

# JAXA status 2017

—Japan's Space-related Geant4 Activity—

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# General Status

Visible space-related activities are still limited in academic fields: commercial use cases are still unknown. Probably there are few direct users.

- Sadly most people probably do not know many of their favorite tools now depend on Geant4, such as SPENVIS, CRÈME, etc.

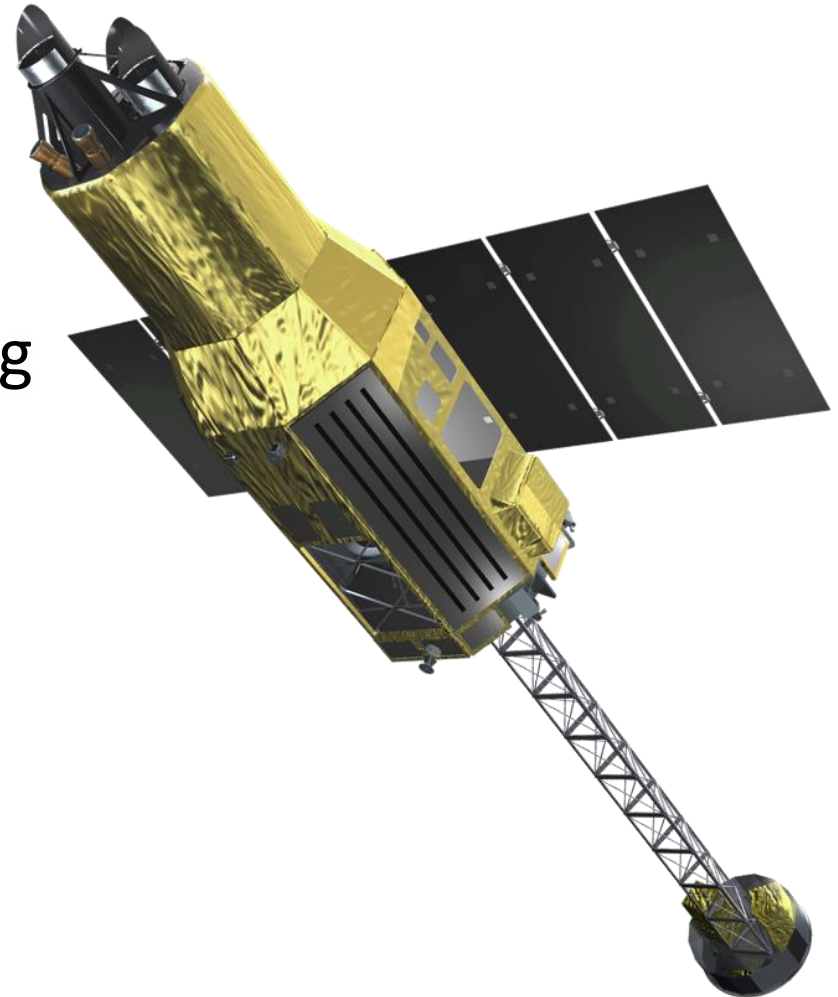
Another MC toolkit “PHITS” sometimes considered, but seems less popular than G4: due to the resource (toolkit manual, source code, ...) accessibility?

- Hitomi (ASTRO-H)  
Launched, operated, and lost
- Arase (ERG)  
Launched and in operation
- GALA on JUICE development in progress  
Shielding simulation is essential for geometry design

# Hitomi: X-ray observatory



- 6th Japanese X-ray astronomy satellite (ASTRO-H)
- 1.7t mass, 14m length
- LEO of 550 km altitude, ~30 deg inclination angle
- Launched on 2016-02-17
- Lost due to attitude control accident on 2016-03-26
- All the detectors worked as expected: in-orbit BGDs evaluation in progress



# Hitomi: Detectors BGDs



Four kinds of detectors:

**SXS**: X-ray micro calorimeter, with a few hundred Kg aluminum alloy

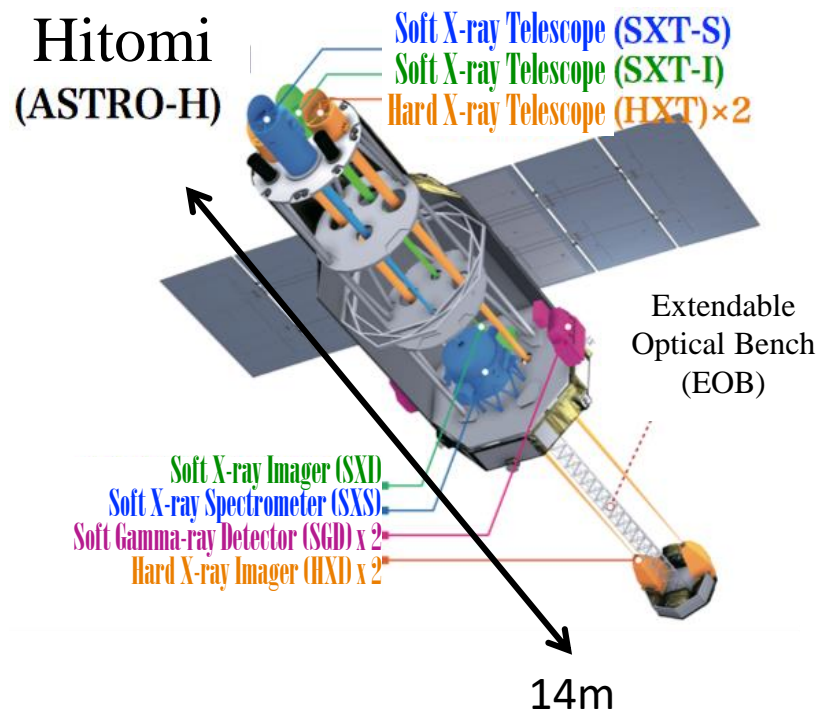
**SXI**: X-ray CCD camera with thick Al shield for < 10 keV band

**HXI**: Si-strip and CdTe-pixel cameras for > 10 keV band, also sensitive for atmospheric neutron backgrounds

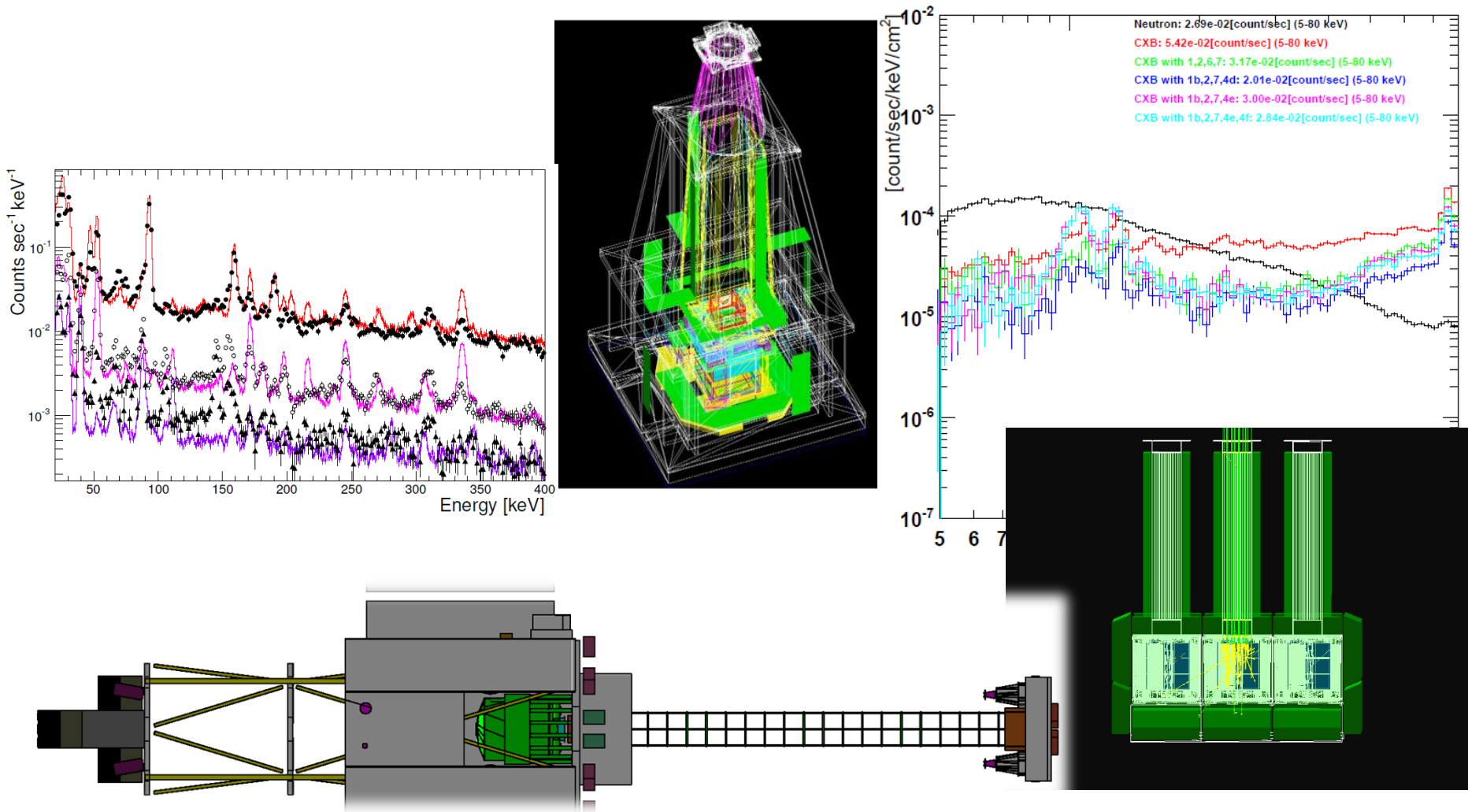
**SGD**: Compton kinematics telescopes with BGO active shields for a few hundred keV band

Different photon detection mechanism and sensitivity for background radiation

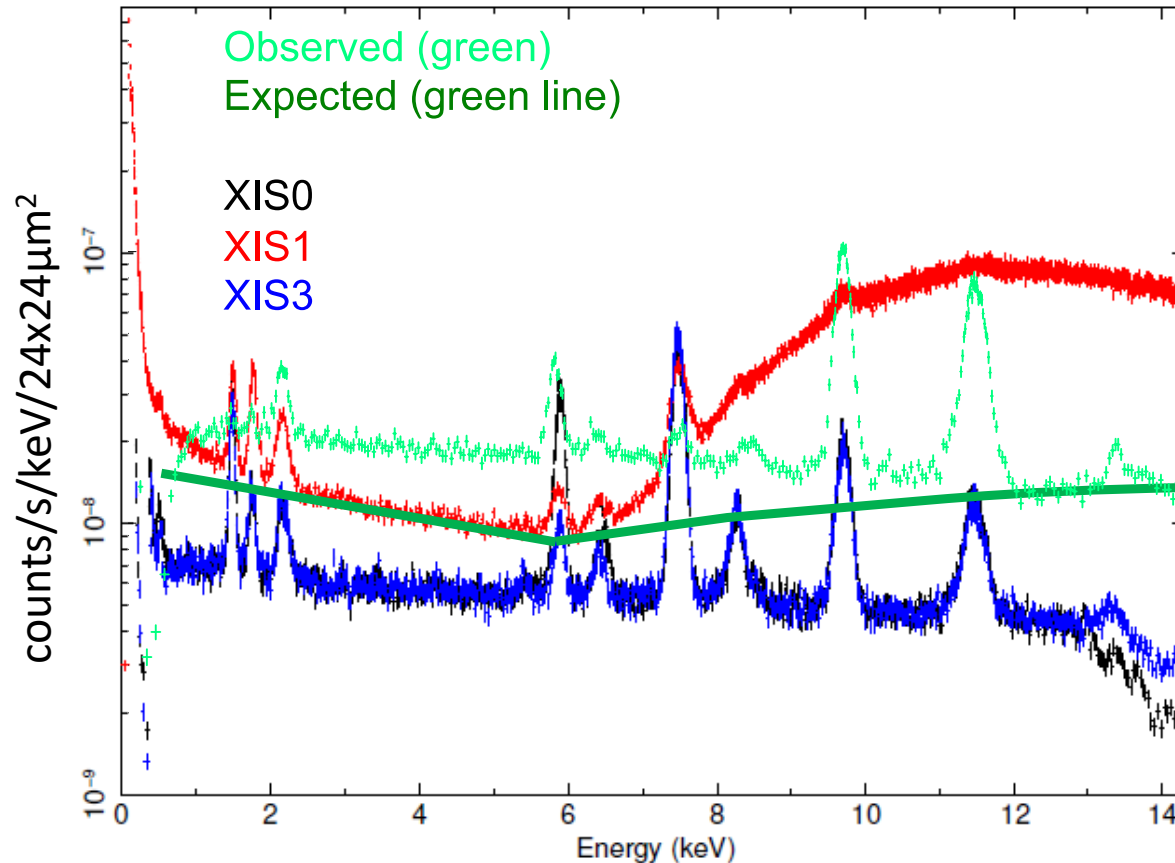
-> **MC simulation is essential**



# Hitomi: Geant4 activities



# Hitomi: X-ray CCD (SXI) background



- **Green solid line** level was expected before launch (G4 simulation)
  - **Pale green** are in-orbit data
- (Black, Red and Blue are previous satellite's in-orbit data)



# ERG: Exploration of energization and Radiation in Geospace



First assembly test  
(Spring 2015)

**Launched**  
**on 2016-12-20**  
**In operation**

## **Orbit:**

- Orbit type: elliptical
- Apogee: 32,000 km
- Perigee: 400 km
- Inclination: 32 deg

## **Configuration:**

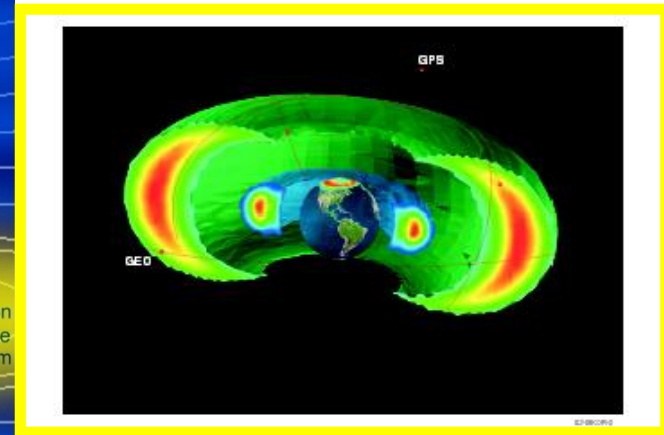
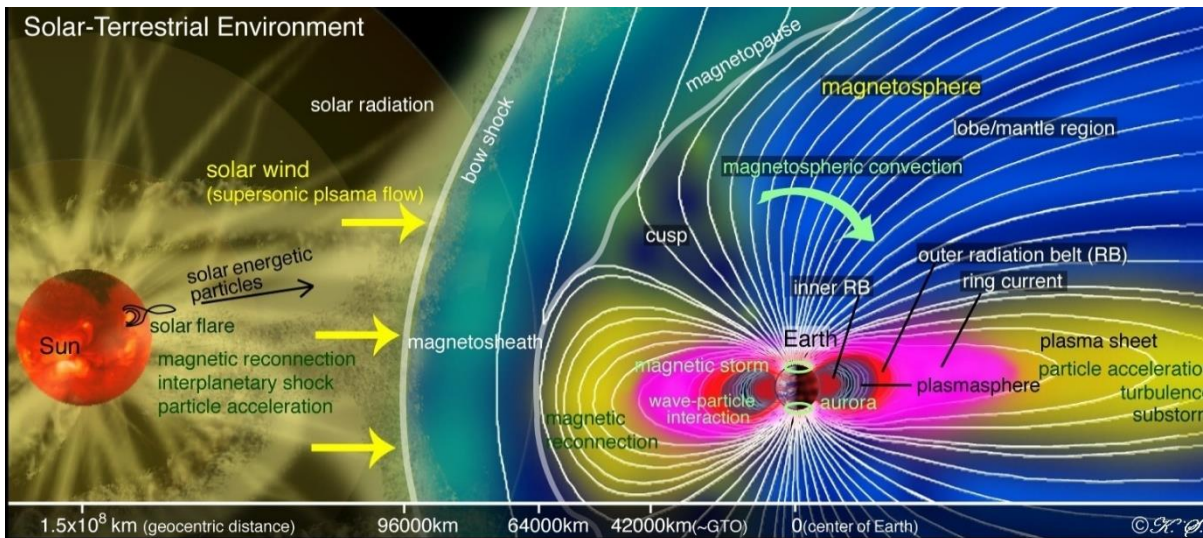
- Size: 1.5x1.5x2.7m
- Mass: ~350 kg
- Spin period: 8 sec

## **Data:**

- Science data
- Real time data for space weather

- **Mission:** understanding how relativistic electrons are accelerated and generated in the Geospace and evolutions of space storms.
- A comprehensive in-situ observations of electrons and ions as well as fields and waves in the Van Allen belts where accelerations take place to cause the large flux enhancements of electrons.
- **Wide Energy Range:** from 10 eV to >10 MeV.

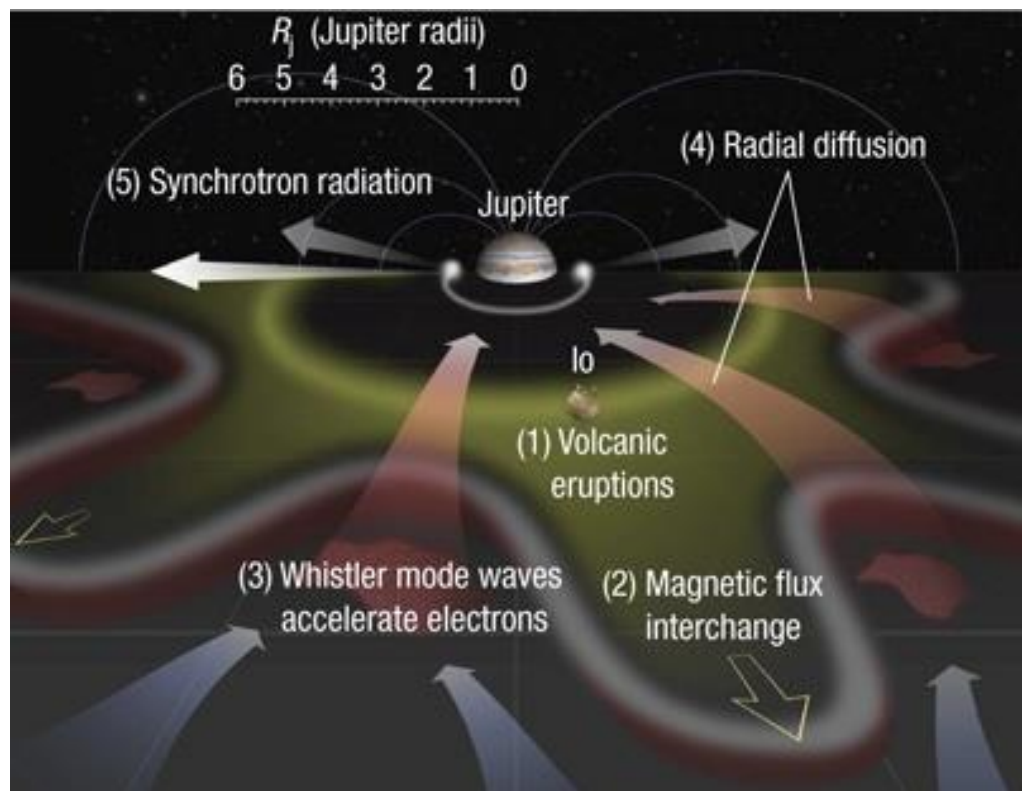




- In geospace the region of outer space near the Earth, high-energy electrons and ions are trapped in the Van Allen Radiation Belts.

# General understanding relativistic particle accelerations in the universe

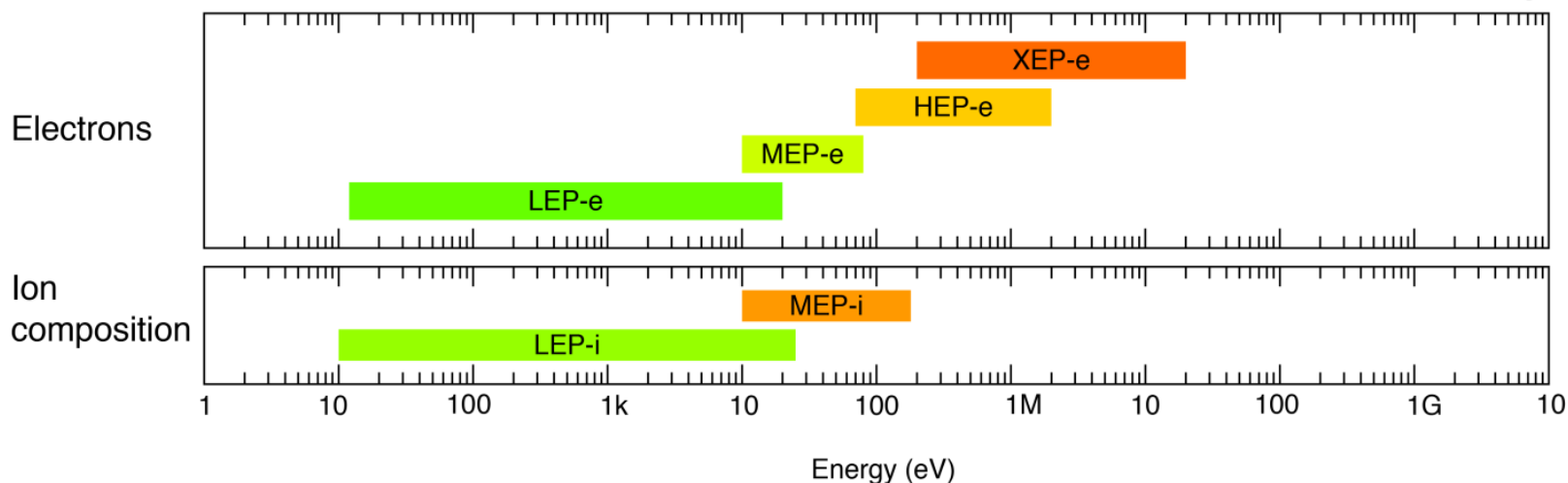
- Besides the terrestrial magnetosphere, Jupiter, Saturn, Neptune, and Uranus also have radiation belts. In-situ detail measurements are only possible in the terrestrial magnetosphere, so that the findings by the ERG satellite can also help unlock the mysteries of such particle accelerations occurring throughout the universe.



Horne+, Nature, 2008

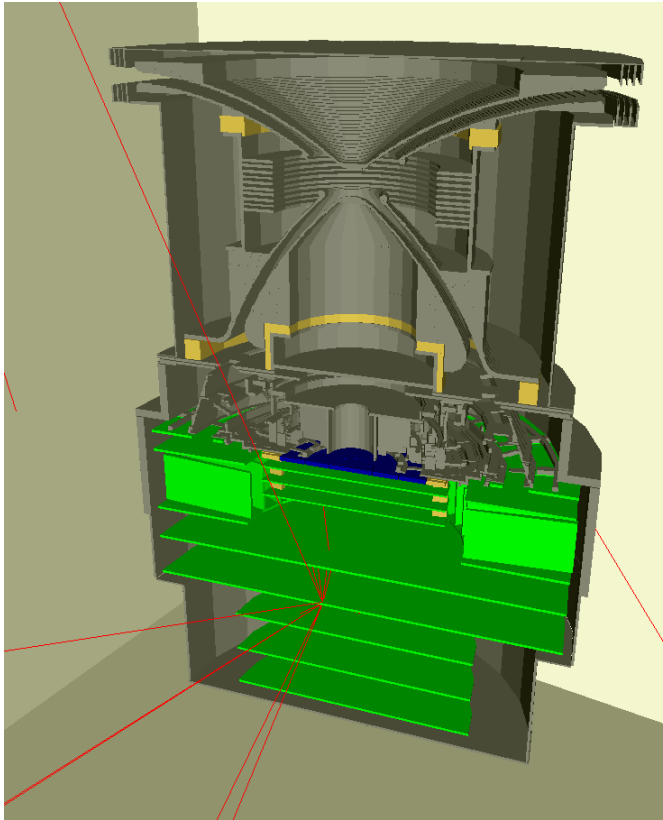
# ERG Science Instruments: Particles

- Particle instruments: electrons & ion compositions
- (12 eV -20 MeV: electrons, 10eV/q – 180 keV/q

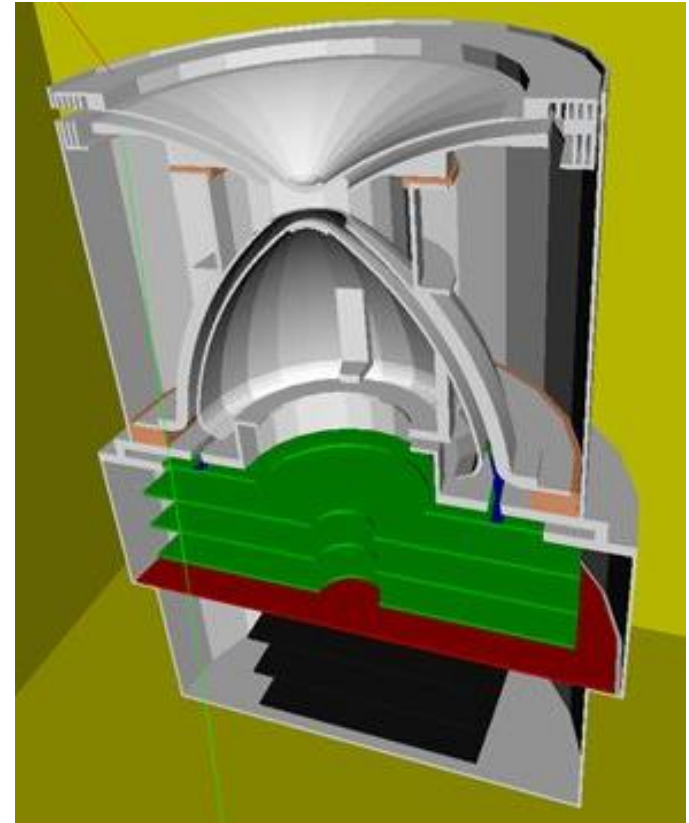


# ERG/MEPi and ERG/MEPe

(by courtesy of S. Kasahara@JAXA)



10-180 keV/q ion



10-80 keV electron

- G4 is used for BGD estimation from MeV electrons and  $>30$  MeV protons in the radiation belt.
- (Kasahara+2012 PSS, “Radiation background and dose estimates for future X-ray observations in the Jovian magnetosphere”)



# JUICE: JUper ICy moons Explorer

ESA mission with **international participation**

- Emergence of habitable worlds around gas giants
- Jupiter system as an archetype for gas giants

## JUICE concept

- Single spacecraft mission to the Jovian system
- Investigations from orbit and flyby trajectories
- Synergistic and multi-disciplinary payload



# JUICE: JUpiter ICy moons Explorer

## Callisto:

*remnant of the early solar system*

- Icy shell, ocean
- Geology, surface composition
- Past activity

## Europa: recently active zones

- Surface non-water-ice material
- Search for liquid water
- Recent activity

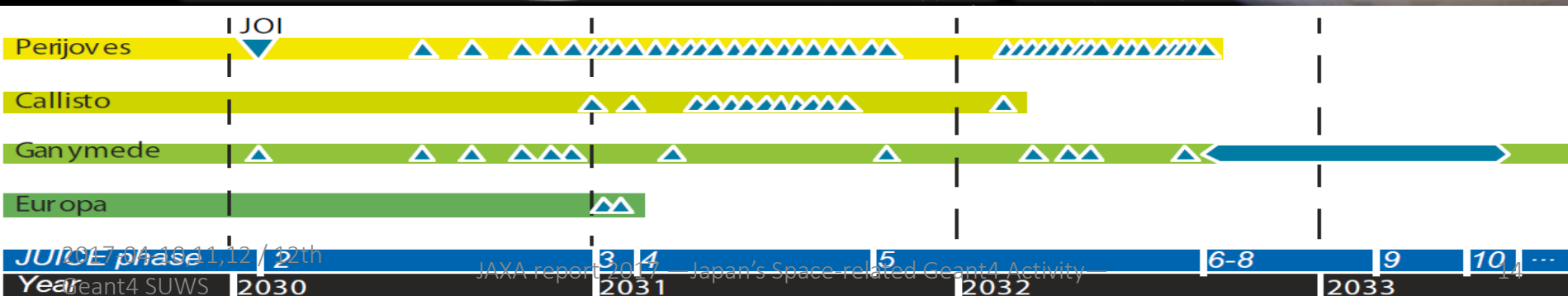
## Ganymede:

*planetary object and potential habitat*

- Sub-surface, ice shell, ocean, interiors
- Geology, surface composition
- Atmosphere, ionosphere
- Magnetosphere, plasma environment

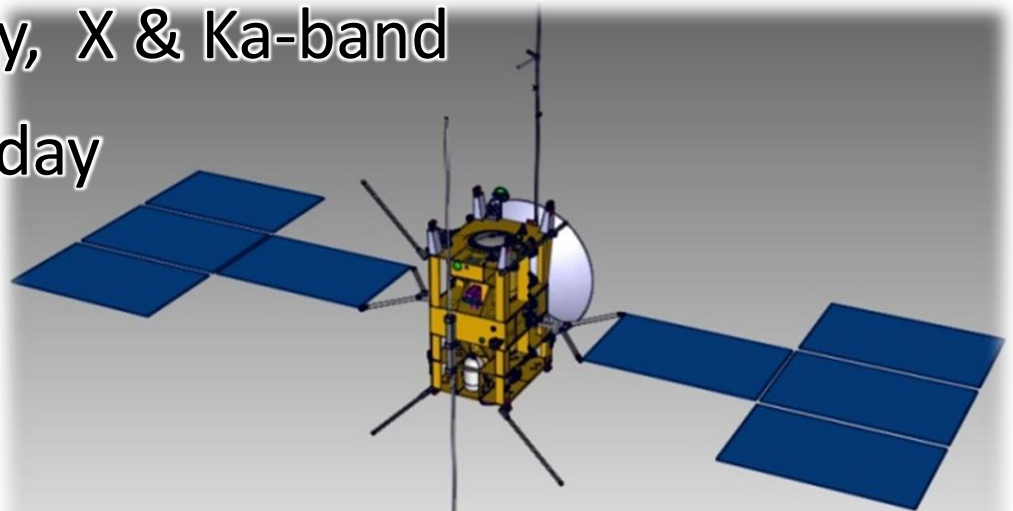
## Jupiter System:

- Atmospheric structure, chemistry and dynamics
- Magnetosphere as fast rotator and giant accelerator
- Moons as plasma sources and sinks
- Couplings and interactions



# JUICE spacecraft specs

- 1.7 t Dry mass 1.7 t, 2.9 t Propellant
- High  $\Delta v$  required: 2600 m/s
- Payload  $\sim 140$  kg,  $\sim 150$  W
- 3-axis stabilized s/c
- Power: solar array  $\sim 100$  m<sup>2</sup>,  $\sim 800$  W
- HGA:  $\sim 3$  m, fixed to body, X & Ka-band
- Data return  $>1.4$  Gb per day





# GALA (Ganymede Laser Altimeter)

## Science objectives

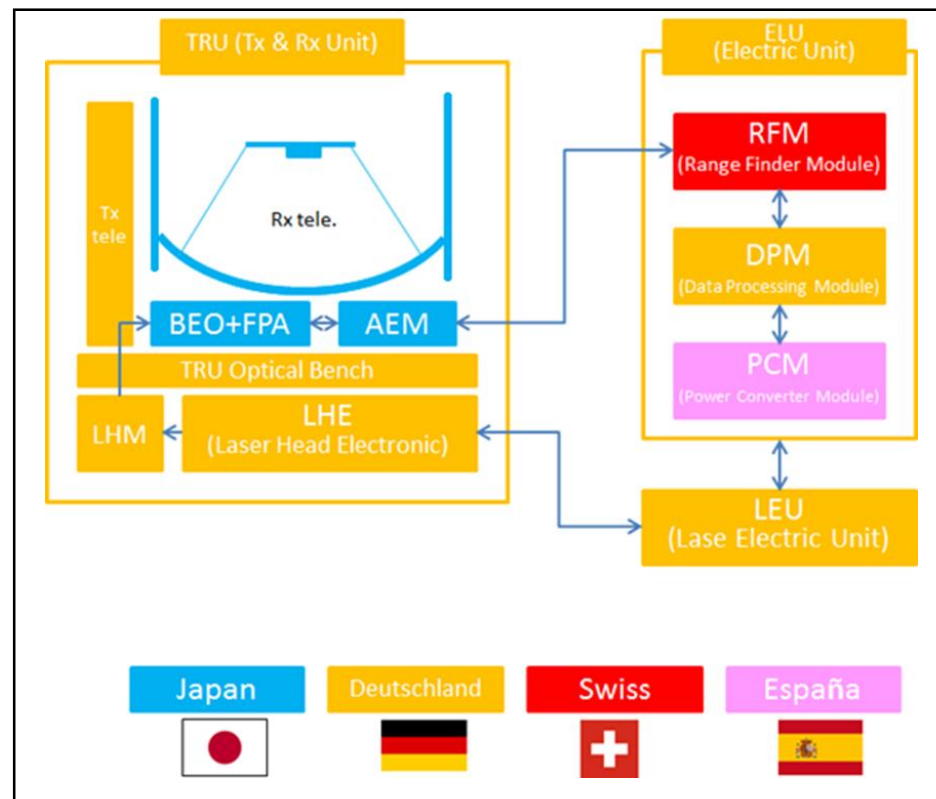
- Investigating internal ocean via monitoring surface tidal deformation of Ganymede.
- Characterizing Ganymede/Europa/Callisto surfaces via measuring topography, albedo and roughness.

## Instrument function

- Altitude obs. by  $\Delta t$  of emitted and received laser light.
- Albedo and roughness obs. by received light curve.

## GALA-Japan provides

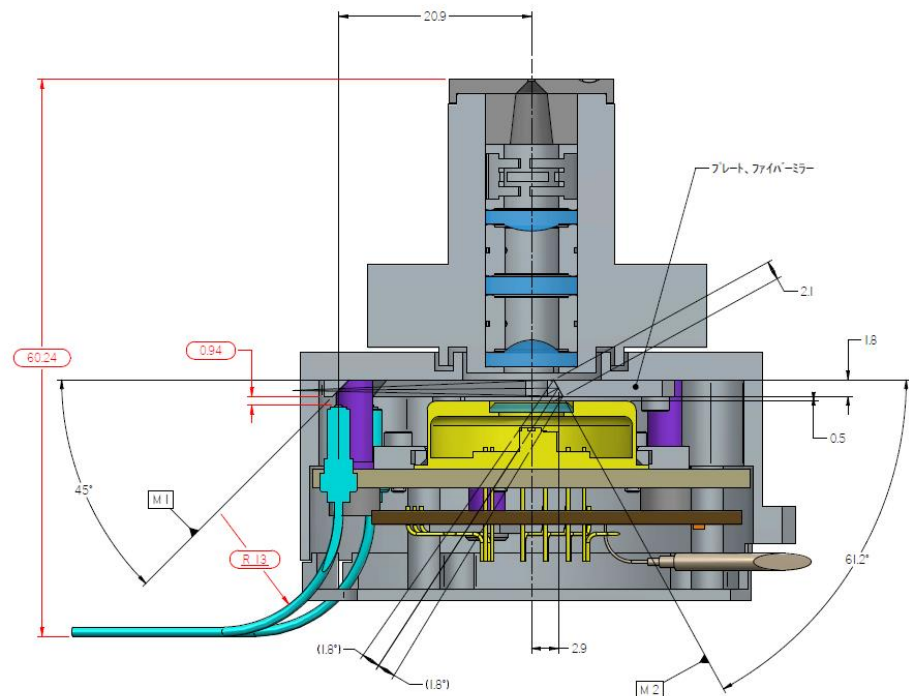
- Receiver telescope.
- Backend optics.
- APD** & Analog electronics.



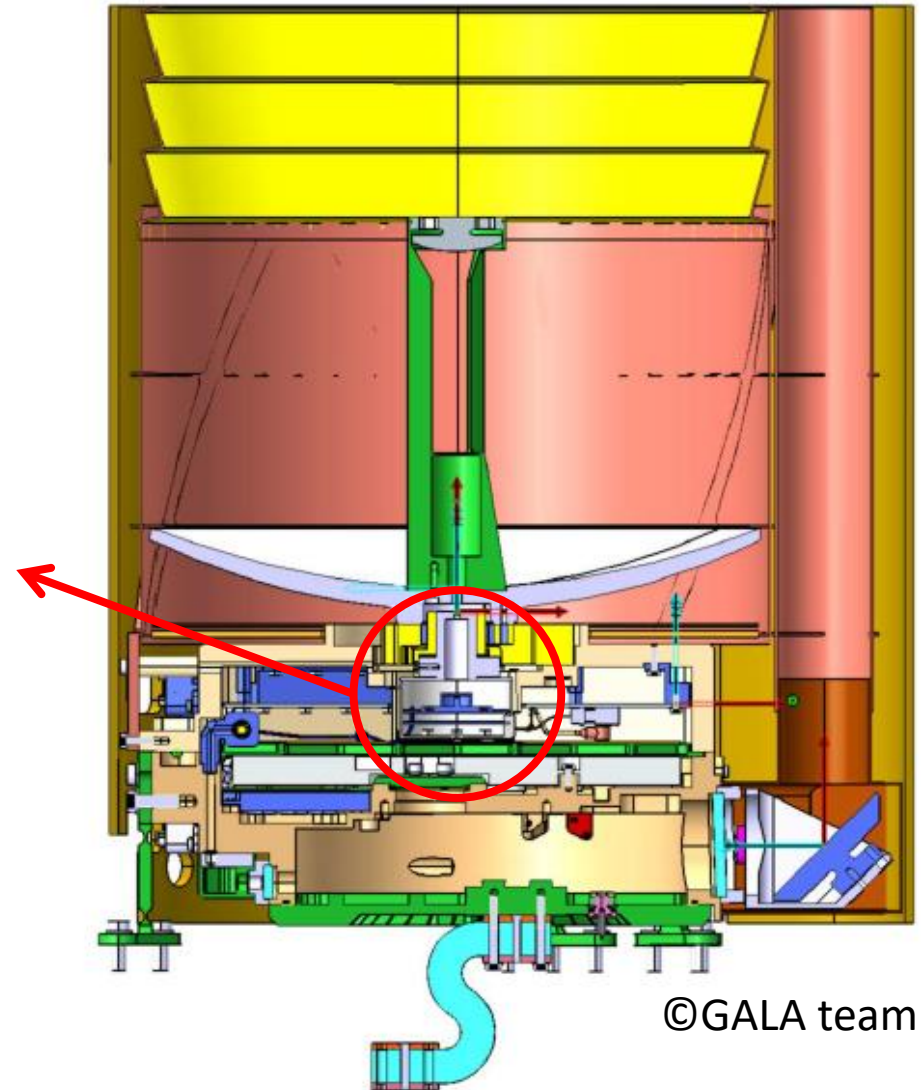
## Major specifications of Japanese part

Altitude obs.	Accuracy: 2 m, Frequency: 30 Hz
Wavelength	1064 nm
Receiver telescope	D = 25 cm, Al mirrors & structure, Passive cooling (-100~-40 deg.)
Detector	<b>APD</b>

# The Ganymede Laser Altimeter (GALA)



©GALA Japan



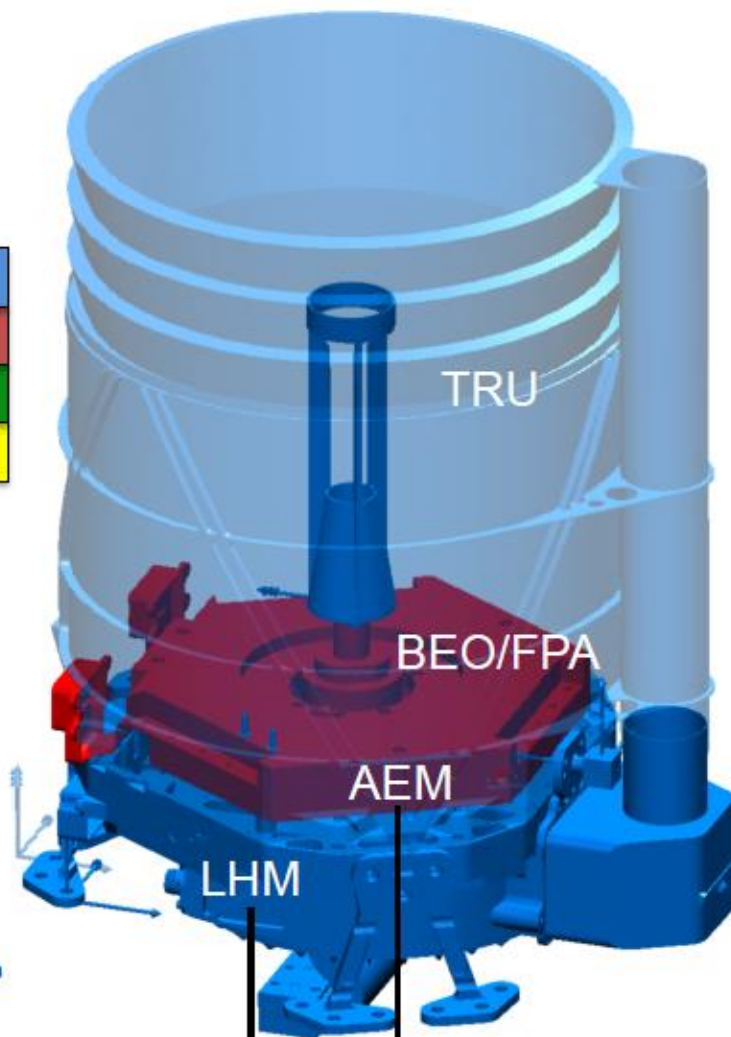
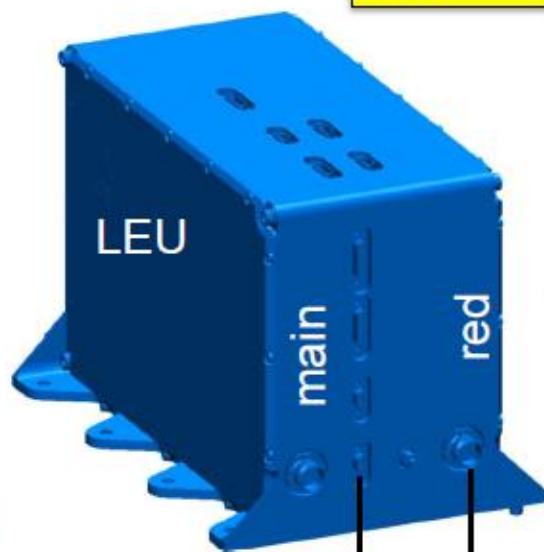
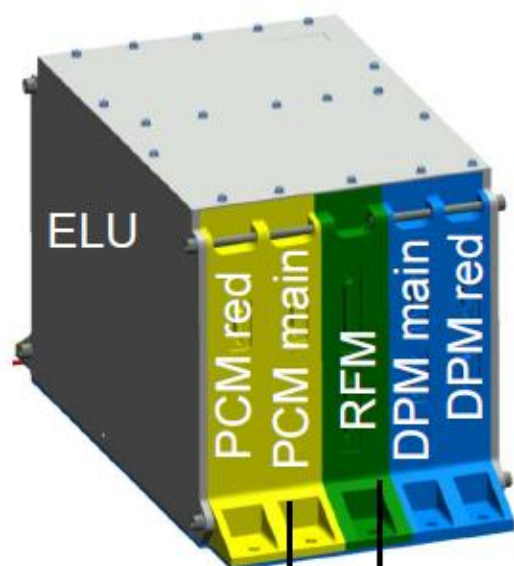
©GALA team

## GALA instrument overview (1)

- international team from Germany (DLR), Japan (JAXA/CIT), Switzerland (UBe) and Spain (IAA)



Germany
Japan
Switzerland
Spain

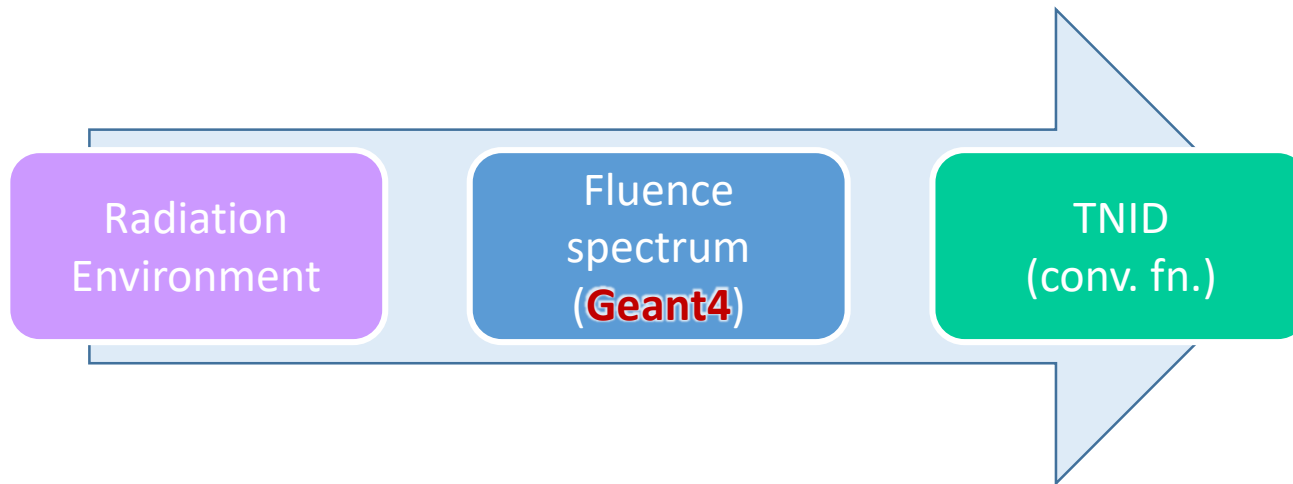


©GALA team



# JUICE-GALA: APD damage by radiation

- Significant factor: dark current noise due to radiation damage
  - Good correlation with total non-ionizing dose (TNID)
- GALA team used Geant4 to estimate TNID
  - Geant4: estimation for the spectrum of incident flux
  - A table: spectrum -> TNID conversion



# Summary

- No new activity is observed.
  - “Hitomi” (ASTRO-H) was lost, but its in-orbit data validation compared with G4 is in progress
  - “Arase” (ERG) launched: update in next WS?
  - GALA is active G4 user, while not very visible from outside
- Visible activities are still limited in academic fields: commercial use cases are still unknown. Probably there are few direct users.