

Fermi/LAT data analysis tutorial

Introduction

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- 1 Fermi/LAT
- 2 Astrophysical processes at GeV energies
- 3 Fermi/LAT scientific highlights

The Fermi Gamma-ray observatory



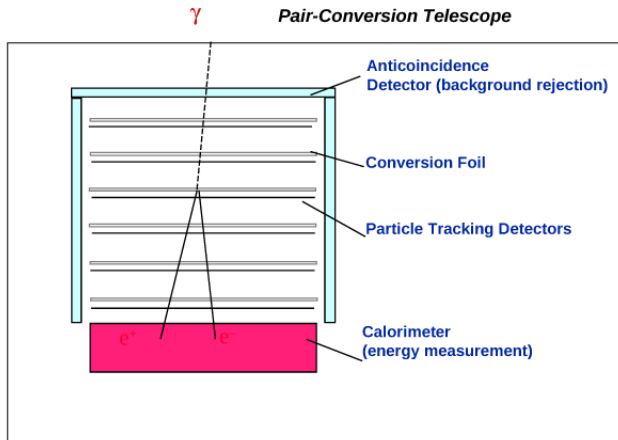
Large Area Telescope (LAT):
 e^+e^- pair conversion telescope

30 MeV - > 300 GeV

Gamma ray Burst Monitor (GBM):

12 x NaI (8 keV – 1MeV)

2 x BGO (200 keV – 40 MeV)



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- ▶ Arrival time
- ▶ Estimated arrival direction
- ▶ Estimated energy

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The event lists can then be binned in

- ▶ energy space → spectra
- ▶ time space → lightcurves
- ▶ direction space → maps

- ▶ The Fermi/LAT analysis is based on the construction of the likelihood that a given model is applicable to the obtained data.
- ▶ This likelihood is computed over many dimensions of the photon data, including direction and energy, for a given Region of Interest (ROI), which includes our source.
- ▶ The likelihood is given by

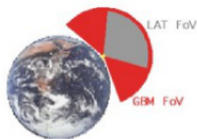
$$\mathcal{L} = e^{-N_{pred}} \prod_k \frac{m_k^{n_k}}{n_k!}$$

, where, for each bin k , n_k is the detected counts and m_k the expected counts for the given model.

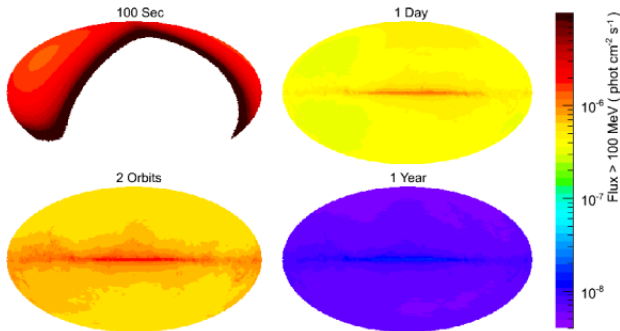
- ▶ The **test statistic (TS)** will be used to evaluate the fitness of a given model:

$$TS = -2 \log \left(\frac{\mathcal{L}_{max,0}}{\mathcal{L}_{max,1}} \right)$$

Fermi/LAT observation strategy



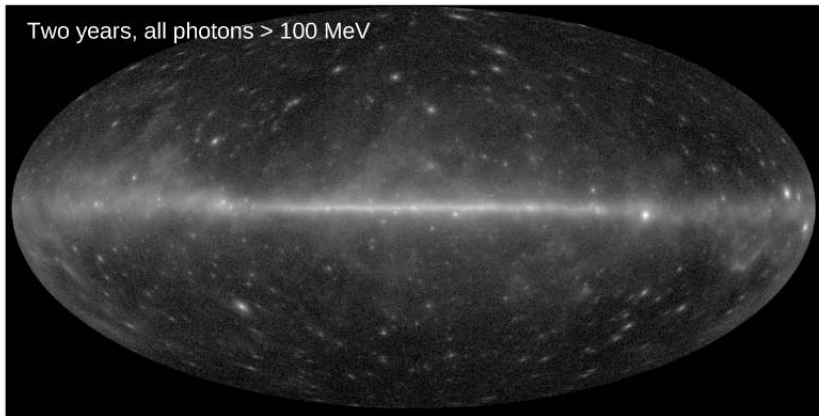
LAT sees 1/5 of the sky at any time
GBM sees entire un-occulted sky



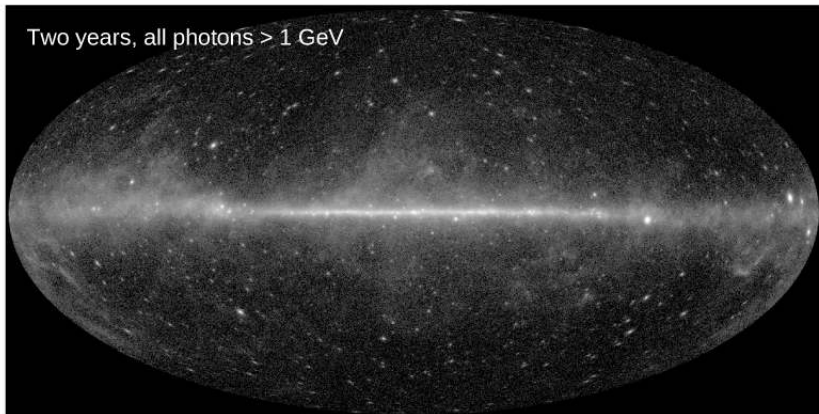
Fermi spends every other orbit rocked either north or south.

3 hours to survey entire sky

The Fermi/LAT sky above 100 MeV



The Fermi/LAT sky above 1 GeV



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Energy sources:

- ▶ Explosions (SNR)
- ▶ Accretion (AGN, microquasars)
- ▶ Variable magnetic fields (pulsars)

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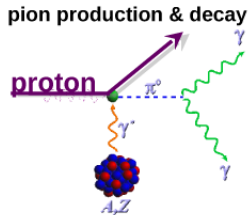
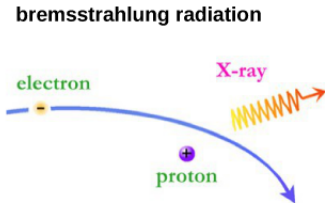
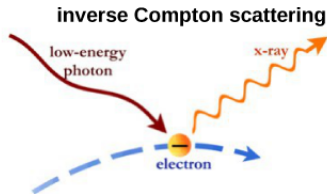
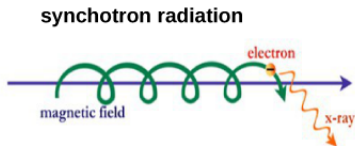
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Acceleration processes:

- ▶ Rotating magnetic fields
- ▶ Magnetic reconnection
- ▶ Poynting fluxes
- ▶ Shock acceleration

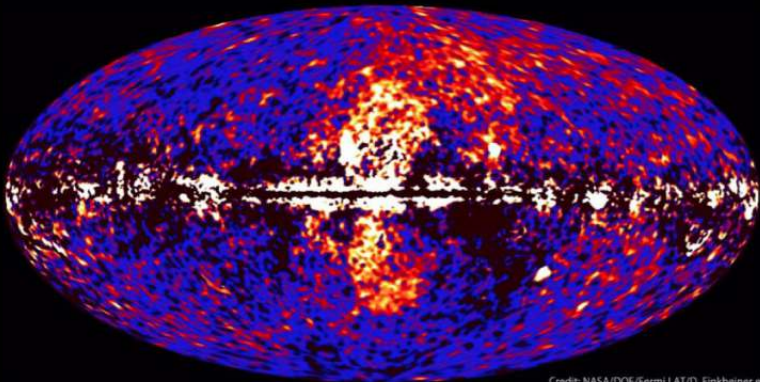
Astrophysical processes at GeV energies

At GeV energies only non-thermal processes are relevant:



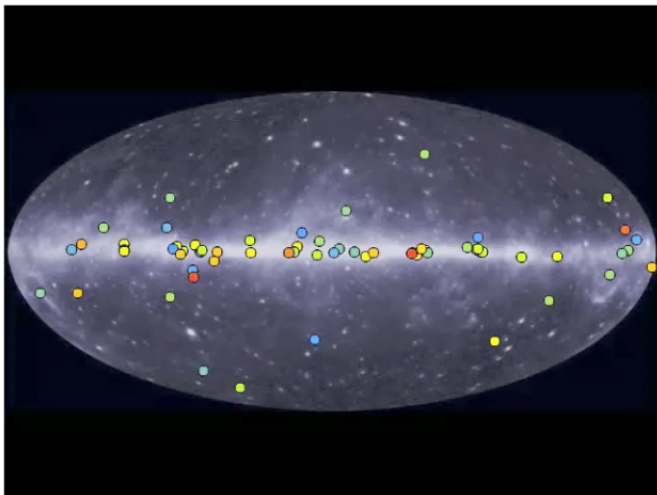
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Fermi data reveal giant gamma-ray bubbles

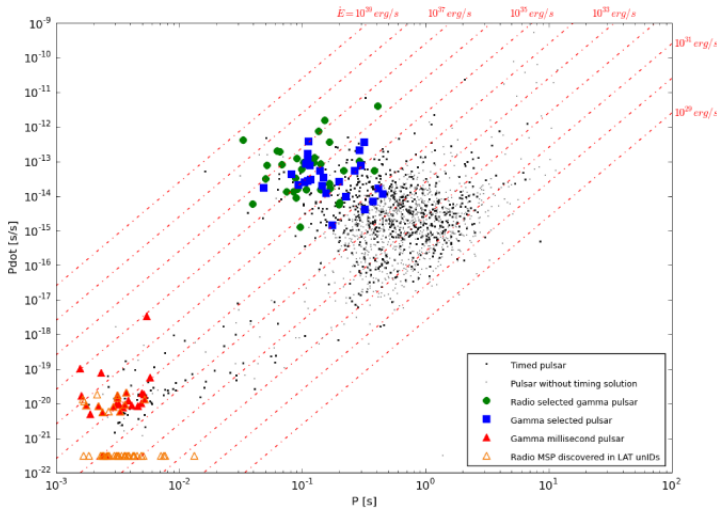


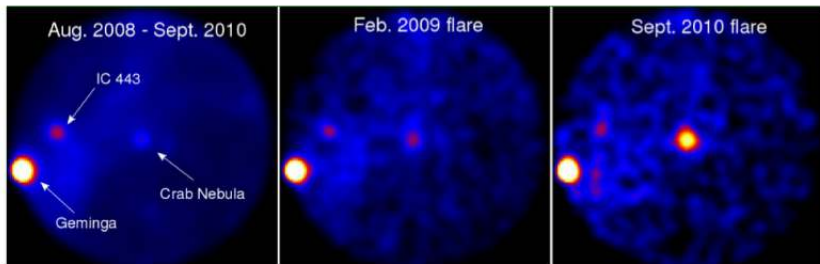
Credit: NASA/DOE/Fermi LAT/D. Finkbeiner et al.

Population of GeV pulsars

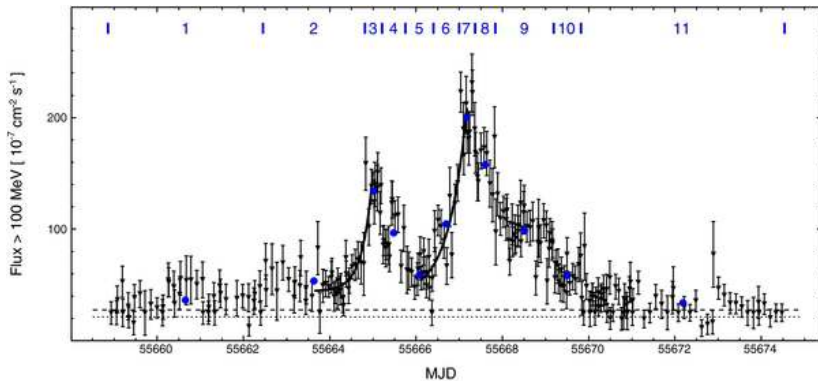


Population of GeV pulsars

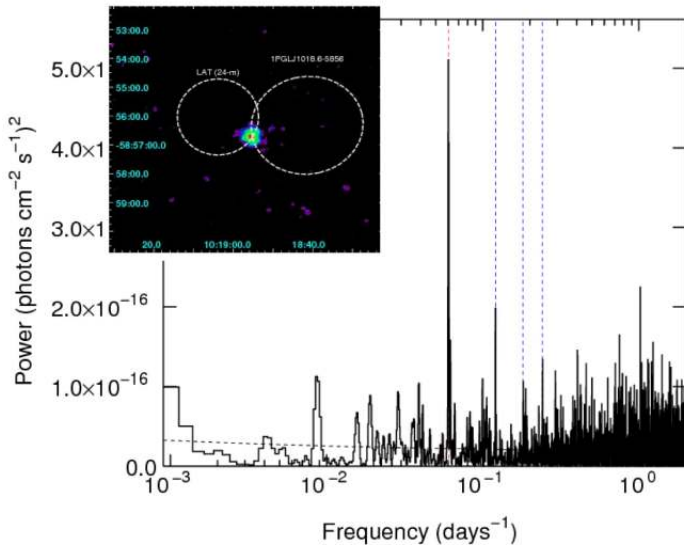




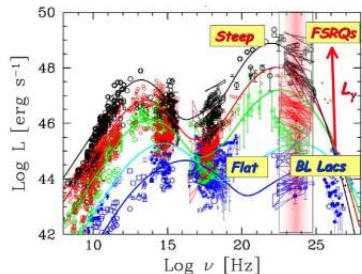
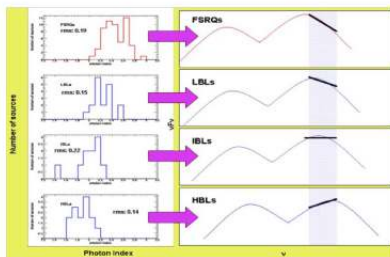
Crab Nebula flare (April 2011)



Discovery of a new gamma-ray binary, 1FGL J1018-5856



AGN population studies



And many many more results!

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