Long-term Monitoring of Accreting Pulsars with Fermi GBM

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Pulsar Monitoring with GBM

The full sky coverage of GBM enables long term monitoring of the brighter accreting pulsars allowing:

- Precise measurements of spin frequencies and orbital parameters.
- Study of spin-up or spin-down rates and hence the flow of angular momentum.
- Detection and study of new transient sources or new outburst of known transients.

Data Analysis

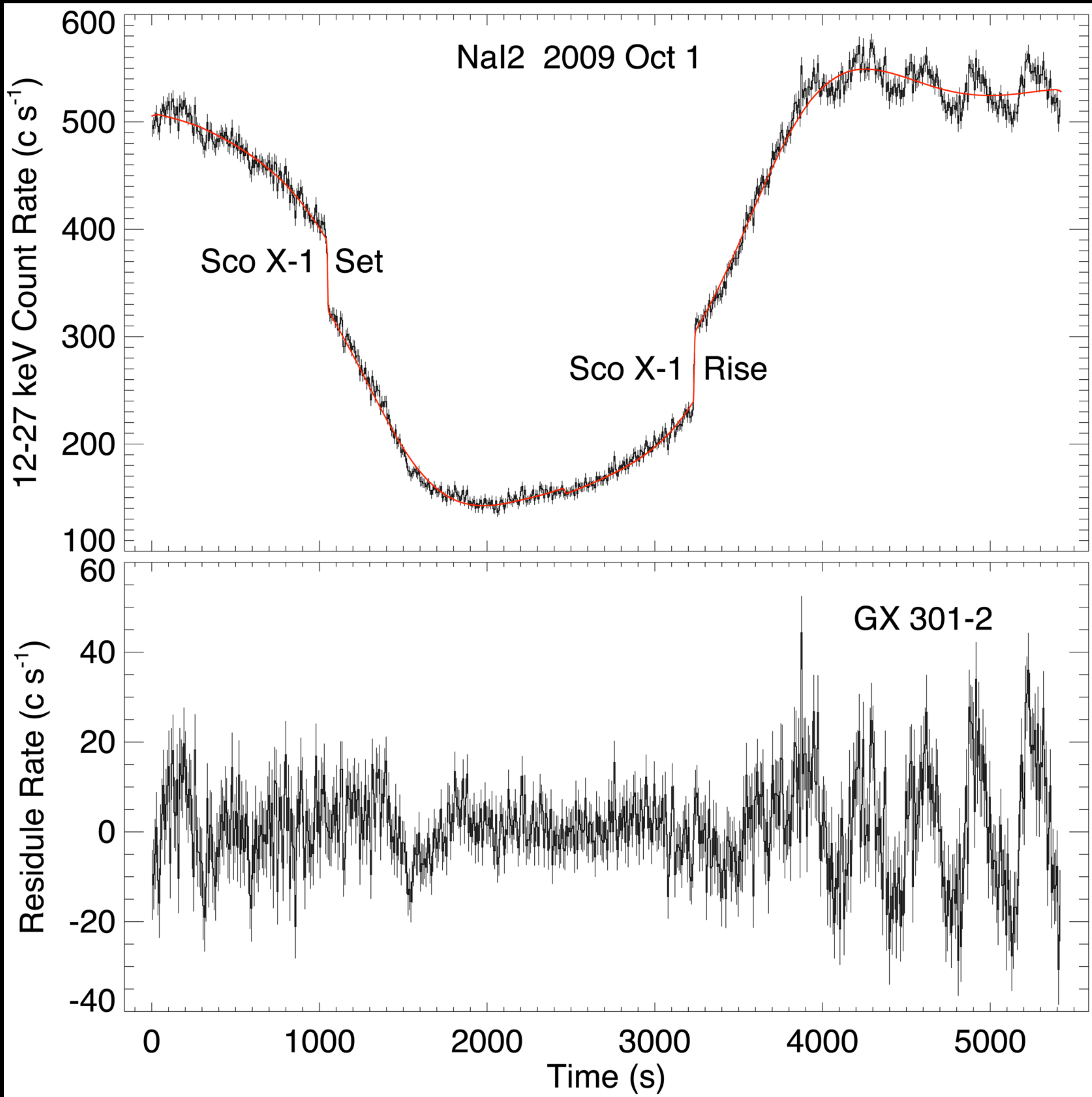
The analysis of GBM observations of pulsars presents two main challenges:

- The background rates are normally much larger than the source rates, and have large variations.
- The responses of the detectors to a source are continuously changing because of Fermi's ever changing orientation.

The initial steps of the analysis are:

- Data Screening
- Background subtraction of the NaI detector count rates
- Determination of fluxes from remaining rates

Background Subtraction



The rates in each channel of the 12 NaI detectors is fit with a model with the following components:

- Models for bright sources.
- A stiff empirical model that contains the low-frequency component of the remaining rates.

The fits are made independently for each channel and subtracted from the rates.

Estimating Fluxes

For a given source we combine the rate residuals over detectors and obtain an estimate of the variable part of the source flux. Using a model of the source spectrum and the time dependent detector responses we compute the source induced rate μ_{ik} expected in detector *i* at time t_k if the source has unit flux in the channel's energy range. The variable part of the flux $\tilde{f}_k$ is then estimate by minimizing

$$\chi_k^2 = \sum_i \frac{(\tilde{r}_{ik} - \tilde{f}_k \mu_{ik})^2}{\sigma_{ik}^2}$$

where $\tilde{r}_{ik}$ is the residual rates and σ_{ik} the associated errors.

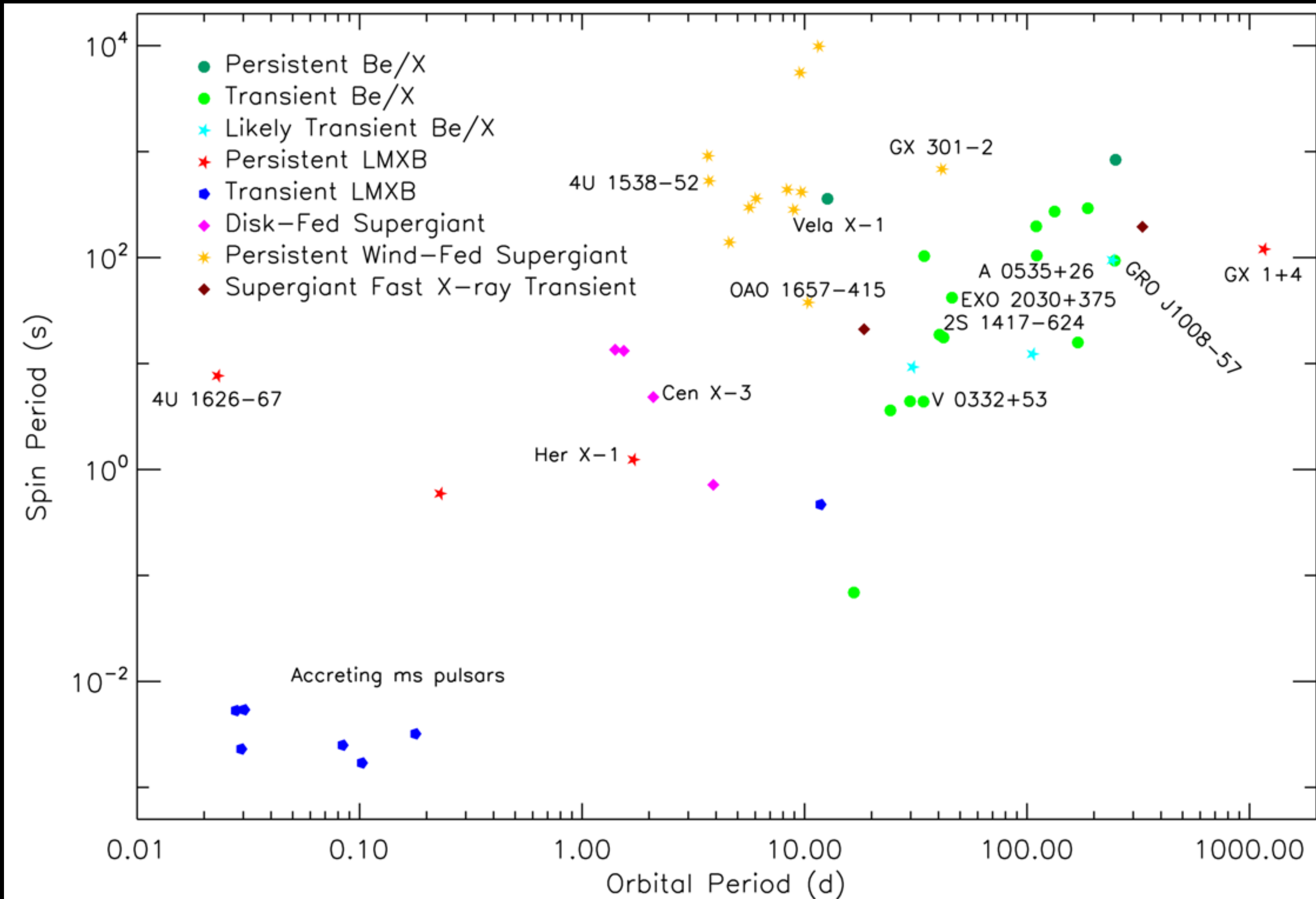
Pulse Searches

We have implemented two different pulse search strategies:

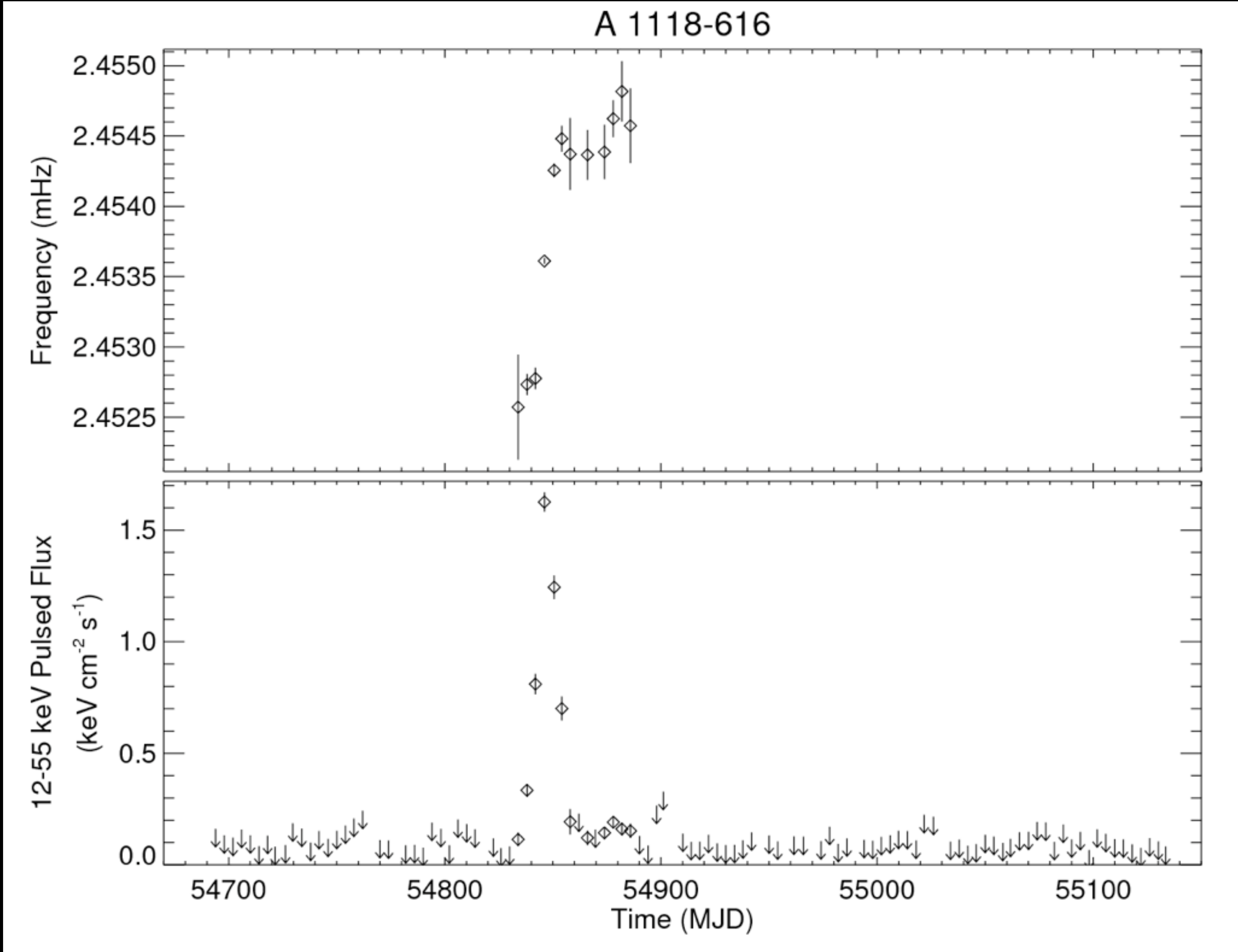
- Daily Blind Search. For this we compute fluxes from a days data for 24 source directions equally spaced on the galactic plane. For each direction we do an FFT based search from 1 mHz to 2 Hz.

- Source Specific Searches. These are searches over small ranges of frequency and sometimes frequency rate based on phase shifting and summing pulse profiles that are made from short intervals of data, using barycentered and possibly orbitally corrected times.

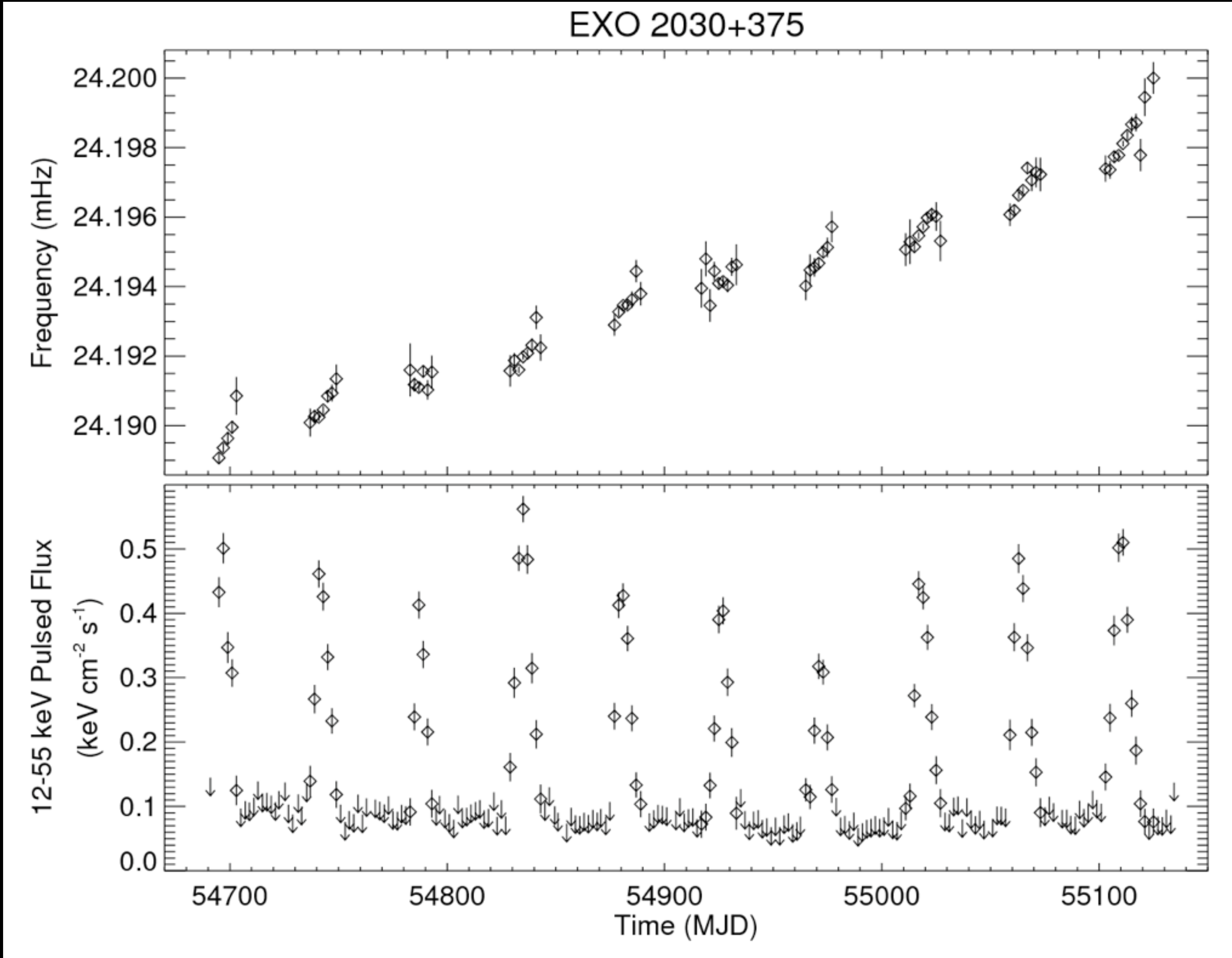
Detected Sources



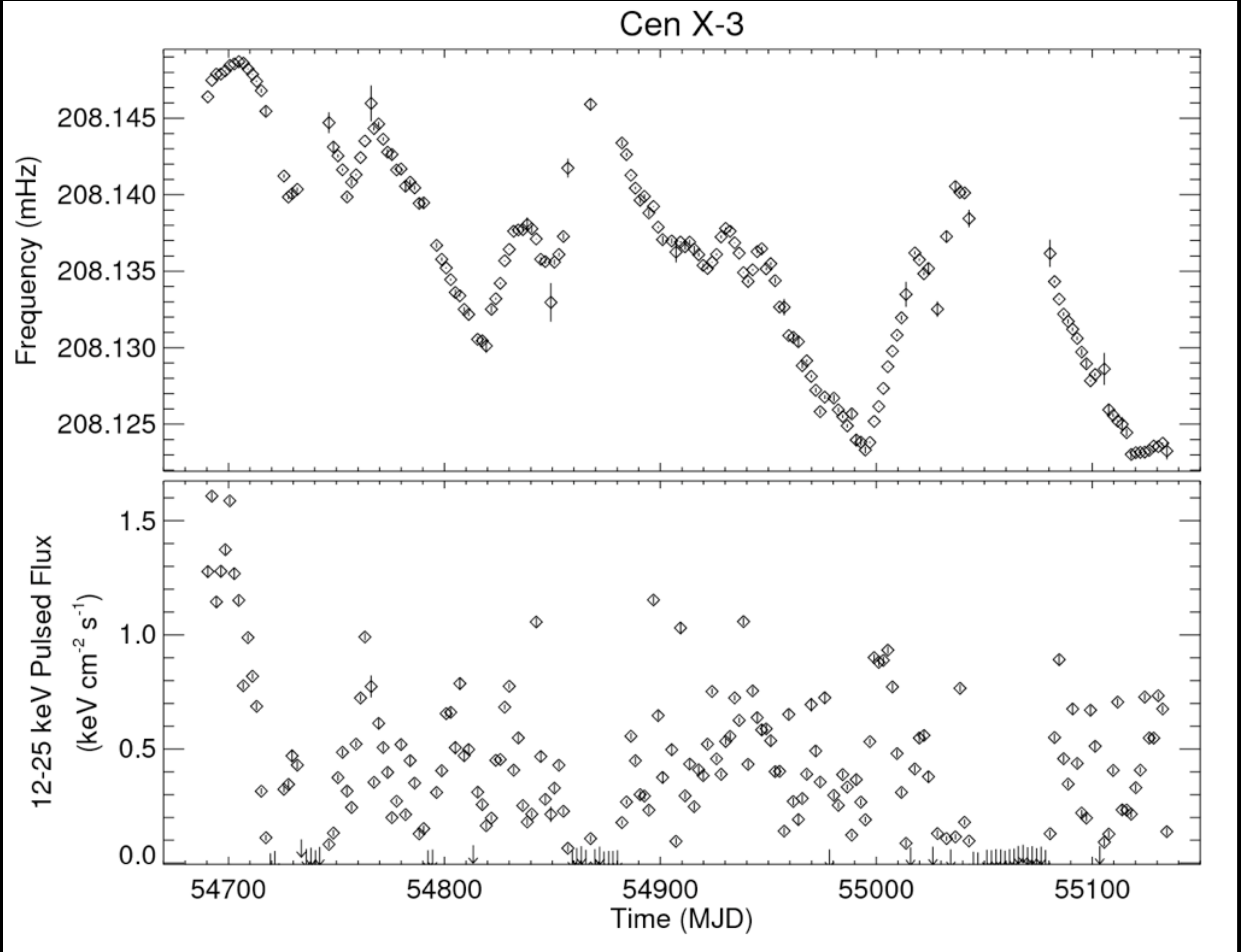
Unknown orbital periods: Cep X-4, A 1118-616, Swift J05131.4-6547 (in LMC) & MXB 0656-074



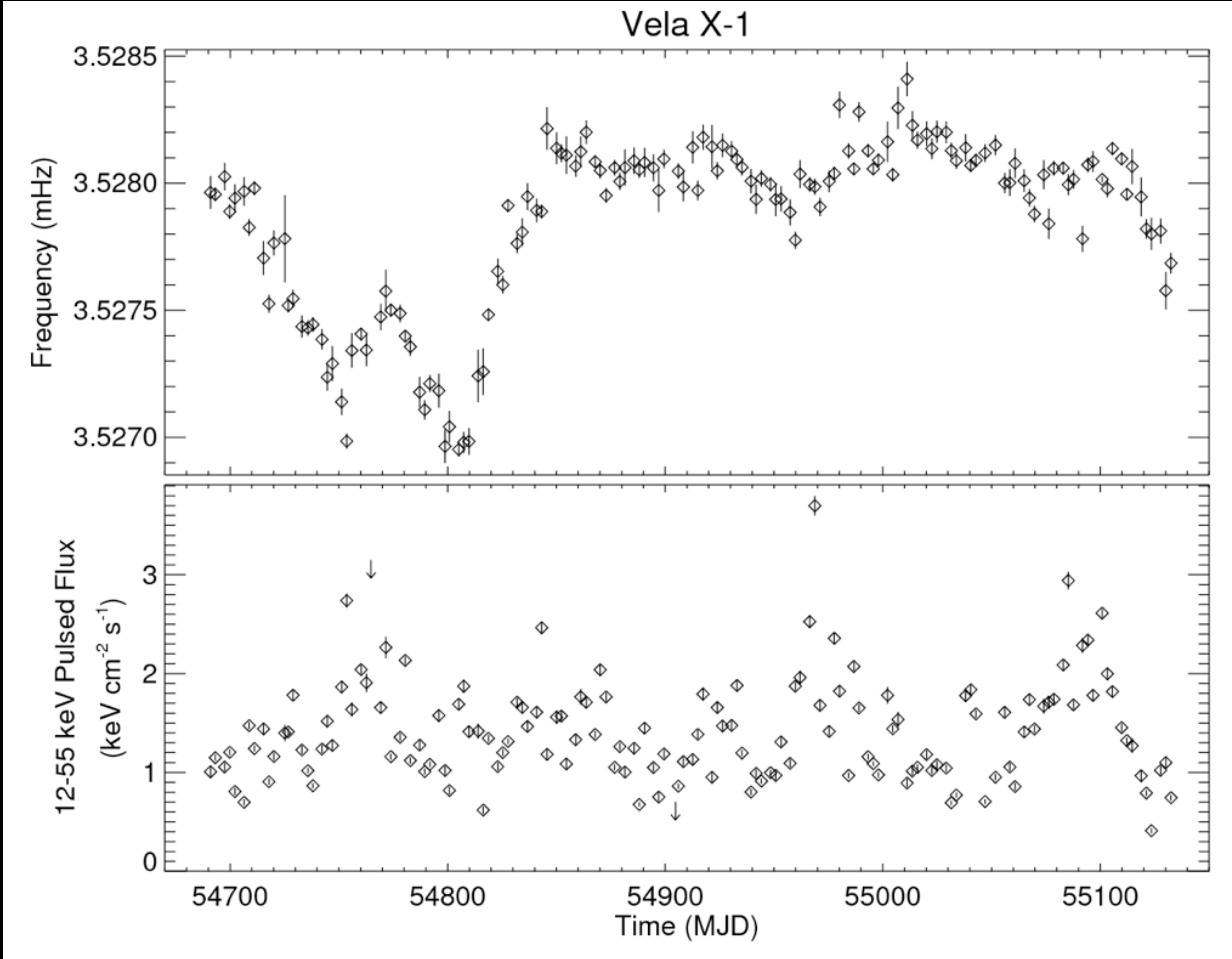
Be/X-ray binary P_{orbit} unknown P_{spin} = 407.6 s



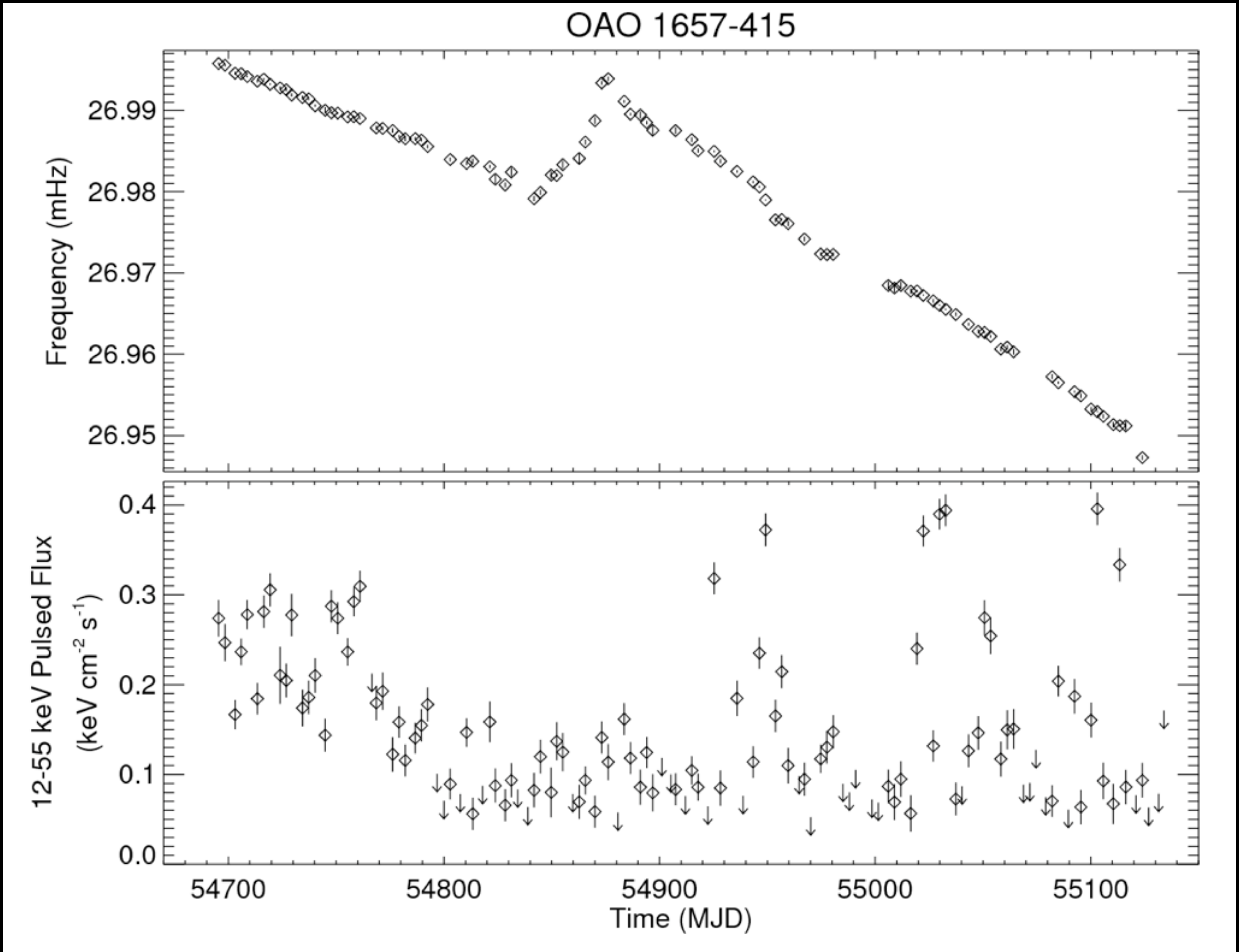
Be/X-ray binary $P_{orbit} = 46.0$ d $P_{spin} = 41.3$ s



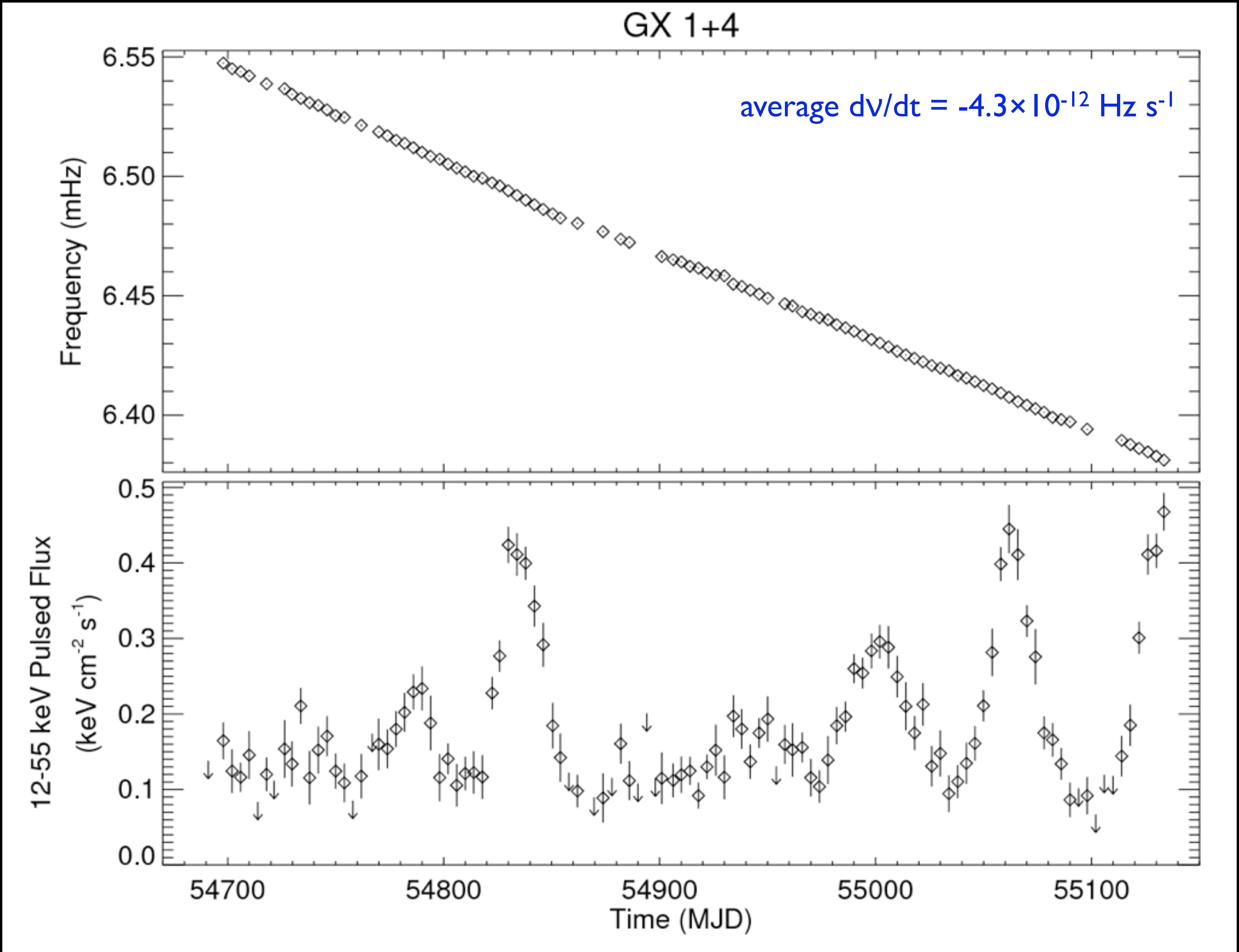
Disk-Fed Supergiant P_{orbit} = 46.0 d P_{spin} = 41.3 s



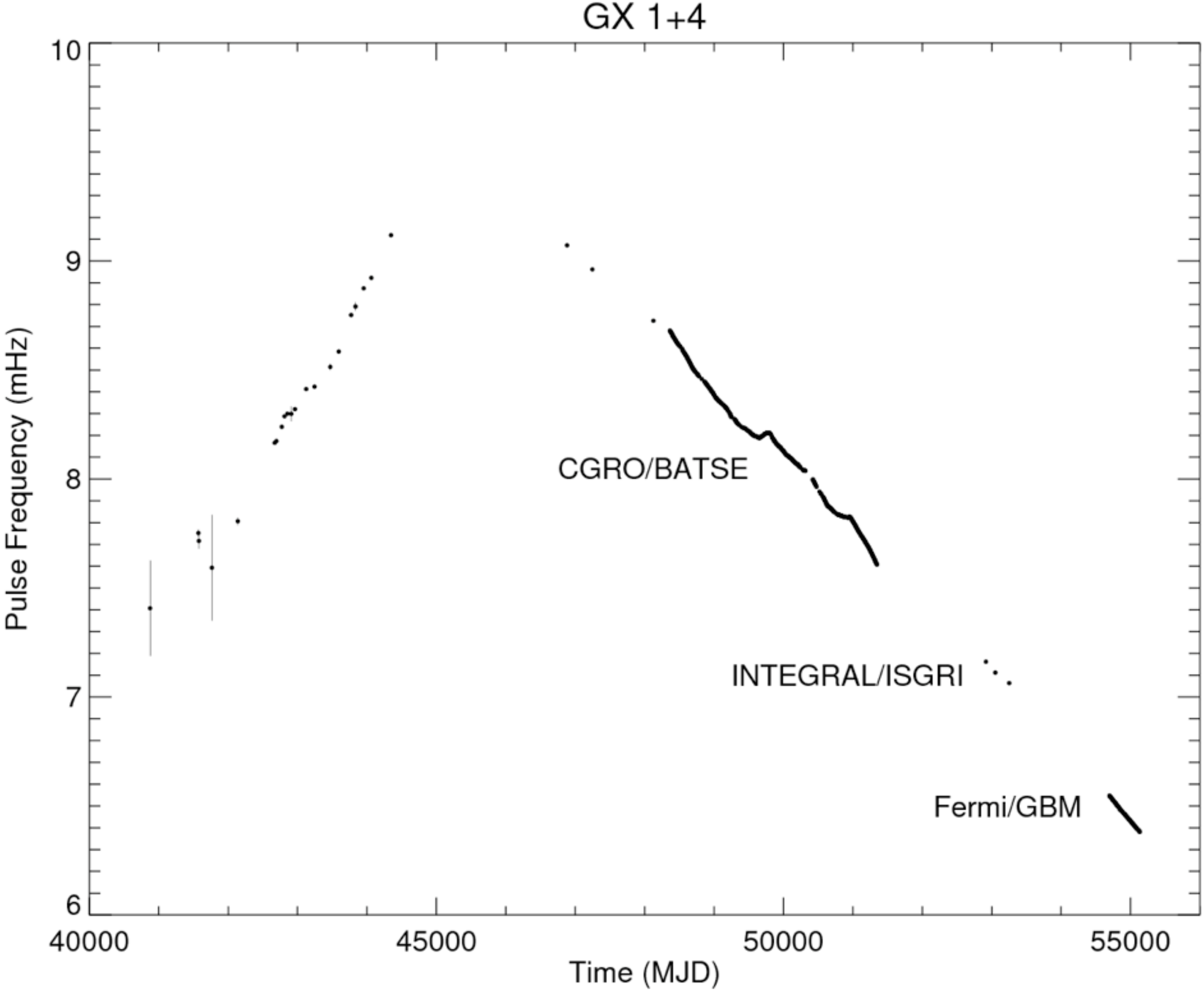
Wind-Fed Supergiant P_{orbit} = 8.96 d P_{spin} = 283 s



Wind-Fed Supergiant P_{orbit} = 10.45 d P_{spin} = 37.1 s



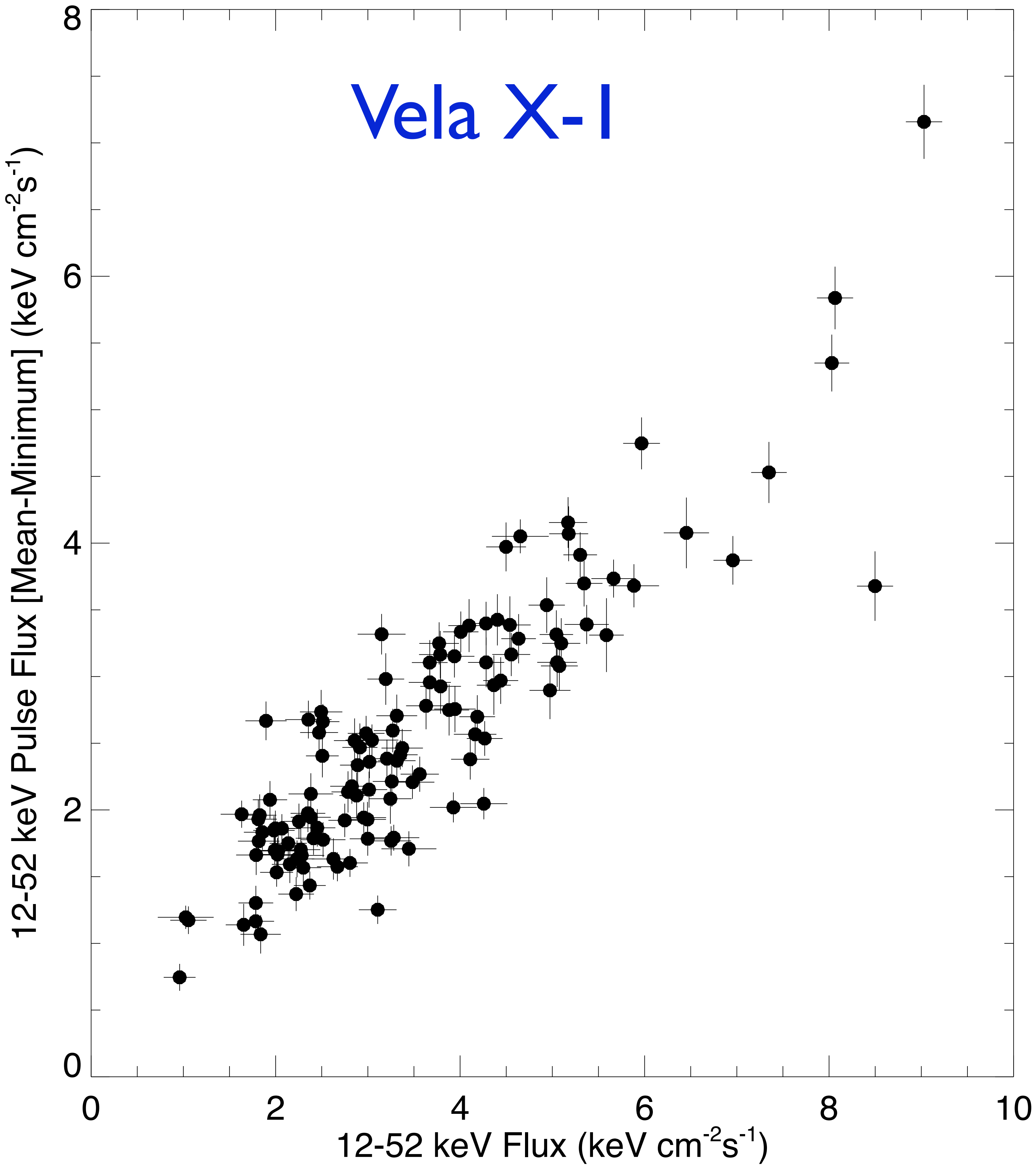
Persistent LMXB (Symbiotic Binary) P_{orbit} = 1161 d P_{spin} = 155 s



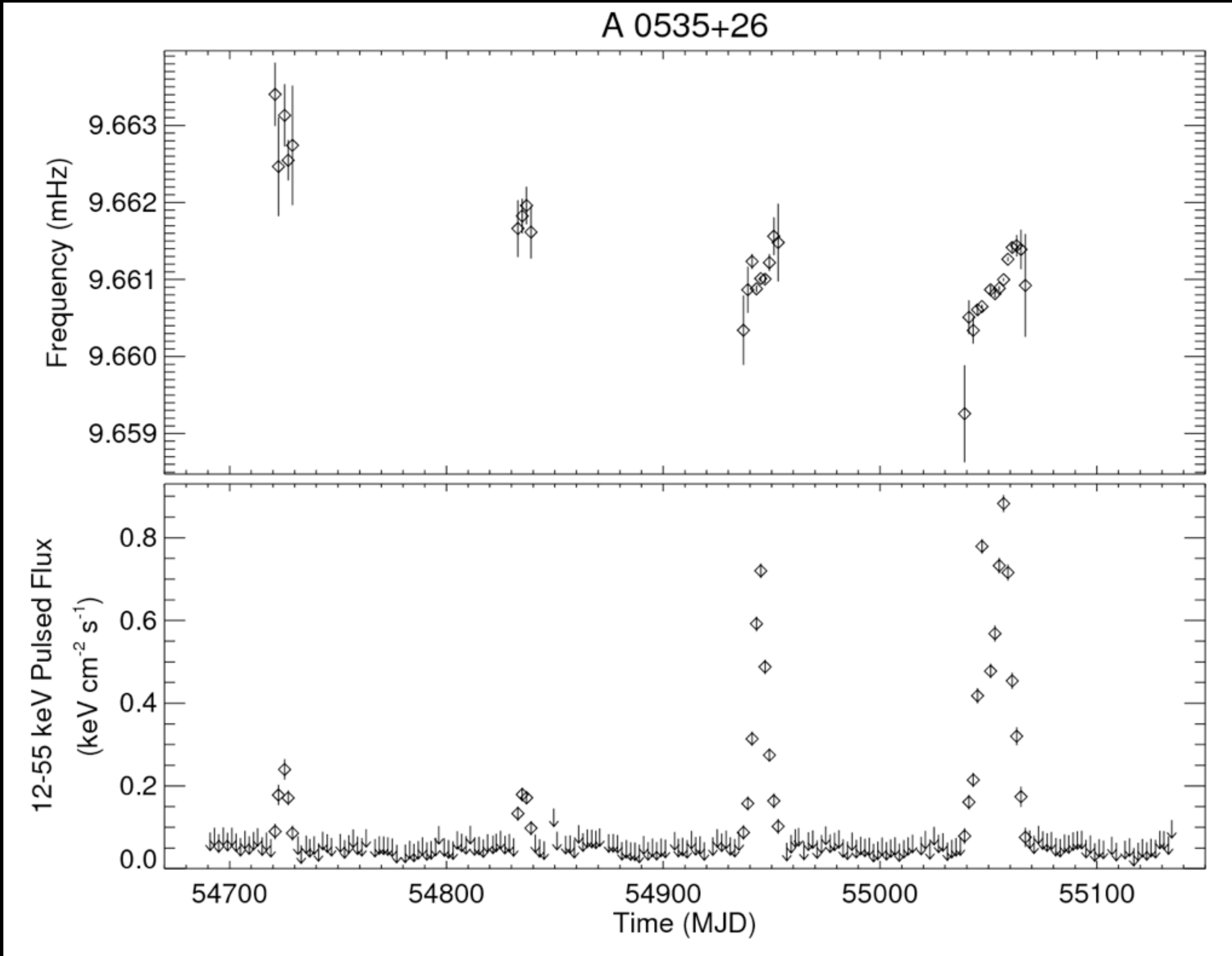
GX 1+4
Pulse Frequency (mHz)
Time (MJD)
CGRO/BATSE
INTEGRAL/ISGRI
Fermi/GBM
10
9
8
7
6
40000
45000
50000
55000

Projects In Progress

- A study of spin-up in normal outburst of A 0535+26.
- Determining new orbital element for Cen X-3, Vela X-1, OAO 1657-415, and GX 301-2, looking for orbital evolution.
- Tracking the 30 mHz QPO of GRS 1915+105 which frequently appears in our pulsar blind searches.
- Automation of our data screening process.
- End to end testing of our pulsar analysis using simulated data.



Since our background subtraction removes the phase averaged flux, this must be determined from Earth occultation measurements. The figure show the correlation between pulsed flux and the flux from Earth occulations for Vela X-1.



Be/X-ray binary P_{orbit} = 111.1 d P_{spin} = 103.5 s