

Software Requirements for GLAST Periodicity Searches

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As described elsewhere, if the outer gap model for pulsar γ -ray emission pertains, it should be possible to detect ~ 50 radio-quiet pulsars directly from the GLAST data through a fast Fourier transform (FFT) detection of periodicity.

The technique used by Mattox et al. (1996 A&A S, **120**, C95) for EGRET sources is also appropriate for GLAST. In the last decade of the 20th century, a super-computer was required to provide sufficient memory for a Gigapoint FFT without swapping to disk. By the time of the scheduled launch of GLAST in 2005, it is expected that sufficient memory will be available on a scientific work station.

The size of the Fourier transform is $\frac{T}{\delta T}$, where T is the duration of the exposure being searched for periodicity, and δT is $1/\nu_{\max}$, where ν_{\max} is the maximum frequency to be considered for the periodicity. For ~ 1 megasecond observations and harmonics of interest up to ~ 1 kHz, a ~ 1 Gigapoint Fourier transform is required. Multiple frequency derivatives are searched by accelerating event times before computing the Fourier transform.

The GLAST pulsar program will be used to “pre-process” GLAST event data for a periodicity search. This “pre-processing” will include:

- (1) Selection of events to maximize the signal to noise ratio, e.g., events with estimated energies which maximize S/N (for the measured γ -ray spectrum of the unidentified GLAST source), and with estimated directions which are within a cone with an energy dependent opening angle such that 68% of the GLAST PSF is included at each energy.
- (2) Writing the barycenter arrival time of each selected event to a file on disk for subsequent analysis. The barycenter correction is based on the GLAST estimate of the source position.

The analysis of Mattox et al. (1996) shows that the expected error of several arcminutes in the GLAST position will not result in any loss of harmonic power, but it can cause a substantial displacement of the apparent frequency and frequency derivative of periodicity. Consequently, the maximum duration of the exposure which can be searched for periodicity is ~ 3 weeks.

The Periodicity Search program first reads the arrival time file written by the GLAST Pulsar program and creates a binary time series with time resolution δT . This binary time series is then Fourier transformed. If the γ -ray-pulsar has a substantial frequency derivative, it will not be detected through the FFT unless event times are accelerated at approximately the value of the pulsar frequency derivative prior to the creation of the binary time series. Thus, multiple accelerated time series must be Fourier transformed to detect young pulsars.

The Periodicity Search program should also analyze the result of each Fourier transform once obtained since it would require a large amount of disk storage to save it. The program should combine power at specified harmonics (e.g., first, second, third, + fourth) of each trial frequency to maximize sensitivity for a potential range of lightcurves. It should estimate the statistical significance of potential periodicity detections, and write sufficient detail to a file on disk for follow-up studies utilizing epoch folding.

In summary, the GLAST Periodicity Search program must do the following:

- (1) The program must arrange for a series of FFTs with a range of time accelerations to cover the range of interest for the pulsar frequency derivative.

- (2) For a specific acceleration, the program will create in RAM a binary time series with specified time resolution δT .
- (3) The program will then transform this time series in a computationally efficient manner to produce the corresponding power spectrum.
- (4) Each power spectrum will be searched for periodicity by summing the power of specified combinations of harmonics for each potential pulsar frequency.
- (5) The program will determine the significance of all potential periodicities, and write sufficient detail to a file on disk for follow-up studies of potential periodicities with significance above a specified threshold.

The scientific work station to be used for GLAST periodicity searches must have at least 500 megabytes of RAM. It should be procured ~ 1 year prior to launch. The operating system and programming language are not critical choices, and will be determined by considerations of availability, the requirements for appropriate software libraries, and other potential uses for this computer within the GLAST mission.