ASTRO-H

INSTRUMENT CALIBRATION REPORT
SXS ANTICOINCIDENCE DETECTOR GAIN
ASTH-SXS-CALDB-GAINANT

Version 0.1

13 February 2016

ISAS/ GSFC

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Introduction

1.1 Purpose

A fraction of cosmic rays that traverse the SXS calorimeter pixels will leave behind energy comparable to photons in the SXS bandpass. An anticoincidence detector ("anti-co") sits behind the calorimeter array to enable rejection of these cosmic ray events as well as to provide an independent monitor of the particle background. The anti-co is a silicon ionization detector with a temperature invariant gain that sits behind the calorimeter array.

This document describes the CALDB gain file for the SXS anticoincidence detector.

1.2 Scientific Impact

The anti-co gain is used to convert anti-co PHA (ADC units) to PI (energy in keV). The anti-co events may be used to flag cosmic ray events in the pipeline task `sxsflagpix.`

2 Release CALDB 20160310

Filename	Valid data	Release data	CALDB Vrs	Comments
ah_sxs_gainant_20140101v001.fits	2014-01-01	20160310	001	Original ASCII file: AnticoGain_20150806_v0b.tx

2.1 Data Description

The calibration of the anti-co gain was performed on January 1, 2015 during SXS instrument-level testing at Tsukuba Space Center (TKSC). We used a Rotating Target X-ray Source (RTS) positioned above the dewar to provide x-ray lines at known energies.

The RTS consists of a bright x-ray continuum source (TruFocus model 5110 with tungsten target) that illuminates single crystal targets mounted on a rotating wheel. Fluorescence from the targets provides x-ray line emission directed to the instrument aperture. For the case of the anti-co gain measurement we used the RTS in non-rotating mode to provide a constant flux of x-rays at 22.105 keV (Ag-Kα_{12}) and 24.94 keV (Ag-Kβ) for a total of 1.5 hours. The x-ray source settings were HV=30 kV and $I_{emission}$ = 51 μA.

The data were acquired using the Pulse Shape Processor (PSP). The PSP calculates the PHA of each anti-co event onboard by subtracting the anti-co pedestal from the raw pulse height (the maximum ADC sample for each triggered event). The anti-co pedestal is a commandable value that was determined in previous ground testing to 'zero' the anti-co PHA so that histograms of anti-co baseline events are centered at the origin. We do not plan to change the anti-co pedestal during the mission lifetime. Table 1 provides a summary of relevant PSP parameters.

Anti-co Channel ID	Anti-co Pedestal [ADC units]	Anti-co Threshold [ADC units]
0 (PSP side A)	-6613	15
2 (PSP side B)	-6611	15
PSP UAPP_VER: 0x141118		

Table 1 Relevant PSP parameters during anti-co gain calibration measurement. There is a single anticoincidence detector, but, for redundancy, it is read out using two separate readout chains.

The instrument was in a nominal operating state with a detector temperature of 50mK and an anti-co bias of 6V for each channel. Note that these data were acquired prior to installation of the isolators between the dewar and the cryocoolers; however, this change should not affect the anti-co gain. The SXS data were recorded into an Igor Pro experiment, filename = `15-01-01.10.49.34Z.pxp`, using the XRSGSE software suite version 10.4.15. The data were subsequently reprocessed using XRSGSE version 10.5.7.

2.2 Data Analysis

The anticoincidence detector is linear over its operating range of ~1 keV – 6 MeV. We parameterize the anti-co gain as follows:

$$E \text{ [keV]} = \text{coef0} + \text{coef1*PHA} + \text{coef2*PHA}^2 + \text{coef3*PHA}^3. \qquad \textbf{Eq. (1)}$$

The anti-co gain is primarily described by the linear coefficient (coef1). The offset coefficient (coef0) is included to correct any sub-ADC-sample shift in the zero-point, which is likely since the pedestal is limited to an integral number of ADC units. We expect that the quadratic and cubic terms (coef2 and coef3) will always be zero, but include them for flexibility.

Figure 1 presents the anti-co spectrum for Channel 0 (PSP side A). To derive the anti-co gain we require a precise measure of the centroid of the Ag-Kα_{12} complex. Because the anti-co resolution is ~1.7 keV FWHM, the Ag-Kα line is blended with the Ag-Kβ line. Thus instead of a simple Gaussian fit, we performed a two-Gaussian fit to the Ag-Kα and Kβ region. We found that the resulting fit was skewed by the counts at lower energy (from 15–40 ADU), and instead employed a four-gaussian fit (blue curve). We also fit the anti-co baseline events to determine the sub-ADC-unit offset parameter. The fit results are presented in Table 2. The gain parameters are determined using these parameters and assuming linearity (coef2=coef3=0), which has been proven in previous sub-system tests. The data show each anti-co channel has a scaling of 0.42 keV per ADC unit. This is consistent with gain scale measurements taken during sub-system testing at GSFC using ^{241}Am to provide ~60 keV photons and checks of the gain scale using Ag photons during instrument-level testing in March 2015 after installation of the SXS isolators (final flight configuration of the instrument).

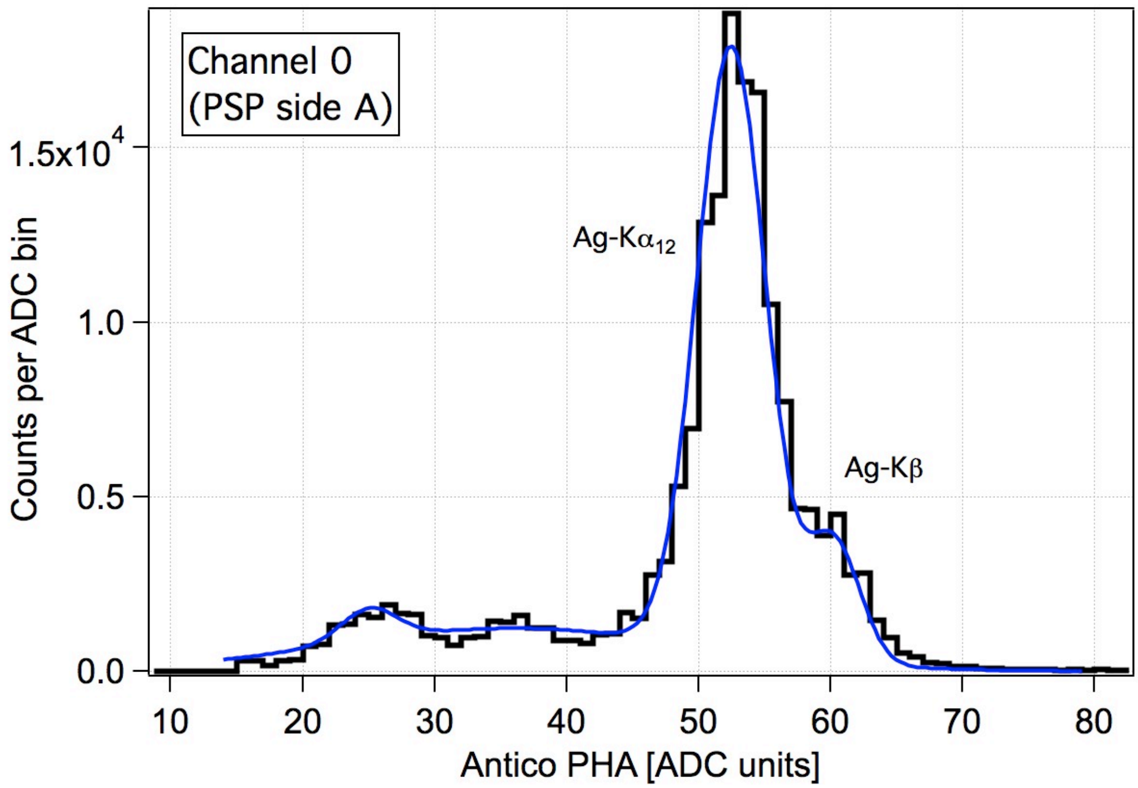

Figure 1 Anti-co channel 0 spectrum (black curve) and corresponding fit (blue curve).

Anti-co Channel ID	Centroid of Ag Kα line [ADC units]	Centroid of Baseline Histogram [ADC units]
0 (PSP Side A)	52.476 ± 0.064	-0.11 ± 0.05
2 (PSP Side B)	51.806 ± 0.043	-0.83 ± 0.05

Table 2 Fit results of spectra acquired for anti-co gain calibration.

Note that the anti-co lines show an asymmetric distribution, with a tail to low energy, due to an arrival-time–PHA dependence. This asymmetry is not apparent at low energies (e.g., at Ag Kα), but becomes more pronounced at higher energies. Thus a simple PHA–energy gain conversion becomes less-well-defined at higher energies; however, the only requirement on the knowledge of the anti-co energy scale is to provide knowledge of the energy and resolution near the threshold, which is typically set at ~10 keV. Having information about the rest of the spectrum is expected to be an interesting diagnostic, but there is no requirement on it.

2.3 Results

The CALDB file contains the polynomial coefficients, as defined in Eq. 1, for each anti-co channel. The results are displayed in Table 3.

Anti-co Channel ID	coef0 [keV]	coef1 [keV/ADC]	coef2 [keV/ADC^2]	coef3 [keV/ADC^3]
0 (PSP Side A)	0.0462	0.420	0.0	0.0
2 (PSP Side B)	0.3486	0.420	0.0	0.0

Table 3 SXS anti-co gain coefficients.

The uncertainty on the offset (coef0) values are ~0.02 keV; the uncertainty on the scaling terms (coef1) are ~0.001 keV/ADC.

2.4 Final remarks

This is the first release of this CALDB file based on ground measurements. We expect that the anti-co gain will not change and these values will be valid for the entirety of the mission; however, the small offset term (coef0) depends on the choice of PSP anti-co pedestal so if that parameter is changed the CALDB file should be updated accordingly.