One decade of pulsar studies with Fermi

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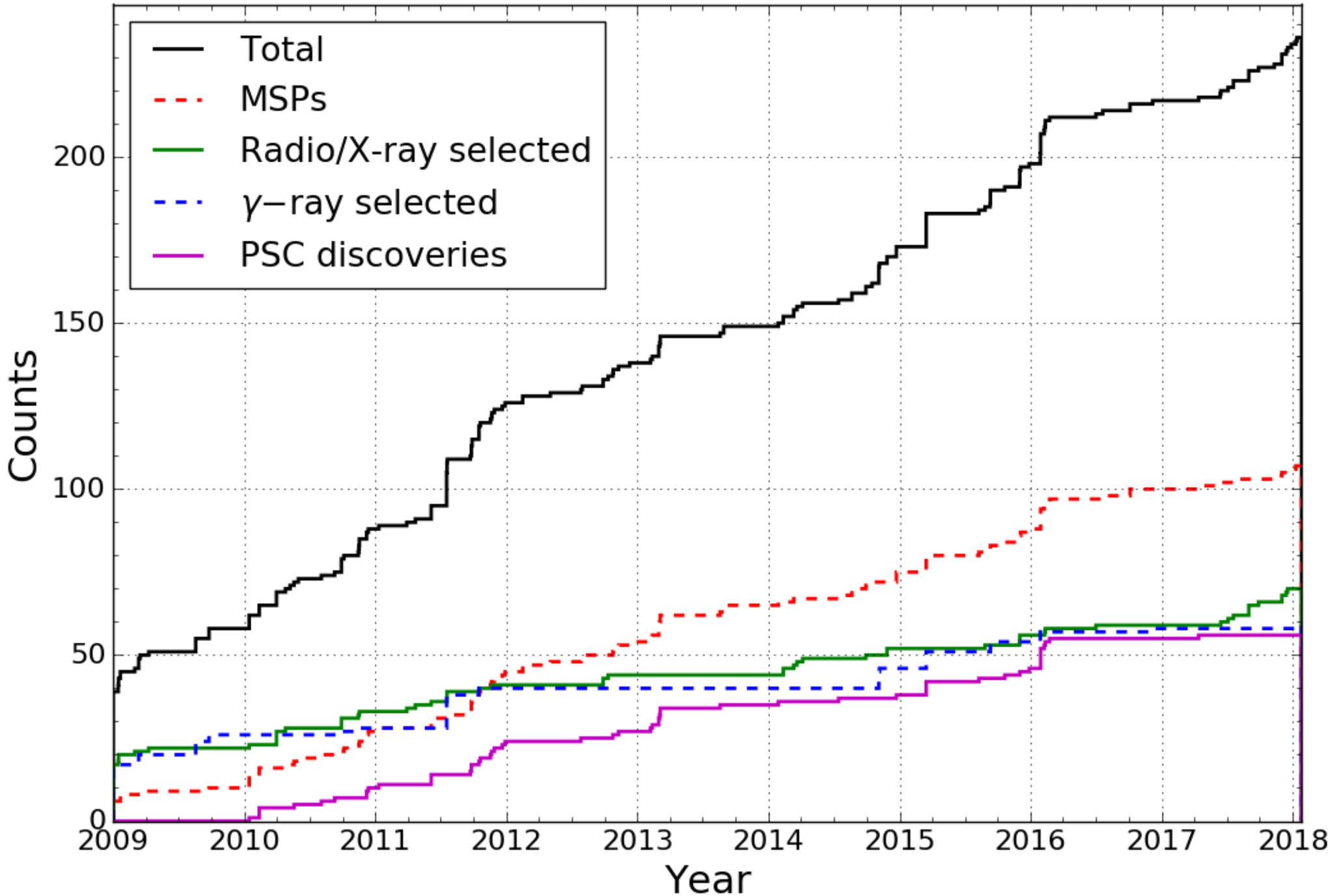
FAST/Future Pulsar Symposium 7, Guangzhou, 4 July 2018

11 June 2008

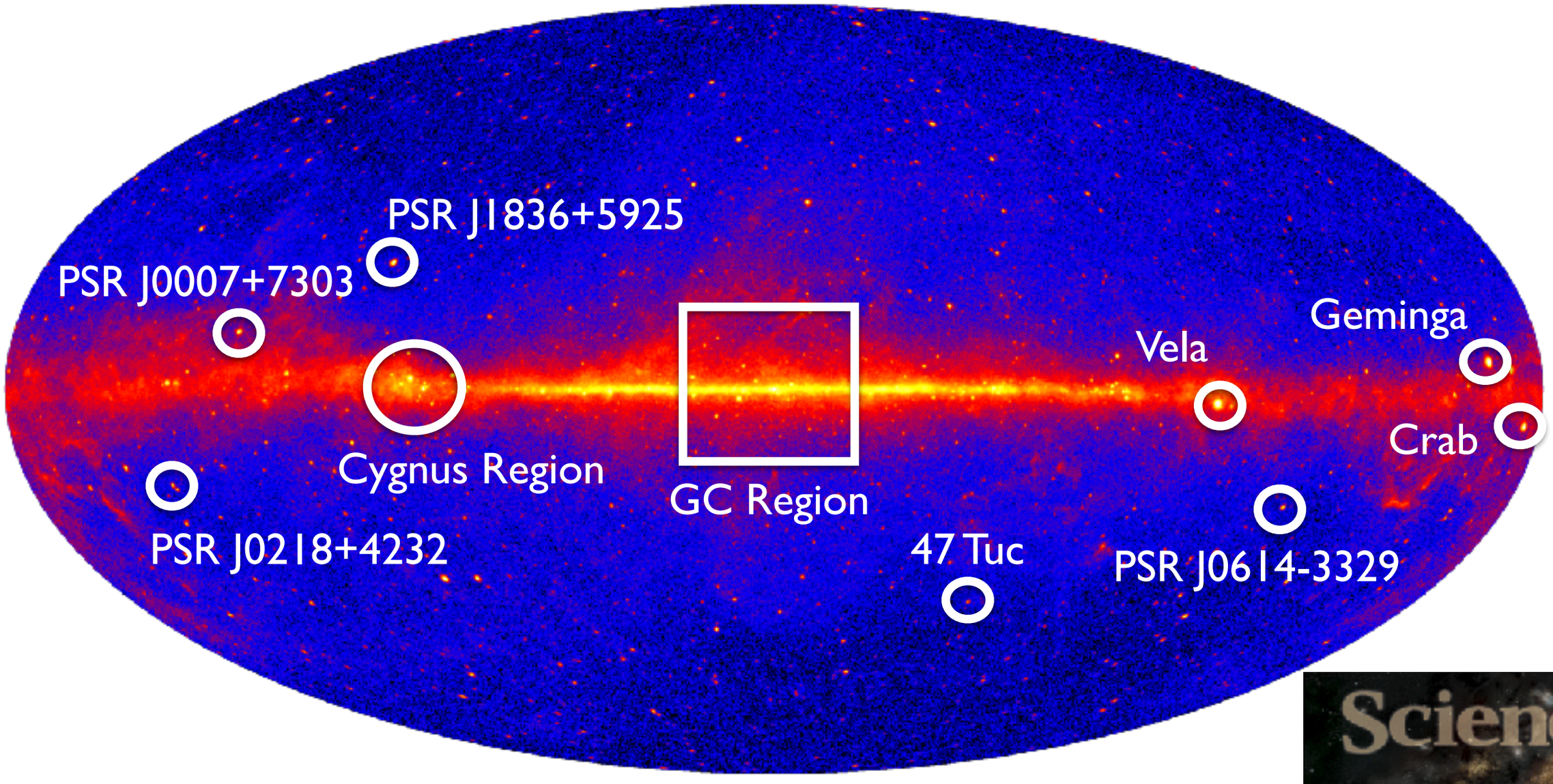
Credit: Marcus Ziegler

Fermi LAT Pulsar Discoveries



http://tinyurl.com/fermipulsars

Early pulsar *Science* with Fermi

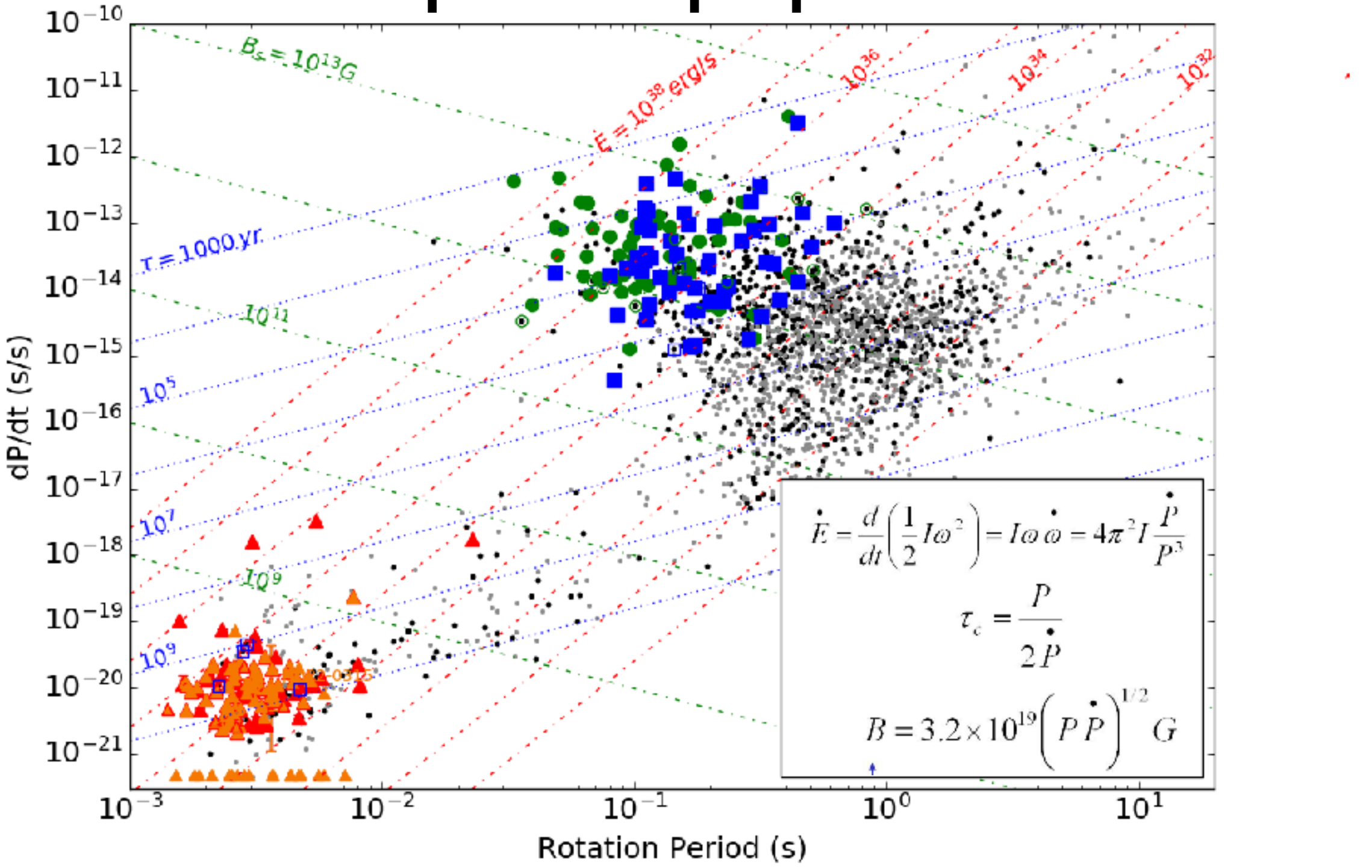


Abdo et al., *Science*, **325**, 840 (2009): Gemingas

Abdo et al., *Science*, **325**, 845 (2009): Globular Clusters

Abdo et al., *Science*, **325**, 848 (2009): MSPs

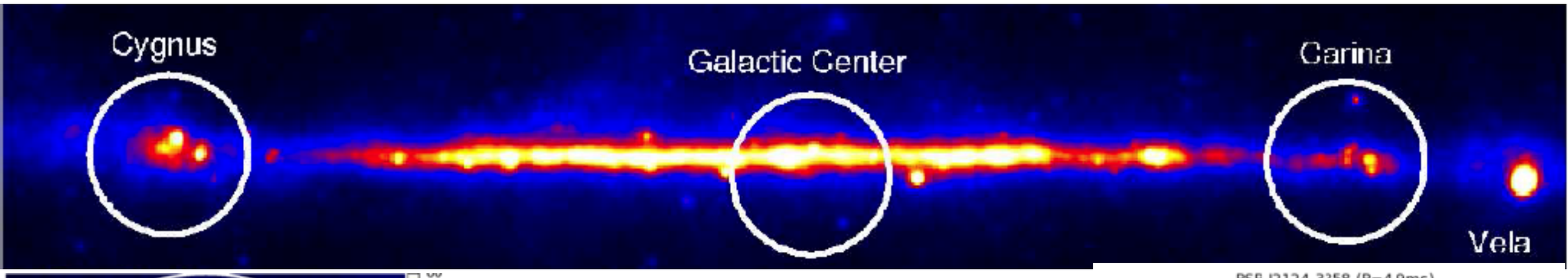
The pulsar population

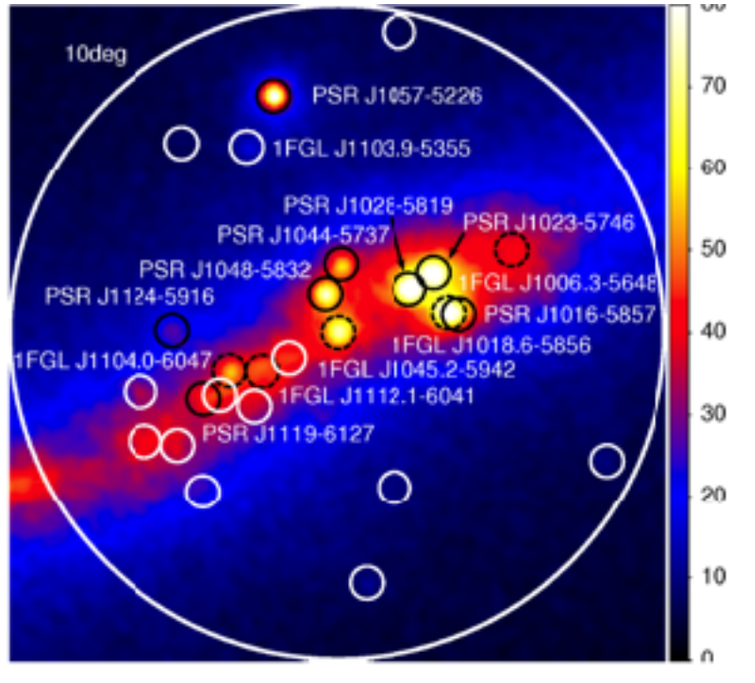


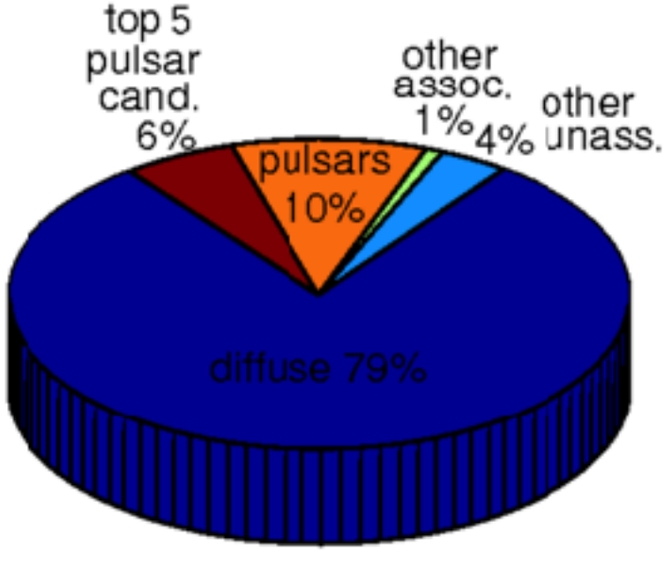
http://tinyurl.com/fermipulsars

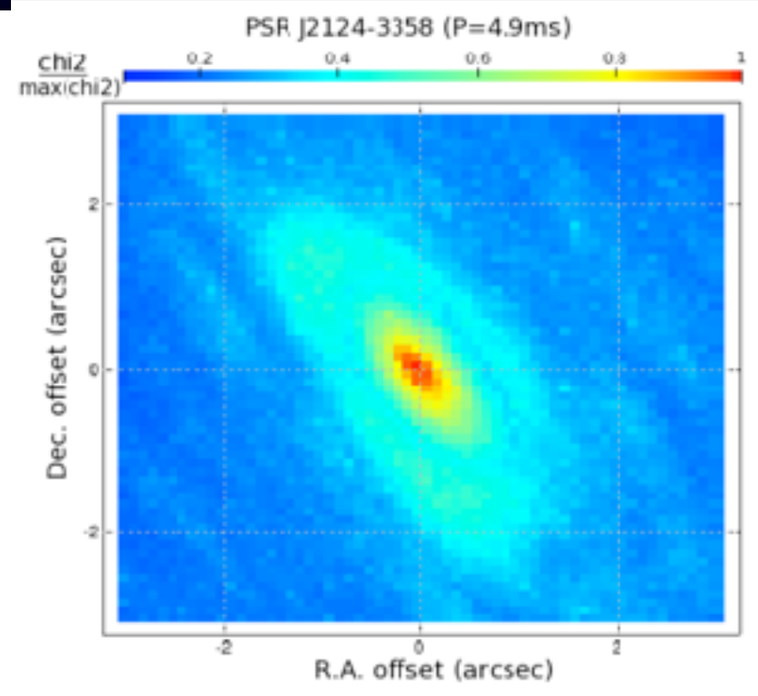
Searches for gamma-ray pulsars

- The PSF of a gamma-ray instrument is broad (~deg)
- Pulsars are often in the Galactic plane, where there are many sources and a strong diffuse background
- Very accurate position is needed



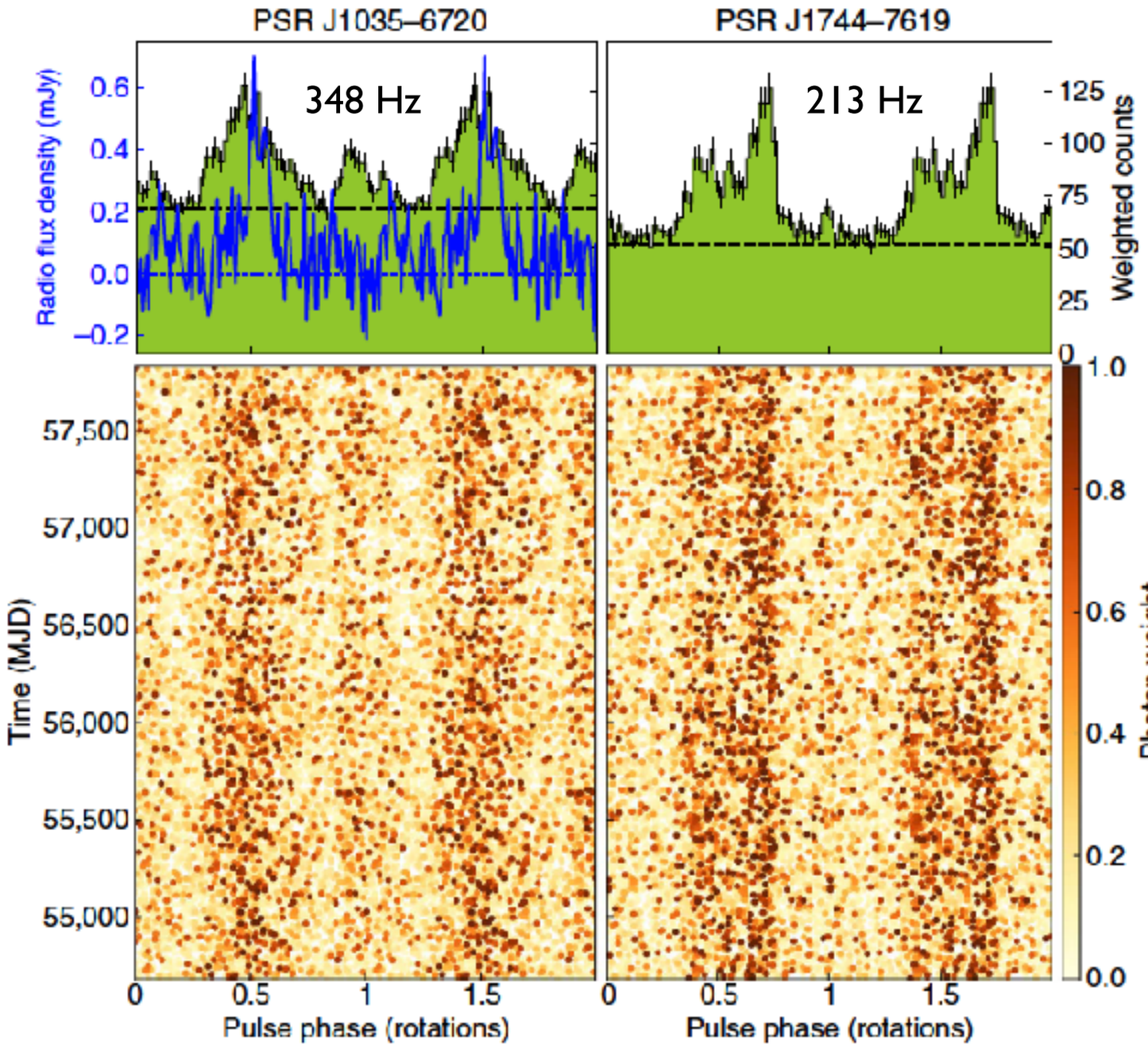






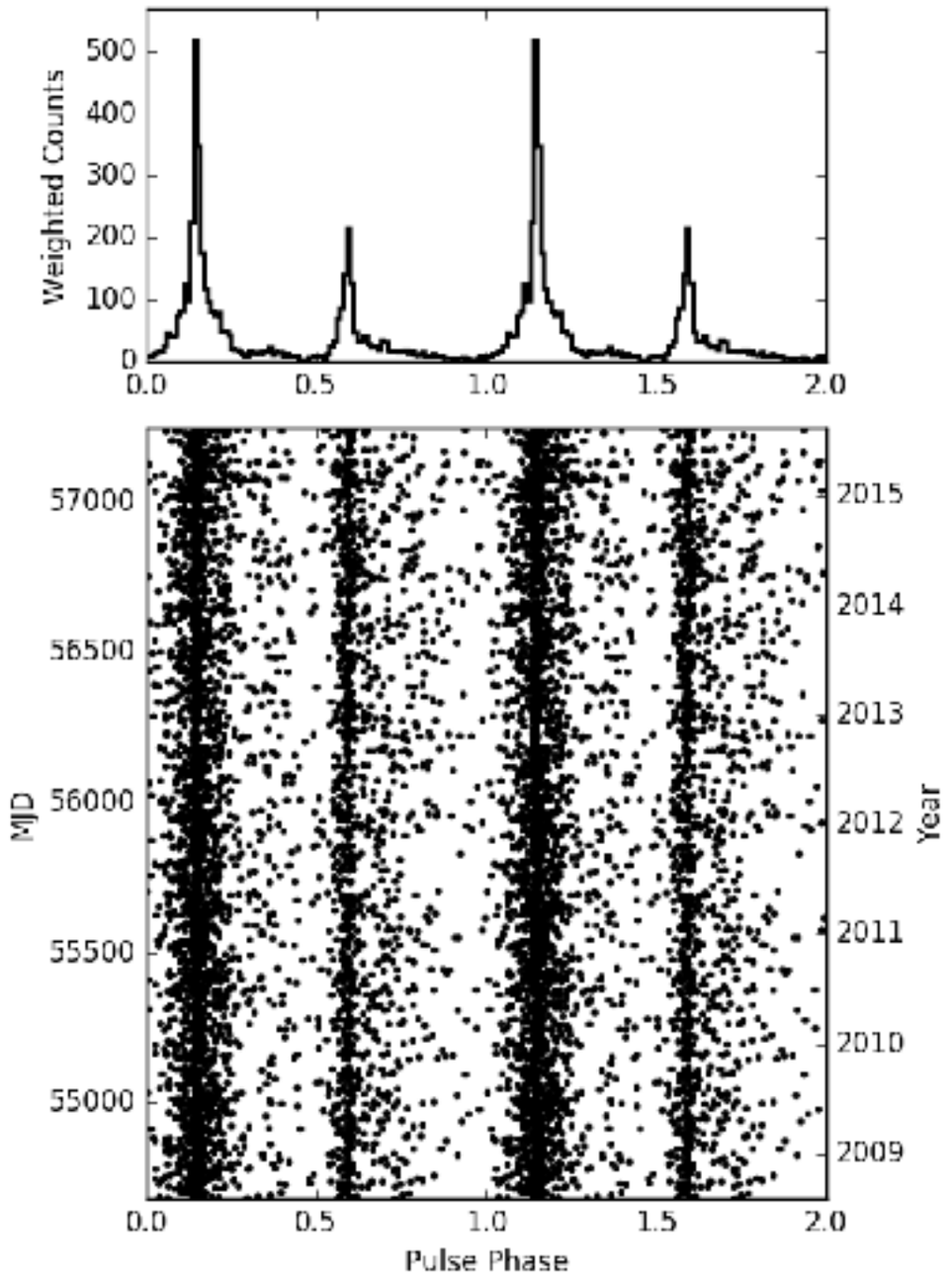
The first radio-quiet MSP

- Discovered using Einstein@Home (>10,000 CPU yr)
- First MSP not detected in radio
- Searched with Parkes ~10 times
- Could be only the tip of the iceberg



Clark et al. 2018

Long term pulsar timing

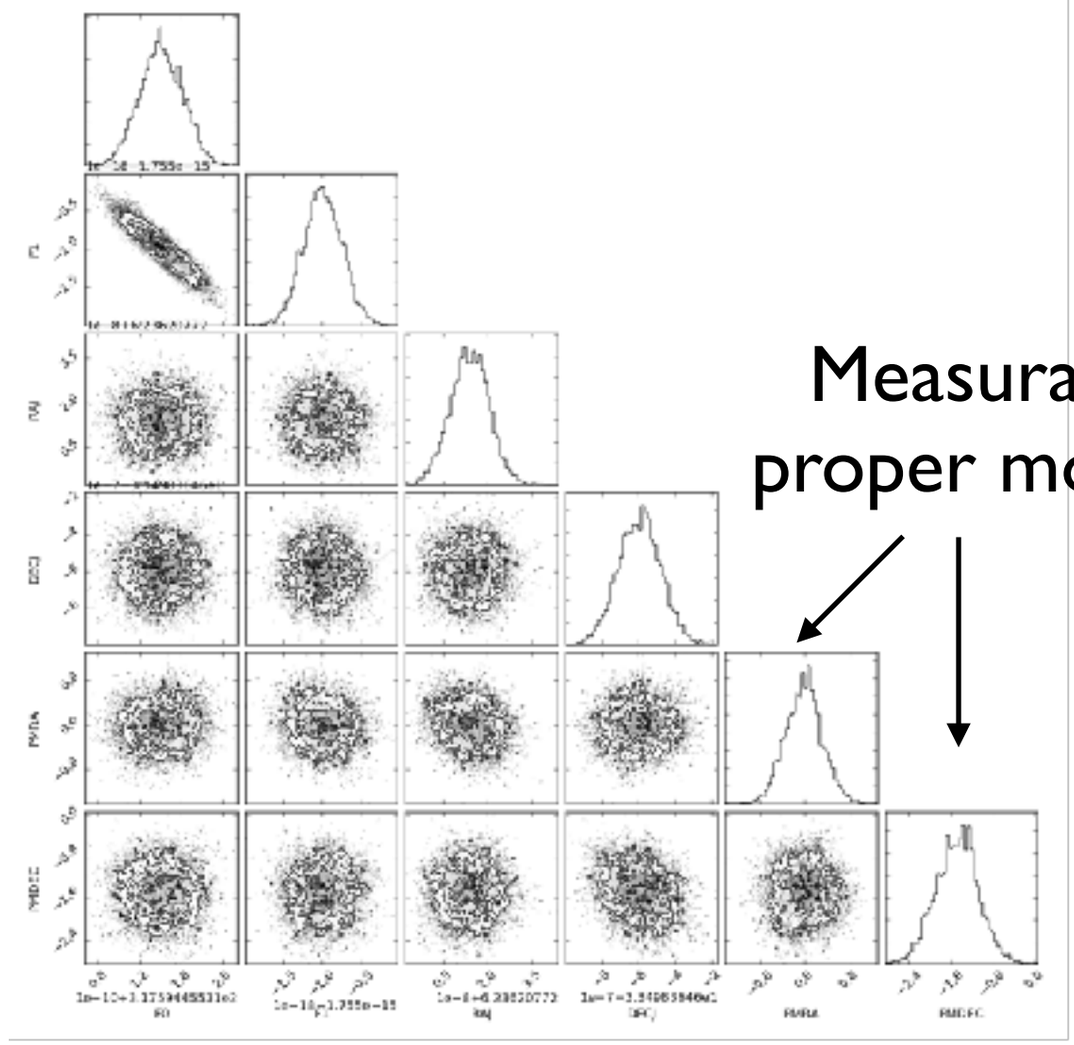


~3000 days

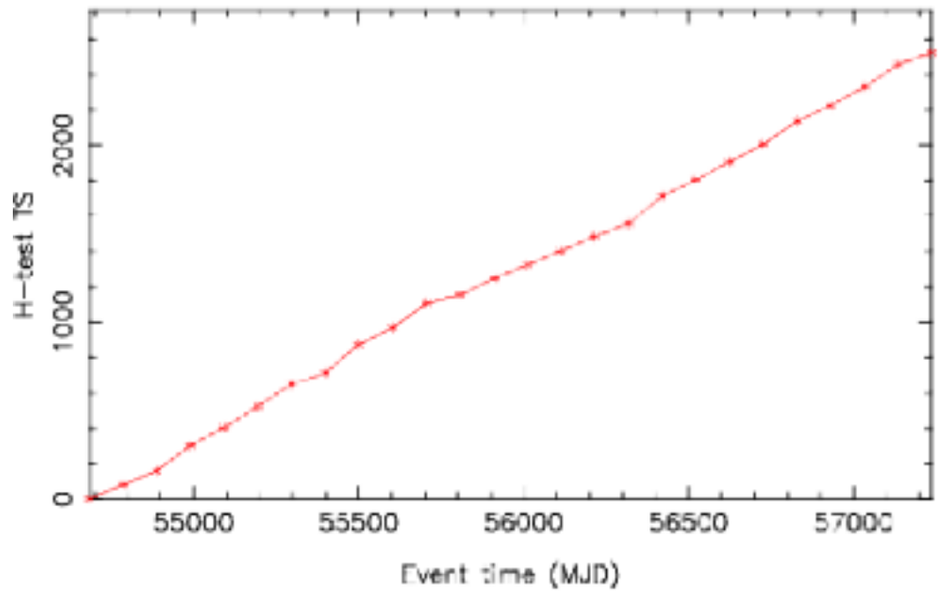
> 80 billion rotations

< 20,000 photons

~ 1 photon every 5 million rotations



Measurable proper motion



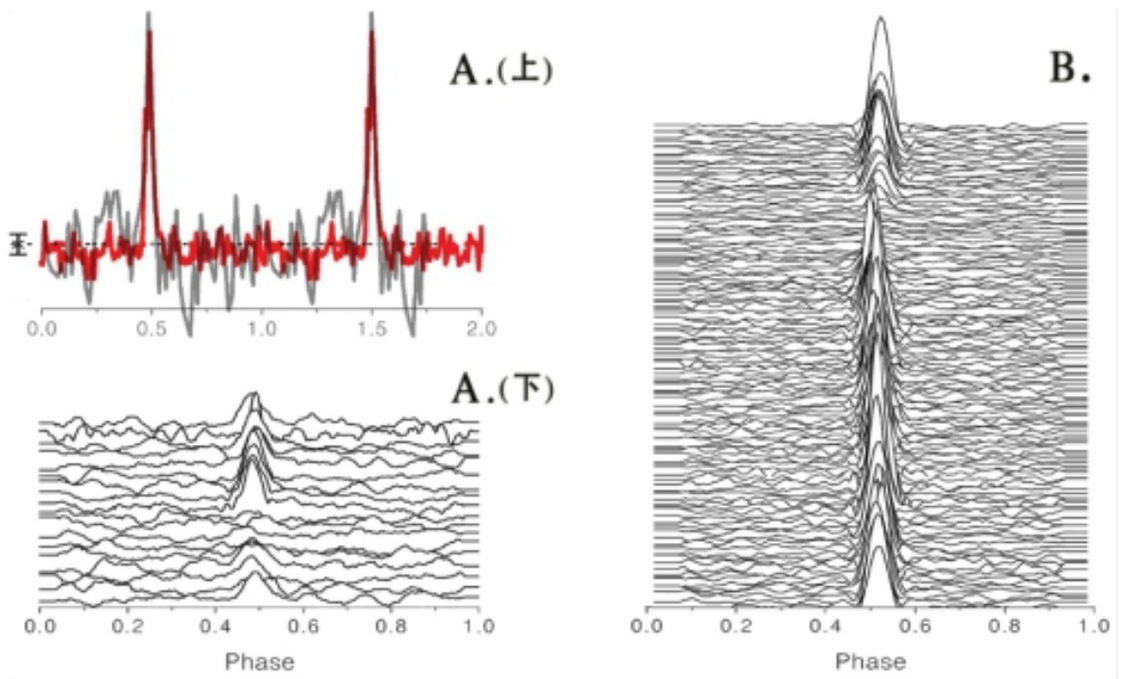
The Pulsar Search Consortium





Formed in 2009 between LAT pulsar searchers and radio astronomers (Ray et al. 2012: arXiv: 1205.3089)

FAST joins the PSC!

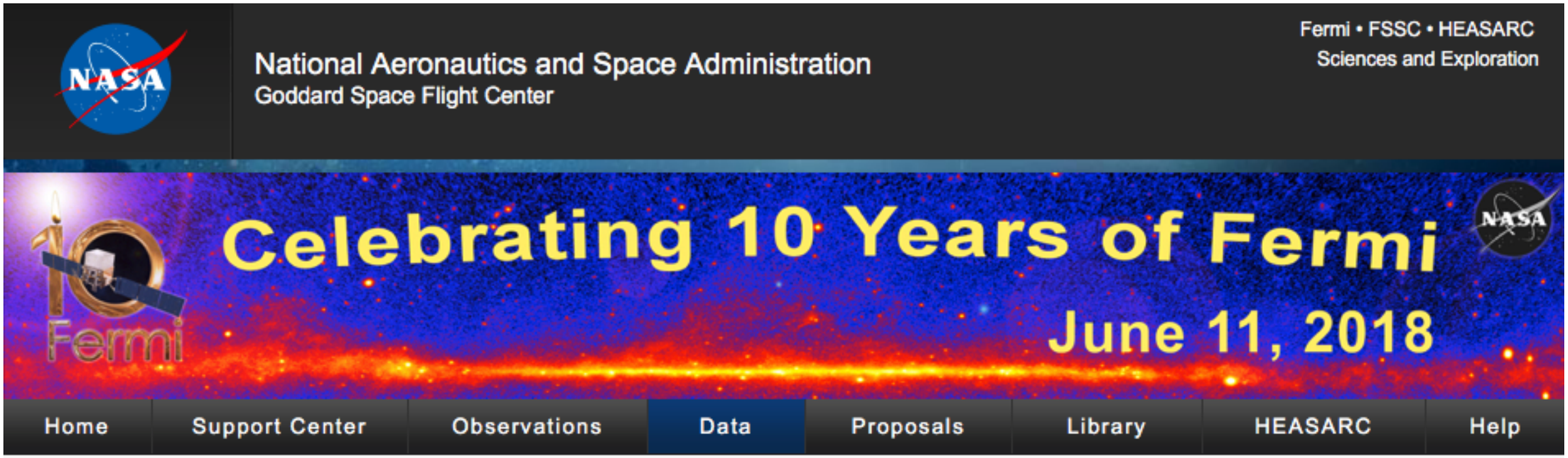


http://crafts.bao.ac.cn/pulsar/

- FAST and Fermi recently signed an MOU
- Fermi GI and NSFC proposals submitted (2018)
- Searches for new pulsars in LAT sources and radio pulsations from radio-quiet gamma-ray pulsars are ongoing …

See next talk by Pei Wang

4FGL catalog in preparation …

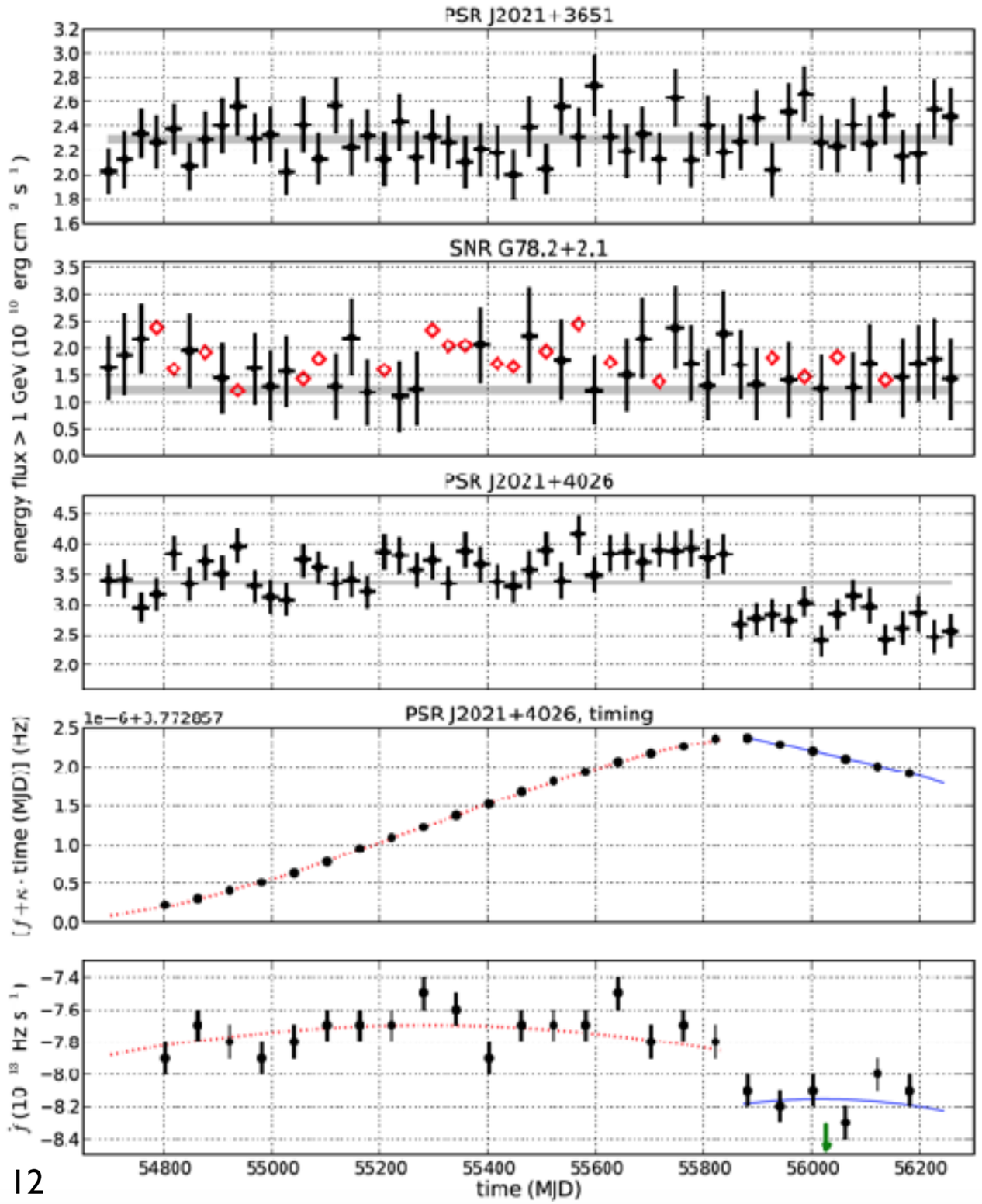


2900 AGN, 217 pulsars, 2130 unassociated

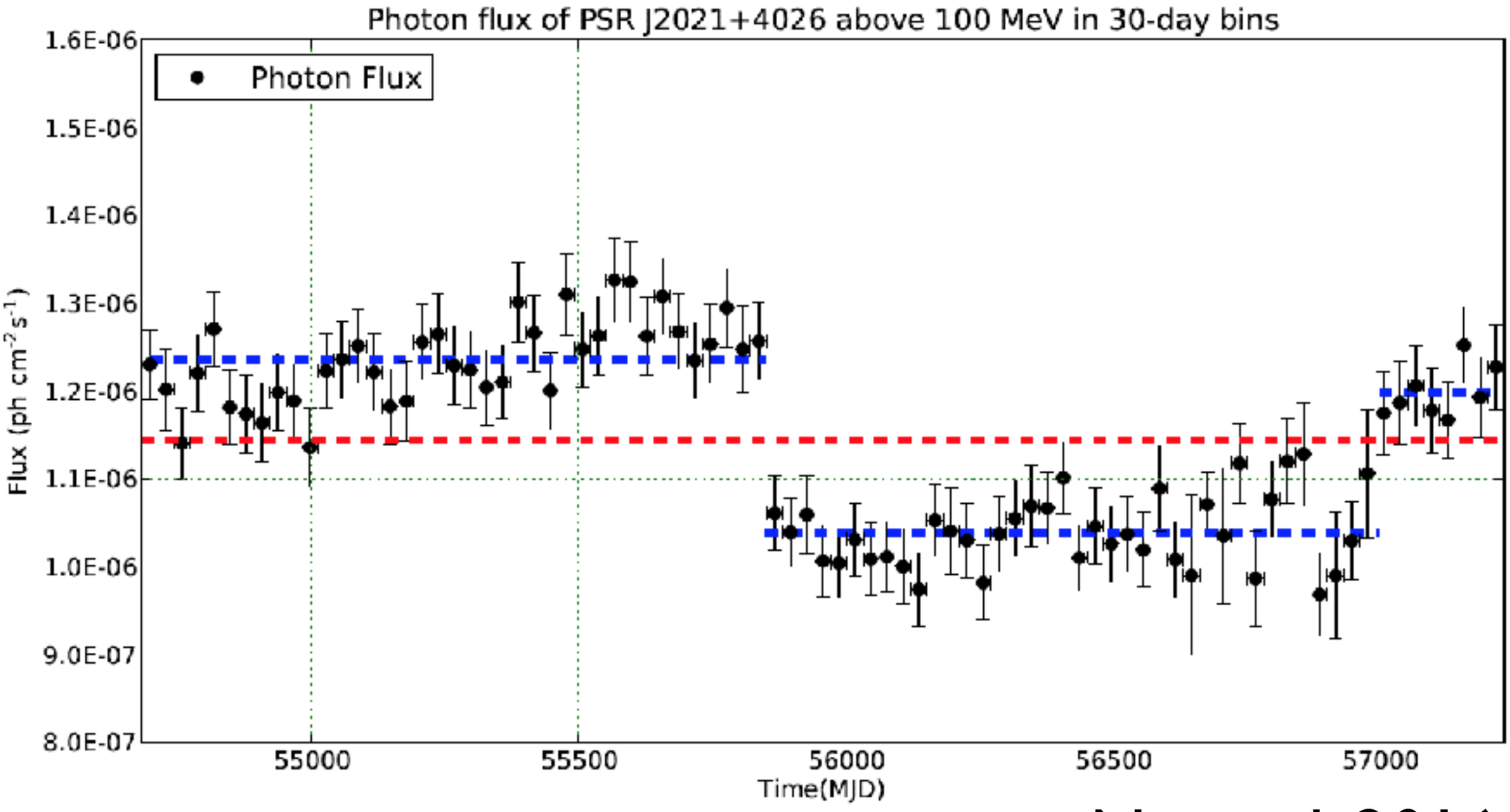
PSR J2021+4026:
The first variable gamma-ray pulsar

- ~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



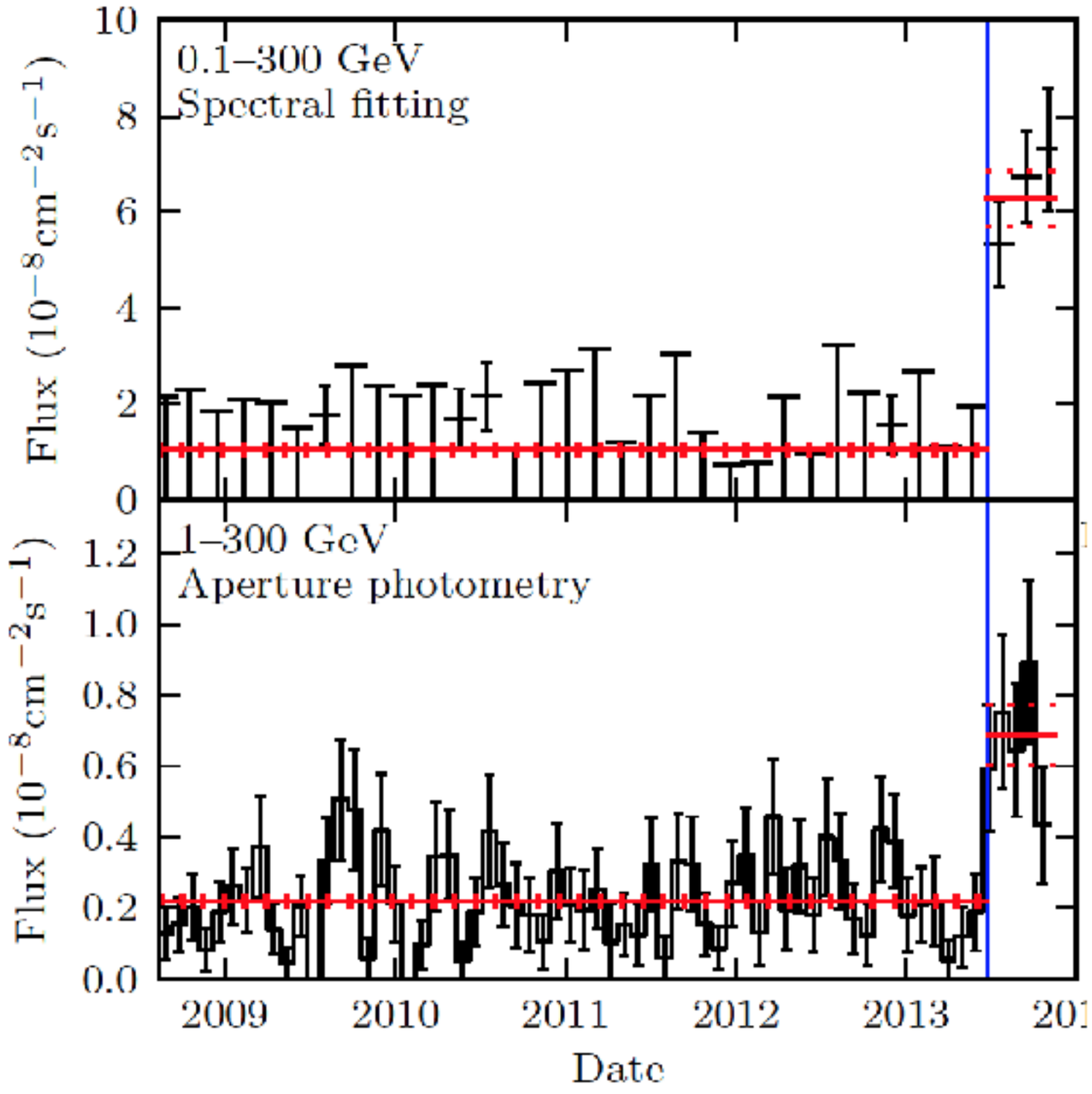
The first variable gamma-ray pulsar



Ng et al. 2016

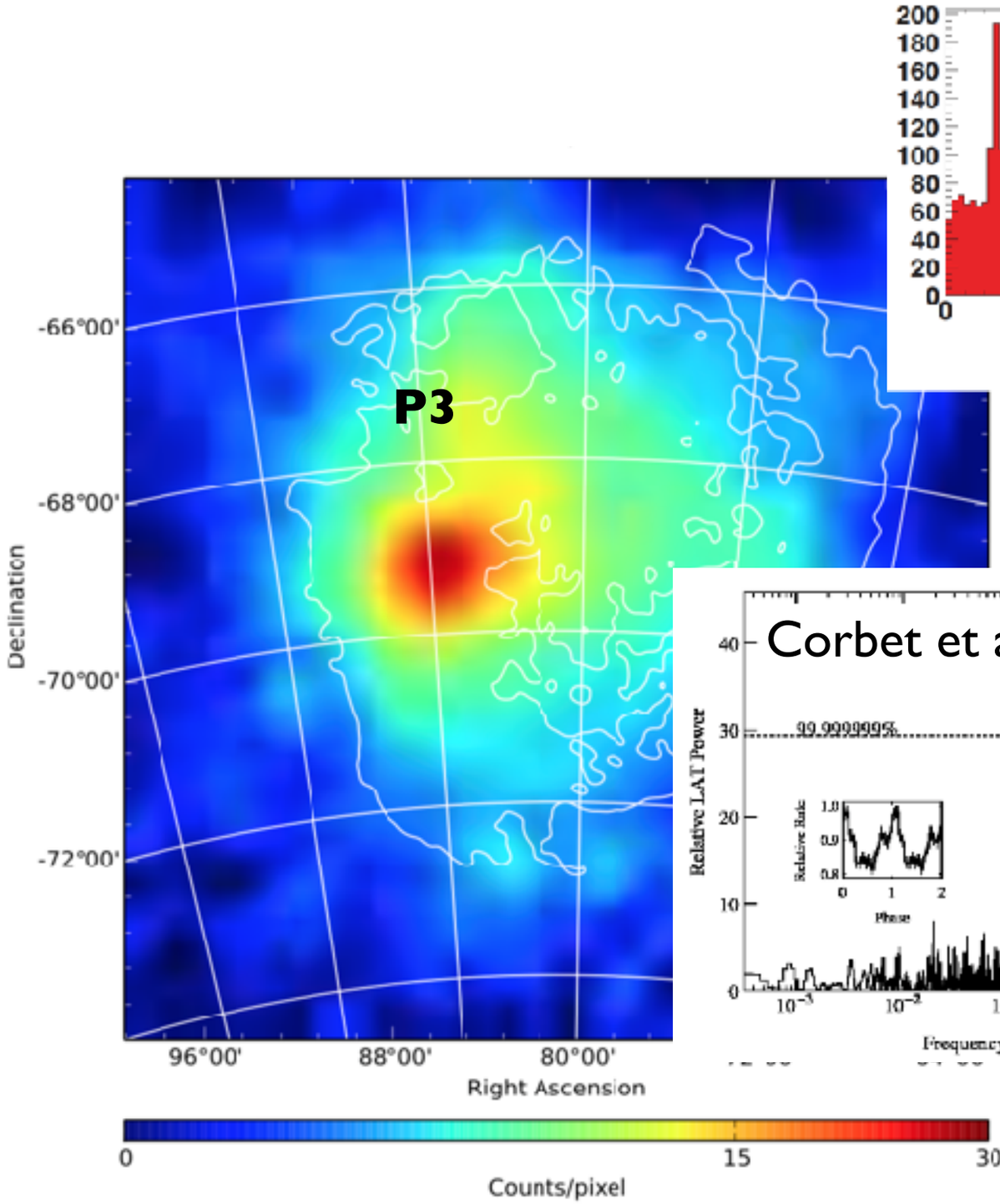
A state change in J1023+0038

- 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

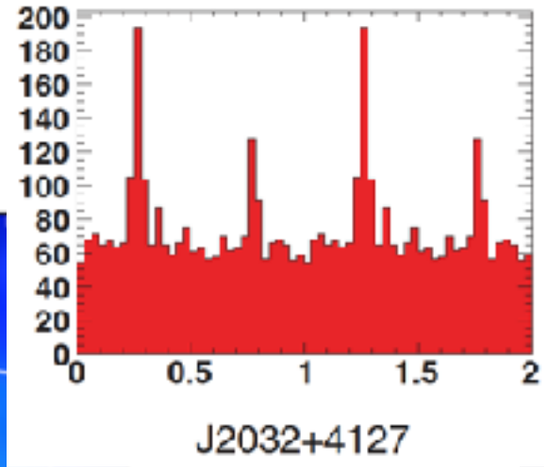


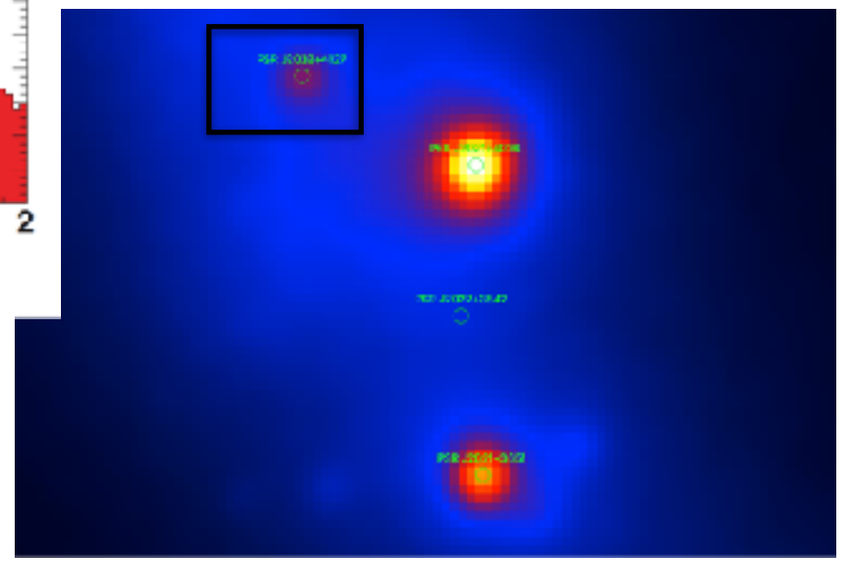
Stappers et al. 2014

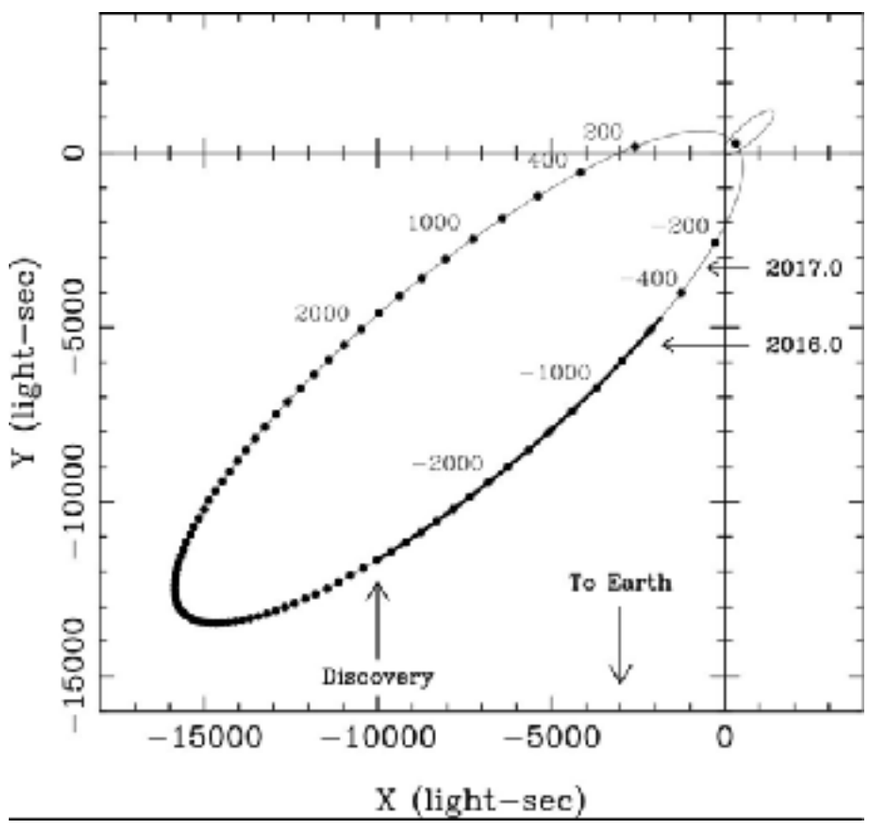
Latest gamma-ray binaries



Ackermann et al. 2015

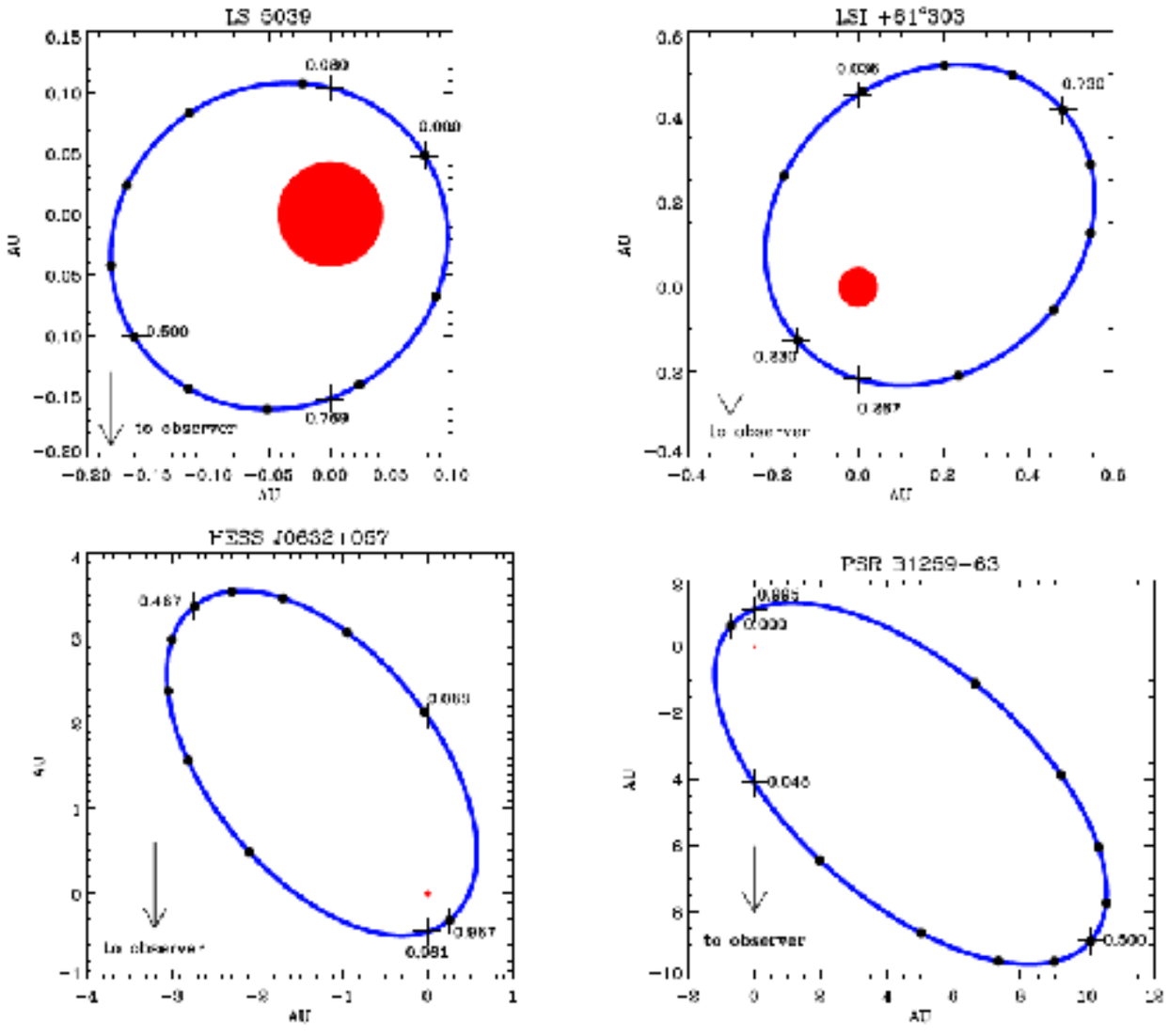




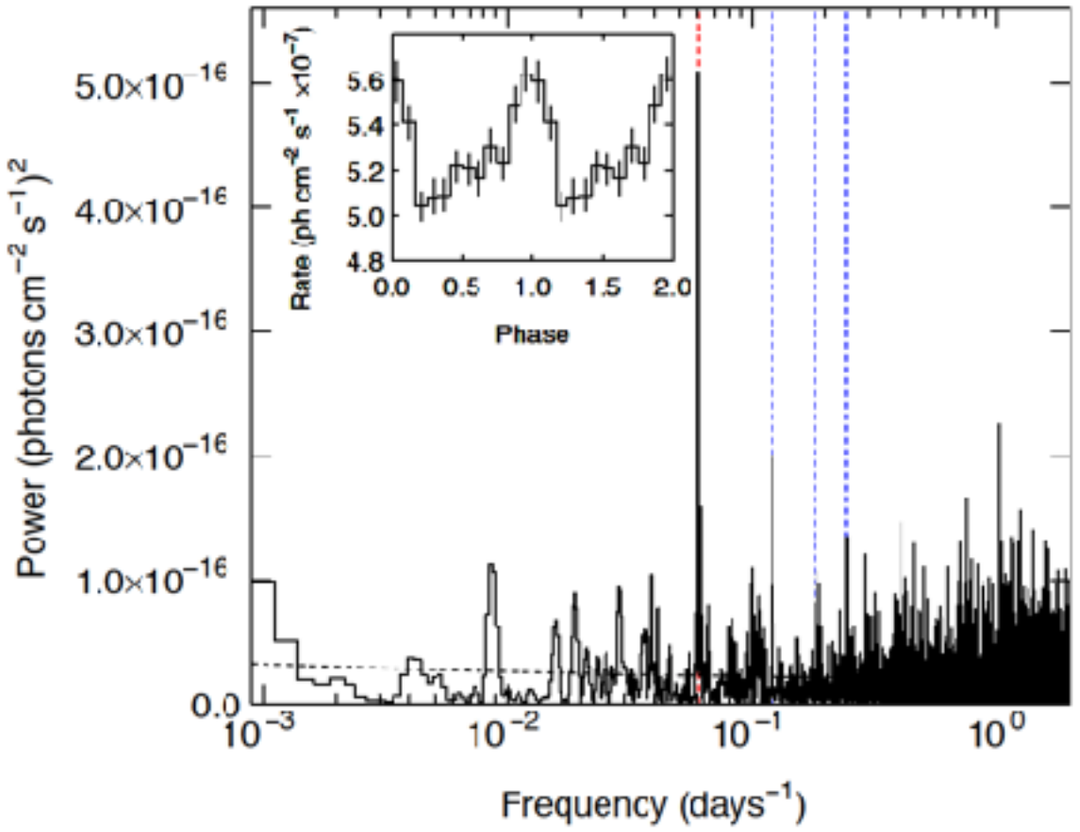


Lyne et al. 2015

Young gamma-ray binary pulsars?



Credit: Dubus et al. 2017

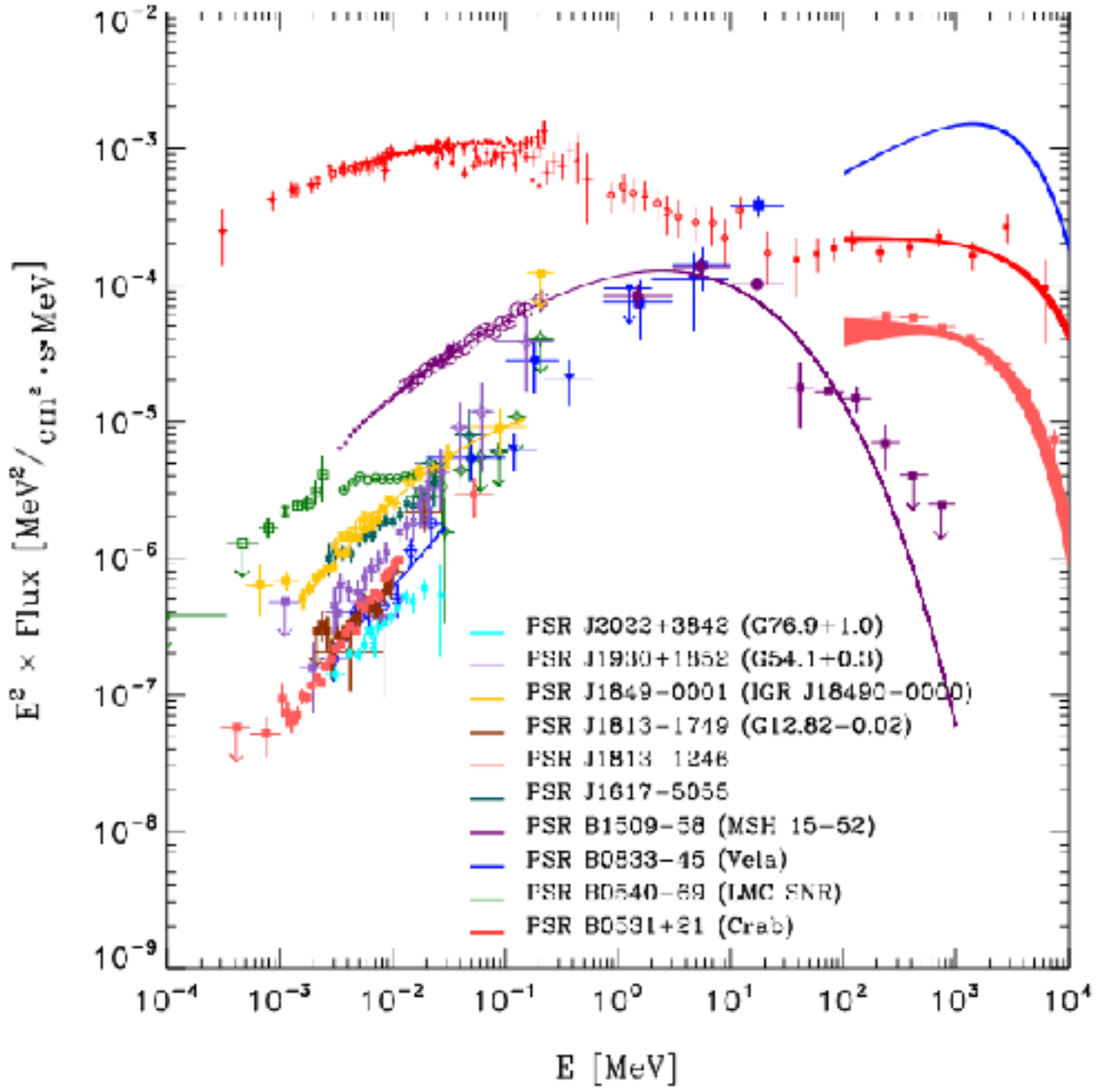


First gamma-ray binary discovered by Fermi: 1FGL J1018.6-5856: Ackermann et al, *Science*, **335**, 6065 (2012)

Gamma-ray binaries: typically consist of a massive star in orbit with a compact object, characterized by a broad non-thermal emission peaking at ~MeV energies.

Soft gamma-ray pulsars: a missing population

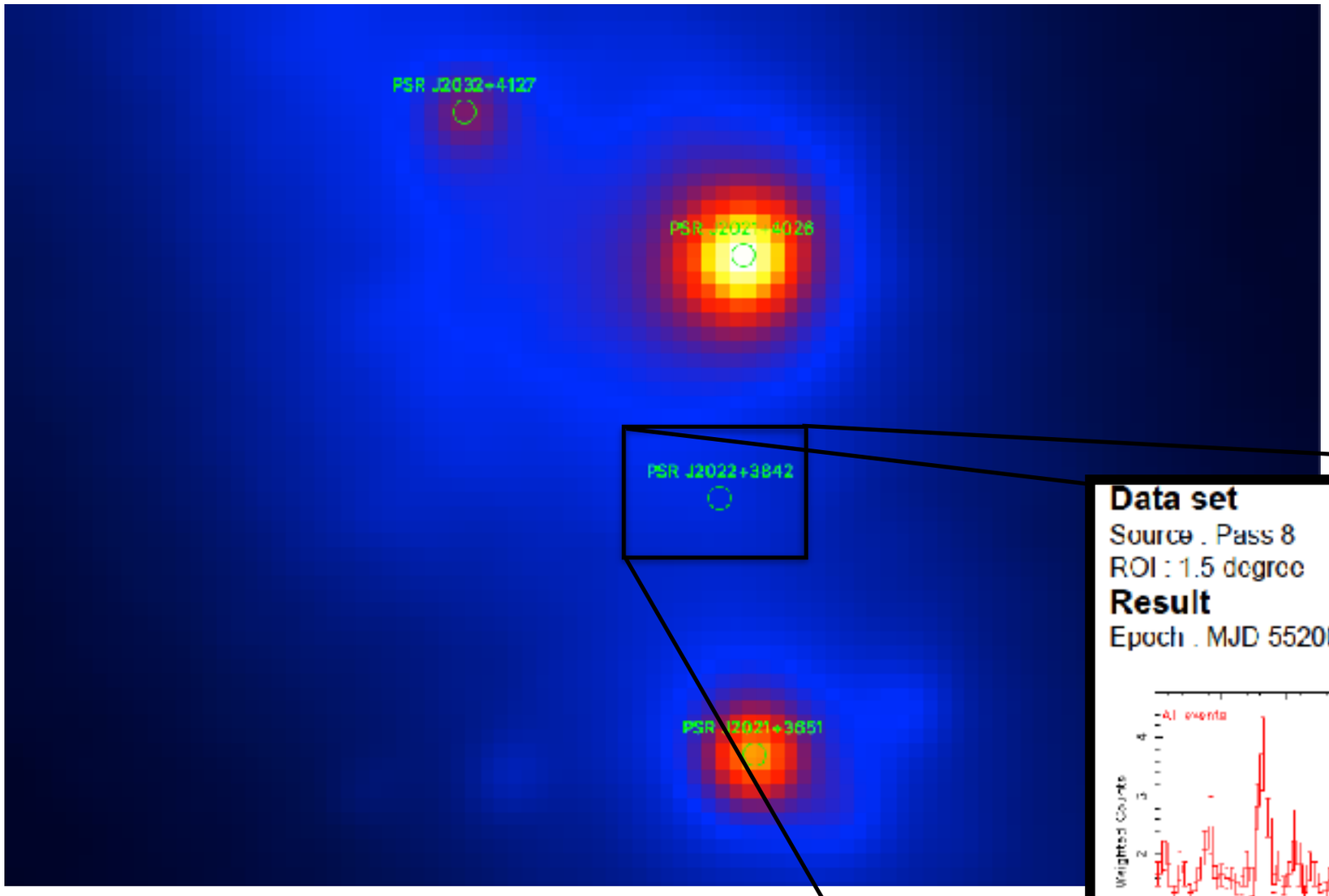
- Peak of emission below 100 MeV
- Typically young and very energetic, high B-field
- Often associated with SNRs, TeV sources
- Very few detected by Fermi LAT



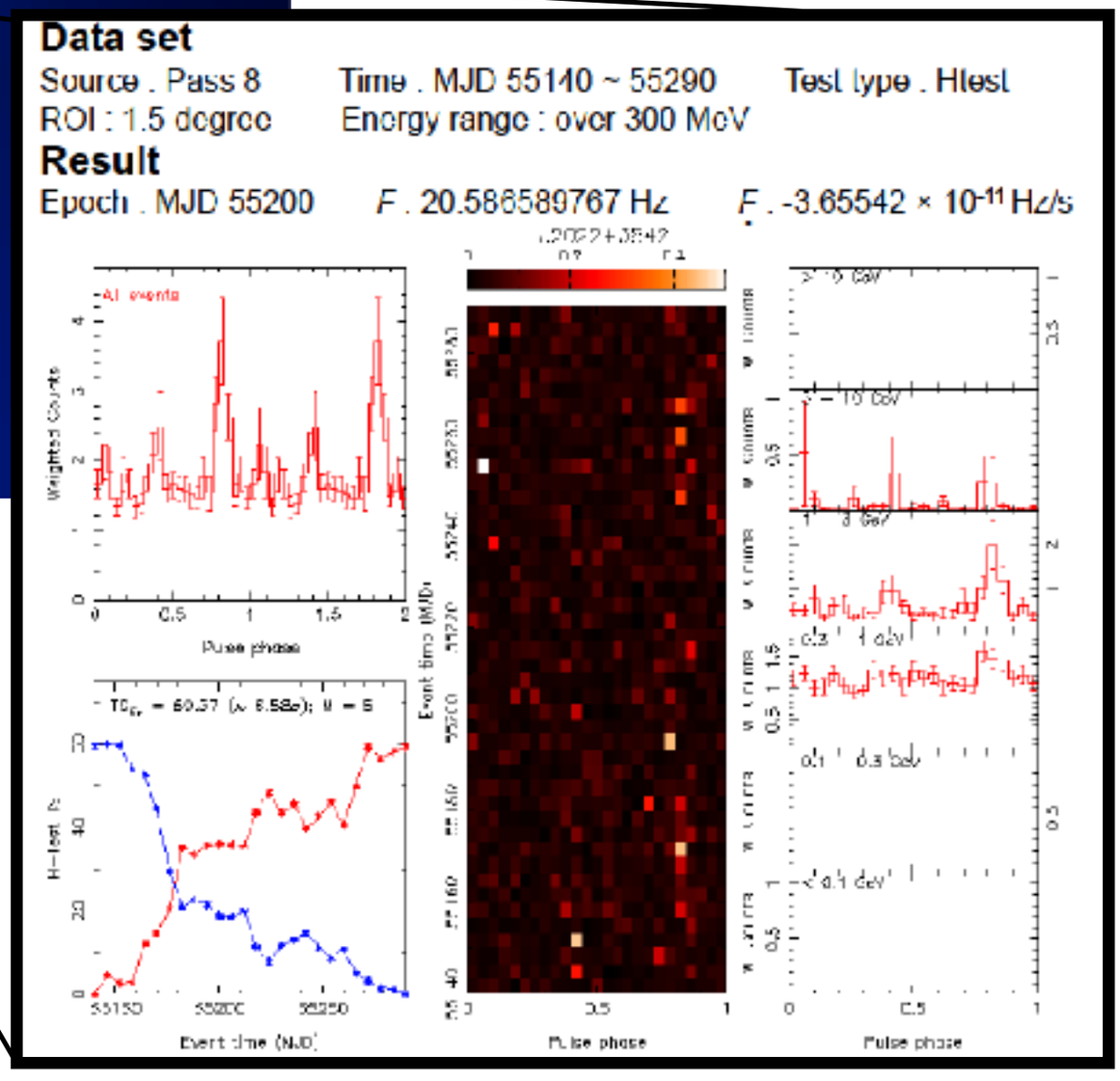
Kuiper & Hermsen (2015)

See poster by Brent Limyansky

PSR J2022+3842: soft gamma-ray pulsar?



Ohuchi et al. 2015
(Fermi Symposium)



One of the most
energetic pulsars (3E37 erg/s),
seen in X-rays and radio
Associated with SNR G76.9+1.0
Arzoumanian et al. (2011)

Summary

- Fermi is a highly efficient pulsar-finding machine, revealing energetic pulsars of (almost) all types, young, recycled, radio-loud, radio-quiet, etc.
- Long-term observations will uncover more and likely new classes of pulsars and behaviors …
- Multi-wavelength observations are crucial: radio, soft and hard X-rays, MeV, TeV, etc … the recent addition of FAST to the PSC will have a big impact!

Extra slides

Finding soft gamma-ray pulsars is hard