Monitor of All sky X-ray Image (MAXI) on the International Space Station


E-mail: tomida.hiroshi@jaxa.jp  Web: http://www-maxi.tksc.jaxa.jp

aJapan Aerospace Exploration Agency (JAXA), bThe Institute of Physical and Chemical Research (RIKEN), cDepartment of Earth and Space Science, Osaka University, dDepartment of Physics and Mathematics, Aoyama Gakuin University, eDepartment of Physics, Tokyo Institute of Technology, fDepartment of Physics, Nihon University, gResearch Center for Measurement in Advanced Science, Rikkyo University

Abstract

MAXI (Monitor of All-sky X-ray Image) is a payload to be mounted on the Japanese Experiment Module Exposed Facility (JEM-EF) of the International Space Station (ISS). A space shuttle launches MAXI in 2009 and MAXI works at least 2 years. This paper briefly reports the camera system and the mission objectives of MAXI.

1. MAXI

MAXI is an all-sky X-ray monitor developed for the JEM-EF of the ISS as shown in Figure 1. It is capable of monitoring almost all sky every 90-minute orbital period. It has no capability of the pointing observation, while the directions of its fields of view change with the rotation of the ISS (Isobe., et al., 2006; Ueno., et al., 2004).

![MAXI Configuration and Location on ISS](image1)

2. X-ray Cameras on MAXI

MAXI has two types of X-ray camera: one is Gas Slit camera (GSC) and the other is Solid-state Slit camera (SSC). Each camera has two fields of view (FOV): one in the anti-earth direction (Zenith FOV) and the other in the forward direction to the earth (Horizontal FOV). About 24 minutes after the horizontal FOV covered a sky area, the zenith one covers the same area. Since the ISS passes through any individual radiation zone (where the MAXI cameras do not work) for less than 24 minutes, the combination of the zenith and horizontal FOV achieves the-whole-sky-scan (except for the Sun direction) for every one orbit (Figure 2).

![FOV of MAXI](image2)
The basic concept of MAXI slit camera is shown in Figure 3. A slat collimator (a set of parallel plates) provides a narrow and a wide field of view (FOV), where the wide FOV through slit spans the sky perpendicular to ISS moving. On the other hand the narrow FOV gives a triangular response for each point source according to ISS moving. The cross image through slit and triangular response corresponds to precise angular response. Thus, a location of the image is determined with reasonable angle on the sky.

3. GSC
GSC utilize the 1-dimensional (1D) position-sensitive gas proportional counter that has carbon fiber anodes with a diameter of 10 µm. GSC is sensitive to 2 – 30 keV X-ray photons. The nominal position resolution of the counter is 1mm for 8keV photon. Figure 4 shows the slits, slat collimators, and 1-dimensional position sensitive proportional counters of a GSC unit. GSC has a large detective area of about 5350 cm² in total, and a wide FOV of 1.5 x 160 degrees for each of the zenith and horizontal set. GSC has a high sensitivity to detect X-ray sources as faint as one mCrab in one week observation.

4. SSC
Figure 5 shows an SSC unit when the collimators and slit are removed. One unit views in the zenith direction and the other in the horizontal. SSC adopts the X-ray CCD chips which were fabricated by Hamamatsu Photonics K.K. Sixteen CCD chips are used for each unit. The CCD chips are cooled below −60 °C with a Peltier cooler behind each CCD chip. Heat from Peltier coolers is emitted to the space through the Loop Heat Pipe Radiator System (Muto., et al., 2002). The depletion layer of the CCD chip is about 70 µm thickness. An aluminum deposition layer of 2000Å is applied on each CCD chip to block visible light.
These make SSC to be sensitive to X-ray photons in 0.5 - 12 keV range. The CCD chip has the charge injection mechanism to recover from the radiation damage. Although SSC has a smaller detector area (200 cm$^2$) and smaller field of view (1.5 x 90 degree) than GSC has, the energy resolution of SSC is 150 eV at 5.9 keV (Mn Kα line), much better than that of GSC. Figure 6 shows the SSC spectra for various characteristic X-ray emission lines.

The characteristics for GSC and SSC are summarized in Table 1.

**Table 1. The characteristics of GSC and SSC.**

<table>
<thead>
<tr>
<th>Detector</th>
<th>Energy Range</th>
<th>Effective Area</th>
<th>Field of View</th>
<th>Energy Resolution</th>
<th>Nominal Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSC</td>
<td>Proportional counter</td>
<td>2 – 30 keV</td>
<td>5350 cm$^2$</td>
<td>1.5 x 160 degree</td>
<td>0.1 degree</td>
</tr>
<tr>
<td>SSC</td>
<td>X-ray CCD</td>
<td>0.5 – 12 keV</td>
<td>200 cm$^2$</td>
<td>1.5 x 90 degree</td>
<td>0.1 degree</td>
</tr>
</tbody>
</table>

5. **Science with MAXI**

Figure 7 shows X-ray fluxes of known astronomical sources with the sensitivity of MAXI. MAXI target are not limited to galactic objects such as stellar mass black holes and neutron stars, and include extra galactic objects such as AGNs and the clusters of galaxies. MAXI enables the systematic monitoring of a considerable sample of extra galactic objects for the first time.

Figure 7. The fluxes of the known bright X-ray sources, which are taken from the Uhuru and HEAO-1 catalogues, are plotted against the distances to them. The expected sensitivities of MAXI GSC in 1 orbit, day and week are indicated with arrows on the right of the figure.
The following study is planned with MAXI.
- Long-term variability of AGNs.
- Alert of novae and X-ray transients.
- Complete light curve of X-ray novae.
- Gamma-ray bursts and their afterglow.
- Distribution of distant AGNs (measurement of X-ray BGD).
- Survey of emission lines from diffuse soft X-ray source (with CCD camera).
- Serendipitous discoveries new kinds of X-ray objects.
- Dynamic catalogue of X-ray sources.

Figure 8 show two simulated all sky X-ray image of MAXI, where galactic ridge diffuse emission and cosmic X-ray background are not included.

6. Data flow

The Data flow from MAXI to the ground system at Tsukuba Space Center of JAXA (Japan Aerospace Exploration Agency) is shown in Figure 9. The MAXI observation data of 50 to 70% are downlinked in real time. Other data are stored in data recorder on ISS during communication outages and are downlinked later. The data are processed to make light curves, spectra, and celestial maps. The processed data can be accessed via internet. Alerts are rapidly sent also via the internet, when the MAXI ground system detects significant events such as transient phenomena including X-ray novae and X-ray bursts, and appearances of new X-ray sources. These alerts can trigger quick follow-up observation in various wavelengths with ground-based and space telescopes. Quick follow-up observations are crucial for investigating the nature of the transient phenomena. MAXI does not only play the transient alert system, but also a systematic X-ray all-sky monitor every a few hours. MAXI also provides a public archives of the long-term observed data for X-ray objects in all sky.

References
N.Isobe., et al., 2006, Proceedings of EAYAM
S.Ueno., et al., 2004, SPIE vol 5488