

# Study of several TeV gamma-ray sources with Fermi-LAT data

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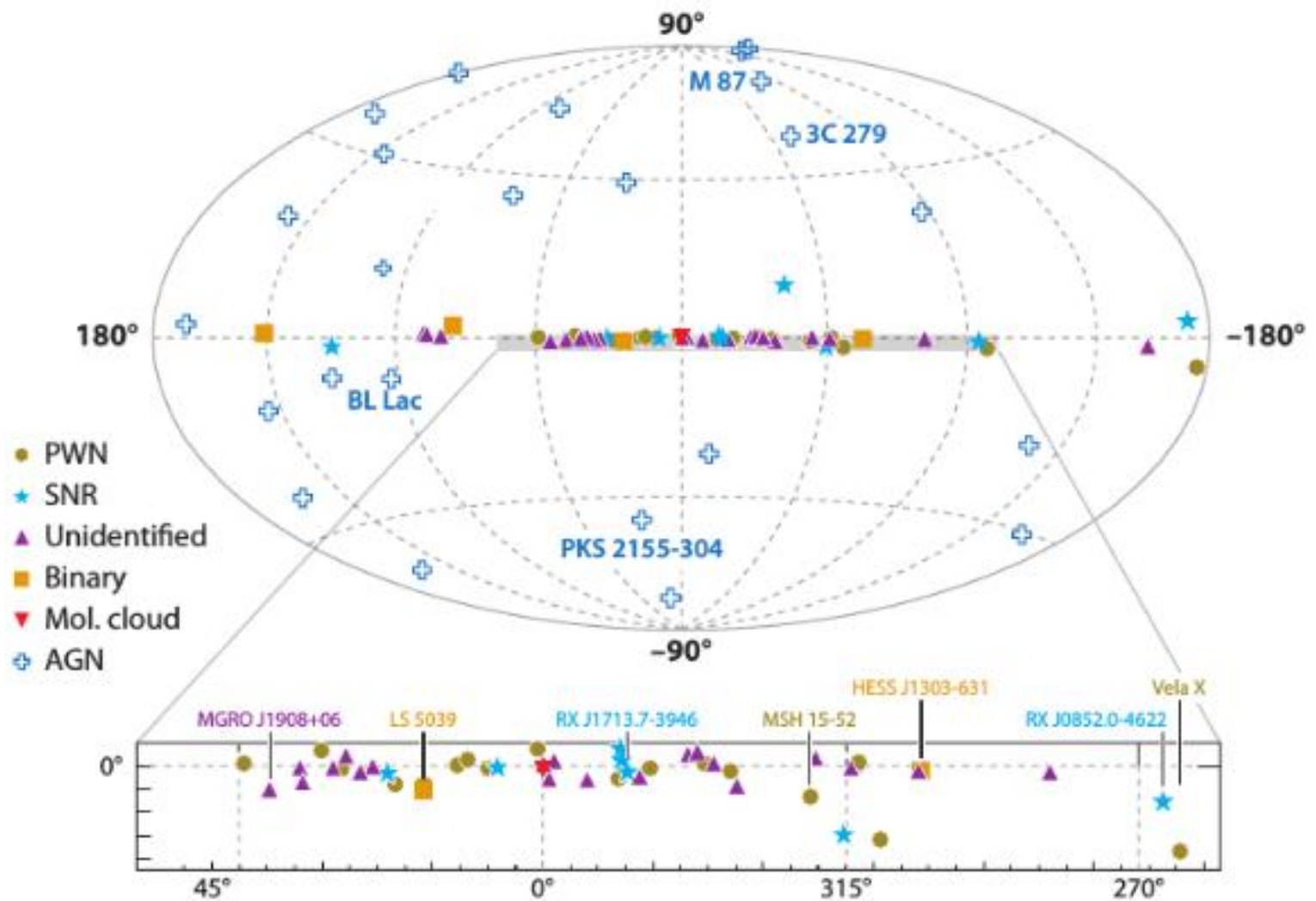
Purple Mountain Observatory, CAS

2018-03-22

LHAASO Conference, E'mei, Sichuan; 22-24 March, 2018

# Outline

- Introduction of SNRs & PWNe with Fermi-LAT
- The gamma-ray emission from HESS J1731-347
- The gamma-ray origin of HESS J1640-465
- Conclusion

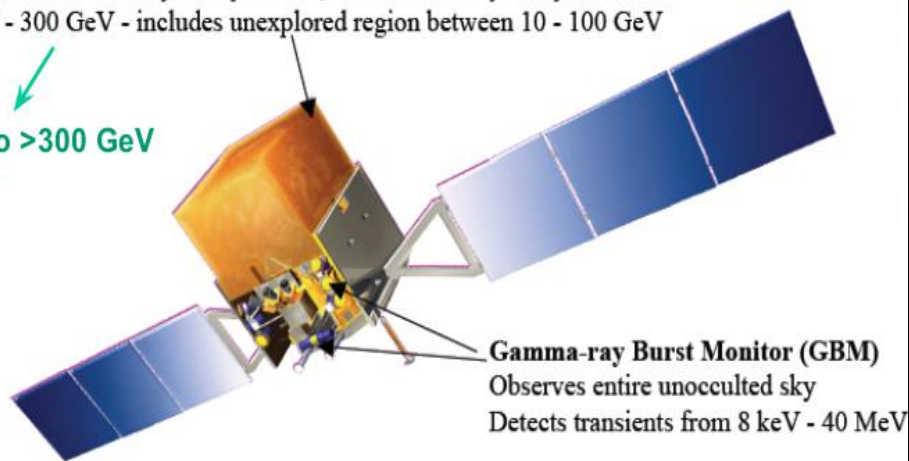


## TeV gamma-ray sources in Galactic plane: **SNRs & PWNe**

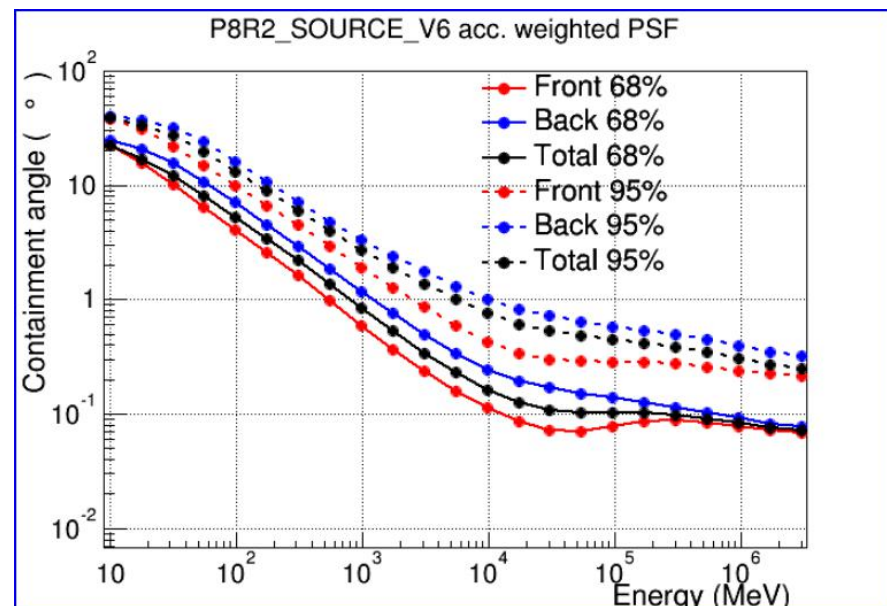
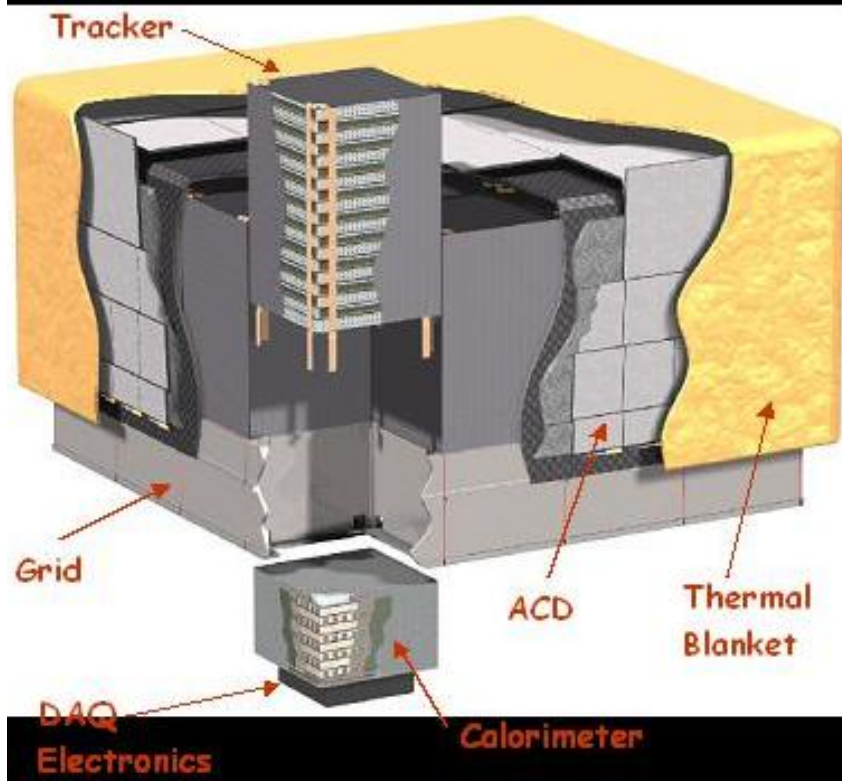
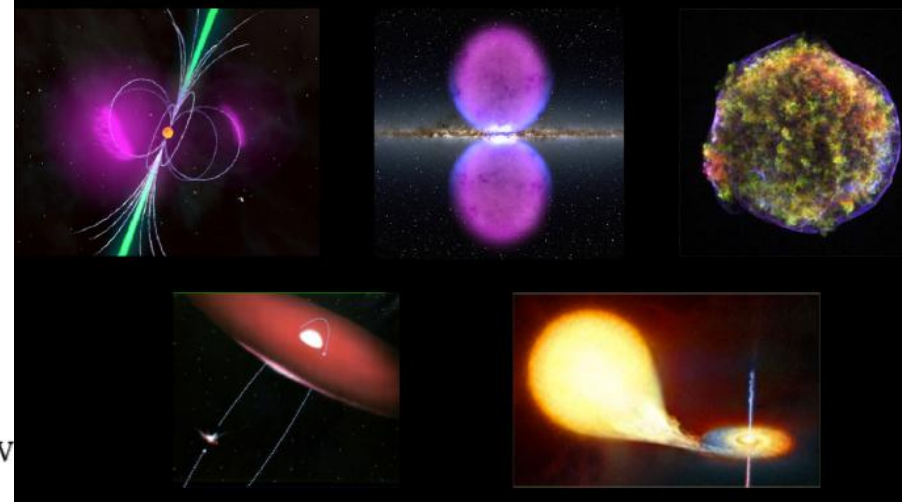
### Large Area Telescope (LAT)

Observes 20% of the sky at any instant, views entire sky every 3 hrs  
20 MeV - 300 GeV - includes unexplored region between 10 - 100 GeV

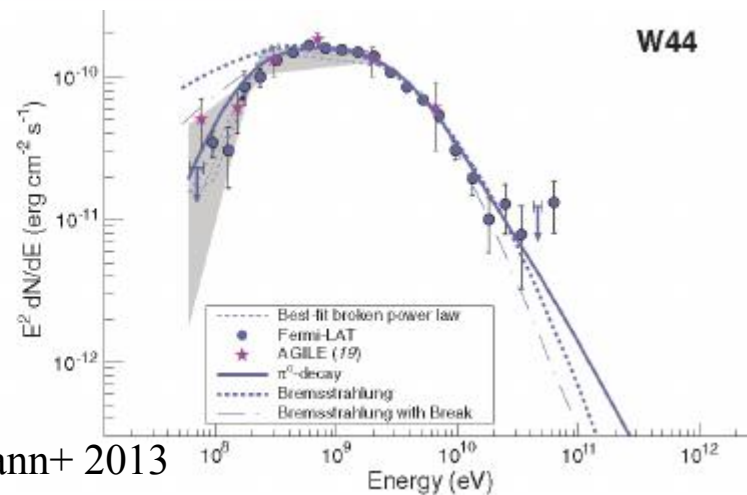
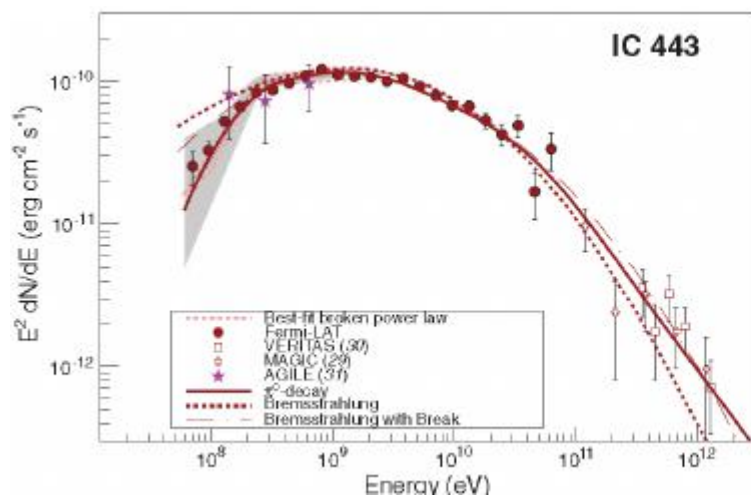
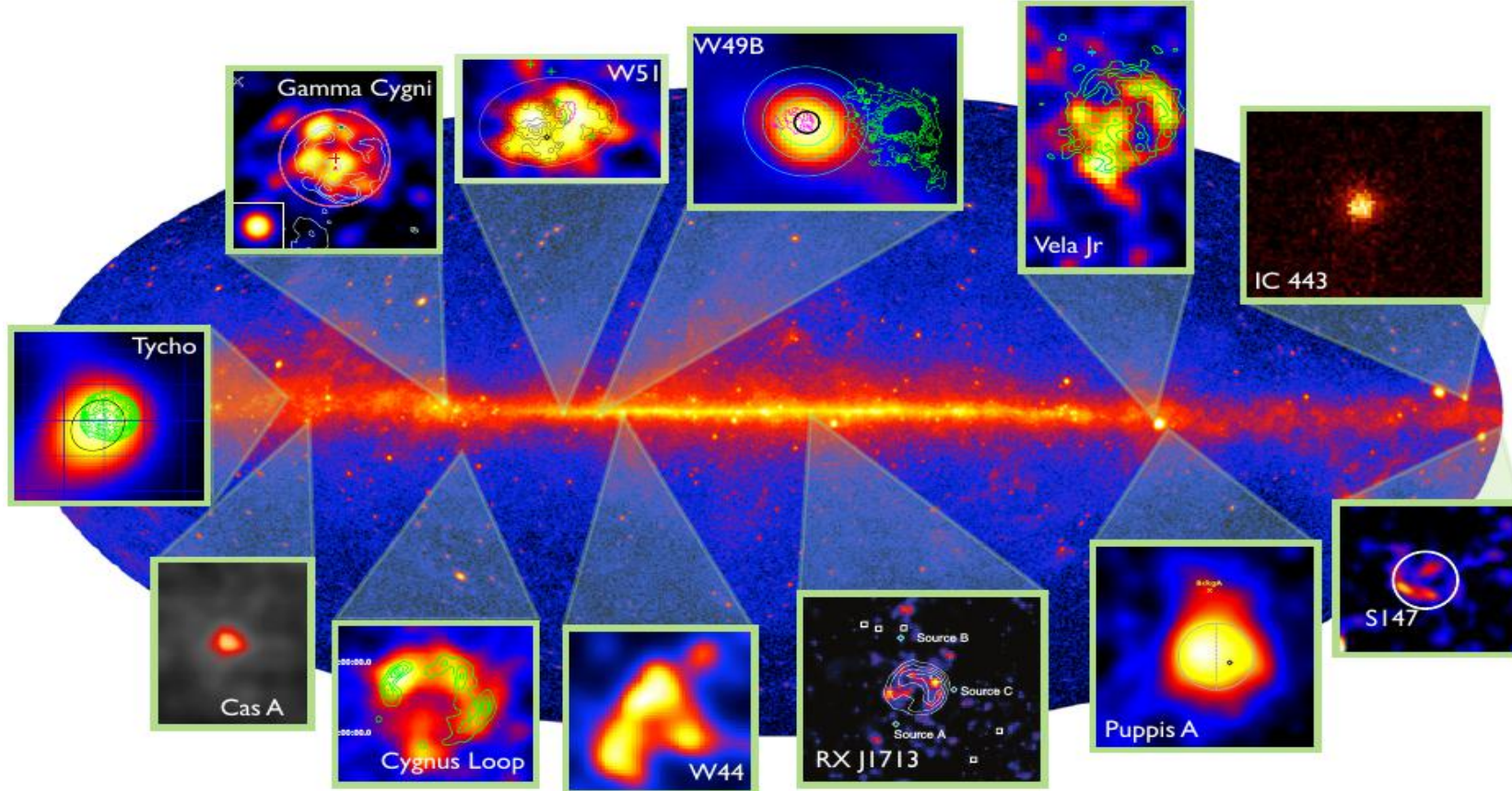
Can go >300 GeV



### GALACTIC $\gamma$ -RAY SOURCES







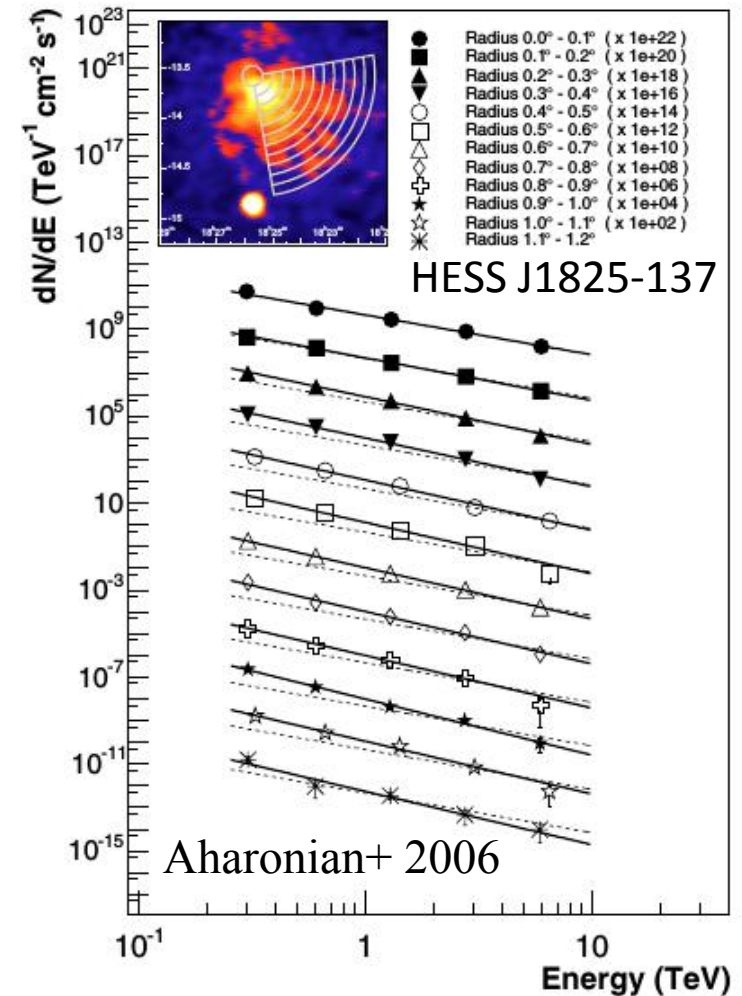
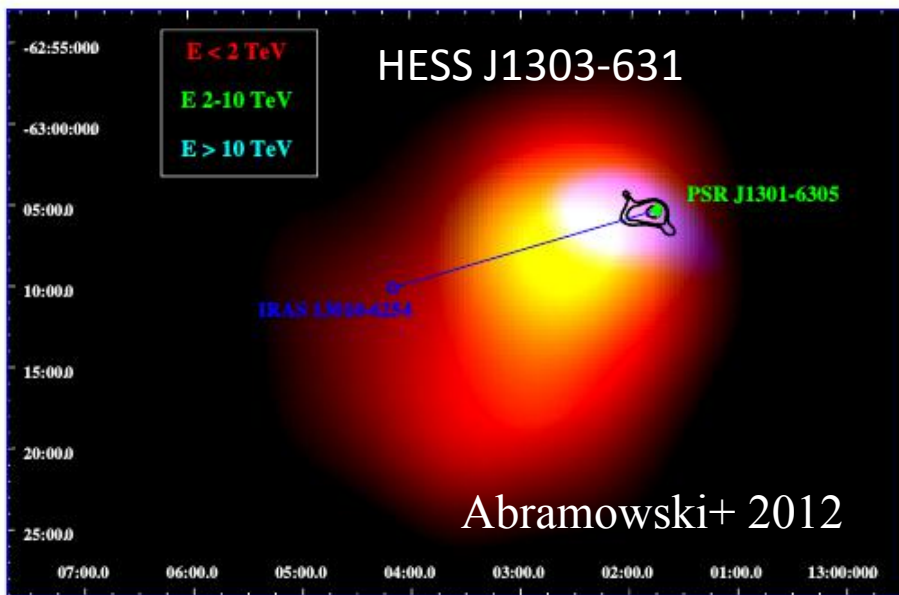
Ackermann+ 2013

LHAASO Conference, E'mei, Sichuan; 22-24 March, 2018

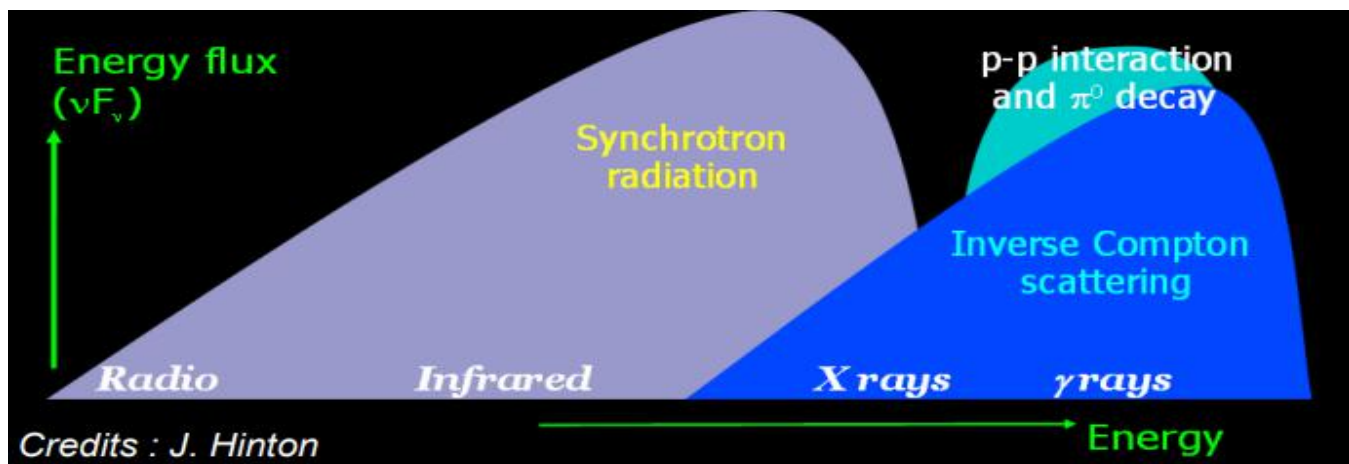
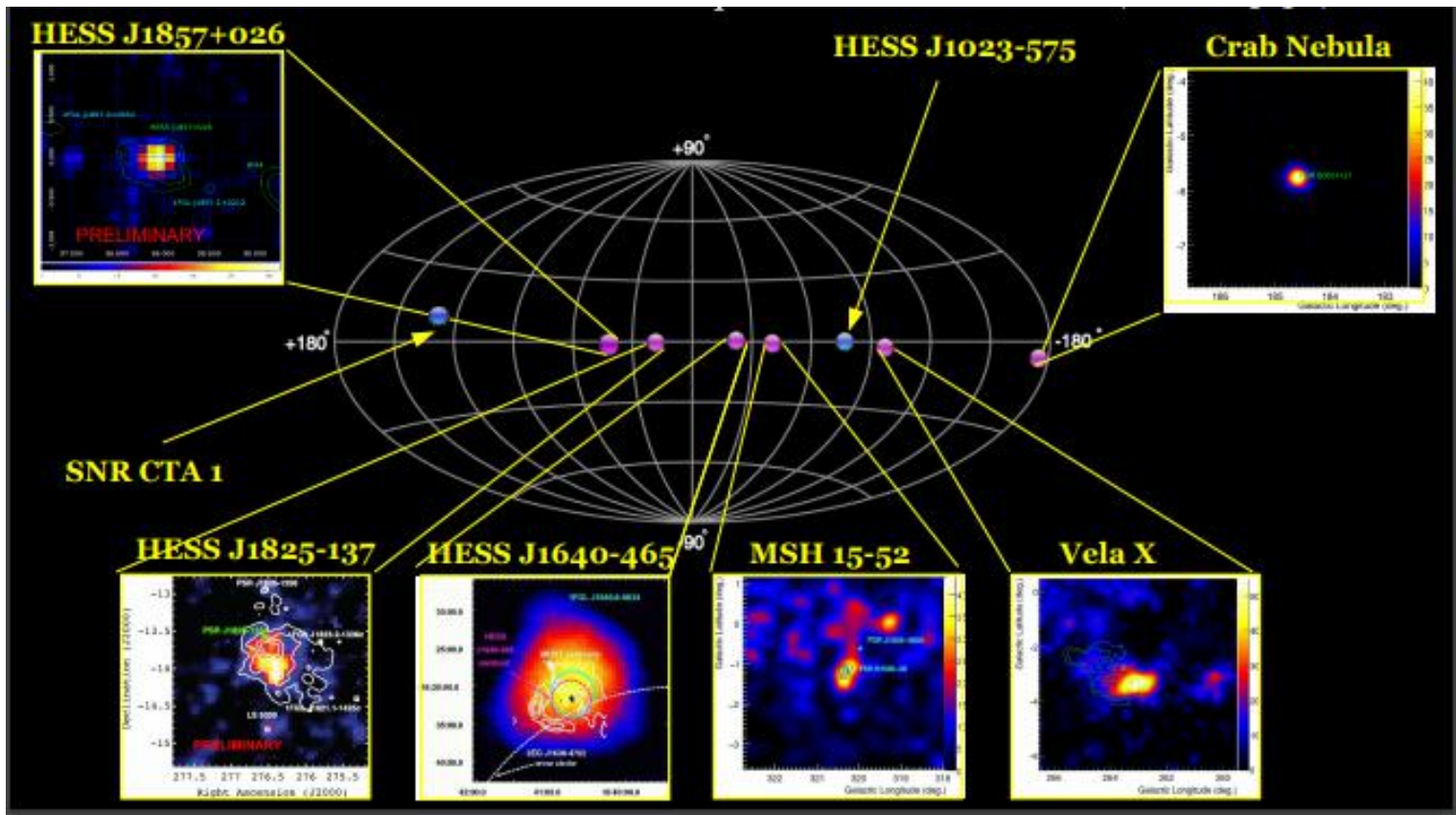
# Pulsar wind nebulae:

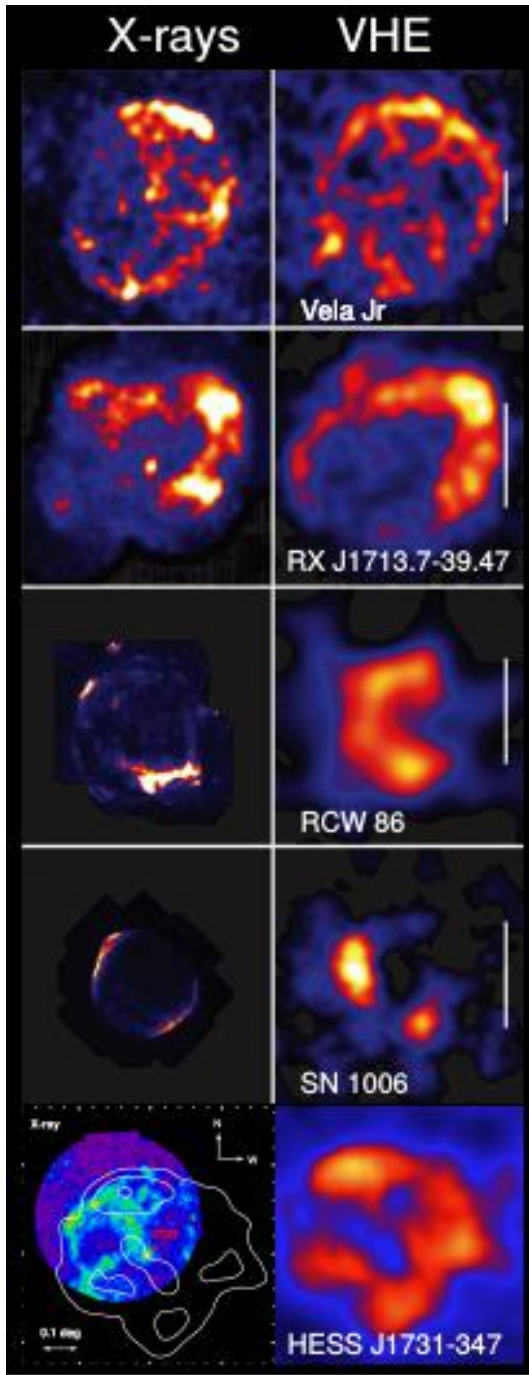
Pulsars power a highly relativistic, magnetized wind of  $e^+/e^-$  pairs that forms a termination shock in surrounding medium.

- \* Extremely efficient particle acceleration
- \* Associated with young powerful pulsars
- \* Largest class of Galactic TeV sources



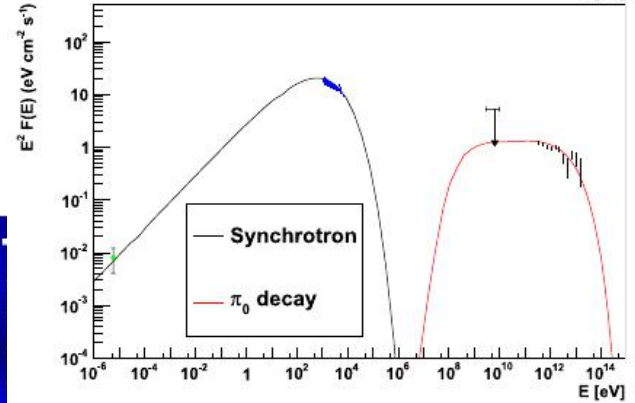
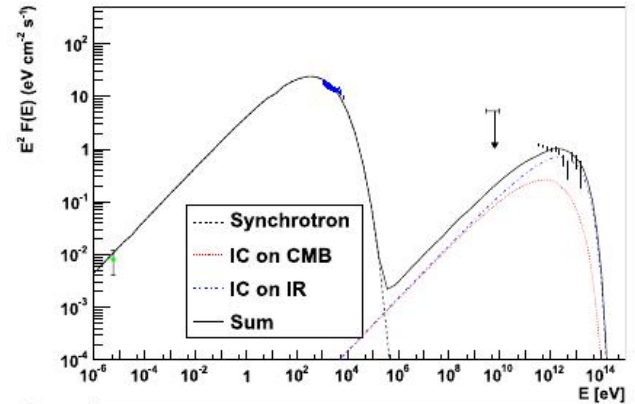
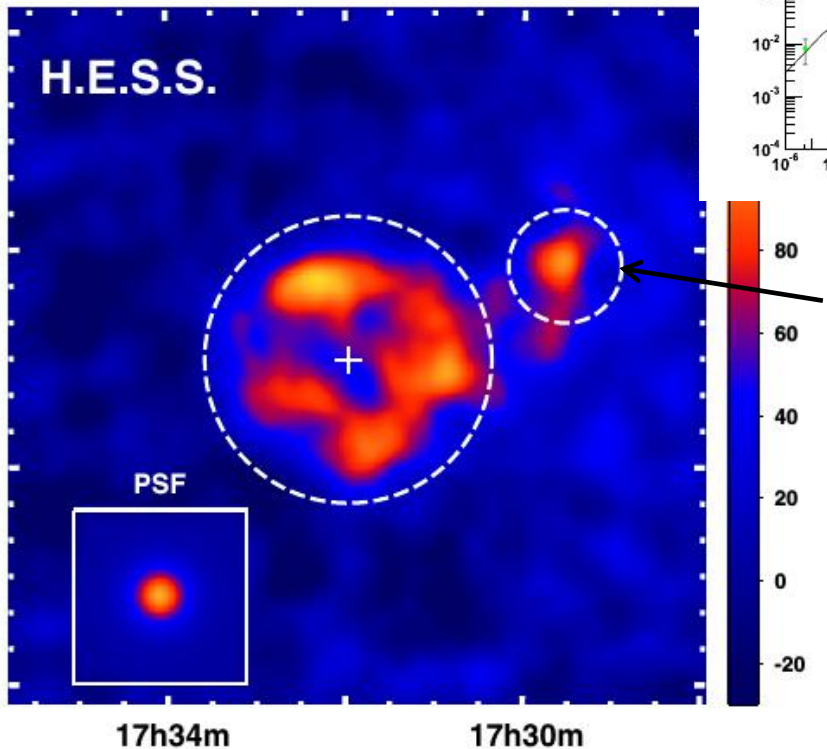






# HESS J1731-347 -a shell-type TeV source

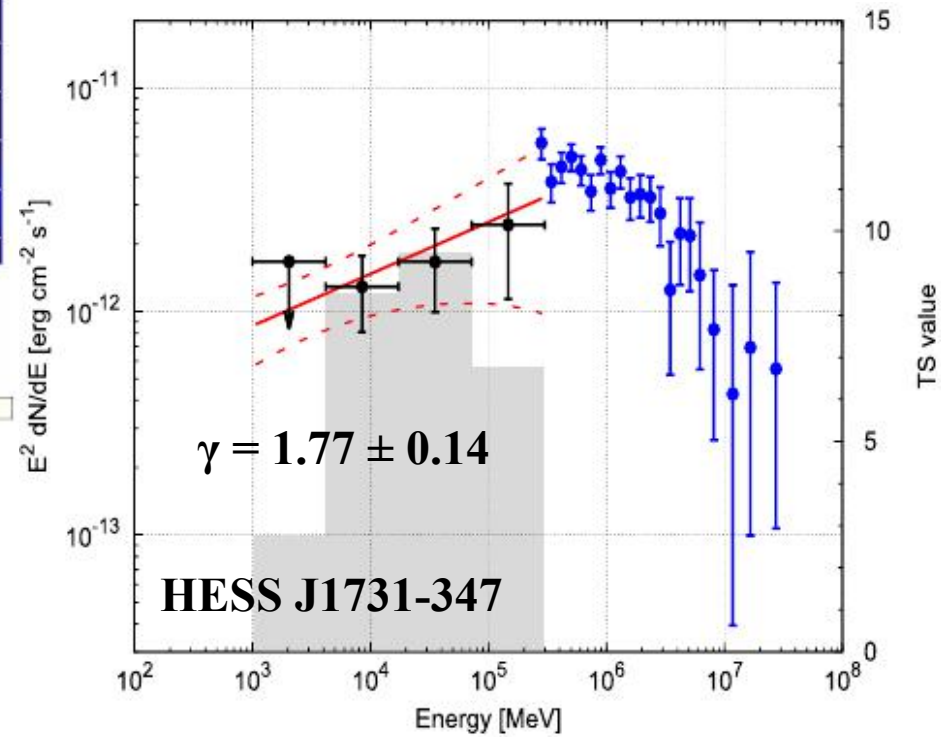
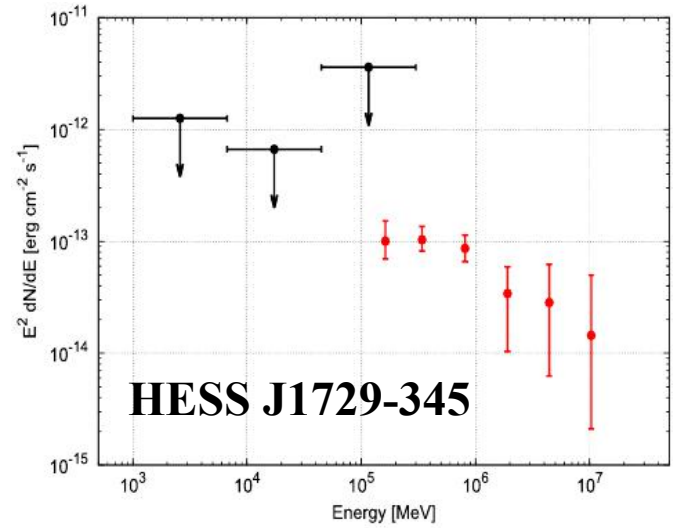
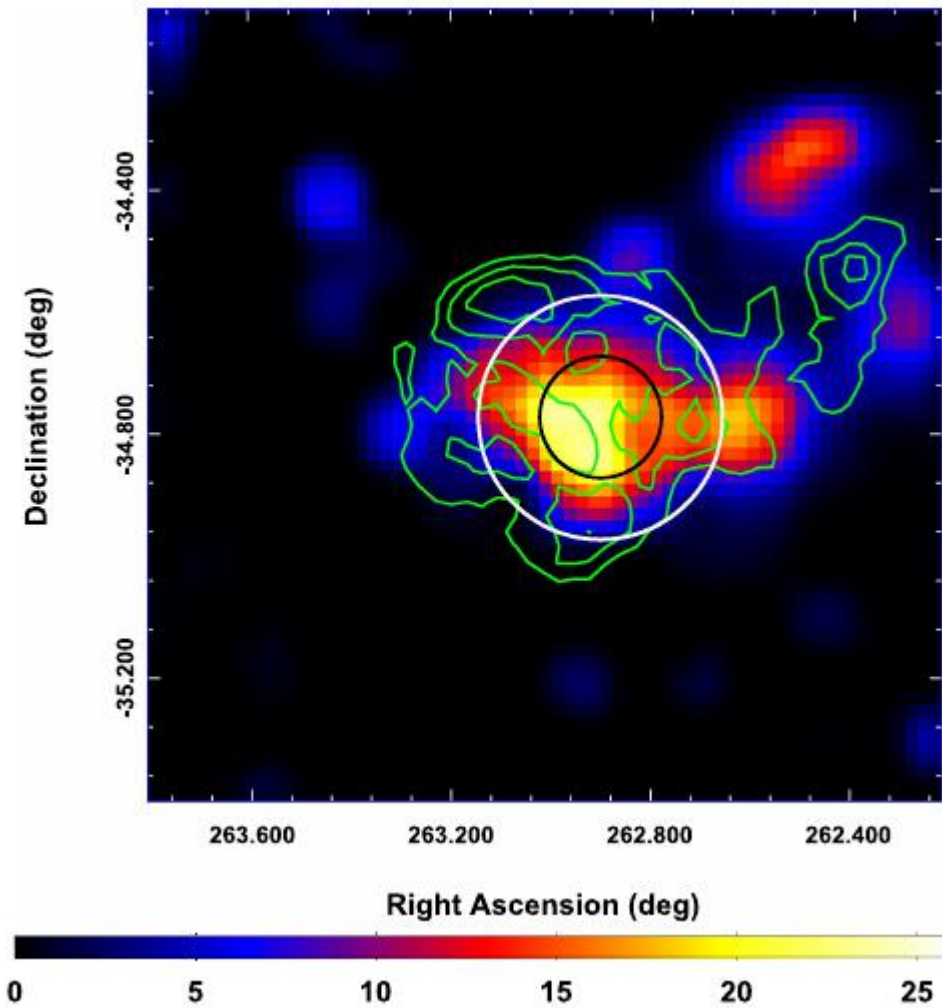
leptonic ?  
or  
hadronic ?



HESS J1729-345:  
MCs illuminated by  
escaped particles ?

Abramowski+ 2011



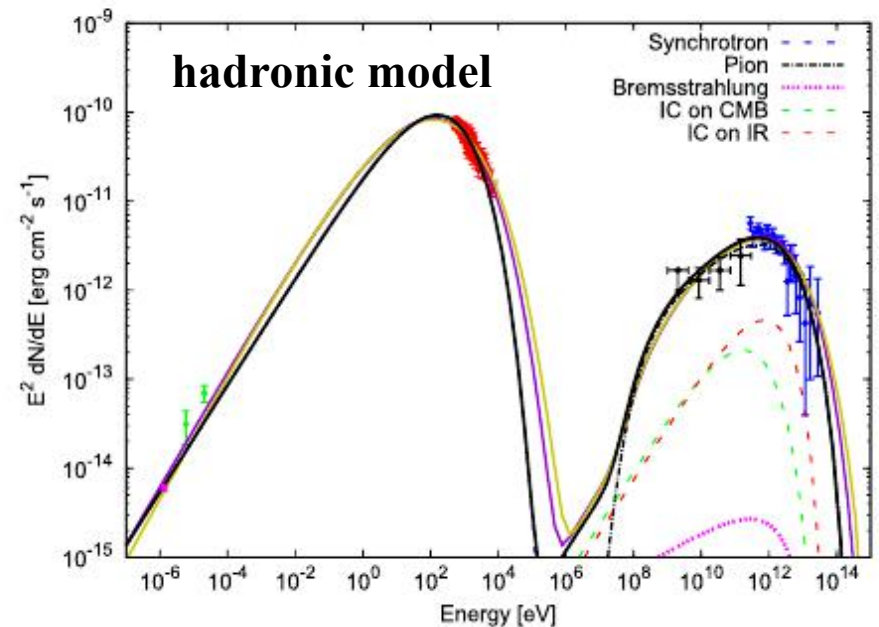
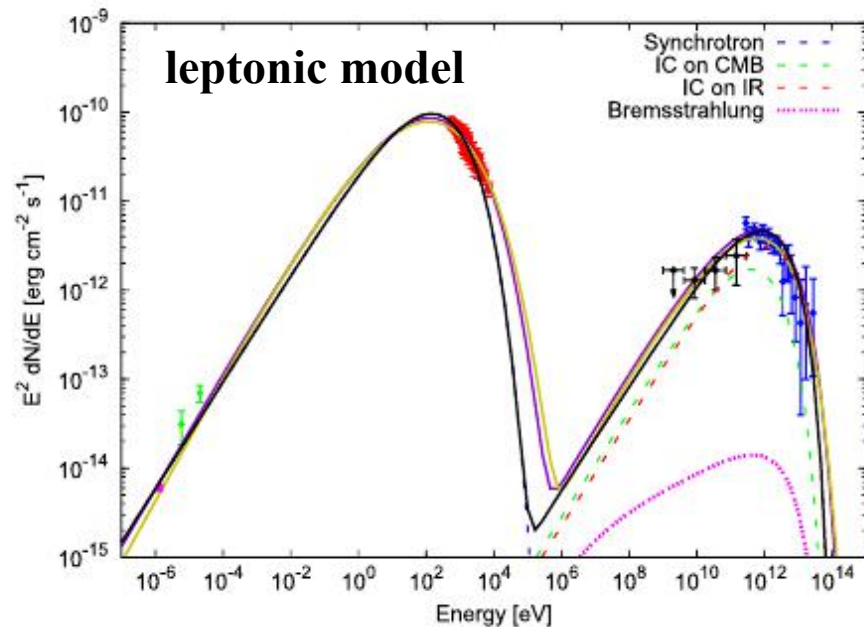


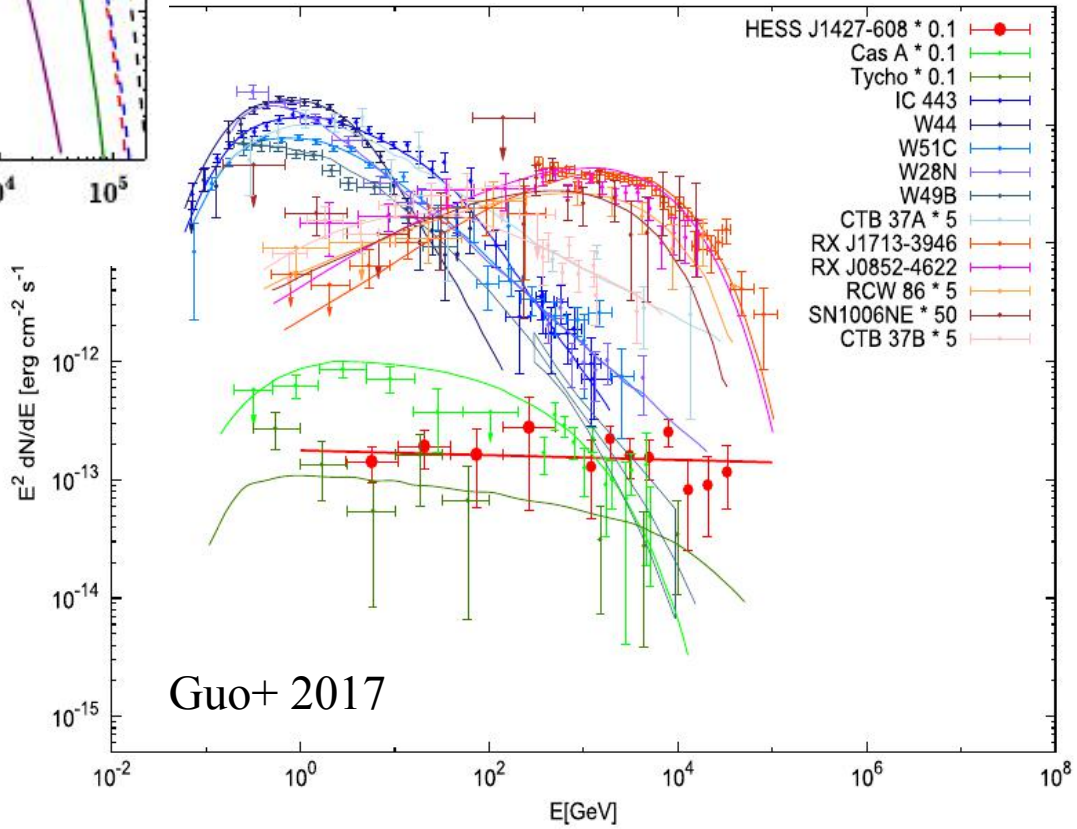
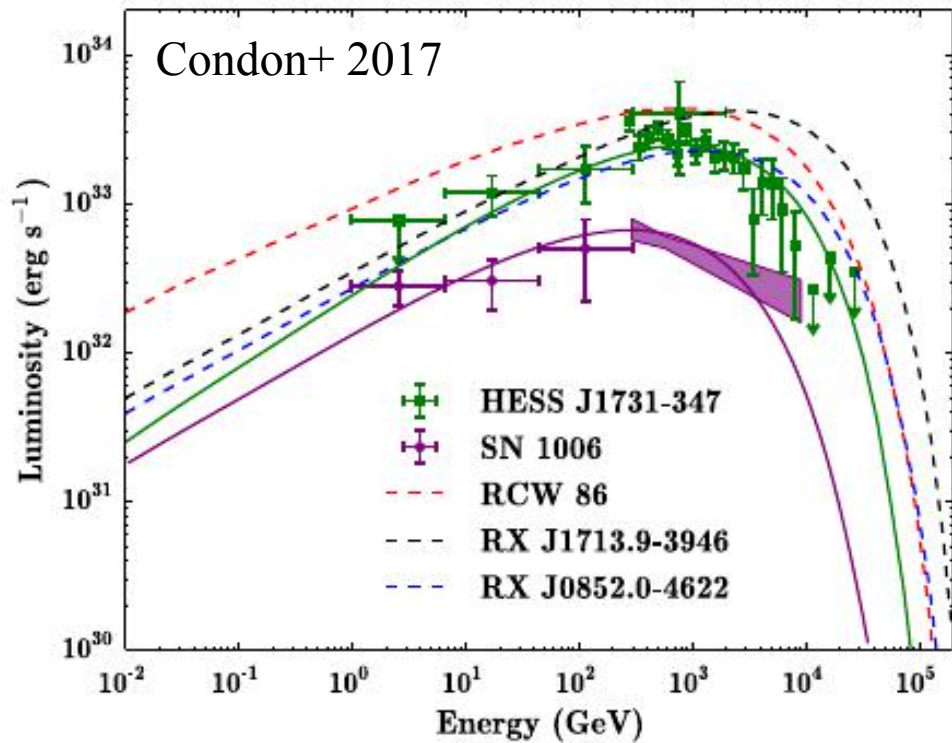
Guo, Xin, Liao, et al 2018

$$dN/dE \propto E^{-\alpha_i} \exp[-(E/E_{c,i})^\delta],$$

Model	$\delta$	$\alpha_p$	$\alpha_e$	$B_{\text{SNR}}$ ( $\mu\text{G}$ )	$W_e$ ( $10^{47}$ erg)	$E_{c,e}$ (TeV)	$W_p$ ( $10^{50}$ erg)	$E_{c,p}$ (TeV)	$\chi^2$
<u>Leptonic</u>	0.5	...	1.6	29.0	1.7	1.2	...	...	529.27/320
	0.6	...	1.7	27.0	2.0	2.8	...	...	428.96/320
	1.0	...	1.8	28.0	1.6	8.9	...	...	406.27/320
Hybrid	0.5	1.5	1.6	85.0	0.35	0.7	1.4	10.0	472.04/317
	0.6	1.5	1.7	87.0	0.35	1.5	1.5	15.0	372.33/317
	1.0	1.7	1.8	80.0	0.3	5.5	1.5	38.0	377.31/317

**Note.** The total energy of relativistic particles,  $W_{e,p}$ , is calculated for  $E > 1$  GeV.

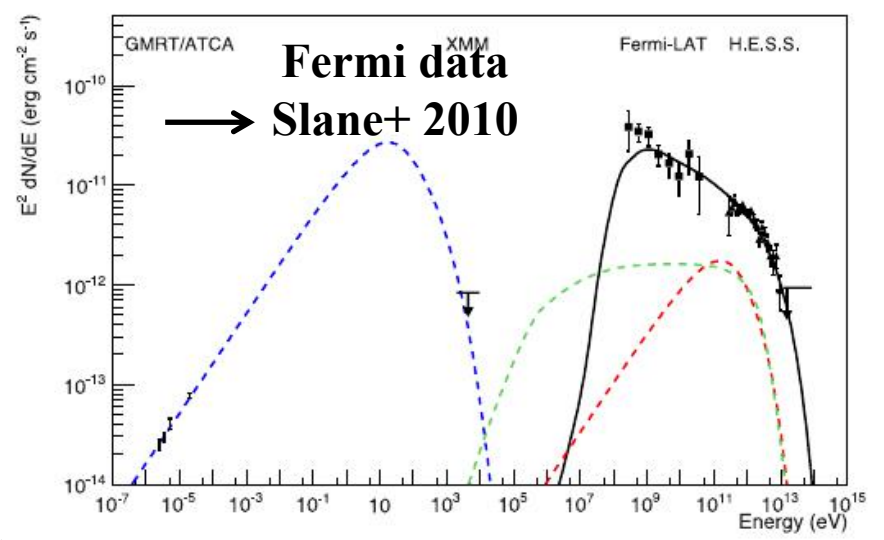
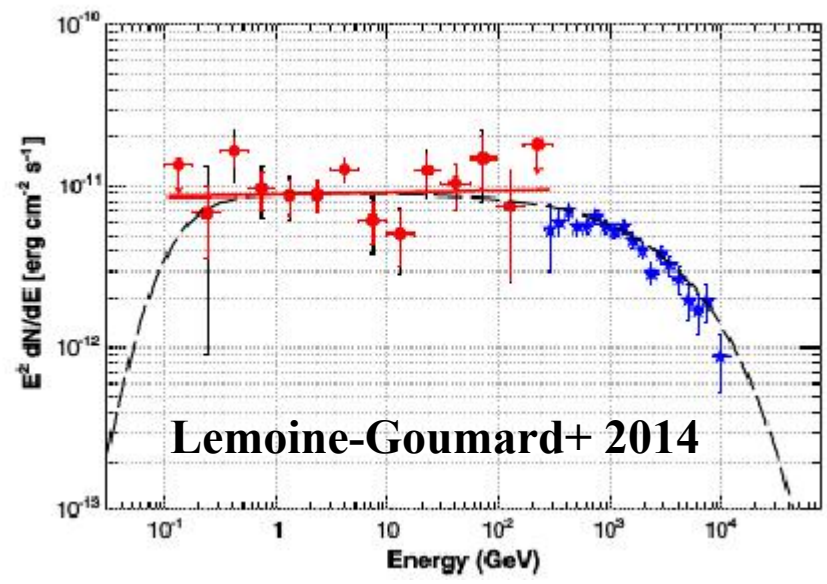
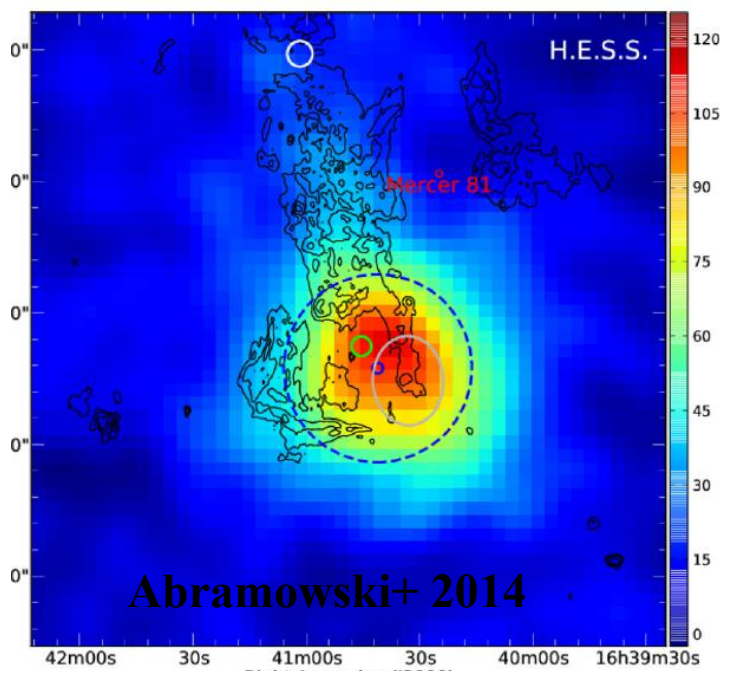
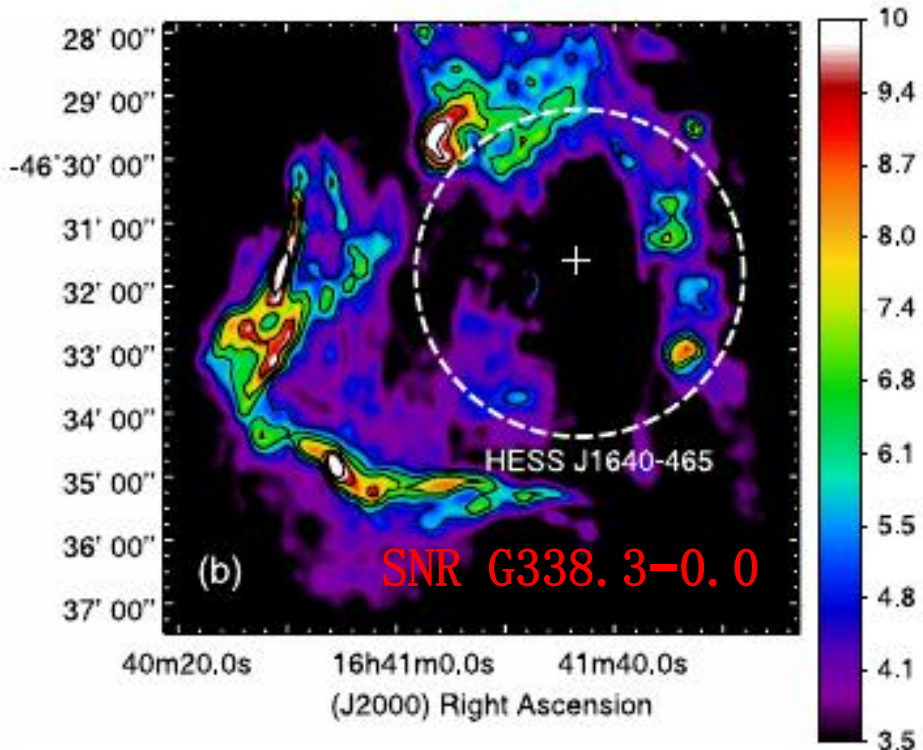


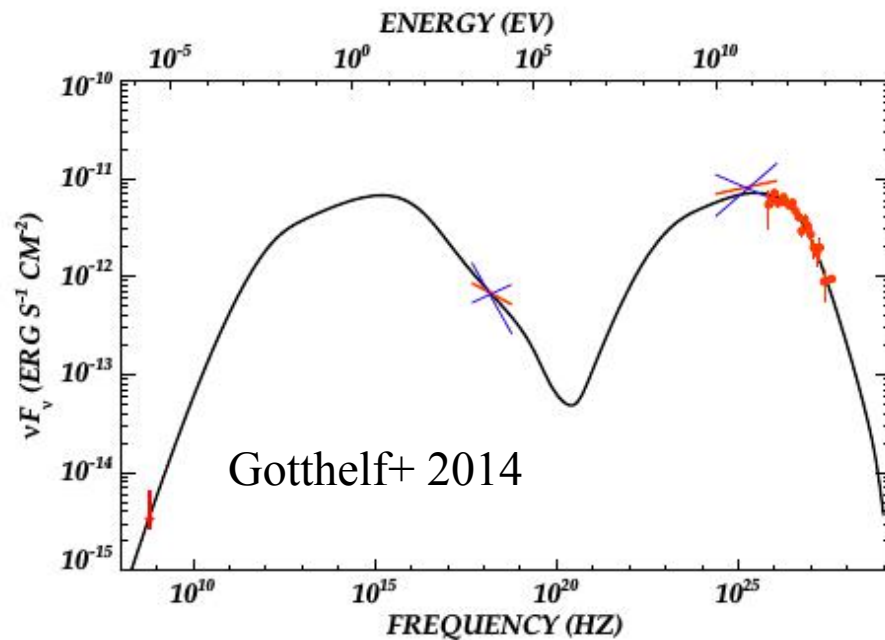
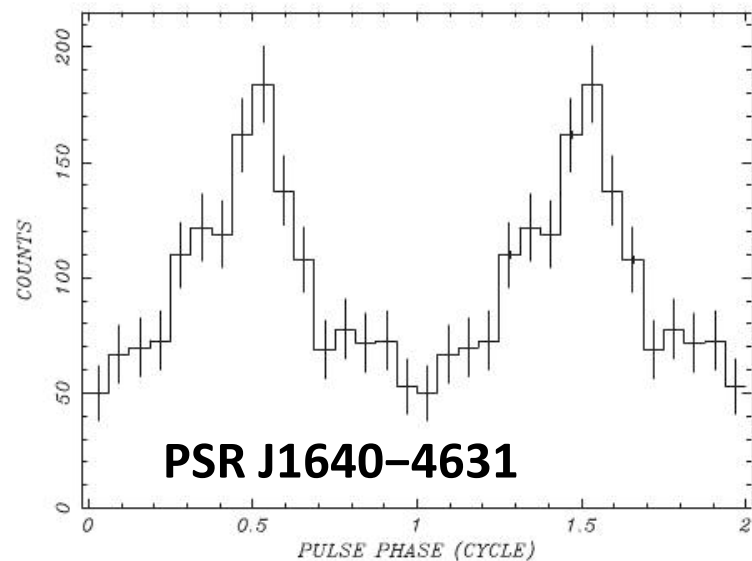
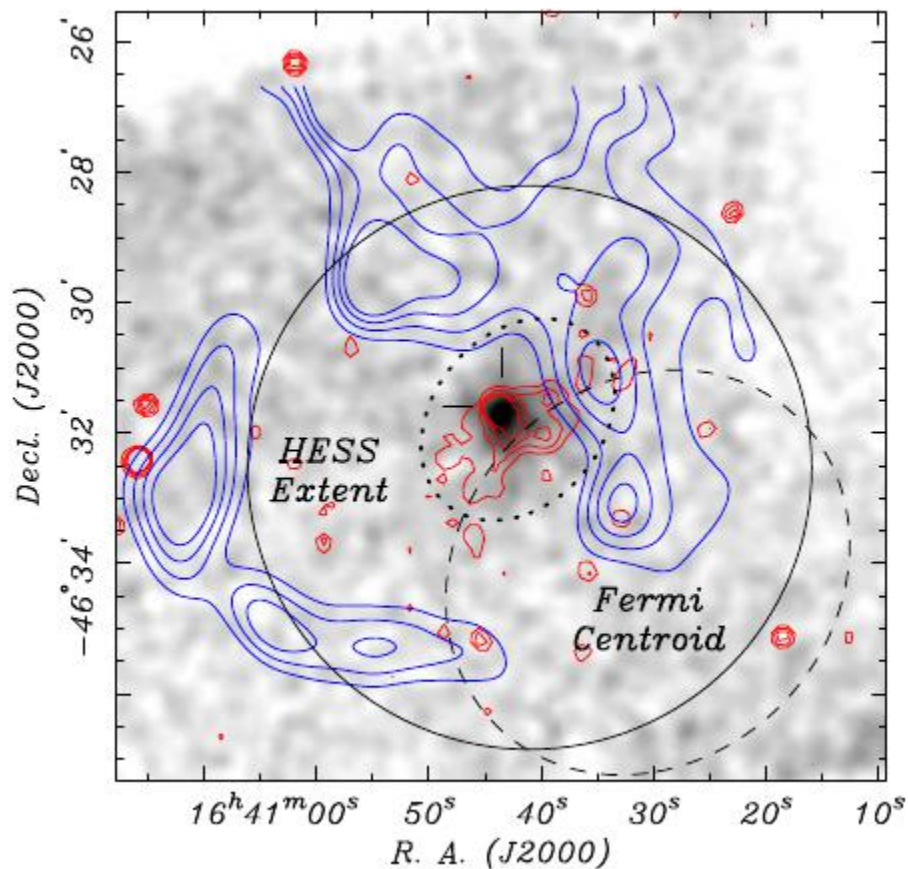


Guo+ 2017



# HESS J1640-465: a exceptionally luminous TeV source



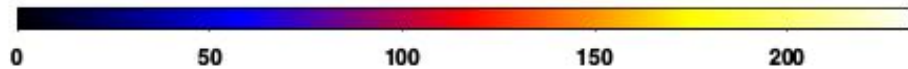
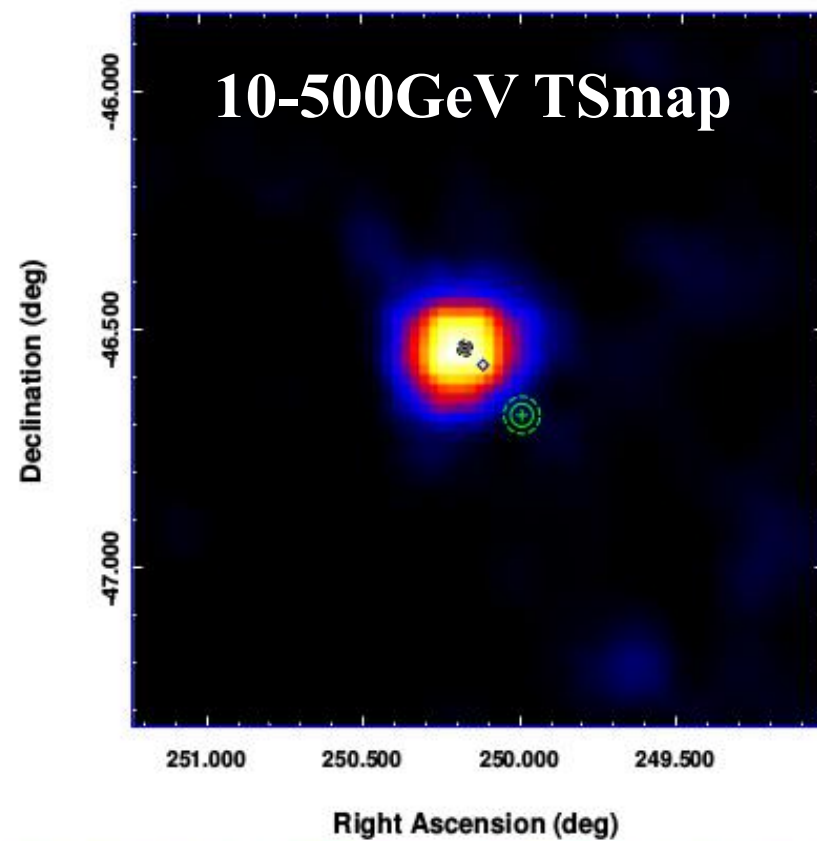
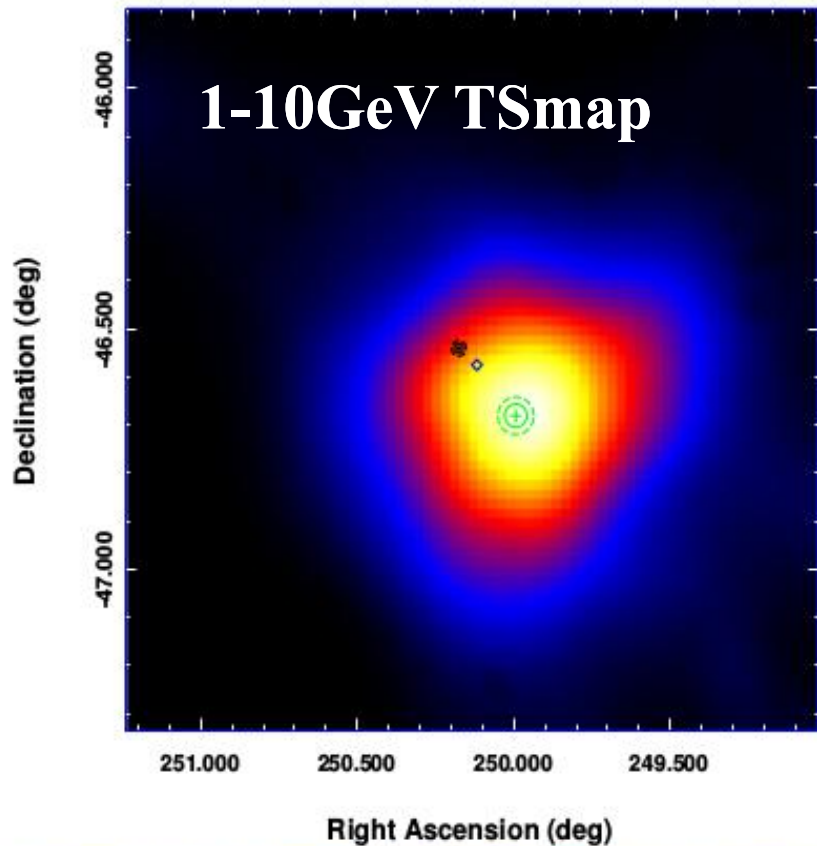


**HESS J1640-465:**

**the shell of SNR G338.3-0.0 ?**

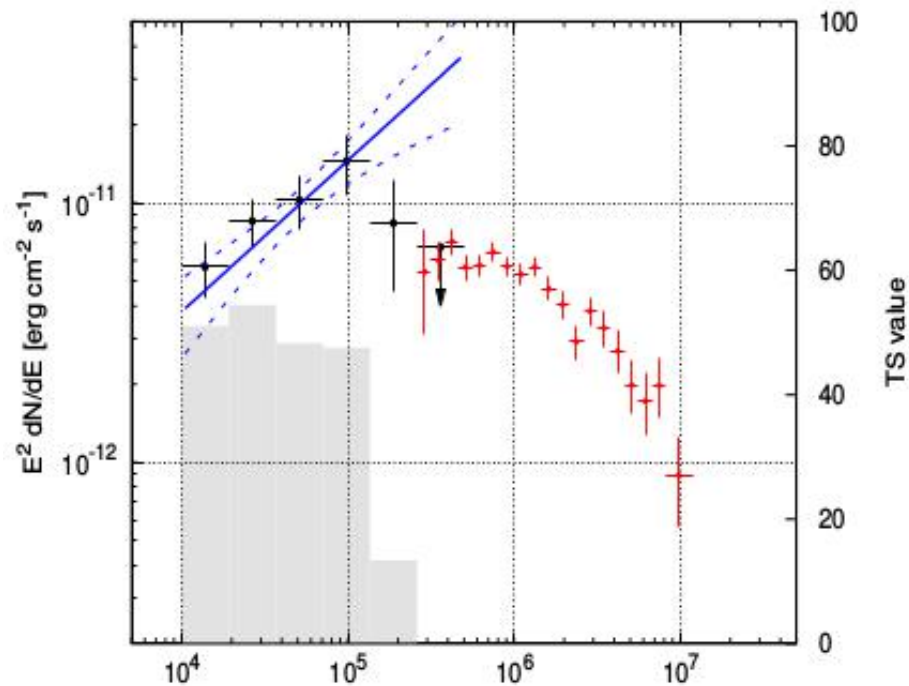
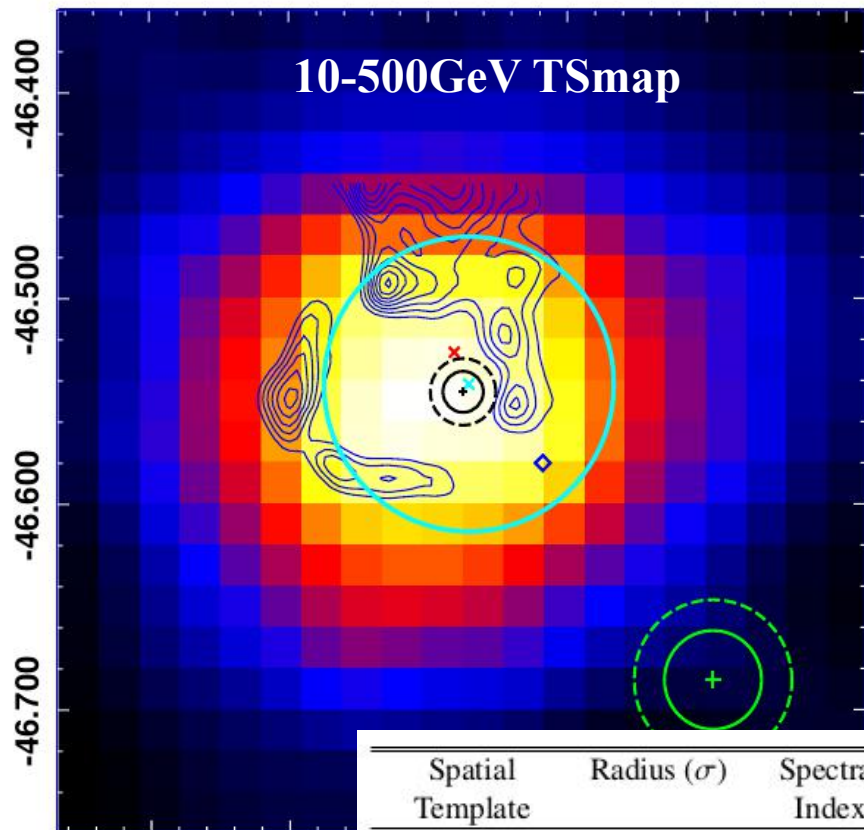
**or**

**the PWN powered by PSR J1640-4631 ?**



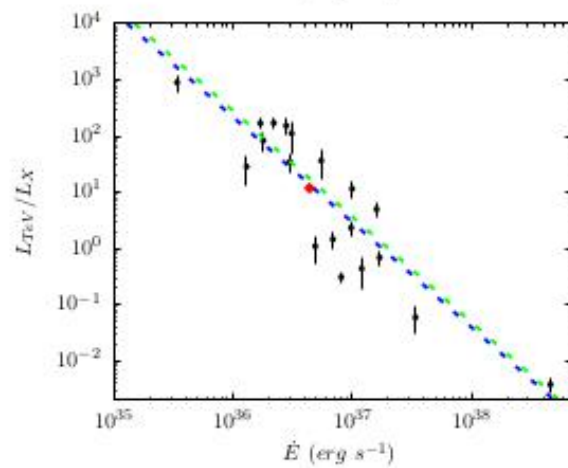
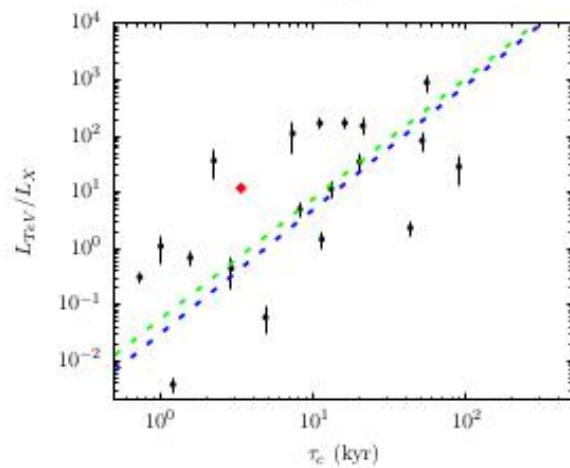
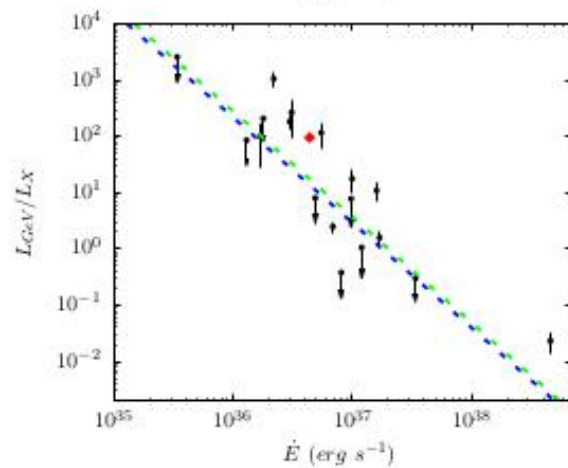
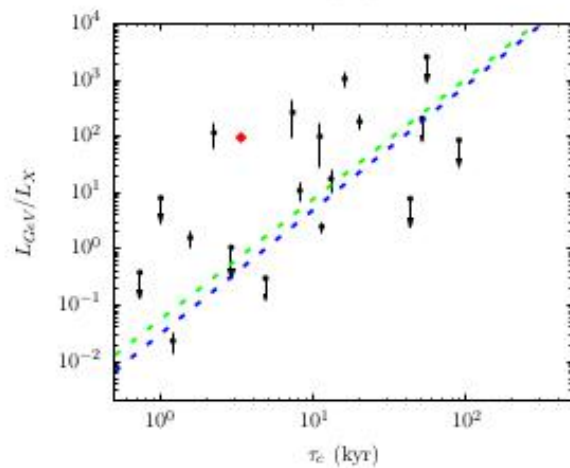
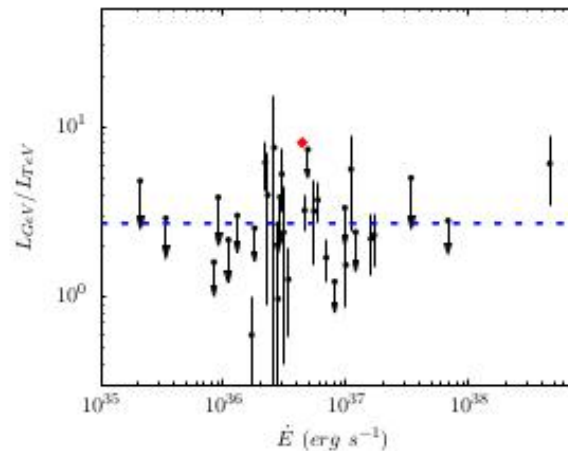
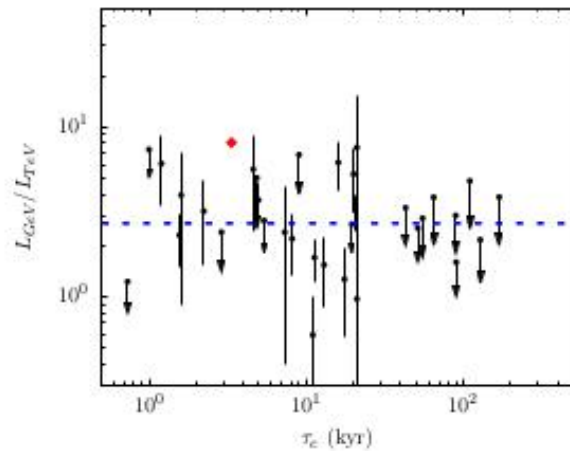
**arXiv: 1802.03520**



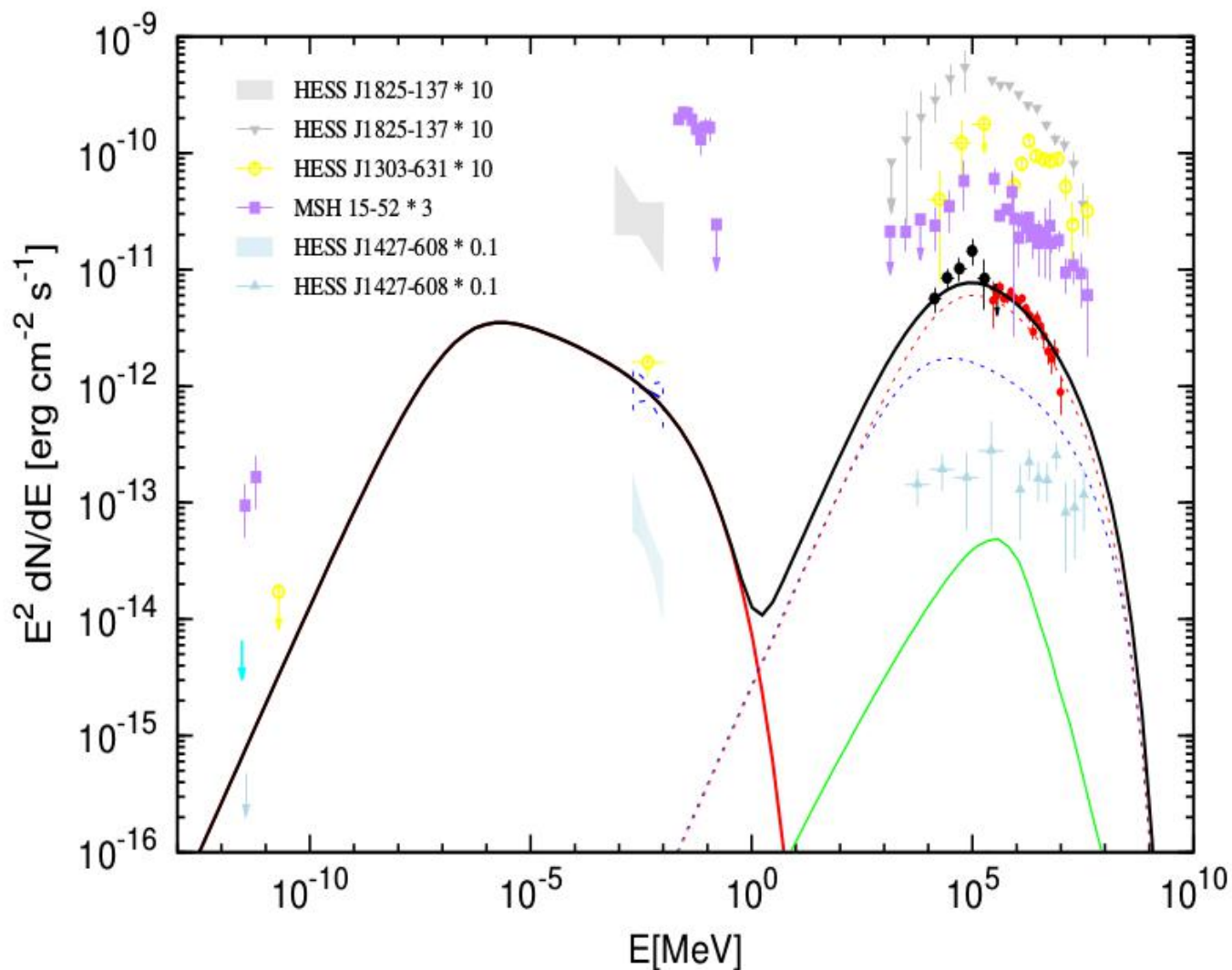


250.400 250.300

Spatial Template	Radius ( $\sigma$ )	Spectral Index	PHOTON FLUX ( $10^{-10}$ ph cm $^{-2}$ s $^{-1}$ )	TS Value	DEGREES OF FREEDOM
Point Source	--	$1.24 \pm 0.22$	$3.03 \pm 0.45$	148.6	4
Uniform disk	$0.05^\circ$	$1.34 \pm 0.20$	$4.97 \pm 0.71$	169.5	5
	$0.06^\circ$	$1.35 \pm 0.20$	$5.10 \pm 0.71$	170.7	5
	$4.3'$ <sup>a</sup>	$1.37 \pm 0.19$	$5.30 \pm 0.72$	172.4	5
	$0.08^\circ$	$1.38 \pm 0.19$	$5.39 \pm 0.72$	172.8	5
	$0.10^\circ$	$1.40 \pm 0.19$	$5.60 \pm 0.73$	173.2	5
	$0.12^\circ$	$1.41 \pm 0.19$	$5.74 \pm 0.73$	172.3	5
2-D Gaussian	$0.05^\circ$	$1.39 \pm 0.19$	$5.52 \pm 0.73$	174.9	5
	$0.06^\circ$	$1.40 \pm 0.19$	$5.64 \pm 0.74$	174.8	5
	$4.3'$ <sup>a</sup>	$1.42 \pm 0.19$	$5.72 \pm 0.73$	174.3	5
	$0.08^\circ$	$1.42 \pm 0.18$	$5.78 \pm 0.74$	173.4	5
	$0.10^\circ$	$1.43 \pm 0.18$	$5.83 \pm 0.74$	171.9	5
	$0.12^\circ$	$1.44 \pm 0.18$	$5.87 \pm 0.74$	170.7	5



$$\frac{dN_e}{dE} \propto \frac{(E/E_{e,br})^{-\gamma_1}}{1 + (E/E_{e,br})^{\gamma_2 - \gamma_1}} \exp\left(-\frac{E}{E_{e,cut}}\right)$$





# Conclusion

- GeV & TeV observations would be helpful to distinguish the different radiation mechanisms/origins for different sources.
- The gamma-ray emission from HESS J1731-347 is favored to be leptonic origin, like RX J1713.7-3946, etc.
- The gamma-ray emission of HESS J1640-465 may originate from the PWN rather than the shell of the SNR.
- More similar TeV sources should be studied by Fermi-LAT and LHAASO.

Thanks for your attention !