

# Decoding the SFXT IGRJ17544–2619

Varun Bhalerao

(IUCAA)

Based on Bhalerao et al., 2014, (arXiv:1407.0112)

1 What are Supergiant  
Fast X-ray Transients?

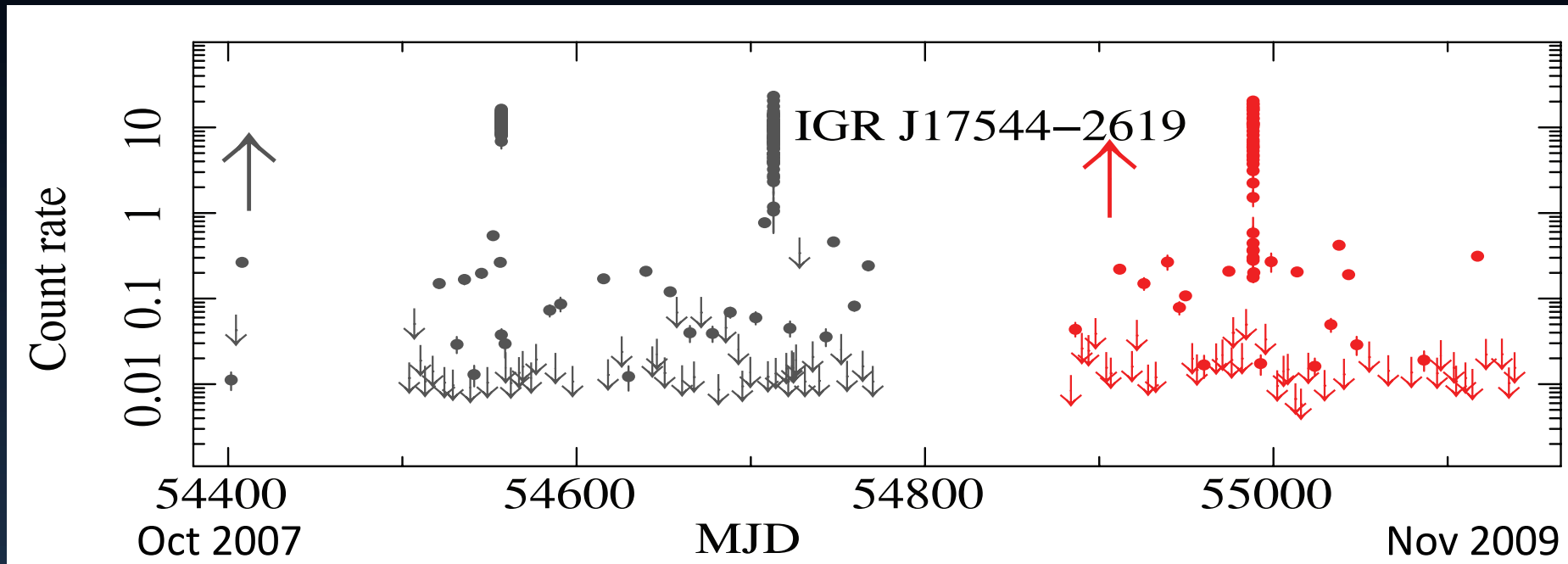
## Decoding the SFXT IGRJ17544–2619

2 Target of the day

3 NuSTAR results:  
X-ray timing  
Cyclotron lines

Bhalerao et al., 2014 (arXiv: 1407.0112)

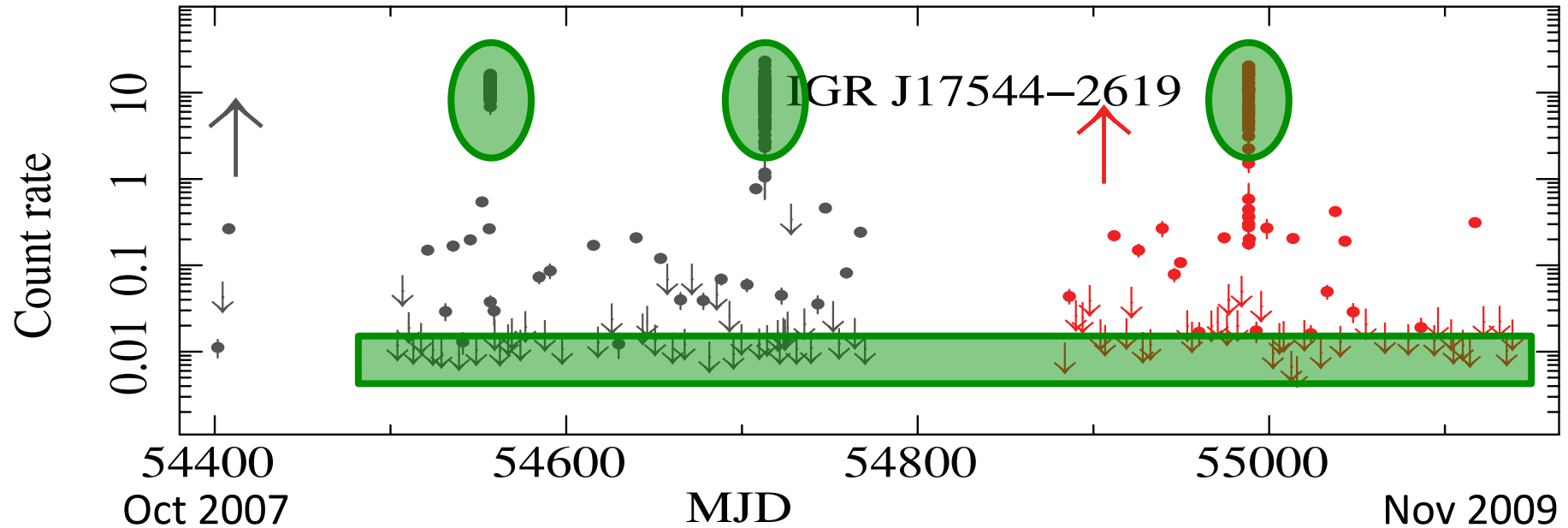
# Supergiant Fast X-ray Transients



Romano et al., 2011, MNRAS, 410, 1825

Swift XRT lightcurve in 2–10 keV band

# Supergiant Fast X-ray Transients



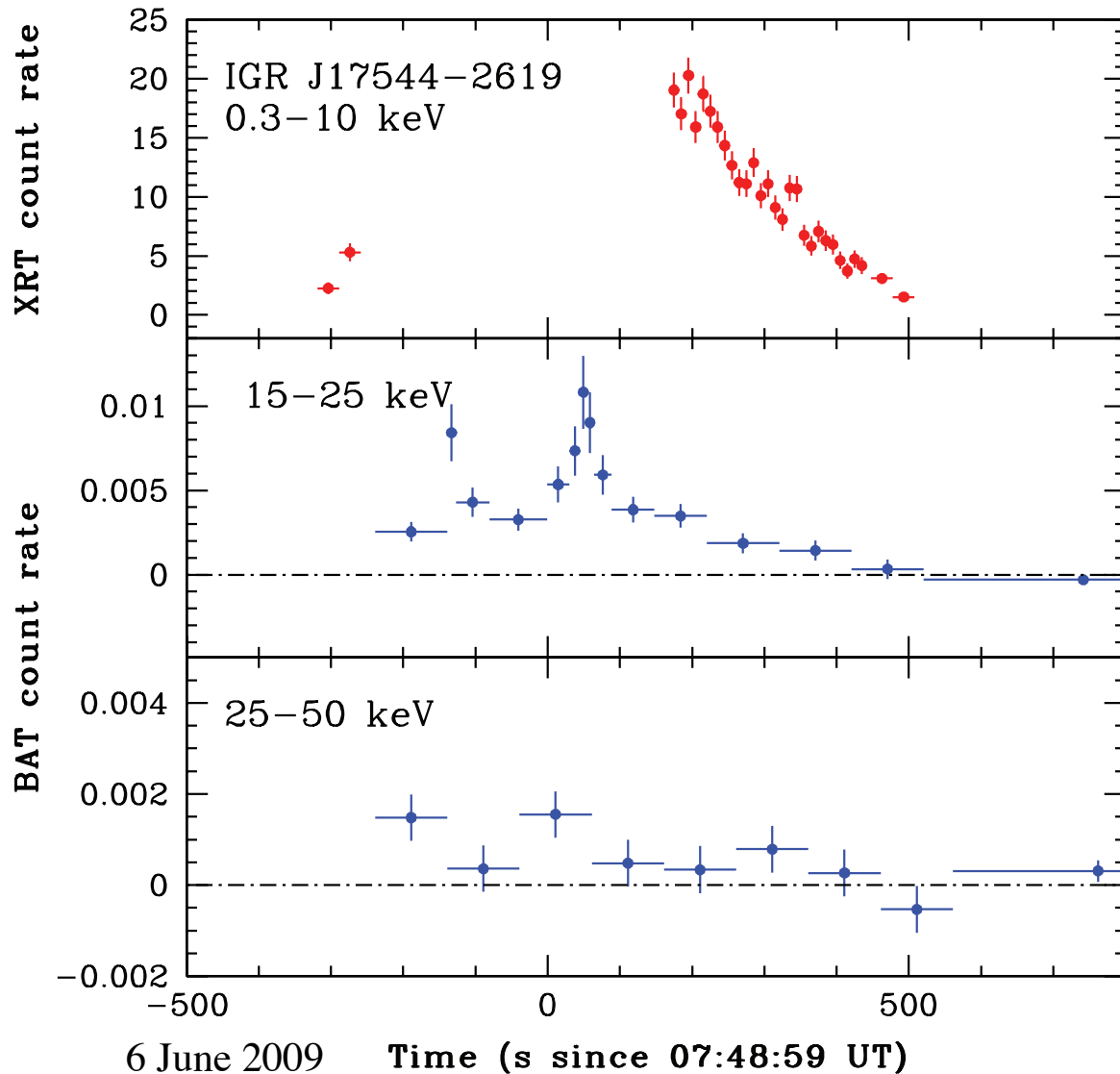
Romano et al., 2011, MNRAS, 410, 1825

Swift XRT lightcurve in 2–10 keV band

# Supergiant **Fast** X-ray Transients

- Typical **High Mass X-ray Binaries**:
- Orbital periods: few days to months
- “Classical” – always on
- Be XRBs – outbursts for few days
  - » Once/twice per orbit

# Supergiant **Fast** X-ray Transients

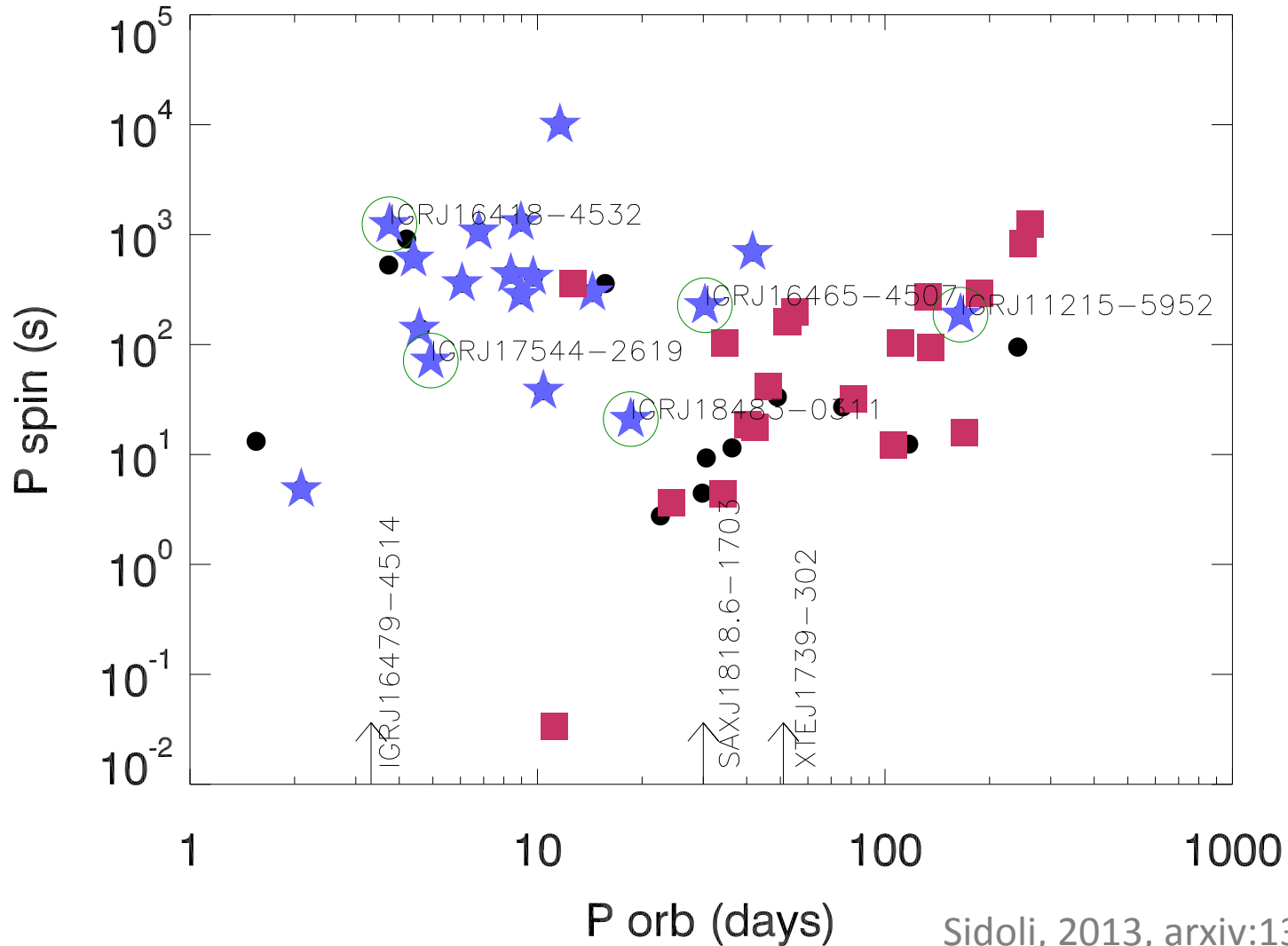


SFXT outbursts:  
minutes – hours

Dynamic range:  
up to  $10^5$

Romano et al.,  
2011, MNRAS, 410, 1825

# Supergiant Fast X-ray Transients



Sidoli, 2013, arxiv:1301.7574

# Clumpy wind mechanism

- Supergiants have clumpy winds
- Typical level – low flux
- Accrete clump – flare
- in't Zand 2005; Walter & Zurita Heras 2007; Negueruela et al. 2008; Sidoli et al. 2007...



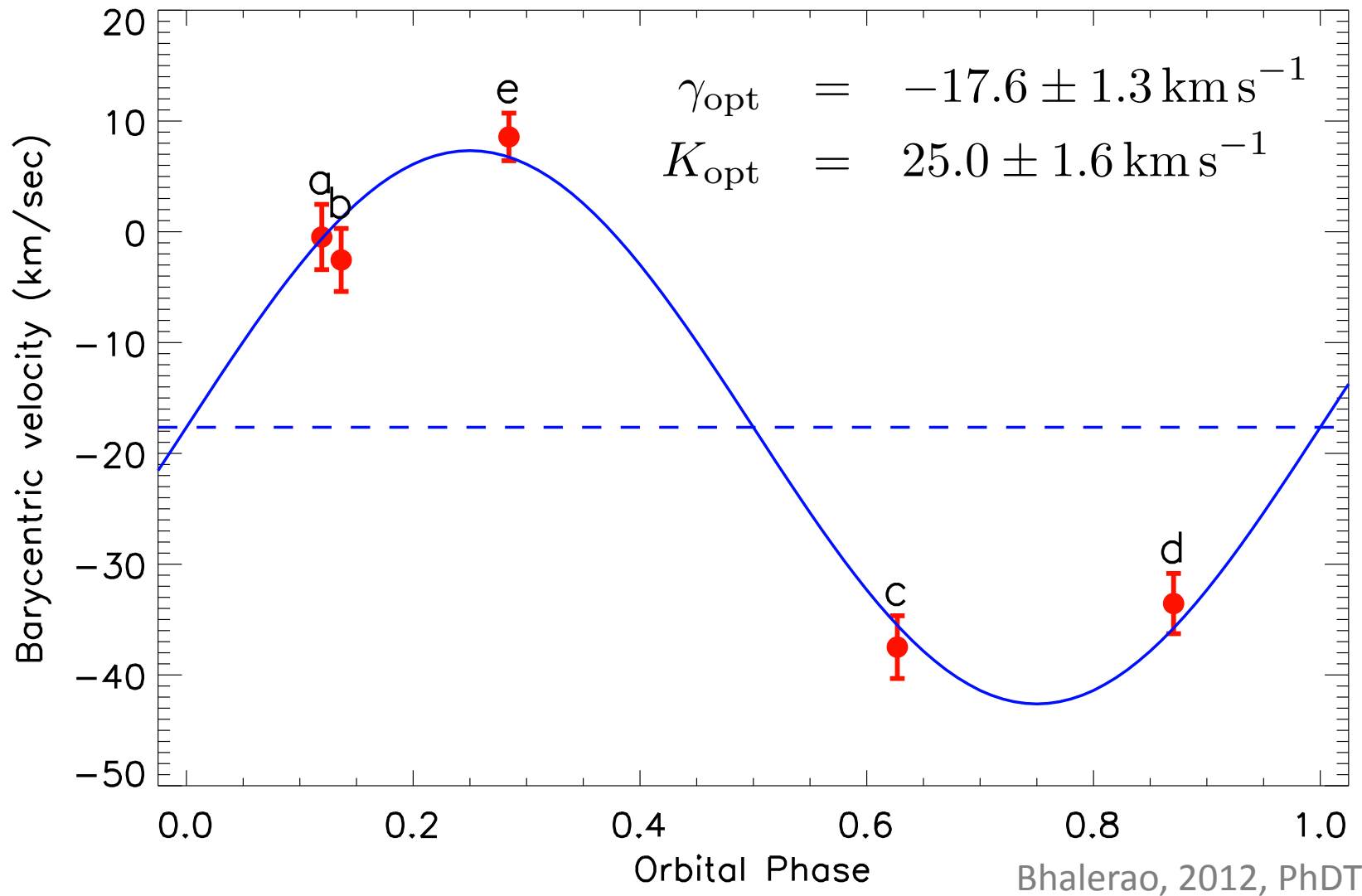
# Gating mechanisms

- Magnetar-based (Bozzo et al., 2008)
  - » If magnetospheric radius  $>$  corotation radius : low accretion
  - » Radii change with accretion rate, can transfer to high accretion regime
- Propeller effect (Grebenev & Sunyaev, 2007)
  - » Spin period close to a critical value, slight change in accretion rate enables/disables propeller effect
- ... and more

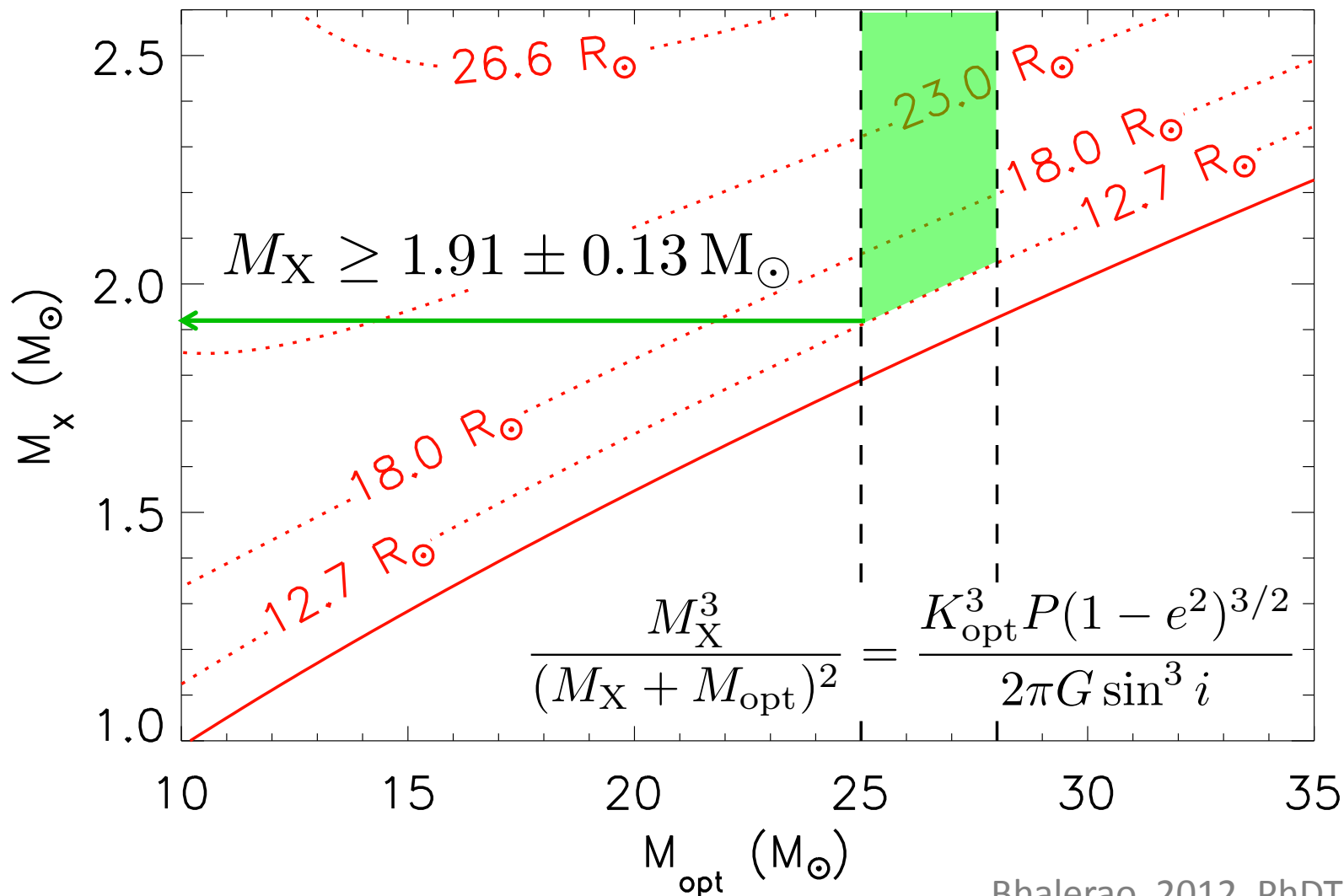
IGRJ17544-2619



# Orbit



# Lower limit on mass

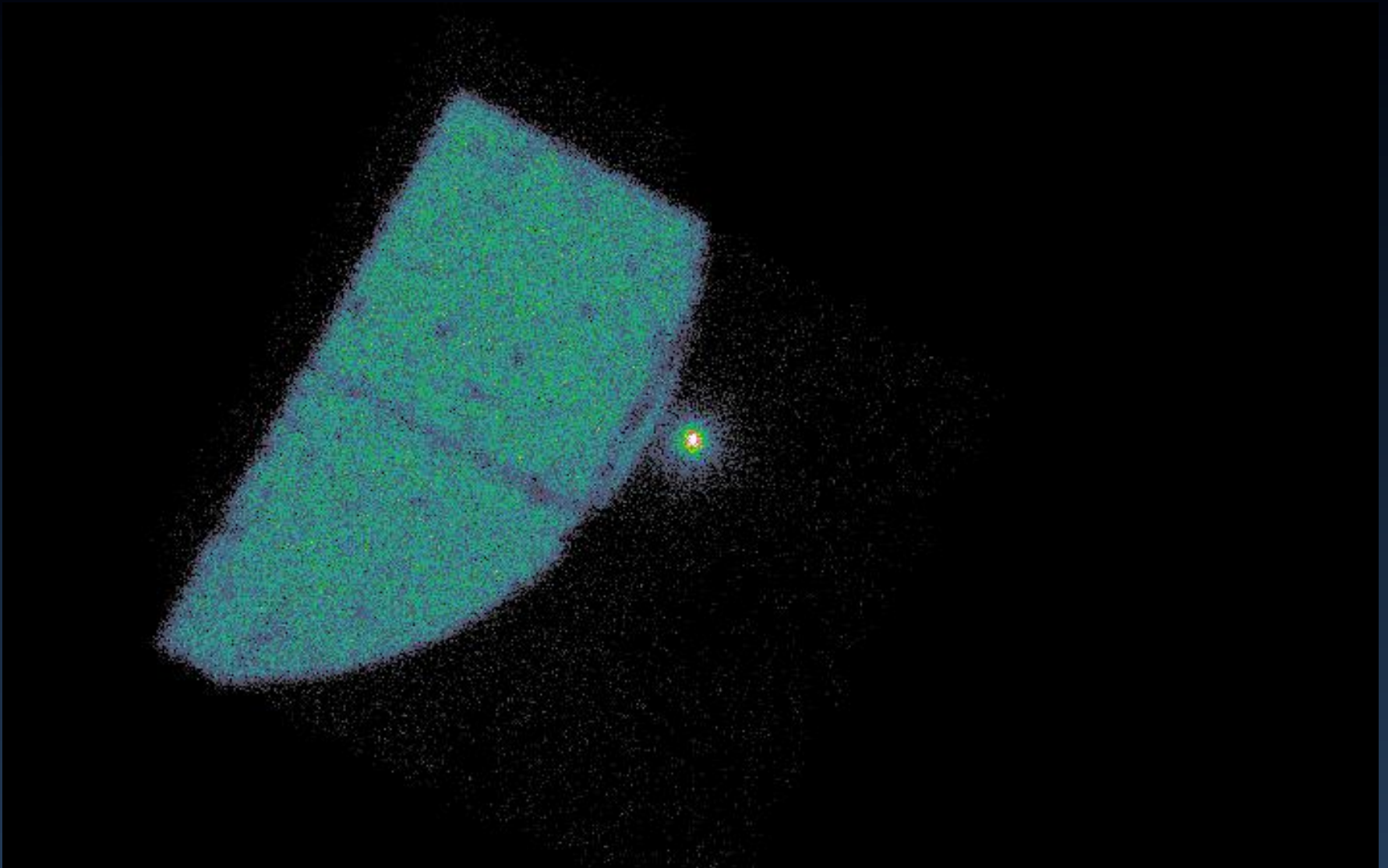


Bhalerao, 2012, PhDT

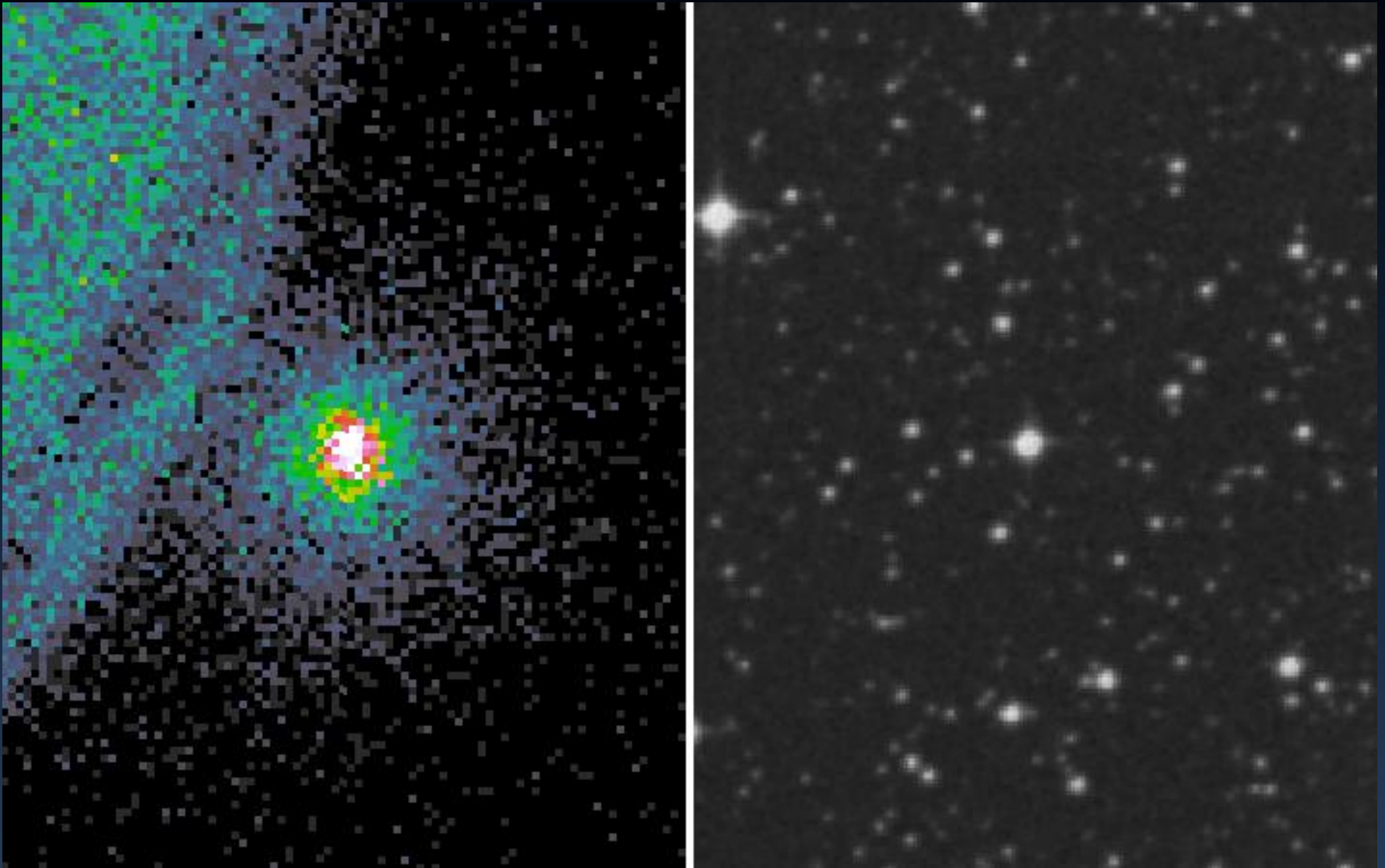
# Observations



# Observations



# NuSTAR & DSS2 (red)



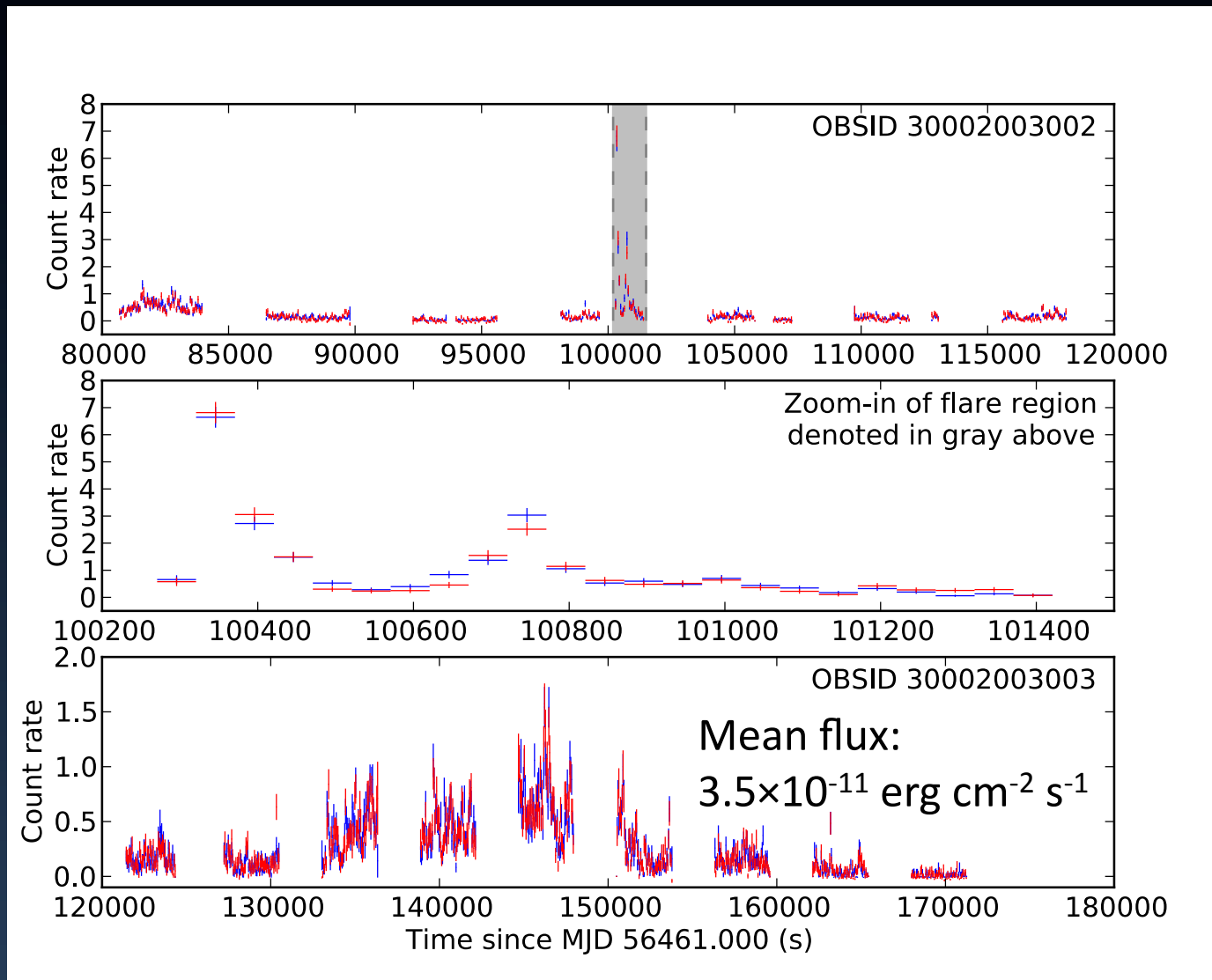


# NuSTAR lightcurve

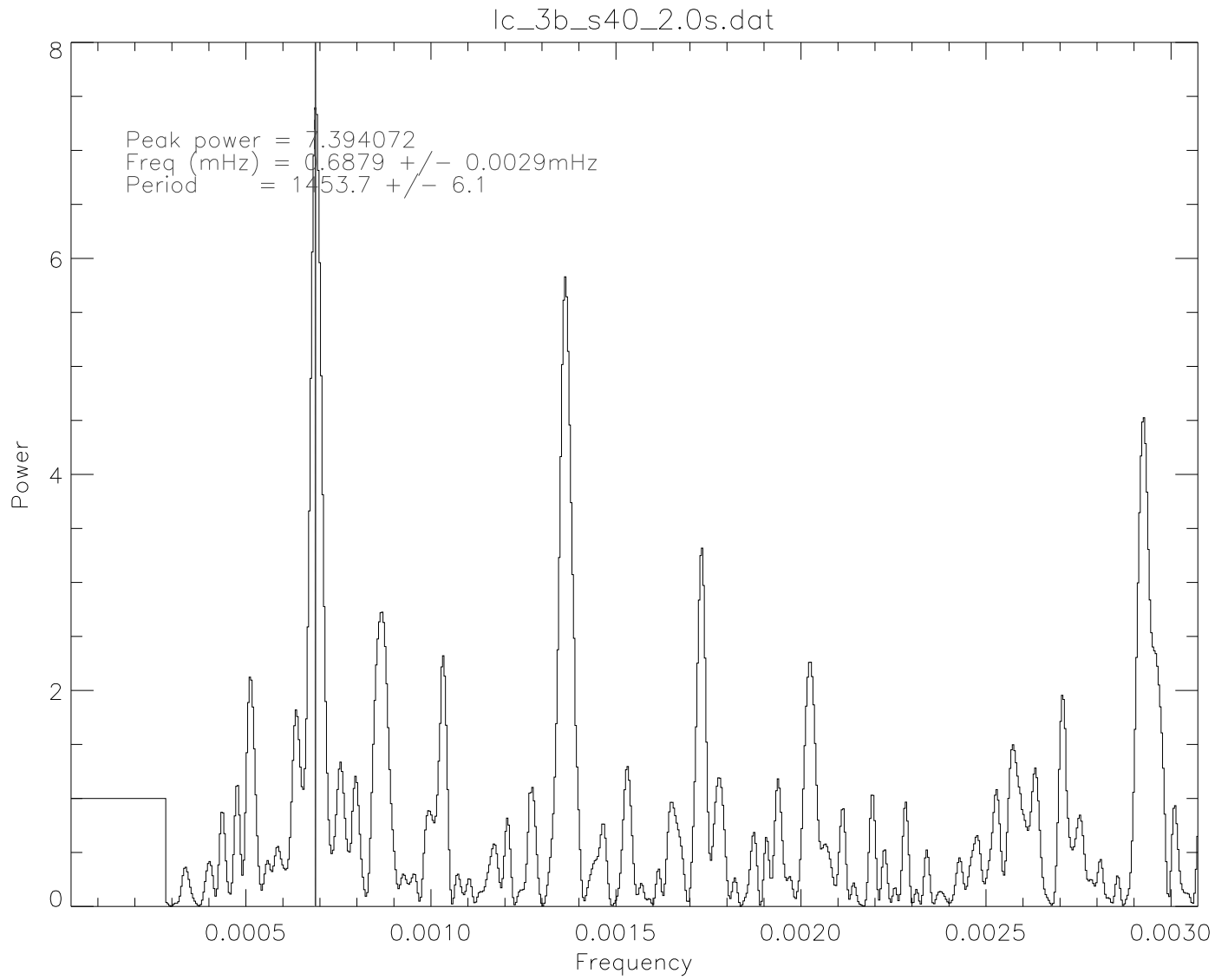
NuSTAR:  
Two obs  
18-19 June  
2013

44 ksec

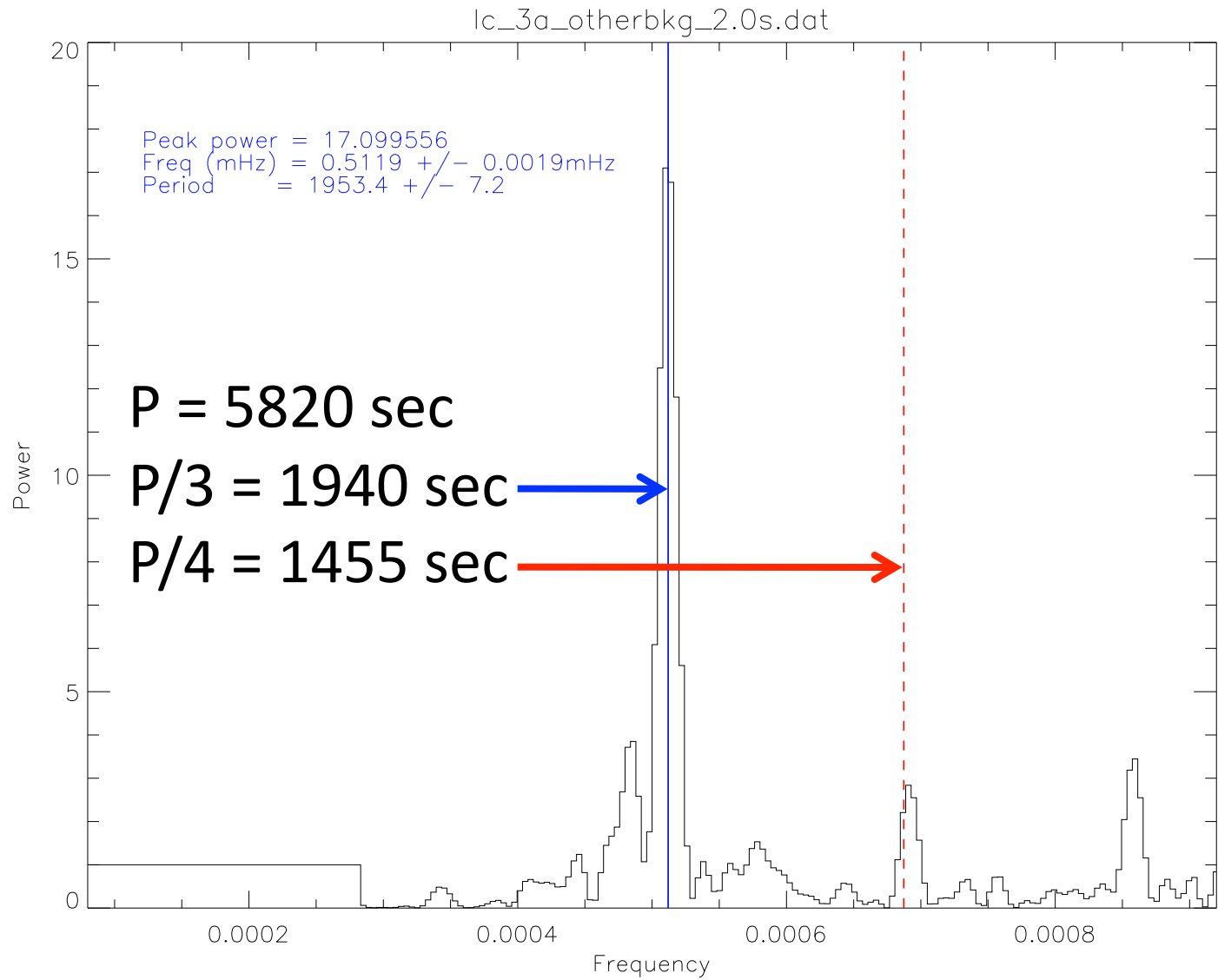
Swift XRT:  
2 ksec



# Timing



# Reference region



# Flare

- Flux:  $3.1 \pm 0.1 \times 10^{-10}$  erg cm<sup>-2</sup> s<sup>-1</sup>
  - » Typical level  $3.53 \pm 0.05 \times 10^{-11}$  erg cm<sup>-2</sup> s<sup>-1</sup>
- Time: ~220 seconds
- Spectrum:

# Flare

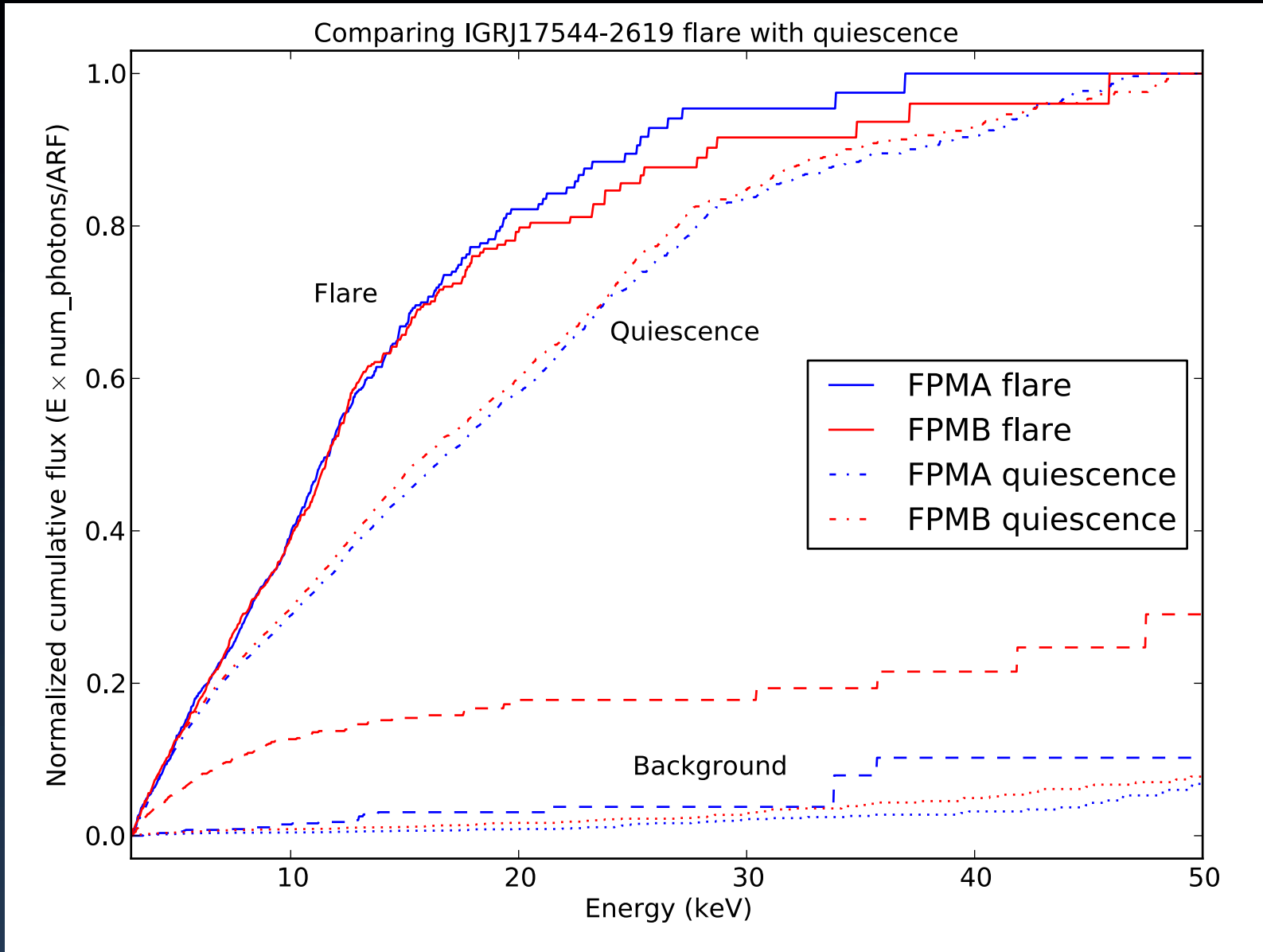
- Flux:  $3.1 \pm 0.1 \times 10^{-10}$  erg cm<sup>-2</sup> s<sup>-1</sup>
  - » Typical level  $3.53 \pm 0.05 \times 10^{-11}$  erg cm<sup>-2</sup> s<sup>-1</sup>
- Time: ~220 seconds
- Spectrum:
  - ✗ absorbed powerlaw
  - ✗ absorbed blackbody
  - ✗ absorbed cutoff powerlaw
  - ✗ absorbed broken power law
  - ✓ absorbed bkn2pow
  - ✓ absorbed (blackbody + powerlaw × high E cutoff)

# Flare

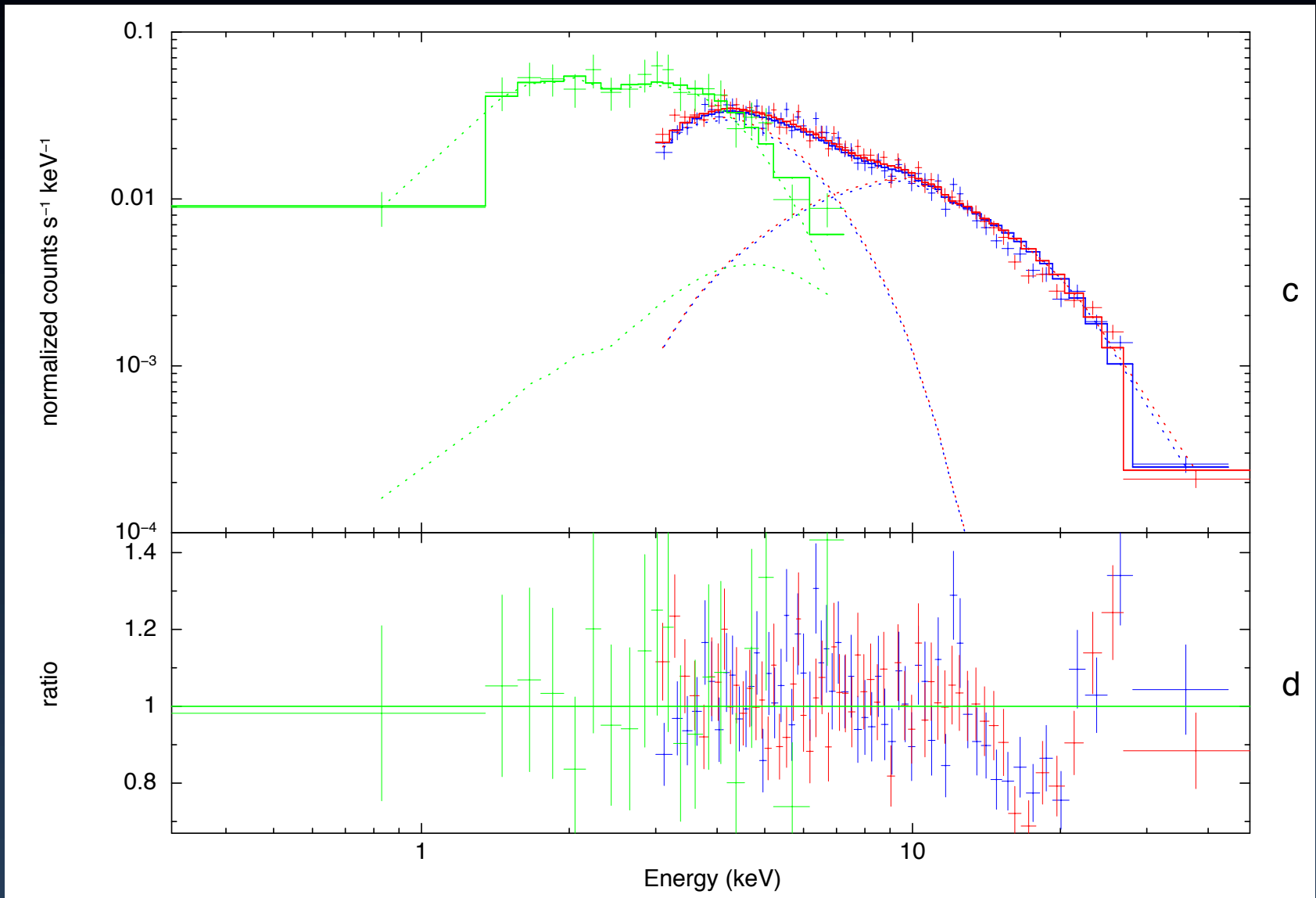
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- Time: ~220 seconds
- Spectrum:

**The chasm of  
Xspec desperation**

# Flare v/s typical

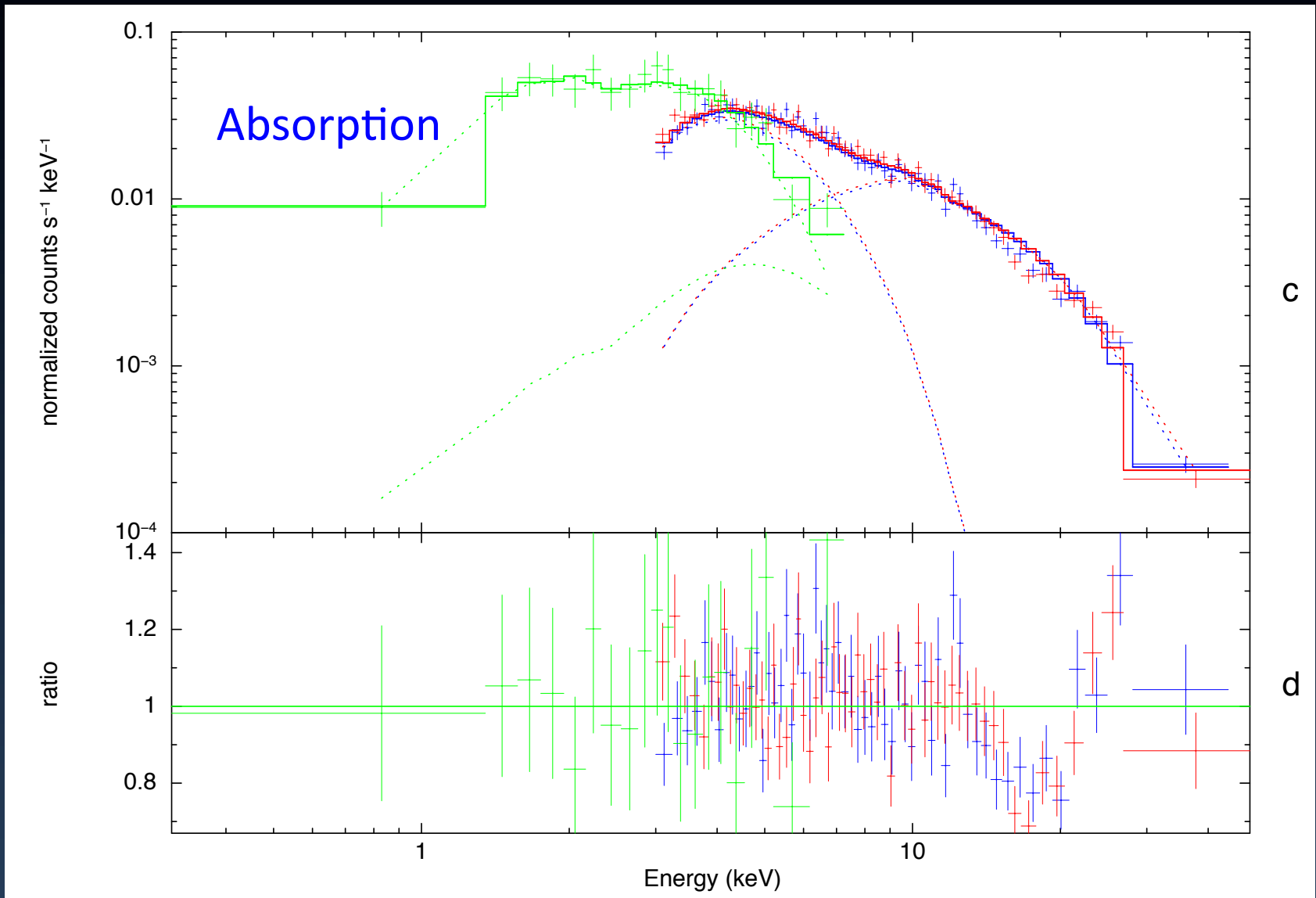


# Spectrum

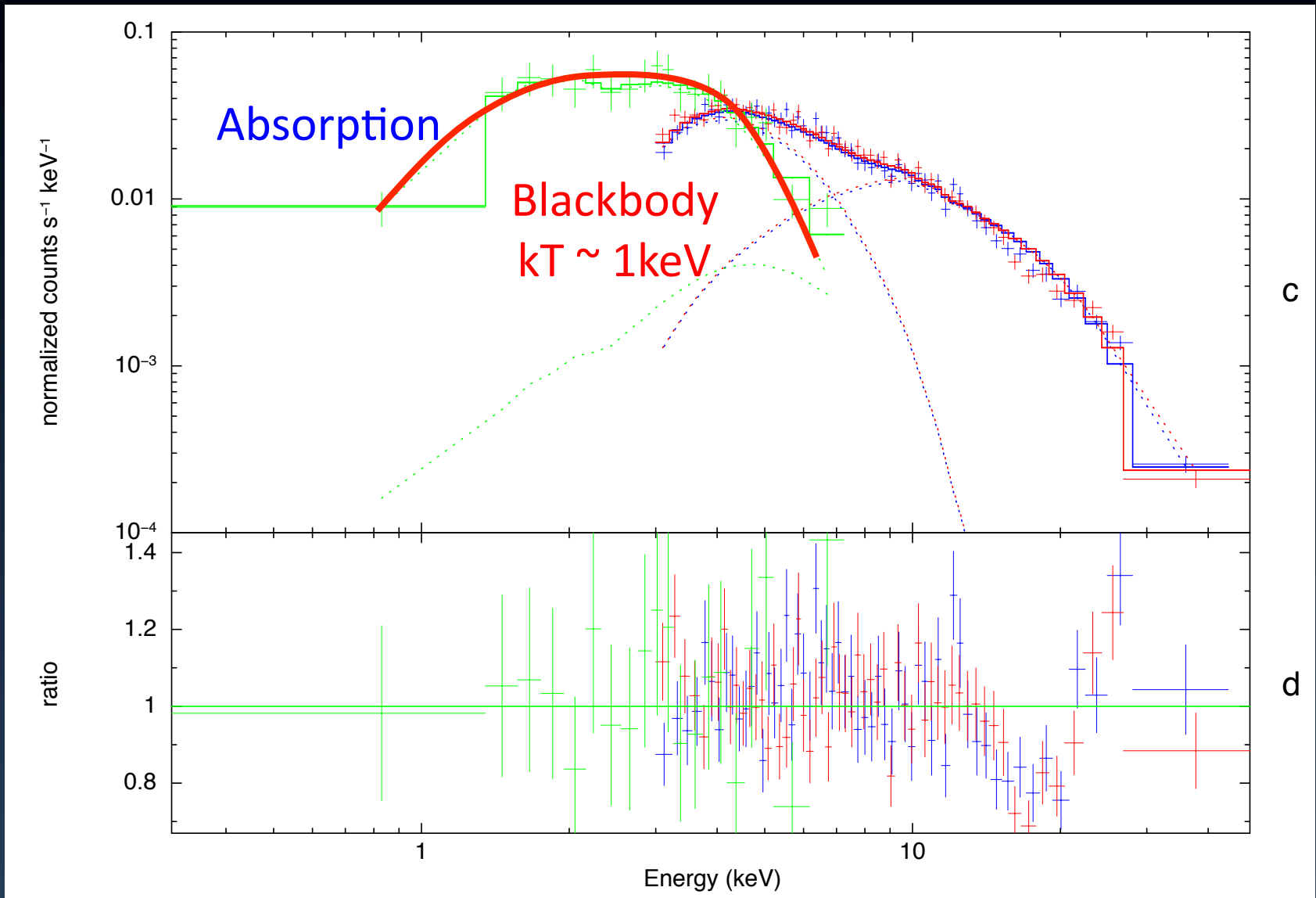




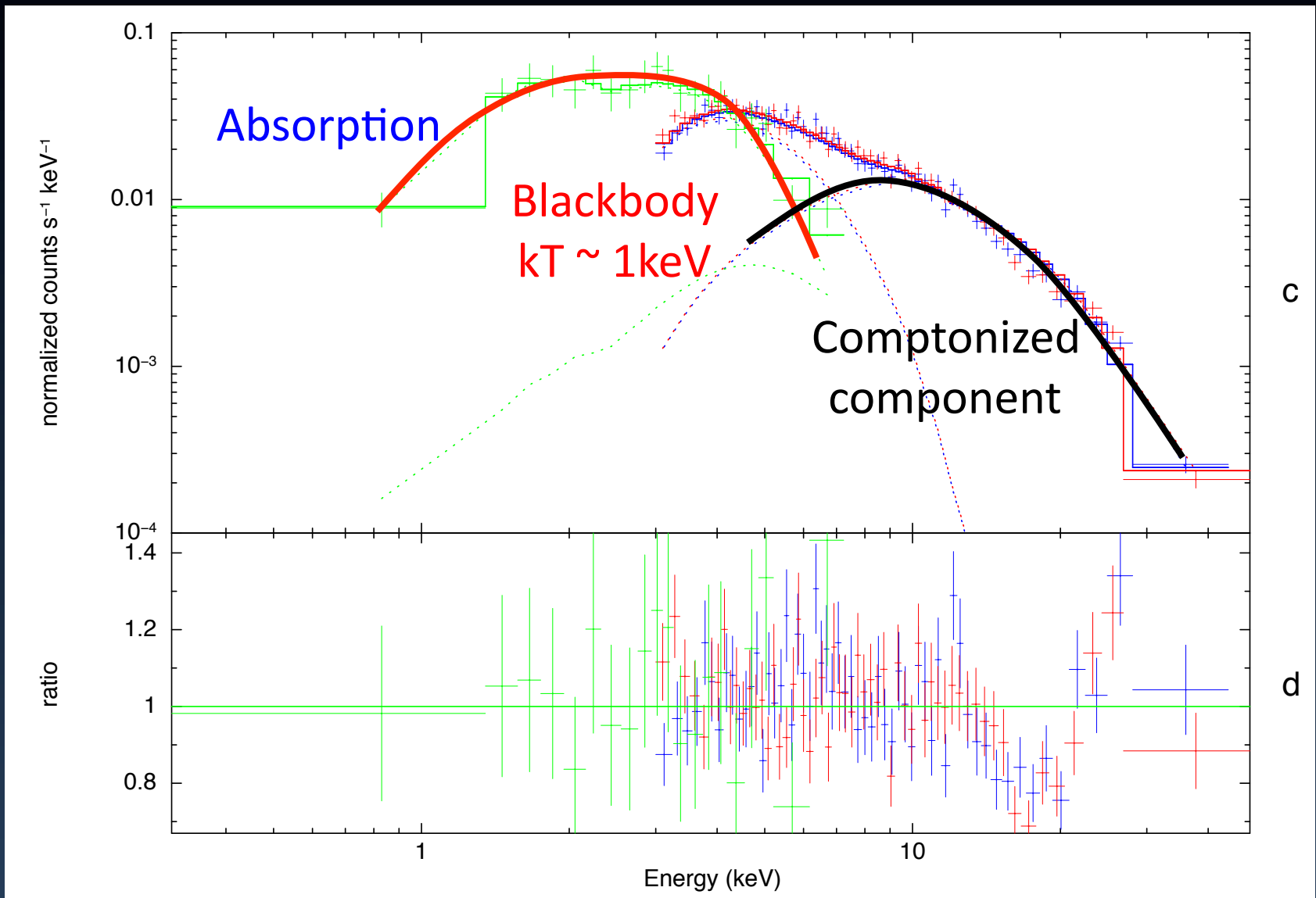
# Spectrum



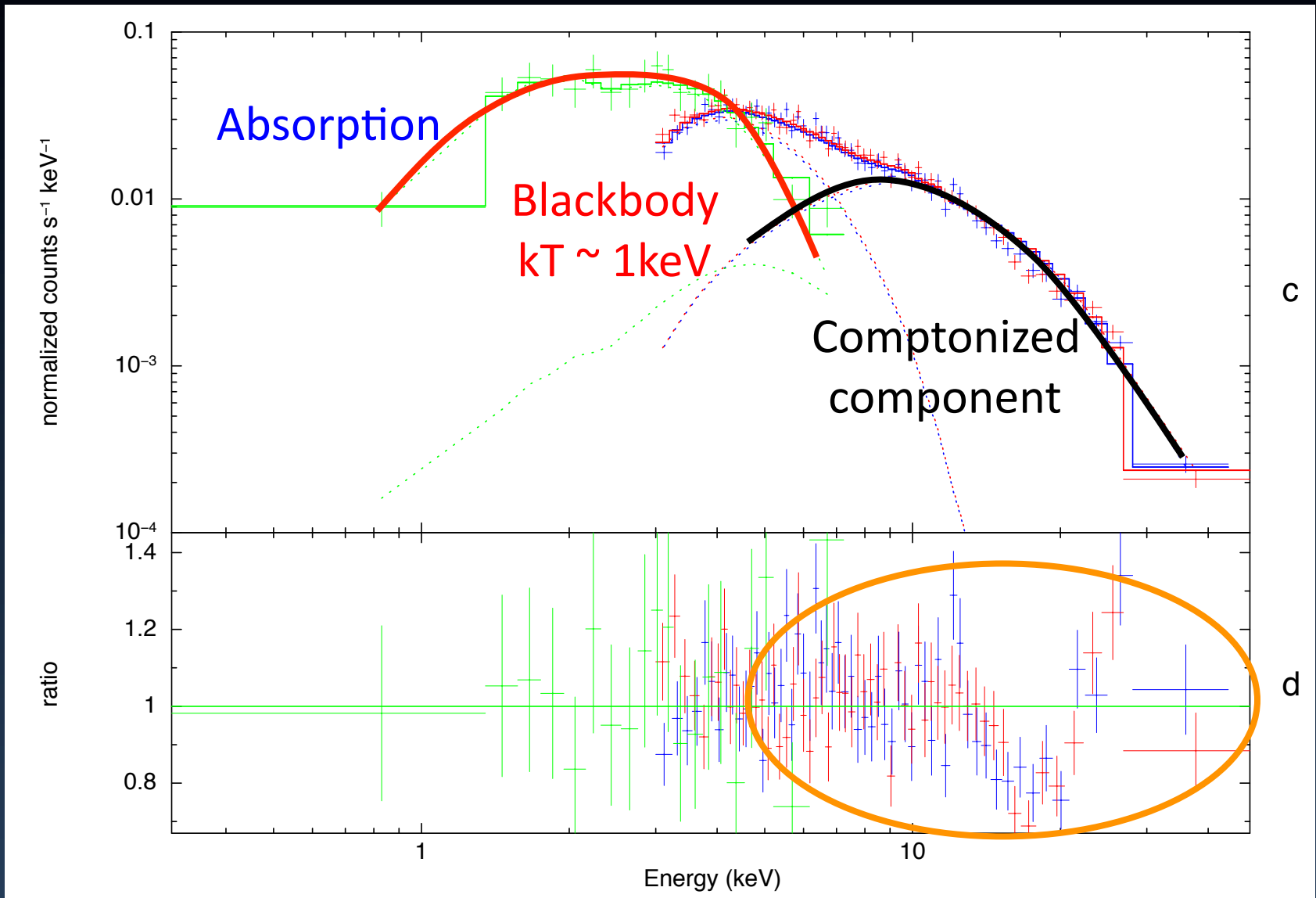
# Spectrum

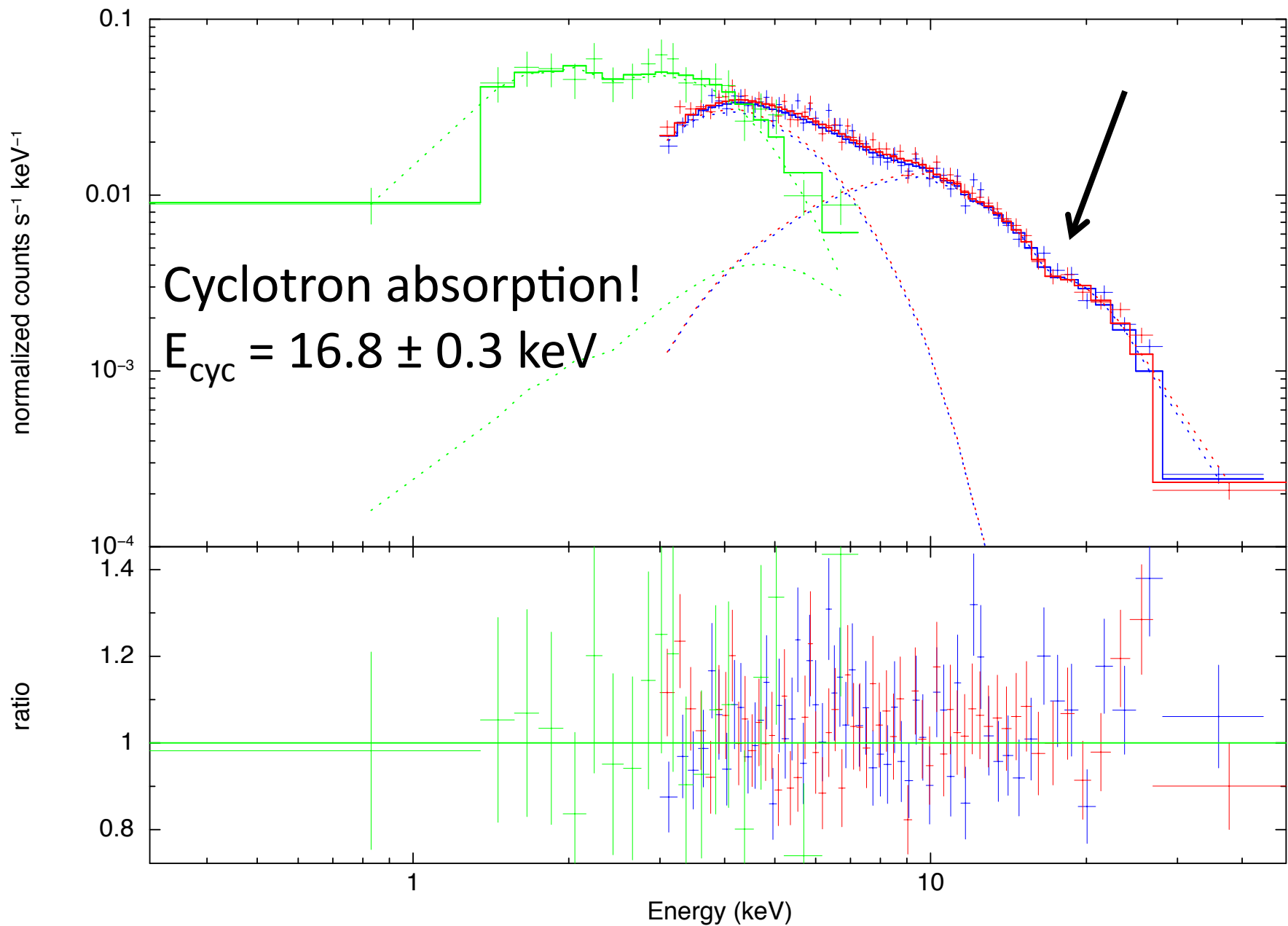


# Spectrum



# Spectrum





# Line significance

## Model 1 (nthcomp)

- $\Delta\chi^2 = 38.7$ 
  - » F-test:  $p = 2e-8$
- Depth  $\neq 0$ 
  - »  $\Delta\chi^2 > 52 (7\sigma)$
- Monte-carlo simulations:
  - » 1000 simulations give  $\max(\Delta\chi^2) = 18.7$ , obs 41.2

## Model 2 (cutoffpl)

- $\Delta\chi^2 = 42.6$ 
  - » F-test:  $p = 2e-9$
- Depth  $\neq 0$ 
  - »  $\Delta\chi^2 > 52 (>7\sigma)$
- Monte-carlo simulations:
  - » 1000 simulations give  $\max(\Delta\chi^2) = 12$ , obs 37.1

Conclusion: absorption feature is real,  $> 5\sigma$  !

# Magnetic field

- Line is cyclotron feature

$$B_{12} = \frac{E_{cyc}}{11.6 \text{ keV}} (1 + z)$$

- $E_{cyc} = 16.8 \pm 0.3 \text{ keV}$
- $B = 1.45 \pm 0.03 \times 10^{12} \text{ G } (1+z)$
  
- Harmonic seen at 33 keV
- No line at 8 keV

# Conclusion

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## ARE THERE MAGNETARS IN HIGH-MASS X-RAY BINARIES? THE CASE OF SUPERGIANT FAST X-RAY TRANSIENTS

E. BOZZO,<sup>1,2</sup> M. FALANGA,<sup>3</sup> AND L. STELLA<sup>1</sup>  
*Received 2008 February 17; accepted 2008 May 12*

# No!

### ABSTRACT

In this paper we explore the theory of wind accretion in high-mass X-ray binaries having a compact companion and a magnetized companion. We concentrate on the different types of interaction between the wind and the companion and supergiants that are relevant when accretion of matter onto the compact object is inhibited. These include inhibition through the coronal and magnetospheric winds, which reduce the expected luminosity for each system and define the “inhibition radius” within which accretion can take place. We show that very large luminosity savings  $\sim 10^2$  or more are observed in some X-ray binaries and that these savings occur in different systems. The savings observed in supergiant fast X-ray transients, a recently discovered class of high-mass X-ray binaries in our galaxy, are also being interpreted as being due to such a reduction due to inhibition in an extremely strong stellar wind. We show here that the interaction between the supergiant and its coronal/magnetospheric wind can explain the variability properties of these sources as a result of relatively modest variations in the stellar wind velocity and/or density. According to this interpretation we expect that supergiant fast X-ray transients which display very large luminosity savings and have a clearly expanding feature are all characterized by supergiant-like fields, irrespective of whether the supergiant or the coronal/magnetospheric wind is responsible for the inhibition. This provides a new opportunity to detect and study magnetars in binary systems.

**Subject headings:** accretion, accretion disks — stars: neutron — supernovae — X-ray binaries — X-ray stars

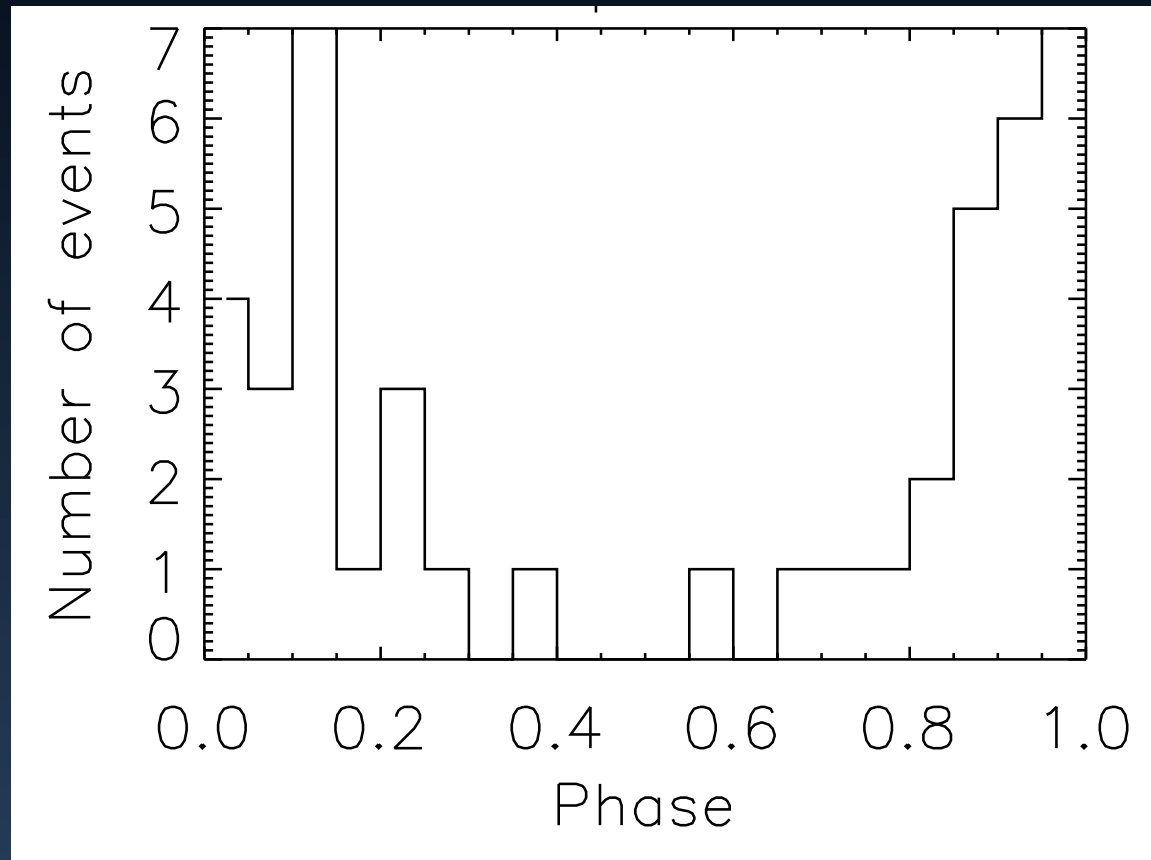
...at least not in  
this prototypical case!



Further work

# Flares are clustered

- Orbit should be circular: then why does it flare at a particular phase?
- Orbit study with SALT to measure eccentricity



D. Smith, ATEL 6227  
+ private communication

# Line variation with flux level

- Planning another observation with NuSTAR, aiming for different flux level
- If a strong flare is seen, better spectral modeling
- Also studying another SFXT