Decoding the SFXT IGRJ17544–2619

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

Decoding the SFXT IGRJ17544–2619

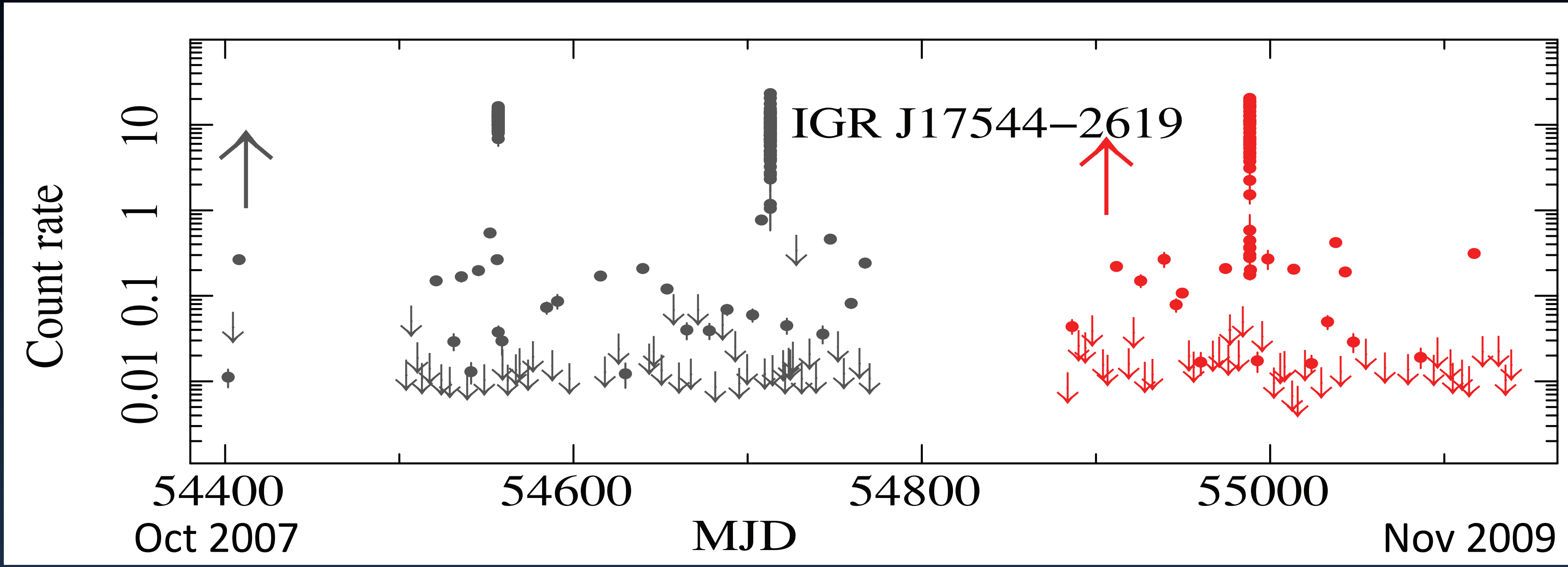
1. What are Supergiant Fast X-ray Transients?

2. Target of the day

3. NuSTAR results:
   X-ray timing
   Cyclotron lines

Bhalerao et al., 2014 (arXiv: 1407.0112)

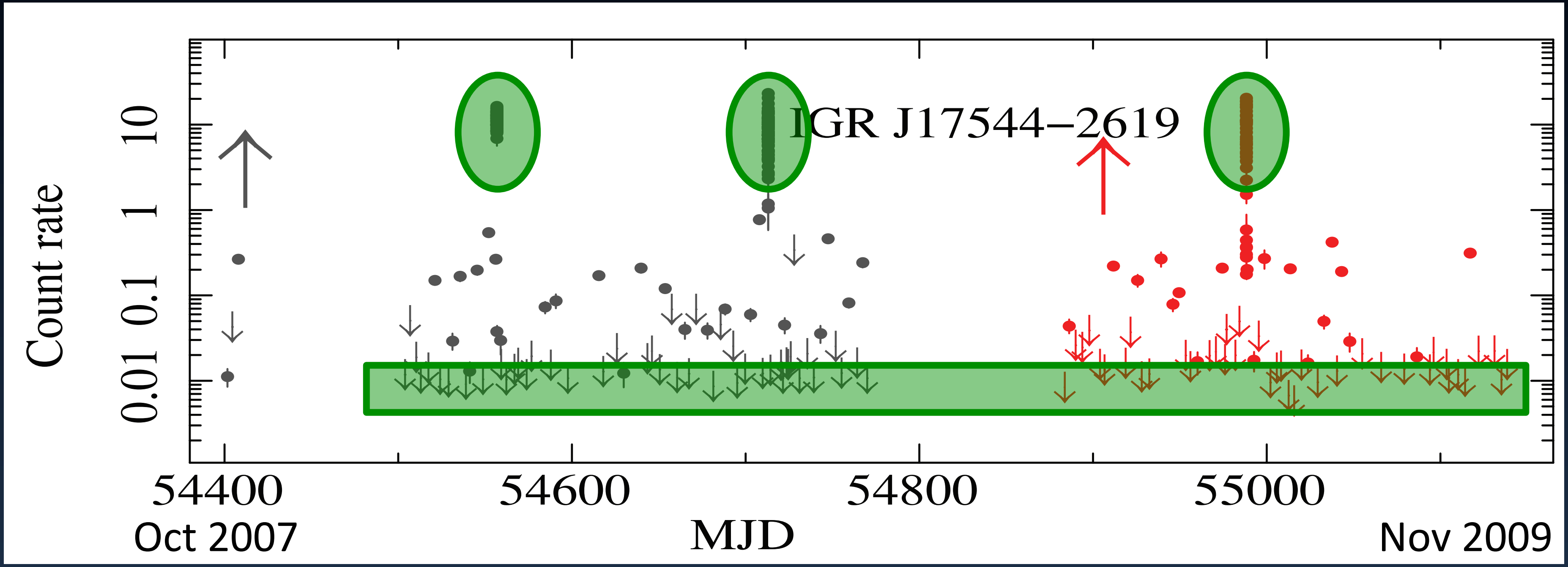
Supergiant Fast X-ray Transients



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

Swift XRT lightcurve in 2–10 keV band

Supergiant Fast X-ray Transients



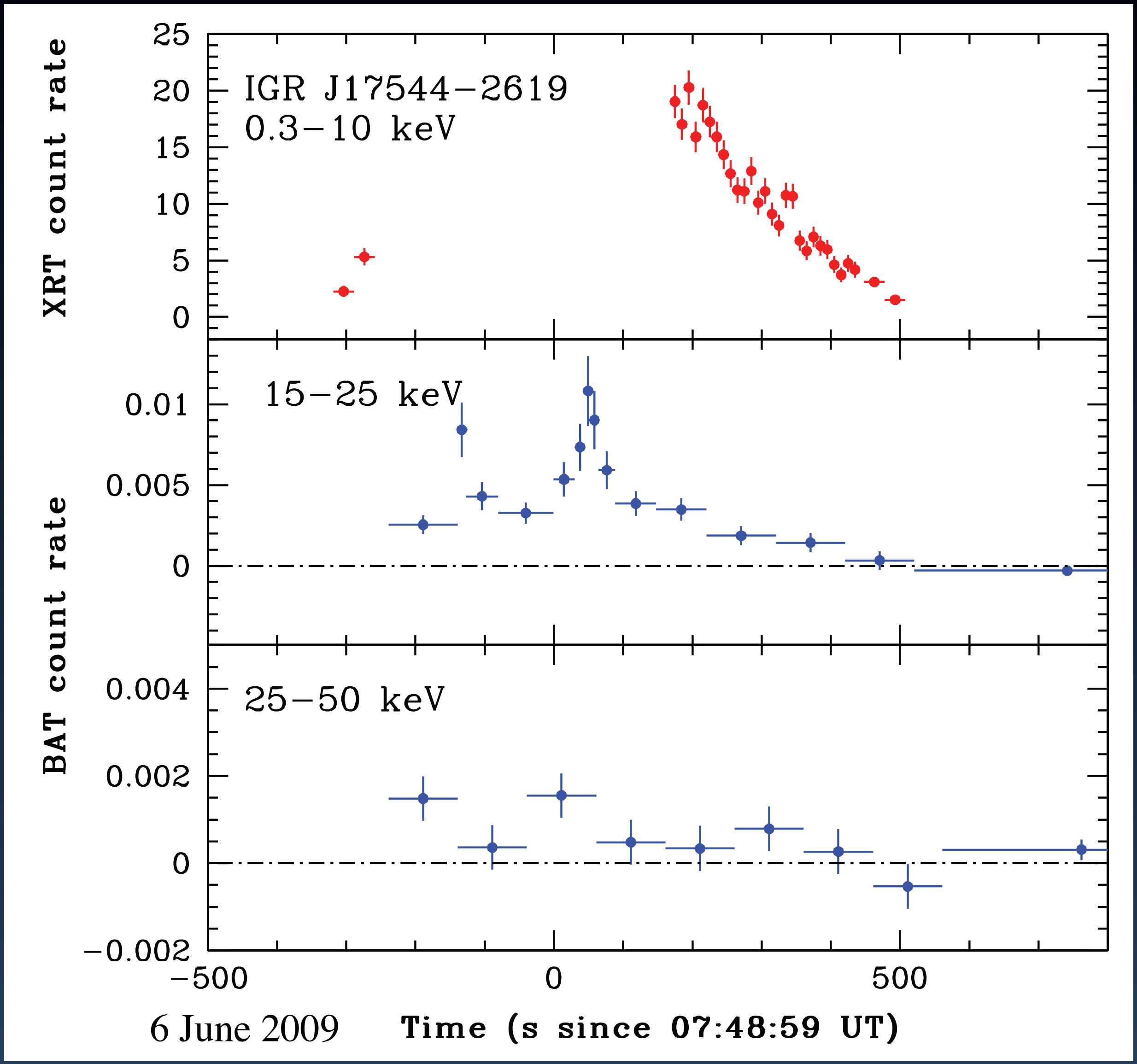
Romano et al., 2011, MNRAS, 410, 1825

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

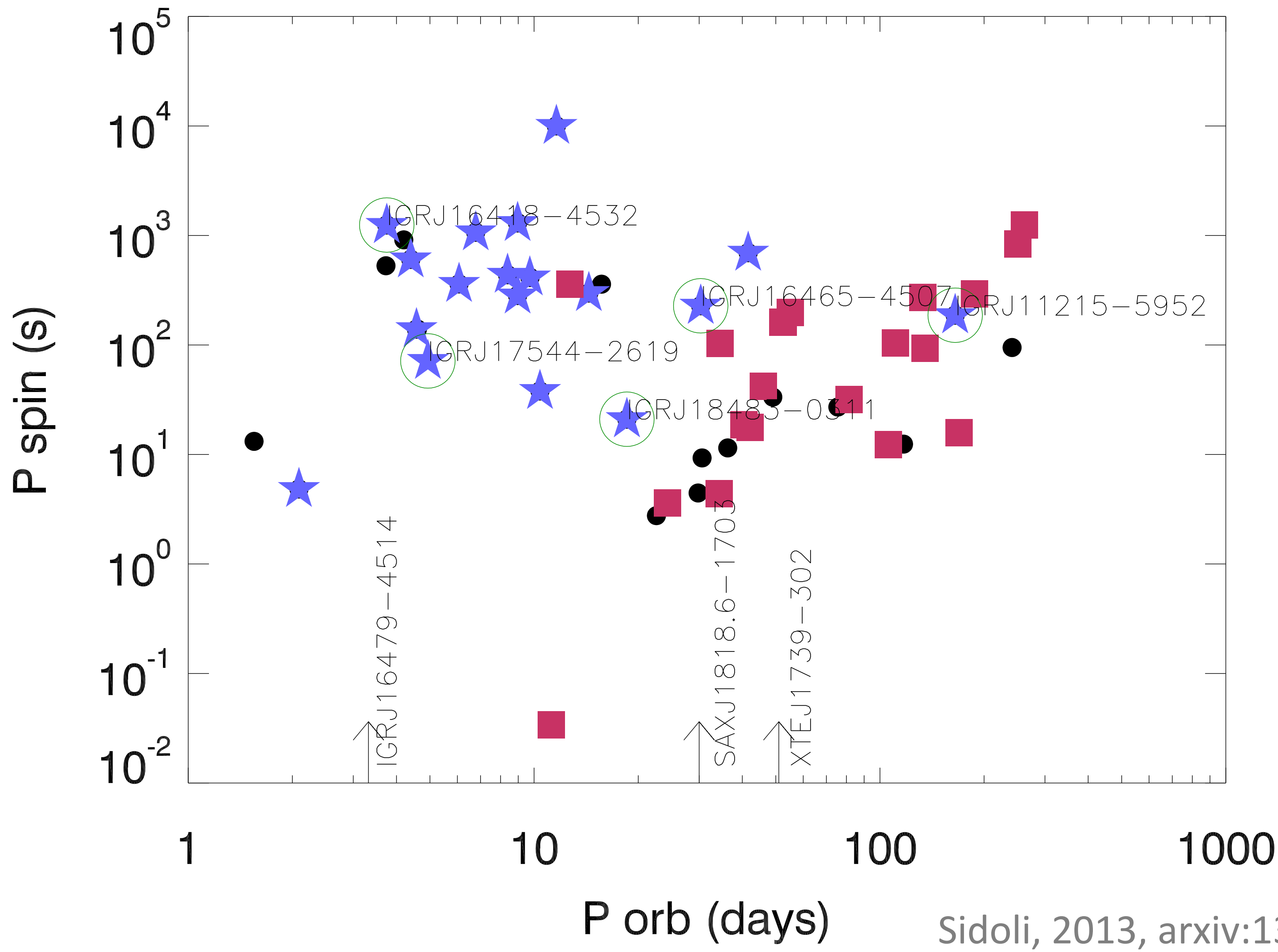


SFXT outbursts: minutes – hours

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

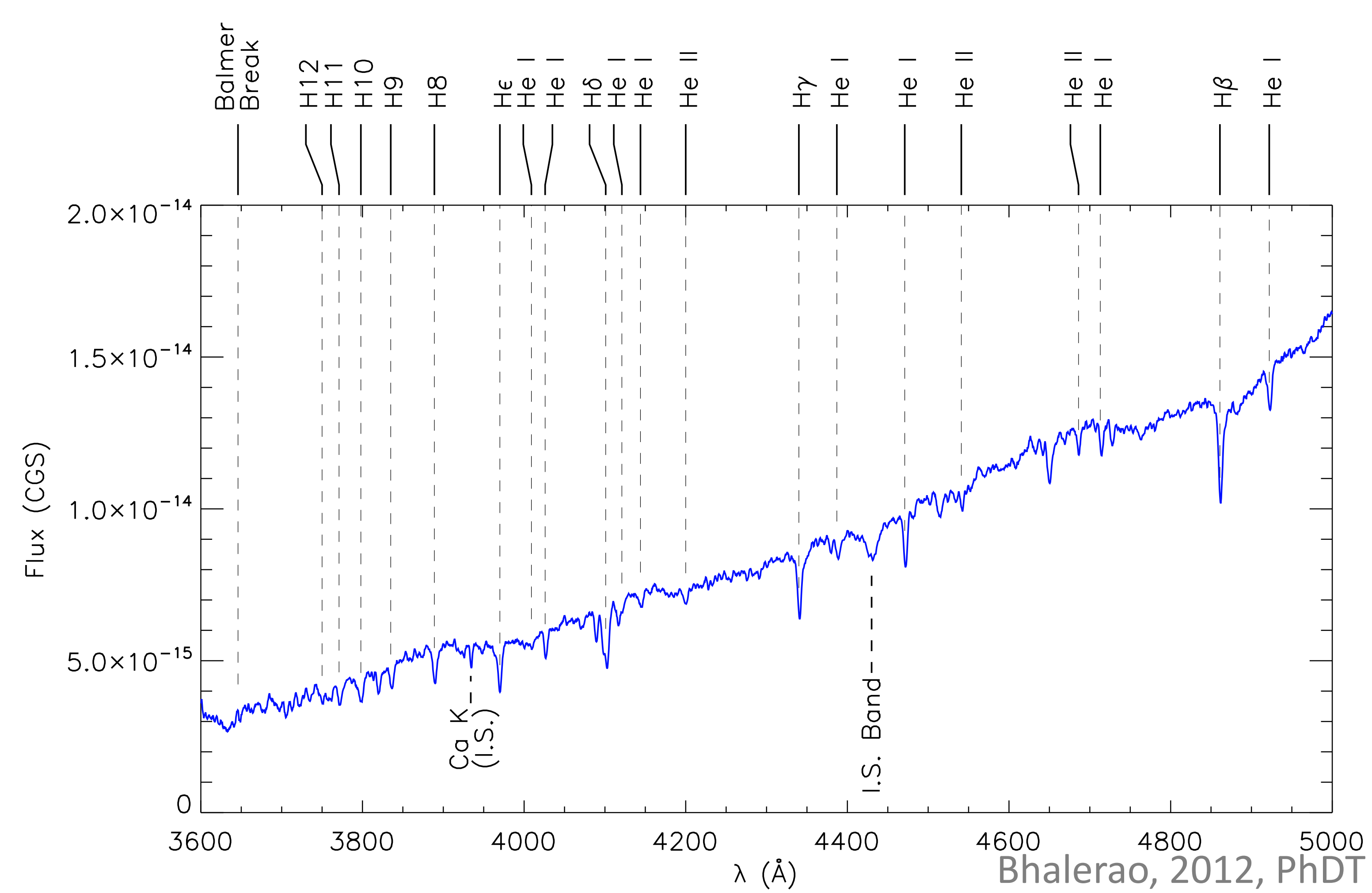
- in't Zand 2005; Walter & Zurita Heras 2007; Negueruela et al. 2008; Sidoli et al. 2007…

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

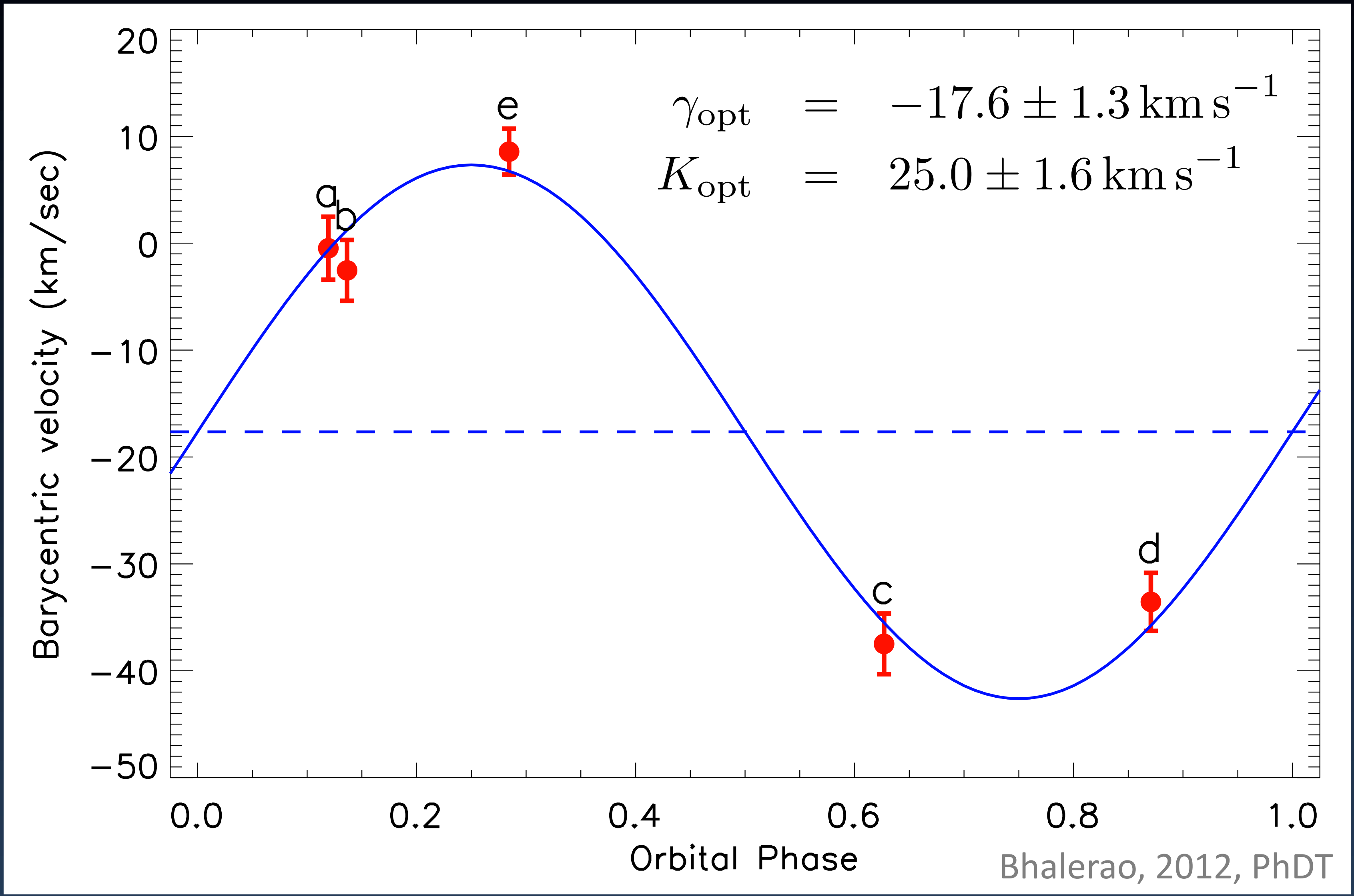
IGRJ17544–2619

IGRJ17544-2619



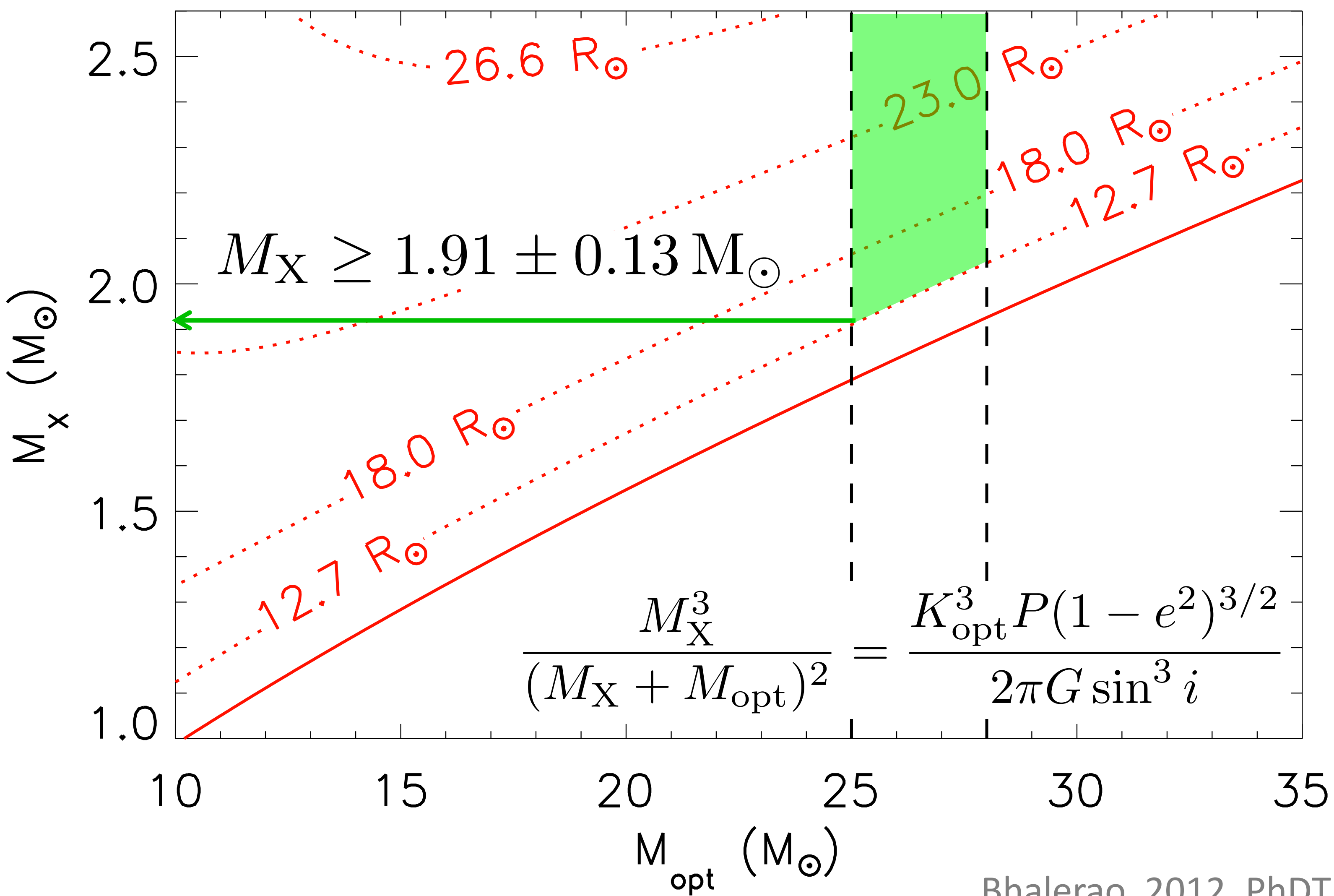
NS (?) + O9 Ib supergiant in 4.93d orbit

Orbit



$\gamma_{\rm opt} = -17.6 \pm 1.3\,{\rm km\,s^{-1}}$
$K_{\rm opt} = 25.0 \pm 1.6\,{\rm km\,s^{-1}}$
a
b
c
d
e
Barycentric velocity (km/sec)
Orbital Phase
20
10
0
−10
−20
−30
−40
−50
0.0
0.2
0.4
0.6
0.8
1.0
Bhalerao, 2012, PhDT

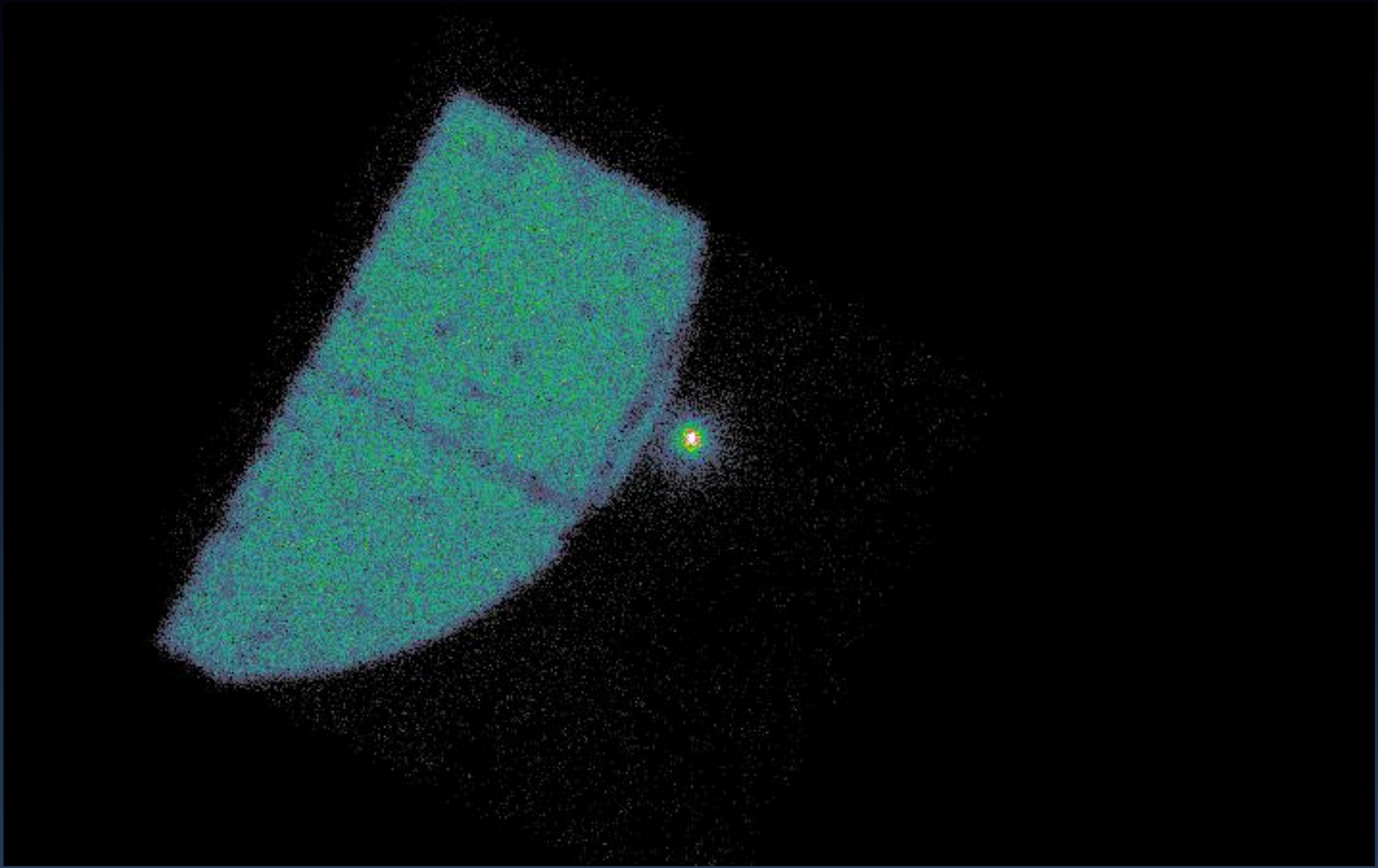
Lower limit on mass



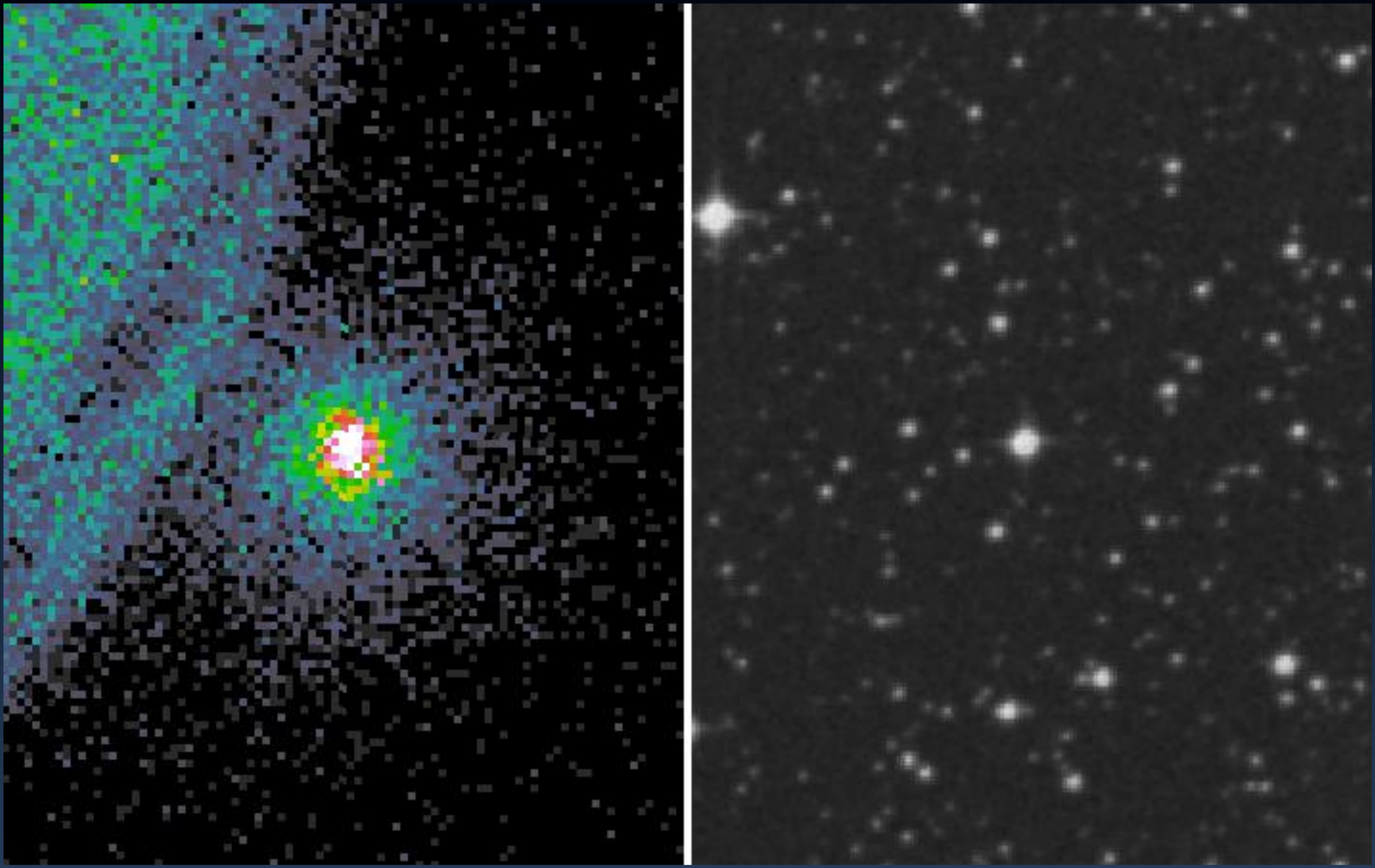
Bhalerao, 2012, PhDT

Observations

Observations



NuSTAR & DSS2 (red)



NuSTAR lightcurve

NuSTAR:

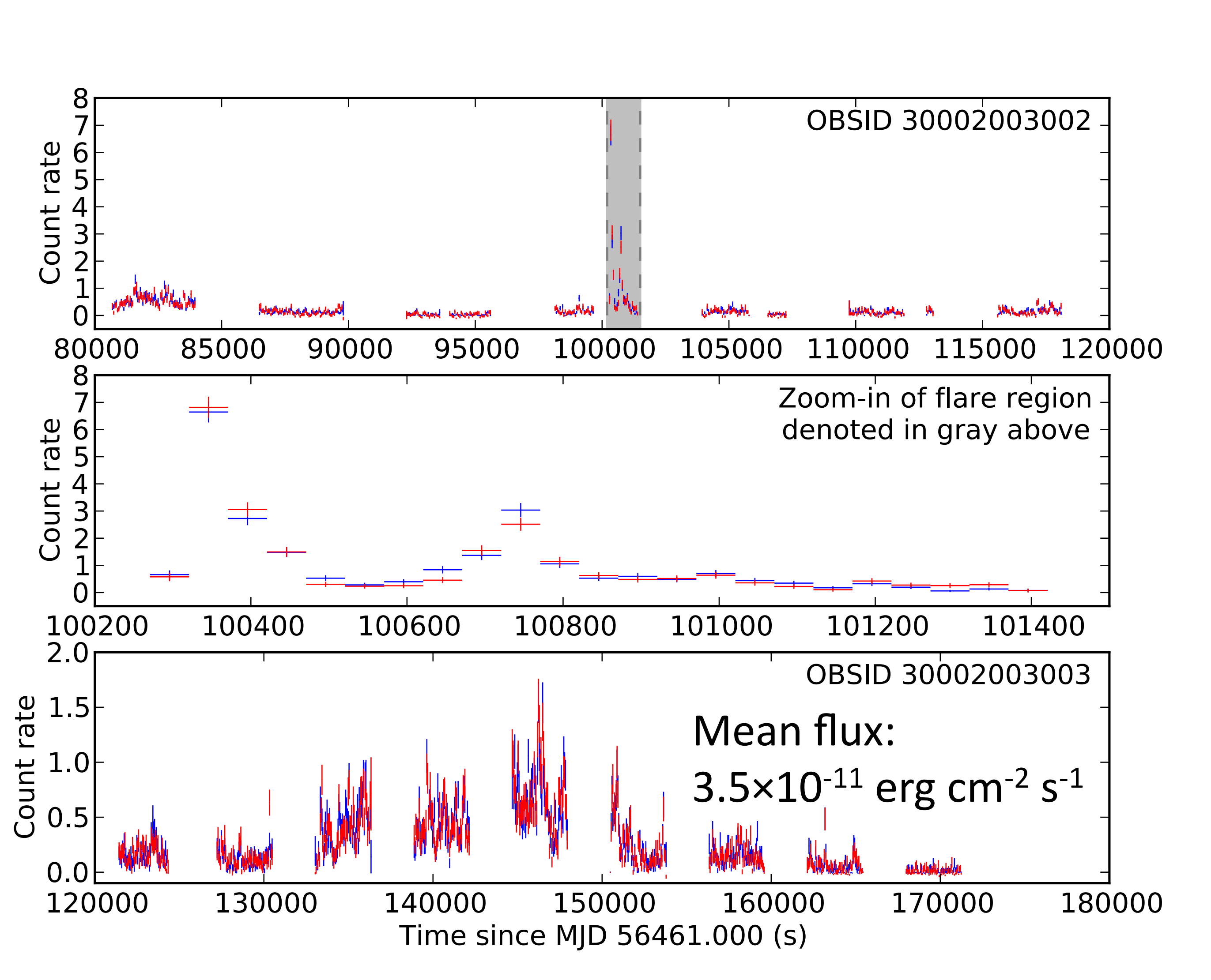
Two obs

18-19 June 2013

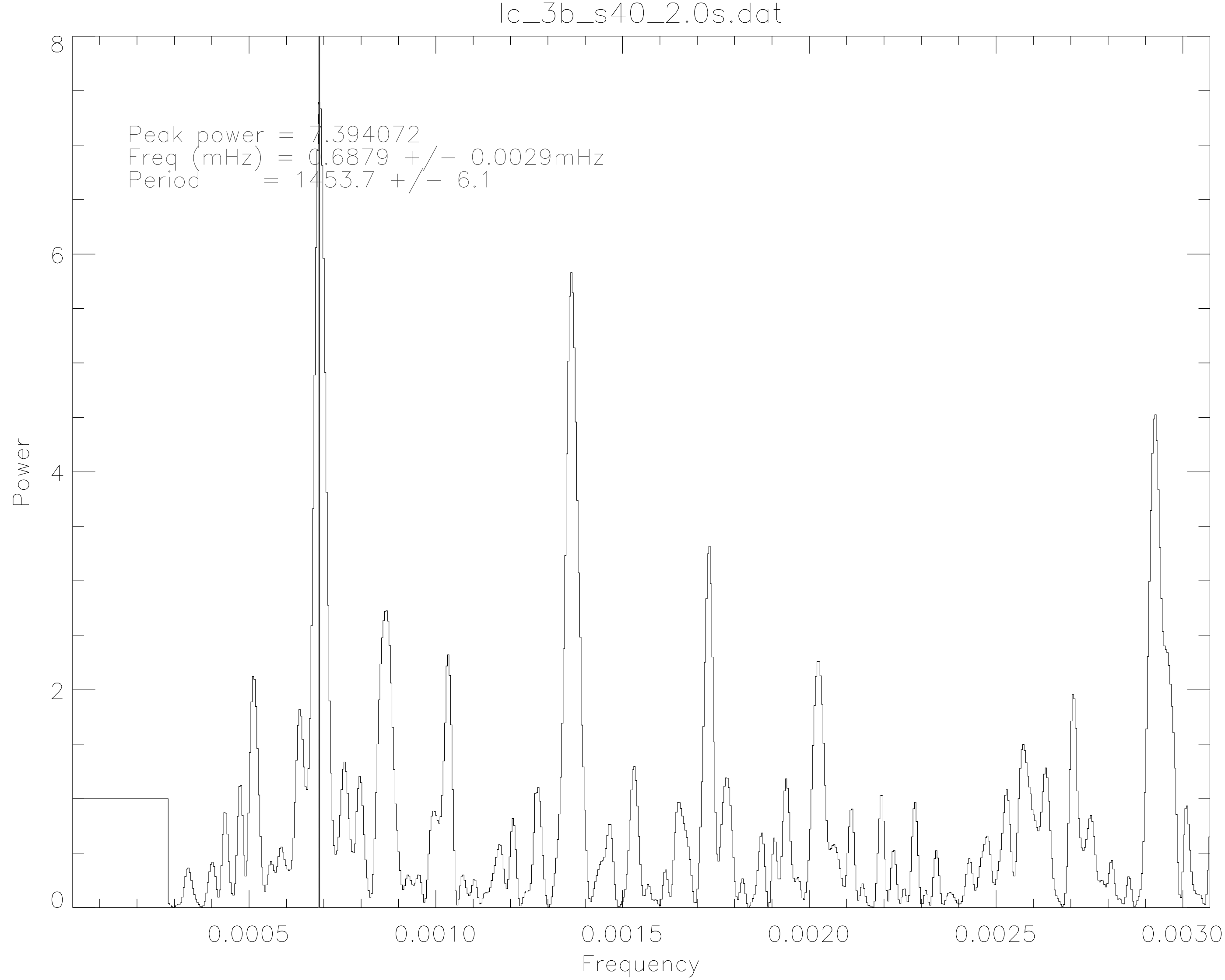
44 ksec

Swift XRT:

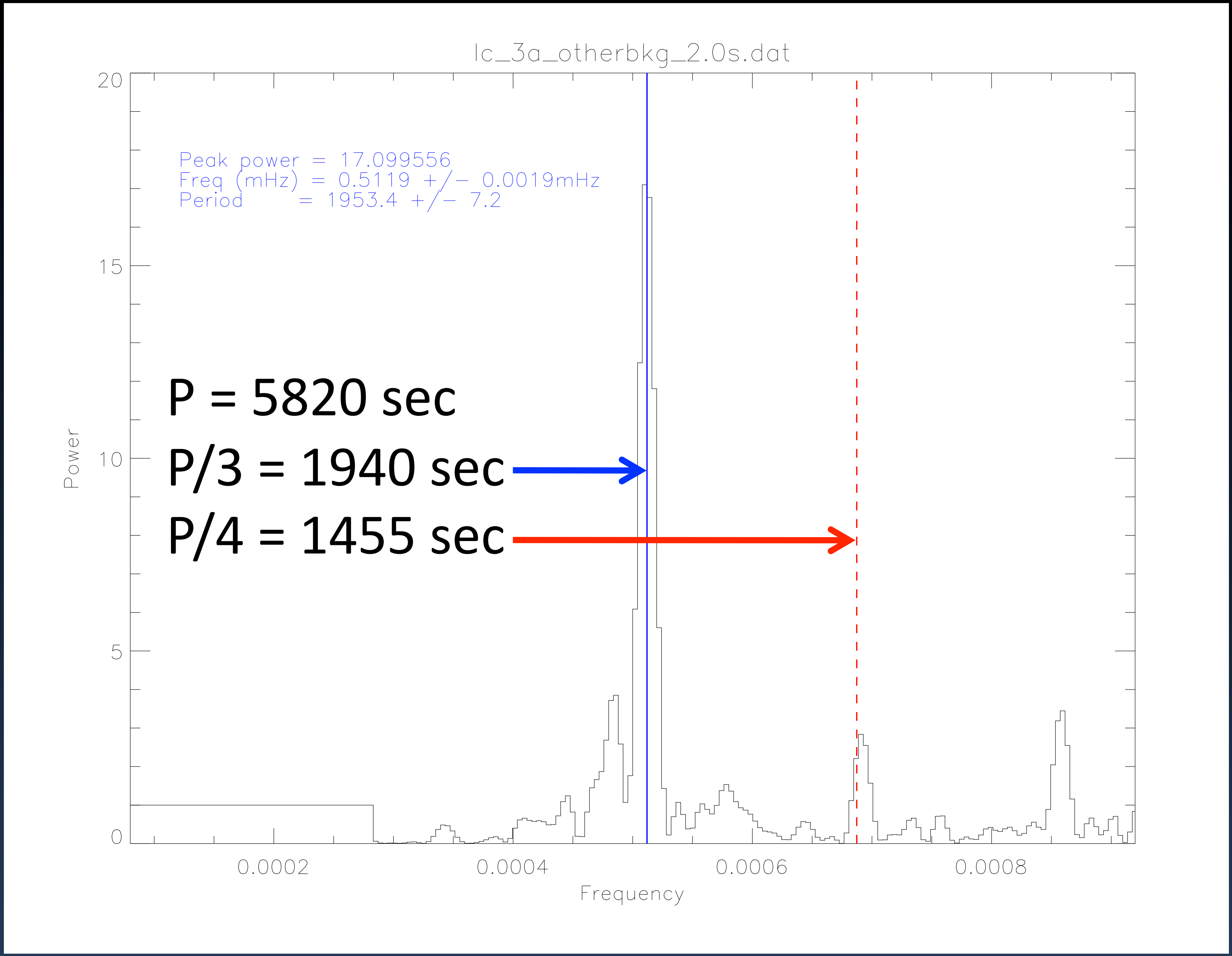
2 ksec



Timing


lc_3b_s40_2.0s.dat
Peak power = 7.394072
Freq (mHz) = 0.6879 +/- 0.0029mHz
Period = 1453.7 +/- 6.1
Power
0
2
4
6
8
0.0005
0.0010
0.0015
0.0020
0.0025
0.0030
Frequency

Reference region



Flare

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

Flare

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  - » Typical level $3.53 \pm 0.05 \times 10^{-11}$ erg cm^{-2} s^{-1}
- 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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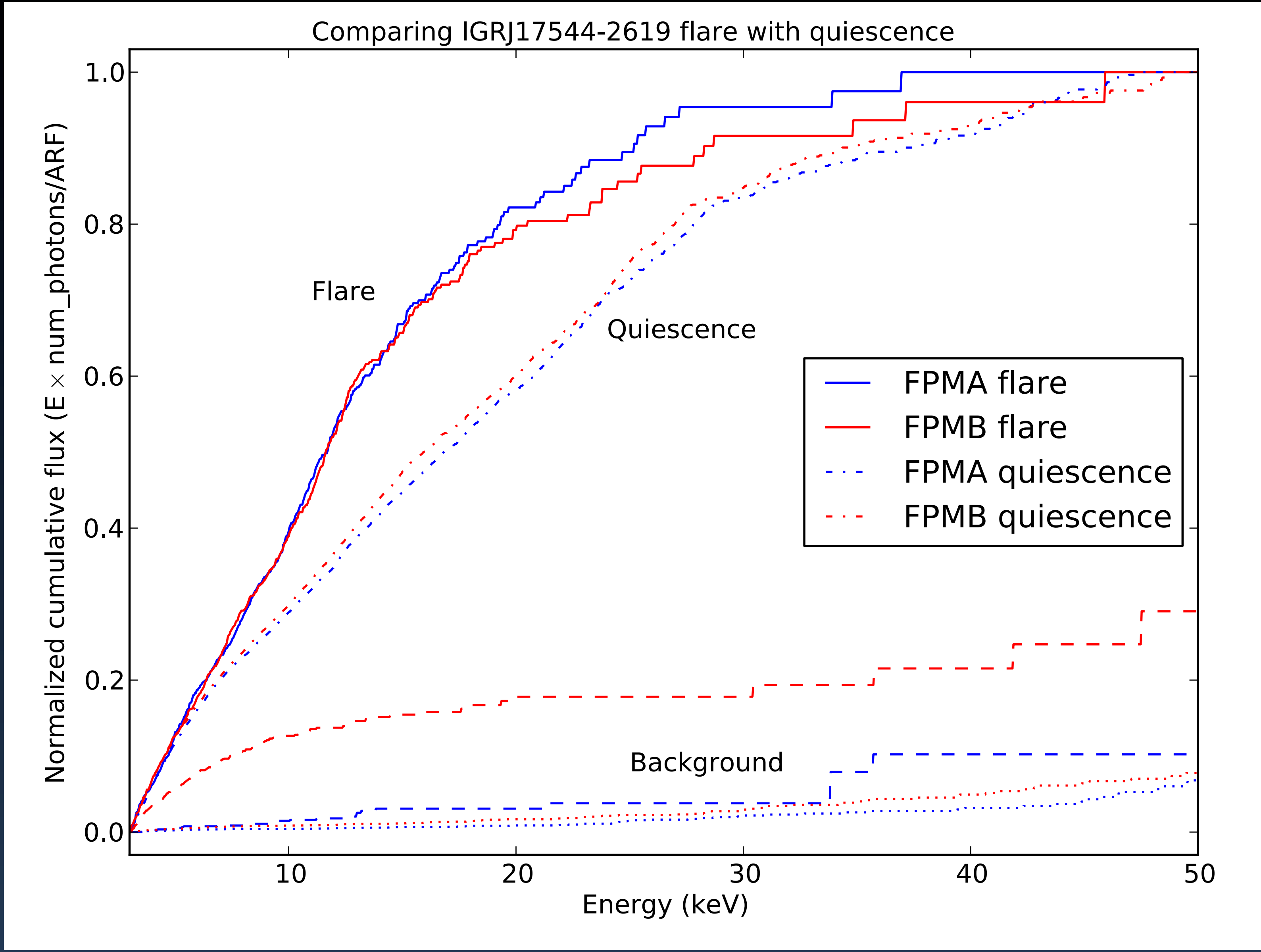
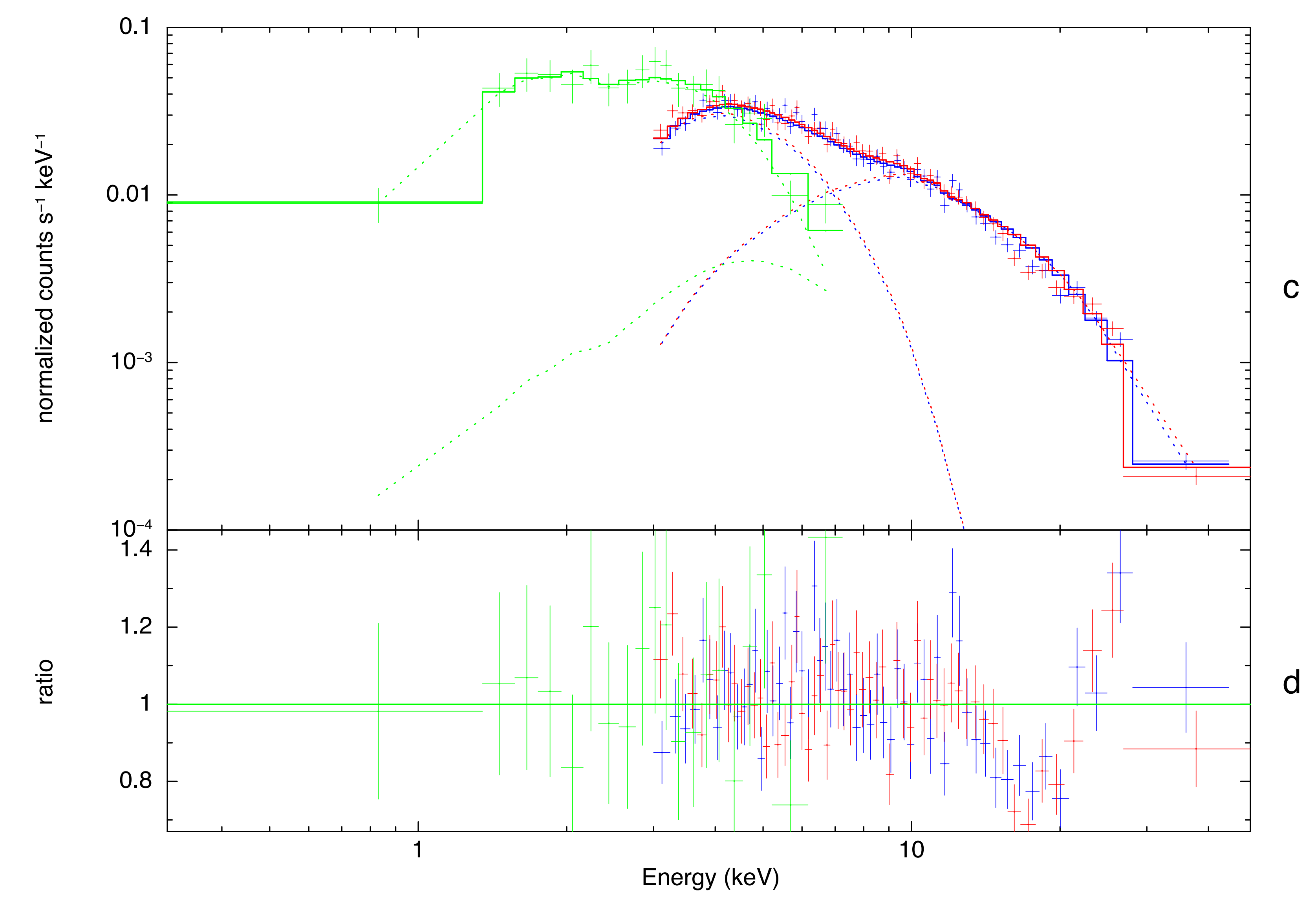
- Time: ~220 seconds
- Spectrum:

The chasm of
Xspec desperation

Flare v/s typical

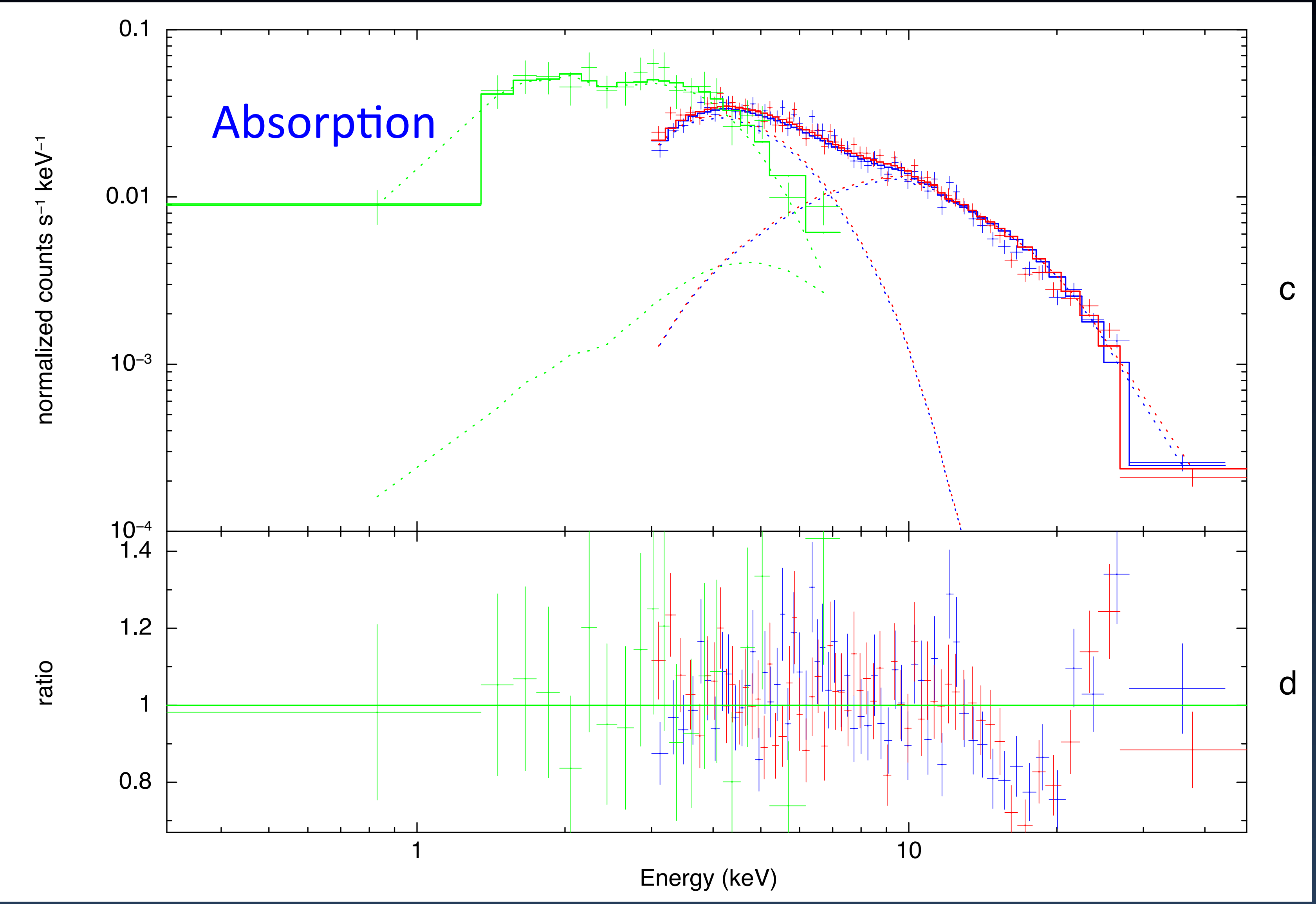


Spectrum



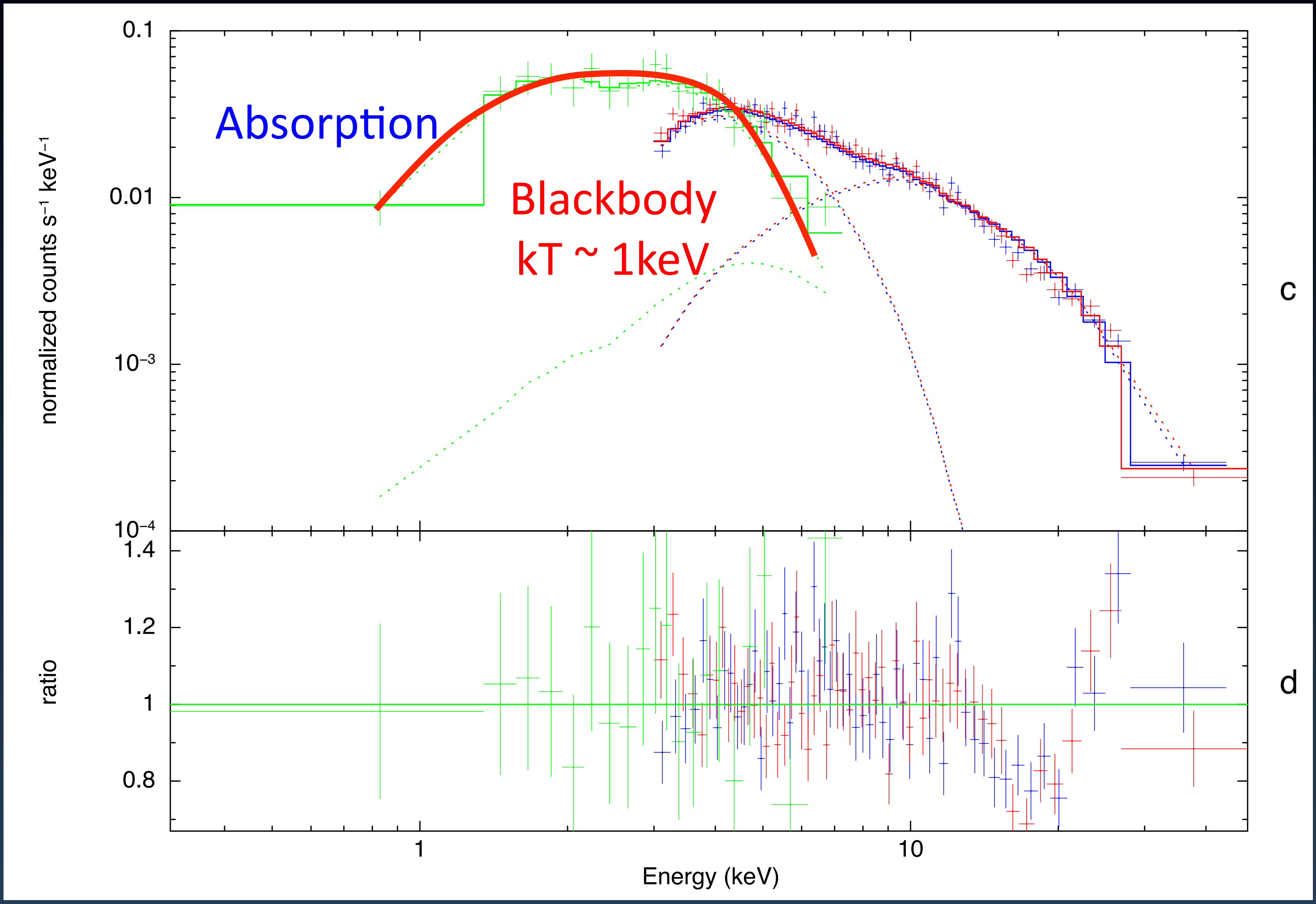
0.1
0.01
10⁻³
10⁻⁴
normalized counts s⁻¹ keV⁻¹
c
1.4
1.2
1
0.8
ratio
d
1
10
Energy (keV)

Spectrum



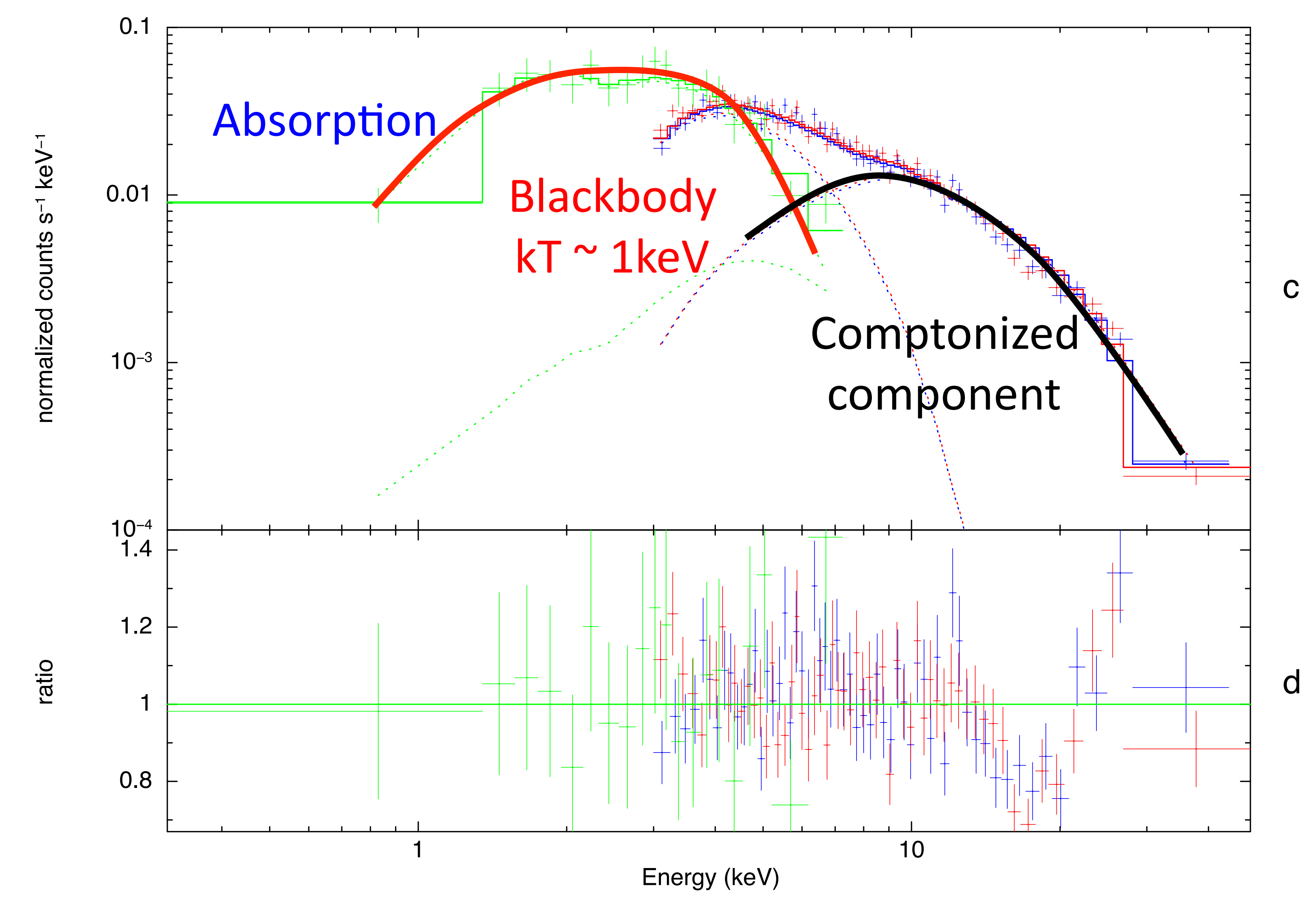
Absorption
0.1
0.01
10⁻³
10⁻⁴
normalized counts s⁻¹ keV⁻¹
c
1.4
1.2
1
0.8
ratio
d
1
10
Energy (keV)

Spectrum



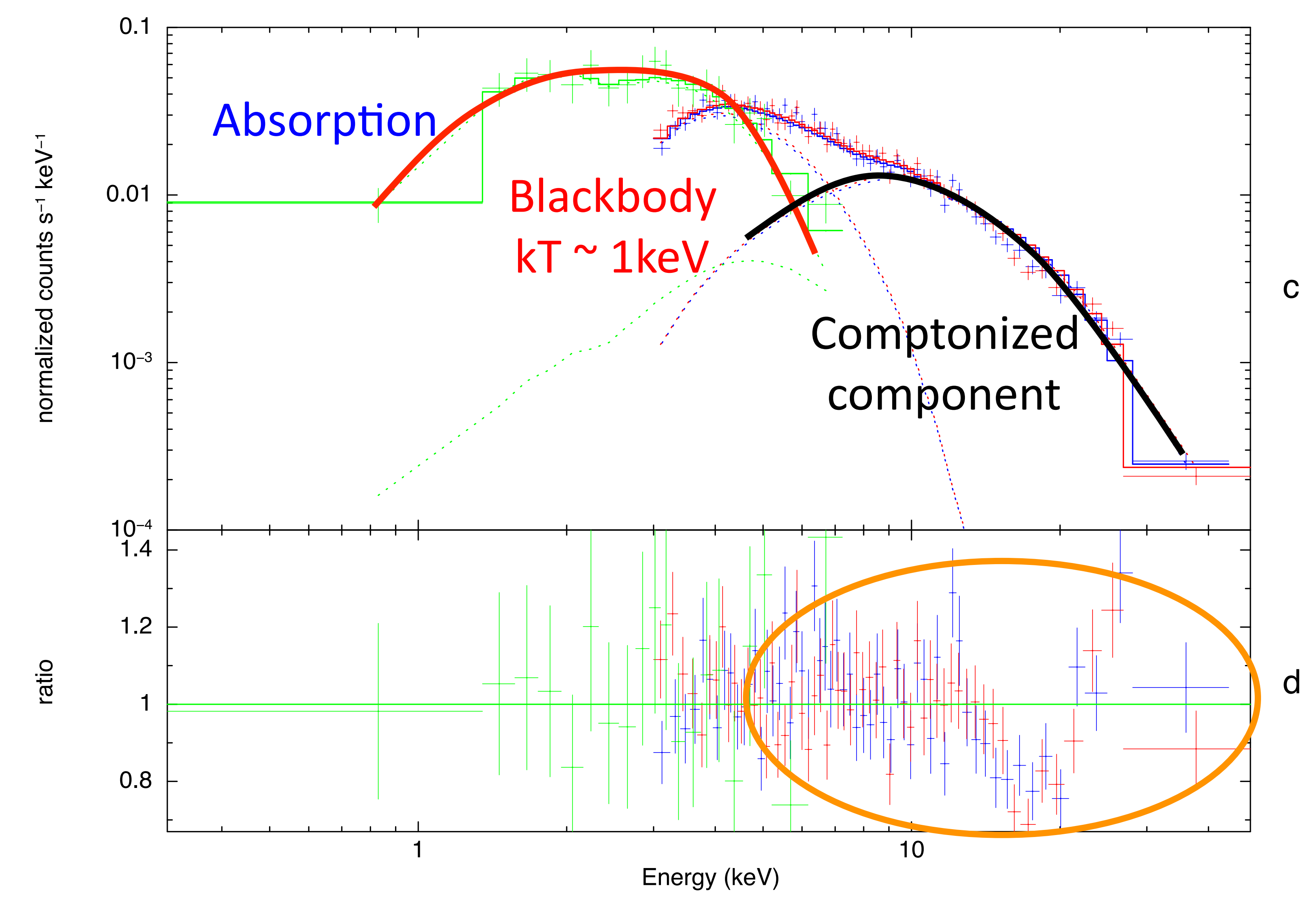
0.1
0.01
10⁻³
10⁻⁴
normalized counts s⁻¹ keV⁻¹
Absorption
Blackbody
kT ~ 1keV
c
1.4
1.2
1
0.8
ratio
d
1
10
Energy (keV)

Spectrum

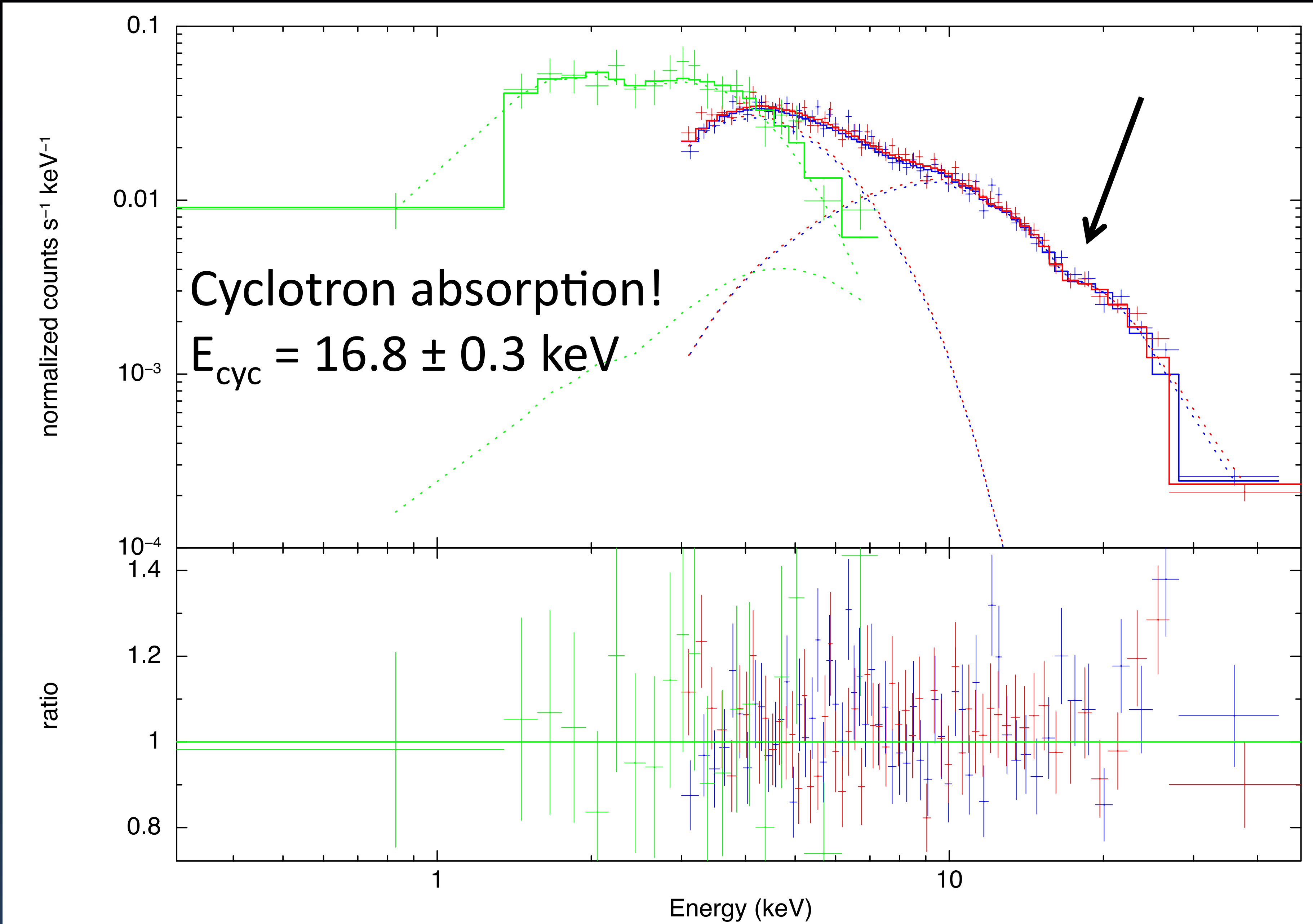


Absorption
Blackbody
kT ~ 1keV
Comptonized
component
normalized counts s^{-1} keV^{-1}
0.1
0.01
10^{-3}
10^{-4}
c
ratio
1.4
1.2
1
0.8
d
1
10
Energy (keV)

Spectrum



0.1
0.01
10^{-3}
10^{-4}
normalized counts s^{-1} keV^{-1}
1.4
1.2
1
0.8
ratio
1
10
Energy (keV)
c
d
Absorption
Blackbody
kT ~ 1keV
Comptonized
component


0.1
0.01
10^{-3}
10^{-4}
normalized counts s^{-1} keV^{-1}
Cyclotron absorption!
E_{cyc} = 16.8 ± 0.3 keV
1.4
1.2
1
0.8
ratio
1
10
Energy (keV)

Line significance

Model 1 (nthcomp)

- $\Delta\chi^2 = 38.7$
  - F-test: $p = 2e\text{-}8$
- Depth ≠ 0
  - $\Delta\chi^2 > 52$ (7σ)
- 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: $p = 2e\text{-}9$
- Depth ≠ 0
  - $\Delta\chi^2 > 52$ (>7σ)
- Monte-carlo simulations:
  - 1000 simulations give $\max(\Delta\chi^2) = 12$, obs 37.1

Conclusion: absorption feature is real, > 5σ !

Magnetic field

- Line is cyclotron feature

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

- E_{cyc} = 16.8 ± 0.3 keV
- B = 1.45 ± 0.03 × 10^{12} G (1+z)

- Harmonic seen at 33 keV
- No line at 8 keV

Conclusion

THE ASTROPHYSICAL JOURNAL, 683:1031–1044, 2008 August 20

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

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Received 2008 February 17; accepted 2008 May 12

ABSTRACT

No!

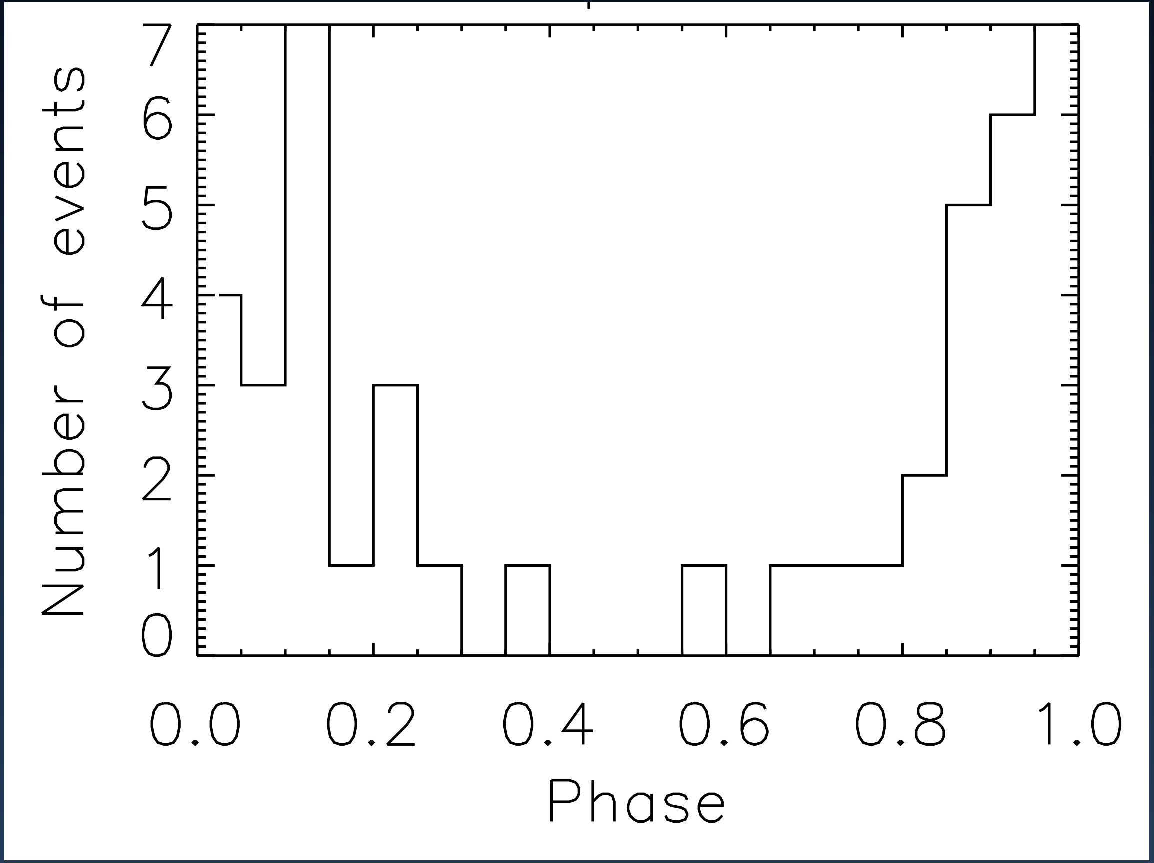
…at least not in
this prototypical case!

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