

Science and source catalogs with JEM-X

Niels Jørgen Westergaard National Space Institute, Technical University of Denmark



DTU Space National Space Institute

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1. Presentation of JEM-X

The physical mask made of 0.5 mm W:



Mask diameter:	535 mm
Mask hexagonal hole size:	3 mm
Detector area diameter:	250 mm
Mask-Detector distance:	3401 mm

Imaging is achieved by the coded mask which encodes the incoming beam from a particular source depending on the position in the field-of-view with diameter 13°.

The detector







The two identical JEM-X instruments onboard the *INTEGRAL* satellite.

The team:



National Space Institute, Technical University of Denmark

Søren Brandt, PI, burst searches

Carol Anne Oxborrow, calibration (gain corrections)

Jérôme Chenevez, burst analysis etc.

Niels Lund, software for images and source spectra

Carl Budtz-Jørgensen, detectors

NJW, software in general, source catalog, light curves

INTEGRAL Science Data Centre

Stéphane Paltani (until Jan. 2011)

Lucia Pavan (from Jan. 2011)

European Space Astronomy Center

Erik Kuulkers

University of Alicante

Silvia Nuñez-Martiñez, software, science analysis (from ~Jan 2011)



2. Search for X-ray bursts

Søren Brandt, Jérôme Chenevez

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[Previous]

INTEGRAL and RXTE spectral analysis of IGR J17480-2446, the new transient in Terzan 5.

ATel #2940; <u>C. Ferrigno (ISDC/University of Geneva), S. Brandt (DTU Space, Denmark), E.</u> <u>Kuulkers (ESA/ESAC), P. Bordas (ISDC/IAAT), E. Bozzo (ISDC/Univeristy of Geneva), J.</u> <u>Chenevez (DTU Space, Denmark), C. Kouveliotou (NASA/MSFC), A.J. van der Horst</u> <u>(NASA/MSFC/ORAU), on behalf of a larger collaboration</u> on 15 Oct 2010; 9:07 UT Distributed as an Instant Email Notice (Transients) Password Certification: Nami Mowlavi (Nami.Mowlavi@obs.unige.ch)

Subjects: X-ray, Gamma Ray, Binaries, Neutron Stars, Pulsars, Transients

During the ongoing INTEGRAL ToO observation of MAXI J1659-152, IBIS/ISGRI detected again the recently discovered X-ray transient located in the direction of Terzan 5 (ATels #2919, #2920, #2922, #2924, #2929, #2932, #2933, #2937, #2939). An association of the source with the transient LMXB EXO 1745-248 was initially suggested (ATels #2919, #2920), but this was considered less likely after the reanalysis of archival Chandra and RXTE observations (ATels #2933, #2937). Since the transient was first reported using INTEGRAL data (ATel #2919), we suggest to name it IGR J17480-2446.

(From a quick search in ADS abstracts: 55 ATELs, 58 conf. proc.

26 refereed papers, disregarding the A&A INTEGRAL volume.)



The burst with both JEM-Xs combined and the result of period folding around the XTE suggested period. Absent in later part of the burst.

Courtesy of Søren Brandt



Hence the last section of the ATEL:

A more in-depth analysis of the type-I X-ray burst observed with the JEM-X monitor on board INTEGRAL (ATel #2924) revealed the presence at 3.2 sigma c.l. of burst oscillations during the ~20 s following the burst on-set at the barycentric corrected frequency of 11.04+/-0.01 Hz, in agreement with the result reported in ATel #2932.

Further INTEGRAL observation of the FOV around the source will be performed on 2010 October 16 at 19:21:40.



3. Results on X-ray bursts

Jérôme Chenevez, Erik Kuulkers

Following slides by courtesy of Jérôme Chenevez

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

Long X-ray burst from GX 3+1



Type I X-ray bursts are **thermonuclear explosions** in the surface layers of a neutron star accreting H and/or He from the envelope of a companion star. Their profile is characterized by a **fast rise** followed by an **exponential decay**. The emission is described by **blackbody radiation** with peak temperature \approx 2 keV and X-ray softening (**cooling**) during the decay.

X-ray burst mechanisms



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Example 2: JEM-X detector light curve (30s bins)





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A weak persistent, long bursting only source



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3 bursts in INTEGRAL; all intermediate long!



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Transition between Two Regimes?









JEM-X 5-10 keV 6/4/2008

- Located in the Galactic Bulge, 0.8° from GX 3+1
- Transient X-ray source, discovered in 2005 (Grebenev et al., ATel 467) NIR counterpart (ATels 521, 634) - 2 (unpublished) X-ray bursts in RXTE
- 2nd outburst March September 2008 (ATels 1445, 1459, 1460, 1461, 1468, 1651) INTEGRAL + RXTE + Swift coverage (57 X-ray bursts)







4. The quest for the galactic ridge

Niels Lund and Niels J. Westergaard



























5. Catalog work now and later

Niels J. Westergaard

Observations

The INTEGRAL observations are for a large part concentrated along the galactic plane and around the center in particular leading to a very uneven sky coverage.

Data analysis

The steady pointings (science windows) typically last between 1200 and 2000 s.

The JEM-X data from each of these are combined to images in three energy intervals. Then a search for sources is performed. The result is compared with a standard X-ray source catalogue. In this way an individual source can be observed many times, up to 1400 times. The result is a – rather detailed in some cases – lightcurve as well as spectral changes for each source.

The images from the same sky regions are combined to socalled mosaic images that cover a much longer time span and much more data. This will make some of the weaker, steady sources visible. The search for very short transients and bursts must be done with other means.

The sky coverage map

Exposure time Fraction of sky > 10^6 s 1 % $10^5 - 10^6$ s 18 $10^4 - 10^5$ s 29 $10^3 - 10^4$ s 18 $10^2 - 10^3$ s 10 $10 - 10^2$ s 3 < 10 s 21 %

The sources in the catalog

All sources are shown on the same scale irrespective of their intensity in galactic coordinates.

Distribution of Low Mass X-ray Binaries:



Distribution of High Mass X-ray Binaries:



Of 147 sources located there are: 6 X-ray binaries (unspecified) 52 HMXB 69 LMXB 2 Cataclysmic Variables (WD) 1 GRB source 3 SNR

- 2 Clusters of galaxies
- 7 Seyfert galaxies
- 2 QSO
- 1 BL Lac

1 Unidentified

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Here is shown an example of a mosaic image for energies between 8 and 15 keV including the center of the galaxy (the grid is in galactic coordinates).

The noisy background in the upper left and lower right corners is due to less exposure than in the other regions.

The black hole in the galactic center is very quiet (for the time being) in these energies and hence does not show.





Light curves for three selected sources in the three energy ranges as designated.

The upper panel shows the results for the Crab Nebula which is used as a calibration source, the only strong X-ray source that is constant in strength and spectral shape.

The two others are examples of transients. The periods where the source is in the FOV is marked on the lower abscissa. It must be kept in mind that the sensitivity is strongly dependent on the offaxis angle.



The micro-quasar GRS 1915+15 exhibits a large number of different states. It has been observed many times with *INTEGRAL*. The spectra shown here are from different times in the standard pointing duration of about 2000 s.

Energy [keV]

Mosaic images for all the covered sky regions are being produced. They will be scanned for sources that were not found in the original image reconstruction. For regions with a large exposure e.g. the galactic center the mosaic images will be made for several time intervals in order to catch nonsteady sources.

Next generation catalog:

- 1) One year more of data is now available
- 2) Better imaging and light-curve production is on their way
- 3) Collaboration with ESAC for
 - computing assistance
 - world-wide availability through ESAC database
 - combination with other data

Thank you ...