Calibration Status of MAXI/SSC

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Abstract

The Monitor of All sky X-ray Image (MAXI) mission is the first astronomical payload to be installed on the Japanese Experiment Module - Exposed Facility (JEM- EF or Kibo-EF) on the International Space Station (ISS). It is scheduled for launch in the middle of 2009 to monitor all sky X-ray objects on every ISS orbit. MAXI consists of two X-ray detector systems:the Gas slit camera (GSC) and the Solid-state Slit Camera (SSC). These are combinations of a narrow slit, a collimator, and a one-dimensional position-sensitive detector. The energy range of the GSC and the SSC are 2-30 keV and 0.5-12 keV, respectively.

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1. MAXI SSC

The SSC (Solid State Camera) consists of 32 CCDs. CCDs are installed in two camera units called SSC-H and SSC-Z, each includes 16 CCDs where each CCD acts as one dimensional position sensitive detector. The moderate energy resolution enables us to detect the various emission lines including 0.5 keV oxygen line. The averaged energy resolution at the CCD temperature of -70 deg is 145 eV (FWHM) for 5.9 keV X-ray. The energy resolution and the energy scale of the SSC are calibrated using ground data. However, their change in the orbit is inevitable due to degradation of the charge transfer efficiency (CTE) caused by radiation damage. Therefore Orbital calibration using bright X-ray source is needed.

2. Calibration System

We evaluated the performance of the SSC with a calibration system constructed at JAXA. The compact X-ray generator which generates flourescent X-rays is connected to a secondary target chamber. We employ Al, Cl, Ti, Fe, Ni, and Zn as secondary targets. These secondary X-rays are then incident on the SSC. The SSC is cooled down using a cryogenic cooler to $-30°$C, and then peltier element was used to cool them down to -70°C .

3. Energy Resolution

The energy resolution was measured using ground calibration system. Each CCD had slightly different energy resolution, but they were all fitted by a function of

$$\mathrm{FWHM} = \sqrt{a + b\mathrm{E} + c\mathrm{E}^2} \qquad (1)$$

where E is the energy and a, b and c are the free parameters. Figure 1 shows the energy resolution of SSC-H CCD0. The data points shows the FWHM of each secondary target line, and the solid line shows the fitted function. As a ground calibration result, parameter c is set to 0. From the fitted function, we found that energy resolution of every 32 CCD is whithin FWHM=92.3-110.3eV at 0.5keV and FWHM=142.0-152.3eV at 6.0keV.

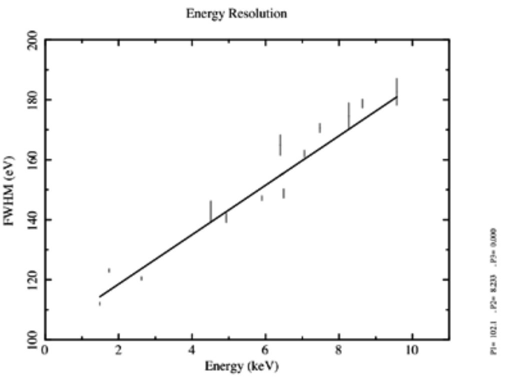

Fig. 1. The energy resolution of SSCU-Z CCD-0 and its fitted function.

4. Quantum Efficiency

Since the SSC is a slit camera, X-ray will hit the CCD with incident angle $\theta < 40°$. Since the thickness of the depletion layer that X-ray experiences depends on the incident angle, the quantum efficiency (QE) is position dependent. Fig 2 shows the QE as a function of energy. The dotted line represents the QE at the incident angle of nearly 0° and the solid line is at incident angle of 40°. For both line, O, Al, Si-edge can been seen. Each CCD is divided into 4 different positions and their QEs are stored into CALDB.

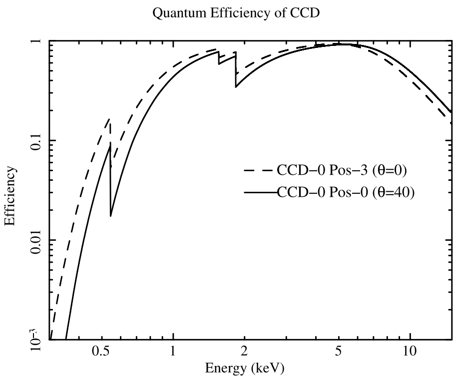

Fig. 2. Quantum efficiency of SSCU.

5. Response function

The CCD's response to monochromatic X-ray is very similar to that of the Suzaku XIS. It can be expressed as a function of 4 Gaussian components and constant component. The 4 Gaussian components represents, main peak, Sub peak, Si escape peak and Si peak. The sub peak component is a part of "tail" components and its gaussian center is slightly lower PH channel than that of the main peak component. An X-ray photon is absorbed at the depletion layer, but electrons are split over a few pixels. Some of the pixels have a PH lower than the split threshold and are not counted as a signal. The Si escape can be expressed by a Gaussian model centered at the PH channel lower than the main peak by 1.74 keV which is the energy of the Si K α line. After an X-ray photon is absorbed at the depletion layer, the fluorescent X-ray photon of Si is generated. The Si X-ray photon escapes from the pixel which absorbed the incident X-ray photon. The Si component can be described by a Gaussian model centered at 1.74 keV. The fluorescent X-ray photon of Si is absorbed at a pixel far from the place where an incident X-ray photon was absorbed.

6. Orbital Calibration

We simulated the spectrum of Cas A for orbital calibration of the SSC. This SNR is known for its brightness

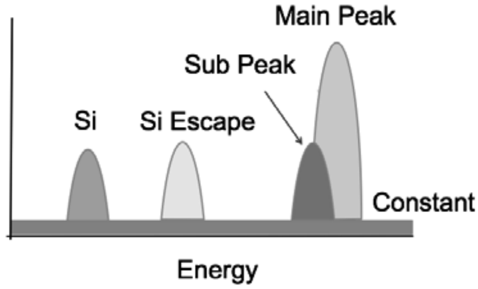

Fig. 3. Responses function of CCD, consists of 4 gaussian components and a constant component.

and strong emission lines which makes perfect candidate for calibration. Fig 4 shows the simulated one month spectra of Cas A. The response function acquired by analyzing the ground data was used for this simulation. We fitted Si, S, and Fe emission lines and determined the center energy of emission line by 0.04% for Si and S, 0.15% for Fe.

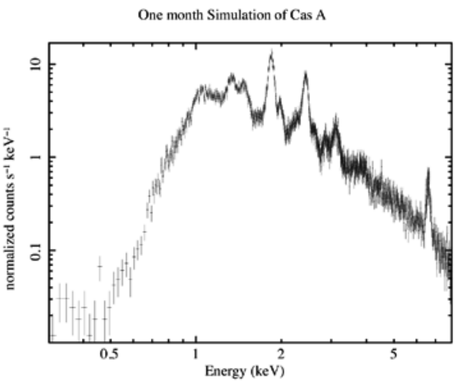

Fig. 4. Simulated one month spectra of Cas A.

7. Summary

We calibrated the MAXI SSC using ground data and determined the energy resolution to be around 150eV at 6.0keV. We also determined the quantum efficiency of the CCD for several different incident angle. The response function of CCD to monochromatic X-ray can be described by 4 gaussian and a constant conponent. For orbital calibration, we simulated the one-month spectra of Cas A and figured out the SSC can determine its line center of emission lines by 0.04% for Si and S, 0.15% for Fe.

References

Ueno. et al. (this proceeding)
Tomida et al.(this proceeding)
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