Observations of MAXI Unidentified Short Soft Transients

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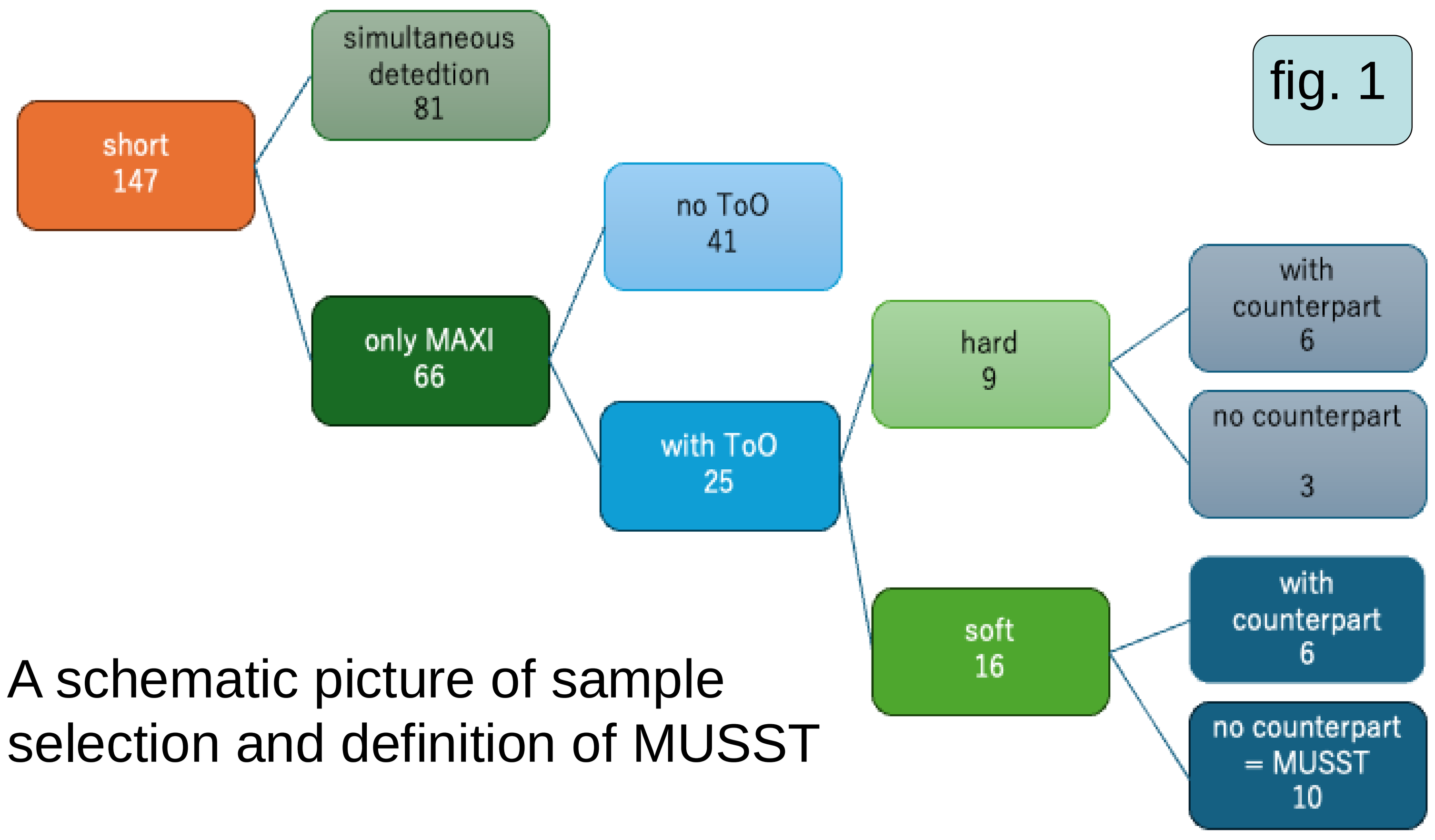
Short X-ray transients are observed by various X-ray missions. Origins of these transients are both galactic (X-ray bursts, stellar flares, soft gamma-ray repeaters, etc.) and extra-galactic (Gamma-ray bursts, tidal disruption events, AGNs, etc.). Among them MAXI observed short soft transients which were not observed by other instruments including X-ray follow-up observations. We named them MUSST for MAXI unidentified short soft transient. We found 10 MUSSTs since the start of the MAXI observation. Here we describe the properties of MUSSTs by comparing with soft events with afterglows and discuss the possibility that MUSST is a completely different class from ordinary GRBs.

1. Introduction – MUSST and other short transients observed by MAXI –

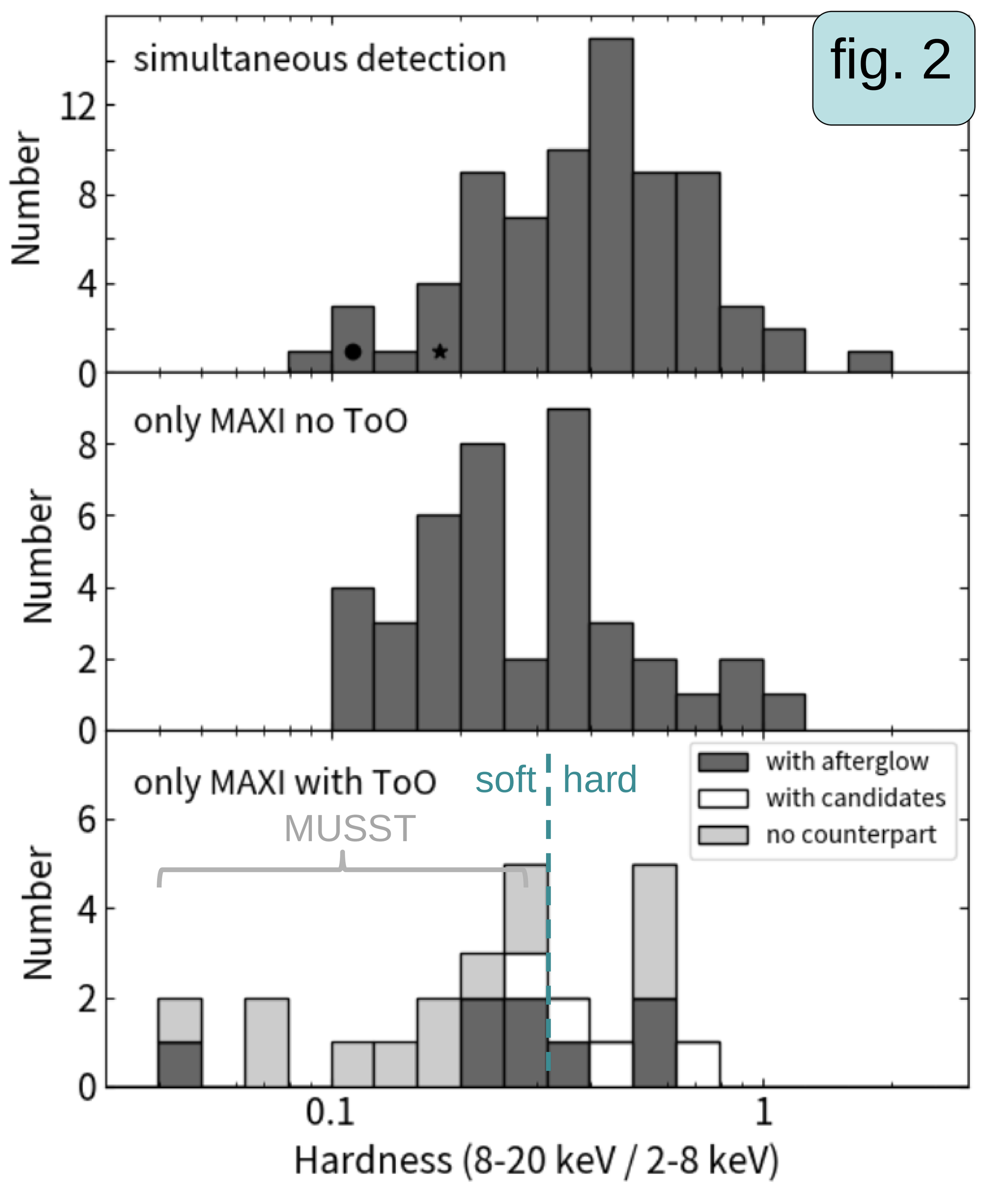
MAXI detected 211 unknown transients since the start of the operation. Among them, 64 lasted more than one scan and 147 lasted only one scan transit. About a half of the short transients were observed by other instruments simultaneously, but 66 were "only MAXI" events. We performed follow-up observations for 25 only MAXI events to clarify the sources of the transients. Because hard bursts are well studied with other instruments, **we focus on soft events and compare the event classes with and without counterparts** (Figure 1). Here we define "soft" as "Hardness < 0.3", which is an indicator of X-ray flashes [1].

fig. 1



A schematic picture of sample selection and definition of MUSST

fig. 2



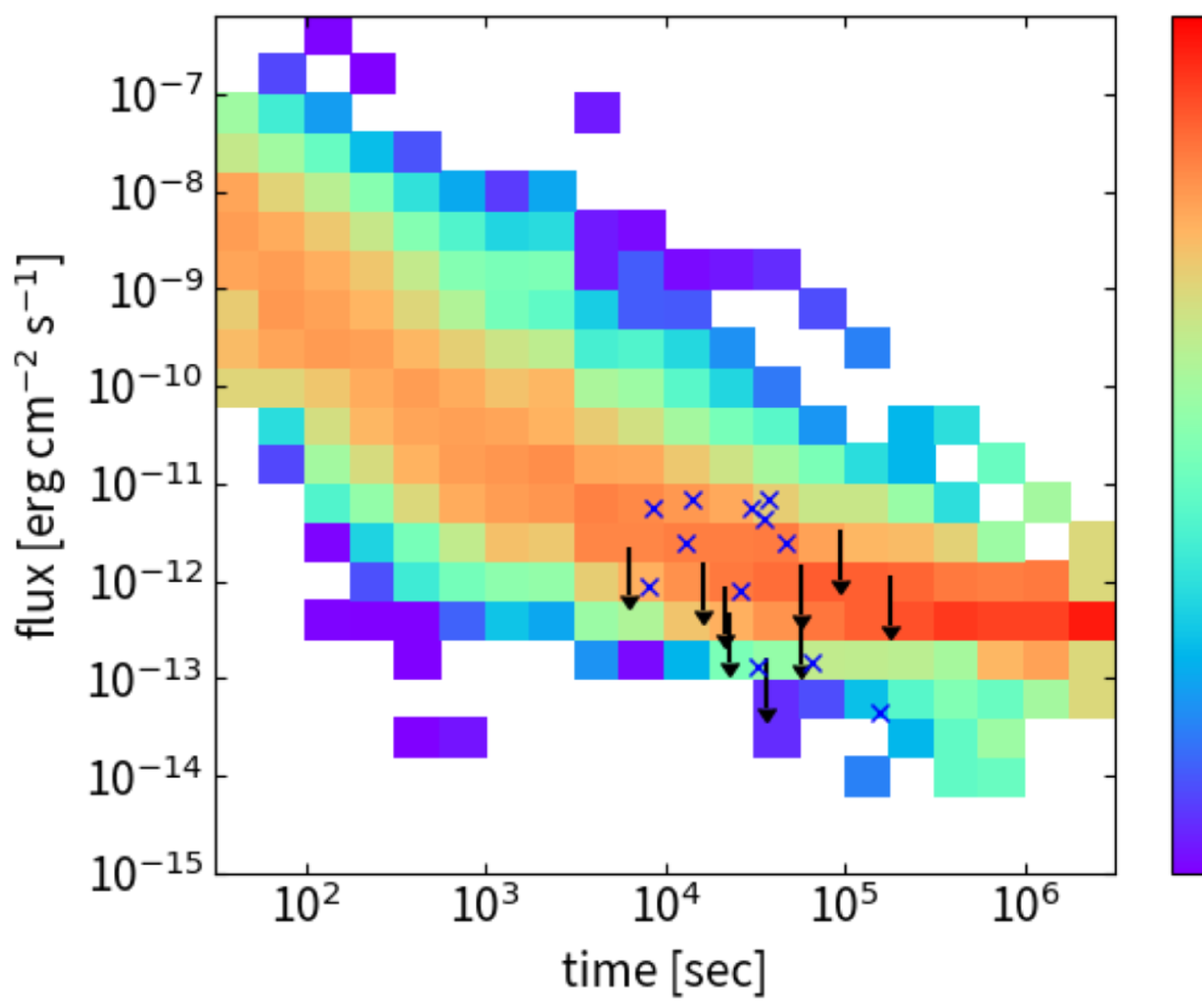
2.1. Comparison in spectral hardness

First, we compared the distributions of hardness of each class. We plotted histograms of hardness ratio of 8-20 keV to 2-8 keV band in figure 2. The top and middle panels of the figure show the distributions of "simultaneous detection" events and "only MAXI but without ToO" events. From the bottom panel of the figure 2, we know **that events with afterglows (including candidates) have higher hardness than MUSSTs**. An exception is GRB 210102B, and it has the lowest hardness 0.05±0.02. The afterglow of this GRB was detected in X-ray and optical bands and then faded below the detection limit in the following observations in the both bands [2-5]. This behavior was **consistent with ordinary GRBs**.

2.2. Comparison in afterglow observations

Next, we compared flux of X-ray afterglows of soft event classes in figure 3. We used Swift XRT for afterglow observations. The flux of X-ray counterparts in 0.3–10 keV are plotted with blue crosses and upper limits are plotted with black arrows. The color scale shows the probability of the flux level in 0.3–10 keV at each time region calculated from all the available data of X-ray afterglows detected by Swift XRT as of May 2024. From the figure we conclude that the upper limit fluxes are not low compared with detected afterglows, and **the afterglow might be detected if the observations were performed with sufficient exposure or started earlier**. In addition, the observation coverage of the 90% MAXI error region of MUSST events were as low as 22–51%. It is important **to improve the coverage** for detections of afterglows of only MAXI events.

fig. 3



3. Summary

MAXI detected short soft transients which were not detected by other instruments. Although X-ray afterglows were not found for some of these events, properties of the events are not completely different from ordinary GRBs. It suggest that MUSSTs originate from sources like GRBs. We consider measurements of the distance to the sources are essential to know the origin of the MUSSTs. Early and comprehensive follow-up observations are needed.

References

[1] Serino, M. et al., Publ. Astron. Soc. J., 66, 87 (2014)
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[3] D'Avanzo, P. et al., GCN circular 29271 (2021)
[4] Pozanenko, A. et al., GCN circular 29240 (2021)
[5] Pozanenko, A. et al., GCN circular 29270 (2021)