Overview of Pulsar Tools

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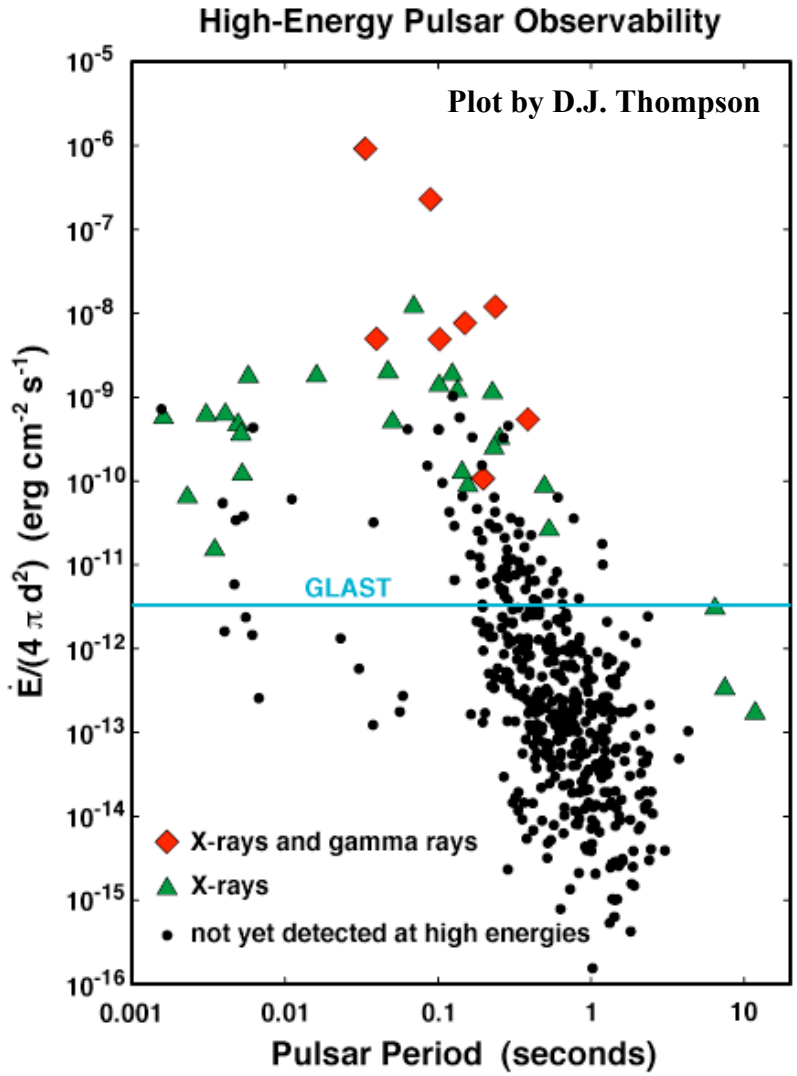
Pulsars for GLAST LAT

- Pulsars are point sources
- GLAST expected to detect pulsations from 50-100 pulsars
  - 10-50% are predicted to be radio quiet like Geminga
  - Most need 1 year exposure for detection
- Sparse data
  - One photon per 500 pulses (Crab 30 MeV – 300 GeV)
- Scanning with large FOV
  - All sources get some exposure every day throughout a year
  - Large number of short observations

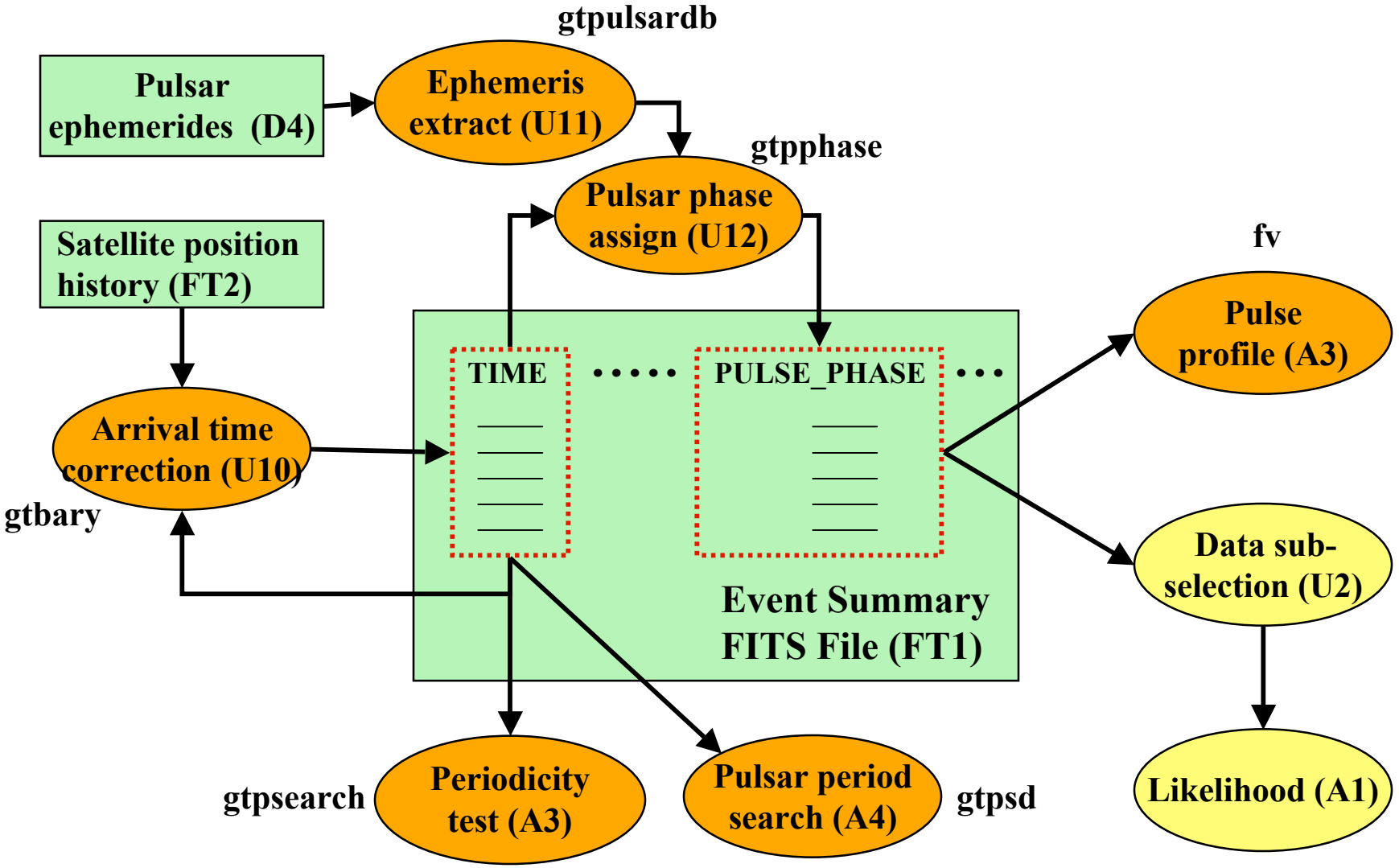


Typical Pulsar Analysis

http://glast-ground.slac.stanford.edu/workbook/science-tools/sciTools_Home.htm

1. Download data and screen events.
2. Barycentric correction. gtbary
   To cancel Doppler effect resulting from the orbital motions of the Earth and the spacecraft.
3. Find pulsar ephemeris at the time of observation. gtephcomp
   Option 1: Use a radio ephemeris as is.
   Option 2: Scan pulse frequencies around extrapolation of radio ephemeris. gtpsearch
   Option 3: Search for pulsations even if no radio ephemeris is available. (New tool gtpsd).
4. Calculate pulse phase for each photon. gtpphase
   - Epoch folding (pulse shape) using fv, fplot, etc.
   - Phase-resolved spectrum (or image) gtselect, gtlike

Pulsar Tools In Action



GUC Action Item 18

- The methodology will be described for the simple pulsar search tool provided by the standard analysis environment.
- Standard Analysis Environment identifies two tools:
  - Periodicity tests (A3) gtpsearch already implemented
    - Previous measurements provide an estimate of the frequency that may not be accurate for the current data.
  - Blind period search (A4) gtpsd? under consideration
    - Source has not been identified as a pulsar.
- Blind search methodologies are open ended and many are outside the scope of SAE.
  - Many techniques exist and are still being developed.
  - Best technique depends strongly on the scientific goal, and on personal preference.
  - Powerful techniques are too computationally intensive.

Algorithms

- **Periodicity tests**
  - **Chi-squared test (Leahy et al. 1983, ApJ 266, 160; Vaughan et al. 1994, ApJ 435, 362)**
  - **Zn^2 test (Buccheri et al. 1983, A&A 128, 245)**
  - **Rayleigh test (equivalent to Zn^2 test for n = 1)**
  - **H test (De Jager et al. 1989, A&A 221, 180)**
  - **Bayesian approach (Gregory and Loredo 1992, ApJ 398, 146; Gregory and Loredo 1996, ApJ 473, 1059)**
- **Period search**
  - **Discrete Fourier transforms (Ransom 2002, AJ 124, 1788)**
  - **Lomb-Scargle periodogram (Lomb 1976, Ap&SS 39, 447; Scargle 1982, ApJ 263, 835; Press & Rybicki 1989, ApJ 338, 277)**

Pulsar period search tool (A4)

- Searches for periodic emission from a point source.
  - Position of the source is well-known.
  - No prior knowledge on pulse frequency.
  - The source is either not in a binary system, or in a binary system whose binary parameters are known.

  Example case:

  Search for pulsations from EGRET un-identified sources.
- Recommended algorithm for period search.
  - Discrete Fourier transforms (Ransom 2002, AJ 124, 1788)
  - Implementation is FFTW (Fastest Fourier Transform in the West) http://www.fftw.org/

Backup Slides

Utility Tools

- Ephemeris computer gtephcomp
  - Reads pulsar ephemerides database (D4) and compute pulsar-related parameters (such as pulse frequency) at a given moment in time.
  - Also serves as a sanity checker for first-time users of our pulsar ephemerides database (D4).
- Orbital phase assignment gtophase
  - To assign an orbital phase to each photon (just like a pulse phase for each photon).
  - Pulse phase assignment tool (U12) is a natural candidate to do this task.
- Pulsar ephemerides extraction tool gtpulsardb
  - To sub-select pulsar ephemerides from a master database.
  - Also, used to create, modify, merge pulsar ephemerides database.

Pulsar Tools