Contents and Construction of the Second *Fermi* Large Area Telescope Catalog of Gamma-ray Pulsars

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on behalf of the *Fermi* LAT Collaboration and Pulsar Timing Consortium

We describe the second *Fermi* LAT gamma-ray pulsar catalog. The catalog contains spectral and timing characteristics of 116 pulsars using 3 years of sky-survey data.
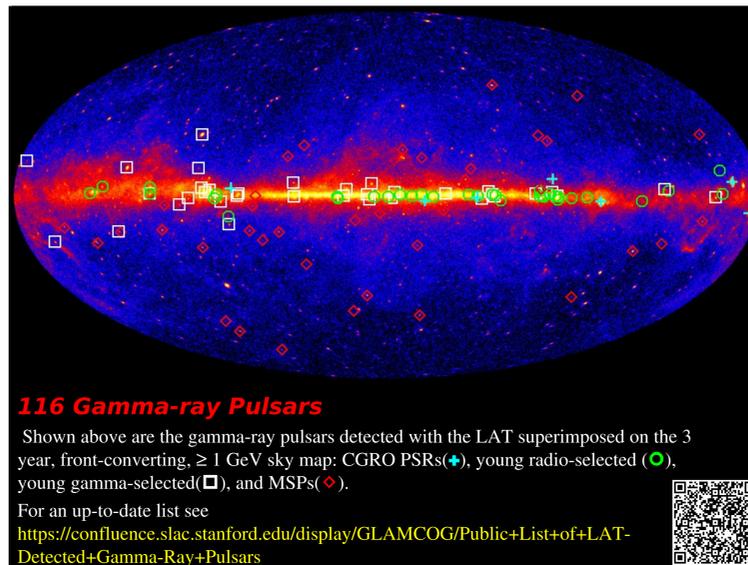
Using 6 months of survey data, the first *Fermi* Large Area Telescope (LAT) catalog of gamma-ray pulsars detailed the spectral and light curve characteristics of 46 rotation-powered pulsars observed to pulse above 100 MeV. With 3 years of survey data and enhanced analysis techniques, the second LAT catalog of gamma-ray pulsars promises to shed more light on the pulsing gamma-ray sky. The number of known gamma-ray pulsars has more than doubled and separated into 3, equally numerous classes: young radio-selected, young gamma-ray selected, and millisecond pulsars. We will outline the methods used to search for pulsed signals in the LAT data, the criteria by which pulsed signals are considered significant, and the basic content of the catalog.

Gamma-ray Pulsars:

Pulsars are rapidly rotating, highly-magnetized neutron stars slowly losing rotational energy via radiation and the generation of a wind of relativistic particles. High-energy (HE, ≥ 0.1 GeV) gamma rays from pulsars are thought to be, primarily, curvature radiation from electrons/positrons accelerated along the magnetic field lines far from the stellar surface.

Prior to the launch of *Fermi* only 6 HE pulsars were known. All were young, non-recycled pulsars and only 1 was not detected in radio. Observations with the LAT have revealed 116 gamma-ray pulsars, established that millisecond (recycled) pulsars are gamma-ray emitters, and discovered more than 30 pulsars through their HE pulsations alone.

With this revolution in gamma-ray pulsar science a consistent treatment of all LAT-detected, gamma-ray pulsars will provide insights into the physics behind the emission mechanisms and the Galactic neutron star population. This in turn improves models of the pulsar population's contribution to the diffuse Galactic gamma and electron/positron fluxes which are foregrounds to studies such as dark matter searches.

116 Gamma-ray Pulsars
Shown above are the gamma-ray pulsars detected with the LAT superimposed on the 3 year, front-converting, ≥ 1 GeV sky map: CGRO PSRs(+), young radio-selected (○), young gamma-selected(□), and MSPs(◇).
For an up-to-date list see
https://confluence.slac.stanford.edu/display/GLAMCOG/Public+List+of+LAT-Detected+Gamma-Ray+Pulsars

Catalog Construction:

Pulsar timing solutions were collected from radio and X-ray telescopes around the world [6]:

¤Jodrell Bank	¤Parkes	¤Green Bank	¤GMRT
¤Effelsberg	¤Nançay	¤Arecibo	¤Westerbork
¤RXTE	¤Urumqi		

For gamma-ray only, radio-faint, and/or very gamma-ray bright pulsars the LAT data was used to generate timing solutions [7].

Sky-survey data from 4 August 2008 through 4 August 2011 was selected, the appropriate pulse phase was calculated for all events within 5° of each pulsar, and a pulsed signal optimizer was run to identify candidate gamma-ray pulsars.

A binned likelihood spectral analysis was then run on a 20° × 20° region for all candidates. The best-fit models were used to calculate spectrally-weighted H test probabilities [8]. Only pulsars with a weighted, pulsed detection significance ≥ 5σ will be included in the final catalog. For more details on the spectral analysis and results see the talk by Ö. Çelik (**217.08**) Tuesday afternoon.

Timing solutions from published LAT papers are available at:
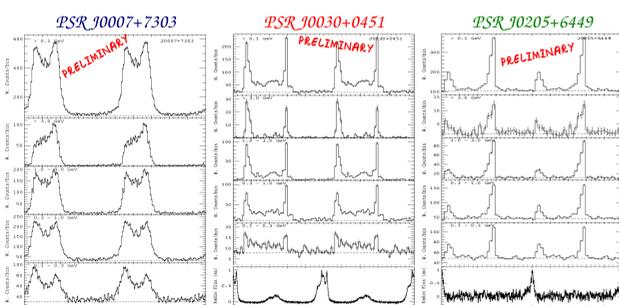http://fermi.gsfc.nasa.gov/ssc/data/access/lat/ephems/

Catalog Contents:

For each pulsar the catalog will include the following:

» Timing, orbital and spatial parameters as well as pulsed and point-source detection significances
» Profile shape parameters from an unbinned maximum likelihood fit to the weighted-counts light curve
» Light curve in multiple energy bands including the radio profile (if it exists).
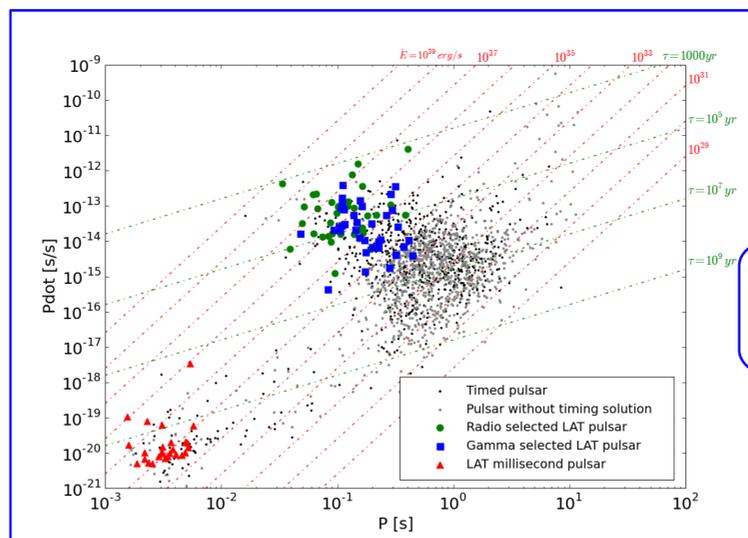» Best-fit spectral parameters including gamma-ray luminosity

We plan to provide additional content through the *Fermi* Science Support Center [9], such as:

» A second pulsar catalog browse table
» Gamma-ray spectrum for each pulsar
» Plot of the light curve fit for each pulsar

Sample light curves are shown below and to the far right.

PSR J0007+7303   PSR J0030+0451   PSR J0205+6449

To the left are plotted the periods and period derivatives of all pulsars in the ATNF database [10] with colored markers denoting detected gamma-ray pulsars, black dots denoting pulsars for which we had timing solutions, and gray dots denoting pulsars for which we did not have timing solutions.

PSR J0613-0200   PSR J1023-5746   PSR J1119-6127
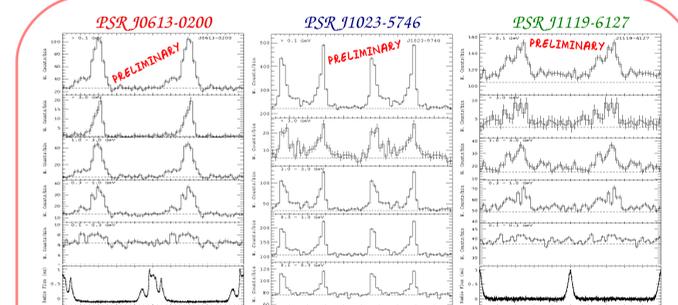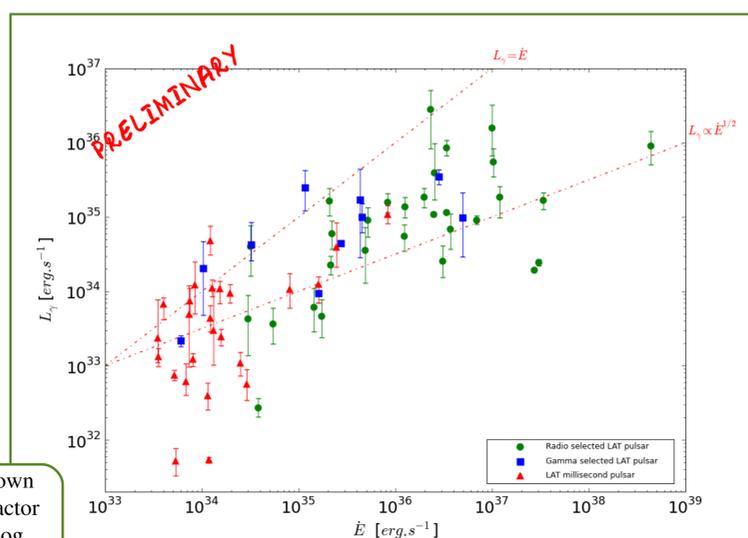
Weighted light curves in 5 energy bands, as labeled, over 2 rotations for clarity. The bottom panel shows the radio profile (if it exists).

To the right is plotted the gamma-ray luminosity versus the spin-down power for pulsars with reliable distance estimates (for a beaming factor $f_\Omega = 1$ [11]). These luminosities were derived from the 2FGL catalog [12] and will be updated. The distance estimates used may change.

References:
6. Smith, D. A., et al. 2008, A&A 492, 923
7. Ray, P. S., et al. 2011, ApJS, 194, 17
8. Kerr, M. 2011, ApJ, 732, 38
9. <http://fermi.gsfc.nasa.gov/ssc/>
10. Manchester, R. N., et al. 2005, AJ, 129, 1993
    <http://www.atnf.csiro.au/people/pulsar/psrcat/>
11. Watters, K. P., et al. 2009, ApJ, 695, 1289
12. Abdo, A. A., et al., *submitted*
    <http://fermi.gsfc.nasa.gov/ssc/data/access/lat/2yr_catalog/>

All *Fermi* presentations