Detection of High-Energy Gamma-Ray Emission from the Globular Cluster 47 Tucanae with Fermi

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on behalf of the Fermi LAT collaboration

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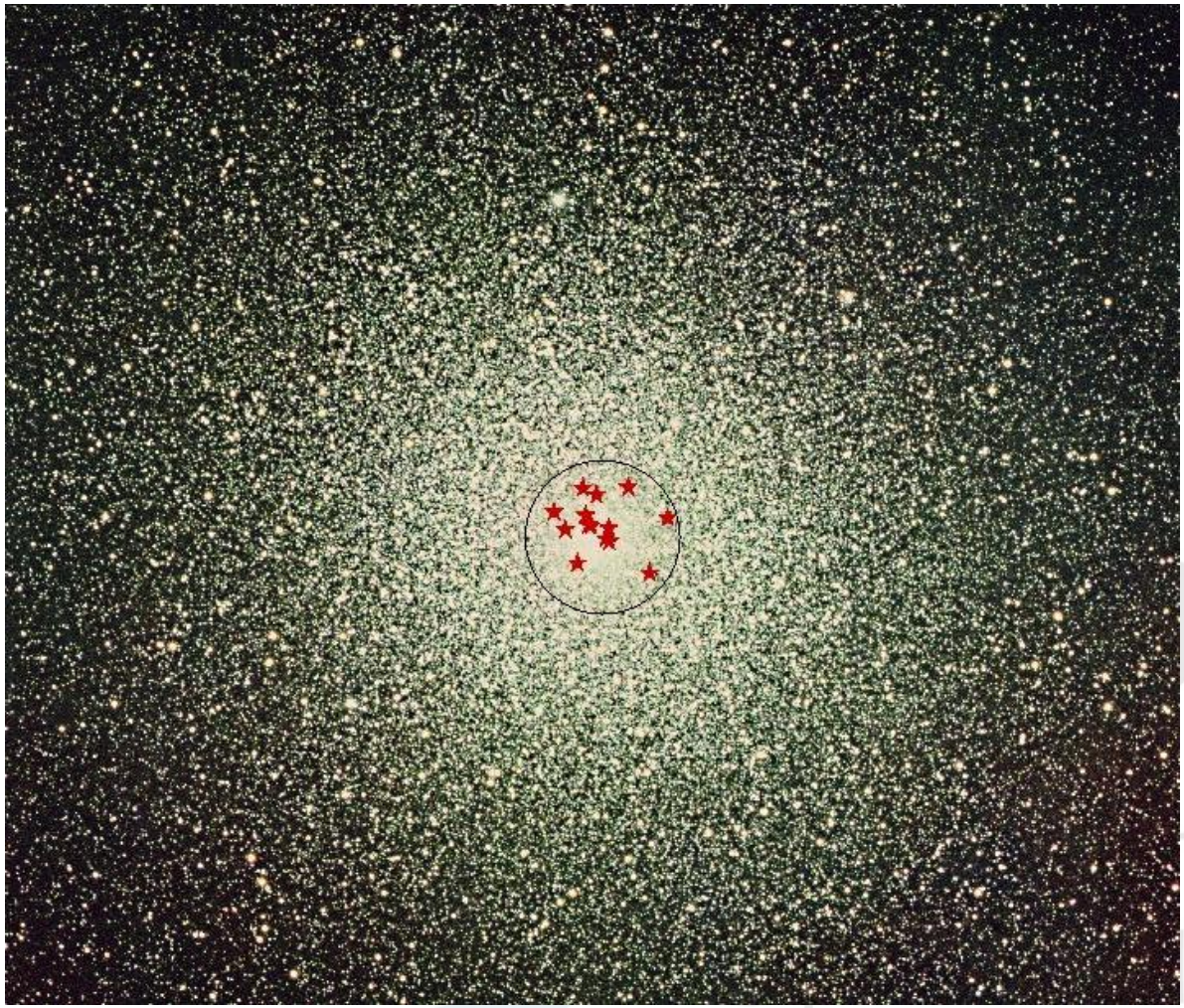
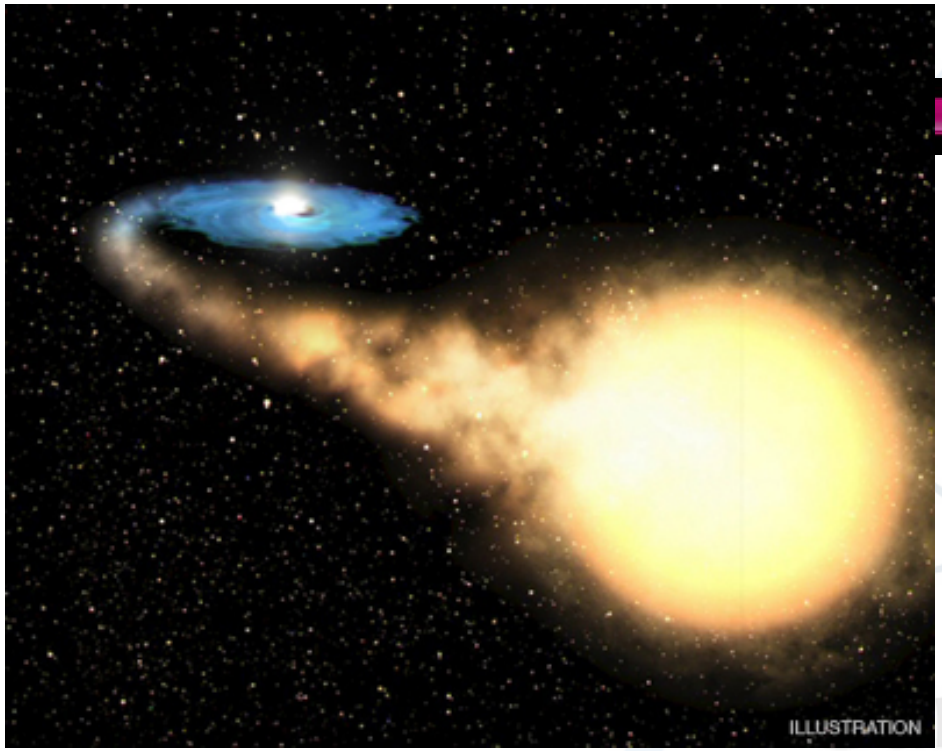
Galactic globular clusters



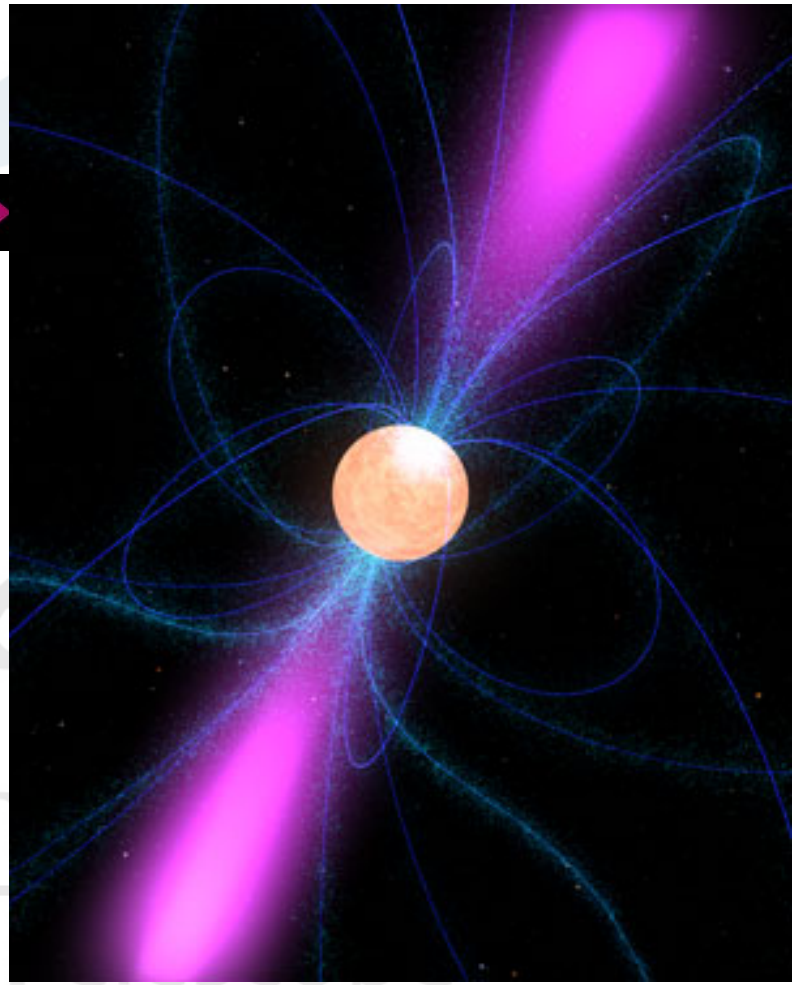
47 Tuc, Anglo-Australian Observatory
Red stars = radio MSPs

- Dense groups of old stars (10^{5-6} stars)
- Stable on dynamical timescales ($\sim 10^6$ yr)
- Unstable on thermal timescales ($\sim 10^9$ yr)

Compact binaries:



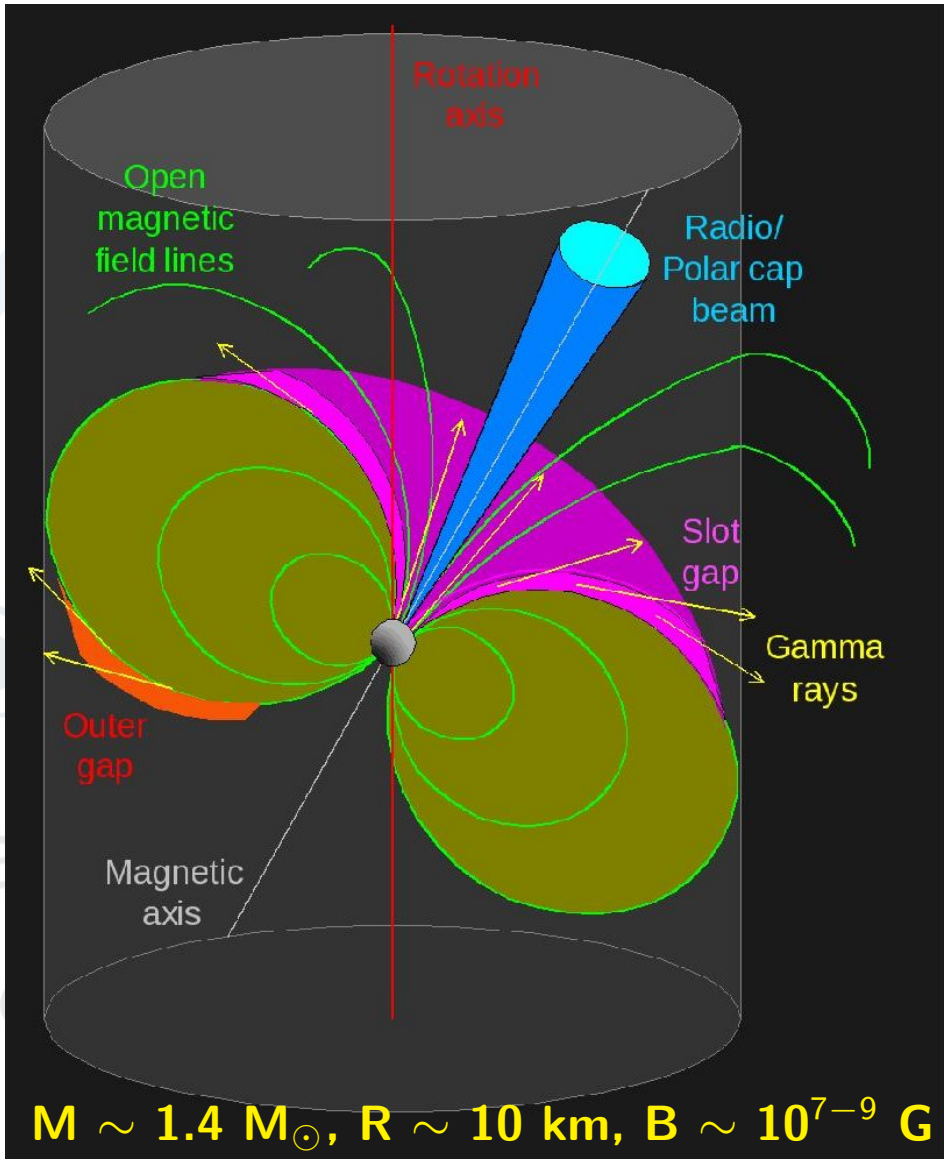
Artist's impression of an X-ray binary (Credits: ESA, NASA and Felix Mirabel)



Artist's impression of a pulsar (Credit: NASA)

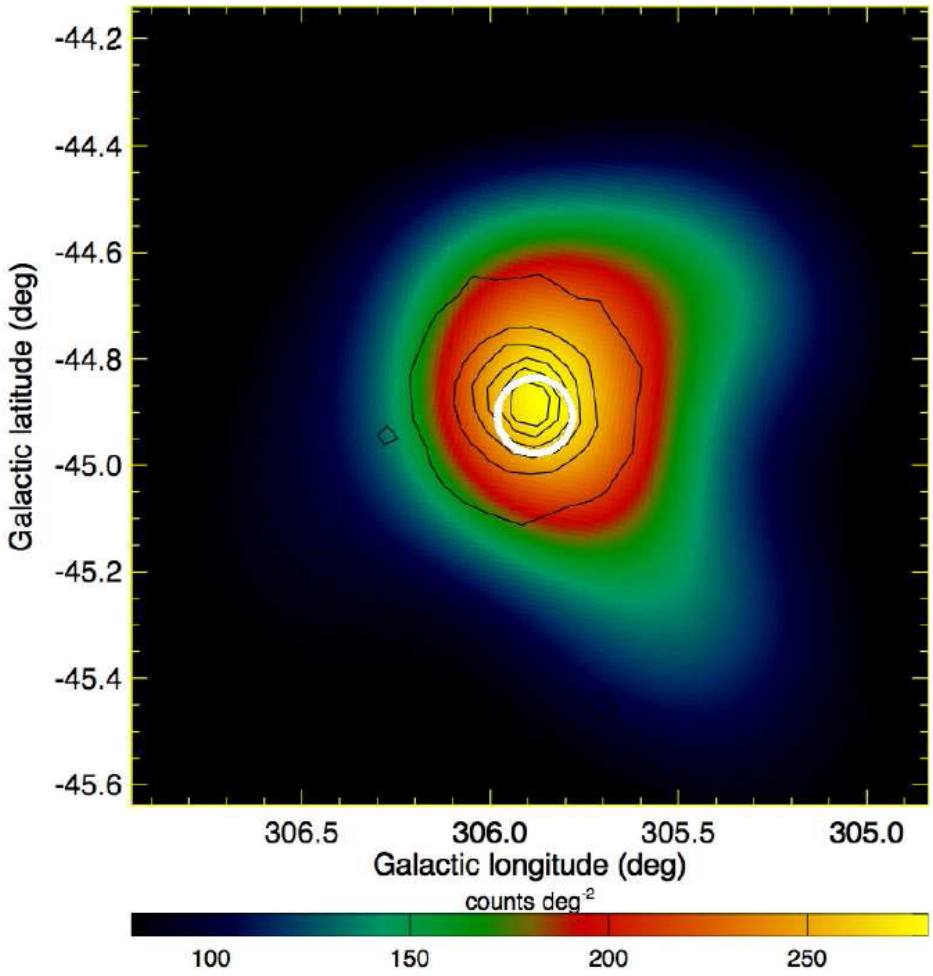
High energy emission from pulsars

- **Three models:**
  - **polar cap**
  - **outer gap**
  - **slot gap**
- **Inverse Compton scattering/ curvature radiation $\longrightarrow$ γ-rays**
- **Discovery of γ-ray emission from MSPs (Abdo et al. 2009a,b)**



47 Tucanae

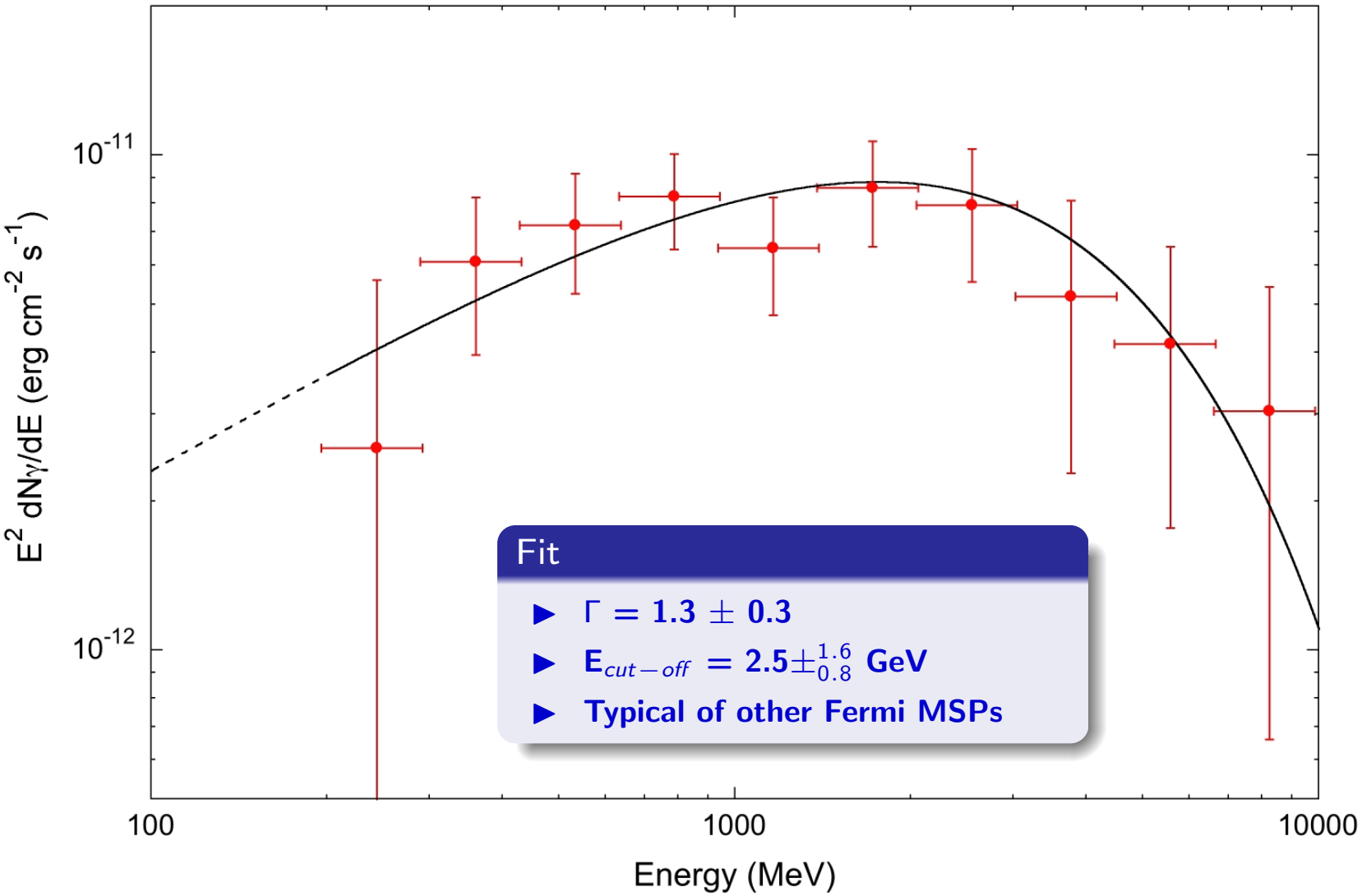
- **23 millisecond pulsars known (radio detection, Freire[a])**
- **γ-ray emission detected with the Fermi LAT (17 σ)**
- **$L_{(200MeV-10GeV)}$ = $(4.8 \pm 1.2) \times 10^{34}$ erg s^{-1} (distance = 4.0 $\pm$ 0.4 kpc)**



Circle: 95% confidence region for the location of the gamma-ray source.

[a] http://www.naic.edu/ pfreire/GCpsr.html

Gamma-ray spectrum of 47 Tuc



Fit

- $\Gamma = 1.3 \pm 0.3$
- $E_{cut-off} = 2.5 \pm^{1.6}_{0.8}$ GeV
- Typical of other Fermi MSPs

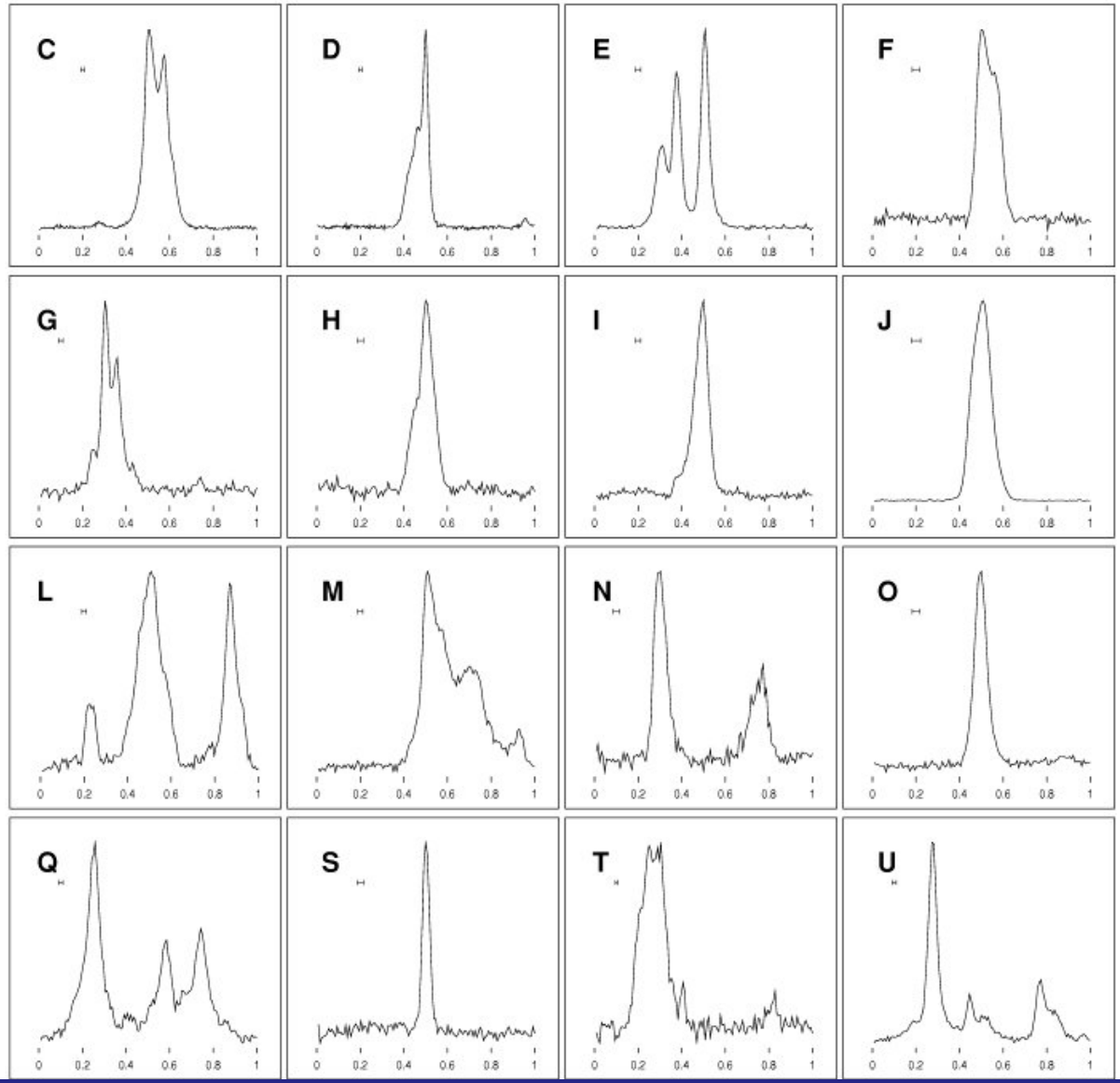
How many millisecond pulsars in 47 Tuc?

- **Spin down energy ($\dot{E}$) $\propto$ I ω $\dot{\omega}$**
- **Efficiency (η_γ) = L / $\dot{E}$**
- **Using the average $\dot{E}$ $\rightarrow$ η_γ = 0.12 $\pm$ 0.05 f_Ω / N_{23}**
- **Using η_γ = 0.08 $\pm$ 0.02 f_Ω (for the closest Fermi MSPs) implies < 60 MSPs in 47 Tuc**

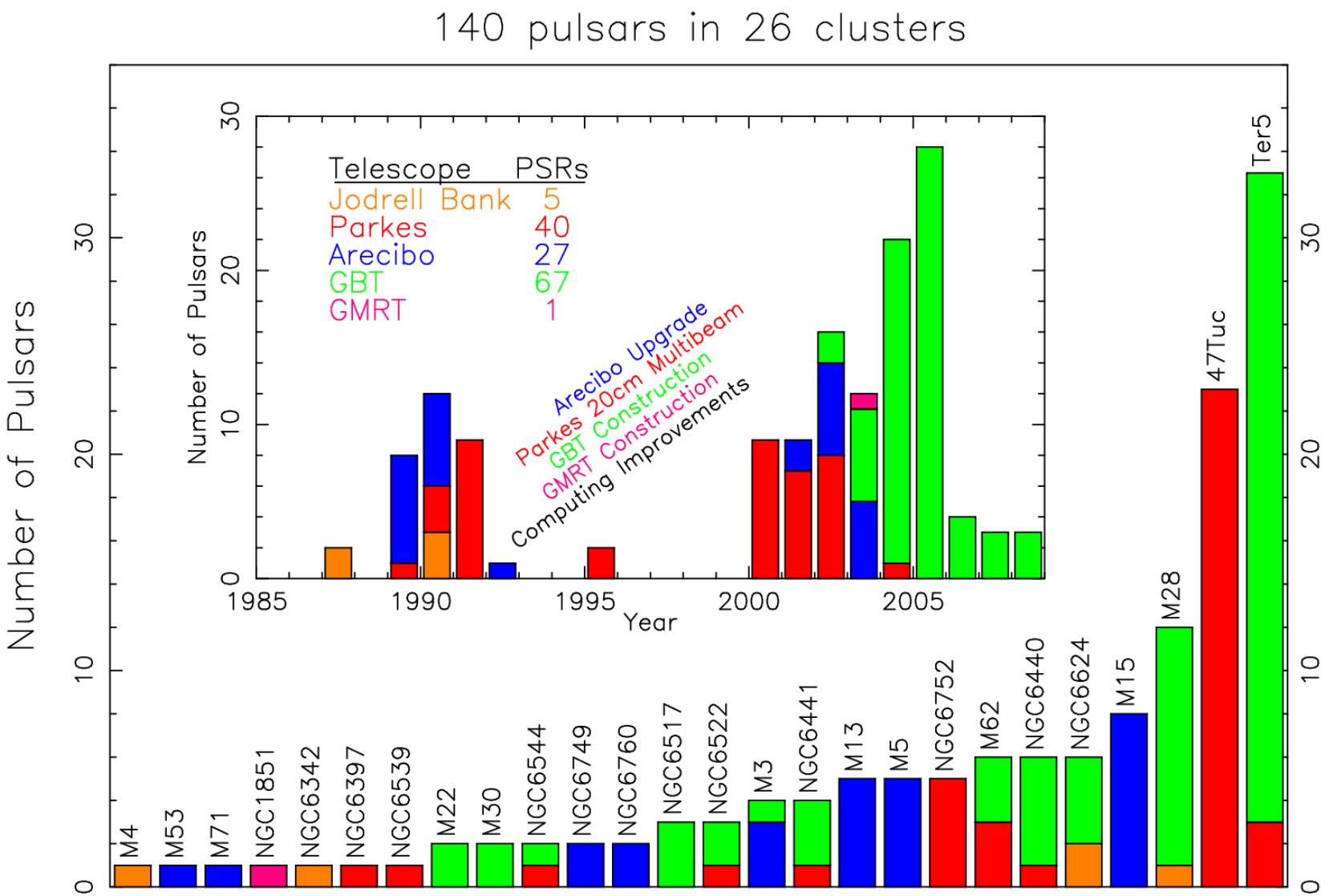
Looking for γ-ray pulsations

- **Ongoing work**
- **No pulsations confirmed at $> 5\ \sigma$**
- **Appears that the emission is not dominated by one/ a few pulsar(s)**

Radio observations (Freire et al. 2003)



...and what about other Galactic globular clusters?



Summary

- γ-ray emission detected from a globular cluster for the first time
- Emission appears to be consistent with a population of millisecond pulsars
- Estimate $<$60 millisecond pulsars in 47 Tucanae
- Some other globular clusters are starting to be detected