FERMI
Gamma Ray Space Telescope (GLAST)

First Scientific Results

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University of Perugia and INFN

On behalf of the Fermi LAT Collaboration

Why explore the Universe in gamma?

IL NUOVO CIMENTO Vol. VII, N. 6 16 Marzo 1958

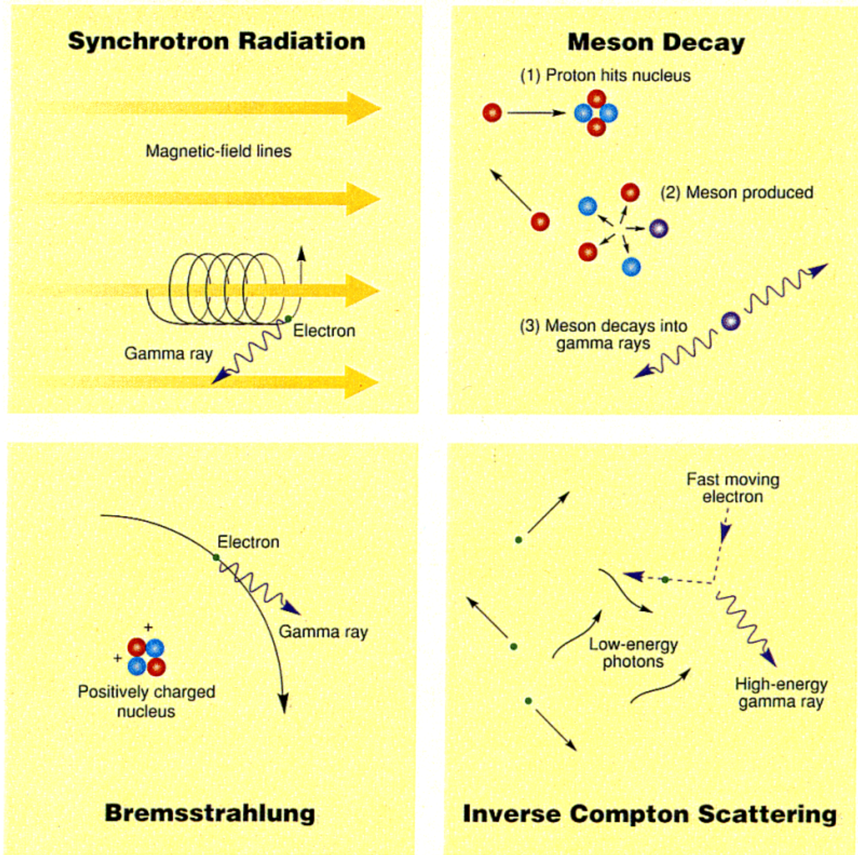
On Gamma-Ray Astronomy.

P. Morrison

Department of Physics, Cornell University - Ithaca, N. Y.

(ricevuto il 22 Dicembre 1957)

Summary. — Photons in the visible range form the basis of astronomy. They move in straight lines, which preserves source information, but they arise only very indirectly from nuclear or high-energy processes. Cosmic-ray particles, on the other hand, arise directly from high-energy processes in astronomical objects of various classes, but carry no information about source direction. Radio emissions are still more complex in origin. But γ-rays arise rather directly in nuclear or high-energy processes, and yet travel in straight lines. Processes which might give rise to continuous and discrete γ-ray spectra in astronomical objects are described, and possible source directions and intensities are estimated. Present limits were set by observations with little energy or angular discrimination; γ-ray studies made at balloon altitudes, with feasible discrimination, promise valuable information not otherwise attainable.



- Gamma-rays are produced by *non-thermal* processes!

Extreme High-Energy end of em spectrum => extreme universe.

The discovery of the Gamma Ray Sky

- 1967-1968, **OSO-3** **Detected Milky Way as an extended γ-ray source**

  621 γ-rays
- 1972-1973, **SAS-2**,

  ~8,000 γ-rays
- 1975-1982, **COS-B**

  orbit resulted in a large and variable background of charged particles

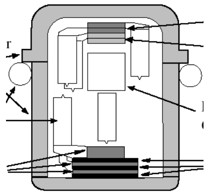
  ~200,000 γ-rays
- 1991-2000, **EGRET**

  Large effective area, good PSF, long mission life, excellent background rejection

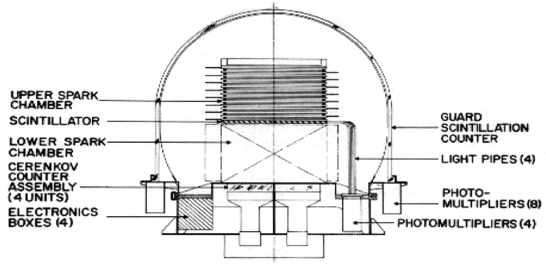
  >1.4 × 10^6 γ-rays

- 2007- **AGILE Small Italian mission, in operation**

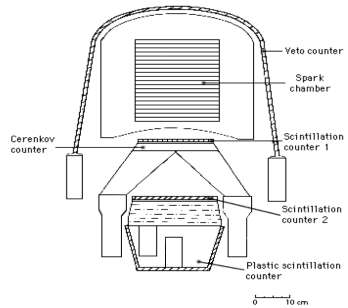
OSO-3



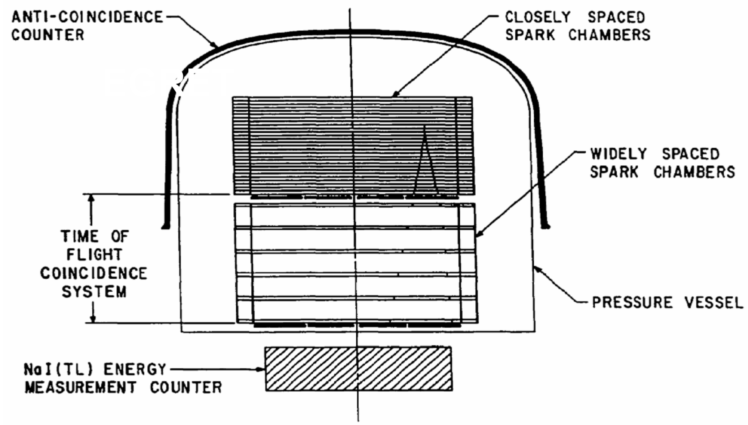
SAS-2



COS-B

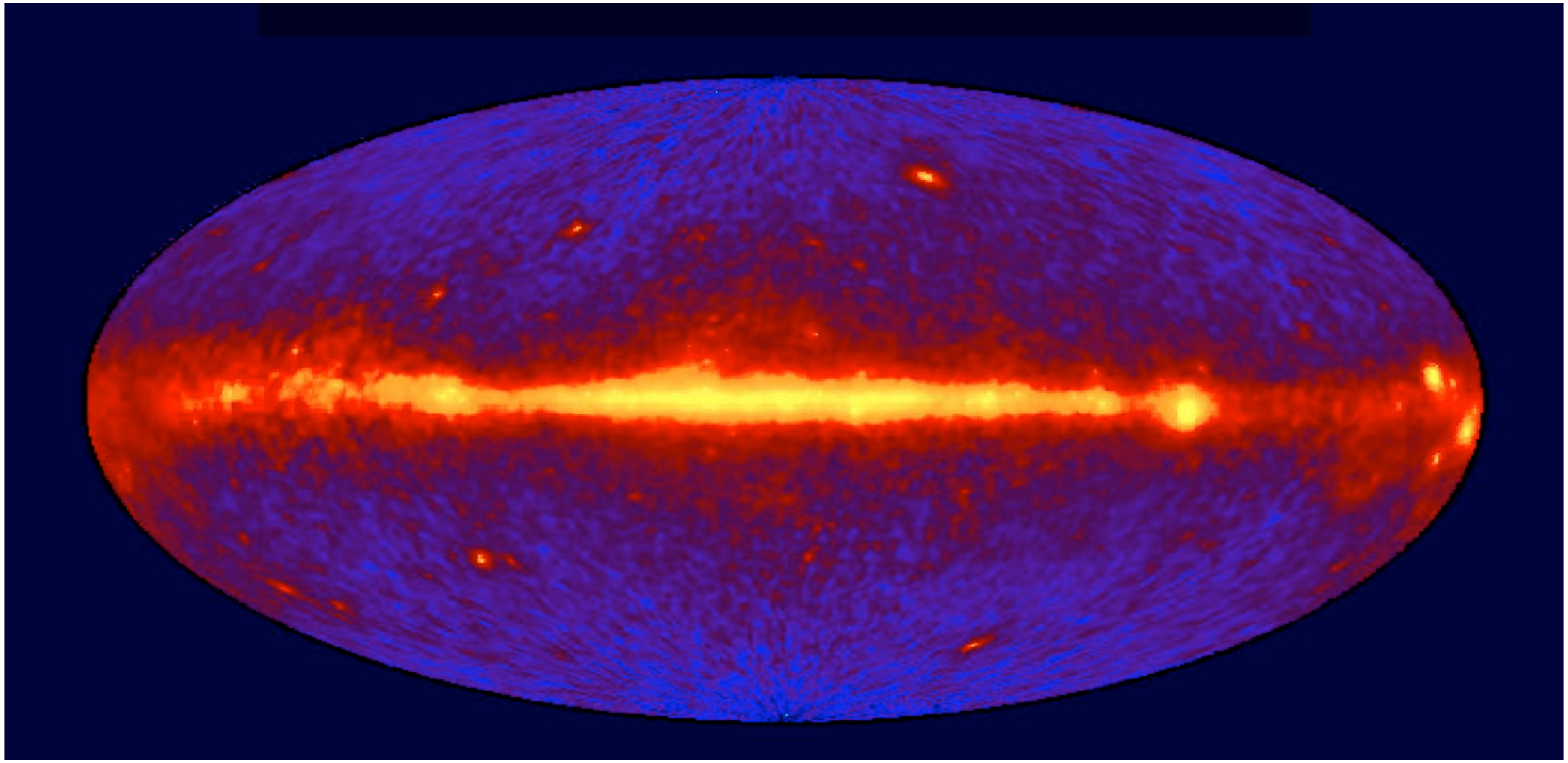


EGRET



AGILE

The EGRET Gamma Ray Sky

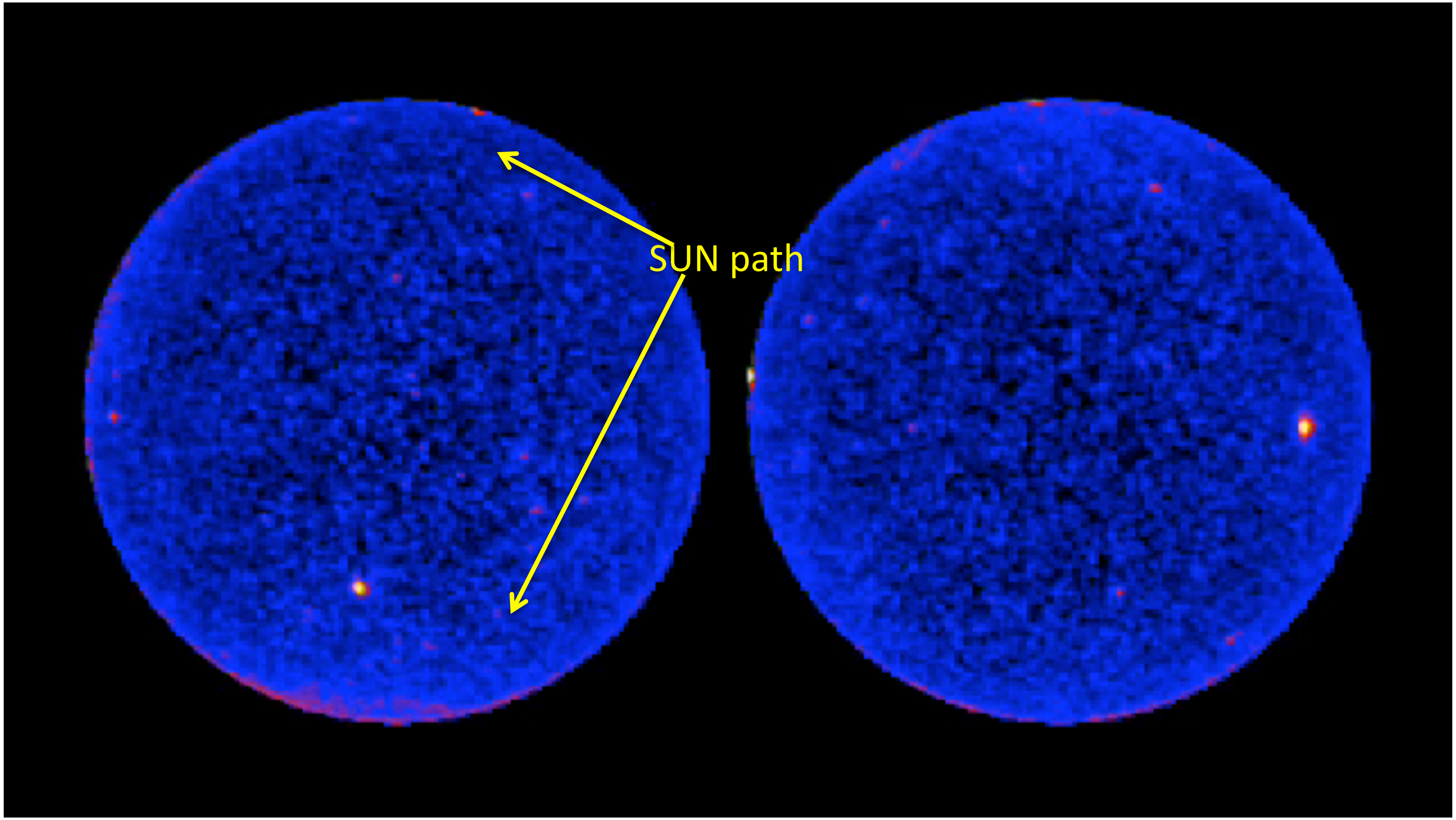


diffuse extra-galactic background (flux ~ 1.5×10^{-5} $cm^{-2}s^{-1}sr^{-1}$)
galactic diffuse (flux ~30 times larger)
high latitude (extra-galactic) point sources (typical flux from EGRET sources O(10^{-7} - 10^{-6}) $cm^{-2}s^{-1}$)
galactic sources (pulsars, un-ID'd)

An essential characteristic: VARIABILITY in time!

Field of view important for study of transients.

Variability over 3 months (north-south Galactic Emisphere)



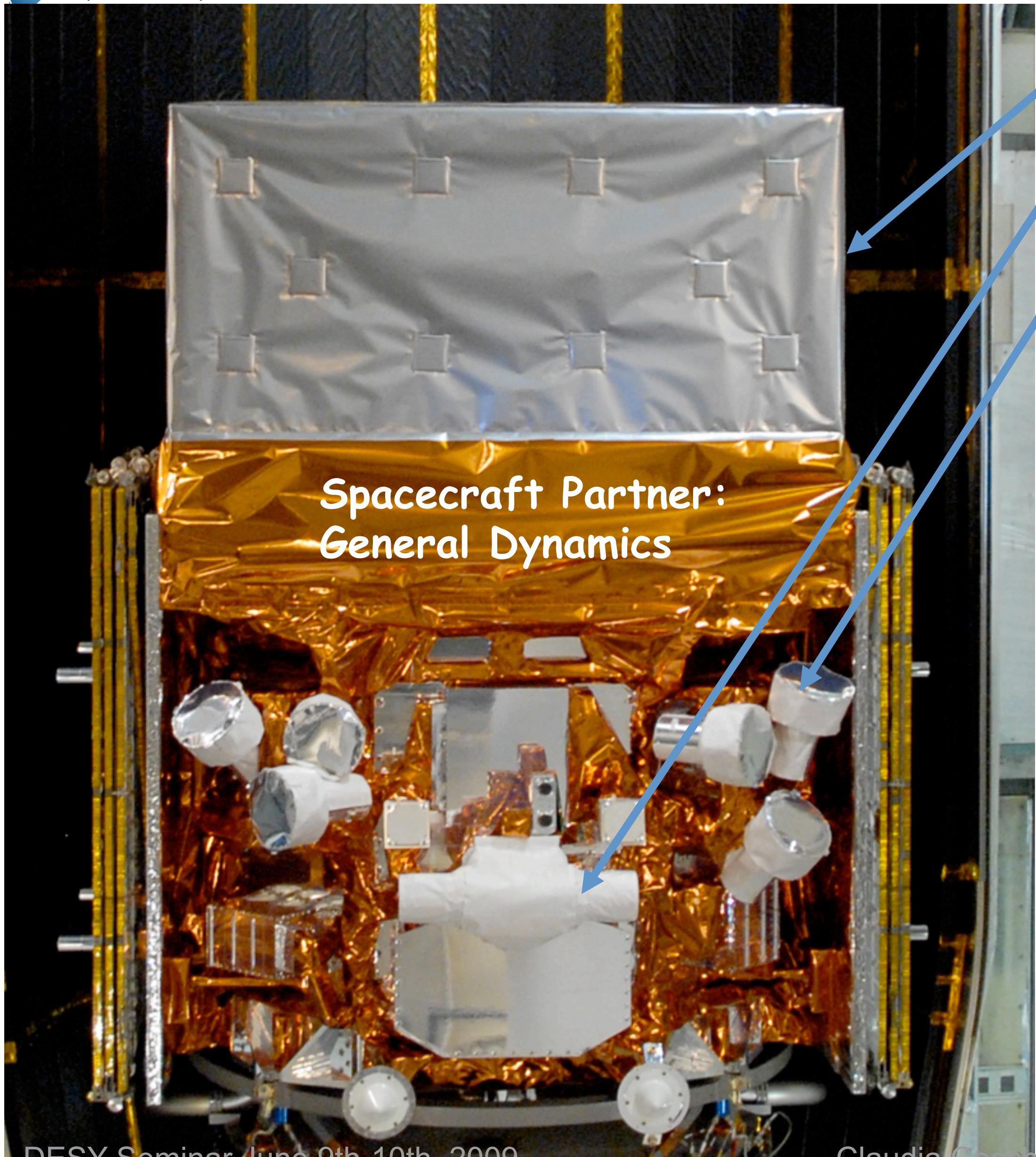
E>100 MeV, poles view, 1 day time interval, extreme sensitivity to flux variation

2008 - Fermi

The Observatory

Large AreaTelescope (LAT)
20 MeV - >300 GeV

Gamma-ray Burst Monitor (GBM)
NaI and BGO Detectors
8 keV - 30 MeV

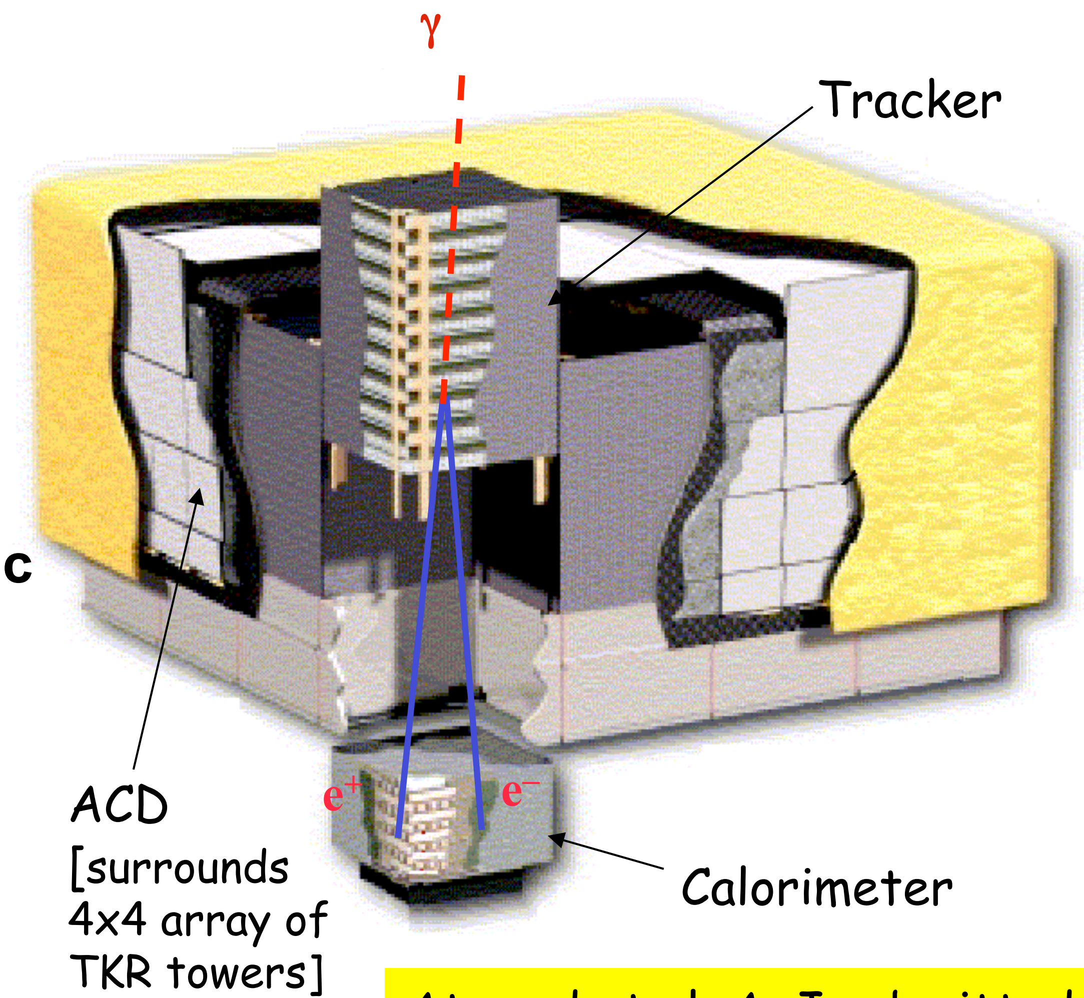


KEY FEATURES

- Huge field of view
  - LAT: 20% of the sky at any instant; in sky survey mode, expose all parts of sky for ~30 minutes every 3 hours. GBM: whole unocculted sky at any time.
- Huge energy range, including largely unexplored band 10 GeV - 100 GeV. Total of >7 energy decades!
- Large leap in all key capabilities. Great discovery potential.

The LAT: how it works

- **Precision Si-strip Tracker (TKR):** measure the photon direction; gamma ID.
- **Hodoscopic CsI Calorimeter (CAL):** measure the photon energy; shower shape.
- **Segmented Anticoincidence Detector (ACD):** reject background of charged cosmic rays; segmentation removes self-veto effects at high energy.
- **Electronics System** includes flexible, robust hardware trigger and software filters.



Atwood et al, ApJ submitted

Systems work together to identify and measure the flux of cosmic gamma rays with energy 20 MeV - >300 GeV.

The Launch!

- **Launch from Cape Canaveral Air Station 11 June 2008 at 12:05PM EDT**
- **Circular orbit, 565 km altitude (96 min period), 25.6 deg inclination.**

A moment later....

And then....

The LAT Collaboration

- France
  - CNRS/IN2P3, CEA/Saclay
- Italy
  - INFN, ASI, INAF
- Japan
  - Hiroshima University
  - ISAS/JAXA
  - RIKEN
  - Tokyo Institute of Technology
- Sweden
  - Royal Institute of Technology (KTH)
  - Stockholm University
- United States
  - Stanford University (SLAC and HEPL/Physics)
  - University of California, Santa Cruz - Santa Cruz Institute for Particle Physics
  - Goddard Space Flight Center
  - Naval Research Laboratory
  - Sonoma State University
  - The Ohio State University
  - University of Washington

PI: Peter Michelson
(Stanford)

~390 Scientific Members (including 96 Affiliated Scientists, plus 68 Postdocs and 105 Students)

Cooperation between NASA and DOE, with key international contributions from France, Italy, Japan and Sweden.

Managed at SLAC.

Fermi Science

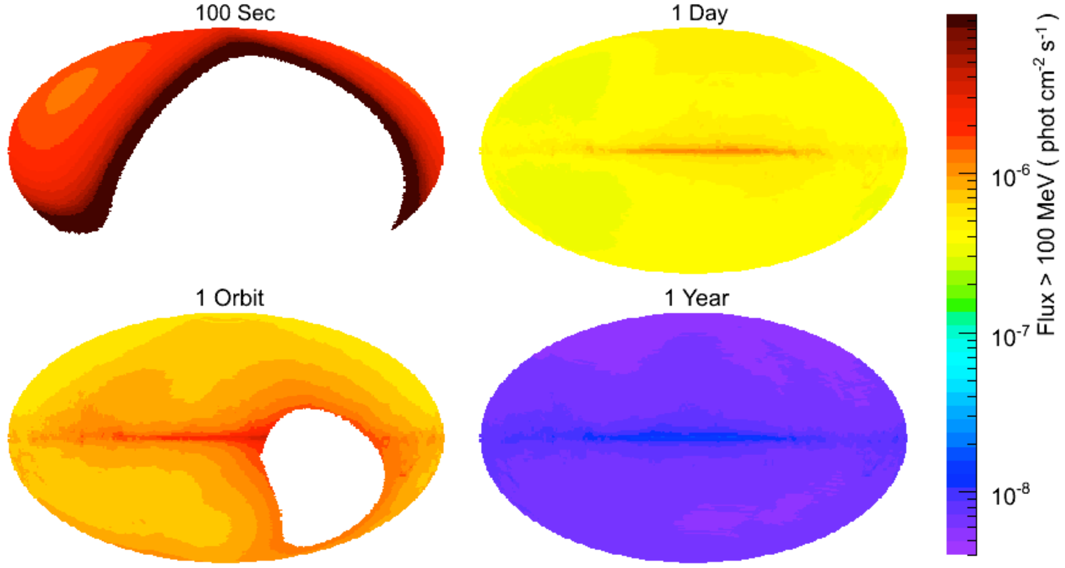
A very broad menu, including:

- Systems with supermassive black holes (Active Galactic Nuclei)
- Gamma Ray Bursts (GRB)
- Pulsars
- Supernova Remnants (SNR), PWNe, Origin of Cosmic Rays
- Diffuse emission
- Solar physics
- Probing the era of Galaxy formation, optical-UV background light
- Unidentified sources
- Discovery! New source classes, Dark Matter (?)

Draw the interest of both High Energy Particle Physics and High Energy Astrophysics communities

Operating modes

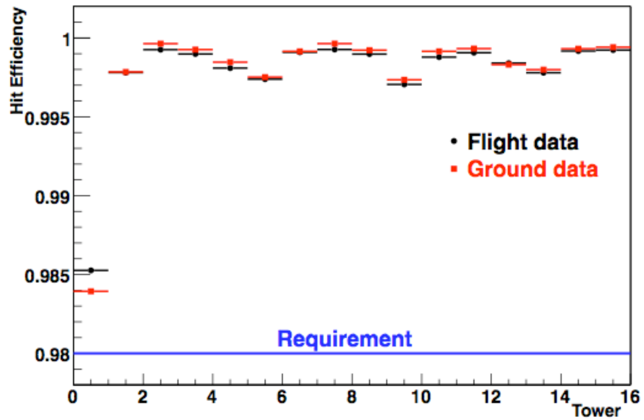
- Primary observing mode is Sky Survey
  - Full sky every 2 orbits (3 hours)
  - Uniform exposure, with each region viewed for ~30 minutes every 2 orbits
  - Best serves majority of science, facilitates multiwavelength observation planning
  - Exposure intervals commensurate with typical instrument integration times for sources
  - EGRET sensitivity reached in days



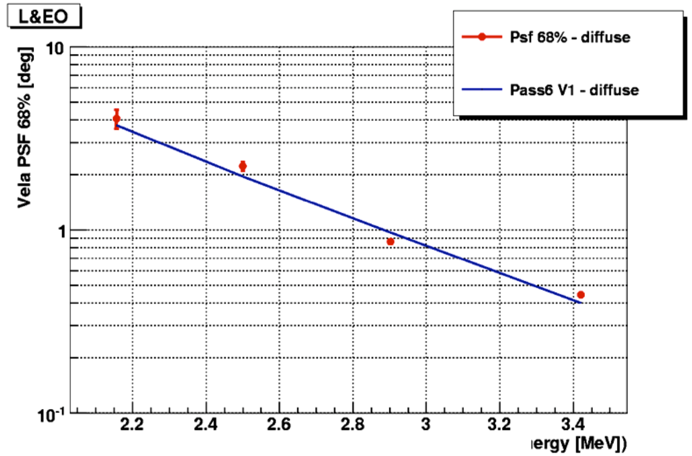
- Pointed observations when appropriate (selected by peer review in later years) with automatic earth avoidance selectable. Target of Opportunity pointing.
- Autonomous repoints for onboard GRB detections in any mode.

Performance of the LAT on Orbit

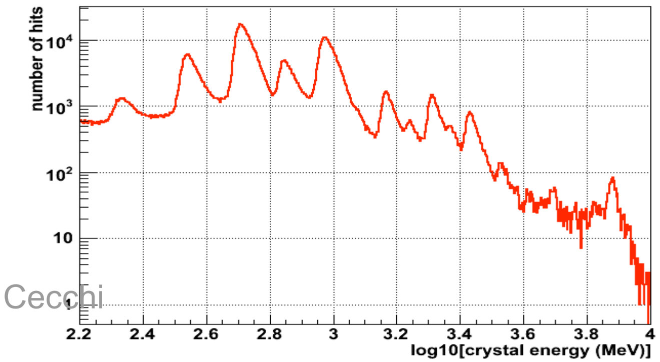
- **Total background rates very close to expectation (non-trivial!)**
- **Spectacular charged-particle hit efficiency:**



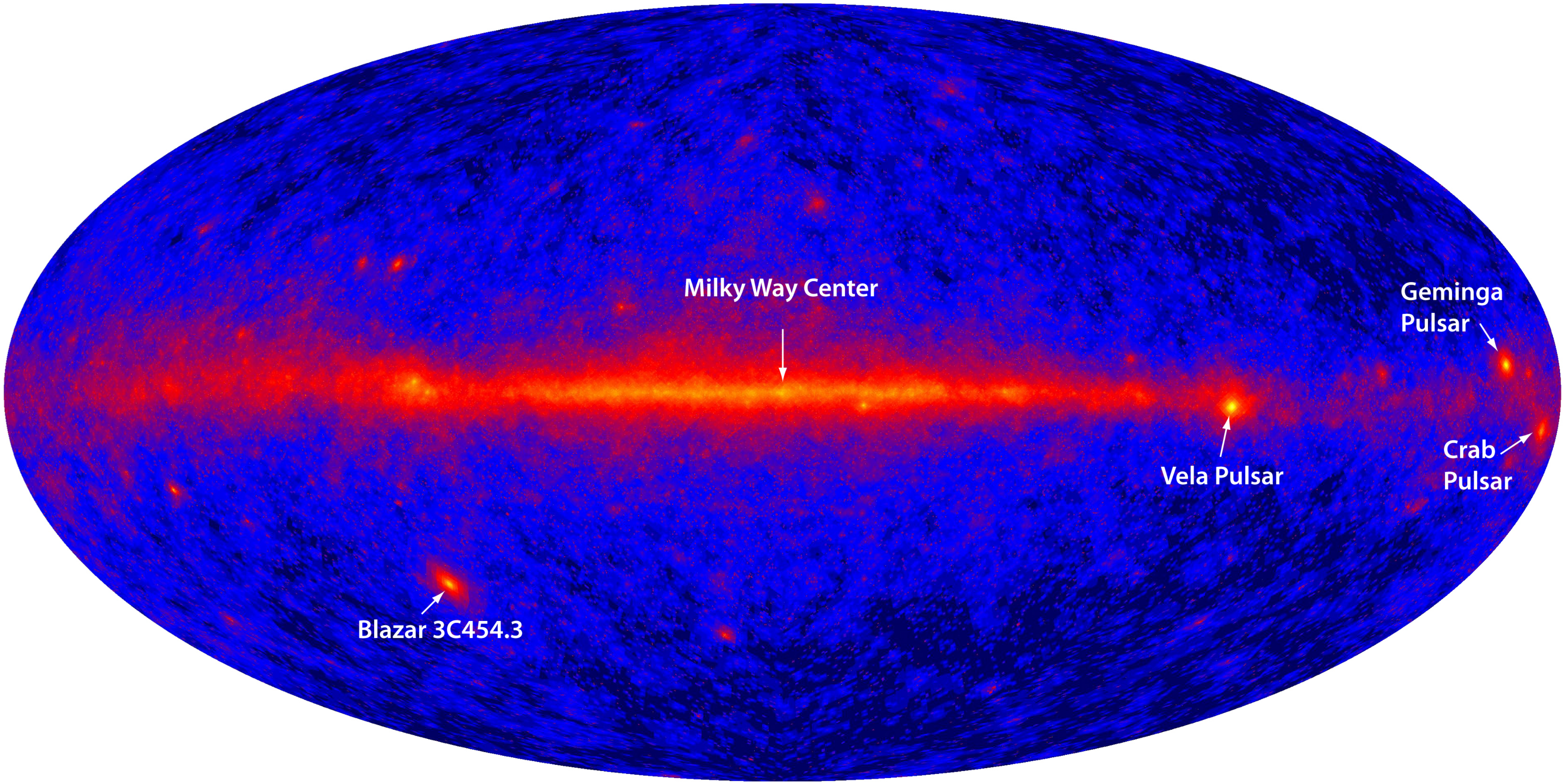
- **PSF on-orbit as expected (note intrinsic energy dependence => localization is source-dependent)**
  - **verify using on-pulse photons from Vela, compare with detailed MC simulation:**



- **On-orbit calorimeter calibration stable**
  - **use cosmic ray heavy ions:**



The First Light

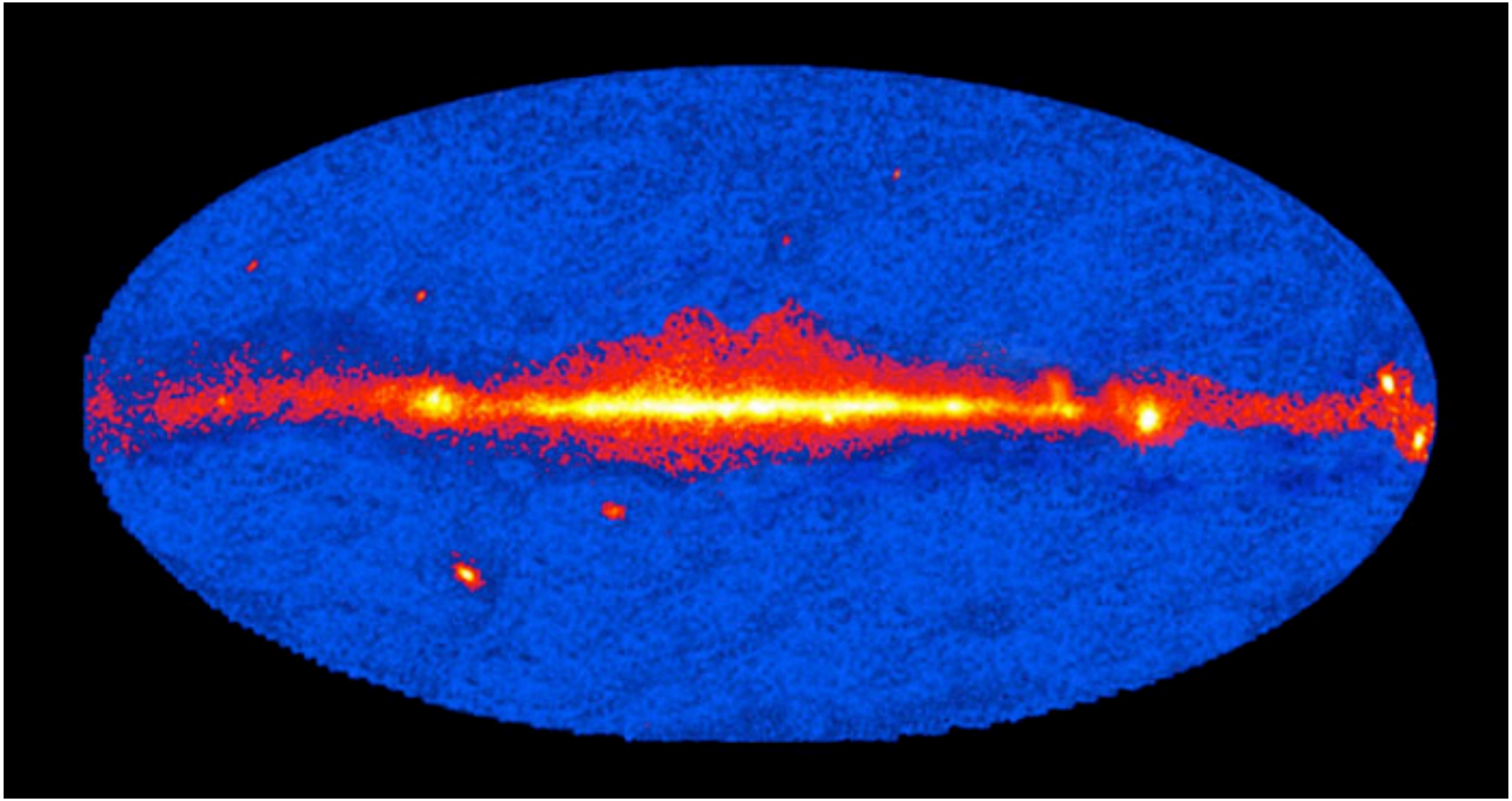


Four days of all-sky survey engineering data.

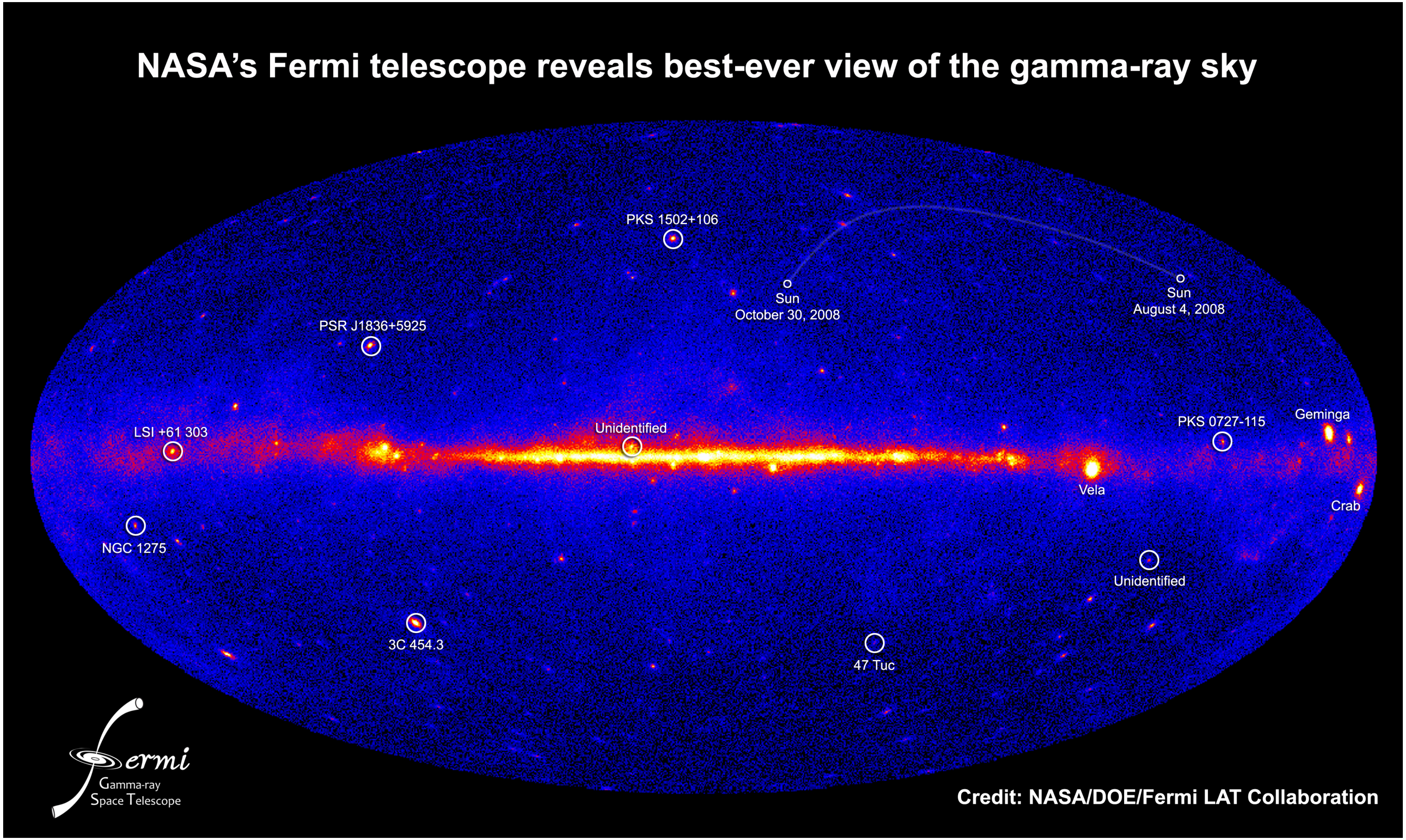
Fermi
Gamma-ray
Space Telescope

AGILE 9-month sky map

Perugia
INFN
Istituto Nazionale di Fisica Nucleare



LAT Bright Sources
(March 11th 2009)

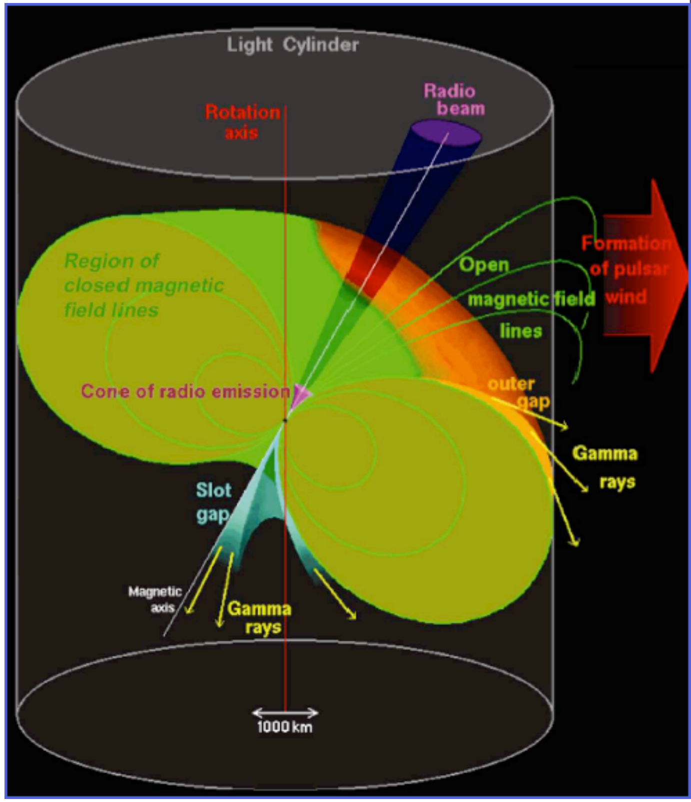


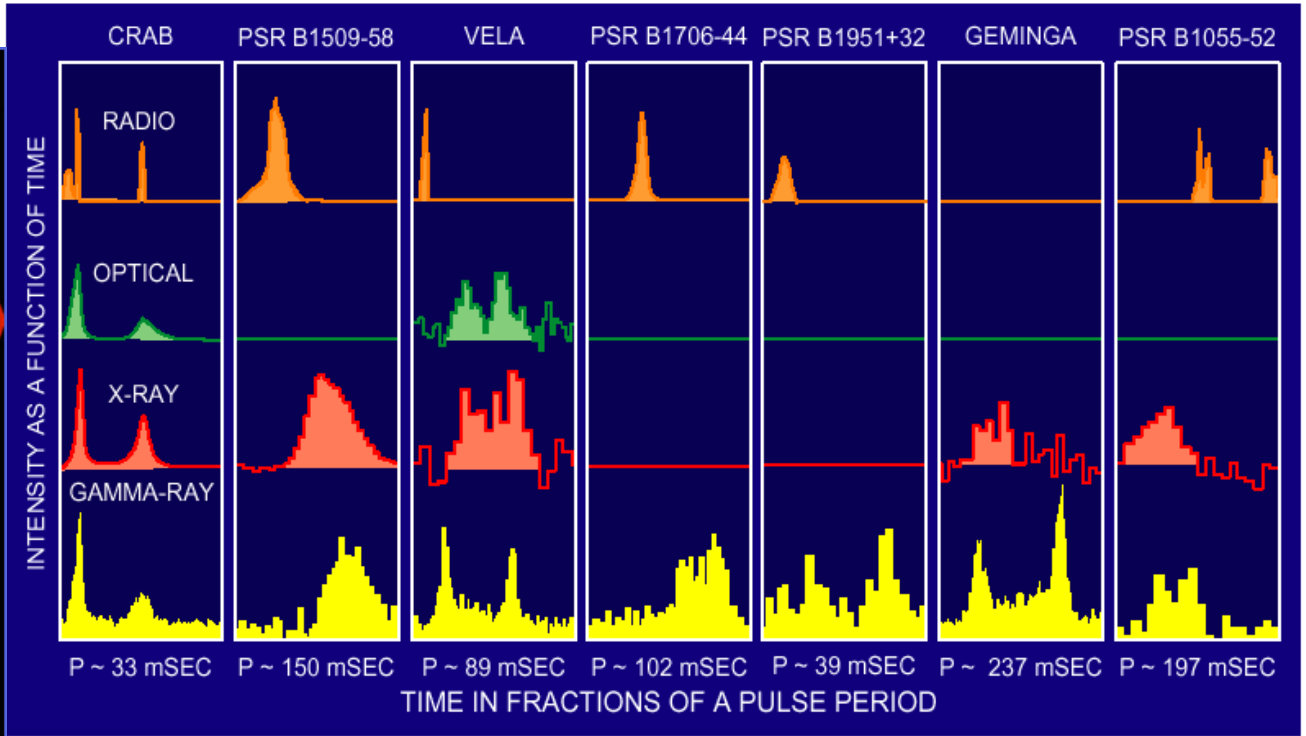
Open questions from EGRET

- How and where do pulsars emit gamma rays? How common are radio-quiet pulsars?
  - necessary clue to magnetic field configurations and dynamics
- What are the EGRET Unidentified Sources?
  - most of the EGRET source identifications are a mystery
- What are the energy budgets of gamma-ray bursts? What are the temporal characteristics of the high-energy emission?
  - not well characterized yet, key tests of models.
- What are the origins of the diffuse emissions?
  - galactic: cosmic-ray and matter distributions; sources
  - extragalactic: populations
  - new sources (Dark Matter annihilations, clusters, …)
- How do the supermassive black hole systems of AGN work? Why do the jets shine so brightly in gamma rays?
  - temporal and spectral variability over different timescales
- What remains to be discovered with great new capabilities?
  - EGRET showed us the tip of the iceberg. New sources and probes for new physics.

EGRET Gamma-ray Pulsar light curves

- Rotating neutron stars
- Magnetic axis inclinated with respect to the rotation axis
- Rotation energy dissipated in the emission of the EM radiation and in the charged particle acceleration
- Most of the energy emitted in the gamma band



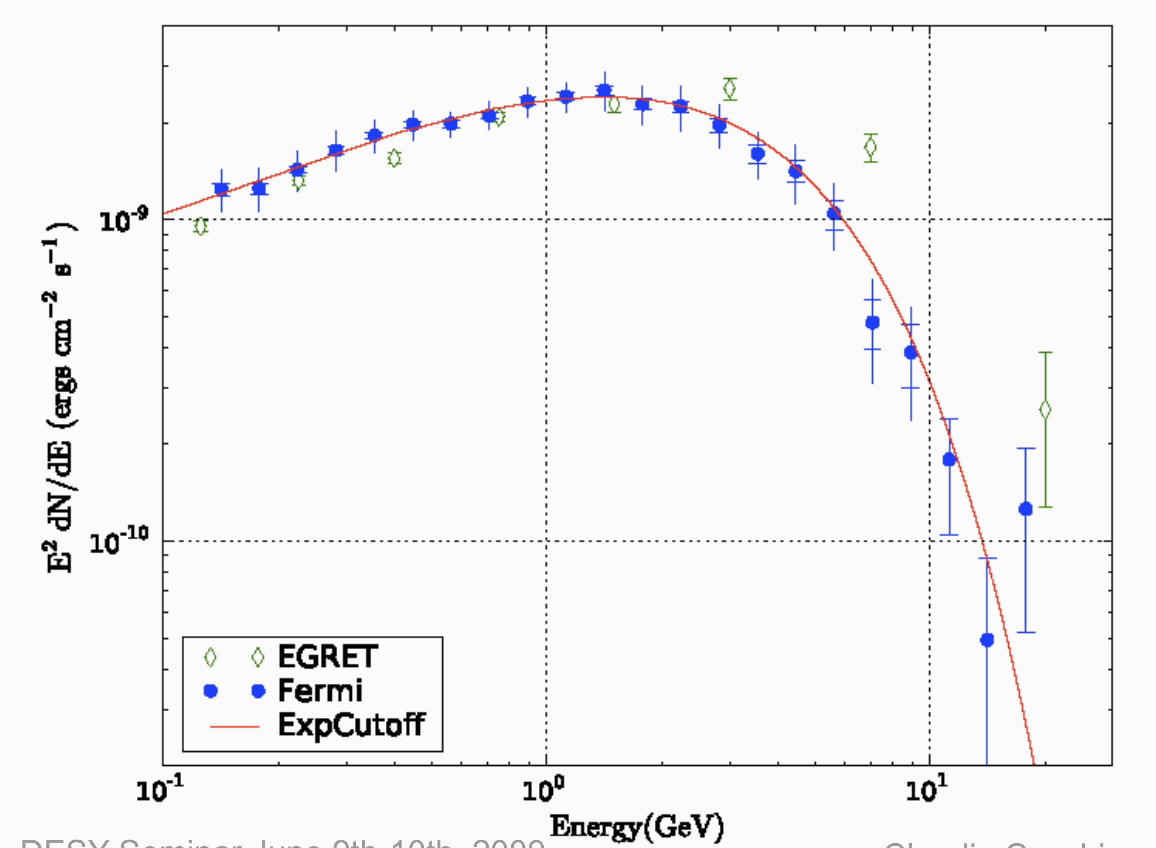


Multiwavelength light curves of the seven pulsars detected with EGRET. A flat line in the radio, optical or X-ray bands means that no such pulsation has been detected. GLAST should provide gamma-ray light curves for several dozen pulsars, which combined with the pulse shapes measured at other energies will severely constrain theoretical models for pulsar emission.

Phase averaged SED for VELA

$$N(E) = N_0 E^{\Gamma} e^{-(E/E_c)^b}$$

Consistent with b=1, simple exponential
b=2 superexponential rejected at 16.5σ



$$\Gamma = 1.51^{+0.05}_{-0.04}$$

$$E = 2.9 \pm 0.1$$ **GeV**

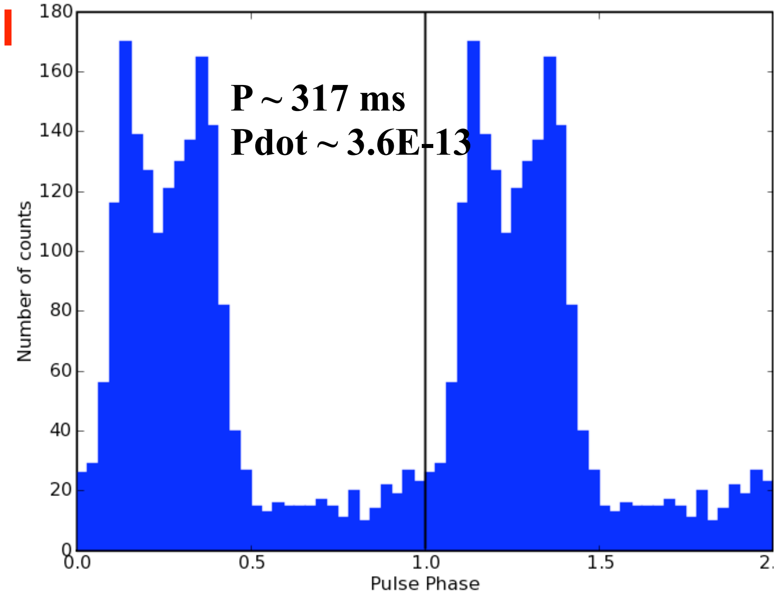
No evidence for magnetic pair attenuation → near surface emission ruled out

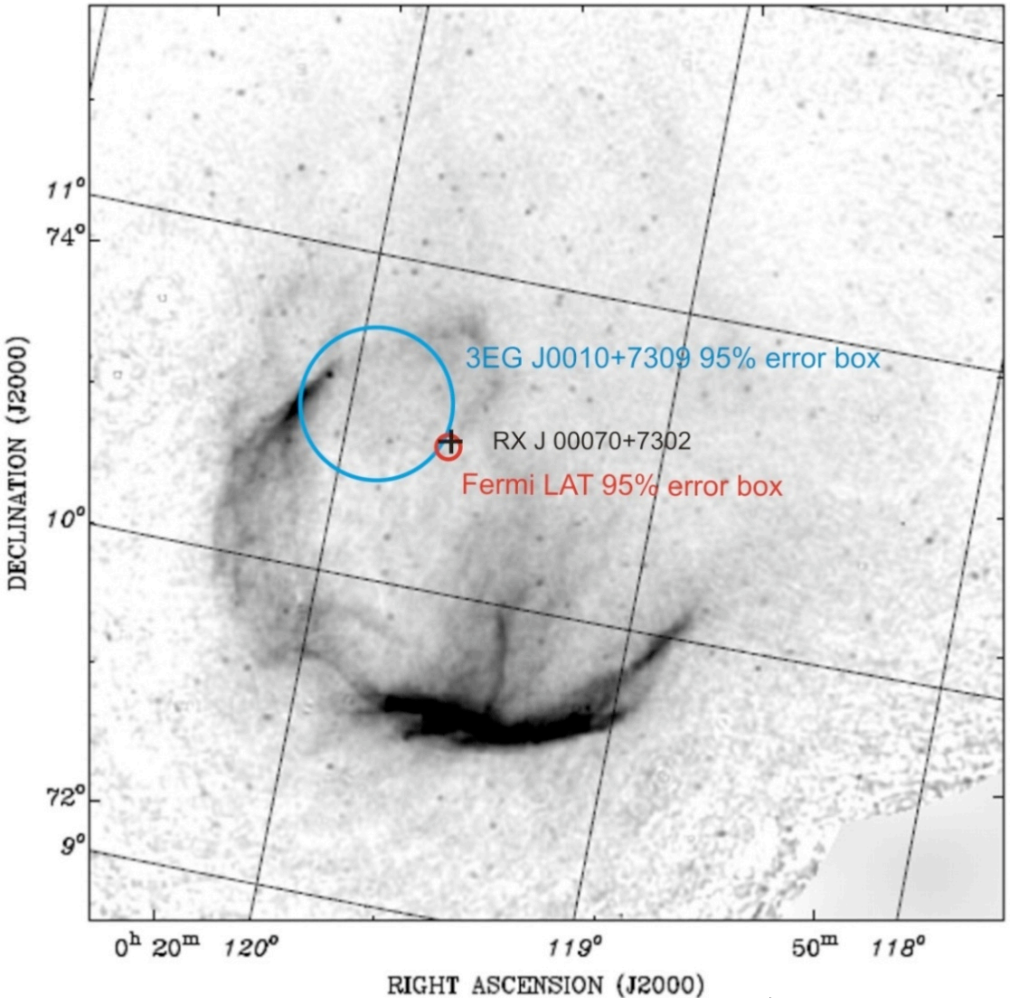
Discovery of the first Gamma-ray-only Pulsar

A radio-quiet, gamma-ray only pulsar, in Supernova Remnant CTA1

Quick discovery enabled by

- **large leap in key capabilities**
- **new analysis technique (Atwood et al**

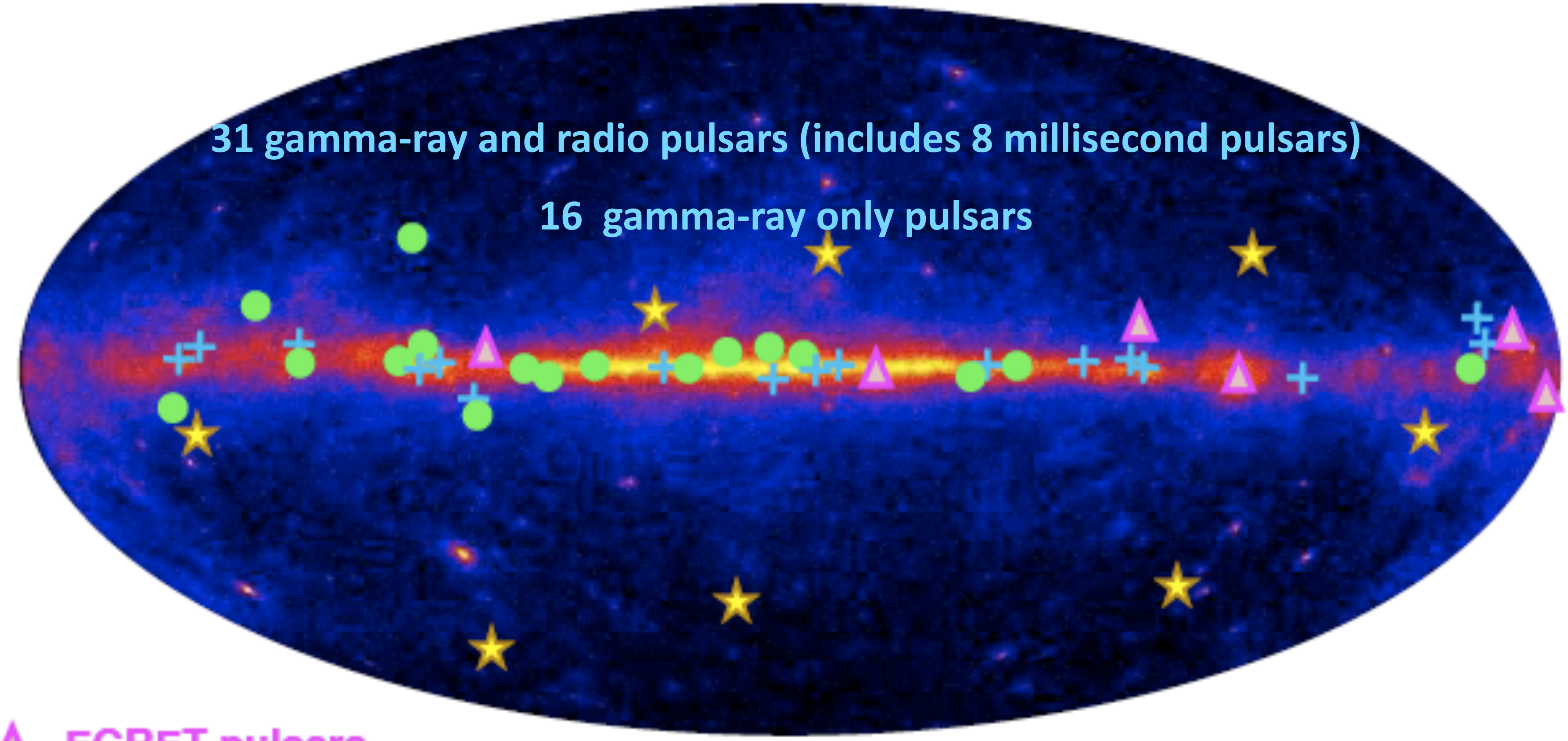




- Spin-down luminosity ~10^{36} erg s^{-1}, sufficient to supply the PWN with magnetic fields and energetic electrons.
- The γ-ray flux from the CTA 1 pulsar corresponds to about 1-10% of E_{rot} (depending on beam geometry)

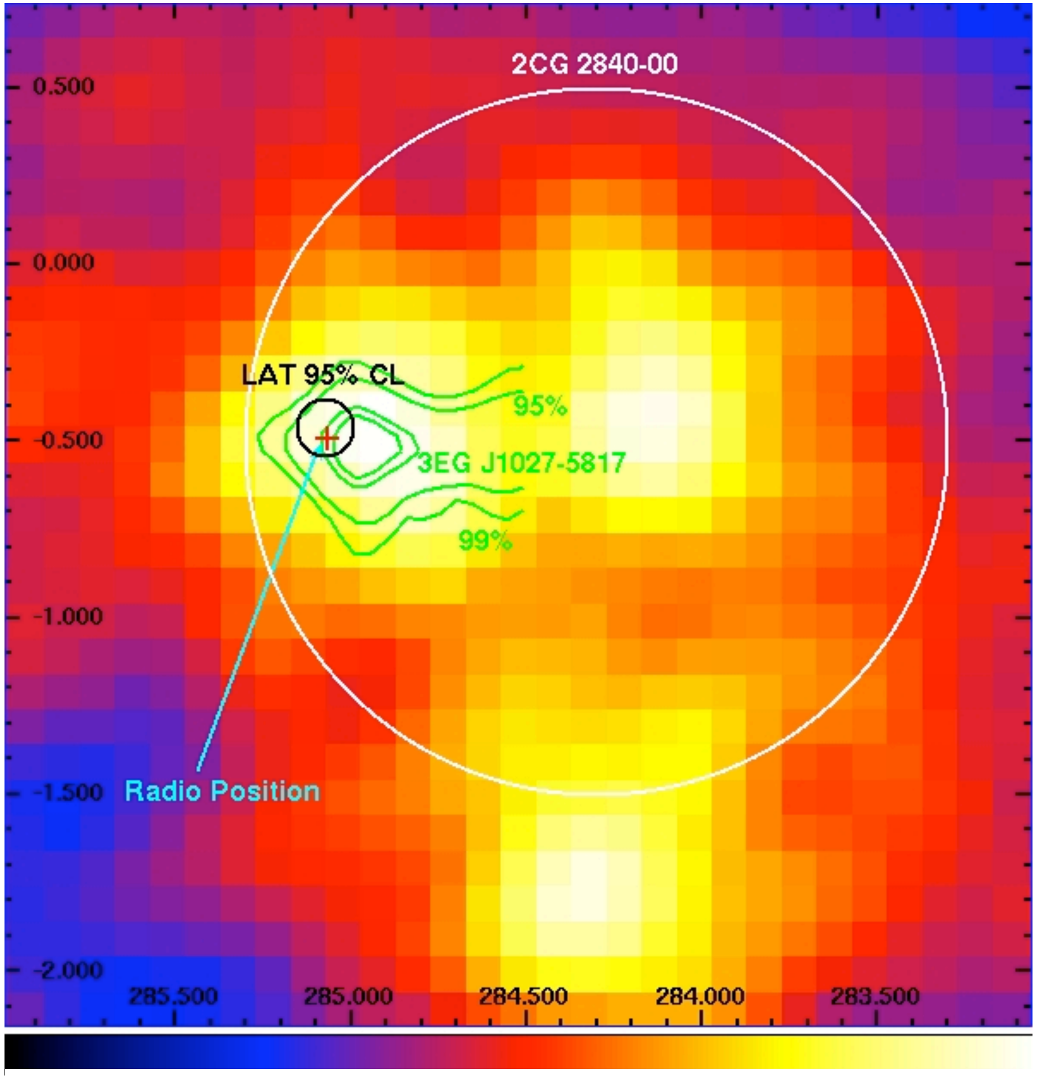
Age ~(0.5 – 1)x10^4 years
Distance ~ 1.4 kpc
Diameter ~ 1.5°

The Pulsing sky



- △ EGRET pulsars
- + young pulsars discovered using radio ephemeris
- ● pulsars discovered in blind search
- ☆ millisecond pulsars discovered using radio ephemerides

Resolving EGRET UNID's: Pulsar J1028

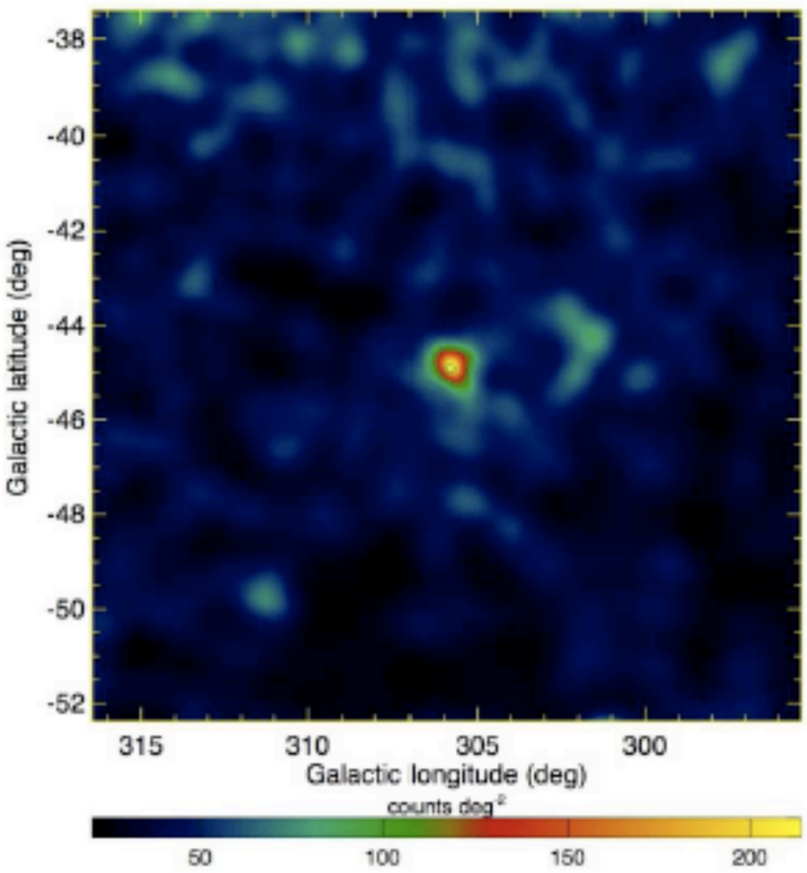


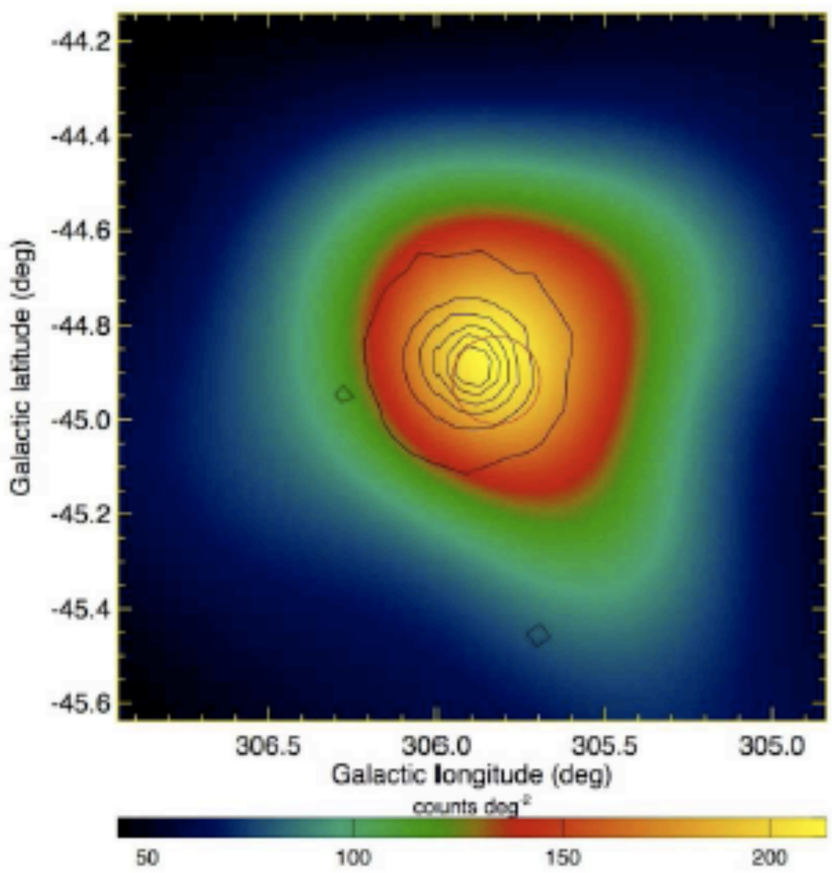
- LAT point source
  - (l,b)=(285.074,-0.459)
  - 95% CL radius of 0.079°
- Power law with a simple exponential cutoff
  - Cutoff ~2-3 GeV
  - Index ~1.2
  - Integrated flux (0.1-30GeV) 1.62±0.27±0.32 e-7 ph/cm^2/s
- 3EG flux 6.6±0.7 e-7 ph/cm^2/s
  - From power law with index 2
  - No cutoff modeled
  - Low energy contribution from nearby source
- COS-B source
  - Flux 2.7 e-6 ph/cm^2/s
  - Actually multiple sources

Counts map above 100MeV, gaussian smoothing applied with kernel radius of 3. Also plotted, 2CG position (Swanenberg et al 1981), 3EG countors (Hartman et al 1999), and radio position.

23 radio ms pulsars in the Globular Cluster 47 Tucanae

Adaptively smoothed counts maps (200 MeV - 10 GeV, s.n.r = 5)





Large area

The source lies in an isolated sky region

Publication in preparation (J. Knodsleder, CESR Toulouse).

Zoom

Location of LAT source relative to 47 Tuc
red circle: LAT 95% error radius
contours: DSS2 stellar distribution (arbitrary units)

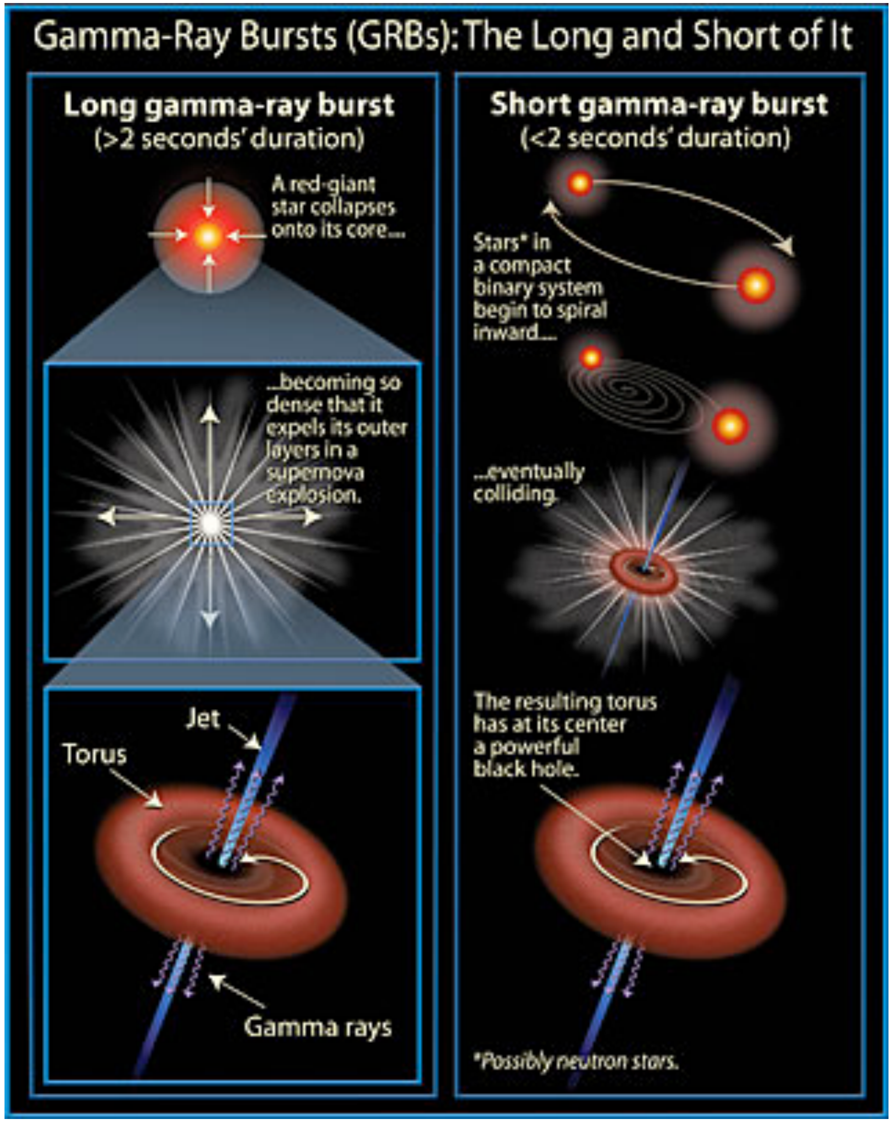
Fermi-LAT Pulsar discovery summary

First 4 month of the mission more than 36 pulsars detected!

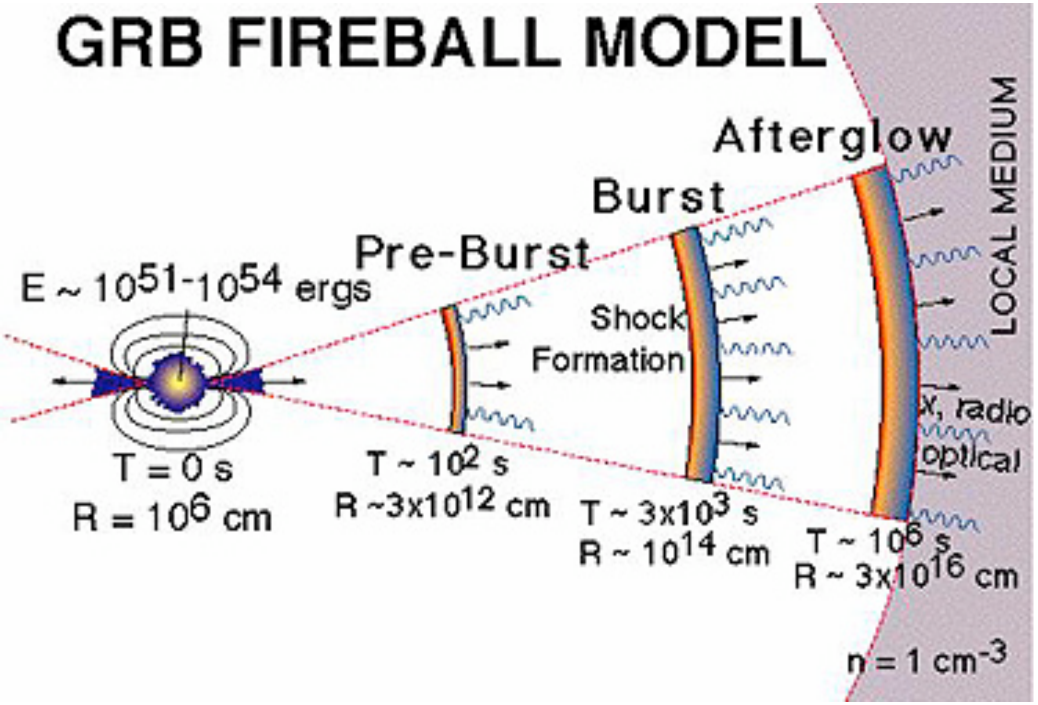
- confirmed 7 known egret pulsars (and several EGRET candidates)
- 12 new young Radio pulsars
- 16 young pulsars pulsing in Gamma-Ray only
- 8 “milliseconds” Gamma-ray pulsars (establishing a new class) (EGRET low significance candidate confirmed PSR J0218+4232)

- 16 new pulsars found directly in the Gamma-rays (blind search)
- 20 additional pulsars seen for the first time as Gamma-ray emitters

Gamma Ray Burst's



Most explosive cosmological events!

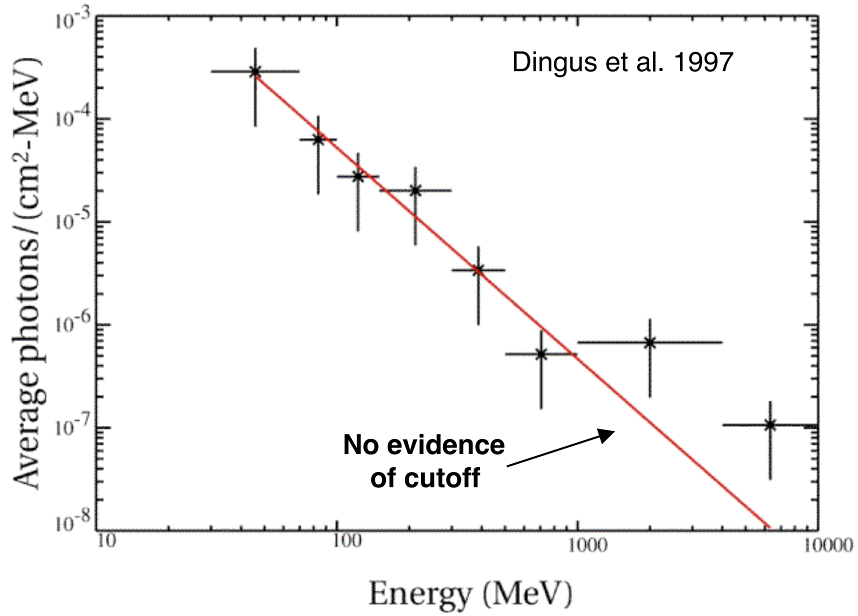


Gamma Ray Burst at High Energy

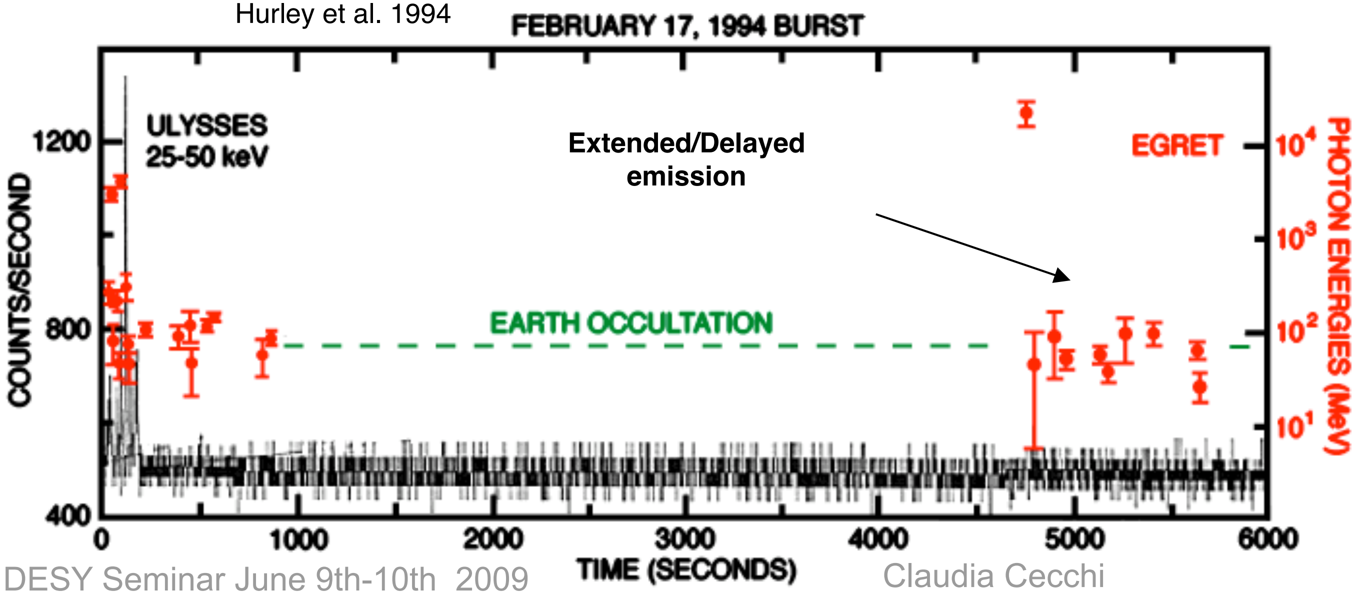
- **Little is known about GRB emission in the >50 MeV energy regime**
- **EGRET detected few high-energy bursts**

- **GLAST, compared to EGRET, will have:**
  - **Wider FoV**
  - **Short deadtime (~25 μs)**
  - **Repoint**

Composite spectrum of 5 EGRET Bursts

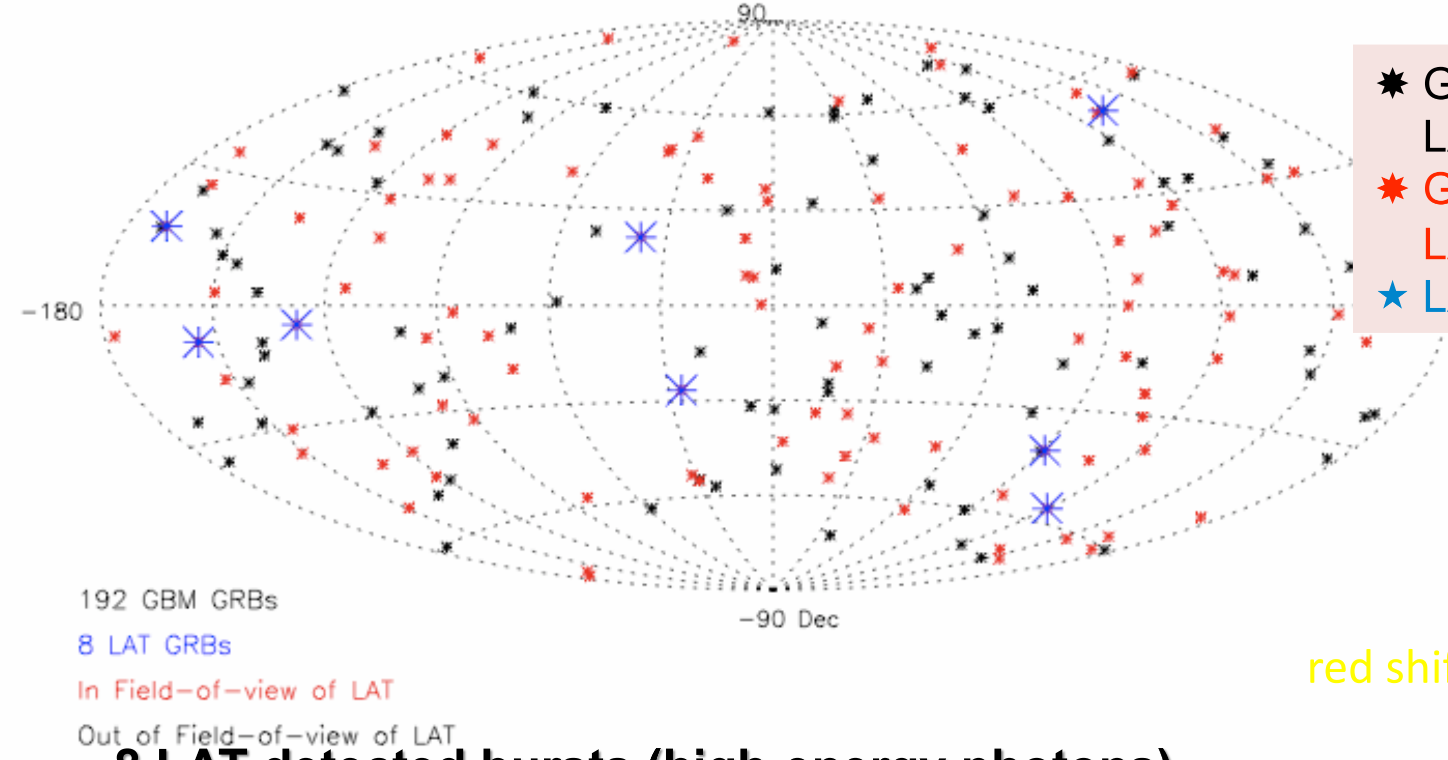


Hurley et al. 1994



Extended or delayed GeV emission may require more than one emission mechanism, and remains one of the unsolved problems.

Gamma-Ray Bursts (GRB)



- GBM GRB outside the LAT field of view
- GBM GRB within the LAT field of view.
- LAT GRB

red shift: $z = \frac{f_{\text{emitted}}}{f_{\text{observed}}} - 1$

8 LAT-detected bursts (high-energy photons)

GRB 080825C
GRB 080916C z = 4.35 +/-0.15 (GROND/photometric) **13 GeV photon!**
GRB 081024B short-duration burst
GRB 081215A
GRB 090217
GRB 090323 z = 3.6 (Gemini/spectroscopic)
GRB 090328 z = 0.736 (Gemini/spectroscopic)
GRB 090510 z = 0.903 (VLT/spectroscopic); short duration; **31 GeV photon!**

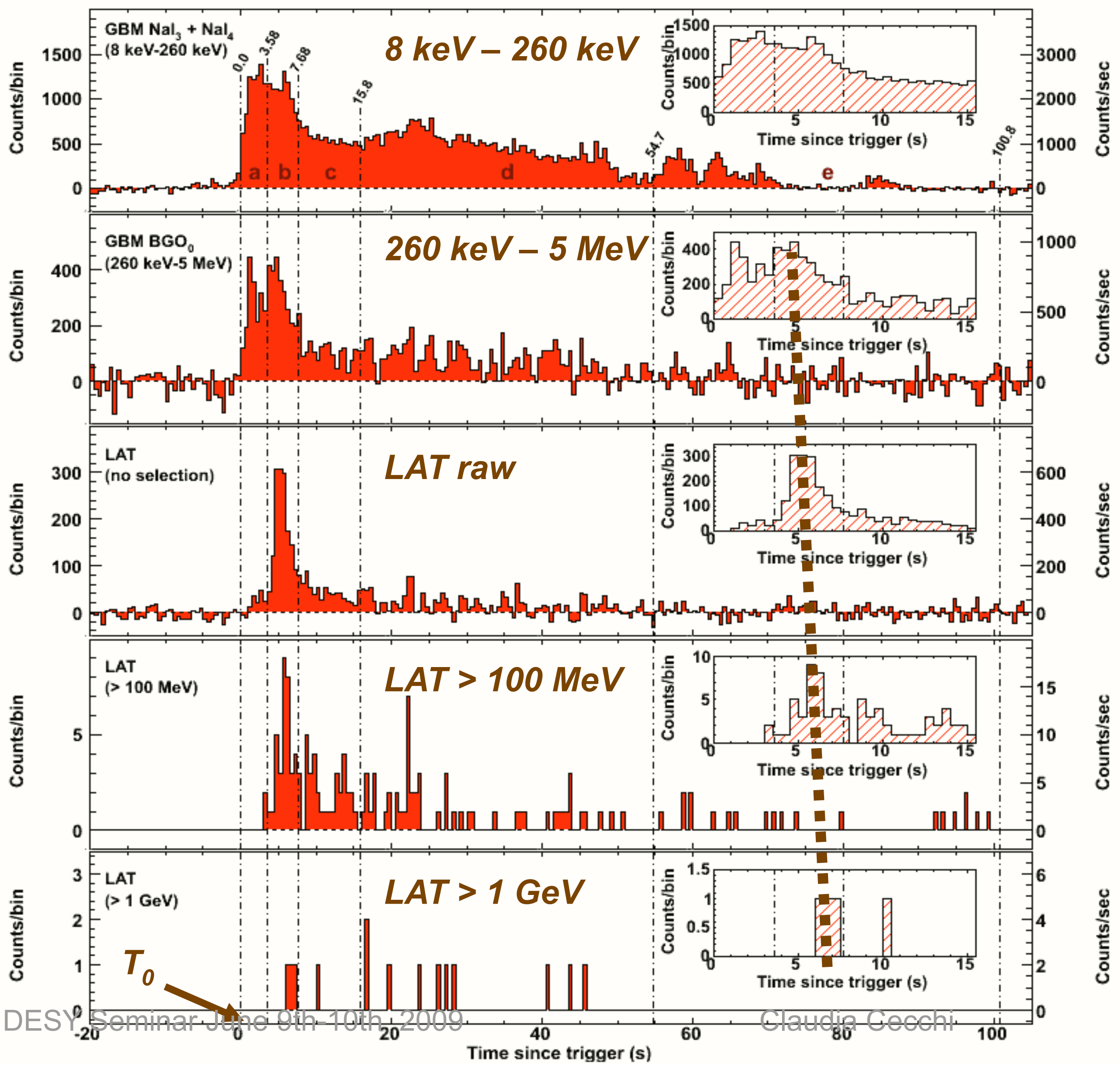
GRB080910C
...first look at this burst...

- Largest number, ≈ 200, of high-energy, >100 MeV photons (second is GRB 940217, with 28), allowing time-resolved spectral studies
- Significant ≅4.5s delay between onset of >100 MeV and 100 keV radiation
- First high-energy 100 MeV – GeV detection of a GRB with known redshift
- Redshift z = 4.2±0.3 from GROND photometry on 2.2 m in La Silla, Chile (Greiner et al. 2008)
- Large fluence burst (2.4×10^{-4} ergs cm^{-2}) at 10 keV – 10 GeV energies
  - Apparent isotropic energy release is 8.3×10^{54} ergs
  - Supports the black-hole jet/collapsar paradigm of GRBs
  - Extreme γ-ray events ⇒ extreme particle acceleration
    - GRBs as sources of the UHECRs
    - Test particle acceleration models
- Highest energy photon (E = 13.22+0.70-1.54 GeV) from GRB with z
  - Largest minimum Doppler factors from opacity constraints (G_{min} ≅ 900)
  - Best limits on quantum gravity mass

GRB080916C

PRELIMINARY!

[Paper submitted, in review]



- The first low-energy peak is not observed at LAT energies
- 14 events above 1 GeV
- The bulk of the emission of the 2nd peak is moving toward later times as the energy increases
    - Clear signature of spectral evolution
- new era of GeV GRB lightcurves!

GROND optical follow up
[GCN 8257, 8272]
Faint (21.7 mag at T_0+32h) and fading (T_0+3.3d) source
RA = 119.8472˚,
Dec = −56.6383˚ (±0.5” at 68% C.L.)

Photometric redshift of z=4.2 +/- 0.3

Summary on GRB's

Updated on May : 129 bursts detected by GBM (Gamma Ray Burst Monitor) including 8 LAT detection

High Energy GRB' observation:

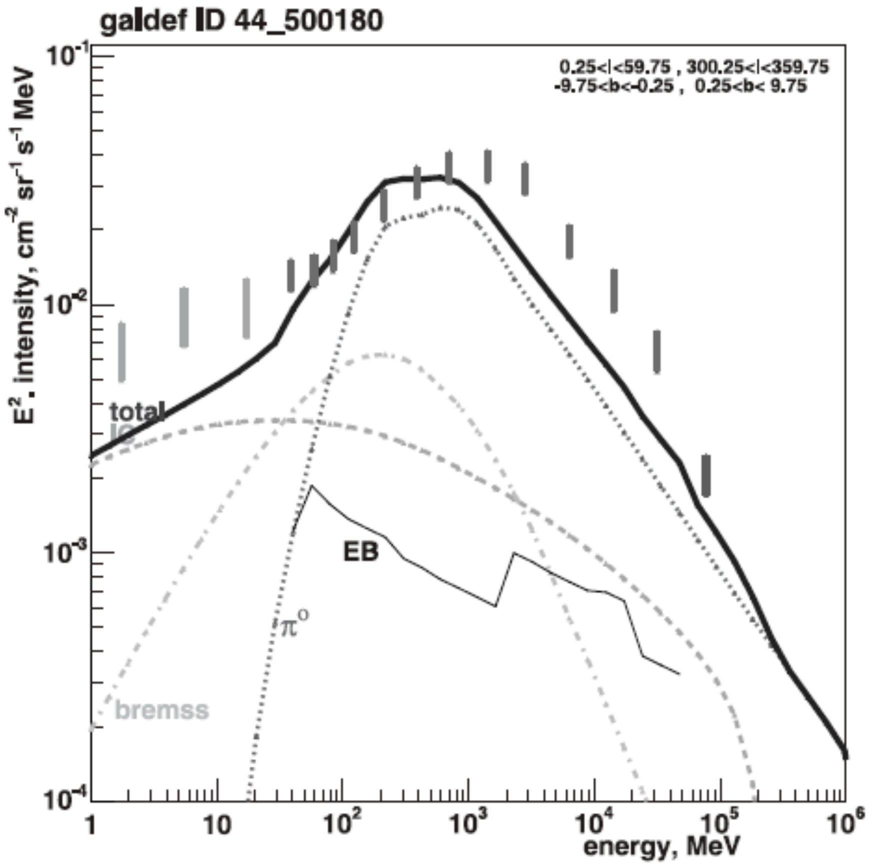
- evidence for a delay between KeV-MeV emission and >100MeV emission
- all spectra consistent with a Band function
- first >GeV observation from a short burst
- most energetic burst with a measured red shift
- evidence of a temporally extended GeV emission, up to 23 min

→ Derived considerations:

- narrow collimated relativistic jet
- KeV-GeV spectrum and variability: unique mechanism, same emission region
- leptonic or hadronic origin?
- best constraint ever on Γ (> 600 - 900) and M_{QG} (1.50e18 GeV/c^2 ~ 0.1 M_{Planck})

EGRET: diffuse emission from the Galaxy

GeV Excess



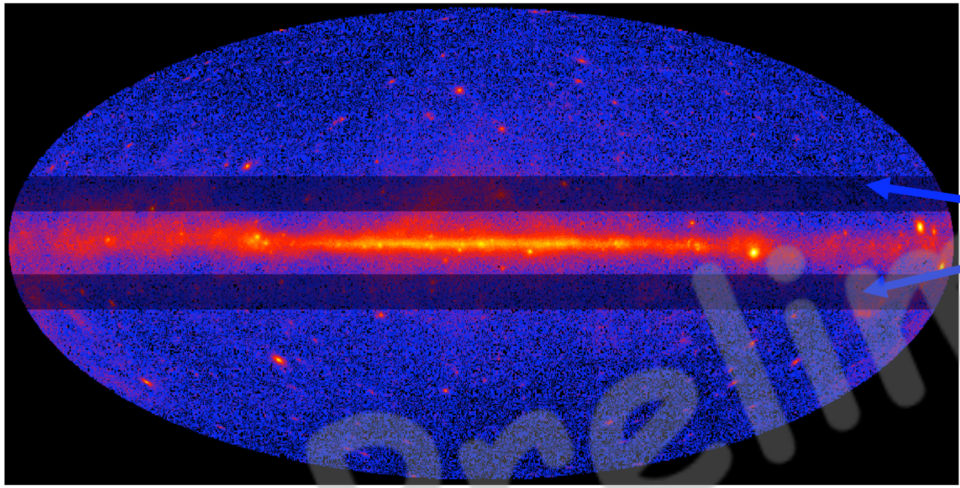
Credit: Strong, Moskalenko & Reimer 2004

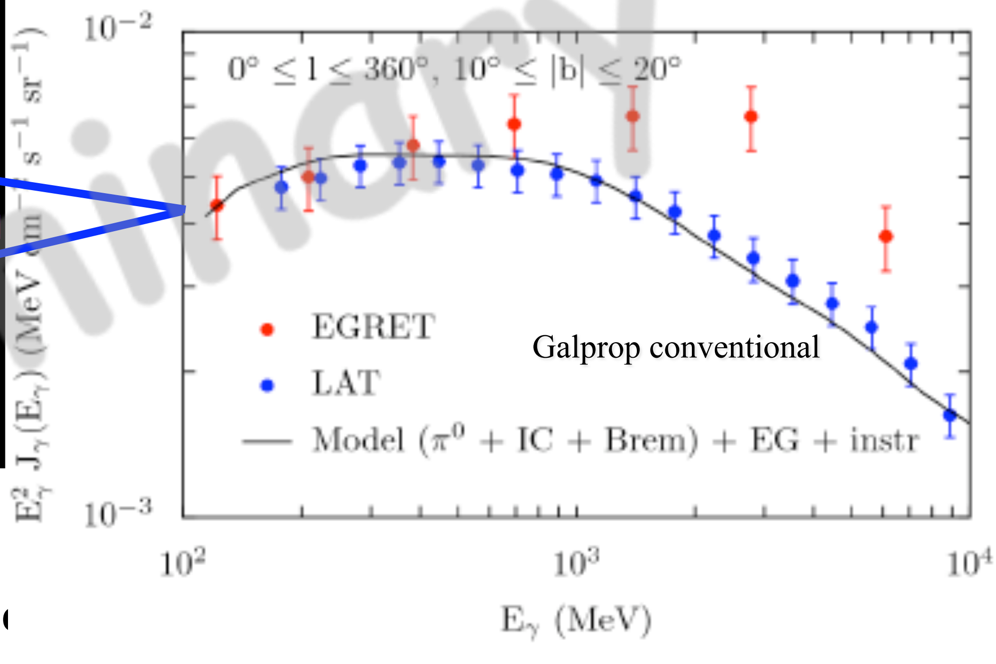
Diffuse emission model:

- **Locally measured CR spectrum**
- **Observed distribution of interstellar matter + light**
- **Theoretical/experimental cross sections for relevant interactions**

Adding this component it is posssible to calculate energy spectrum of gamma-ray intensity

Diffuse emission: nailing the EGRET "GeV excess"

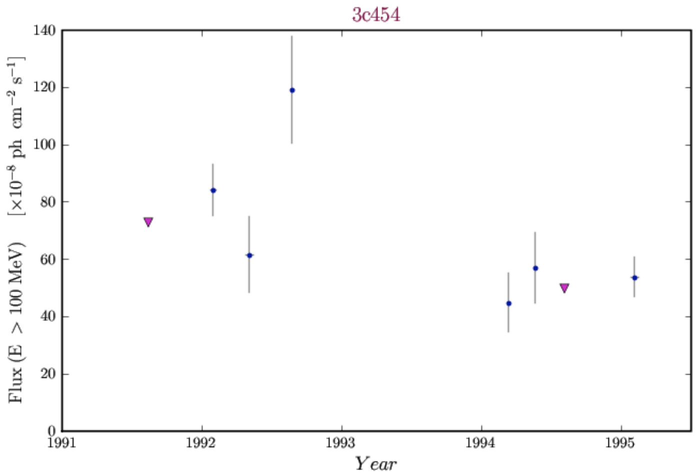


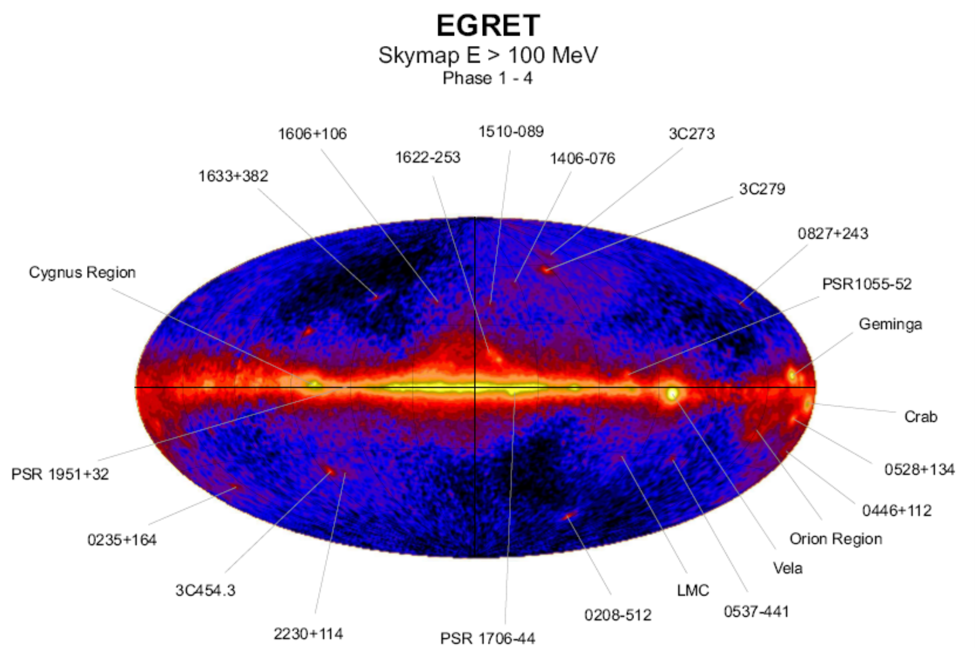


- Spectra shown for mid-latitude range G
  confirmed.
- Sources are not subtracted but are a minor component.
- LAT errors are dominated by systematic uncertainties and are currently estimated to be ~10% this is preliminary.
- EGRET data is prepared as in Strong, et al. 2004 with a 15% systematic error assumed to dominate (Esposito, et al. 1999).
- EG + instrumental is assumed to be isotropic and determined from fitting the data at $|b| > 10°$.

Gamma-ray loud Blazar: EGRET Era

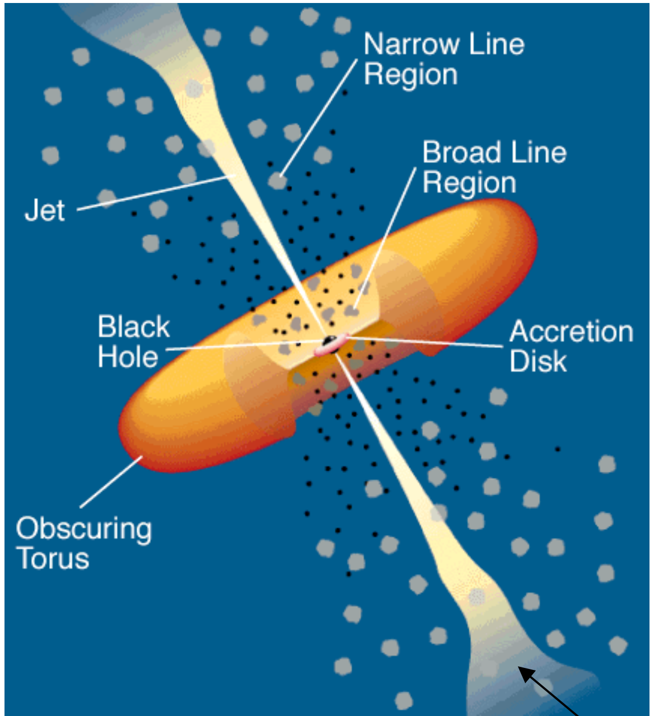
Although blazars are only a few per cent of the overall AGN population, they dominate the
high-energy sky





The Energetic Gamma Ray Experiment Telescope (EGRET) onboard the Compton Gamma Ray Observatory (CGRO) discovered about 70 (3rd Catalog, Hartman et al 1999; >100 Sowards-Emmerd et al. 2003,2004) blazars emitting gamma-rays

Extragalactic sources: Blazars



Almost all galaxies contain a massive black hole
-99% of them is (almost) silent (e.g. our Galaxy)

-1% per cent is active (mostly radio-quiet AGNs): BH+disk: most of the emission in the UV-X-ray band

0.1% is radio loud: jets mostly visible in the radio

Blazar characteristics

- Compact radio core, flat or inverted spectrum
- Extreme variability (amplitude and t) at all frequencies
- High optical and radio polarization

FSRQs: bright broad (1000-10000 km/s) emission lines often evidences for the “blue bump” (acc. disc)

BL Lac: weak (EW<5 Å) emission lines no signatures of accretion

Blazars: Fermi LAT

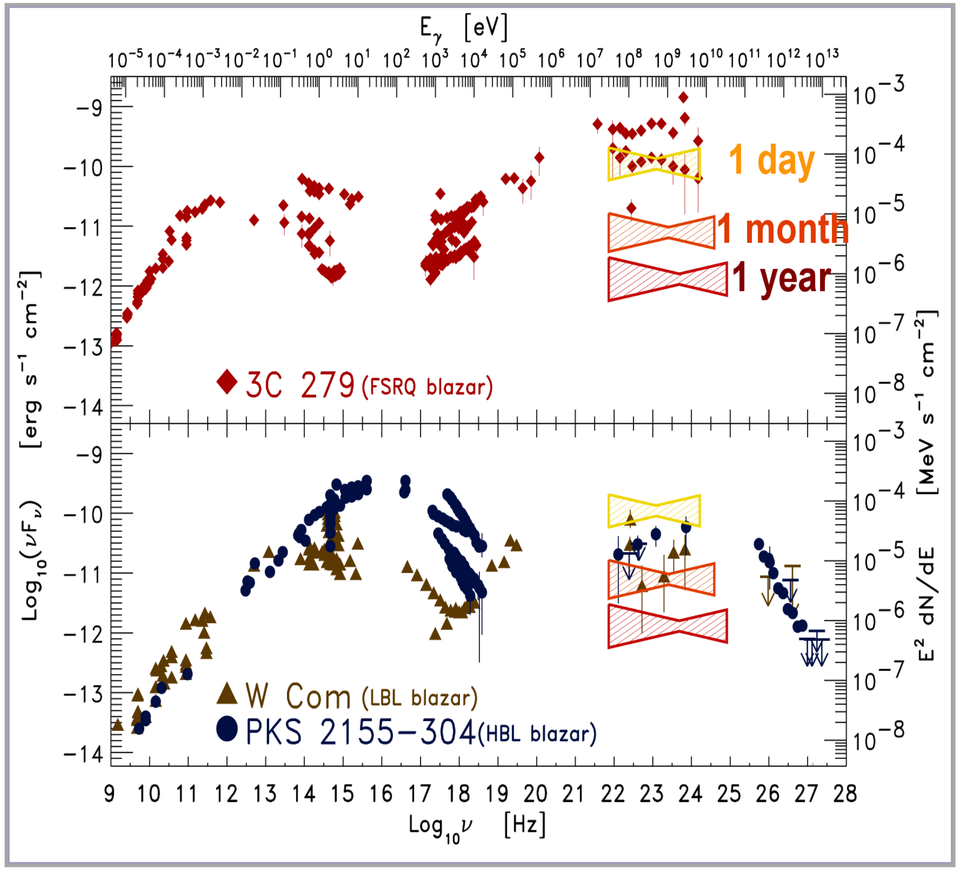
- ❑Population Studies

- ❑Daily sampled LC can be easily obtained for most of the bright blazars → Variability on timescales >= 1 day can be well investigated.

- ❑Intra-day (hours) variations can be detected for the brightest gamma-ray blazars.

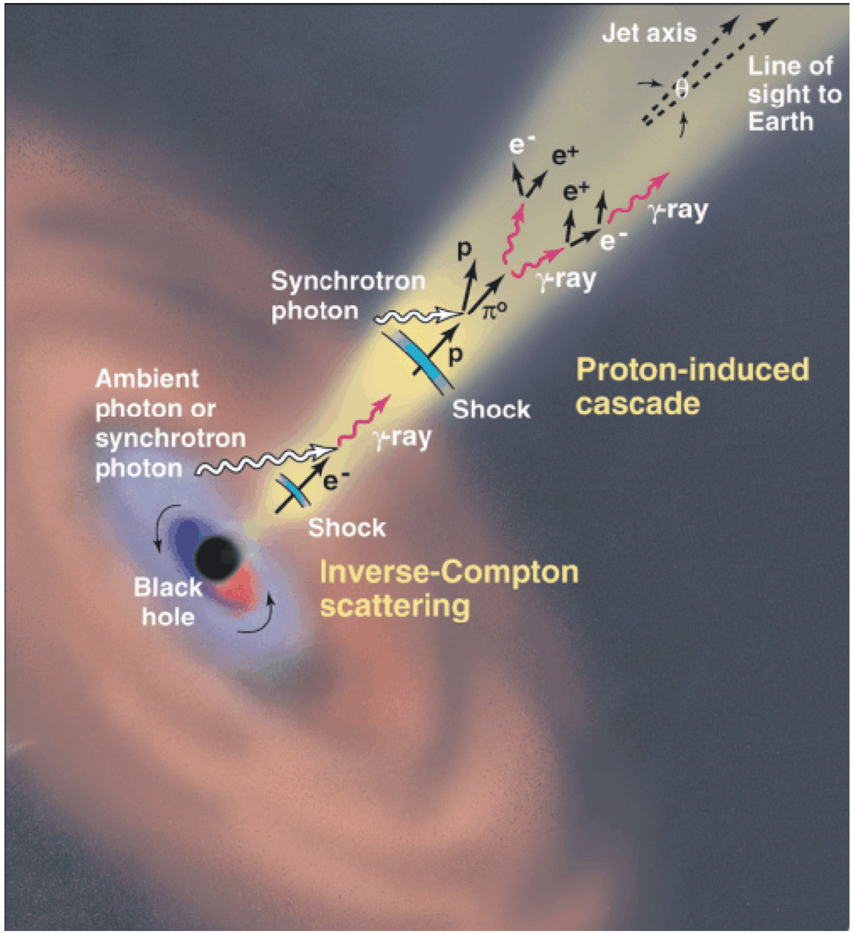
- ❑ Detailed spectral variation analysis and intrabands delays studies may be performed

- ❑ Multiepoch SEDs can be obtained.



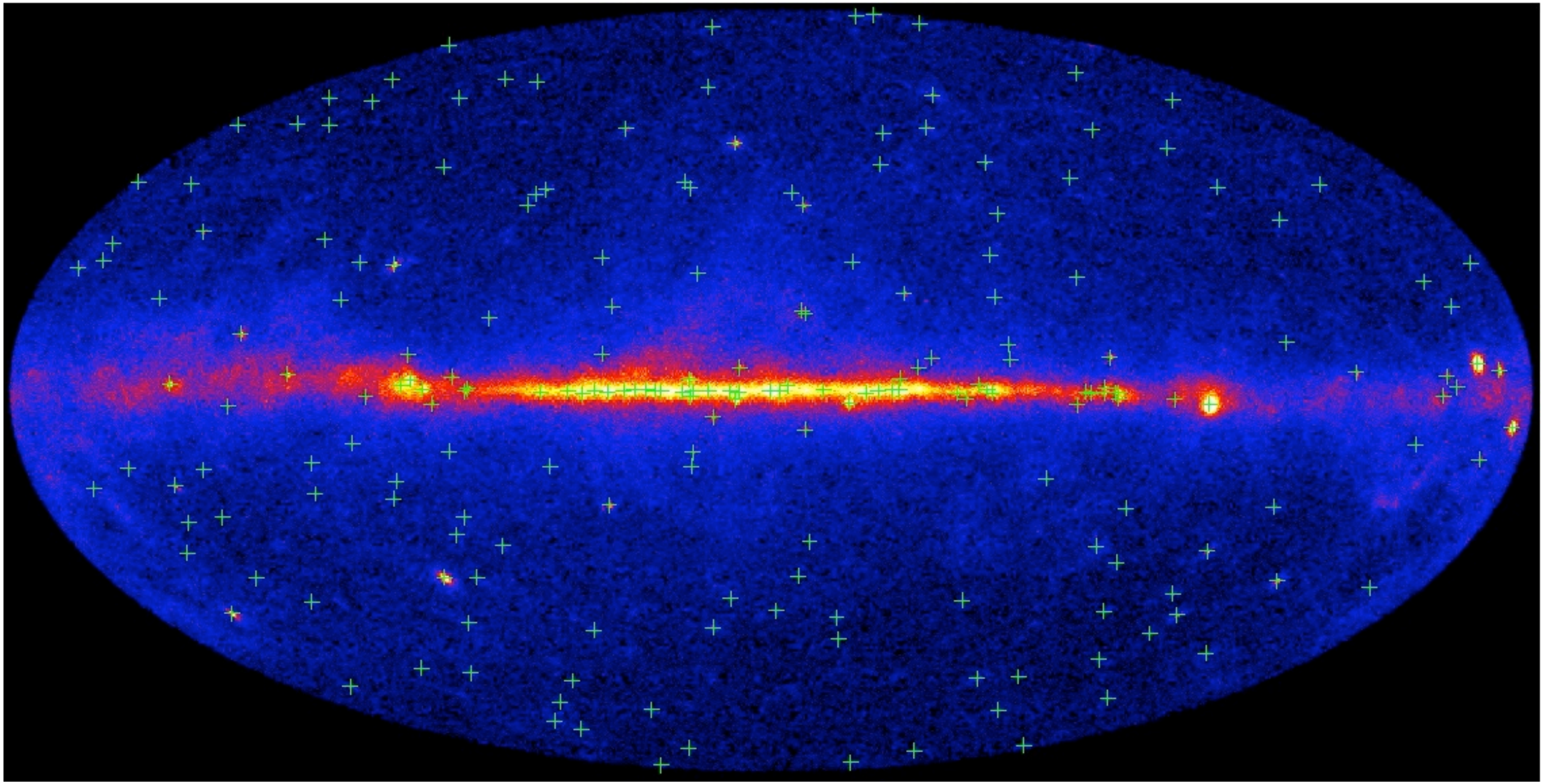
Open questions about Blazars

- How are jets made by accreting black holes?
- How and where are jets accelerated (why they have high Lorentz factors)?
- How are jets focused to opening angles less than a few degrees?
- How do shocks, turbulence, instabilities, jet bending and precession arise?
- What is the jet matter content (electron-proton vs. pair plasmas)?
- How are the relativistic electrons accelerated?
- Which is the jet emission mechanism ?
- How and where jets emit gamma-ray ?
- What are the mechanisms producing blazar variability?
- Which is the blazar duty-cycle?
- Etc…



Fermi-LAT is starting to give an answer to most of these questions

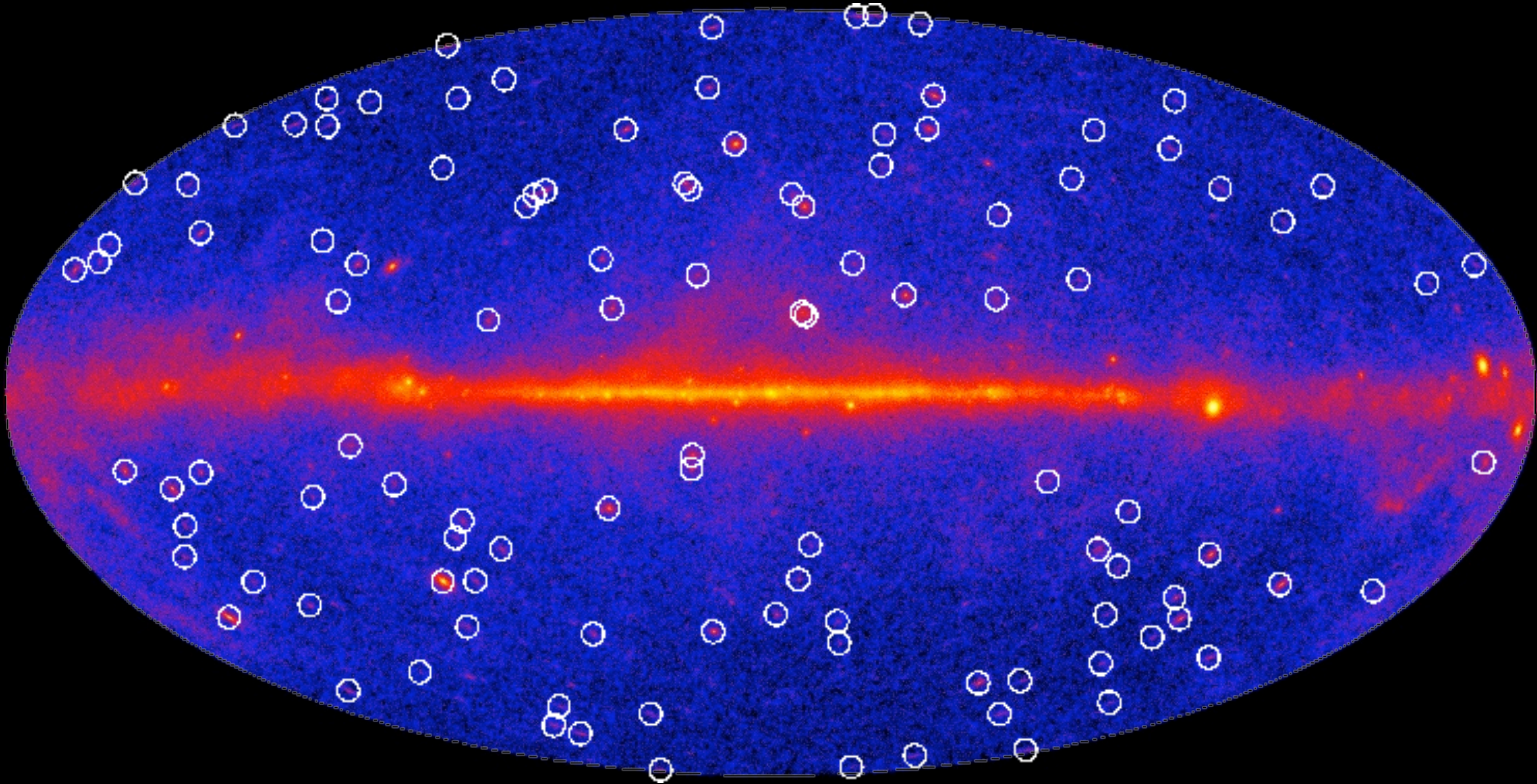
205 preliminary LAT Bright Sources



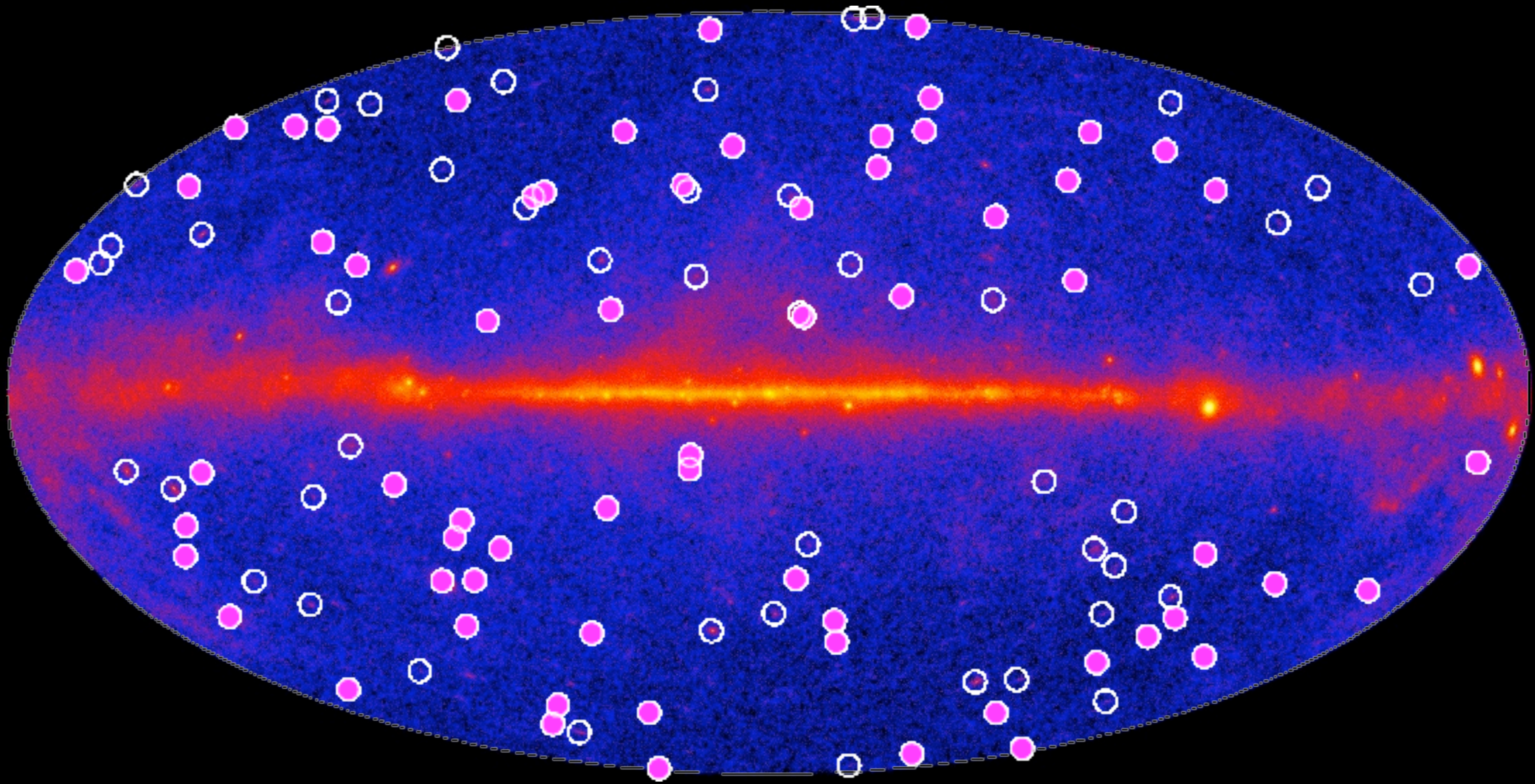
Vital statistics

- **205 "bright source list"**
  132 sources with >10σ detection and |*b*| > 10°
  - **7 are pulsars or pulsar candidates**
  - **111 of the remaining 125 are associated with *bright, flat-spectrum radio sources* (89%)**
    - **98/111 have optical classifications (88%)**
    - **89/111 have measured redshifts (80%)**
  - **Much higher association rate than for 3EG (~60%)**

The LAT Sky, August – October

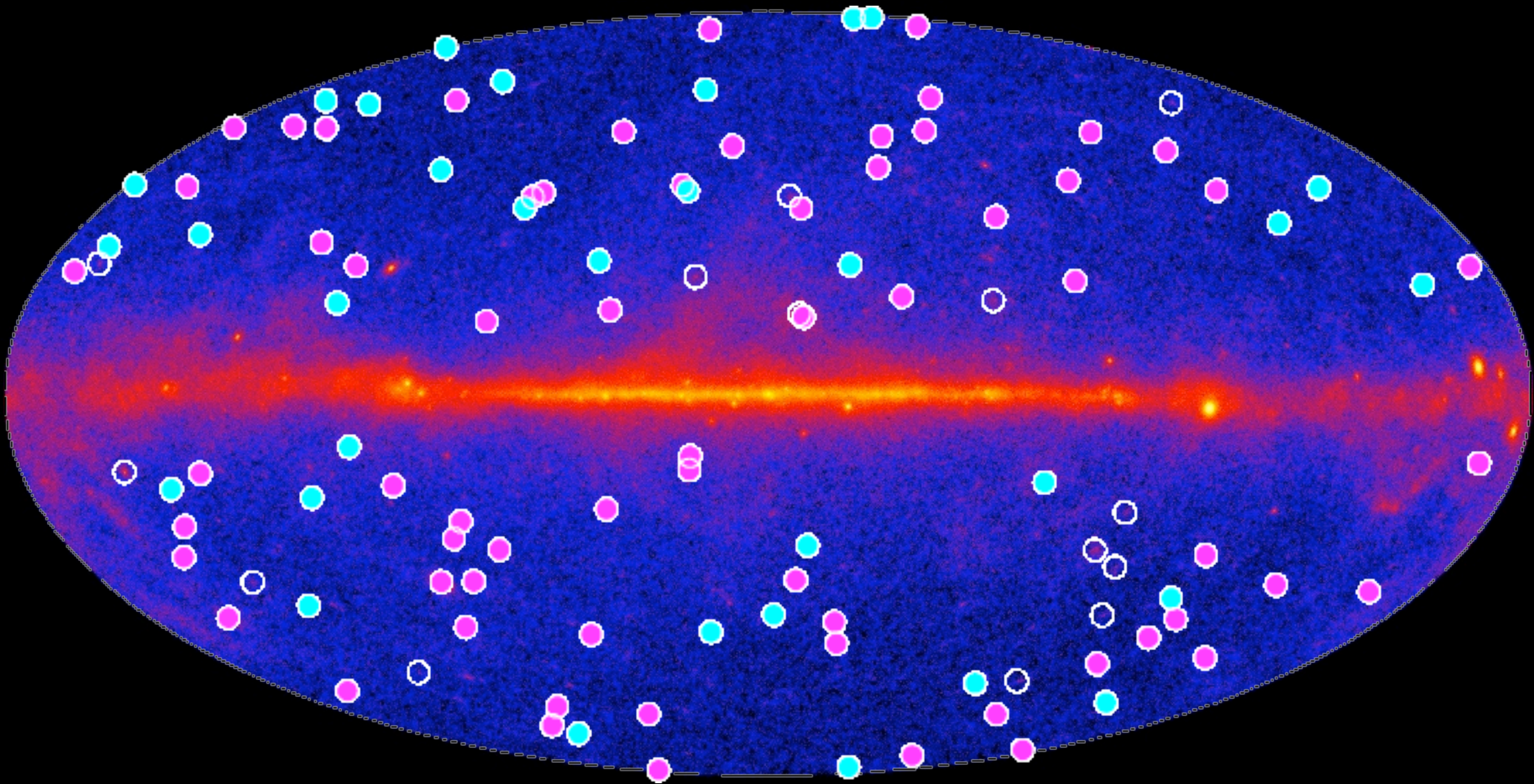


The LAT Sky, August – October



FSRQ

The LAT Sky, August – October

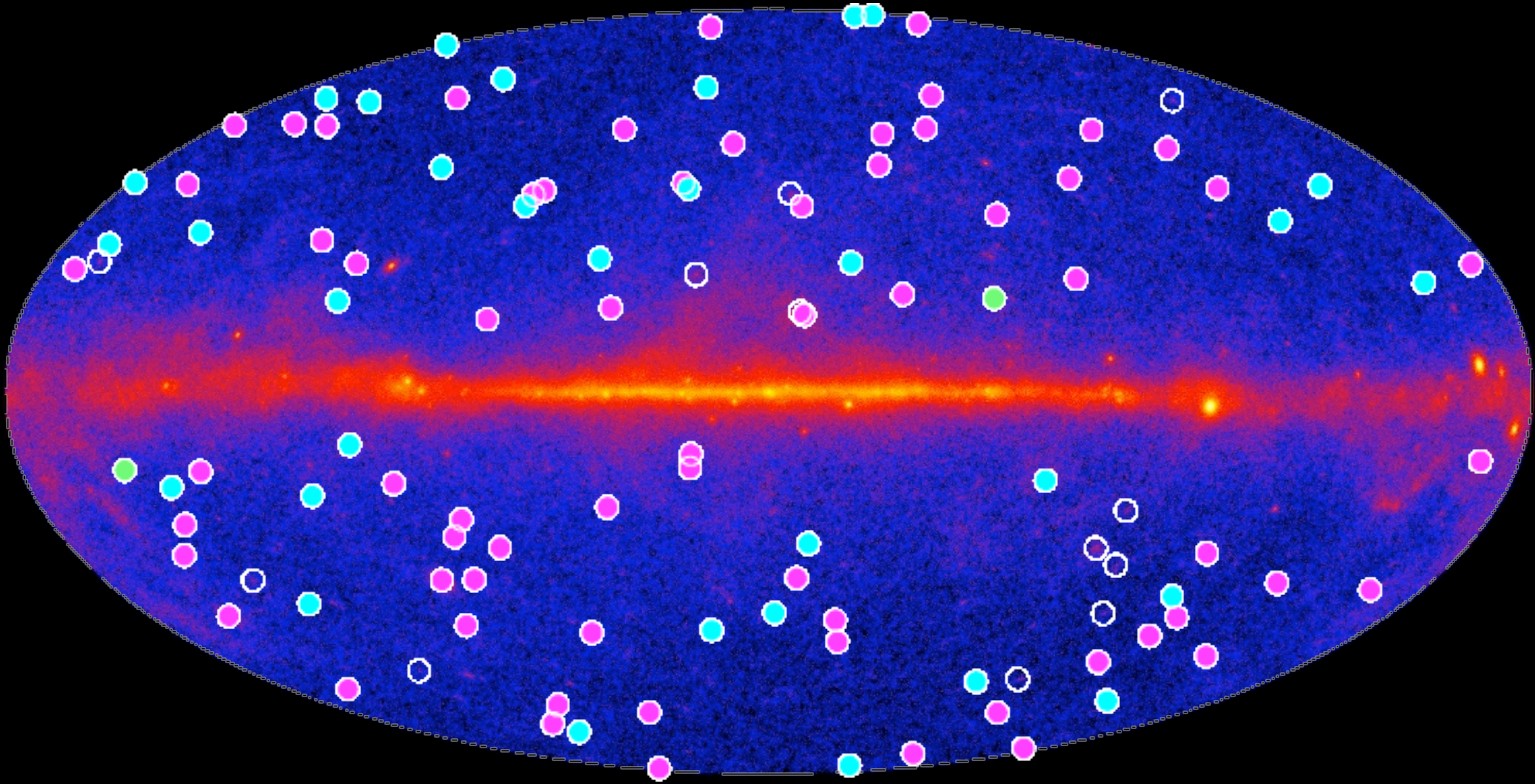


FSRQ

BL Lac

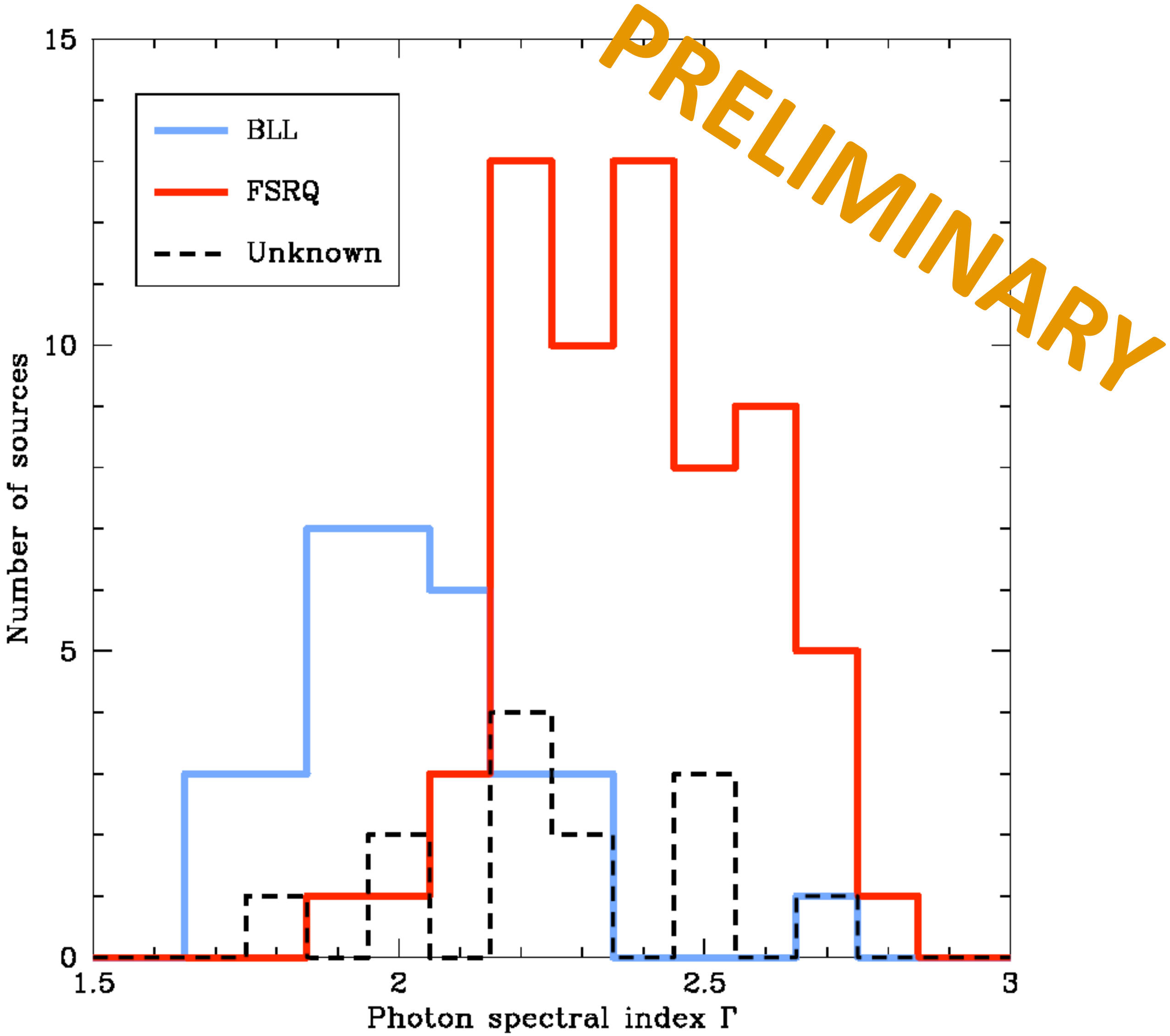
Claudia Cecchi

The LAT Sky, August – October

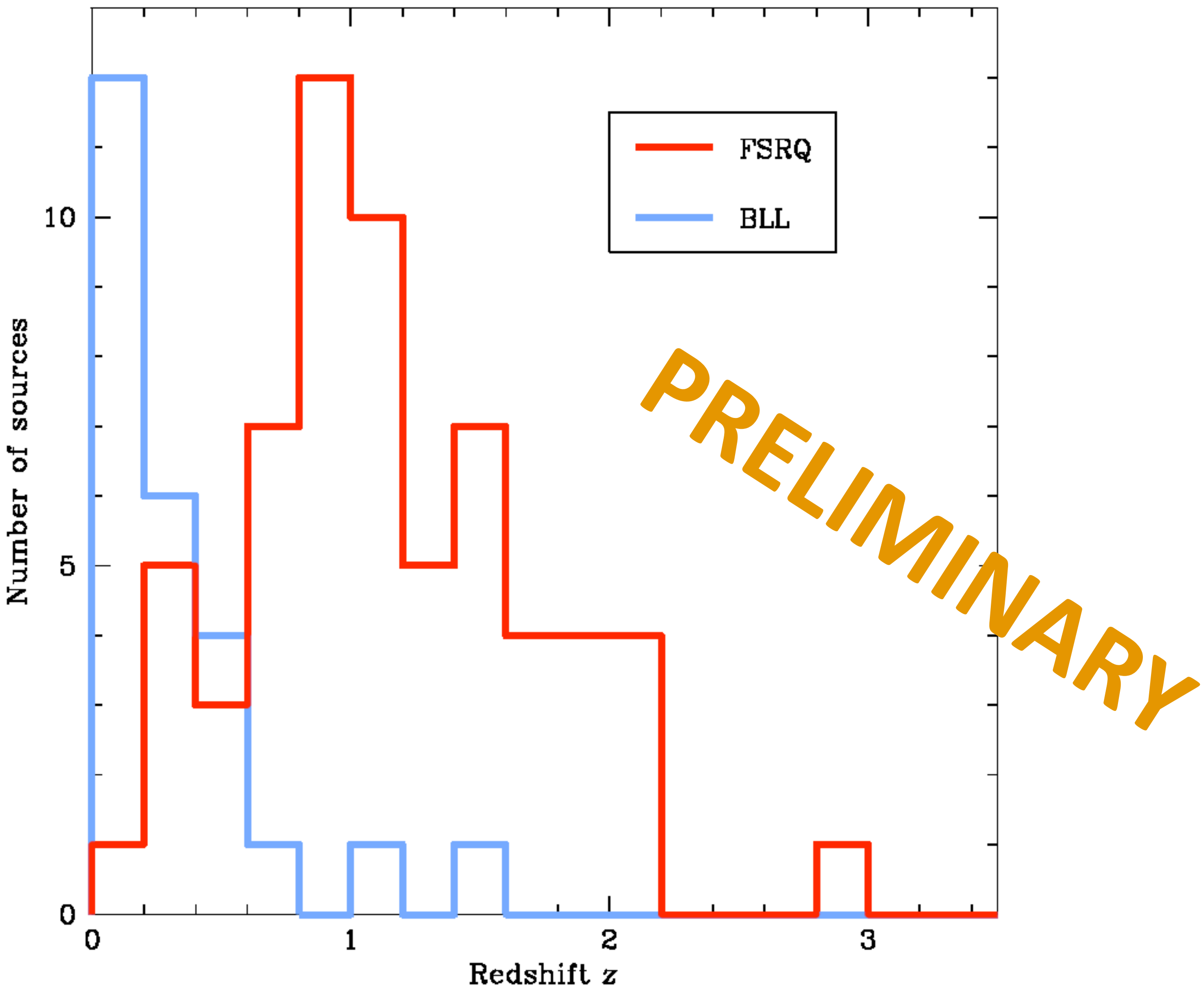


FSRQ BL Lac Other AGN

Spectral Index distribution



Redshift distribution



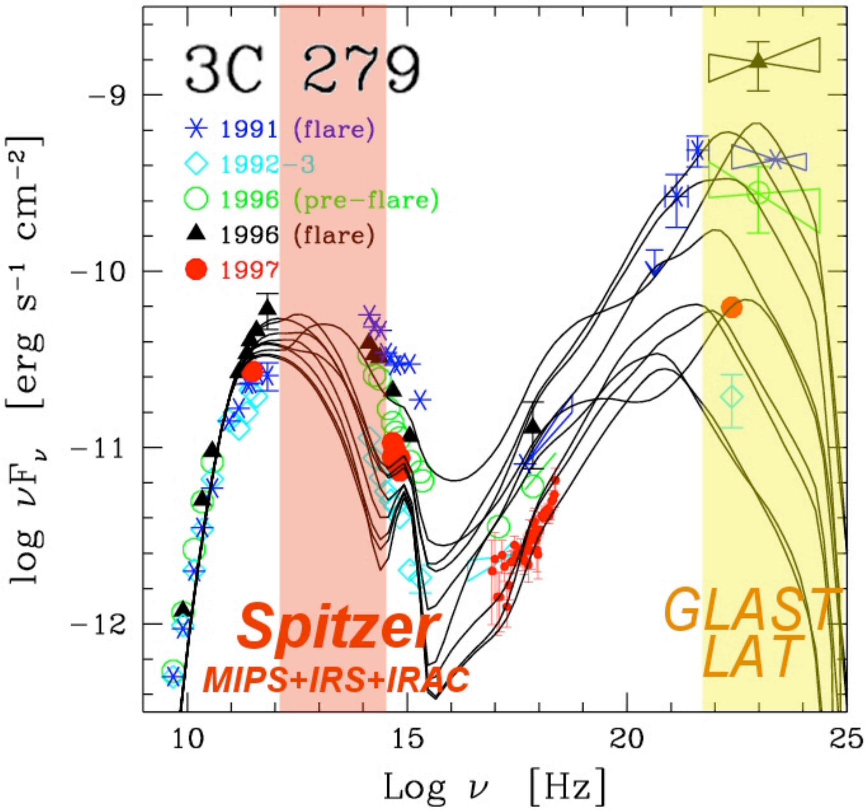
Flaring and variability of Gamma-Ray Blazars

In survey mode, the LAT would detect a flaring source from any point in the sky at any time.

Detailed studies require many photons, are only possible for flaring sources.

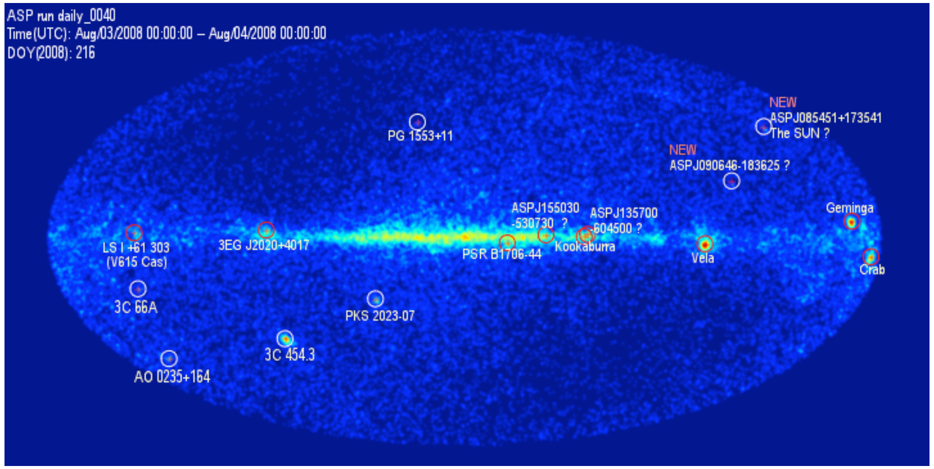
Correlated variability across different bands is tell-taling, providing rich information on:
- acceleration/cooling
- emission processes (EC/SSC)

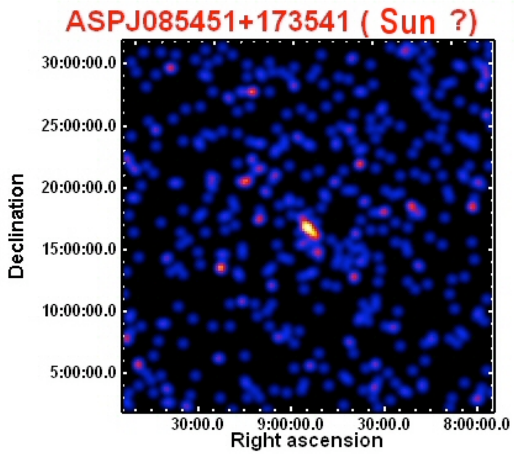
Target-of-opportunity proposals have been submitted (Chandra, Suzaku, Spitzer, RXTE, Swift…).



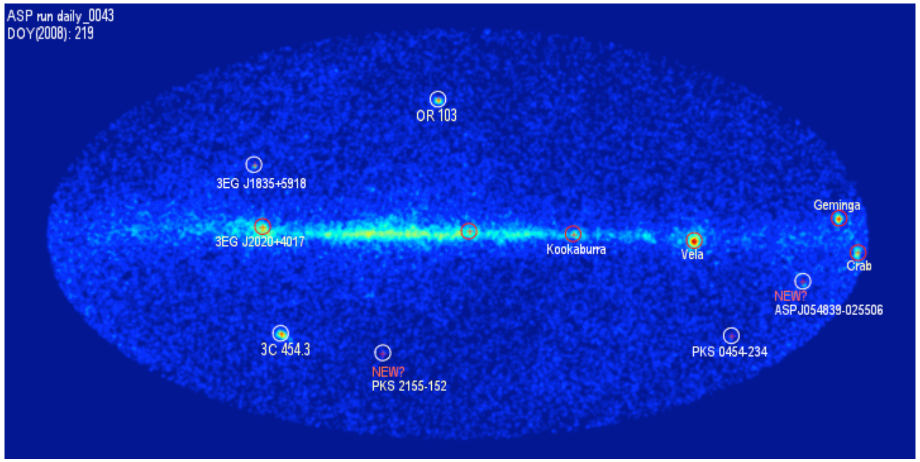
The very first week: Aug 3 – Aug 10

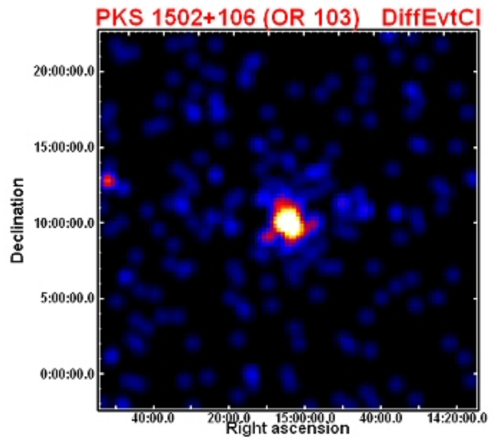
Aug. 03. 2008 : First day: a possible discovery (detection of quiet-Sun on daily basis ?)





Aug. 06. 2008 : a new gamma-ray emitting and flaring blazar (PKS 1502+106, (OR 103)).

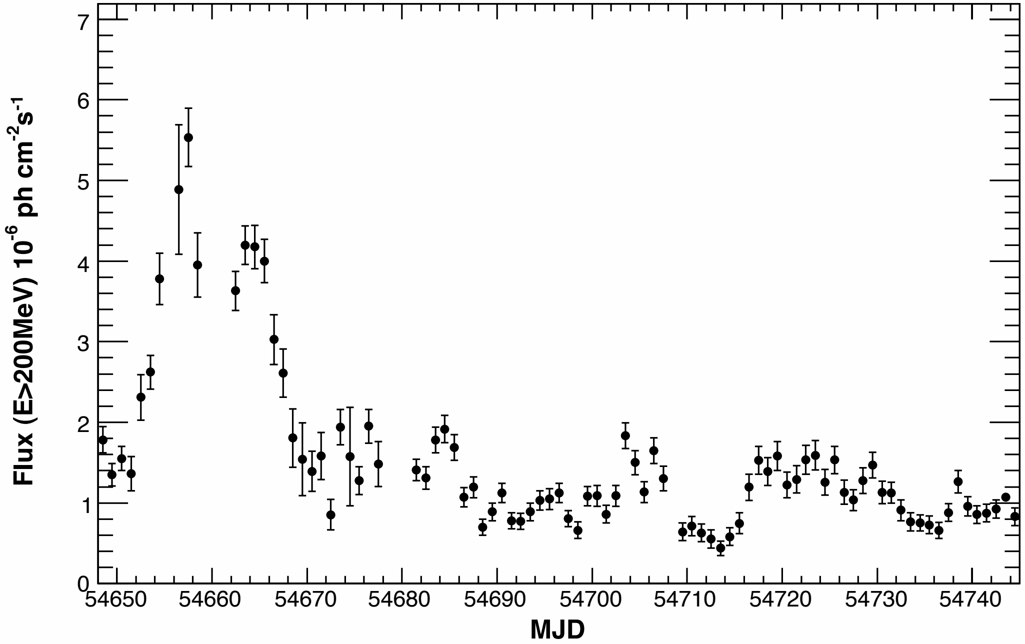


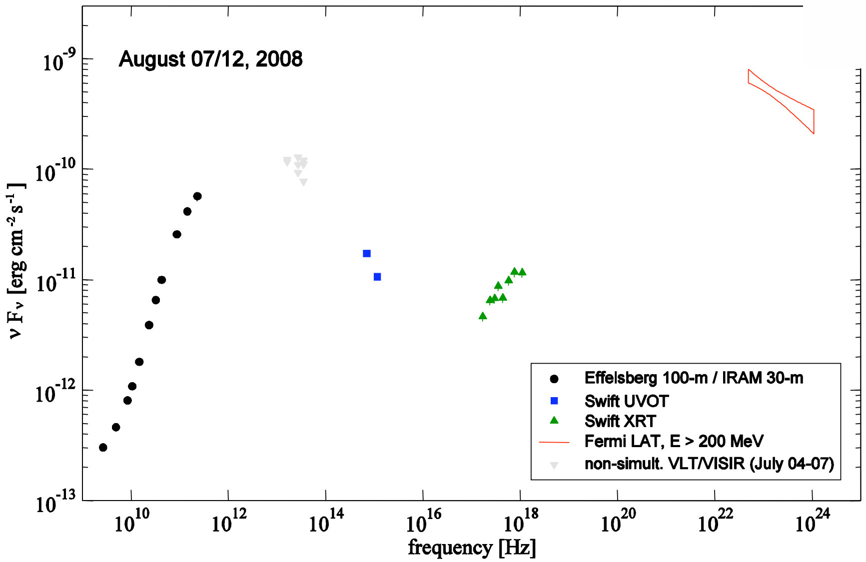


3C454.3 with LAT

Vital statistics:

* Well-known radio source,
identified with an OVV quasar at z = 0.859
* Good VLBI data, superluminal
expansion, d = 25, G_{jet} ~15, q ~ 0.8°
* Detected by EGRET, AGILE
* Very active (bright, rapidly variable) since 2000





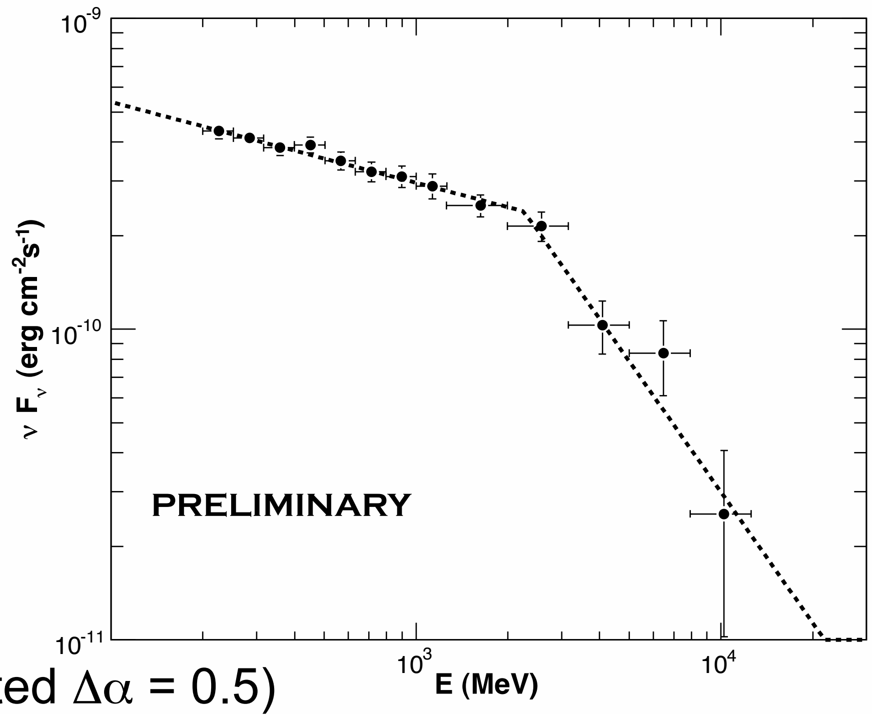
•3C454,3 has been clearly detected in the early Fermi LAT data, and showed rapid flares, with the risetime on a scale of ~3 days

•Such rapid variability by itself implies a very compact emission region which would be optically thick to the escape of γ-rays via e+/e- pair production

•Problem is avoided via invoking relativistic motion with Doppler factor d > 6 – consistent with the VLBI-measured jet geometry

3C454.3 with LAT

* The quality of Fermi LAT data is good enough to measure departures from simple spectral forms: 3C454.3 LAT spectrum is not a simple power law
* It steepens to higher energy – can be described as a broken power law with a break, Γ_1 ~ 2.3 to Γ_2~3.5 at E_{br} ~ 2 GeV
* Broken power law isn't unique description

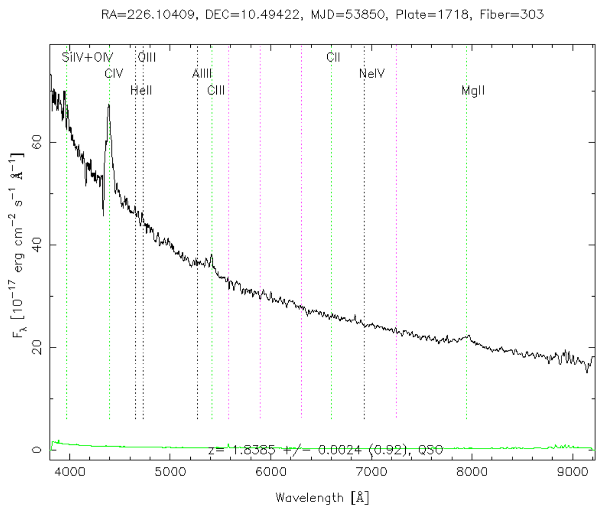


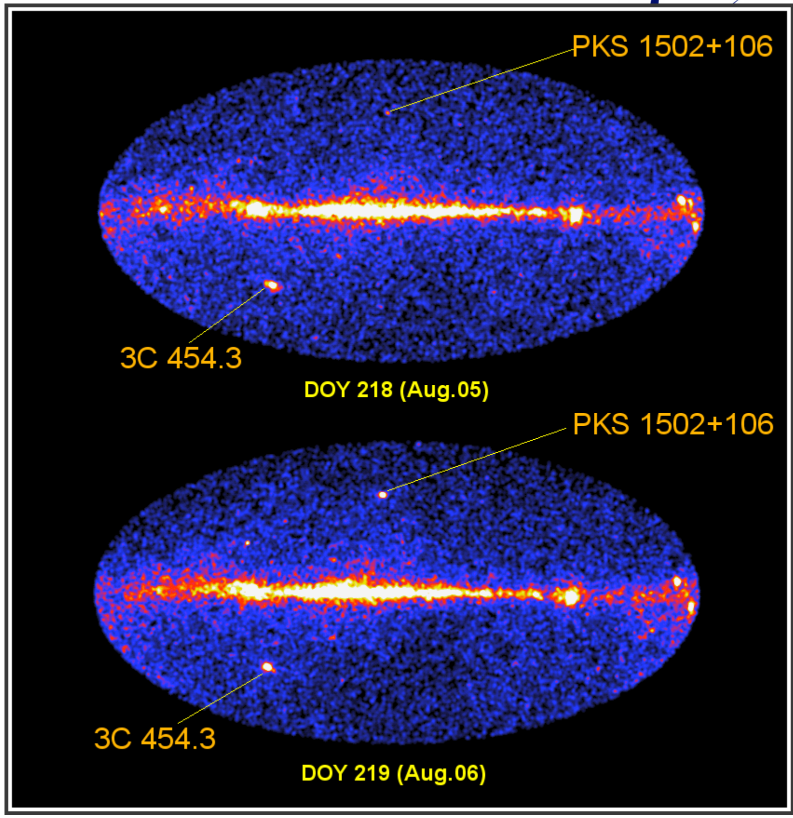
- **Origin of the break?**

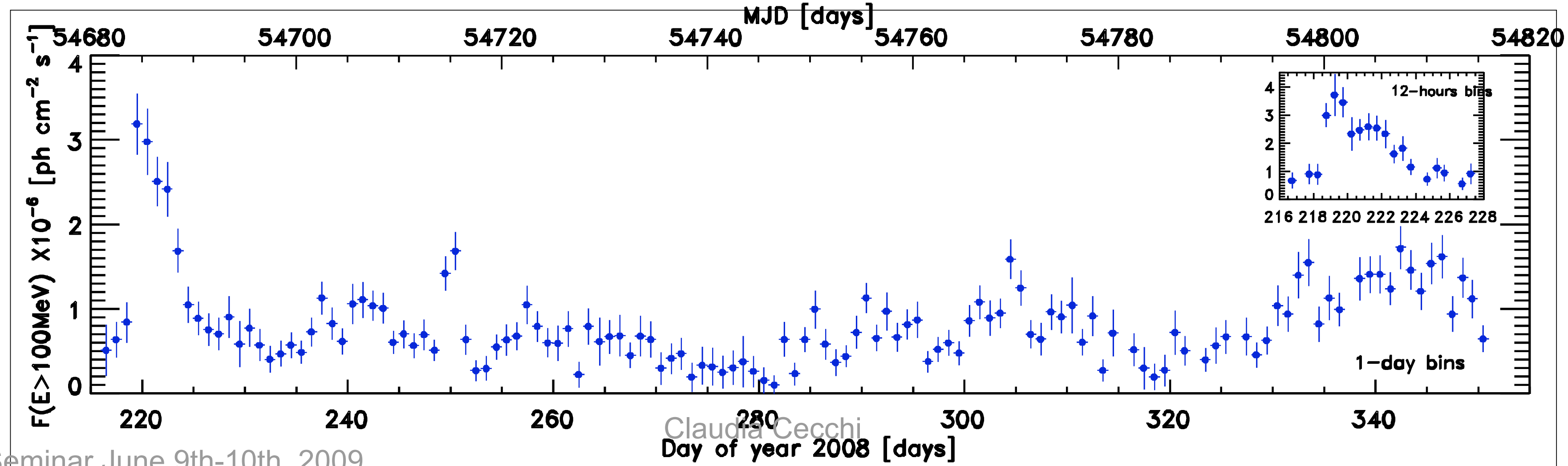
- It is not a simple "cooling break" (expected $\Delta\alpha$ = 0.5)
- Instead, it can be either due to absorption on "local photons" due to the accretion disk, or a signature of intrinsic break in the electron distribution
- First explanation is possible but, given the X-ray emission from the accretion disk – somewhat unlikely
- **Broken power law of the electron distribution is a better explanation: that would indicate the break at γ_{br} ~ 1000**
- There, the cooling time scales are quite short, much shorter than the source crossing time, and imply distributed acceleration throughout the jet volume

PKS 1502+106

- Another example: PKS 1502+106 (aka OR 103), at z=1.84 (SDSS)
- Extremely rapid flare, possibly the highest ΔL/Δt detected to date in the GeV band (see insert in the light curve)
- Allows us to provide the independent measure of the Doppler factor

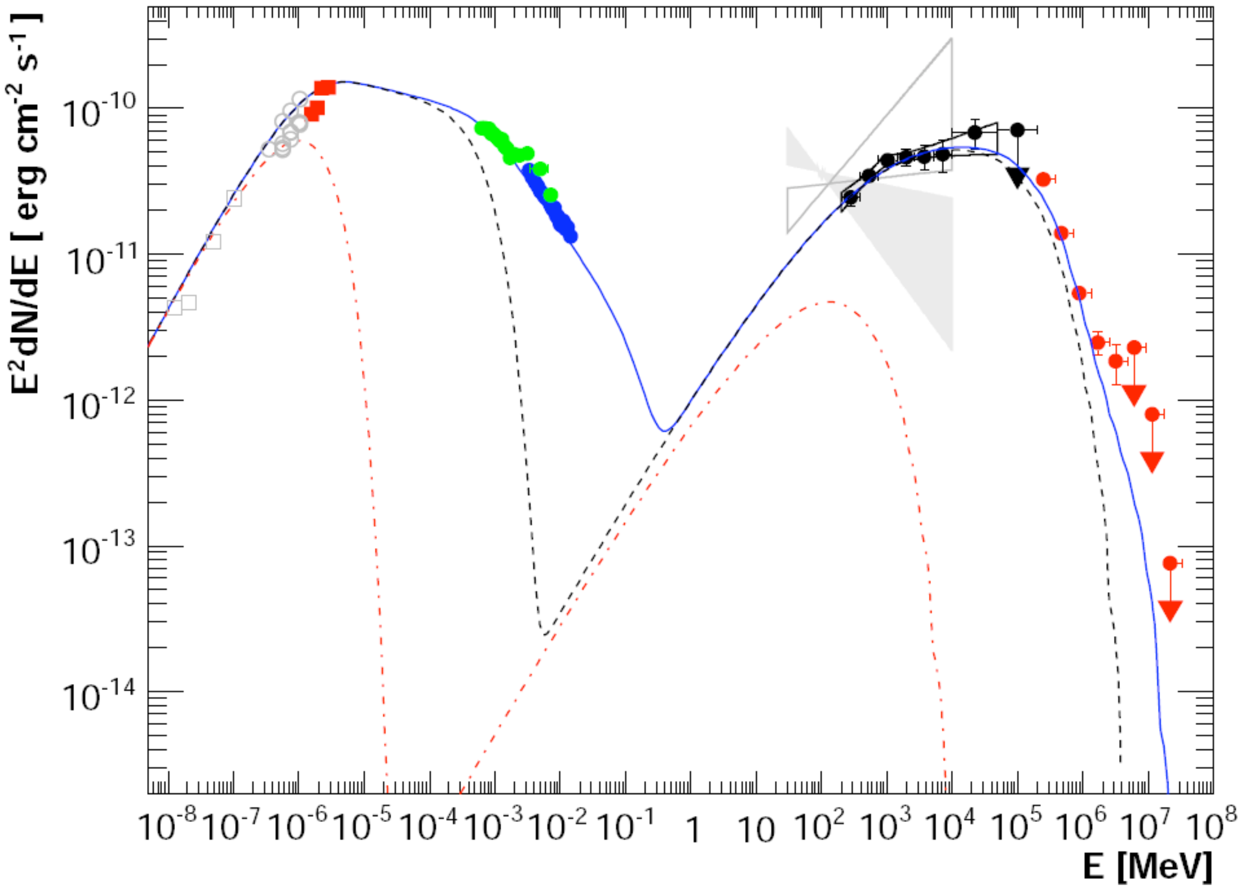






GeV-TeV connection: PKS 2155+304
Spectral

- VHE: ~0.2 Crab, $\Gamma_{int} \approx 2.5$
- HE: Γ_L=1.61±0.16, Γ_h=1.96±0.08, E_b=1.0±0.3 GeV
- X-ray: Γ_L=2.36±0.01, Γ_h=2.67±0.01, E_b=4.4±0.5 keV
- SSC Model parameters (3-component power-law):
  - p_0=1.3, p_1=3.2, p_2=4.3 where $dn/d\varepsilon \propto \varepsilon^{-p}$
  - break energies: ε_1=7.4GeV, ε_2=120GeV
  - R=1.5×10^{17}cm, δ=32, B=0.02G



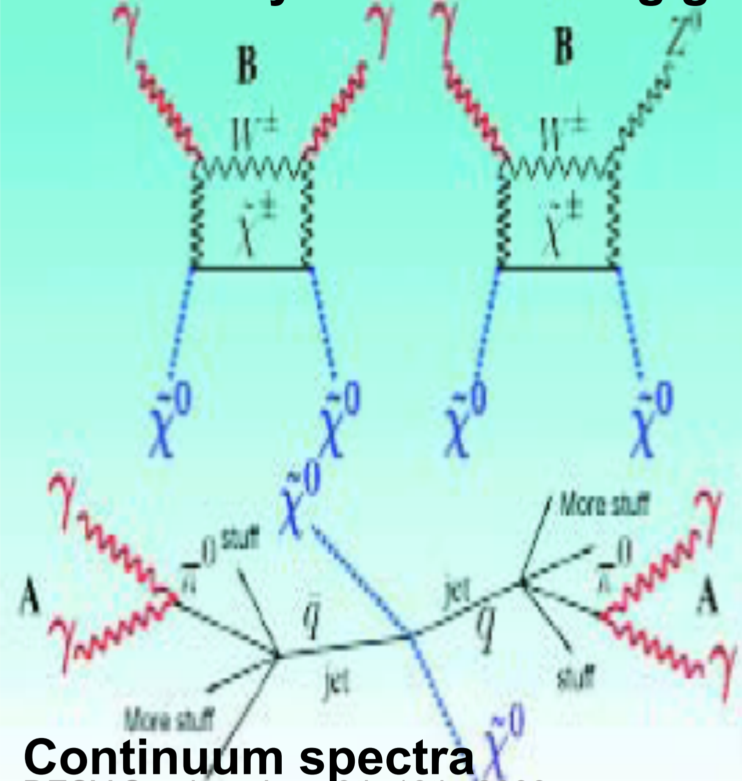
- X-rays are produced by highest energy electrons, $\varepsilon > \varepsilon_2$
- HE and VHE are produced by electrons with $\varepsilon_1 < \varepsilon < \varepsilon_2$

⇒ X-rays can vary (mostly) independently of VHE emission (cf. July 2006 flare)

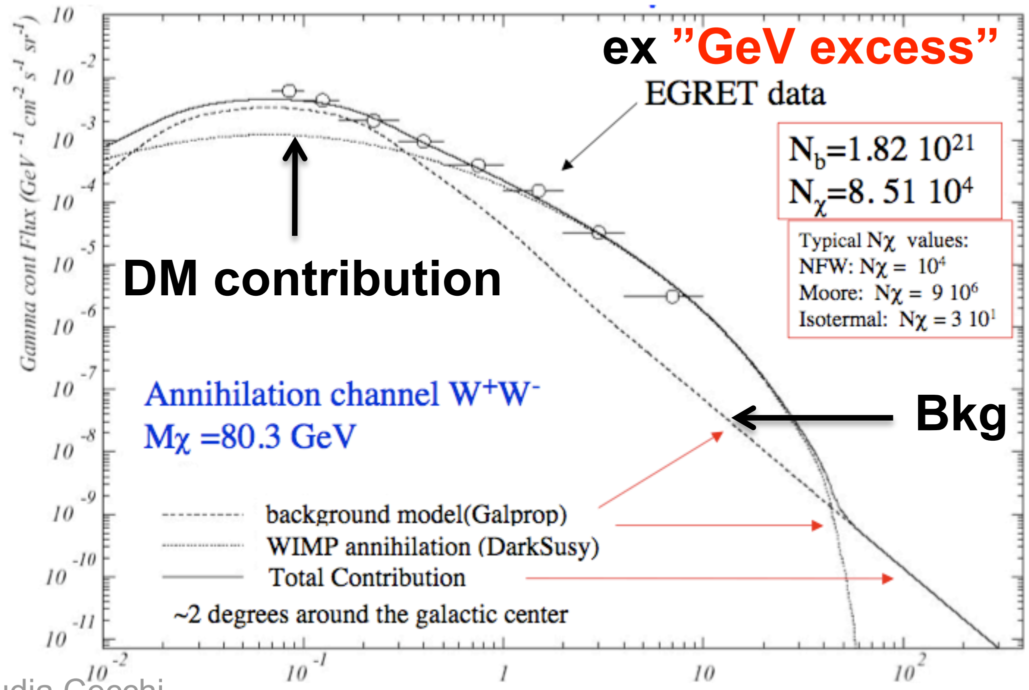
Dark matter searches with Fermi

$$\frac{d\Phi_\gamma}{dE_\gamma} = \frac{1}{4\pi} \underbrace{\frac{\langle\sigma v\rangle}{2m_\chi^2} \sum_f \frac{dn_\gamma^f}{dE_\gamma} B_f}_{Particle\ Physics} \underbrace{\int_{\Delta\Omega} \int_{l.o.s} \rho^2(l)\ dl(\psi)\ d\Omega}_{Astrophysics\ J(\Delta\Omega)}$$

Gamma-ray lines "smoking gun" signal, but loop suppressed

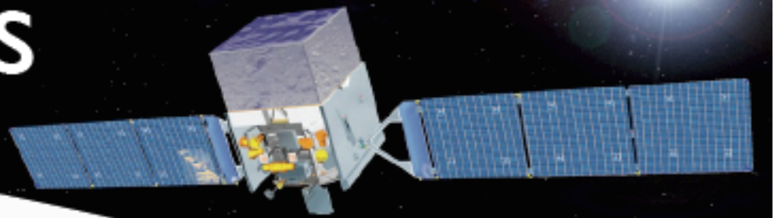


Continuum spectra



How Fermi can help to disentangle the Dark Matter Puzzle?

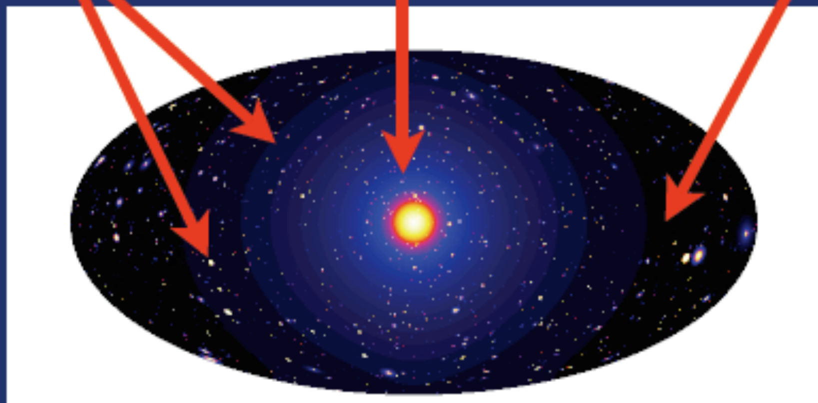
Search Strategies



Galactic center:
Good Statistics but source confusion/diffuse background

Satellites:
Low background and good source id, but low statistics, astrophysical background

Milky Way halo:
Large statistics but diffuse background



All-sky map of DM gamma ray emission (Baltz 2006)

Spectral lines:
No astrophysical uncertainties, good source id, but low statistics

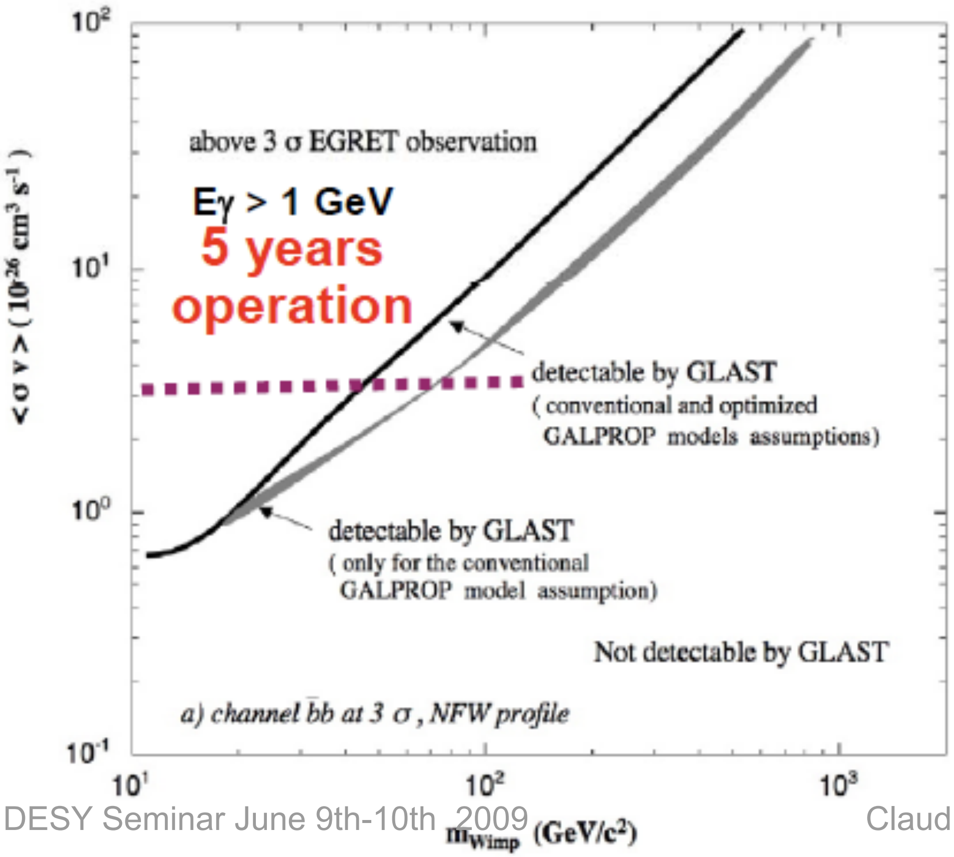
Extra-galactic:
Large statistics, but astrophysics, galactic diffuse background

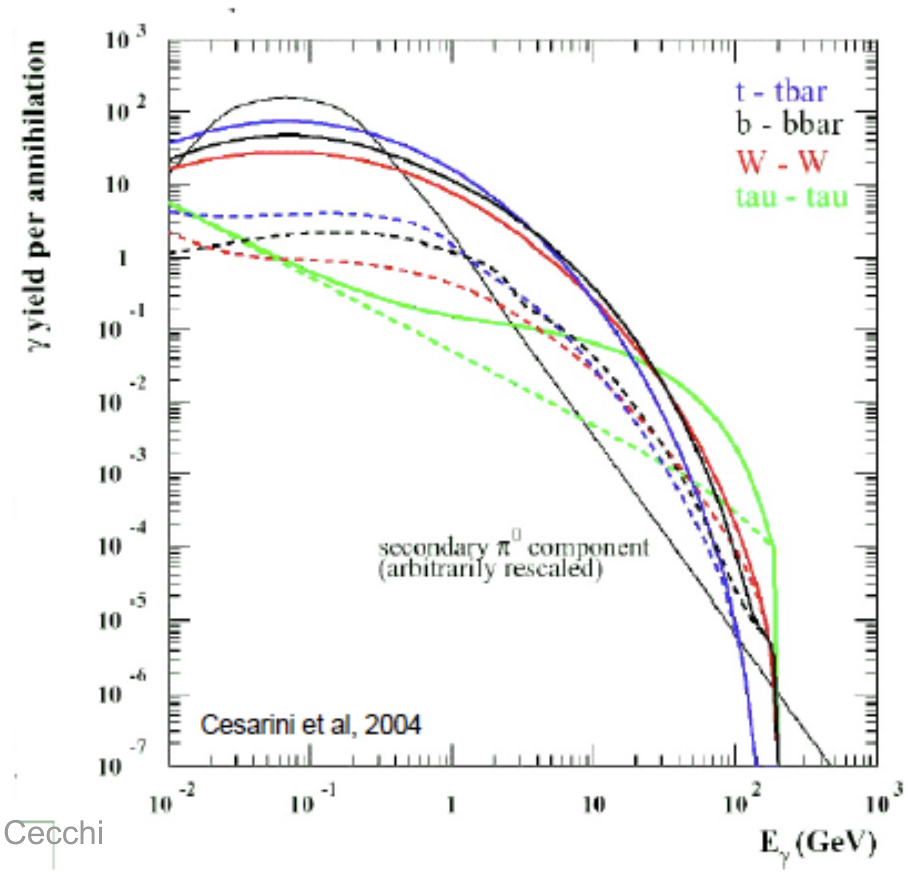
➡ Uncertainties in the underlying particle physics model and DM distribution affect all analyses

Pre-launch sensitivities published in Baltz et al., 2008, JCAP 0807:013 [astro-ph/0806.2911]

Sensitivity Map for GC with Fermi

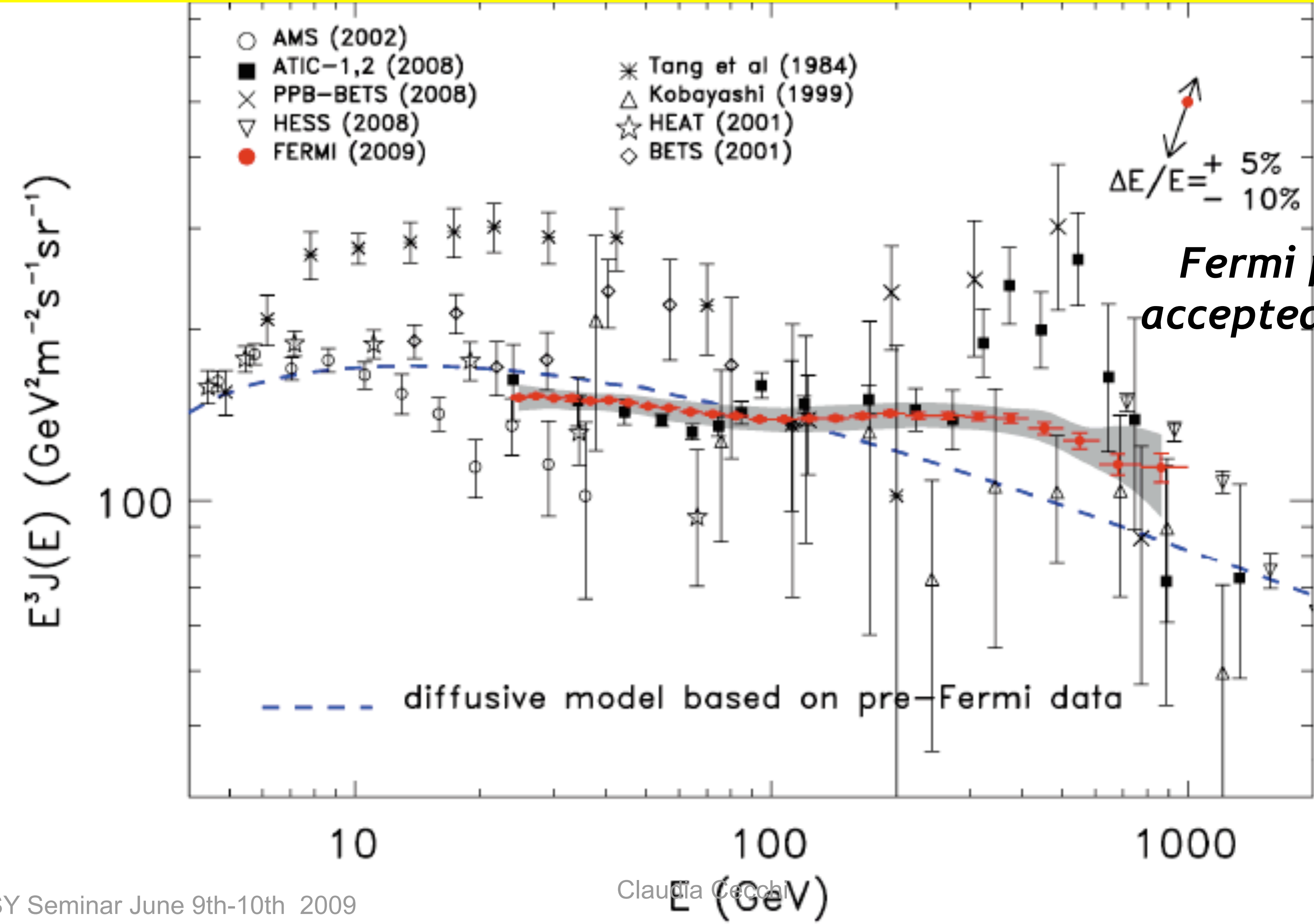
- Select a region of 0.5deg around the GC, assume NFW profile and consider one WIMP annihilation channel at the time.
- <u>Remove astrophysical sources</u> (based on spectral analysis, multiwavelength observations. Difficult, their behaviour at these energies needs to be determined) in the region and perform χ^2 test to disentangle dark matter contribution from diffuse background.





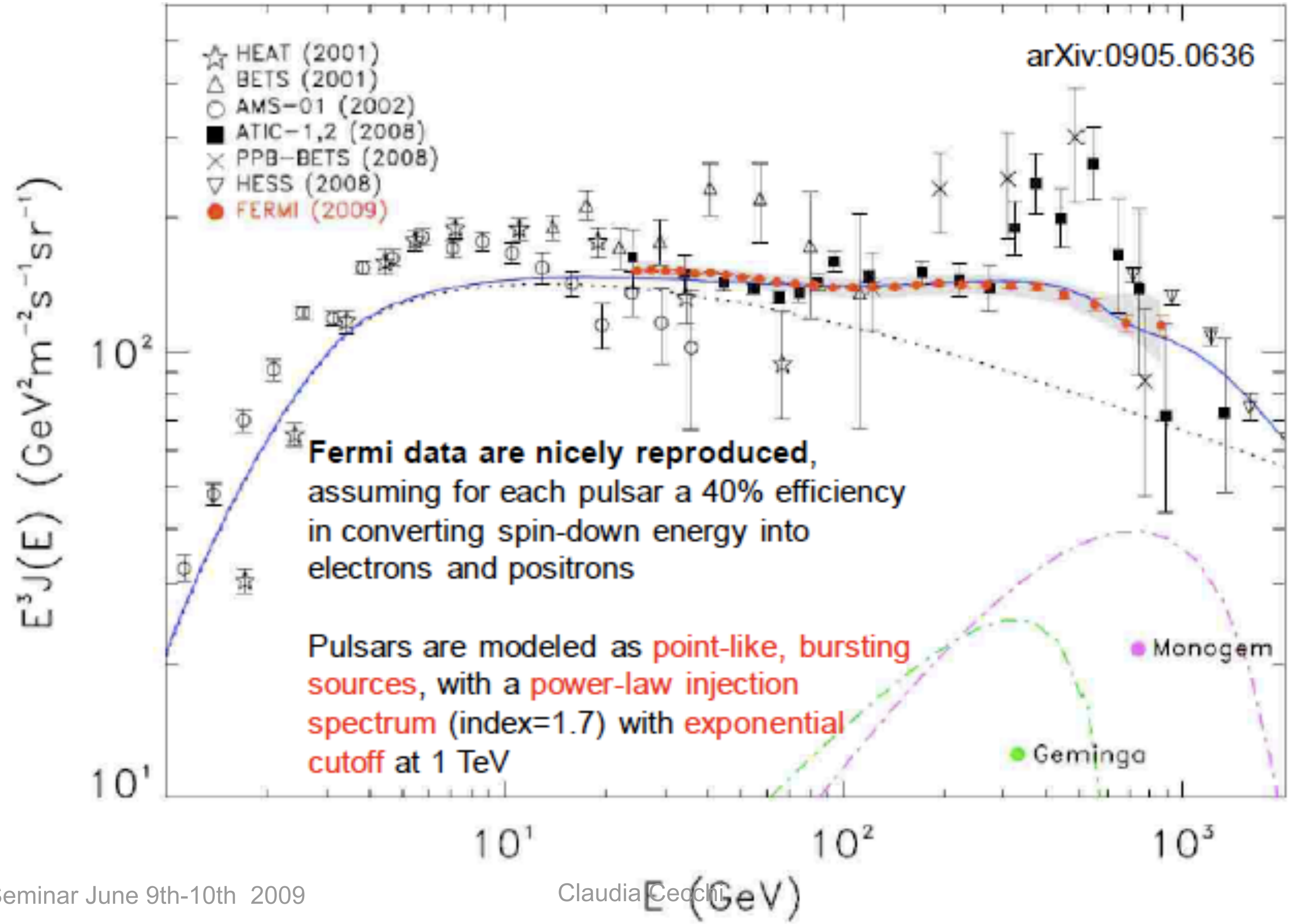
Electron + Positron flux

Fermi covers electron energy measurement 20GeV – 1000 GeV



Fermi paper accepted to PRL

Adding candidate pulsars within 1Kpc



Fermi data are nicely reproduced, assuming for each pulsar a 40% efficiency in converting spin-down energy into electrons and positrons

Pulsars are modeled as point-like, bursting sources, with a power-law injection spectrum (index=1.7) with exponential cutoff at 1 TeV

Conclusions

Fermi telescope is off to a great start!

Instruments are working very well, gamma ray sky is showing itself in its beautiful composition

Already addressing many important questions from EGRET era:

- **EGRET GeV excess excluded**
- **Many variable sources discovered**
- **Many pulsars discovered**
- **Challenge of great discovery potential**

November 2-5 2009 Second Fermi Symposium in Washington DC

Gamma-ray data are very fascinating join the fun!