Description of the XIS calibration files for the rev1.0 data

Hironori Matsumoto (Kyoto Univ.) and the XIS team
E-mail: matumoto@cr.scphys.kyoto-u.ac.jp, xishelp@astro.isas.jaxa.jp
ver 2.1 by H. Matsumoto May 13, 2006 ver 2.0 by H. Matsumoto May 12, 2006 ver 1.0 by H. Matsumoto May 12, 2006

1 Introduction

This document is intended for guest observers to get minimum required information about the XIS CALDB files in order to analyze the Suzaku XIS data.

2 Bad Pixel File

2.1 Files

```
ae_xi0_badcolum_20051224.fits
ae_xi1_badcolum_20051224.fits
ae_xi2_badcolum_20051224.fits
ae_xi3_badcolum_20051224.fits
```

2.2 Description

These files contain the information about the bad CTE columns and the flickering pixels, which are collectively called "bad columns."

The bad columns were determined based on our ground calibrations before the launch of Suzaku. It is known that normal columns or pixels can suddenly become the bad columns, which is probably due to the radiation damage in the space environment. Therefore the information in the files are not perfect. You are strongly encouraged to do "sisclean" for your event files to remove the hot pixels not listed in the bad column files.

2.3 Where are they used?

They are used in "xisputpixelquality" to put a pixel quality code ("STATUS") in an XIS event file. The code shows whether an event pixel belongs to bad pixels or not.

3 Calibration Source Mask File

3.1 Files

```
ae_xi0_calmask_20051105.fits
ae_xi1_calmask_20051105.fits
ae_xi2_calmask_20051105.fits
ae_xi3_calmask_20051105.fits
```

3.2 Description

These are image FITS files showing where the calibration sources (^{55}Fe) illuminate in the ACTX/Y coordinate. Pixels illuminated by the calibration sources have a value of 0, while the other pixels have 1.

The illuminated regions are determined based on our ground calibrations before the launch.

3.3 Where are they used?

These files are used in "xisputpixelquality" to put a pixel quality code ("STATUS") in an XIS event file.

4 Makepi File

4.1 Files

```
ae_xi0_makepi_20060125.fits
ae_xi1_makepi_20060125.fits
ae_xi2_makepi_20060125.fits
ae_xi3_makepi_20060125.fits
```

4.2 Description

These files have 7 extensions other than the Primary extension. We will explain what information each extension contains.

4.2.1 CHARGETRAIL Extension

We have found that a part of charge in an XIS pixel spills out to the pixel just behind it as the charge is transferred. We call this phenomenon "charge trailing." The charge trailing looks similar to the CTI phenomenon described below. However, the charge trailing is different in that the charge is not lost.

The spilled-out charge is proportional to the original charge. Thus we can correct this phenomenon if we can know the number of transfer and the "leftover" charge. This extension contains parameters used in the charge trail correction.

The charge trailing makes an X-ray event spread. Thus if we cannot correct the charge trailing accurately, some X-ray events are classified as grade 7 and they will be filtered as background events mistakenly. This causes an apparent decrease of the quantum efficiency.

The parameters were determined based on the ground calibrations before the launch. The parameters may change since the launch.

4.2.2 PARALLEL_CTI Extension and SERIAL_CTI Extension

Charge in a pixel is lost as it is transferred. The charge transfer inefficiency (CTI) is defined as

$$Q' = Q_0 \times (1 - \mathrm{CTI})^n, \tag{1}$$

where Q_0 and Q' are the original and read-out charges, respectively, and n is the number of transfer.

In the case of XIS, there are two types of transfer; a parallel transfer, which is along the ACTY coordinate, and a serial transfer, which is along the ACTX coordinate. These extensions contain parameters to correct the charge loss due to the CTI.

The parallel CTI parameters are determined using the onboard calibration source data (^{55}Fe) from Sep. 2005 to Jan. 2006. Currently all serial CTI parameters are set to 0.

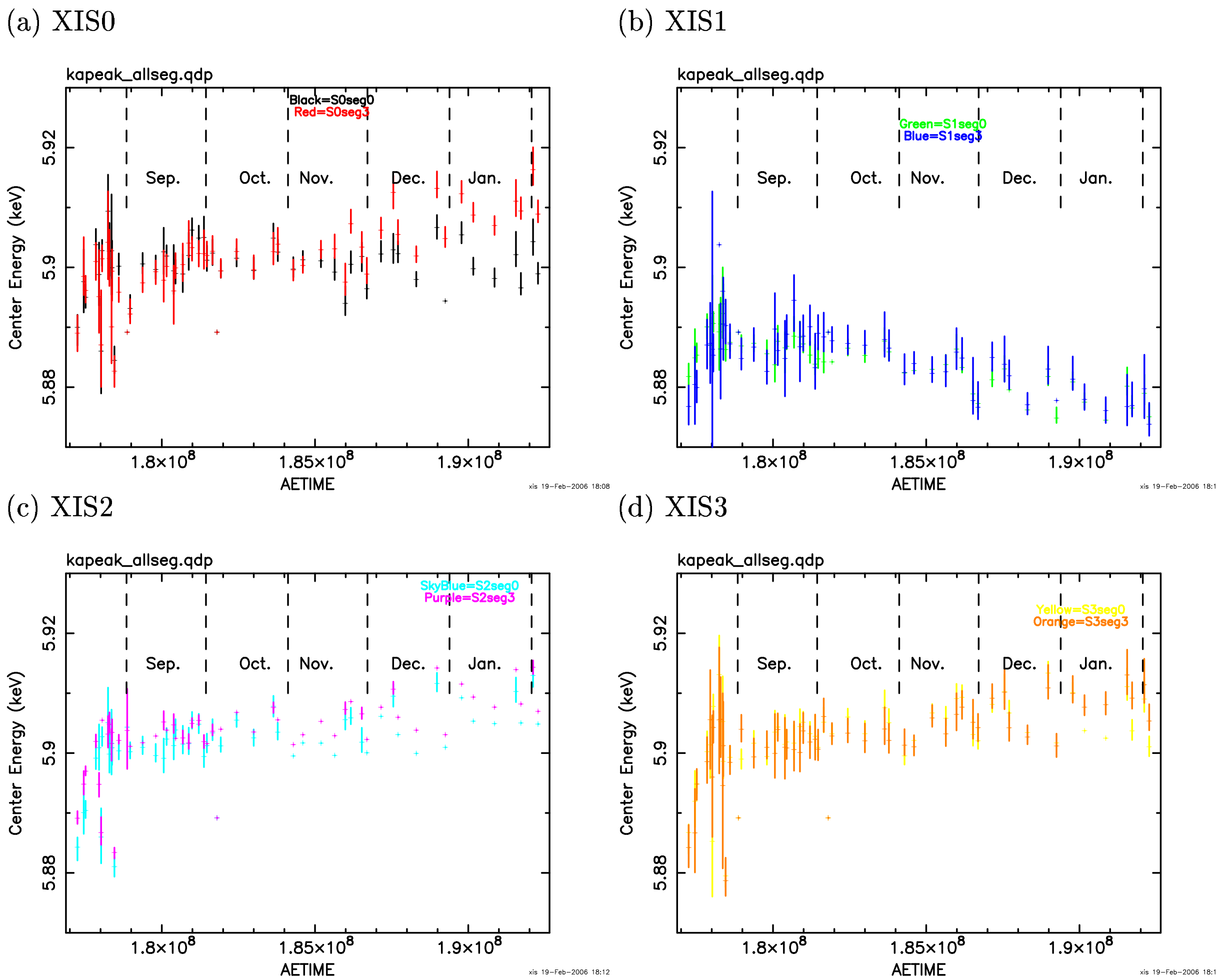

Figure 1: Center energy of the 55Fe K-α events after the CTI correction of rev. 1.0. as a function of the Astro-E time:(a) XIS0 (FI), (b) XIS1 (BI), (c) XIS2 (FI) and (d) XIS3.

Figure 1 shows the center energy of the ^{55}Fe K-α events after the CTI correction with these makepi files. If the CTI correction is perfect, the center energy should be always 5.895 keV. However, the center energy of the FI sensors is over corrected, and that of the BI sensor is under corrected. Furthermore, the deviation from 5.895 keV becomes larger as time passes in both sensors. These show the imperfection of the current CTI correction.

One of the reasons for it is that the CTI parameters were determined by using the pulse height analyzer (PHA), which is the summed pulse height of the center and surrounding pixels of an X-ray event according to the grade classification, while the CTI correction is made to the pulse height of each pixel. Since the CTI depends on the pulse height and we do not fully understand the dependence, if an X-ray event spreads over several pixels, our estimated CTI value is not correct. There is also a systematic error in the CTI correction at other energies.

4.2.3 SPTH_PARAM Extension

In the case of X-ray CCDs on board satellites before Suzaku, the split threshold is constant for all X-ray photons. The constant split threshold is still used for the FI CCDs of the XIS (XIS0, 2, and 3). Contrastingly, the split threshold is changed according to the pulse height of each

X-ray photon in the case of the BI CCD (XIS1). This extension contains information about how to determine the split threshold as a function of the pulse height.

In the case of the BI CCD, a low energy photon tends to be absorbed at a place far from the electrode. This means that a low energy photon tends to make a split event despite its small pulse height. Therefore it is reasonable to change the split threshold according to the pulse height.

The parameters were determined based on the ground calibrations before the launch.

4.2.4 GAIN-AETEMP Extension

The pulse height of an X-ray event weakly depends of the temperature of the analog electronics (AE). This extension contains information to correct the AE temperature dependence. The parameters were determined based on the ground calibrations before the launch.

4.2.5 GAIN_NORMAL Extension and GAIN_PSUM Extension

These extensions contain information about the gain which is the conversion from the PHA to the pulse invariant (PI); the PI directly corresponds to the X-ray energy. The gain for the normal mode is different from that of the P-sum mode.

The gain is determined based on the ground date before the launch. In the case of the normal mode, if the CTI correction is perfect, the gain do not change as time passes. However, since we cannot know the number of transfer of an X-ray event in the case of the P-sum mode, it is impossible to do the CTI correction and the gain in the P-sum mode should depend on time. However, we currently ignore the gain variation of the P-sum mode.

The gain suddenly change at the energy of the Si edge (1.84 keV) due to the change of the w value at that energy. Since the current version of "xispi" cannot handle the change properly, there is a "jump" structure in PI spectra. In spectral analyses, we recommend to ignore the PI channel from 500 to 504 where the jump can be seen. Furthermore, the gain below $\sim$ 2 keV is not modeled perfectly, there is a systematic error of $\sim$ 10 eV in the energy scale at the low energy band.

4.3 Where are they used?

The makepi files are used in "xispi" which calculates the PI value by taking into consideration the charge trail correction, the CTI correction, the gain, and so on. They are also used in "xisrmfgen" to calculate RMF files.

5 Quantum Efficiency File

5.1 Files

```
ae_xi0_quanteff_20060404.fits
ae_xi1_quanteff_20060404.fits
ae_xi2_quanteff_20060404.fits
ae_xi3_quanteff_20060404.fits
```

5.2 Description

These files include the data of the quantum efficiency of the CCD and the optical blocking filter (OBF). The data were determined based on the ground calibration before the launch. Thus the putative contaminant built up on the OBF is not taken into account.

5.3 Where are they used?

They are used in "xisrmfgen" to calculate the RMF files.

6 RMF Parameter File

6.1 Files

ae_xi0_rmfparam_20051017.fits
ae_xi1_rmfparam_20051017.fits
ae_xi2_rmfparam_20051017.fits
ae_xi3_rmfparam_20051017.fits

6.2 Description

These files include information on the response matrix of the XIS. The parameters were determined based on the ground calibrations before the launch. Thus the degradation of the energy resolution due to the CTI is not currently taken into account.

6.3 Where are they used?

They are used in "xisrmfgen" to calculate the RMF files.

7 RMF Files

7.1 Files

ae_xi0_20051102.rmf
ae_xi1_20051103.rmf
ae_xi2_20051102.rmf
ae_xi3_20051102.rmf

7.2 Description

These are the RMF files for each XIS sensor. The RMF files include information on the energy response and quantum efficiency of the XIS sensor and the transmission of the OBF. They do not take into account the degradation of the energy resolution of the CTI. Furthermore, the RMF files ignore the putative contaminant on the OBF.

8 ARF Files

8.1 Files

ae_xi0_onaxis_20051211.arf, ae_xi0_hxdnom_20051211.arf

ae_xi1_onaxis_20051211.arf, ae_xi1_hxdnom_20051211.arf
ae_xi2_onaxis_20051211.arf, ae_xi2_hxdnom_20051211.arf
ae_xi3_onaxis_20051211.arf, ae_xi3_hxdnom_20051211.arf

8.2 Description

These are the ARF files for a point source for each XIS sensor. The ARF files specify the effective area of the XRT. ae_xi[0-3]_onaxis_20051211.arf is for observations at the XIS nominal position (tentatively substituted with ARF files at on-axis), while ae_xi[0-3]_hxdnom_20051211.arf is for observations at the HXD nominal position. It is assumed that a spectrum is extracted from a circular region with a radius of 6 mm ($\sim 4.3'$ on the sky).