IGR J11215-5952:
un transiente X con outbursts in perfetto orario !

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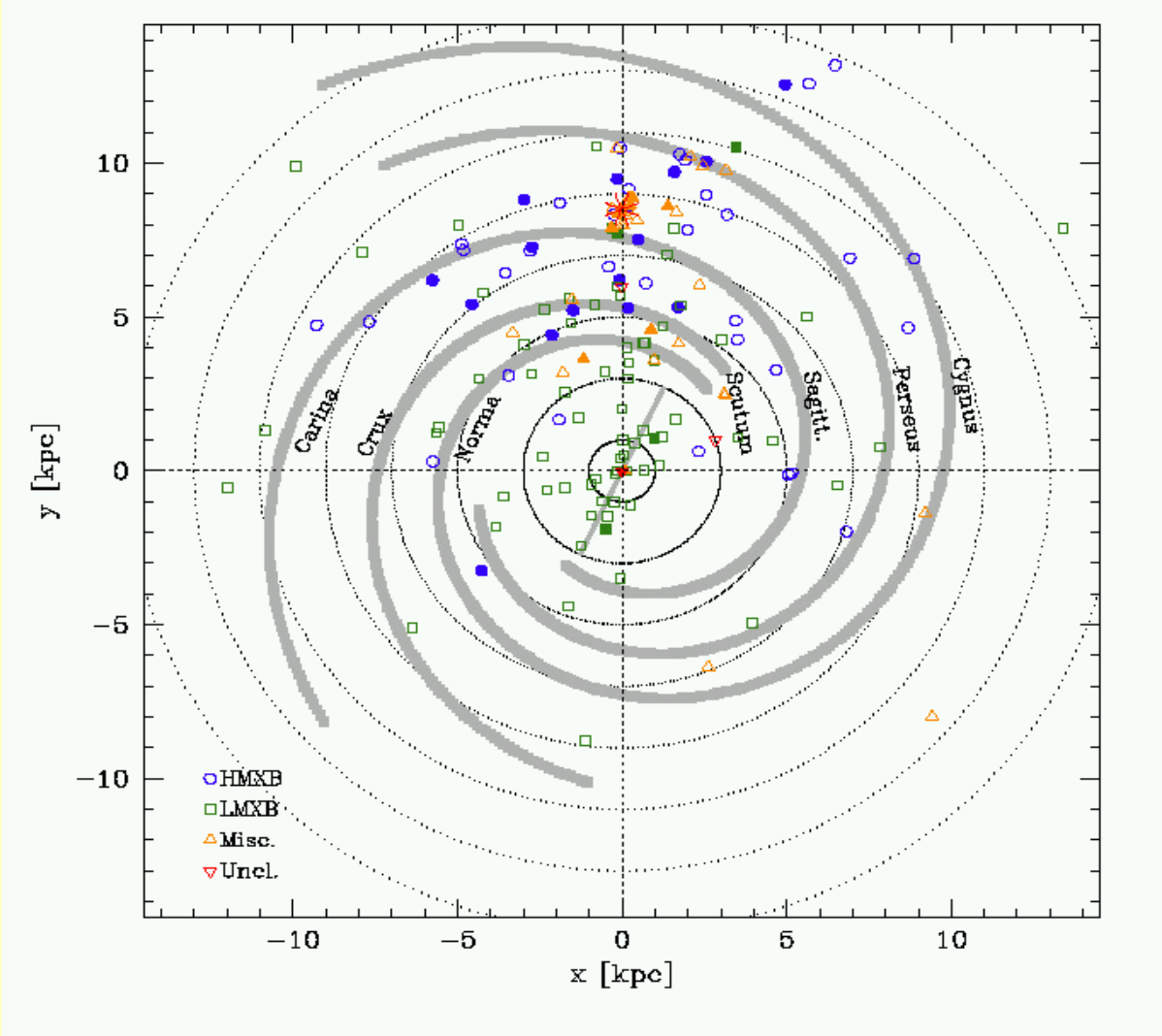
Sources detected with ISGRI during the first 4 years of observations

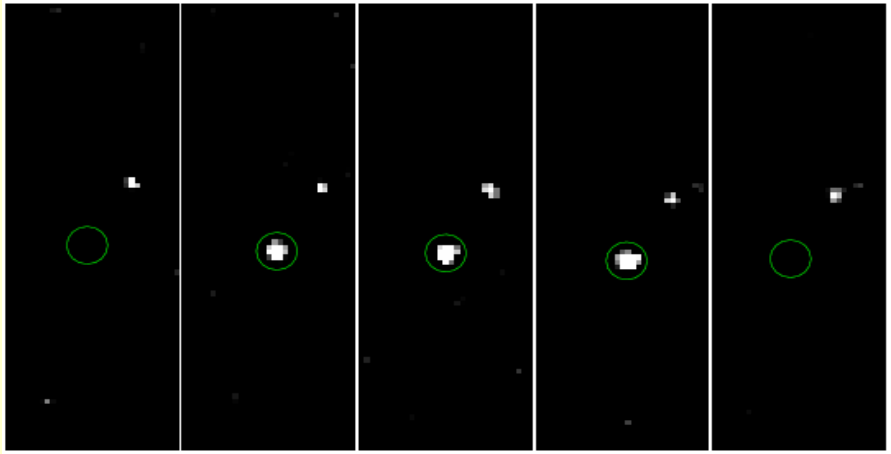


from Bodaghee et al., 2007, astro-ph/0703043

~ 10% of the new IGRs are Supergiant Fast X-ray Transients

SFXTs are a new class of sources discovered
with INTEGRAL
thanks to the Galactic Plane monitoring

INTEGRAL discoveries and observations
Supergiant Fast X-ray Transients



IGR J17391-3021/XTE J1739-302

ISGRI SWs (~2 ks)
image sequence
(20-30 keV)
flux at peak=254 mCrab

from Sguera et al. 2005

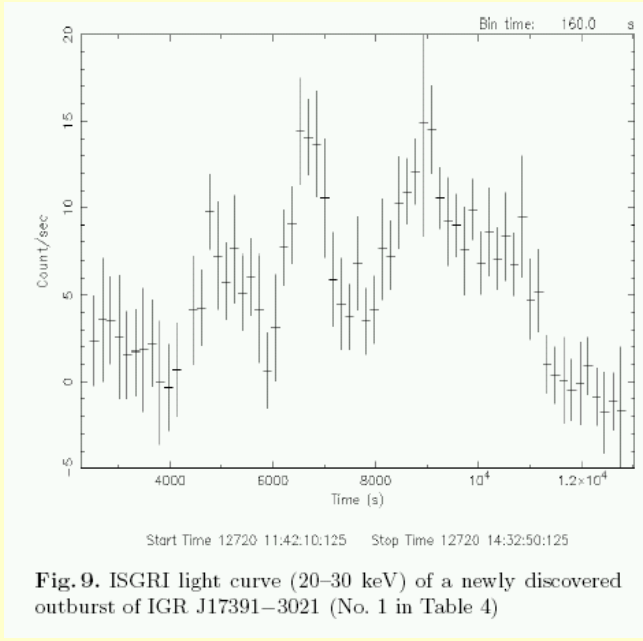


Fig. 9. ISGRI light curve (20–30 keV) of a newly discovered outburst of IGR J17391−3021 (No. 1 in Table 4)

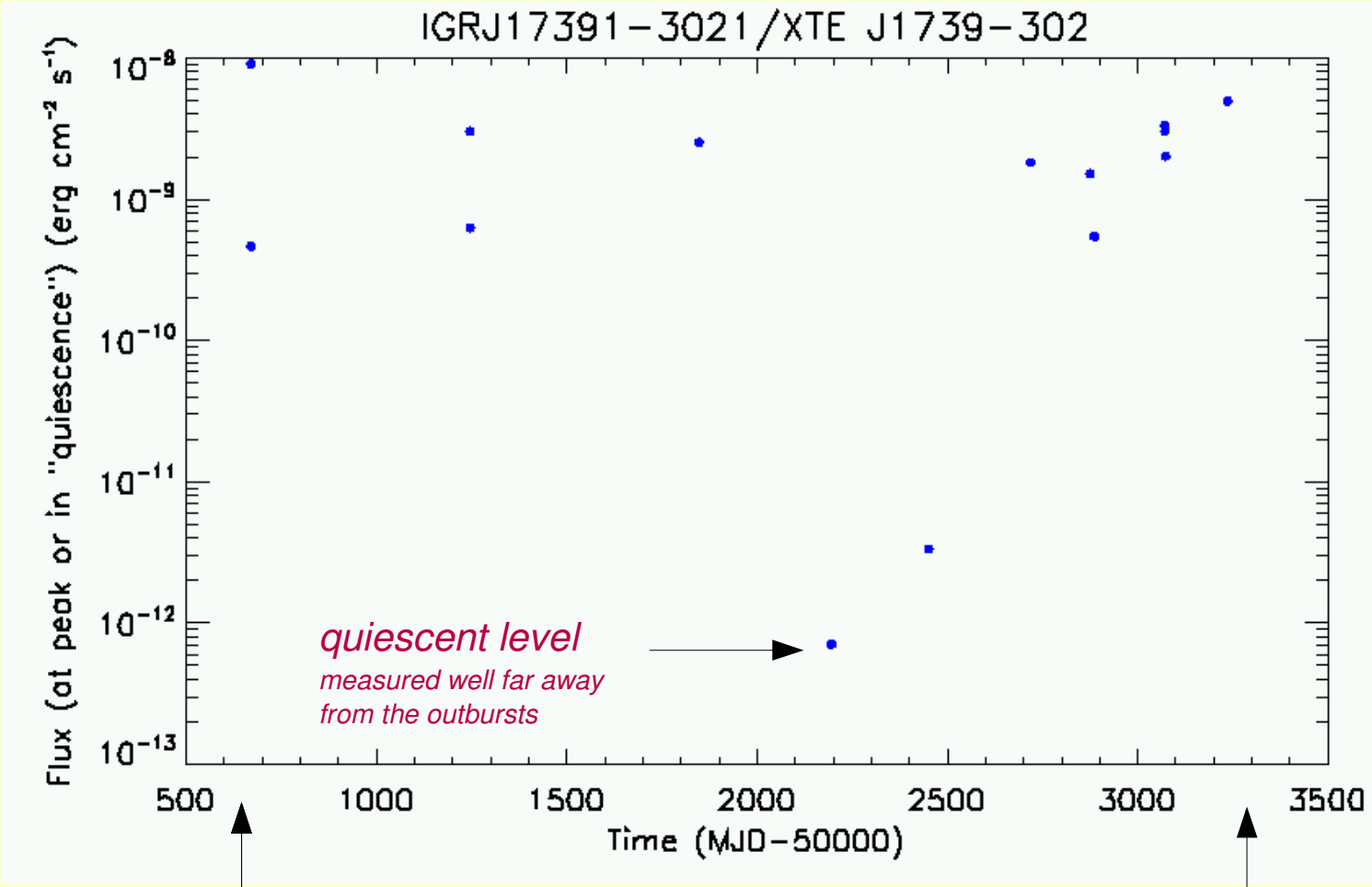
- **OUTBURST DURATION:** **~ few hours**, less than a day
- RECURRENT OUTBURSTS
- **HARD AND HIGHLY ABSORBED X-RAY SPECTRUM**
  - reminiscent of an X-ray pulsar
- **OPTICAL COUNTERPART**:
  highly reddened **O B supergiants**

Another interesting property of SFXTs:

L outburst / L quiesc. ~ 1000-10000

(from ASCA archival, or XMM or Chandra obs)
but only from few sources!

Flux (20-40 keV) at the peak of the outburst, together with the “quiescent” level

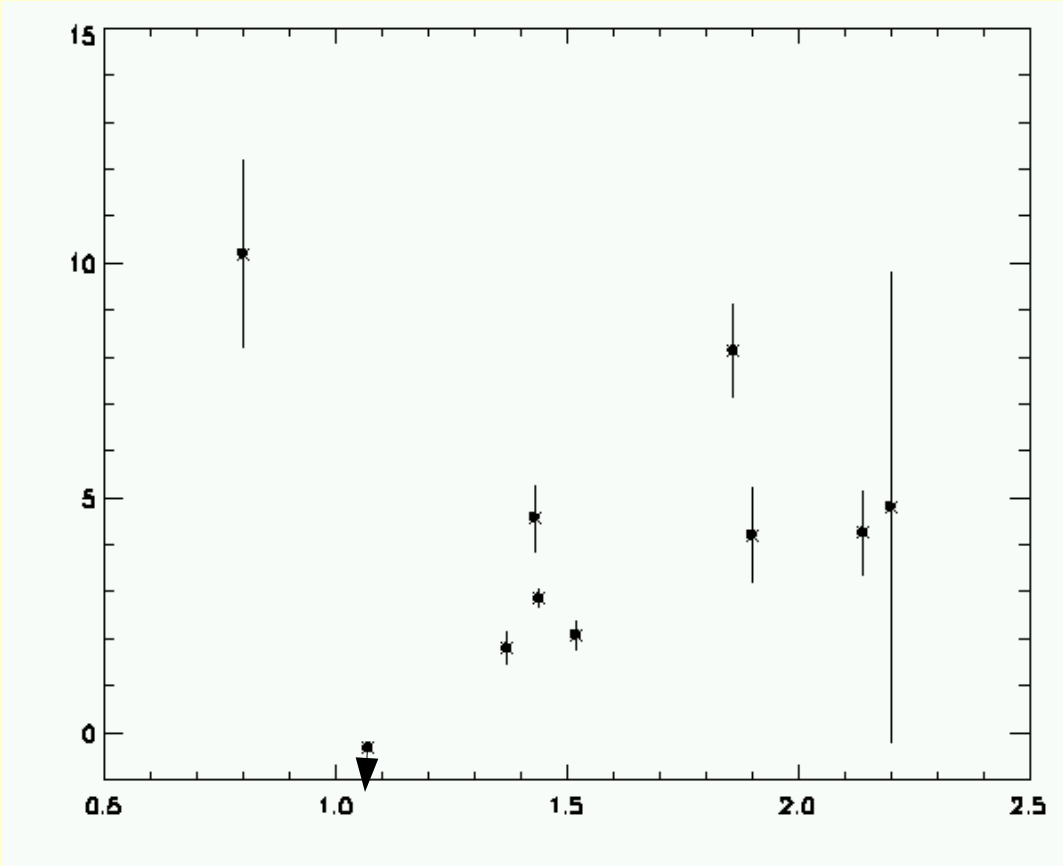


1997, Aug, XTE obs

2004, Aug, ISGRI obs

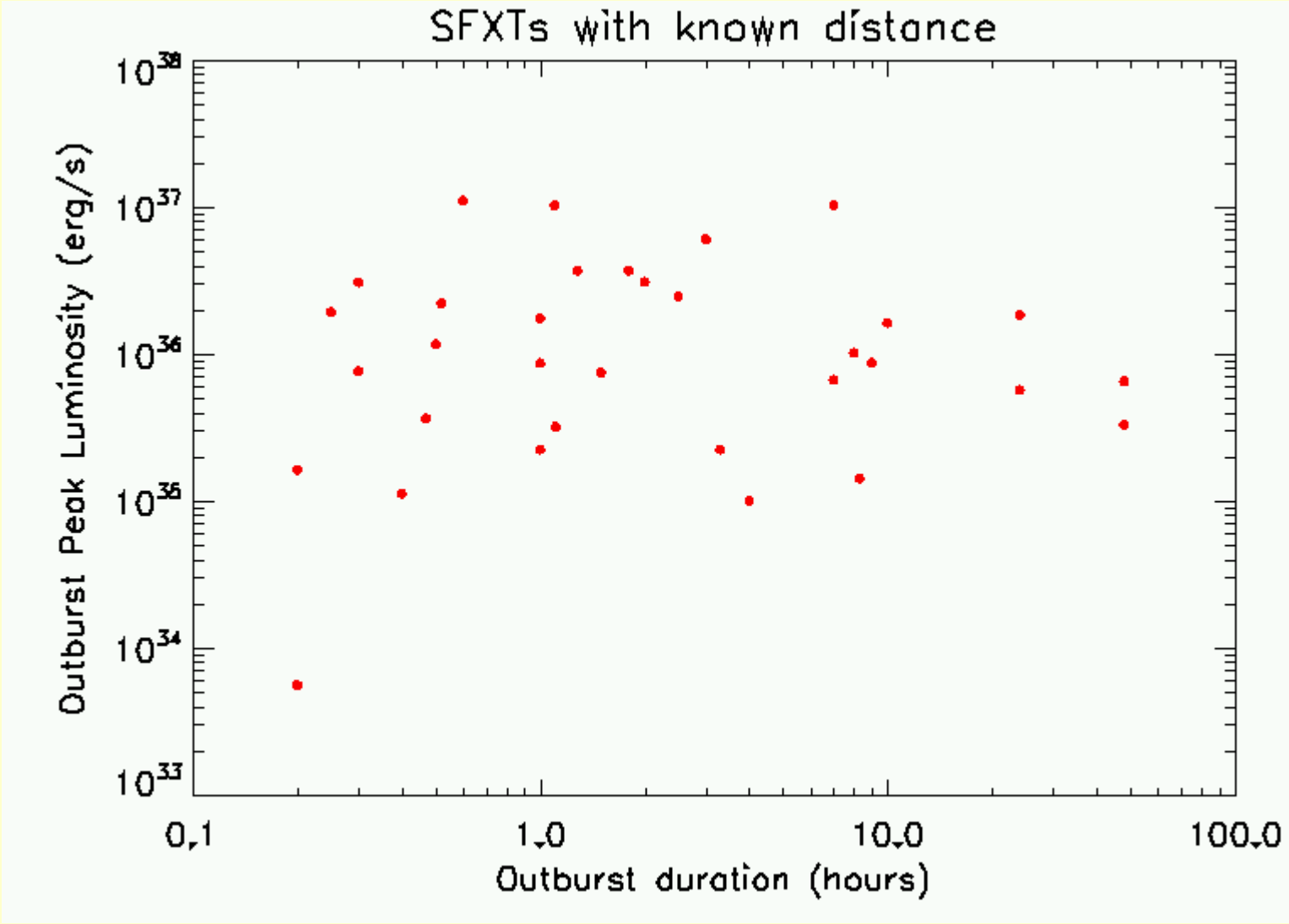
SFXTs properties: absorbing column density from X-ray spectra

N_H – N_H Gal (1E22 cm-2)



Total N_H Galactic (1E22 cm-2) towards the sources

SFXTs properties: X-ray luminosity during the short flares

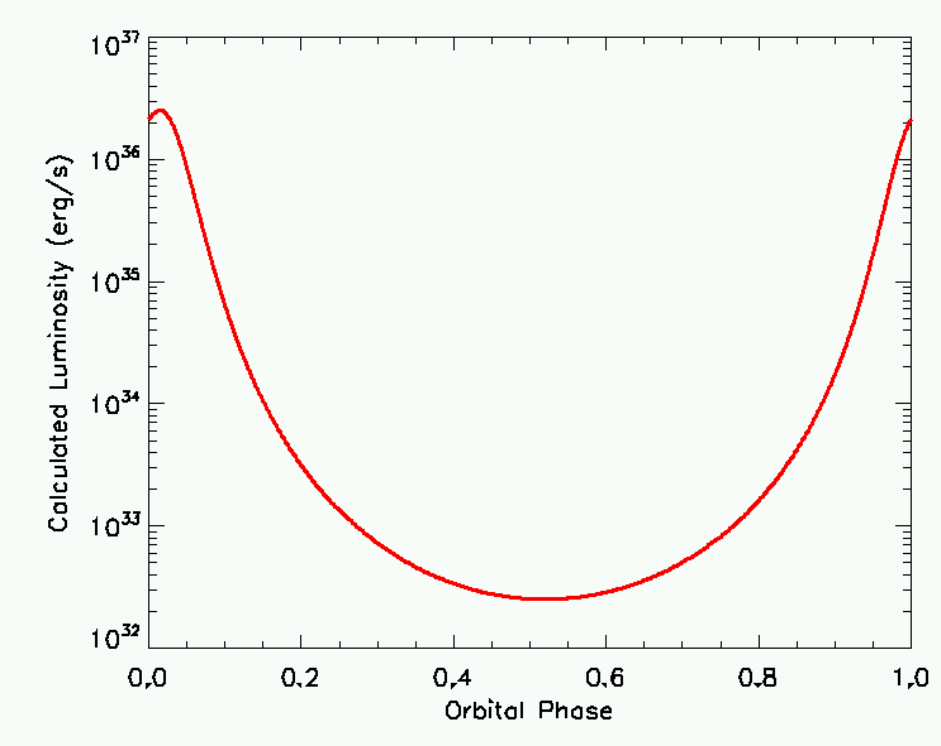


Supergiant Fast X-ray Transients: proposed interpretations *(I)*

- Outbursts produced by **short ejections** from the donor stars in XRBs? or **clumpy winds**? (in 't Zand 2005)

Supergiant Fast X-ray Transients: proposed interpretations *(III)*

- A new kind of supergiant HMXRBs in **wide eccentric orbits**? (wider than "normal" supergiants HMXRBs, like Vela X-1, in nearly circular orbits) *also to explain the large Lmax / Lmin* (*Negueruela et al. 2005*)

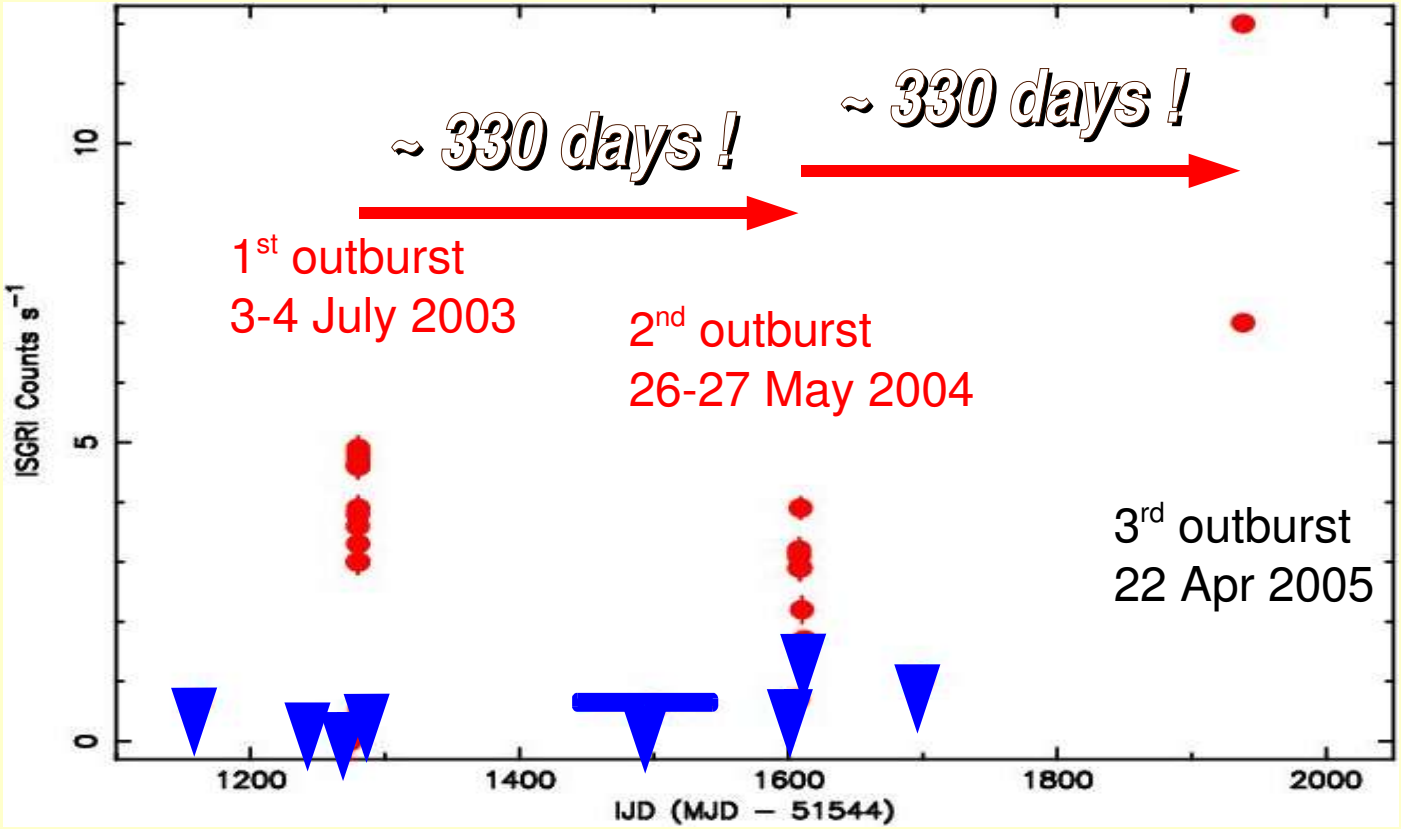


IGR J11215-5952: a unique SFXT

Fast transient discovered on April 22, 2005 (Lubinski et al. 2005)

The companion is a B-type Supergiant: HD 306414 (Negueruela et al. 2005; Masetti et al. 2006)

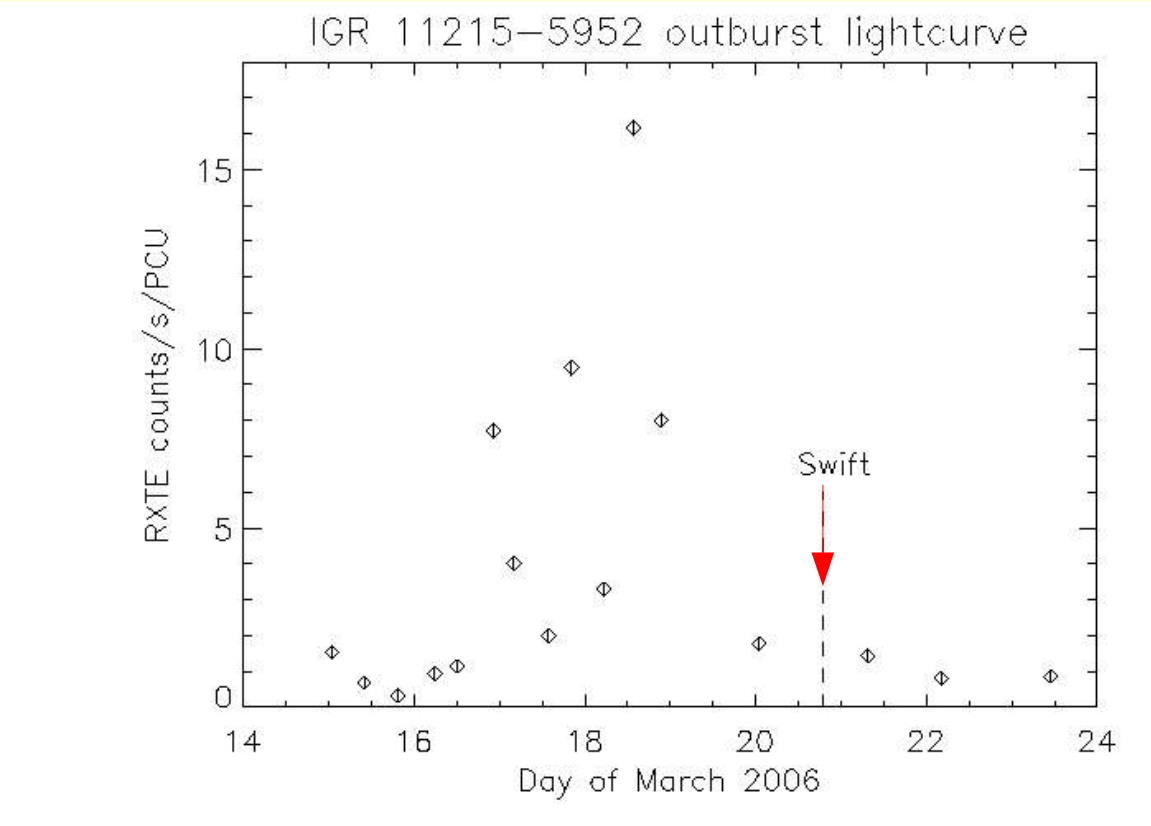
The INTEGRAL lightcurve shows a periodicity of ~ 330 days in the recurrence of the outbursts *(Sidoli, Paizis & Mereghetti, 2006, A&A, 450, L9; astro-ph/0603081)*.



ISGRI lightcurves (17-40 keV)

330 days = likely orbital period

4th outburst lightcurve *(Smith et al. 2006, ATel 766 and ATel 773)*



from http://scipp.ucsc.edu/~dsmith/atel/atel0306/

IGR J11215-5952 is a slow X-ray pulsator

XTE/PCA pointings revealed a spin period of the **neutron star** of

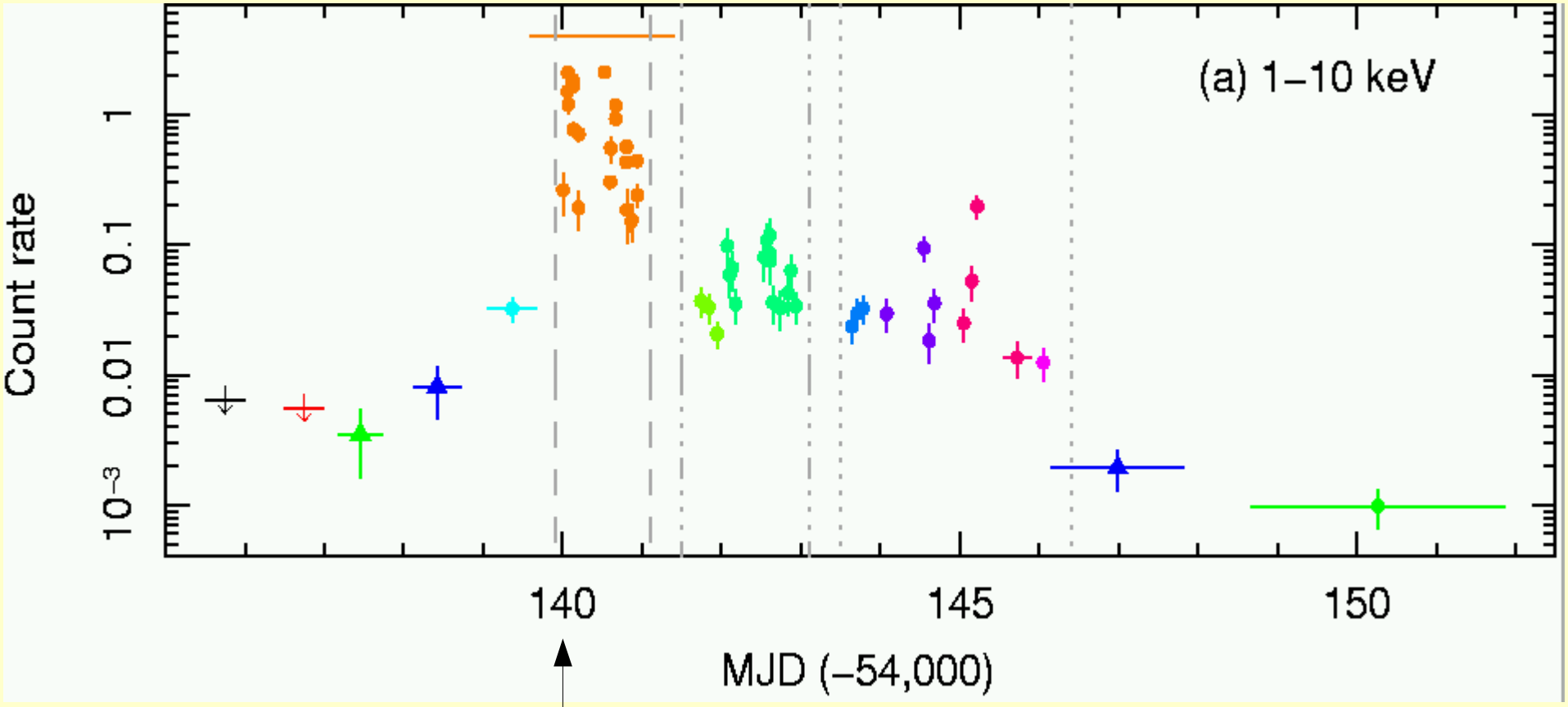
Pspin=186.8 +/- 0.3 *(Swank et al. 2007)*

Porb=329 days seems to suggest that outbursts in SFXTs might be related to wide eccentric orbits and not to clumpy winds

The periodic nature of the outbursts
from IGR J11215-5952 allowed us to plan & perform for the first time
a sensitive and complete monitoring
of the *entire outburst from a SFXT*,
during the latest outburst, expected on 2007, 9th February
with Swift/XRT

Results in *Romano, Sidoli, Mangano, Mereghetti & Cusumano ,*
2007 (A&A in press; astro-ph/0704.0543)

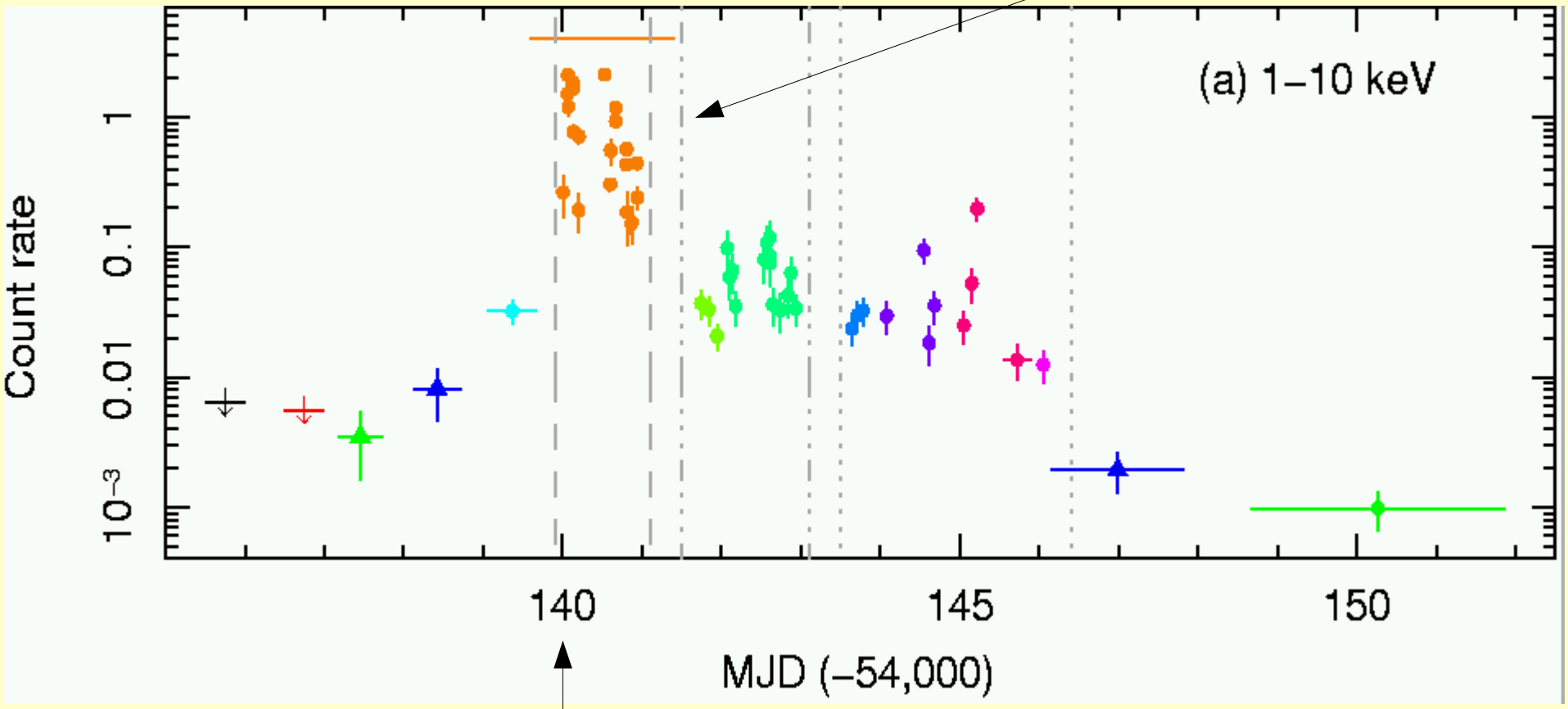
Final lightcurve from Swift / XRT observations of ***IGR J11215-5952***



9th February 2007

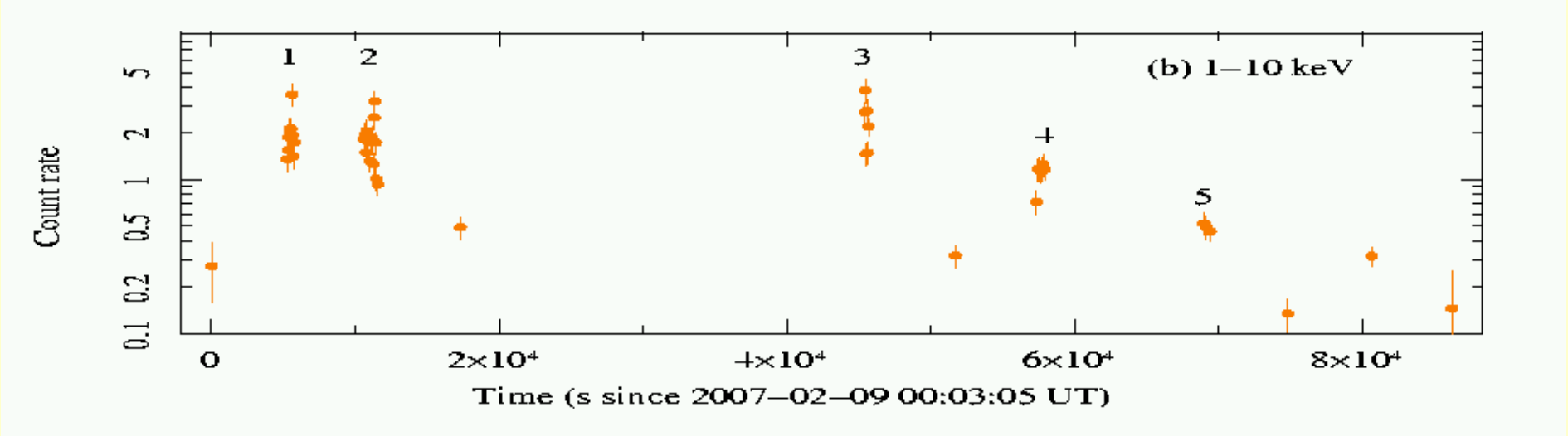
Romano et al. 2007

Note that *INTEGRAL would have seen ONLY the bright "orange" region of the lightcurve,* ***lasting less than 1 day*** *and composed of several ``short flares"*



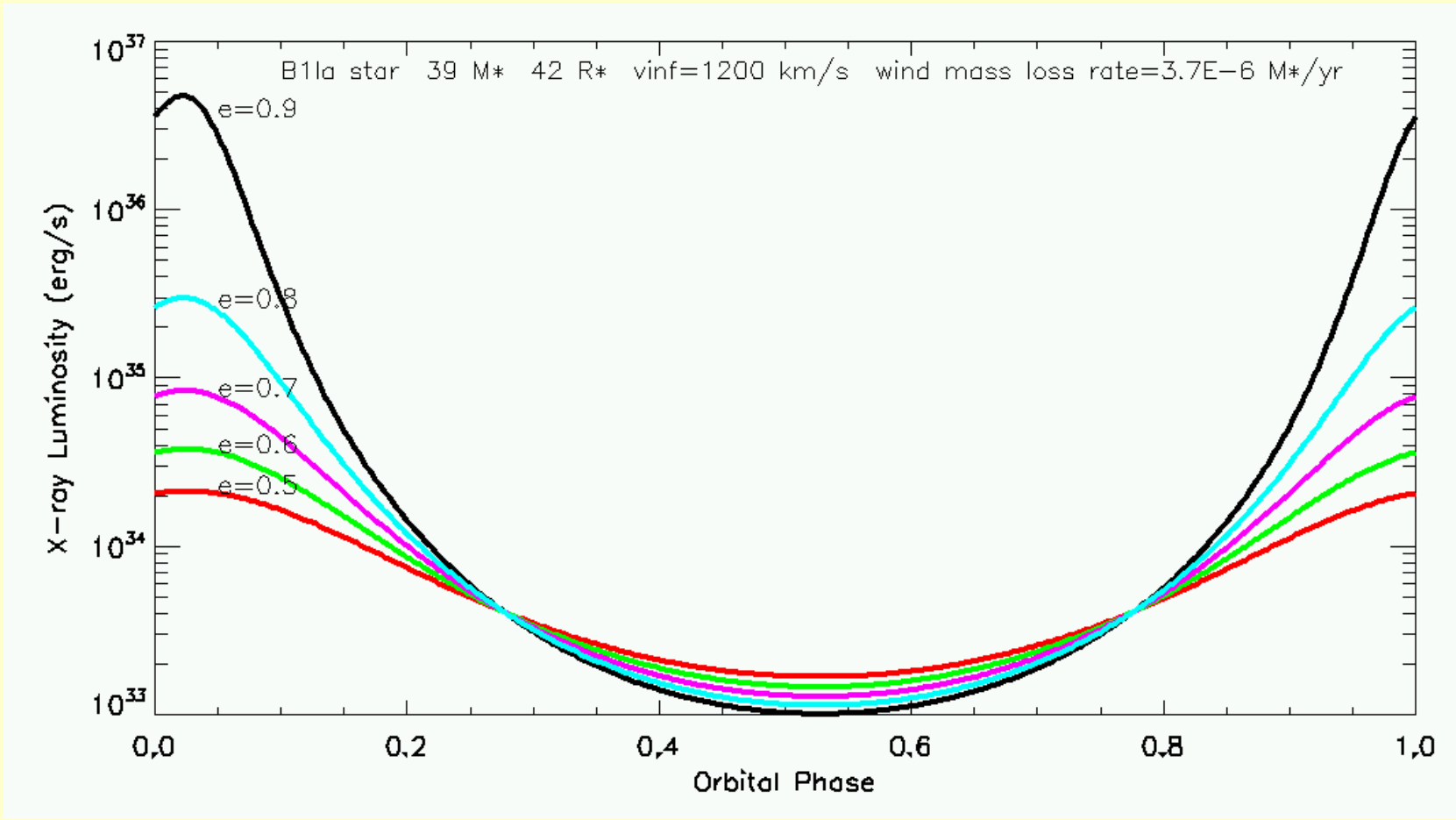
9th February 2007

*Close-up view of the **brightest** part of the outburst (9th Feb)*

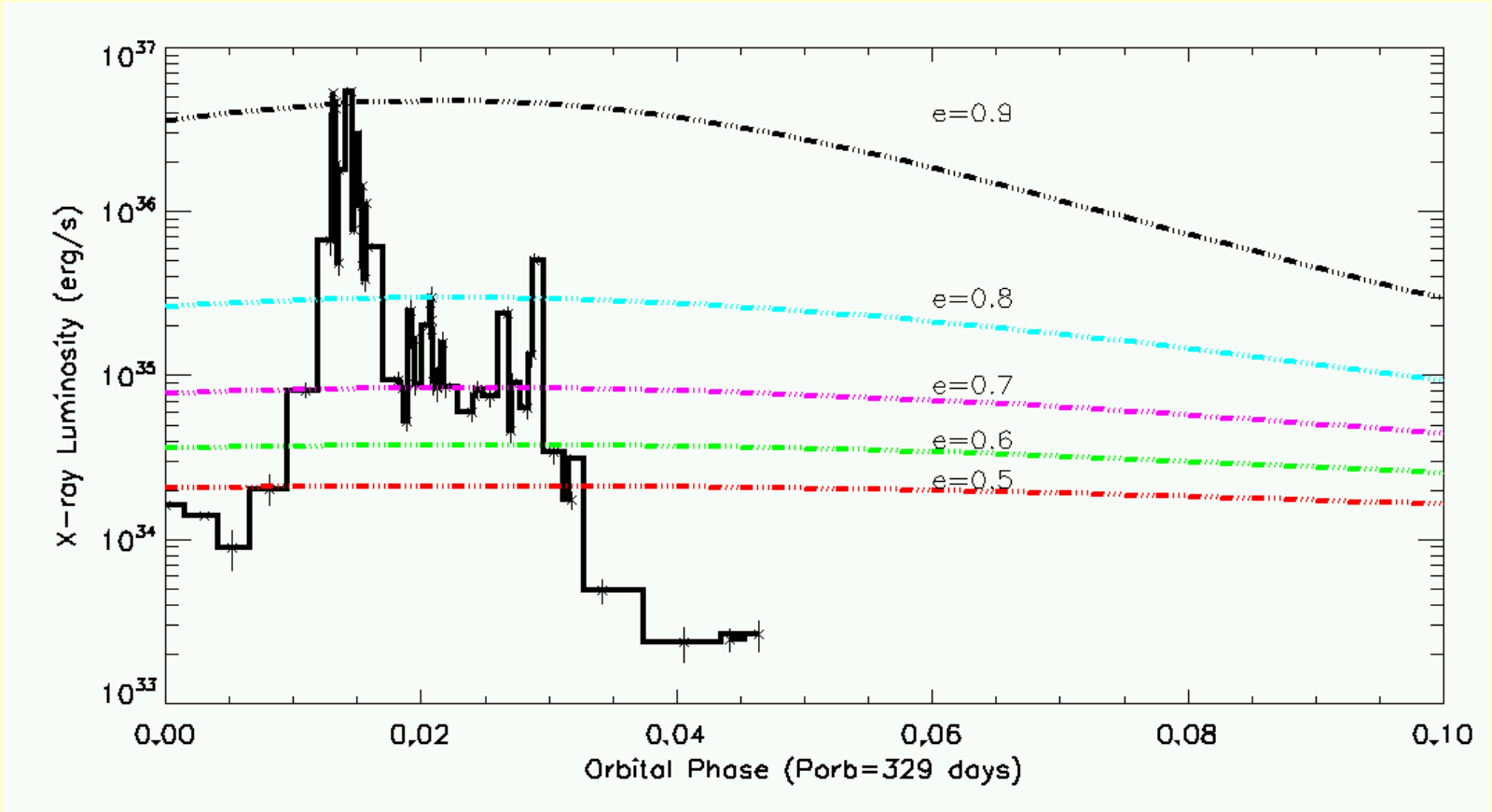


How to explain the outburst?

The recurrence time of **329 days** is the underlying clock of the phoenomenon, which can be interpreted in a natural way as the **orbital period** of the binary system

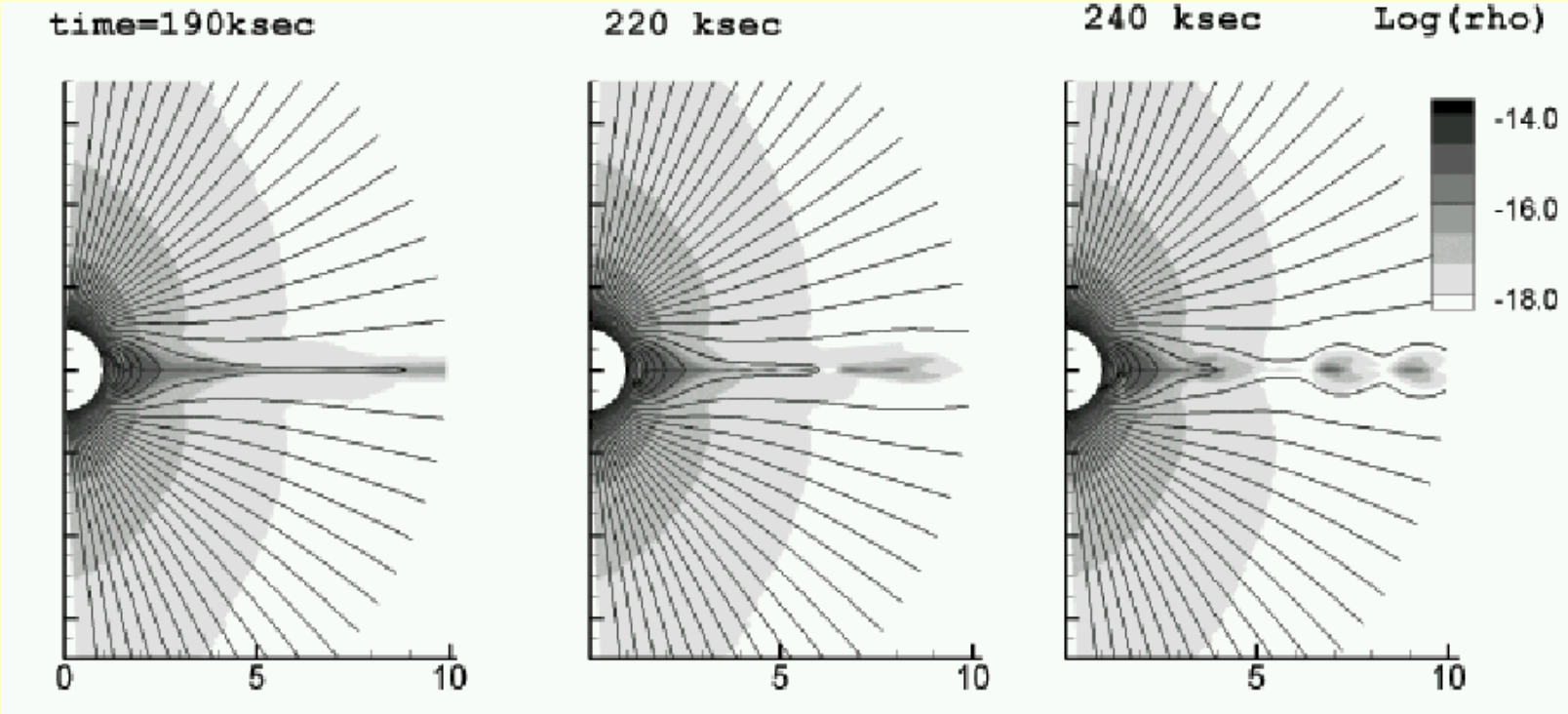


Model of accretion from a spherical homogeneous wind in an eccentric orbit around the HD star


X-ray Luminosity (erg/s)
10^{37}
10^{36}
10^{35}
10^{34}
10^{33}
e=0.9
e=0.8
e=0.7
e=0.6
e=0.5
0.00
0.02
0.04
0.06
0.08
0.10
Orbital Phase (Porb=329 days)

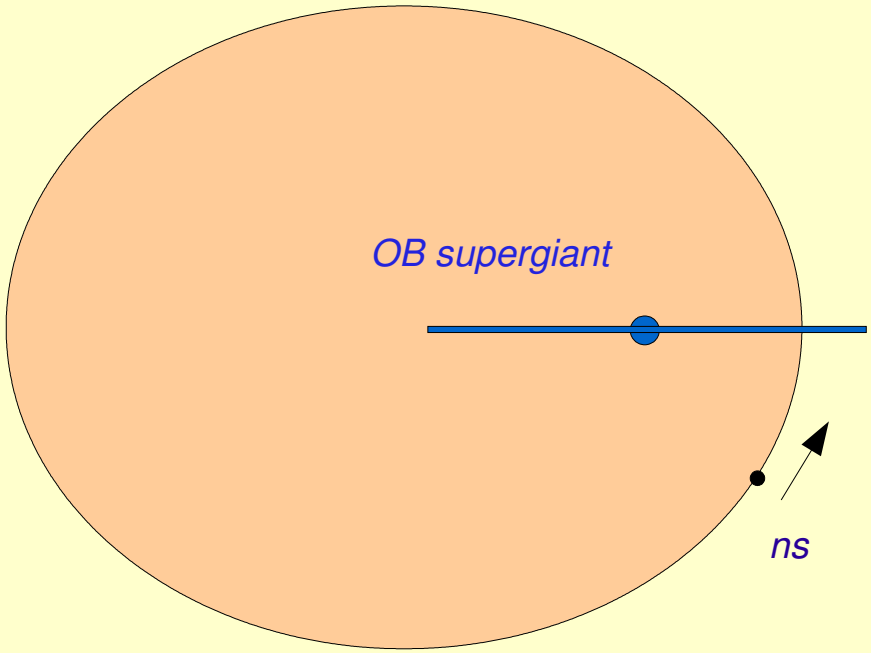
Simulation of the radiatively driven outflow from a rotating hot star with a dipole magnetic field

Log (wind density)



from Ud-Doula, Townsend & Owocki, 2006, ApJ, 640, L191

The proposed geometry to explain the short SFXT outbursts:

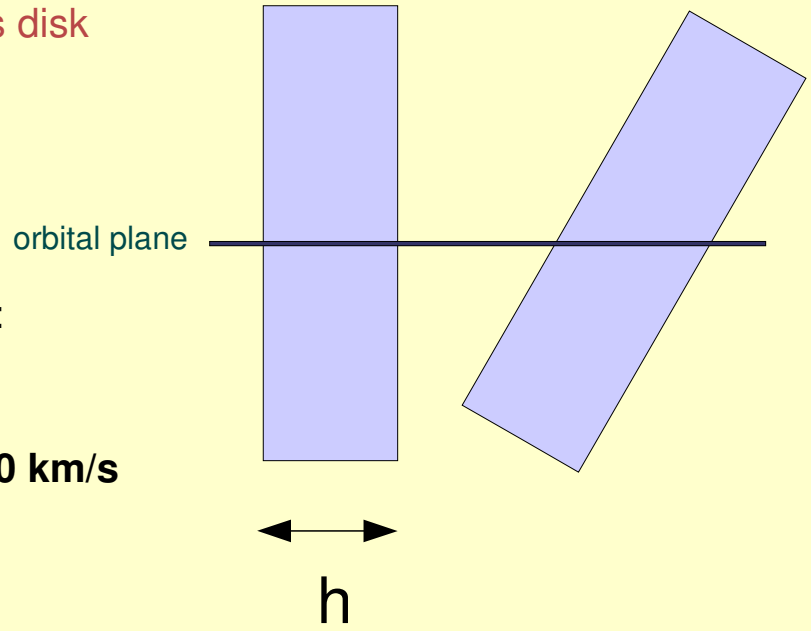


The thin equatorial disk of the B-supergiant
is inclined with respect to the orbital plane

The star has also a polar wind with higher velocity and lower mass loss rate (~0.01 * Mass loss rate in the disk)
thus, in order to explain the low X-ray emission level out of the outburst, we need anyway a not circular orbit

Sidoli et al., 2007, in preparation

The thickness “**h**” of the densest region of this disk



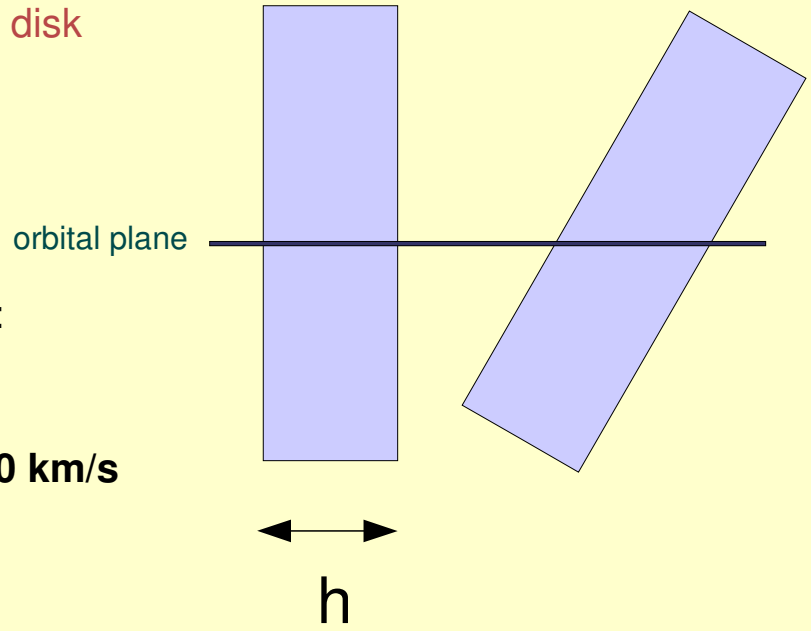
“h” can be estimated from the duration of the outburst:
the duration **t** of the brightest part of the outburst
is **t ~ 1 day,**
the ns velocity near periatron is roughly **vns ~ 100-200 km/s**

thus:

h ~ 8E11 – 1.7 E12 cm

(0.3-0.6 Ropt, if Ropt ~ 40 Rsun)

The thickness “**h**” of the densest region of the disk



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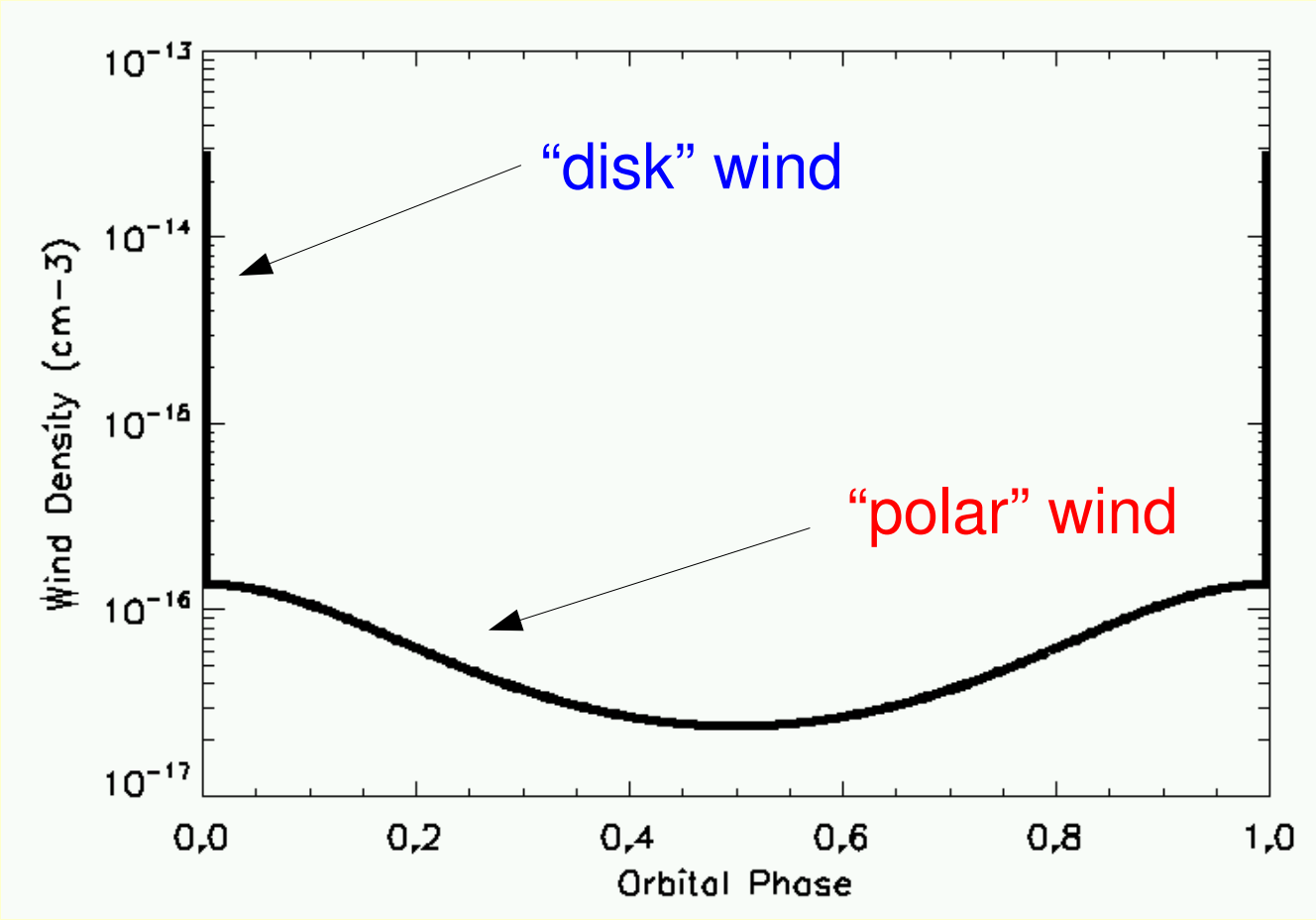
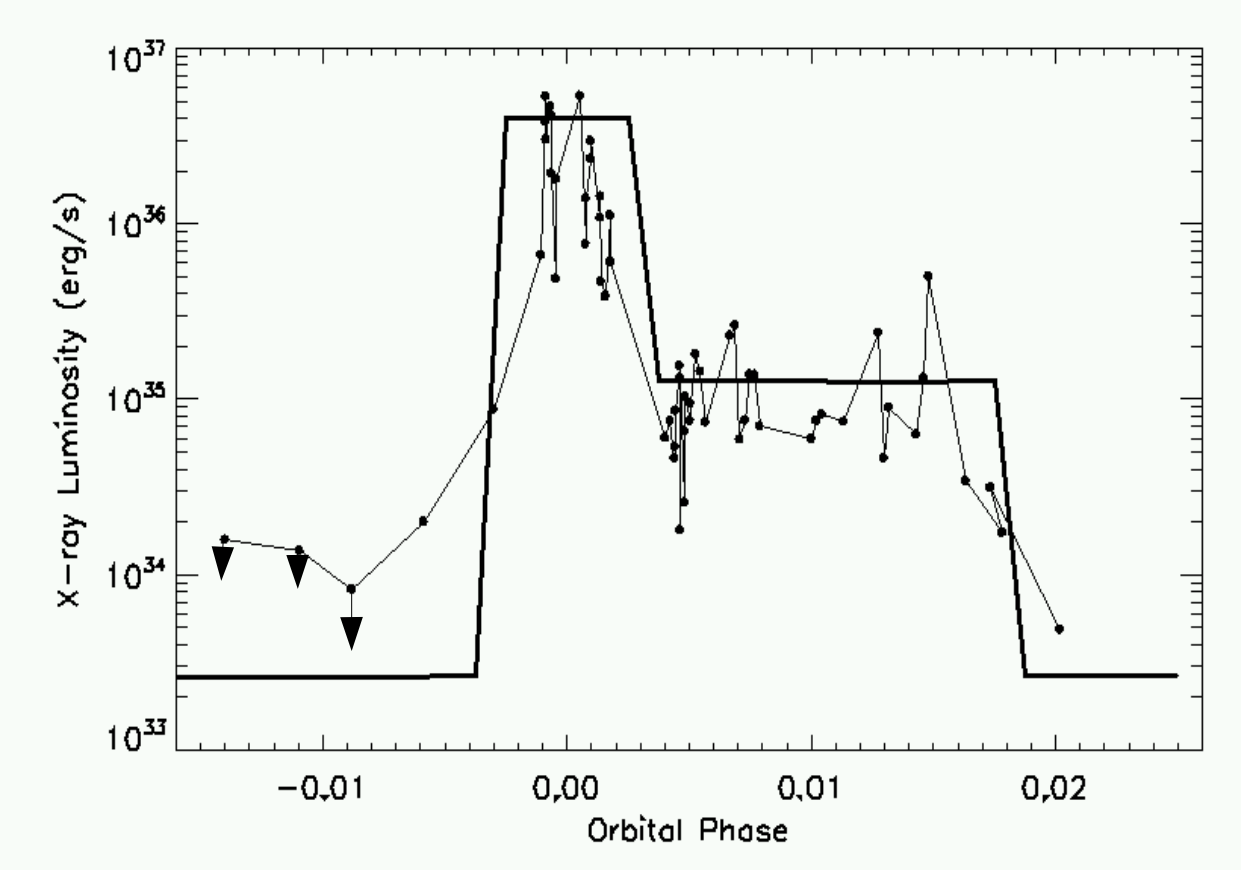
Nh galactic < 0.8 E 22 cm-2; Nh from X-ray spectra ~1-2 * 1E22 cm-2
Assuming about 1E22 cm-2 is local and mainly due to the supergiant disk,
a rough estimate of the **ρ density of the supergiant disk** is:

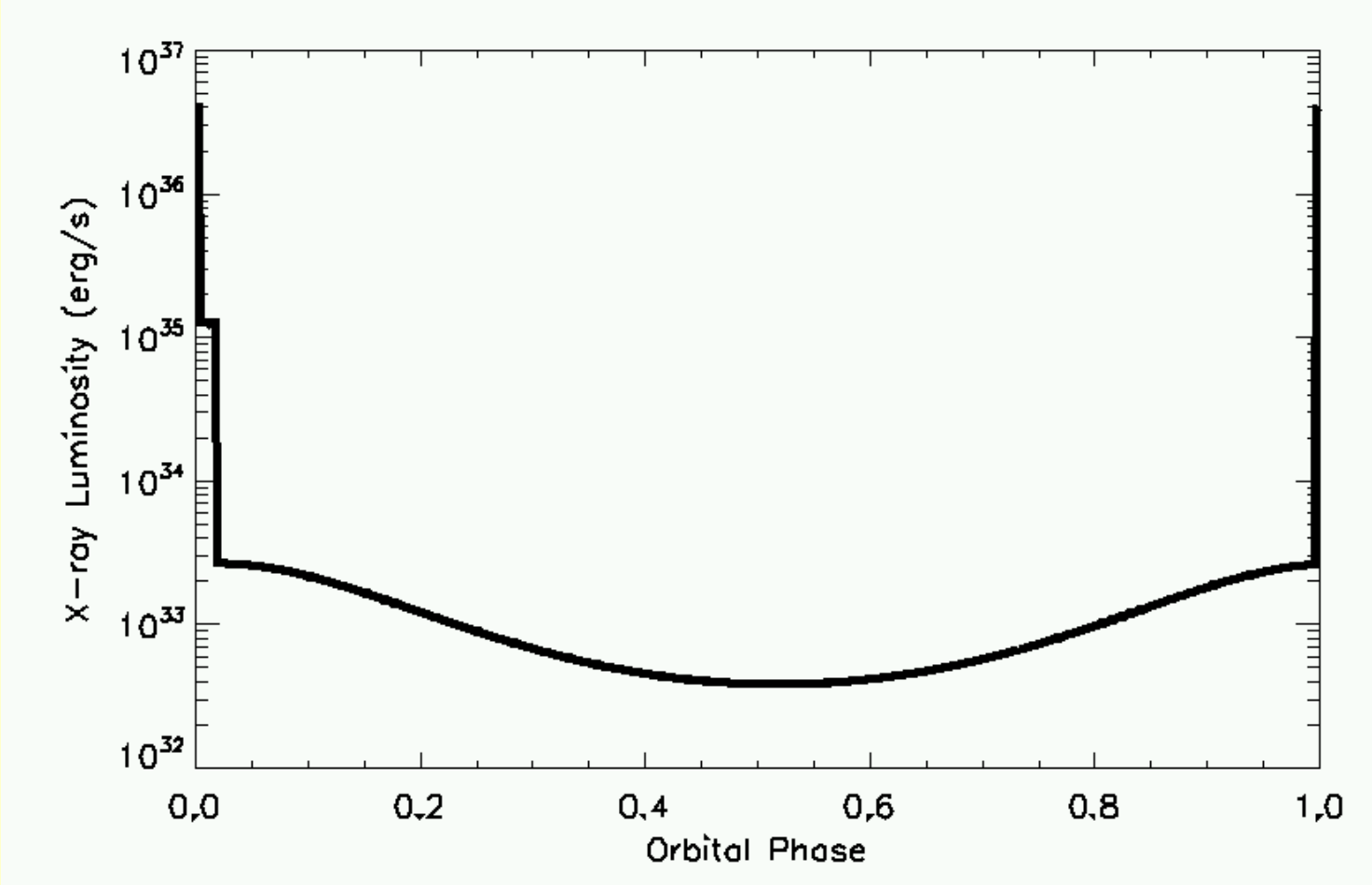
Nh*mH / h = ρ ~ 1E–14 cm–3

variable wind density along the orbit



Example of the model of wind accretion

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10^37
10^36
10^35
10^34
10^33
10^32
0.0
0.2
0.4
0.6
0.8
1.0
Orbital Phase

Conclusions

- INTEGRAL observations opened a **new view on High Mass X-ray Binaries**

- The new class of SFXTs has been discovered

- The SFXT **IGRJ11215-5952** is a **key system** to understand this new class of X-ray sources

- We proposed a **new hypothesis** to explain the properties of the SFXTs, where the supergiant has an **equatorial component of the wind**, besides the “standard” “polar” high velocity wind. The enhanced accretion rate when the neutron star cross this disk produce the short duration X-ray outburst

Grazie !!!