Status of XRISM/Xtend Transient Search

Tomokage Yoneyama (Chuo Univ.)
on behalf of XRISM/XTS team

17th IACHEC Meeting
2025-05-15@Osaka bay

Take-home Message

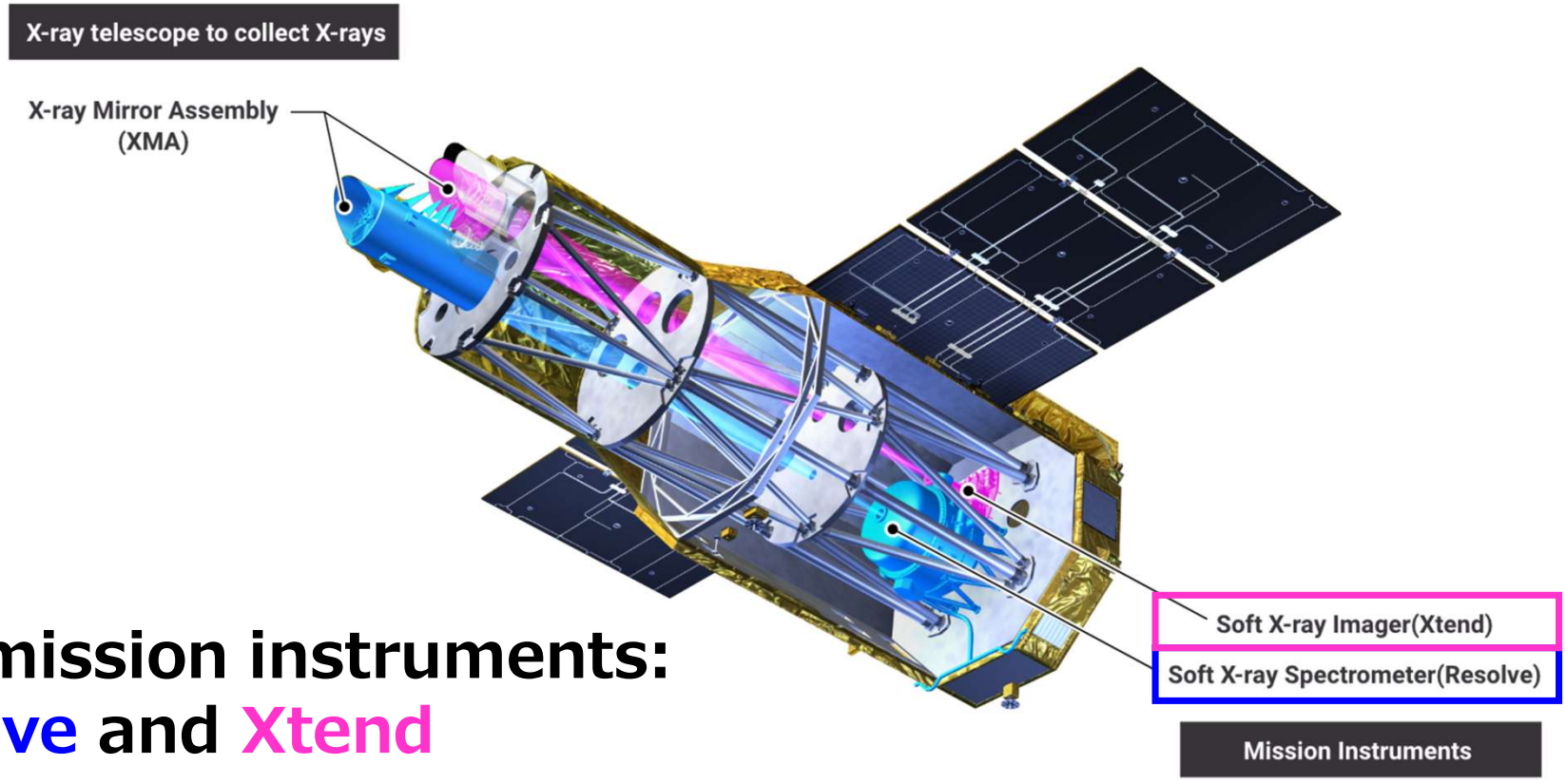
What's XTS?

What's XTS?

Time-domain Astronomy with *XRISM*

About XRISM

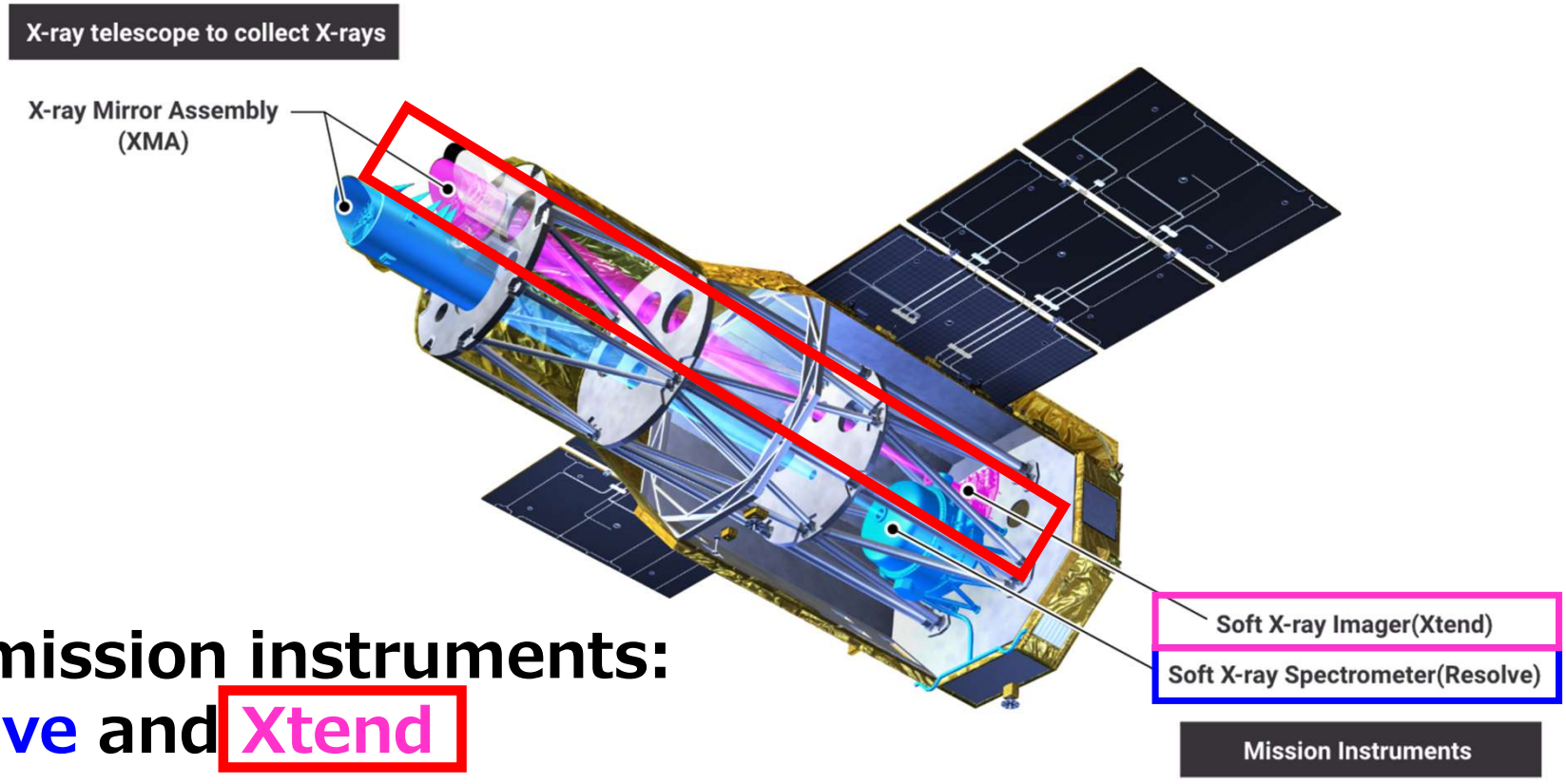
X-ray Imaging and Spectroscopy Mission



Two mission instruments:
Resolve and Xtend

About XRISM

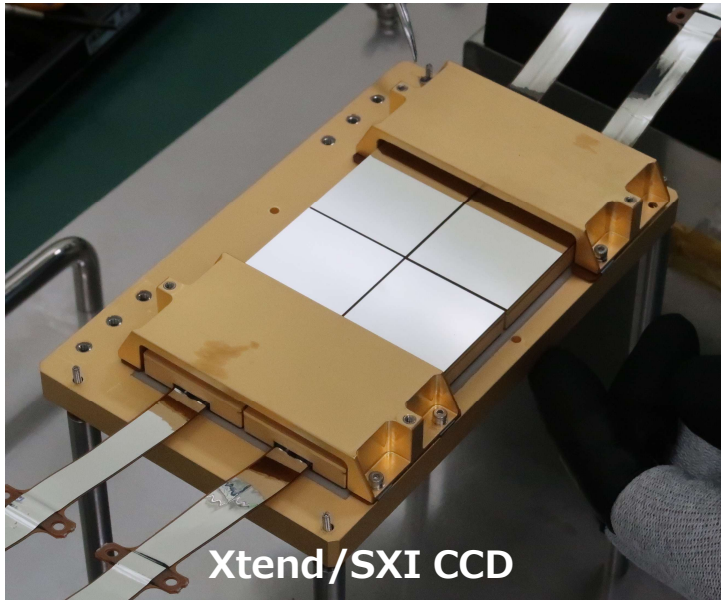
X-ray Imaging and Spectroscopy Mission

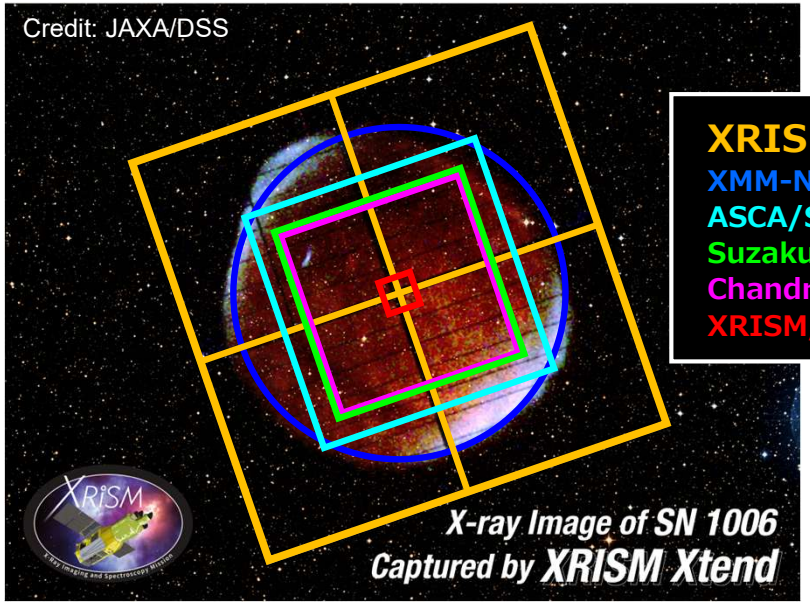


Two mission instruments:
Resolve and Xtend

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: 38.5' x 38.5'** ⇒ ***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	**38.5 x 38.5 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}

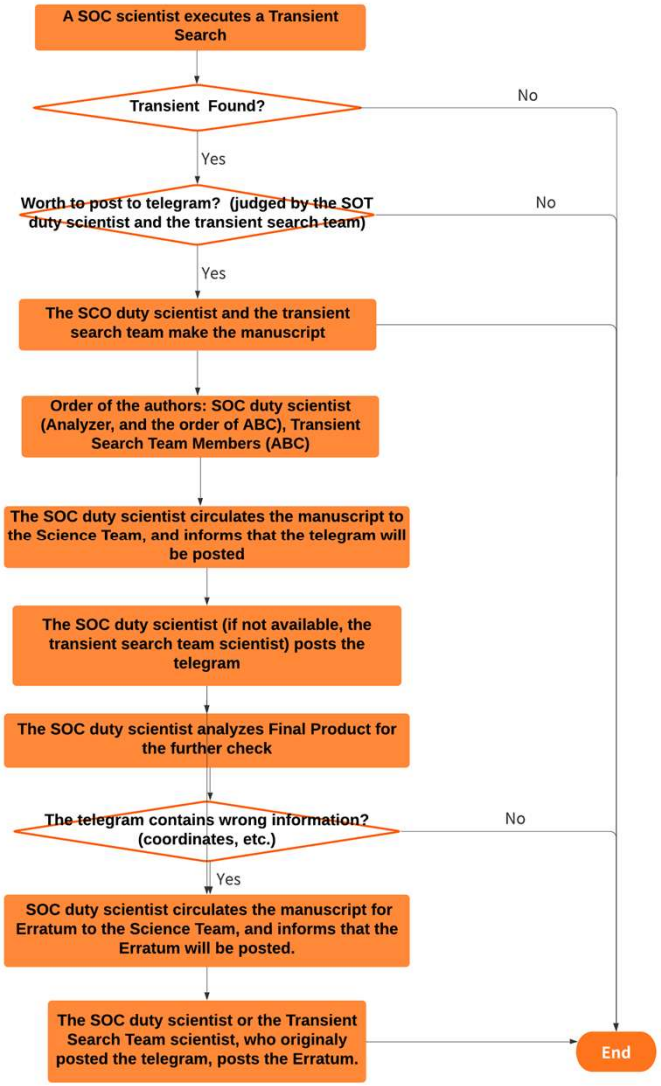
Comparison with survey missions

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

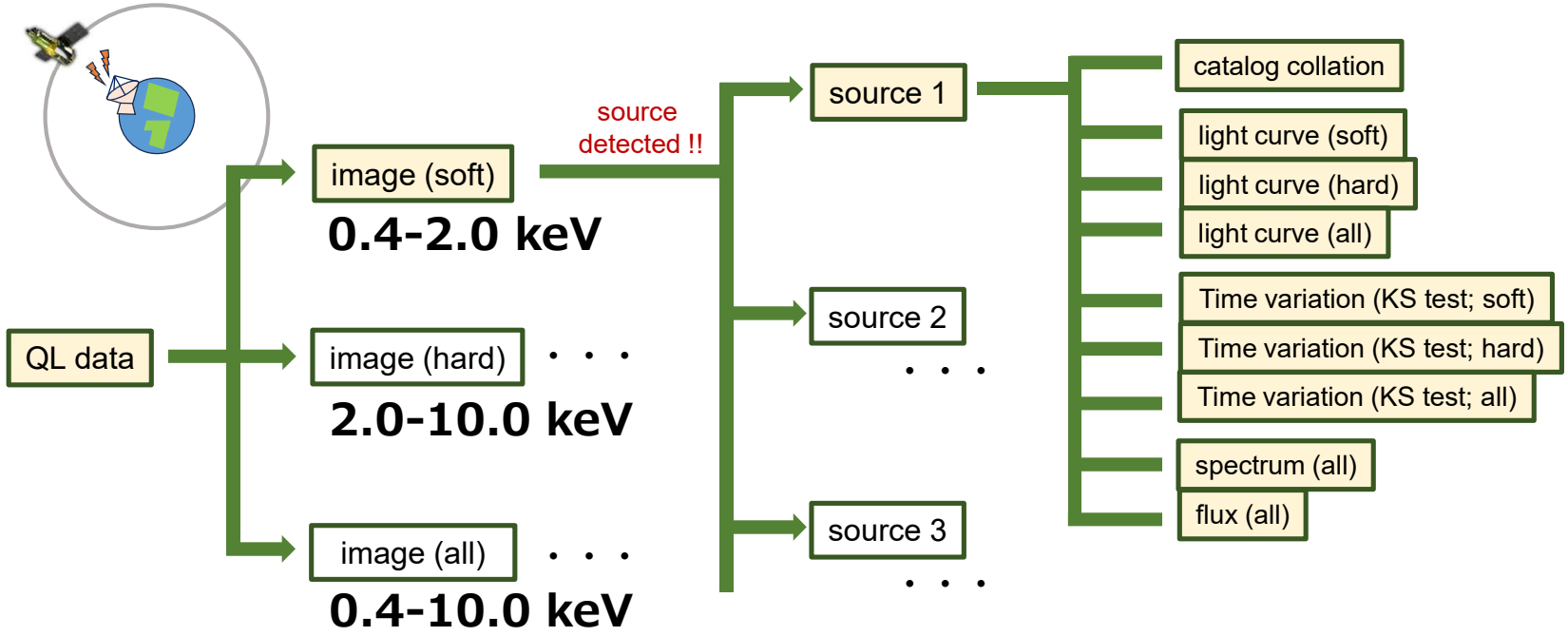
Fast report for deep X-ray transients!

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...



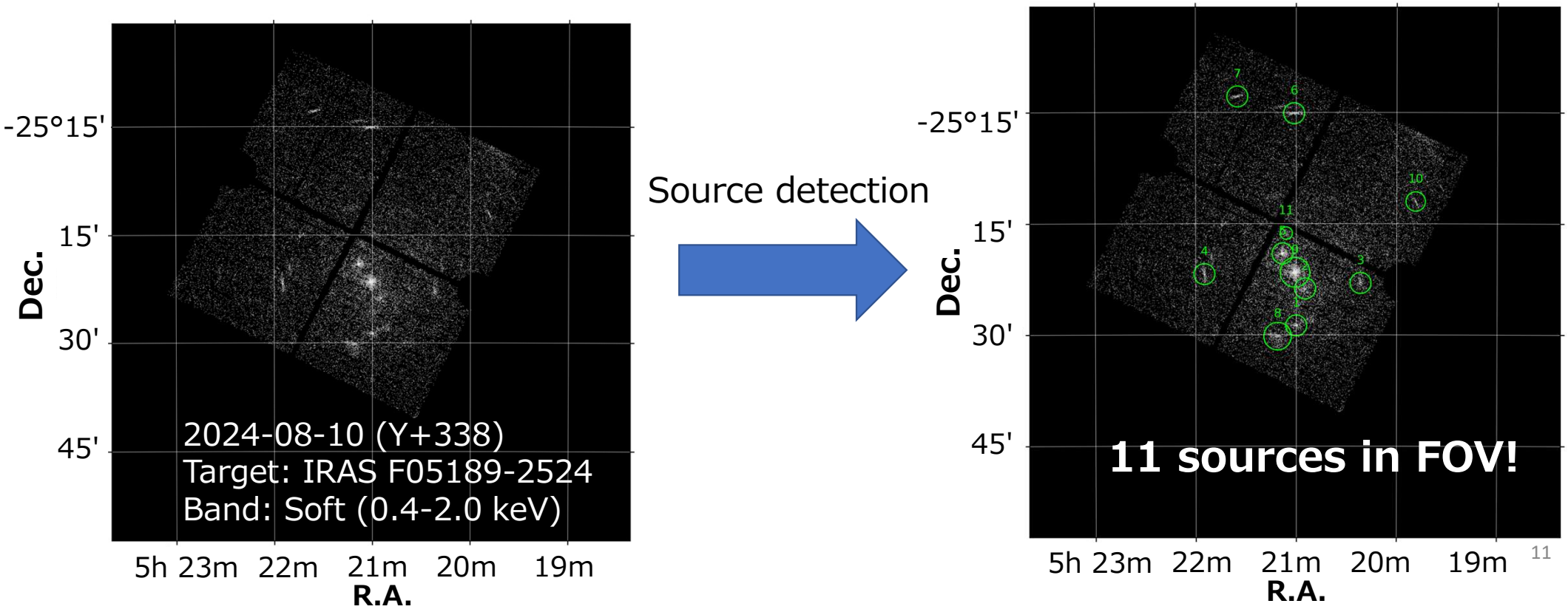
XTS Automated Process



- 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, summarizing on web pages...

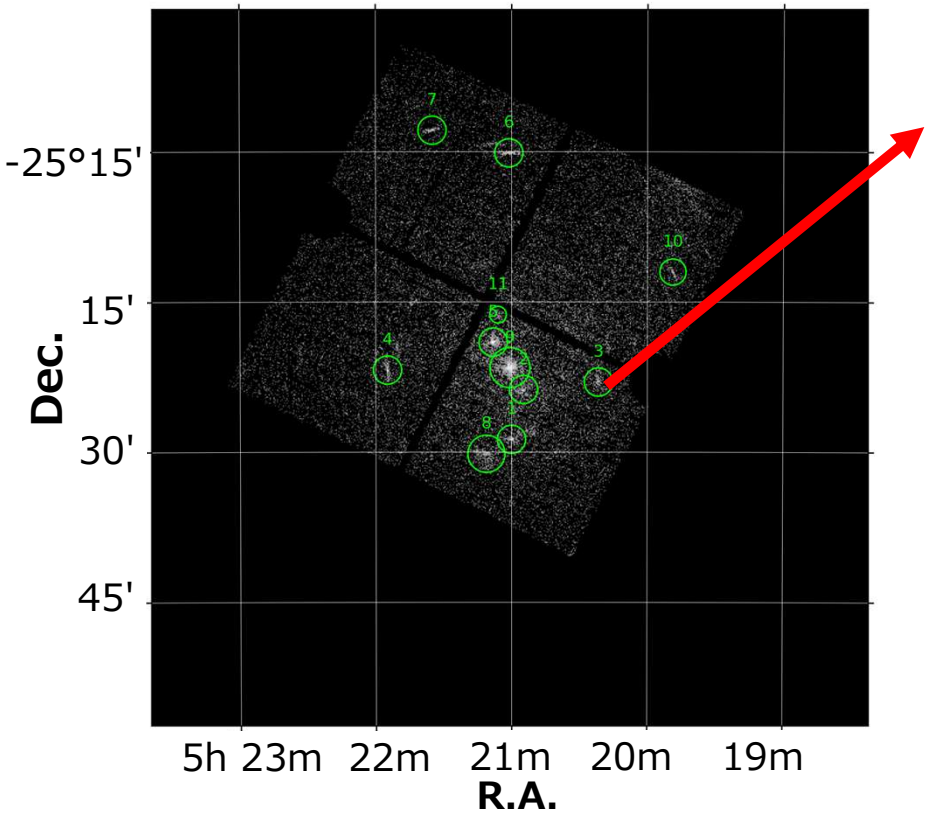
XTS Process: Source Detection

- 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 from entire FOV excluding the source regions



XTS Process: Catalog Collation

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



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

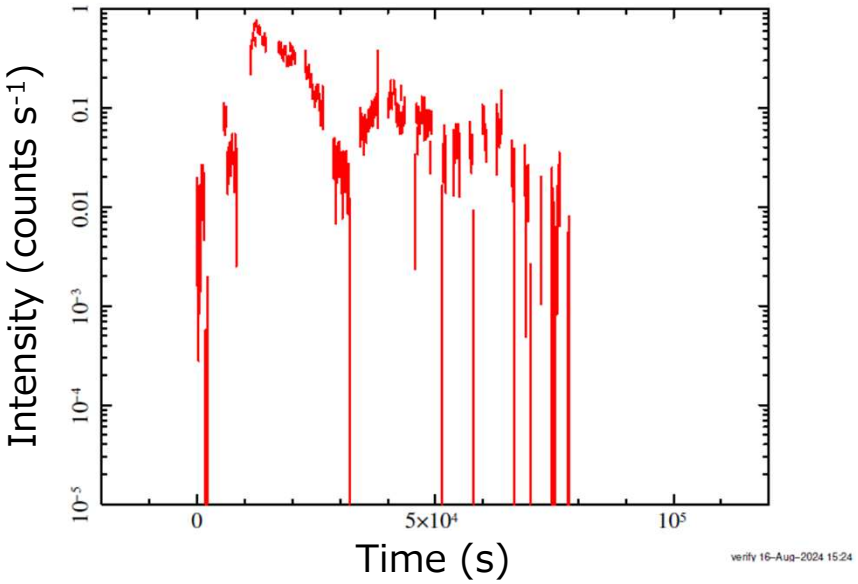
Name	RA (deg)	Dec (deg)	Separation (asec)
2CXO J052022.1-252309	80.0925	-25.3860	12.480785
1WGA J0520.3-2522	80.0933	-25.3822	11.508993
4XMM J052022.5-252218	80.0938	-25.3717	43.431317
4XMMs J052022.4-252218	80.0935	-25.3717	43.16883
2CXO J052022.3-252217	80.0933	-25.3714	44.084233
LP 836-22	80.1003	-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

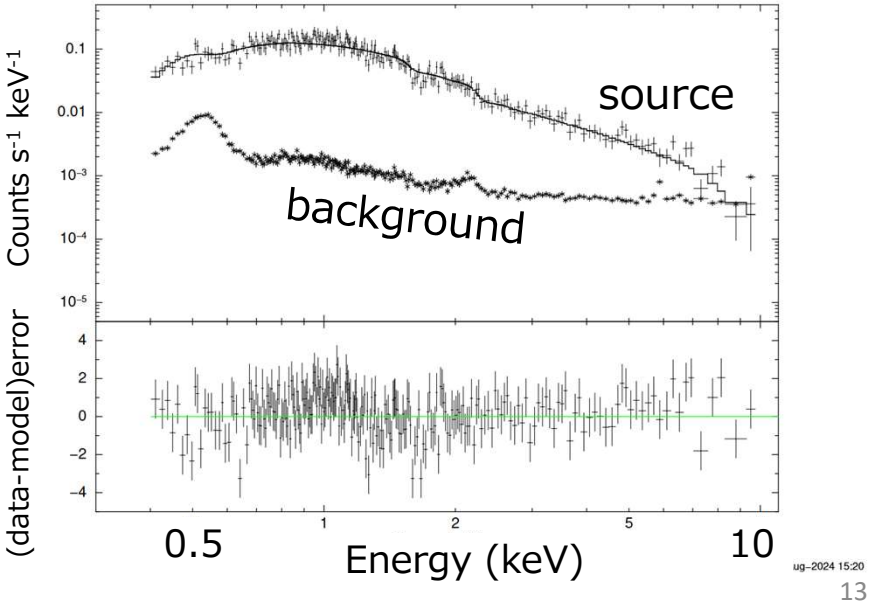
- Light curves are extracted for each source with several time scales
- Kolmogorov-Smirnov test is applied to examine the source variability
- Spectral fitting is performed with an absorbed power-law & thermal plasma (APEC) model
  - ARF library is prepared to assign appropriate ARFs for the sources.
- Software: **heasoft package**

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

0.4-2.0 keV Light curve (1024 s bin)



Spectrum (absorbed power-law)



XTS Process: Check & Scientific Discussion

- After the XTS process, results are uploaded to a web page
- The result page is automatically constructed by **python** scripts
- XTS scientists check the daily result
- If a transient is confirmed to have scientific value, ATel is prepared
- Scientific threshold:
  - Star/protostar: flare (ATel #16523 and many)
  - X-ray binary: outburst (#16607)
  - Any source: flux increase by more than one order of magnitude compared to previous observations (#17145, 17177)

XTS Operation

- XTS operation is started on 2024-03 (passed 1st anniversary!)
- By 2025-05-09……

XTS Operation

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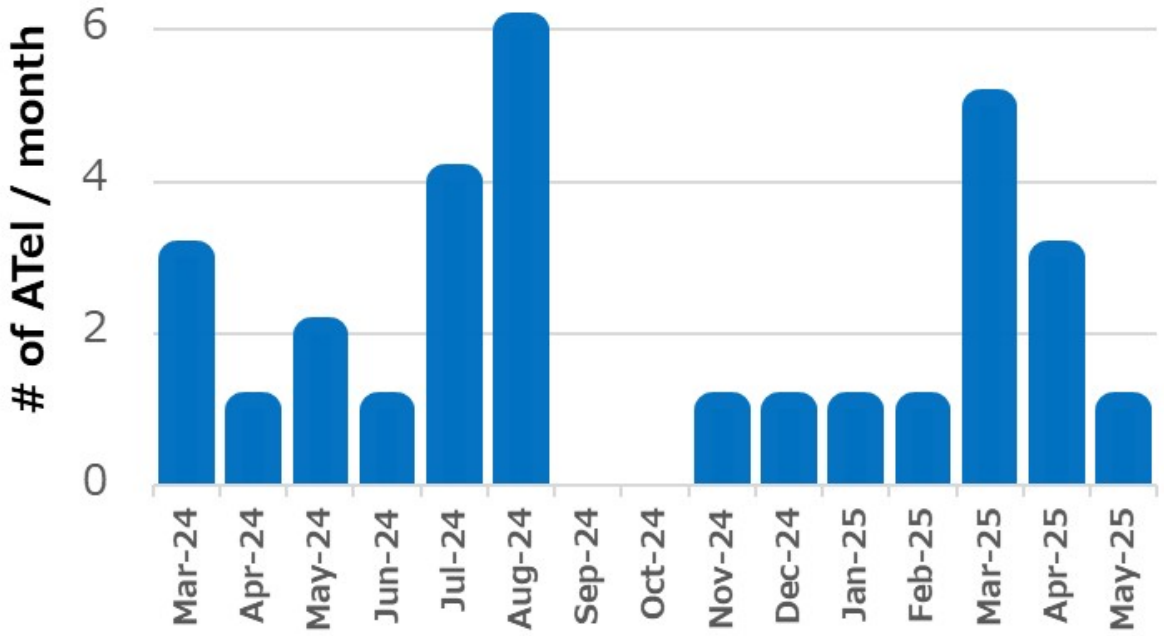
- By 2025-05-09……

30 transients from 26 sources were reported!



XTS Results: Published ATels

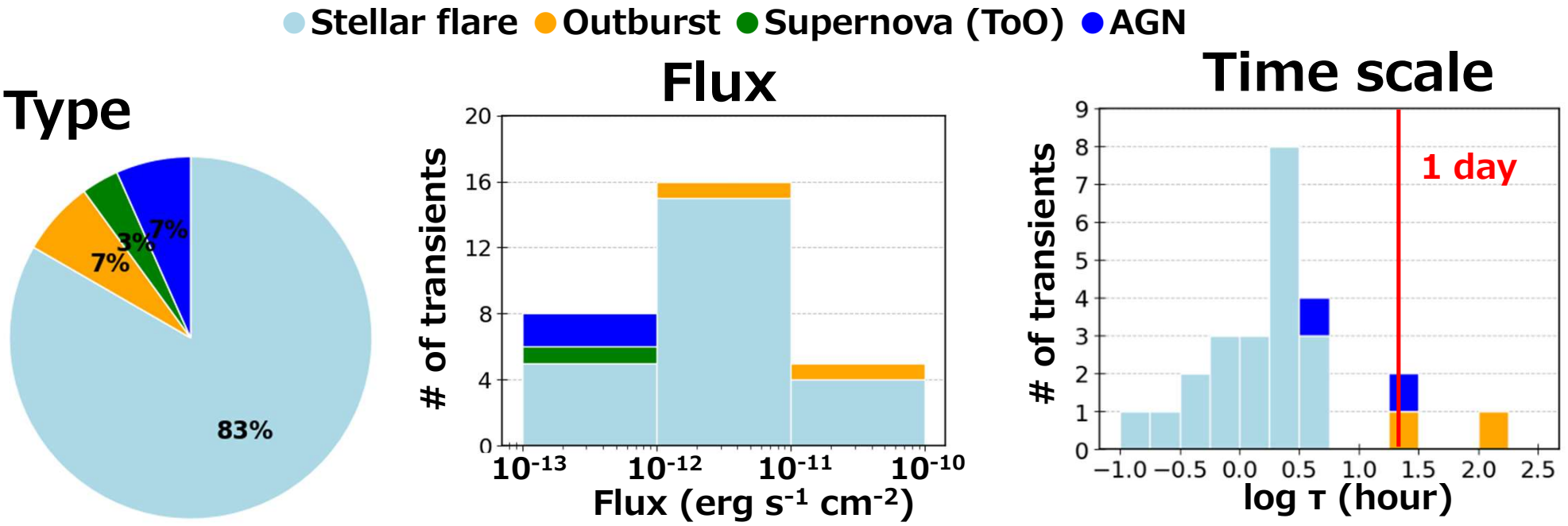
ATel #	Publ. Date (UTC)	Counterparts	Transient type
#16532	2024-03-15	LP 593-21	Stellar flare
#16558	2024-03-28	4XMM J190821.5+065854	Stellar flare
#16561	2024-03-31	SSTGLMC G335.2665-00.0151?	Stellar flare
#16592	2024-04-17	UCAC4 476-091023	Stellar flare
#16607	2024-05-01	AX J1910.7+0917	Outburst / 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: Published ATels

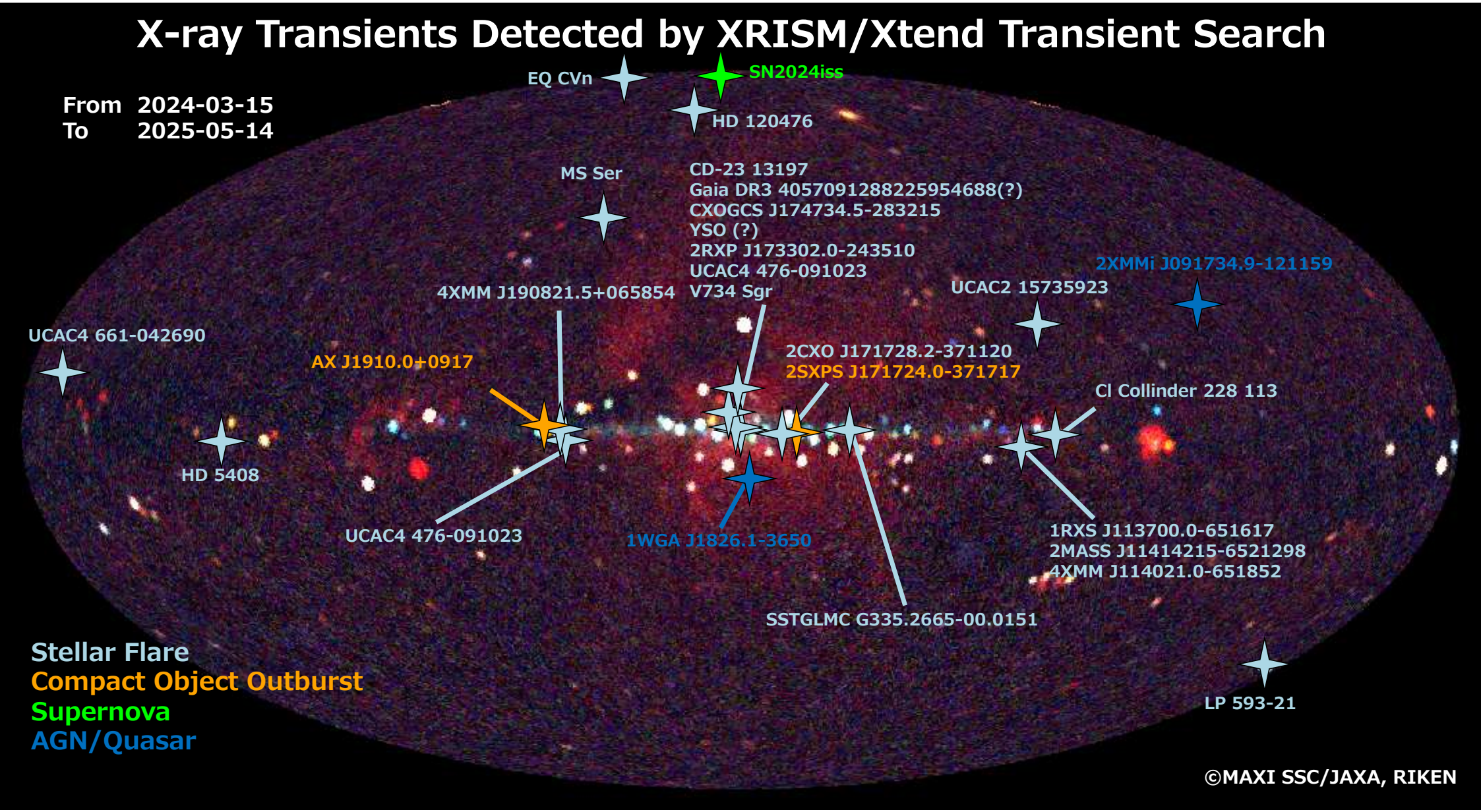
ATel #	Publ. Date (UTC)	Counterparts	Transient type
#16905	2024-11-12	EQ CVn	Stellar flare
#16962	2024-12-31	HD 5408?	Stellar flare
#16990	2025-01-23	HD 120476	Stellar flare
#17060	2025-02-24	2SXPS J171724.0-371717	Outburst of X-ray binary
#17067	2025-03-07	2CXO J171728.2-371120	Stellar flare
#17071	2025-03-10	CXOGCS J174734.5-283215 or SPICY 64348	Stellar flare
#17092	2025-03-20	YSO? in the Galactic center	Stellar flare
#17113	2025-03-27	2RXP J173302.0-243510	Stellar flare
#17121	2025-03-31	UCAC4 476-091023	Stellar flare
#17136	2025-04-07	CD-23 13197	Stellar flare
#17144	2025-04-14	V734 Sgr	Stellar flare
#17145	2025-04-14	1WGA J1826.1-3650	Blazar*
#17177	2025-05-09	2XMMi J091734.9-121159	AGN candidate

* Initially reported as a white dwarf, but confirmed as a blazar by the Swift follow-up

XTS Results: Statistics



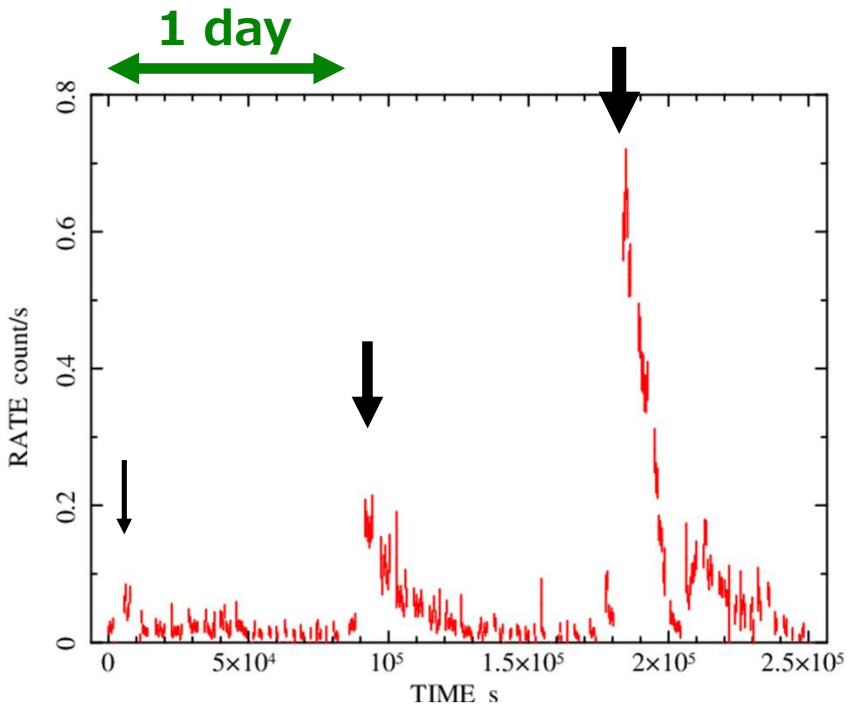
- 25 x stellar flare (from 11 stars), 2 x XRB outburst, 1 x SN (ToO), 2 x AGN
  - Unexpectedly **many stellar flares!**
- Flux sensitivity ~ 10^{-13} cgs (0.4 – 10 keV; during brightening)
- Time scales ~ 10 min – 9 day (decay time for flares, duration for outbursts)
- **Our Universe is active than we expected!**


X-ray Transients Detected by XRISM/Xtend Transient Search
From 2024-03-15
To 2025-05-14
EQ CVn
SN2024iss
HD 120476
MS Ser
CD-23 13197
Gaia DR3 4057091288225954688(?)
CXOGCS J174734.5-283215
YSO (?)
2RXP J173302.0-243510
UCAC4 476-091023
V734 Sgr
4XMM J190821.5+065854
2XMMi J091734.9-121159
UCAC2 15735923
UCAC4 661-042690
AX J1910.0+0917
2CXO J171728.2-371120
2SXPS J171724.0-371717
Cl Collinder 228 113
HD 5408
UCAC4 476-091023
1WGA J1826.1-3650
1RXS J113700.0-651617
2MASS J11414215-6521298
4XMM J114021.0-651852
SSTGLMC G335.2665-00.0151
LP 593-21
Stellar Flare
Compact Object Outburst
Supernova
AGN/Quasar
©MAXI SSC/JAXA, RIKEN

Science Highlights

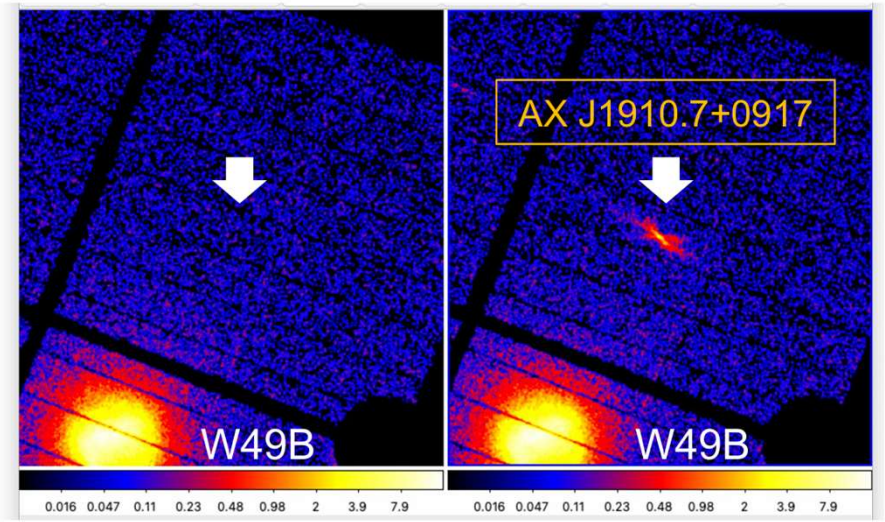
Repeating flares from the YSO candidate 2MASS J11414215-6521298

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

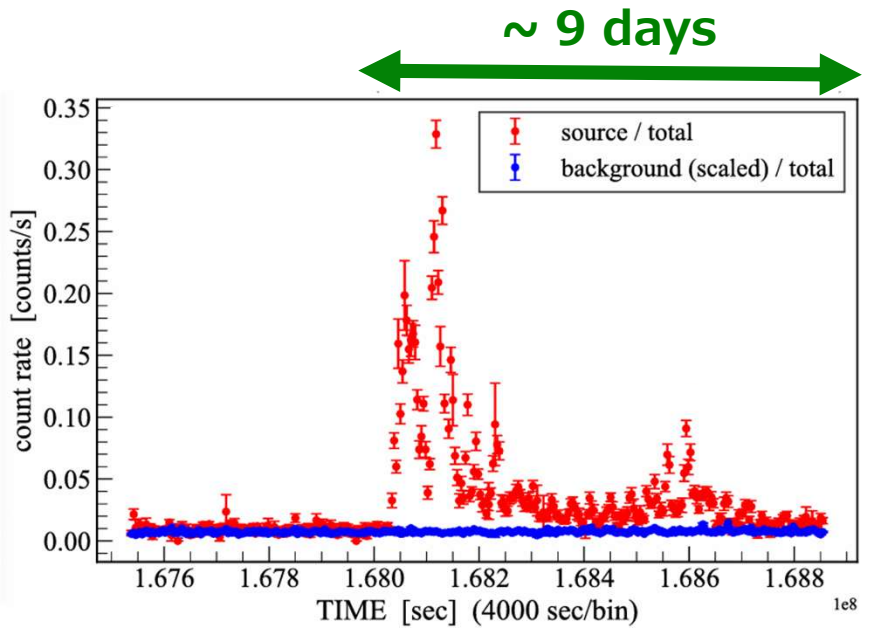


SFXT from the HMXB AX J1910.7+0917 (near SNR W49B)

- "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**



【0.4-10 keV Image】

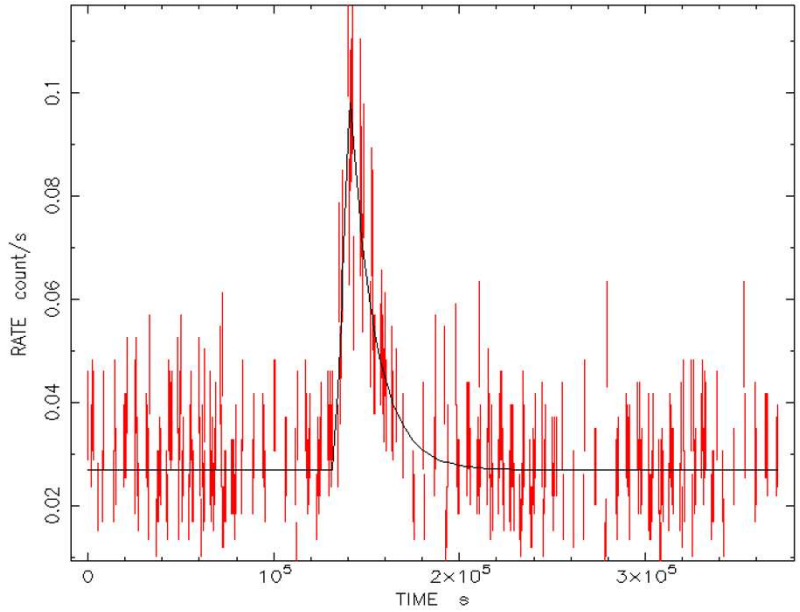


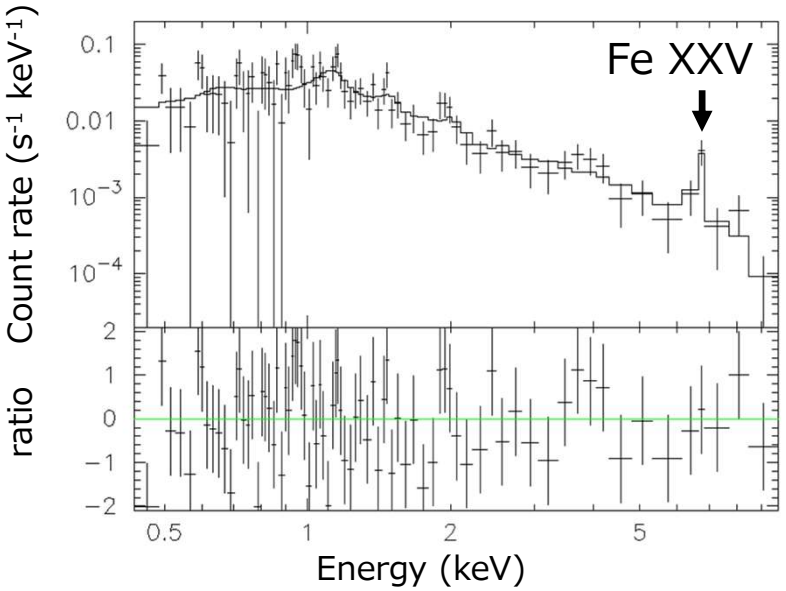
【0.4-10 keV Light curve】

Science Highlights

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

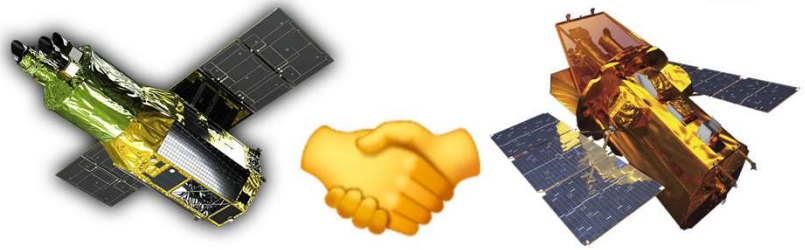
- Distance: **1.3 kpc**
- X-ray flare with kT ~ 5 keV
- Prominent line of Fe XXV (He-like)
- **2 (+2/-1) Solar abundance during the flare** (0.3 solar typically)





Science Highlights

First follow-up observation by Swift



- Target: XRISM J1826-3651 (ATel #17145)
- Identified as a **white dwarf candidate** (Gaia DR3 source)
- Swift follow-up observation is reported as ATel #17159 (Orio, Behar+)
- XRISM J1826-3651 is confirmed to be the **blazar 1WGA J1826.1-3650**

[Previous | Next | ADS]

XRISM/Xtend Transient Search (XTS) detected an outburst from a white dwarf candidate

ATel #17145; *N. Nagashima (Chuo U.), K. Fukushima, Y. Kanemaru, S. Ogawa (JAXA), M. Audard (U. de Geneve), E. Behar (Technion), S. Inoue (Kyoto U.), Y. Ishihara (Chuo U.), T. Kohmura (TUS), Y. Maeda (JAXA), M. Mizumoto (UTEF), M. Nobukawa (NUE), K. Pottschmidt (UMBC, NASA GSFC, CRESST), M. Shidatsu (Ehime U.), H. Sugai (Chuo U.), Y. Terada (Saitama U.), Y. Terashima (Ehime U.), Y. Tsuboi (Chuo U.), H. Uchida (Kyoto U.), T. Yoneyama (Chuo U.), M. Yoshimoto (Ehime U.)*
*on **14 Apr 2025; 12:02 UT***
Credential Certification: Tomokage Yoneyama (tyoneyama263@g.chuo-u.ac.jp)

[Previous | Next | ADS]

X-ray outburst of a radio-loud quasar

ATel #17159; *M. Orio (University of Wisconsin and INAF-Padova), E. Behar (Technion), N. Nagashima (Chuo U.), K. Fukushima, Y. Kanemaru, S. Ogawa (JAXA), M. Audard (U. de Geneve), S. Inoue (Kyoto U.), Y. Ishihara (Chuo U.), T. Kohmura (TUS), Y. Maeda (JAXA), M. Mizumoto (UTEF), M. Nobukawa (NUE), K. Pottschmidt (UMBC, NASA GSFC, CRESST), M. Shidatsu (Ehime U.), H. Sugai (Chuo U.), Y. Terada (Saitama U.), Y. Terashima (Ehime U.), Y. Tsuboi (Chuo U.), H. Uchida (Kyoto U.), T. Yoneyama (Chuo U.), M. Yoshimoto (Ehime U.)*
*on **23 Apr 2025; 14:14 UT***
Distributed as an Instant Email Notice Transients
Credential Certification: Marina Orio (orio@astro.wisc.edu)

Lessons Learned

- Xtend position uncertainty by off-axis angle is not well studied
  - Results in a large nominal uncertainty of ~ **40 asec**
- The data downlink and subsequent process go on even at midnight
  - Limits the response speed for the result check/report
- When the main target is bright, the extended PSF makes a lot of false detection that burdens the XTS process system

Future Works

- Collaboration with ground observatories
  - Currently, Chuo University's observatory (CHAO) covers a part of the northern sky
  - We need more follow-up observation, including **southern sky!**
- Collaboration with multi-messenger facility (GW, neutrino)
  - Gravitational wave events are to be matched with XTS via GCN
  - Working in progress
- Self-ToO to Resolve

Summary

- XTS is a transient search & report system with XRISM/Xtend
- XTS reported 30 transients in ~ 14 month
- Most of them were stellar flares, with several XRB and AGN
- The flux sensitivity is down to 10^{-13} erg s^{-1} cm^{-2}

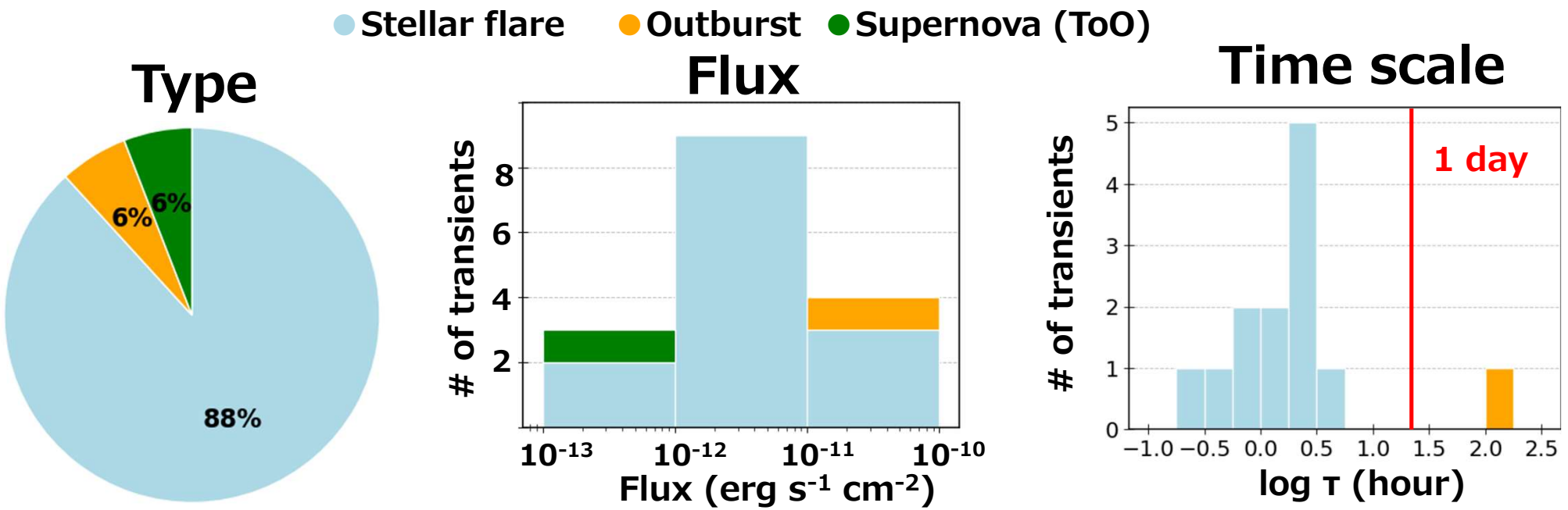
XTS is performed with PI's approval.
Please select
"XTS = yes"
for your AO-2 proposal!

FAQ

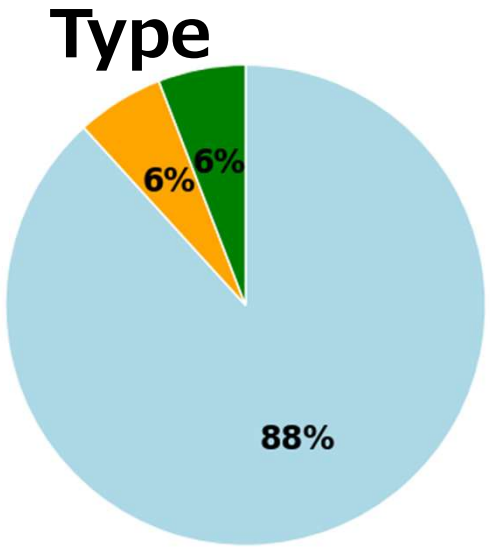
Q. Pointing accuracy of XRISM is less than 20 asec.
Why worse value of ~ 40 asec is derived for XTS?
A. XTS uses QL (on-board) attitude, which is a preliminary one,
to achieve fast report.

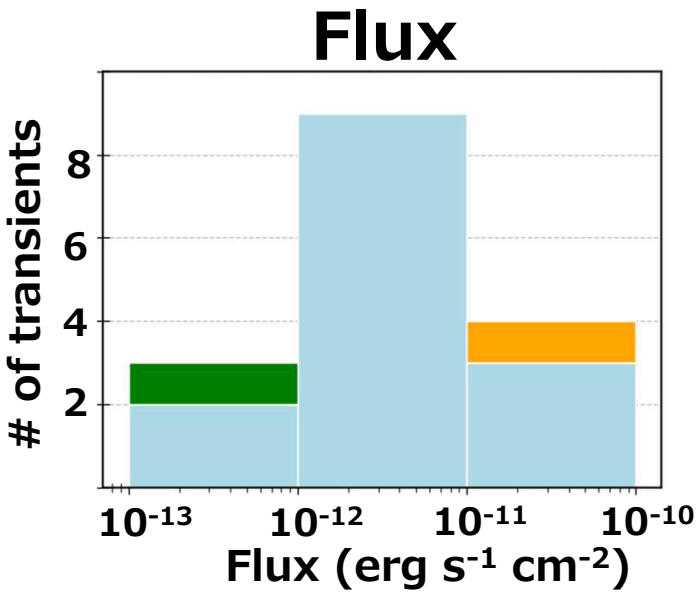
Q. Was the number of transients that XTS found as expected?
A. Under verification. To be reported in Yoneyama et al. (PASJ; in prep.)

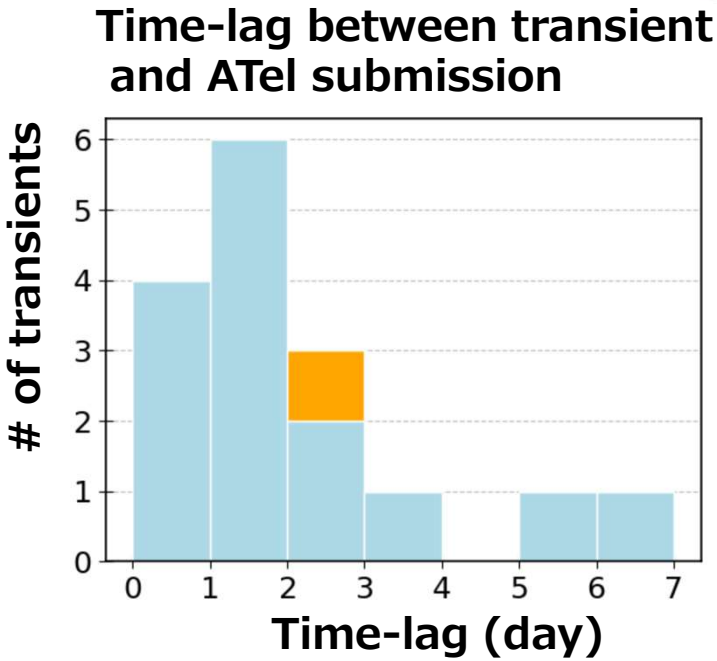
Q. XRISM is now in the General Observer phase. How XTS uses GO's data?
A. With GO's allowance, Xtend data excluding the Resolve FOV is analyzed.


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!**