Supernova Remnants and Pulsar Wind Nebulae as Gamma-Ray source class. The Fermi view

F. Giordano

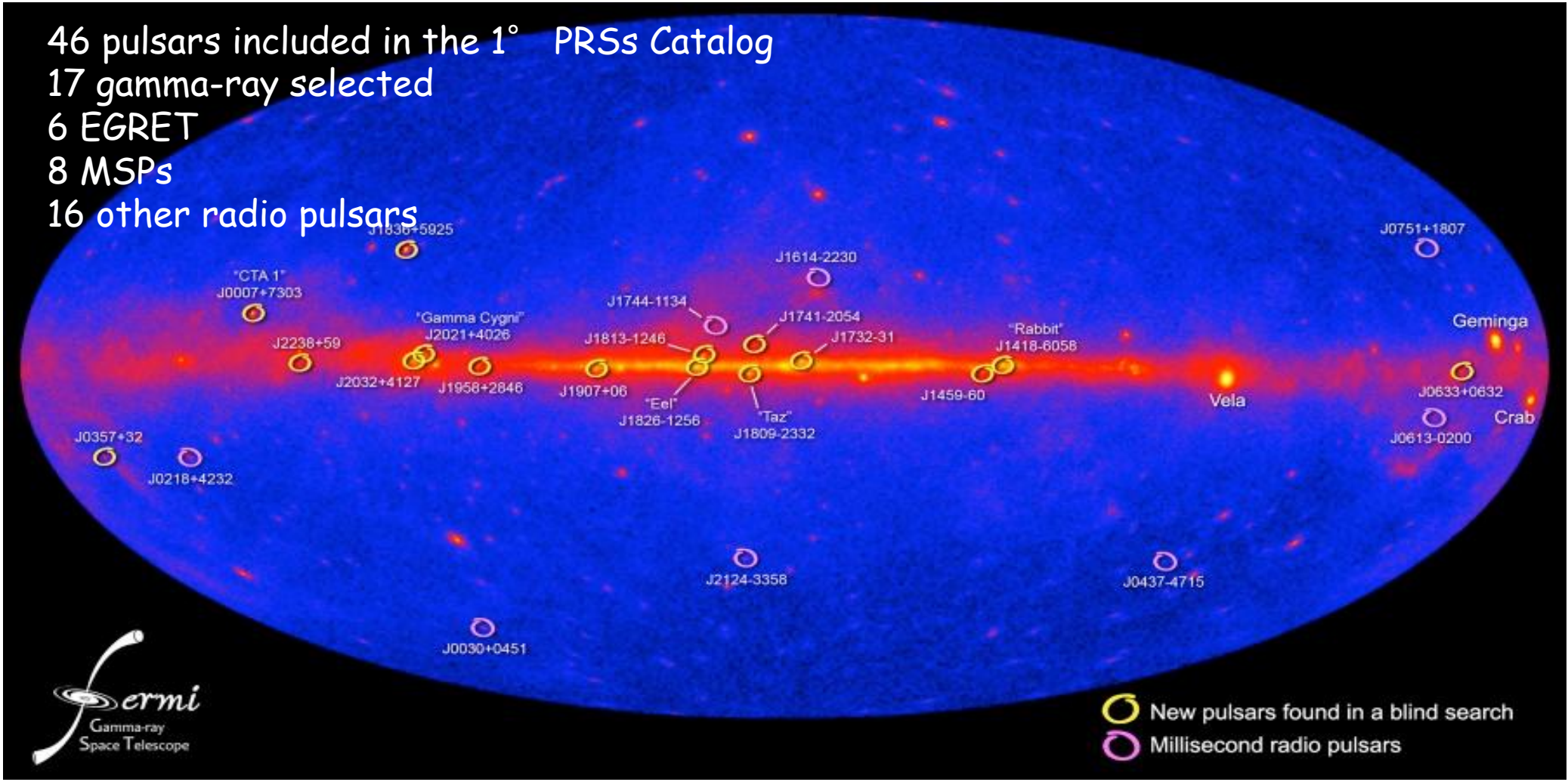
Dipartimento Interateneo di Fisica and INFN Sez. Bari

For the Fermi-LAT Collaboration

8th Agile Workshop

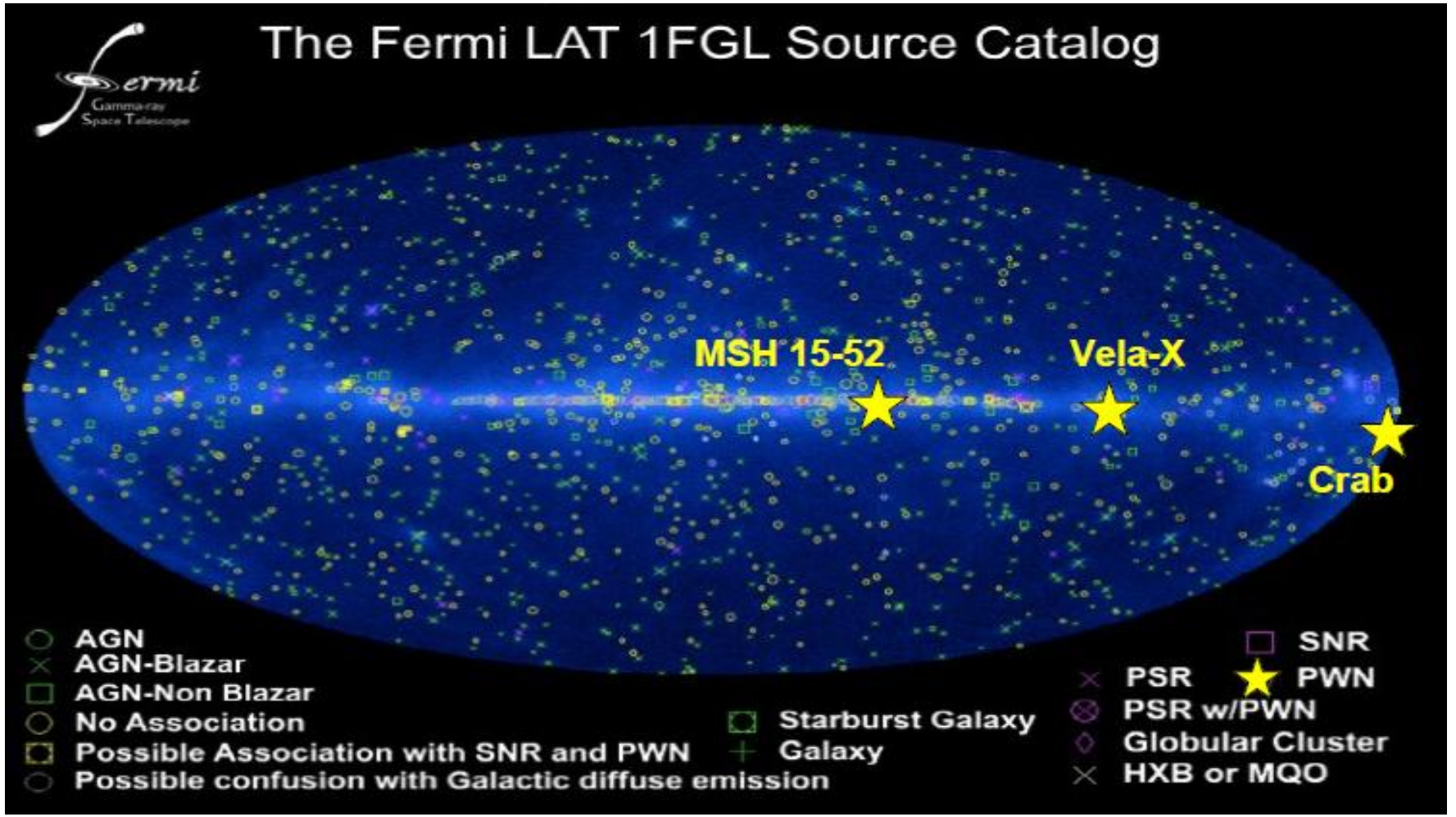
We can not - not start from pulsars…

Abdo et al. 2010, ApJS, **187, 460**



Then… move on PWNe

Abdo et al. 2010, Sumitted ApJS, arXiv:1002.2280v1



Before results… a bit of Analysis

• Gamma-ray Pulsars are everywhere !!!
One can use only the unpulsed signal to analyse most of these sources => we keep only ~1/3 of the signal for analyses such as Crab, Vela-X…

• SNR & PWN are steady sources: we don't have the variability as an identification tool (as for AGNs) and no timing information (as for Pulsars)

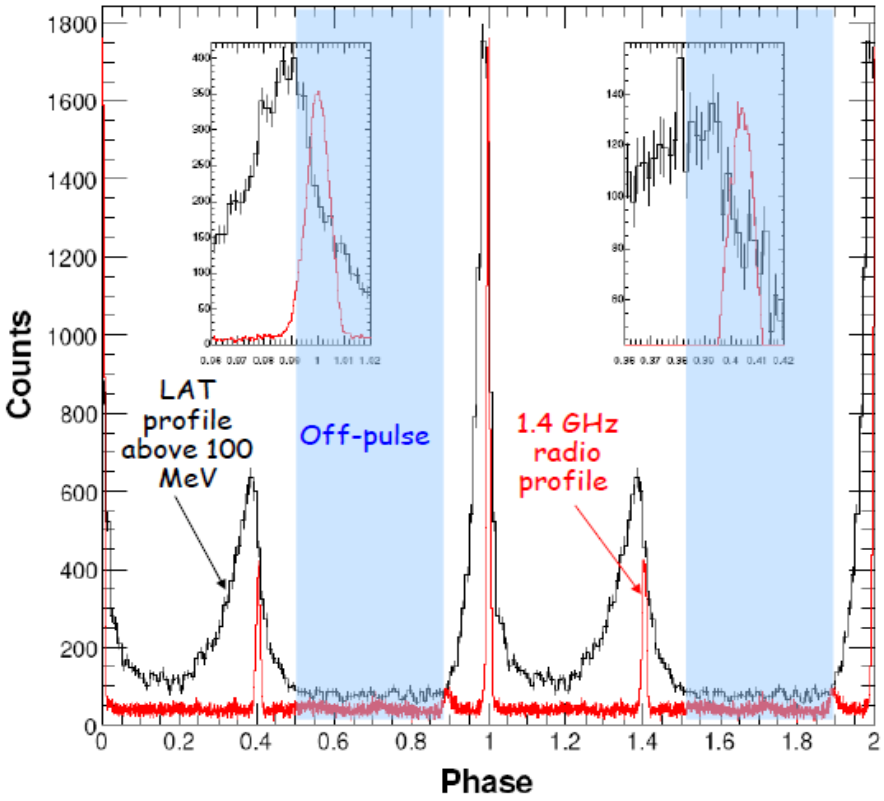
• SNR & PWN are predominantly located in the Galactic Plane => contamination from the Galactic diffuse background

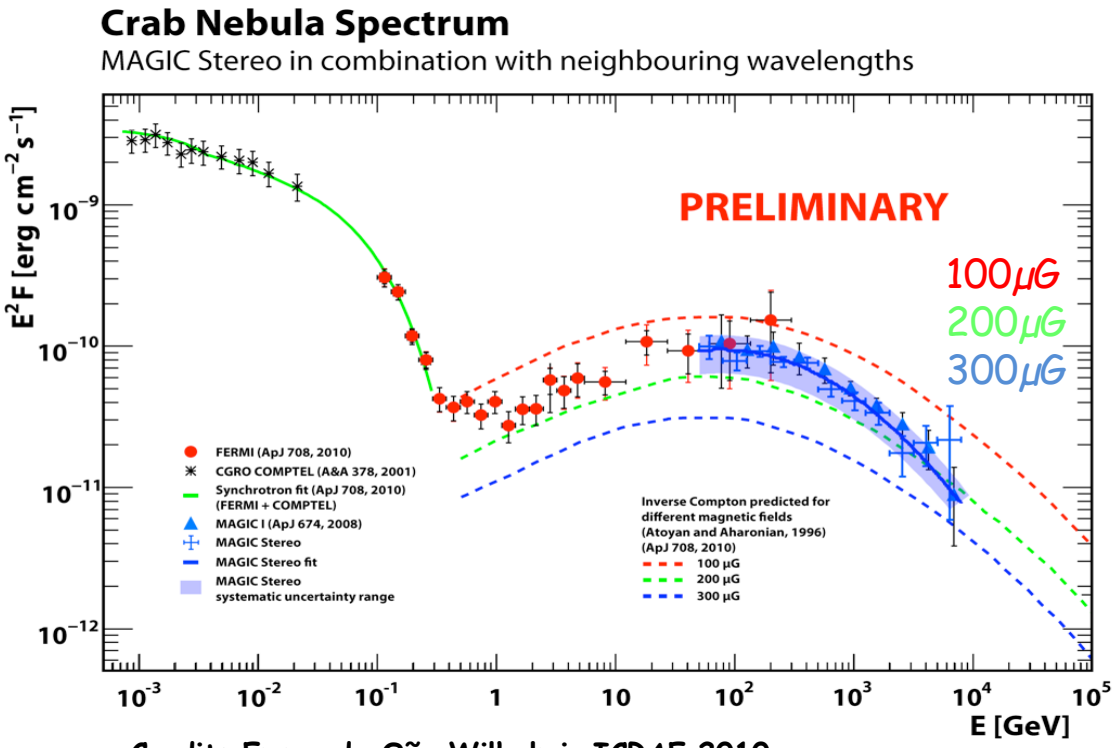
• SNR & PWN can be extended sources (W44, Vela-X…): gamma-ray photons are spread over larger regions which render the analysis and identification with a potential counterpart very hard (and even more in the Galactic plane !)

It is not an easy job… but there's a lot of fun!!!

First came CRAB…

Abdo et al., 2010, ApJ, 708, 1254

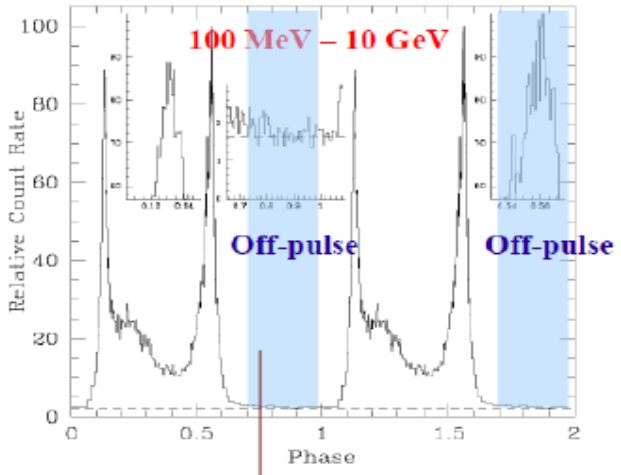


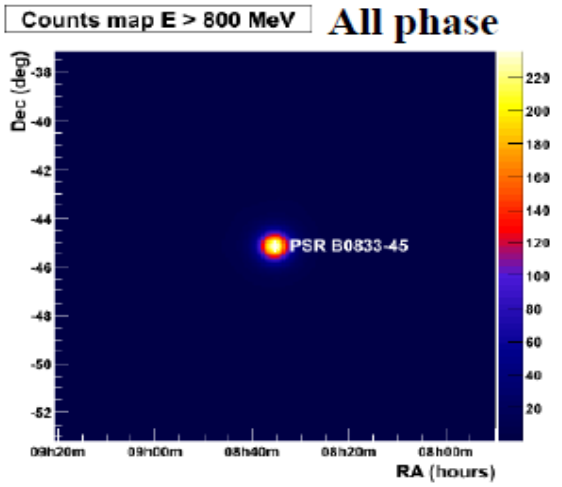


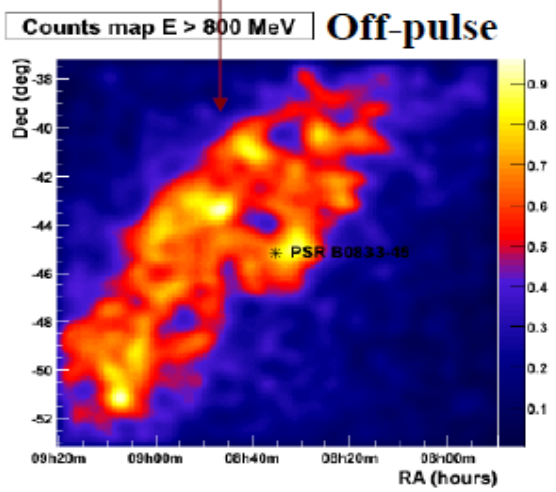
Credit: Emma de Oña Wilhelmi, ICRAE 2010

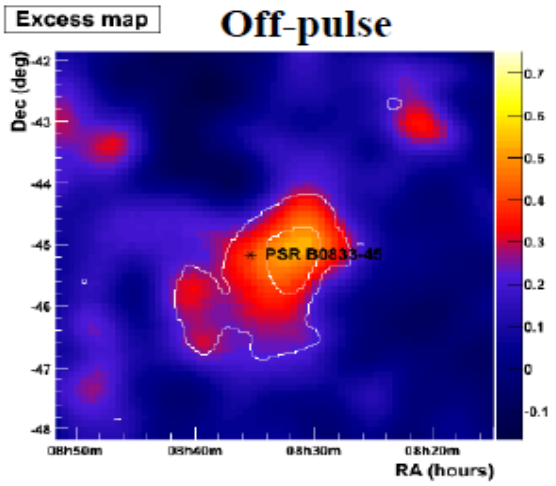
…then VelaX: Timing, Maps,

Abdo et al., 2010, ApJ,713, 146



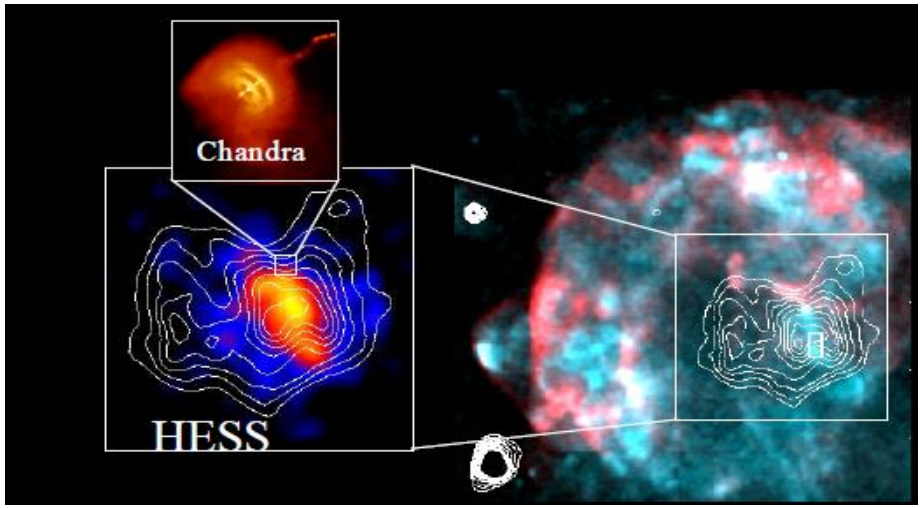


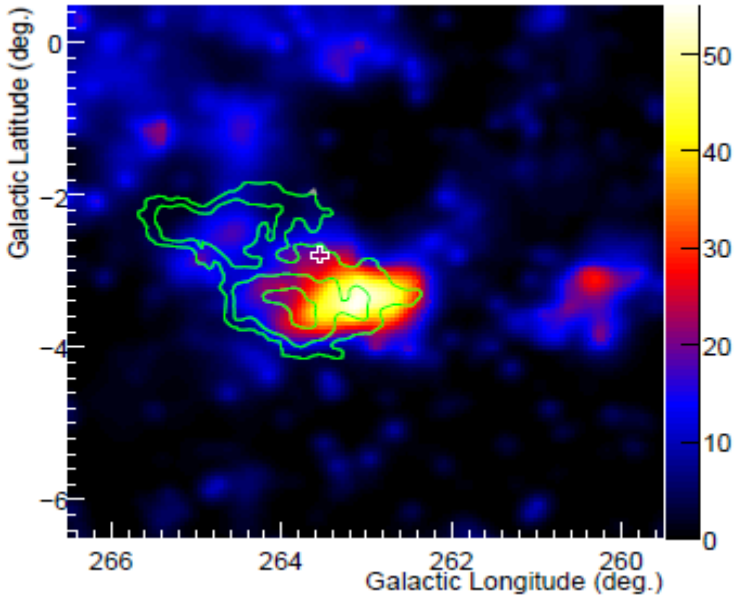




Credit: Lemoine-Goumard & Grondin ICRC 2009

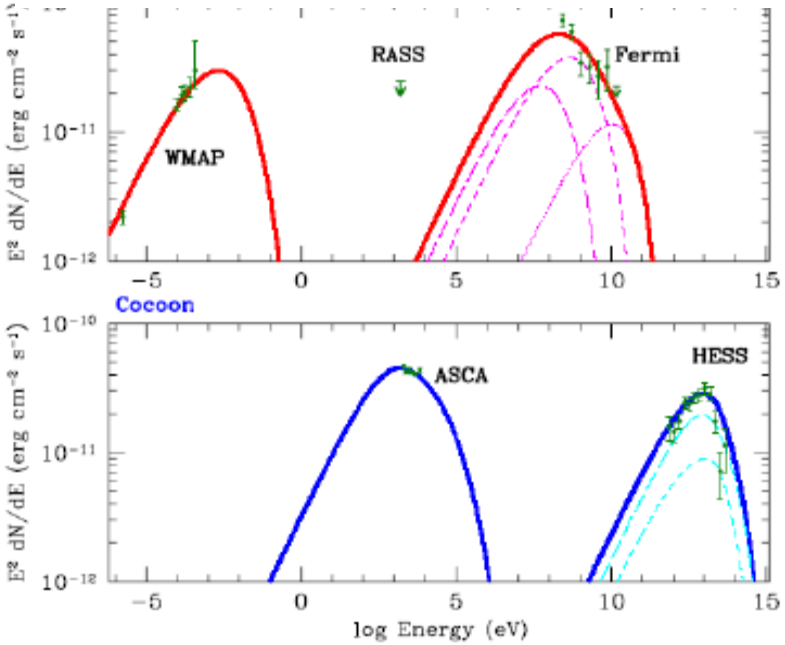
energy spectrum and models





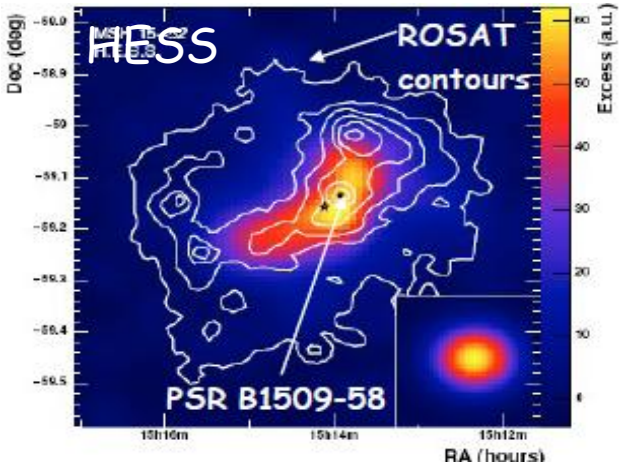
- Spectral index = 2.41 (soft spectrum)
- Flux E>100 MeV = 4.73 x10^{-7} cm^{-2} s^{-1}

- the SED strongly favors a <u>two</u> component leptonic model
- Hadronic model is disfavoured



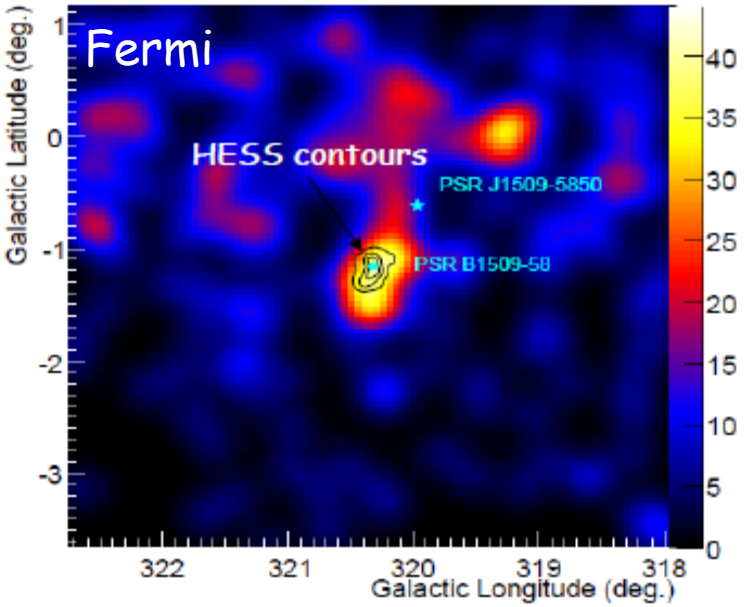
Lastly the MSH15-52

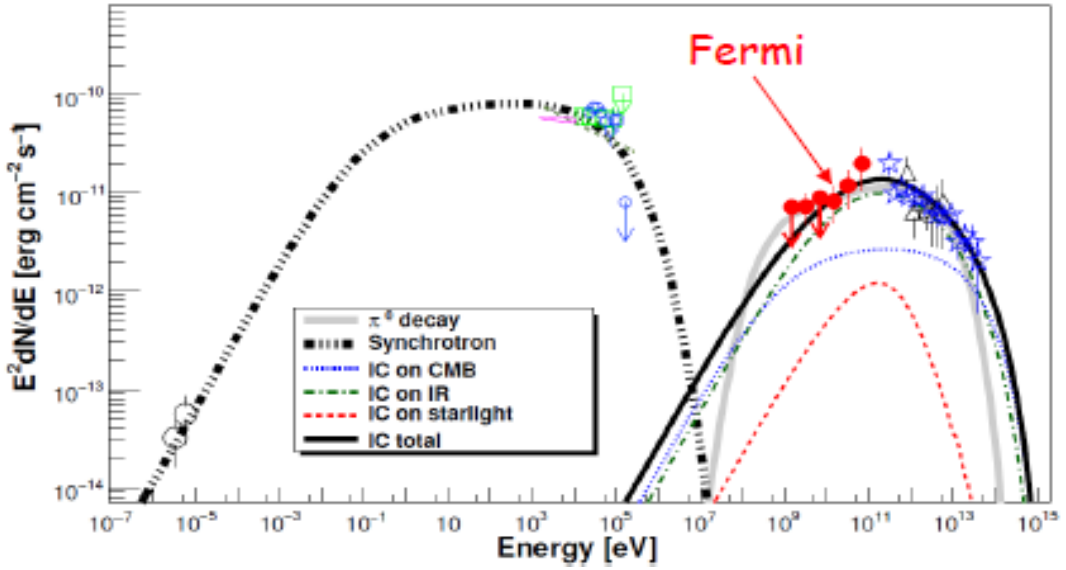
(Abdo et al., 2010, ApJ, accepted, arXiv:1003.3833)



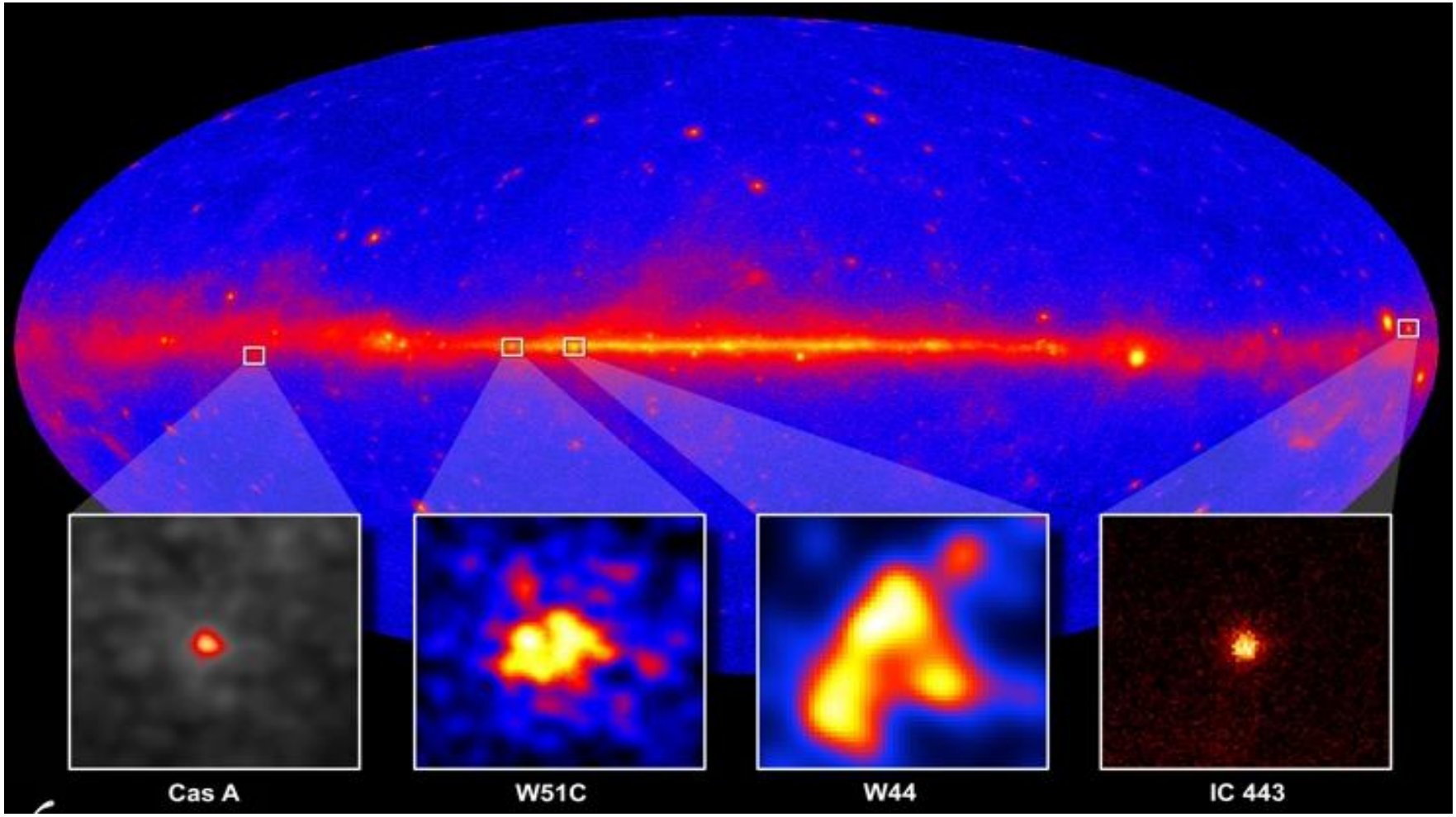
- Source extended : Rdisk = (0.25 ±0.05)°
- Flux (E>1 GeV) : ~ 3×10^{-9} cm^{-2} s^{-1}
- Spectral index : 1.6 ± 0.2

high energy emission can be explained by Inverse Compton scattering (mostly on FIR photon field)



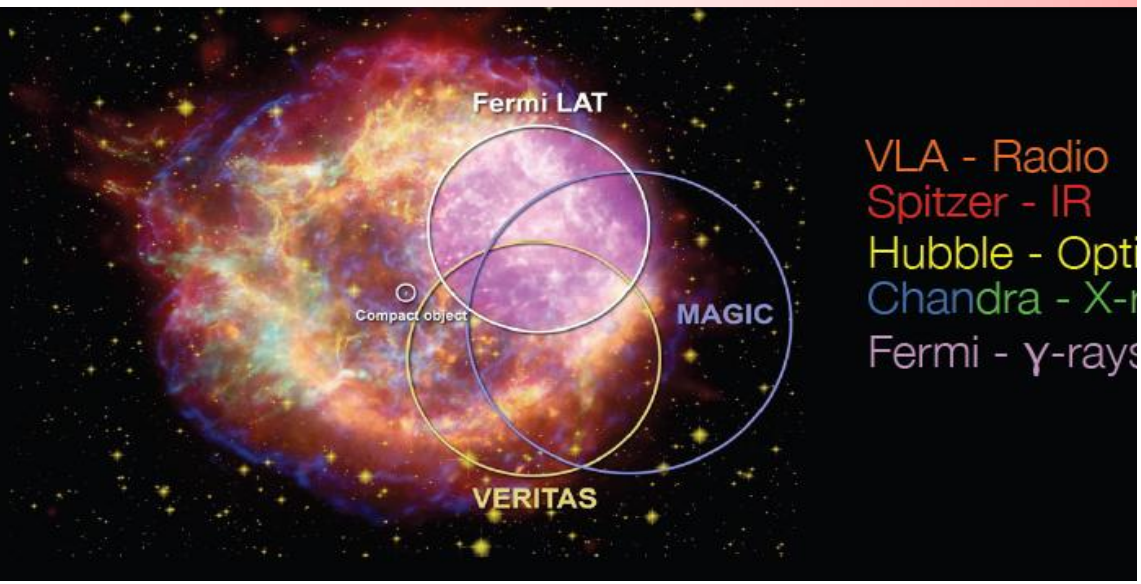


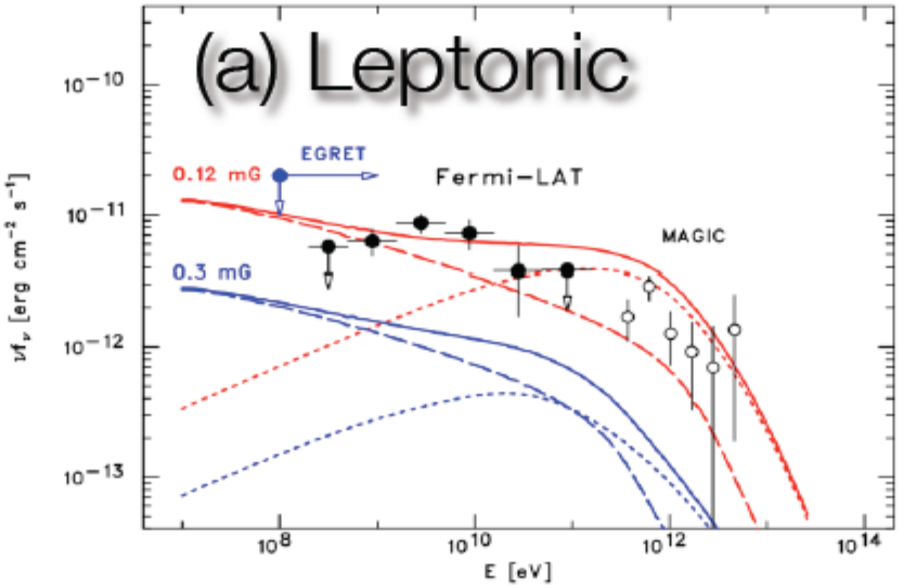
Fermi SNRs

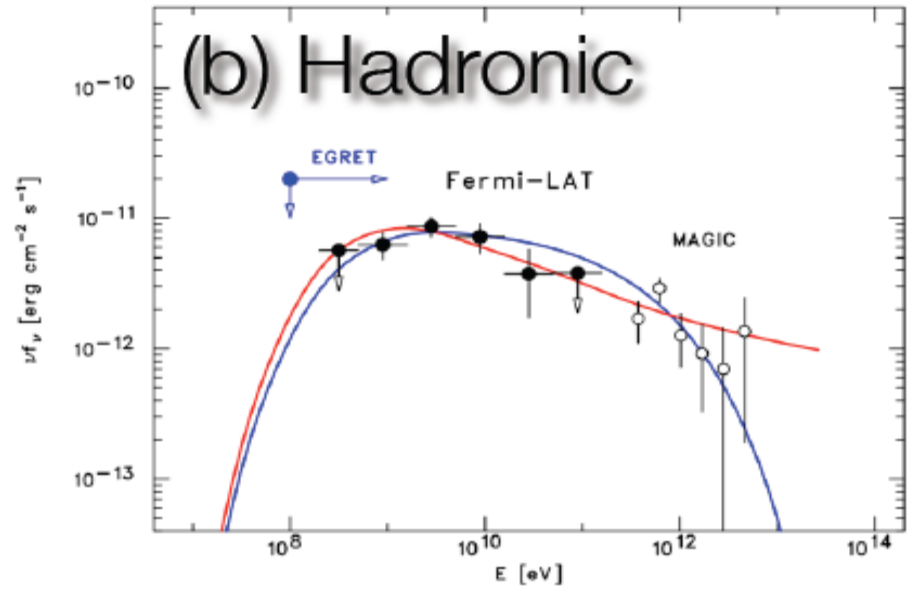


CasA

The Astrophysical Journal Letters 710, L92 (2010)



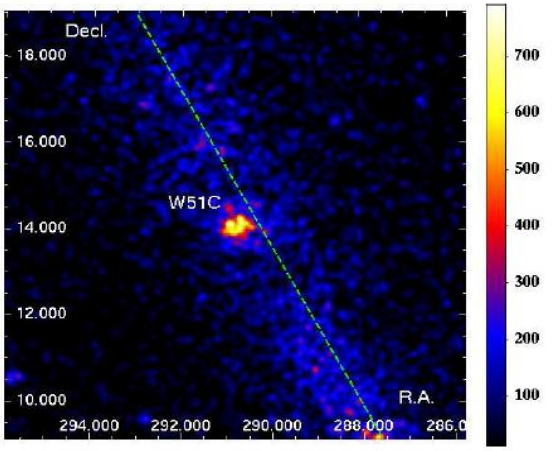


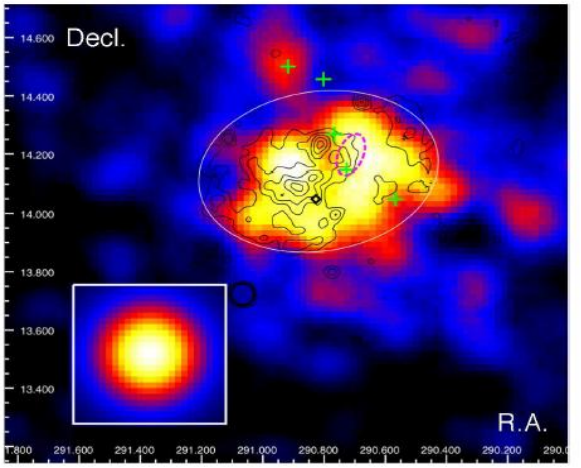


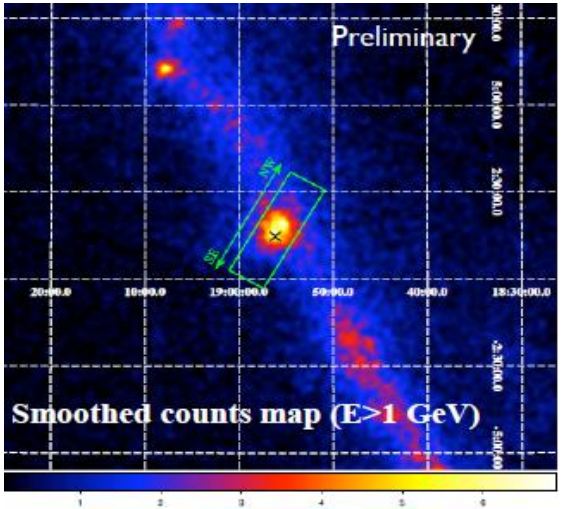
Leptonic scenario (Brems + IC):
B = 0.12 mG
– CR eletrons: We=1 × 10^{49} erg
• Hadronic scenario (π^0 decay):
B > 0.12 mG
Good fit with proton spectral index ~2.3 (red) or ~2.1 (blue) with cut-off at 10 GeV
– Total proton content: Wp=3 × 10^{49} erg

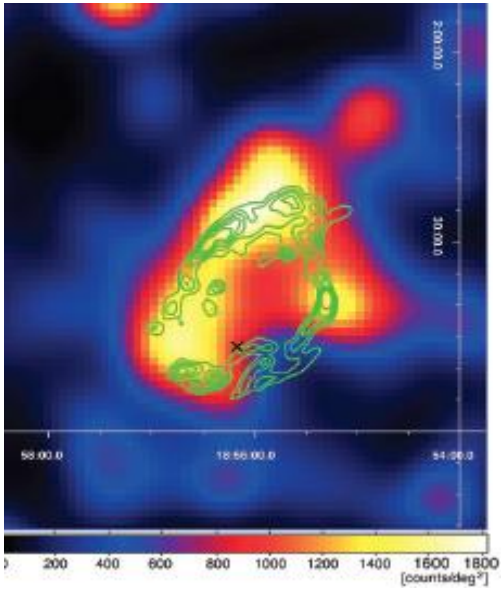
W51C* & W44**: Morpholgy and…

- Ages: 3 000 ÷ 50 000 years
- Interaction with molecular clouds can act as target material for π^0 production
- Typically rather steep (compared to young remnants)
- Rollover or break in proton spectrum at ~10GeV/c
- Extremely luminous (W51C: 10^{36} erg/s at 6 kpc)
- Detection of remnants interaction with clouds favours p+





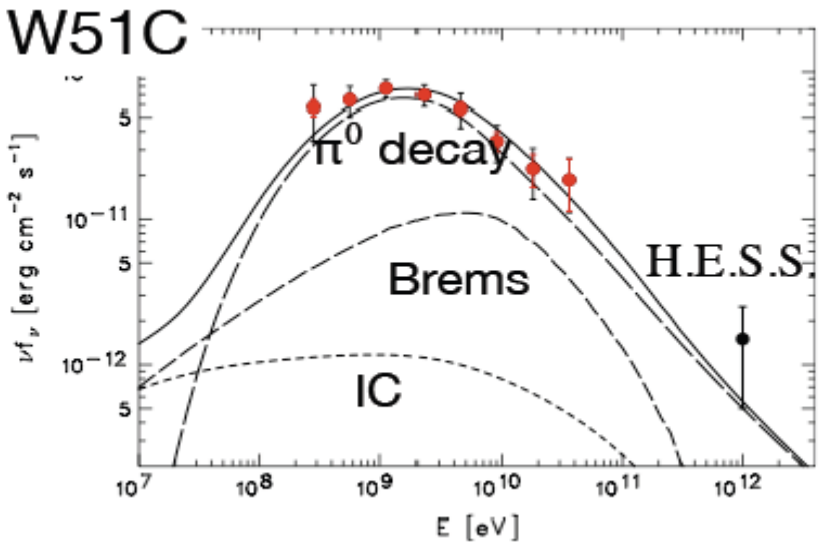


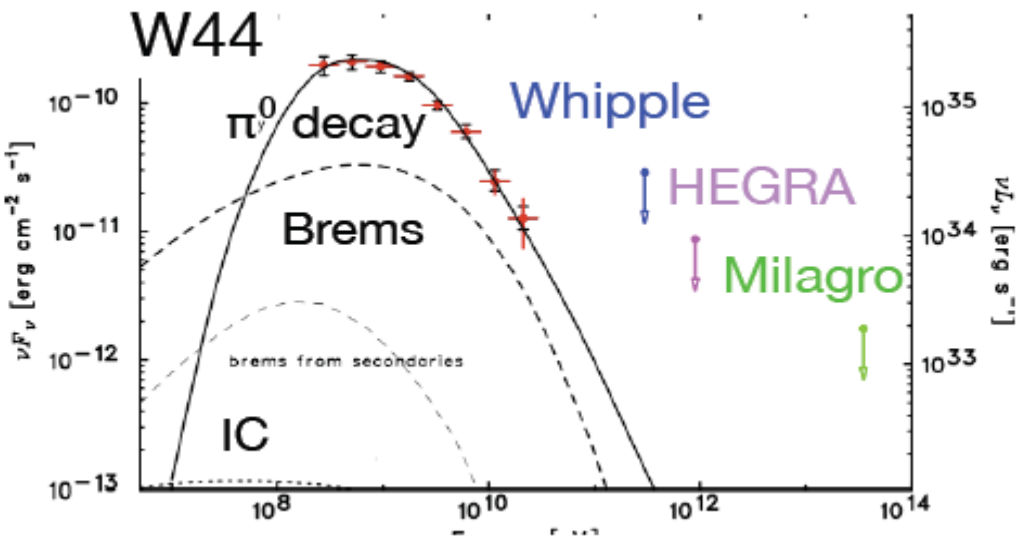


*Abdo et al., 2009, ApJ, 706, L1

** Abdo et al. *Science* 26 Febrary 2010 pp. 1103 - 1106

…spectra

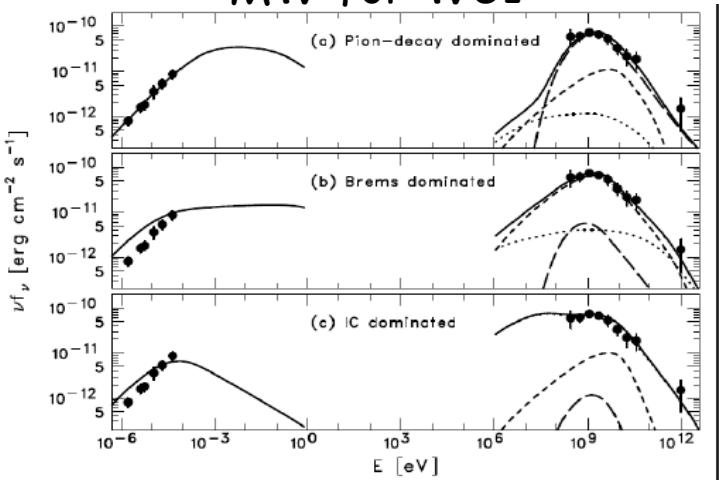




Leptonic models need large electron/proton ratios; piondecay is favoured

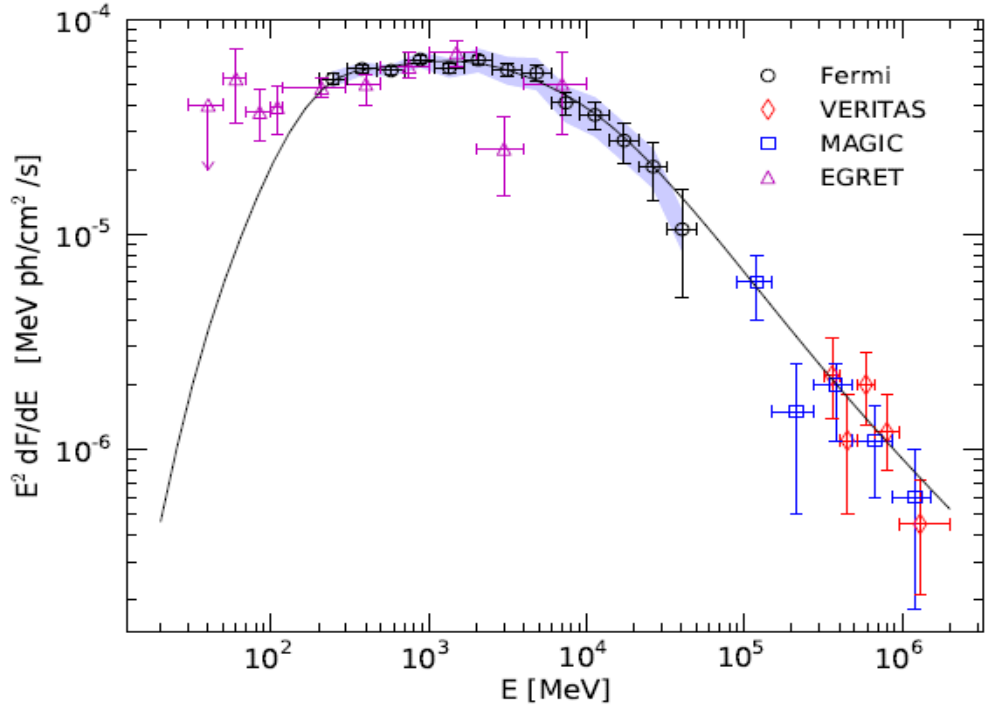
Brems: hard to reproduce the radio synchrotron spectrum => less likely but not fully excluded
IC: very large energy content in electrons and very low density => very unlikely

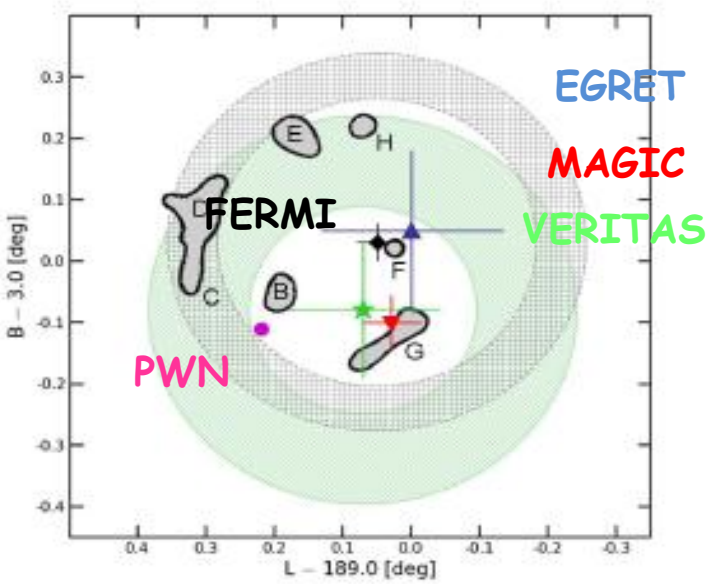
MW for W51



The IC443

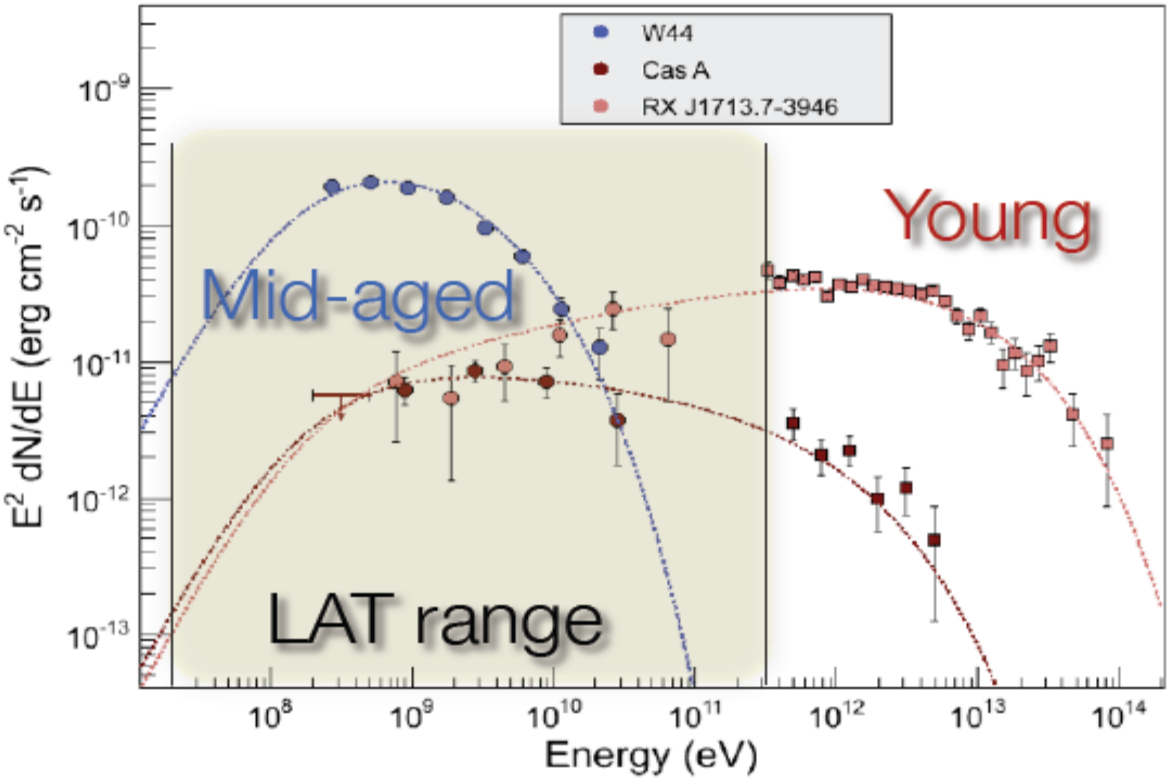
Abdo et al., 2010, ApJ, 712, 459





- Electron bremsstrahlung can hardly explain the observed IC 443 gamma-ray emissivity
- In a hadronic scenario, pion-producing proton population with a broken power-law spectrum well fit the data
- The bremsstrahlung likely makes a non-negligible contribution below E = 200 MeV where the EGRET data points exceed the best-fit pionic spectrum

SNR at different evolutionary stages



Credit: S.Funk HEAD 2010

- may probe **how** particles are accelerated
- and later released in the Galaxy

Conclusions

PWNe and SNRs are HE gamma-ray sources

Fermi-LAT can detect PWNe and SNRs in different evolutionnary stages and in different environments

- PWNe

  Vela-X with 2 electron populations vs Crab Nebula

- SNRs

  Cas A and RX J1713 vs W44 and W51C

More results will come soon!!!

Fermi
Gamma-ray
Space Telescope

Thanks for your attention!