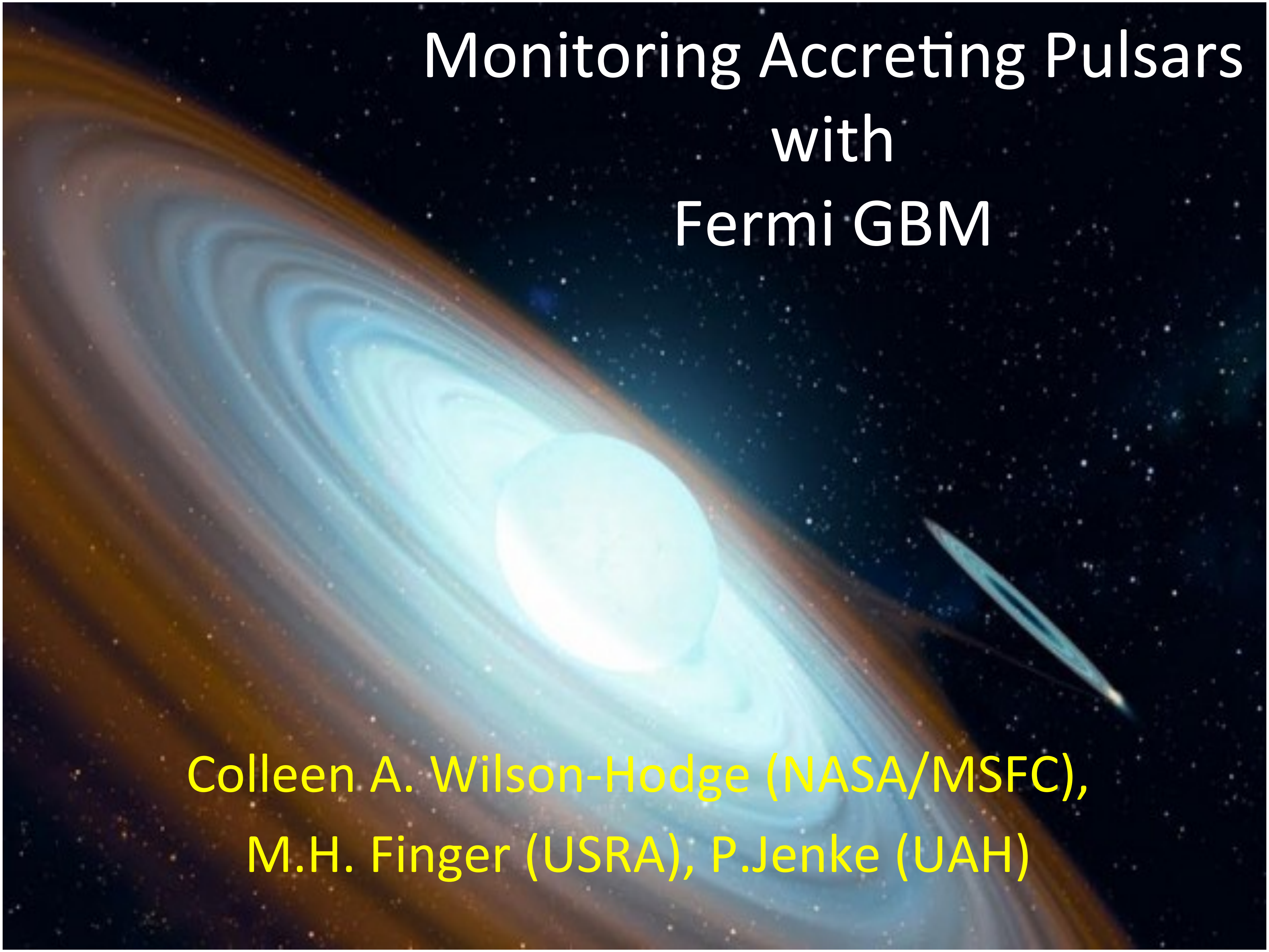
Monitoring Accreting Pulsars with Fermi GBM



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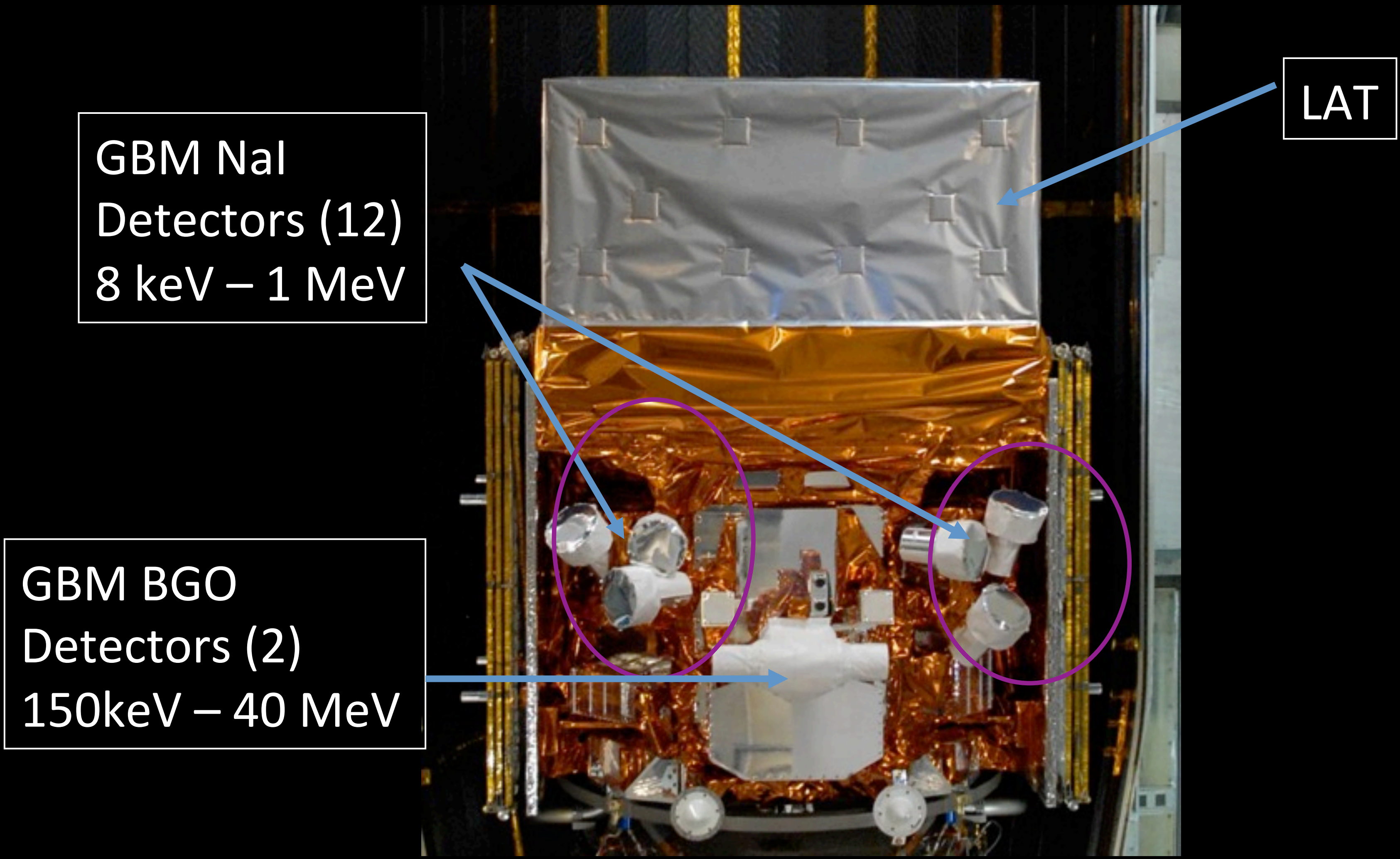
Talk Outline

- Introduction
  - Fermi GBM
  - Techniques
- Sources – Be X-ray binaries
  - XTE J1946+274
  - EXO 2030+375
  - V0332+53
- Summary and Conclusions

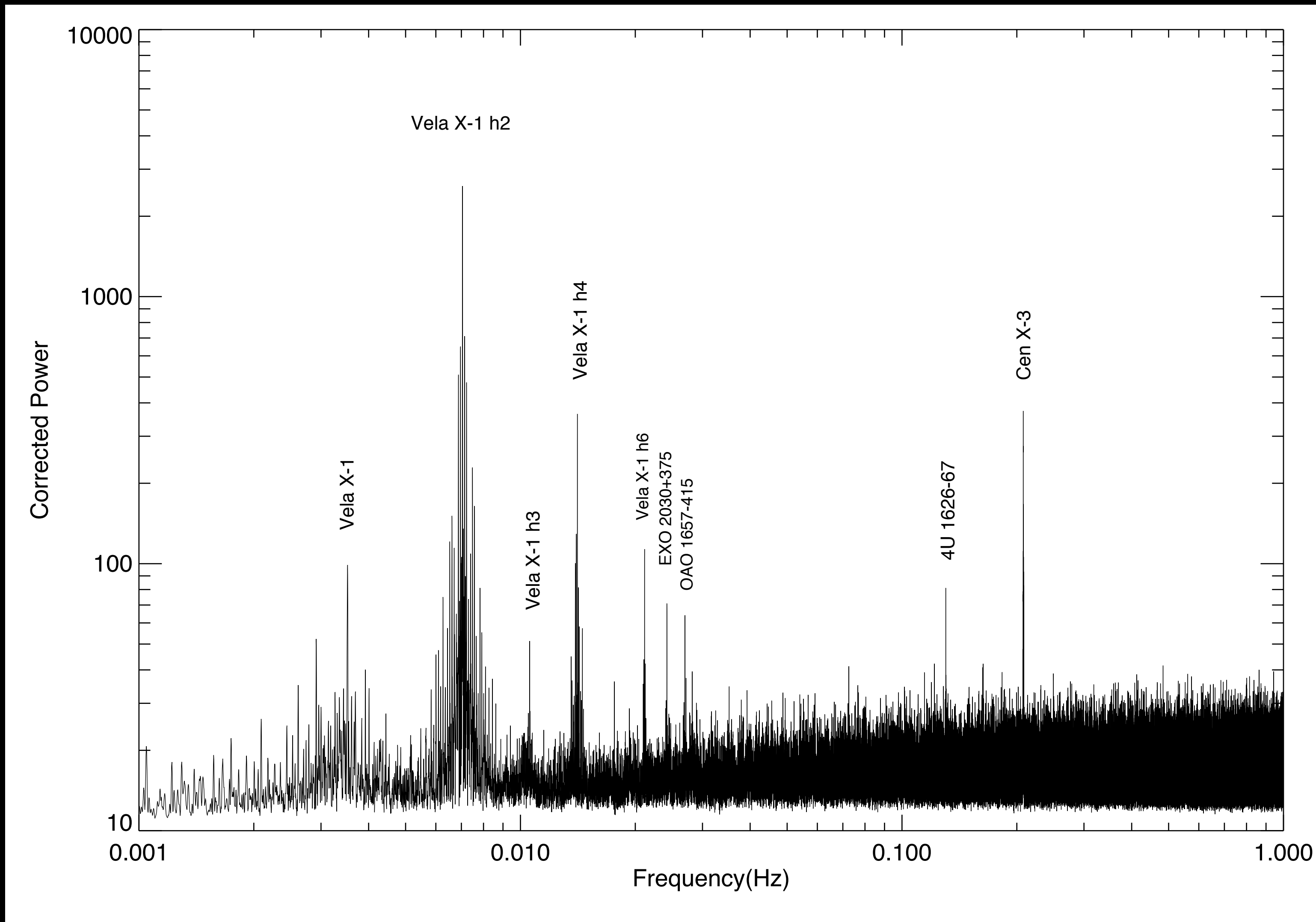
Fermi Gamma Ray Burst Monitor (GBM)



GBM Pulse Searches

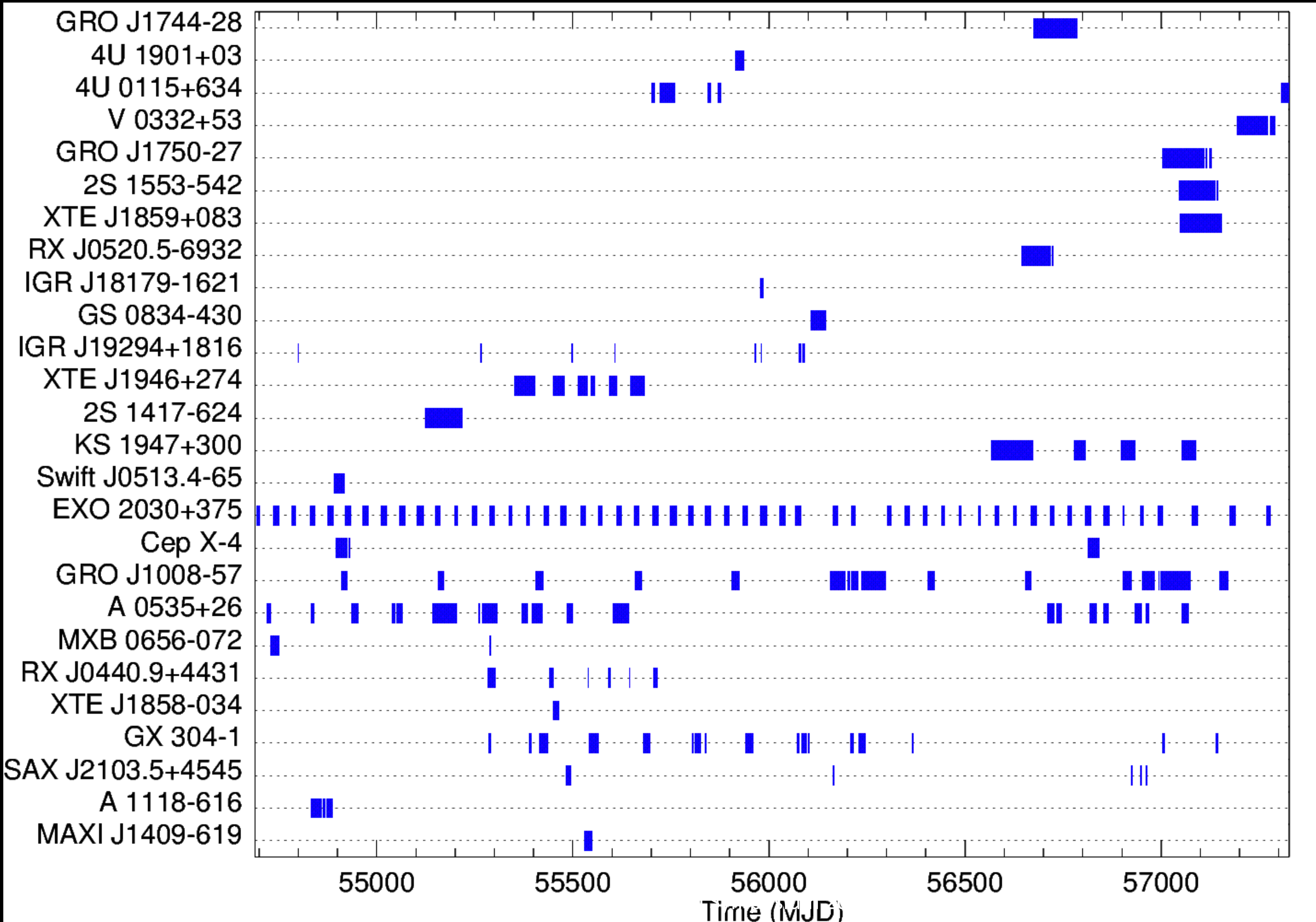
- Daily Blind Search
  - 24 source directions equally spaced on the galactic plane + LMC and SMC.
  - Each direction - FFT based search from 1 mHz to 2 Hz.
- Source Specific Searches.
  - Small ranges of frequency and frequency derivative
  - Phase shifting and summing pulse profiles from short intervals of data
  - Barycentered and possibly orbitally corrected times.
  - Typical exposure times are ~40 ks/day.
- Detections – Total of 37 systems monitored
  - 8 of 8 persistent sources
  - 26 of 29 transients

Blind Pulse Search

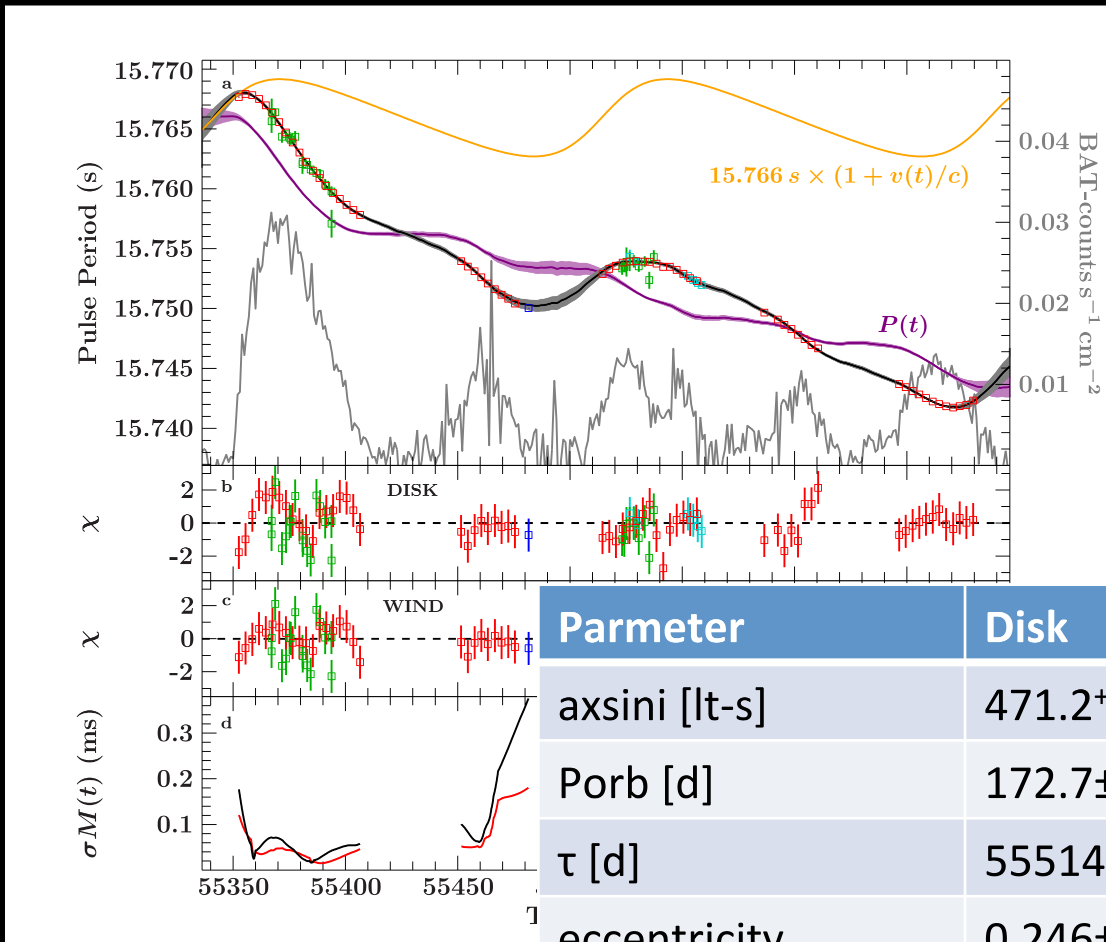


Blind pulse search in 20-50 keV band, for 2010 January 8.

http://gammaray.nsstc.nasa.gov/gbm/science/pulsars



XTE J1946+274 –New Orbital Solution



- Discovered with RXTE in 1998
- 15.8 s pulsations with BATSE
- Active 1998-2001, 2010-11
- GBM (red) – spin periods, RXTE (green), Swift/BAT (grey) – fluxes
- 2-3 outbursts per orbit
- GBM data crucial to orbit determination

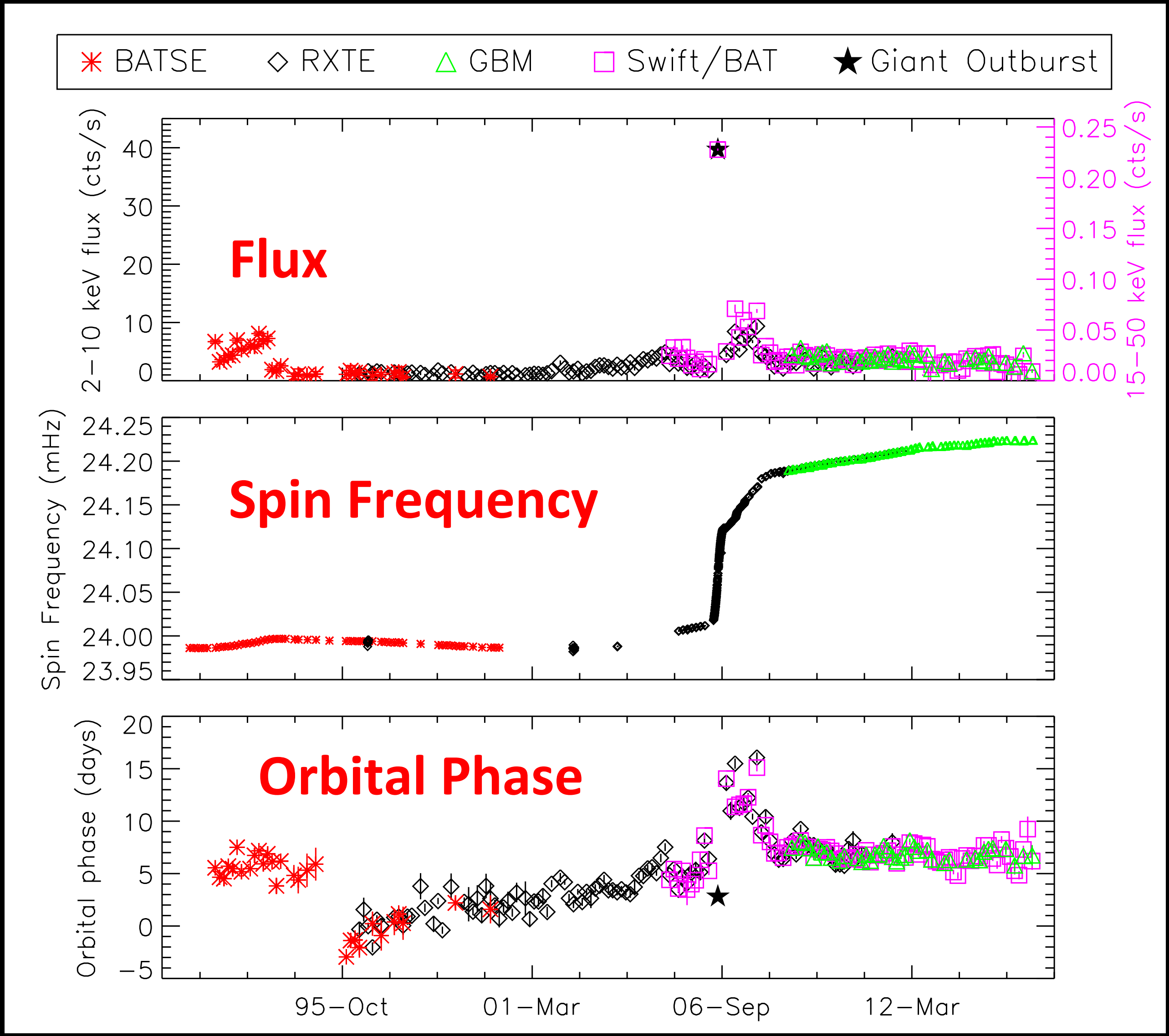
Parmeter	Disk	Wind
axsini [lt-s]	$471.2^{+2.6}_{-4.3}$	$471.1^{+2.7}_{-2.8}$
Porb [d]	172.7±0.6	171.4±0.4
τ [d]	$55514.8^{+0.8}_{-1.1}$	$555515.5^{+0.8}_{-0.7}$
eccentricity	0.246±0.009	0.266±0.007
ω (°)	$-87.4^{+1.5}_{-1.7}$	$-87.1^{+1.2}_{-1.0}$

Marcu-Cheatham, D. et al. 2015, ApJ in press, arXiv:1510.05032v1

EXO 2030+375 (P_s= 42 s, P_{orb} = 46 d)

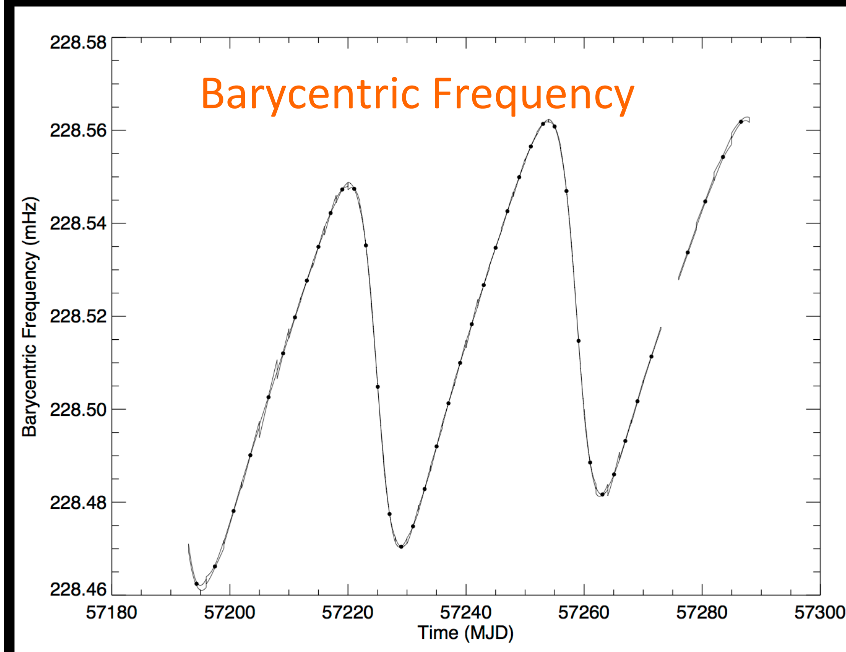
- Discovered during a giant outburst in 1985 with EXOSAT; Second giant outburst in 2006 (RXTE)
- Transitioned to spin down in 1995; In 2014, transitioned to neither spin-up or spin down (frequencies flattened)
- Abruptly shifted in outburst orbital phase in 1995 accompanied by drop in outburst flux; in 2015, ouburst flux has again dropped.
- Detected in outburst at nearly every periastron passage since 1991, unlike most Be X-ray binaries.
- Correlated peak flux and orbital phase of outburst peak – delay of accretion from Be disk onto NS due to accretion disk?

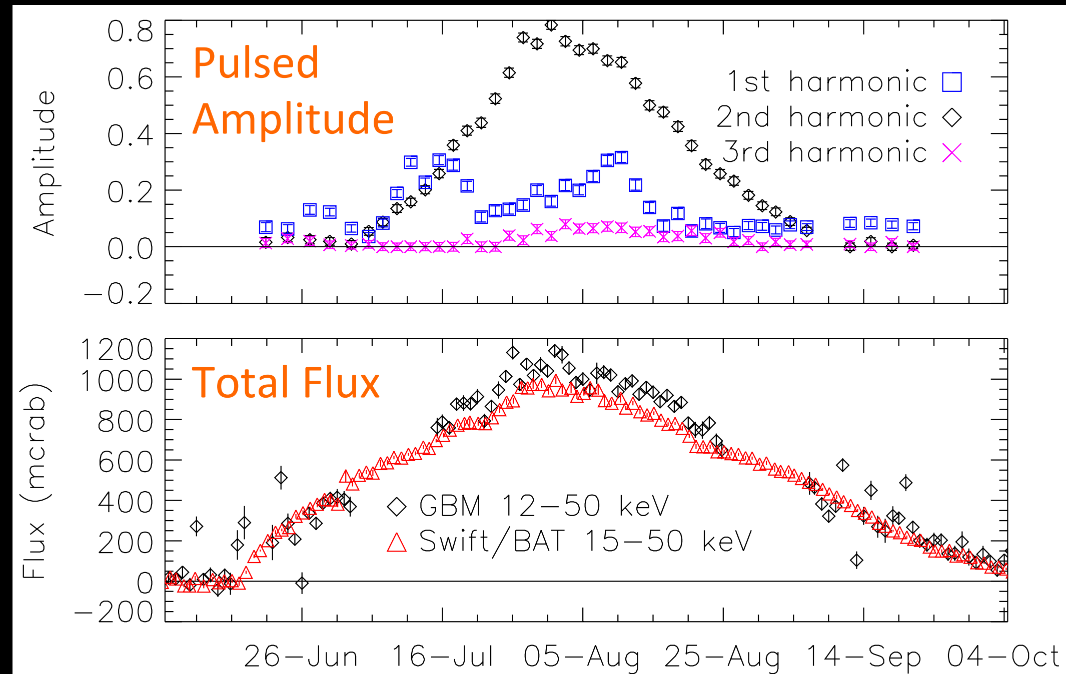
EXO 2030+375 Long Term Behavior



Time (date)

GBM Observations of V0332+53





- V0332+53 – 4.3 s pulsar orbiting an O8-9Ve star in a 34.25 d orbit
- Major outbursts in 1983, 1989, 2004 and 2015
- Current outburst shows considerable pulse profile evolution
- Existing orbital solutions do not propogate well to 2015 outburst
- New orbital analysis in progress

Summary and Conclusions

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

- Detection and study of new transient sources or new outbursts of known transients.
- Precise measurements of spin frequencies and orbital parameters (e.g. XTE J1946+274, soon for V0332+53)
- Study of spin-up or spin-down rates and hence the flow of angular momentum and accretion disk physics
- Observations of unexpected and long-term outburst behaviors (e.g. possible ~20 year cycle in EXO 2030+375)

GBM Pulsar Project
http://gammaray.nsstc.nasa.gov/gbm/science/pulsars/

GBM Earth Occultation Project
http://heastro.phys.lsu.edu/gbm

Future directions

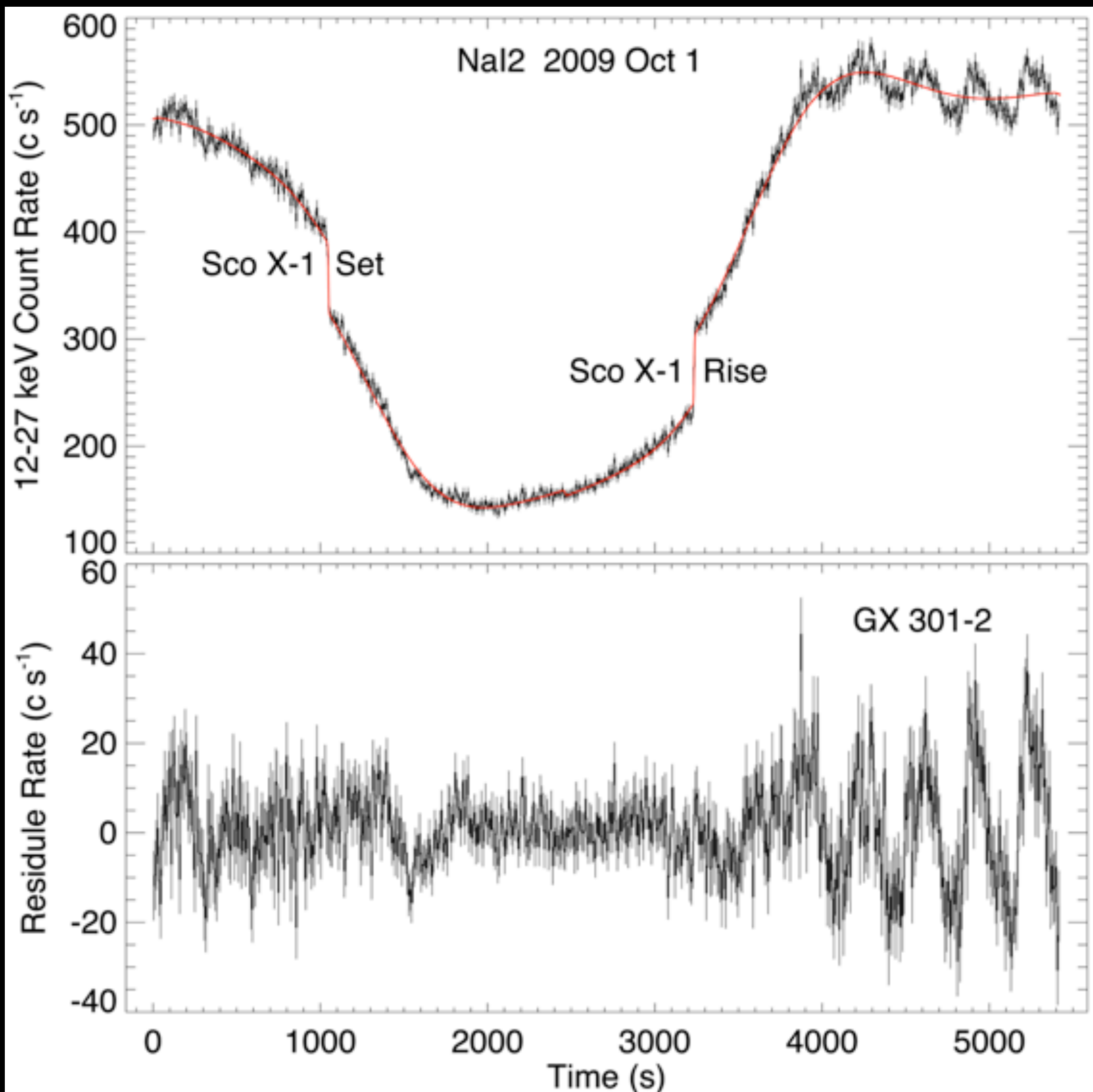
– What can we learn from classical accreting pulsars in Be X-ray binaries to futher our understanding of gamma-ray Be binaries?

Many Thanks to the GBM Pulsar Team!

– C.A. Wilson-Hodge (PI), Mark H. Finger, E. Beklen, P.N. Bhat, D. Buckley, A. Camero-Arranz, M.J. Coe, V. Connaughton, P. Jenke, G. Kanbach, I. Negueruela, W.S. Paciesas

Backup

Background Subtraction



The rates in each channel of the 12 NaI detectors are 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.