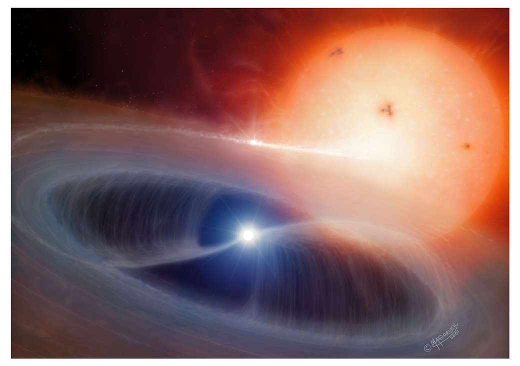


JEM-X observations of GRO J1744-28, the bursting pulsar, during the 2014 outburst

C. Sánchez-Fernández, N. Masetti, P. Parsi, E. Kuulkers, M. Fiocchi

1. Introduction: GRO J1744–28

The bursting pulsar GRO J1744–28 is a unique source that presents both the characteristics of a Type II X-ray burster and an X-ray pulsar.

- Basic facts:

- GRO J1744-28 is a **467 ms X-ray pulsar** in a Low Mass X-ray binary (LMXB) system with an **orbital period of 11.8 days** (Finger et al. 1996).
- The neutron star (NS) posseses a **strong magnetic field ($B \sim 10^{11}$ G**; Cui 1997, Rappaport & Joss 1997).
- GRO J1744-28 displays a extremely low mass function, which implies a very low mass companion star (**$M_c \approx 0.07\ M_\odot$** for M_{NS} = 1.4 $M_\odot$ and i≈ 52°; Degenaar et al. 2014) and suggests that **significant mass transfer to the NS has happened over the system evolution, this is not compatible with the system strong magnetic field and spin frequency**, according to evolutionary models.

- Type II bursts:

- Type II bursts are accretion powered bursts possibly resulting from spasmodic accretion onto the neutron star. The only other LMXB known to display Type II X–ray bursts is MXB 1730–335, the Rapid Burster.

- Bursting history:

- discovered in December 1995 by the Burst and Transient Source Experiment (BATSE) onboard the Compton Gamma-Ray observatory (CGRO), during a very intense bursting phase (~20 hard X-ray bursts per hour; Fishman et al, 1995). The source was active until April 1996. It was found that the X-ray bursts displayed pulsations with the same 467 ms period (Kouveliotou et al. 1996).
- A new outburst was detected on December 1996, when bursting activity was detected with a similar burst rate as in the previous outburst (Woods et al. 1999).
- After ~17 years of quiescence, the source experienced a new ouburst in January 2014 (Kennea et al. 2014; Negoro et al. 2014, Degenaar et al, 2014). We present here INTEGRAL/JEMX observations of the system during the 2014 outburst.

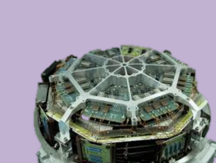
2. Observations

GRO J1744–28 was frequently observed by the INTEGRAL instruments during the 2014 outburst via ongoing monitoring programs around the Galactic Center Field. The source was also observed during dedicated Target of Opportunity observations (ToO).
In this work we study the evolution of burst activity in relation with the overall outburst evolution, as seen by The Joint European Monitor for X-rays (JEM-X; Lund et al, 2003). Analysis of the data from the Imager on Board the Integral Satellite (IBIS; Ubertini et al, 2003) is also being conducted (Sanchez-Fernandez et al, 2014).

- **JEM-X onboard INTEGRAL**

The Joint European Monitor for X-rays (JEM-X) on-board INTEGRAL is a coded-mask instrument which provides data in the 3-35 keV range.

Energy resolution (FWHM)	$\Delta E/E = 0.40 \times [(1/E\ \text{keV})+(1/8\ \text{keV})]^{1/2}$
Angular resolution (FWHM)	3' (1' Relative point source location error)
Field of view (diameter)	4.8° (Fully illuminated, 7.5° Half response)



Data Analysis

- The data were processed following standard OSA 10.0 procedures. Type-II X-ray burst and dip candidates were identified using our own code, procedures which allowed us to derive the relevant bursta and dip parameters parameters such as peak count rate, e-folding decay time, burst integrated count rate, and the source persistent emission by the time of burst detection. When possible, Good Timing Intervals (GTI) around the burst profile were generated, and the integrated burst spectrum was extracted, and fit.

3. Results

- 187 Type II X-ray bursts were detected by JEM-X during the INTEGRAL observations of GRO J1744–28 in the 2014 outburst (see figures 1 and 2).
- Each burst was followed by a dip in the X-ray light curve, when the source count rate decreased by up to ~50% of the pre-burst values, and then returned smoothly to pre-burst count rates (see figure 3). These dips are in agreement with the explanation of Type II X-ray bursts in terms of spasmodic accretion onto the NS.
- We have explored the relations between burst, dip and persistent emission properties. Preliminary results of this analysis are displayed in figure 4.
- The scientific analysis of these data is still ongoing.

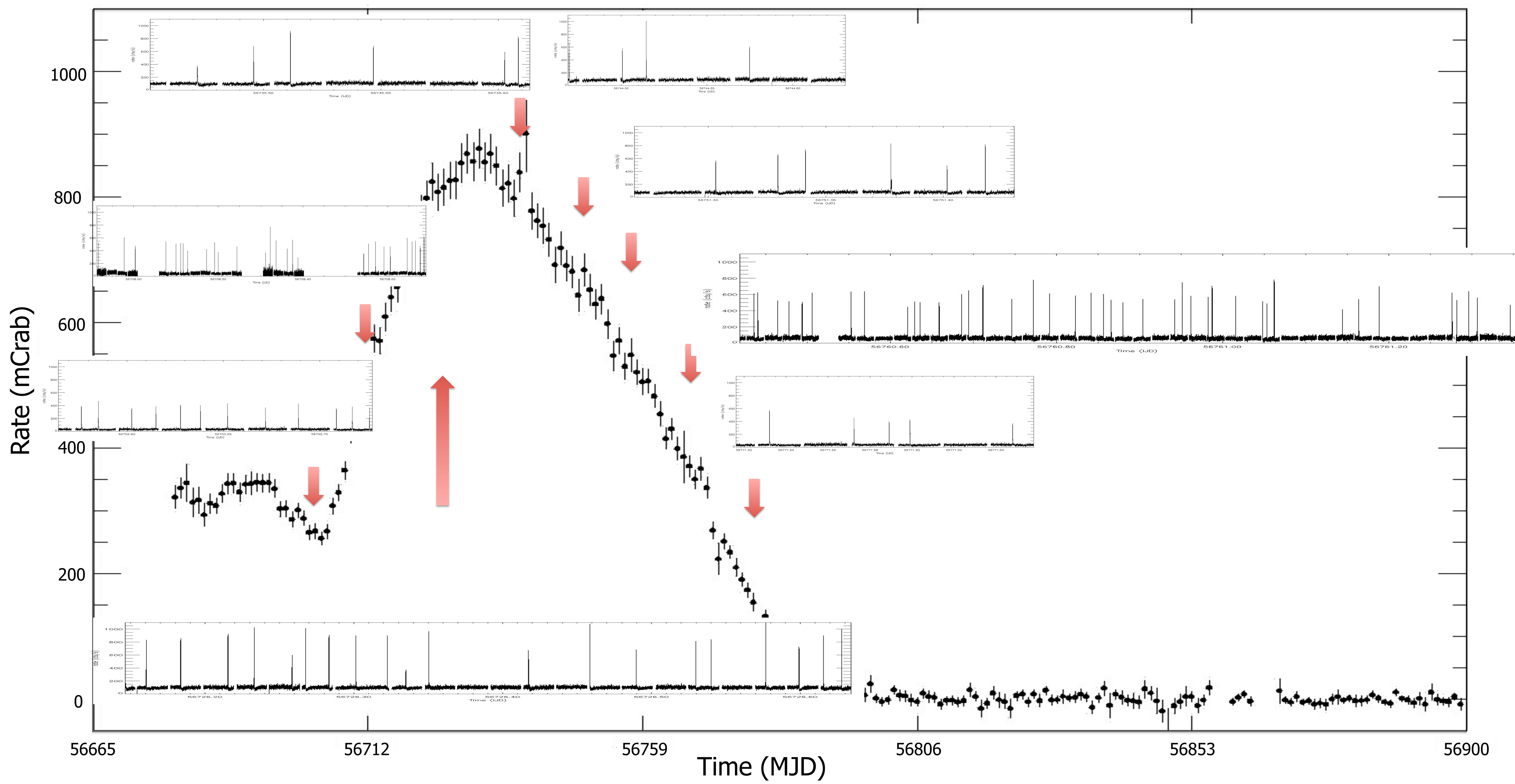


Figure 1. Overall Swift/BAT light curve of GRO J1744-28 during the 2014 outburst (15-150 keV, time resolution: 1 day). We mark with vertical red arrows the times of the INTEGRAL observations analyzed in this work. For each observation we display the system light curve as measured JEM-X (3-25 keV; 5-sec time resolution). The duration of the INTEGRAL observation ranges between ~4 and ~22 hours. Gaps in the data are due to spacecraft slewing during sucessive pointings of a dither pattern.

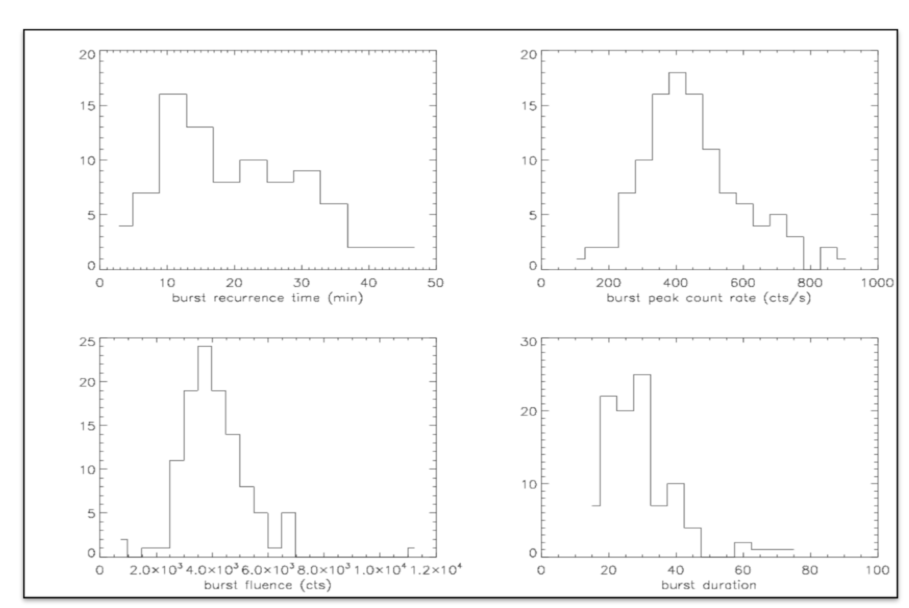


Figure 2. Distribution of the burst parameters derived in this study. We explore in this figure the main properties of the 187 Type-II X-ray bursts detected during the observations analyzed in this work.

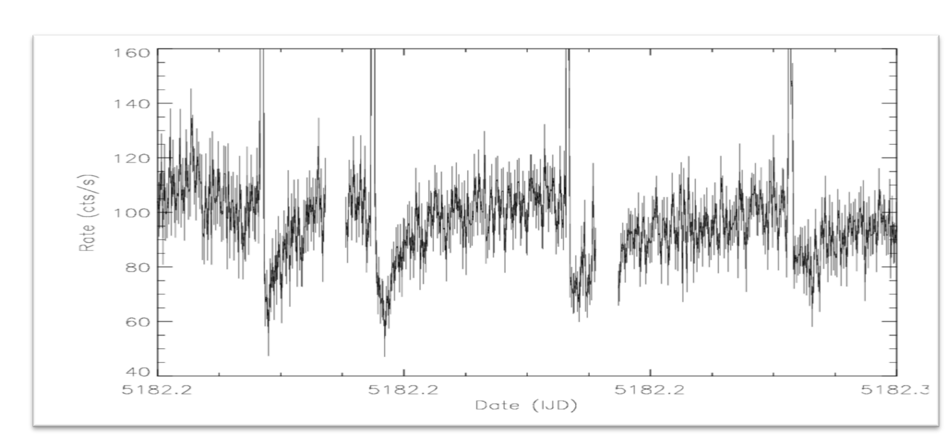


Figure 3. The bursts detected in our observations displayed deep post-burst dips. We provide here a closer view of a subset of these dips, (JEMX-1 3-25 keV; 5 sec time resolution).

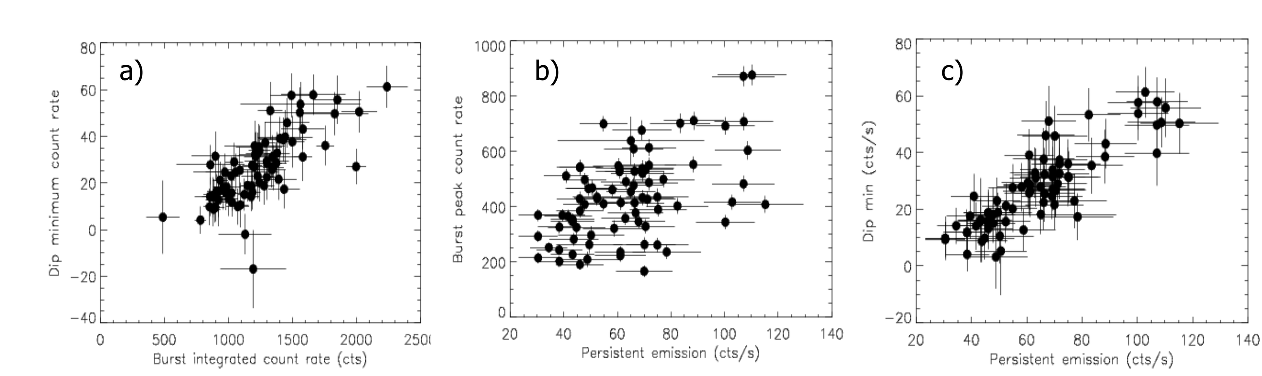


Figure 4. Panel a) we explore here the relation between the burst fluence, approximated as the burst integrated count rate, and the depth of the subsequent dip. Panel b, c) in these two panels we explore the relation between burst peak count rate, and dip minimum with the measured persistent emission. The system persistent emission was derived from the JEM-X light curves in the same science window when the burst/dip were detected, but excluding any burst/dip.
All these relations are in agreement with the system bursts being of gravitational origin. Full exploitation of these data is in progress.

4. References

Bildsten, L. & Brown, E. F., 1997, ApJ, 477, 897
Cui, W., 1997 ApJ 482, 613
Degenaar et al, 2014, arXiv1410.4814D
Finger, M. H. et al, 1996, Nature, 381, 291
Fishman, G. J. et al., 1995, IAUC 6272
Sanchez-Fernandez, C., et a., 2014, in preparation
Kouveliotou, K. et al, Nature, 379, 799
Lewin et al, 1996, ApJ, 462, 39
Lund, N., et al. 2003, A&A, 411, L231
Rappaport, S., & Joss, P. C., 1997 ApJ, 486, 435
Ubertini, P., et al. 2003, A&A, 411, L131