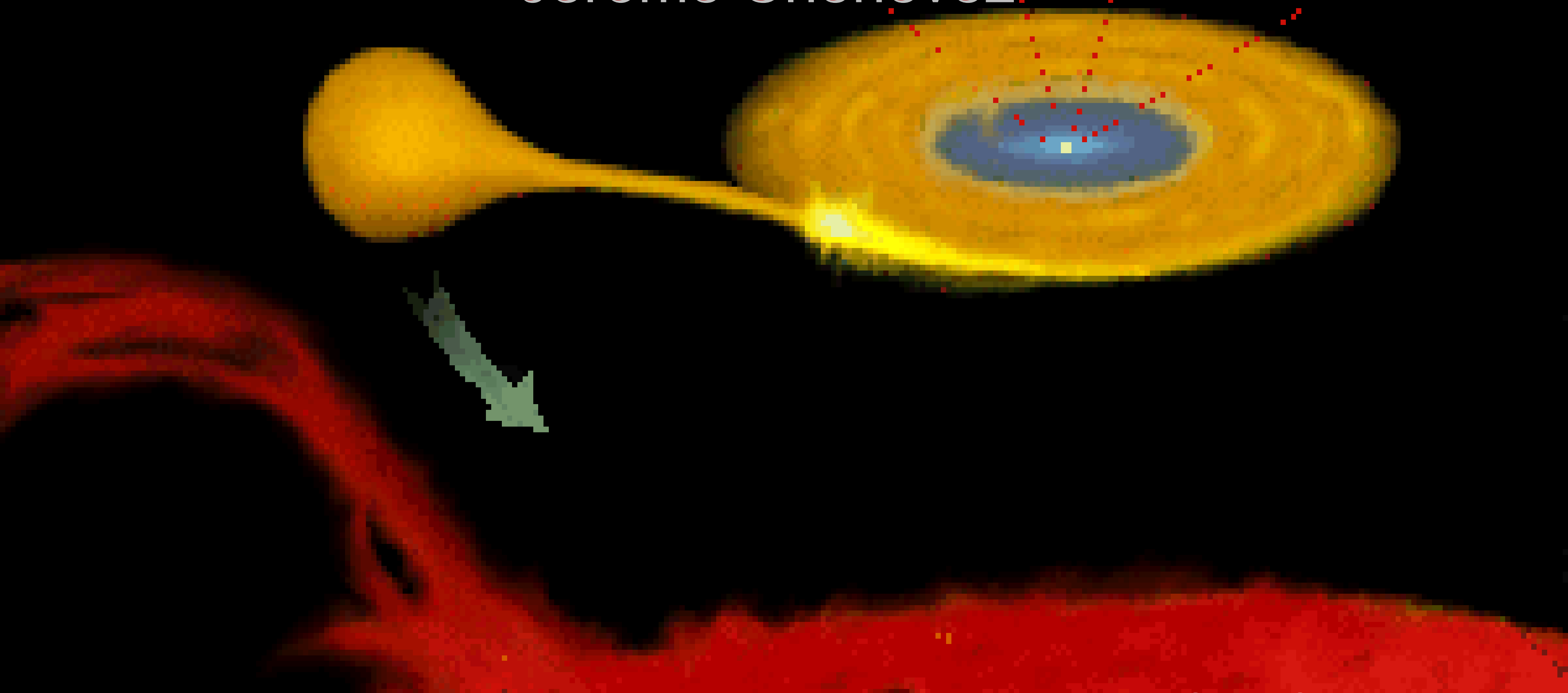
DTU Space
National Space Institute

# INTEGRAL observations of long X-ray bursts

Jérôme Chenevez



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# INTEGRAL observations of long X-ray bursts

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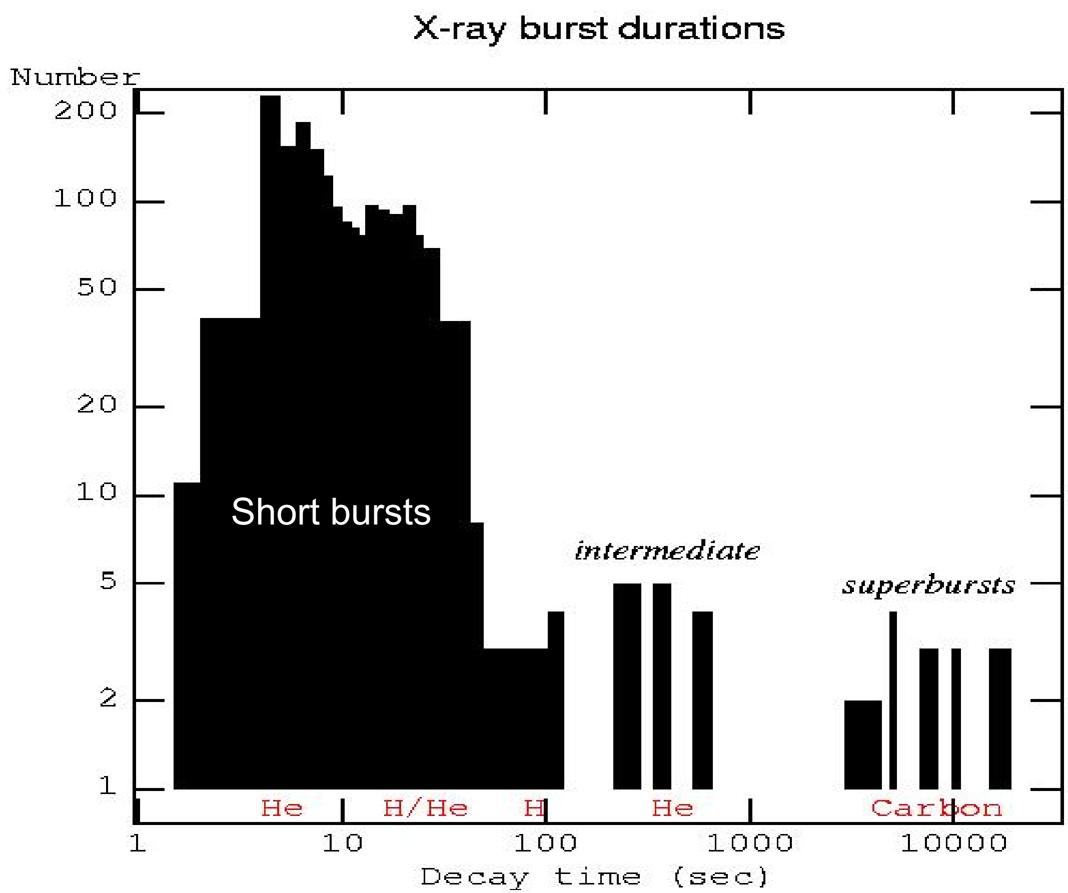
# MOTIVATION

## More or less long bursts



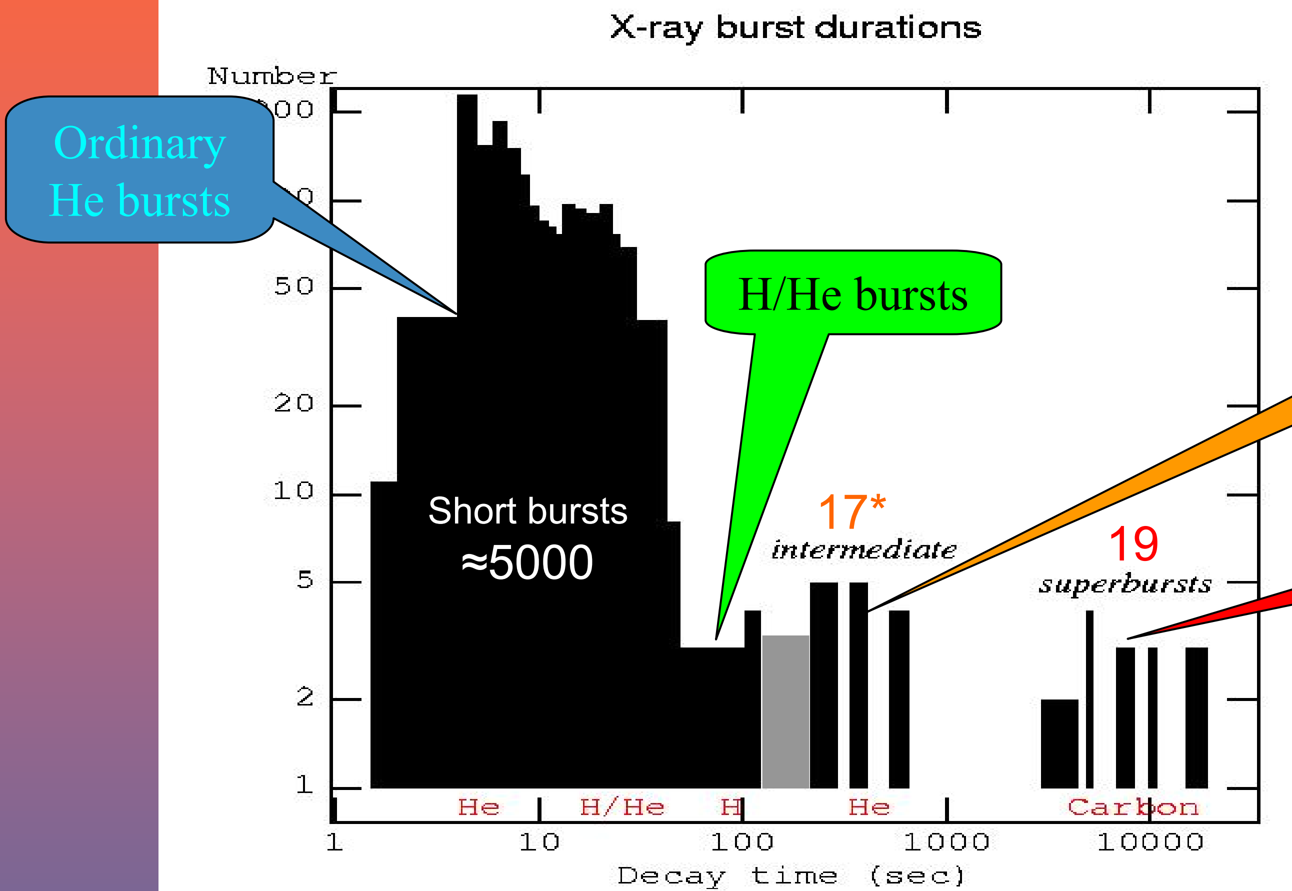

Distribution of *all* (MINBAR*) X-ray bursts as a function of their exponential decay time

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




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

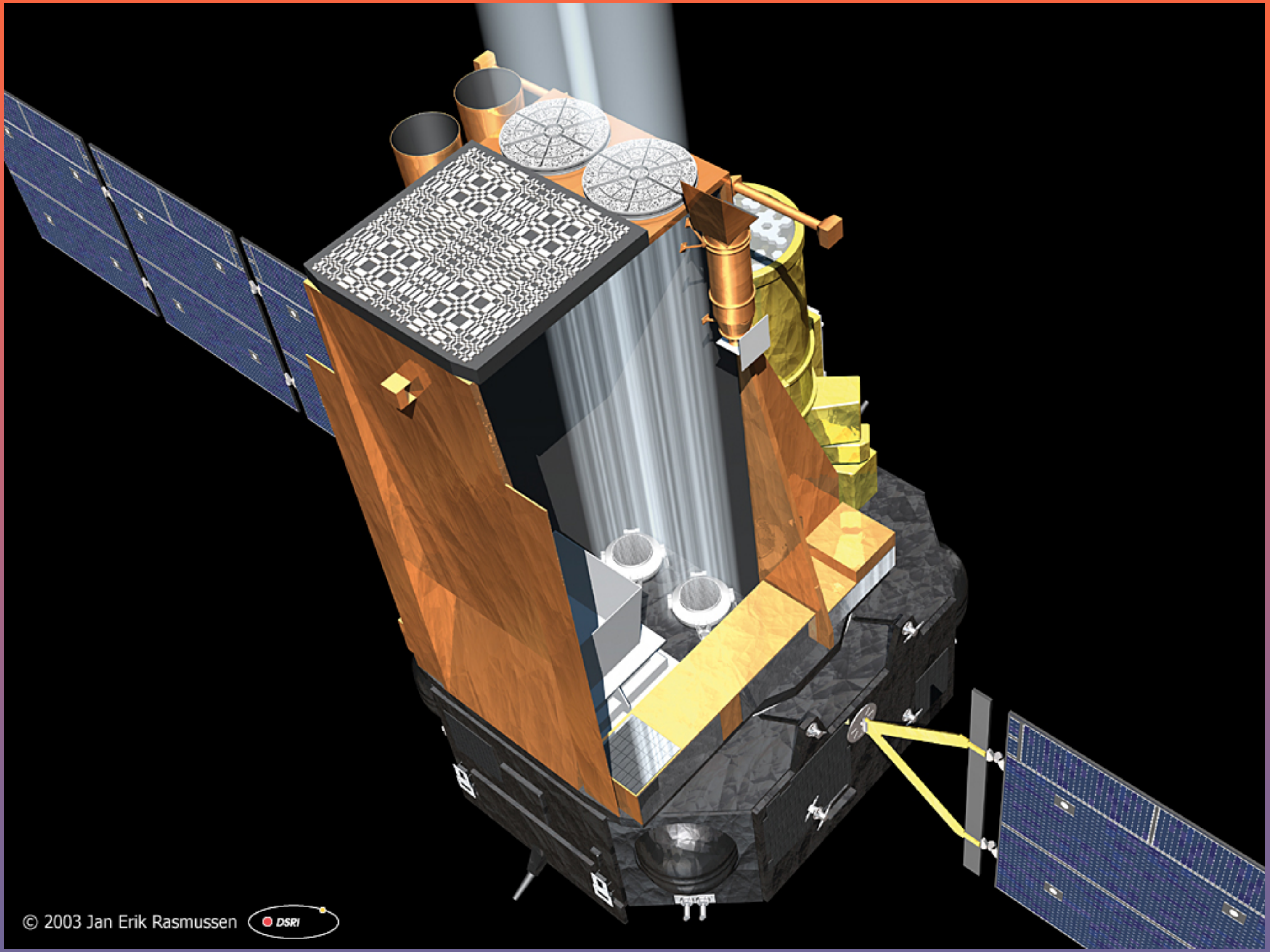
***Intermediate long bursts: duration > 12 min**

From 14 sources

**From 11 sources**

*Multi-Instrument Burst Archive in collaboration with D. Galloway, J. in ‘t Zand, et al.

# INTEGRAL

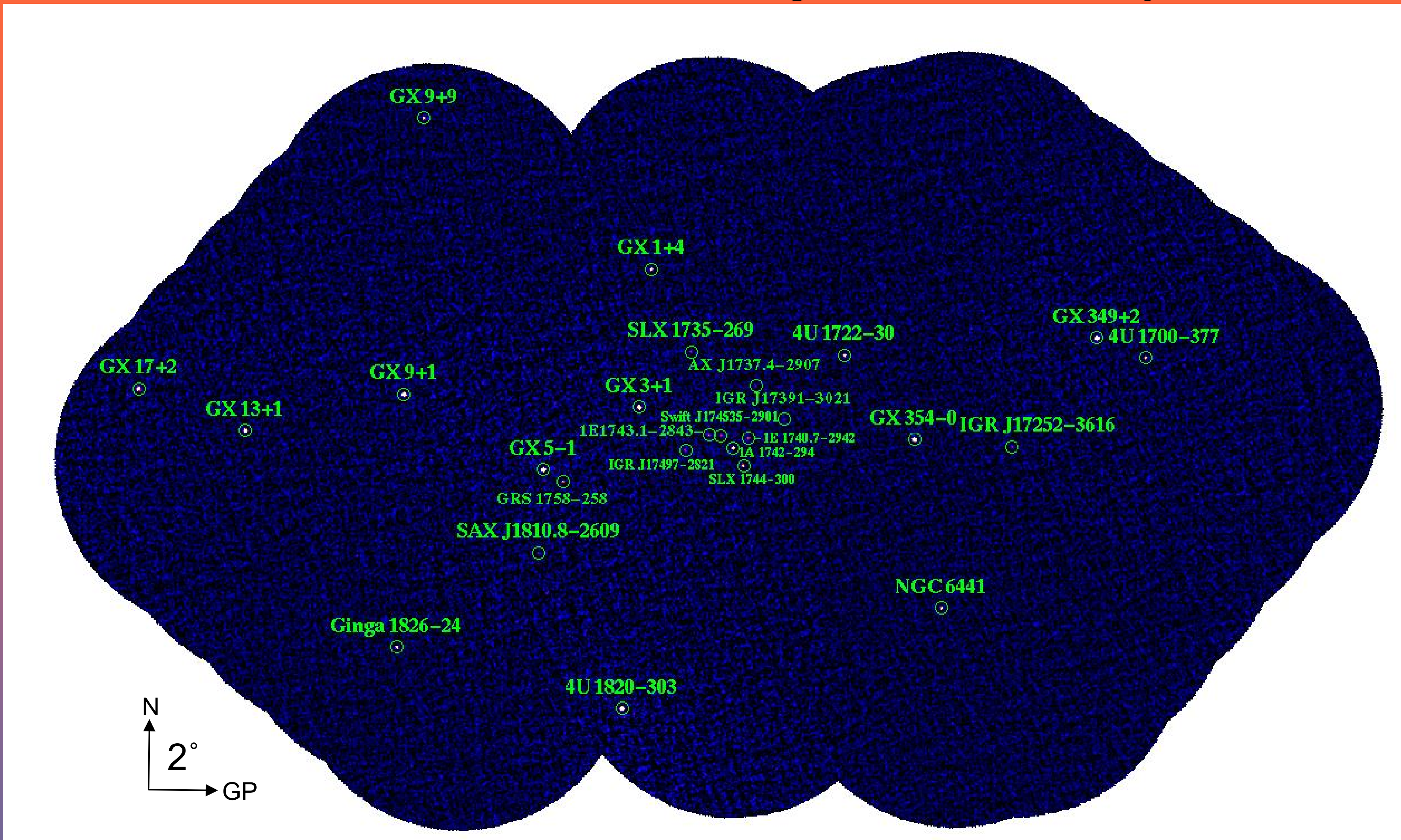



**JEM-X** :
100 cm$^2$ @ 10 keV
**3-25 keV**
FoV: 5º,   3' reso.

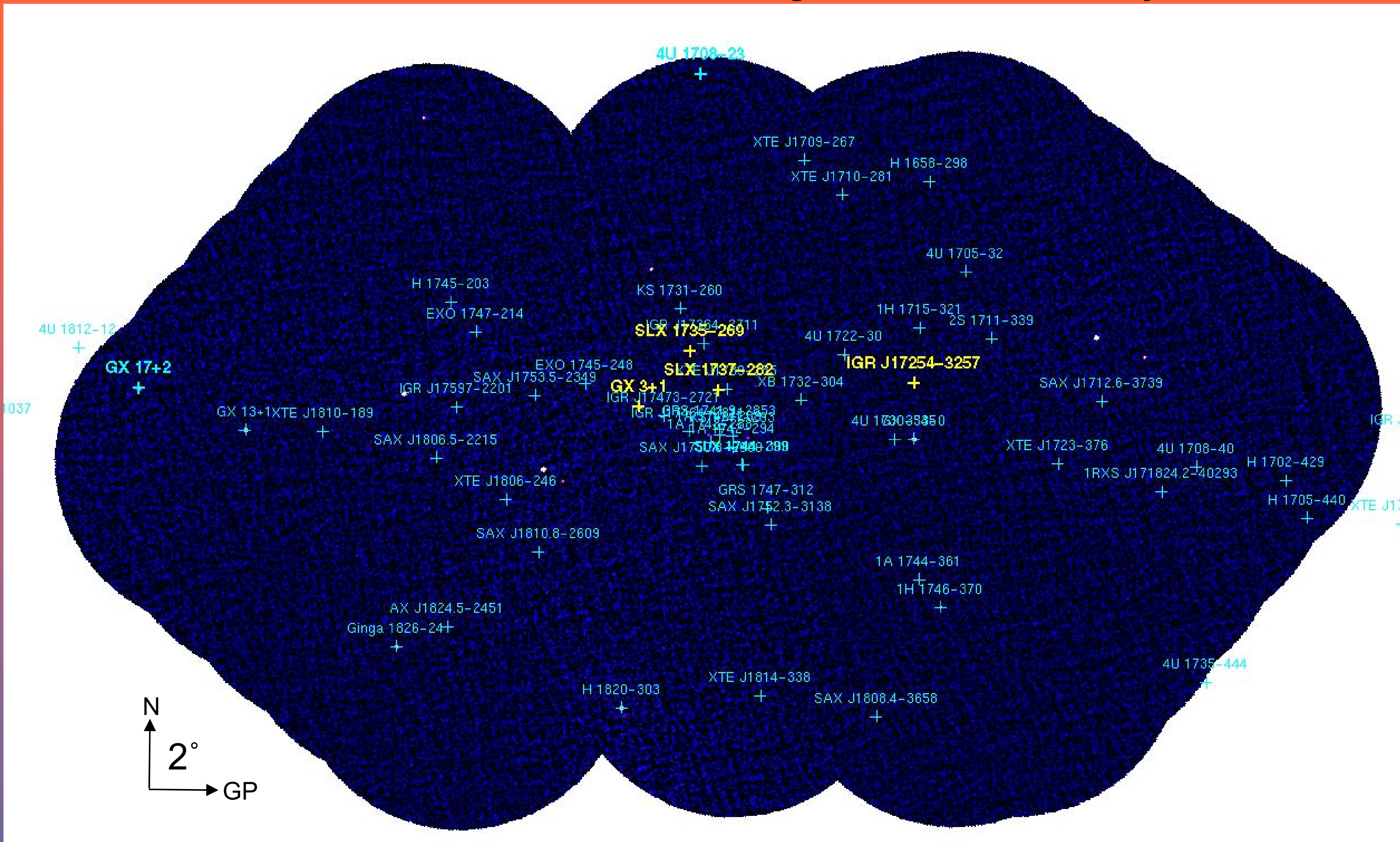
IBIS :
1000 cm$^2$ @ 20 keV
18 keV – 10 MeV
FoV ≈ 12º

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

# The Galactic Center region as seen by JEM-X

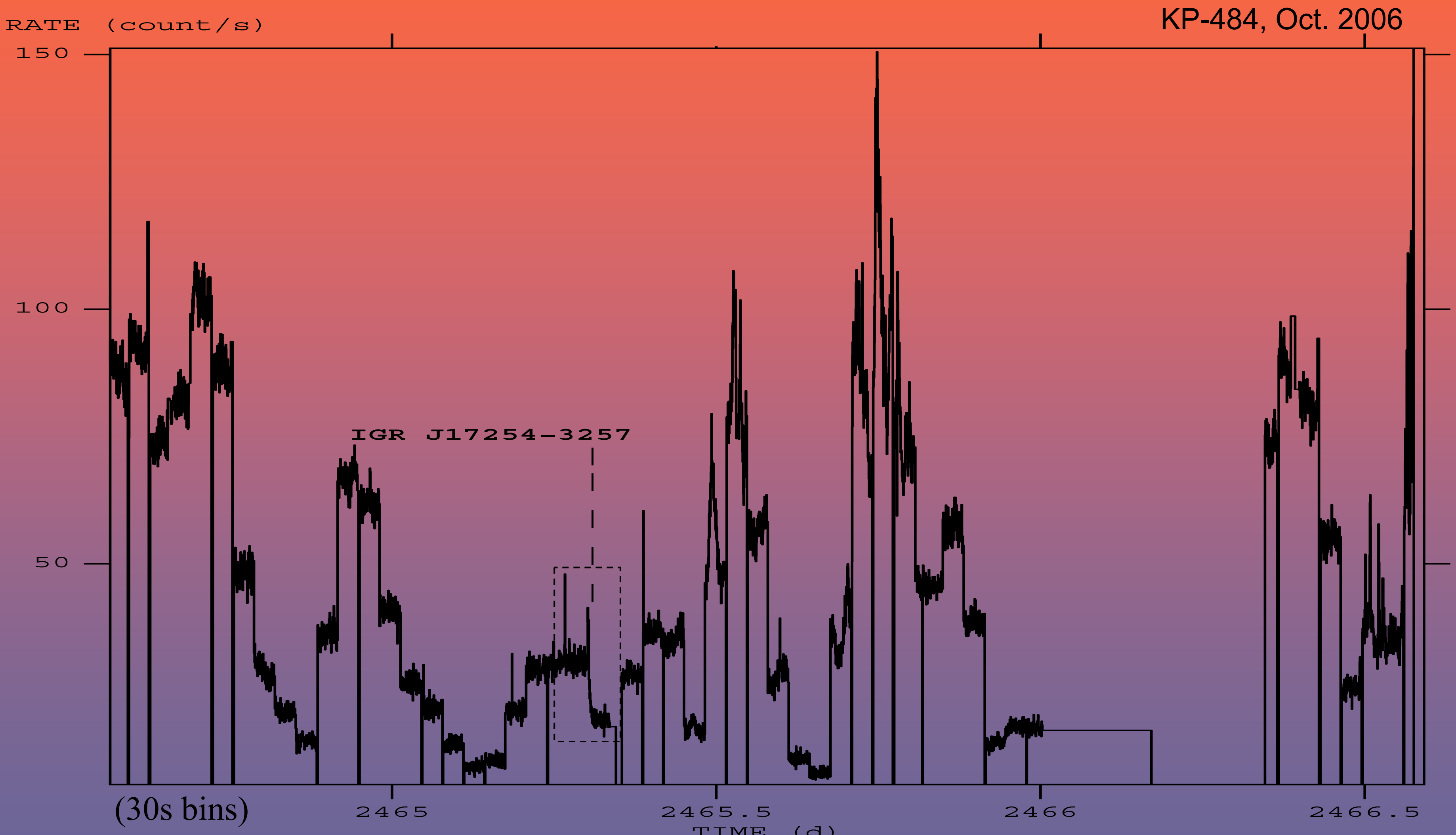


# The Galactic Center region as seen by JEM-X

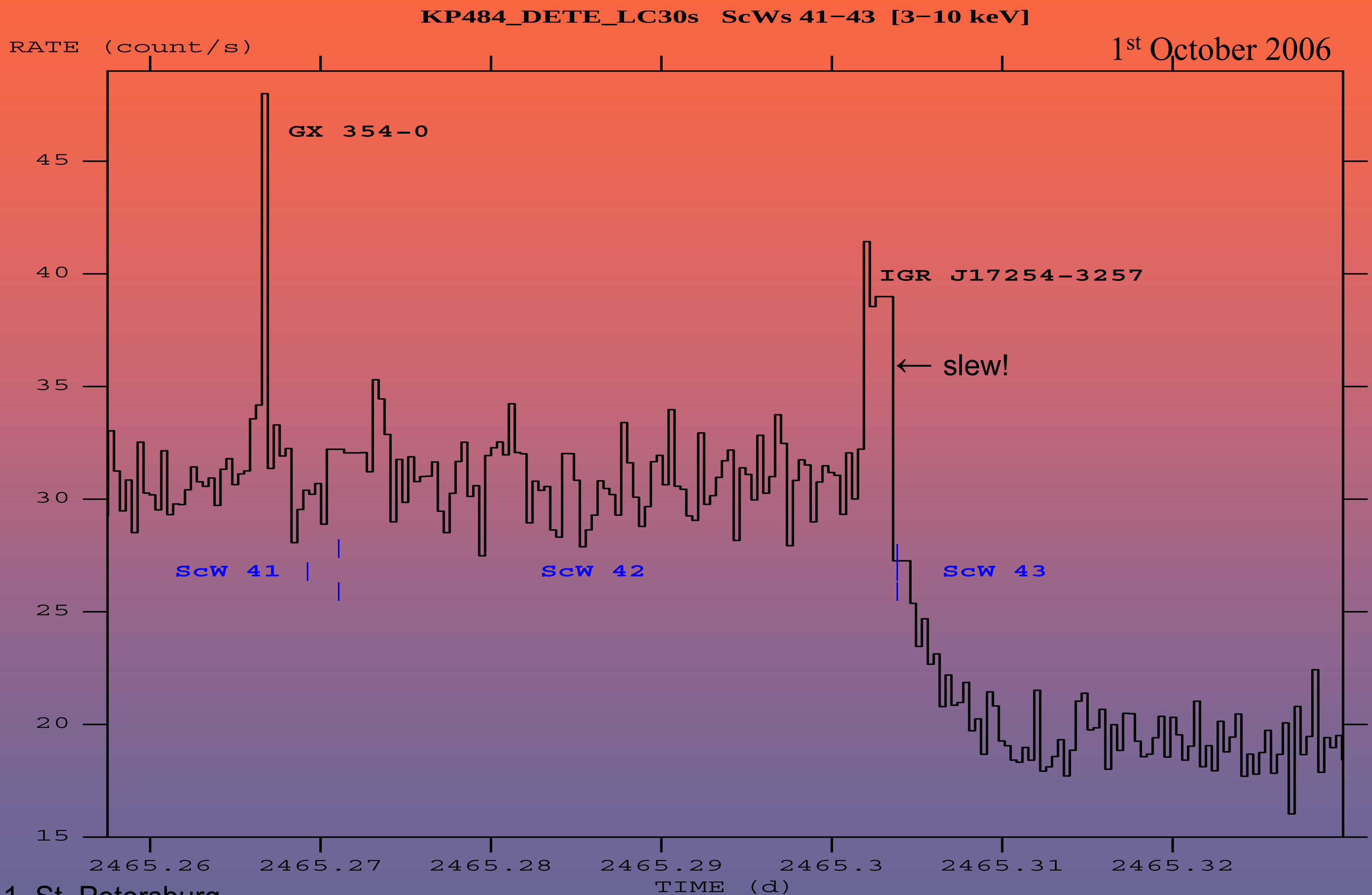



94 X-ray bursters known to date; ≈2/3 located in the Galactic Bulge region

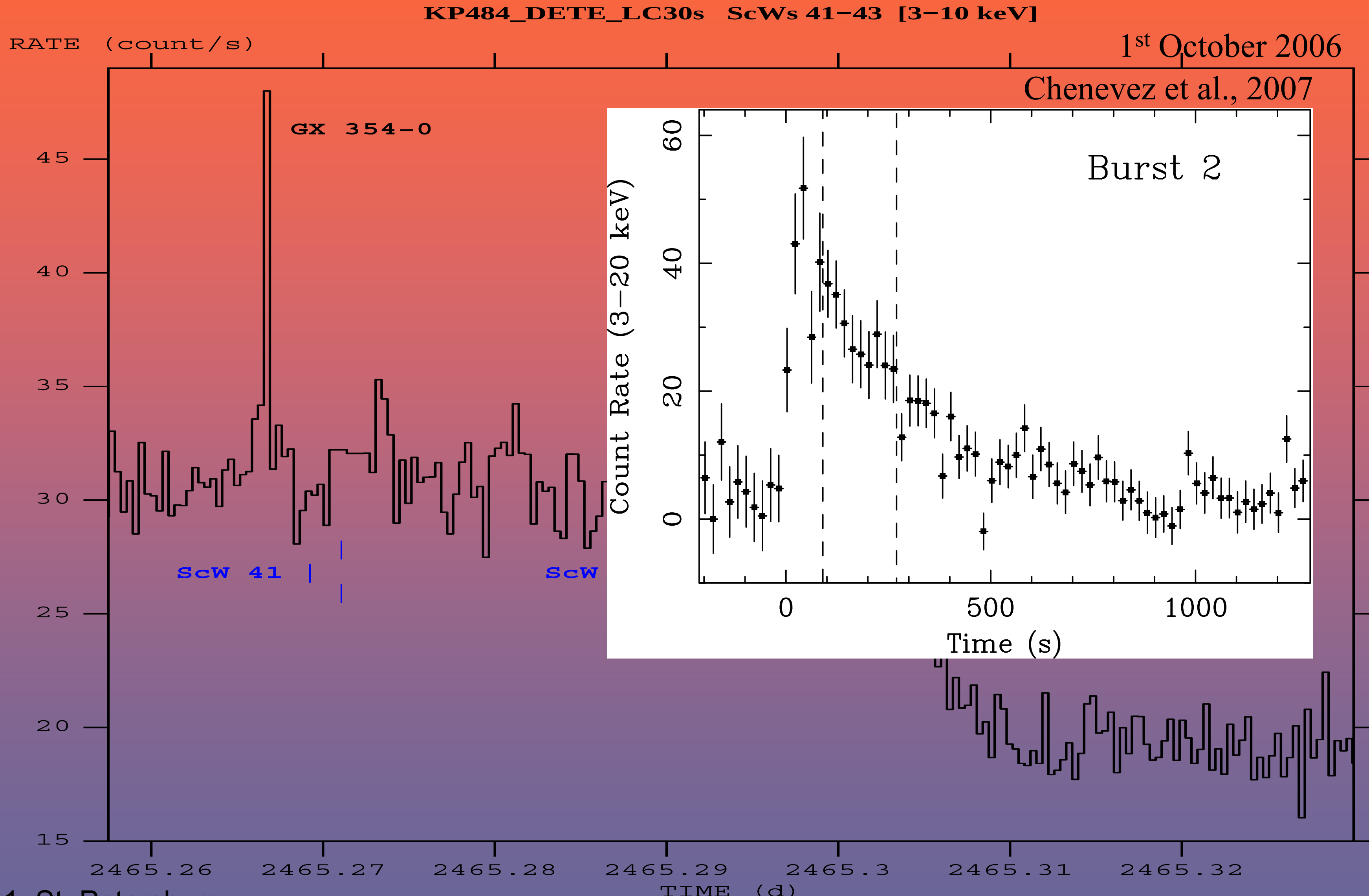
# Example of burst detections in **JEM-X detector light curve**



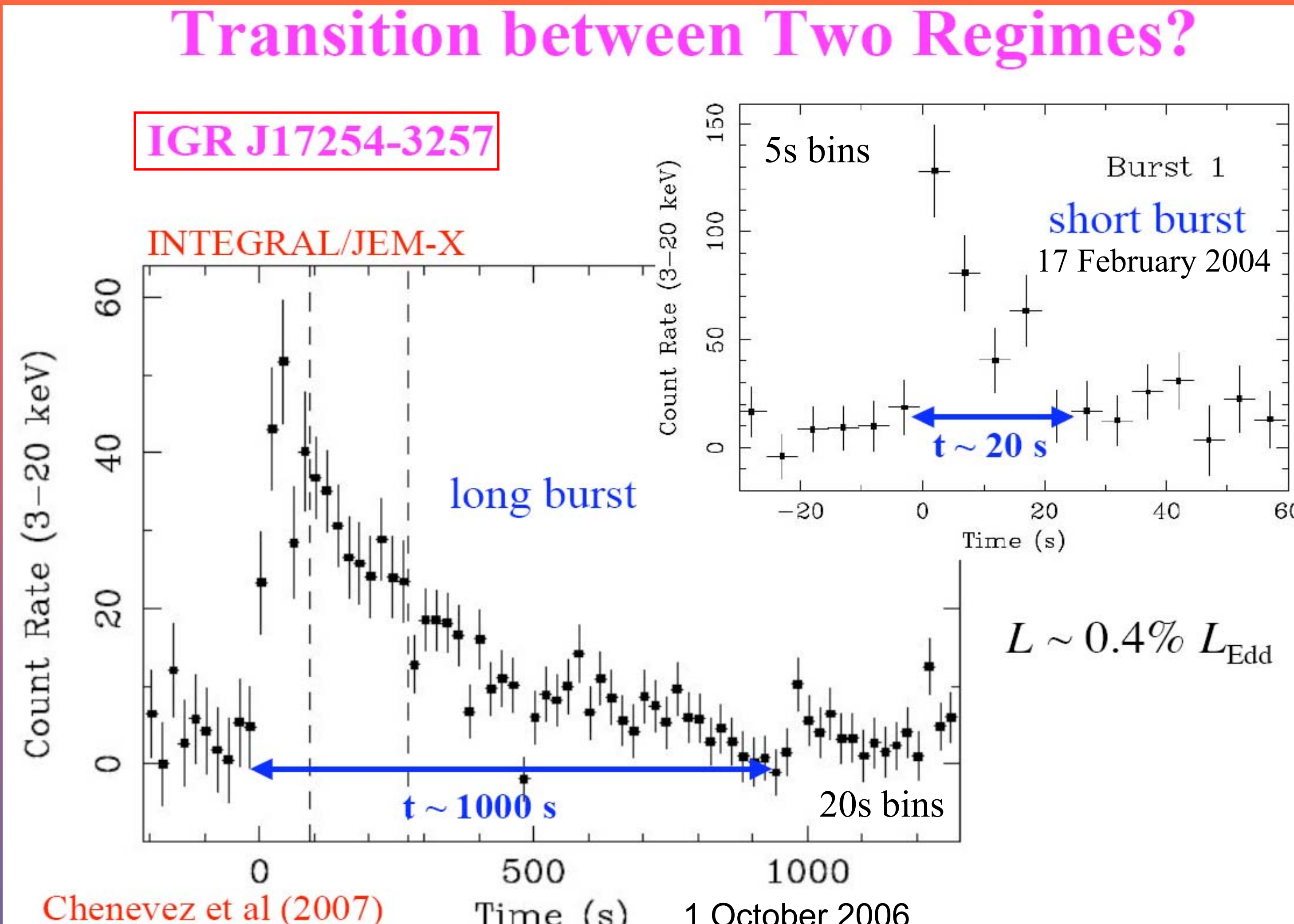
# Long burst from IGR J17254-3257



# Long burst from IGR J17254-3257



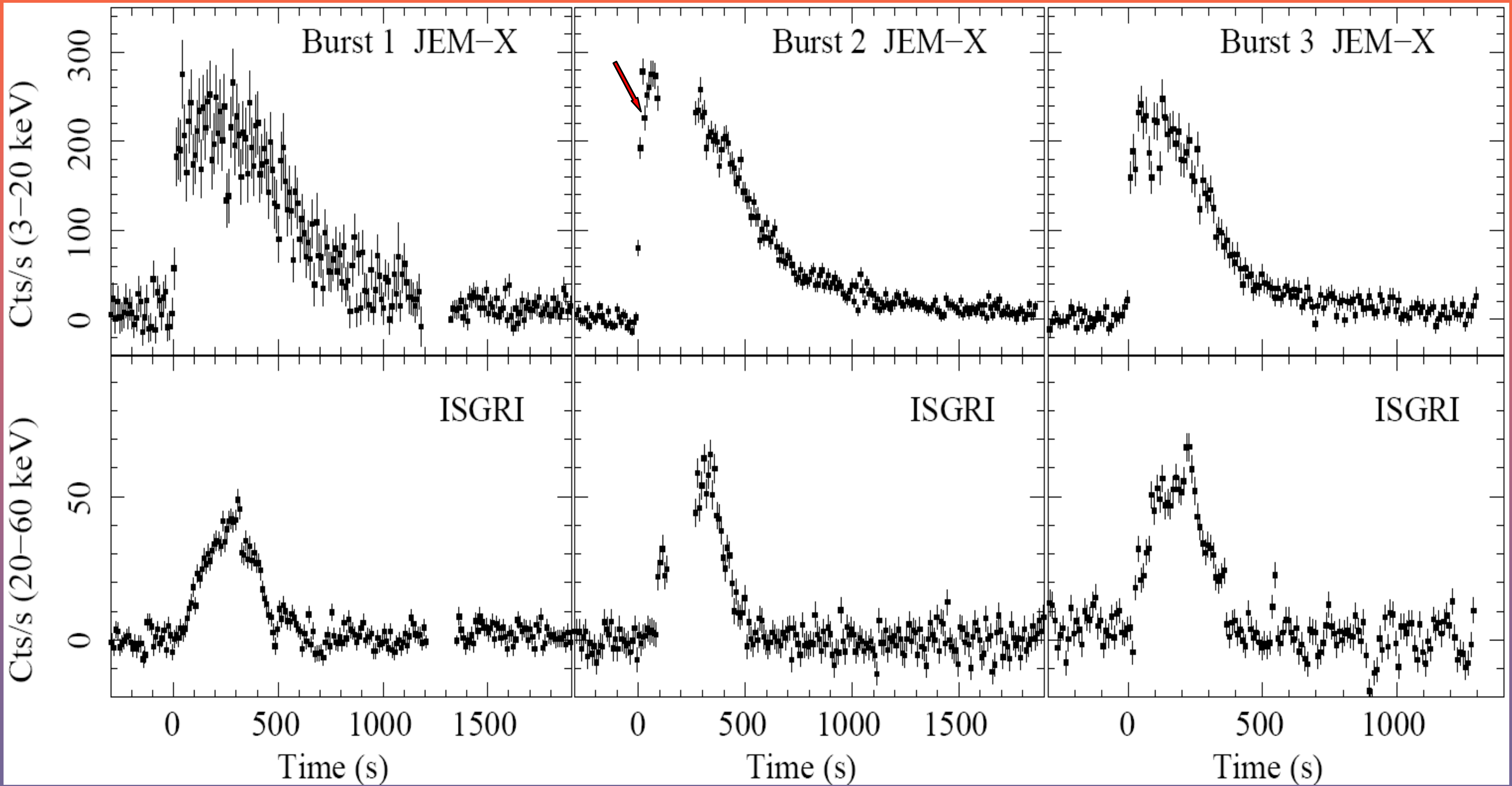
# Long burst from IGR J17254-3257




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!

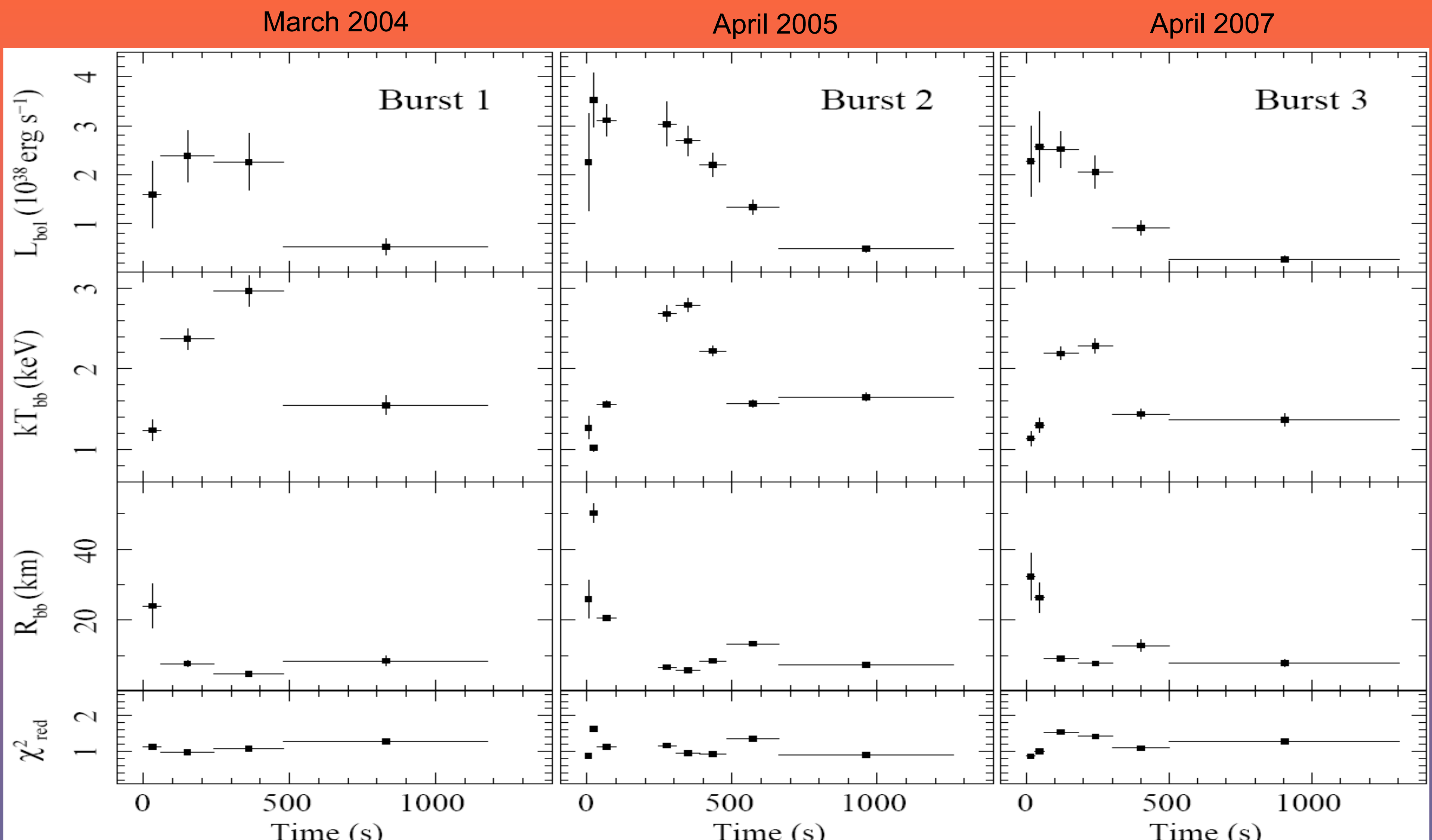
March 2004 | April 2005 | April 2007




10s bin light-curves

(Falanga, Chenevez, et al., 2008)

# SLX 1737-282
# Time-resolved spectral analyses



# SLX 1737-282
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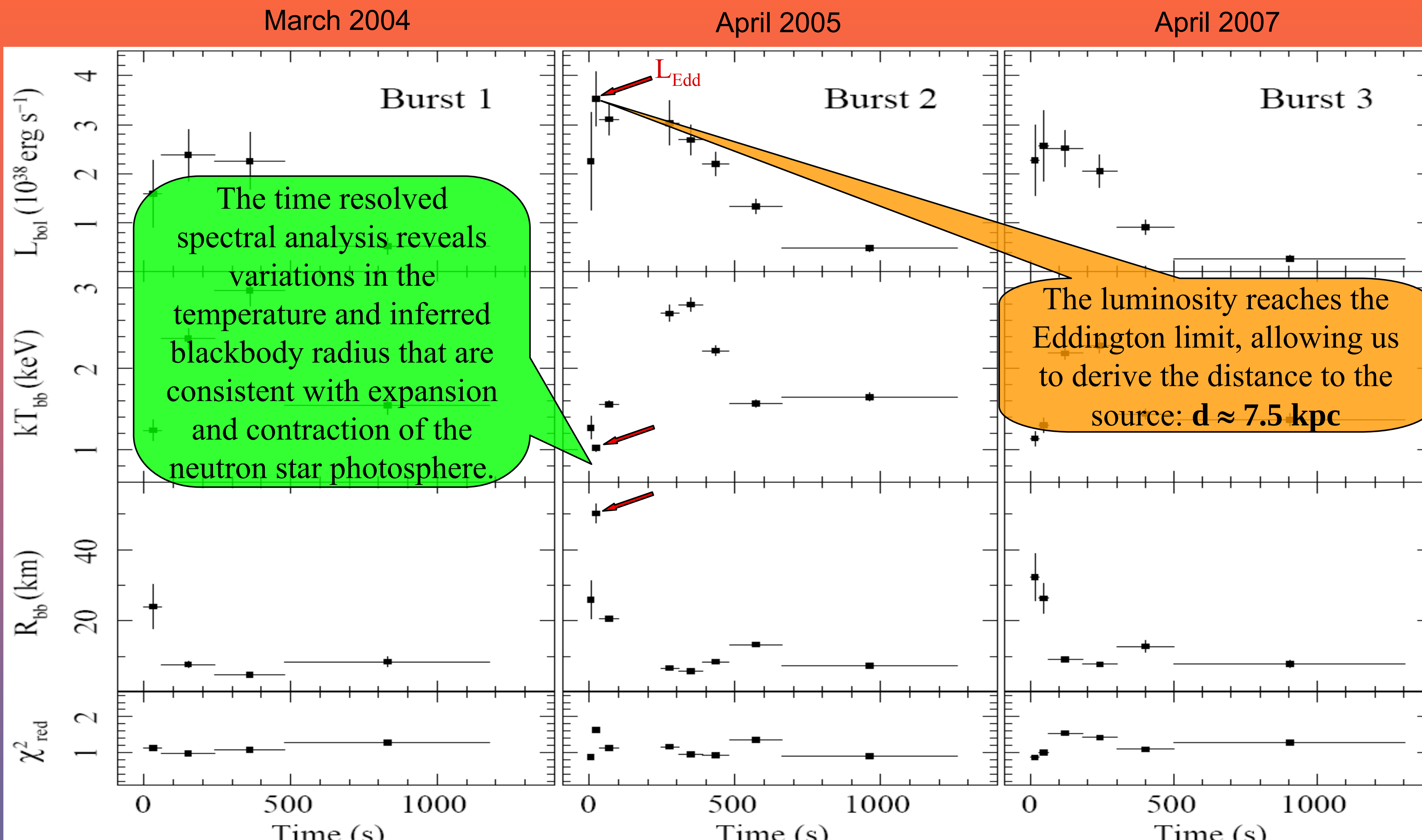


# SLX 1735-269
# The first long burst detected by INTEGRAL

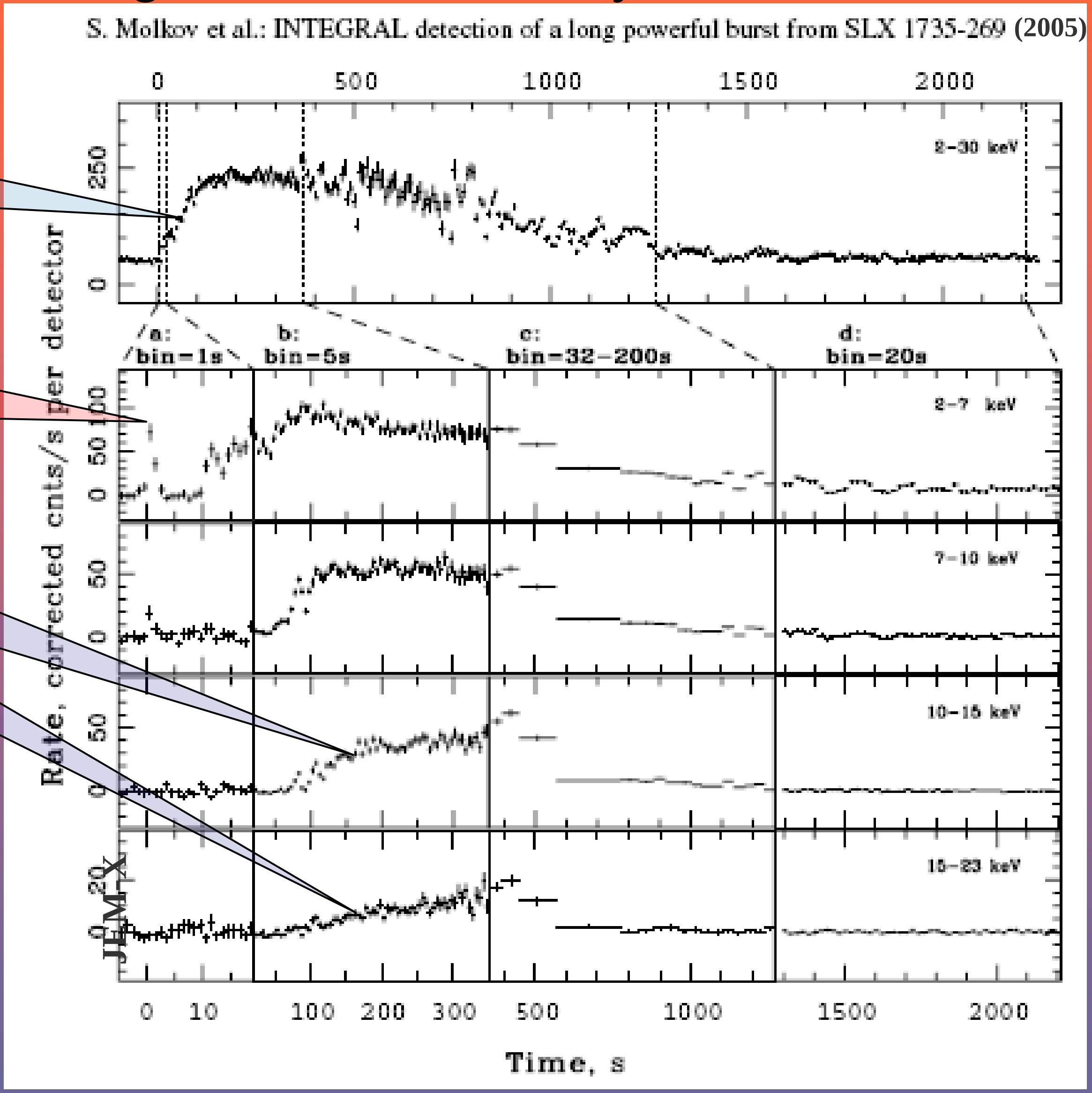
15 September 2003

Long rise

Large radius expansion followed by contraction.

Soft precursor

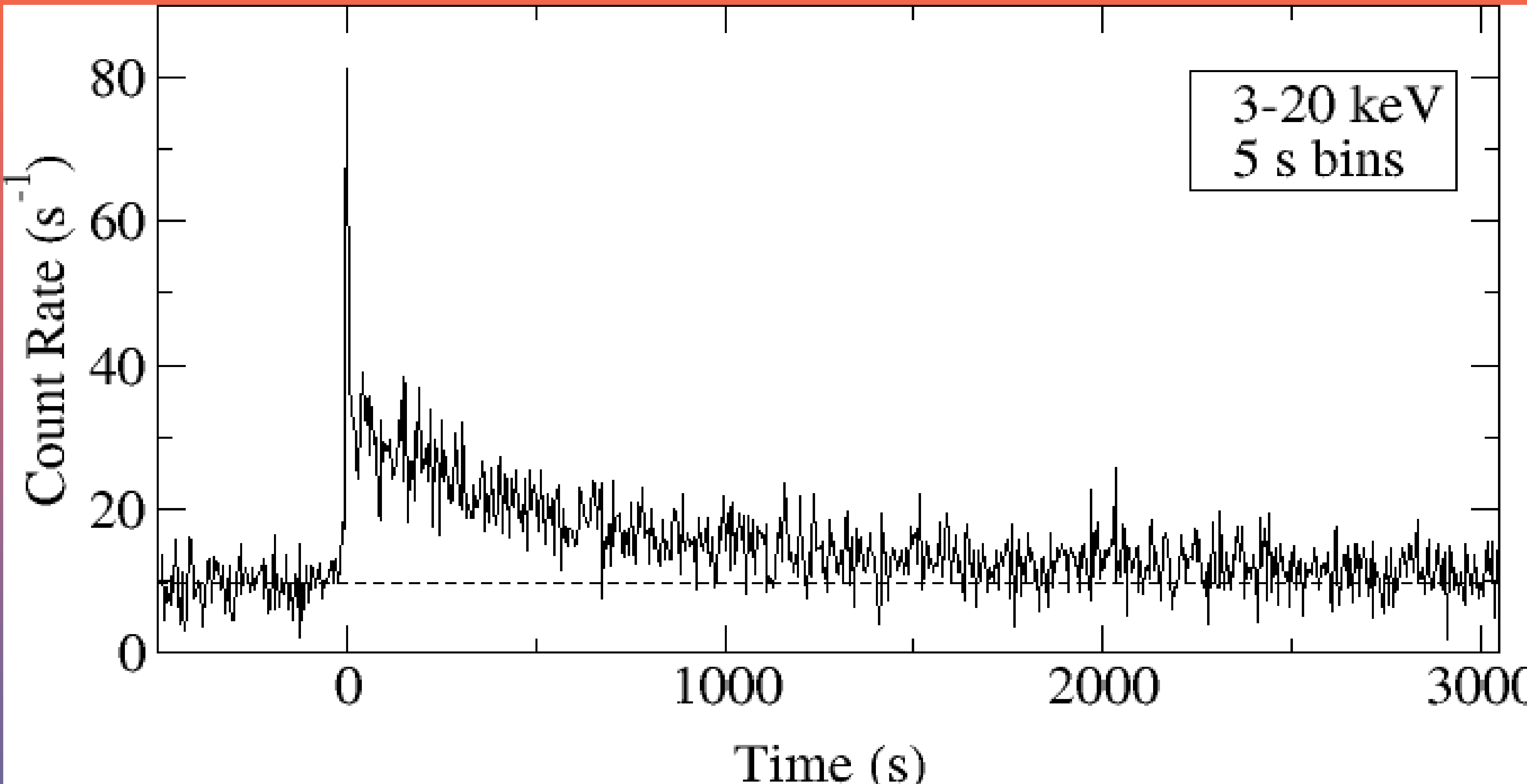
Progressive hardening




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

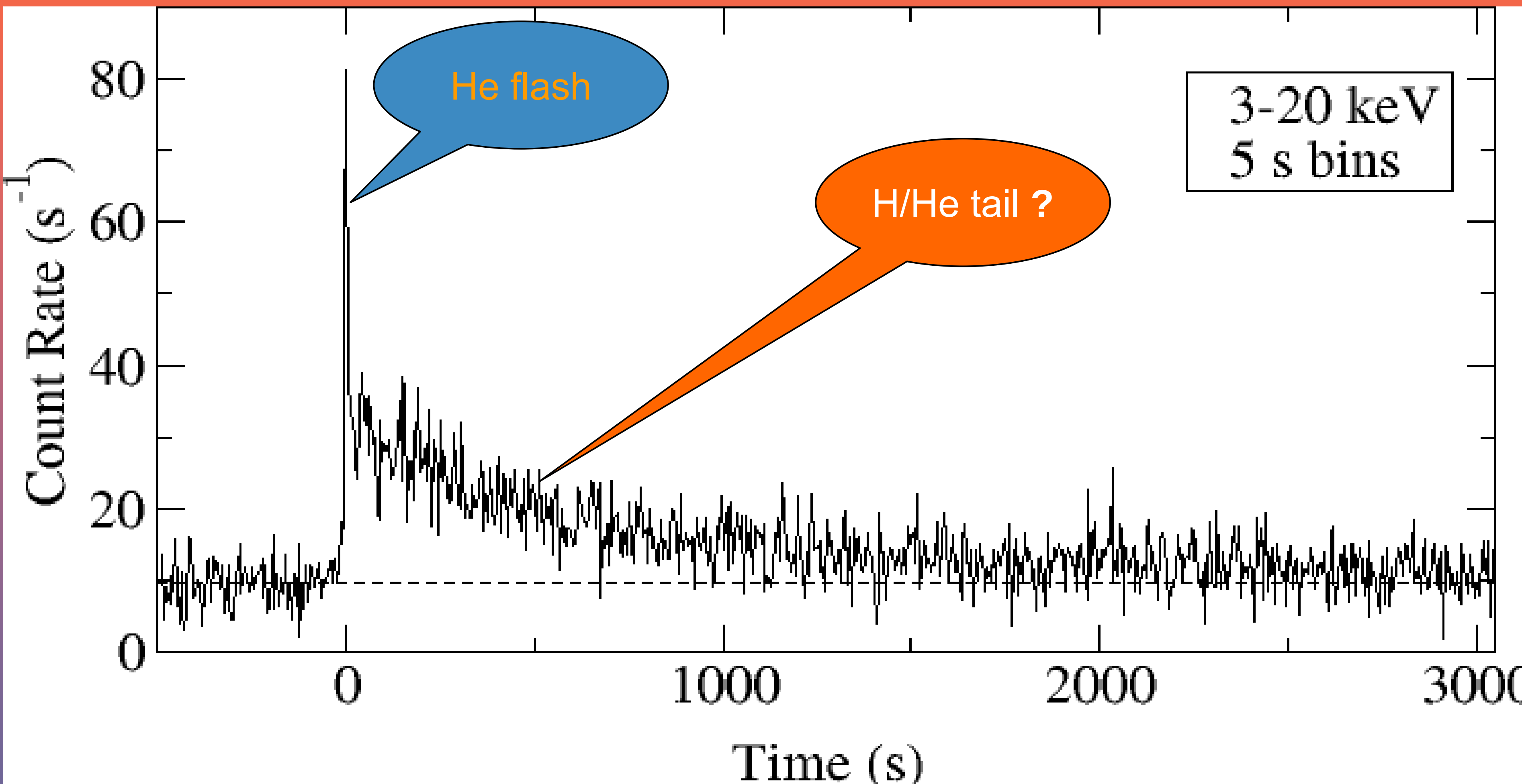
(Chenevez et al., 2006)



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

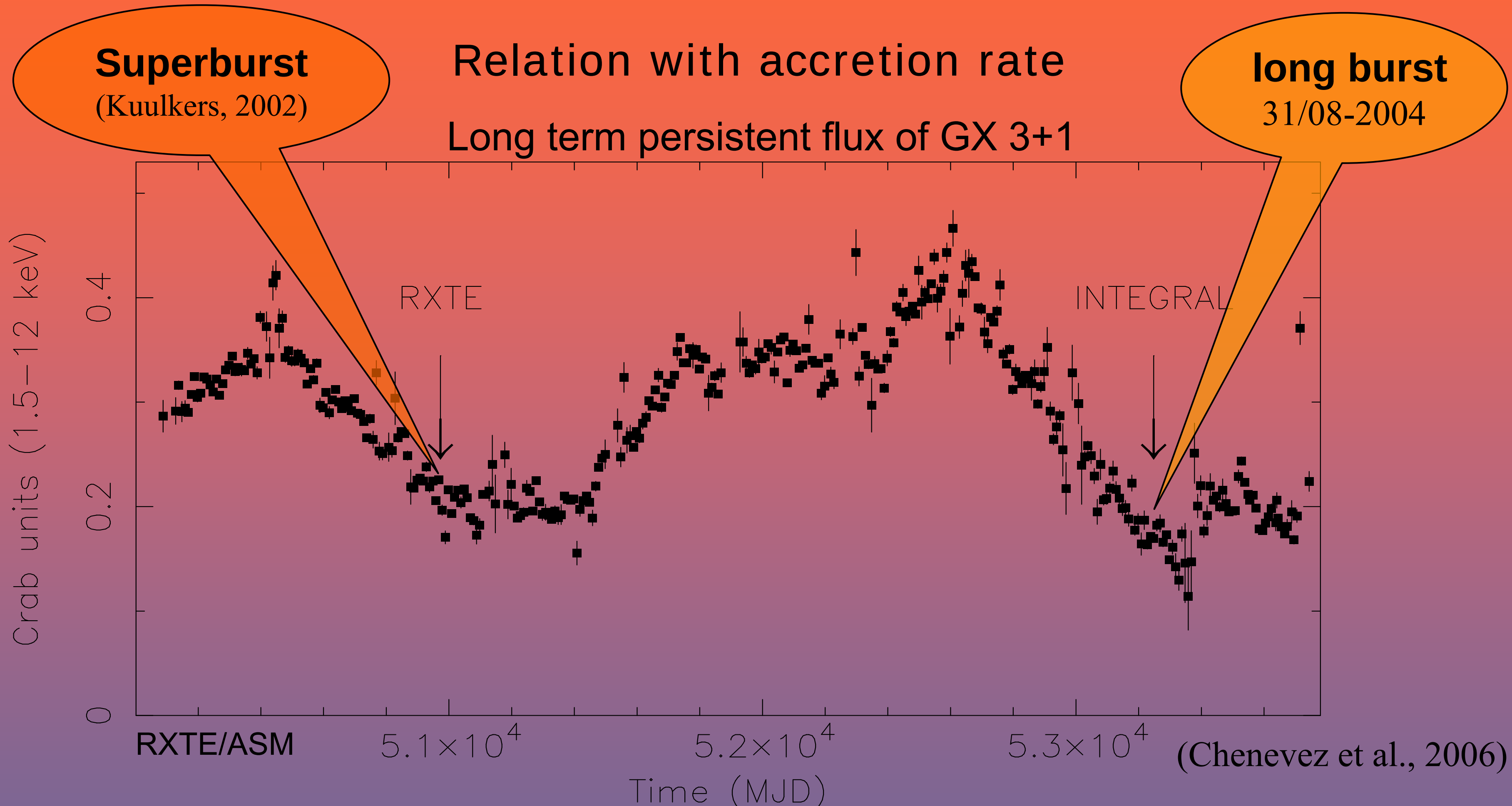
Two-phases burst

(Chenevez et al., 2006)



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

## Relation with accretion rate




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

# 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**

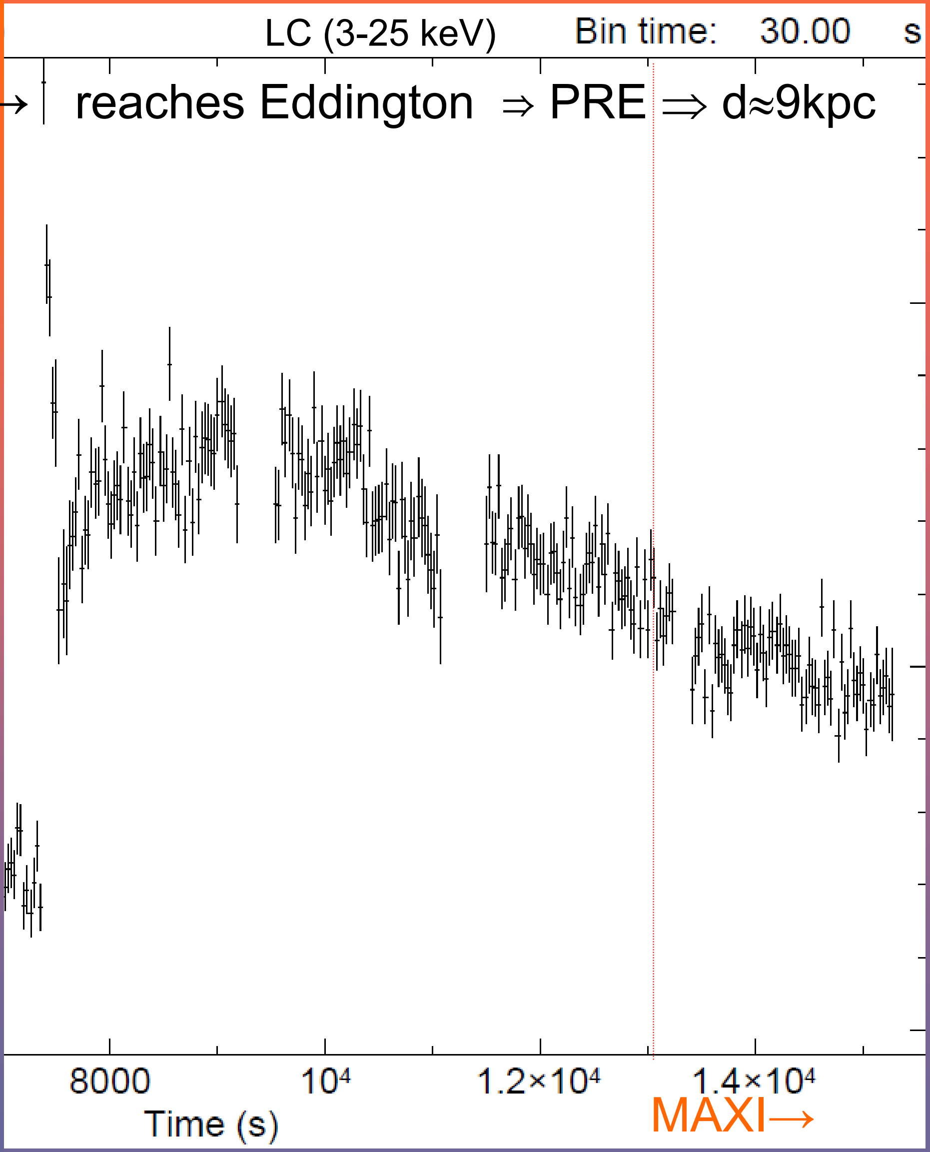
| Source | Date | $T_b$ (s) \| $\tau$ (s) | $E_b$ (erg) | Acc. Rate* ($g/cm^2/s$) | Burning | Reference |
|---|---|---|---|---|---|---|
| GX 3+1 | 20040831 | 1800 \| 131 | $2 \cdot 10^{40}$ | 10 000 | He / H | Chenevez et al., 2006 |
| IGR J17254-3257 | 20061001 | 900 \| 216 | $2 \cdot 10^{40}$ | 400 | (H⇒)He | Chenevez et al., 2007 |
| SLX 1737-282 | 20040309<br>20050411<br>20070402 | 1500 \| 275<br>1800 \| 323<br>~900 \| 281 | $0.7 \cdot 10^{41}$<br>$1.2 \cdot 10^{41}$<br>$1.0 \cdot 10^{41}$ | 800 | He<br>He<br>He | Falanga, Chenevez et al., 2008 |
| 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)

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

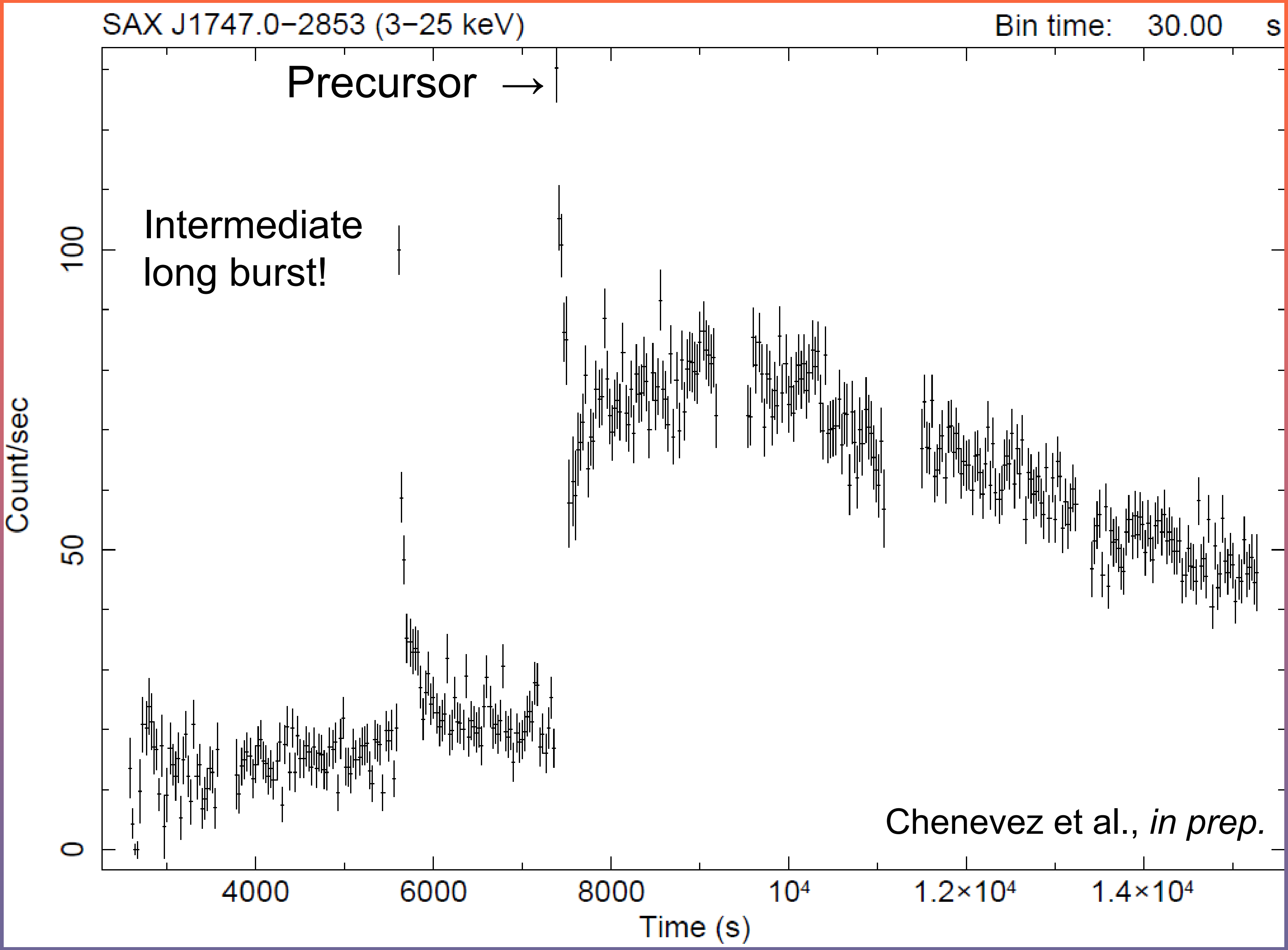
Chenevez et al., ATel 3183




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.*

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



# 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 <u>3 days</u> 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).

# 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

# 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…?