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New features in the *JEM-XOSA-11* software

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Abstract. The main new feature in the *JEM-X* software for *OSA-11* is the possibility to extract light curves directly in *j_ima_iros*, the imaging tool for *JEM-X*. Many improvements in the description of and corrections for the two instrument units has been implemented in *j_ima_iros* over the years, whereas only limited evolution has taken place for the light curve tool. Thus, it appeared advantageous to include the new light curve analysis in the *j_ima_iros* package rather than doing a complete re-write of the old light curve tool. A prescription for how to activate the *j_ima_iros* light curve analysis can be found in the *OSA-11* Analysis Manual. Here I shall discuss some of the new features and some optional possibilities which I have found useful.

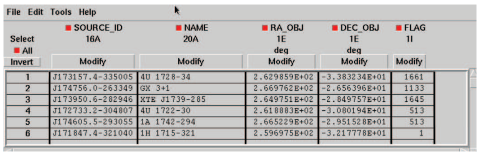
1. Introduction

The major new feature in the *JEM-X OSA-11* software is the introduction of a new light curve tool in the *j_ima_iros* package. Compared to the existing software the new tool features better discrimination between sources and includes an automatic search for bursts in the light curves. Light curves will be generated for all the sources found during the blind source search of *j_ima_iros*. In addition a detector light curve will be generated on the total detector count rate. The energy ranges and time binning are specified as usual in OSA.

The new light curves will be output to *jmx1/2_src_iros_lc.fits*.

All source light curves as well as the full detector light curve will be searched for burst activity. If bursts are detected for a specific source their presence will be indicated by the '512'-bit in the flag word for this source in the *srcl_res* file. Additional sources of particular interest may be specified by setting the '1'-bit in the flag word for these sources in the user catalog. Light curves will be generated for all such user defined sources and the burst search will be done as well. In our own monitoring program for X-ray bursts we therefore flag all known X-ray bursters in our user catalog. This improves the chances for detecting bursts from sources with weak persistent emission or sources near the edge of the field of view.

An observation which illustrates particularly well the results of the burst search comes from *scw* 041100230010 where three sources are detected as persistent, a fourth source is revealed because it gives off a burst which is detected in the global light curve, and a fifth source is found because a burst is found in its light curve - analyzed because it is a known X-ray burster. The burst from 4U 1722-30 is very bright and visible in the global light curve. In such a case *j_ima_iros* automatically extract a a sky image for the burst period and identifies the responsible source. The burst from 1H 1715-321 is weaker and not significant in the global light curve. This burst would be missed unless the specific light curve for this source had been extracted.



File Edit Tools Help

Select / All / Invert	SOURCE_ID 16A	NAME 20A	RA_OBJ 1E deg	DEC_OBJ 1E deg	FLAG 1I
1	J173157.4-335005	4U 1728-34	2.629859E+02	-3.383234E+01	1661
2	J174756.0-263349	GX 3+1	2.669762E+02	-2.656396E+01	1133
3	J173950.6-282946	XTE J1739-285	2.649751E+02	-2.849757E+01	1645
4	J172733.2-304807	4U 1722-30	2.618883E+02	-3.080194E+01	513
5	J174605.5-293055	1A 1742-294	2.665229E+02	-2.951528E+01	513
6	J171847.4-321040	1H 1715-321	2.596975E+02	-3.217778E+01	1

Fig. 1. Extract from *srcl_ res*-file for scw 041100230010 illustrating the use of the '511'-bit in the flag-word to signal the presence of bursts from the three sources GX 3+1, 4U 1722-30 and 1H 1715-321.

Figure 1 displays an extract of the top five rows from the *jmx1_srcl_res*-file from *scw* 041100230010 (this file contains 40 rows since there are 40 known X-ray bursters in the field of view of this observation). The sources actually detected by *j_ima_iros* will always appear of the top of the list. The three first entries have the '1024'-bit set in the flag word, these have been detected as persistent sources during the burst search. Three sources (GX 3+1, 4U 1722-30 and 1H 1715-321) have the '511'-bit set, bursts have been detected from these. The '1'-bits mirrors the '1'-bits in our user catalog, it so happens here that all the five sources are known as X-ray bursters and have been marked as sources of interest in our catalog.

2. User specified energy bands

The light curves are generated and the burst search is carried out for the user specified energy bands. However the burst search will only be carried out for energy bands containing more than 25 % of the total counts. Energy bands with only few counts may produce too many false alarms during the burst search. It is permitted to specify overlapping energy bands, thus it is OK to specify narrow and broad energy bands covering the same energy range in a single run. To generate the stacked burst profiles for GX 354-0 shown in Figure 2 we used a single energy band covering 3 to 10 keV to extract the burst peak times and the seven narrow energy bands shown in the plot to produce the average time profiles all time-aligned according to the peak time.

3. User specified sources of interest

As default light curves will be generated (and burst search executed) for both the full detector counts and for the sources found during the image analysis of the science window. Additionally, the user may in the user-catalogue specify sources of specific interest (f.i. known X-ray bursters) by setting the flag word to 1. The light curves for all "flag-1"-sources will be output in the *jmx1/2_src_iros_lc.fits*-files and the fitted source fluxes will appear in the *jmx1/2_srcl_res.fits*-files. These light curves will also automatically be searched for bursts and if bursts are detected from a specific source the flag word in the *srcl_res*-file will contain a 1 in the "512"-bit. Bursts may also be detected in the detector light curve. If a burst in the detector light curve cannot be matched with a time-coincident burst from a known source then the program will automatically proceed to the extraction of a sky image corresponding to the burst time interval. *j_ima_iros* will then attempt to identify the bursting source from this sky image (see Figure 3).

4. Optional burst time-slice images

The user may want to inspect the burst-images generated internally in *j_ima_iros* to verify the

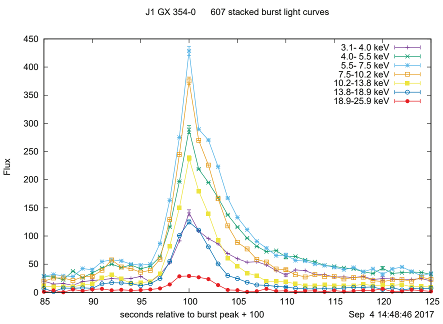


Fig. 2. The average X-ray burst time profile from GX 354-0 with 1 s time resolution in seven spectral bins from 3 to 26 keV obtained by stacking 477 bursts from this source observed with *JEM-X*.

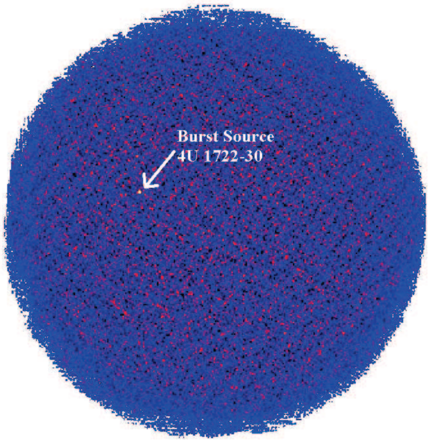


Fig. 3. *j_ima_iros* internal time-slice sky image from *scw* 041100230010 showing burst from the source 4U 1733-30

reliability of the automatic source identification mentioned above. This is possible if the *burstImagesOut*-parameter is set to “yes”. In this case the burst images will appear at the end of the *jmx*1/2*_sky_ima.fits*-file. However, it is **not** recommended to keep *burstImagesOut*=“yes” as a standard setting because this will result in the sky-ima file having an unpredictable number of images, and this will lead to problems if it is later desired to use the these files as input to the *j_ima_mosaic*-tool.

5. Optional reg-files for *DS9*

To facilitate a quick inspection of the results from a single science window one may add the keyword “DEVEL” to the *skyImagesOut* parameter string. With this setting some additional ASCII text files will be output in the directory where *j_ima_iros* is running. (This option is outside the standard *OSA*-environment). These ‘*reg*’-files can be loaded in the *DS9* plotting program after the sky image from the science window has been loaded. The *J*1/2`_12digitScwId.fits`-file will display the persistent sources found in this *scw*, and the *J*1/2`_12digitScwId_E03.fits`-file will display the burst sources and their light curves for the first user defined energy band. The corresponding files for the subsequent energy bands will be numbered ..E04, ..E05 ...

The light curves on the *DS9* display are for orientation only. Any quantitative analysis should be based on data extracted from the standard fits files. The curves are typically rescaled to fit within the *DS9* plotting window dimensions of 512x512 pixels. The time scale will be adjusted to fit within 512 time bins and the flux scale for each source will be individually adjusted so the *rms*-value is 20 image pixels. The bin width used in the *DS9* plot will be shown below the light curves. In order to separate the light curves they are vertically offset by 40 pixels vertically. The full detector light curve is plotted as the first (lowest) curve and shown in red.

Comment lines in the reg-files contain additional auxiliary information which may be used to select specific types or sequences of bursts. The reg-files can therefore be a convenient tool for quick data searches and for educational purposes.

6. Conclusion

The light curve extraction from *j_ima_iros* has been improved in *OSA-11* . Automatic burst search have been implemented. The light curves demonstrates that the source light curves have a very low level of cross talk between them. Even bright bursts in one source normally have a negligible effect on the light curves of other sources in the field.