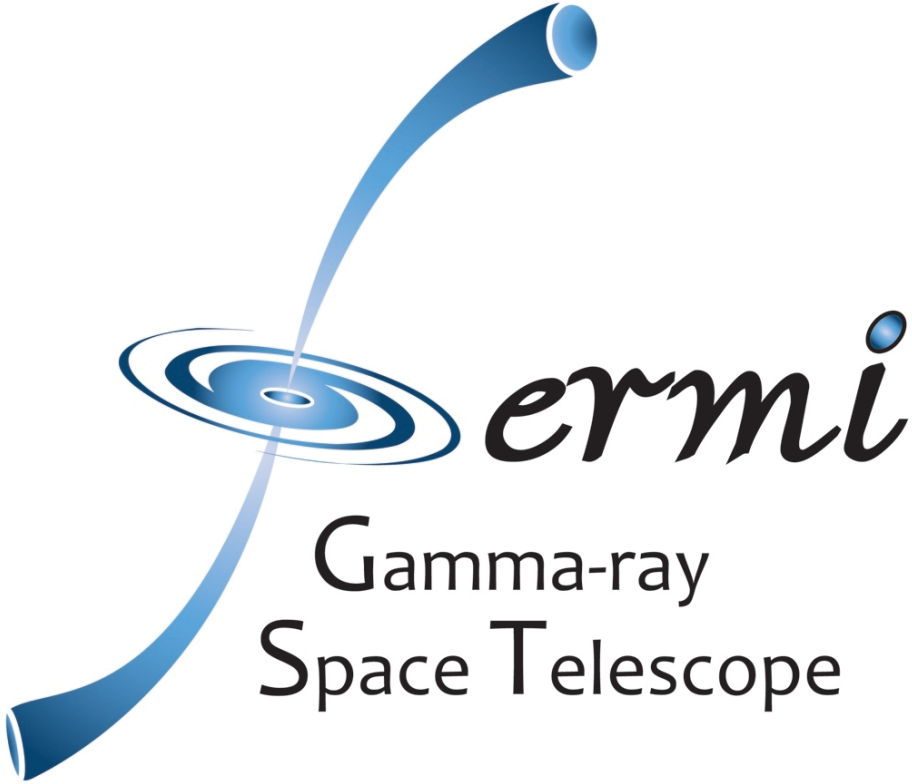


Latest results

Miranda Jackson

27 Nov, 2012

Fermi

- launched 11 June, 2008
- Objectives:
  - Explore the most extreme environments in the Universe, where nature harnesses energies far beyond anything possible on Earth.
  - Search for signs of new laws of physics and what composes the mysterious Dark Matter.
  - Explain how black holes accelerate immense jets of material to nearly light speed.
  - Help crack the mysteries of the stupendously powerful explosions known as gamma-ray bursts.
  - Answer long-standing questions across a broad range of topics, including solar flares, pulsars and the origin of cosmic rays.

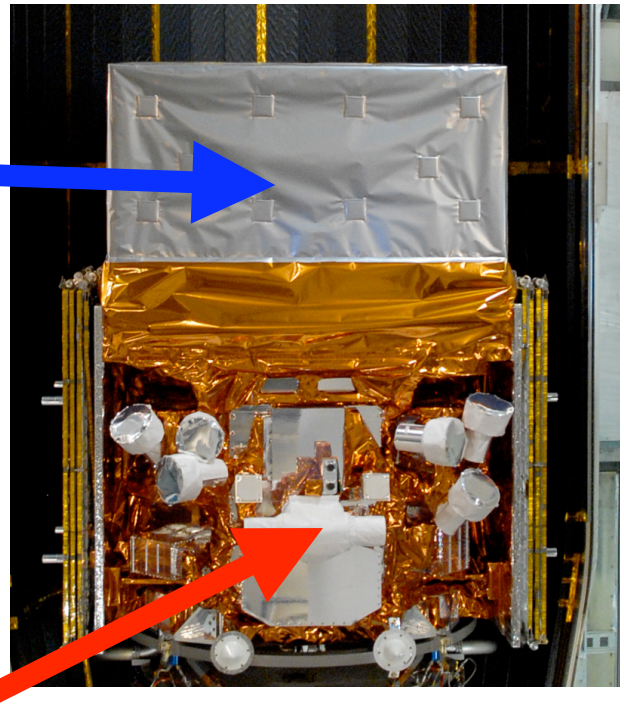
Fermi instruments

LAT

- sensitive to 20 MeV - >300 GeV γ-rays
- 2.4 sr FoV, scans entire sky every 2 orbits (3 h)

GBM

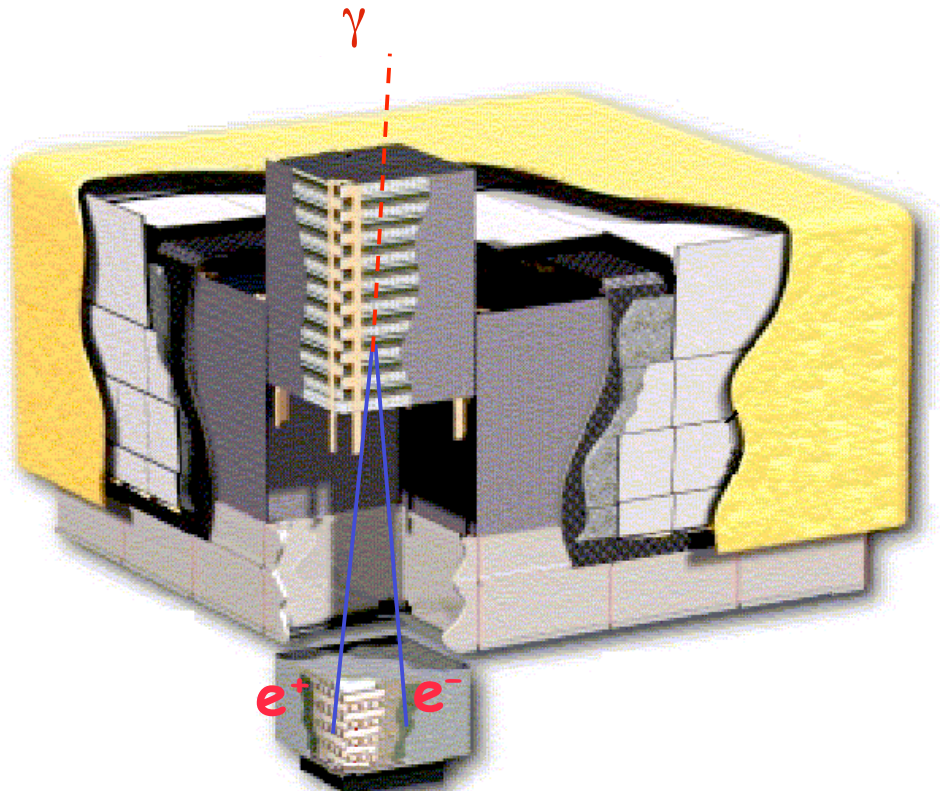
- sensitive to 8 keV - 40 MeV
- views entire unocculted sky



Fermi Gamma-ray Space Telescope

Large area telescope

- Precision Si-strip tracker - measures the photon direction
- Hodoscopic CsI Calorimeter - measures the energy, images the shower
- Segmented Anticoincidence detector - rejects background
- Electronics system with flexible robust hardware trigger and software filters

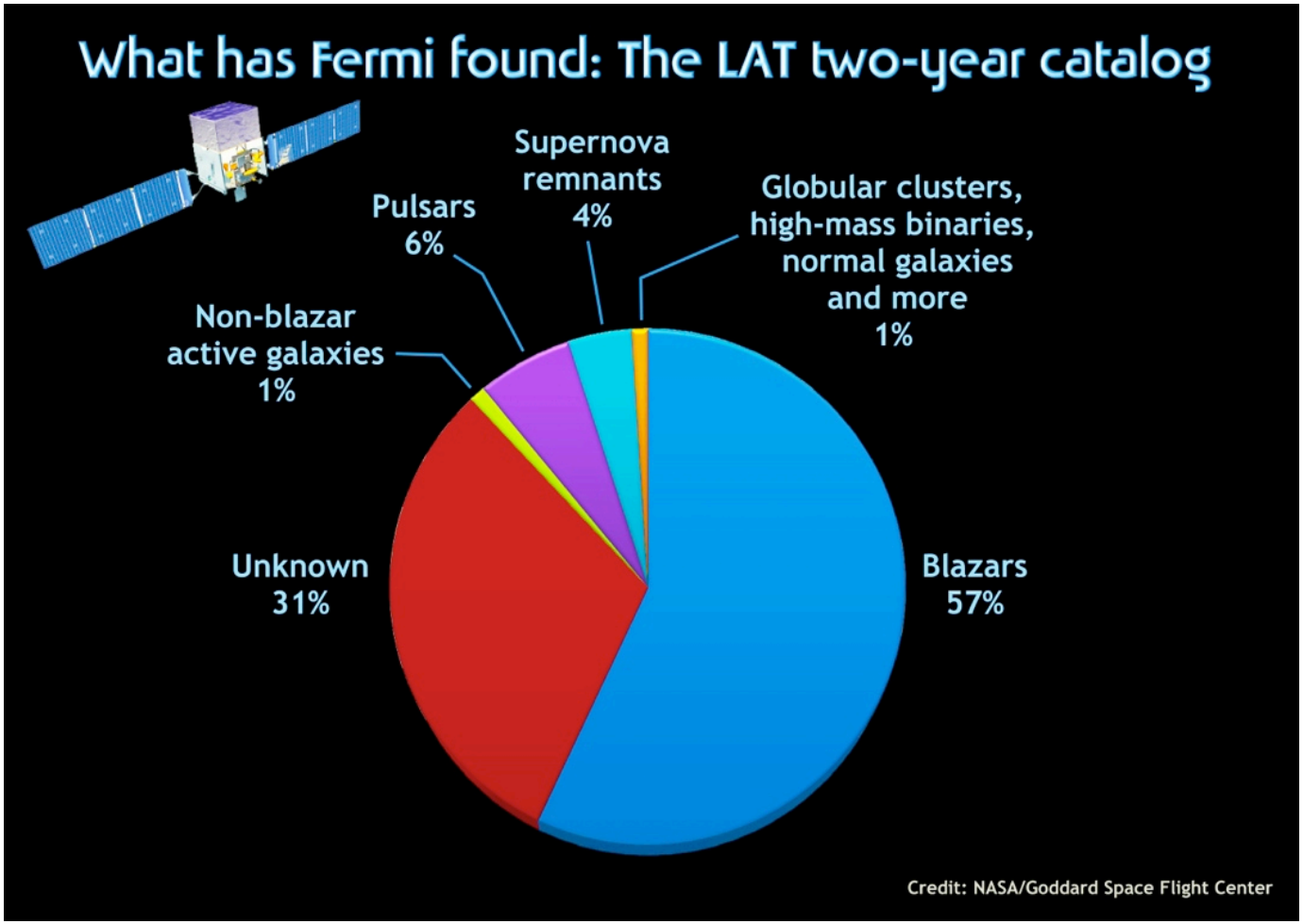


Fermi Gamma-ray Space Telescope

Fermi in Sweden

- Focus on dark matter, gamma-ray bursts, active galactic nuclei, and pulsars
- Compact objects and GRB: F. Ryde, M. Jackson, E. Moretti, T. Nymark, M. Axelsson, C. Lundström, J. Larsson, S. Larsson, S. Iyyani
- Dark Matter: B. Anderson, P. Carlson, J. Conrad, L. Bergström, J. Edsjö, S. Carius, G. Martinez, M. Llena-Garde, S. Zimmer

Fermi sources

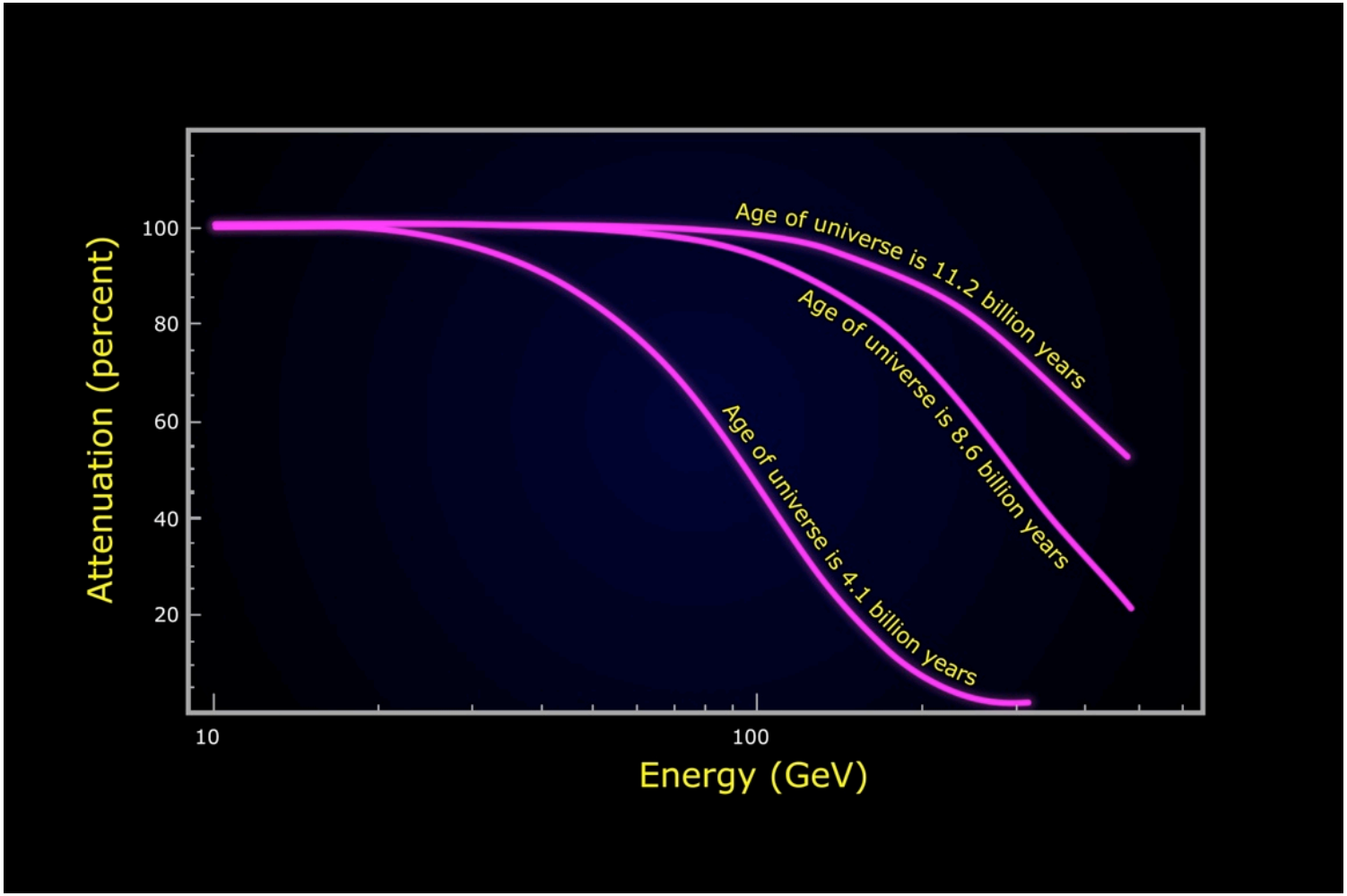


Gamma-ray Space Telescope

Cosmic Fog

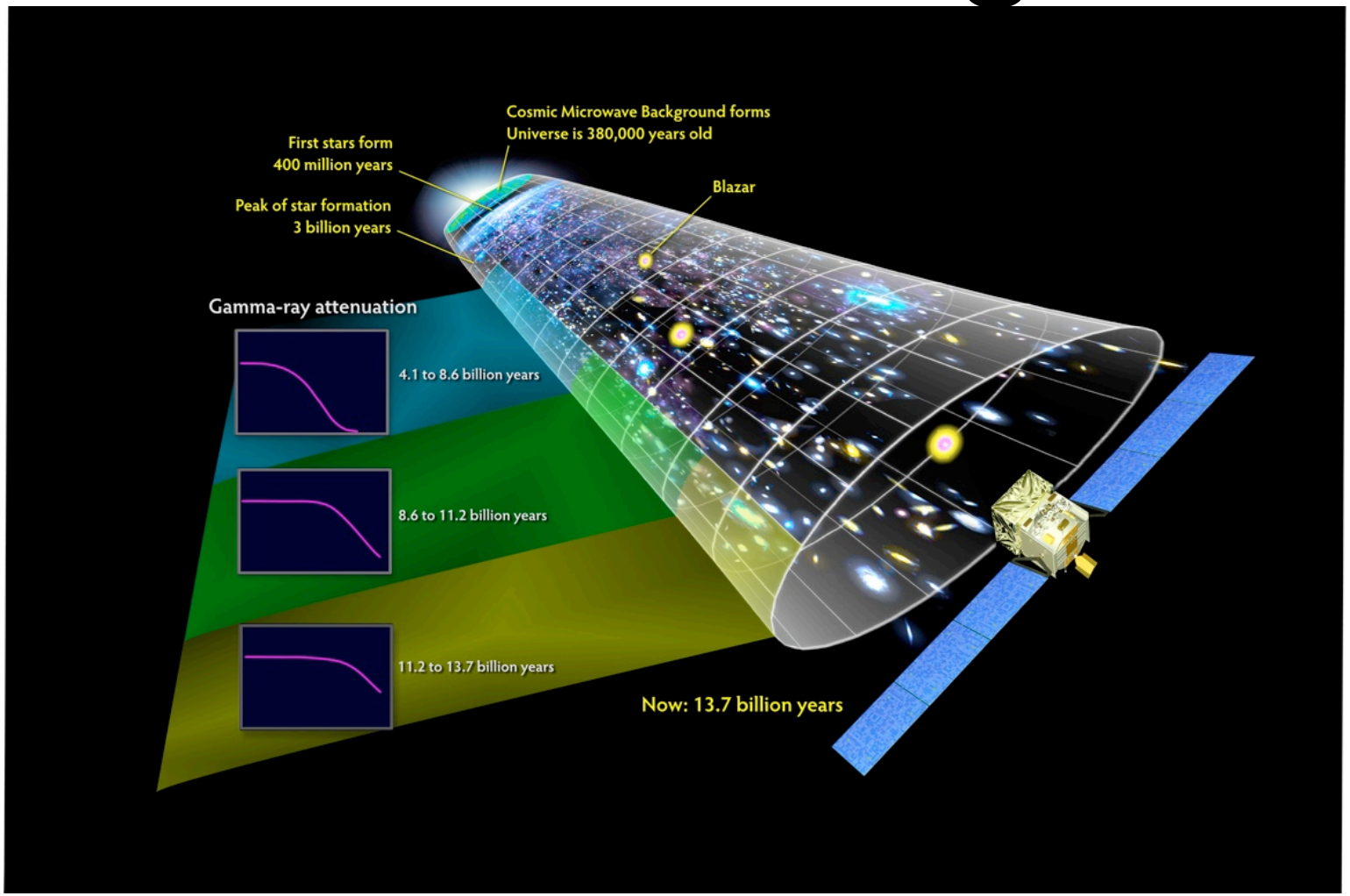
- γ-rays from blazars interact with photons from starlight and disappear from the γ-ray background
- Fermi sees less light coming from distant blazars than expected from observations of close blazars
- Fermi can be used as a probe of past star formation

Cosmic Fog



Fermi Gamma-ray Space Telescope

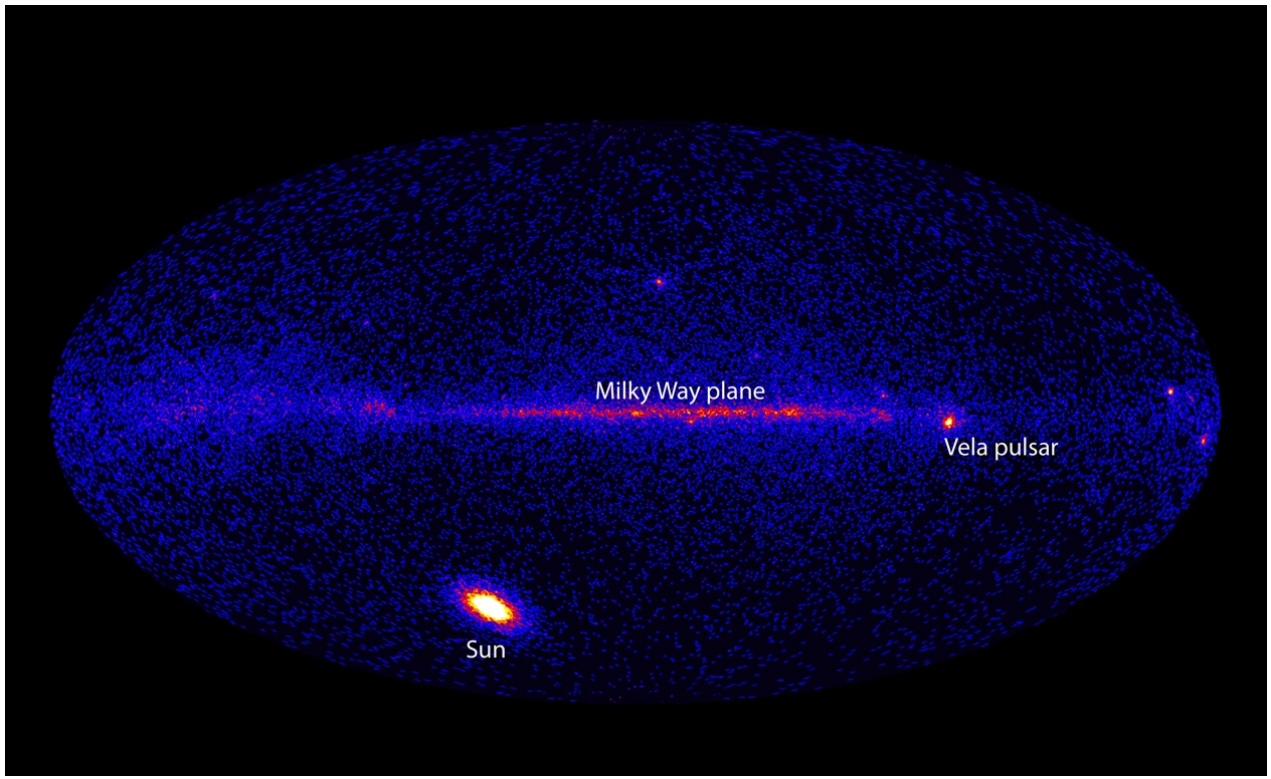
Cosmic Fog



Fermi Gamma-ray Space Telescope

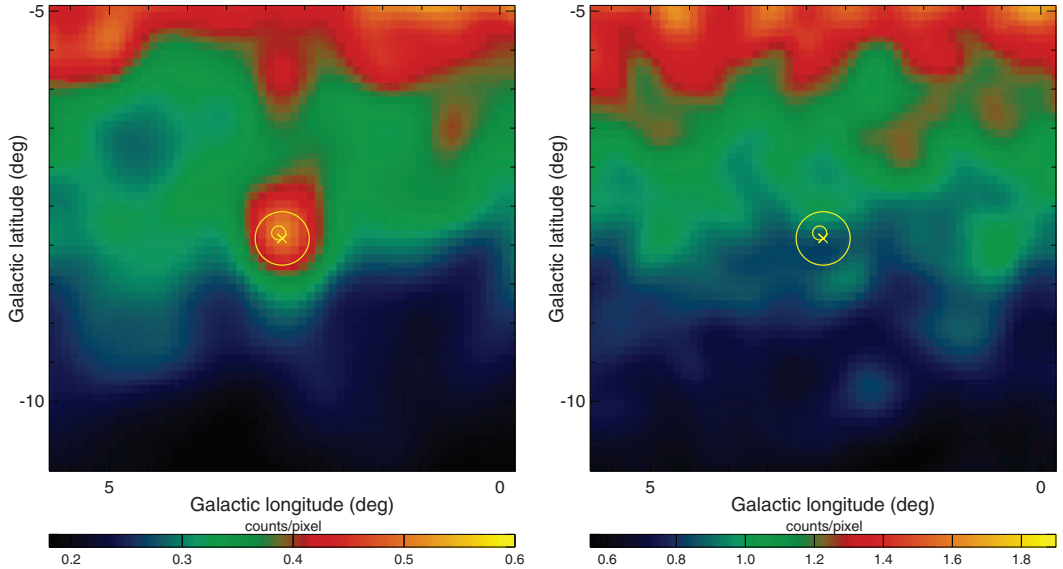
Solar Flares

- March 7, 2012, Fermi detects highest energy light ever seen from the sun



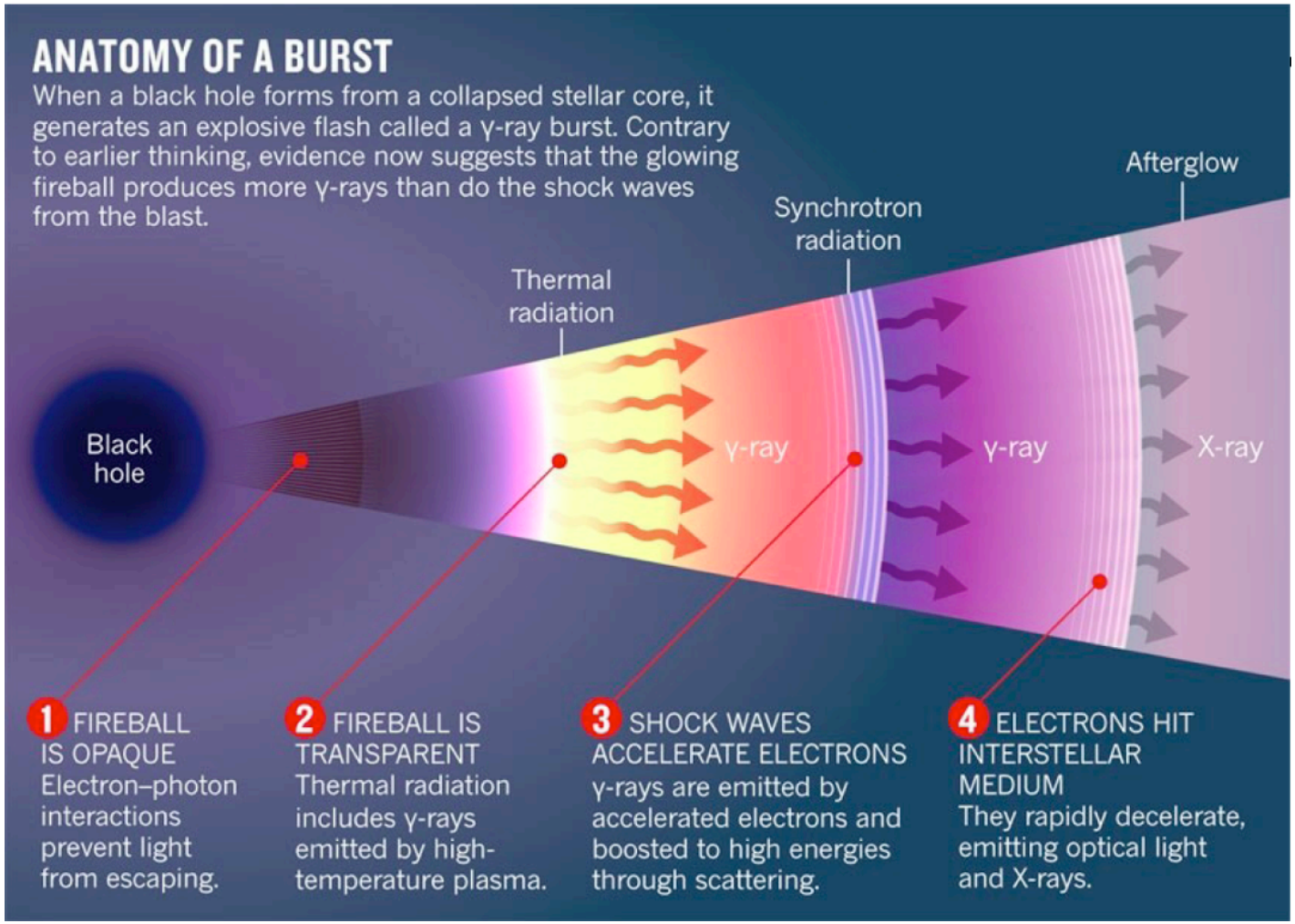
Pulsars

- Fermi observations show that in globular clusters, formation of anomalous high magnetic field millisecond pulsars is comparable to that of normal MSPs (Science 334, 1107 2011)



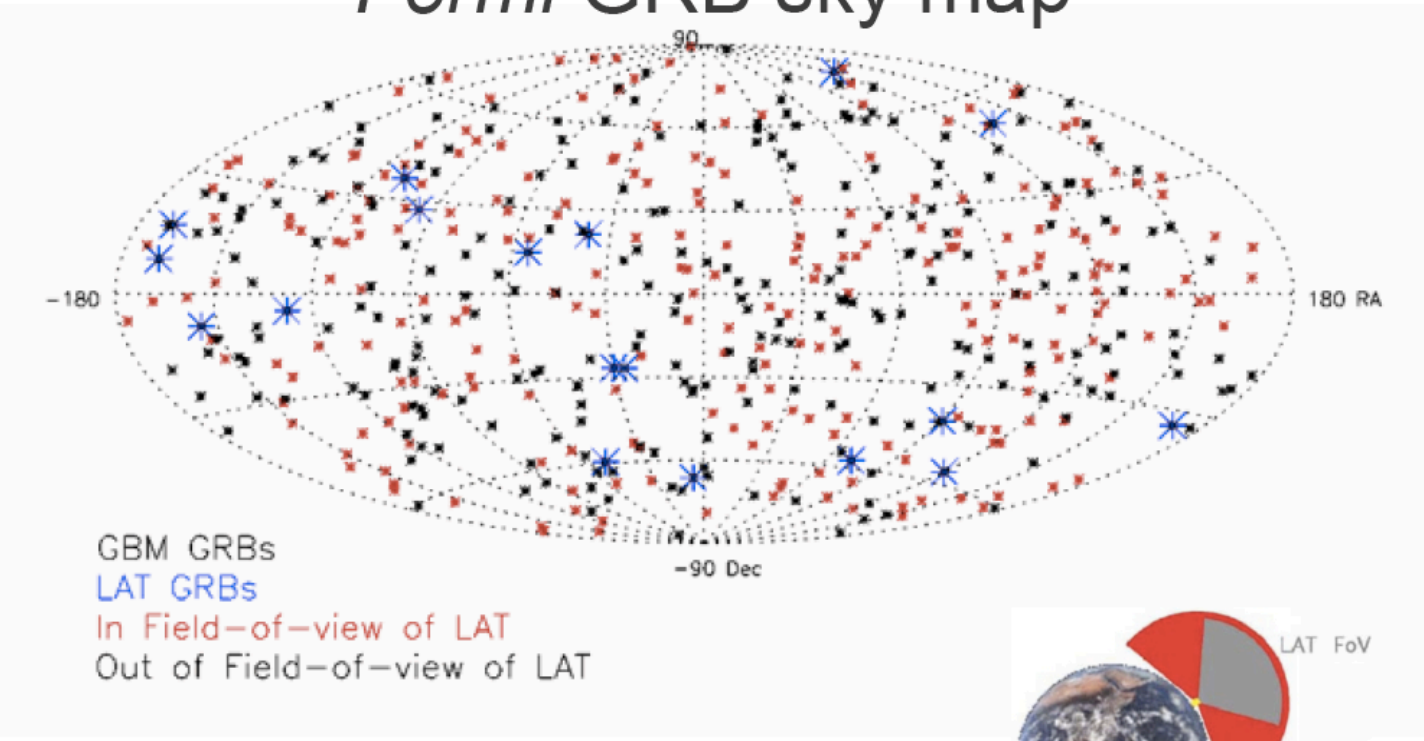
- 2nd Fermi pulsar catalog nearly ready for submission!

Gamma-ray bursts



GRB

Fermi GRB sky map



~20 GRBs/month seen by GBM
~1/30 of GBM bursts seen by LAT

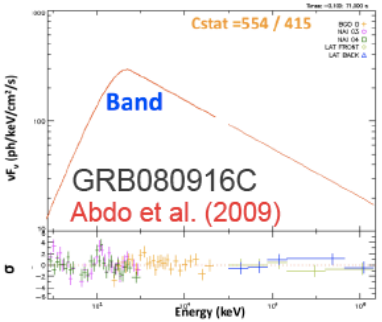
GBM: 8 keV - 40 MeV
LAT: 20 MeV- 300 GeV

Gamma-ray Space Telescope

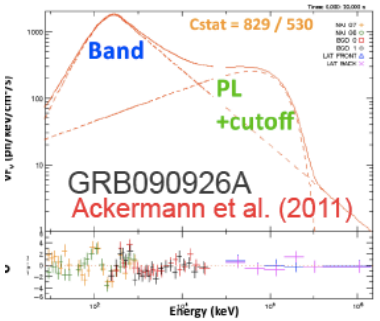
GRB

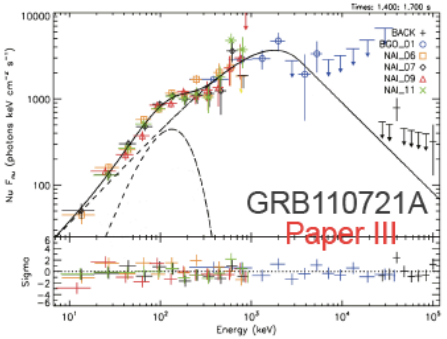
GRB observations by *Fermi*

Several spectral shapes observed!

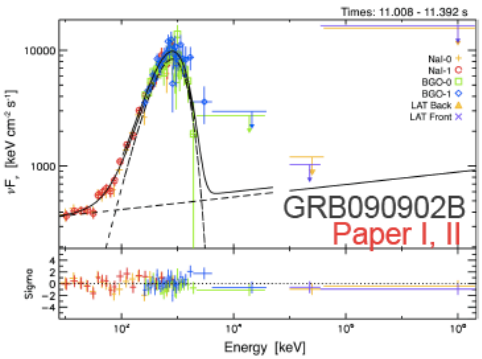


"Band" crisis!





Axelsson et al. 2012

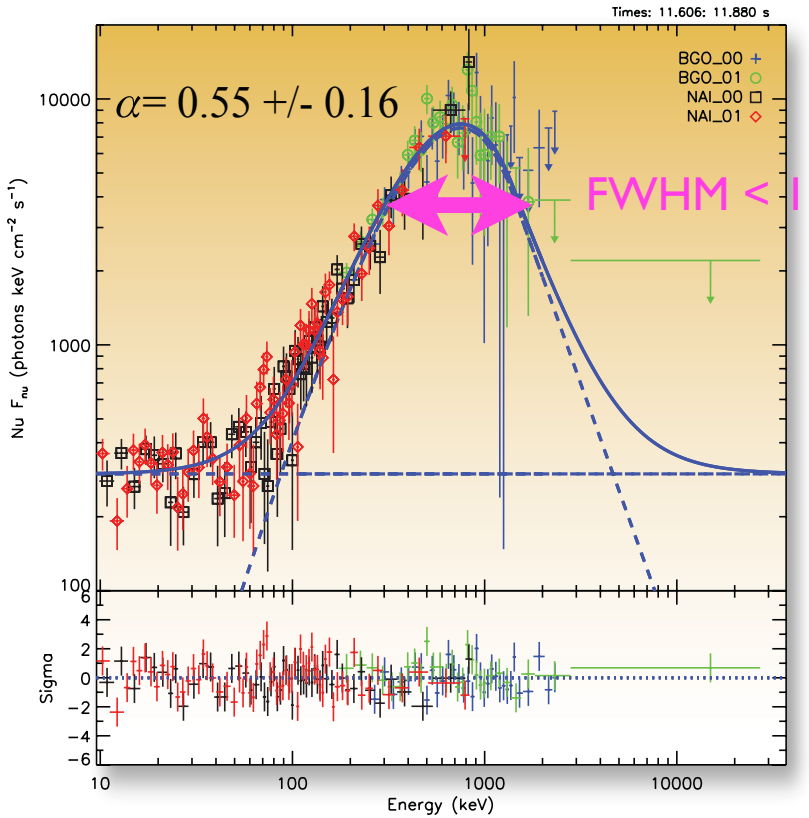


Ryde et al. 2010

Broad energy range!

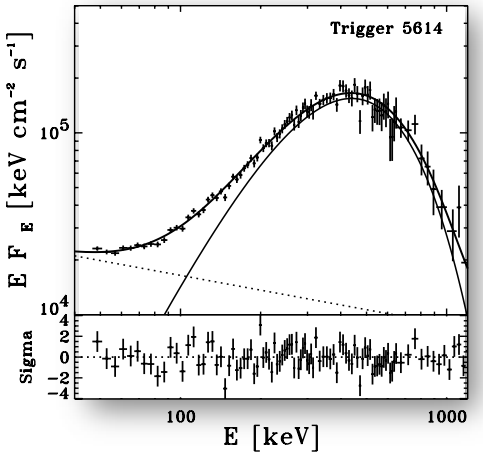
GRB 090902B

Time resolved spectrum (11.608-11.880 s)



Ryde et al. (2010) Zhang et al. (2010)

CGRO BATSE



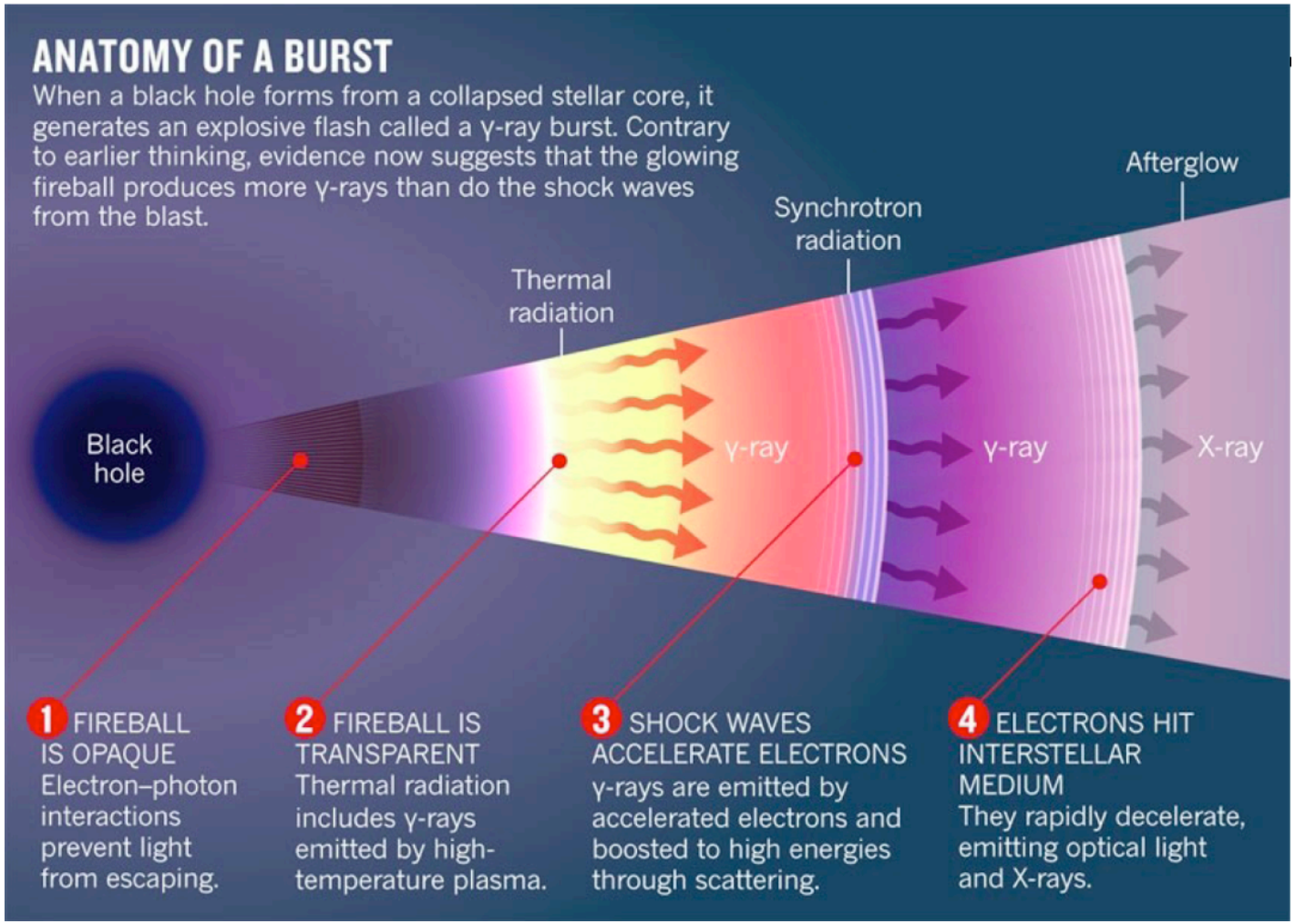
Ryde (2004)

Clearest detection of photospheric emission in a burst

$$\Gamma = 750 \qquad \bar{R}_{\rm ph} = (1.1 \pm 0.3) \times \bar{1}0^{12}\, \bar{Y}^{1/4}\ {\rm cm}$$

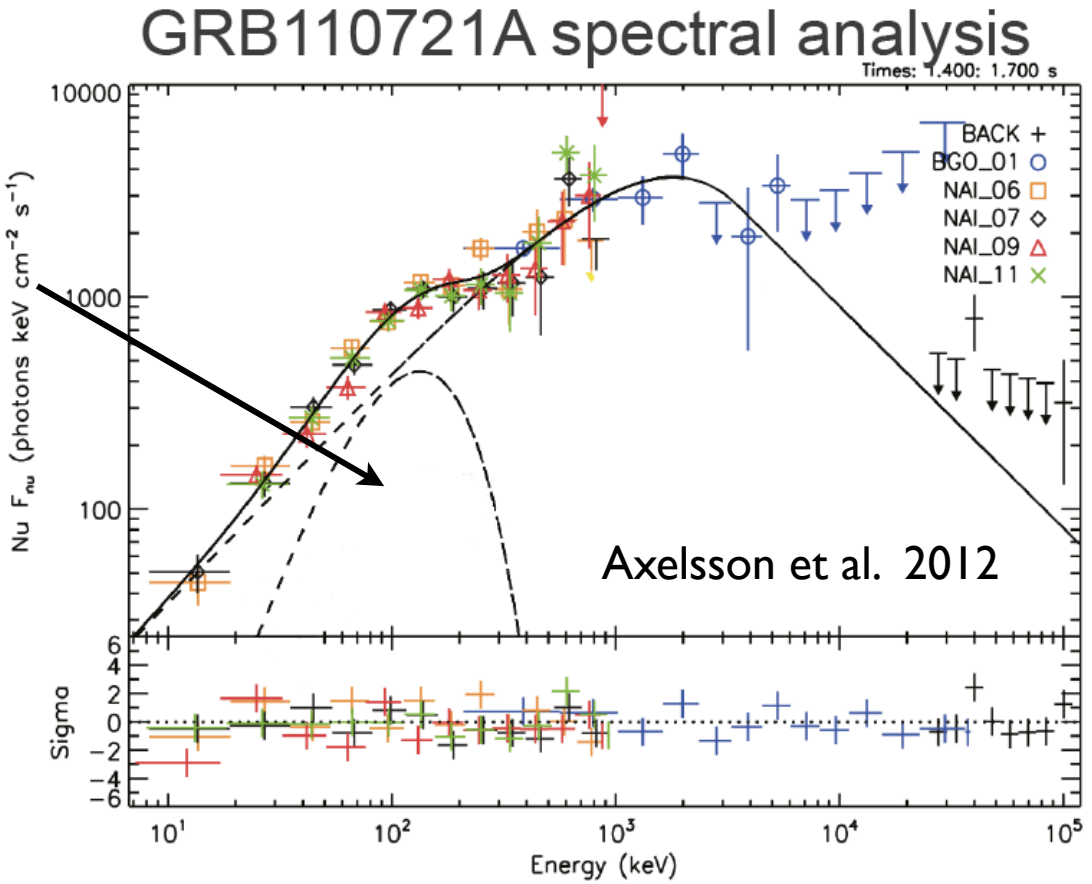
Ryde et al. 2010

GRB


ANATOMY OF A BURST
When a black hole forms from a collapsed stellar core, it generates an explosive flash called a γ-ray burst. Contrary to earlier thinking, evidence now suggests that the glowing fireball produces more γ-rays than do the shock waves from the blast.
Afterglow
Synchrotron radiation
Thermal radiation
Black hole
γ-ray
γ-ray
X-ray
1 FIREBALL IS OPAQUE
Electron–photon interactions prevent light from escaping.
2 FIREBALL IS TRANSPARENT
Thermal radiation includes γ-rays emitted by high-temperature plasma.
3 SHOCK WAVES ACCELERATE ELECTRONS
γ-rays are emitted by accelerated electrons and boosted to high energies through scattering.
4 ELECTRONS HIT INTERSTELLAR MEDIUM
They rapidly decelerate, emitting optical light and X-rays.

GRB

Blackbody (photosphere)



Two spectral components **statistically required (>5σ)**

Fermi Gamma-ray Space Telescope

NATURE | NEWS

Cosmic blasts powered by a hot glow

Spectral sensitivity of Fermi satellite reveals physics of gamma-ray generation

Eric Hand

08 May 2012

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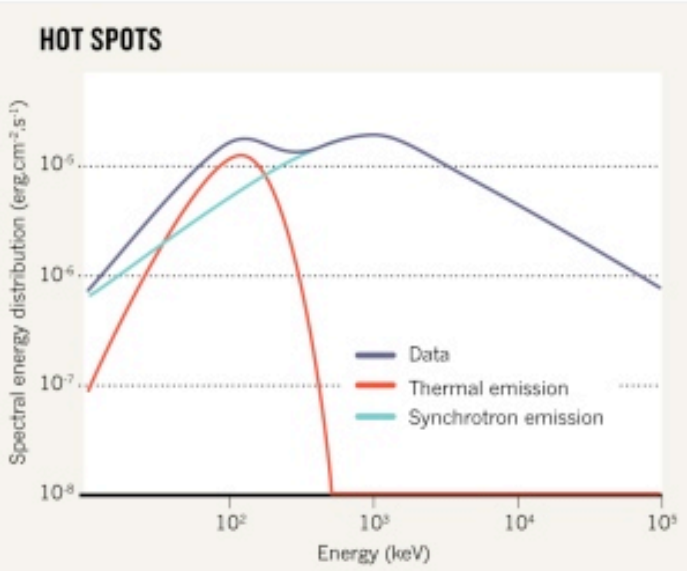
Since its launch in 2008, the Fermi space telescope has recorded hundreds of gamma-ray bursts (GRBs), flashes of light that, for just a few seconds or minutes, are the brightest objects in the Universe. And now the telescope is yielding data that is starting to explain the mechanisms that unleash these beam-like jets of light, which are thought to emanate from the poles of a spinning star as it collapses to form a black hole and explode in a supernova.

New light



A preliminary model for the energy spectrum of gamma-ray burst 120323A, discovered in March by the Fermi telescope, shows a bump that is likely to come from thermal emissions — casting doubt on a long-held view that synchrotron emissions alone could explain the

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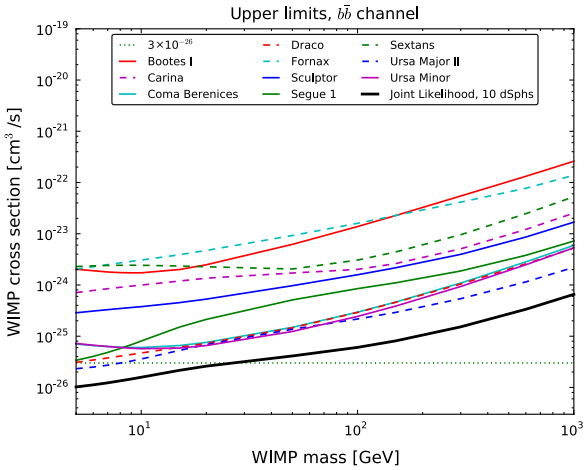
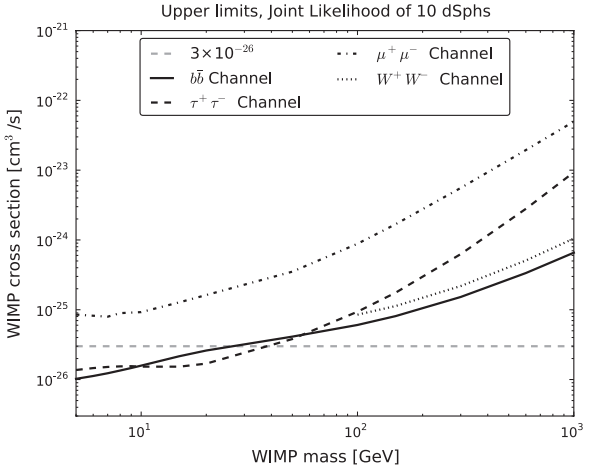
Dark Matter

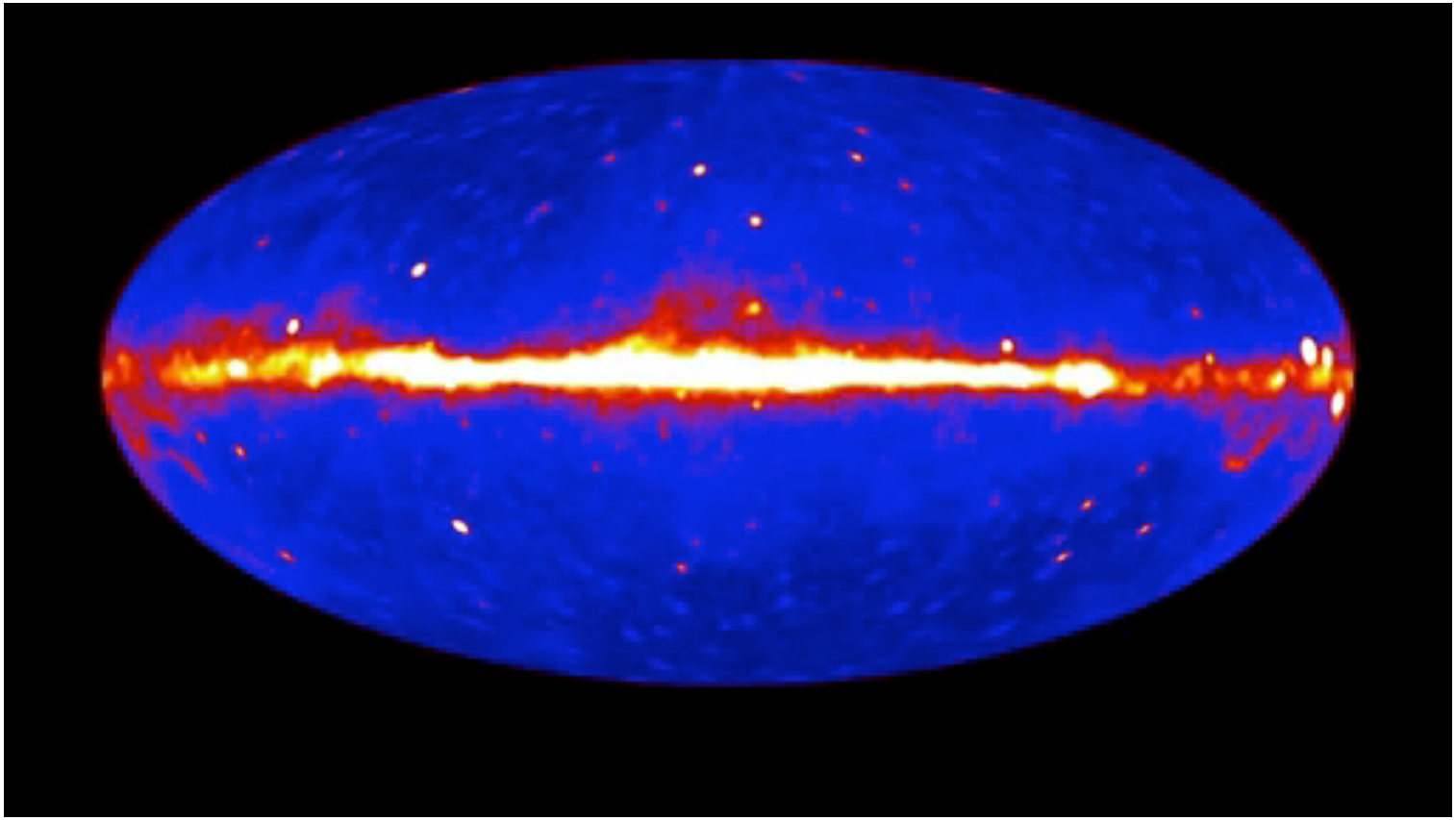
- A combined fit of observations of Milky Way satellites has set upper limits on the cross sections for 4 dark matter candidate particles





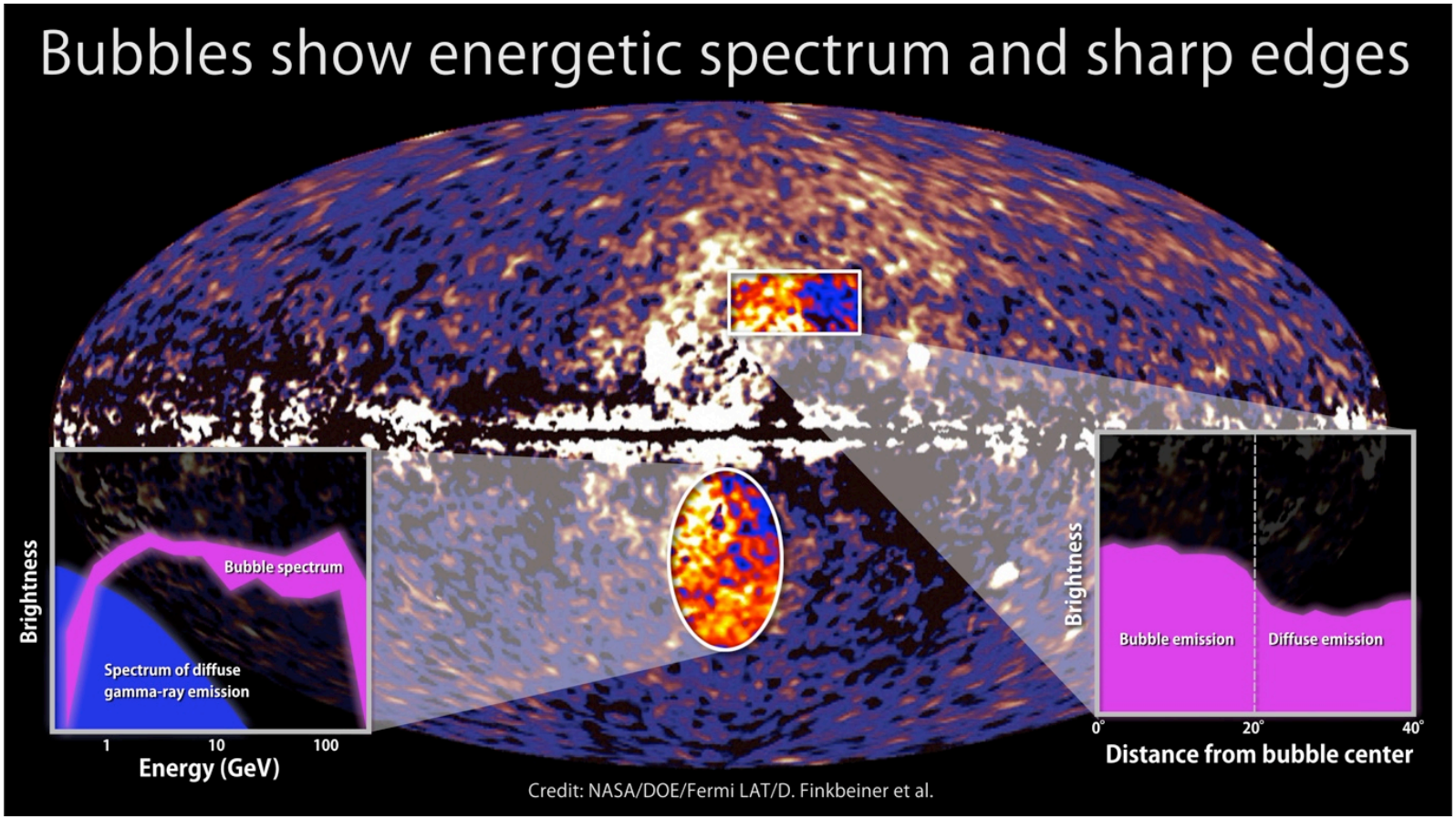
- check out Oscar Stål's talk at 12:10

γ-ray bubbles in the Milky Way



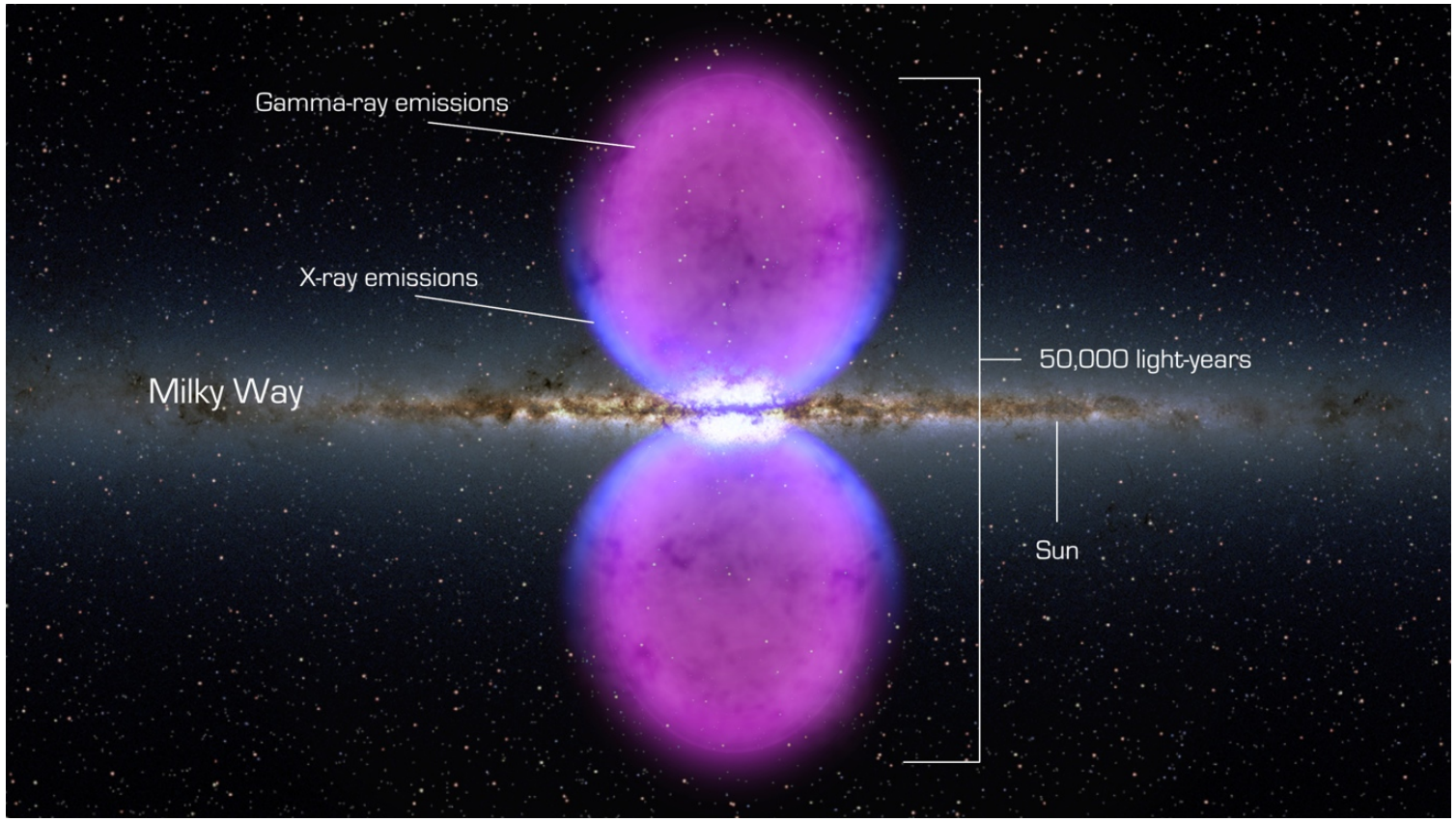
Partikeldagarna, 27 Nov 2012

γ-ray bubbles in the Milky Way



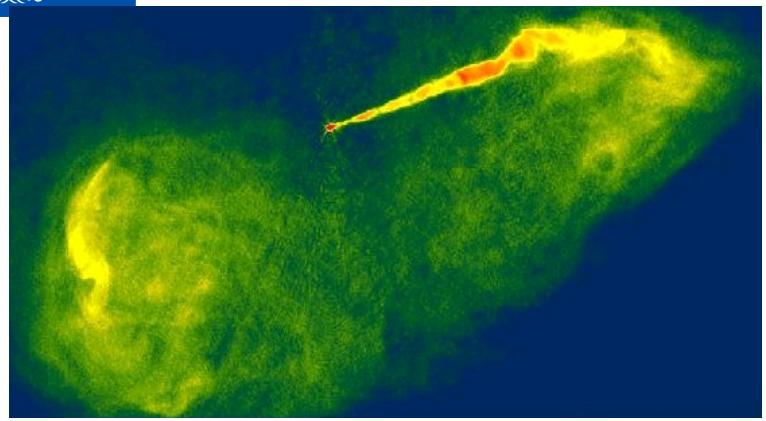
Gamma-ray Space Telescope

γ-ray bubbles in the Milky Way

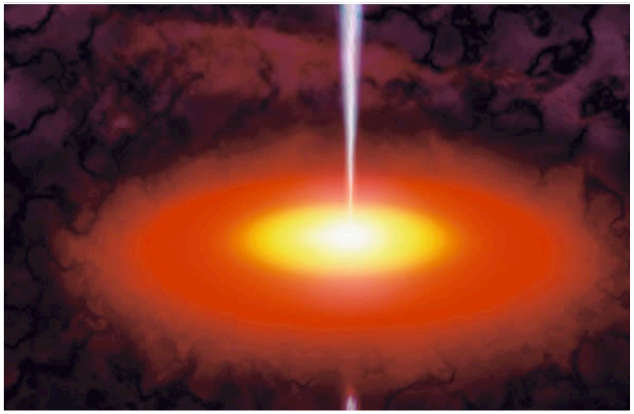


Possible explanations: a relic of a jet or gas outflow from a burst of star formation

Fermi and multiwavelength observations of Blazars: *AGNs with relativistic jets*

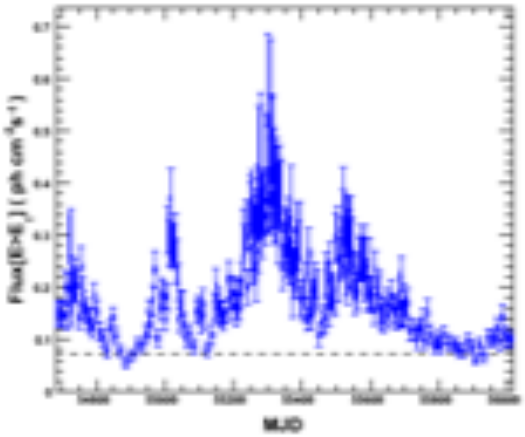


M87



AIM: To Understand

- Radiation mechanisms
- Jet physics
- Black hole/Jet connection



OBSERVATIONS:

- Gamma-ray sky maps every 3 hours (Fermi)
- Radio to X-ray monitoring and follow up obs.

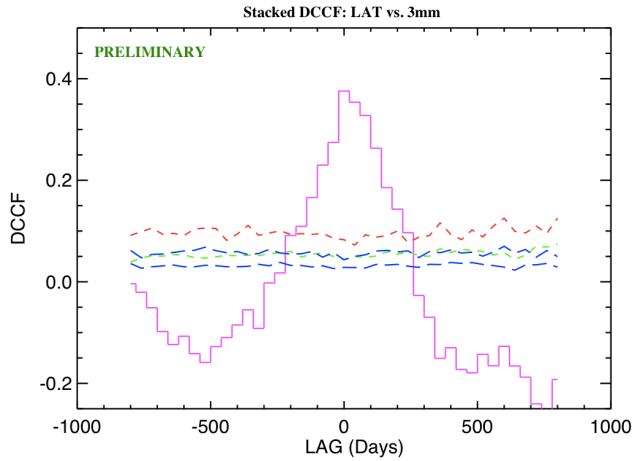
>1000 gamma-ray AGNs detected

Fermi Gamma-ray Space Telescope

Many new results on blazars, E.g:

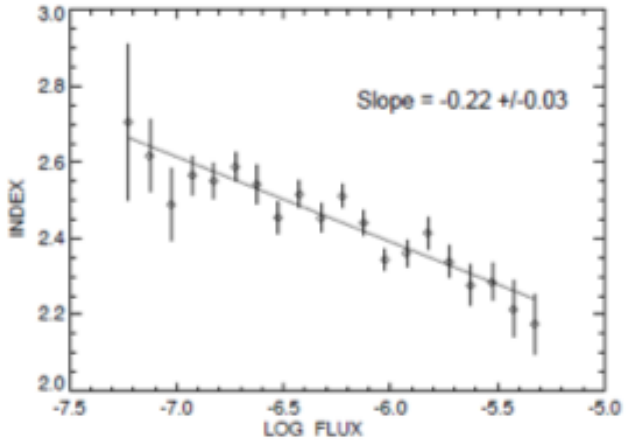
Gamma-ray Radio Cross correlations

First solid proof of correlated variability of the gamma-ray (inverse Compton) and radio (synchrotron) emission



Spectral changes

Systematic relation between spectral hardness and flux



Gamma-ray Space Telescope

Summary

- Fermi is working excellently
- 5 more years of operation
- main Swedish contribution:
  - paradigm shift in GRB
  - upper limit measurements of DM
- important recent Fermi results: cosmic fog, gamma ray bubbles, MSP formation in GC