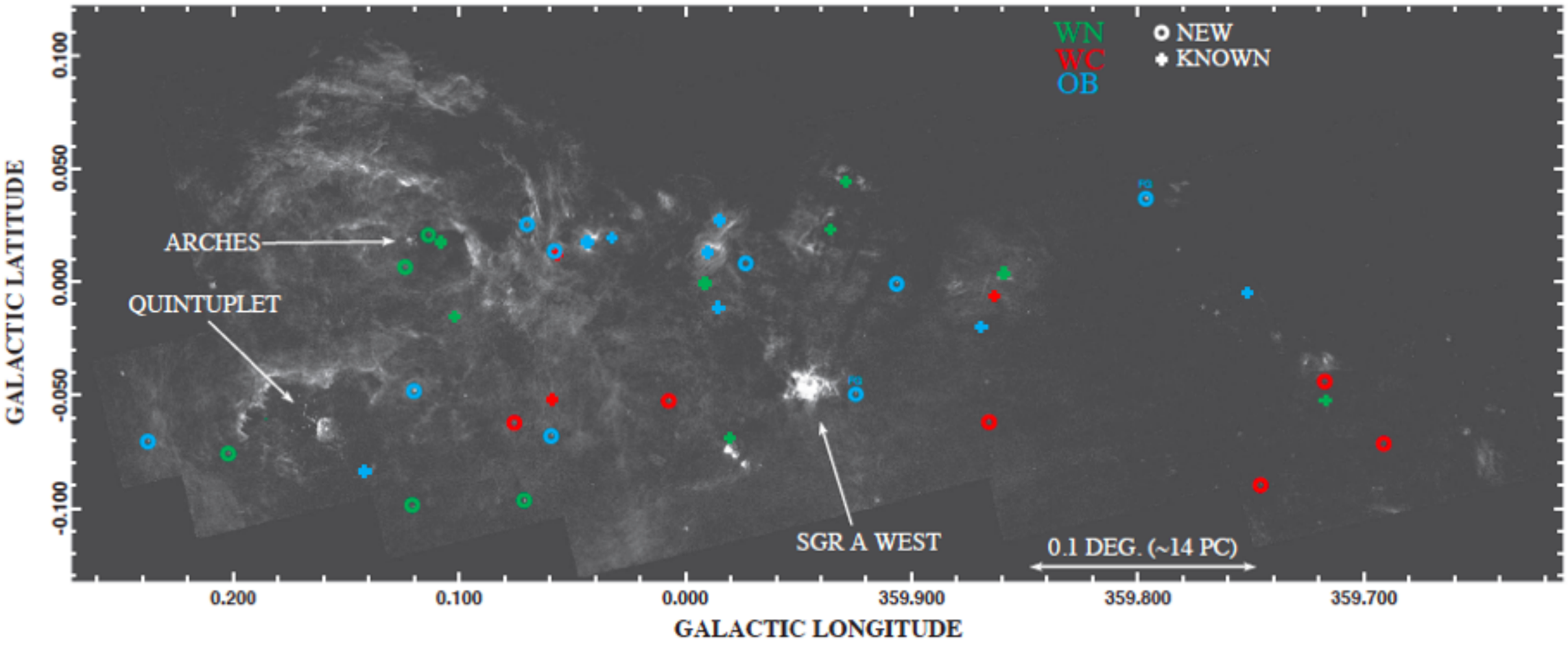
Enhanced Searches for Gamma-ray Pulsars in the Galactic Center Region

Pablo Saz Parkinson (UCSC/HKU),
A. Belfiore, G. Pivato, M. Razzano, A. Vladimirov
on behalf of the Fermi-LAT Collaboration

Fifth International Fermi Symposium
Nagoya, Japan
23 October 2014

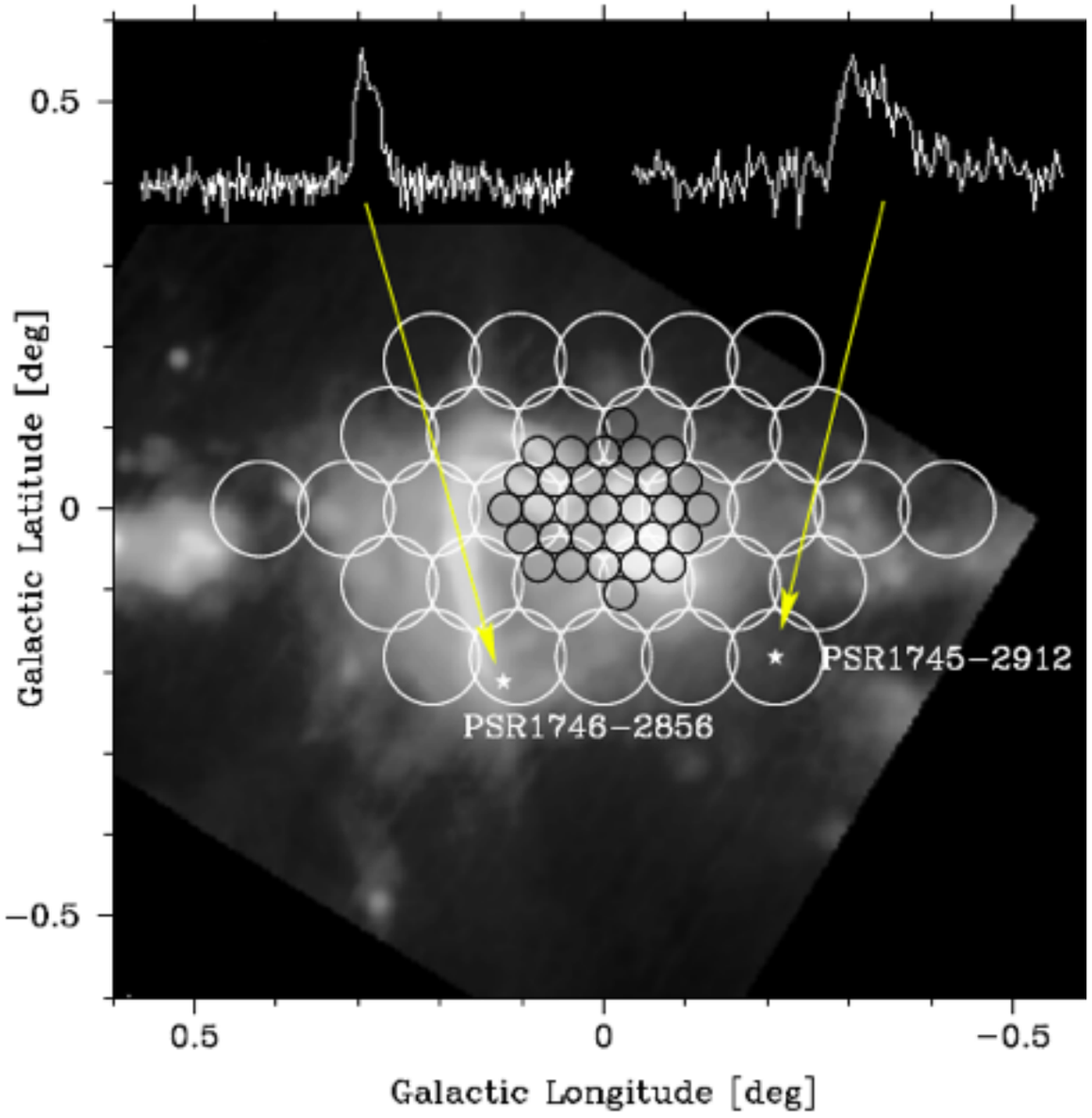
Massive Stars in the Galactic Center region



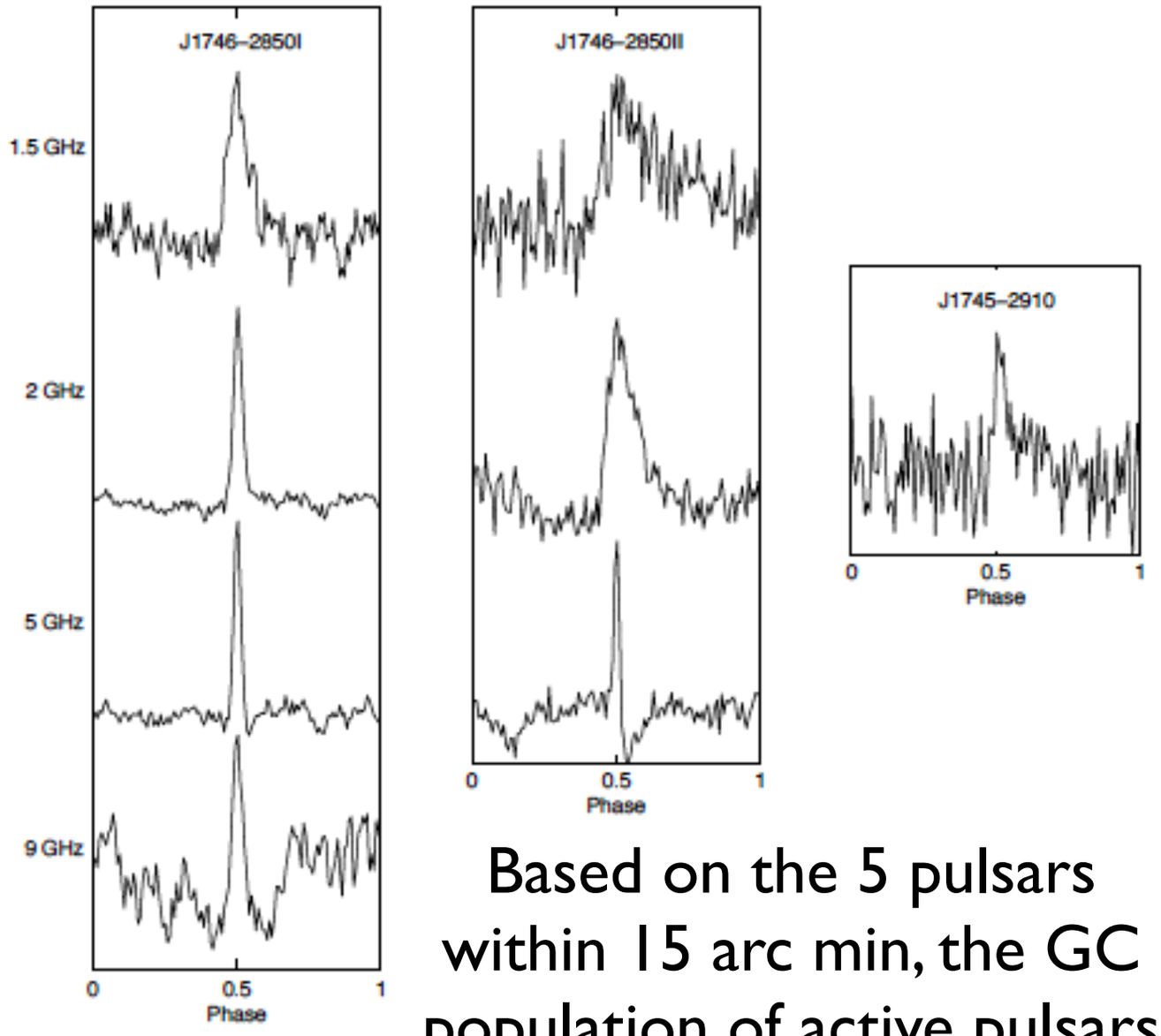
HST/NICMOS Pα survey image of the GCR from Wang et al. (2010)
Figure from Mauerhan et al. 2010

The birth rate of 1.69±0.24 γ-ray PSR/100y is comparable to the Galactic OB star birth rate and core collapse SN rate of 2.3 ± 0.48/100y implying that a large fraction of all B2 and heavier stars produce short birth period neutron stars, that pass through a γ-ray active phase potentially visible to the LAT. (Romani 2011)

The pulsar population of the Galactic Center



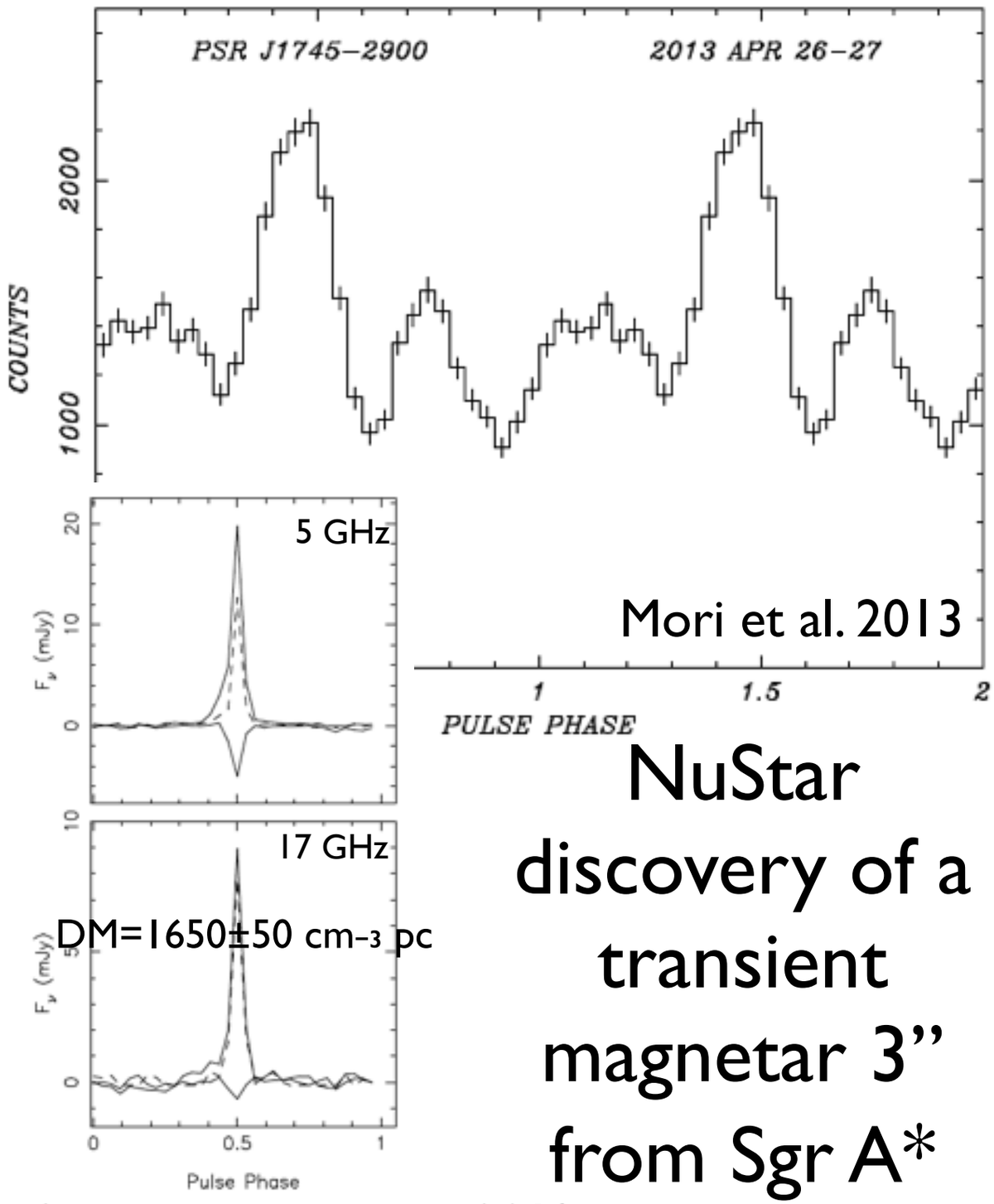
Johnston et al. 2006



Based on the 5 pulsars within 15 arc min, the GC population of active pulsars is estimated to be > 2000

Deneva et al. 2006

The pulsar population of the Galactic Center

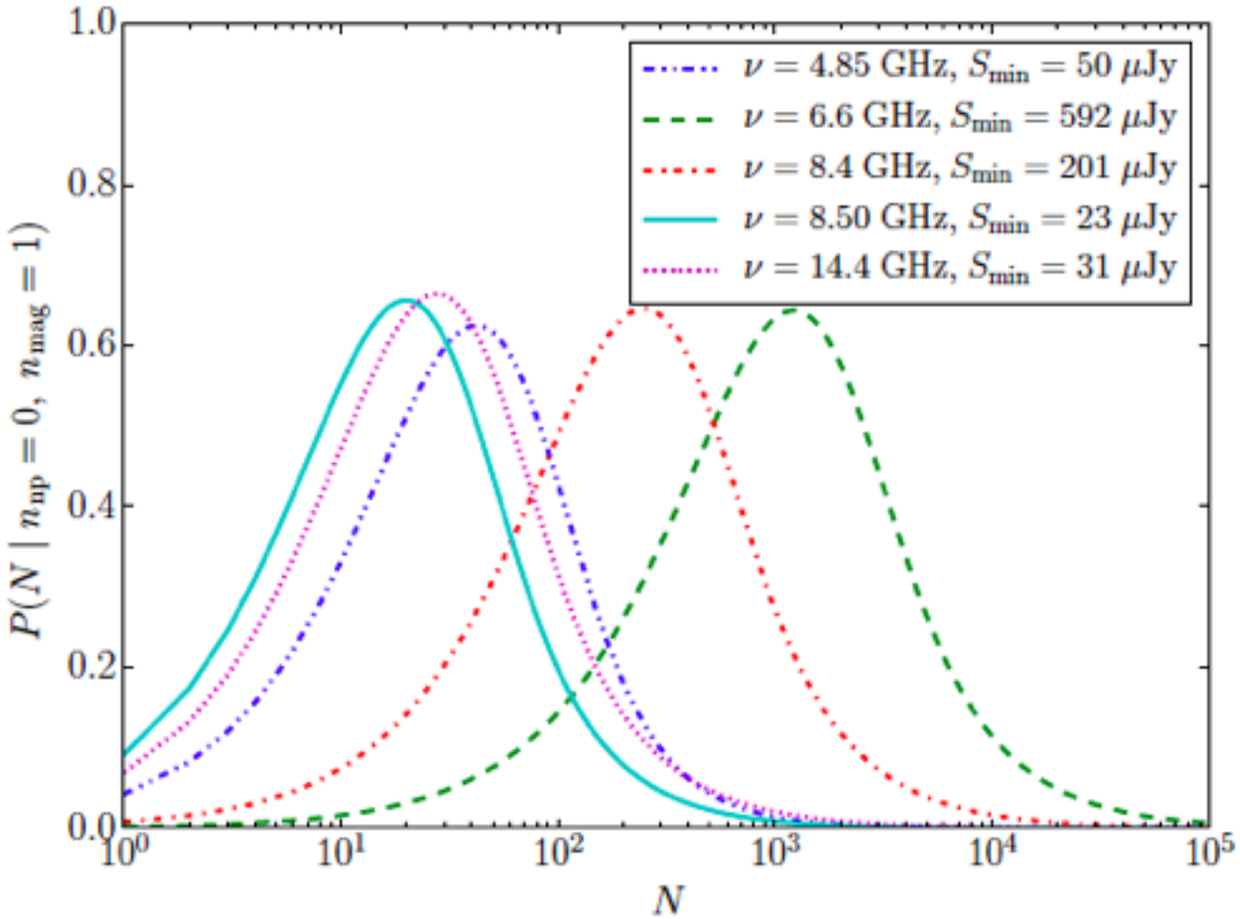


Mori et al. 2013

NuStar discovery of a transient magnetar 3" from Sgr A*

DM=1650±50 cm^{-3} pc

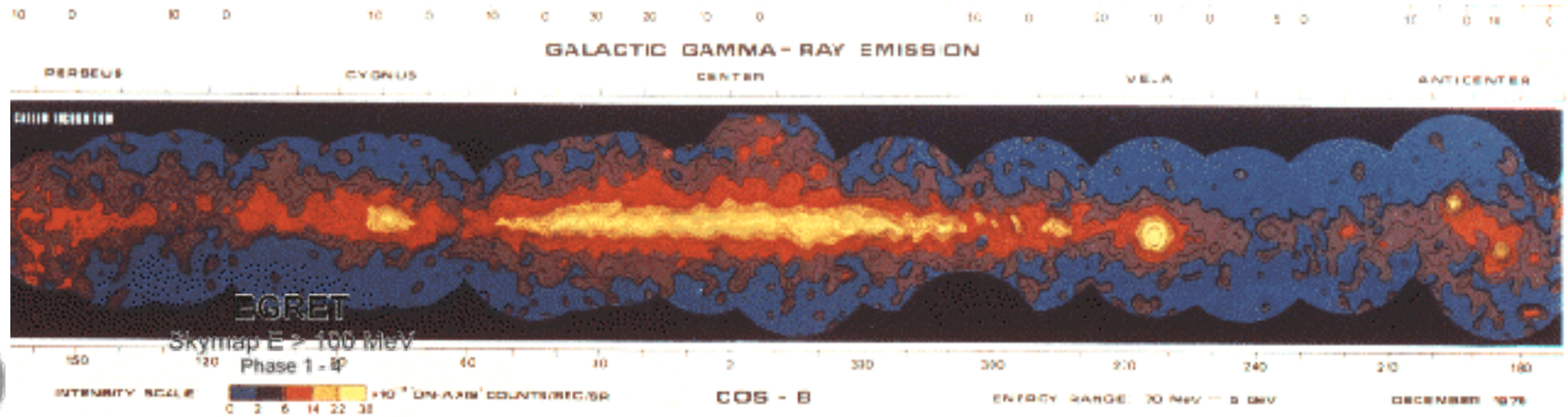
Shannon & Johnston 2013



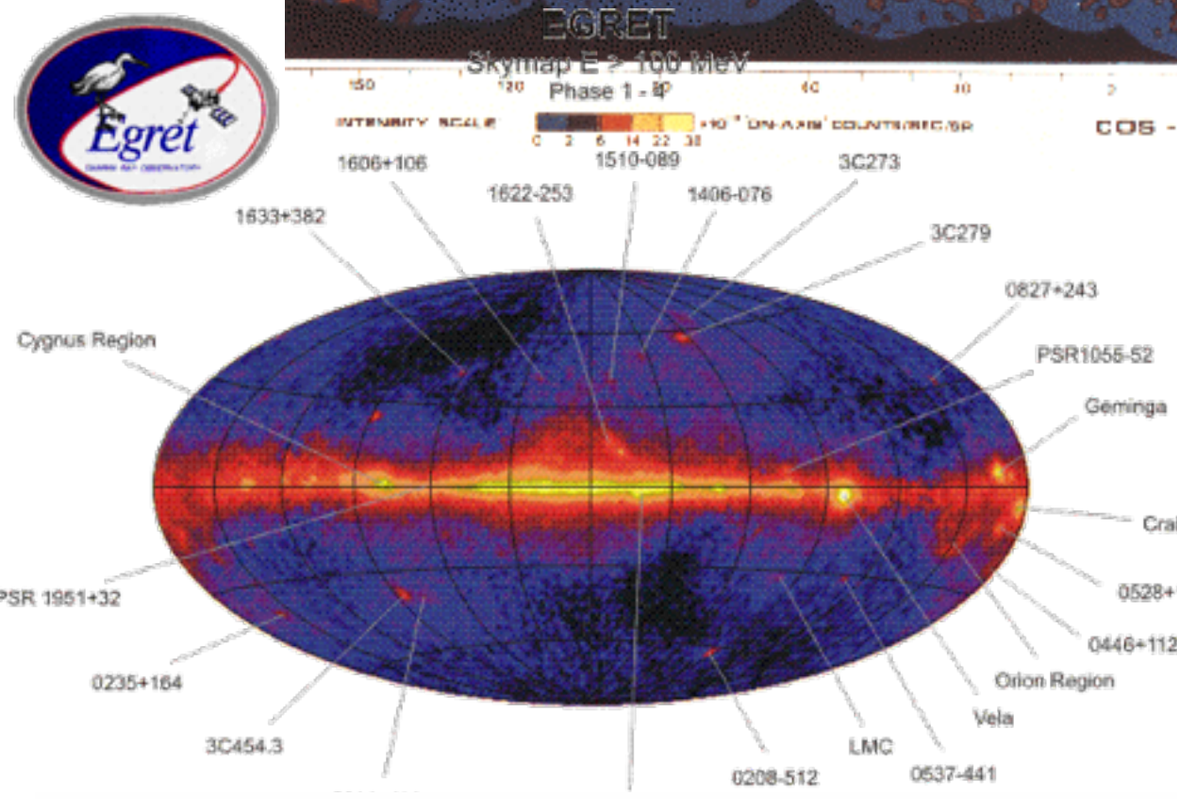
Posterior probability density functions of N for various radio surveys

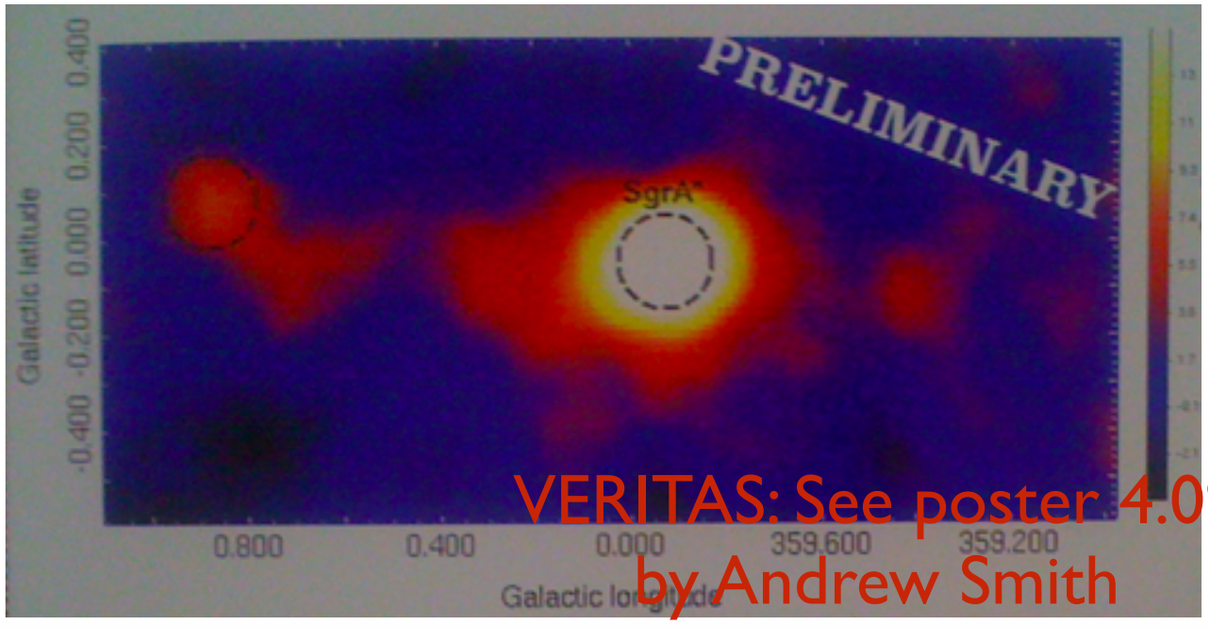
"The potentially observable [*in radio*] population of pulsars in the inner parsec has a conservative upper limit of ~200" (Chennamangalam & Lorimer 2014)

Gamma rays from the Galactic Center

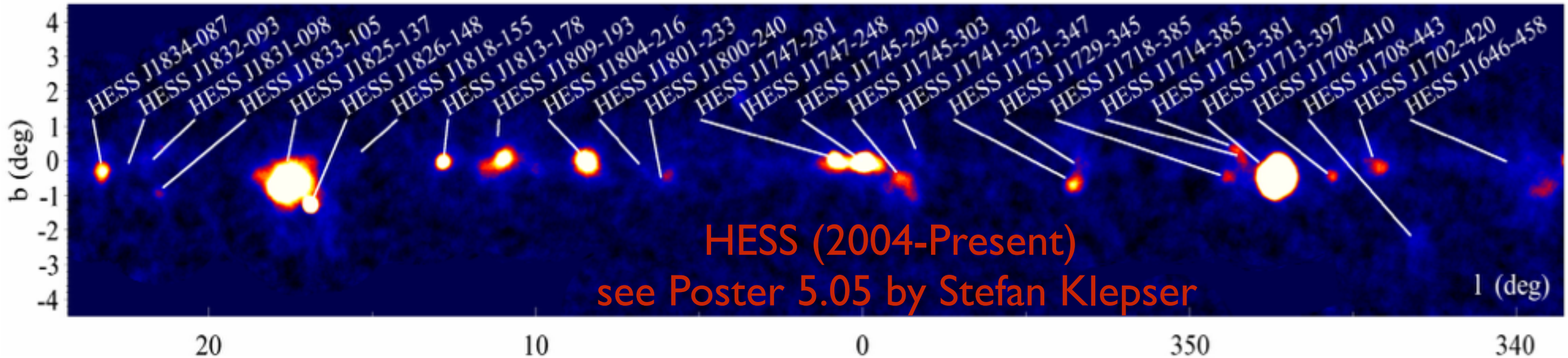


COS-B
(1975-1982)



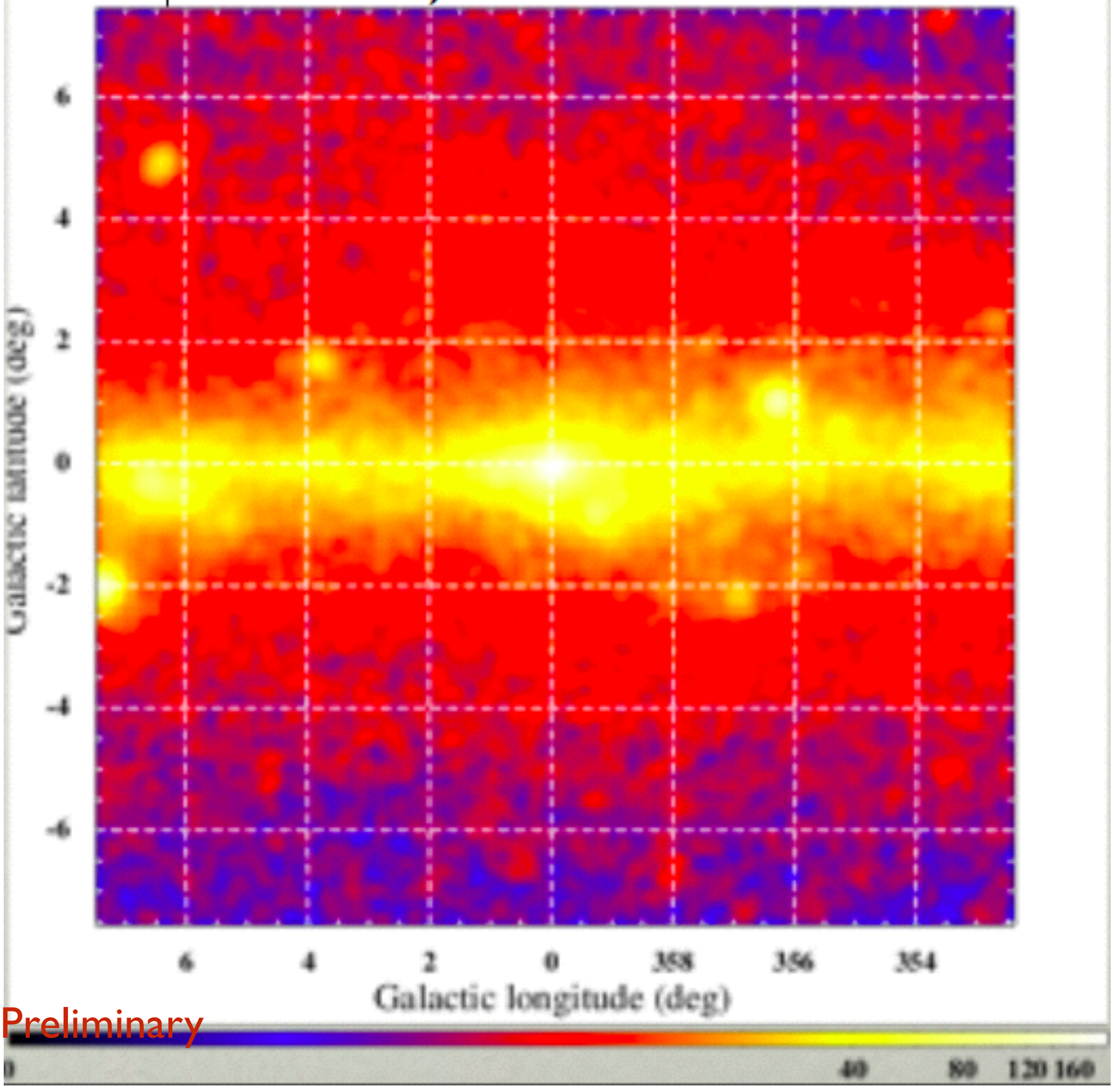


VERITAS: See poster 4.09
by Andrew Smith



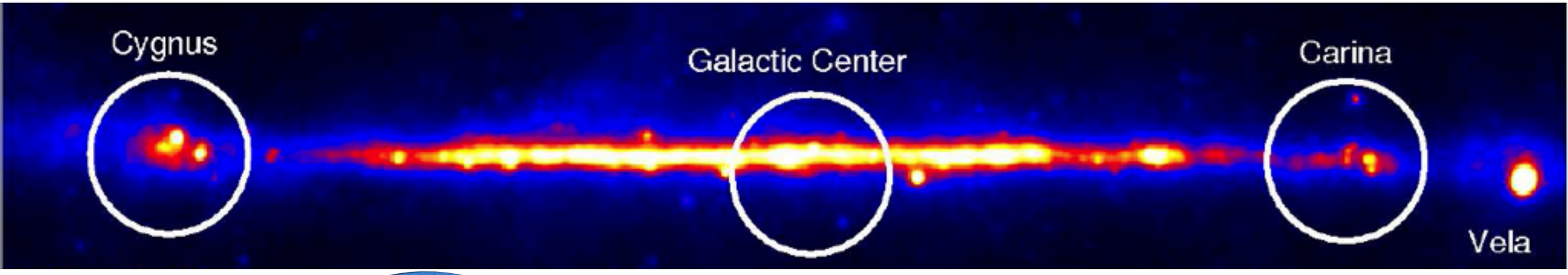
HESS (2004-Present)
see Poster 5.05 by Stefan Klepser

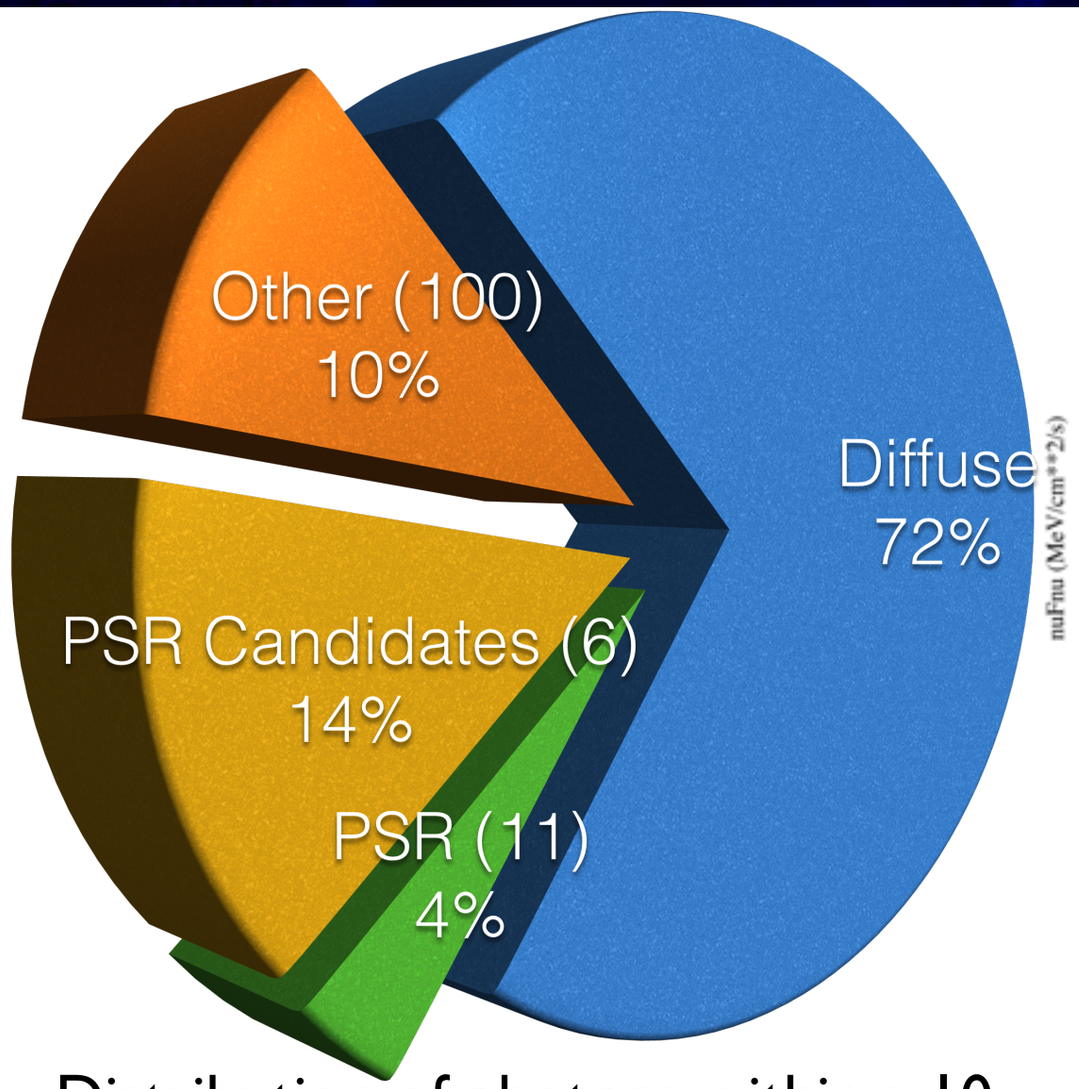
LAT counts, 1-100 GeV



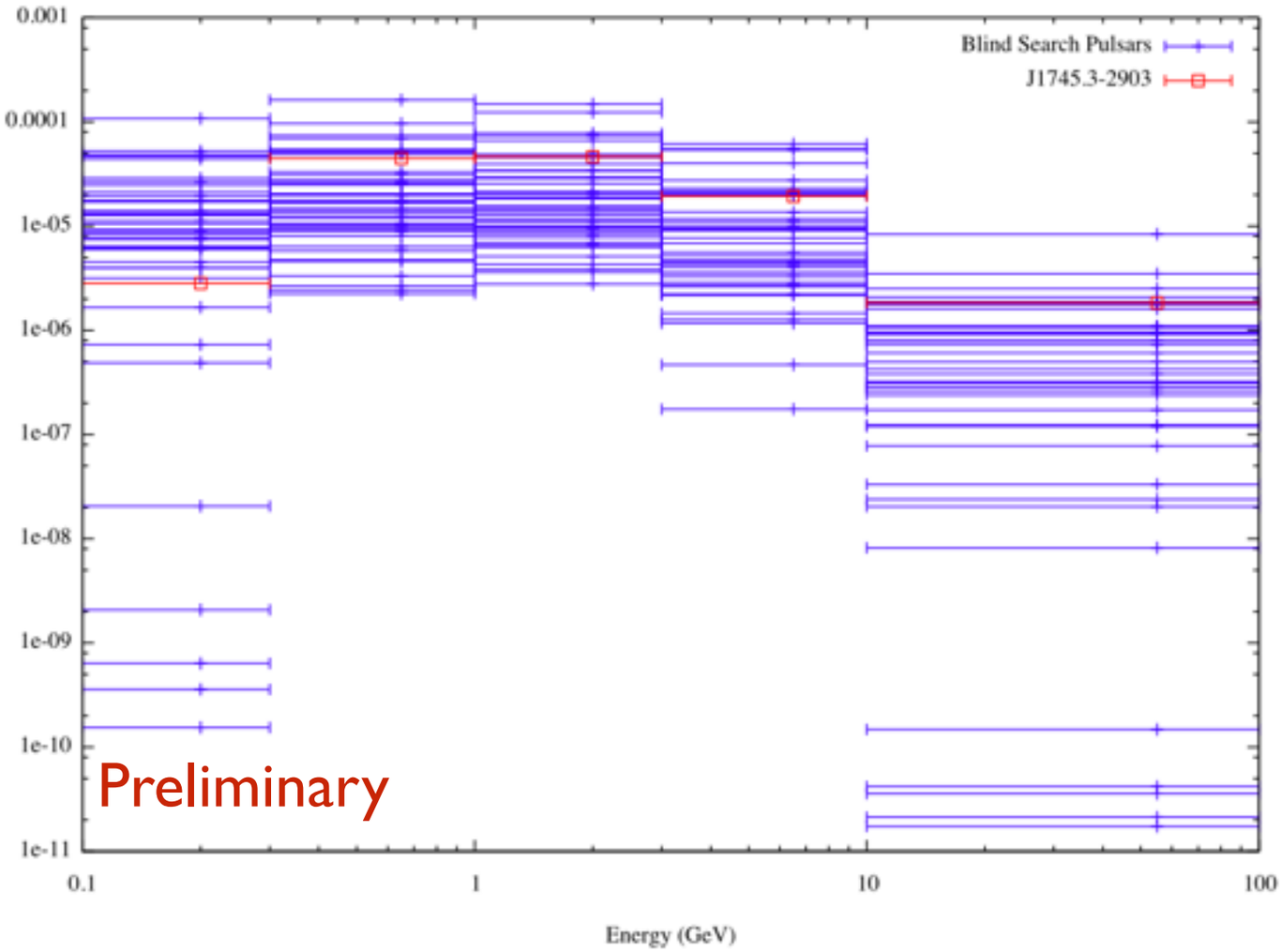
cf. talk by S. Murgia

Fermi events from Galactic Center region

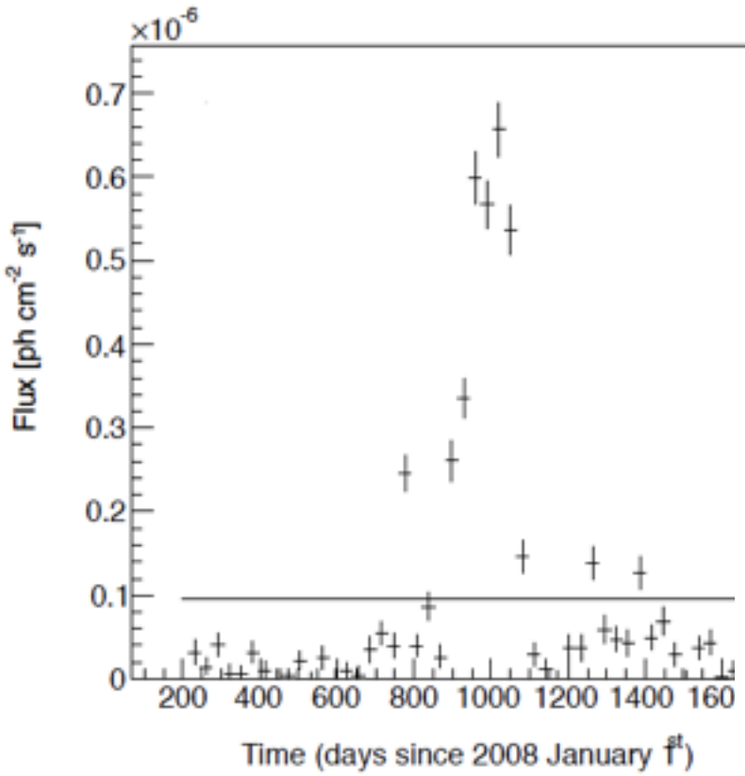


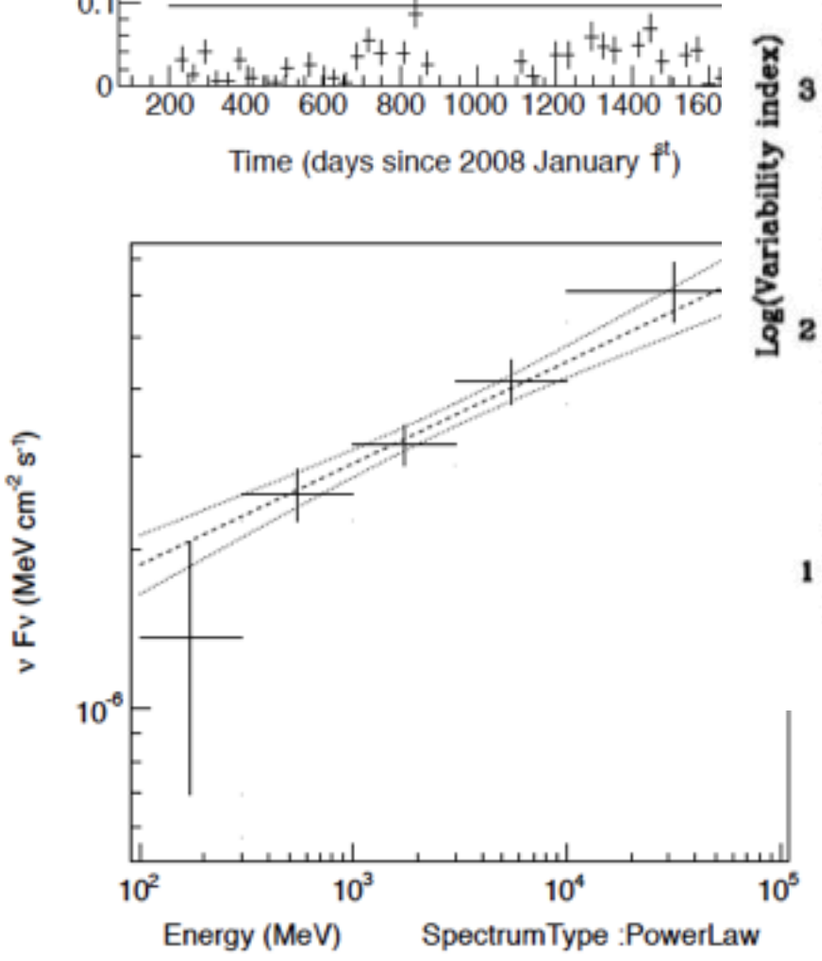


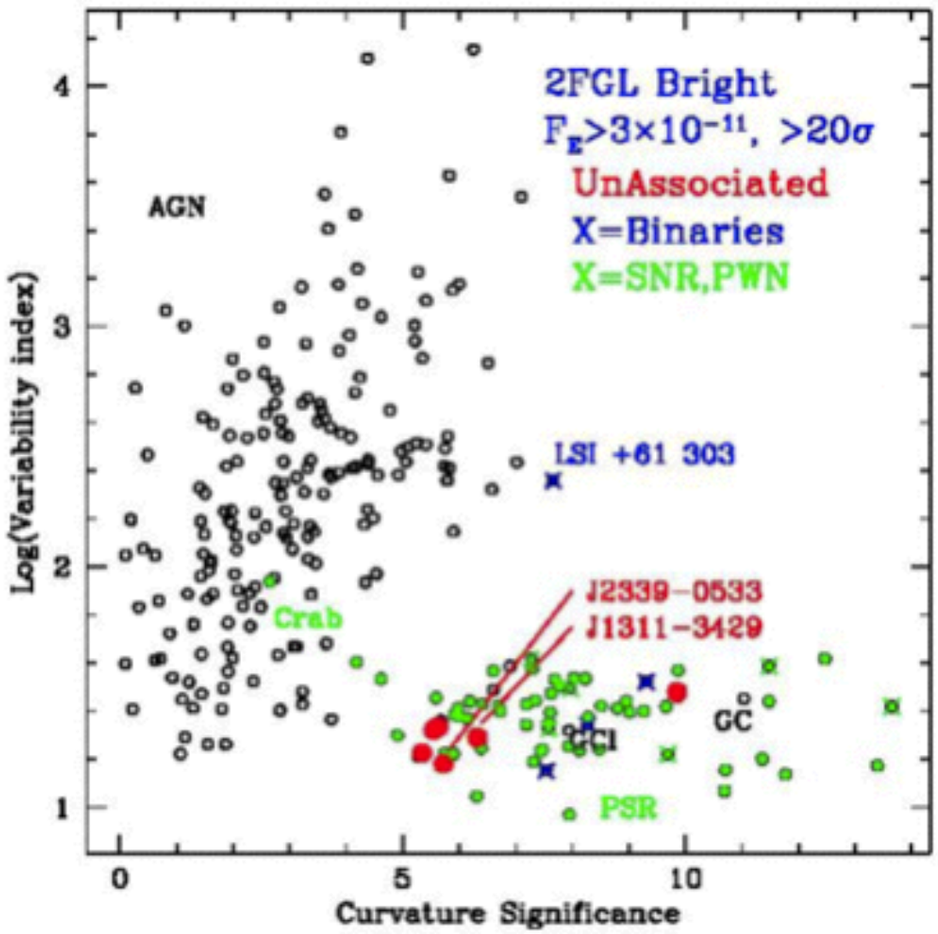
Distribution of photons within a 10 deg. region of the Galactic Center



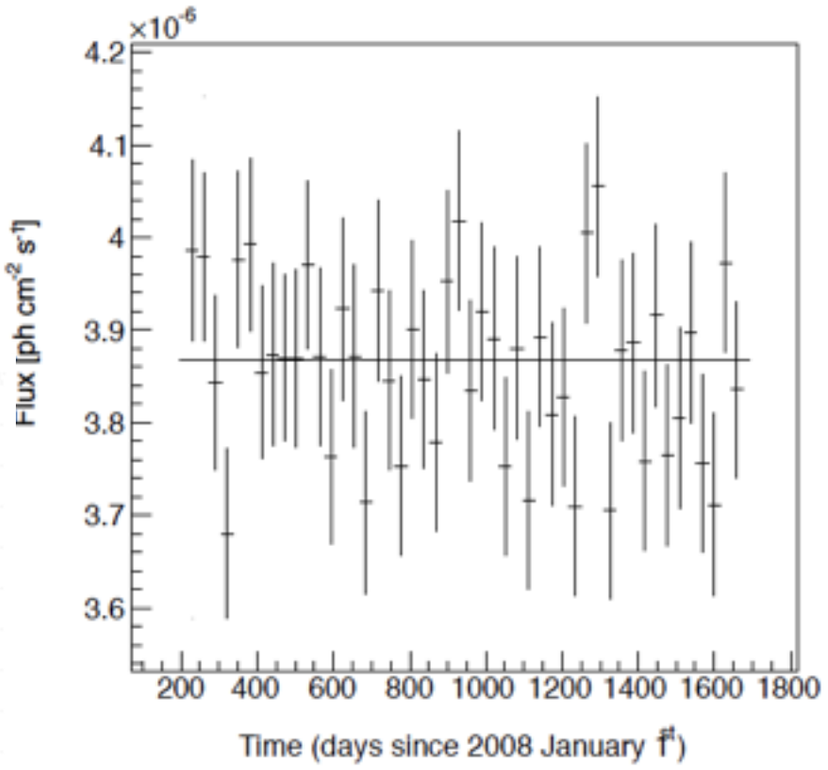
Timing and spectral characteristics of pulsars vs other gamma-ray sources



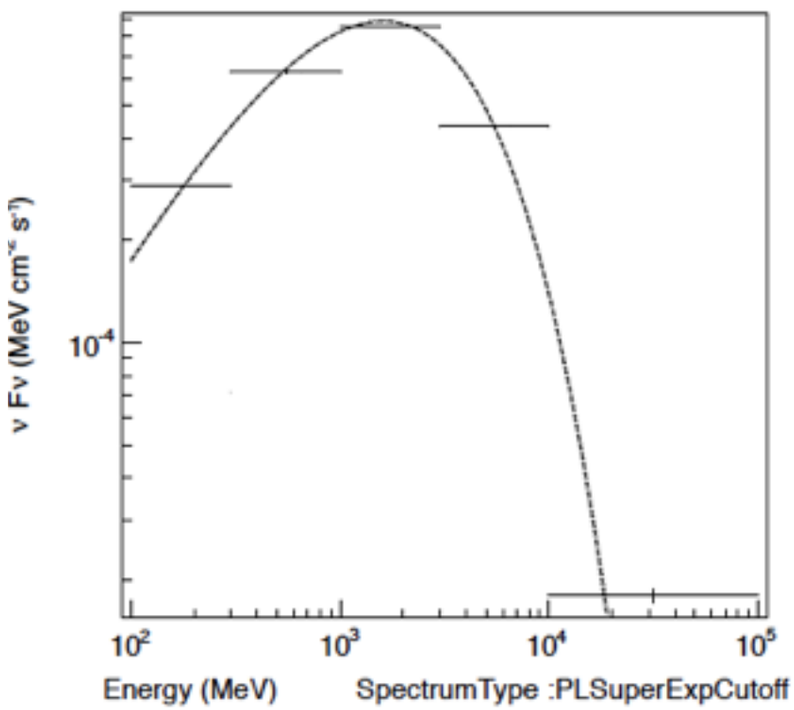




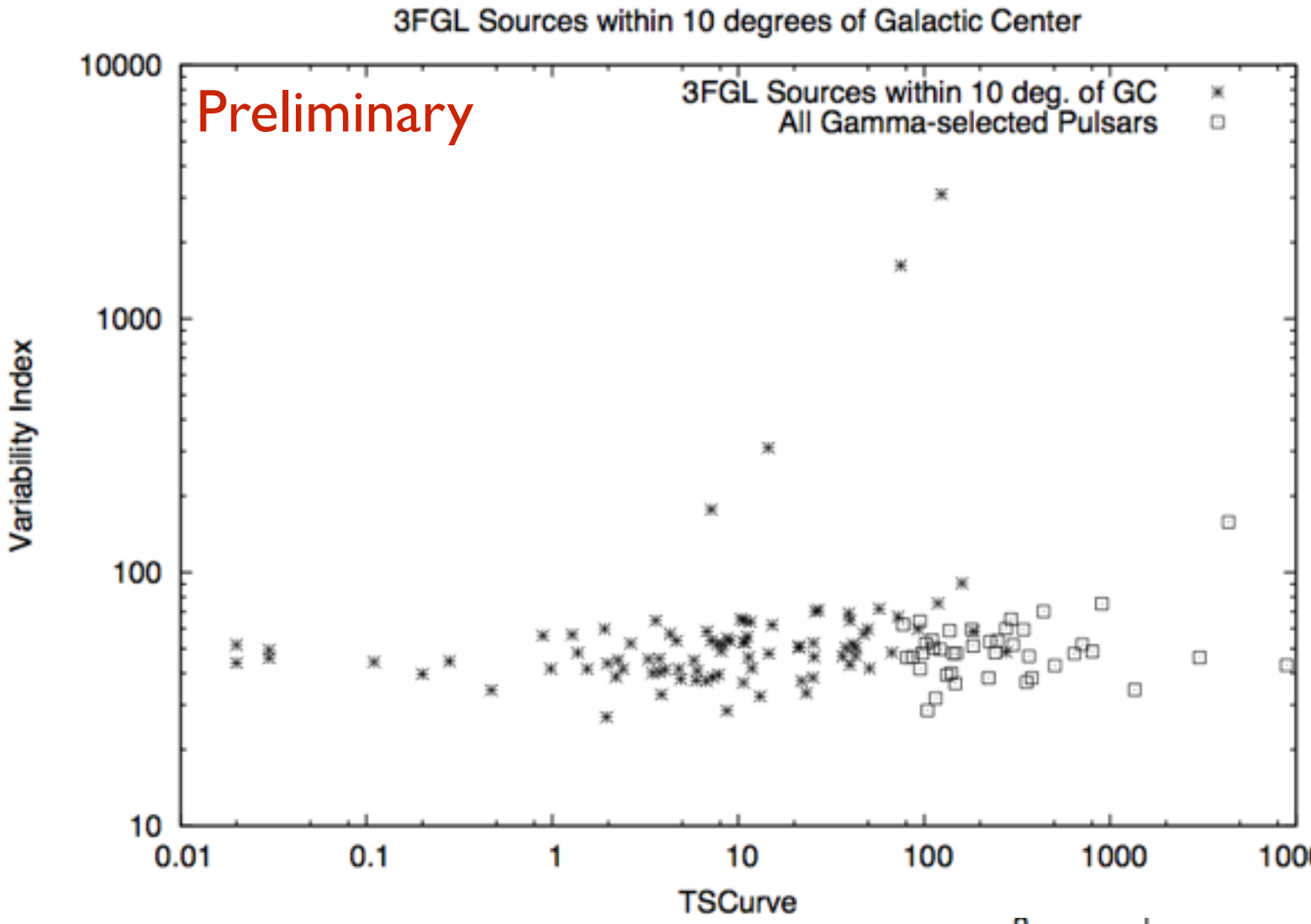
PSRJ0633+1746

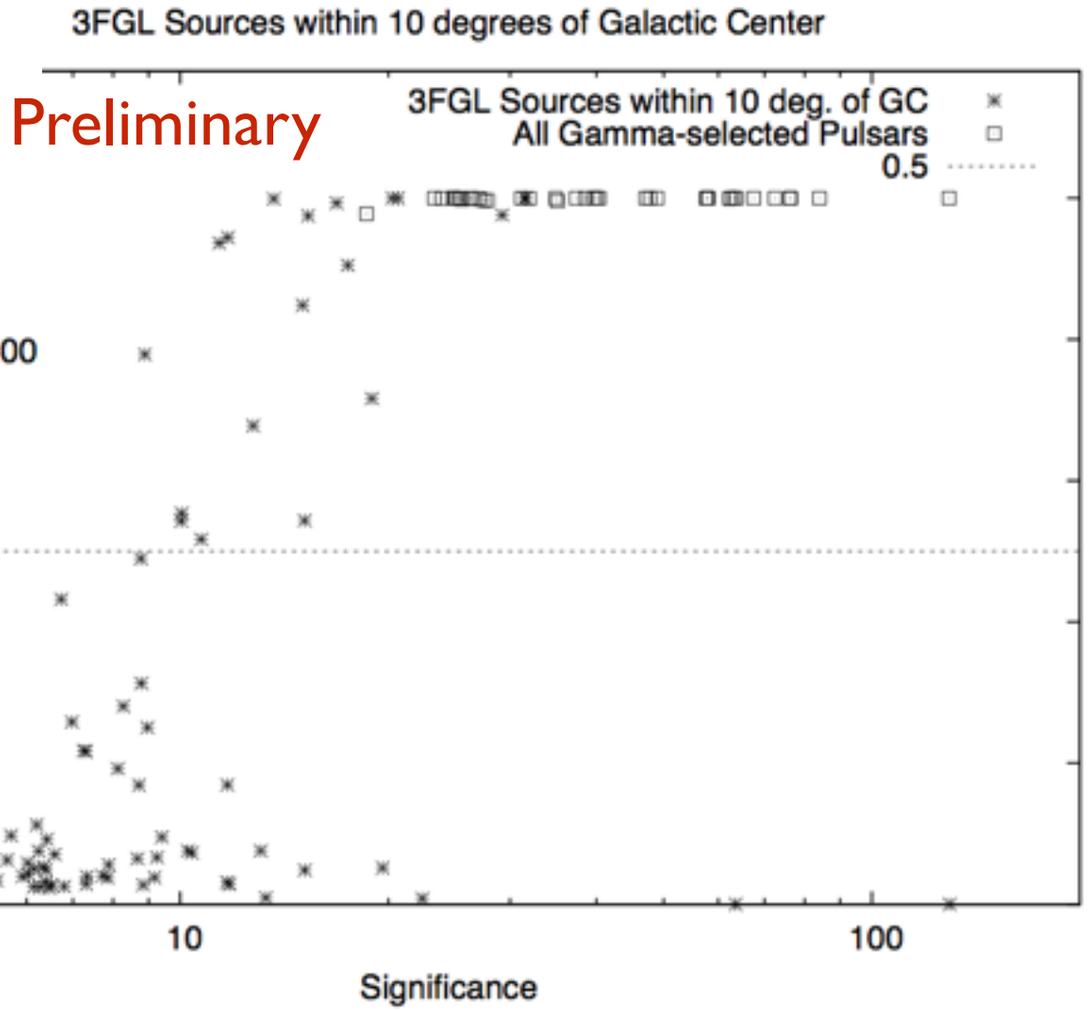


PSRJ0633+1746

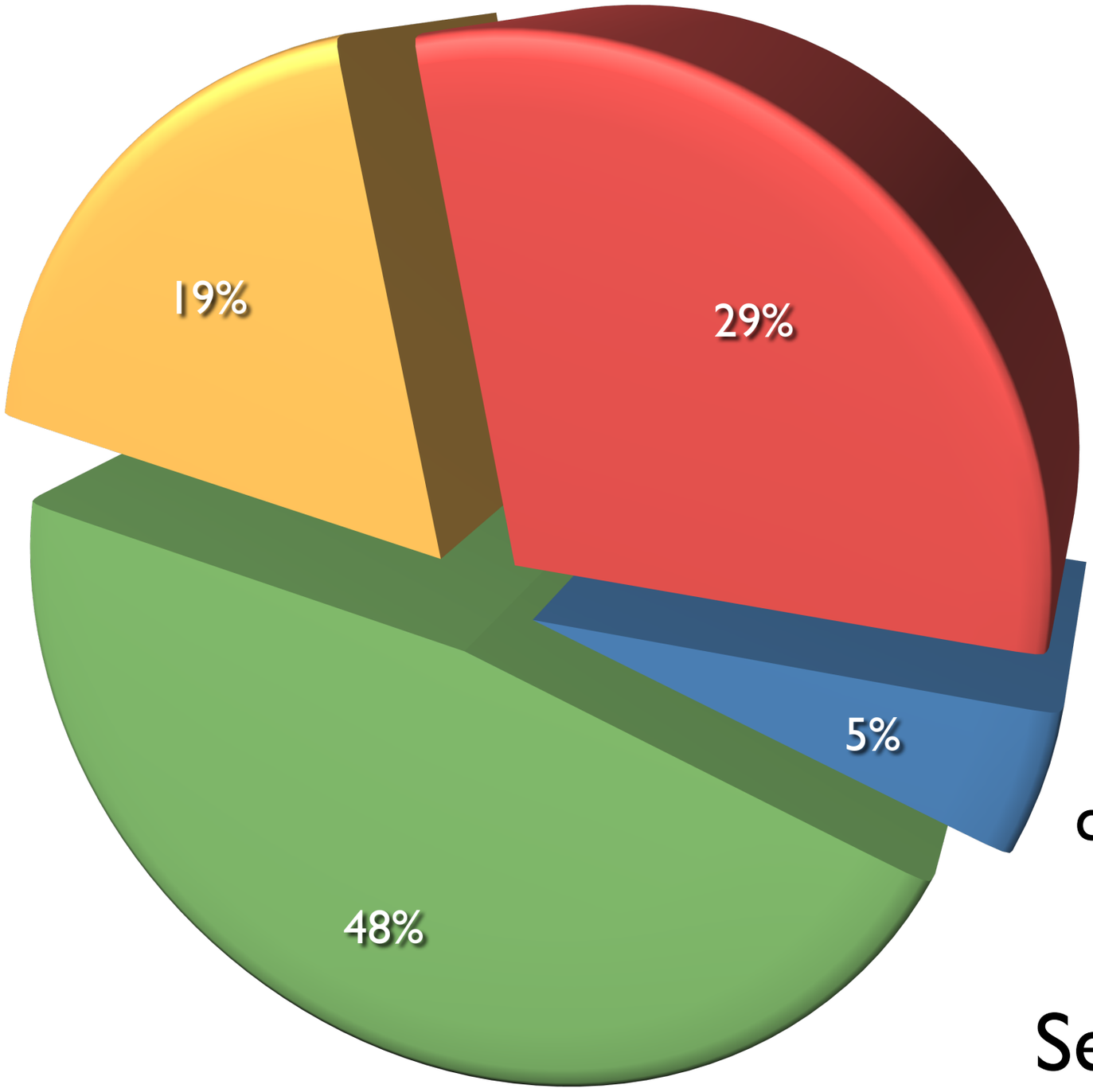


Pulsar Candidates in GC region





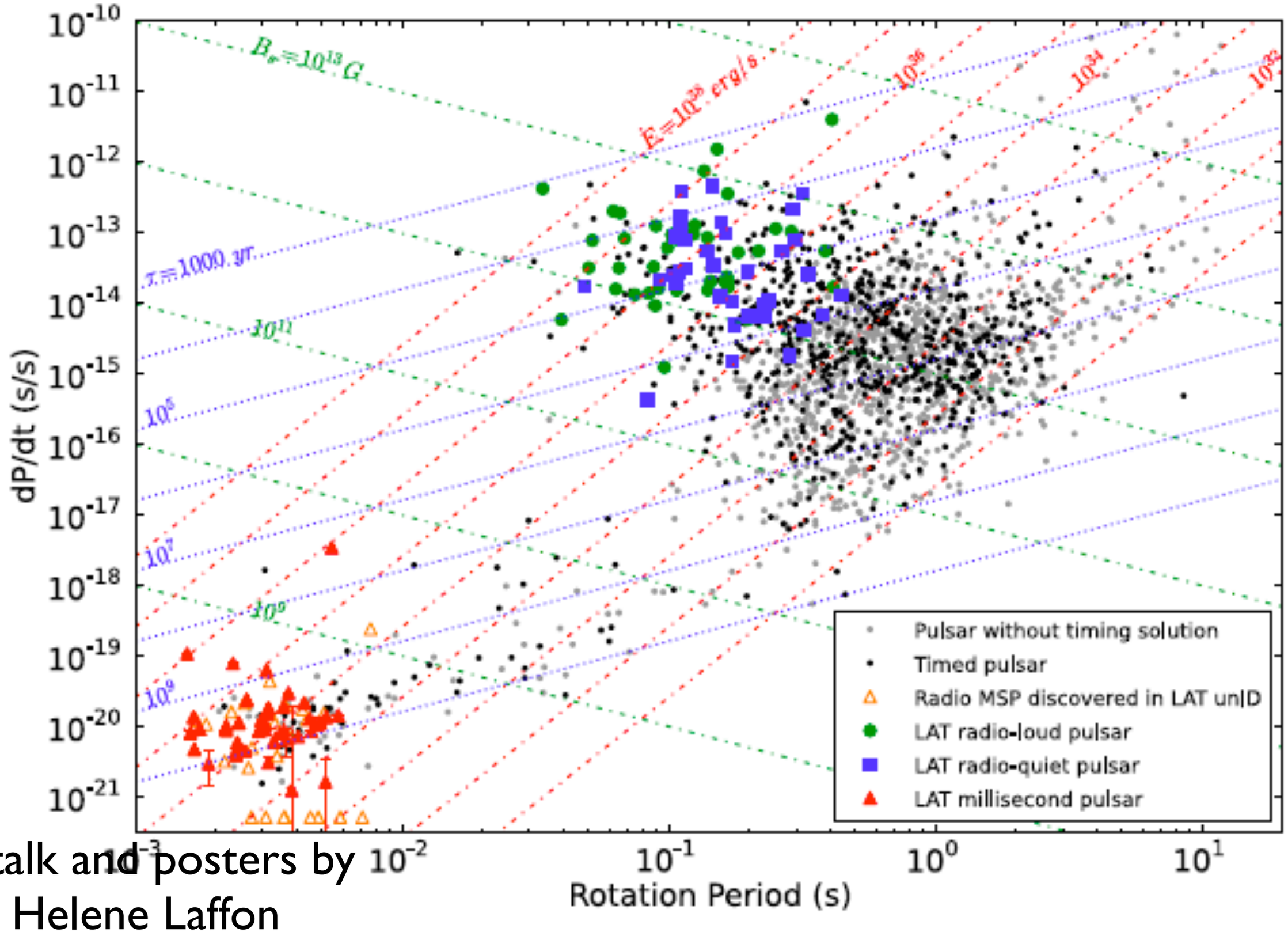
The gamma-ray pulsar pie



cf. talk and posters by Helene Laffon

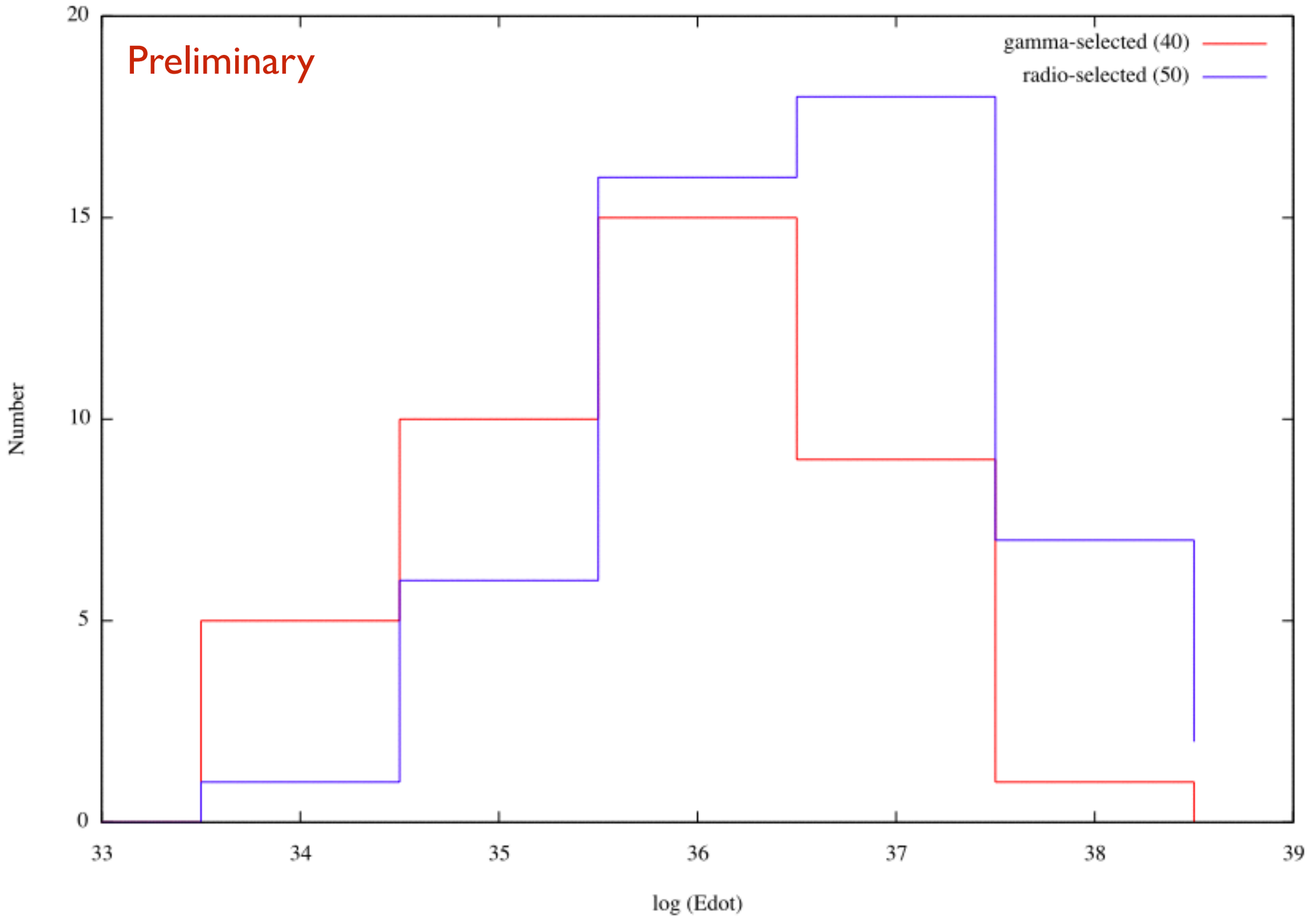
See 2PC:
ApJS, **208**, 17 (Dec 2013)
arXiv:1305.4385

Gamma-ray pulsar population

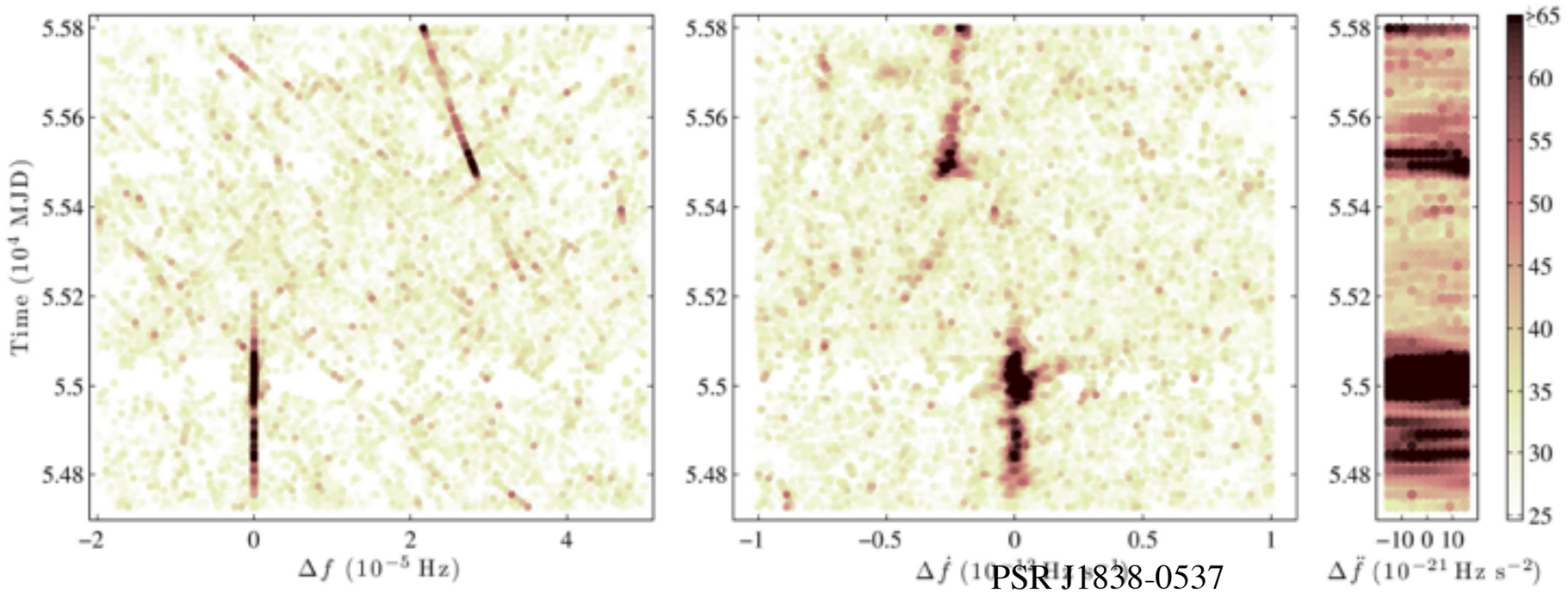


cf. talk and posters by Helene Laffon

Pulsar Detections: Gamma-selected vs Radio-selected



Glitches

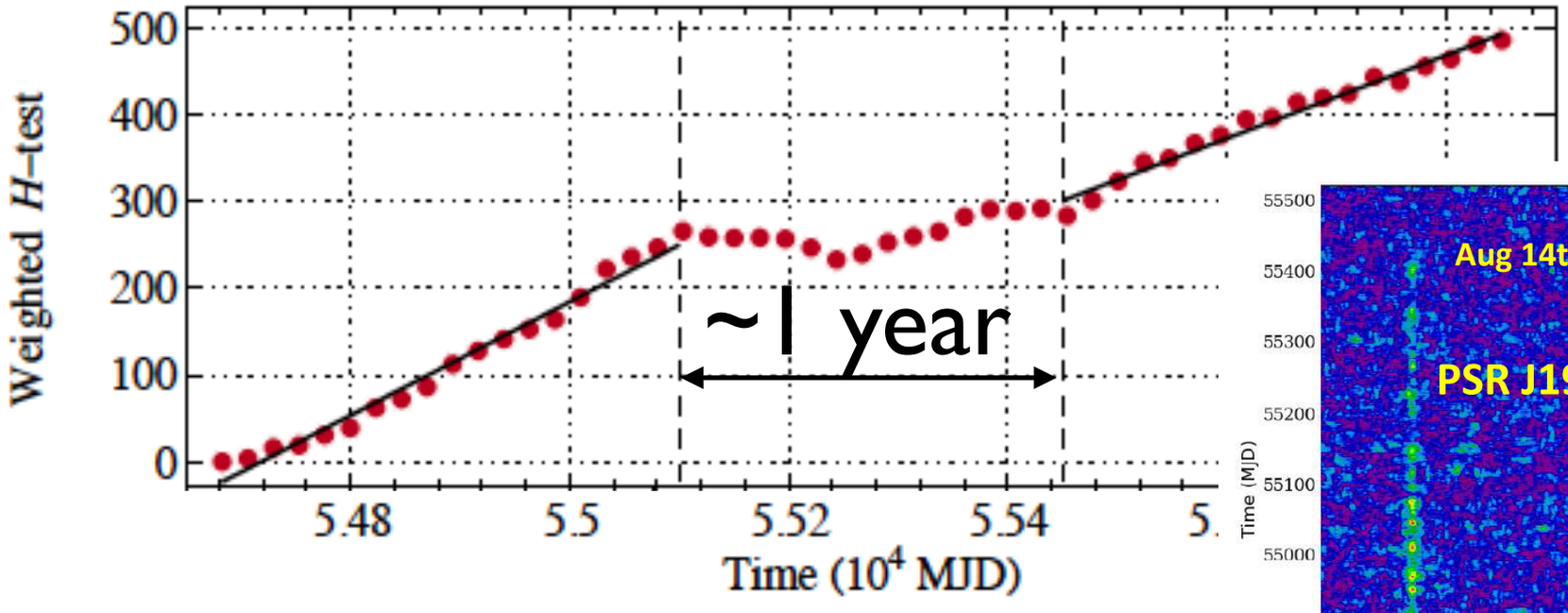


PSR J1838-0537

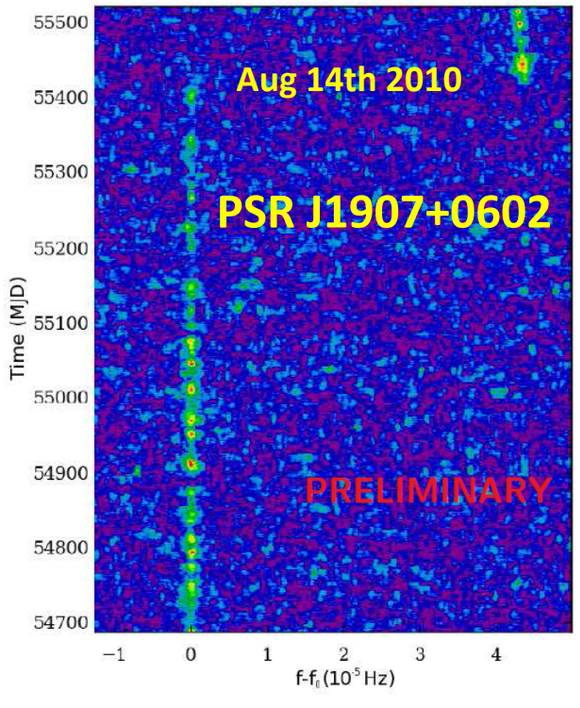
PSR J1838-0537
Edot=5.9E36 erg/s

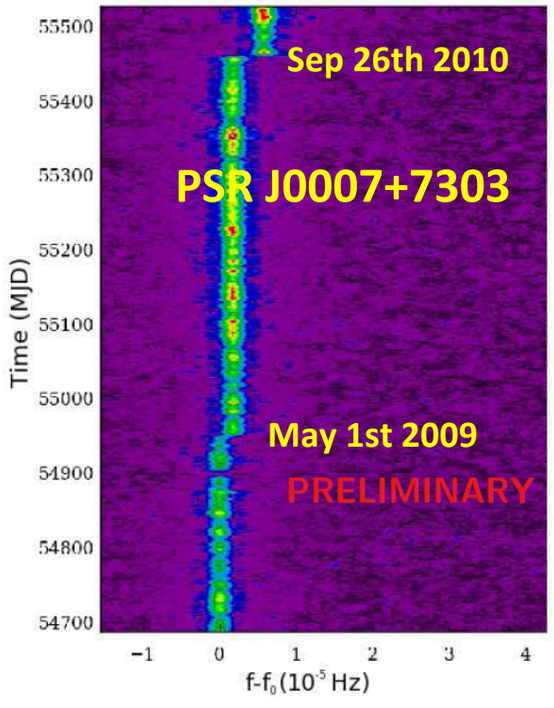
PSR J1907+0602
Edot=2.8E36 erg/s

PSR J0007+7303
Edot=4.5E35 erg/s



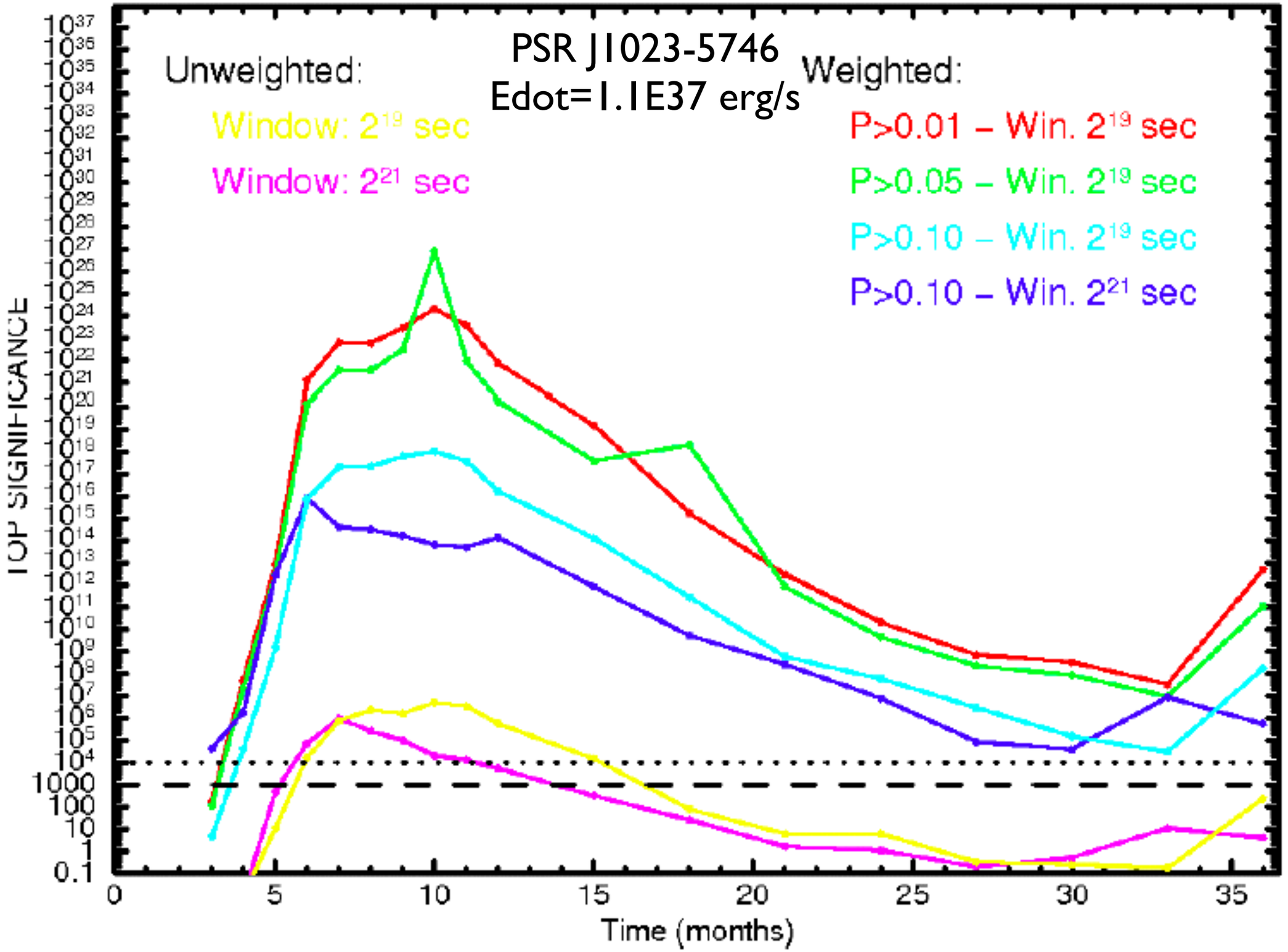
Pletsch et al., ApJ **755**, 20 (2012)



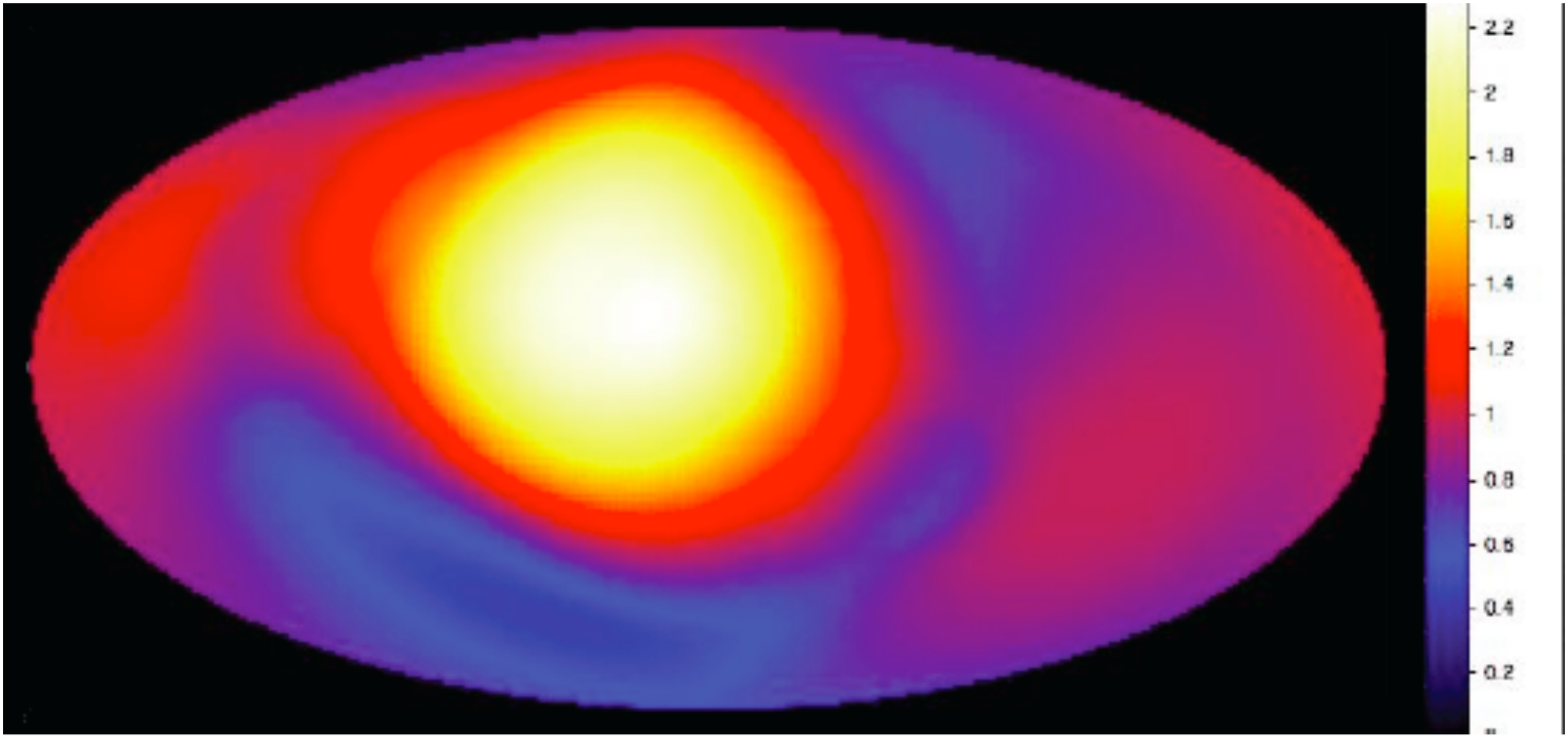


Timing Noise

Top Significance (1st Harmonic) Evolution for PSR J1023–5746

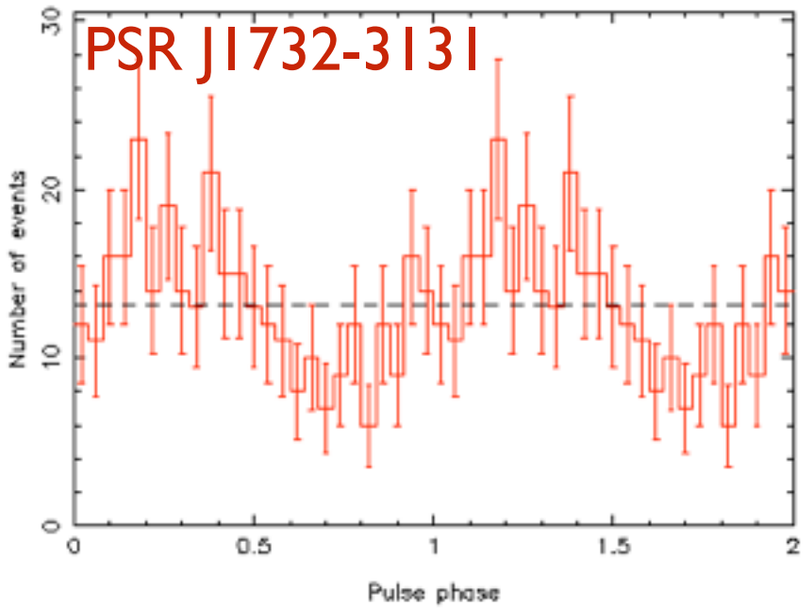


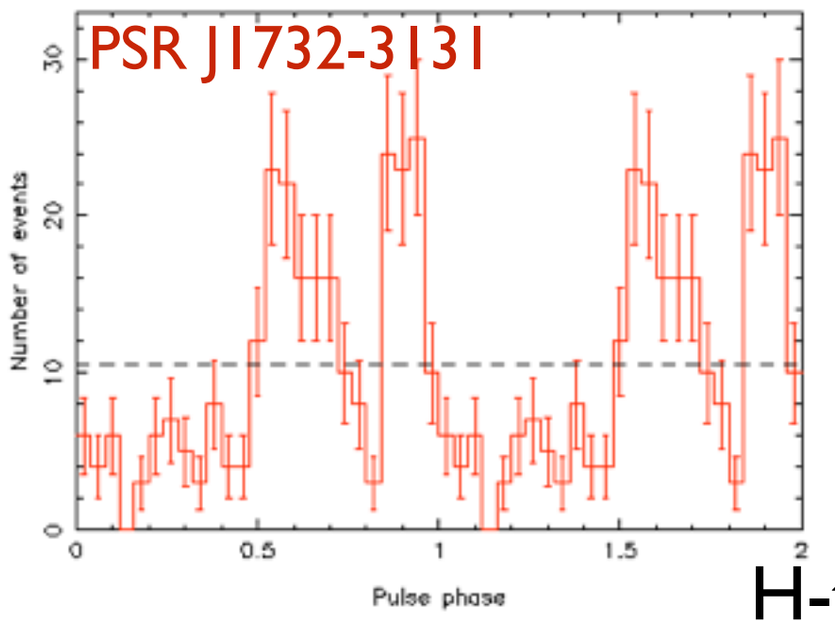
Modified observing strategy (Dec 2013 - Present)



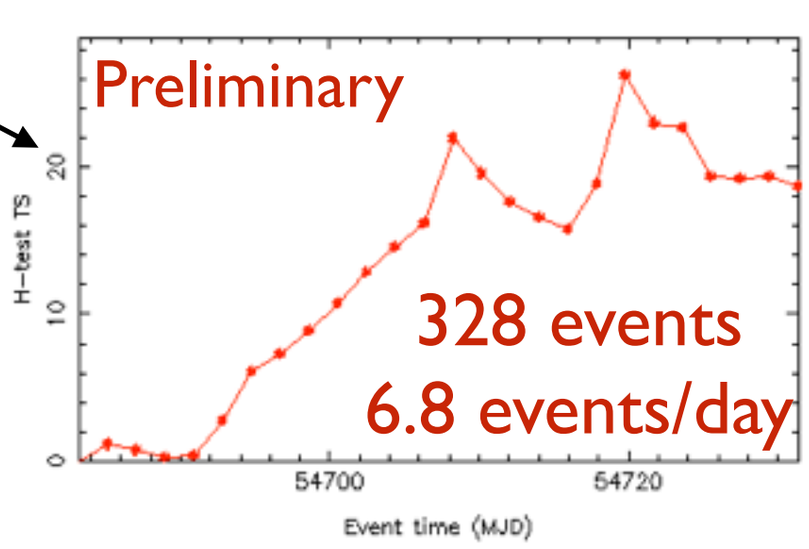
Ratio of exposure to "standard" survey exposure

7(3) weeks of Survey (Pointed)

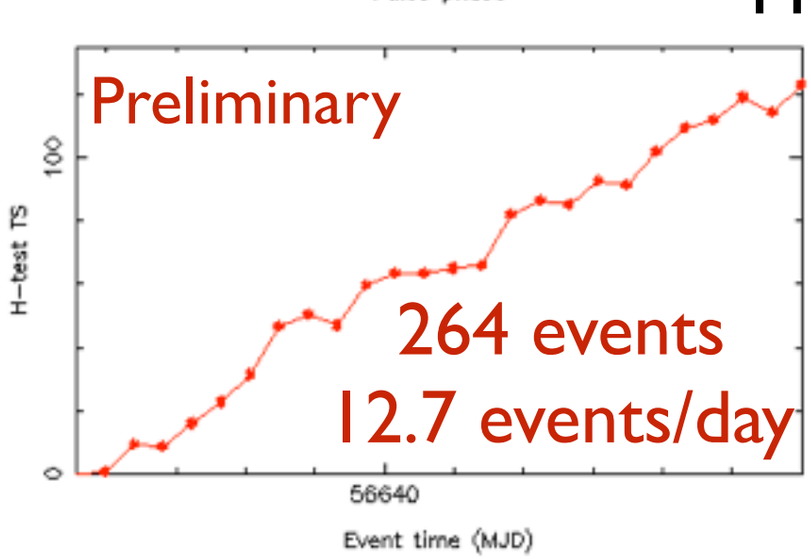




H-test TS=20



H-test TS=120



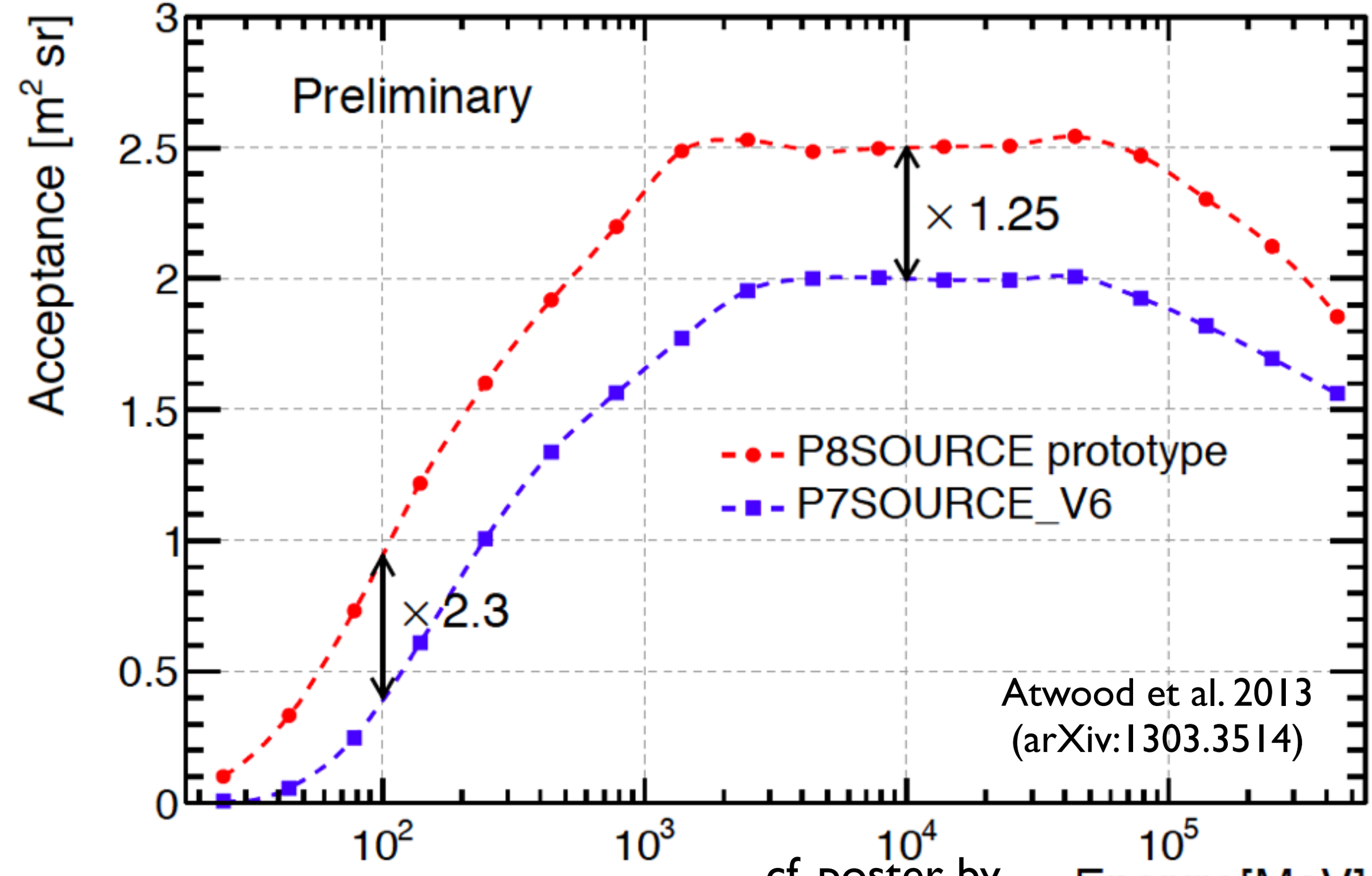
7-week survey search: The best pulsar candidate is:
F0=5.08795547 F1=-7.482e-13 P-Value=5.84e-02

3-week pointed mode search: Best pulsar parameters
F0=5.08783340 F1=-6.753e-13 P-Value=2.37e-08

Pulsars around the GC

- Can we detect gamma-ray pulsars that far?
  - PSR J1823-3021A in NGC 6624 at 8.4±0.6 kpc
  - PSR J0540-6919 in LMC at ~50 kpc (cf. talk by P. Martin)
  - Crab at 8x distance = flux of faintest Blind Search Pulsar
- Detailed diffuse model should improve event selection/ weighting (cf. talk by S. Murgia)
- Multi-wavelength observations can improve sensitivity
- The modified observing profile increases the exposure in the GC region by ~2

Fermi improvements: Pass 8



cf. P. Bruel's talk

cf. poster by Helene Laffon

Detected P8 Events (per day)

Source	Epoch 1 (85 d) 9/11/13-12/05/14	Epoch 2 (49 d) 12/05/14-01/23/14	Epoch 3 (85 d) 02/05/14-04/30-14
PSR J1809-2332	4,009 (47.2)	3,745 (76.4)	6,285 (73.9)
PSR J1741-2054	1,043 (12.3)	1,058 (21.6)	1,697 (20.0)
PSR J1746-3240	792 (9.3)	666 (13.6)	1,084 (12.8)
PSR J1803-2149	674 (7.9)	649 (13.3)	1,082 (12.7)
PSR J1732-3131	640 (7.5)	537 (11.0)	894 (10.5)
3FGL J1745.3-2903	4,942 (58.1)	4268 (87.1)	6,996 (82.3)

Summary

- The Galactic Center region is a bright but complex source of gamma-ray emission whose origin is unclear
- Pulsars are among the prime candidate sources
- A number of recent developments/improvements are enabling much more sensitive gamma-ray pulsar searches
  - A modified observing strategy (more exposure)
  - Pass 8 (more reconstructed events, lower E)
  - 3FGL (more and better characterised catalog sources)
- Searches for pulsars are ongoing …
- Future improvements: Use of new diffuse models, more data (Pass 8, modified observing)