The Solid-state Slit Camera, SSC, onboard MAXI

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Abstract

Soli-state Slit Camera (SSC) is X-ray CCD camera onboard MAXI, which start the operation in Aug 2009. We describe the SSC hardware and report the in-orbit performance in initial phase.

Key words: space: vehicles — instrumentation: detectors — X-ray: general

1. Overview of SSC

Soli-state Slit Camera (SSC) is X-ray CCD camera onboard the MAXI mission (Ueno *et al*, this proceeding). SSC covers 0.5 to 10keV with moderate energy resolution (150eV at 5.9keV in FWHM).

The SSC system is composed of two SSC Units (SSCUs) and SSC Electronics (SSCE). SSCU is a sensor part of SSC. Each SSCU includes X-ray CCDs, pre-amplifiers, multiplexers, slit-collimator system, calibration source, and so on. Fig.1 shows the schematic view of SSCUs. One of SSCUs monitors X-ray sky in the horizontal direction of MAXI (ISS moving direction), and another is for zenith (anti-earth) direction. Hence, the former is called SSCU-H, and another is called SSCU-Z.

SSCE controls SSCUs. SSCE generates CCD drive signal according to commands from main computer of MAXI, and digitizes the video signal from SSCUs. SSCE also generates CCD clocking signal. CCD is two dimension array, while SSC requires only 1-dimensional position information. Hence, electrons in multiple rows are gathered in serial register at the bottom of imaging region, and the charges in serial register are transferred to read-out node. The number of summed rows in normal observation can be selected from 16, 32 and 64 by commands. We call this number "binning" parameter. The binning of 64 is selected for the nominal observation. Binning=1,2,4,8 can be selected for the diagnosis only. The clocking speed is 8μs/pixel, and a two-phase vertical transfer takes $\sim$100 μs. The video signal from 16 CCDs in a SSCU are processed by one read-out electronics and one analog-to-digital converter (ADC). When a CCD is driven and read-out, other 15 CCDs are in exposure. SSCE also controls CCD temperature using thermo-electric cooler embedded in CCD chips.

Loop heat pipe and radiator system (LHPRS) is not a portion of SSC, however, they are very important to cool X-ray CCDs. MAXI has two radiator panels whose total size is about 1.0m^2.

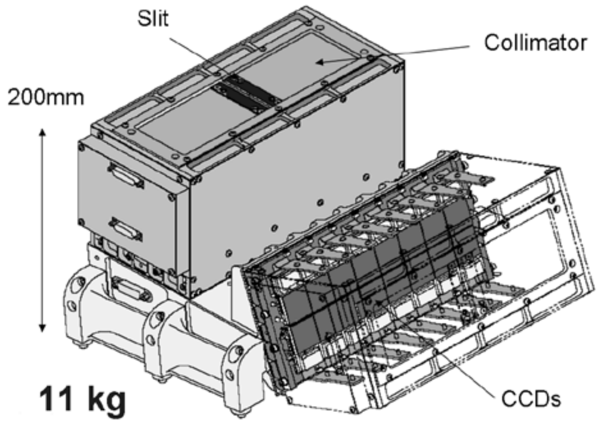

Fig. 1. SSC camera units (SSCUs)

CCDs of MAXI are type of FFTCCD-4673 fabricated by Hamamatsu Photonics K.K.[1] Fig.2 is a photograph of MAXI-CCD. The chip is front-illuminated and two-phase CCD operated in full frame transfer mode. The pixel number is 1024$\times$1024, and the pixel size is 24 μm$\times$24 μm, giving the CCD size of 25 mm $\times$ 25 mm for X-ray detection. In order to obtain the large X-ray collection area, each SSCU includes 16 CCDs, which are placed in 2$\times$8 array. The total X-ray detection area of 32 CCDs is $\sim$200cm^2. Charge injection (CI) is available to minimize the damage of particle radiation. The energy range covered by SSC is 0.5–10keV.

SSC has collimator and slit system but not X-ray mirrors. Collimators of SSC limit field of views (FOV) to be narrow and long shaped, and slit and CCDs determine the direction from which each X-ray photon comes in the

*1 http://www.hamamatsu.com/

narrow FOV. Slat collimators are made of thin sheets of phosphor bronze. The thickness is 0.1mm, and 24 sheets are placed above CCDs in the interval of 2.3 mm. The width of narrow FOV determined by slat collimators is 1.5° in FWHM. Slit of SSC consists of two sharp edges made of tungsten. The width between the two edges is 2.7mm. Since the position resolution of CCD is much better than the slit width, the angular resolution along the narrow FOV is determined by the slit width to be 1.5°. The angular length of the FOV is 90°.

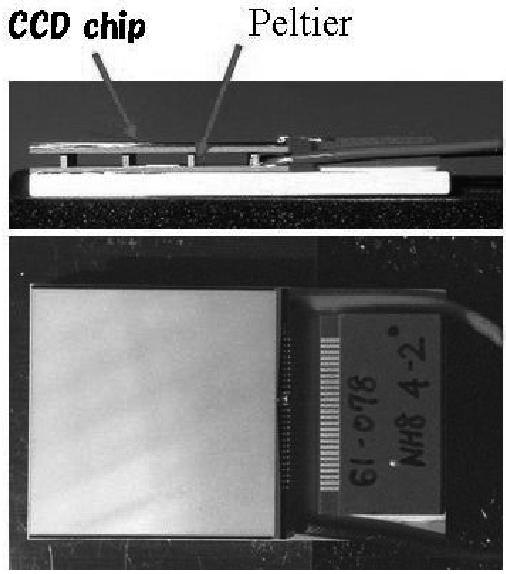

Fig. 2. X-ray CCD of MAXI

2. In-orbit performance

After the successful installation of MAXI onto the International Space Station, SSC and LHPRS were activated 15 Aug 2009. SSCUs are cooled down to ~ -15C° by LHPRS, and averaged temperature of CCDs cooled by thermo electric coolers got less than -60C°. Fig.3 shows the spectrum of a X-ray CCD in SSCU-H. Mn k_α/k_β lines from calibration source and fluorescence lines of Cu k_α/k_β coming from collimators are clearly detected. Cu lines are confirmed to be detected in all of 32 CCDs.

X-ray CCD has sensitivity for the optical light. Although the surface of MAXI-CCD is coated with aluminum to block optical light, it is not possible to conduct the observation when sun is close to the SSC filed of view. So SSC has been operated when ISS is at night during the early calibration phase. Fig.4 is the X-ray sky image obtained with SSCU-H for the first 3 weeks. Non X-ray background are not subtracted, and the exposure time and effective area are not corrected. The energy band is 1.0 to 9.0keV. As can be seen, about a half of the whole-sky is covered by SSCU-H, and about 20 X-ray objects are clearly detected. While the most of them are detected in GSC, another camera of MAXI, low energy sorces, such as Cygnus Loop, are detected in SSC only.

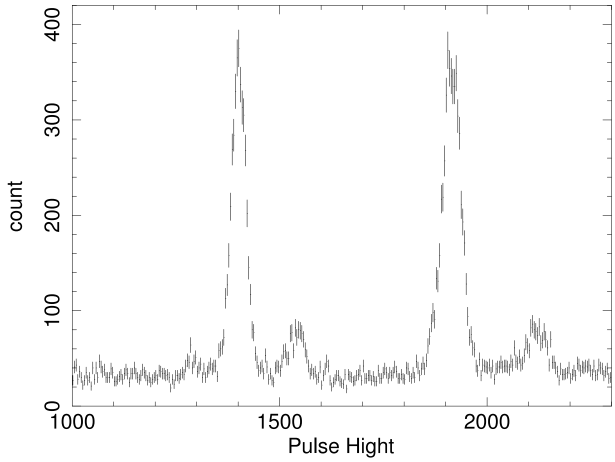

Fig. 3. X-ray spectrum obtained with CCDID=0 of SSCU-H.

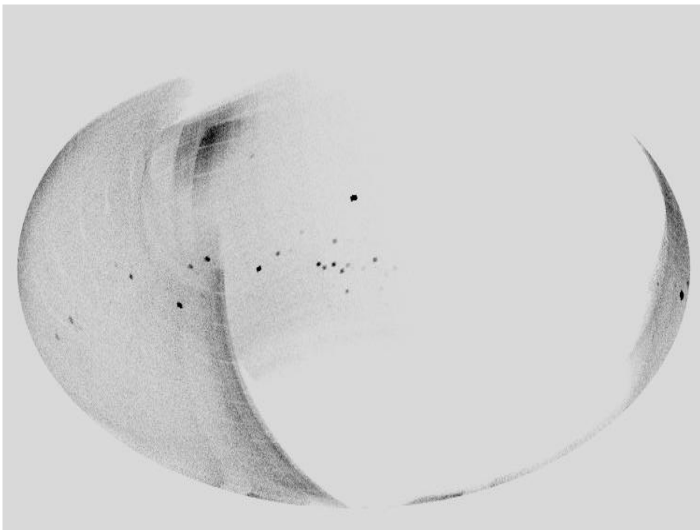

Fig. 4. X-ray sky viewed with SSCU-H in the galactic coordinate.