In Orbit Performance of the MAXI/SSC 1

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Abstract

Solid-state Slit Camera is an X-ray CCD camera onboard the MAXI mission of the InternationalSpace Station. Its observational energy range is 0.5?12 keV, and the field of view is 1.5 degree (FWHM) × 90 degree. Two sets of the SSC sensors scan the sky as the rotation of the ISS. The moonlight generates high background region forming a diamond shape. We notice an edge glow of each CCD probably due to the IR of Sun light. In case of the edge glow at the daytime, the background becomes continuously high and prevents us from observing the sky. The CCD of SSC is normally cooled down to around -60 degree C. Sometimes the temperature of a certain CCD becomes higher than about ?51 degree C. We found that the thermal noise of CCD explodes at this condition. Another background appeared in all CCD sometimes increse simaltaeniously. The countrate of the SSC due to this background depends on the position of the ISS against to the earth. We will show how all these background can be predicted to screen them.

Key words: ISS: MAXI — SSC: CCD — background

1. Introduction

MAXI (Monitor of All-sky X-ray Image) onboard the ISS (International Space Station) is launched by Space Shuttle on 2009 July 16 and its operation was started on 2009 August 3. MAXI has two kinds of instrument. One of which is called SSC (Solid-state Slit Camera). SSC consists of two identical sensors. Each sensor has the field of view of 1.5 degree (FWHM) × 90 degree. One sensor is orientated to horizontal direction and the other is to zenith. SSC can scan the sky as the rotation of the ISS in each 90 minutes (Matsuoka et al. 2009). Because of its high energy resolution and high sensitivity for low energy x-rays, it is expected that the all-sky soft x-ray image and the distribution of emission lines in our galaxy can be studied by SSC. Figure 1 shows the all-sky image obtained by the one-day SSC observation. From this image, we noticed some kinds of background which should not be used exist. In this paper, we have studied the characteristics of in-orbit background and propose the way of background screening.

2. SSC

One sensor of SSC is consisting with 16 x-ray CCD chips as shown in figure 2. Each chip is cooled normally to -60 degree C using Pertier device (Tomida et al. 2011).

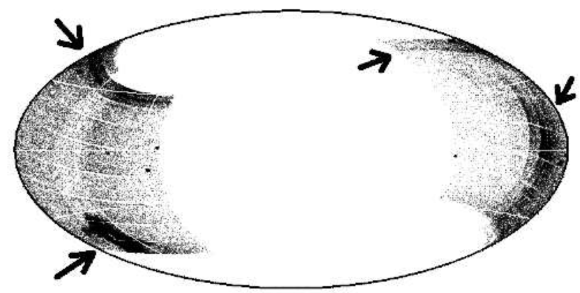

Fig. 1. SSC all-sky image using raw data.

Detector coordinates are defined as shown in figure 2. The unit of its coordinate is the pixel size of CCD. The separations between chips are also measured using the same unit. By combining with the collimator and slit, SSC has one dimensional field of view along to DET-X axis. All-sky image can be obtained by scanning along the DET-Y direction.

3. Characteristics of in-orbit background

In-orbit background of SSC appears temporally. Its intensity is variable and the region size affected by the background is also variable. So it is important to iden-

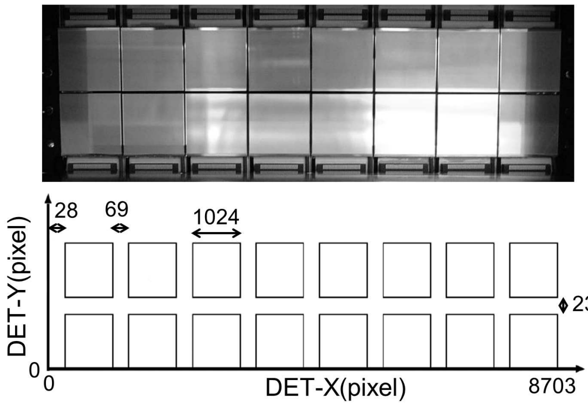

Fig. 2. Inner structure of SSC.

tify the origin of background for screening it.

3.1. Moon Light

Diamond shaped background sometimes appear in the all-ski image as shown in figure 3. The position of background of this type moves with time. Its rotational period around the all-sky is about 27 days. It is found that the position of it moves synchronous to the position of moon. Although the surface of CCD chip is coated by aluminum to avoid the incidence of optical light, the side plane of chip is not coated.

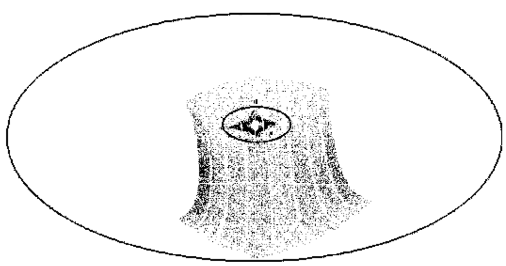

Fig. 3. Diamond shaped background.

Figure 4 shows the raw image obtained by one CCD chip when sun is near the SSC field of view. It is clearly seen that the edge region of chip become bright by infrared or optical light leakage through the side plane (Tsunemi et al. 2010). Similar to this phenomenon, the origin of diamond shaped background is considered to be the moon light leakage.

Figure 5 shows the count rate map. The solid diamond in the figure is the region which should be screened. The position of this region can be predicted by the moon position. Its size is also predicted by the lunar age. Sometimes the region is elongated along to DET-X direction. Because we can not predict yet when the phenomenon appears or the size of it, the data is screened during the time before and after 45 second from the time when the

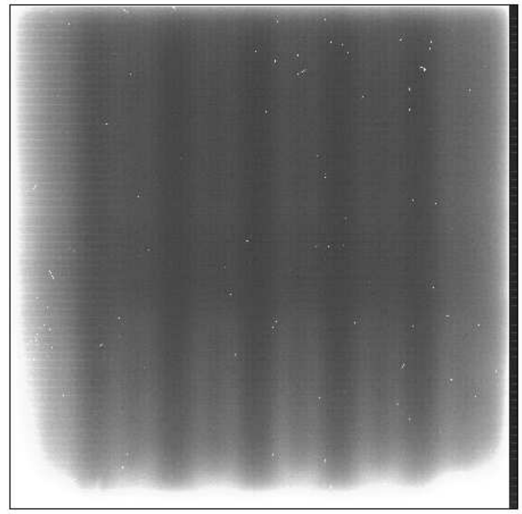

Fig. 4. Raw image of one CCD chip.

moon center enters the field of view. This region is also displayed in figure 5 as the region between parallel solid lines.

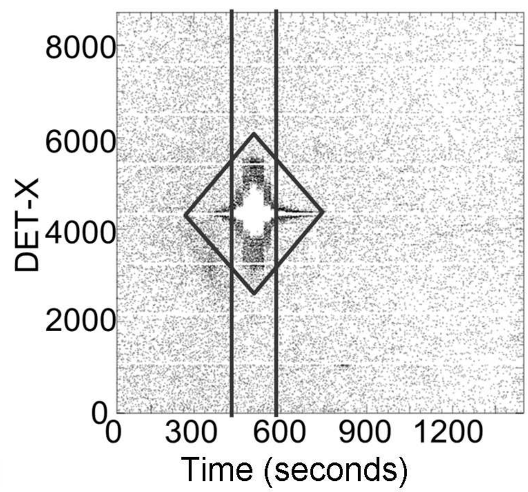

Fig. 5. Region for screening.

3.2. Sun Illumination

Other kind of background sometimes appears continuously at the individual coordinates as shown by the arrow in figure 6. This background moves along DET-X direction with time. Figure 7 shows the relation between the DET-X coordinate experienced sun illumination during daytime and the coordinate where the background appears. From this figure, we can see this background appears at almost same position with the sun illumination. The physical processes why the background counts remain high at the position the sun illuminated before the SSC night observation are unknown, but the position of this background region can be calculated from the attitude of MAXI. The size of background region depends on the position of CCD chip. In the case it appears at the edge of chip, the size of it is larger. So the size of screened region should be changed with the position of sun.

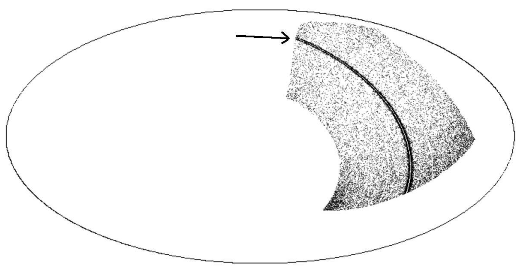

Fig. 6. Background appeared at individual coordinates.

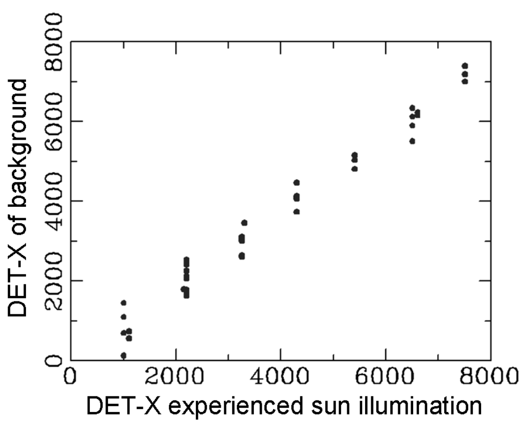

Fig. 7. Relation between the positions of sunlight illumination and background.

3.3. Thermal Noise

In the SSC all-sky map, high count rate region sometimes appears in the individual CCD chip as shown by the arrow in figure 8.

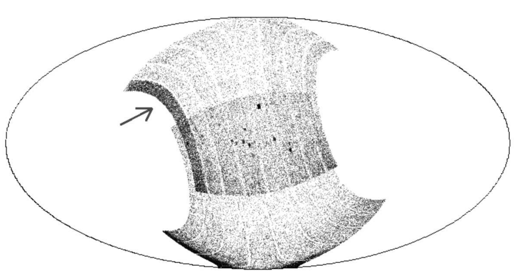

Fig. 8. Background appeared in the individual CCD chip.

Figure 9 displays the temperature variability of CCD chips. The uppermost data in this figure is obtained by the CCD of high count rate. As the temperature of this chip is about 10 degree C higher than the other chips, it is expected that the high count rate is due to the thermal noise of CCD. The temperature dependence of CCD thermal noise is shown in figure 10. Thermal noise is rapidly increased at the temperature higher than -51 degree C. So the background of this type can be screened by rejecting the data obtained during the CCD temperature is higher than -51 degree C.

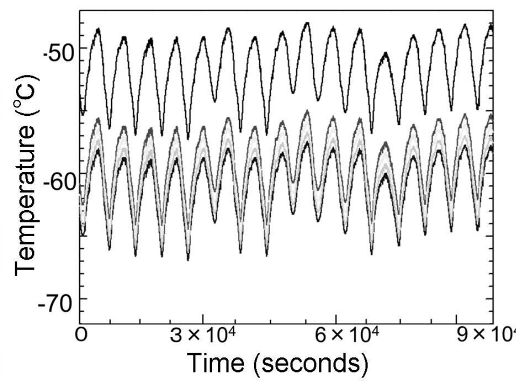

Fig. 9. CCD temperature.

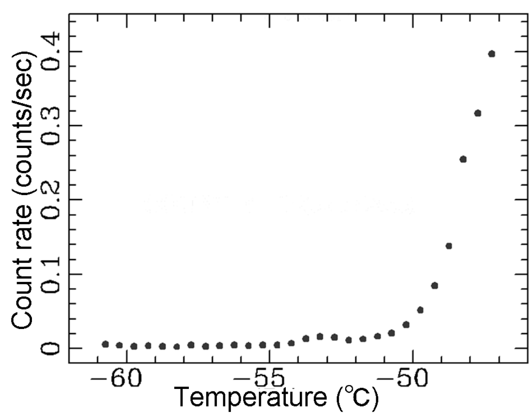

Fig. 10. Temperature dependency of thermal noise.

3.4. Charged Particles

Another high count rate region shown in figure 11 sometimes appears. This background appears simultaneously in all CCD. This nature means that the background does not depend on the direction of the SSC field of view but the attitude of ISS. Figure 12 shows the count rate map against to the ISS position. The background becomes higher when the ISS passes through the high latitude region of earth. Because even the low energy charged particles can arrive at the orbit of ISS at high latitude region, the total number of them becomes large. So this type of background can be explained by charged particles. Figure 12 implies that the screening of the region where the count rate is grater than 4 counts/sec works well for rejecting this background.

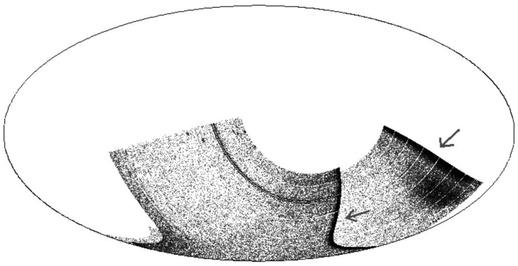

Fig. 11. Background appeared simultaneously in all CCD.

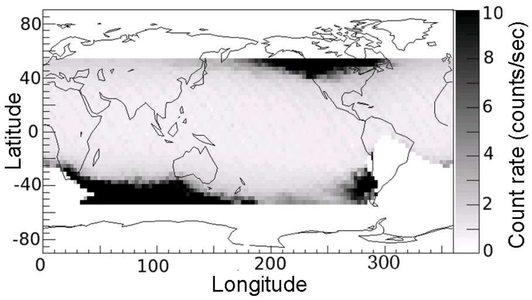

Fig. 12. Count rate map.

4. Result of Data Screening

Figure 13 is the SSC all-sky map created by using screened data. Screening is applied for moon light, sun illumination, thermal noise, and charged particles. By comparing with figure 1 which is created using raw data, it is apparent that all background explained above is screened well.

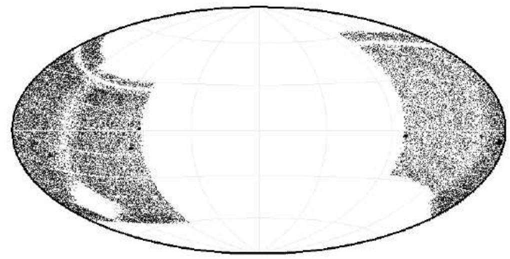

Fig. 13. SSC all-sky map using screened data.

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