

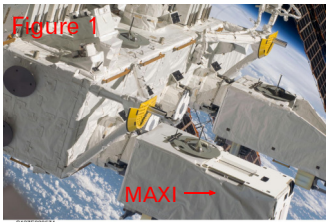
# Development of Image Analysis Software of MAXI

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- Abstract -

Monitor of All-sky X-ray Image (MAXI) is an X-ray all-sky monitor, attached to the Japanese experiment module Kibo on the International Space Station. The main scientific goals of the MAXI mission include the discovery of X-ray novae followed by prompt alerts to the community (Negoro et al., in this conference), and production of X-ray all-sky maps and new source catalogs with unprecedented sensitivities. To extract the best capabilities of the MAXI mission, we are working on the development of detailed image analysis tools. We utilize maximum likelihood fitting to a projected sky image, where we take account of the complicated detector responses, such as the background and point spread functions (PSFs). The modeling of PSFs, which strongly depend on the orbit and attitude of MAXI, is a key element in the image analysis. In this poster, we present the status of our software development.

## 1. Introduction



Monitor of All-sky X-ray Image (MAXI) is a Japanese X-ray all-sky monitor, which was carried to the International Space Station (ISS) with the space shuttle Endeavour on 2009 July 16. It is attached to the payload of the Japanese experiment module Kibo. The

main scientific goals of the mission are the detection of X-ray novae, production of new source catalogs, and monitoring of time variabilities of X-ray sources.

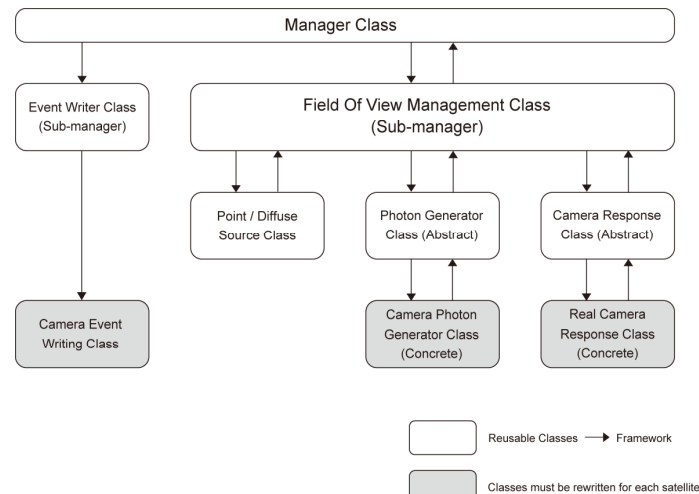
Accurate determination of the position and flux by considering the complex detector responses is a key process in all scientific analysis of the MAXI data. In this poster, we present our analysis method, which utilizes maximum-likelihood image fitting to a projected sky image.

## 2. The MAXI Simulator

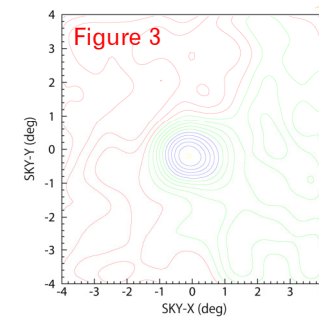
The MAXI simulator is a software that generates fully simulated data of the MAXI instruments by Monte Carlo method. The original role of the simulator is creating the test data for developing and debugging of the alert system and data analysis software.

To achieve the complex functions required for the simulator, we code the program in C++ language, utilizing its concept of object oriented programming (OOP). Figure 2 illustrates the schematic structure of the MAXI simulator. MAXI carries two-type cameras, 12 Gas Slit Cameras (GSCs) and 2 Solid State Cameras (SSCs). We create an abstract camera class, and then derive the two concrete camera classes corresponding to the GSC and SSC, to treat their responses in the same manner. We apply this class relation to the photon generators and event containers. This abstraction enables us to divide the MAXI simulator into a set of reusable classes and the rest. Hence, it can be used as a framework of general satellite simulators.

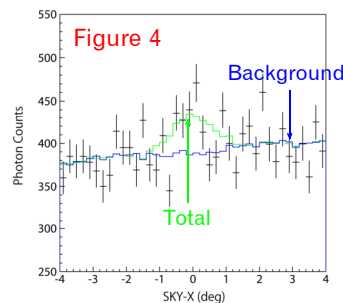
Figure 2



## 3. Image Analysis Based on Maximum Likelihood Fit



To extract the best sensitivities from the observation data, we have developed an analysis method by employing image fitting with the maximum likelihood algorithm. Firstly, we project the positions in RA and DEC of photon events in the vicinity of a target in the "sky coordinates", as in the case of an image analysis of pointing satellite's data. To derive the flux, position and their errors, we perform 2-dimensional fitting to this simulated image by a model consisting of the point spread function (PSF) and background (the non X-ray background and the cosmic X-ray background).



One complexity in the analysis of MAXI data is that the PSF and background are position dependent, being determined by the orbit and attitude condition. To take this into account, we also utilize the MAXI simulator to construct the PSF and background models with a sufficiently larger number of photons to suppress

the statistical fluctuation.

In the fitting, the normalization of the PSF (i.e., flux) and background level are set to free parameters, as well as its position. Here we assume that the shape of the PSF does not significantly differ in the region of interest, and ignore its position dependence for simplicity.

Figure 3 displays a smoothed image in the vicinity of the target, located in the center, for the 1-week simulation. Figure 4 displays its projection onto the X-axis in a central region (with error bars), superposed with the best-fit model.

## 4. Summary and Future Work

We present the image analysis technique for the detection of faint sources using the data generated by the MAXI simulator. We have started to apply this method to the real observation data. Figure 5 is a false color all-sky image in Galactic coordinate in the 2-10 keV band. The red color represents the real observation data, while the green color the simulation data (one week). Basically, the all sky map pattern is well reproduced, except for systematic difference in source positions and shape of the point spread functions, which are due to insufficient calibration at this moment.

A current problem of this method utilizing the MAXI simulator is a long CPU time required to compute PSF models. We plan to develop another software that can compute PSFs more quickly with sufficient accuracy. This task shall be utilized in producing MAXI source catalogs.

Figure 5

