INTEGRAL observations of long X-ray bursts

Chenevez, Jérôme

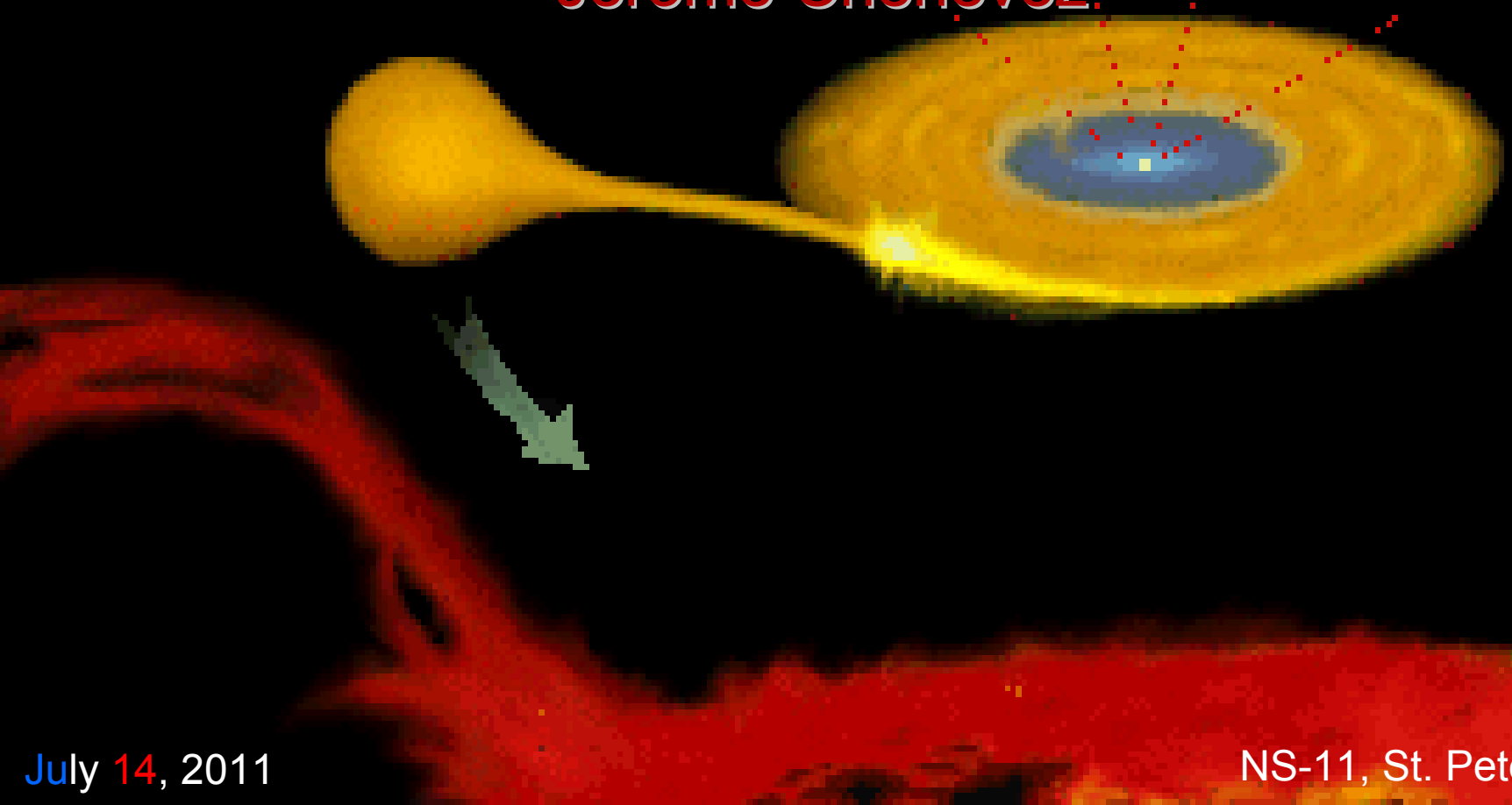
Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

DTU Space
National Space Institute

INTEGRAL observations of long X-ray bursts

Jérôme Chenevez



July 14, 2011

NS-11, St. Petersburg

DTU Space
National Space Institute

INTEGRAL observations of long X-ray bursts

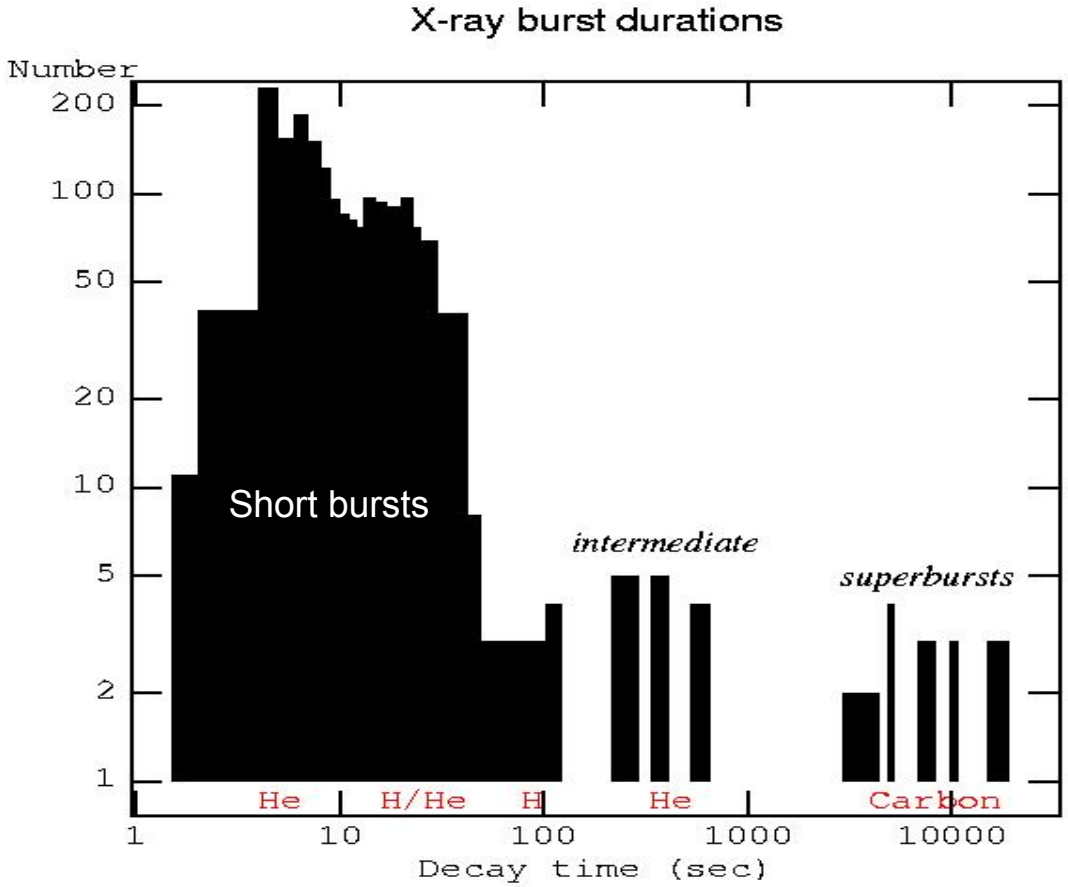
Jérôme Chenevez

Maurizio Falanga
Erik Kuulkers
Søren Brandt
Niels Lund
Andrew Cumming

Hendrik Schatz
Duncan Galloway
Tim Oosterbroek

MOTIVATION

More or less long bursts



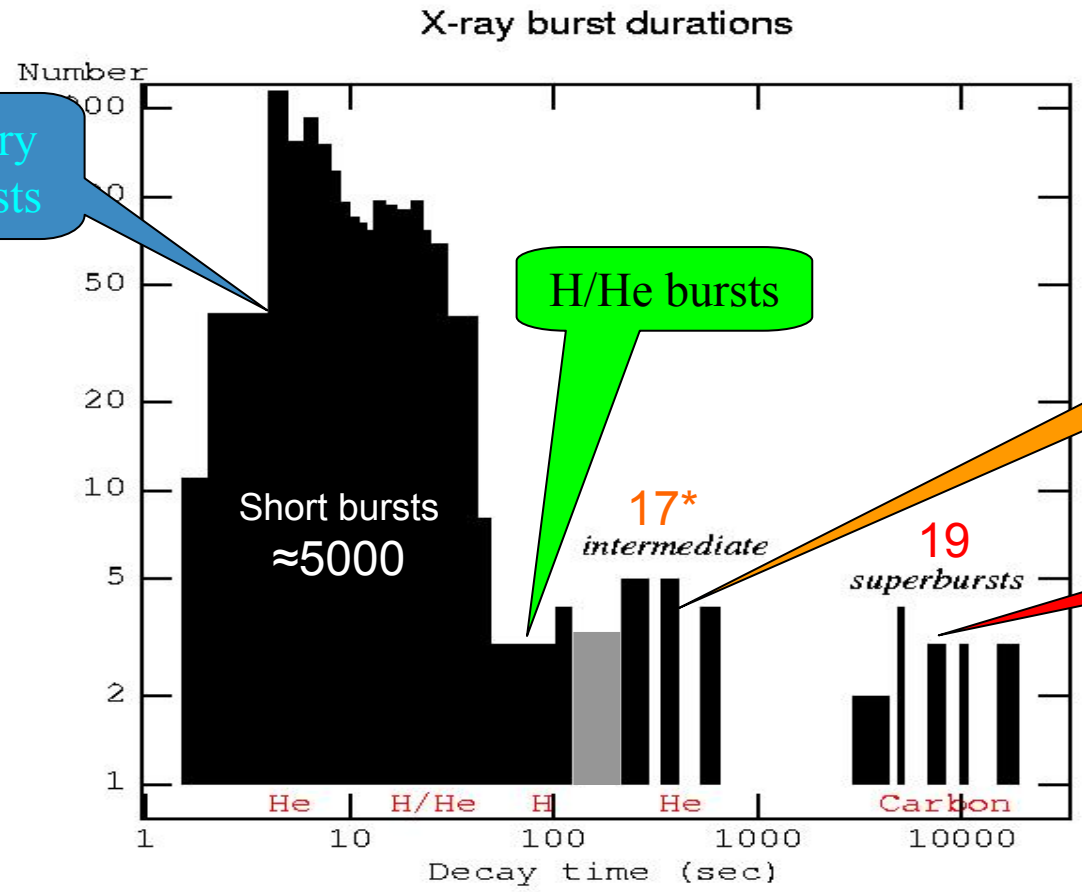
Distribution of *all* (MINBAR*) X-ray bursts as a function of their exponential decay time

Current investigations of the various types of thermonuclear bursts aim to draw a consistent picture of the ignition and burning processes in relation with the accretion regime of the neutron stars.

*Multi-Instrument Burst Archive in collaboration with D. Galloway, J. in 't Zand, et al.

MOTIVATION

More or less long bursts



Ordinary He bursts

H/He bursts

Unusual long* bursts

Superbursts

From 11 sources

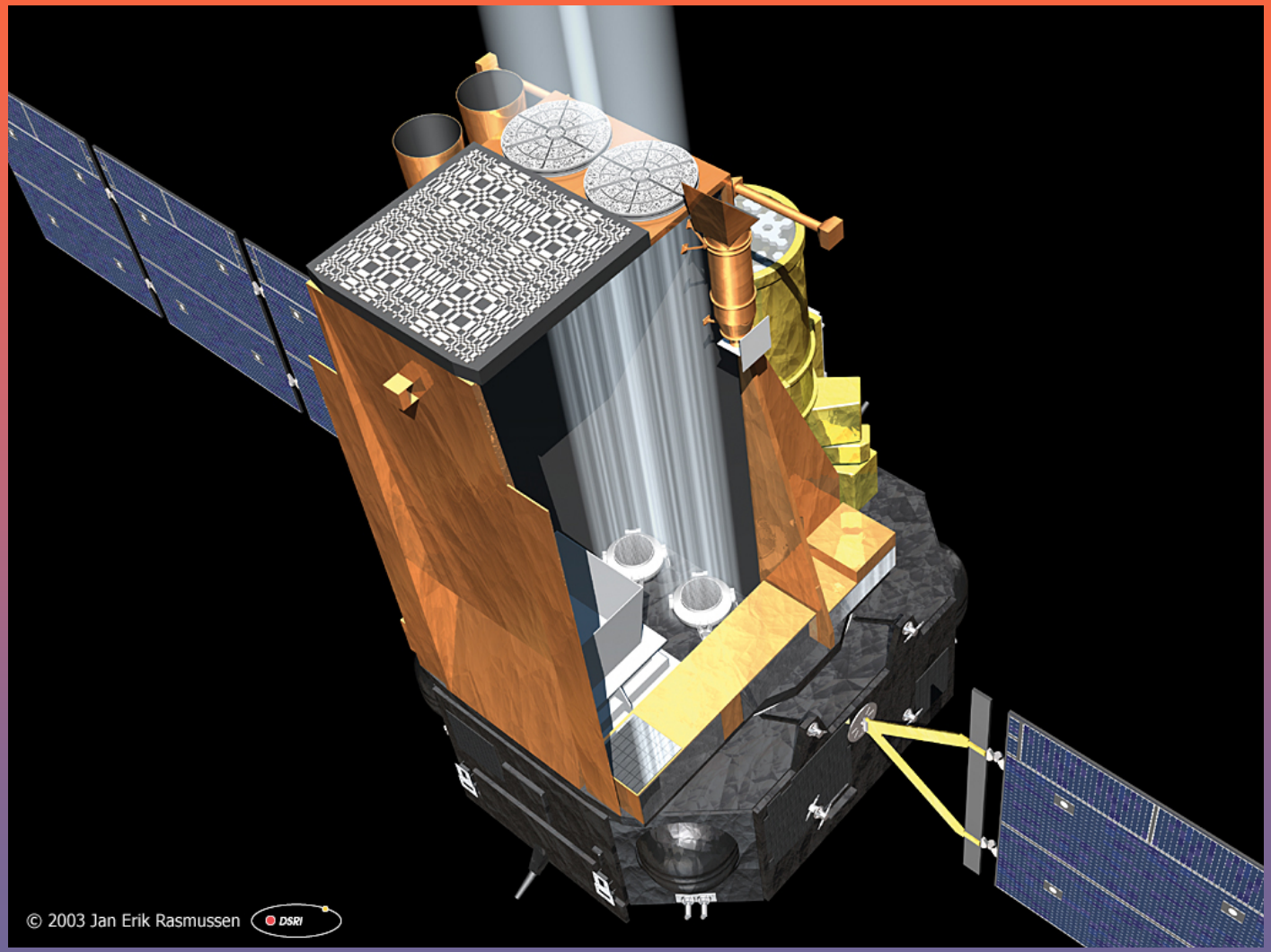
***Intermediate long bursts: duration > 12 min**
From 14 sources

Distribution of *all* (MINBAR*) X-ray bursts as a function of their exponential decay time

*Multi-Instrument Burst Archive in collaboration with D. Galloway, J. in 't Zand, et al.

Jérôme Chenevez, DTU Space,
Technical University of Denmark

INTEGRAL

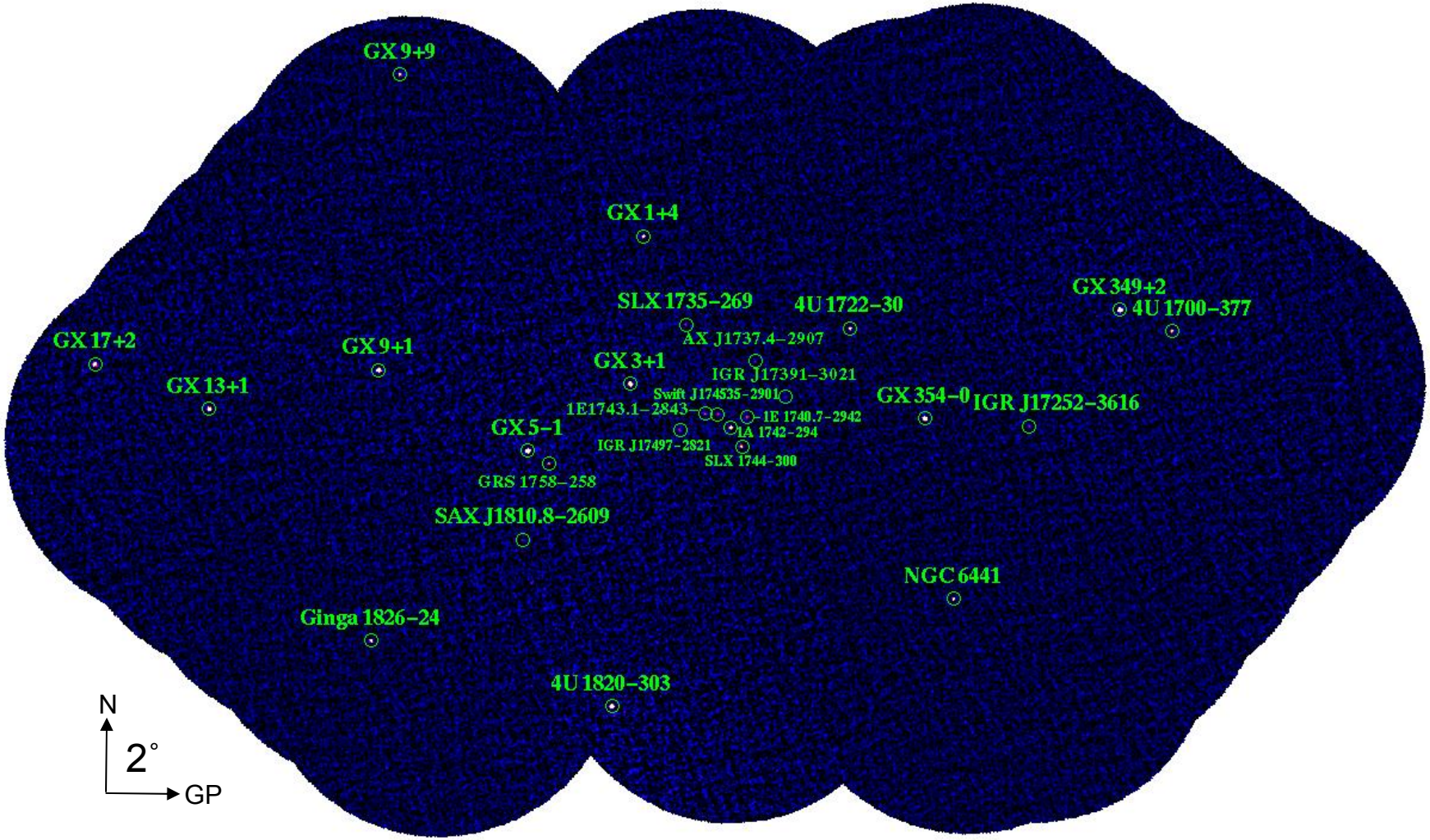


JEM-X :
100 cm^2 @ 10 keV
3-25 keV
FoV: 5º, 3' reso.

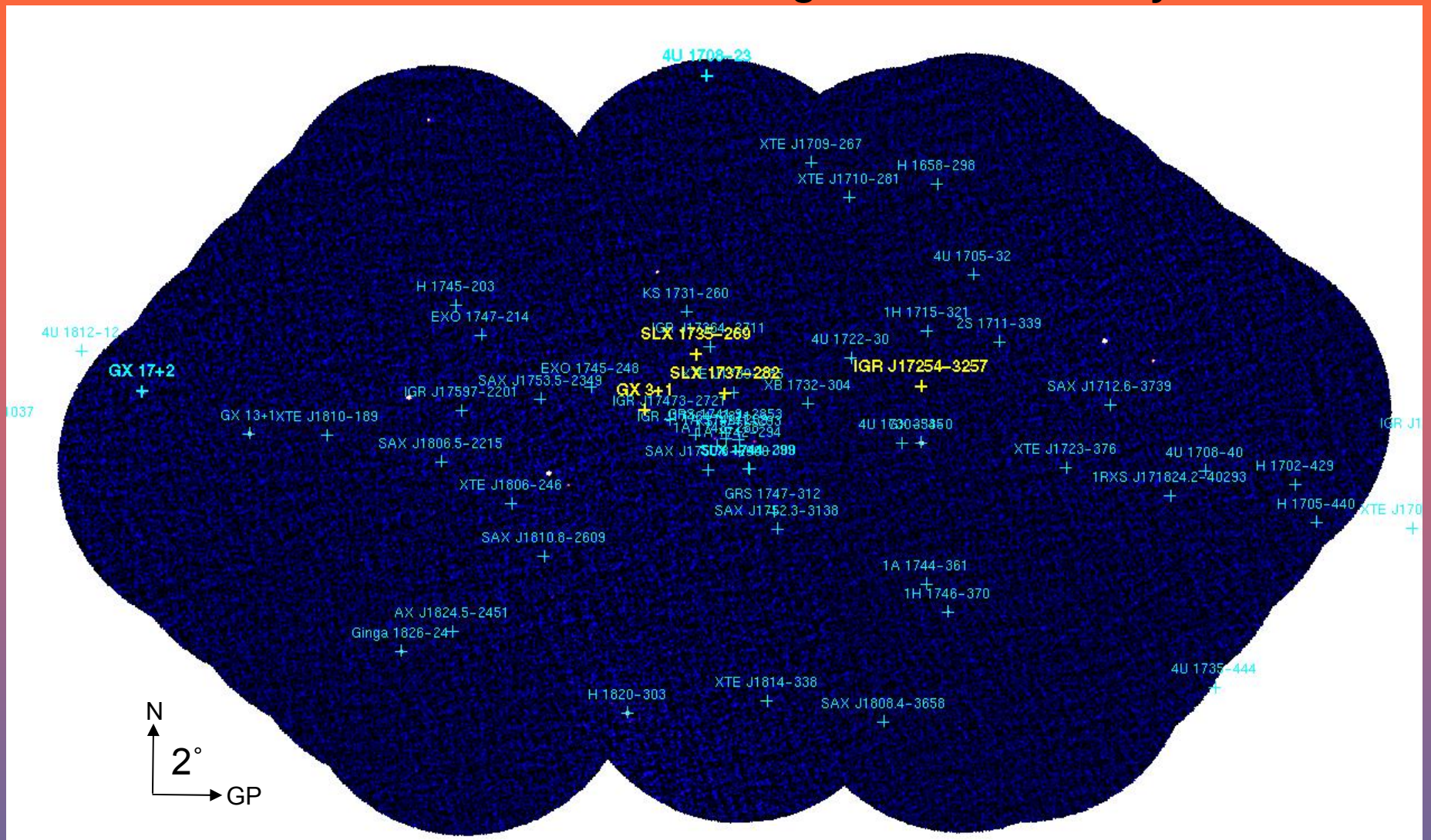
IBIS :
1000 cm^2 @ 20 keV
18 keV – 10 MeV
FoV ≈ 12º

SPI :
20 keV – 8 MeV
2.2 keV @ 1.3 MeV
FoV ≈ 15º

The Galactic Center region as seen by JEM-X



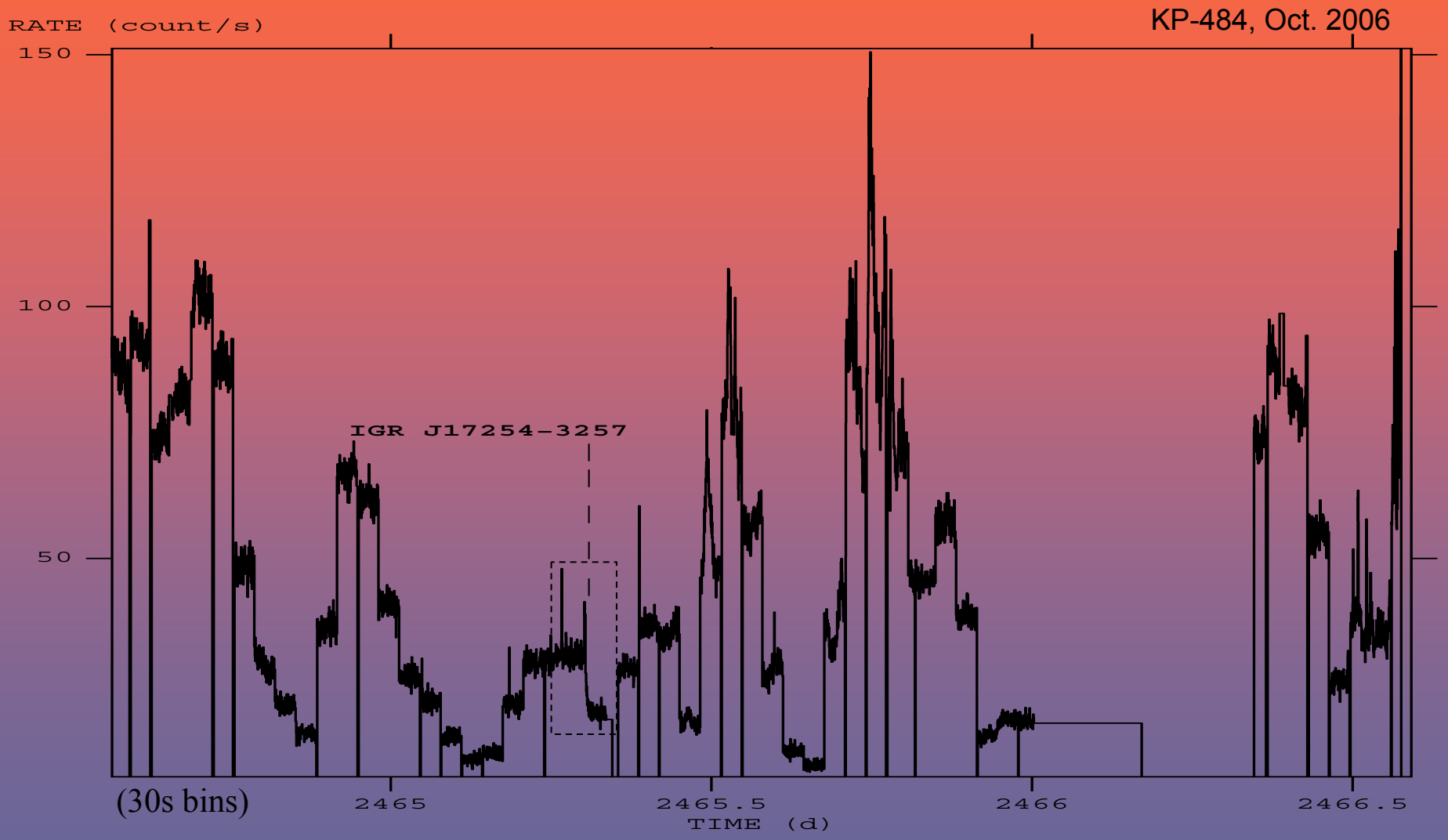
The Galactic Center region as seen by JEM-X



94 X-ray bursters known to date; ≈2/3 located in the Galactic Bulge region

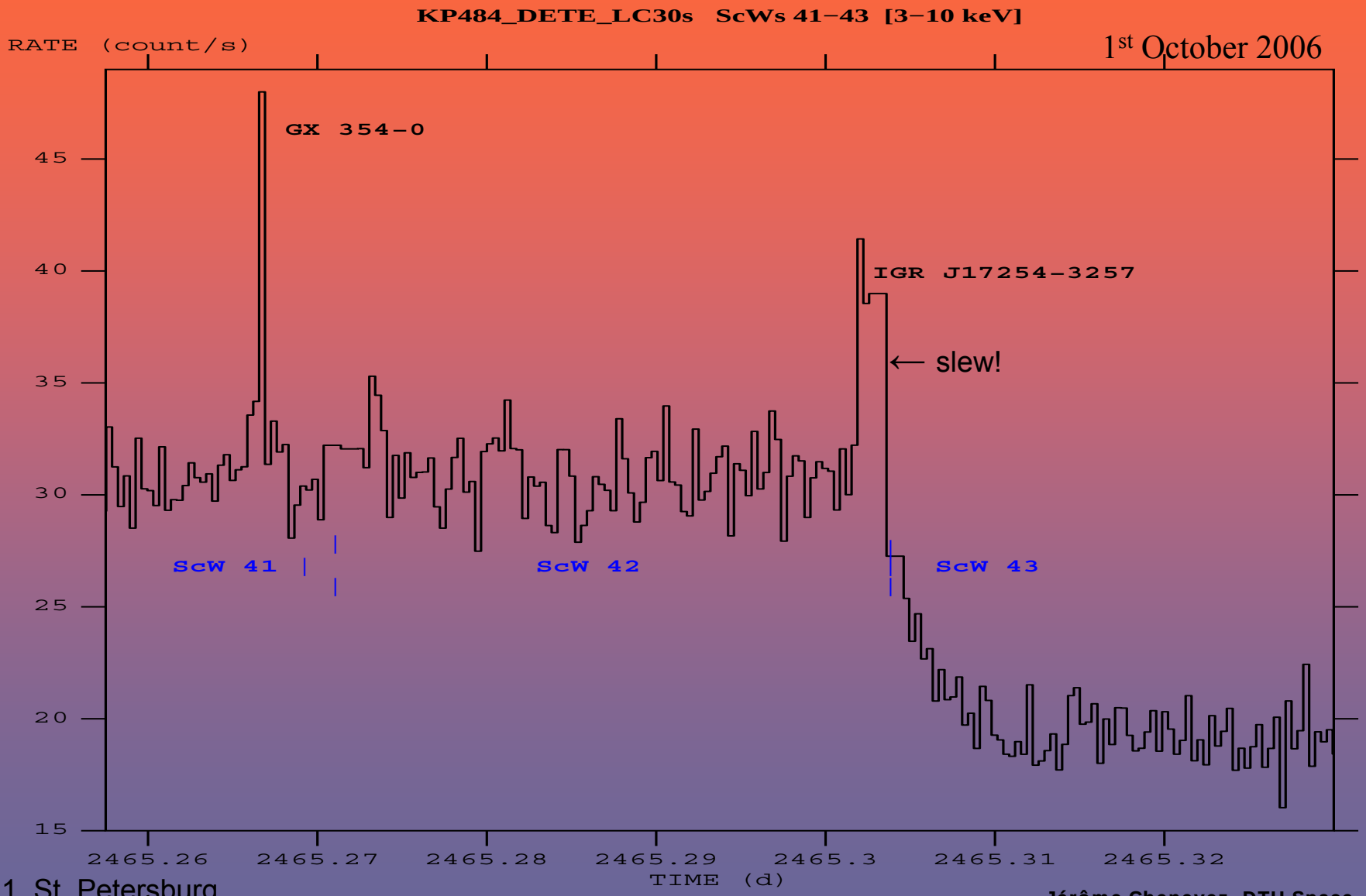
Jérôme Chenevez, DTU Space,
Technical University of Denmark

Example of burst detections in **JEM-X detector light curve**



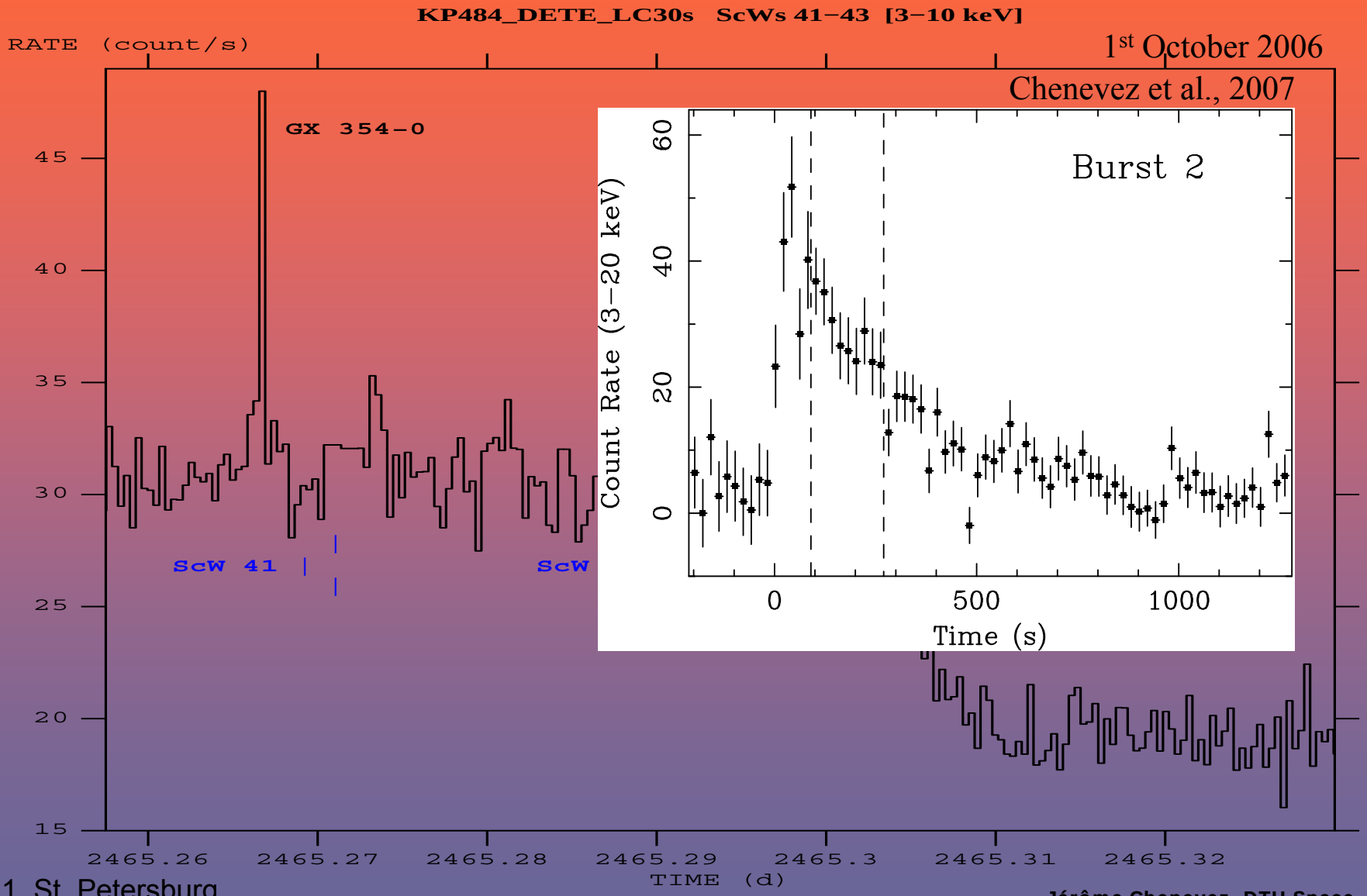
Jérôme Chenevez, DTU Space,
Technical University of Denmark

Long burst from IGR J17254-3257



Jérôme Chenevez, DTU Space,
Technical University of Denmark

Long burst from IGR J17254-3257

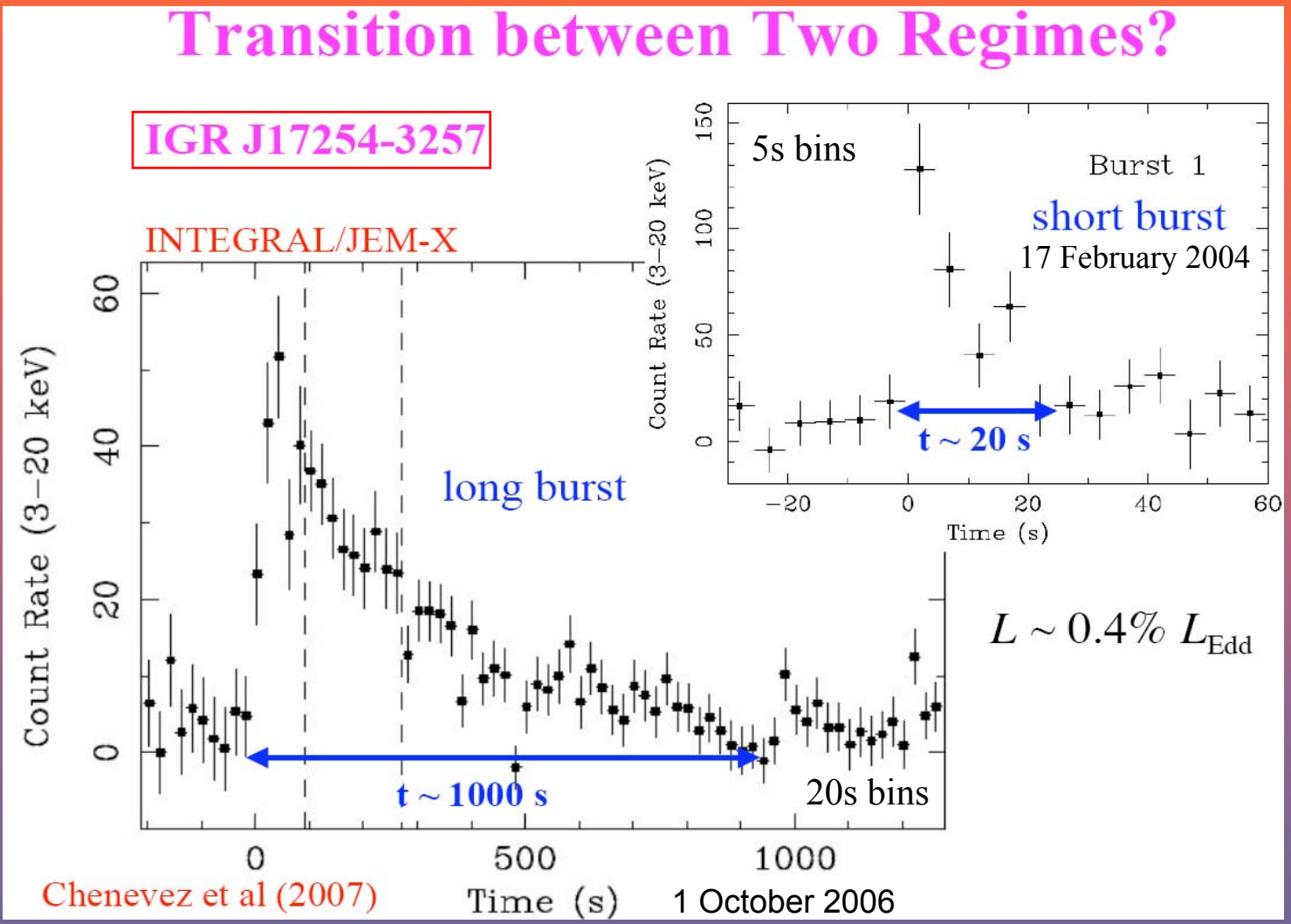


1st October 2006

Chenevez et al., 2007

Jérôme Chenevez, DTU Space,
Technical University of Denmark

Long burst from IGR J17254-3257

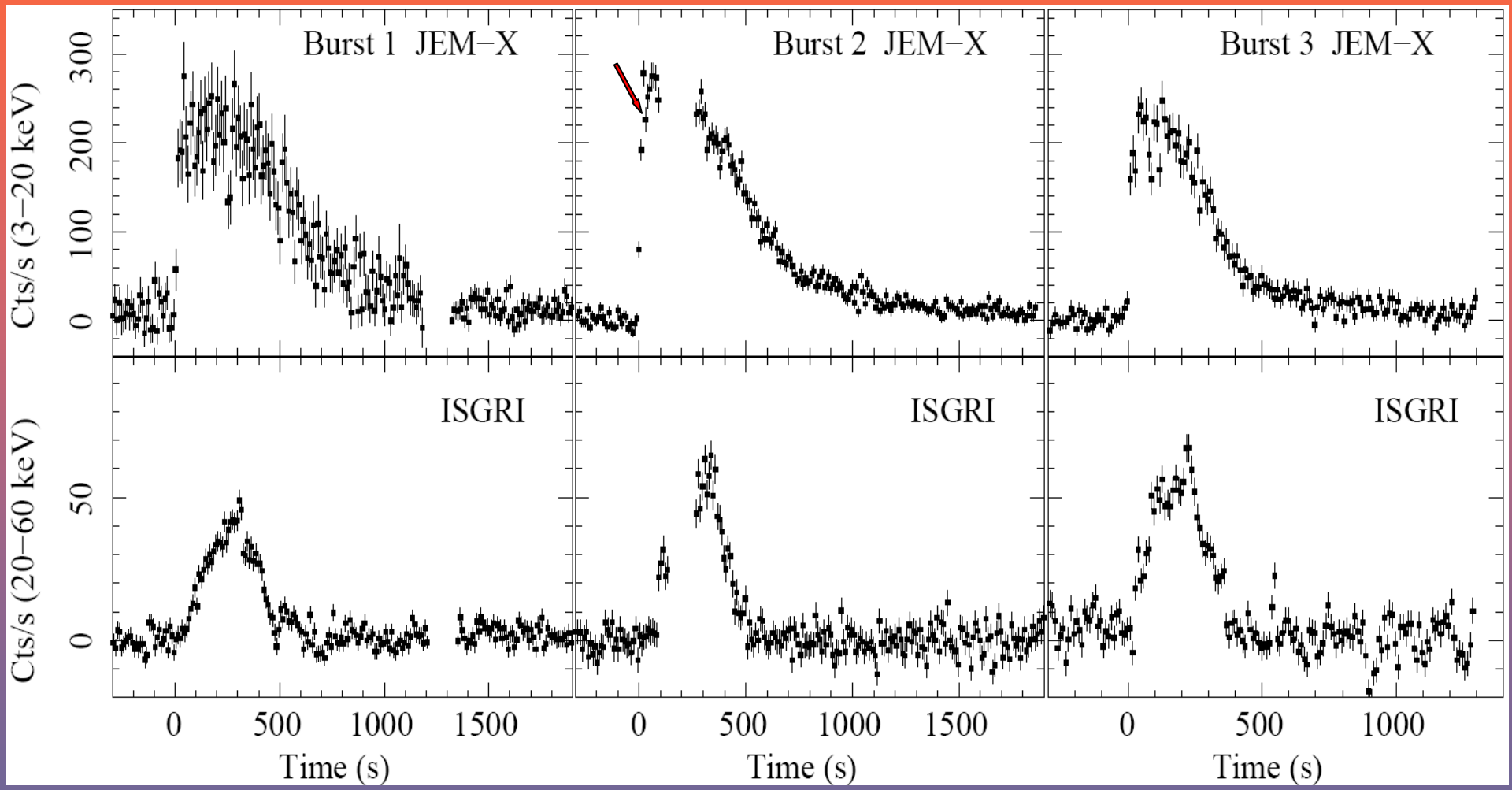


Different lasting bursts from IGR J17254-3257 can be explained by a transition between two slightly different accretion rates. The short event is a mixed H/He burst triggered by a weak H flash, while the long burst is the result of the burning of a large He pile produced by steady H burning at a slightly higher accretion rate.

SLX 1737-282

3/4 bursts in INTEGRAL; all intermediate long!

March 2004 | April 2005 | April 2007



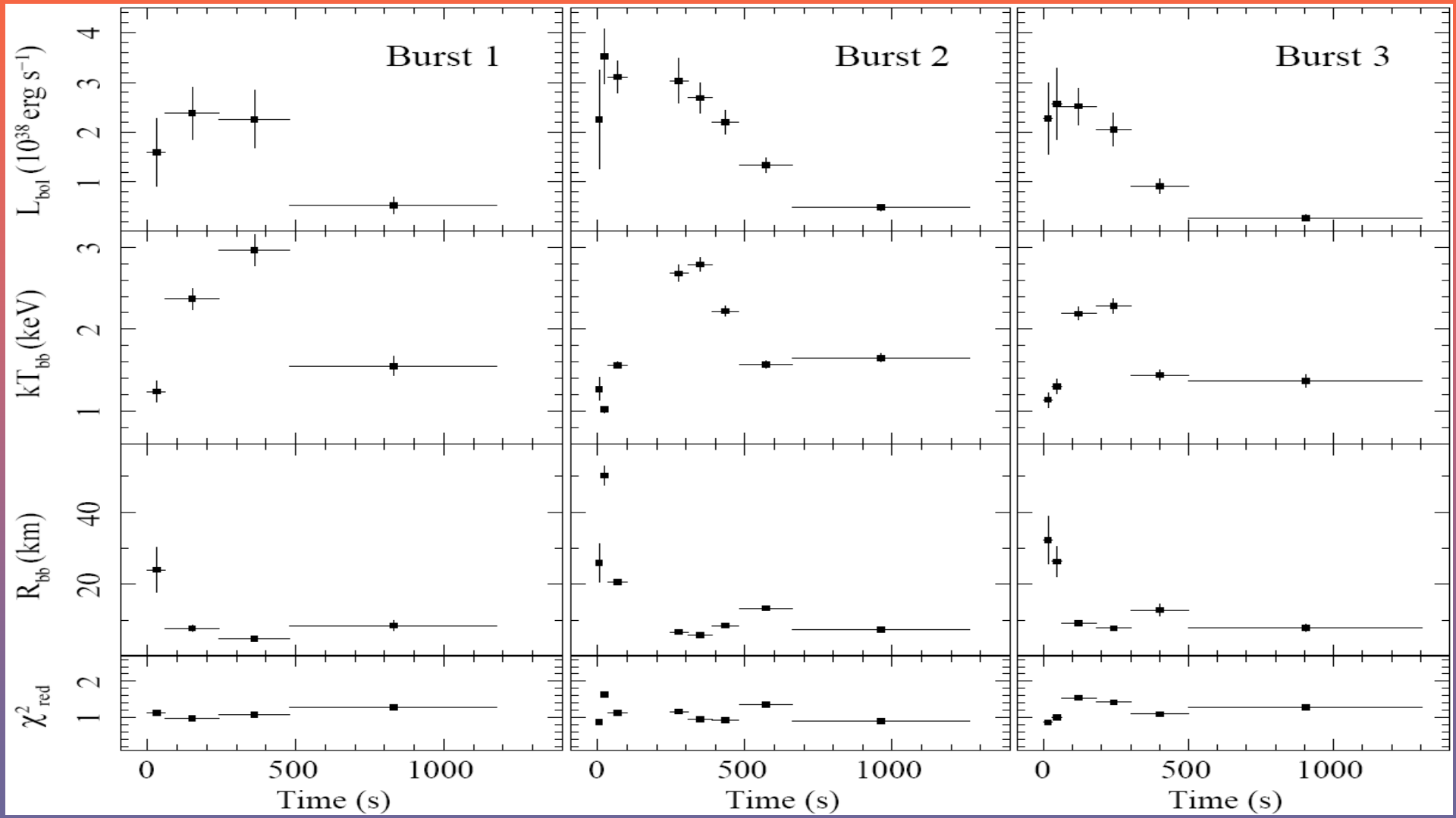
10s bin light-curves

(Falanga, Chenevez, et al., 2008)

Jérôme Chenevez, DTU Space,
Technical University of Denmark

SLX 1737-282
Time-resolved spectral analyses

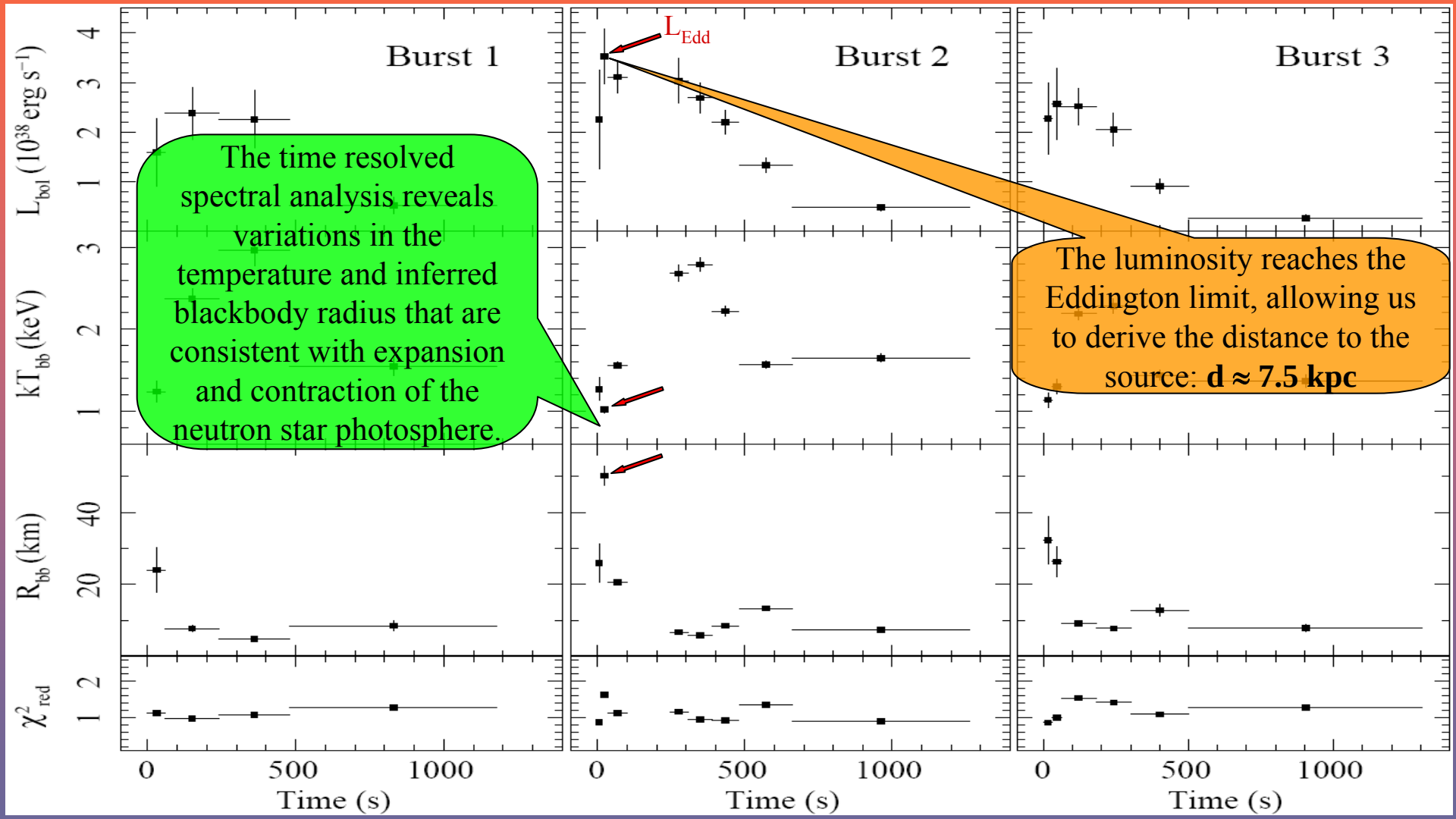
March 2004 | April 2005 | April 2007



Jérôme Chenevez, DTU Space,
Technical University of Denmark

SLX 1737-282
Time-resolved spectral analyses

March 2004 | April 2005 | April 2007



Jérôme Chenevez, DTU Space,
Technical University of Denmark

SLX 1735-269
The first long burst detected by INTEGRAL

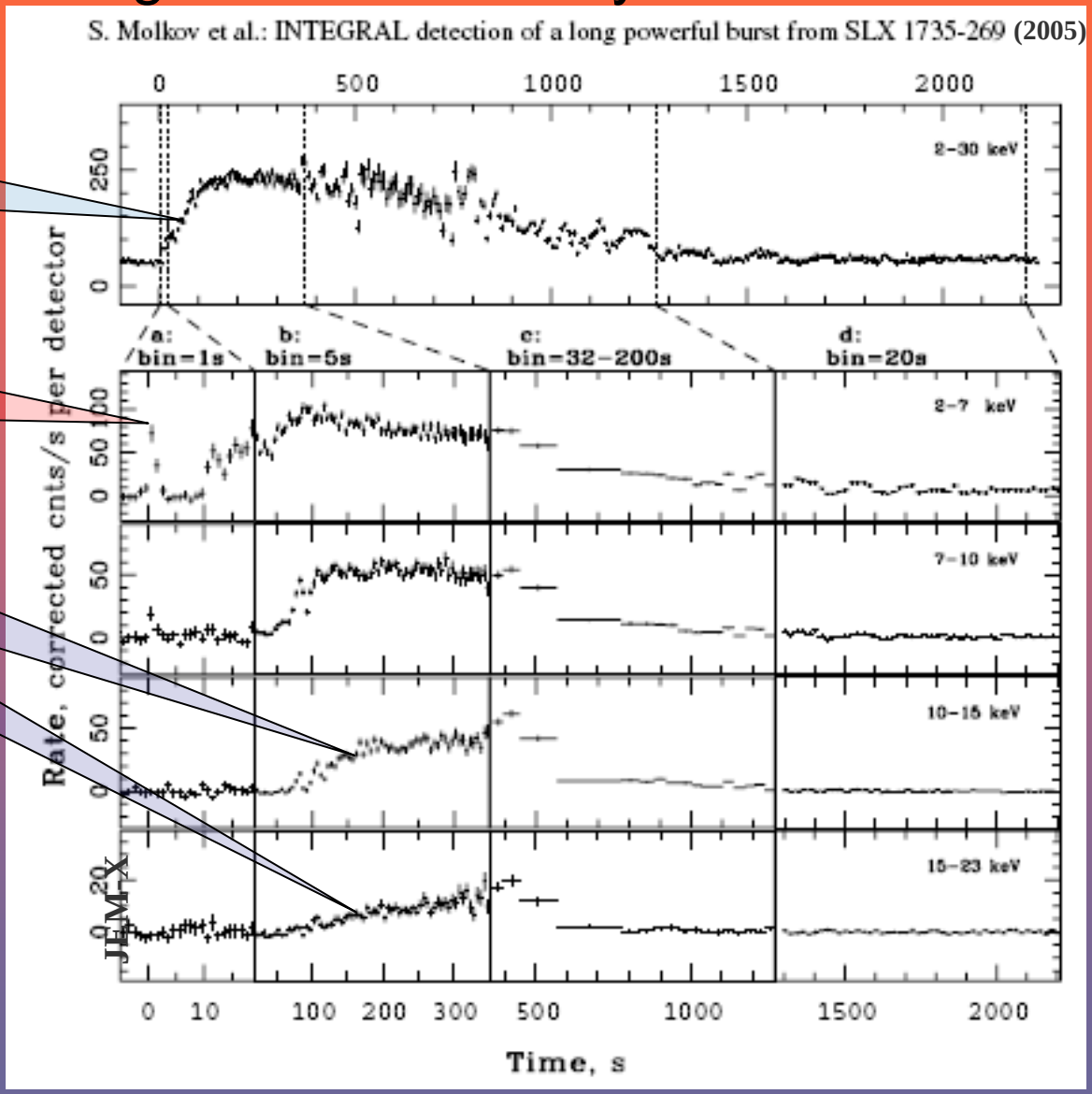
15 September 2003

Long rise

Large radius expansion followed by contraction.

Soft precursor

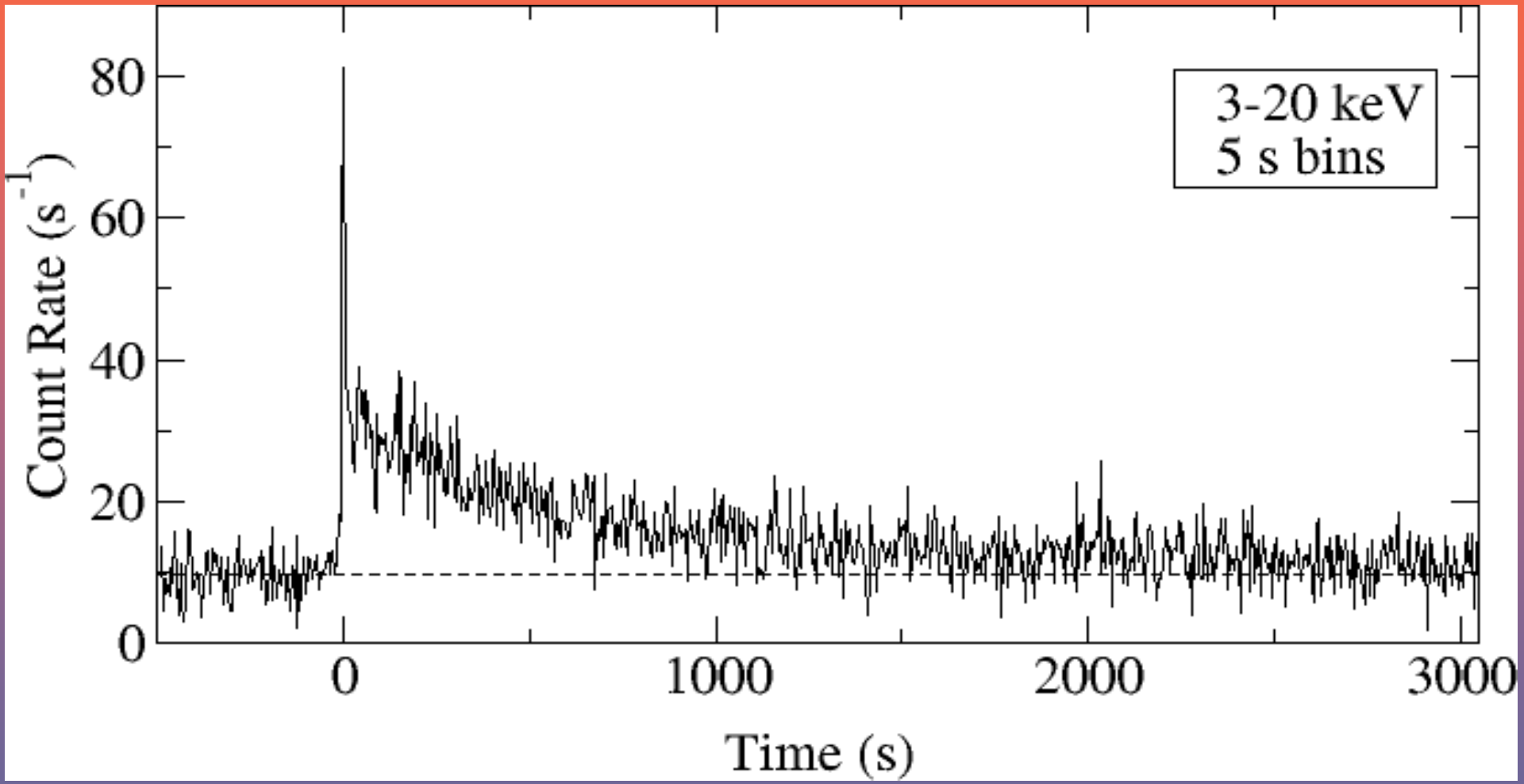
Progressive hardening



1st interpretation was mix burning of H/He (Molkov et al. (2005). In 't Zand et al. (2007) classified the source as UCXB candidate.
⇒ **Pure He burning**.

The peculiar long burst from GX 3+1 on August 31, 2004

(Chenevez et al., 2006)

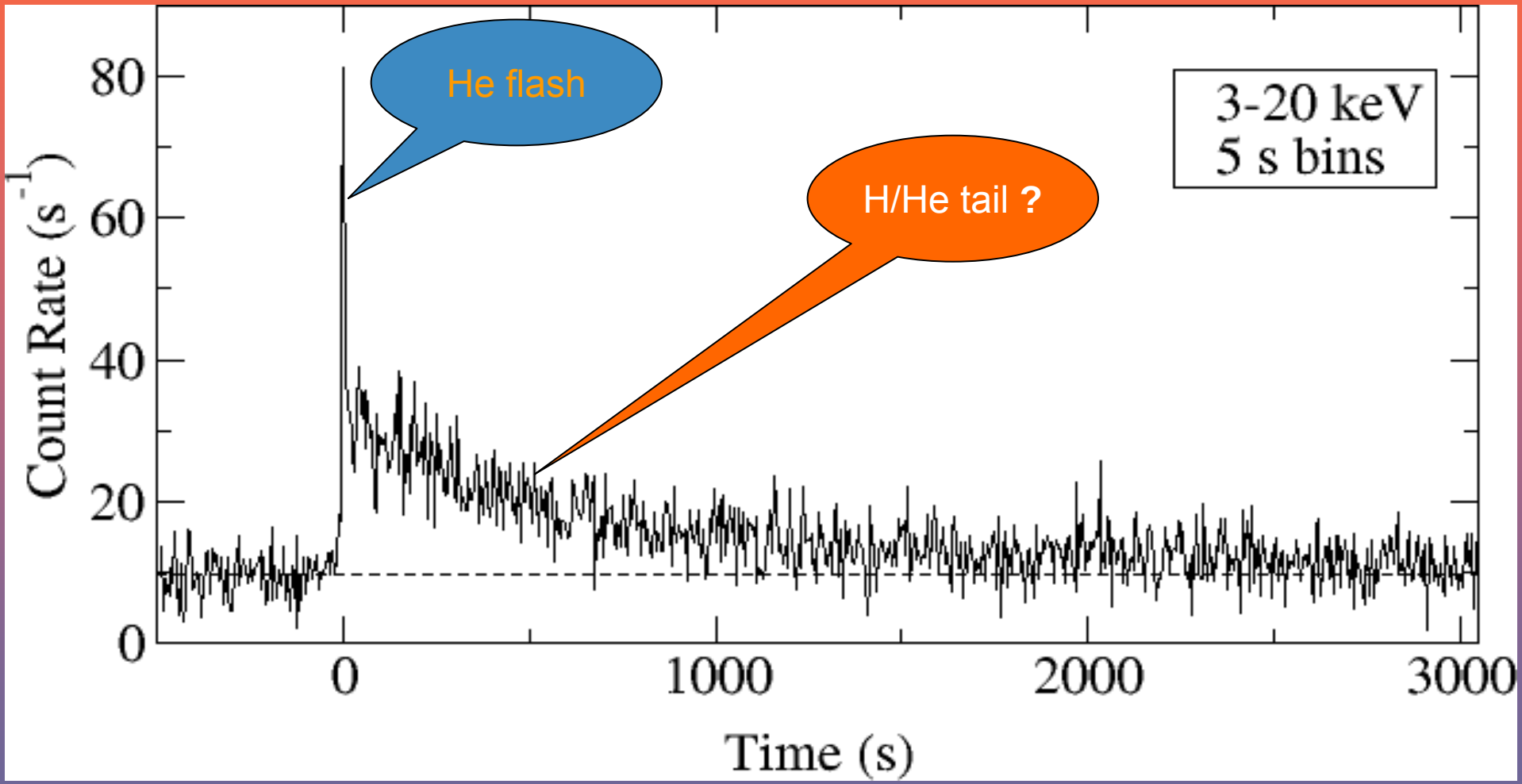


Jérôme Chenevez, DTU Space,
Technical University of Denmark

The peculiar long burst from GX 3+1 on August 31, 2004

Two-phases burst

(Chenevez et al., 2006)



Jérôme Chenevez, DTU Space,
Technical University of Denmark

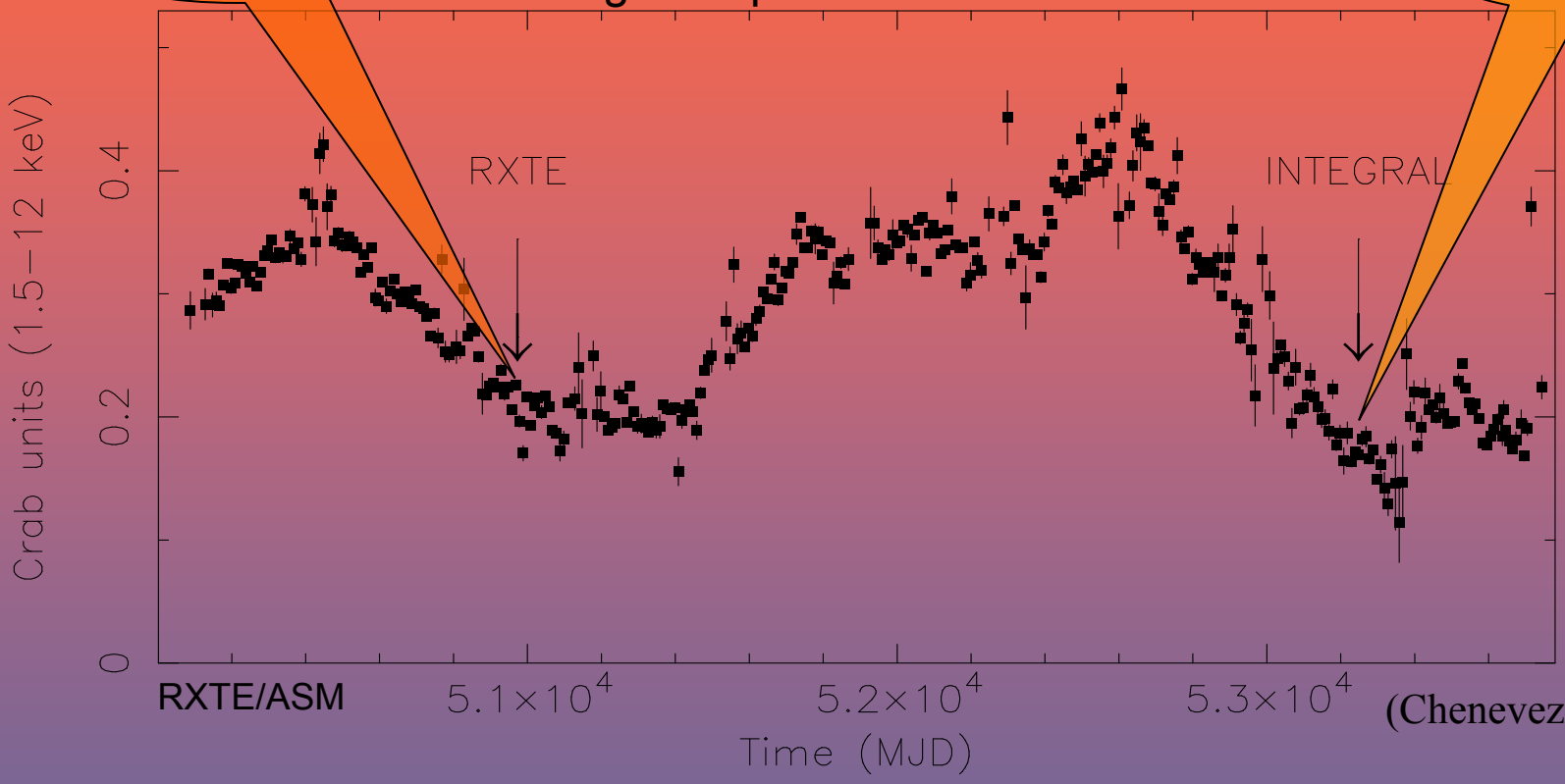
The peculiar long burst from GX 3+1 on August 31, 2004

Superburst
(Kuulkers, 2002)

long burst
31/08-2004

Relation with accretion rate

Long term persistent flux of GX 3+1



(Chenevez et al., 2006)

An aborted superburst due to the premature ignition of a carbon layer triggered by an He detonation could also be considered.

Jérôme Chenevez, DTU Space,
Technical University of Denmark

SUMMARY

The monitoring of long X-ray bursts with INTEGRAL/JEM-X has led to the discovery of **six** intermediate bursts longer than ≈15 minutes: ⅓ of the total population, and ½ of the bursts, which occurred in the same period.

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	$2 \cdot 10^{40}$	400	(H⇒)He	Chenevez et al., 2007
SLX 1737-282	20040309	1500 | 275	$0.7 \cdot 10^{41}$	800	He	Falanga, Chenevez et al., 2008
	20050411	1800 | 323	$1.2 \cdot 10^{41}$		He	
	20070402	~900 | 281	$1.0 \cdot 10^{41}$		He	
SLX 1735-269	20030915	2000 | 400	$2 \cdot 10^{41}$	1 500	He	Molkov et al., 2005

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

(UCXB: in 't Zand et al, 2007)

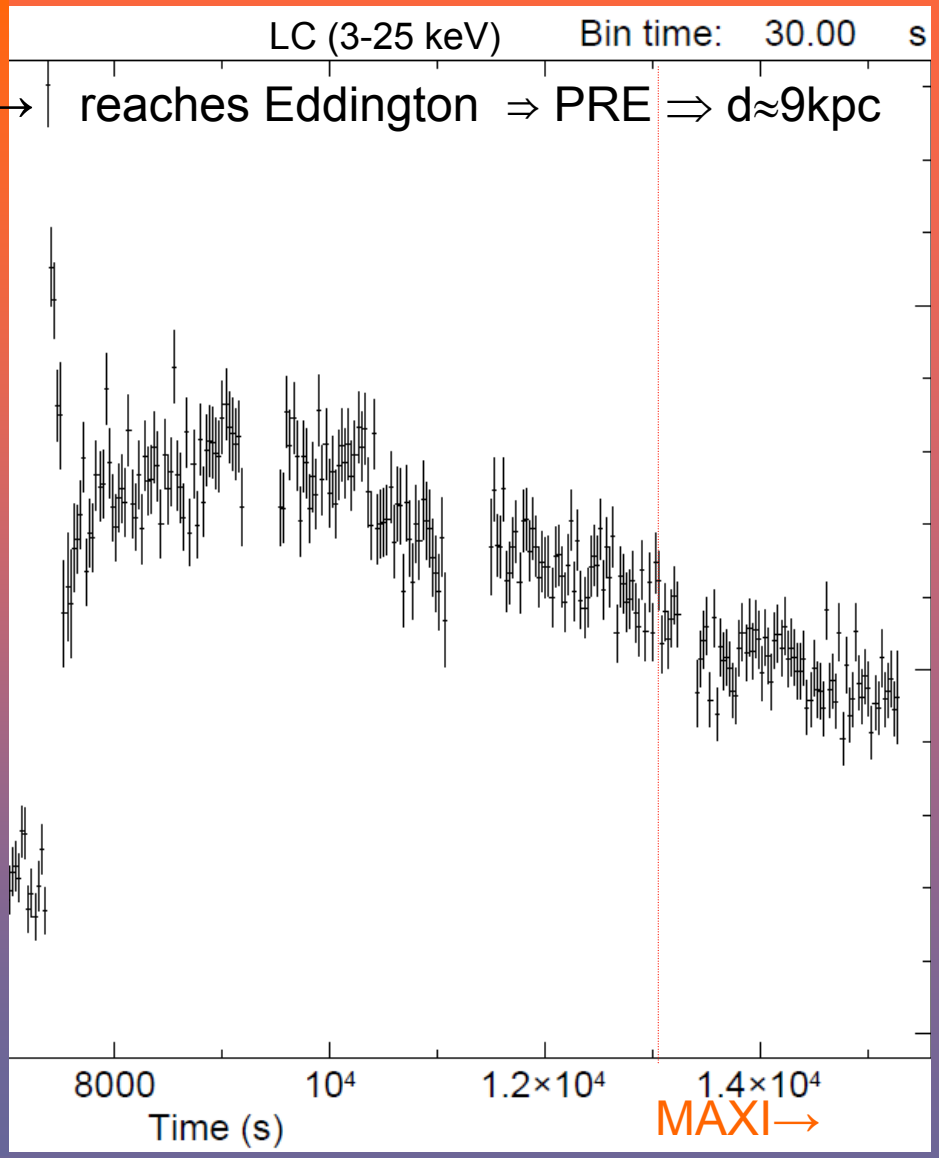
Jérôme Chenevez, DTU Space,
Technical University of Denmark

To-date last observed superburst
SAX J1753.0-2853 on February 13th

Chenevez et al., ATel 3183

Precursor → reaches Eddington ⇒ PRE ⇒ d≈9kpc

The superburst peak reaches similar count-rate as previous PRE bursts from this source, and is consistent with a shock-triggered He flash precursor as seen in other superbursts (Weinberg & Bildsten, 2007).

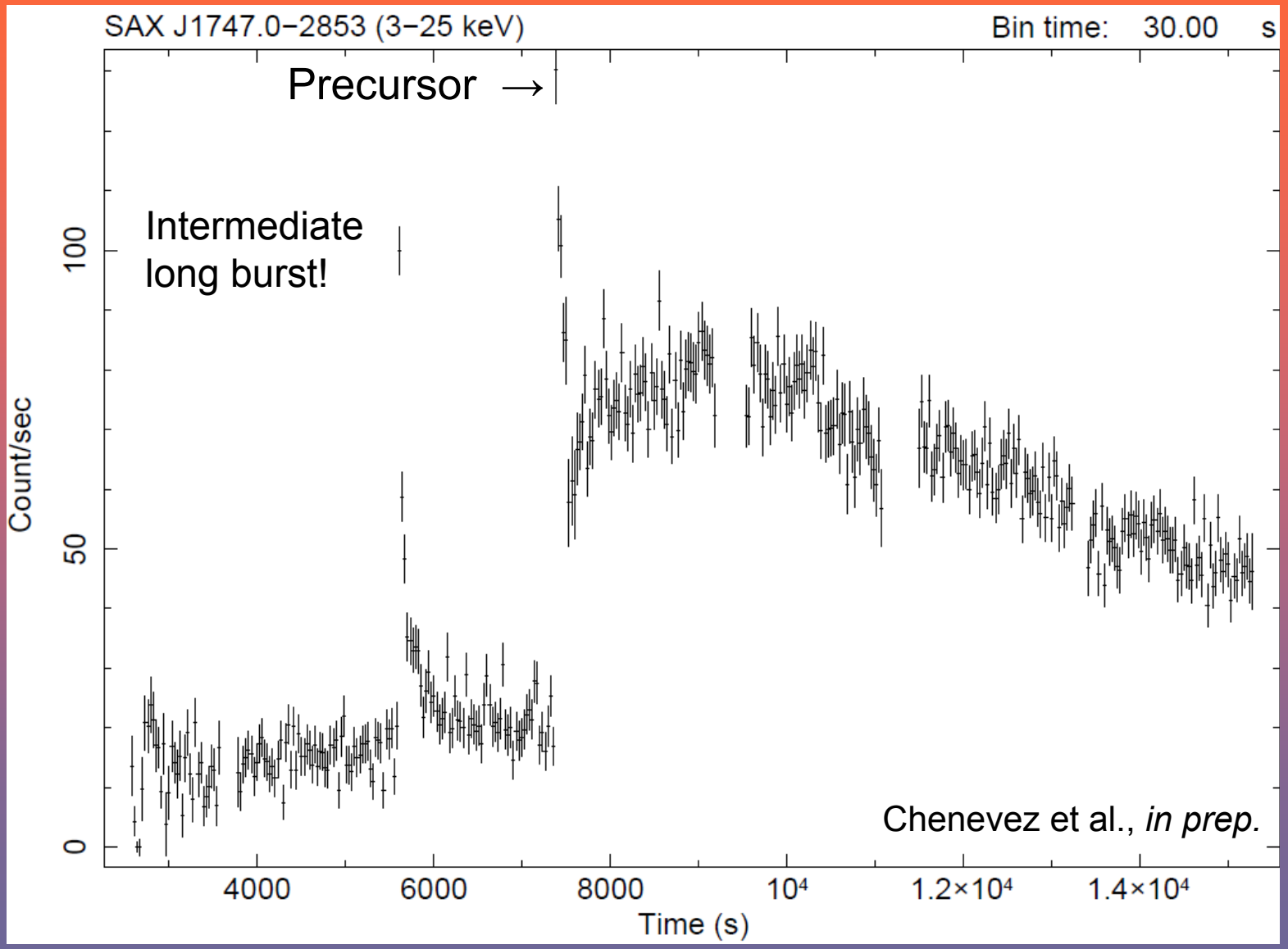


Chenevez et al., *in prep.*

Jérôme Chenevez, DTU Space,
Technical University of Denmark

To-date last observed superburst

SAX J1753.0-2853 on February 13th



Jérôme Chenevez, DTU Space,
Technical University of Denmark

To-date last observed superburst

SAX J1753.0-2853 on February 13th

An exceptional sequence of events:

1. ATel 3162 : "*Fermi LAT detection of an outburst from the Galactic center region*"
   ≈20s **GeV** burst 3 days prior to the superburst.

2. ATel 3163 : "*Swift/XRT detects SAX J1747.0-2853 in outburst*"
   Associates this source with the origin of the LAT burst.

3a. ATel 3172* : *"INTEGRAL sees continuing activity from SAX J1747.0-2853"*
   Reports only on strong X-ray flaring activity!

3b. ATel 3183* : "*First superburst observed by INTEGRAL, from SAX J1747.0-2853*"
   Superburst preceded by an intermediately long burst.

4. ATel 3217 : *"SAX J1747.0-2853: 'normal' thermonuclear bursts resumed"*
   Burst quenching time upper limit of 25 days (as expected).

Jérôme Chenevez, DTU Space,
Technical University of Denmark

To-date last observed superburst
SAX J1753.0-2853 on February 13th

Summary

- First superburst observed from SAX J1753.0-2853 – *early* in outburst
- 2nd superburst so far from a (normal) X-ray *transient* (4U1608-52 in 2005)
- 2nd shorter quenching time (4U 0614+09 : 19 days)
- Photospheric Radius Expansion (TBC)
- Peculiar start of the outburst with a GeV event
- **First observation of a *firestarter*** (right heating / C supply conditions?)
- Need theoretical explanation from numerical simulations

Jérôme Chenevez, DTU Space,
Technical University of Denmark

CONCLUSIONS

Most intermediate bursts are observed from low luminosity sources and are interpreted as long pure He bursts. If no H is accreted, they are consistent with the burning of a slowly accreted, thick He layer, in Ultra Compact X-ray Binaries (UCXB) where the donor star is probably a degenerated helium white dwarf.

Of special interest are bursters showing events with very different durations, thus allowing us to study transitions between different nuclear burning regimes.

Depending on the actual accretion rate, either the burning of a large amount of H-rich material is triggered by an He flash, or a thick sedimented column of He is triggered by weak H ignition.

Relation with superbursts…?

Jérôme Chenevez, DTU Space,
Technical University of Denmark