



ASTRO-H

**INSTRUMENT CALIBRATION REPORT**  
**QUANTUM EFFICIENCY**  
**ASTH-SXI-CALDB-QE**

Version 1.0

30 November 2016

**ISAS/ GSFC**

**Prepared by:** Takayoshi Kohmura and Hiroshi Nakajima on behalf of the SXI team

## Table of Contents

Introduction.....	4
1.1 Purpose.....	4
1.2 Scientific Impact.....	4
2 Release CALDB 20160308.....	4
2.1 Data Description .....	4
2.2 Data Analysis .....	4
2.3 Results.....	5
2.4 Final remarks .....	6

**CHANGE RECORD PAGE (1 of 2)**

DOCUMENT TITLE :SXI quantum efficiency			
ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Version 0.0	May 2011	All	First draft
Version 0.1	June 2011	All	Caldb realese
Version 1.0	November 2016	Section 2	Final realese (There is no change in CALDB)

## Introduction

### 1.1 Purpose

This document describes how the quantum efficiency for the Soft X-ray Imager (SXI) is assigned in the ground software and how the parameters defined in the caldb file were derived. 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 Scientific Impact

The X-ray flux calculated from the energy spectrum with the SXI is derived using an ancillary response file (ARF). The ARF of the SXI combined with SXT-I includes this caldb file in the ARF generator.

## 2 Release CALDB 20160308

Filename	Valid data	Release data	CALDB Vrs	Comments
ah_sxi_qe_20140101v001.fits	20140101	20160308	001	

### 2.1 Data Description

The QE in the soft energy range is determined from the thickness of the dead layer (SiO<sub>2</sub> and Al) on the surface of CCD chips to block the optical light. On the other hand, the thickness of the depletion layer made by Si determines the QE in the hard energy range.

The quantum efficiency (QE) of the SXI was measured from a ground experiment performed at the synchrotron facility in Japan (KEK photon factory) in May 2012, and May and December 2015. We measured the QE below 3keV. The QE in the hard band was calculated based on the designed thickness, 200 μm, of the depletion layer.

In this experiment, we used the CCD chip named mini-CCD which had an equivalent performance with the FM CCDs. We also used the different electronics from SXI FM electronics to derive the CCD system with same clocking speed and voltages and had an equivalent readout noise. We applied the slant incident method in order to measure the quantum efficiency of mini-CCD.

After the launch, we verified the CALDB with the SXT+SXI spectrum of Crab nebula. The cloned event file is produced after finalizing the CALDB suhx as gain , trail, and CTI.

### 2.2 Data Analysis

We measured X-ray flux of a given monochromatic X-ray beam for each incident angle of 0 deg and 50 deg, and then obtained the X-ray flux ratio between the two incident angles. Figure 1

shows the X-ray flux ratio as a function of the X-ray energy. From this data, we derived the thickness of the dead layer of Al, Al<sub>2</sub>O<sub>3</sub> and Si on the surface of CCD chips.

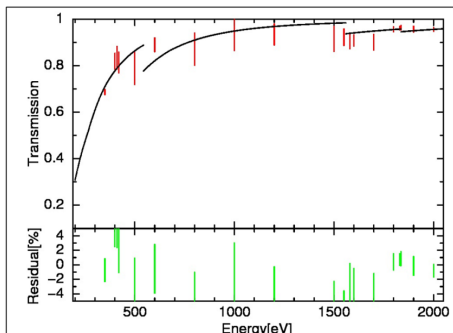


Figure 1. The flux ratio as a function X-ray energies. The upper panel shows the model curve based on the measurement of the KEK photon factory. The bottom panel shows the residuals between the data and the model.

The verification of the QE in orbit is performed by the Crab nebula data. In order to avoid the pile-up effect, the out-of-time events are extracted.

### 2.3 Results

On Ground we calculated the QE derived from the values as shown in Table 1. See figure 2.

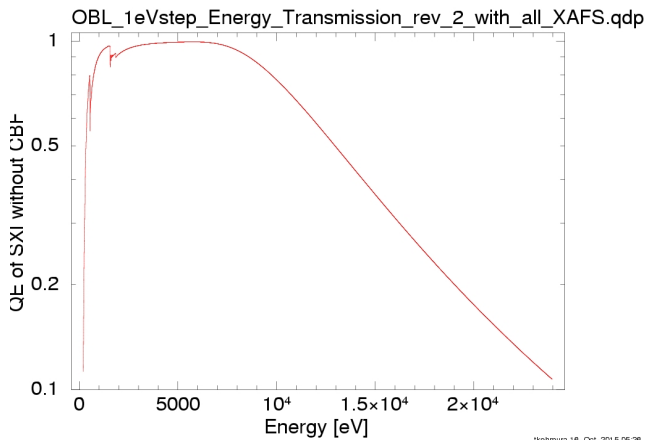
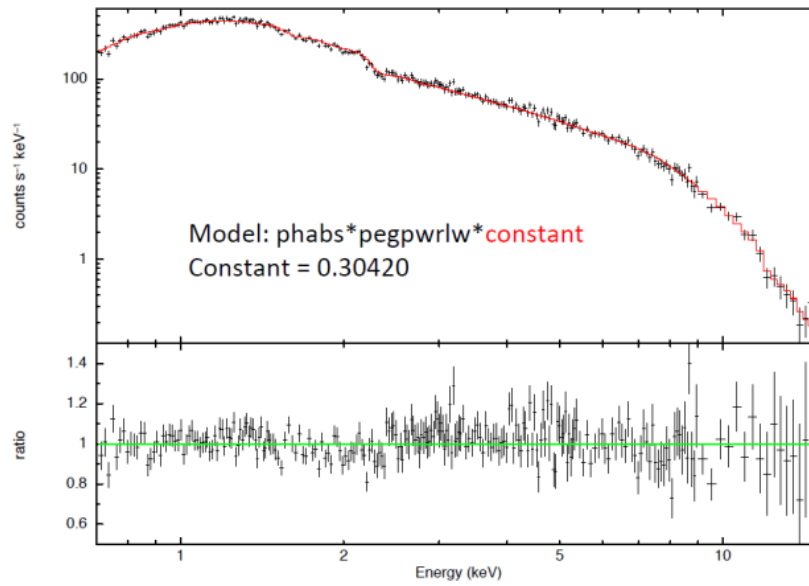


Figure 2. The QE of SXI which are released.



	nH (10 <sup>22</sup> )	Photon Index	Flux(2-10 keV)(10 <sup>-12</sup> erg · cm <sup>-2</sup> sec <sup>-1</sup> )	χ <sup>2</sup>
Hitomi/sxi	0.341(±0.009)	2.104(±0.017)	2.096E+04(0.022E+04)	1.329(dof: 245)
Suzaku/XIS1	0.30 ± 0.01	2.07 ± 0.02	2.14E+04	1.27

Figure 3 shows the fit results of the Crab nebula performed by SXT team. The best-fit parameters are almost consistent with those obtained with Suzaku/XIS1. There is no apparent feature in residual around Al and Si edge, which indicates the validity of the QECALDB determined from the ground test.

## 2.4 Final remarks

This is the first release of this CALDB file based on ground measurements.