SWIFT-XRT-CALDB-01
Release Date: April 24th, 2006
Prepared by: David Morris
Date Revised: 24 April 2006
Revision 6.0
Revised by: David Morris
Pages Changed: all

SWIFT XRT CALDB RELEASE NOTE

SWIFT-XRT-CALDB-01: Bad Pixels

1. Component Files:

FILENAME	VALID FROM	VALID UNTIL	RELEASE DATE	CAL VERSION
swxbadpix20010101v005.fits	1-Jan-2001	27-May-2005	12-Oct-2005	001
swxonboardbp20010101v005.fits	1-Jan-2001	27-May-2005	12-Oct-2005	001
swxbadpix20050527v001.fits	27-May-2005	9-Jun-2005	17-Apr-2006	001
swxonboardbp20050527v001.fits	27-May-2005	9-Jun-2005	17-Apr-2006	001
swxbadpix20050609v001.fits	9-Jun-2005	18-Jan-2006	17-Apr-2006	002
swxonboardbp20050609v001.fits	9-Jun-2005	18-Jan-2006	17-Apr-2006	002
swxbadpix20050609v002.fits	18-Jan-2006	9-Feb-2006	17-Apr-2006	003
swxonboardbp20050609v002.fits	18-Jan-2006	9-Feb-2006	17-Apr-2006	003
swxbadpix20050609v003.fits	9-Feb-2006		17-Apr-2006	003
swxonboardbp20050609v003.fits	9-Feb-2006		17-Apr-2006	003

2. Scope of Document:

The description of the XRT bad pixels is contained in two files in CALDB. The file swxonboardbp*.fits (from here forward *swxonboardbp*) contains all bad pixels uploaded to the instrument and contained in the onboard bad pixel map, the second file, swxbadpix*.fits (from here forward *swxbadpix*), contains both the pixels loaded onboard and some additional pixels which should be ignored by the ground processing. These two files have three extensions describing the bad pixels for each of the following modes: Photon Counting (PC) Mode, Windowed Timing (WT) Mode and Imaging Mode. For each mode, each bad pixel identified in the CCD array is described in RAWX and

RAWY co-ordinates relative to each of the two CCD amplifiers. This document contains a description of the latest updates installed in the XRT pipeline bad pixel calibration file and in the XRT on-board bad pixel table.

3. Overview of Changes Incorporated in this Revision:

New hot pixels have been identified from analysis of on-orbit data and were uploaded to the XRT bad pixel map on February 9th 2006. In addition, a complete re-inventory of all bad pixels uploaded to the XRT throughout the mission has been performed. This re-inventory has identified several discrepancies between the values previously contained in the CALDB swxonboardbp and the real pixels that were uploaded and the times/dates at which they were uploaded. The same is also true for the swxbadpix. To correct these discrepancies, new versions of the CALDB bad pixel tables have been generated for the uploads which took place on May 27th 2005, June 09th 2005 and January 18th 2006 in addition to the latest upload which took place on February 9th 2006. The files containing bad pixel information prior to May 27th 2005 have remained unchanged.

4. Identification of Hot, Bad and Flickering Pixels:

The XRT CCD contains several dead, hot or warm pixels. Dead pixels are those that do not effectively register charge for X-rays which strike them. Hot pixels are those that produce noise levels that are too high to use effectively at all temperatures. Warm pixels are those that produce a higher noise level than normal pixels but which are still able to be used for science observations below particular XRT CCD temperatures. In the case of warm and hot pixels, the anomalous behavior is due to charge traps in the lattice, which cause the pixels to overproduce dark current as compared to normal pixels. For temperatures high enough that the dark current charge produced exceeds the event threshold, these warm pixels are identified as X-ray events by the flight software. For the XRT CCD, it appears that most of the charge traps which produce warm pixels are frozen out below temperatures of about -54 °C. Furthermore, the onboard software allows an upload of hot pixel co-ordinates to a bad pixel map, so that they may be eliminated from the count rate evaluation and removed from the telemetry stream. The ground processing software task *xrthotpix* also determines hot pixels as pixels persistent from frame to frame of an observation. The hot pixel upload is thus a trade-off between mitigating the effects of the warm pixels at high temperatures and reducing the effective area of the CCD at lower temperatures for which the effects of the warm pixels are largely frozen out. It should be noted that the effects of a particular warm pixel are most severe in PC mode where the readout time is the longest. In the higher resolution timing mode (WT), the contribution of particular warm pixels are much less significant due to the much faster clocking of the CCD.

The XRT bad pixel list at the time of launch consisted of one partial dead column (composing 209 out of 600 pixels in one column) and one additional bad pixel, defined from ground calibration data collected at -100 ºC. At the actual on-orbit operating temperature of XRT, several more hot pixels have become apparent. The number of noise events detected in each XRT pixel follows an exponential function with respect to CCD temperature. For most pixels the function remains below the XRT event threshold of 80 DN at temperatures up to -54 °C. A small fraction of the pixels do exceed the event threshold at temperatures colder than -54 °C; these are designated as warm pixels. The most extreme of these 'warm pixels' have been uploaded to the XRT and added to the CALDB bad pixel list.

Table 2 shows the additional pixels, which are listed in the swxbadpix CALDB product to define the region of the 'burn-spot' on the XRT CCD. The burn-spot is a region of anomalously warm pixels slightly off-center from the XRT boresight which produce a noticeable excess number of events above temperatures of approximately -60 °C.

A warm-pixel-tracking algorithm has been developed to monitor the performance of all pixels on the XRT CCD throughout normal daily operations of the instrument. Most XRT observations are performed in PC mode. In this mode, each event recorded by the CCD above the event threshold is position tagged and telemetered to the ground. Because typical noise levels are 0.01 counts per second over the entire CCD the likelihood of any individual pixel recording multiple events during the course of a single orbit is extremely low unless the events recorded are due to thermally generated charge produced by the pixel itself. Thus, a search is performed on each orbit of PC data and pixels which record events in greater than 10% of the PC mode frames are collected. Bright sources such as gamma ray bursts and other observing targets do not cause false identification of hot pixels because multiple targets (typically 4-6) are observed during a single orbit at slightly different locations on the XRT CCD due to the ~ 3 arcminute pointing accuracy of the spacecraft.

5. Scientific Impact of Bad Pixels:

The masked out pixels may occur near the center of the CCD, so that there is a significant chance that the point spread function of the intended target may fall partially on the masked out columns or other hot pixels. The hot pixels which are defined in the CALDB swx*onboardbp* files are excluded onboard from the telemetry and the pixels defined in swx*badpix* are not processed by the XRTPIPELINE software. In XRTPIPELINE versions prior to version 0.9.9 (released 10-November-2005), no exposure map correction is made to account for the decreased collecting area in such a situation. Thus any user wishing to perform a proper exposure map correction on their data must be aware of the masked out pixels/columns identified in this calibration product and adjust their data accordingly. XRTPIPELINE version 0.9.9 and after correctly account for the exposure.

As a result of the re-inventory of bad pixel uploads throughout the mission, bad pixel information contained in this CALDB release is different and more accurate than the information contained in previous releases. The changes made are outlined in Section 9.

6. Caveat Emptor:

XRT bad pixels are highly temperature dependent and as a result, some pixels which are not contained in these CALDB products may appear anomalous at higher temperatures than those used to identify bad pixels for inclusion in the CALDB. Hot pixels are identified at temperatures at or below -54 °C, so data taken at temperatures above this level may show additional bad pixels. The XRTPIPELINE task *xrthotpix*, identifies and eliminates these pixels from an observation.

7. Expected Updates:

It is expected that radiation damage during the orbital lifetime of *Swift* will degrade the XRT CCD by introducing more bad pixels. Periodic updates to the Bad Pixel table files will be made to account for these changes.

8. Pre-launch Bad Pixel Table:

Prior to launch the XRT CCD bad pixels consisted of 1 partial bad column (209 pixels in extent) and 1 other hot pixel. In CALDB bad pixel files after the 27th May 2005*, the dead column is marked only in the on-ground bad pixel table and the single bad pixel is included in *swxbadpix* and *swxonboardbp* files, mapped through both the A and B amplifier. These are shown in Table 1.

Table 1: Original pre-launch bad pixel and dead pixel list

RawX	RawY	AMP	Y-extent
453	391	1	209
146	391	2	209
453	390	1	1
146	390	2	1

9. On-orbit Bad Pixel Uploads:

May 27th 2005

Between the 25th and 27th May 2005, new flight software was uploaded to the XRT, such that in PC Mode, a source countrate is only evaluated within a small window in the centre of the CCD. This means that only the bad pixels within the central 200x200 pixel window need to be uploaded to the flight software. The hot pixels in the outer region of the CCD are telemetered and identified either in the *swxbadpix* file or from running the *xrthotpix* task in the XRT Pipeline. Prior to this time all the bad pixels in the 600x600 pixel array had to be identified.

An isolated event on May 27th 2005, possibly a micrometeorite strike to the XRT detector or extremely high-energy charged particle, damaged several additional pixels and

* For the bad pixel files prior to 27th May 2005 the dead columns is listed in both swxonboardbp and swxrtbadpix

columns. It is possible that the severity of the excess charge seen in the pixels affected by the May 27th event may change over time. The state of these warm/hot pixels will be tracked throughout the course of the mission to note any changes in state (for better or worse) so that they may be added or removed from the bad pixel lists accordingly. 4 hot columns were uploaded for PC Mode and Imaging mode and 4 hot columns were identified in the onboard WT bad pixel row. Bad pixels from the 27th May 2005 are shown in Table 4, Table 7, Table 11 and Table 14.

9th June 2005

From observing the hot columns uploaded to the XRT on the 27th May for PC mode, WT Mode and Imaging Mode. It became apparent that there was an off-set of one column between PC mode and WT Mode (SWIFT-XRT-CALDB-08). The hot columns identified onboard were corrected for this fact on the 9th June 2005 (Table 4; Table 8; Table 12; Table 16).

18th January 2006

At temperatures above -56 ºC, the hot columns in the center of the CCD were found to be overflowing into additional columns in PC Mode and causing mode-switching between PC Mode and WT Mode. To minimize this effect, a partial column was uploaded in PC Mode (Table 5; Table 9; Table 13; Table 17).

9th February 2006

Eleven bad pixels were uploaded to the onboard bad pixel map for PC Mode and Imaging Mode and an additional hot column was uploaded to the WT Mode bad pixel row. These pixels are listed in Table 6, Table 10, Table 14 and Table 18.

10. CALDB Updates

12th October 2005

The XRT on-board and ground bad pixel lists swxonboardbp20010101v005.fits and swxbadpix20010101v005.fits contain the partial dead column, the hot-spot region and several hot pixels that were uploaded to the XRT. Hot columns and hot pixels due to micrometeroid damage were not included in these files.

24th April 2006

The XRT on-board and ground bad pixel lists identified in Section 1, include the 12th October update covering launch until 27th May 2005 and the re-inventory all of the bad pixels and also the 9th February upload to the XRT.

A re-inventory of all bad pixels that have appeared from launch through 9th February 2006 has been done to correct discrepancies that existed between the true bad pixel list and the values that had been loaded into the CALDB tables. Discrepancies were found in both the positions of some bad pixels and in the exclusion times (time/date at which a particular bad pixel is designated as having become unusable) of some bad pixels. The current bad pixel lists contained in the CALDB represent the best and most accurate catalog of bad pixels throughout the history of the mission. This catalog is detailed in

Table 3-Table 18 below. Table 3-Table 6 show the PC/Image mode bad pixels in the ground bad pixel catalog. Table 7-Table 10 show the PC/Image mode bad pixels in the onboard bad pixel catalog. Table 11-Table 14 show the WT bad pixels in the ground bad pixel catalog. Table 15-Table 18 show the WT bad pixels in the onboard bad pixel catalog. All bad pixels are listed only showing their positions as read out through amplifier #1, though the CALDB products also contain the complementary bad pixel entry for the detector as read out through amplifier #2. The 'Time' column in the tables below represents the mission elapsed time (MET) at which the pixel is first considered as bad. 'RAWX' and 'RAWY' identify the position of the bad pixel in raw detector coordinates (see Appendix for an explanation of the various XRT coordinate systems). 'Amp' defines to which amplifier the current CALDB row corresponds (only Amp1 entries are listed below for brevity, though both Amp1 and Amp2 entries are contained in the CALDB). 'Type' defines whether the CALDB row refers to an individual bad pixel (1) or a partial or full bad column (2). 'Yextent' describes the length of the column of detectors masked out in cases where Type=2 (starting at the RawX, RawY position and extending in the +RawY direction).

In the current release of the CALDB, 8 badpixel files are included, 4 ground and 4 on-orbit. The reason for having 4 files of each type is that the XRTPIPELINE does not currently read the 'Time' column of the CALDB file to identify whether a particular bad pixel should be applied to a given dataset. Because this functionality is not yet included, a work-around method has been developed using 4 files of each type whereby the filenames are used to select between the appropriate bad pixel table to use for each time period. When the functionality to read the 'Time' column from the CALDB tables is included in the XRTPIPELINE in a future release, only one CALDB file of each type will be required and the others will be removed at that time.

Table 2: Burn Spot warm pixels

RawX	RawY	Y-Extent
307	256	54
308	256	54
309	256	54
310	256	54
311	256	54
312	256	54
313	256	54
314	256	54
315	256	54
316	256	54
317	256	54
318	256	54
319	256	54
320	256	54
321	256	54
322	256	54
323	256	54
324	256	54
325	256	54
326	256	54
327	256	54
328	256	54
329	256	54
330	256	54
331	256	54
332	256	54
333	256	54
334	256	54
335	256	54
336	256	54
337	256	54
338	256	54
339	256	54
340	256	54
341	256	54
342	256	54
343	256	54
344	256	54
345	256	54
346	256	54
347	256	54
348	256	54

Table 3: May 27th 2005 PC/IM ground

Time	RawX	RawY	Amp	Type	Yextent
138844800	236	301	1	1	1
138844800	260	246	1	1	1
138844800	301	332	1	1	1
138844800	306	303	1	1	1
138844800	345	224	1	1	1
138844800	347	390	1	1	1
138844800	389	271	1	1	1
138844800	230	306	1	1	1
138844800	289	361	1	1	1
138844800	304	265	1	1	1
138844800	453	391	1	2	209
138844800	307	256	1	2	54
138844800	308	256	1	2	54
138844800	309	256	1	2	54
138844800	310	256	1	2	54
138844800	311	256	1	2	54
138844800	312	256	1	2	54
138844800	313	256	1	2	54
138844800	314	256	1	2	54
138844800	315	256	1	2	54
138844800	316	256	1	2	54
138844800	317	256	1	2	54
138844800	318	256	1	2	54
138844800	319	256	1	2	54
138844800	320	256	1	2	54
138844800	321	256	1	2	54
138844800	322	256	1	2	54
138844800	323	256	1	2	54
138844800	324	256	1	2	54
138844800	325	256	1	2	54
138844800	326	256	1	2	54
138844800	327	256	1	2	54
138844800	328	256	1	2	54
138844800	329	256	1	2	54
138844800	330	256	1	2	54
138844800	331	256	1	2	54
138844800	332	256	1	2	54
138844800	333	256	1	2	54
138844800	334	256	1	2	54
138844800	335	256	1	2	54
138844800	336	256	1	2	54
138844800	337	256	1	2	54
138844800	338	256	1	2	54
138844800	339	256	1	2	54
138844800	340	256	1	2	54
138844800	341	256	1	2	54
138844800	342	256	1	2	54
138844800	343	256	1	2	54
138844800	344	256	1	2	54
138844800	345	256	1	2	54
138844800	346	256	1	2	54
138844800	347	256	1	2	54
138844800	348	256	1	2	54
138931200	147	0	1	2	599
138931200	178	0	1	2	599
138931200	293	0	1	2	599
138931200	320	0	1	2	599

Table 4: June 9th 2005 PC/IM ground

Time	RawX	RawY	Amp	Type	Yextent
139968000	236	301	1	1	1
139968000	260	246	1	1	1
139968000	301	332	1	1	1
139968000	306	303	1	1	1
139968000	345	224	1	1	1
139968000	347	390	1	1	1
139968000	389	271	1	1	1
139968000	230	306	1	1	1
139968000	289	361	1	1	1
139968000	304	265	1	1	1
139968000	146	0	1	2	599
139968000	177	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599
139968000	453	391	1	2	209
139968000	307	256	1	2	54
139968000	308	256	1	2	54
139968000	309	256	1	2	54
139968000	310	256	1	2	54
139968000	311	256	1	2	54
139968000	312	256	1	2	54
139968000	313	256	1	2	54
139968000	314	256	1	2	54
139968000	315	256	1	2	54
139968000	316	256	1	2	54
139968000	317	256	1	2	54
139968000	318	256	1	2	54
139968000	319	256	1	2	54
139968000	320	256	1	2	54
139968000	321	256	1	2	54
139968000	322	256	1	2	54
139968000	323	256	1	2	54
139968000	324	256	1	2	54
139968000	325	256	1	2	54
139968000	326	256	1	2	54
139968000	327	256	1	2	54
139968000	328	256	1	2	54
139968000	329	256	1	2	54
139968000	330	256	1	2	54
139968000	331	256	1	2	54
139968000	332	256	1	2	54
139968000	333	256	1	2	54
139968000	334	256	1	2	54
139968000	335	256	1	2	54
139968000	336	256	1	2	54
139968000	337	256	1	2	54
139968000	338	256	1	2	54
139968000	339	256	1	2	54
139968000	340	256	1	2	54
139968000	341	256	1	2	54
139968000	342	256	1	2	54
139968000	343	256	1	2	54
139968000	344	256	1	2	54
139968000	345	256	1	2	54
139968000	346	256	1	2	54
139968000	347	256	1	2	54
139968000	348	256	1	2	54
140313600	291	0	1	2	599

Table 5: January 18th 2006 PC/IM ground

Time	RawX	RawY	Amp	Type	Yextent
139968000	236	301	1	1	1
139968000	260	246	1	1	1
139968000	301	332	1	1	1
139968000	306	303	1	1	1
139968000	345	224	1	1	1
139968000	347	390	1	1	1
139968000	389	271	1	1	1
139968000	230	306	1	1	1
139968000	289	361	1	1	1
139968000	304	265	1	1	1
139968000	146	0	1	2	599
139968000	177	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599
139968000	453	391	1	2	209
139968000	307	256	1	2	54
139968000	308	256	1	2	54
139968000	309	256	1	2	54
139968000	310	256	1	2	54
139968000	311	256	1	2	54
139968000	312	256	1	2	54
139968000	313	256	1	2	54
139968000	314	256	1	2	54
139968000	315	256	1	2	54
139968000	316	256	1	2	54
139968000	317	256	1	2	54
139968000	318	256	1	2	54
139968000	319	256	1	2	54
139968000	320	256	1	2	54
139968000	321	256	1	2	54
139968000	322	256	1	2	54
139968000	323	256	1	2	54
139968000	324	256	1	2	54
139968000	325	256	1	2	54
139968000	326	256	1	2	54
139968000	327	256	1	2	54
139968000	328	256	1	2	54
139968000	329	256	1	2	54
139968000	330	256	1	2	54
139968000	331	256	1	2	54
139968000	332	256	1	2	54
139968000	333	256	1	2	54
139968000	334	256	1	2	54
139968000	335	256	1	2	54
139968000	336	256	1	2	54
139968000	337	256	1	2	54
139968000	338	256	1	2	54
139968000	339	256	1	2	54
139968000	340	256	1	2	54
139968000	341	256	1	2	54
139968000	342	256	1	2	54
139968000	343	256	1	2	54
139968000	344	256	1	2	54
139968000	345	256	1	2	54
139968000	346	256	1	2	54
139968000	347	256	1	2	54
139968000	348	256	1	2	54
140313600	291	0	1	2	599
159235201	290	199	1	2	91

Table 6: February 9th 2006 PC/IM ground

Time	RawX	RawY	Amp	Type	Yextent
139968000	236	301	1	1	1
139968000	260	246	1	1	1
139968000	301	332	1	1	1
139968000	306	303	1	1	1
139968000	345	224	1	1	1
139968000	347	390	1	1	1
139968000	389	271	1	1	1
139968000	230	306	1	1	1
139968000	289	361	1	1	1
139968000	304	265	1	1	1
139968000	146	0	1	2	599
139968000	177	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599
139968000	453	391	1	2	209
139968000	307	256	1	2	54
139968000	308	256	1	2	54
139968000	309	256	1	2	54
139968000	310	256	1	2	54
139968000	311	256	1	2	54
139968000	312	256	1	2	54
139968000	313	256	1	2	54
139968000	314	256	1	2	54
139968000	315	256	1	2	54
139968000	316	256	1	2	54
139968000	317	256	1	2	54
139968000	318	256	1	2	54
139968000	319	256	1	2	54
139968000	320	256	1	2	54
139968000	321	256	1	2	54
139968000	322	256	1	2	54
139968000	323	256	1	2	54
139968000	324	256	1	2	54
139968000	325	256	1	2	54
139968000	326	256	1	2	54
139968000	327	256	1	2	54
139968000	328	256	1	2	54
139968000	329	256	1	2	54
139968000	330	256	1	2	54
139968000	331	256	1	2	54
139968000	332	256	1	2	54
139968000	333	256	1	2	54
139968000	334	256	1	2	54
139968000	335	256	1	2	54
139968000	336	256	1	2	54
139968000	337	256	1	2	54
139968000	338	256	1	2	54
139968000	339	256	1	2	54
139968000	340	256	1	2	54
139968000	341	256	1	2	54
139968000	342	256	1	2	54
139968000	343	256	1	2	54
139968000	344	256	1	2	54
139968000	345	256	1	2	54
139968000	346	256	1	2	54
139968000	347	256	1	2	54
139968000	348	256	1	2	54
140313600	291	0	1	2	599
159235201	290	199	1	2	91
161136001	220	231	1	1	1
161136001	237	253	1	1	1
161136001	245	354	1	1	1
161136001	258	204	1	1	1
161136001	284	205	1	1	1
161136001	298	364	1	1	1
161136001	320	238	1	1	1
161136001	344	398	1	1	1
161136001	364	310	1	1	1
161136001	392	247	1	1	1
161136001	400	383	1	1	1

Table 7: May 27th 2005 PC/IM on-orbit

Time	RawX	RawY	Amp	Type	Yextent
138844800	236	301	1	1	1
138844800	260	246	1	1	1
138844800	301	332	1	1	1
138844800	306	303	1	1	1
138844800	345	224	1	1	1
138844800	347	390	1	1	1
138844800	389	271	1	1	1
138844800	230	306	1	1	1
138844800	289	361	1	1	1
138844800	304	265	1	1	1
138931200	147	0	1	2	599
138931200	178	0	1	2	599
138931200	293	0	1	2	599
138931200	320	0	1	2	599

Table 8: June 9th 2005 PC/IM on-orbit

Time	RawX	RawY	Amp	Type	Yextent
139968000	236	301	1	1	1
139968000	260	246	1	1	1
139968000	301	332	1	1	1
139968000	306	303	1	1	1
139968000	345	224	1	1	1
139968000	347	390	1	1	1
139968000	389	271	1	1	1
139968000	230	306	1	1	1
139968000	289	361	1	1	1
139968000	304	265	1	1	1
139968000	146	0	1	2	599
139968000	177	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599
140313600	291	0	1	2	599

Table 9: January 18th 2006 PC/IM on-orbit

Time	RawX	RawY	Amp	Type	Yextent
139968000	236	301	1	1	1
139968000	260	246	1	1	1
139968000	301	332	1	1	1
139968000	306	303	1	1	1
139968000	345	224	1	1	1
139968000	347	390	1	1	1
139968000	389	271	1	1	1
139968000	230	306	1	1	1
139968000	289	361	1	1	1
139968000	304	265	1	1	1
139968000	146	0	1	2	599
139968000	177	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599
140313600	291	0	1	2	599
159235201	290	199	1	2	91

Table 10: February 9th 2006 PC/IM on-orbit

Time	RawX	RawY	Amp	Type	Yextent
139968000	236	301	1	1	1
139968000	260	246	1	1	1
139968000	301	332	1	1	1
139968000	306	303	1	1	1
139968000	345	224	1	1	1
139968000	347	390	1	1	1
139968000	389	271	1	1	1
139968000	230	306	1	1	1
139968000	289	361	1	1	1
139968000	304	265	1	1	1
139968000	146	0	1	2	599
139968000	177	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599
140313600	291	0	1	2	599
159235201	290	199	1	2	91
161136001	220	231	1	1	1
161136001	237	253	1	1	1
161136001	245	354	1	1	1
161136001	258	204	1	1	1
161136001	284	205	1	1	1
161136001	298	364	1	1	1
161136001	320	238	1	1	1
161136001	344	398	1	1	1
161136001	364	310	1	1	1
161136001	392	247	1	1	1
161136001	400	383	1	1	1

Table 11: May 27th 2005 WT ground

Time	RawX	RawY	Amp	Type	Yextent
138931200	291	0	1	2	599
138931200	292	0	1	2	599
138931200	293	0	1	2	599
138931200	319	0	1	2	599

Table 12: June 9th 2005 WT ground

Time	RawX	RawY	Amp	Type	Yextent
139968000	291	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599

Table 13: January 18th 2006 WT ground

Time	RawX	RawY	Amp	Type	Yextent
139968000	291	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599

Table 14: February 9th 2006 WT ground

Time	Amp	RawX	RawY	Type	Yextent
139968000	291	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599
161136001	293	0	1	2	599

Table 15: May 27th 2005 WT on-orbit

Time	Amp	RawX	RawY	Type	Yextent
138931200	291	0	1	2	599
138931200	292	0	1	2	599
138931200	293	0	1	2	599
138931200	319	0	1	2	599

Table 16: June 9th 2005 WT on-orbit

Time	Amp	RawX	RawY	Type	Yextent
139968000	291	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599

Table 17: January 18th 2006 WT on-orbit

Time	Amp	RawX	RawY	Type	Yextent
139968000	291	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599

Table 18: February 9th 2006 WT on-orbit

Time	RawX	RawY	Amp	Type	Yextent
139968000	291	0	1	2	599
139968000	292	0	1	2	599
139968000	319	0	1	2	599
161136001	293	0	1	2	599

Appendix – Coordinate Transformation Algorithms

We copy here the coordinate transformation algorithms from XRT-PSU-037, XRT Science Algorithms for the convenience of the reader:

- X_{raw}, Y_{raw}: These are raw detector coordinates of the image area. Pixels are numbered (0:599, 0:601) and are relative to the output amplifier. The conversion from *chip* to *raw* coordinates is:

$$X_{raw} = X_{chip} - 6 \qquad \text{for } (6 \le X_{chip} \le 605)$$

2.1

$$Y_{raw} = Y_{chip}$$

This is the coordinate system reported by the flight software in Low Rate Photodiode Mode and Windowed Timing Mode.

- X_{det}, Y_{det}: These are focal plane coordinates of image area in pixels, numbered (1:600, 1:602), so they can be compared with pixel numbers from image display software like *ds9*. Pixels are numbered relative to physical location on the CCD, not to amp readout. The conversion from *raw* to *det* coordinates is:
  - Amp 1:

2.2

$$X_{det} = X_{raw} + 1$$
$$Y_{det} = Y_{raw} + 1$$

  - Amp 2:

2.3

$$X_{det} = 600 - X_{raw}$$
$$Y_{det} = Y_{raw} + 1$$

- X_{foc}, Y_{foc}: These are focal plane coordinates in millimeters from the center of the detector. The conversion from *det* to *foc* coordinates is

$$X_{foc} = A + K{*}X_{det}$$

2.4

$$Y_{foc} = B + K{*}Y_{det}$$

where

$$K = 0.0400 = \text{pixel scale in mm/pixel}$$
$$A = -300.5 * K = \text{pixel offset in mm}$$
$$B = -300.5 * K = \text{pixel offset in mm}$$