Unraveling the Complex Gamma-Ray Emission from eHWC J1825-134 Region with HAWC: the Transition of TeV Halo

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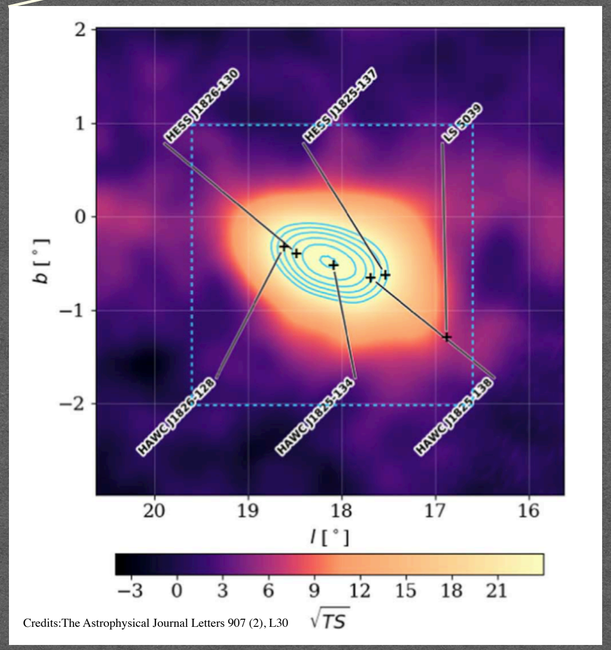
University of Maryland, College Park
TeV Particle Astrophysics (TeVPA), Chicago, 2024

Improved Pass5 Reconstruction

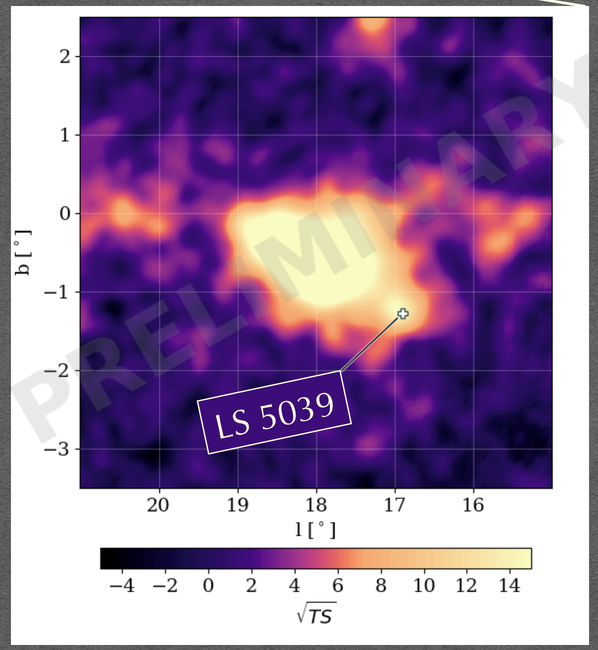
Pass 4



Credits:The Astrophysical Journal Letters 907 (2), L30

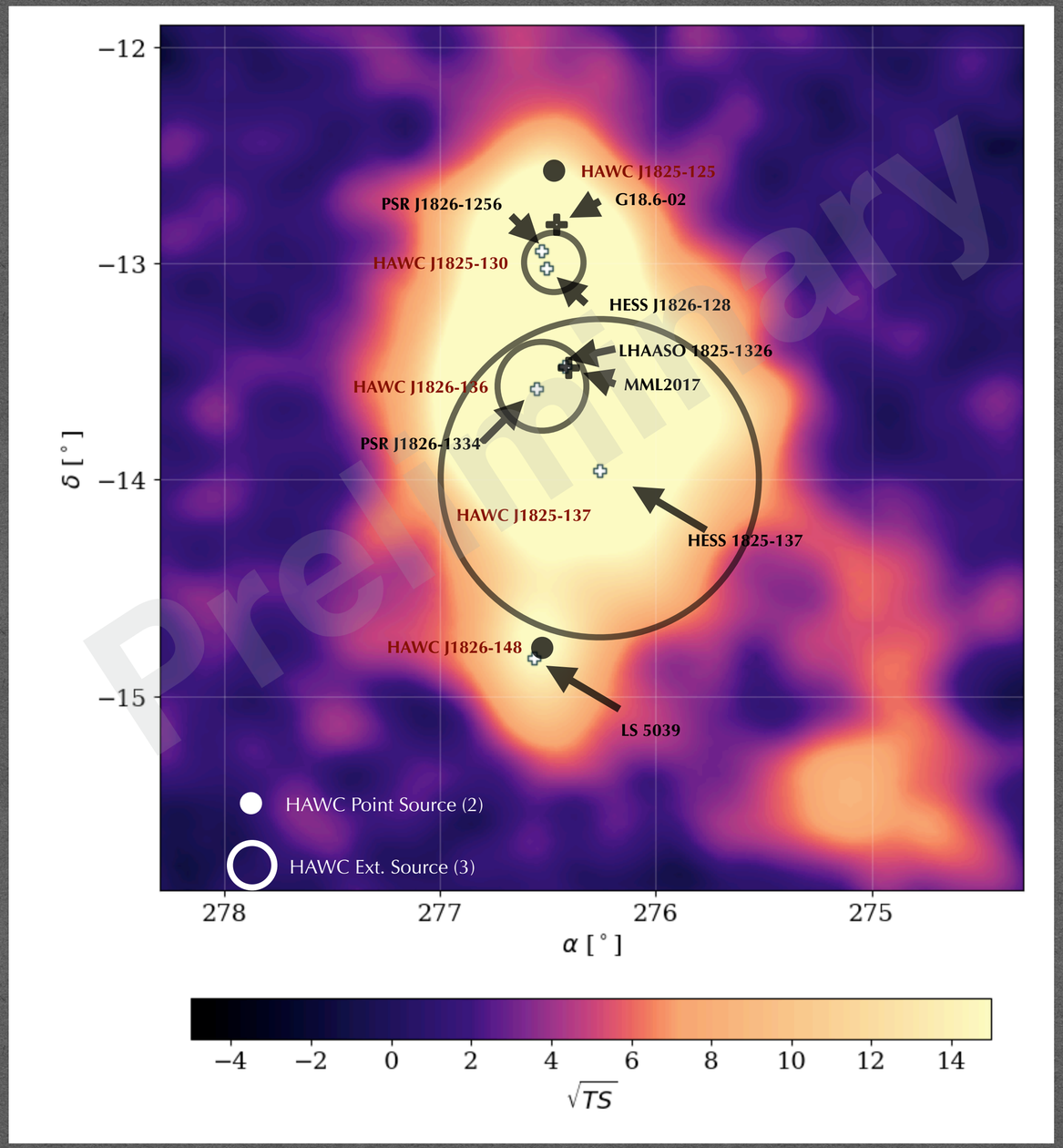
- Two extended source associated with PWNe
- One ultra-high energy point like source with the energy beyond 200 TeV

Pass 5



- More structures are emerging in this complex region
- One bright hotspot located on top of the gamma-ray binary LS 5039

Modeling the Region

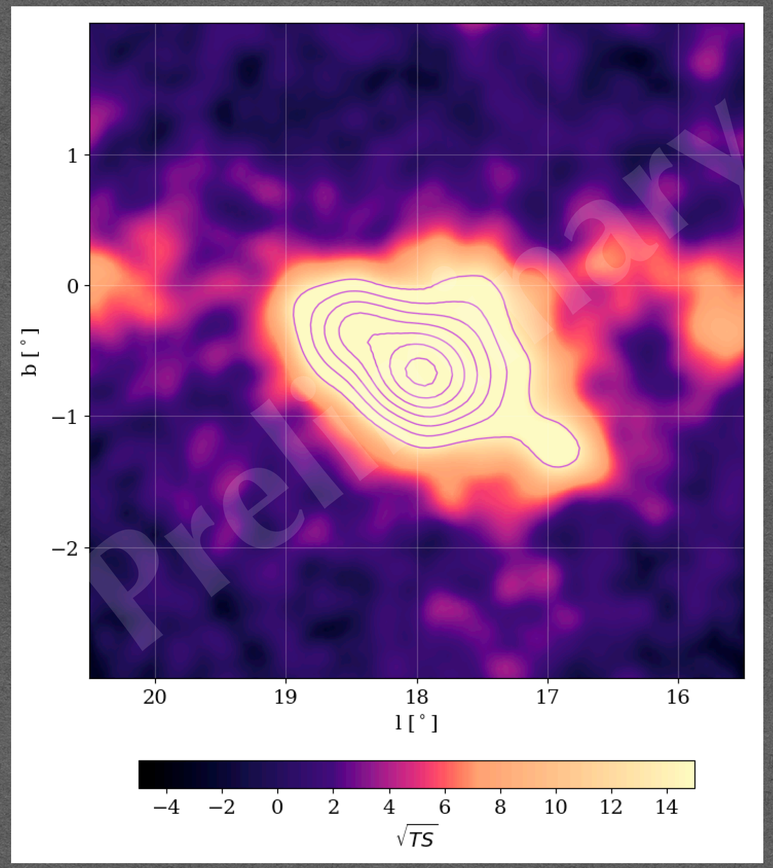


- Using 3ML framework and HAL plugin
- Utilized systematic multi-source fitting to model the entire region
- Best-fit contains 5 gamma-ray sources and diffuse background emission
- 3 extended sources (Gaussian model), and 2 point like sources
- LHAASO resolve 3 sources inside this region

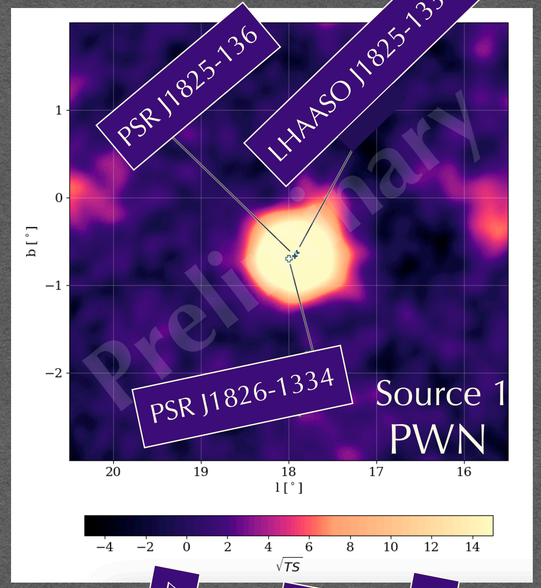
3ML Multi-Mission Maximum Likelihood Framework

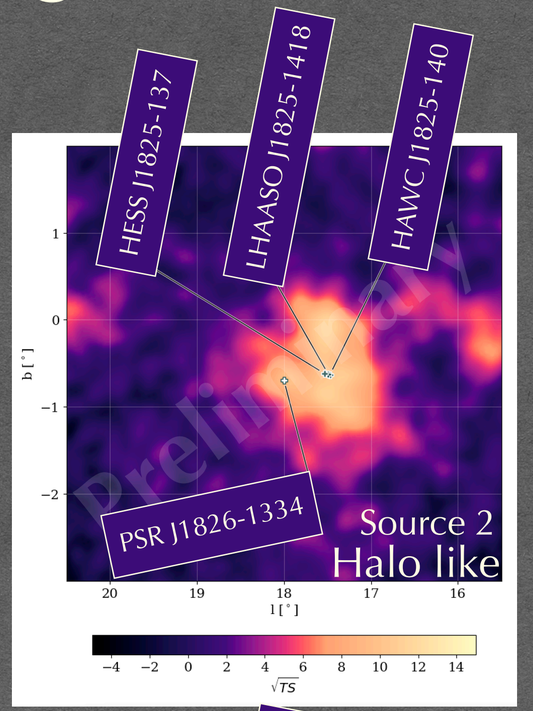
Modeling the Region

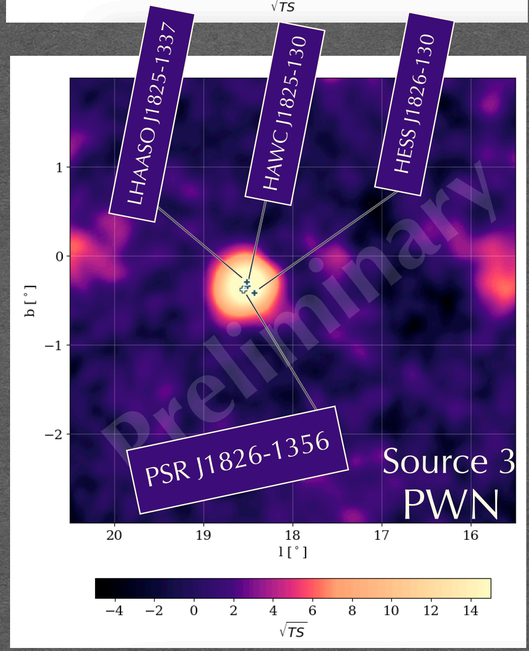
Four Major Sources in the Region

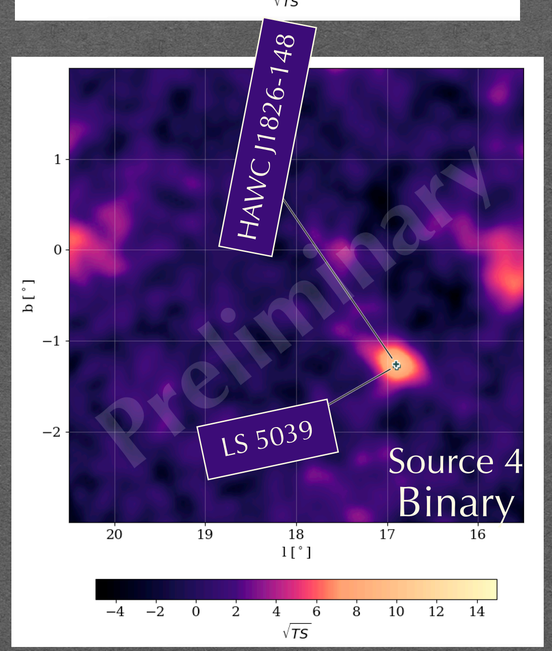


Significance contours from 14 to 52 sigma









1.J1825 PWN

- 0.22° extended

2.J1825 Halo

- 0.77° extended

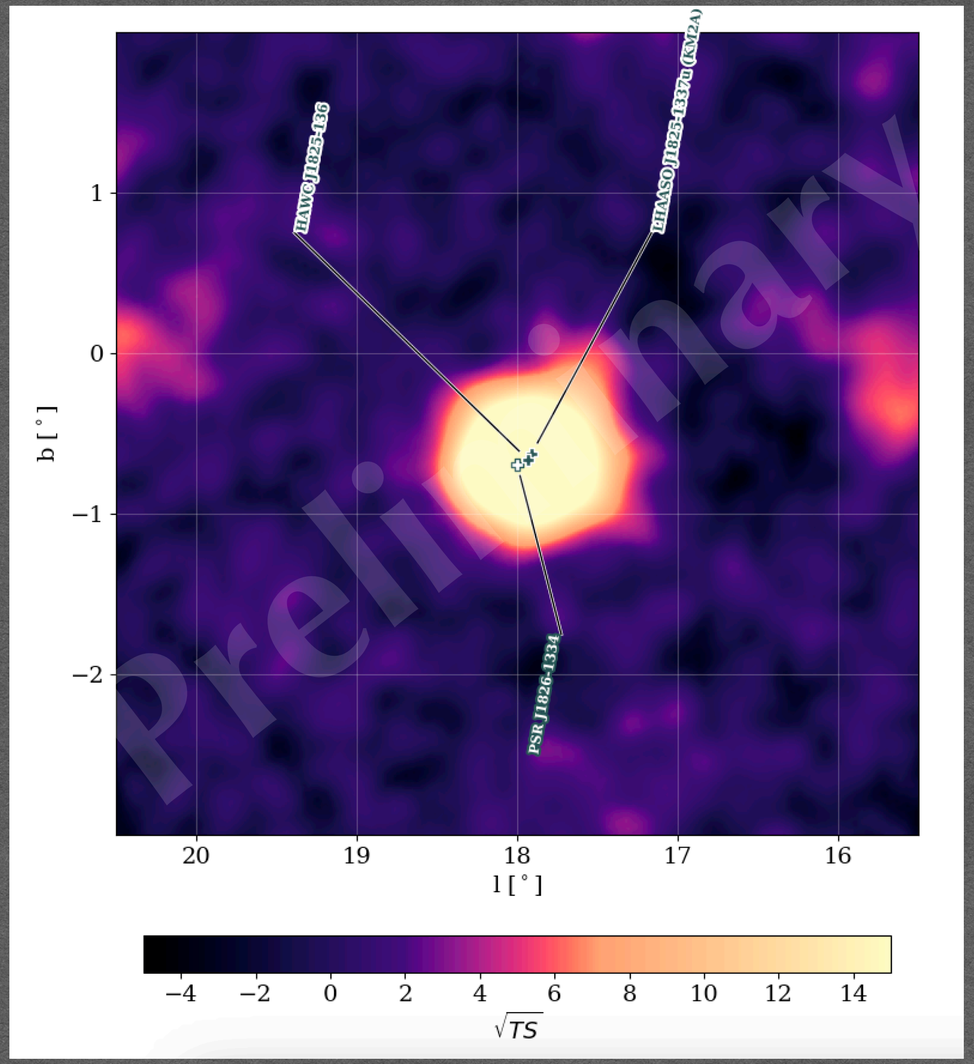
3.J1826 PWN

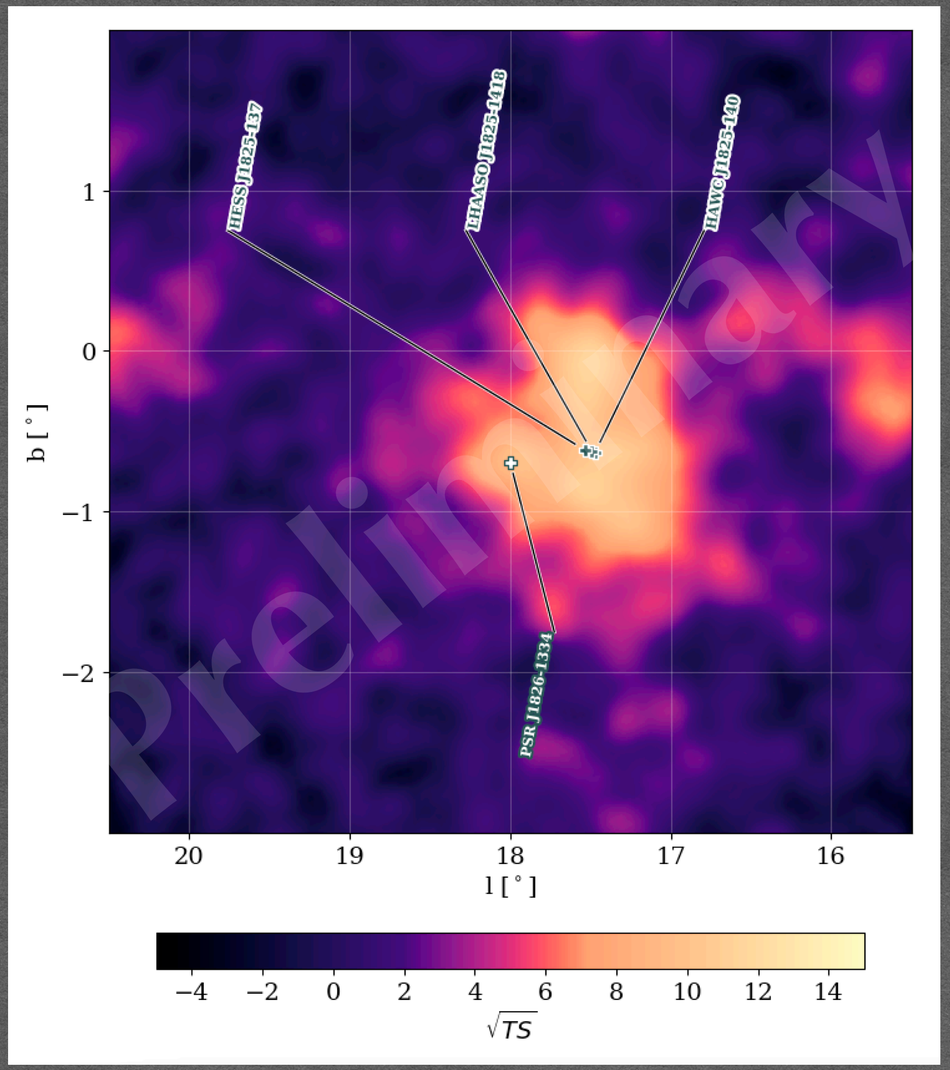
- 0.14° extended

4.LS 5039

- Point like

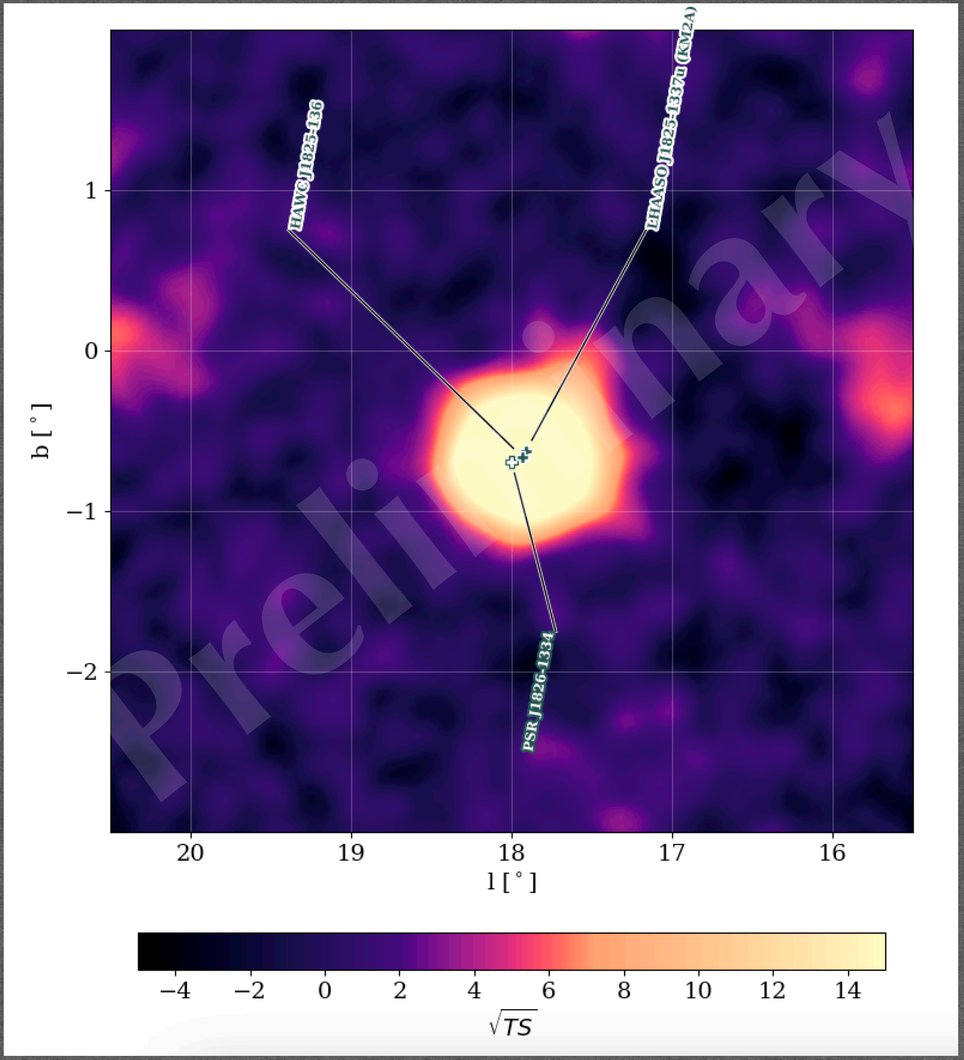
Two Sources Powered by PSR J1826-1334

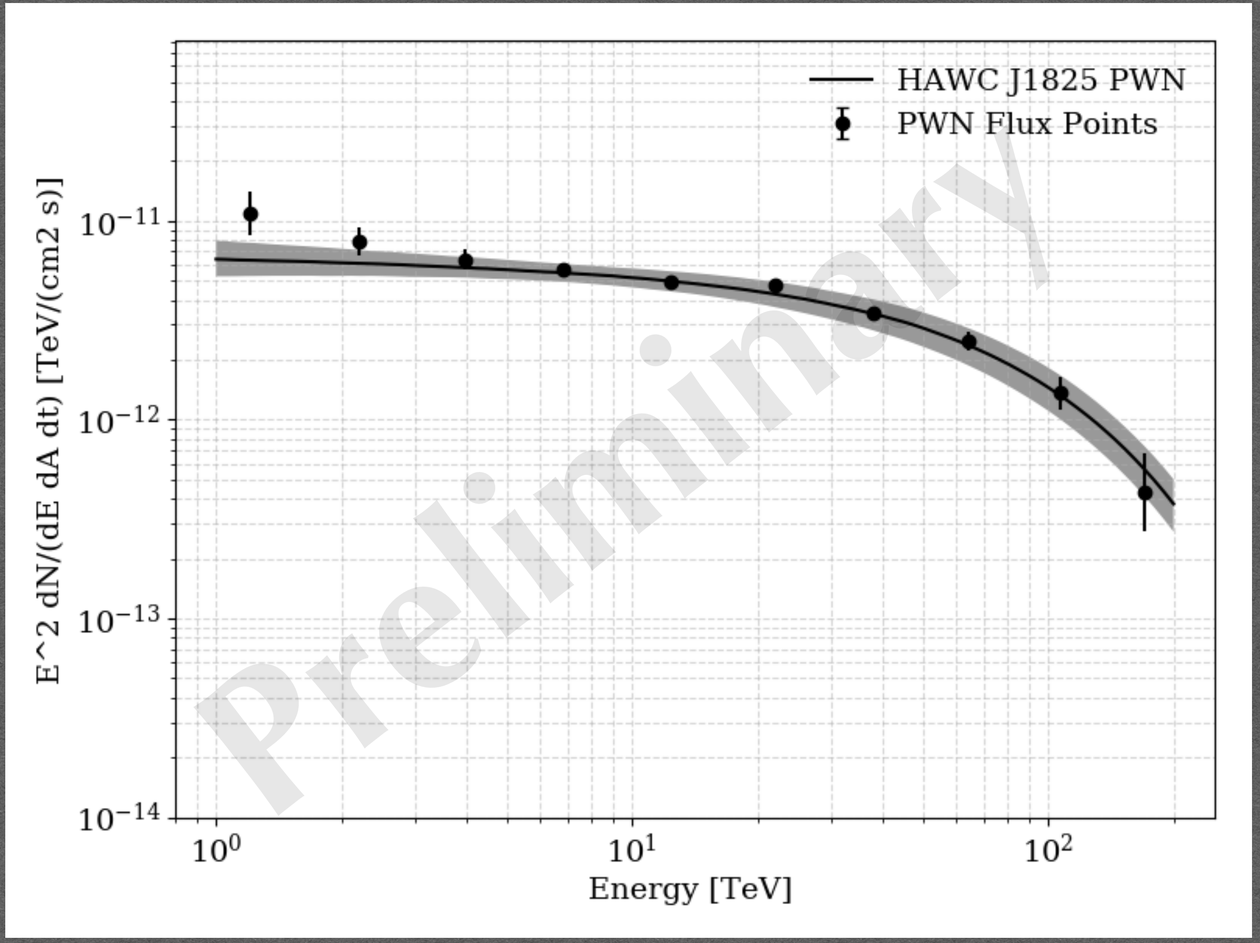




PSR J1826-1334 is a powerful pulsar with $\dot{E} = 2.8 \times 10^{36} erg/s$ at age of 21.4 kyr

Two Sources Powered by PSR J1826-1334





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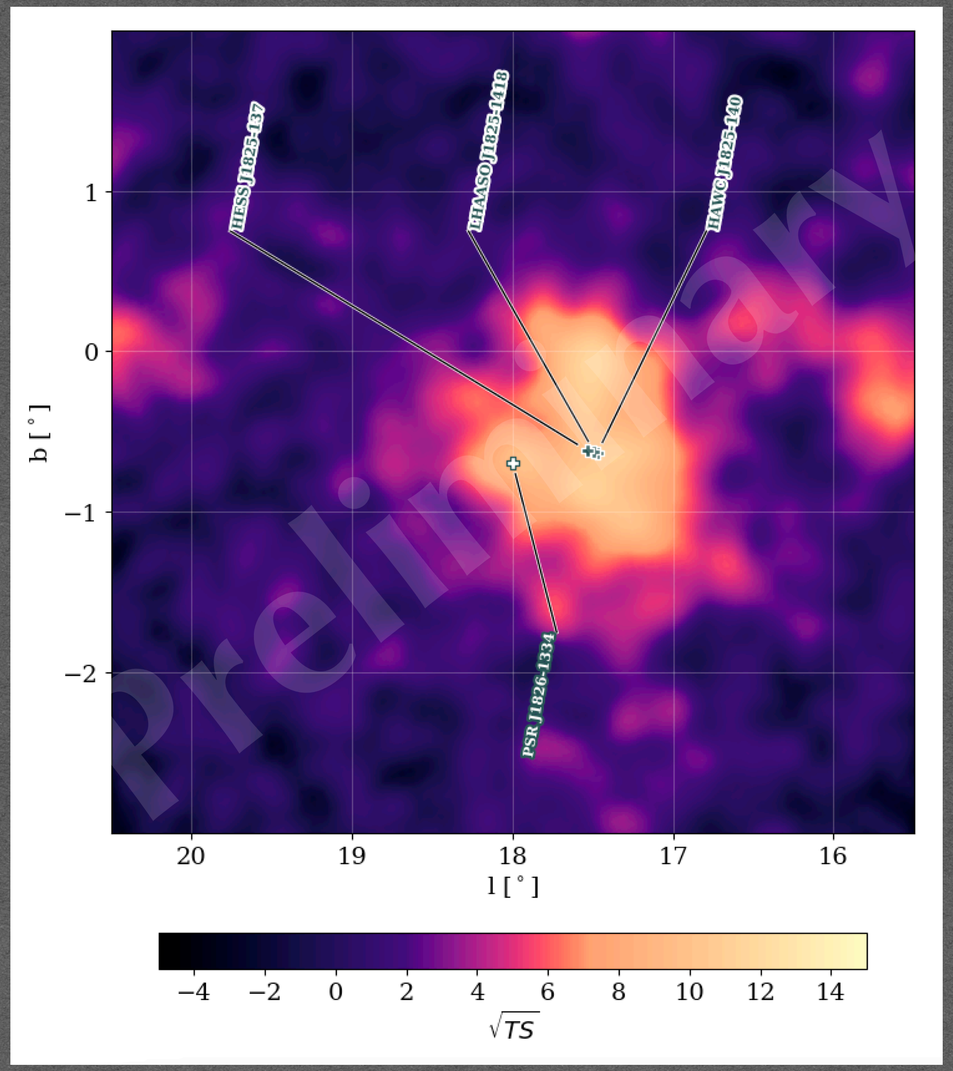

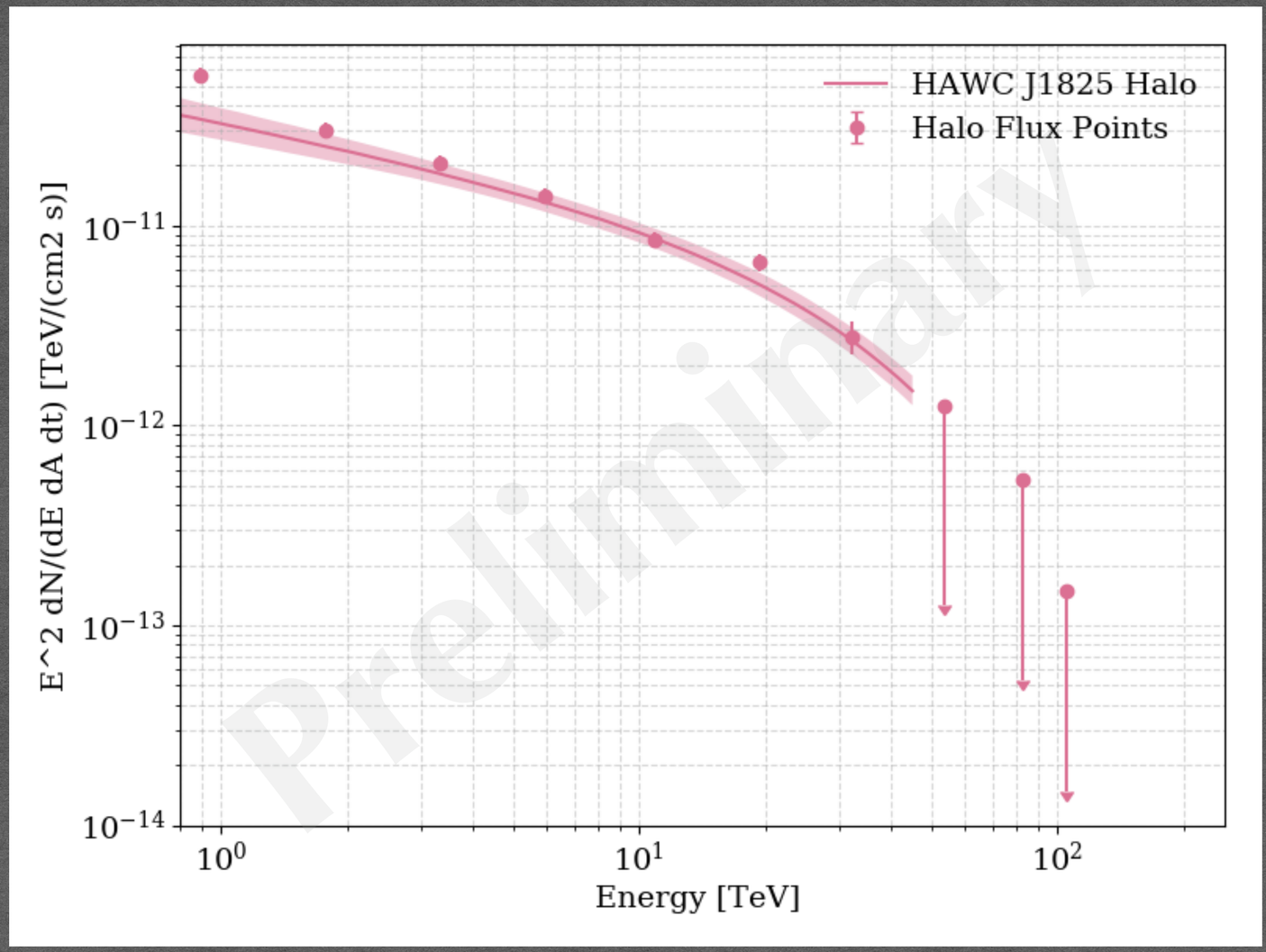

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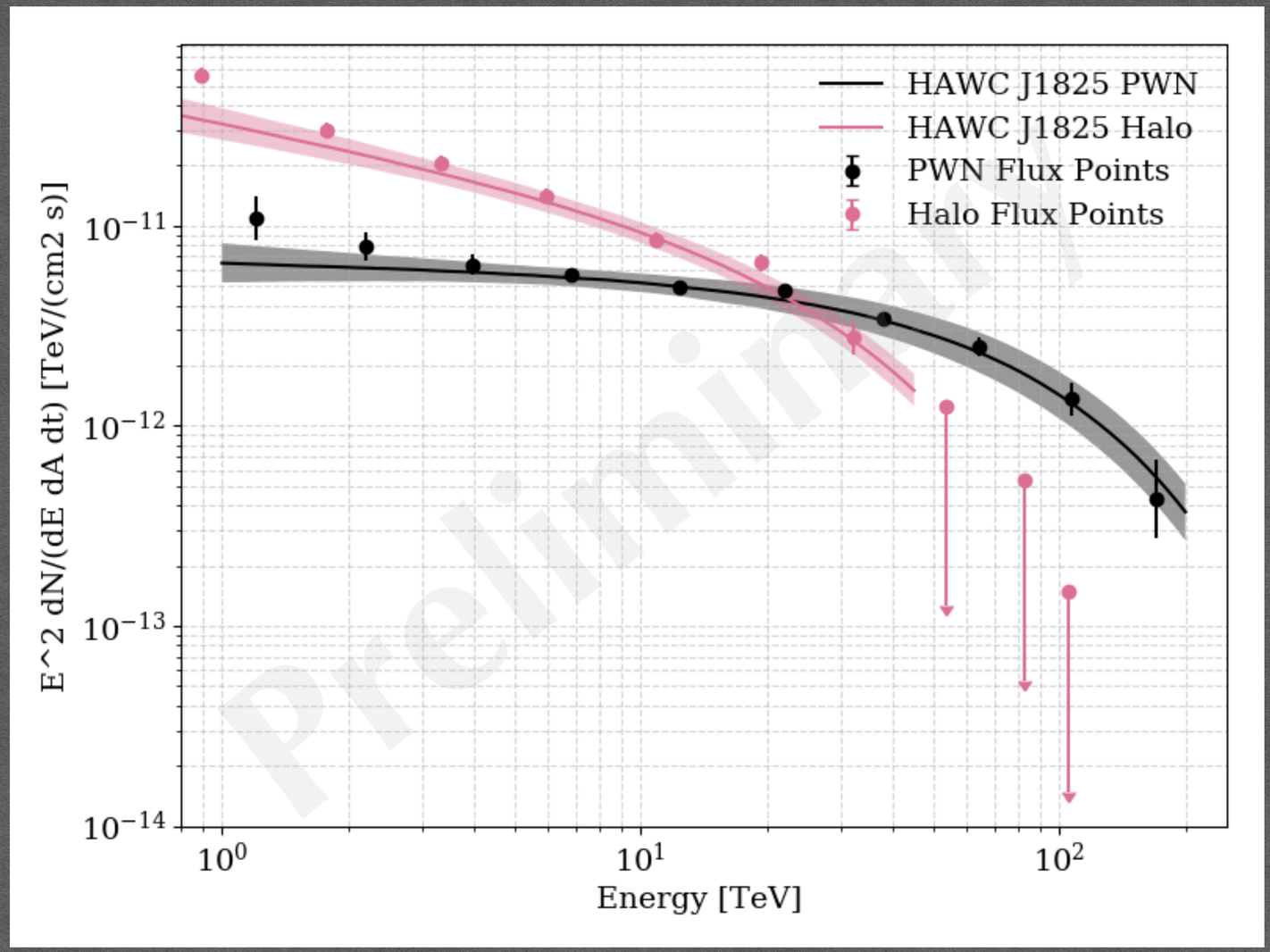
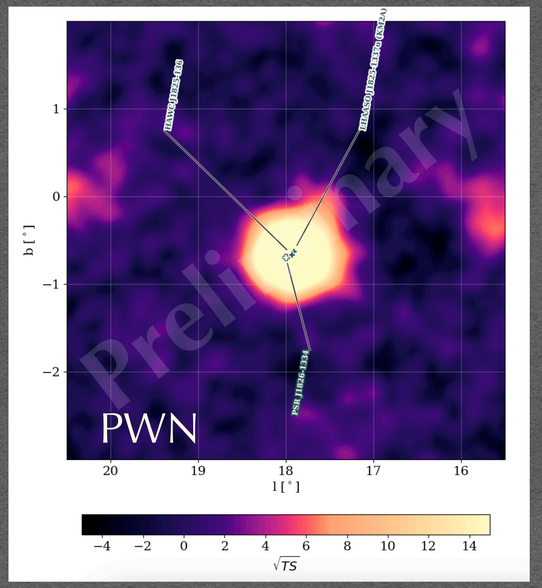
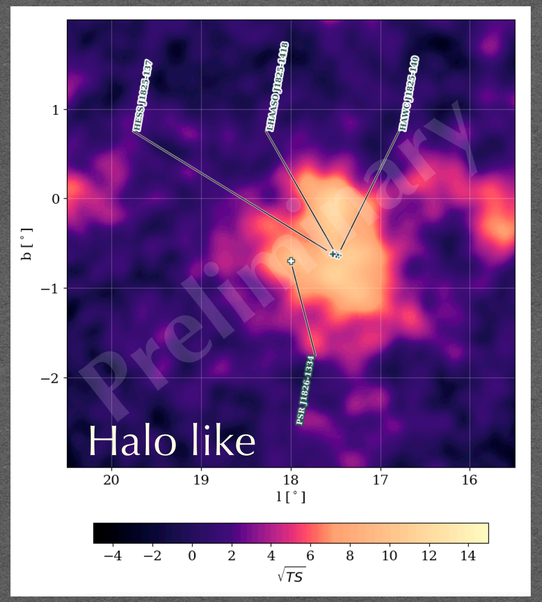
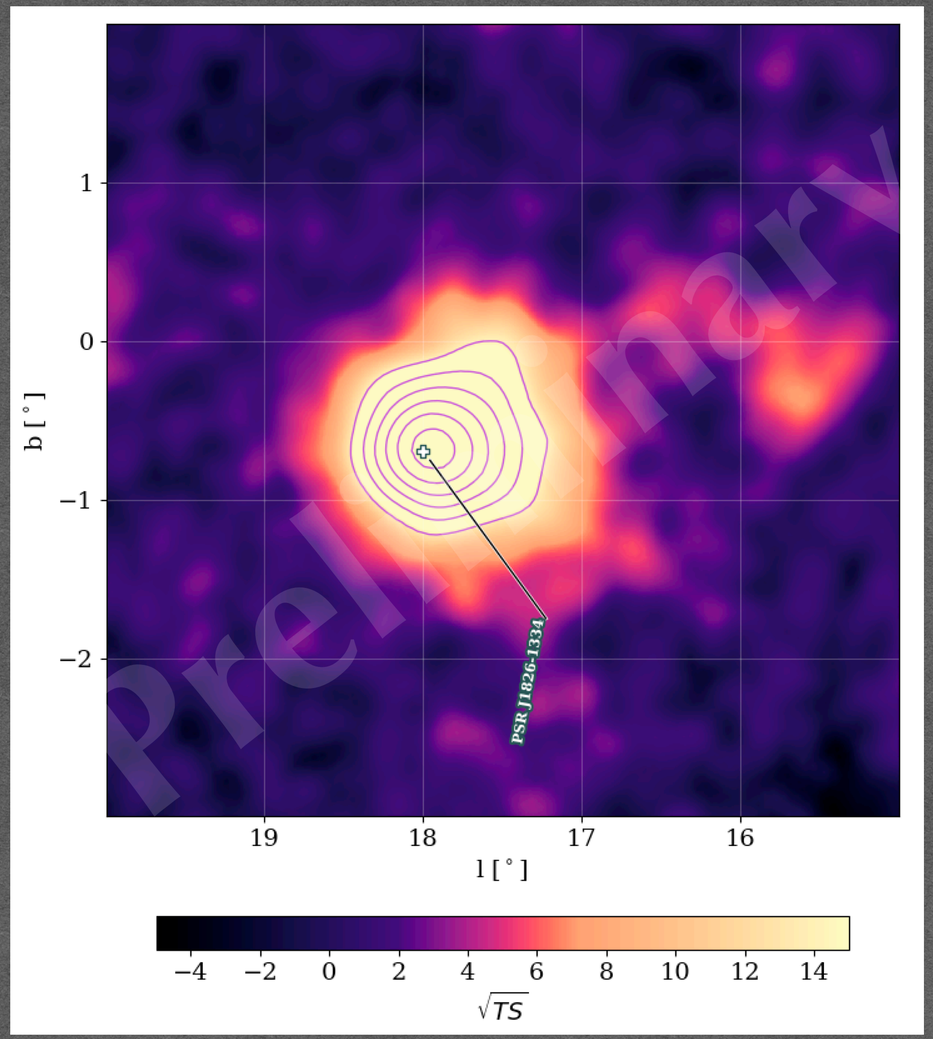






- PWN part has harder spectrum to higher energy
- Halo part has softer spectrum cut off around 30 TeV

Hybrid System of PWN and Halo



- Removed the emission from other sources inside the region
- The hybrid system measured with 47 σ in the HAWC data
- Previous studies indicate the energy dependent morphology of the system

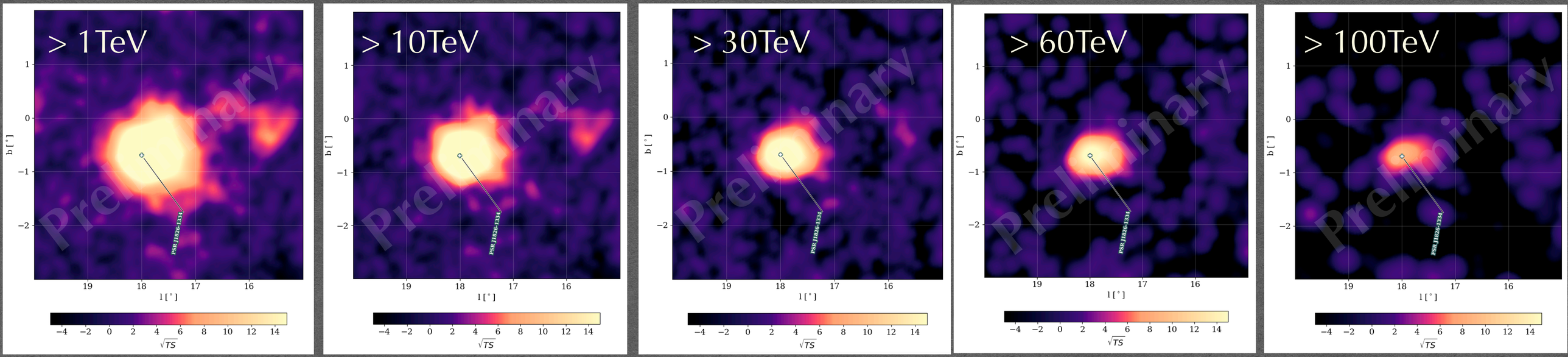
Significance contours from 14 to 46 sigma

Energy-Dependent Morphology — Extension

- Higher energy electrons will cool faster, higher energy photos will have a smaller extension
- An extended gaussian with powerlaw spectrum fitted to the different energy data sets

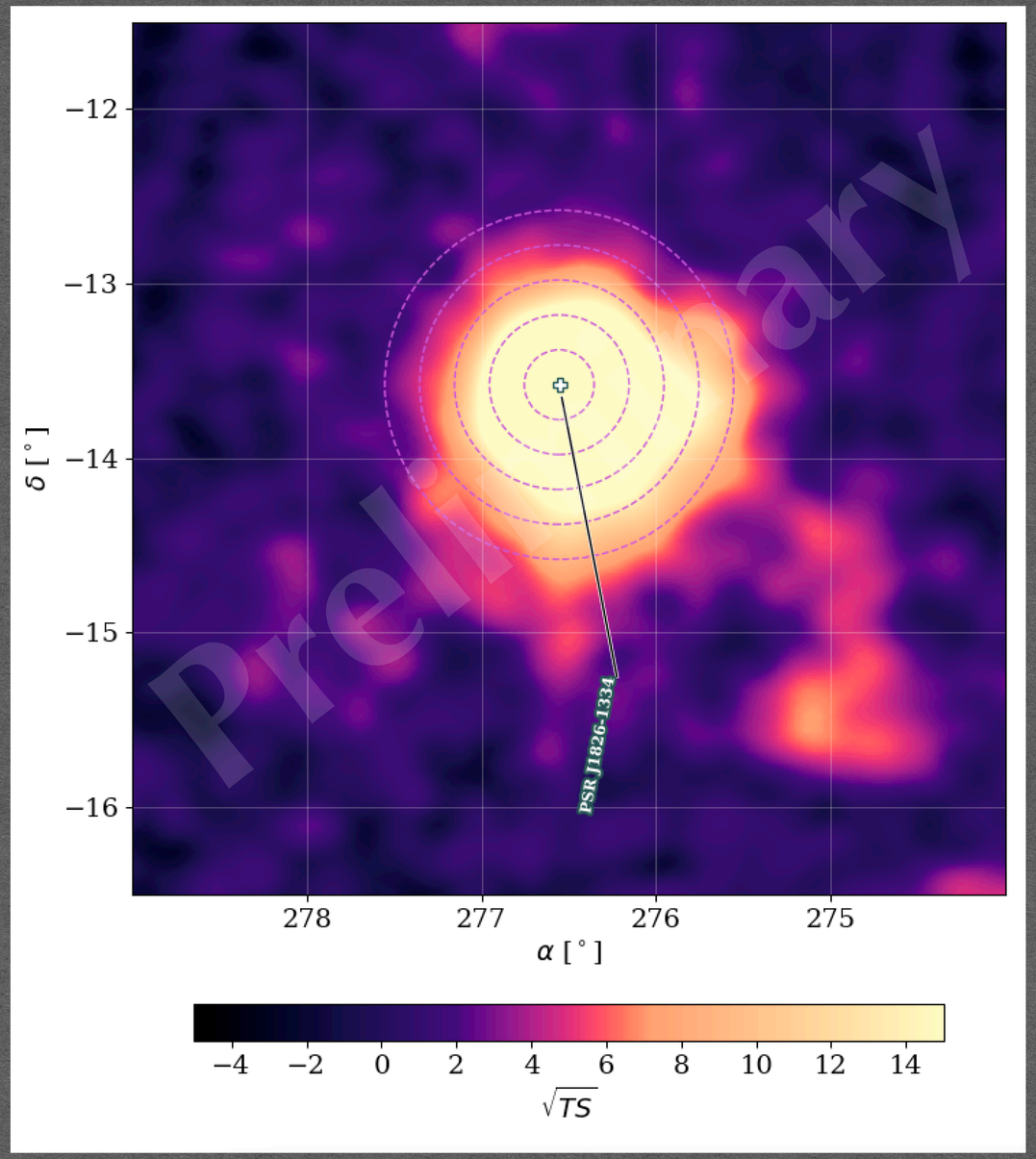
Gaussian Width

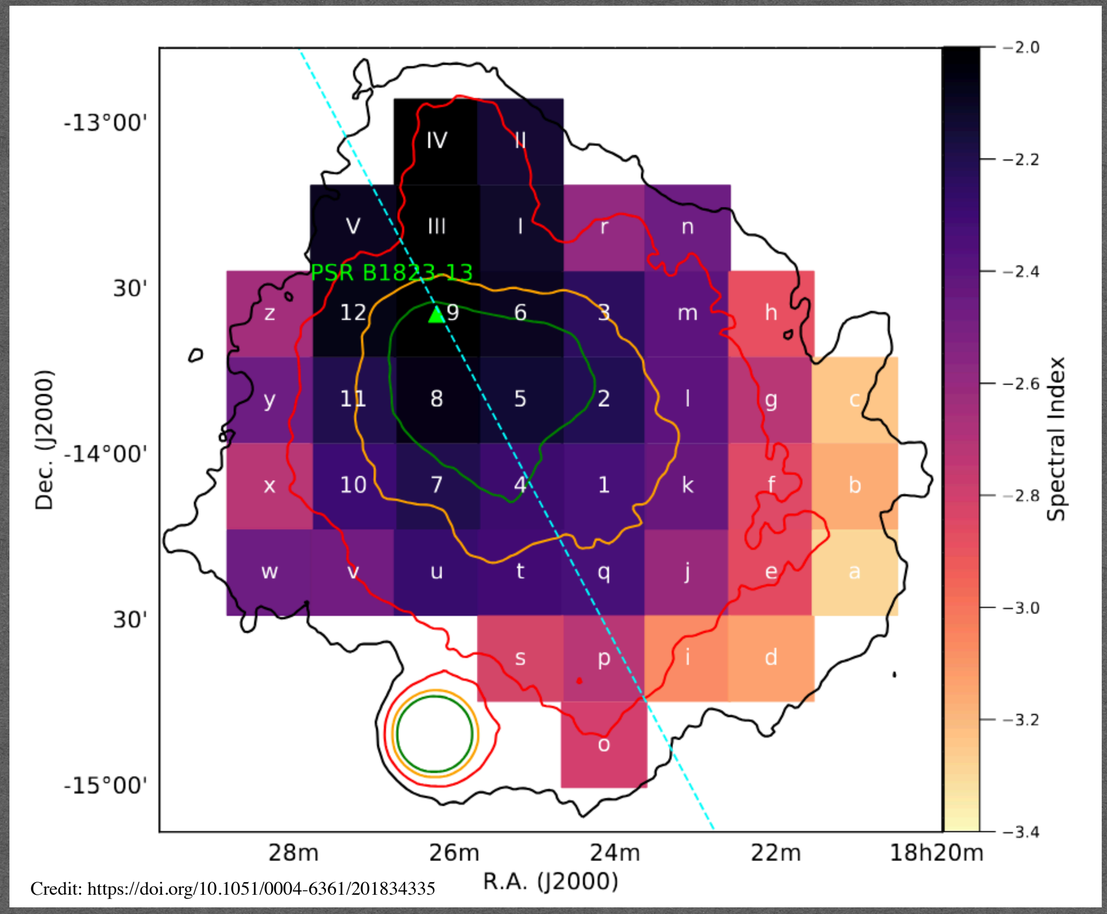
0.33° -/+ 0.01°	0.32° -/+ 0.011°	0.28° -/+ 0.015°	0.25° -/+ 0.02°	0.23° -0.035°, +0.04°



The size from different energy range and individual source will be studied in the future analysis

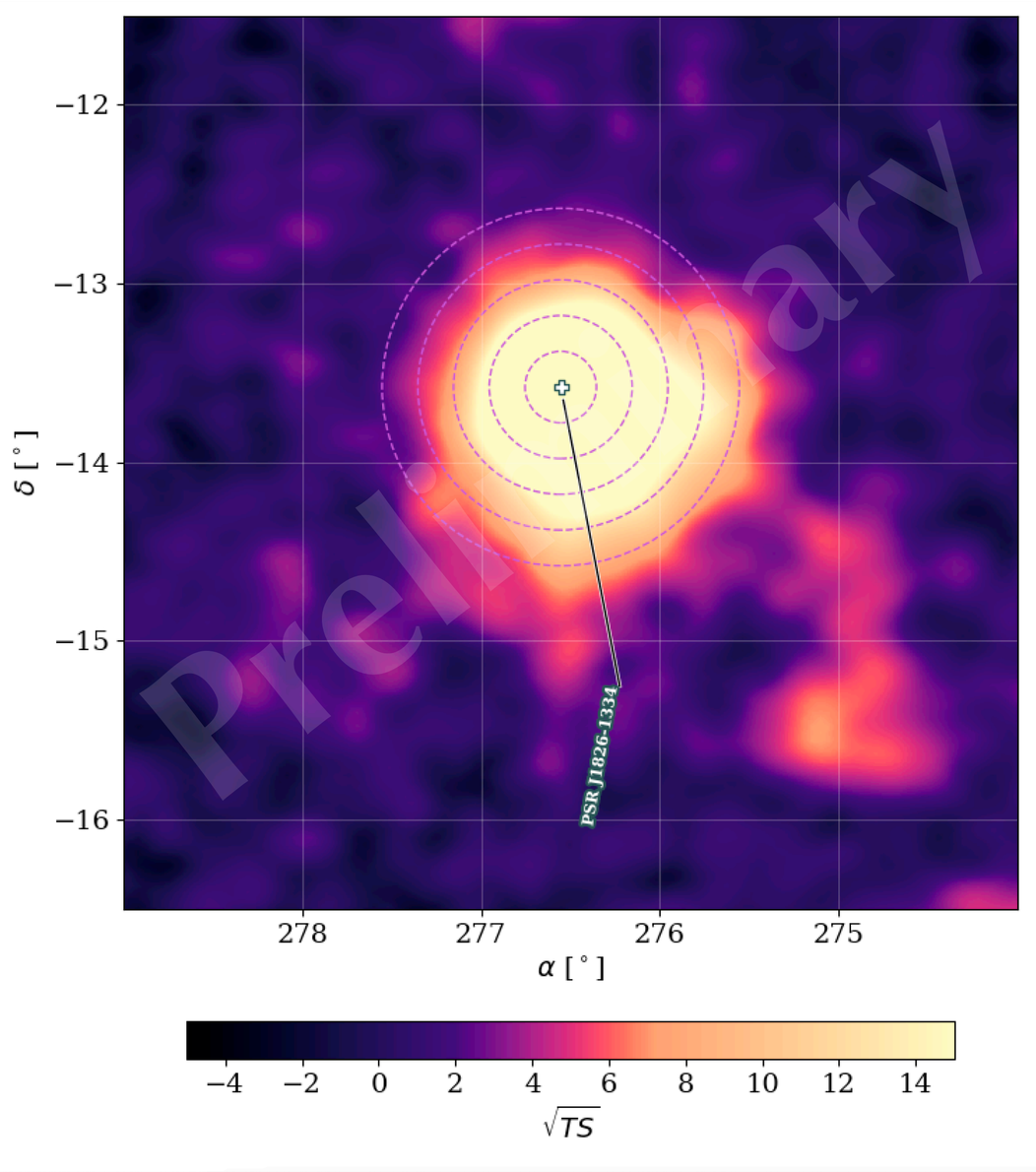
Energy-Dependent Morphology — Spectrum Index

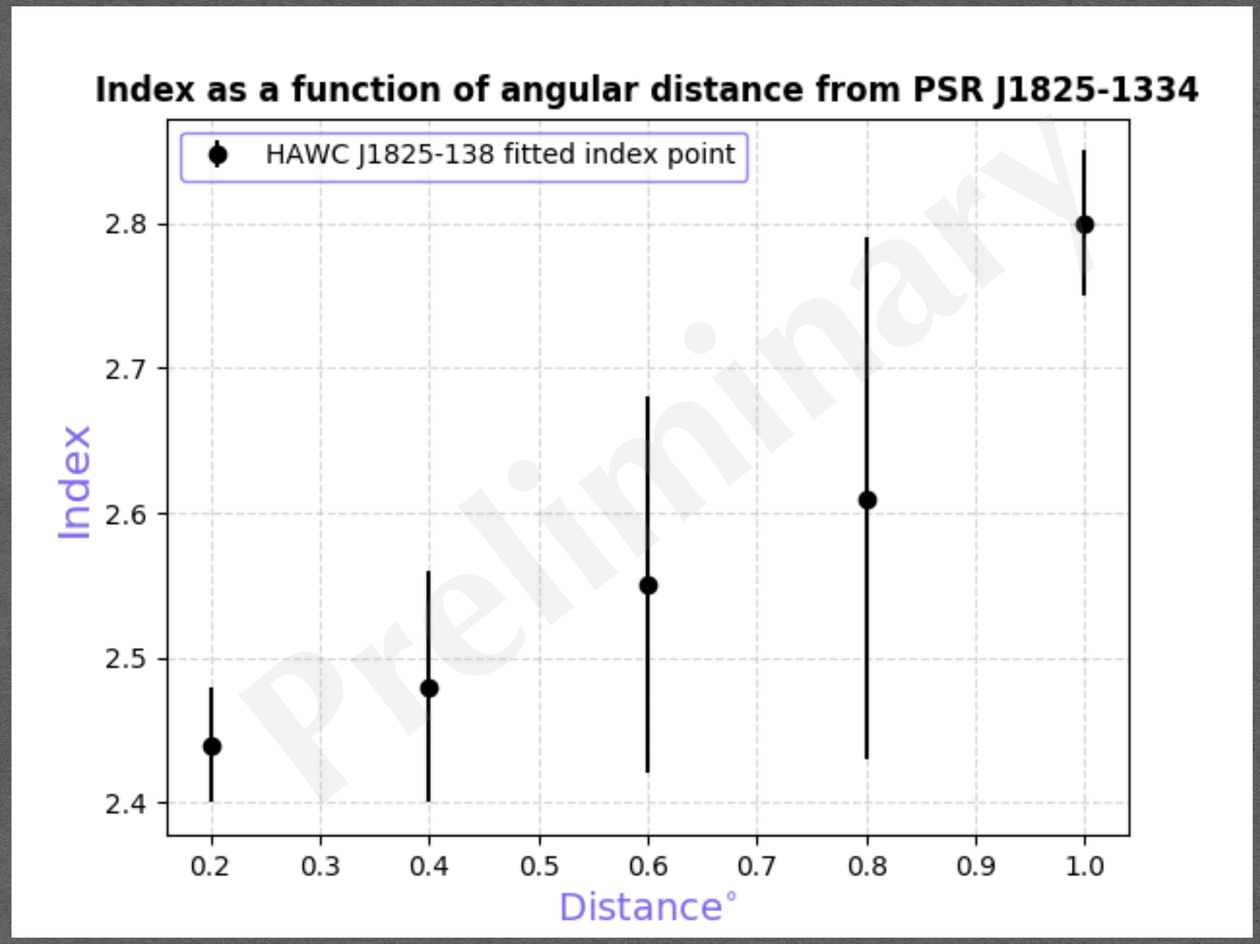




- H.E.S.S. looked at index inside square regions
- HAWC look at index inside annulus

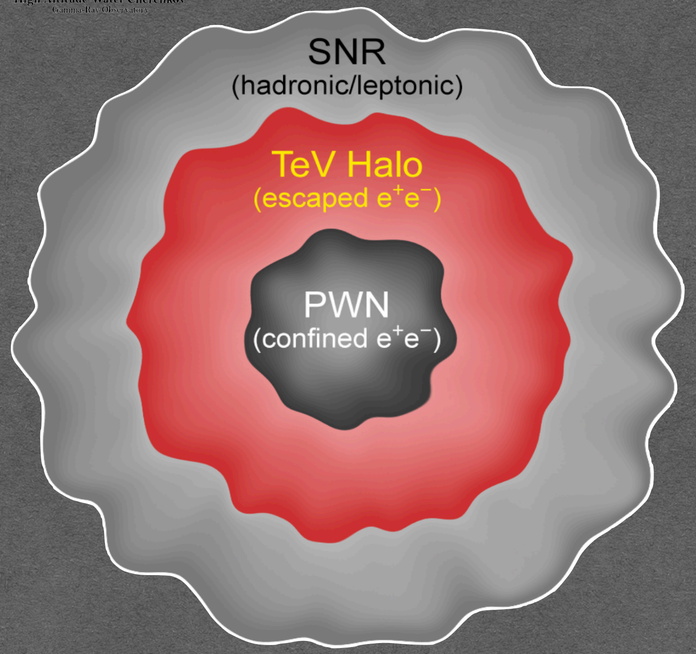
Energy-Dependent Morphology — Spectrum Index



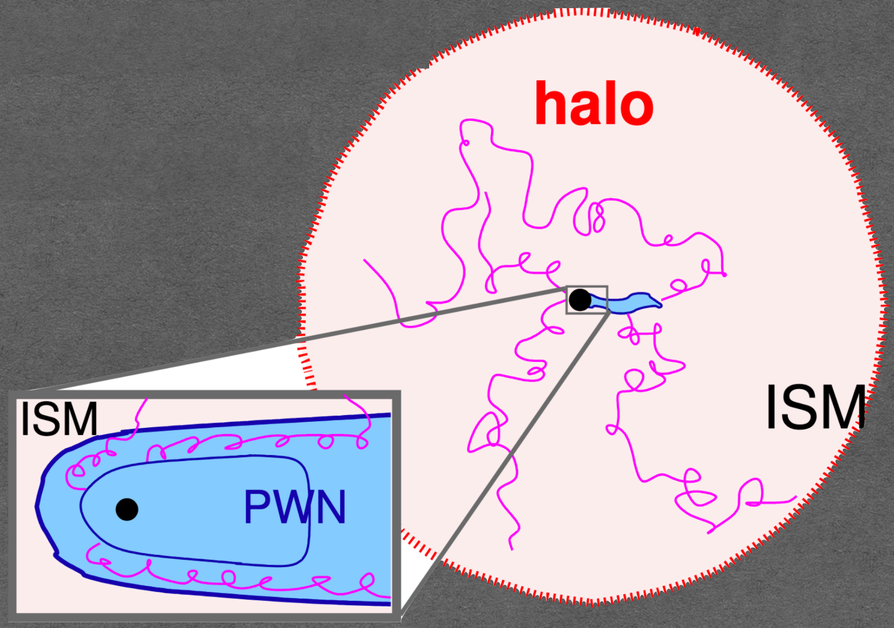


- Location fixed at pulsar PSR J1826-1334
- Fit a powerlaw inside each 0.2° annuli

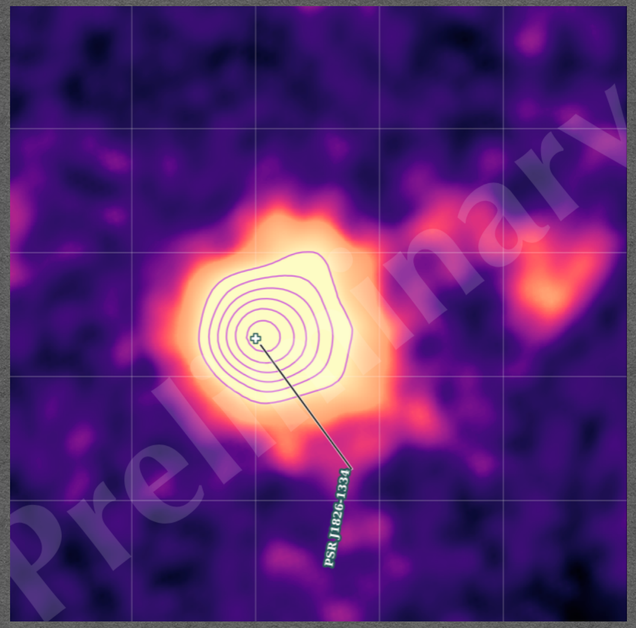
Discussion

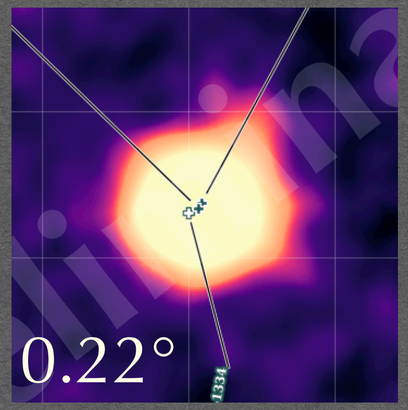


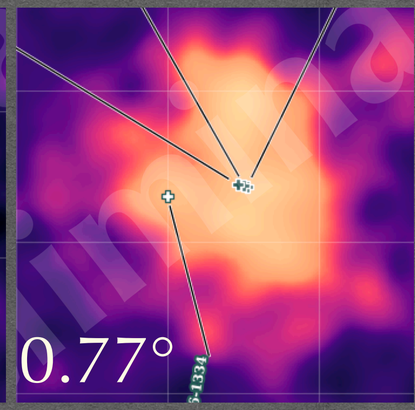
Credit: https://doi.org/10.1103/PhysRevD.100.043016



Credit: https://doi.org/10.1051/0004-6361/201936505







Electrons are diffusing through the ISM

Electron density falls lower than the ISM

Could this be a hybrid system where electrons have started diffusing into the ISM?

Acknowledgments