The XMM-Newton view of **Supergiant Fast X-ray Transients:** the case of **IGR J16418-4532**

Lara SIDOLI
INAF-IASF Milano (Italy)

Sandro MEREGHETTI
(INAF-IASF Milano, Italy)

Vito SGUERA
(INAF-IASF Bologna, Italy)

Fabio PIZZOLATO
(INAF-IASF Milano, Italy)

X-ray Astronomy 2011, Berlin

IGR J16418-4532:

Short duration flares observed with INTEGRAL: a SFXT ?

Source discovered by Tomsick et al. (2004) with INTEGRAL

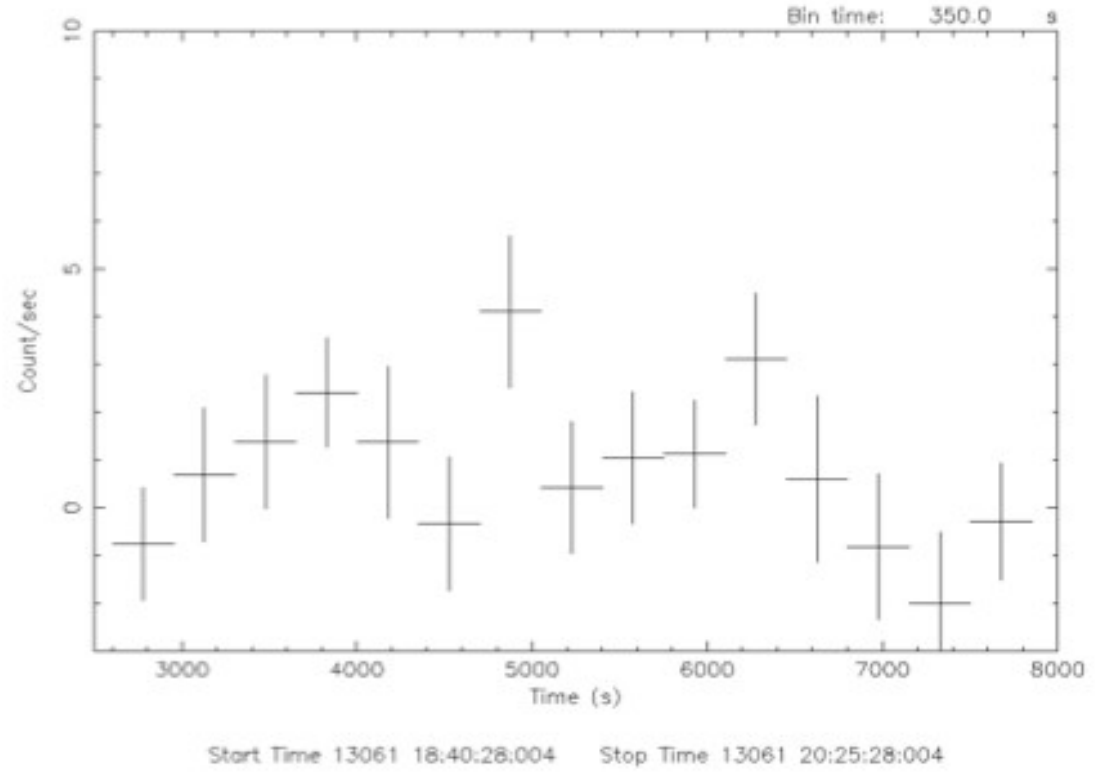
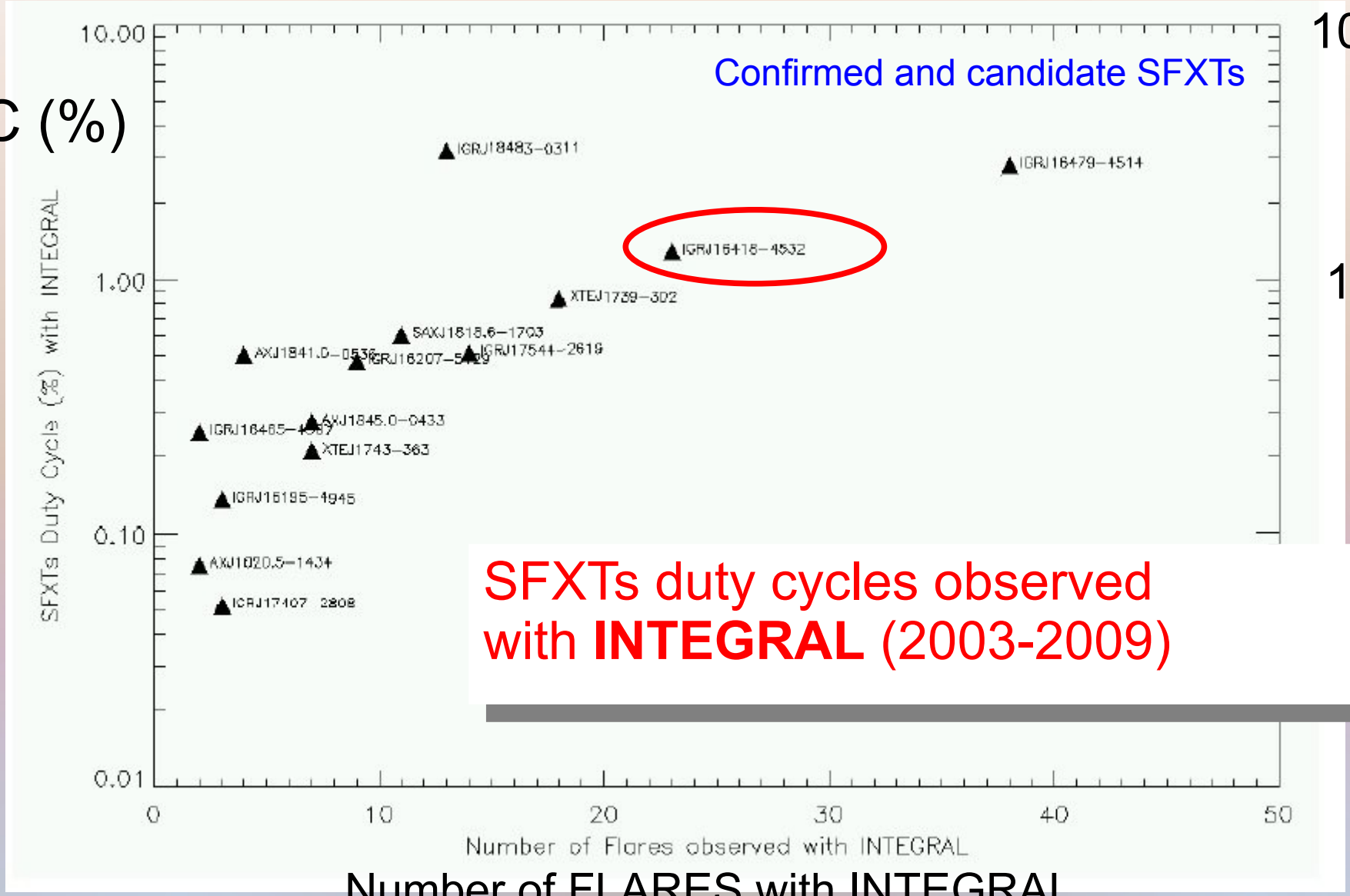


Fig. 13.— The ISGRI light curve (20–30 keV) of a newly discovered outburst of IGR J16418−4532.

Sguera et al. 2006

IGR J16418-4532 observed with INTEGRAL

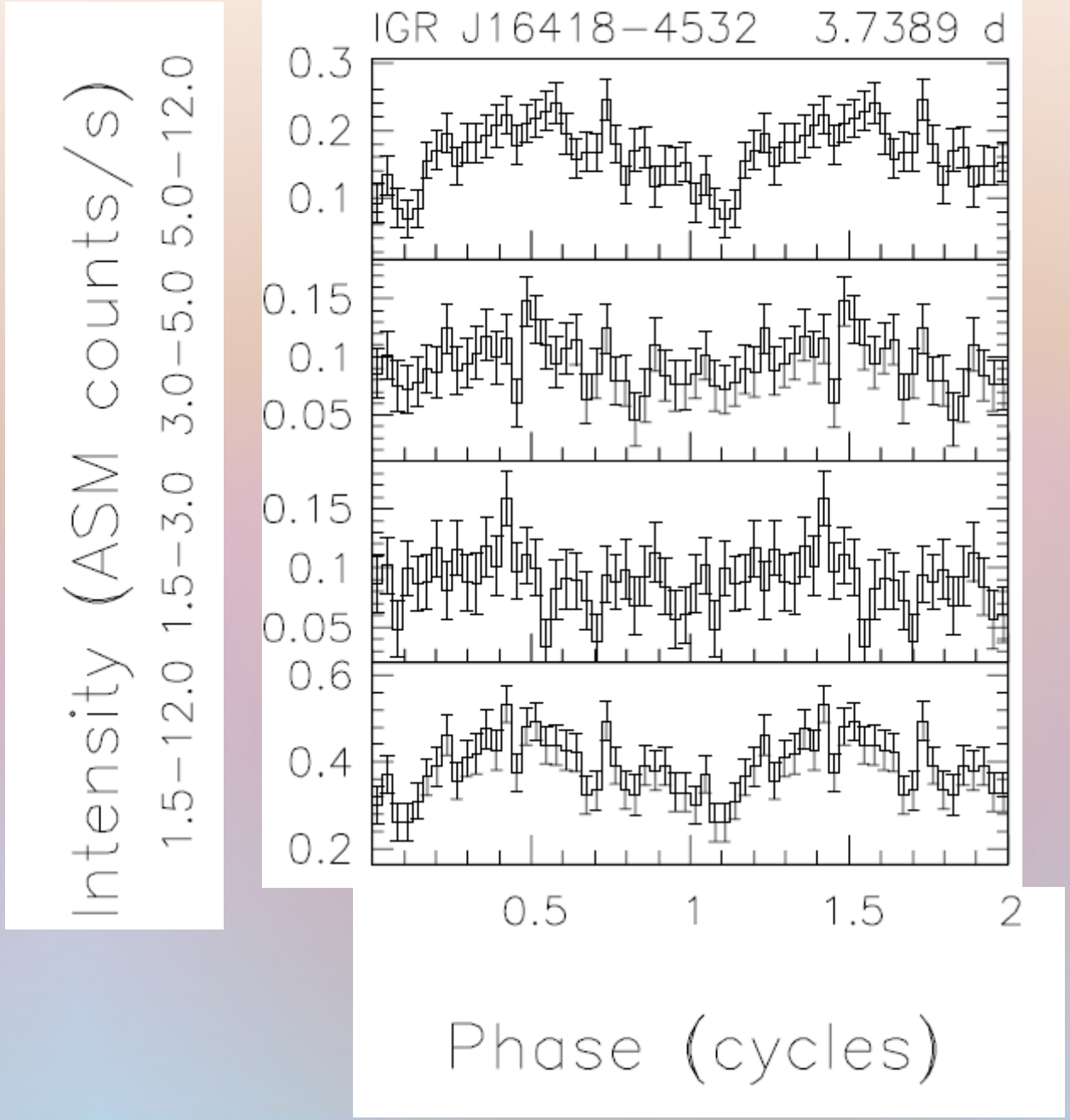


SFXTs duty cycles observed with **INTEGRAL** (2003-2009)

Number of FLARES with INTEGRAL

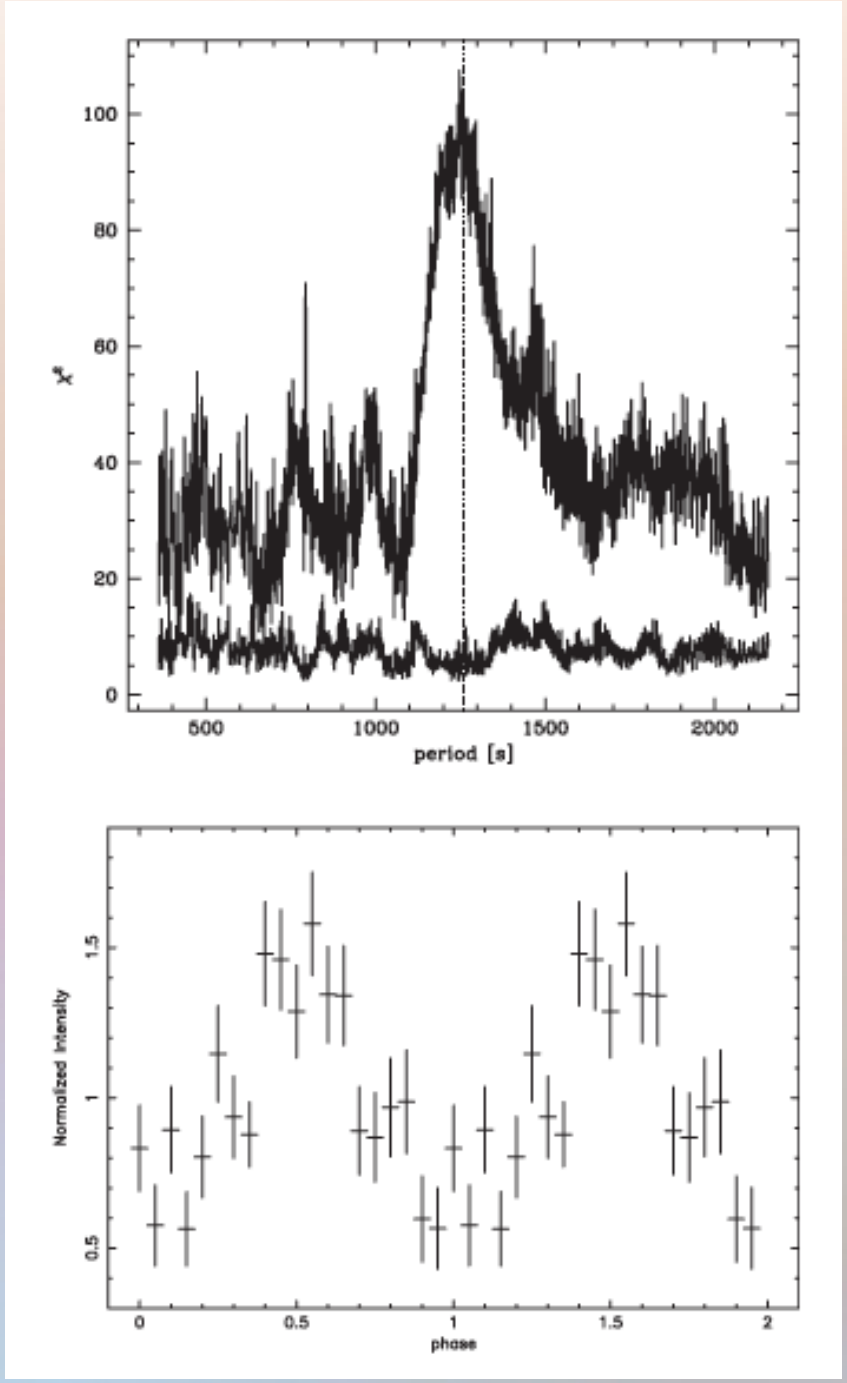
data taken from **Ducci, Sidoli & Paizis, 2010**

Candidate **Orbital Period** (ASM/XTE)



3.7389 days

Corbet et al. 2006, Levine et al. 2010

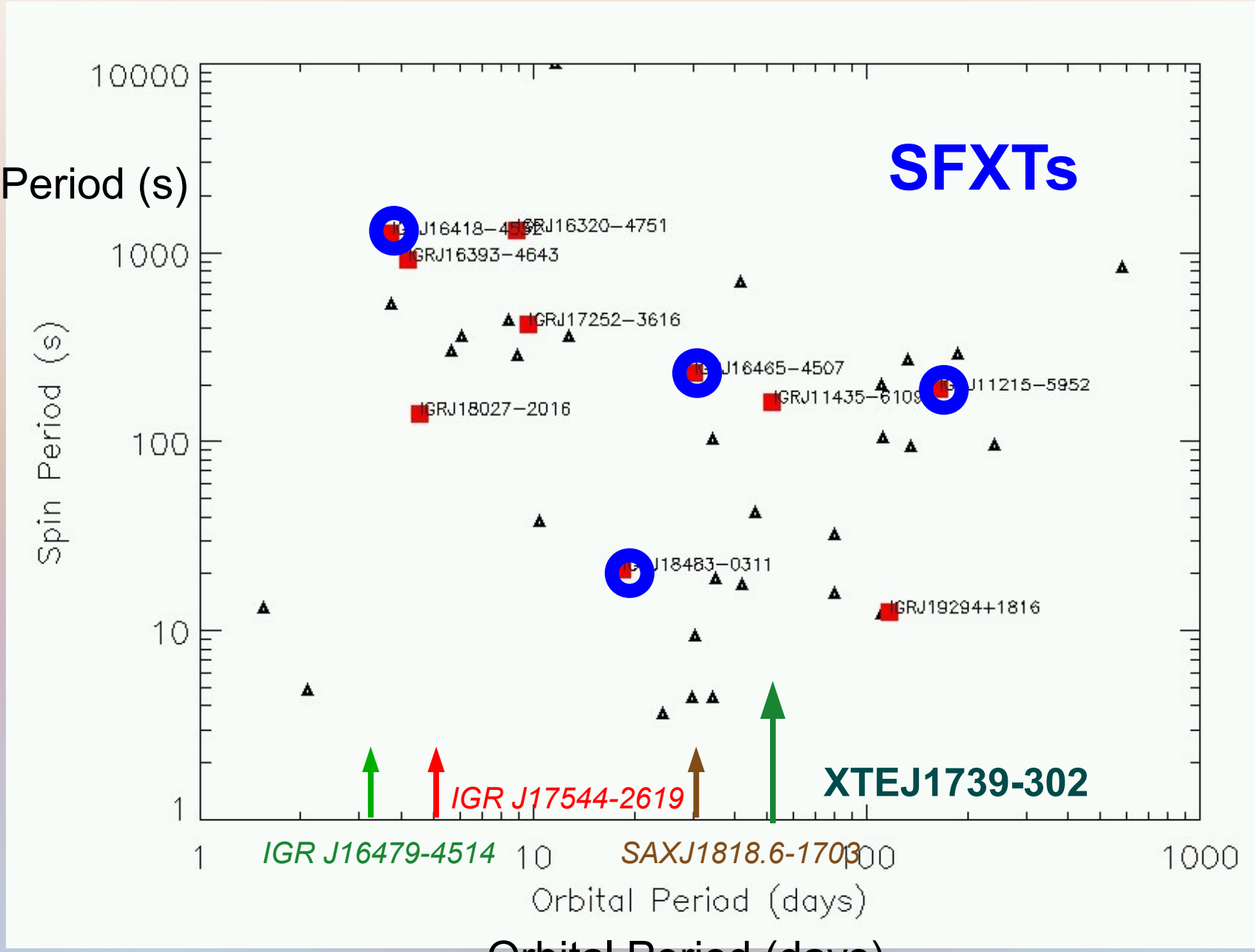


Walter et al. 2006

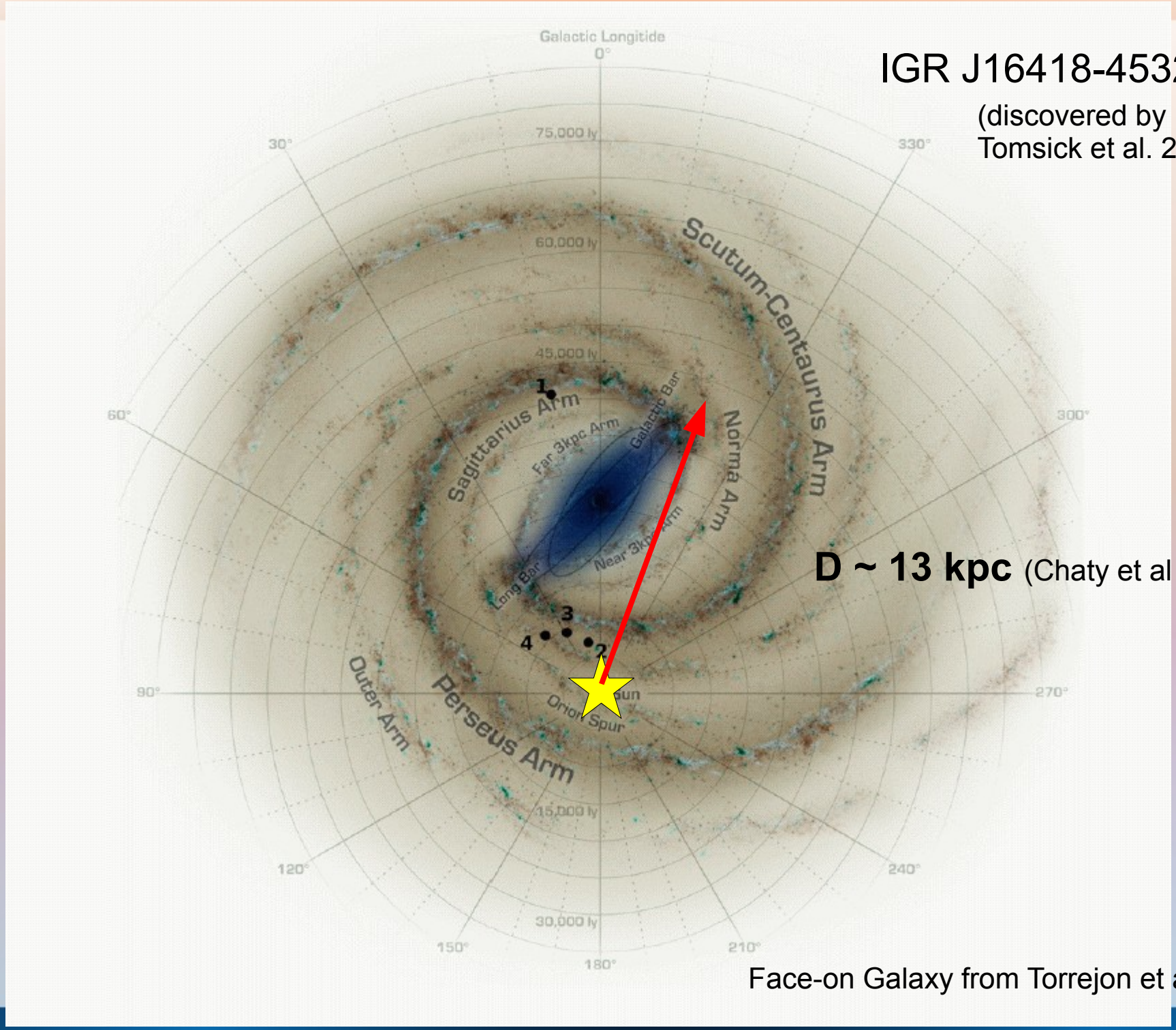
XMM observation In 2004

Ppulse = 1246 +/- 100 s

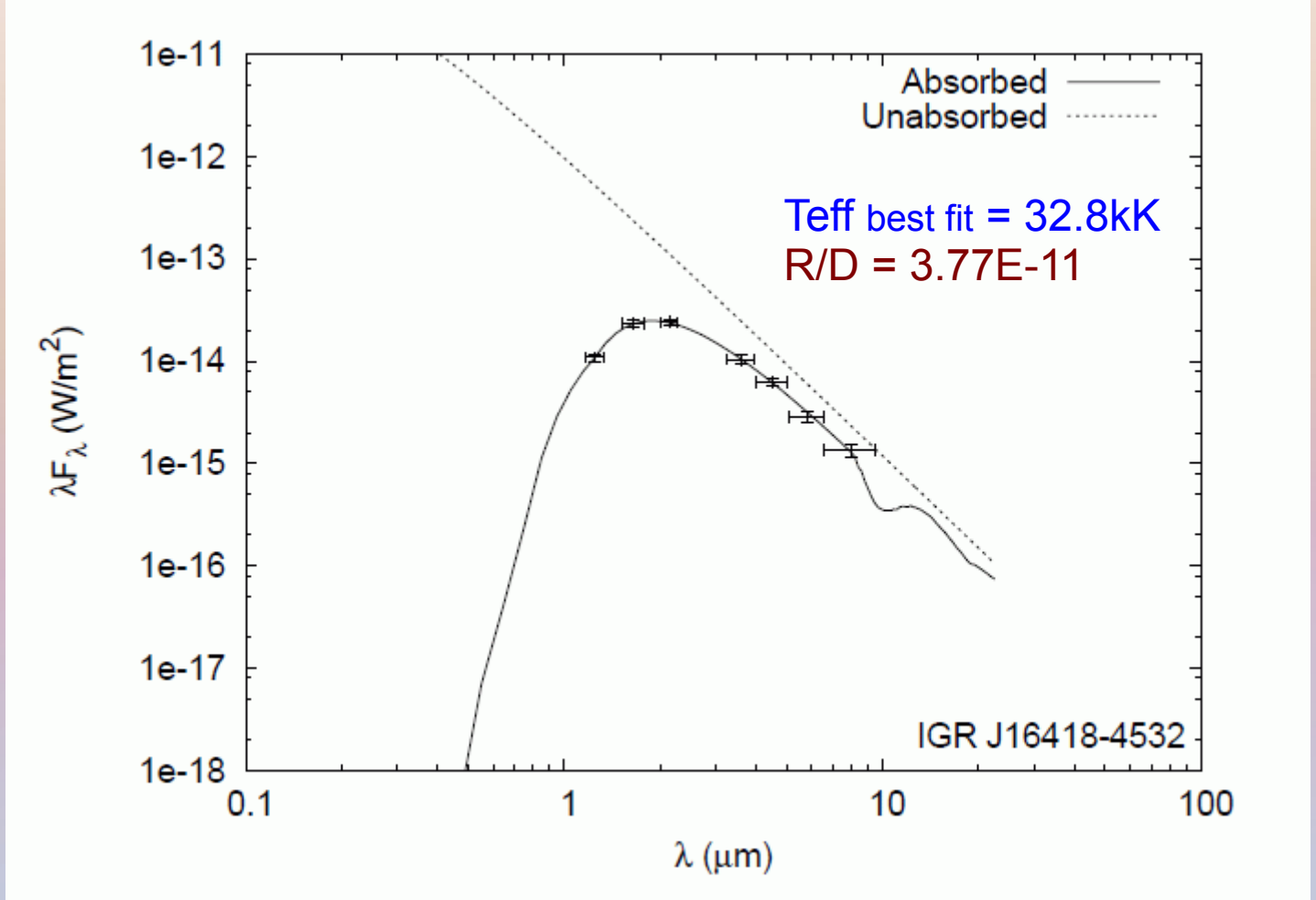
Corbet diagram



Orbital Period (days)


IGR J16418-4532
(discovered by
Tomsick et al. 2004)
D ~ 13 kpc (Chaty et al 2008)
Face-on Galaxy from Torrejon et al. 2010
Galactic Longitide
0°
30°
330°
60°
300°
90°
270°
120°
240°
150°
210°
180°
75,000 ly
60,000 ly
45,000 ly
30,000 ly
15,000 ly
Scutum-Centaurus Arm
Sagittarius Arm
Norma Arm
Perseus Arm
Outer Arm
Far 3kpc Arm
Near 3kpc Arm
Galactic Bar
Long Bar
Orion Spur
1
2
3
4

Optical to MIR SED
of the candidate optical counterpart



Rahoui et al. 2008

ESO/NTT, 2MASS, GLIMPSE, VISIR observations

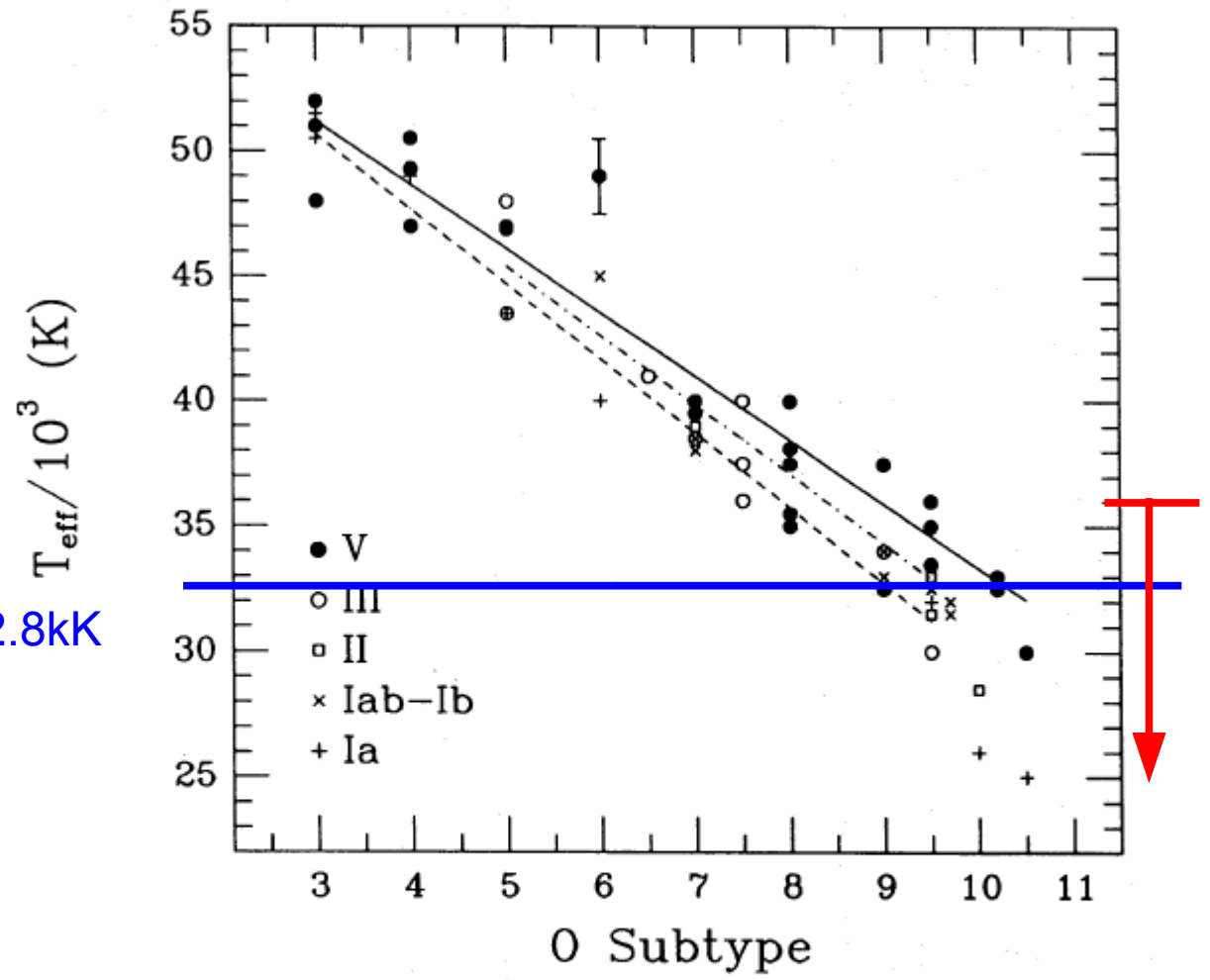


FIG. 2.—The variation of effective temperature, T_{eff}, with spectral subtype and luminosity class for the stars in the sample. A representative error bar is shown on one point. Subtypes 10 and greater refer to B stars. Lines denote the fits determined for three luminosity classes: the solid line is the best fit for luminosity class V stars; the dot-dashed line is for class III stars; the dashed line is for class Ia stars.

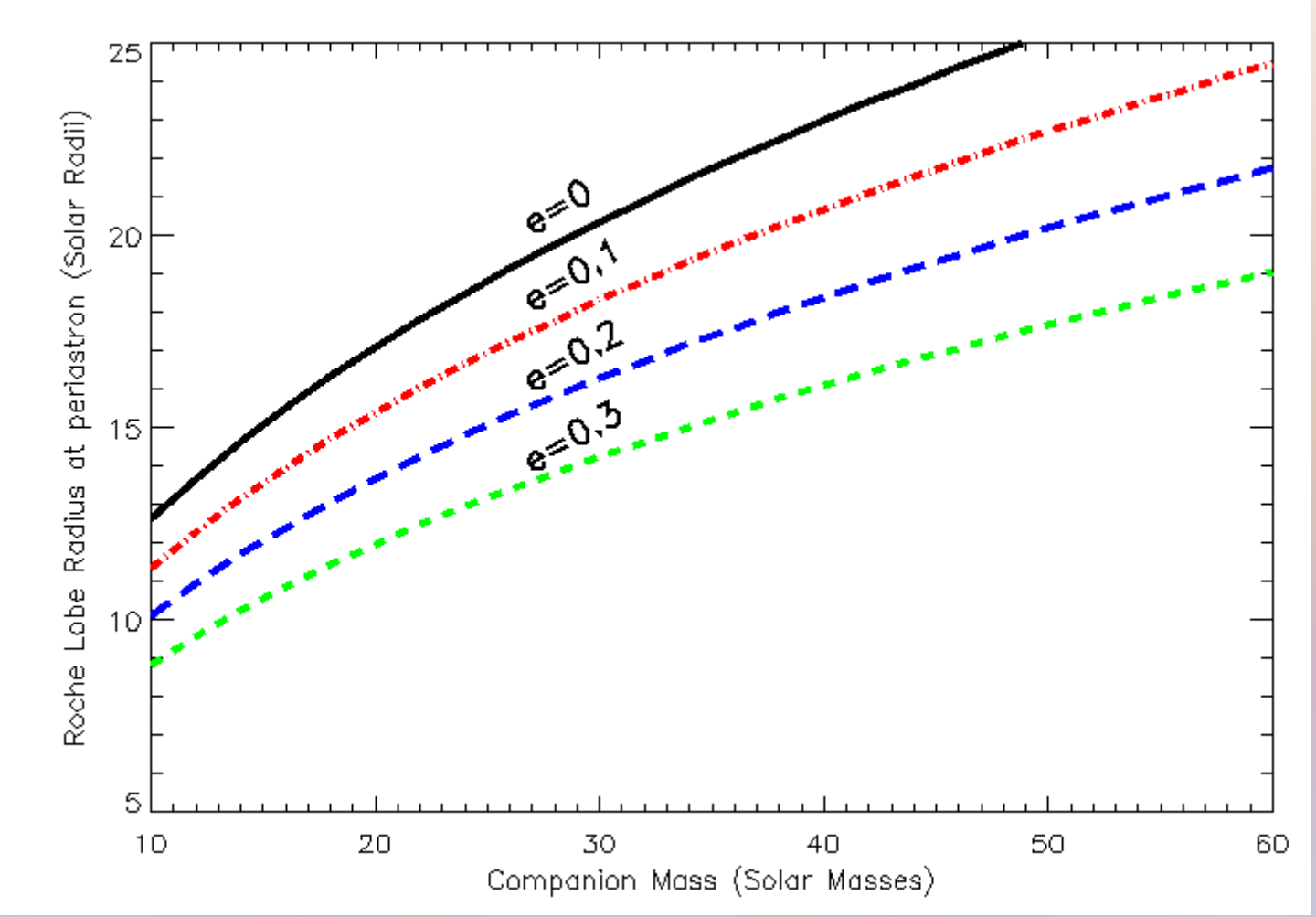
Teff best fit = 32.8kK

Teff uncertainty

36 kK →
10.6 kK

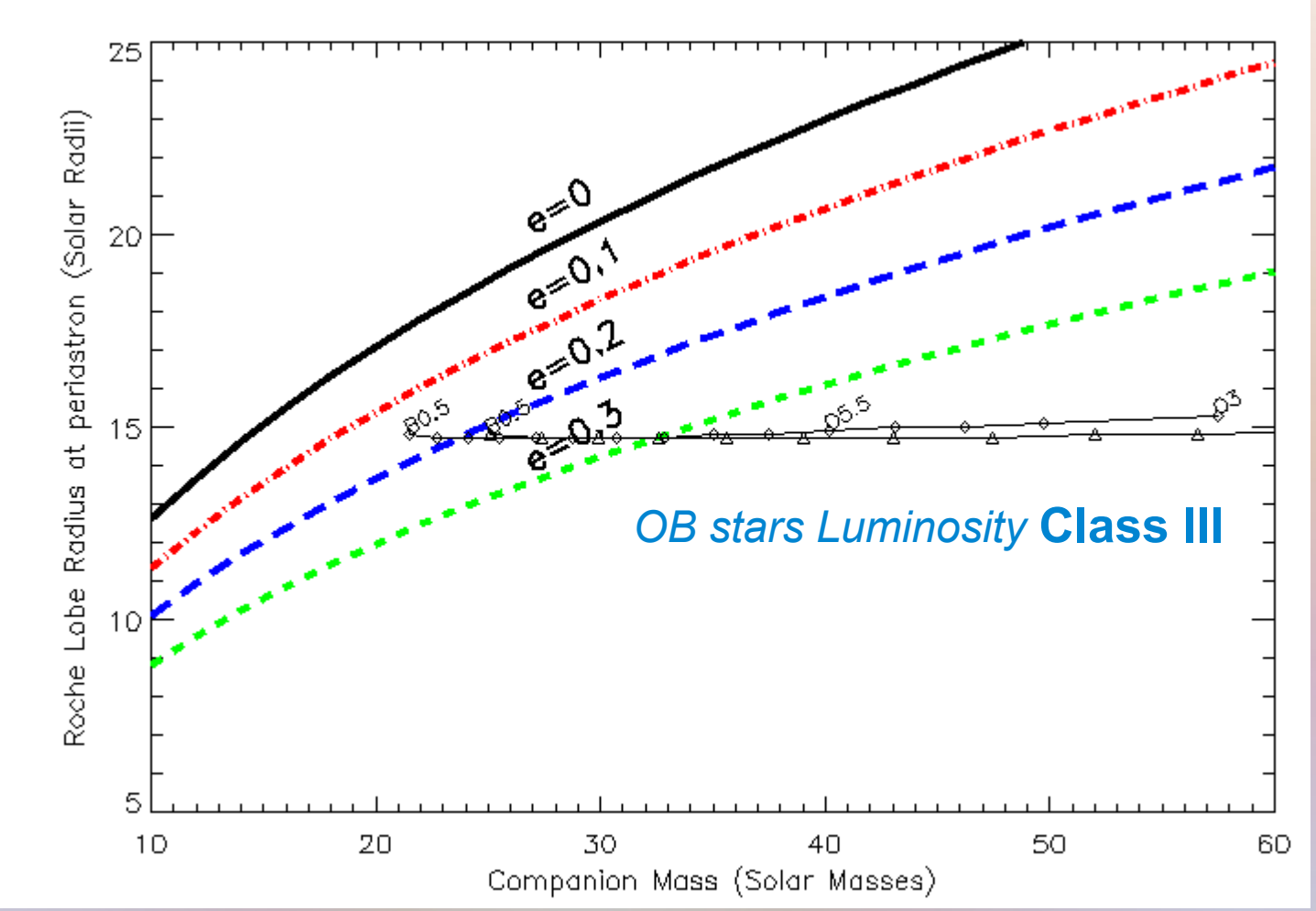
Vacca et al. 1996

R_L


Roche Lobe Radius at periastron (Solar Radii)
Companion Mass (Solar Masses)
e=0
e=0,1
e=0,2
e=0,3
5
10
15
20
25
10
20
30
40
50
60

Mass

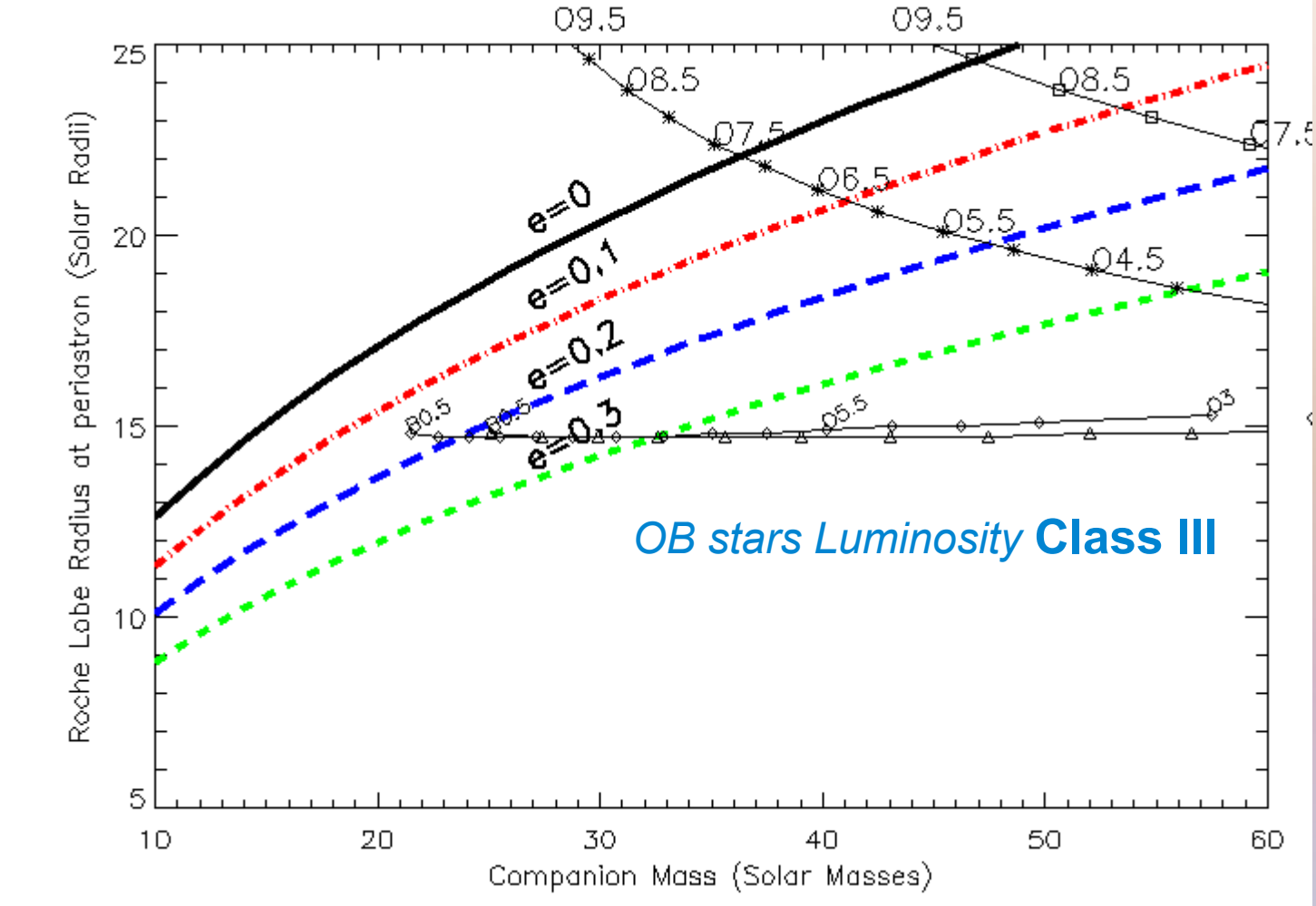
R_L



M

M spec – M evol
vs
Stellar Radius
(Vacca et al. 1996)

OB stars Luminosity **Class Ia**



OB stars Luminosity **Class III**

R_L

M

M spec – M evol
vs
Stellar Radius
(Vacca et al. 1996)

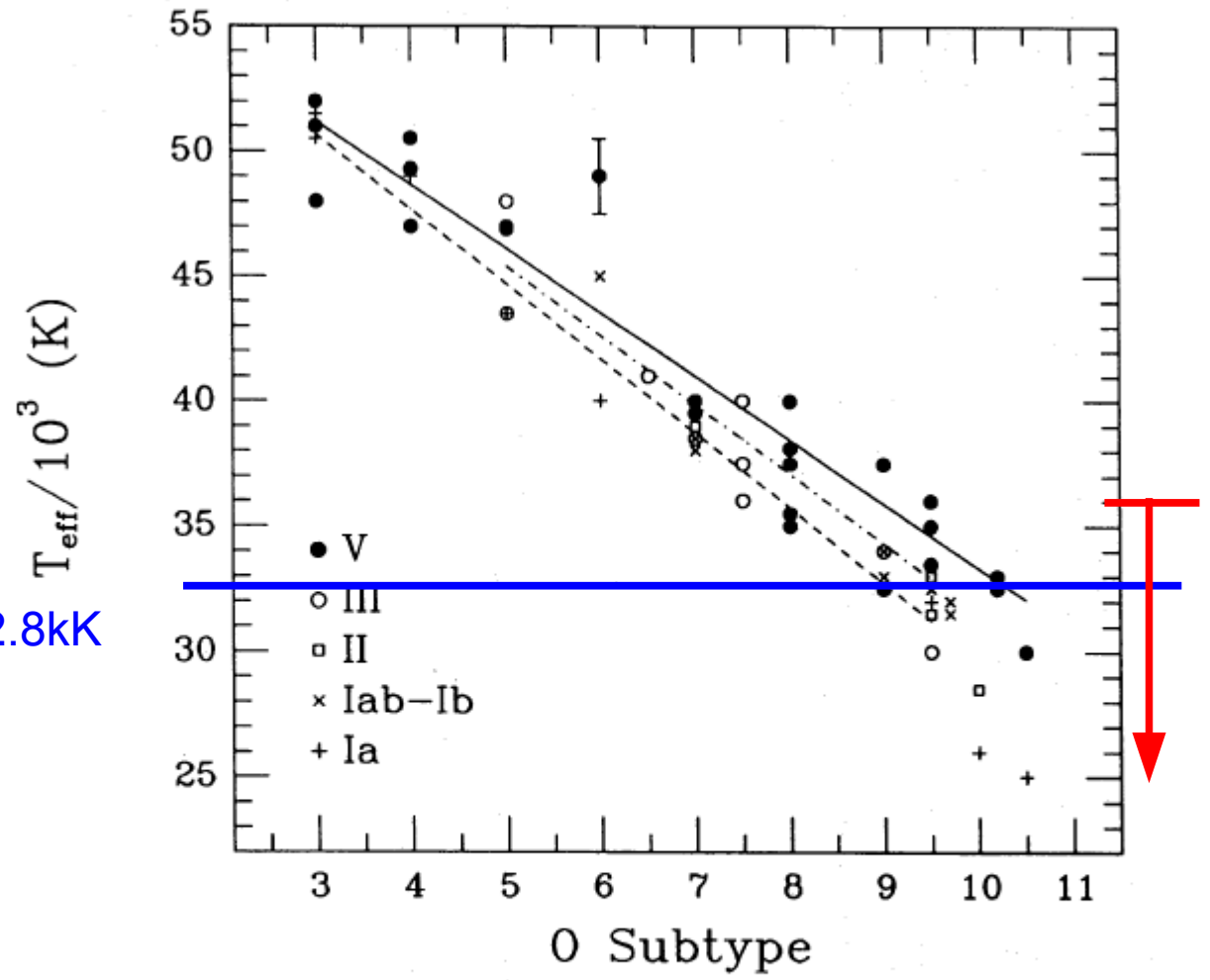


FIG. 2.—The variation of effective temperature, T_{eff}, with spectral subtype and luminosity class for the stars in the sample. A representative error bar is shown on one point. Subtypes 10 and greater refer to B stars. Lines denote the fits determined for three luminosity classes: the solid line is the best fit for luminosity class V stars; the dot-dashed line is for class III stars; the dashed line is for class Ia stars.

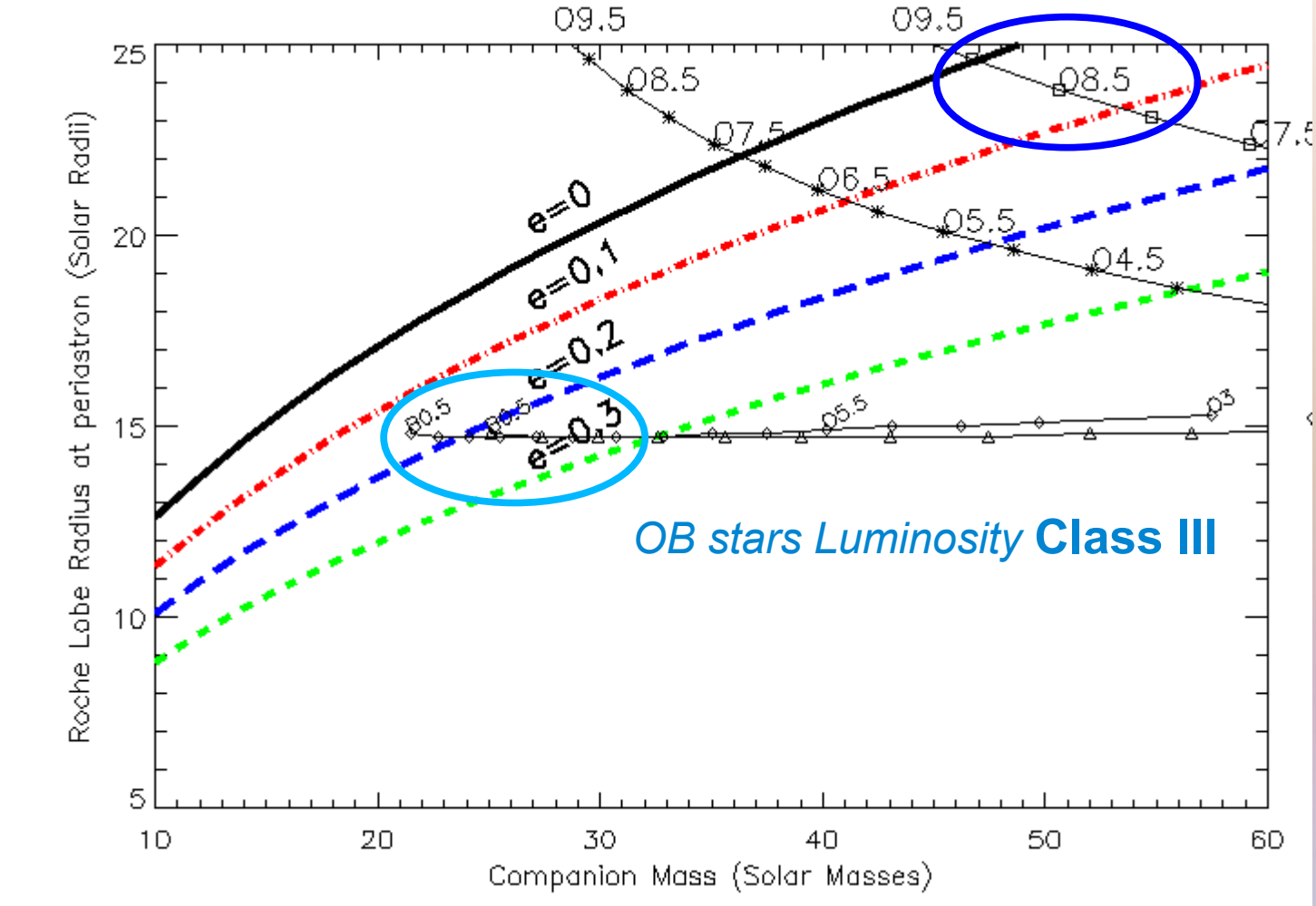
Teff best fit = 32.8kK

Teff uncertainty

36 kK →
10.6 kK

Vacca et al. 1996

OB stars Luminosity **Class Ia**



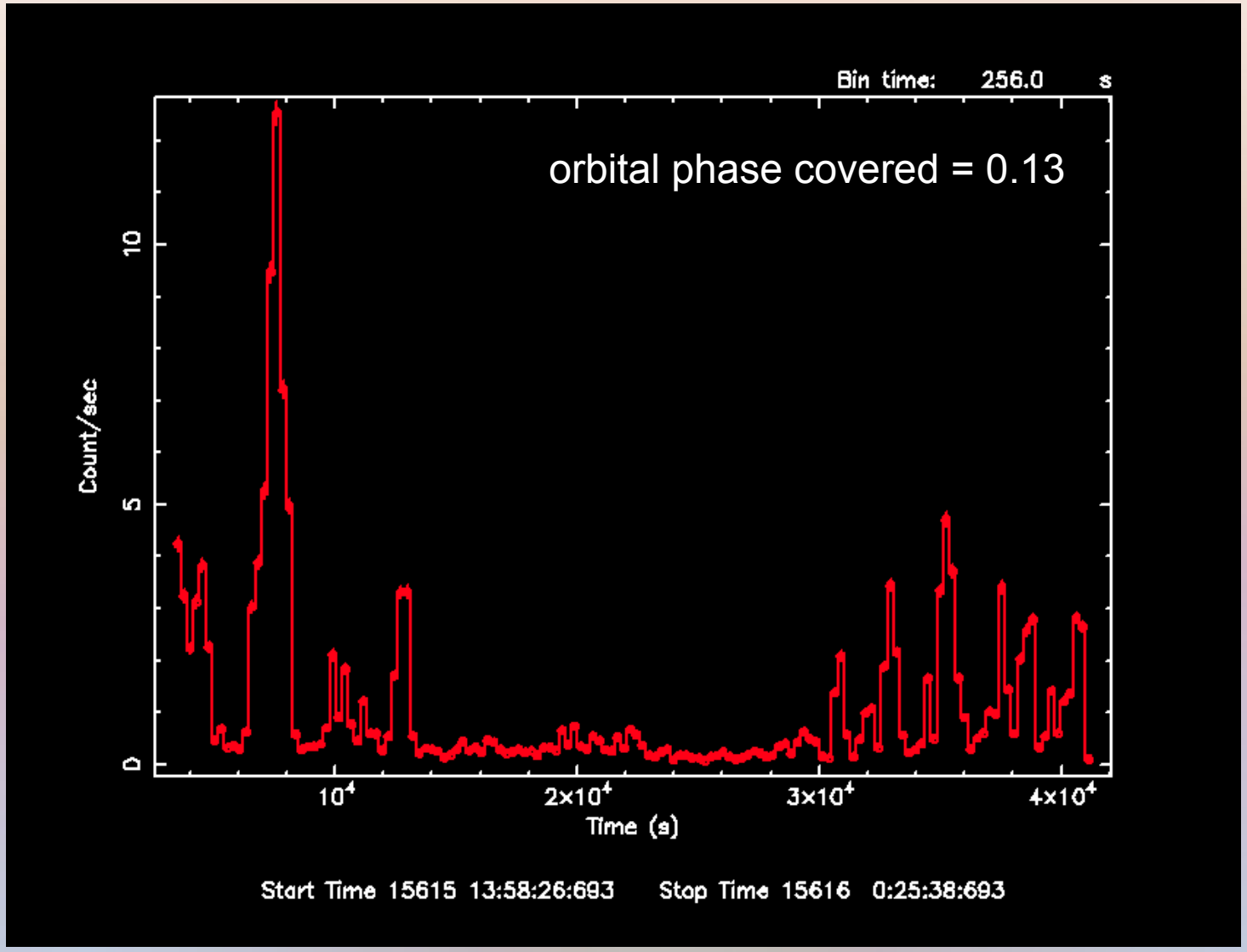
OB stars Luminosity **Class III**

R_L

M

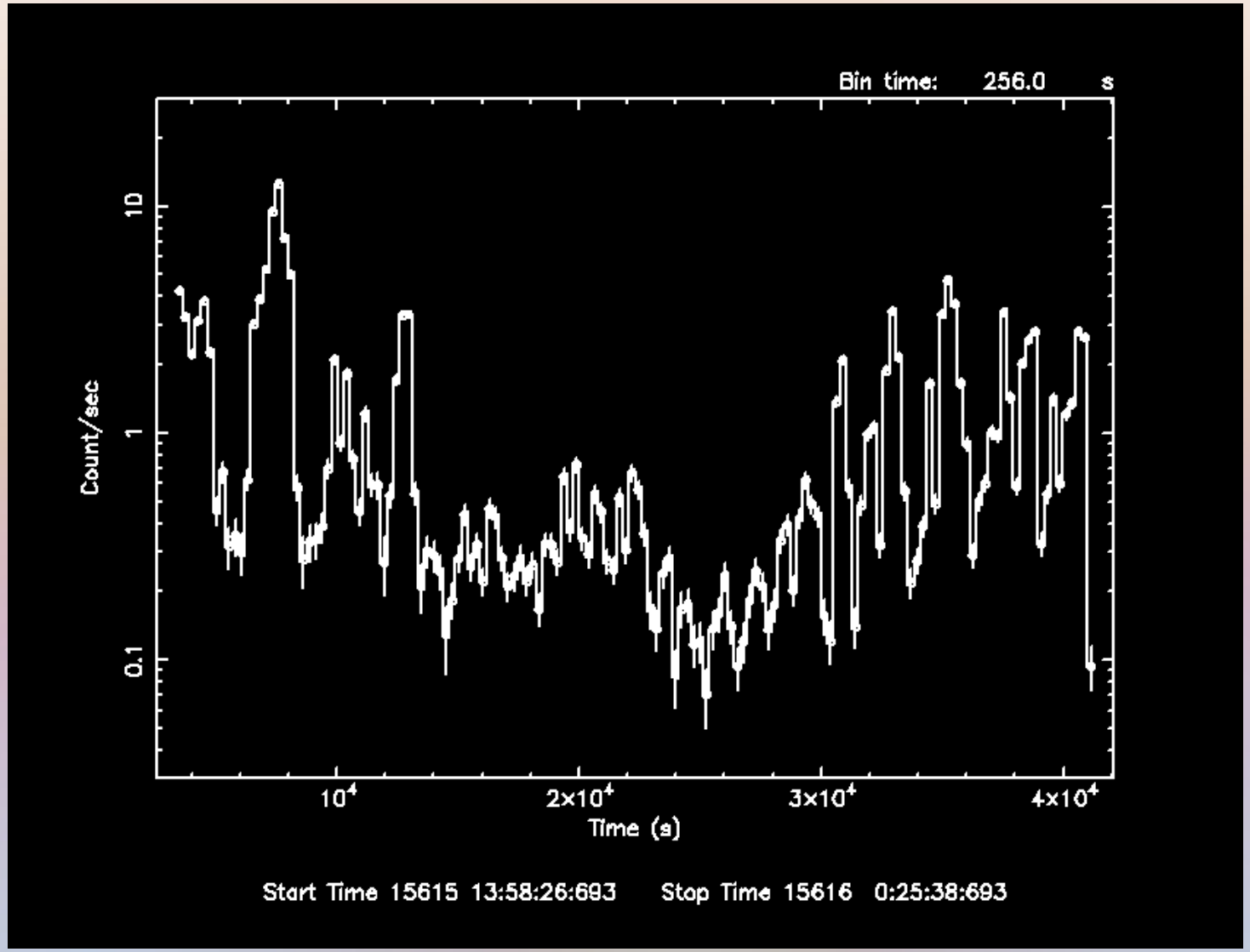
M spec – M evol
vs
Stellar Radius
(Vacca et al. 1996)

New XMM-Newton observation performed in February 2011



EPIC pn background subtracted light curve (0.3-12 keV)

New XMM-Newton observation performed in February 2011



2 orders of magnitude

5E36 erg/s

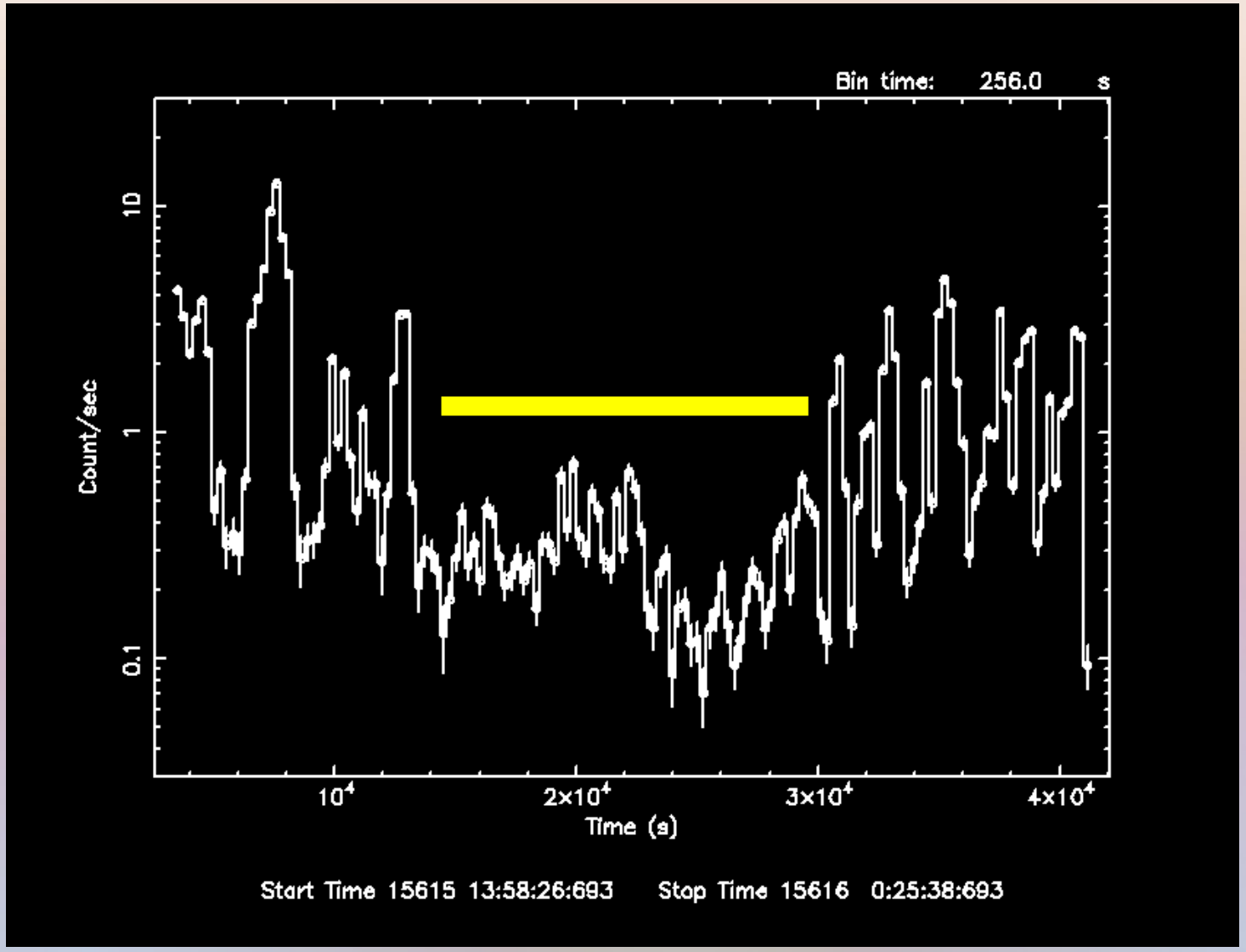
(@13 kpc)

5E34 erg/s

EPIC pn background subtracted light curve (0.3-12 keV)

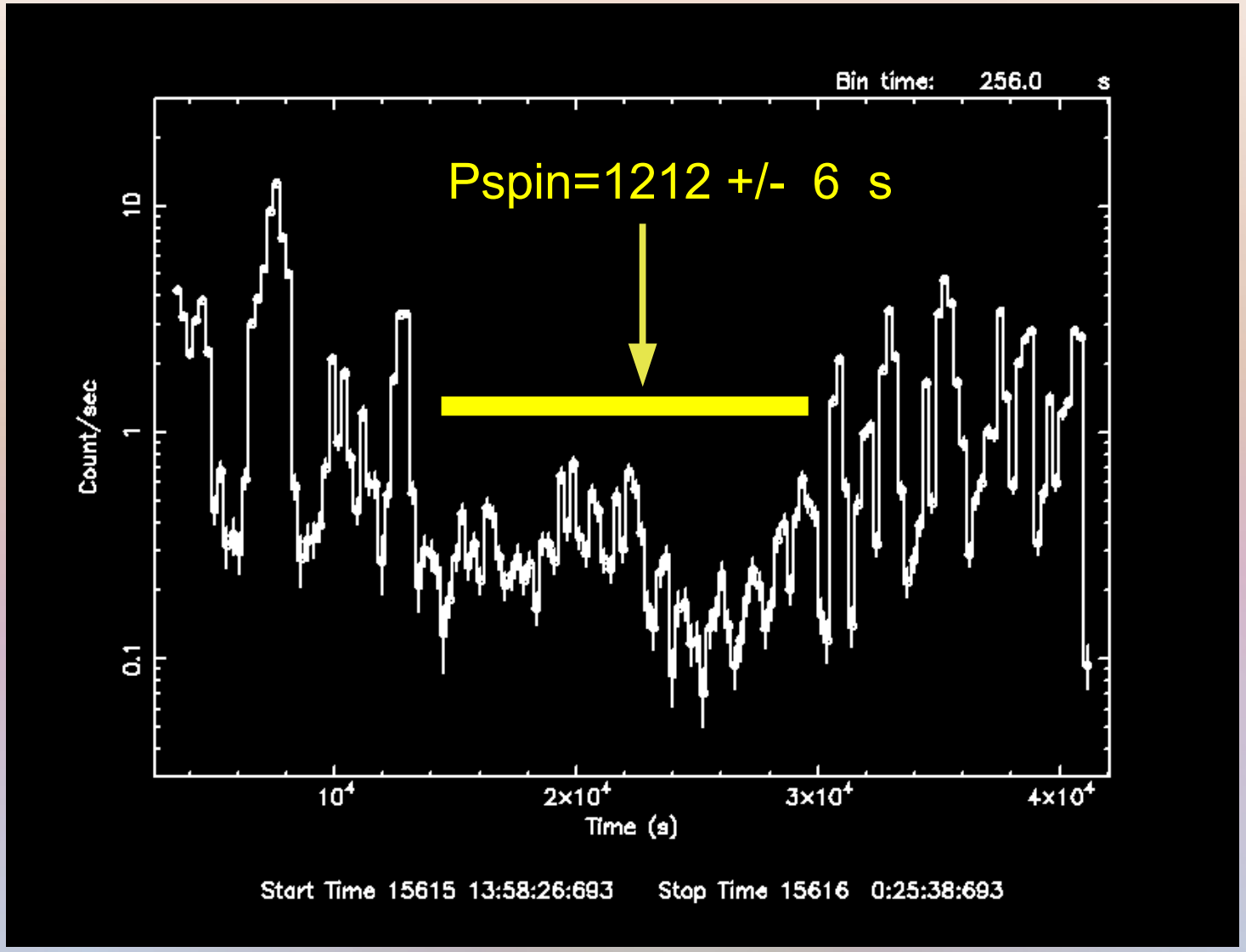
High dynamic range, **never observed** before in this source

Pulsations are clearly observed only during the low intensity level

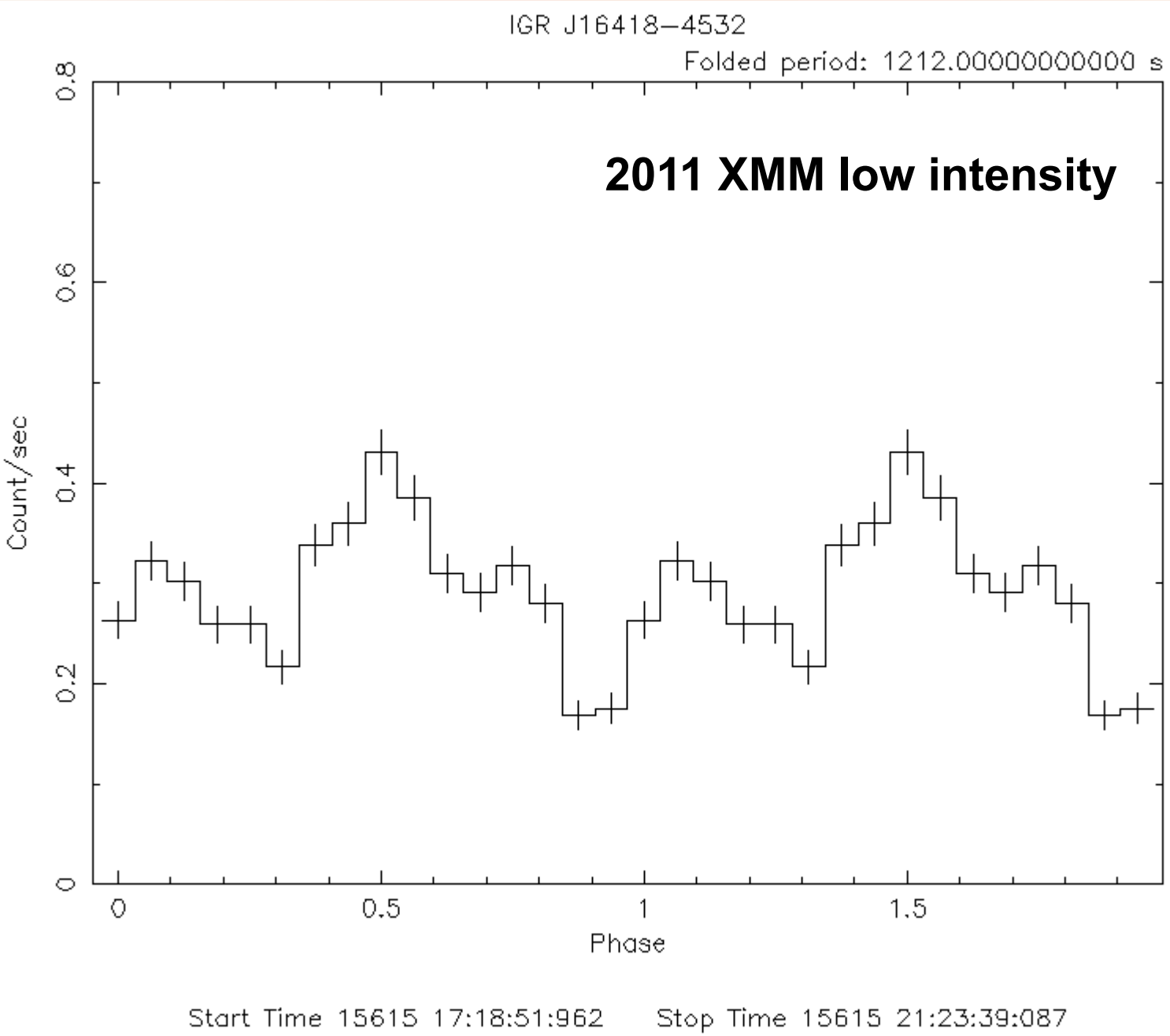


EPIC pn background subtracted light curve (0.3-12 keV)

Pulsations are clearly observed only during the low intensity level

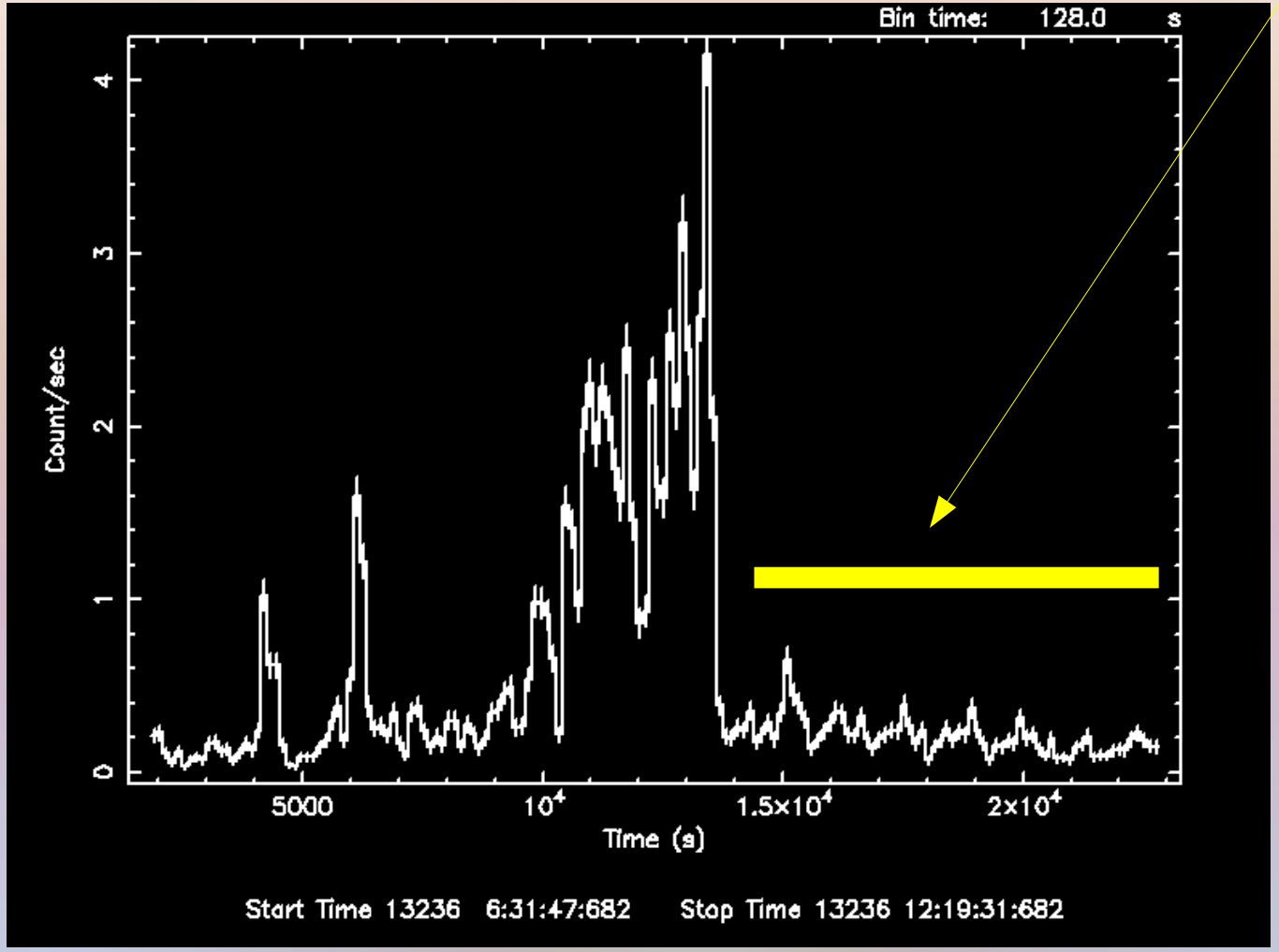


EPIC pn background subtracted light curve (0.3-12 keV)

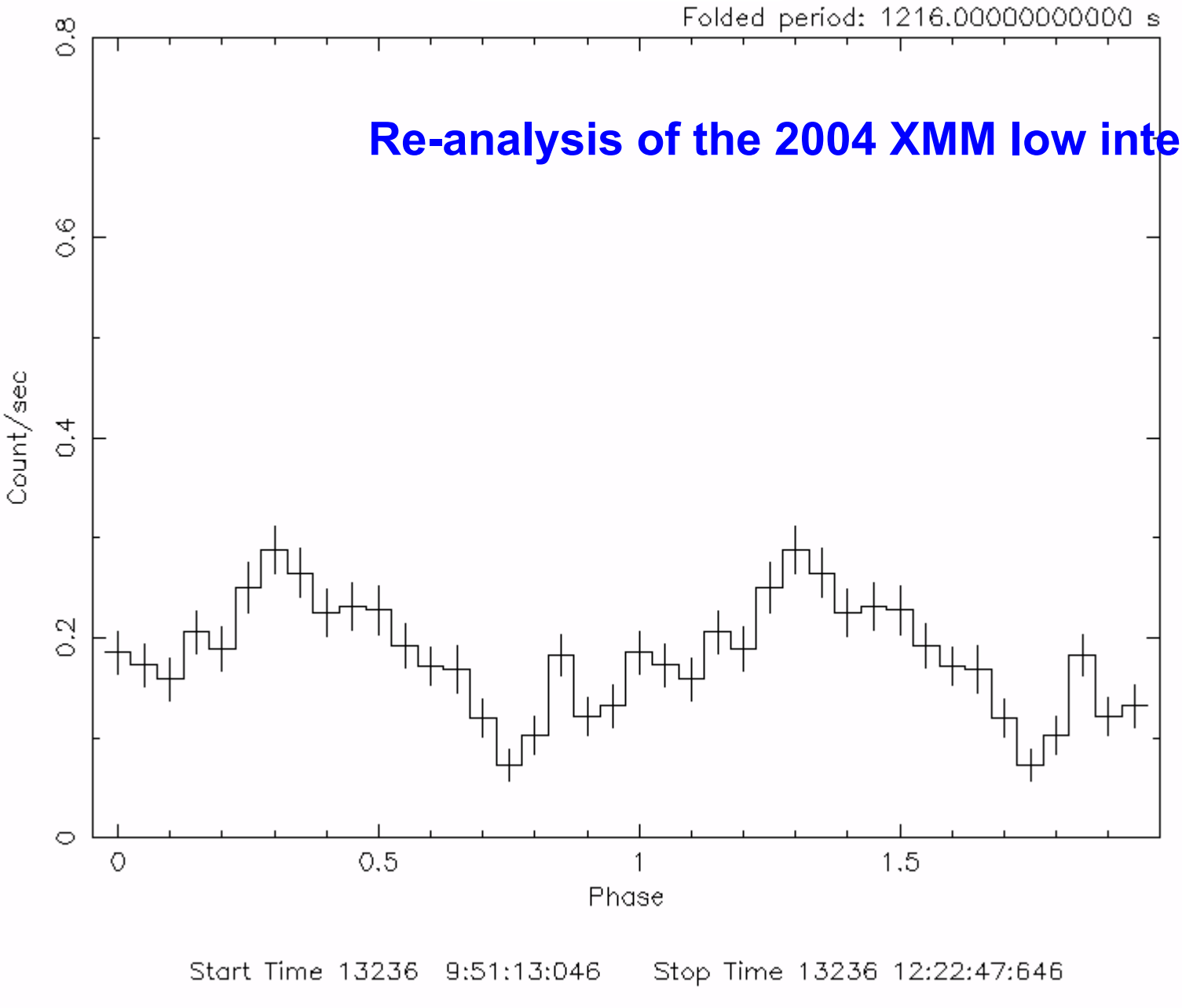

IGR J16418−4532
Folded period: 1212.00000000000 s
2011 XMM low intensity
Count/sec
0
0.2
0.4
0.6
0.8
0
0.5
1
1.5
Phase
Start Time 15615 17:18:51:962
Stop Time 15615 21:23:39:087

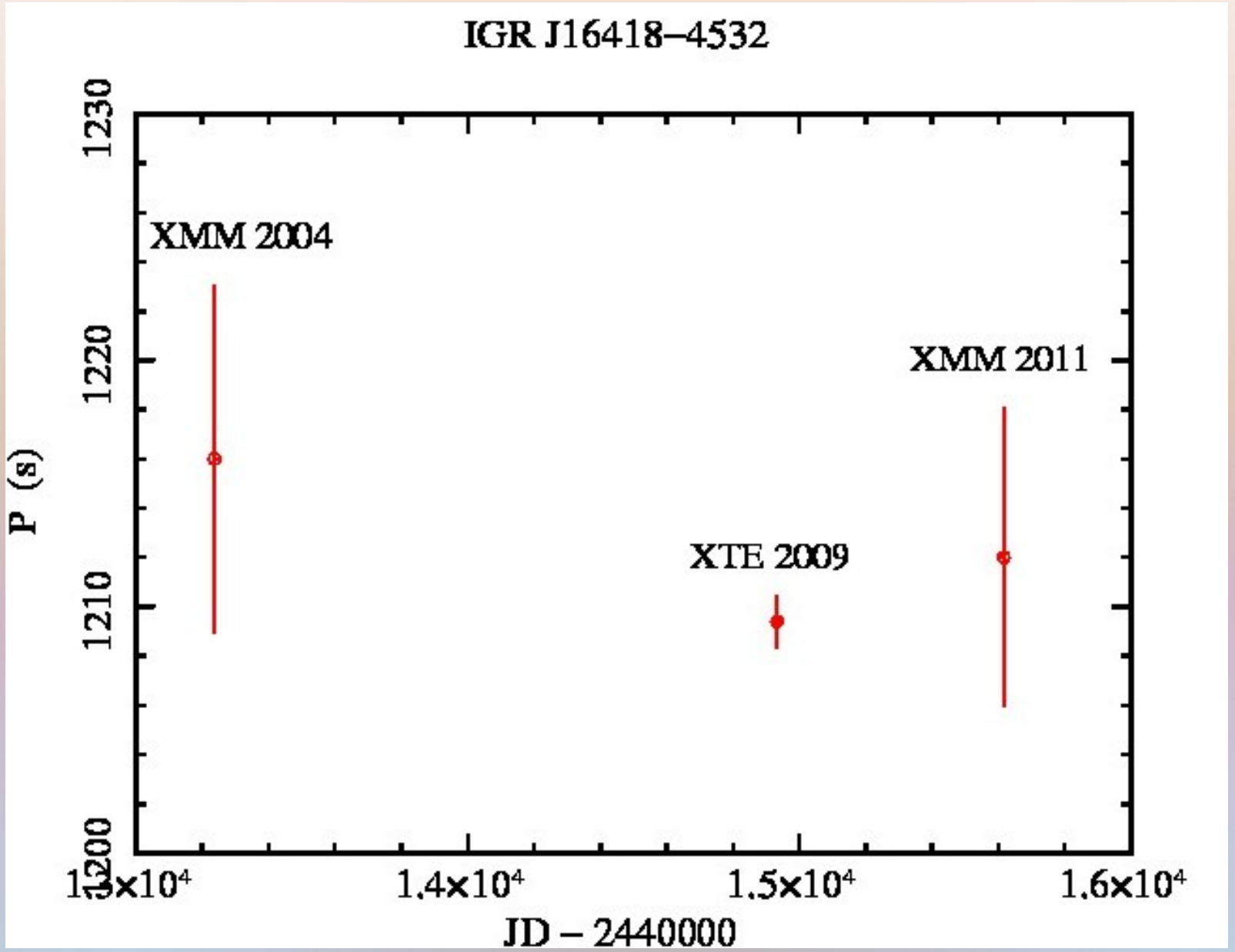
Re-analysis of the 2004 XMM of IGRJ16418

Pspin=1216 +/- 7 s

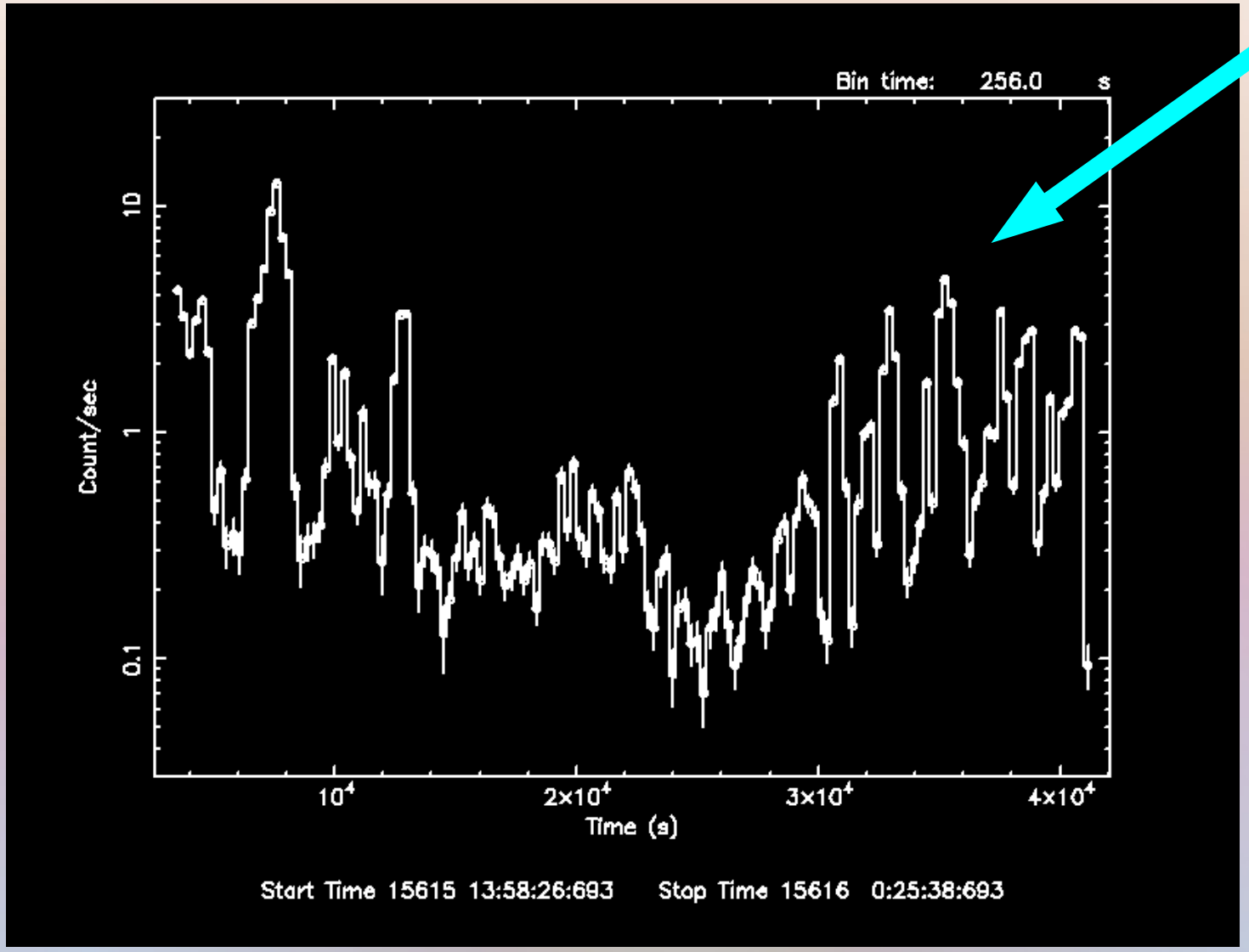


Re-analysis of the 2004 XMM low intensity



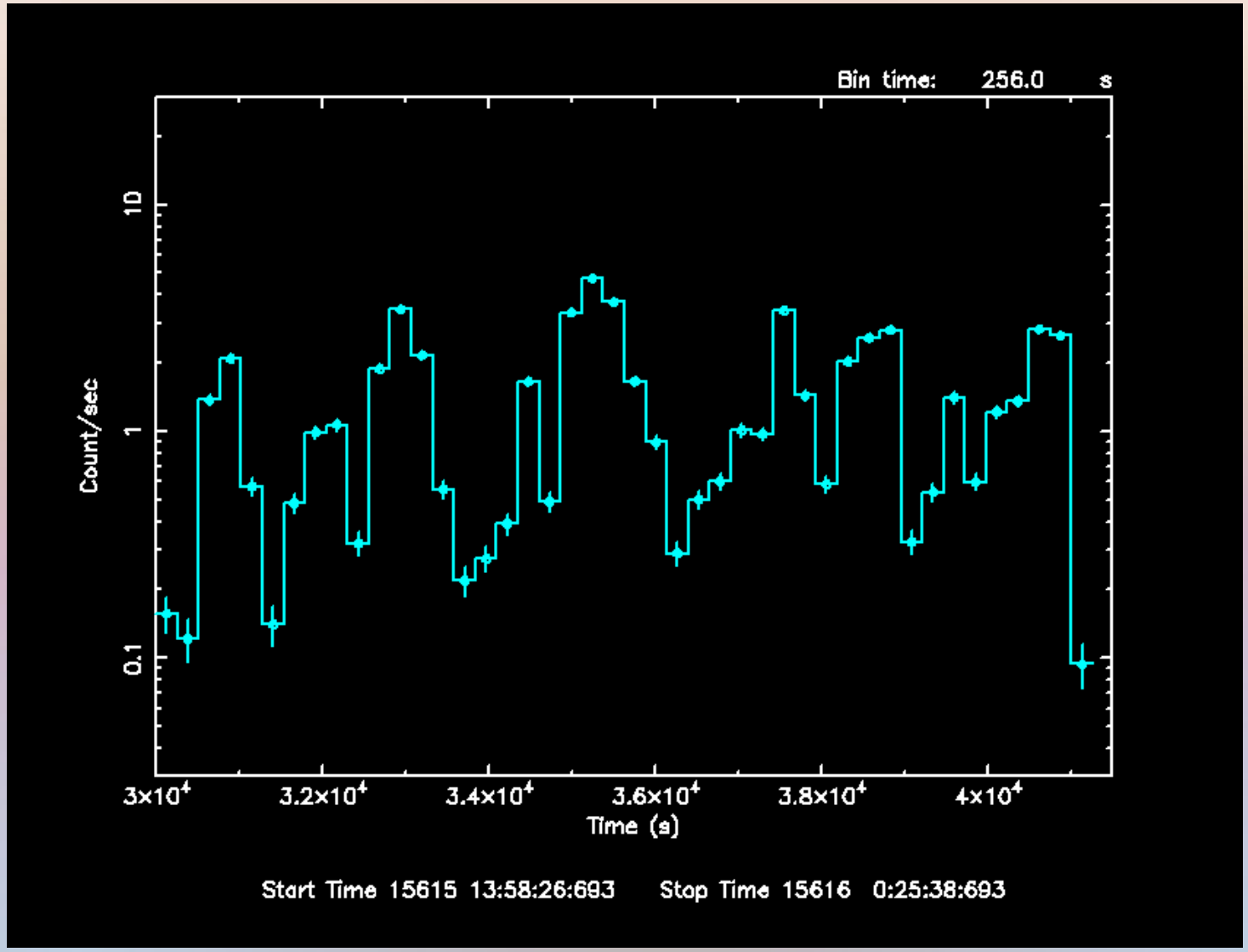

IGR J16418−4532
XMM 2004
XTE 2009
XMM 2011
P (s)
1230
1220
1210
1200
1.3×10⁴
1.4×10⁴
1.5×10⁴
1.6×10⁴
JD − 2440000

Last part of the 2011 XMM observation: quasi periodic flares?



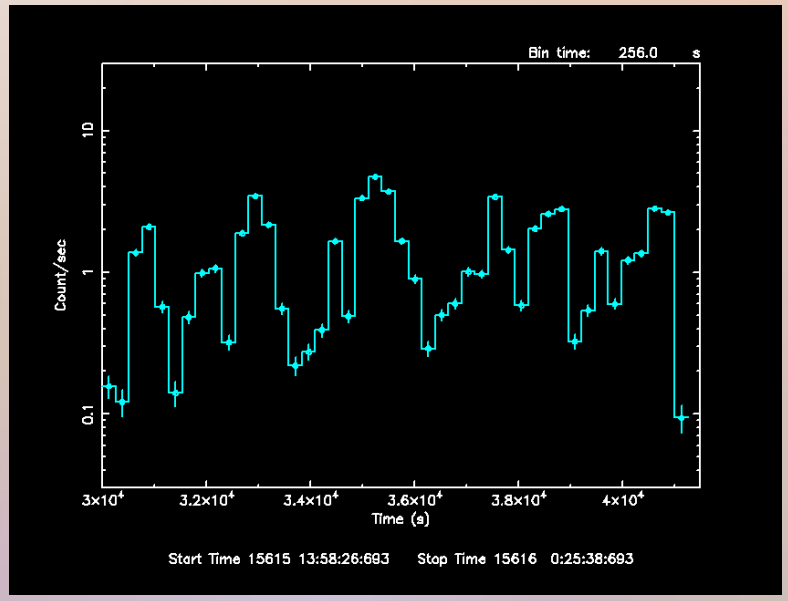
EPIC pn background subtracted light curve (0.3-12 keV)

Close-up view of the last part of the XMM observation:
flares NOT repeating at the pulsar spin



Close-up view of the last part of the XMM observation:
Quasi-periodic flaring similar to other sources

XMM IGRJ16418



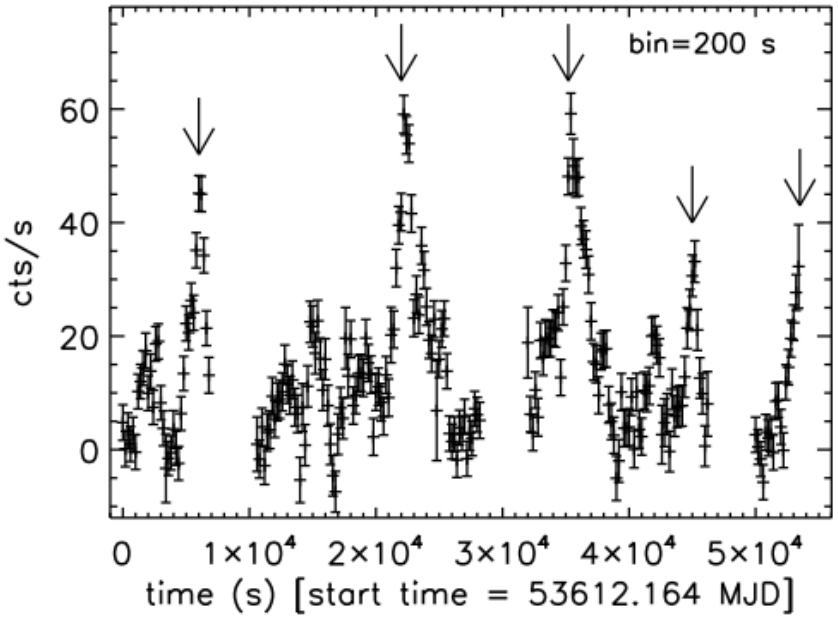
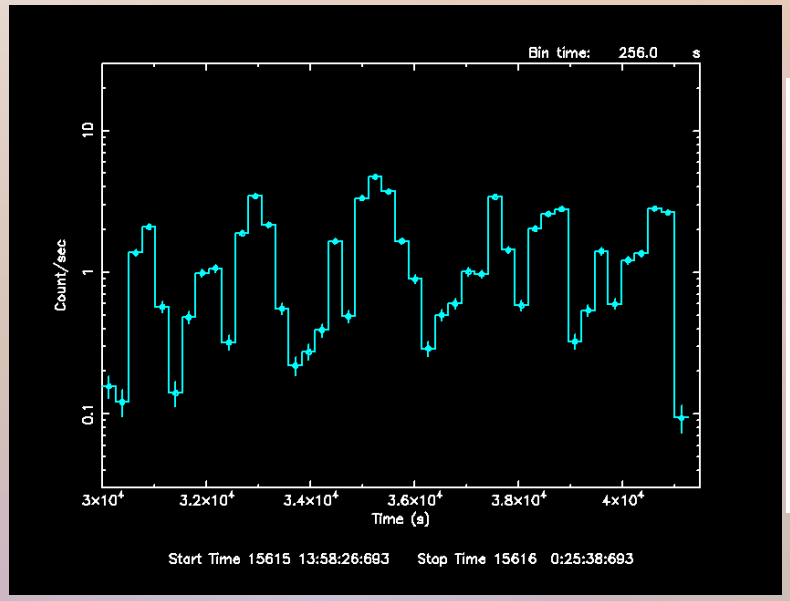


Figure 9. Lightcurve of the observation of XTE J1739−302, in the energy range 18 − 60 keV (IBIS/ISGRI). Arrows indicates the peaks of luminosity.

INTEGRAL SFXT XTE J1739-302
(Ducci et al. 2010)

Close-up view of the last part of the XMM observation:
Quasi-periodic flaring similar to other sources

XMM IGRJ16418



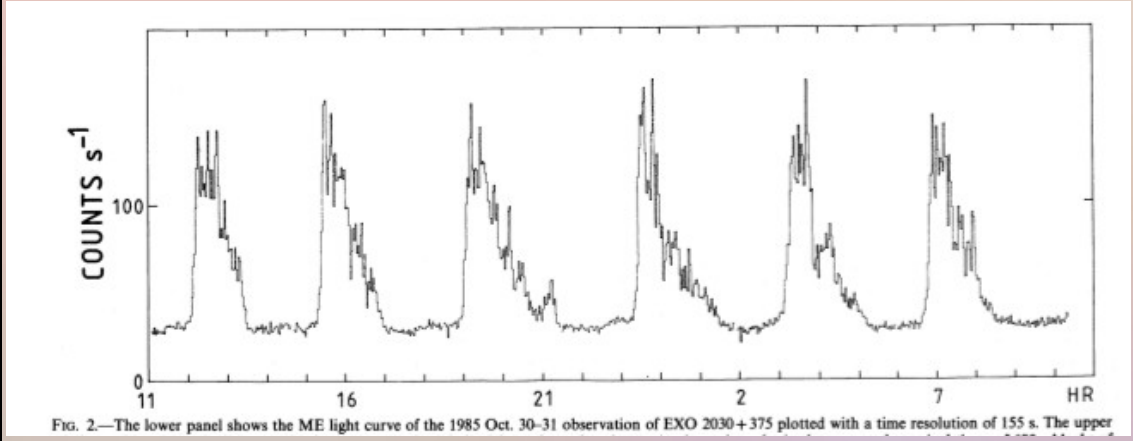
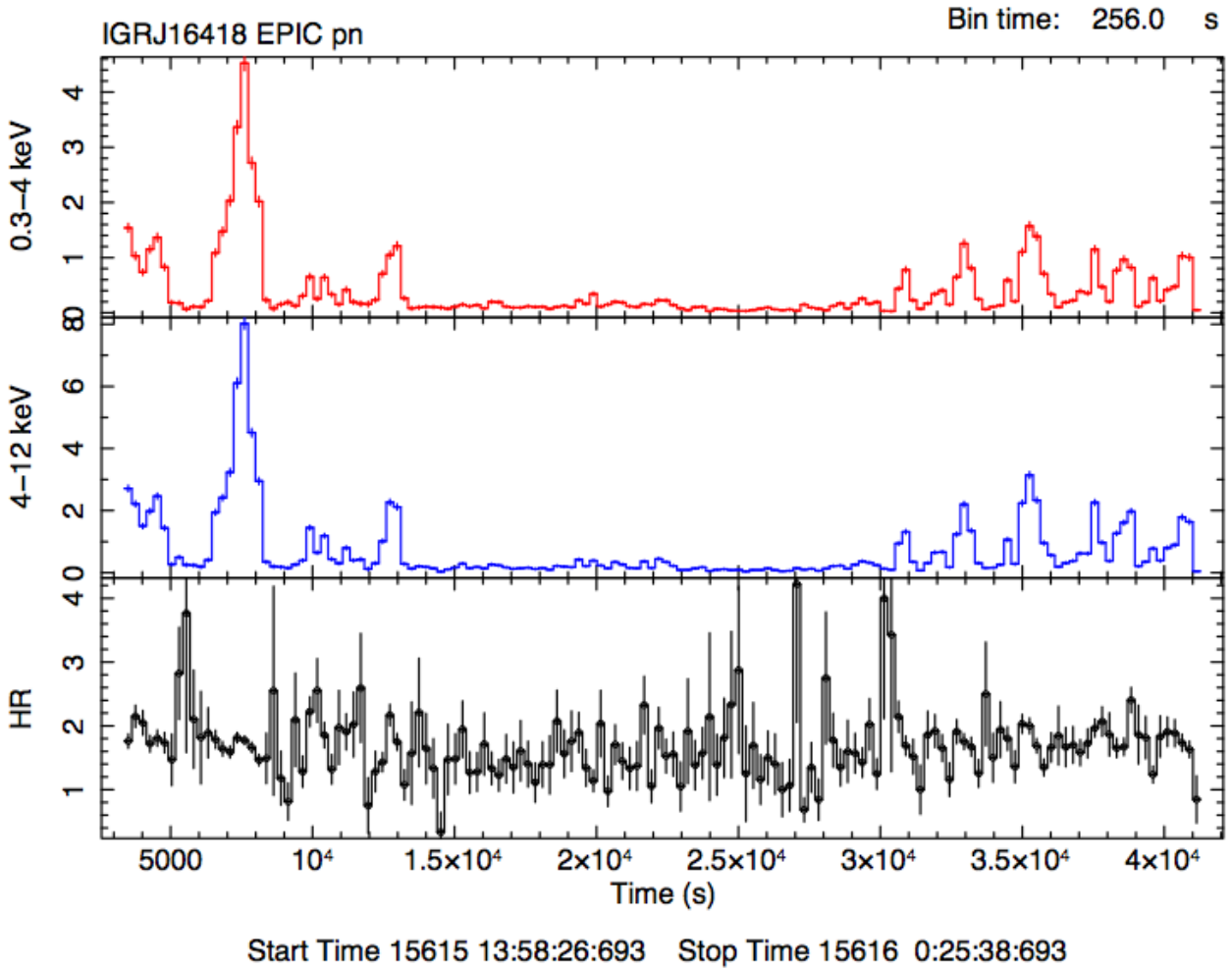
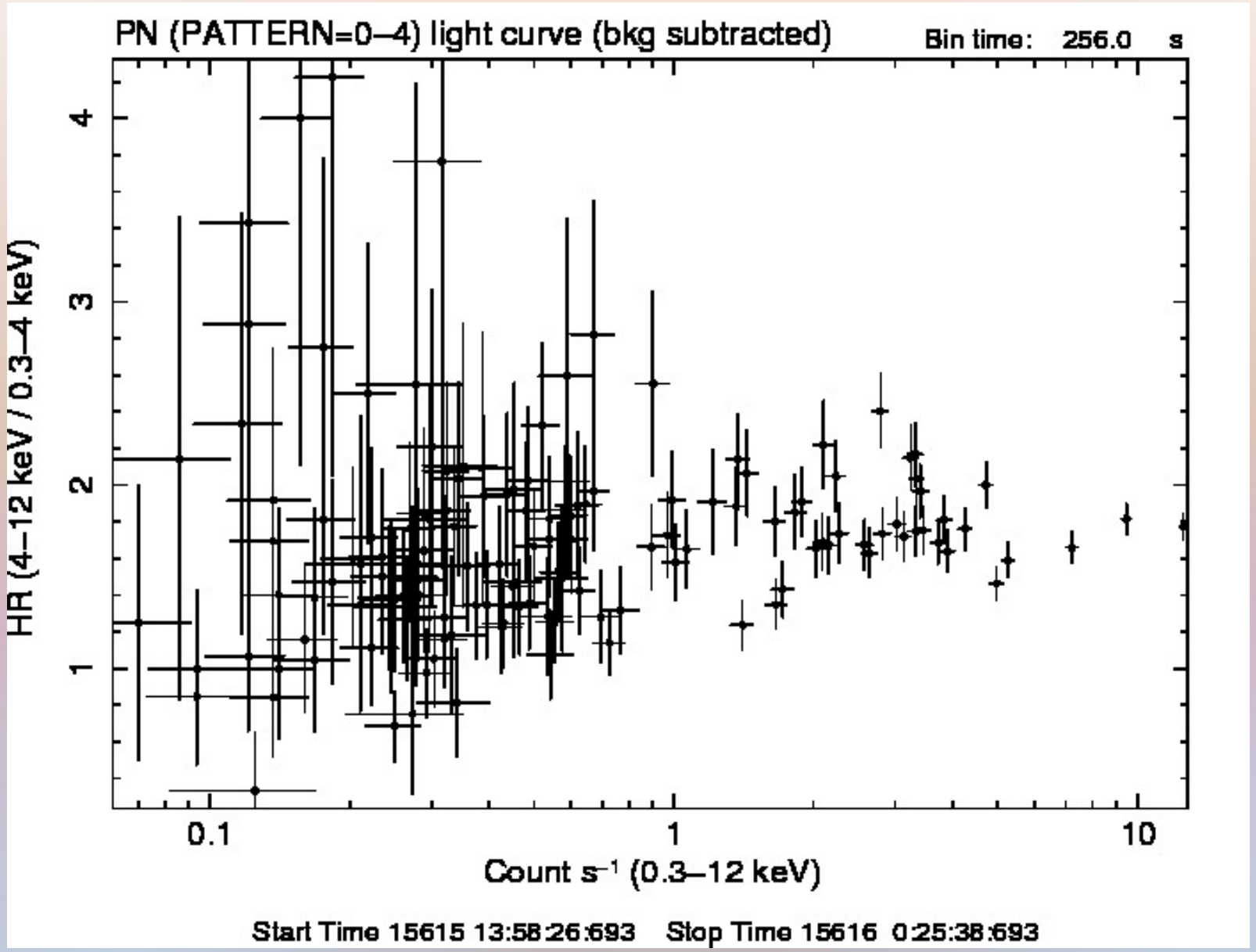


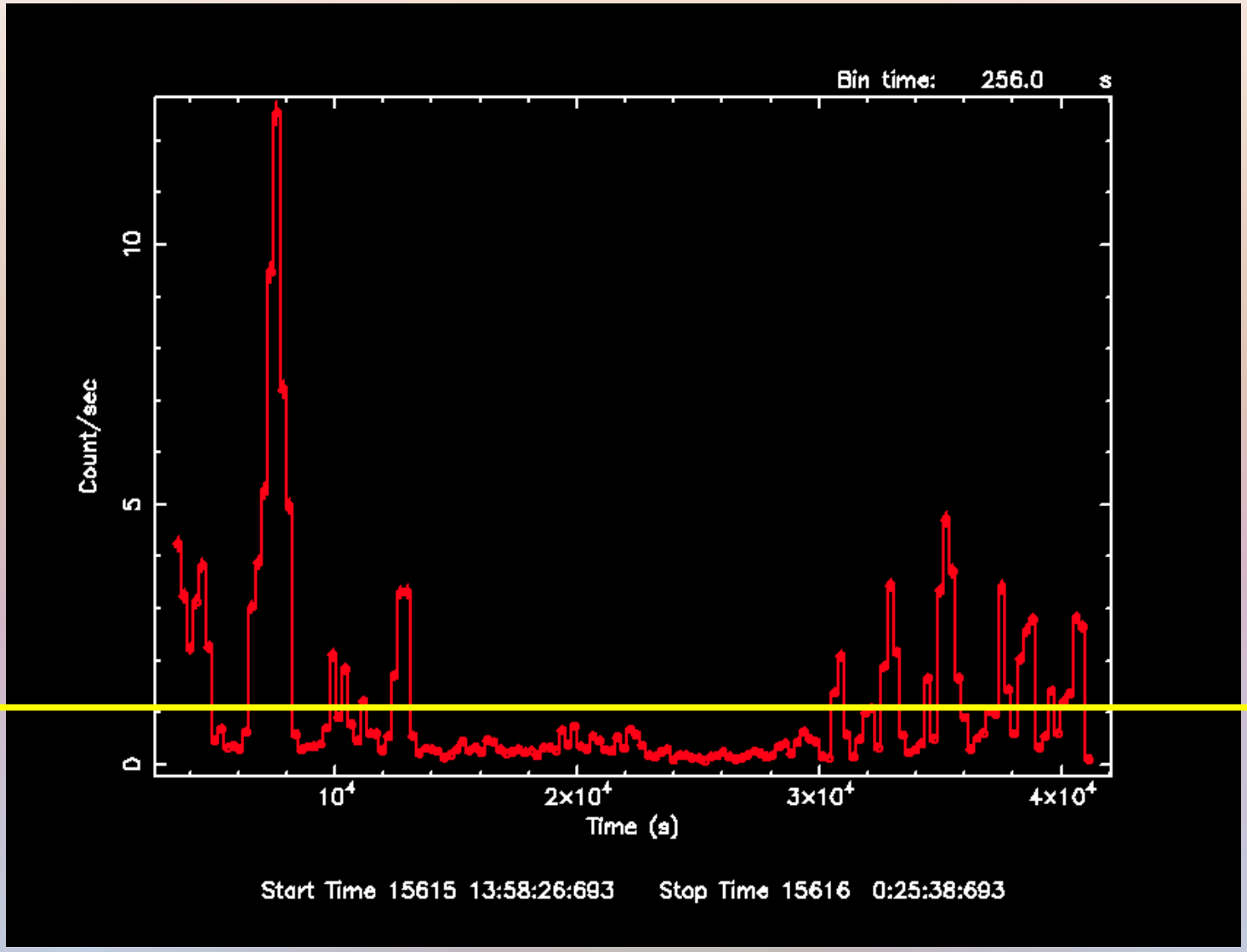
FIG. 2.—The lower panel shows the ME light curve of the 1985 Oct. 30–31 observation of EXO 2030+375 plotted with a time resolution of 155 s. The upper

EXOSAT EXO2030+375 (Parmar et al. 1989)


IGRJ16418 EPIC pn
Bin time: 256.0 s
0.3–4 keV
4–12 keV
HR
5000
10⁴
1.5×10⁴
2×10⁴
2.5×10⁴
3×10⁴
3.5×10⁴
4×10⁴
Time (s)
Start Time 15615 13:58:26:693 Stop Time 15616 0:25:38:693

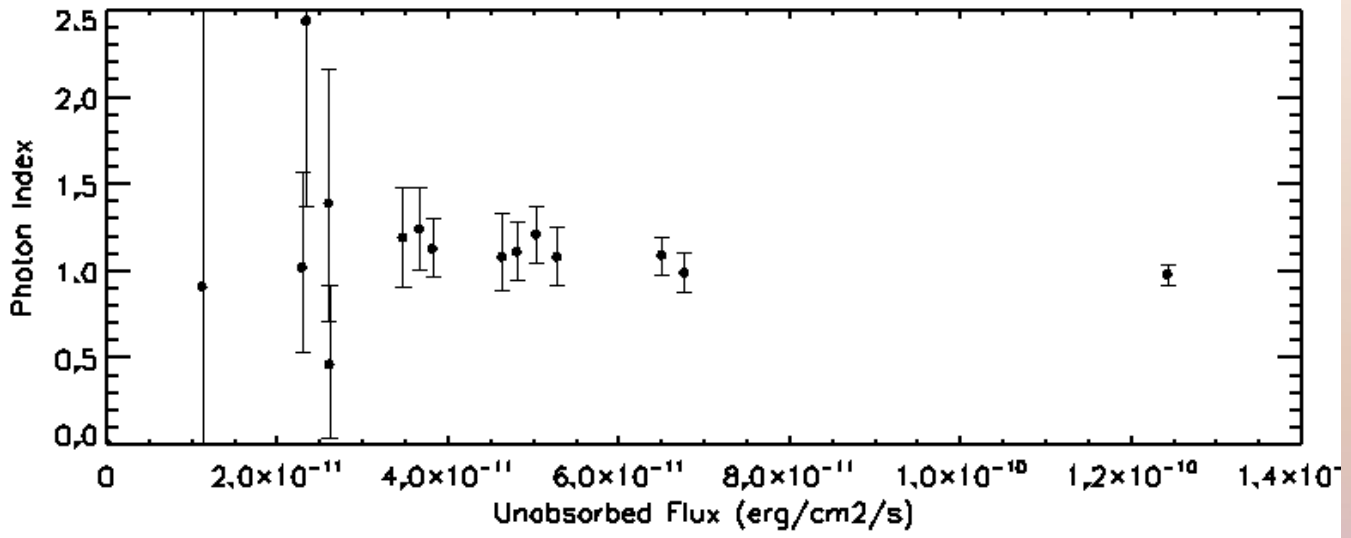

PN (PATTERN=0–4) light curve (bkg subtracted)
Bin time: 256.0 s
HR (4–12 keV / 0.3–4 keV)
1
2
3
4
0.1
1
10
Count s⁻¹ (0.3–12 keV)
Start Time 15615 13:58:26:693 Stop Time 15616 0:25:38:693

XMM EPIC pn intensity selected spectroscopy



Spectroscopy during FLARES

Photon Index

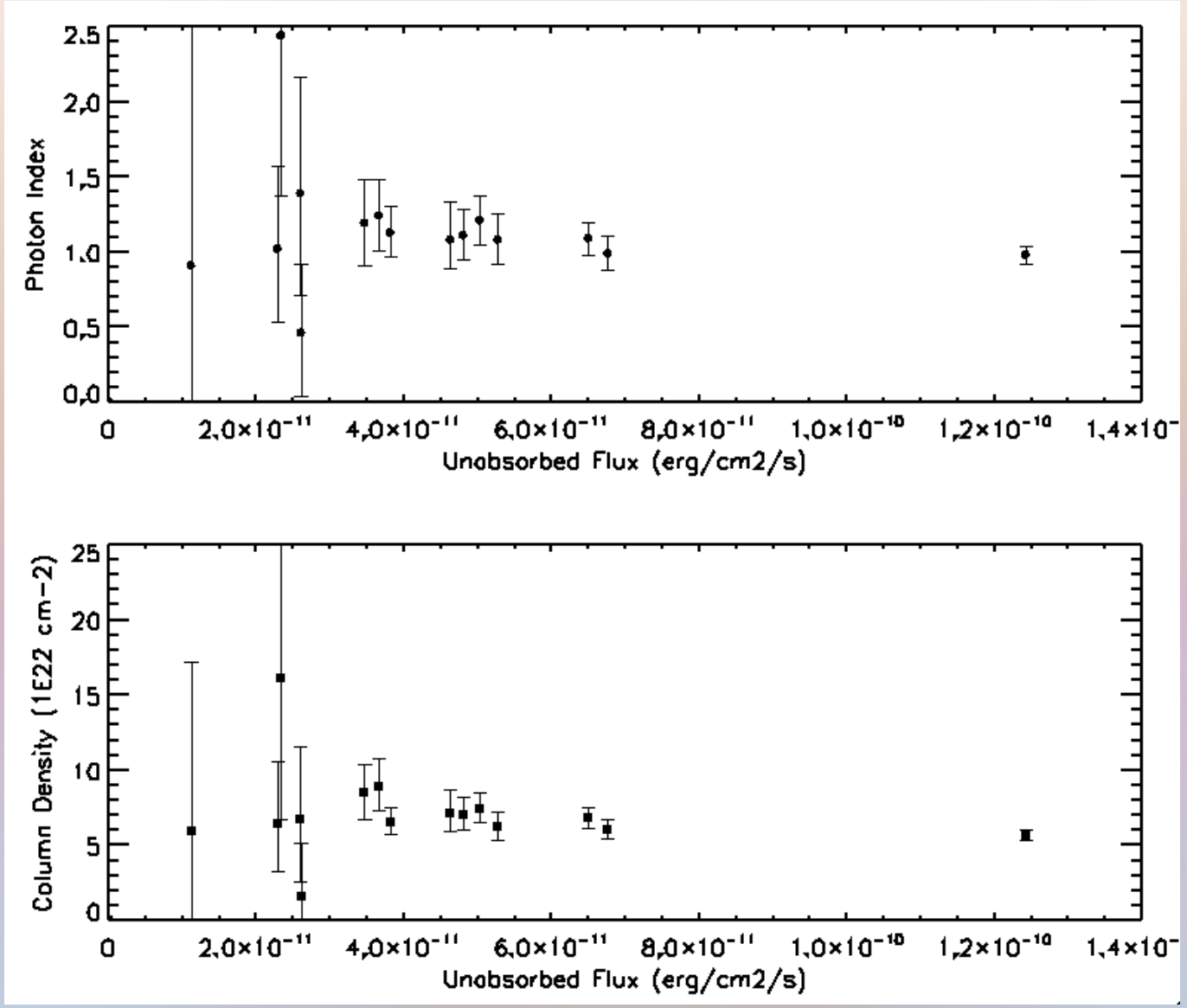


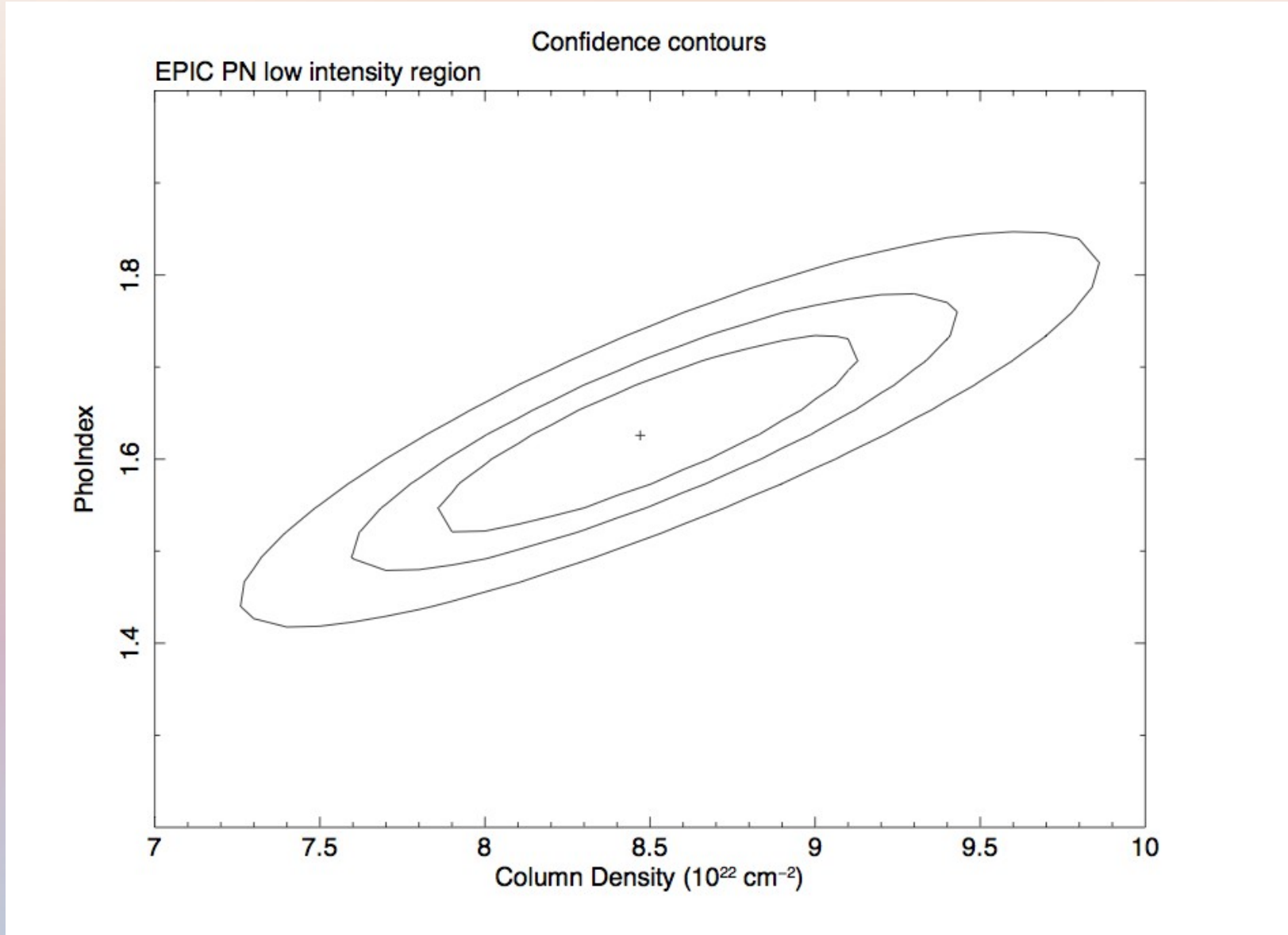
Spectroscopy during FLARES

Photon Index

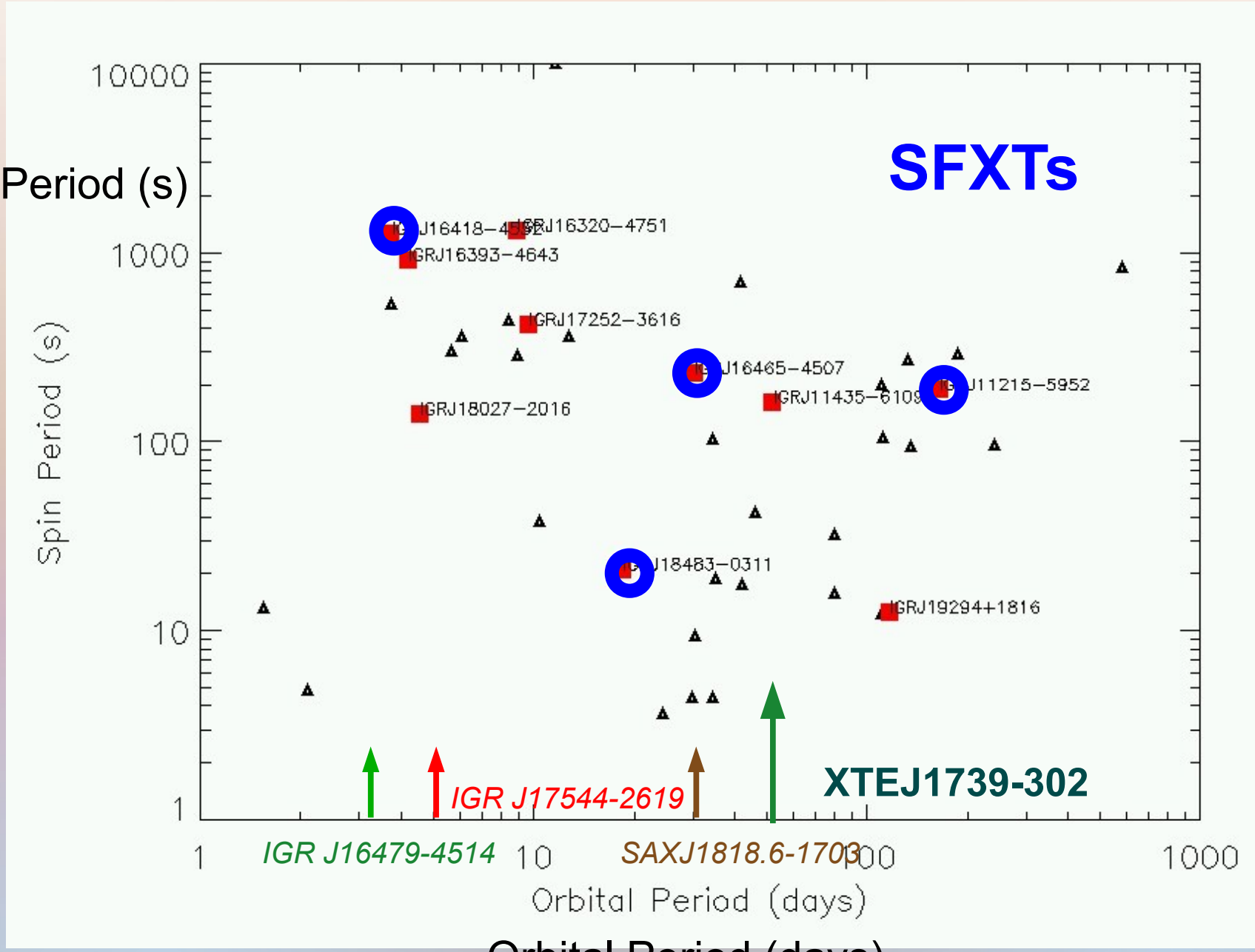
NH

Galactic NH

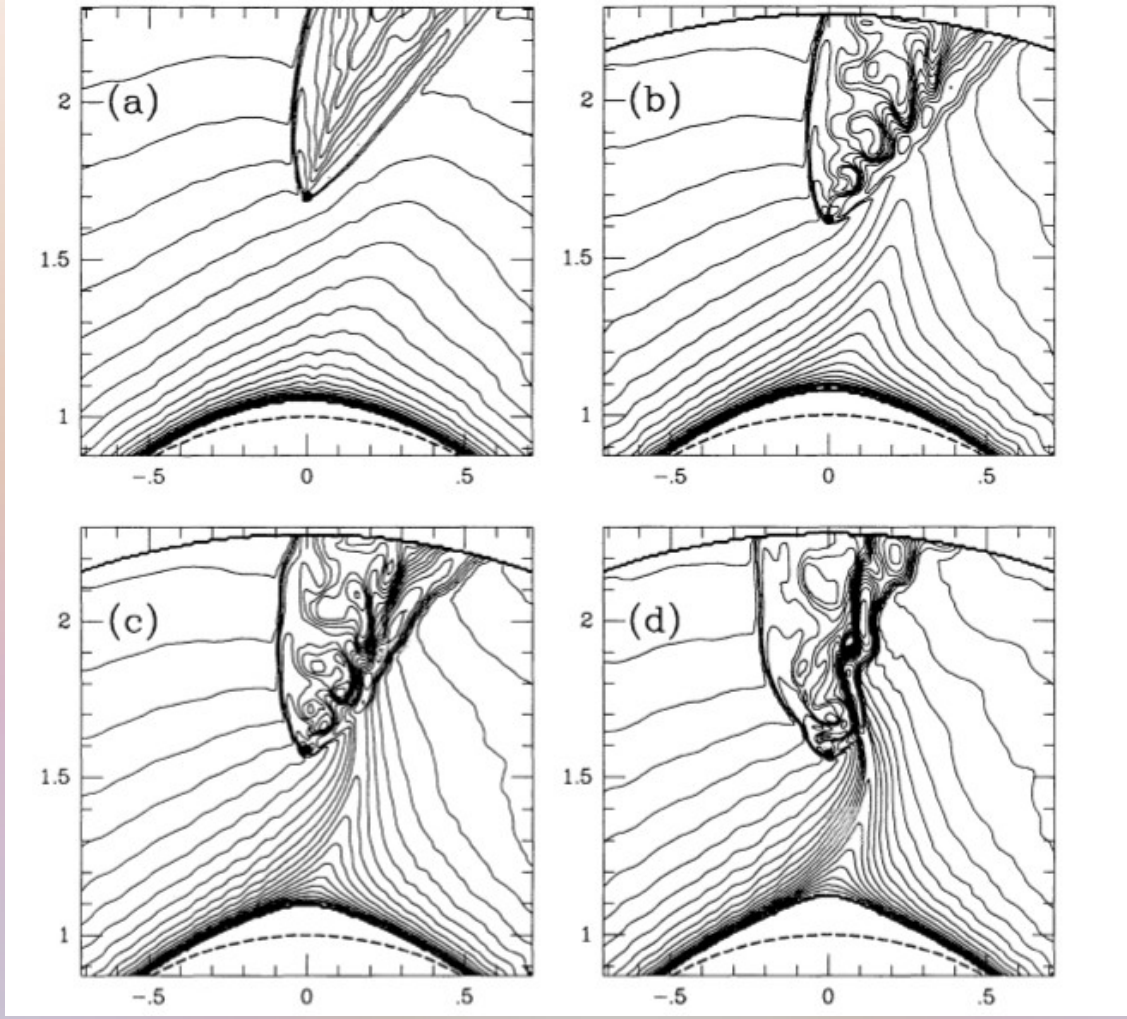



Confidence contours
EPIC PN low intensity region
PhoIndex
1.8
1.6
1.4
7
7.5
8
8.5
9
9.5
10
Column Density (10^{22} cm^{-2})

Corbet diagram



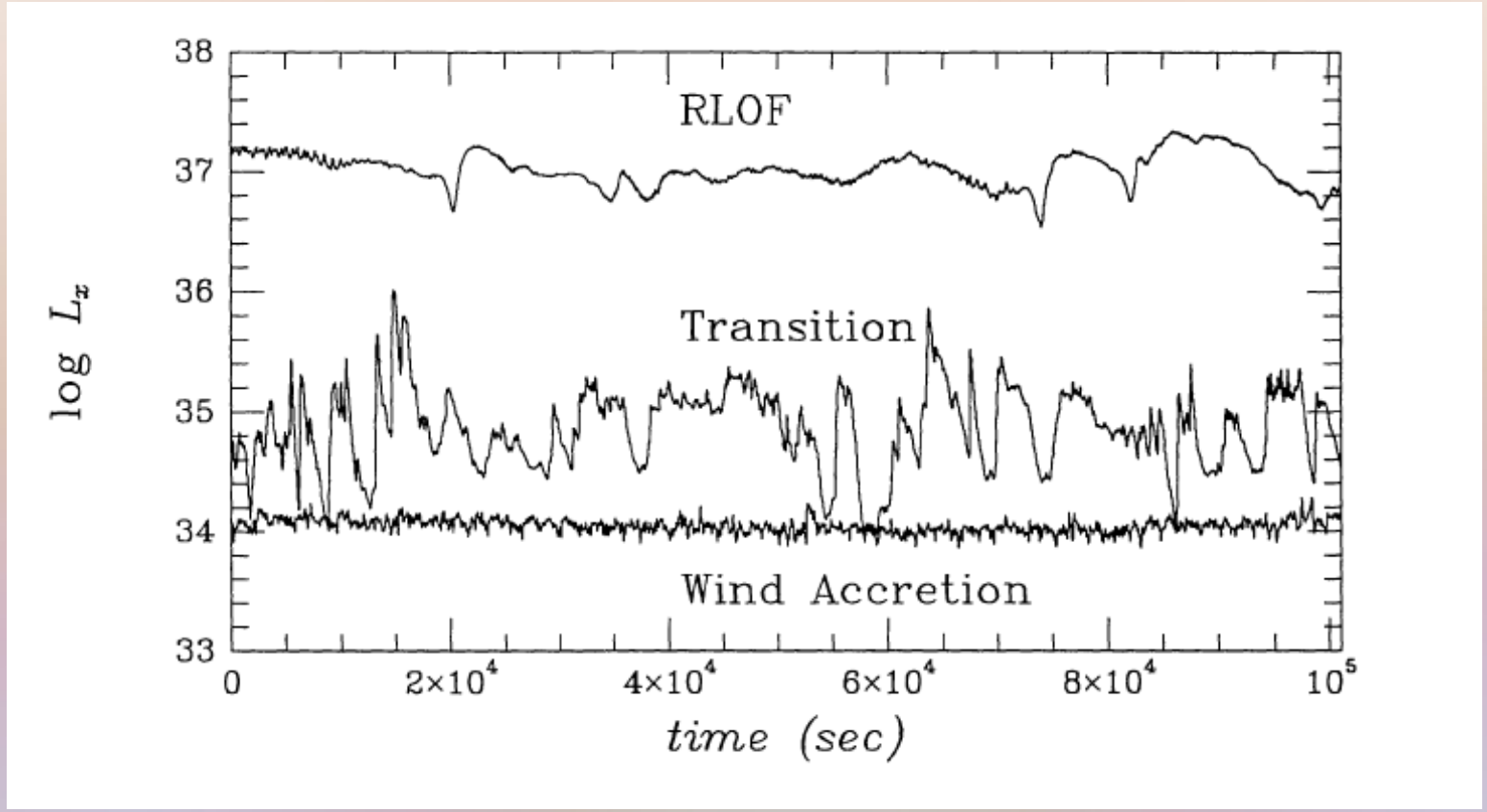
Orbital Period (days)



Formation of a gas stream as the binary separation is dicreased in HMXBs

Blondin, Stevens, Kallman 1991

simulations



Blondin & Owen 1997

CONCLUSIONS

IGRJ16418-4532 has revealed for the first time an intensity **variability** range of **2 orders of magnitude** during an interrupted observation with XMM-Newton, covering about 0.13 orbital phase.

This dynamic range is typical of other **"intermediate" SFXTs** (although we cannot exclude unobserved brighter flares).

If the small orbital period will be confirmed, it is one of the **SFXTs with one of the narrowest orbits.**

We suggest that a possibility to **explain the variability in these SFXTs** with Small orbital periods is (besides ionization effect and other mechanisms) that they could represent a **transitional case b**etween RLO and wind accretion, as obtained in the simulations reported by Blondin & Owen (1997).

Unveiling the properties of SFXTs (E1.4)

SOC:

L. Sidoli (MSO)
V. Sguera (DO)
A. Bazzano
A.J. Bird
E.P.J. van den Heuvel
I. Negueruela
D.M. Smith
J. Tomsick

Call for papers in August 2011 !!!