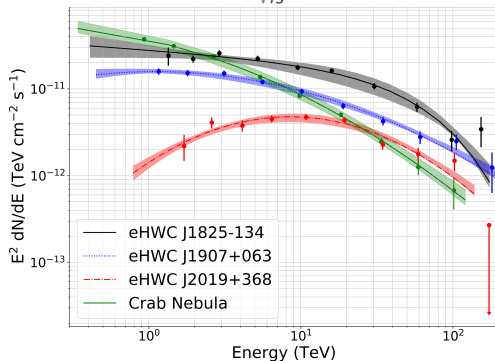
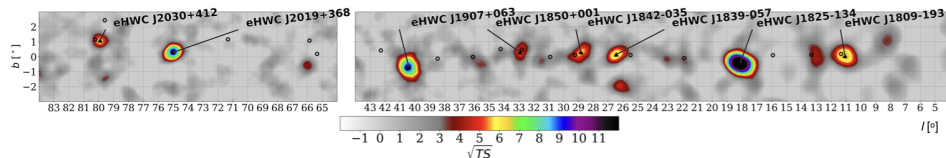
3HWC significance map



SED of 3HWC J1930+188

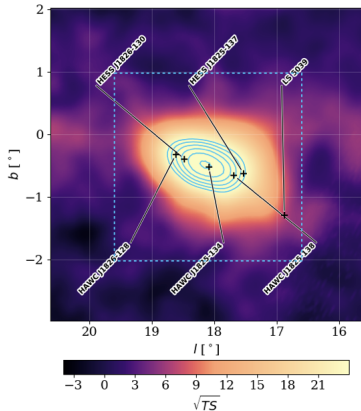
CATALOG OF γ -RAY SOURCES ABOVE 56 TeV

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

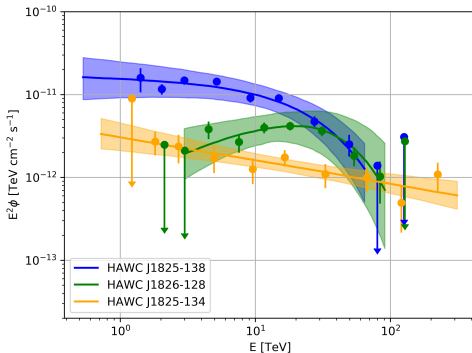


EVIDENCE OF 200 TeV γ RAYS

► eHWC J1825-134



Significance map

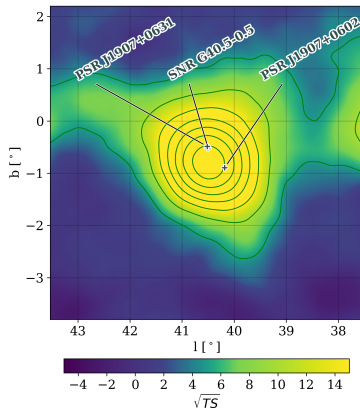


SED from HAWC data

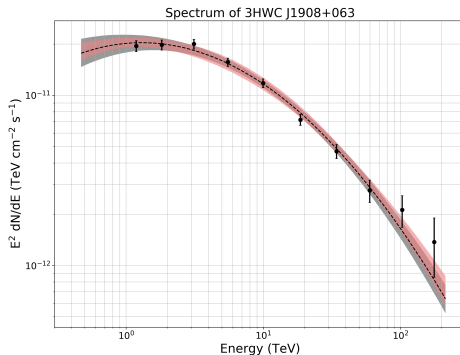
HAWC J1825-134, HAWC Collaboration: *ApJL* **907** (2021) L30

HE γ -RAY SPECTRA

► MGRO J1908+06



Significance map

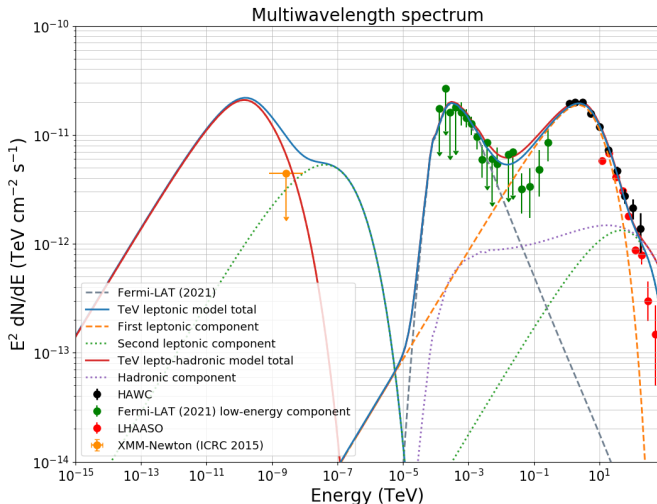


SED from HAWC data

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

HE γ -RAY SPECTRA

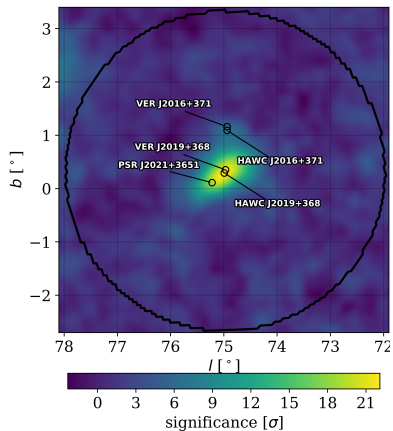
► MGRO J1908+06



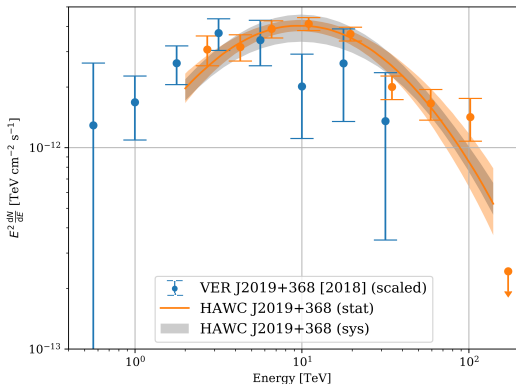
MGRO J1908+06, HAWC Collaboration: *ApJ* **928** (2022) 116

HE γ -RAY SPECTRA & MORPHOLOGY

► HWC J2019+368



Significance map

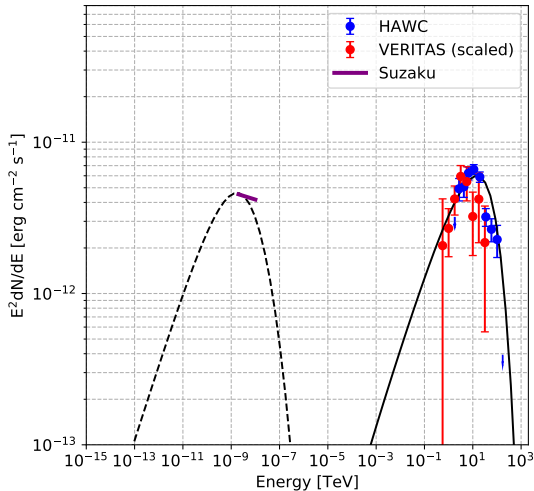


SED from HAWC data

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

HE γ -RAY SPECTRA & MORPHOLOGY

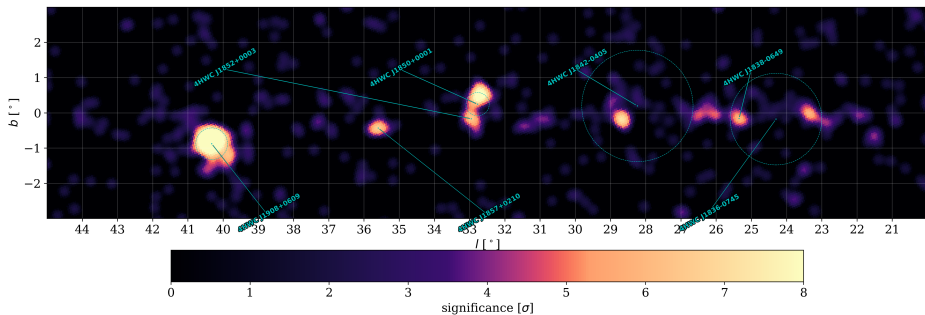
► HWC J2019+368



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

2nd CATALOG OF ULTRA-HIGH ENERGY γ -RAY SOURCES

- 2eHC: 28/21/7 sources above 56/100/177 TeV

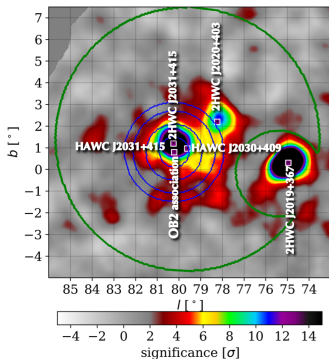


Significance map; Galactic plane ($45^\circ < l < 20^\circ$); $E > 100$ TeV; point-source hypothesis

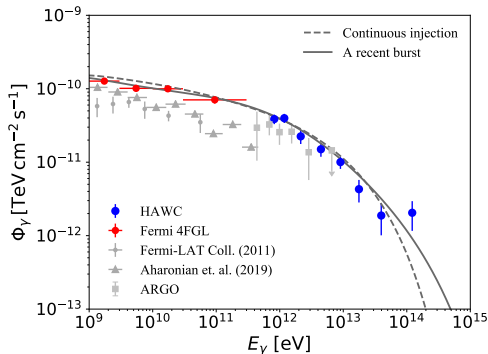
2eHC, HAWC Collaboration: under internal review

VHE COSMIC-RAY ACCELERATORS

► Cygnus Cocoon



3HWC significance map

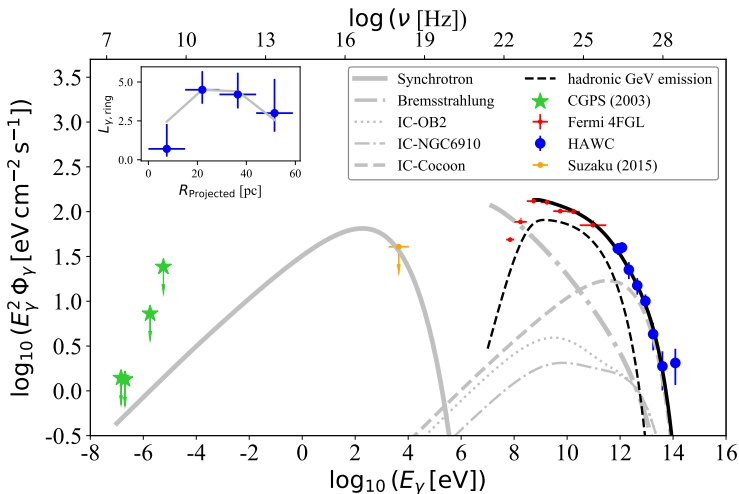


SED from HAWC and LAT data

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

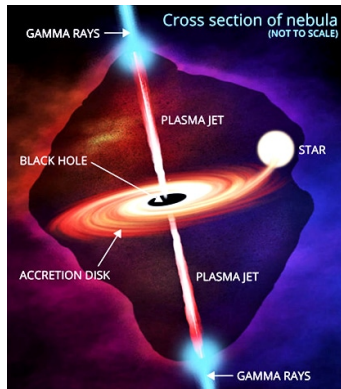
VHE COSMIC-RAY ACCELERATORS

► Cygnus Cocoon



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

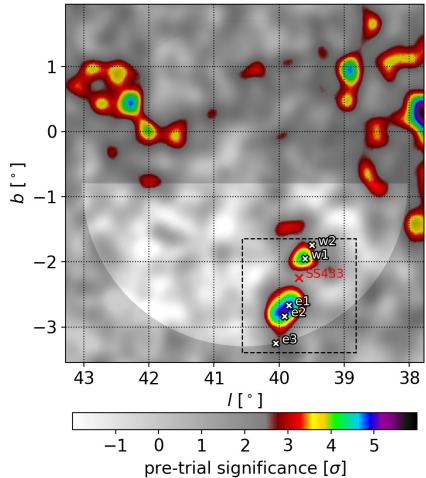
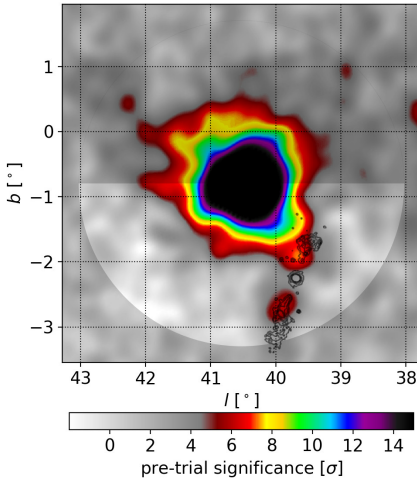
MICROQUASARS



- ▶ stellar-mass black holes or neutron stars that exhibit behavior similar to quasars
- ▶ compact object accreting matter from a companion star
- ▶ relativistic jets
- ▶ intense multi-wavelength emission with rapid changes in brightness

SS 433

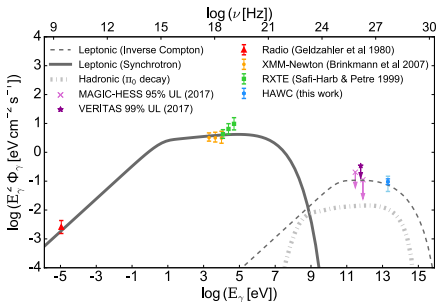
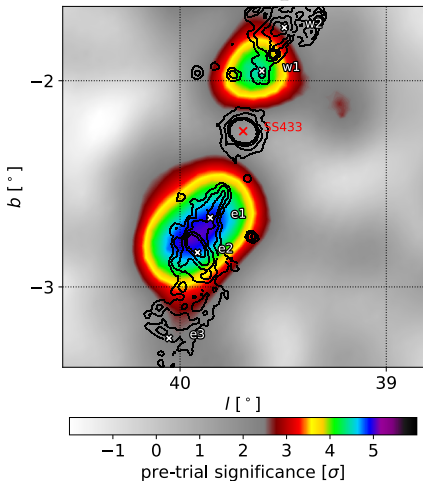
- Very high energy particle acceleration powered by the jets of the microquasar SS 433



HAWC Collaboration: *Nature* **562** (2018) 82-85

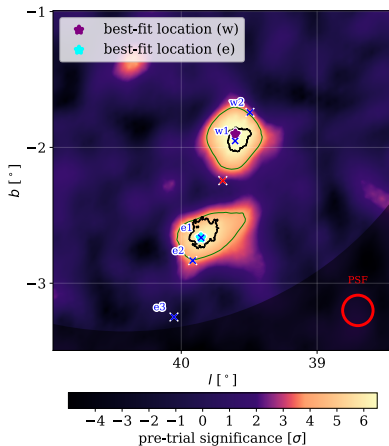
SS 433

- Very high energy particle acceleration powered by the jets of the microquasar SS 433

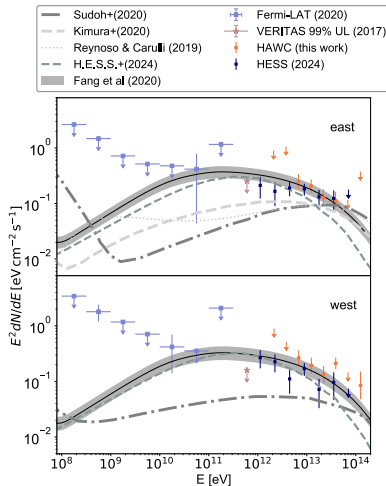


SS 433

- Spectral study of very high energy gamma rays from SS 433 with HAWC



$E > 10 \text{ TeV}$

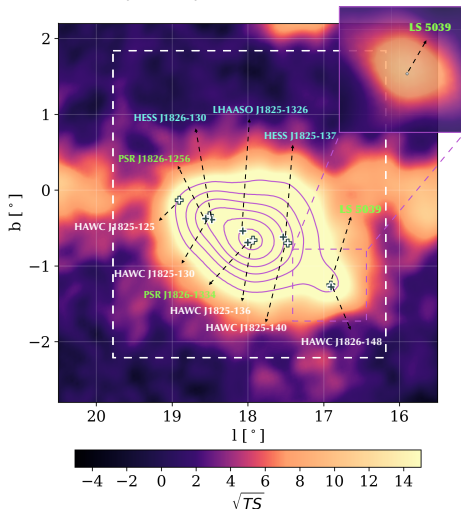


HAWC Collaboration: *The Astrophysical Journal* **976** (2024) 30

LS 5039

► Orbital Modulation of Gamma-Rays Beyond 100 TeV

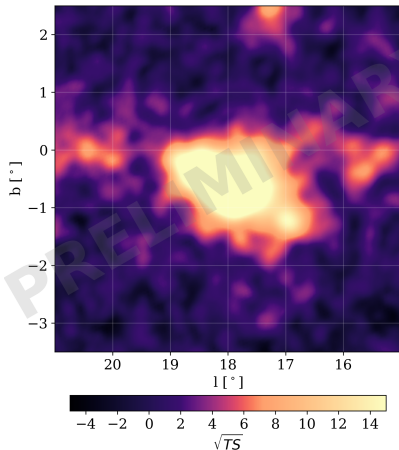
- distance ~ 3 kpc
- compact object orbiting an O type star
- emission from radio to γ rays
- TeV emission observed by H.E.S.S. modulated with the 3.9 d orbit
- highly efficient accelerator



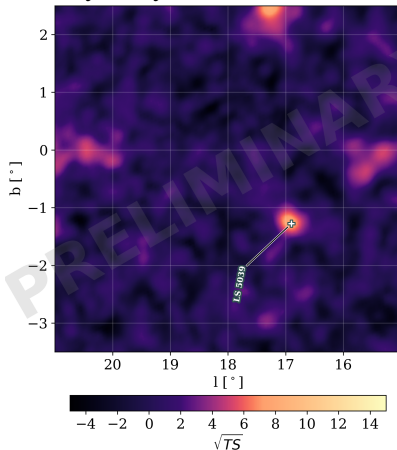
HAWC Collab.: *The Astrophysical Journal Letters* **987** (2025) L42

LS 5039

► Orbital Modulation of Gamma-Rays Beyond 100 TeV



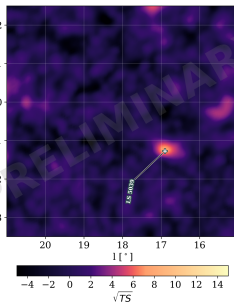
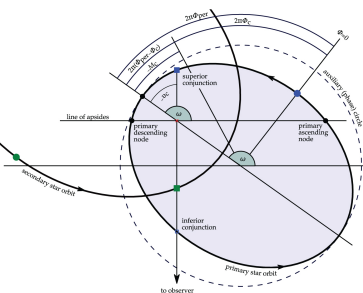
Region of interest



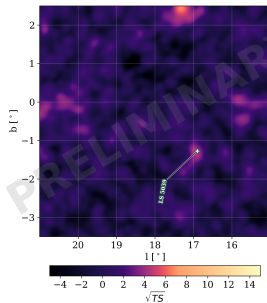
LS 5039 after bkg src subtraction

LS 5039

► Orbital Modulation of Gamma-Rays Beyond 100 TeV



Inferior conjunction



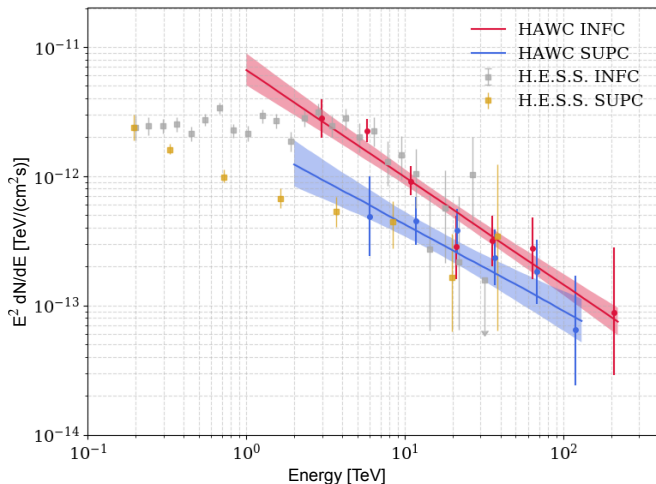
Superior conjunction

Geometry and Dynamics of Binary Stars, Prša

HAWC Collab.: *The Astrophysical Journal Letters* **987** (2025) L42

LS 5039

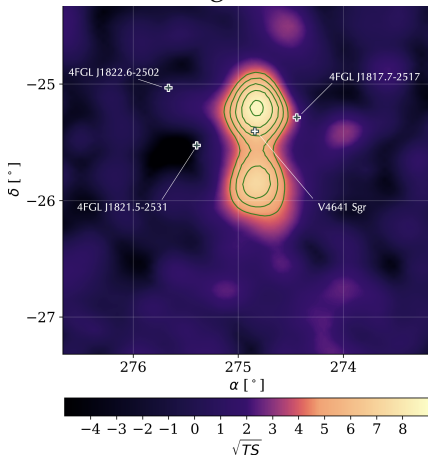
► Orbital Modulation of Gamma-Rays Beyond 100 TeV



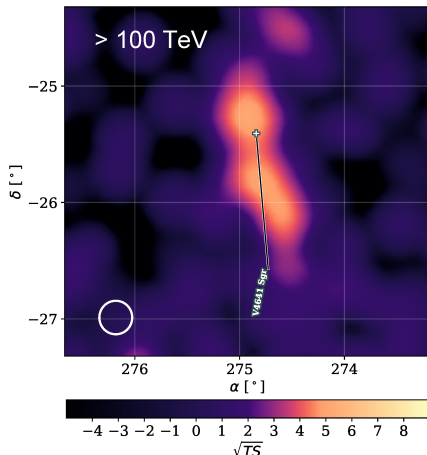
HAWC Collab.: *The Astrophysical Journal Letters* **987** (2025) L42

V4641 SGR

- Ultra-High-Energy γ -ray bubble around microquasar V4641 Sgr



$E > 1$ TeV

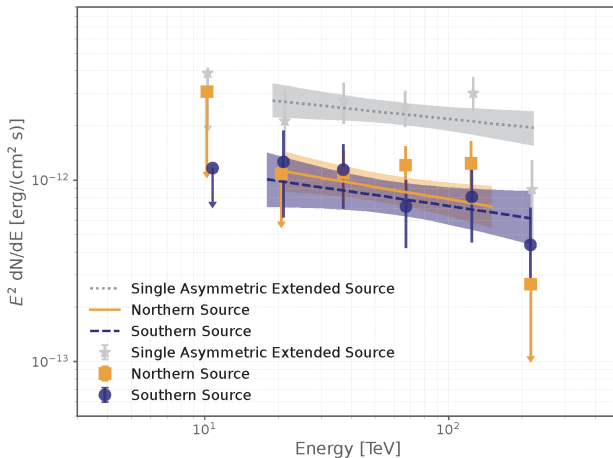


$E > 100$ TeV

HAWC Collaboration: *Nature* **634** (2024) 557-560

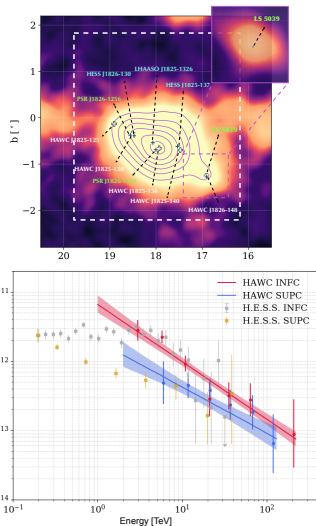
V4641 SGR

- Ultra-High-Energy γ -ray bubble around microquasar V4641 Sgr



CONCLUSIONS & OUTLOOK

- ▶ objects $\Rightarrow$ **population!**
- ▶ extended emission $\Rightarrow$ particle acceleration in the **jets**
- ▶ Possible substantial contribution to Galactic CRs at the highest energies
- ▶ detailed studies with IACTs, search for neutrinos, next generation arrays





THANK YOU VERY MUCH!

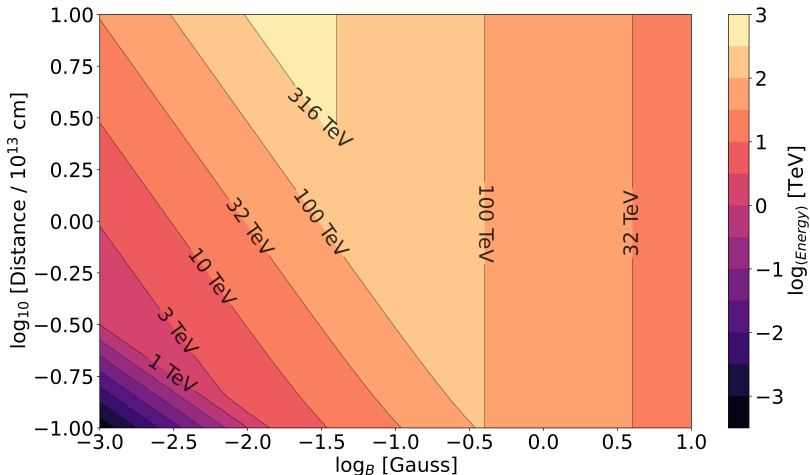
BACK-UP SLIDES

MOST RECENT HAWC PAPERS

- ▶ “Constraints on Axion-Like Particles from Ultra-High Energy Observations of 3HWC J1908+063 with HAWC,” JCAP **05** (2026), 024
- ▶ “Search for signatures of dark matter annihilation in the Galactic Center with HAWC,” PRL **136** (2026), 191001
- ▶ “Search for TeV emission from spider millisecond pulsars with HAWC,” PRD **113** (2026), 083016
- ▶ “Constraints on axion-like particles from ultra-high-energy observations of M87 with the HAWC observatory,” Physics of the Dark Universe **52** (2026) 102260
- ▶ “Combined dark matter search towards dwarf spheroidal galaxies with Fermi-LAT, HAWC, H.E.S.S., MAGIC, and VERITAS,” JCAP **03** (2026), 035
- ▶ “Longtime Monitoring of TeV Radio Galaxies with HAWC,” ApJ **994** (2025) 191
- ▶ “Extended TeV Halos May Commonly Exist around Middle-Aged Pulsars,” PRL **134** (2025) 171005

LS 5039

► Orbital Modulation of Gamma-Rays Beyond 100 TeV

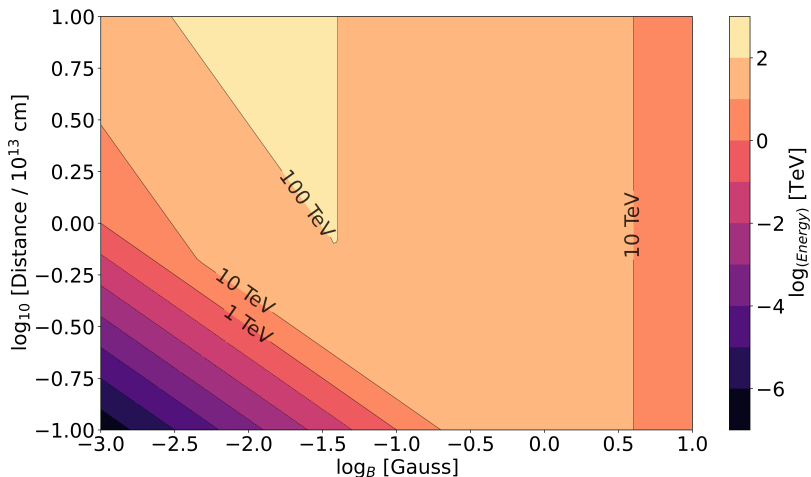


Maximum electron energy ($\eta = 1$)

HAWC Collab.: *The Astrophysical Journal Letters* **987** (2025) L42

LS 5039

► Orbital Modulation of Gamma-Rays Beyond 100 TeV



Maximum electron energy ($\eta = 10$)

HAWC Collab.: *The Astrophysical Journal Letters* **987** (2025) L42