

Subaru ToO Observations of Short-duration GRB 210704A and GRB 211023B

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on behalf of the Subaru GRB team

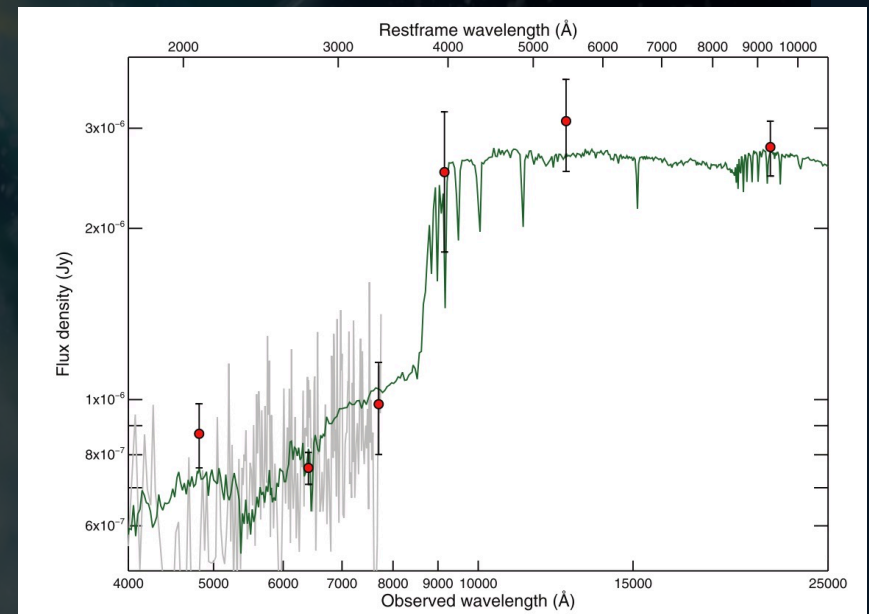
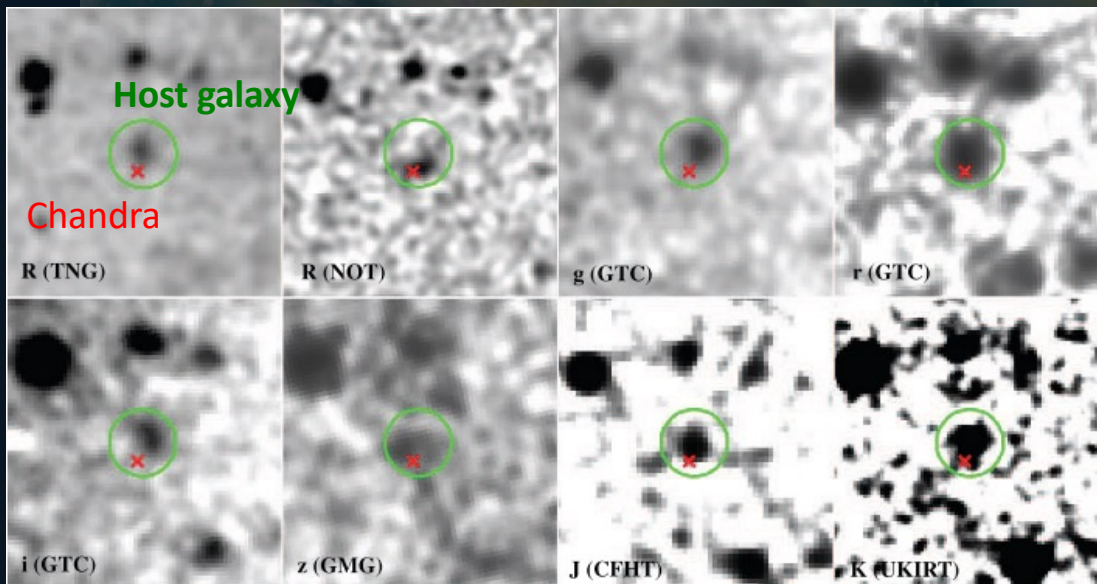
Abstract

We present the Subaru ToO observations (S21B) of two short-duration GRBs, GRB 210704A and GRB 211023B. The fields of GRB 210704A and GRB 211023B were observed by the Hyper Suprime-Cam in r filter on October 28, 2021. The optical source was clearly detected for GRB 211023B, which was dominated by the possible host galaxy. No optical source was detected for GRB 210704A. We present the results based on our ToO observations.

Host Galaxy Identification of Short GRBs

Chandra ToO program: Obtain sub-arcsec position in X-rays of short GRBs with no optical afterglow
(Cycle 13,14,15,18,20,21,22,23)

GRB 11117A (Sakamoto et al. 2008)



Images of the host galaxy of short GRB 11117A observed in R, g, r, I, z, J and K. A green circle shows the host galaxy and a red cross is the location of X-ray afterglow by Chandra.

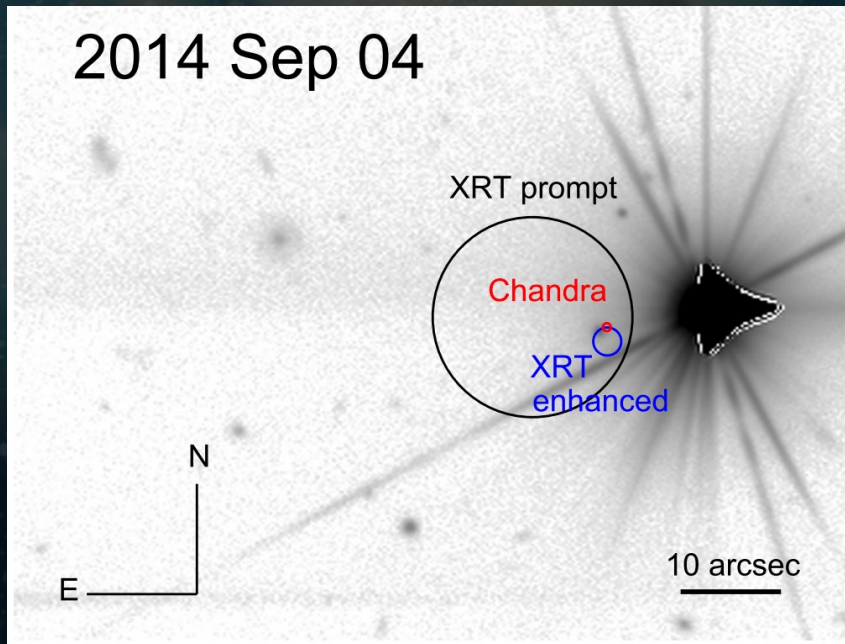
The SED fit to the photometric data of the host galaxy of GRB 11117A. The best-fit SED template of ~ 0.1 Gyr post-starburst galaxy.

Jet Collimation in Short GRBs

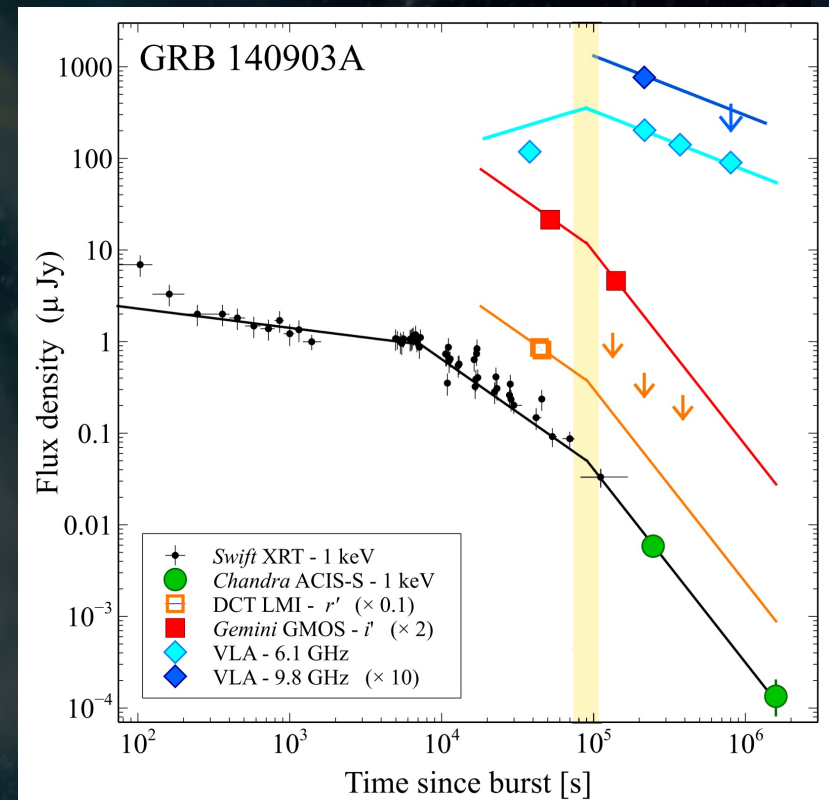
Chandra ToO program:
(Cycle 12,15,20,21,22,23)

Identifying the jet break of short GRBs

GRB 140903A (Troja et al. 2016)



DCT r-band image of the field of GRB 140903A at $T_0+0.5$ days.



Afterglow light curves of GRB 140903A. Clear jet break is evident combining X-ray and optical data.

GW170817: Binary neutron star merger event

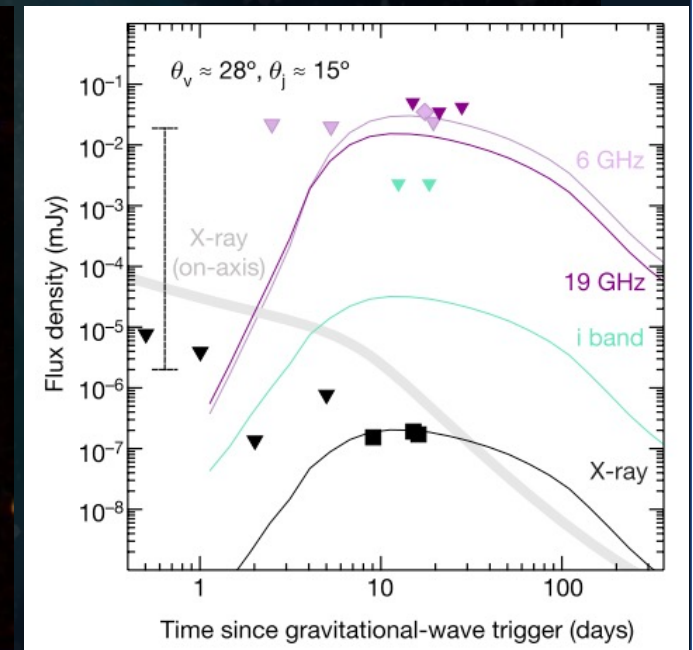
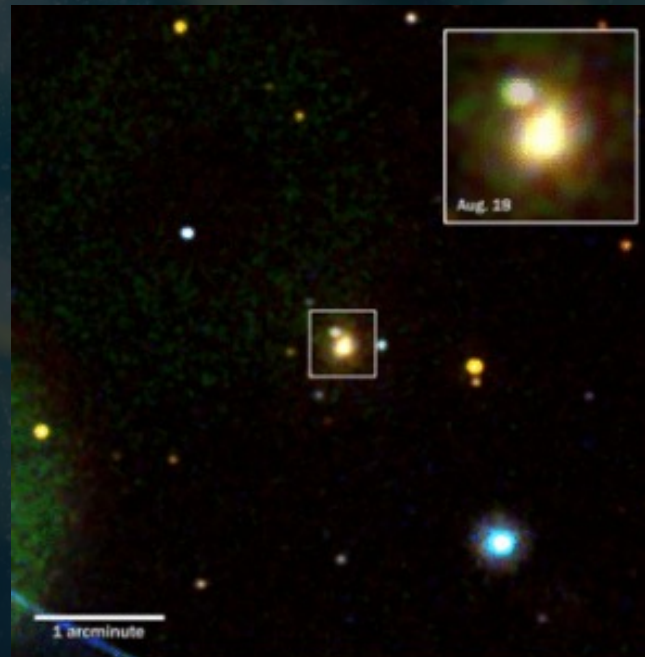
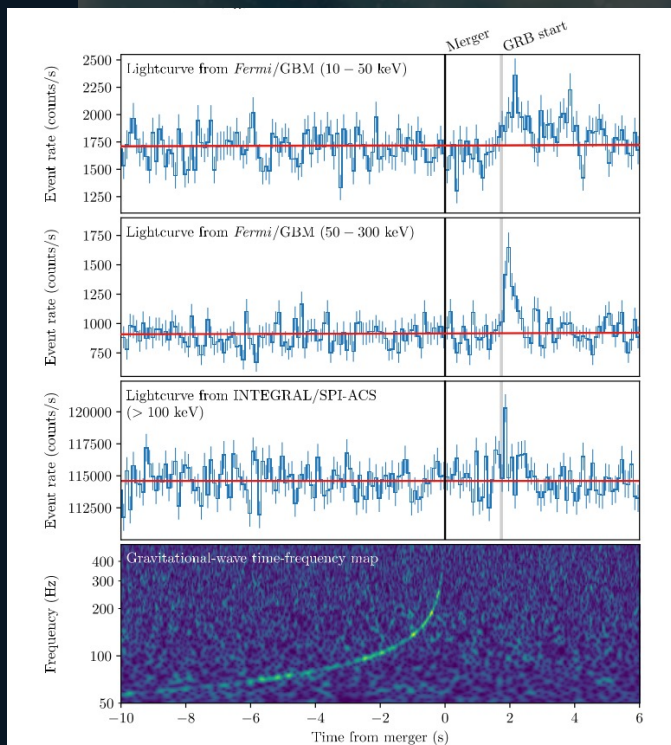
GW170817: Gravitational wave + kilonova + Short GRB

- Detailed data of r-process elements synthesized in the ejecta
- Off-axis emission from a short GRB jet

A short GRB association to the gravitational wave signal from a neutron star merger (Abbott et al. 2017)

Blue kilonova detection by the NASA Swift/UVOT (Evans et al. 2017)

Relativistic jet X-ray and radio emission (e.g., Troja et al. 2017)



Goals of Subaru Short GRB ToO Program

1. Identification of a host galaxy of a short GRB to constrain the nature of a progenitor
2. Detection of a jet break from a short GRB to understand the true energy release of short GRBs

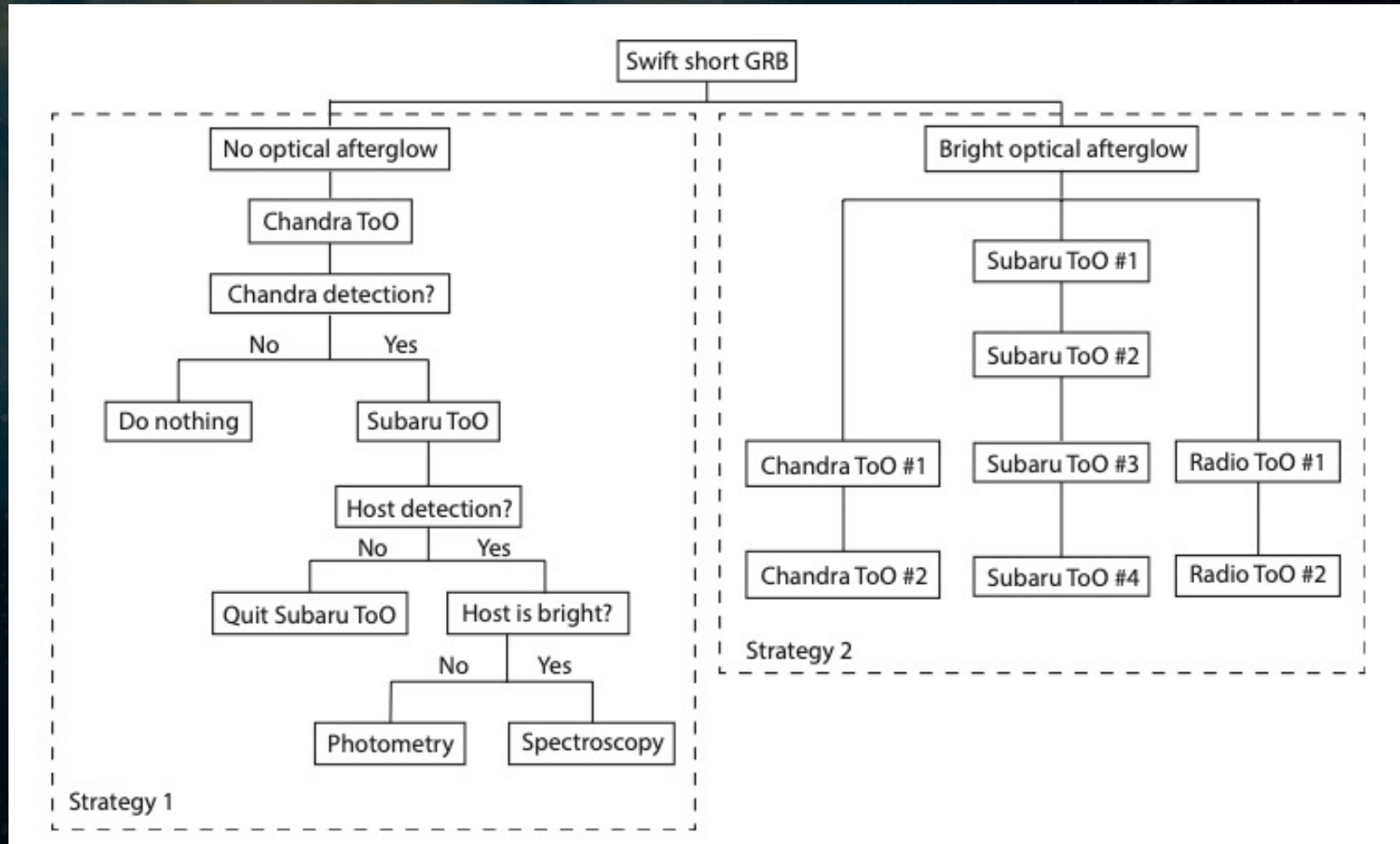
A clear identification of the host galaxy of short GRBs will provide a crucial understanding of the **redshift distribution** and the **properties of the environment** of short GRBs.

The collimation angle of the GRB jet is the key to understand the **true energy release** in short GRBs.

Strategy of the Subaru ToO

Strategy #1: Host galaxy photometry and spectroscopy for a short GRB identified by Chandra

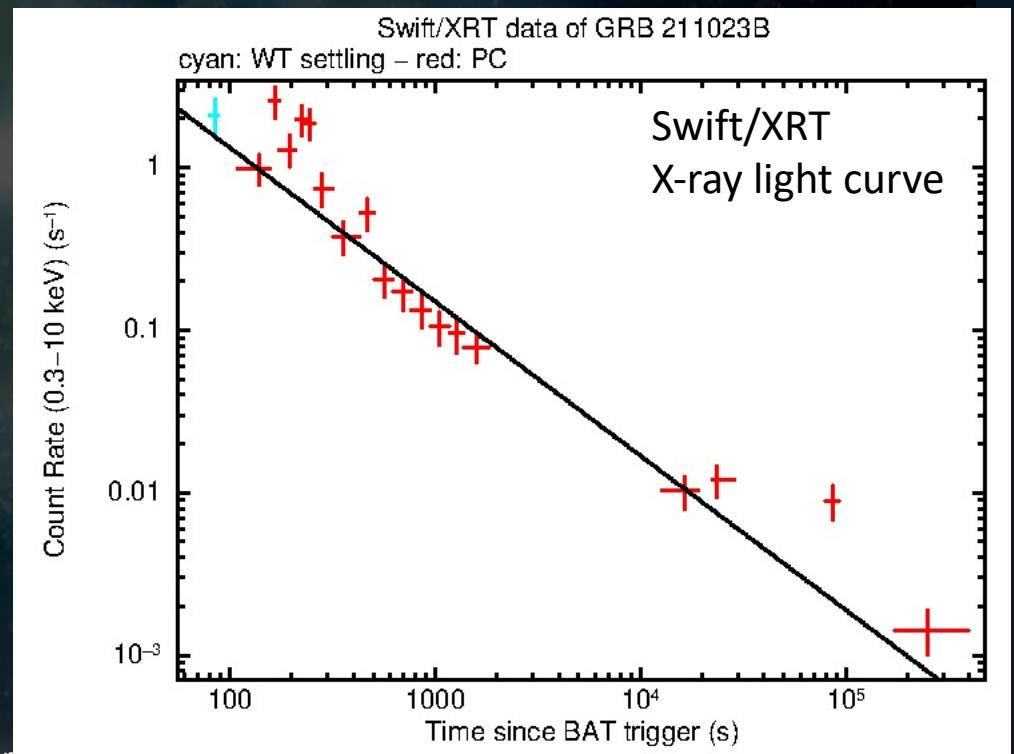
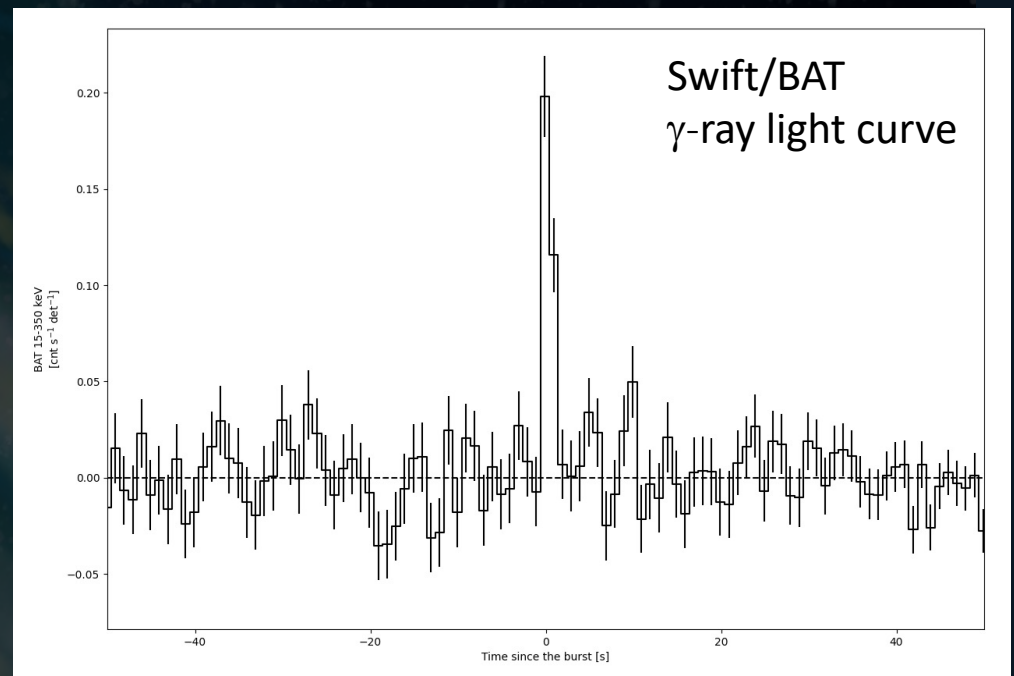
Strategy #2: Identify a jet break of a short GRB



GRB 211023B

- Swift/BAT trigger time: **2021-10-23 21:05:52.14 UT** (Dichiara et al. 2021)
- BAT T_{90} duration: **1.3 ± 0.3 sec** (15-350 keV)
- **X-ray** (Dichiara et al. 2021, Beardmore et al. 2021) and **optical** (Dichiara et al. 2021, Kuin et al. 2021, Kann et al. 2021, O'Connor et al. 2021, Rastinejad et al. 2021, Pozanenko et al. 2021) **afterglow detection**

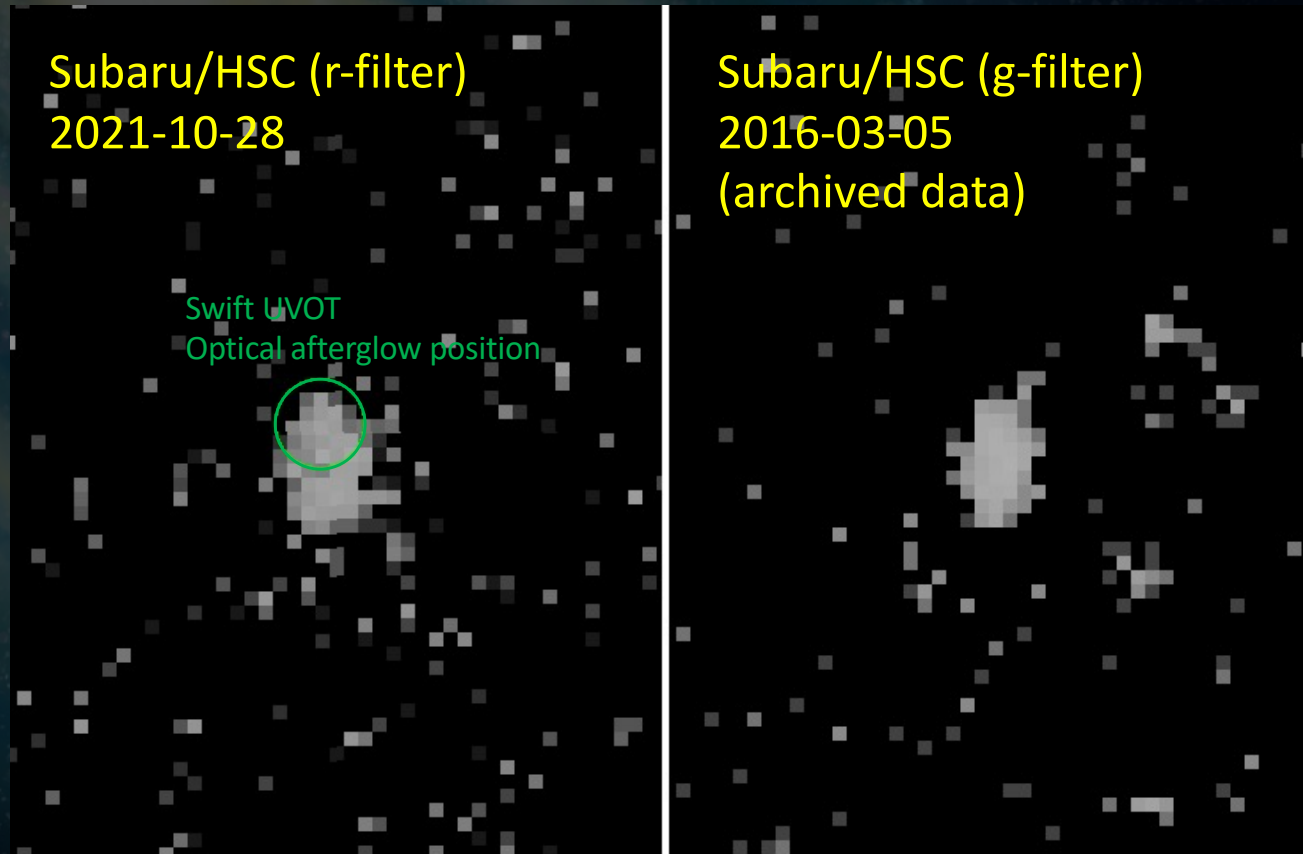
Execute Subaru Strategy #2 ToO



GRB 211023B: Subaru/HSC Observation

Subaru/HSC (r-filter) observation: 2021-10-28 13:36 UT ($T_0+4.7$ days)

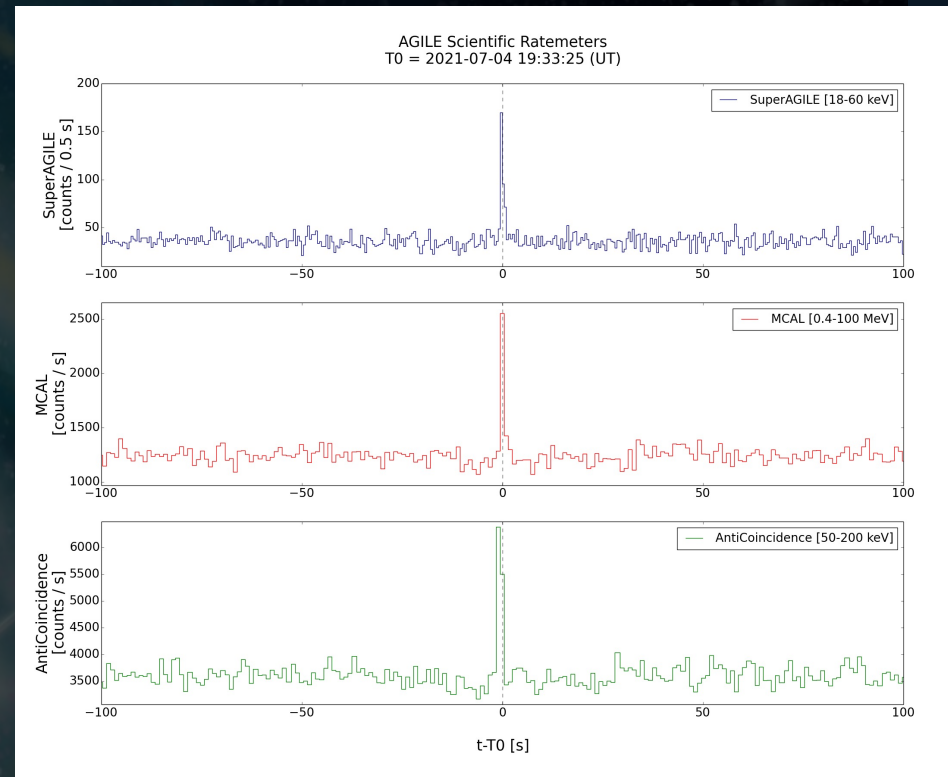
Total exposure time: 4800 s (32 x 150 s)



The magnitude of an optical source is $r \sim 23.6$ (AB) which is consistent with the reported Gemini-North observation (Rastinejad et al. 2021). The source is **dominated by the host galaxy contribution** (Sakamoto et al. 2021).

GRB 210704A

- **Fermi/GBM trigger time: 2021-07-04 19:33:24 UT** (Fermi/GBM; Kunzweiler et al. 2021, Malacaria et al. 2021, Fermi/LAT; Berretta et al. 2021, AGILE/MCAL; Ursi et al. 2021, AstroSat/CZTI; Prasad et al. 2021, Konus-Wind; Ridnaia et al. 2021)
- Fermi GBM **T90 duration: 4.7 sec** (50-300 keV)
- **Optical/IR afterglow detection** (Kim et al. 2021, D'Avanzo et al. 2021a, 2021b, Kann et al. 2021a, 2021b, 2021c, Rastinejad et al. 2021, Watson et al. 2021, Fong et al. 2021, O'Connor et al. 2021, Volnova et al. 2021)
- Spectroscopic observation: **$z < 3.15$** (de Ugarte Postigo et al. 2021)
- Possible host galaxy cluster at **$z \sim 0.2$** (Levan et al. 2021)



AGILE prompt γ -ray emission light curve (Ursi et al. 2021)

Although the duration of the prompt emission is 'long', the burst could be the merger origin due to the possible association of a near-by galaxy cluster.

GRB 210704A: Subaru/HSC Observation

Subaru/HSC (r-filter) observation: 2021-10-28 12:33 UT ($T_0+115.7$ days)

Total exposure time: 3030 s (10 x 300 s + 30 s)



No source detection at the optical afterglow location

5σ upper limit: ~ 24.0 mag (AB)

Summary

- Subaru ToO program (S21B) for identifying a host galaxy and a jet break of short GRBs was initiated for GRB 211023B and GRB 210704A.
- The optical source was detected for GRB 211023B by the Subaru/HSC r-filter data. The source is dominated by the host galaxy contribution.
- No optical afterglow was observed for GRB 210704A by the Subaru/HS r-filter data.