X-ray Binaries

Lara **Sidoli**

&

Ada ***Paizis***

Sandro ***Mereghetti***

Nicola ***La Palombara***

Andrea ***Tiengo***

Students:

Lorenzo Ducci (PhD student from Univ. Insubria-Como)

Renzo Capelli (undergraduate student from Univ. Milano-Bicocca)

INAF ISTITUTO NAZIONALE DI ASTROFISICA NATIONAL INSTITUTE FOR ASTROPHYSICS IASF

The *main* activities of the "XRBs group"

High Mass X-ray Binaries:

new INTEGRAL sources

Supergiant Fast X-ray Transients

Be/XRB

Low Mass X-ray Binaries:

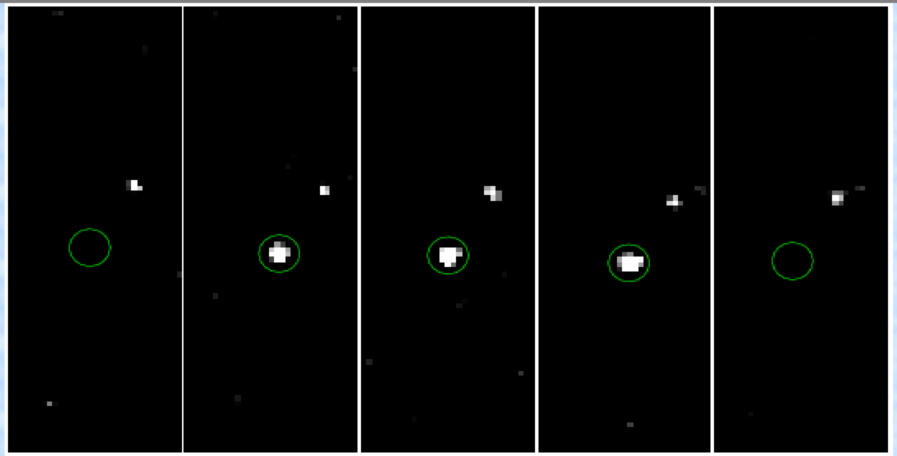
new INTEGRAL sources

hard tails in LMXBs

High Mass X-ray Binaries:

new INTEGRAL sources

Supergiant Fast X-ray Transients



Sguera et al. 2005, 2006

ISGRI (20-40 keV)

consecutive observations (~2ks each)

"SHORT" outbursts *lasting few hours*
(typically < 1 day)
as observed with IBIS/ISGRI

About 20 SFXTs to date

High Mass X-ray Binaries:
Supergiant Fast X-ray Transients

By definition, a **SFXT** is a source with:

Transient *& "SHORT"* X-ray OUTBURSTS (biased def)

&

OB supergiant companions

Other properties:

Luminosity:

Lx outburst ~ 1E36 erg/s

Lx quiescence ~ 1E32 erg/s

-> high dynamic range ~ 1000-10000

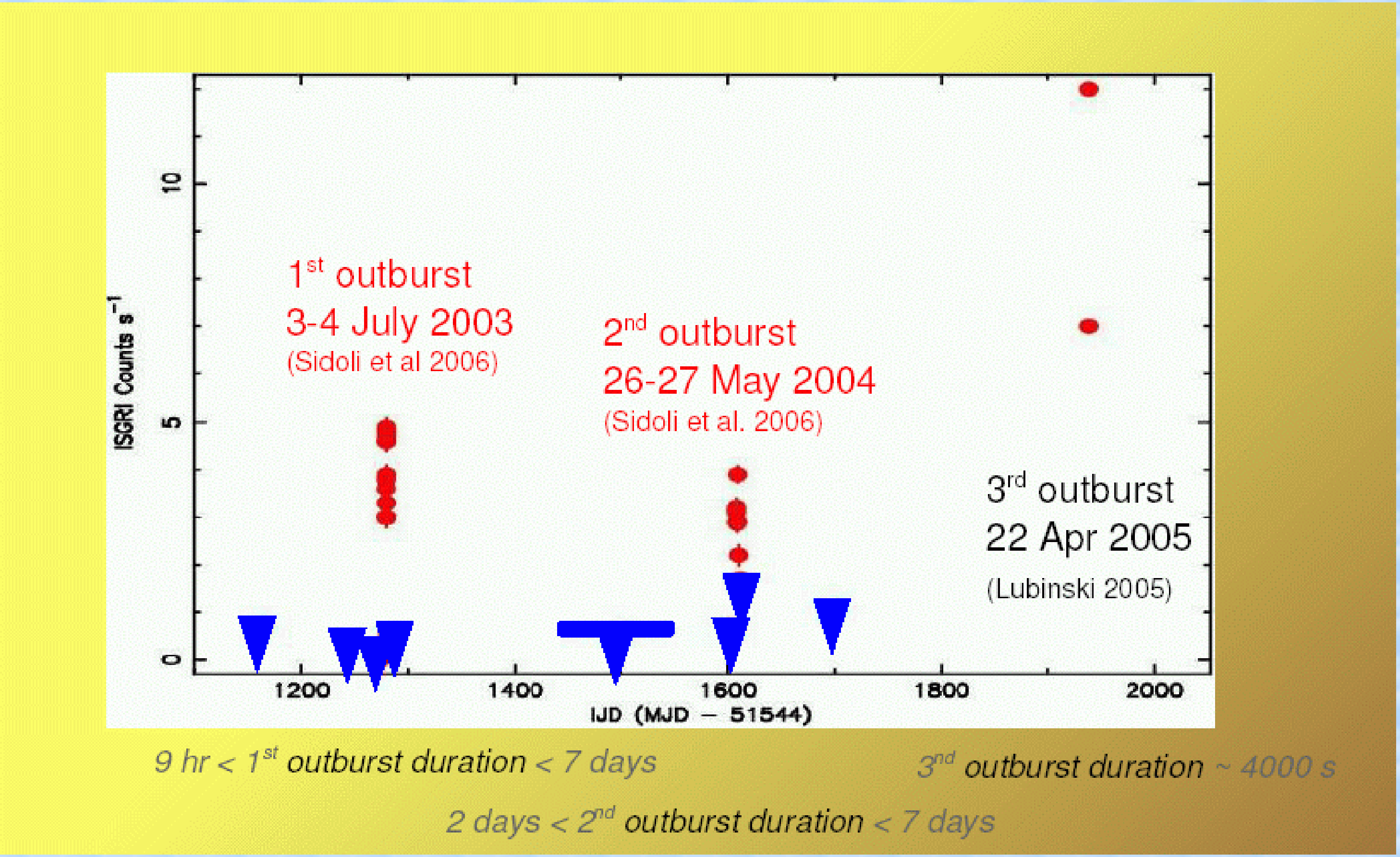
Spectrum similar to typical accreting pulsars

0.1-10 keV – hard powerlaw

cut-off around 10-30 keV

A key system to understand SFXTs: **IGR J11215-5952**

discovery of a **periodicity** in the outburst recurrence with INTEGRAL data (Sidoli et al. 2006)

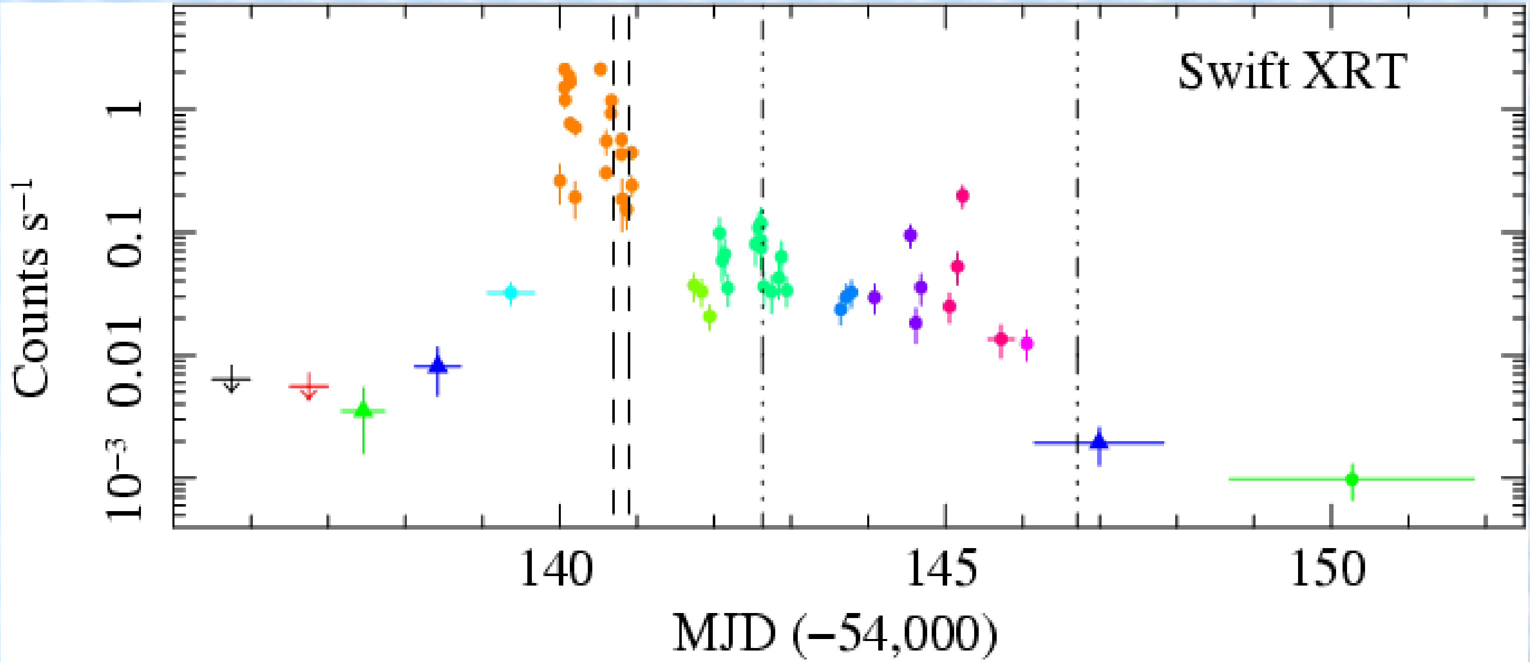


outbursts every ~ 330 days

likely orbital period?

outbursts near periastron passage?

***The predictable outbursts led us to propose a monitoring campaign with* Swift / XRT**
of ***IGR J11215-5952 during the February 2007 outburst***

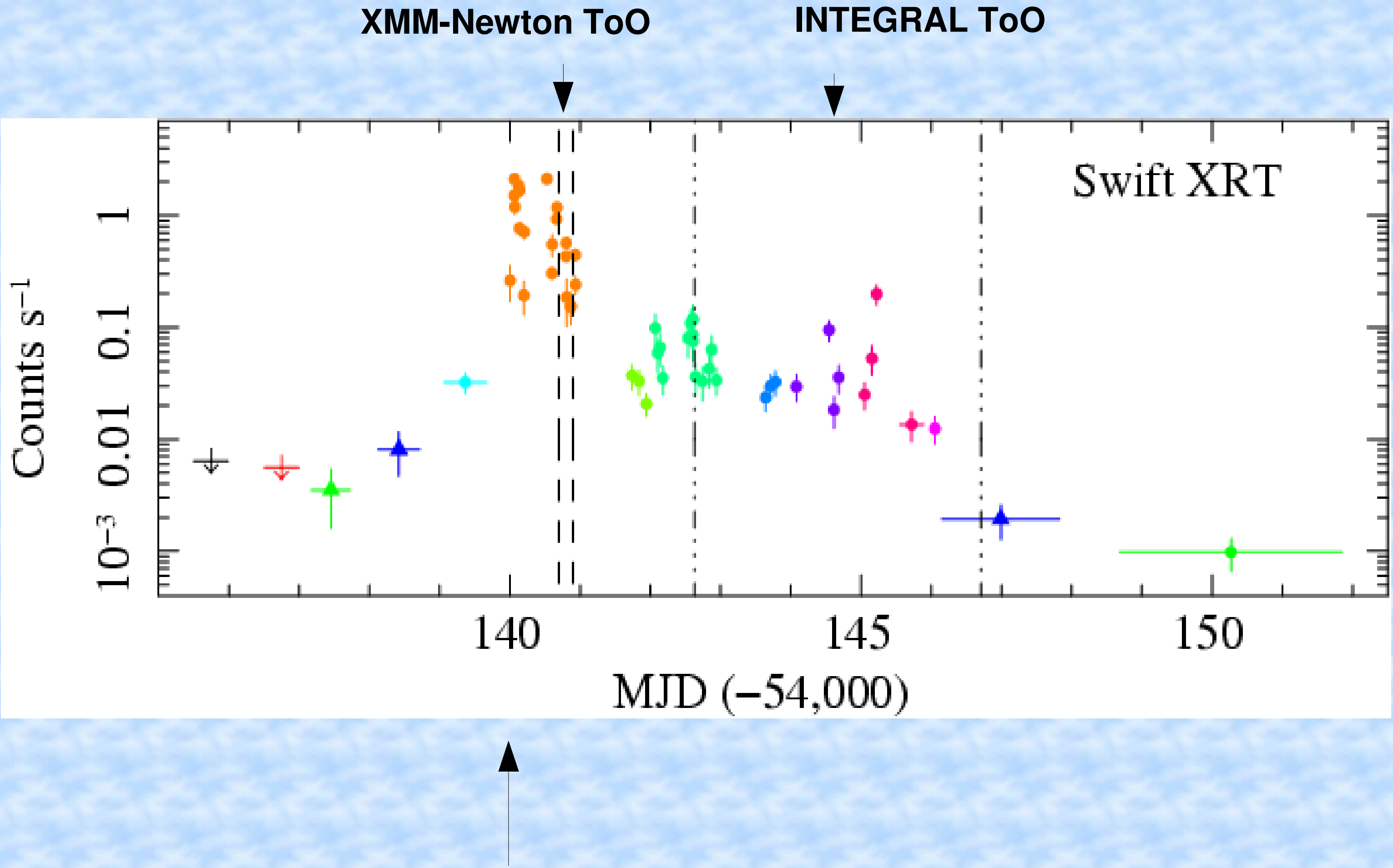


The accretion phase lasts longer than what previously known!!!

(Romano, **Sidoli**, Mangano et al. 2007)

9th February 2007

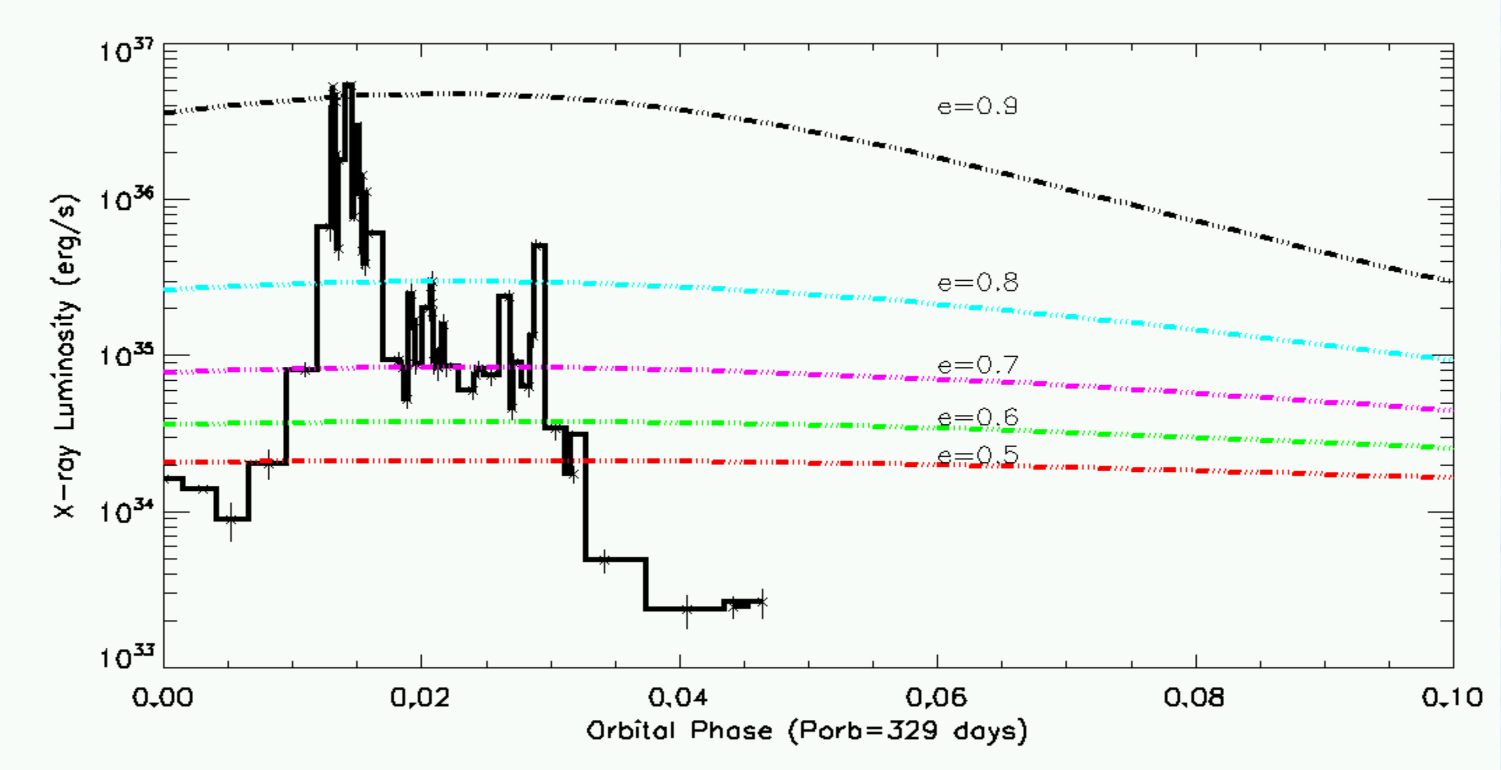
Swift / XRT observations of IGR J11215-5952 allowed us to trigger our XMM-Newton and INTEGRAL observations (PI: Sidoli)



9th February 2007

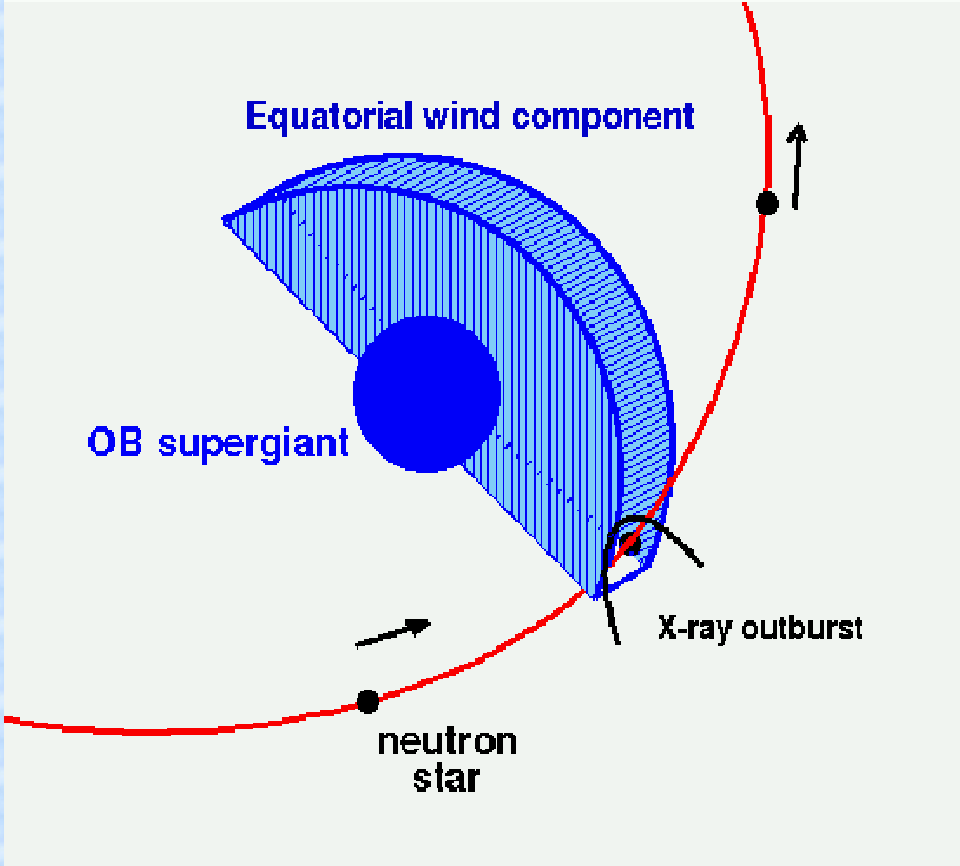
An important result of the Swift/XRT monitoring

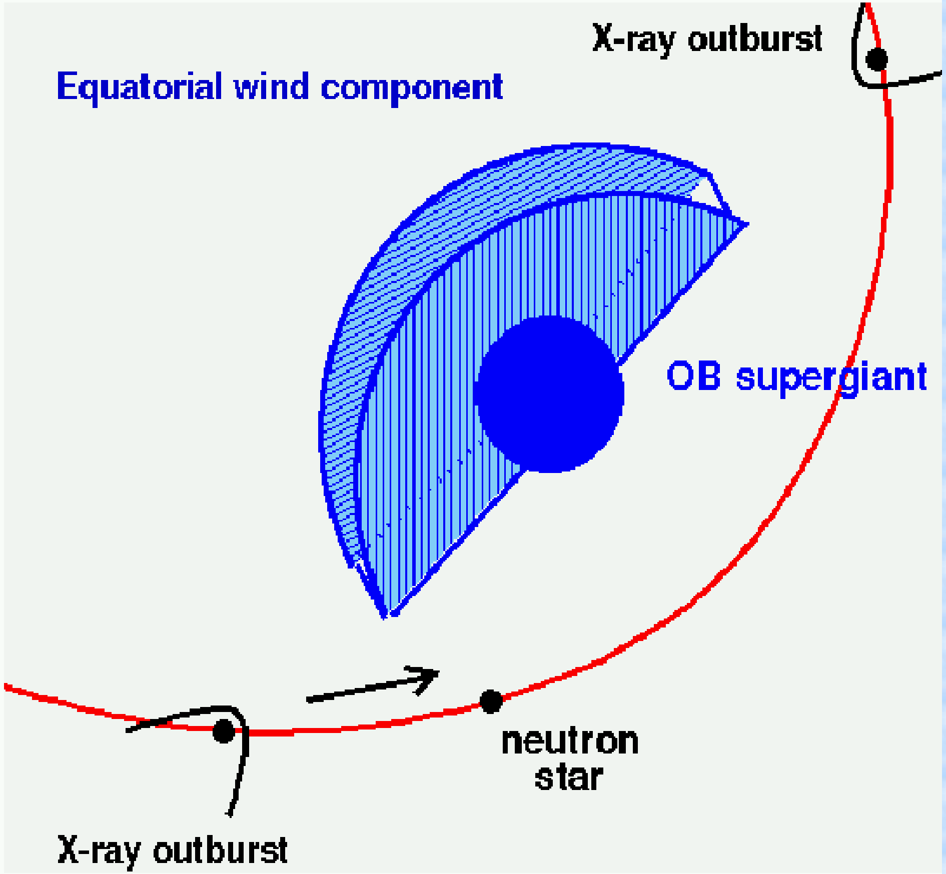
The lightcurve is **too narrow and steep** to be explained within a model of Bondi accretion from a spherical and homogeneous wind in an eccentric binary (even with extreme eccentricities!)



Sidoli et al. 2007, A&A in press

We proposed a *new model* to explain the **SFXTs** outbursts



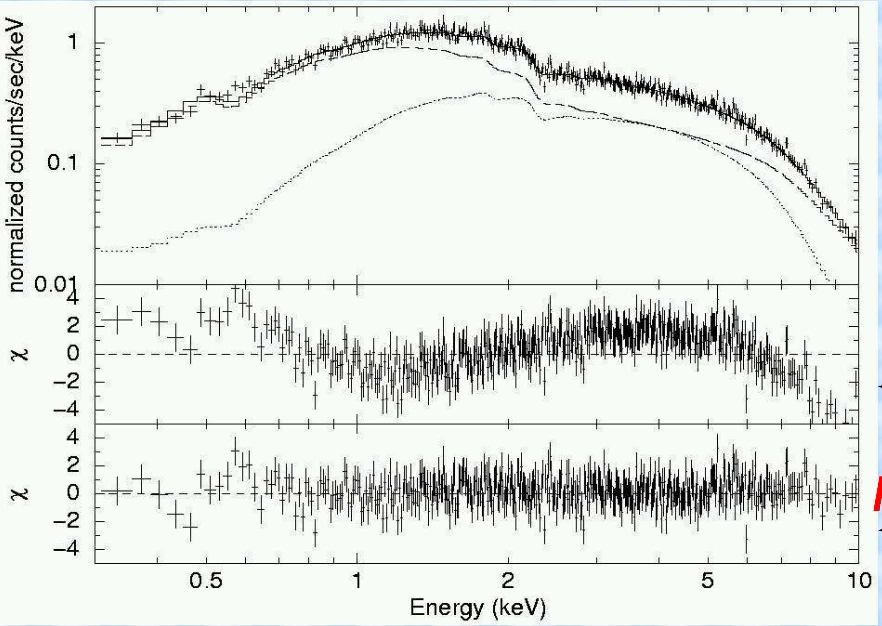


Sidoli et al., 2007, A&A in press
Sidoli et al., 2007, proceedings of the conf. “A Population Explosion” held in St. Pete, Florida, Oct 2007

High Mass X-ray Binaries: *Be/XRB*

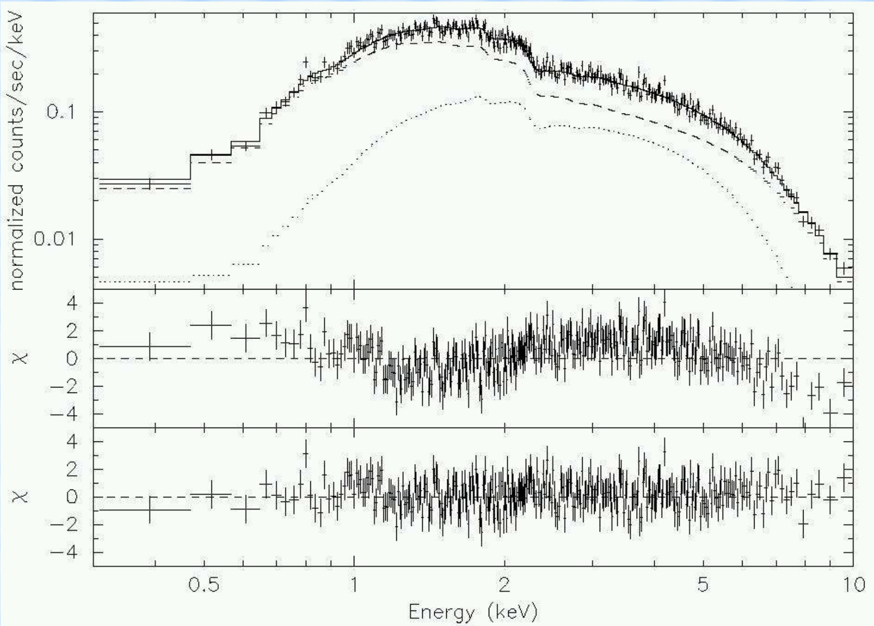
Persistent BeXRBs of low luminosity (L_X ~ 10^{34-35} erg s^{-1}) and long pulse period (P ~ 1000 s)

XMM observation of 4U 0352+309 and RX J0146.9+6121



PL

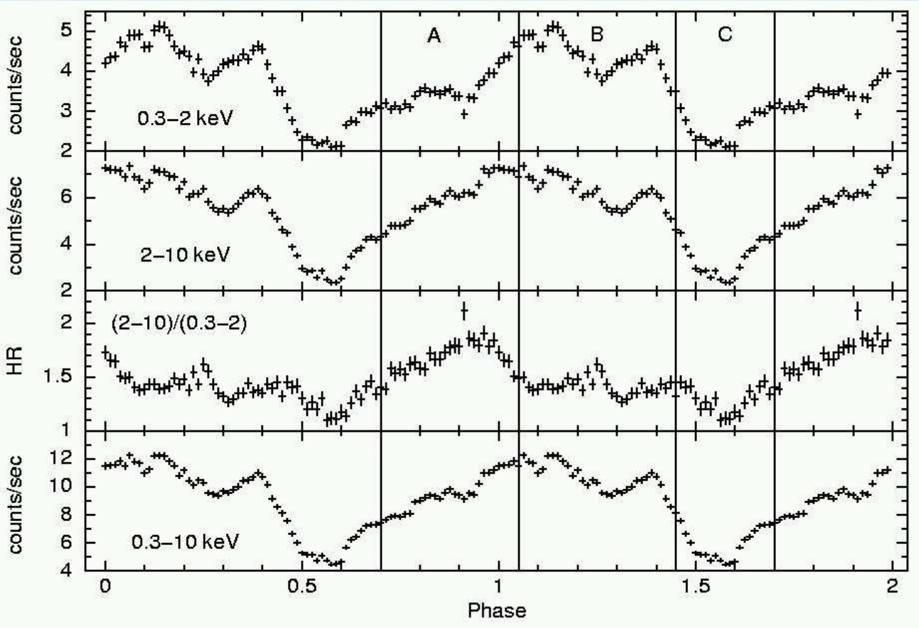
PL+BB

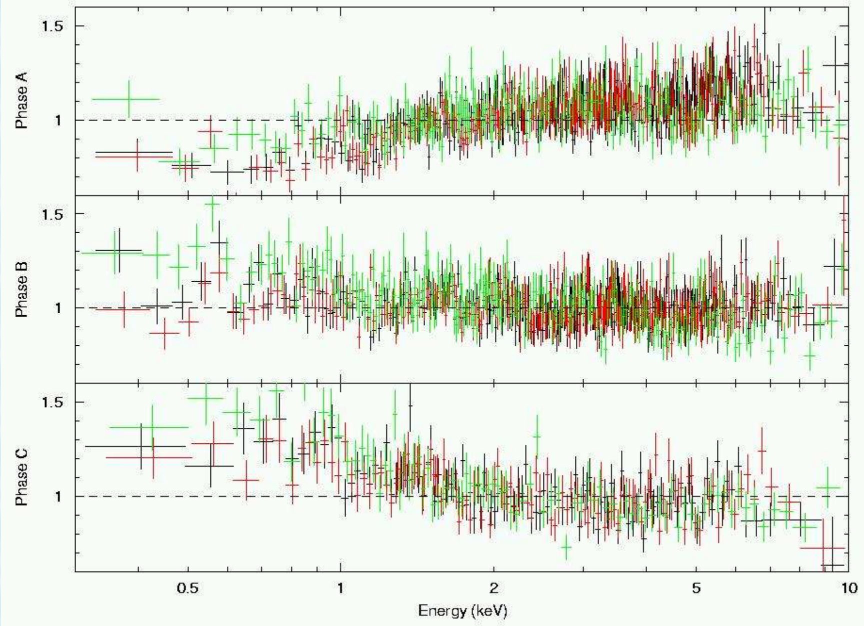


- data excess over the main PL component of BB type (~ 30 % of the total flux)
- high BB temperature (kT > 1 keV)
- small emission area (R < 0.5 km)
- no evidence of an Iron line between 6 and 7 keV (EQW < 0.1 keV)

La Palombara & Mereghetti 2006, 2007

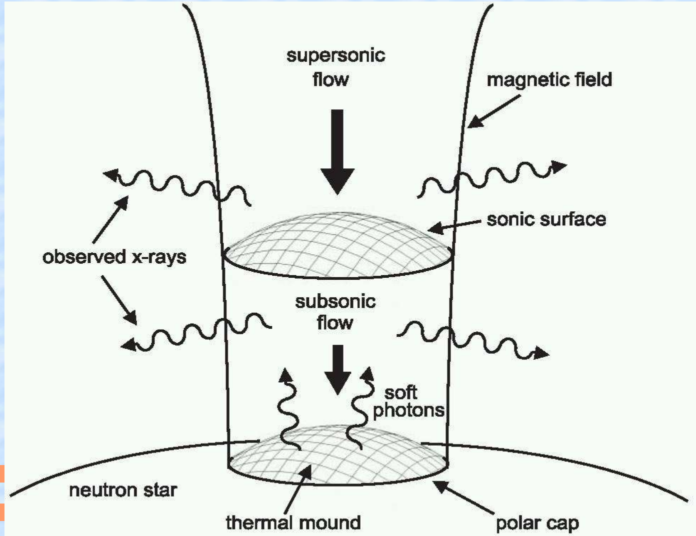
XMM observation of 4U 0352+309 and RX J0146.9+6121





- the pulse profile is energy dependent and not simply sinusoidal
- pulsed emission also below 2 keV
- spectral variability with the pulse phase

thermal emission from the neutron star polar caps?



XMM observation of 4U 0352+309 and RX J0146.9+6121

X-ray source	4U 0352+309	RX J0146.9+6121
Luminosity (2-10 keV)	~ 10^{35} erg s^{-1}	~ 10^{34} erg s^{-1}
Accretion rate	~ 5 x 10^{14} g s^{-1}	~ 5 x 10^{13} g s^{-1}
Magnetospheric radius	~ 9.5 x 10^{8} cm	~ 1.8 x 10^{9} cm
Accretion column radius	~ 330 m	~ 230 m
Black-body radius	~ 360 m	~ 150 m

↓

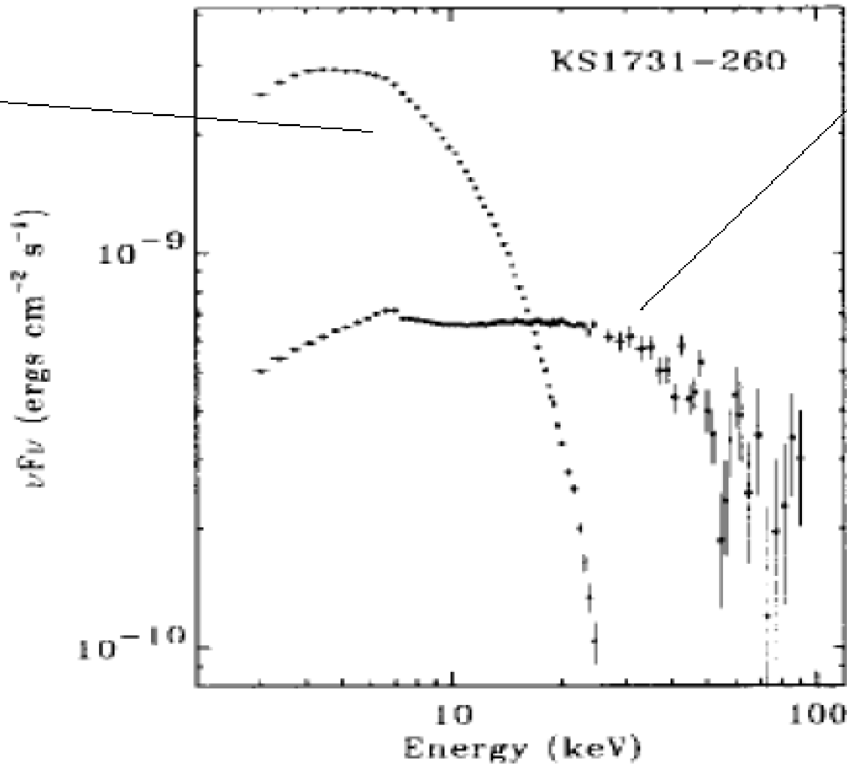
the BB size is in agreement with the polar-cap origin of the thermal excess

La Palombara & Mereghetti 2006, 2007

Low Mass X-ray Binaries: *hard tails in LMXBs*

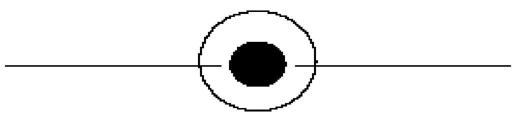
NS LMXBs: spectral states dominated by IC by different plasma temperatures

High/soft state:
disc: ~1 keV
NS: ~2 keV
plasma: kT~3keV
tau~5-15

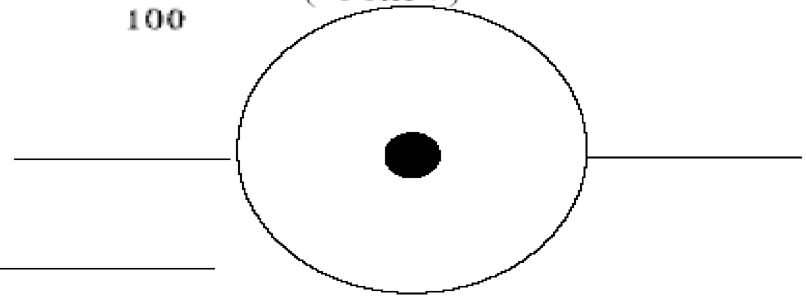


Low/hard state:
plasma: kT~30keV
tau~2-3

Efficient cooling (~3keV)

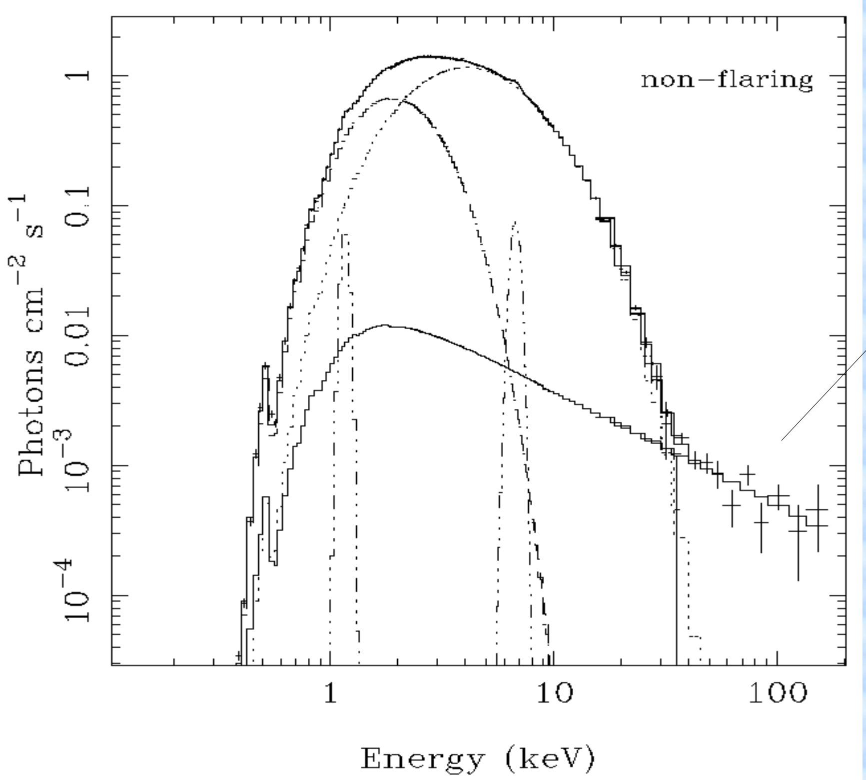


Non-efficient cooling (~30keV)



Mdot

Low Mass X-ray Binaries: *hard tails in LMXBs*



Hard Tails *Mostly* fit with power-laws

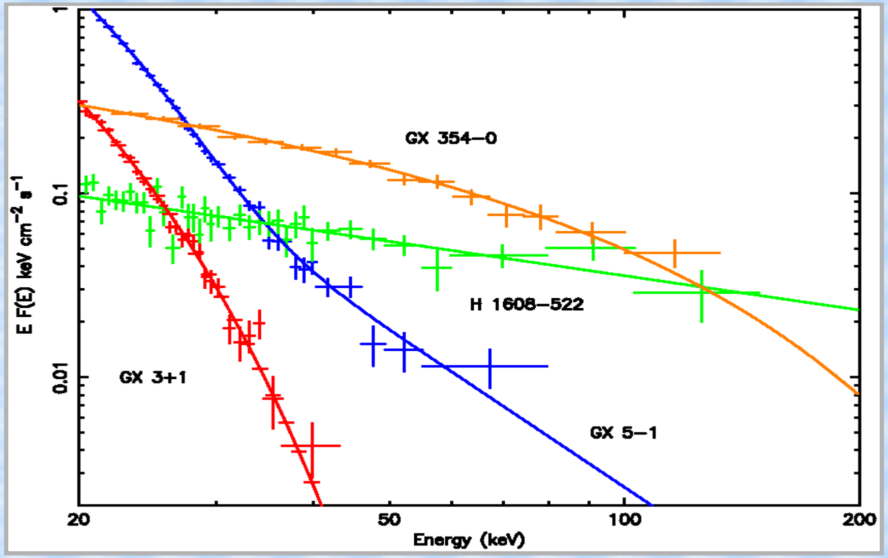
Current physical interpretations:

- Hybrid corona (Coppi 1999) - local injection of non-thermal electrons *ad hoc*;
- Emission from the jet (Markoff et al., 2005)
- Bulk motion Comptonization – bulk expected in the vicinity of compact object caused by the intense gravitational potential. It produces an extended PL (Titarchuk et al., 1996, 1997)

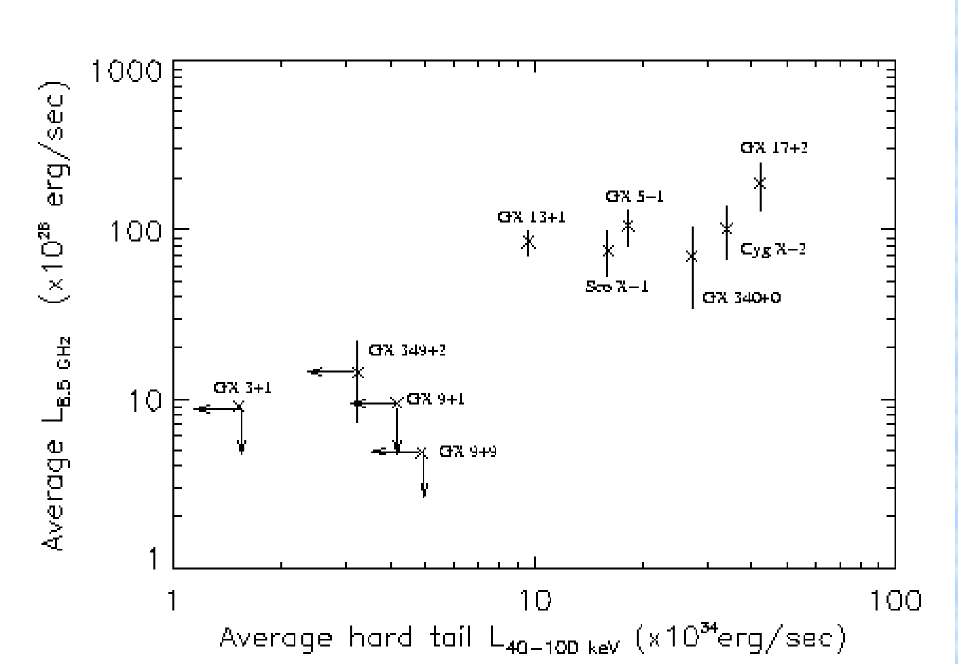
No physical scenario has been proposed up to now in order to explain in a coherent way all the spectral states that are observed (i.e. the spectral evolution)

Paizis et al., (2006, P06) proposed for the first time a unified physical scenario to both explain the hard tail and the evolution between the spectral states

P06 identified four different spectral states that they studied with the Bulk Motion Comptonisation model (BMC, Titarchuk et al., 1996, 1997)

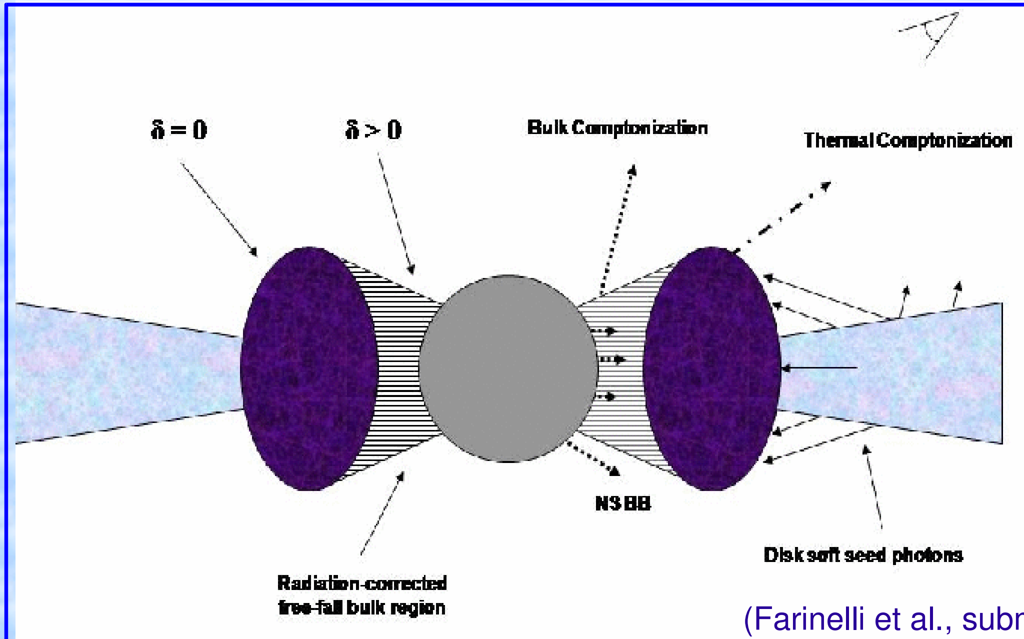


A clear correlation between our average hard X-ray tail and Radio emission is found

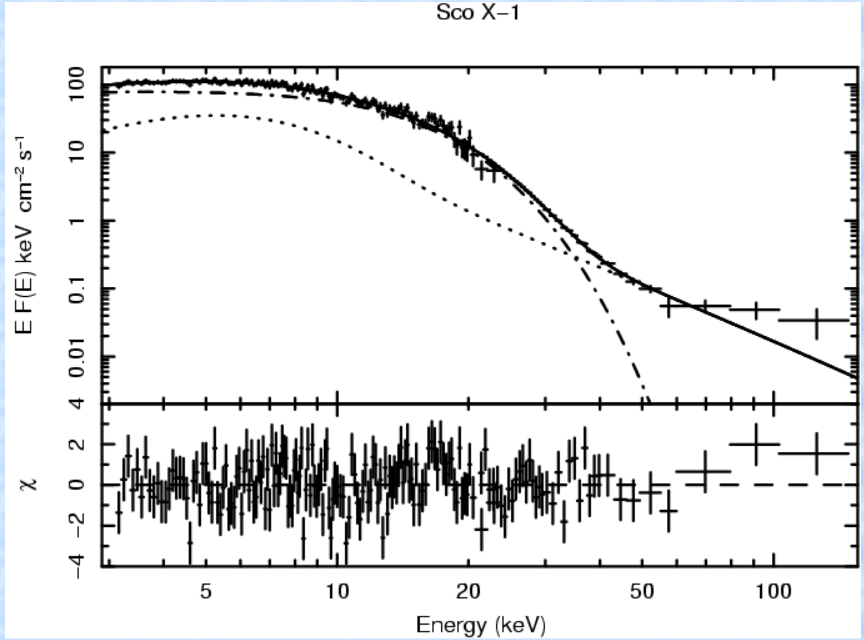


- *The BMC model can explain the* ***spectral evolution*** *<u>and</u> the* ***Radio – X-ray tail correlation****;*
- *In this scenario, <u>bulk motion is at the origin of the hard X-ray tails;</u>*
- *The <u>final spectral state</u> is the result of <u>interplay</u> of thermal and bulk Comptonization and it is <u>driven by the accretion rate</u>;*

*Given the success of the model to describe the hard X-ray data of NS LMXBs, we developed **a new model** (XSPEC format) to optimize and complete the existing BMC model: CompFT (Farinelli, Titarchuk, Paizis & Frontera submitted)*



(Farinelli et al., submitted)



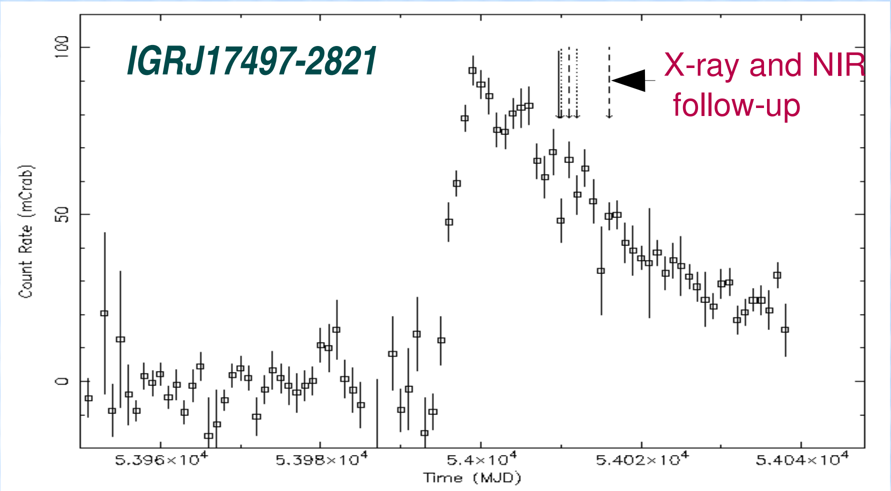
- CompFT includes simple thermal as well as thermal plus bulk Comptonization;
- *SAX*, *RXTE* and *INTEGRAL* spectra of NS LMXBs can be fitted with *two* CompFT
    1) thermal component from outer corona (seed photons mainly from disc)
    2) thermal+bulk component from inner region (seed photons mainly from NS)

→ On-going work: QPO vs spectral evolution (simultaneous *RXTE-INTEGRAL*, PI Paizis); theoretical support to the model

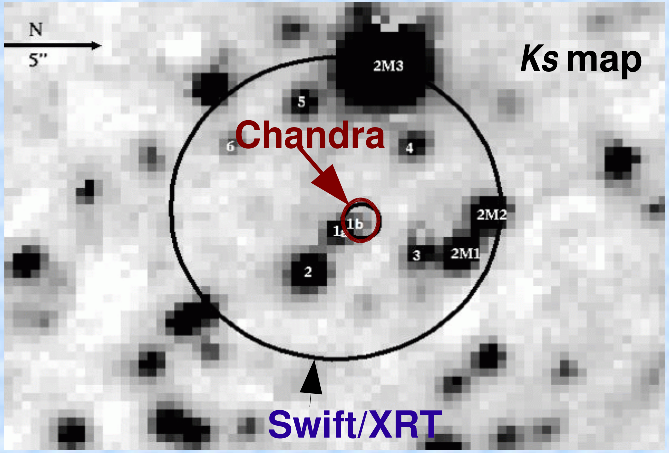
Multi-λ follow-up observations of new INTEGRAL sources

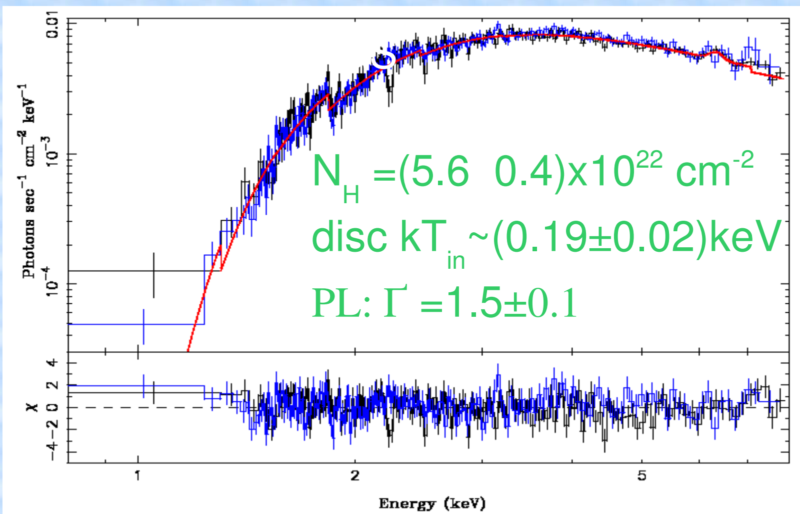
(**<u>Paizis et al., 2007</u>**, Paizis et al., 2005, Rodriguez et al., 2007, Beckmann et al., 2005)

Sept. 19, 2006: INTEGRAL discovers a new source in the Galactic Centre (Soldi et al., 2006).
Paizis et al. 07 performed X-ray (*Chandra*/HETGS) and NIR (*NTT*/SofI) follow-up observations.



The 0".6 arcsec (90%) Chandra error box (versus 5".3 *Swift*/XRT) allowed us to find a possible NIR counterpart (m_{Ks} ~16)





*The **synergy of NIR and X-ray properties** seem to suggest that **IGRJ17497-2821** is a LMXB with red giant K-type companion, most likely hosting a black hole.*

Chandra AO 9 still active (PI: Paizis)

Future perspectives of our group in the study of XRBs

We are *PIs* of several approved on-going observing programs:

Programs to monitor Galactic sources AND test/optimize our new physical models on SFXTs and LMXBs:

INTEGRAL: L.Sidoli & A.Paizis are PIs
of **3** on-going **Key Programs** on XRB
-> this implies ~ **1 Ms/source** of observing time
(for **12 sources**!)

Swift: L.Sidoli is PI of several **on-going monitoring programs**
to observe 4 SFXTs and 1 very faint X-ray transient
-> this implies ~ **1-2ks/week/source during 2008**

Observations to study the Be/XRBs thermal component and the nature of the pulsating RXJ0648.0-4418:

XMM-Newton: N.LaPalombara & A.Tiengo are PIs
of **3** accepted **AO7** proposal -> for a total obs time = **210 ks**

Identification of new INTEGRAL sources:

Chandra: A.Paizis is PI of a ToO (AO9) on 2 IGR sources
-> 40 ks in total

A few words about the non-permanent staff

- A significant part of the scientific output of our institute (not only of the XRBs group) comes from NON-PERMANENT staff

- Non permanent staff in IASF Milano (updated to 2008/01/01):
  14 scientists (excluding PhD students!) who have on average
  7.5 years of experience in the research field (including 3 years of PhD)
  and PhD students

- A clear long-term human resource plan is lacking (both in our institute and in INAF in general)