Einstein Probe mission status

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on behalf of the Einstein Probe consortium

Image credit CAS/ESA

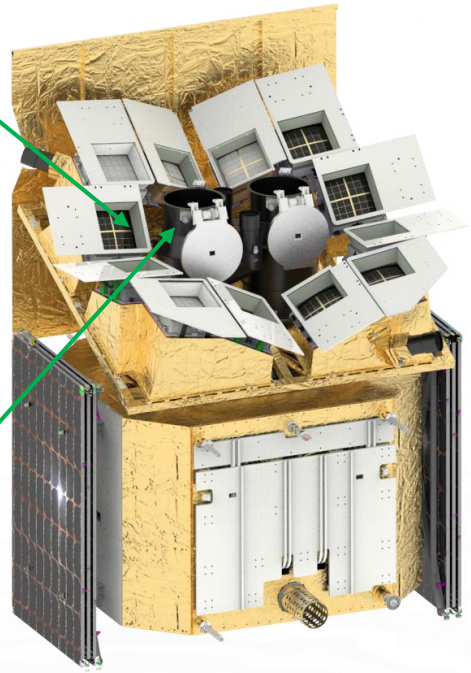
Instruments & spacecraft

Wide-field X-ray Telescope
WXT (12 modules)

36 Lobster-eye MPO + 4 CMOS
FoV: ~3,600 sq deg (1.1 sr)
Band: 0.5 – 4 keV
Resolution: ~ 5’ (FWHM)
Sensitivity: ~1 mCrab @1ks

Follow-up X-ray Telescope
FXT (2 units)

Wolter-1 + pn-CCD (eROSITA)
FoV: ~1 deg
Band: 0.3 -10keV
Resolution: 24” (HPD, on-axis)
Effe. area: ~300 cm² @1keV (x 2 units)



Spacecraft

On-board data processing
Quick slew & autonomous follow-up

Telemetry

X/S-band (several hours)
B (down/up-link; minutes)
VHF (down-link; minutes)

Yuan, et al. 2022 *Handbook of X-ray and Gamma-ray Astrophysics*

Launch of EP on Jan. 9, 2024

6 yrs after mission adoption
11 yrs after EP proposed
13 yrs after beginning of MPO technology R&D @ NAOC/CAS

LM-2C @Xichang

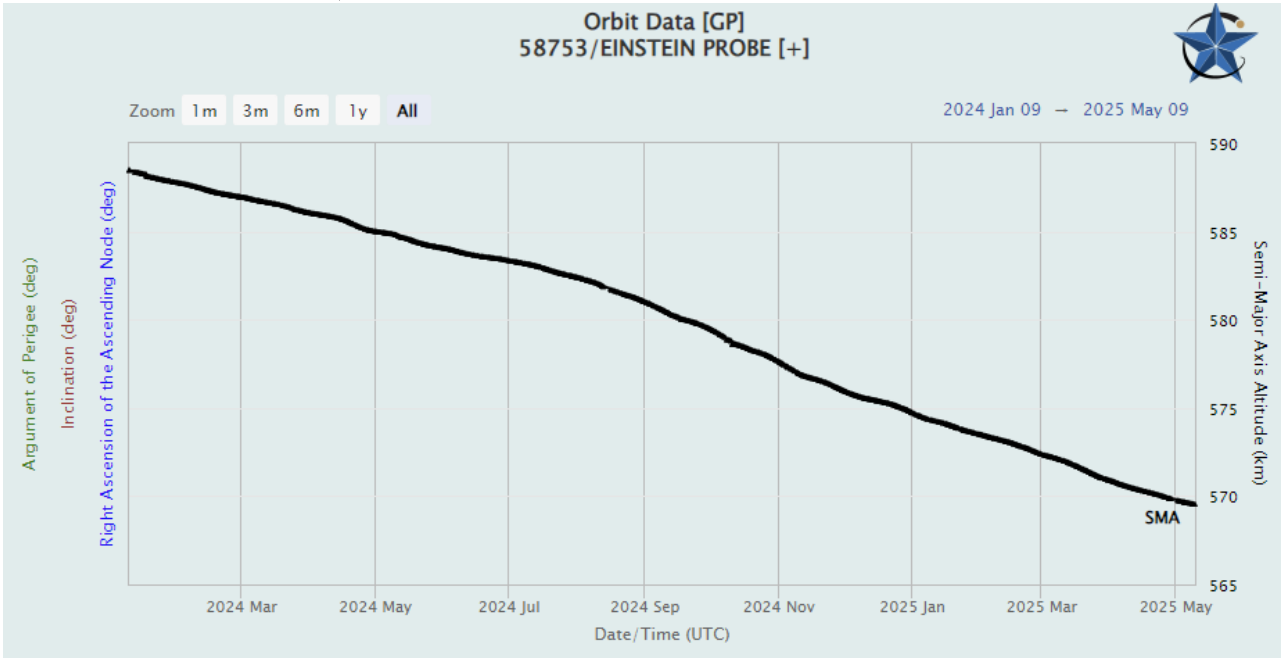
A loong in Chinese mythology

Mission status

- Orbit: 570 km (20 km lower since launch)
- Inclination: 29°
- Period： 95 min

FXT and WXT calibrition :

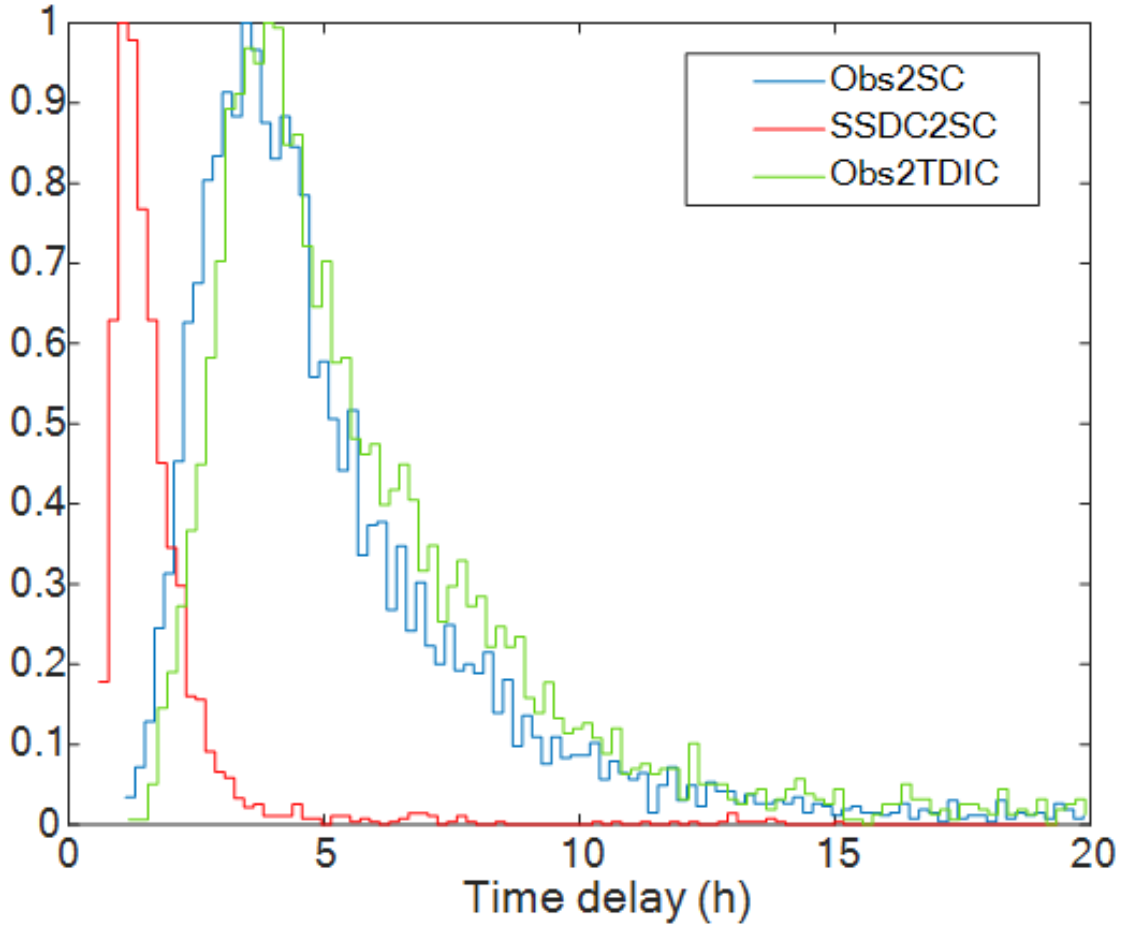
- Spectrum,
- positioning



- WXT : ~ 20 micro- meteroid hitting
- ~ 2 severe hitting (1/4 CMOS lost)
- Effective area and gain do not show variations (huaqing's talk).

Data Real time performance

- Data downlink：
- Alert： several minutes
- Whole data： < 10 hours



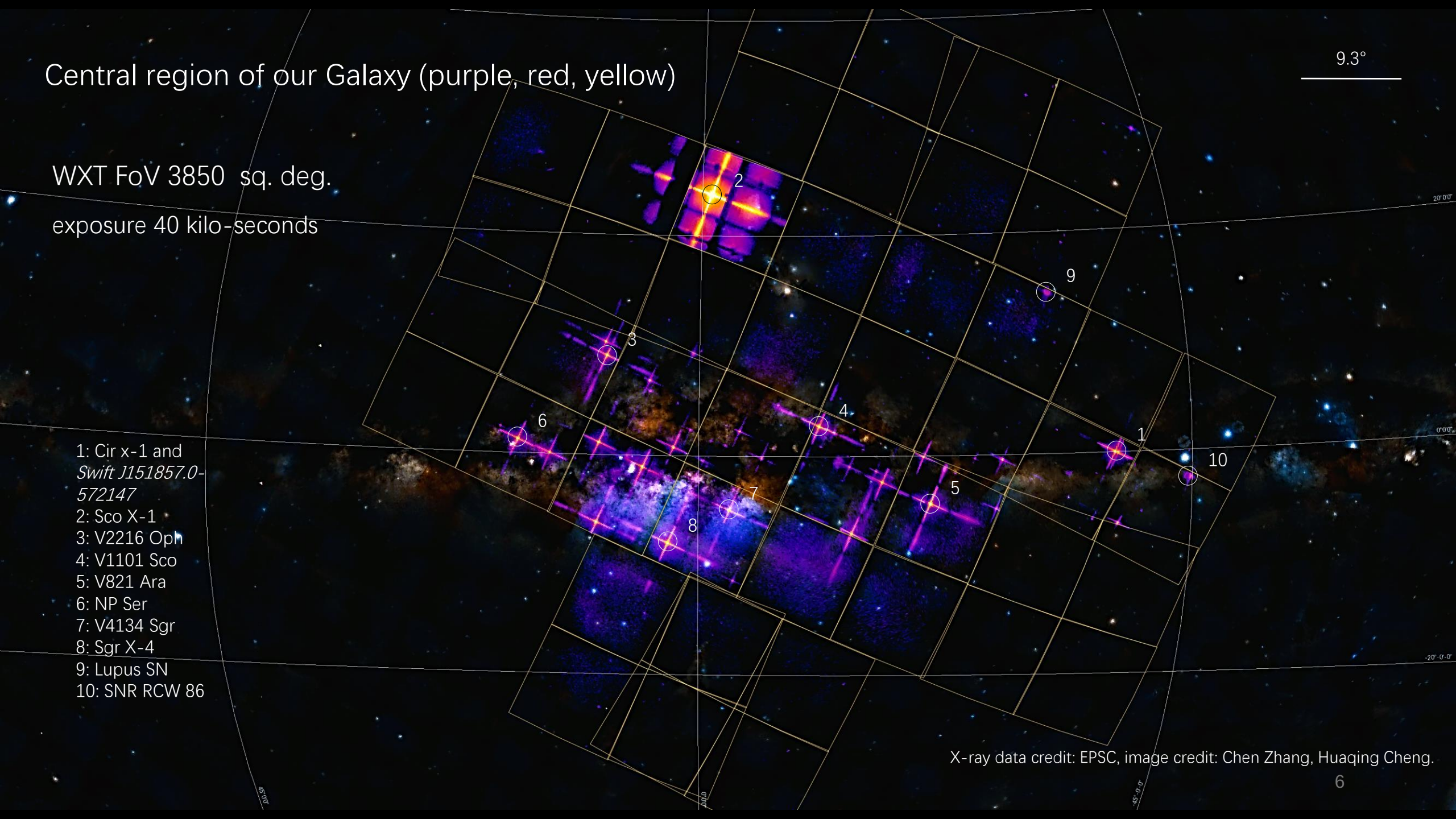
- ~ 10 Orbits per day
- Including China and ESA’s station.

- Data uplink: Too observation command in 1 minute.

Central region of our Galaxy (purple, red, yellow)

WXT FoV 3850 sq. deg.

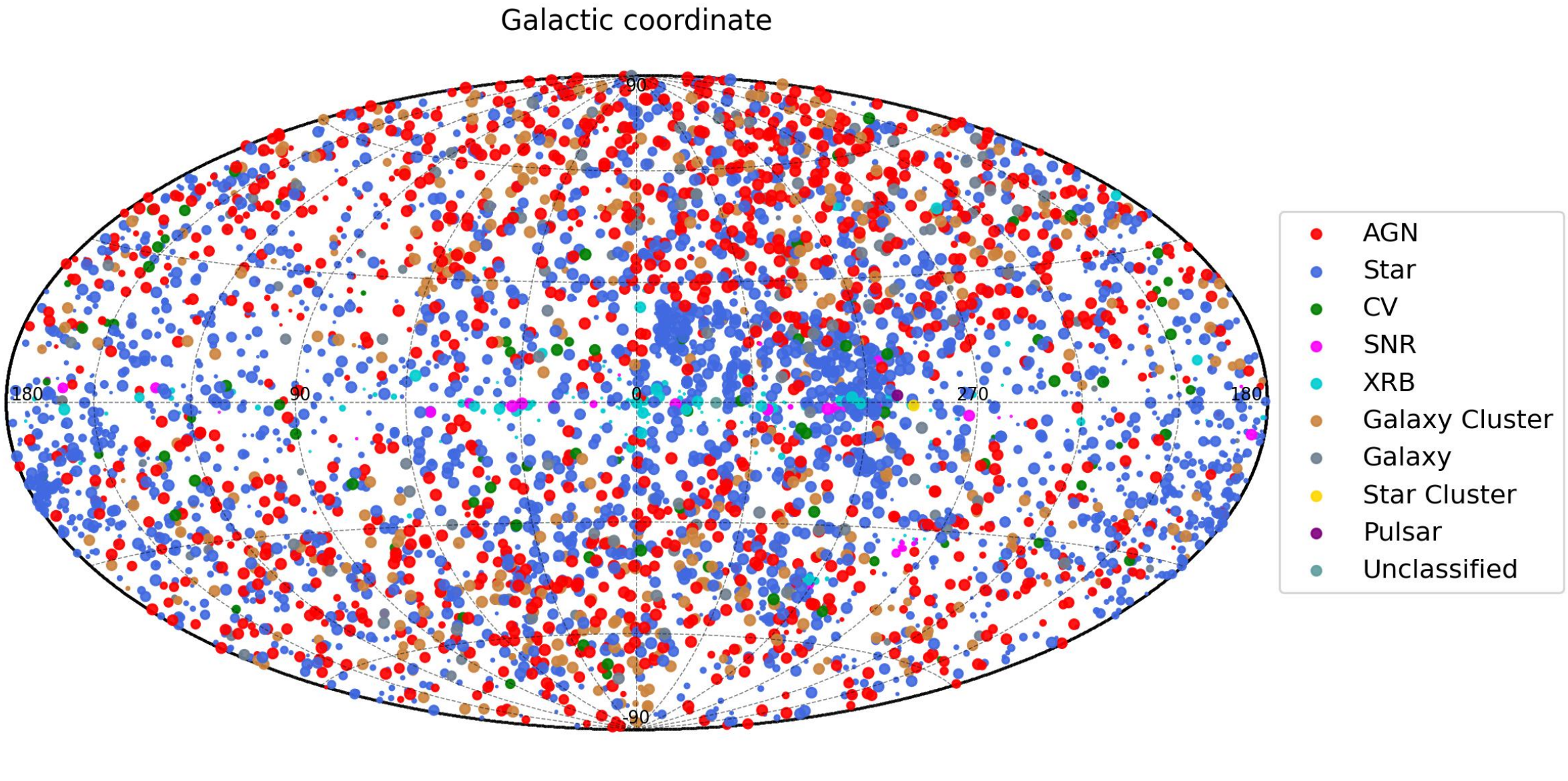
exposure 40 kilo-seconds



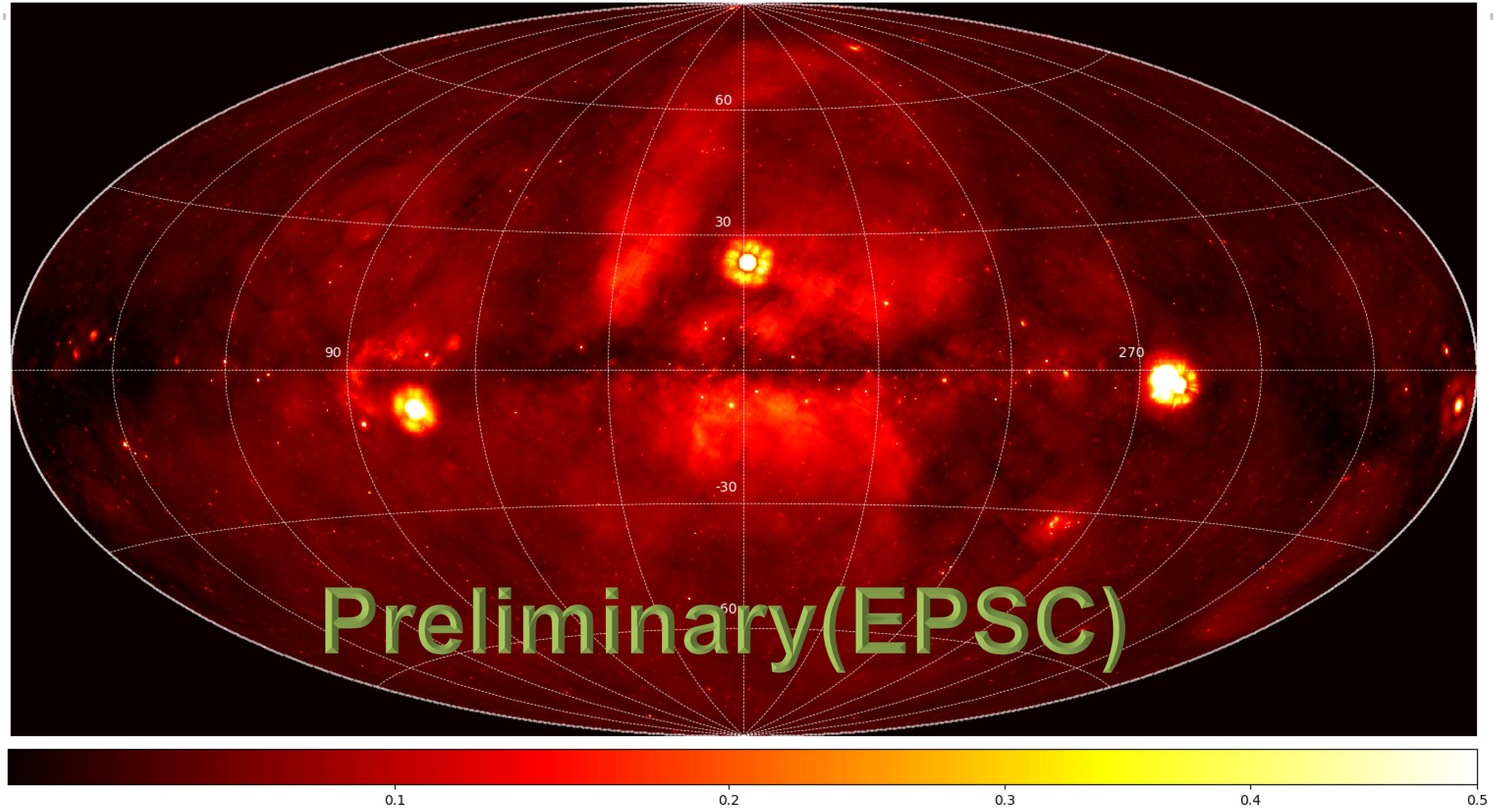
1: Cir x-1 and *Swift J151857.0-572147*
2: Sco X-1
3: V2216 Oph
4: V1101 Sco
5: V821 Ara
6: NP Ser
7: V4134 Sgr
8: Sgr X-4
9: Lupus SN
10: SNR RCW 86

X-ray data credit: EPSC, image credit: Chen Zhang, Huaqing Cheng.

EP-WXT sources （5242）

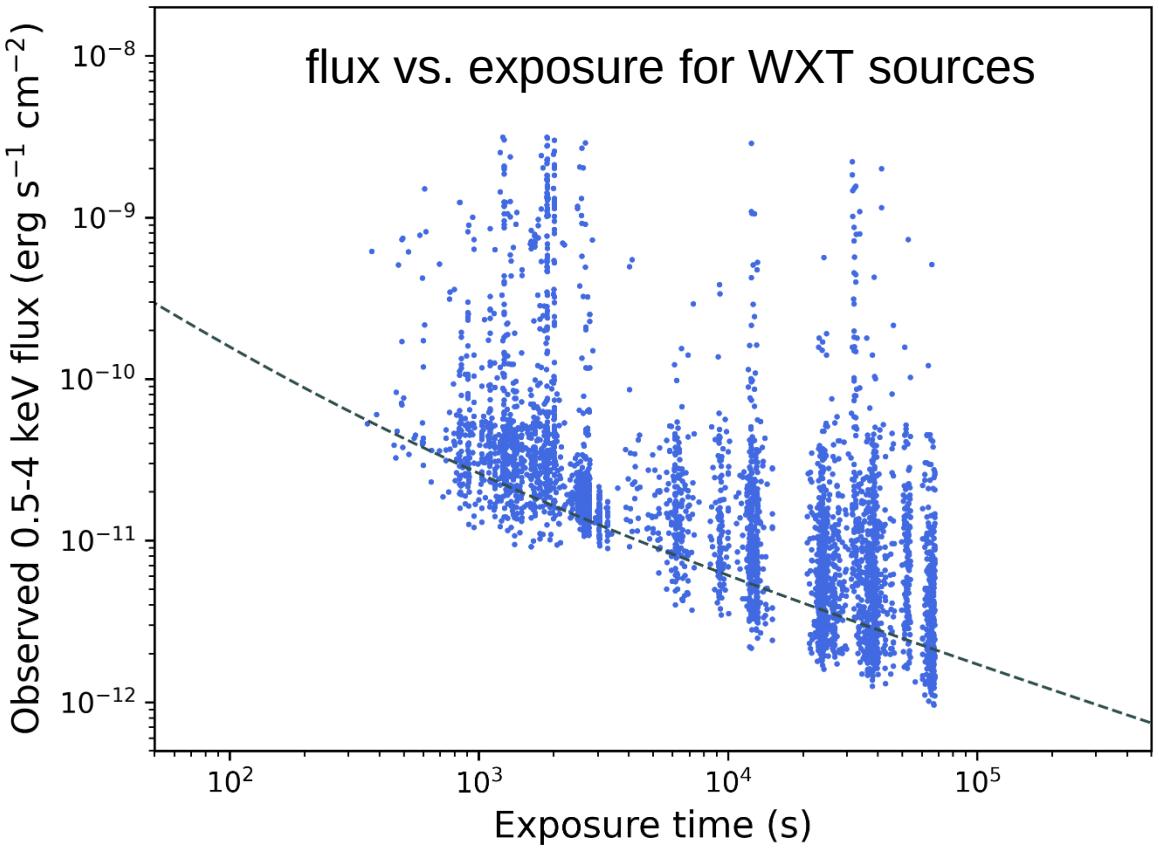


WXT's All sky map



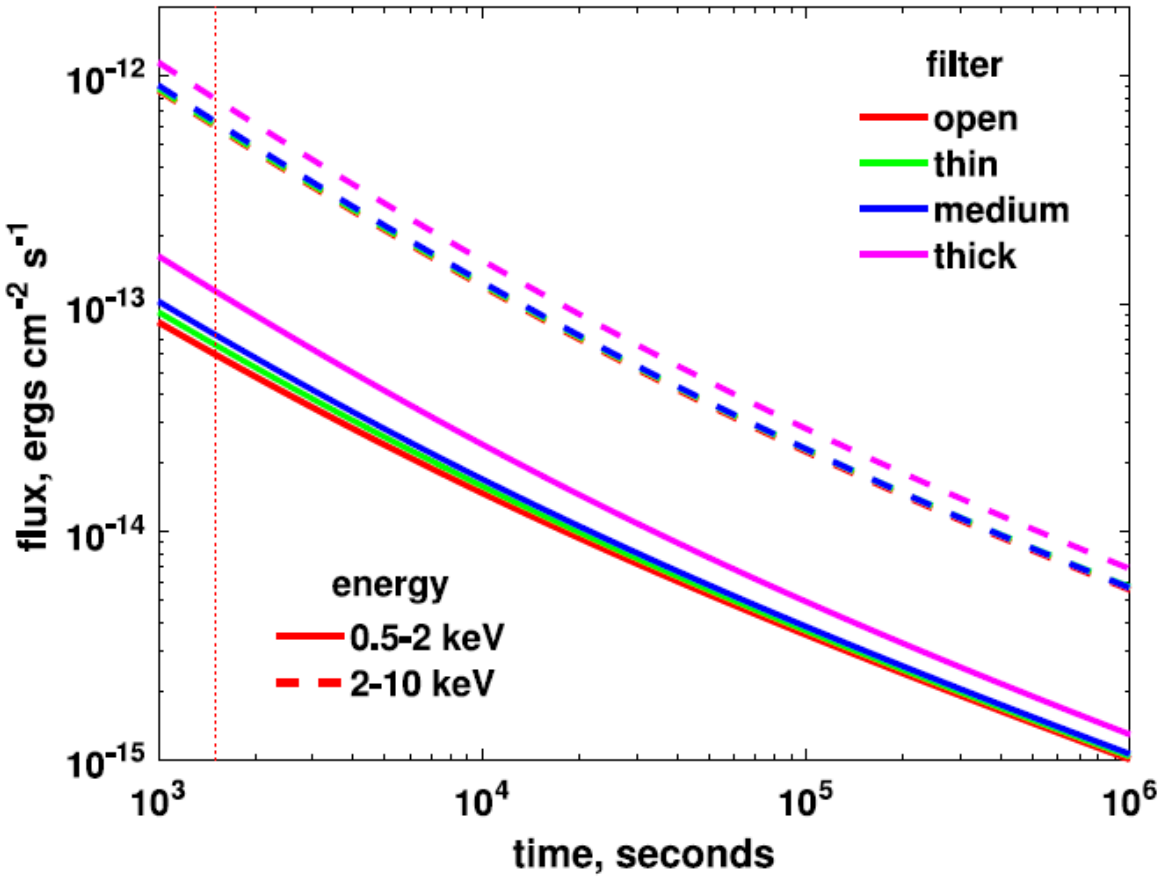
Sensitivity

WXT



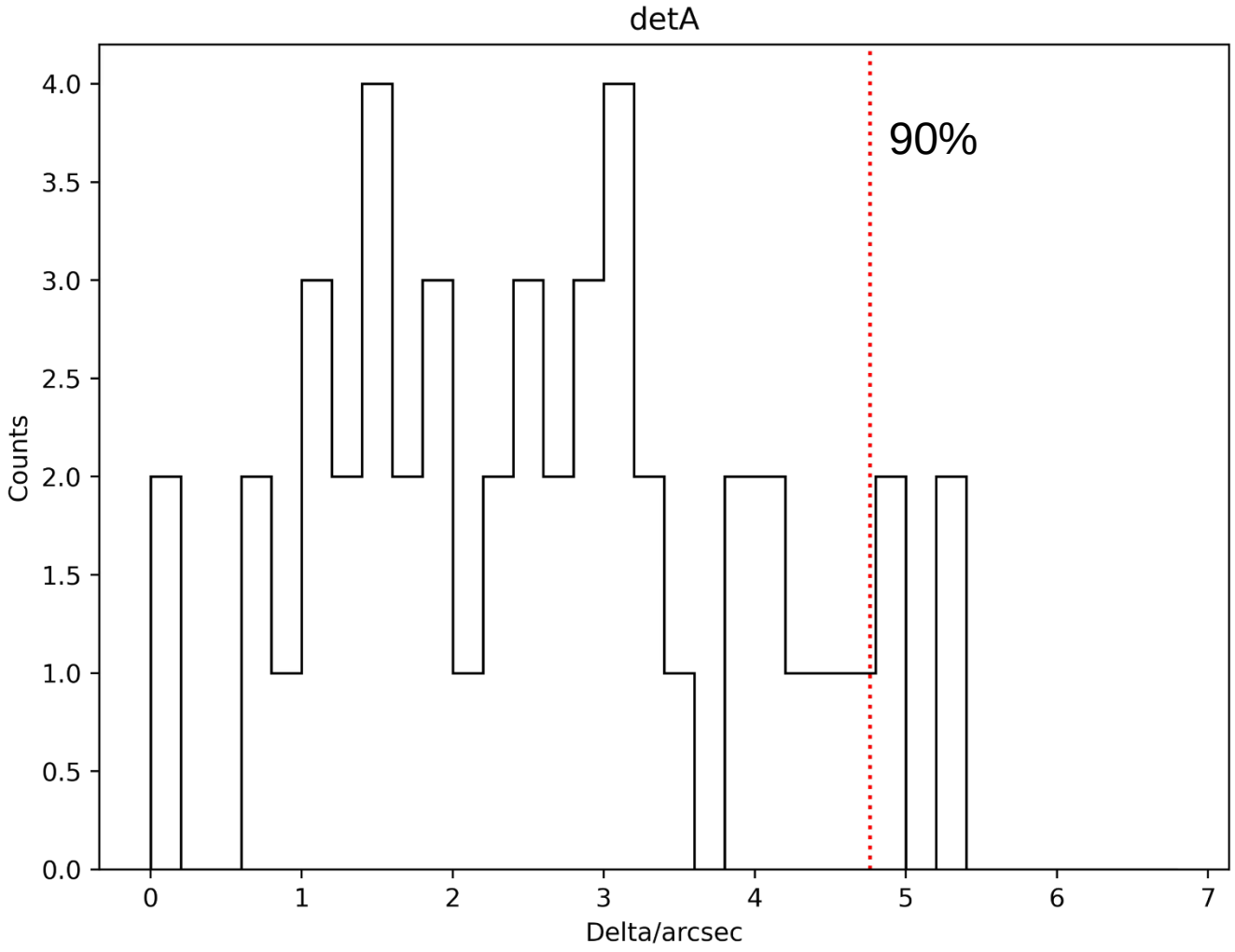
see Huaqing Cheng's talk

FXT (1 unit)

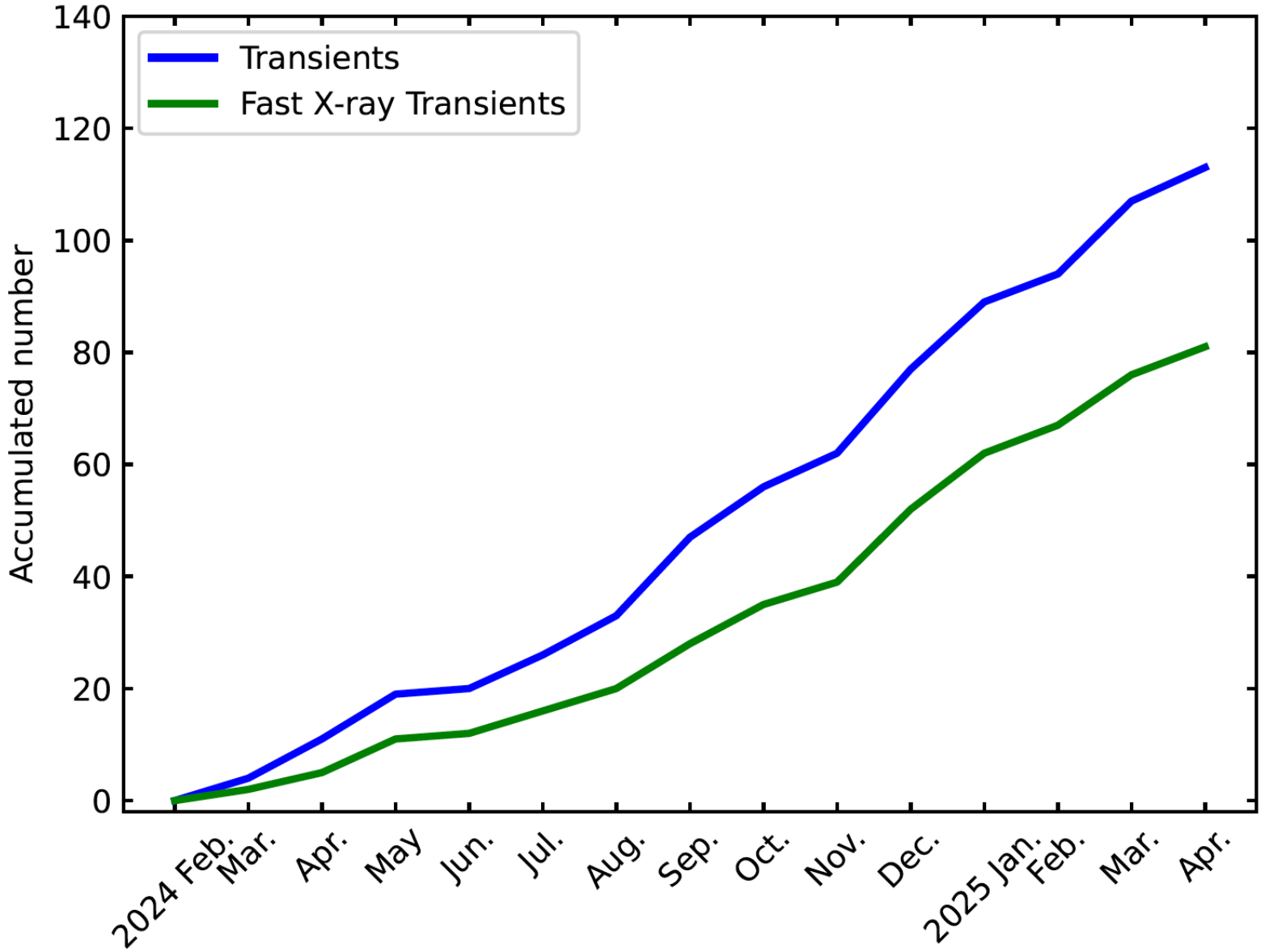


see Yusa Wang's talk

FXT localisation precision for bright sources

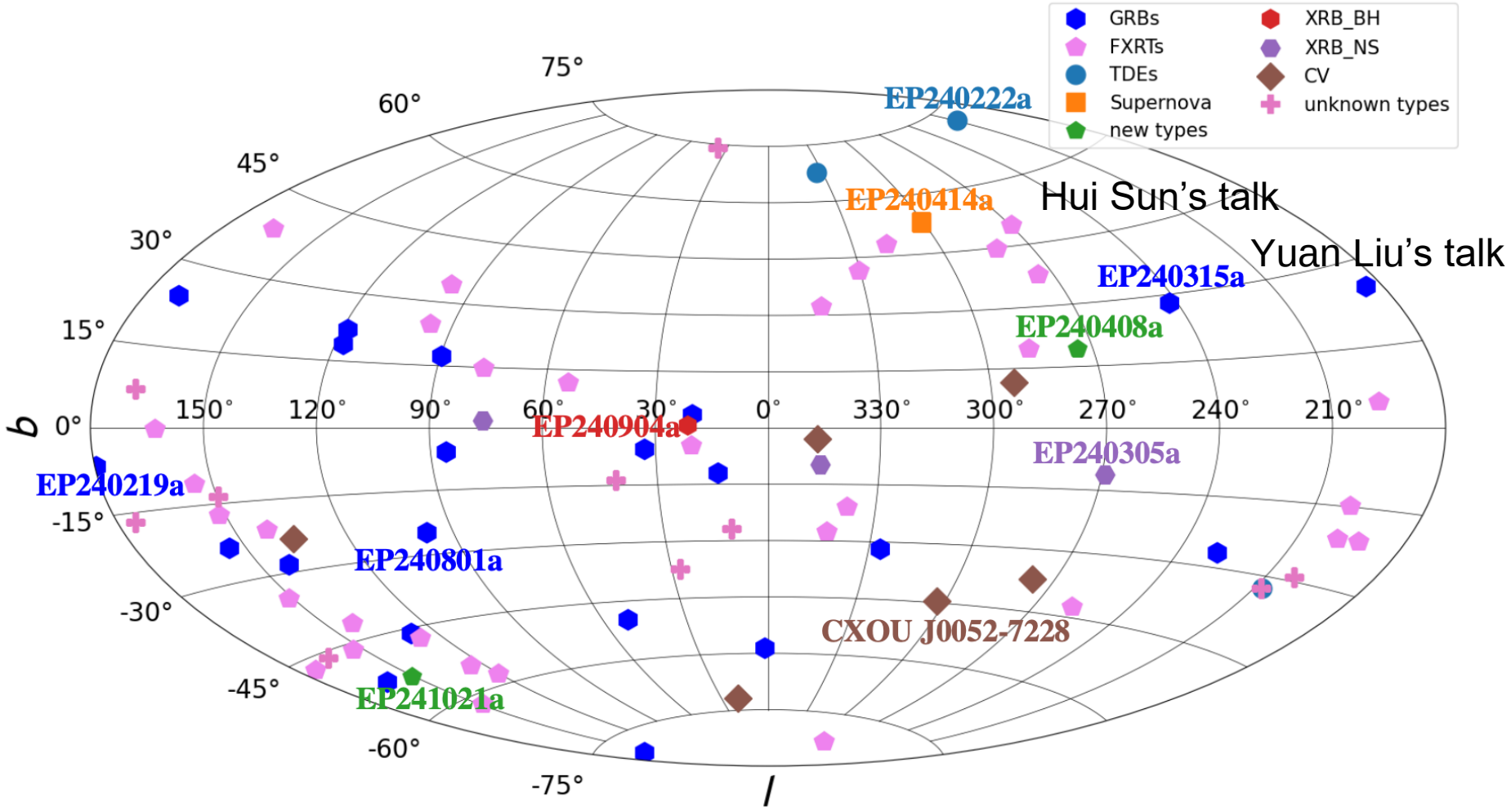


EP X-ray transients since launch



- X-ray transients
  - WXT:~100 /yr
  - all-sky: ~1100/yr
- Fast X-ray transients
  - WXT: ~ 80 /yr
  - all-sky: 880/yr

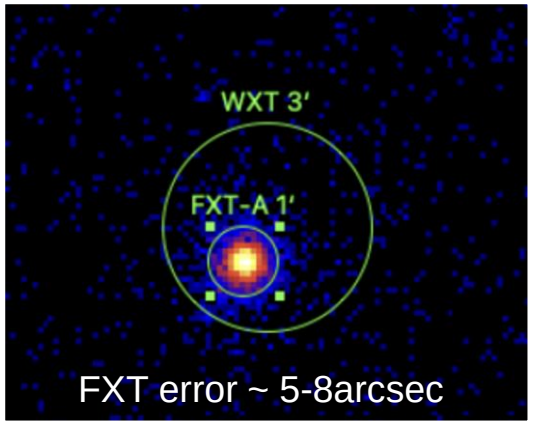
X-ray transients detected by EP-WXT

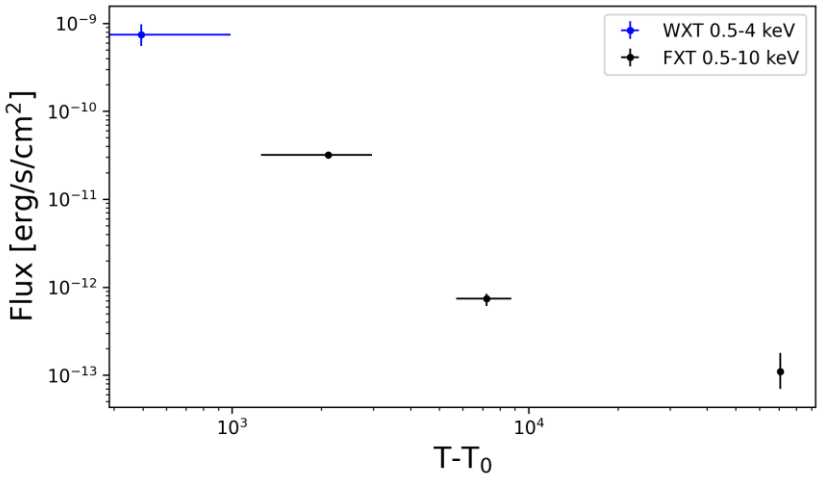


EP240908a: example of quick onboard follow-up

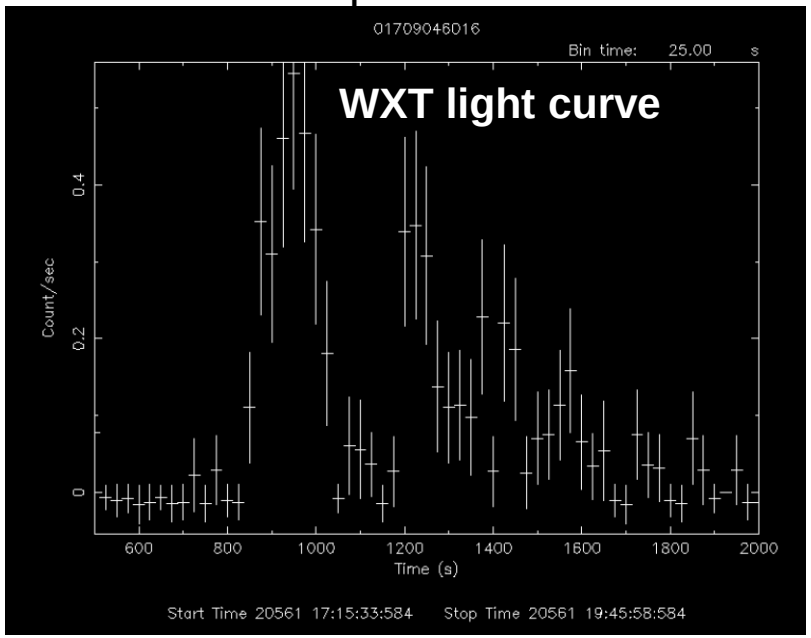
- WXT onboard trigger:
  - T0=2024-09-08T17:28:27 (UTC)
  - peak flux: ~1e-9 erg/s/cm^2
    (EP team et al. GCN 37443)
- T0+7min: automated FXT follow-up
  (EP team et al. GCN 37432)
- T0+19hrs: FXT ToO
  - flux ~1.1x10^(-13) erg/s/cm^2
- optical afterglow candidate:
  - AB magnitude r ~ 24

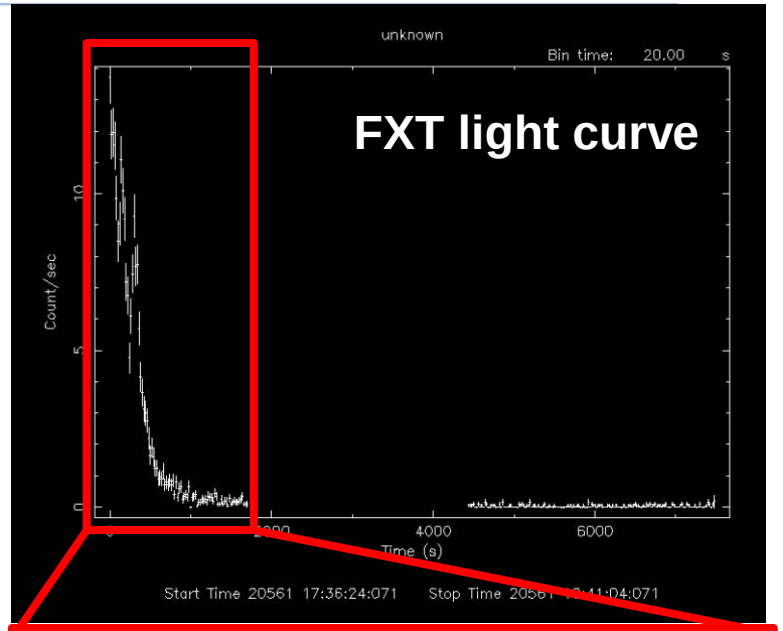
  (Quirola-Vasquez et al. GCN 37438)

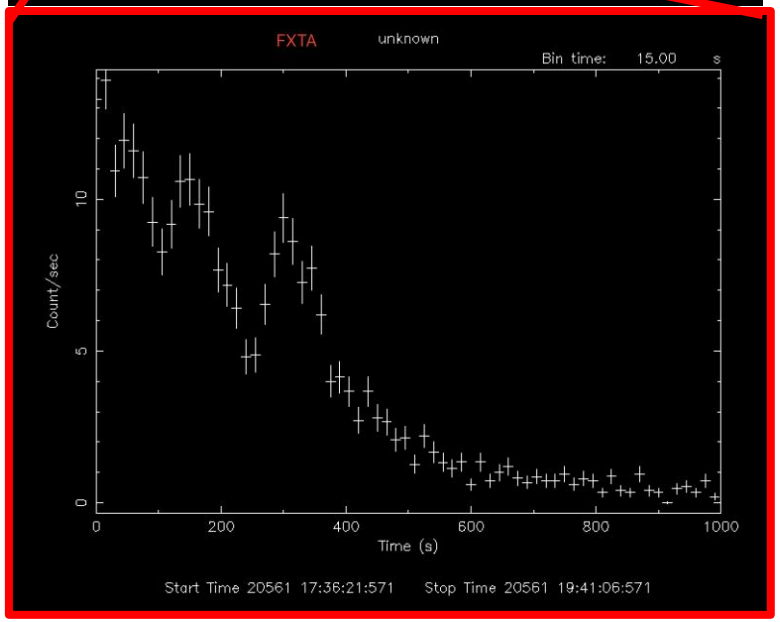




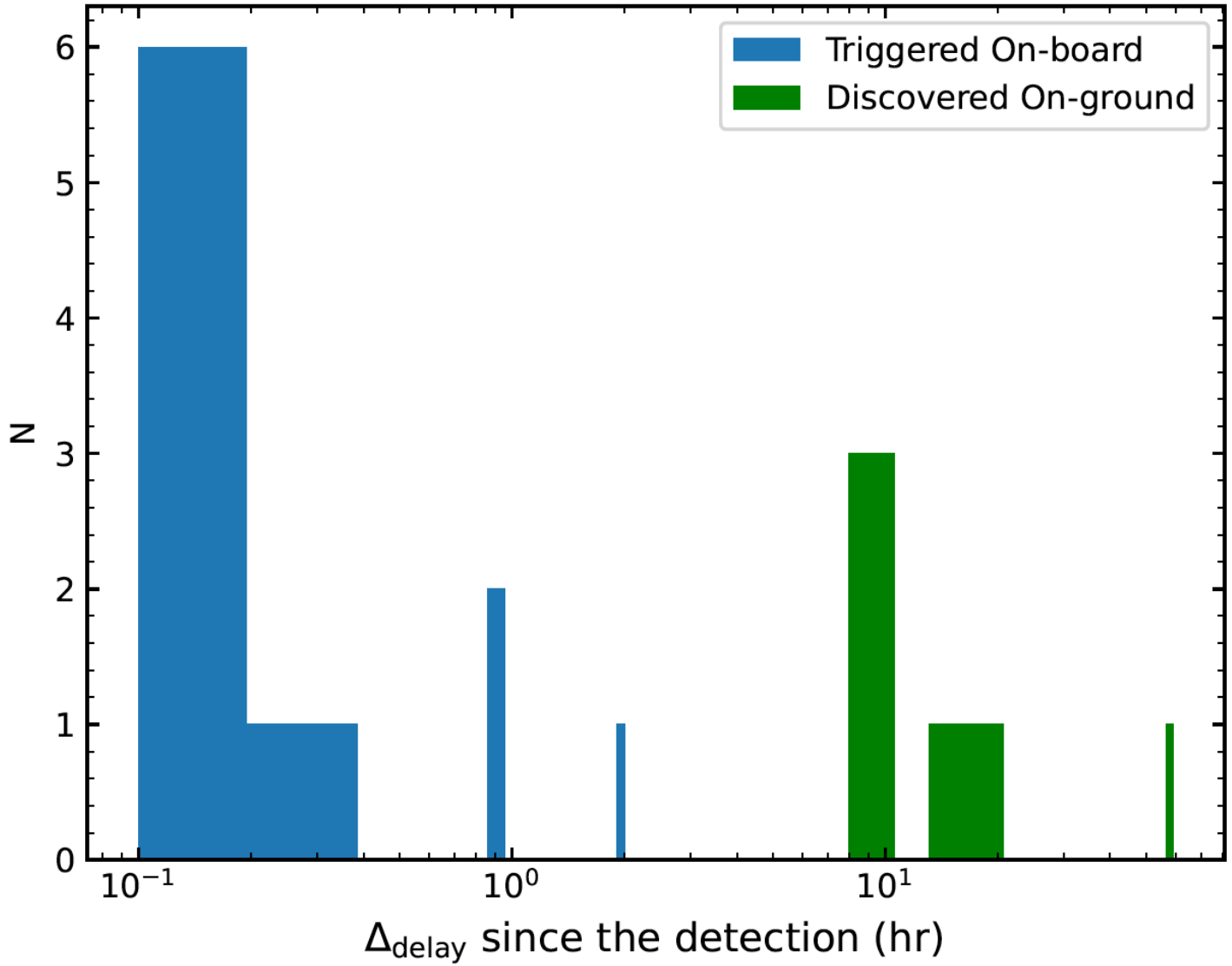
no GRB counterpart







Typical latencies for issuing transient alerts



to be improved

Follow-up of GW event: S250206dm

S240422ed: T0=2025-02-06 21:25:30.439 UTC; NSBH (55%), BNS (37%); 373 +/- 104 Mpc; 90% area=547 deg^2

EP follow-up observations:

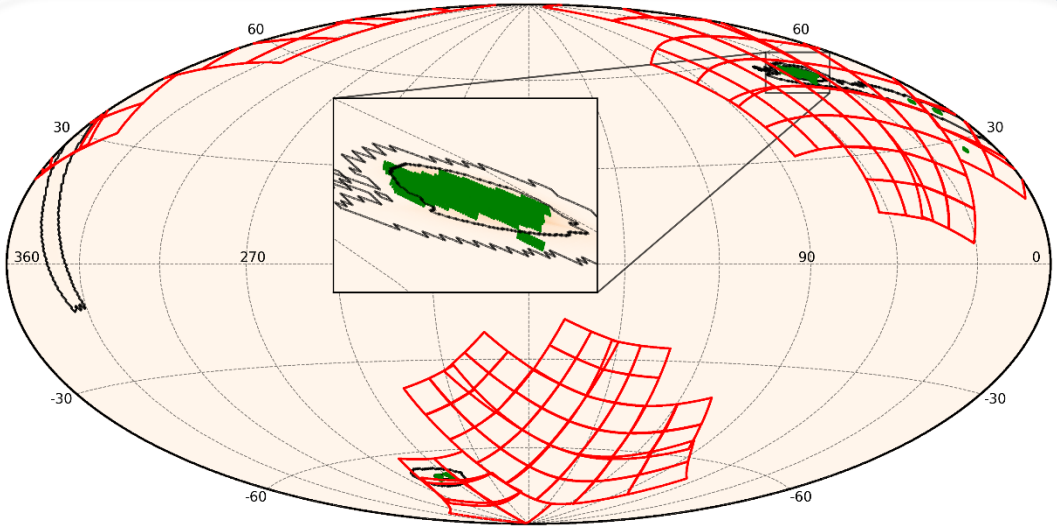
1^{st} round: 2×2400s WXT coverage + 100×300s FXT targeting galaxies (2025-02-07T02:55:12Z ~ Feb. 8th)

2^{nd} round: 59×2000s FXT tiling (from Feb. 11th to 18th)

Search for transient or variable candidates in the FXT data (apparently associated with the galaxies):

found ~20 uncatalogued sources, two of which exhibit significant flux decay.

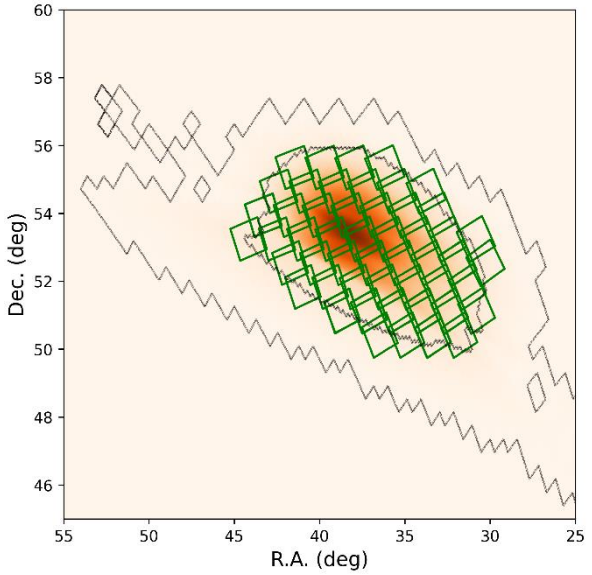
Detailed information: GCN Circular 39545; https://ep.bao.ac.cn/ep/cms/article/view?id=185



1^{st} : WXT covered 302 deg^2 within (55% of) the 90% GW area

WXT 0.5-4 keV flux limits: 1×10^{-11} erg $s^{-1}cm^{-2}$

FXT 0.5-10 keV flux limits: 3×10^{-13} erg $s^{-1}cm^{-2}$

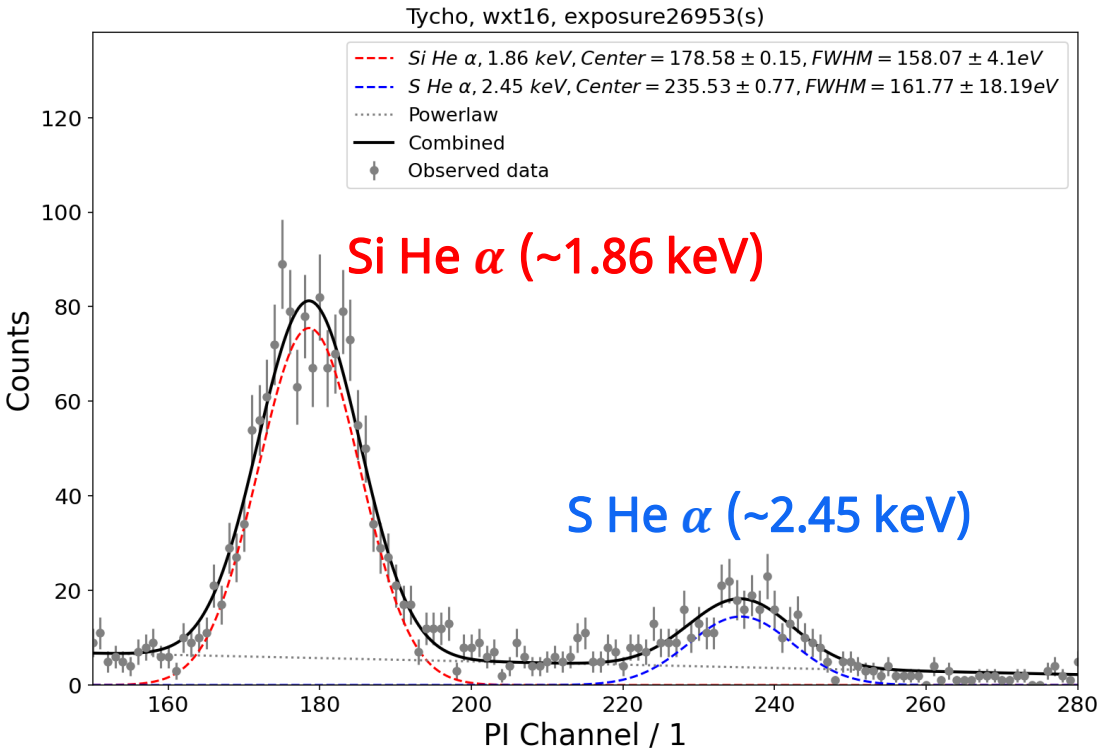


2^{nd} : FXT covered 34 deg^2 within (89% of) the 50% GW area

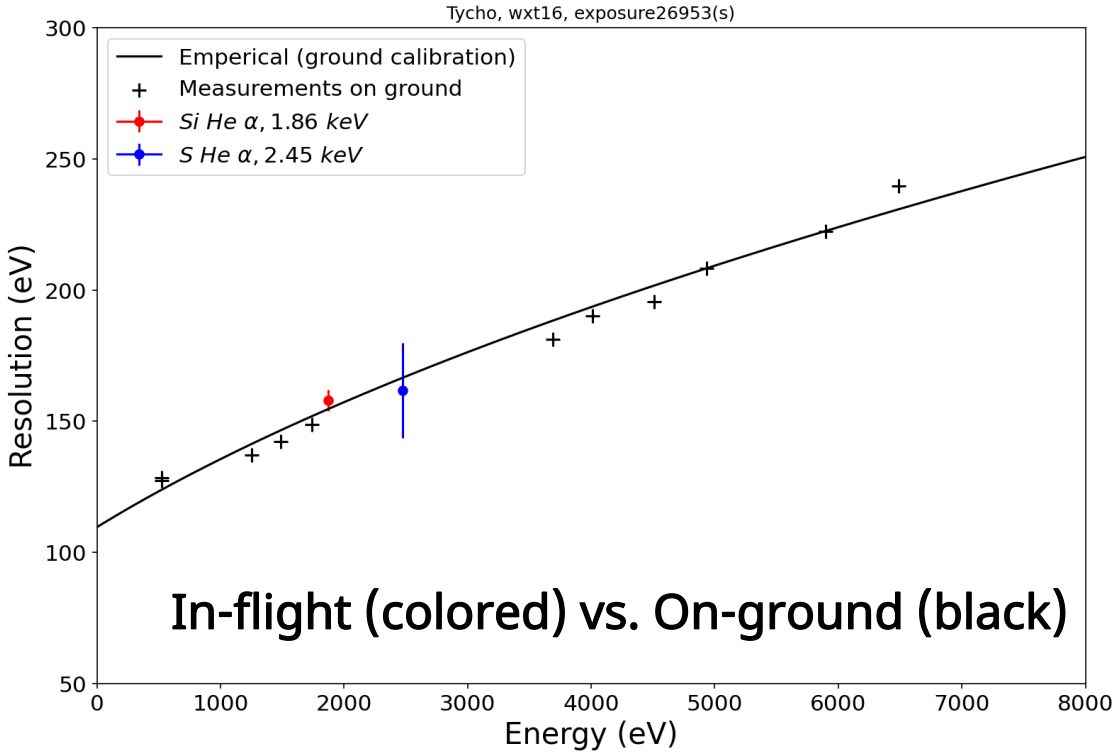
FXT 0.5-10 keV flux limits: 5×10^{-14} erg $s^{-1}cm^{-2}$

WXT's CMOS detector response

- Analysis on Tycho spectrum



Spectral analysis of (stacked) spectrum of Tycho (FM4, CMOS16)

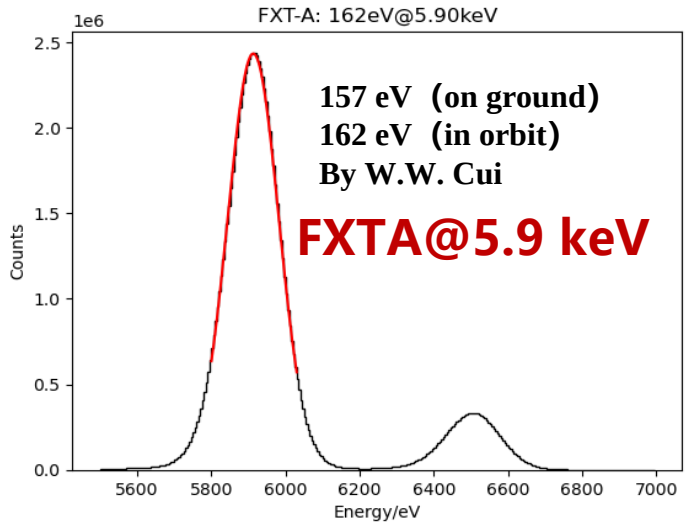


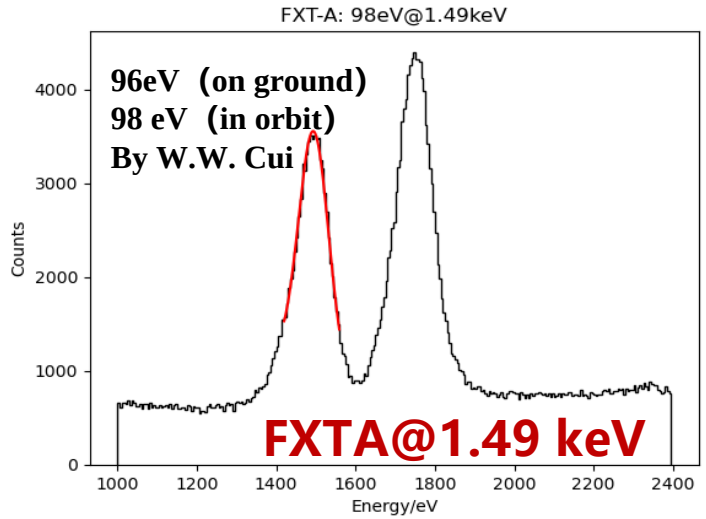
Energy resolution (compared with ground measurements, FM4, CMOS16)

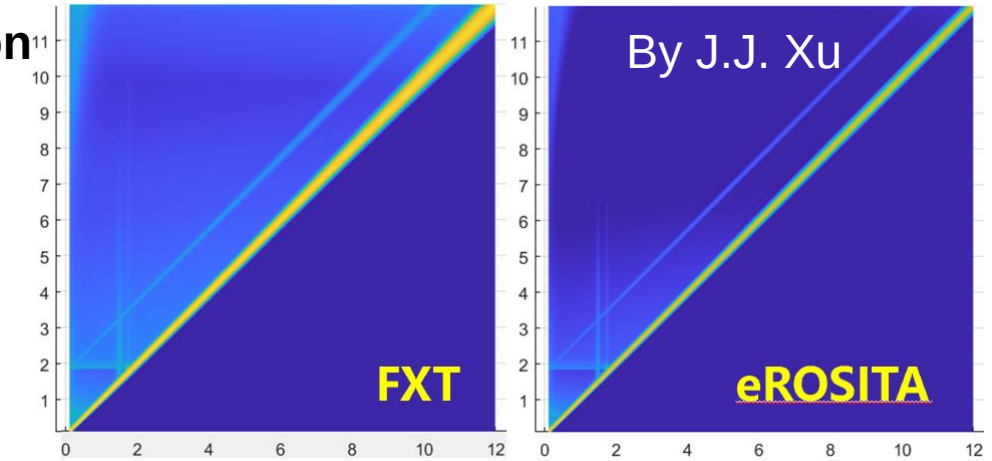
No obvious variations in GAIN and energy resolution for most of the detectors after launch. See Huaqing's talk in detail.

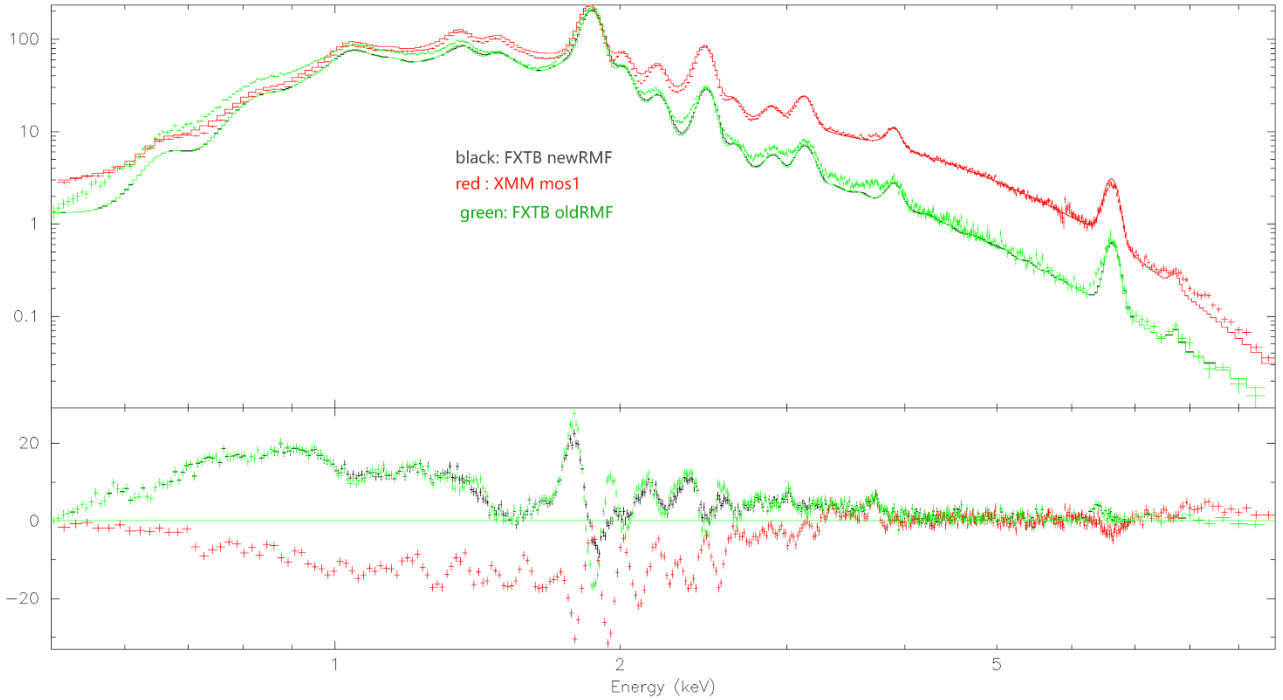
FXT calibration

Variation in Energy Resolution - RMF Correction









Summary

- Science operations have been started since July 2024
- ~110 X-ray transients with high/SN detected
- A wide range of targets: FXT, GRB, TDE, WD+NS+BH, flaring stars, MMA ……
- Monitored the activity of large samples of known sources
- Great potential for more discoveries in X-ray time-domain and MM astronomy

http://ep.bao.ac.cn
https://www.esa.int/Science_Exploration/Space_Science/Einstein_Probe_factsheet

Thanks to the Swift, NICER, NuSTAR, XMM, Chandra, etc. and ground-based optical and radio telescopes around the world for supports of follow-up observations