ASTRO-H

Instrument Calibration report
HXI Energy Cut
ASTH-HXI-CALDB-ENECUT

Version 0.1

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ISAS/ GSFC

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

Introduction
1.1 Purpose

This document describes how the Energy Cut is assigned in the ground software and how the parameters defined in the CALDB file 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 Energy Cut (ECUT)

The HXI Camera consists of four double-sided Si detector detectors (DSSDs) and one CdTe double sided detector (CdTe DSD) each of which have 128 readout strips on the both side (in total 256 per detector). When an X-ray photon is absorbed or Compton scattered within a detector (DSSD or CdTe DSD), it produces electrons and holes of which number varies depending on its energy deposit. Ideally, the energy, equivalently the number of electrons/holes, measured in each side should be consistent within the energy resolution. However, this is not the case in some particular detection situation. For example, if some fraction of electrons/holes in either side was lost due to readout with a disabled strip or by charge trapping at lattice defect, energies measured by the two sides may become inconsistent. This energy loss may lead to a misestimation of the intrinsic energies and/or detected positions.

The HXI FTOOL hxievtid filters such energy-inconsistent events during the event reconstruction stage, and this filter is called “energy cut”. The tool checks whether an energy detected by the top layer of a detector can be considered as the “same” with that from the bottom side within a certain energy range defined by the energy resolution. Those events that have consistent energies in the both sides will be only processed in the reconstruction process, and energy-inconsistent events will be discarded. The Energy Cut CALDB contains the definition of the acceptable energy range for the five detectors. Since the energy resolution of the detectors is determined by a combination of the electrical readout noise, the Fano factor, and the charge loss due to lower mobility of holes (than that of electrons), the content of Energy Cut CALDB should be updated, when these characteristics change in orbit; for example, (1) when operating bias voltage is changed, (2) when the operation mode of signal readout ASIC is changed, and/or (3) when a significant change in noise level is observed.

1.3 Scientific Impact

Energy Cut CALDB will have a significant impact to both spectroscopic and imaging science. If the energy-cut filtering is not applied to events, some fraction of the reconstructed events have inaccurate energy and/or detection position.

Release CALDB 20160310

Filename	Valid date	Release date	CALDB Vrs	Comments
ah_hxi1_enecut_20140101v001.fits	2014-01-01	20160310	001	
ah_hxi2_enecut_20140101v001.fits	2014-01-01	20160310	001	

2.1 Data Description

The following conditions are contained in the current version of Energy Cut CALDB.

Si: $E_n - 5\sigma_n (E_n) \leq E_p \leq E_n + 5\sigma_n (E_n)$; $\sigma_n = (P_0^2 + P_1 E_n)^{0.5}$

CdTe: $P_0 E_{Al} - 5\sigma_{Al}(E_{Al}) \leq E_{Pt} \leq E_{Al} + 5\sigma_{Al}(E_{Al})$; $\sigma_{Al} = (P_1{}^2 + P_2 E_{Al})^{0.5}$

where $\sigma_{n/Al}$, $E_{p/n/Pt/Al}$, $P_{0/1/2}$, are the energy resolution, detected energy, and constant parameters, respectively. If the energy detected in the n-side of DSSD or the Pt-side of CdTe DSD is not consistent with that from the p side (DSSD) or the Al side (CdTe DSD) within 5 times the energy resolution of the p side (or the Al side), that event will be discarded. In addition, the low mobility of holes is taken into account in CdTe DSD (described as P_0) by assuming that every 7.1% of charges are lost during the drift toward the Pt-side strips from the incident position. The energy resolution term is resolved into two components, the noise factor term ($\propto E^0$), and the Fano factor term ($\propto E^{0.5}$). Here we set the former ($P_{0/1}$) as 1.0 keV, and the latter ($P_{1/2}$) as 0.00036(0.00042) for Si(CdTe).

Figure 1 shows examples of the energy cut applied to DSSD and CdTe DSD. Events fall within the two green lines are considered valid in the reconstruction process. In DSSD, there are some branches whose slopes are not same as y=x but somewhere y=0.5x or 1.5x. These are coming from negative pulse events, which is a unique phenomenon in HXI DSSDs. These events should be discarded from analysis, because they produce almost no signal in the n side of the detector; in these events, the positions of X-ray photons cannot be reconstructed. As can be seen from the figure, the energy cut selection effectively excludes the negative pulse events. The energy cut selection discards the “tail” structure seen in CdTe Pt-side. In these examples, 1-3% of total events are discarded by the energy cut.

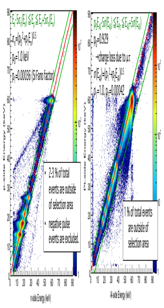

Figure 1. Visual illustration of the energy cut. The two-dimensional histogram of X-ray events detected by DSSD (right) and CdTe DSD (right). Green lines are the lower and the upper limits defining the acceptable energy region. Red line corresponds to $E_p=E_n$ or $E_{Al}=E_{Pt}$.

2.2 Data Analysis

Not applicable.

2.3 Results

Not applicable

2.4 Comparison with previous releases

Not applicable.

2.5 Final remarks

Not applicable.