XRISM/Xtend Transient Search (XTS): Deep X-ray Transients

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on behalf of XRISM/XTS team

MAXI 15 Year Workshop for the Time Domain Astronomy
2024-12-10@Nihon Univ., Tokyo, Japan

Take-home Message

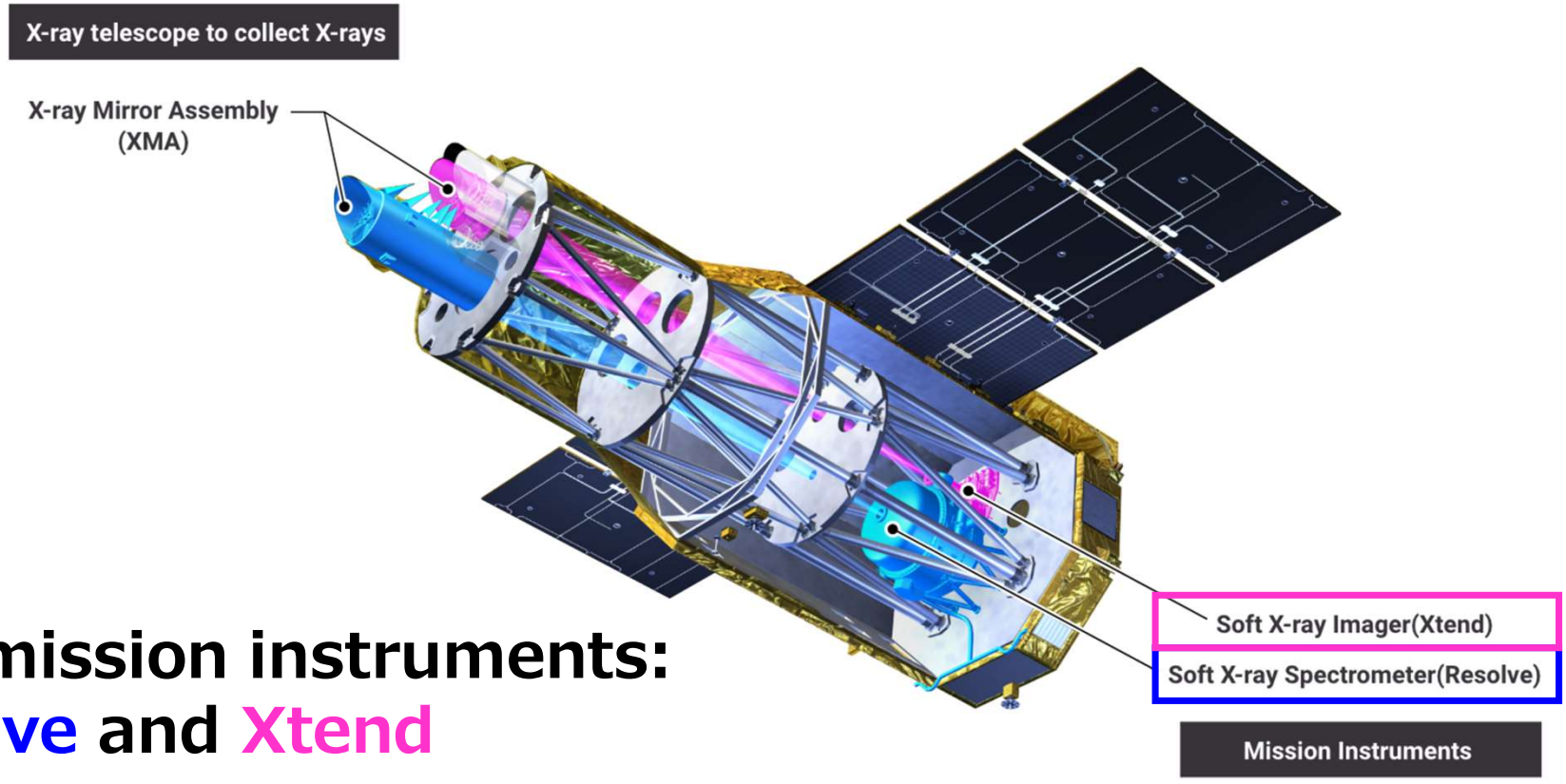
What’s XTS?

What's XTS?

Time-domain Astronomy with *XRISM*

About XRISM

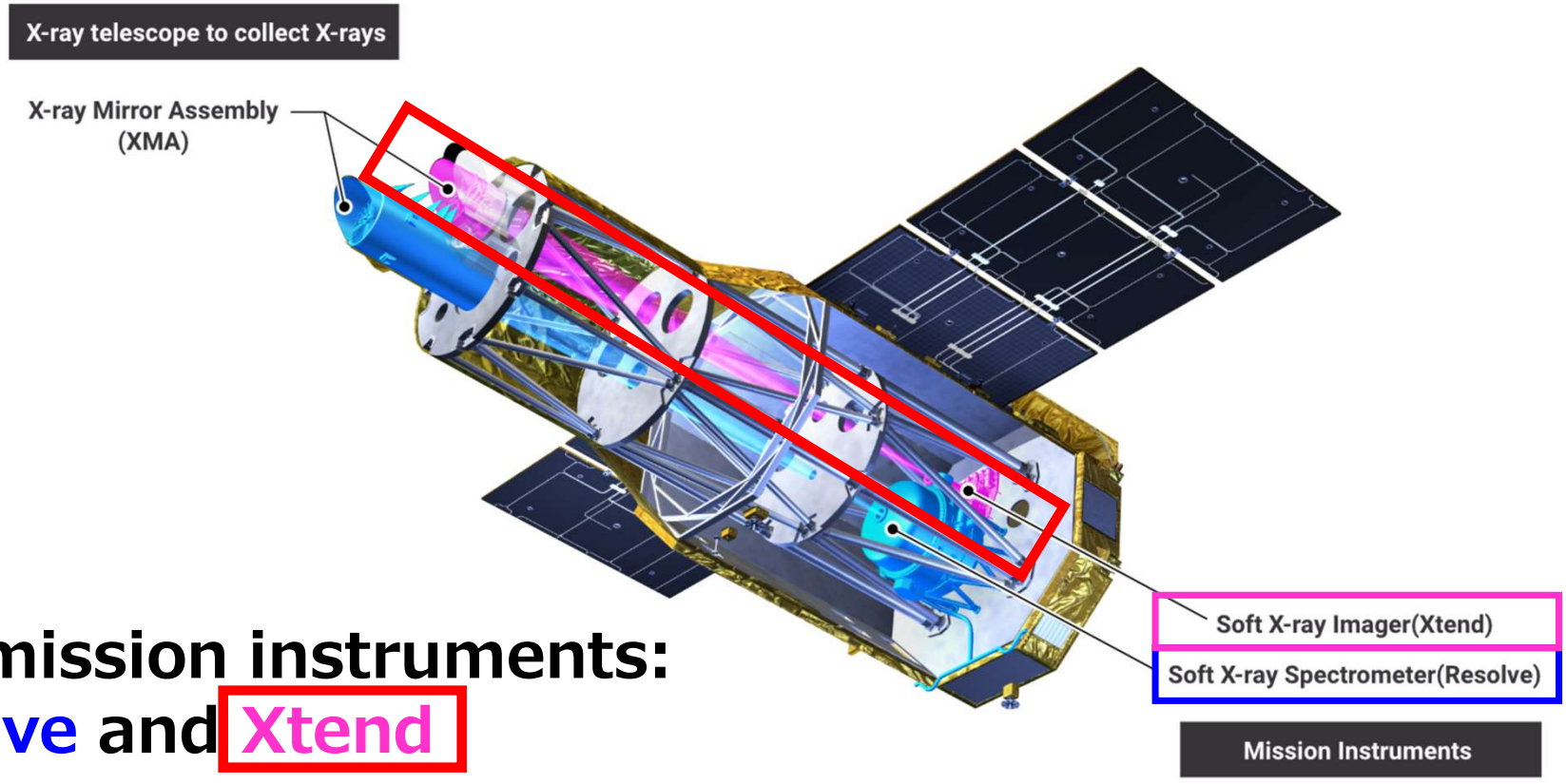
X-ray Imaging and Spectroscopy Mission



Two mission instruments:
Resolve and Xtend

About XRISM

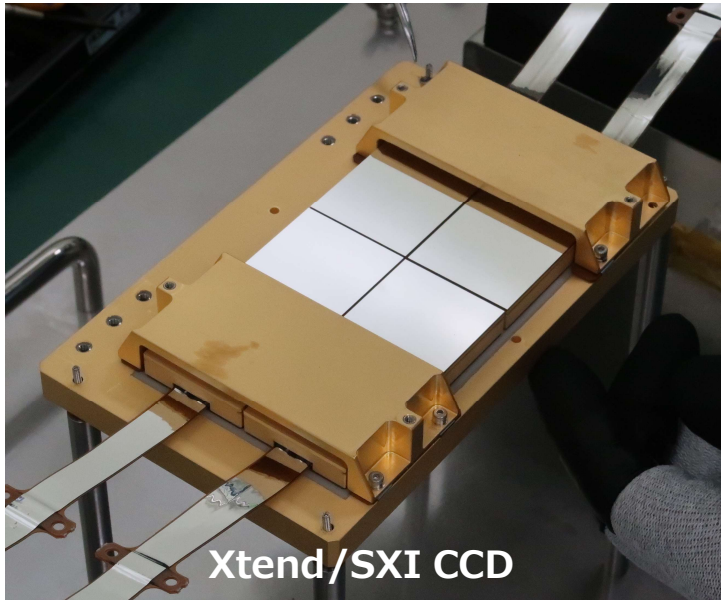
X-ray Imaging and Spectroscopy Mission

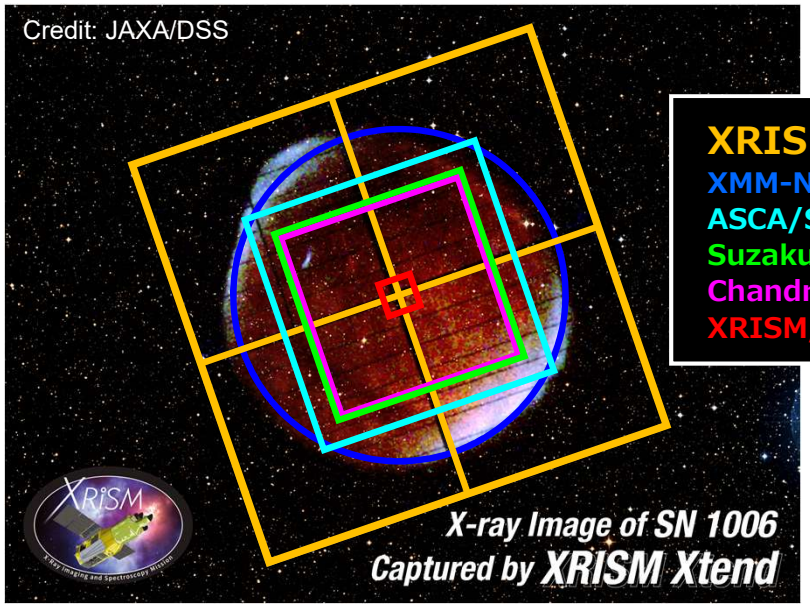


Two mission instruments:
Resolve and Xtend

Xtend, the soft X-ray imager

- X-ray telescope (XMA) + X-ray CCD array (SXI)
- Bandpass: 0.4 -- 13 keV
- Angular resolution: ~1.5' (HPD)
- Timing resolution: 4 s (full window mode)
- **FOV: 38' x 38'** ⇒ ***Many serendipitous sources expected!***





XRISM/Xtend Transient Search (XTS)

Ref.: Tsuboi et al. 2024, Proc. SPIE & JATIS (in prep.)

- Additional science operation in XRISM
  to address **Time Domain Astronomy**
- Search for transients ASAP after daily data downlinks
- If found, it is report via the Astronomer's Telegram (ATel)
  to encourage multi-wavelength follow-up observations

XTS Fact Sheet (w/ MAXI)

Item	XTS	MAXI
FOV	**38 x 38 amin**	~ All sky
Observation time scale	**Day -- Week**	90 min
Position accuracy	**< 40 asec**	~ 1 deg
Sensitivity	**~ 10^{-14} erg s^{-1} cm^{-2} (1 day)**	~ 10^{-10} erg s^{-1} cm^{-2}

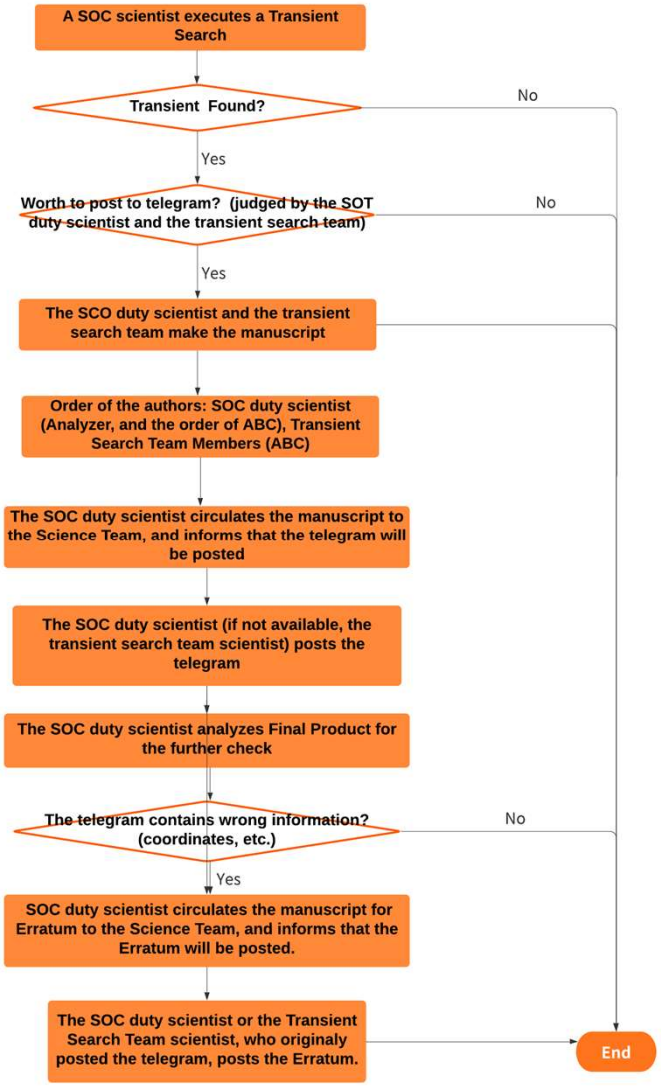
Comparison with survey missions

- High pointing accuracy
  -> **Easy follow-up observations**
- High sensitivity (but limited FOV)
  -> Aiming **Distant & Faint Transients**

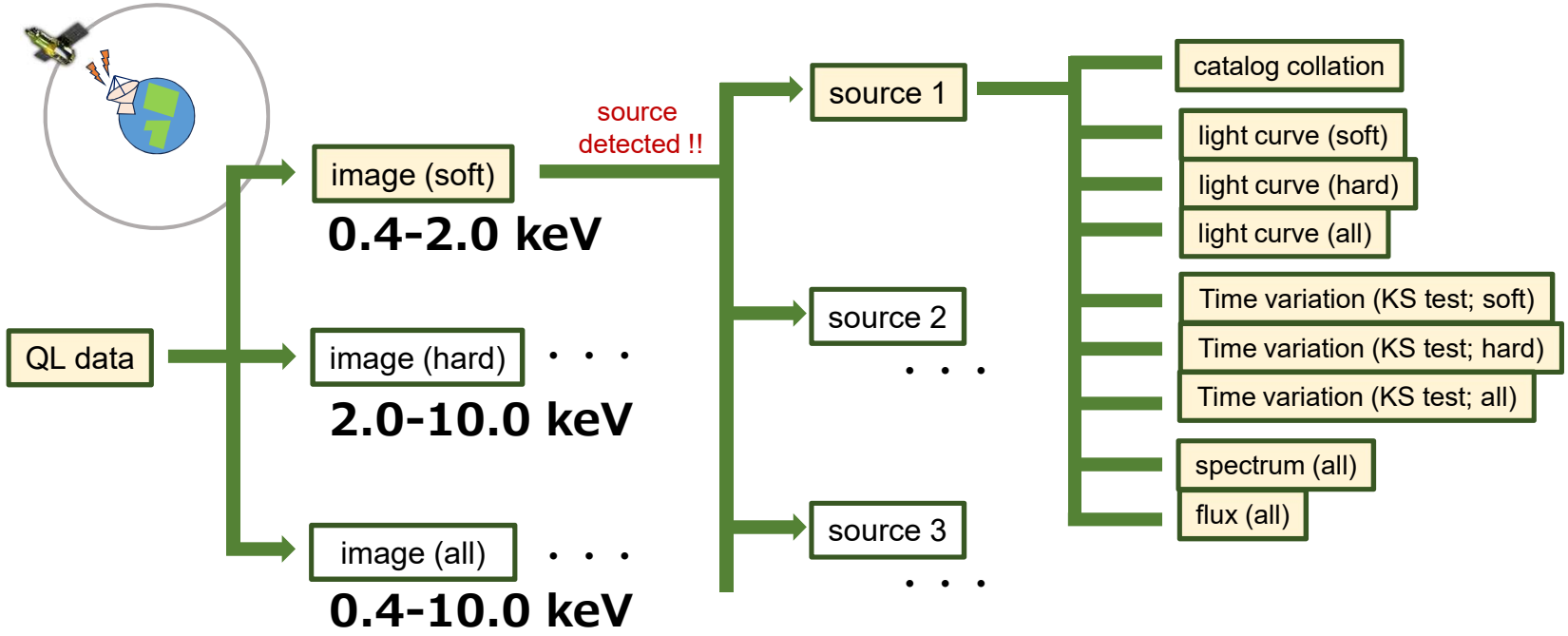
Fast report for deep X-ray transients!

XTS Daily Operation

0. XRISM observation
   - for nominal targets
1. Daily data downlink
   - 4-5 times per day
2. QL data processing
   - Quick look to check instruments' health
3. XTS automated process
   - with QL event data
4. Check by XTS scientists
   - Transients in FOV?
5. Report via ATel
   - Got it! X-ray burst from...



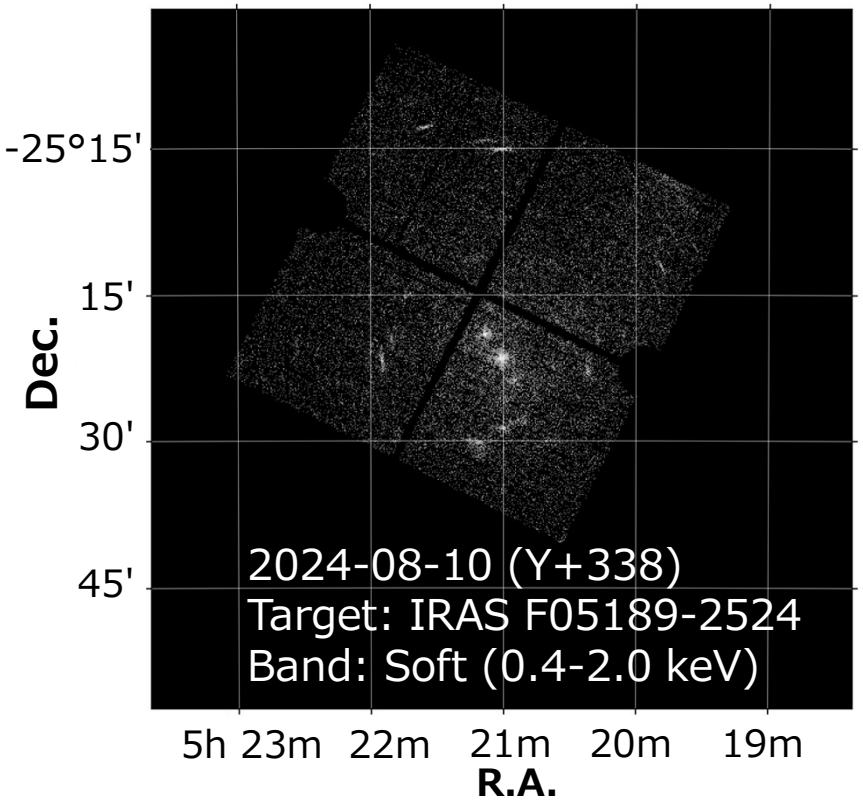
XTS Automated Process



- After daily data downlinks and QL process, QL events are analyzed
- 3 energy bands are independently analyzed to get high S/N ratio for soft/hard sources
- Automatic source detection
- Products (light curve, spectrum) are extracted for each detected source
- Catalog collation, variability verification, spectral fitting

XTS Process: Source Detection

- For images, wavelet transform is applied to detect point sources
  - "ewavelet" in the SAS package (XMM-Newton)
- Source region to extract the source photons is determined to optimize the S/N ratio
- Background is estimated by entire FOV excluding the source regions



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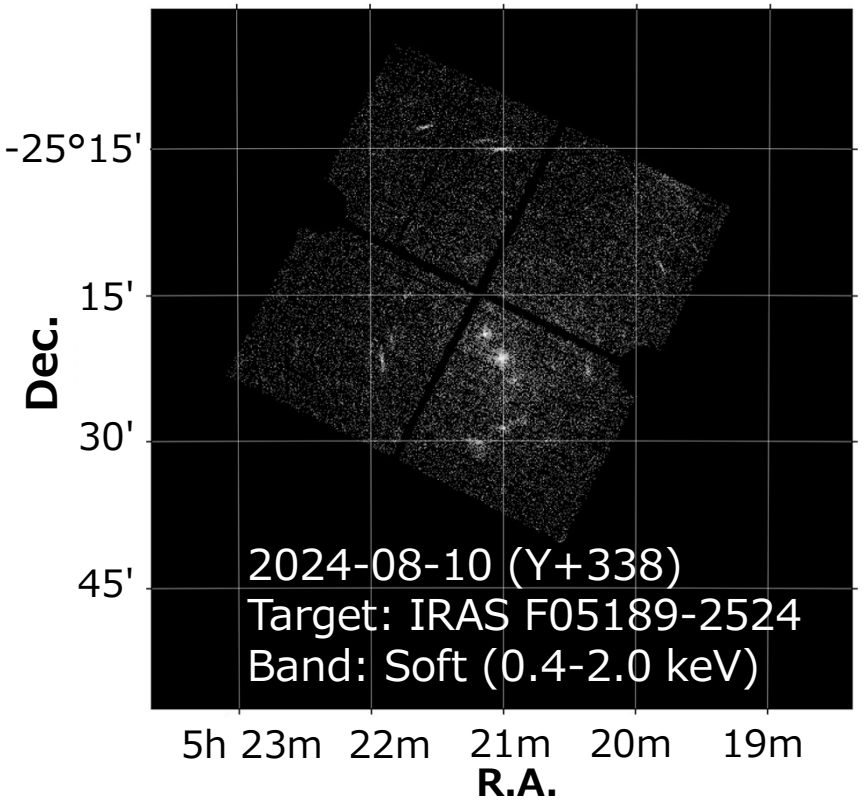

Source detection

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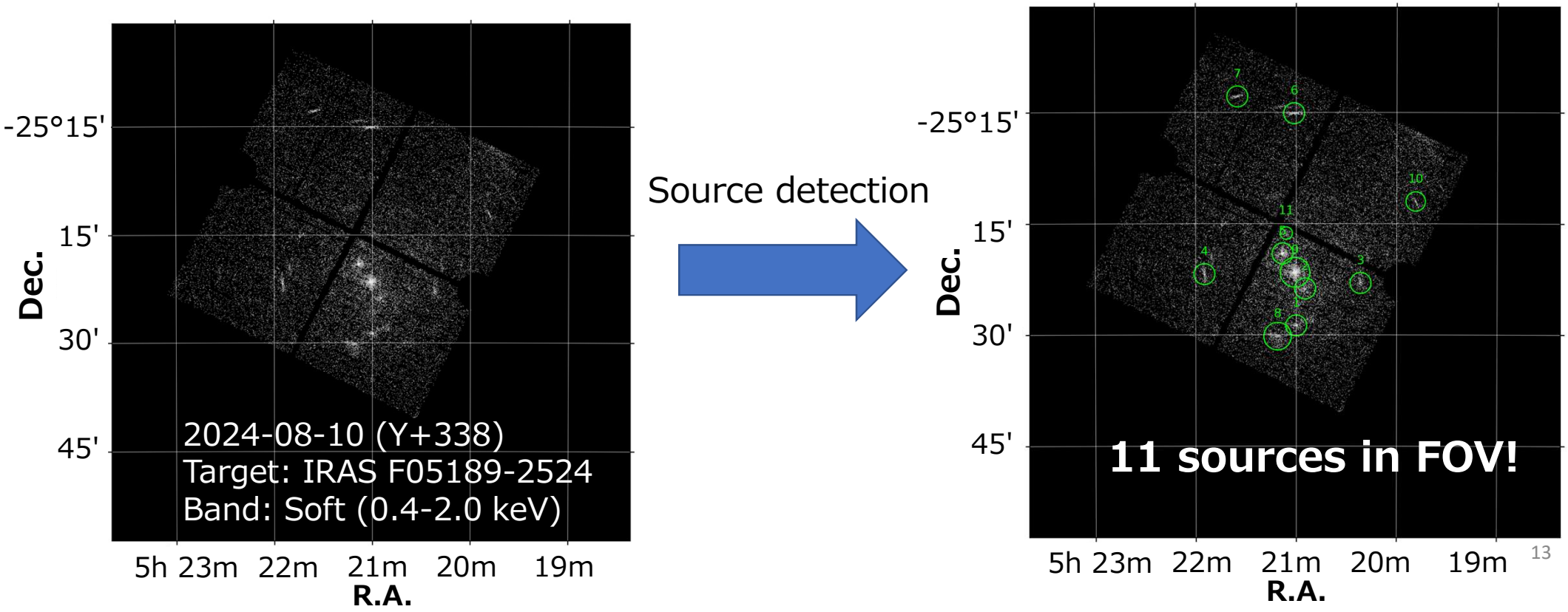
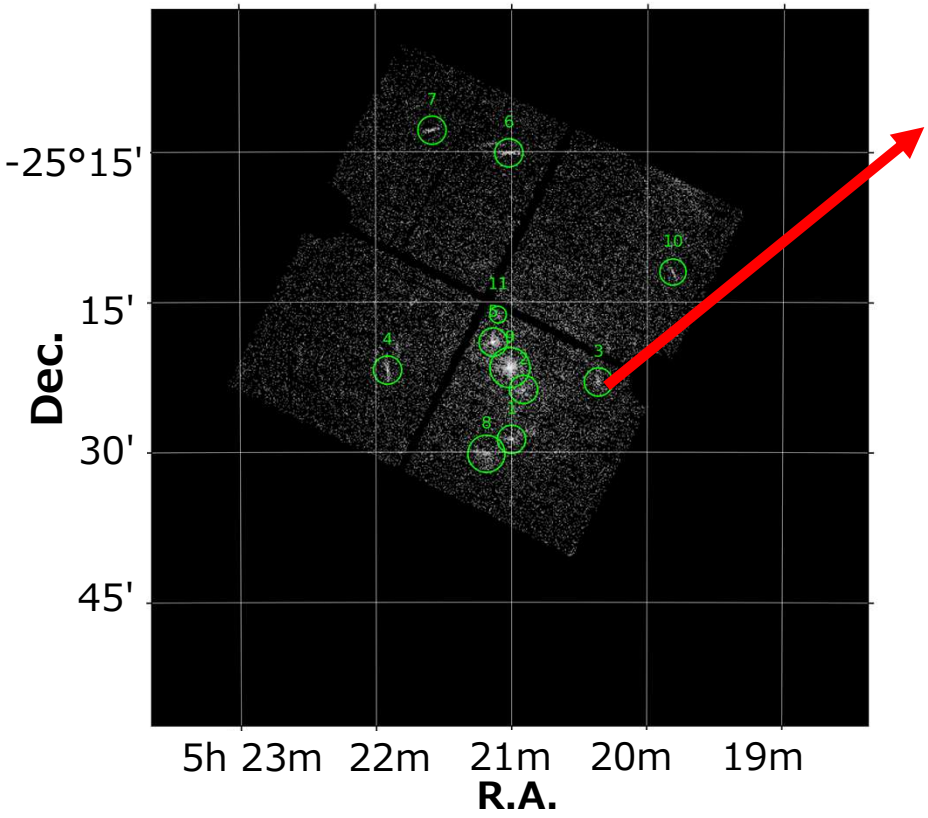


XTS process: Catalog Collation

- For each source, counterpart candidates are listed from catalogs
  - X-ray master catalog, SIMBAD, MAXI, Swift, eROSITA...



Source 3: (RA, Dec) [deg] = (80.0900, -25.3833)

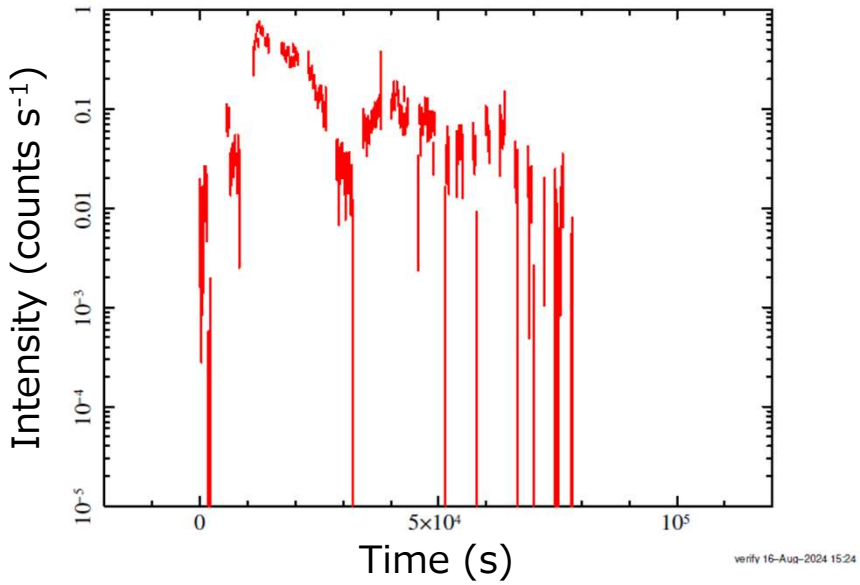
Name	RA (deg)	Dec (deg)	Separation (asec)
2CXO J052022.1-252309	80.0925	-25.3860	12.480785
1WGA J0520.3-2522	80.0933	-25.3822	11.508993
4XMM J052022.5-252218	80.0938	-25.3717	43.431317
4XMMs J052022.4-252218	80.0935	-25.3717	43.16883
2CXO J052022.3-252217	80.0933	-25.3714	44.084233
LP 836-22	80.1003	-25.3727	49.100246
LP 836-21	80.0984	-25.3742	42.471389
XBS J052022.0-252309	80.0925	-25.3862	13.21985
1eRASS J052020.8-252325	80.0870	-25.3905	27.520494

XTS process: Light Curve & Spectrum

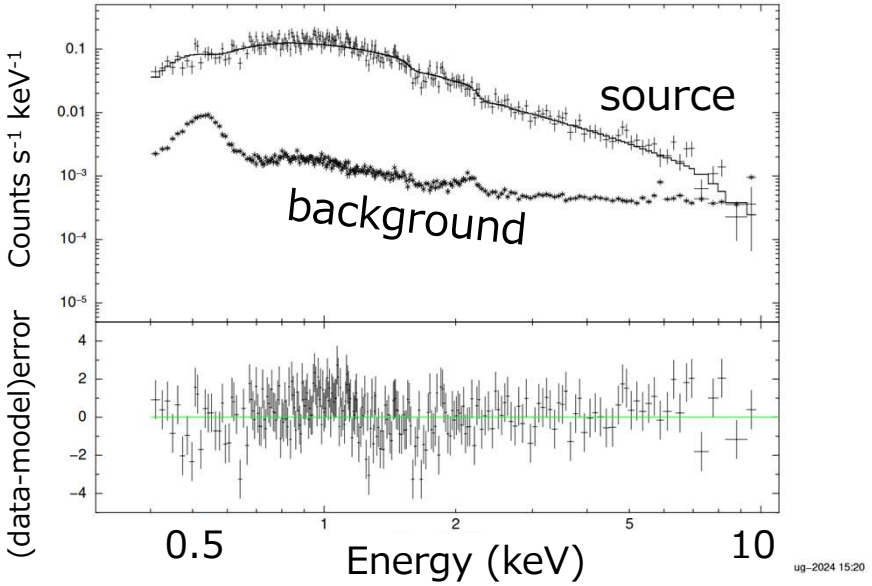
- Light curves are extracted for each source with several time scales
- Kolmogorov-Smirnov test is applied to examine variability
- Spectral fitting is performed with an absorbed power-law & thermal plasma (APEC) model

2024-08-15 (Y+0343): XRISM J1142-6522, ATel #16777

0.4-2.0 keV Light curve (1024 s bin)



Spectrum (absorbed power-law)



All products are summarized in a web page, which XTS scientists check everyday

XTS Operation

- XTS operation is started on 2024-03
- By the end of the performance verification phase on 2024-09-04.....

XTS Operation

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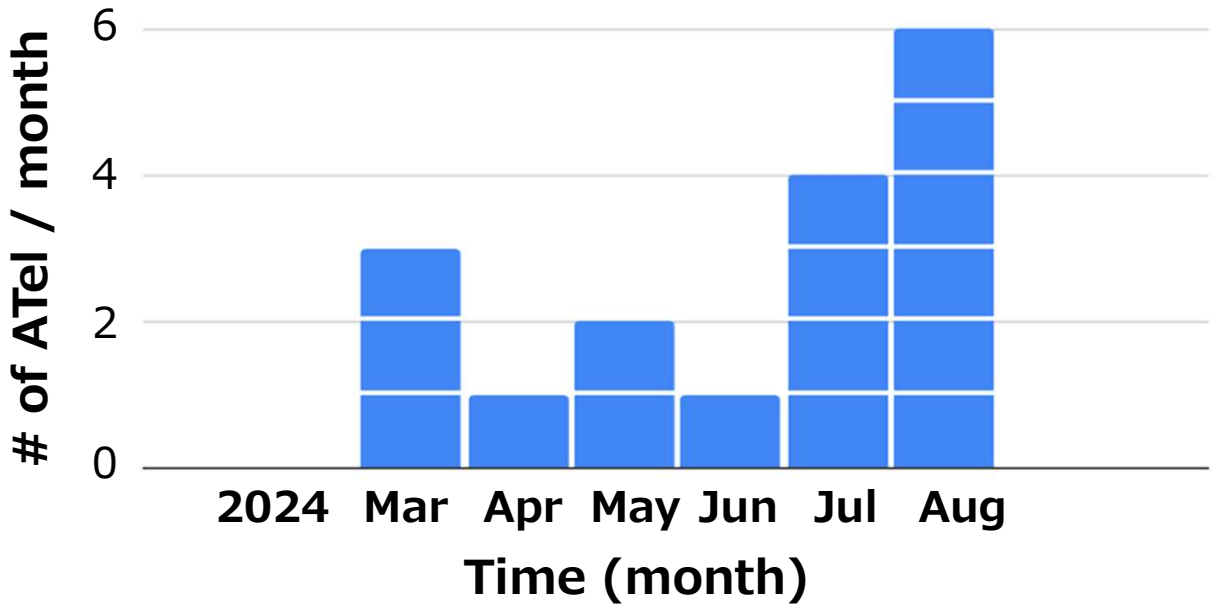
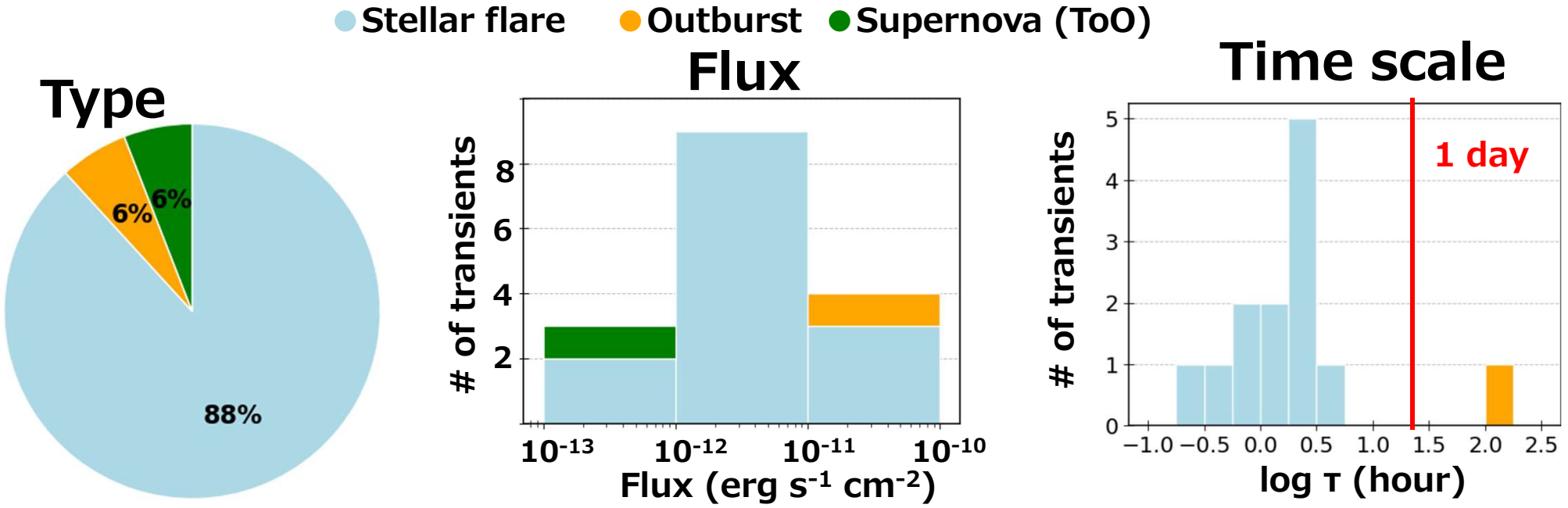
17 transients from 13 sources were reported!



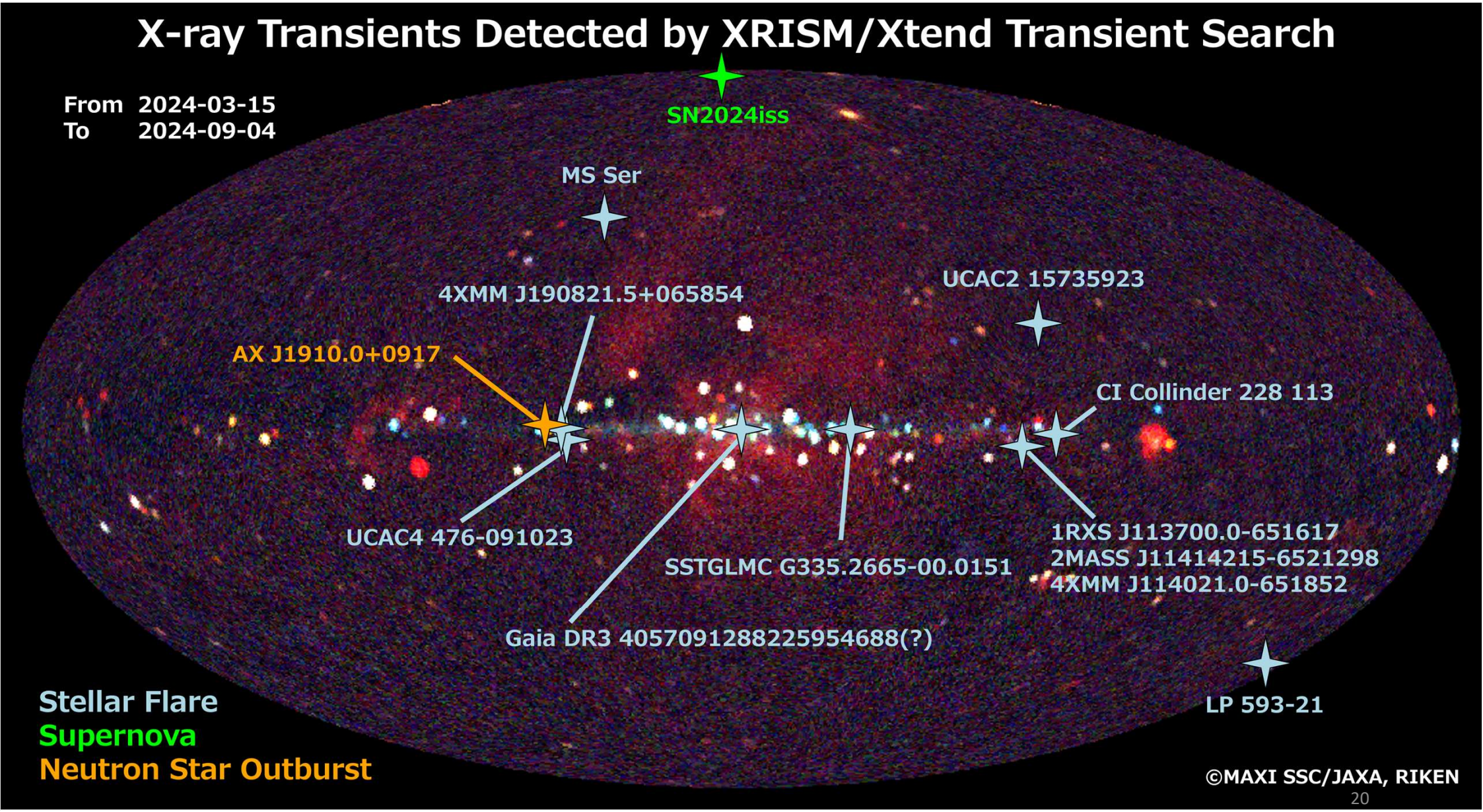
XTS Results: Published ATels

ATel #	Publ. Date (UTC)	Counterparts	Transient type
#16532	2024-03-15	LP 593-21	Stellar flare
#16558	2024-03-28	4XMM J190821.5+065854	Stellar flare
#16561	2024-03-31	SSTGLMC G335.2665-00.0151?	Stellar flare
#16592	2024-04-17	UCAC4 476-091023	Stellar flare
#16607	2024-05-01	AX J1910.7+0917	Outburst / SFXT
#16632	2024-05-28	SN2024iss	Supernova (ToO)
#16652	2024-06-14	CI collinder 228 113	Stellar flare
#16683	2024-07-02	MS Ser	Stellar flare
#16685	2024-07-03	MS Ser	Stellar flare (2nd detection)
#16728	2024-07-21	UCAC2 15735923	Stellar flare
#16731	2024-07-31	UCAC2 15735923	Stellar flare (2nd detection)
#16773	2024-08-15	1RXS J113700.0-651617	Stellar flare
#16774	2024-08-15	2MASS J11414215-6521298	Stellar flare
#16775	2024-08-15	2MASS J11414215-6521298	Stellar flare (2nd detection)
#16777	2024-08-16	2MASS J11414215-6521298	Stellar flare (3rd detection)
#16779	2024-08-19	4XMM J114021.0-651852	Stellar flare
#16794	2024-08-30	Gaia DR3 4057091288225954688?	Stellar flare

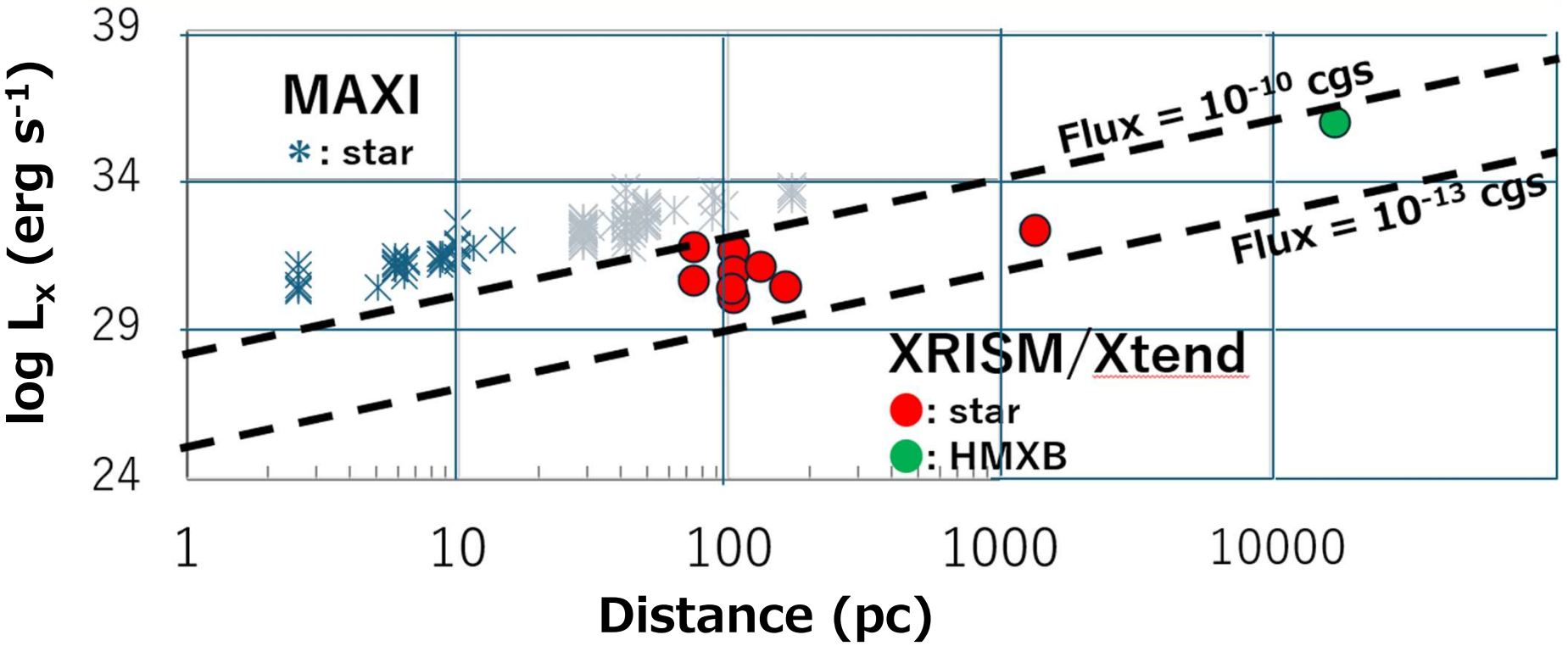
XTS Results: Statistics



- 15 x stellar flare (from 11 stars), 1 x NS outburst, 1 x SN (ToO)
  - Unexpectedly **many stellar flares!**
- Flux sensitivity ~ 10^{-13} cgs (0.4 – 10 keV; during brightening)
- Time scales ~ 10 min – 9 day (decay time for flares, duration for outbursts)
- **Our Universe is active than we expected!**


X-ray Transients Detected by XRISM/Xtend Transient Search
From 2024-03-15
To 2024-09-04
SN2024iss
MS Ser
4XMM J190821.5+065854
UCAC2 15735923
AX J1910.0+0917
CI Collinder 228 113
UCAC4 476-091023
SSTGLMC G335.2665-00.0151
1RXS J113700.0-651617
2MASS J11414215-6521298
4XMM J114021.0-651852
Gaia DR3 4057091288225954688(?)
LP 593-21
Stellar Flare
Supernova
Neutron Star Outburst
©MAXI SSC/JAXA, RIKEN

XTS Results: Sensitivity and Distance

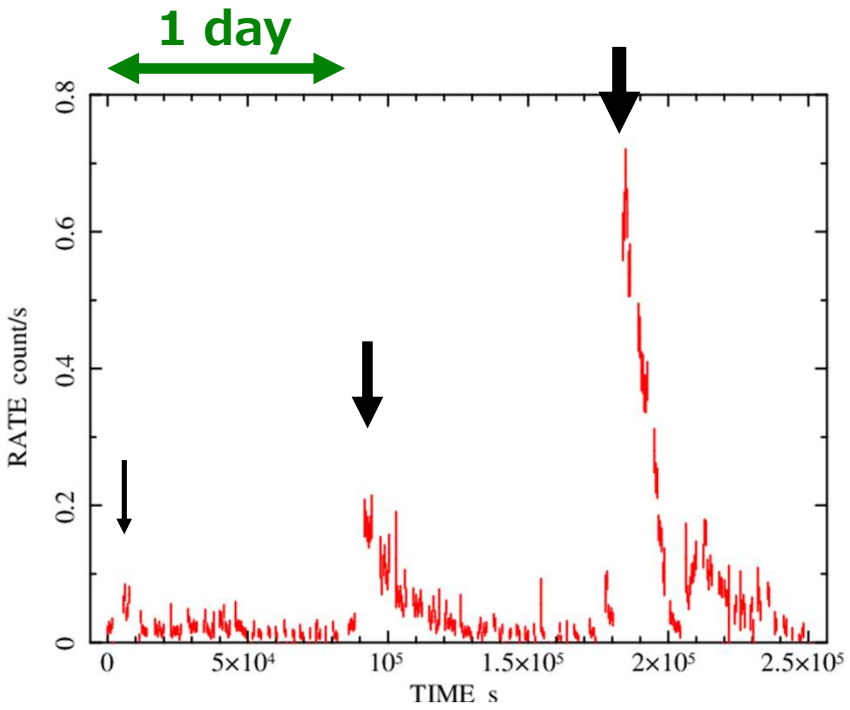


Compared with MAXI, XTS finds **faint & distant transients**

Science Highlights

Repeating flares from the YSO candidate 2MASS J11414215-6521298

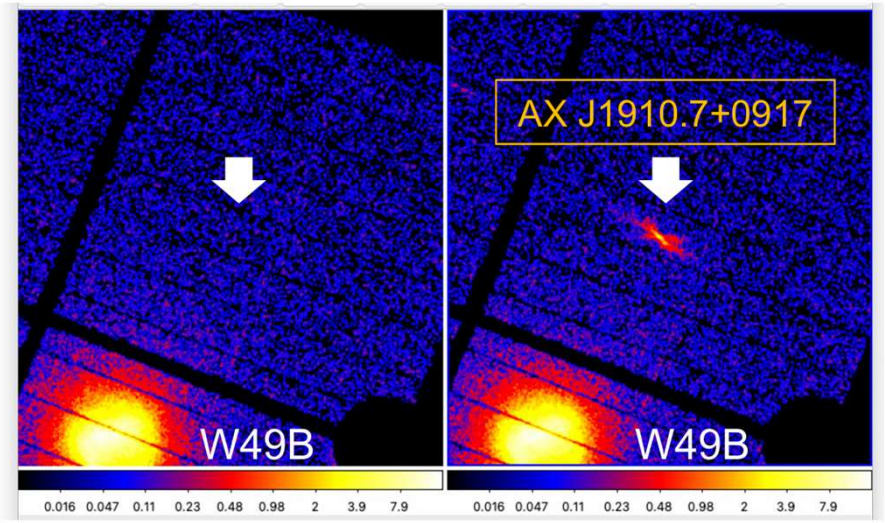
- Repeating and growing flares with ~ 1 day cycle
- **3 ATels within 2 days** (in Japanese summer holidays!!!)
- Magnetic activity of YSO will be studied



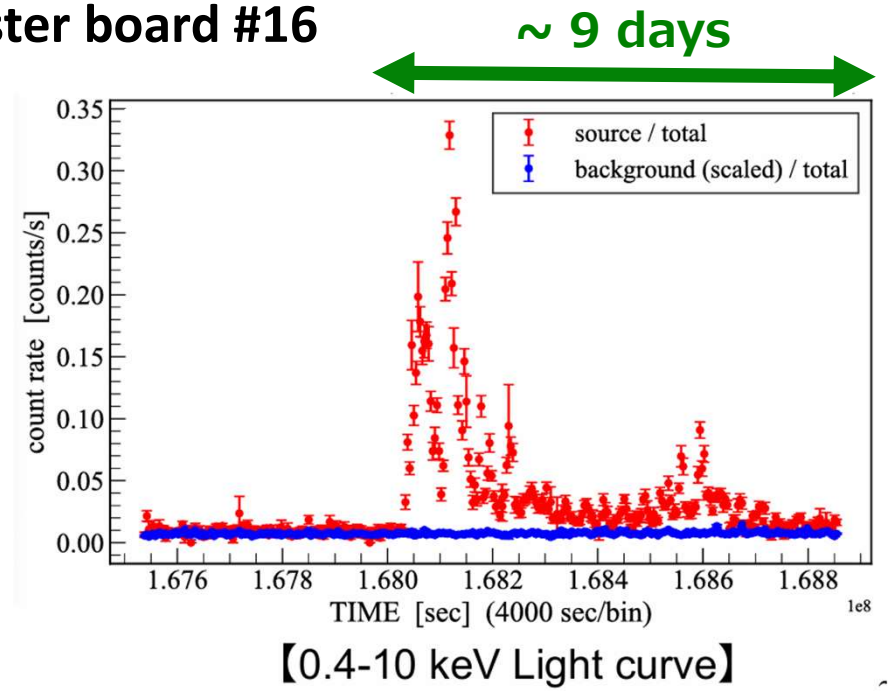
SFXT from the HMXB AX J1910.7+0917 (near SNR W49B)

- "The slowest pulsar" with P ~ 10 h
- First observation that covered the whole brightening phase
- 2 bursts and stable phase with clear pulsation
- Fast fluctuation -> **SFXT**

M. Yoshimoto, Poster board #16



【0.4-10 keV Image】



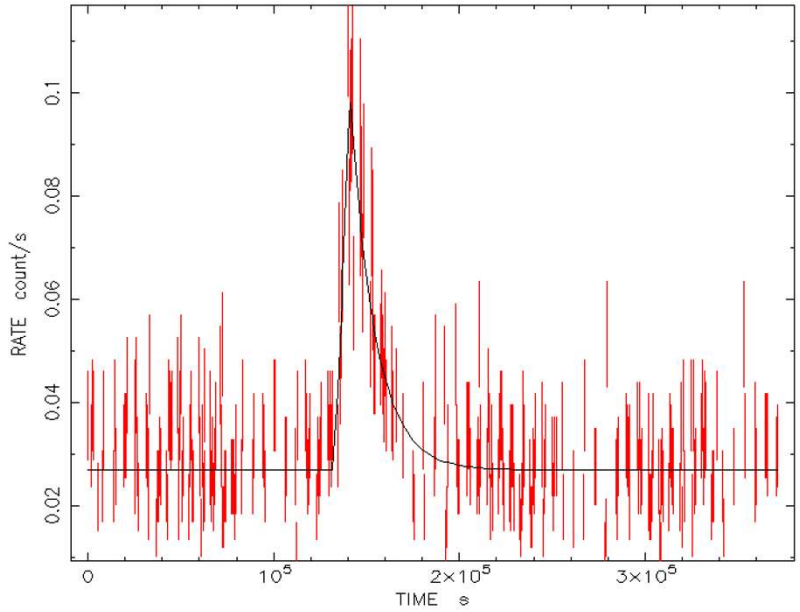
【0.4-10 keV Light curve】

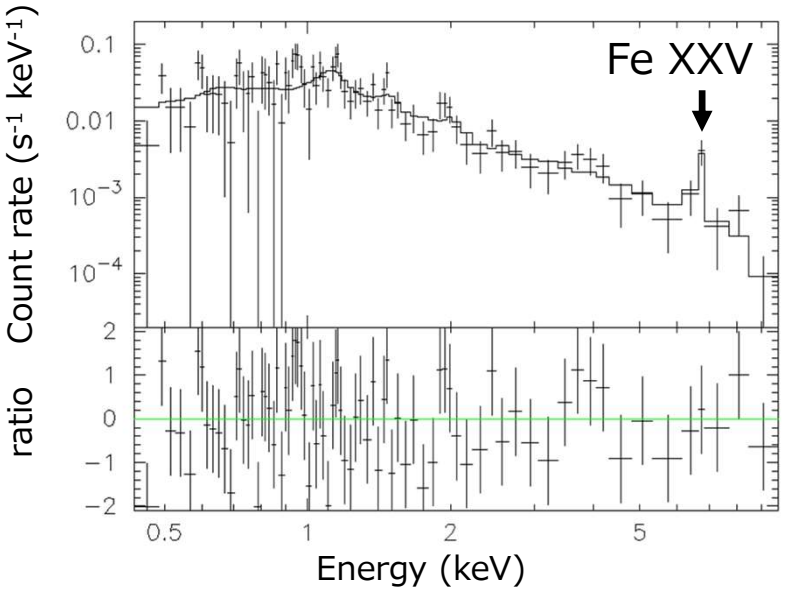
Science Highlights

High-abundance flare from a K giant Cl Collinder 228 113

- Distance: **1.3 kpc**
- X-ray flare with kT ~ 5 keV
- Prominent line of Fe XXV (He-like)
- **2 (+2/-1) Solar abundance during the flare** (0.3 solar typically)

Y. Ishihara, Poster board #14





Future Works

- Collaboration with ground observatories
  - Chuo University's observatory (CHAO) covers northern sky
  - We need follow-up observation for **southern sky!**
- Collaboration with multi-messenger facility (GW, neutrino)
  - Gravitational wave events are to be matched with XTS via GCN
  - **T. Yanagi, Poster board #10**
- Self-ToO to Resolve

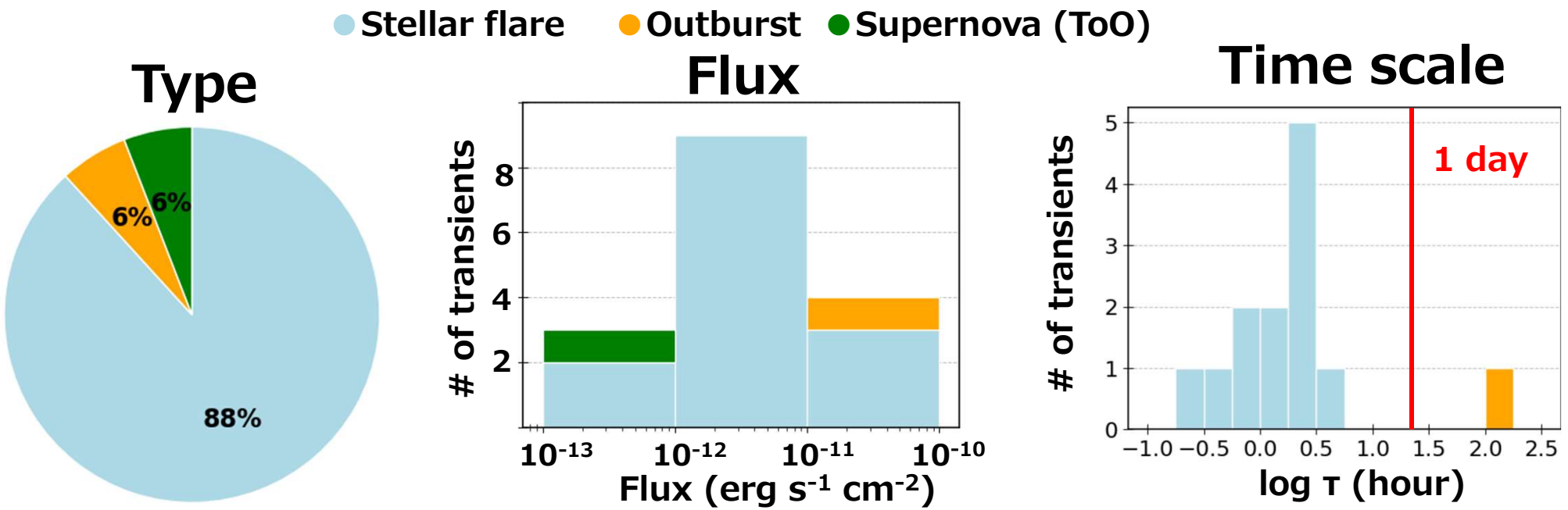
XTS explores deep X-ray transients!

FAQ

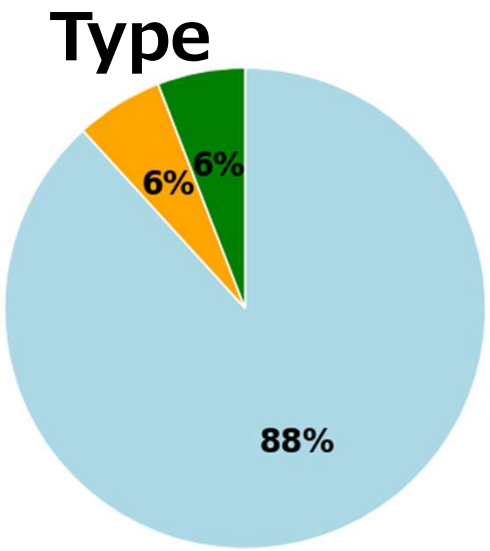
Q. Pointing accuracy of XRISM is less than 20 asec.
Why worse value of ~ 40 asec is derived for XTS?
A. XTS uses QL (on-board) attitude, which is a preliminary one,
to achieve fast report.

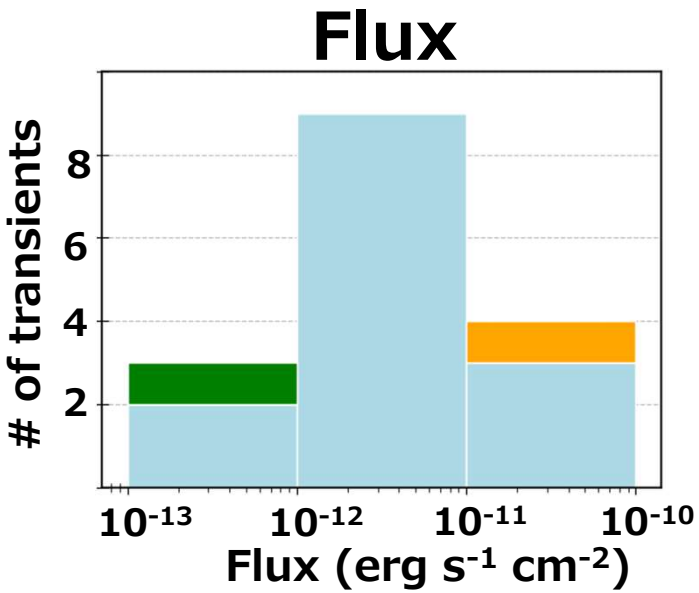
Q. Was the number of transients that XTS found as expected?
A. Under verification. To be reported in Yoneyama et al. (PASJ; in prep.)

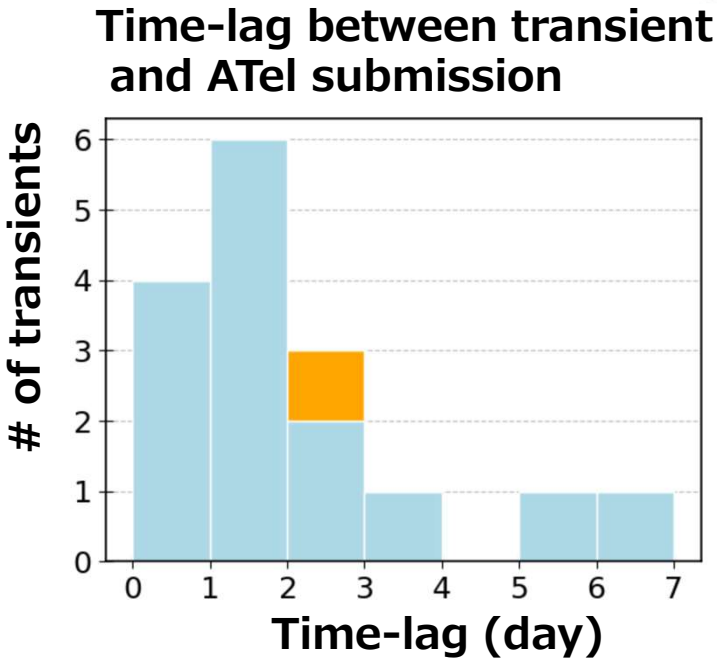
Q. XRISM is now in the General Observer phase. How XTS uses GO's data?
A. With GO's allowance, Xtend data excluding the Resolve FOV is analyzed.


Stellar flare
Outburst
Supernova (ToO)
Type
6%
6%
88%
Flux
# of transients
8
6
4
2
10-13
10-12
10-11
10-10
Flux (erg s-1 cm-2)
Time scale
# of transients
5
4
3
2
1
0
1 day
−1.0 −0.5 0.0 0.5 1.0 1.5 2.0 2.5
log τ (hour)

XTS during PV Phase: Statistics







- 15 x stellar flare, 1 x NS outburst, 1 x SN (ToO)
  - Unexpectedly **many stellar flares!**
- Flux sensitivity ~ 10^{-13} cgs (0.4 – 10 keV; during brightening)
- The fastest report was made 15 h after flare
- Most transients are reported within ~ 2 days
- **Our Universe is active than we expected!**