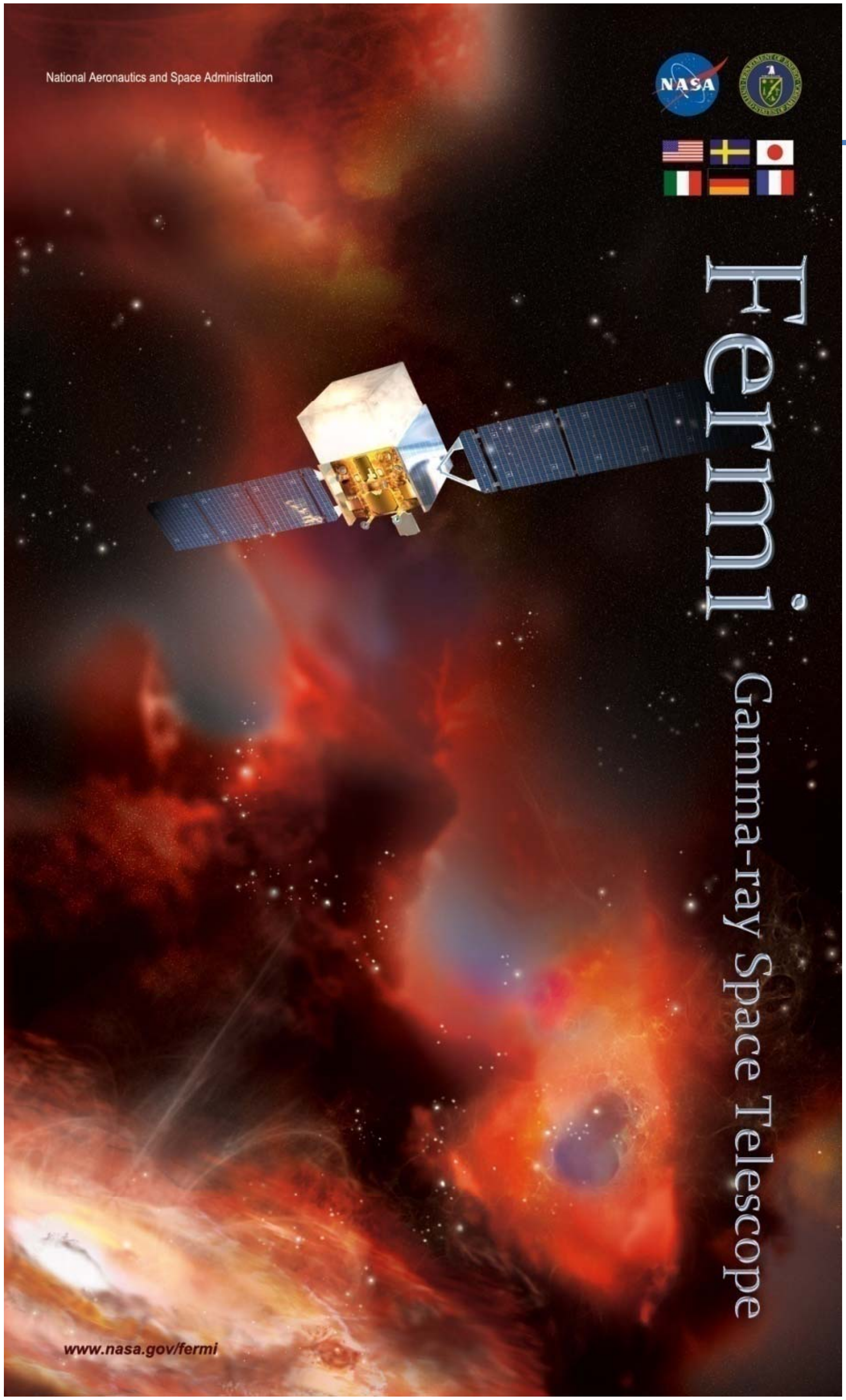


Fermi Space Telescope Highlights

W. B. Atwood
atwood@scipp.ucsc.edu

On behalf of the LAT collaboration

See http://www-glast.stanford.edu/ and links therein


The LAT at 2 Years
Happy 2nd Birthday, Fermi!

Fermi is Making a Major Impact

Science, December 2009

THE

RUNNERS-UP >>

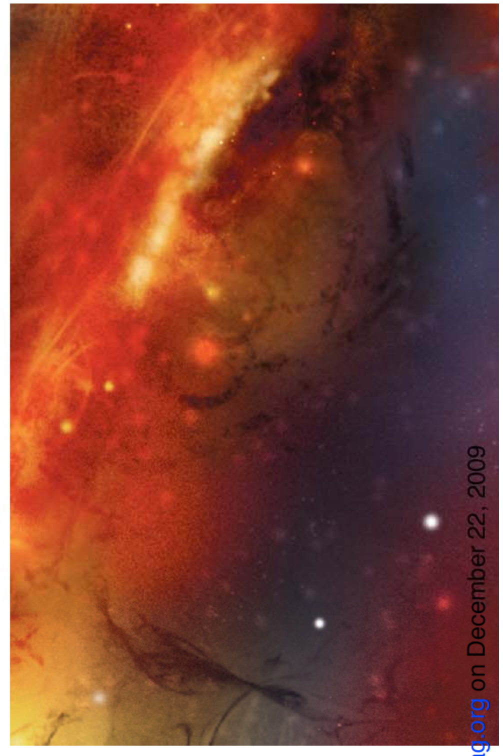
Opening Up the Gamma Ray Sky

LIKE A LIGHTHOUSE BLINKING IN THE NIGHT, A pulsar appears to flash periodically as it spins in space, sweeping a double cone of electromagnetic radiation across the sky. Since the discovery of the first pulsar 4 decades ago, astronomers have detected hundreds more of these enigmatic objects from the pulsing radio waves they emit. Now, astronomers have opened a new channel of discovery—the highly energetic gamma ray spectrum—to find pulsars that radio observations could not detect. The advance, part of a torrent of recent gamma ray observations, is giving researchers an improved understanding of how pulsars work, along with a rich haul of new pulsars that could help in the quest to detect gravitational waves.

The findings come from the Fermi Gamma-ray Space Telescope, which has been mapping the gamma ray universe since it was launched by NASA in June 2008. Combing through data the telescope collected in its first few months, an international team discovered 16 new pulsars; strong gamma ray pulsations from eight previously known pulsars with spin times of milliseconds, proving that these objects pulse brightly at gamma wavelengths as well as in the radio range; and high-energy gamma rays from the globular cluster 47 Tucanae indicating that the cluster harbors up to 60 millisecond pulsars.

Those Fermi results might be just the beginning. Armed with their new knowledge of pulsar behavior, researchers are checking whether some of the unidentified gamma ray sources Fermi has detected might be pulsars. In November alone, teams of astronomers in the United States and France discovered five new millisecond pulsars by training ground-based radio telescopes on candidate objects Fermi had pointed out—a much more targeted search technique than scanning the sky blindly with ground-based radio telescopes.

Gamma ray beams of pulsars are believed to be wider than their radio beams, so in principle a space-based gamma ray telescope should be more likely to encounter and discern a pulsar's sweep than a radio telescope on Earth is. However, Fermi's forerunner—

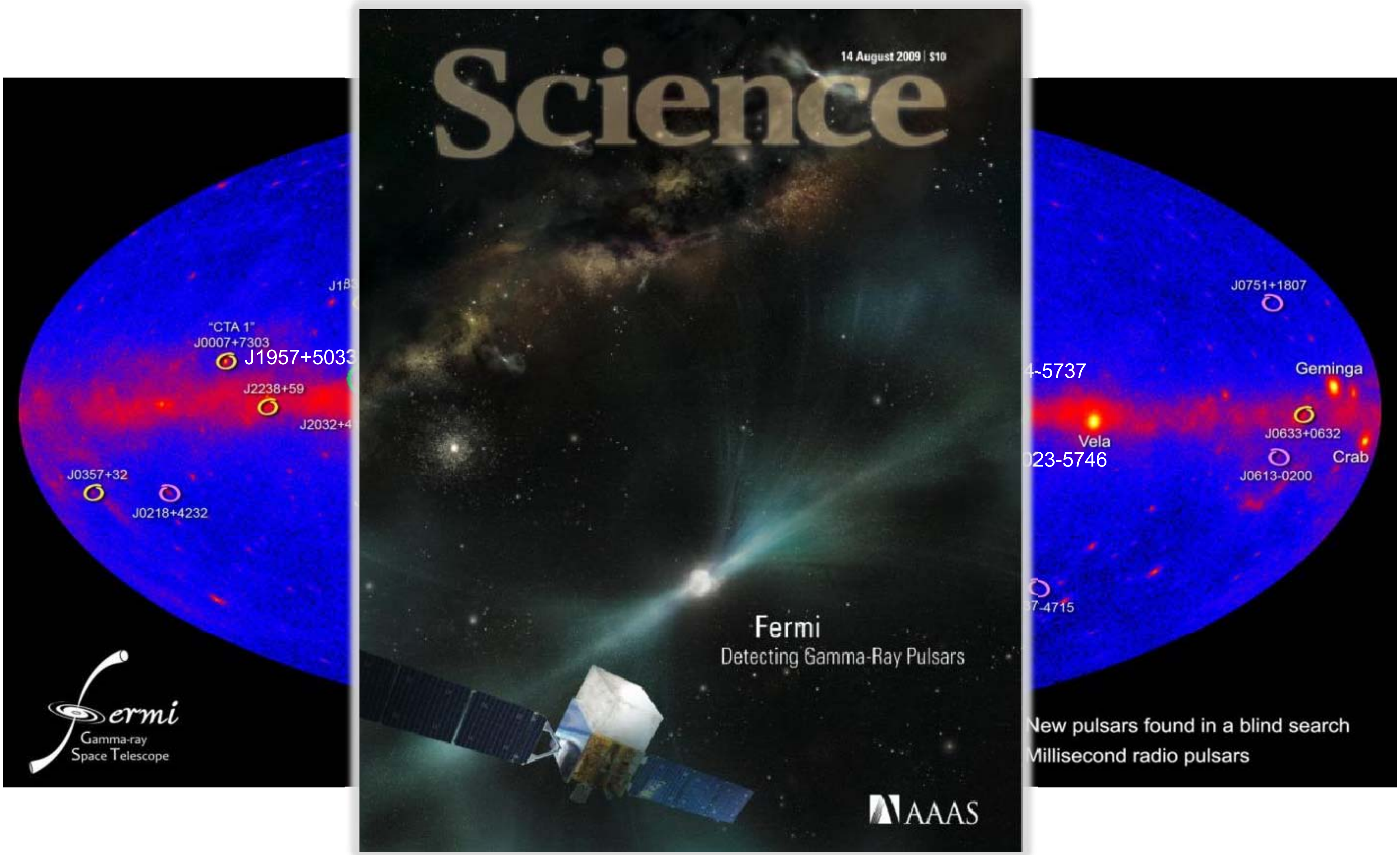


the Compton Gamma Ray Observatory, which flew from 1991 to 2000—did not have much luck finding these objects. What has made the difference is Fermi's high sensitivity, which enables it to detect pulsations that would have been too faint for Compton.

Already, the discoveries are shedding new light on the physics of pulsars. Researchers

Breakthrough of the Year was the reconstruction of the 4.4-million-year-old ***Ardipithecus ramidus*** skeleton

Fermi Pulsars make the Cover of Science



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)

~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.

Highlights Overview

- 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
- Deepest yet searches for Dark Matter signatures in gamma rays
- Many new results on supermassive black hole systems (AGN), including sources never seen in the GeV range
- More cosmic accelerators: Galactic X-ray Binaries and Supernova Remnants. Probing the cosmic ray distributions in other galaxies; LMC, SMC and now M31!
- Extragalactic Background Light constraints
- Year-one Catalog: 1451 sources
- ….

Clearly too much to squeeze into this talk!

Fermi LAT Talks at SciNeGHE 2010

Filippo D'Ammando
Flaring Active Galactic Nuclei

Elena Orlando
Local Gamma Ray Sources seen by Fermi/LAT

Emanuele Bonamente
Dark Matter Search with Fermi: spectral analysis of Unassociated

Claudia Monte
Fermi-LAT view of Intermediate Synchrotron Peaked Blazars

Teddy Cheung
Fermi-LAT Discovery of Gamma-ray Emission Concurrent with the Nova in the Symbiotic Binary V407 Cygni

Germán Arturo Gómez Vargas
Anisotropies in the diffuse gamma-ray background measured by the Fermi-LAT

Silvia Rainò
Fermi Large Area Telescope results from the evaluation of the Gamma-Ray Opacity of the Universe

Keith Bechtol
GeV Observations of Star-Forming Galaxies with the Fermi-LAT

Luigi Tibaldo
The interstellar environment in the outer Galaxy as seen in gamma-rays by Fermi

Lise Escande
Fermi Gamma-ray Space Telescope observations of recent gamma-ray outbursts of 3C 454.3

Pablo Saz Parkinson
Gamma-ray pulsars in the Fermi LAT era

Luis Reyes
Constraining the Opacity of the Universe to Gamma Rays with Fermi

Rolf Buehler
Discovery of a GeV blazar shining through the Galactic plane

Massimiliano Razzano
The gamma-ray pulsar in the Gamma Cygni supernova remnant

Mario Nicola Mazziotta
Electron/Positron Spectrum and Anisotropies search with Fermi-LAT

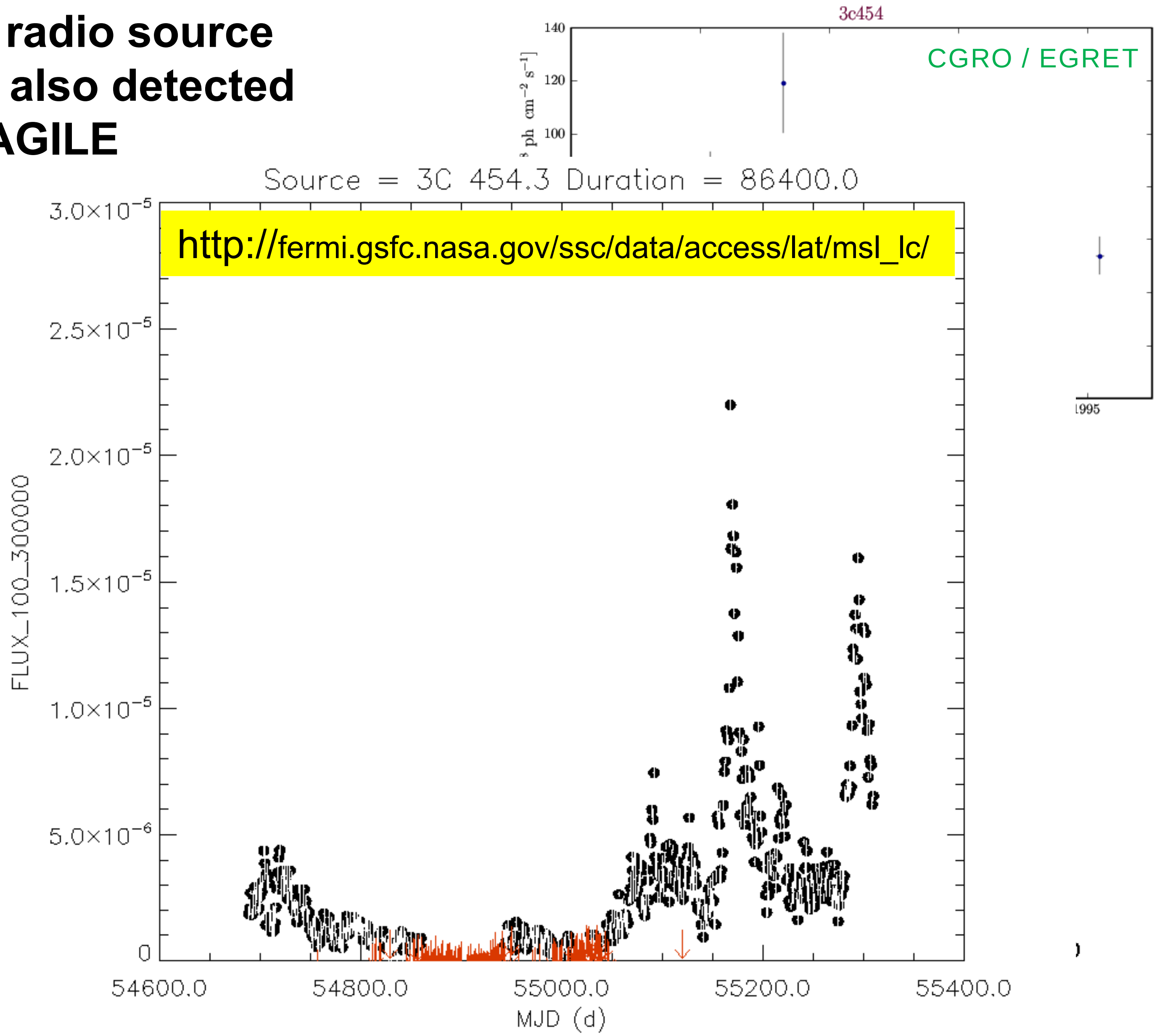
Igor Moskalenko
Galprop code for CR Propagation and Difuse Emission

Monica Brigida
Gamma-ray emission from the Moon as observed by Fermi

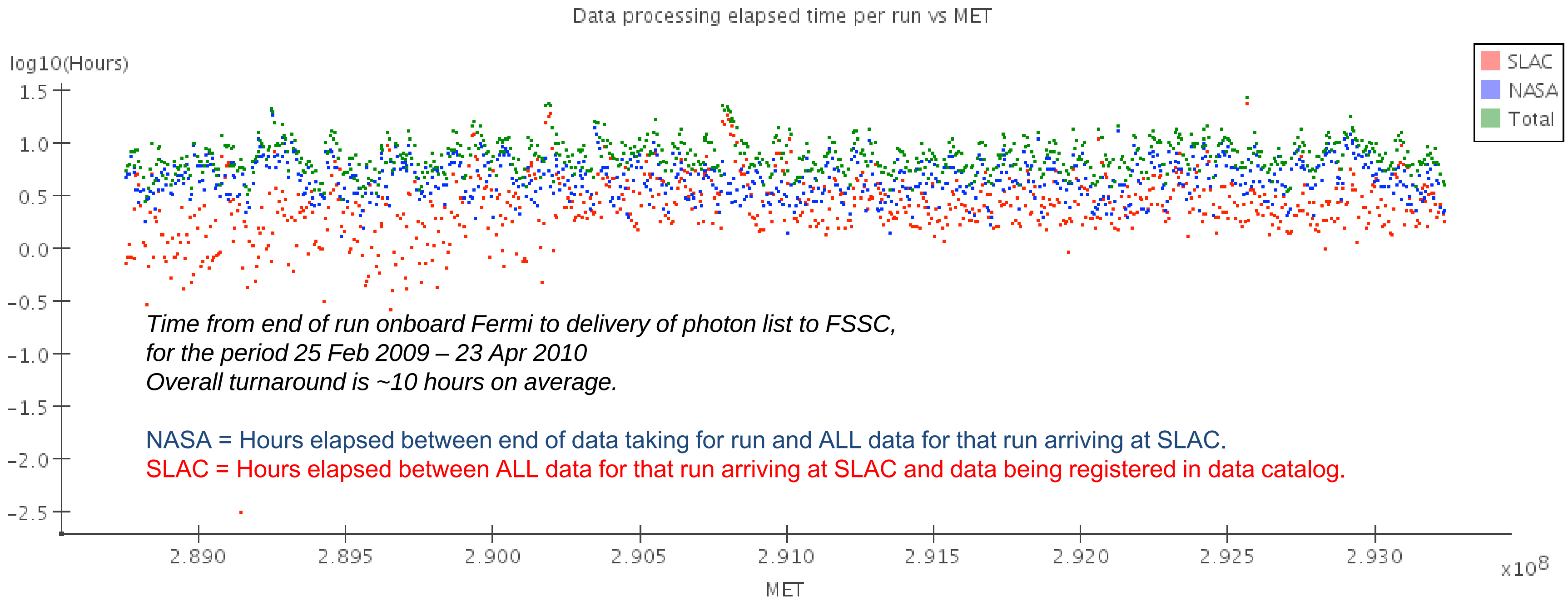
Rolf Buehler
Detecting gamma-ray polarization with the Fermi-LAT

All Sky Monitoring Payoff: 3C454 Flares

- **Well-known radio source at z = 0.859; also detected by EGRET, AGILE**



LAT Operations



Last Feburary - 2010/049 09:59:40 UTC

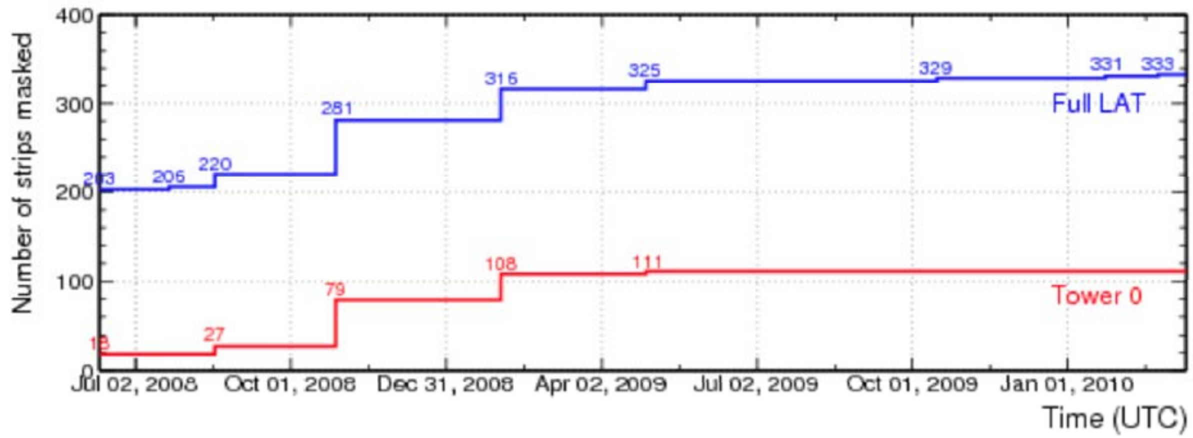
LAT MILESTONE: 100 billion on-orbit triggers

TKR* Very Stable; Performing Beautifully!

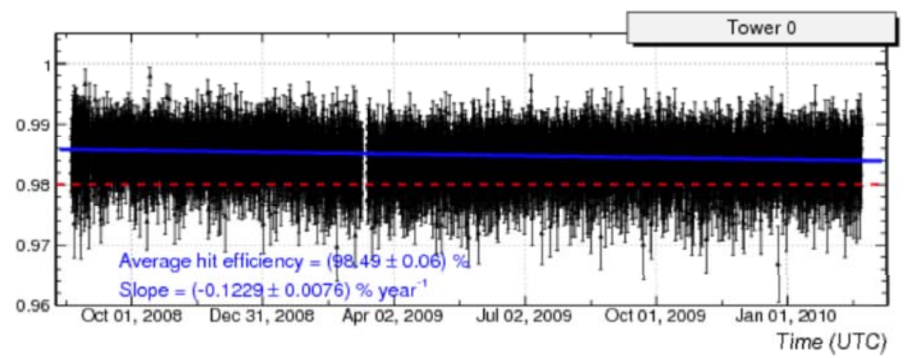
* *Assembled with Pride in Italy*

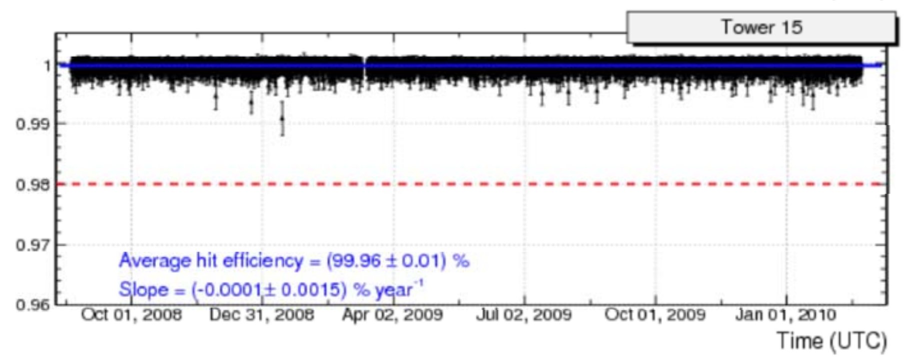
Total number of Silicon Strip Channels: 884736

Fraction Masked: .038 %

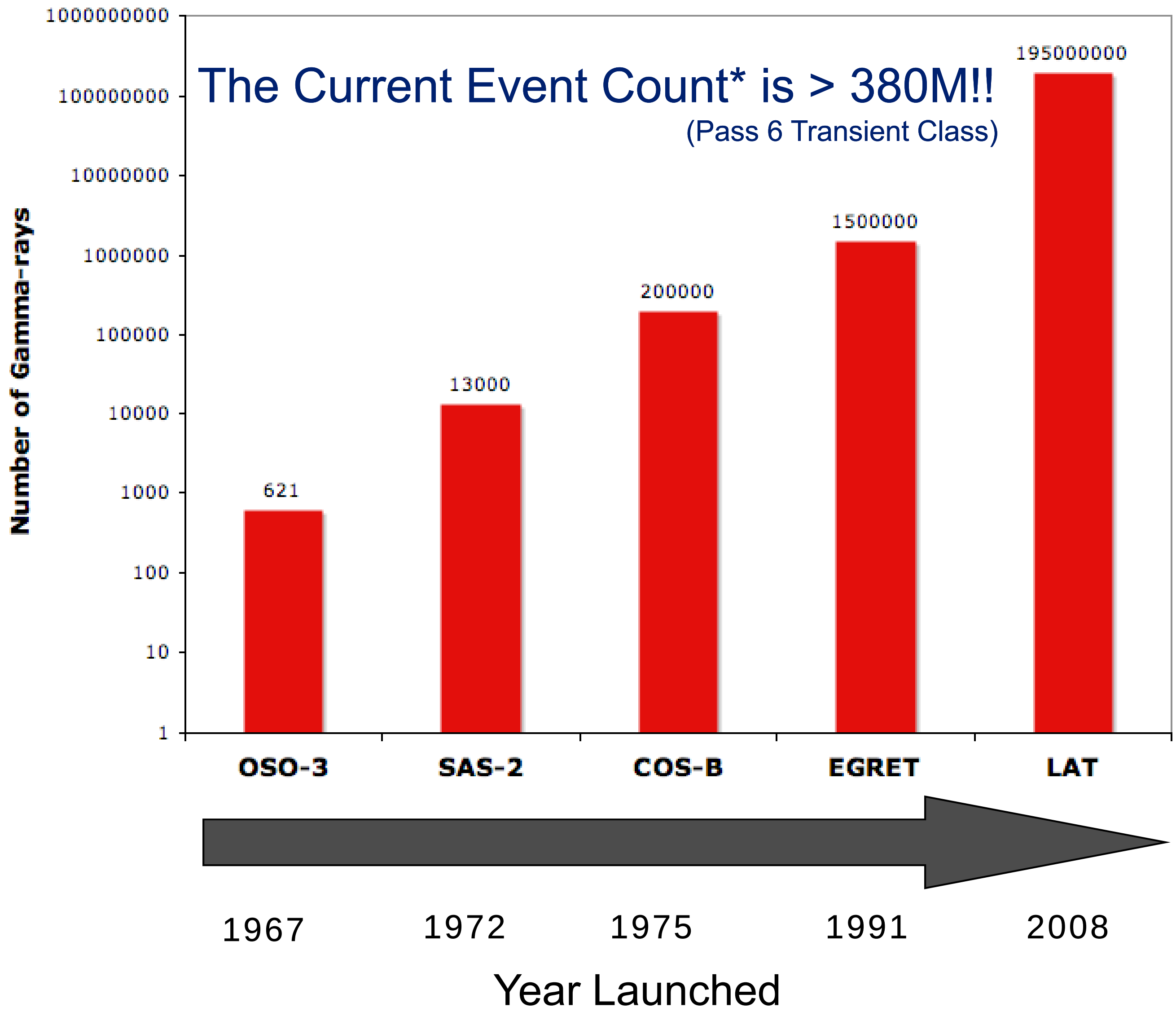


And.. degradation with time *VERY SLOW..*

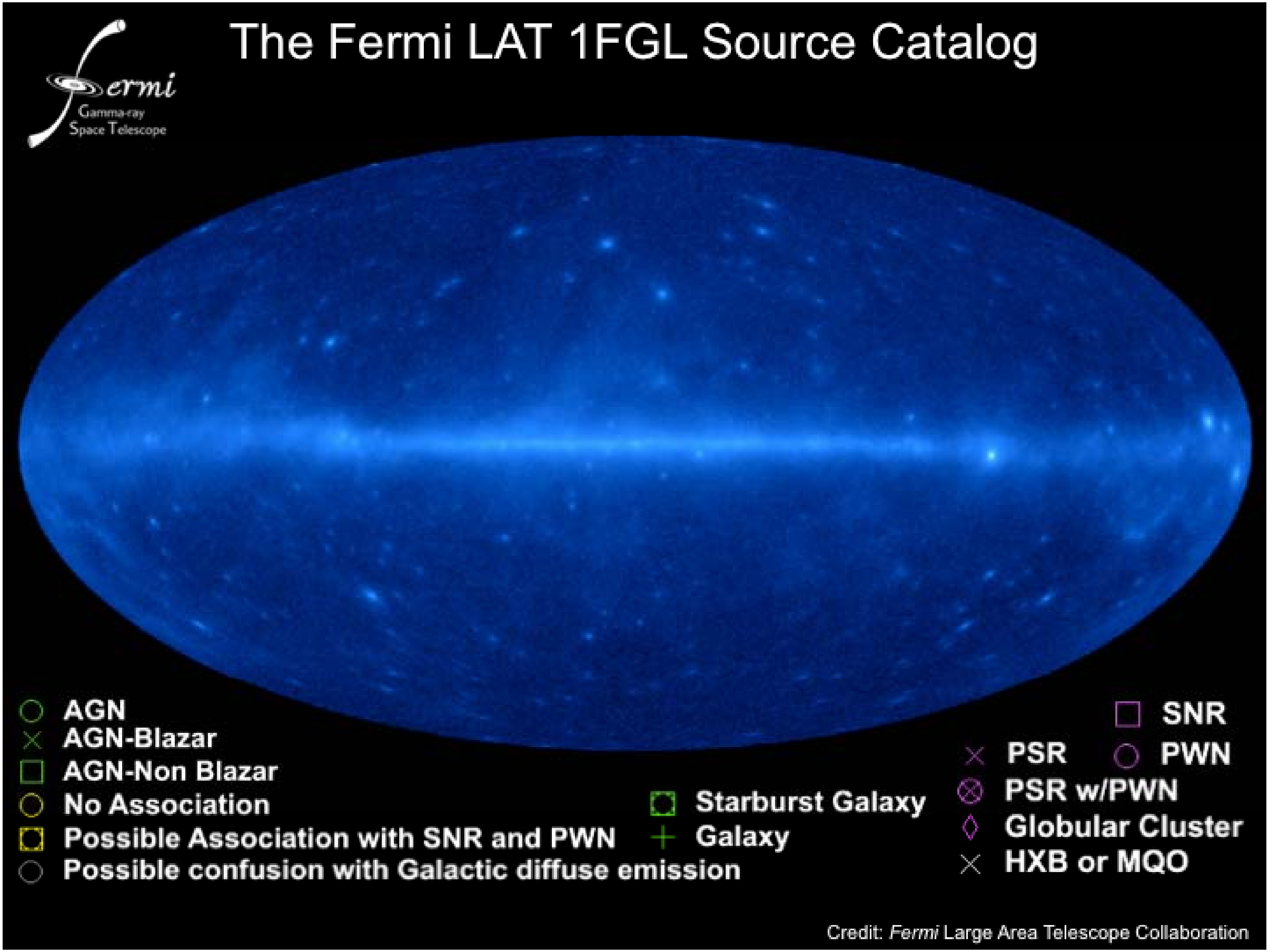




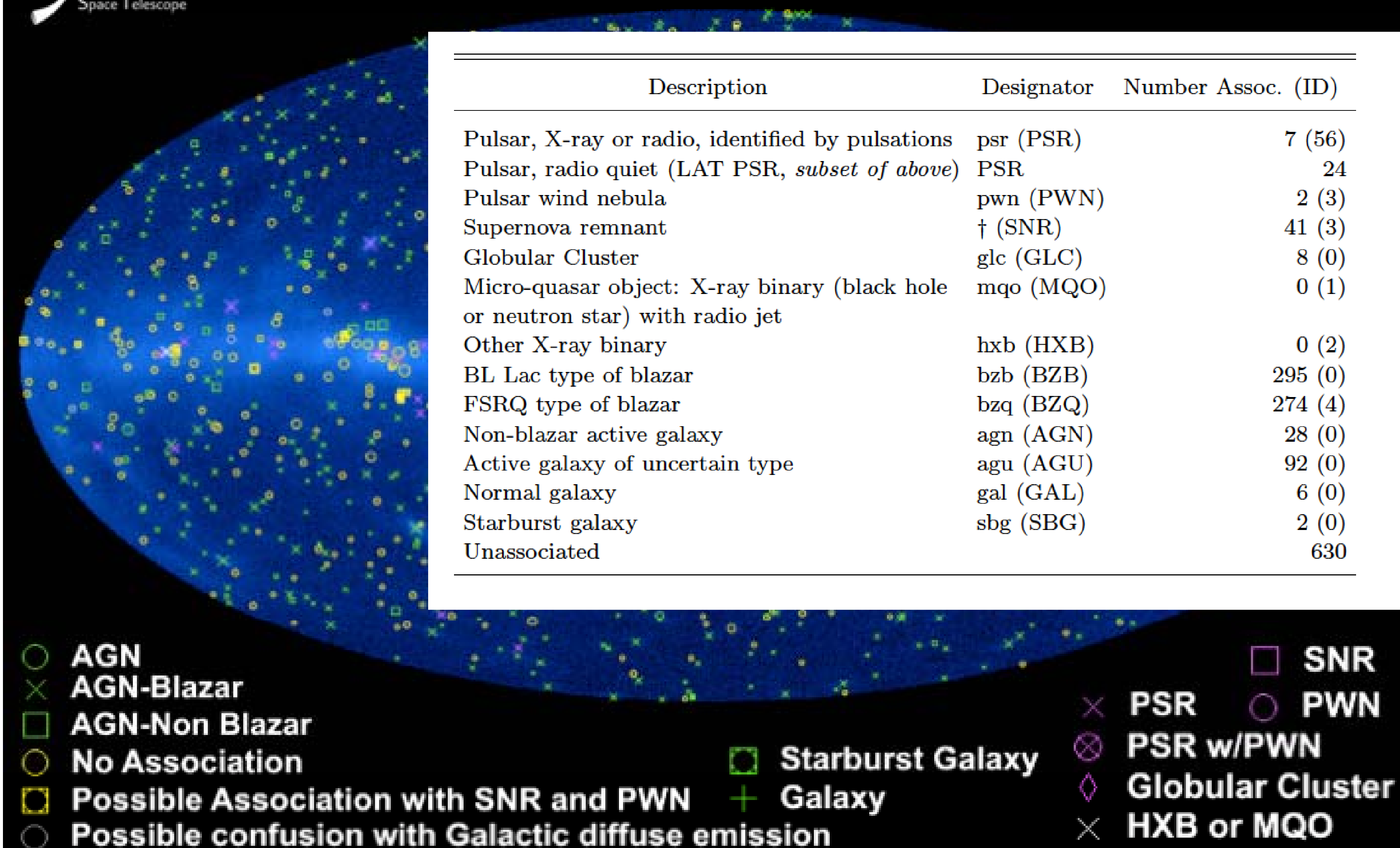
Number of Gammas by Experiment



** Contains some background counts*


The Fermi LAT 1FGL Source Catalog
Fermi
Gamma-ray Space Telescope
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
Credit: Fermi Large Area Telescope Collaboration

The Fermi LAT 1FGL Source Catalog



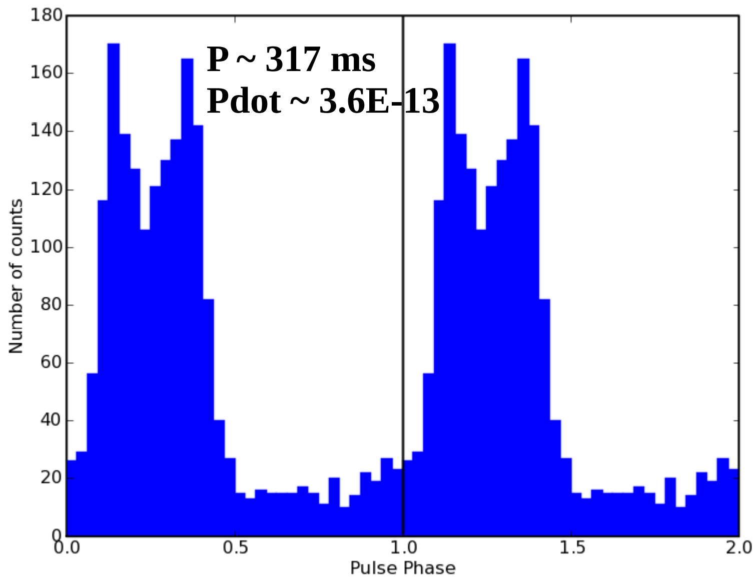
Description	Designator	Number Assoc. (ID)
Pulsar, X-ray or radio, identified by pulsations	psr (PSR)	7 (56)
Pulsar, radio quiet (LAT PSR, *subset of above*)	PSR	24
Pulsar wind nebula	pwn (PWN)	2 (3)
Supernova remnant	† (SNR)	41 (3)
Globular Cluster	glc (GLC)	8 (0)
Micro-quasar object: X-ray binary (black hole or neutron star) with radio jet	mqo (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

Credit: *Fermi* Large Area Telescope Collaboration

Discovery of First Gamma-ray only Pulsar

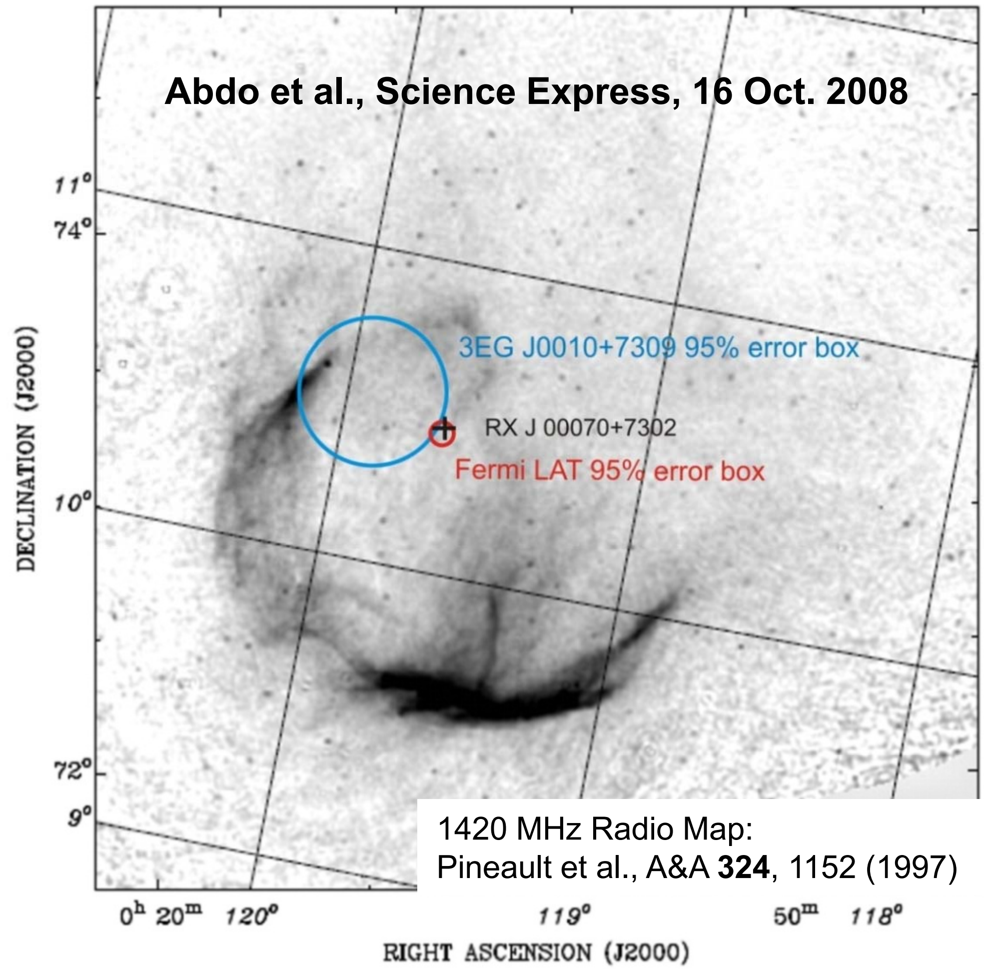
A radio-quiet, gamma-ray only pulsar, in Supernova Remnant CTA1

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.

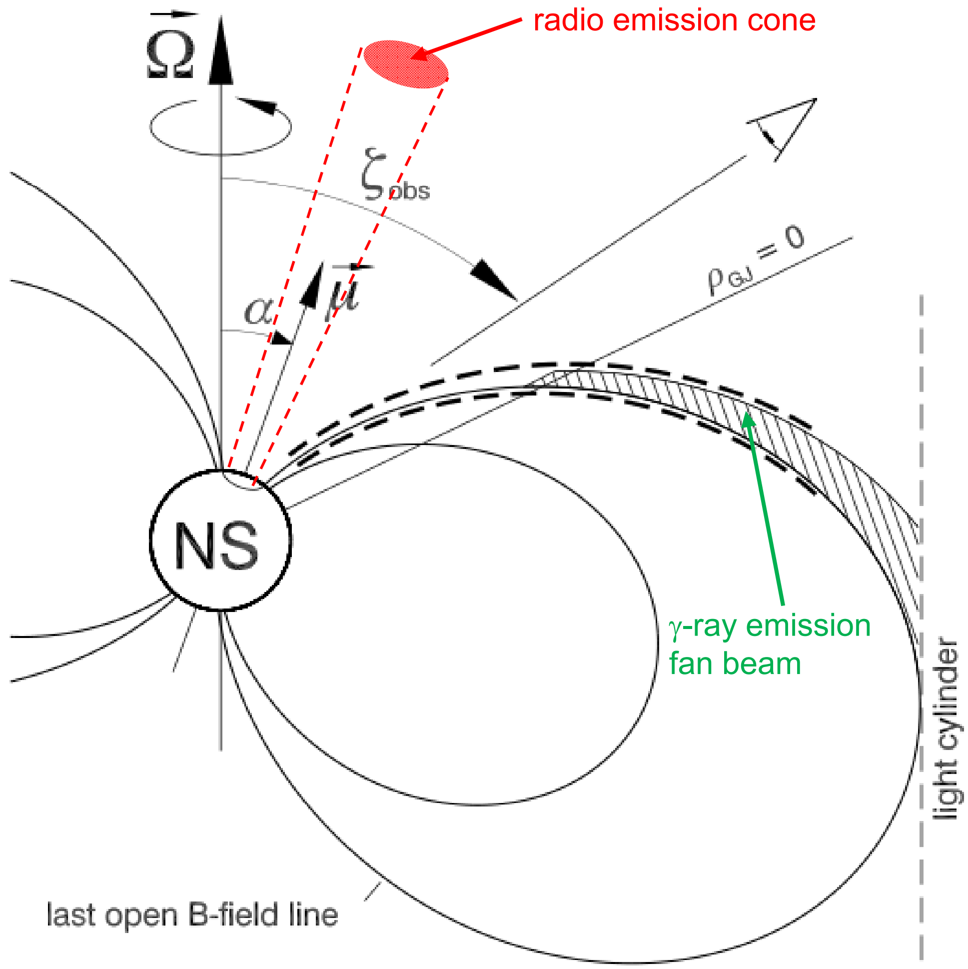
- The γ-ray flux from the CTA 1 pulsar corresponds to about 1-10% of E_{rot} (depending on beam geometry)



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

Pulsar Field Geometry Simplified

Pulsars more often send gamma rays towards earth then radio waves due to beaming effects!



Gamma Ray Pulsar Tally

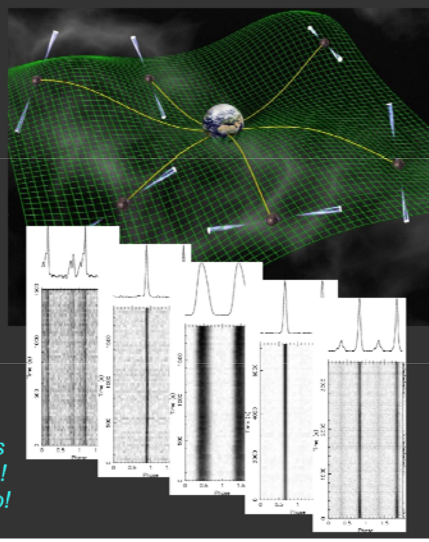
6 - EGRET
65 – LAT Total
> 23 – LAT gamma-ray only
> 18 - LAT seed MSPs

Fermi: millisecond pulsars

Scott Ransom (NRAO), HEAD meeting talk, March 2010

Gravitational Wave Detection with a Pulsar Timing Array

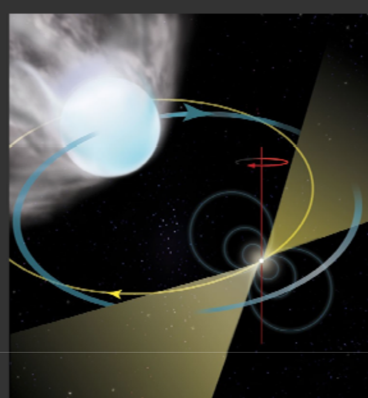
- Need good MSPs
- Significance scales directly with the number of MSPs being timed. Lack of good MSPs is currently the biggest limitation
- Must time the pulsars for 5-10 years at a precision of 0.1-0.2 micro-sec!
- North American (NANOGrav), European (EPTA), and Australian (PPTA) efforts



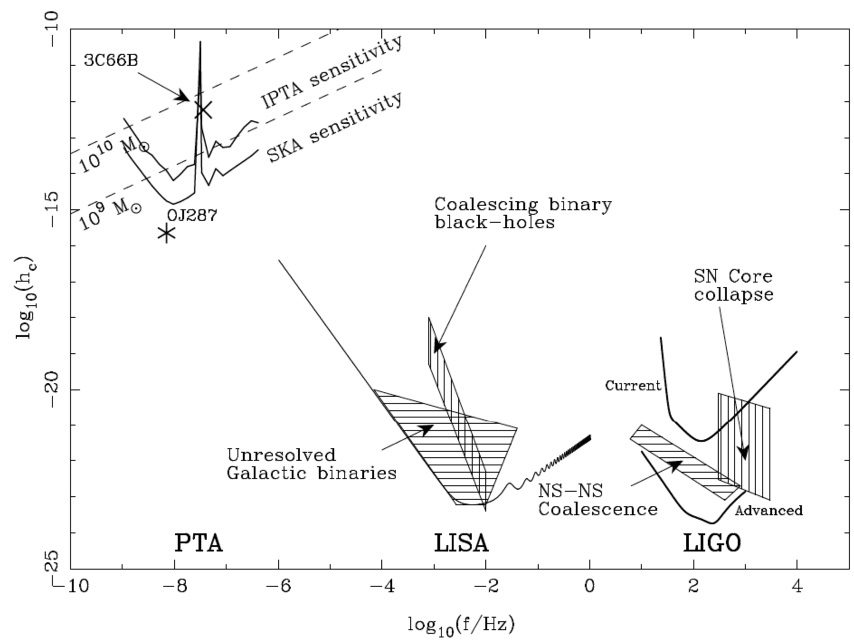
Several of the new MSPs are fast, bright, and sharp! Several visible by Arecibo!

At least *five* new "Black-Widow" Systems

- Have short period orbits (3-10 hr) with very low-mass companions (10-80 Jupiter Masses) which are being ablated by the MSPs
- Previously only 3 of these known in the Galatic disk!
- Another "nearly" black-widow shows eclipses of radio waves
  - Bad for timing, but good for evolution studies



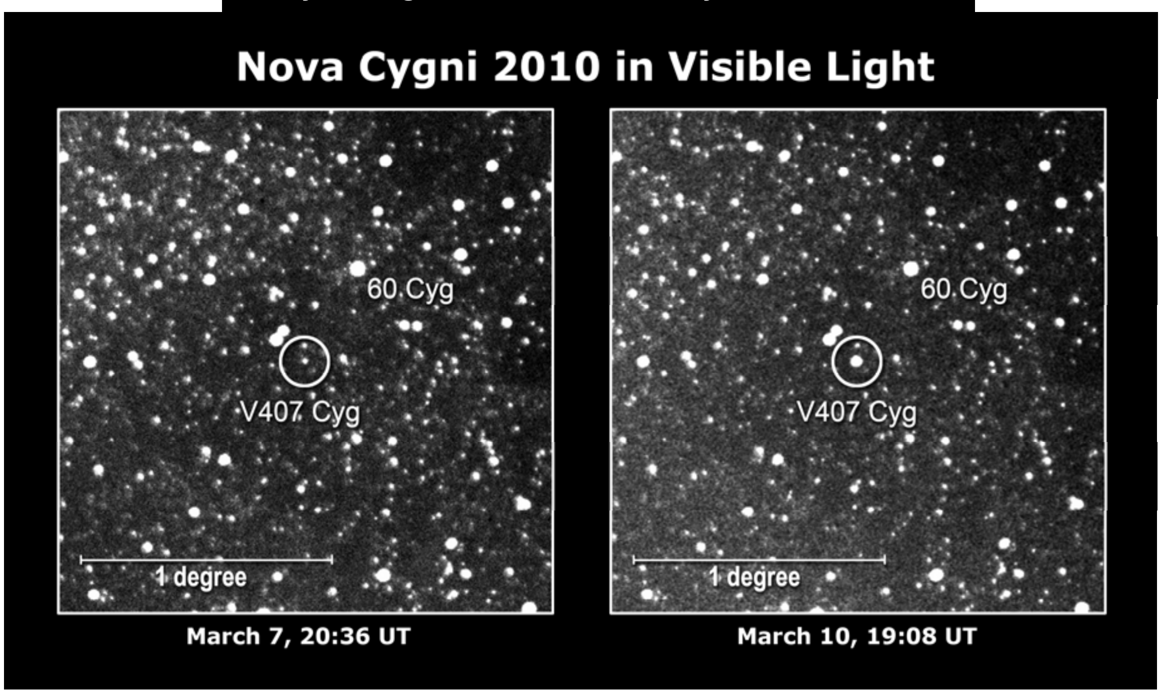
Why are these systems copious gamma-ray emitters?

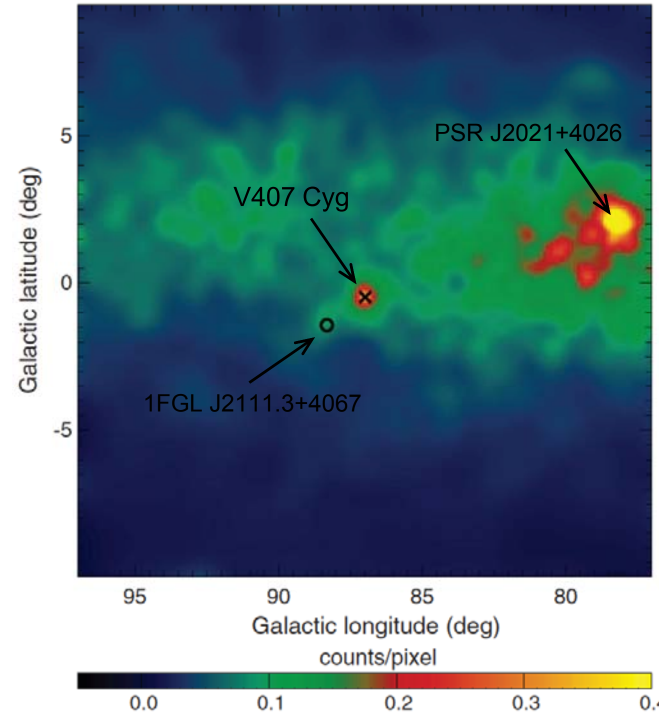


Nature January 14, 2010

t: Nova in V407 Cygni

Amateur astronomers Fujio Kabashima, 68 (left), and Koichi Nishiyama, 70, show off their private observatory in Miyaki, Saga Prefecture, in January. KYODO PHOTO



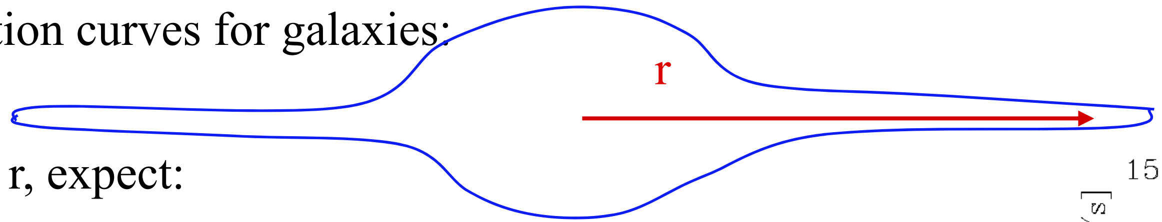


T γ-ray counts map 10-29 March 2010
tical Nova discovery 10 March 2010 (peak
ıg. ~7)
ay peak: 13-14 March 2010

γ-ray emission consistent with Fermi-accelerated electrons and protons in outgoing nova shock expanding into RG wind

The Dark Matter Problem

Observe rotation curves for galaxies:

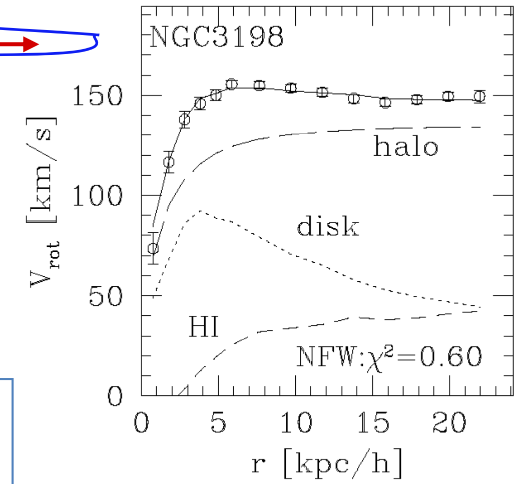


For large r, expect:

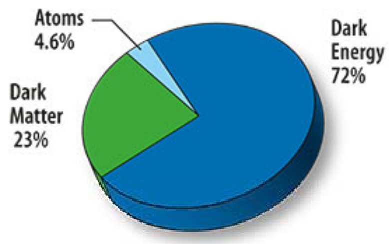
$$G\frac{M}{r^2} = \frac{v^2(r)}{r} \qquad v(r) \sim \frac{1}{\sqrt{r}}$$

see: flat or rising rotation curves

Begeman/Navarro



Hypothesized Solution: the visible galaxy is embedded in a much larger halo of dark matter.



Credit: NASA/WMAP team

Famous Bullet Cluster

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!

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

Fermi Gamma-ray Space Telescope

Many Places to Seek DM!

Galactic Center

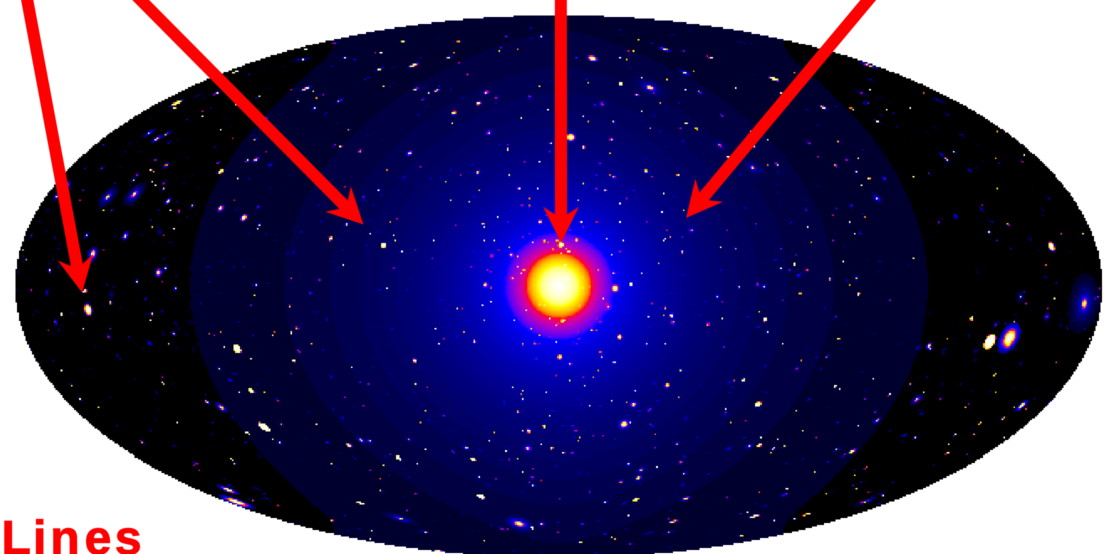
Good Statistics but source confusion/diffuse background

Satellites

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

Milky Way Halo

Large statistics but diffuse background



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

Spectral Lines

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

Extra-galactic

Large statistics, but astrophysics, galactic diffuse background

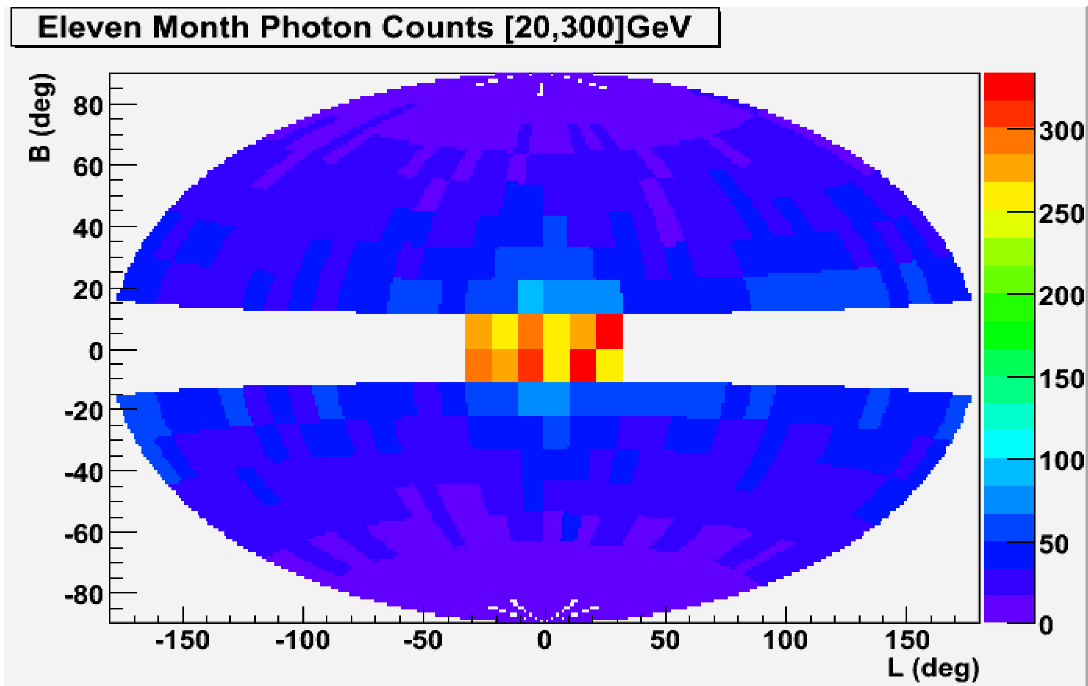
Search for Spectral Lines

Search for lines in the first 11 months of Fermi data

- **|b|>10°, keep 20° around galactic center**

Exclude point sources (for >1° from Galactic Center): remove 0.2° radius around the source, PSF =0.1° at 20 GeV

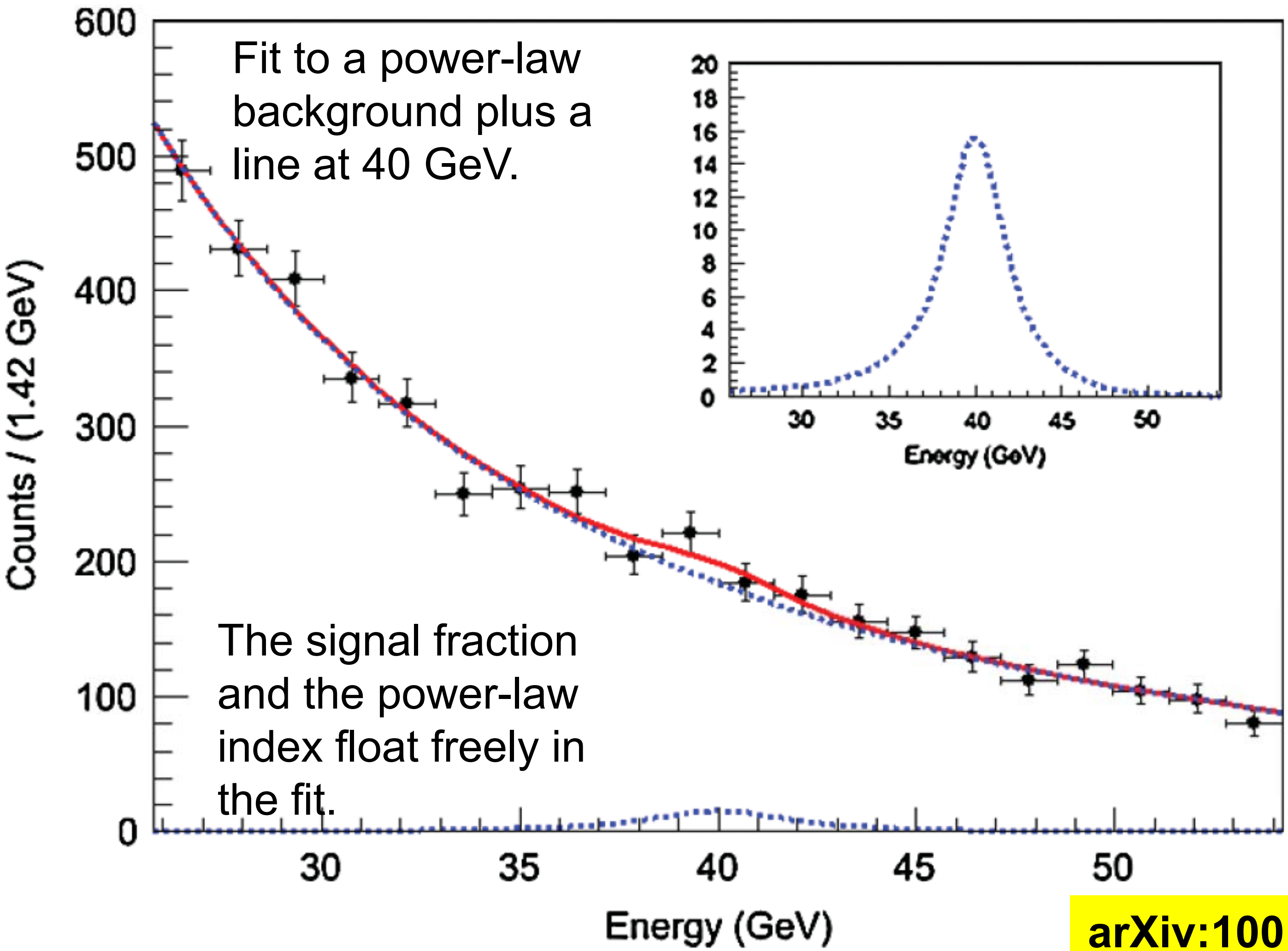
The data selection includes additional cuts compared to standard LAT analyses to reduce residual charged particle contamination.



DM Gamma-Ray Line Search

Analysis based on the first 11 months of data.

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



arXiv:1001.4836

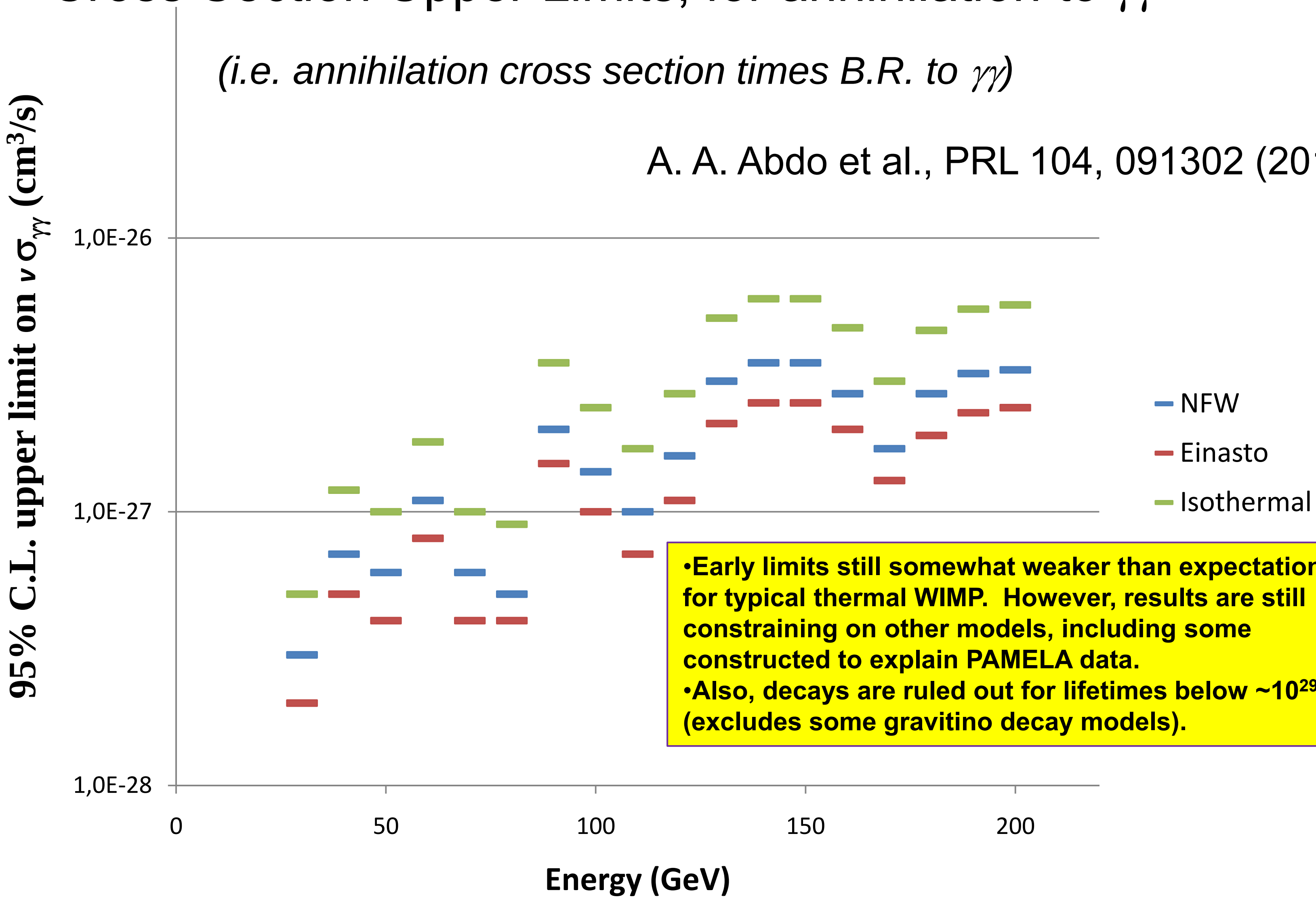
Fermi Gamma-ray Space Telescope

Gamma-ray Line Search Limits

Cross Section Upper Limits, for annihilation to $\gamma\gamma$

(i.e. annihilation cross section times B.R. to $\gamma\gamma$)

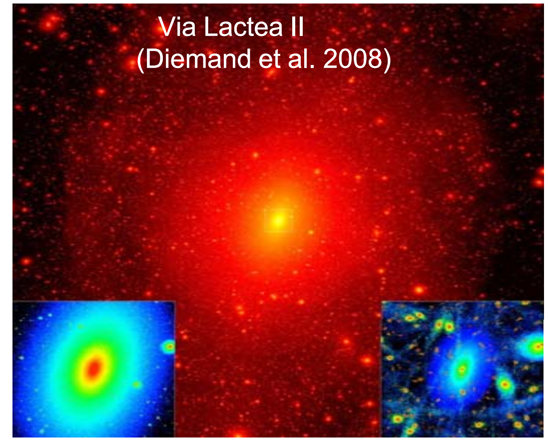
A. A. Abdo et al., PRL 104, 091302 (2010)



•Early limits still somewhat weaker than expectations for typical thermal WIMP. However, results are still constraining on other models, including some constructed to explain PAMELA data.
•Also, decays are ruled out for lifetimes below ~10^{29}s (excludes some gravitino decay models).

Search for DM Subhalos : Two Kinds

DM substructures: very low background targets for DM searches



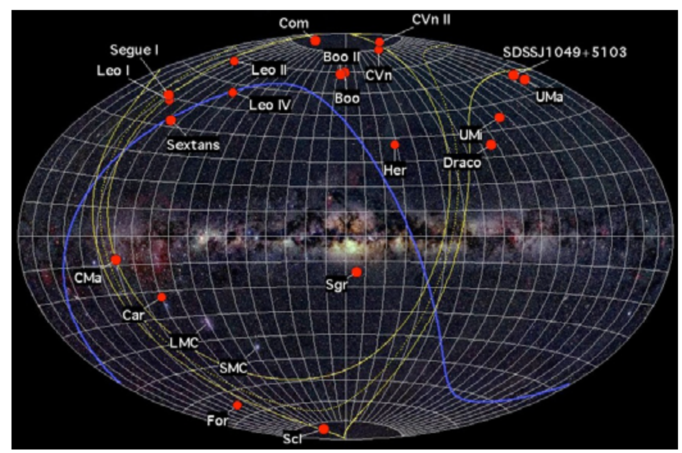
Never before observed DM substructures (DM Satellites)

- **Would significantly shine only in radiation produced by DM annihilations or decays**
- **Search for promising candidates in the Fermi sky**
- **Some of these satellites could be within a few kpc from the Sun (N-body simulations). Their extension could be resolved by the LAT**
- **Only upper limits so far,**

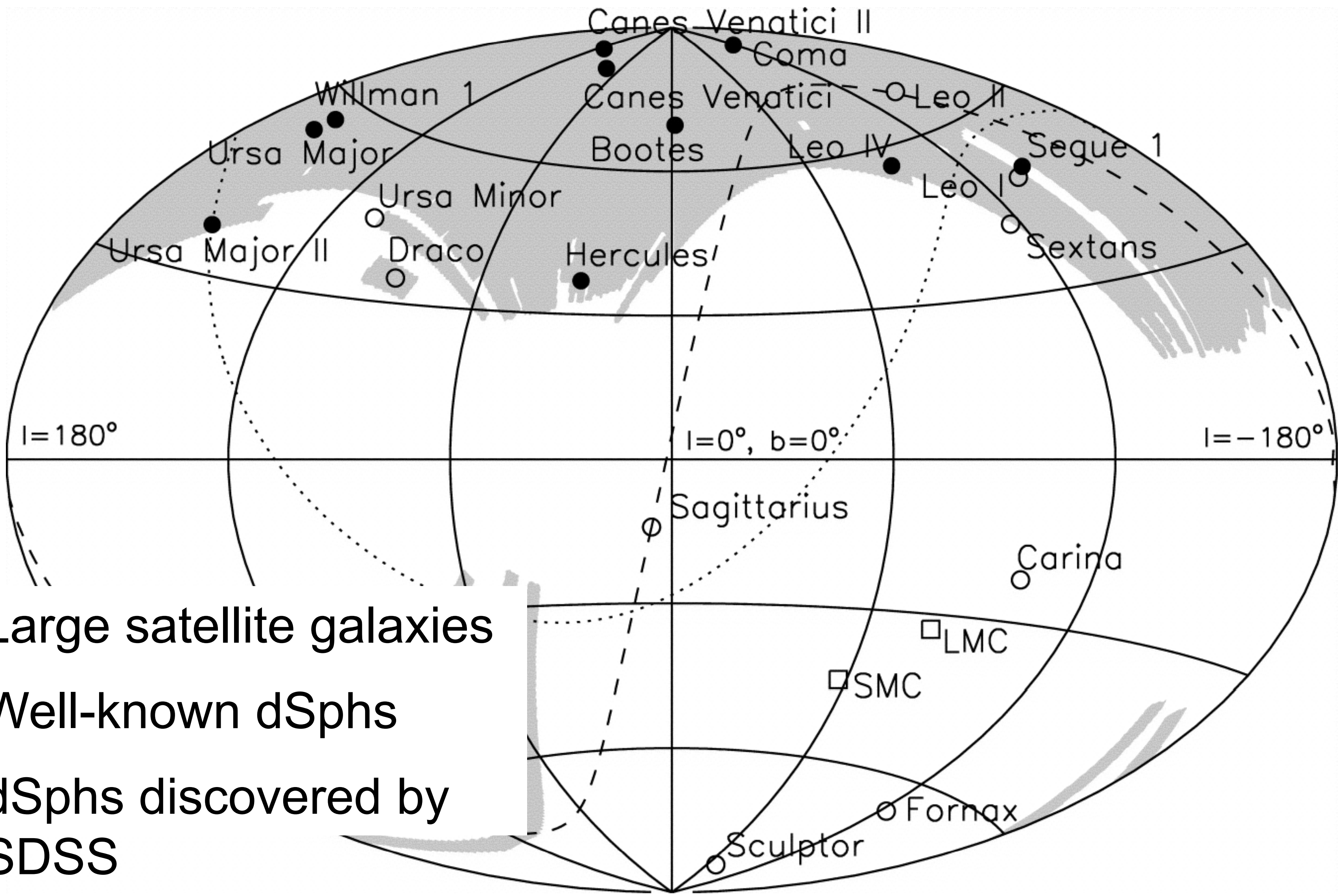
Optically observed Dwarf Spheroidal Galaxies (dSph)

- **Most are expected to be free from other astrophysical gamma ray sources and have low content in dust/gas, very few stars**
- **Select most promising candidates**
- **Given the distance and the LAT PSF, they are expected to be consistent with pointlike objects**

Abdo et al. (2010),
http://adsabs.harvard.edu/abs/2010ApJ...712..147A



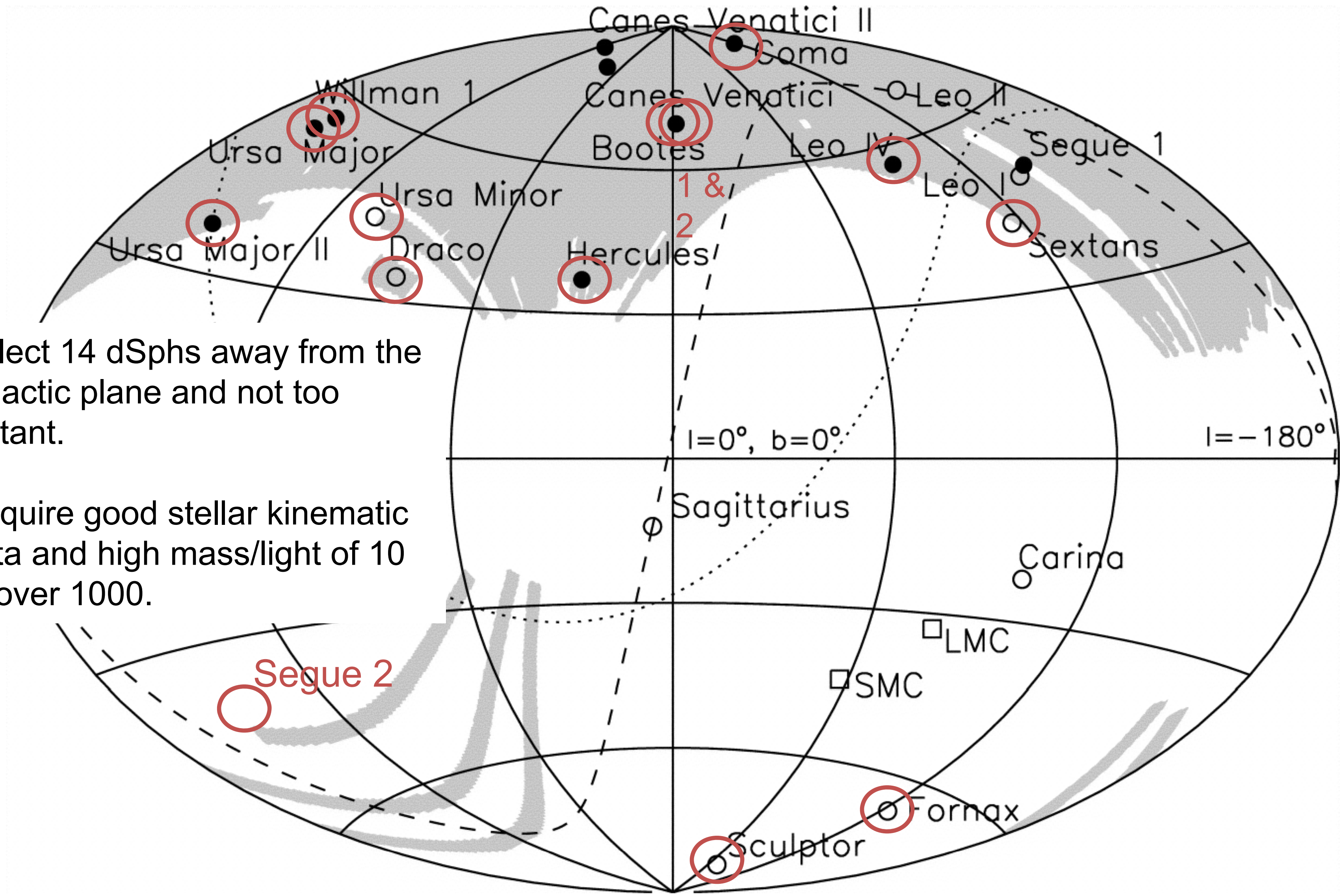
Dwarf Spheroidal Galaxies



- □ Large satellite galaxies
- ○ Well-known dSphs
- ● dSphs discovered by SDSS

Belokurov, V., et al. 2007, ApJ, 654, 897

Dwarf Spheroidal Galaxies



Select 14 dSphs away from the galactic plane and not too distant.

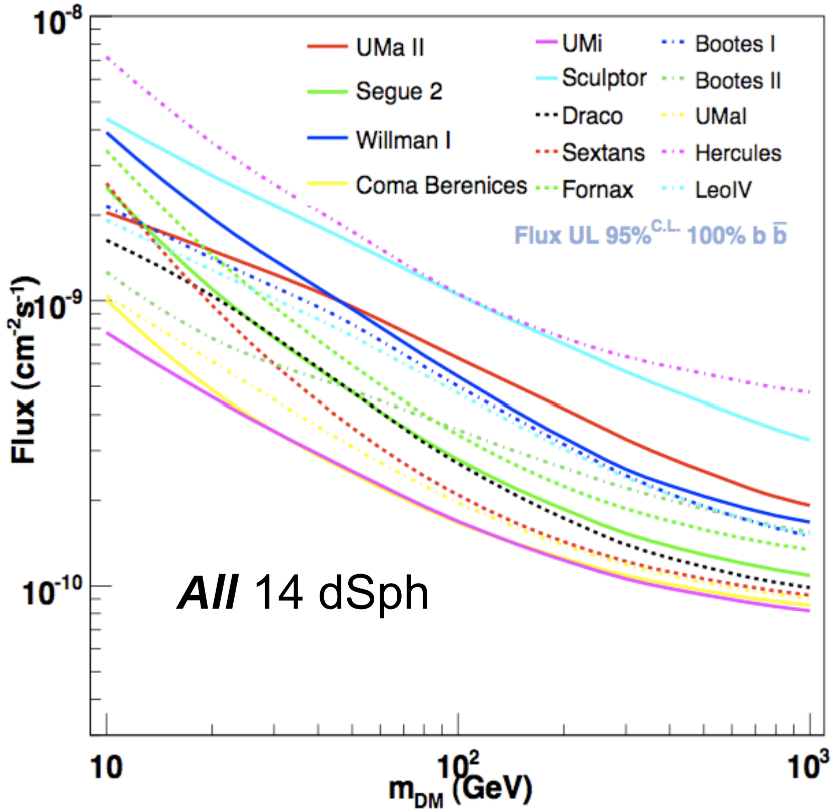
Require good stellar kinematic data and high mass/light of 10 to over 1000.

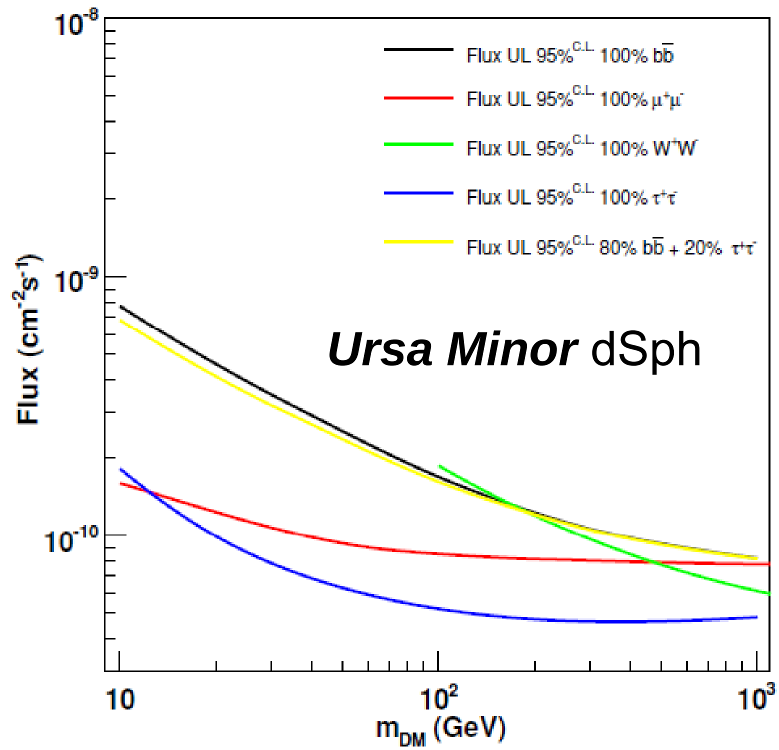
Belokurov, V., et al. 2007, ApJ, 654, 897

Limits for DM in dSph

A.A. Abdo et al., ApJ 712 (2010) 147.

No detection by Fermi (100 MeV – 50 GeV) with 11 months of data. 95% flux upper limits are placed for several possible annihilation final states.

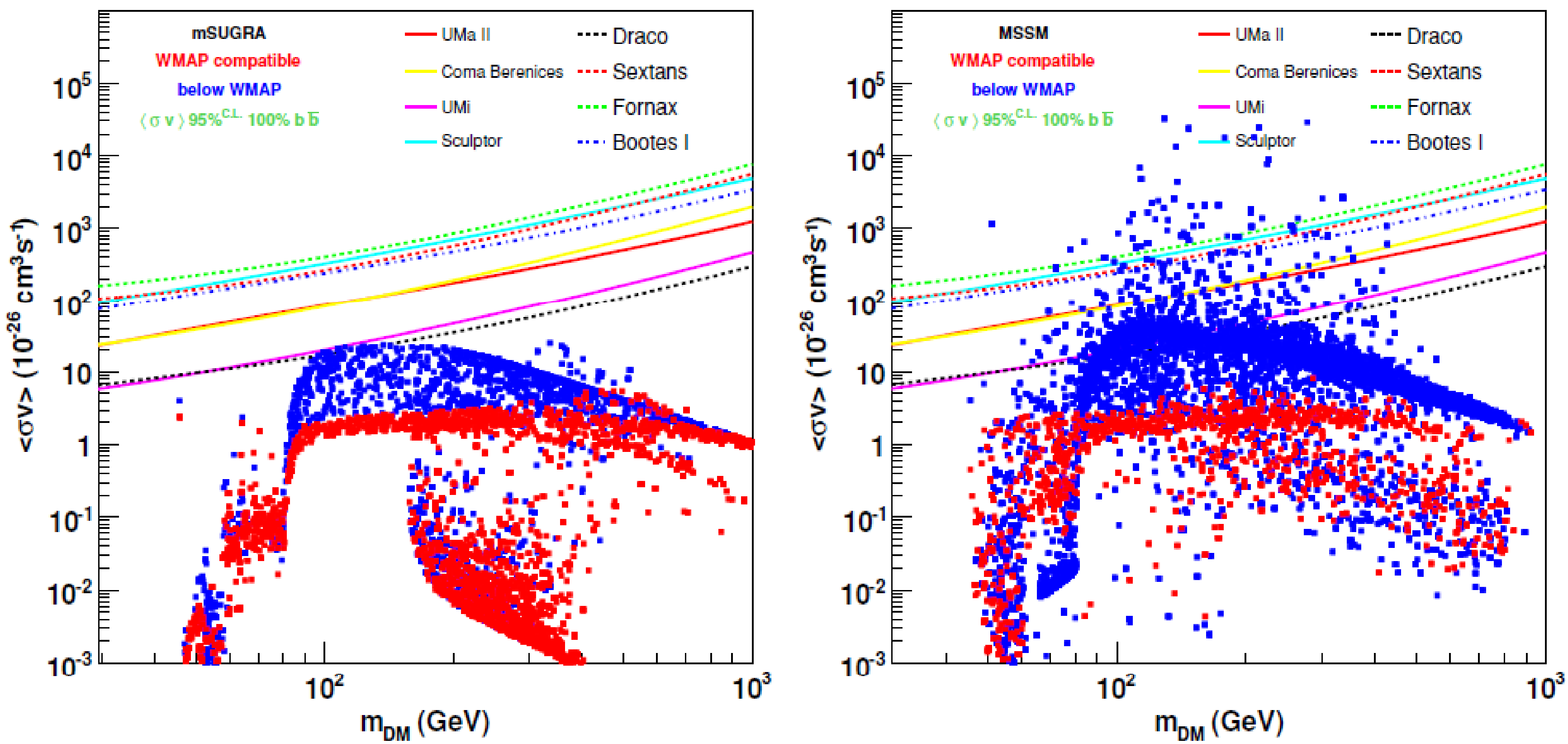




Its not just that we see no signs of a DM signal – we don't see any gamma emission at all!

Dwarf Spheroidal Galaxy Constraints

- Stellar data from Keck (Bullock, Kaplinghat, Martinez) were used to evaluate the DM content of each of 8 Dwarfs, to translate the flux limits into annihilation cross section limits. ***No substructure boost assumed.***
- Red points are models with a cosmological WIMP thermal relic density compatible with WMAP data.



Galaxy Clusters

- Similar to dwarf galaxies, clusters are DM rich.
- However, clusters are expected to have gamma-ray emission from conventional sources (proton and electron cosmic rays).
- So far we see ***no*** significant gamma-ray signals from galaxy clusters (arXiv:1006.0748v1).
- The following 6 clusters are used to set DM limits:

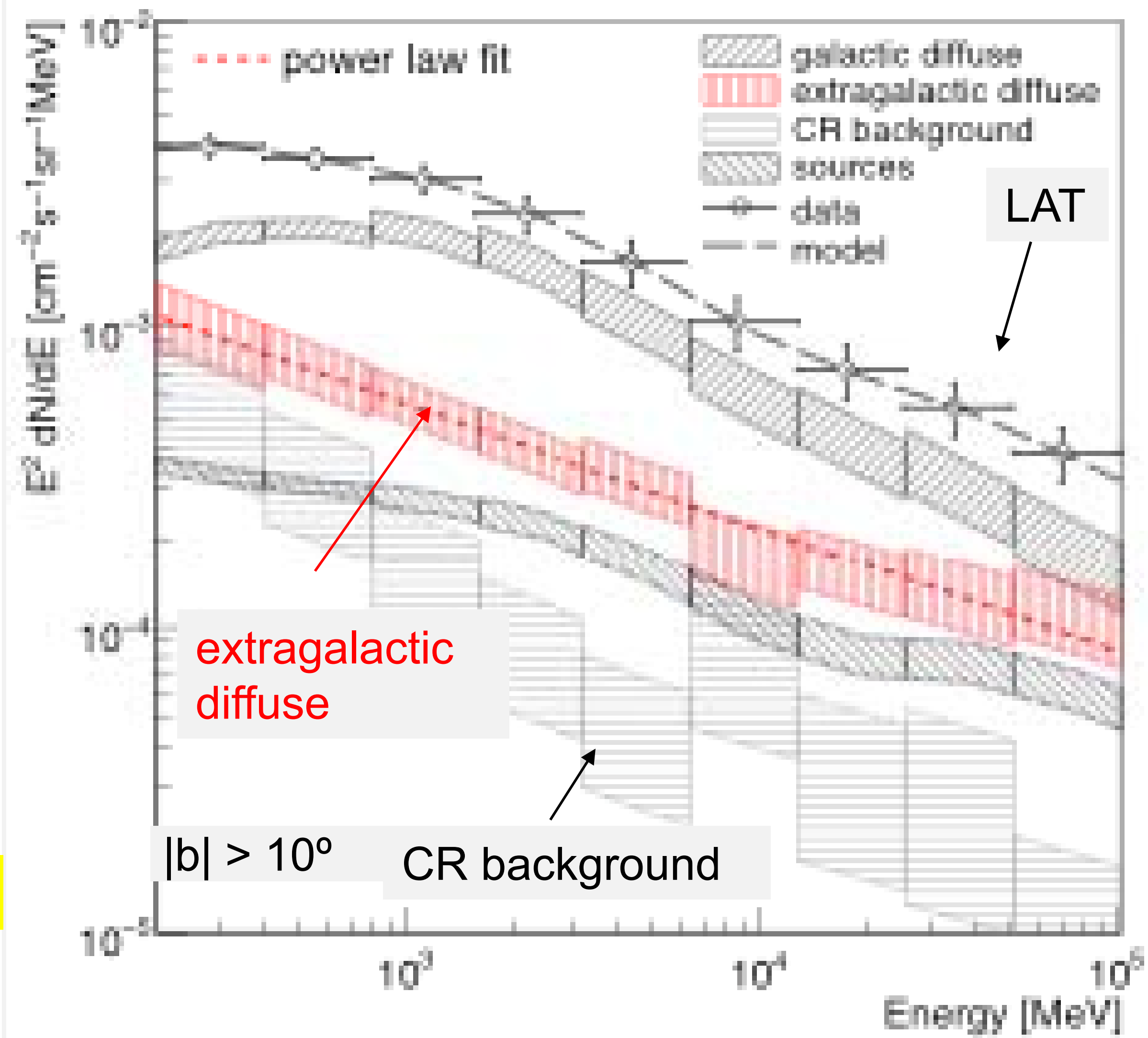
l.o.s integral of ρ^2

Cluster	RA	Dec.	z	J $(10^{17}$ GeV^2 cm$^{-5})$
AWM 7	43.6229	41.5781	0.0172	$1.4^{+0.1}_{-0.1}$
Fornax	54.6686	-35.3103	0.0046	$6.8^{+1.0}_{-0.9}$
M49	187.4437	7.9956	0.0033	$4.4^{+0.2}_{-0.1}$
NGC 4636	190.7084	2.6880	0.0031	$4.1^{+0.3}_{-0.3}$
Centaurus (A3526)	192.1995	-41.3087	0.0114	$2.7^{+0.1}_{-0.1}$
Coma	194.9468	27.9388	0.0231	$1.7^{+0.1}_{-0.1}$

- With substructure “boost” the limits are similar to those from the dSph analysis.

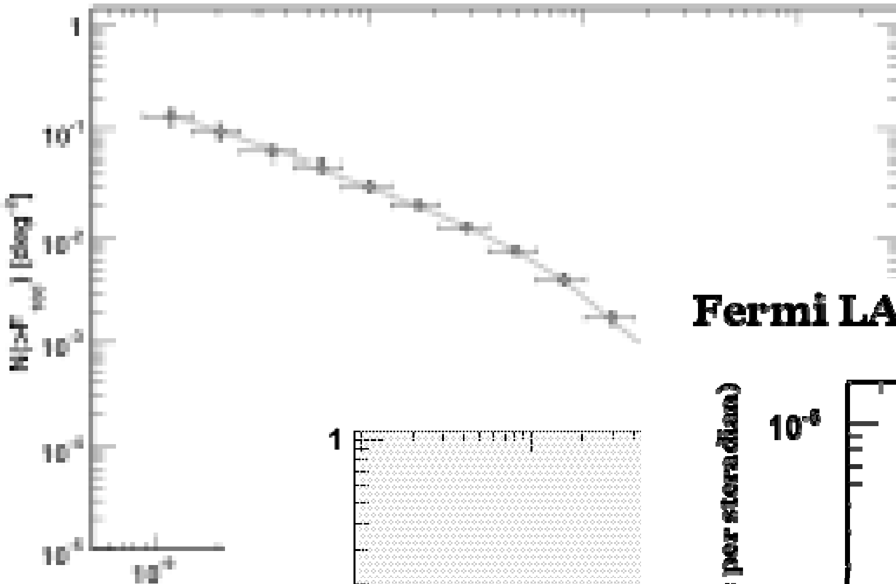
LAT Isotropic Diffuse Flux

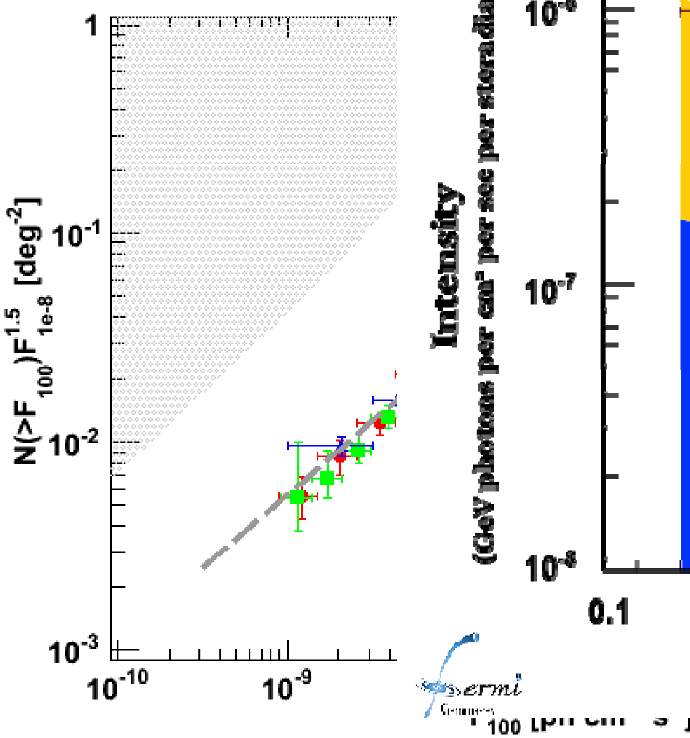
What's actually measured and what the



arXiv: 1002.3603

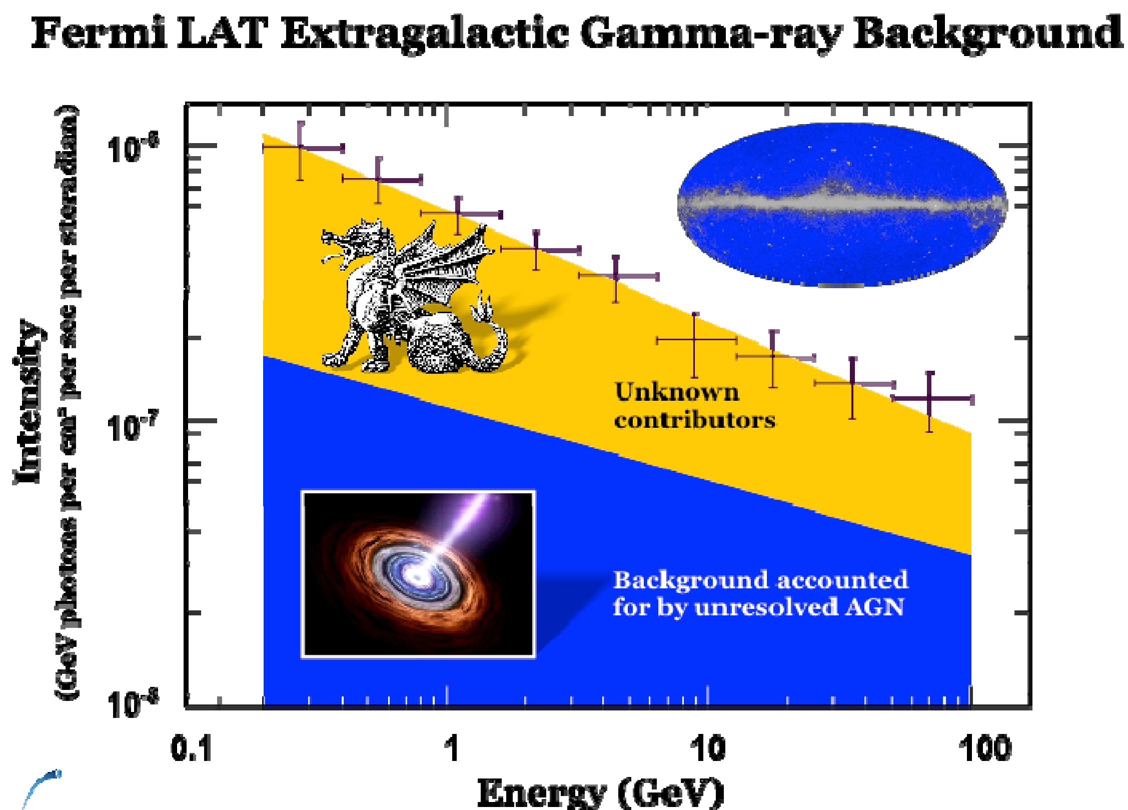
Diffuse *NOT* just Unresolved Blazars!





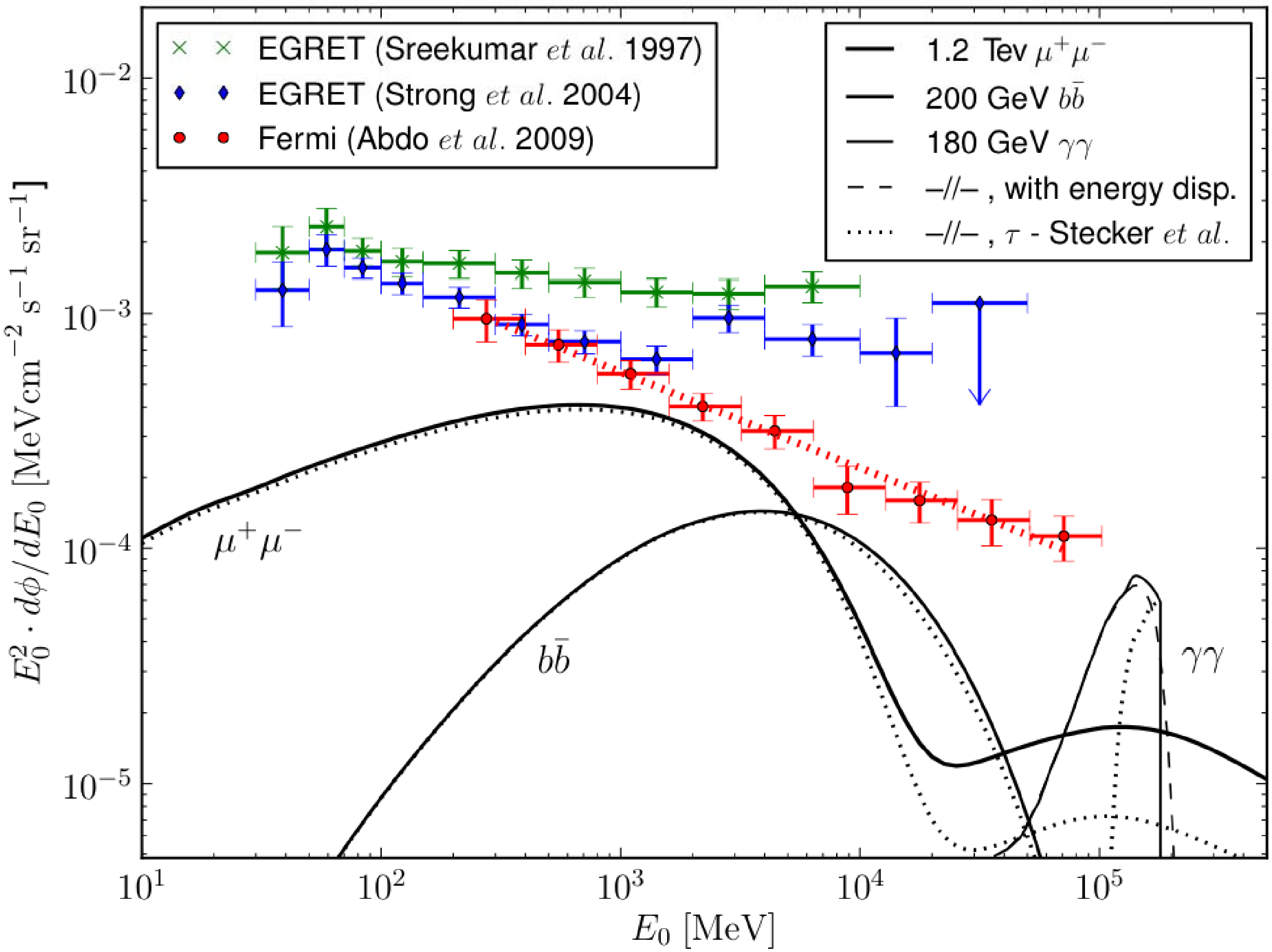
See arXiv:1003.0895

27,144 sq deg! (b>20deg)

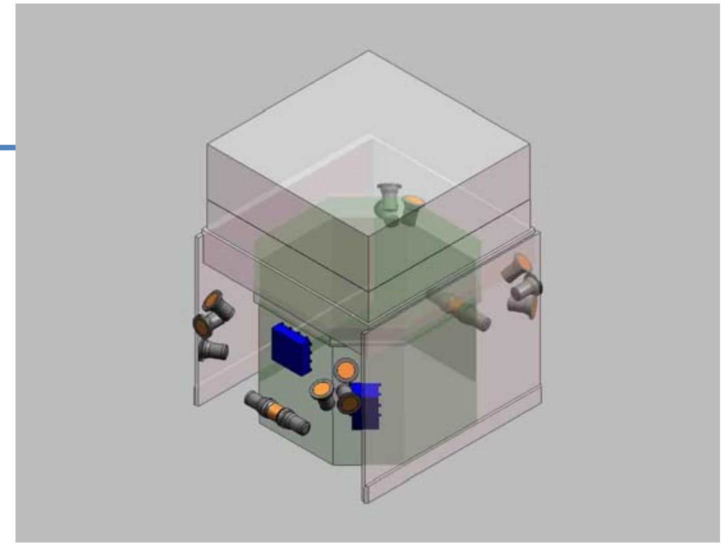


“Cosmological” DM Limits

arXiv:1002.4415v1



GBM Collaboration



National Space Science & Technology Center

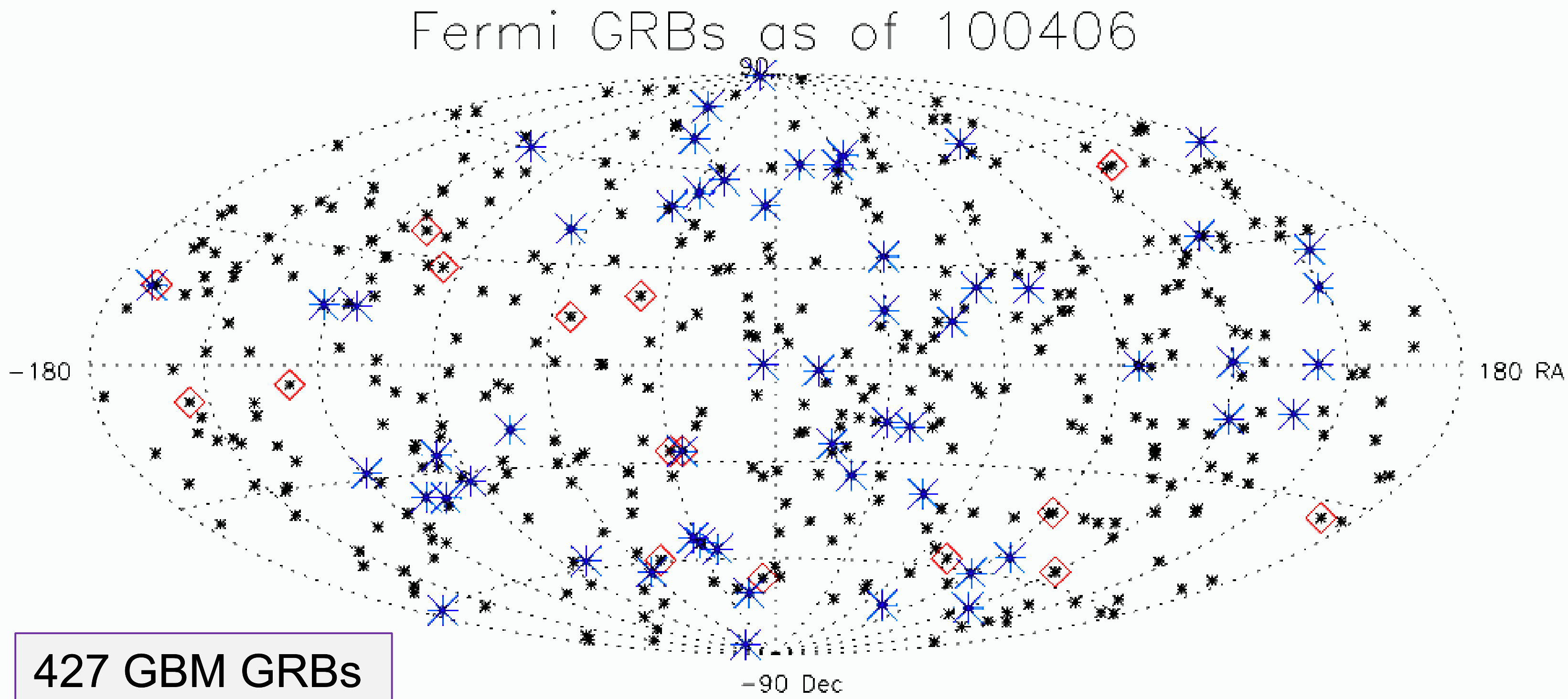
University of Alabama in Huntsville

NASA
Marshall Space Flight Center

Max-Planck-Institut für extraterrestrische Physik

Bill Paciesas (PI)
Jochen Greiner (Co-PI)

Fermi GRBs



427 GBM GRBs
56 Swift GRBs
16 LAT GRBs

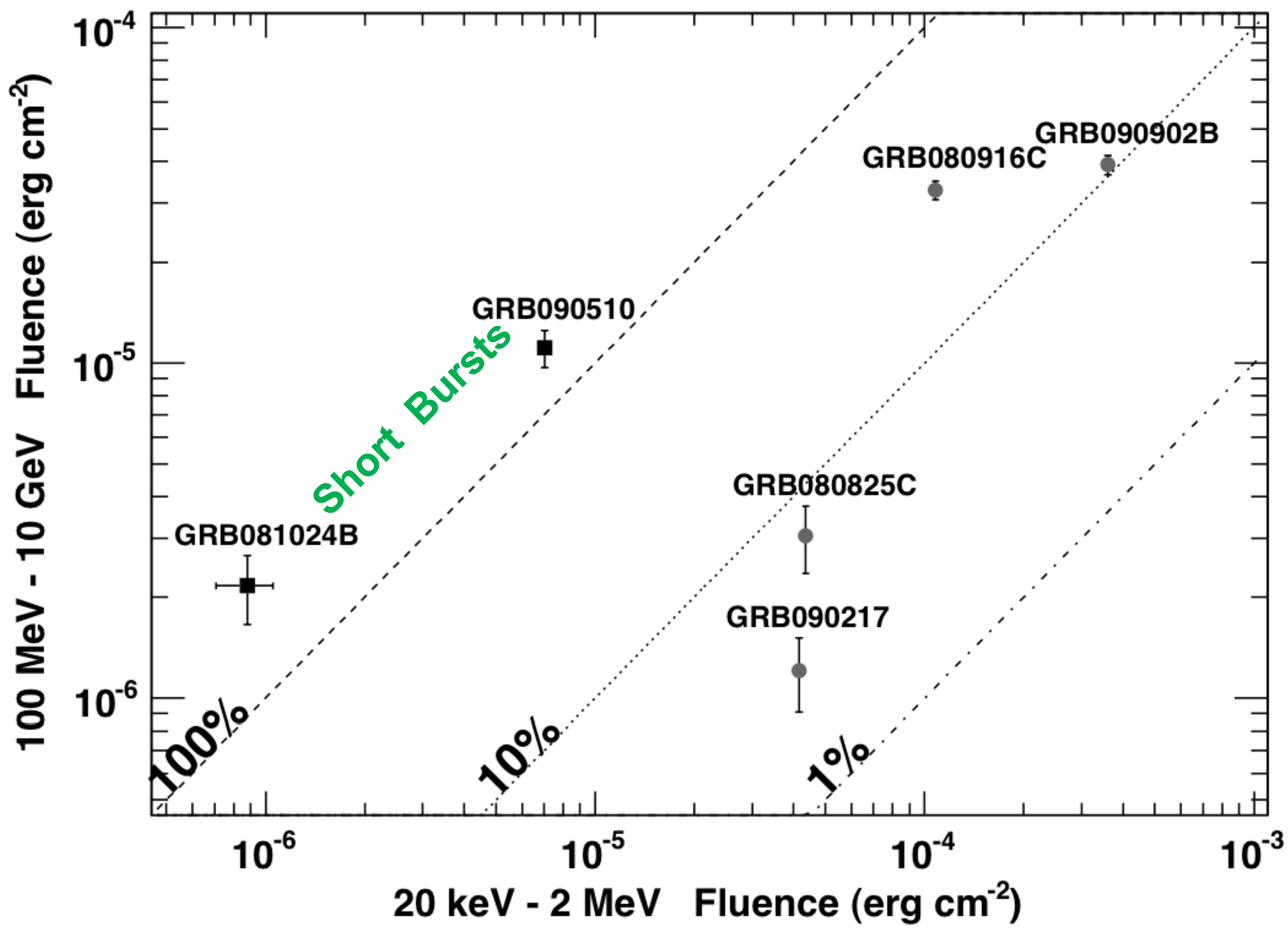
- GBM: ~250 GRB/yr
- LAT: ~9 GRB/yr

Summary of LAT GRBs

GRB	Angle from LAT	Duration (or class)	# of events > 100 MeV	# of events > 1 GeV	Delayed HE onset	Long-lived HE emission	Extra spectral comp.	Highest photon Energy	Redshift
080825C	~ 60°	long	~ 10	0	?	✔	X	~ 600 MeV	
080916C	49°	long	145	14	✔	✔	?	~ 13.2 GeV	~ 4.35
081024B	21°	short	~ 10	2	✔	✔	?	3 GeV	
081215A	~ 86°	long	—	—	—	—	--	—	
090217	~ 34°	long	~ 10	0	X	X	X	~ 1 GeV	
090323	~ 55°	long	~ 20	> 0	?	✔	?		3.57
090328	~ 64°	long	~ 20	> 0	?	✔	?		0.736
090510	~ 14°	short	> 150	> 20	✔	✔	✔	~ 31 GeV	0.903
090626	~ 15°	long	~ 20	> 0	?	✔	?		
090902B	51°	long	> 200	> 30	✔	✔	✔	~ 33 GeV	1.822
090926	~ 52°	long	> 150	> 50	✔	✔	✔	~ 20 GeV	2.1062
091003A	~ 13°	long	~ 20	> 0	?	?	?		0.8969
091031	~ 22°	long	~ 20	> 0	?	?	?	~ 1.2 GeV	
100116A	~ 29°	long	~ 10	3	?	?	?	~ 2.2 GeV	

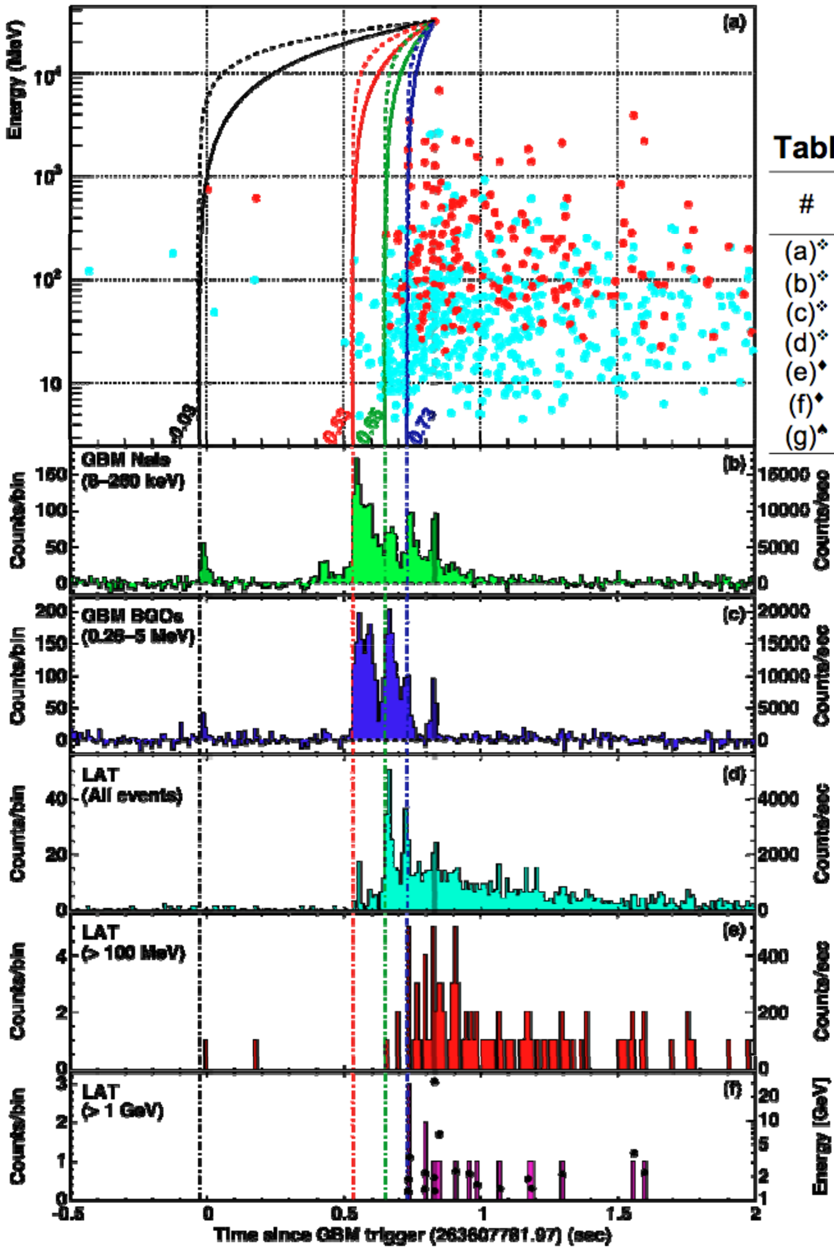
See http://fermi.gsfc.nasa.gov/ssc/resources/observations/grbs/grb_table/

Short and Long Burst Emission



arXiv: 0910.1629

QG-Related Limits from GRB 090510



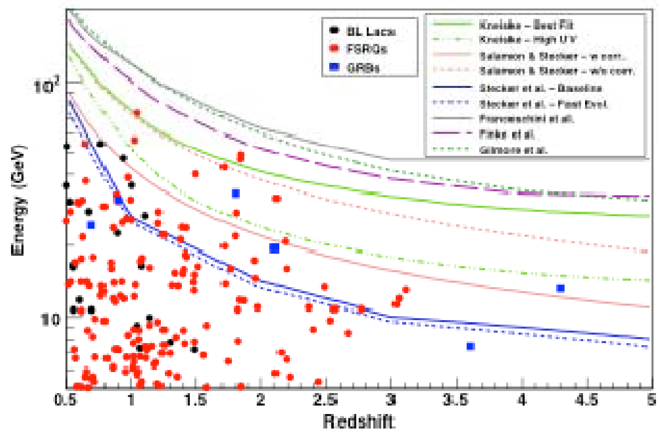
Published in Nature, vol 462, p331 (plus comment on p291)

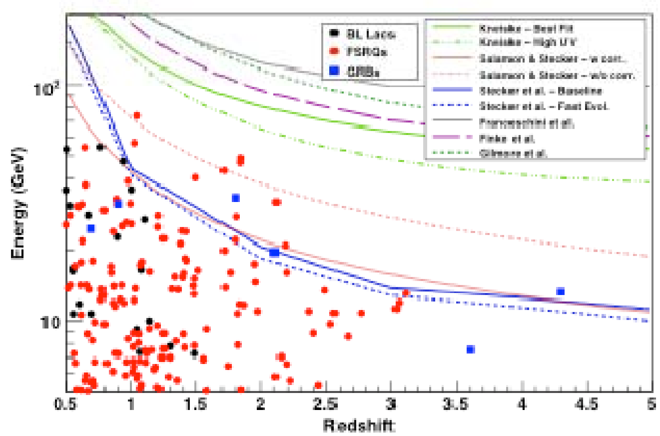
Table 2 | Limits on Lorentz Invariance Violation

#	$t_{start} - T_0$ (ms)	Limit on $\lvert\Delta t\rvert$ (ms)	Reasoning for choice of t_{start} or limit on Δt or $\lvert\Delta t/\Delta E\rvert$	E_l † (MeV)	Valid for s_n*	Lower limit on $M_{QG,1}/M_{Planck}$
(a)✧	−30	< 859	start of any < 1 MeV emission	0.1	1	> 1.19
(b)✧	530	< 299	start of main < 1 MeV emission	0.1	1	> 3.42
(c)✧	*648*	< 181	start of main > 0.1 GeV emission	100	1	> 5.63
(d)✧	730	< 99	start of > 1 GeV emission	1000	1	> 10.0
(e)♦	—	< 10	association with < 1 MeV spike	0.1	±1	> 102
(f)♦	—	< 19	If 0.75 GeV‡ γ-ray from 1st spike	0.1	−1	> 1.33
(g)♠	$\lvert\Delta t/\Delta E\rvert$ < 30 ms/GeV		lag analysis of > 1 GeV spikes	—	±1	> 1.22

…with the assumption that the HE photons are not emitted *before* the LE photons.

EBL Constraints





arXiv:1005.0996

Looking Ahead

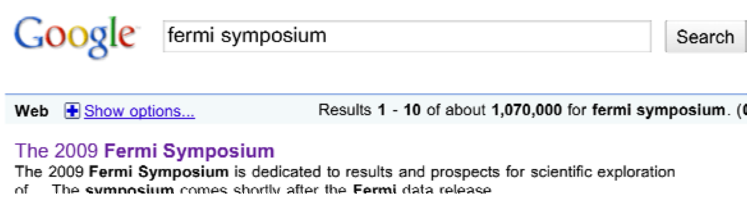
- Many further improvements in instrument performance in progress http://fermi.gsfc.nasa.gov/ssc/data/analysis/LAT_caveats.html
  - Onboard science processing improvements under study, including updates to GRB algorithm parameters
  - Event reconstruction and choices of event selection “knobs” all determine instrument performance. For stability, standard event class definitions established with IRFs.
  - Current data released with “Pass 6.”

    Next iteration, “Pass 7,” almost out-the-door
  - Pass 8
    - » Grounds-up re-write of Recon. Software
    - » Full compenstation “ghost” events
- Work also on Diffuse Model improvements.

NEXT SYMPOSIUM
9-12 May 2011
in Rome

The last Fermi Symposium was in Washington, D.C. in 2009

http://fermi.gsfc.nasa.gov/science/symposium/2009/



Summary

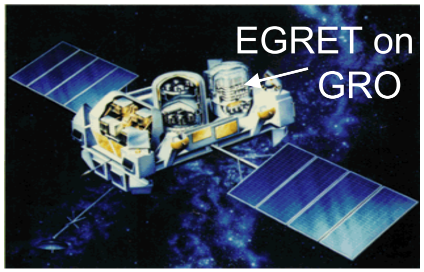
- Fermi had a great start and has been going strong!
  - instruments are beautiful, the observatory is working very well. The gamma-ray sky is keeping its promise.
- Already addressing many important questions from EGRET era and moving beyond
  - new analysis techniques and approaches are essential -- new topics! **The look ahead.**
  - 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
- Next Fermi Symposium 9-12 May 2011 in Rome
- ***JOIN THE FUN!***

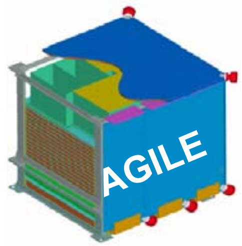
Sign up for newsletters:
http://fermi.gsfc.nasa.gov/ssc/resources/newsletter/

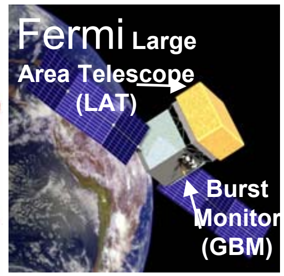
Additional slides

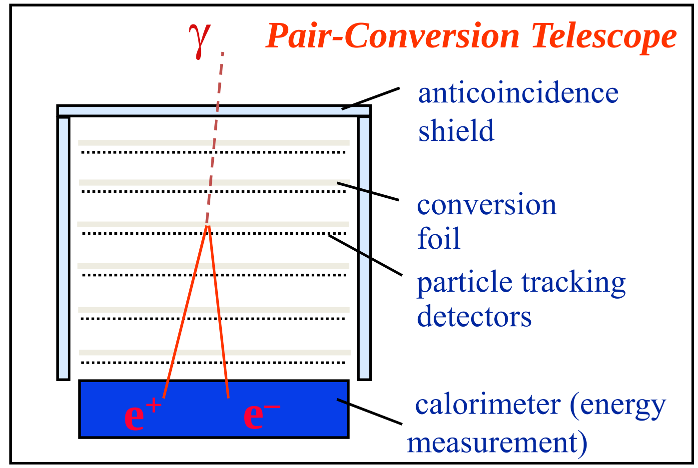
HE Gamma-ray Experiment Techniques

- Space-based:
  - use pair-conversion technique





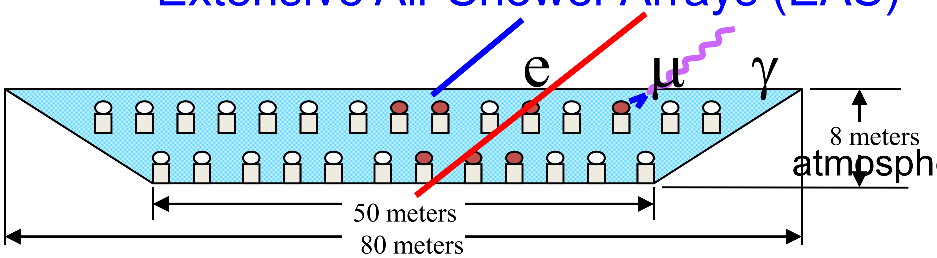




- Ground-Based:
  - Atmospheric Cerenkov Telescopes (ACTs)

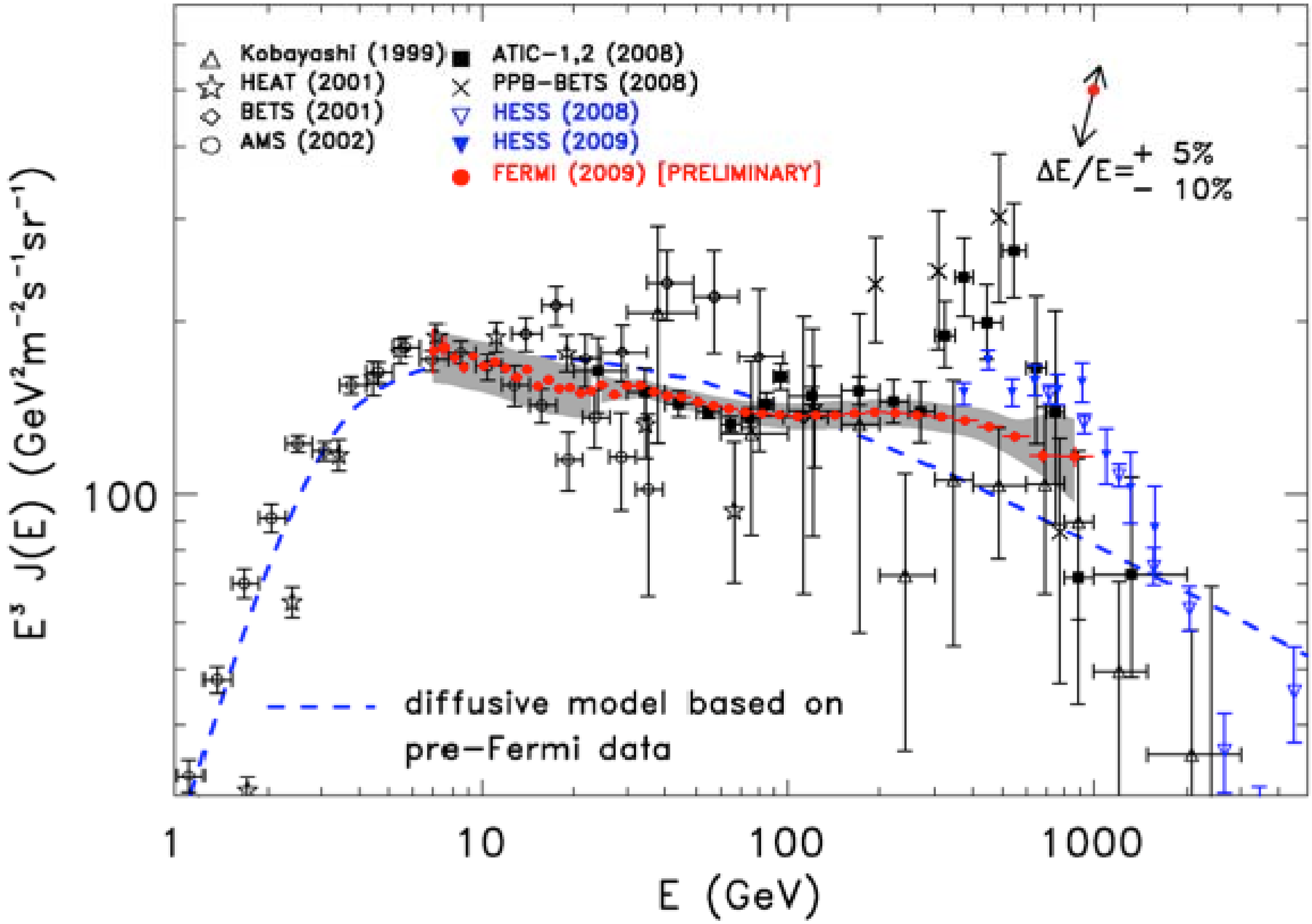
image the Cerenkov light from showers induced in the atmosphere. Examples: VERITAS, MAGIC, HESS; CTA, AGIS.

  - Extensive Air Shower Arrays (EAS)



Directly detect particles from the showers induced in the atmosphere. Example: Milagro; HAWC.

The Fermi CRE spectrum in october 2009

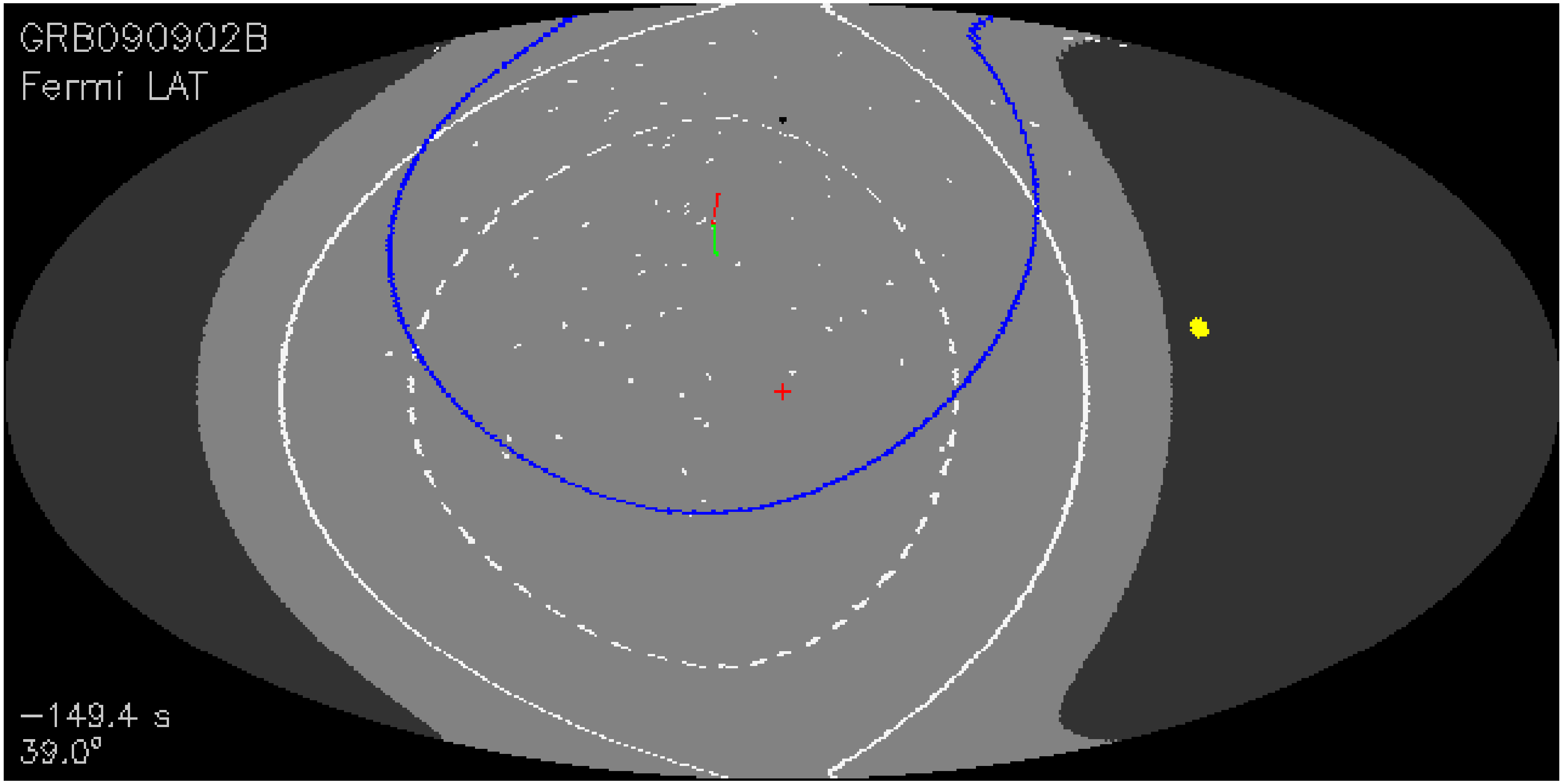


Extended Energy Range (7 GeV – 1 TeV) – One year statistics (8M evts)

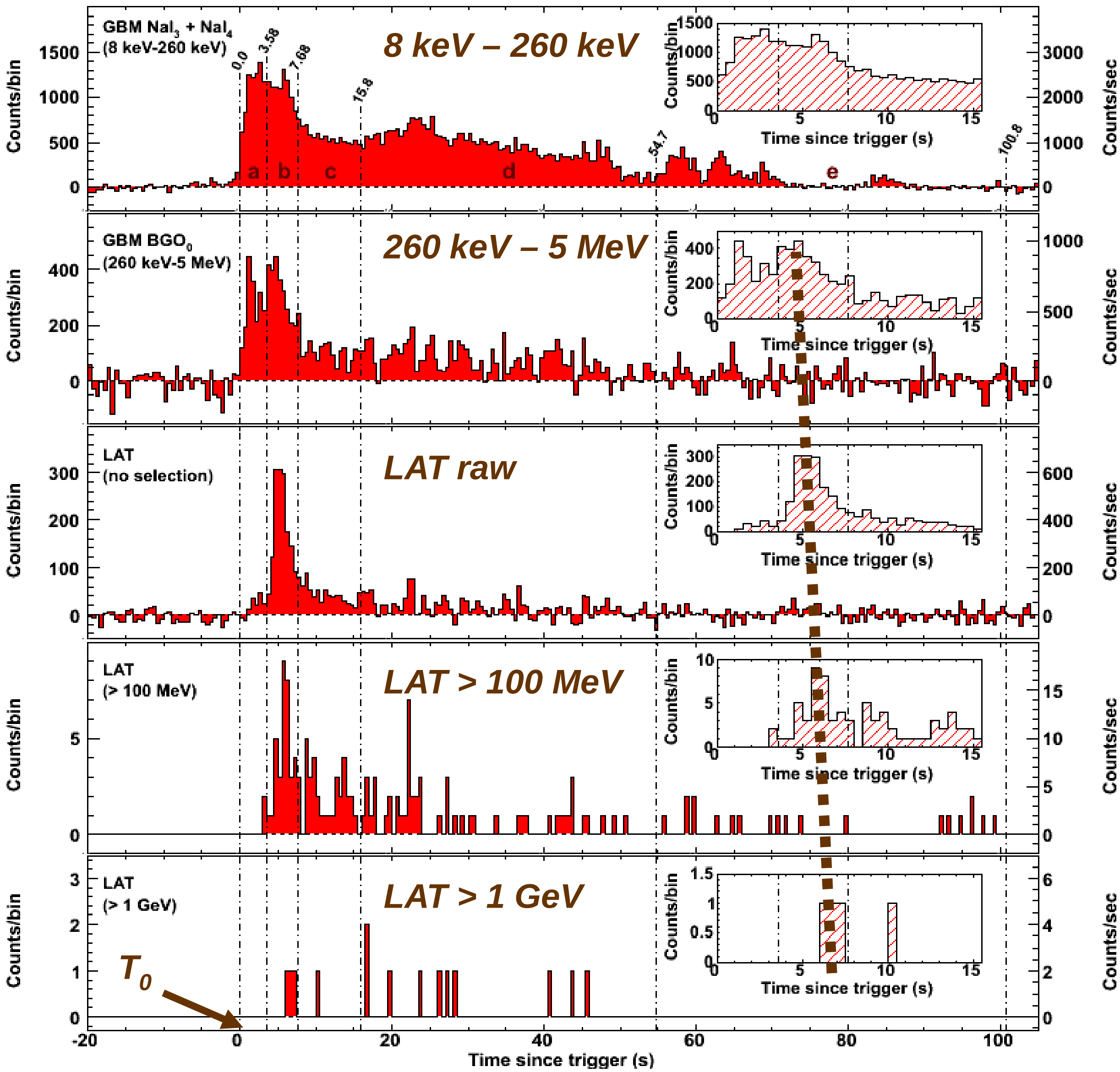
Autonomous Repoints

- **LAT pointing in celestial coordinates from -120 s to 2000 s**
  - **Red cross = GRB 090902B**
  - **Dark region = occulted by Earth**
  - **Blue line = LAT FoV (±66°)**
  - **White points = LAT events (no cut on zenith angle)**

arXiv:0909.2470



GRB080916C



- 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=4.35 +/- 0.15

GCN Circulars for GRB 090510

TITLE: GCN CIRCULAR
NUMBER: 9334
SUBJECT: Fermi LAT detection of GRB 090510
DATE: **09/05/10 04:26:20 GMT**
FROM: Masanori Ohno at ISAS/JAXA <ohno@astro.isas.jaxa.jp>

Masanori Ohno(ISAS/JAXA), Veronique Pelassa(CNRS/IN2P3/LPTA) report
on behalf of the Fermi LAT team:

At 00:23:01.22 UT on 10 May 2009, the Fermi Large Area Telescope (LAT) triggered and located GRB 090510 (trigger 263607783 / 090510016). Emission was observed in the LAT up to GeV energy band with a detection significance of more than 5 sigma.

The best LAT on-board localization is found to be (RA,Dec=333.400, -26.767) with an error radius of 7 arcmin (statistical only).
This position is consistent with both Fermi/GBM and Swift/XRT position.

Further analysis is ongoing.
We suggest follow up observation for this burst.

The points of contact for this burst is

Masanori Ohno ohno@astro.isas.jaxa.jp

The Fermi LAT is a pair conversion telescope designed to cover the energy band from 20 MeV to greater than 300 GeV.
It is the product of an international collaboration between NASA and DOE in the U.S. and many scientific institutions across France, Italy, Japan and Sweden.

This message can be cited.

TITLE: GCN CIRCULAR
NUMBER: 9350
SUBJECT: GRB 090510: Fermi-LAT follow-up analysis
DATE: 09/05/11 21:33:14 GMT
FROM: Nicola Omodei at INFN(Pisa)/GLAST <nicola.omodei@pi.infn.it>

N. Omodei (INFN Pisa), J. Granot (University of Hertfordshire),
P. Meszaros (PSU), J. McEnery (GSFC), F. Piron (LPTA), S. Razzaque (NRL)
H. Tajima (SLAC), V. Vasileiou (GSFC/UMBC), D. Williams (UCSC),
report on behalf of the Fermi LAT Collaboration.

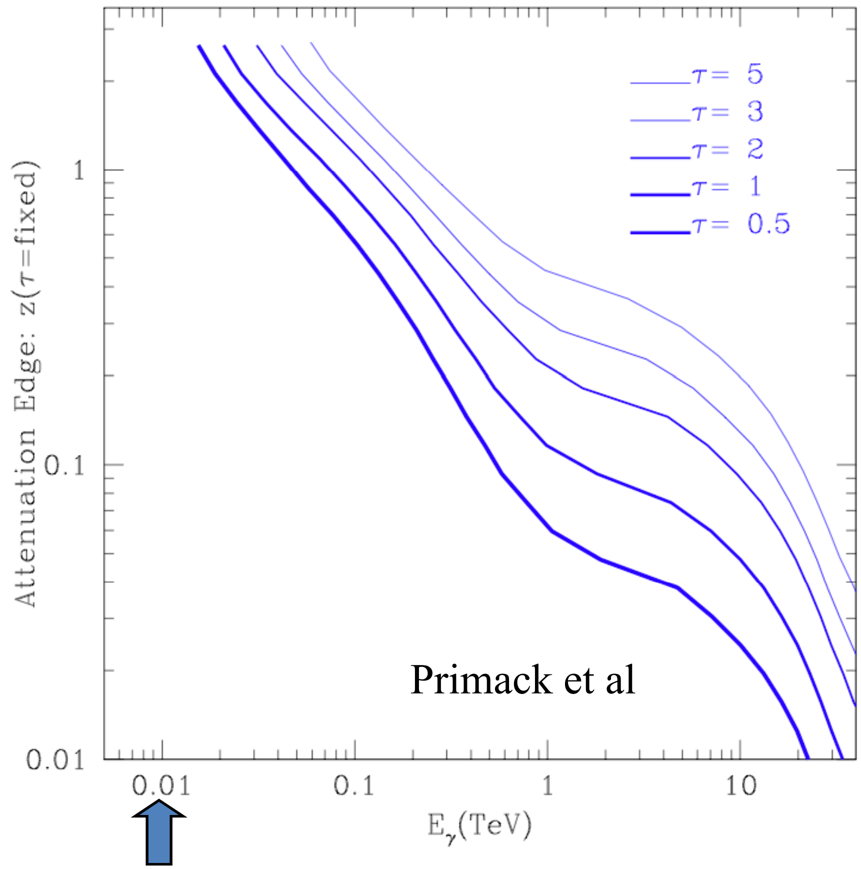
A follow-up analysis of the **short** bright Fermi GRB 090510 (Ohno et al., GCN 9334, Guiriec et al., GCN 9336) has been performed by the Fermi-LAT team.

Fermi LAT has detected more than 50 events above 100 MeV (>10 above 1 GeV) during the first second and more than 150 events above 100 MeV (>20 above 1 GeV) in the first minute after the GBM trigger. All these events are positionally consistent (within the 95% containment radius of the LAT point spread function) with the position reported by Swift (Goad et al. GCN 9339). **They indicate extended emission above GeV energies, making this burst an absolute priority for follow-up searches, especially a redshift determination.**

The points of contact for this burst is:
Masanori Ohno ohno@astro.isas.jaxa.jp
The Fermi LAT is a pair conversion telescope designed to cover the energy band from 20 MeV to greater than 300 GeV.
It is the product of an international collaboration between NASA and DOE in the U.S. and many scientific institutions across France, Italy, Japan and Sweden.

LAT Covers an Important Energy Band

Photons with E>10 GeV are attenuated by the diffuse field of UV-Optical-IR extragalactic background light (EBL)



No significant attenuation below ~10 GeV.

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

EBL over cosmological distances is probed by gammas in the 10-100 GeV range.

In contrast, the TeV-IR attenuation results in a flux that may be limited to more local (or much brighter) sources.

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