

National Aeronautics and Space Administration



Fermi

Gamma-ray Space Telescope

www.nasa.gov/fermi

Fermi Users Group

LAT Results, Status, Plans

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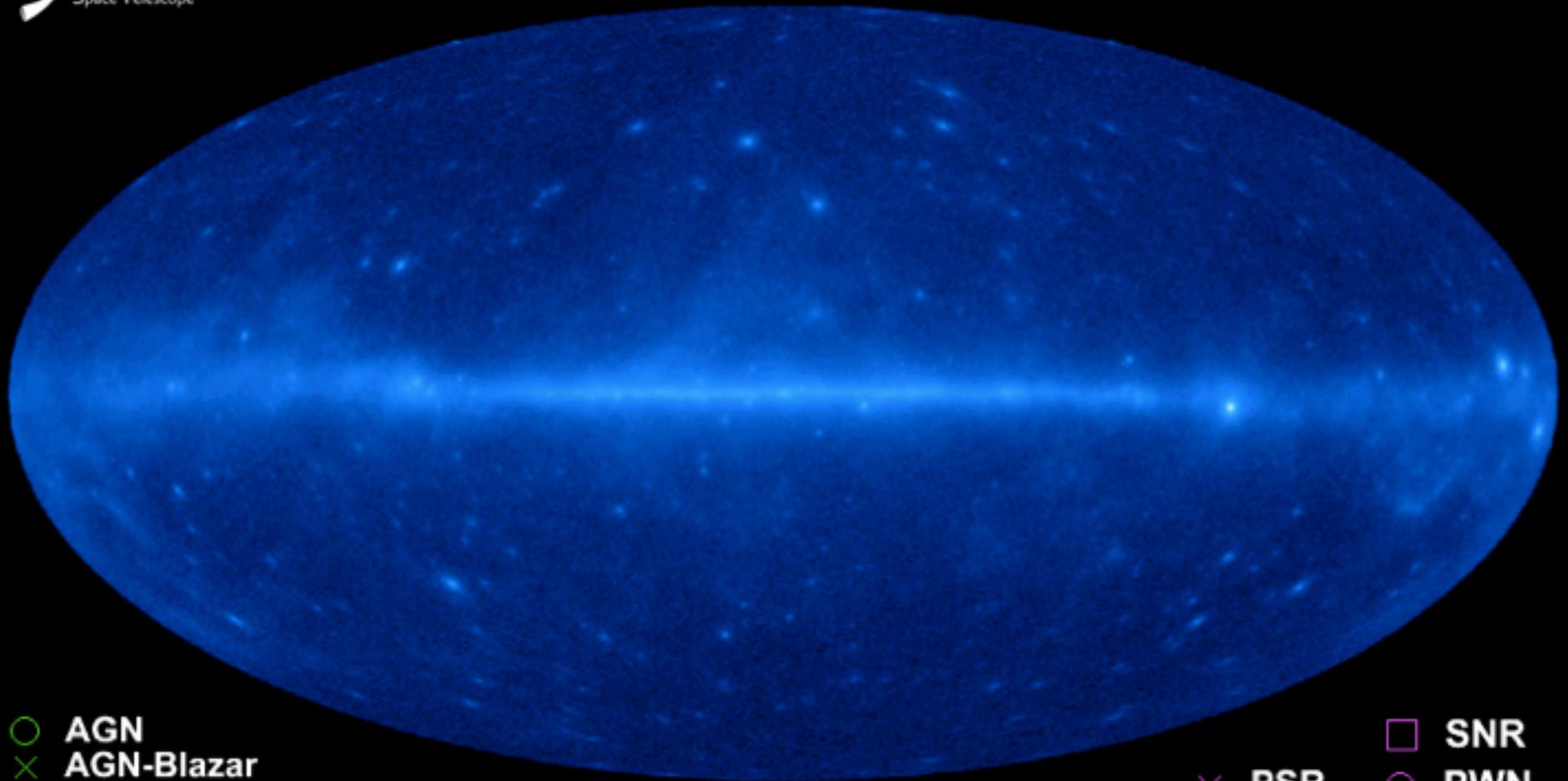
***On behalf of Peter Michelson
and the LAT collaboration***

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





The Fermi LAT 1FGL Source Catalog

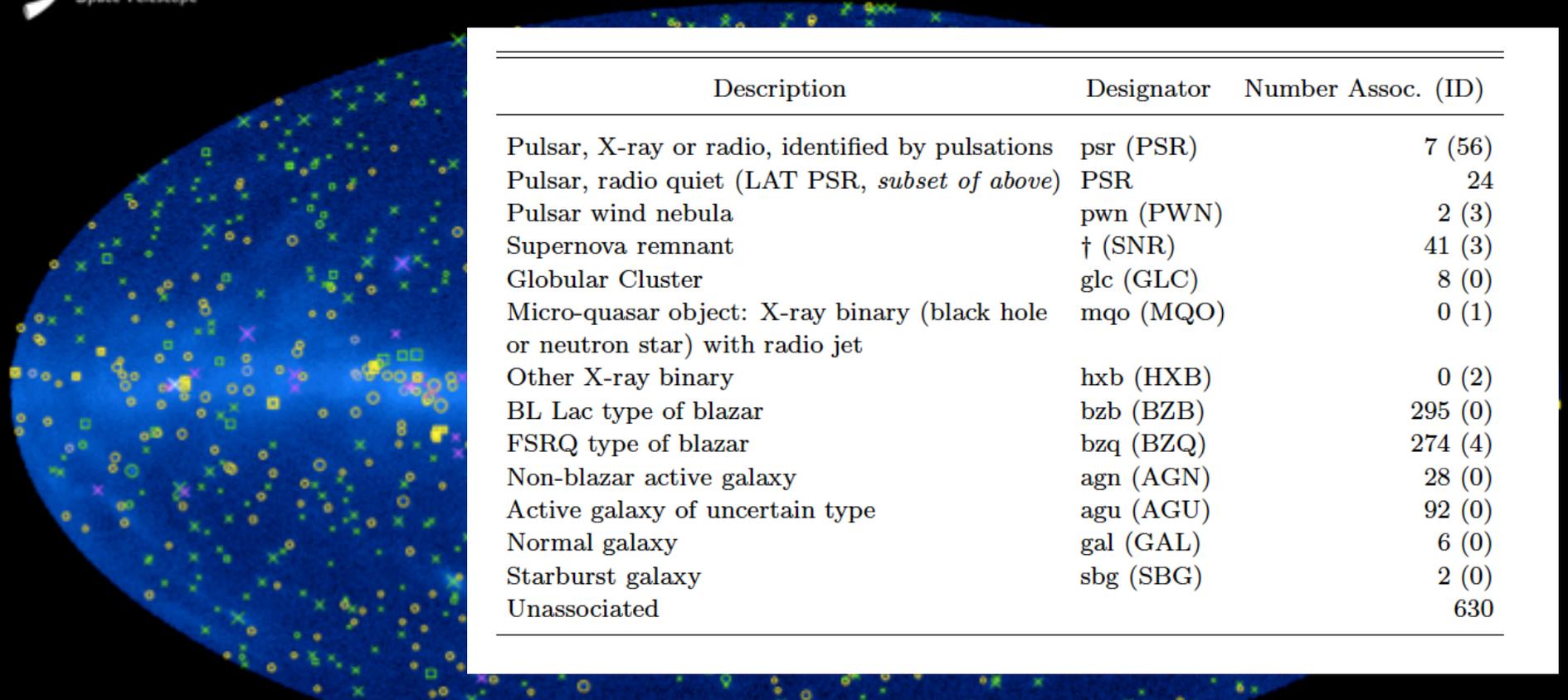


- | | |
|---|--------------------|
| ○ AGN | □ SNR |
| × AGN-Blazar | × PSR |
| □ AGN-Non Blazar | ○ PWN |
| ○ No Association | ⊗ PSR w/PWN |
| □ Possible Association with SNR and PWN | ◇ Globular Cluster |
| ○ Possible confusion with Galactic diffuse emission | × HXB or MQO |
| □ Starburst Galaxy |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



The Fermi LAT 1FGL Source Catalog

See talk by DJT



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
- ⊗ PSR w/PWN
- ◇ Globular Cluster
- × HXB or MQO
- PWN



Rapid Publications from Fermi LAT: GCN and ATEL

Astronomer's Telegrams (ATEL):

~80 ATEls thus far

date	number	title
2010-Apr-09	2543	Fermi LAT detection of a GeV flare from PKS 0906+015
2010-Apr-06	2539	Fermi LAT detection of a GeV flare from PKS 2142-75
2010-Apr-06	2534	Fermi LAT detection of increasing gamma-ray activity of 3C 454.3
2010-Apr-01	2531	Fermi LAT detection of a GeV flare from PKS B 1622-297
2010-Mar-31	2528	Fermi LAT detection of a new gamma-ray transient: J1512-3221
2010-Mar-18	2487	Cygnus Region: Fermi J2102+4542, and its Possible Association with V407 Cyg
2010-Feb-24	2456	Fermi LAT detection of GeV flare in high redshift blazar 4C 38.41
2010-Feb-15	2440	Fermi LAT detection of a GeV flare from PKS 0244-47
2010-Feb-03	2420	Swift/XRT Follow-up of the Fermi-LAT Galactic Plane Transient J0109+6134
2010-Feb-03	2414	Fermi LAT detection of a flaring, new GeV source near the Galactic plane: J0109+6134
2010-Feb-02	2413	Fermi LAT detection of a GeV flare from PKS 0402-362
2010-Jan-28	2408	Fermi LAT detection of a GeV flare from blazar PMN J2345-1555
2010-Jan-25	2402	Fermi LAT detection of increased gamma-ray activity of two blazars PKS 0420-01 and BL Lacertae
2010-Jan-20	2393	Fermi LAT detection of a GeV flare from OX 169 (S3 2141+17)
2010-Jan-13	2386	Fermi LAT detection of a GeV flare from blazar S5 1803+784
2010-Jan-07	2373	Fermi LAT detection of a GeV flare from blazar PKS 2155-83
2010-Jan-04	2366	Fermi LAT detection of a GeV flare from PKS 0426-380
2009-Dec-16	2349	Fermi LAT confirmation of a strong GeV flare from 4C 21.35 (PKS 1222+21)
2009-Dec-03	2328	Fermi LAT detection of an extraordinary GeV outburst from 3C 454.3
2009-Nov-28	2316	Fermi LAT observation of ongoing GeV activity from spectrally hard blazar GB6 B1310+4844 (GB1 1310+487)
2009-Nov-21	2306	Fermi LAT detection of a GeV flare from GB6 B1310+4844
2009-Nov-12	2293	H.E.S.S. and Fermi-LAT discovery of VHE and HE emission from blazar 1ES 0414+009
2009-Oct-29	2272	Discovery of High-Energy Gamma-Ray Emission from the BL Lac Object RBS 0413

Outside

GCN
IAUCs

Other

MacOS: Dashboard Widget
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The Astronomer's Telegram
for reporting and commenting on new astronomical observations
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Present Time: 23 Apr 2010; 17:15 UT

RSS

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SGRs
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Comets

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Fermi LAT Detection of a New Galactic Plane Gamma-ray Transient in the Cygnus Region: Fermi J2102+4542, and its Possible Association with V407 Cyg

ATel #2487: C.C. Cheung (NRC/NRL), D. Donato (NASA GSFC), E. Wallace (U. Washington), R. Corbet (NASA GSFC), G. Dubus (U. Grenoble), K. Sokolovsky (MPI/R), H. Takahashi (Hiroshima U.); on behalf of the Fermi Large Area Telescope Collaboration on 18 Mar 2010; 16:52 UT

Distributed as an Instant Email Notice (Request for Observations)
Password Certification: Julie McEnery (julie.mcenery@nasa.gov)

Subjects: Gamma Ray, >GeV, Transients
Referred to by ATEL #: 2498, 2506, 2511, 2529, 2536, 2546

The Large Area Telescope (LAT), on board the Fermi Gamma-ray Space Telescope, has detected a transient gamma-ray source in the Galactic Plane: Fermi J2102+4542. Preliminary analysis of the Fermi-LAT data indicates that on the 13th and 14th of March 2010, the source was detected with a >100 MeV flux of $(1.0 \pm 0.3) \times 10^{-6}$ ph cm⁻² s⁻¹ and $(1.4 \pm 0.4) \times 10^{-6}$ ph cm⁻² s⁻¹, respectively (statistical only) – corresponding significances on these days are 8 sigma and 6 sigma. A systematic uncertainty of 30% should be added to this number. There is no previously reported gamma-ray source at this location.

Combining data for the period from Mar 12 0:0:0 UTC and ending Mar 16 ~8:30 UTC, the preliminary LAT position is (J2000.0): RA = 315.60 deg., Dec = 45.71 deg. (l, b = 86.96 deg., -0.55 deg) which is in the Cygnus region of our Galaxy. There is no previously reported EGRET or LAT gamma-ray source at this position. Within the 95% confidence error circle radius of 0.12 deg (statistical only) is the symbiotic star V407 Cyg, with a reported optical outburst beginning approximately 2 days earlier (CBET #2199) than the onset of gamma-ray activity detected by the LAT. Swift/XRT observations triggered on the optical outburst of V407 Cyg and performed on March 13th and 15th resulted in 2.4-2.6 sigma (0.3-10 keV) detections of an X-ray source coincident with the position of the star in each of the two 960 sec exposures.

Because Fermi operates in an all-sky scanning mode, regular gamma-ray monitoring of this source will continue. In consideration of the activity of this gamma-ray source, and its possible association with V407 Cyg, we strongly encourage multiwavelength observations of the star. For this source the Fermi LAT contact person is C.C. Cheung (Teddy.Cheung.ctr@nrl.navy.mil).

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.

[Telegram Index]

R. E. Rutledge, Editor-in-Chief
Derek Fox, Editor

rrutledge@astronomerstelegram.org
dfox@astronomerstelegram.org



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

LAT Continuous Source Releases

The LAT team continuously releases flux & spectra as a function of time for all sources in a pre-defined list + flaring sources during flares.

- Modified data release after ~6 months:
 - Lowered flux threshold to release information on flaring sources by factor of 2.
 - Provided information continuously (not just during flares).
 - started with 23 sources, now have >50, with contact people assigned.

• <http://fermisky.blogspot.com>

Contact Information for Individual Sources

Added by David J. Thompson, last edited by C. C. Teddy Cheung on May 05, 2010

Please note: **This is a public page (for multifrequency purposes).**

List of Contacts for Individual Sources

LAT Monitored Source List Light Curves are available for most of these sources

Fermi-LAT Weekly Sky blog and Daily Sky blog

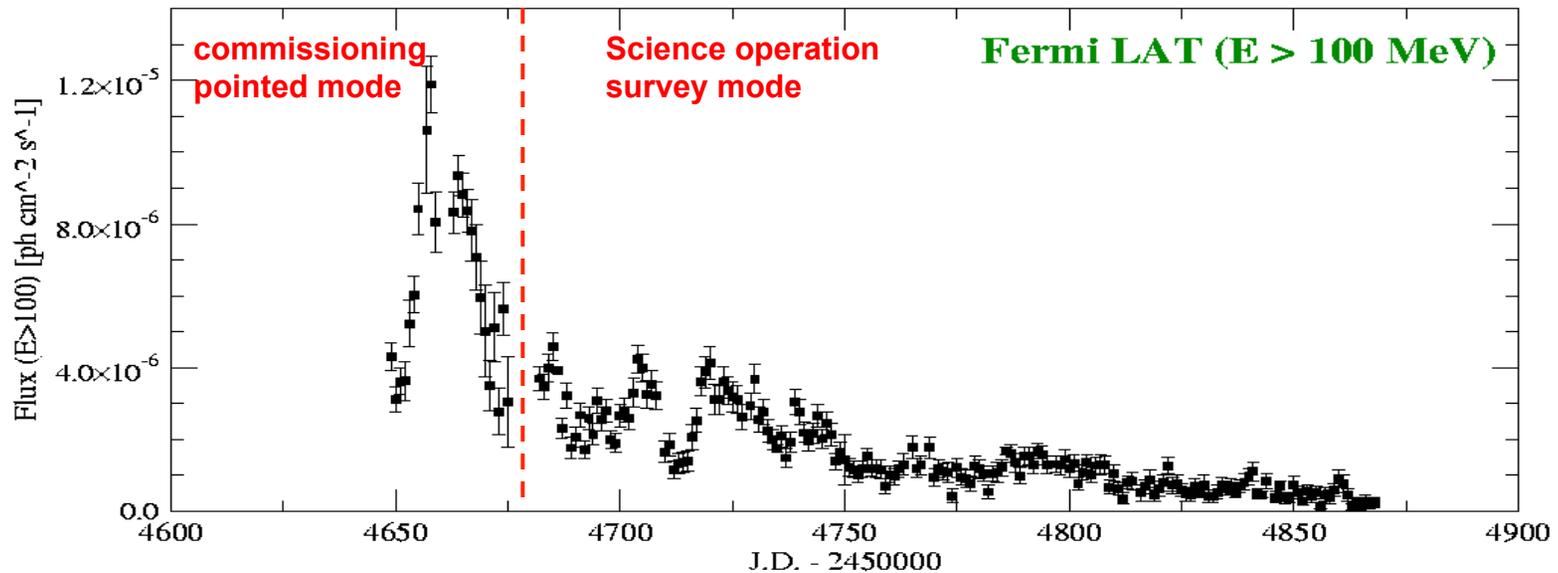
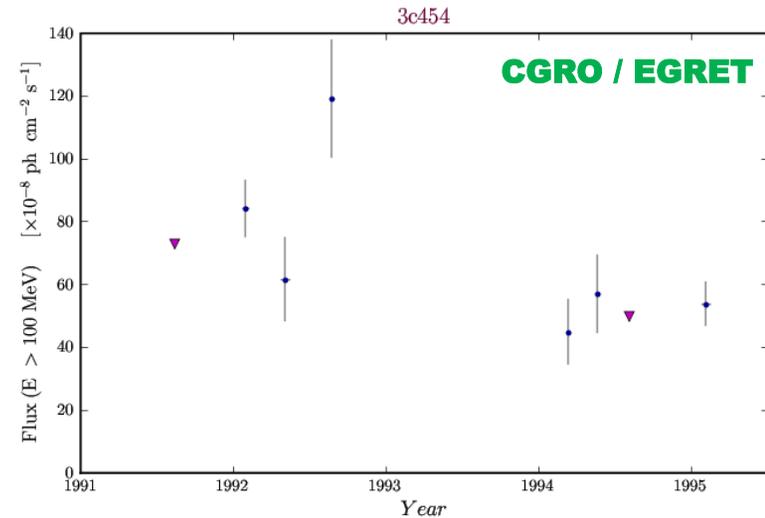
For reference, see all Astronomer's Telegrams from the Fermi-LAT collaboration

Extragalactic sources from ATels, in order of (the First) ATel number, starting with earliest

Source Name(s)	Friend(s) of the Source	ATEL number(s)
3C 454.3	Greg Madejski (madejski at stanford.edu)	1628, 2200, 2328, 2534
PKS 1502+106	Stefano Ciprini (stefano.ciprini at pg.infn.it)	1650, 1905
PKS 1454-354	??	1701
3C273	Jim Chiang (jchiang at slac.stanford.edu), Werner Collmar (wec at mpe.mpg.de)	1707, 2168, 2200
1510-089	Andrea Tramacere (tramacer at slac.stanford.edu)	1743, 1897, 2033
AO 0235+164	Luis C. Reyes (lreyes at kicp.uchicago.edu)	1744, 1784
3C 66A	Luis C. Reyes (lreyes at kicp.uchicago.edu)	1759
PKS 0208-512	Werner Collmar (wec at mpe.mpg.de)	1759
PKS 0537-441	Gino Tosti (tosti at pg.infn.it)	1759, 2124, 2591
3C279	Greg Madejski (madejski at slac.stanford.edu), Werner Collmar (wec at mpe.mpg.de)	1864, 2154
Bo133+47	Hiroimitsu Takahashi (hirotaka at hep01.hepl.hiroshima-u.ac.jp), Gino Tosti (tosti at pg.infn.it)	1877
J123939+044409	Andrea Tramacere (tramacer at slac.stanford.edu), Nanda Rea (N.Rea at uva.nl)	1888
PKS 1244-255	Andrea Tramacere (tramacer at slac.stanford.edu), Nanda Rea (N.Rea at uva.nl)	1894
PKS 0454-234	Dario Gasparri (dario.gasparri at asdc.asi.it)	1898
0917+449	William McConville (wmconvi at umd.edu)	1902

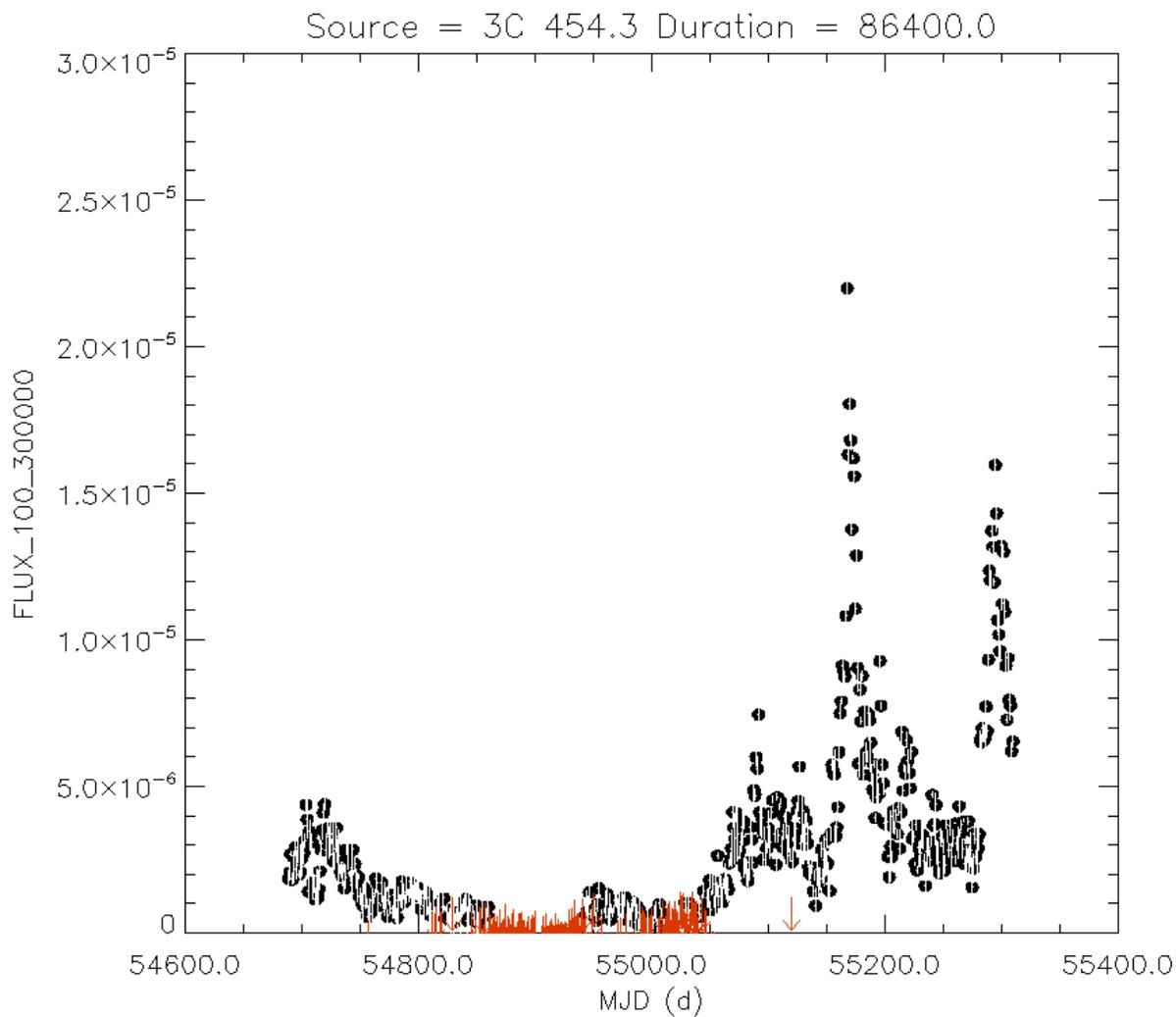
3C454.3

- Well-known radio source, identified with an OVV quasar at $z = 0.859$; also detected by EGRET, AGILE

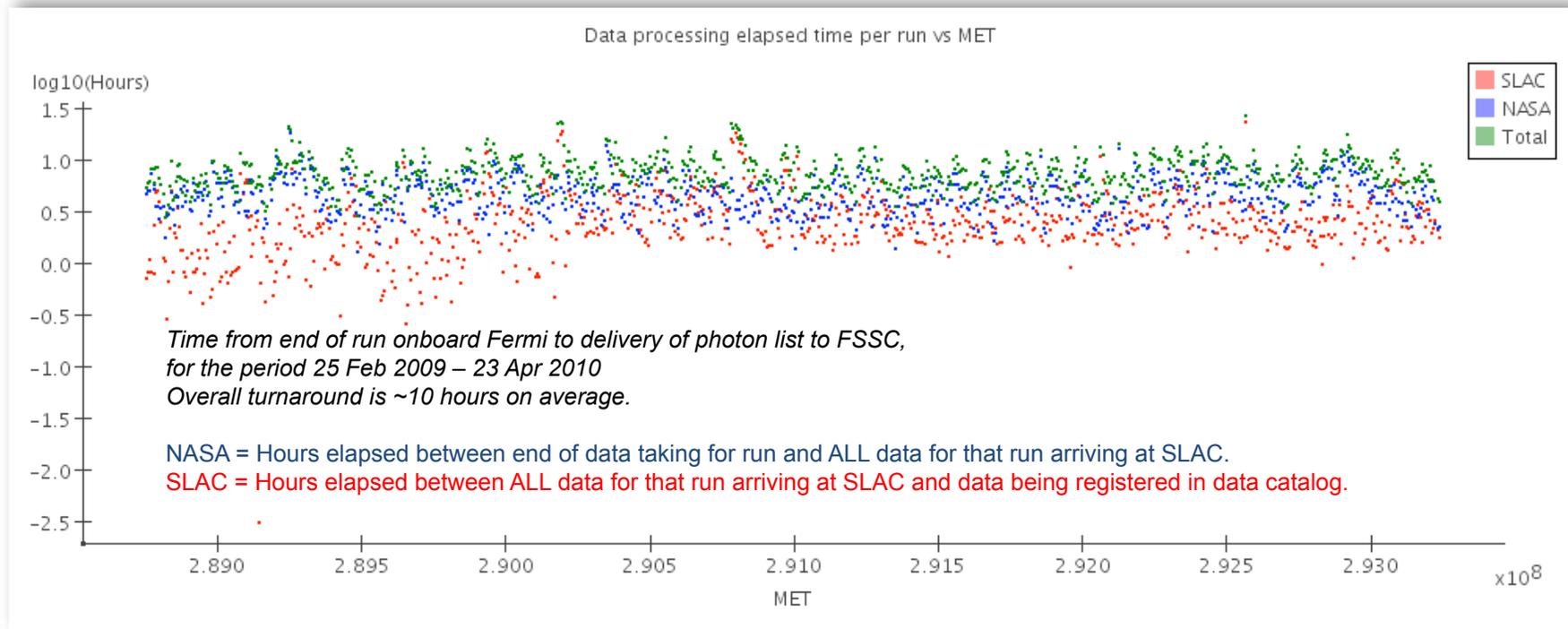


3C454.3

http://fermi.gsfc.nasa.gov/ssc/data/access/lat/msl_lc/



LAT Operations



- 2010/019 05:15 PST – 2010/020 18:30 PST:
SLAC Power outage.
– ISOC Operations briefly transferred to backup ISOC
- 2010/049 09:59:40 UTC: LAT MILESTONE:
100 billion on-orbit triggers

Many LAT papers out...

Fermi LAT Publications

5/10/10 2:22 PM



Fermi LAT collaboration publications

Select a topic:

Links:

- 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

Gamma-ray Spectral Evolution of NGC 1275 Observed with Fermi LAT

Kataoka, J. et al. 2010, ApJ, 715, 554 doi: 10.1088/0004-637X/715/1/554

arXiv: 1004.2352

ADS: 2010ApJ...715..554K BibTeX Citations

SPIRES

The First Catalog of Active Galactic Nuclei Detected by the Fermi Large Area Telescope

Abdo, A. A. et al. 2010, ApJ, 715, 429 doi: 10.1088/0004-637X/715/1/429

arXiv: 1002.0150

ADS: 2010ApJ...715..429A BibTeX Citations

SPIRES

Detection of the energetic pulsar PSR B1509-58 and its pulsar wind nebula in MSH 15-52 using the Fermi Large Area Telescope

Abdo, A. A. et al. 2010, ApJ, 714, 927 doi: 10.1088/0004-637X/714/1/927

arXiv: 1003.3833

ADS: 2010ApJ...714..927A BibTeX Citations

SPIRES

The discovery of gamma-ray emission from the blazar RGB J0710+591

Fermi LAT Publications

5/10/10 2:22 PM

Abdo, A. A. et al. 2010, Phys. Rev. Lett., 104, 101101 doi: 10.1103/PhysRevLett.104.101101
arXiv: 1002.3603
ADS: 2010PhRvL.104j1101A BibTeX Citations
SPIRES

ADS: 2010ApJS...187..460A BibTeX Citations
SPIRES

Constraints on Cosmological Dark Matter Annihilation from the Fermi-LAT Isotropic Diffuse
5/10/10 2:22 PM
Acciari, V. A. et al. 2010, ApJL, 715, L49 doi: 10.1088/2041-8205/715/1/L49
arXiv: 1005.0041
ADS: 2010ApJ...715L..49A BibTeX Citations
SPIRES

Fermi-Large Area Telescope Observations of the Exceptional Gamma-Ray Outbursts of 3C 273 in 2009 September
Abdo, A. A. et al. 2010, ApJL, 714, L73 doi: 10.1088/2041-8205/714/1/L73
ADS: 2010ApJ...714L..73A BibTeX Citations

Fermi Gamma-ray Imaging of a Radio Galaxy
Abdo, A. A. et al. 2010, Science, 328, 725 doi: 10.1126/science.1184656
ADS: 2010Sci...328..725A BibTeX Citations
Public: Abstract Full text

The Vela Pulsar: Results from the First Year of Fermi LAT Observations
Abdo, A. A. et al. 2010, ApJ, 713, 154 doi: 10.1088/0004-637X/713/1/154
arXiv: 1002.4050
ADS: 2010ApJ...713..154A BibTeX Citations
SPIRES

Fermi-LAT Observations of the Vela X Pulsar Wind Nebula
Abdo, A. A. et al. 2010, ApJ, 713, 146 doi: 10.1088/0004-637X/713/1/146
arXiv: 1002.4383
ADS: 2010ApJ...713..146A BibTeX Citations
SPIRES

Fermi Large Area Telescope observations of PSR J1836+5925
Abdo, A. A. et al. 2010, ApJ, 712, 1209 doi: 10.1088/0004-637X/712/2/1209
arXiv: 1002.2977
ADS: 2010ApJ...712..1209A BibTeX Citations
SPIRES

Discovery of Pulsed Gamma-rays from PSR J0034-0534 with the Fermi LAT: A Case for Co-located Radio and Gamma-ray Emission Regions
Abdo, A. A. et al. 2010, ApJ, 712, 957 doi: 10.1088/0004-637X/712/2/957
arXiv: 1002.2607
ADS: 2010ApJ...712..957A BibTeX Citations
SPIRES

The First Fermi Large Area Telescope Catalog of Gamma-ray Pulsars
Abdo, A. A. et al. 2010, ApJS, 187, 460 doi: 10.1088/0067-0049/187/2/460
arXiv: 0910.1608

http://www-glast.stanford.edu/cgi-bin/pubpub

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...with many more in the pipeline!

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

Some Highlights

- Discovery and study of >60 gamma-ray pulsars, 25 of which are seen to pulse only in gamma rays. 16 are ms pulsars.
 - 19 new ms radio pulsars discovered thanks to LAT data!
- Remarkable high-energy emission from gamma-ray bursts
 - Starting to see what was missing
 - Also provides interesting limits on photon velocity dispersion
- Very high statistics measurement of the cosmic e⁺e⁻ flux to 1 TeV
- Nailing down the diffuse galactic GeV emission
- First Fermi determination of the isotropic diffuse flux
- Early searches for Dark Matter signatures in different kinds of sources
- 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 and SMC.
- EBL constraints
- Year-one catalog: 1451 sources

HUNTING GRAVITATIONAL WAVES USING PULSARS

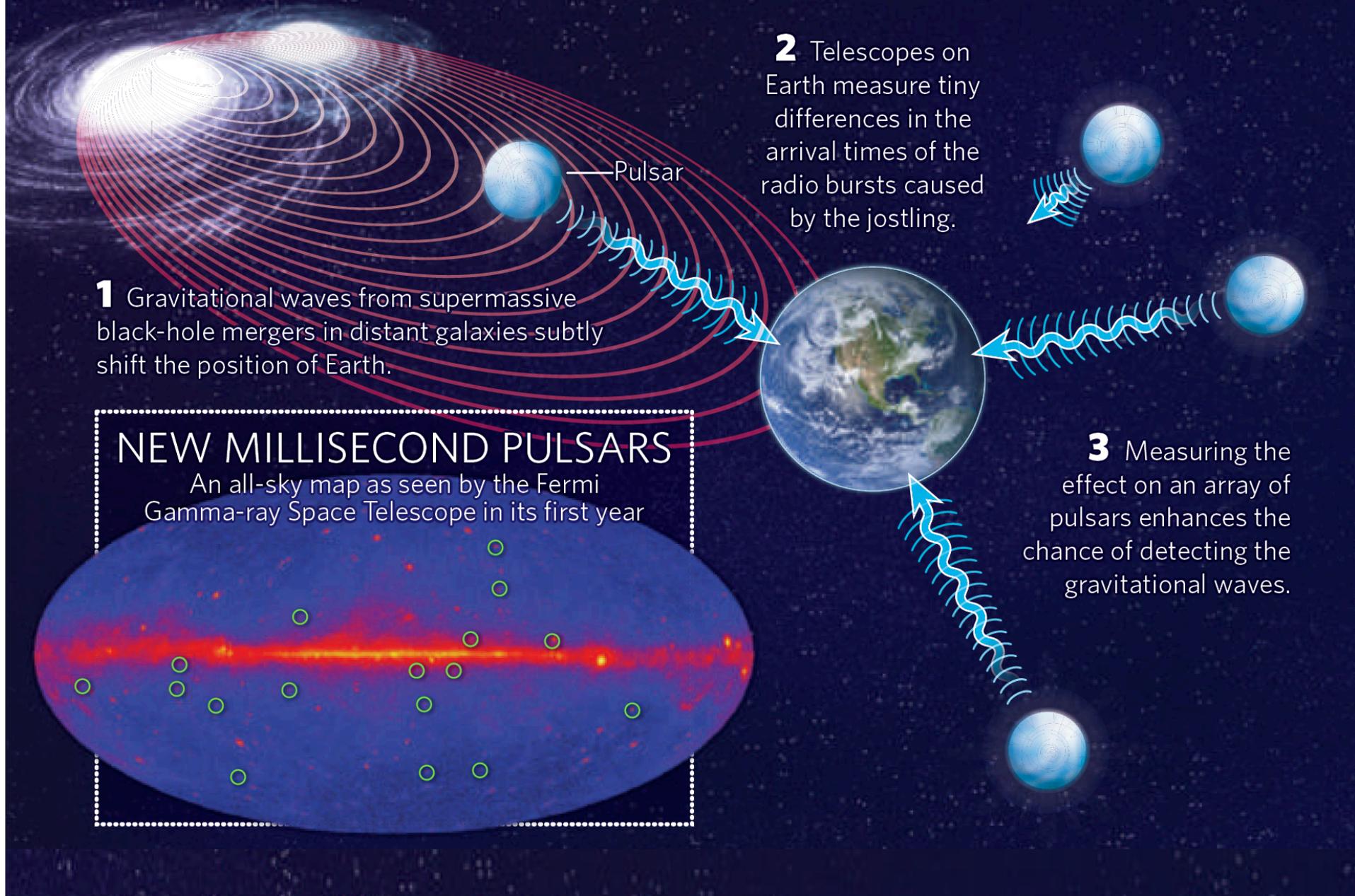
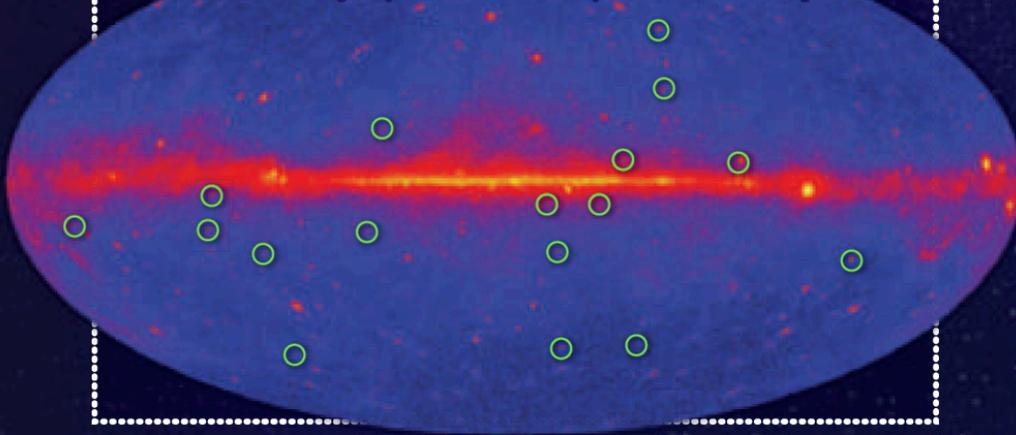
1 Gravitational waves from supermassive black-hole mergers in distant galaxies subtly shift the position of Earth.

2 Telescopes on Earth measure tiny differences in the arrival times of the radio bursts caused by the jostling.

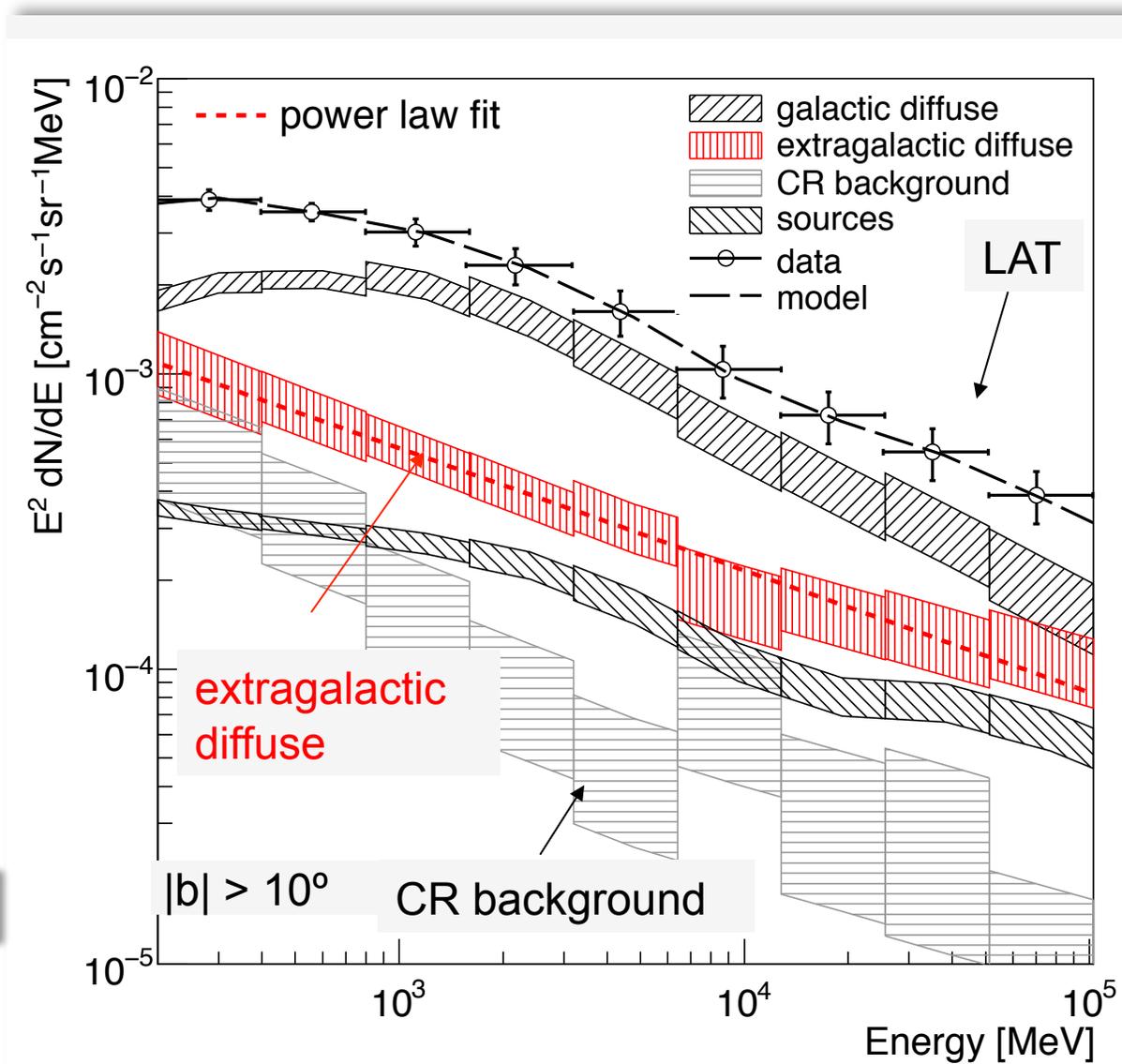
3 Measuring the effect on an array of pulsars enhances the chance of detecting the gravitational waves.

NEW MILLISECOND PULSARS

An all-sky map as seen by the Fermi Gamma-ray Space Telescope in its first year



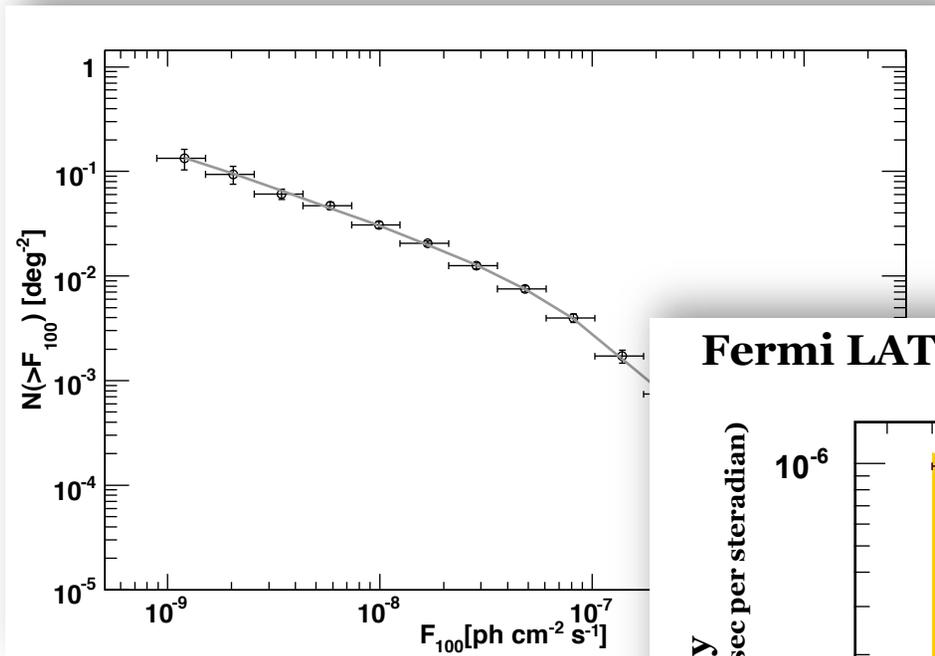
LAT Isotropic Diffuse Flux



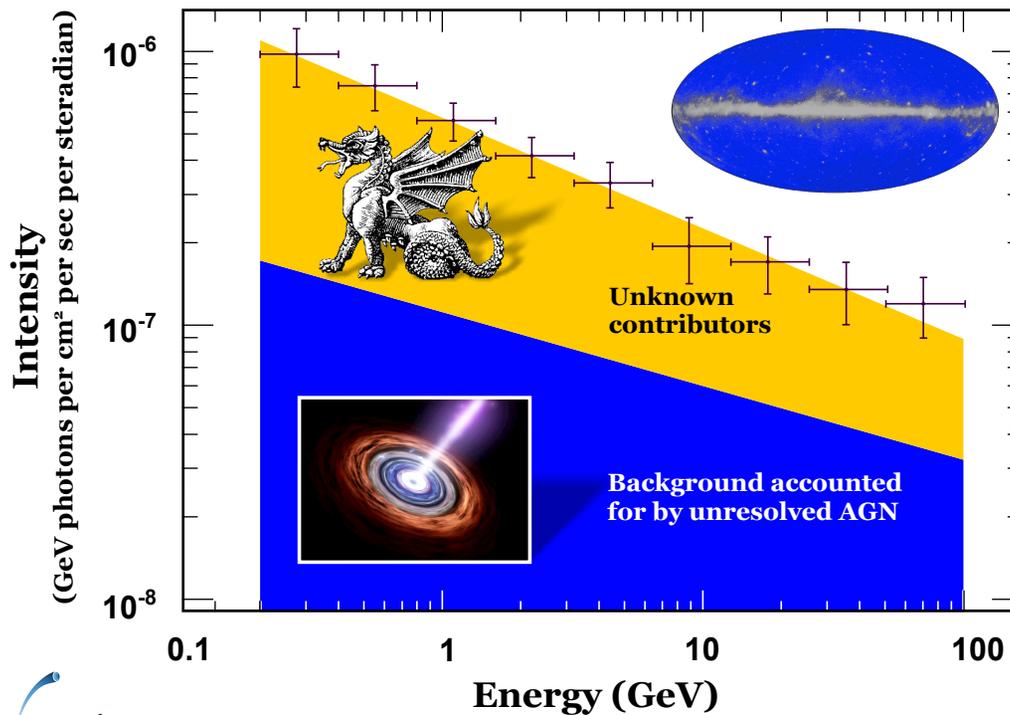
arXiv: 1002.3603

Not just unresolved blazars!

See arXiv:1003.0895



Fermi LAT Extragalactic Gamma-ray Background



LAT Resolves the LMC

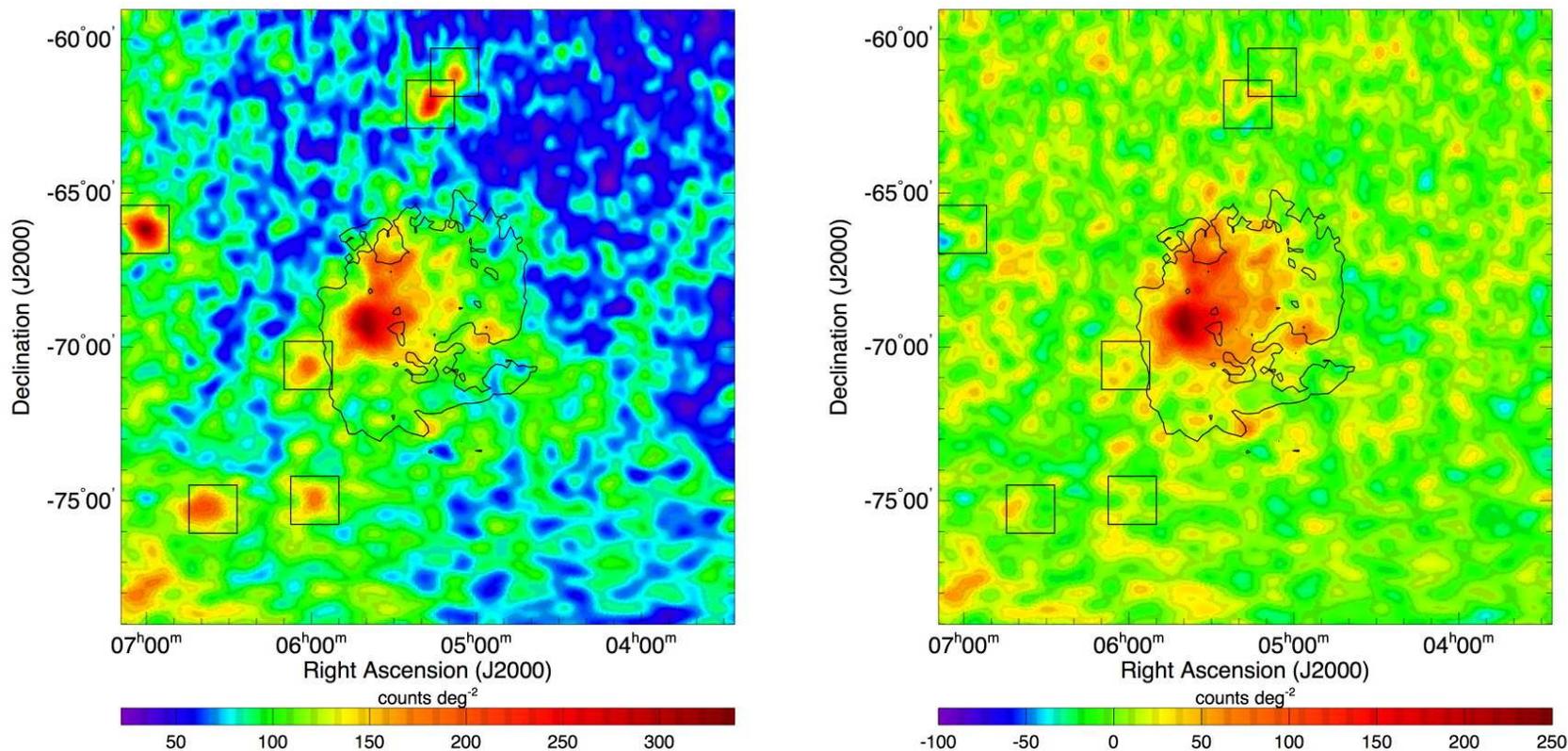


Fig. 1. Gaussian kernel ($\sigma = 0.2^\circ$) smoothed counts maps of the region of interest (ROI) in a true local projection before (left) and after subtraction of the background model (right) for the energy range 200 MeV – 20 GeV and for a pixel size of $0.1^\circ \times 0.1^\circ$. Overlaid is the N(H I) contour of $1 \times 10^{21} \text{ H cm}^{-2}$ of the LMC to indicate the extent and shape of the galaxy. The boxes show the locations of the 6 point sources that have been included in the background model. The right panel has a true dynamic range from -46 to $+248 \text{ counts deg}^{-2}$ that has been expanded for display to cover the full dynamic range of the residuals that are shown in Fig. 4.

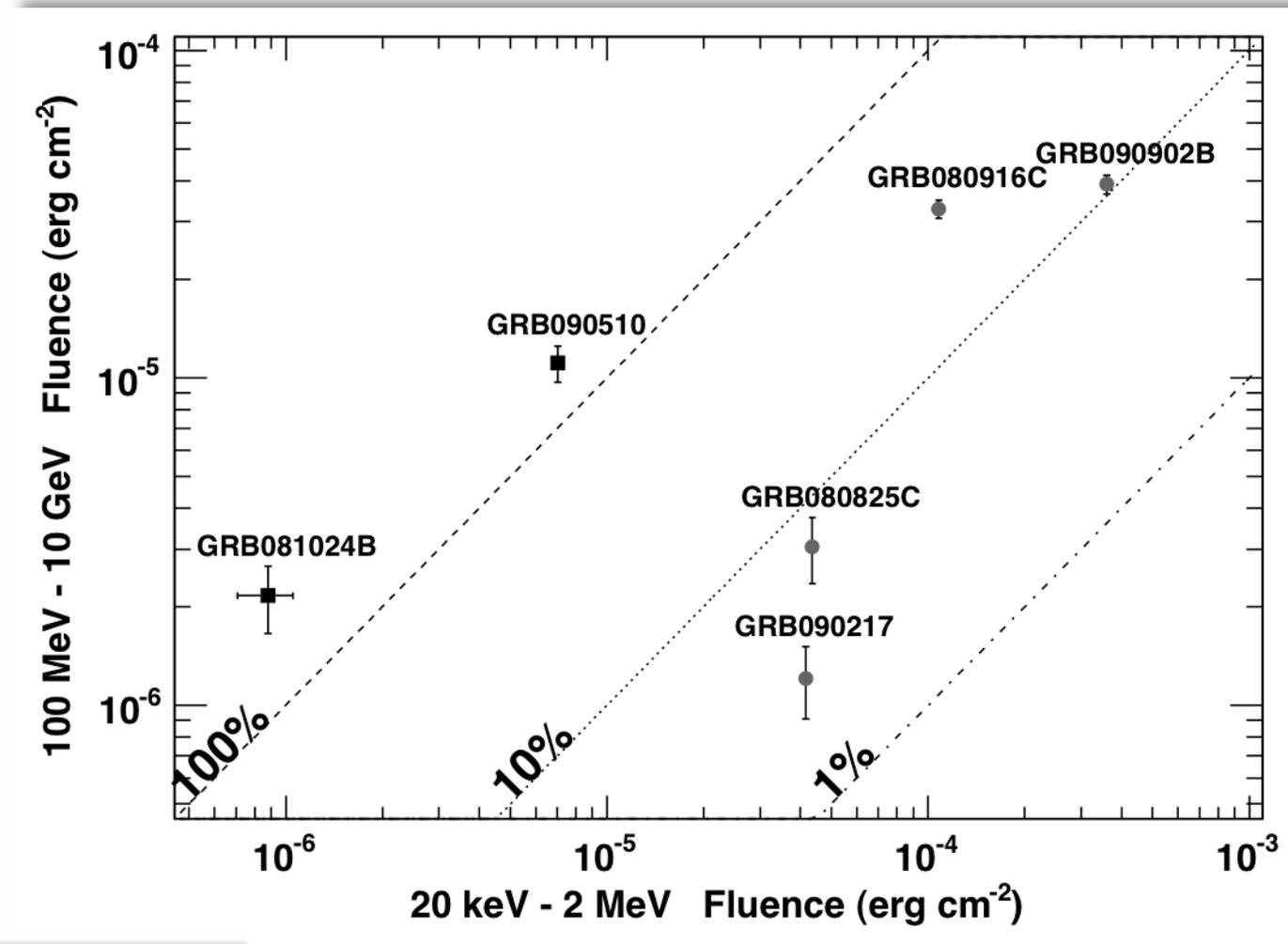
arXiv: 1001.3298

Summary of LAT Bursts

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



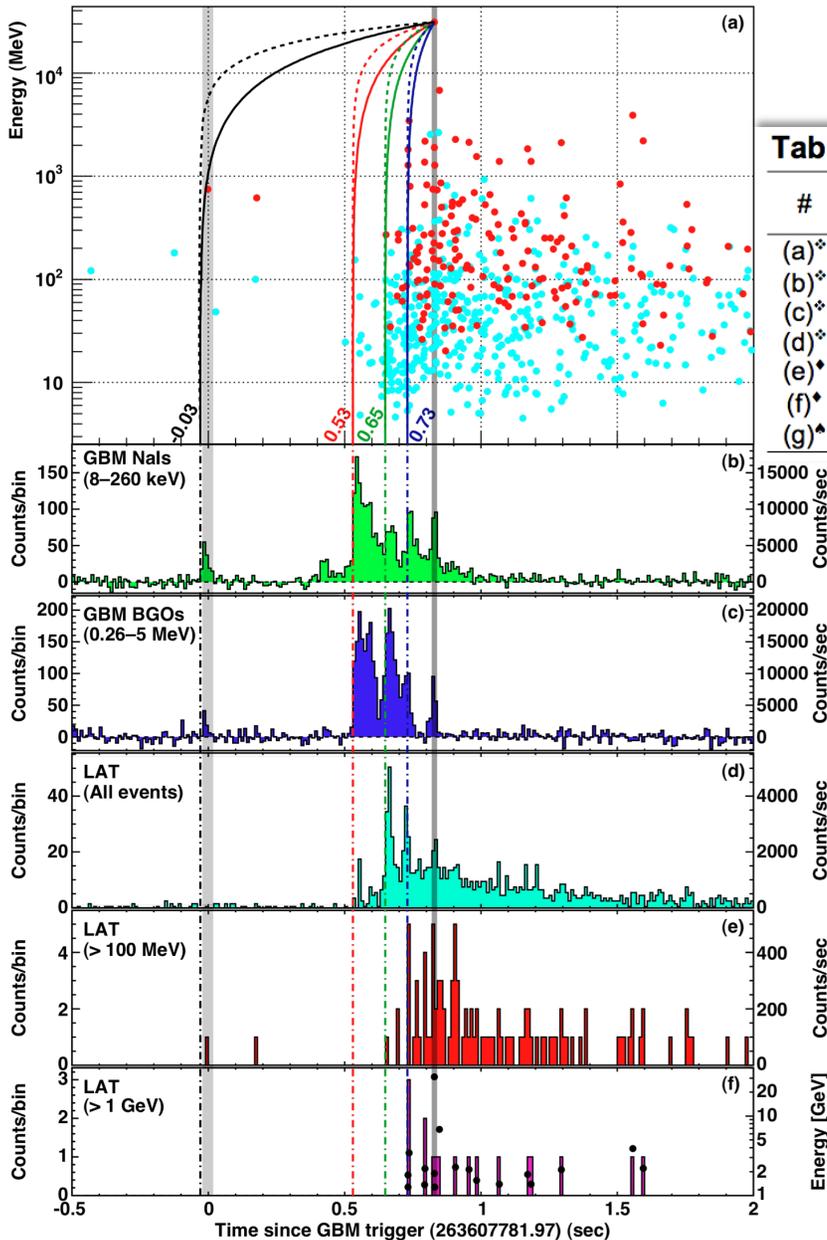
arXiv: 0910.1629

QG-Related Limits from GRB 090510

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

Table 2 | Limits on Lorentz Invariance Violation

#	$t_{\text{start}} - T_0$ (ms)	Limit on $ \Delta t $ (ms)	Reasoning for choice of t_{start} or limit on Δt or $ \Delta t/\Delta E $	E_l^\dagger (MeV)	Valid for s_n^*	Lower limit on $M_{\text{QG},1}/M_{\text{Planck}}$
(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 1 st spike	0.1	-1	> 1.33
(g)†	$ \Delta t/\Delta E < 30 \text{ 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.

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 (see JEM talk)
 - 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 “Pass6”
 - Pass7 under study
 - » Improved standard photon classes
 - » Event analysis taking into account “ghost” events
 - Detailed report at next FUG meeting.
 - Working closely with FSSC on ease of use for user community.
 - On further horizon, there is also work on Pass8.
- Work also on Diffuse Model improvements. 

Current Diffuse Model

- **v02 (gll_iem_v02.fit) has been the standard recommended model within the LAT team since July 2009, and in particular was used to prepare the 1FGL catalog**
- v02 was publicly released in August 2009 with the LAT data
- Derived from a template fitting approach to the Fermi LAT data
 - $N(\text{H I})$, $W(\text{CO})$ rings, and $E(\text{B-V})_{\text{res}}$ as gas tracers
 - GALPROP-derived template for inverse Compton scattering
 - Large-scale fits to the LAT data for the gamma-ray emissivity (CR densities)
 - Templates for local structures in the gamma-ray sky related to variations of cosmic-ray density were also fit (e.g., around Cygnus and the Aquila Rift)
 - The fitting took into account the known gamma-ray point sources

See <http://fermi.gsfc.nasa.gov/ssc/data/access/lat/BackgroundModels.html>

Plan for Diffuse V03

- The $E(B-V)_{\text{res}}$ map filtered to remove small-scale artifacts from star-forming regions
- The IC template (formerly 54_87Xexph7S) will be updated based on current GALPROP studies (54_z10G4c5rS)
- The grid for the model will be 0.125° , with a row centered on $b=0^\circ$. This will be approximately the full resolution of the input CO survey data.
 - By contrast v02 was 0.5° resolution with pixel boundaries at $b = 0^\circ$

Plan for Diffuse V03 (cont)

- The fitting for v03 is from 63 MeV to 40 GeV in 14 energy bands, based on 19 months of LAT data, with detected point sources taken into account.
 - With the greater depth of the data this is an improvement over v02 (~10 months).
 - NB: The fitting produces the corresponding isotropic diffuse spectrum, including residual background, which will be updated for the new model
- The v03 model will be extrapolated to lower (50 MeV) and higher energies (to the limit of the IRFs, currently 562 GeV) taking into account the energy dependences of the various components separately
 - This is an improvement over v02, which relied on an extrapolation of the overall model (and stopped at 100 GeV)

Timeline

- The v03 model currently is in preparation
- First internal tests expected this summer.
- The v03 model will be the input to the 2FGL catalog analysis, which will begin in August
 - Plan to release 2FGL in early 2011
- A detailed description will be published, along with the model, by time of 2FGL release.
- NOTE:
 - The full v03 model will be considerably larger than v02 (which is 31 Mbyte)
 - We plan to study the effects on accuracy from reducing the number of energy planes (now anticipated to be 17, v02 has 30 planes)
 - We anticipate preparing a script that uses FTOOLS to sub-select a region of the sky for a particular ROI

Discussion
