LAT status

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Fermi User Group Meeting
November 6, 2015

Summary

- Fermi LAT Collaboration is very busy and very productive
  - Maintaining good coverage in all areas due to multitasking, in spite of reductions in core operations staff at SLAC.

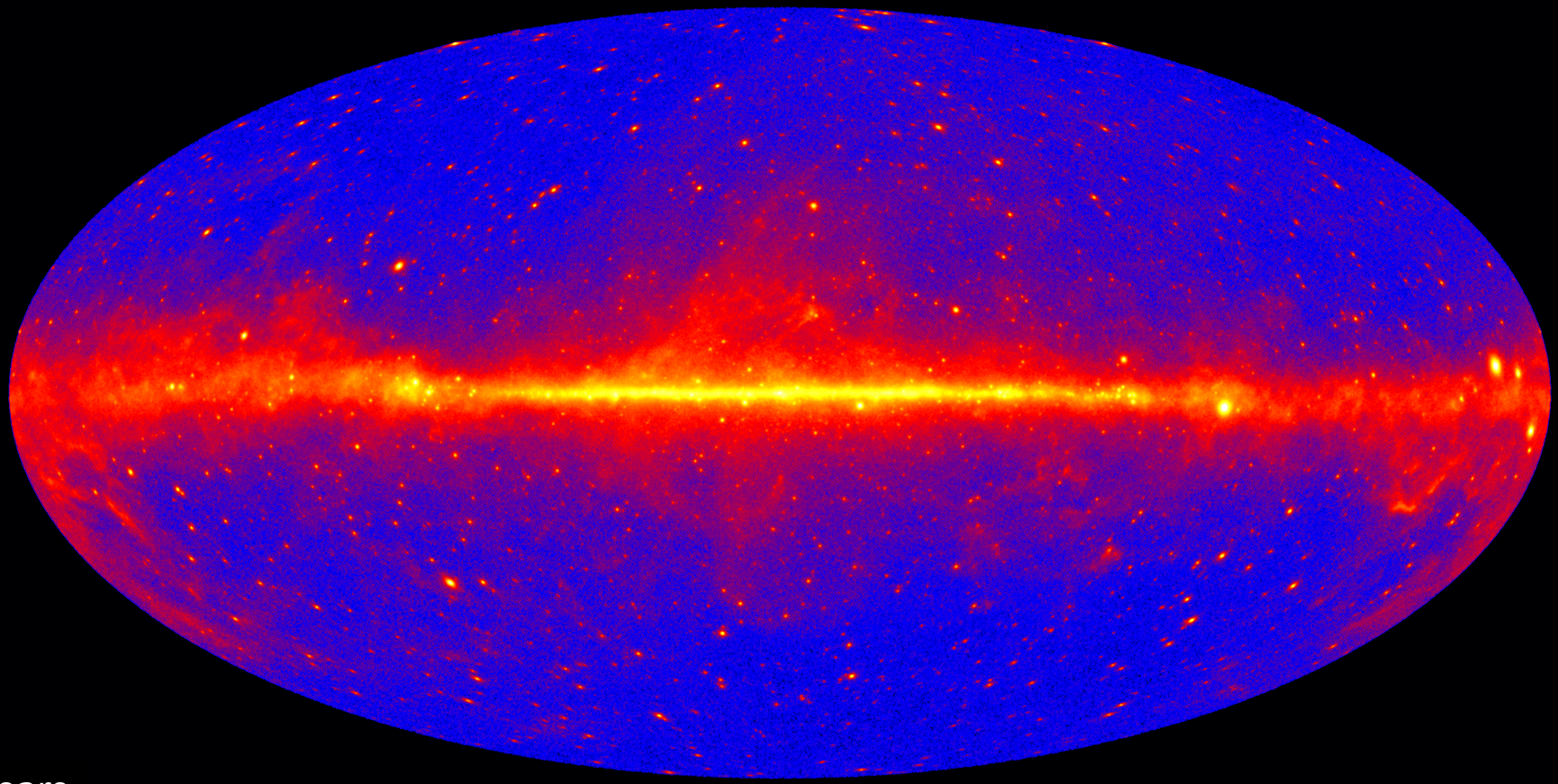
•Pass 8 pipeline now fully operational - Pass 8 data being delivered to science community by FSSC;

- Looking forward to many new results from Pass 8 being reported at this week's Fermi Symposium
- completion of analysis tools and supporting science analysis results (catalog and updated diffuse model) for Pass 8 underway

- LAT Instrument operation remains stable; science performance better than ever

- Science productivity of LAT remains high

2015: A good year for Fermi LAT science

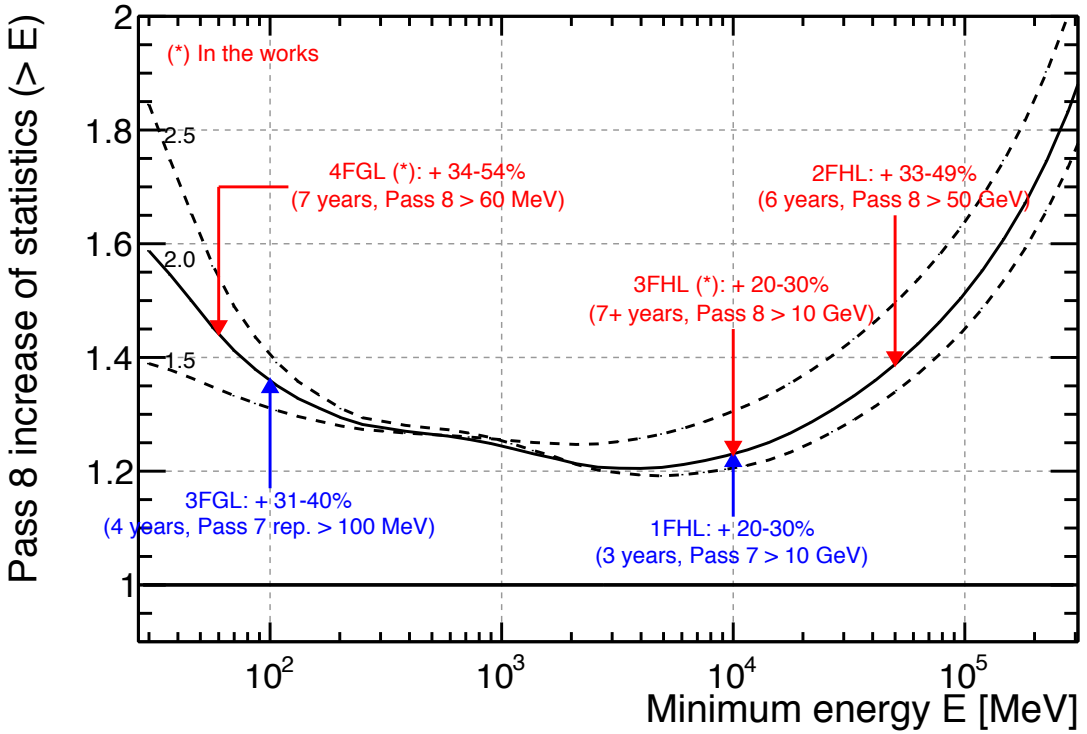


7 years

Pass 8 is here!

- Pass 8 is the most profound revision of the LAT event-level analysis since launch.
  - And improving on all the metrics related to high-level science analysis.
- The LAT processing pipeline switched to Pass 8 on June 24.
  - No more Pass 7 data being produced.
- The FSSC started serving Pass 8 data (since the beginning of the mission) on the same day.
  - And associated analysis components and tools.
- A fundamental milestone, closing a loop started in 2009.
- Many different pieces finally coming together.
  - Development and validation of the underlying event-level analysis and instrument response functions.
  - Update of the analysis tools.
  - Update of the processing pipeline and associated data quality monitoring.
  - Development of the documentation.
  - Update of the FSSC infrastructure for serving photons to the community.
- And an extraordinary example of collaboration between the LAT Science Team, the Instrument Science Operation Center, the *Fermi* Science Support Center and the ASI Science Data Center (among others).

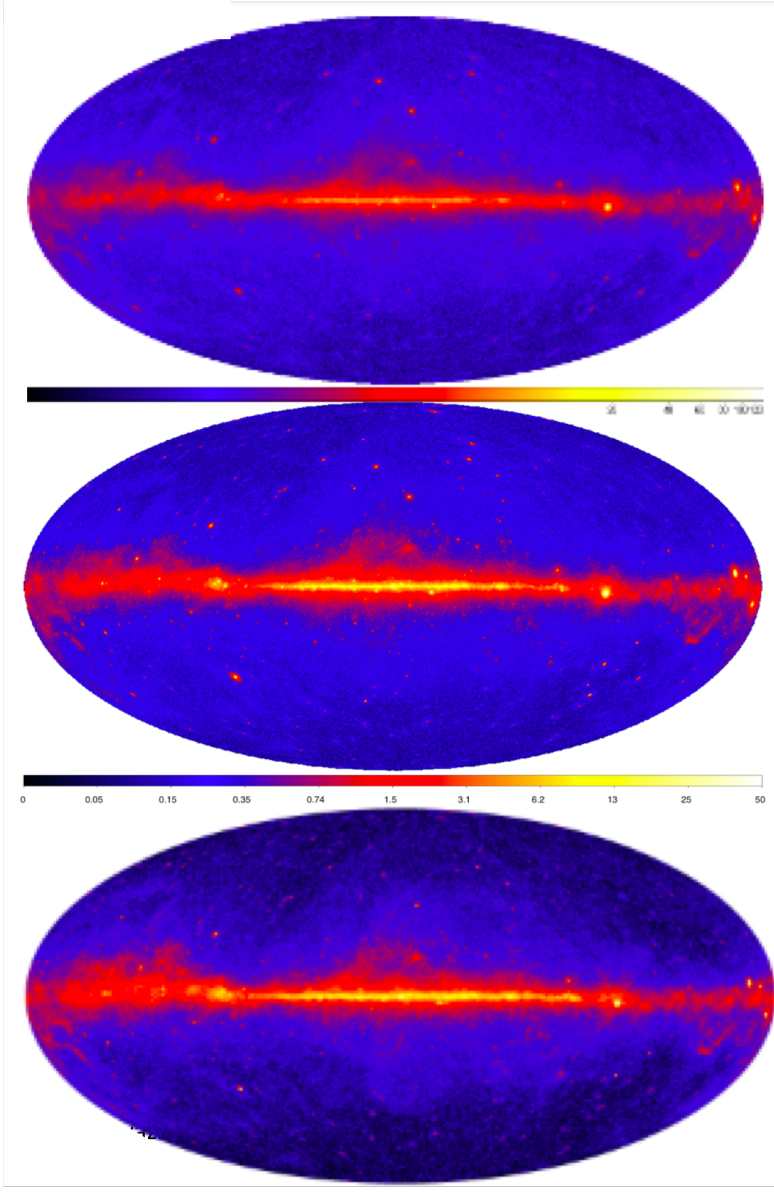
Overview of Pass 8



- Significantly increase the gamma-ray throughput ($> \times 1.2$ everywhere).
  - $\times 1.5$ above $\sim$ 60 MeV and above $\sim$ 50 GeV.
- Better angular resolution—and better modeled.
  - $\times 1.3$ at 10 GeV (or background $\times 0.6$).
- Event-by-event reconstruction quality fully integrated in the analysis framework.
  - PSF event types (dSphs, source extension, AGN pair halo).
  - Energy dispersion event types (searches for spectral lines and ALPs).

3nd Fermi LAT Catalog

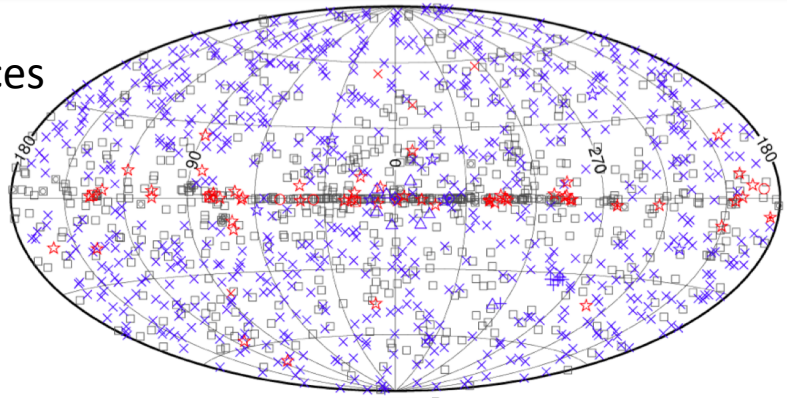
LAT Collaboration, ApJS 218:23 (June 2015)



1451 sources

1FGL

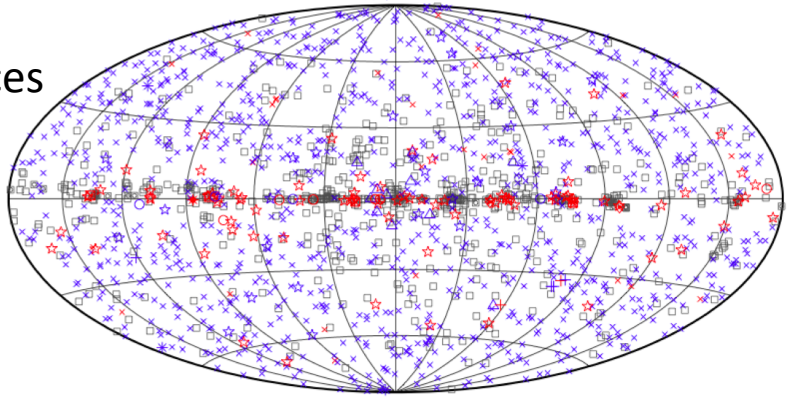
11 m



1873 sources

2FGL

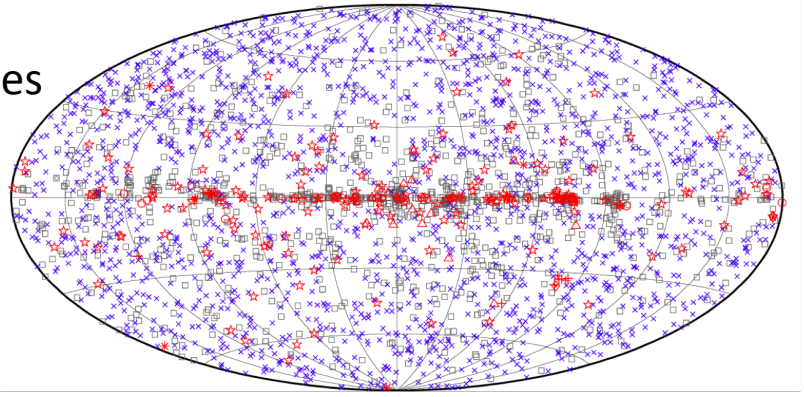
2 y



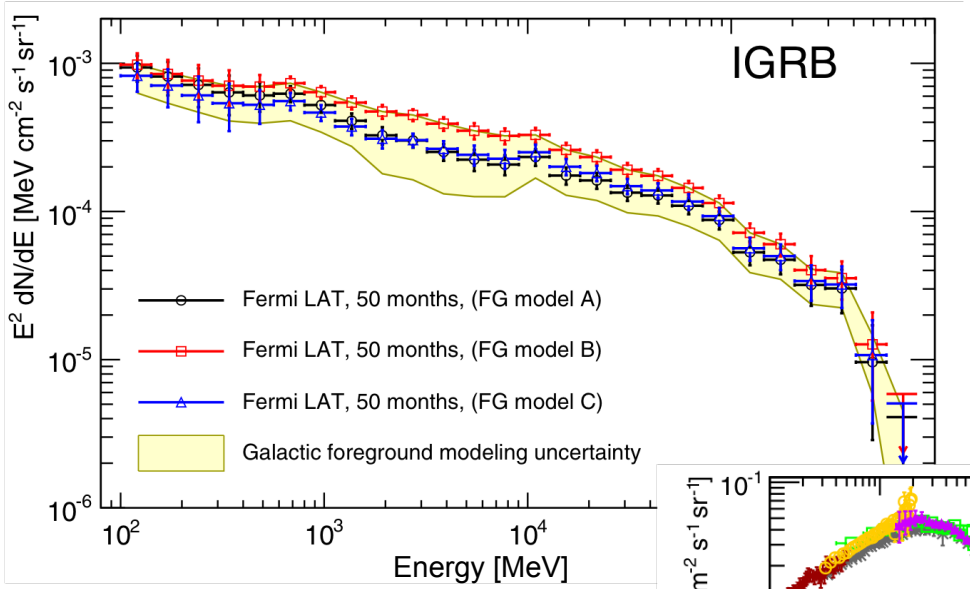
3033 sources

3FGL

4 y

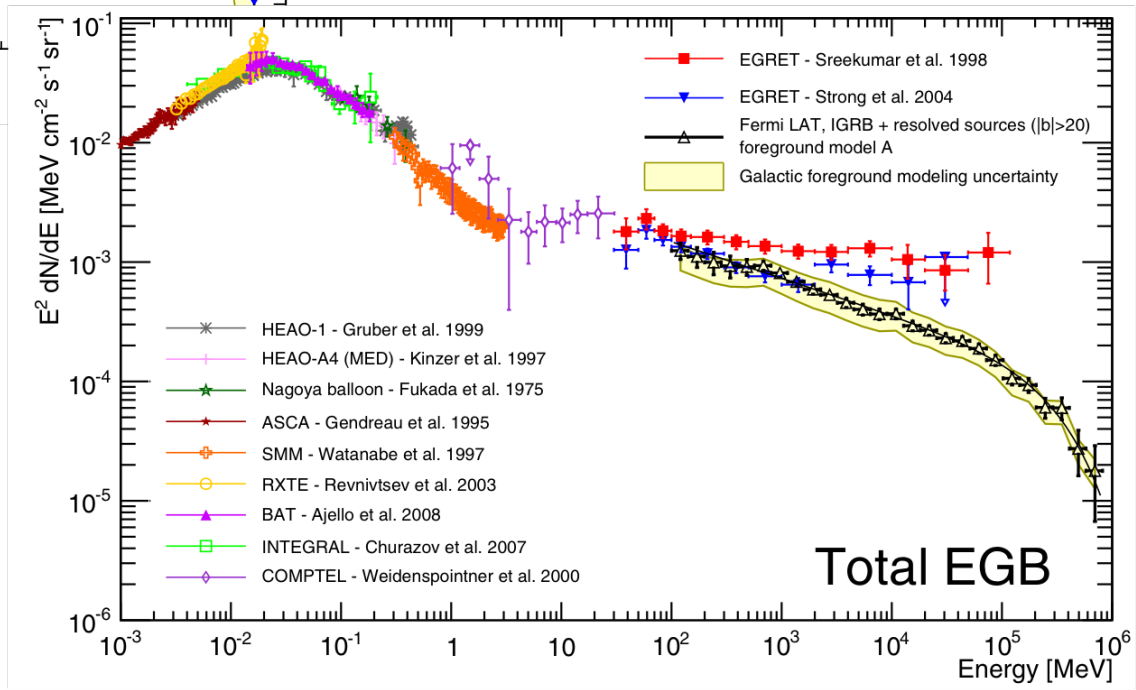


Measurement of isotropic diffuse gamma-ray background to 820 GeV



IGRB: extragalactic emission too faint or too diffuse to be resolved + any Galactic foregrounds that are ~isotropic.

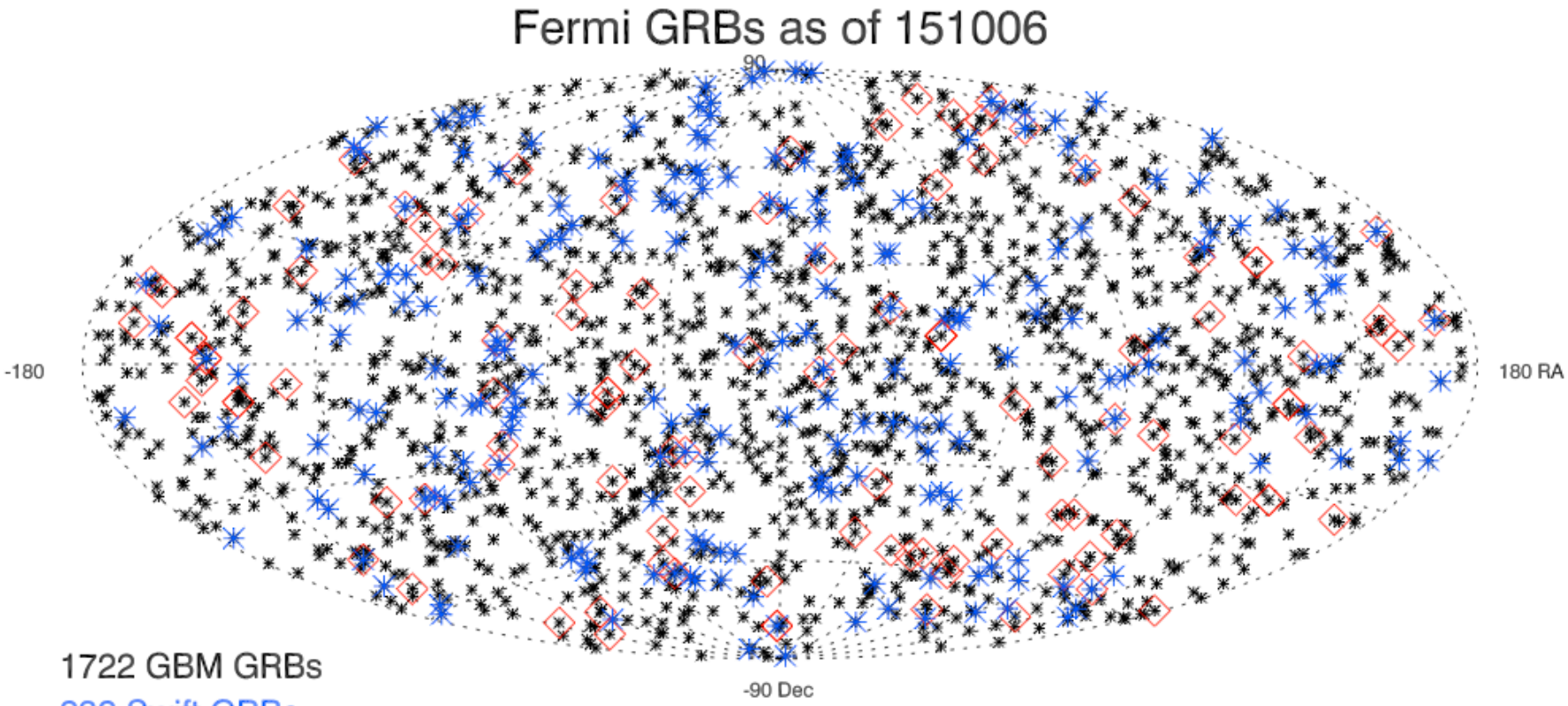
- now extended from 100 GeV to 820 GeV; significant high-energy cutoff – consistent with EBL attenuation of source population with little or no evolution



Fermi LAT Collaboration,
ApJ 799:86 (January 2015)

Gamma-Ray Bursts

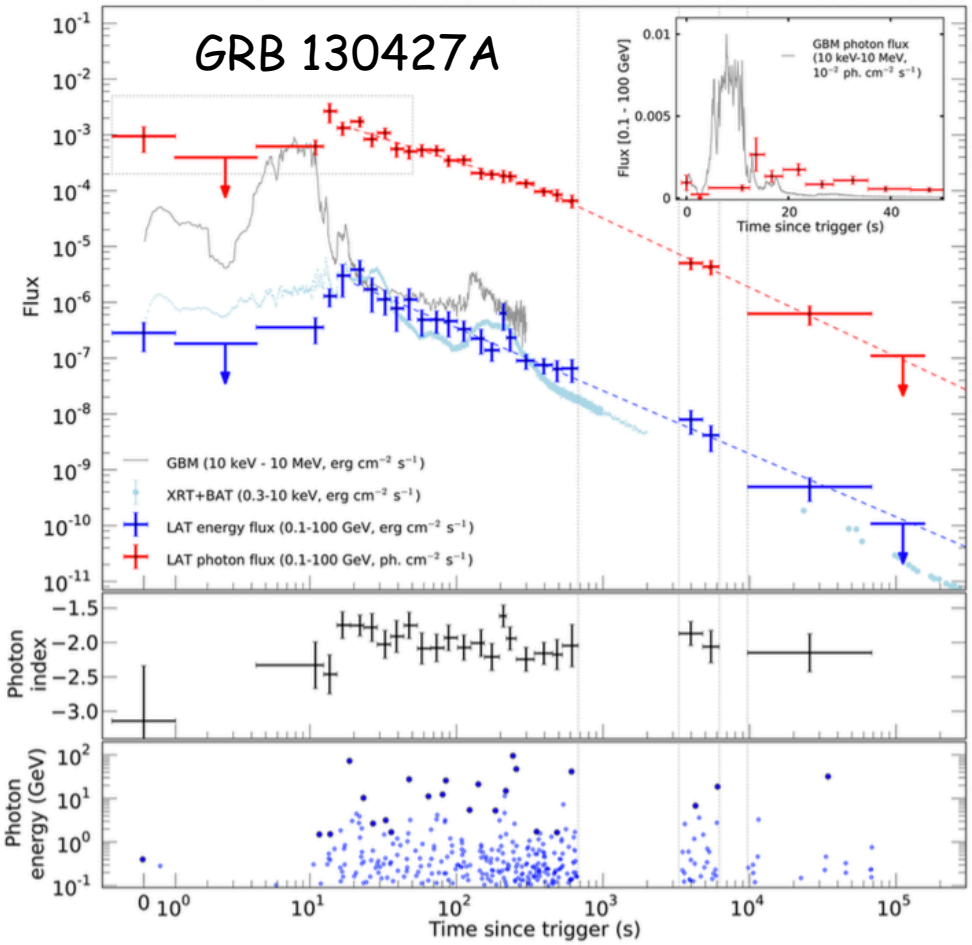
Fermi is the most prolific detector of GRBs



GRB observations with LAT have prompted theoretical advances and posed big challenges to understanding of these extreme sources, despite the fact that GRB emission above 100 MeV is a fairly rare event.

Unveiling the nature of GRB

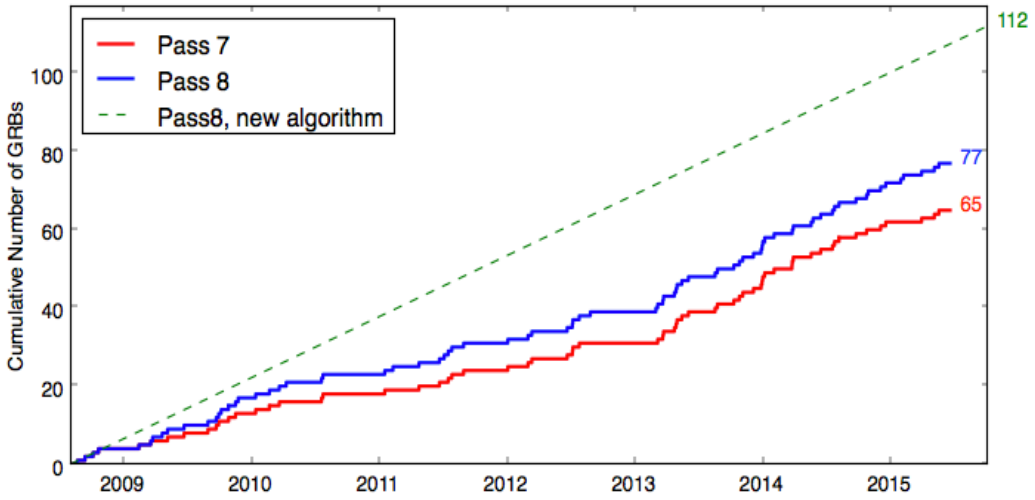
- Fermi LAT is changing our knowledge of Gamma-Ray Bursts:
  - High energy emission is **delayed** and lasts much **longer** than low energy emission: probably related to afterglow rather than prompt gamma-ray emission;
  - **Synchrotron emission** alone **cannot explain very high energy gamma-rays;**
  - Conventional models have problem explaining rich dataset: "extra components" both at low and high energy are required to fit data;
- Rare bright events (such as 130427A) will continue to occur, offering an important tool to study **particle acceleration** and **emission mechanisms** in GRBs;
- **larger population** of LAT GRBs with known redshift:
  - provides tool to constrain **EBL models,** extending sample of high energy emitter to high high redshift;
  - Improves constraints on Lorentz invariance violation (V. Vasileiou, et al. 2013, PRD)

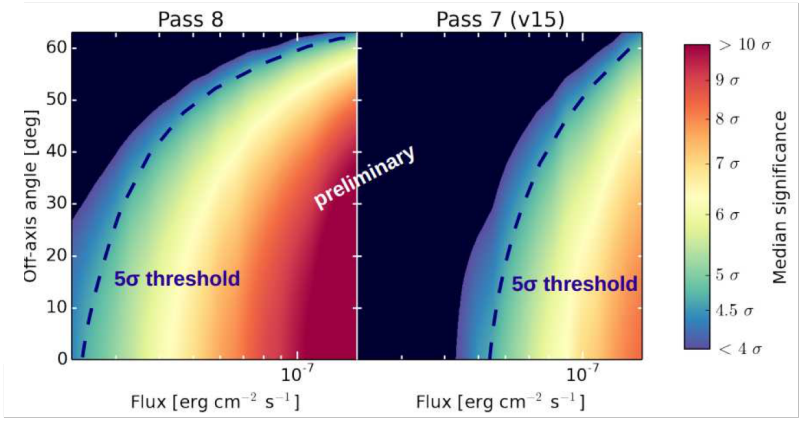


Brightest GRB detected by Fermi: high-energy LAT emission resembles the Swift X-ray emission rather than soft-gamma GBM emission

LAT GRB detections: enhanced by Pass 8 and improved algorithm

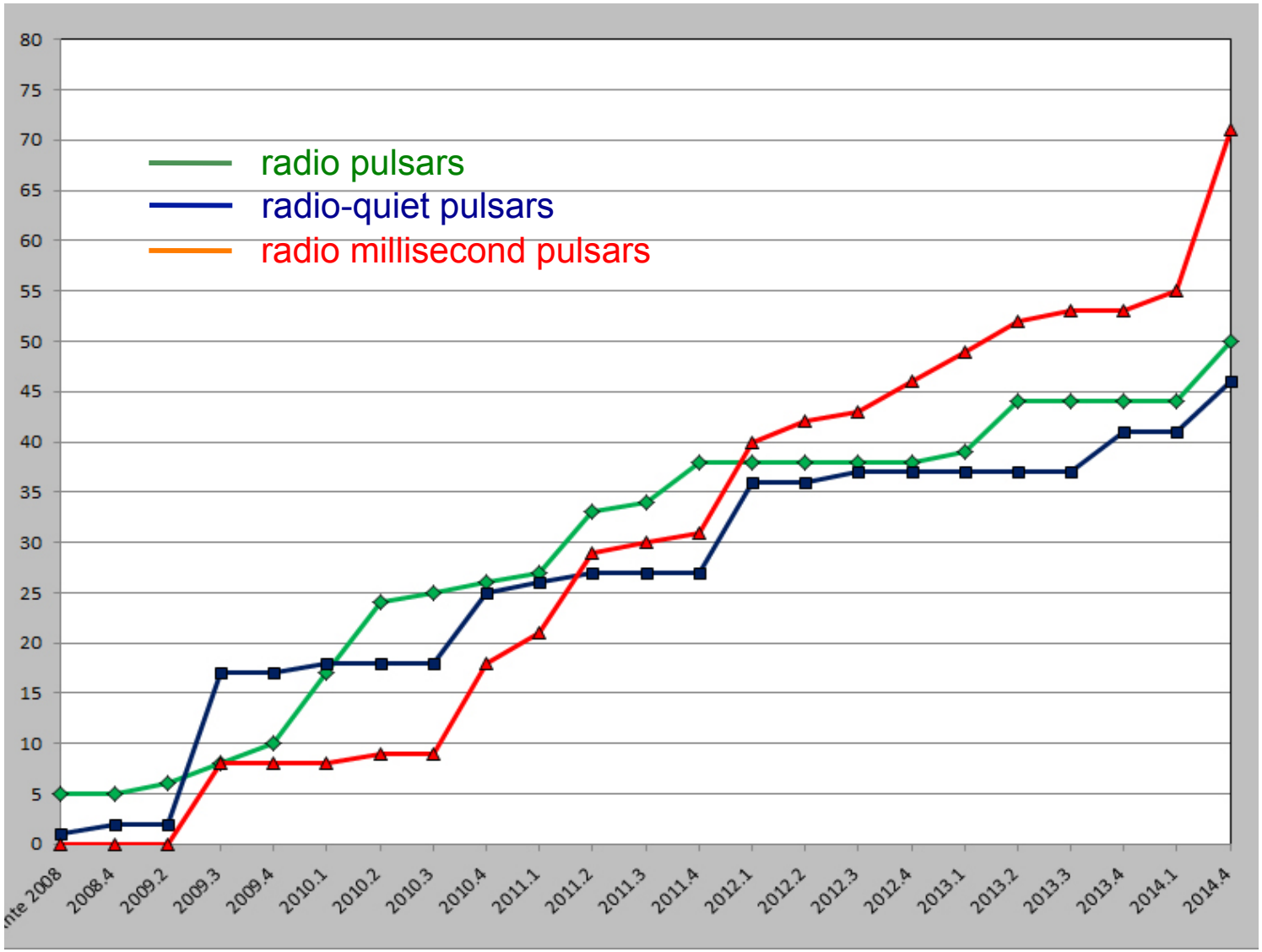
- **Pass 8** brings 20% increase of GRB detections;
- A **new** detection **algorithm** (used since March 2013) increased number of GRB detections resulting in more GCNs (and more follow-ups);
- Applying the new algorithm on Pass 8 data since the beginning of the mission: **resulted in more than 100 GRB detected at high energy** (2nd LAT catalog in prep.)





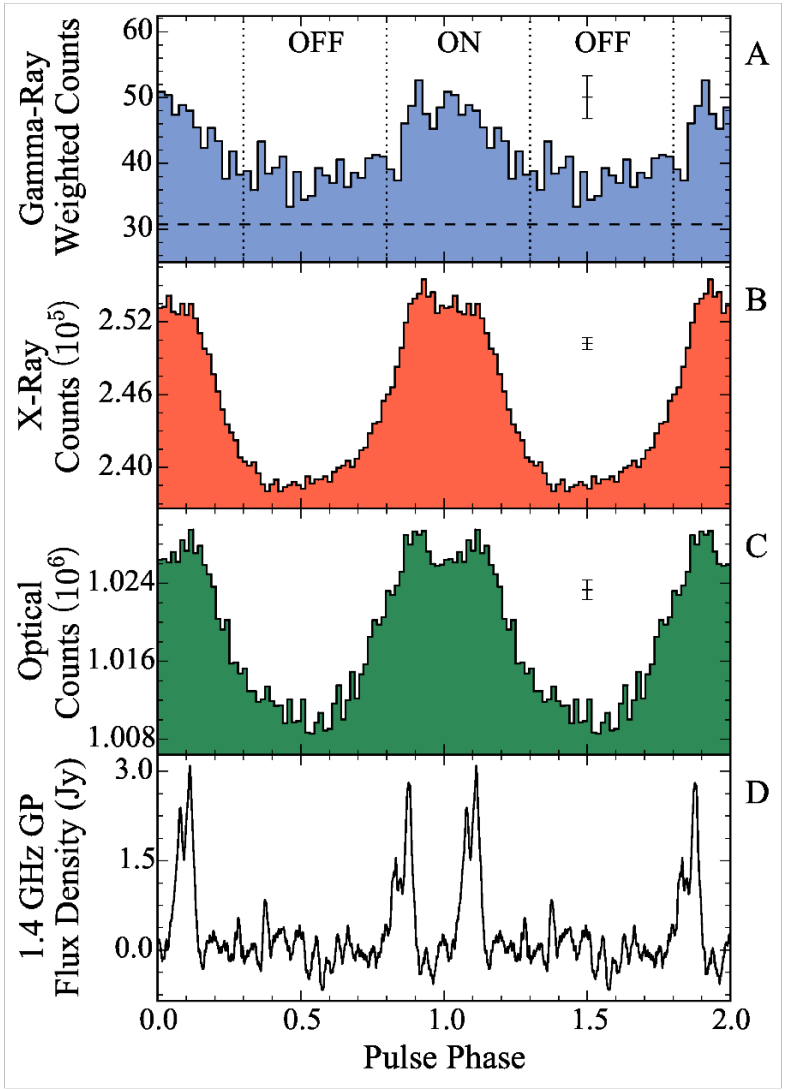
2015: A good year for Fermi LAT pulsar science

- pulsar discovery rate undiminished

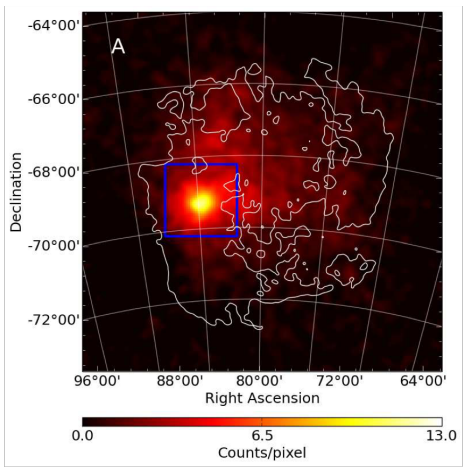


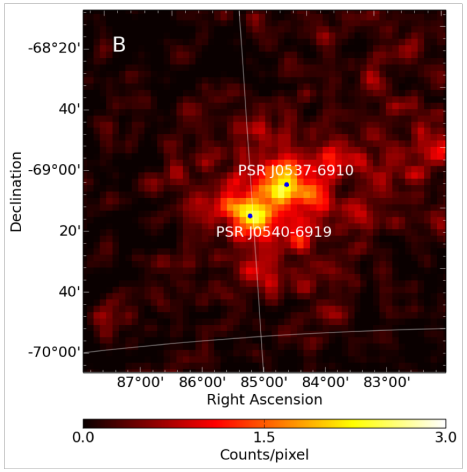
PSR J0540-6919: first extragalactic gamma-ray pulsar

- to be published in *Science* this week



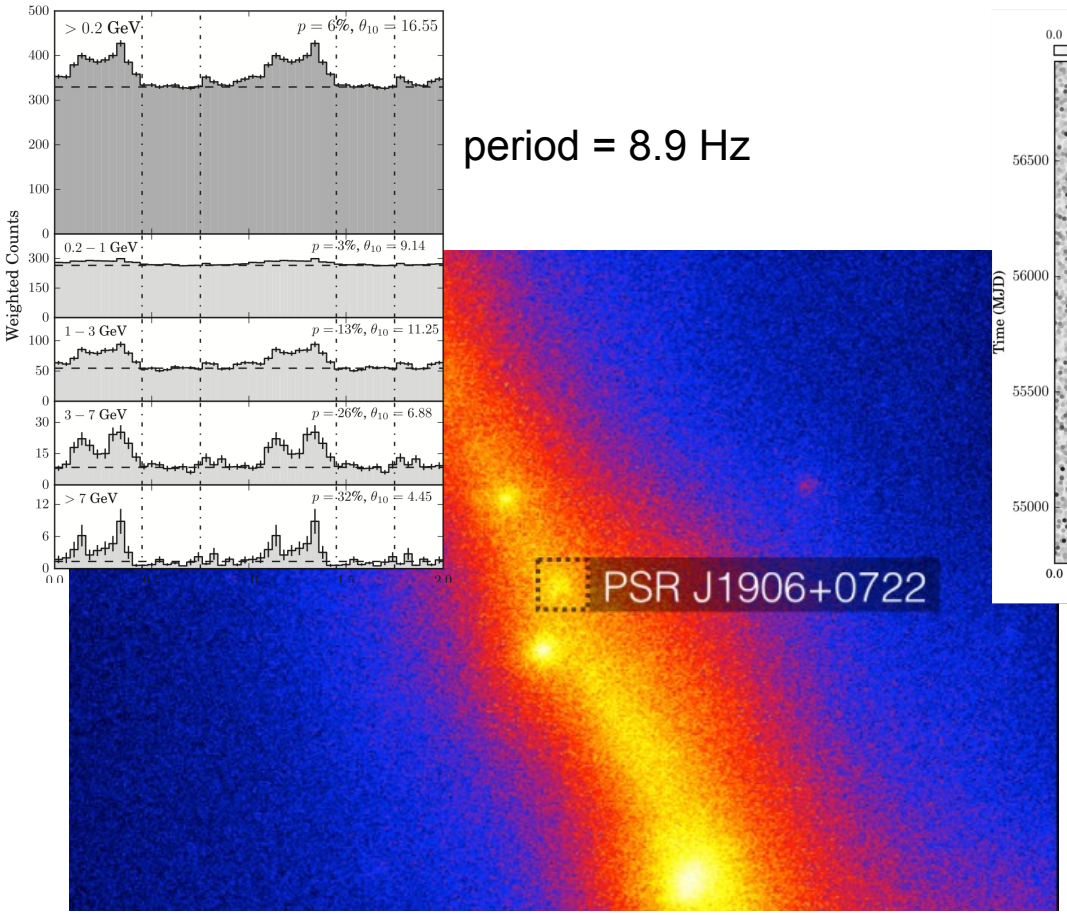
- most luminous pulsed gamma-ray emission yet observed; 20x the Crab
- upper limit for gamma-ray emission from PSR J0537-6910



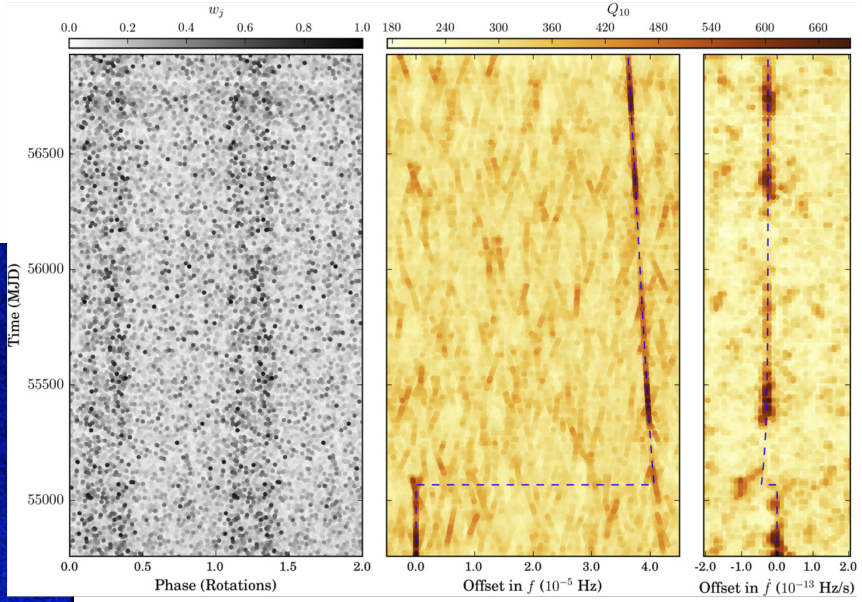


recently discovered pulsar found with Einstein@Home

PSR J1906+0722: an energetic pulsar: detection complicated by a huge glitch



period = 8.9 Hz



$\Delta f/f \approx 4.5 \times 10^{-6}$

$\dot{E} = 10^{36}$ erg/s

Fermi LAT Collaboration, ApJLett 809:12 (August 2015)

Pass 8 pushed this to detection

off-pulse analysis revealed an additional nearby source, possibly interaction between SNR and molecular cloud

Continuing productive synergy with radio pulsar community

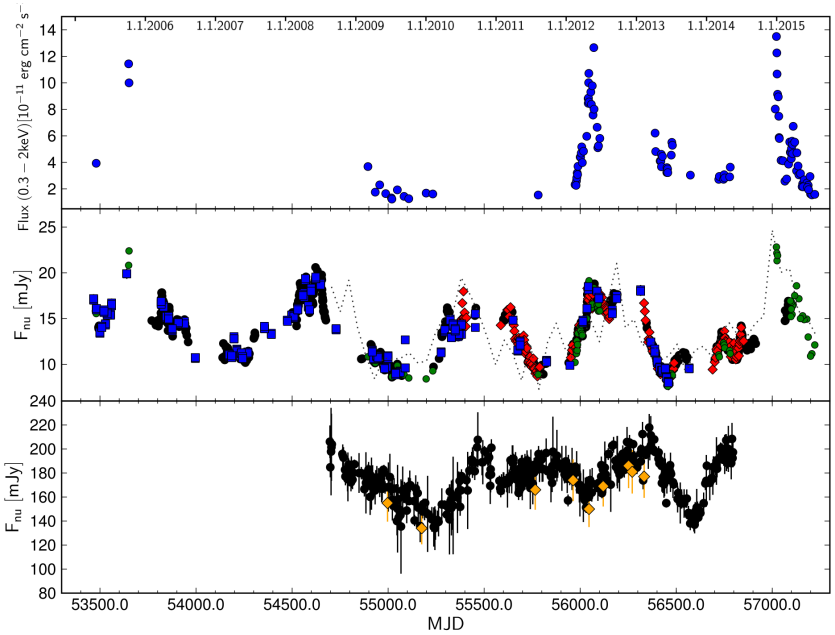
Most recently reported Parkes survey of 56 unidentified LAT sources resulted in discovery of 10 millisecond pulsars – Camilo, et al, ApJ 810:85 (Sept 2015)

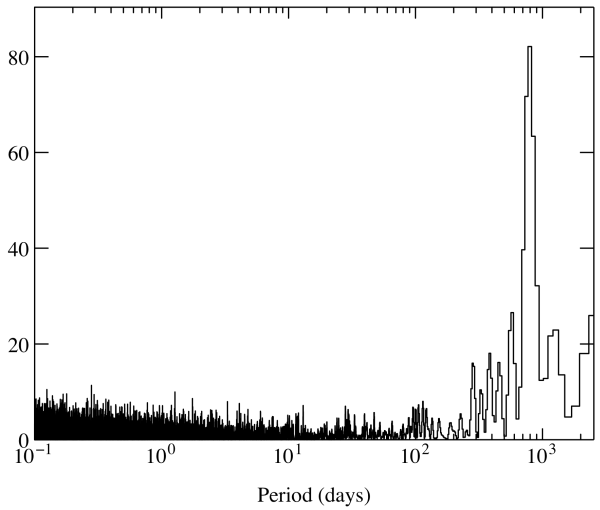
PARKES RADIO SEARCHES OF *FERMI* GAMMA-RAY SOURCES AND MILLISECOND PULSAR DISCOVERIES

ABSTRACT

In a search with the Parkes radio telescope of 56 unidentified *Fermi*-Large Area Telescope (LAT) gamma-ray sources, we have detected 11 millisecond pulsars (MSPs), 10 of them discoveries, of which five were reported by Kerr et al. We did not detect radio pulsations from six other pulsars now known in these sources. We describe the completed survey, which included multiple observations of many targets conducted to minimize the impact of interstellar scintillation, acceleration effects in binary systems, and eclipses. We consider that 23 of the 39 remaining sources may still be viable pulsar candidates. We present timing solutions and polarimetry for five of the MSPs and gamma-ray pulsations for PSR J1903–7051 (pulsations for five others were reported in the second *Fermi*-LAT catalog of gamma-ray pulsars). Two of the new MSPs are isolated and five are in >1 day circular orbits with 0.2–0.3 $M_\odot$ presumed white dwarf companions. PSR J0955–6150, in a 24 day orbit with a ≈ 0.25 $M_\odot$ companion but eccentricity of 0.11, belongs to a recently identified class of eccentric MSPs. PSR J1036–8317 is in an 8 hr binary with a >0.14 $M_\odot$ companion that is probably a white dwarf. PSR J1946–5403 is in a 3 hr orbit with a >0.02 $M_\odot$ companion with no evidence of radio eclipses.

PG 1553+113: an active galaxy with quasi-periodic gamma-ray emission





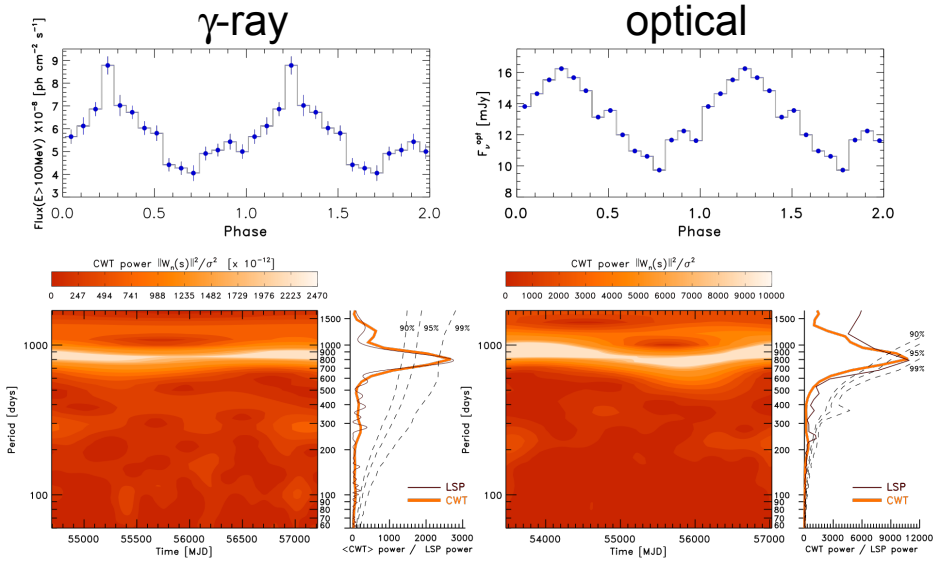
Fermi LAT Collaboration, ApJ, accepted

first observation of γ-ray and nearly-periodic multiwavelength oscillation in an AGN

P = 2.18 ± 0.08 years

- pulsational accretion flow instability ?
- jet precession ?
- gravitationally-bound supermassive black hole binary ?

If periodic modulation is coherent, as expected for binary scenario, then subsequent maxima expected in 2017 and 2019



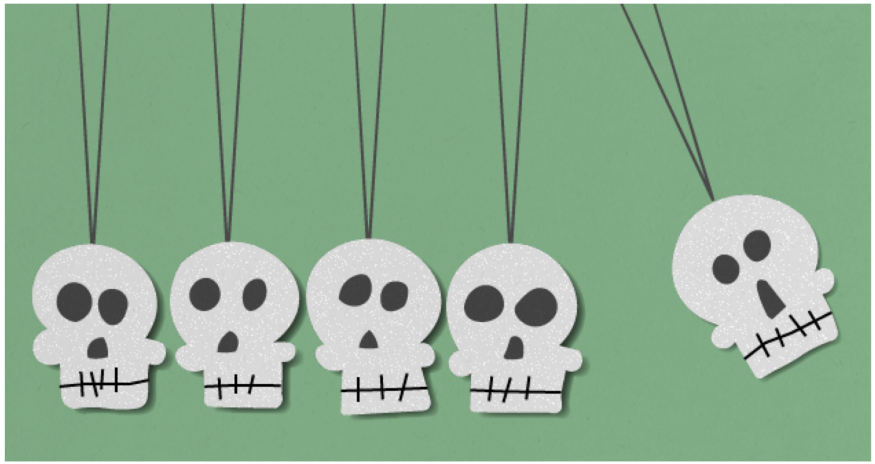
NATURE | NEWS

Zombie physics: 6 baffling results that just won't die

To celebrate Halloween, *Nature* brings you the undead results that physicists can neither prove — nor lay to rest.

Davide Castelvecchi

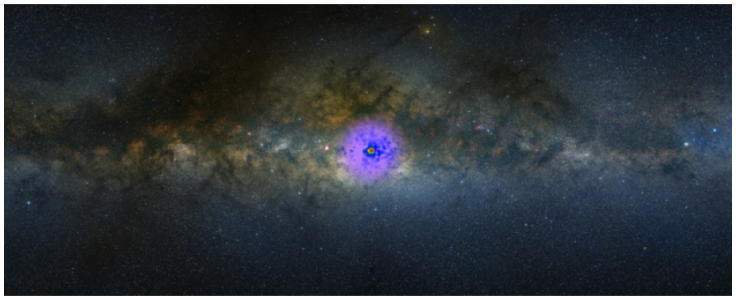
30 October 2015



When a scientific result seems to show something genuinely new, subsequent experiments are supposed to either confirm it — triggering a textbook rewrite — or show it to be a measurement anomaly or experimental blunder. But some findings seem to remain forever stuck in the middle ground between light and shadow. Even efforts to replicate these results — normally science's equivalent of Valyrian steel — have little effect. Welcome to the realm of undead physics.

Ahead of Halloween, *Nature* guides you through some findings in physics, astronomy and cosmology that researchers have repeatedly left for dead — only to find that they keep coming back.

glowing galactic saga



A. Mellinger, CMU; T. Linden, Univ. of Chicago/NASA Goddard

A gamma ray excess at the centre of the Milky Way is freaking out physicists.

More dark-matter drama has unfolded in space. In 2009, two physicists discovered[8] a mysterious glow in data from NASA's Fermi Gamma-Ray Space Telescope. They say that the electromagnetic radiation, which took the form of γ-rays and seemed to exceed what known sources should produce, could be the result of dark-matter particles concentrating near the centre of the Milky Way and then colliding with and annihilating each other.

Since then, several teams have posited alternative, non-dark-matter explanations for the γ-rays — most recently pulsars[9–12], the remnants of dead stars — only to see dark-matter claims crawl back into existence soon after. In the past few months, Christoph Weniger, a theoretical astrophysicist at the University of Amsterdam in The Netherlands, co-authored papers that presented evidence both for[13] and against[11] a dark-matter source. "I want just to figure out what's going on," he says, adding that he now leans slightly more towards the pulsar explanation.

A long-awaited official analysis by the Fermi team itself, presented in October 2014 and yet to be published, left the matter undecided, says Simona Murgia, a physicist at the University of California, Irvine, who led the analysis. "In the end, we observe an excess, too," she says, "although we cannot say if it's dark matter."