Kanazawa-SAT^3

: Microsatellite-borne X-ray Transient Localization Experiment Searching for Electromagnetic Counterparts of Gravitational-wave Sources

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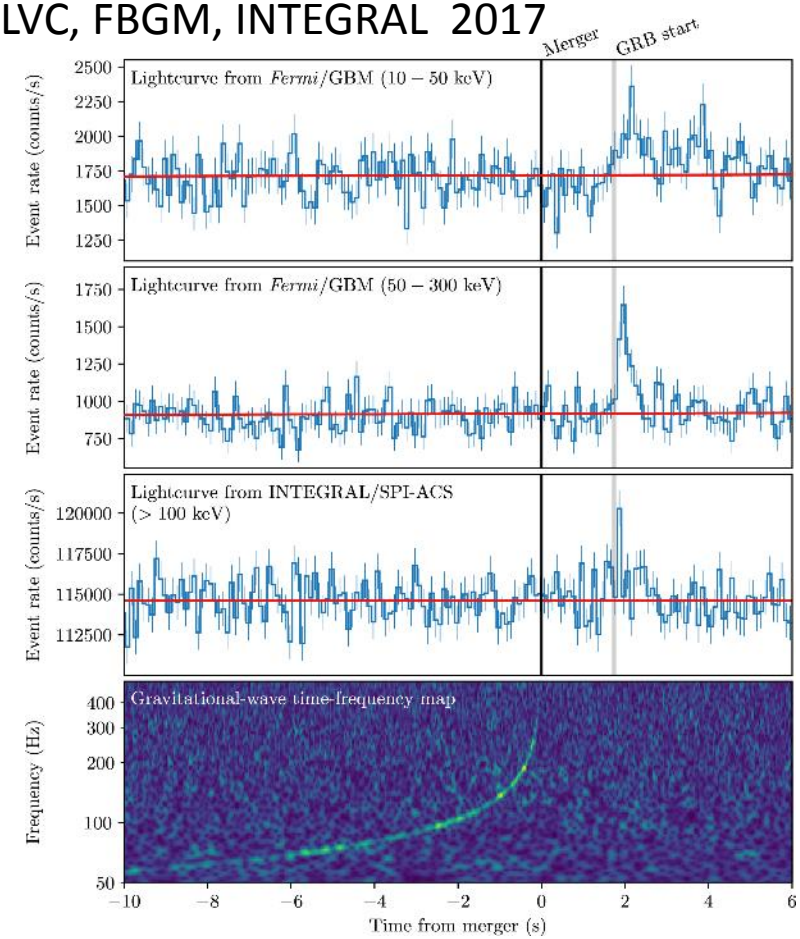
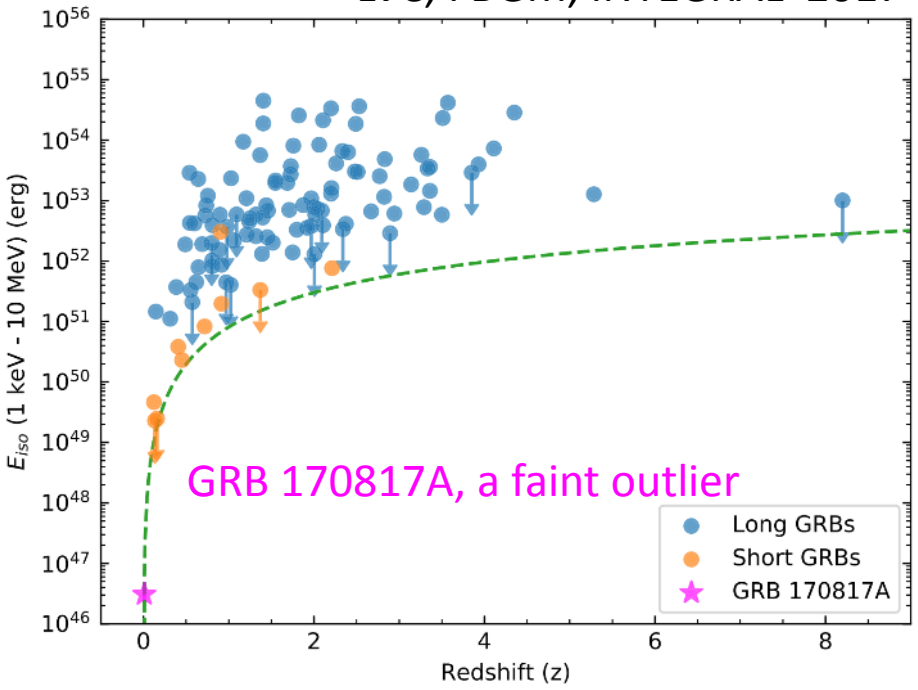
Eighth International Fermi Symposium, 2018-10-18, Baltimore, MD

Are NS-NS mergers really progenitors of short gamma-ray bursts?

LVC, FBGM, INTEGRAL 2017



LVC, FBGM, INTEGRAL 2017

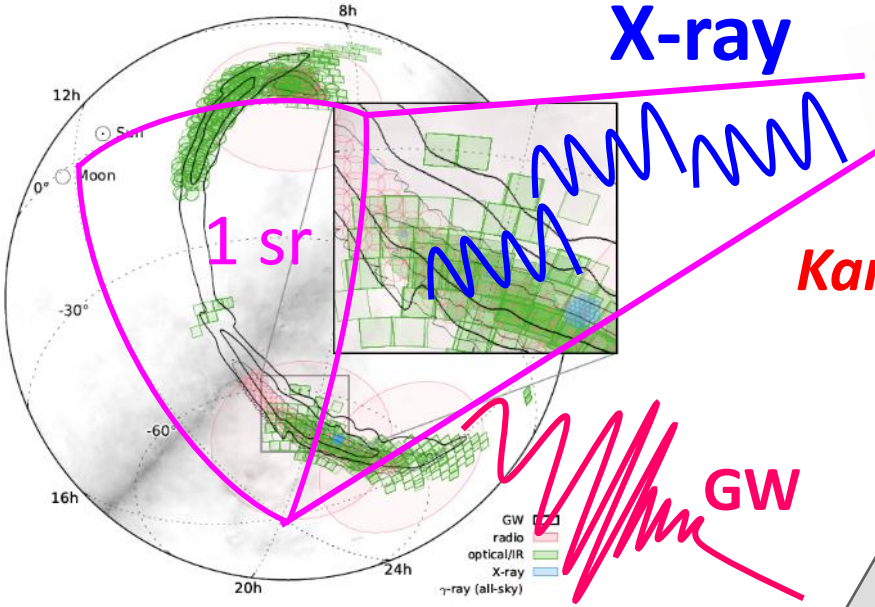


Jet geometry, or cocoon shock breakout?

Short GRB monitoring associated with GW observation is still crucial to investigate extreme environments at the moment of coalescence of binary compact objects!

Objectives of *Kanazawa-SAT*^{3}

- monitoring a wide FoV of 1 sr,
  localizing X-ray transients within ~ 15',
  contributing to gravitational wave astronomy
- alerting the trigger times and coordinates of transients
  using a commercial mobile satellite service with latencies of
  1 min for a few percent of events, and less than a few hours for the others



Abbott+ 2016

X-ray

!

Kanazawa-SAT^3

X-ray transient alert

✓ trigger time
✓ coordinates

optical/NIR/radio

OK

GW

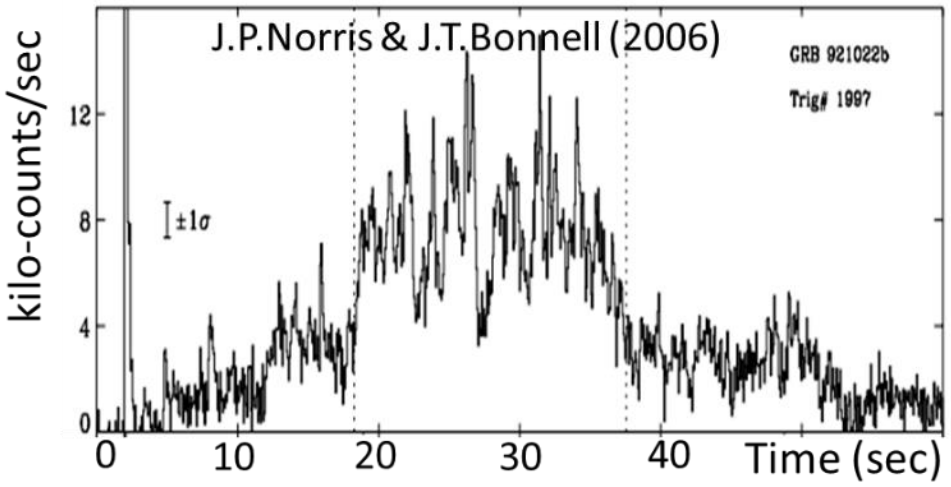
alert on GW

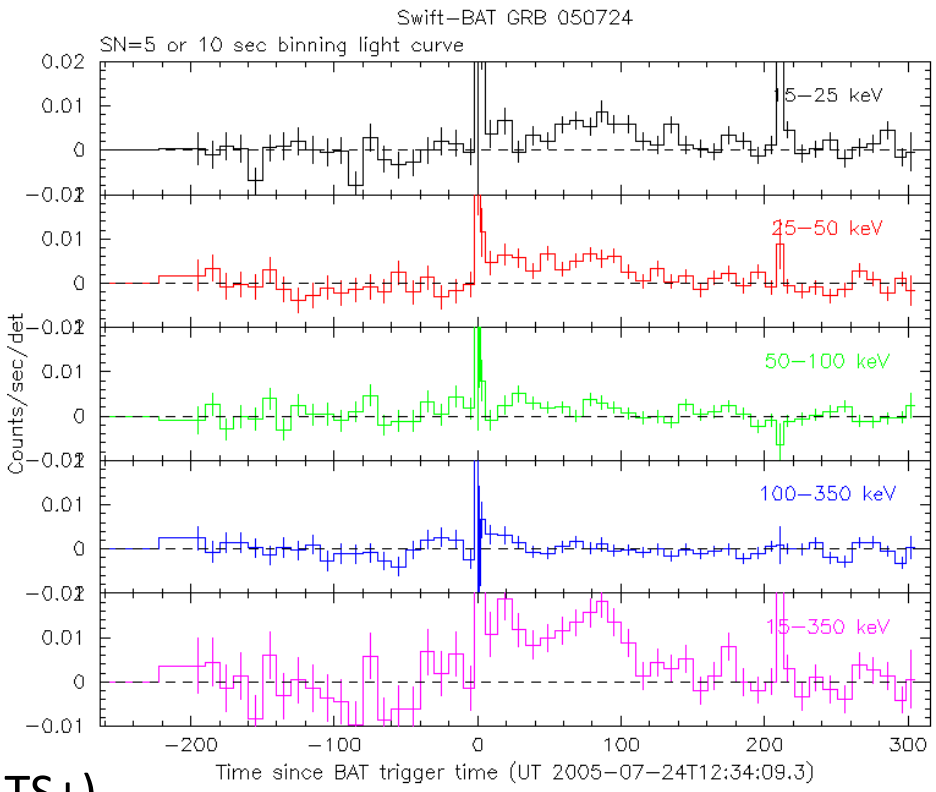
GW detectors

ground telescopes

X-ray extended emission associated with short GRBs

https://gcn.gsfc.nasa.gov/notices_s/147478/BA/



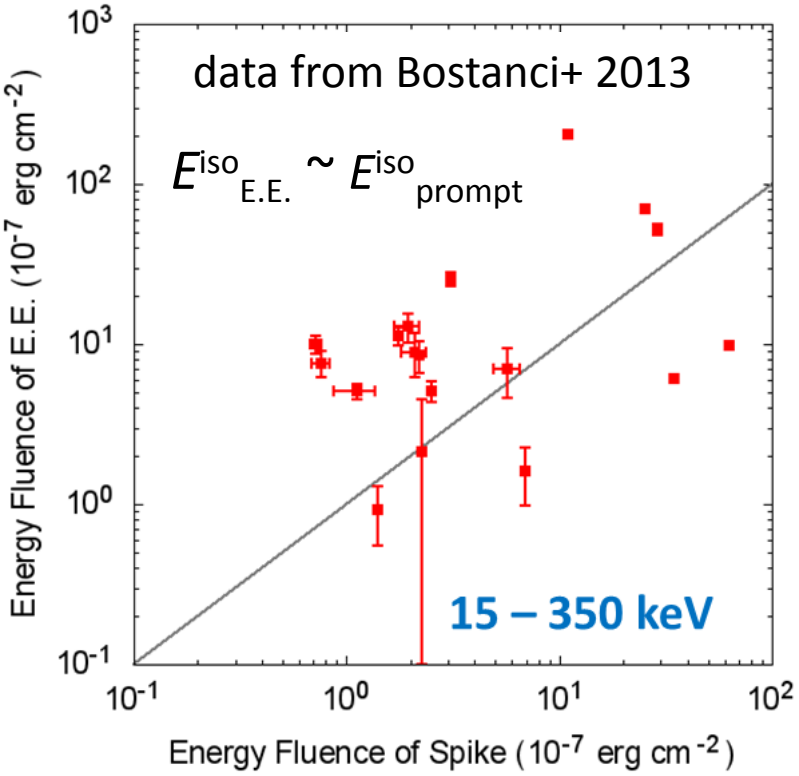


Association fraction:

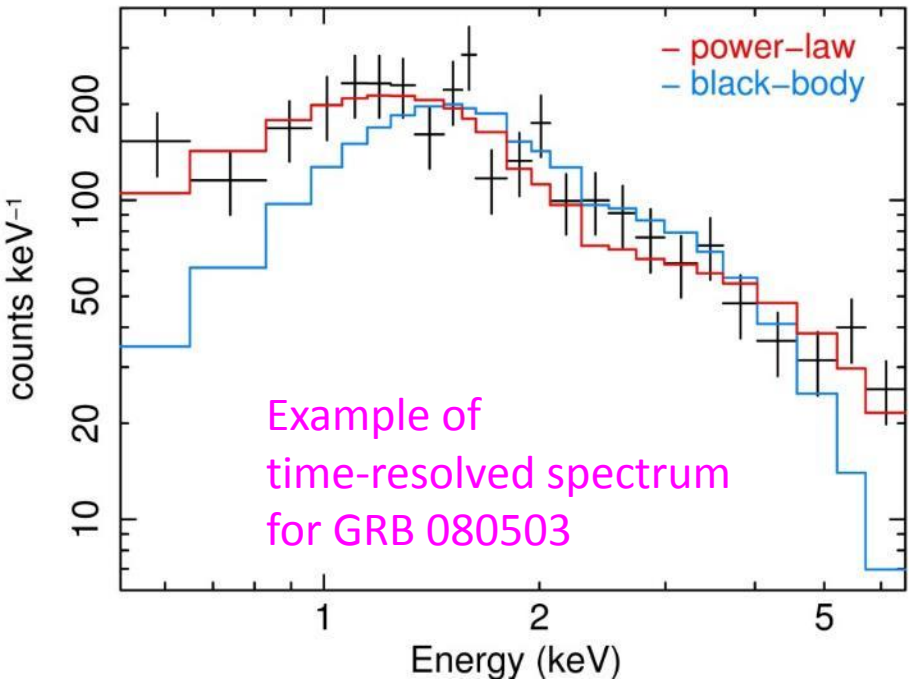
- 7% (*CGRO*/BATSE: Bostanci+ 2013)
- 25% (*Swift*/BAT: Norris+ 2010)
- 40% (*Swift*/BAT+XRT: Kagawa, Yonetoku, TS+)

It is unclear the association fraction is real or artificial by the instrument energy range.
We need a soft X-ray wide monitor!

Strategy to study X-ray extended emissions



Kagawa, Yonetoku, TS+ 2015



Energetics and Geometry:

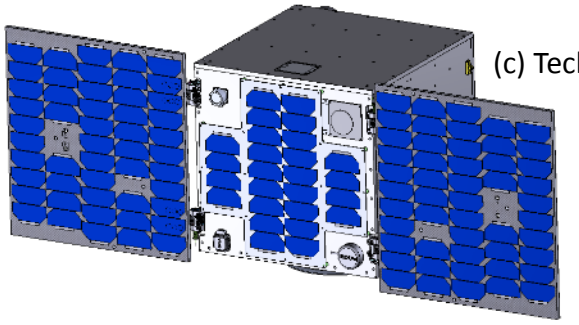
Isotropic energies are reported to be comparable!!
(Perley+ 2009, Bostanci+ 2013)
Associated GW observation will constrain an inclination angle.

Emission process:

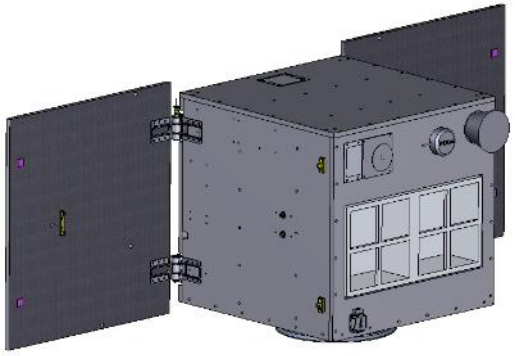
They have soft spectra modeled by rather power law than black body.
(Kagawa+ 2015)
Associated MeV-to-TeV observation will constrain emission models.

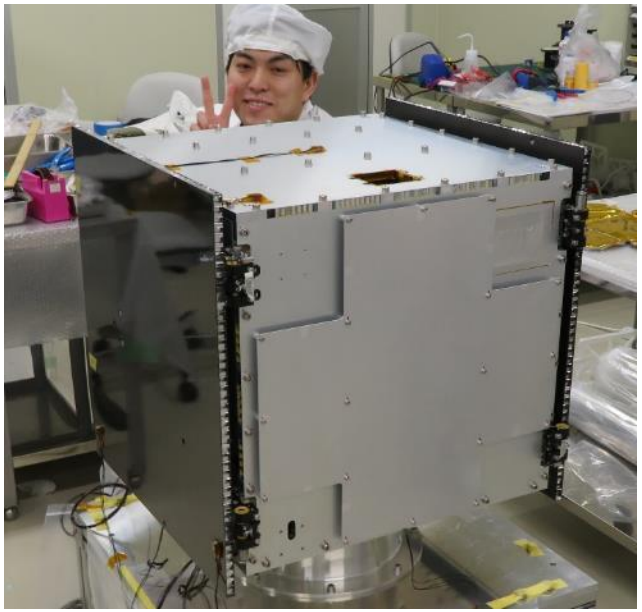
Satellite Bus Configuration

Weight & Size	50 kg, 50 cm cube
Target Launch	in 2020
Mission Life	> 3 years as goal
Target Orbit	Sun-synchronous, LEO
Attitude	Anti-direction of the Sun No follow-up maneuver
Communication	Iridium satellite (Alert) S-band and UHF (TM/TC)
Mission Payload	**T-LEX**: X-ray imaging detector **KGD**: Wide field gamma-ray burst monitor



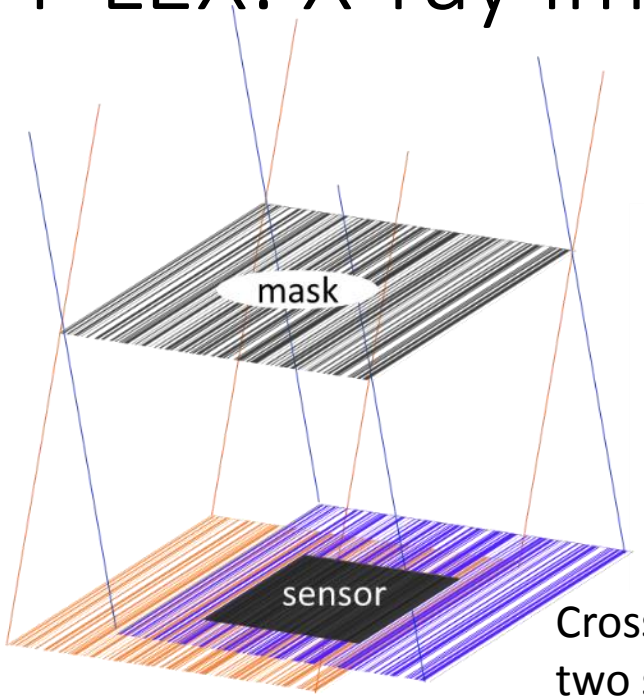
(c) TechSol



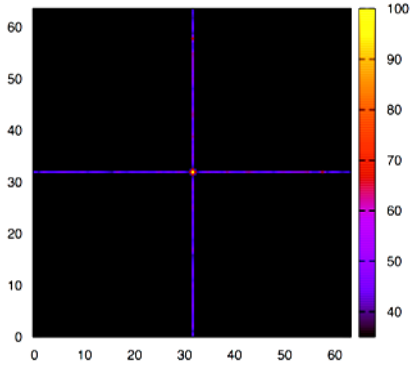


Structural and Thermal Model

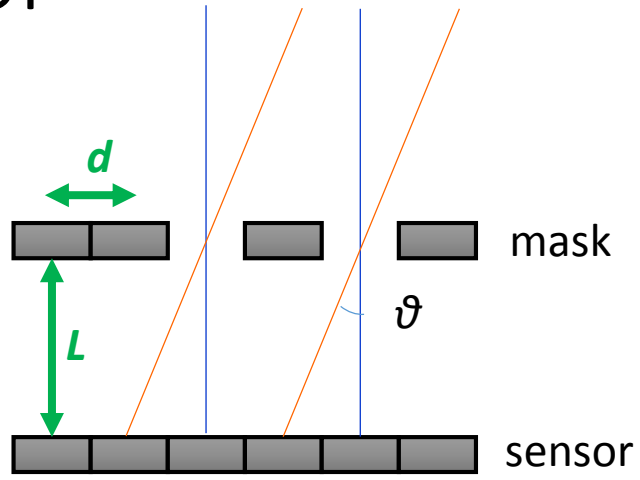
T-LEX: X-ray imaging detector



$$r_j = \sum_i d_i \cdot m_{i+j}$$



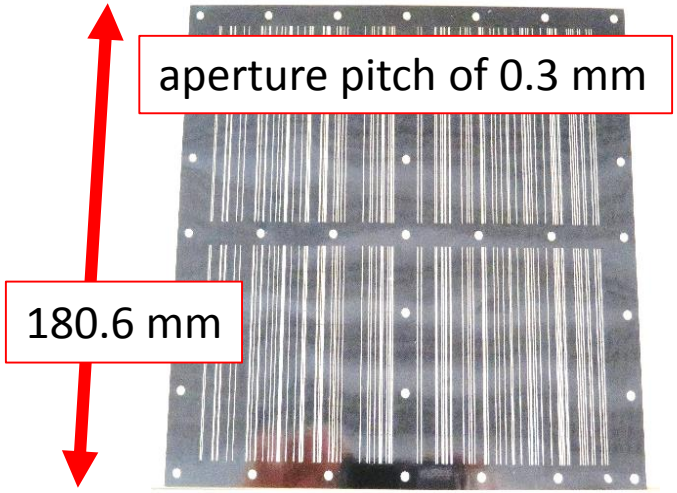
Cross correlation sky image by two sets of 1-d coded apertures



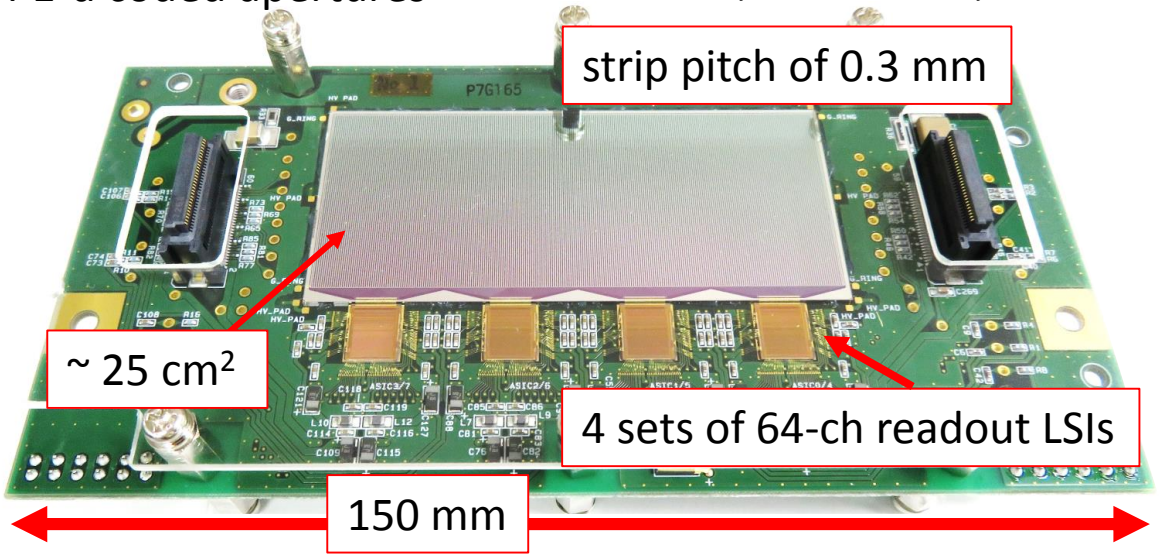
Reconstructed Image Pitch Size

$\vartheta = \tan^{-1}(d/L) = 15$ arcmin

for d = 0.3 mm, L = 70 mm, face-on



tungsten random aperture mask



silicon strip detector (SSD), a quarter of the whole

Sensitivity of T-LEX

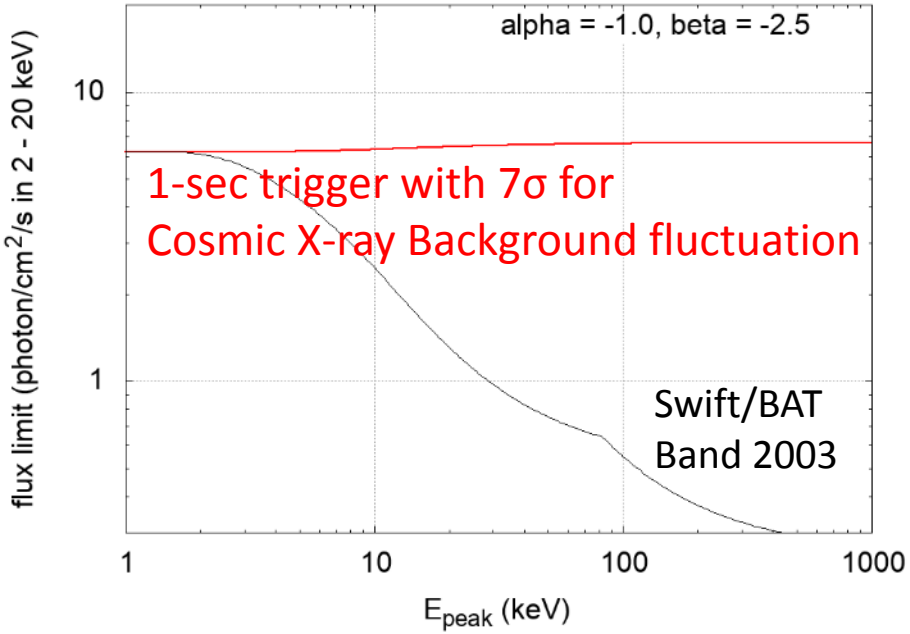
T-LEX configuration

Energy range: 2 – 20 keV

Detector size: 100 cm^2 (in total of X/Y)

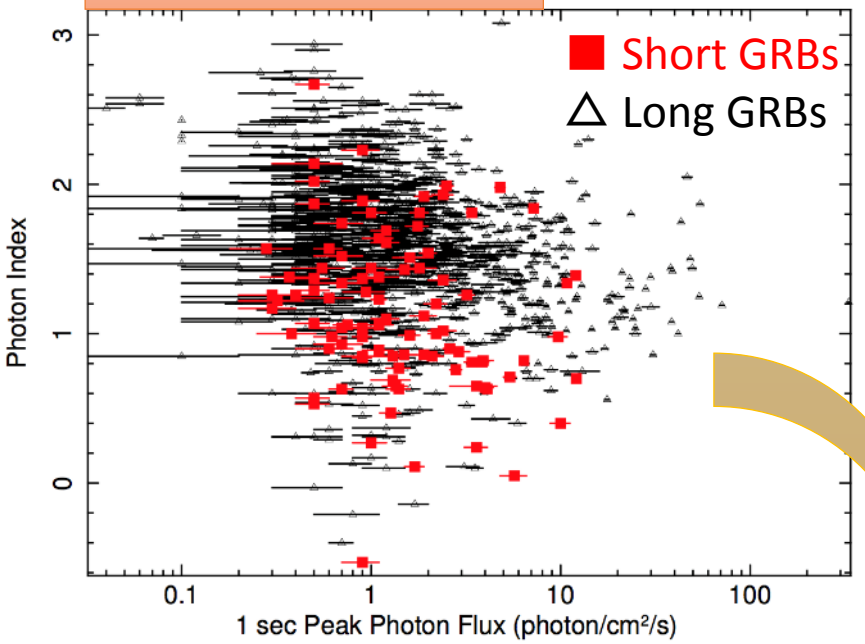
Aperture fraction: 0.2

FoV: 1 sr (full-coded)

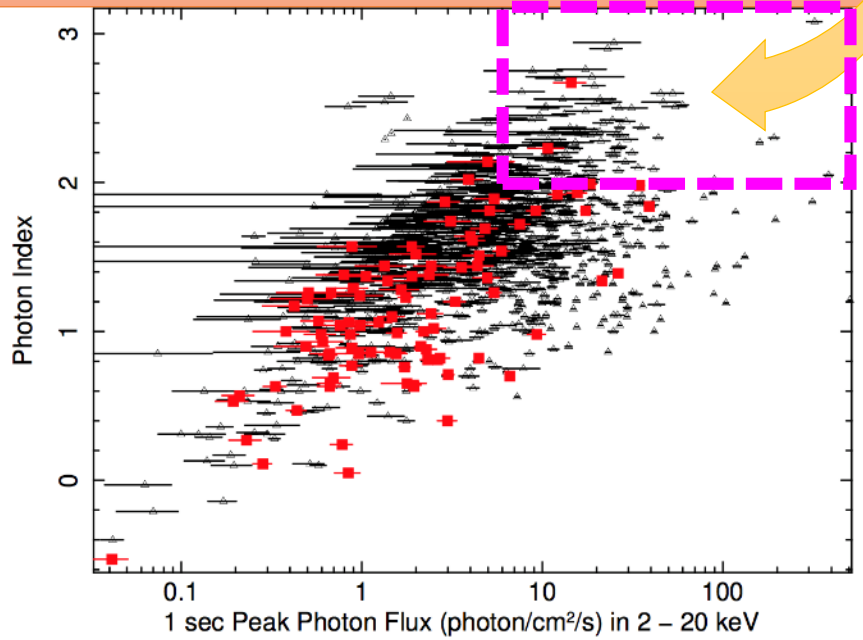


T-LEX has a comparable sensitivity for GRBs with Epeak of a few keV to *Swift*/BAT, and will efficiently detect GRBs with photon indices of > 2.

Swift/BAT 15 - 150 keV

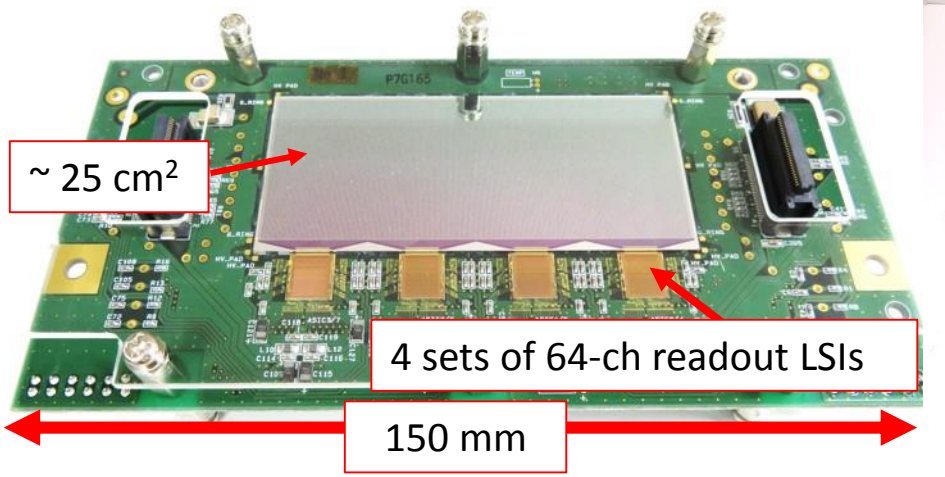


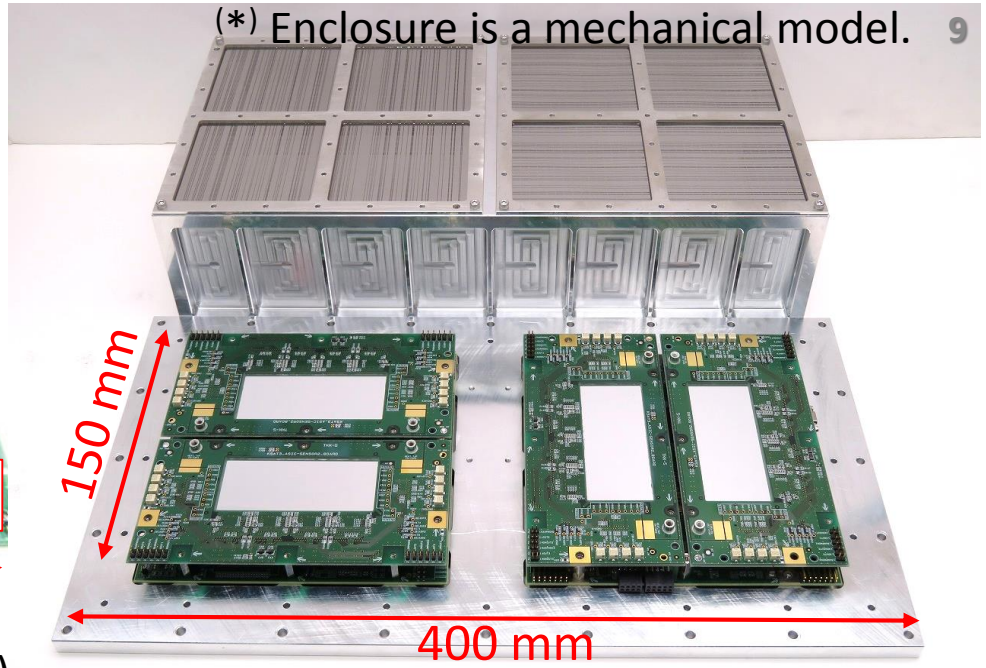
extrapolated to *Kanazawa-SAT*^{3}/T-LEX 2 - 20 keV



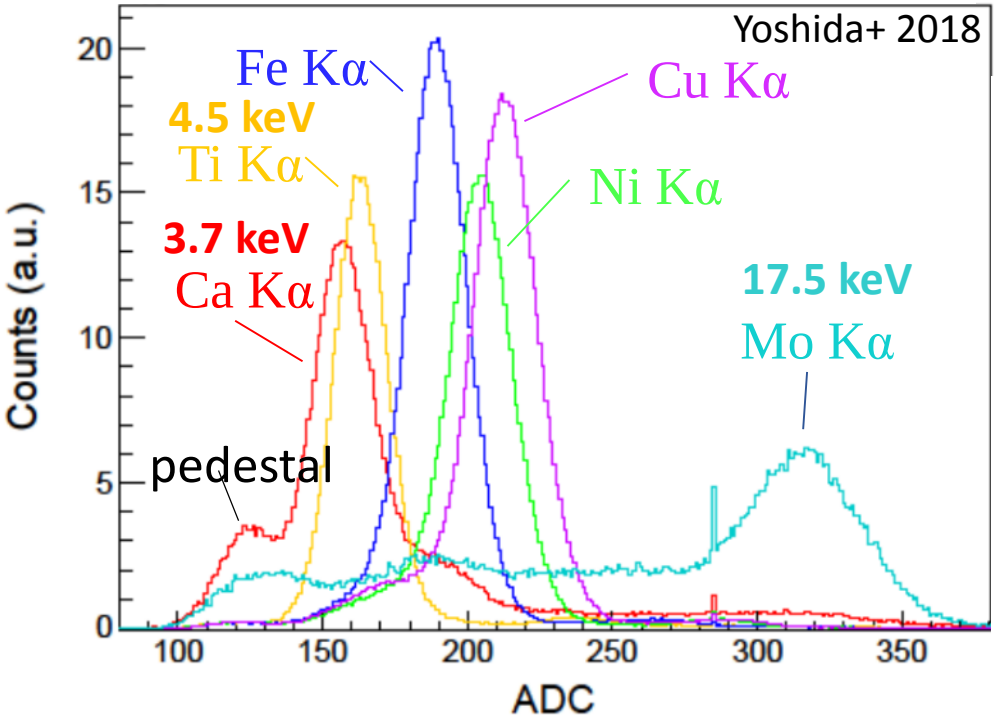
Proto-Flight Model

(*) Enclosure is a mechanical model.

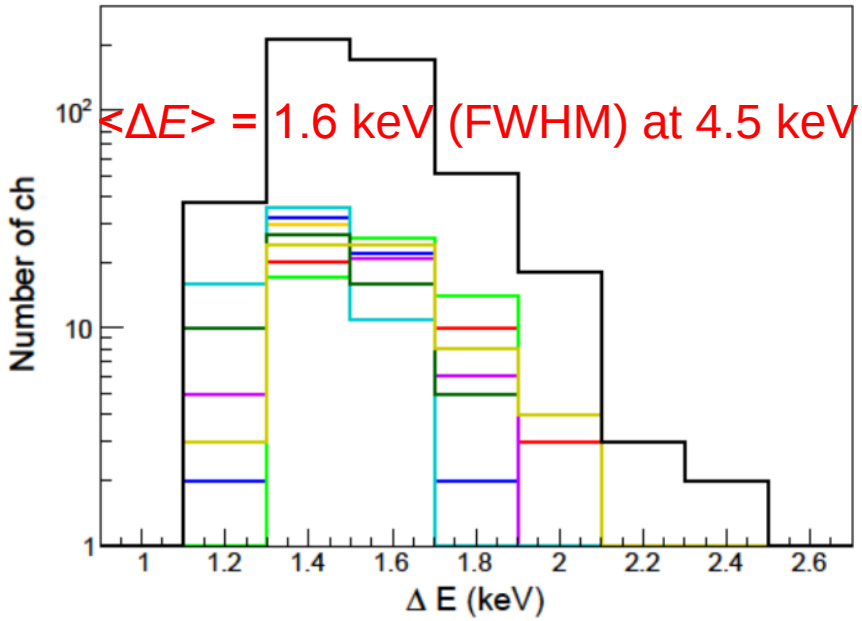




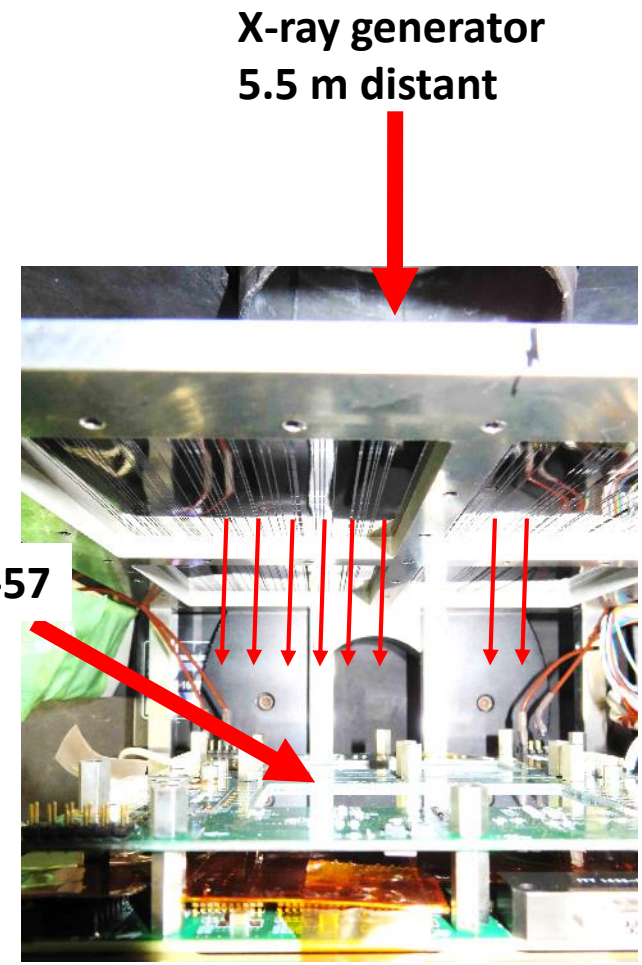
Spectra of 64 channels (1/16 of the whole)



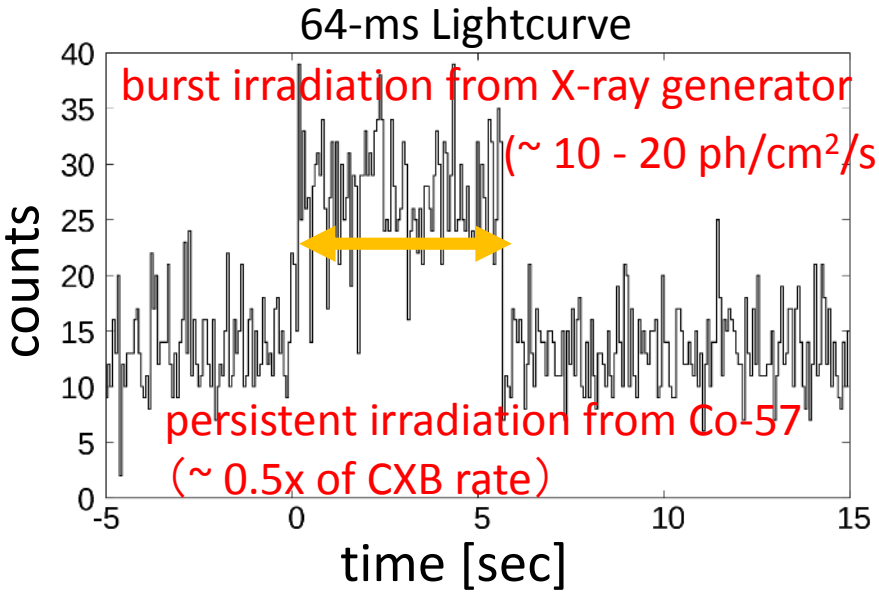
Energy resolutions for 512 channels (half of the whole)

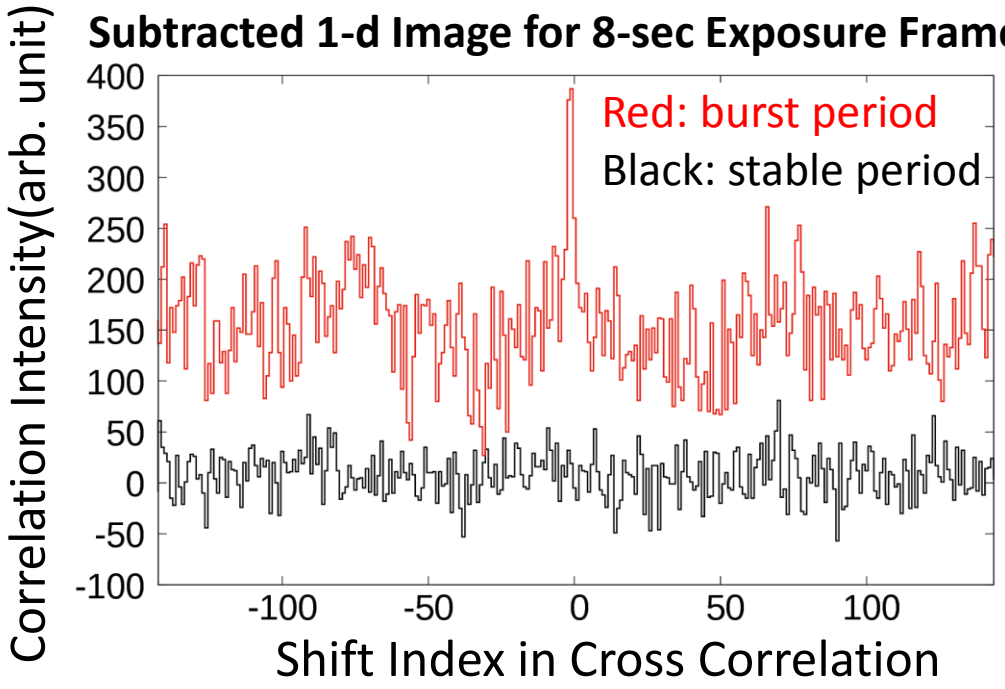


Imaging Performance Test at Lab.

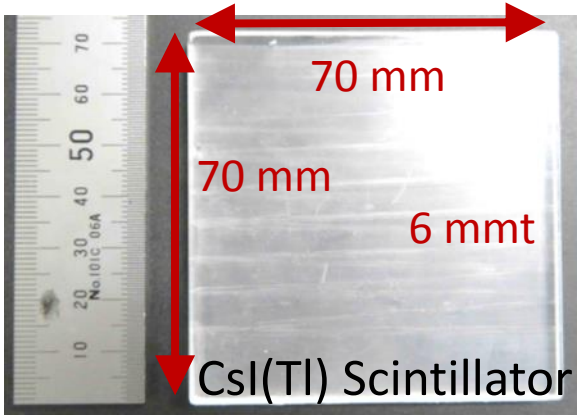


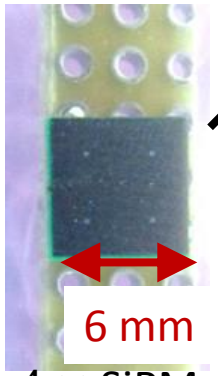
We are confirming on-board imaging and burst trigger systems.

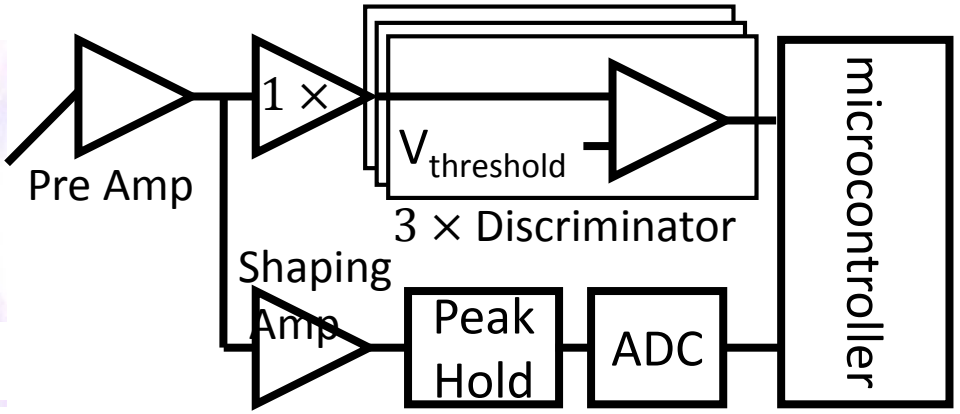


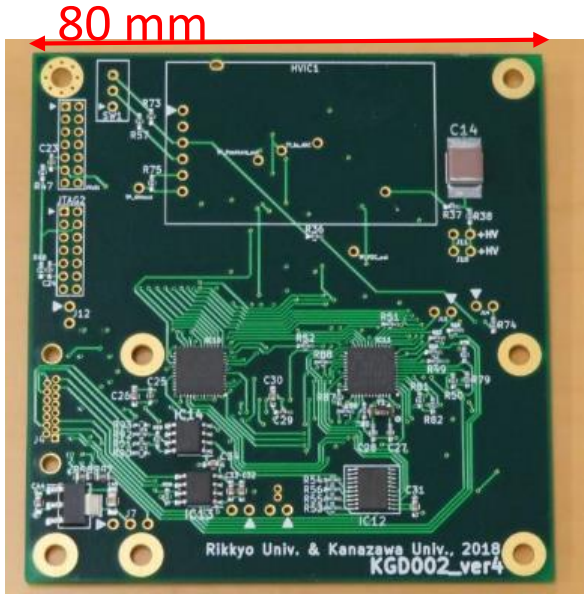


KGD: gamma-ray burst monitor



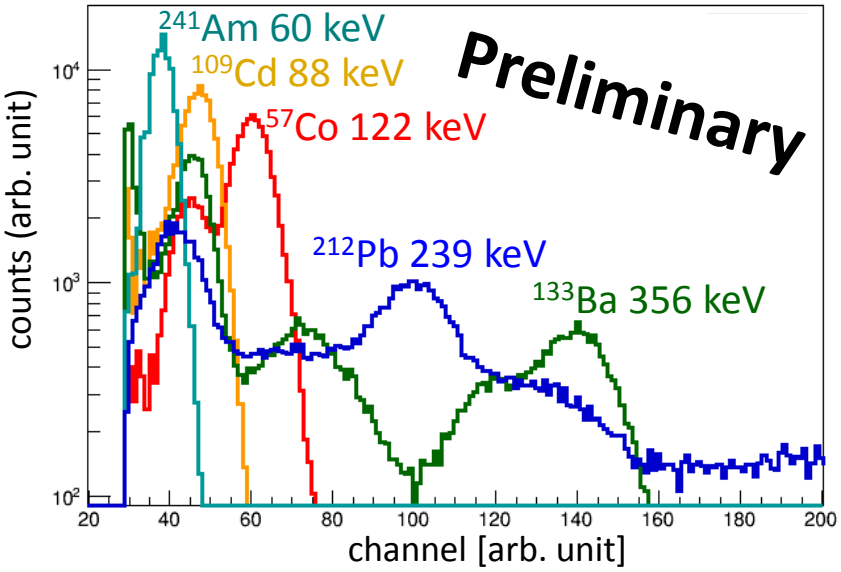




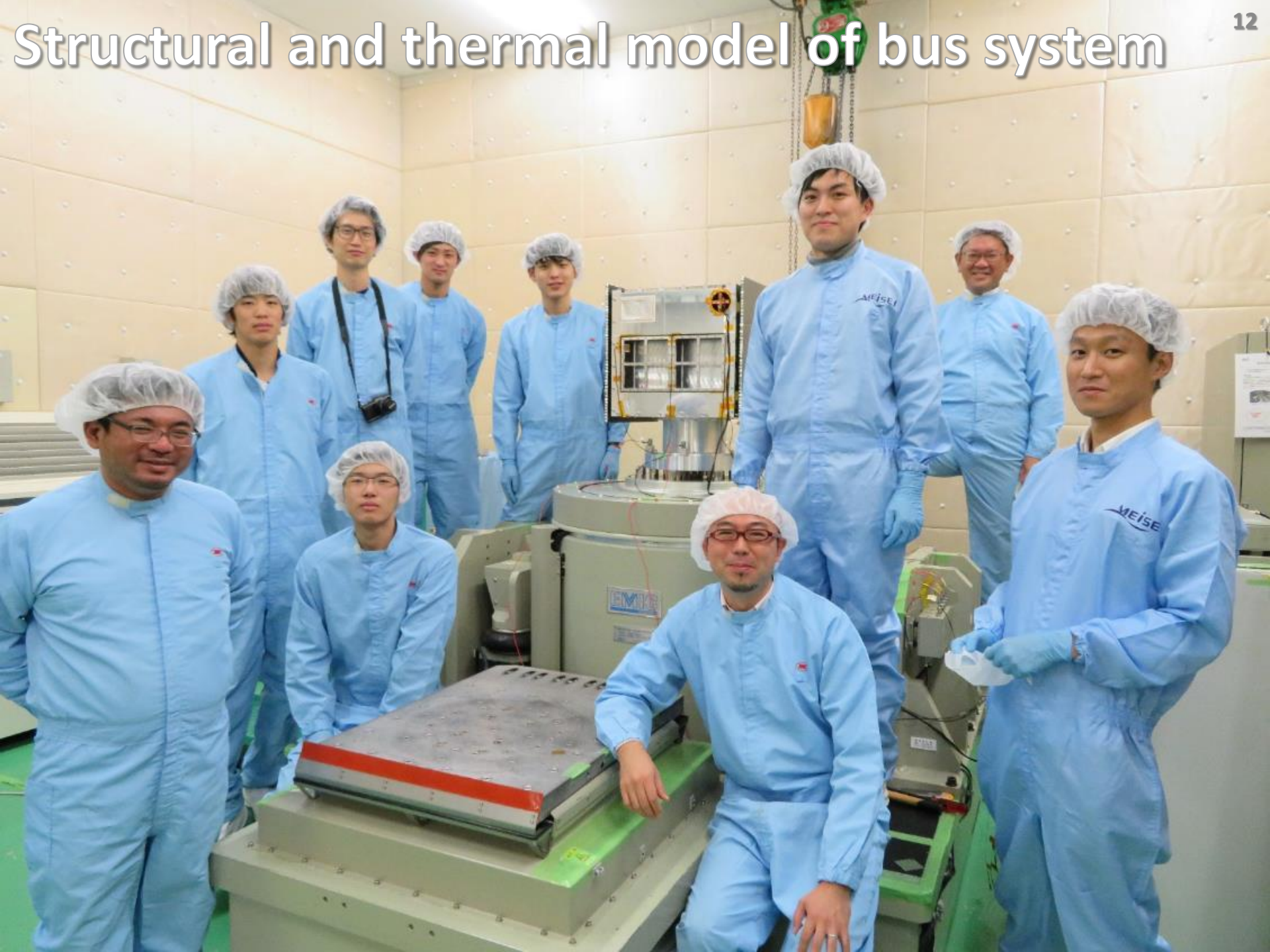


Prototype Readout Board

- sensitive area of ~ 50 cm^2, hard X-rays of > 30 keV
- comprising commercial products (low cost ☺)
- radiation tolerance confirmed (TID of > 20 krad)
- low power consumption of < 1 W.



Structural and thermal model of bus system



Summary

- Soft X-ray Extended Emissions in short GRBs are poorly understood. Their geometries and energies, and emission process are unclear.
- We plan to launch a micro-satellite, ***Kanazawa-SAT^3***, in **~ 2020**, **alerting the trigger time and coordinate** of X-ray transients.
- **T-LEX**, a soft X-ray imager, has a comparable sensitivity to that of *Swift*/BAT for ultra soft GRBs.
- Currently, we have developed a proto-flight model of T-LEX, and are confirming on-board trigger and localization systems.
- **KG**D, an optional gamma-ray burst monitor, is small, inexpensive, and made of commercial products, but validated in total dose tests. It will help to detect hard X-ray transients.
- So far, we performed environmental tests such as vibration tests to the structural and thermal model of the satellite bus system.

Back up

T-LEX system block diagram

Yoshida+ SPIE 2018