MAXI GSC In-orbit Performance and Response Calibration

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Abstract

GSC (Gas Slit Camera) is a major X-ray instrument on the MAXI payload. It employs position sensitive proportional counters with 1.4-atm Xe gas and resistive carbon anodes. The counters have been working properly since 2009 August. In-orbit instrument responses are calibrated with data of $^{55}$Fe calibration sources and backgrounds, the Crab nebula, and the pulsar. The GSC backgrounds highly depend on the in-orbit radiation environment, largely parametrized by the geomagnetic field. Due to the large inclination angle ($51^\circ$) of the ISS orbit, all payloads must suffer from heavy irradiation near the geomagnetic pole and the SAA. To decelerate the radiation damage, we restrict the counter operation in the low radiation region, and also reduce the anode voltage from 1650 V to 1550 V. The background rate was also found to be almost doubled when the Soyuz spacecraft is docked on the ISS. This is understood as due to a radioactive gamma-ray source in it.

Key words: Instrument: MAXI

1. In-orbit Operation for 4.5 years

MAXI GSC is a one-dimensional slit camera consisting of position sensitive proportional counters and slit collimators with slits (Mihara 2011). Utilizing twelve identical units aimed at the earth horizon and zenith directions, it covers $\sim 90\%$ of the whole sky every ISS-orbital cycle of 90 minutes in the 2–30 keV energy band. The counters employ 1.4-atm Xe gas including 3% CO$_2$ for a detector and resistive carbon anodes to localize the X-ray position. In the initial test phase, the carbon anodes are found to suffer from degradation largely proportional to the high background-event rate near the geomagnetic poles and the SAA (Sugizaki 2011). Hence, we restricted the counter operation in the low radiation zones which covers $\sim 40\%$ in time, and reduced the voltage of irregularly high-gain anodes from 1650 V to 1550 V. Thanks to the twelve unit assemblies, the daily sky coverage of $\sim 90\%$ is still established. Figure 1 shows the daily duty cycle of the observation operation in each camera. After the initial test phase, the duty cycles of all active counters have been almost constant at $\sim 40\%$.

2. Calibration

2.1. Gas amplifier gain

The gas and readout-amplifier gain has been monitored by $^{55}$Fe calibration source installed in each camera unit. Figure 2 shows the changes of the pulse height peak. Except for the GSC_0, they are almost constant within ±1% for 4.5 years operation. On the other hand, the peak of the GSC_0 began to increase suddenly on 2013 June 10 (MJD=55453). The gain-voltage relation suggests that the gas pressure has been decreasing gradually. We suspect that a micrometeorite might create a small gas leak on the 100-μ-think beryllium window. We then reduced the anode voltage of the GSC_0 counter step by step so that the gain keep constant. The pressure is estimated to be 0.7 atm on 2014 April, indicating that it decreased to the half by about a year. We estimate that the counter will continue to be functional for another year.
2.2. Background rate

Figure 3 plots daily background rates of 12 counters for 4.5 years, obtained by excluding resolved bright point sources per day. Therefore, these events include unresolved X-ray sky emission of cosmic X-ray background, Galactic ridge emission besides the residual particle background. As clearly seen in the data of GSC_4 and GSC_5, the rate sometimes dropped to the half synchronously. The root cause is found to be a radioactive gamma-ray source on the Soyuz space craft, which is used in the elevation monitor. The effect highly depends on the counter location on the payload. In the long term, the rates are mostly stable in each counter.

2.3. Effective area

To present the status of the quick data reduction and the effective area calibration, the Crab-nebula light curve in the 4–10 keV band is shown in figure 4. The data is updated every day and archived on the MAXI web site (http://maxi.riken.jp/top). The detector efficiency is almost 100% in the 4–10 keV band. Therefore, it is mostly free from the calibration uncertainty. Several artificially dropped points are due to the error in the data reduction which includes interference by the ISS structures and incomplete telemetry data. The long-term small variation is considered to represent the real source variation (Wilson-Hodge et al. 2011; Morii et al. 2011). The energy-dependent detector efficiency is being calibrated using the average Crab-nebula spectrum, which is still in the progress.

3. Concluding Remarks

The data reduction process and the instrument response calibration are updated frequently. The latest information will be announced at the MAXI web site (http://maxi.riken.jp/top).

We would like to thank all MAXI operation team members as well as MAXI users.

References

Sugizaki, M., et al. 2011, PASJ, 63, 635