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JEM–X Position Correction
Technical Note

DSRI Project JEM–X

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1 Introduction

Due to the details of the JEM–X detector and the read-out system the pixels as represented by the RAWX and RAWY event positions returned in the telemetry packages are not of uniform size and shape.

The need for a renewed event position correction has been stated. Here is described how to use the IMOD data after 2004-08-24 together with j_cor_position-5.6.7(?)

As a consequence of this the concept of an "idealized" shadowgram is used. It has been proposed by Niels Lund in the midisky software and is a regular grid of pixels to which the irregular pixels are mapped.

In this note the convention is to count in the C-sense i.e. starting from zero, unless explicitly mentioned.

2 IMOD data structures

A set of five arrays in the IMOD part of the IC files describe the resulting pixel properties. When an array has been read in in a C-program then the value to use is array[RAWX][RAWY] or array[RAWY*256 + RAWX] i.e. order by X increasing fastest.

The origin of the coordinate system on the detector is the central "cross" of the collimator walls or lamellae.

The X direction is the direction given by the cathode strip read-out. The Y-direction is the direction given by the backplane read-out.

CORX Center of pixel in the X-direction.
Found in `/home/njw/jemx/imod_grp/JMXi-CORX-MOD_006.fits`.

CORY Center of pixel in the Y-direction.
Found in `/home/njw/jemx/imod_grp/JMXi-CORY-MOD_006.fits`.

PLLX Lower left corner of pixel in X-direction.
Found in `/home/njw/jemx/imod_grp/JMXi-PLLX-MOD_002.fits`.

PLLY Lower left corner of pixel in Y-direction.
Found in `/home/njw/jemx/imod_grp/JMXi-PLLY-MOD_002.fits`.

PSIZ Pixel area in mm^2.
Found in `/home/njw/jemx/imod_grp/JMXi-PSIZ-MOD_001.fits`.

3 Remapping of events

The ideal shadowgram is based on a regular grid 256×256 of 1.000 mm spacing and with origin between pixel number 127 and 128.

A FITS file `jmx1_pixred_01.fits` and the `jmx2` equivalent with the first extension being a binary table with three columns: NUMBER, IDX_LIST, and FRACTIONS. Except NUMBER the columns are variable length columns to save disk space. The number of rows is 65536 i.e. the number of possible combinations of RAWX and RAWY, each in the range 0 – 255 incl. Not all are used due to the circular detector shape but adding an extra column with pixel indices will not save diskspace.

Each row, rownumber is RAWY*256 + RAWX, counting from 0 (zero), is a description of the redistribution of the raw pixel into the ideal shadowgram where "NUMBER" gives number of ideal pixels involved, "LIST_IDX" the indices of them, and "FRACTION" the fractions for redistribution.

This means that shadowgram construction, e.g. in ISSW, is no longer a matter of using correction positions, but building a preliminary shadowgram based on raw positions and afterwards convert to the ideal shadogram by using the redistribution table in `jmx1_pixred_01.fits` and `jmx2_pixred_01.fits`.

4 Observational data used

The SWIDs in the table below are Crab observations with the Crab 2° off-axis that have been used for pinpointing the shadow of the collimator walls.

Sample 1	Sample 2	Sample 3	Sample 4
004400080010	004400100010	004400180010	004400080010
004400150010	004400130010	004400190010	004400090010
004400180010	004400200010	004400200010	004400100010
004400340010	004400320010	004400320010	004400420010
004400370010	004400390010	004400330010	004400430010
004400440010	004400420010	004400340010	004400440010
004400930010	004400880010	004400670010	004400570010
004500310010	004500290010	004400680010	004400580010
017000850010	017000750010	017000770010	017000750010
017000860010	017000760010	017000800010	017000820010
017000870010	017000770010	017000870010	017000850010
017000940010		017000960010	017000940010
017000950010			
017000960010			

The offset happens in all cases to be very close to along one of the main directions in the JEM–X detectors/collimators. Due to the height of 57 mm of the collimator a 2° off-axis angle the shadow will have a width of 2 mm.

5 Analysis method

First a histogram was constructed from each of the four samples with the event positions corrected in the old way modulo 7.05 mm – the collimator wall-to-wall distance. By fitting (or rather using an fft analysis and removing all higher frequencies) a cos function the lowest position was determined. This gave initial shifts in X and Y. By using them and the correct way of getting the pixel position values a redistribution table was made. The IDL program is found in `/home/njw/work/pixred_mk_table.pro`.

With the help of the constructed `/home/njw/work/jmx1_pixred_01.fits` table (and the equivalent one for JEM–X2) ideal shadowgrams for the four samples were constructed.

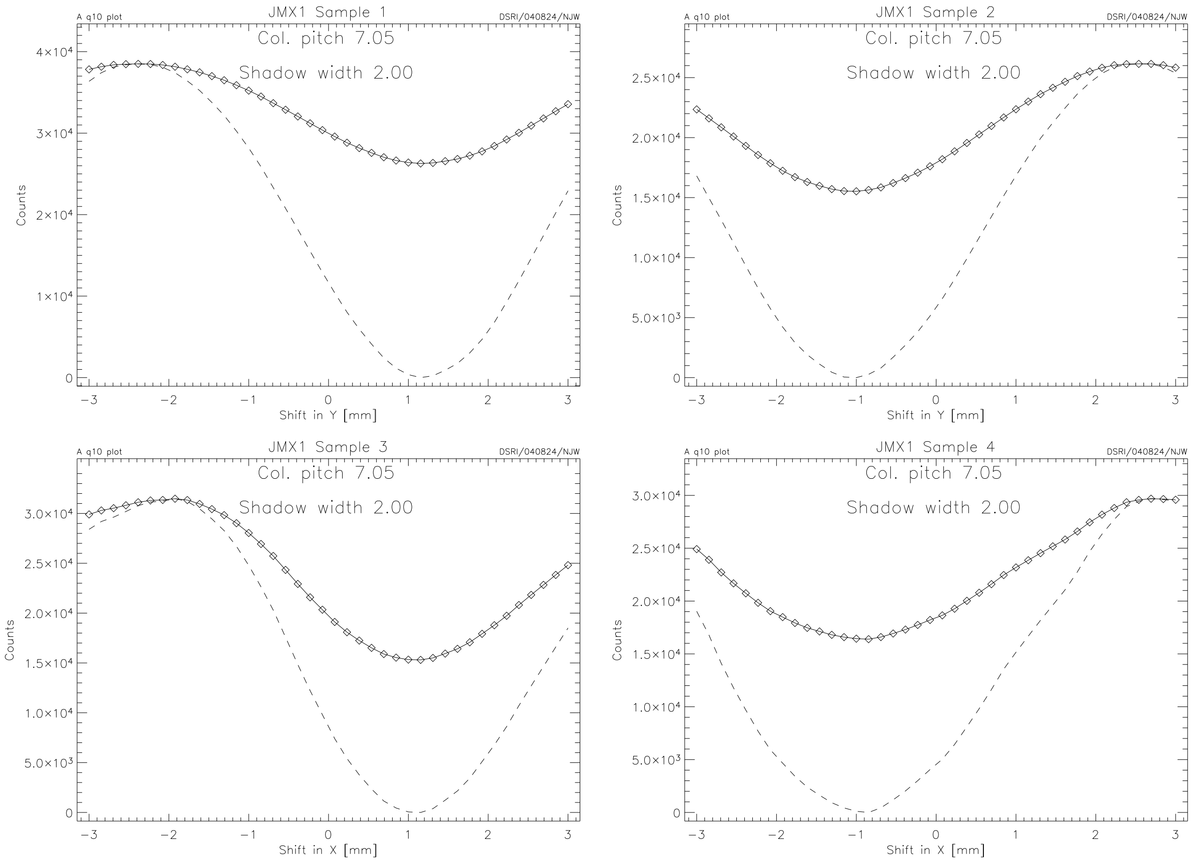

Figure 1: JMX1: Sum of counts under assumed shadow as a function of shift of shadowpattern. The dashed curve repeats the original curve but rescaled to show the minimum better.

As a verification of the result a shadow area was defined making stripes across the detector with a width of 2 mm and a spacing of 7.05 mm and the number of counts under it was summed. By changing position between -3 mm and +3 mm the composite figures 1 and 2 have been constructed.

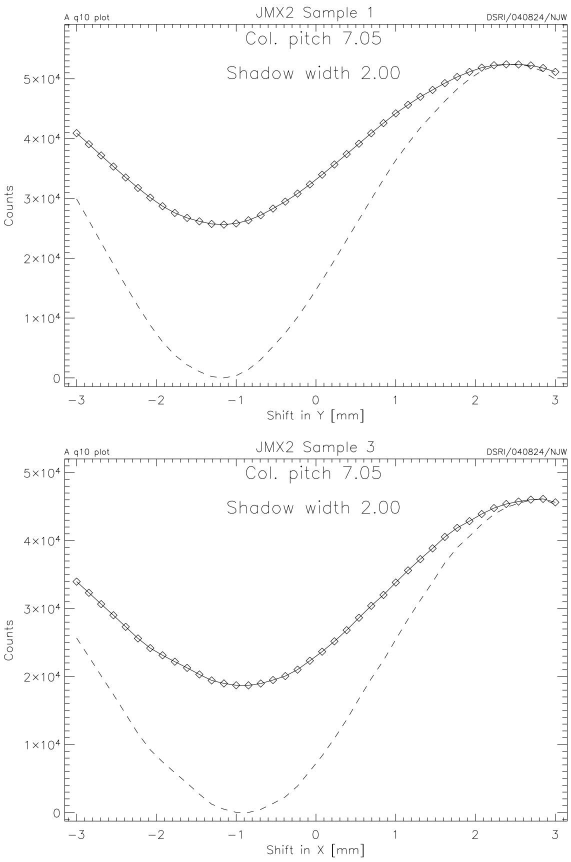

Figure 2: JMX2: Sum of counts under assumed shadow as a function of shift of shadowpattern. The dashed curve repeats the original curve but rescaled to show the minimum better.

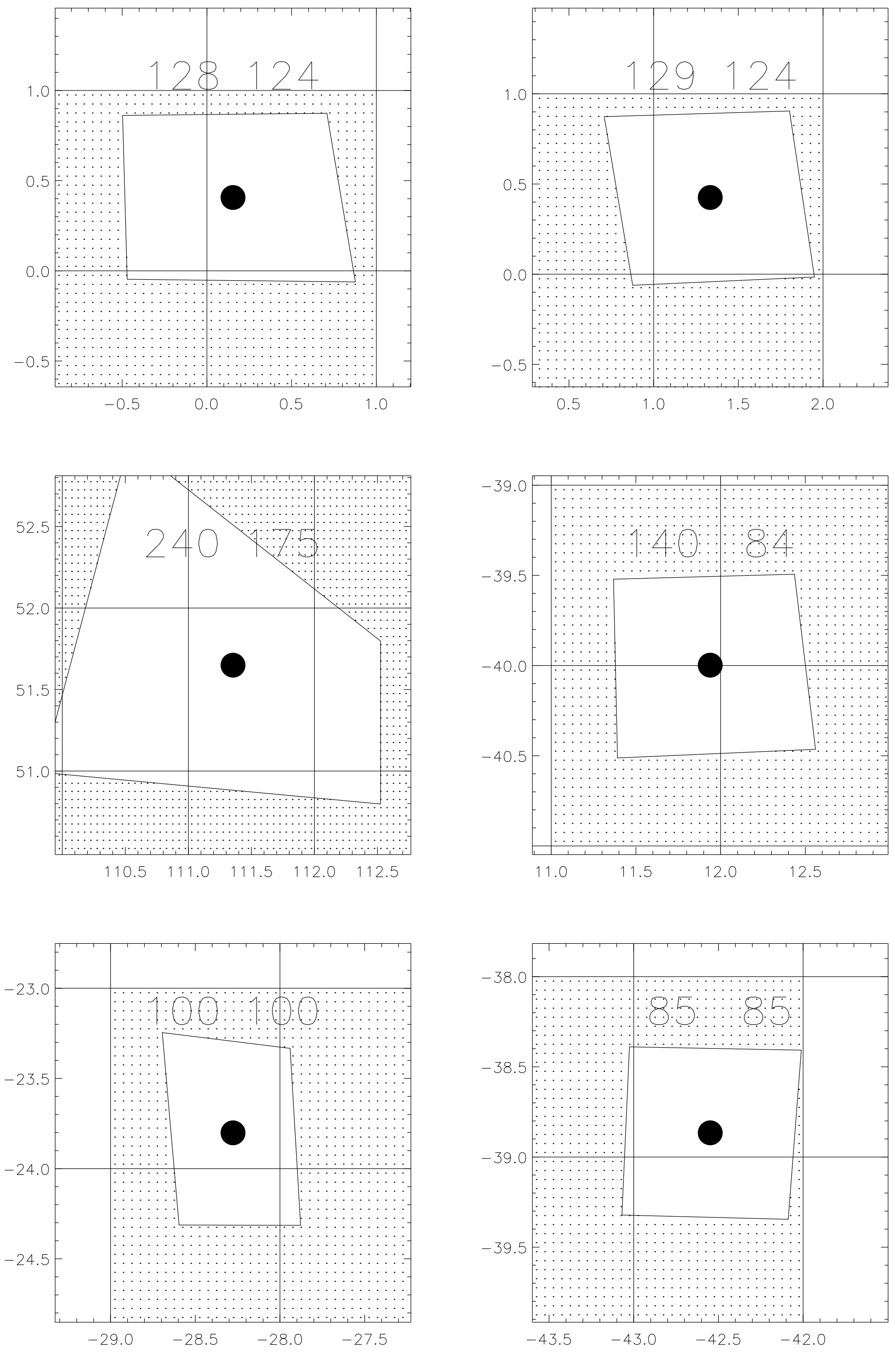

Figure 3: Examples of raw pixels as represented in the ideal grid. The dots indicate the test points (concealed in the pixel itself) for calculating the fractional area. (From JMX1)

6 The pixel size/background counts correlation

In the above treatment is assumed that with an isotropic illumination of the detector the number of counts in each "raw" pixel will be proportional to the measured pixel size.

This correlation is tested with JEM–X1 data by making a combined shadowgram in raw positions from around 600 SWIDs where no known sources were found. Systematic variations of the count rates will disturb this correlation so the events have been selected not only in PHA value but also in radius by requiring $r < 105$ mm. The result is shown in the Figure 4.

The correlation is wider than expected and indeed so wide that the value of using the pixel size information can be questioned. Further investigations are undertaken.

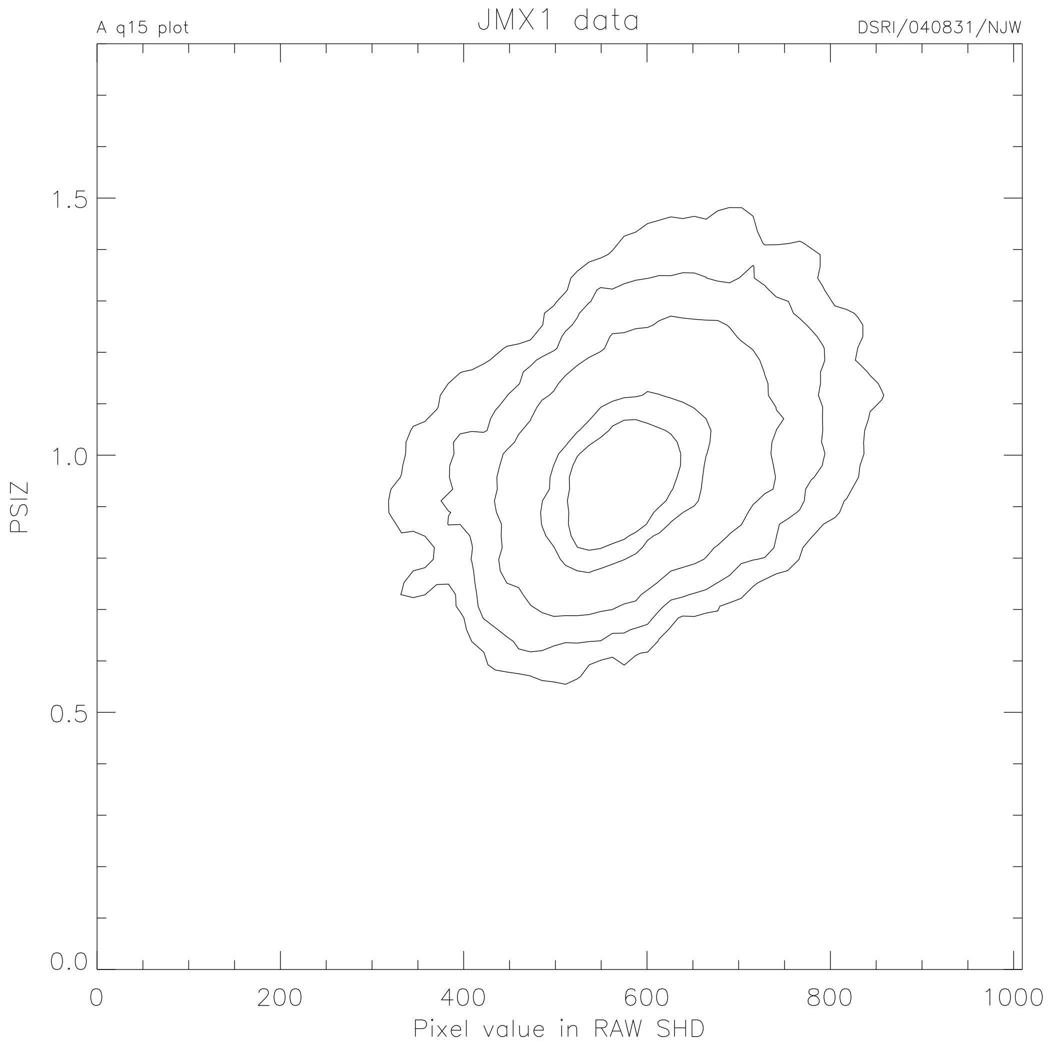

Figure 4: JMX1: The distribution of pixel values in a shadowgram with 18 million counts versus the pixel size

7 Appendix: Various files

/home/njw/jemx/work/jmx**i**_redpix_01.fits

/home/njw/jemx/imod_grp/JMX**i**-CORX-MOD_006.fits

/home/njw/jemx/imod_grp/JMX**i**-CORY-MOD_006.fits

/home/njw/jemx/imod_grp/JMX**i**-PLLX-MOD_002.fits

/home/njw/jemx/imod_grp/JMX**i**-PLLY-MOD_002.fits

/home/njw/jemx/imod_grp/JMX**i**-PSIZ-MOD_001.fits