A report on the XIS calibration of the 2×2 mode and window option and the current status of the XIS NXB database

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Abstract

We report the XIS calibration on the data taken with the 2×2 mode and window option and the current status of the XIS Non-X-ray Background (NXB) database. The 2×2 mode and window option are useful for bright source observations to avoid telemetry saturation and event pile-up. The NXB database provides the best-estimated NXB spectrum for any specific observations obtained with the standard mode (Normal-Clock with no Window or Burst and 5×5- (3×3-) Editing mode). The data taken with the 2×2 mode in the "SCI-off" era are fully calibrated, and there is no practical difference from those taken with the standard mode. A calibration study for the data taken with the 2×2 mode in the "SCI-on" era is on-going. The calibration for the data taken with the window option was significantly improved in the HEASOFT 6.6.2 released at 2009 April 1st. In the comparison with the standard-mode data, the gain difference around 6 keV becomes less than 10 and 15 eV in XIS 0,3 and XIS 1, respectively. We have been updating the NXB database every half a year. There is no drastic change in the light curves, but steady ~4 % year^{-1} level increase and decrease are found in those of XIS 0,3 and XIS 1, respectively.

Key words: instrumentation: detectors — methods: data analysis — X-ray CCDs

1. Introduction

The X-ray Imaging Spectrometers (XISs) on-board Suzaku (Koyama et al. 2007) have two different data processing modes, Clock mode and Editing mode. The Clock mode describes how the CCD clocks are driven, and consists of Normal mode and P-sum mode. The Normal-Clock mode, furthermore, has two options, Burst (shorten exposure time) and Window (limiting processing region). The Editing mode specifies how detected X-ray events are edited, and consists of 5×5, 3×3, 2×2 mode and Timing mode. Combination of these modes and options affords a flexible XIS operation.

So far, most observations have used a combination of the Normal-Clock mode with no Burst or Window options and the 5×5- (or 3×3-) Editing mode (we hereafter call this mode "standard" tentatively). On the other hand, some bright source observations utilize the Normal-Clock mode with Burst and Window options and/or the 2×2-Editing mode in order to avoid severe event pile-up and/or telemetry saturation.

We here report the XIS calibration on the data taken with the 2×2 mode and the Window option. In addition, we also report the current status of XIS Non X-ray Background (NXB) database, which is basically prepared for the "standard" mode observation.

2. Calibration on the 2×2 mode

The $n \times n$ mode records pulse hight information about $n \times n$ pixels around the local peak of an X-ray event. Thus, compared to the standard 5×5 (3×3) mode, the advantage of using the 2×2 mode is to save telemetry, while disadvantage is that a part of pulse hight correc-

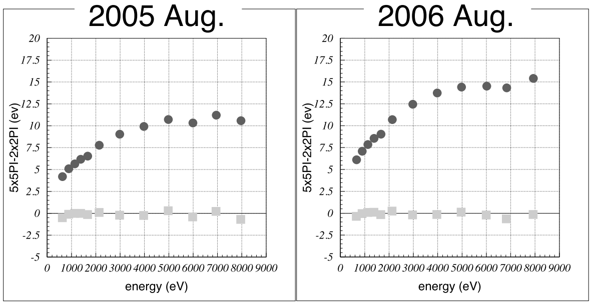

Fig. 1. "5×5 PI - 2×2 PI" (see text for this definition) as a function of energy at two different epoch. Circle and box points indicate those before and after calibration, respectively.

tion (the trail correction) can not be applied due to the lack of information, resulting in a lower gain with the same processing with that for the 5×5 mode data.

Since an X-ray event recored in the 5×5 mode can be converted into that recored in the 2×2 mode on the ground, we can measure the difference of Pulse Invariant (PI) before and after the conversion. Figure 1 shows such "5×5 PI - 2×2 PI" as a function of energy at two different epoch. This plots were made using XIS 0 data, and those using XIS 3 data show basically the same trend. The XIS 1 is not operated with the 2×2 mode. There used to be a significant (>10 eV at 6 keV) difference between 5×5 PI and 2×2 PI which had energy and time dependence (circle points). However, with the latest gain file (`ae_xi?_makepi_20080825.fits`), such a difference has been diminished down to less than 1 eV without energy and time dependence (box points). There are no practical differences in energy resolution and detection efficiency either. We note that this is still limited to data taken in "SCI-off" era as of 2009 Sep. A calibration study for the data taken in the "SCI-on" era is on-going.

3. Calibration on the window option

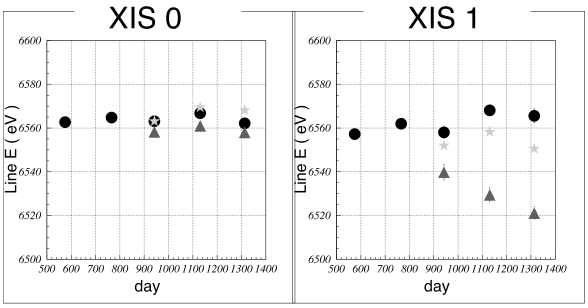

Fig. 2. Central energy measured for Fe XXV K_α line from the Perseus cluster as a function of day since launch for XIS 0 (left) and XIS 1 (right). Circle points indicate those for no Window option data (namely full window). Triangle and star points show those for 1/4 window option data before and after calibration, respectively.

We regularly observe the Perseus Cluster with and without the Window option (1/4 window) for calibration purpose. Figure 2 shows central energy measured for Fe XXV K_α line from the Perseus cluster as a function of day since launch about XIS 0 and 1. XIS 3 shows basically the same trend with that of XIS 0. There used to be a significant difference between the data without (circle point; should be regarded as reference) and with the Window option (triangle point), especially for XIS 1. This situation was improved by updating `xispi` in the HEASOFT 6.6.2 released at 2009 April 1st (star point). Currently, the gain difference around 6 keV is less than 10 and 15 eV for XIS 0, 3 and XIS 1, respectively.

4. Long-term variation of the NXB count rate

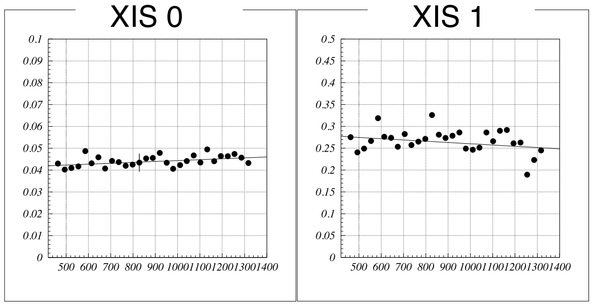

Fig. 3. NXB count rate as a function of day since launch for XIS 0 (left) and XIS 1 (right). Each point indicates a mean value per month with COR > 6 GV and energy from 5 to 12 keV.

We have been updating the NXB database every half a year. The NXB database is an accumulation of the data taken while Suzaku is pointed toward the night Earth. The NXB database is utilized by `xisnxbgen` and provide the best-estimated NXB spectrum for each individual observation performed with the "standard" mode. The details of this method and the reproducibility of the NXB spectrum are described by Tawa et al. (2008).

Figure 3 shows the NXB count rate (cnt s^{-1} CCD^{-1}) as a function of day since launch for XIS 0 and XIS 1. XIS 3 shows basically the same trend with that of XIS 0. Each point indicates a mean value per month with COR > 6 GV and in the 5–12 keV. There is no drastic change in their light curves. However, steady increase and decrease can be seen in the light curve of XIS 0 (and XIS 3) and XIS 1, respectively. Taking the count rate at the day 1000 as a reference point, XIS 0 and 3 show annual increases of 3.4 % and 2.3 %, respectively, while XIS 1 shows annual decrease of 4.1 %. The cause of this long-term variation is currently under study.

References

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