JX-ISAS-SUZAKU-MEMO-2010-01
Title: Anomaly of XIS0 in June 2009
Category: XIS
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1 Summary

The XIS0 suddenly showed an anomaly on June 23, 2:00 UT. During a Normal clocking operation, a part of the segment A of the XIS0 was flooded with a large amount of charges, which caused saturation of the analogue electronics. The anomaly was very similar to that occurred in the XIS2 in 2007. We suspect that both anomalies have the same origin, possibly a micro-meteorite impact. In the Normal clocking mode, the effect is almost localized to a 1/8 area of the XIS0. The XIS team continues to operate the XIS0 in this mode. Users need to be aware of several remaining artifacts after the event. In the Psum clocking mode, the effect spreads to the entire XIS0 with severe degradation of the data. The XIS team discontinues the use of Psum clocking mode for the XIS0.

2 Nature of the anomaly

The anomaly occurred at 2:00 UT on June 23, 2009, when the satellite was out of the SAA and no XIS-related command was executed. There was no sign of anomaly beforehand.

Figure 1 shows an example of the frame mode data obtained from XIS0 after the anomaly. Phenomenologically, the anomaly was caused by the leakage of charges somewhere in the imaging area of the segment A. About a quarter of the segment A was flooded with a large amount of leaked charges, which was so large that the analogue electronics was saturated and no event was recorded.

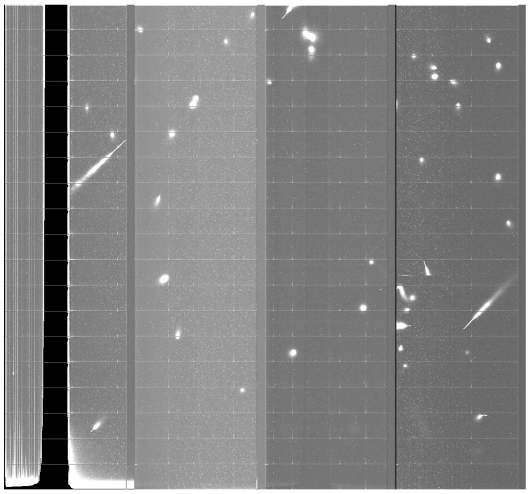

Figure 1: XIS0 frame data image taken at 19:59 UT on June 23, 2009. Segments A to D from left to right in the ACTXY coordinate.

Although the cause of the anomaly is yet to be identified, all the phenomena are very similar to those occurred in the XIS2 in 2007 (Suzaku memo 2007-08). We suspect that both anomalies were caused by an impact of micro-meteorite. The probability of micro-meteorite impacts is non-negligible for instruments equipped with X-ray telescopes with a large effective area. For XIS, two impacts in four years is not beyond the statistical expectation.

3 Symptoms and Post-event Operation of XIS0

3.1 Normal Clocking Mode without Burst/Window Options

In the Normal clocking mode without window/burst options, the damage to the sensor is limited to a part of the segment A and is stable since the occurrence of the anomaly. The damaged part is at the fringe of the imager, causing little loss of photons for normal observations. The XIS team decided to continue the XIS0 operation in the Normal clocking mode without burst/window options.

Figure 2 shows a non X-ray background image constructed from the data during the night-earth occultation. Two artifacts are apparent:

- All events in the damaged part (DETX=70–150) in the segment A are discarded onboard. This part appears blank in post-event images from June 27, 2009 onward.
- In some data, artificial signals frequently appear close to the bottom end of the segment A (red regions in figure 2).

All science data taken after the anomaly are subject to these artifacts. Users need to pay attention to these when reducing and interpreting their data.

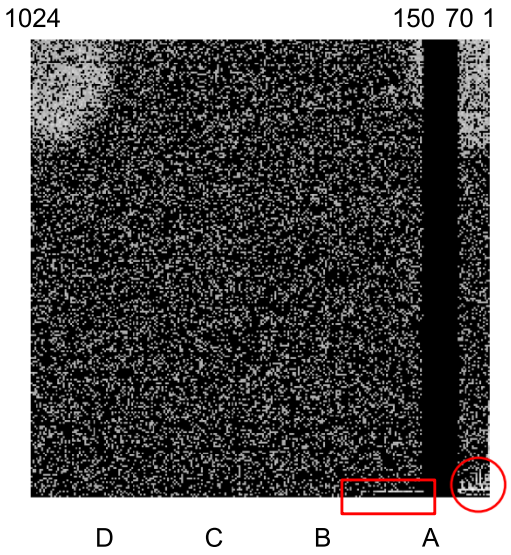

Figure 2: XIS0 image of non X-ray background constructed from observations during night-earth occultation in the DETXY coordinate with segments A to D from left to right. Regions with frequent artificial signals are shown with red shapes.

3.2 Normal Clocking Mode with Window/Burst Options

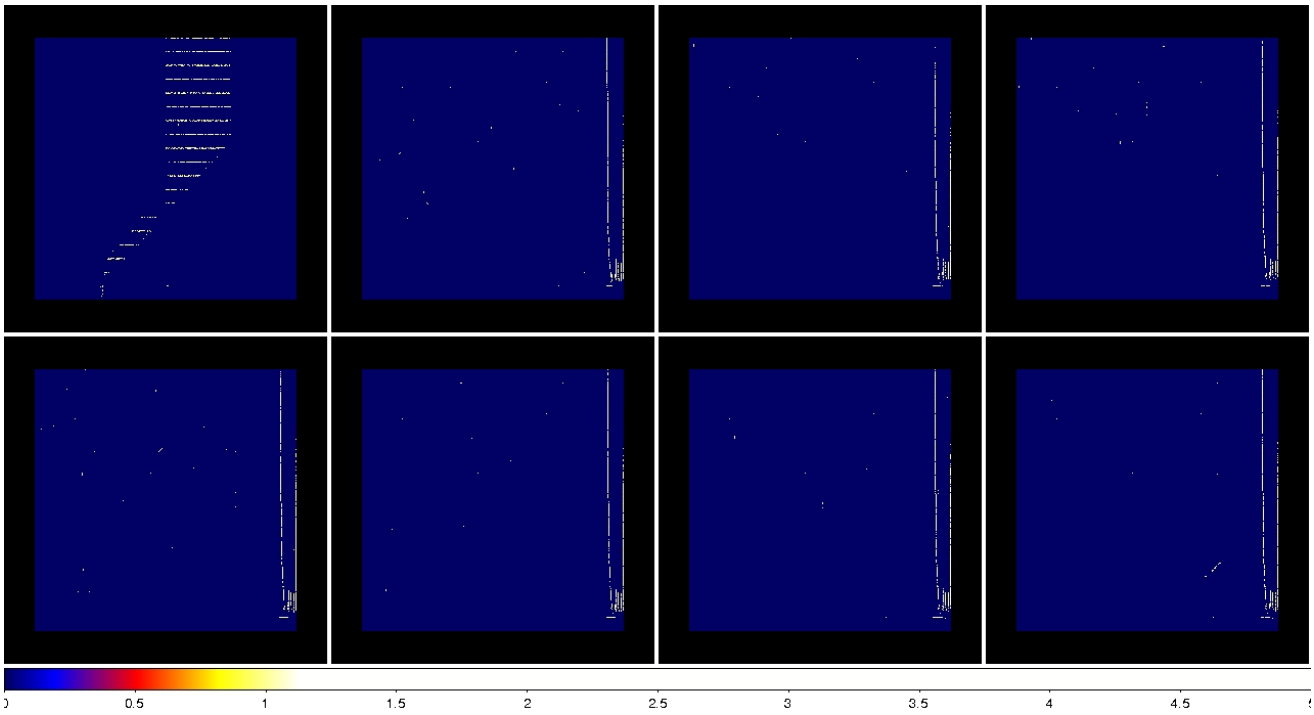

Figure 3: First eight frame images of the XIS0 in the Normal clocking mode with a 0.1 s burst option in the DETXY coordinate.

The XIS team took frame data of the Normal clocking mode for all the officially supported combination of burst and window options, spending a month after the anomaly. Some frames show leaked charges outside of the damaged part of the segment A. Figure 3 shows the first eight frames taken in the frame data acquisition operation with the 0.1 s burst option on July 30, 2009.

The XIS team considers that the effect by the additional artifact outside the damaged area is minimal, taking account of the fact that the use of burst/window options is limited to bright point-like sources observed in the segments B and C. The team thus decided to continue the XIS0 operation in the Normal clocking mode with burst/window options as before the accident.

3.3 Psum Clocking Mode

On the contrary to the Normal clocking mode, the Psum clocking mode is severely affected by the accident. Figure 4 shows a frame data of the XIS0 taken on October 10, 2009. The pixel level is 0 in the entire segment A. Moreover, many columns in the segment B and the entire segment D show a very high pixel level. The spectra taken in the segment B and C are distorted in comparison to those taken in the XIS3.

Because the effect spreads to the entire XIS0 chip and the data are severely degraded, the XIS team decided to terminate the XIS0 operation in the Psum clocking operation mode. All XIS0 data taken in the Psum clocking mode after the incident are not suitable for any scientific purposes.

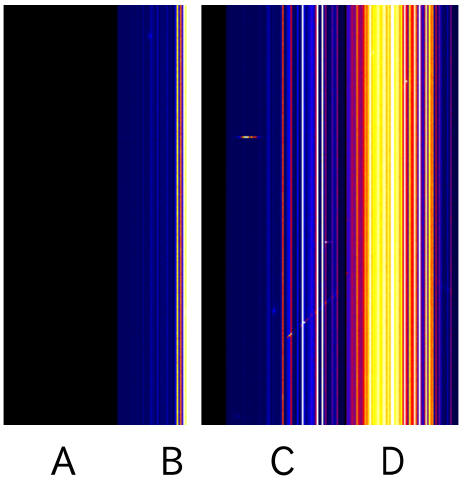

Figure 4: Frame image of the XIS0 in the Psum clocking mode in the ACTXY coordinate.

3.4 Comparison of Pre-event and Post-event Detector Responses

We are currently investigating the possible change of the XIS0 detector response before and after the anomaly. A small discontinuous change (a few eV at 5.9 keV) in the gain history was observed in the segments A and D, whereas no measurable change was found in the energy resolution for all the segments. The gain shift will be compensated in the upcoming version of the response generator. Overall, the XIS team considers that the change of the response due to the anomaly is minor if any. A comparison of the E0102-72 spectrum is shown in figure 5, where no significant change was found before and after the anomaly below 2 keV, where the emission is dominated by this source.

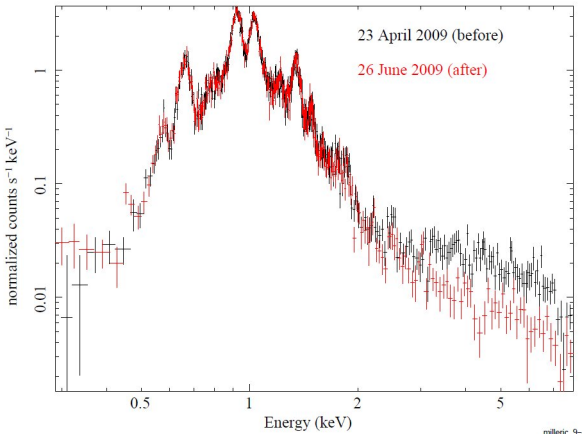

Figure 5: Comparison of E0102-72 spectrum before (black) and after (red) the anomaly. The difference above 2 keV is due to the variation in a contaminating HMXB and is irrelevant to the anomaly.