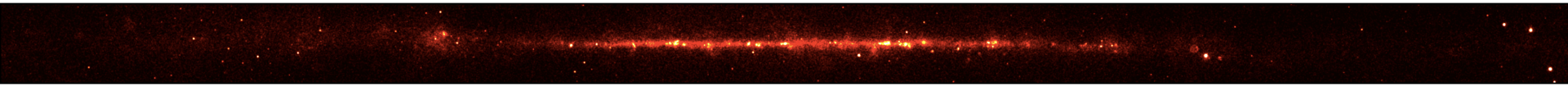
New Extended GeV Sources in the Galactic Plane Found using 6 years of Fermi-LAT Pass 8 data

(Ackermann, M. et al. 2017, ApJ, 843, 139)



Marie-Hélène GRONDIN[1], Jamie COHEN[2,3], Liz HAYS[2,3], Marianne LEMOINE-GOUMARD[1]

on behalf of the Fermi-LAT collaboration

[1] *CENBG, IN2P3/CNRS, Bordeaux, France ;*

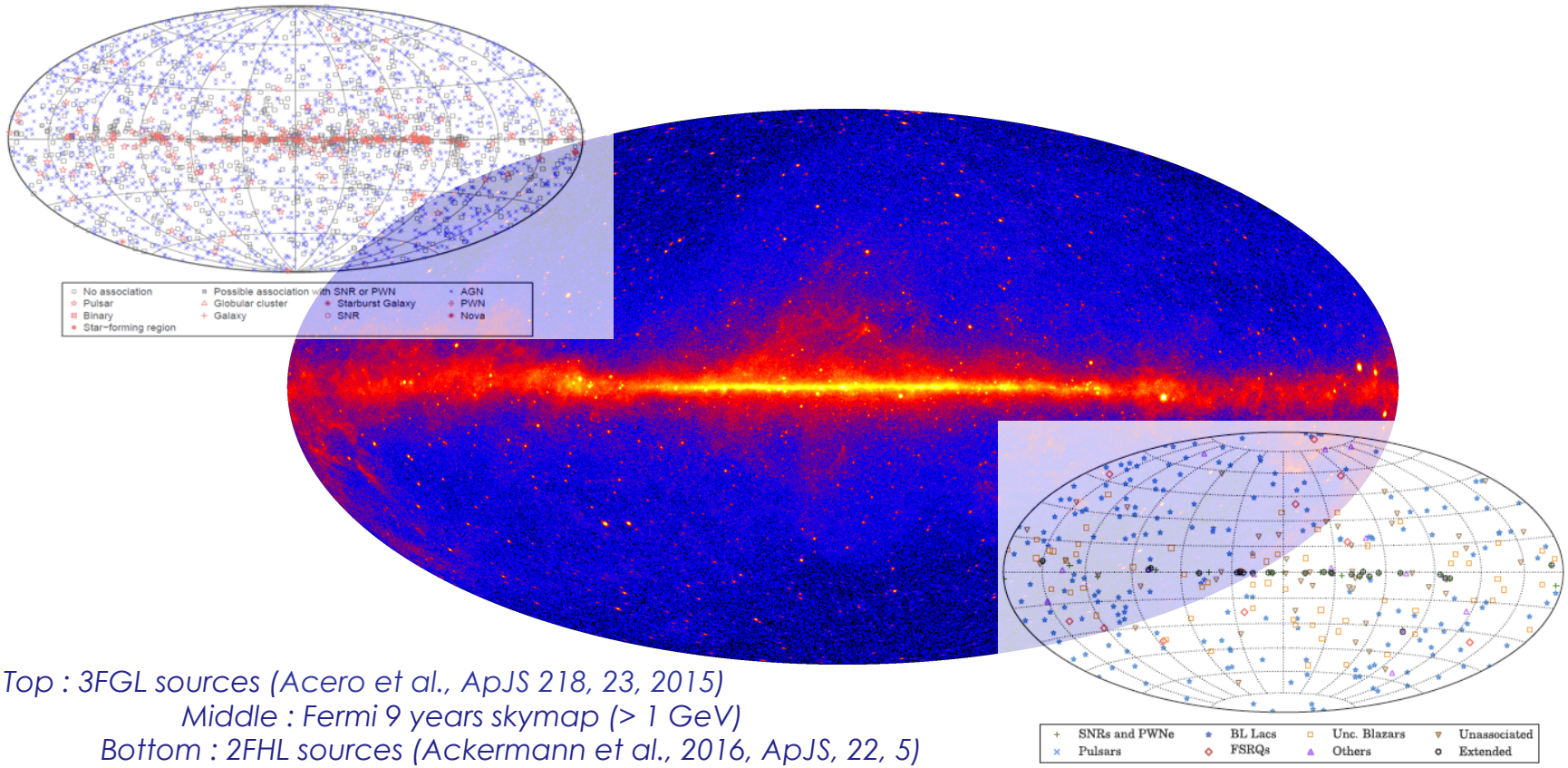
[2] *NASA GSFC, Greenbelt, MD, USA ;* [3] *University of Maryland, College Park, MD, USA*

– 7th International Fermi Symposium –

Garmisch-Partenkirchen, Germany, October 2017

Where do we start from ?

Catalog name	Period (months)	Energy range	Reconst.	# of sources	# of ext. sources
2FGL	24	>100 MeV	Pass7	1900	12
3FGL	48	>100 MeV	Pass7	3033	25
2FHL	80	>50 GeV	Pass8	360	31



Top : 3FGL sources (Acero et al., ApJS 218, 23, 2015)
Middle : Fermi 9 years skymap (> 1 GeV)
Bottom : 2FHL sources (Ackermann et al., 2016, ApJS, 22, 5)

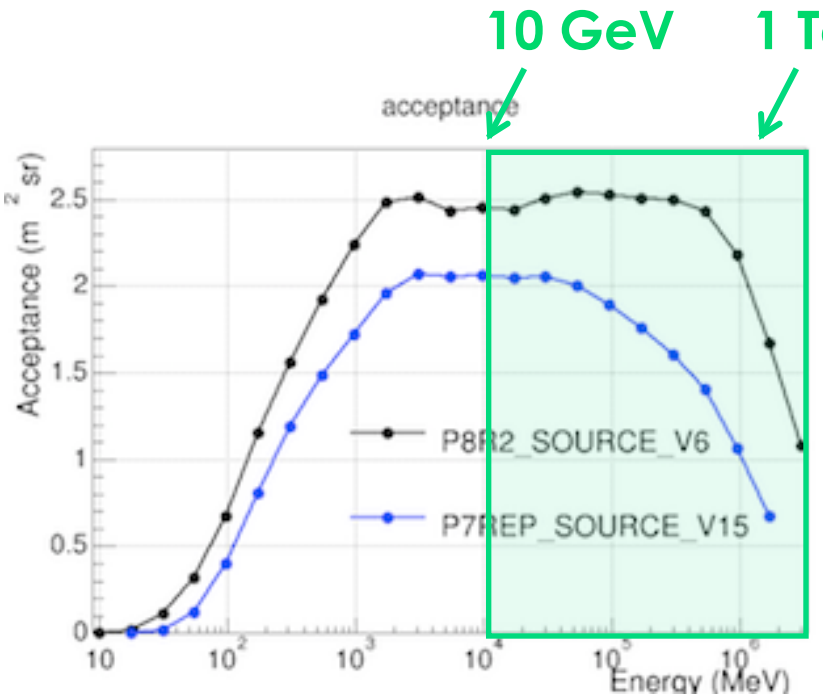
Latest reconstruction : Pass 8

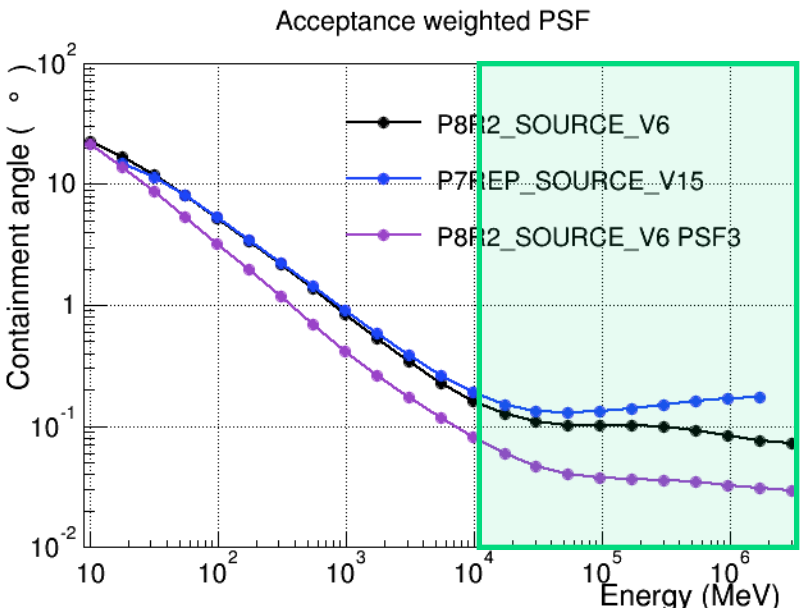
(Atwood et al., arXiv:1303.3514)

- Data public since 2015

- Acceptance:
  - multiplied by ~2 at 100 MeV
  - Improvement by ~30% at 1 GeV

- Angular resolution :
  - clear improvement above 10 GeV



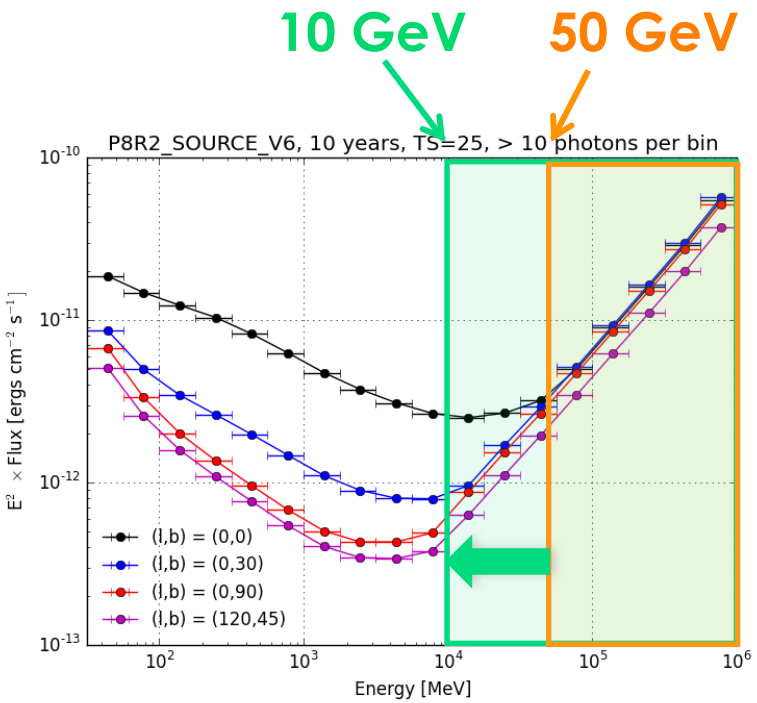


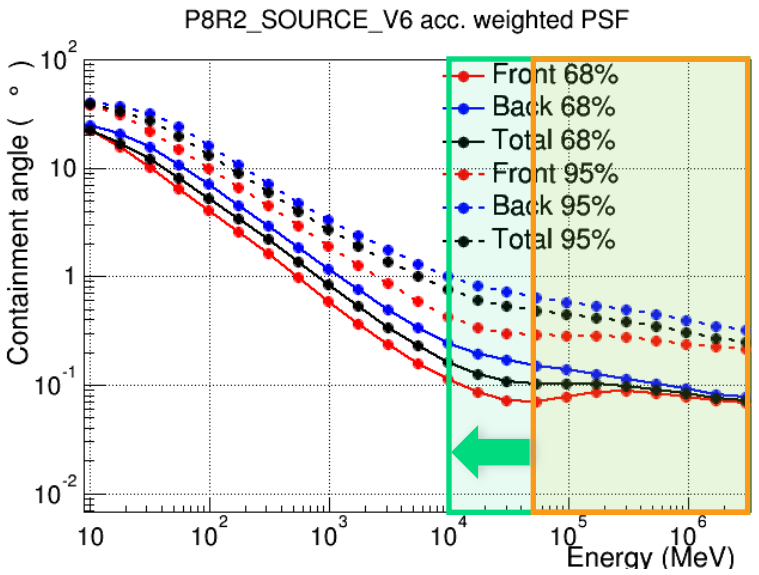
Lowering the energy threshold

Going down from 50 GeV (2FHL) to 10 GeV (this work) :

- Enhanced sensivity => more statistics
  (650000 in the whole sky, **~10x more photons**)
- **Still good angular resolution**
  (0.11°, 68% containment angle)

=> high capability to resolve and detect extended sources

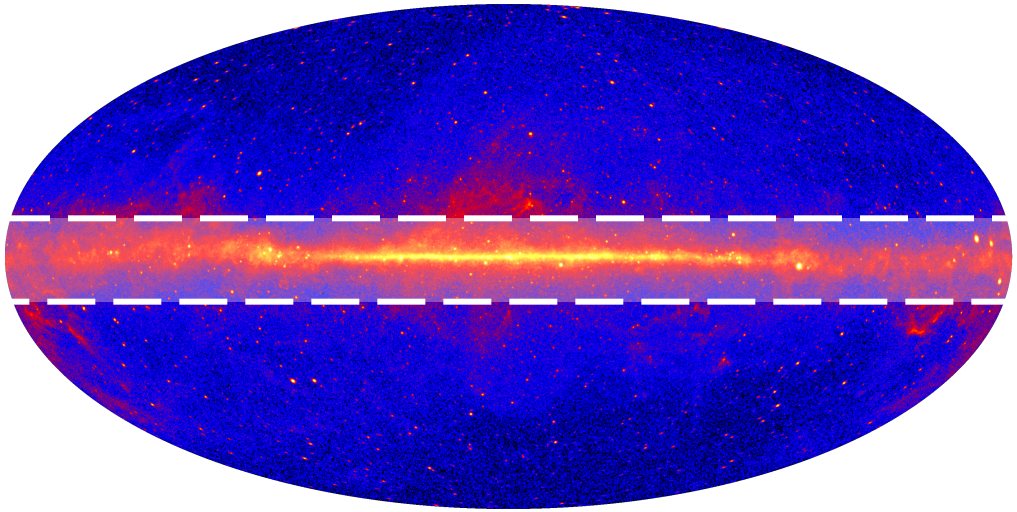




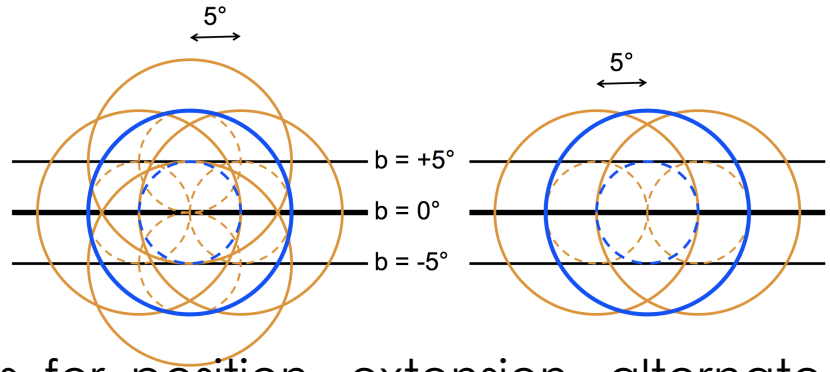
FGES Catalog: Analysis method

- 80 months of Pass 8 data
- Energy : 10 GeV – 2 TeV

Complementary to FHES Catalog (|b|>5°, E > 1 GeV; see **Caputo's talk** on Wednesday)



- Start from 3FGL source positions & scan the Galactic plane covering latitudes from -7° to +7° (2 indep. pipelines : CENBG /GSFC)



- Test candidates for position, extension, alternate hypotheses (2 pt. sources vs 1 ext. source) and spectral curvature
- Extended sources : TS > 25 & TS_{ext} > 16 & TS_{2pts} < TS_{ext}

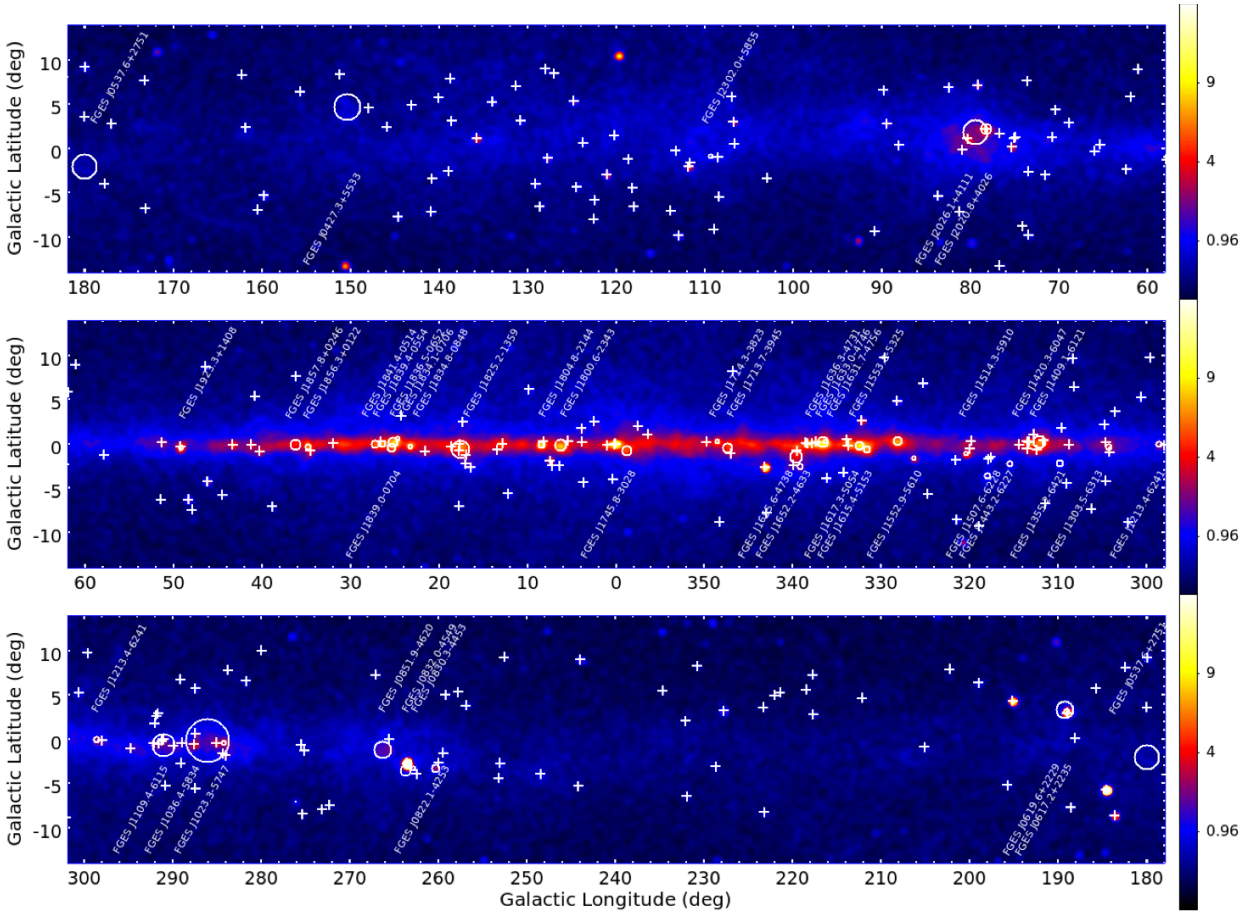
The Galactic plane above 10 GeV

46 extended sources are detected :

- 13 in agreement with previous publications
- 17 have different morphology
- **16 new extended sources**

We detect more sources & improve knowledge on already published ones

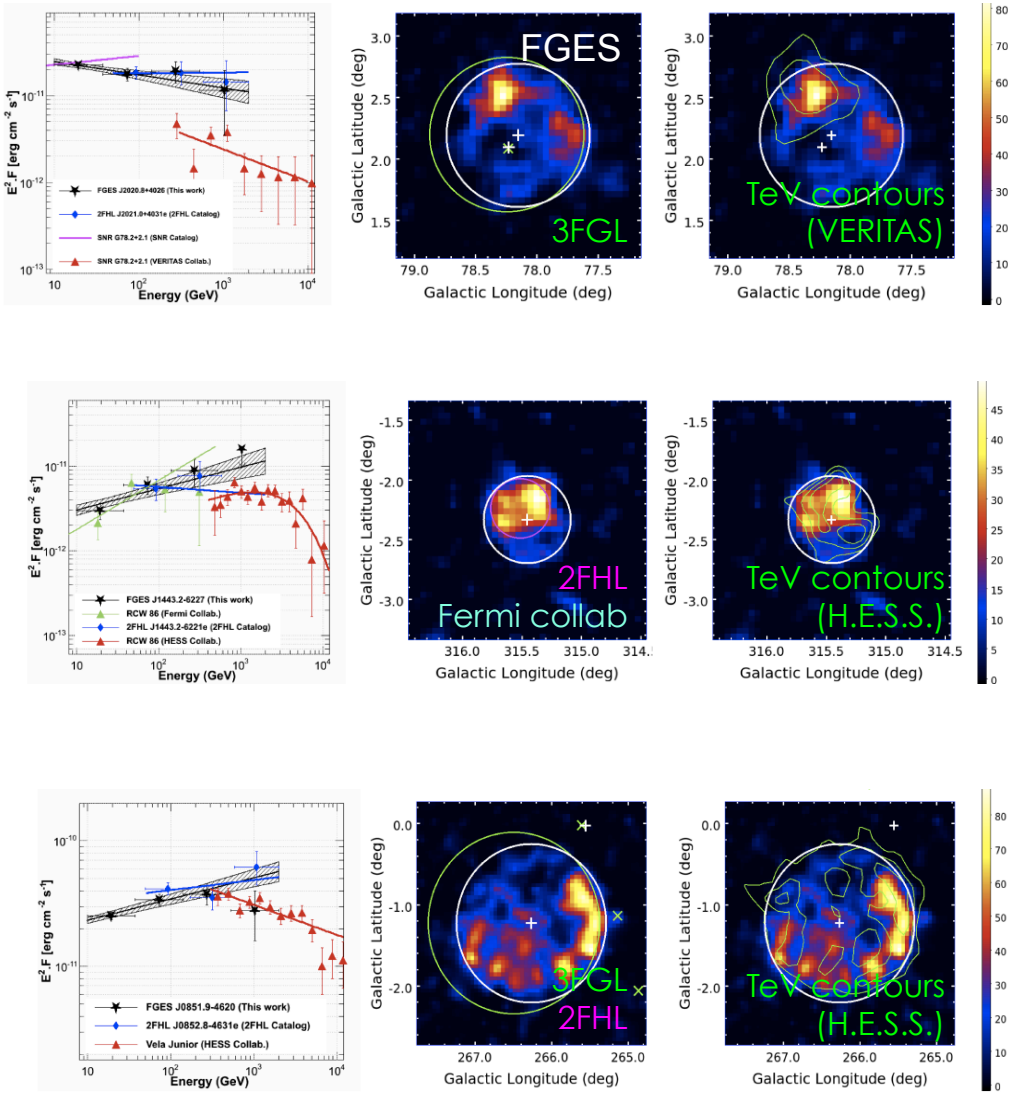
Smoothed count map above 10 GeV



Marie-Hélène GRONDIN
7th International Fermi Symposium

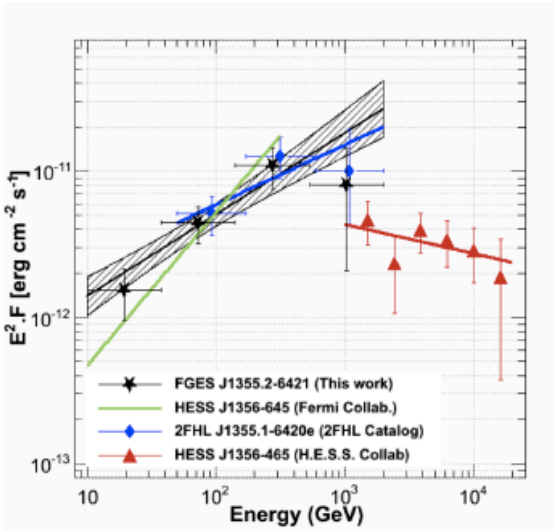
Excellent agreement with previous publications

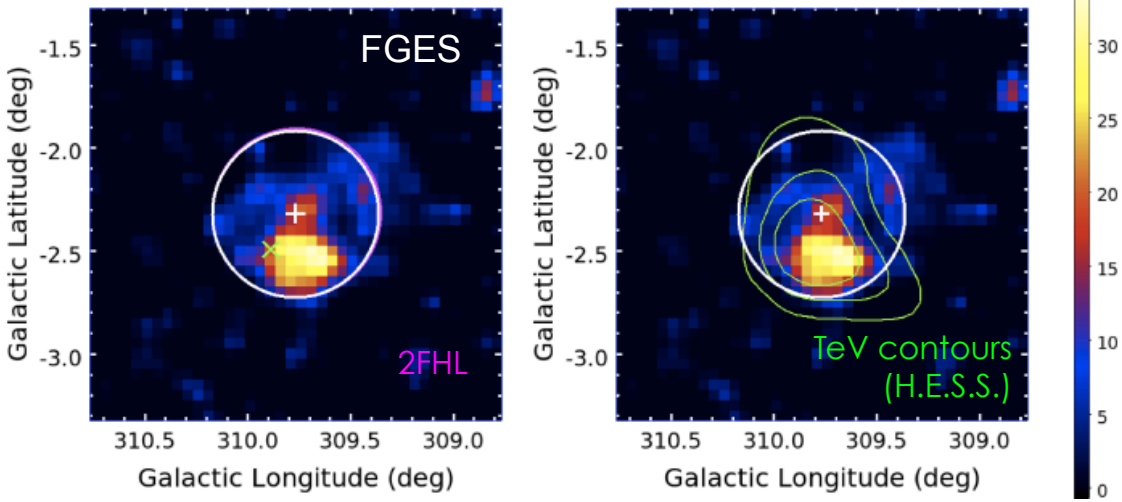
- SNR W41
- HESS J1356-645
- HESS J1303-631
- HESS J1614-518
- SNR G24.7+0.6
- Gamma Cygni
- IC 443
- Vela Jr
- RCW 86
- MSH 15-56
- MSH 15-52
- RX J1713.7-3946
- Puppis A



HESS J1356-645

- PWN powered by PSR J1357-6429
- Detected at TeV by H.E.S.S.
- 10 GeV Extension : 0.40° ± 0.02°$_{stat}$ (*2FHL* : ext ~ 0.40°)
- TS = 84, TS$_{ext}$ = 41
- Position and extension compatible with HESS J1356-645
- Excellent morphological and spectral agreement with H.E.S.S.



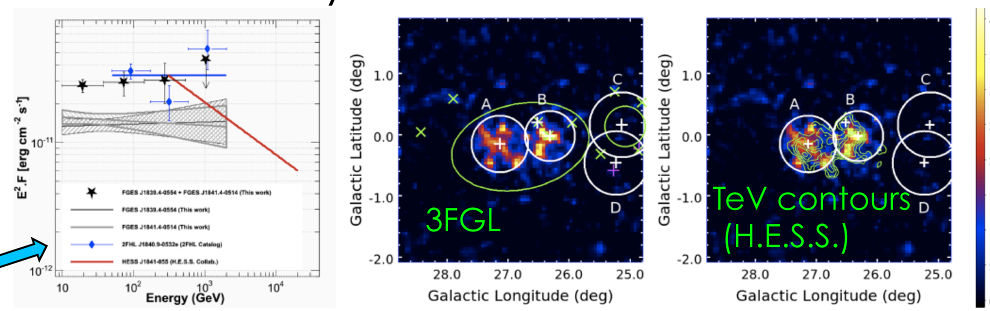


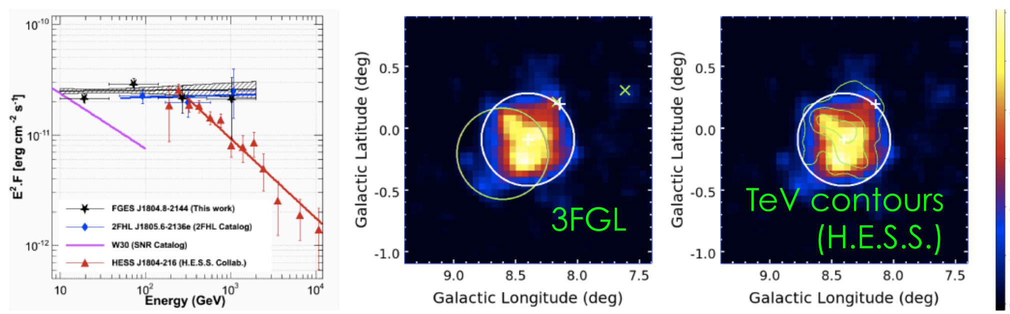
Fermi
Gamma-ray Space Telescope

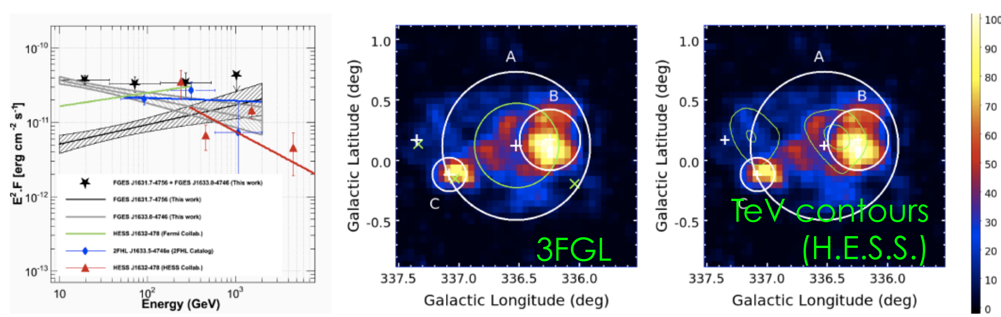
Differences with previous publications

3 main reasons to explain the difference:
- Different morphological template
- Energy dependent morphology
- Source confusion/contamination in one analysis

- W28
- HESS J1825-137
- Region of HESS J1837-655 (x2)
- Region of HESS J1841-055 (x2)
- W44
- W51
- Cygnus Cocoon
- Region of Vela X (x2)
- SNR S147
- W30
- HESS J1616-508
- HESS J1632-478
- CTB 37A/B complex
- SNR G150.3+4.5



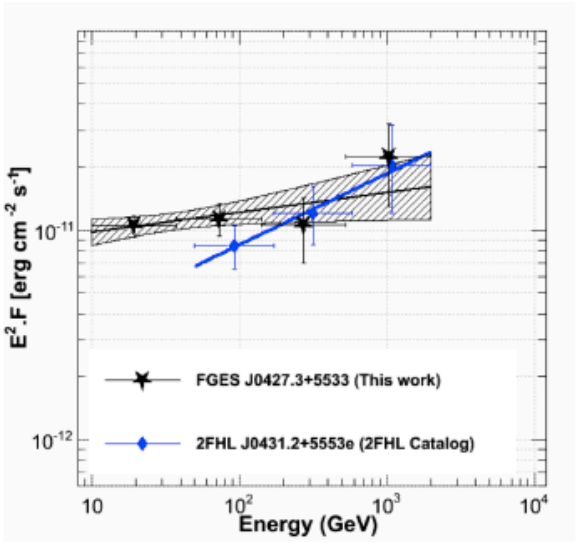


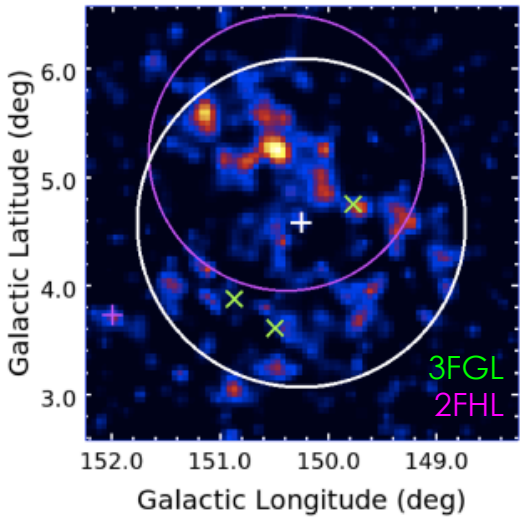


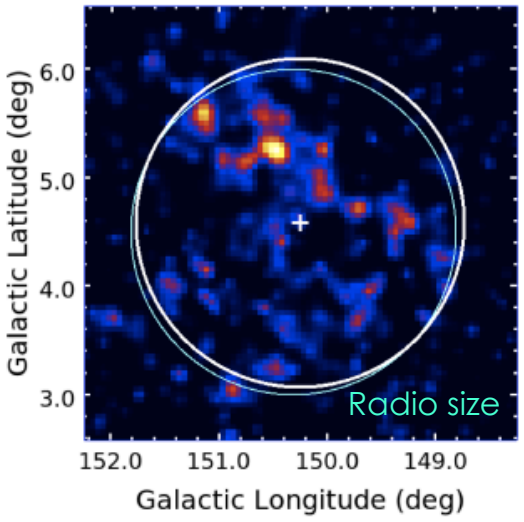
Marie-Hélène GRONDIN
7th International Fermi Symposium

SNR G150.3+4.5

- Recently discovered radio remnant by *Gao & Han (2014)*
- Identified as an extended gamma-ray source in 2FHL
- Above 10 GeV, the full shell is detected: excellent agreement with the radio size
- Large size seems to argue that the remnant is quite old or quite nearby but hard spectrum unusual for such SNRs







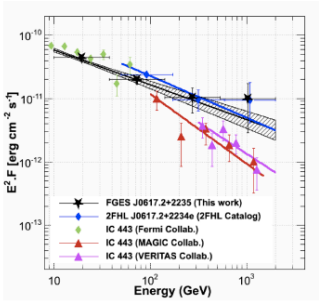
New extended sources

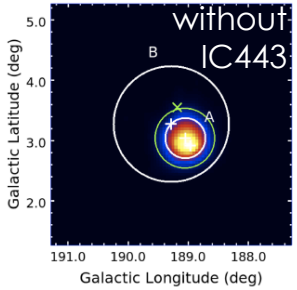
16 new sources detected, half coincide with clear counterparts :

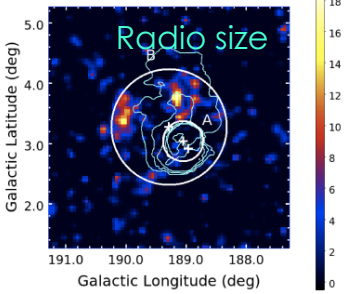
- HESS J1857+026
- CTB 109
- HESS J1023-575
- Large SNR close to IC 443
- SNR G298.6-0.0
- Kookaburra/K3
- HESS J1507-622
- SNR G337.0-0.1

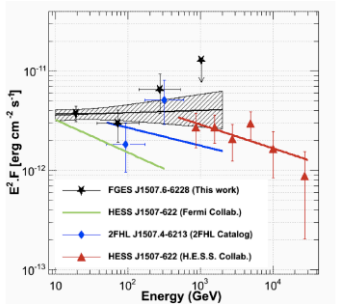
The other half is confused (large disk extension & systematics) :

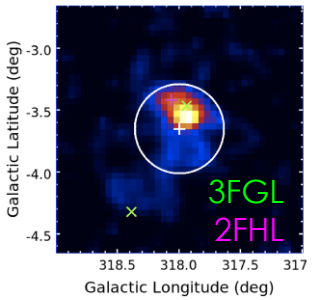
- Region of the Galactic Center
- Region of Westerlund 2
- Region of MSH 11-62
- FGES J1409.1-6121
- FGES J1553.8-5325
- FGES J1633.0-4746
- FGES J1652.2-4633
- FGES J1655.6-4738

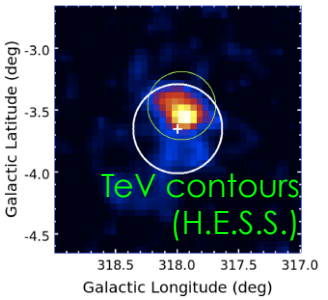






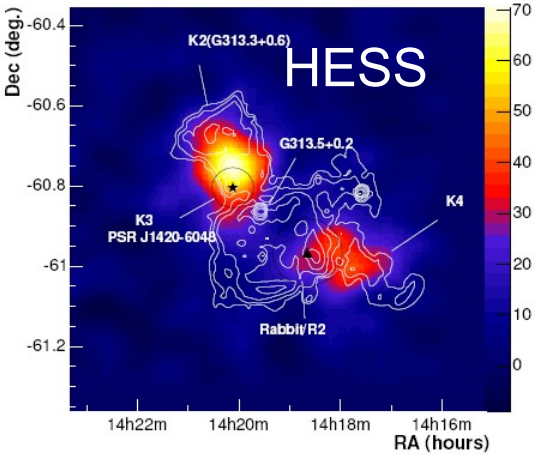


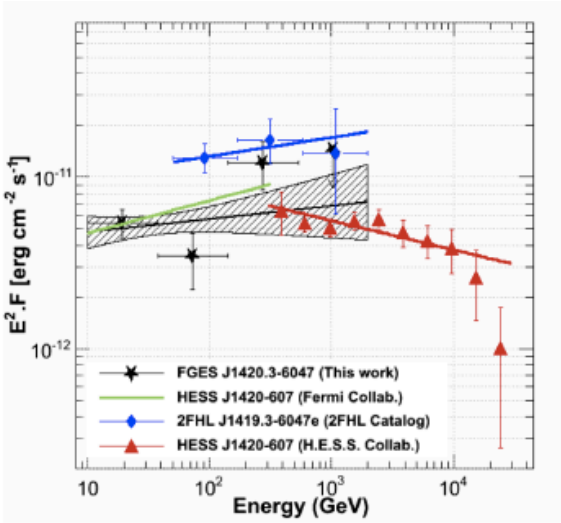


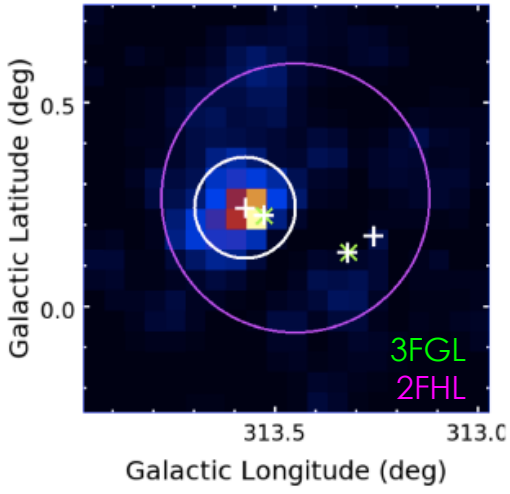


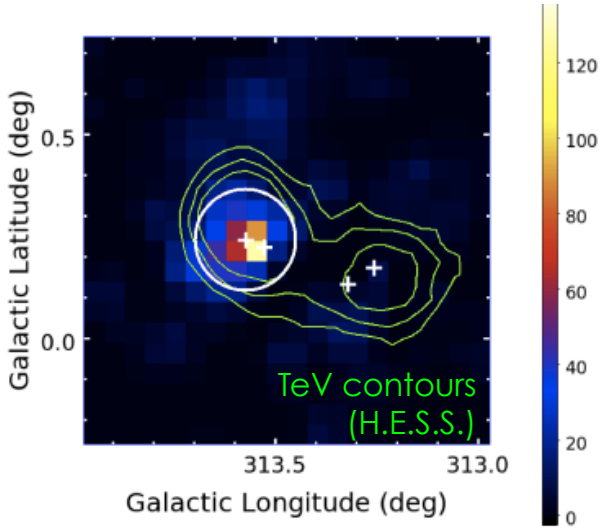
Kookaburra complex

- Complex contains 2 pulsars and 2 PWNe
- Both PWNe detected at TeV
- 2FHL detects the whole complex
- Extension : $0.12° \pm 0.01°_{stat}$
- TS = 77, TS_{ext} = 32
- Position and extension compatible with HESS J1420-607 (K3)

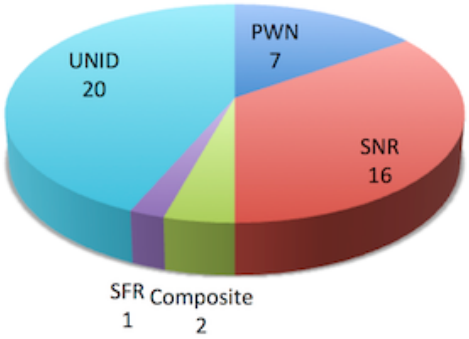








Summary

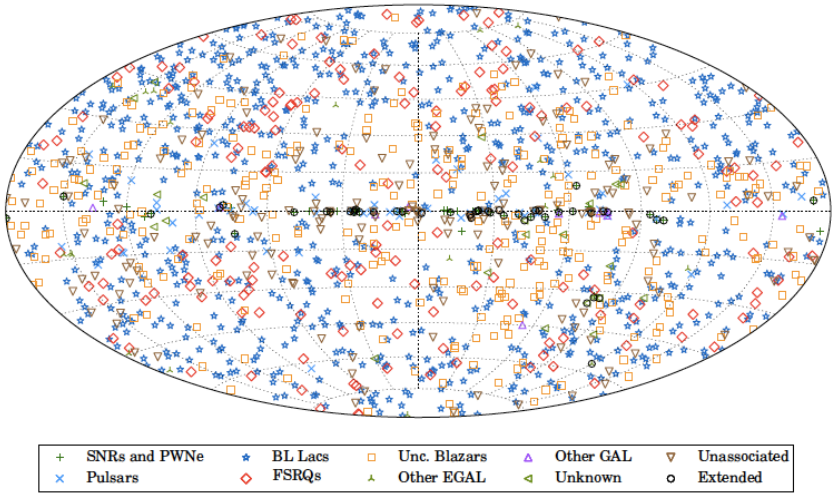


- 46 extended sources, 16 new ones
  - Average spectral index : ~2.1
  - Average disk radius : ~0.5°
  - **Dominant fraction of identified sources : SNRs**
  - All PWNe detected in this work are coincident with TeV sources

We have resolved sources that were previously unknown to be spatially extended or were confused in GeV, thus helping for the identification or the modeling.

3FHL catalog

see **Thompson's talk** on Monday



- LAT large FoV avoids biases wrt usual observation programs
- Large SNR (such as SNR G150.3+4.5) are difficult to detect at TeV

Going beyond HE catalogs is a good preparation for CTA science