

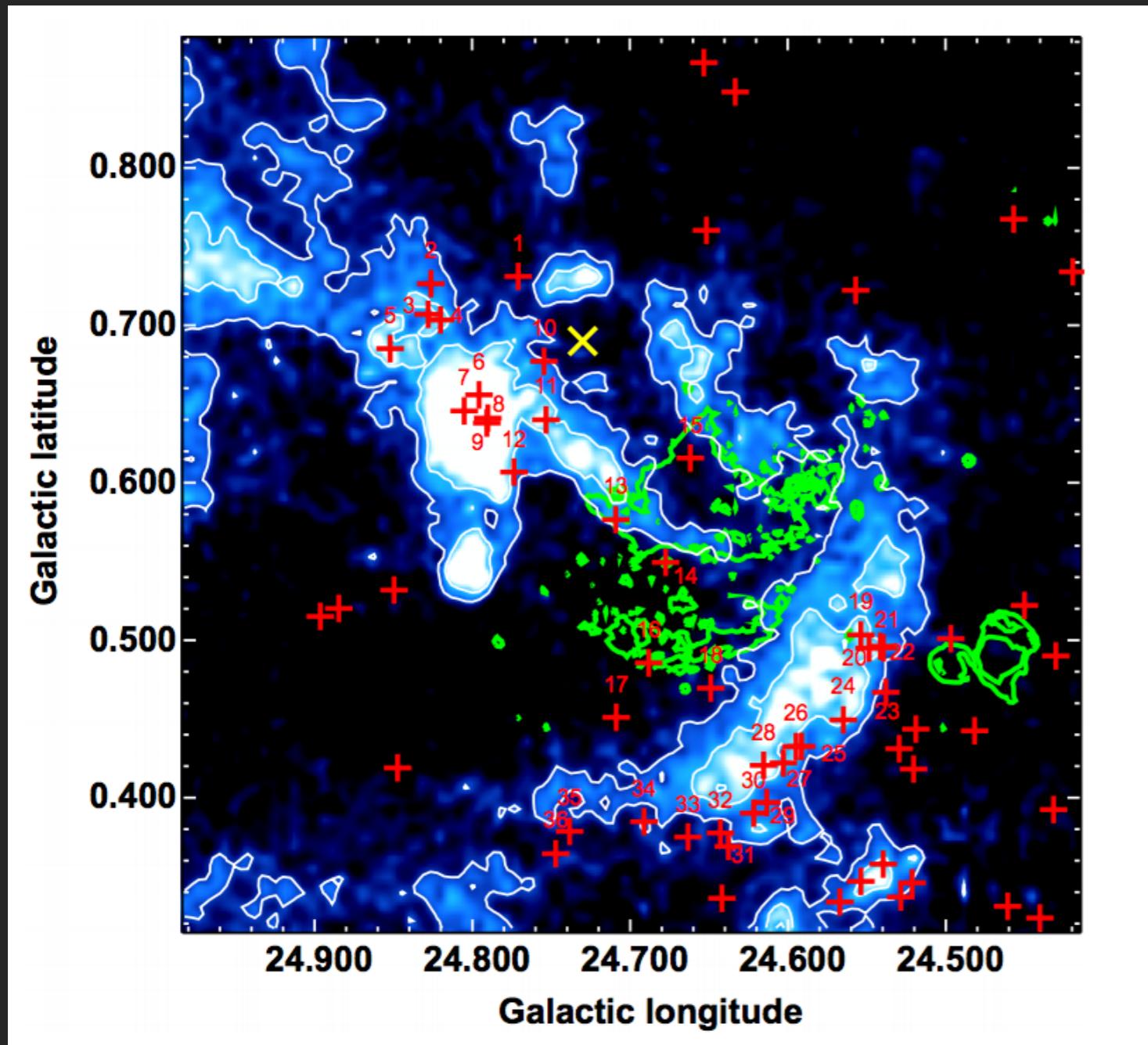


Observations of SNR G24.7+0.6 with the MAGIC Telescopes

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*"Discovery of TeV gamma-ray emission from the neighborhood of the supernova
remnant G24.7+0.6 by MAGIC" MAGIC Col. 2018 submitted to MNRAS*



- ★ Composite SNR located at 5kpc
- ★ 9.5 kyrs SNR
- ★ Dimension: $30' \times 15'$
- ★ Interacting with MC:
Several HII regions
Complex environment
- ★ Morphology:
couple incomplete shells and
polarised filled center
- ★ **SN explosion occurred in a
region of active star formation
rich in HII gas**

Fig. 1. Emission of the ^{13}CO integrated between +38 and +50 km/s . The green contours are the radio continuum MAGPIS (from Petriella et al. 2011)

FERMI LAT

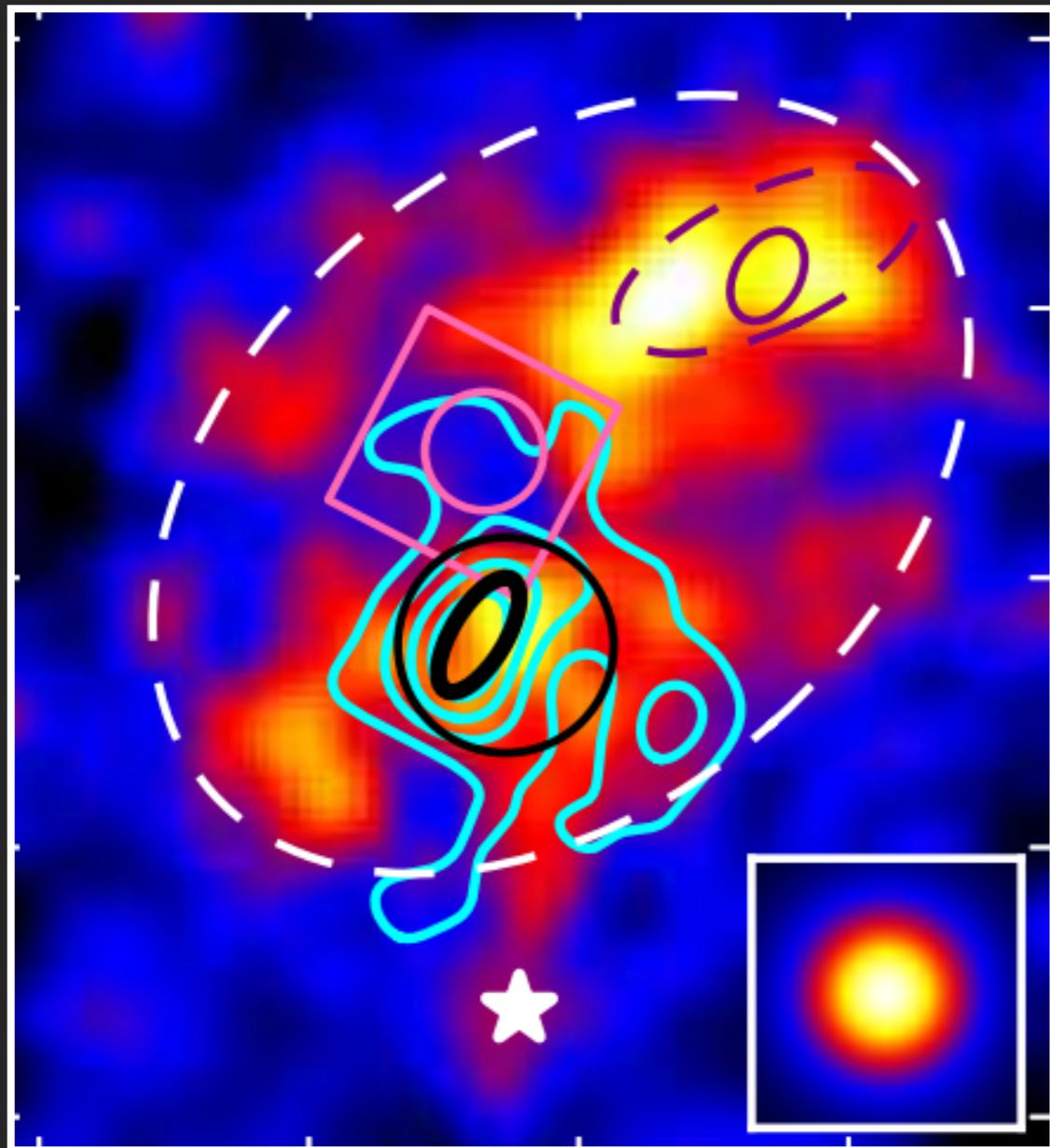


Fig. 2. Fermi LAT above 3 GeV from Katsuta et al. 2017. Cyan contours and black lines corresponds to H.E.S.S. data. The purple dashed and solid ellipses represent the candidate PWN associated to the SNR.

HESS

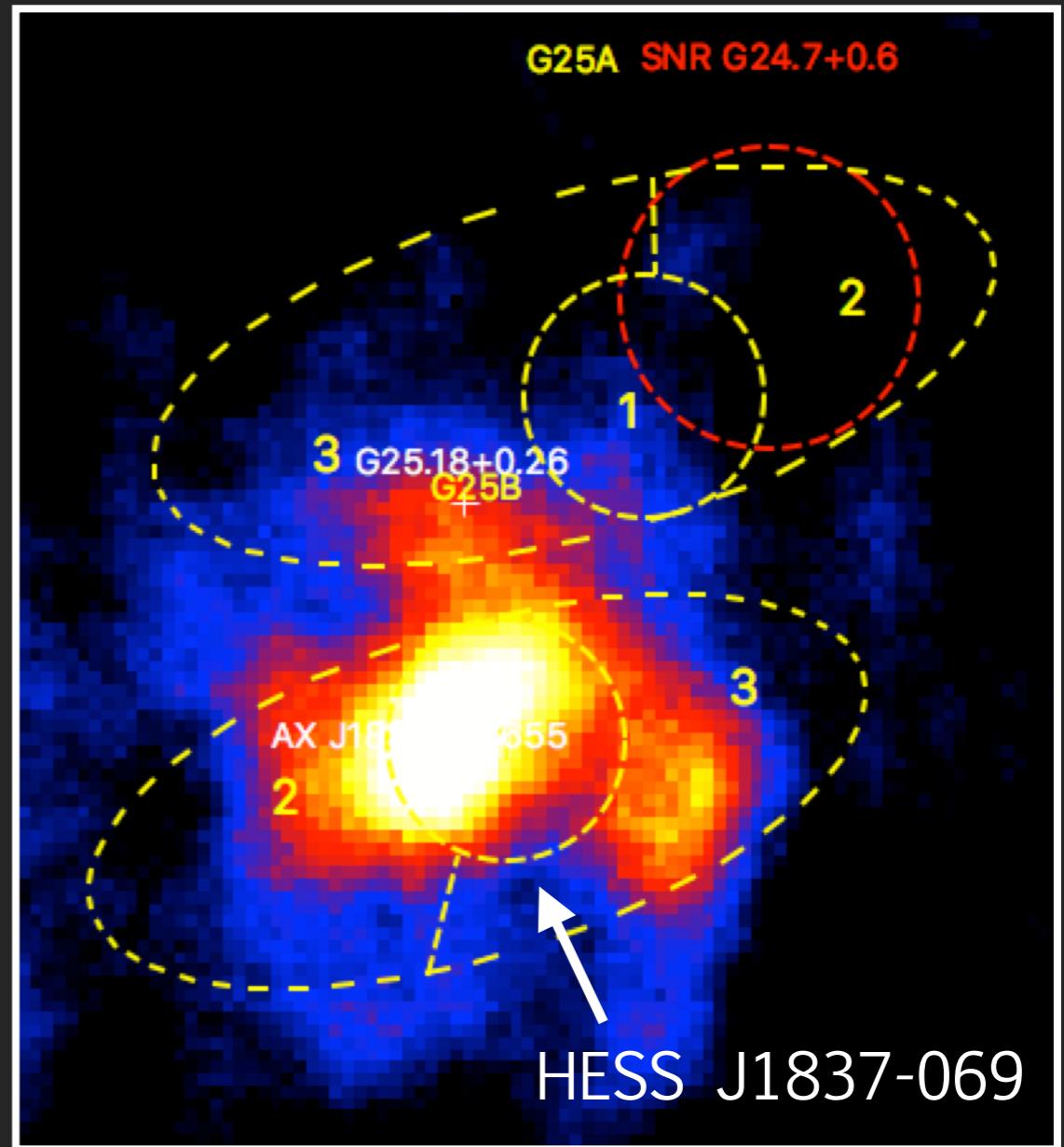


Fig. 3. HGPS from H.E.S.S. Col et al. 2018. The yellow lines corresponds to the regions defined by Katsuta et al 2017. The red circle shows the position of the SNR.

- ★ FermiLAT SNR (red or 2) extends to **very high energies E>100 GeV (FGES J1834.1-0706)**
- ★ The high energy emission shows a very complex morphology:
G25A: Similar spectral features along different regions - related to the OB association G25.18+0.26?
G25B: PWNe associated to AX J1837.3-0.652 / HESS J1837-069

Gotthelf and Halpern (2008)

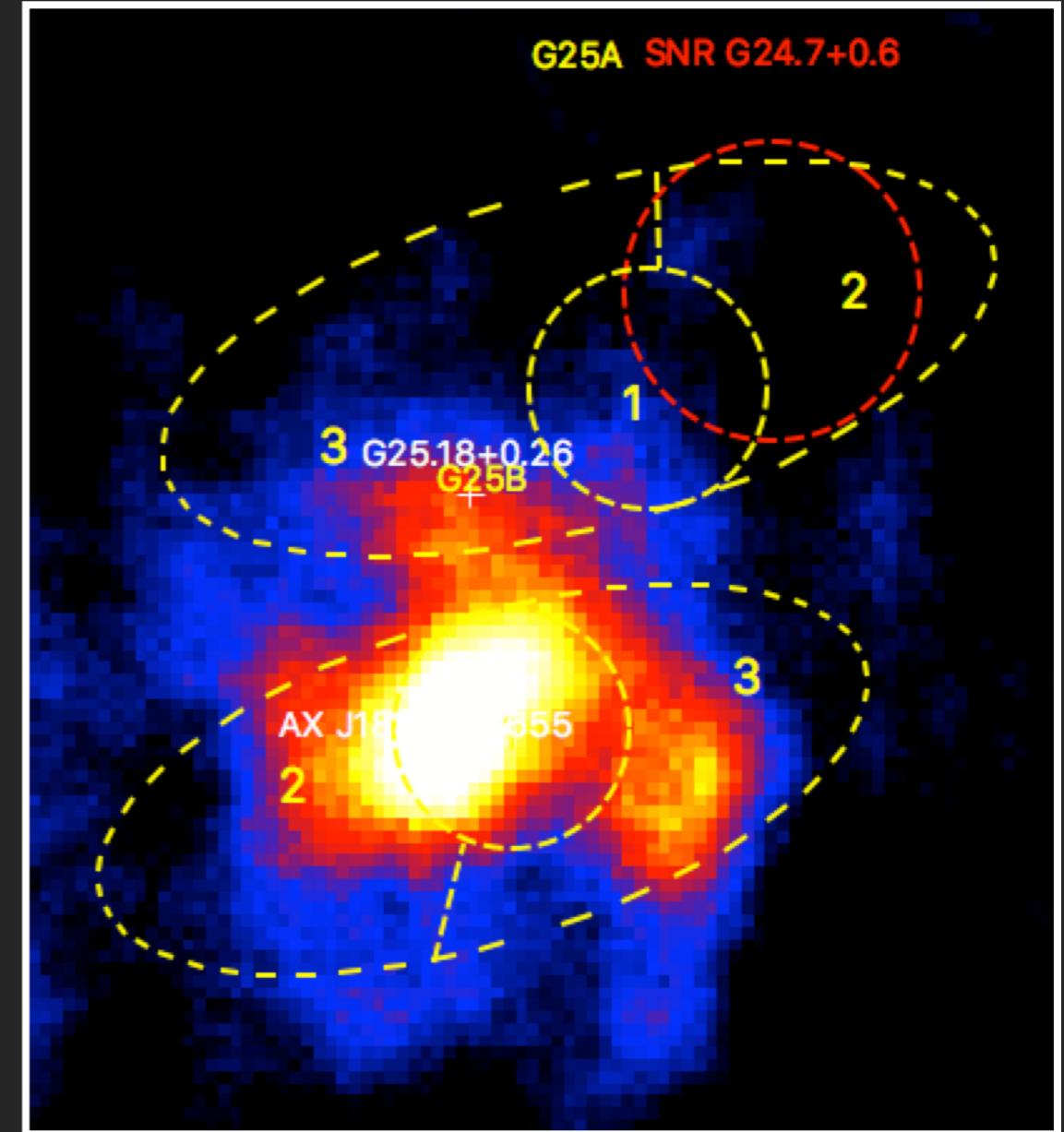


Fig. 3. HGPS from *HESS Coll et al. 2018*

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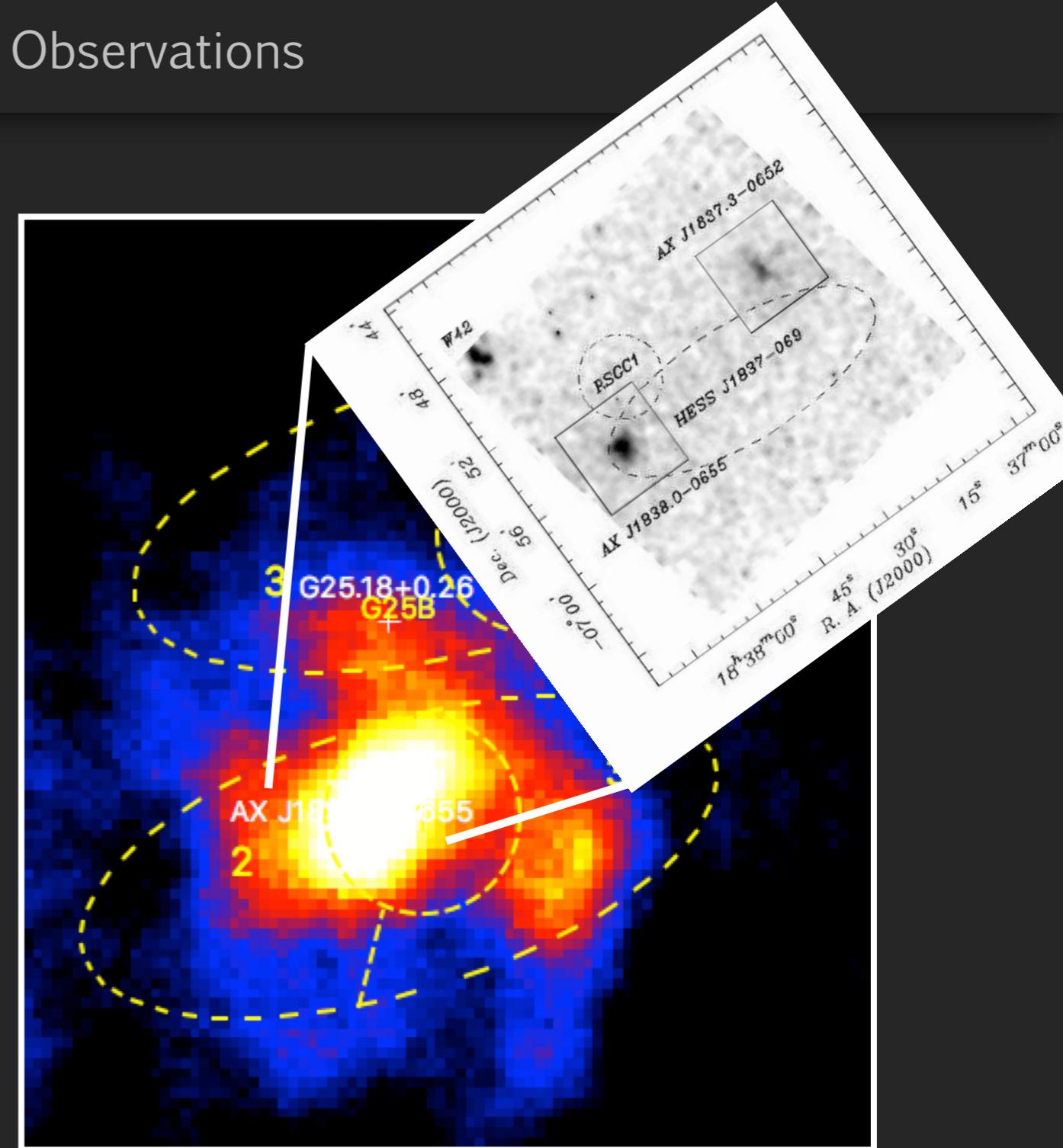


Fig. 3. HGPS from *HESS Coll et al. 2018*

MAGIC is a system of two 17m diameter IACT telescopes designed to observe very high energy (VHE, ≥ 50 GeV) γ rays, located in La Palma (Spain), at Roque de los Muchachos observatory.



- We accumulated ~ 33 hr of good quality data (2014)
- All data for zenith angles $Zd: \sim 33\text{-}50^\circ$ yielding a $E_{th} \sim 200$ GeV
- Also analyzed more than 8 yr of Fermi* data, combining multiple data selections (PSF0-3) into a joint likelihood

**Fermipy1 v0.13.3*

Fig. 4. MAGIC Significance Map of the SNR G24.7+0.6 region

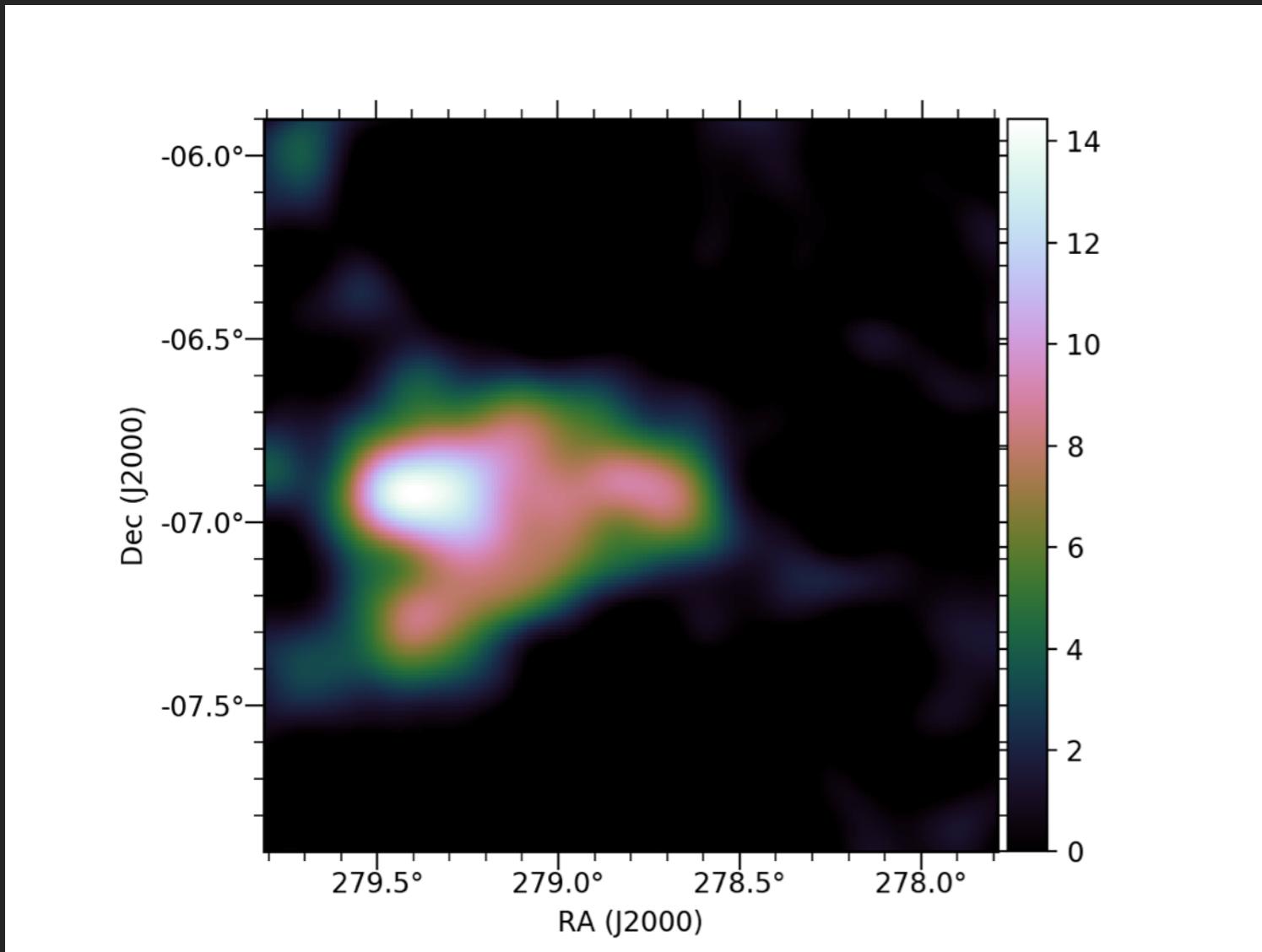


Fig. 4. MAGIC Significance Map of the SNR G24.7+0.6 region

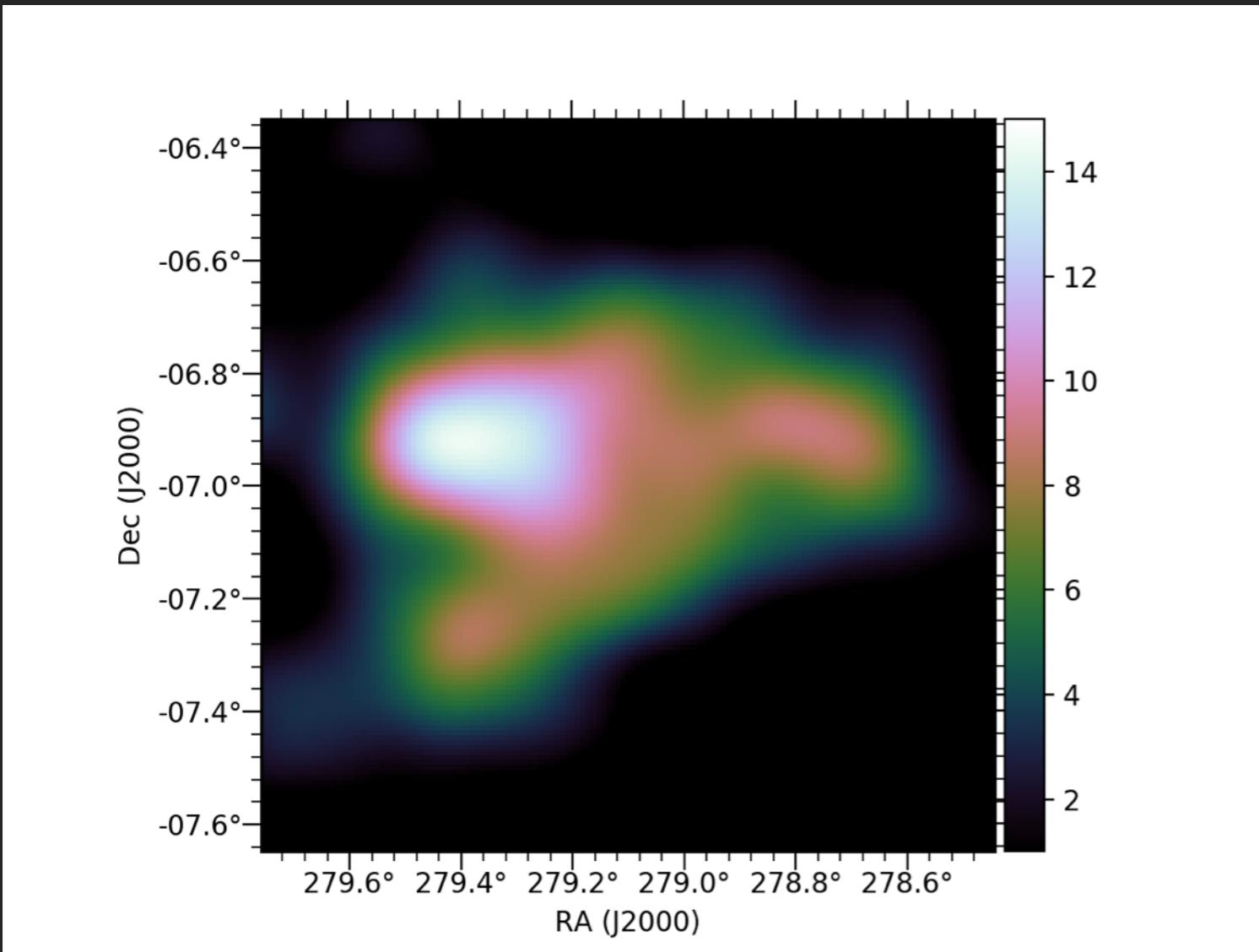
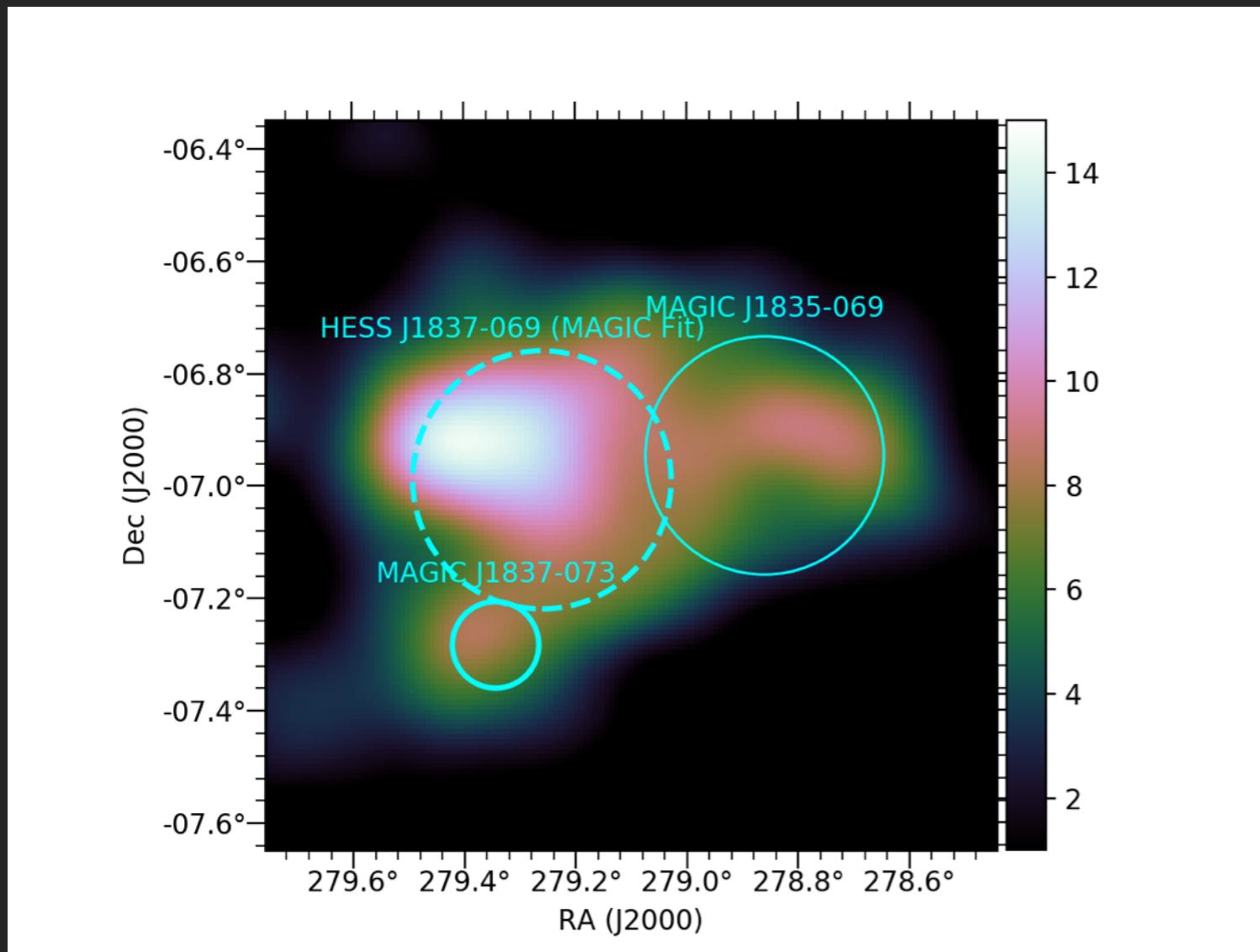


Fig. 5. MAGIC Significance Map of the SNR G24.7+0.6 region



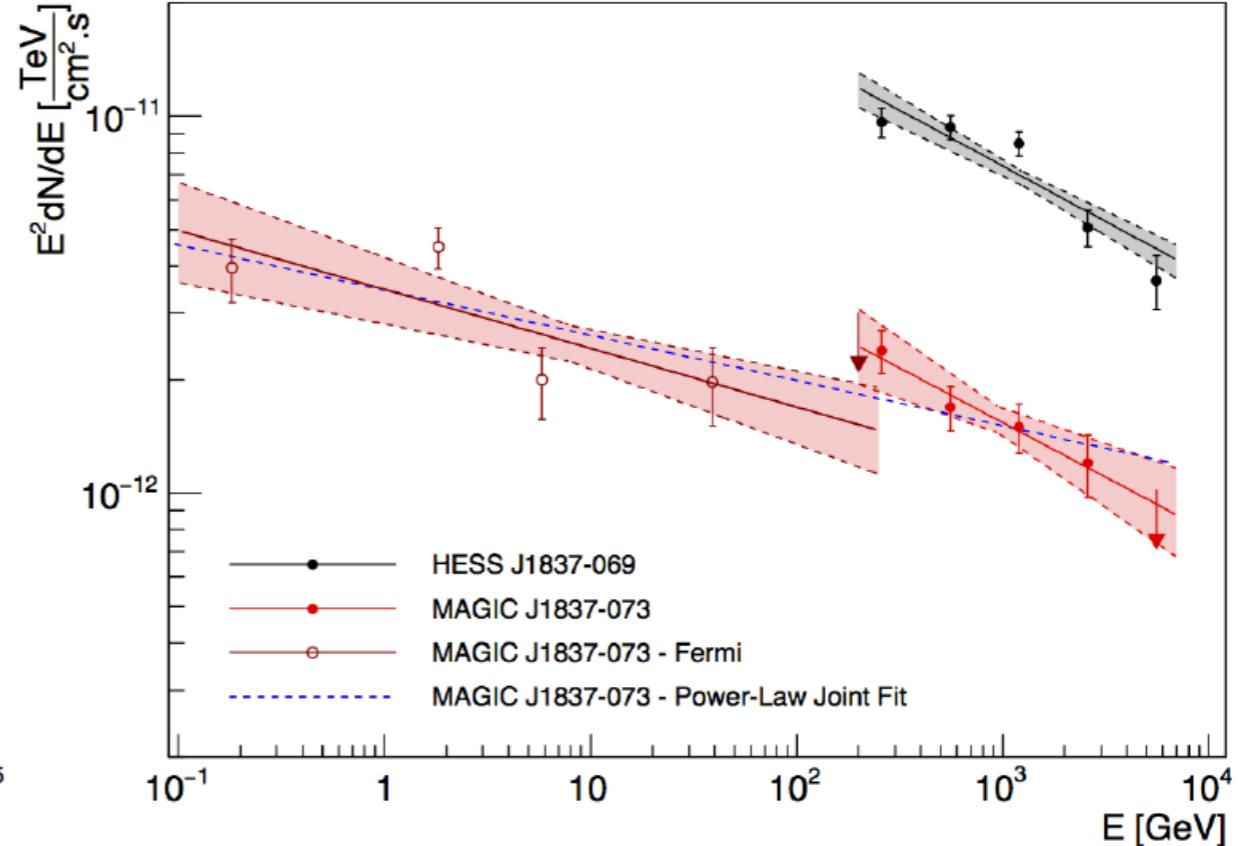
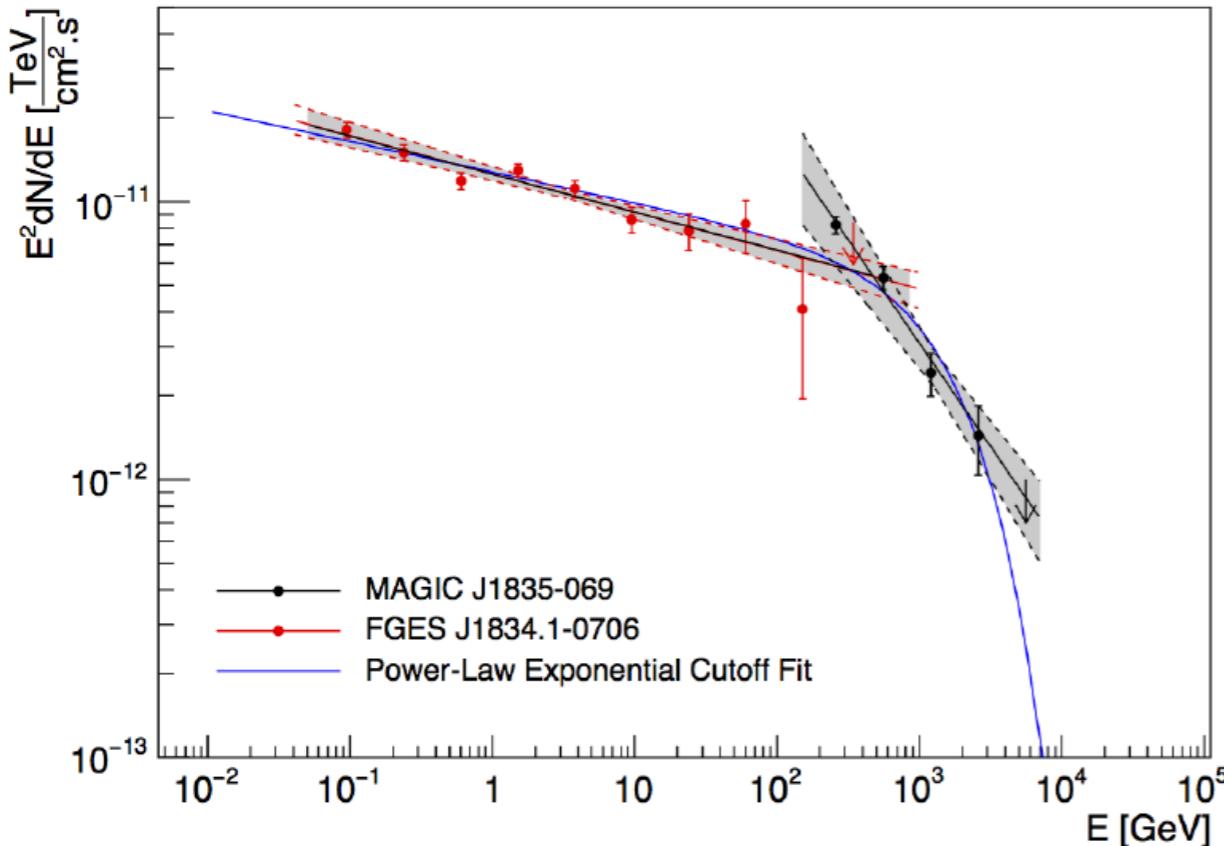
Morphological Analysis *Sherpa** & *Skyprism***

- ★ HESS J1837-069
 $\text{RA}_{\text{J}2000} = (279.26 \pm 0.02)^\circ$
 $\text{DEC}_{\text{J}2000} = (-6.99 \pm 0.01)^\circ$
Size = $(0.23 \pm 0.01)^\circ$
- ★ MAGIC J1837-07 (7.7 σ)
 $\text{RA}_{\text{J}2000} = (279.34 \pm 0.14)^\circ$
 $\text{DEC}_{\text{J}2000} = (-7.28 \pm 0.24)^\circ$
Size = $(0.08 \pm 0.05)^\circ$
- ★ MAGIC J1835-069 (13.5 σ)
 $\text{RA}_{\text{J}2000} = (278.86 \pm 0.23)^\circ$
 $\text{DEC}_{\text{J}2000} = (-6.94 \pm 0.05)^\circ$
Size = $(0.21 \pm 0.05)^\circ$

*(Doe et al. 2007; Freeman et al. 2001)

**(Vovk et al. 2018)

Spectral Analysis



	$\phi(>200 \text{ GeV})$ erg/cm ² /s	Γ
HESS J1837-069	$(7.2 \pm 0.3)10^{-11}$	2.29 ± 0.04
MGCJ1837-073	$(1.5 \pm 0.1)10^{-11}$	2.29 ± 0.09
MGCJ1835-069	$(4.4 \pm 0.6)10^{-11}$	2.74 ± 0.08

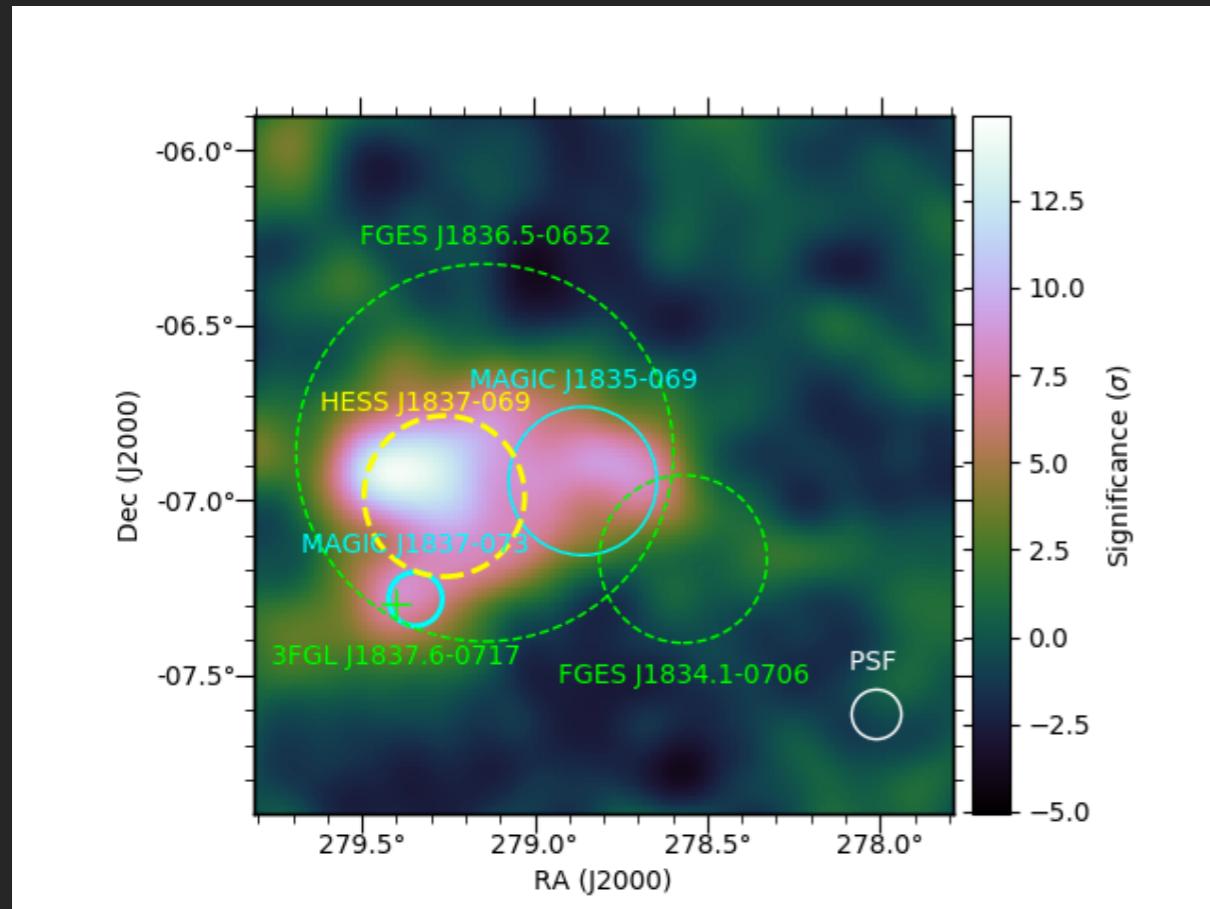


Fig. 7 MAGIC Significance map. MGCJ1835–069 and MGCJ1837–073 are represented by blue circles. Fermi-LAT sources from FGES and 3FGL catalogs are displayed in green. The position and extension of HESS J1837–069 as measured by MAGIC is in yellow.

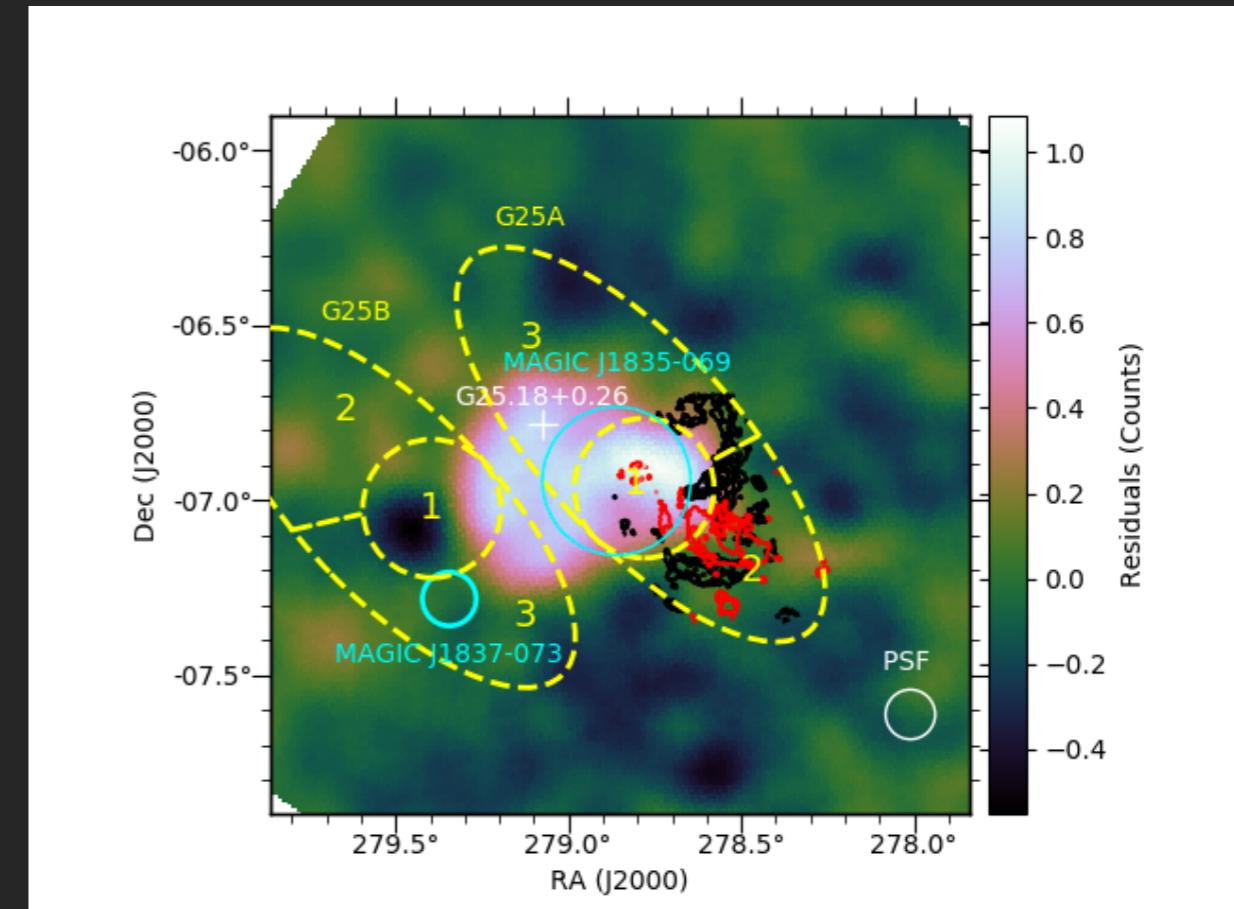
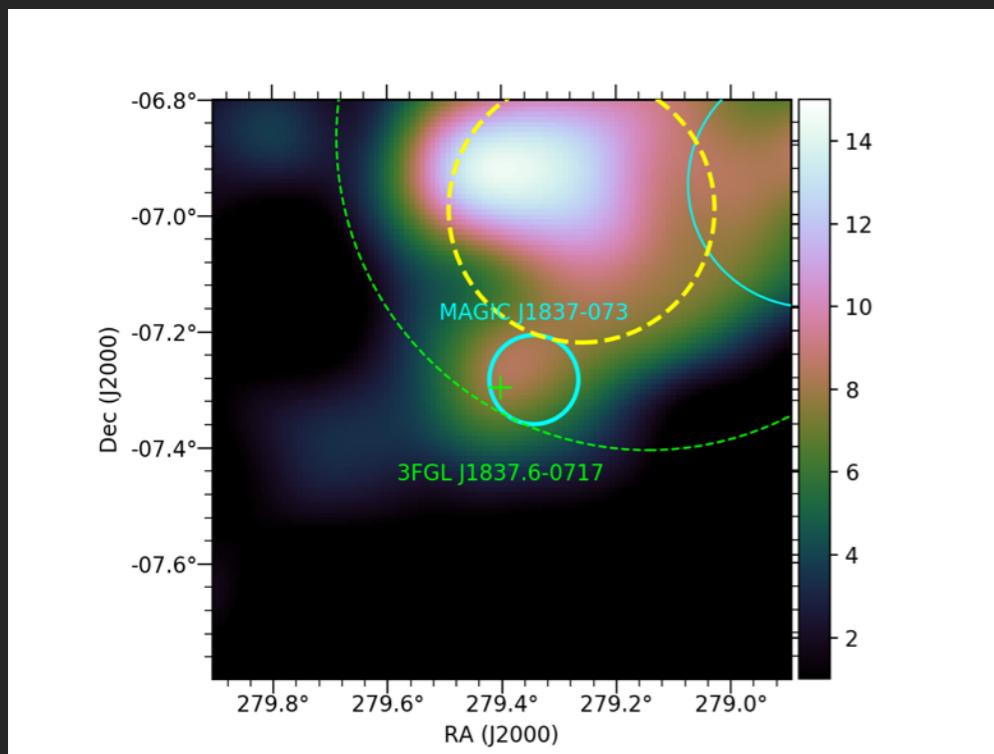


Fig. 8 MAGIC Residual map after subtracting the emission from HESS J1837–069 and MGCJ1837–073. SNR G24.7+0.6 radio emission and CO contours are overlaid in red and black. The yellow represent the region defined by *Katsuda et al 2017*.

MAGIC J1837-073

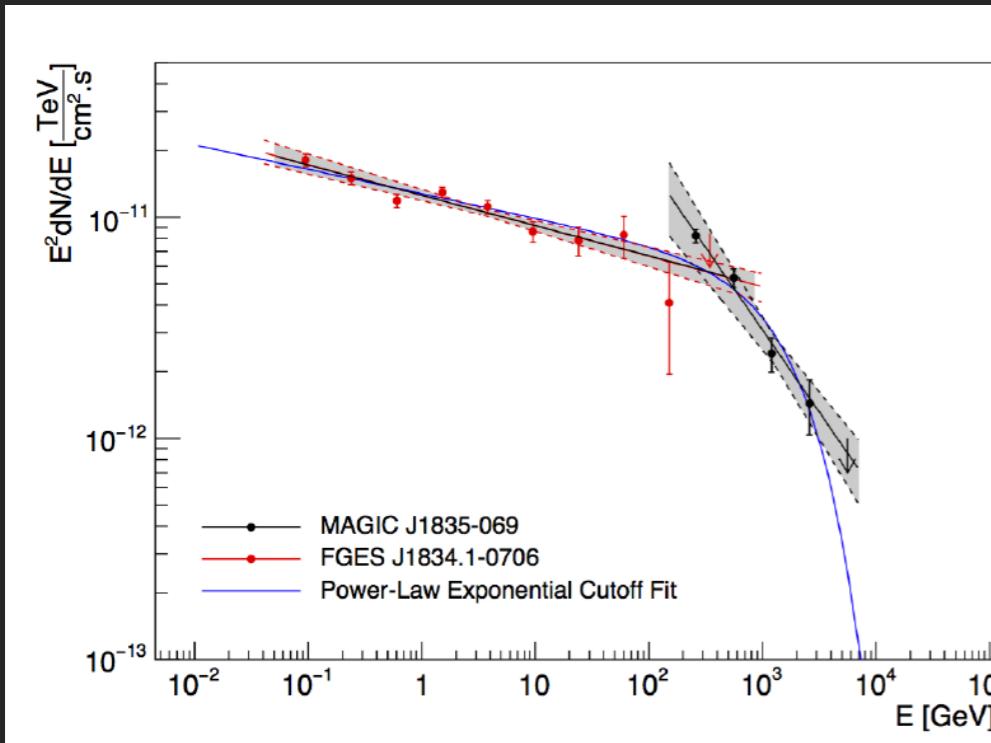
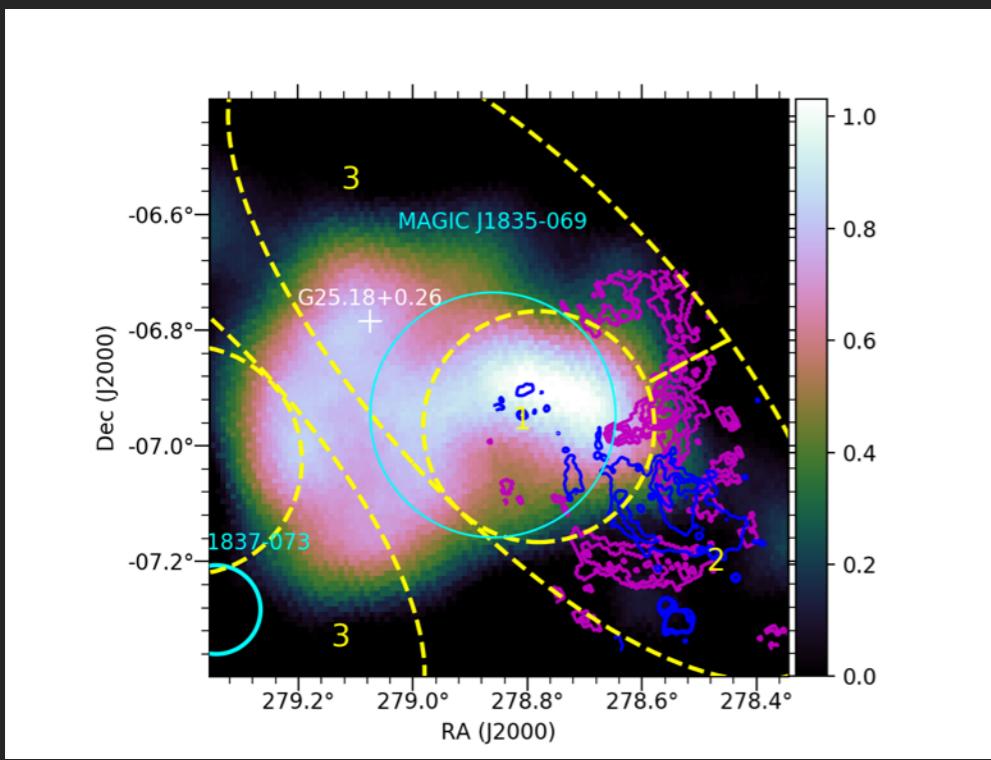


MAGIC J1837-07 \equiv 3FGL J1837.6-0717
(\equiv G25B3)

- ★ *Extended $\sim 0.21^\circ_{MAGIC} - 0.24^\circ_{LAT}$*
- ★ *Hard $\sim 2.3_{MAGIC} - 2.2_{LAT}$*
- ★ *Good spectral agreement*

- ★ *No SNR/PWN/Pulsar counterpart*
- ★ *Rich in MC at $d \sim 5$ kpc and the large number of X-ray point sources suggest a stellar cluster (Katsuda et al 2017)*

$$L_\gamma(>100 \text{ MeV}) = 1.3 \times 10^{35} \text{ erg/s} \rightarrow W_p \sim 2.1 \times 10^{50} \text{ erg (cm}^{-3}/\text{n})$$

MAGIC J1835-069

MAGIC J1837-07=FGES J1834.1- 0706
(\equiv G25A)

- MAGIC and LAT source partially overlap (30 pc projected distance)*
- Good spectral agreement*
- Break in the GeV-TeV regime*

$$L_\gamma(>100 \text{ GeV}) = 7.5 \times 10^{34} \text{ erg/s}$$

$$\rightarrow W_p \sim 1.3 \times 10^{50} \text{ erg (cm}^{-3}/\text{n})$$

- PWNe?*

$$S \sim 1.2 \times 10^{30} \text{ erg/s/pc}$$

$$\rightarrow \dot{E} \sim 10^{37} \text{ erg/s}$$

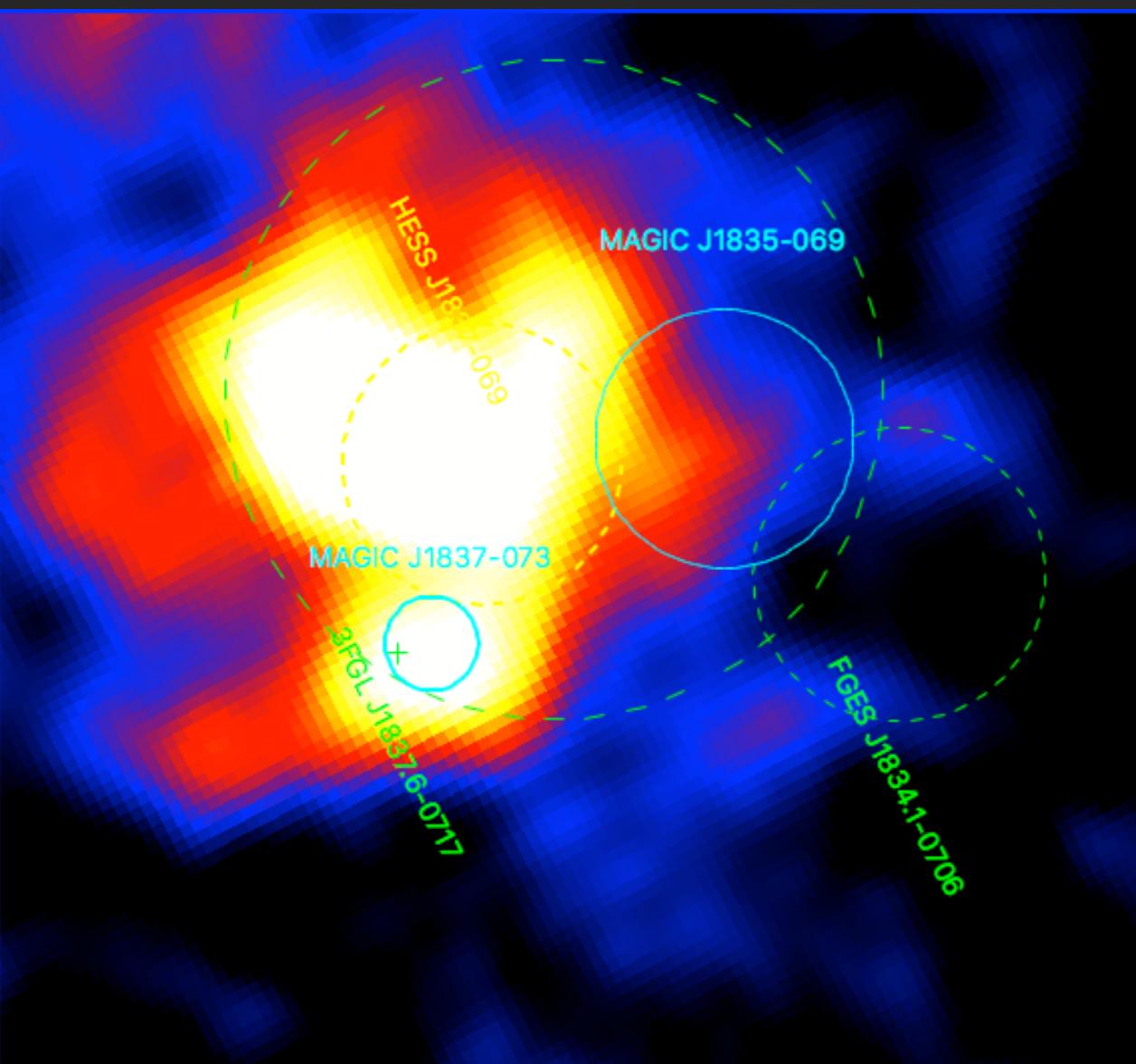
HESS Col. 2018

$$S \sim \dot{E}^{0.81}$$

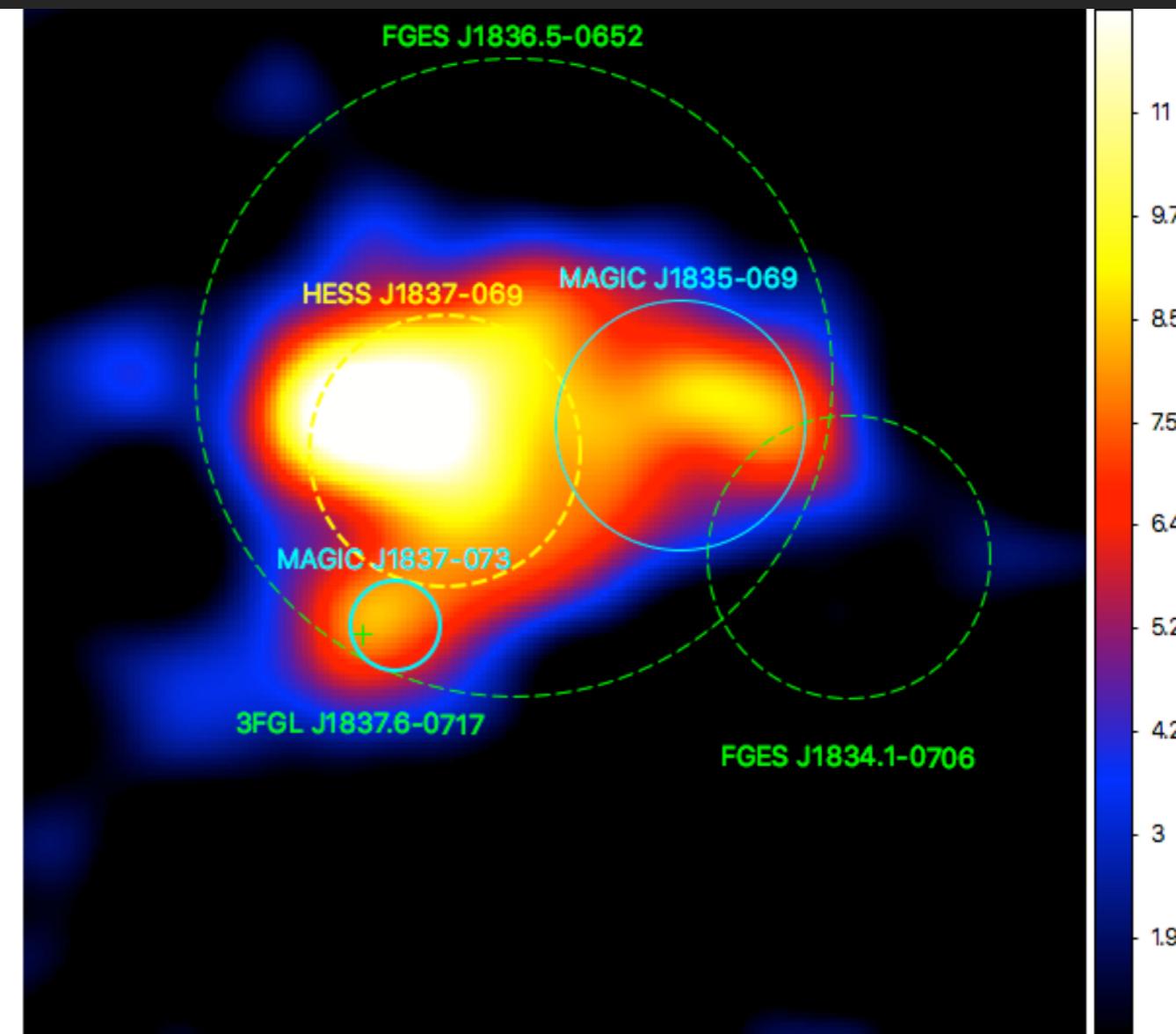
	F_0 [$\text{TeV}^{-1} \text{ cm}^{-2} \text{ s}^{-1}$]	Γ	E_C [TeV]	E_0 [GeV]
EPWL	$(9.1 \pm 3.0) \times 10^{-10}$	2.12 ± 0.02	1.9 ± 0.5	92

MAGIC J1835-069

HESS HGPS Sig. Map. Hard cuts



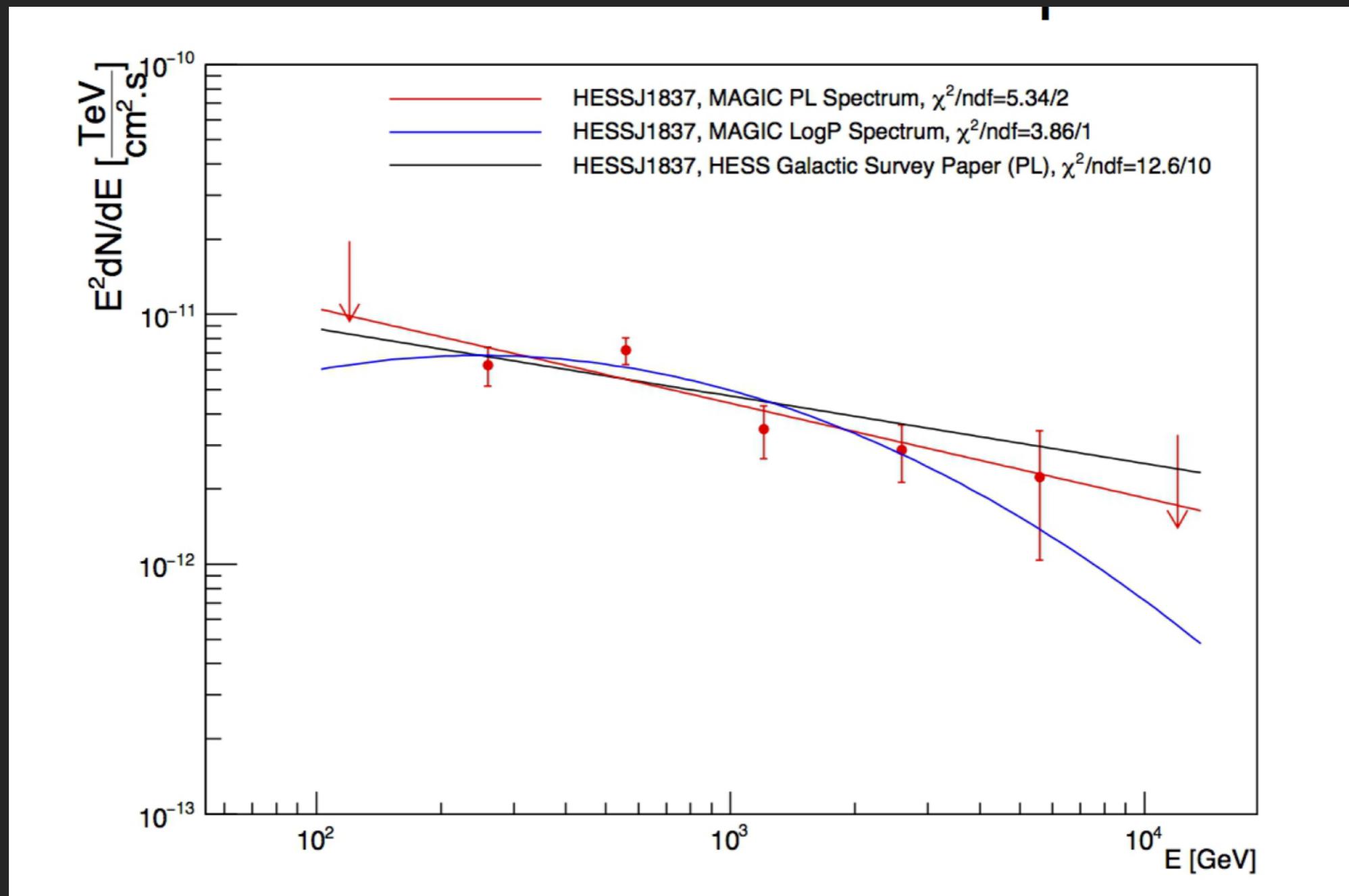
MAGIC Sig. Map. Eth~100 GeV



- ★ *MAGIC observed the complex region around the evolved SNR G24.7+0.6 for 33 hours*
- ★ *Beside the known source HESS J1837-069, two new sources were resolved in the vicinity: MAGIC J1837-073 & MAGIC J1835-069*
- ★ *MAGIC J1837-073 shows a hard spectrum from 100 MeV up to 10 TeV and could be associated with an OB stellar cluster interacting with molecular clouds*
- ★ *MAGIC J1835-069 shows a exponential cutoff spectral shape from 100 MeV to a few TeV. Possible Counterparts:*
 - ★ *Hadronic emission originated by the SNR interacting with the dense surrounding medium.*
 - ★ *G25.18+0.26 young massive OB association (but not emission detected from the G25-2/3 regions)*

Backups

Thanks to all the speakers of the Galactic Sessions!



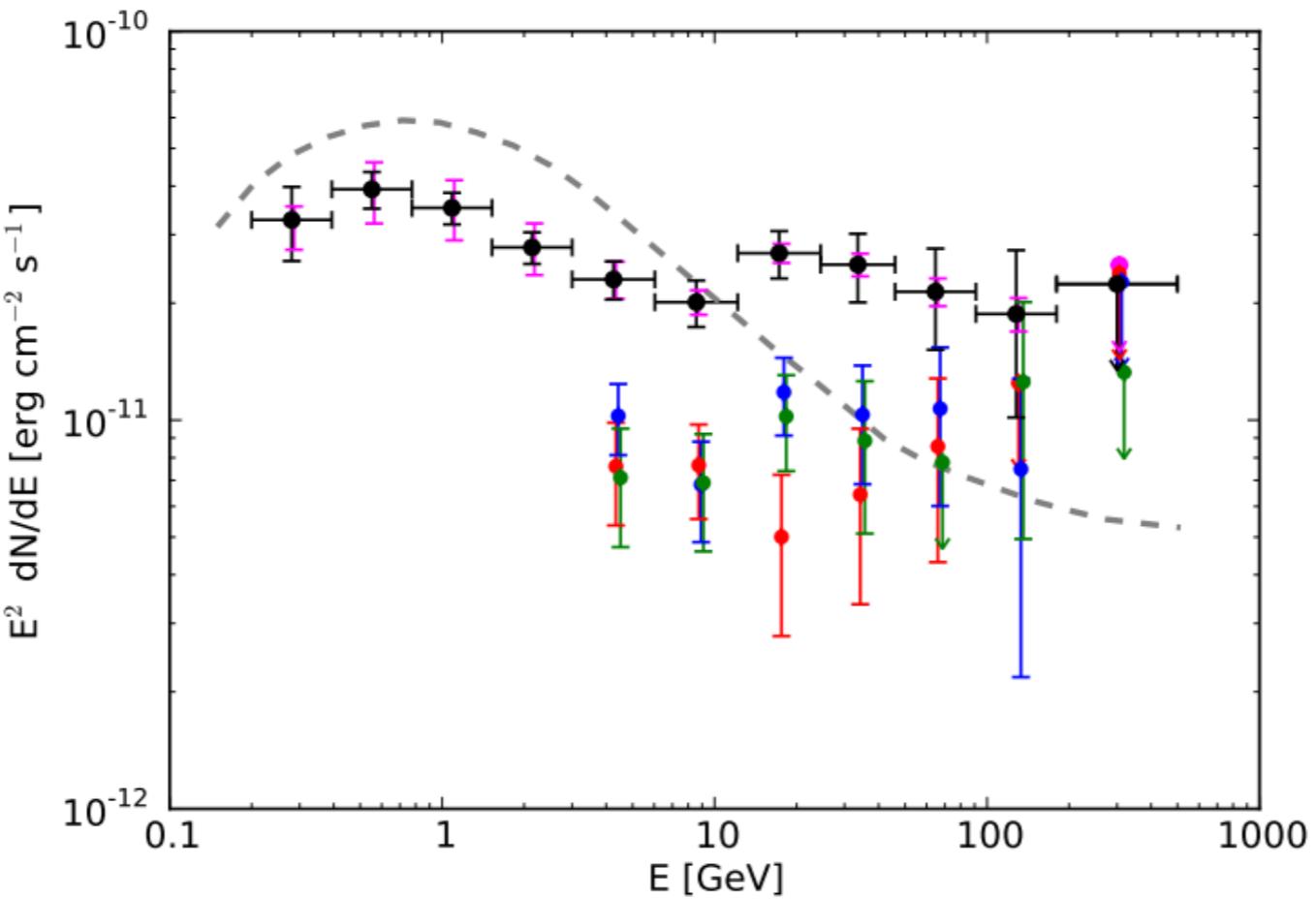


FIG. 3.— SED of the G25A region measured by the *Fermi* LAT. The arrows represent the 95% confidence level upper limits. Upper limits are calculated for energy bins with $\text{TS} < 4$. The statistical errors (1σ) are indicated by the black error bars, while the total systematic errors (method 1; see text) are indicated by the magenta error bars. The magenta points and arrows represent upper limits taking the systematic errors into consideration. SEDs of G25A1, A2, and A3 are also presented as red, blue, and green points with their statistical errors (1σ) respectively. Note that the points and arrows are slightly off-set to clearly show the spectra. The gray dashed line represents the Galactic diffuse emission from the G25A region, which is estimated by using the best-fit scaling of the Galactic diffuse model.