SWIFT-XRT-CALDB-05
Release Date: October 15th, 2004
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Pages Changed: all

SWIFT XRT CALDB REV 2.0 RELEASE NOTE

SWIFT-XRT-CALDB-05: CTI

1. Component Files:

FILENAME	VALID DATE	RELEASE DATE	CAL VERSION
swxpcgain20010101v003.fits	01 January 2001	15 October 2004	003
swxpdgain20010101v003.fits	01 January 2001	15 October 2004	003
swxwtgain20010101v003.fits	01 January 2001	15 October 2004	003

2. Scope of Document:

This document contains a description of the CTI analysis performed at Penn State to produce the gain calibration products for the XRT calibration database.

3. Changes:

This is the first released version of the CTI Calibration document.

4. Scientific Impact of this Update:

This is the first released version of the CTI Calibration document.

5. Caveat Emptor:

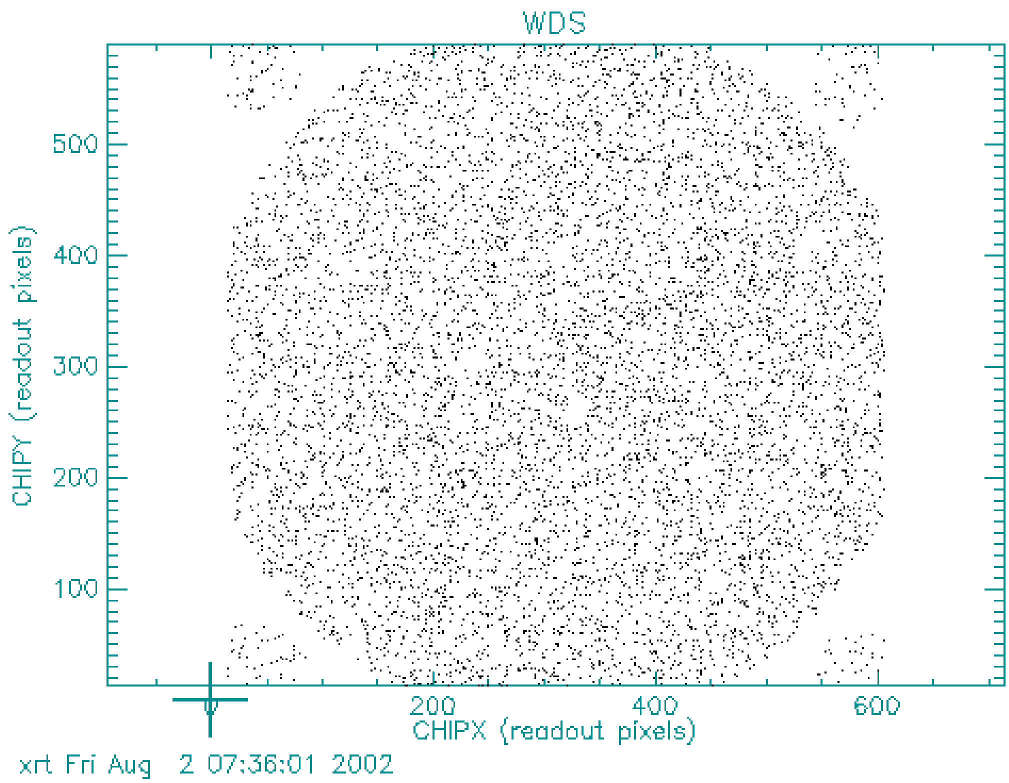
We note that significant charge traps exist in certain columns (as indicated within the document text) of the XRT CCD which may cause the local effective gain to be markedly different from that described by the global gain/CTI coefficients contained in the released gain calibration files. The form of the Calibration Database does not currently allow for precise correction for such traps in the XRT standard processing tools (*xrtpipeline*).

6. Expected Updates:

It is expected that radiation damage during the orbital lifetime of Swift will degrade the XRT CCD charge transfer efficiency through the production of more charge traps. Periodic updates to the gain files will be made to account for these changes.

7. CTI analysis:

The XRT CCD has 4 ^{55}Fe calibration sources mounted at the 4 corners of the detector for in-flight calibration and monitoring. In addition, an ^{55}Fe source mounted on the back of the XRT focal plane camera door illuminates the focal plane while the door is in the closed position (that is, blocking the optical path). The regions of the detector illuminated by each source can be clearly seen in the figure below.



The CTI analysis is performed using Mn K_ data from the thermal vacuum testing period (with CCD temperature of –100 C). Approximately 1.9x10^6 single pixel events have been selected from the output of the PSU *pass1* software from the following list of days/observations:

150_0355	150_0448	150_0719	150_1050
152_1658	153_0234	155_0351	158_1031
159_1935	160_0403	160_0500	160_0816
160_1956	160_2153	160_2327	161_0146

These events are composed both of corner source events (about 1x10^5 events) and door source events (about 1.8x10^6 events). We will henceforth define the XRT corner source configuration as follows:

```
          X>
     CS2    CS3
^
Y
     CS0    CS1
     SERIAL REG
amp/
```

Following this numbering convention, the initial strategy for determining the global CTI coefficients for the detector is to measure the Gaussian centroid of the Mn K_ events from each of the 4 corner sources, where we have defined a 50 pixel x 50 pixel square region at each corner of the detector to spatially select events. We then calculate the difference in the Gaussian centroids measured at CS0 and CS1 divided by the mean Detector X position as the fractional serial CTI coefficient (that is, the calibration file CTI coefficient times the photon DN value). The parallel CTI coefficient is measured analogously using the CS2-CS0 corner source pair and also using the CS3-CS1 pair.

The Gaussian centroids found for each individual corner source are shown below with 1-sigma errors (FWHM/2.35) shown in parentheses:

CS0: 2328.7 (22.5) DN
CS1: 2324.3 (23.1) DN
CS2: 2326.2 (22.8) DN
CS3: 2322.5 (23.7) DN

Using the strategy outlined above, these Gaussian centroid values lead to serial and parallel CTI measures of:

2-0 parallel: 2.0×10^{-6}
3-1 parallel: 1.4×10^{-6}
0-1 serial: 3.4×10^{-6}

Using the door source counts, though, we can investigate the parallel CTI in greater detail by actually mapping out the parallel CTI column by column. We do so as follows:

Between columns 50 and 550 (roughly where the door source cts strike the CCD) each column of the detector receives about 3500 counts, evenly distributed among the 600 pixels in the column. Below column 50 and above column 550 where primarily corner source counts reach the detector, we have only about 1000 cts per column. We do a simple least squares linear fit to all the events in each column (one column at a time).

We expect the CTI coefficient found for each individual column using this method to be similar to the coefficients noted above found using only the corner sources, with possible exceptions due to traps in individual columns. The overall average of the CTI coefficients found for each column using this method (average of 596 individual columns since the use of single pixel events excludes columns 1-2 and columns 599-600 from this analysis) is 1.6×10^{-6}, in good agreement with the average value found from the 2 parallel pairs of corner sources of 1.7×10^{-6} (average of 1.4×10^{-6} and 2.0×10^{-6}).

We additionally note, however, that there are 6 columns containing significant charge traps; Detector X coord columns: 54, 78, 110, 140, 259, 294. The traps found in columns are demonstrated below in plots of (DN vs row) for each column considered to contain a charge trap. The left plot in each pair shows all events in the column plotted as individual points while the right plot show only the median DN value recorded in each (row) pixel of the column. The top of the left plot in each pair is labeled with the Detector X position column number and the derived parallel CTI coefficient for that column.

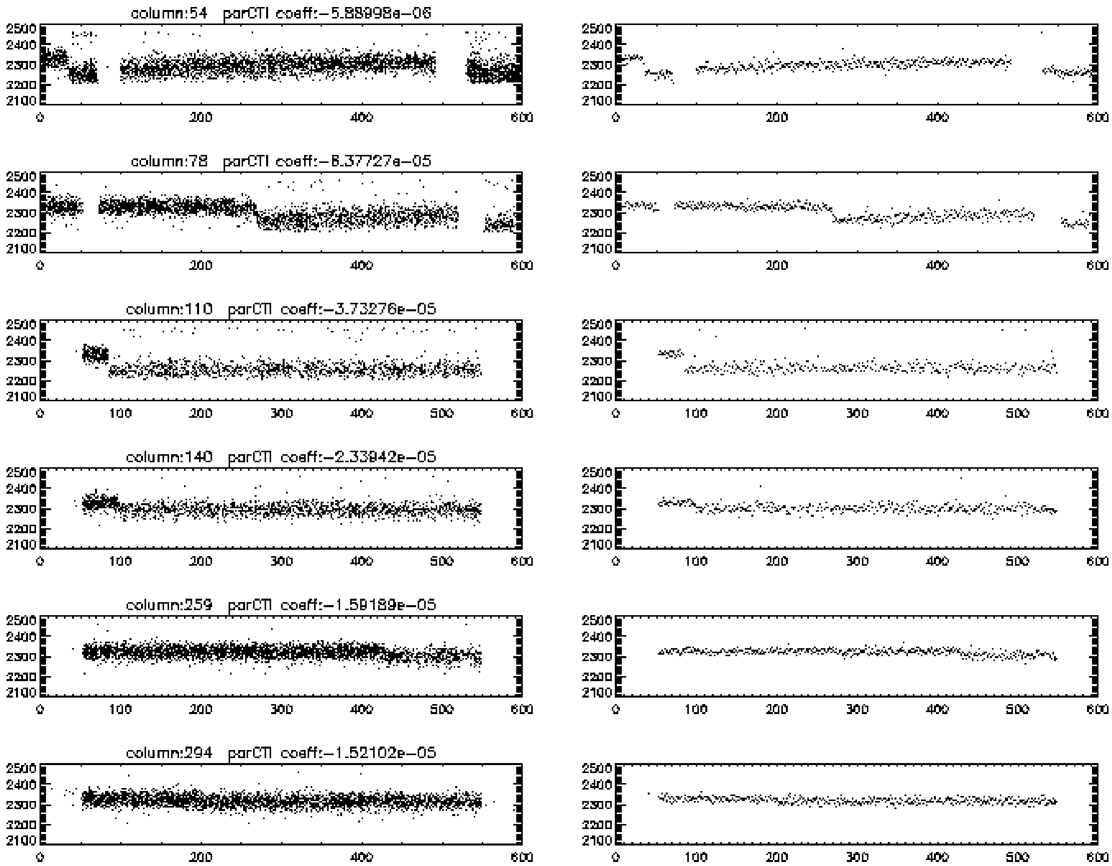
If we exclude these 6 columns from the average of all column CTI coefficients we did earlier, we find an overall parallel CTI average coefficient of 1.4×10^{-6}, now using 590 columns rather than 596 as before.

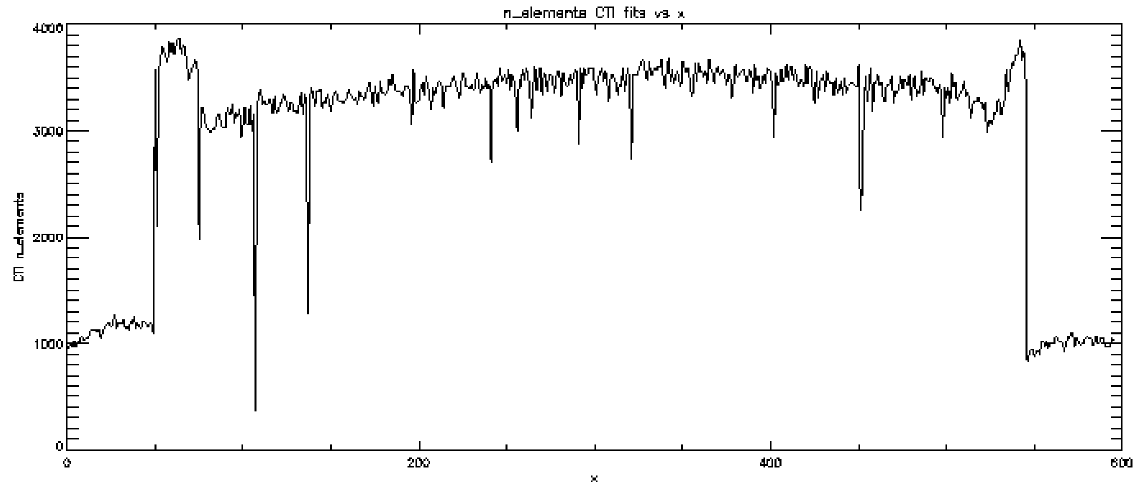
Shown in the second figure below we present (from top to bottom)

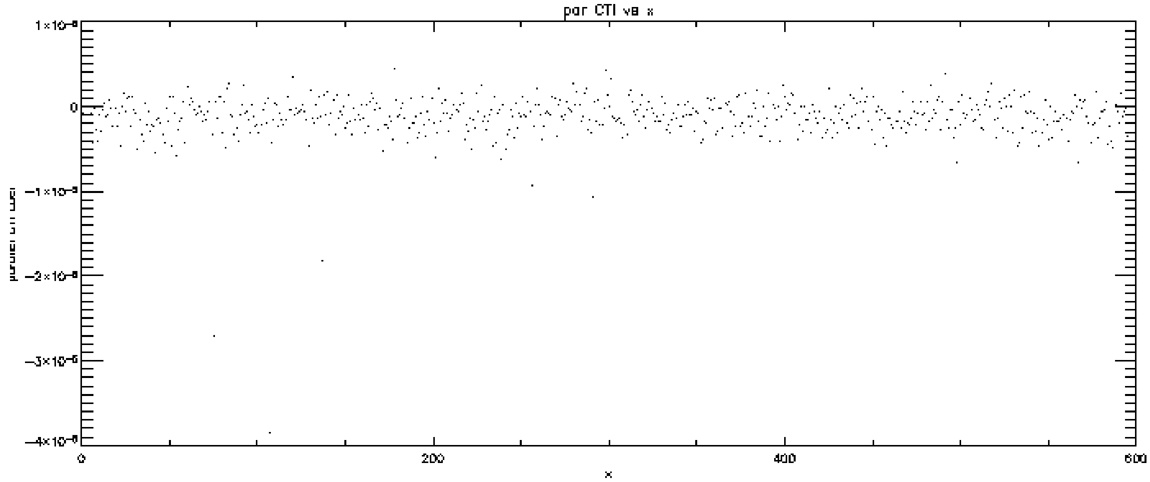
1. a figure of (number of events) vs (column number) showing that most columns are fit using more than 3000 events and that no column is fit using fewer than 1000 events
2. a plot of the parallel CTI coefficient determined from the individual column fits vs column number. 5 of the 6 columns containing charge traps are clearly identifiable in the figure by the CTI coefficient in excess of -1×10^{-5} while the 6th trapped column (column 54) oddly fits best to a moderate CTI value of -6×10^{-6}, though a trap clearly exists (from the plot of DN vs column)
3. an expanded view of the CTI coefficient vs column number, where we have shown only the columns believed to <u>not</u> contain a trap.

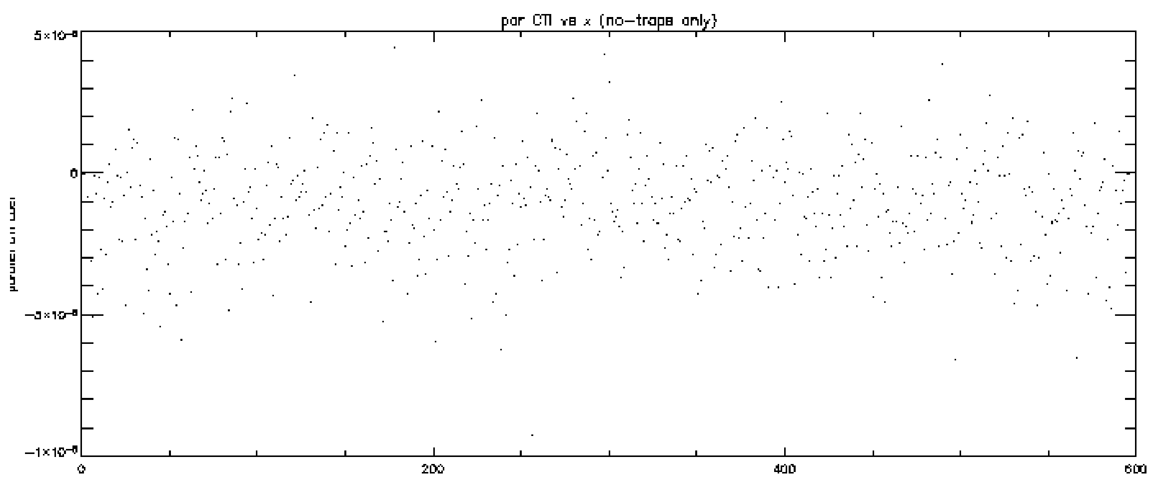
Given this analysis, we have uploaded gain calibration files to the SDC using the following CTI coefficients:

serial CTI: 3.4×10^{-6}
parallel CTI: 1.4×10^{-6} (the average across the detector)


column:54 parCTI coeff:−5.88998e−06
column:78 parCTI coeff:−8.37727e−05
column:110 parCTI coeff:−3.73276e−05
column:140 parCTI coeff:−2.33942e−05
column:259 parCTI coeff:−1.59189e−05
column:294 parCTI coeff:−1.52102e−05


n_elements CTI fits vs x
CTI n_elements
x


par CTI vs x
x


par CTI vs x (no-traps only)
x