Short Report on the XIS BI Data Obtained at Kyoto

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Abstract

We examined BI CCD data (L1W18C5 and L1W18C2) obtained at Kyoto University in June 2004. We found that the best split threshold is 14, which is different from the value recommended by the MIT group. We can detect events even though no X-ray illuminates the CCD. This "dark events" are distributed not uniformly on the CCD chip. The response of the BI CCDs has a significant low-energy continuum component against low energy X-ray.

1 Introduction

In June 2004, we took the data of the XIS BI sensors by using the fluorescent X-ray lines of various elements at Kyoto University. We also took the data of ^{55}Fe. The system we used is described in Hamaguchi et al. (2000) [1]. In this experiment, we used two flight sensors: BI0 (L1W18C5) and BI1 (L1W18C2).

2 Split Threshold

We investigated the effect of the split threshold on the energy resolution and the quantum efficiency (QE). The spectra of low energy lines are not simple; for example, there are low- and high-energy continuum components (figure 7; see section 4). However, there is no such complex structure in the spectra of high energy lines such as Fe, Zn, and Se (figure 1), and we determined the best split threshold by studying the Fe Kα (6.4 keV) and Zn Kα (8.6 keV) lines. In this analysis, we used the events in the segment A. The results are shown in figures 3 and 4. To estimate the quantum efficiency (QE) of the BI sensors, we simply compared the counting rate of the BI sensor with that of the reference Ge detector behind the BI sensor (figure 2; see also Hamaguchi et al. 2000[1]).

The energy resolution is almost constant against the split threshold, but the QE depends on the split threshold. When we use the split threshold 7, the QE is much lower than the values in the MIT report [2]. However if we use the split threshold larger than 14, the QE is almost constant and is close to the values in the MIT report [2]. Thus we determine to use the split threshold of 14 hereafter.

3 Dark Data

We took 150 frames of the dark data for each BI sensor when no X-rays illuminate the CCD. We determined the dark level for each pixels by using the first 16 frames. Using the dark levels thus determined, we did the event extraction for the entire 150 frames with the split threshold 14 and the event threshold 20. Furthermore, we picked up only the events with the ASCA grade of 0, 2, 3, 4, or 6. Theoretically we should detect no events in the process, but surprisingly many events were

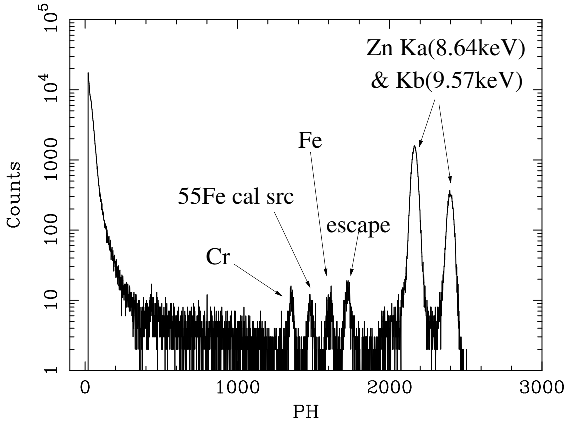

Figure 1: Spectrum of the fluorescent lines of Zn obtained with BI0 (L1W18C5). The origin of the Fe and Cr lines are probably the wall of the chamber.

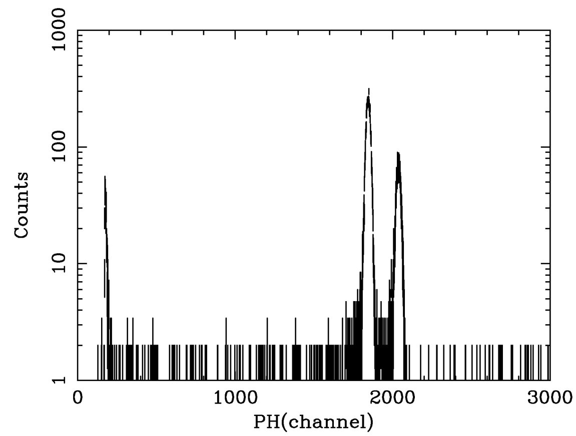

Figure 2: Spectrum of the same beam as in figure 1 obtained with the reference Ge detector behind the XIS sensor. When we obtained the spectrum, the XIS was removed from the beam line.

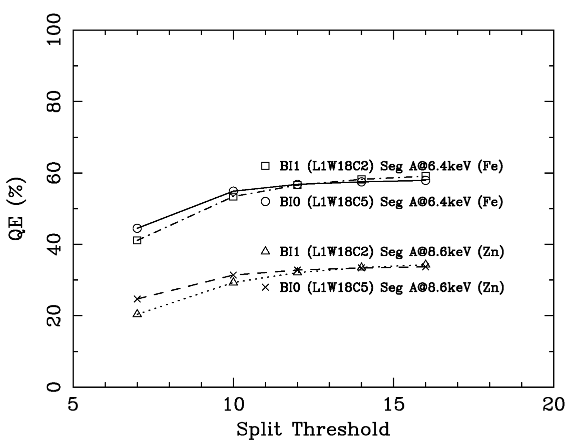

Figure 3: Quantum efficiency at 6.4 keV (Fe Kα) and 8.6 keV (Zn Kα) as a function of the split threshold.

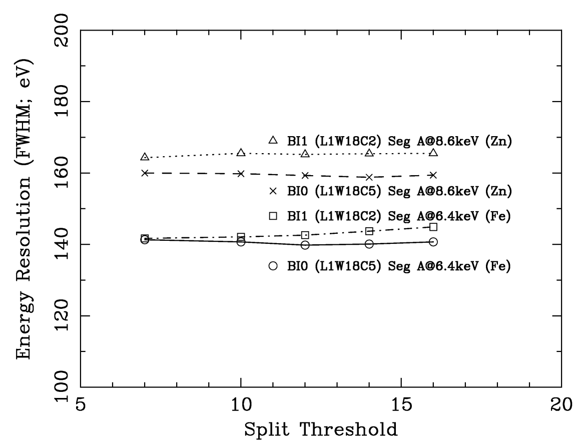

Figure 4: Energy resolution (FWHM) at 6.4 keV (Fe -Kα) and 8.6 keV (Zn Kα) as a function of the split threshold.

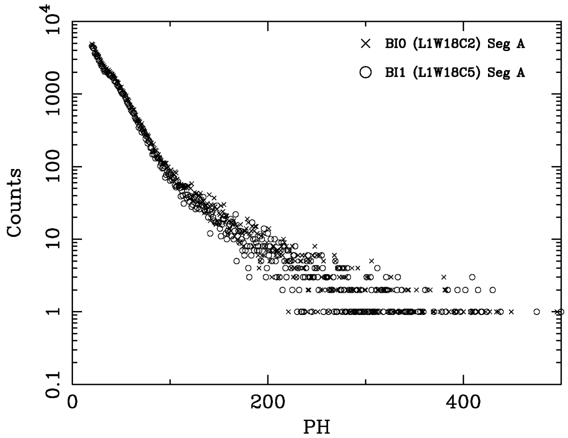

Figure 5: Spectrum of the "dark event". The split threshold is 14 and the event threshold is 20. The events with the ASCA grade 0, 2, 3, 4, or 6 are selected.

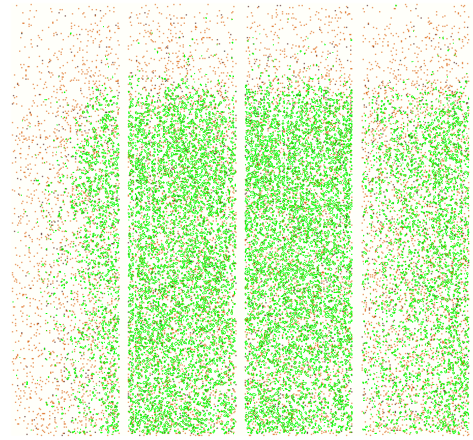

Figure 6: Image of the "dark event" of BI0 (L1W18C5). Note that the images of Seg B and D (the 2nd and 4th segments from the left) are flipped from side to side. The green region is the place where the "dark events" are concentrated.

detected with both BI0 and BI1 in reality. Figure 5 shows the spectrum of these "dark events." The pulse height of the "dark event" extends up to $\sim$ 200 ($\sim$ 0.87 keV). We made the image of the "dark event," and found that the "dark event" is not distributed uniformly on the CCD chip (figure 6). We have not yet clarified the cause of the "dark event" and its concentration.

4 Continuum Component of Low Energy Lines

Figure 7 is the X-ray spectrum of the fluorescent lines of Cl obtained with the XIS with the split threshold 14 and the event threshold 20. We found there are low- and high-energy continuum components below and above the Cl lines. We confirmed that there are no such components in the X-ray beam by using the reference Ge detector (figure 8).

Table 1 shows the grade branching ratio of the low- and high-energy continuum components and the Cl Kα events. We found that the grade branching ratio of the low energy continuum is similar to that of the Cl Kα line. Furthermore, the spatial distribution of the low-energy continuum on the CCD is uniform, which is similar to that of the Cl Kα events. Thus the low-energy component seems to be real events. If we estimate the QE at 2.6 keV by using the events with the PH between 600 and 720 ch, the QE is $\sim$ 90%, which is lower than the value in the MIT report ($\sim$ 96%) [2]. Including the low-energy continuum events in the calculation increases the QE and it may improve this situation. However, if we include the events with the PH of 250 – 600 ch in the calculation, the QE becomes $\sim$ 100%, which is clearly overestiamted.

The grade branching ratio of the high-energy continuum is different from those of the low-energy continuum and the Cl Kα events; the branching ratio of the ASCA grade 7 is rather large. The level of the high-energy continuum is lower than the low-energy continuum. We thus think that the origin of the high-energy continuum is the pileup between the low-energy continuum and the Cl events.

Table 1: Grade branching ratio of the Seg A of BI0(L1W18C5).

	ASCA grade								
	0	1	2	3	4	5	6	7	total
250-600 ch (low-energy continuum)	0.27	0.01	0.23	0.11	0.11	0.03	0.16	0.08	1 (25659 cts)
600-720 ch (Cl Kα)	0.25	0.01	0.25	0.12	0.12	0.01	0.21	0.02	1 (214756 cts)
750-1200 ch (high-energy continuum)	0.15	0.002	0.16	0.08	0.07	0.06	0.19	0.29	1 (4599 cts)

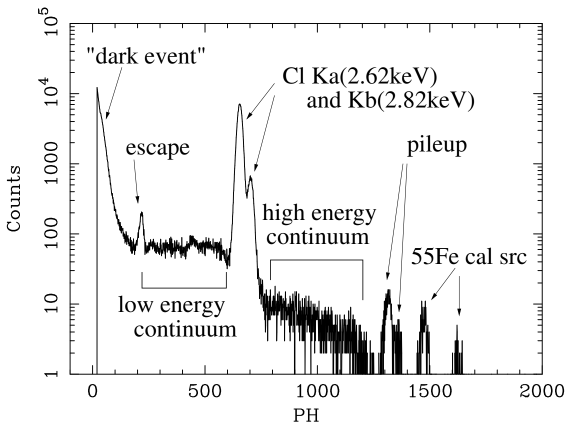

Figure 7: Spectrum of Cl obtained with BI0(L1W18C5). The split threshold is 14 and the event threshold is 20. The events with the ASCA grade 0, 2, 3, 4, or 6 are selected.

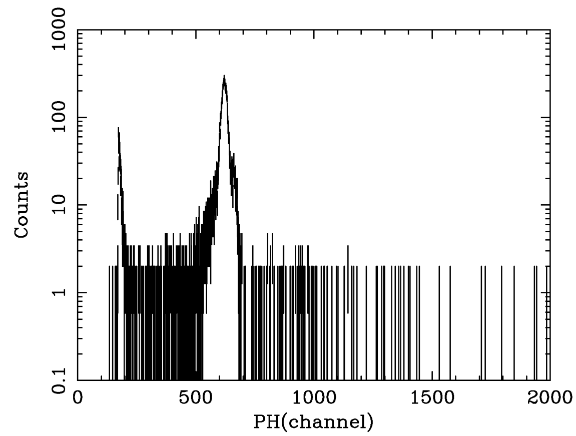

Figure 8: Spectrum of the same beam as in figure 7 obtained with the reference Ge detector. There is no continuum component.

5 Summary

We found that the best split threshold is 14, which is different from the value 7 recommended by the MIT report [2]. Event though we illuminate the BI sensors with no X-rays, we can detect events from the data with the standard event detection algorithm. The spatial distribution of the "dark events" on the CCD chip is not uniform. The response of the BI sensors has significant low-energy component against low-energy X-rays, which is not conspicuous against for high-energy X-rays.

References

[1] Hamaguchi et al. 2000, NIM in Physics Research A, 450, 360

[2] Bautz, M. et al. 2004 (`ftp://space.mit.edu/pub/mwb/astroe2/bi/bi_details.pdf`)