ASTRO-H

Instrument Calibration report
SGD Energy Gain
ASTH-SGD-CALDB-GAIN

Version 0.1

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ISAS/ GSFC

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DOCUMENT TITLE : SGD Energy Gain			
ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Version 0.1	November 2015	All	First Release

Introduction

1.1 Purpose

This document describes how the energy gain calibration curves are produced from the ground and the in-orbit data. The CALDB file structure is defined in the ASTH-SCT-04 and available from the CALDB web page at http://hitomi.gsfc.nasa.gov.

1.2 Energy gain calibration curve

Arrived X-ray signals with certain pulse heights are first converted to 0-1023 integer (ADC) values by 10-bit ADC circuit onboard ASIC. This ADC values become the primitive energy information that we can obtain on the satellite. Since we discuss physics in energy space, these ADC values must be converted to energy via software on ground. This ADC-to-energy conversion is done in “hxisgdpha” software by using the table of gain calibration curve defined in the CALDB. This table consists of 13312 Spline functions for individual pixels on the sensors (256 pixels × 32 sensors for Si and 64 pixels × 80 sensors for CdTe in one Compton camera), giving the relation between ADC and energy. In orbit, the ADC-energy relations are obtained by using test pulse function onboard ASIC, or from the designated calibration targets, which both give line feature with known energy in their spectra. These gain calibration curves should be updated every time when the gain of Compton camera varied due to following example situations.

1. Changing the sample-hold timing in ADC circuit.
2. Changing the triggering threshold level (affect gain, especially in lower energy).
3. Changing the shaping time in ADC slow shaper (“ifss” in terms of ASIC parameter).
4. Changing the operating bias voltage.

1.3 Scientific Impact

This gain calibration curves will directly affect the science. The CALDB should be immediately updated if necessary. Otherwise, it may form some fake instrumental structures in SGD spectrum.

Release CALDB 20160310

Filename	Valid date	Release date	CALDB Vrs	Comments
ah_sg1_gain_20140101v001.fits	2014-01-01	20160310	001	
ah_sg2_gain_20140101v001.fits	2014-01-01	20160310	001	

2.1 Data Description

The CALDB file contains two extensions for each Compton camera, “GAIN” and “ALTGAIN”. Among the Compton events, gain functions for Si un-triggered events become non-continuous due to a gap in ASIC sample hold timing. In the function of “ALTGAIN”, Si calibration curve is scaled by 1.4 in order to compensate the gap due to Si un-triggered events. Columns of each extension in the CALDB file are summarized in Table 1.

Table 1. The column names in the current release of CALDB

Column Name	Description
ASIC_ID	ASIC ID
READOUT_ID	Channel ID of each ASIC
READOUT_ID_RMAP	Remapped channel ID of each Compton camera
NINTERVAL	Number of plot intervals for the Spline fitting
NINTERVALX	Lower edge point for the Spline fitting
COEFFX3	Third-order coefficient of the Spline function
COEFFX2	Second-order coefficient the Spline function
COEFFX1	First-order coefficient the Spline function
COEFFX0	0-order coefficient the Spline function

These calibration data are taken in the on-ground low-temperature calibration experiment and the thermal-vacuum test conducted from October 2014 to February 2015. Test pulses with charge amounts divided into 5 or 6 steps were input from the ASICs, and ADC values corresponding the input energies were measured. In order to investigate the energy dependence in an ASIC more precisely, ~40 and ~80 steps of charge amounts were input only for two channels of each ASIC for Si and CdTe, respectively. Gamma-ray lines from several radioisotopes and the environmental radioactivity were used for the energy calibration. In Table 2, utilized emission lines are summarized.

Table 2. The list of the radioisotope-irradiation data used for generating the present CALDB.

Radioisotope	^{241}Am	^{133}Ba	^{57}Co	^{22}Na	^{137}Cs	Background		
						Bi-Kα	^{212}Pb	^{214}Pb
Lines (keV)	59.5	31.0, 81.0	122.1	511.0	661.7	77.1	238.5	352.0

2.2 Data Analysis

The ADC-energy relation of each channel is obtained by searching ADC values for line peaks of the input test pulses and radioisotope gamma-ray lines. Slight ADC variations among channels in one ASIC are corrected by using calibration data of two channels in which detailed charge dependence were investigated. Finally, these ADC-energy data points are smoothly connected using a third-order spline function. In order to cover wider ADC channel range, the spine functions are extrapolated in ADC values from -1 to 1000 with the boundary condition that the first two derivatives are zero.

As described in Data Description, gain functions for Si un-triggered events become non-continuous due to a gap of the ASIC sample hold timing. Figure 1 shows deposited energy relations for two hit events including Si un-triggered events. As compared to the not corrected relation (left panel), the relation with Si data scaled by 1.4 (right panel) is improved.

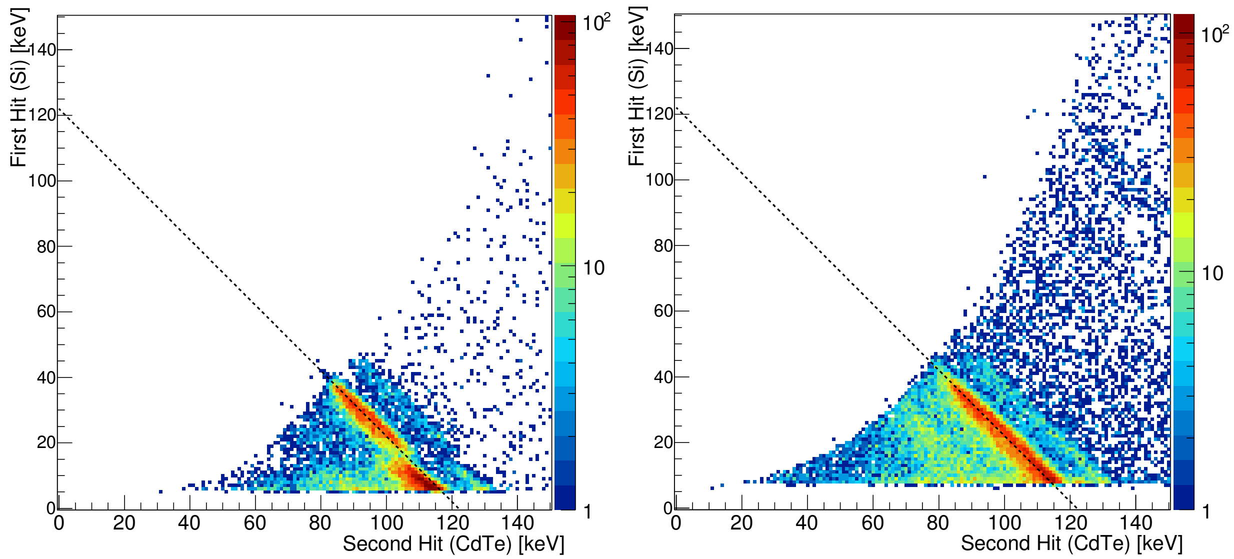

Figure 1. Relation of Si-CdTe two-hit events (including Si un-triggered events) using the gain functions of "GAIN" (left panel) and "ALTGAIN" (right panel).

2.3 Results

Figure 2 shows an example of gain calibration curves for a channel of Si and CdTe sensors in SGD2-CC1. Those are produced by the gain functions defined in "GAIN" of the CALDB file. The gain function defined in "ALTGAIN", the calibration curve of Si is scaled by 1.4.

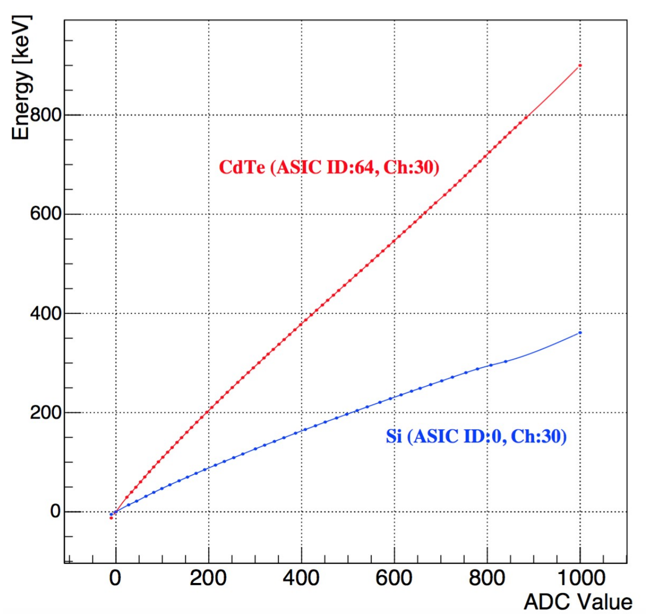

Figure 2. Examples of obtained Spline functions of a channel in Si and CdTe sensors.

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Figures 3 and 4 show obtained radioisotope spectra of each Compton camera for SGD1 and SGD2, respectively. All gamma-ray lines from radioisotope sources are nicely reconstructed, suggesting the gain curves are acceptable.

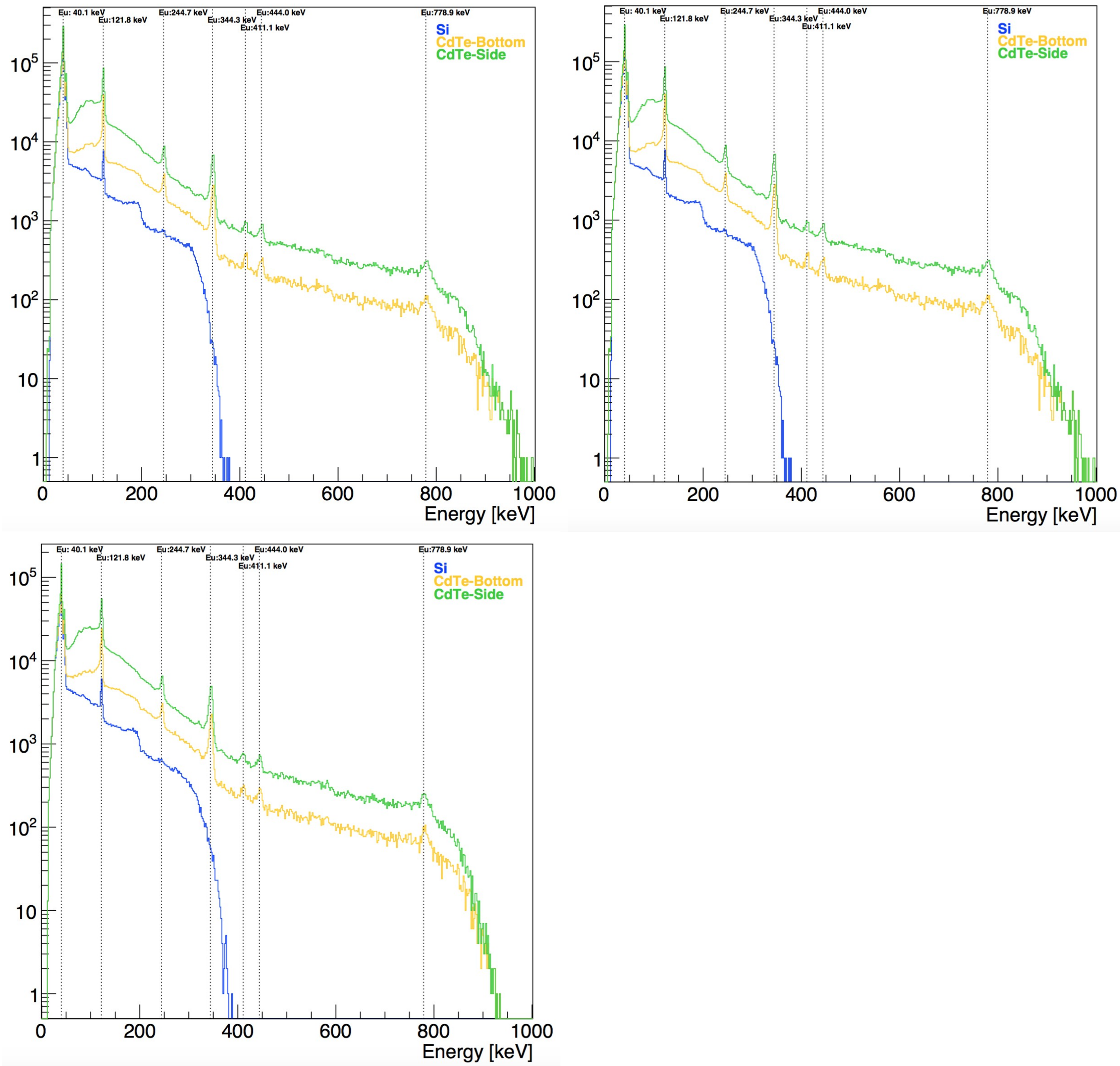

Figure 3. Energy-converted 1-hit radioisotope spectra obtained with SGD1-CC1 (top-left), CC2 (top-right) and CC3 (bottom-right).

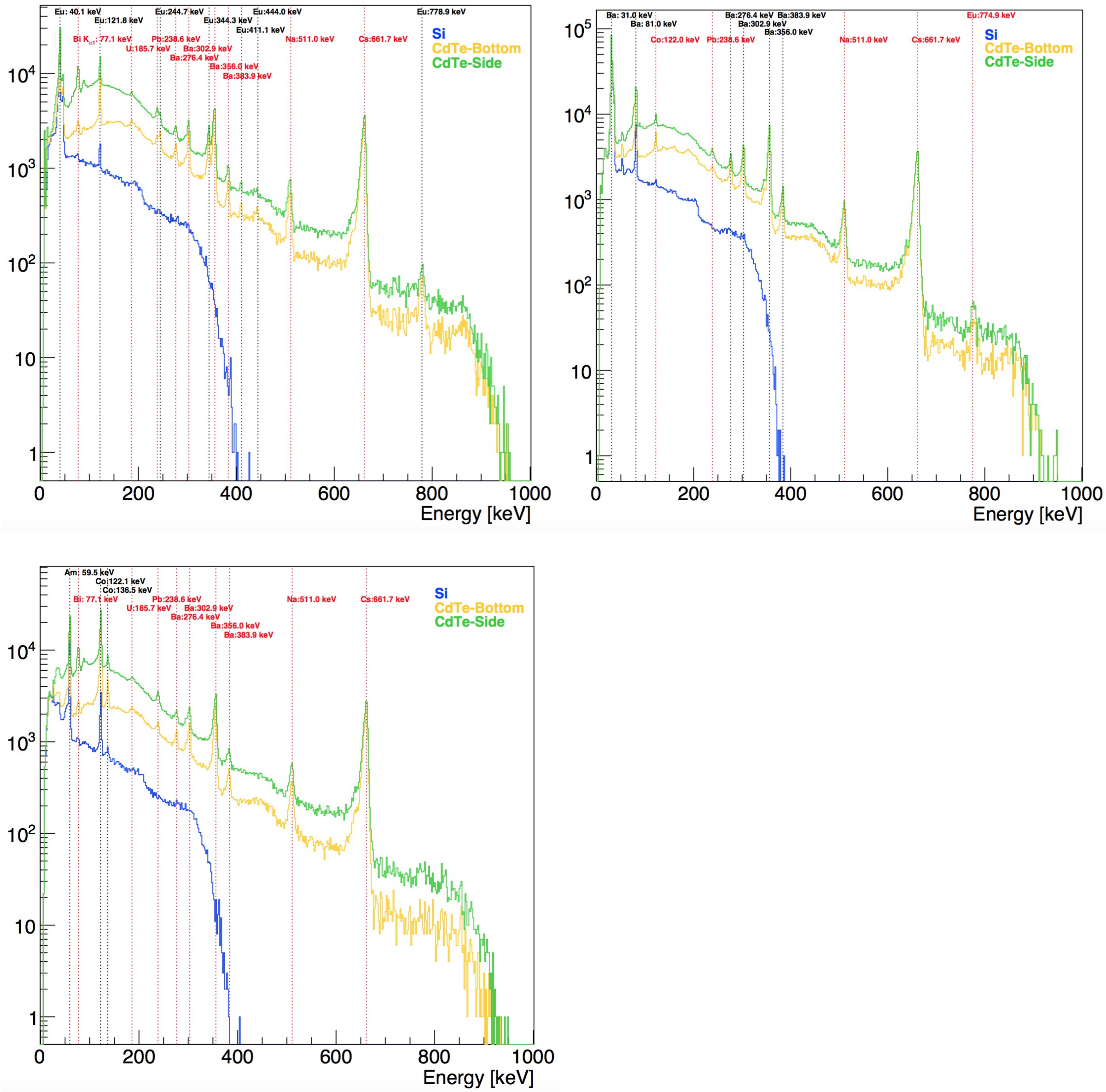

Figure 4. Energy-converted 1-hit radioisotope spectra obtained with SGD2-CC1 (top-left), CC2 (top-right) and CC3 (bottom-right).

2.4 Final remarks

Not applicable.