

2017/3/3

MAXI による IceCubeアラートへの 対応

Searching for Counterparts of Neutrino Events with MAXI

Motoko Serino (RIKEN)

マルチメッセンジャー天文学研究会@千葉大学

1

on behalf of the MAXI Team

Introduction

- **MAXI/GSC observations of IceCube-160731A**
ATel #9313; *H. Negoro, et al.*; on **4 Aug 2016; 01:14 UT**
- We report on MAXI/GSC observations of the neutrino event IceCube-160731A ...

At 02:32 UT on 2016 July 31 (**about 37 min** after the IceCube event trigger), MAXI/GSC scanned the error region of the event at (R.A., Dec) = (214.54, -0.33) with a radius of 0.75 deg. No significant excess emission was detected from the region, and we obtained the 2-20 keV **3-sigma upper limit of 0.104 photons/cm²/s** (corresponding to approximately 32 mCrab) for a point source at the above position.

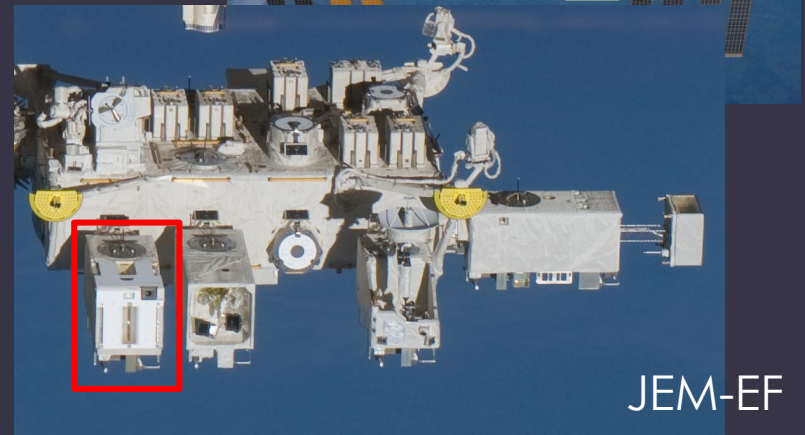
We also investigated transient events around the region **from 2016 July 20 to August 3**, but no significant events were found. A typical 2-20 keV 3-sigma upper limit for one day was 0.03 photons/cm²/s (~9 mCrab). **MAXI continues to observe the region every 92 min.**

Contents

- Operation and Observation of MAXI
- MAXI Nova-Alert System
- Sensitivity and Coverage
- Observations of Transients
- Searches for Neutrino Event Counterparts
- Summary

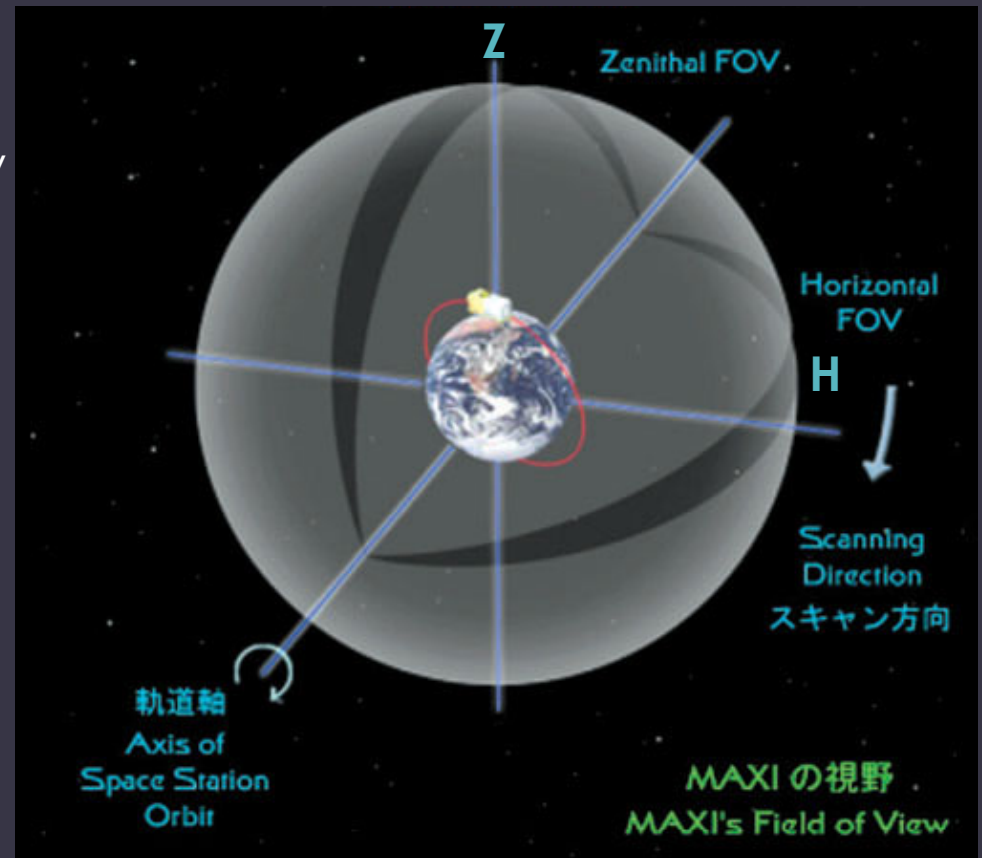
MAXI instruments

- MAXI (Monitor of All-sky X-ray Image)
- Observation started in August 2009
- Two science instruments
 - Gas Slit Camera (GSC) 2-20 keV
 - Solid-state Slit Camera (SSC) 0.7-10 keV
 - **GSC** has larger effective area and covering fraction
- **Large FoV/Observe whole sky**
 - MAXI can cover entire error region even if the localization is not accurate
- **Always monitoring**
 - The data before the trigger are available
- **Alert system is available**
 - Transient events can be found automatically
 - Real time alert via MAXI mailing lists

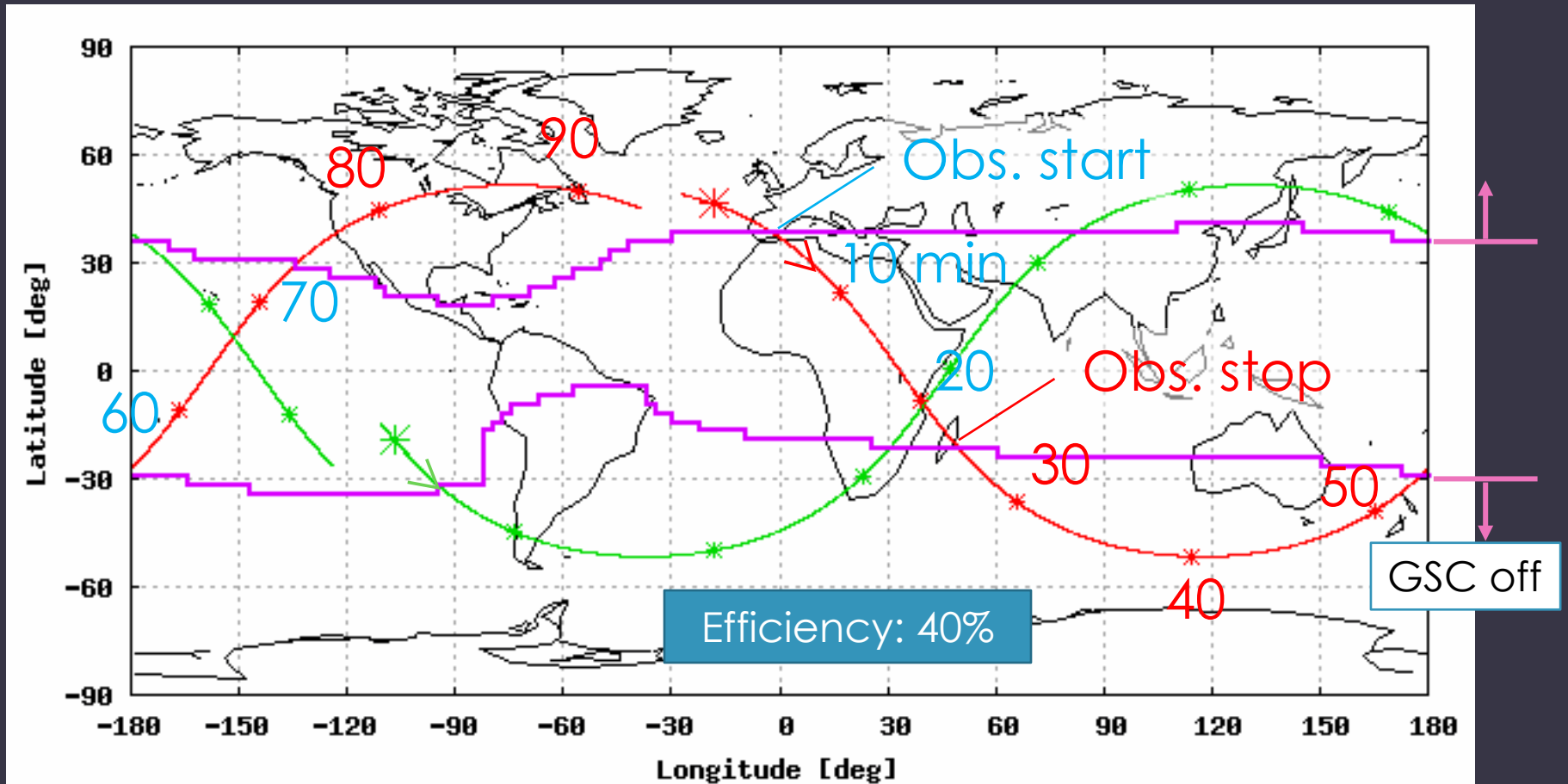


Field of View and Scan

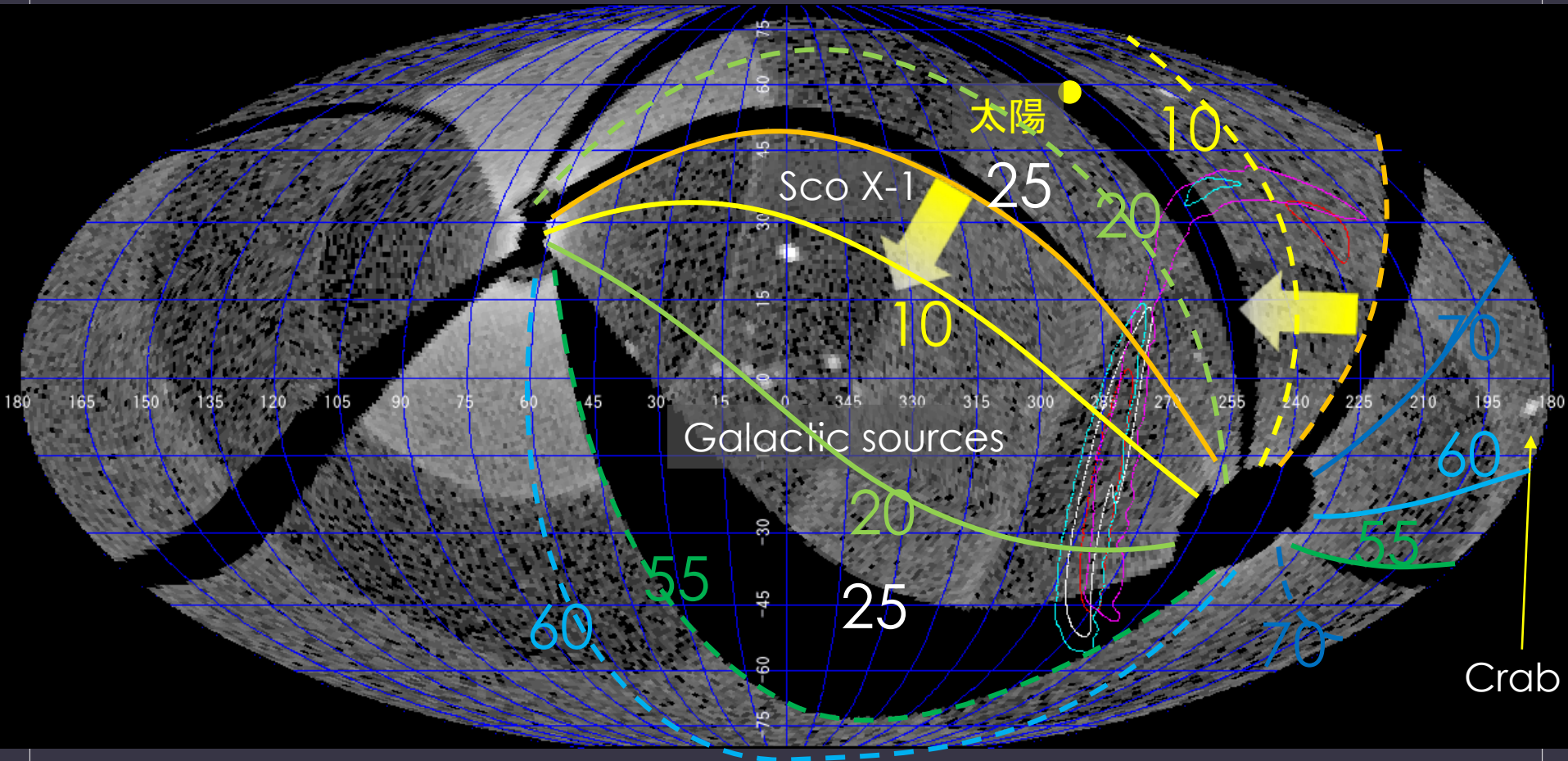
- Two FoVs (3 x 160 deg)
 - about 2% of the whole sky
- 92 min orbit



Orbit and Operation of GSC



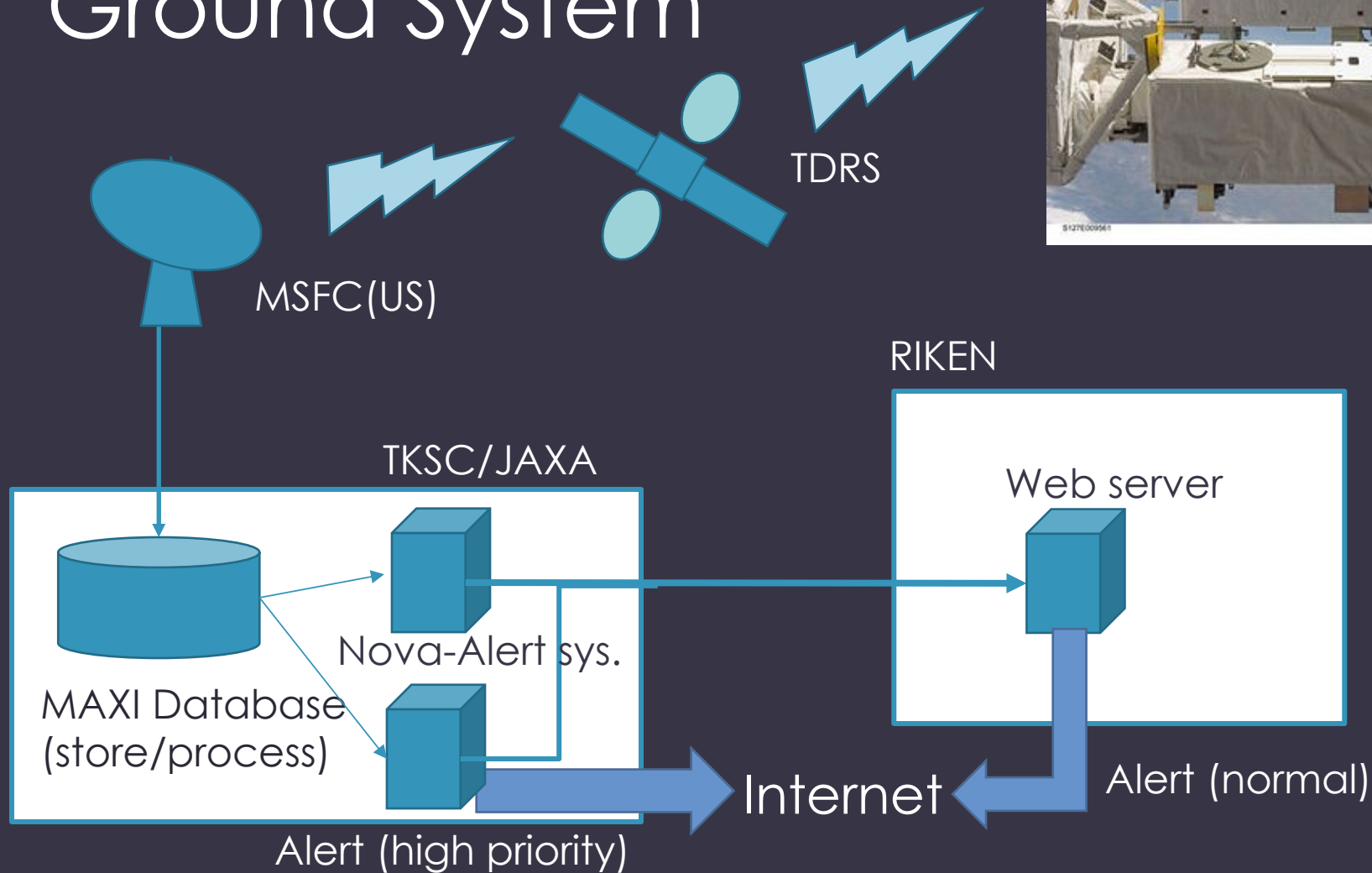
1 orbit (~92 min)



2017/3/3

MAXI NOVA-ALERT SYSTEM

Ground System



Novasearch + Alert System

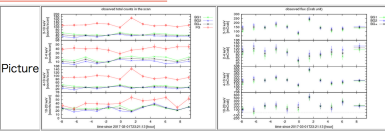
- *Novasearch*: pick up pixels with flux excesses
 - generating light curves for each HEALPix pixel (4 energy bands, 8 timescales)
 - selecting the pixels with increasing flux
 - sending "trigger" information to Alert System
- *Alert System*: select significant events
 - excluding bright variable sources, solar events, particle events, etc.
 - combining the information from Novasearch and judging "significance"
 - sending alert/warning mails and running quick look tool

Automatic/Manual Alerts to ML

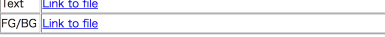
- MAXI mailing lists : 5 categories
X-ray star, new-transient, AGN, nova-cv, supernova
- "burst" (highest significance) events are directly sent from Alert System
- otherwise send manually after the check by duty scientist (当番)

Images and Alert Mail

Lightcurve



Picture

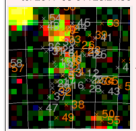


Text [Link to file](#)

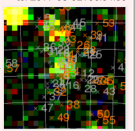
FG/BG [Link to file](#)

Image

before



trigger



Alert Mail

```

[Ground Trigger ID]
ID : 7813899996

[Count Weighted Position]
RA,Dec: (266.299, -29.580)
Galact.: (339.476, -8.223) jufo andem
Eclip.: (266.761, -6.182)

[Triggered Criteria]

[Highest Significance]
DPIC : 117244603
VT : 2017/03/01 23:21:13
on : 35con (S-band)
signs : 4,0

[Observed Flux]
S : 81 +- 20 mCrab (3-10keV)
L : 30 +- 22 mCrab (2-4keV)
M : 135 +- 35 mCrab (4-10keV)
H : 178 +- 100 mCrab (10-20keV)

nearby(r<5deg) object
-----
dist flux (RA, Dec) name
[deg][mCrab] [deg]
1 0.16 unknown (266.21, -29.35) KS 1741-293,AK J1744.8-2921 wiki
2 0.28 180.0 (266.52, -29.52) ZE 1742.9-2929,GC 1-1 wiki
3 0.36 unknown (266.19, -29.85) Sm11 J17444.9-292842 wiki
4 0.37 8.7 (265.98, -29.74) IE 1748.7-2942,SABWC J1743.8-2945.1 wiki
5 0.50 192.4 (266.42, -29.81) Galactic.Center.Region wiki
6 0.59 unknown (266.20, -28.91) CXOUJ3 174302.2-285449 wiki
7 0.66 9.4 (266.50, -28.87) 000 J1744.28,SABWC J1744.5-2844.6 wiki
8 0.70 unknown (266.86, -30.00) SLX 1744-290 wiki
9 0.73 14.1 (266.86, -30.04) IUXJ 174225.6-300041,SLX 1744-300 wiki
10 0.74 188.7 (266.70, -28.88) SAK J1747.0-2853.1A,1743-288 wiki
11 0.81 unknown (266.09, -28.73) IE 1743.1-2843,GC 1743.1-2842 wiki
12 0.97 unknown (265.27, -29.88) EXS 1737.9-2952 wiki
                    
```

Event Fits

Fits : [Link to fits](#)

Script : [Link to xselect script](#)

Past Variability

No	maxitime (ut)		Image	lc	event	camera angle
	Start	End				
1	541697207.717 (2017-03-01T15:26:42)	541697888.530 (2017-03-01T15:38:03)		link to lc	link to evt	5 57.6
2	541702760.994 (2017-03-01T16:59:15)	541703445.598 (2017-03-01T17:10:40)		link to lc	link to evt	5 57.9
3	541708318.177 (2017-03-01T18:31:53)	541709016.993 (2017-03-01T18:43:31)		link to lc	link to evt	5 58.2
4	541713872.701 (2017-03-01T20:04:27)	541714567.110 (2017-03-01T20:16:02)		link to lc	link to evt	5 58.4
5	541719427.533	541720126.045		link to lc	link to evt	5

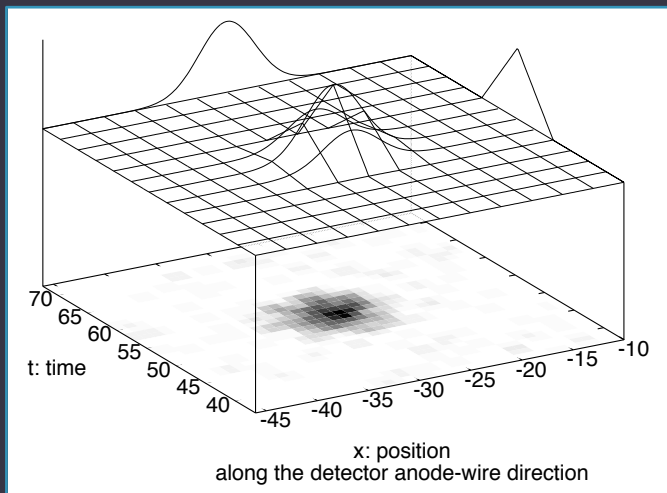
MASIV and “MOXI(目視い)”

- MAXI All Sky Image Viewer
- Web interface for finding transients by visual inspection from MAXI all-sky image

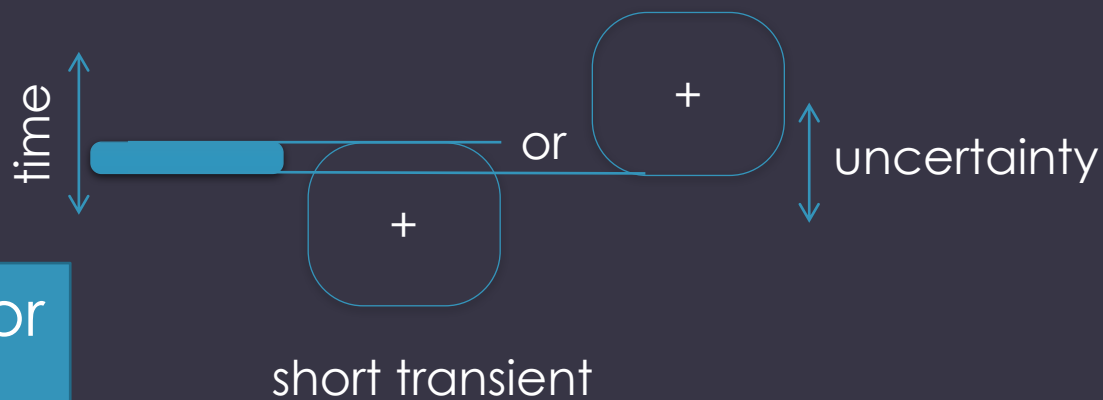
The screenshot displays the MASIV web interface. The central part is a large, dark, circular all-sky image showing a grid of stars and some brighter spots. The interface is divided into several panels:

- Top Left:** A dropdown menu set to "GSC Normal" and another set to "GSC AC3". Below them is a slider and a section titled "- timescale -" with buttons for "1scn", "4orb", "1day", and "4day".
- Bottom Left:** A section titled "- back&forth -" with buttons for "Prev", "Next", "AKB", and "Back". Below that is a section titled "- size/cursor -" with buttons for "Full", "2full", "Fit", and "2fit". Further down are buttons for "Marker-off", "Cursor-off", and a section titled "- variations -" with buttons for "Catalog", "Color", and "BackGround".
- Top Center:** Text indicating the image ID "DPTC 1172456693-1172462213", the date "17/03/02 02:24:37 UTC", and the time "03/02 03:56:37 UTC".
- Top Right:** Text "Galactic 1scan,RGB".
- Right Panel:** A control panel with "Master: 170302j", "la170302-035637-1scn.jp", "Slave: 170302j", and "la170302-035637-1scn.jp". It includes input fields for $\alpha =$ and $\delta =$ with a "GO" button, input fields for $l =$ and $b =$ with a "GO" button, a "JSearch" button, and a "data load status:" section showing "Loading 100%/ 100%", "ImgList 0:OK/ 1:OK", "DirList 0:OK/ 1:OK", and "Catalog : OK(1024)". At the bottom is a "fluxOption" section with a dropdown menu.

Localization of Transients



PSF of a constant source



large systematic error
for short transients

2017/3/3

SENSITIVITY & COVERAGE

Exposure and Sensitivity

- No significant source was detected
→ upper limit
- (1) report typical upper limit of Nova-Alert System
- (2) calculate from the background counts

time scale	1 scan	4 orbit	1 day	4 days
2-4 keV	80-120	50-70	25	15
4-10 keV	100	35	15	8

from
Negoro et al. 2016

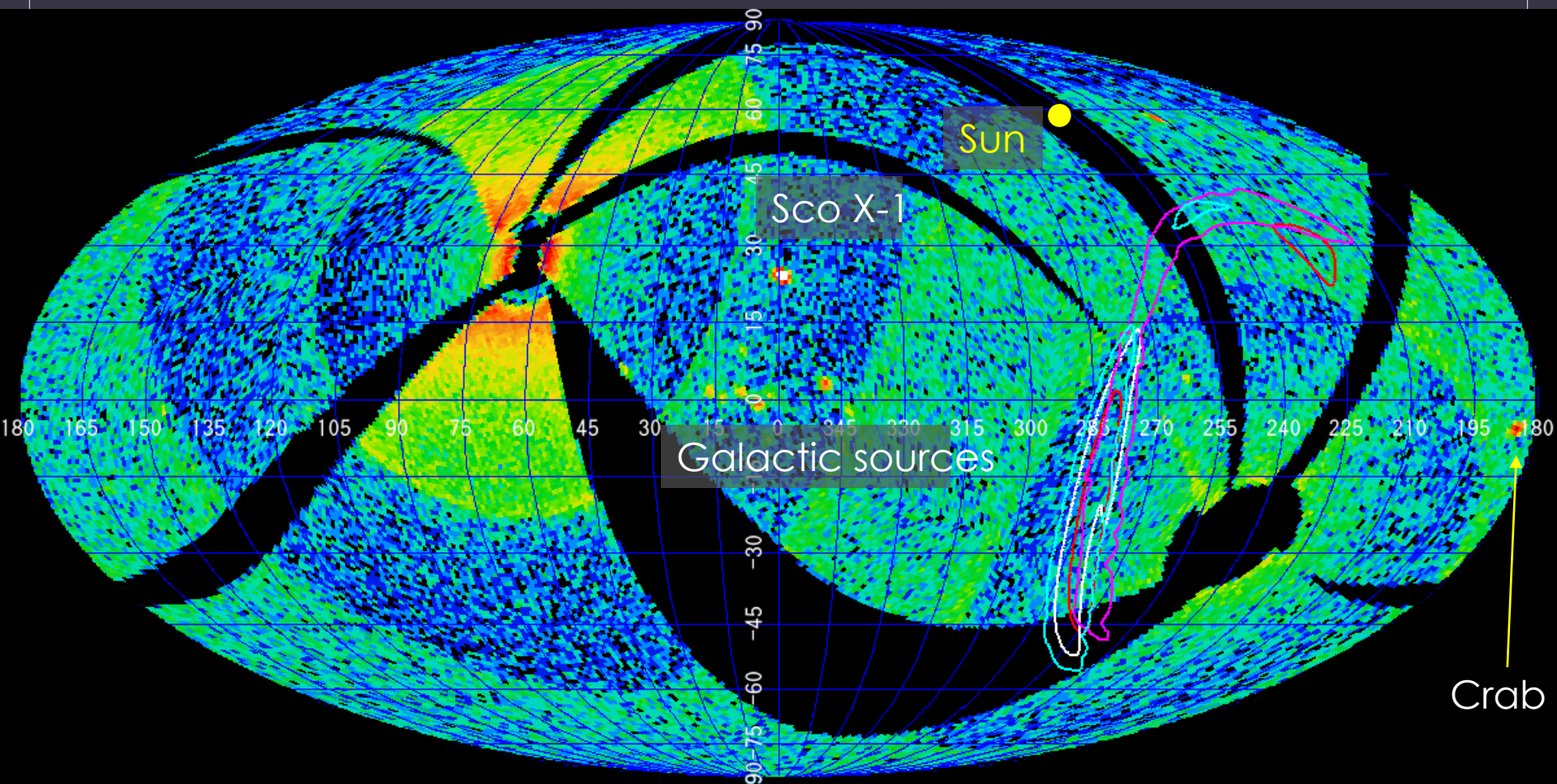
Typical 3σ upper limit (mCrab) by Nova-Alert System

Exposure and Coverage

- GSC covers

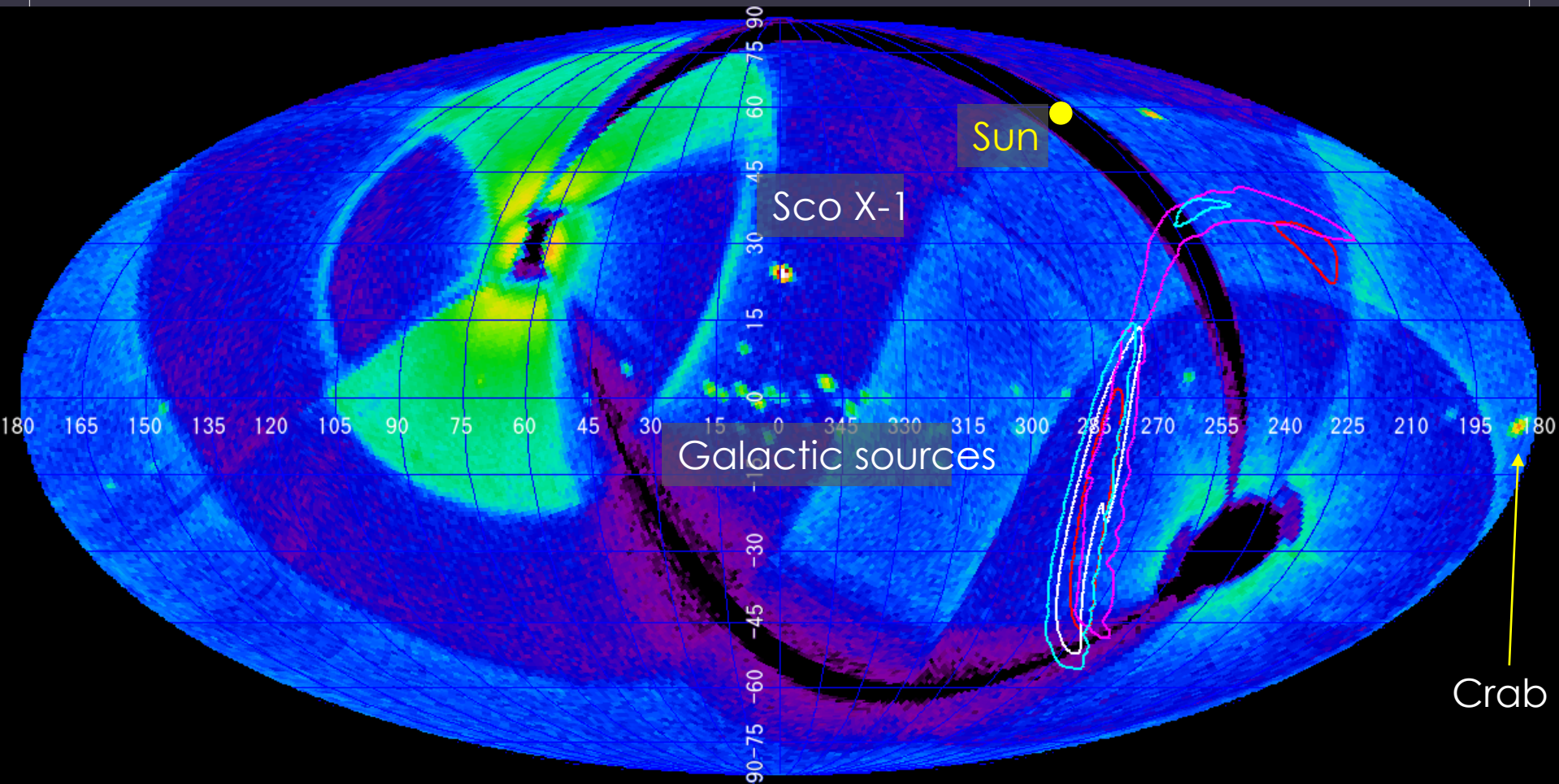
85% of the sky in	92 min
95%	1 day
100%	3 weeks

1 orbit (~92 min)



typically 85% of the whole sky

1 day after the detection



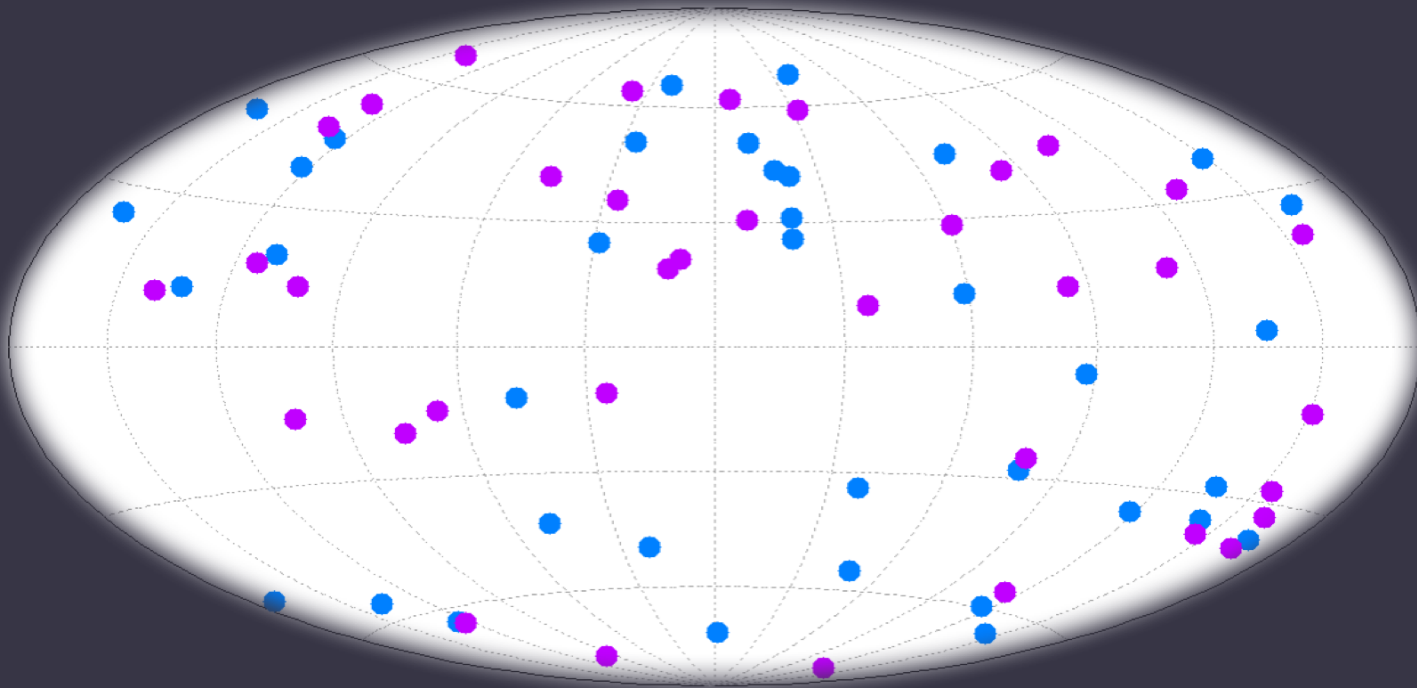
typically 95% of the whole sky

2017/3/3

OBSERVATIONS OF TRANSIENTS

MAXI GRBs : 70 events in 7 years

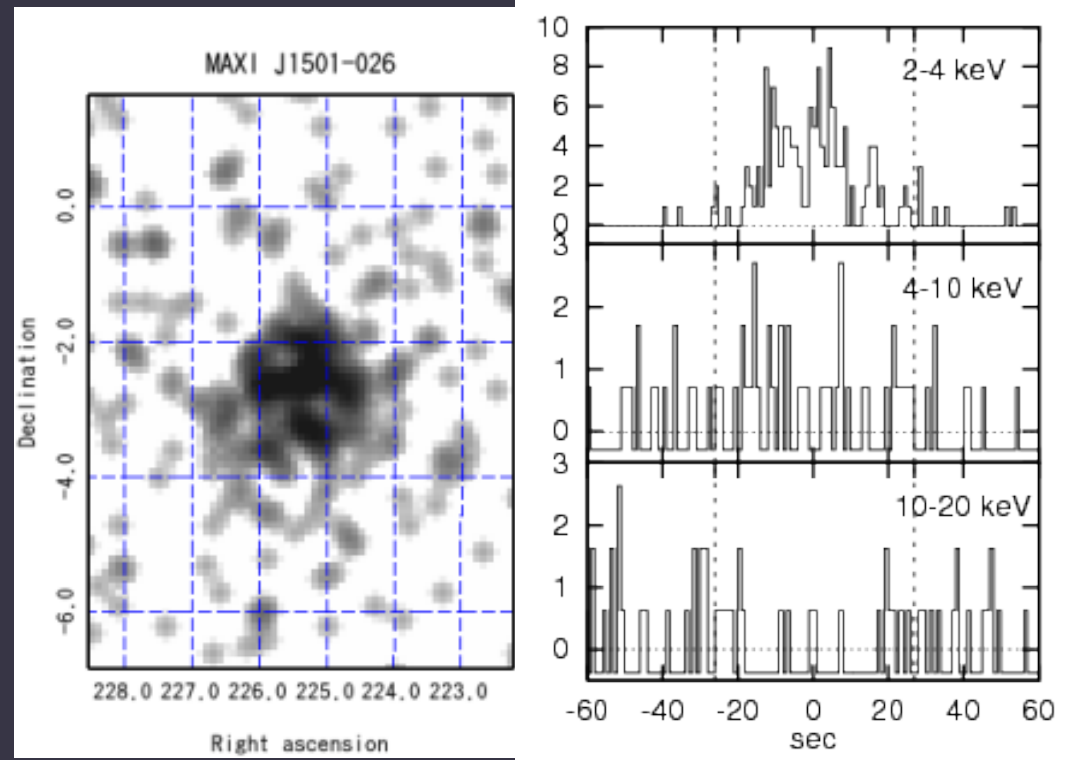
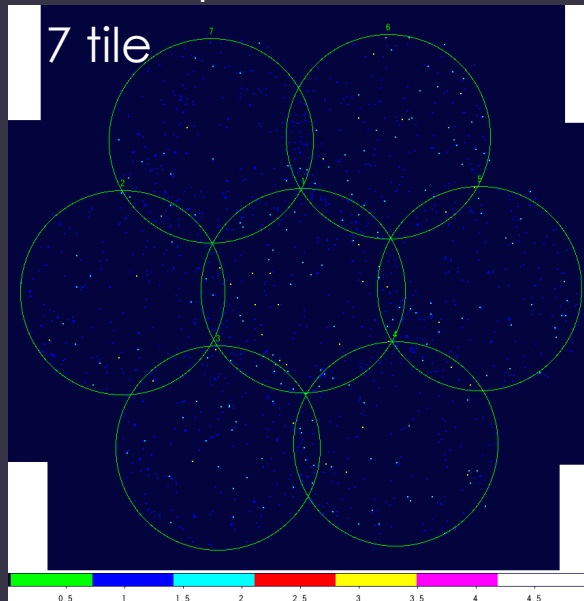
observed by other instruments? — yes: ●
no: ●



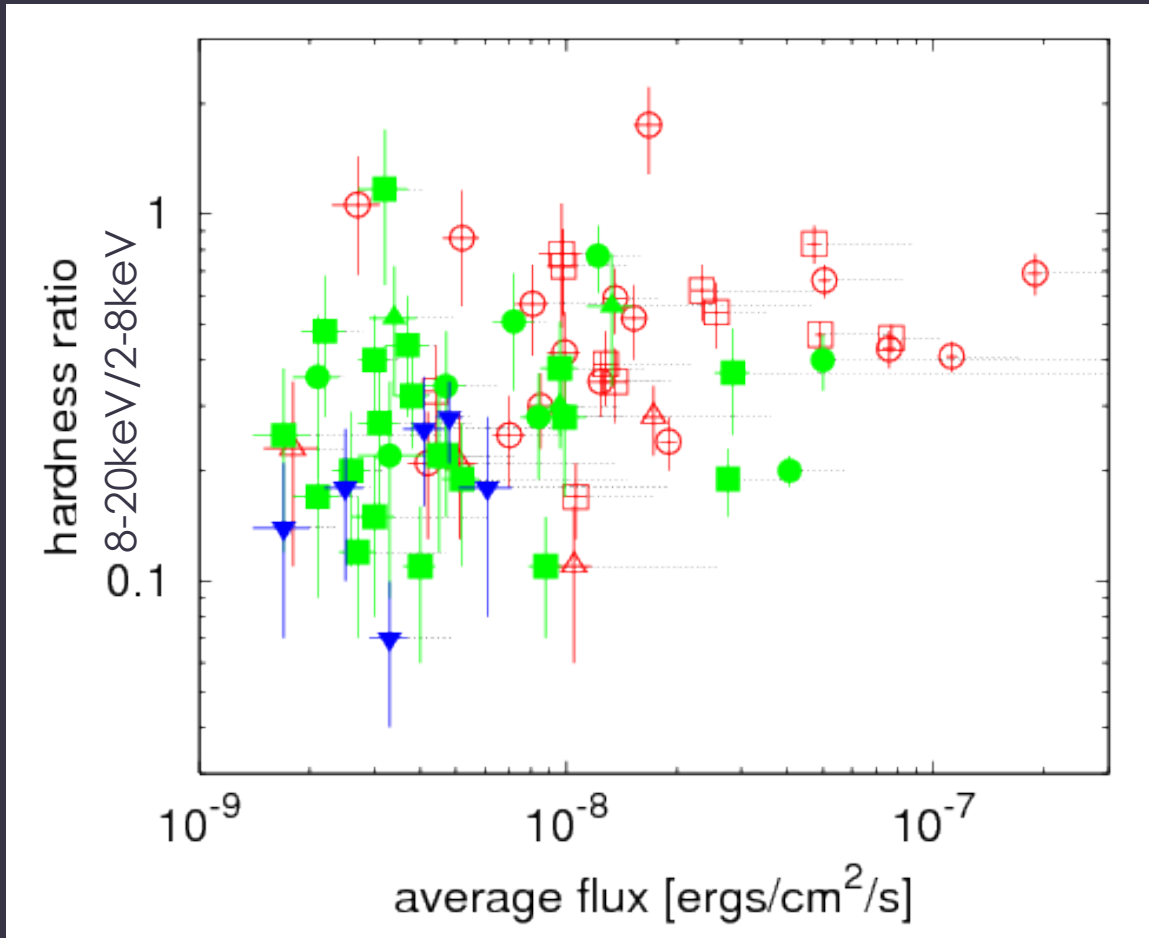
<http://maxi.riken.jp/grbs>

MUSST: MAXI Unidentified Short Soft Transient

- only detected in 2-10 keV
- no detection in the next scan
- no detection in Swift/XRT follow-up



MAXI GRB and MUSST



all GRB+MUSST

r: MAXI+other sat.

g: MAXI only

b: MUSST

counterpart
(candidate)

○: yes

△▽: no

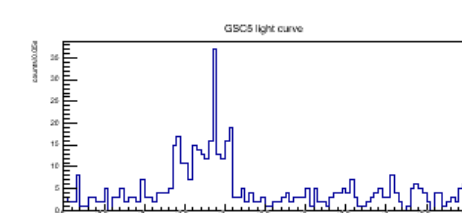
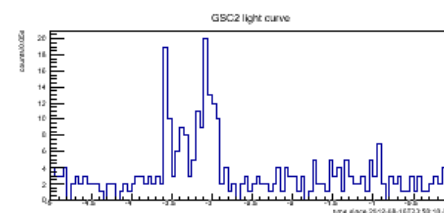
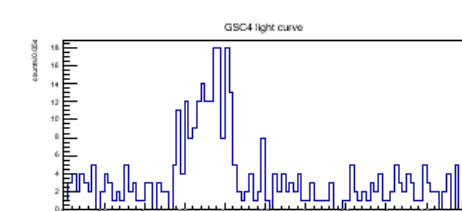
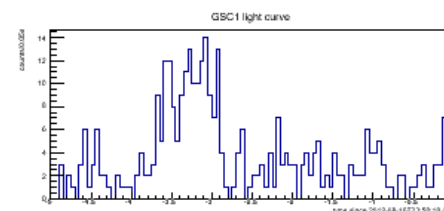
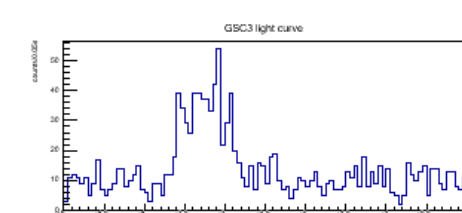
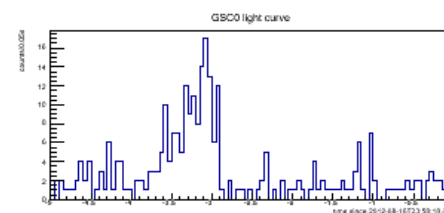
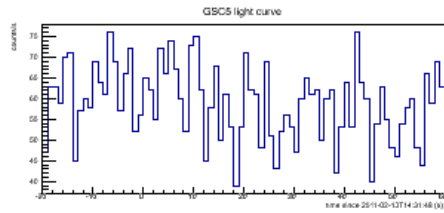
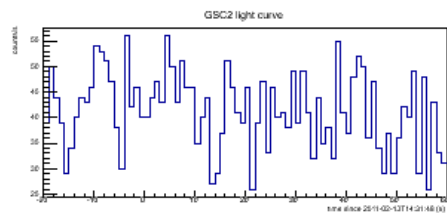
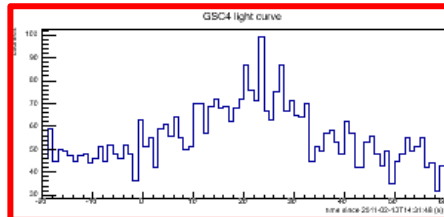
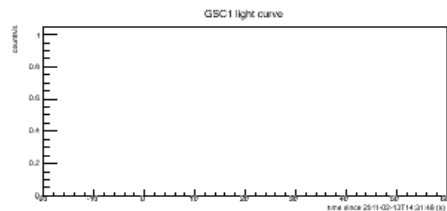
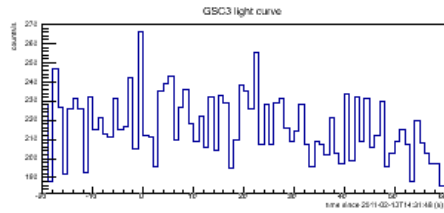
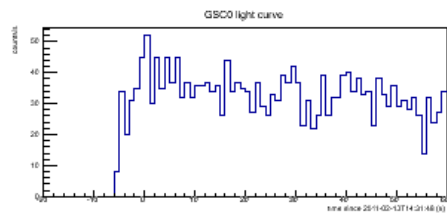
□: no follow-up

hardness is not available
for MAXI J1501-026

short hard emission in GSC

- normal: 1-2 cameras

- hard: all cameras



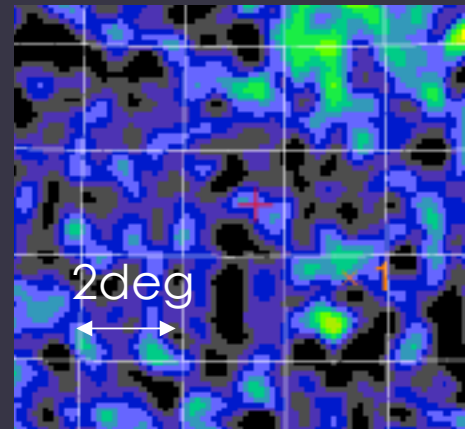
2017/3/3

SEARCHES FOR NEUTRINO EVENT COUNTERPARTS

IceCube-160731 & 161210

- IceCube-160731 (ATel 9313)
- First scan
 - **37min** after the trigger
 - 2-20 keV 3-sigma upper limit 0.104 photons/cm²/s
- from **July 20 to August 3**
 - no significant event
 - 2-20 keV 3-sigma upper limit 0.03 photons/cm²/s (one day)

- IceCube-161210 (GCN 20248)
- First scan
 - **12min** after the trigger
 - 4-10 keV 3-sigma upper limit 20 mCrab



2-20 keV
-30 – +5 hour

Summary

- MAXI's strong points
 - Real time alert
 - Data before the trigger are available
- Upper limit (3σ , 4-10 keV)
 - 100 mCrab for 1 scan, 1.5mCrab for 1 day
- Observations in 2016
 - IceCube-160731: first scan observation started 37 min after the trigger
 - IceCube-161210: first scan observation started 12 min after the trigger
 - upper limits are reported to ATel/GCN

MAXI on-demand data

Click “On-demand” button on
<http://maxi.riken.jp/top/>

or

<http://maxi.riken.jp/mxondem/>

MAXI on-demand process

[MAXI Top](#) | [About This Page, Notes](#) | [Coordinate Converter](#)

Basic Information

- Position (J2000)
(R.A., Dec)=
Search by Name
- TargetName (used for a filename not for position)
- TIME
MJD or date (e.g. 2009-08-15T12:34:56,
Aug 15 2009 12:34:56 ...)
from to
- Light Curve Time Bin
- energy bands for LC and image
GSC band1
GSC band2
 USE SSC
SSC band1