Spectral Calibration of Microsatellite KOYOH

Credit: SpaceX

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on behalf of KOYOH Team

KOYOH microsatellite

- **50-kg Class, Developed by Kanazawa University**
- satellite conceptual design since 2015, and launched on Dec. 1, 2023.

Mission:

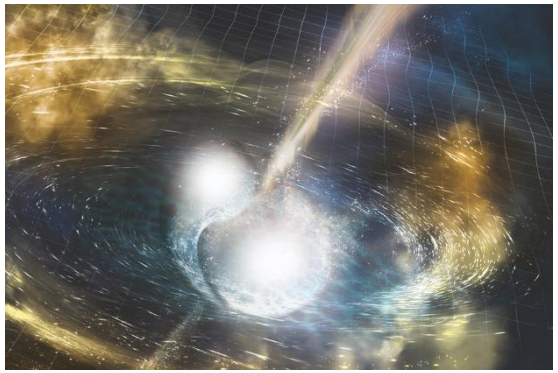
- To observe X-ray transients such as gamma-ray bursts (GRBs).
- To alert other telescopes with the trigger time and direction information of the transients.

Key Science:

- Can NS-NS and/or NS-BH mergers be progenitors of short gamma-ray bursts (GRBs)?
- How long is the observation time delay between the signal loss time of the GW and the GRB, and what causes it? (jet launch time, radiation process, etc…)
- What kind sources of short GRBs and GWs produce red/blue kilonovae?

Mission Instruments:

- Wide-field X-ray imager
- Gamma-ray detector



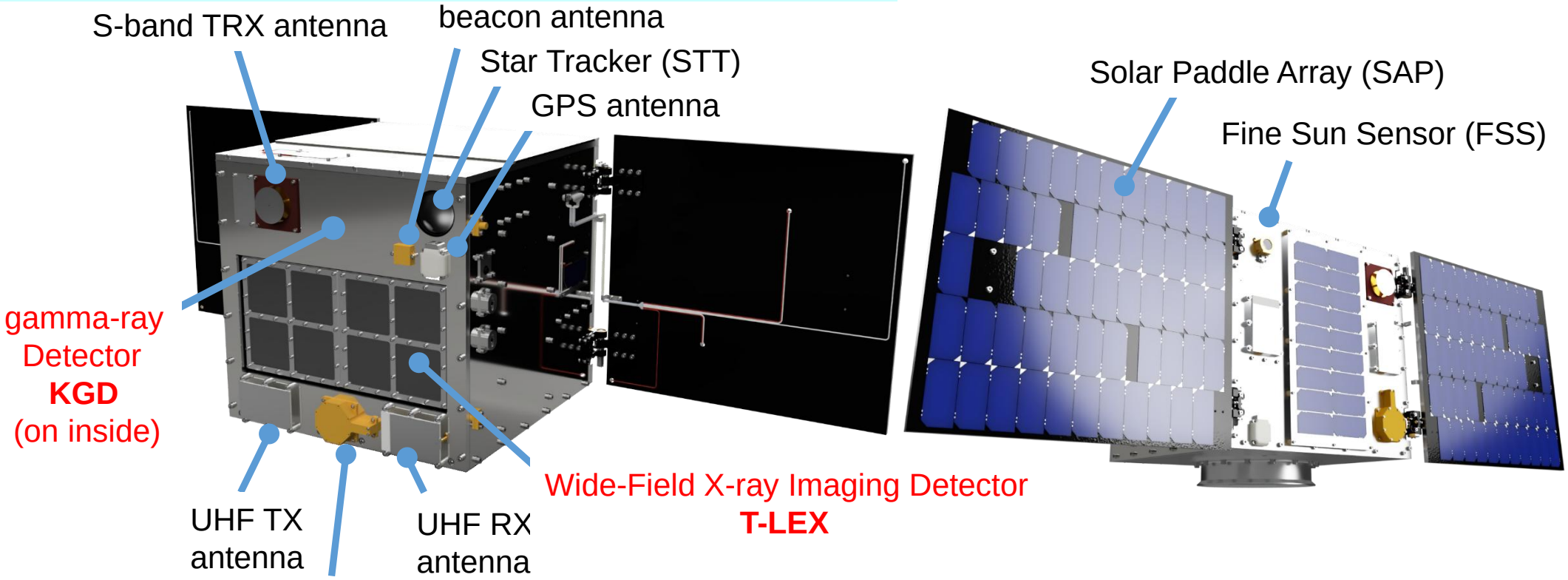
credit: NSF/LIGO/Sonoma State University/A. Simonnet

KOYOH satellite system overview

Satellite Operation:

- ✓ Maintains inertial pointing toward the Sun using three-axis reaction wheels.
- ✓ Carries two mission instruments
- ✓ Onboard X-ray transient trigger system.
- ✓ rapid alert via Iridium satellite communication module.

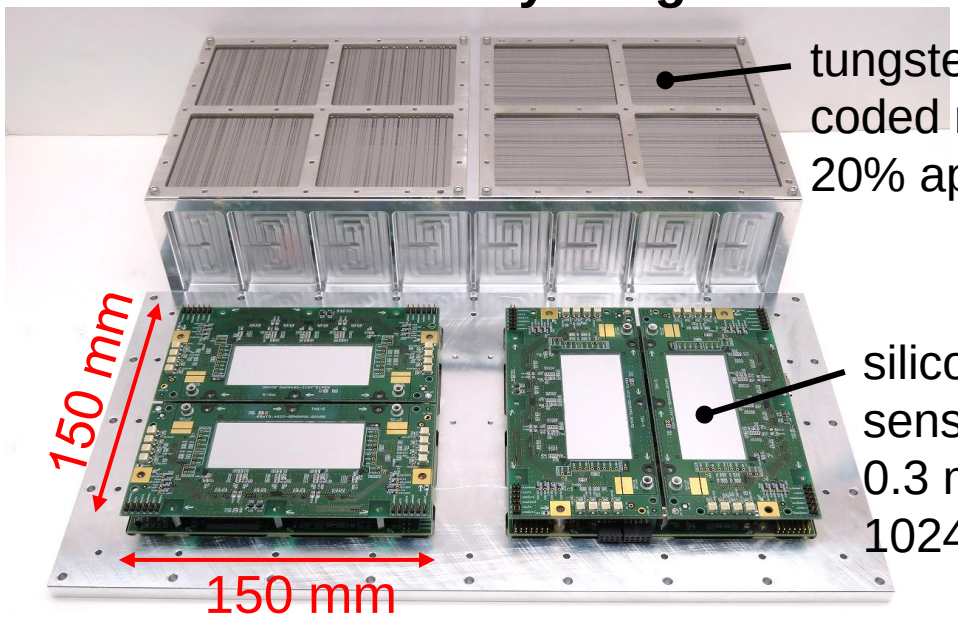
Mass	43 kg
Dimensions	502 mm x 491 mm x 498 mm
Designated Mission Life	More than 1 year
Orbit	Sun-Synchronous Orbit (SSO), LTDN 10:00am, alt. 560 km



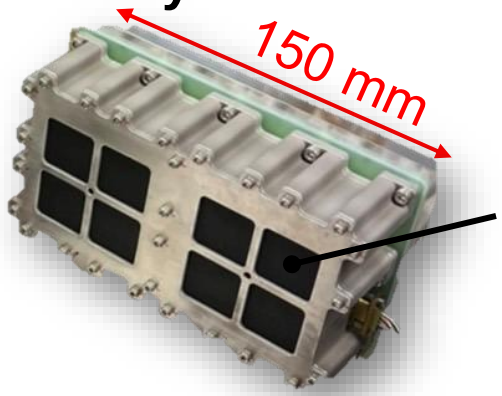
Iridium satellite telecommunication module (Short Burst Data; SBD)

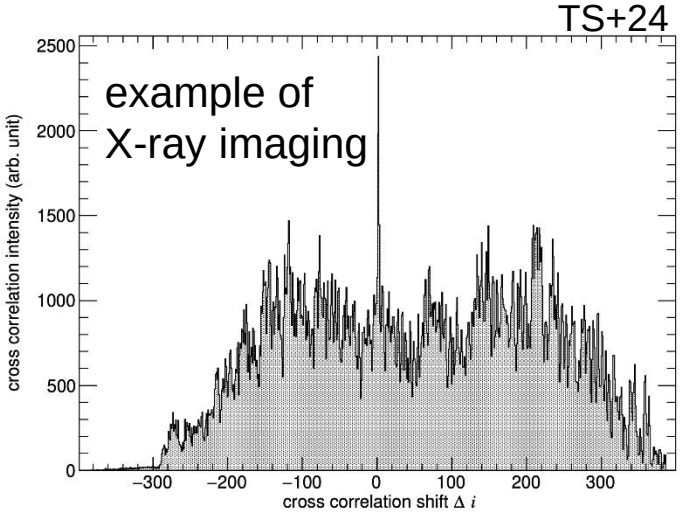
Mission Instruments

Wide-Filed X-ray imager T-LEX

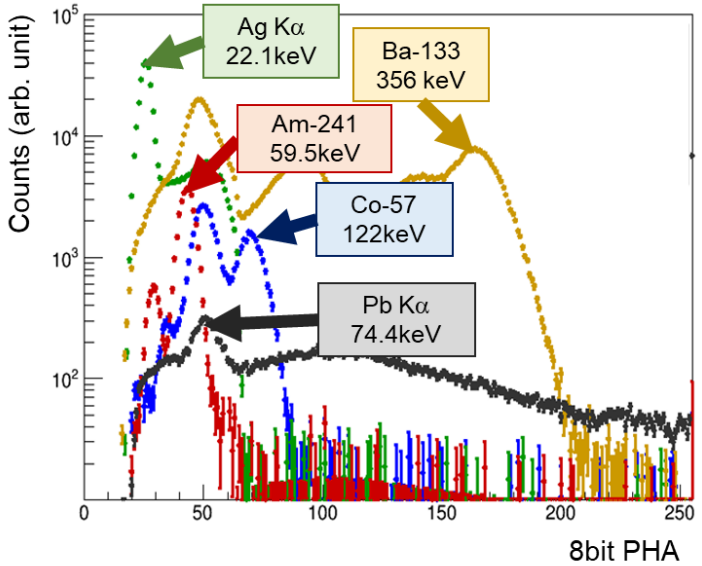


Gamma-ray Detector KGD



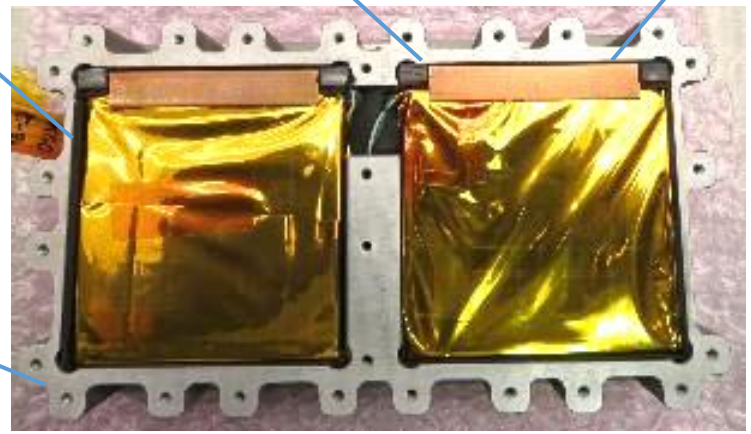


	T-LEX	KGD
localization accuracy	~ 15 arcmin	—
energy range	4 – 20 keV	20 – 600 keV
FoV	≳ 1 steradian	~ 3 steradian
time resolution	8 ms	8 ms
sensor area	98 cm^2	98 cm^2
power consumption	3.0 W	0.35 W

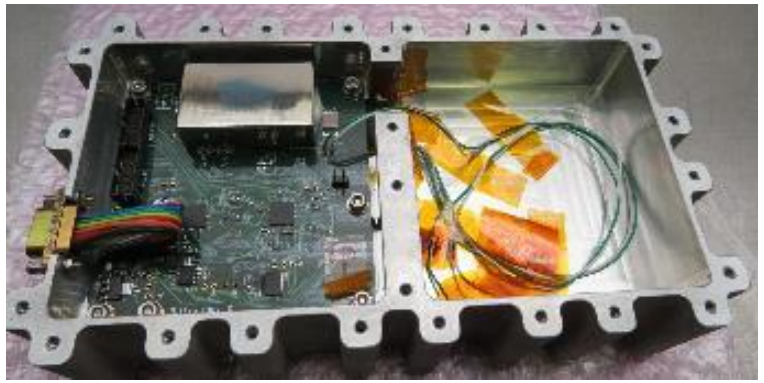


Readout Electronics of KGD

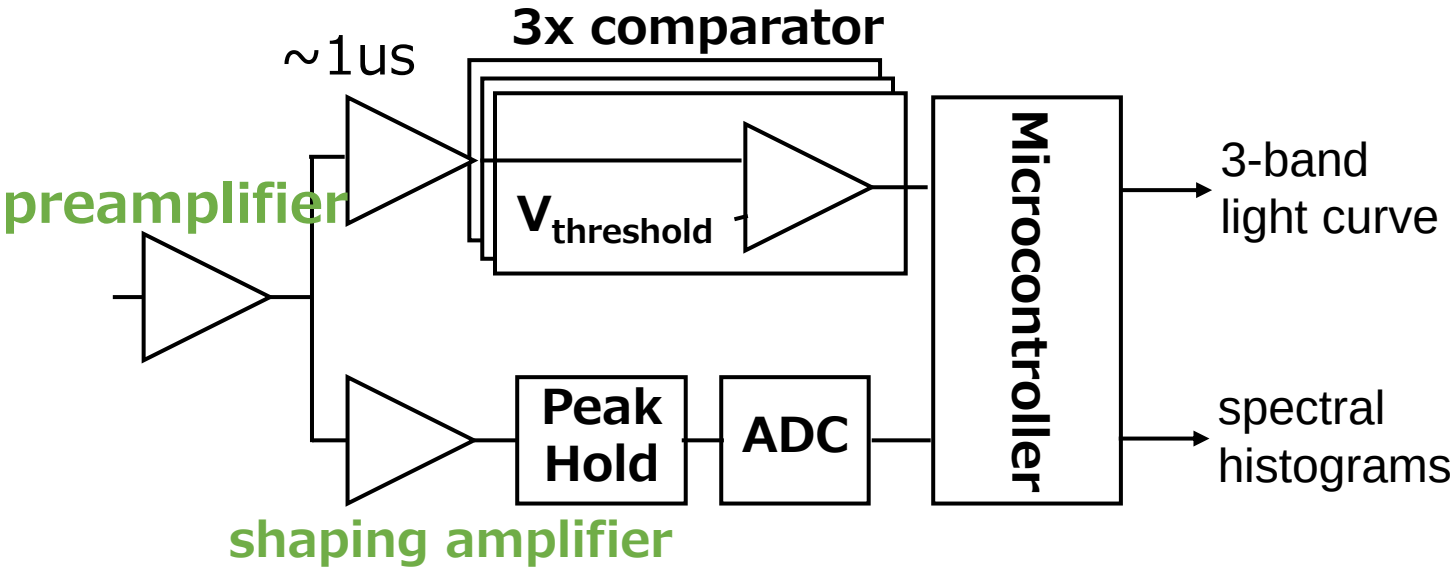
SiPM (12 pieces of 3mm x 3mm)



Front side



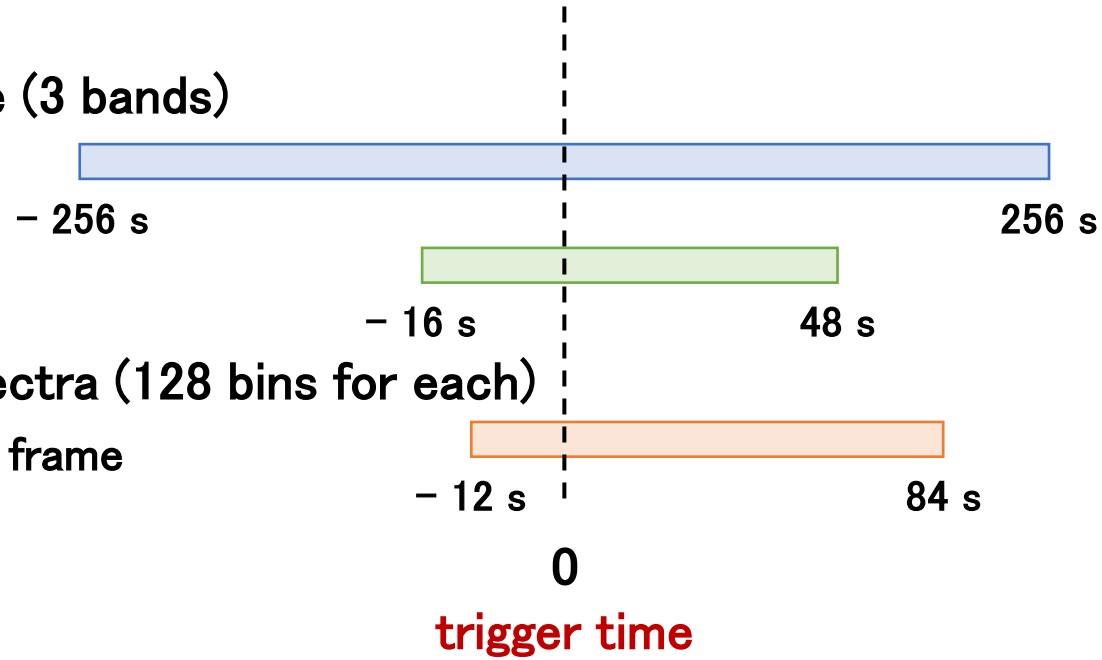
Back side



Format of Observation Data

Burst Data

- Light curve (3 bands)
  - 1024 ms
  - 64 ms
- Energy Spectra (128 bins for each)
  - 1024 ms frame



Calibration Data

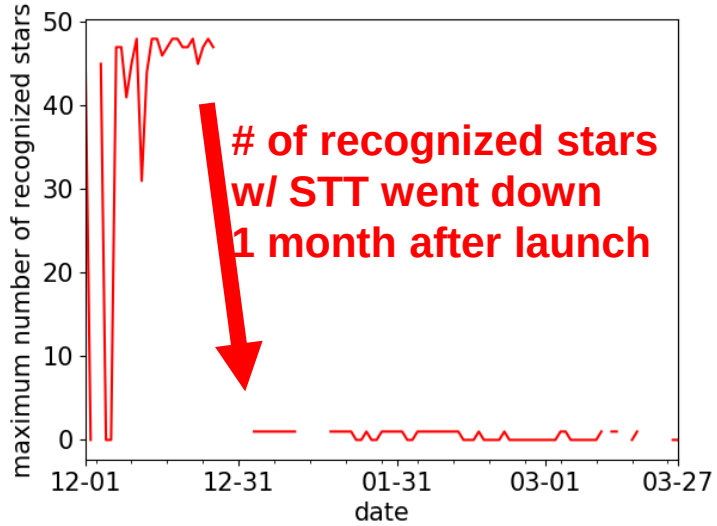
- Energy Spectrum (256 bins, one buffer)

Launch of the Satellite

Credit: SpaceX

Credit: SpaceX

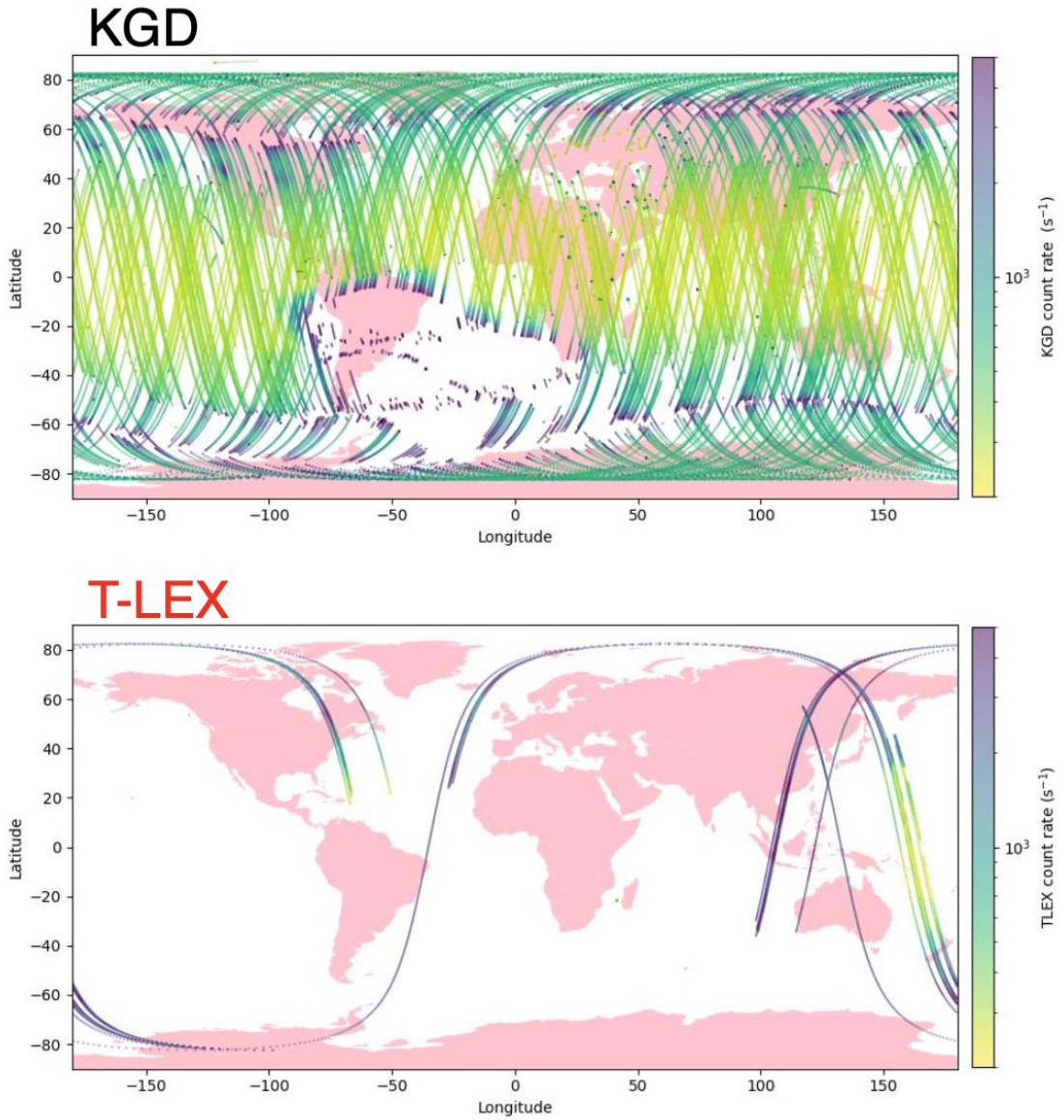
- KOYOH was launched on December 1, 2023 (UTC).
- Monitoring and control are performed via the S-band ground station at Kanazawa University.
- Initially, the bus system was healthy.
- About one month after launch, the star tracker stopped providing position data.
- Switched to gyro-based inertial pointing during the night side to continue operations.



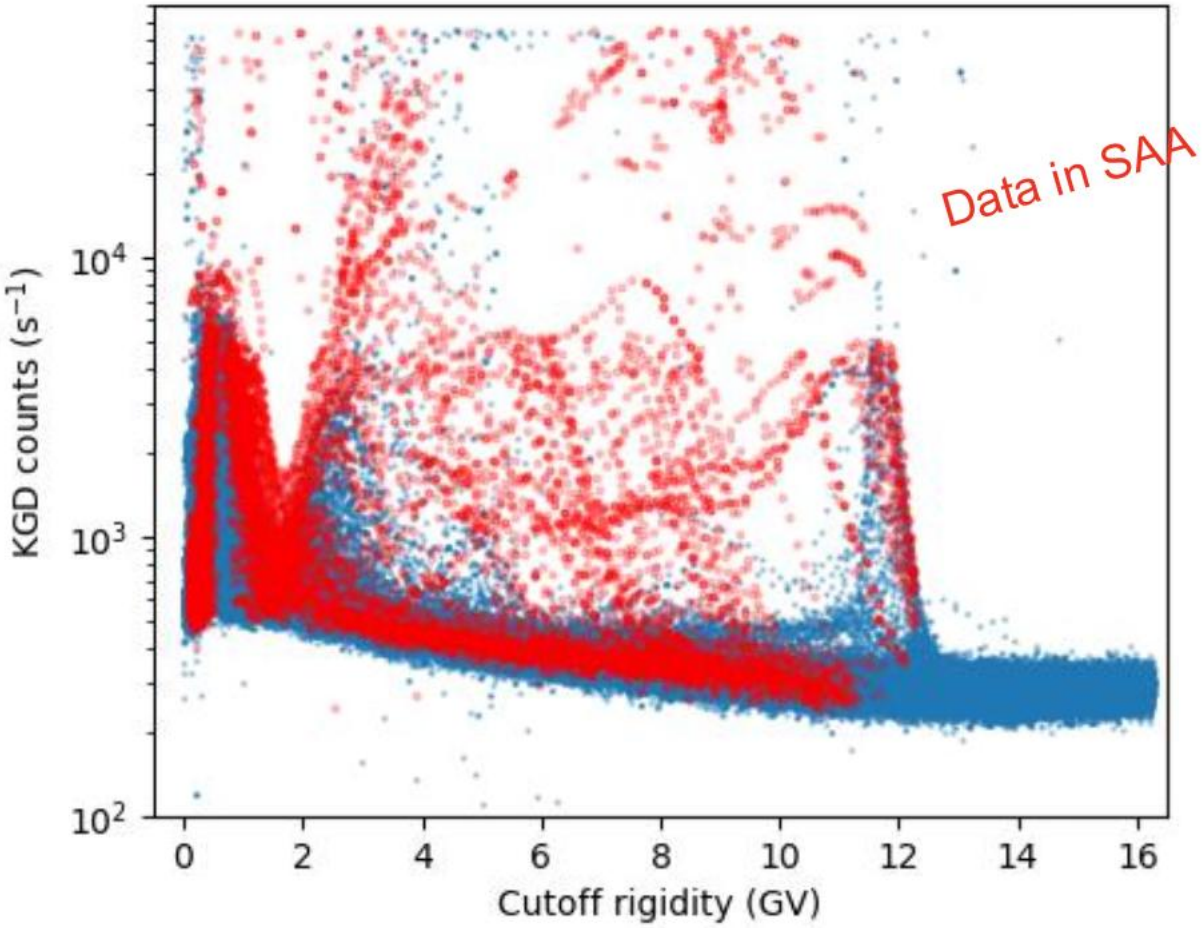
Satellite Data and Radiation Count Rate

- Data from Jan. to May in 2024
  - Available observation time of ~ 2 Msec
- Stored House Keeping Data
  - Stored every 16 (or 8) seconds
  - GPS (lat., long., alt.)
  - 1-sec light curve of instruments
- Auxiliary Data
  - Satellite Orbit (TLE)

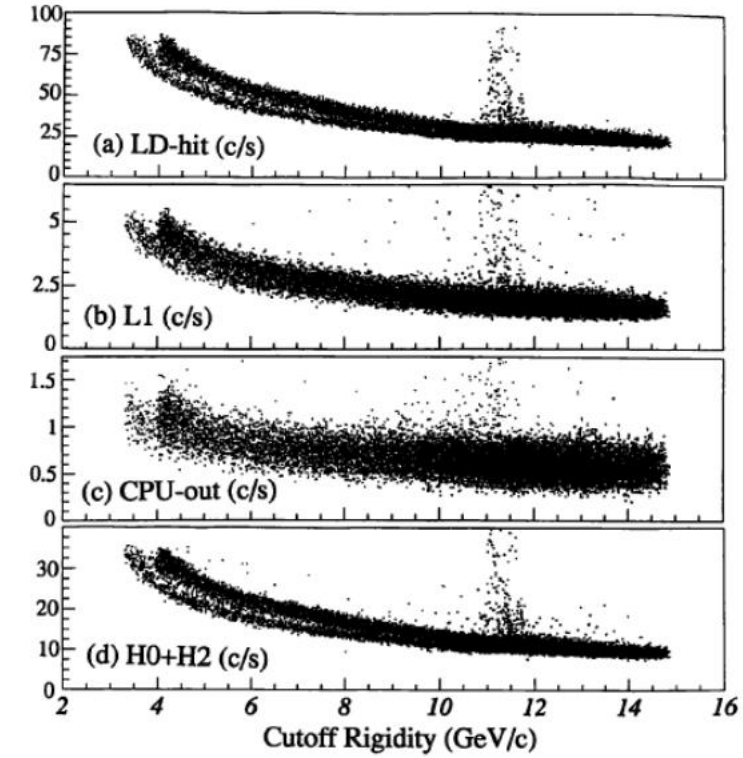
Clear increase of radiation count rate in aurora belt and SAA



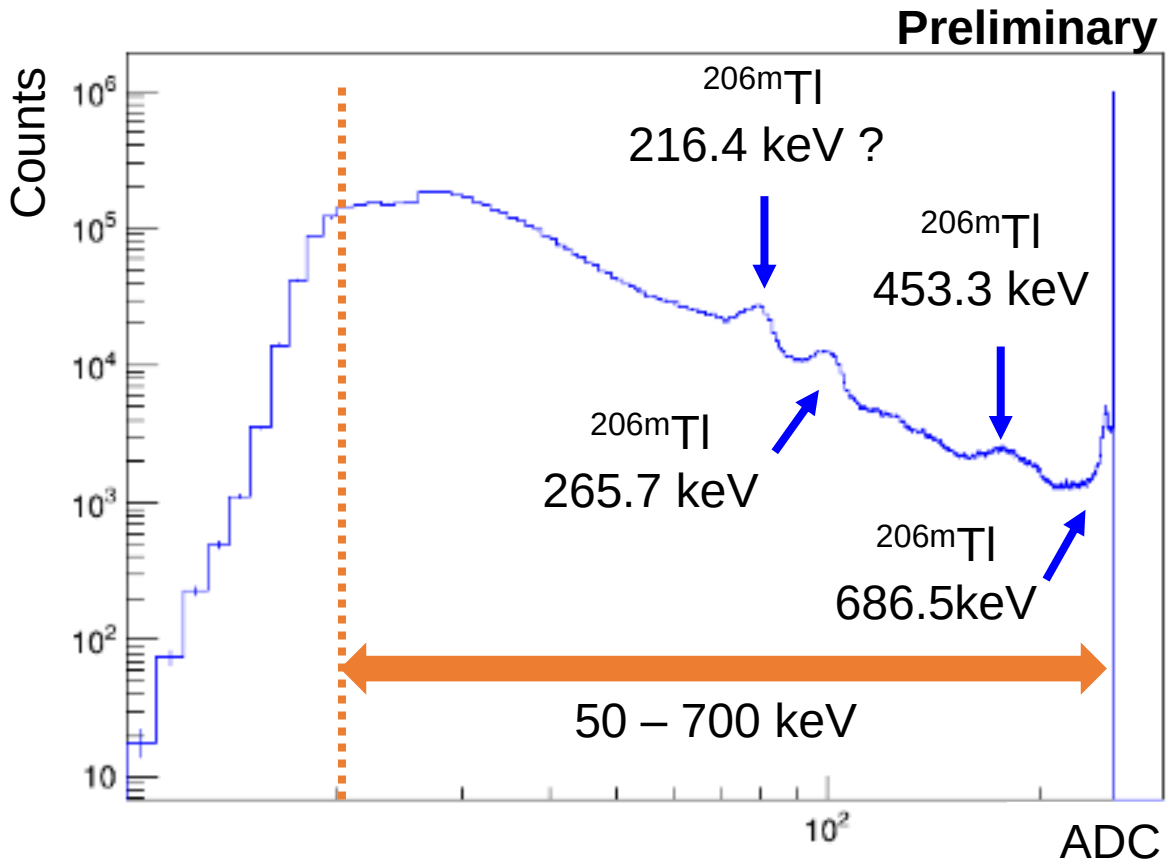
Correlation between Cutoff Rigidity and Radiation Count Rate

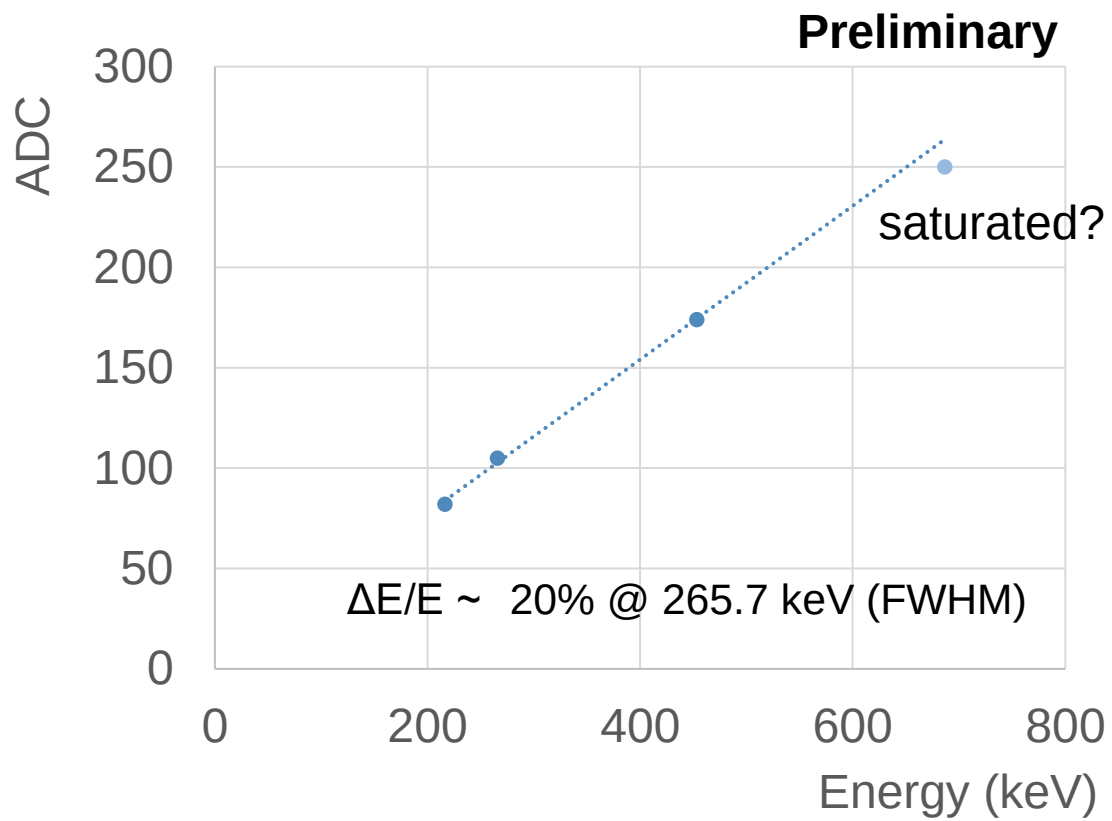


ASCA GIS
(Makishima+1996)

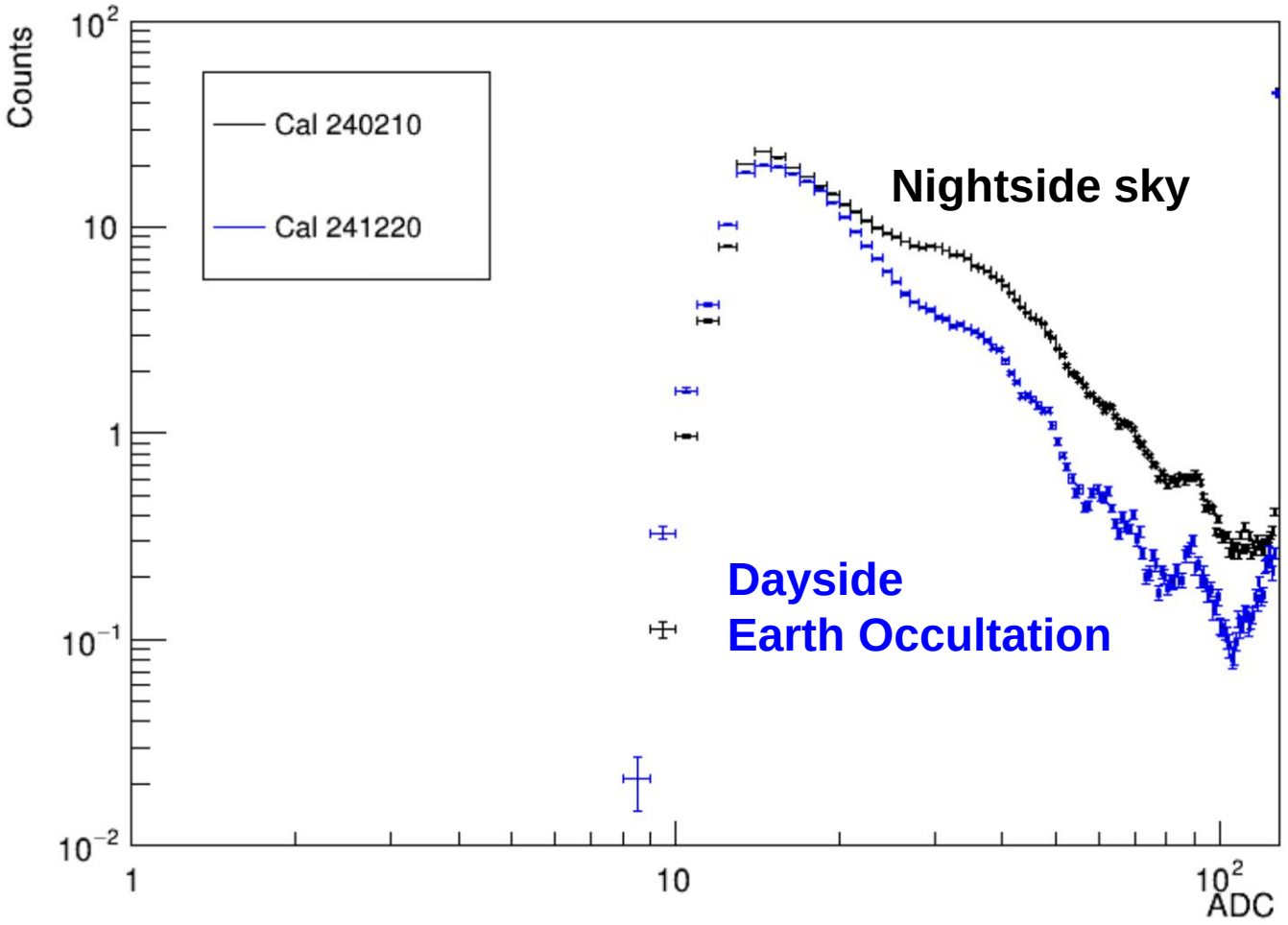


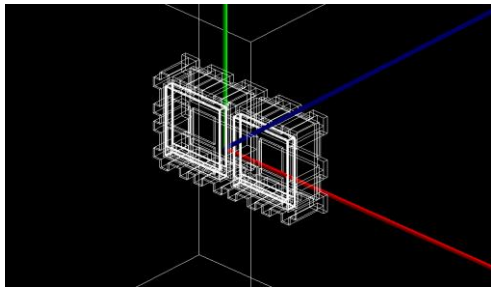
On-orbit Background Spectrum and Line Identification





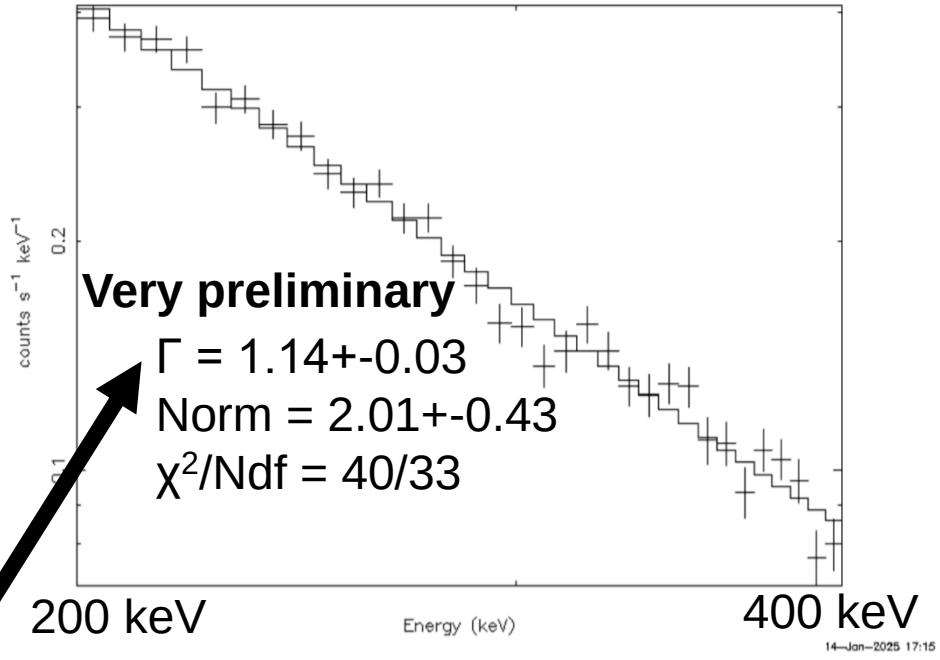
On-orbit Background Spectrum: Comparison between Deep Space and Earth Occultation





Response function constructed with Geant4

Subtracted spectrum



Harder than CXB – contribution from Galactic plane X-ray sources?

Summary and Future Prospects

- KOYOH is the first satellite developed and launched by Kanazawa University.
- Valuable on-orbit data has been obtained, and we aim to utilize it as scientific data.
- The satellite occasionally communicates with the ground, but when it does, the bus system temperature is often low.
- Due to limited power-on time for mission instruments, we continue operations with a long-term perspective.