Analyzing Pulsar “Glitches” Using the Fermi LAT

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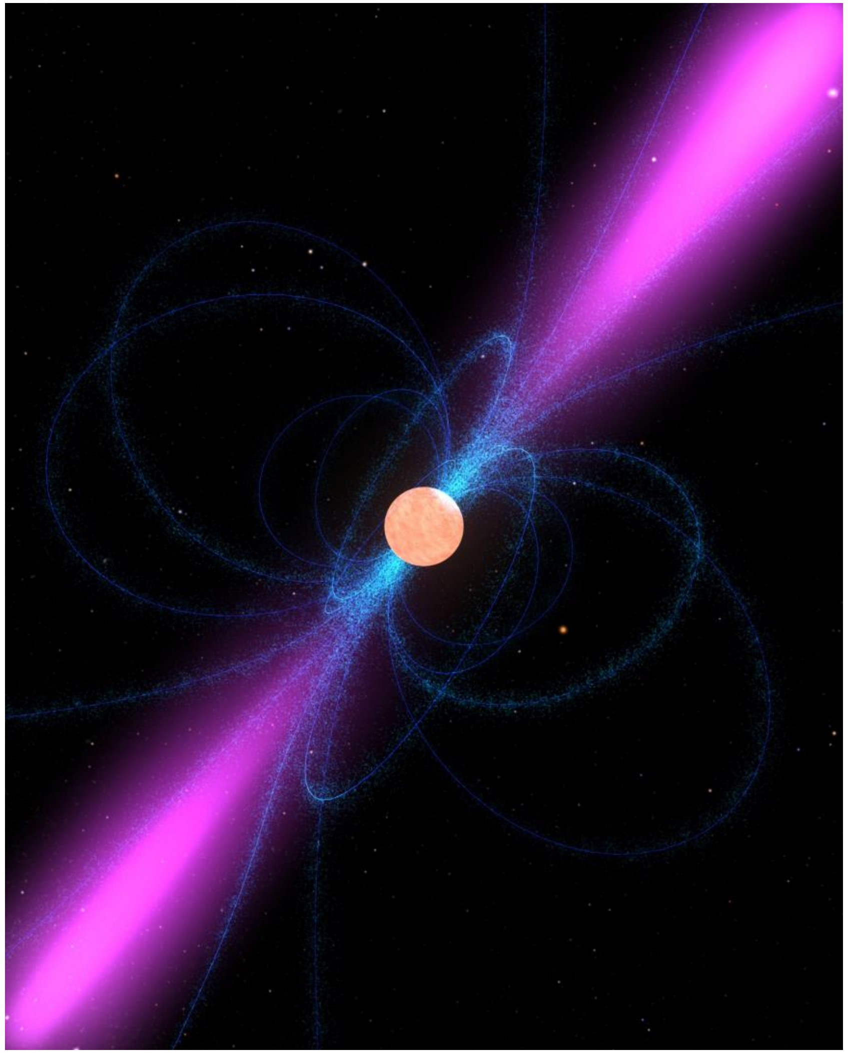
Common Characteristics

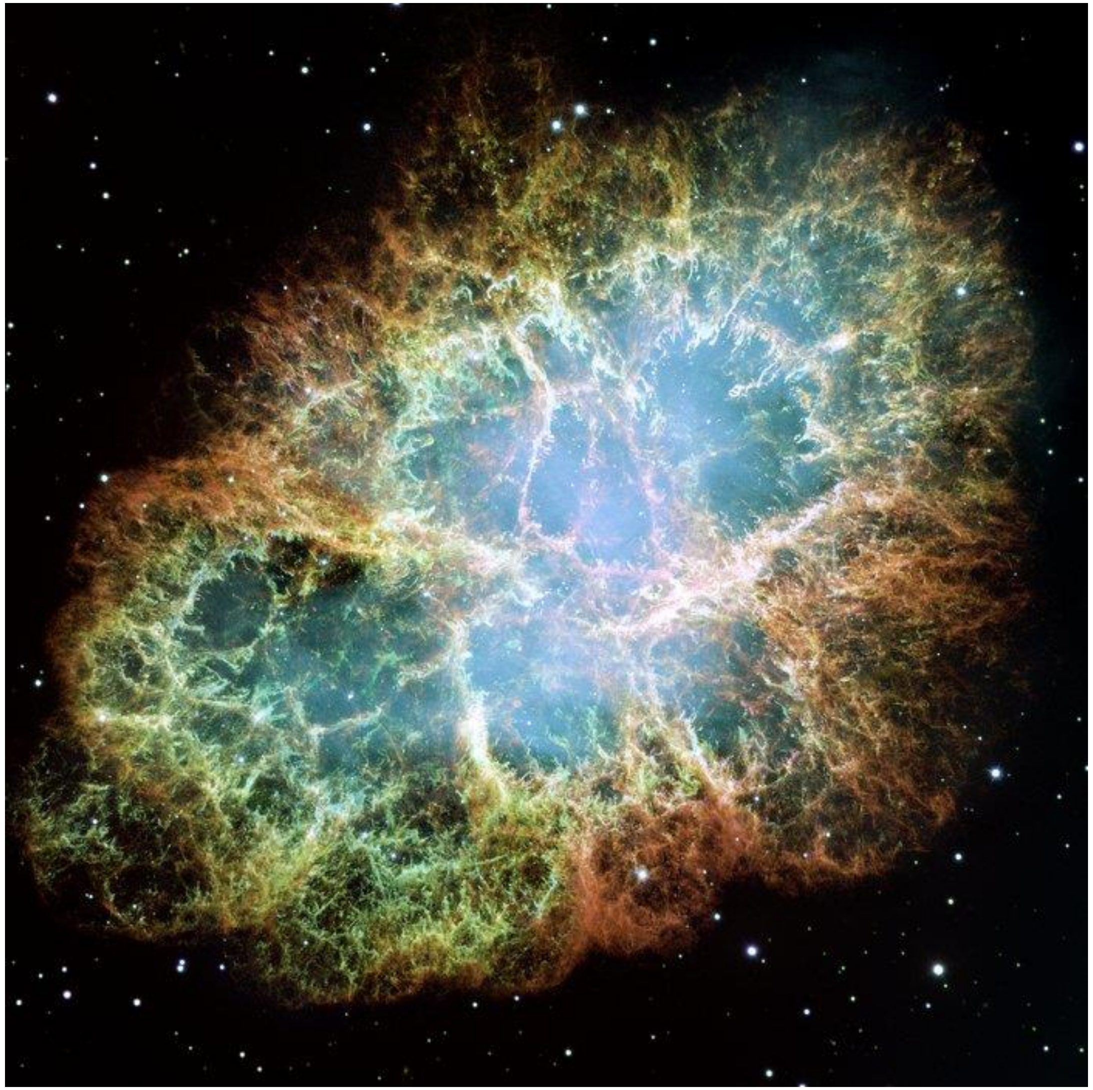
- Neutron Stars
- Variable Sources
  - Milliseconds to Minutes
- Radius ~ 10 km
- Mass ~ 1.4 $M_\odot$
- Strong Magnetic Fields
- High rates of Spin
- Focused Radiation Beams



NASA

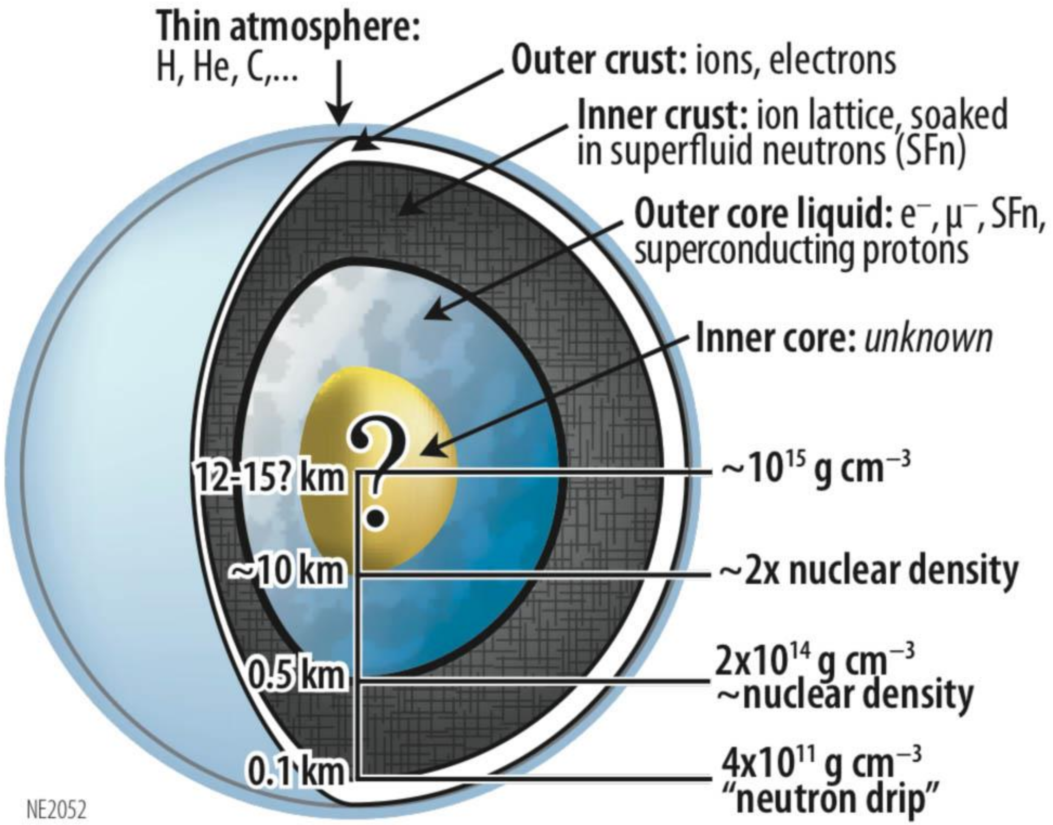
Stellar Origins

- **Formed During Supernovas**
  - **Commonly Associated with SNRs**
  - **Core Collapse**
- **Progenitor Mass 8-25 $M_\odot$**
  - **Possibly Greater in Binary Systems**
- **Between White Dwarf and Black Hole**


NASA, ESA and Allison Loll/Jeff Hester

Internal Structure

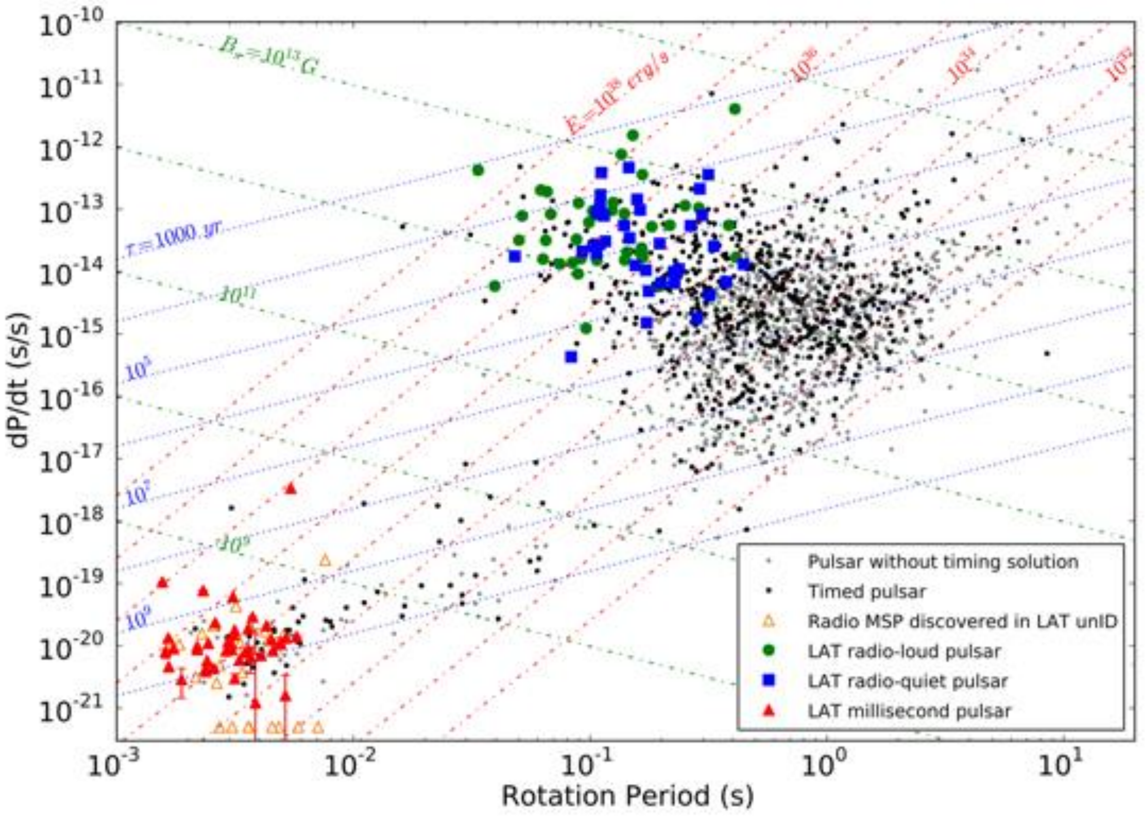
- **Magnetosphere**
  - Coupled to Crust
  - Radiation Generation
- **Inner Superfluid Component**
  - Differential Rotation
- **Core**
  - Unknown Composition
  - Determines Maximum Mass



Gendreau et al. 2012

Classification

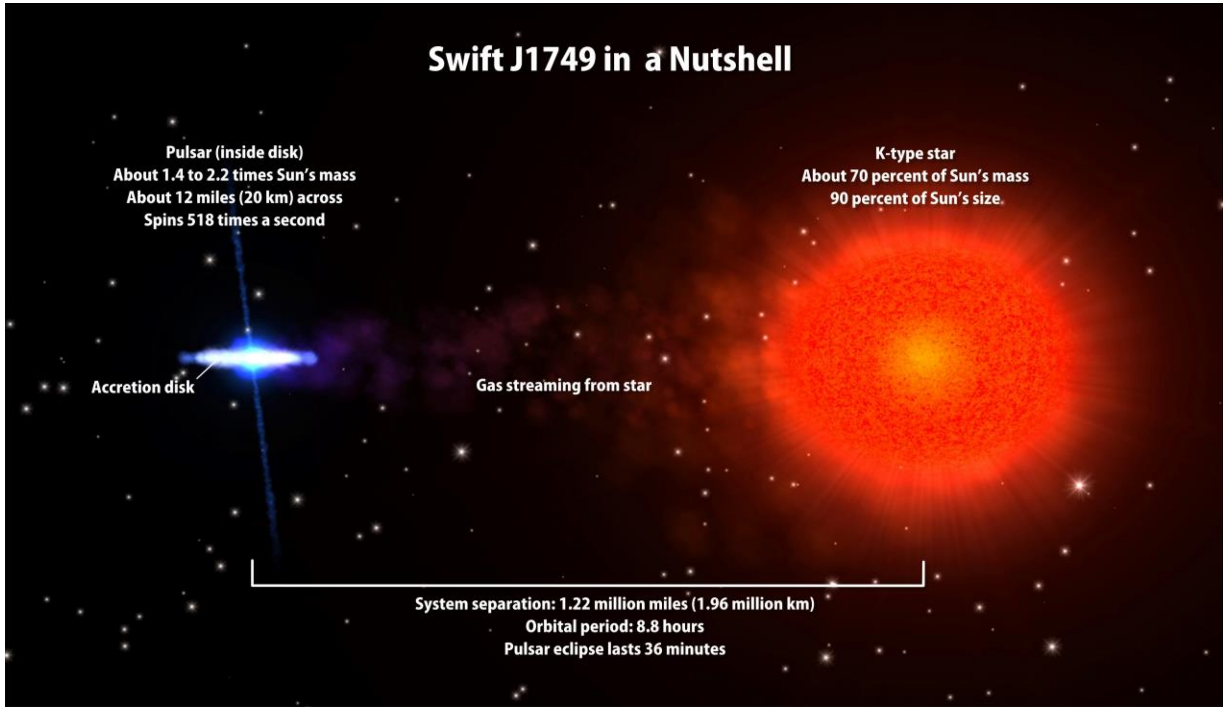
- **Main Factors**
  - Period
  - Period Derivative
  - Power Source
- **Correlated Factors**
  - Magnetic Field Strength
  - Characteristic Age



Fermi-LAT Collaboration

Notable Evolutions

- Binary Systems
- Accreting Neutron Stars
  - Mass Transfer from Companion
  - Bright in X-Ray (GBM)
- Recycled Pulsars
  - Redback System
  - Black Widow System



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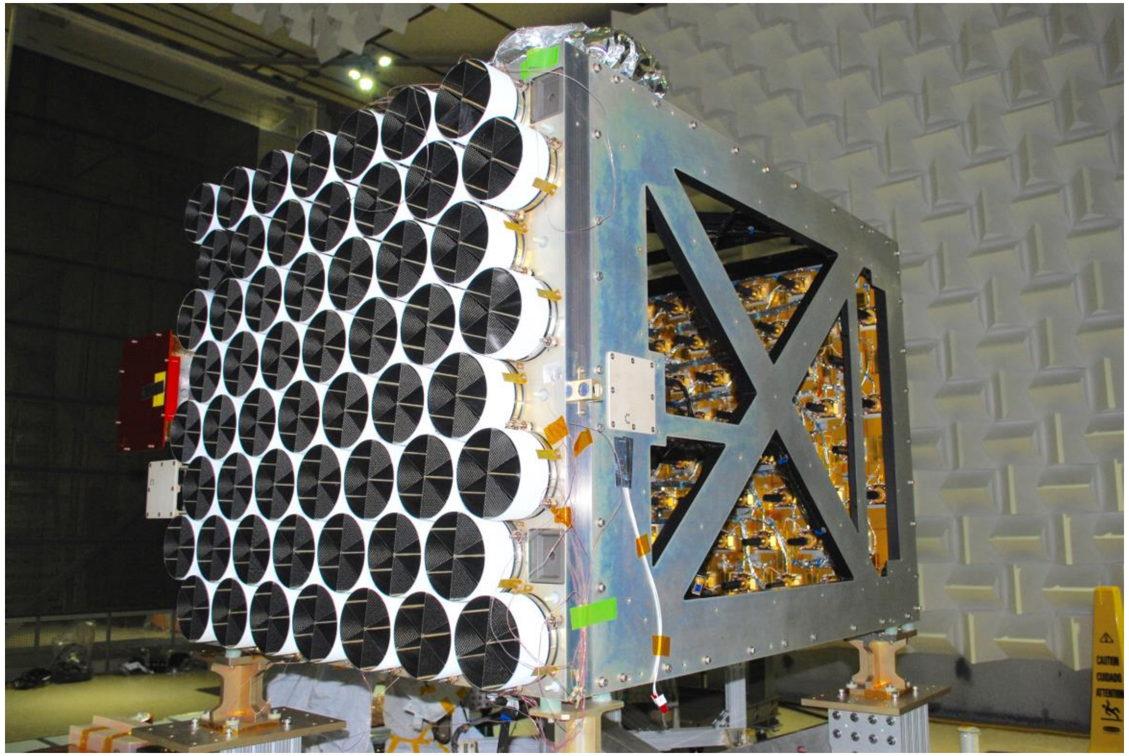
Millisecond Pulsars

- Precise
  - Rival Early Atomic Clocks
  - Don’t Glitch
- Possible Gravitational Wave Detectors
  - NANOGrav
- Possible Navigational Applications
  - NICER



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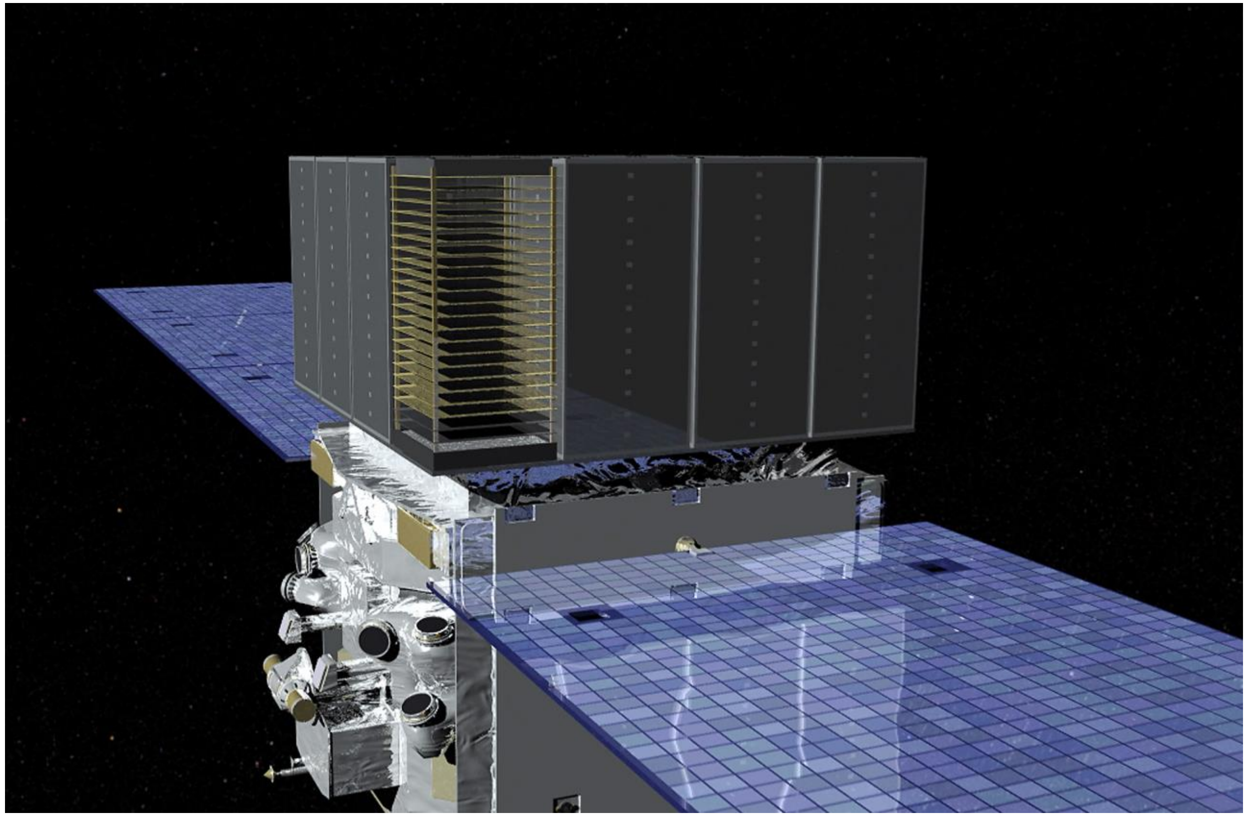
Fermi and Pulsars

- Detection of over 200 Gamma-Ray Pulsars
- Discovery of Many Millisecond Pulsars
  - Spectral Searches
- This Project:
  - Build a Catalog of Glitches Observed by the Fermi Spacecraft



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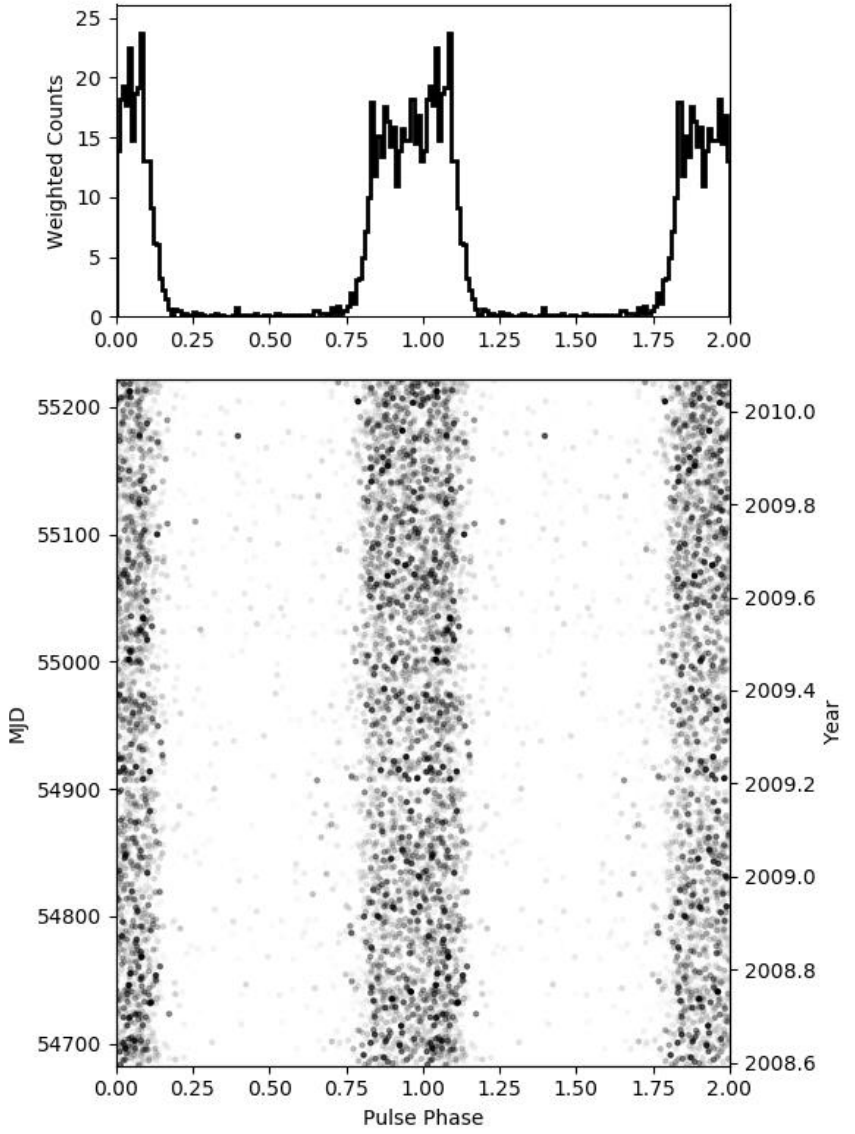
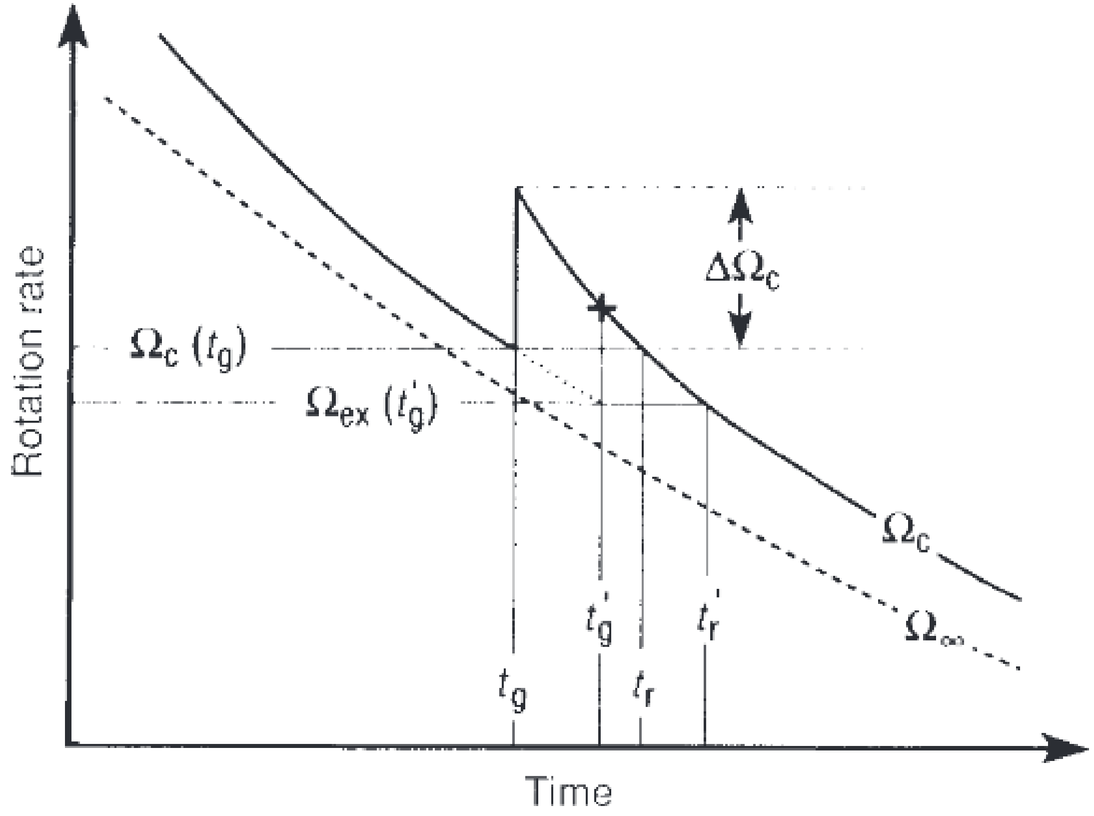
Pulsar Challenges

- One Photon for Many Revolutions
  - Timing Noise
- Barycentering
  - Position of Spacecraft
  - Position of Pulsar
- Techniques
  - Existing Solutions
  - Blind Searches
  - Spectral Searches



Pulsar "Glitches"

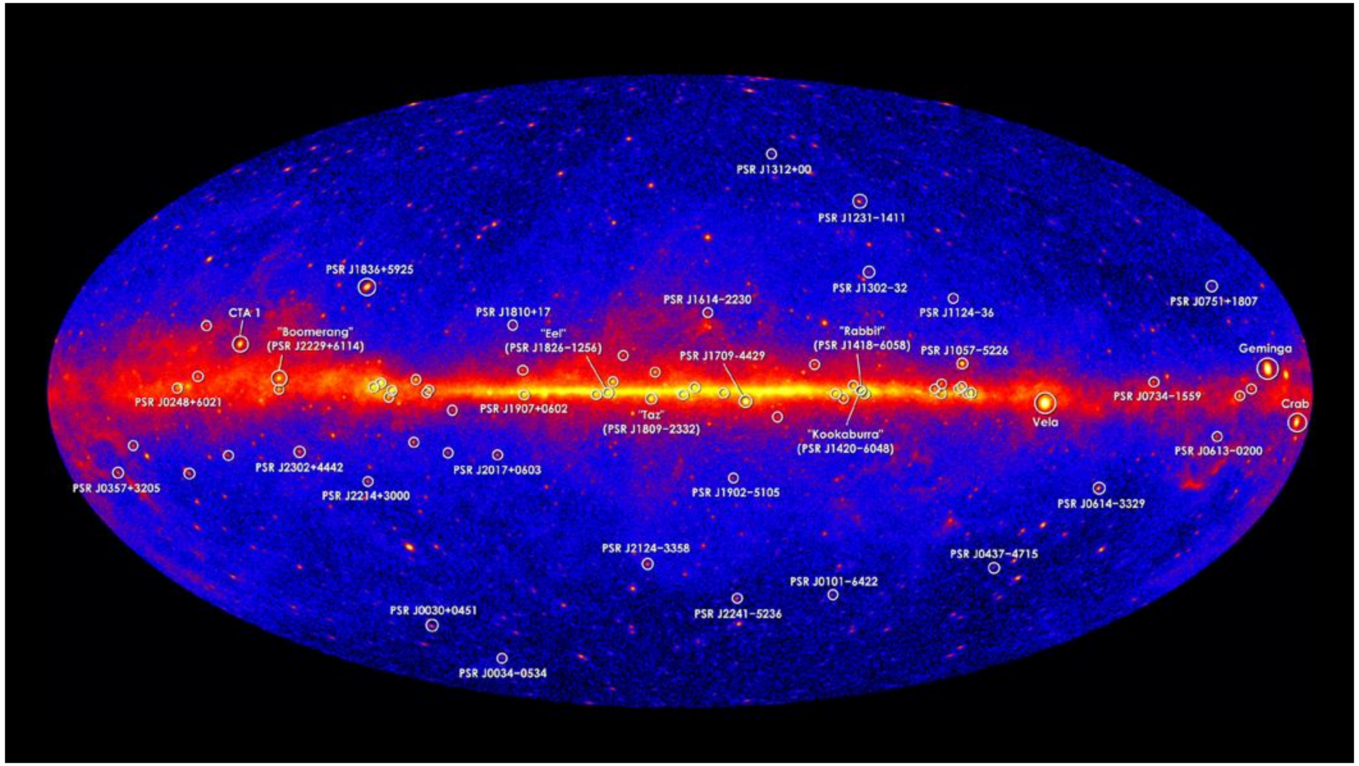
- **Sudden Changes in Rotation Rate**
- **Mechanisms**
  - **Coupling of Crust and Superfluid**
  - **Starquakes and Crust Rearrangement**
- **Investigate Equation of State**
- **Gravitational Wave Source**



Link et al., Nature, 1992

Fermi and Glitches

- **Continual Monitoring**
  - **Prompt Observation**
- **All Sky**
  - **Large Population**
- **Previous Searches**
  - **128 Glitches**
  - **63/700+ Since 1978**
- **Fermi Subset**
  - **44 Glitches**
  - **24/81 Monitored**
  - **~ 5 years**



NASA/DOE/Fermi LAT Collaboration

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