XMM-Newton & NuSTAR joint observations of the *periodic* Supergiant Fast X-ray Transient IGR J11215-5952

Lara Sidoli

INAF/IASF-Milano (Italy)

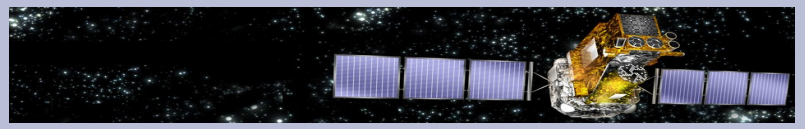
A. Paizis (IASF Milano) **V. Sguera** (IASF Bologna) **L. Natalucci** (IAPS Roma)

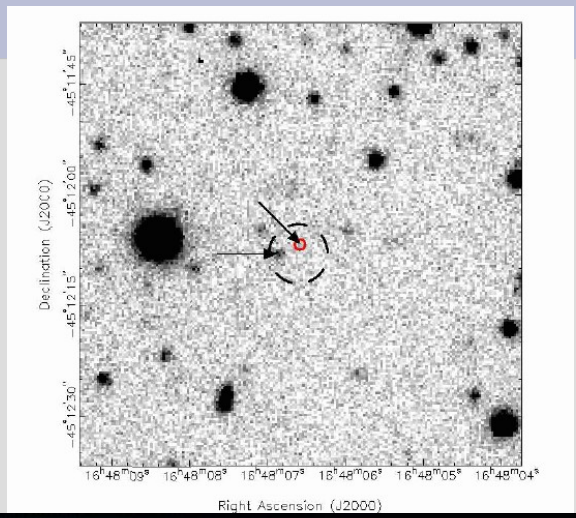
XMM-Newton: The Next Decade
ESA/ESAC 2016 May 10

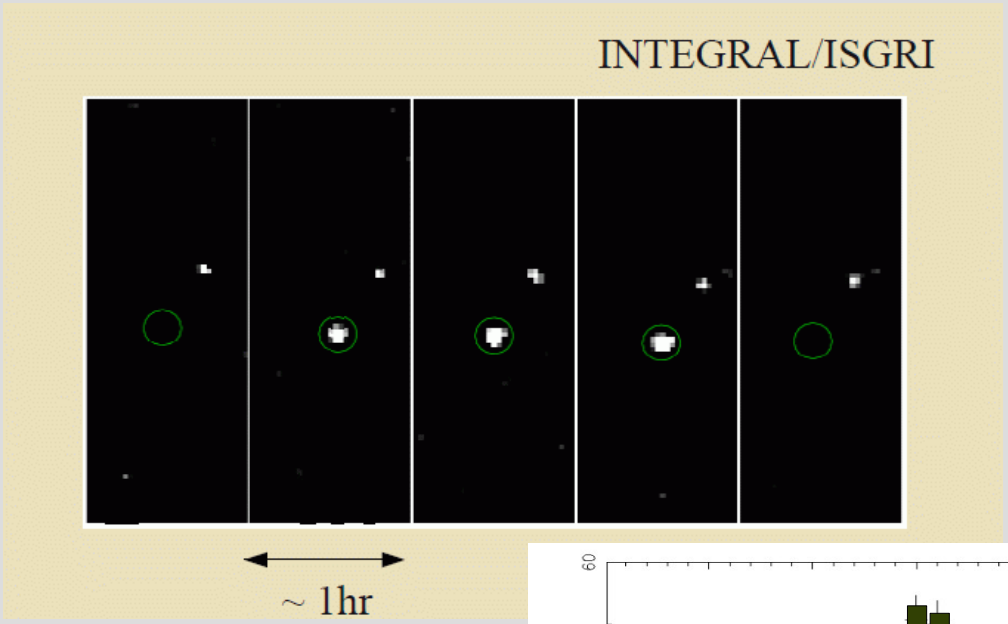
Supergiant Fast X-ray Transients

New source IGR J17544-2619 discovered with INTEGRAL

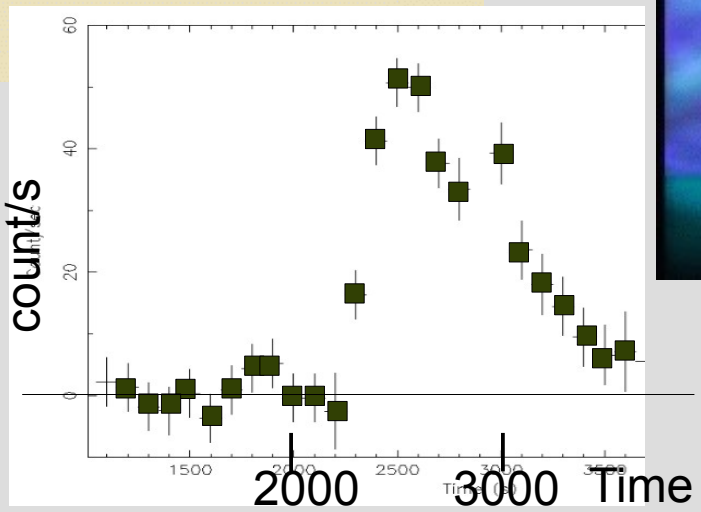
ATel #190; *R. A.Sunyaev (IKI, Moscow; MPA, Garching), S. A.Grebenev (IKI, Moscow), A. A.Lutovinov (IKI, Moscow), J. Rodriguez (CEA/SAp, Saclay), S. Mereghetti (IASF, Milano), D. Gotz (IASF, Milano), T. Courvoisier (ISDC, Versoix) and the shift team*
on 17 Sep 2003; 15:15 UT

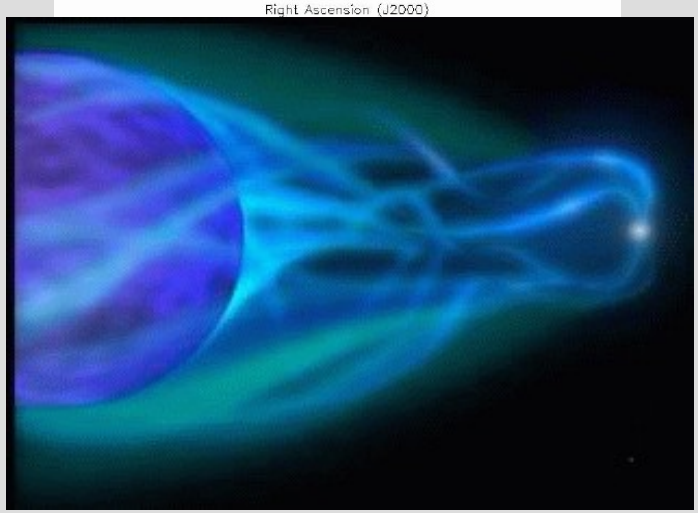






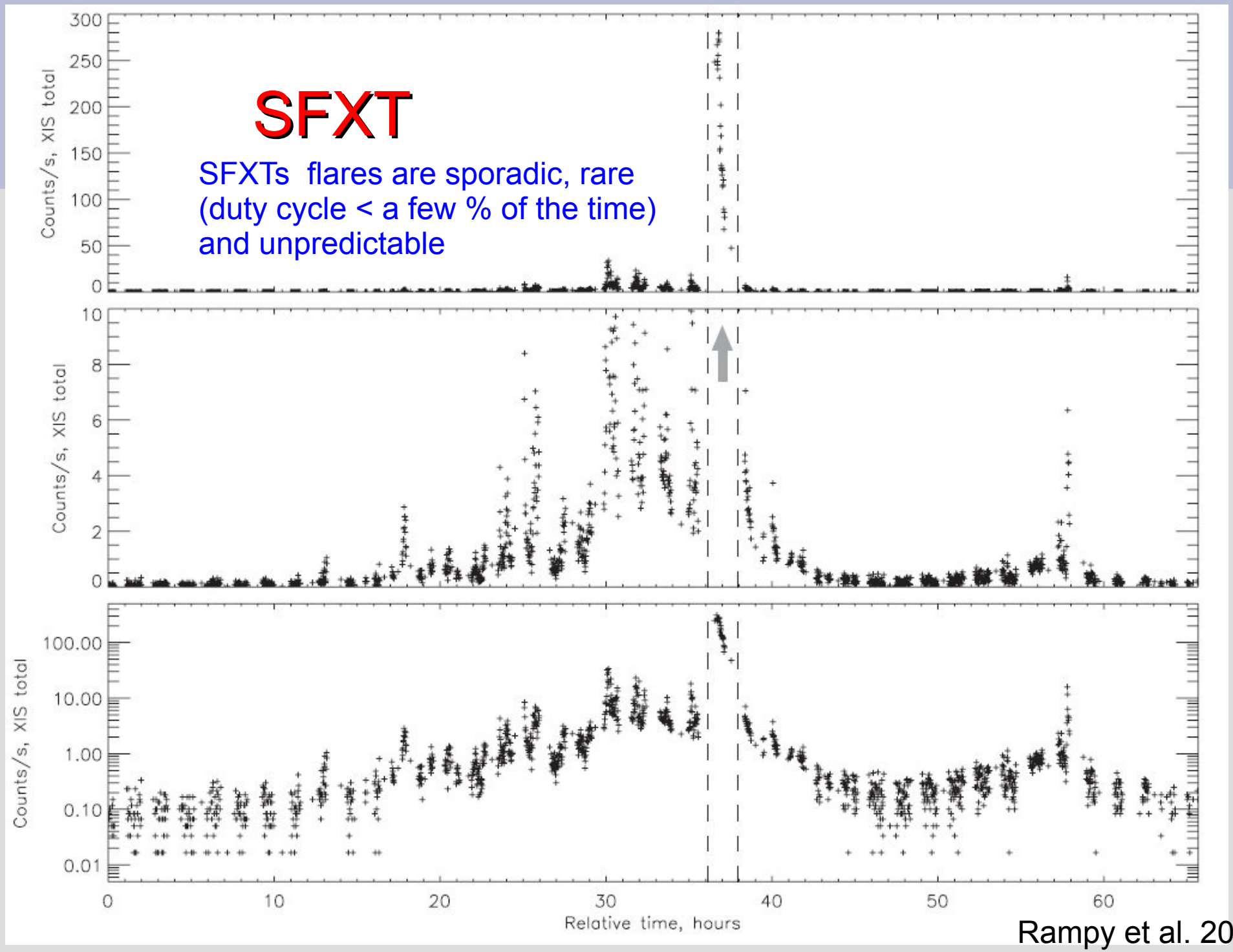
Sguera et al. 2005





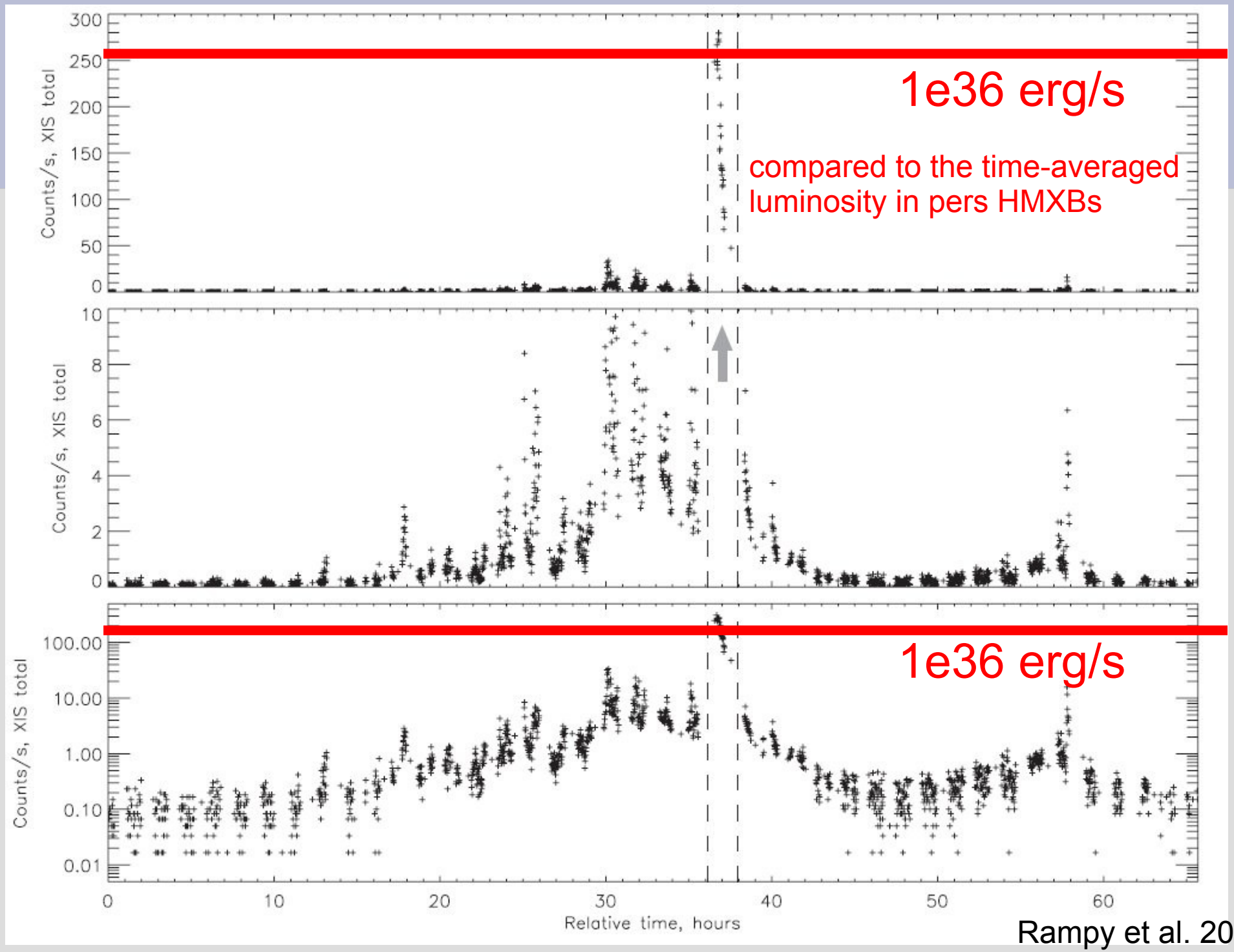
Negueruela et al. 2006

Suzaku observation of IGRJ 17544-2619



Rampy et al. 2009

Suzaku observation of IGRJ 17544-2619



Rampy et al. 2009

SFXT proposed explanations

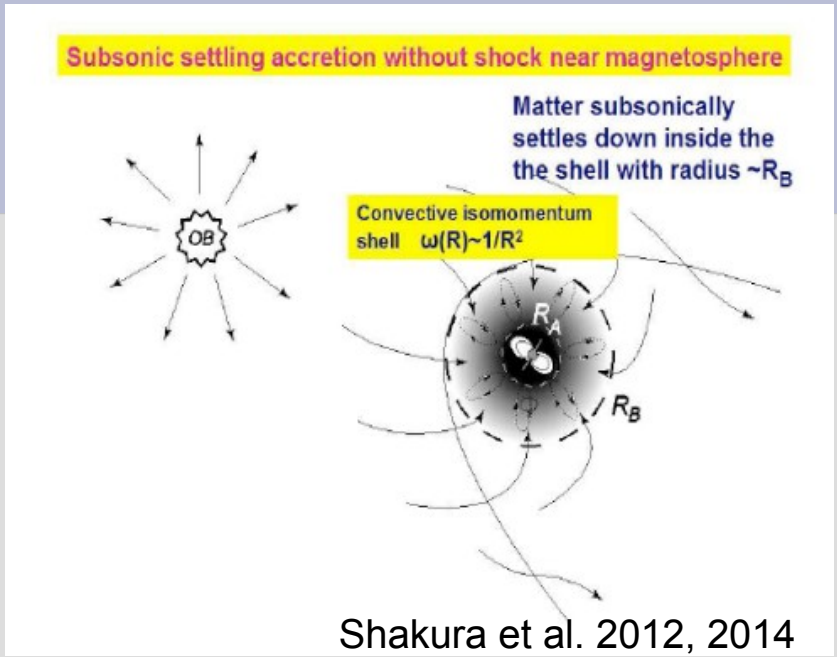
A mechanism is needed to largely reduce the accretion for most of the time:

- Centrifugal barrier (Grebenev&Sunyaev 2007)
- Magnetic barrier (Bozzo et al. 2008) → magnetar-like B field
- Quasi-spherical settling accretion (Shakura et al. 2012)

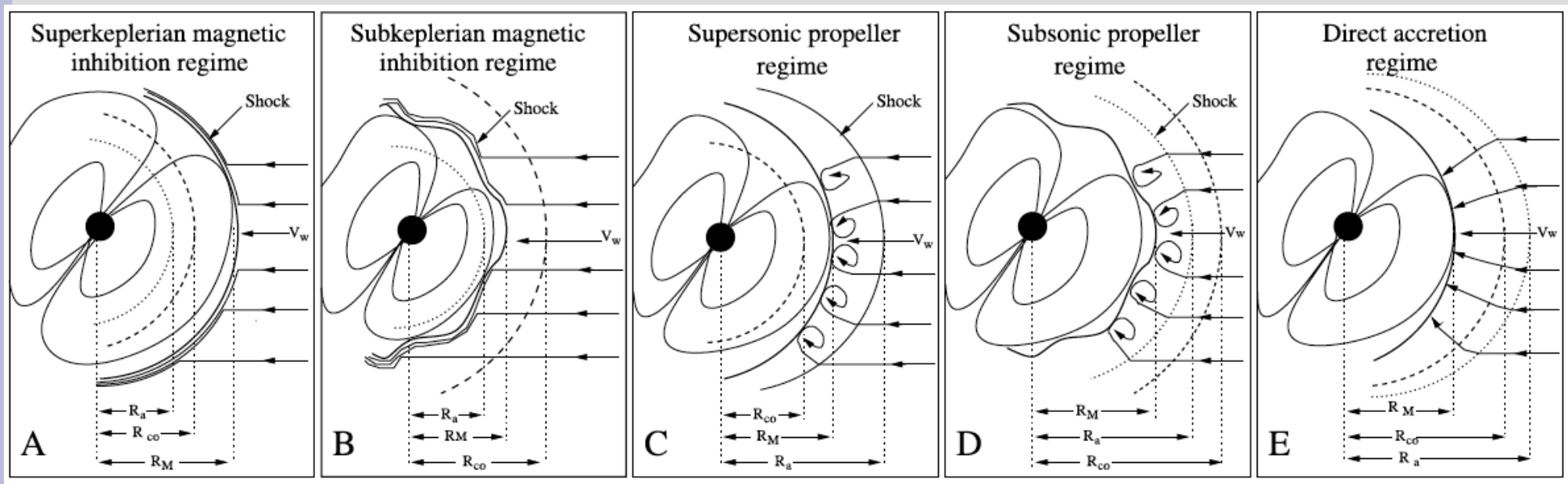
→ more standard B fields and slow pulsars

To disentangle between them we need

Pspin & neutron star **B field**



Shakura et al. 2012, 2014

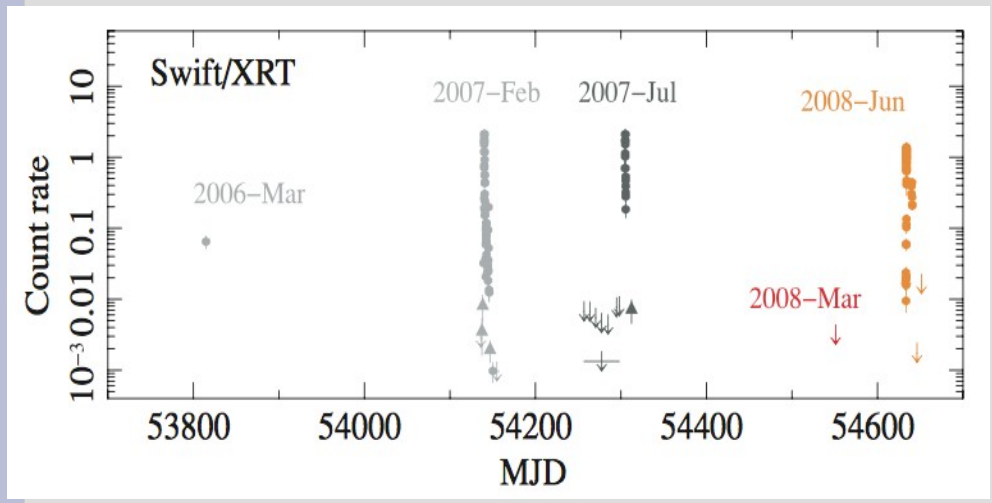


Bozzo et al. 2008

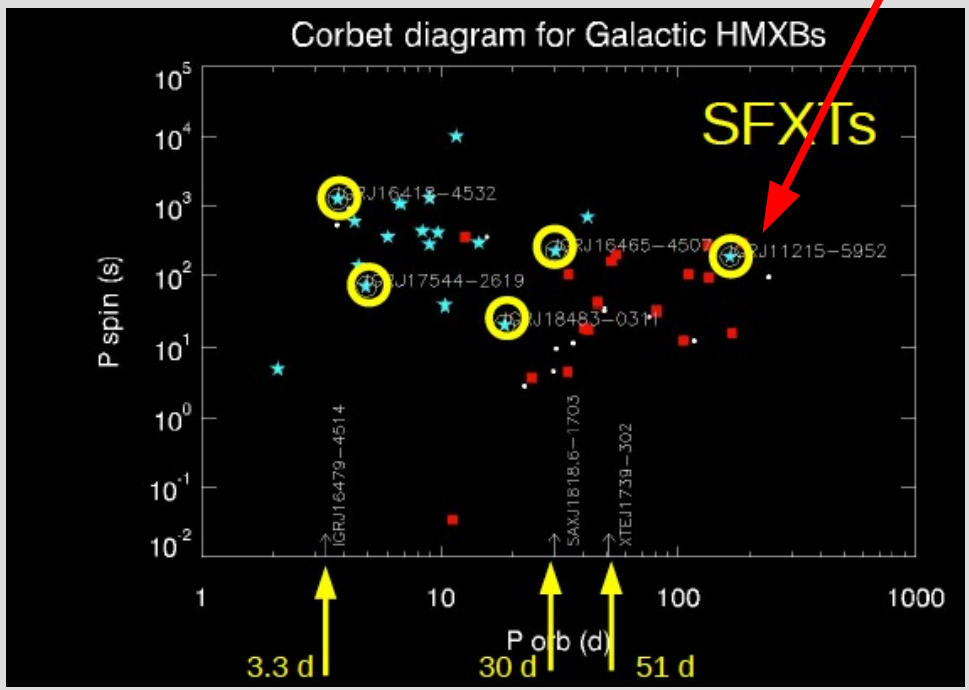
IGRJ 11215-5952

The only SFXT with **periodic** outbursts (Sidoli et al. 2006)

X-ray transient discovered with INTEGRAL (Lubinski et al. 2005)
Associated with the B supergiant **HD306414** (Negueruela et al. 2005)
located at d=>7 kpc (Lorenzo et al. 2014)
Periodicity in the X-ray **outbursts occurrence** (Sidoli et al. 2006, 2007)
likely the orbital period of the system, later refined to **164.6 days** (Romano et al. 2009)
X-ray pulsar **Pspin = 187 s** (Swank et al. 2007)



Romano et al. 2009



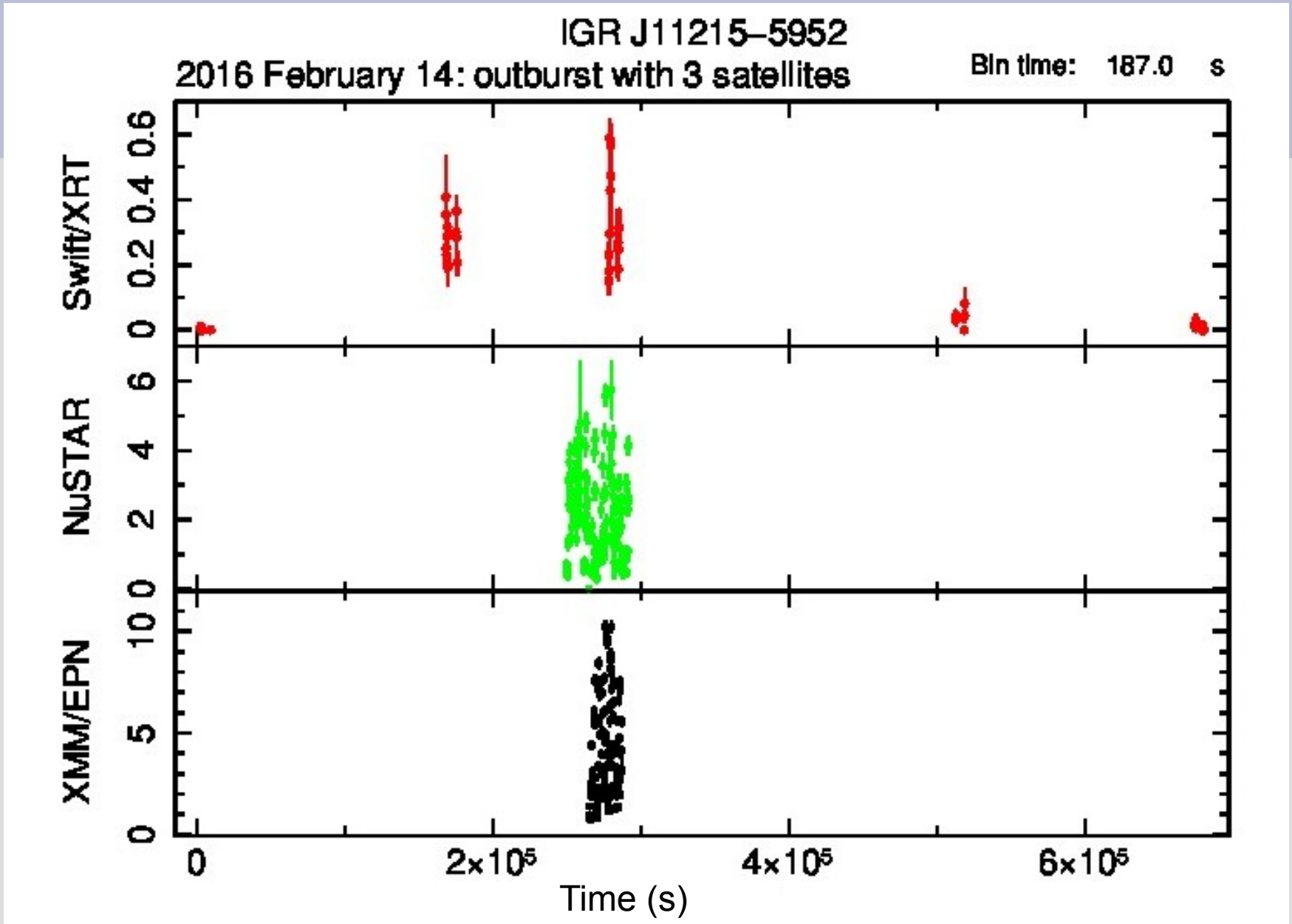
The only SFXT with predictable (periodic) outbursts is IGRJ11215-5952 (every 165 days, likely the Porb of the system)

→ It was possible to plan fixed time observations with a relatively short exposure time (Net Texp = 20 ks) at the time of the expected outburst

XMM-Newton AO time in 2014 + NuSTAR

The main goal was to **search for** the **cyclotron line**
To directly measure the neutron star B field

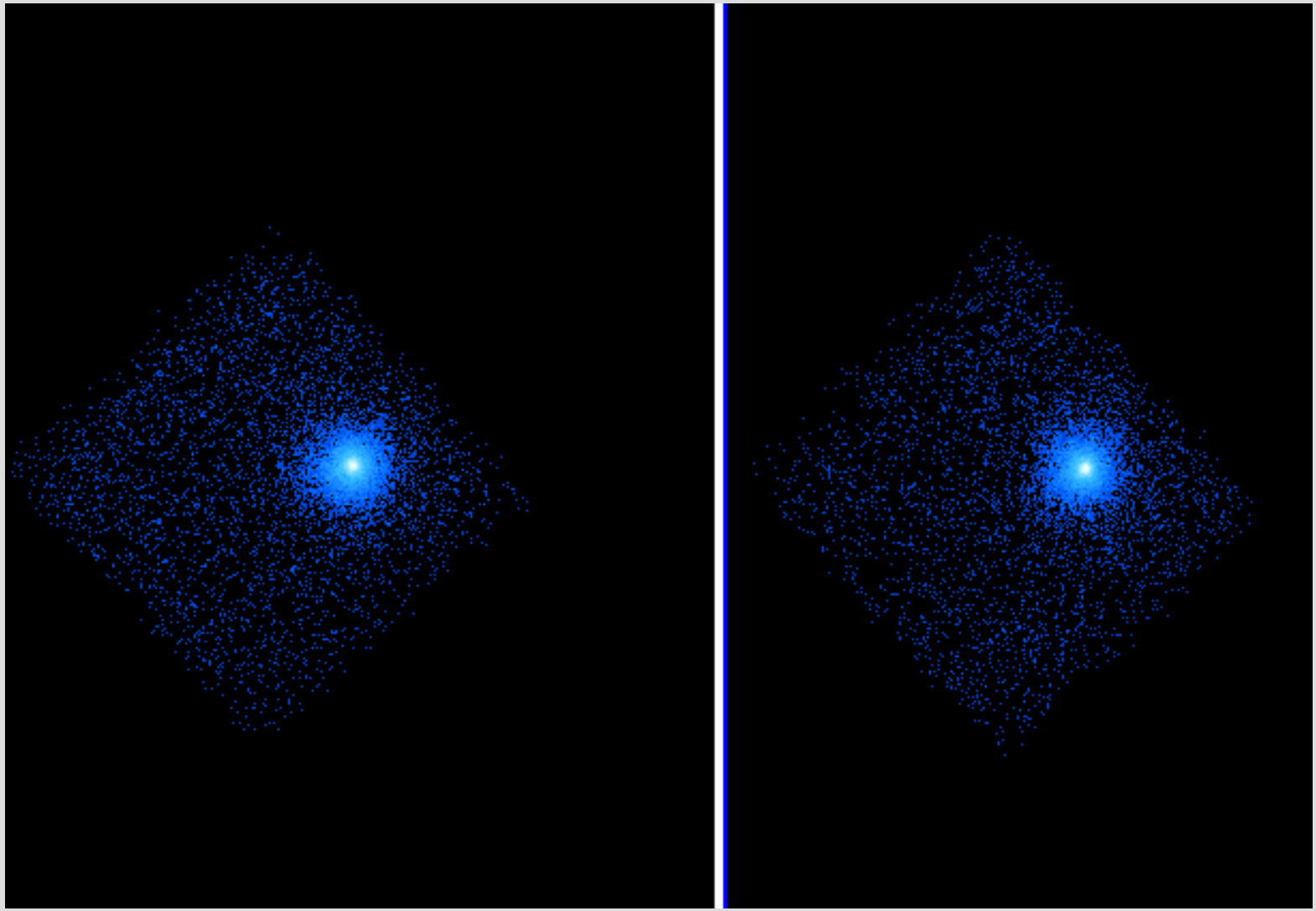
After acceptance, in February 2016, we asked for a **Swift/XRT** monitoring of the week around the times of the expected XMM+NuSTAR observations, planned at the flux peak (2016, Feb 14)


IGR J11215–5952
2016 February 14: outburst with 3 satellites
Bin time: 187.0 s
Swift/XRT
NuSTAR
XMM/EPN
0
0.2
0.4
0.6
2
4
6
10
5
0
2×10^5
4×10^5
6×10^5
Time (s)

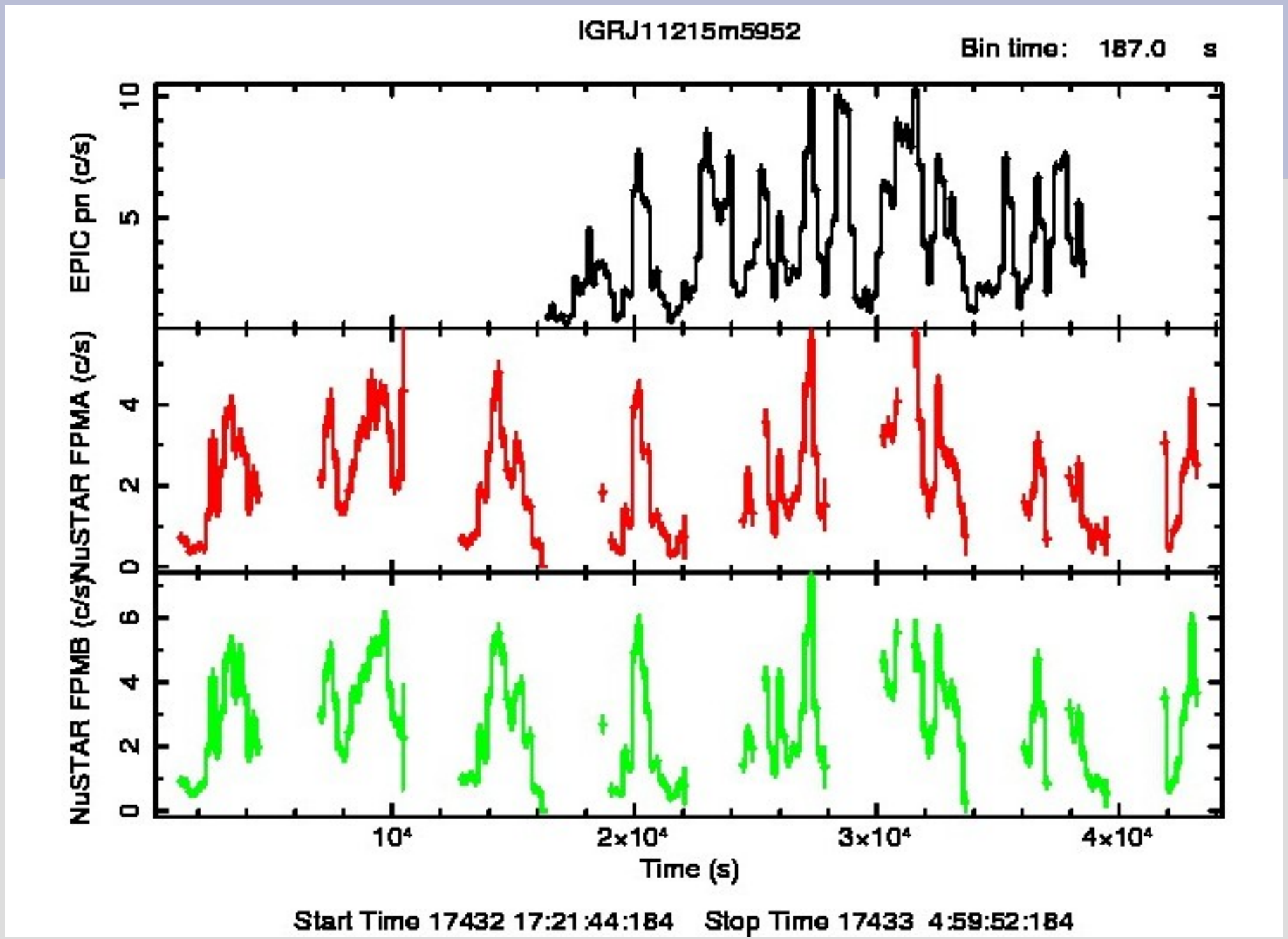
IGRJ11215-5952

NuSTAR FPMA

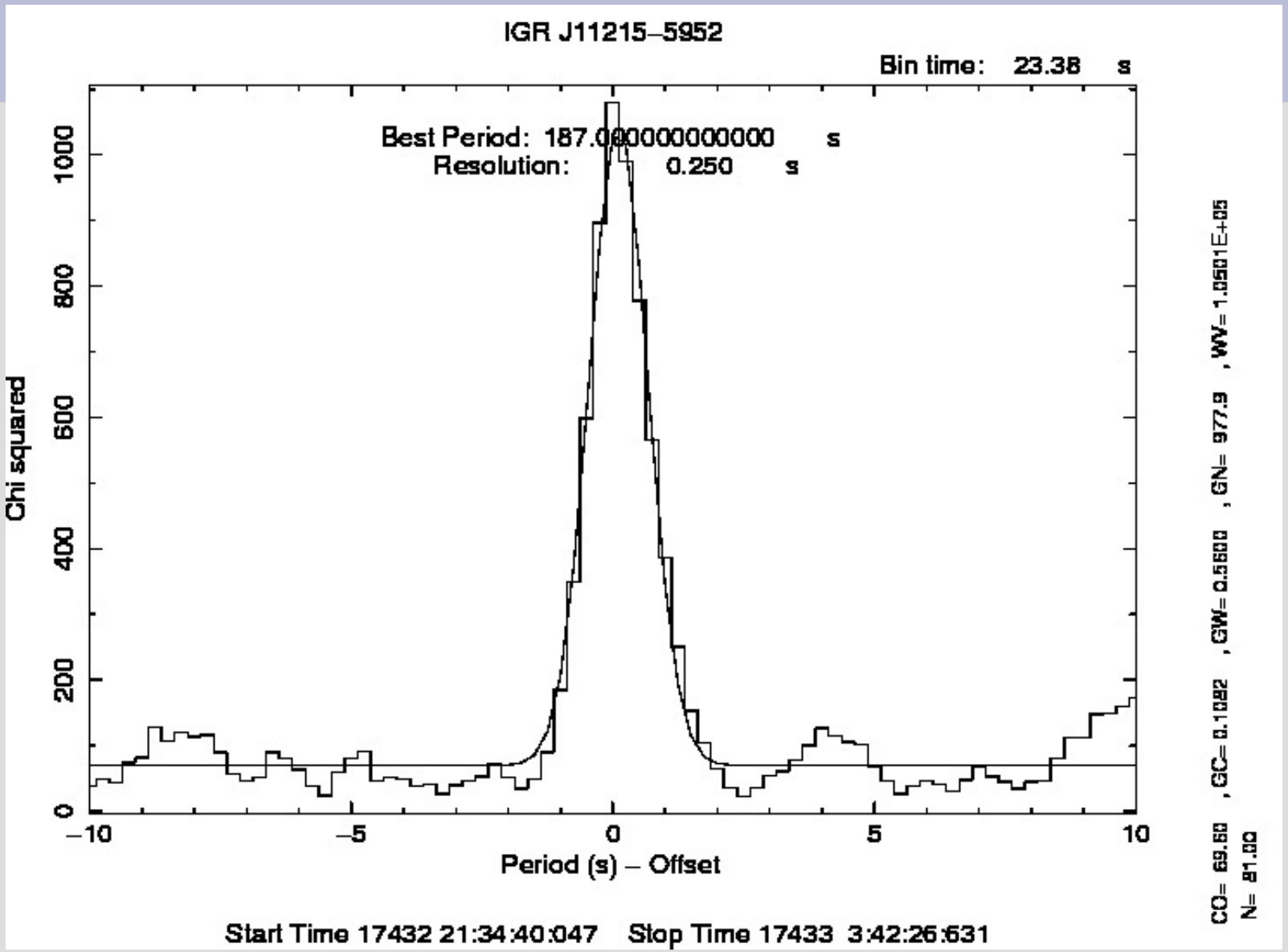
NuSTAR FPMB



Net exposure
20 ks


IGRJ11215m5952
Bin time: 187.0 s
EPIC pn (c/s)
NuSTAR FPMA (c/s)
NuSTAR FPMB (c/s)
10
5
0
4
2
0
6
4
2
0
10⁴
2×10⁴
3×10⁴
4×10⁴
Time (s)
Start Time 17432 17:21:44:184 Stop Time 17433 4:59:52:184

XMM-EPIC pn (2-12 keV) – efsearch around the known spin period



No evidence for Pdot with respect to previous observations in 2007

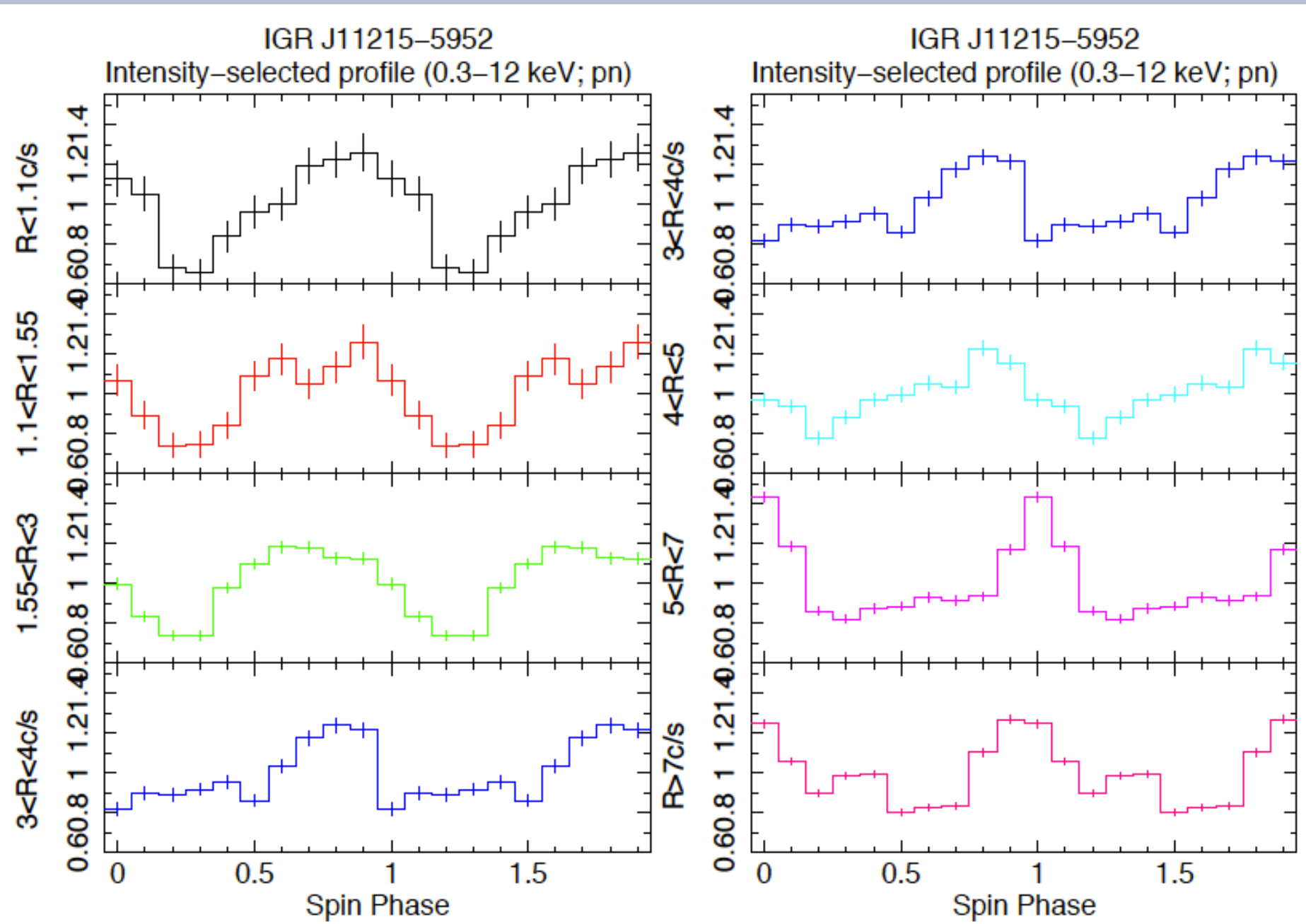
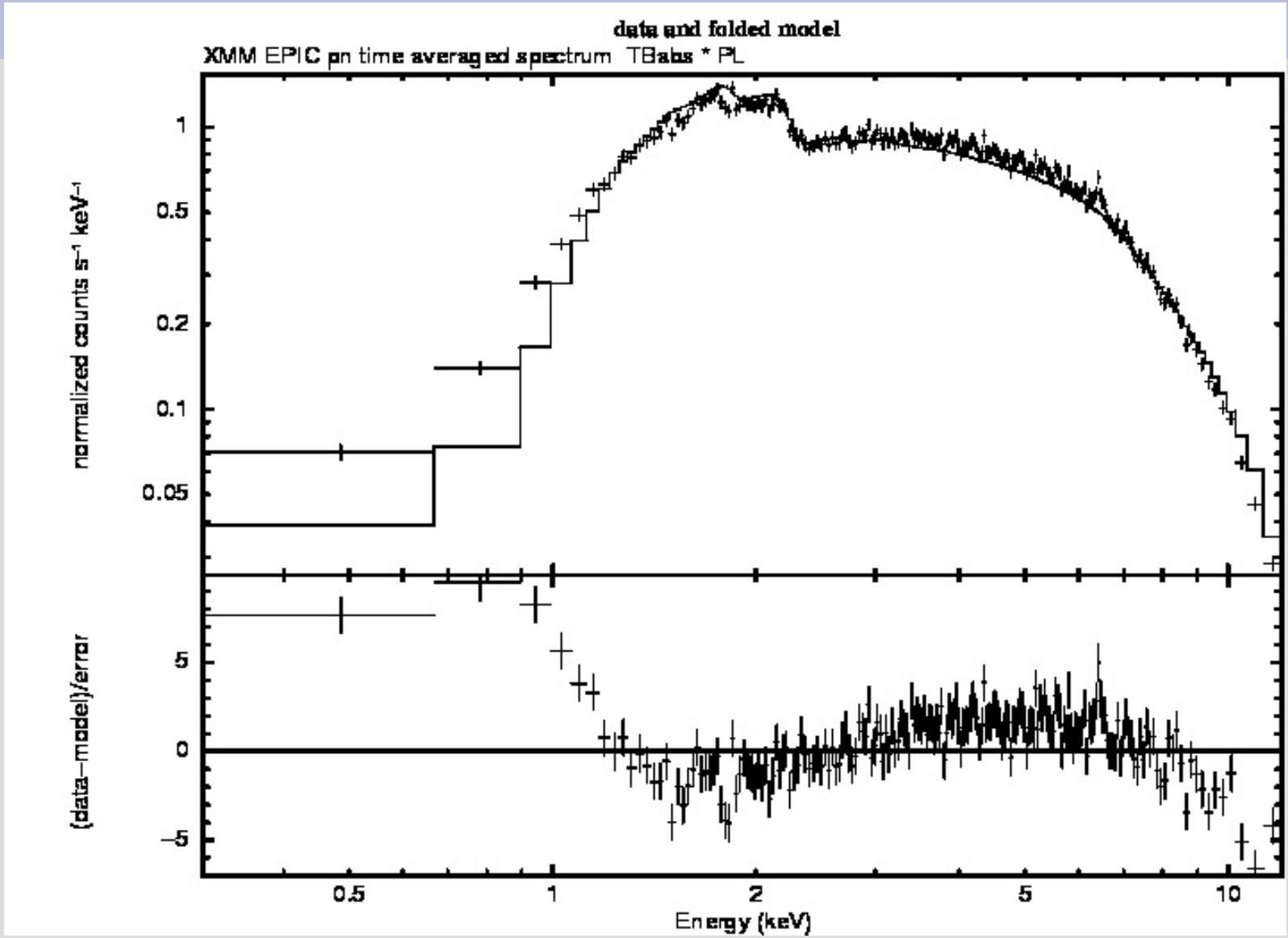


Figure 2. Intensity-dependent IGR J11215–5952 pulse profiles observed by *XMM-Newton* EPIC pn (0.3-12 keV).

XMM EPIC pn time-averaged spectrum fitted with an absorbed PL

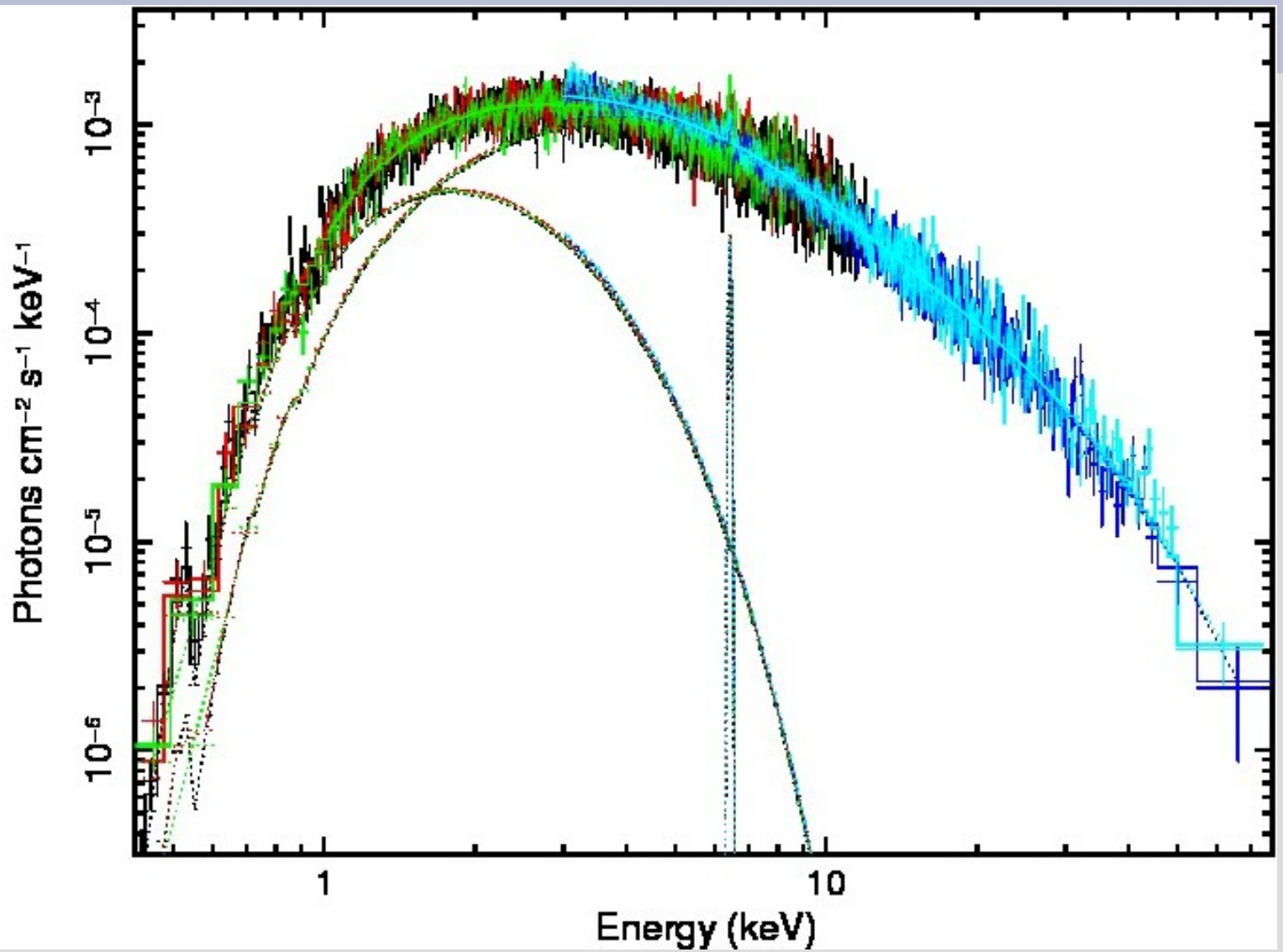


The spectrum has been severely rebinned here, to clearly show the residuals

Time-averaged XMM EPIC (0.4-12 keV) and NuSTAR (3-79 keV) spectra

Fx (0.1-100 keV) = 1.6e-10 erg/cm2/s
Lx = 10 36 erg/s

N_H =(0.83 +/- 0.05) x10^22 cm-2



BB

kT=0.7 +/- 0.09 keV
Rbb = 1.1 +/- 0.2 km

compTT

kT0=1.4 +/-0.9 keV
kTe= 9.0 +/-0.6 keV
tau=7.4+/-0.5

Fe line @ 6.44 keV
EW = 40 eV

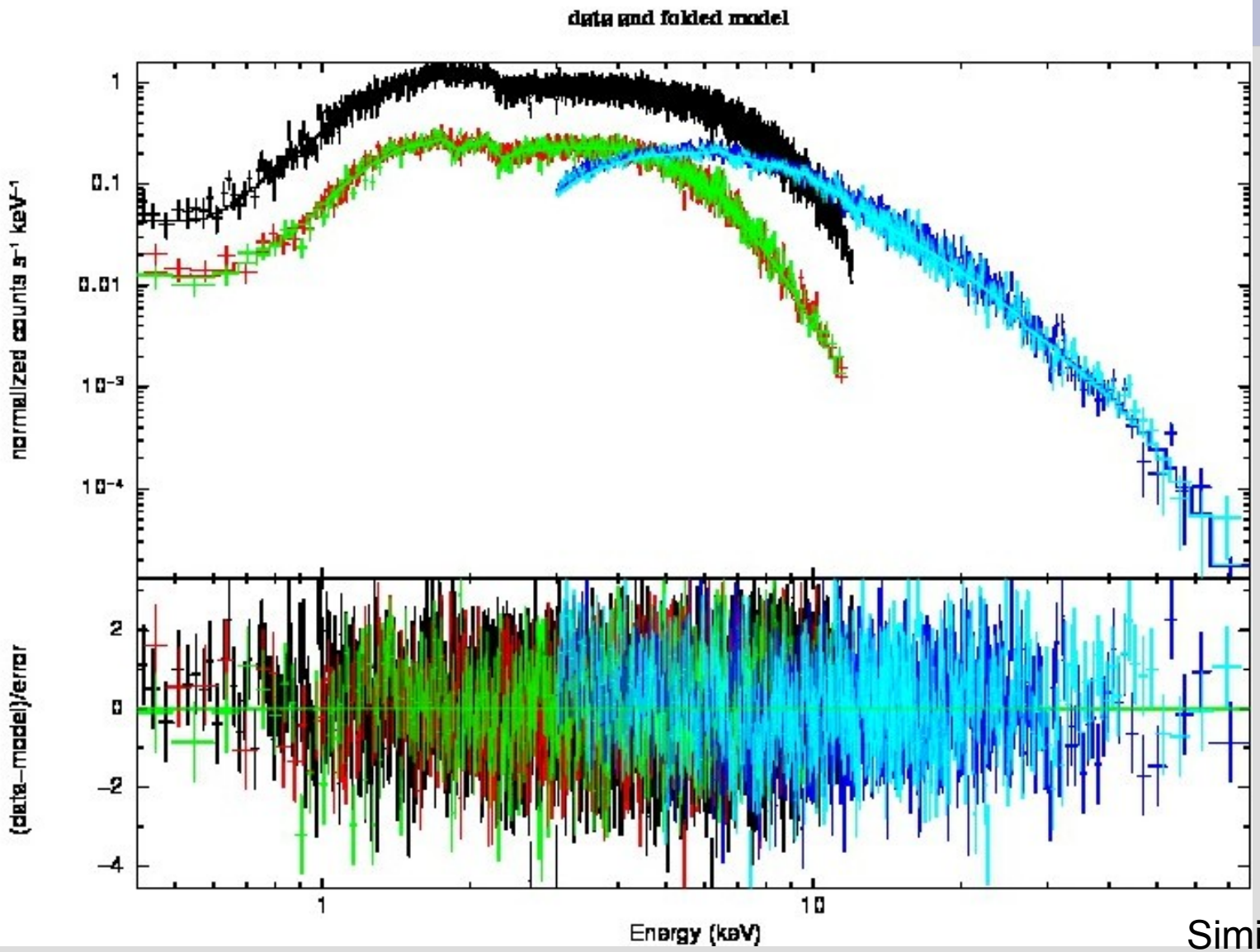
Unabs Flux (0.1 – 100 keV) = 1.7 E-10 erg/cm2/s

Similar good fit
with BB+CPL continuum

Time-averaged XMM EPIC (0.4-12 keV) and NuSTAR (3-79 keV) spectra

Fx (0.1-100 keV) = 1.6e-10 erg/cm2/s
Lx = 10 36 erg/s

N_H =(0.83 +/- 0.05) x10^22 cm-2



BB

kT=0.7 +/- 0.09 keV
Rbb = 1.1 +/- 0.2 km

compTT

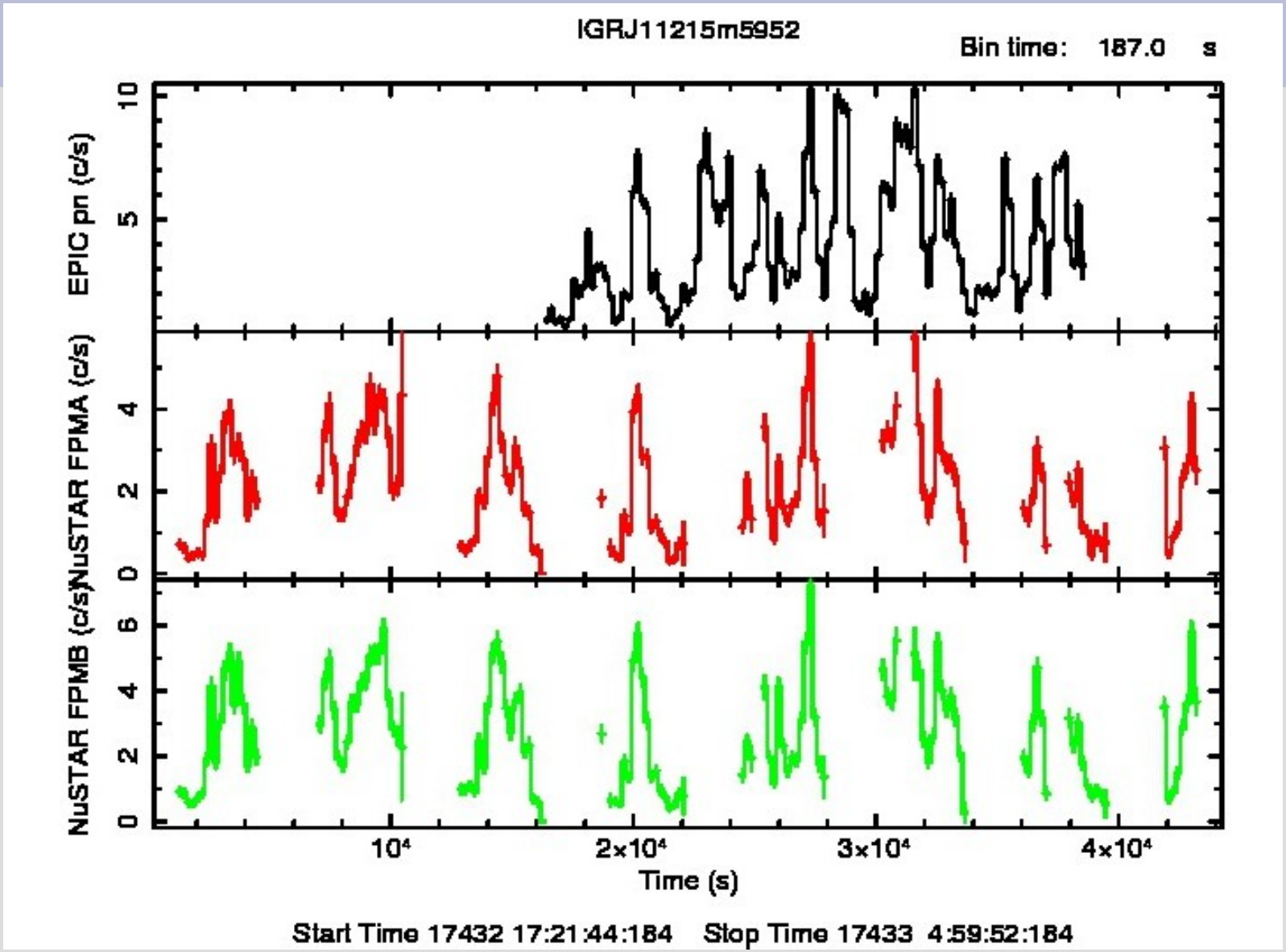
kT0=1.4 +/-0.9 keV
kTe= 9.0 +/-0.6 keV
tau=7.4+/-0.5

Fe line @ 6.44 keV
EW = 40 eV

Similar good fit
with BB+CPL continuum

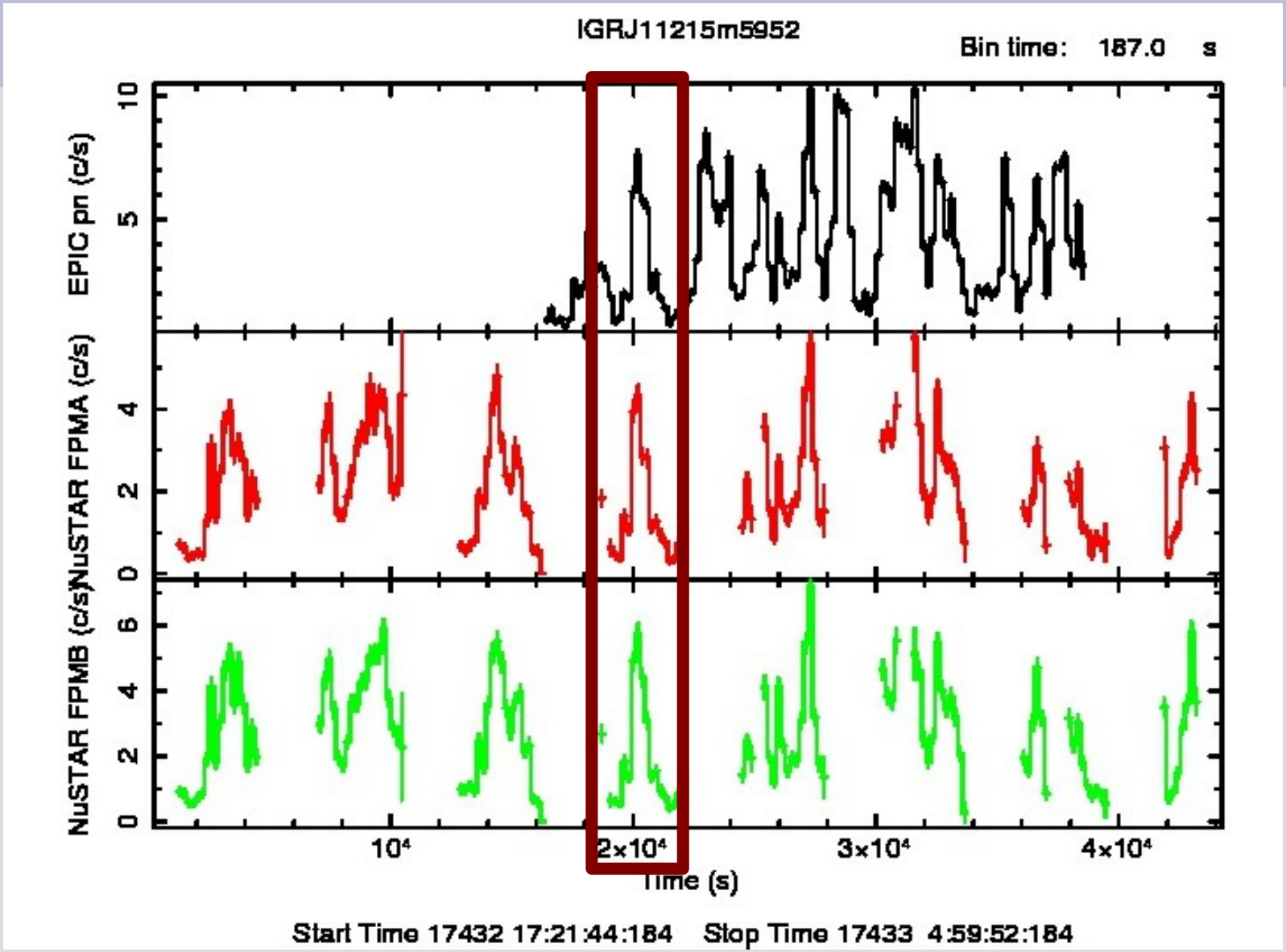
Unabs Flux (0.1 – 100 keV) = 1.7 E-10 erg/cm2/s

Spectroscopy of flares simultaneously observed by both XMM and NuSTAR (0.4-79 keV)

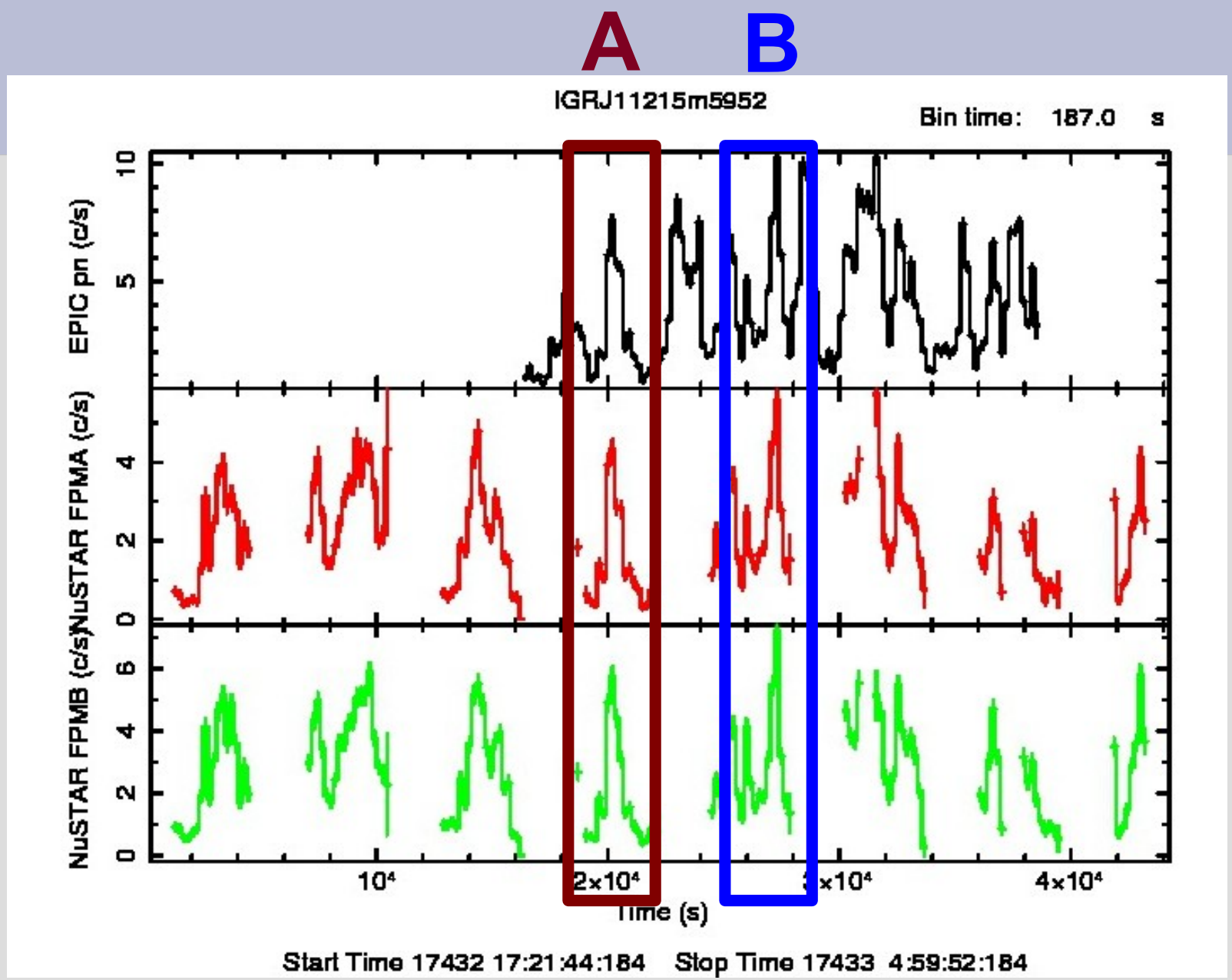


Spectroscopy of flares simultaneously observed by both XMM and NuSTAR (0.4-79 keV)

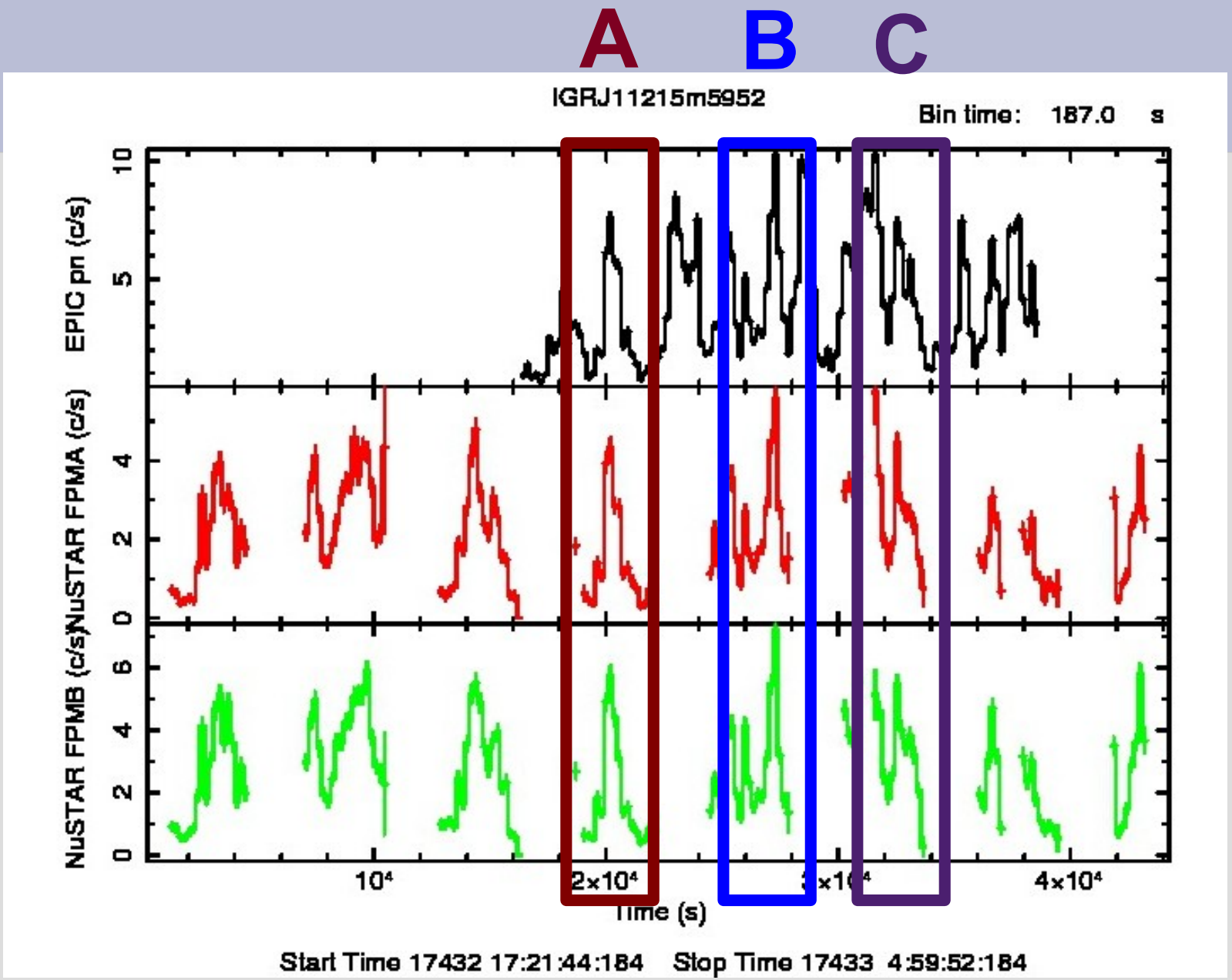
A



Spectroscopy of flares simultaneously observed by both XMM and NuSTAR (0.4-79 keV)

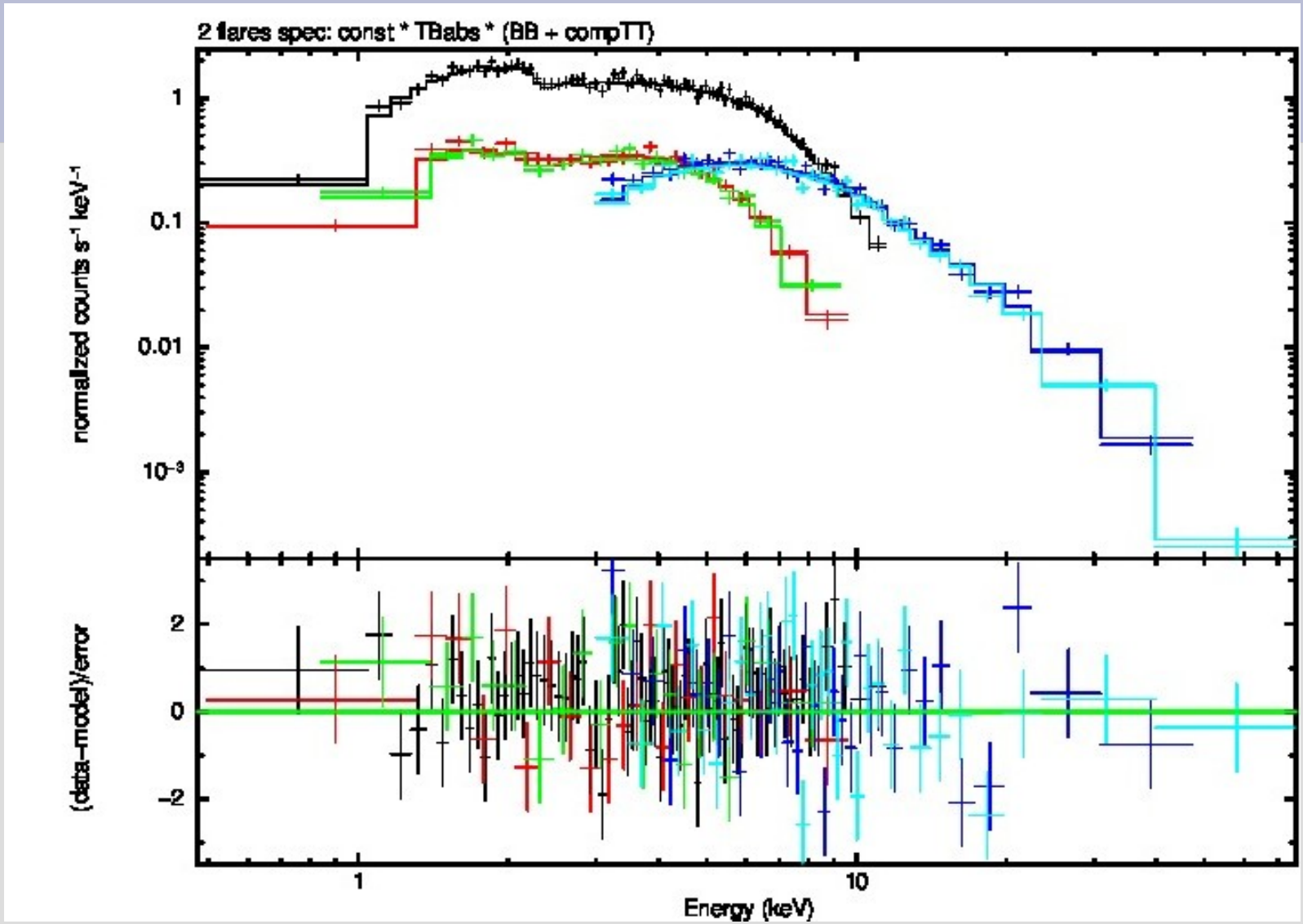


Spectroscopy of flares simultaneously observed by both XMM and NuSTAR (0.4-79 keV)



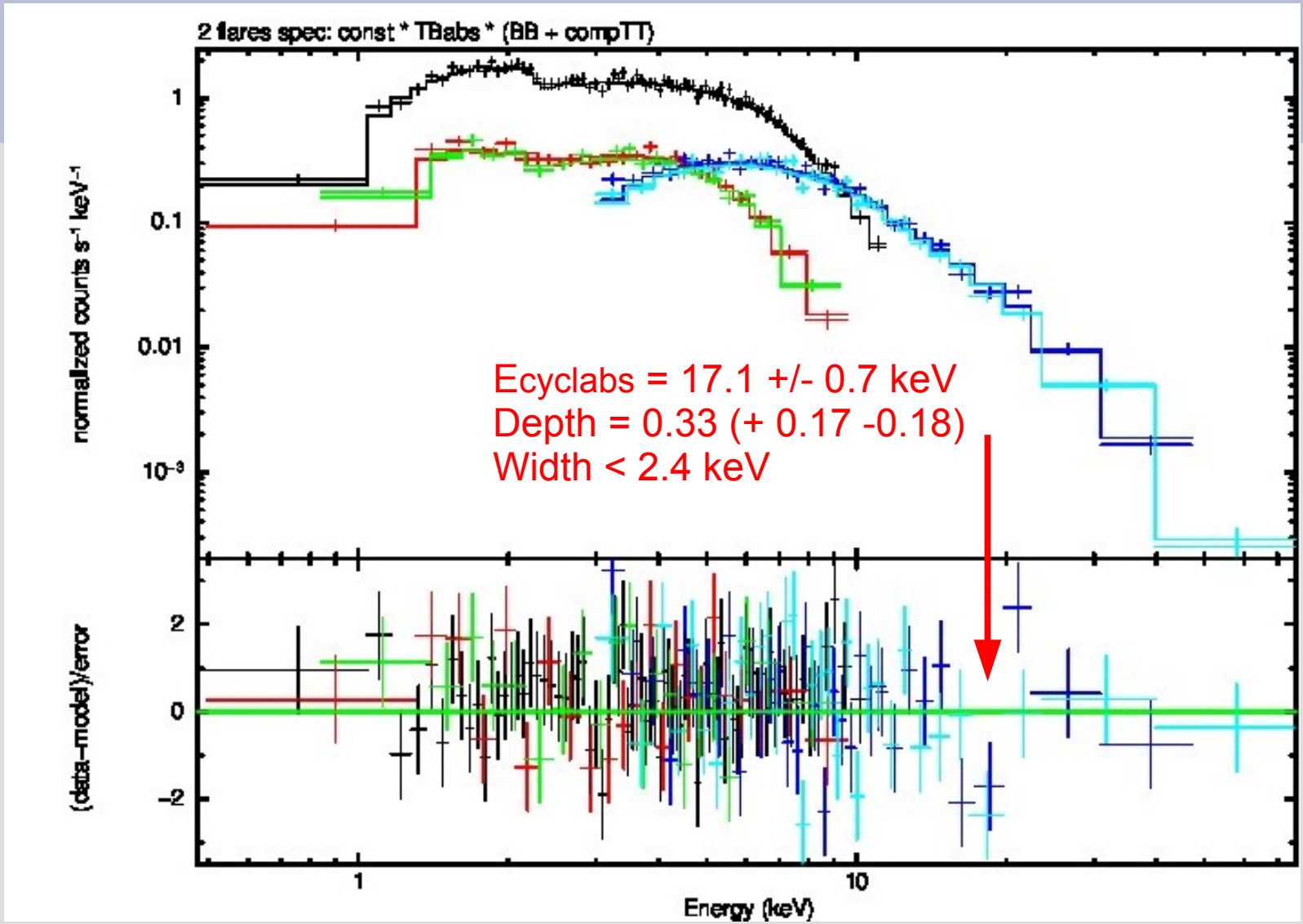
Spectra extracted from flares A and C

To date, this is the only spectrum in this obs. where a hint of cyclotron line can be found



Spectra extracted from flares A and C

To date, this is the only spectrum in this obs. where a hint of cyclotron line can be found



significance at 3 sigma

preliminary CONCLUSIONS

Preliminary analysis of our XMM+NuSTAR data hints of a cyclotron line at Ecycl = 17.1 +/- 0.7 keV in IGRJ11215-5952 (@ 3 sigma)

Another cyclabs line was caught in IGRJ17544-2619 (Bhalerao et al. 2015) with NuSTAR data at E=16.8 keV, but the spin period in IGRJ17544 is still highly debated, Therefore no firm conclusion can be drawn on the mechanism producing the X-ray flares

Our tentative cyclotron line indicates a neutron star B field
B = 1.5 10^{12} G

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

→ Since IGR11215 is a 187 s pulsar, this neutron star B field (if confirmed), would disfavour centrifugal and magnetic barrier

Work is still in progress …