

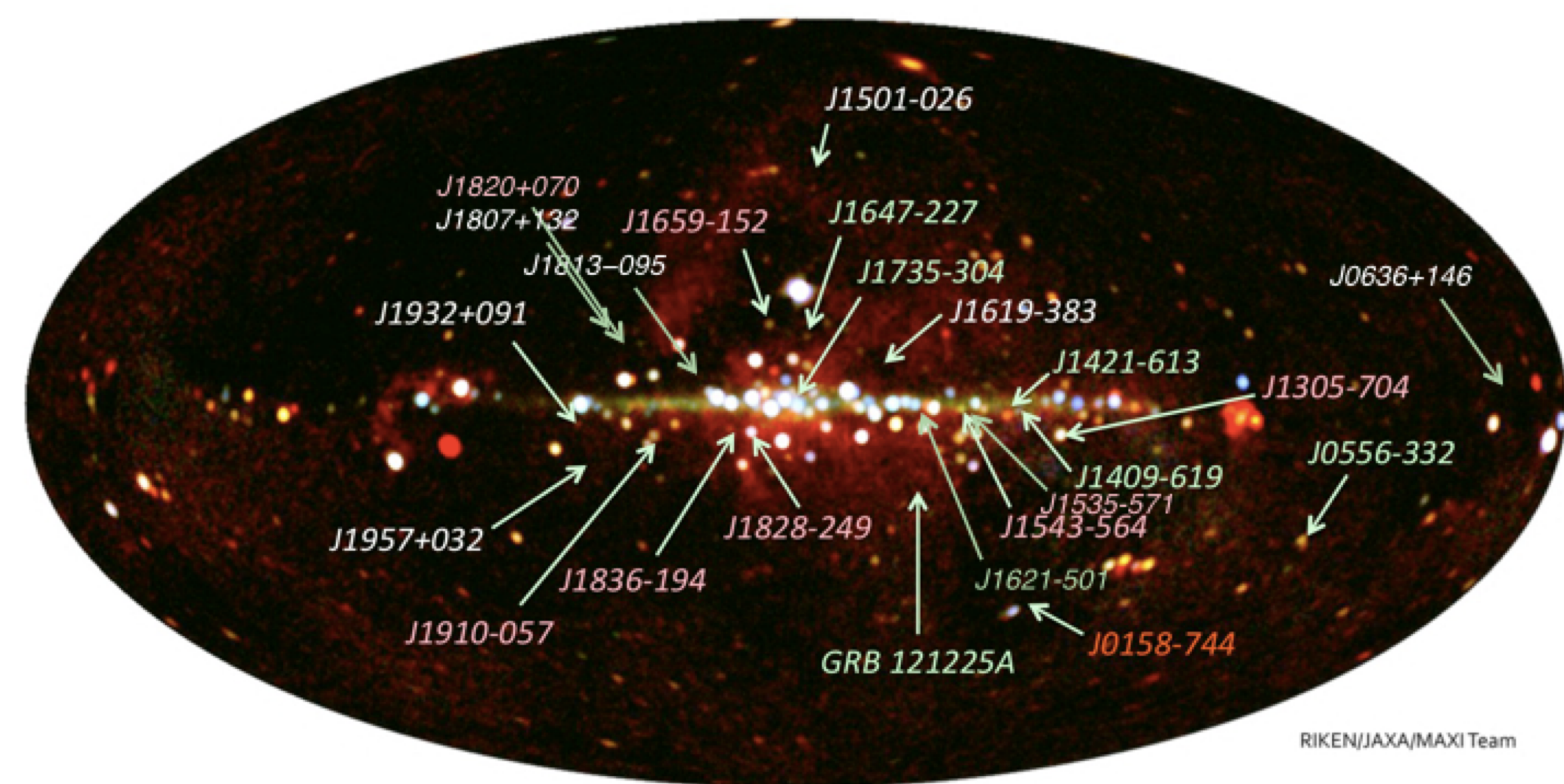
Recent results of MAXI all-sky X-ray survey on the ISS

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MAXI (Monitor of All-sky X-ray Image) is an X-ray astronomical mission that has been carried out on the ISS (International Space Station) since 2009 August. The GSC (Gas Slit Camera) on board has been scanning the whole sky every 92 minutes for over 9 years. By the systematic search for transient X-ray sources, we have discovered 21 new X-ray objects which include 7 black-hole binaries, 11 neutron-star binaries, 1 white-dwarf binary. The origins of 2 objects out of the 21 have not been identified. In the recent two years, 3 remarkable new transients that brightened up to the several Crab, MAXI J1535-571, MAXI J1820+070, and Swift J0243.6+6124, appeared. MAXI monitoring observations revealed their throughout outburst evolution. On the course of these analysis process, short transient events identified as gamma-ray bursts (GRBs) or X-ray bursts (XRBs), and recurrent events from known X-ray objects were also detected. The information about possible GRBs are sent to the GCN. We have posted 14 GCN circulars in these 2 years. We also reported important new/recurrent events in the Astronomer's Telegram and the MAXI mailing list. The MAXI all-sky source catalogs were created from the detailed image analysis. The 3rd MAXI catalog (682 sources) in the high Galactic-latitude sky (Kawamuro et al. 2018) and the 1st catalog (214 sources) in the low Galactic-latitude sky (Hori et al. 2018) have been released. Since the LIGO/Virgo gravitational-wave (GW) experiments started in 2015, our MAXI team join the collaboration to search for the electromagnetic counterparts. We reported X-ray upper limits on three GW events (Kawai et al. 2017, Serino et al. 2017, Sugita et al. 2018). As for GW 170817/GRB 170817A, the GSC field of views passed through the source location a few minutes after the event. However, the GSC gas counters were turned off at that time, because the ISS was in the high cosmic-ray background area. The first MAXI observation of the GW 170817/GRB 170817A position was then carried out 4.6 hours later. We are now optimizing the operation scheme for the GW counterpart search. We started cooperation with NICER, the new X-ray mission on ISS started in 2017. So far, NICER observations of new transients and recurrent stellar flares detected by MAXI were carried out via e-mail communications. We develop the ISS-onboard system to enable immediate NICER observations of new MAXI transients within a few minutes, under the project named by OHMAN (On-orbit Hookup of MAXI And NICER).

Discoveries of New X-ray transients (~21 objects in total)



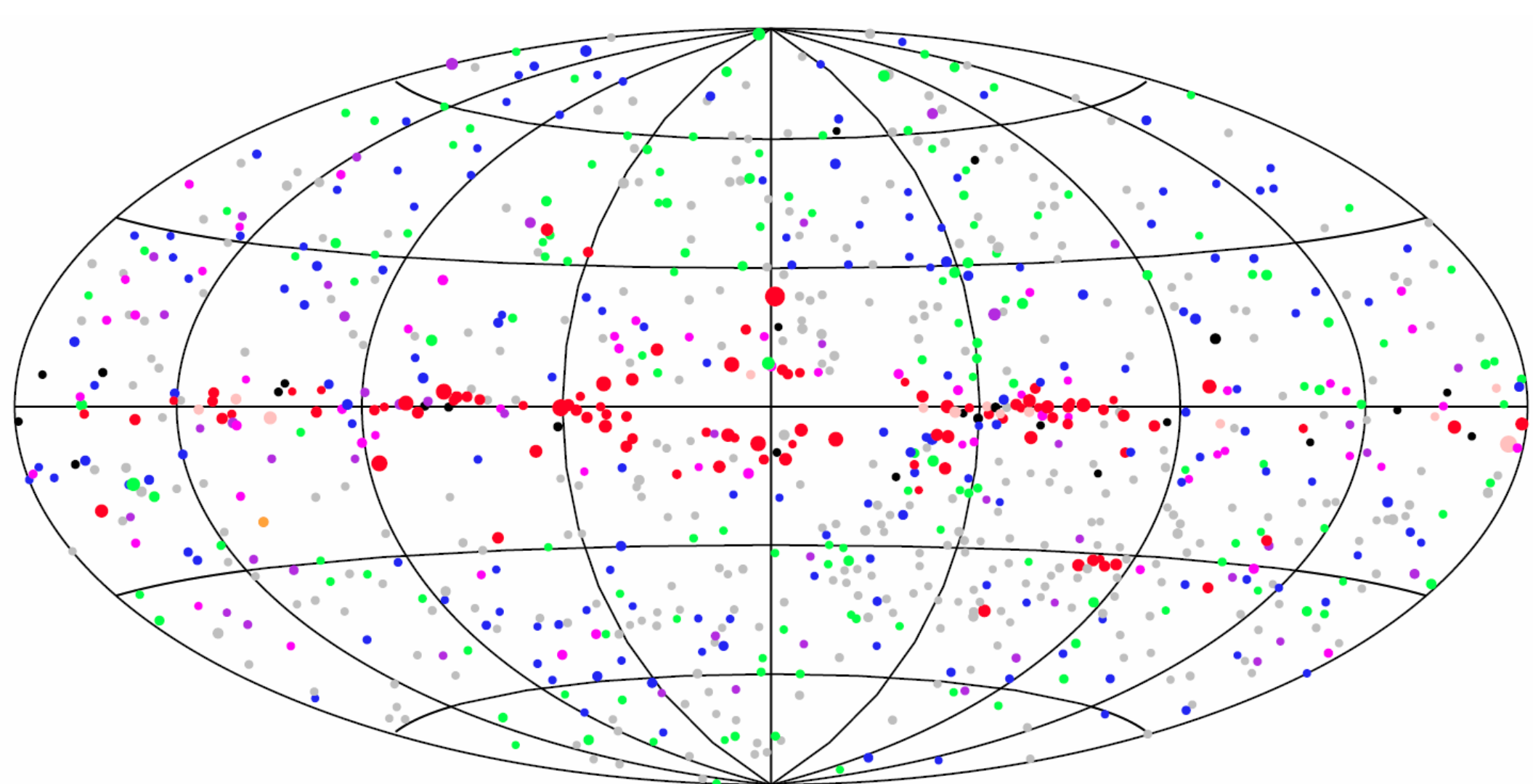
BHXB, NS-XB, WD binary

7 new objects since 2017.1.1

Name	date	ID	Ref.
MAXI J1727-203	2018. 6. 5	BHXB	Atel #11683
MAXI J1820+70	2018. 3.11	BHXB	Atel #11399
MAXI J1813-095	2018. 2.20	Unknown	Atel #11323
MAXI J1621-501	2017.10.20	LMXB burster?	Atel #10869
(Swift J0243.6+6124)	2017. 9. 30	Be XBP	Poster
MAXI J1535-571	2017. 9. 3	BHXB	Nakahira+2018
MAXI J1807+132	2017. 3.25	Unknown	Atel #10208

MAXI source catalog

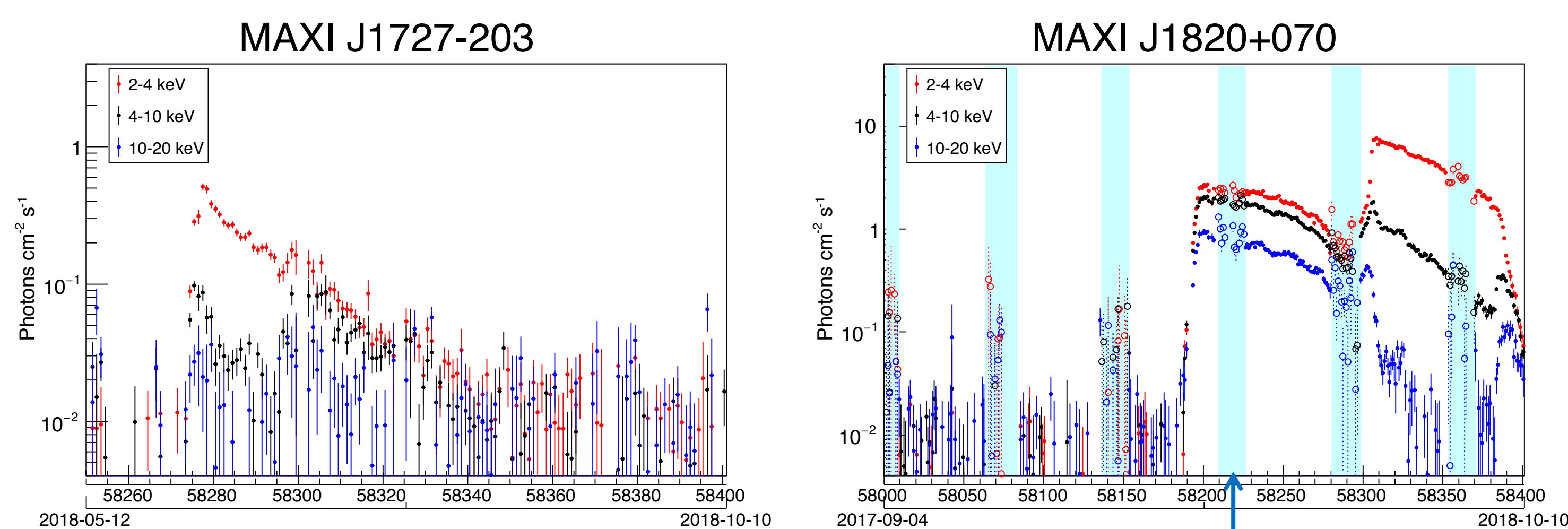
(Hori+2017)
(Kawamuro+2018)



Seyfert Cluster Quasar Galaxy X-ray Binary Pulsar CV Star SNR Unidentified

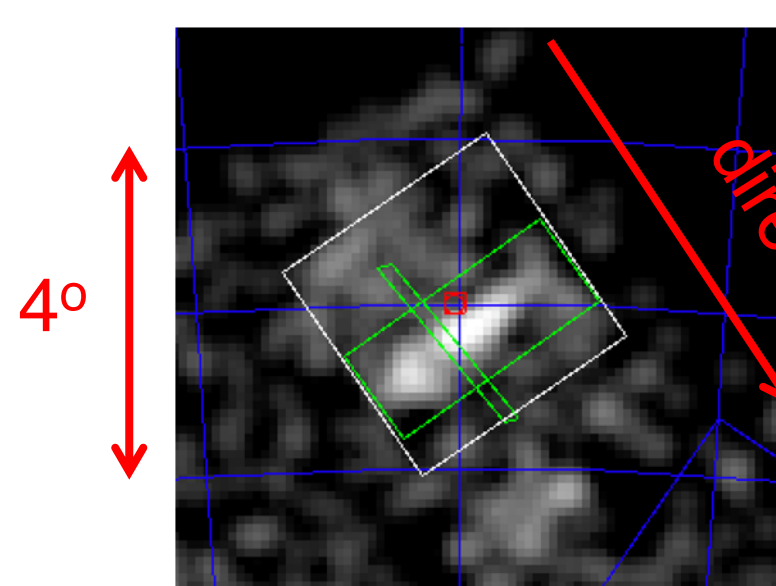
- MAXI/GSC 7-year data from 2009 August to 2016 July.
- 214 sources in low Galactic latitude ($b < 10$ deg.)
- 682 sources in high Galactic latitude ($b > 10$ deg.)
- The two catalogs contain 896 sources, which includes a significant fraction of unidentified objects.
- The sensitivity limit reaches ~ 0.4 mCrab for half of the whole sky. It is mostly determined by the source confusion limit.
- The deepest source catalogs in the 4-10 keV band among all previous and on-going all-sky X-ray missions.
- Advantages of 4-10 keV energy range are
 - Free from the galactic absorption.
 - Energy range cover the major part of the emission from black-hole and neutron-star X-ray binaries.
- MAXI scans thousands of times for each target
 - Correctly averages the fluxes of variable sources.
 - Also can make a variability catalog, in one-month time-bin etc.

Standard MAXI-GSC light curves of emergent targets are processed every 4 hours. These data are available at <http://maxi.riken.jp>.



Data in shaded area were taken by degraded GSC instruments which have large systematic uncertainty.

MAXI J1621-501

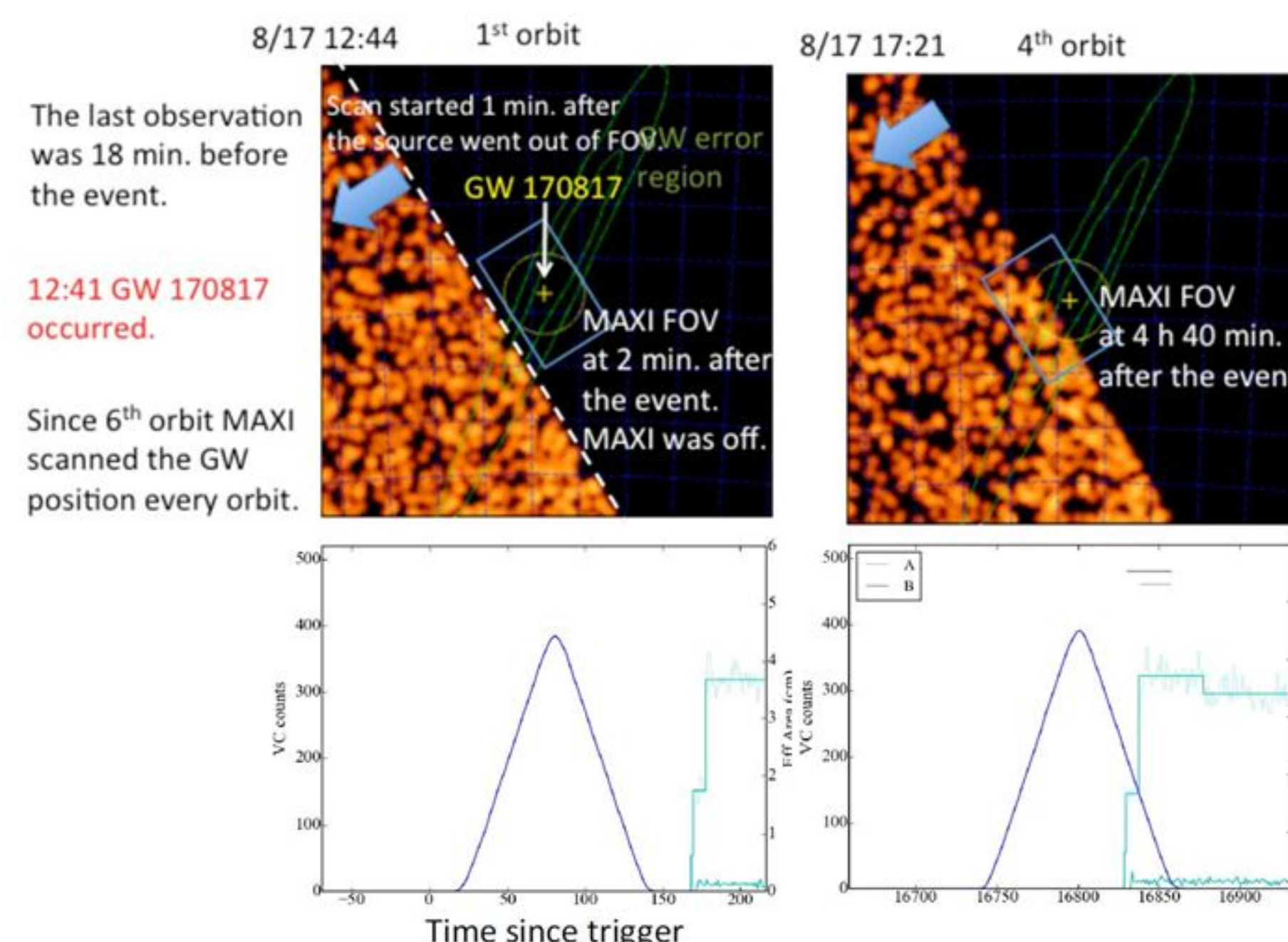


GSC detected an X-ray burst during a scan transit of ~ 40 s (ATEL#10869).

Search for X-ray counterparts of GW sources

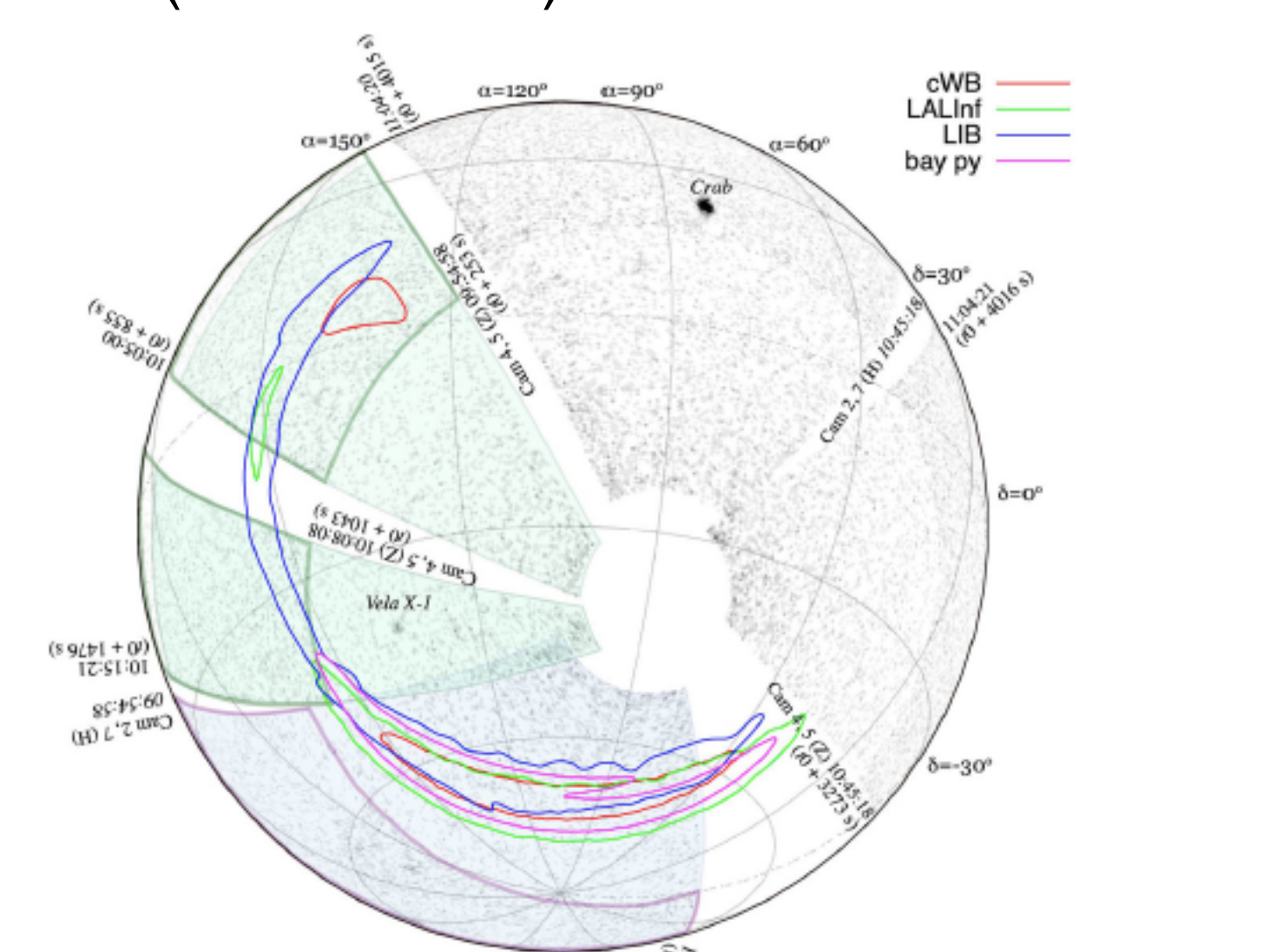
GW 170817/ GRB 170817A (Sugita+2018)

At 12:41 on 2017 August 17, GW170817/ GRB170817A was detected by LIGO/Virgo and Fermi/GBM. ISS was in the high BGD region and all GSC HVs were turned off. From t_0+20 s to t_0+130 s, GSC scanned the location, but HVs were still off. At t_0+170 s, GSC resumed the observation, but the target was out of FOV. Finally, at $t_0+4.6$ h, GSC scanned the GW location and it gave the earliest X-ray upper limit.



GW 151226 (Serino+2017)

GW 150914 (Kawai+2017) the first GW event

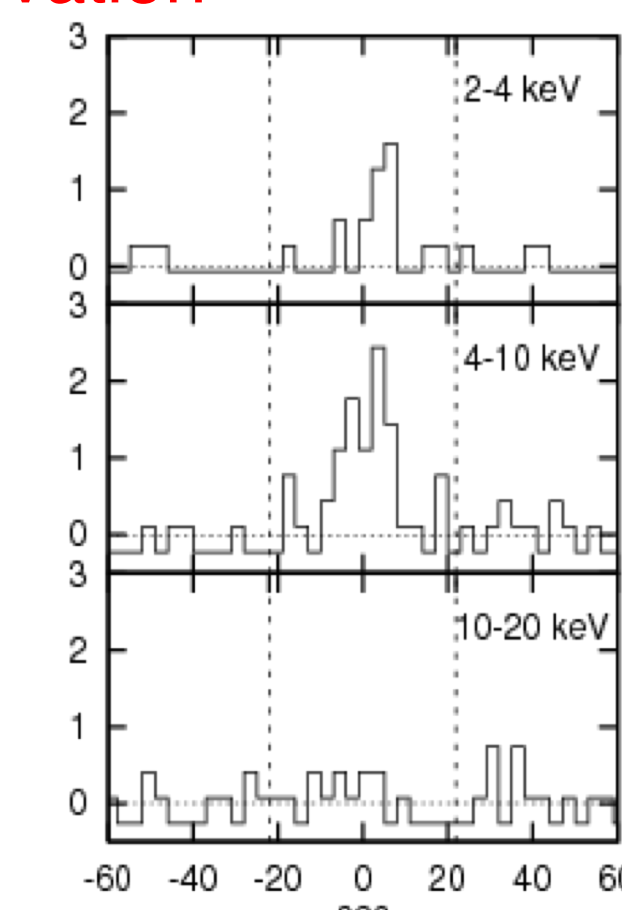


Schematic view of area covered by MAXI GSC from t_0+4 min to t_0+74 min and GW 90% contours by various algorithms.

MUSST (MAXI Unidentified Short Soft Transient)

- Soft** : Detected only in MAXI X-ray band (2-10 keV).
No detection by Swift/BAT (15-50 keV)
- Short** : Faded away before Swift/XRT follow-up (~ 0.5 d).
- Unidentified** :
⇒ Rapid X-ray follow-up is needed.
(100 mCrab in 1 min, 1 mCrab in 20 min).
- ⇒ MAXI-NICER coordinated observation

One of the MUSST examples, GRB 140814A. The source was initially reported as a GRB, but not detected by the Swift follow-up. The figure shows the GSC light curve during the scan of the discovery. There was no significant signal in the hard (10-20keV) band.



8 MUSST candidates

name	l	b	flux [Crab]	reference
GRB 161123A	255.8	-69.6	0.1	Atel #8050
MAXI J1501-026	354.6	+46.8	0.44	Atel #7954
GRB 150428C	139.3	+11.2	0.2	GCN #17772
MAXI J1540-158	351.6	+30.6	0.1	GCN #17568
GRB 140814A	139.9	+66.4	1	GCN #16686
MAXI J0545+043	201.1	-12.6	0.2	Atel #6066
GRB 130407A	26.4	+35.6	4	GCN #14359
MAXI J1631-639	324.4	-10.8	0.12	Atel #3316

MAXI-NICER cooperation project

- MANGA (MAXI And NICER Ground Alert)
 - Several NICER follow-ups of MAXI X-ray new transients and stellar flares have been carried out via ground e-mail communication
- OHMAN (On-orbit Hookup of MAXI And NICER)
 - MAXI nova-search process run in a laptop PC on the ISS/JEM
 - Convey new-source information from MAXI to NICER via the ISS network.
 - Rapid NICER follow-up within 2 minutes from the MAXI discoveries

