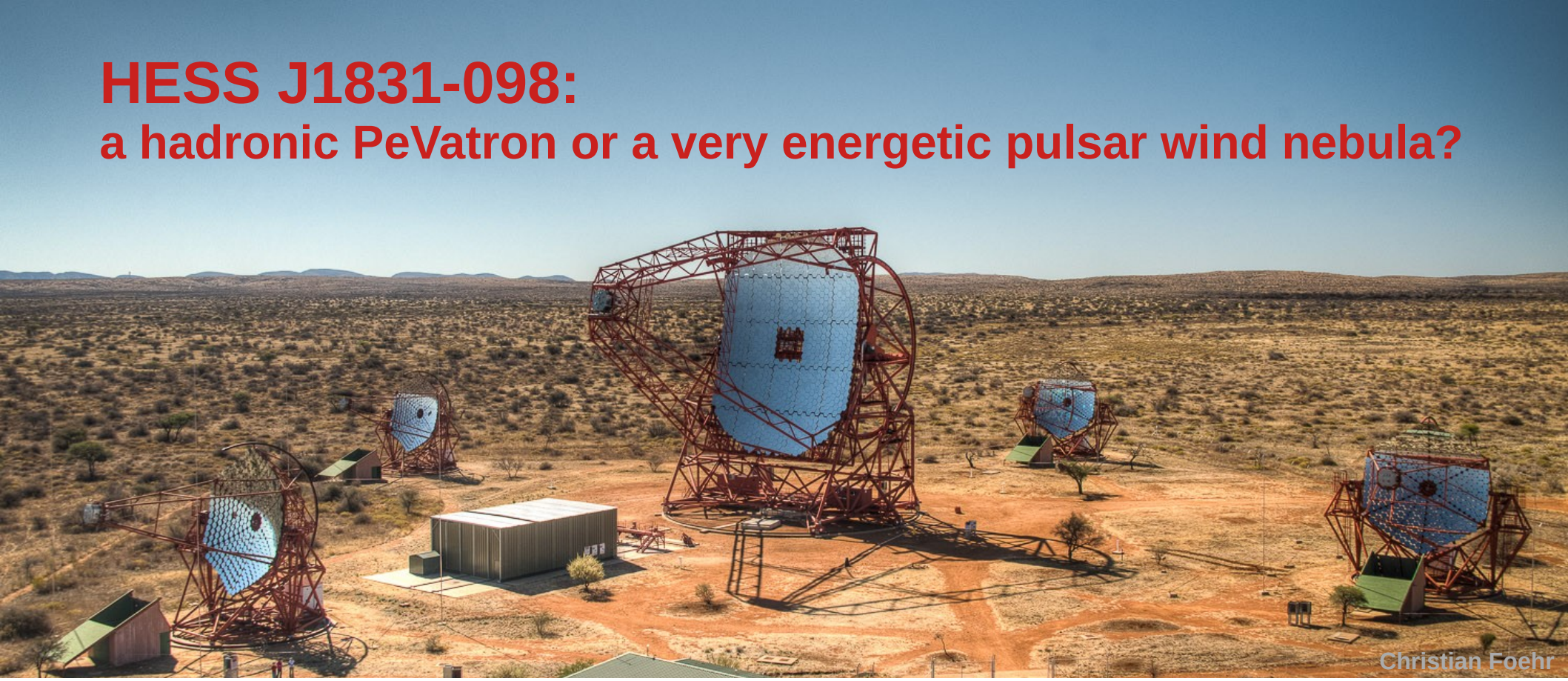
HESS J1831-098:
a hadronic PeVatron or a very energetic pulsar wind nebula?



H.E.S.S.

7th Heidelberg International Symposium on High-Energy Gamma-Ray Astronomy

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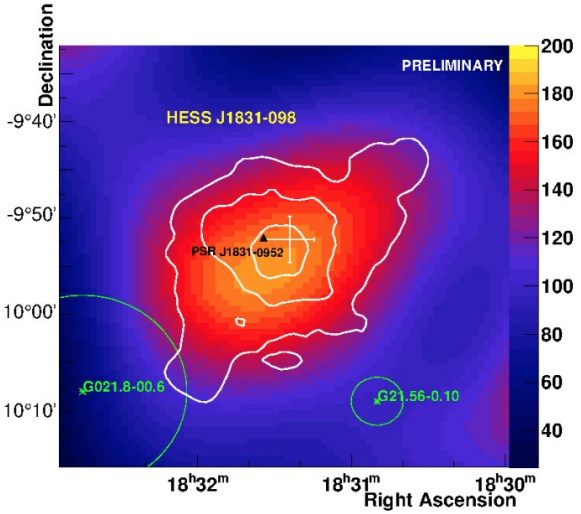
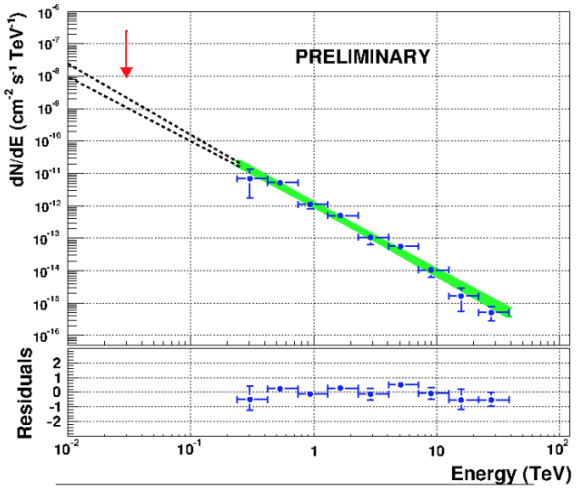
for the H.E.S.S. collaboration

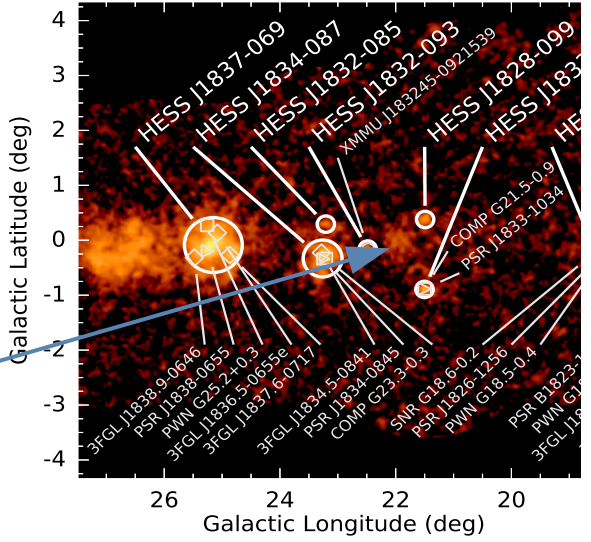
HESS J1831-098

- F. Sheidaei et al., 2011
  Fermi Symposium proceeding





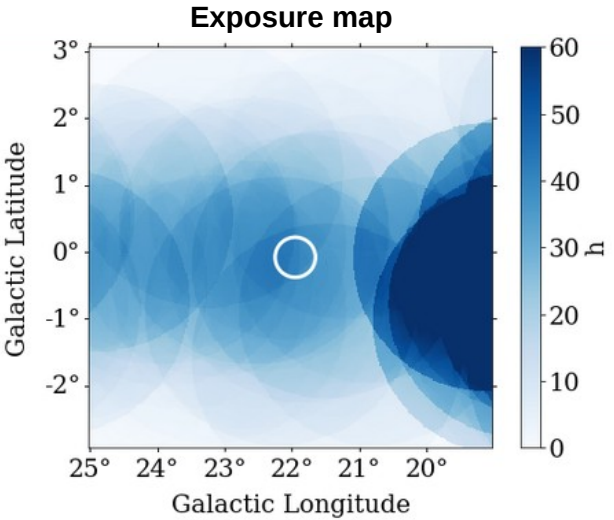
- Hotspot in H.E.S.S. GPS (A&A 612, A1, 2018)
  - Detection in main analysis
  - UL in x-check



HESS J1831-098

HESS J1831-098: new data and re-analysis

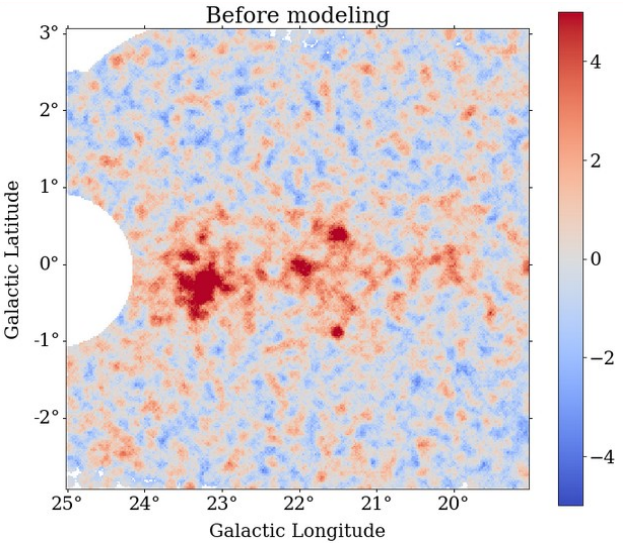
- Data set:
  - Original dataset = ~50 h (Fermi Symp. proc., 2011)
  - More data taken since the original proceeding publication
    - additional ~30 h
  - Very few observations dedicated to HESS J1831-098
    - most observations were pointed at neighboring sources
    - Galactic scan runs
    - → average offset is large

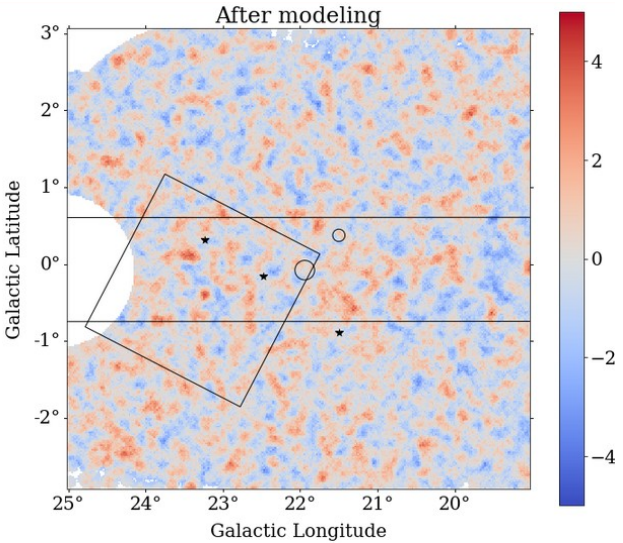


- Data analysed and x-checked with two different H.E.S.S. calibration and analysis chains
  - Main analysis – high-energy optimized analysis (A&A, 653, A152, 2021)
  - Considered energy range: > 1 TeV
    - No significant emission at lower energies in the source region

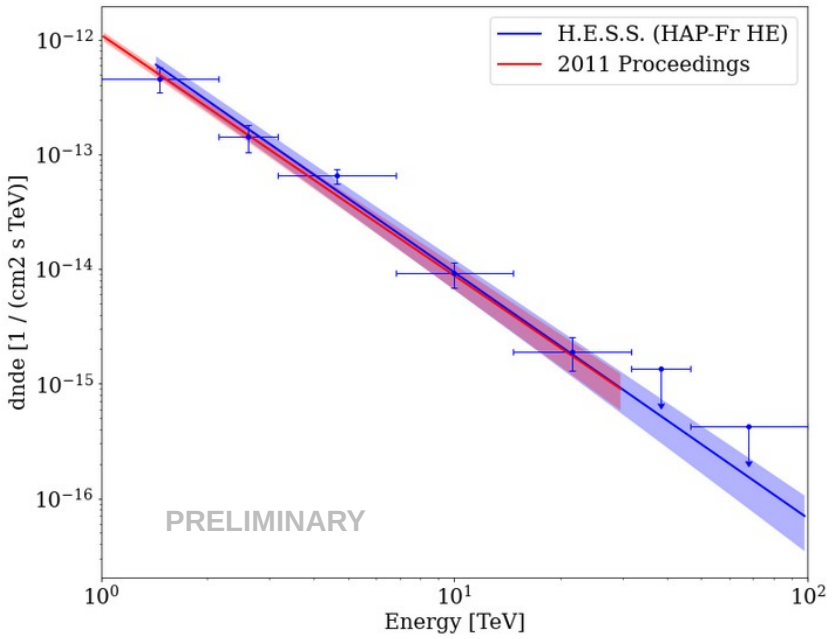
HESS J1831-098: new data and re-analysis

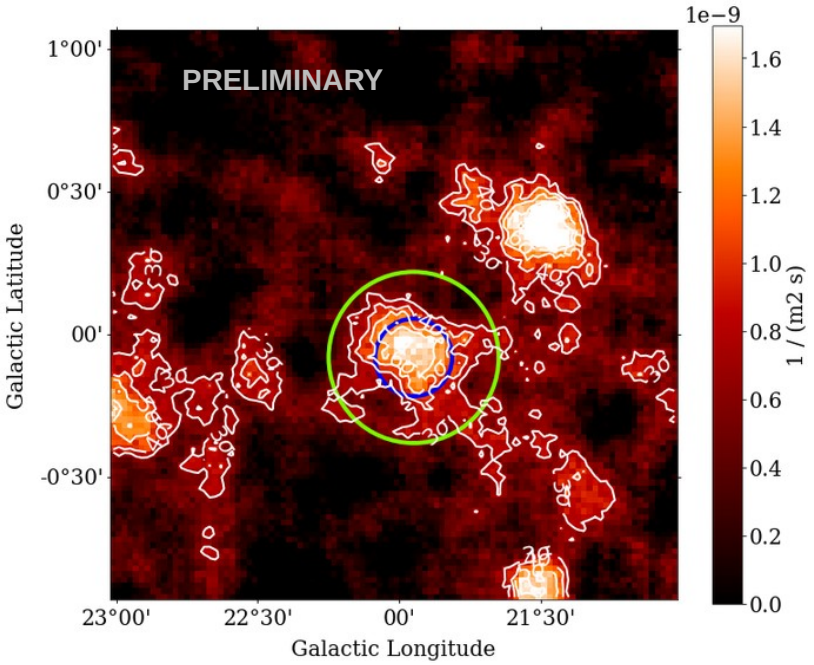
- Source analysis performed with gammapy (v0.19)
  - 1D and 2D analysis
- Model includes:
  - hadronic background model
    - FoV background method
  - known H.E.S.S. sources:
    - J1828-099, J1832-085, J1832-093, J1833-105, J1834-087
  - large scale diffuse emission
    - gaussian or dust model
  - HESS J1831-098





HESS J1831-098: spectrum and flux map

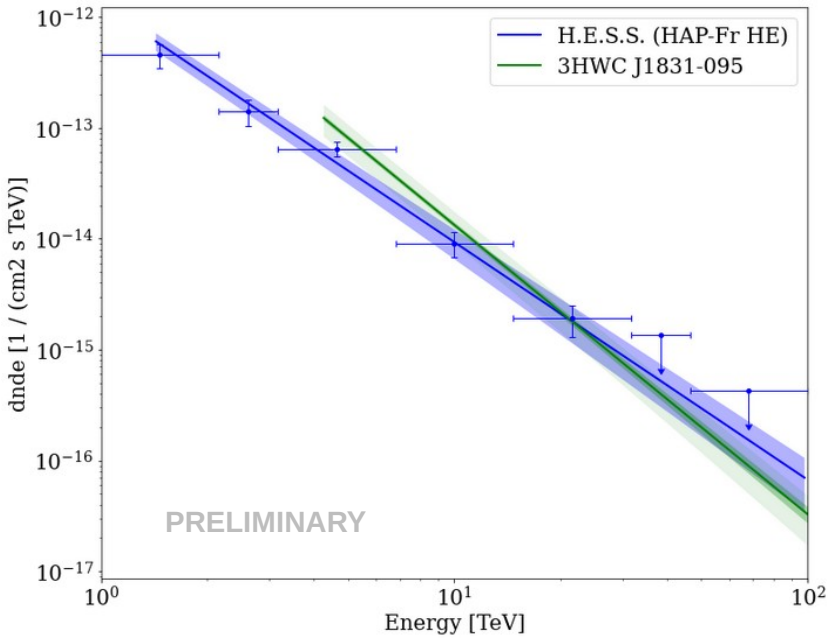




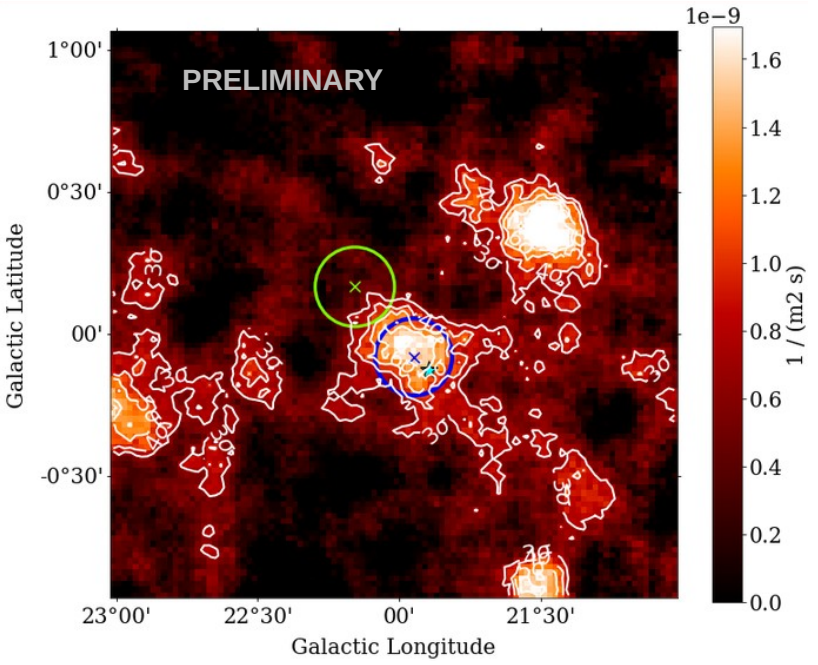
Index: 2.14 +/- 0.10
Pivot energy: 4.11
F(pivot energy): 6.27e-14 +/- 6.47e-15
F(> TeV): 1.13e-12 +/- 1.34e-13 cm-2 s-1

- blue circle – HESS J1831-098 best-fit position (l = 21.94, b = -0.078) and extension (0.14 deg)
- green – 0.3 deg region used for spectrum
- contours – significance (3, 4, 5 sigma)

Possible associations: 3HWC J1831-095



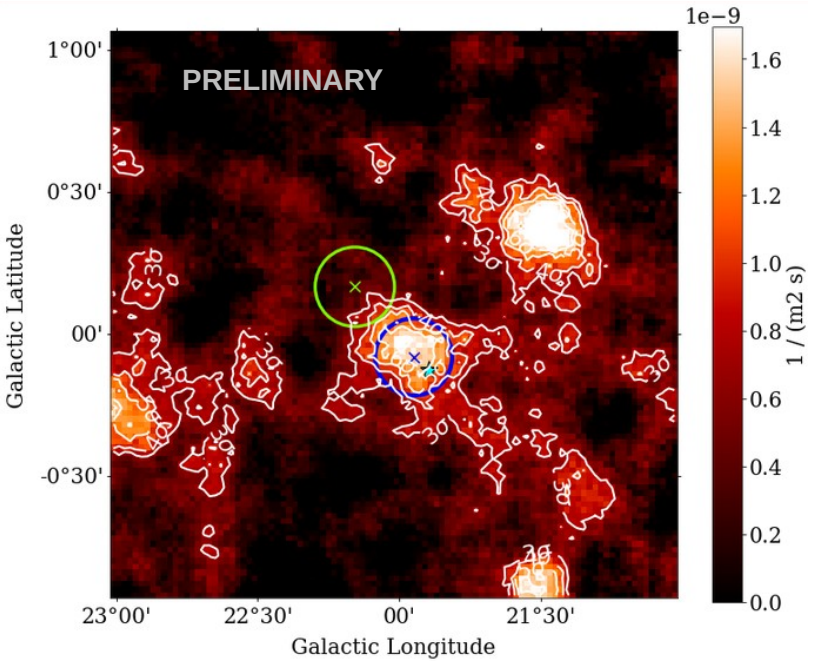
3HWC J1831-095 (ApJ 905, 76, 2020) & HESS J1831-098 → position proximity and good spectral similarity



- blue cross & circle – HESS J1831-098 best-fit position and size
- green cross & circle – best-fit position and position uncertainty for 3HWC J1831-095

Possible associations: PSR J1831-0952

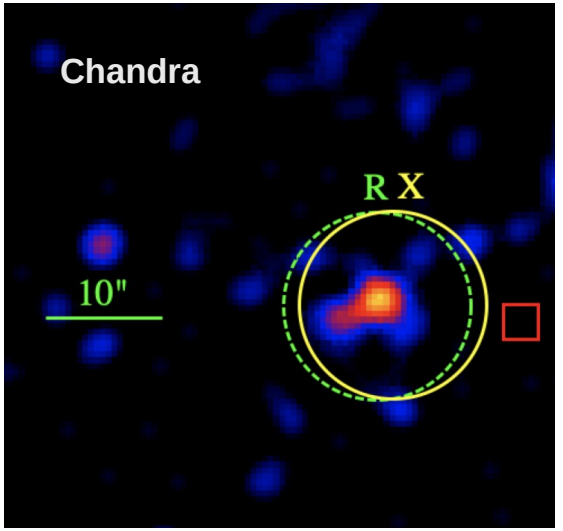
- VHE emission is located in the vicinity of PSR J1831-0952
  - old energetic pulsar
    - Edot = 1.1e+36 erg/s
    - Age 128 kyr
    - Distance 3.68 kpc

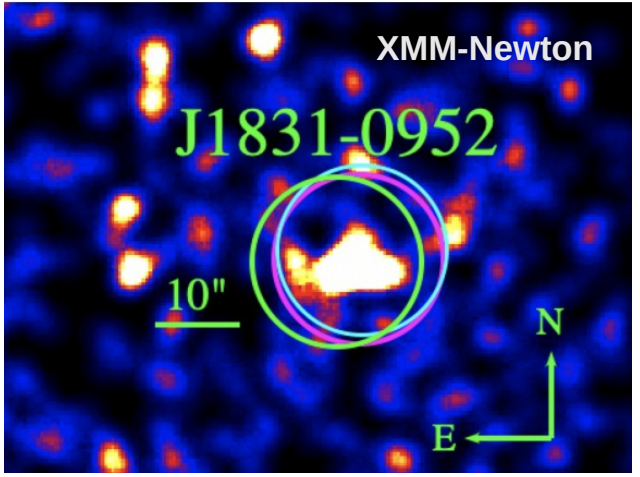


- blue cross & circle – HESS J1831-098 best-fit position and size
- cyan star – PSR J1831-0952 position

Possible associations: PSR J1831-0952

- VHE emission is located in the vicinity of PSR J1831-0952
  - old energetic pulsar
    - Edot = 1.1e+36 erg/s
    - Age 128 kyr
    - Distance 3.68 kpc
- Likely extended X-ray emission (A&A 658, A95, 2022)
  - could be a PWN
  - would also suggest PWN nature of VHE emission

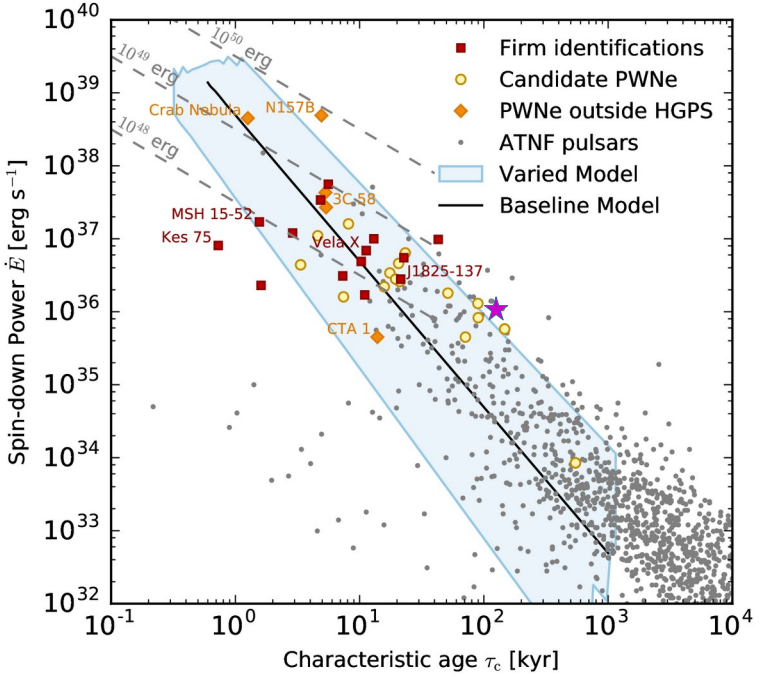


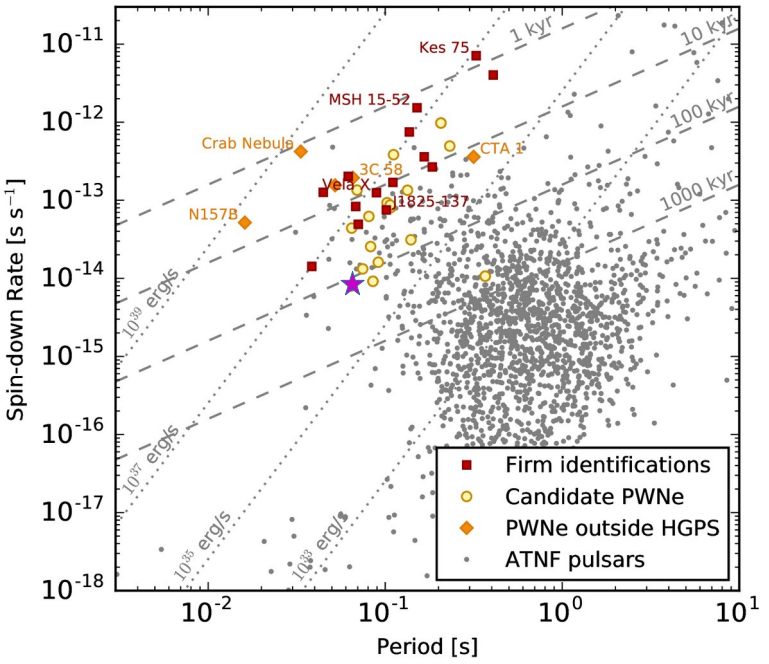


- green – centered at radio position
- yellow, blue, magenta – X-ray position

PWN scenario: comparison with other pulsars

A&A 612, A2, 2018





PSR J1831-0952 – magenta star

Age = 128 kyr
Distance = 3.68 kpc
Period = 6.7e-2 s

Edot = 1.1e+36 erg/s
Spin-down rate = 8.3e-15 s/s

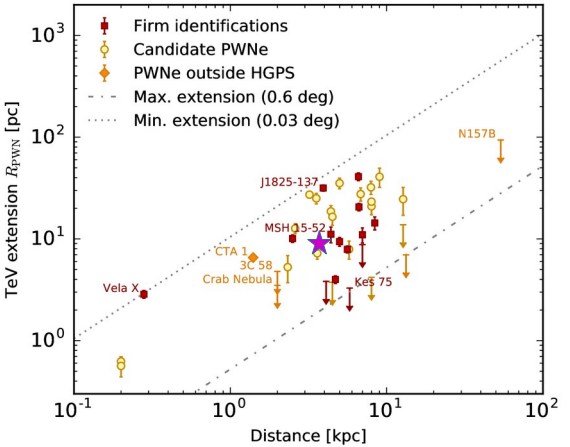
PWN scenario: comparison with TeV PWNs

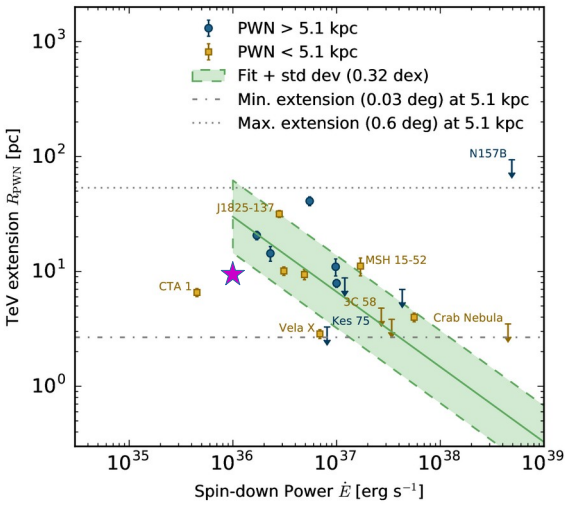
PSR J1831-0952

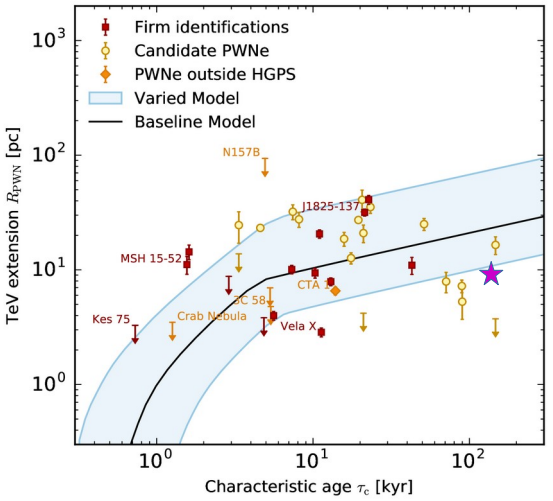
Edot = 1.1e+36 erg/s
Spin-down rate = 8.3e-15
Period = 6.7e-2 s
Age 128 kyr
Distance 3.68 kpc

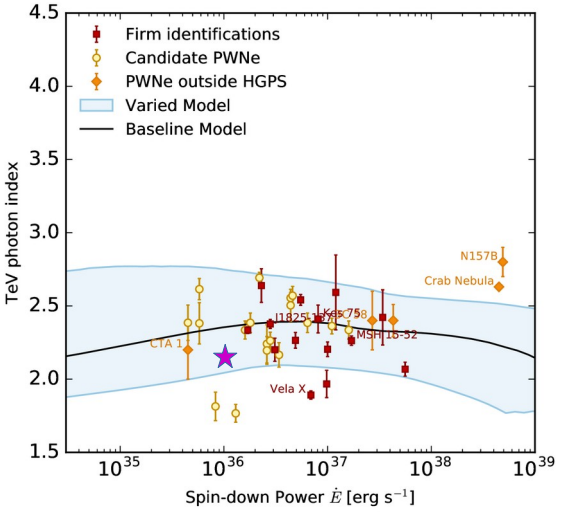
HESS J1831-098

Extension = ~0.14 deg +/- 0.04 → 9 pc
Index = 2.14 +/- 0.10



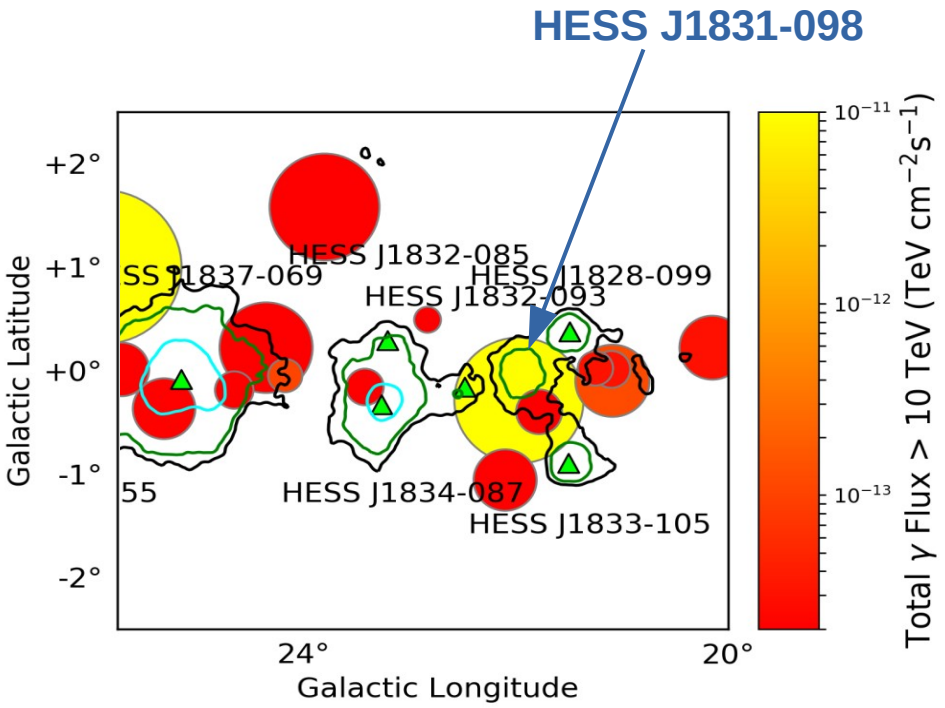






Possible associations: molecular cloud illuminated by SNR

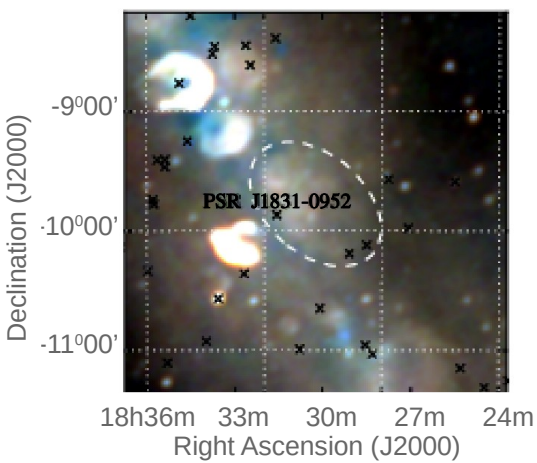
- Predicted integral gamma-ray flux > 10 TeV from interstellar clouds that could be detectable by H.E.S.S.
  (MNRAS, 503, 3, 2021, p. 3522–3539)
- Cloud (21.97, -0.29) – one of the four interstellar clouds with the brightest predicted fluxes identified in the study
  - distance: 3.57 kpc
  - size: 0.608 deg
- SNR G21.6-0.8 – assumed source of energetic particles
  - distance estimate not available

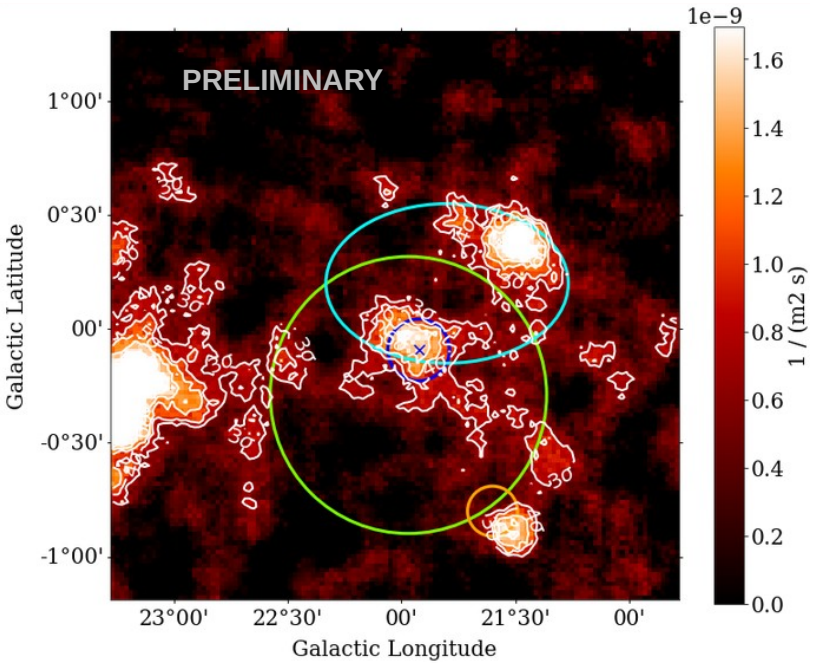


- Black, green and cyan – significance contours at 3, 5 and 15 sigma from the HESS GPS
- green triangles – best fit positions of known H.E.S.S. sources

Possible associations: molecular cloud illuminated by SNR

- SNR candidate G21.8+0.2 (PASA, 36, E045, 2019)
  - recently detected in radio in GLEAM survey
  - estimated distance = 1.8 – 3.45 kpc
  - estimated age = 40 – 120 kyr
  - could be associated with PSR J1831-0952
- was not considered in the previous study
  but could be a suitable source of energetic particles





- blue cross & circle – HESS J1831-098 best-fit position and size
- green – molecular cloud
- cyan – SNR candidate G21.8+0.2
- orange – SNR G21.6-0.8

Summary

- HESS J1831-098
  - significantly detected (> 7 sigma)
    in both analysis chains (main and x-check)
- Hard spectrum, extends to 30 - 40 TeV
  - suitable PeVatron candidate
- Possible associations:
  - 3HWC J1831-095
    - Position proximity and good spectral similarity
  - PSR J1831-0952
    - possibly extended X-ray counterpart (PWN?)
    - suggests PWN nature for HESS J1831-098
  - Molecular cloud (21.97, -0.29) illuminated by nearby SNR
    - SNR G21.6-0.8 ?
    - SNR candidate G21.8+0.2 ?