ASTRO-H

INSTRUMENT CALIBRATION REPORT
SXI TOTAL GAIN CORRECTION
ASTH-SXI-CALDB-ALLGAIN

Version 0.2

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ISAS/ GSFC

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DOCUMENT TITLE: SXI ASTH-SXI-CALDB-ALLGAIN			
ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Version 0.1	Dec 2016	All	First release
Version 0.2	Jan 2018	All	Second release

Introduction

1.1 Purpose

This document describes how all the Soft X-ray Imager (SXI) ground/inflight calibration data to be included in the Pulse Invariant of the ground software were derived. The CALDB file structure is define in the ASTH-SCT-04 and available from the CALDB web page at http://hitomi.gsfc.nasa.gov.

1.2 Scientific Impact

The final Pulse invariant assignment is determined using information of the Charge Trail, Charge Transfer Inefficiency (CTI), the gain difference in the odd and even columns and the gain variation due to the video temperature (vtevenodd), and finally the Gain.

a) Charge Trail
During an X-ray charge is transferred from pixel to pixel, a fraction of the charge remains in the original pixel due to inefficiency of the charge transfer. This causes "charge trail". Charge trail should be corrected before a PHA value of the X-ray event is calculated.

b) CTI
The CTI correction is related with charge loss during transfer. The CTI value is almost uniform, but there are a few local areas where the CTI is rather larger. The CTI correction recovers the lost charge in the pulse height (PH) before the PHA calculation.

c) Vtevenodd
This CALDB covers two calibration items: gain correction due to video temperature, and gain difference between in even/odd columns. The former is caused by the characteristics of video boards: temperature dependency of gain. About the latter, signals of pixels in even and odd columns are readout by different ASICs, and hence those signals are adapted by different gain. These should be corrected before the PHA calculation.

d) Gain
This CALDB is used for detector gain correction to convert from PHA to PI. PHA is a sum of pulse heights (PH) of a given event depending on Grade. PI (pulse invariant) is an invariant channel converted to X-ray energy; E= PI x 6.0 [eV].

2 Release CALDB 20160310

	Filename	Valid data	Release data	CALDB Vrs	Comments
Charge Trail	ah_sxi_chtrail_20140101v001.fits	2014-01-01	2016-03-10	001	
CTI	ah_sxi_cti_20140101v001.fits	2014-01-01	2016-03-10	001	
Vtevenodd	ah_sxi_vtevenodd_20140101v001.fits	2014-01-01	2016-03-10	001	
Gain	ah_sxi_gain_20140101v001.fits	2014-01-01	2016-03-10	001	

2.1 Data Description

The data were taken from a ground experiment performed at Kyoto University in Aug. 2014 using the SXI FM system. The CCD chips were set to be cooled at -110 degC. rframe (raw frame) data were taken in the experiment. During the experiment, X-ray emission line of F-K (0.7 keV), Mn-K (5.9 keV), Ge-K (9.8 keV) were irradiated.

For the VT parameters only, the data were taken from a ground experiment at Osaka University using the FM video board.

2.2 Data Analysis and Results

a) Charge Trail

Dark frame data were generated from raw frame data according to the same algorithm as that used in the SXI electronics. Charge trail effect was measured by using pulse heights (PHs) of 5x5 pixels of an event detected in the above process.

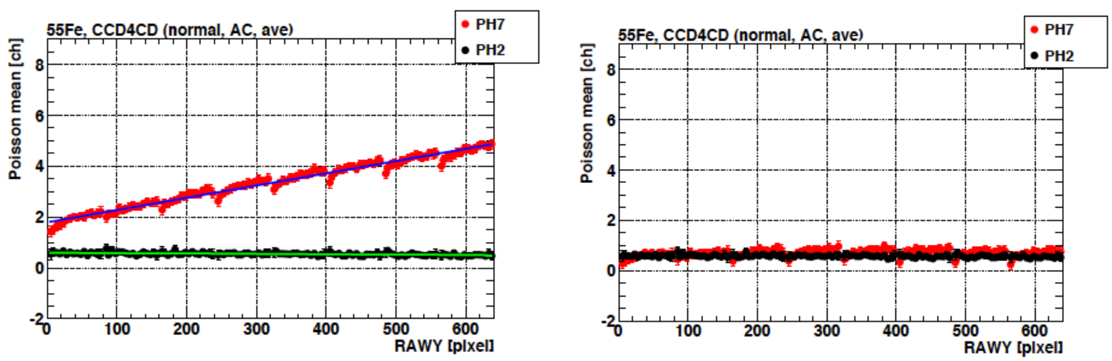

Fig.2-1 Left figure shows PHs of preceding (black) and succeeding (red) pixels of Fe-55 events. PHs of succeeding pixels are shifted to positive due to the charge trail as a function of the number of transfer. Right figure shows the same plot as shown in left but after trail correction

b) CTI

In order to measure the CTI effect, spectra extracted from each ACTY position were fitted with Gaussians. Fig. 2a shows the best-fit center values of F, Mn, and Ge lines. From the data, CALDB parameters were derived. After the correction of CTI, the emission lines became flat in Fig. 2b.

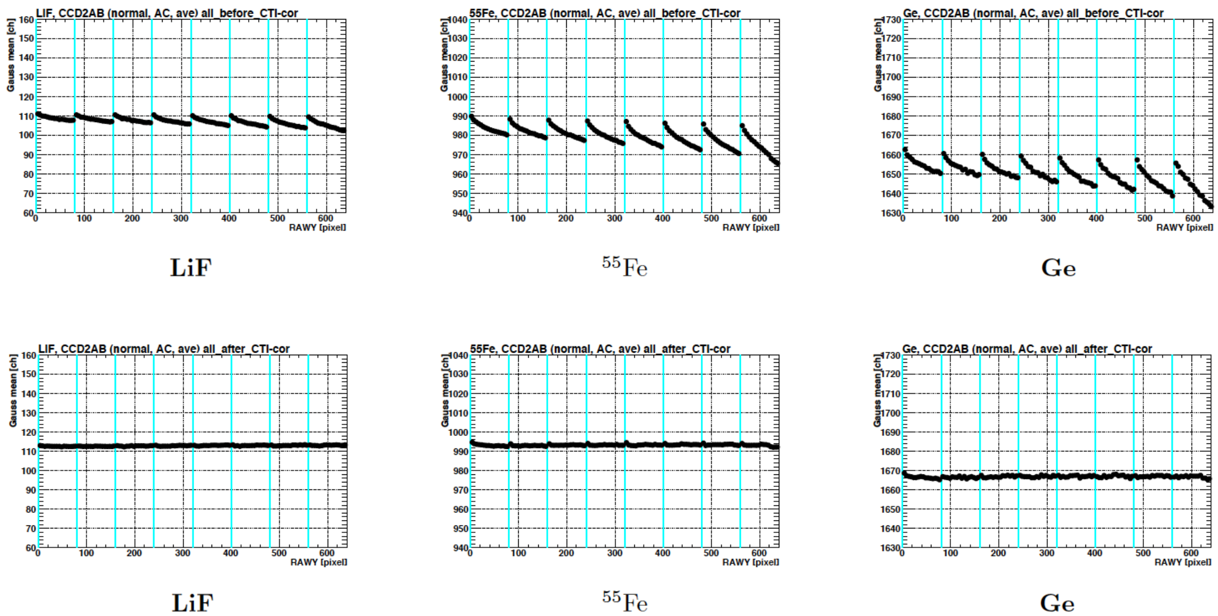

Fig.2-2 a) Top and b) bottom figures show a PH of each line as a function of the number of transfer before and after CTI correction, respectively. Before correction, so-called saw-tooth shape is seen due to periodic charge-injection (CI) technique. Blue vertical lines indicate CI rows.

c) Vtevenodd

The VT characteristics were measured as is shown Fig.2-3. Using the trend, the VT parameters were derived.

Grade0 events were extracted from the FM CAL data (Fe-55), and obtained the Gaussian center in PH (pulse height) channel. The even/odd parameters were decided to reduce the difference of the PH values between data in even and odd columns. (Fig.2-4)

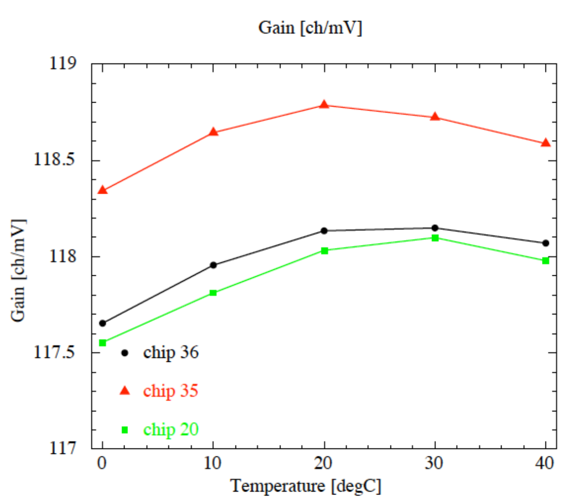

Figure 2-3 shows temperature dependences of video gain, which show a loose peak around 20-30 degree Celsius and individual characteristic.

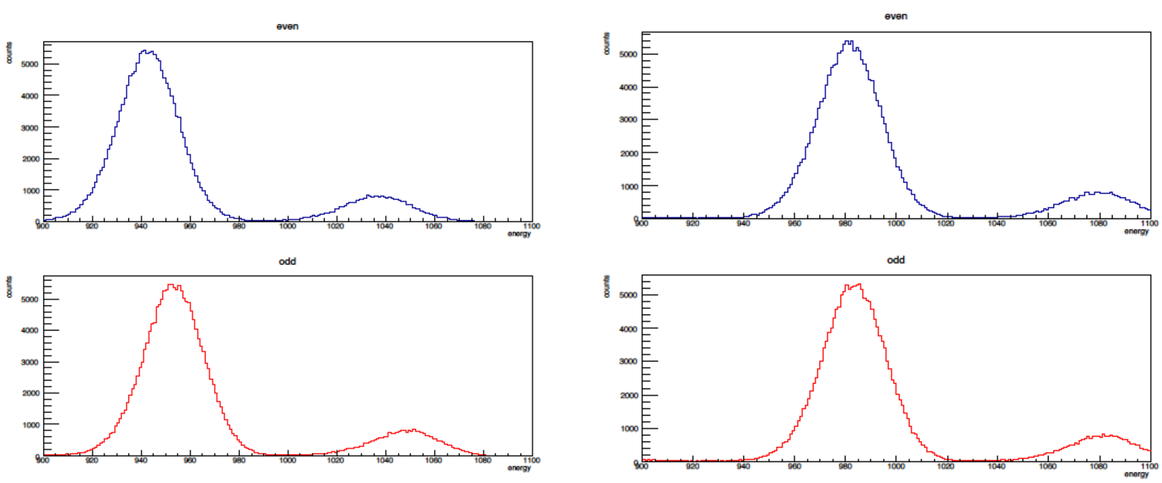

Fig.2-4 (left): Grade 0 spectra of 55Fe data taken with CCD1CD before even/odd correction. Top and bottom figures show the even and odd column data, respectively.
Individual even/odd gains were measured (left) and corrected (right) segment by segment.

d) Gain

After vtevenodd, charge trail, and CTI correction, PHA of events were calculated for F, Mn, and Ge emission lines, respectively. From the PHA values, gain function was derived. A single liner function was adapted.

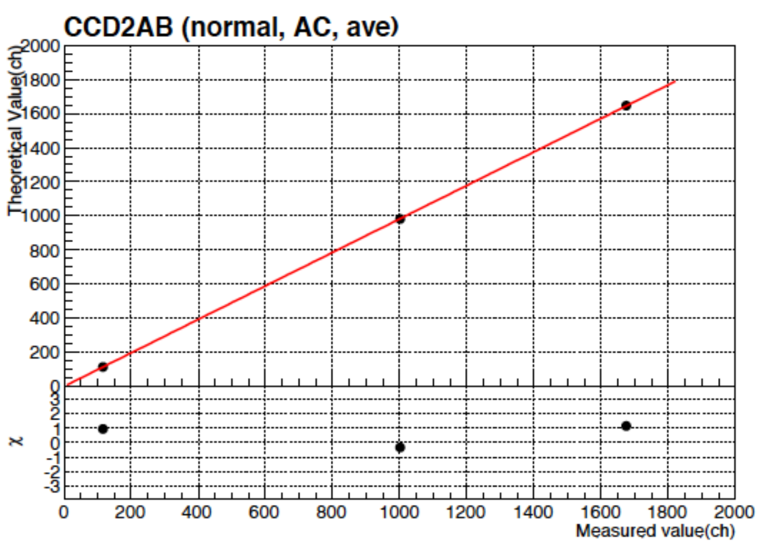

Fig.2-5 Relationship between measured peak values and expected ones for F, Mn, and Ge. A linear function represents well their relation.

Corrected spectrum

Fig.2-6 shows the Fe-55 spectra of good Grade events before and after all the corrections described above. The line center is 982 ch corresponding to the Mn Kα energy 5.9 keV.

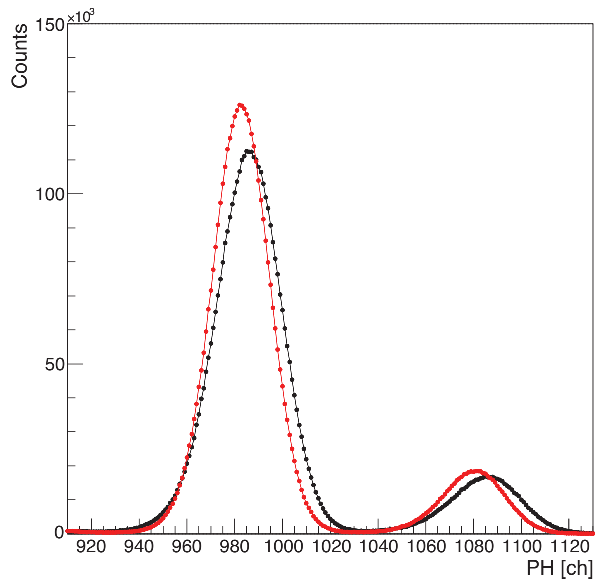

Fig.2-6 Fe-55 spectra before and after correction shown in black and red, respectively.

3 Release CALDB 20161122

	Filename	Valid data	Release data	CALDB Vrs	Comments
Charge Trail	ah_sxi_chtrail_20140101v002.fits	2014-01-01	2016-11-22	005	
CTI	ah_sxi_cti_20140101v002.fits	2014-01-01	2016-11-22	005	
Vtevenodd	ah_sxi_vtevenodd_20140101v002.fits	2014-01-01	2016-11-22	005	
Gain	ah_sxi_gain_20140101v002.fits	2014-01-01	2016-12-xx	002	

3.1 Data Description

a) Charge Trail
Since the ground software of the charge trail correction was changed, the CALDB parameters were adjusted accordingly. The same data set is used as section 2.1.

b) CTI
All the Fe-55 data obtained in orbit were used.

c) Vtevenodd
All the Fe-55 data obtained in orbit were used.

d) Gain
All the Fe-55 (calibration source) and RX J1856 data obtained in orbit were used.

3.2 Data Analysis

a) Charge Trail
Same as section 2.2.

b) CTI
Since statistics of the data were limited, all the CALDB parameters cannot be measured. Thus, energy dependency is assumed to be the same as that in the ground experiment (in the previous release), and only normalization was updated.

c) Vtevenodd
The Fe-55 data were analyzed in the same manner in Sec 2.2.

d) Gain
Data analysis for Fe-55 was done in the same manner as in sec 2.2. Also assuming the spectral parameters of RX J1856, the gain shift in the low energy band was searched. Combining the two results, the gain function was updated.

3.3 Results

a) Charge Trail
Same as section 3.2 since the procedure is the same.

b) CTI
The time history of Fe-55 PHA value shows a decline. Therefore, we implement CTI parameters with time dependency. Results are summarized in the gain CALDB document

c) Vtevenodd
Onboard data shows small discrepancies from the ground calibration values. We update the even/odd gain table for adjustment.

d) Gain

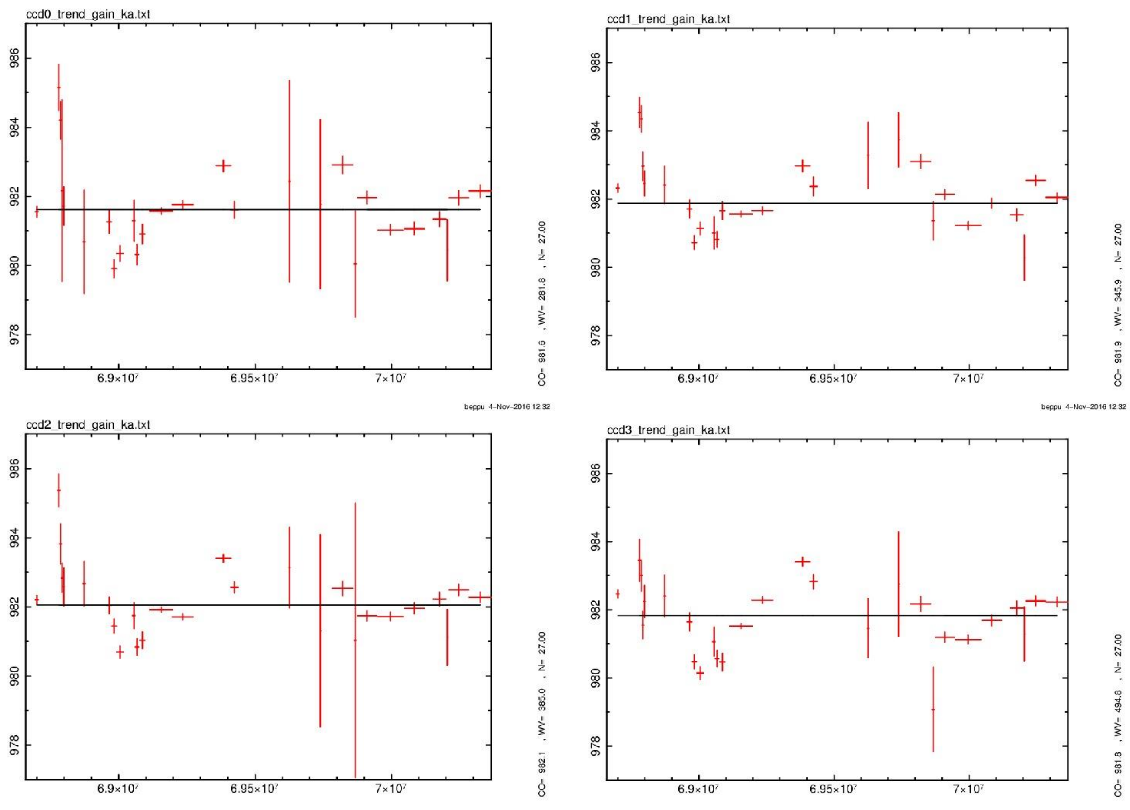

Fig.3-1 Time history of peak value of 55Fe data taken in CCD1 (top left), 2(top right), 3(bottom left) and 4(bottom right) after adopting the CALDB parameters. The uncertainty of ~12 eV at 5.9 keV was found.

4 Release CALDB 20170405

	Filename	Valid data	Release data	CALDB Vrs	Comments
CTI	ah_sxi_cti_20140101v003.fits	2014-01-01	2017-04-05	00?	
Vtevenodd	ah_sxi_vtevenodd_20140101v003.fits	2014-01-01	2017-04-05	00?	
Gain	ah_sxi_gain_20140101v003.fits	2014-01-01	2017-04-05	00?	

4.1 Data Description

This CALDB update was based on results obtained from both of the ground and onboard data. Note that the onboard data taken during a Minus-Z day earth passage were excluded.

4.2 Data Analysis

a) CTI

G0 events of Fe-55 (5.9 keV X-rays) were used to measure the CTI. For the ground data, CTI parameters were obtained in the same manner as sec 2.2 (b). Since the onboard data have limited statistics to measure the CTI in detail, PH correction was checked by summing data in the same segment.

b) Vtevenodd

G0 events of Fe-55 (5.9 keV X-rays are used to measure the parameters for even/odd gain including VT (video temperature) gain. the Fe-55 spectra collected in even and odd columns on the CCD chip were fitted with a Gaussian, and then the center PH values were obtained.

c) Gain

After vtevenodd, chtrail, and CTI corrections, G0, 2, 3, 4, 6 events were collected to make good Grade spectra. The Gain parameters for conversion of PHA to X-ray energy were measured using onboard data of the calibration source Fe-55 and an astronomical object RX J1856. A Gaussian center of Fe-55 in PHA channel corresponds to an energy 5.895 keV. On the other hand, the RX J1856 spectra were fitted with a physical model (Beuermann et al. A&A, 458, 541) to measure a gain shift at low energy. Combining the results, gain curves for each CCD/segment were obtained.

4.3 Results

a) CTI

Using the in-flight data, no time variation was examined. Also, SXI IT confirmed that CTI measured for the in flight data is consistent with that obtained from the ground experiment (see Sec.2).

b) Vtevenodd

Data set used in this CALDB release are slightly different from that in the previous CALDB (20161122). Thus, the vtevenodd parameters were measured. Almost the same parameters were obtained in the previous one.

c) Gain

Figure 4-1 shows the history of the Fe-55 energy after the gain correction. The standard deviation of 2-3 eV was found.

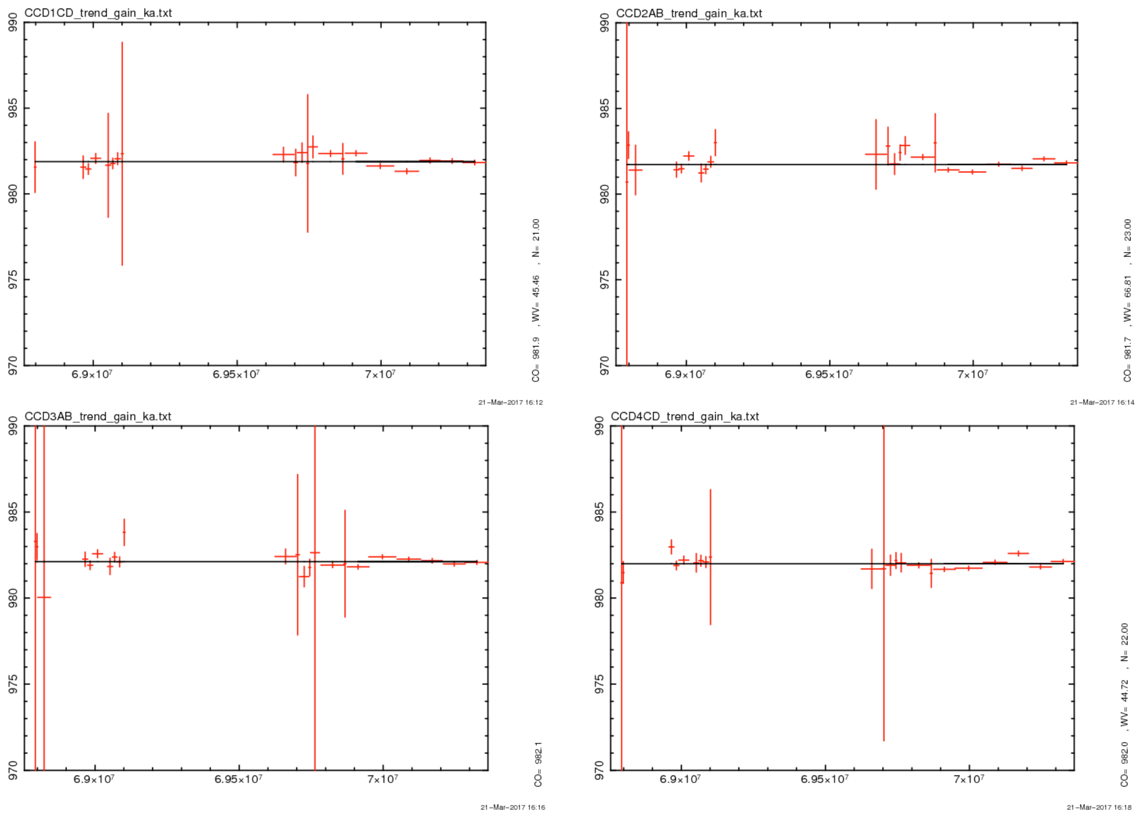

Fig.4-1 Time history of peak value of 55Fe data (PI) taken in CCD1 (top left), 2(top right), 3(bottom left) and 4(bottom right) after the gain correction.