

MAXI alert system and its improvement

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ABSTRACT

The MAXI Nova-Alert system consists of a real-time X-ray transient monitor (so-called nova-search) and an alert system at TKSC, Tsukuba Space Center (Negoro et al. 2010). The nova-search system receives obtained data, and analyzes time series data at each small ($\sim 1^\circ \times 1^\circ$) spherical area in real-time. If the system detects large intensity variations above a threshold, the data at the area are sent to the alert system, where adjoining data are put together as one event. If it is admitted that the event is a transient object, the system reports the information soon to MAXI-team members. 48 transient objects or phenomena were reported to ATel, and 14 GRBs including soft X-ray flashes were reported to GCN by the end of December in 2010, mostly using this system. We present here the outline of the systems and improvements newly added to the alert system, for instance, a check of ISS solar paddles in the line of sight, which is necessary in the complete auto-alertsystem coming soon.

KEY WORDS: system: detector - X-ray

1. MAXI Nova-Alert system

One of main objectives of MAXI, Monitor of All-sky X-ray Image, is to discover X-ray transient objects. MAXI can observe short- and long-term X-ray variabilities by scanning all the sky. Currently, MAXI is therefore the best X-ray instrument for the discovery of X-ray transient objects in the soft X-ray band.

Observed data are analyzed by the Nova-Alert system at TKSC. The Nova-Alert System is consists of a nova-search system that is a real-time X-ray transient monitor and an alert system. If the system detects a transient objects, the system sends an alert e-mail to MAXI-team members.

1.1. Data transimission

Observed data are sent from the ISS, International Space Station, to the MAXI-DB (MAXI database) via OCS (Operations Control System) at TKSC on the ground. It takes about 8 seconds from X-ray detection to the MAXI-DB. The nova-search analyzes the data received from the MAXI-DB to discover transient objects every seconds. When the system detects a transient event, the system sends the event to the alert system.

The alert system checks whether or not the event is a transient object. If the event is admitted as a transient object, the data are sent to a flash-report system and MAXI-team members. It takes about 10-30 seconds to put the data of one event together and send an alert e-mail by the system. The system analyzes data, including data prior to the time of the event detection, in about 5

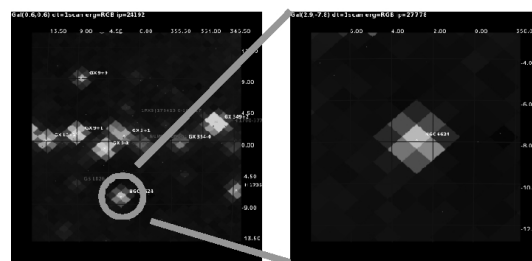


Fig. 2. (Left): Magnified image near the Galactic center. (Right): Expansion image of left. A diamond area is one pixel.

minutes. The flash-report via the web interface displays results of the quick-look analysis. After the MAXI-team members confirm the information, alert e-mails are sent to the world (Fig.1).

1.2. Data sent by the nova-search system

The nova-search system analyzes time-series data at each pixel with the some spherical surface areas divided by the HEALPix library¹ (Ozawa et al. 2011). The number of pixels is 49,152, and the size is about 1 degree squared (Fig.2). The system analyzes the data on 8 time-scales and in 4 energy bands. If the system detects large intensity variations above a threshold, the data of the pixel are sent to the alert system.

*1 Gorski et al. 2005

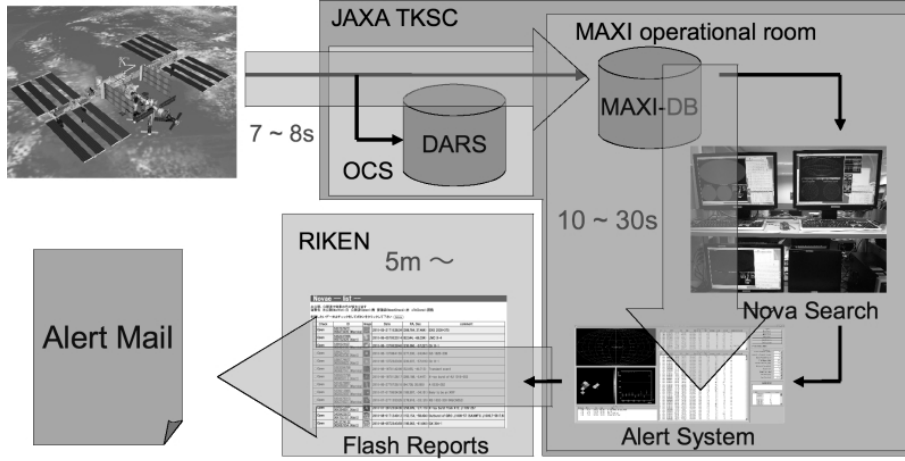


Fig. 1. MAXI Nova-Alert system from X-ray detection to alert e-mail.

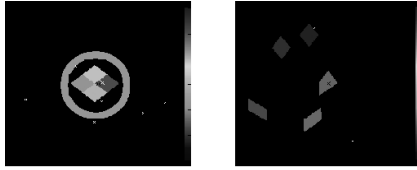


Fig. 3. (Left): An example of a true event shown by circle. (Right): Background events.

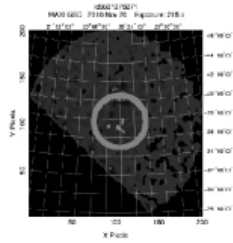


Fig. 4. An example of the detection on one pixel condition. (November 21, 2010, EXO 2030+375).

2. Alert system

First, the alert system confirms that the system has received the data sent by the nova-search correctly. Next, the system puts together adjoining data as one event (Fig.3). If the event satisfies the following conditions, the information is reported soon to MAXI-team members. Recently, we have added a single pixel condition and a check of the solar paddles in the line of sight to the system.

2.1. multi-pixels condition

The data from the nova-search system also include a lot of events caused by background fluctuations (Fig.3). It is therefore necessary to remove the background events. The Nova-Alert system uses the data obtained with GSC, Gas Slit Camera (Mihara et al. 2011). A FWHM

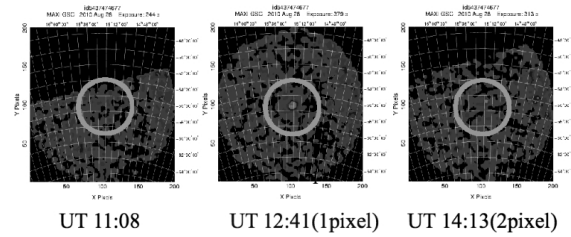


Fig. 5. An example of earlier detection. (August 29, 2010, Cir X-1).

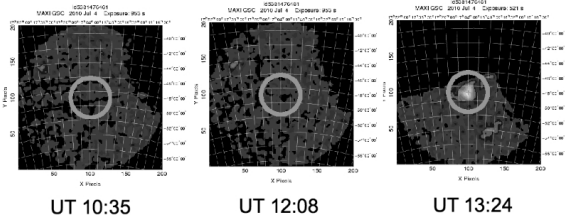


Fig. 6. An example of the fake event by a solar paddle. The paddle had shaded the object in the first two image. (July 4, 2010, GX 339-4).

of the GSC detector is about 1.5 degree. A true event is expected to split into two or more pixels, since the FWHM is larger than the size of a pixel (~ 1 deg). Only such multi-pixels events had been selected to suppress a number of background events.

2.2. single pixel condition

If a low-flux event is detected at the center of a pixel, X-ray counts in any surrounding pixels might not exceed a threshold. If the data come from the nova-search system more than 4 times (in one orbit) in a single pixel close ($\leq 1^\circ$) to a known object, the single event is reported. As a result, low-flux events that had been overlooked can be detected (Fig.4) and earlier detection for a gradually brightening source is expected (Fig.5).

2.3. Solar paddle

The ISS has four solar paddles. The solar paddles shade about 10 percent of all the sky at the maximum. A fake event occurs when an object has come out from shade by a solar paddle (Fig.6). To remove such an event, a check of the solar paddles in the line of sight has been added to the system. The system obtains ISS attitude and solar paddle data from the MAXI-DB to check the solar paddles. The system calculates a shape of the solar paddles from the data and checks whether or not the solar paddles are in the field of views of the GSC. This check is possible in about 5 seconds. Figure 7 shows results on the solar paddle check for events including fake ones occurred on November 23, 2010 (Fig.7).

3. Preliminary Results

The Nova-Alert system has been detected a lots of transient objects. 48 transient objects or phenomena including two new X-ray novae were reported to ATel, and 14 GRBs including soft X-ray flashes were reported to GCN by the end of December in 2010, mostly using the system. Some objects were discovered by the all-sky image that had been drawn by the nova-search. The system automatically detected events from 57 objects including not reported to ATel by the end of December in 2010 (Table.1).

4. References

References

- Gorski K.M. et al. 2005, ApJ., 622, 759
Mihara M. et al. 2011, PASJ., in print
Negoro H. et al. 2010, in ASP Conf. Ser.434, ADASS XIX, ed Y. Mizumoto, K.I. Morita, and M.Ohishi, [P.127]
Ozawa H. et al. 2011, in this volume
Serino M. et al. 2011, in this volume

Table 1. Transient objects and frequencies automatically detected by the Nova-Alert system from the first of November 2009 to the end of December 2010.

Source name	Frequency	Source name	Frequency
SMC X-1	7	4U 1630-472*	4
4U 0114+65	2	H 1636-536	1
Algol*	1	Her X-1	12
HR 1099*	2	MAXI J1659-152*	2
X Per	4	GX 339-4	3
LS V +44 17*	2	XTE J1709-267	1
4U 0513-40	1	RXS J172525.5	1
LMC X-4	5	SWIFT J1729.9-3437	1
A 0535+262*.*	5	Rapid/Slow Burster	13
H 0614+091	1	GX1+4	1
Vela X-1	25	H1743-322*.*	2
1H 0918-548	2	NGC6440*	1
GRO J1008-57*	2	4U 1746-37	1
Mrk 421*.*	2	GRS 1747-312	1
Cen X-3	1	XTE J1752-223*	1
GT Mus*	1	3A 1812-121	1
H 1145-619	1	GS 1826-238	10
4U 1210-64	1	XB 1832-330	1
EX Hya	1	RX J1832-33	1
GX 304-1*.*	4	AX J1841.0-0536*	1
4U 1323-619	1	4U 1850-086	2
SAX J1324.5-631	1	HETE J1900.1-2455	4
MAXI J1409-619*	1	Aql X-1	8
2S 1417-624	1	4U 1916-053	1
Cir X-1*.*	7	EXO 2030+375	3
4U 1538-52	2	4U 2206+543	1
4U 1543-624	1	II Peg	2
H 1608-522*	1	Short X-ray transient [†]	7
H 1624-490	3	XRF [†]	3
H 1627-673	1	GRB [†]	3

* reported to ATel.

[†] see Serino et al. 2011

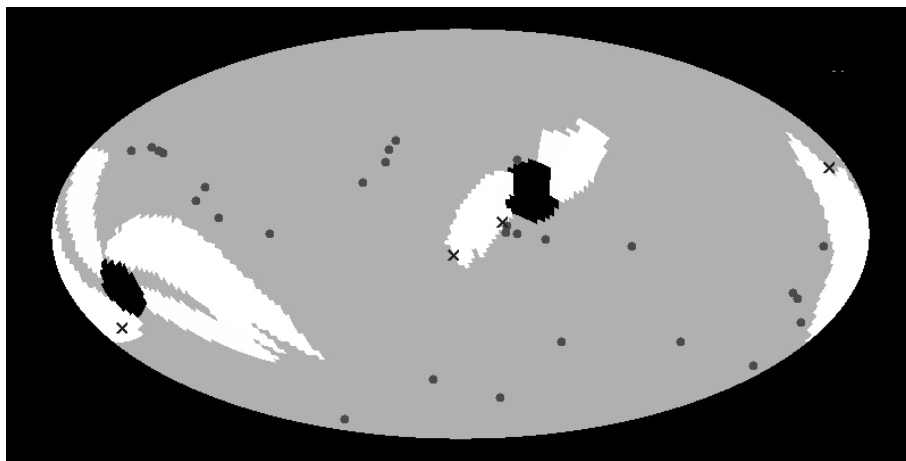


Fig. 7. Results on the solar paddle checks on November 23, 2010. The white parts indicate the field of views of the GSC shaded by the solar paddles. The crosses marks are events judged to be due to the shade of the solar paddles, and the filled circles are events not shaded.