

Some scarcely known X-ray pulsars

Ingo Kreykenbohm
Dr. Karl Remeis Observatory

F. Fürst, M. Kühnel, L. Barrágan, J. Wilms, R. E. Rothschild

Tübingen, July 16, 2010

(un)known Sources

Very well **known** sources:

- Vela X-1
- Her X-1
- transients like
 - A0535+263
 - 4U 0115+63
- (bright) Uhuru sources

(un)known Sources

Very well **known** sources:

- Vela X-1
- Her X-1
- transients like
 - A0535+263
 - 4U 0115+63
- (bright) Uhuru sources

unknown sources:

- very dim
- need XMM/Chandra
- most AGNs etc

(un)known Sources

Very well **known** sources:

- Vela X-1
- Her X-1
- transients like
 - A0535+263
 - 4U 0115+63
- (bright) Uhuru sources



unknown sources:

- very dim
- need XMM/Chandra
- most AGNs etc

imagine...

a source that

- is reasonably bright
- is persistent
- has been discovered in the early days

imagine...

a source that

- is reasonably bright
- is persistent
- has been discovered in the early days

and that **NOBODY** ever looked at?

4U 1909+07

- discovered with Uhuru (Giacconi et al. 1974)
as 3U 1912+07

4U 1909+07

- discovered with Uhuru (Giacconi et al. 1974)
as 3U 1912+07
- up to 50 mCrab

4U 1909+07

- discovered with Uhuru (Giacconi et al. 1974)
as 3U 1912+07
- up to 50 mCrab
- ?

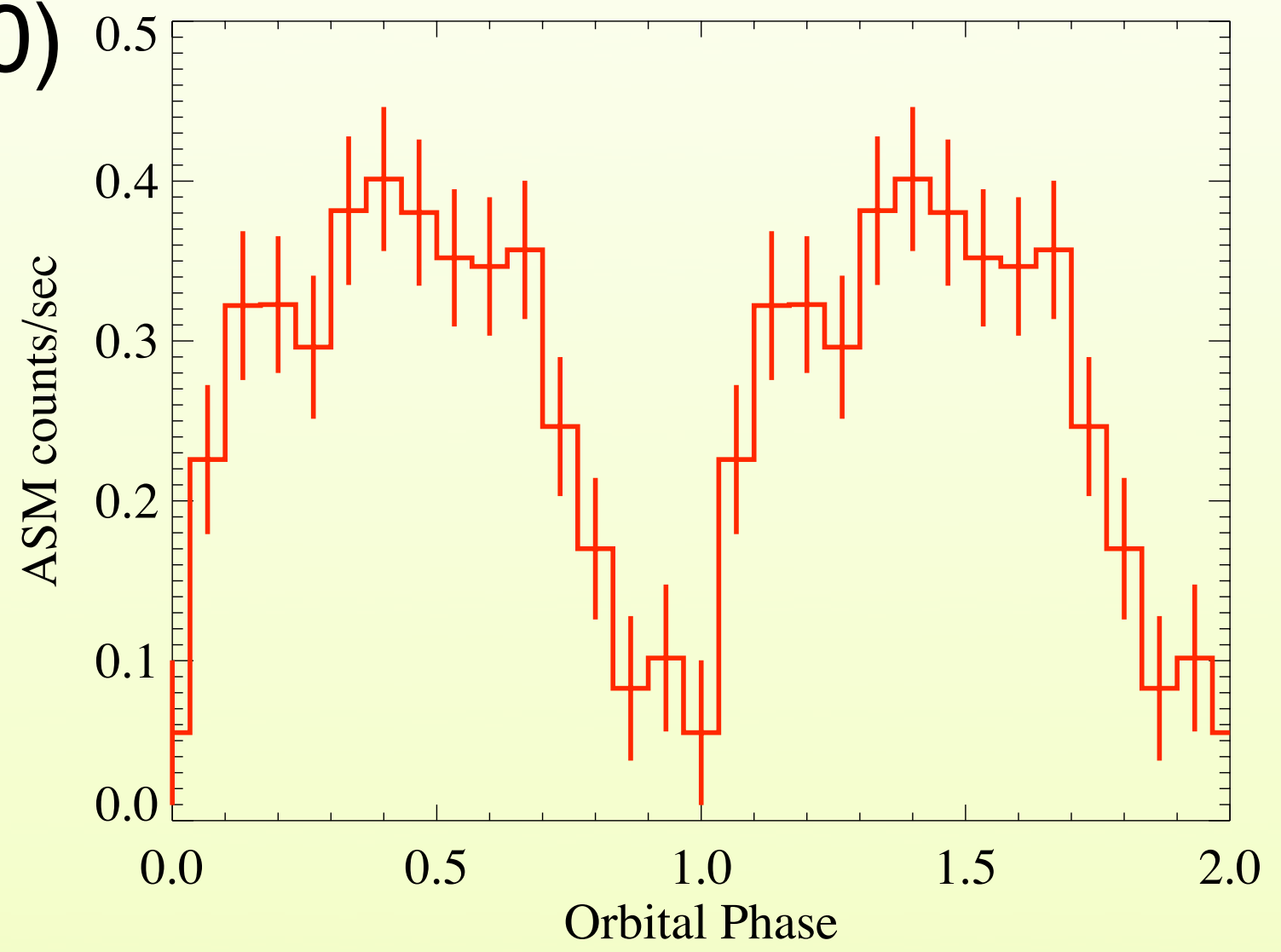
4U 1909+07

- discovered with Uhuru (Giacconi et al. 1974) as 3U 1912+07
- up to 50 mCrab
- ?

- that's it for the next >25 years!

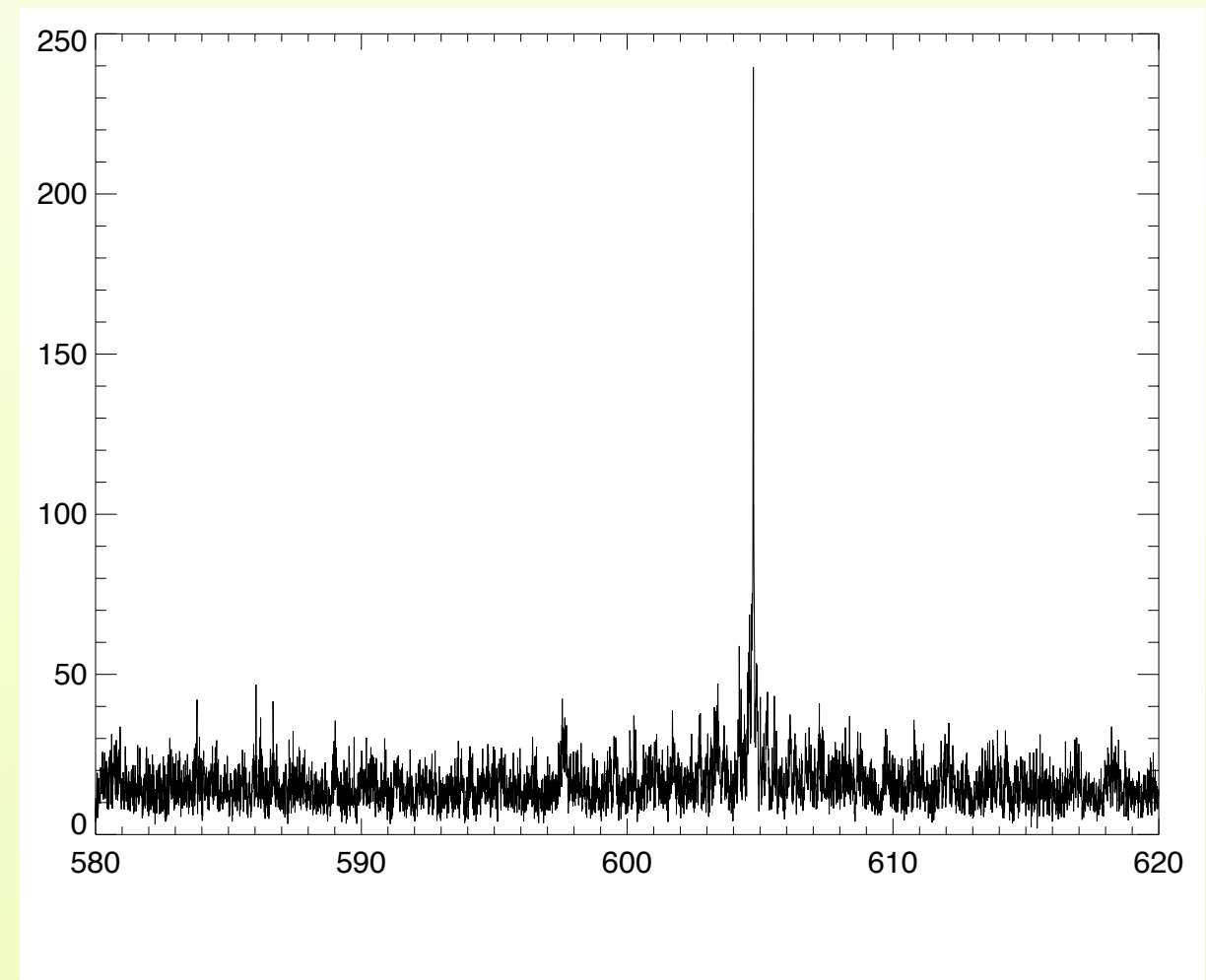
4U 1909+07

- 4.4 d orbit detected with RXTE/ASM
(Wen et al. 2000)



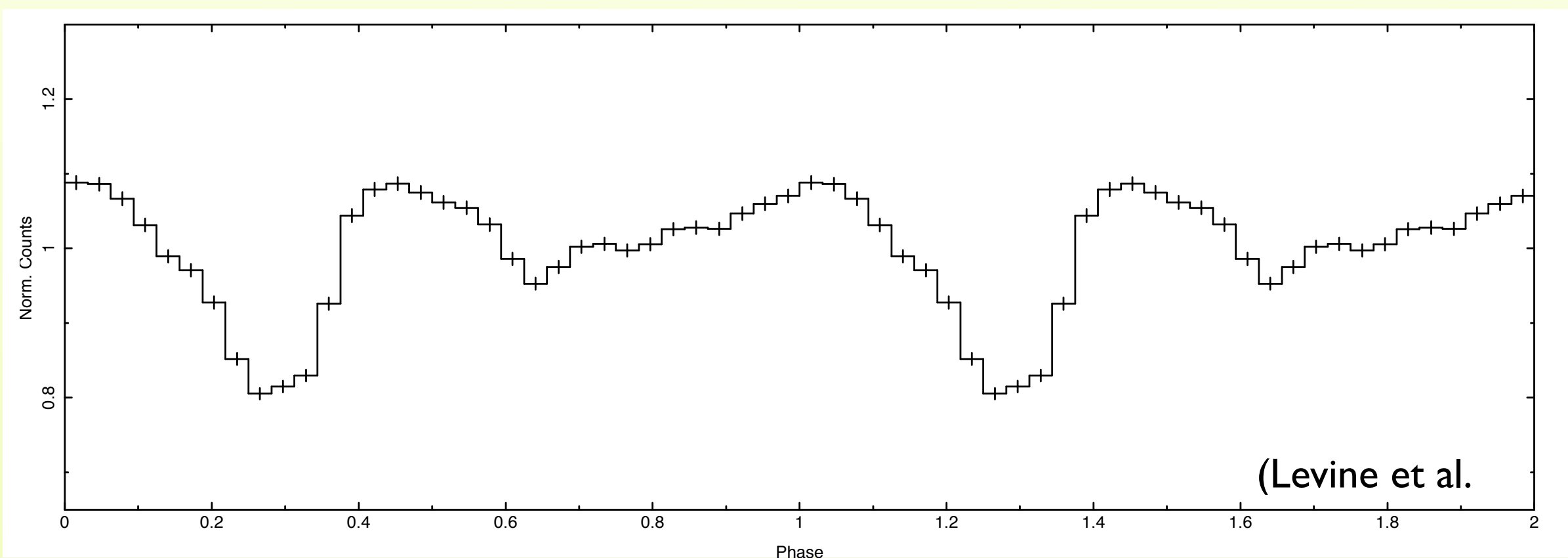
4U 1909+07

- **4.4 d** orbit detected with RXTE/ASM
(Wen et al. 2000)
- **605 s** pulse period discovered with RXTE/PCA
(Levine et al. 2004a)



4U 1909+07

- **4.4 d** orbit detected with RXTE/ASM (Wen et al. 2000)
- **605 s** pulse period discovered with RXTE/PCA (Levine et al. 2004a)



4U 1909+07

- **4.4 d** orbit detected with RXTE/ASM (Wen et al. 2000)
- **605 s** pulse period discovered with RXTE/PCA (Levine et al. 2004a)
- companion identified in infrared as **OB star** with $M = 9-31 M_{\odot}$ (Morel et al. 2005a)

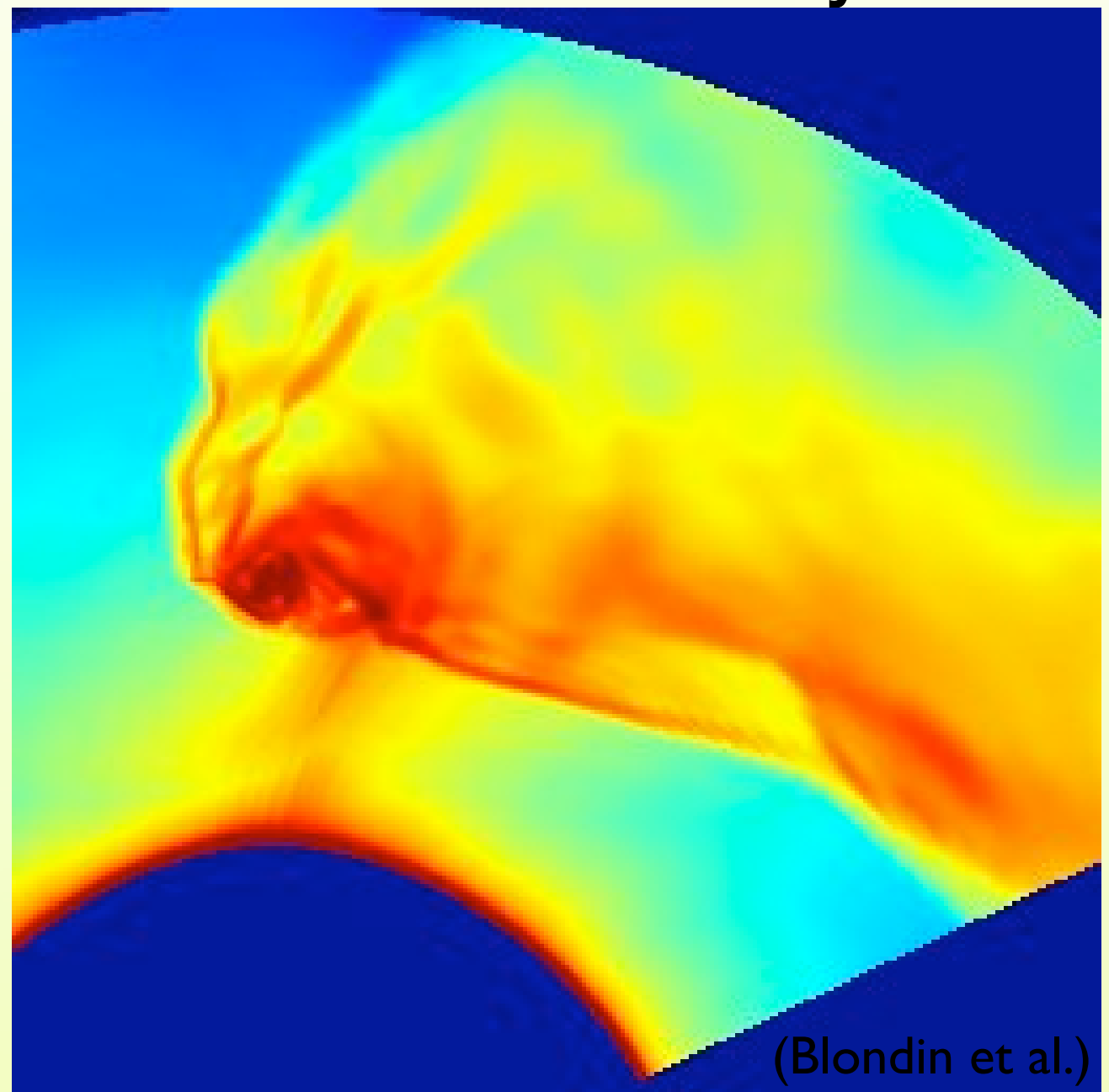
HMXBs

- young companion: dense wind $\sim 10^{-6} M_{\odot}/\text{year}$
- absorption!
- strong **magnetic** field
- wind is **structured!**
- shock fronts
- **strongly variable**



HMXBs

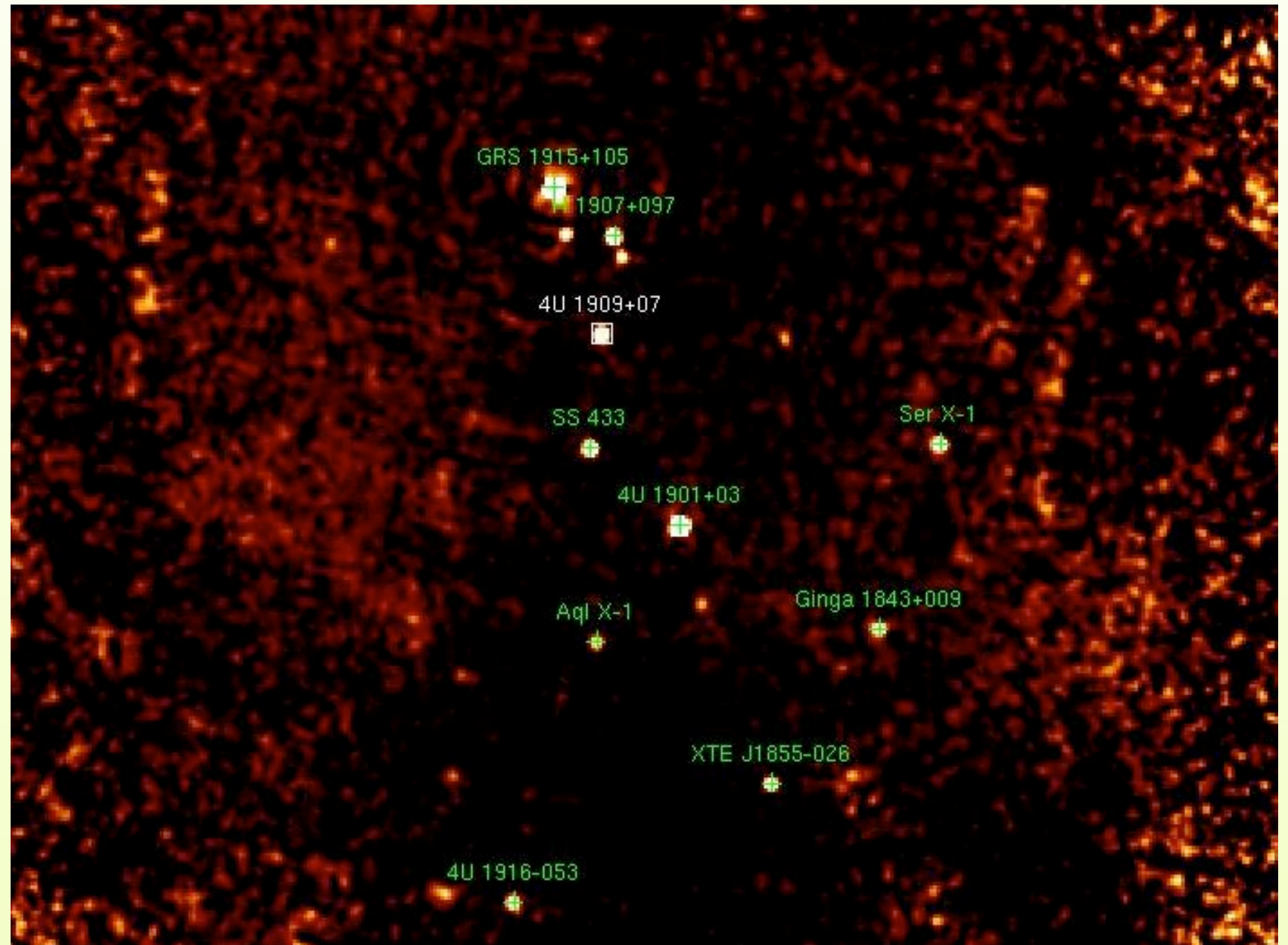
- young companion: dense wind $\sim 10^{-6} M_{\odot}/\text{year}$
- absorption!
- strong **magnetic** field
- wind is **structured!**
- shock fronts
- **strongly variable**



(Blondin et al.)

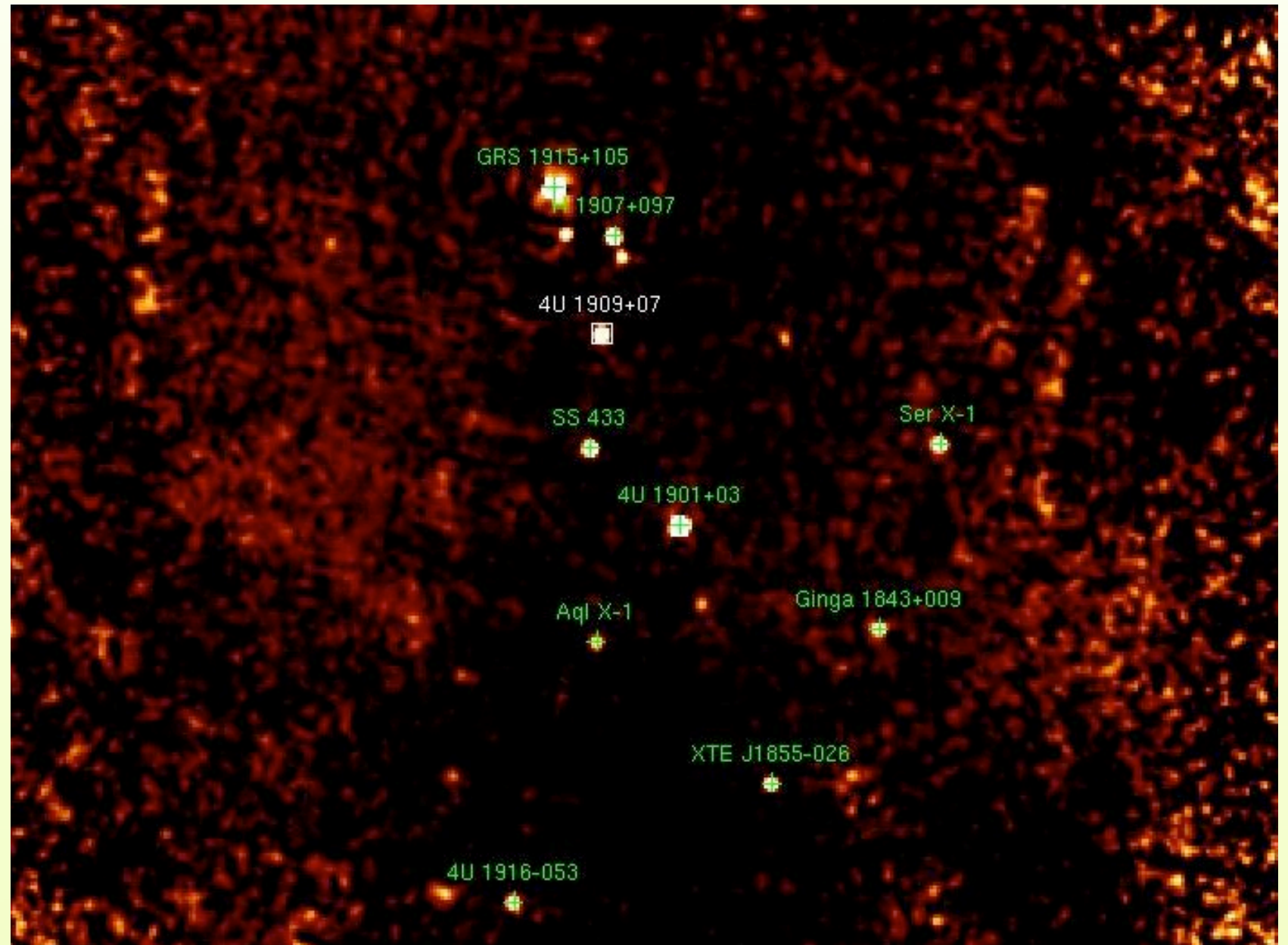
The Field

- **RXTE:**
 - Obs. in 2000 / 2003
 - 180 ksec



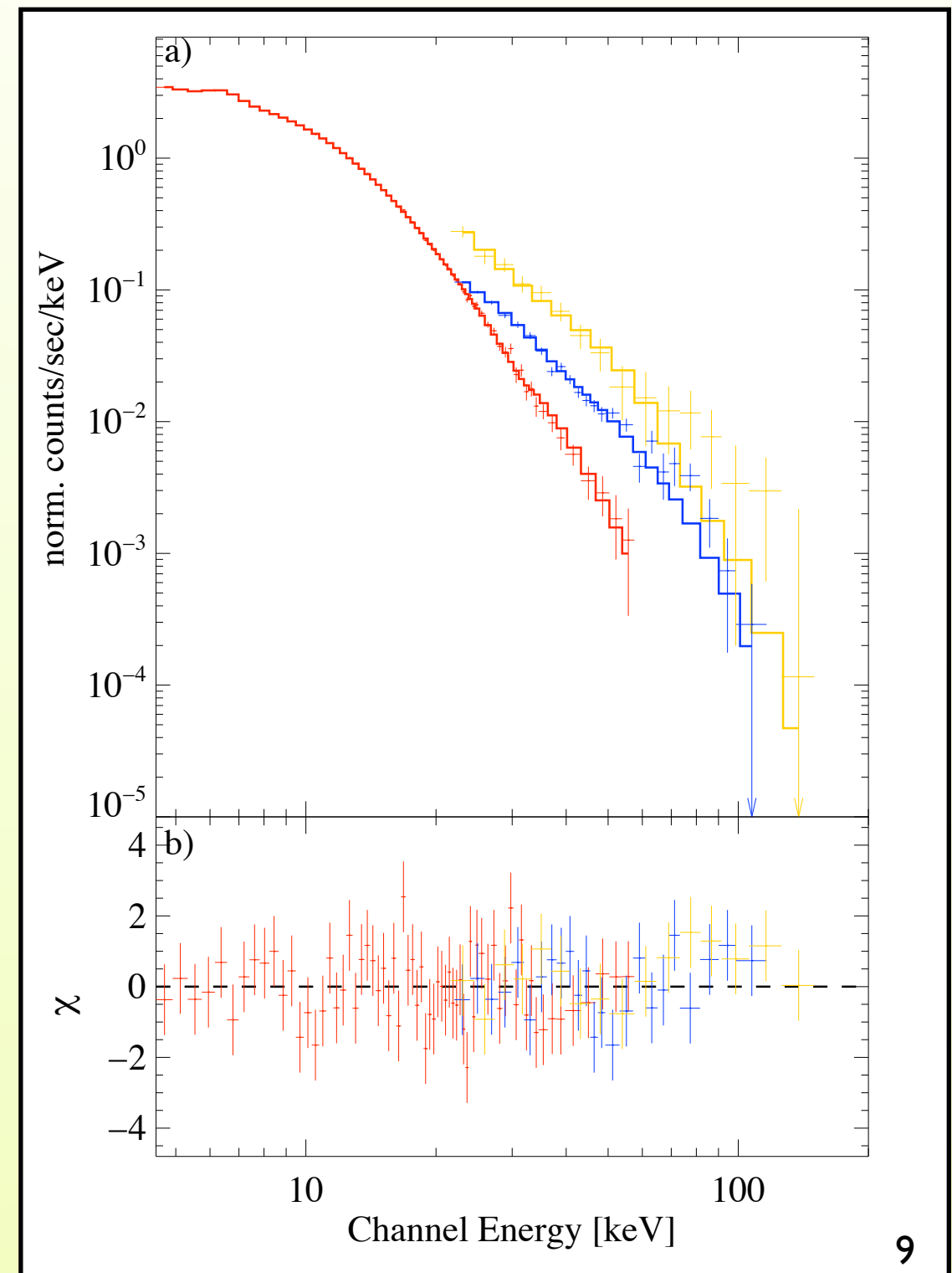
The Field

- **RXTE:**
 - Obs. in 2000 / 2003
 - 180 ksec
- **Integral:**
 - **> 7 Msec**
 - no pointed observations



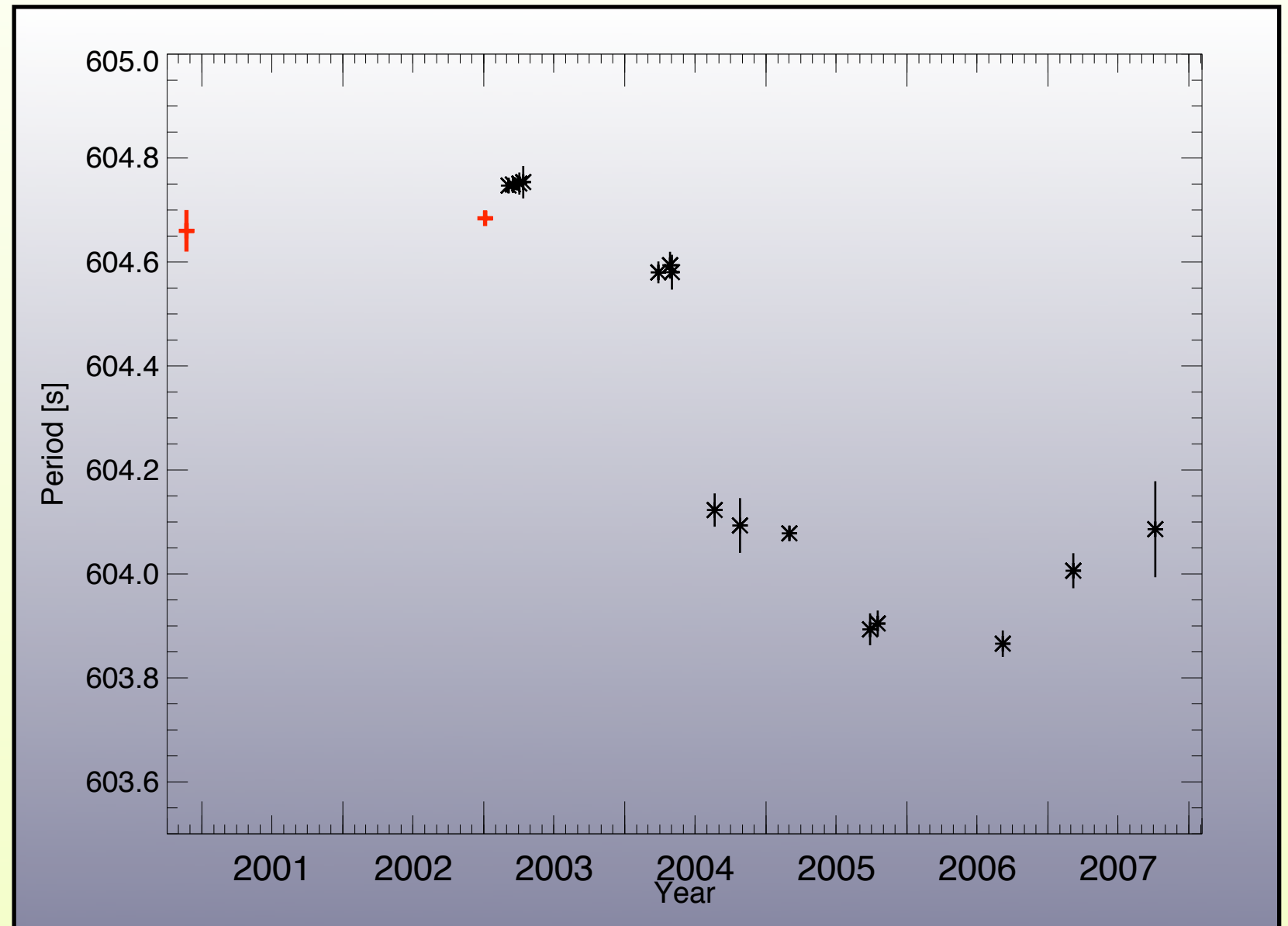
Spectrum

- RXTE PCA/HEXTE + Integral/ISGRI
- NH x cutoffpl + Fe-line
- **soft excess:**
additional bb required
- **no evidence for a cyclotron line**
- CRSF can be filled up
- $\chi_{\text{red}}=1.01$



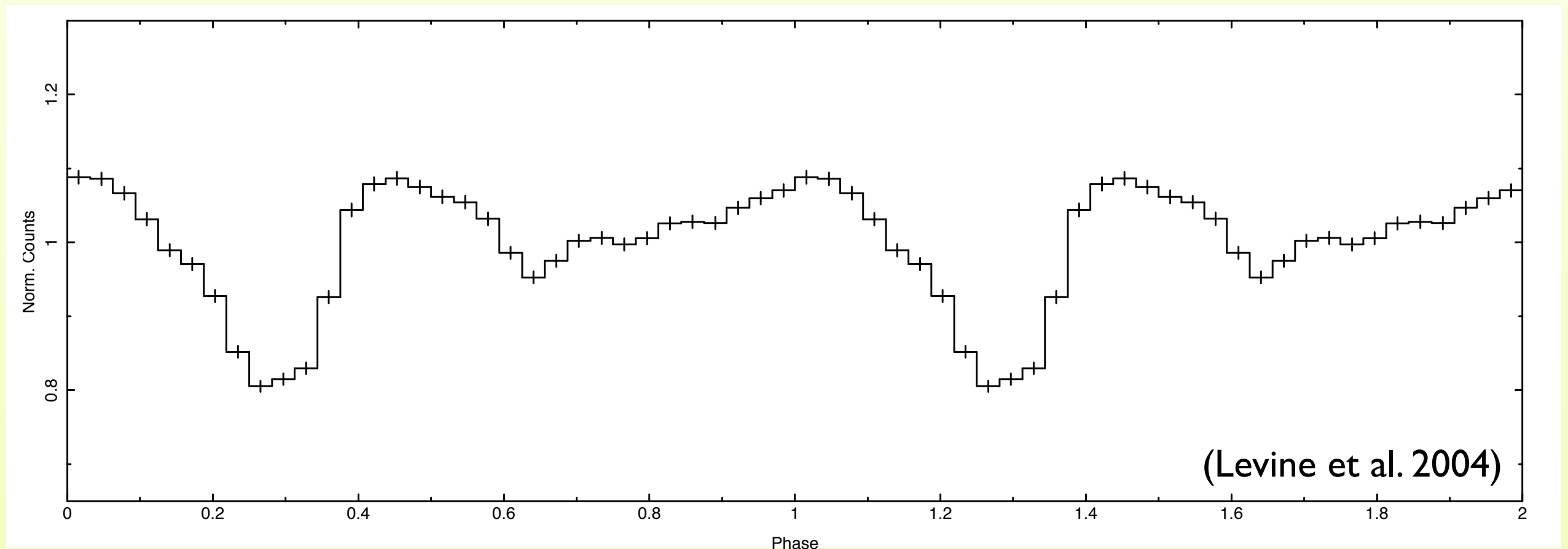
Period Evolution

- need 500 pulses for good determination
→ 300 ksec
- torque reversal?
- random walk
- similar to 4U1907+09

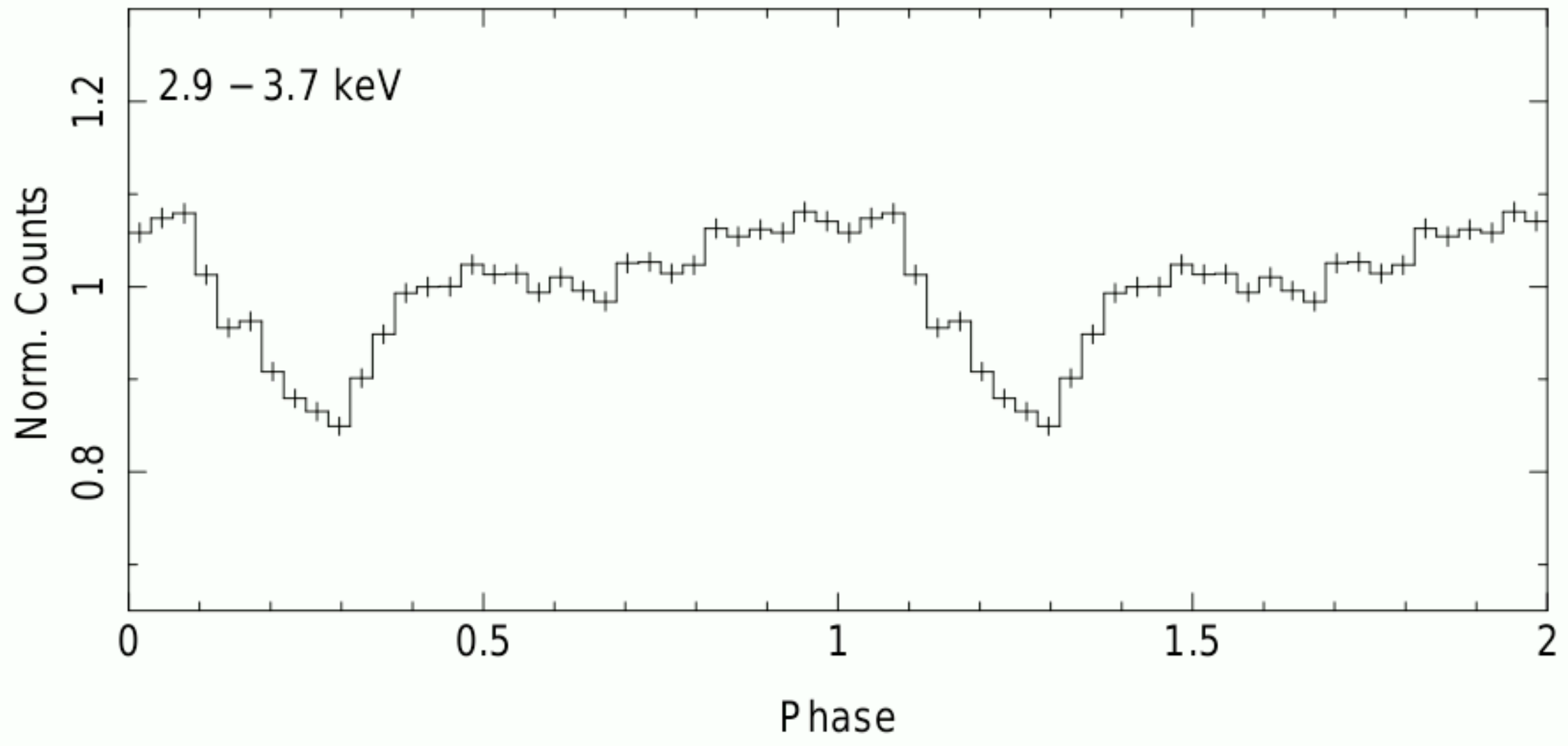


Pulse Profiles

- RXTE: average 3.7-17keV pulseprofile shows two-peaked shape
- pulses are separated by deep minimum

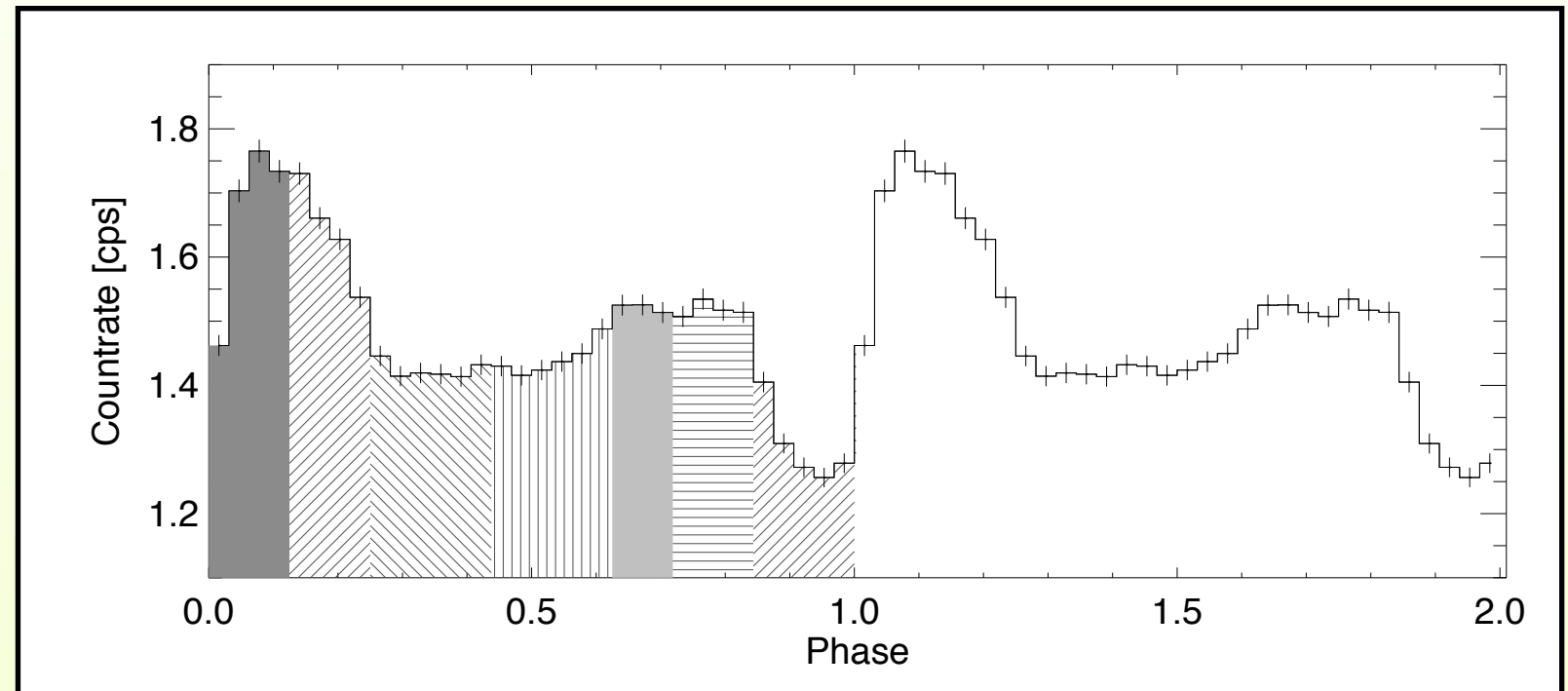


Pulse Profiles



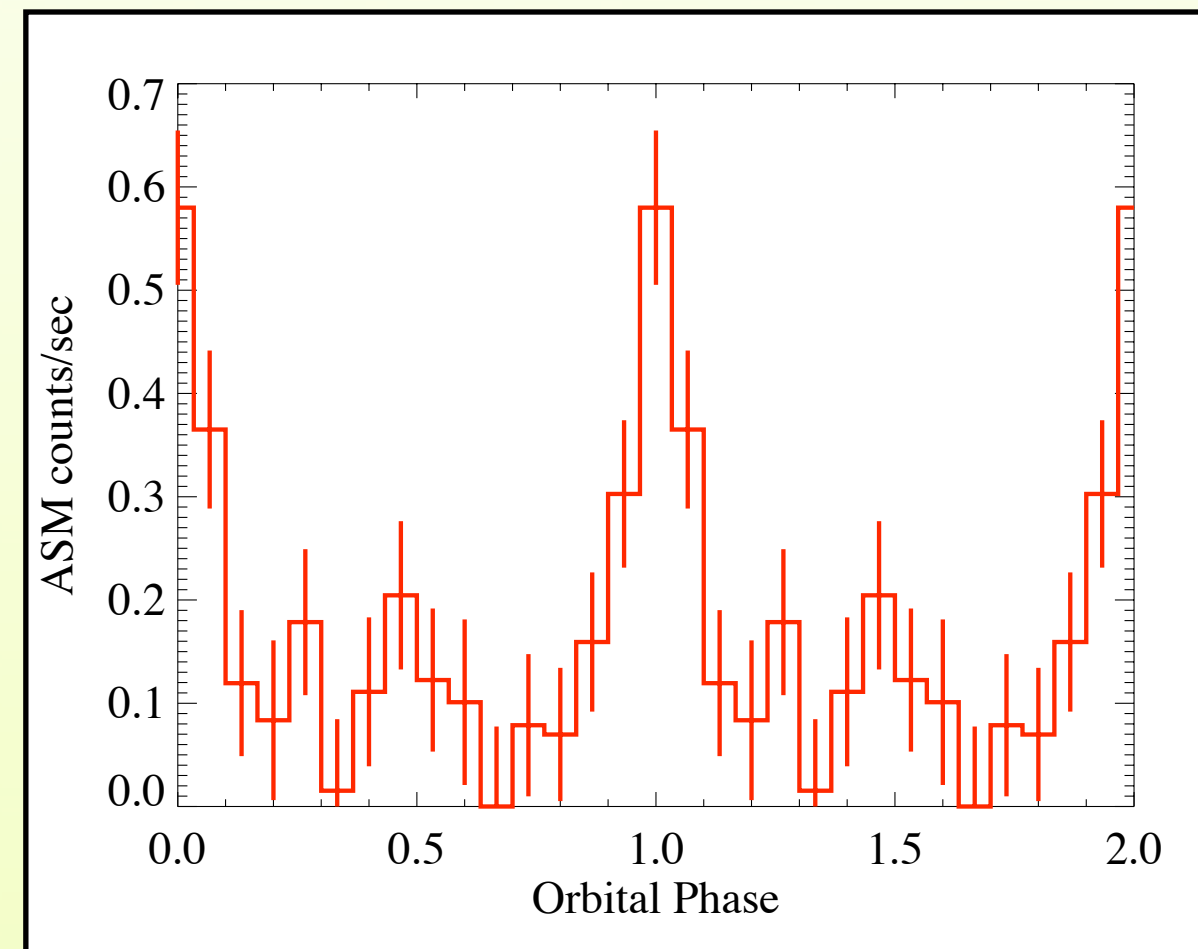
Phaseresolved Spectra

- only RXTE
- 7 bins
- same model
- $\chi_{\text{red}} < 1.4$
- looking for deviations, but **no cyclotron line**
- strongly variable blackbody
- changes in the folding energy



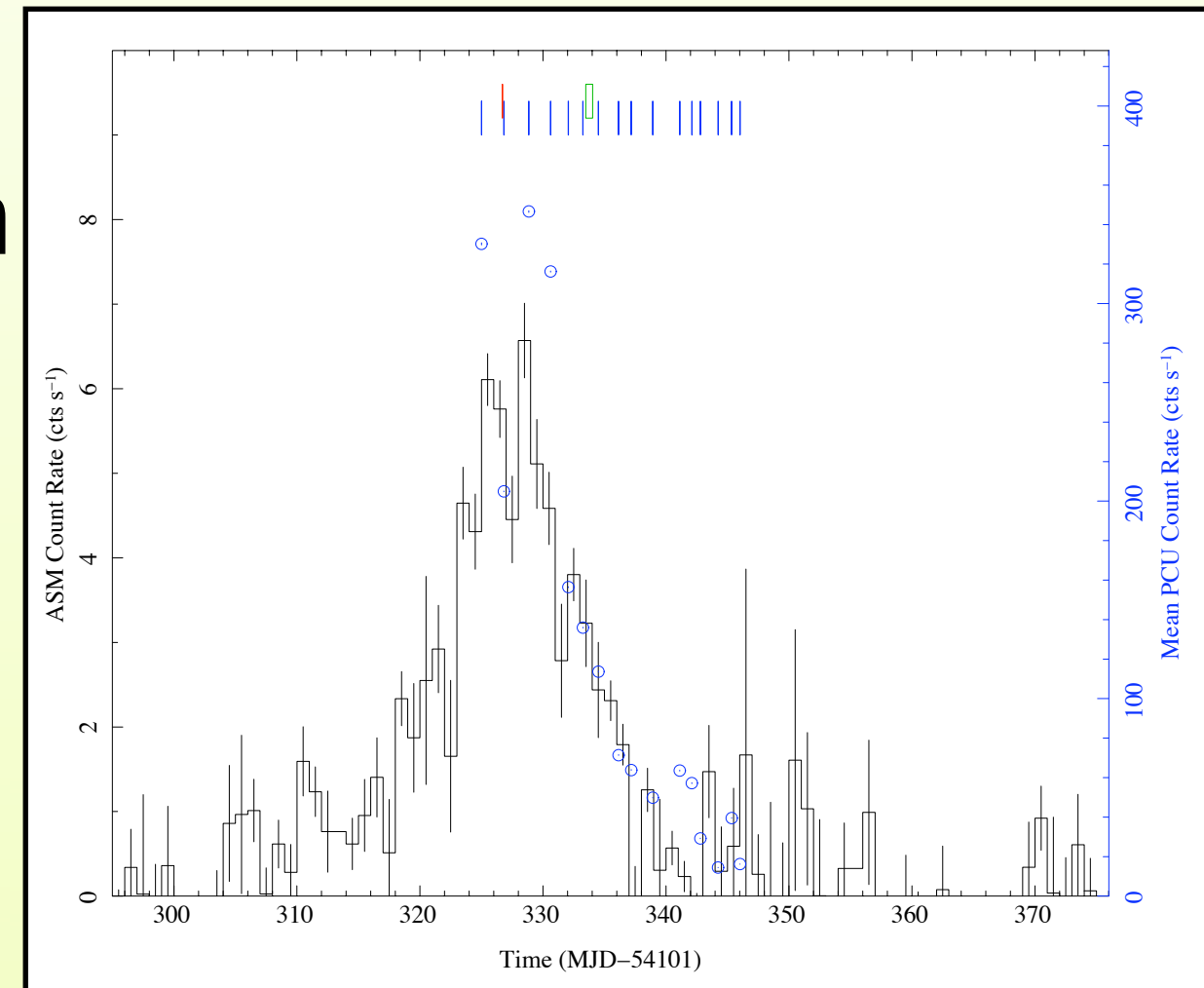
GRO J1008-57

- discovered 1993 with BATSE
(Shrader et al. 1999)
- pulse period: **93.5 s**
- Be supergiant companion
- binary period: **247.8 d**
(Coe et al. 2002)



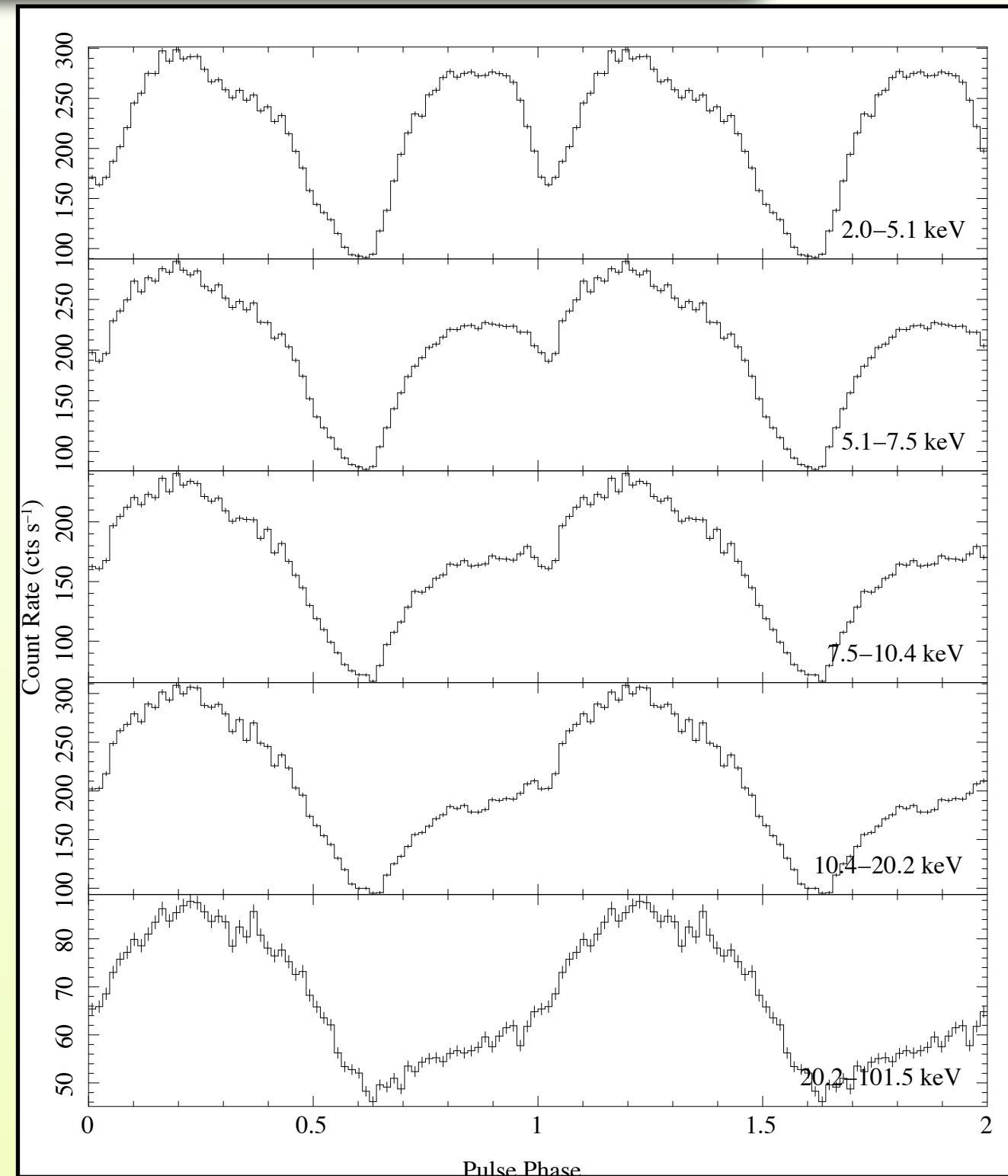
GRO J1008-57

- discovered 1993 with BATSE
(Shrader et al. 1999)
 - pulse period: **93.5 s**
 - Be supergiant companion
 - binary period: **247.8 d**
(Coe et al. 2002)
 - **sporadic** Be disc
- ➔ **outbursts**



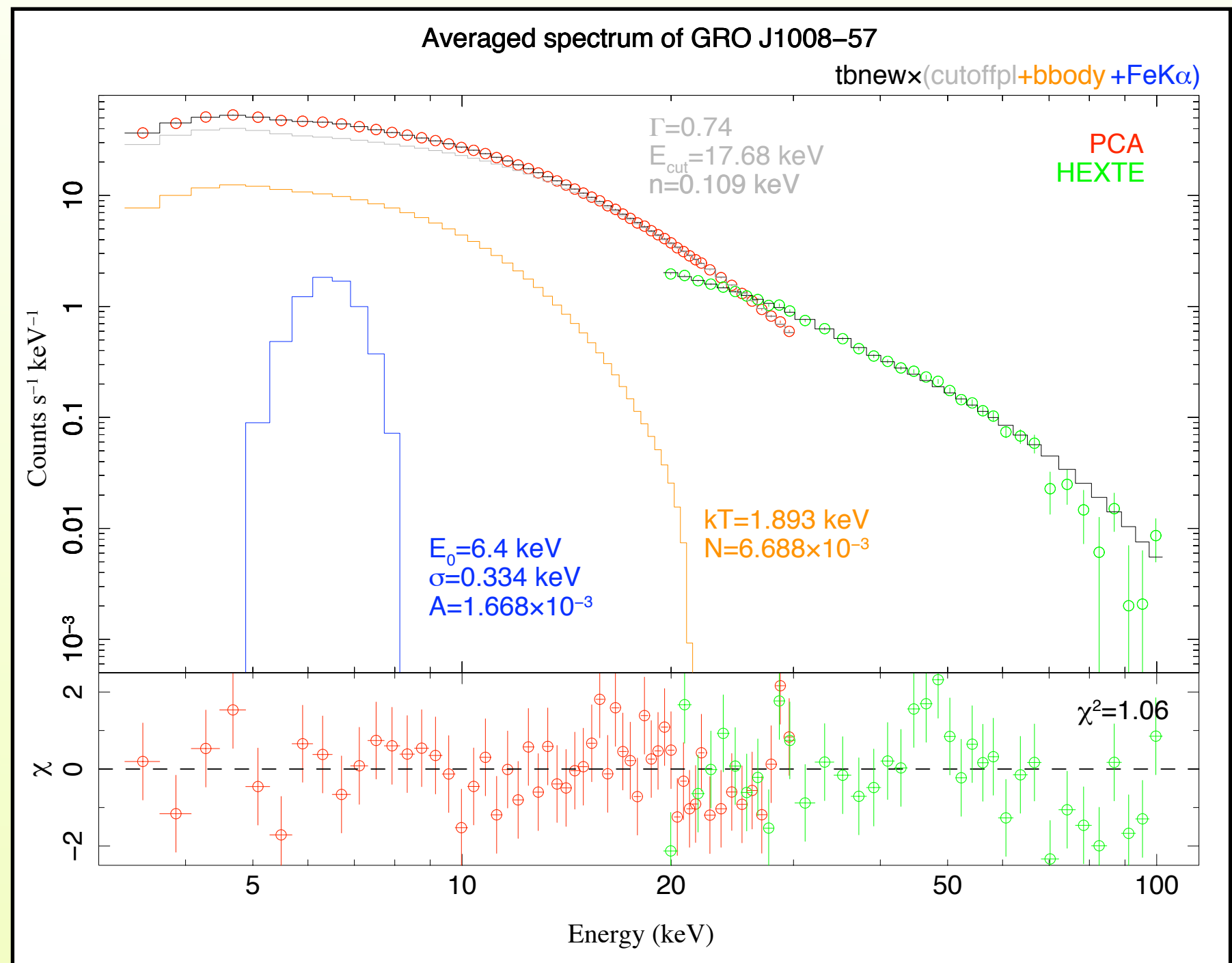
Profiles

- **double** peaked structure at low energies
- **single** peaked at high energies
- period $P=93.75\text{s}$



Spectrum

CRSF at
88keV???



Discussion

- complicated pulse profile
 - **broad / double** peak at lower energies
 - **single** sharp peak at high energies

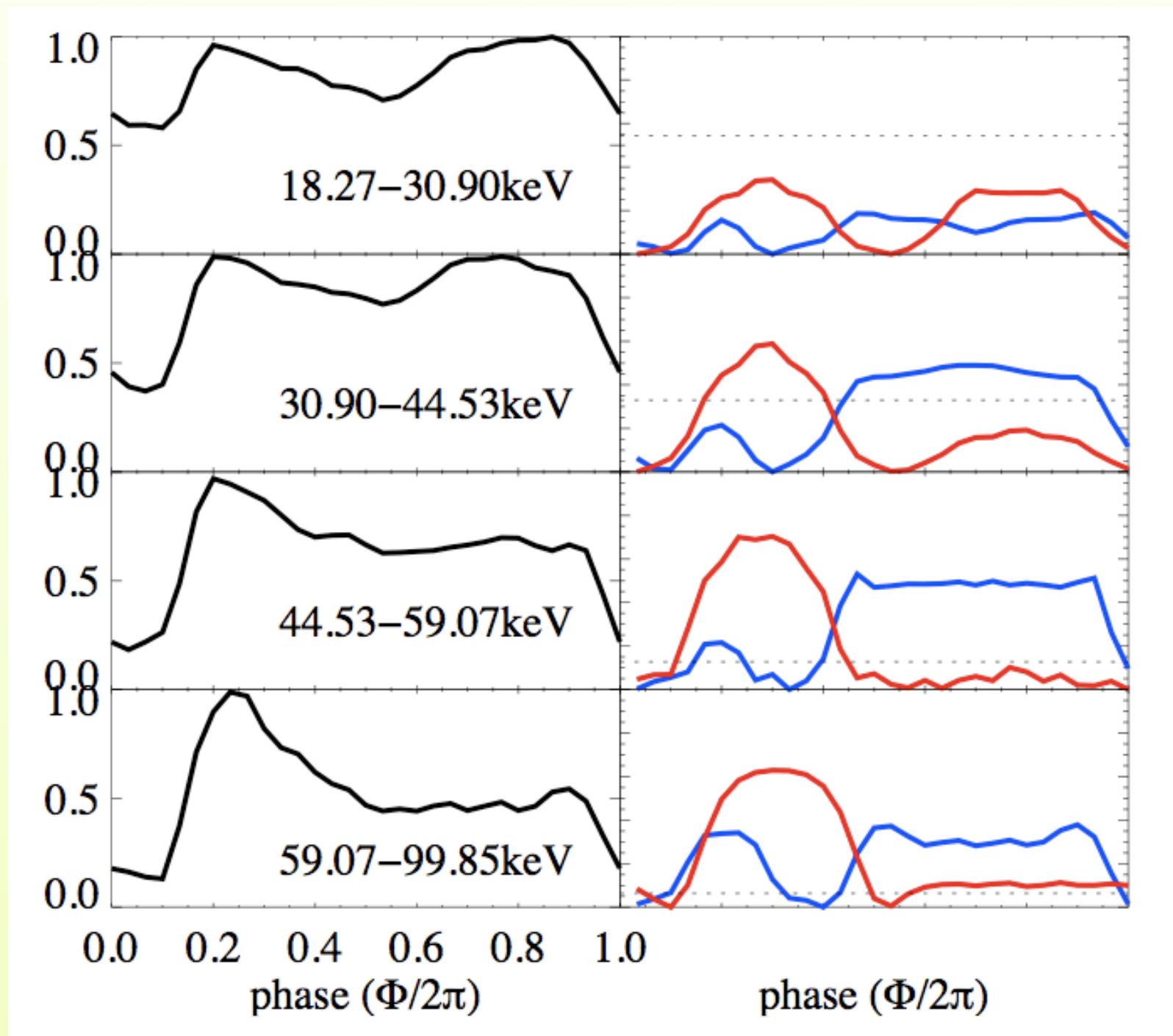
Discussion

- complicated pulse profile
 - **broad / double** peak at lower energies
 - **single** sharp peak at high energies
- phase dependence of spectral parameters
 - **emission from two poles?**
 - different environment above the two poles (cooler accretion column?)?

Discussion

gravitational
light bending!

→ always
contribution
from both
poles!



(Caballero et al.)

Summary

- there are quite bright almost unknown sources
- pulse period strongly variable
 - compatible with **random walk**
 - no stable accretion disk
- **no evidence** for cyclotron line
 - can not determine magnetic field
 - CRSFs can be filled up (**photon spawning**)
- complicated pulse profiles
- but beware of light bending

Summary

- there are quite bright almost unknown sources
- pulse period strongly variable
 - compatible with **random walk**
- **Thank you for your Attention!**
- **no evidence** for cyclotron line
 - can not determine magnetic field
 - CRSFs can be filled up (**photon spawning**)
- complicated pulse profiles
- but beware of light bending