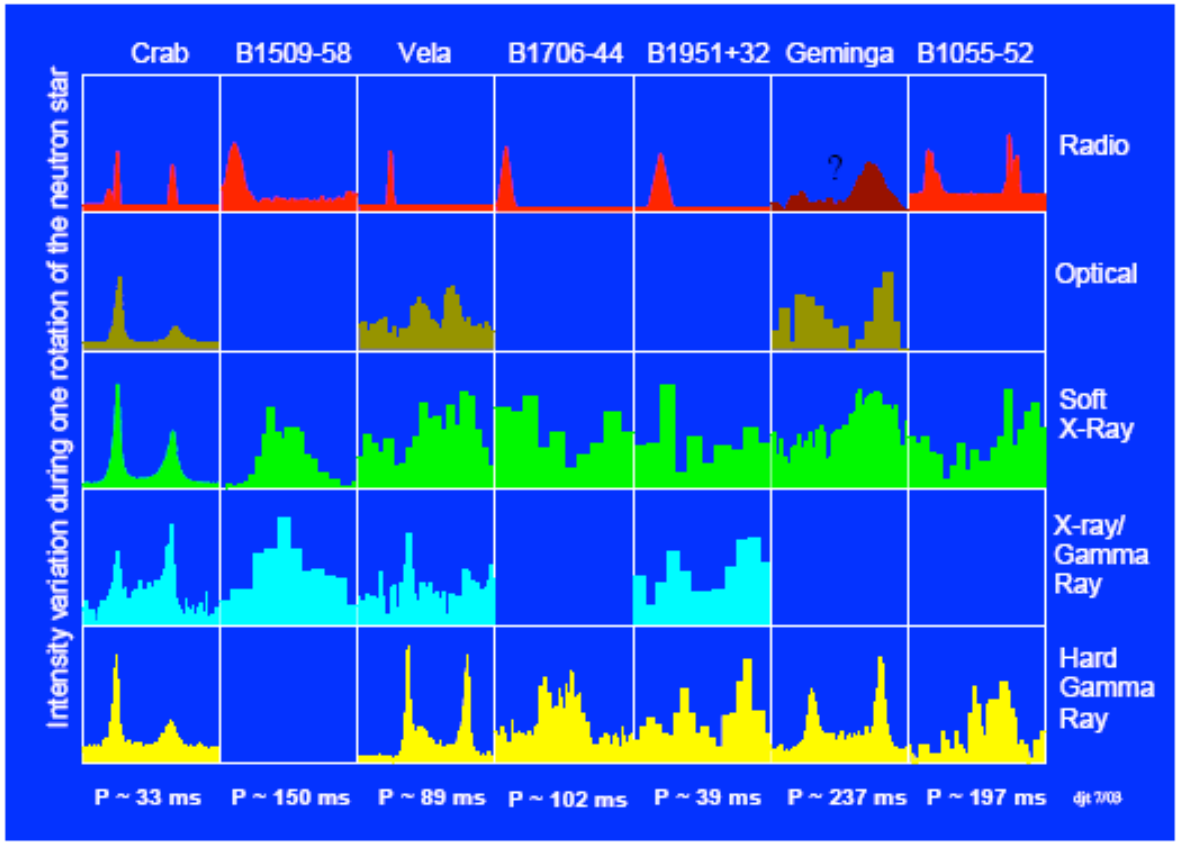
Latest results on Gamma-ray Pulsars

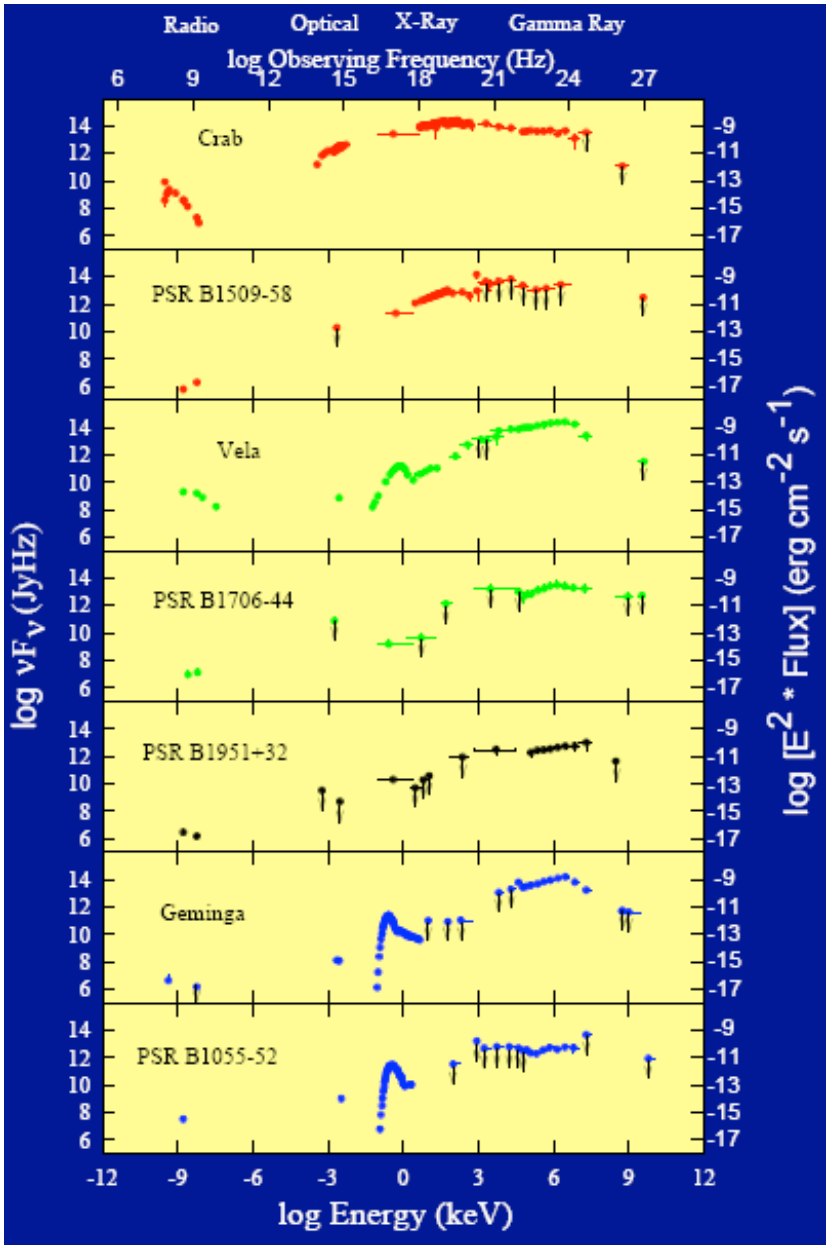
Pablo Saz Parkinson
UCSC/HKU
on behalf of the LAT Collaboration

SciNeGHE 2016 (Pisa, Italy)
20 October 2016

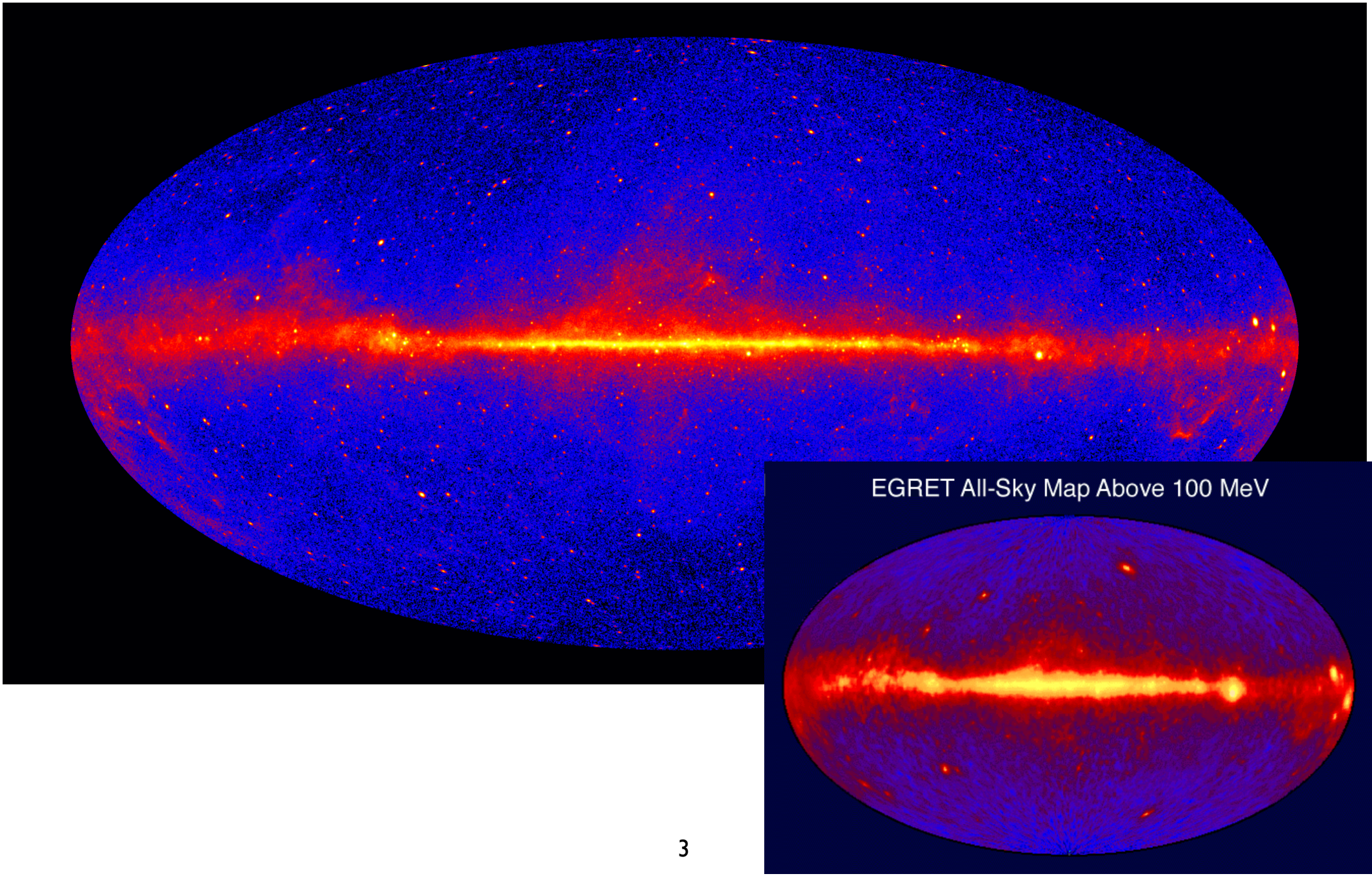
Gamma-ray pulsars pre-Fermi



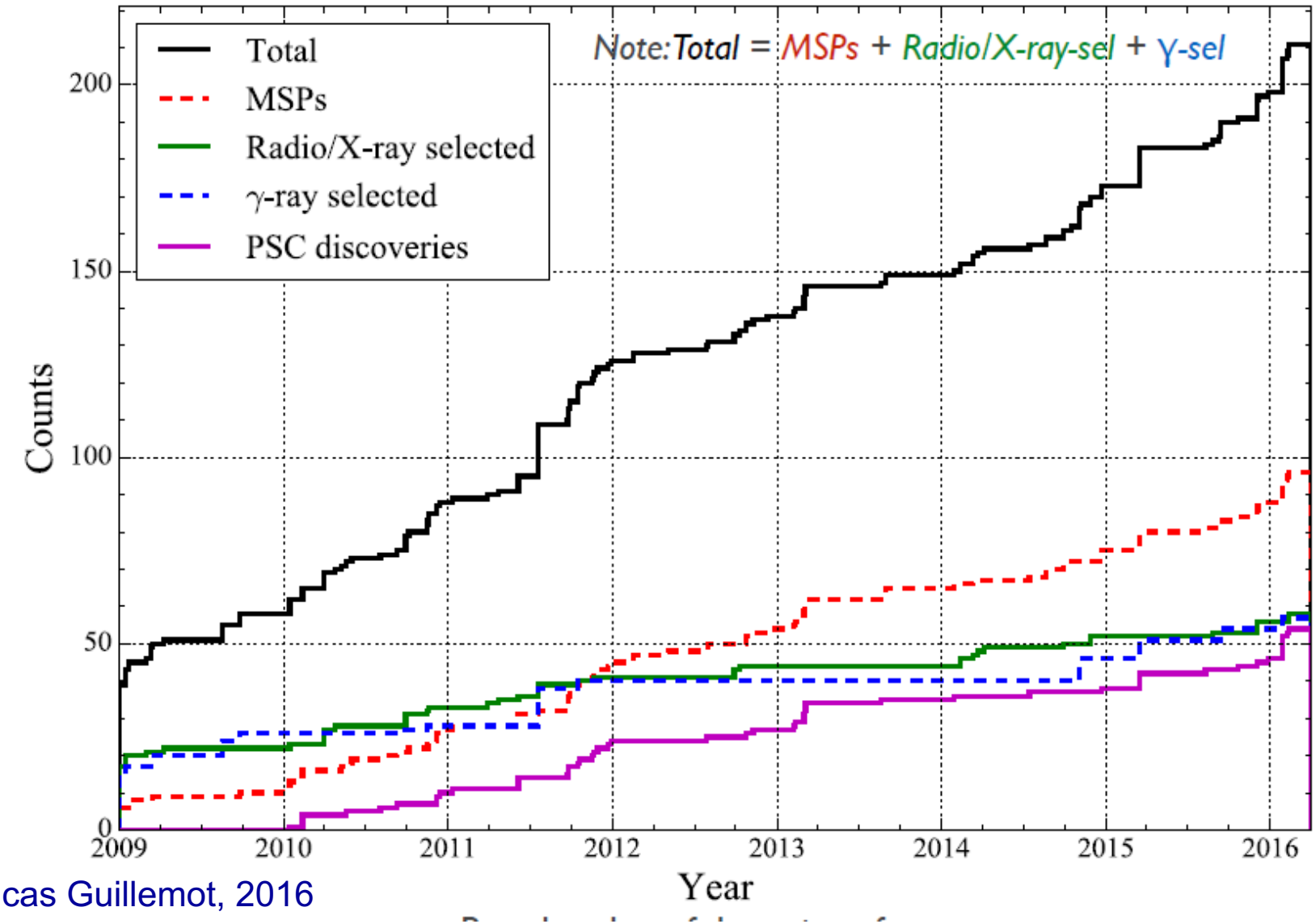
Credit: Thompson 2004



7-year Fermi sky



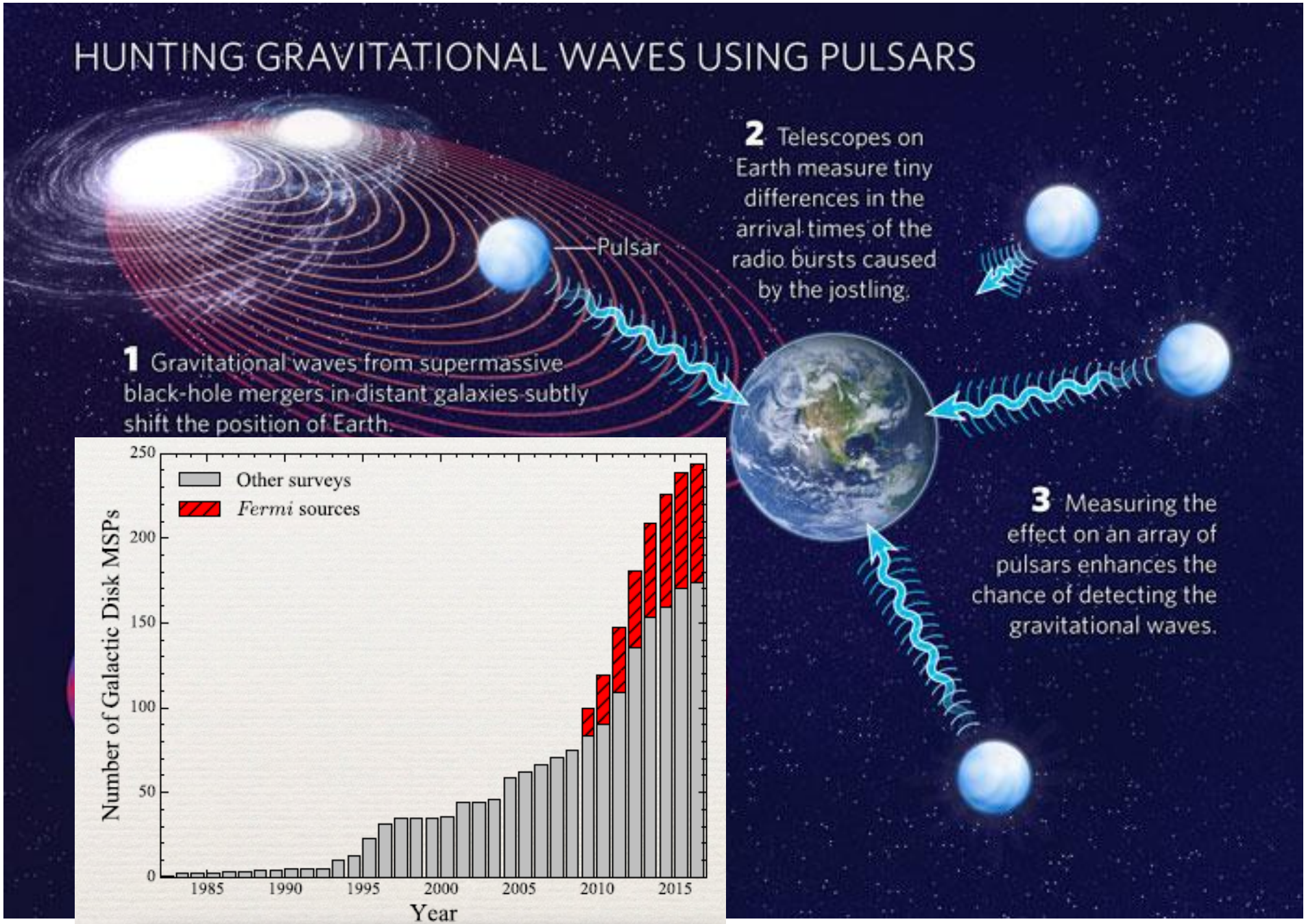
Detected pulsars versus time



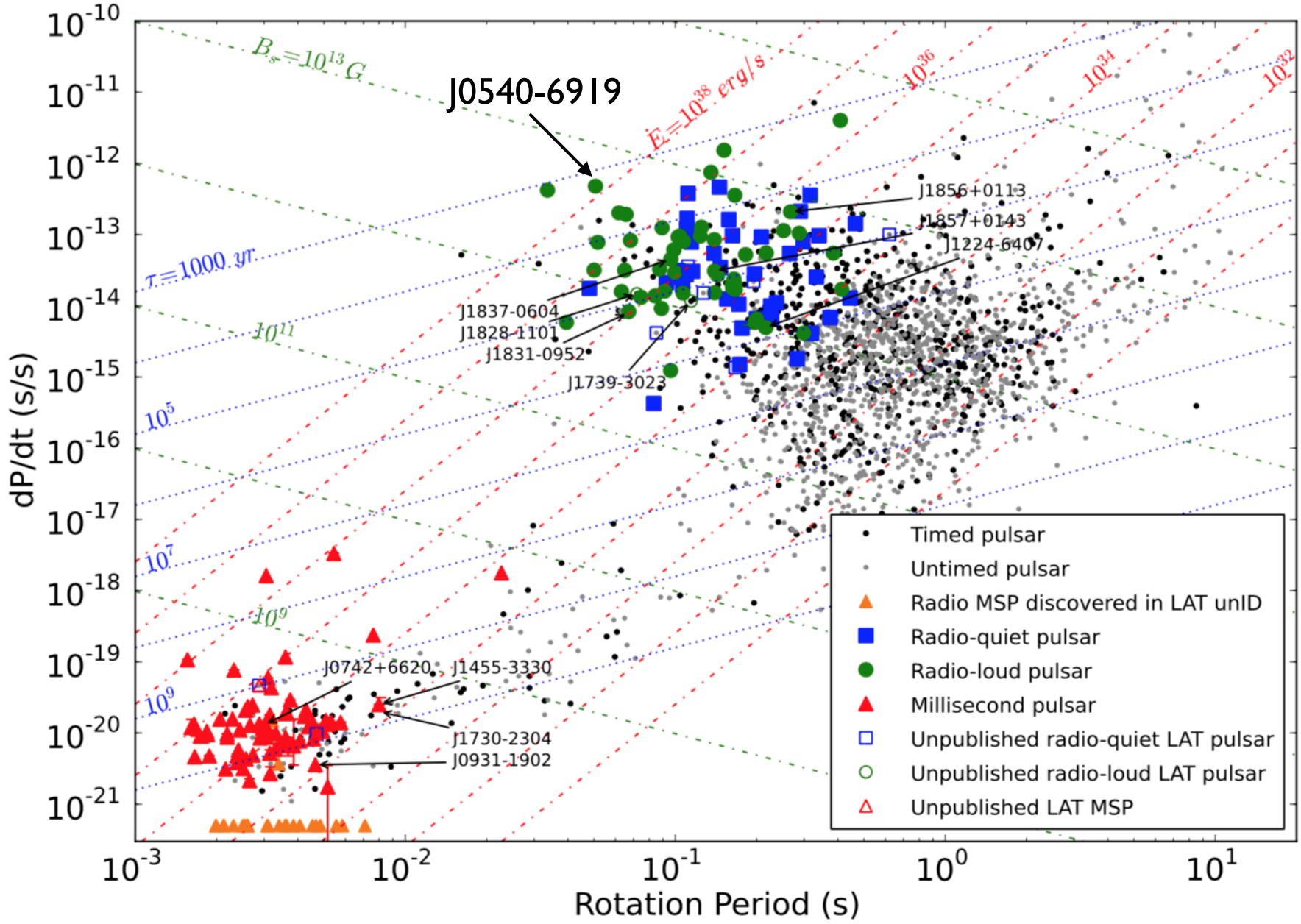
Lucas Guillemot, 2016

https://confluence.slac.stanford.edu/display/GLAMCOG/Public+List+of+LAT-Detected+Gamma-Ray+Pulsars

Pulsar timing arrays

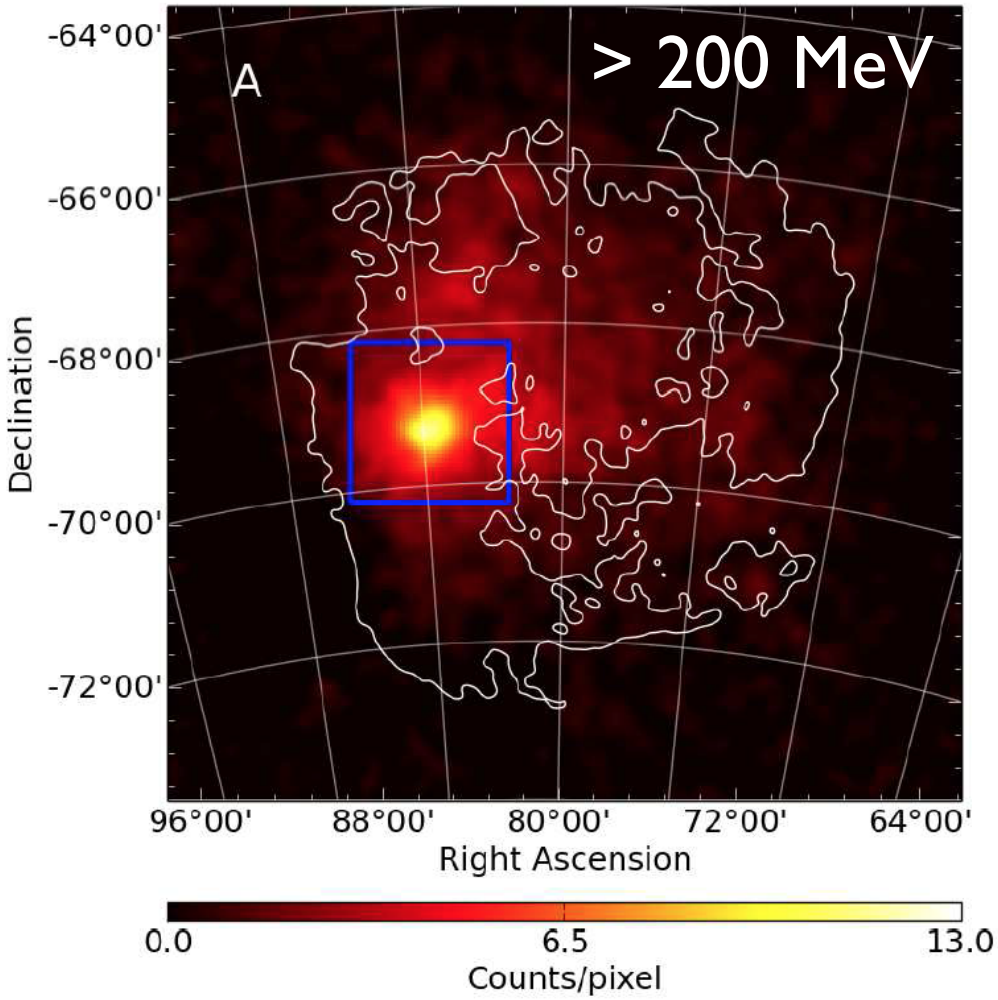


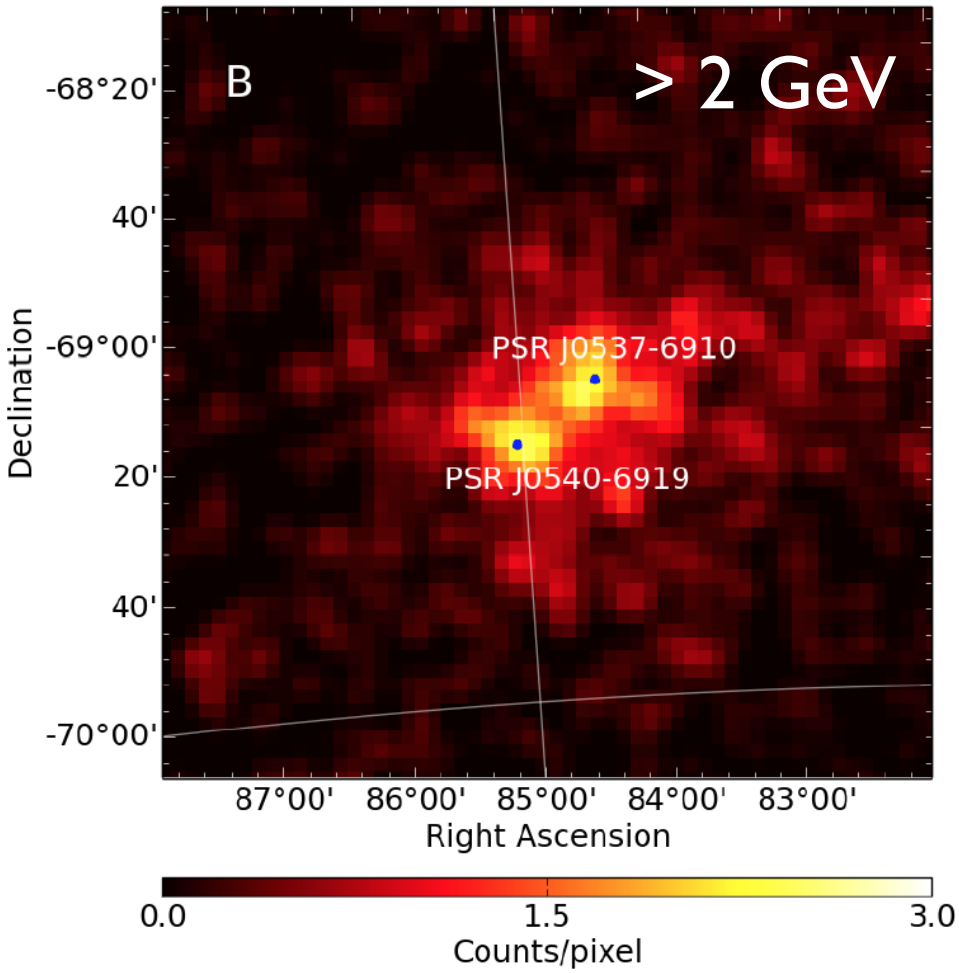
New pulsars with Pass 8



Laffon, Smith, & Guillemot 2015

LMC Pulsar J0540–6919

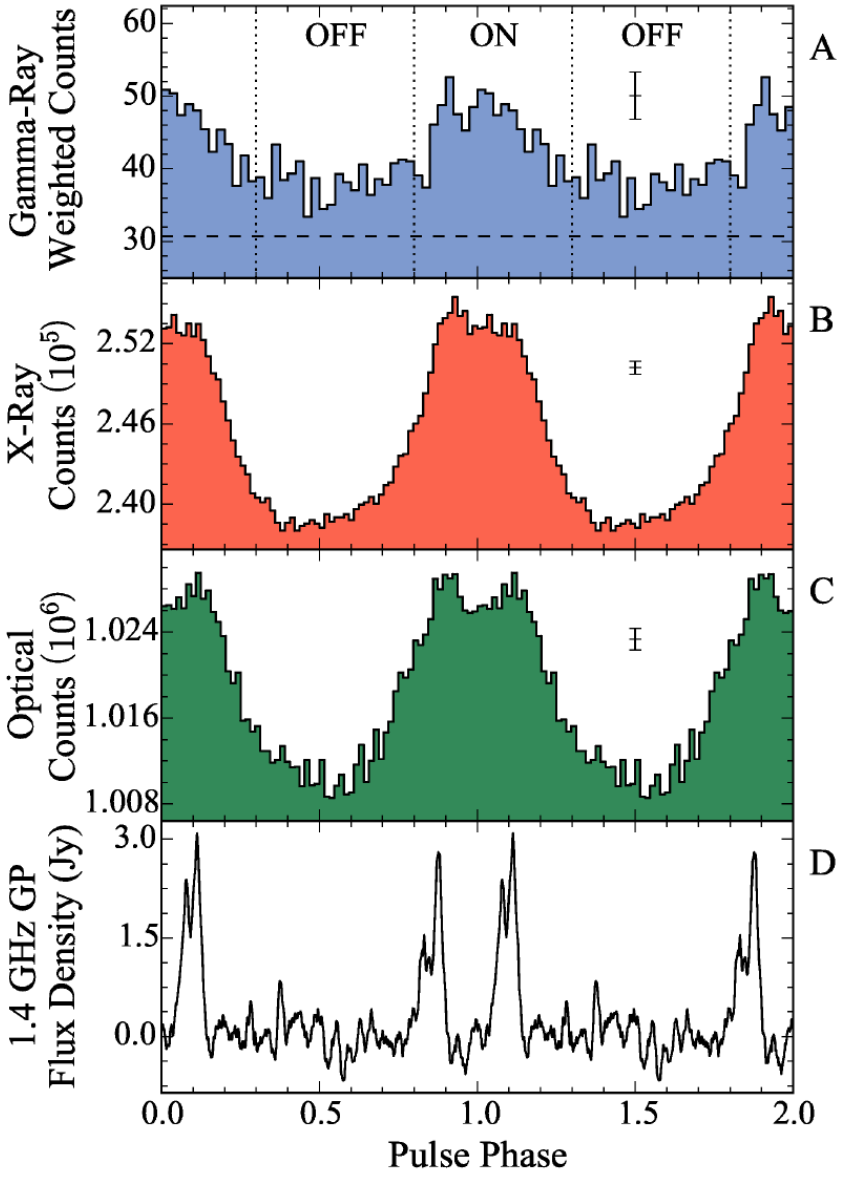




Ackermann et al., Science, **350**, 801(2015)

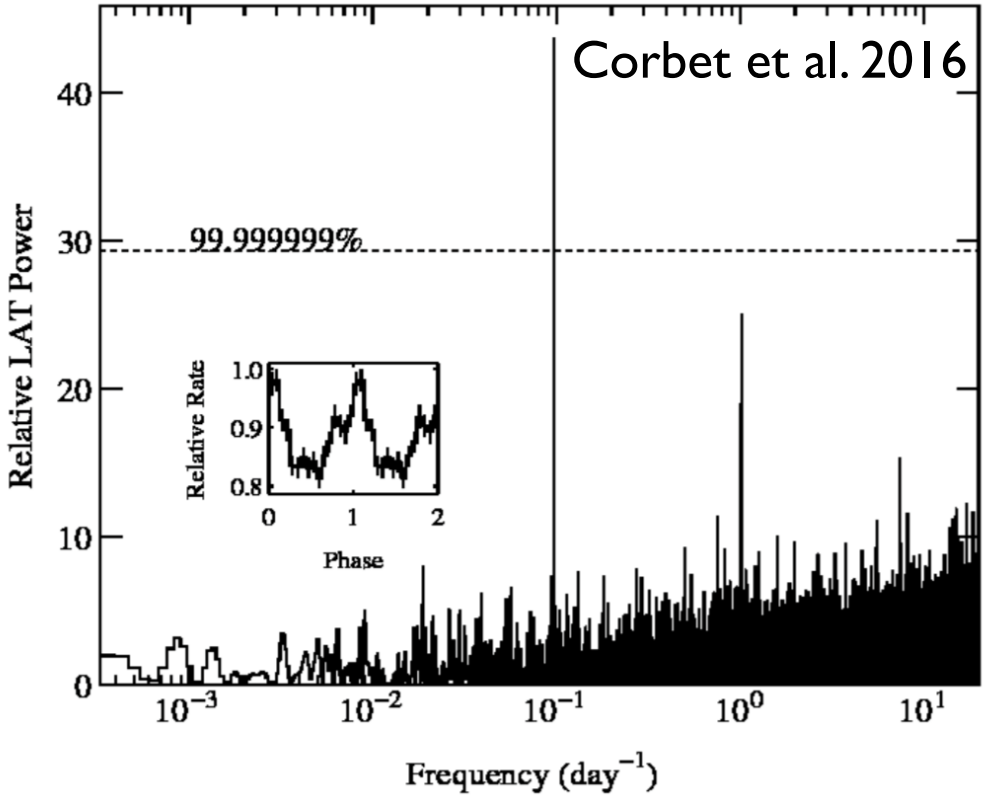
LMC Pulsar J0540–6919

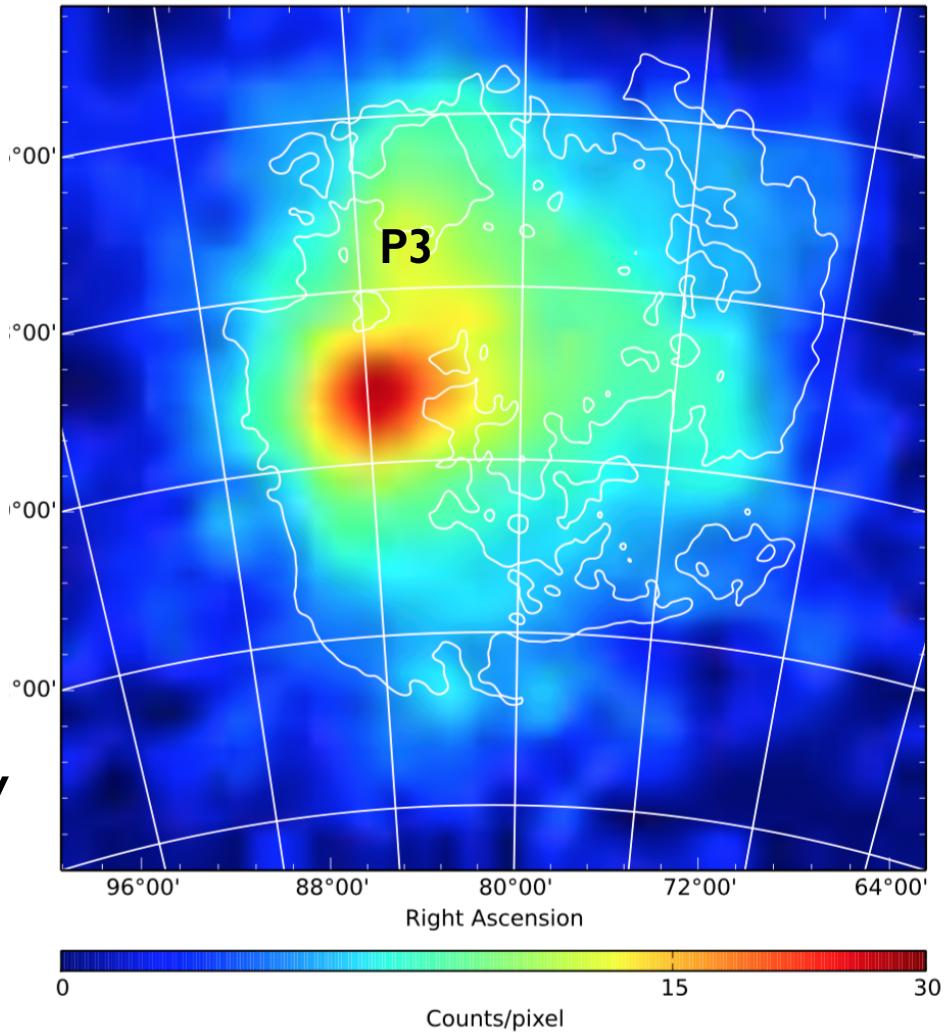
- First extra-Galactic gamma-ray pulsar (d~50 kpc)
- Most luminous gamma-ray pulsar (> 20 Crab)
- 50 ms pulsar, ~1400 yr old, 1.5E38 erg/s
- No pulsed emission from J0537-6910 (~16 ms, 4.9E38 erg/s)



Ackermann et al., Science, **350**, 801 (2015)

Another surprise in the LMC





First extra-Galactic gamma-ray binary

10.3 day binary

Radio and X-ray modulation also detected

Most luminous gamma-ray binary yet

Likely powered by energetic (> 4E36 erg/s) pulsar

Ackermann et al. 2015

PSR J2032+4127: A new gamma-ray binary

25-Year Period Pulsar Binary

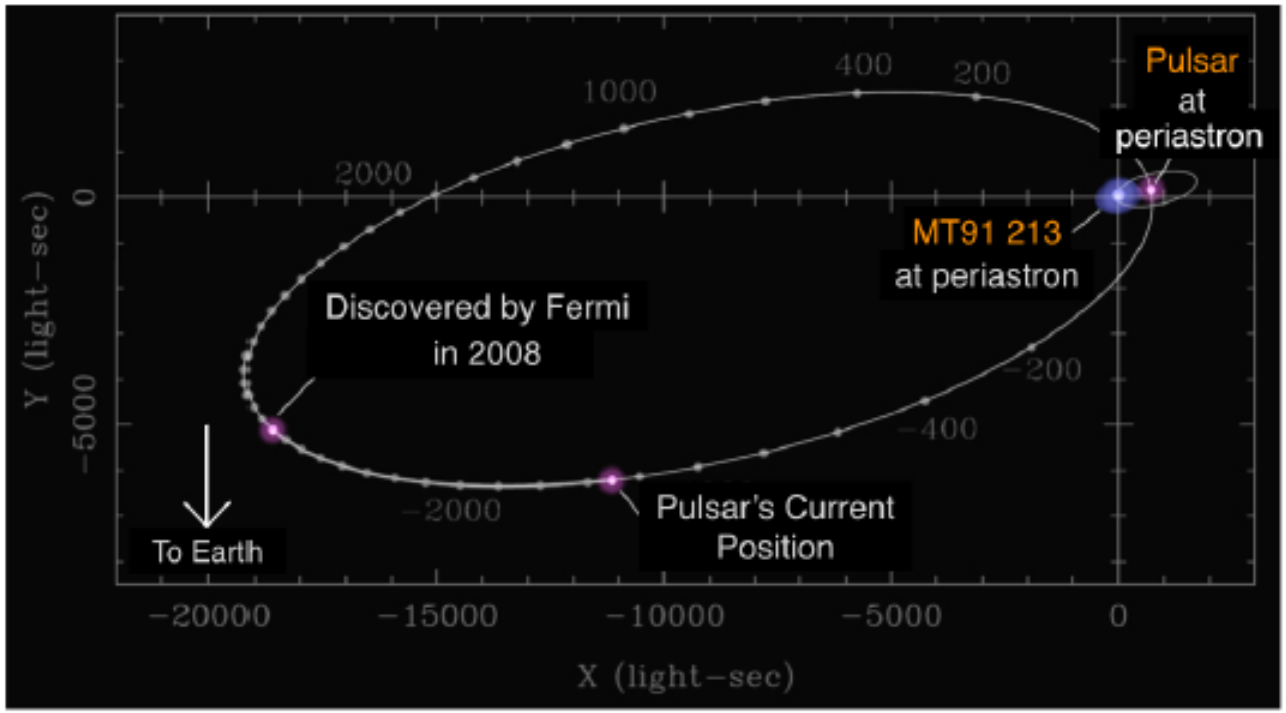


Figure 6: In 2018 *Fermi* will provide critical observations of the periastron passage of the 25-year binary system MT91 213/PSR J2032+4127 [31].

Lyne et al. 2015

Multiwavelength monitoring and X-ray brightening of Be X-ray binary PSR J2032+4127/MT91 213 on its approach to periastron

Wynn C. G. Ho[1,2⋆], C.-Y. Ng[3], Andrew G. Lyne[4], Ben W. Stappers[4], Malcolm J. Coe[2], Jules P. Halpern[5], Tyrel J. Johnson[6†], Iain A. Steele[7]

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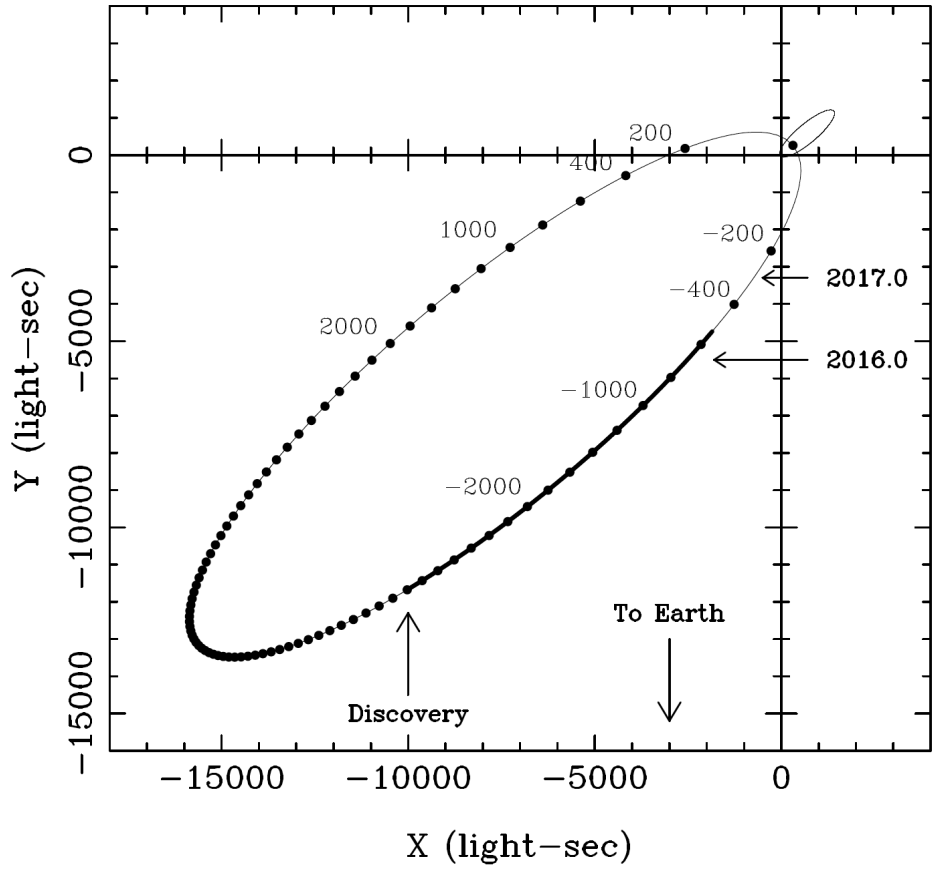
[2]*Physics and Astronomy and STAG Research Centre, University of Southampton, Southampton, SO17 1BJ, UK*
[3]*Department of Physics, the University of Hong Kong, Hong Kong, China*
[4]*Jodrell Bank Centre for Astrophysics, School of Physics and Astronomy, University of Manchester, Manchester, M13 9PL, UK*
[5]*Columbia Astrophysics Laboratory, Columbia University, New York, NY, 10027, USA*
[6]*College of Science, George Mason University, Fairfax, VA, 22030, USA*
[7]*Astrophysics Research Institute, Liverpool John Moores University, Liverpool, L3 5RF, UK*

Accepted 2016 September 19. Received 2016 September 14; in original form 2016 August 19

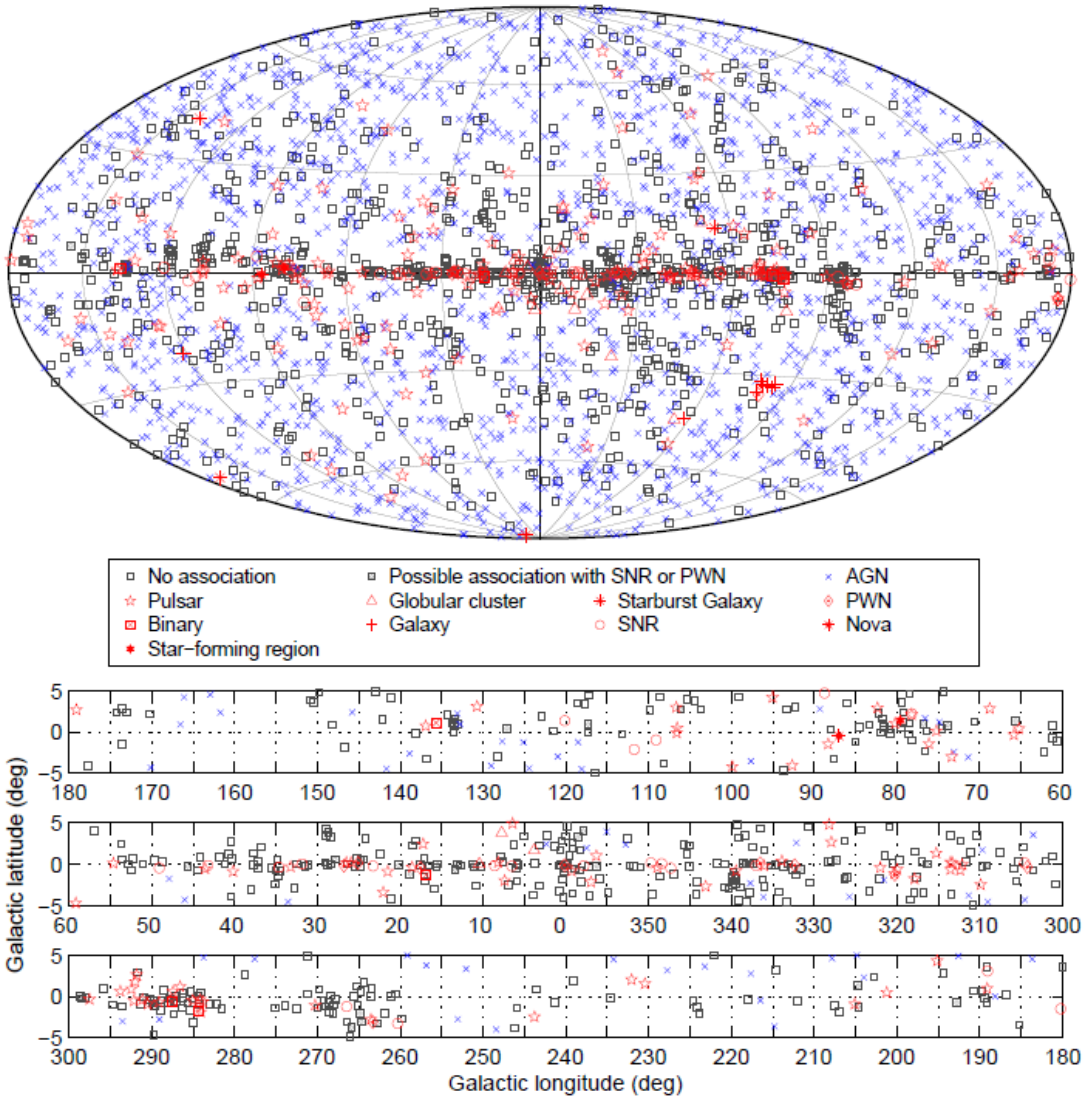
- Similar to PSR B1259– 63
- 45-50 yr orbital period
- Periastron: Nov 2017
- Brightness in X-rays increasing (by ~20 since 2010 and ~70 since 2002)



Finding new gamma-ray pulsars

3rd LAT source catalog (3FGL)

Acero et al. ApJS 218, 23 (2015)

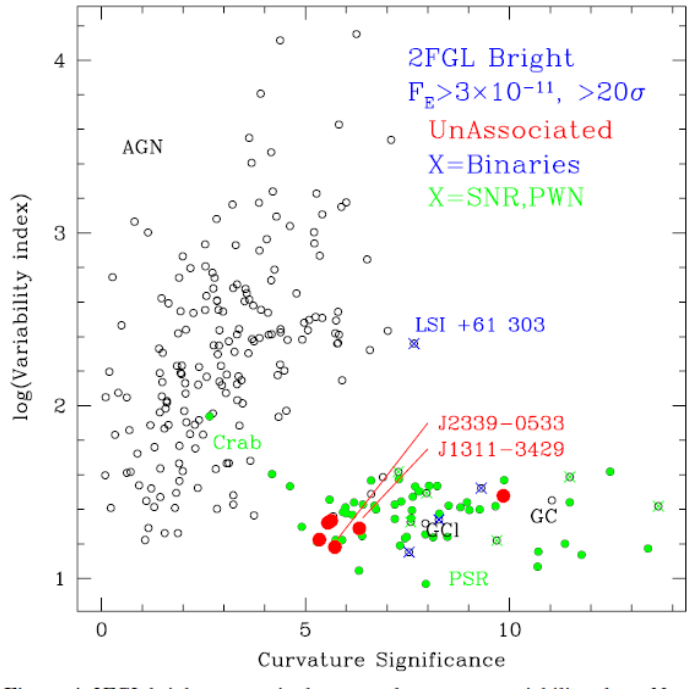


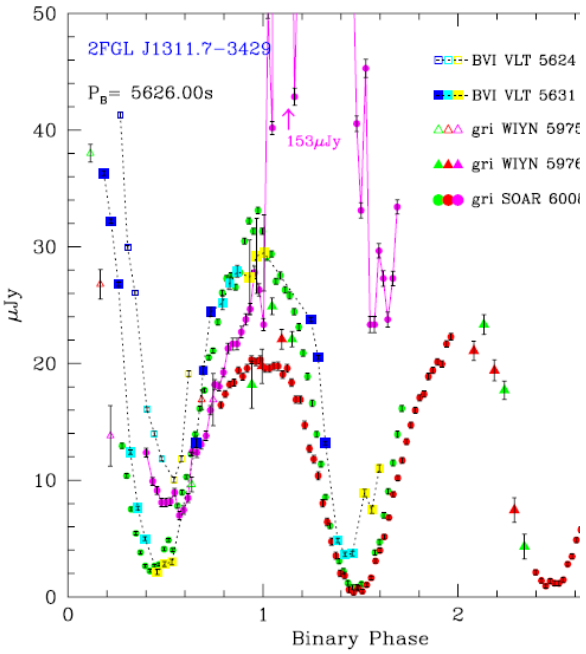
3033 total sources (>4σ)

Red: Firm I.D. (232, mostly pulsars)
Blue: 'Association' (> ⅓ of sources, mostly blazars.)
Black: No I.D. (< ~⅓ of sources)

See talk by Jean Ballet

Finding new gamma-ray pulsars





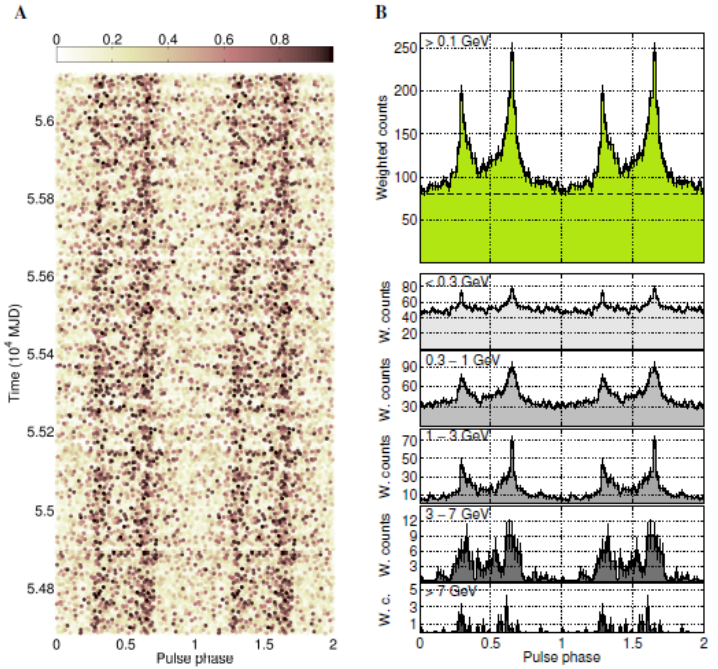


Fig. 1. Phase-time diagram (A) and gamma-ray pulse profiles (B) for PSR J1311−3430. The

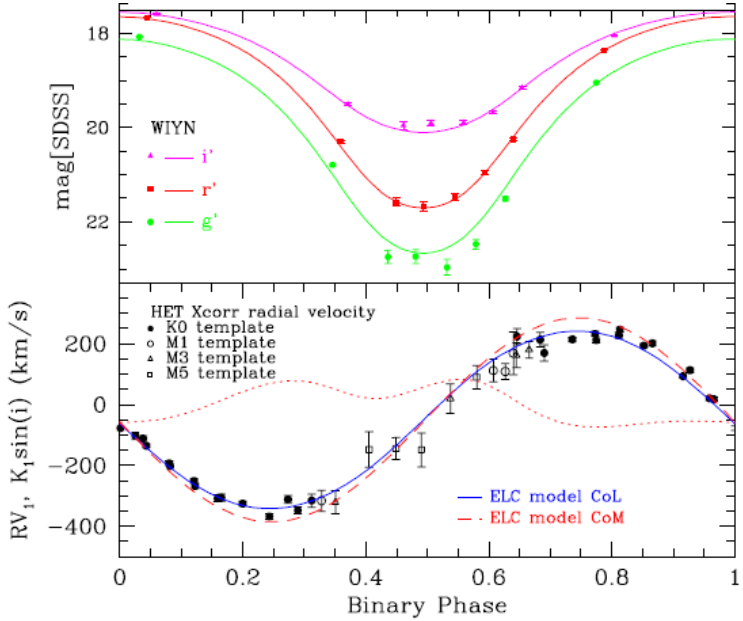
Romani 2012

Pletsch et al. 2012

THE ORBIT AND COMPANION OF *PROBABLE* γ-RAY PULSAR J2339−0533

ROGER W. ROMANI[1] AND MICHAEL S. SHAW
Department of Physics, Stanford University, Stanford, CA 94305
To Appear in ApJ Letters, 742, L1

We have measured dramatic flux and spectral variations through the 0.193 d orbit of the optical counterpart of the unidentified γ-ray source 0FGL J2339.8−0530. This compact object companion is strongly heated, with T_{eff} varying from $\sim$ 6900 K (superior conjunction) to $<$ 3000 K at minimum. A combined fit to the light curve and radial velocity amplitudes implies $M_1 \approx 0.075 M_\odot$, $M_2 \approx 1.4 M_\odot$ and inclination $i \approx 57°$. Thus this is a likely 'black widow' system with a $\dot{E} \approx 10^{34-34.5}$erg s^{-1} pulsar driving companion mass loss. This wind, also suggested by the X-ray light curve, may prevent radio pulse detection. Our measurements constrain the pulsar's reflex motion, increasing the possibility of a pulse detection in the γ-ray signal.



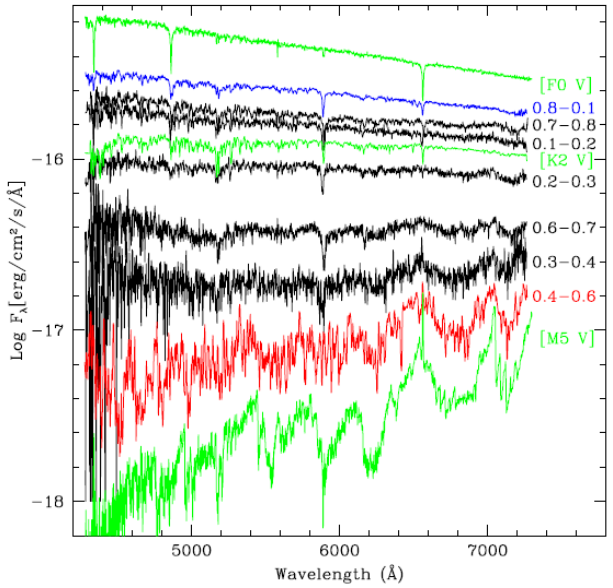


FIG. 3.— Averaged spectra for several phase bins during the orbit of J2339-0533. Green traces show three comparison spectra [F0,K2,M5]. The average

Long-term timing in gamma rays

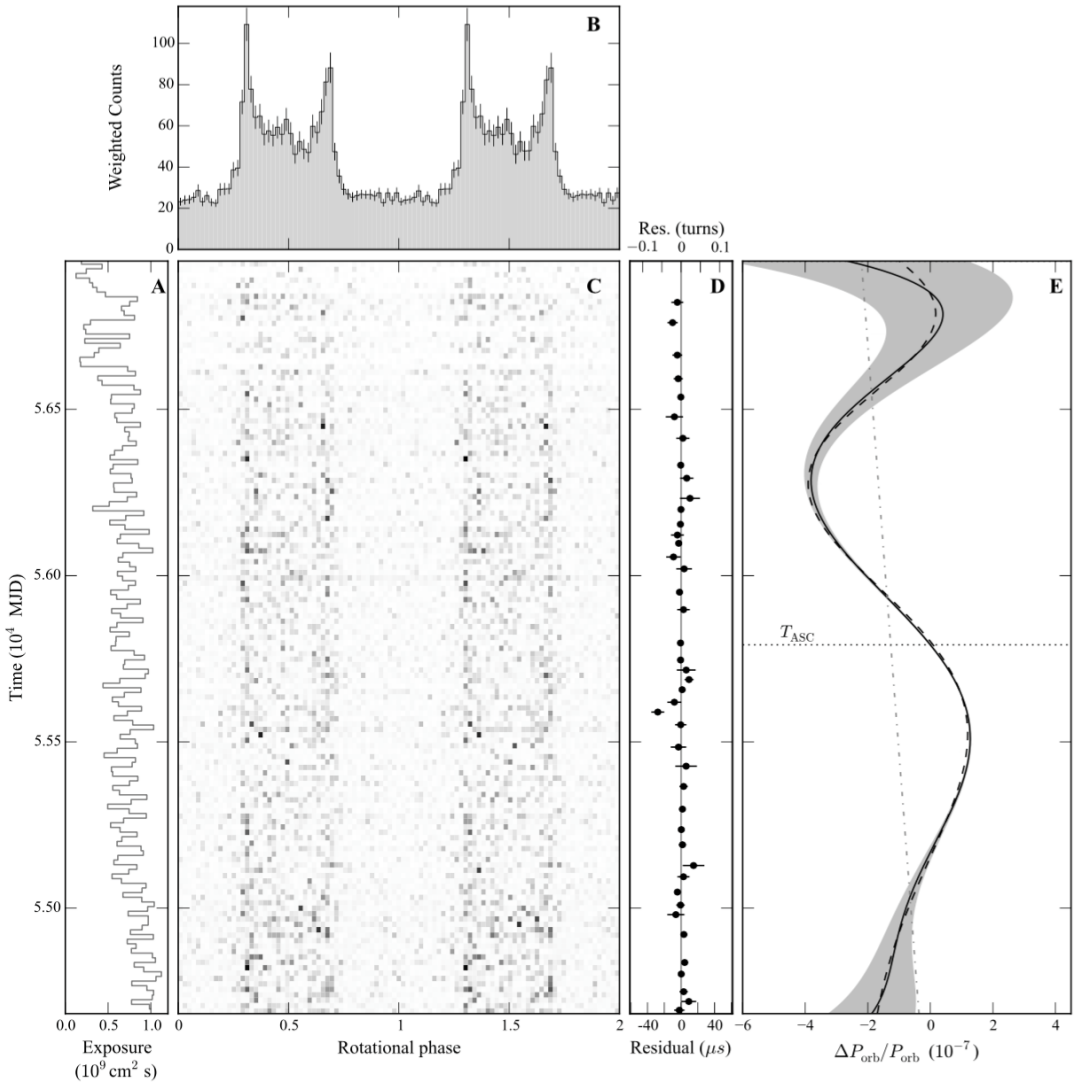
Gamma-Ray Timing of Redback PSR J2339-0533: Hints for Gravitational Quadrupole Moment Changes

Holger J. Pletsch[1,2] and Colin J. Clark[1,2]
Show affiliations

Holger J. Pletsch and Colin J. Clark 2015 *ApJ* **807** 18. doi:10.1088/0004-637X/807/1/18
Received 11 February 2015, accepted for publication 21 April 2015. Published 25 June 2015.

Abstract

We present the results of precision gamma-ray timing measurements of the binary millisecond p system of the "redback" type, using data from the *Fermi* Large Area Telescope. We describe an a long-term phase-coherent timing solution spanning more than six years, including a measured constraints on the proper motion of the system. A major result of this timing analysis is the discov 4.6 hr orbital period $P_{\rm orb}$ over time, showing alternating epochs of decrease and increase. We in approximate cycle duration of 4.2 yr and a modulation amplitude of $\Delta P_{\rm orb}/P_{\rm orb} = 2.3 \times 10^{-7}$. Co causes, the observed orbital-period modulation most likely results from a variable gravitational q due to cyclic magnetic activity in its convective zone.



A new redback candidate

THE ASTROPHYSICAL JOURNAL

MULTI-WAVELENGTH OBSERVATIONS OF 3FGL J2039.6–5618: A CANDIDATE REDBACK MILLISECOND PULSAR

D. Salvetti[1], R. P. Mignani[1,2], A. De Luca[1,3], C. Delvaux[4], C. Pallanca[5], A. Belfiore[1], M. Marelli[1], A. A. Breeveld[6], J. Greiner[4], W. Becker[4] Show full author list

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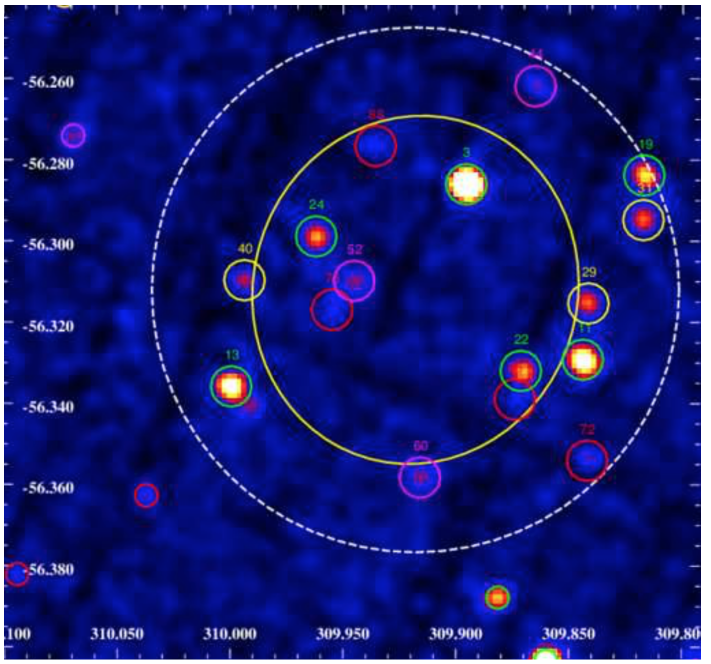
The Astrophysical Journal, Volume 814, Number 2



THE ASTROPHYSICAL JOURNAL LETTERS

A LIKELY MILLISECOND PULSAR BINARY COUNTERPART FOR *FERMI* SOURCE 2FGL J2039.6–5620

Roger W. Romani

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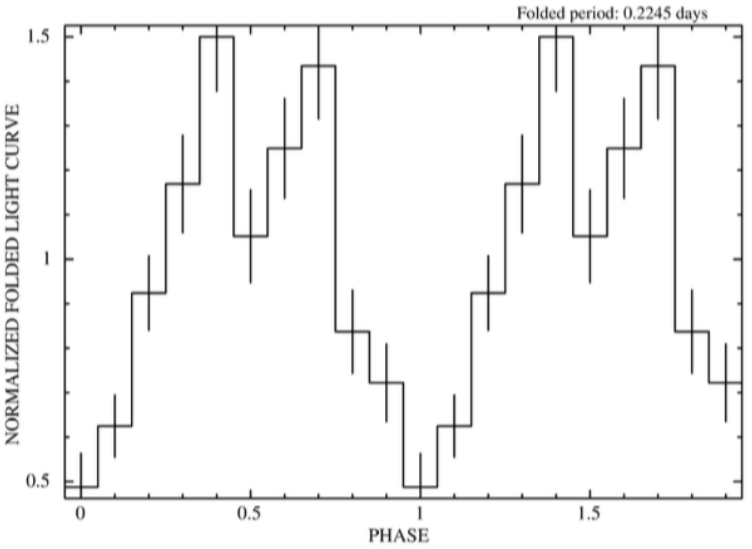
The Astrophysical Journal Letters, Volume 812, Number 2



The latest redback candidate

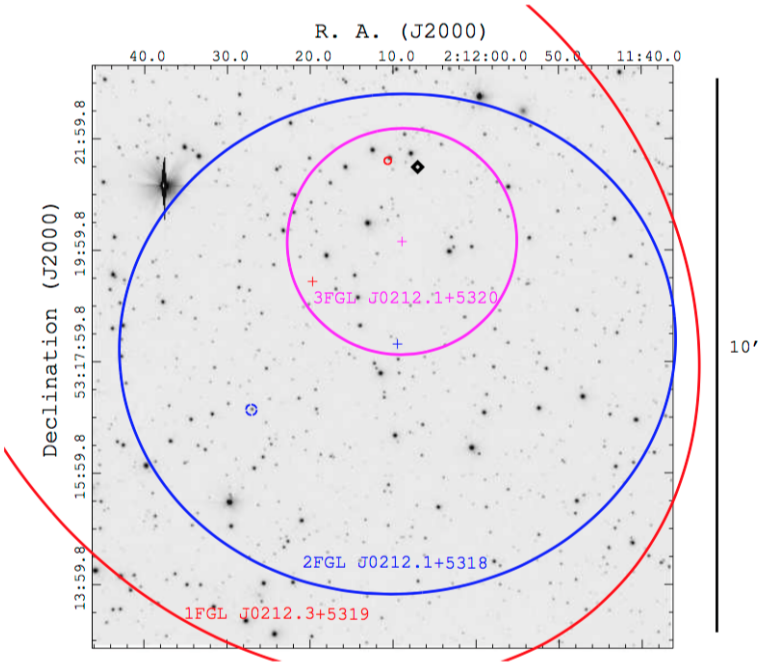
A millisecond pulsar candidate in a 21-hr orbit: 3FGL J0212.1+5320

Manuel Linares[1,2,3⋆], Paulo Miles-Páez[1,2], Pablo Rodríguez-Gil[1,2], Tariq Shahbaz[1,2], Jorge Casares[1,2,4], Cecilia Fariña[1,5], Raine Karjalainen[5]

[1] *Instituto de Astrofísica de Canarias, c/ Vía Láctea s/n, E-38205 La La*
[2] *Universidad de La Laguna, Departamento de Astrofísica, E-38206 La Lc*
[3] *Institutt for fysikk, NTNU, Trondheim, Norway*
[4] *Department of Physics, Astrophysics, University of Oxford, Denys Wilk*
[5] *Isaac Newton Group of Telescopes, E-38700 S.C. de La Palma, Tenerife*

8 Sep 2016

9 September 2016



DISCOVERY OF A REDBACK MILLISECOND PULSAR CANDIDATE: 3FGL J0212.1+5320

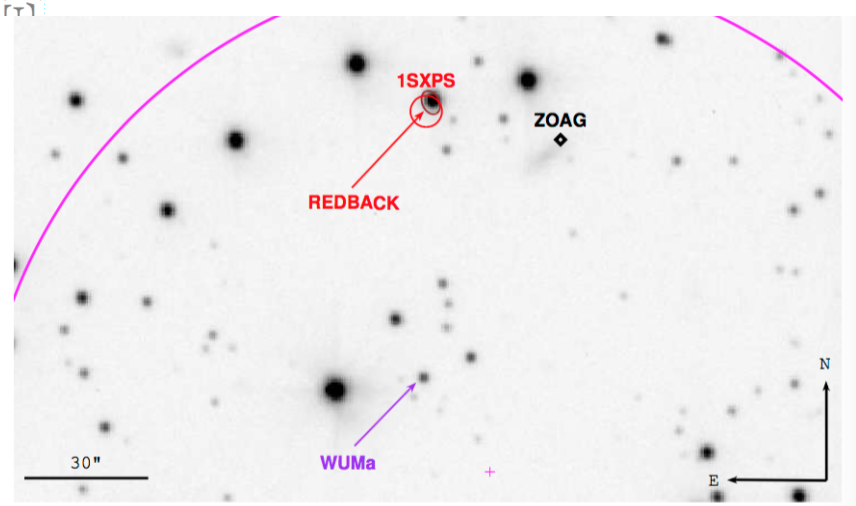
Kwan-Lok Li[1], Albert K. H. Kong[2], Xian Hou[2,3,4], Jirong Mao[3,4], Jay Strader[1], Laura Chomiuk[1], Evangelia Tremou[1]

Draft version September 13, 2016

ABSTRACT

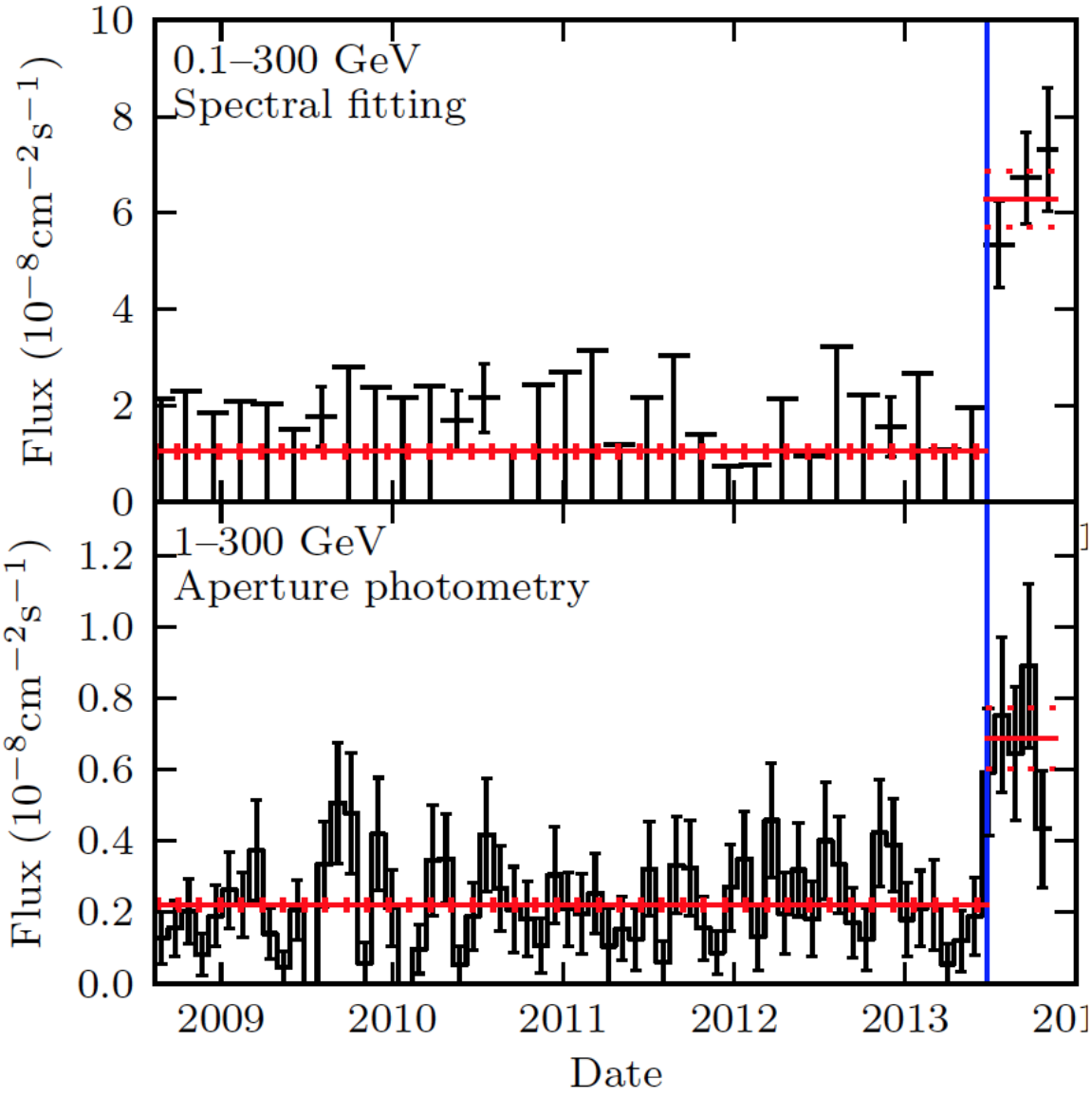
We present a multi-wavelength study of the unidentified *Fermi* object, 3FGL J0212.1+5320. Within the 95% error ellipse, *Chandra* detects a bright X-ray source, which has a low-mass optical counterpart ($M \lesssim 0.4 M_\odot$ and $T \sim 6000$K). A clear ellipsoidal modulation is shown in optical/infrared at 20.87 hours. While the gamma-ray properties of 3FGL J0212.1+5320 are all consistent with that of a millisecond pulsar, we suggest that it is a γ-ray redback millisecond pulsar binary with a low-mass companion filling of $\gtrsim 64\%$ of the *Roche*-lobe. Spectroscopic data taken in 2015 from the *Lijiang* observatory show no evidence of strong emission lines, revealing the accretion is currently inactive (the pulsar state). While the X-ray luminosity and the X-ray-to-γ-ray flux ratio are both high that are comparable to that of the two known γ-ray transitional millisecond pulsars, 3FGL J0212.1+5320 could be a promising target to search for future transition to the accretion active state.

] 9 Sep 2016



A state change in J1023+0038

- Known as the "missing link": RPP MSP in 2009. Previously in LMXB state
- Radio pulsar disappearance coinciding with five-fold increase in gamma-ray flux
- Transition from MSP state back to qLMXB
- Radio pulsar mechanism probably still active but radio pulsations obscured
- Appears to swing between states every several years

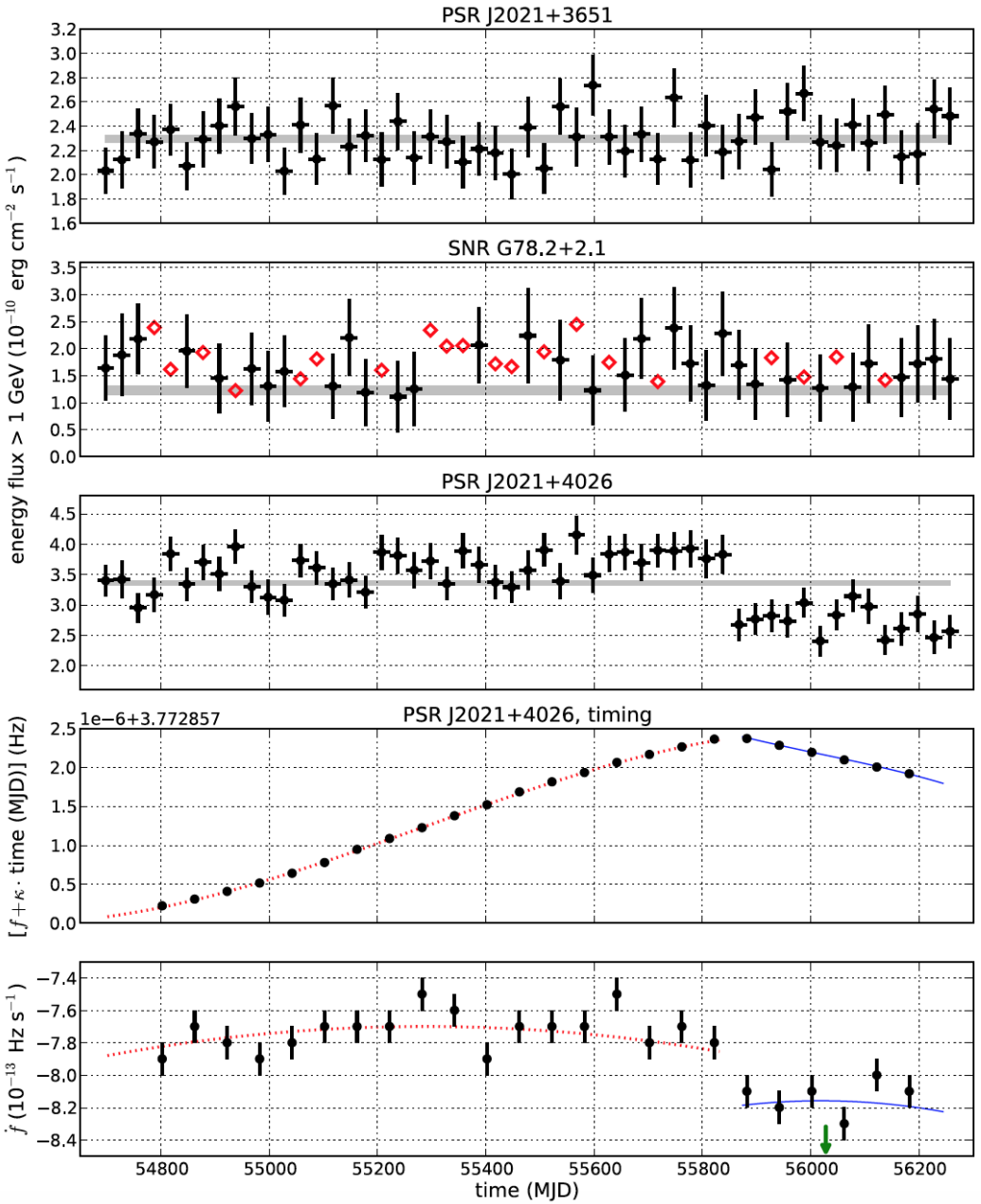


Stappers et al. 2014

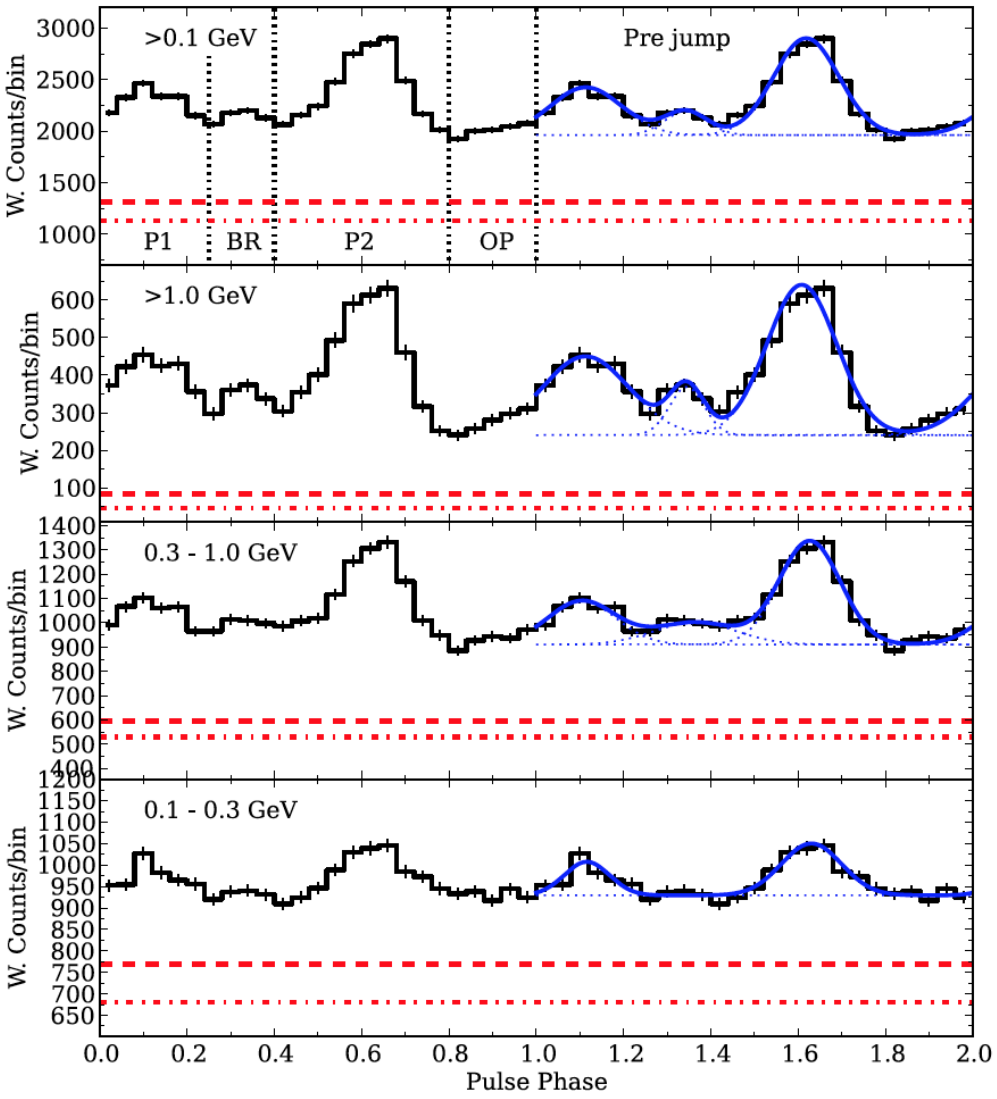
PSR J2021+4026: The first variable gamma-ray pulsar

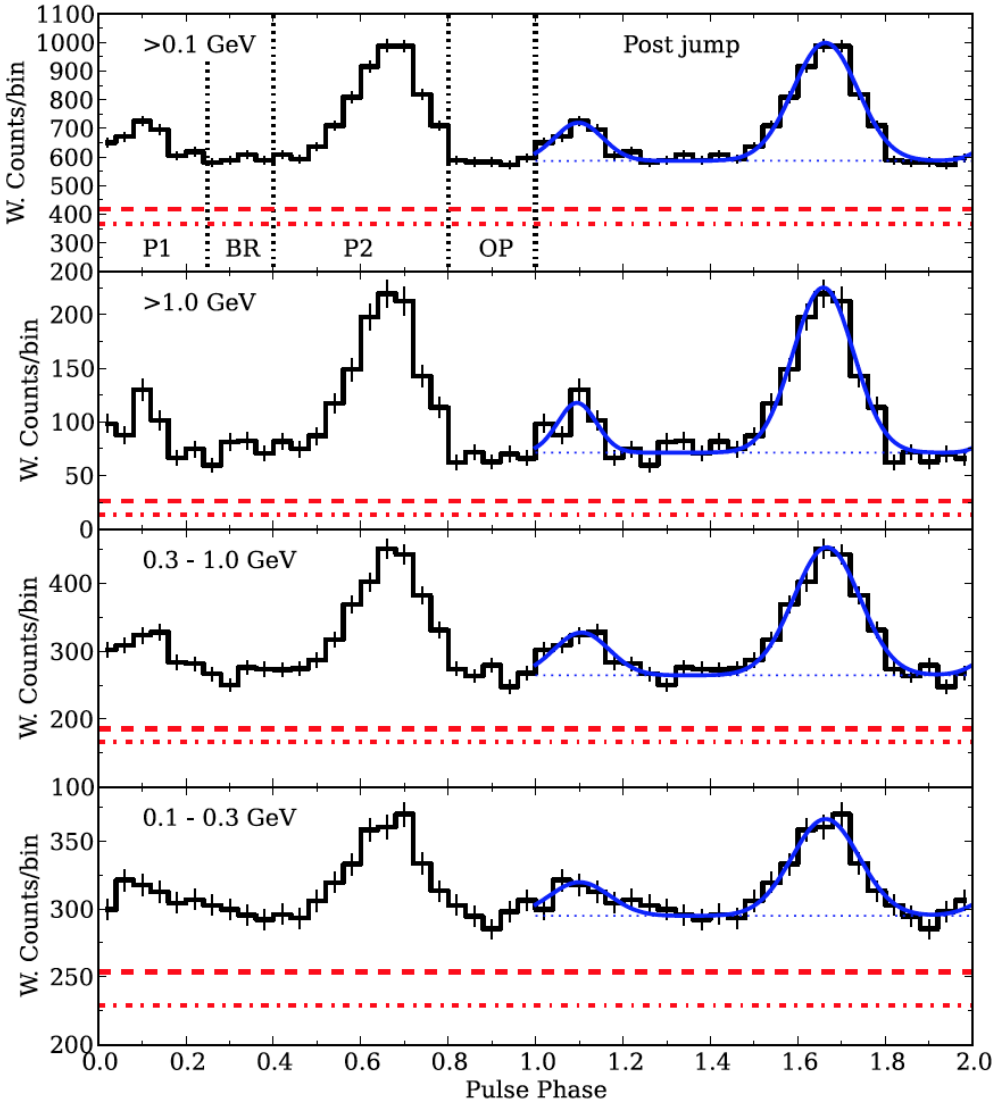
- ~20% drop in flux
- Increase in spin down rate
- Changes in pulse profile
- First case of mode changes observed in gamma-ray pulsars

Allafort et al. 2013

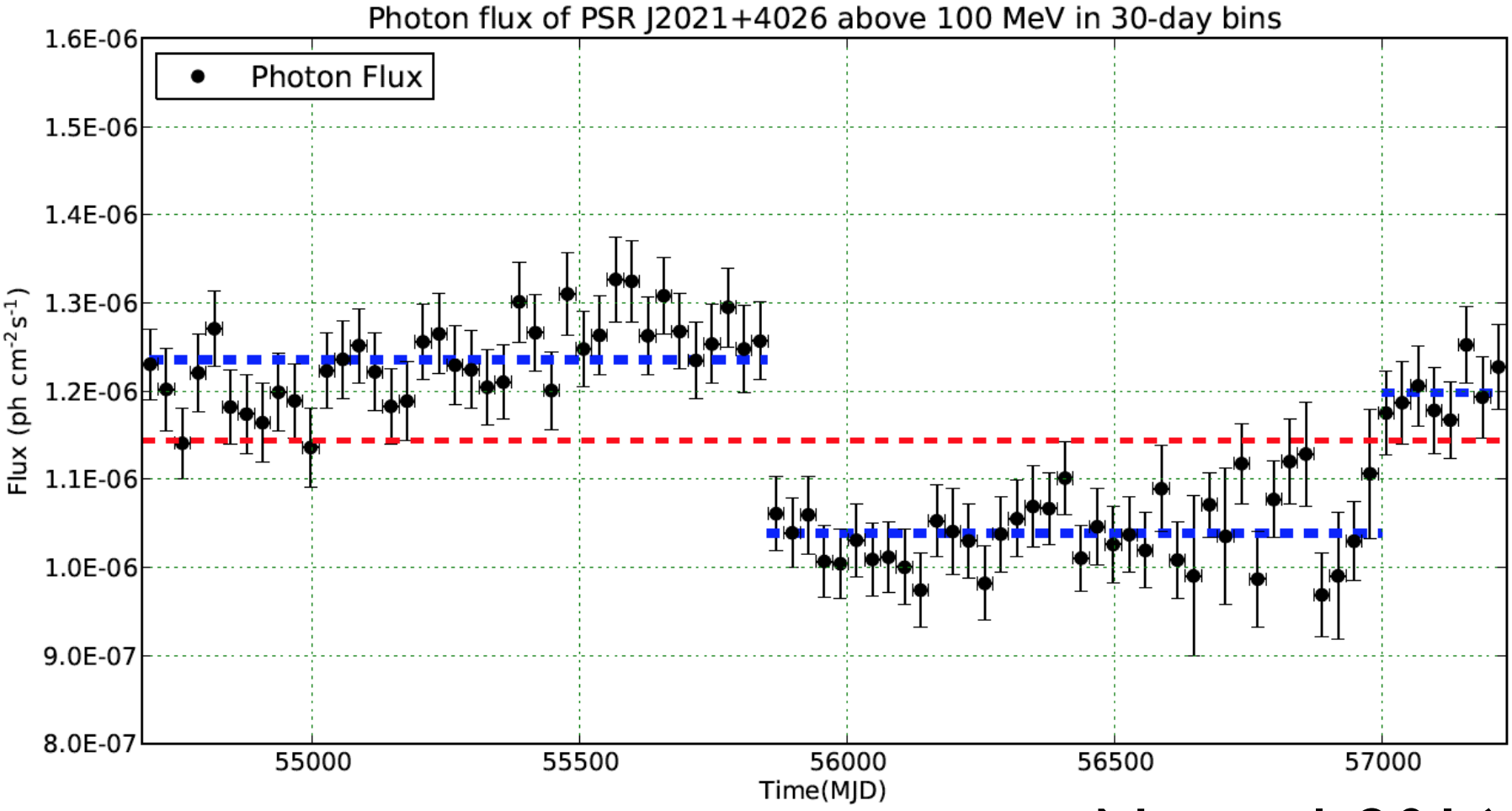


The first variable gamma-ray pulsar





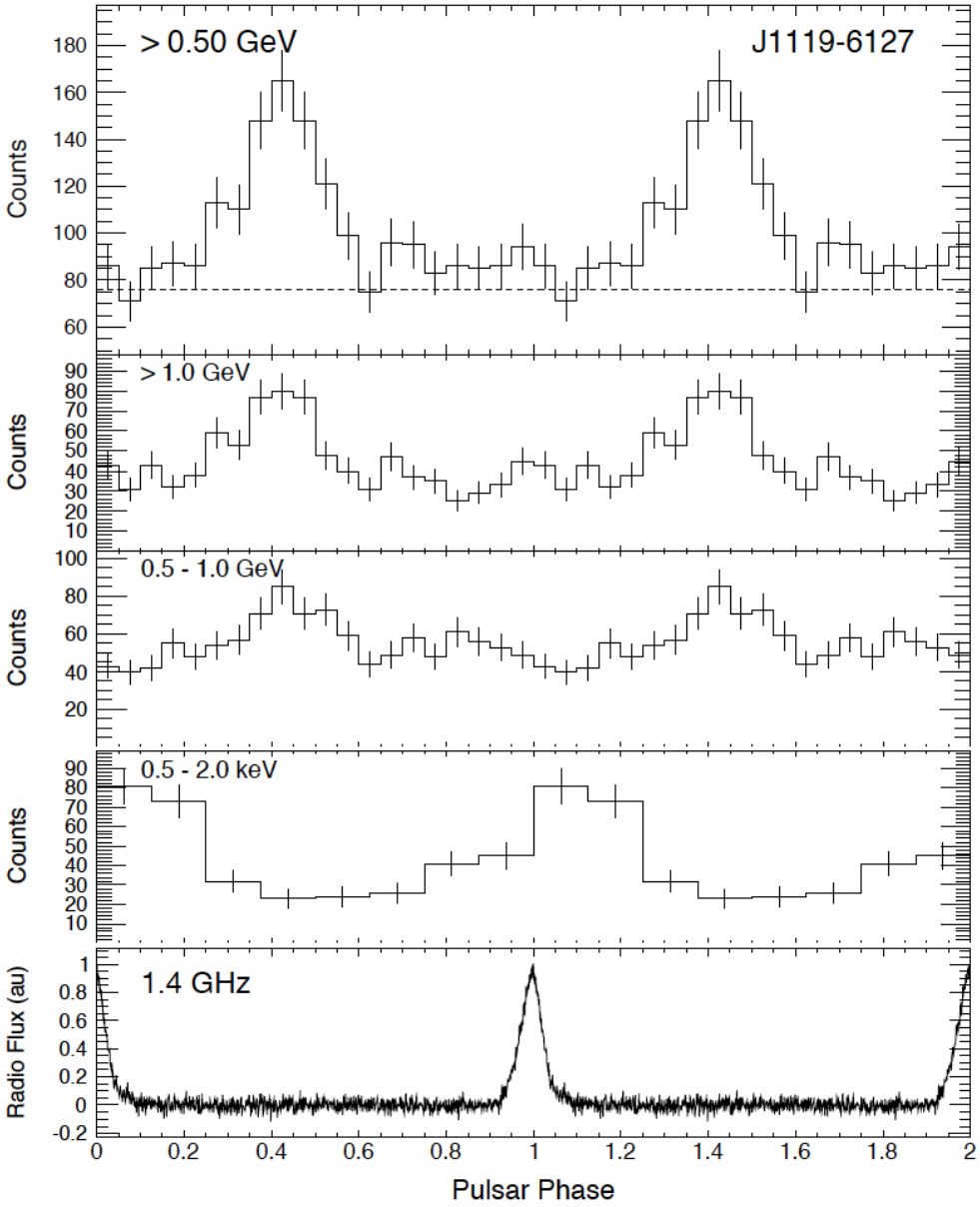
The first variable gamma-ray pulsar



Ng et al. 2016

PSR J1119-6127

- Young (< 2kyr), energetic (2E36 erg/s) associated with an SNR
- B ~ 4.1E13 G
- Soft X-ray pulsar
- No pulsations above 2.5 keV (Ng et al. 2012)
- Early Fermi-LAT detection



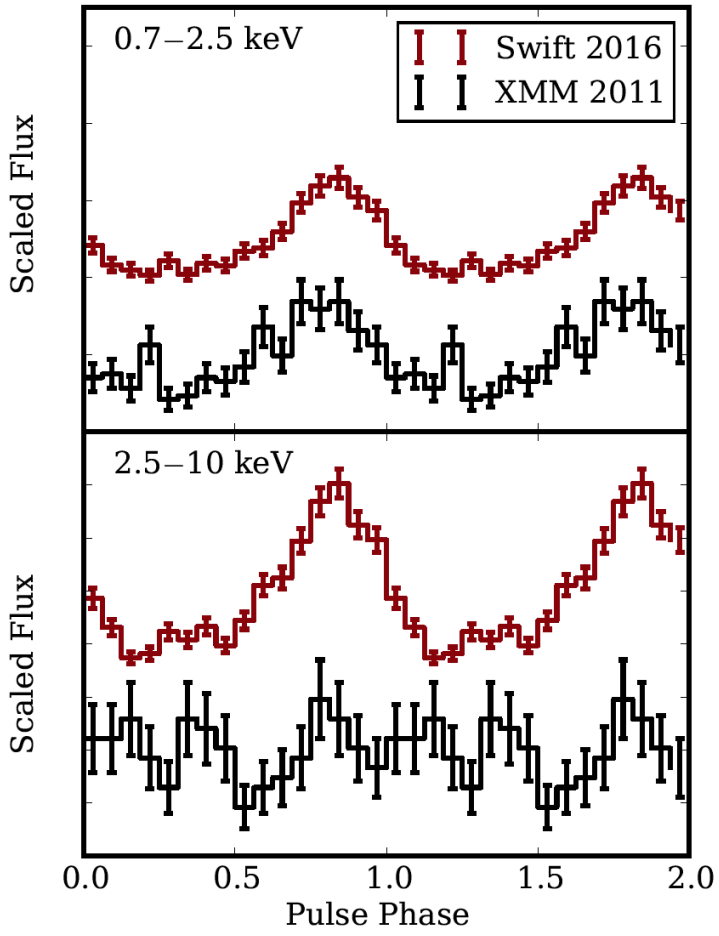
Parent et al. 2011

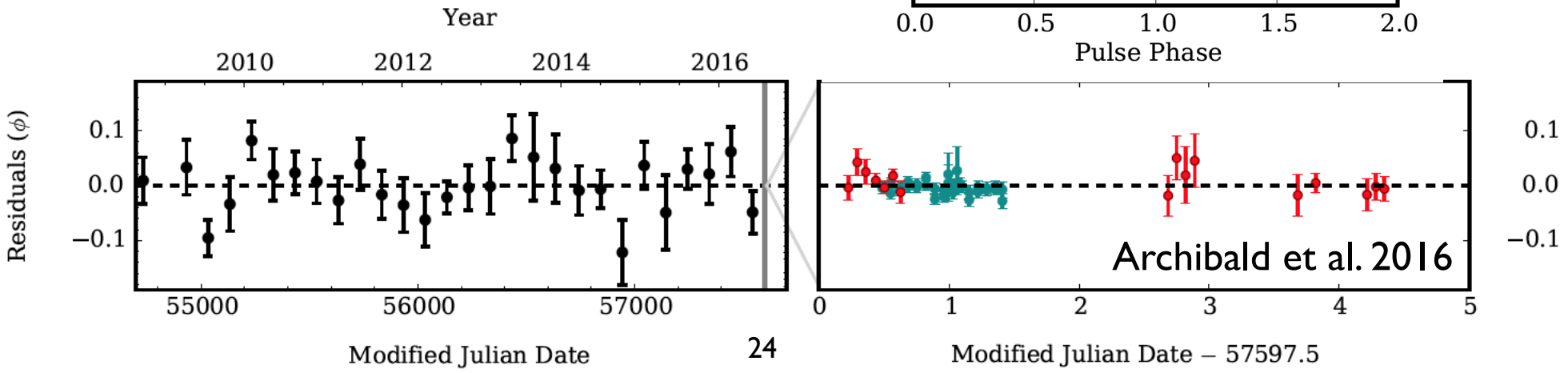
SGR-like bursts from PSR J1119-6127

- ATel #9274, #9282, #9284, #9286, #9321, #9365, #9366, #9378 (between July and August 2016)
- GBM and Swift detection of a SGR-like bursts from PSR 1119-6127
- Glitch detection
- Pulsed Radio Emission disappears, then reappears ~2 weeks later
- Fermi LAT TOO observations (1 week)
- No evidence of *post-glitch* gamma-ray pulsation

PSR J1119-6127

- Flux brightened by a factor of ~160 in the 0.5–10 keV band
- Strong pulsations suddenly present in the 2.5-10 keV band (~60% pulsed fraction)
- Large spin-up glitch (5.7E-6)





Another soft, high B-field gamma-ray pulsar?

The Astronomer's Telegram

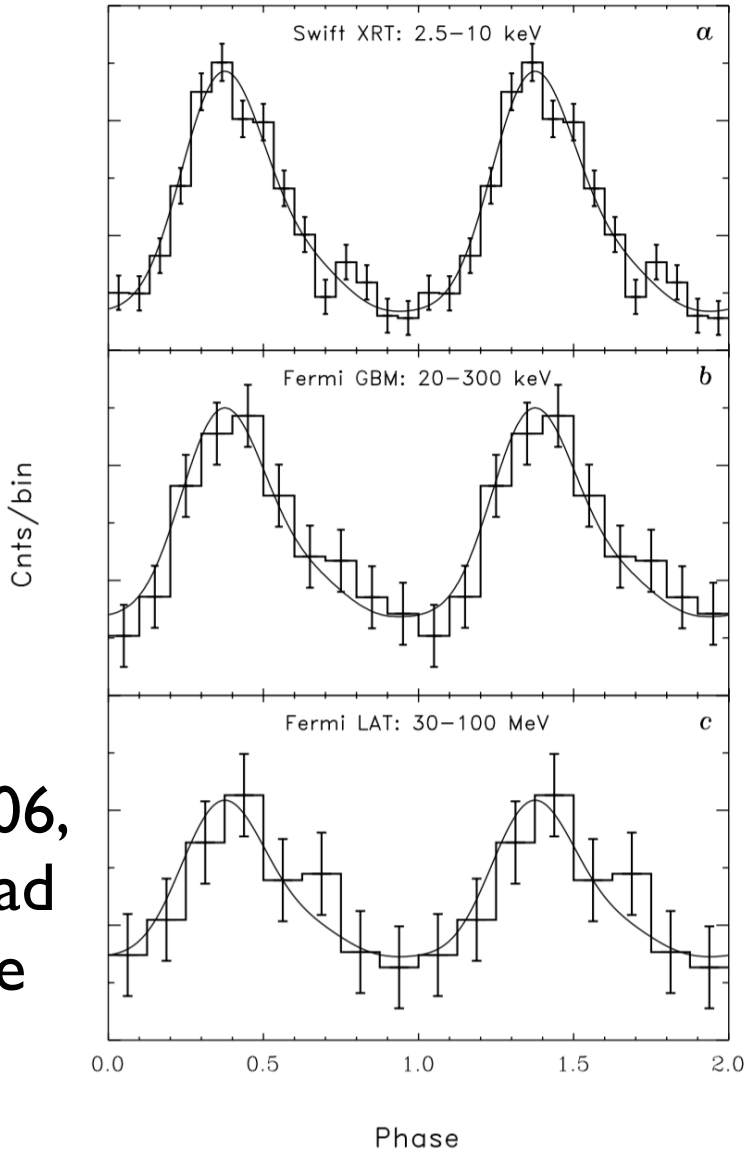
Post | Search | Policies
Credential | Feeds | Email

The Fermi LAT/GBM detection of pulsed gamma-ray emission from PSR J1846-0258 up to 100 MeV

ATel #9077; *Lucien Kuiper (SRON), Ariane Dekker (SRON, UU)*
on 24 May 2016; 13:57 UT
Credential Certification: Lucien Kuiper (L.M.Kuiper@sron.nl)

Subjects: X-ray, Gamma Ray, Neutron Star, Pulsar

PSR J1846−0258 in Kes 75 is the youngest known pulsar (~700 yr), with B ~ 5E13 G (Gotthelf et al. 2000)
J1846-0258 is another "transition" object: In 2006, its pulsed X-ray flux increased dramatically, it had a large glitch, and emitted several magnetar-like bursts



Summary

- The rate of new gamma-ray pulsar discoveries continues unabated, more than 8 years after the launch of Fermi
- New gamma-ray pulsars are being detected by Fermi in every category: young, MSP, radio-loud, radio-quiet, etc.
- Longer data sets and Pass 8 are allowing Fermi to expand into new parameter space and investigate the variable behavior of gamma-ray pulsars