



Fermi

Gamma-ray Space Telescope



Fermi-LAT status and results

Silvia Rainò

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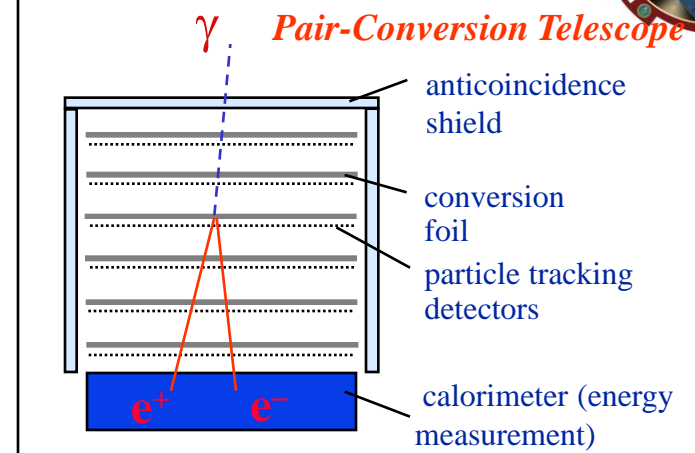
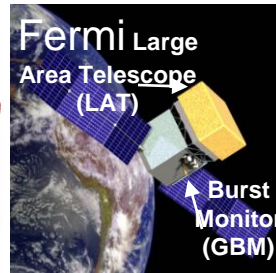
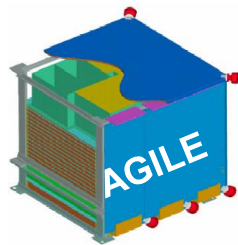
silvia.raino@ba.infn.it

On behalf of the
Fermi-LAT Collaboration



Space based

Use pair conversion technique



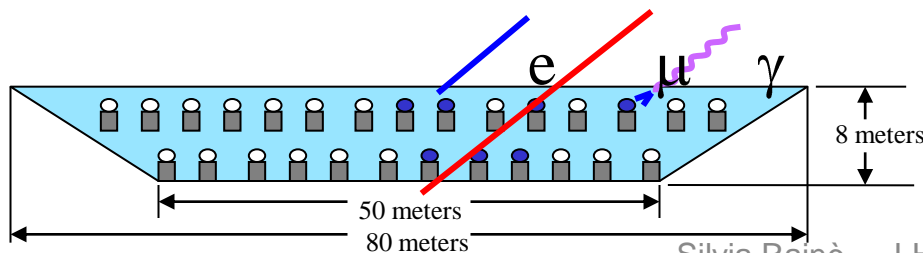
Ground based

Atmospheric Cerenkov Telescopes (ACTs)



Image the Cerenkov light from showers induced in the atmosphere.
Examples: VERITAS, MAGIC, HESS; CTA

Extensive Air Shower Arrays (EAS)



Directly detect particles from the showers induced in the atmosphere.
Examples: Milagro, HAWC

An overview of Fermi



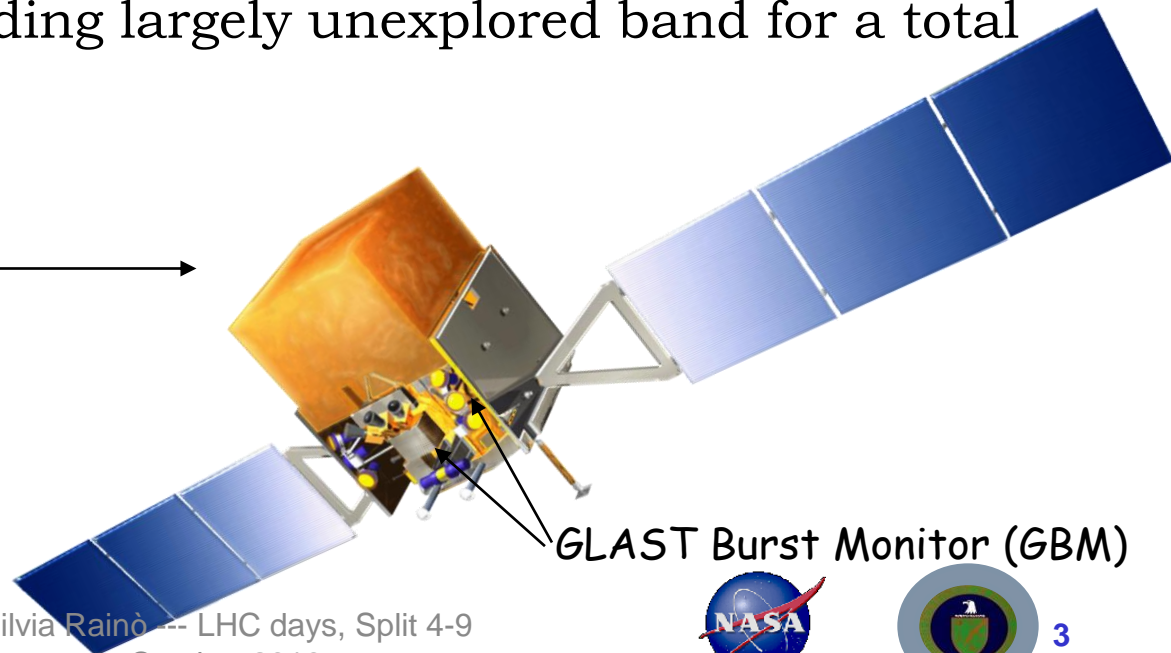
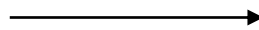
The Fermi Gamma-Ray Space Telescope is an International Science Mission exploring the gamma-ray sky by means of its two main instruments:

–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!

Large Area Telescope (LAT)



GLAST Burst Monitor (GBM)



Silvia Rainò --- LHC days, Split 4-9
October 2010





Large Area Telescope (LAT)

KEY FEATURES

- 20 MeV -> >300 GeV
- 2.4 Steradian field of view
- Operated in scanning mode, so views the entire sky every 3 hours.
- Peak effective area ~8000 cm²
- Single photon angular resolution 0.8° at 1 GeV, better at higher energies.
- Source location capability 1-10 arcmin.
- Energy resolution 10-20%

Gamma-ray Burst Monitor (GBM)
NaI and BGO Detectors
8 keV - 40 MeV

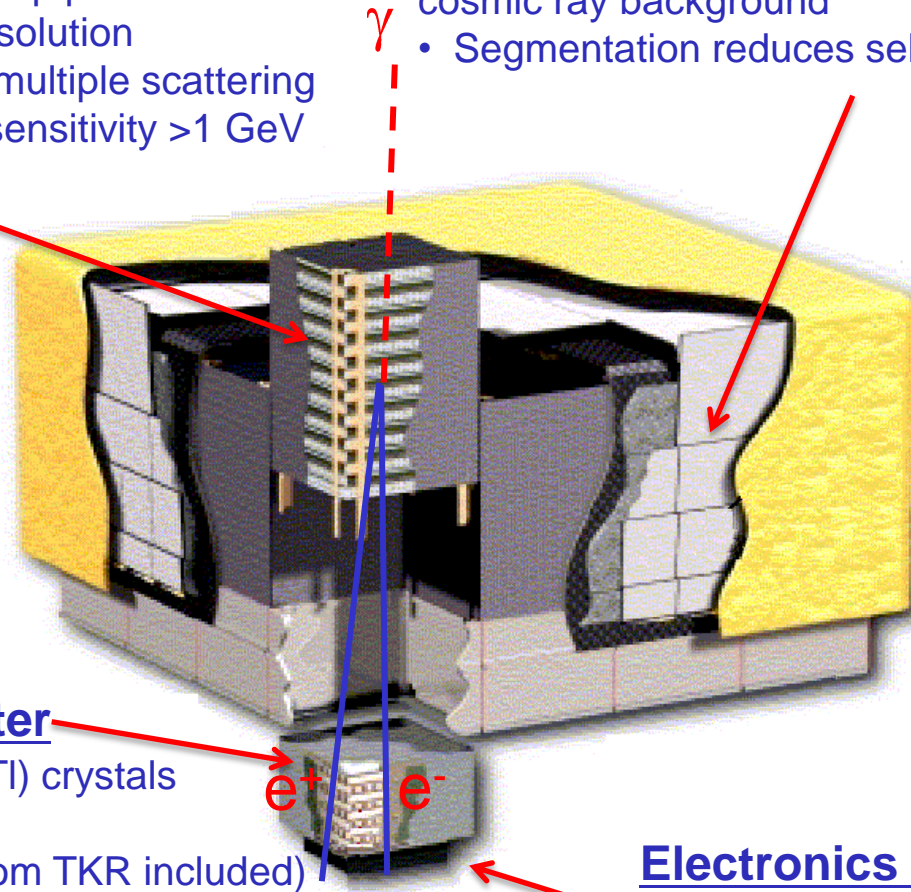


Precision Si-strip Tracker (TKR)

- Measures incident γ -ray direction
- 18 XY tracking planes: 228 μm strip pitch
- High efficiency. Good position resolution
- 12x 0.03 X_0 front end \rightarrow reduce multiple scattering
- 4x0.18 X_0 back-end \rightarrow increase sensitivity >1 GeV

Anticoincidence Detector (ACD)

- 89 scintillator tiles
- First step in the reduction of large charged cosmic ray background
- Segmentation reduces self-veto at high energy



Hodoscopic CsI Calorimeter

- Segmented array of 1536 CsI(Tl) crystals
- 8.6 X_0 : shower max contained
 - ~ 200 GeV normal (1.5 X_0 from TKR included)
 - $\sim 1\text{TeV}$ @ 40 deg (CAL-only)
- Measures the incident γ -ray energy
- Rejects cosmic-ray background

Electronics system

- Includes flexible, highly efficient, multi-level trigger

People who made it happen



- **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)

~400 Scientific Members (including
104 Affiliated Scientists, plus 89
Postdocs and > 100 Students)

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

Project managed at SLAC.

The Accelerator



Silvia Rainò --- LHC days, Split 4-9 October 2010

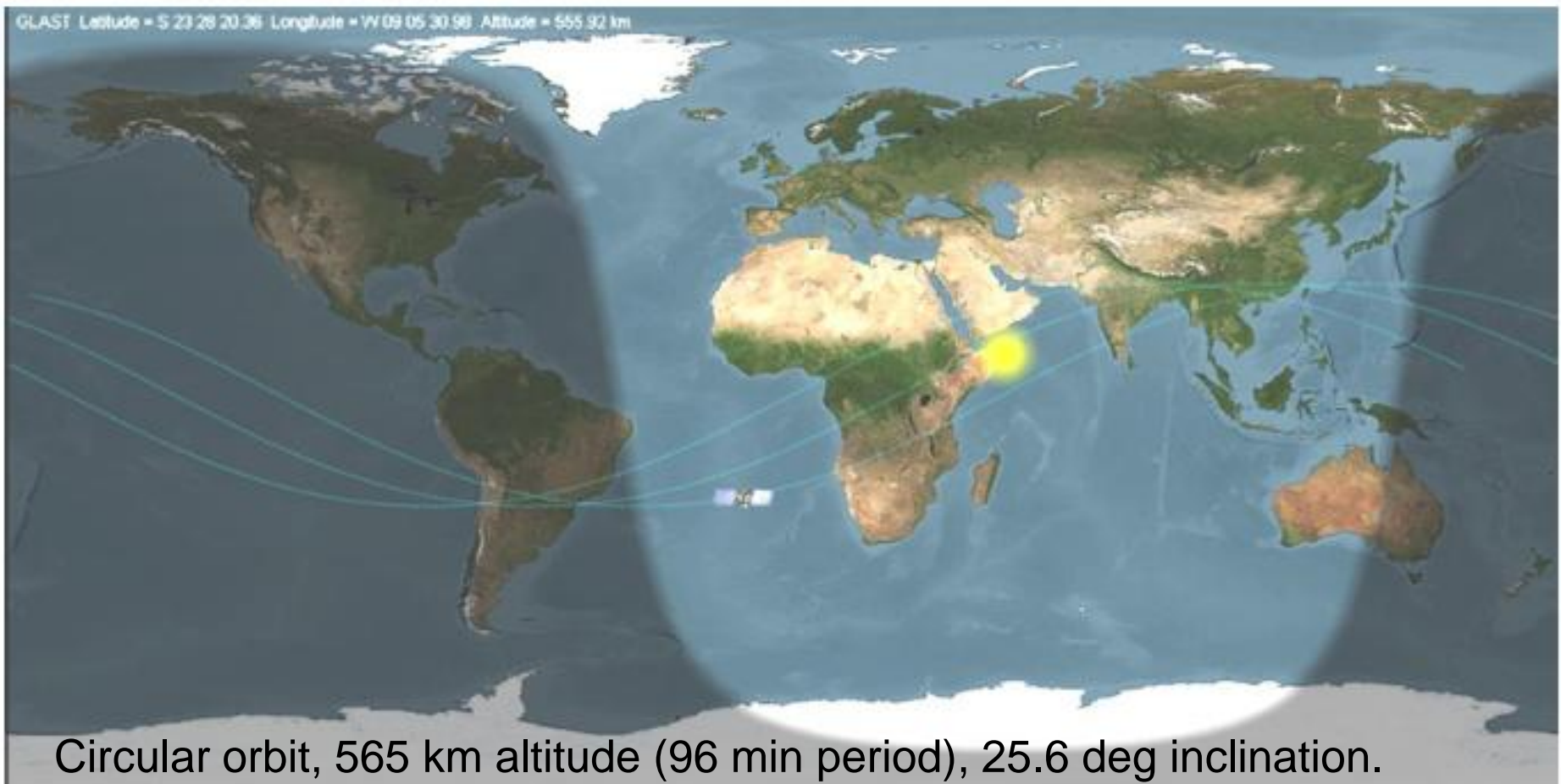


Cape Canaveral Air Station



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October 2010

In orbit



Circular orbit, 565 km altitude (96 min period), 25.6 deg inclination.

9

<http://observatory.tamu.edu:8080/Trakker> (track the satellite: FGRST (GLAST))

http://www.nasa.gov/mission_pages/GLAST/news/glast_online.html (look at

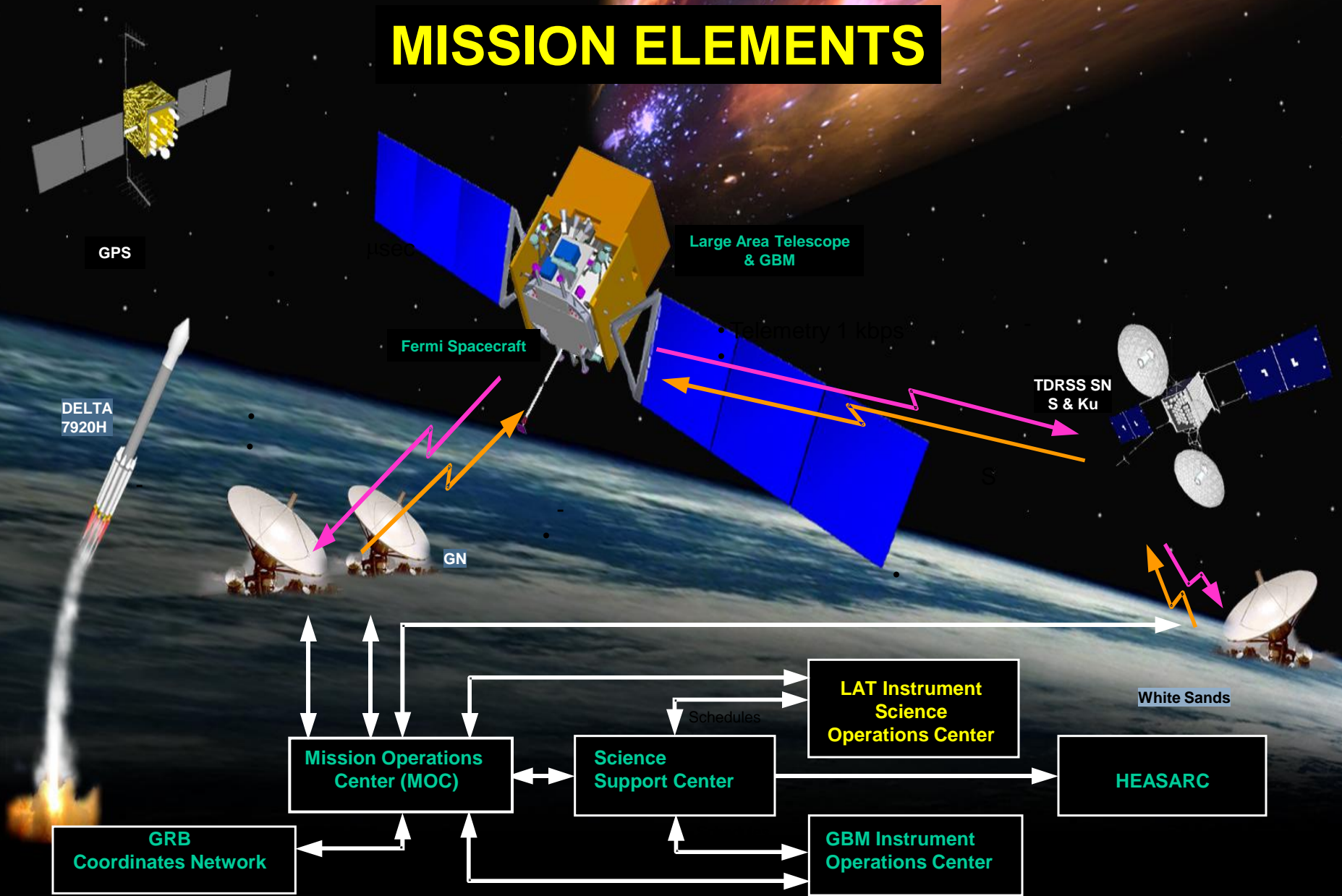
Fermi in the sky from home)



- **24 June 2008** : LAT turn on, beginning of Launch & Early Orbit (L&EO) phase
- **11 August 2008**: Beginning of routine science operations
- **26 August 2008**: Mission name, formerly GLAST, is changed to **Fermi – Gamma-ray Space Telescope**, honoring **Prof. Enrico Fermi (1901 - 1954)**, a pioneer in high-energy physics.
- **25 August 2009**: Fermi γ -ray data become **public**
- **18 February 2010**: 100B triggers (130B in September 2010)
- **99.1 % uptime** from launch
- **99.9 %** from Q₁₀ October 2009

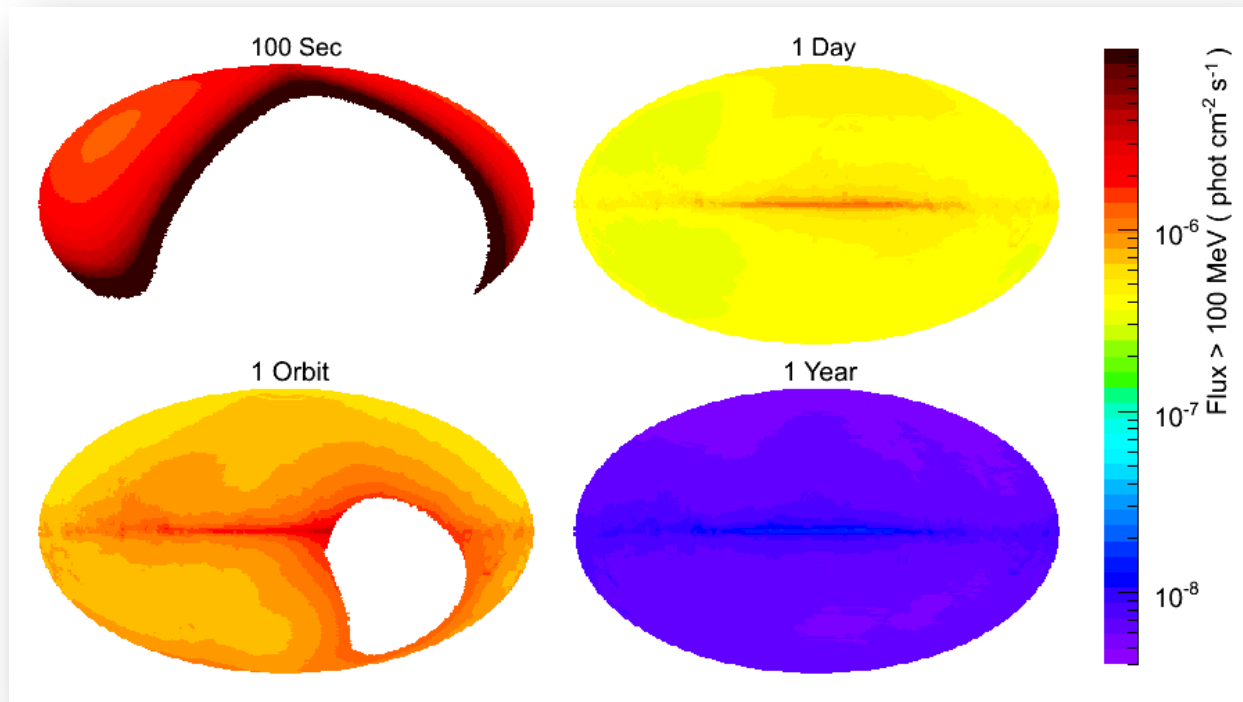


MISSION ELEMENTS





- Primary observing mode is Sky Survey
- Full sky every 2 orbits (3 hours) achieved by rocking the pointing direction by $\pm 50^\circ$ away from the orbital plane on alternate orbits
- Uniform exposure, with each region viewed for ~ 30 min every 2 orbits
- Best serves majority of science, facilitates multi-wavelength observation planning



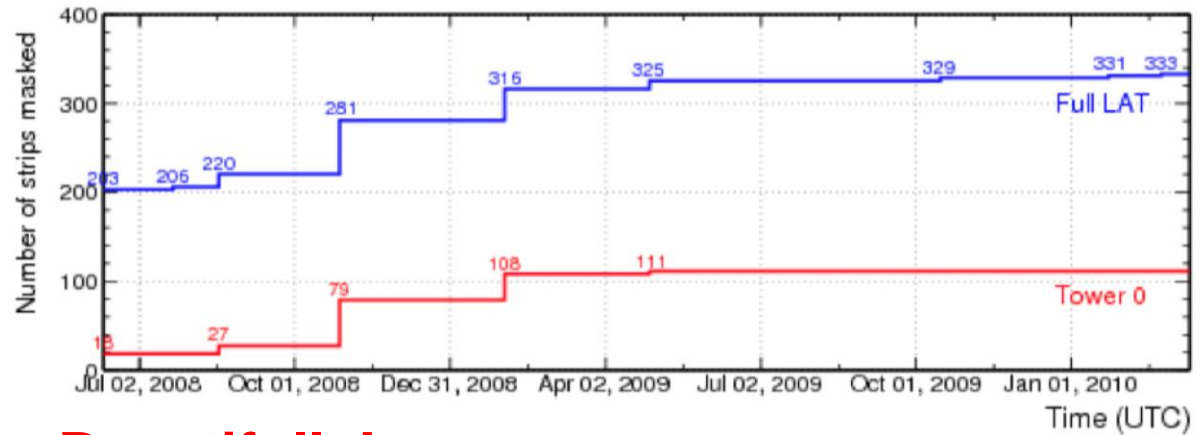
- Pointed observations when appropriate (Target of Opportunity pointing)
- Autonomous re-pointing for onboard GRB detections

Tracker performance



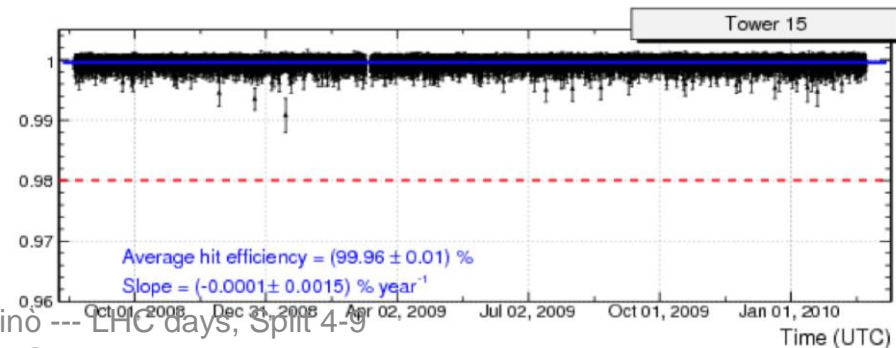
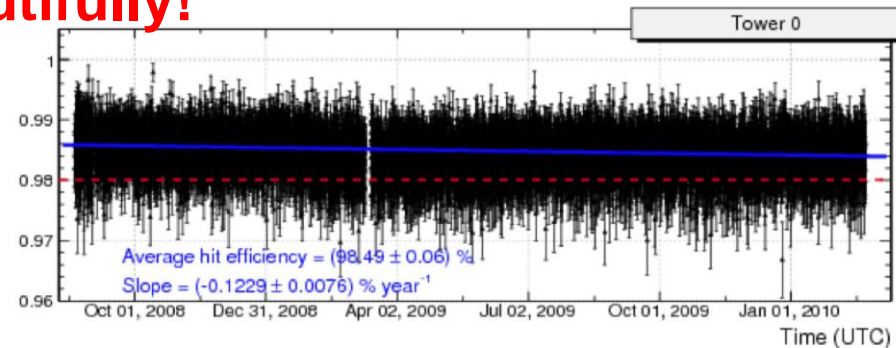
Total number of Silicon
Strip Channels: 884736

% Masked: .038

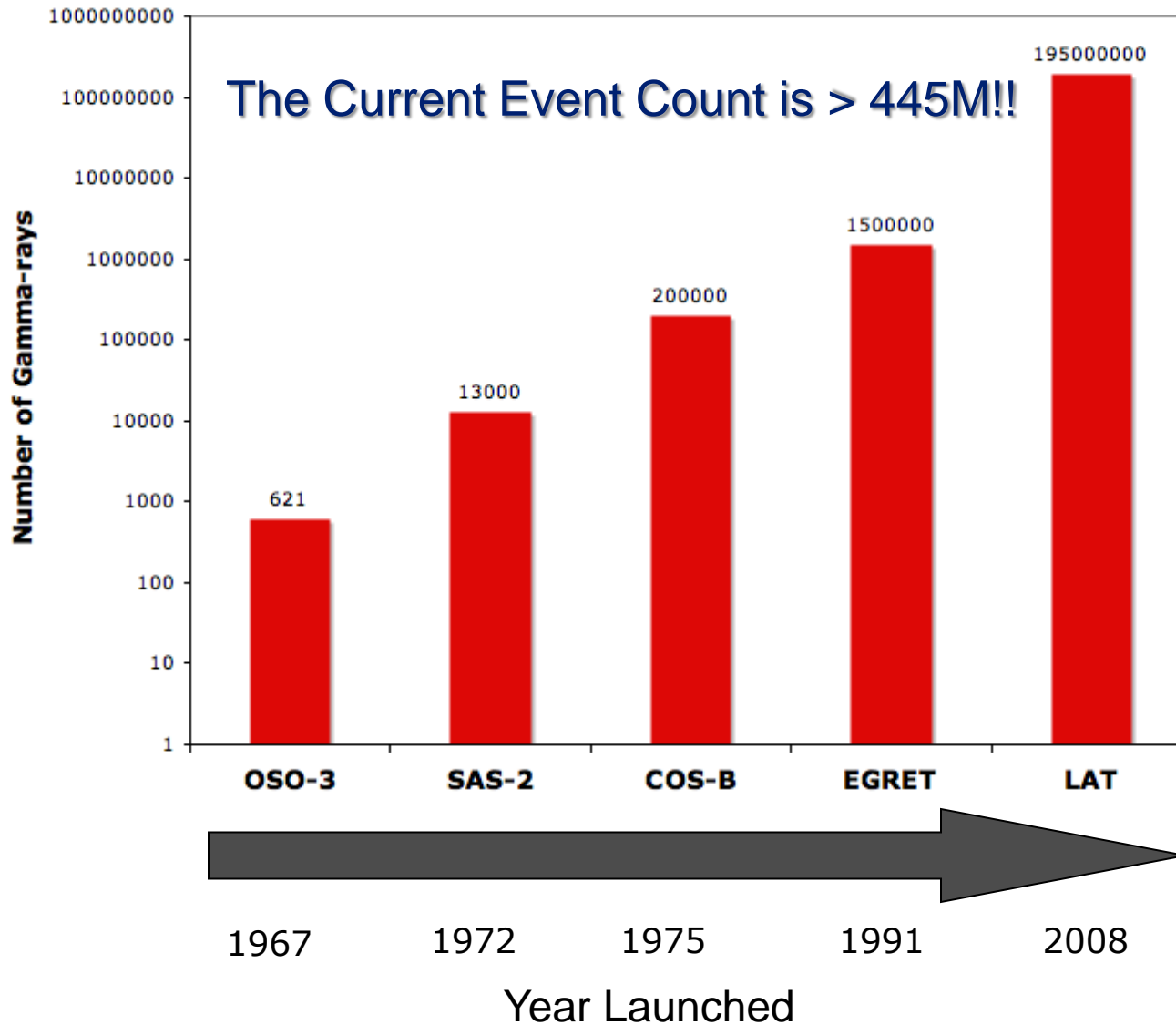


Very Stable; Performing Beautifully!


And.. Degradation with Time
VERY SLOW..



Number of Gammas by Experiment








**GODDARD
SPACE FLIGHT CENTER**

+ NASA Homepage
+ GSFC Homepage
+ Fermi Homepage

SEARCH Fermi:

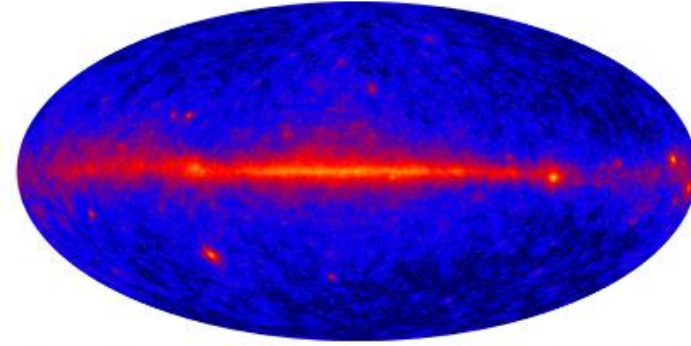
+ GO



Fermi Science Support Center

HOME
OBSERVATIONS
DATA
PROPOSALS
LIBRARY
HEASARC
HELP
SITE MAP

The Fermi Science Support Center (FSSC) runs the guest investigator program, creates and maintains the mission time line, provides analysis tools for the scientific community, and archives and serves the Fermi data. This web site is the portal to Fermi for all guest investigators.



This all-sky view from Fermi reveals bright emission in the plane of the Milky Way (center), bright pulsars and super-massive black holes.
Credit: NASA/DOE/International LAT Team

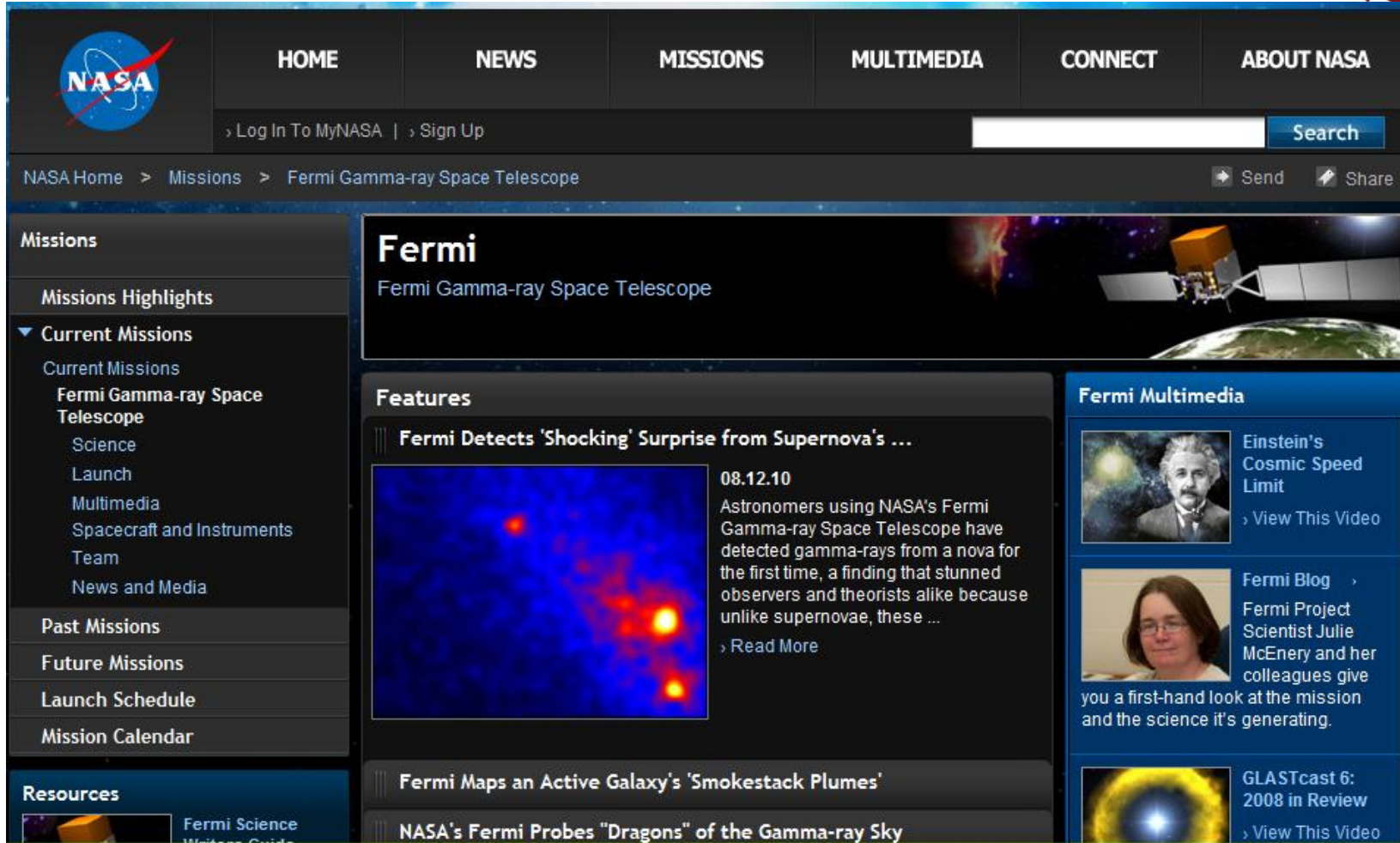
News

Sep 24, 2010
New Python Scripts
New pyLikelihood scripts for generating spectral plots for LAT data using unbinned likelihood, binned likelihood, and binned extended source analysis are now available as user-contributed software. We appreciate user contributions, which continue to increase Fermi Science Tools capabilities.
[+ User contributed software](#)

Sep 8, 2010
New Fermi Science Tools Release

Public data and extensive support for Science Analysis Tools:

<http://fermi.gsfc.nasa.gov/ssc/>



The screenshot shows the Fermi Public Portal website. At the top left is the NASA logo. The main navigation bar includes links for HOME, NEWS, MISSIONS, MULTIMEDIA, CONNECT, and ABOUT NASA. Below this is a search bar and a 'Log In To MyNASA | Sign Up' link. The breadcrumb trail reads 'NASA Home > Missions > Fermi Gamma-ray Space Telescope'. On the left side, there is a 'Missions' sidebar with sub-sections for 'Missions Highlights', 'Current Missions' (with a dropdown arrow), and 'Past Missions'. Under 'Current Missions', there is a list of links: 'Fermi Gamma-ray Space Telescope', 'Science', 'Launch', 'Multimedia', 'Spacecraft and Instruments', 'Team', and 'News and Media'. The main content area features a large header for 'Fermi' with the subtitle 'Fermi Gamma-ray Space Telescope' and an image of the satellite. Below this is a 'Features' section with a featured article titled 'Fermi Detects 'Shocking' Surprise from Supernova's ...' dated 08.12.10. The article text states: 'Astronomers using NASA's Fermi Gamma-ray Space Telescope have detected gamma-rays from a nova for the first time, a finding that stunned observers and theorists alike because unlike supernovae, these ...' with a 'Read More' link. Below the featured article are two more feature titles: 'Fermi Maps an Active Galaxy's 'Smokestack Plumes'' and 'NASA's Fermi Probes "Dragons" of the Gamma-ray Sky'. On the right side, there is a 'Fermi Multimedia' section with three items: 'Einstein's Cosmic Speed Limit' with a 'View This Video' link, 'Fermi Blog' with a link to 'Fermi Project Scientist Julie McEnery and her colleagues give you a first-hand look at the mission and the science it's generating.', and 'GLASTcast 6: 2008 in Review' with a 'View This Video' link.

Large and professional outreach effort

http://www.nasa.gov/mission_pages/GLAST/main/index.html



FERMI GAMMA-RAY SKY

WEDNESDAY, OCTOBER 6, 2010

Fermi LAT weekyl report N.120

Covered period: 2010.September.27 - 2010.October.3

LAT Mission week: 121.57 - 122.57

- Following the increased gamma-ray activity report by the AGILE and LAT collaborations from the **Crab Nebula** (ATel #2855, ATel #2861), the daily flux appears to be returning to typical levels. The Crab was seen throughout the week ranging in daily flux from $(4.2+/-0.7)E-6$ on the 28th to $(2.3+0.5)E-6$ on the 1st.
- The FSRQ **3C279** was detected in a flaring state on the 27th with a daily flux of $(3.9+/-1.4) E-6$, Atel #2886. The flux

LAT DATA

[LAT First Catalog](#)

[LAT Monitored Source List Light Curves](#)

[LAT Bright Source List](#)

[Browse interface to monitored source data](#)

[Contact Information by Individual Sources](#)

BLOG ARCHIVE

▼ [2010 \(46\)](#)

▼ [October \(1\)](#)

[Fermi LAT weekyl report N.120](#)

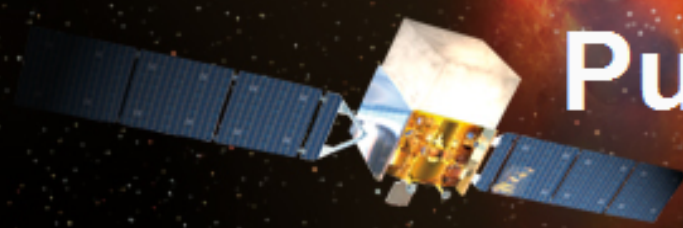
▶ [September \(5\)](#)

▶ [August \(3\)](#)

▶ [July \(7\)](#)

▶ [June \(3\)](#)

<http://fermisky.blogspot.com/>



Fermi LAT collaboration publications

Select a topic:

Links: <https://www-glast.stanford.edu/cgi-bin/pubpub>

- [How we classify papers by collaboration members](#)
- [Independent publications by LAT collaboration members \(Category III\)](#)
- [Ph. D. dissertations](#)
- [Rapid publications: ATel and GCN](#)
- [Proceedings of the 2009 Fermi Symposium](#)
- [Pre-launch publications](#)

2010

Fermi-LAT Study of Gamma-ray Emission in the

Abdo, A. A. et al. 2010, ApJ, 722, 1303 [Show links](#)

Gamma-ray Light Curves and Variability of Bright

Abdo, A. A. et al. 2010, ApJ, 722, 520 [Show links](#)

Category I and II papers in refereed journals

Journal	Published	In press	Total
Astronomy and Astrophysics	1+1=2	2	4
Astroparticle Physics	1+2=3	-	3
Astrophysical Journal	43+5=48	4	52
Astrophysical Journal Letters	16+3=19	-	19
Astrophysical Journal Supplement	3+0=3	-	3
Journal of Cosmology and Astroparticle Physics	2+2=4	-	4
Nature	2+0=2	-	2
Physical Review D	1+0=1	2	3
Physical Review Letters	4+0=4	-	4
Science	9+0=9	-	9
Total	82+13=95	8	103



SCIENCE OVERVIEW

Fermi is Making a Major Impact



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- *A Population of Gamma-Ray Millisecond Pulsars seen with the Fermi-LAT*
Abdo A. et al., 2009 Science, 325, 848

- *Detection of 16 Gamma-Ray Pulsars Through Blind Frequency Searches Using the Fermi LAT*
Abdo A. et al 2009, Science 325, 840

- *Discovery of High Energy gamma-ray emission from the globular cluster 47 Tucanae with Fermi*
Abdo A. et al 2009, Science 325, 845

ray telescope
ounter and dis-
radio telescope
s forerunner—

ity, which enables it to detect pulsations that
would have been too faint for Compton.
Already, the discoveries are shedding new
light on the physics of pulsars. Researchers

from www

struction of the 4.4-million-year-old

days, Split 4-9
2010

Science, December 2009

Highlights Overview



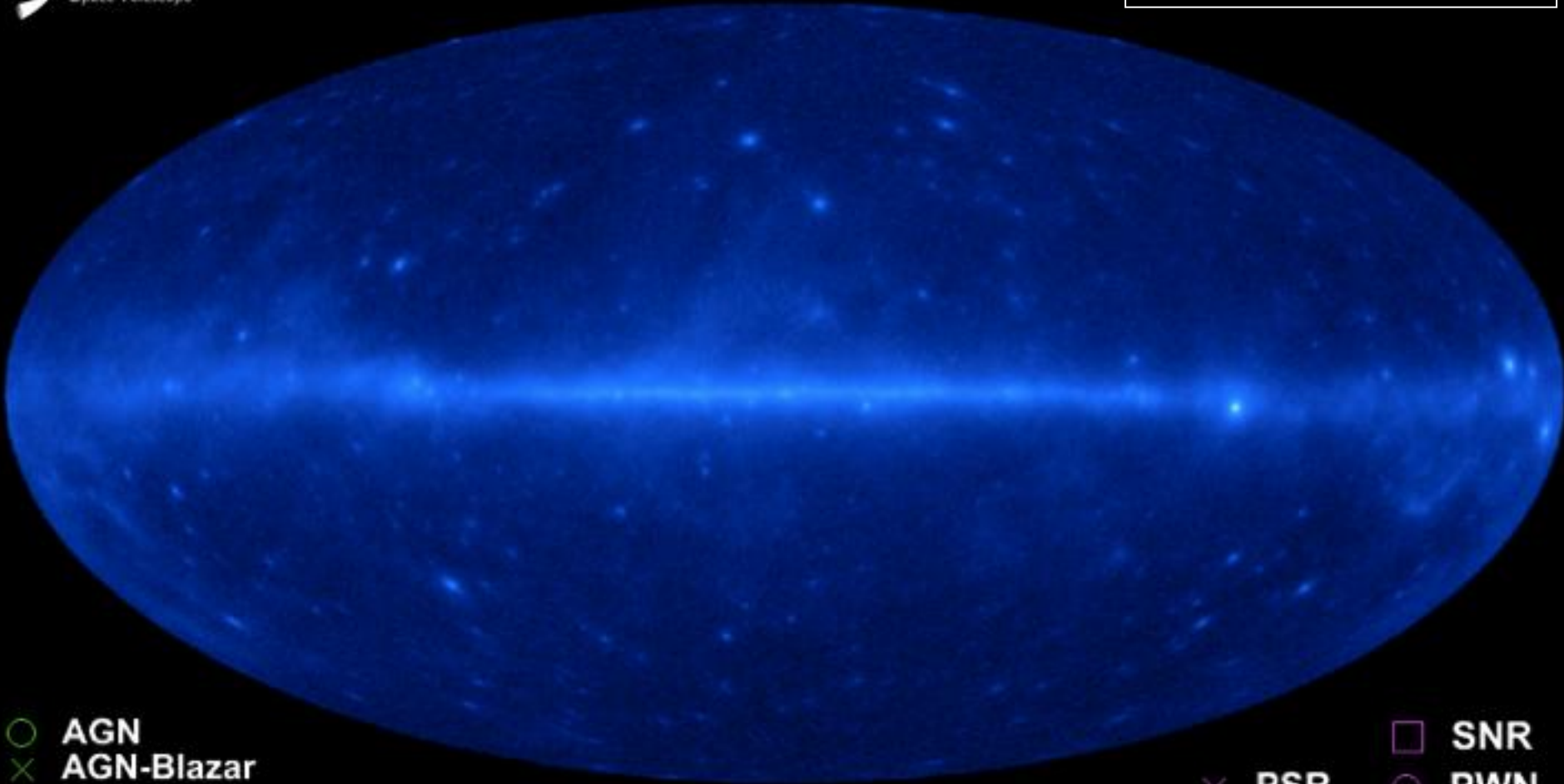
- **Year-one catalog: 1451 sources**
- **Pulsars:**
 - **>60 gamma-ray pulsars**
 - **24 seen to pulse only in gamma rays**
 - **19 new ms radio pulsars discovered thanks to LAT data!**
- **Remarkable high-energy emission from Gamma-Ray Bursts**
 - **Short and Long Bursts, starting to see what was missing**
 - **Limits on photon velocity dispersion**
- **Very high statistics measurement of the cosmic e+e- flux to 1 TeV**
- **Diffuse Galactic GeV emission**
- **First Fermi determination of the Isotropic Diffuse Flux**
- **Search for Dark Matter signatures in gamma rays**
- **Many new results on supermassive black hole systems (AGN) and other sources never seen in the GeV range**
- **More cosmic accelerators: Galactic X-ray binaries, supernova remnants, Galactic Nova, and supernova**
- **Probing the cosmic ray populations in other galaxies; LMC, SMC and now M31!**
- **Extragalactic Background Light constraints**

Clearly too much to squeeze into this talk!





The Fermi LAT 1FGL Source Catalog

ApJS 188, 405 (2010)



- AGN
- × AGN-Blazar
- AGN-Non Blazar
- No Association
- Possible Association with SNR and PWN
- Possible confusion with Galactic diffuse emission
- Starburst Galaxy
- + Galaxy
- SNR
- PWN
- × PSR
- ⊗ PSR w/PWN
- ◇ Globular Cluster
- × HXB or MQO

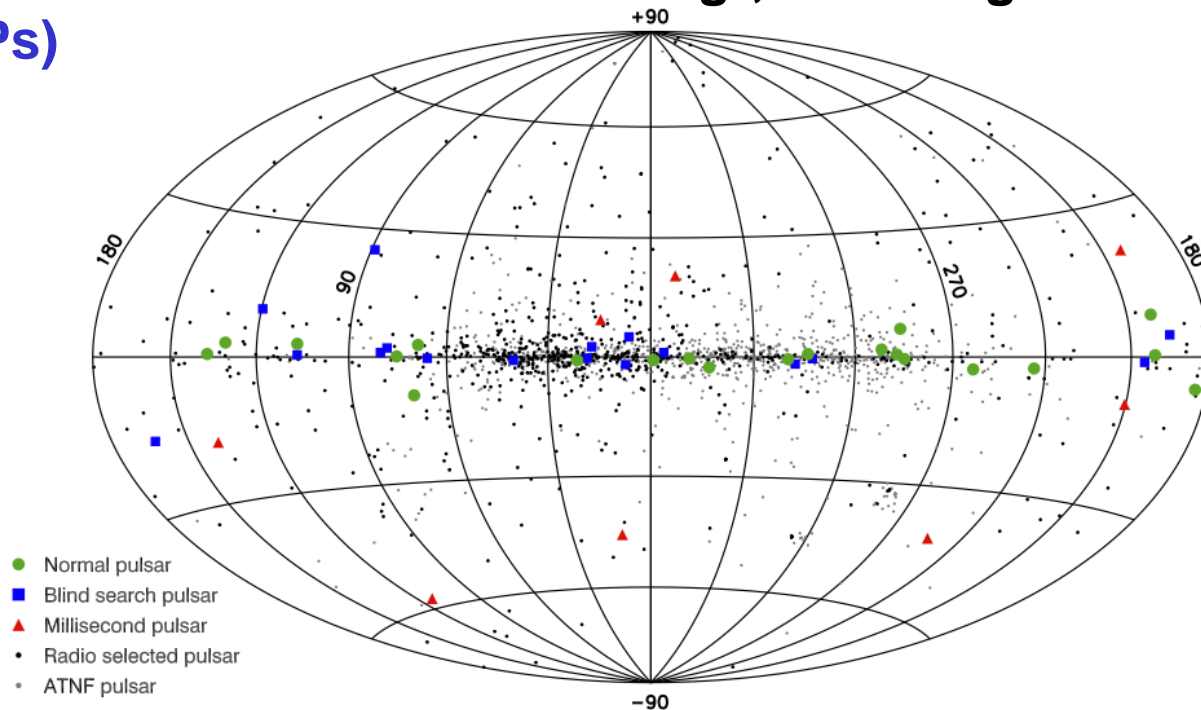
Description	Designator	Number Assoc. (ID)
Pulsar, X-ray or radio, identified by pulsations	psr (PSR)	7 (56)
Pulsar, radio quiet (LAT PSR, <i>subset of above</i>)	PSR	24
Pulsar wind nebula	pwn (PWN)	2 (3)
Supernova remnant	† (SNR)	41 (3)
Globular Cluster	glc (GLC)	8 (0)
Micro-quasar object: X-ray binary (black hole or neutron star) with radio jet	mqq (MQO)	0 (1)
Other X-ray binary	hxb (HXB)	0 (2)
BL Lac type of blazar	bzb (BZB)	295 (0)
FSRQ type of blazar	bzq (BZQ)	274 (4)
Non-blazar active galaxy	agn (AGN)	28 (0)
Active galaxy of uncertain type	agu (AGU)	92 (0)
Normal galaxy	gal (GAL)	6 (0)
Starburst galaxy	sbg (SBG)	2 (0)
Unassociated		630

-  AGN
-  AGN-Blazar
-  AGN-Non Blazar
-  No Association
-  Possible Association with SNR and PWN
-  Possible confusion with Galactic diffuse emission
-  Starburst Galaxy
-  Galaxy
-  SNR
-  PSR
-  PWN
-  PSR w/PWN
-  Globular Cluster
-  HXB or MQO



LAT Pulsar Catalog

- Comprehensive, uniform presentation of **46** pulsars detected by the LAT using the **first 6 months** of LAT data
- Of the 46, **16** resulted from **blind searches**, and **24** were discovered using ephemerides from radio monitoring*, including **8 millisecond pulsars (MSPs)**



Now >60 LAT-detected pulsars

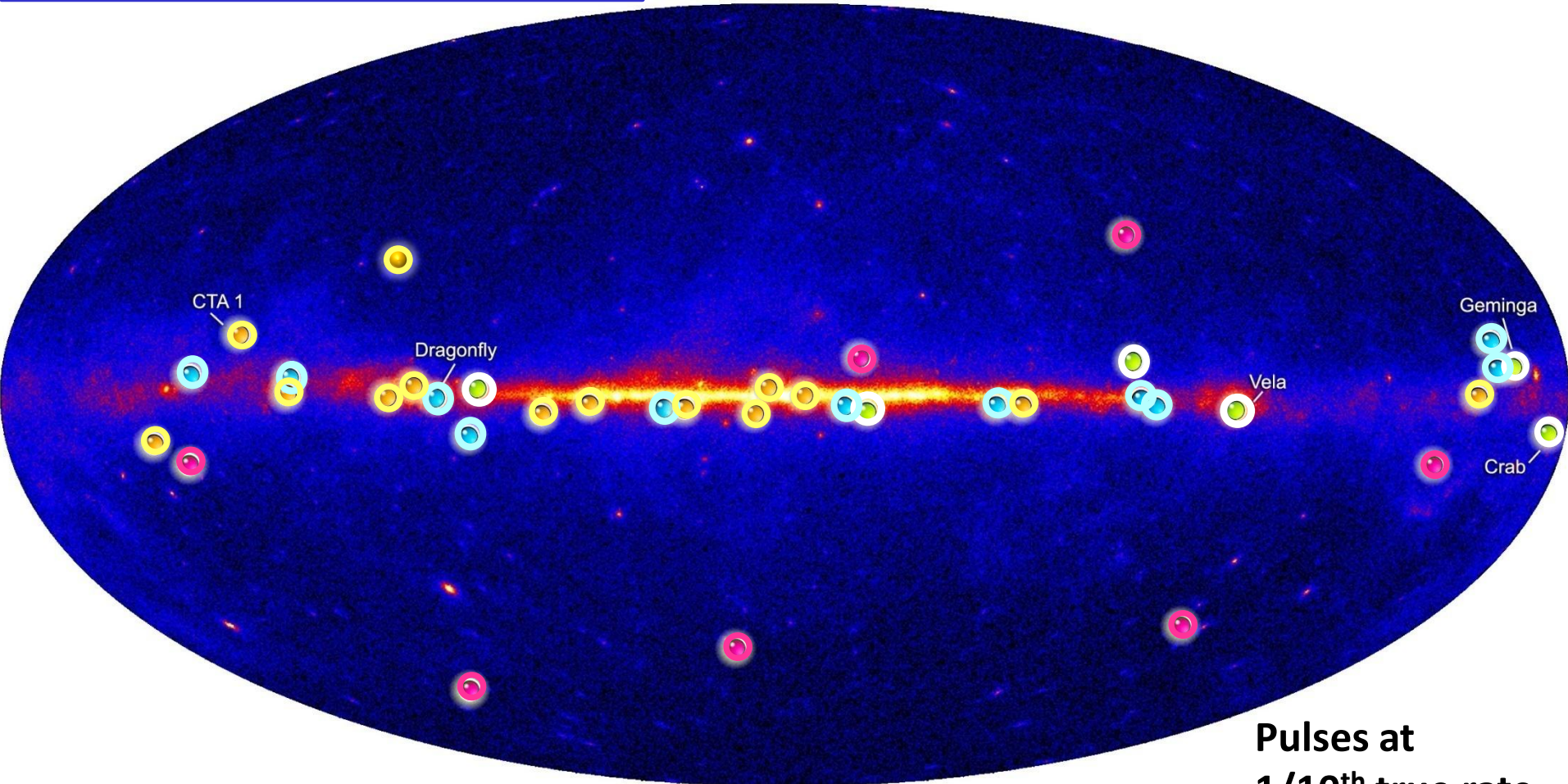
Rainò --- LHC days,
October 2010

•ApJ Supplement 187, 460 (2010)

The Pulsing γ -ray Sky



Now >60 LAT-detected pulsars



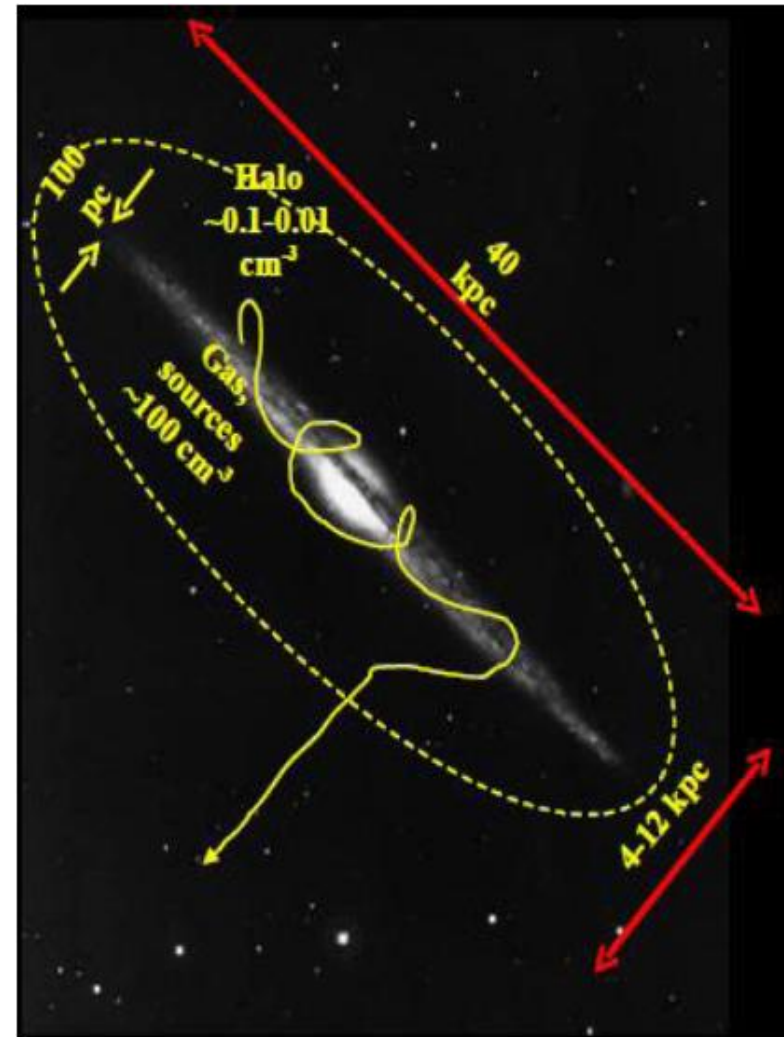
Pulses at
1/10th true rate

Fermi Pulsar Detections

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



- High-energy (GeV–TeV) charged primary Cosmic Rays (CRs) are believed to be produced in our galaxy, most likely in Supernova Remnants (SNRs)
- CRs injected into the Interstellar Medium propagate for millions of years before escaping to intergalactic space
- Particle interactions with interstellar gas, radiation and magnetic fields produce EM radiation from radio to gamma rays, and other secondaries (e^{\pm} , nuclei, etc.)





PRL 102, 181101 (2009)

Selected for a **Viewpoint** in *Physics*
 PHYSICAL REVIEW LETTERS

week ending
 8 MAY 2009



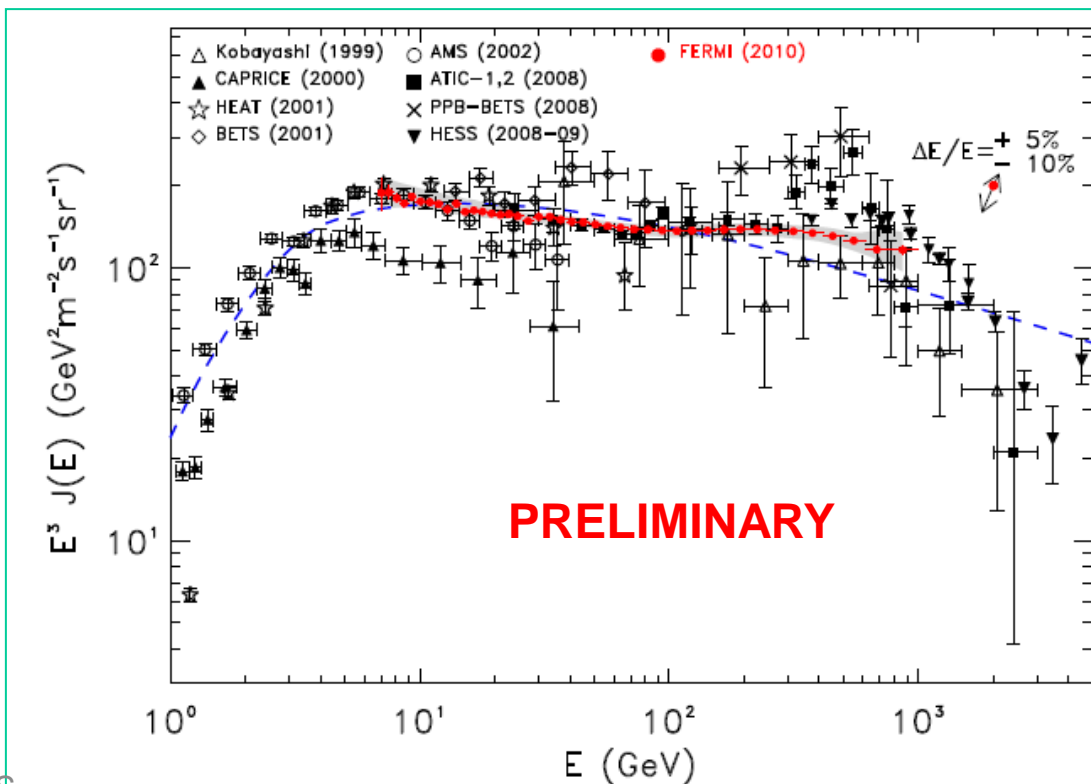
Measurement of the Cosmic Ray $e^+ + e^-$ Spectrum from 20 GeV to 1 TeV with the Fermi Large Area Telescope

Measurement 20 GeV – 1 TeV
 – hard ($\sim E^{-3}$)
 – flat (no spectral features)
 4 M events in 6 months data
 taking

**Extended Energy Range:
 7 GeV – 1 TeV**

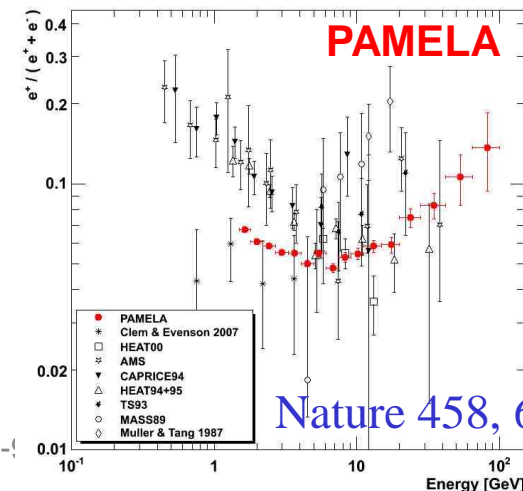
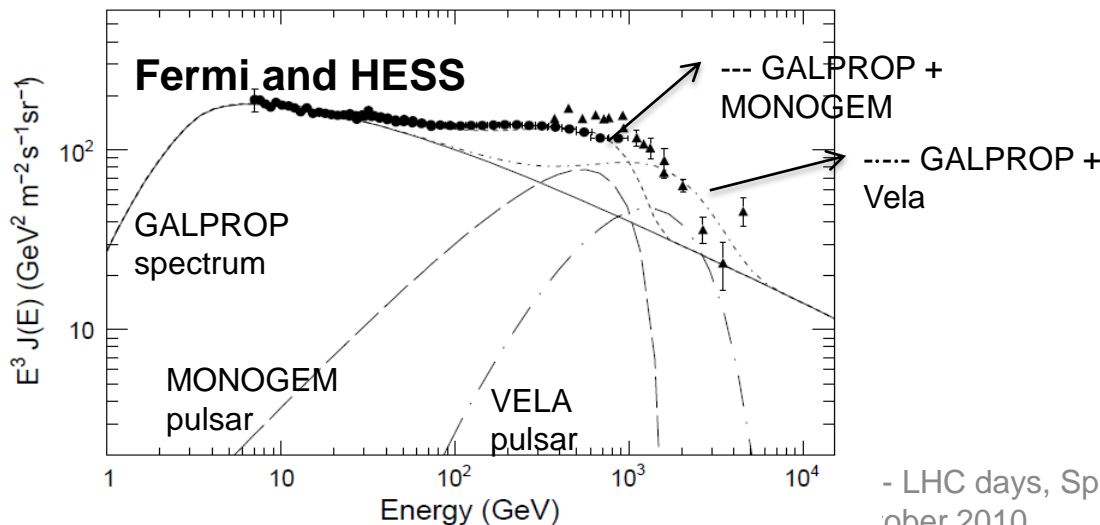
arXiv: 1008.3999

**One year statistics: $8 \cdot 10^6$
 events**





- The electron spectrum is harder than the one expected from conventional diffusive models (GALPROP) based on pre-Fermi data
- Possible interpretations:
 - harder electron spectrum at the source
 - presence of a local source of high energy electrons and positrons
 - Nearby Pulsar or Dark Matter annihilation
 - this interpretation allows also to explain the increase in the $e^+/(e^++e^-)$ ratio observed by PAMELA above 10GeV
- Potentials to search for anisotropies
 - no evidence for anisotropies in the arrival directions of cosmic-ray electrons above 60GeV ([arxiv 1008.5119](https://arxiv.org/abs/1008.5119))



- LHC days, Split 4-1
ober 2010

Nature 458, 697, 2009

Many Places to Seek DM!

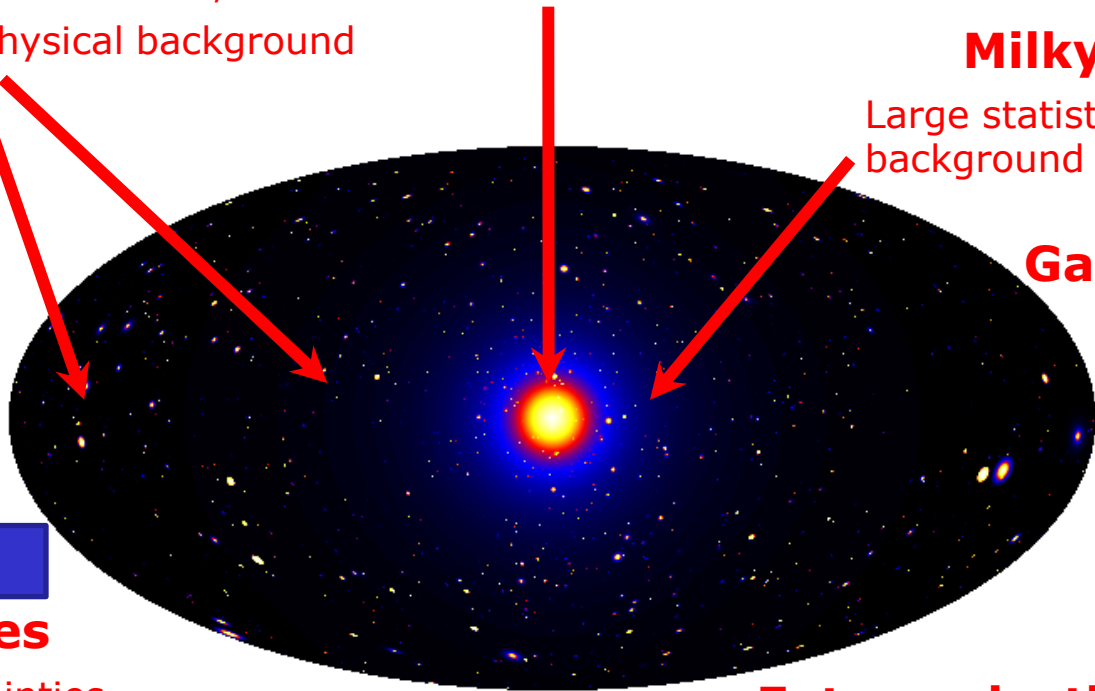


Satellites

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

ApJ 712,147 (2010)

All-sky map of simulated
gamma ray signal from DM
annihilation (Baltz 2006)



Galactic Center

Good Statistics but source
confusion/diffuse background

Milky Way Halo

Large statistics but diffuse
background

Galaxy clusters

Low background
Low statistics

JCAP 05,025
(2010)

Extra-galactic

Large statistics, but astrophysics, galactic
diffuse background

JCAP 04,014 (2010)

Spectral Lines

No astrophysical uncertainties,
good source id, but low sensitivity
because of expected small BR

*They seek it here, they seek it there
Those Physicists seek it everywhere
Is it in heaven or is it in hell?*

That damned elusive Dark Matter Pimpernel! lit 4-9 October 2010

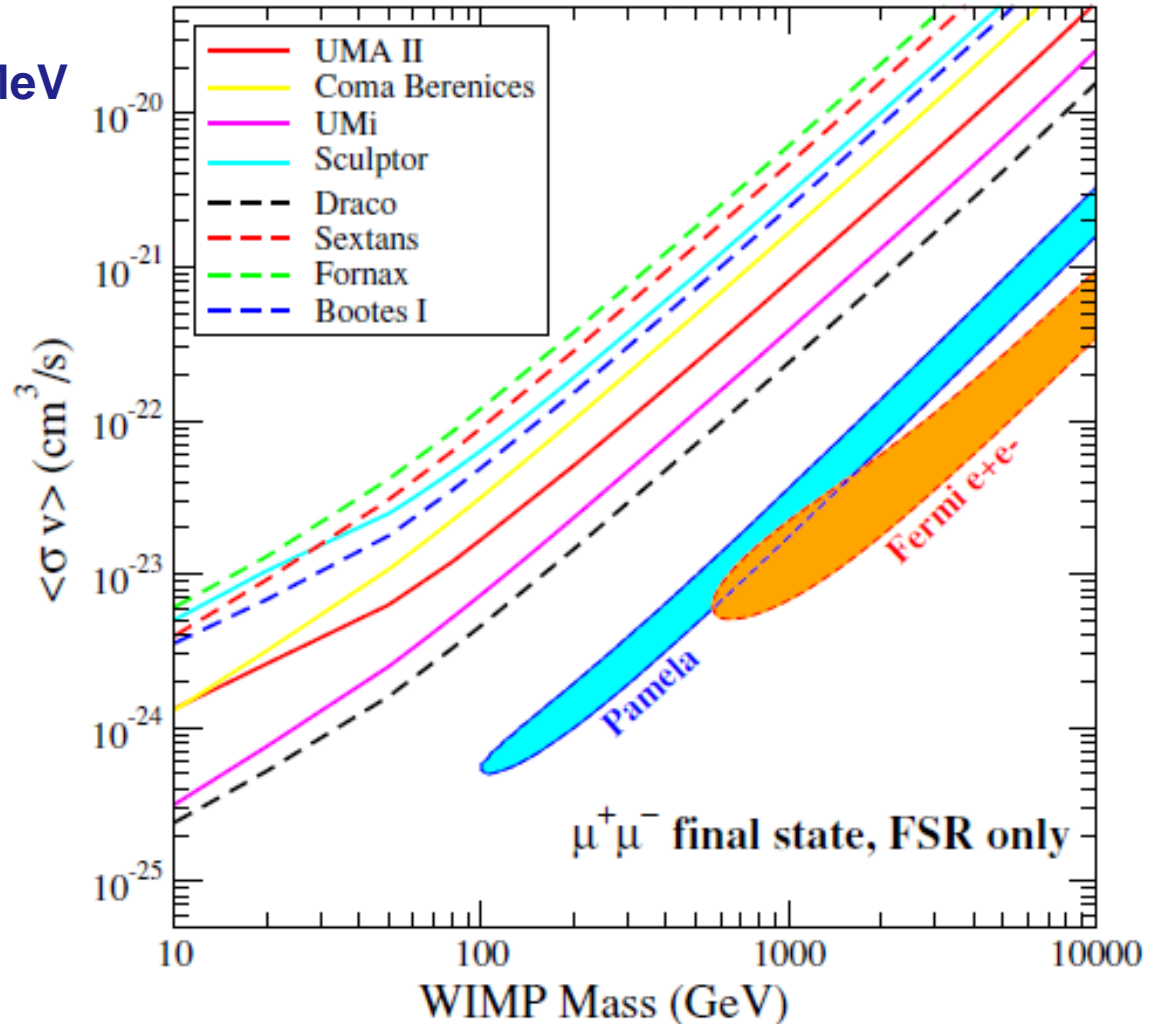
Paraphrased from the **Scarlet Pimpernel** by Baroness Emma
Magdolna Rozália Mária Jozefa Borbála "Emmuska" Orczy de Orczy



No significant γ -ray emission detected by Fermi above 100 MeV with 11 months of data. 95% C.L. flux upper limits are placed for several possible annihilation final states.

Flux upper limits are combined with the DM density inferred by the stellar data (*) for a subset of 8 dSph (based on quality of stellar data) to extract constraints on $\langle\sigma v\rangle$ vs WIMP mass for specific DM models

ApJ 712,147 (2010)

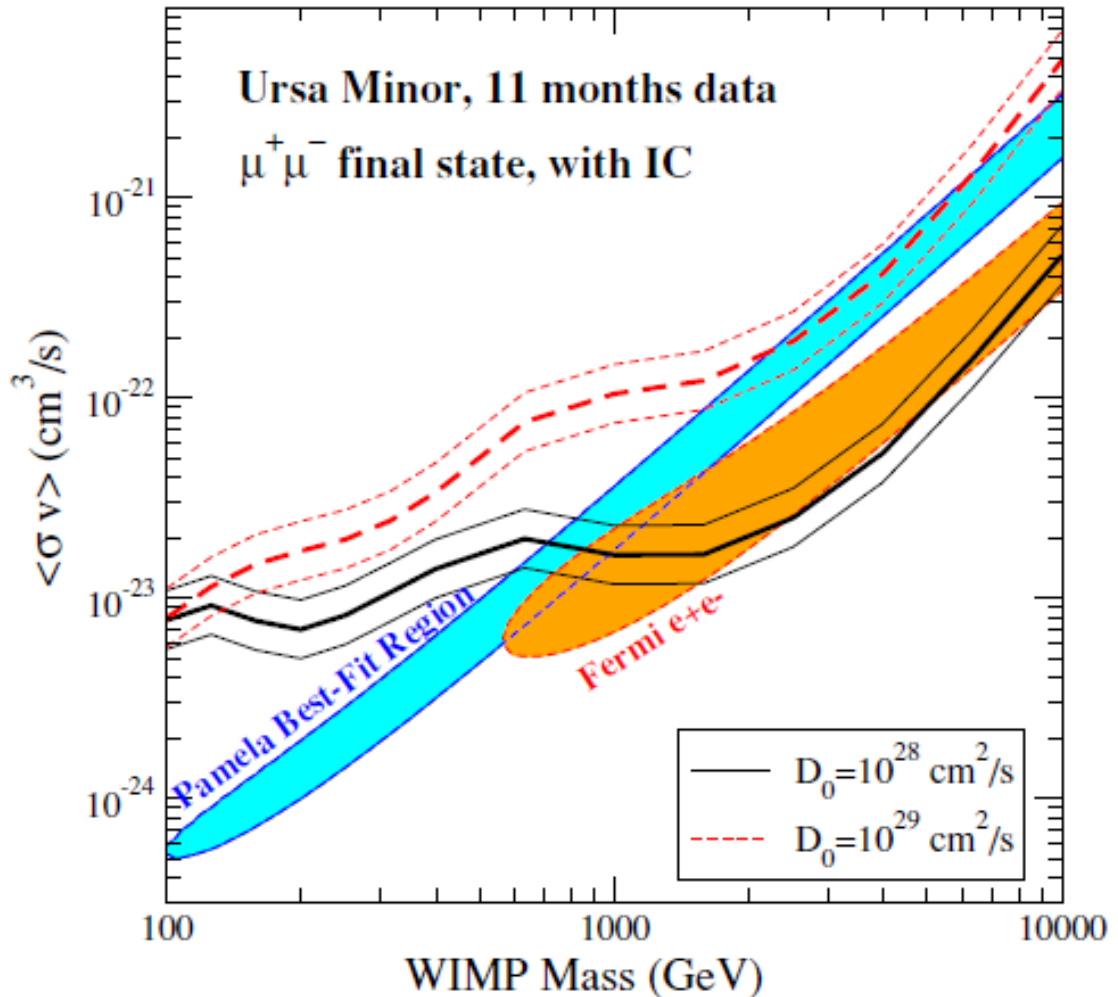


(*) stellar data from the Keck observatory (by Martinez, Bullock, Kaplinghat)



Stronger constraints can be derived if IC of electrons and positrons from DM annihilation off of the CMB is included, however diffusion in dwarfs is not known
 \Rightarrow use values of diffusion coefficients from cosmic rays in the Milky Way

ApJ 712,147 (2010)



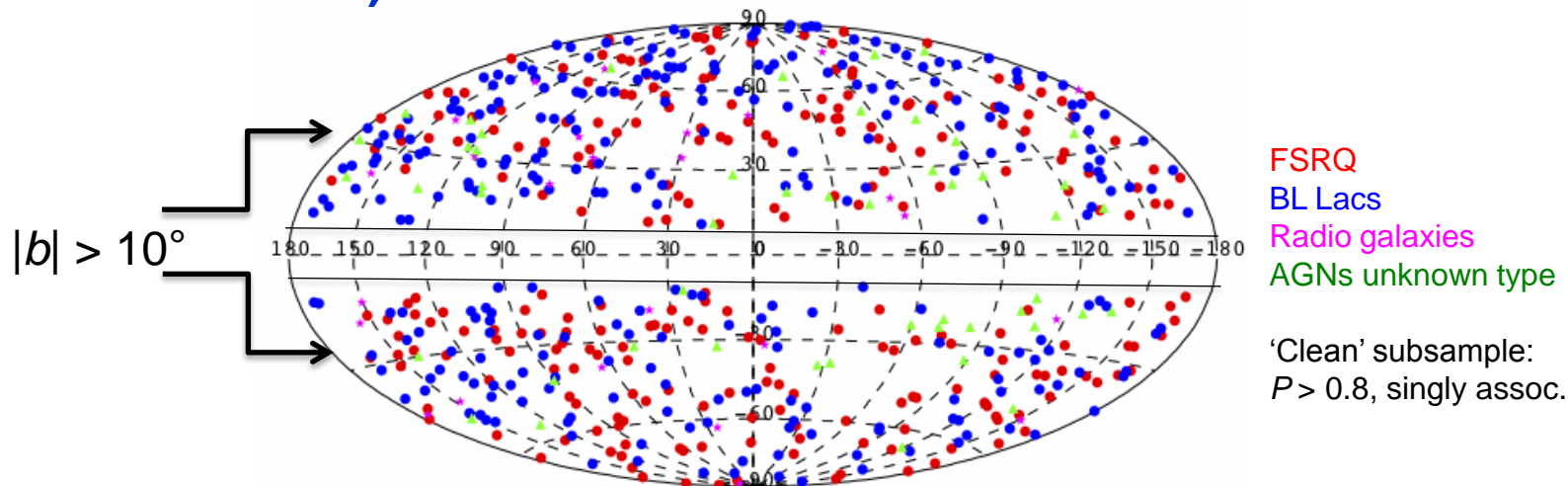
(*) stellar data from the Keck observatory
 (by Martinez, Bullock, Kaplinghat)

Over half the bright sources seen with LAT appear to be associated with Active Galactic Nuclei (AGN)

- Power comes from material falling toward a supermassive black hole
- Some of this energy fuels a jet of high-energy particles that travel at nearly the speed of light
- Fermi LAT sees primarily blazars, for which the jet is pointed toward Earth.



- Based on 1FGL sources associated with AGN for high galactic latitudes, $|b| > 10^\circ$
 - 671 1FGL sources: 300 BL Lacs, 296 FSRQs, 41 AGNs of other types, 72 of unknown type (some multiple associations)

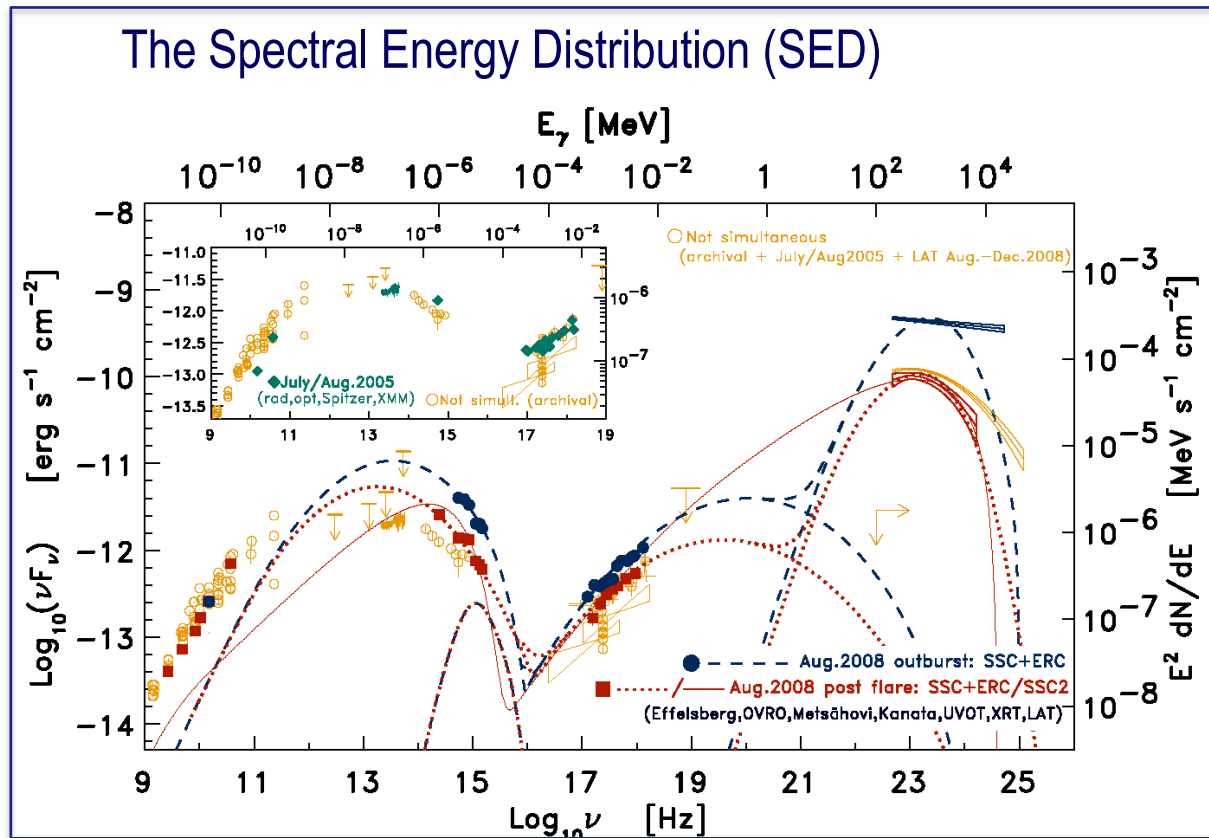
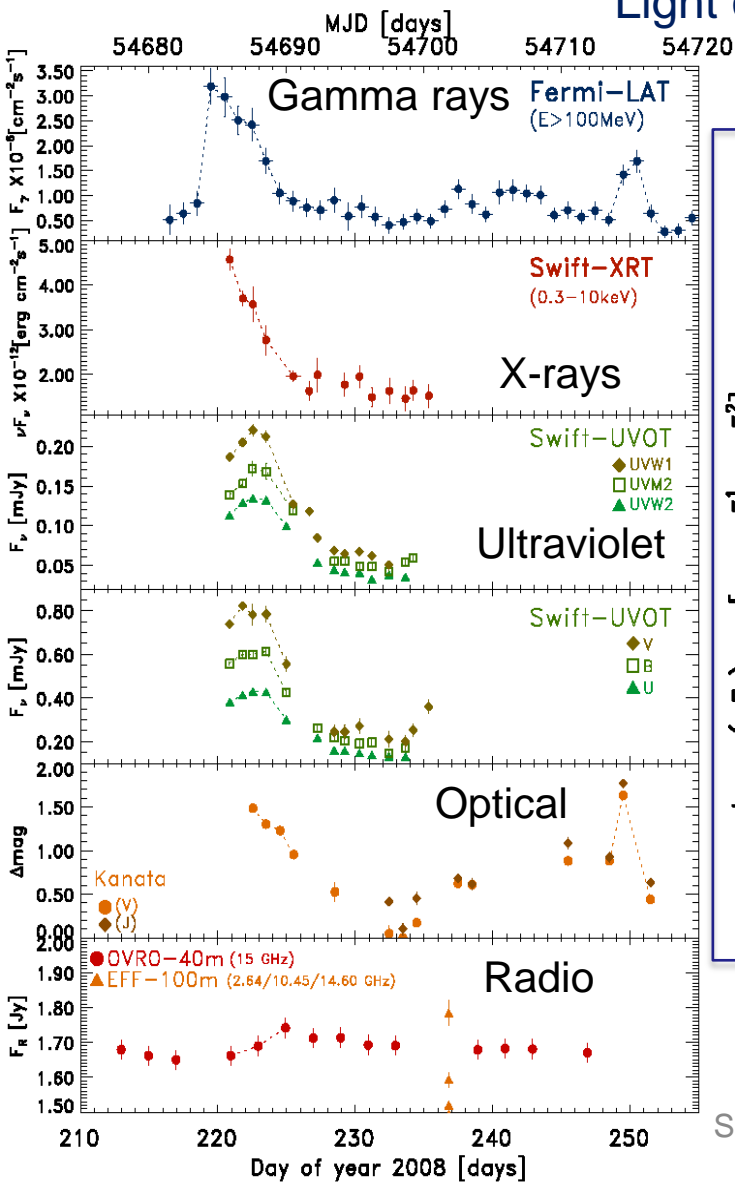


- 1LAC paper also lists 51 low-latitude associations and 104 high-latitude 'affiliations' (plausible associations for which quantitative probabilities could not be defined)



Light curves and variability analysis

ApJ 710, 810 (2010)

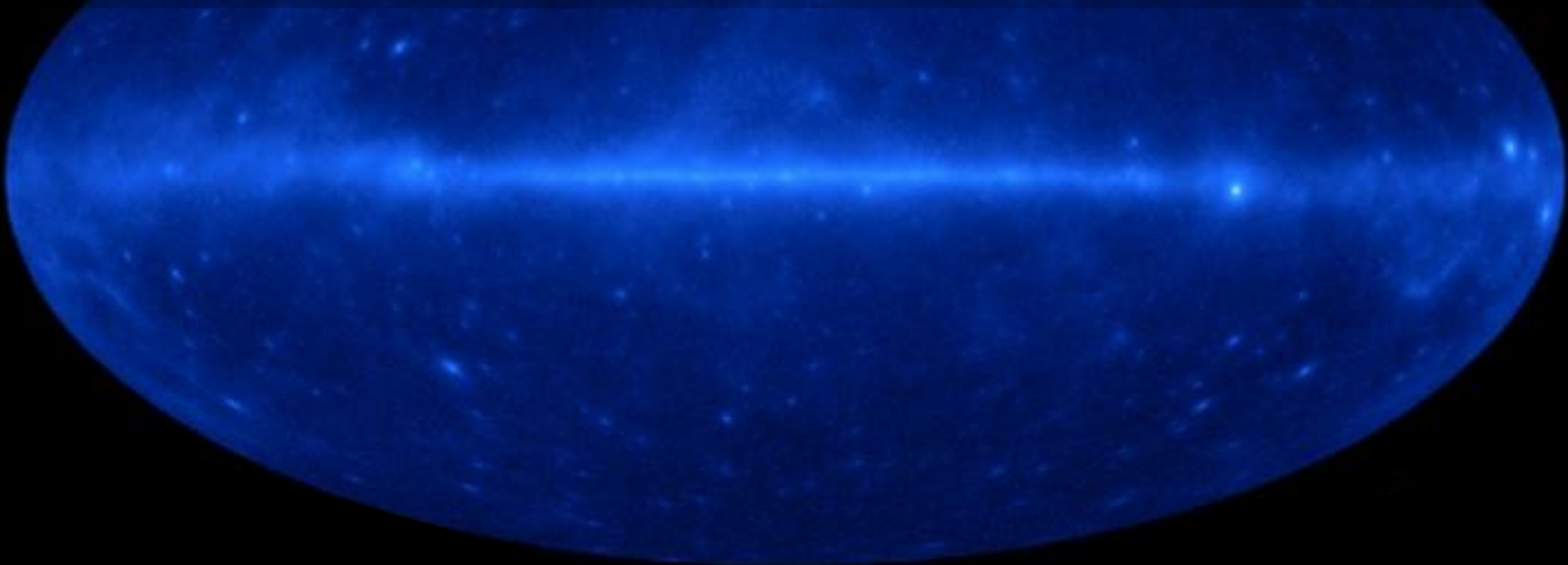


The SED of this blazar is complex, requiring multiple components that vary with time.



The Gamma-ray Sky Seen with Fermi LAT: not only sources

Galactic diffuse emission comes from cosmic-ray interactions with the interstellar medium → LAT observations ideal to study cosmic-ray origin and propagation



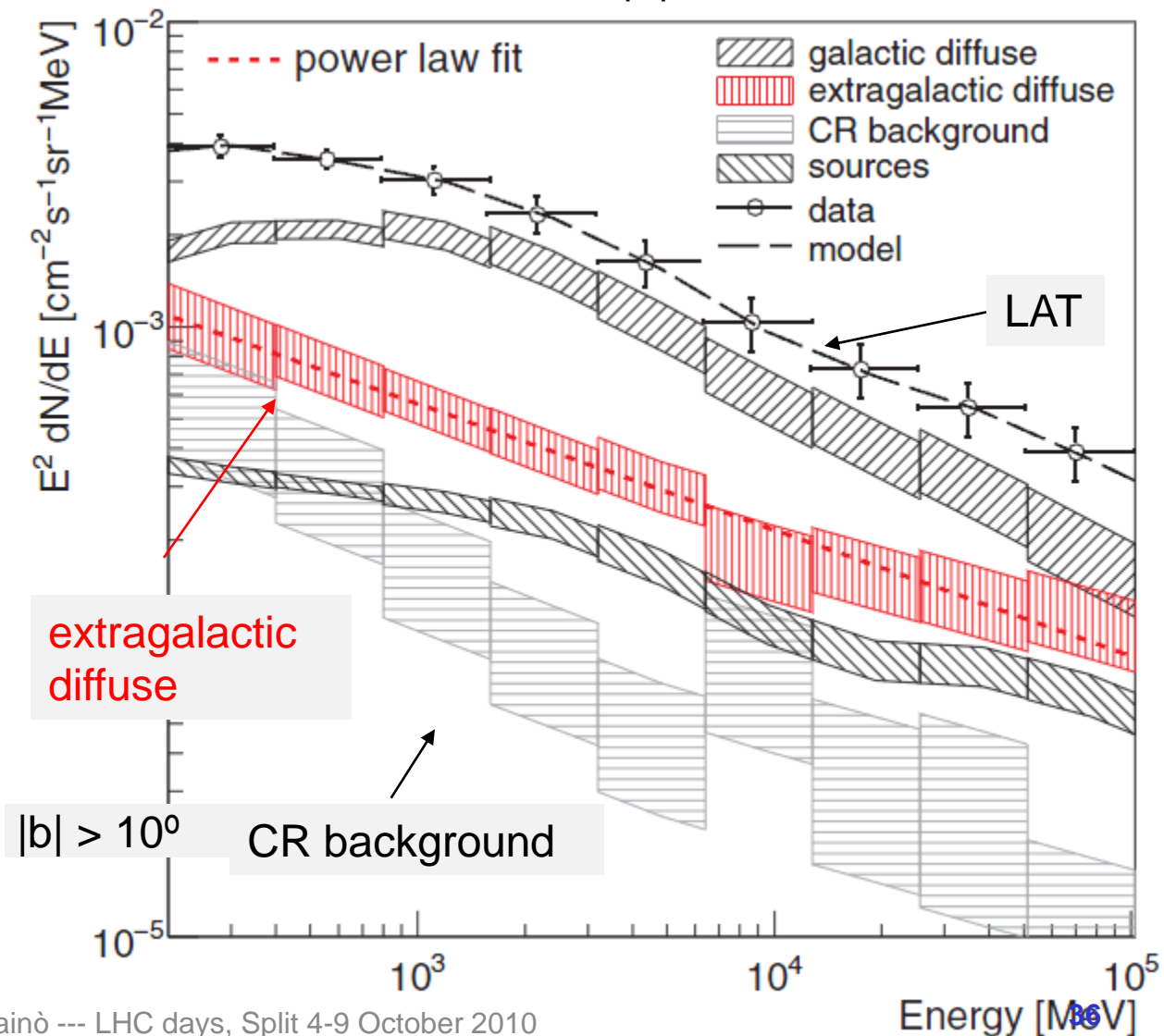
$E > 1$ GeV image.

Sources are seen against a strong diffuse background.

LAT Isotropic Diffuse Flux



$|b| \geq 10^\circ$



Phys. Rev. Lett. 104
101101 (2010)

Summary



- **Fermi is off to a great start!**
 - instruments are beautiful, the observatory is working very well. The gamma-ray sky is keeping its promises.
- **Already addressing many important questions left open by its predecessor EGRET and moving beyond**
 - new analysis techniques and approaches are essential -- new topics!
 - the challenge of great discovery potential
 - the transformational all-sky capability is paying off!
- **Multiwavelength observations are key to many science topics for Fermi.**
 - **LAT collaboration has numerous MOUs and other cooperative agreements with other observatories.**
 - **For campaigners' information and coordination, see <http://fermi.gsfc.nasa.gov/science/multi>**
- **JOIN THE FUN!**

Fermi-LAT newsletters:

<http://fermi.gsfc.nasa.gov/ssc/resources/newsletter/>

27th Fermi-LAT Days, July 1-9
October 2010

LHC Days in Split

4 - 9 October 2010

**Thank you
for your attention!**



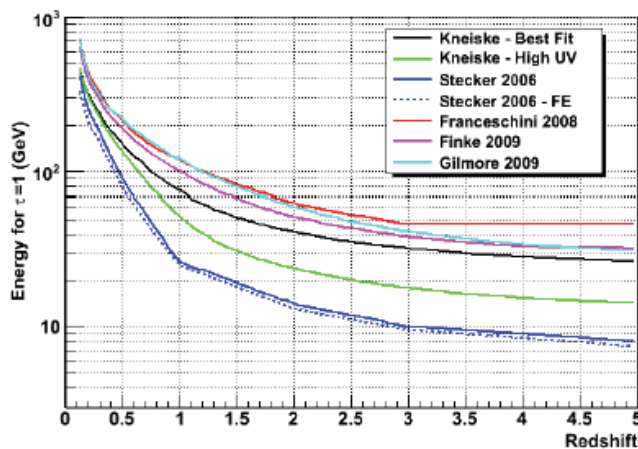
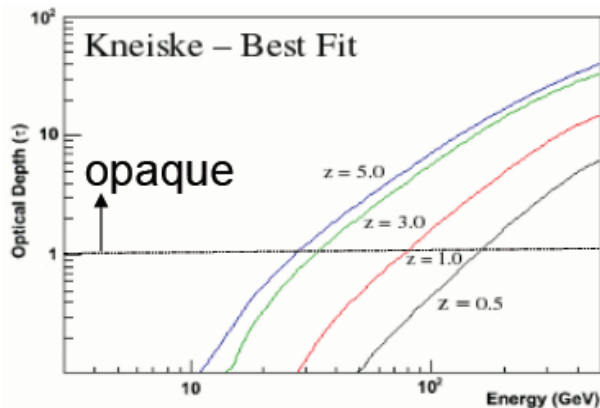


BACK-UP SLIDES



Photons with $E > 10$ GeV are attenuated by the diffuse field of UV-Optical-IR extragalactic background light (EBL) which constitute the main source of opacity for γ -rays from extragalactic sources, such as blazars and GRBs

only $e^{-\tau}$ of the original source flux reaches us



EBL over cosmological distances is probed by gamma-rays in the 10-100 GeV range, unexplored before Fermi.

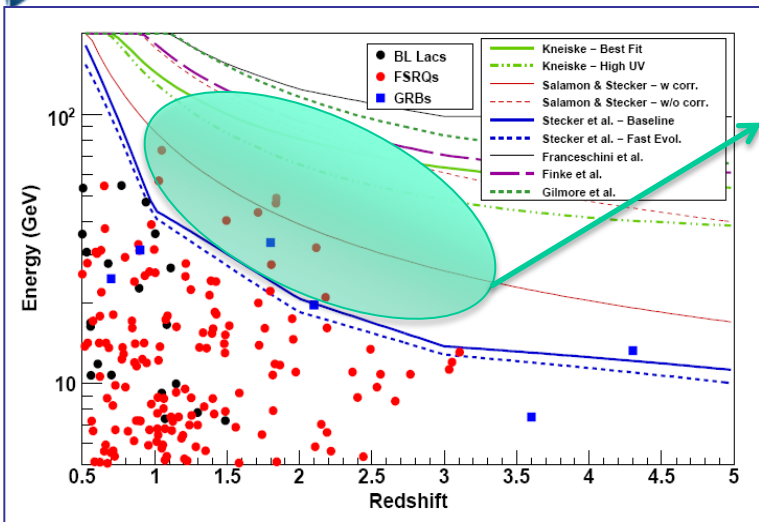
For the relevant redshifts no attenuation is expected for γ -rays with energy below 10 GeV, thus EBL attenuation doesn't limit Fermi's ability to detect distant sources.

- Fermi-detected sources are distributed over a wide range of redshifts ($z \sim 0-4$), thus Fermi is sensitive in the energy range where EBL evolution is relevant.

A dominant factor in EBL models is the star formation rate -- attenuation measurements can help distinguish models.

No significant attenuation below ~ 10 GeV.

EBL Constraints

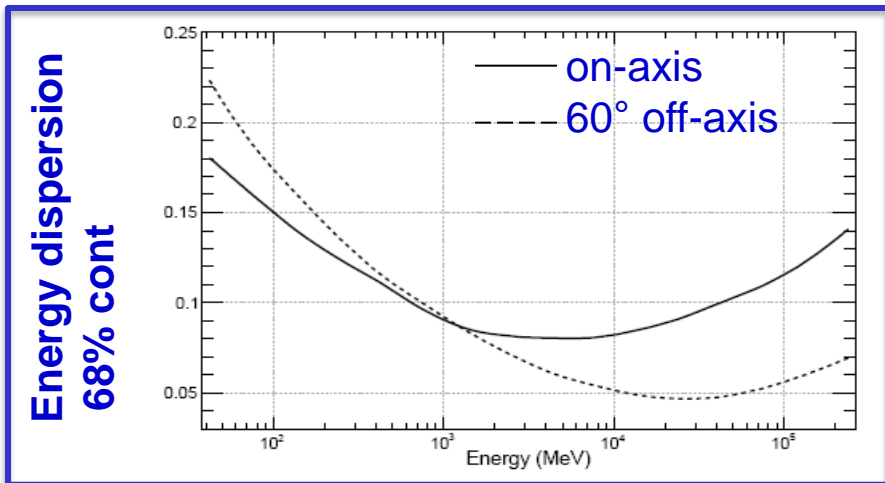
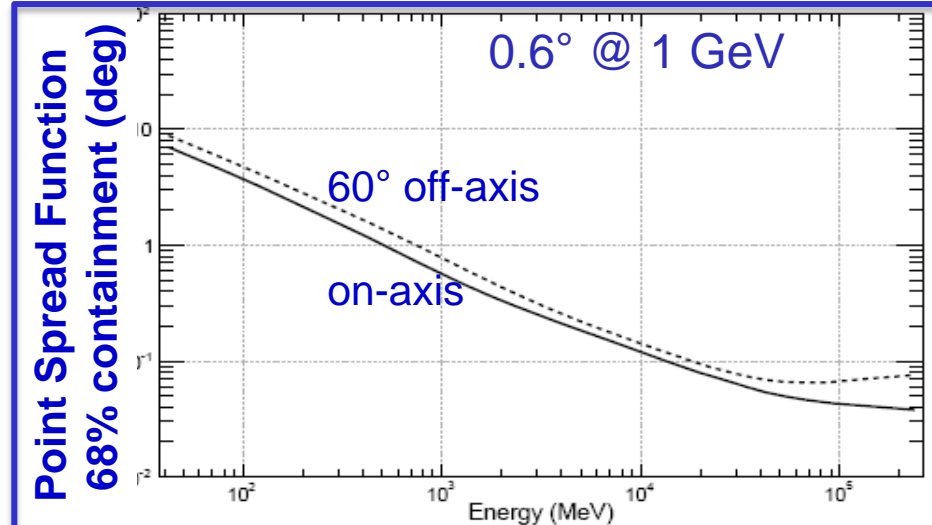
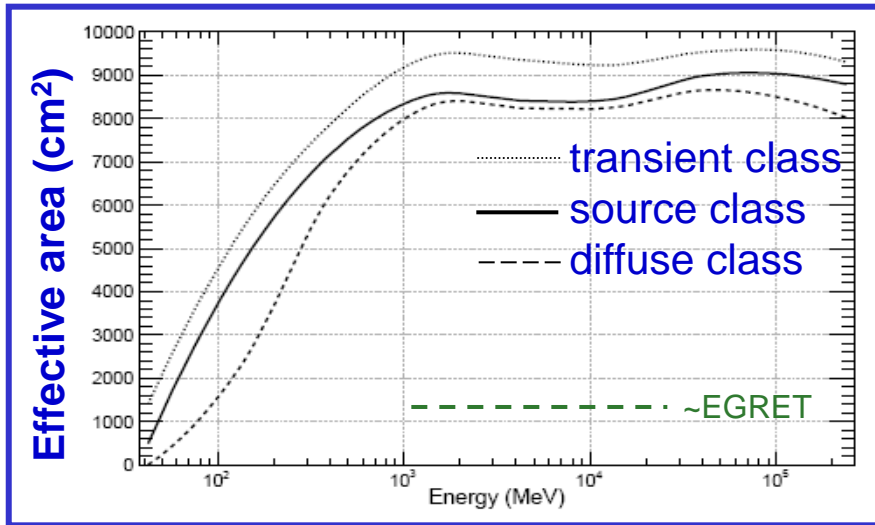


These high-energy photons populate a region heavily suppressed according to some EBL models.

Although we consider all models in the literature, we find that our observations only constrain the model that predicts the strongest EBL attenuation (Stecker 06).

Source	z	Energy (GeV)	P_{bkg}	HEP method applied to Stecker 06		HEP Rejection Significance
				P_{HEP}	$P_{rejection}$	
J1147-3812	1.05	73.7	7.0×10^{-4}	1.2×10^{-4}	8.1×10^{-4}	3.2σ
J1504+1029	1.84	48.9	5.6×10^{-3}	6.7×10^{-5}	5.7×10^{-3}	4.1σ
		35.1	9.8×10^{-3}	6.8×10^{-3}	1.7×10^{-2}	
		23.2	5.6×10^{-3}	1.8×10^{-1}	1.9×10^{-1}	
				Combined $P_{rej} = 1.7 \times 10^{-5}$		
J0808-0751	1.84	46.8	1.5×10^{-3}	1.9×10^{-4}	1.7×10^{-3}	4.5σ
		33.1	2.7×10^{-3}	3.7×10^{-3}	6.4×10^{-3}	
		20.6	6.9×10^{-3}	2.5×10^{-1}	2.6×10^{-1}	
				Combined $P_{rej} = 2.8 \times 10^{-6}$		
J1016+0513	1.71	43.3	1.1×10^{-3}	5.4×10^{-4}	1.6×10^{-3}	3.3σ
		16.8	8.2×10^{-3}	4.9×10^{-1}	4.9×10^{-1}	
		16.1	8.2×10^{-3}	6.5×10^{-1}	6.5×10^{-1}	
				Combined $P_{rej} = 5.3 \times 10^{-4}$		
J0229-3643	2.11	31.9	1.7×10^{-3}	8.9×10^{-5}	1.8×10^{-3}	2.9σ
GRB 090902B	1.82	33.4	2×10^{-6}	2.0×10^{-4}	2.0×10^{-4}	3.7σ
GRB 080916C	4.24	13.2	8×10^{-8}	6.5×10^{-4}	6.5×10^{-4}	3.4σ

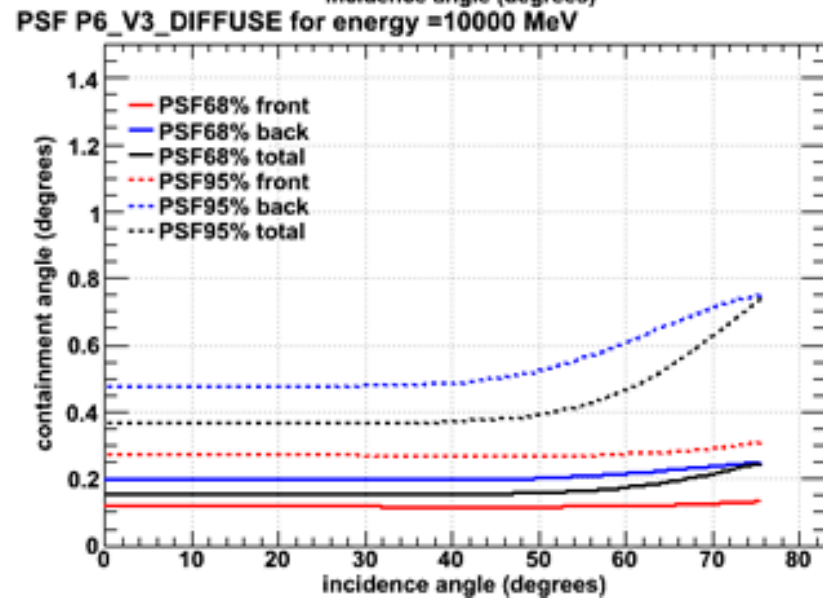
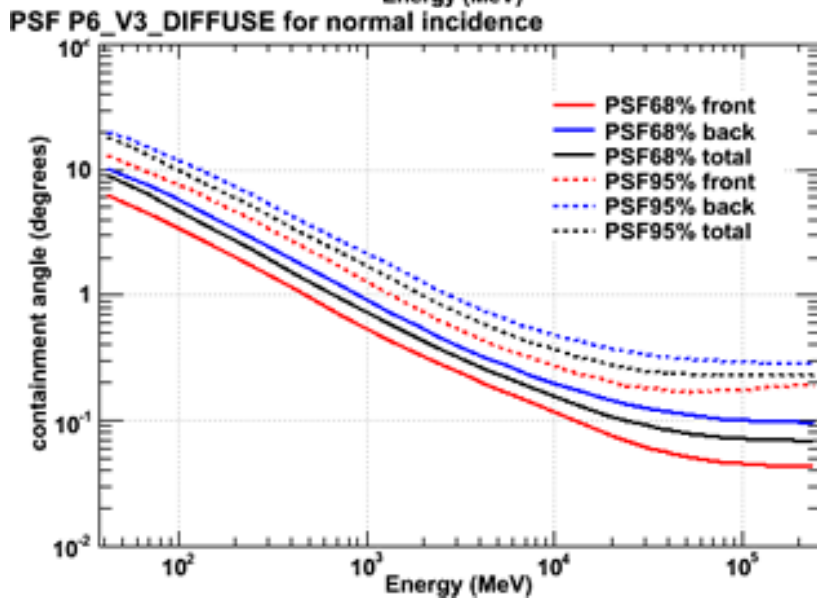
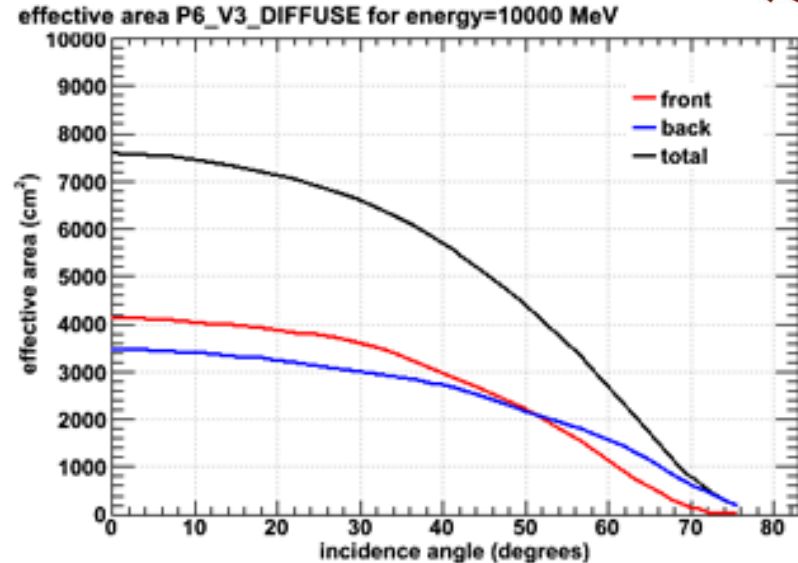
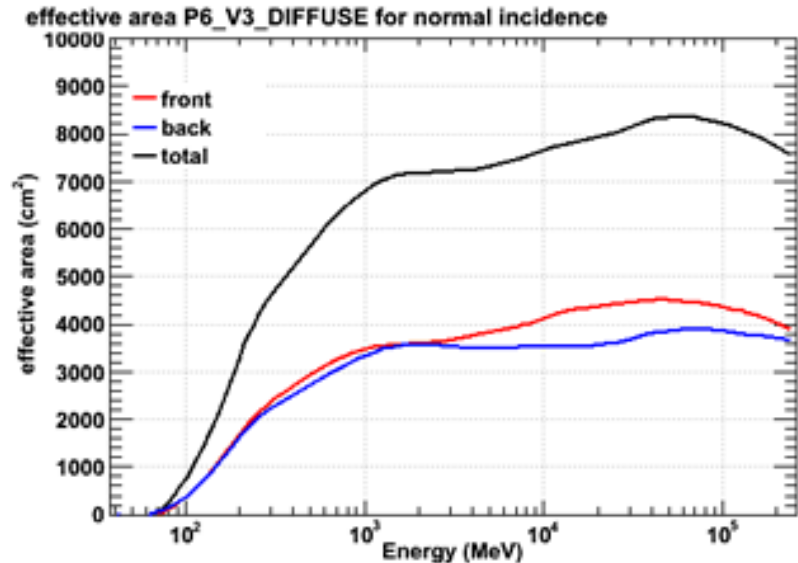
Instrument Performance



The Large Area Telescope on the Fermi
Gamma-ray Space Telescope

Atwood, W. B. et al. 2009, ApJ, 697, 1071

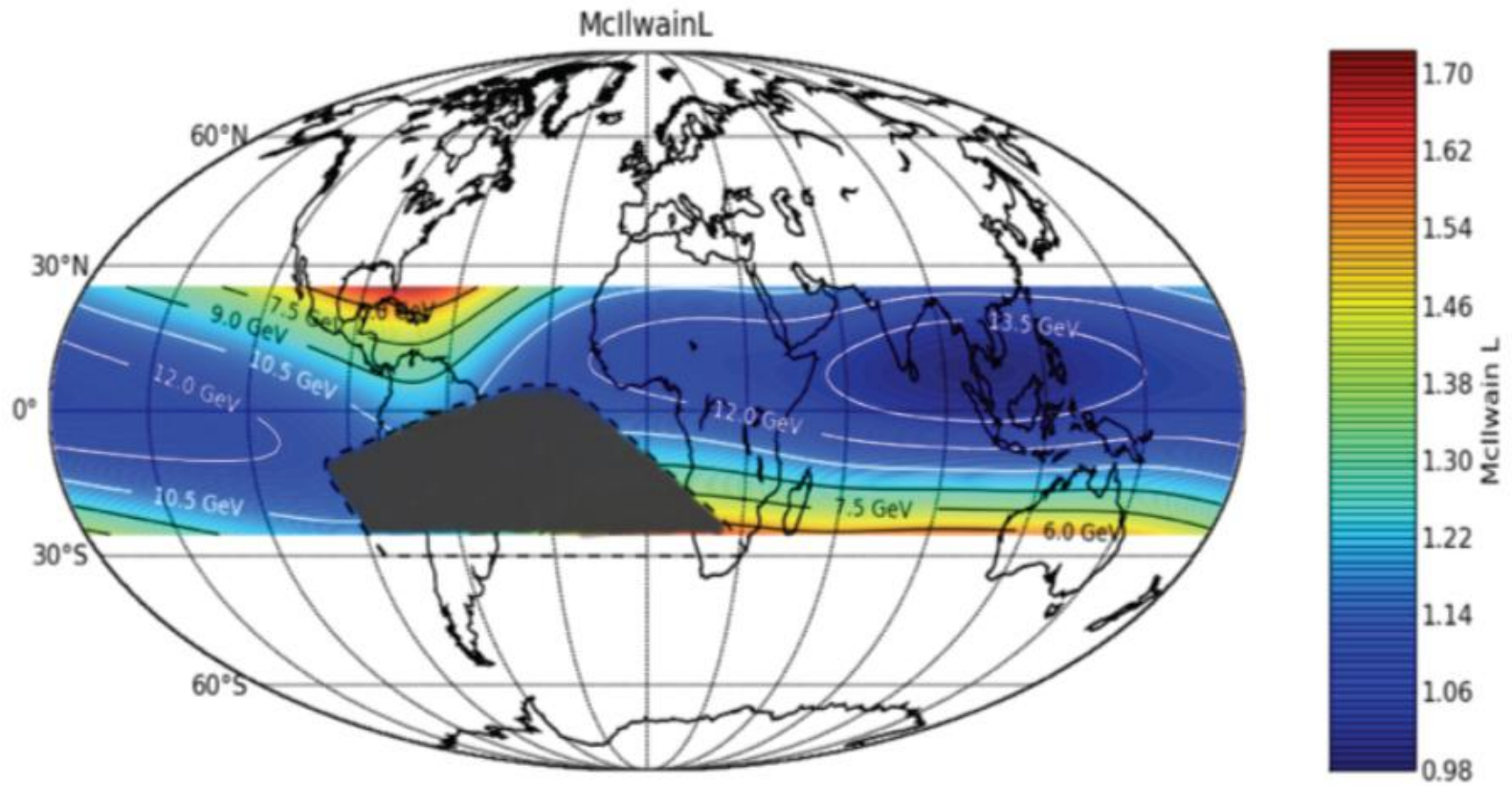
Instrument Performance



South Atlantic Anomaly



Data taking interrupted while passing through the South Atlantic Anomaly → ~13% time lost

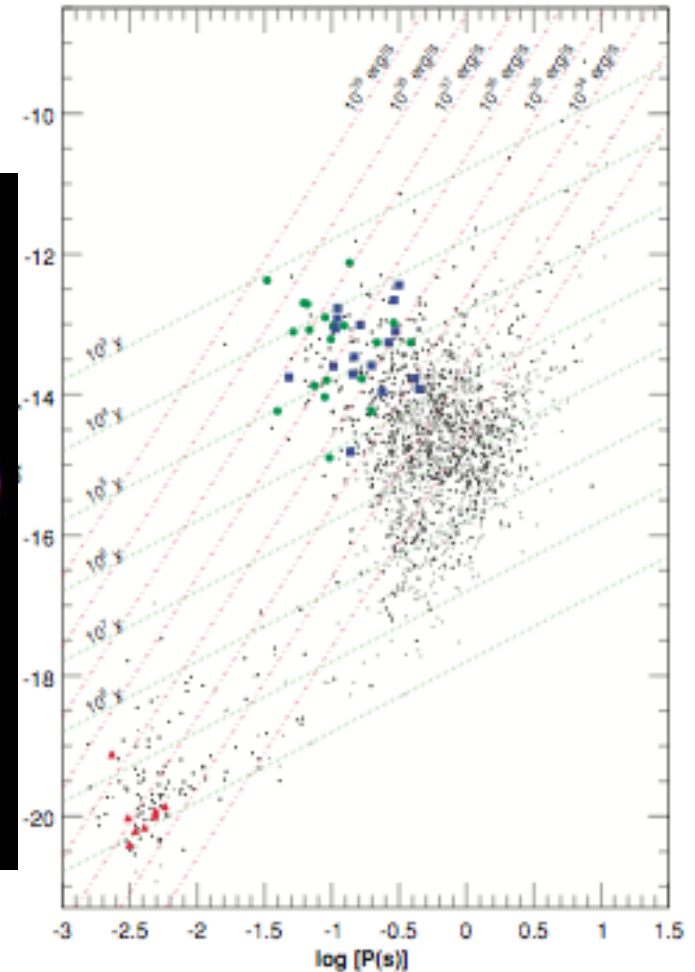
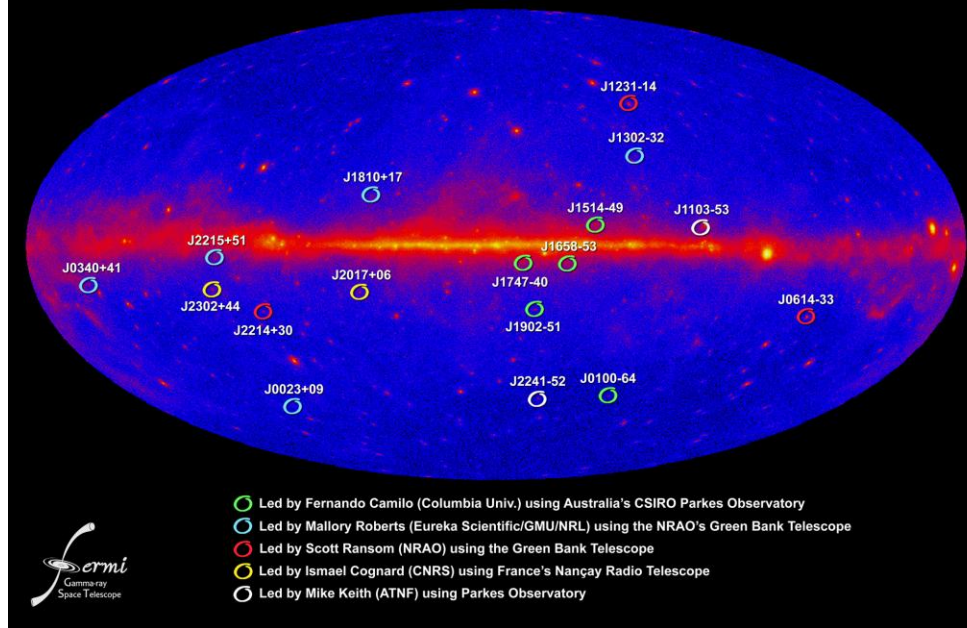




LAT Pulsar Catalog

- Populations
- Spectra

17 New Millisecond Radio Pulsars Found in Fermi LAT Unidentified Sources



Blue = radio quiet

- Globular clusters suspected to be powered by MSPs – 8 globular cluster associations published

Search for Spectral Lines

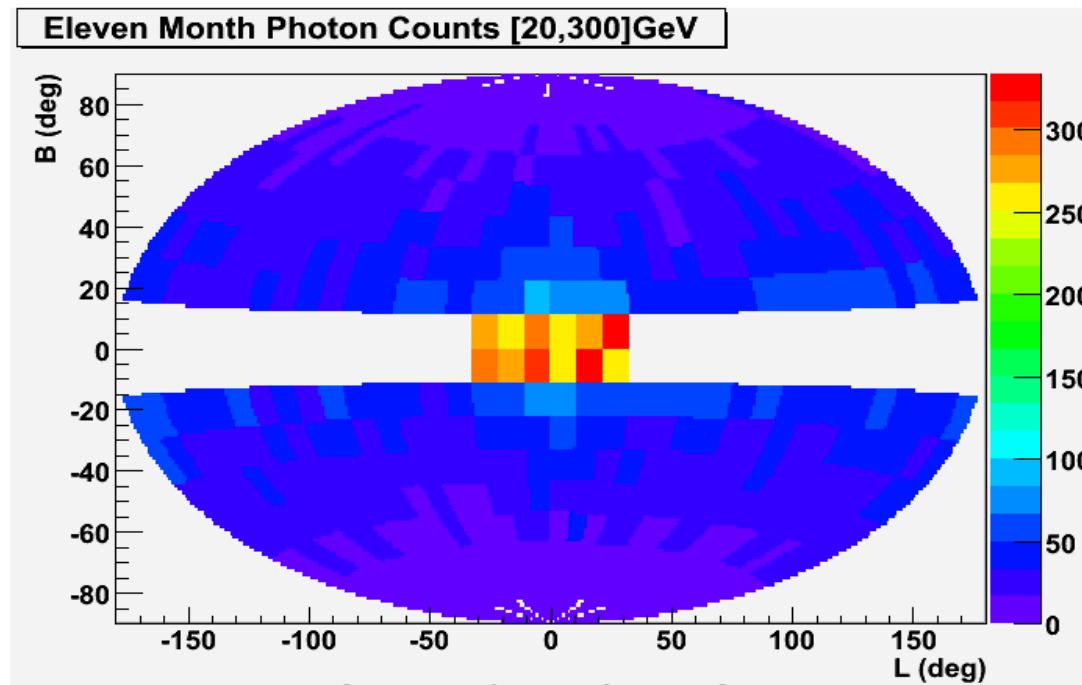


Search for lines in the first 11 months of Fermi data

- high galactic latitude $|b| > 10^\circ$, keep 20° around galactic center

Exclude point sources (for $>1^\circ$ from Gal Center): remove 0.2° radius around the source.

The data selection includes additional cuts compared to standard LAT analyses to remove residual charged particle contamination.

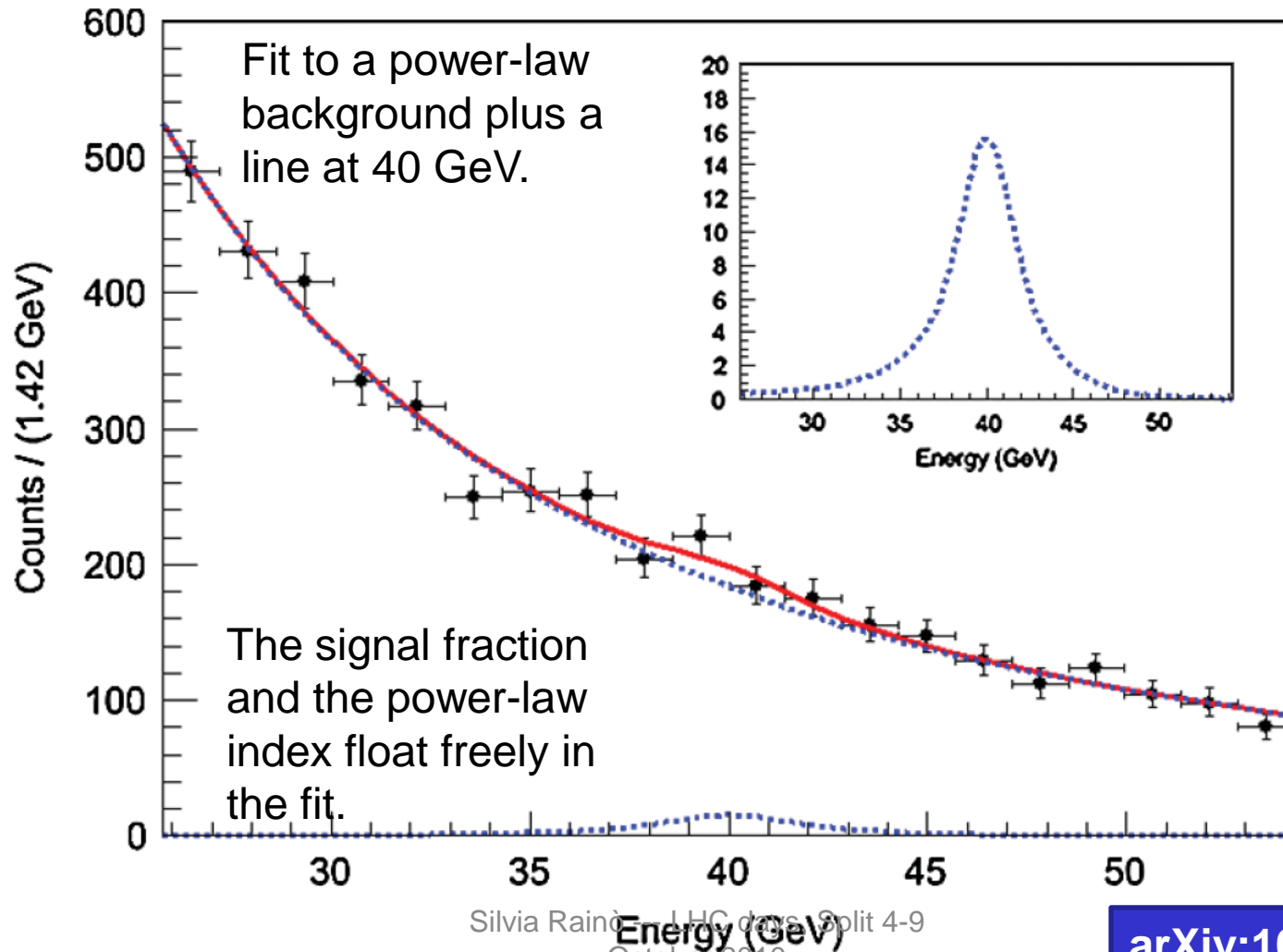


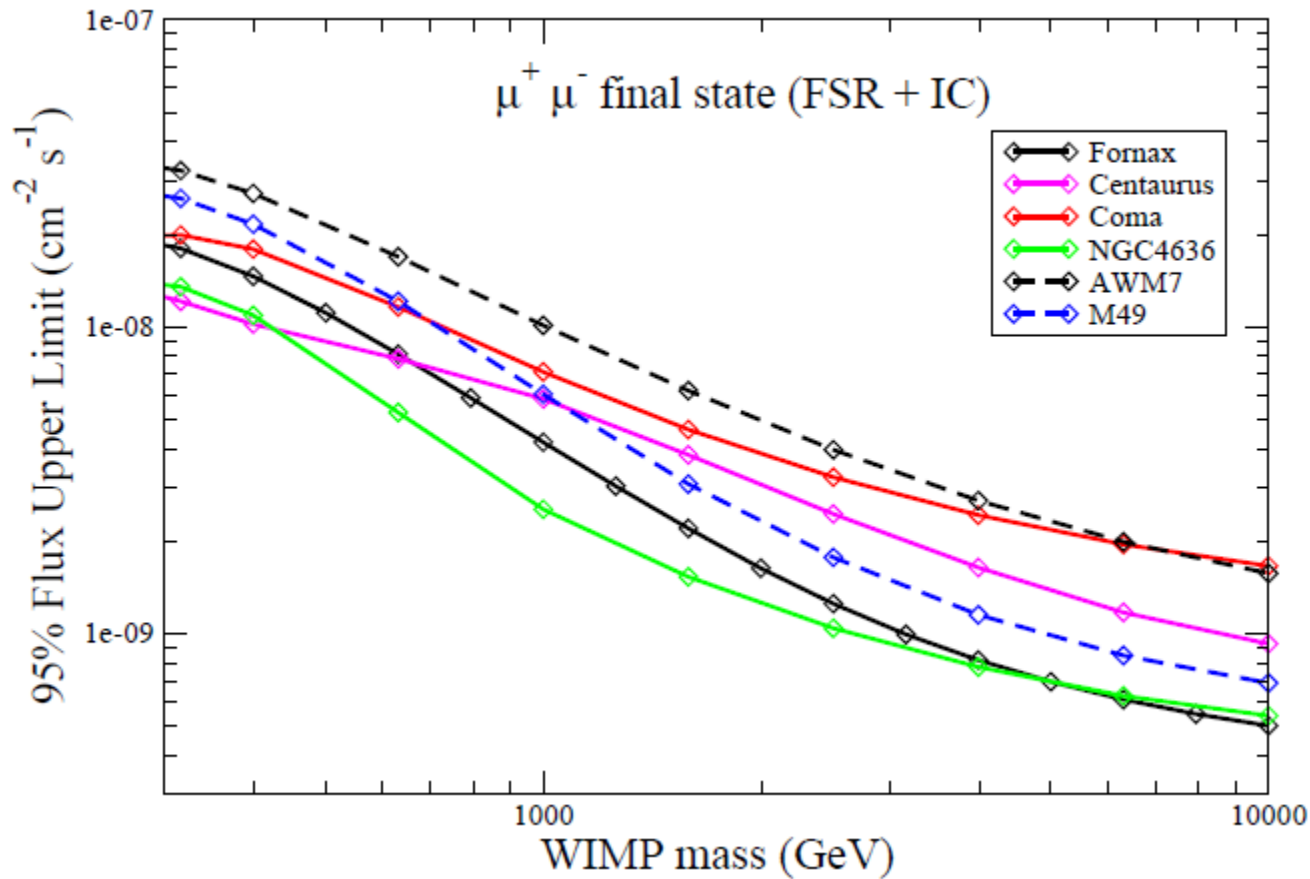
Silvia Rainò --- LHC days, Split 4-9
October 2010



Analysis based on the first 11 months of data.

Example fit, at 40 GeV (the fit with the largest line “signal”)

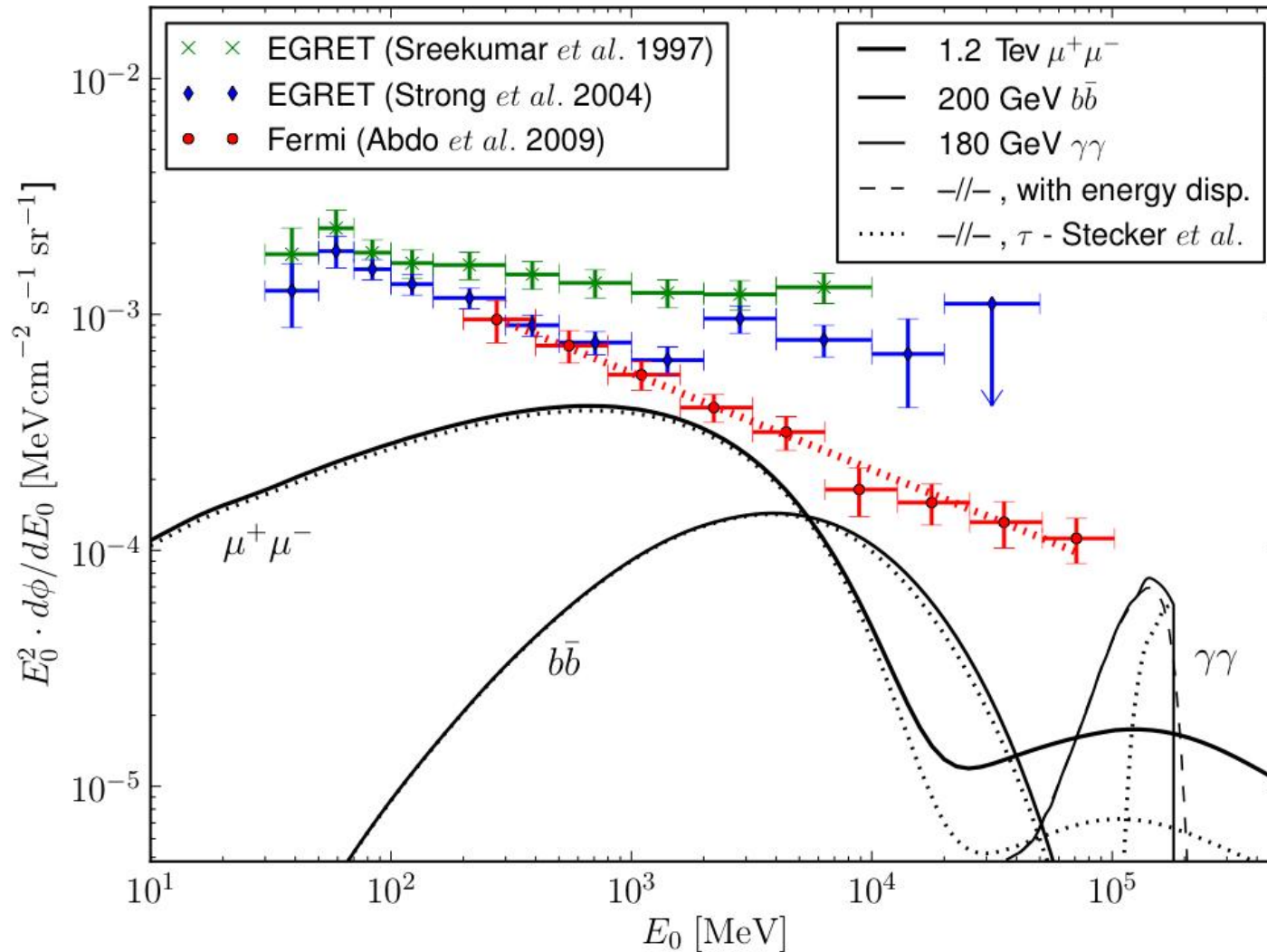




Flux upper limits as a function of particle mass for an assumed $\mu^+\mu^-$ final state, including the contributions of both FSR and IC gamma-ray emission

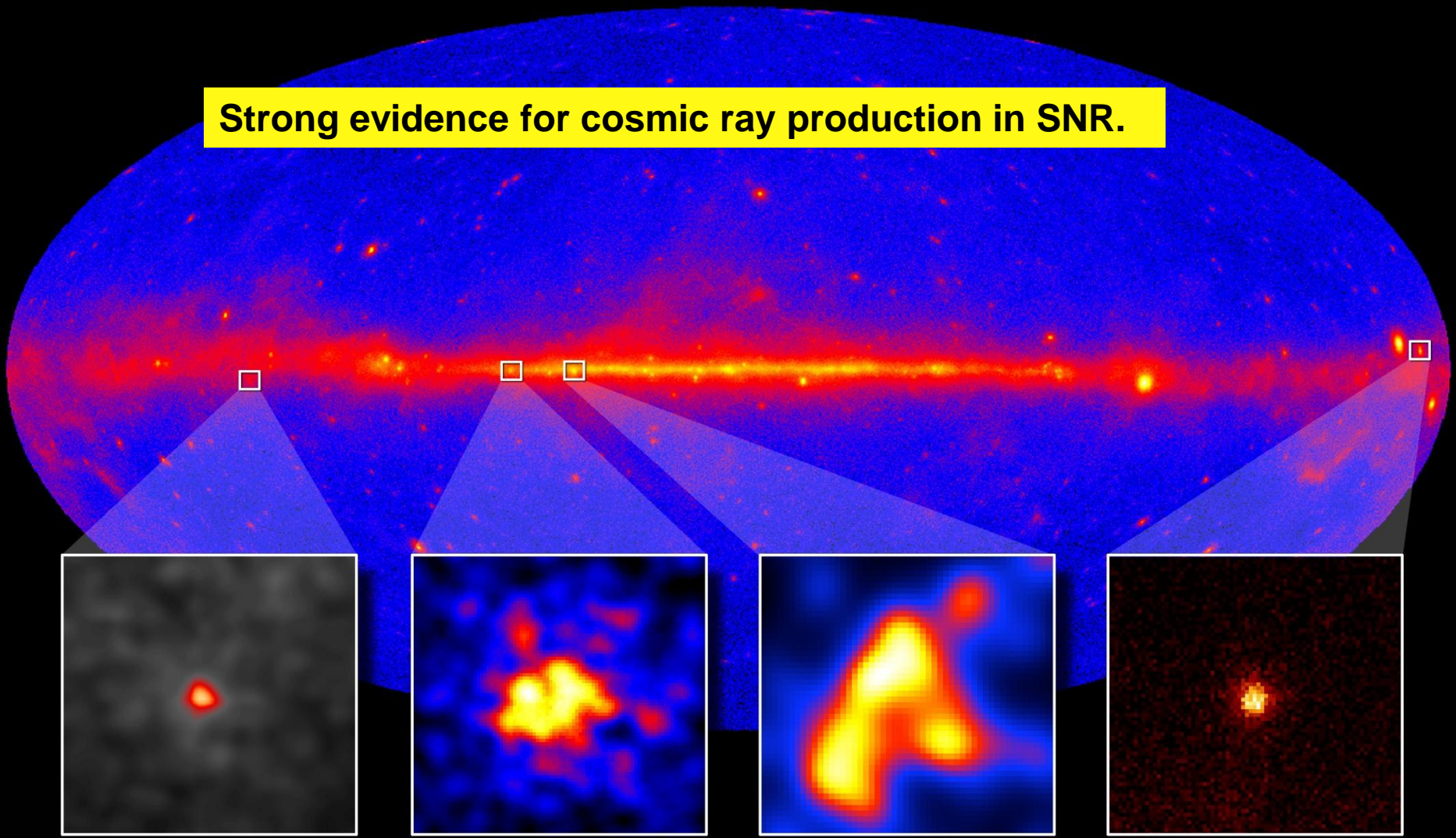


JCAP04, 014 (2010)



Supernova Remnants (SNR) - Spatially Resolved

Strong evidence for cosmic ray production in SNR.



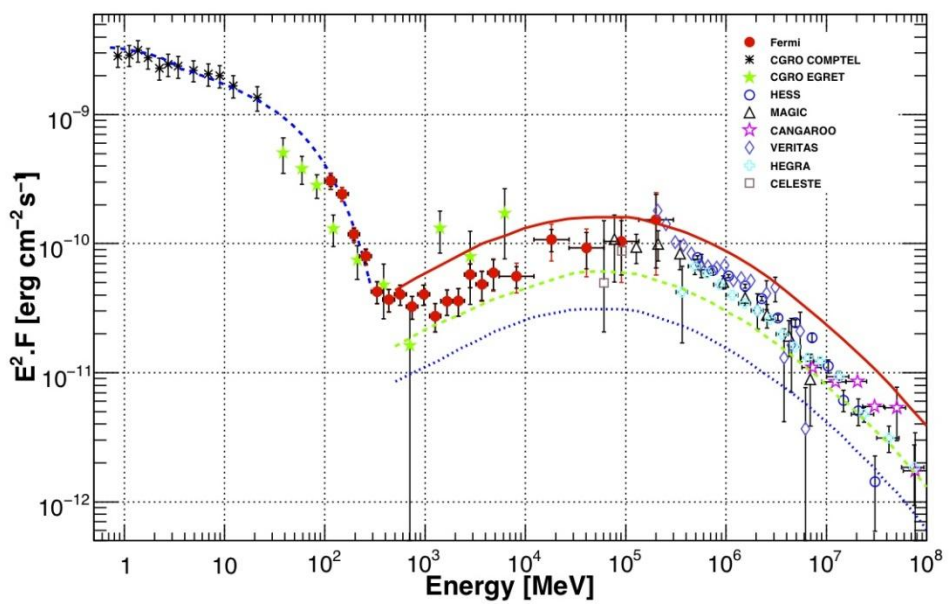
Note: LAT does not resolve Cas A

W51C

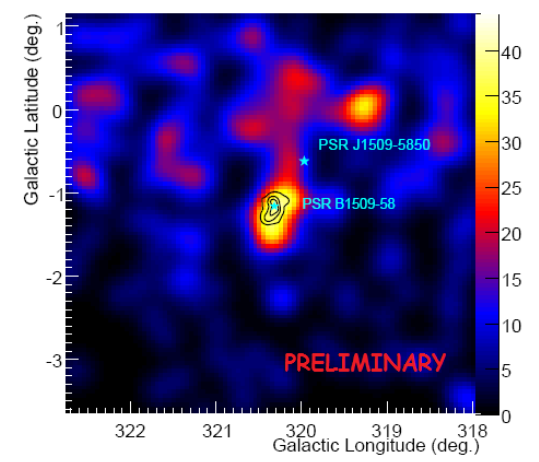
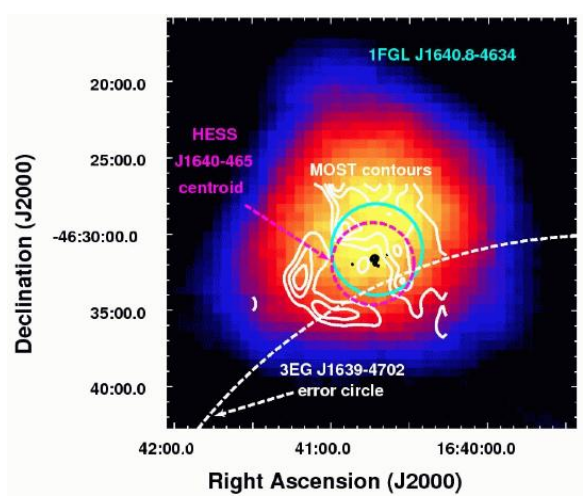
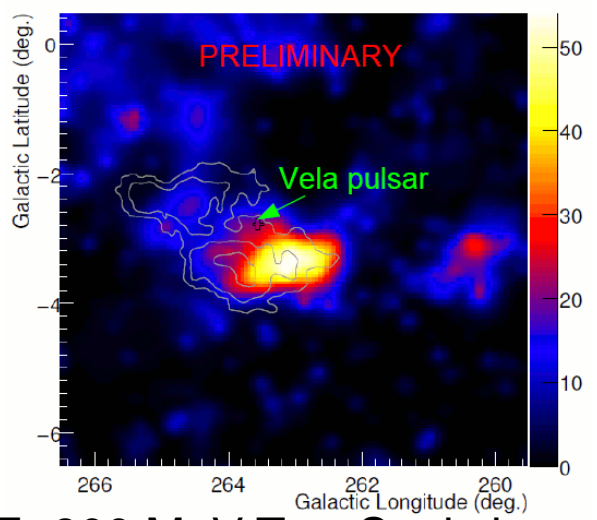
W44

IC 443

Pulsar Wind Nebulae - Powerful Particle Accelerators



Crab Nebula Spectral Energy Distribution. Red points are Fermi LAT data, showing transition from synchrotron to Compton components.



E > 800 MeV Test Statistic (significance) map. PWN Vela X

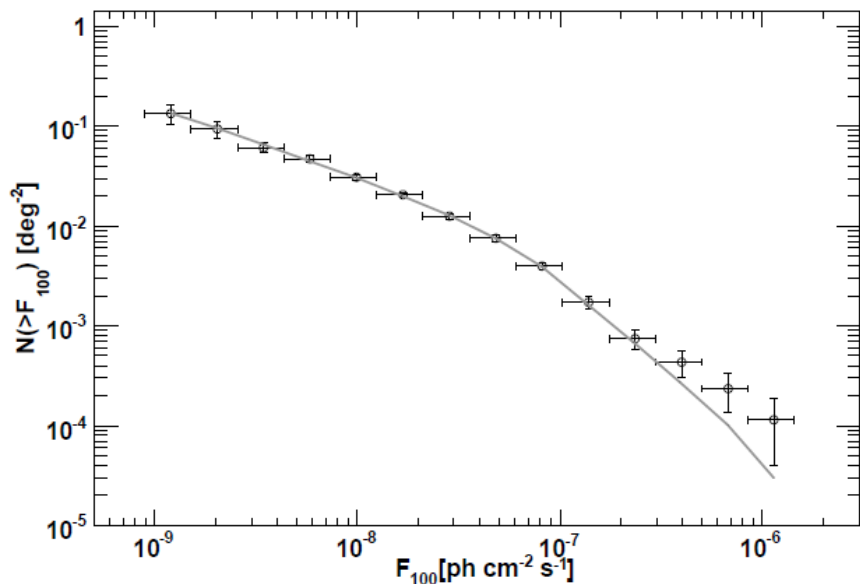
E > 10 GeV counts map. PWN MSH 15-52

Diffuse *NOT* just Unresolved Blazars!



See arXiv:1003.0895

27,144 sq deg! ($b > 20^\circ$)



Fermi LAT Extragalactic Gamma-ray Background

