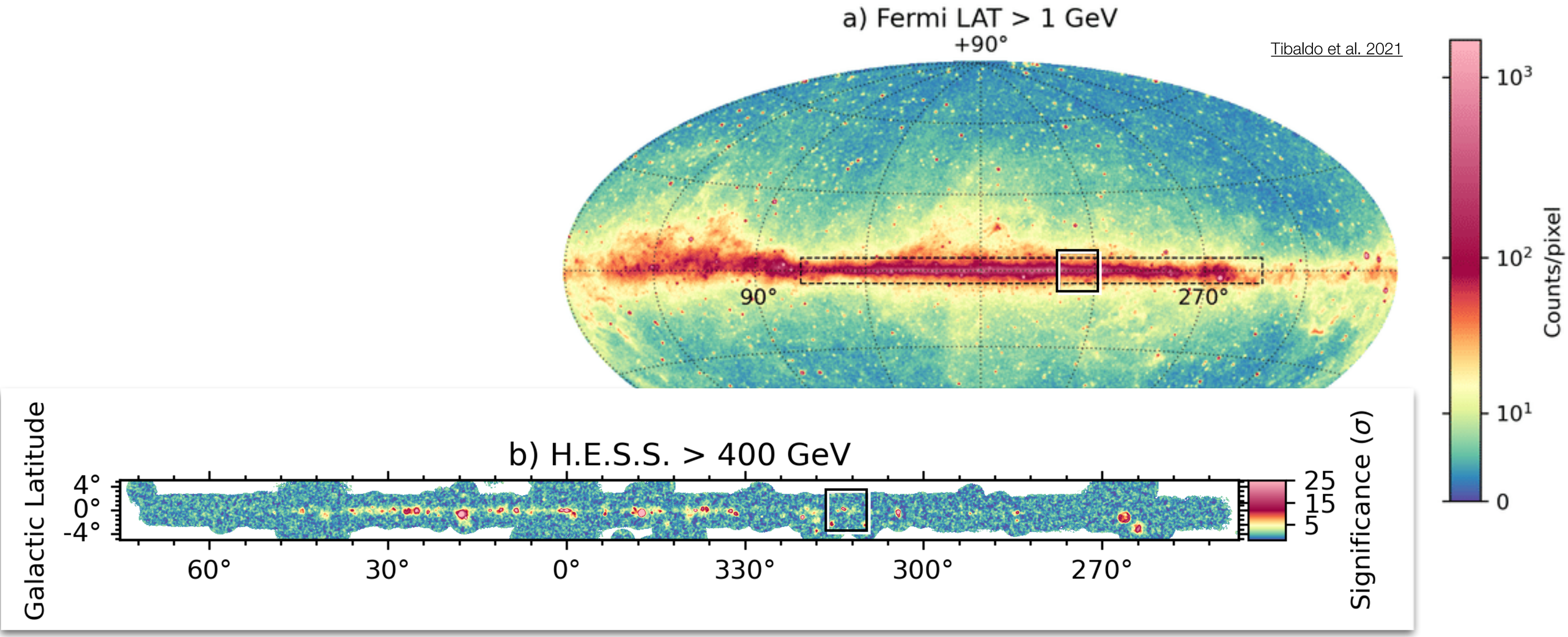
Study of the region in the vicinity of SNR G312.4-0.4 with H.E.S.S. and Fermi-LAT

Armelle Jardin-Blicq
Pauline Chambéry
Marianne Lemoine-Goumard
Vincent Marandon
Atreyee Sinha
Michelle Tsirou
Yves Gallant
Jordan Eagle

Overview of the region of interest



a) Fermi-LAT, 12 years of P8R3 data > 1 GeV, Source/PSF3 event class/type, zenith angles <100°, smoothed with a Gaussian kernel of σ = 0.25°. From Tibaldo et al. 2021.
b) H.E.S.S. Galactic Plane Survey, correlation radius 0.2°.

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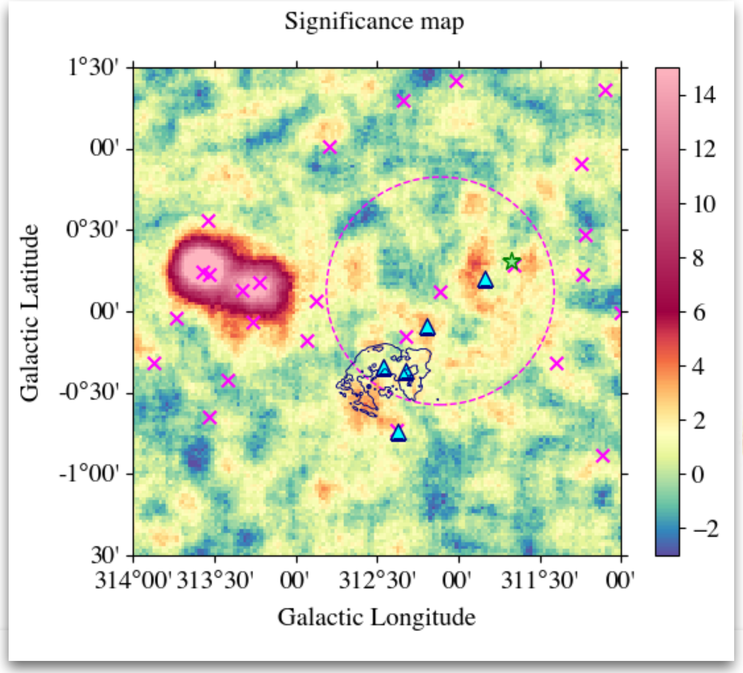
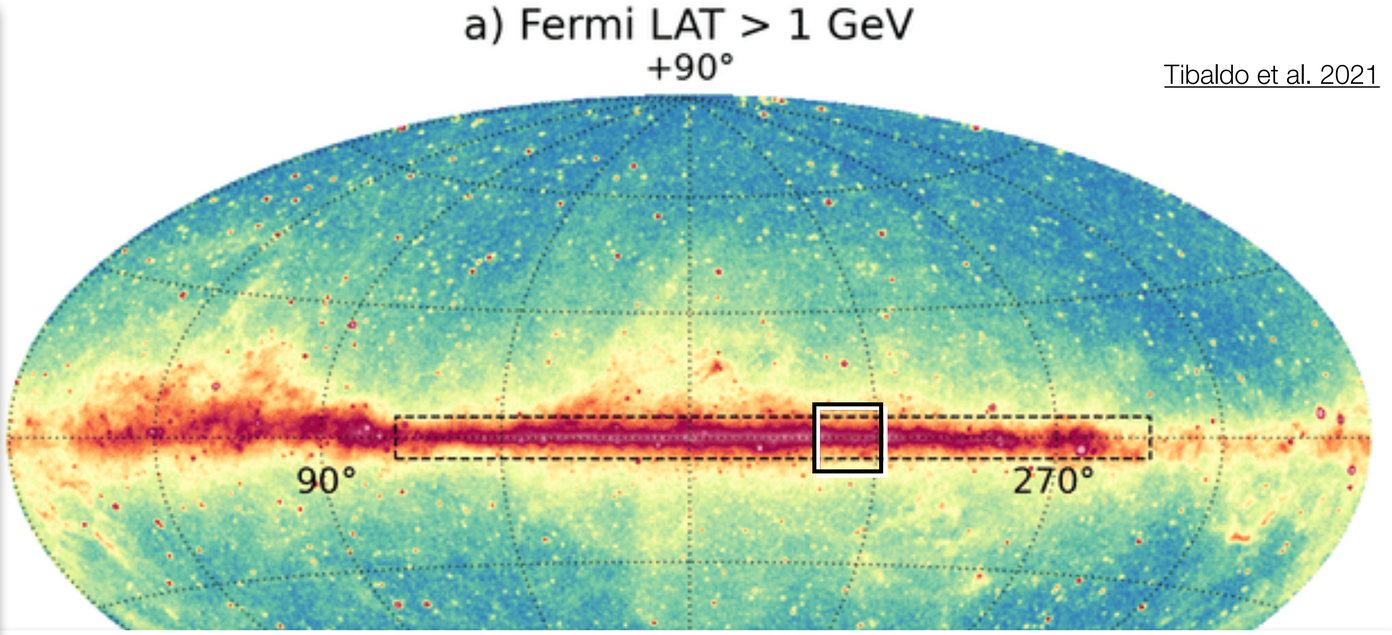
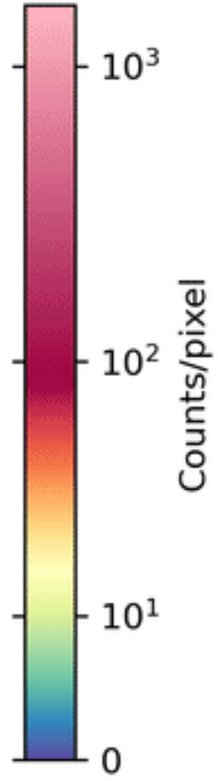
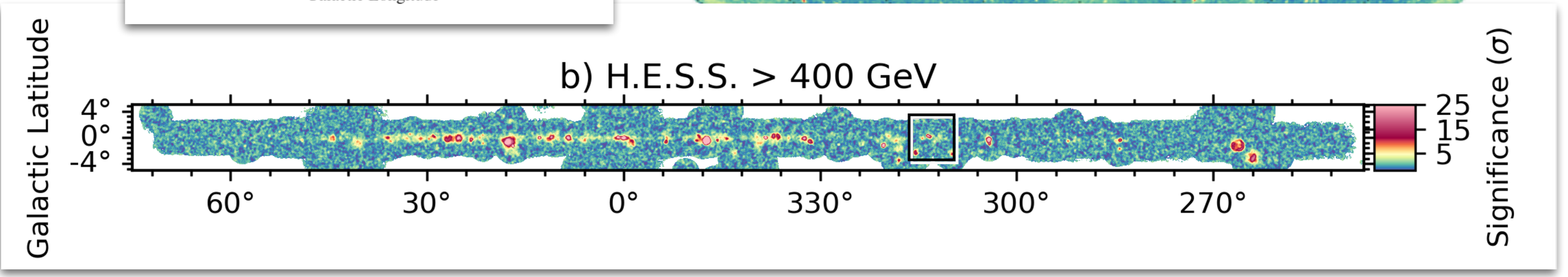




Tibaldo et al. 2021





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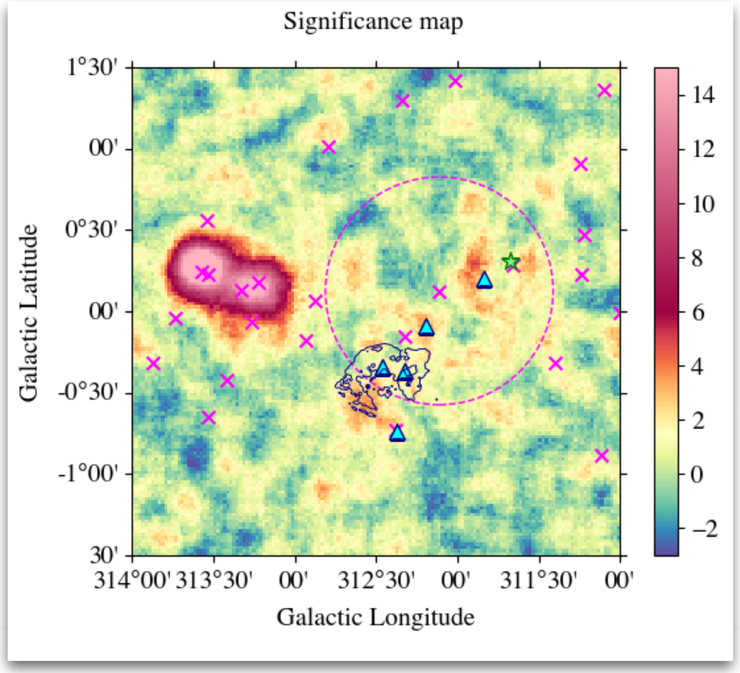

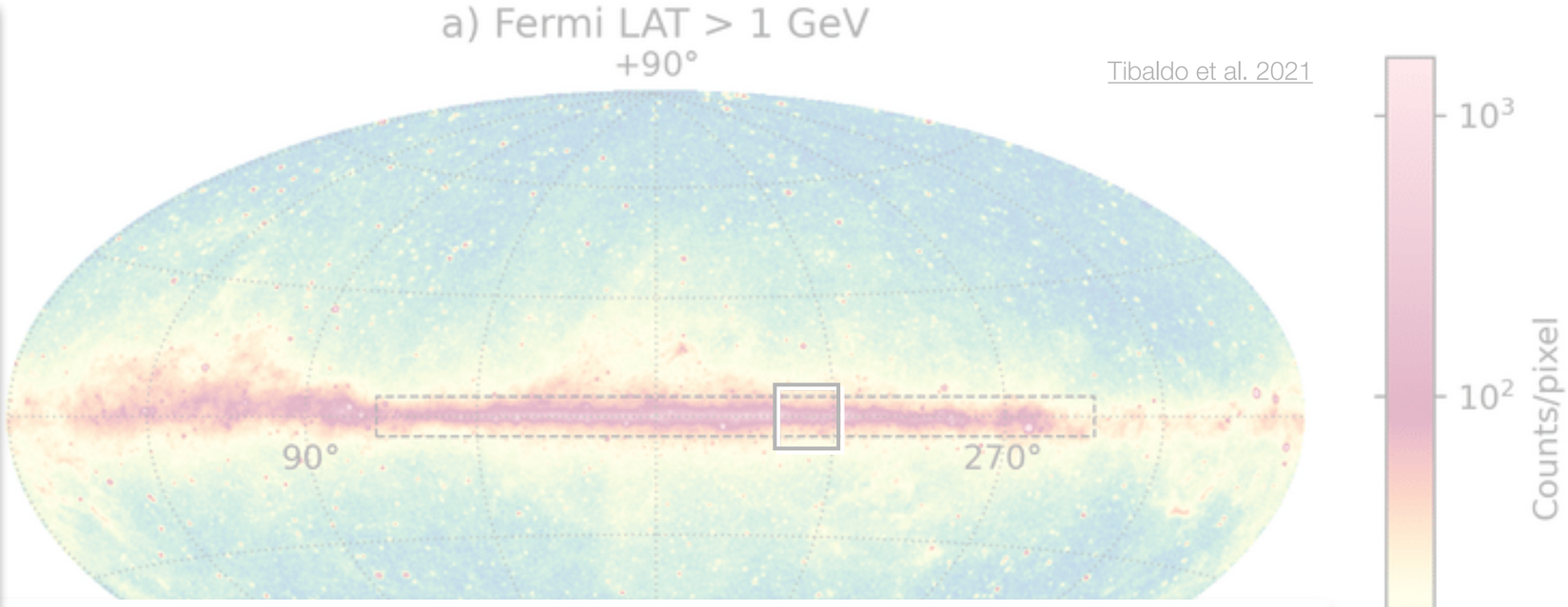

- 5 powerful pulsars (E > 10^{35} erg s^{-1}) ▲
- SNR G312.4-0.4
- 4FGL (DR3) Fermi sources ×
- Binary 4FGL J1405.1–6119 ★
- H.E.S.S. sources (kookaburra)

PSR	τ_c (kyr)	dist. (kpc)	$\dot{E}$ (erg s^{-1})
J1406-6121	61.7	7.3	2.2×10^{35}
J1410-6132	24.8	13.5	1×10^{37}
J1412-6145	50.4	7.1	1.2×10^{35}
J1413-6141	13.6	8.5	5.6×10^{35}
J1413-6205	62.8	2.1	8.3×10^{35}

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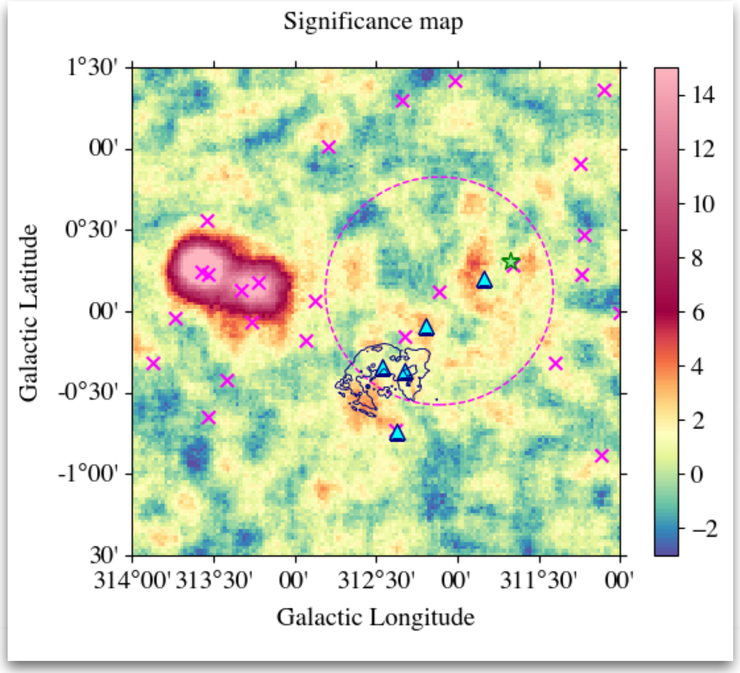

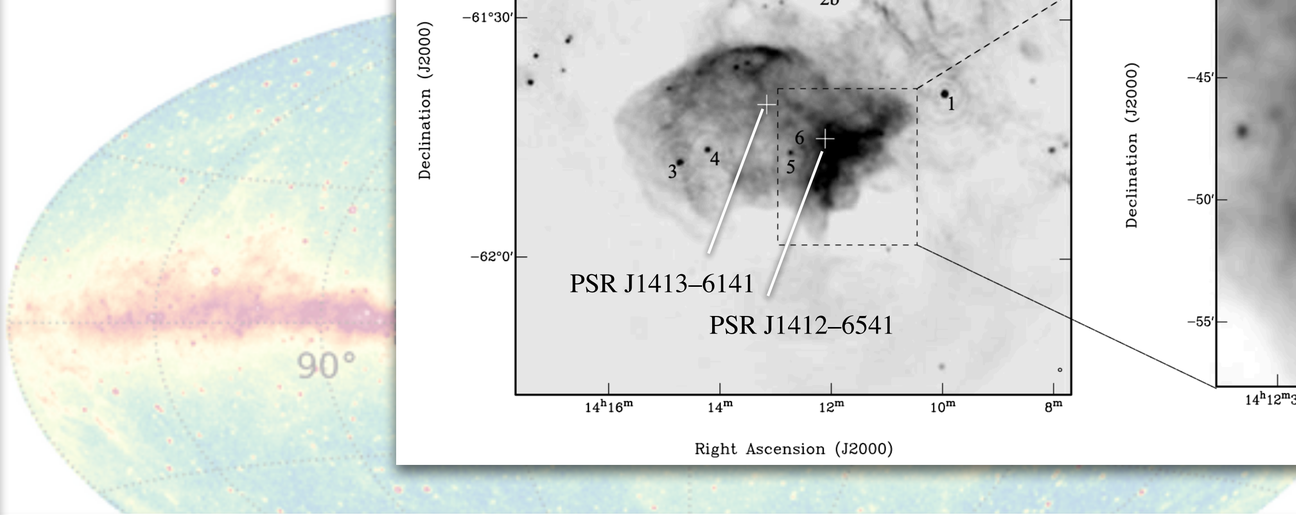

- Discovered by MOST at 408 MHz - Incomplete shell, 38’ diameter
- Northern rim and Western region have different spectral indices : -0.7 vs -0.19
  Western region more typical of PWN
- Distance and age very uncertain : 3.1 < d < 6 kpc
- Does not seem to be associated with PSR J1413-6141 or PSR J1412-6541

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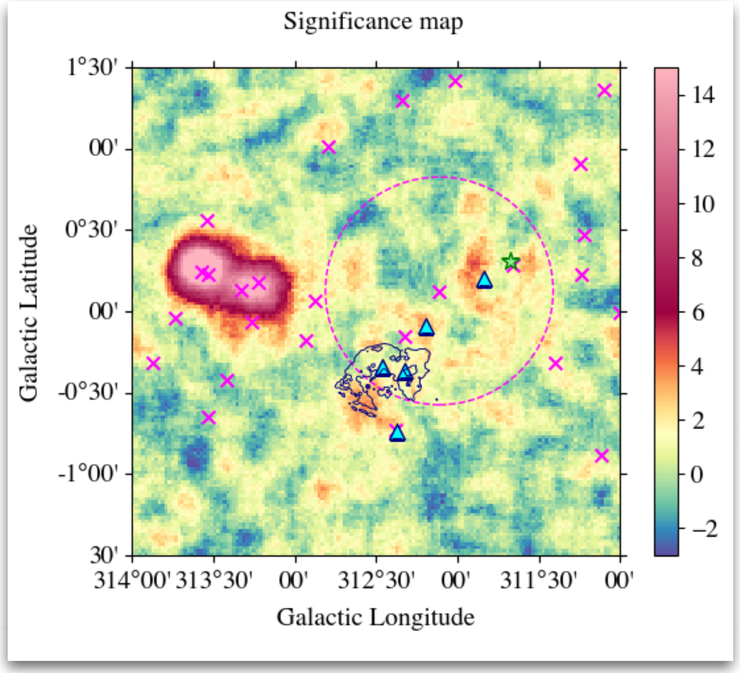

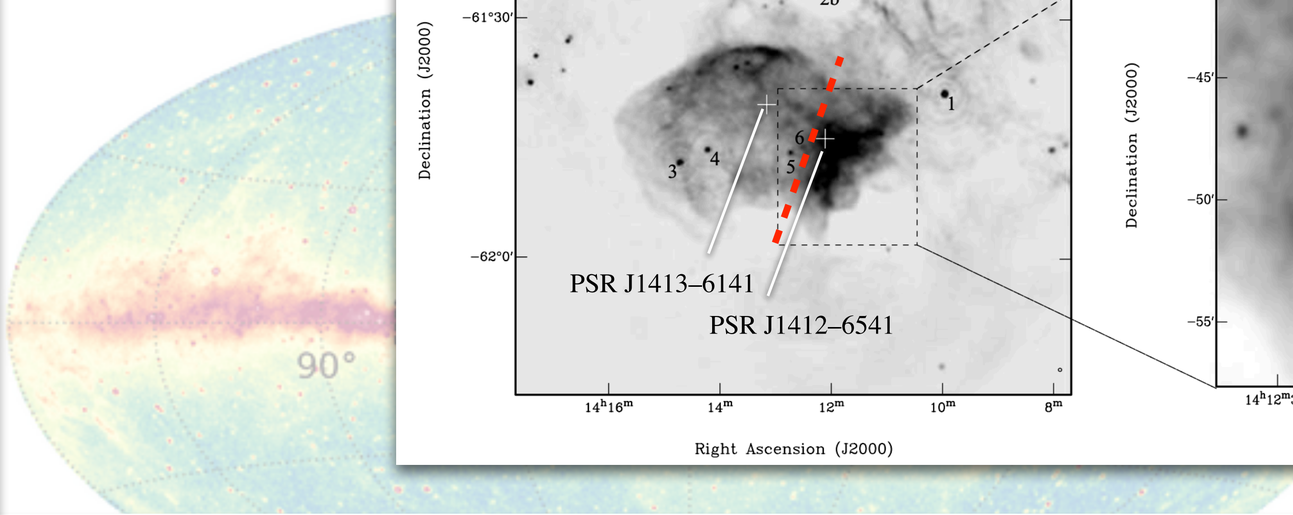

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Fermi analysis

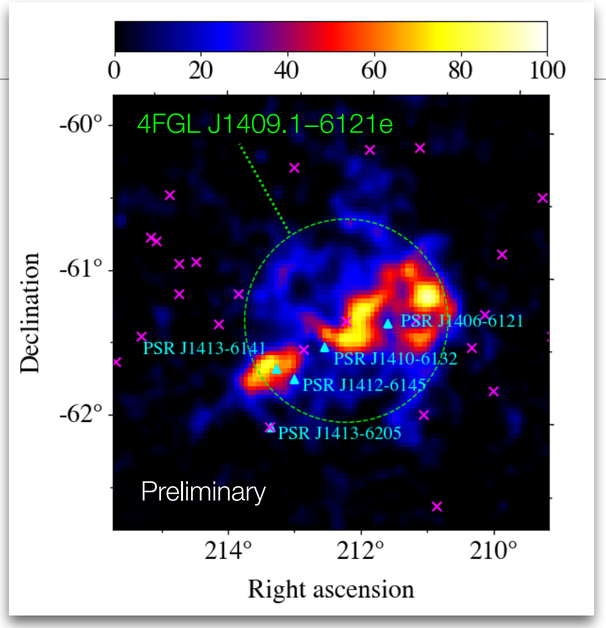
Data selection
- 14 years of pass 8 data
- IRF : P8R3_SOURCE_V3 with associated galactic and isotropic diffuse templates

Morphology
- 9 x 9° region, 0.03° bin size
- 10 GeV – 3 TeV (to avoid contamination from PSR J1413-6205 and PSR J1410-6132)

Spectra
- 15 x 15° region
- 300 MeV – 3 TeV
- 10 energy bins per decade

Analysis performed with fermipy,
Compatible cross-check with gammapy

Fermi-LAT TS map > 10 GeV



Subtracting all Fermi sources (4FGL-DR3))
(including 4FGL J1409.1–6121e)

4FGL J1409.1–6121e
uniform disk model
r = 0.73° ± 0.02° ± 0.06°

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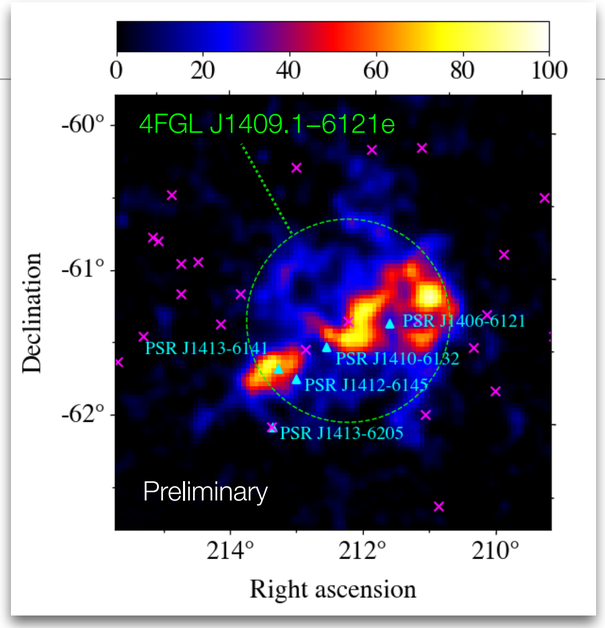

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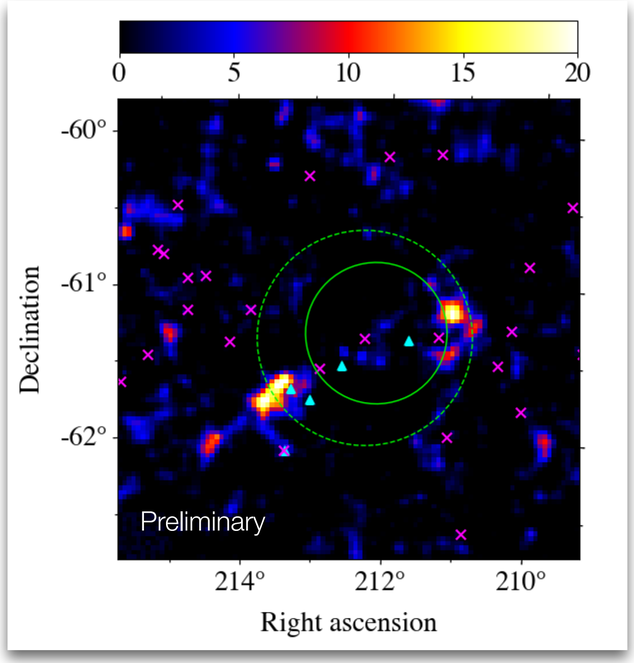
4FGL J1409.1−6121e
gaussian model
σ = 0.46°



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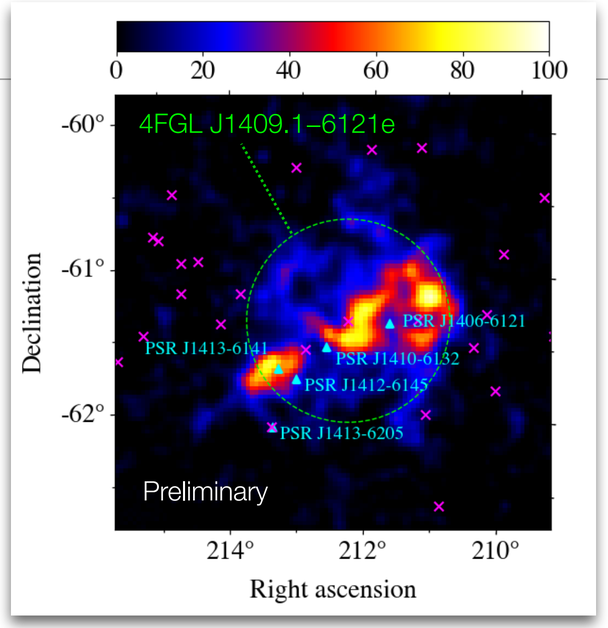

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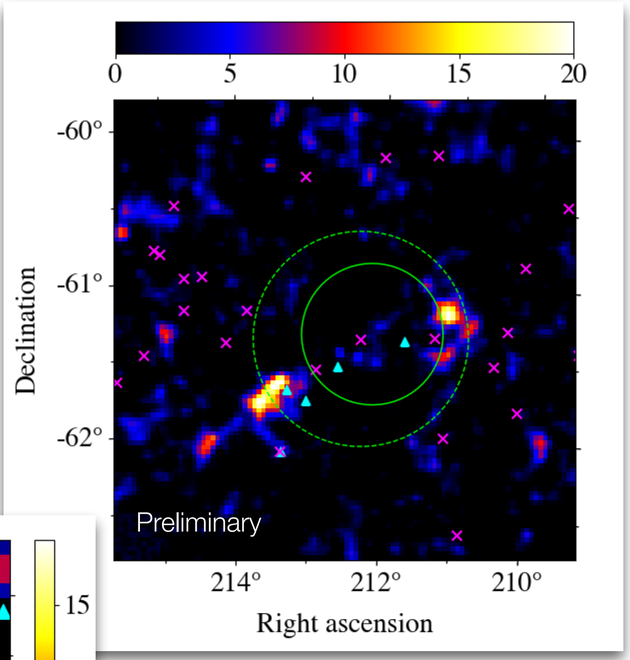
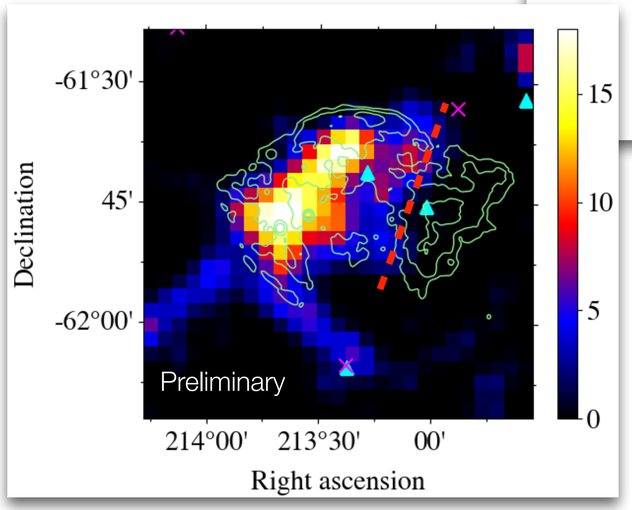


Subtracting 4FGL J1409.1−6121e

SNR G312.4−0.4
MOST template (cut)



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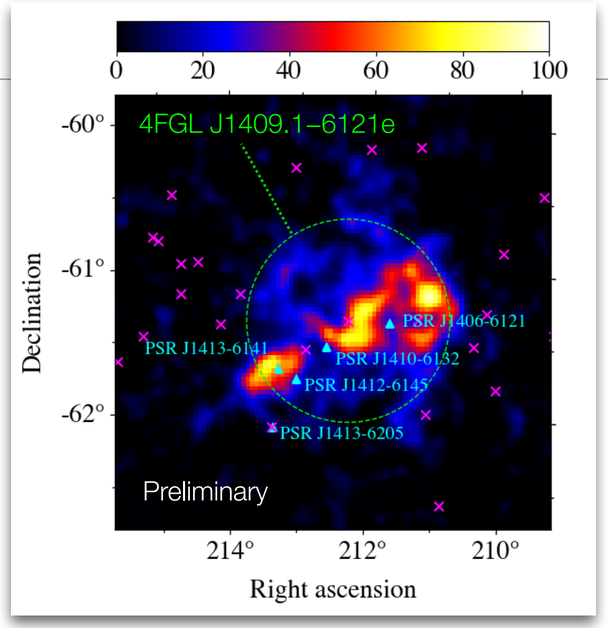

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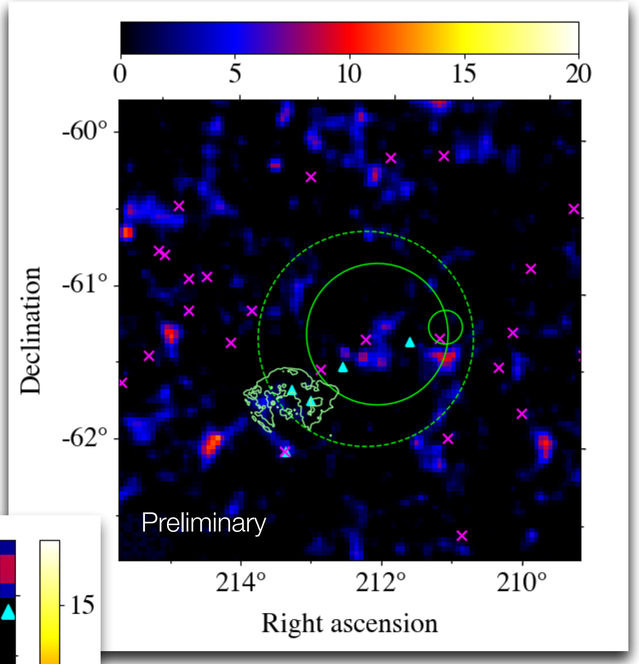

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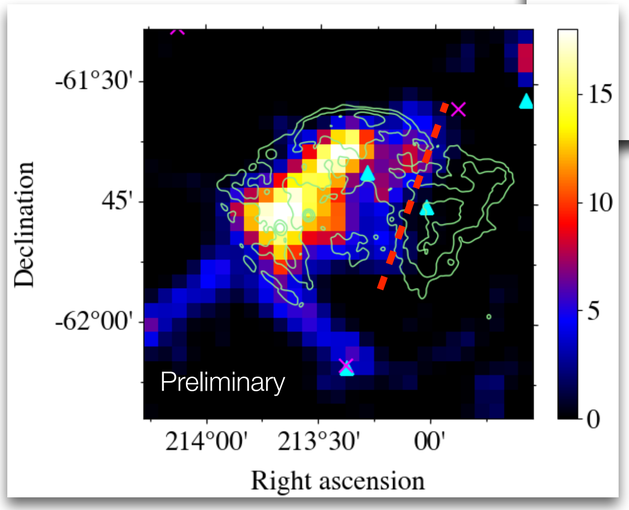
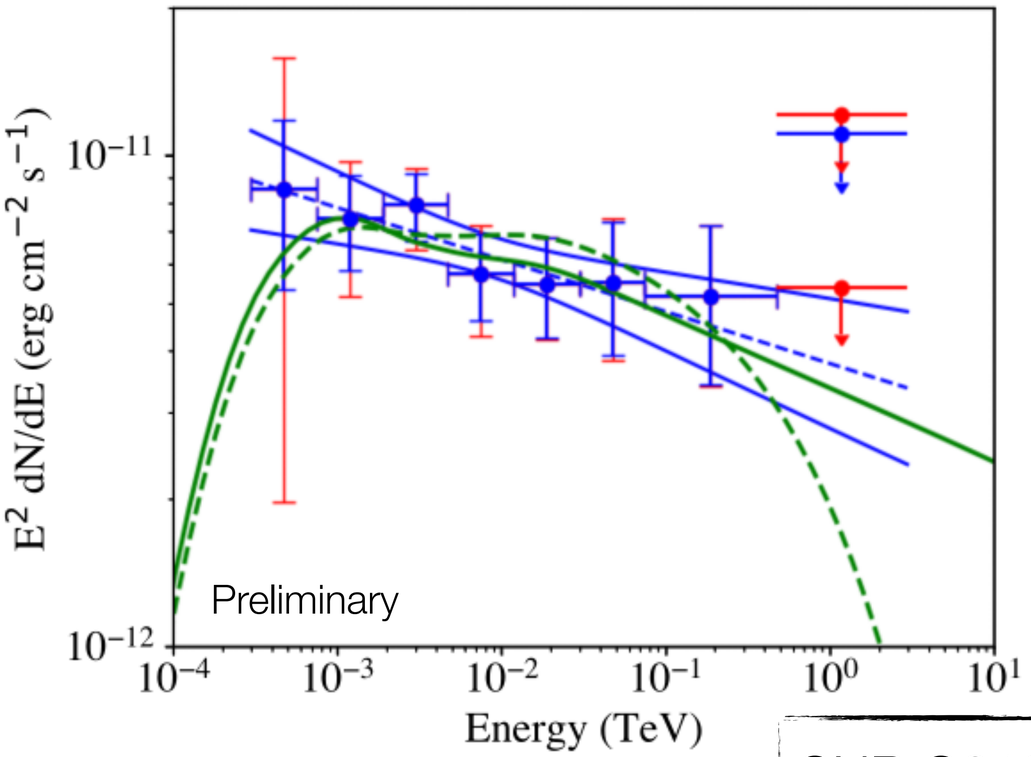


Subtracting 4FGL J1409.1−6121e (gaussian), SNR G312.4−0.4 (MOST template) and an additional small Gaussian

Additional gaussian
σ = 0.11°

Fermi analysis

Parent population spectrum : protons



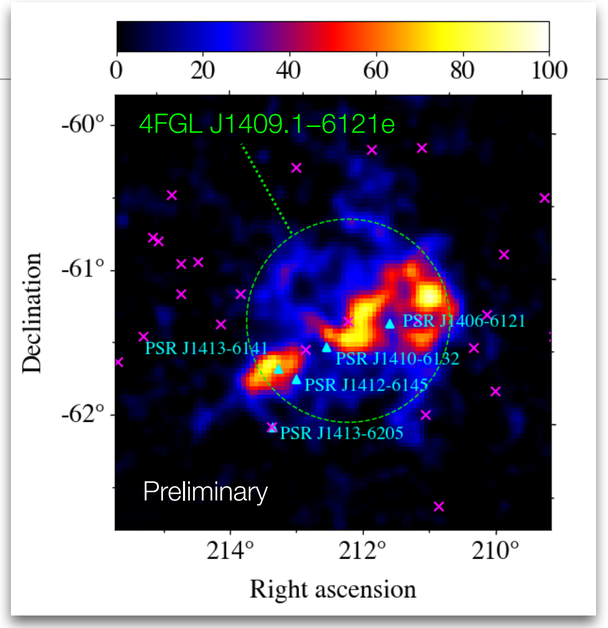
Data points with stat. error

Stat. and syst. error in quadrature

pure power law $\Gamma = 2.2$

power law $\Gamma = 2.1$ with exp. cut-off at 10 TeV

Fermi-LAT TS map > 10 GeV



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4FGL J1409.1−6121e
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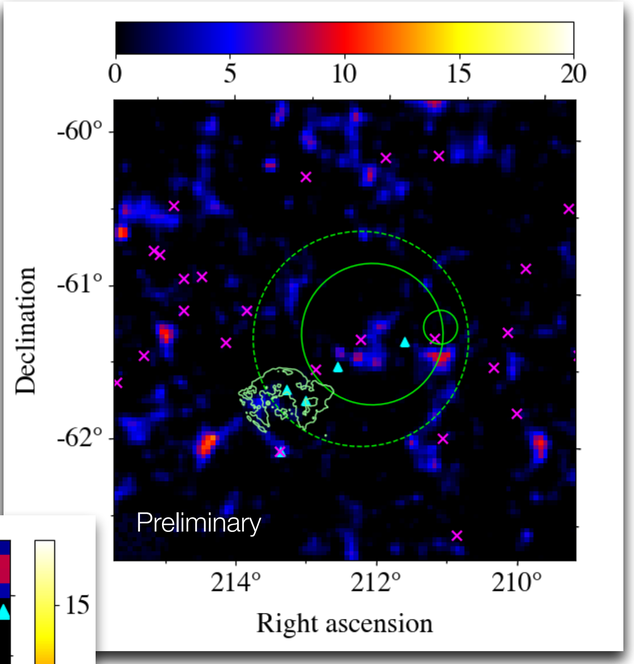

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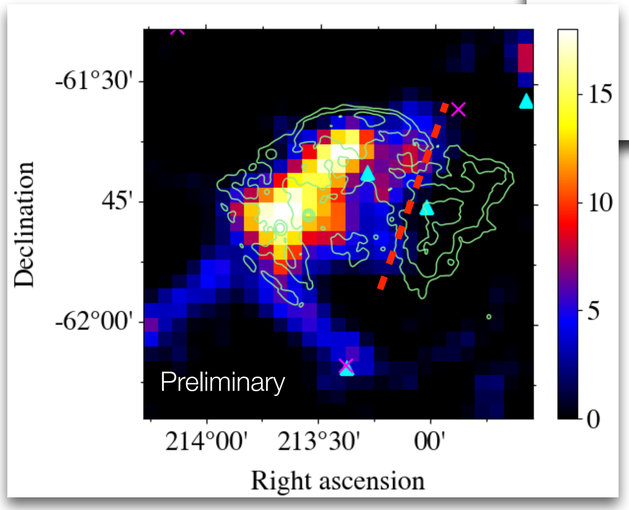

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Additional gaussian
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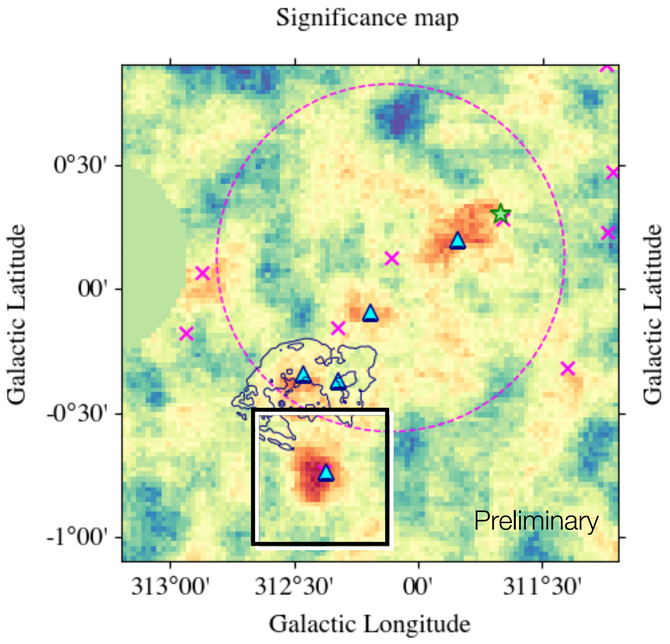
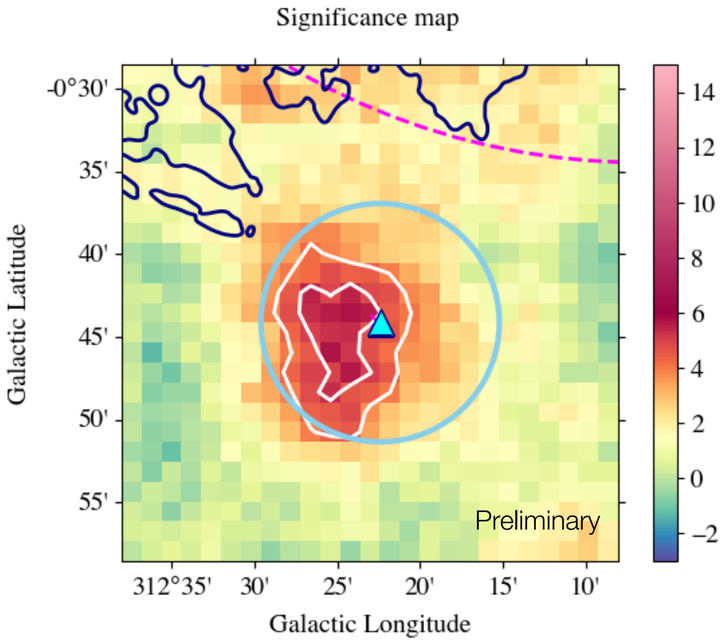
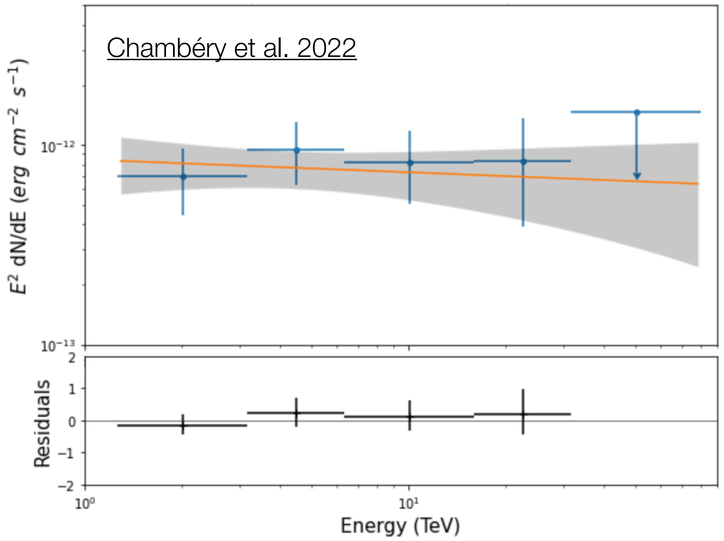
H.E.S.S. analysis

- Analysis > 1.3 TeV
- Reconstruction optimised at the highest energies, 3D Field of View likelihood analysis with gammapy
- Best model contains several extended sources, hadronic background and diffuse emission model







Preliminary spatial parameters	
Pulsar position (l°, b°)	(312.37, -0.74)
Disk radius (°)	$0.12 \pm 0.01_{stat}$
Preliminary spectral parameters	
Index Γ	$2.06 \pm 0.20_{stat}$
Norm ($TeV^{-1}\ cm^{-2}\ s^{-1}$)	$(2.47 \pm 0.52_{stat})\ 10^{-14}$
Pivot Energy (TeV)	4.41

Compatible with a PWN scenario

H.E.S.S. analysis

SNR G312.4–0.4
not detected

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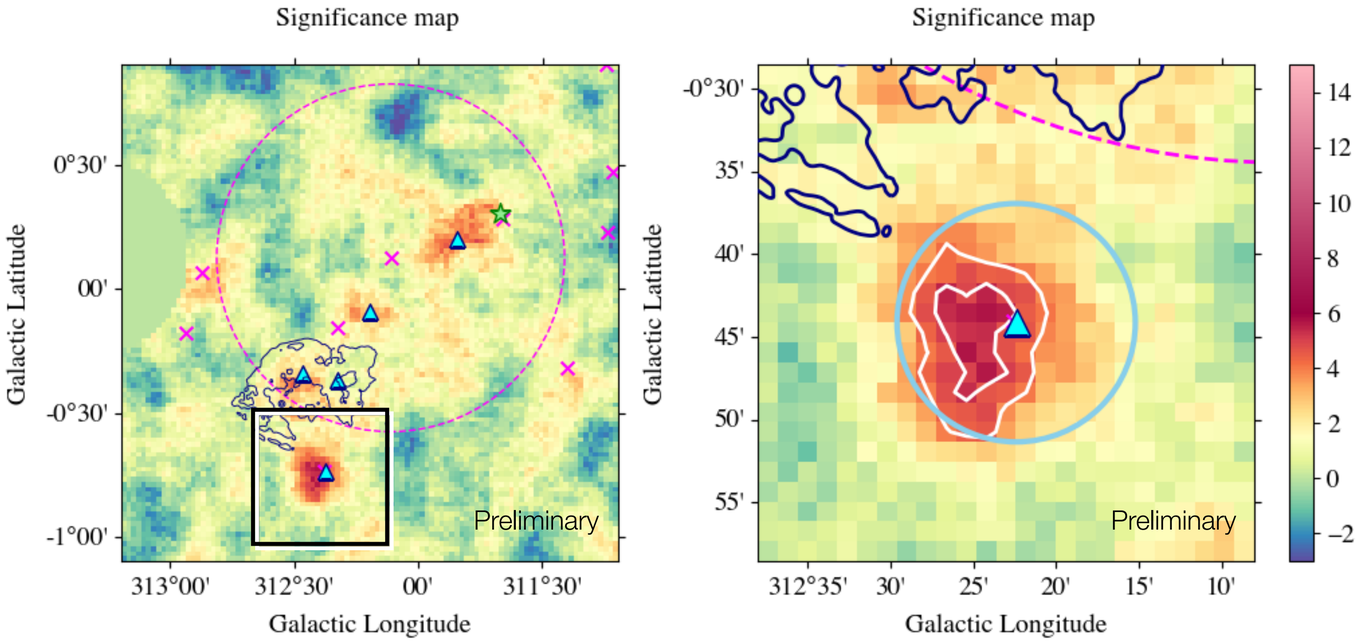
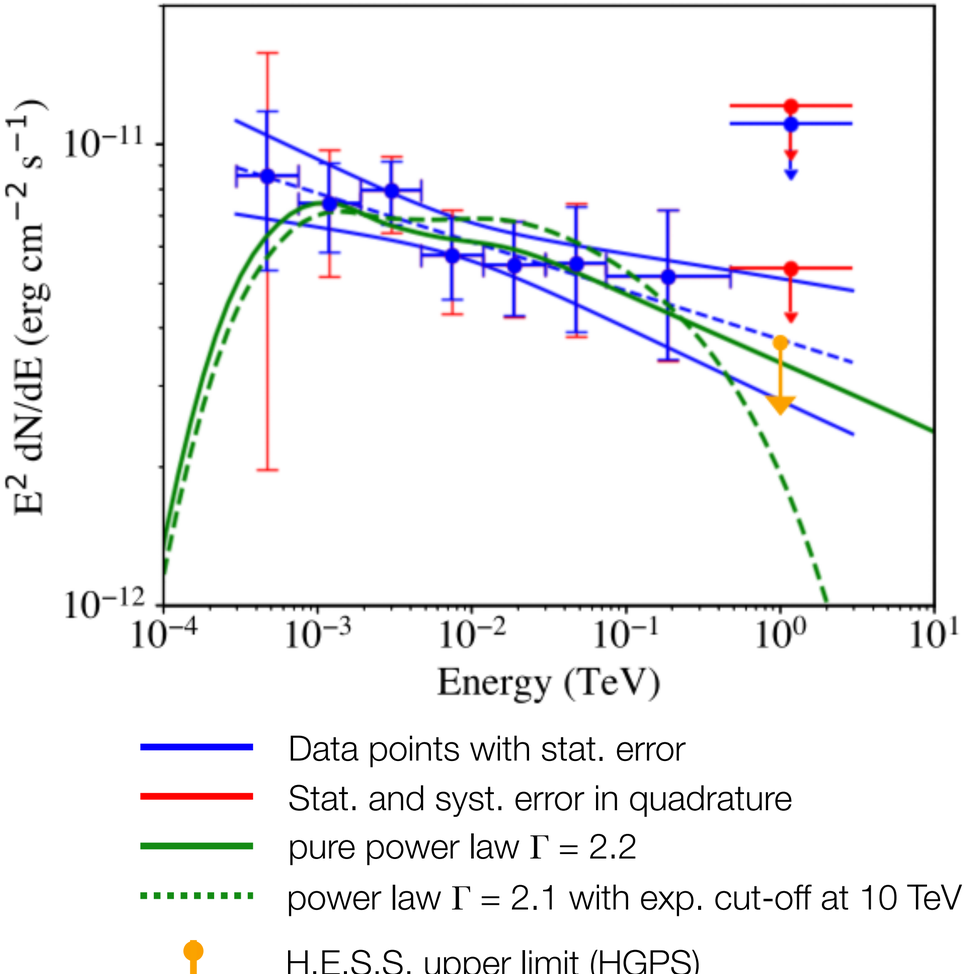
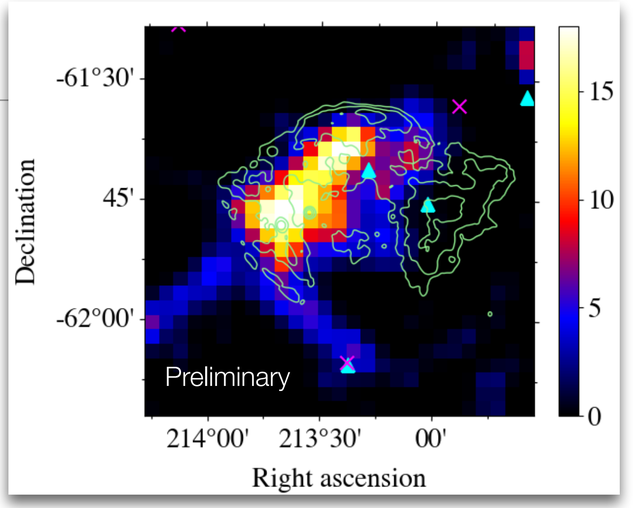




Conclusions

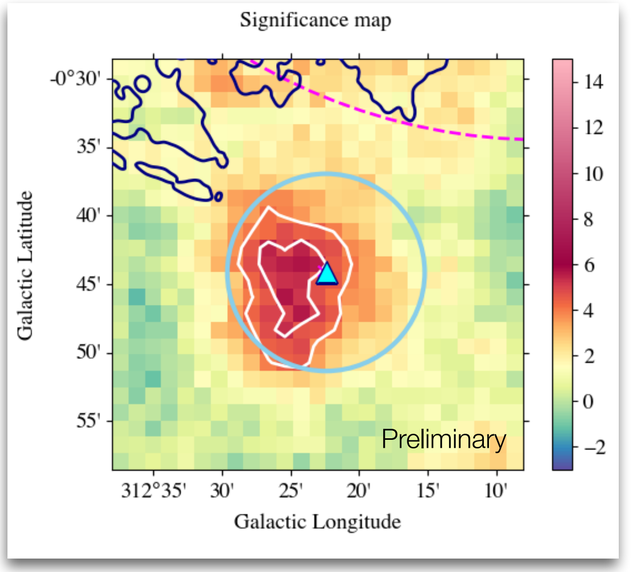
SNR G312.4-0.4

- Newly detected by Fermi LAT
- Not detected by H.E.S.S.
- Parent population well modelled by a single population of protons
- Possible interaction with a dense molecular cloud (3.7 kpc)



PSR J1413-6205

- Extended source (r = 0.12°) newly detected by H.E.S.S.
- Gamma-ray emission compatible with a PWN scenario
- Hard spectrum (flat spectrum with $\Gamma \sim 2$)



Perspectives

- Add new H.E.S.S. data !
- Characterise the emission around PSR J1406-6121 and the binary 4FGL J1405.1–6119

The end.

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