Geant4 in JAXA

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Japanese Space Science Missions

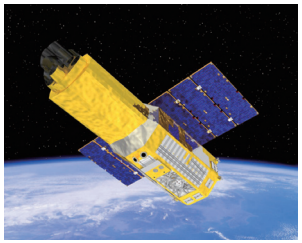
In Japan, most of fundamental researches relating to the on-orbit radiation environment are carried out for non-commercial (i.e., scientific) missions.

1. X-ray and Gamma-ray astronomy
2. Lunar exploration mission
3. Inter-planetary missions
4. Automated ISS mission

This presentation will introduce them briefly.

X- and Gamma-ray astronomy

"Suzaku" Observatory (ISAS/JAXA and many universities)



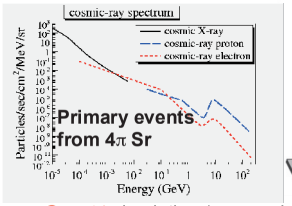
The 5th Japanese X-ray astronomy satellite

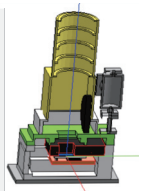
Launched on 2005-07-10

High-precision and Low-noise detector systems

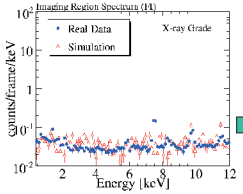
•XIS (X-ray CCD camera) [0.3—12 keV]
•HXD (Hard X-ray Detector) [10—600 keV]

Background-event spectrum of XIS





Geant4 simulation (energy deposition) + charge-diffusion simulation in CCD

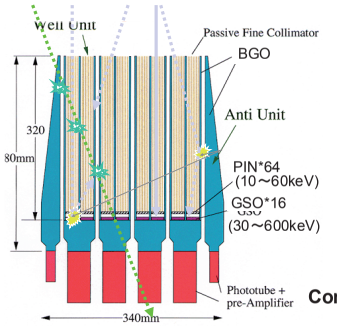


Physics processes
•Electromagnetic Interaction (down to 250eV)
•Hadronic Interaction

Used Geant4 outputs:
•Physics process of particle generation, position, energy, solid-ID
•Energy deposition and its physics process
•ParentID、TrackID、StepNumber

Succeeded in representing the BGD spectrum and resolving the BGD generation mechanism

Suzaku Hard X-ray Detector (HXD)



Si-PIN [2mm thick](10—60 keV)
GSO [5mm thick](30—600keV)
BGO: Shield + Phoswitch
BGO well + Fine Collimator:
narrow FOV as a non-imaging detector
-> Low Background
-> High Sensitivity

Complex Response for incident photons

Performance Key: **Monte Carlo simulator**

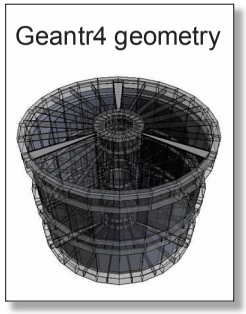
NeXT

New exploration X-ray Telescope

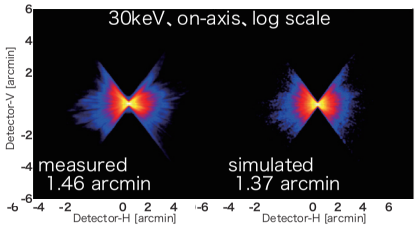
- Experience of Suzaku simulation will be included from the design phase.
- The focusing feature of the X-ray telescope (XRT) will be simulated by Geant4 (NEW!)

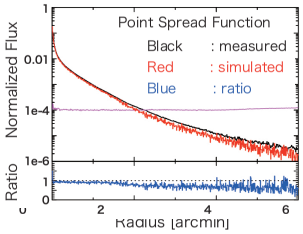
Prototype of NeXT XRT

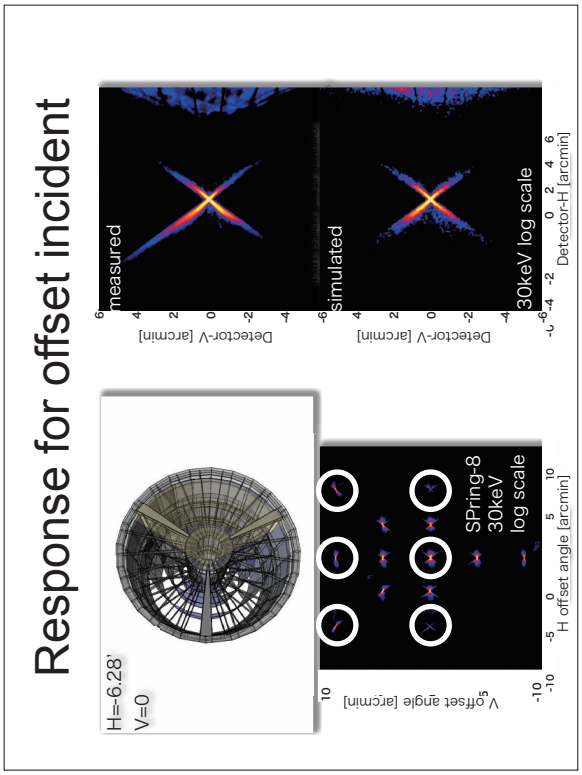
Mirror for balloon experiment

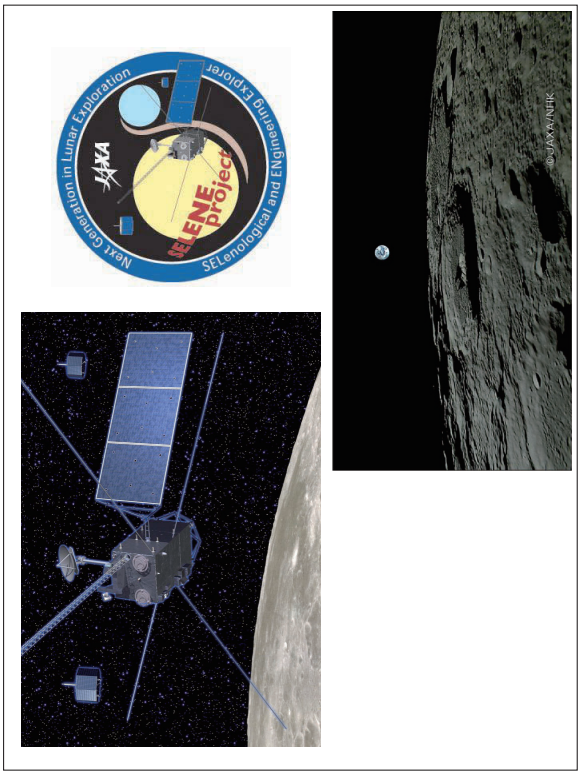


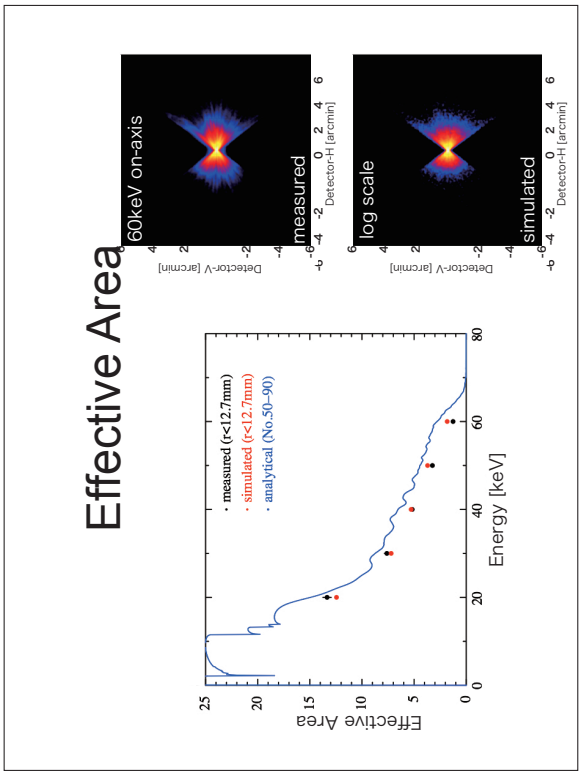
Point Spread Function

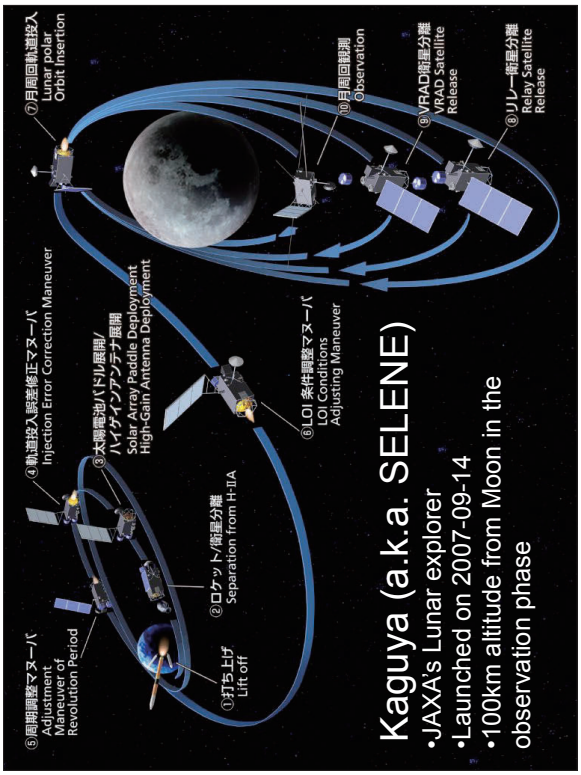






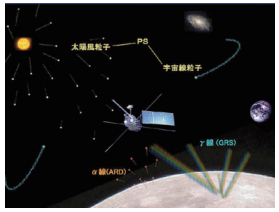


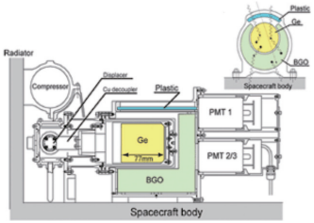




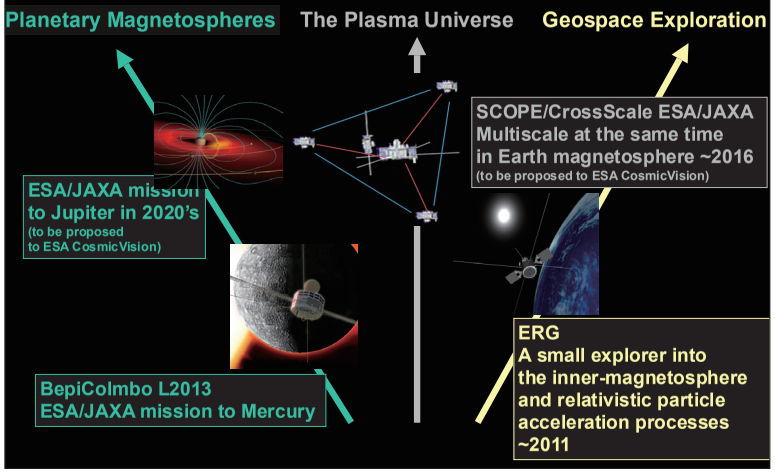
Kaguya Gamma-Ray Spectrometer (GRS)

- Ge detector with BGO active shield
- Many simulations with Geant4 from the development phase (3 talks)

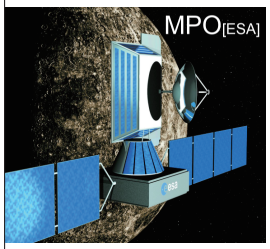




Future Space Plasma Missions at JAXA ~2020's



esa BepiColombo: Mission to Mercury JAXA

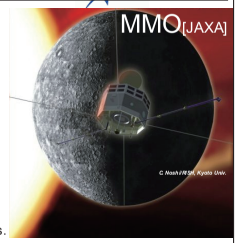


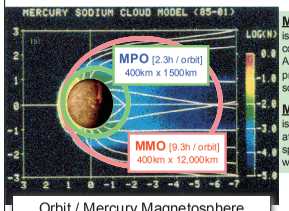
Complete study of Mercury

The innermost planet Mercury was already known in the ancient days, but it was visited only by the Mariner 10 spacecraft 3 decades ago. Mercury is still "unknown" and provides important keys to the solar system science.

First Full-Scale Euro-Japan joint mission

Two orbiters (MPO & MMO) will observe Mercury simultaneously with instruments developed by Euro-Japan joint research teams.





Orbit / Mercury Magnetosphere (model)

MPO (Mercury Planetary Orbiter)
is a three-axis stabilized spacecraft. It studies geology, composition, inner structure and the exosphere. Abnormal structure and composition of Mercury will provide the keys for the planetary formation in the inner solar system.

MMO (Mercury Magnetospheric Orbiter)
is a spin-stabilized spacecraft. It studies magnetic field, atmosphere, Magnetosphere, and inner interplanetary space. Comparison of magnetic field & Magnetosphere with Earth will provide the new vision for space physics.

Design & Development by JAXA
MMO (Mercury Magnetospheric Orbiter)
- High temperature materials & technologies.
- Best scientific instruments from Japan-Euro collaboration.

Baseline Schedule
2012 Launch
2017 Mercury Arrival

Mercury Project Office: http://www.stp.isas.jaxa.jp/mercury/

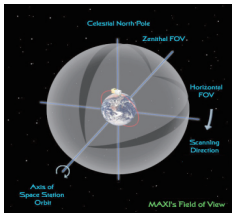
Using Geant4 in future space plasma missions

- Calculation of Radiation Dose in Spacecraft
  1. Solar array
  2. Electric parts (including SEU/SEL)
  3. Sensors (CCD/SSD/MCP …)
- Estimation of Radiation Background in each Scientific & System Instruments
  1. Using Geant4 for development of plasma instruments in order to obtain high quality scientific data under strong radiation environment (Mercury, Radiation Belt, Jupiter etc)

ISS mission: GSC/MAXI

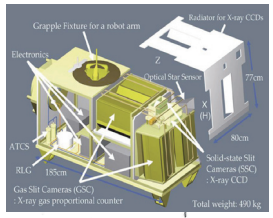
by JAXA and universities

Monitor of All-sky X-ray Image of 2-30 keV (GSC)



FOV : 1.5deg ×160deg

The FOVs sweep almost the entire sky during one ISS orbital period of 90 minutes. A point source stays in the FOV for 45 seconds.



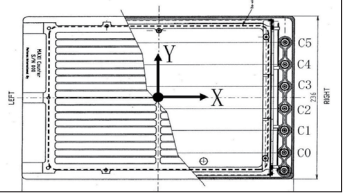
The collimator:

Material : phosphor bronze

Thickness: 0.1 mm, Height: 118.4 mm

The interval between slats: 0.1 mm

128 slats for one GSC unit



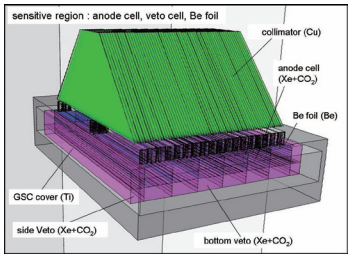
Detector Response Matrix (DRM) builder for GSC/MAXI

Ground calibration:

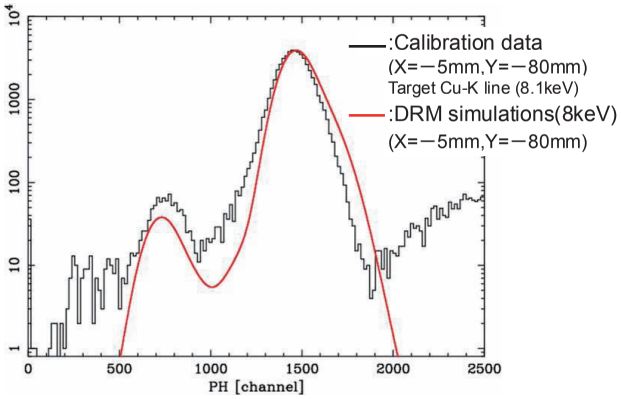
- Energy-PH relation, position-PH relation, energy resolution, position resolution
- The collimator response based on design value

Geant4 simulation

- geometry from design sheet
- photoelectric absorption, energy deposition, multiple scattering
- considering L-escape



Comparison between ground calibration and DRM output



Conclusion

- Several Japanese space science mission use or will use Geant4
  1. To construct the detector response to the incident photons.
  2. To simulate the detector outputs due to the environment radiation.