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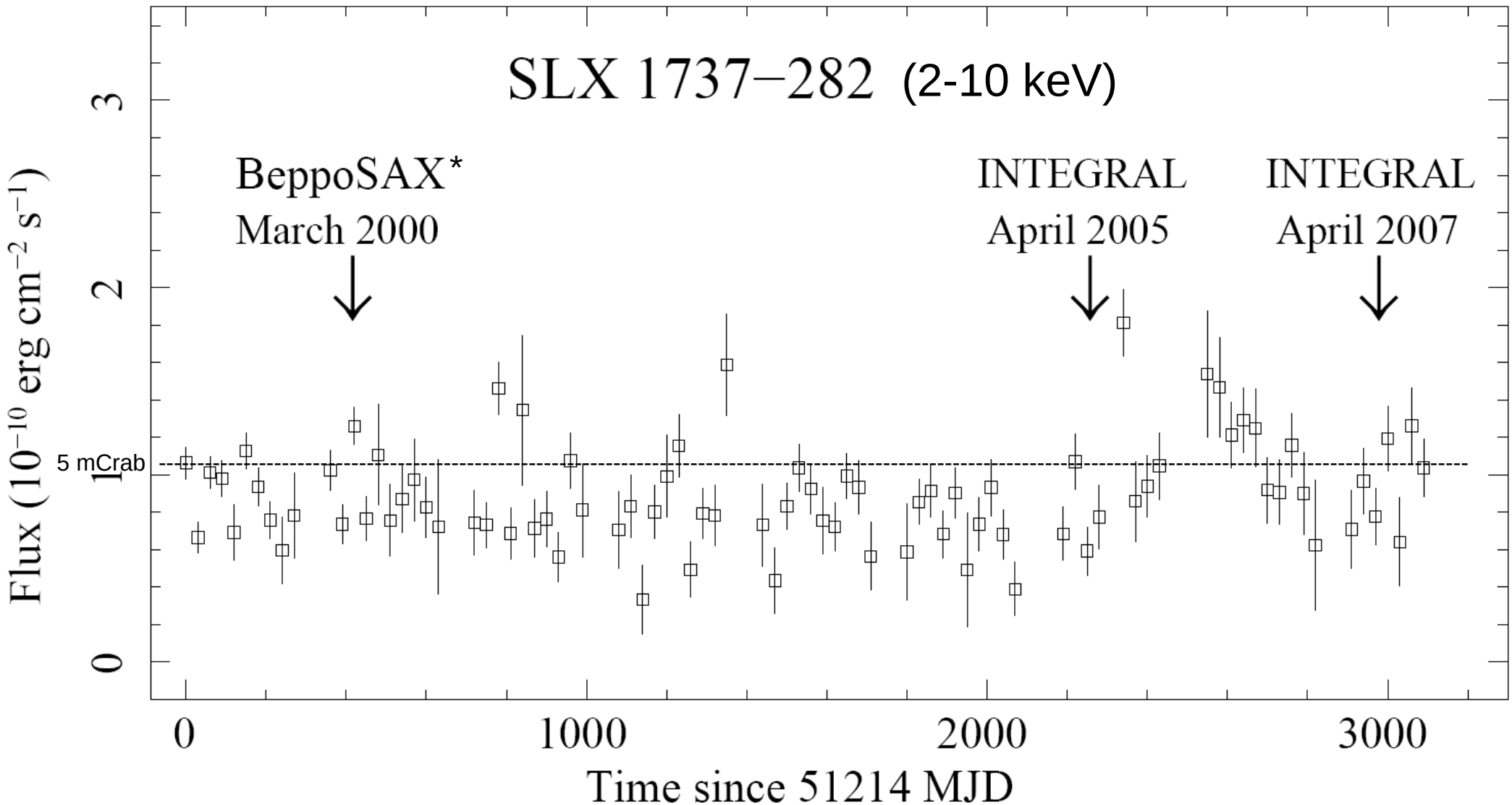
ABSTRACT

Aims. SLX 1737-282 is a low persistent X-ray burster source classified as an ultra-compact binary candidate. We compare the data on SLX 1737-282 with the other similar objects and attempt to derive constraints on the physical processes responsible for the formation of intermediate long bursts.
Methods. Up to now only three intermediate long bursts, all with duration between $\sim 15-30$ minutes, have been recorded for SLX 1737-282. The properties of two intermediate long X-ray bursts observed by *INTEGRAL* from SLX 1737-282 are investigated. The broad-band spectrum of the persistent emission in the 3–100 keV energy band is studied using the *INTEGRAL* data.
Results. The persistent emission is measured to be $< 1\%$ Eddington luminosity. From the photospheric radius expansion observed during the bursts we derive the source distance at 7.3 kpc. The observed intermediate long burst properties from SLX 1737-282 are consistent with helium ignition at the column depth of 7-8 $\times 10^{-9}$ g cm^{-2} and a burst energy release of 10^{41} erg. The apparent recurrence time of $\simeq 80$ days between the intermediate long bursts from SLX 1737-282 suggests a regime of unstable burning of a thick pure helium layer slowly accreted from a helium donor star.

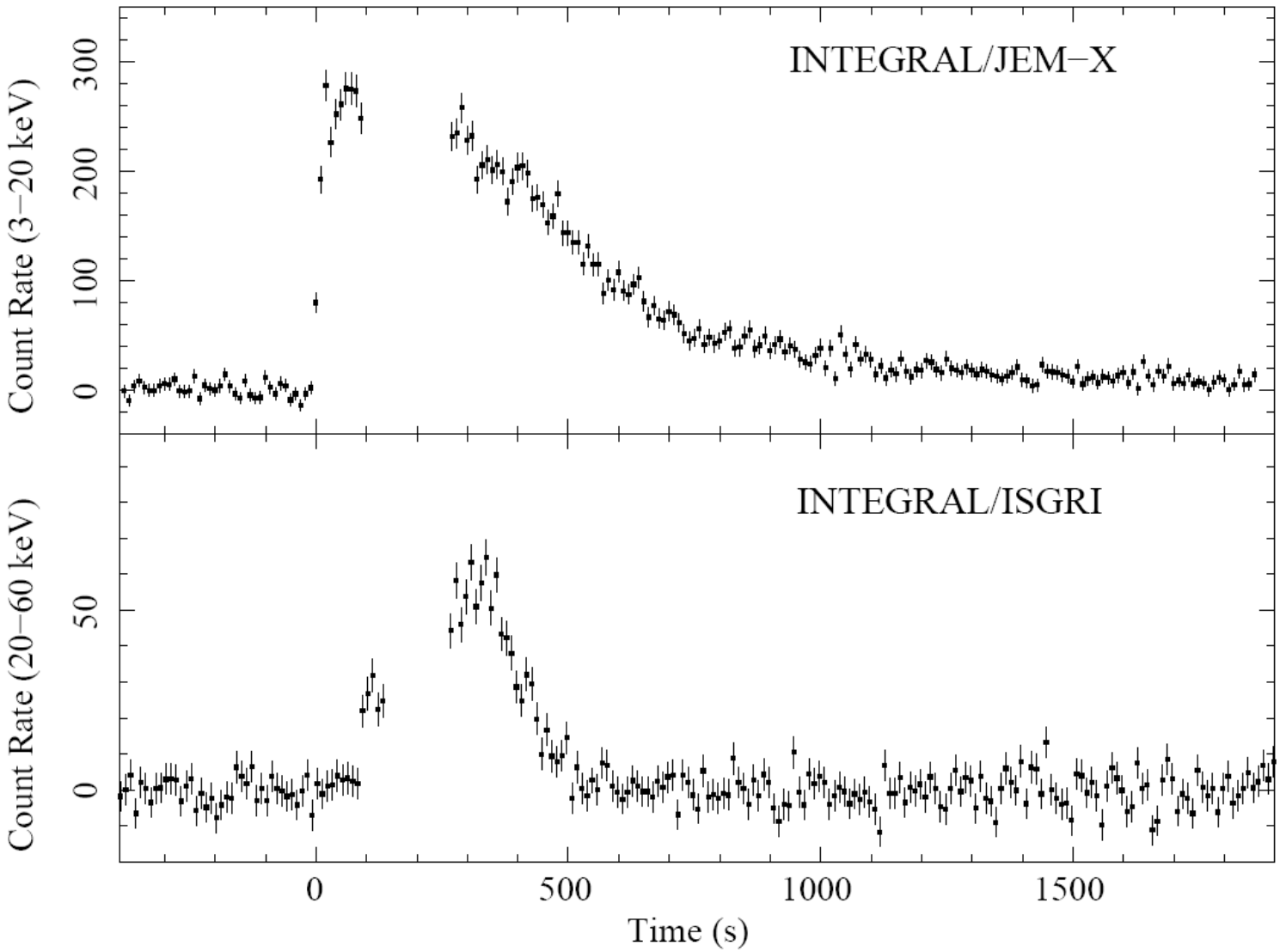
Key words. binaries: close – stars: individual: SLX 1737-282 – stars: neutron – X-rays: bursts

A weak persistent, long bursting only source

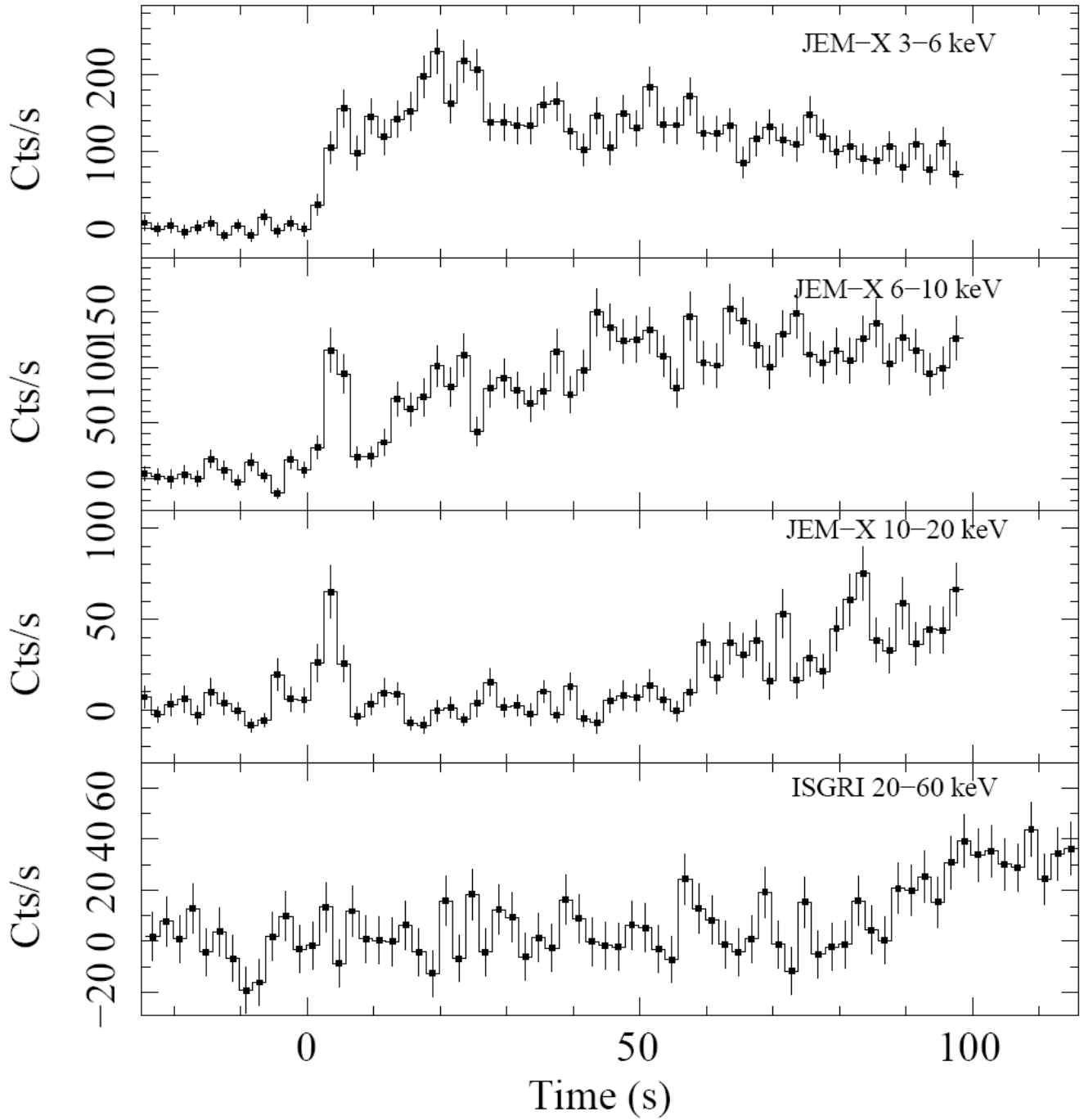


*(in ‘t Zand et al, 2002)

Burst 1: 11th April 2005 (10s bins)



Burst 1 evidence
for a soft precursor

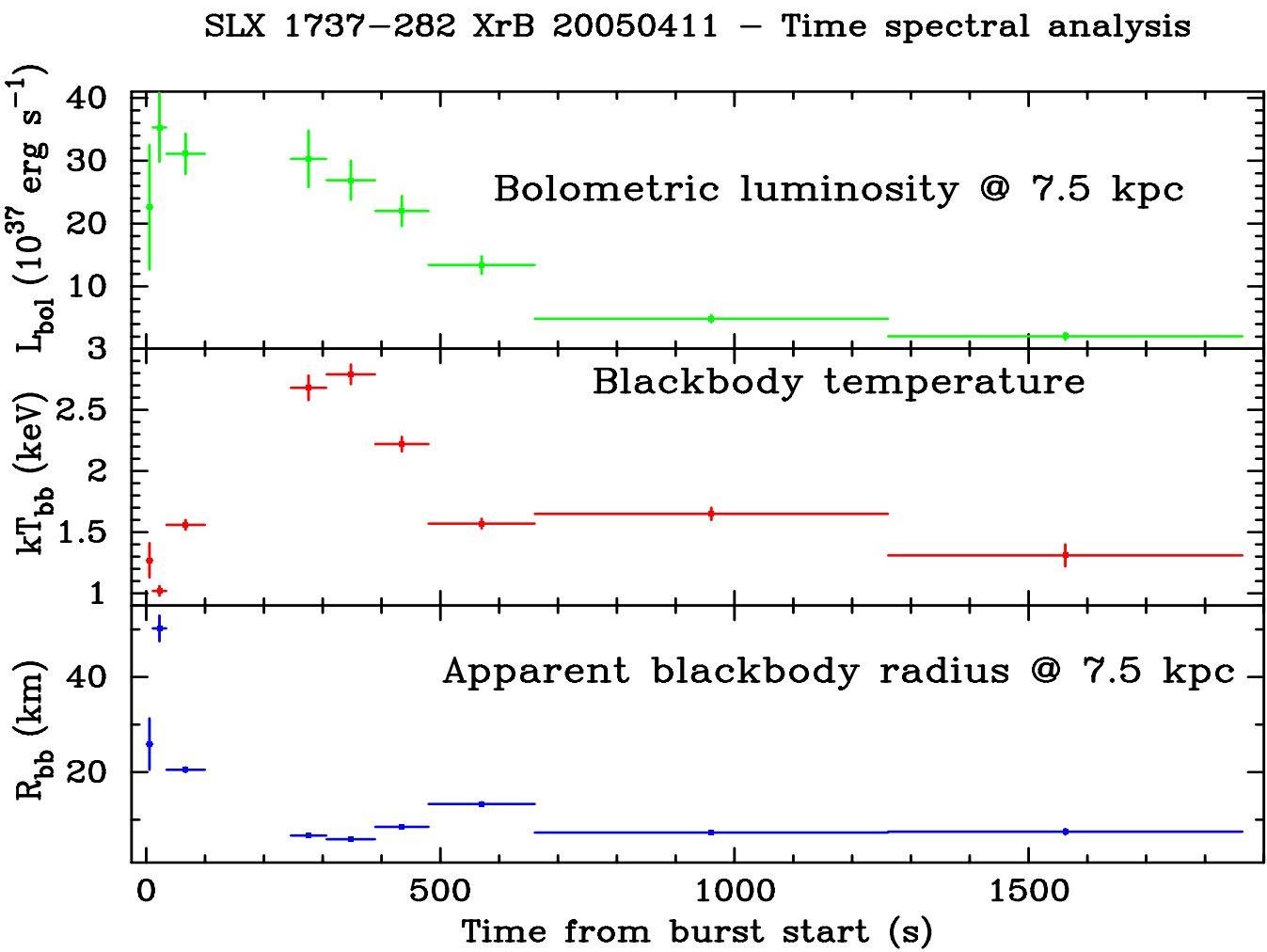


Time resolved analysis of burst 1

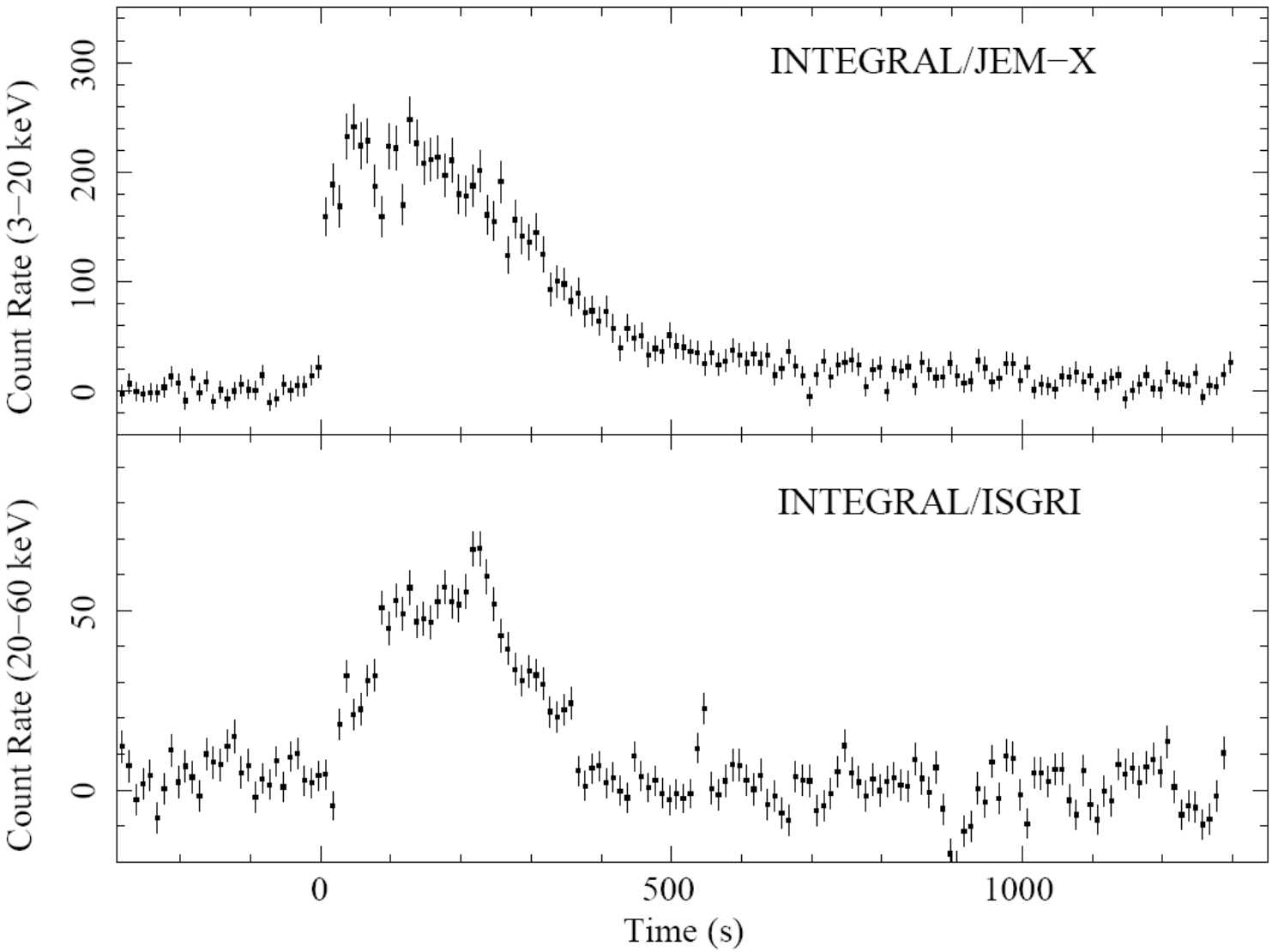
The time resolved spectral analysis reveals variations in the temperature and inferred blackbody radius that are consistent with expansion and contraction of the neutron star photosphere.

This is an indication that the luminosity reached the Eddington limit, allowing to derive the distance to the source: D ≈ 7.5 kpc

(Falanga et al., submitted)



Burst 2: 2nd April 2007 (10s bins)



Time resolved analysis of burst 2

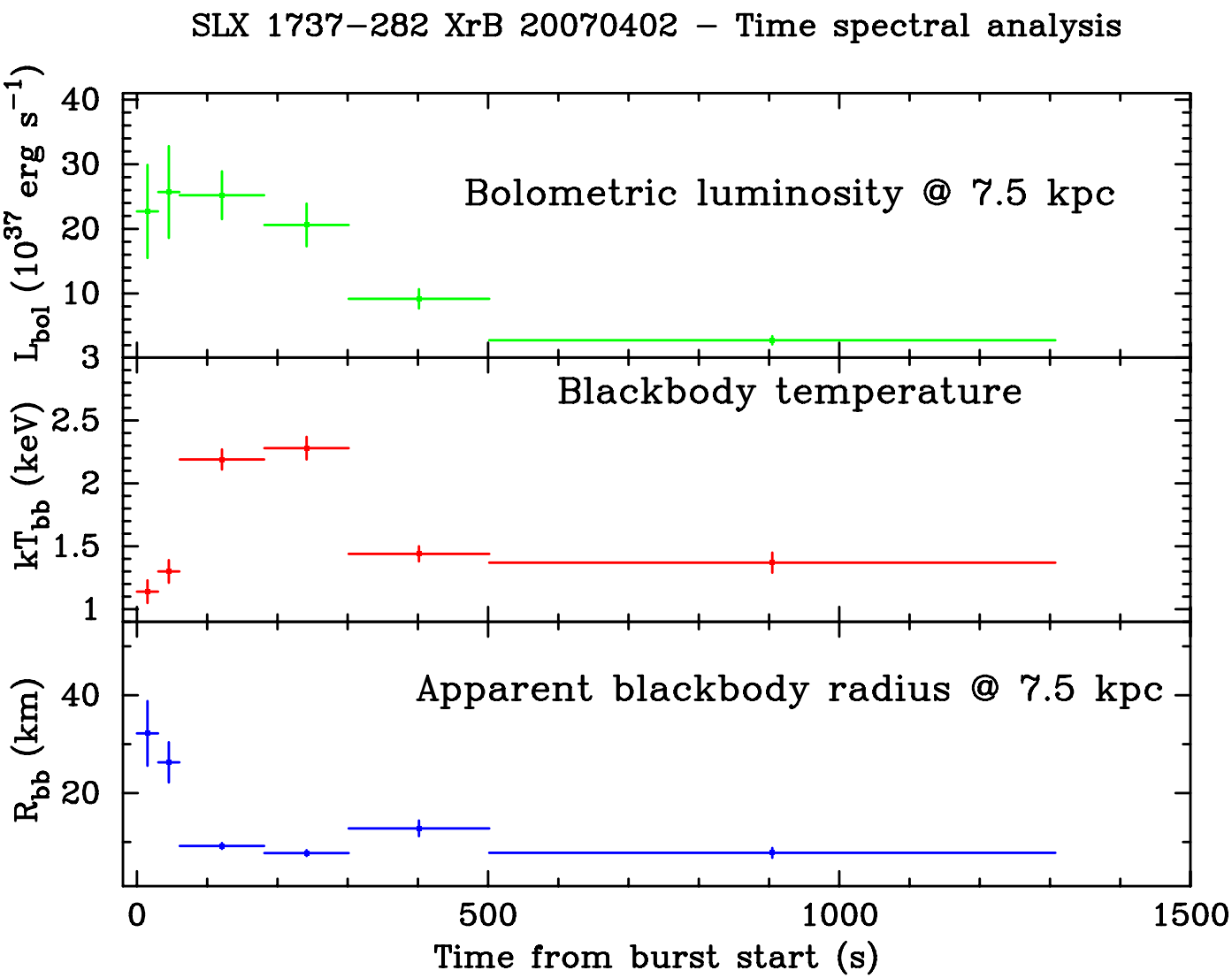


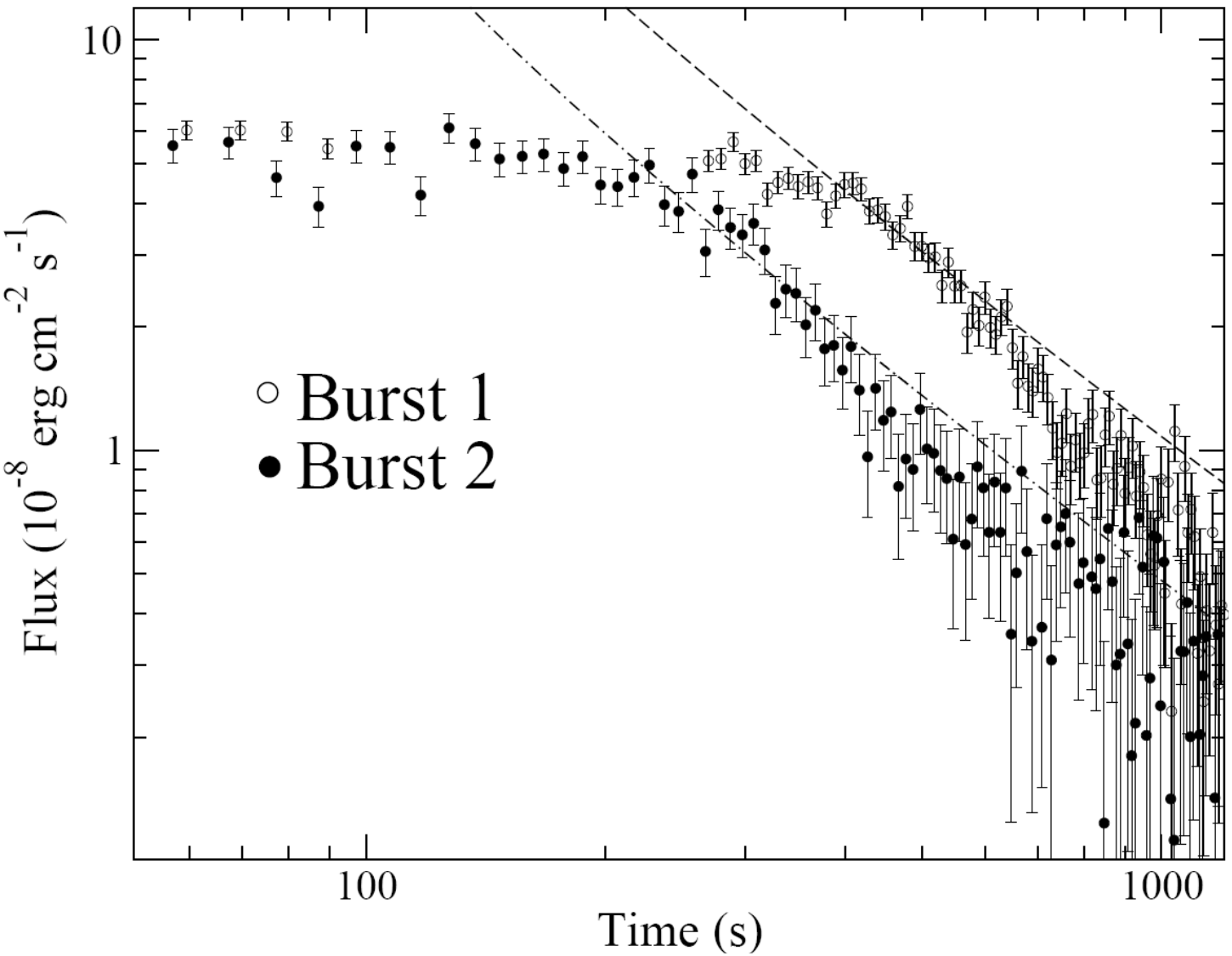
Table 1. Spectral results of the two bursts

Dataset Parameters	Burst 1 average	Burst 2 average
$kT_{\rm bb}$ (keV)	$1.93^{+0.03}_{-0.03}$	$1.77^{+0.04}_{-0.04}$
$R_{\rm bb,d_{7.3kpc}}$ (km)	$6.7^{+0.2}_{-0.2}$	$8.3^{+0.4}_{-0.4}$
$\chi^2_{\rm red}$	1.9	1.5
$F^a_{\rm bol}$ (erg cm^{-2} s^{-1})	1.14×10^{-8}	1.22×10^{-8}
Burst parameters		
$F^a_{\rm peak}$ (erg cm^{-2} s^{-1})	6.0×10^{-8}	5.7×10^{-8}
$f^b_{\rm b}$ (erg cm^{-2})	1.94×10^{-5}	1.6×10^{-5}
$\tau \equiv f_{\rm b}/F_{\rm peak}$ (sec)	323	281
$\gamma \equiv F^c_{\rm pers}/F_{\rm peak}$	1.0×10^{-2}	1.1×10^{-2}

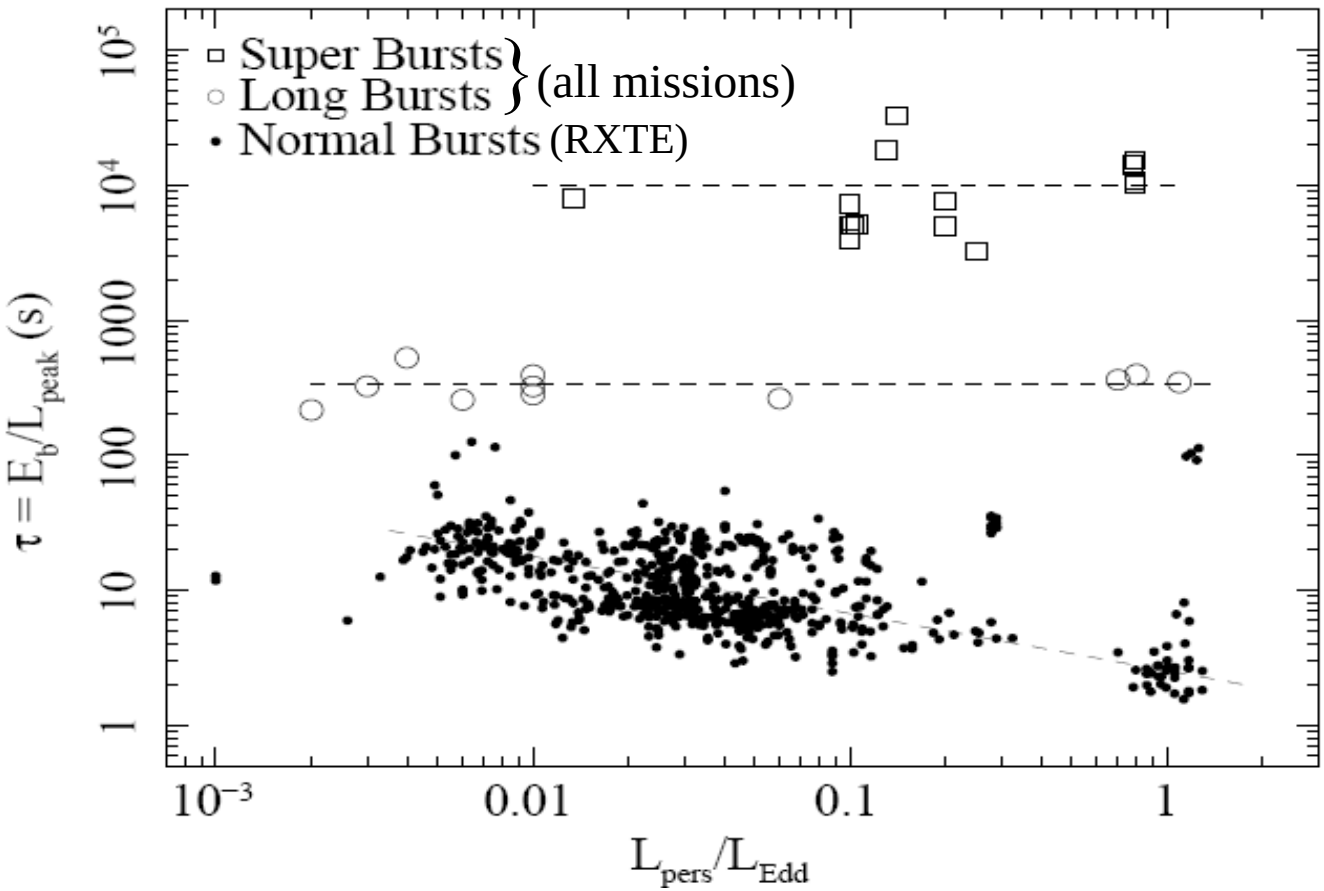
[a] Unabsorbed flux (0.1–100 keV). [b] Fluence. [c] Using the unabsorbed persistent flux $F_{\rm pers} = 6.2 \times 10^{-10}$ erg cm^{-2} s^{-1} (0.1–100 keV).

Bolometric blackbody flux decay

Comparison with a theoretical cooling model (Cumming & MacBeth, 2004) is consistent with the burning of a thick He layer.



Distribution of 700 type-I X-ray bursts



X-ray burst effective durations vs. persistent luminosity

Three branches are obvious: Normal, Intermediate and Super bursts.

The RXTE sampling is from Galloway et al. (2006) for bursts with known E_b and L_{peak}.

PROPERTIES OF INTERMEDIATE LONG BURSTS

Table 2

source	SLX1737-282	SLX 1735-269	2S 0918-549	IGR J17254-3257	GX 3+1	GX 17+2	4U 1708-23
instrument	WFC/JEM-X	JEM-X	WFC	JEM-X	JEM-X	PCA	SAS-3
precursor burst	no/yes;no	yes	no	no	no	no	yes
duration (min)	∼15/30;20	∼33	∼40	∼15	∼30	∼15–30	∼25
$\tau_{\rm rise}$ (sec)	≃1/2;2	≃100	≃1	≃20	≃1.3	≃0.4–1.3	≃20
$\tau_{\rm exp}$ (min)	≃10/5.4;4.5	≃10	≃3.9	≃3.7	≃10.8	≃3.2–8.3	≃5.5
$kT_{\rm max}$ (keV)	≃3.0/2.8;2.3	≃2.9	≃3.0	≃1.6	≃2.3	≃1.8–2.4	≃2.5
$L^{a}_{\rm peak}$ (10^{38} erg s^{-1})	≃3.8/3.8;3.6	≃5.1	≃3.5	≃0.9	≃0.8	≃1.6–2.0	≃3.0
$E_{\rm b}$ (10^{40} erg)	≃19/12;10	≃20	≃9	≃2.0	≃2.1	≃5.1–7.9	≃9.7
$\tau \equiv E_{\rm b}/L_{\rm peak}$ (min)	≃8.4/5.4;4.7	≃6.5	≃4.3	≃3.6	≃4.4	≃5.3–6.6	≃5.4
$L^{b}_{\rm pers}$ ($L_{\rm Edd}$)	≃0.004/0.01;0.01	≃0.01	≃0.006	≃0.002	∼0.06	≃0.75–0.8	0.002
distance (kpc)	7.3	8.5	5.4	8	5	10	6
references	[1,2]	[3]	[4]	[5]	[6]	[7,8,9]	[10]

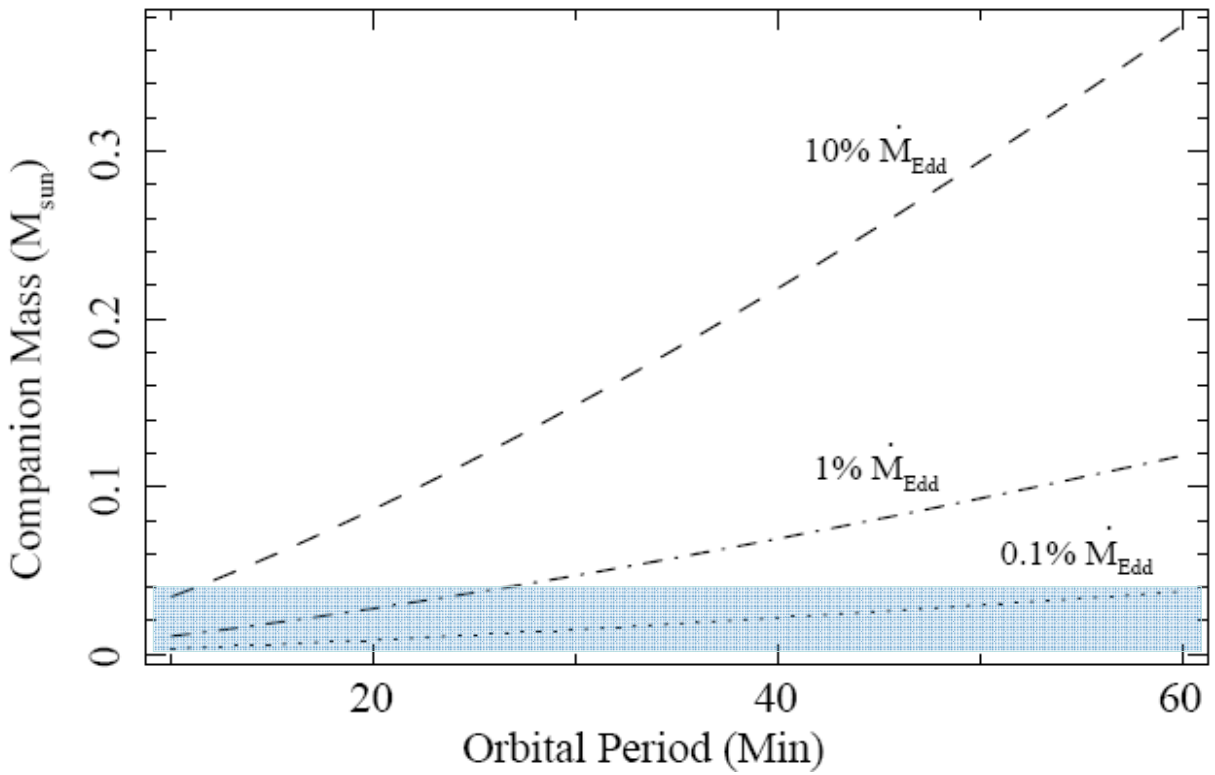
[a] Unabsorbed bolometric peak (black-body) luminosity.

[b] We used the bolometric unabsorbed flux from spectral fits; the observed maximum flux during radius-expansion bursts

1. in 't Zand et al. (2002), 2. this work, 3. Molkov et al. (2005), 4. in 't Zand et al. (2005), 5. Chenevez et al. (2007), 6. Chenevez et al. (2006), 7. Tawara et al (1984), 8. Kuulkers et al. (2002), 9. Galloway et al. (2006), 10. Hoffman et al. (1978)

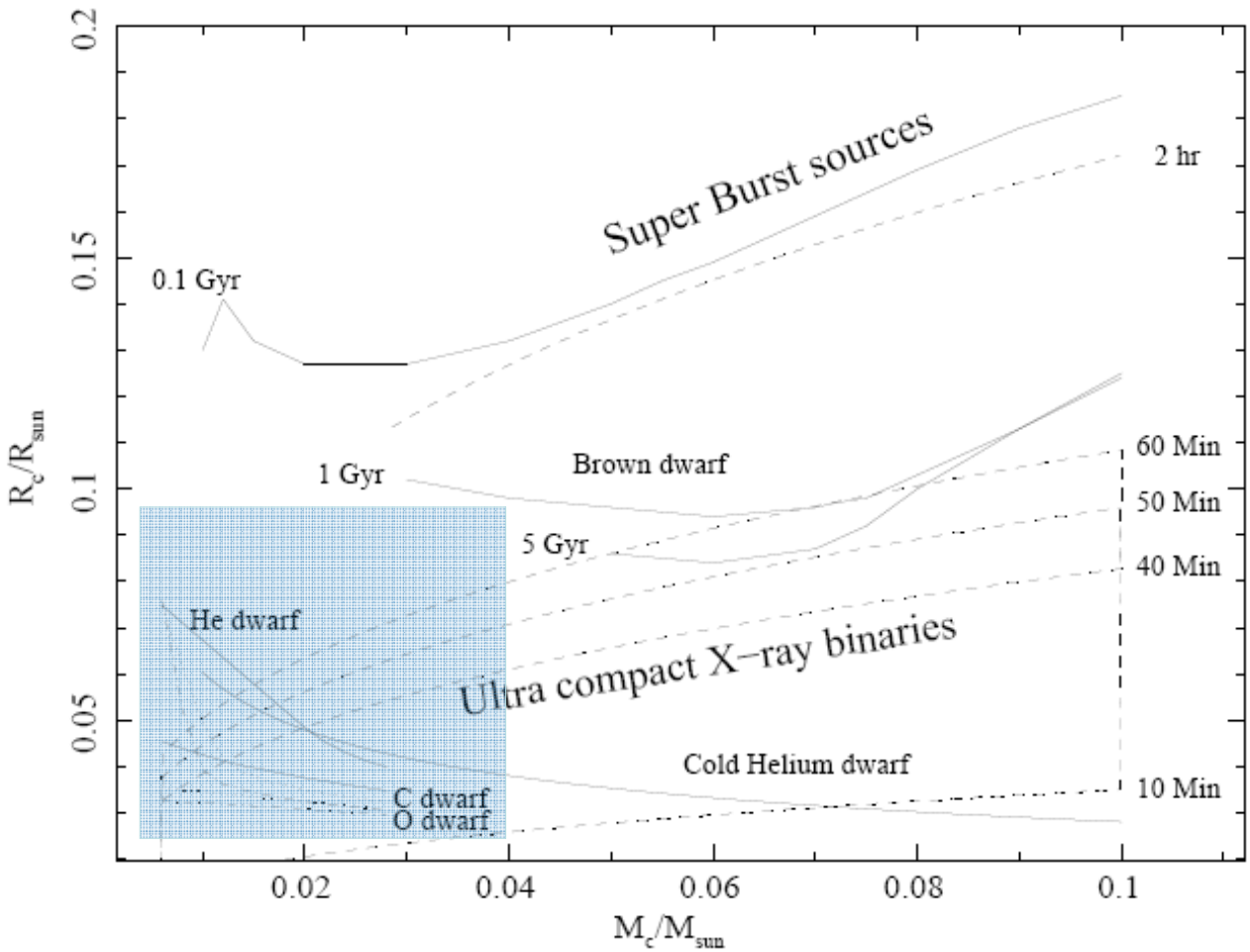
5/11 intermediate long bursts published with JEM-X analysis ☺

Companion mass vs. orbital period



Accretion rates of weak persistent UCXB sources are ~0.1 $\dot{M}_{Edd}$.

Companion radius vs. mass for different kinds of binary



Equation of states and Roche-lobe filling constrains for the companion star.

SUMMARY

Our monitoring of long X-ray bursts with INTEGRAL including archive searches and near real time observations has to date led to the discovery of four intermediate long bursts among the 11 known in total. Of special interest are the low luminosity bursting sources allowing to study unusual burning regimes in the context of Ultra Compact X-ray Binaries (UCXB). Bursts of very different durations from the same source can be explained by the transition from a H-rich bursting regime to a pure He burning regime.

Intermediate long X-ray bursts observed with INTEGRAL

Source	Date	T_b (s) | τ (s)	E_b (erg)	Acc. Rate* ($g/cm^2/s$)	Burning	Reference
GX 3+1	20040831	1800 | 131	$2 \cdot 10^{40}$	10 000	He / H	Chenevez et al., 2006
IGR J17254-3257	20061001	900 | 216	$2 \cdot 10^{40}$	370	H / He	Chenevez et al., 2007
SLX 1737-282	20051105 20070502	1800 | 323 ~900 | 281	$1.2 \cdot 10^{41}$ $1.0 \cdot 10^{41}$	1 000	He He	Falanga et al., submitted
SLX 1735-269	20030915	2000 | 400	$2 \cdot 10^{41}$	1 500	H	Molkov et al., 2005

*Eddington mass accretion rate per unit area: $\dot{m}_{Edd} \approx 10^5 \, \mathrm{g\,cm^{-2} s^{-1}}$