Current Status of KOYOH Satellite

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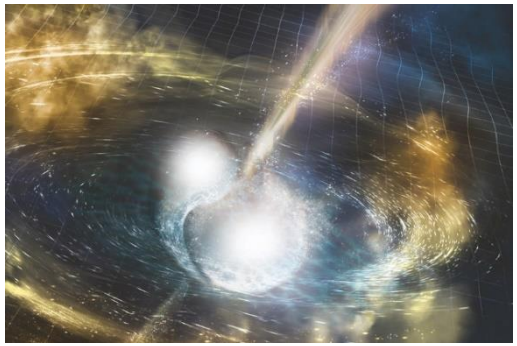
KOYOH satellite

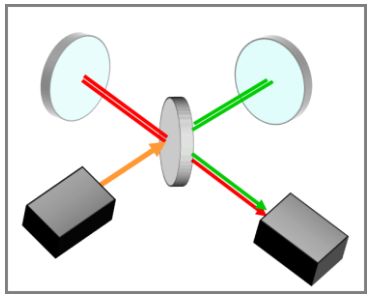
Merger of Compact Binary System



credit: NSF/LIGO/Sonoma State University/A. Simonnet

GW

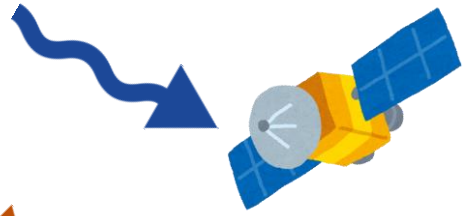
☞measuring mass of progenitors



GRB

X-rays, gamma-rays

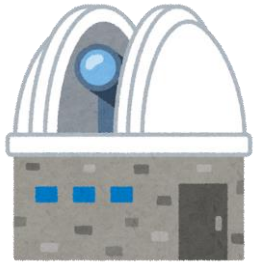
☞measuring energy radiation mechanism



kilonova

optical, NIR

☞identifying heavy elements



X-ray transient monitoring associated with GWs

Searching for the progenitors of GRBs

- ✓ Binary neutrons stars (Abbott+17)
- ✓ Neutron star and black hole?

follow-up observation of kilonovae r-process element nucleosynthesis

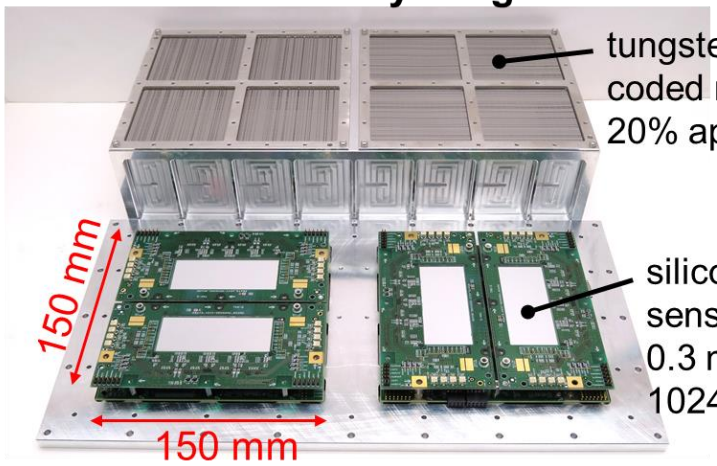
- ✓ absorption line of Ce (Domoto+22)
- ✓ More heavy elements?

✓ Rapid alert of time and direction with wide field X-ray/gamma-ray monitors to contribute multi-messenger astronomy

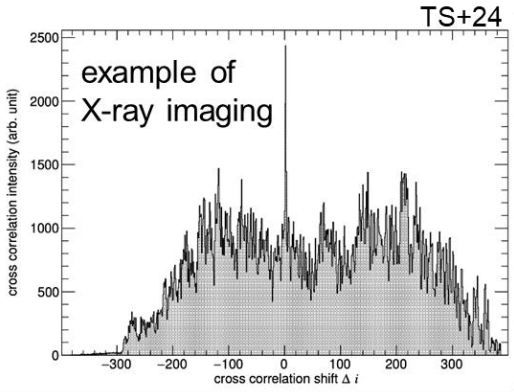
Satellite system and mission instruments

Mass	43 kg
Dimensions	502 mm x 491 mm x 498 mm
Designated Mission Life	More than 1 year
Orbit	Sun-Synchronous Orbit (SSO), LTDN 10:00am, alt. 560 km

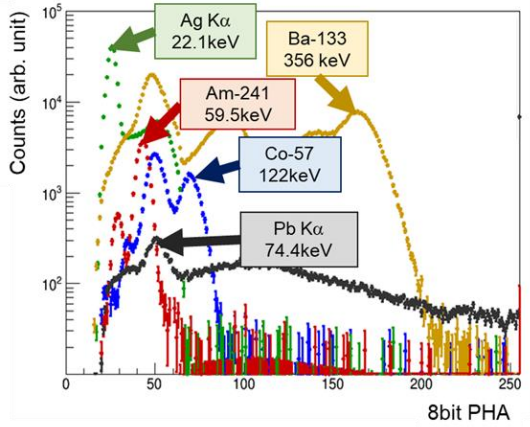
Wide-Filed X-ray imager T-LEX



Gamma-ray Detector KGD



	T-LEX	KGD
localization accuracy	~ 15 arcmin	—
energy range	4 – 20 keV	20 – 300 keV
FoV	≳ 1 steradian	~ 3 steradian
time resolution	8 ms	8 ms
sensor area	98 cm^2	98 cm^2
power consumption	3.0 W	0.35 W

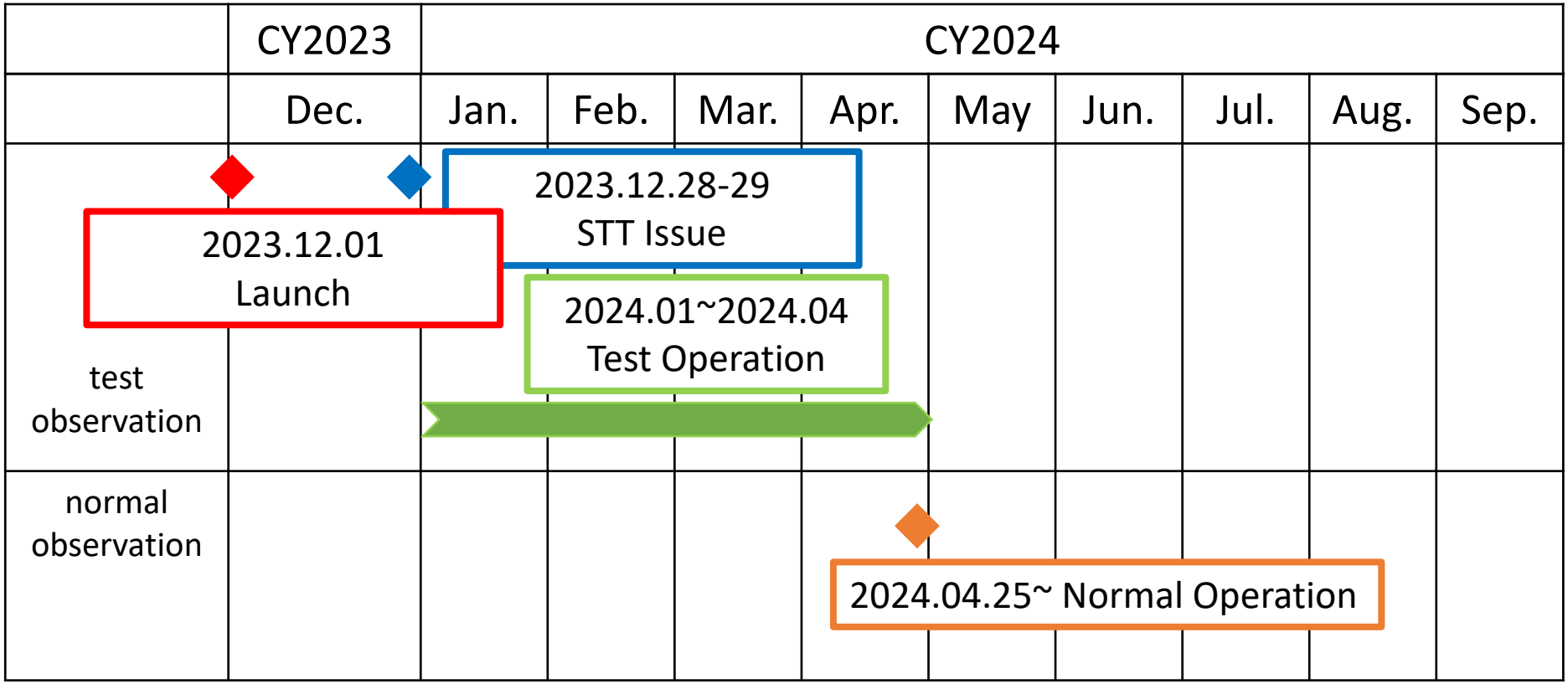


Initial Operations and Health Check of Observation Instruments

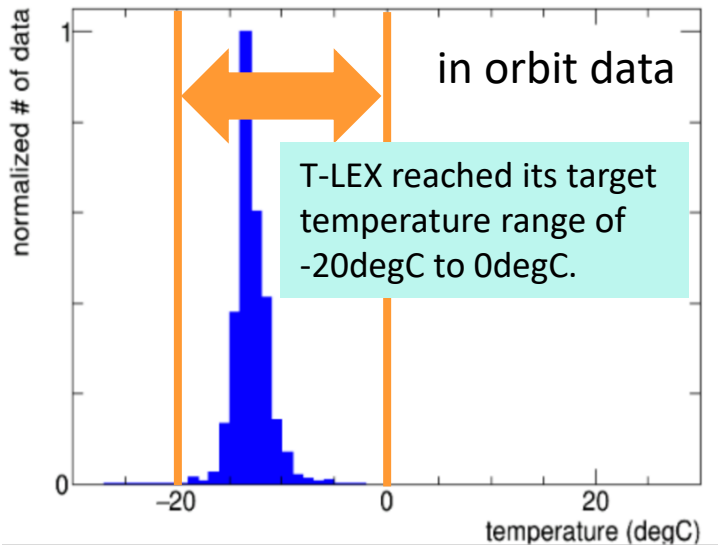
- **Verification Items for Bus Systems**
  - Temperature range check: ✔(△)
    No heater with KGD, but operationally stable
  - Electrical verification of mission equipment power on/off: ✔
  - Communication check
    between the onboard computer and subsystems: ✔
  - Transfer of transient event data to the data recorder: ✔
- Verification Items for Mission Systems
  - Count rate measurement: ✔
  - Imaging performance: **Pending (Postponed due to STT issue)**
  - Spectral measurement: ✔
  - Transient event detection: ✔

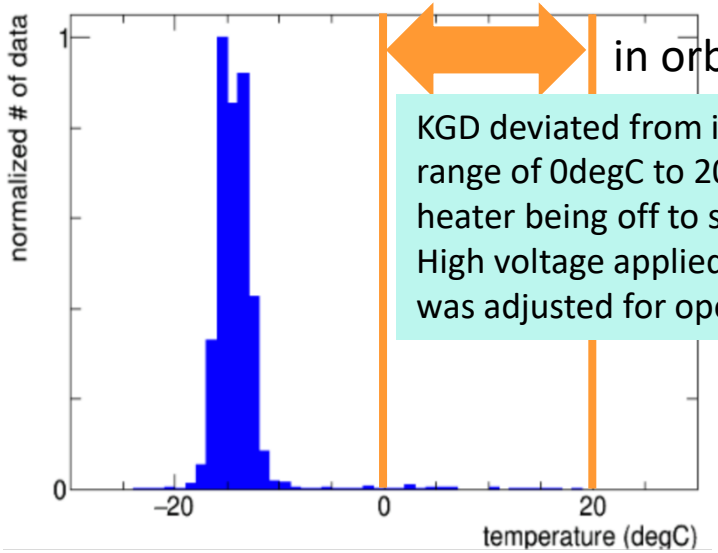
Operational Results of Observation Instruments

- In December, an issue occurred with the STT;
  observations were conducted using the inertia sensor with a best-effort approach.
- Experimental observations were carried out between January 2024 and April 2024.
- Regular mission operations for the instruments began on April 25, 2024.
- Trigger thresholds for transient events were adjusted during experimental observations.

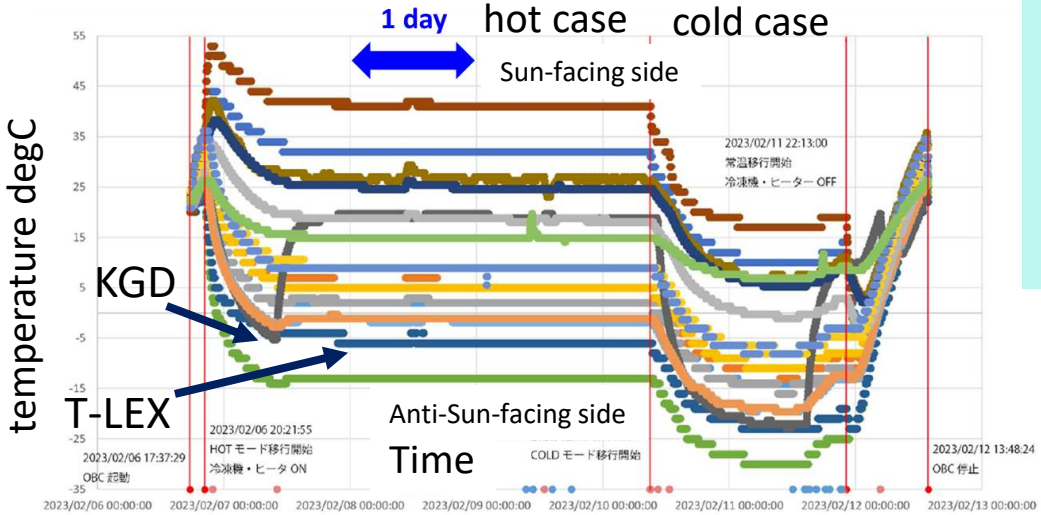


Thermal Environment of Observation Instruments





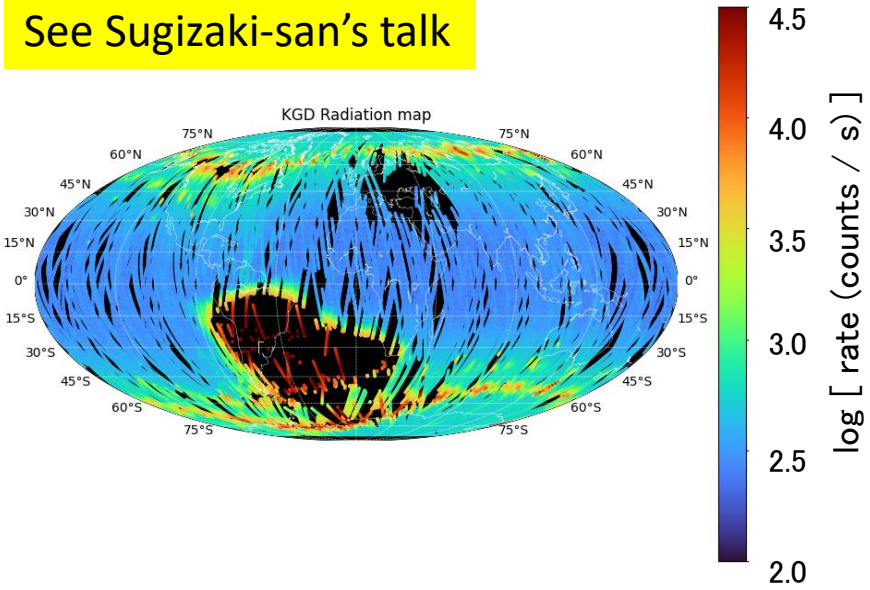
Temperature profile at thermal-vacuum test



In ground thermal vacuum tests, both T-LEX and KGD were expected to operate between -20degC and -5degC with the heater off.
On-orbit temperature data closely followed the ground test results.

Measured count rate

See Sugizaki-san's talk



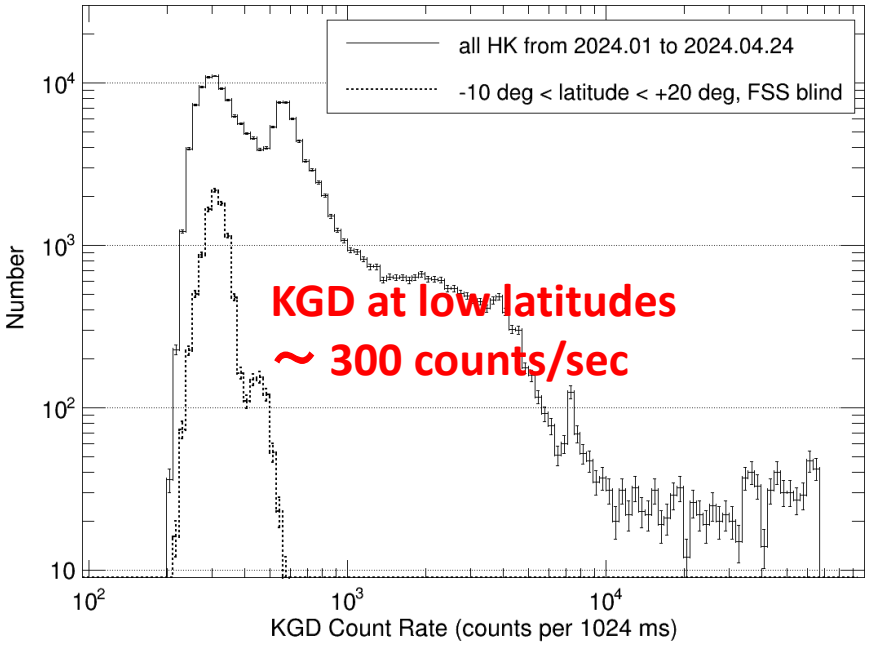
Increase in the electron belts and the SAA
Stable counts near the equator
Spectral model of CXB (Ajello+08)

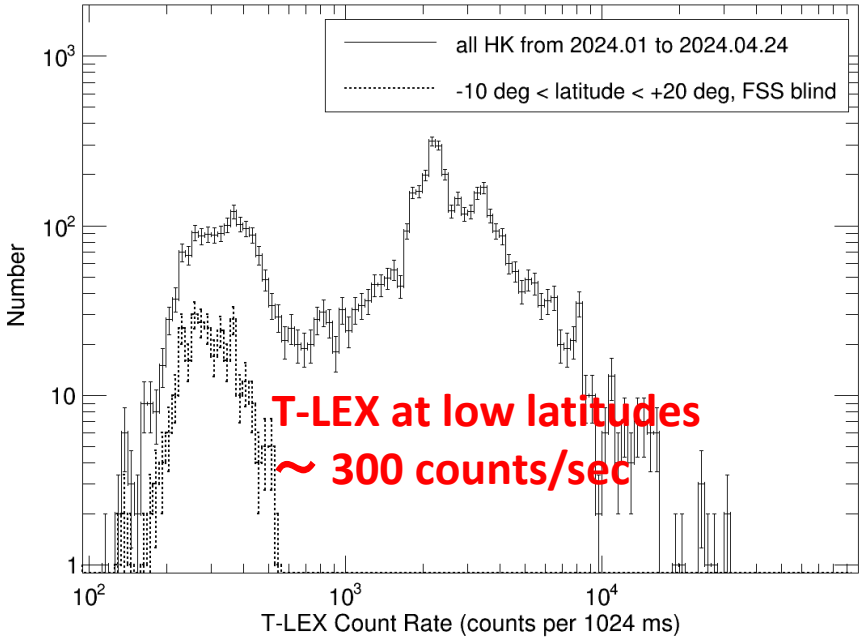
$$\frac{dN}{dE} = \frac{0.1015}{(E/29.99\,\mathrm{keV})^{1.32} + (E/29.99\,\mathrm{keV})^{2.88}}\ \mathrm{photons\,cm^{-2}\,s^{-1}\,sr^{-1}\,keV^{-1}}$$

T-LEX 4 – 20 keV, A = 20 cm^2, FoV = 1.5 sr
⇒photon flux ～ 200 counts/sec

KGD 20 – 300 keV, A = 100 cm^2, FoV = 3 sr
⇒photon flux～ 500 counts/sec

consistent within factor 2, ongoing analysis

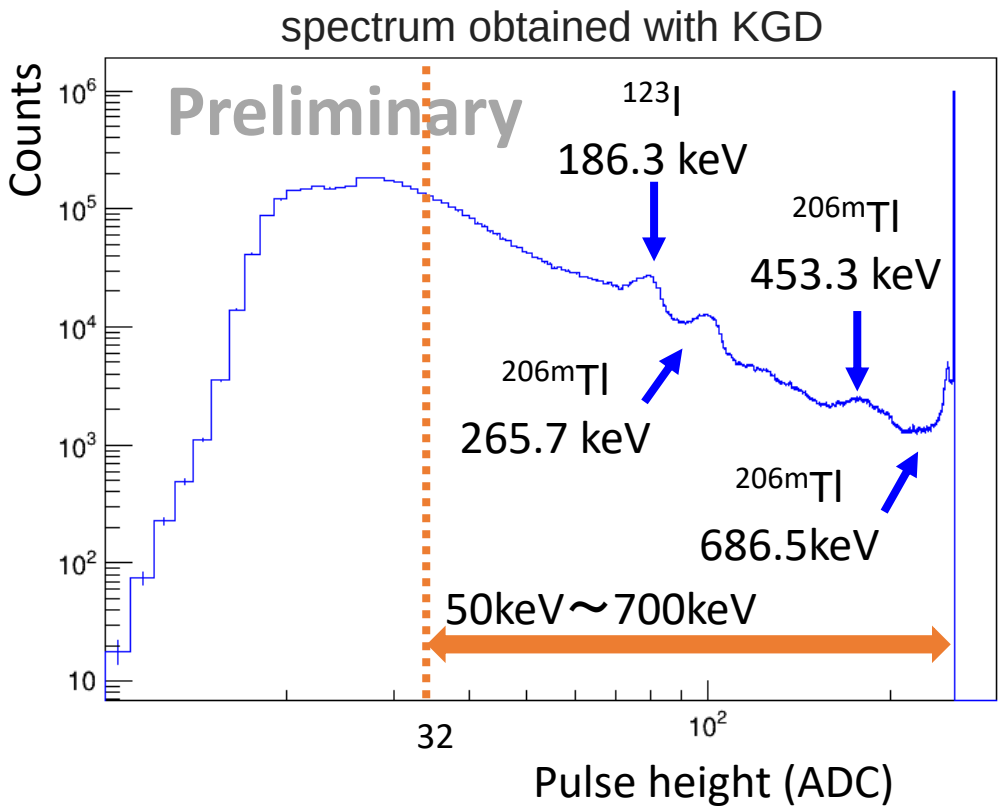




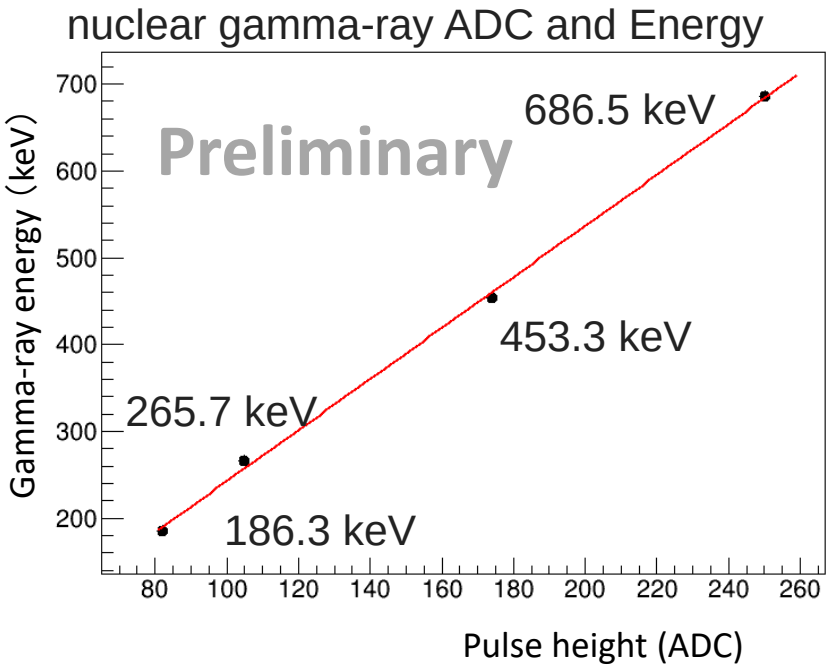
Measured spectrum with KGD

See Takahashi Naoki-san's poster

- Obtained at the night side of low latitudes on 2024-02-10（10 orbit exposure）
- Measured nuclear gamma-rays from activated scintillator



^{123}I 159.00 keV (99.2%) + Te Kα 27.3 keV
= 186.3 keV



Trigger Threshold and Observation Interval Adjustments

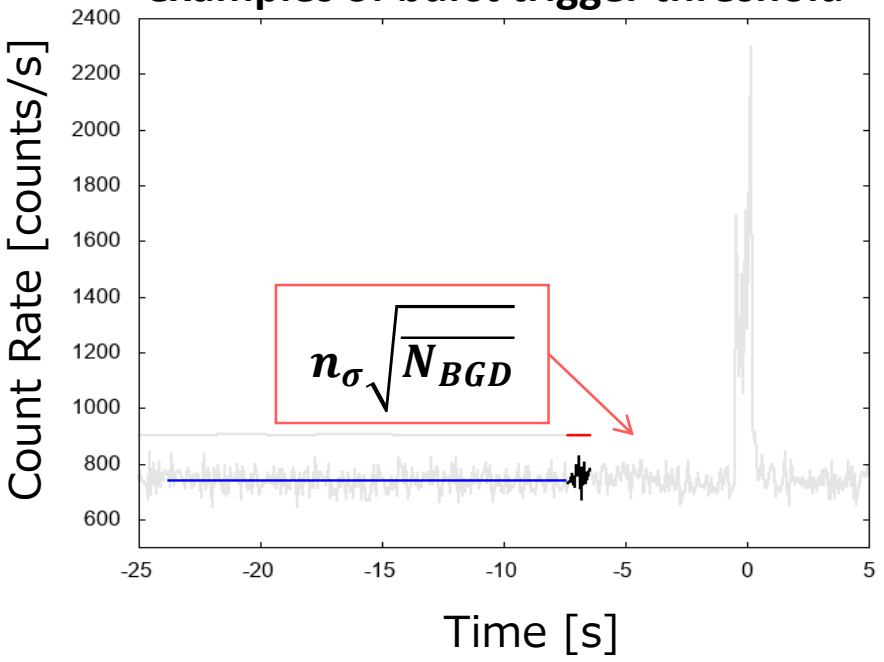
- Detecting bursts focused on prompt emission (~300 ms).
- Burst detection based on light curves with 64 ms and 1024 ms time bins.

burst trigger threshold

$$N - \overline{N_{BGD}} \geq n_\sigma \sqrt{\overline{N_{BGD}}}$$

- N : latest measured counts
- $\overline{N_{BGD}}$: average counts over past 16 sec
- n_σ : detection significance level

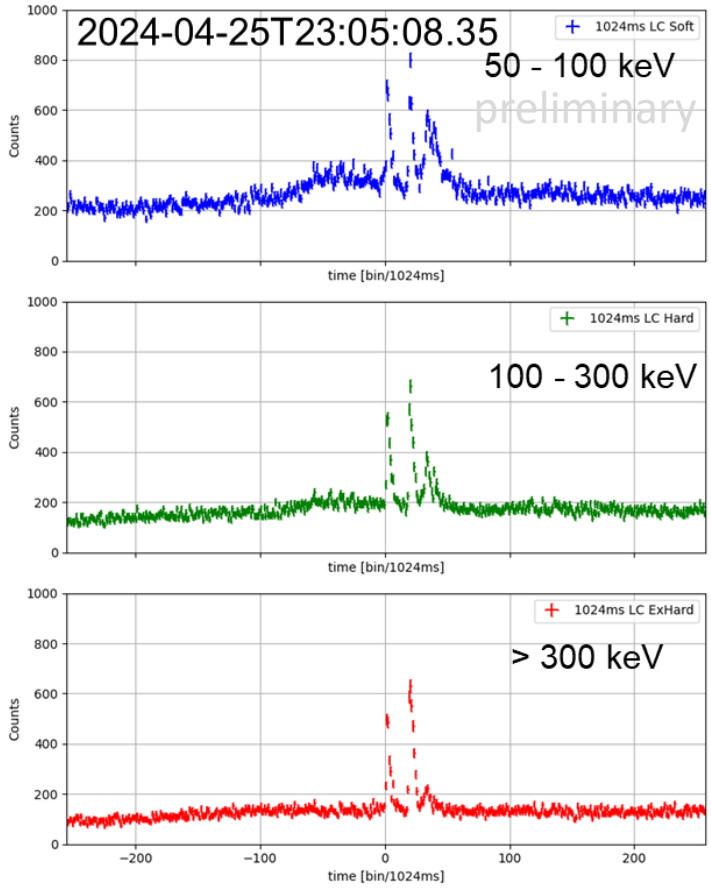
examples of burst trigger threshold

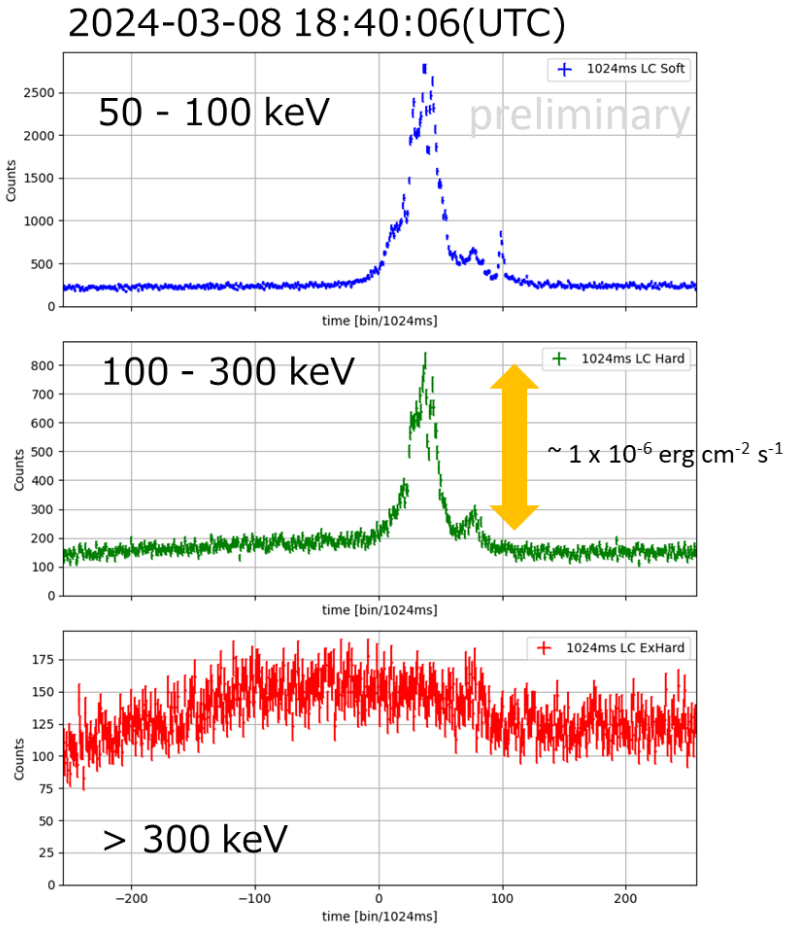


Calculating Poisson fluctuations of count rates over the past 16 seconds every second, and identifying a burst when a significant increase in counts is observed.

Examples of obtained burst light curve

- Set the detection threshold n_σ = 8(1024ms) and 12(64ms),
  and started regular operations on April 25, 2024.
- Restrict detection to low latitudes near the equator for up to 18 minutes per orbit.
  (however, high-latitude data is occasionally recorded due to command transmission errors).





Summary

Achievements of KOYOH

- ✓ First astronomical observation data obtained by instruments onboard a Japanese 50-kg class university satellite.
- ✓ Both observation instruments have been confirmed to be electrically and functionally healthy.
- ✓ Imaging functionality verification of T-LEX remains a future task.
- ✓ Stable radiation conditions near the equator suggest signals attributable to cosmic X-ray background radiation.
- ✓ Transient event detection capability has been confirmed.
- ✓ Investigating the relationship between detected transient events and gamma-ray bursts.