

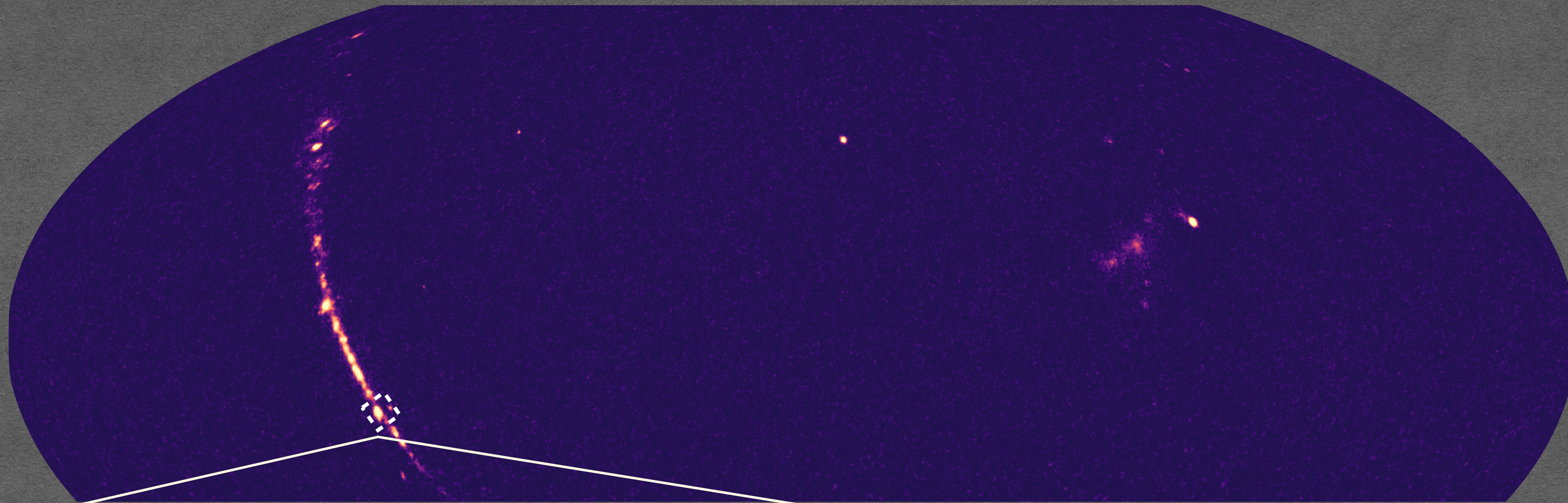


Unraveling PeVatrons from Complex eHWC J1825-134 Region with HAWC

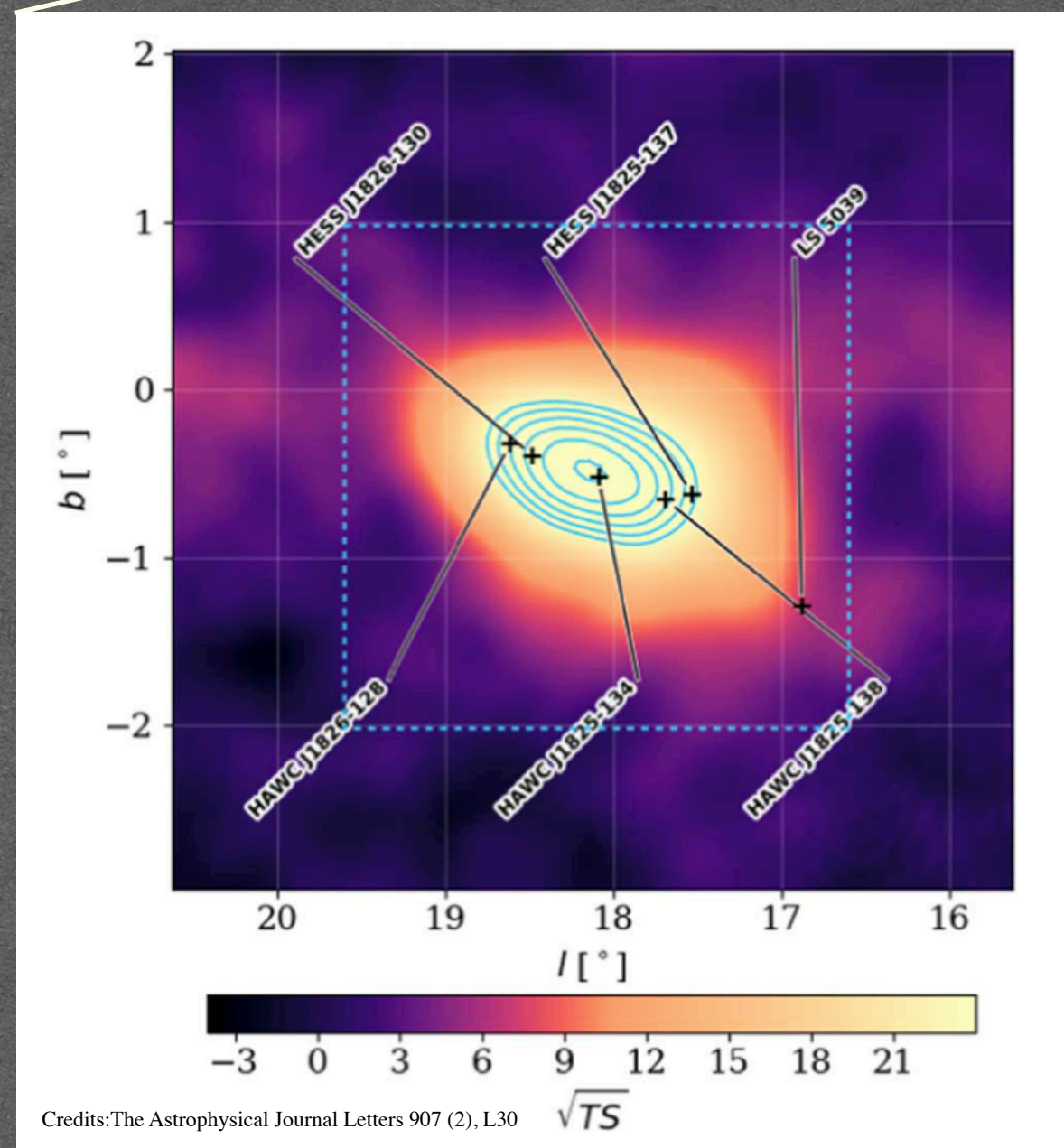
Dezhi Huang & Hazal Goksu
The 3rd CDHY workshop



How Many PeVatron Candidates inside Region?

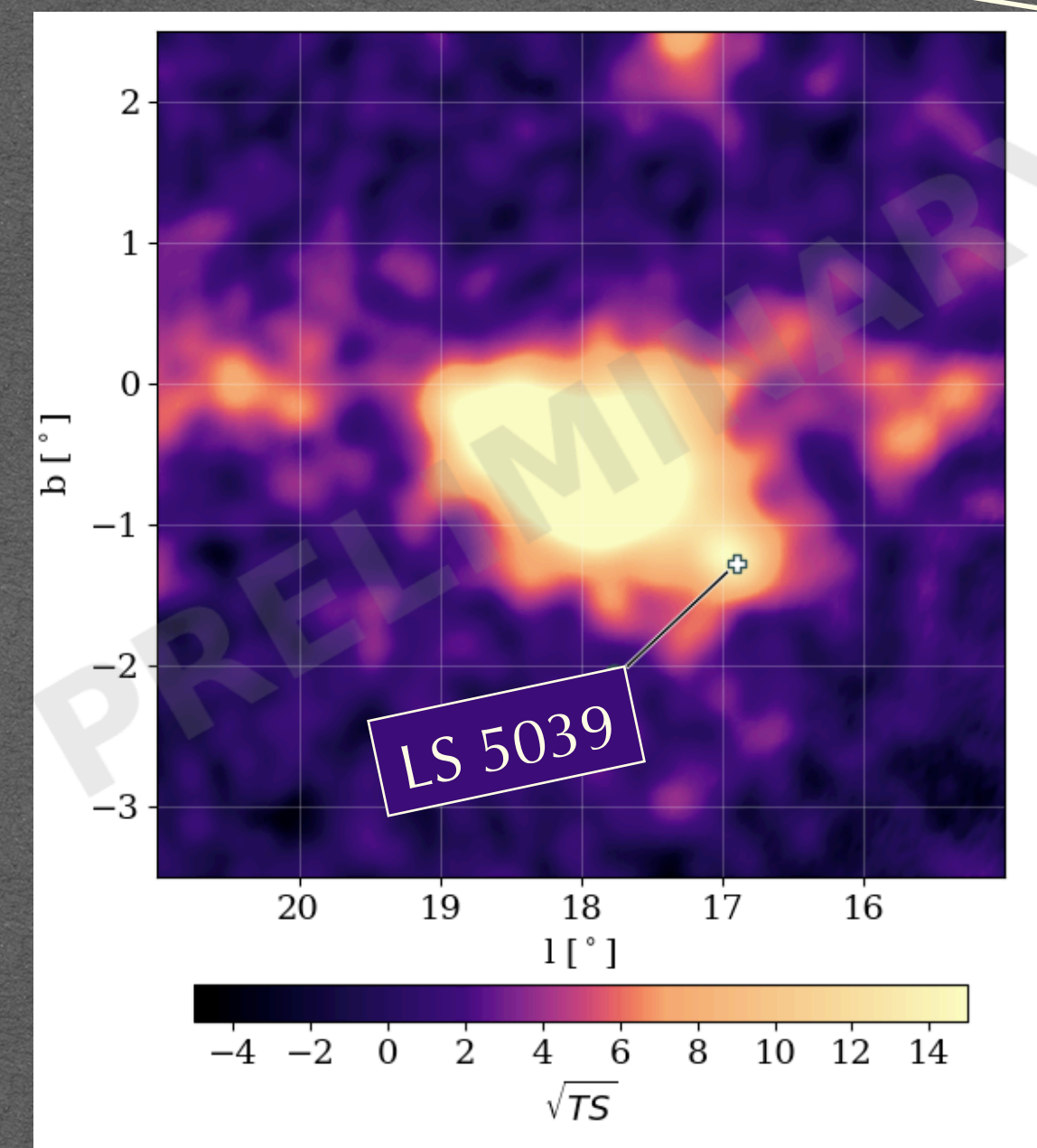


Pass 4



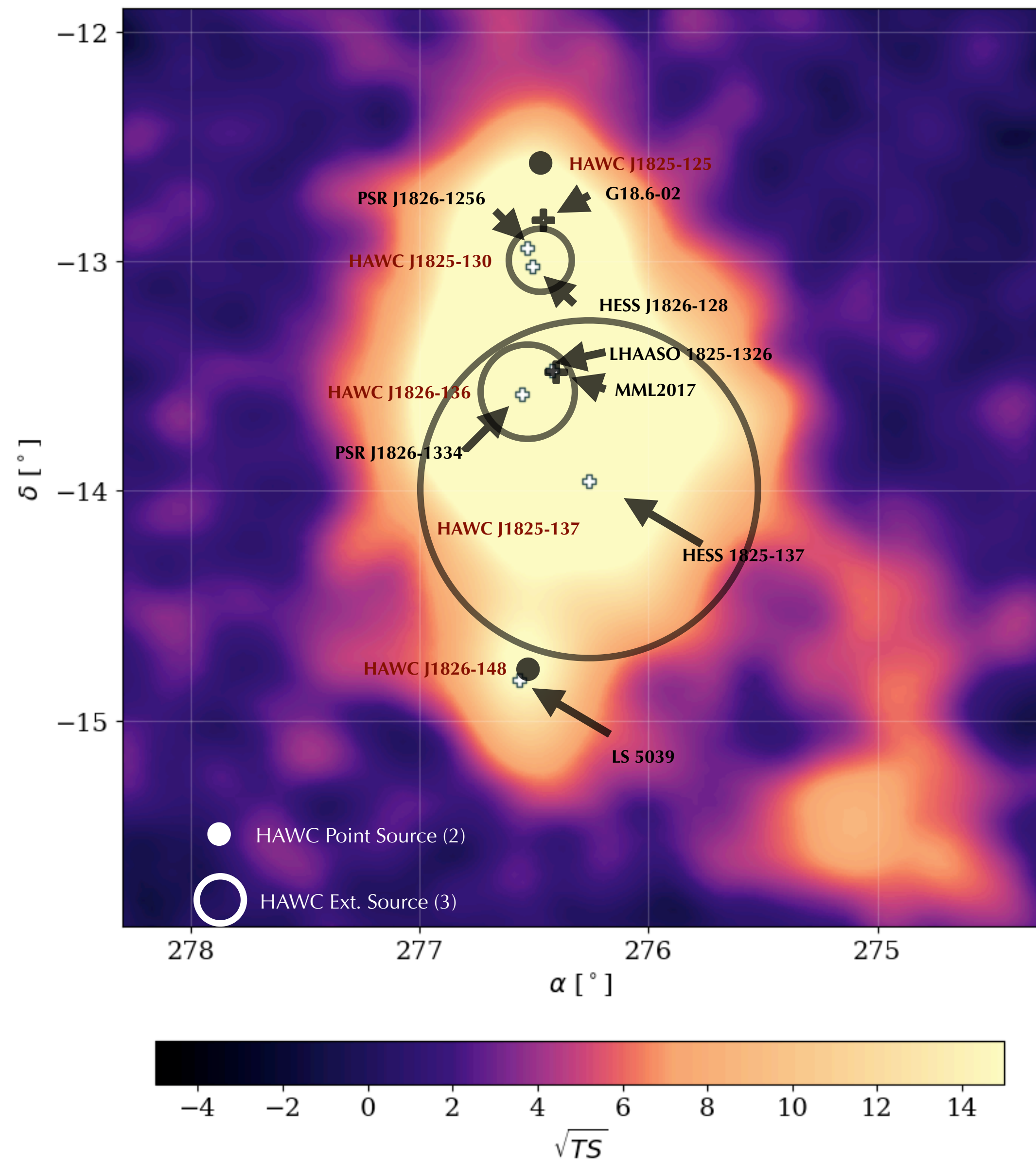
- Two extended source associated with PWNe
- One ultra-high energy point like source with the energy beyond 200 TeV

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



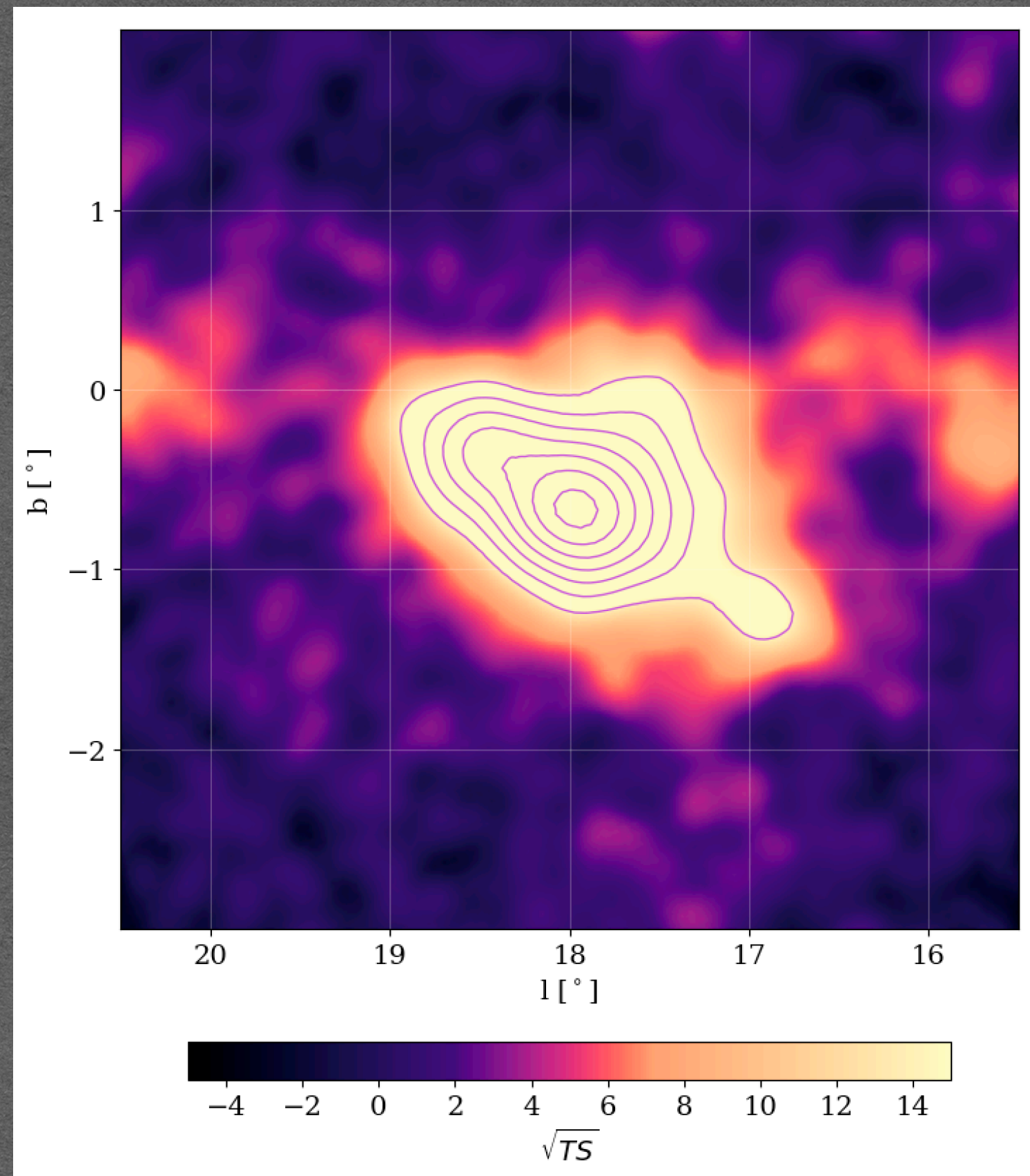
- Using 3ML framework and HAL plugin
- Utilized systematic multi-source fitting to model the entire region
- Best-fit contains 5 gamma-ray sources and diffuse background emission
- 3 extended sources (Gaussian model), and 2 point like sources
- LHAASO resolve 3 sources inside this region



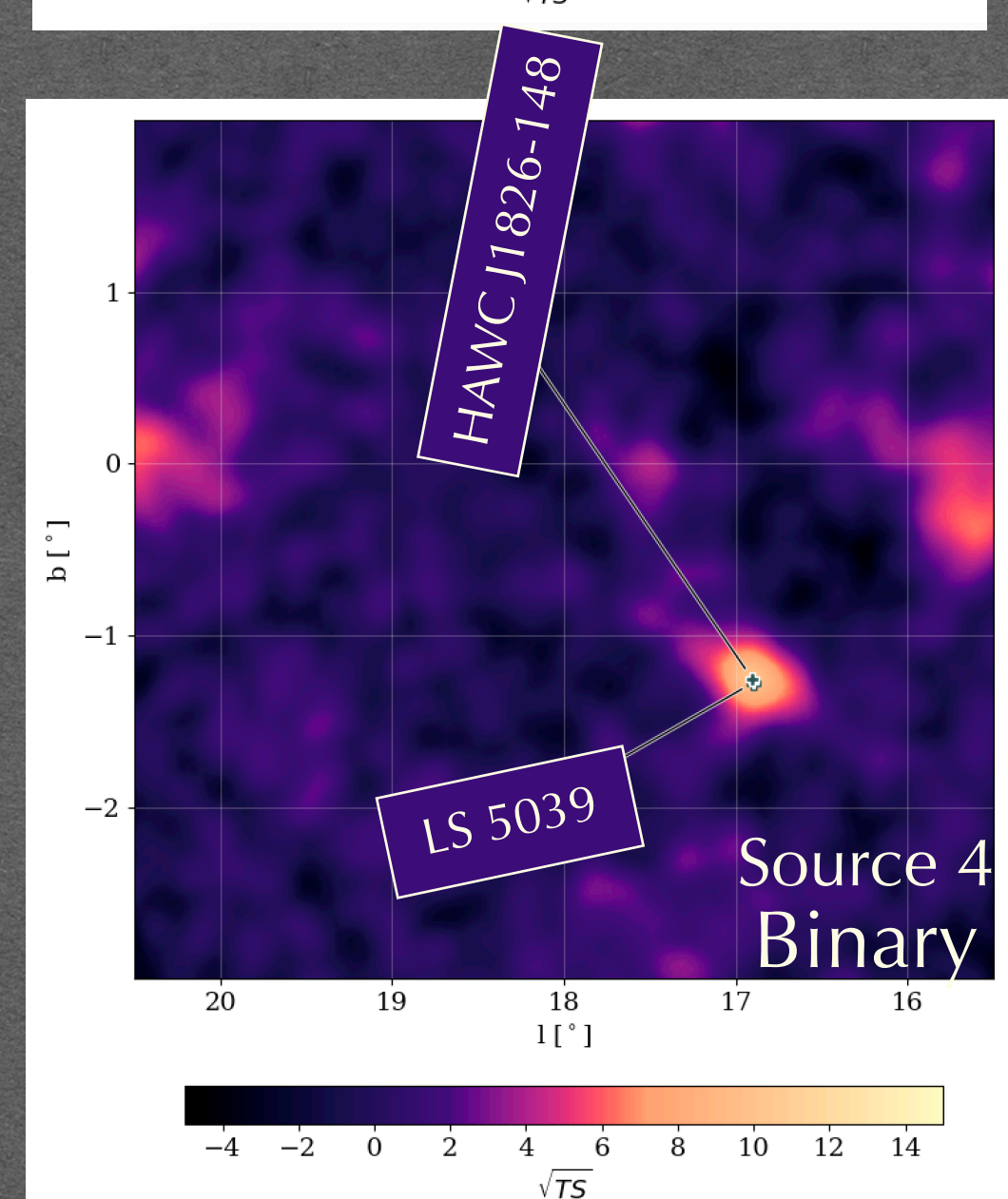
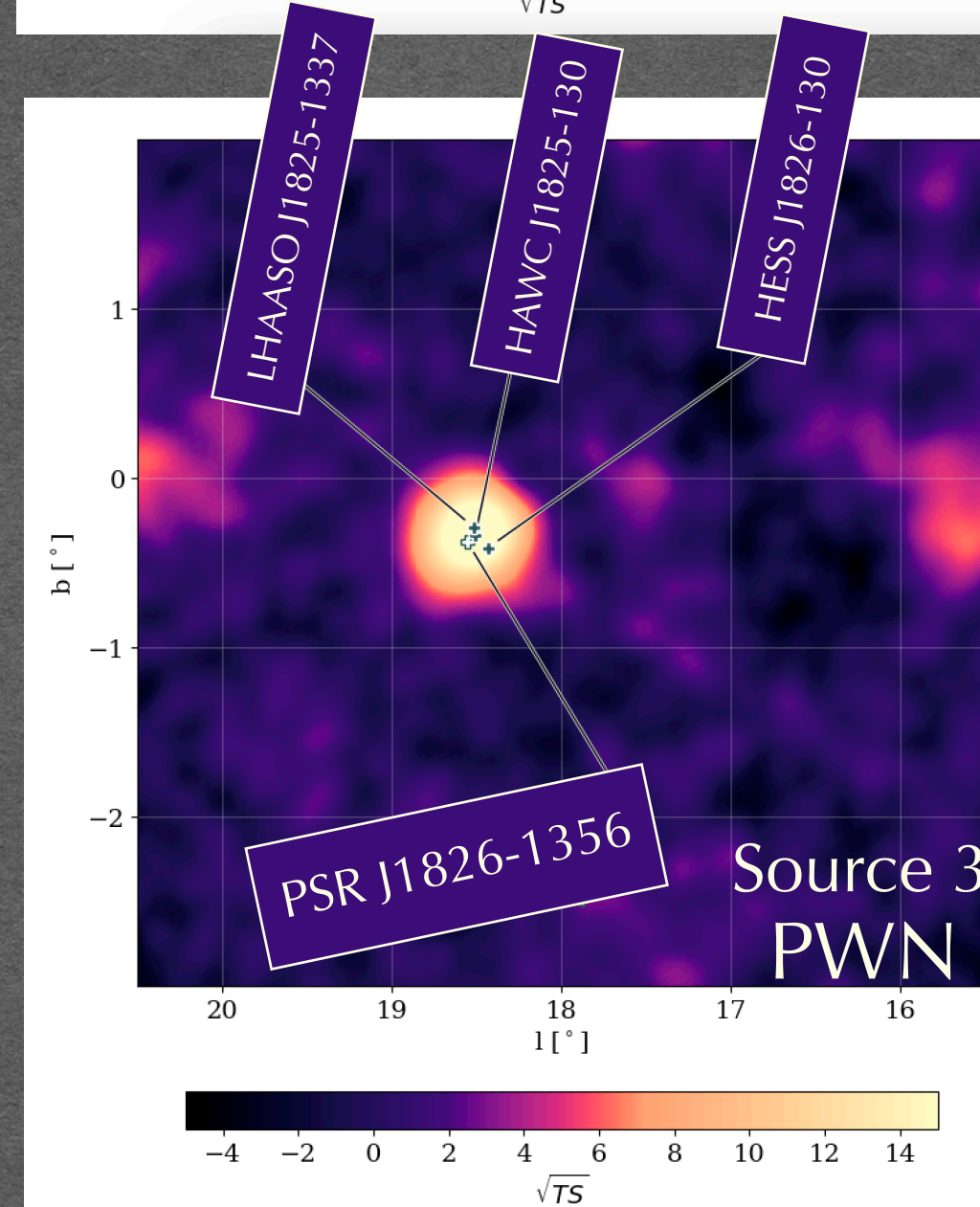
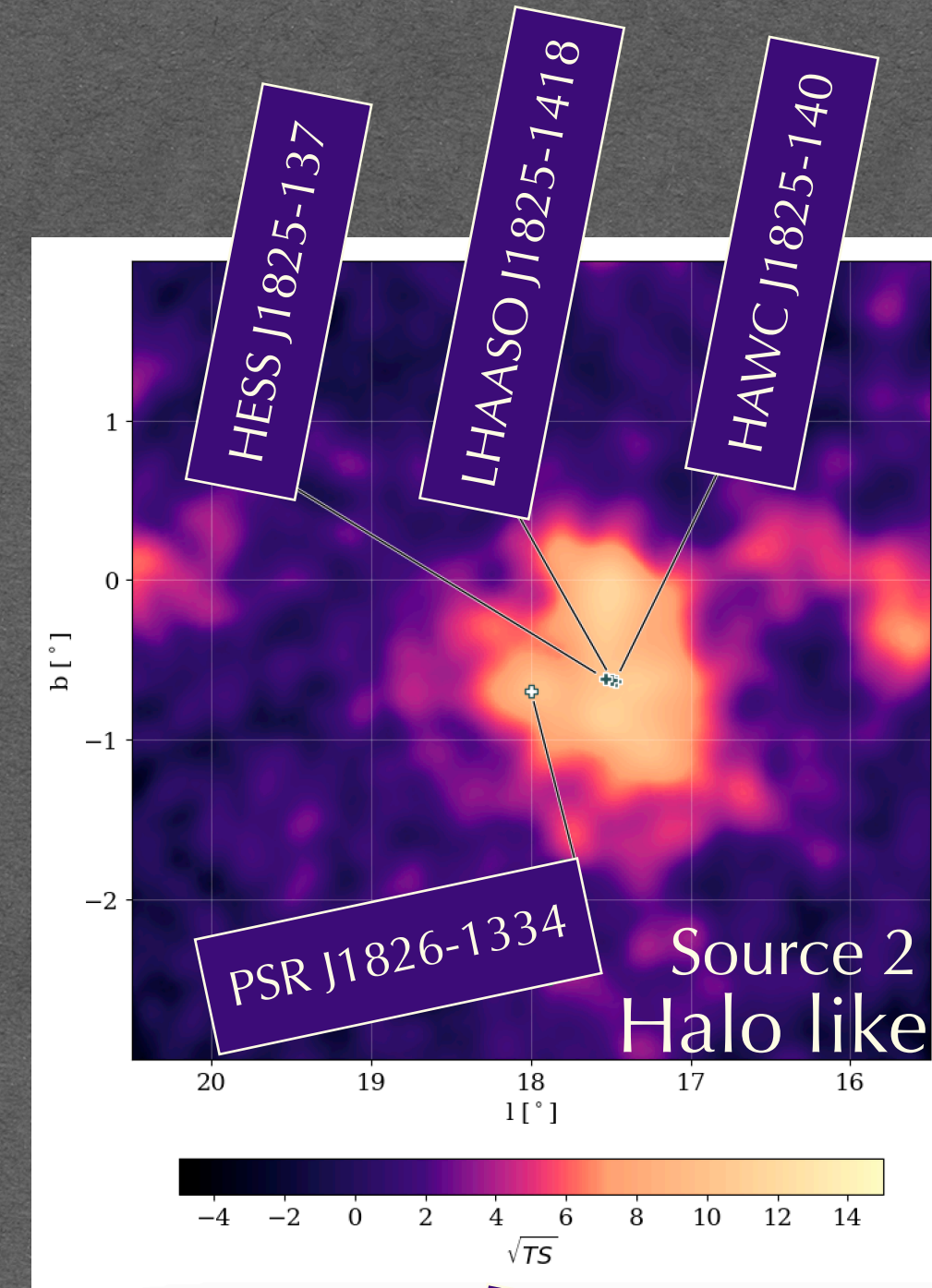
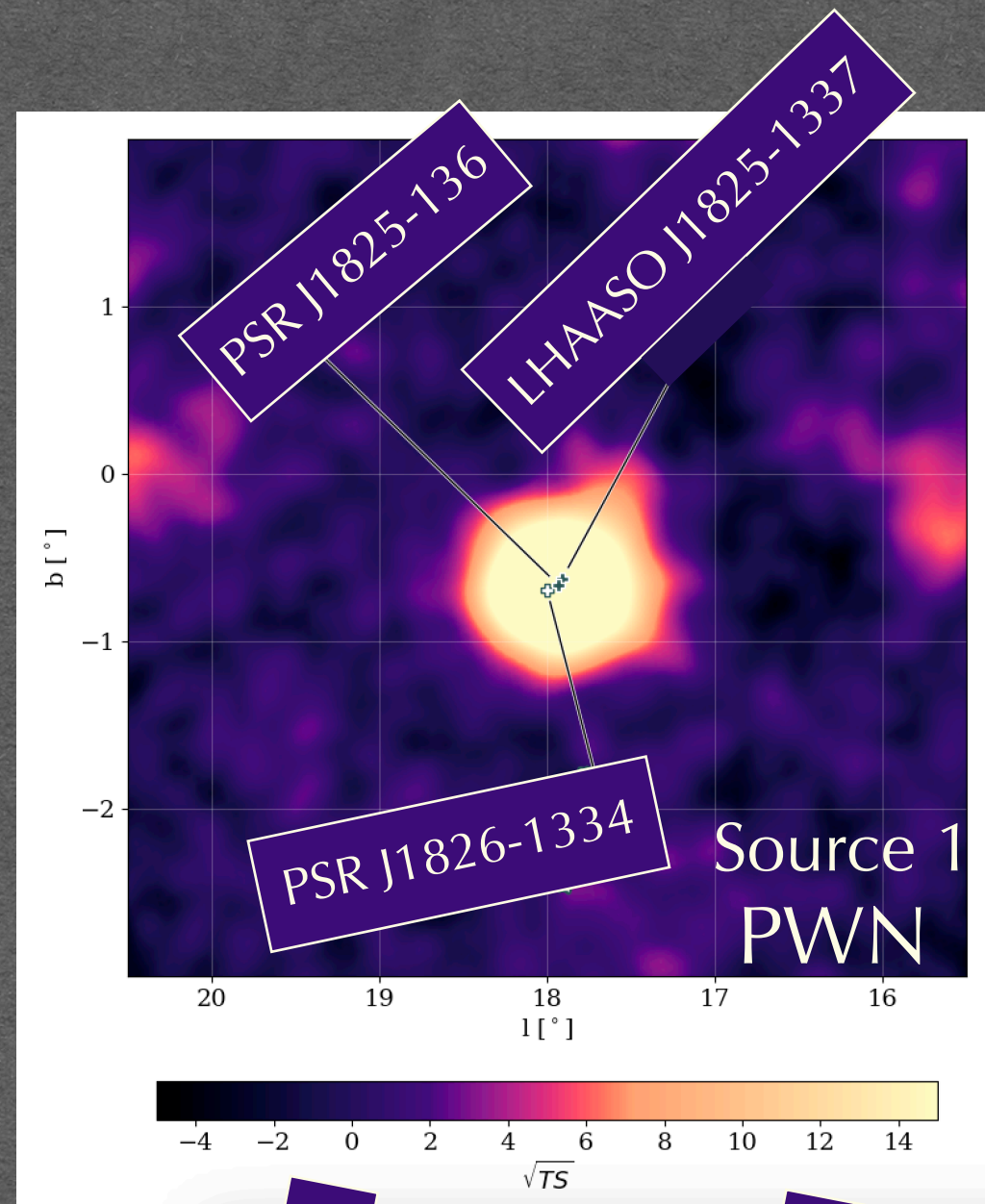
3ML Multi-Mission
Maximum Likelihood
Framework

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

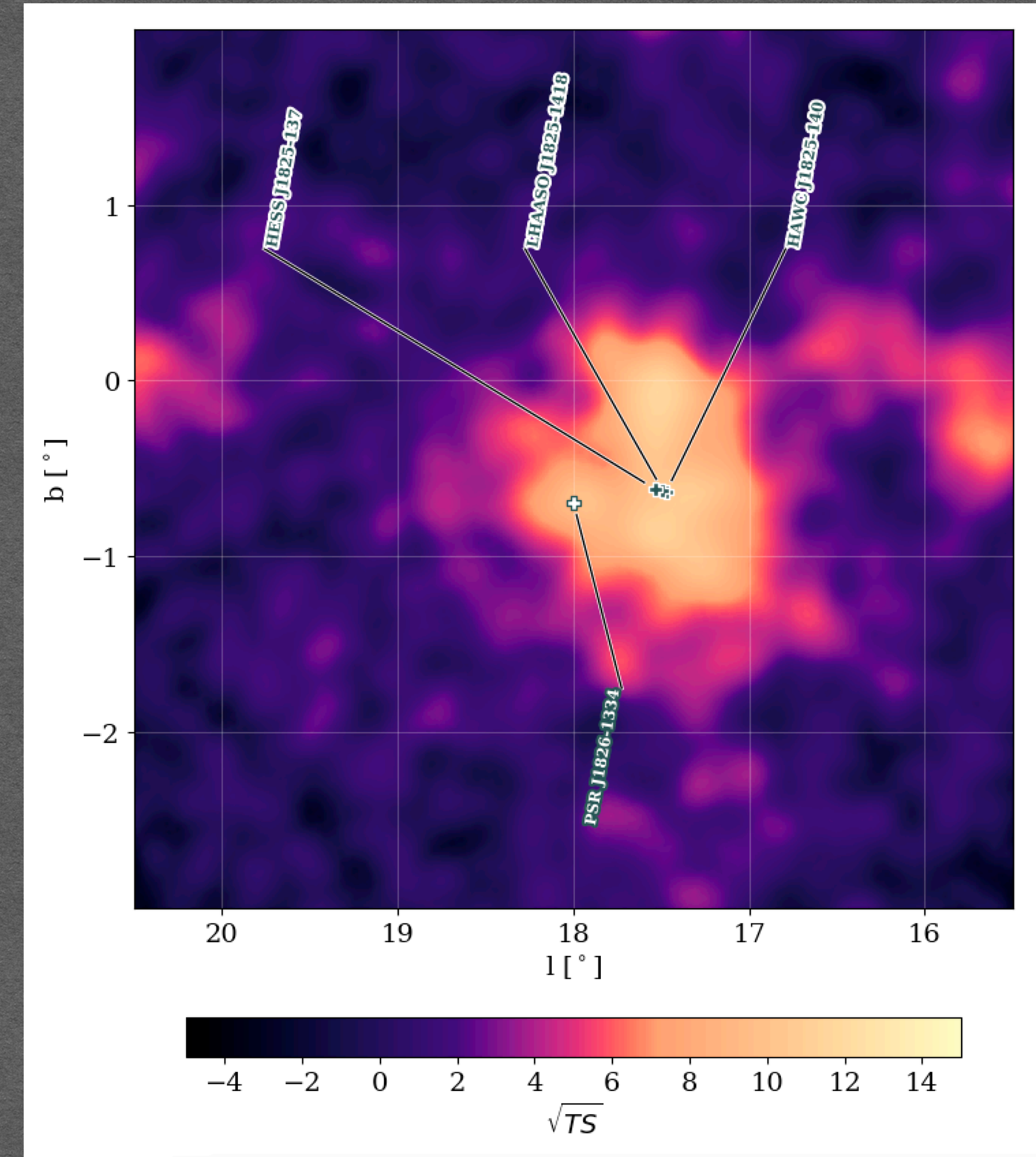
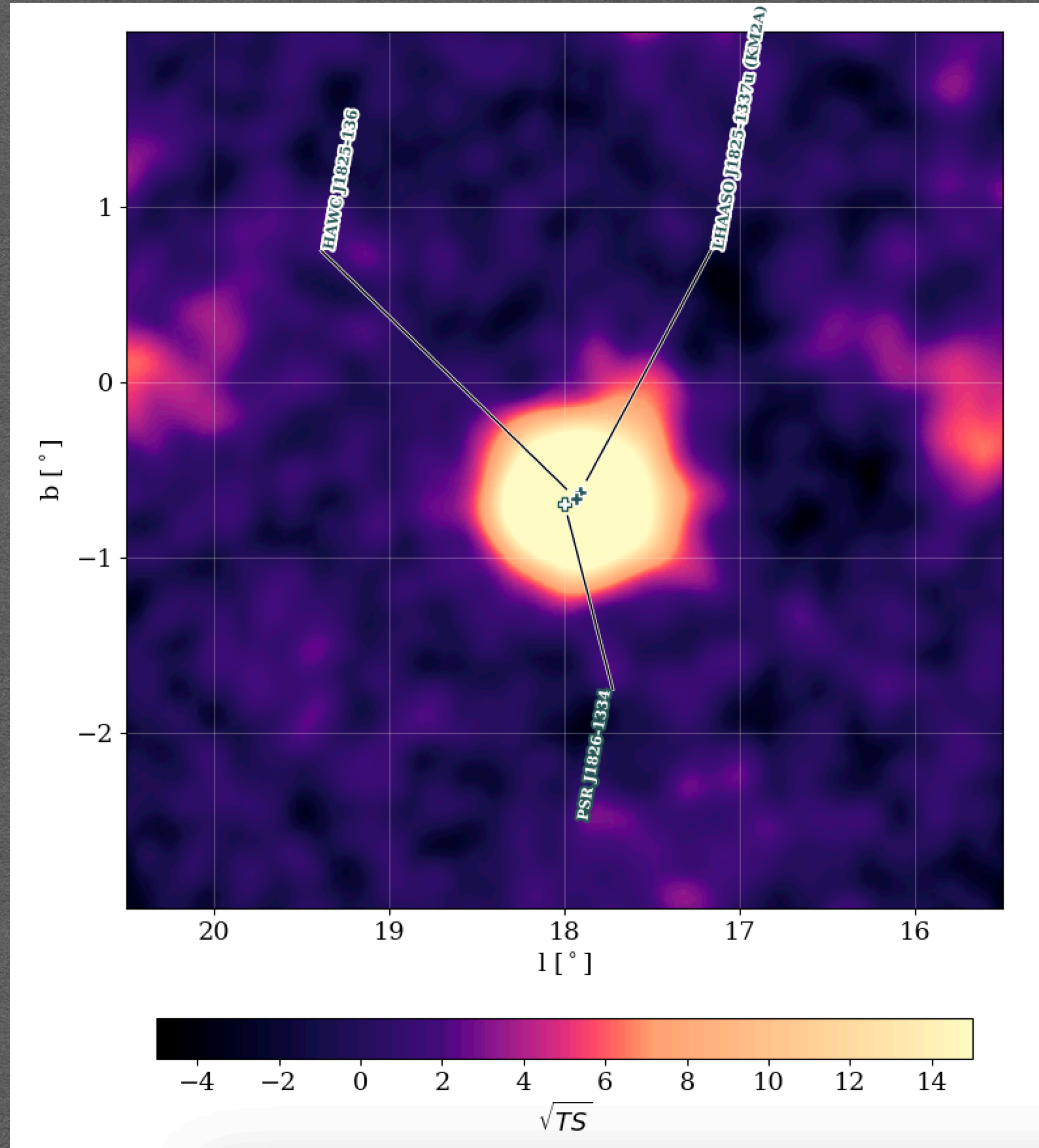
3.J1826 PWN

- 0.14° extended

4.LS 5039

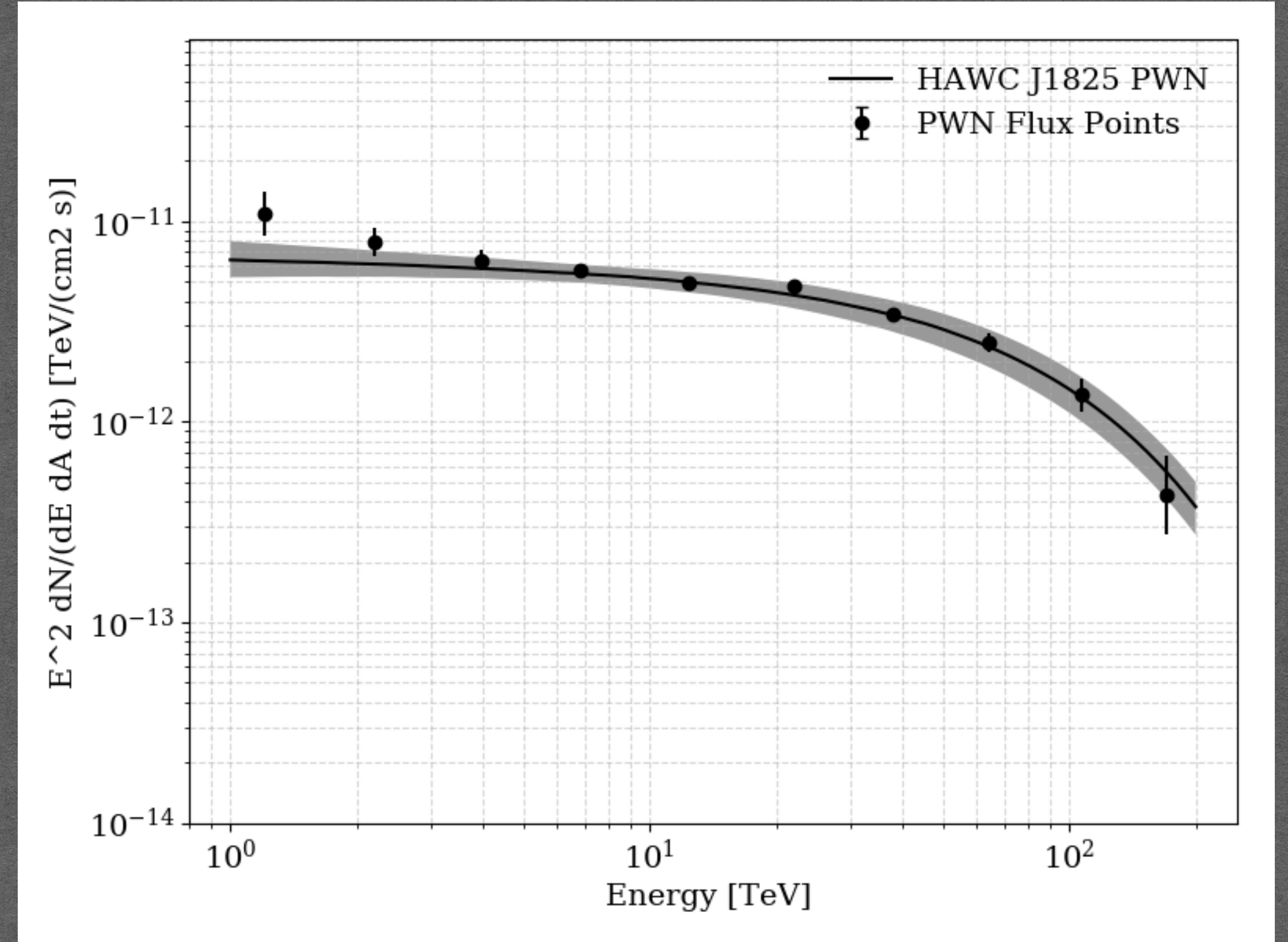
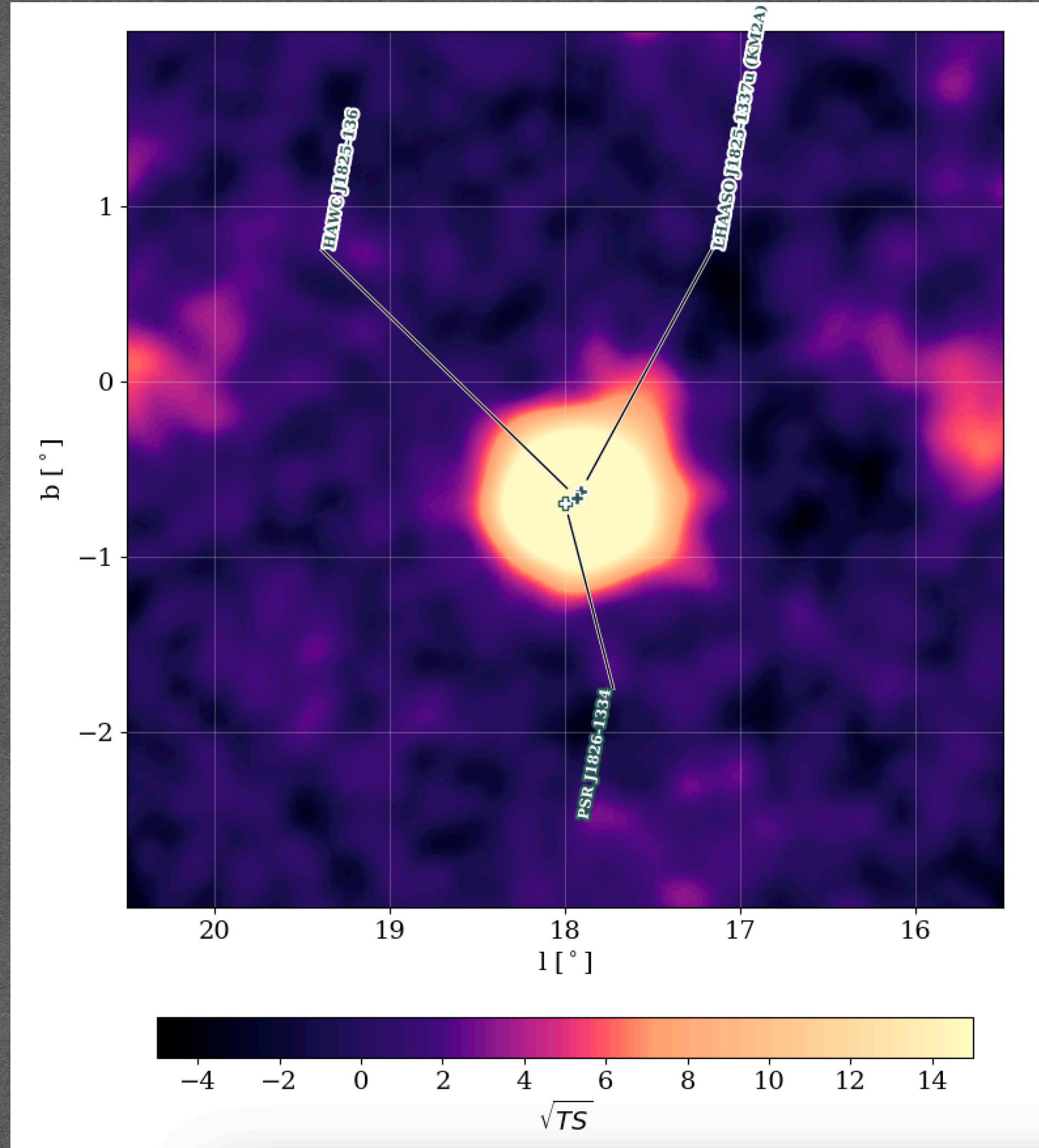
- Point like

Two Sources Powered by PSR J1826-1334



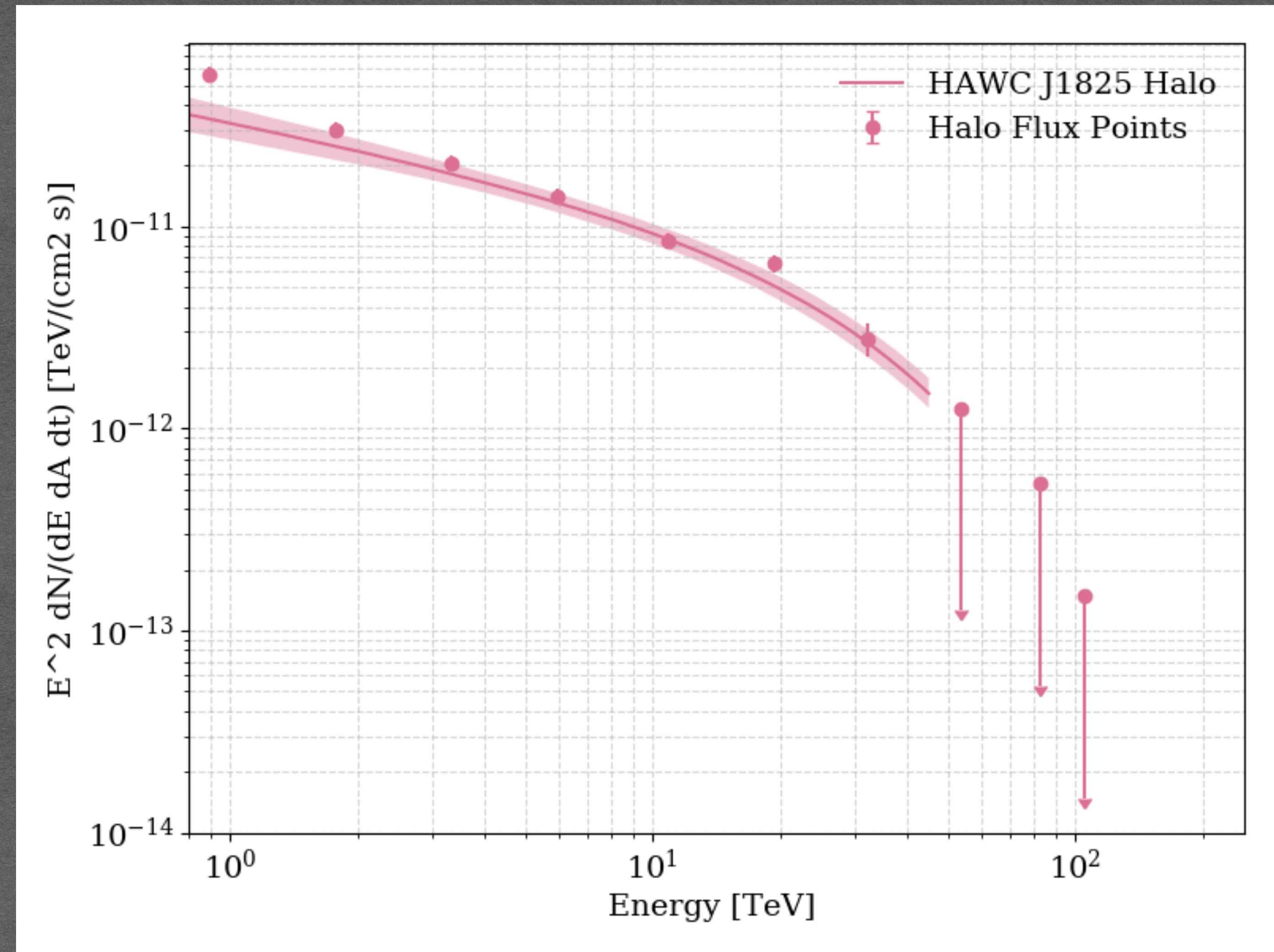
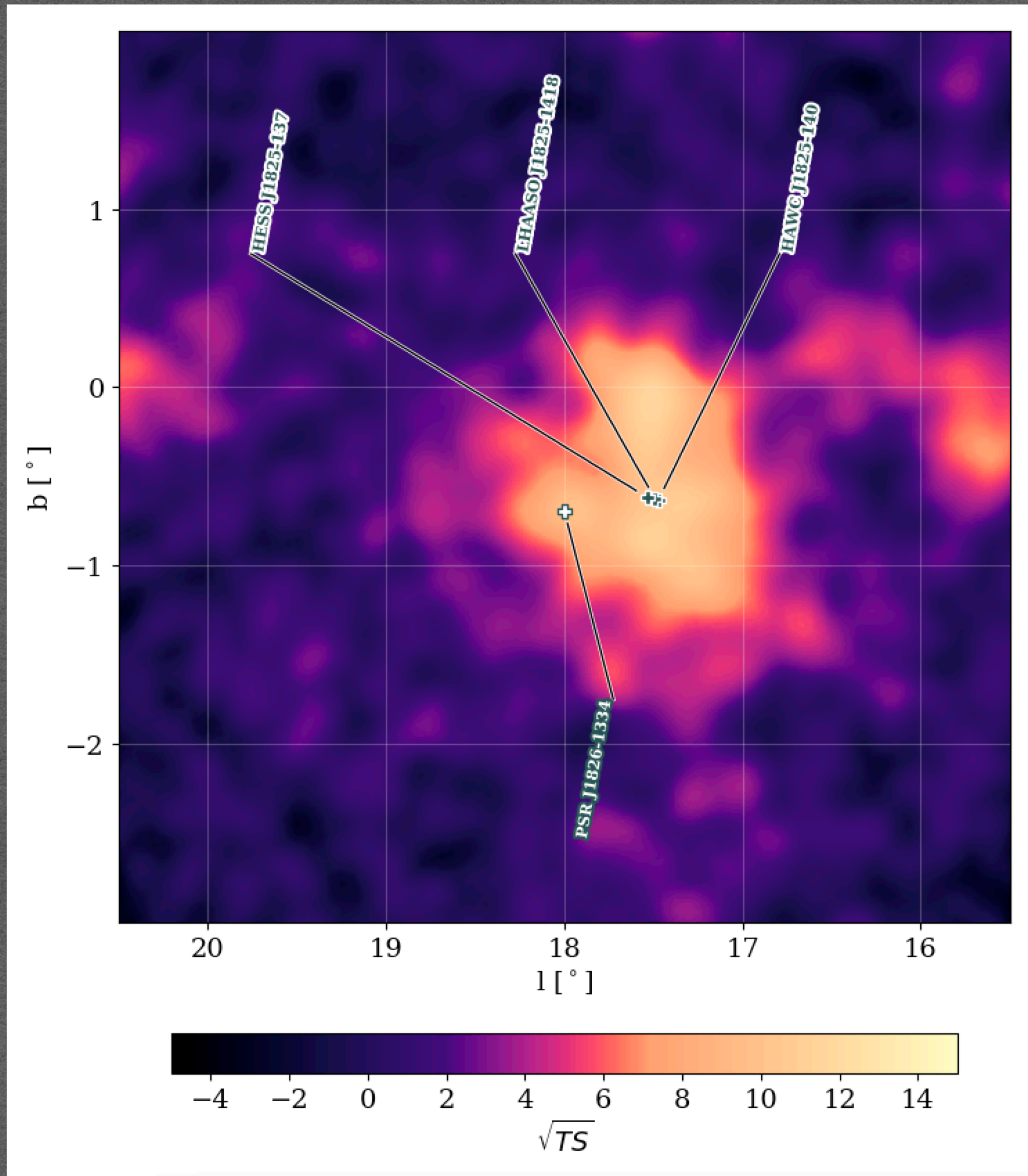
PSR J1826-1334 is a powerful pulsar with $\dot{E} = 2.8 \times 10^{36} \text{ erg/s}$ at age of 21.4 kyr

Two Sources Can be Powered by PSR J1826-1334



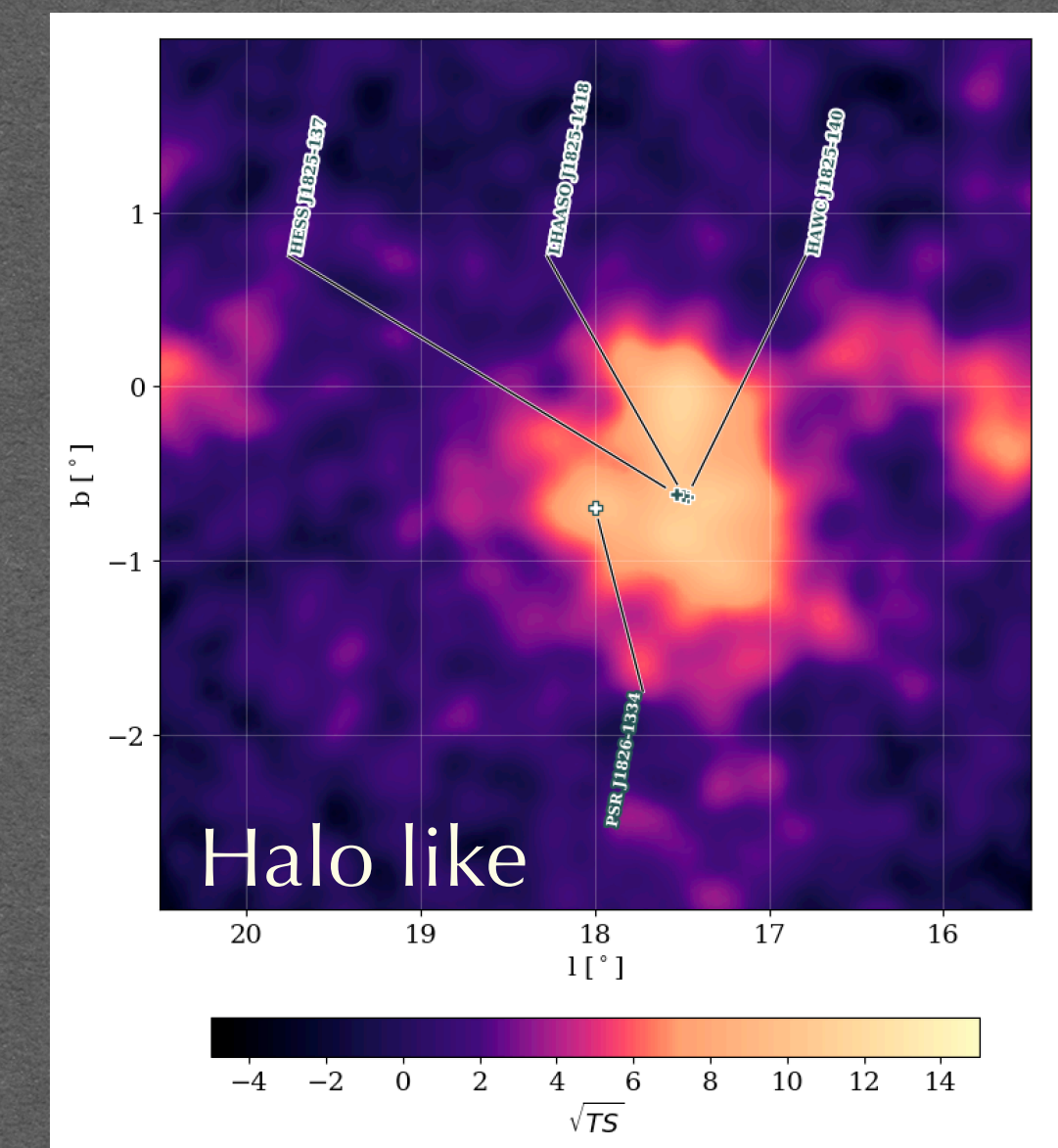
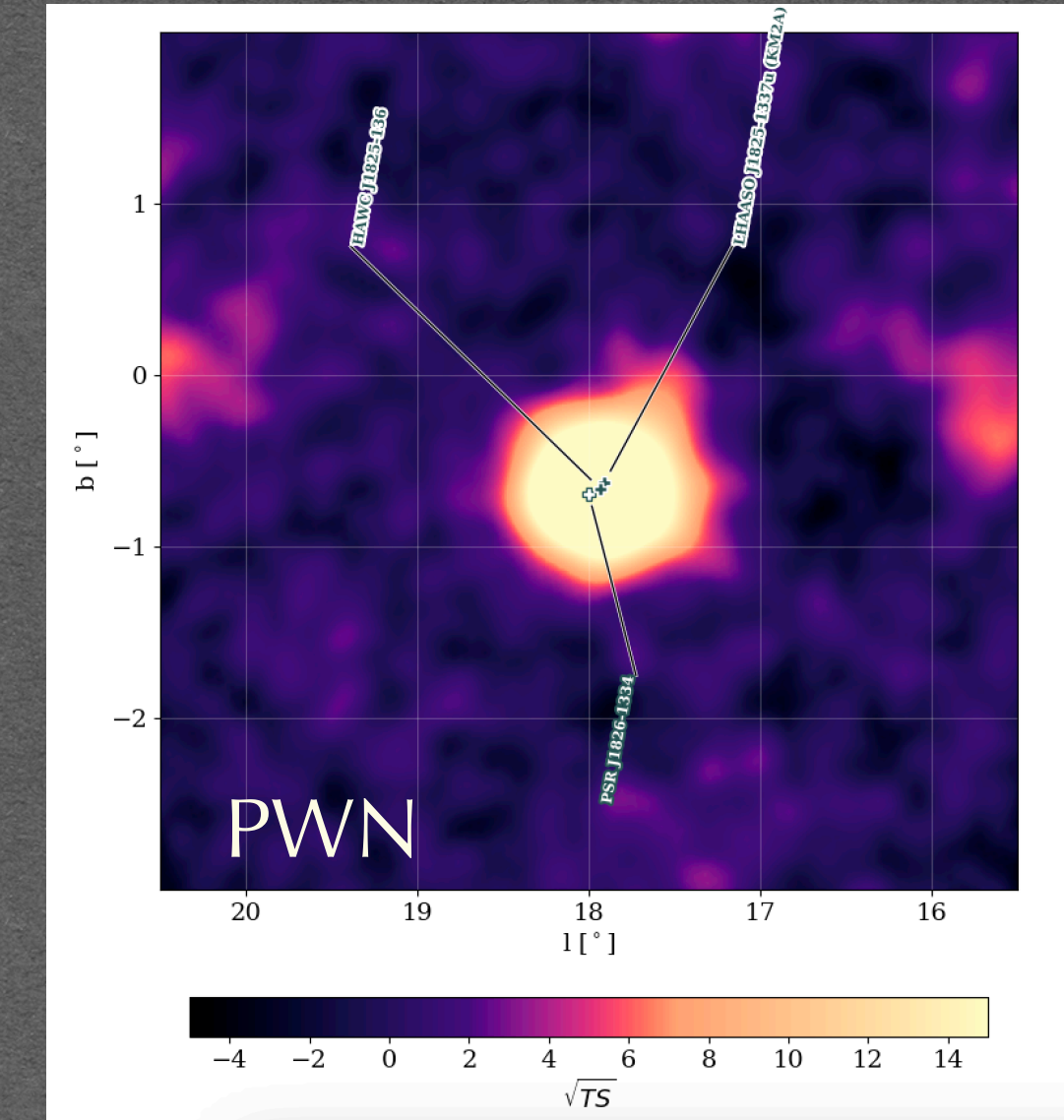
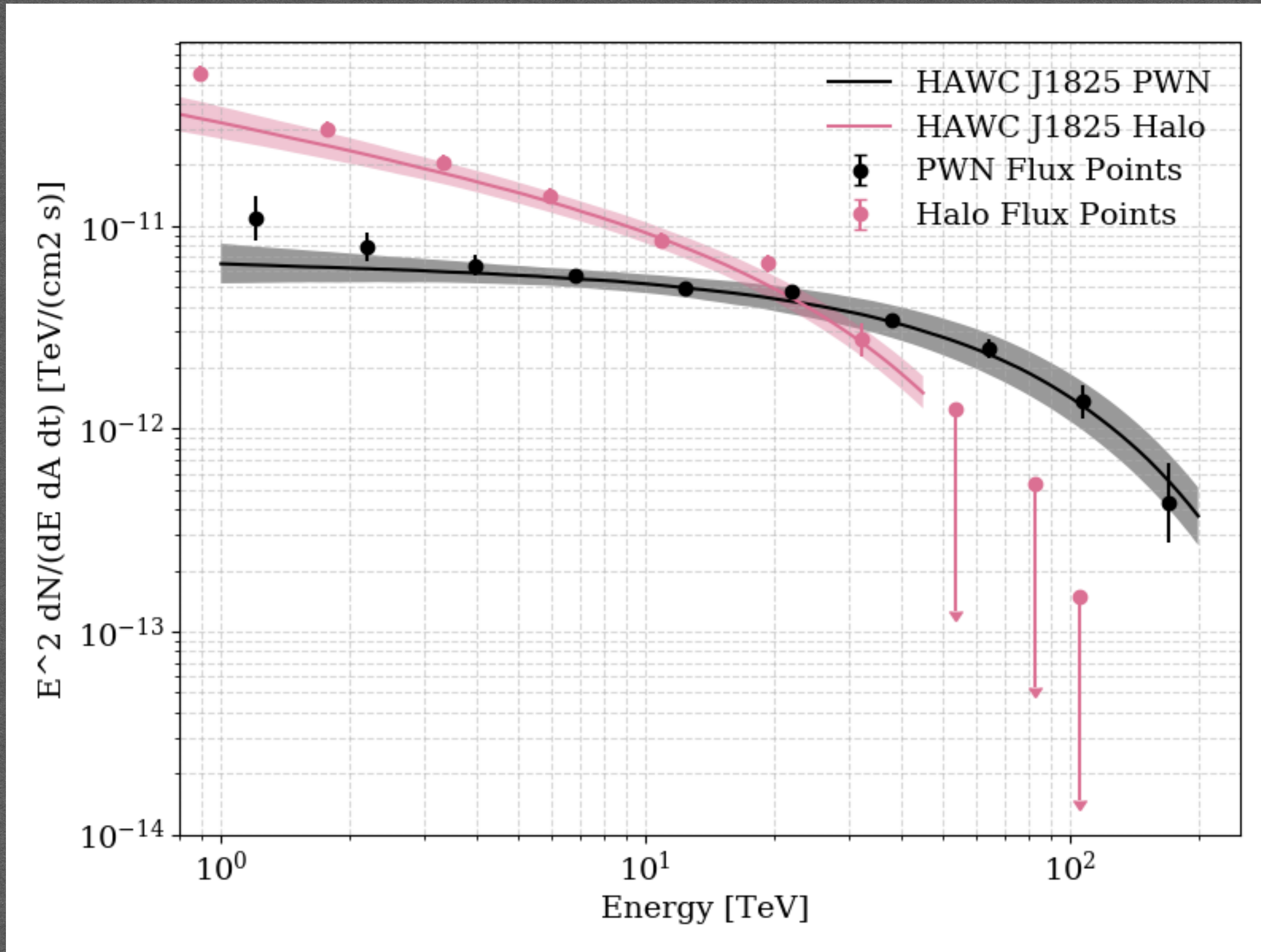
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Two Sources Can be Powered by PSR J1826-1334



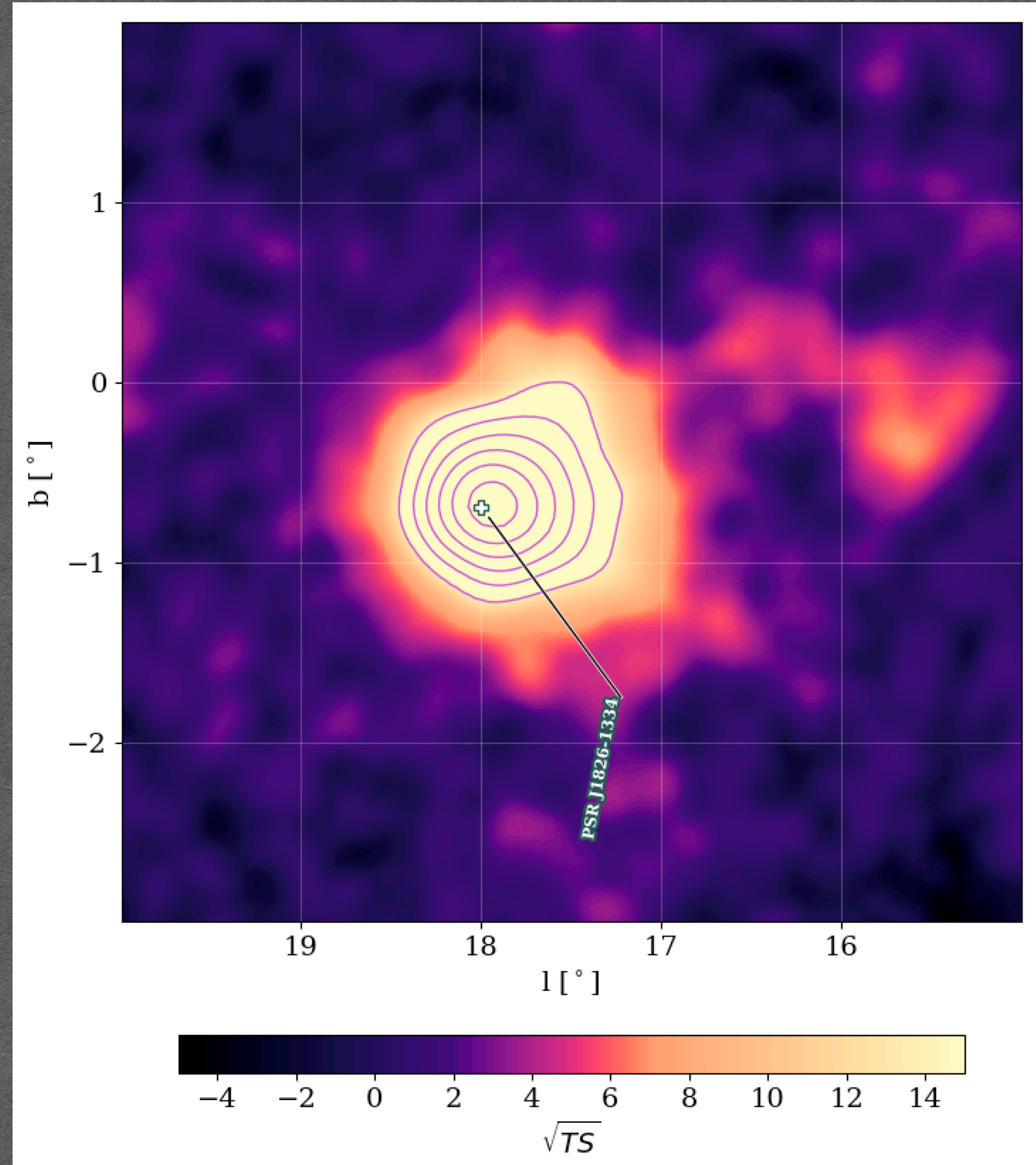
PSR J1826-1334 is a powerful pulsar with $\dot{E} = 2.8 \times 10^{36} \text{ erg/s}$ at age of 21.4 kyr

Two Sources Can be Powered by PSR J1826-1334



- 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 47σ 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 centered at pulsar location was fitted to the different energy data sets

Gaussian Width

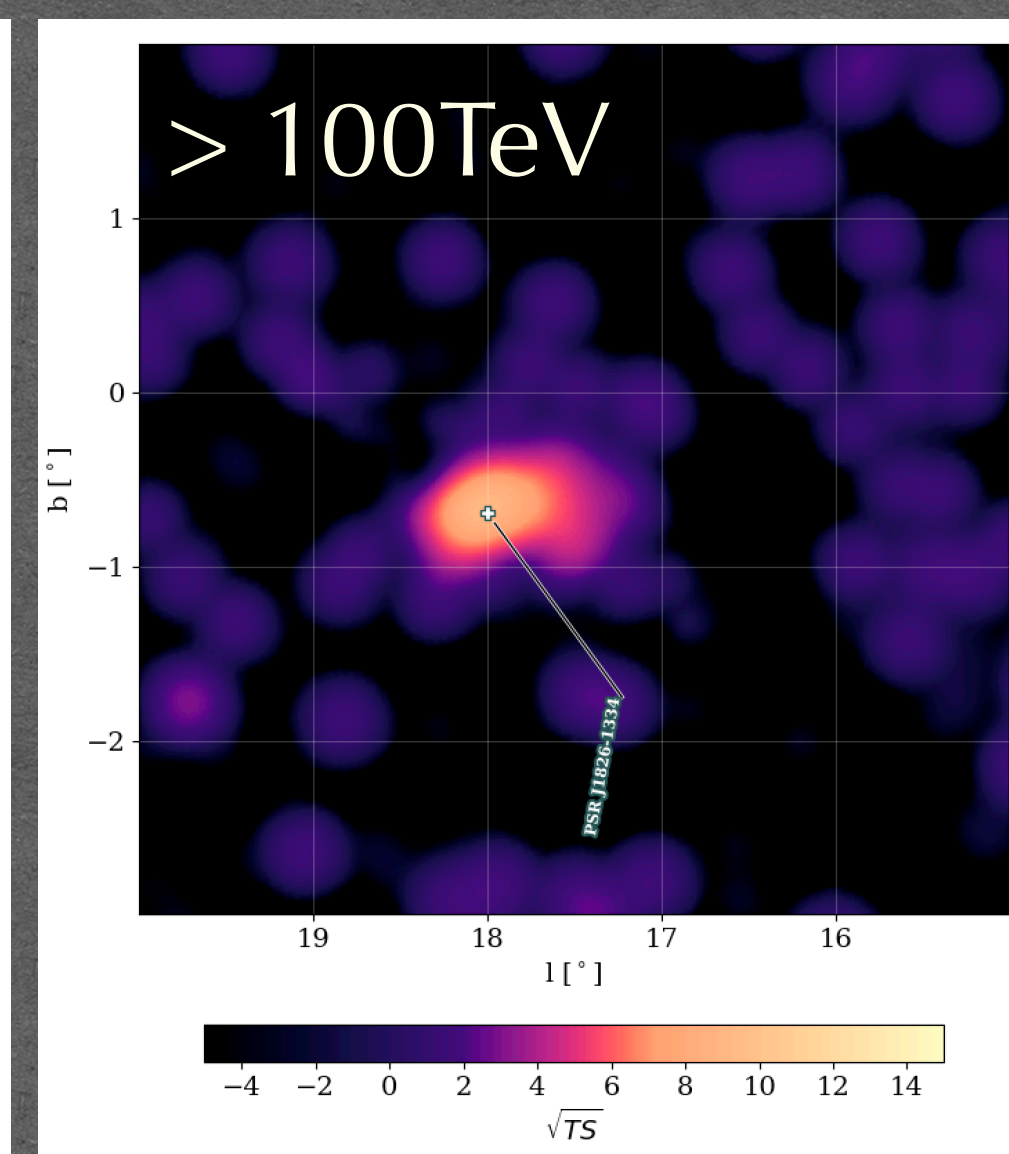
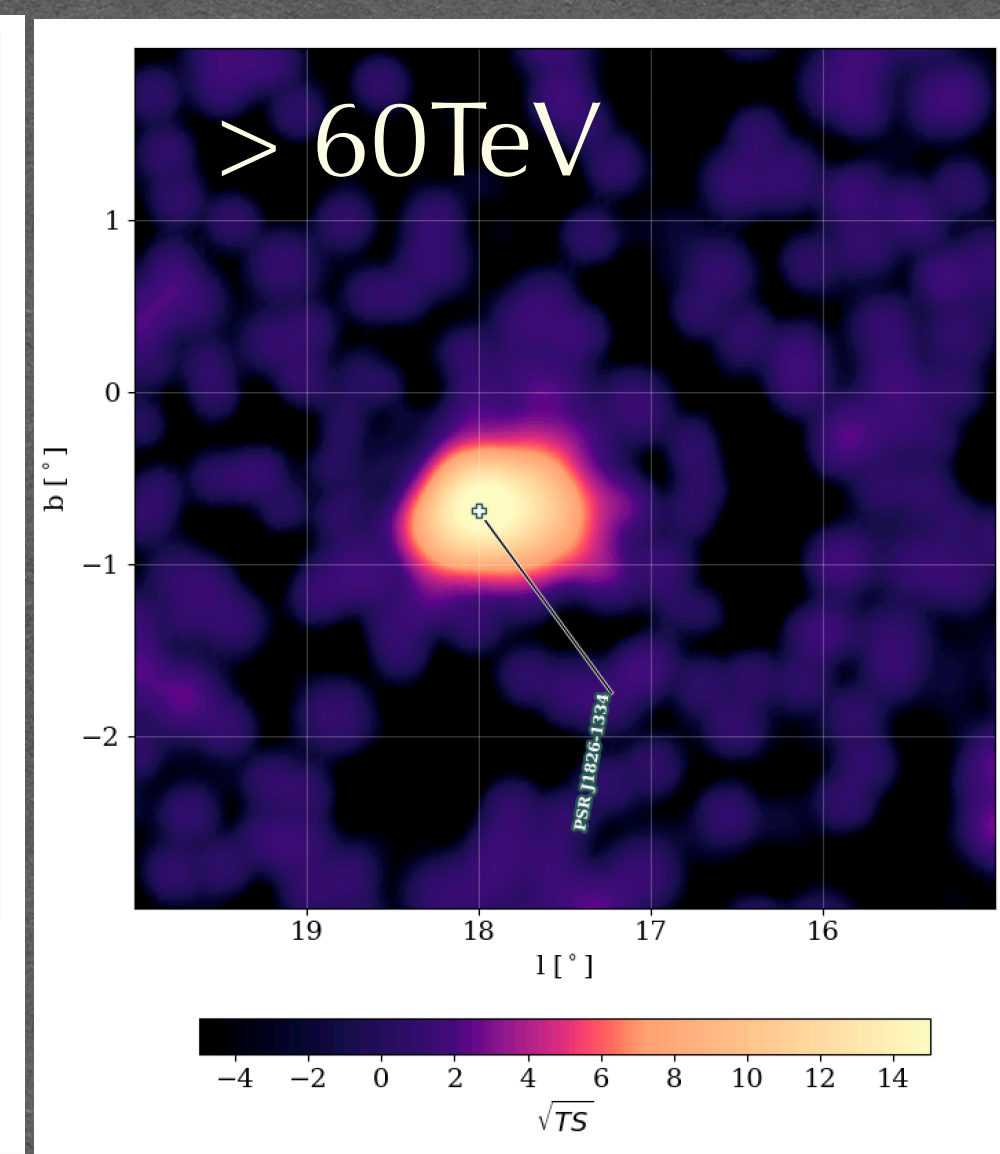
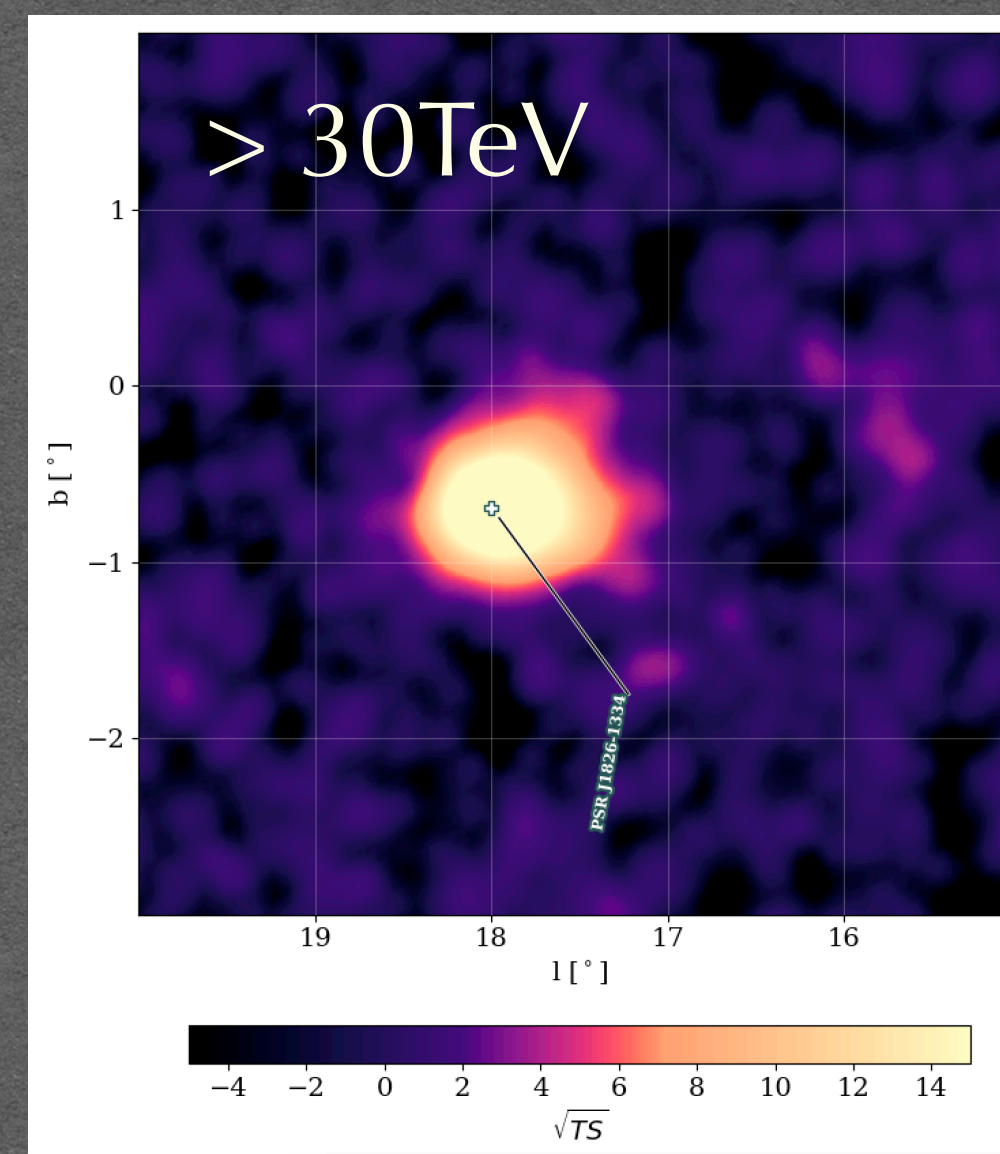
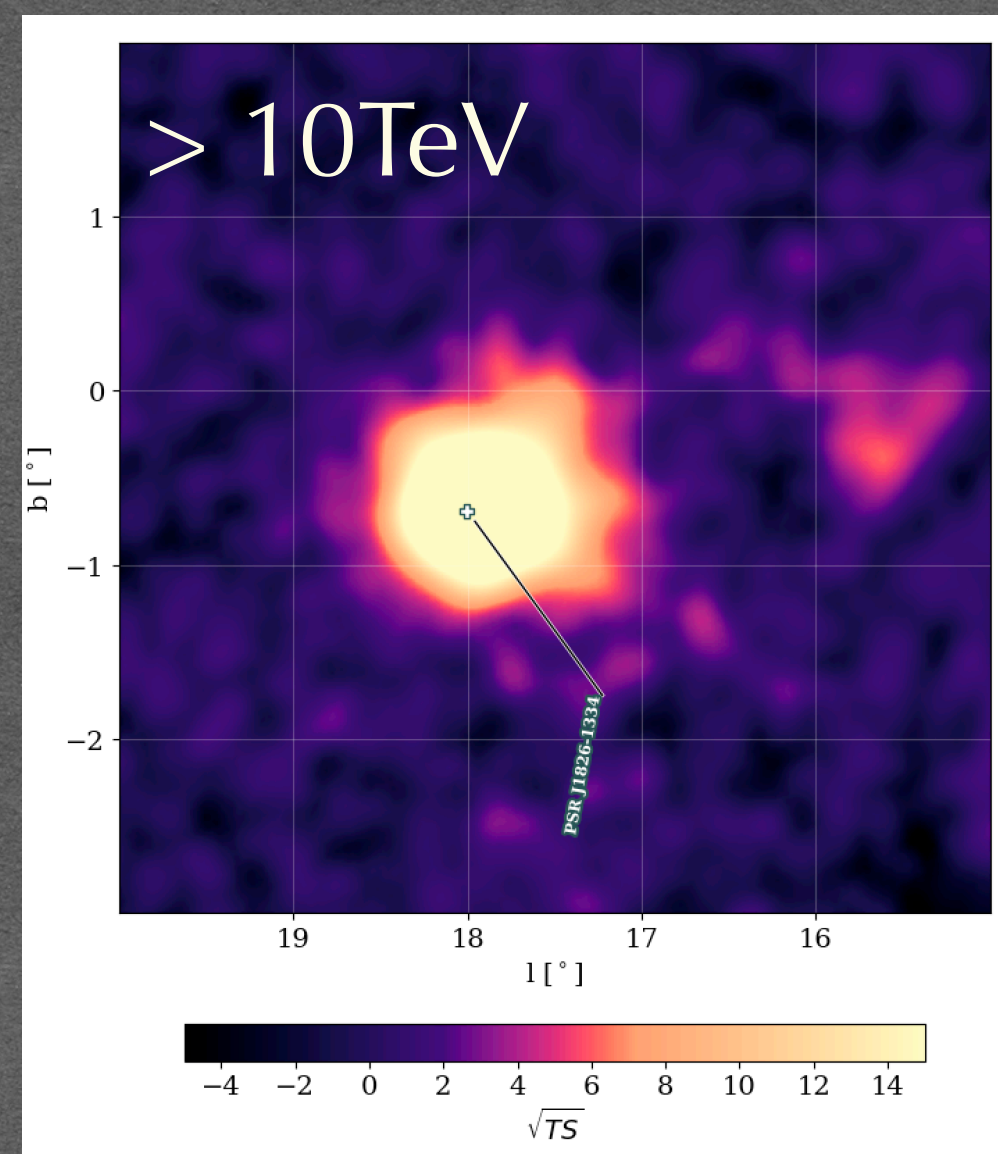
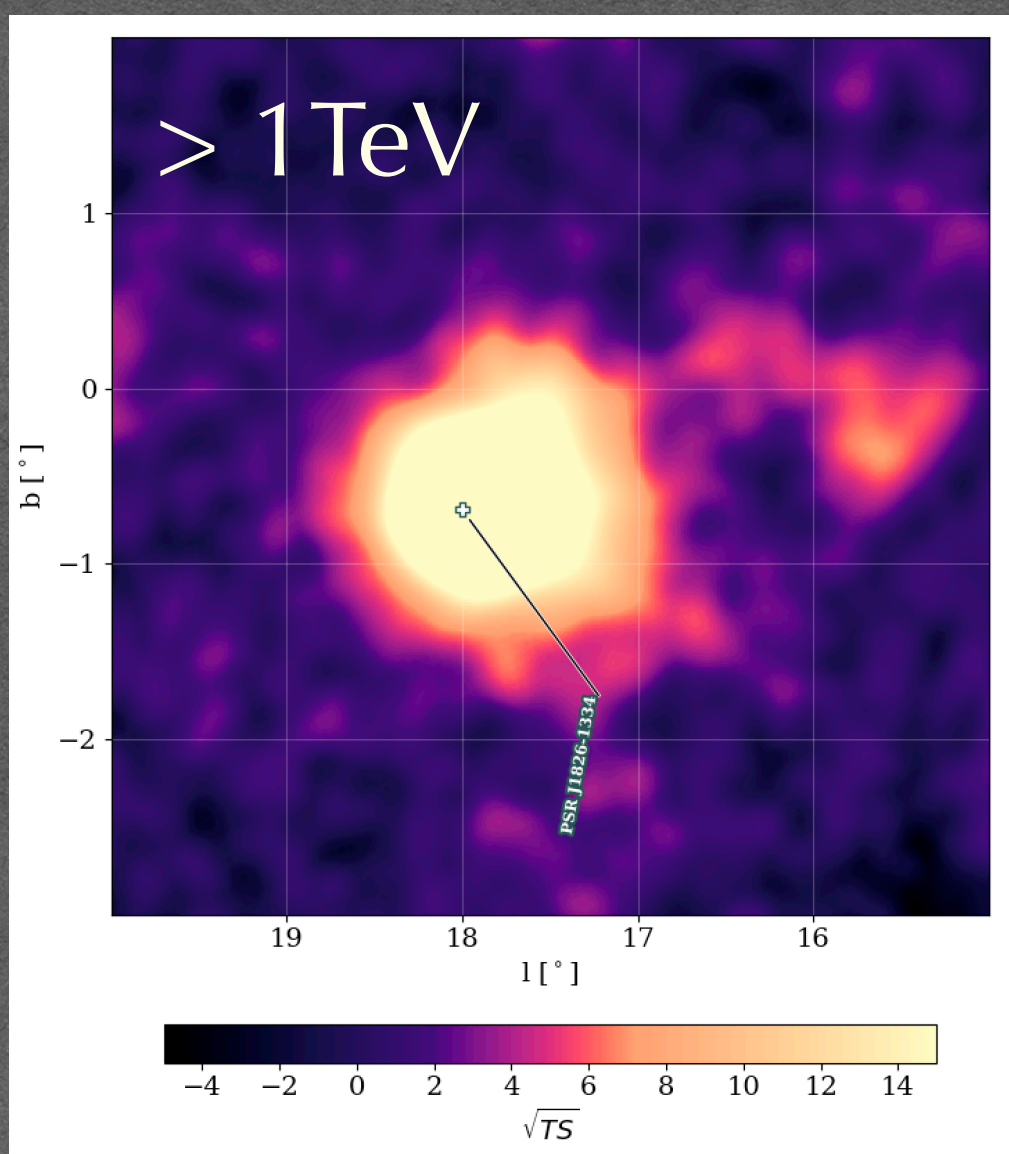
$0.33^\circ \text{ } ^{-/+} 0.01^\circ$

$0.32^\circ \text{ } ^{-/+} 0.011^\circ$

$0.28^\circ \text{ } ^{-/+} 0.015^\circ$

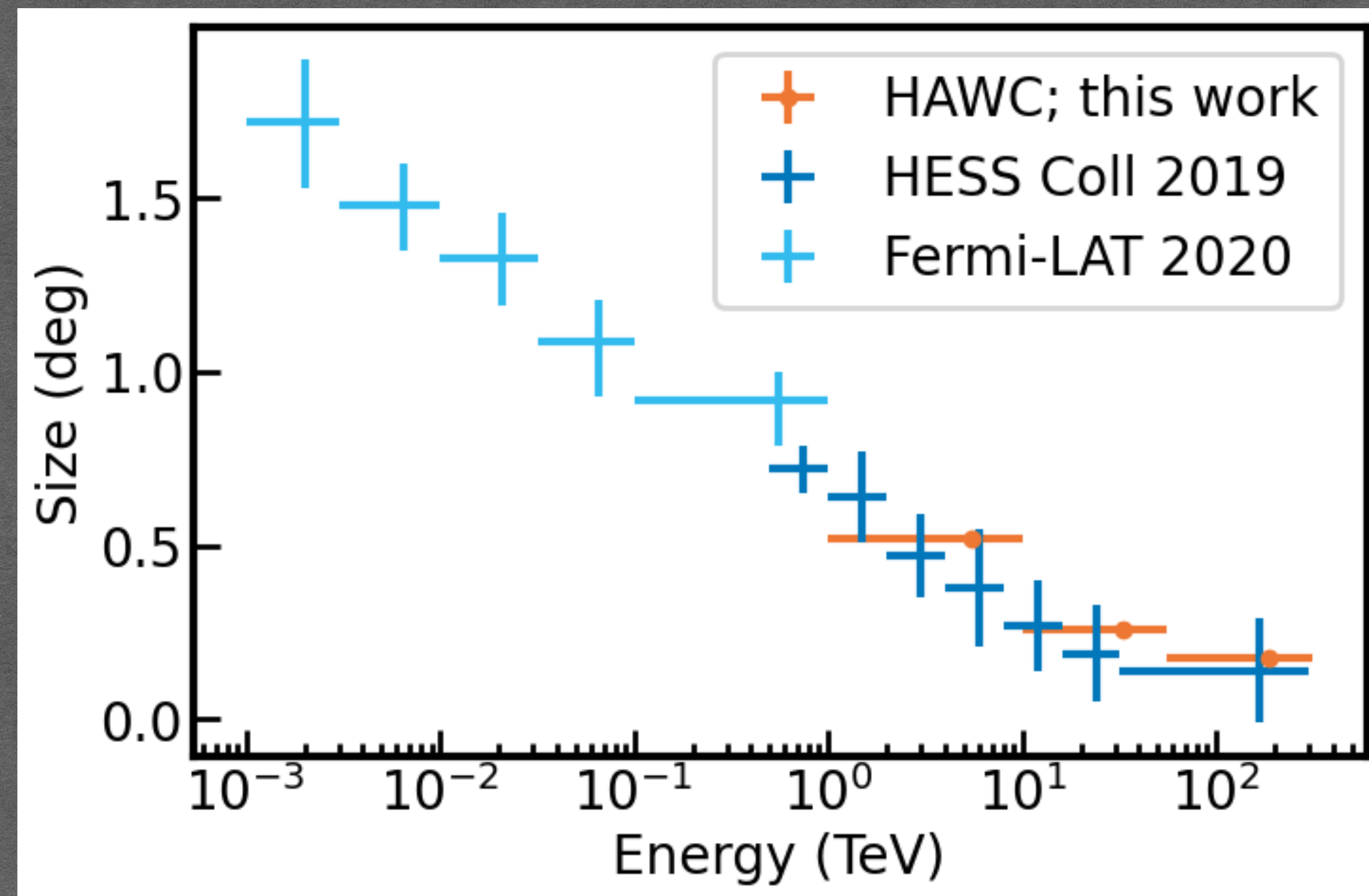
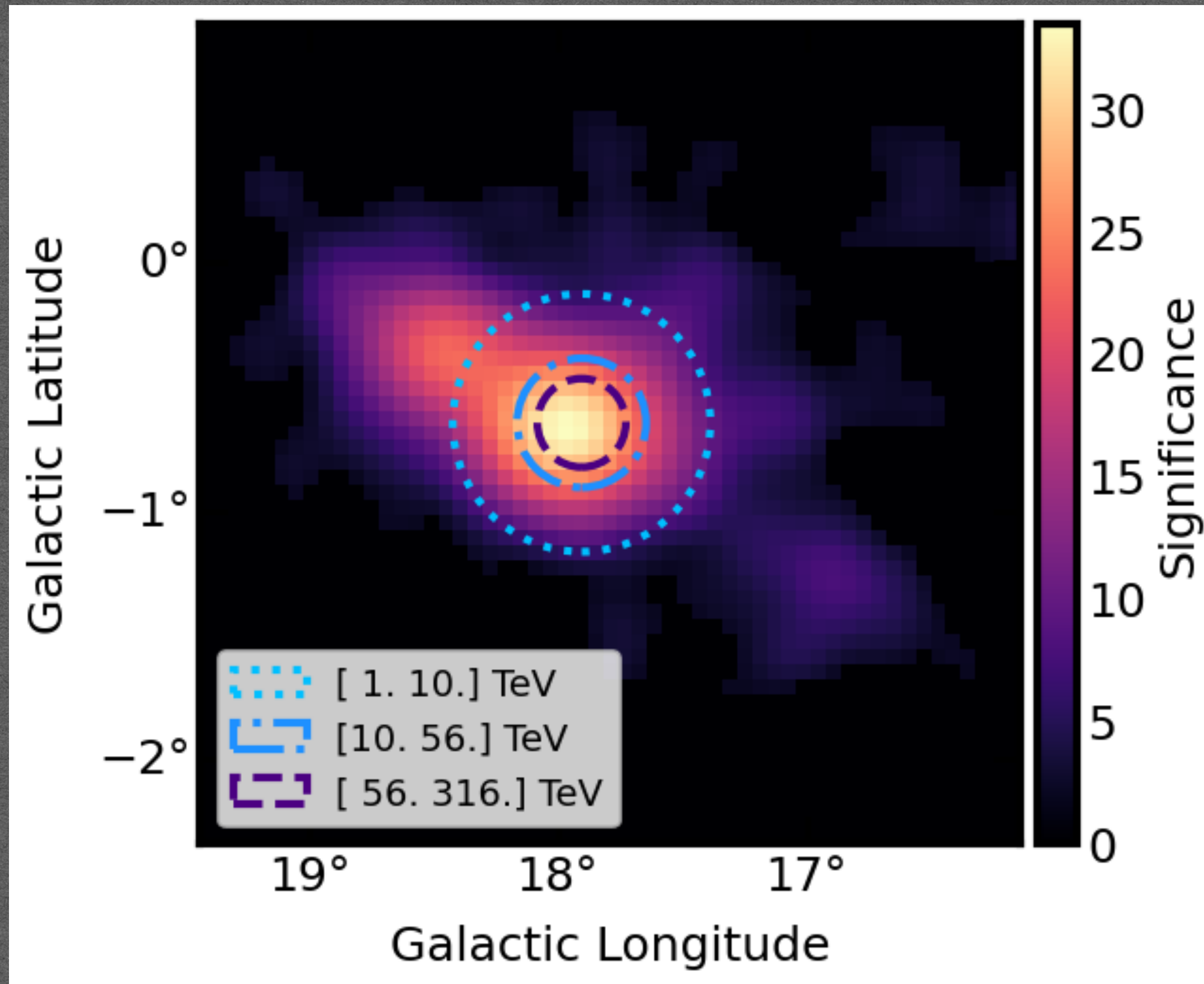
$0.25^\circ \text{ } ^{-/+} 0.02^\circ$

$0.23^\circ \text{ } ^{-0.035^\circ, +0.04^\circ}$



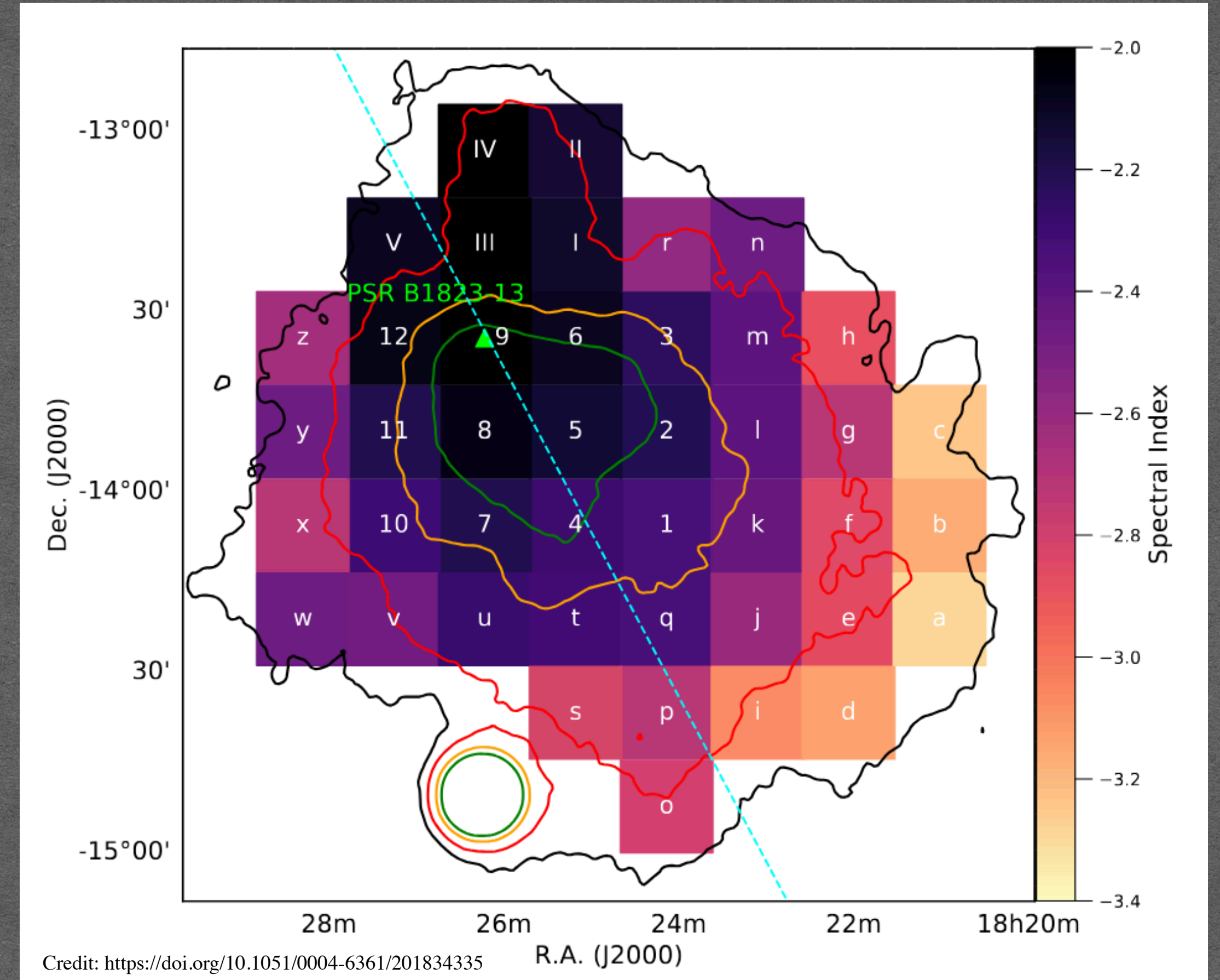
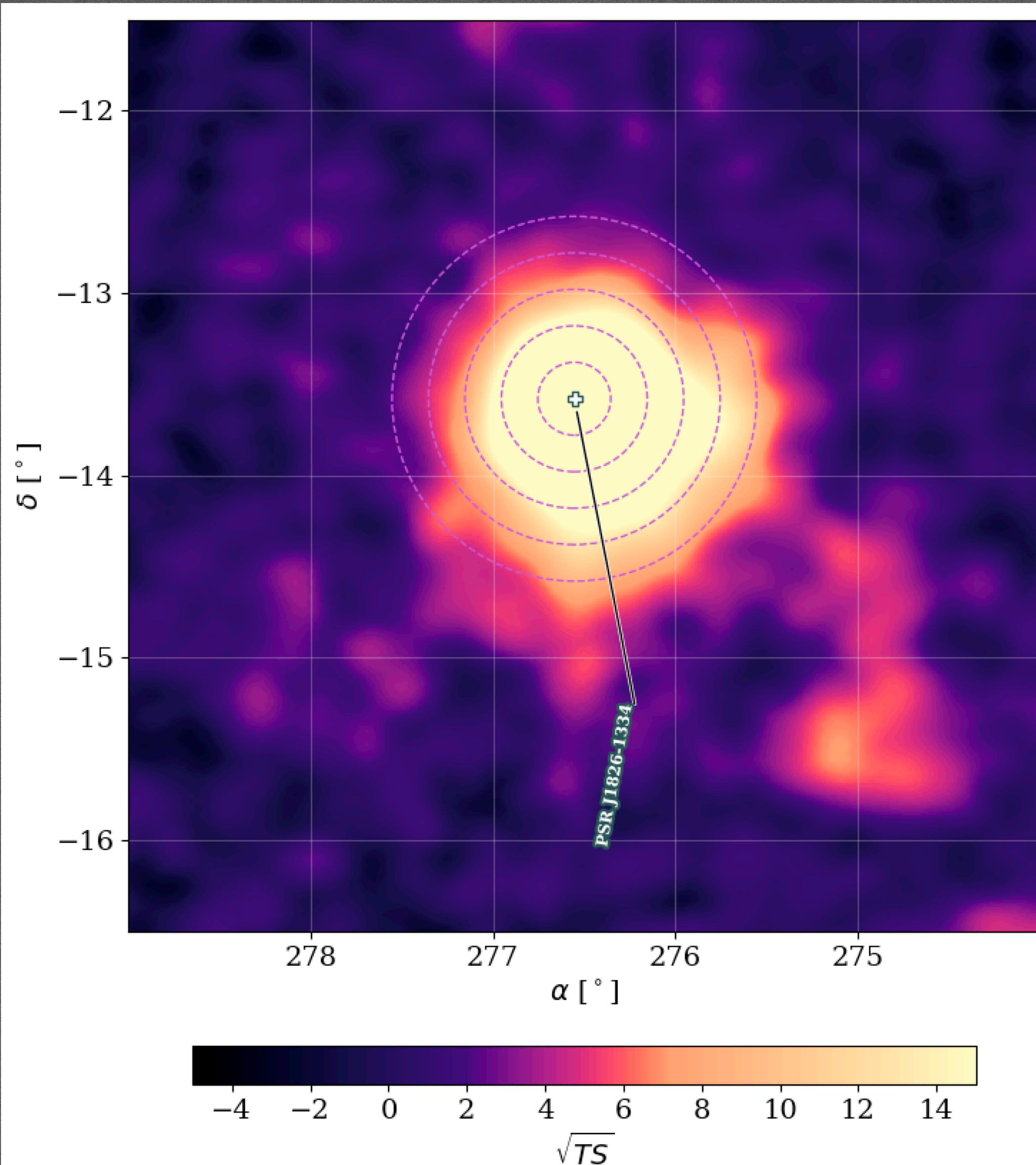
The size from different energy range and individual source will be studied in the future analysis

Energy-Dependent Morphology — Gammapy



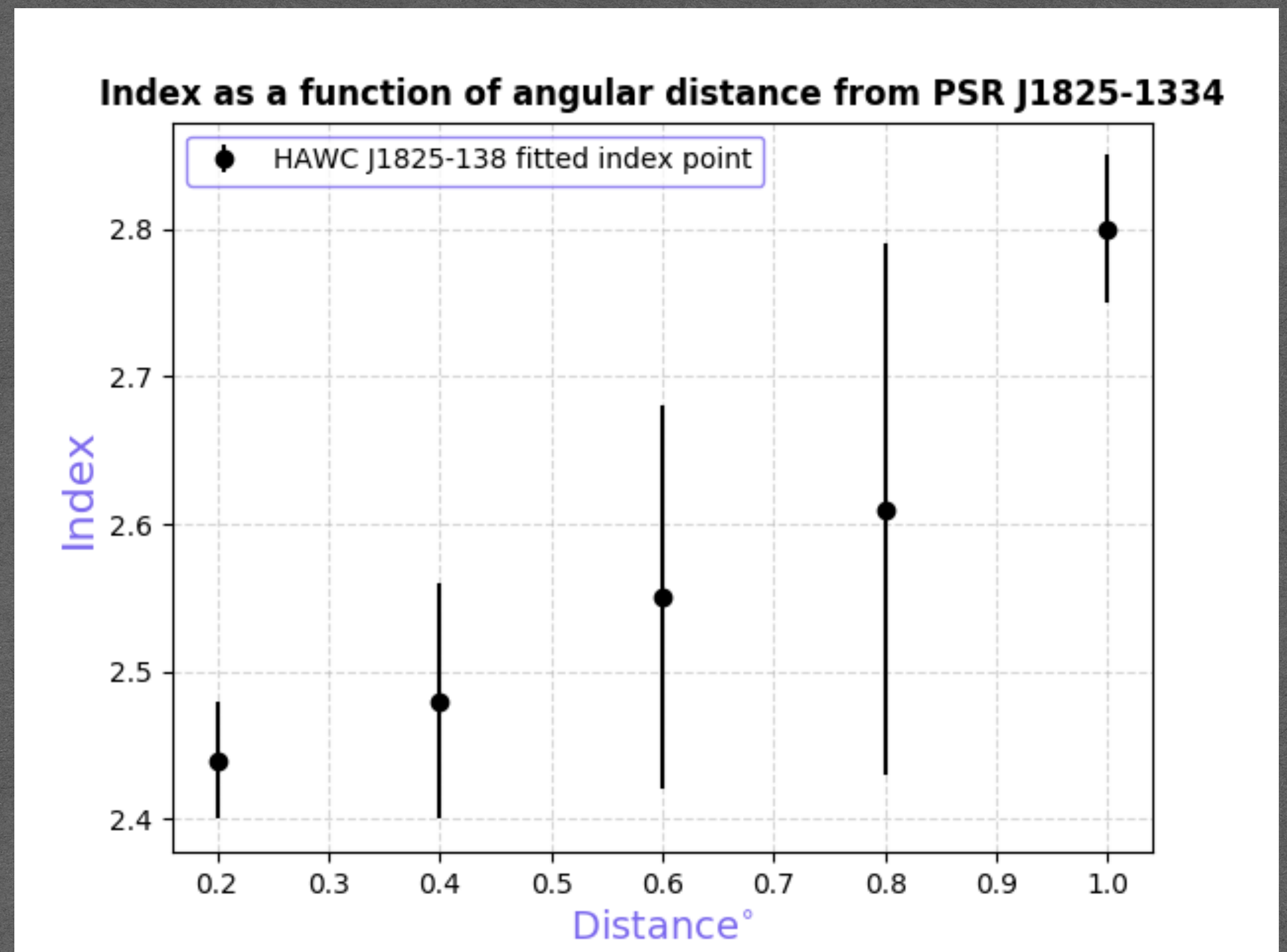
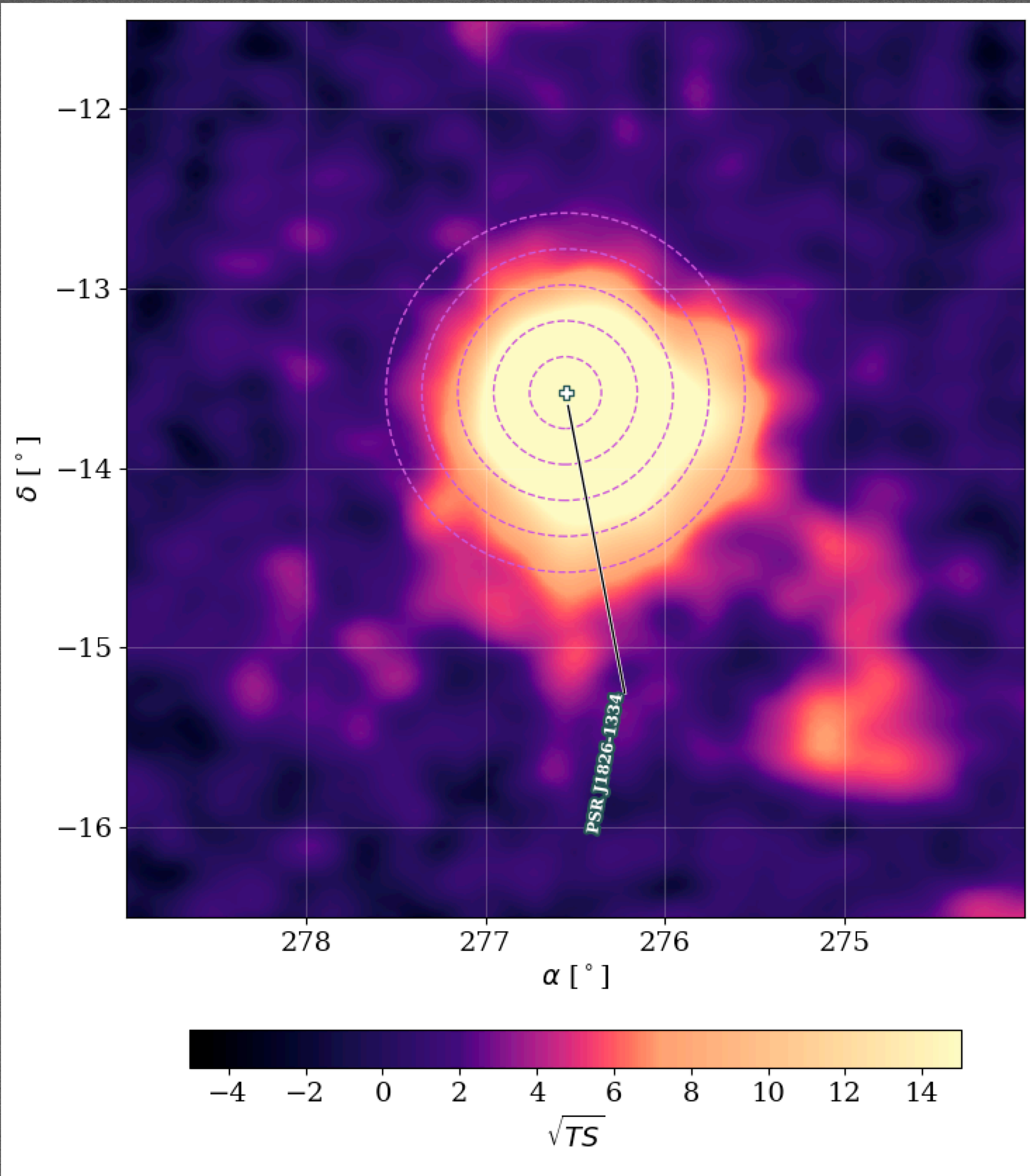
The size from different energy range from [1, 10] , [10, 56] , [56, 316] TeV, also been studied from HAWC data using gammapy (Credit: Hazal Goksu)

Energy-Dependent Morphology — Spectrum Index



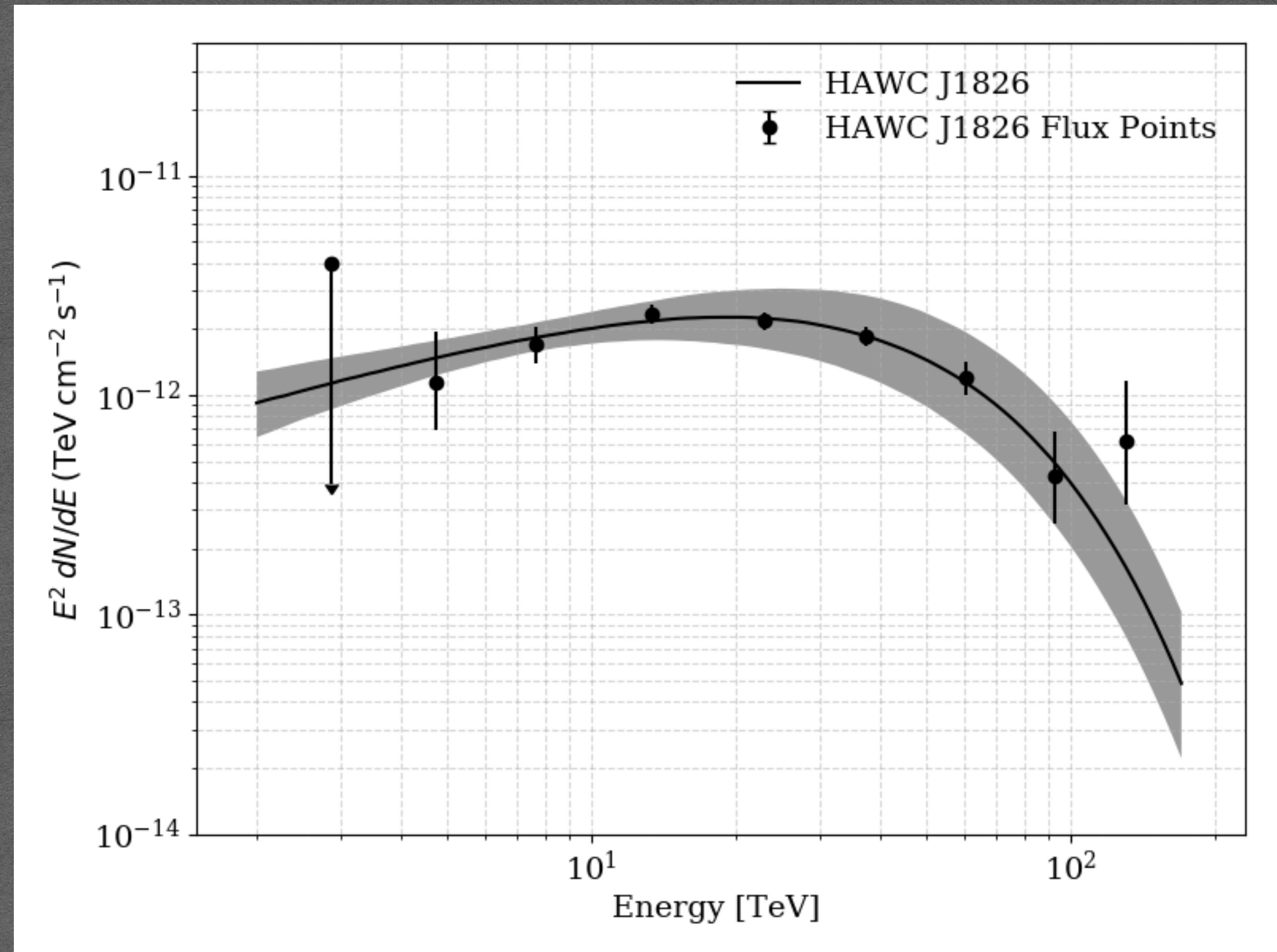
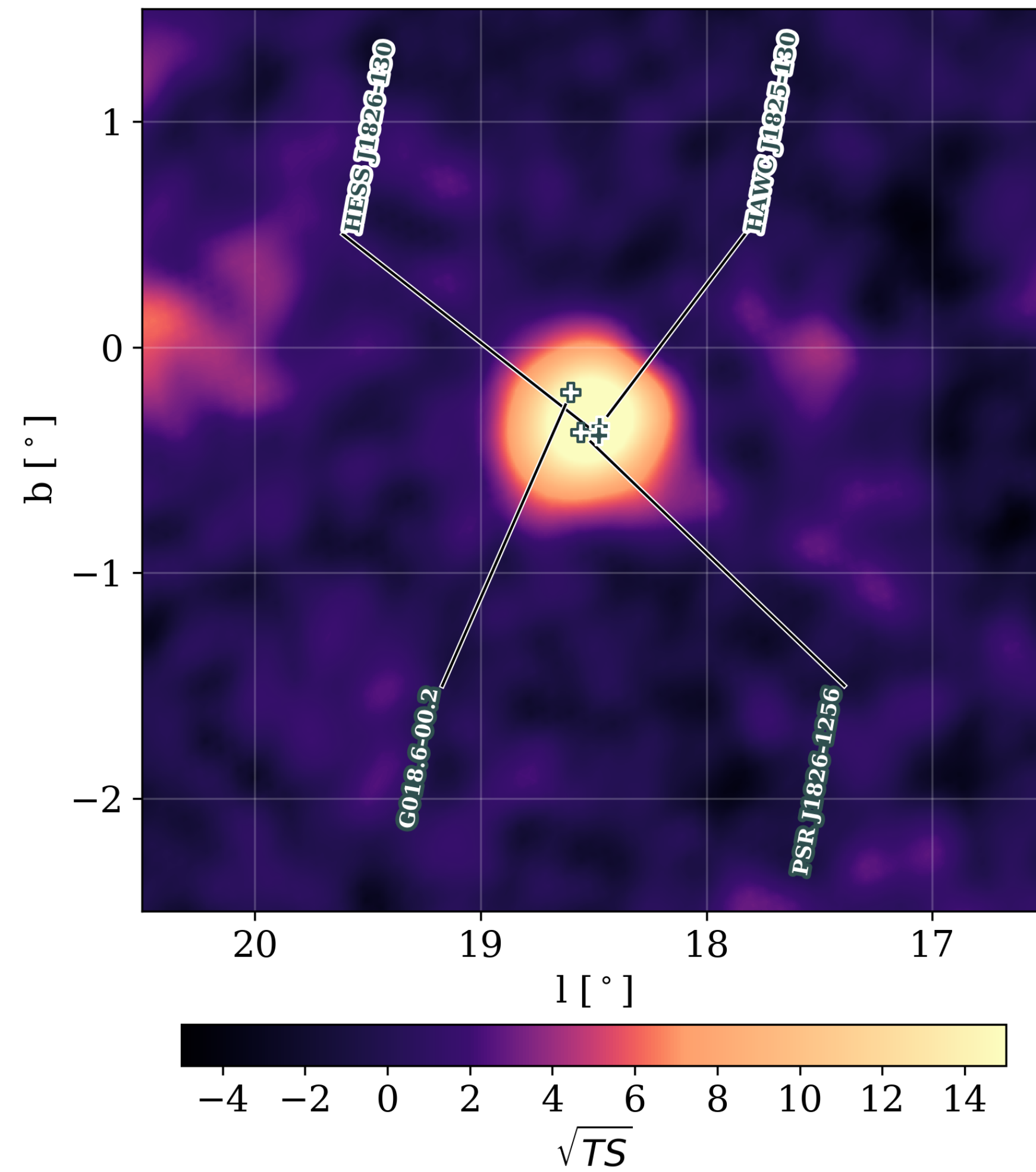
- H.E.S.S. looked at index inside square regions
- HAWC look at index inside annulus

Energy-Dependent Morphology — Spectrum Index



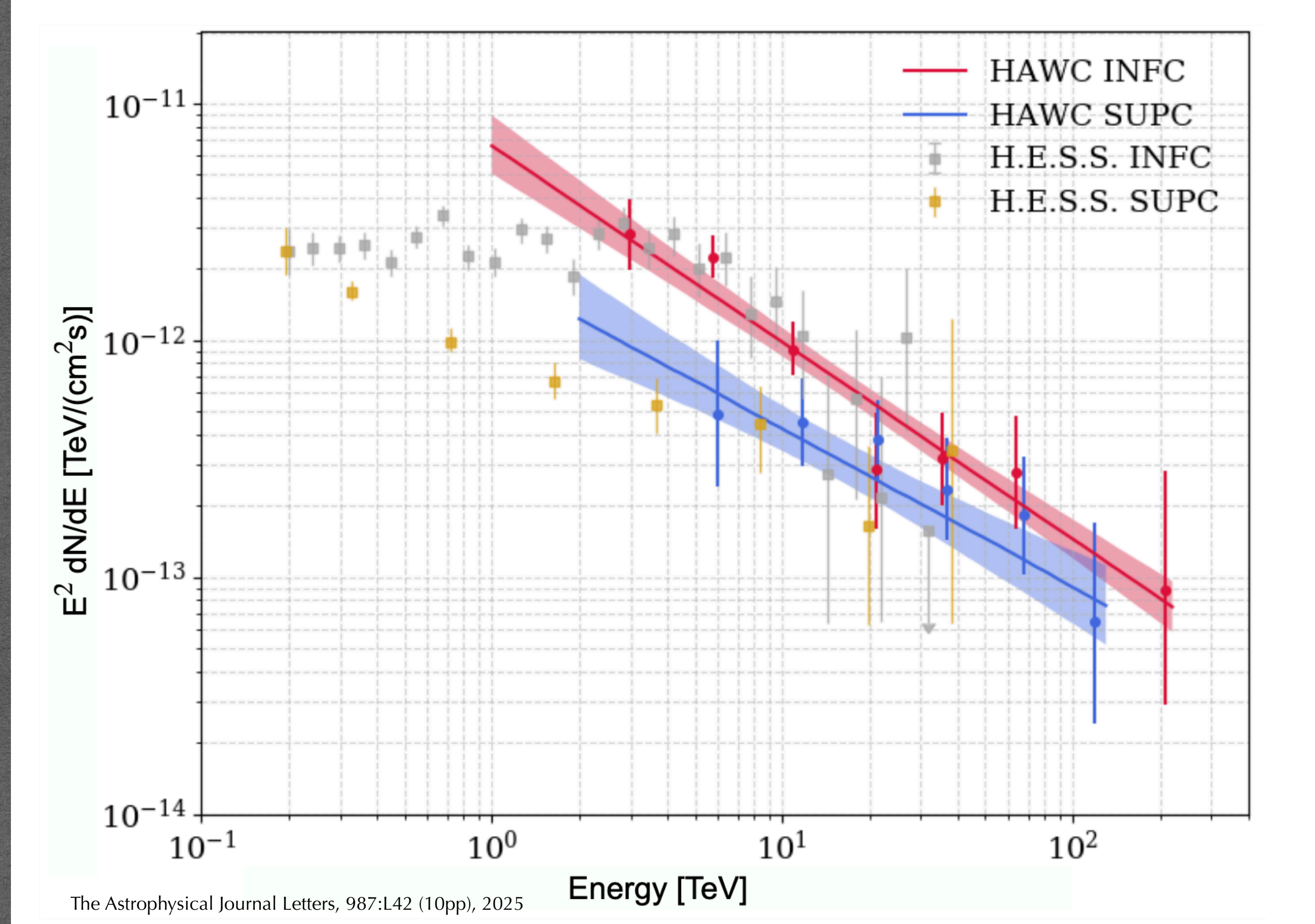
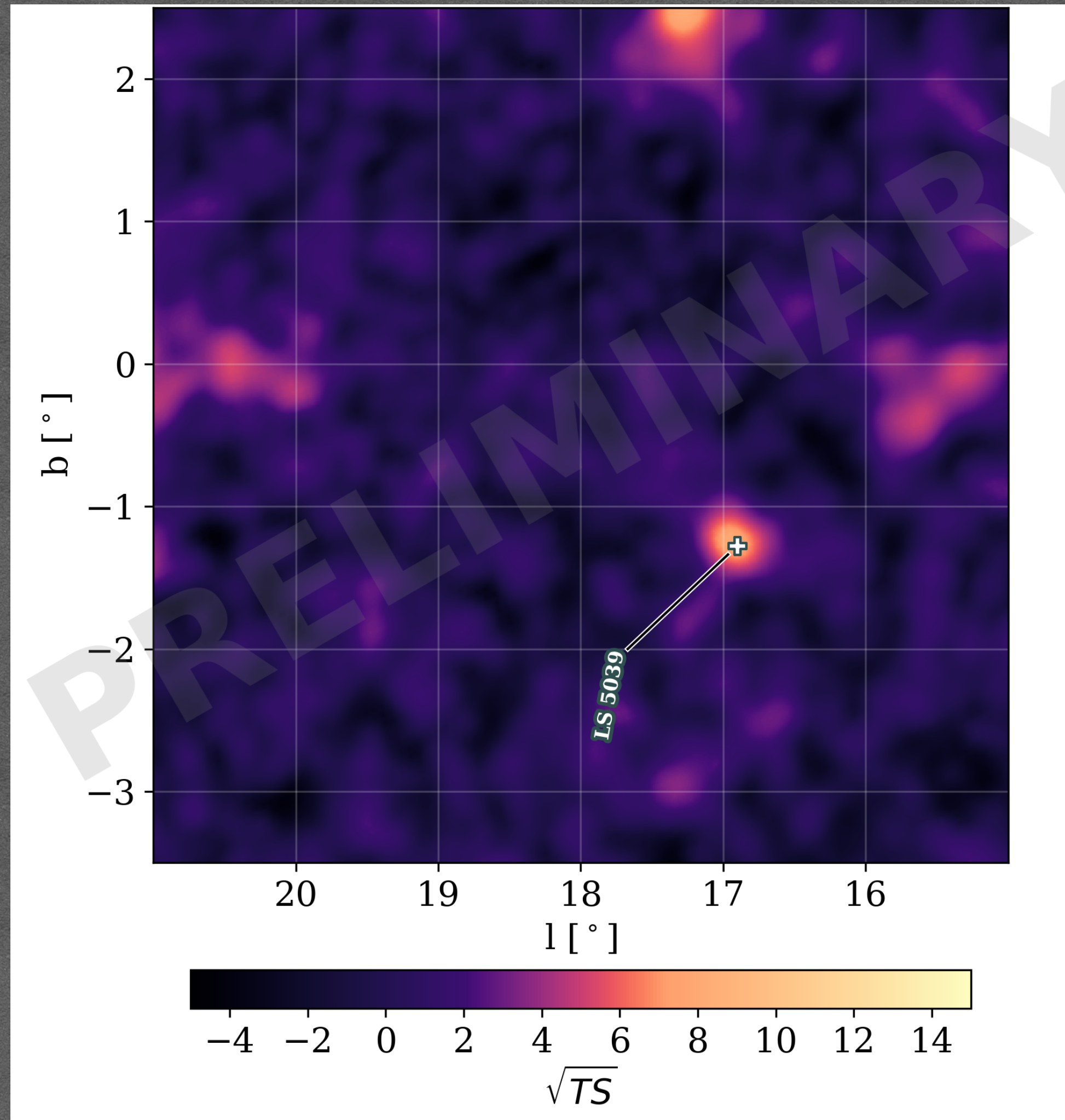
- Location fixed at pulsar PSR J1826-1334
- Fit a power-law inside each 0.2° annuli

Pulsar Wind Nebula Associated with PSR J1826-1256

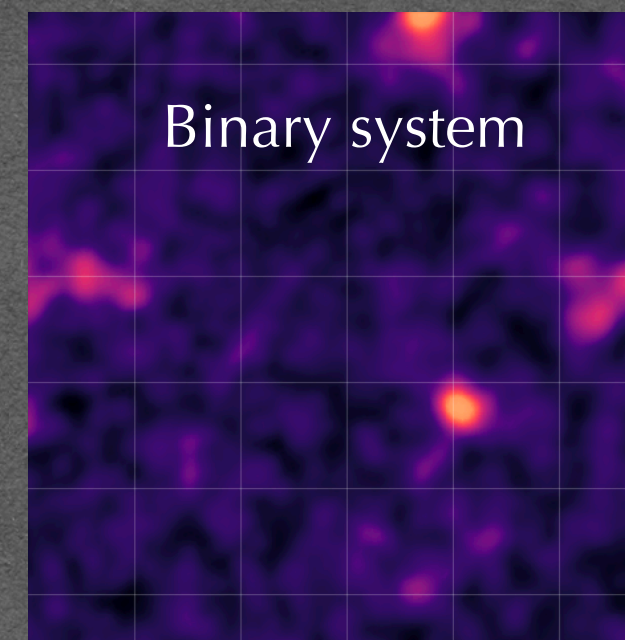
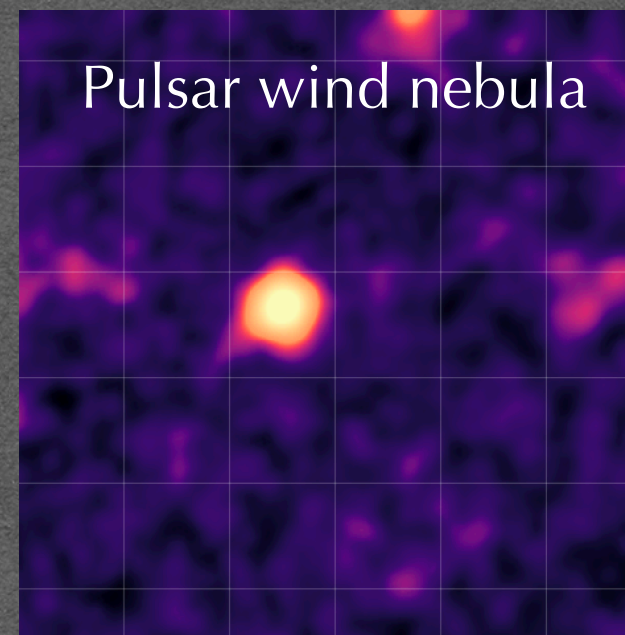
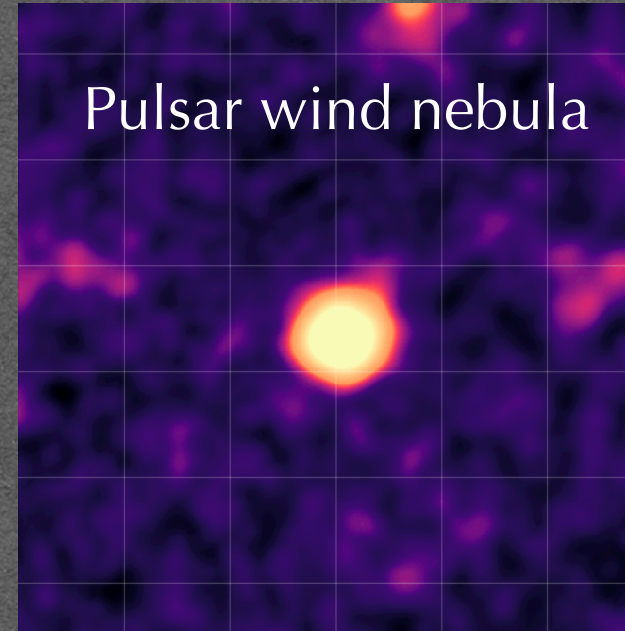
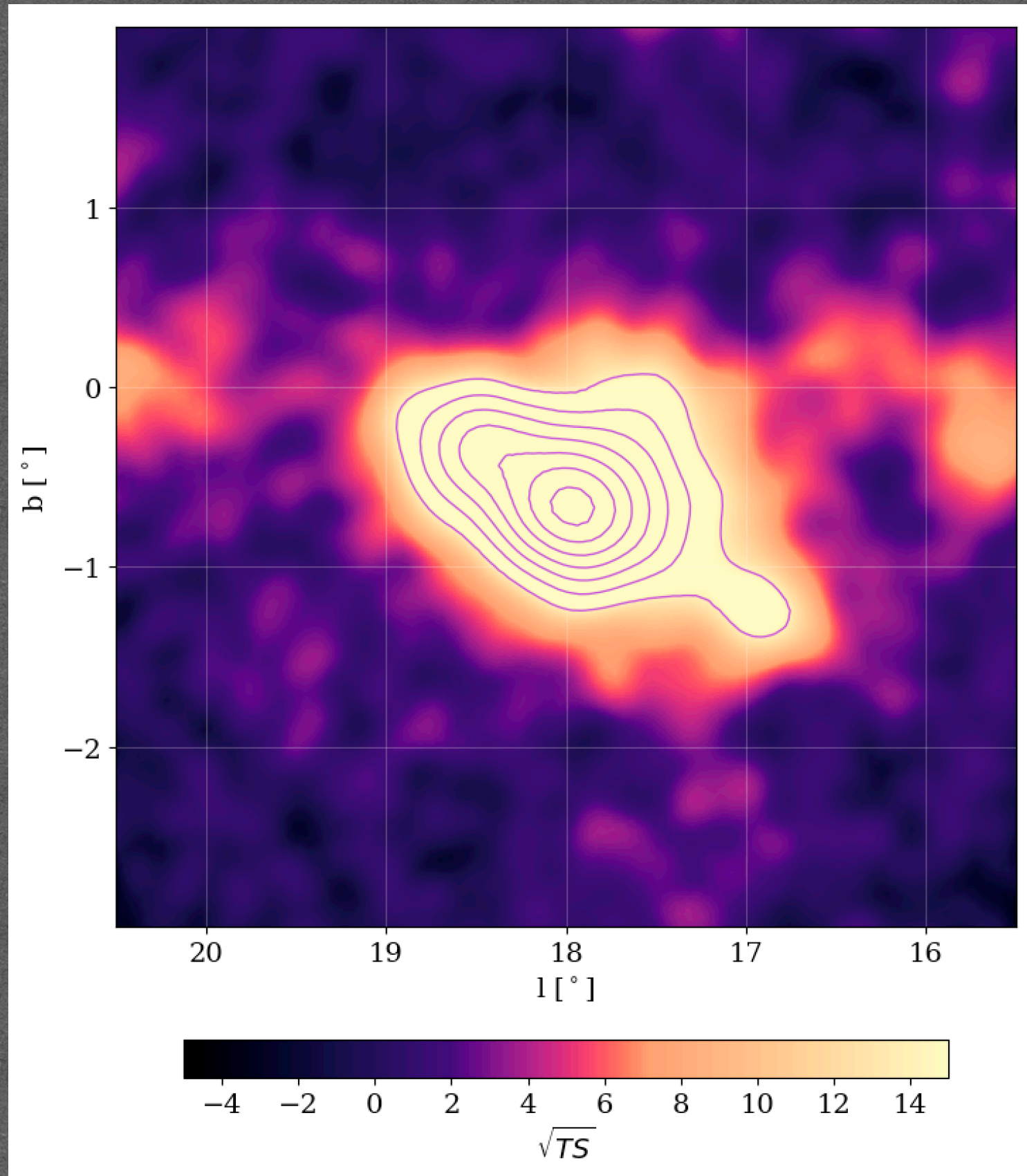


PSR J1826-1256 is a powerful pulsar with $\dot{E} = 3.6 \times 10^{36} \text{ erg/s}$ at characteristic age of 14.4 kyr

Pulsar Wind Nebula Associated with PSR J1826-1256



Discussion



- Identified three PeVatron candidates in the eHAWC J1825–134 region
- Each source exhibits distinct characteristics, yet all emit gamma rays above 100 TeV
- Two sources are likely associated with PWNe powered by energetic pulsars
- One source is associated with the gamma-ray binary LS 5039

Acknowledgments

CDHY workshop Committee

