HESS J1640.6-4633 HESS J1641.0-4619 : Two intriguing high energy gamma sources in the galactic plan

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Outline

I] Motivation

- Two high energy γ sources
- Angular seperation : 0.25°
- HESS J1640.6-4633 :

  -Extended source (HESS, 0.07°)

  $\rightarrow$ **HESS template used in the previous paper (not in 4FGL) but TS_{ext} not significant**

  -Coinciding with SNR 338.3-0.0 $\rightarrow \sim$ 11 kpc (HI abs) and associated plusar PSR J1640-4631 :

  $\tau_c = 3350$ years and $\dot{E}$=$4.4 \times 10^{36} erg\ s^{-1}$

  •Slane et al. 2010 : soft spectrum ($\Gamma = 2.3$)

  •MLG 2014 : harder ($\Gamma = 1.99$) after *J1641.0-4619* detection

  Proton accelerator ?

Motivation-2

- HESS J1641 :
  -Point source (HESS and Fermi)
  -Coinciding with SNR G338.5+0.1 and a dense HII region G338.4+0.0
  -Very hard spectrum at TeV energy (HESS, Γ=*2.0*)

⇒**Pevatron candidate (HESS TeV obs)**

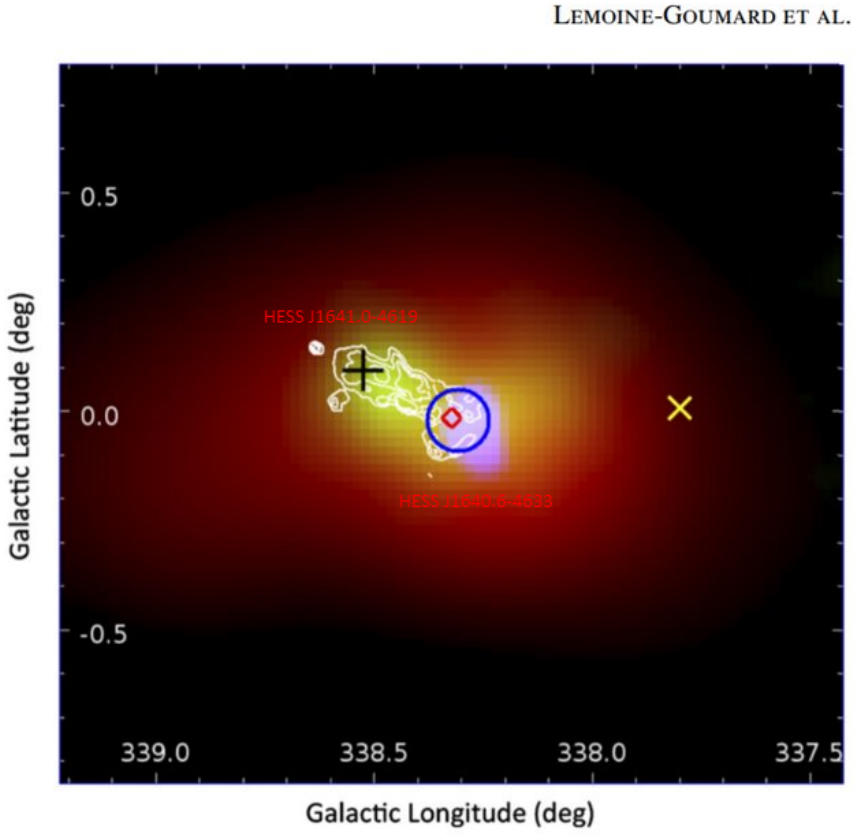


Figure – TS map

II] Localisation

Position and extension analysis : *FermiPy V 0.17.3*

Requirements	
Zenith angle	$<90^\circ$
Energy	1 GeV-800 GeV
roi	10°
sources	4FGL
J1640	Point source
J1641	Point source

isotropic :
*isotropic_8YP305_P8R3_SOURCE_V2*zmax80_v7_YB01_interp2.txt*
Galactic :
test_model_InnerGalaxyYB01_test512_interp_noCO9.fits

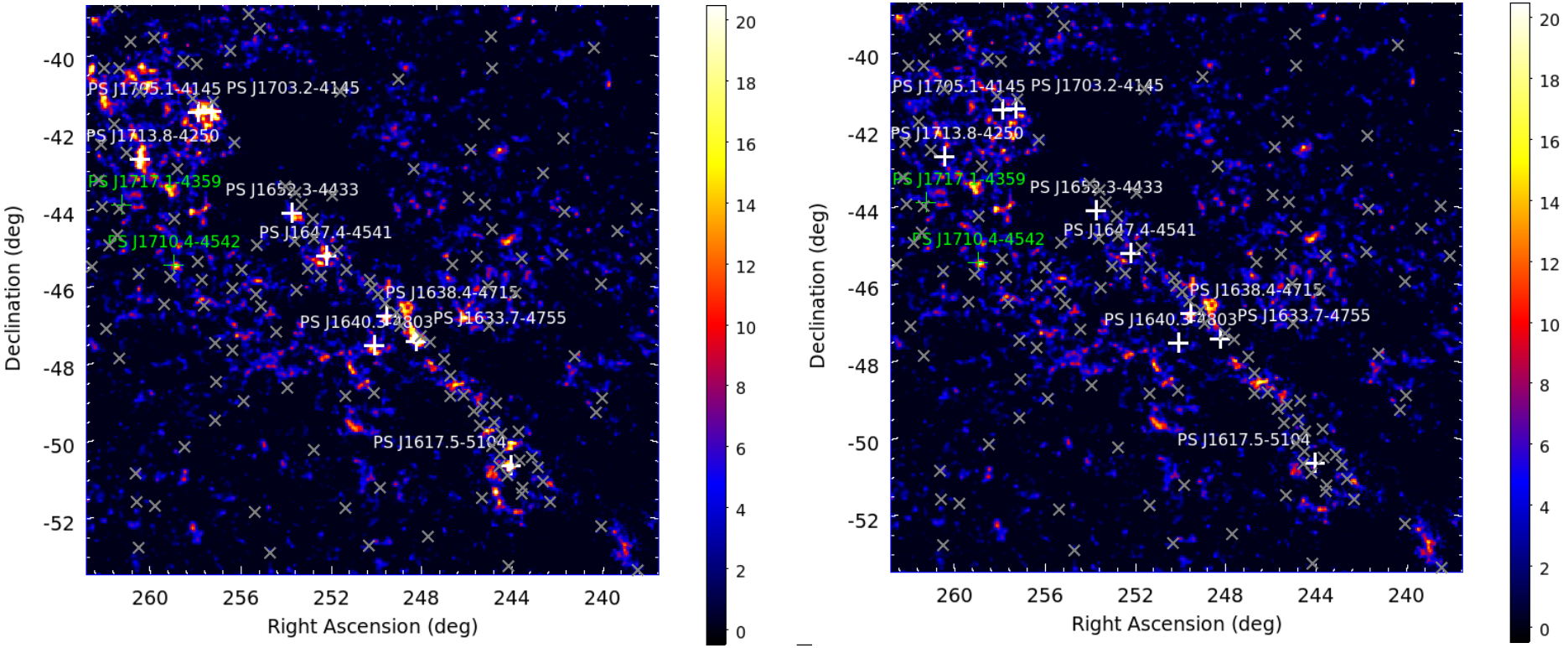
Localisation-2

HESS J1640.6-4632	
4FGL	FermiPy
RA : 250.165	RA : 250.18 $\pm$ 0.01 $^\circ$
DEC : -46.5452	DEC : -46.56$\pm$ 0.01 $^\circ$

HESS J1641.0-4619	
4FGL	FermiPy
RA : 250.255	RA : 250.2529 $\pm$ 0.0094 $^\circ$
DEC : -46.3233	DEC : -46.297$\pm$ 0.096 $^\circ$

"new" sources appear during the analysis :
sources with TS>16 (E> 1 GeV) which became TS $\geq$ 25 after fiting=> significant

Best sources model E> 1 GeV



Residual TS map of the region centering on HESS J1640 before (left) and after adding sources (right).

Grey cross : 4FGL, white cross : 1 GeV sources, green cross : 100 MeV sources

Added sources

Most of these sources were seen before the 4FGL but seem to have disappear.

Added sources (E>1 GeV)

Source name	TS	Index
PS J1617.5-5104	TS=33.7	Gamma= 1.89±0.13
PS J1633.7-4755	TS=87.2	Gamma= 2.74±0.17
PS J1638.4-4715	TS=32.73	Gamma= 2.58± 0.22
PS J1640.2-4803	TS=49.53	Gamma=3.13 ±0.31
PS J1647.4-4541	TS=31.22	Gamma= 2.23 ± 0.72
PS J1652.3-4433	TS=54.30	Gamma=2.820 ±0.15
PS J1703.2-4145	TS=46	Gamma= 3 ± 0.5
PS J1705.1-4145	TS=31.61	Gamma=2.1 ± 0.2
PS J1708.8-4007	TS=59	Gamma=3.07 ± 0.25

III] Extension

Estimation of the extension of J1640 using the new position and adding new sources.

Model comparaison for HESS J1640.6

Model	N_{dof}	Likelihood	ΔTS (point vs model)
Point (estimated)	4	-196791.96	/////
2D Gauss	5	-196772.48	39.5
HESS	2	-196773.48	37

For the first time, we saw the extension of J1640 using the Fermi LAT data.

No significant extension for J1641 : $TS_{ext} = 4.9$

Loglike profil for the extension of J1640

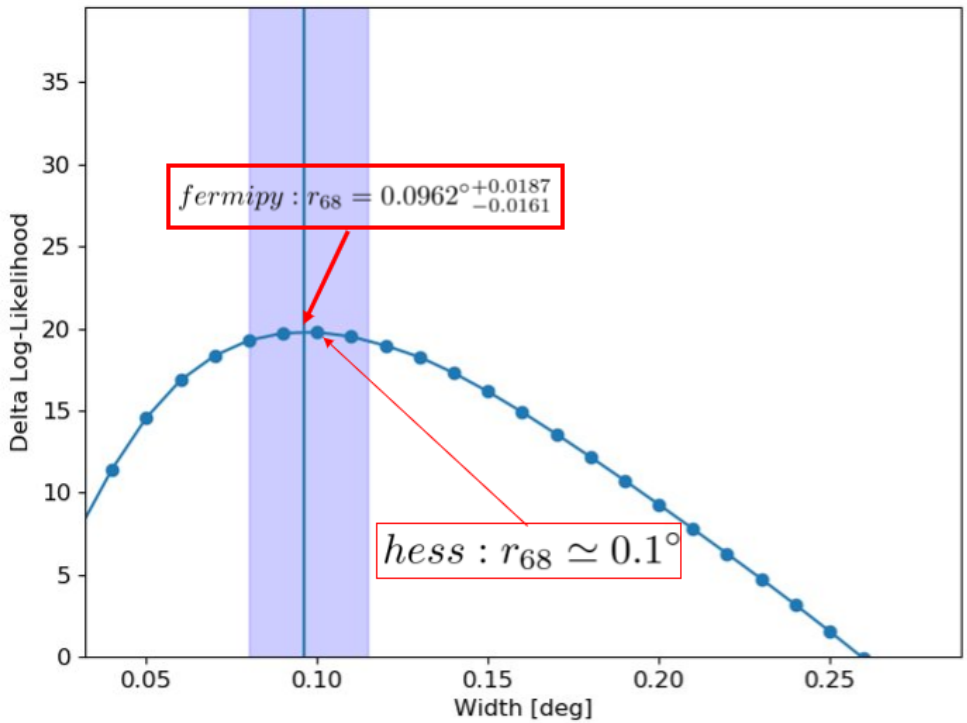
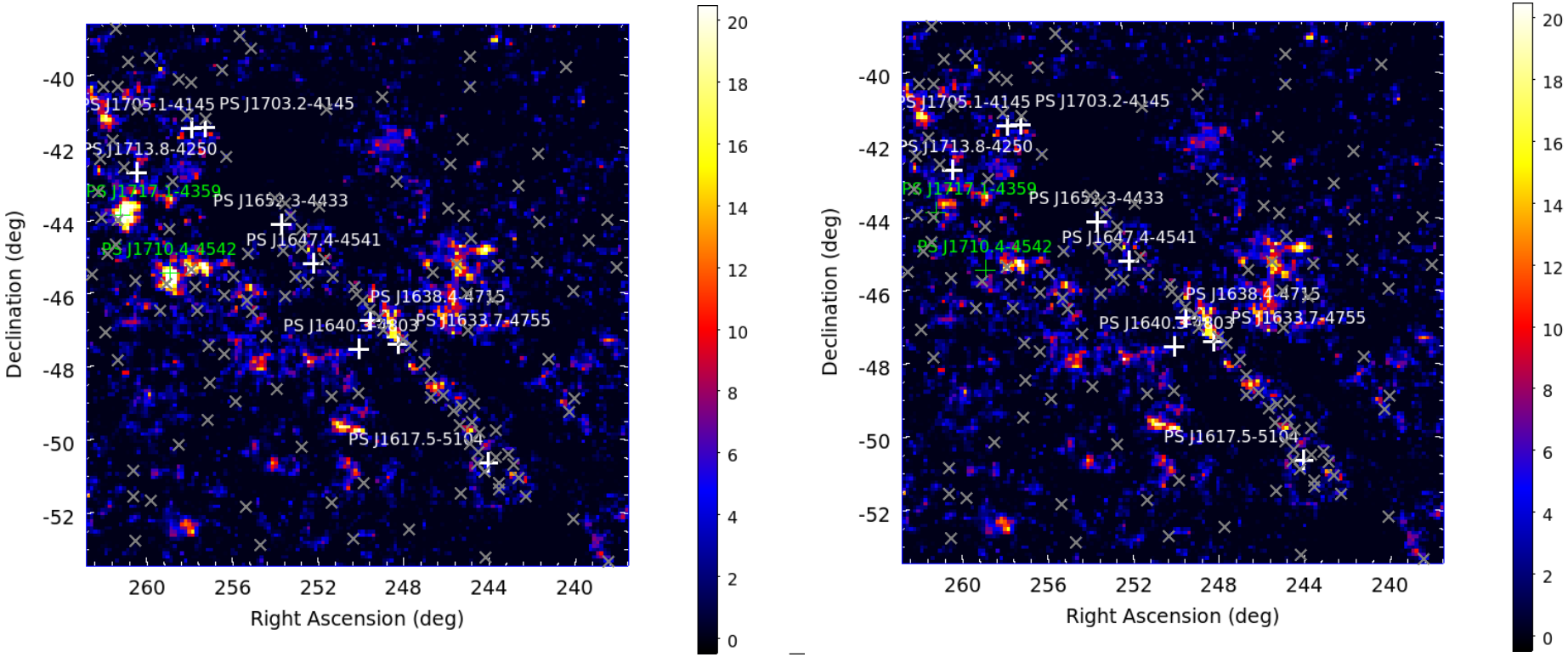


Figure – Evolution of the likelihood with the extension

Extension $\sim 0.064^{\circ}$ measured with fermiPy above 1 GeV
$\rightarrow$ better than HESS template but not in a significant way
we use HESS extension and position (less degrees of freedom)

Best source model E > 100 MeV



Residual TS map before (left) and after adding sources (right).

Grey cross : 4FGL, white cross : 1 GeV sources, green cross : 100 MeV sources

The sources added at 100 MeV were found by seaching area with TS > 25 before fiting them.

Added at 100 MeV :

- PS J1710.4-4542
- PS J1717.1-4359

Spectrum analysis

Selection requirements	
9 years *pass8* data	August 2008 – January 2017 (*Jean's P305 files*)
Zenith angle	$<90°$
Energy	200 MeV-1 TeV
roi	$12°$
	Free : $3.5°$ from center
Sources from 4FGL	$12°$ if variable source
	else fix sources up to $20°$
J1640	*HESS 2D gaussian* ($0.07°$) (*following MLG et al.2014*)*
J1641	Point source

summed likelihood binned analysis using gtlike (*SCTOOLS 11-07-00*)

Spectrum model

Model comparaison : 100 MeV - 1 TeV

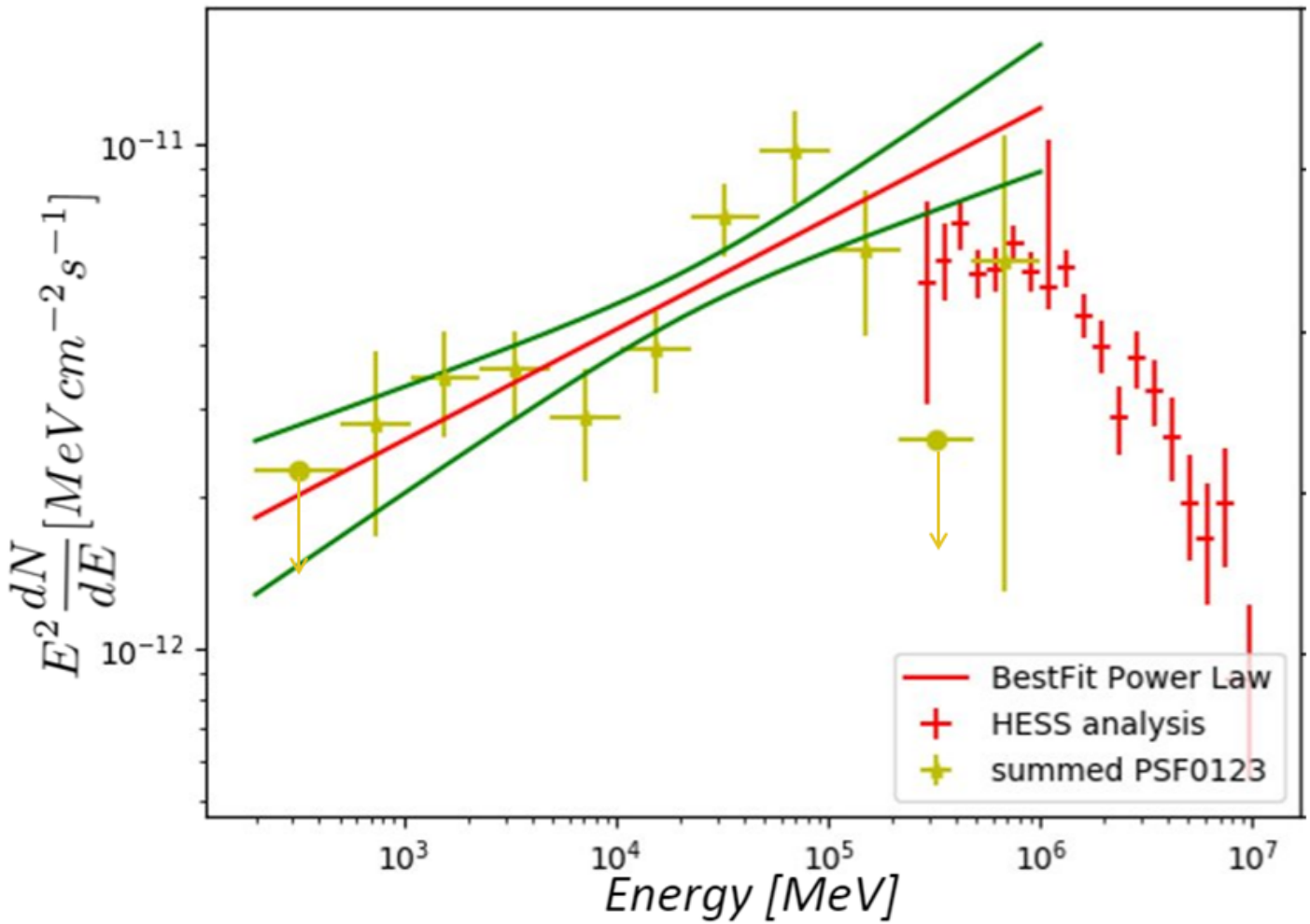
J1640	J1641	DoF	$\Delta\ TS_{model-PLPL}$
PowerLaw	PowerLaw	4	////
PowerLaw	LogParabola	5	18.18
LogParabola	LogParabola	6	25.66

LP instead of PL for J1640 : $\sim 4\sigma \Rightarrow$ significatif

2LP is not significatif : TS<9 compared to PL-LP

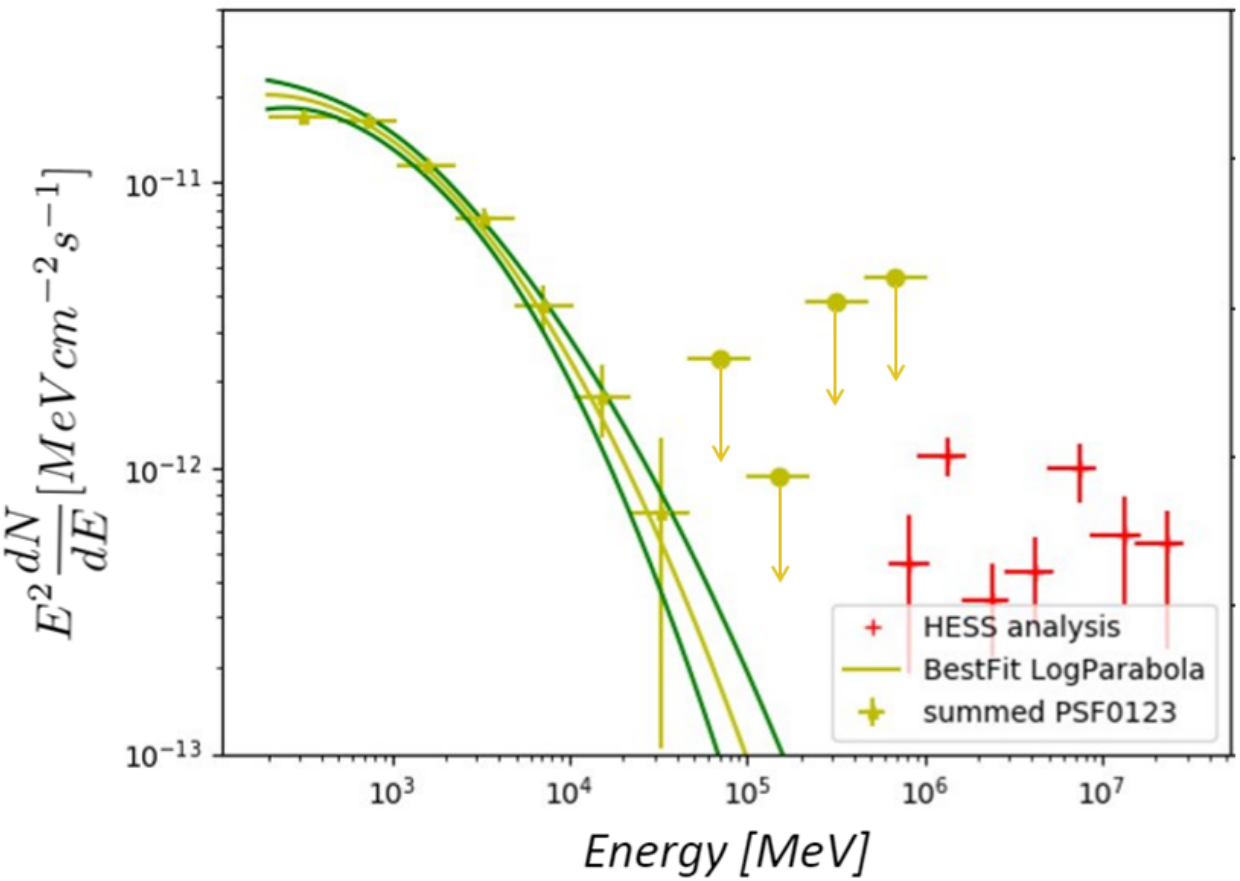
Spectral Energy Distribution : HESS J1640.6-4633

J1640 as PL : 100 MeV-1 TeV	
TS	232.42
Energy flux	4.56e-11 $erg/cm^2/s$
Index	$1.775^{+0.079}_{-0.068}$

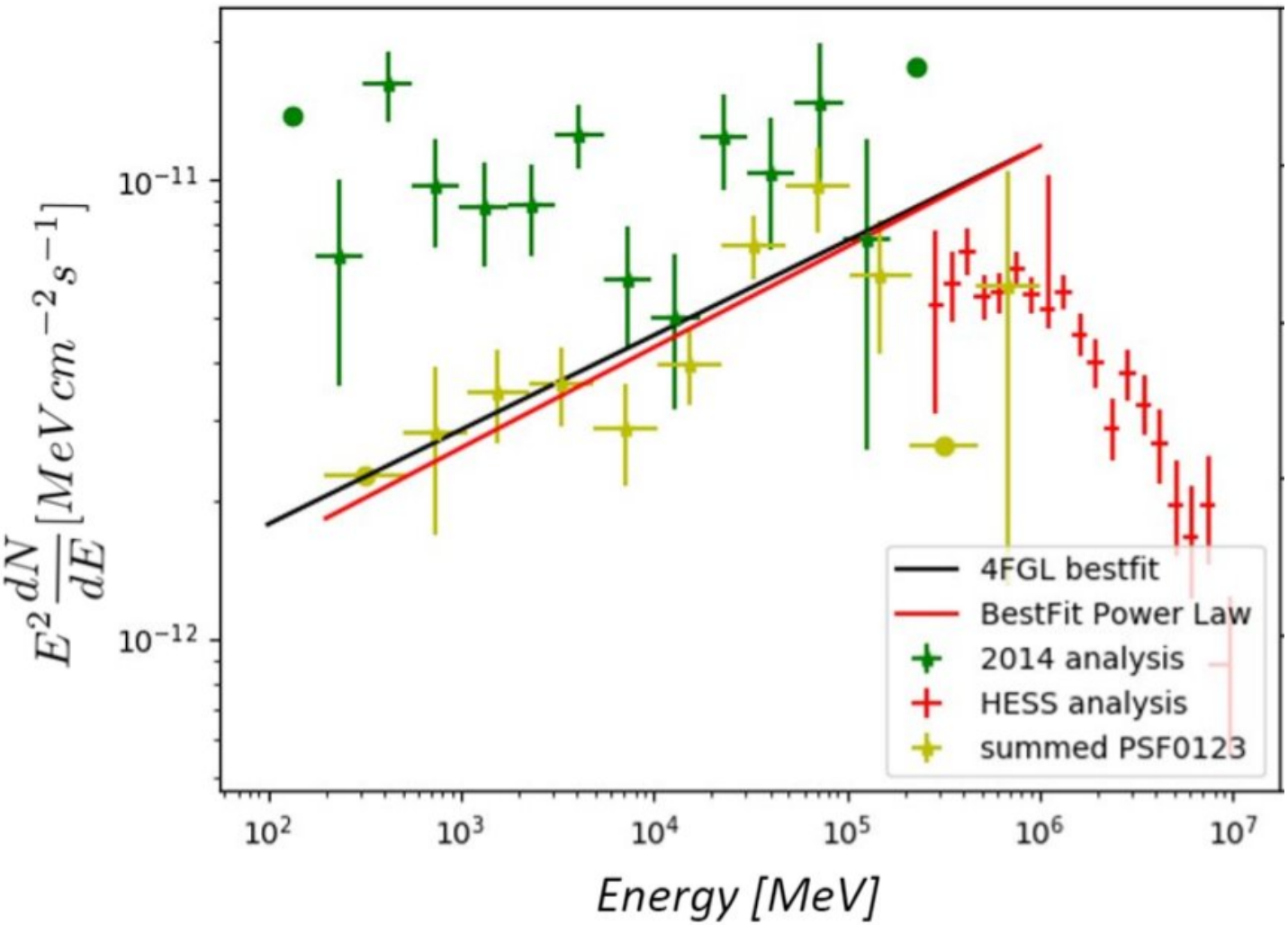


Spectral Energy Distribution : HESS J1641.0-4619

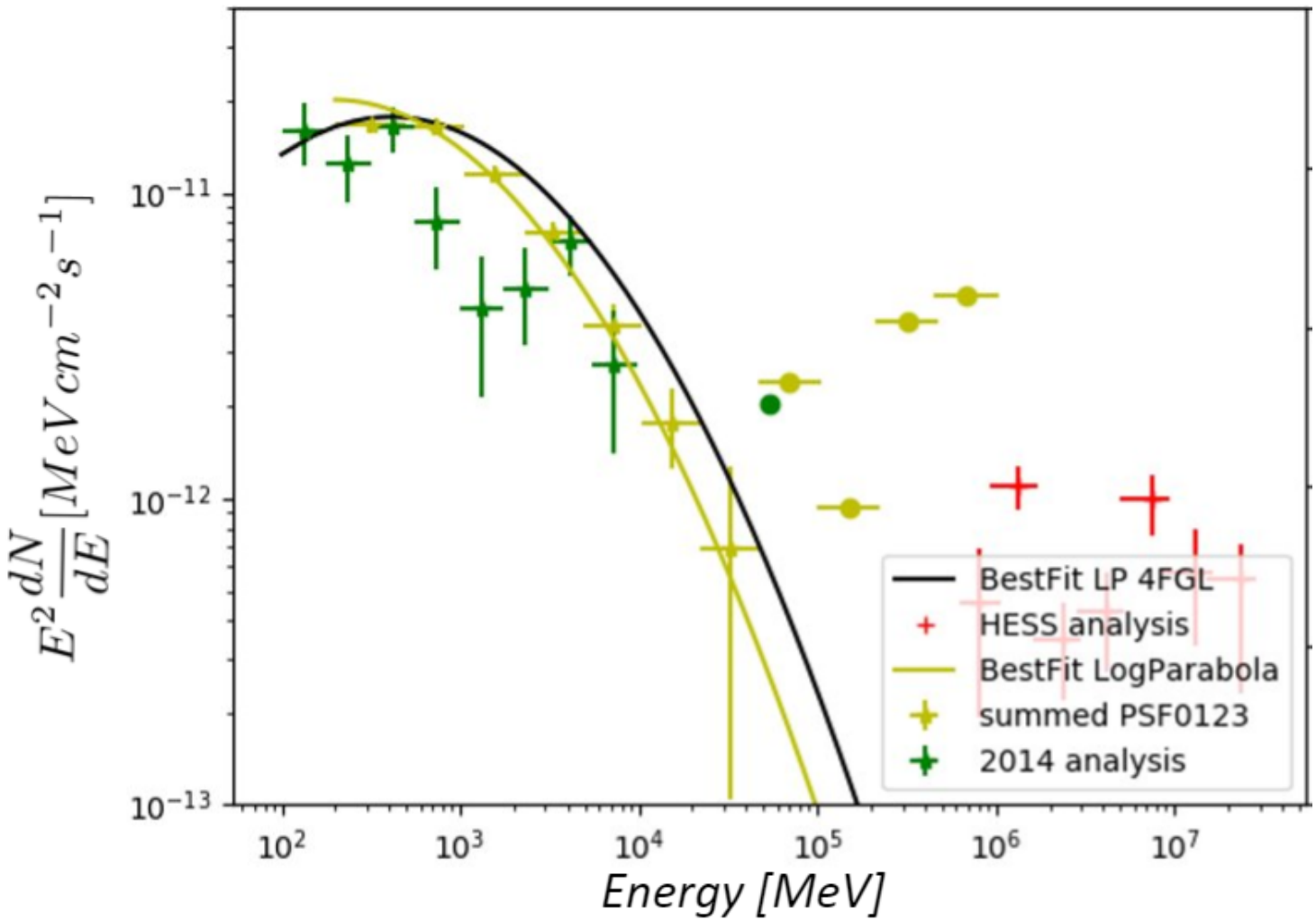
J1641 as LP : 100 MeV-1 TeV	
TS	807.98
Energy flux	4.74e-11 $erg/cm^2/s$
Alpha	$2.771^{0.089}_{-0.085}$
Beta	$0.148^{0.08}_{-0.09}$



V] 4FGL expectation



4FGL expectation : HESS J1641



Then and now

For HESS J1640.6-4632 :

MLG et al 2014 : $\Gamma = 1.99 \pm 0.04$

4FGL : $\Gamma = 1.79 \pm 0.07$

2019 : $\Gamma = 1.78 \pm 0.07$

For HESS J1641.0-4619 :

MLG et al 2014 : $\Gamma = 2.47 \pm 0.05$

4FGL : $\alpha = 2.569 \pm 0.073$, $\beta = 0.143 \pm 0.046$

2019 : $\alpha = 2.77 \pm 0.08$, $\beta = 0.148 \pm 0.08$

VI] Conclusion

New analysis :

- Good agreement betwen our analysis and the 4FGL
- For J1640 :
  - First time detection of the extension with the LAT.
  - Stable SED above 1 GeV, harder index ($\Gamma = 1.77$).
- For J1641
  - Point source
  - plusar-LAT like SED
  - Pevatron candidate (HESS)

VI] Perspective

- negative holes in the residual map $\Rightarrow$ new diffuse model ?
- Investigate the possible variability of HESS J1641 and look at other wavelength counterpart to constrain the type of source
- pulsation research on HESS J1641.0-4619
- submission of an **ICRC** abstract :

  http ://confluence.slac.stanford.edu/pages/viewpage.action ?pageId=243092742
- draft will be ready for this summer