Fermi observations of γ-ray pulsars

Pablo M. Saz Parkinson

Santa Cruz Institute for Particle Physics (University of California)

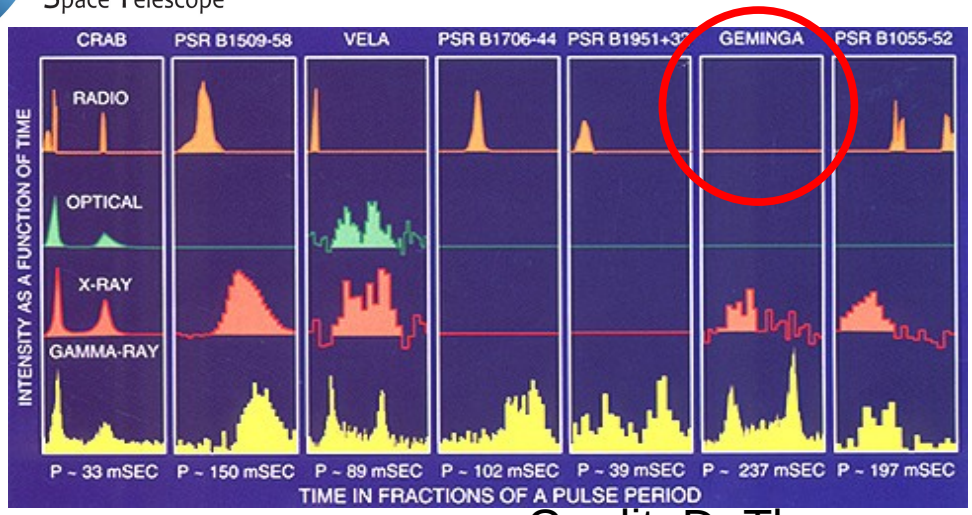
for the Fermi-LAT Collaboration

The Fermi (formerly GLAST) LAT

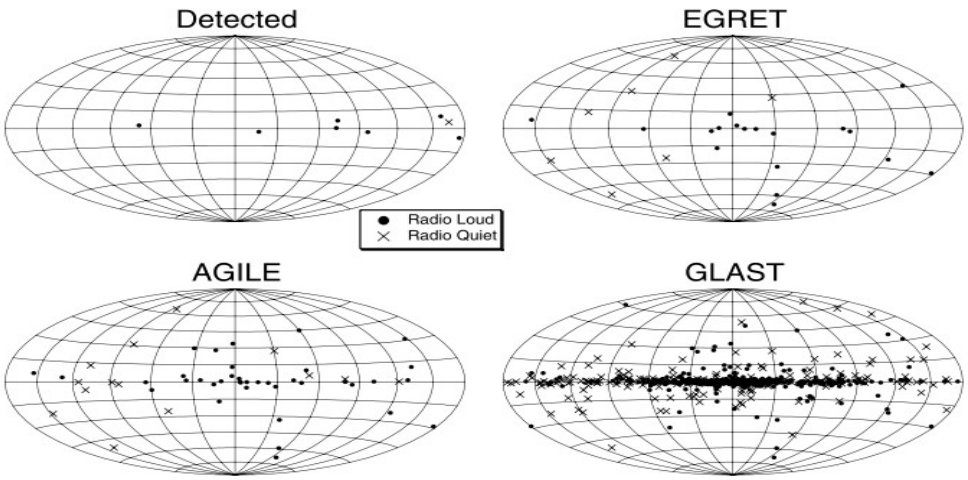
- 20 MeV – 300 GeV
- 2.5 sr FOV
- All-sky every 3 hours
- ~ 25 times EGRET sensitivity
- Angular resolution:
  ~3-6 deg. @ 100 MeV
  ~0.1-0.2 deg. @ 10 GeV
- Many science targets:
  e.g. AGN, Dark Matter, GRB, Pulsars ...

  (NB: in alphabetical order)

Gamma-ray pulsars



Credit: D. Thompson

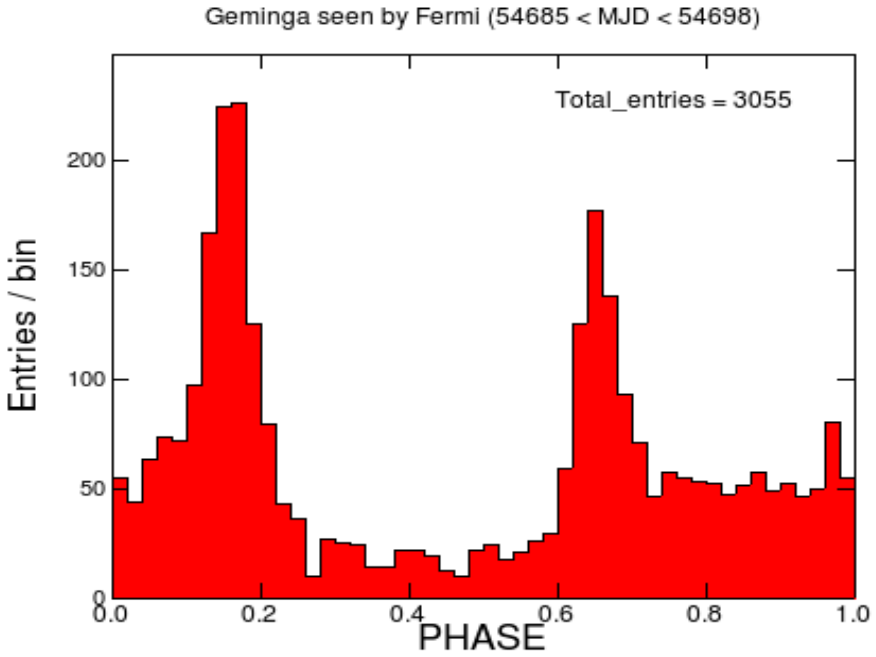


Gonthier, Van Guilder, & Harding (2004)

- Number gamma-ray pulsars pre-Fermi= 7 (6 by EGRET)
- Number of “Gemingas” = 1 (Geminga)
- The “Geminga fraction” can tell us about the different mechanisms responsible for radio and gamma-ray pulsations

Fermi searches for γ-ray pulsars

- Two types of searches for γ-ray pulsars
  - Using known ephemerides of radio/X-ray pulsars
  - "Blind" searches for Geminga-type pulsars



Folded light curve of Geminga using 13 days of "Survey" data

Searches for known pulsars

- Pulsars being timed by a large collaboration of radio and X-ray astronomers and the Fermi-LAT team
- Number of pulsars on the list is large (and increasing)
- Coordinator: David Smith (CENBG, France)
- See M. Razzano talk on Vela pulsar

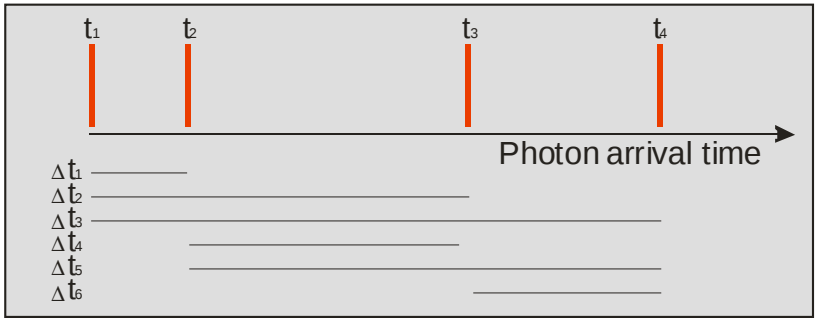
Search for unknown pulsars

- Spin parameters (F0,F1,F2) unknown
- Locations used are from promising “Geminga candidates” and from the LAT catalog
- The low event rates and long observation periods make traditional FFT search techniques prohibitively expensive computationally
- An efficient time-differencing technique makes it feasible to search a large number of pulsar candidates

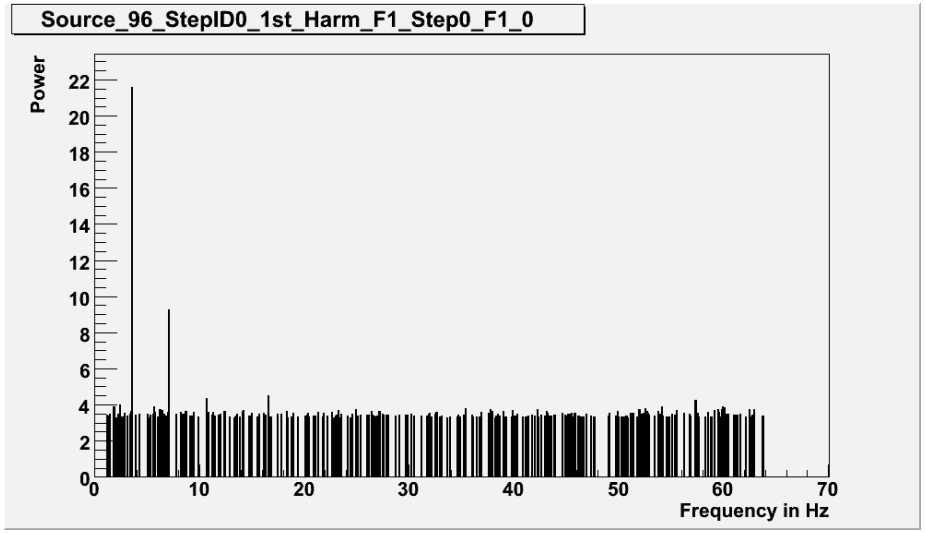
Time Differencing Technique

A Periodic signal will also show up in the differences of the arrival times => Calculate FT based on the time differences

Atwood et. al., **ApJ Lett., 652, 49 (2006)**
Ziegler et. al., **ApJ 680, 620 (2008)**



Credit: M. Ziegler



# of FFT bins = f * t_{max_diff} * 2

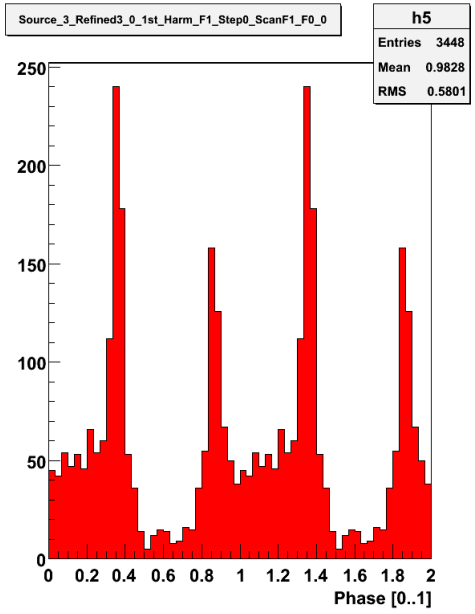
PC with 2GB can handle 33 x 10^6 bin FFT

Sources of interest in our searches

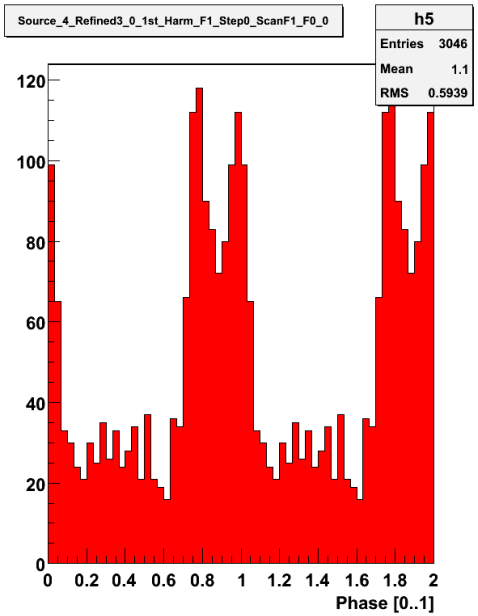
- **Unidentified Fermi-LAT sources**
- **List of known pulsars,** e.g.:
  - EGRET Pulsars
  - Pulsars coincident with EGRET sources
- **List of "Geminga Candidates",** e.g.:
  - 3EG J1835+5918 (aka the "next" Geminga)
  - CTA1
  - Compact objects of PWNe
  - Milagro sources (e.g. MGROJ2019+37)

EGRET Pulsars

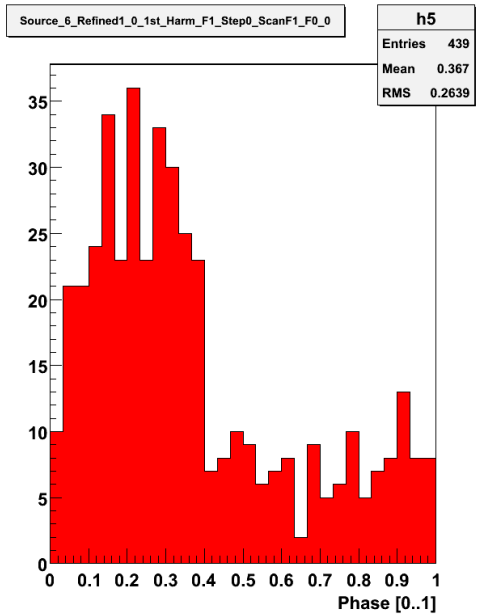
- EGRET pulsars were found in blind search within the 60-day launch and early operations (L&EO) period.



Geminga



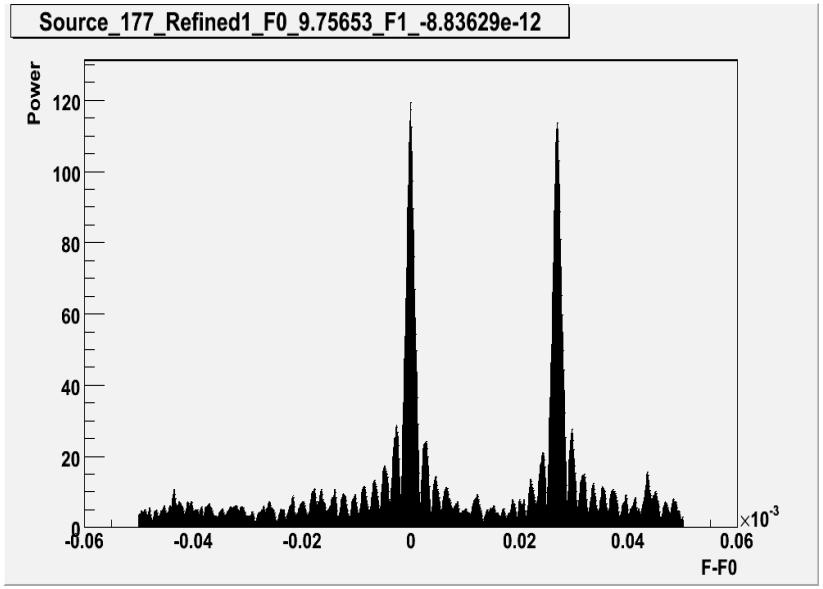
PSR B1706-44

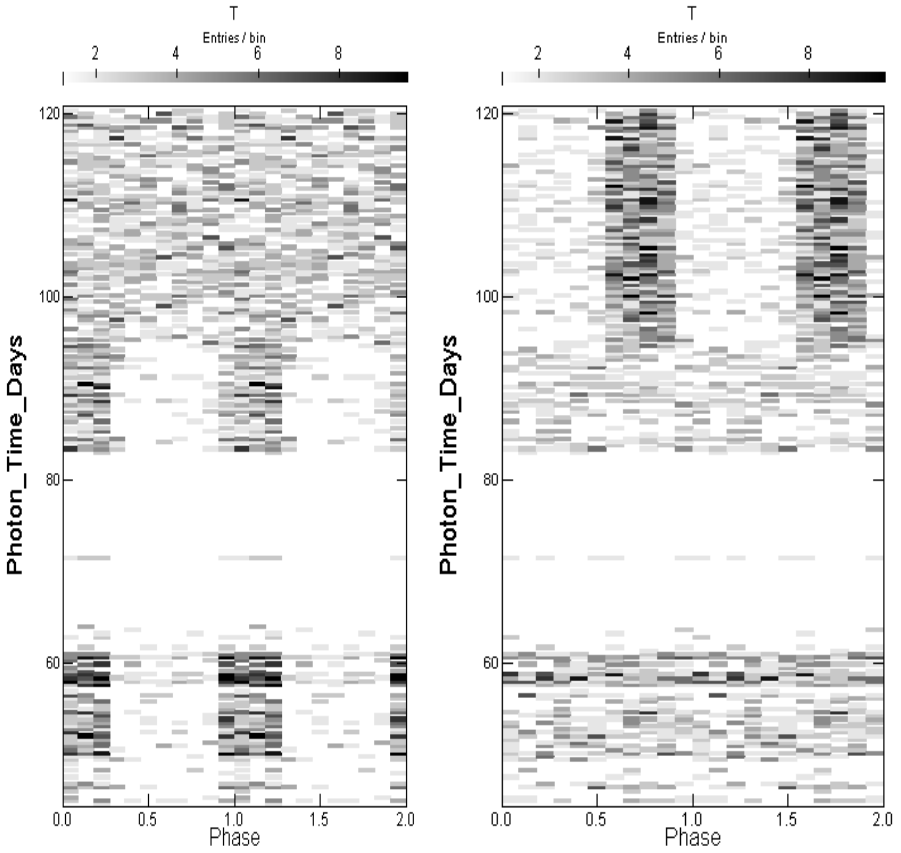


PSR B1951+32

Detection of glitch in PSR B1706-44

- A search around a narrow range of frequencies centered on known ephemeris results in two peaks in power spectrum
- Glitch occurred between 14-15 August
- Known to glitch (e.g. 1992, 1995)
- Radio observations are planned

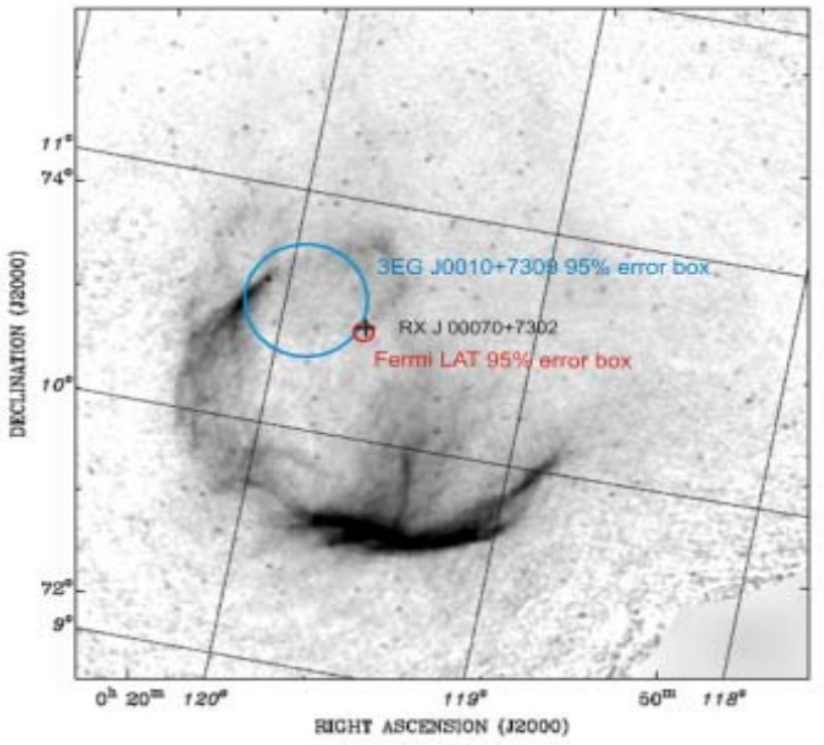




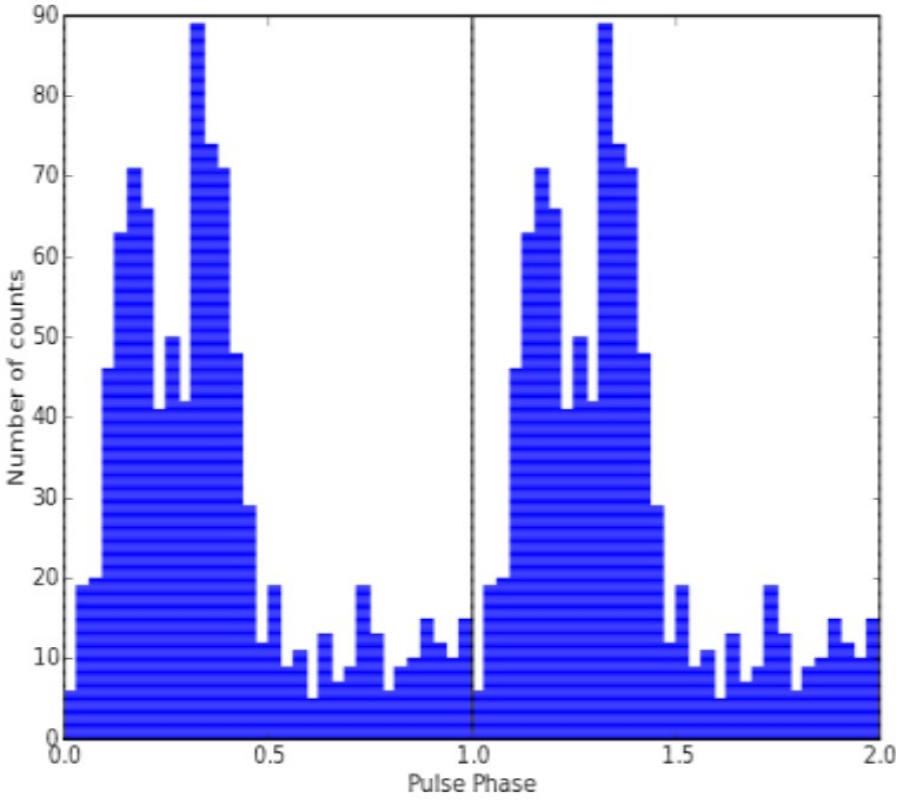
Pre-glitch ephemeris Post-glitch ephemeris

A radio-quiet pulsar in CTA1

P ~ 317 ms
Pdot ~ 3.6E-13
Edot = 4.5E35
Characteristic age ~ 10,000 yrs



Location of EGRET source 3EG J0010+7309, the Fermi-LAT source, and the central X-ray source RX J0007.0+7303



To appear in Science

Conclusions

- GLAST was successfully launched on 11 June 2008 (subsequently renamed Fermi)
- The 60-day L&EO verification period was successfully completed. In addition to tuning, testing, and calibrating the instrument ... science was being carried out.
- Fermi is looking for gamma-ray pulsations from known and unknown pulsars
- A new radio-quiet gamma-ray pulsar has been discovered ... and more are on the way.

Fermi
Gamma-ray
Space Telescope

Grazie!