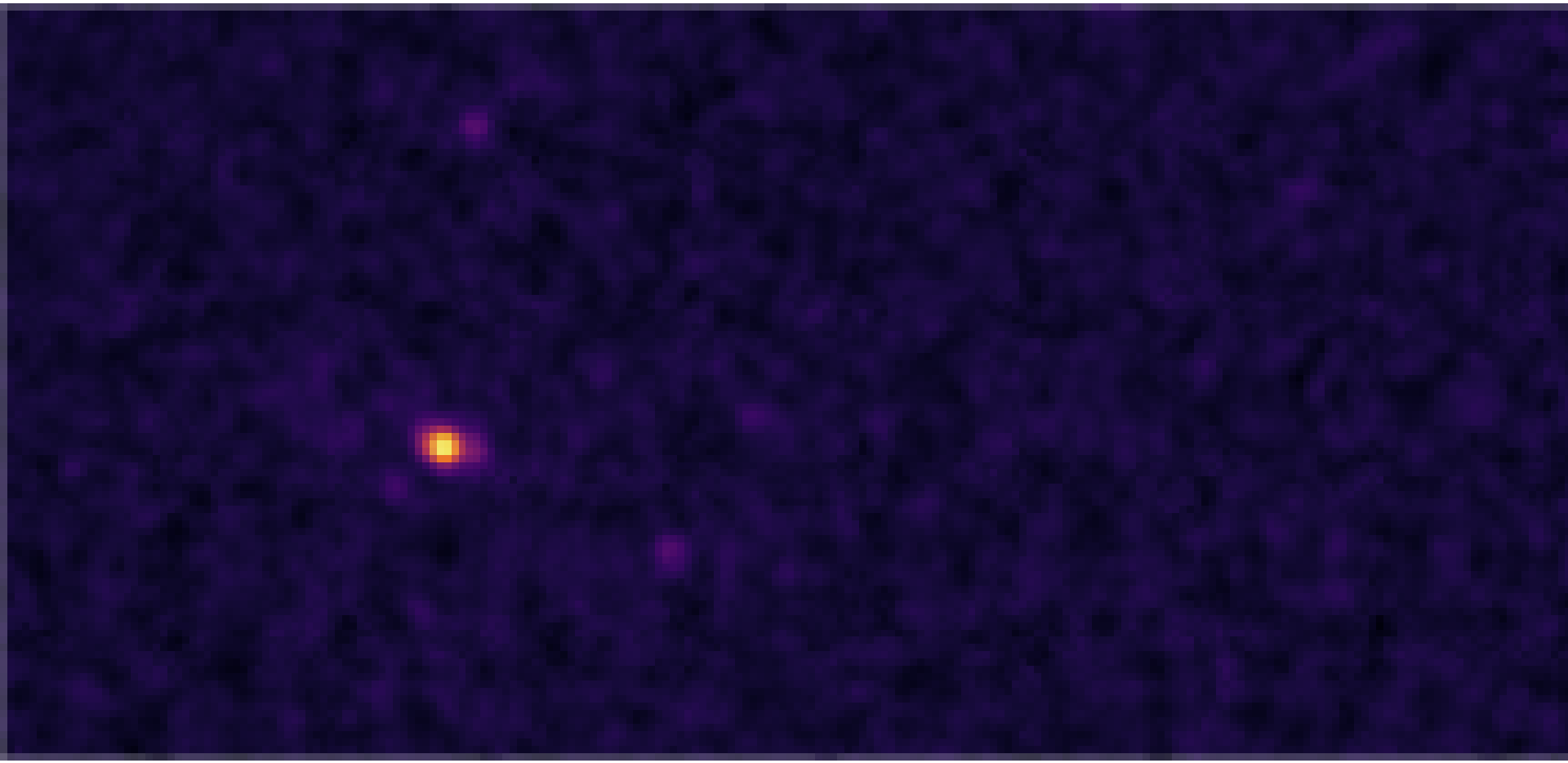


Search for gamma-ray sources in the LMC with H.E.S.S.

E.J. Mckie & N. Komin for the HESS collaboration

TeVPA 2025, Valencia, Spain
November 2025

Introduction to the LMC

- One of our closest neighbours, $\approx$ 50 kpc
- 5 known VHE sources
- Face on towards us
- Located away from the galactic plane
- We have done a complete survey

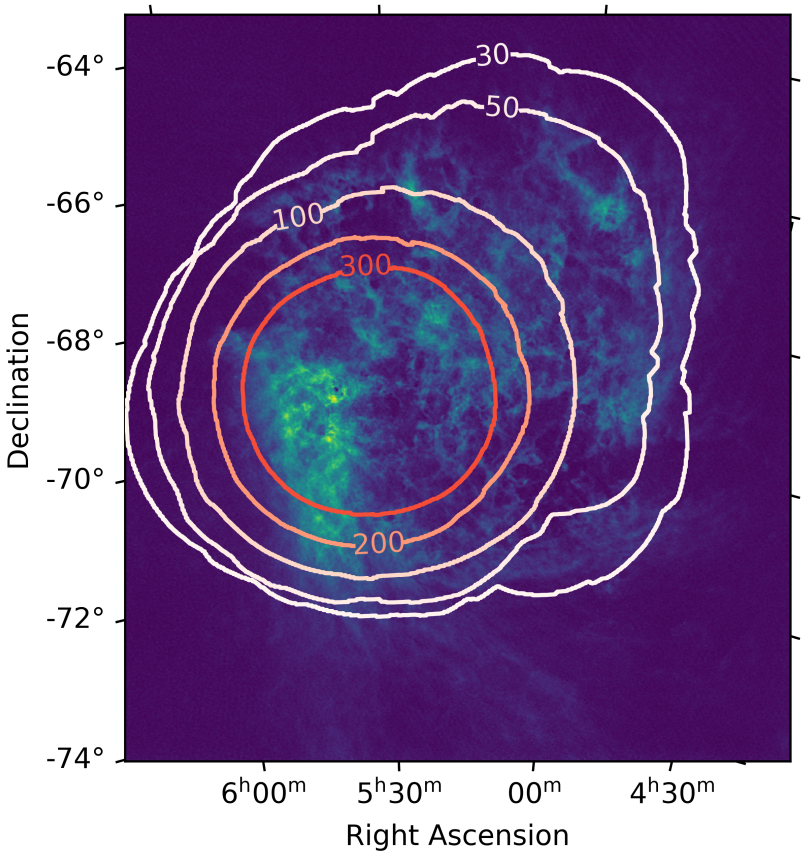
Aims/Goals:

- Re-examine the known sources
- Identify potential new point-like sources
- To enable future study of diffuse emission

LMC as observed by ESO's VISTA

H.E.S.S. Observations of the LMC

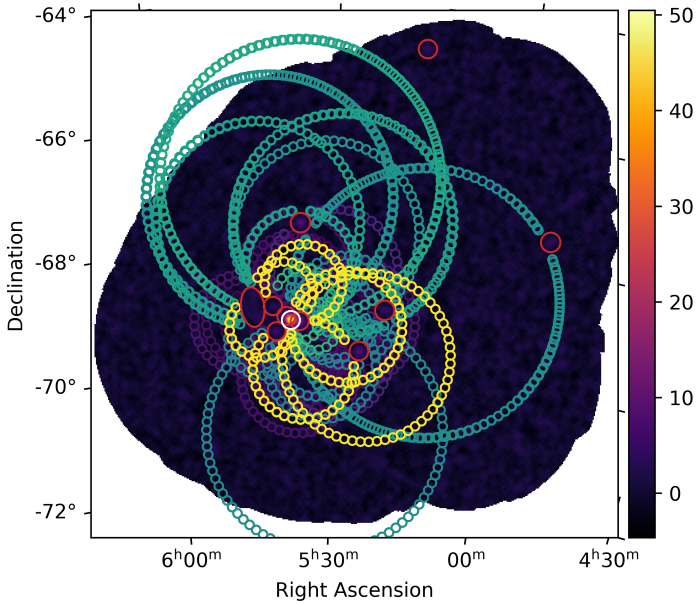
- Observations between Dec 2003 and Nov 2023
- Completed survey of the LMC
- # runs: 1599
- $\approx$ 708 hours of observation
- Minimum exposure of 30h at any point of the LMC



Obs time (hr) over HI

Basics of the analysis

- Ring Background
  - Radius and Width of 0.22°
  - Thus insensitive to large-scale diffuse emission
- Reflected Regions background:
  - Regions with radius of 0.07°
  - Max offset of 2.5°
- Reconstruction chain:
  - Model++
    - `https://doi.org/10.1016/j.astropartphys.2009.09.001`
    - Main Analysis
    - High-level analysis using Gammapy 1.2



Procedure

Datasets used for analysis:

- 3D analysis → Map dataset
  - Background: RingBackground
- Reflected region analysis → Spectrum dataset
  - Background: Reflected Regions background

Model selection:

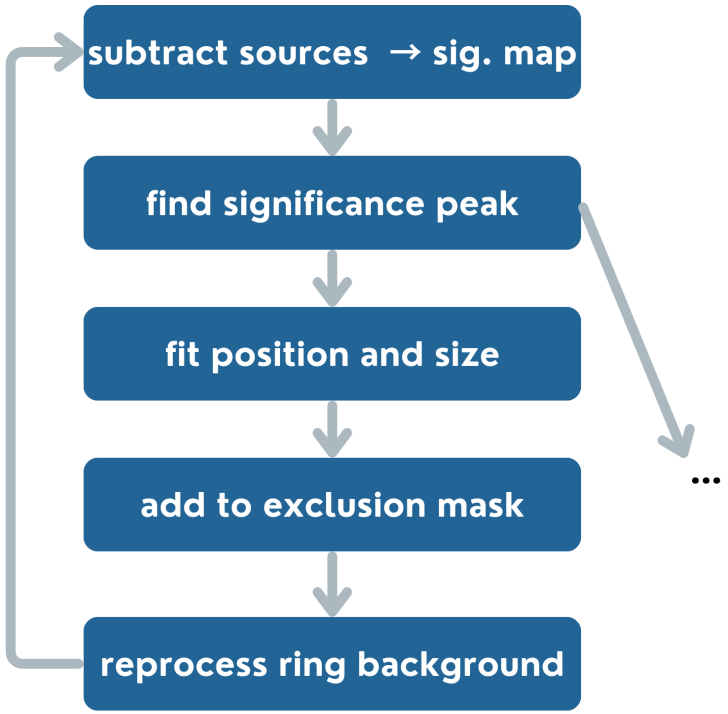
Via Log-likelihood testing with 3σ threshold

1) Spectral models tested:

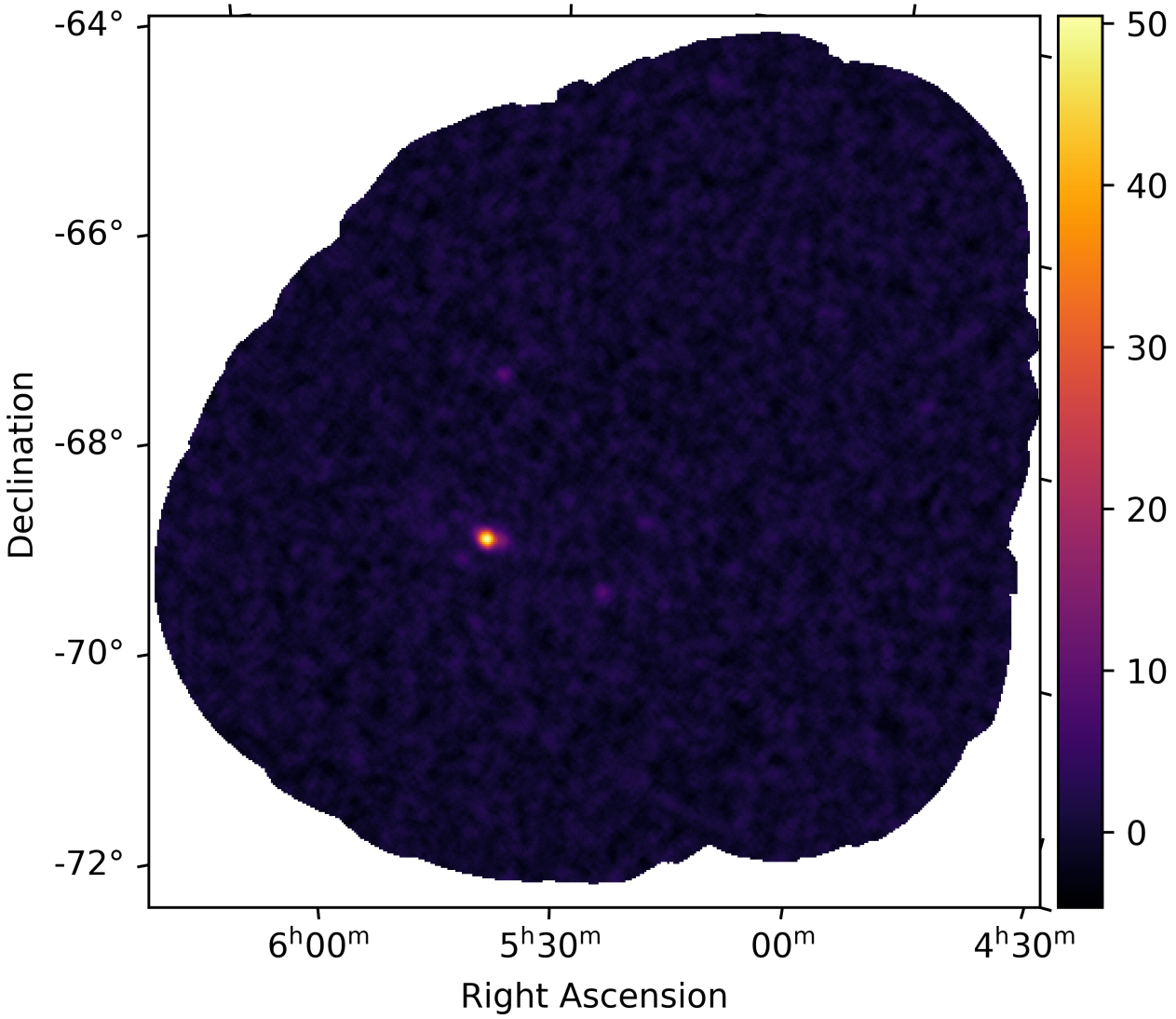
- Power Law
- Power Law with exponential cut-off
- Log Parabola

2) Spatial models tested:

- Point-Like
- Gaussian



Significance skymap of the LMC

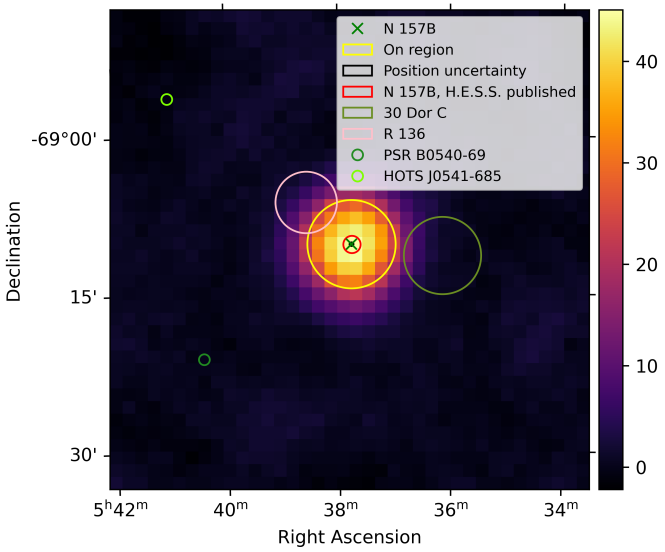


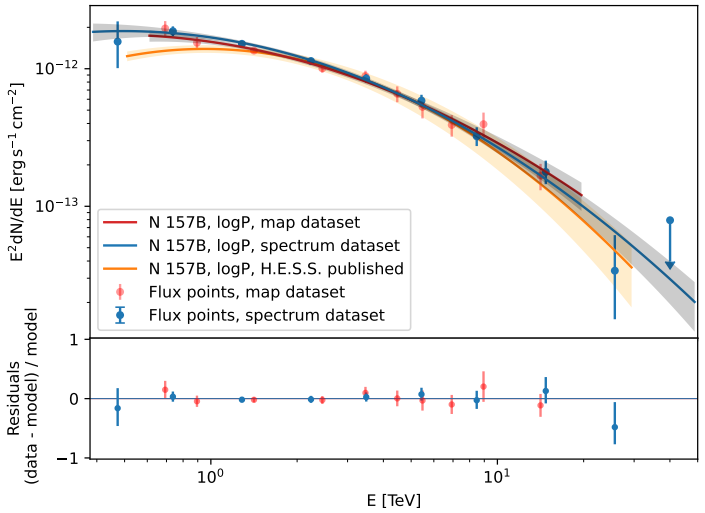
N 157B ⇒ a pulsar wind nebula

- H.E.S.S. Published, 2024
  - https://doi.org/10.3847/2041-8213/ad5e67
- $\approx$ 497 hr
- 51.6σ detection
- Point-like source with Log-Parabola spectrum
- $(2.14 \pm 0.06) \times 10^{-12}\ \mathrm{erg\ s^{-1} cm^{-2}}$

Parameter	Value	Error	Unit
Amplitude	1.05	0.04	$\times 10^{-12} \mathrm{TeV^{-1} s^{-1} cm^{-2}}$
α	2.31	0.09	
β	0.21	0.04	

- VHE emission
  - Associated Pulsar: PSR J0537−6910
    - Highest spin-down luminosity
    - $4.9 \times 10^{38}\ \mathrm{erg\ s^{-1}}$
    - $L/\dot{E} \rightarrow 0.13\%$



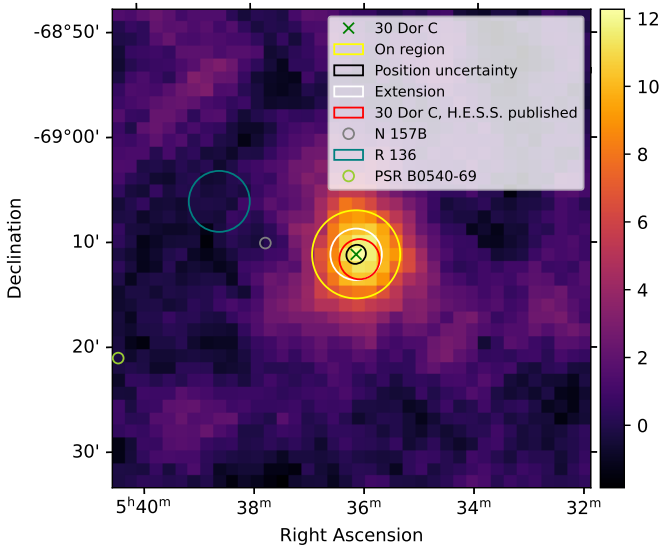


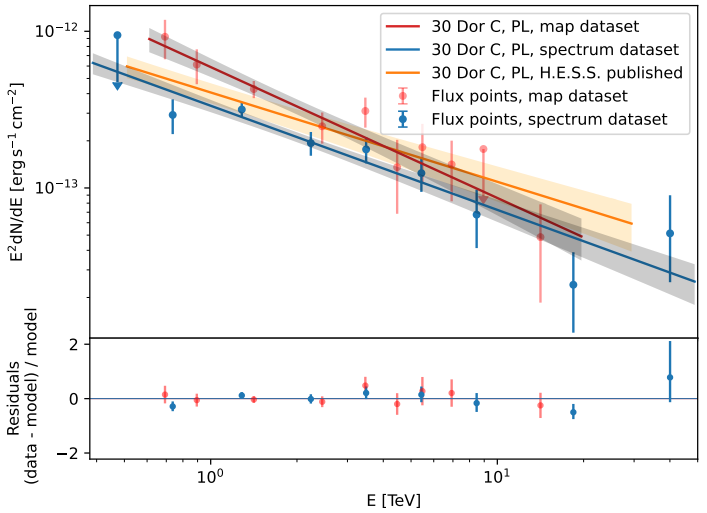
30 Dor C $\Rightarrow$ a superbubble

- H.E.S.S. Published, 2024
  - https://doi.org/10.3847/2041-8213/ad5e67
- $\approx$ 496 hr
- 13.6σ detection
- Gaussian source with Power Law spectrum
- $(4.0 \pm 0.3) \times 10^{-13}$ erg s^{-1}cm^{-2}

Parameter	Value	Error	Unit
Index	2.67	0.09	
Amplitude	2.1	0.2	$\times 10^{-13}$TeV^{-1}s^{-1}cm^{-2}

- Interaction between strong stellar winds and supernovae with the interstellar medium



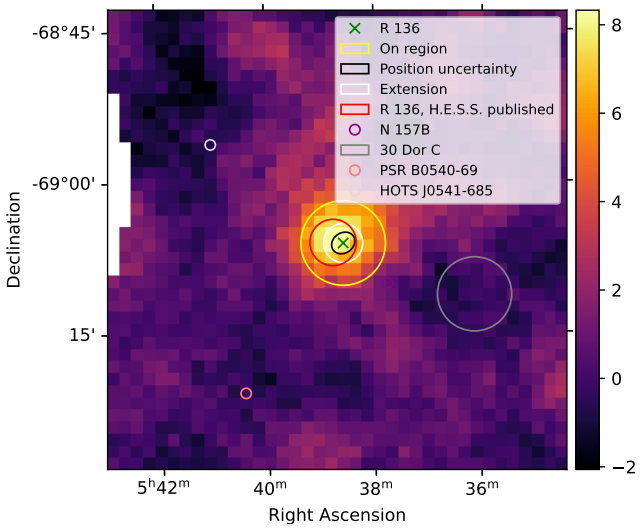


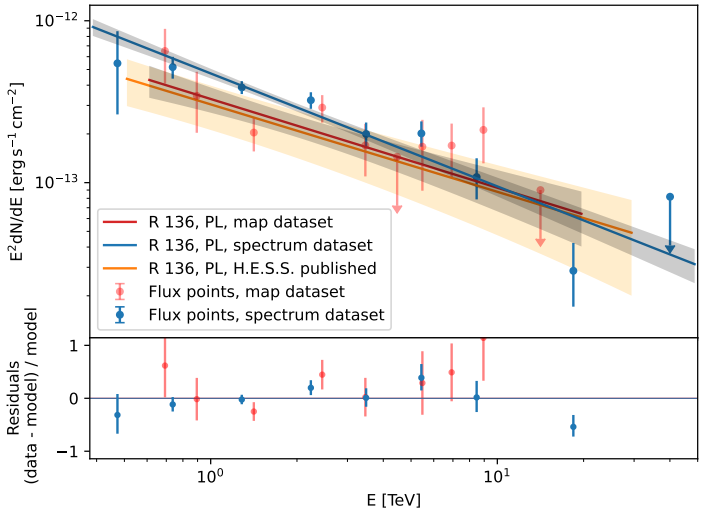
R 136 $\Rightarrow$ a young massive star cluster

- H.E.S.S. Published, 2024
  - https://doi.org/10.3847/2041-8213/ad5e67
- $\approx$ 496 hr
- 9.6σ detection
- Gaussian with Power Law
- $(5.5 \pm 0.3) \times 10^{-13}$ erg s^{-1}cm^{-2}

Parameter	Value	Error	Unit
Index	2.71	0.07	
Amplitude	3.1	0.2	$\times 10^{-13}$TeV^{-1}s^{-1}cm^{-2}

- VHE emmsion
  - Stellar winds interacting with the interstellar medium



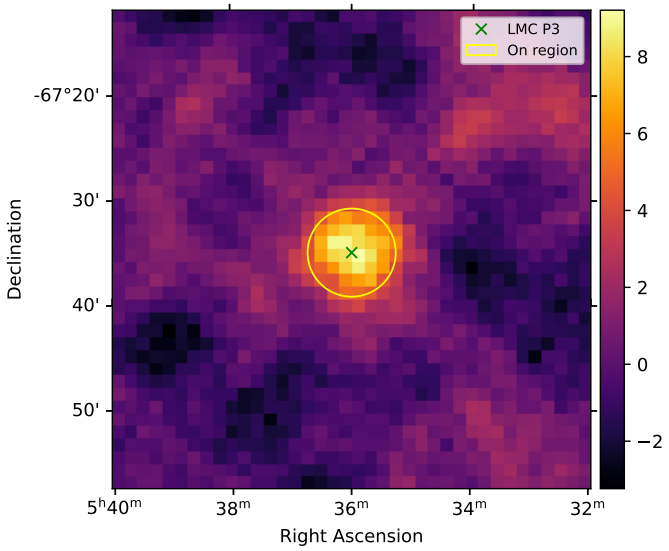


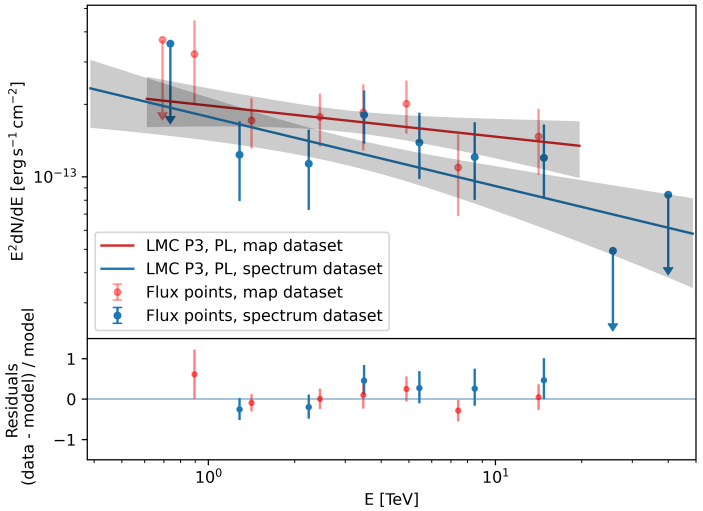
LMC P3 $\Rightarrow$ a gamma-ray binary

- H.E.S.S. Published, 2018
  - https://doi.org/10.1051/0004-6361/201732426
- $\approx$ 515 hr
- 12.6σ detection
- Point-like with Power Law
- Position frozen to O5 III(F) star
- $(3.0 \pm 0.4) \times 10^{-13}$ erg s^{-1}cm^{-2}

Parameter	Value	Error	Unit
Index	2.3	0.1	
Amplitude	1.1	0.2	$\times 10^{-14}$TeV^{-1}s^{-1}cm^{-2}

- Periodicity (not shown here) identifies it as a γ-ray binary.
- Emission could be either:
  - Wind-driven
  - Accretion driven



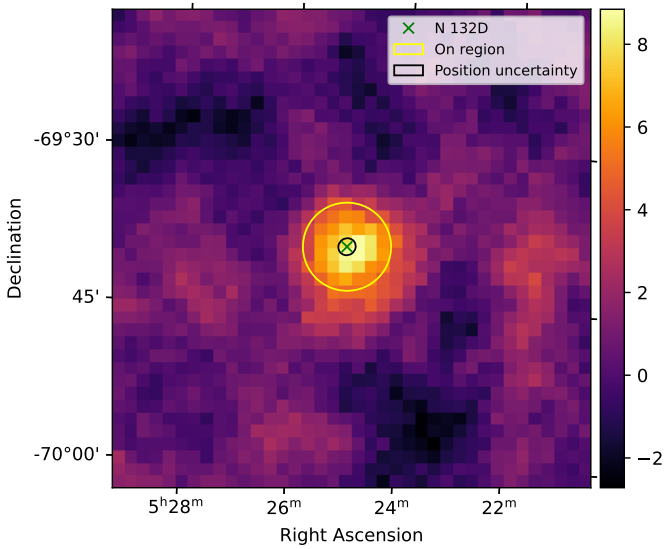


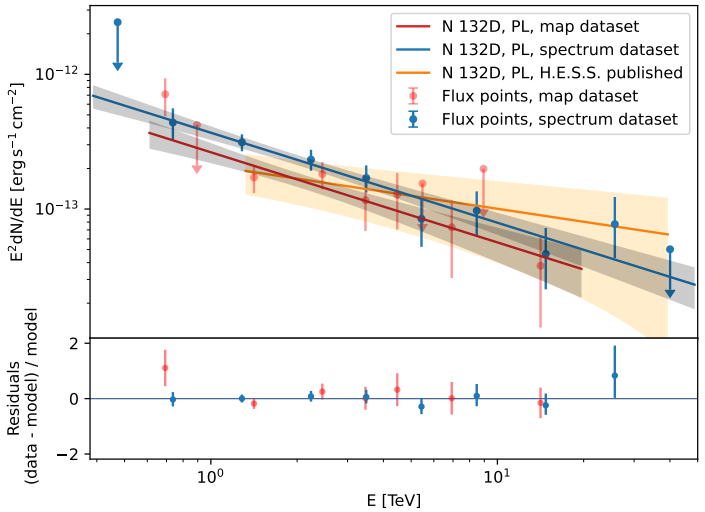
N 132D ⇒ a supernova remnant

- H.E.S.S. Published, 2021
  - https://doi.org/10.1051/0004-6361/202141486
- $\approx$ 530 hr
- 9.1σ detection
- Point-like with Power Law
- $(4.3 \pm 0.4) \times 10^{-13}$ erg s^{-1}cm^{-2}

Parameter	Value	Error	Unit
Index	2.7	0.1	
Amplitude	2.3	0.3	$\times 10^{-13}$TeV^{-1}s^{-1}cm^{-2}

- Brightest SNR in X-rays in LMC
- Two possible mechanisms for VHE emission:
  - Acceleration at the shock front
  - Interaction between SNR and nearby molecular cloud



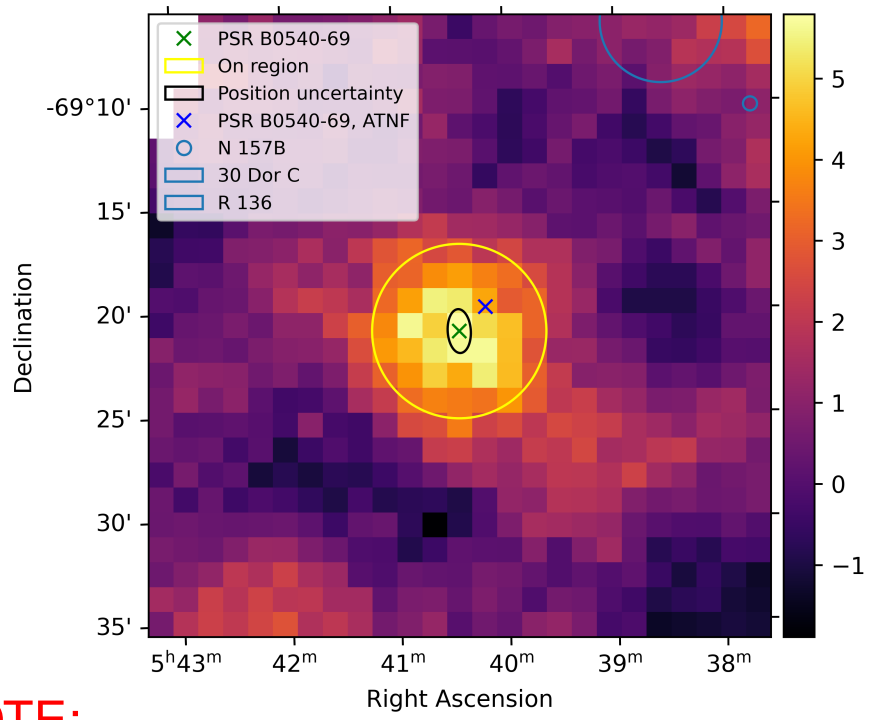


Potential new source: PSR B0540−69 (HESS J0540−692)

- Basic information:
  - Coincides with PSR B0540−69
  - A 50ms pulsar
  - Previously detected by *Fermi*−LAT
- $\approx$ 489 hr
- Hint for emission:
  - Near-threshold excess
- $(2.2 \pm 0.3) \times 10^{-13}\ \mathrm{erg\ s^{-1} cm^{-2}}$

Possible emission sources:

- The Pulsar itself
  - Similar to Fermi
- Supernova Remnant
  - Unlikely, due to only thermal X-rays
- Pulsar Wind Nebula
  - 3rd highest spin-down luminosity
  - $1.5 \times 10^{38}\ \mathrm{erg\ s^{-1}}$
  - $L/\dot{E} \rightarrow 0.044\%$



NOTE:

- Upper limit for extension still under investigation
- Periodicity not investigated

Conclusions

Results

- Completed the first survey of another galaxy in the TeV range
- 5 known sources + 1 potential source
- 5 source types
  - PWN
  - Superbubble
  - YMSC
  - SNR
  - γ-ray binary

Key points:

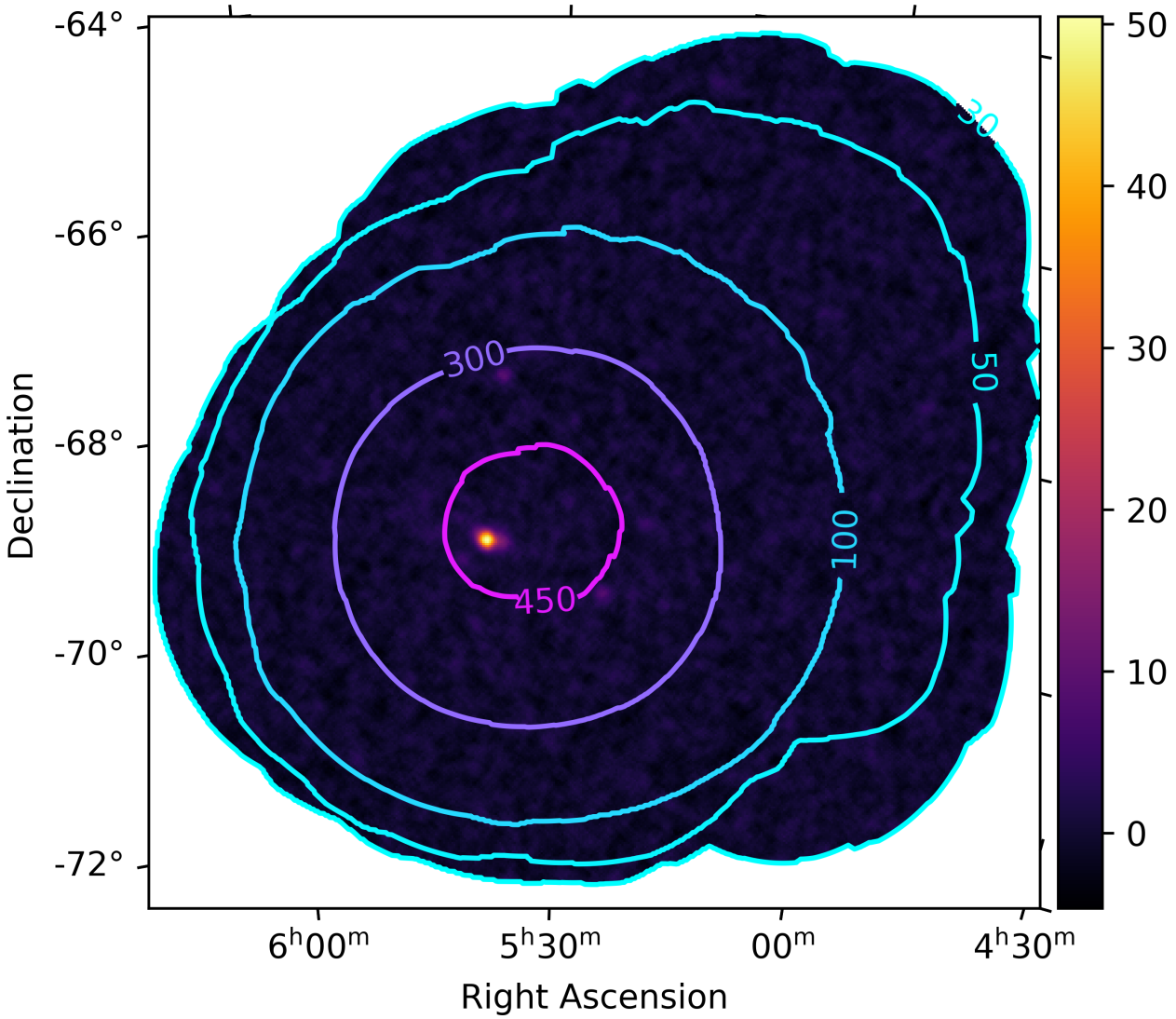
- Completed the survey of LMC in TeV
- Potential detection of PSR B0540−69

Next steps

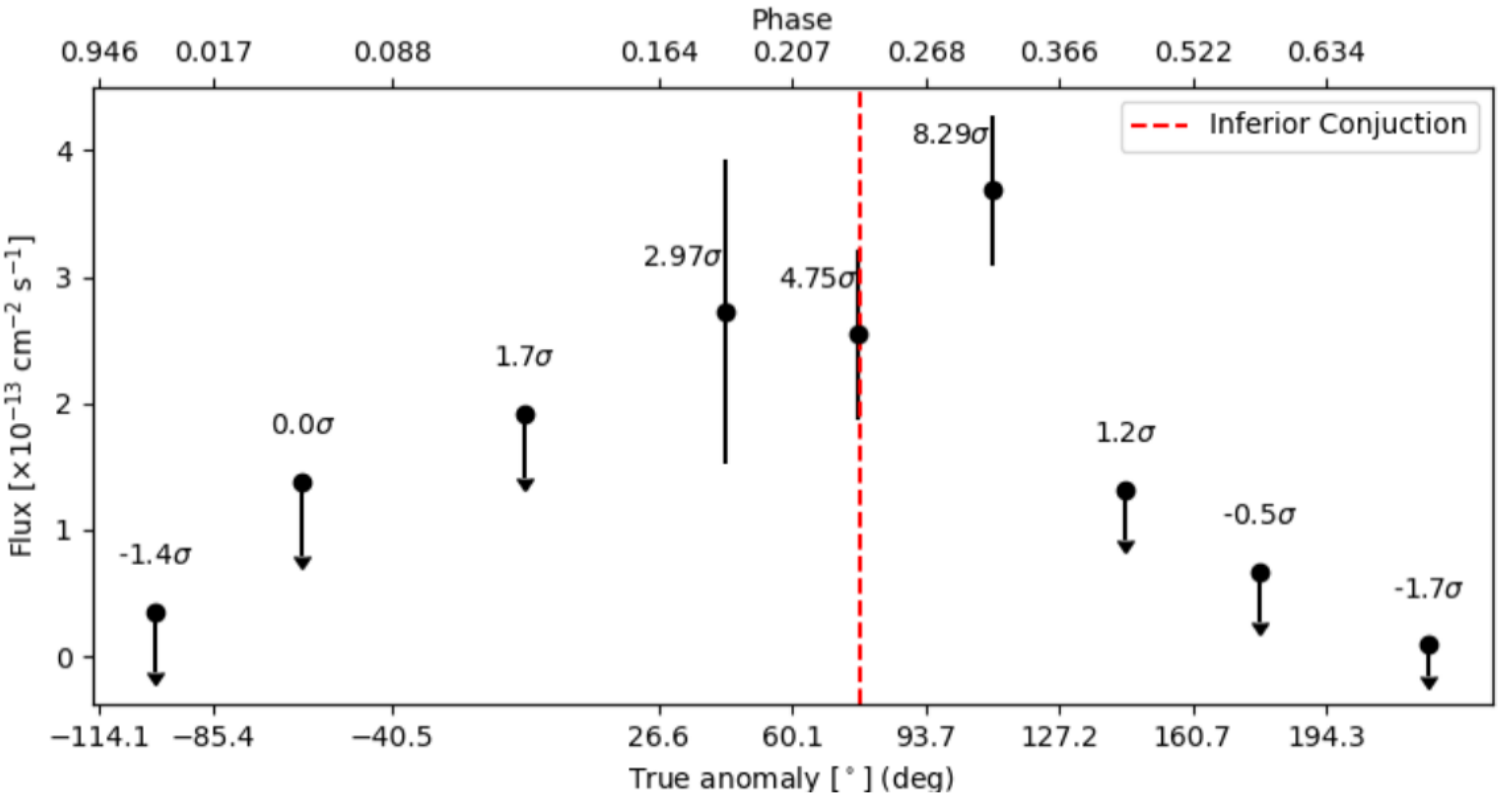
- Investigate pulsation from PSR B0540−69
  - Difficult due to ephemerides only being valid for a part of the dataset
- Remove sources and search for VHE diffuse emissions
  - This will need a new hadronic background model

Backup slides

Exposure time contours over H.E.S.S. skymap



LMC P3's periodogram, by L.Fisher & N.Komin



Presented by L.Fisher at ICRC 2023:
https://doi.org/10.22323/1.444.0906