The Fermi Large Area Telescope:

Highlights from the first year on orbit

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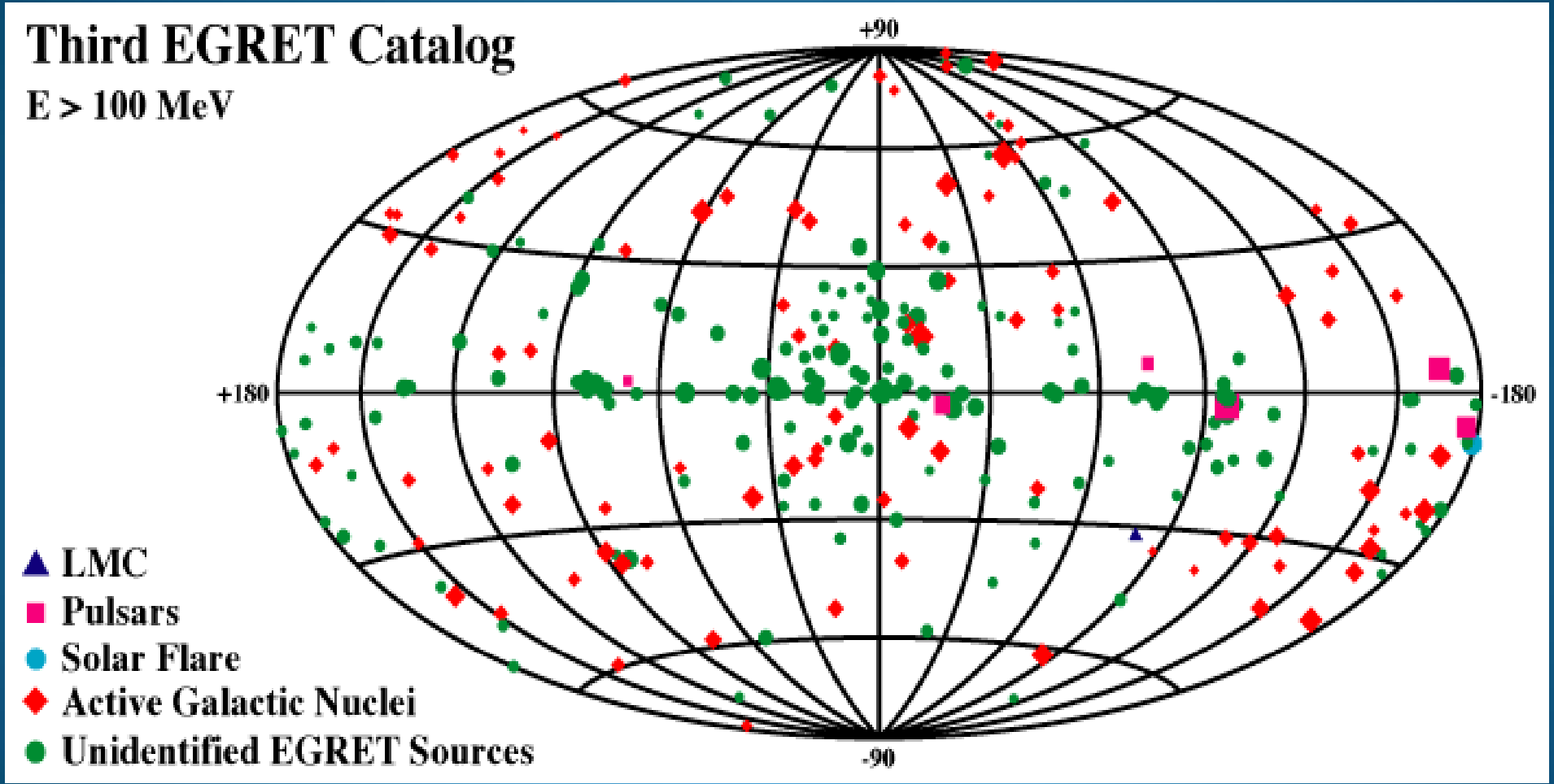
on behalf of the Fermi LAT Collaboration

Before FERMI: the EGRET Era

Data from April 5, 1991 to October 3, 1995



An overview of Fermi

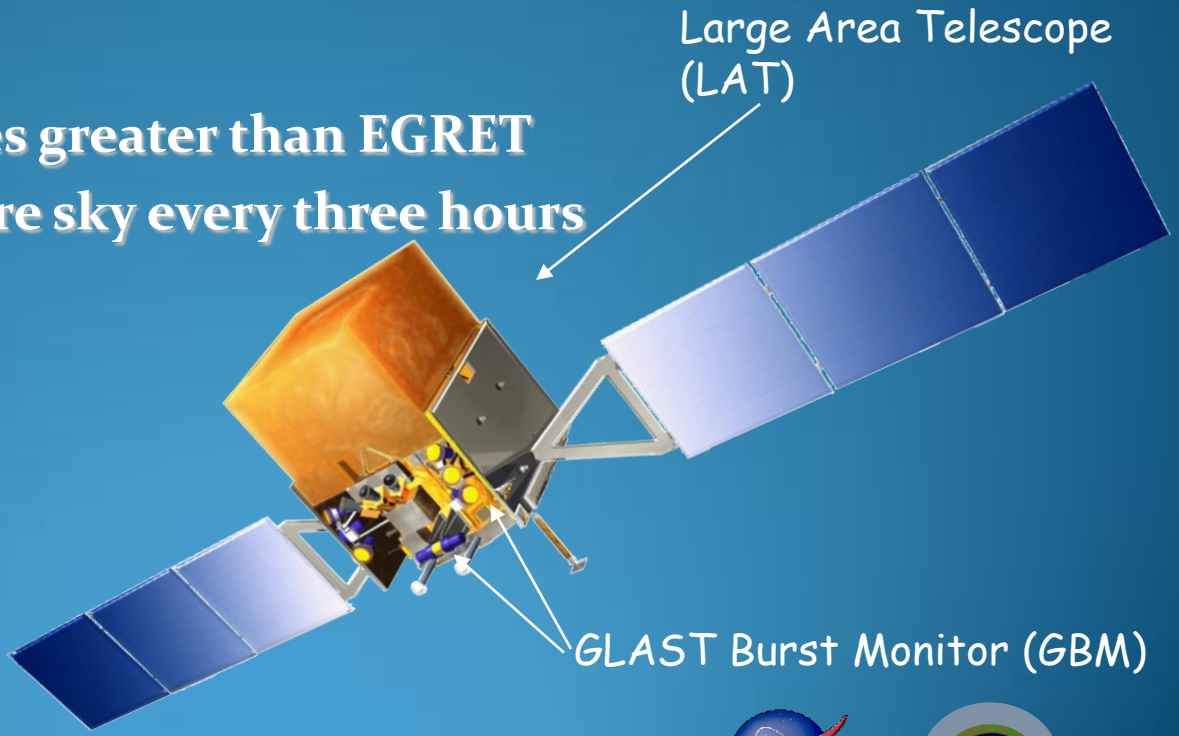
Fermi is an International Science Mission exploring the gamma –ray sky by means of its two main instruments:

- **GLAST Burst Monitor (GBM) : 8 keV to 40 MeV**
- **Large Area Telescope (LAT) : 20 MeV to > 300 GeV**

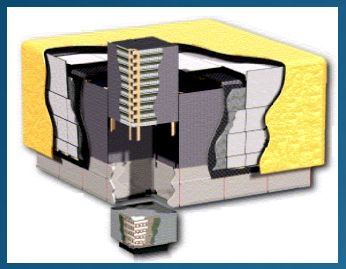
Huge energy range: including largely unexplored band for a total of >7 energy decades!

Strategy:

- **Sensitivity : >10 times greater than EGRET**
- **Survey mode ⇒ entire sky every three hours**



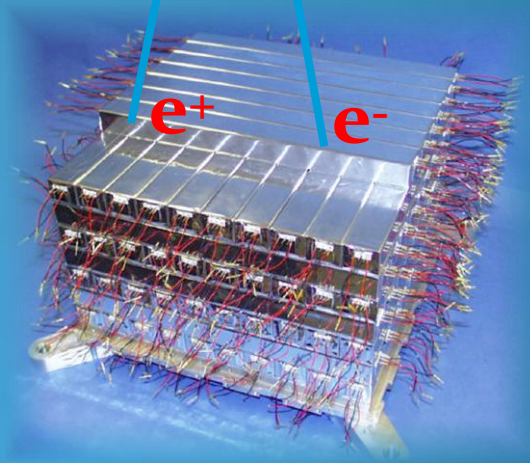
LAT: Large Area Telescope



LAT:
- modular - 4x4 array
- 3 tons – 650 watts

Anti-Coincidence (ACD):
- Segmented (89 tiles + 8 ribbons)
- Self-veto @ high energy limited
- **0.9997 detection efficiency**

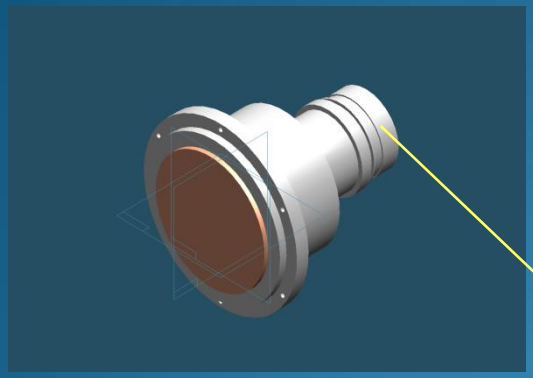
Tracker/Converter (TKR):
- Si-strip detectors
- ~80 m^2 of silicon (total)
- W conversion foils
- **1.5 Xo on-axis**
- 18XY planes
- **~10^6 digital elx chans**
- Highly granular
- High precision tracking



Calorimeter (CAL):
- 1536 CsI(Tl) crystals
- **8.6 Xo on-axis**
- large elx dynamic range (2MeV-60GeV per xtal)
- **Hodoscopic (8x12)**
- Shower profile recon
- leakage correction

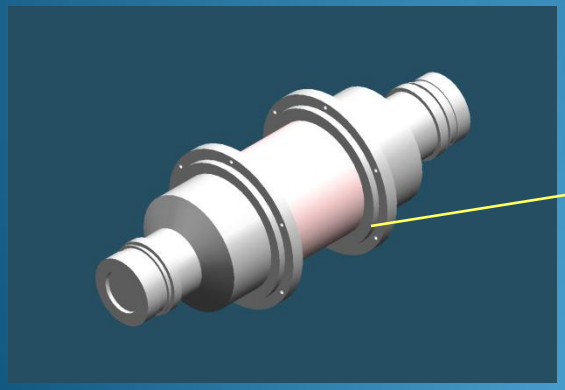
GBM: Gamma-ray Burst Monitor

(12) Sodium Iodide (NaI) Scintillation Detectors

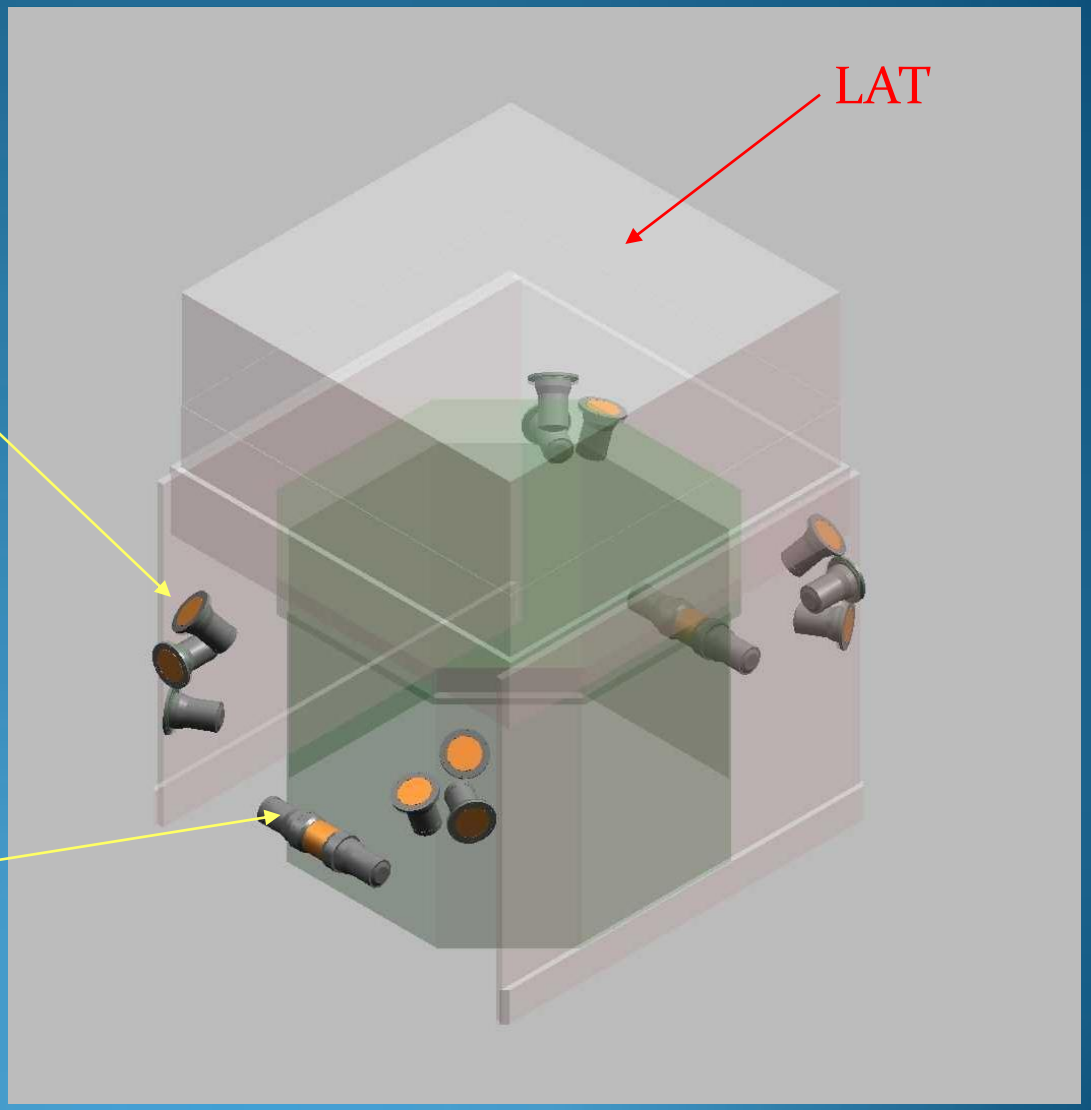


– spectral coverage: 8 keV – 1 MeV

(2) Bismuth Germanate (BGO) Scintillation Detectors



– spectral coverage: 150 keV – 40 MeV



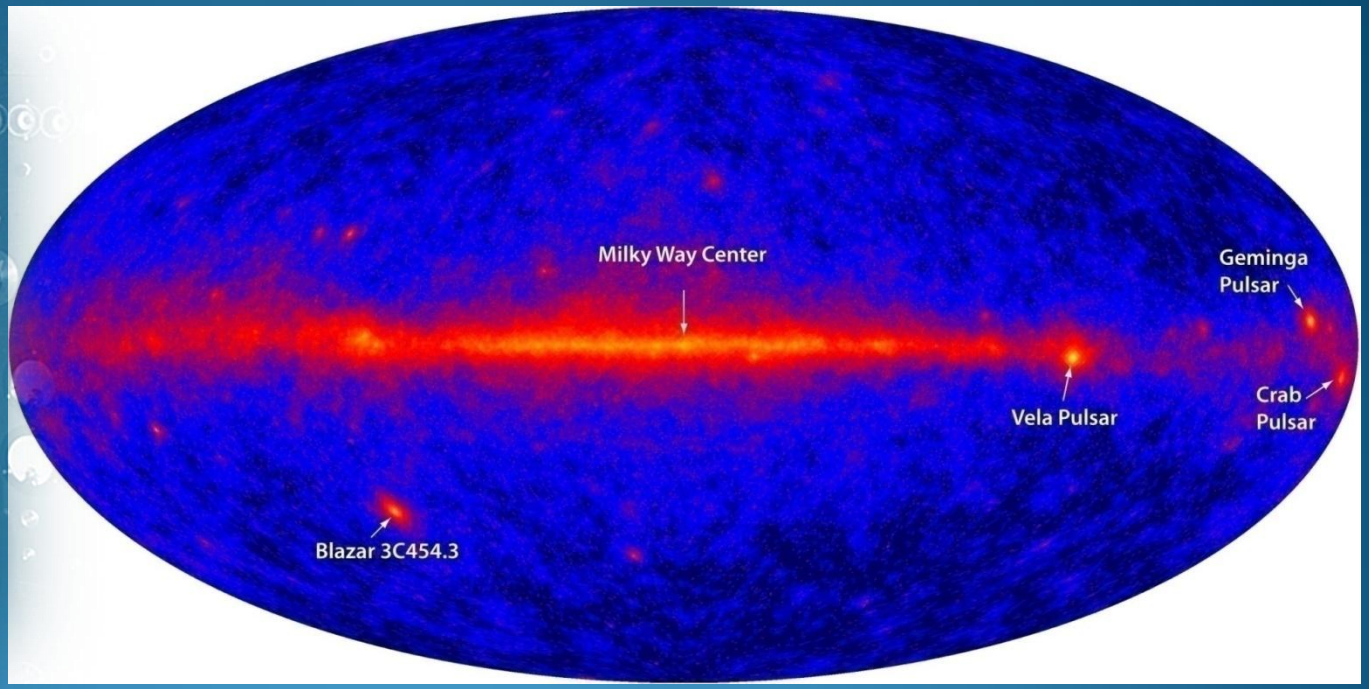
Fermi
Gamma-ray
Space Telescope


Fermi
Gamma-ray
Space Telescope
Cape Canaveral
June 11, 2008

The Fermi Era

- 11 June 2008 at 12:05PM EDT: Launch from Cape Canaveral Air Station
- Circular orbit, 565 km altitude (96 min period), 25.6 deg inclination.
- June 24, 2008 : LAT turn on
- August 11, 2008: Launch & Early Orbit (L&EO) phase ended
- August 26, 2008: Mission name changed to Fermi
- August 25, 2009: Fermi Data public

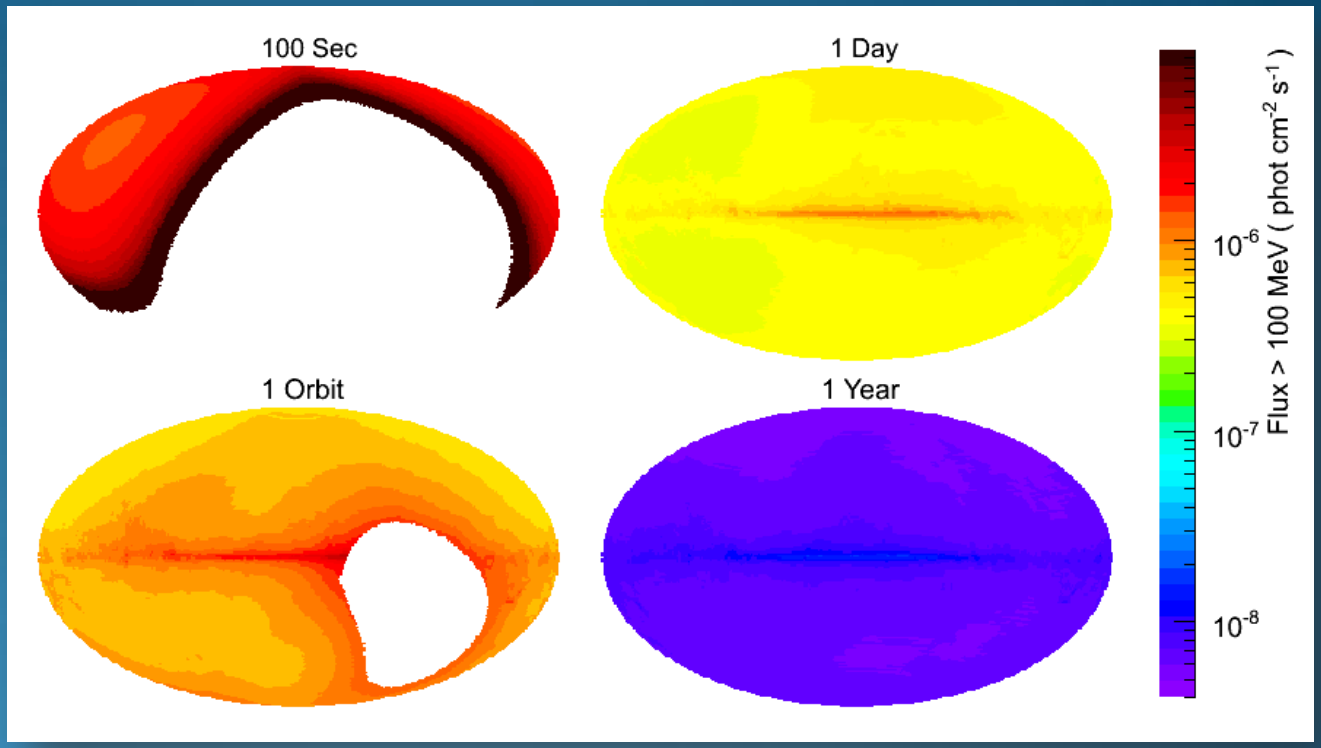
… few weeks after launch: First Light!



The new name, Fermi – Gamma-ray Space Telescope, honors Prof. Enrico Fermi (1901 - 1954), a pioneer in high-energy physics.

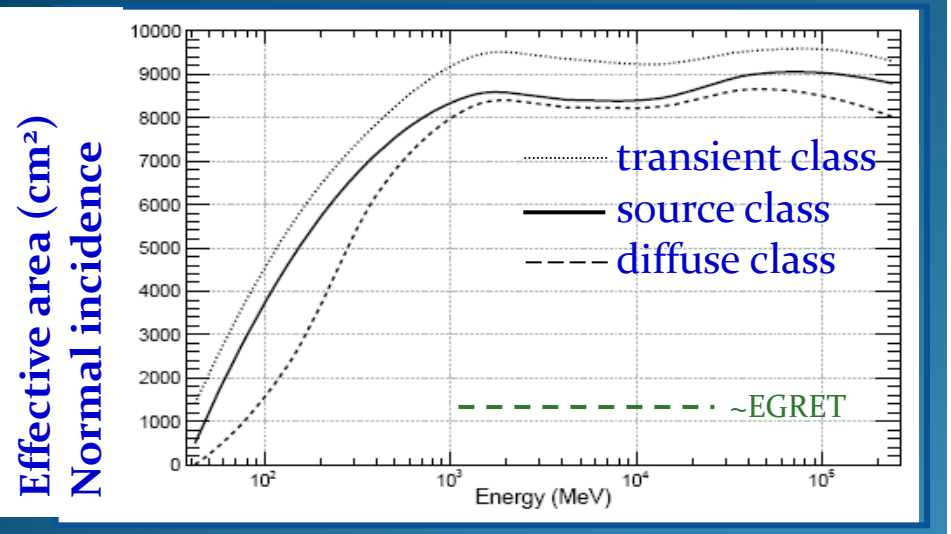
Fermi Operating modes

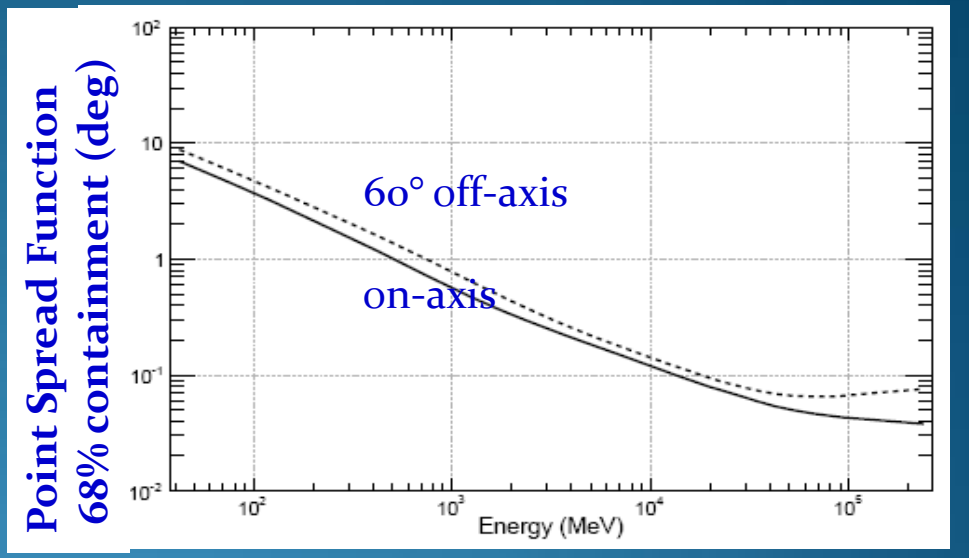
- Primary observing mode is **Sky Survey**
- **Full sky every 2 orbits (3 hours)**
- Uniform exposure, with each region viewed for ~30 min every 2 orbits
- Best serves majority of science, facilitates multi-wavelength observation planning
- EGRET sensitivity reached in days

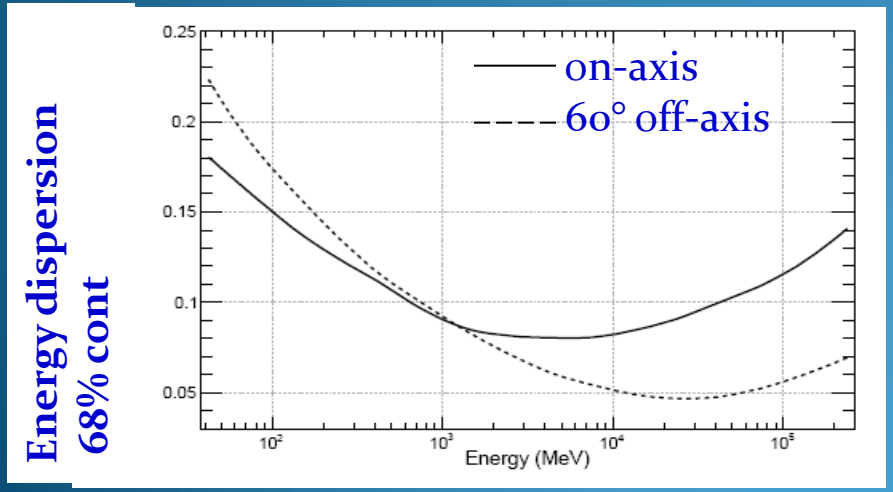


- **Pointed observations when appropriate** (Target of Opportunity pointing)
- Autonomous re-pointing for onboard GRB detections

Fermi-LAT Instrument Performance







The Large Area Telescope on the Fermi Gamma-ray Space Telescope
Atwood, W. B. et al. 2009, ApJ, 697, 1071

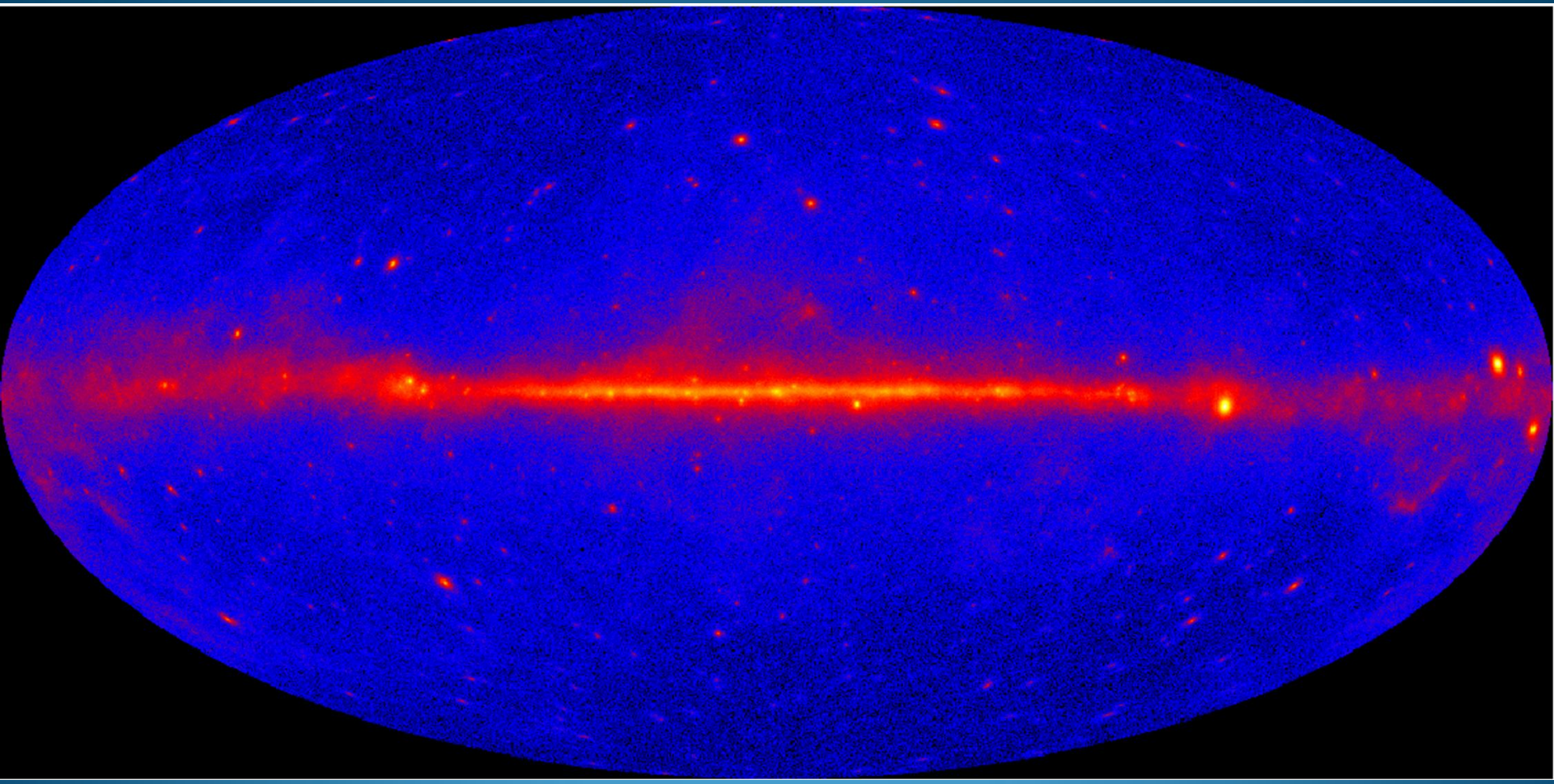
LAT science program

- Active galactic nuclei
- Gamma ray bursts
- Supernova remnants
- Pulsars
- Solar system objects
- Galaxies, clusters of galaxies, X-ray binaries
- Unidentified sources/new populations
- Study of diffuse gamma-ray emission
- Cosmic-ray acceleration & propagation
- Study of Extra-galactic background light (EBL)
- Search for Particle Dark matter/ tests of new physics
- Test Quantum Gravity (?)

Huge increment in capabilities

Draws the interest of both the High Energy Particle Physics and High Energy Astrophysics communities.

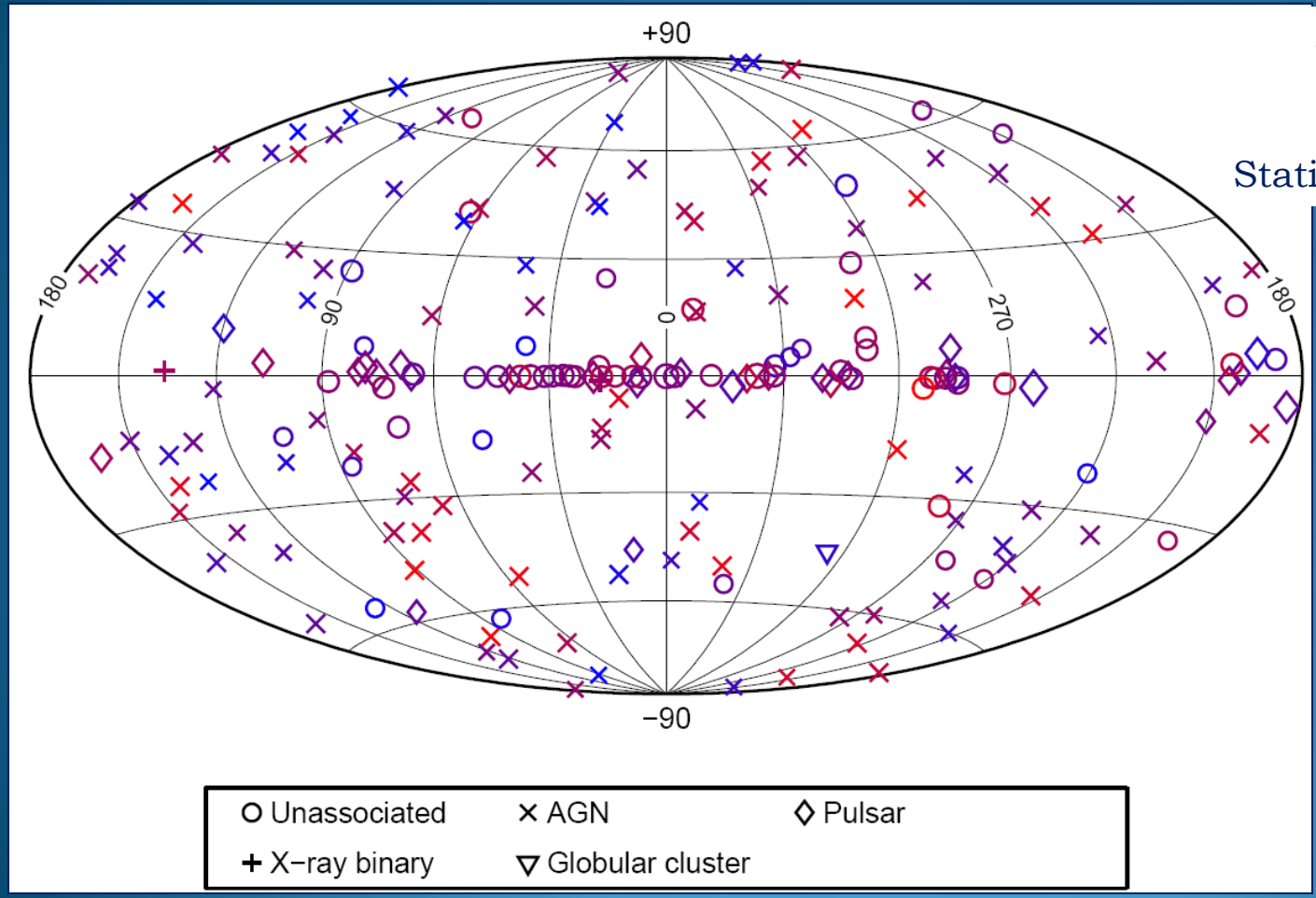
1 year Fermi sky



1 year Fermi sky. E > 200 MeV in 0.3°/pixel

Fermi LAT Bright γ-ray Source List (OFGL)

Fermi Large Area Telescope Bright Gamma-ray Source List
2009, ApJS, 183, 46



3 months LAT data
E > 100 MeV
205 detections with
Statistical significance > 10 σ

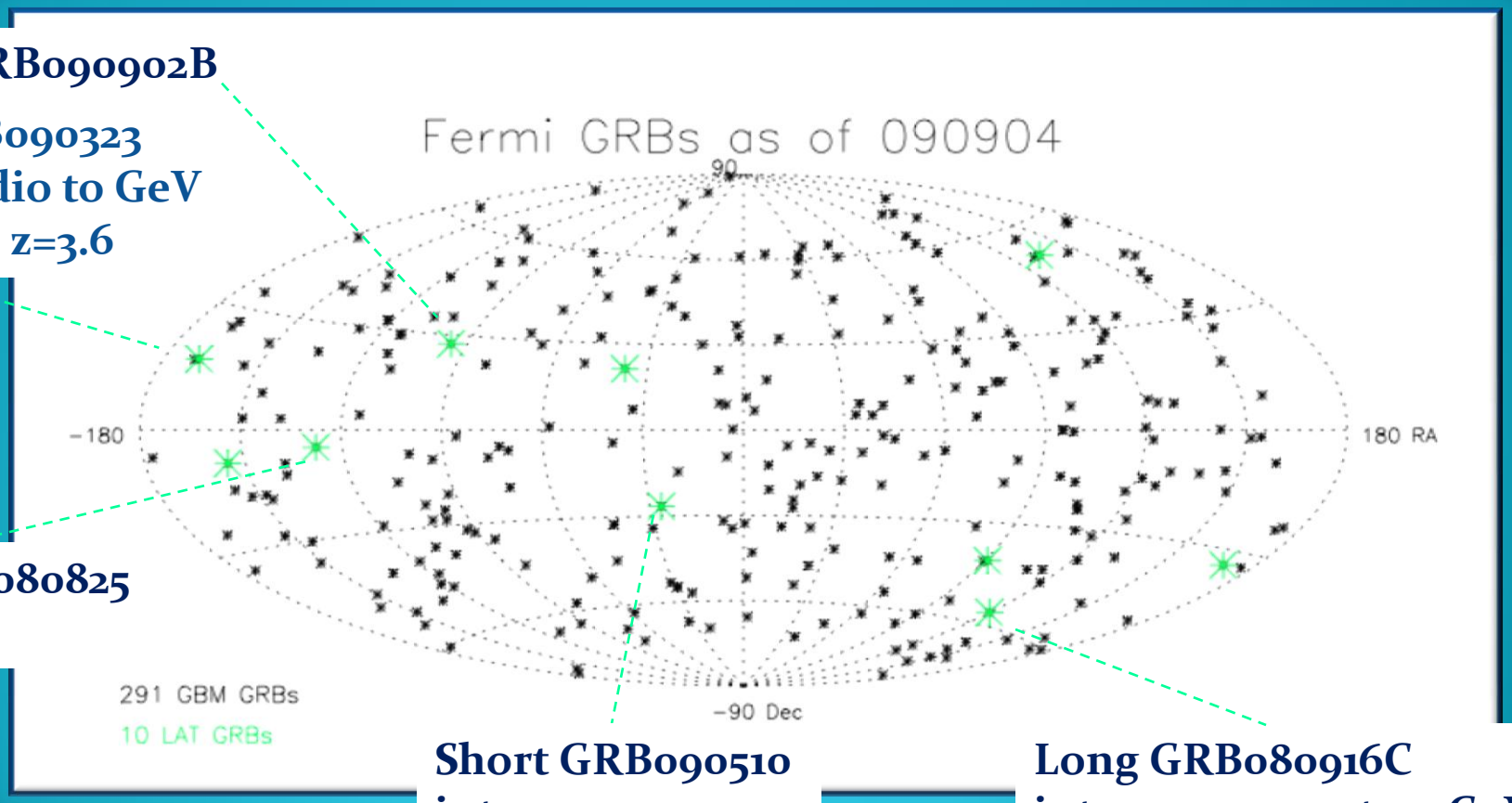
γ-ray bursts in LAT + GBM

So far in the LAT: 12 GRBS, from 8 keV to tens of GeV
In **1 year** from GBM turn on: 252 GRBs, 138 in the LAT FoV

(see E.Moretti and E.Bissaldi talks)

GRB090902B

Long GRB090323 (200 s) radio to GeV afterglow, z=3.6

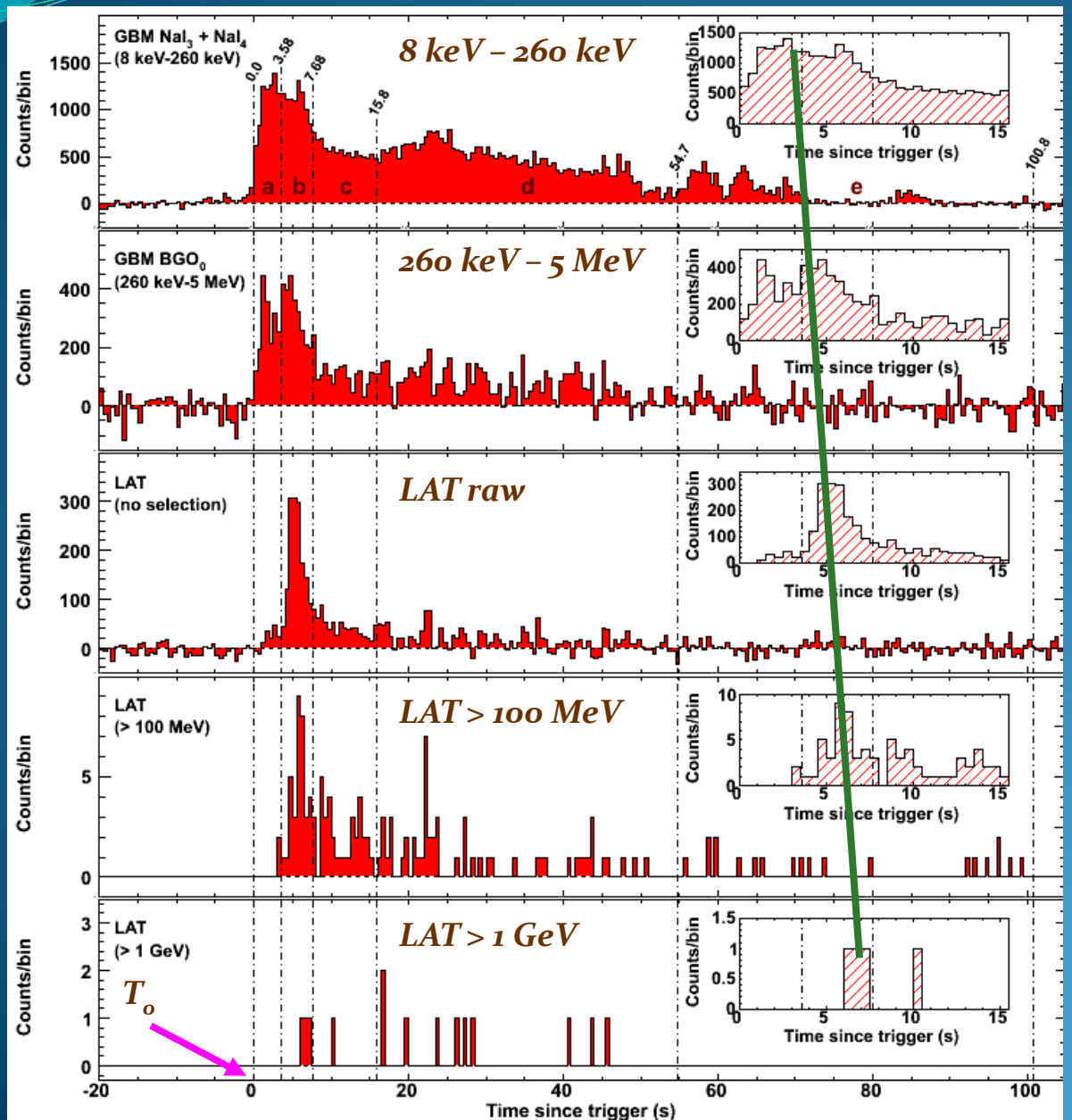


Long GRB080825 afterglow

Short GRB090510 intense, z=0.9

Long GRB080916C intense, z=4.35, to 13GeV

Example of a long burst: GRB 080916C



- First high-energy GRB (>100 MeV) with known redshift
- Largest sample >100 MeV
  - 14 events >1 GeV
  - High energy photon (E = 13.2 GeV after 16.5 s) from GRB

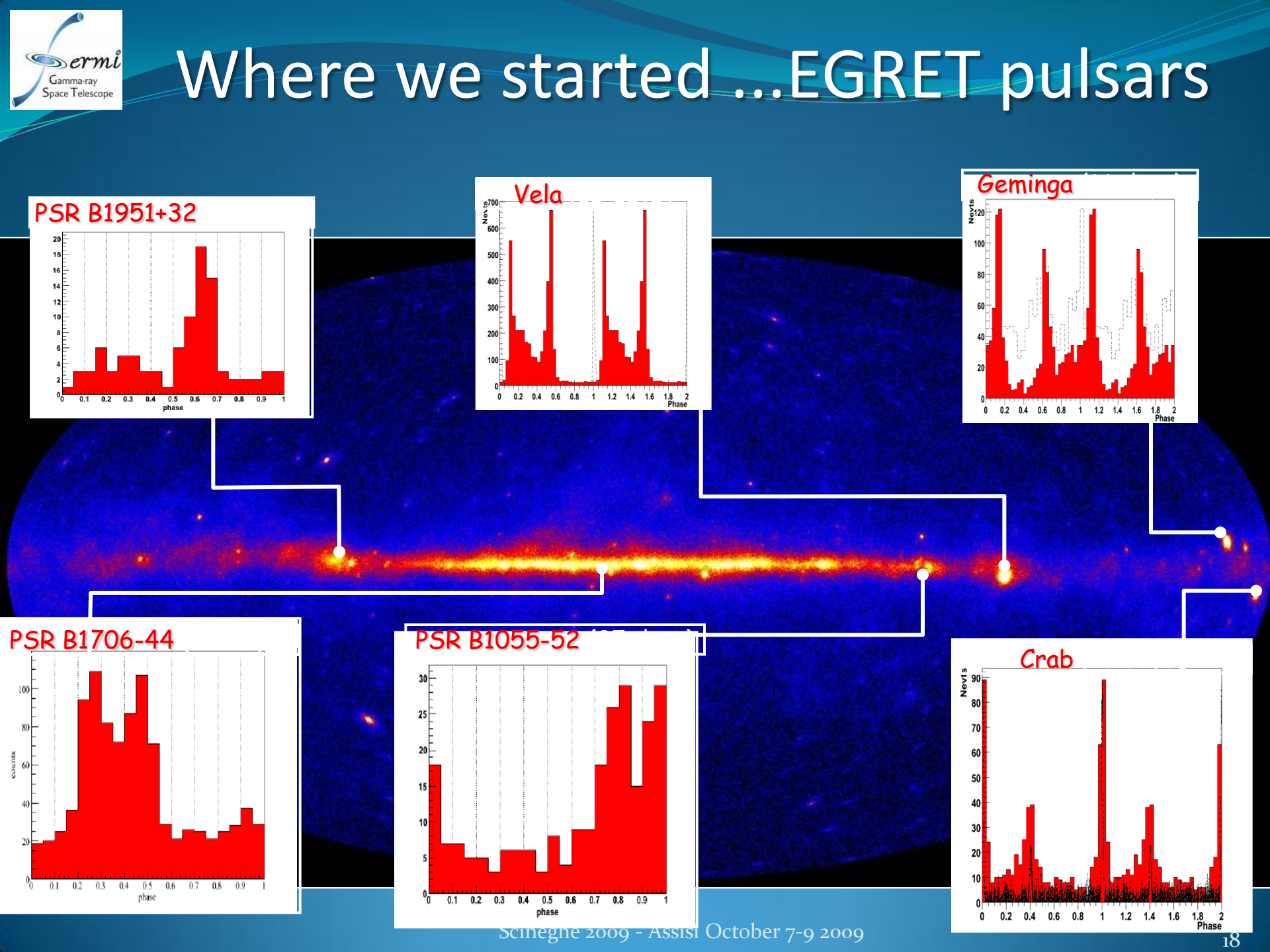
Abdo et al., Science 323, 1688 (2009)

About GRBs :

- Talks:
  - The Fermi observation of gamma-ray bursts - E. Moretti
  - GRB090510 – F. de Palma
  - The Fermi Gamma-Ray Burst Monitor: results from the first year – E.Bissaldi
  - Fermi and other Gamma-ray tests for Lorentz Invariance Violation and Quantum Gravity Models - F.Stecker

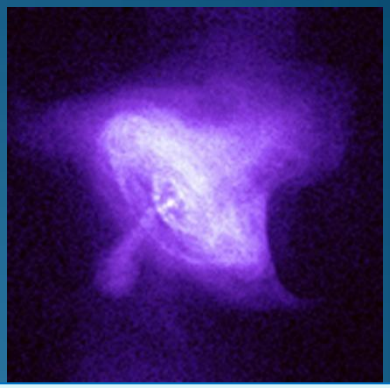
- Posters:
  - Fermi high energy observation of GRB090217 - S.Cutini

Where we started ...EGRET pulsars



Galactic sources

- 6 EGRET pulsars → 46 Fermi pulsars in the first Fermi pulsar catalog with 6 months data(submitted to ApJ)
  - 16 new young, turbulent, radio loud pulsars
  - 8 old, radio loud, millisecond pulsars
  - 16 young pulsars, pulsing in gamma-rays alone
- Globular clusters
- Pulsar Wind Nebula
- Supernova remnants
- X-ray binaries
- So far, EGRET unidentified are pulsars.

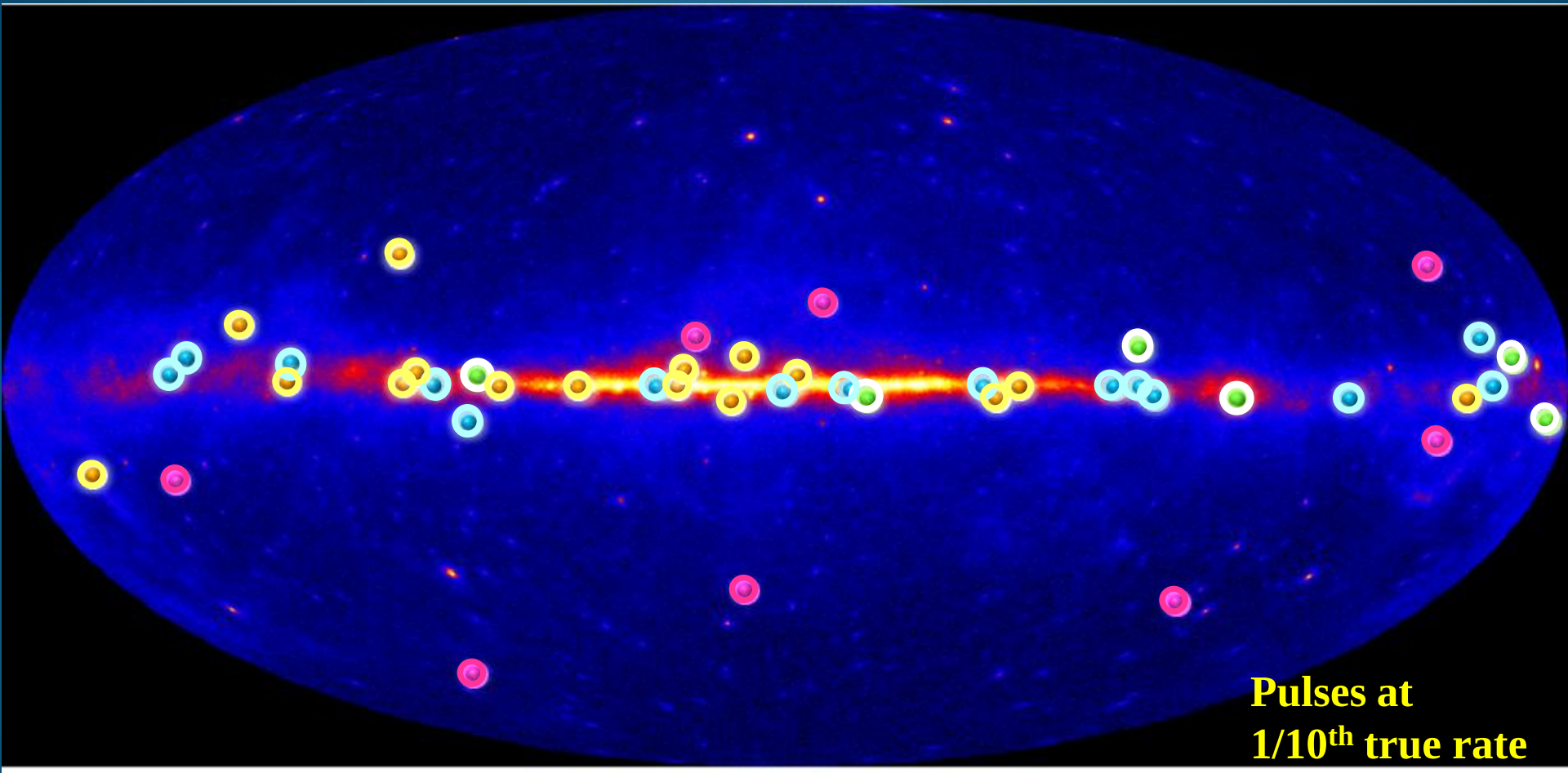


« Pulsar Wind Nebula = PWN »
Chandra X-ray image
Pulsar in the middle

Crab supernova remnant
(optical, Hubble)
Supernova seen in 1054

(see F. Giordano talk)

The “pulsating” sky



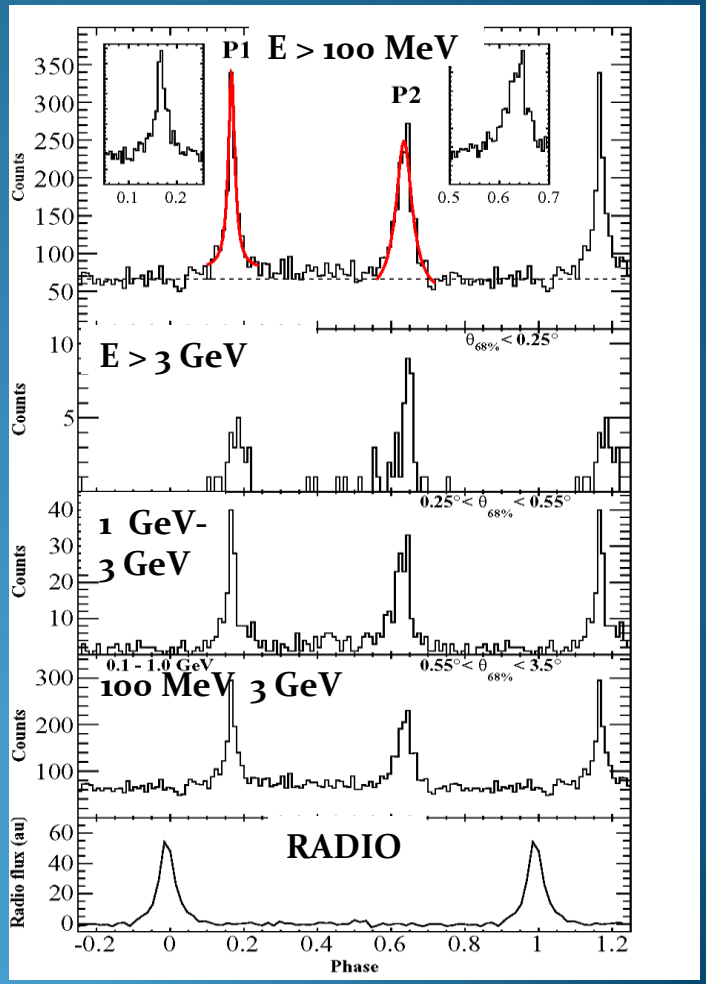
Fermi Pulsar Detections

- New pulsars discovered in a blind search
- Millisecond radio pulsars
- Young radio pulsars
- Pulsars seen by Compton Observatory EGRET instrument

About LAT pulsars

- Generally (but not always), pulse profiles have 2 peaks, separated by ≥ 0.2 of rotational phase.
- Generally (but not always), gamma peak offset from radio.

Pulsed gamma-rays from PSR J2021+3651 with the Fermi Large Area Telescope
Abdo et al. ApJ700, 1059 (2009)



Peak separation = 0.468 ± 0.002

Radio lag = 0.162 ± 0.004

About LAT pulsars

- Generally (but not always), pulse profiles have 2 peaks, separated by ≥ 0.2 of rotational phase.
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- Energy spectra well described by a power-law with exponential cut-offs, with cut-off energy at ~1 to ~5 GeV.

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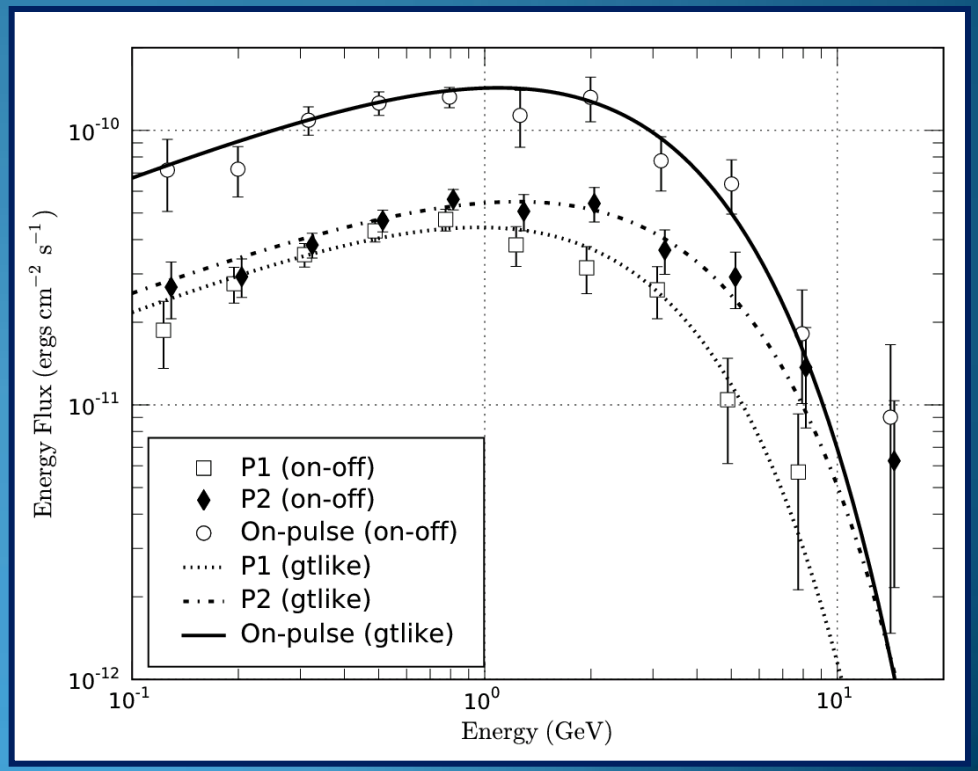

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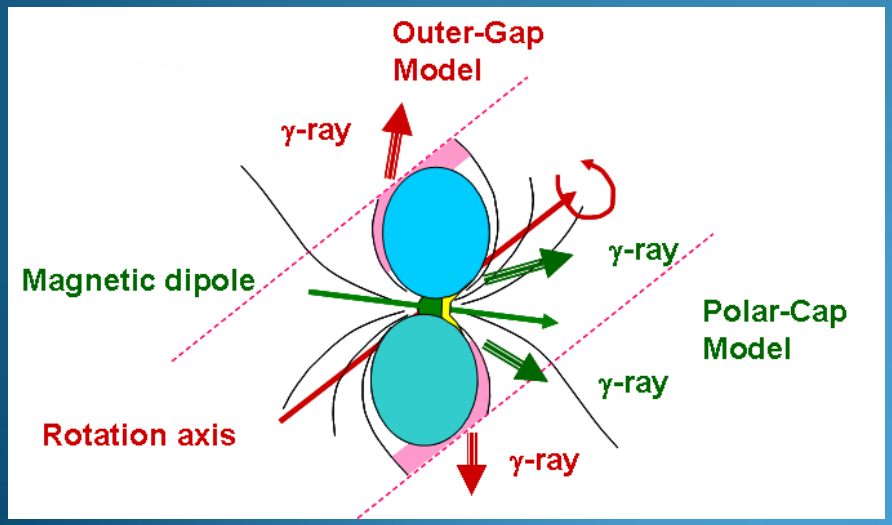
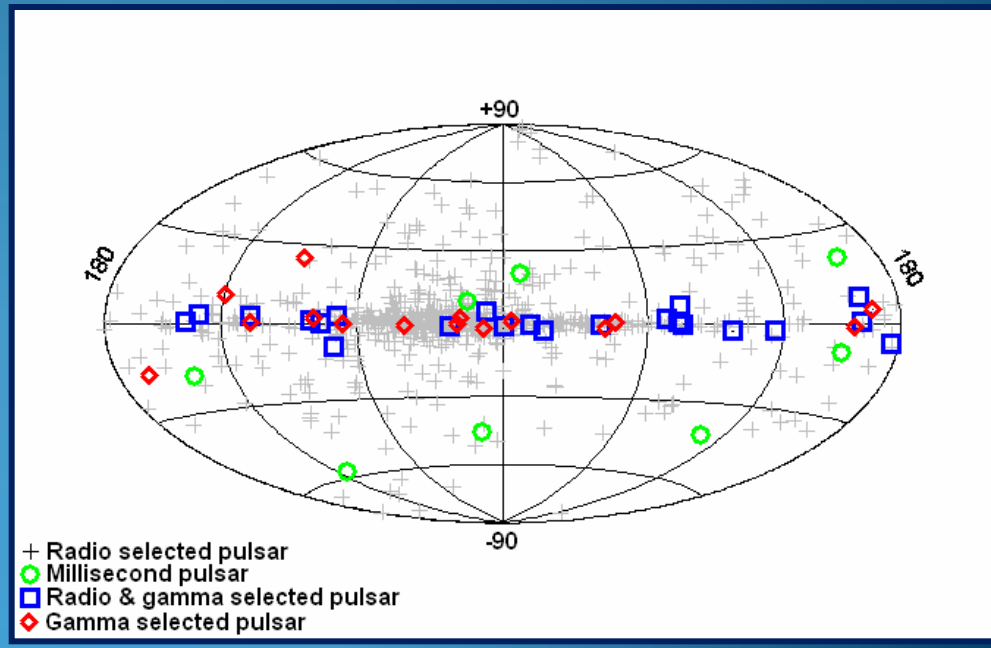
- Energy spectra well described by a power-law with exponential cut-offs, with cut-off energy at ~1 to ~5GeV.
- Favors outer magnetospheric emission.



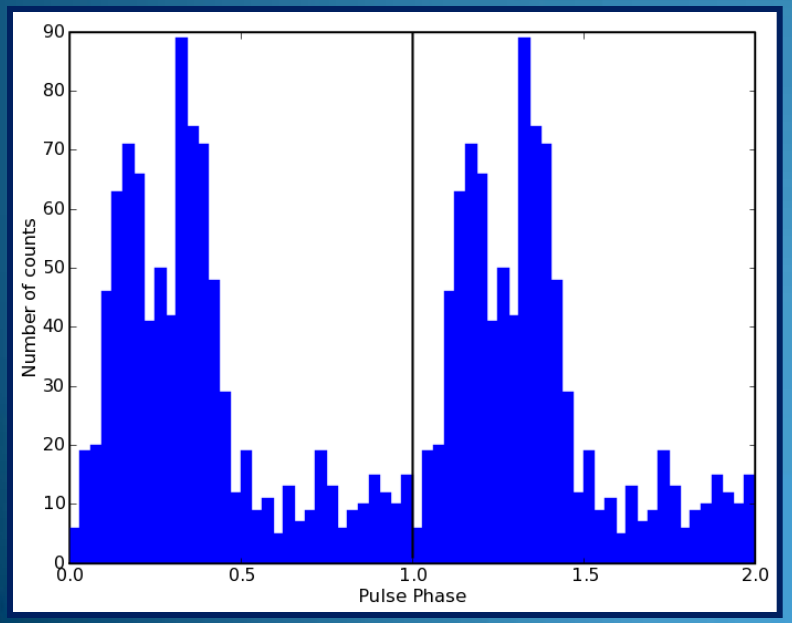


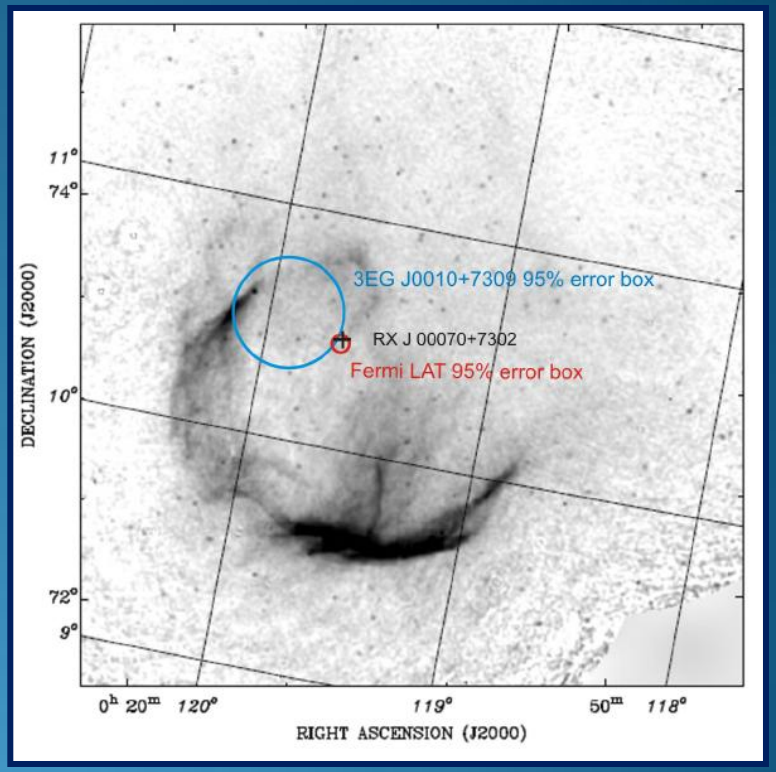
The CTA 1 discovery: the first gamma-ray only pulsar

Discovery of γ pulsation: July 10-11 2008

"The Fermi Gamma Ray Space Telescope discovers the pulsar in the young Galactic Supernova Remnant CTA1
Science 21 November 2008: Vol. 322. no. 5905, pp. 1218 - 1221

- l = 119.652, b= 10.468;
- Period ~ 316 ms, Pdot ~ 3.6°E-13
- ΔΦ = 0.2
- Distance ~ 1.4 kpc

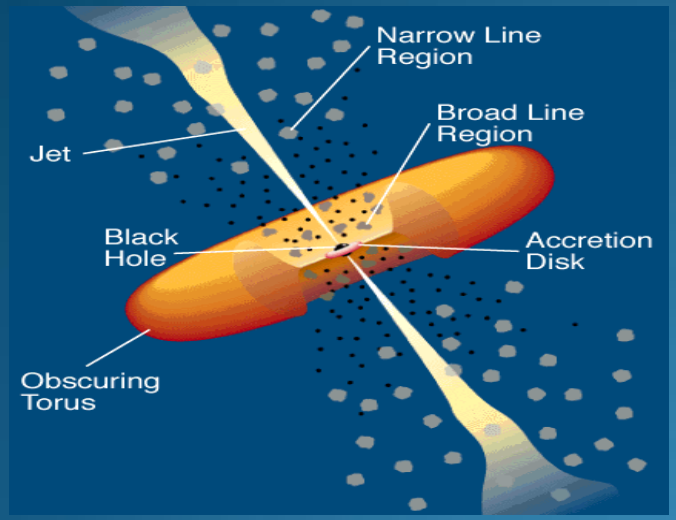


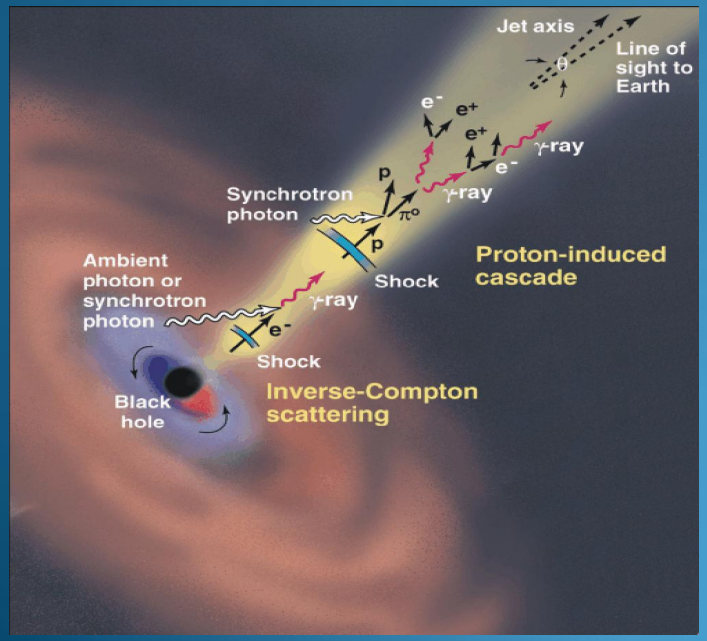


About Galactic sources:

- Talks:
  - High energy Pulsars detection with Fermi LAT - F.Giordano
- Posters:
  - Observation of the Crab pulsar and Nebula with the FermiLarge Area Telescope - M.H.Grondin, M. Lemoine-Goumard, F.Loparco, M.N.Mazziotta

Active Galactic Nuclei (AGN)





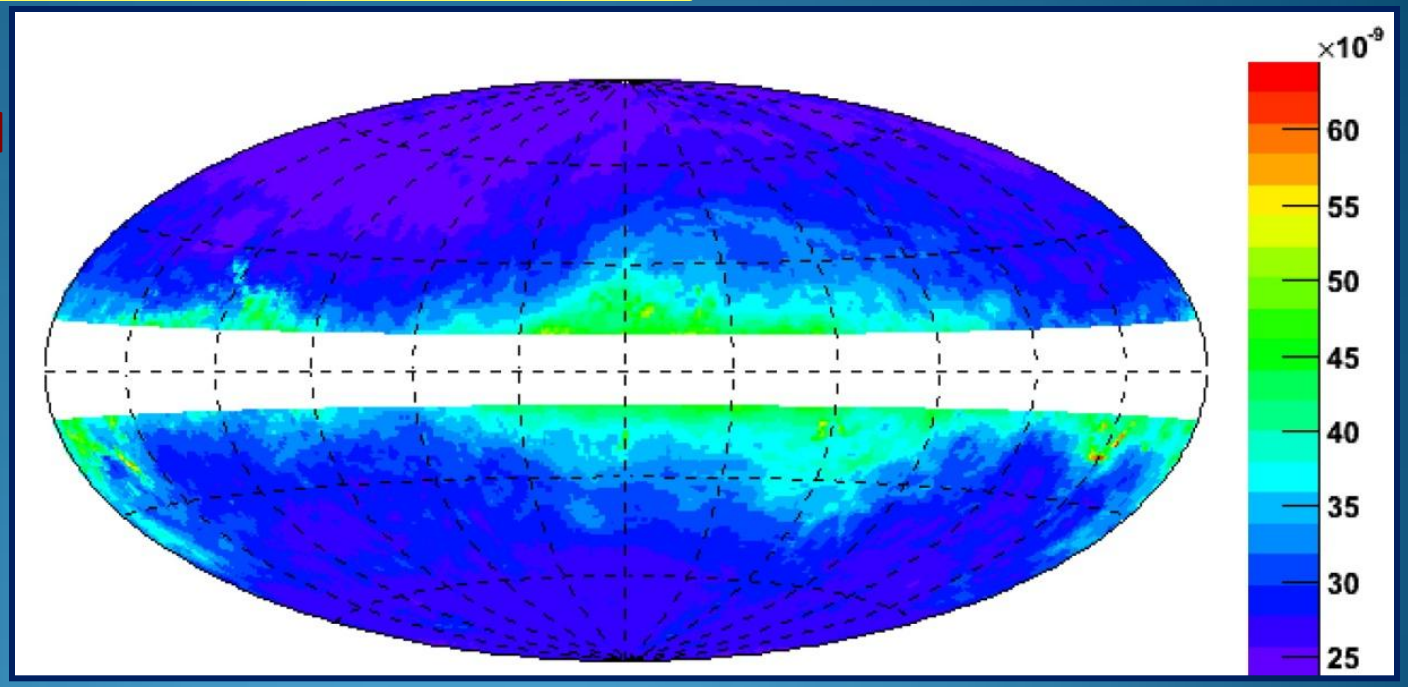
- Active galactic nuclei (AGN) are galaxies with extraordinarily luminous cores powered by super massive black holes
- In the standard model of AGN, cold material close to the central black hole forms an accretion disc
- At least some accretion discs produce jets, twin highly collimated and fast outflows that emerge in opposite directions from close to the disc
- Blazars are objects emitting non-thermal radiation across the entire electromagnetic spectrum from a relativistic jet that is viewed closely along the line of sight

(see P.Giommi talk)

The first Fermi LAT AGNs Source List

Bright AGN Source List from the First Three Months of the Fermi Large Area Telescope All-Sky Survey
ApJ 700, 597 (2009)

3-months flux [ph cm^{-2} s^{-1}]



132 sources with |b|>10 + TS >100

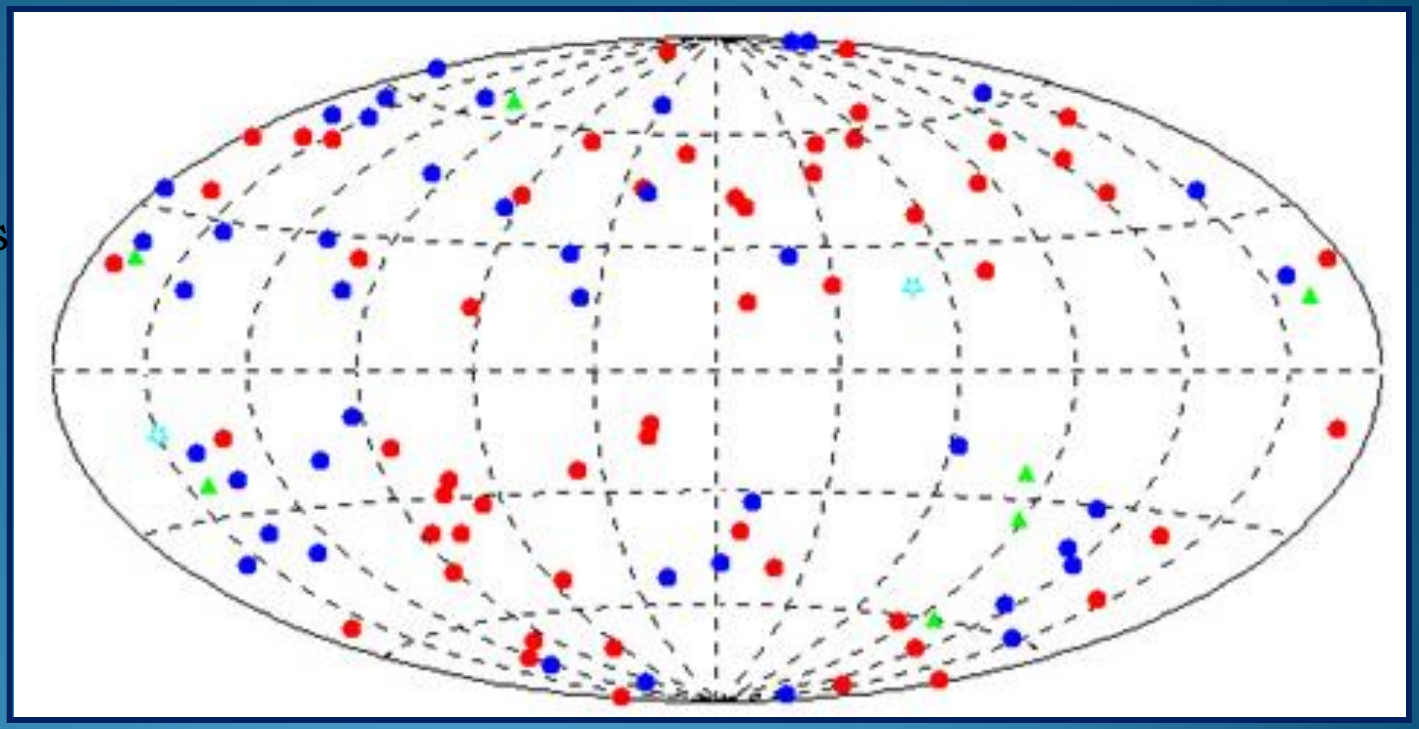
- **7 pulsars**
- **11 unidentified**
- **114 associated with AGNs**

LAT Bright AGN Sample (LBAS)

High confidence associations for 106 AGN (LBAS):

→2 Radio Galaxies
- •Centaurus A
- •NGC 1275

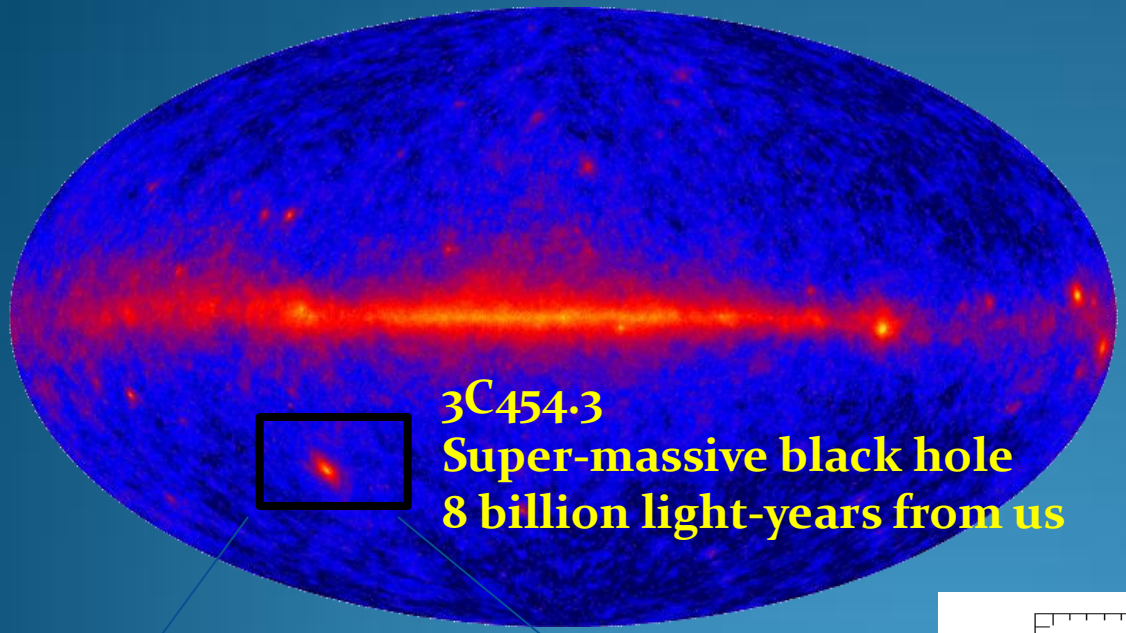
→104 Blazars:
- •58 FSRQ
- •42 BLLac
- • 4 Unknown

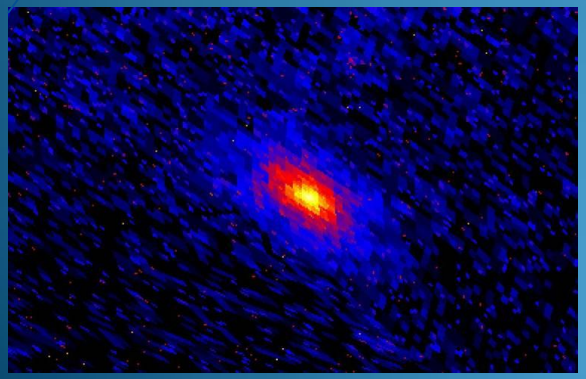


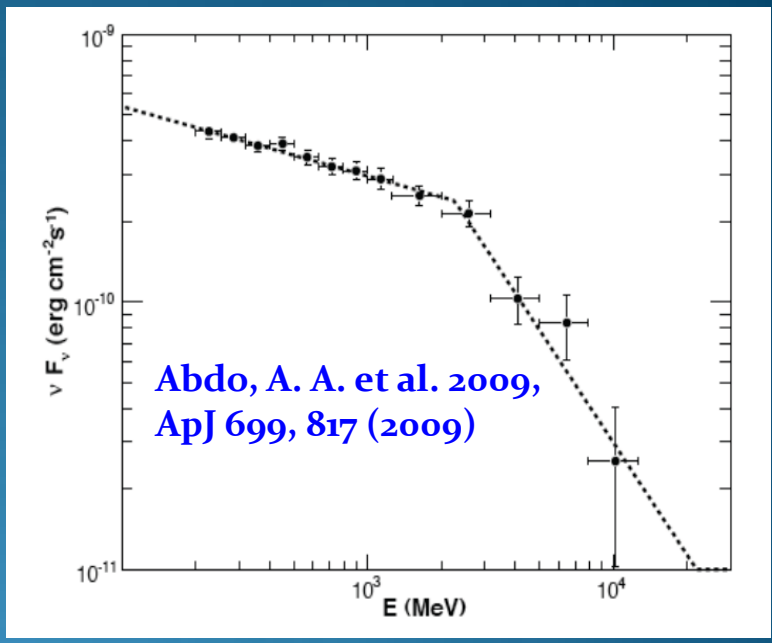
4 NEW BLAZARS DISCOVERED on the basis of the LAT detections (present in the CRATES catalog)

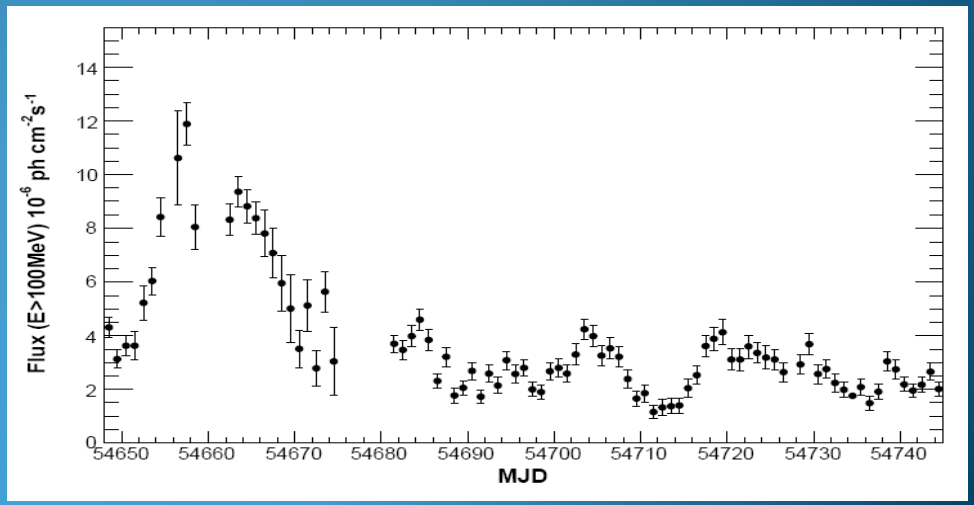
3C454.3

The brightest gamma-ray extra-galactic source observed in the first 3 months Fermi-LAT survey







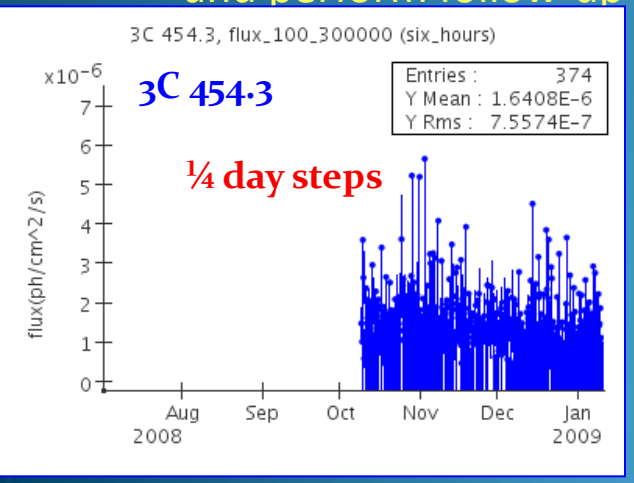


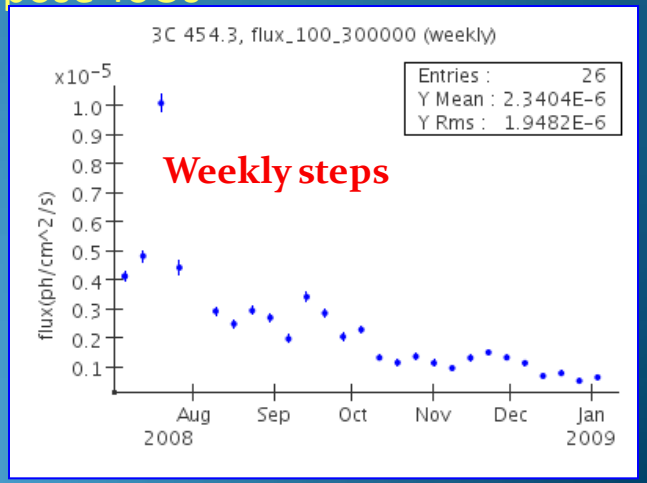
The flaring and variable sky

~50 Astronomers Telegrams: Discovery of new gamma-ray blazars, flares from known gamma-ray blazars, galactic plane transients

Source Monitoring activities

- Automated Science Processing (ASP)
  - Transient detection: Find all point sources in data from each epoch (6hr, day, week).
  - Follow-up monitoring: Run full likelihood analysis on detected sources,
  - and for the "Data Release Plan" (DRP) sources
  - 1×10^{-6} ph cm^{-2} s^{-1} threshold (daily) for public release of non-DRP
- Flare Advocates:
  - LAT scientists from Galactic and Extragalactic groups examine ASP pipeline output and perform follow-up analyses, produce ATels, and propose ToOs





http://fermisky.blogspot.com/

FERMI GAMMA-RAY SKY

WEDNESDAY, JUNE 3, 2009

Fermi LAT Weekly Report N. 52

Covered period: 2009.May.25 - 2009.May.31

- Candidate blazar **4C31.03** (see ATel #2054) seen in day timescales with flux levels reaching 0.8e-6 ph/cm^2/s.
- **PKS 1510-089** remains in the 1e-6 to 2e-6 daily flux range (>100MeV)
- **PKS 1502+106** shows a steady trend with daily fluxes (>100MeV) around 1e-6 ph/cm^2/s.
- **3C 454.3** showed consistent daily flux levels (>100MeV) just below 1e-6 ph/cm^2/s.

LAT DATA

LAT Monitored Source List Light Curves

LAT Bright Source List

Browse interface to monitored source data

BLOG ARCHIVE

▼ 2009 (8)

▼ June (1)

Fermi LAT Weekly Report N. 52

▶ May (4)

▶ April (3)

CONTRIBUTORS

Flare Advocate

About extra-galactic sources:

- Talks:
  - General AGN - P.Giommi
  - Diagnostic of the peak frequencies in the SED of Fermi blazars – A. Tramacere
  - Fermi-Swift synergetic campaign on the new gamma-ray blazar PKS 1502+106 - S.Ciprini
- Posters:
  - Analysis of the Fermi SED - D.Gasparrini
  - Fermi-LAT Flare Advocate Activity during the First Year of Mission - S.Ciprini

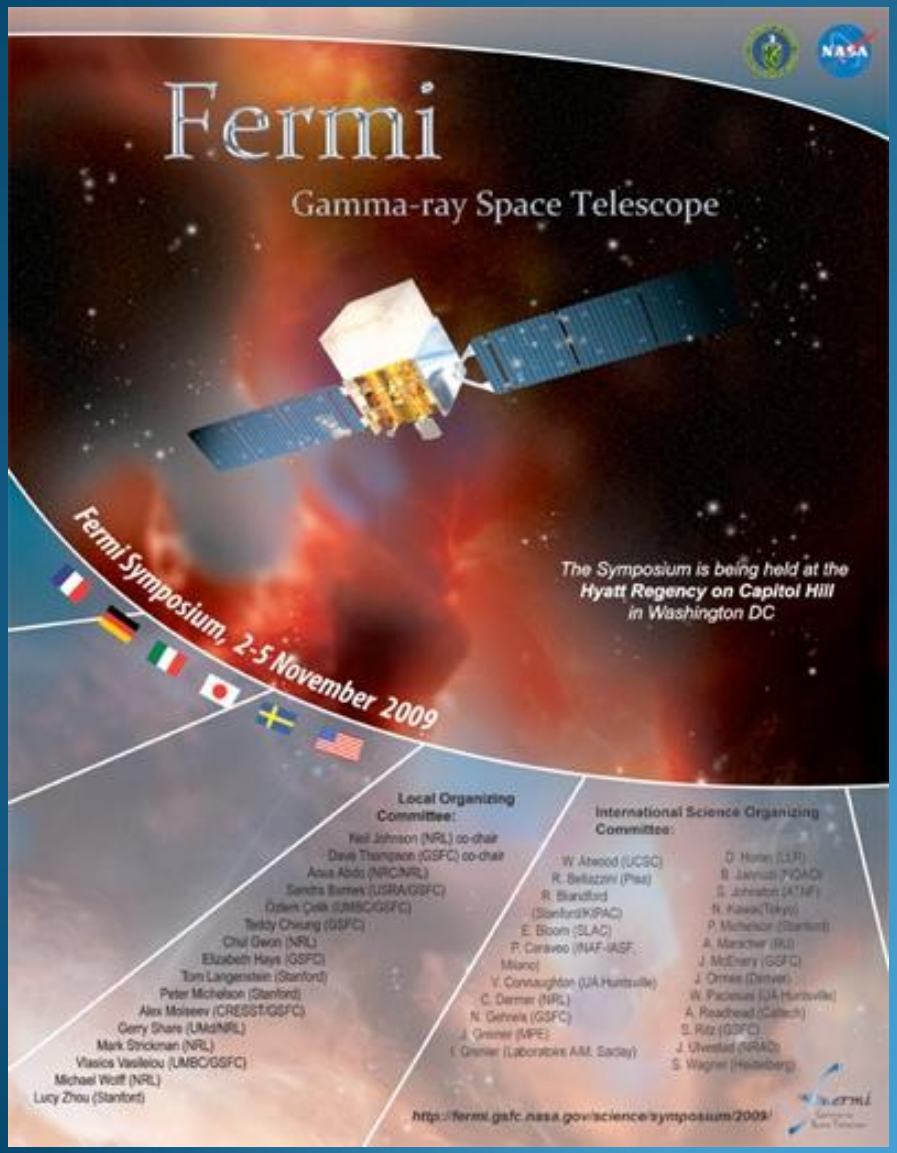
And even more ....

- Talks:
  - Search for Dark Matter in the sky – A. Morselli
  - Indirect Search for Dark Matter from the Milky Way center with the LAT detector on-board Fermi– V. Vitale
  - Measurement of the high energy cosmic-ray electron spectrum with the Fermi Large Area Telescope - F.Loparco
  - Fermi measurements of diffuse gamma-ray emission: results at the first-year milestone - L. Tibaldo

Conclusions

- The Fermi Gamma-Ray Space Telescope has been performing very well and stably for the first year of operations
- Photon data are public since August 25, 2009
  - Join the fun at http://fermi.gsfc.nasa.gov/ssc/
- Wealth of results in γ-ray astrophysics
  - ~ 50 pulsars detected, many only in γ-rays
  - many flaring active galaxies observed
  - 12 GRBs at high energy
  - … and a lot of others results not mentioned

2009 Fermi Symposium



2-5 November 2009
Washington DC

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