
# Search around TeV PWNe candidates

**R. Rousseau[1,2], S. Funk[3], J. Lande[3], M. Lemoine-Goumard[1,2]**

**On behalf of the Fermi-LAT collaboration**

**1-Centre d'Etudes Nucléaires de Bordeaux-Gradignan, Chemin du Solarium, BP 120, F-33175**

**2- Funded by contract ERC-StG-259391 from the European Community**

**3- W. W. Hansen Experimental Physics Laboratory, Kavli Institute for Particle Astrophysics and Cosmology, Department of Physics and SLAC National Accelerator Laboratory, Stanford University, Stanford, CA 94305, USA**

rousseau@cenbg.in2p3.fr

**Fermi Symposium : 30/10/2012**

# Motivations

**Second search for PWNe and PWNe candidates using *Fermi*-LAT data :**

- Search in the off pulse (see poster by J.Lande)
- Search at high energy around TeV sources (This work)

## Why ?

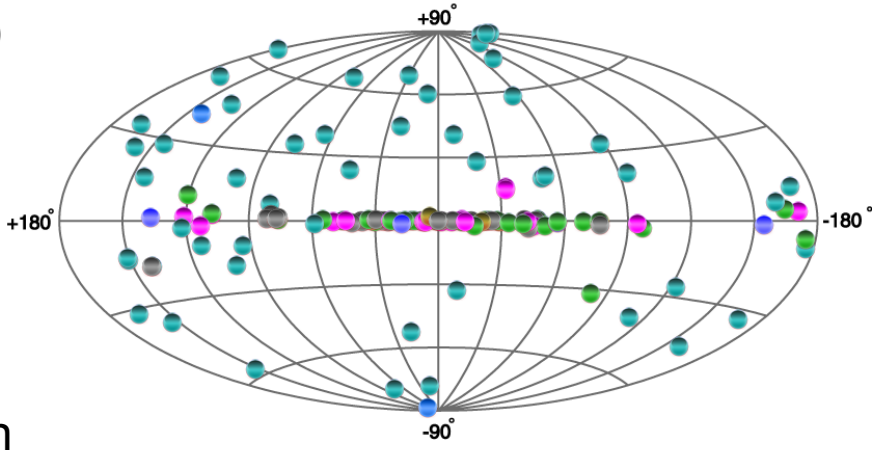
PWNe are the most populous class of Galactic sources in the TeV energy range
~1/3 of TeV Galactic sources are UNID → potential PWNe
→ TeV information on the position and extension could improve sensitivity.

## What are we looking for ?

- New GeV detections
- Study morphology if GeV detection to avoid bias in the spectrum
- Constraints on the SED models either by detection or non-detection → search for IC spectra.

# Source selection

1- Starting point TeVCat (poster by J. Perkins)
→ 137 sources




2- PWNe are Galactic sources → we selected sources within 5° of the Galactic plane.
→ ~80 sources remaining

3- All clearly identified SNRs will be included in the first Fermi-LAT catalog of SNRs (talk by T. Brandt):
→ 63 sources remaining

4- We removed the Galactic center region for reliability
→ 60 sources remaining

5- We removed known complex bright sources (Crab nebula and Vela-X)

→ 58 sources remaining

http://tevcat.uchicago.edu/

# Method

Data > 10 GeV and Clean events (substantial reduction in instrumental background above 10GeV).

- TeV sources have a small extension compared to Fermi PSF → best PSF needed

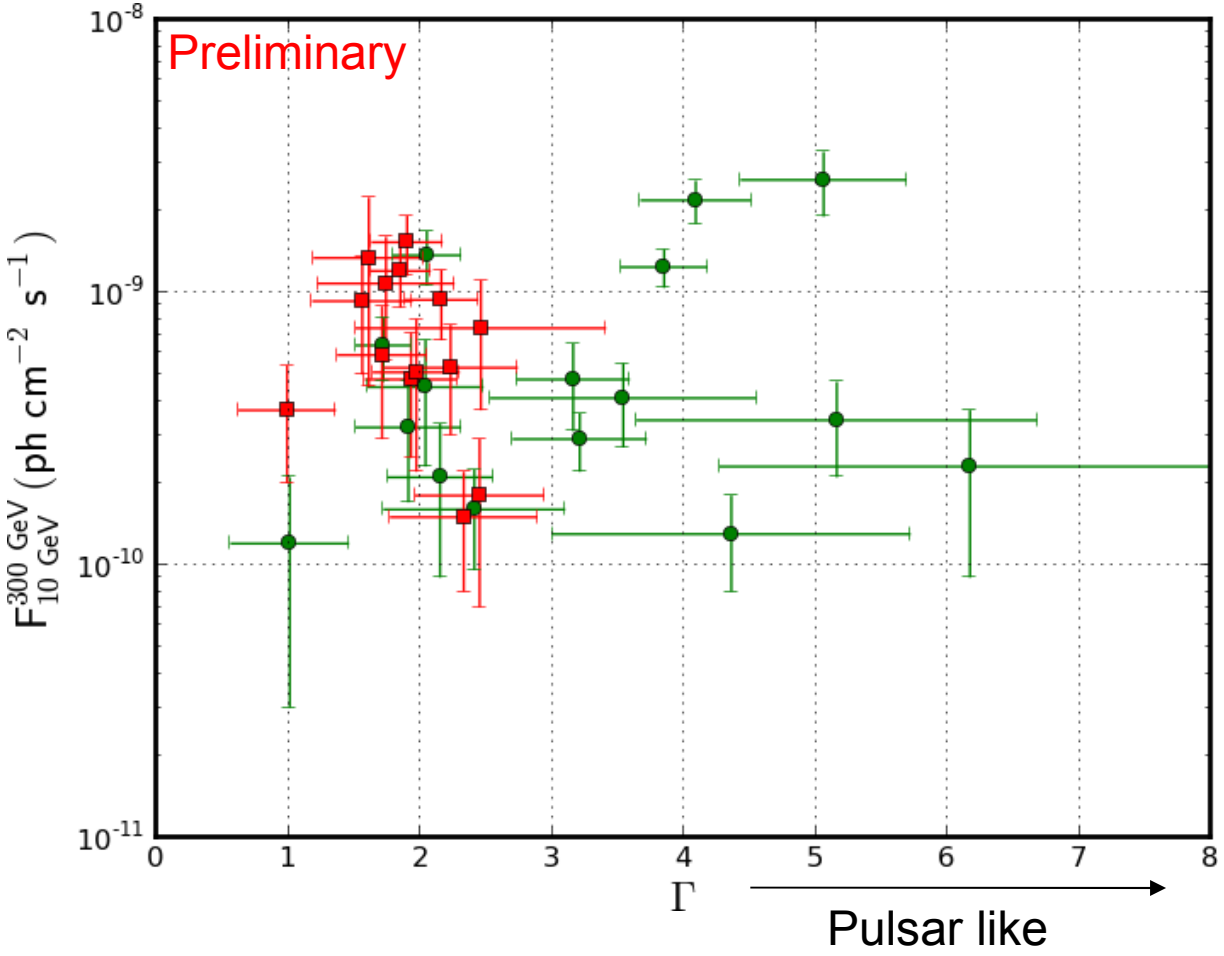
- 10 GeV → reduce Galactic diffuse emission and pulsars

Starting point : 1FHL catalog (see presentation of D. Paneque, Thursday 1)

→ 22 sources within 0.5° of a pulsar. 2 runs :
  - without the pulsar included in the model
  - with the pulsar included in the model (2FGL catalog spectrum fixed)

- Morphological analysis : TeV shape, Point, Gaussian

# Results – Flux vs Index



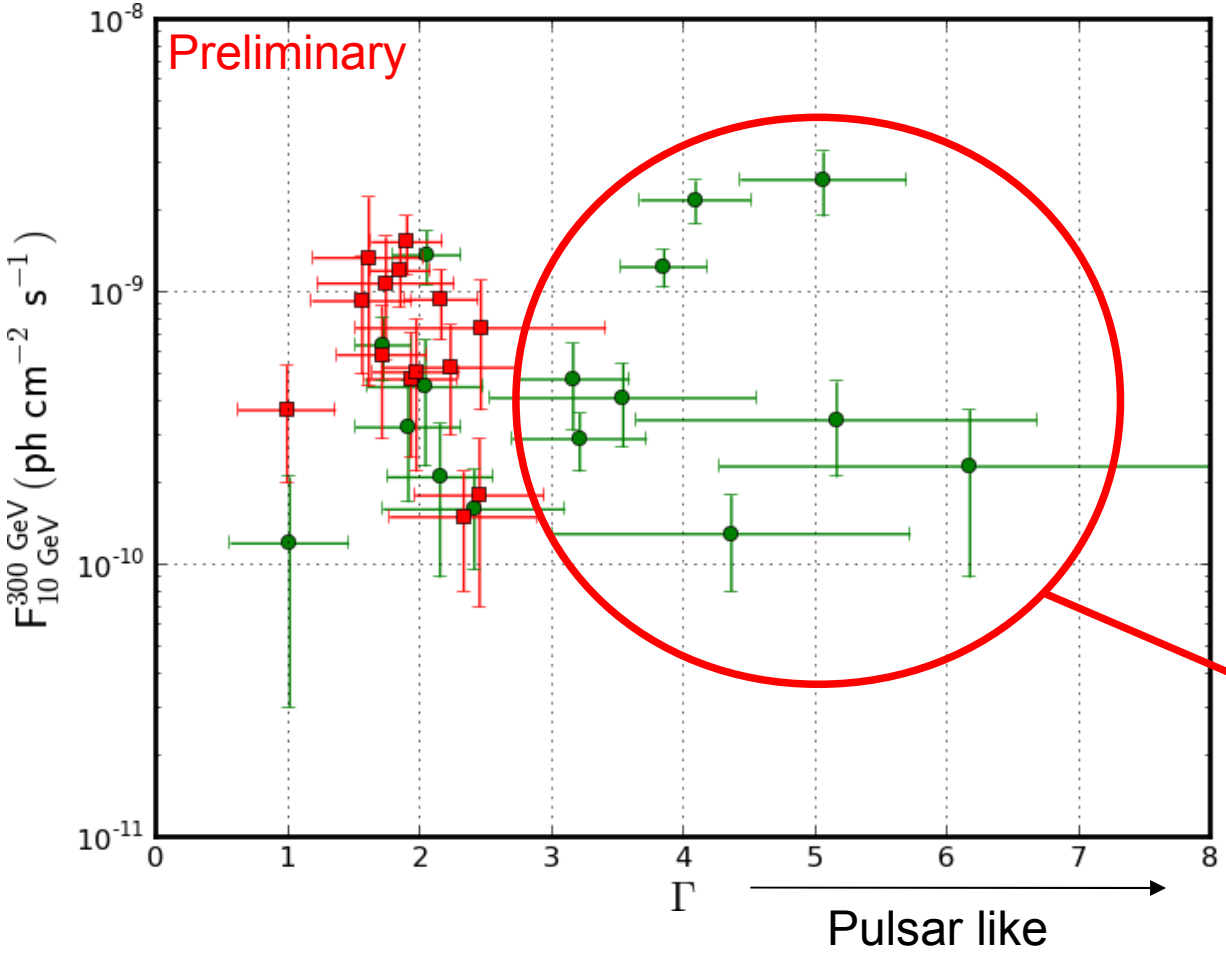

30 detections

- Source without a gamma-ray detected pulsar within 0.5°.
- Source with a gamma-ray detected pulsar within 0.5°.

Error bars² = statistical² + systematic²

Fit without pulsars included In the model.

# Results – Flux vs Index

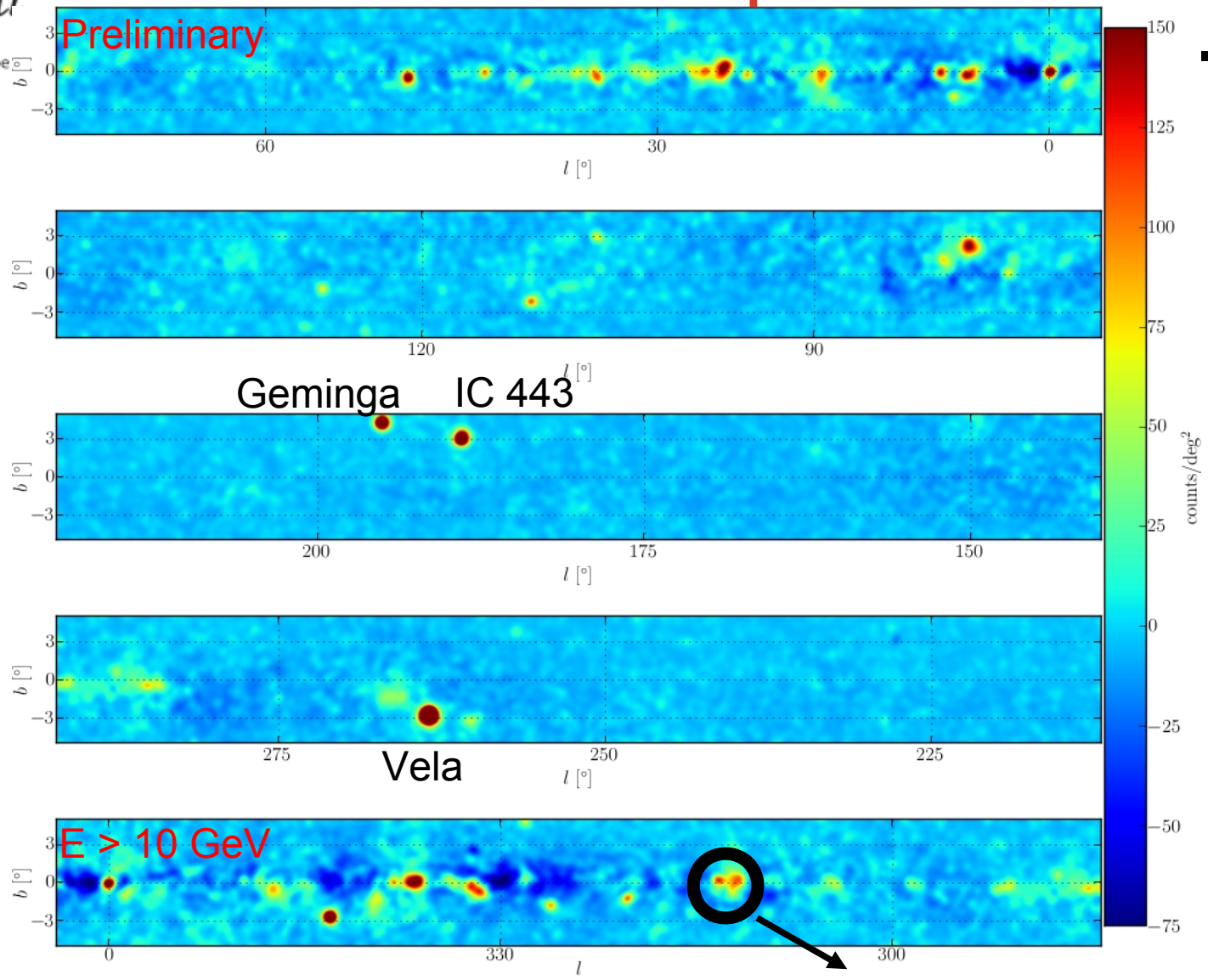



- Source without a gamma-ray detected pulsar within 0.5°.
- Source with a gamma-ray detected pulsar within 0.5°.

9 pulsar like sources

Error bars² = statistical² + systematic²

# Counts map

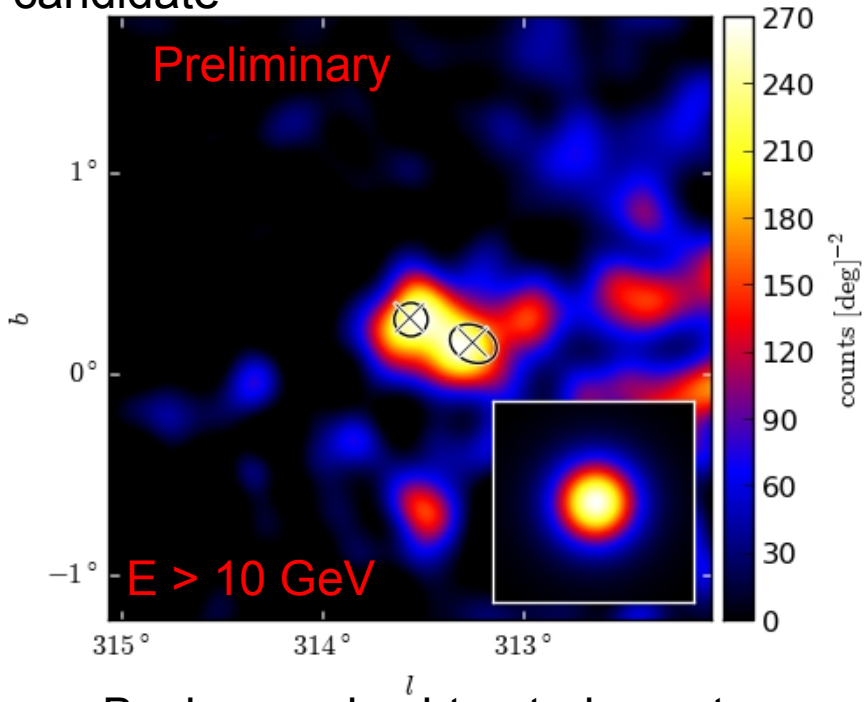


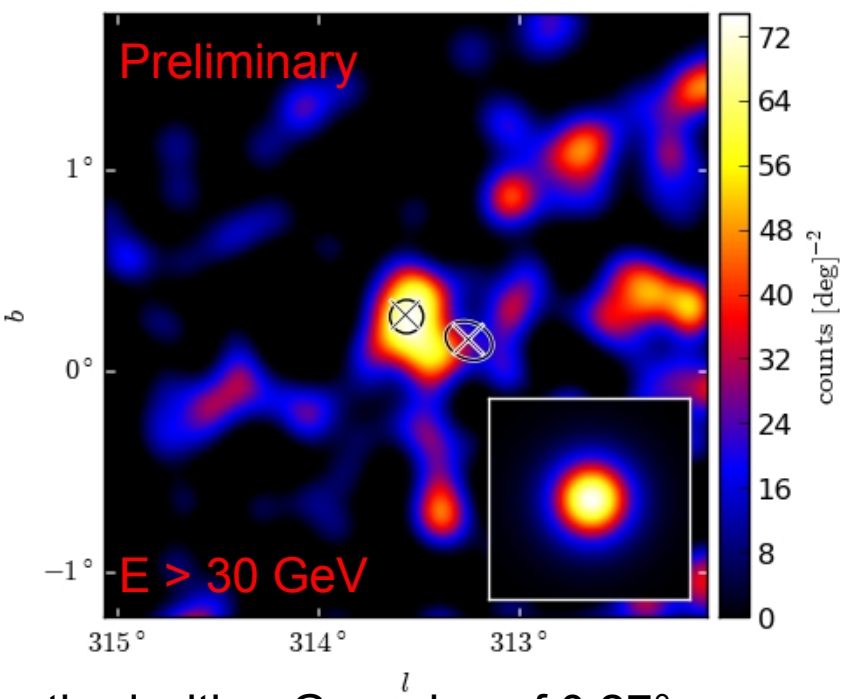

Galactic and Isotropic diffuses subtracted
Smoothed with a Gaussian of 0.27°

# An example K3 nebula = HESS J1420

K3 nebula and the Rabbit = Radio/X-Ray complex.

Discovery of PSR J1420-6048 and PSR J1418-6058 -> TeV = good PWN candidate



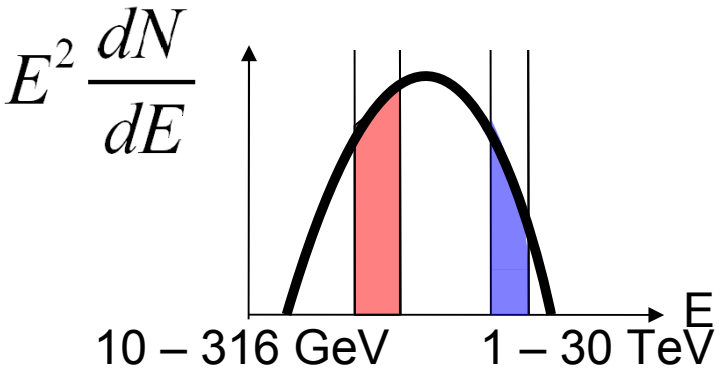

Background subtracted counts map smoothed with a Gaussian of 0.27°.

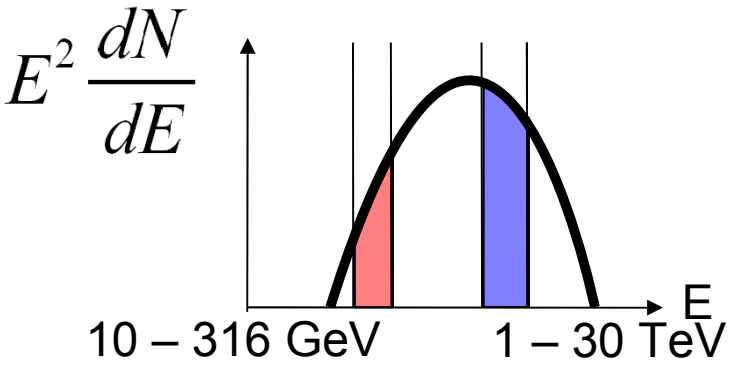
Emission from the Rabbit disappears above 30 GeV → PSR J1418-609.

K3 is detected but it might suffer contamination from PSR J1420-6048 .

# Population – IC peak

A difference in energy flux is expected between the TeV and the GeV energy ranges. This difference depends on the position and shape of the IC peak.




Using the TeV and GeV spectra we fitted the peak as a log parabola (as done in Albert et al. (2008)).

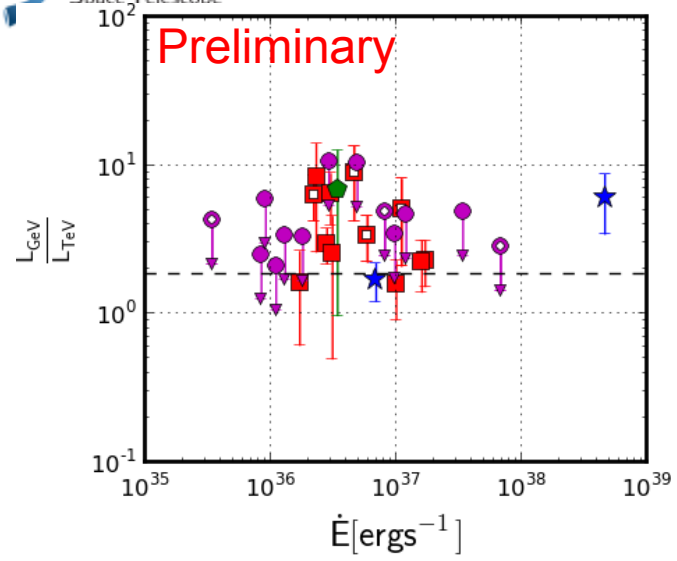
$$\frac{dN}{dE} = N_0 \times \left(\frac{E}{E_0}\right)^{-\left[\alpha+\beta\times\log\left(\frac{E}{E_b}\right)\right]}$$

$$\alpha + \beta \times \log\left(\frac{E_{\mathrm{peak}}}{E_b}\right) = 2.0$$

Using the mean $E_{peak}$ and α we determined the mean ratio between the TeV and the GeV flux.

The mean position of the peak is ~500 GeV.

# Population – GeV/TeV




GeV = PWN like

No detection at GeV

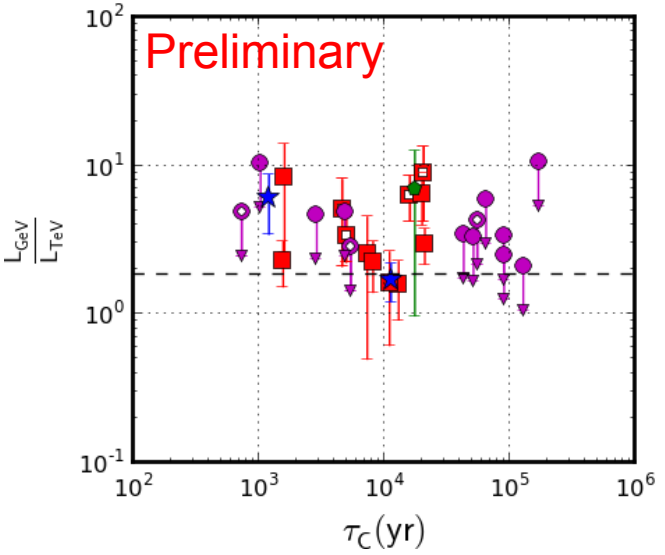
GeV = Pulsar like

Crab, Vela X

TeV = PWN

TeV = UNID

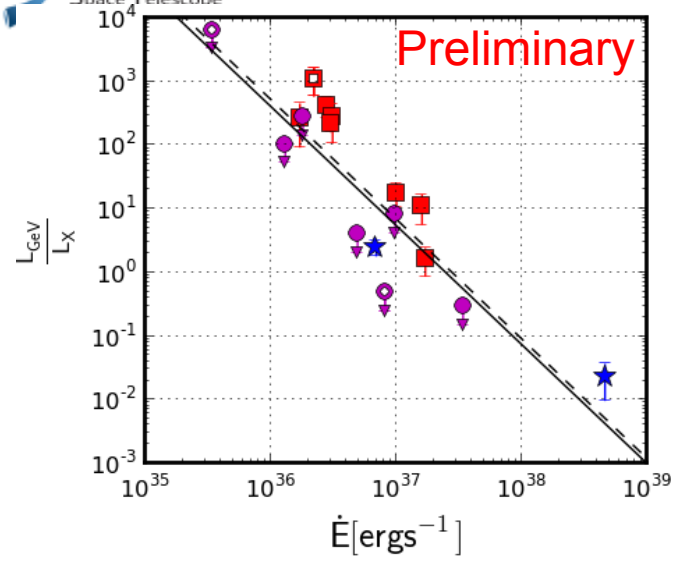
$$\frac{L_{GeV}}{L_{TeV}} = \bar{R} \sim 1.9$$




No source are more than 2σ from the mean ratio except HESS J1804-216.

Ajello et al. (2012) → HESS J1804-216 = hadronic

# Population – GeV vs X-ray




GeV = PWN like

No detection at GeV

GeV = Pulsar like

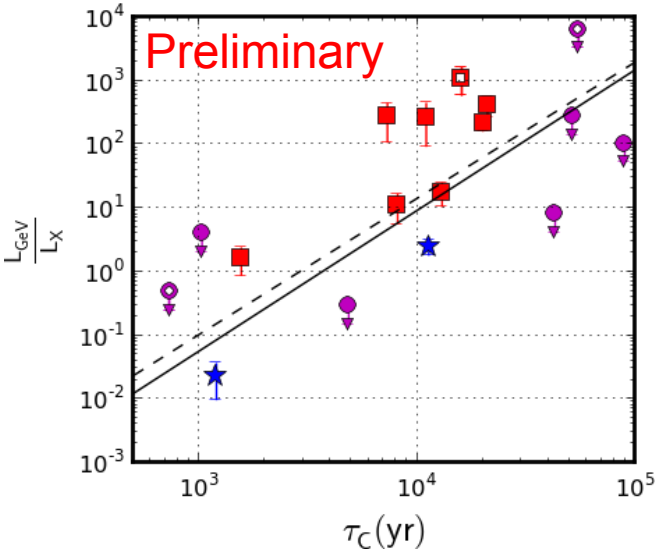
Crab, Vela X

TeV = PWN

TeV = UNID

PWNe in Mattana et al. (2009) $X\ \bar{R}$

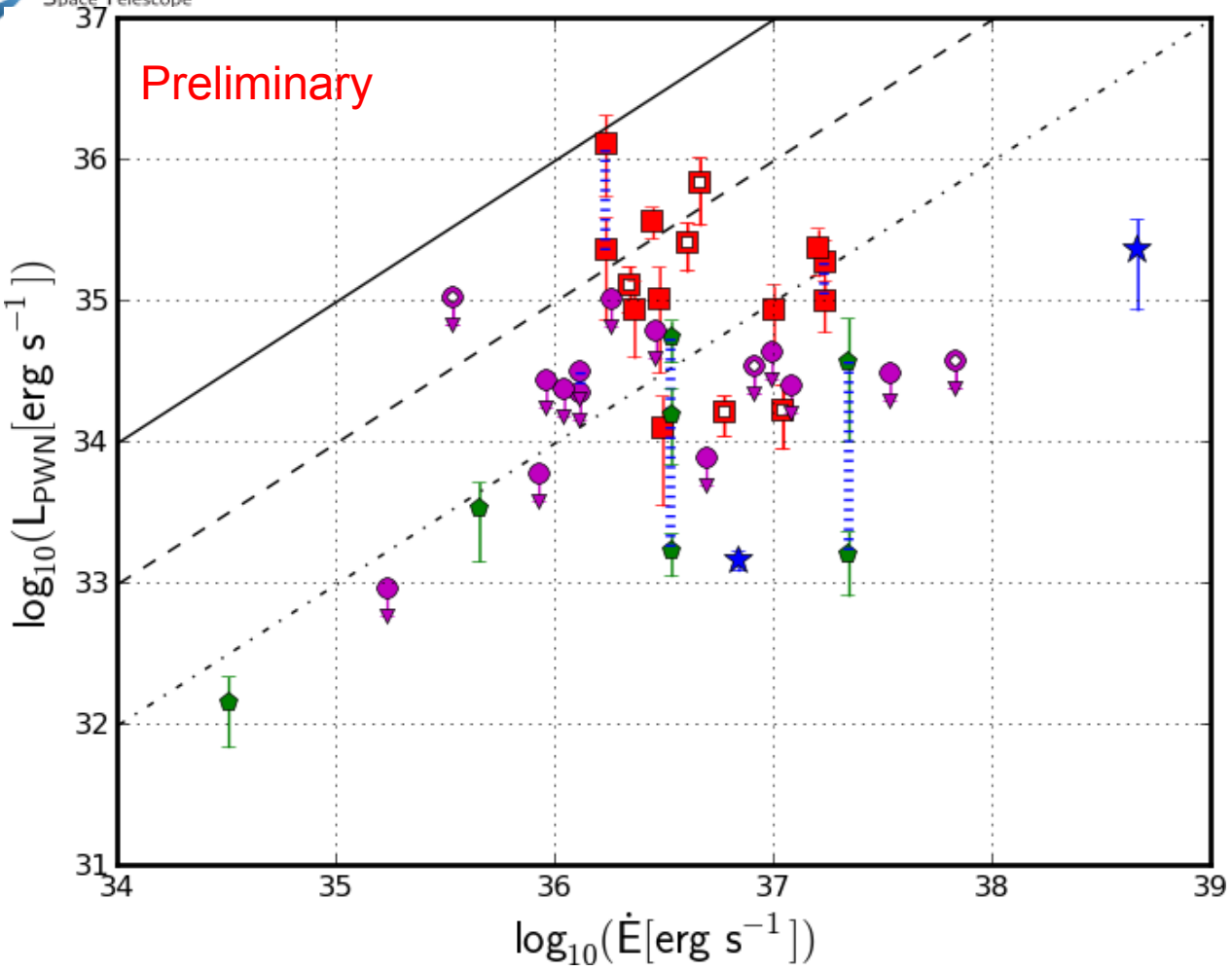
PWNe + UNID in Mattana et al. (2009) $X\ \bar{R}$




Age increases → B decreases → Synchrotron decreases → X-Ray decreases → L(GeV)/L(X) increases.

The same trend is found in the GeV energy range.

# Population – LPWN vs Edot




GeV = PWN like

GeV = Pulsar like

No detection at GeV

Crab, Vela X

Two distances estimates.

LPWN/Edot = 1

LPWN/Edot = 0.1

LPWN/Edot = 0.01

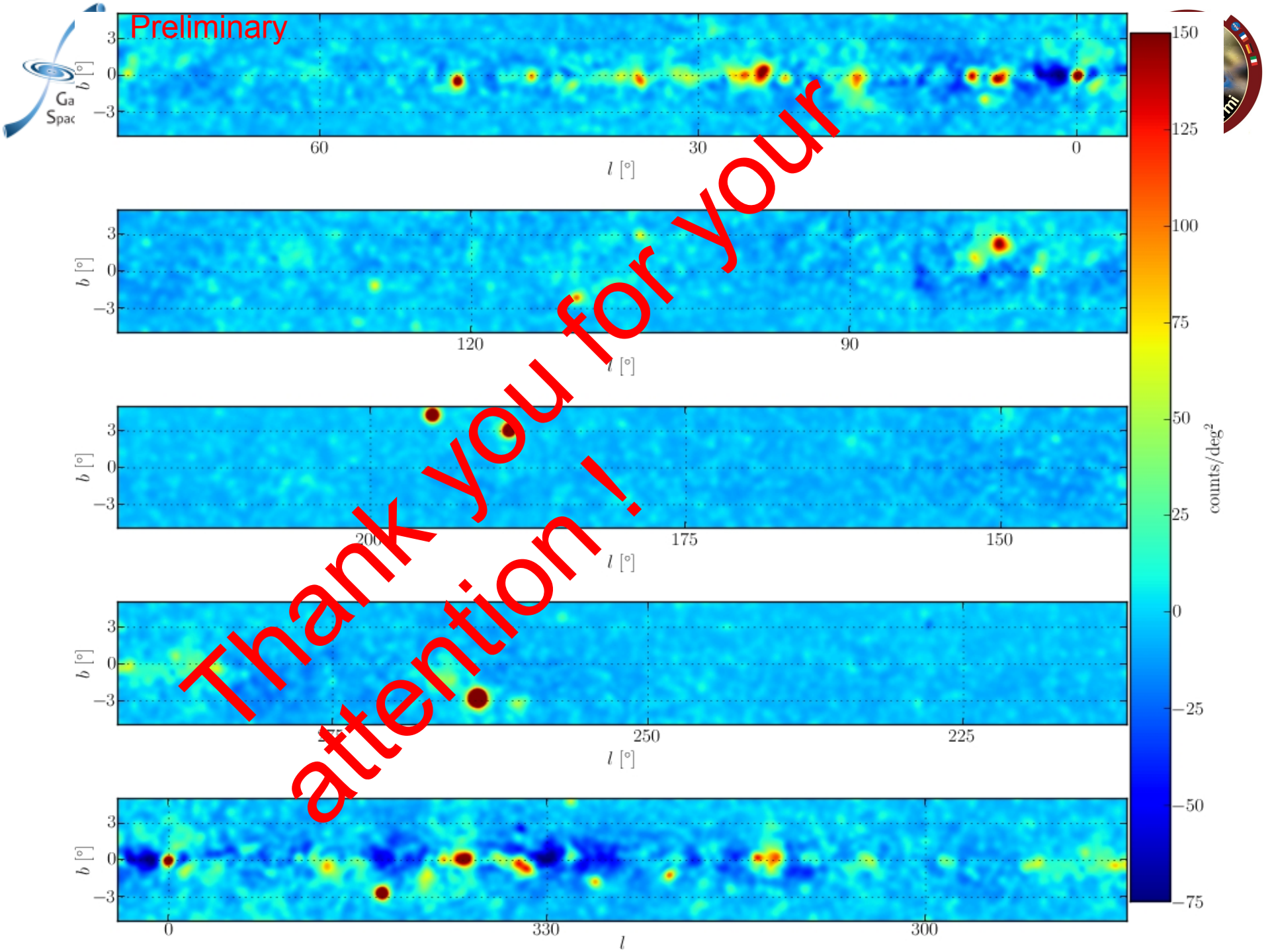
Most detected sources are below an efficiency of 10%. Measured distances suffer large uncertainties. PWNe candidates are powered by young pulsars with a spin-down power $\dot{E} \in [10^{36}, 10^{39}]\, erg\ s^{-1}$.

# Conclusions

Among 58 sources:

- 15 PWNe candidates
- Constraining upper limits found
- The maximum of the IC peak is on average closer to the GeV energy range
- Correlations between GeV and X-Ray fluxes seems consistent with relation between TeV and X-ray fluxes derived in Mattana et al. 2009
- PWNe observed by Fermi are powered by young ( $\tau_C \in [1,30]\, kyr$ ) and powerful pulsars ( $\dot{E} \in [10^{36},10^{39}]\, erg\, s^{-1}$ )

Stay tuned → Paper will soon be submitted


Preliminary
Thank you for your attention !
b [°]
l [°]
counts/deg²