JAXA activities 2010

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Outline

- JAXA space mission overview from radiation simulation point of view
  - Space-science and other missions
- Space-science mission pickup
  - ASTRO-H mass model and GDML
- Summary

JAXA space missions

Space-science missions

- Space observatory, space environment, explorer, ...
- Sometimes peculiar orbit or orbital environment.
- Detectors performance is the first priority, under limited boundary conditions such as mass and radiation environment.
  - Sometimes **order-made MC simulation** is required.

Other missions

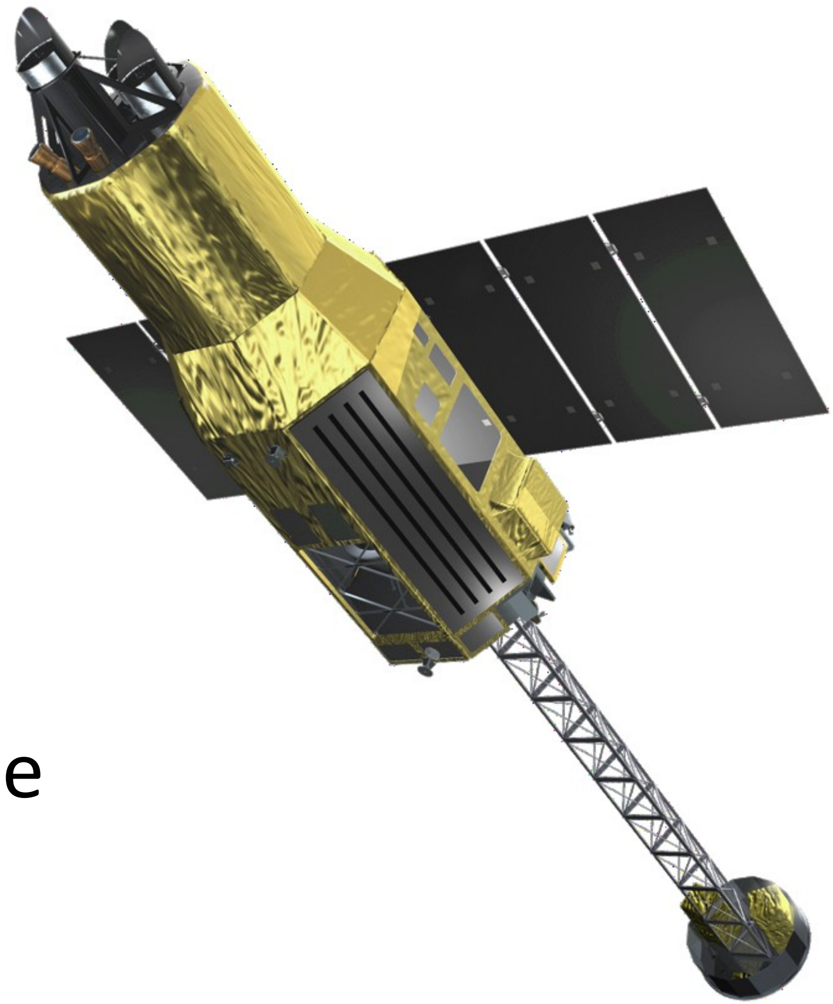
- Earth observation, experiments for new commercial regions, ...
- Well-studied orbital environment.
- System reliability (dependability) is the first priority.
  - Ready-made simulations or good database is enough for most cases.

Space-science mission pickup

- Most use case is SPENVIS
  - Sometimes perform simulations for individual detectors that are sensitive for environment radiation.
  - Examples of Geant4 use cases are shown in the previous workshop report.
- Next X-ray observatory mission (ASTRO-H) began constructing full-satellite mass model. The rest of this report introduces this.

ASTRO-H

- 6th Japanese X-ray astronomy satellite
- Scheduled for launch in 2014
- 1.7t mass, 14m length
- LEO of 550 km altitude, ~30 deg inclination angle



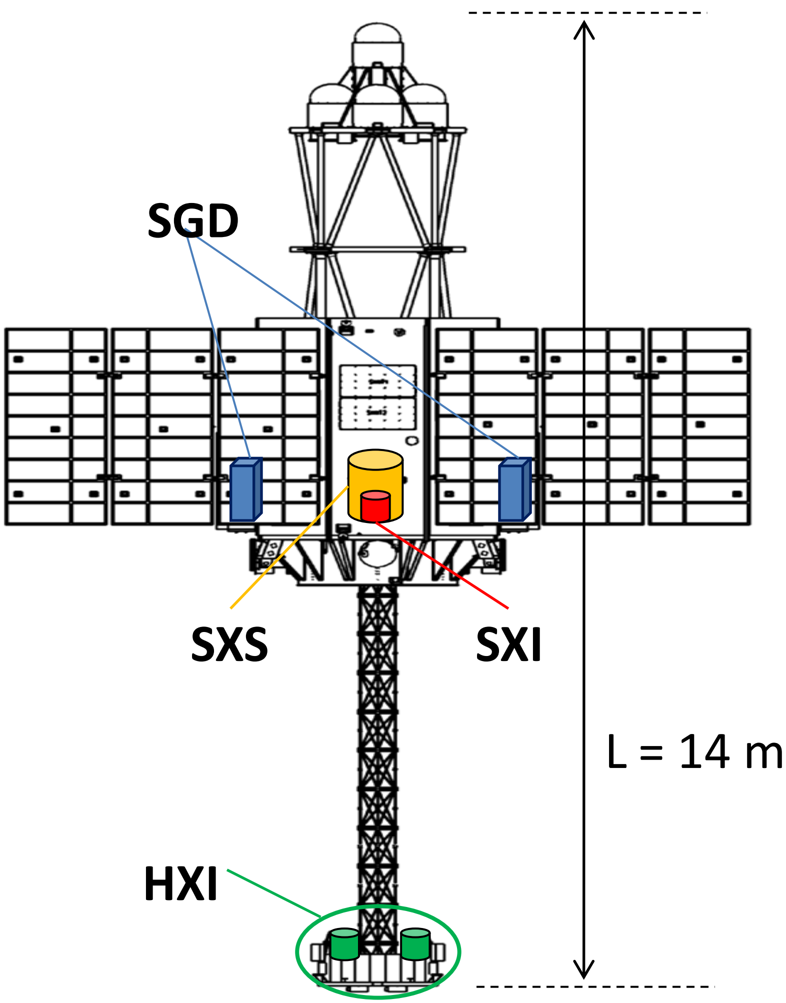
ASTRO-H (2)

Four kinds of detectors:

- **SXS**: X-ray micro calorimeter, with a few hundred Kg stainless steel
- **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**



ASTRO-H MC-sim framework

- Most of components have already been prepared for the current mission "Suzaku".
- Remained major components are external geometry importing and activation processes.
  - Activation is mainly evaluated by Hiroshima-U group for MEGAlib (external library). Maybe they will change to Geant4 activation after trade-off study.
  - The key of geometry importing is to convert CAD files (STEP) to Geant4 geometry. The rest of this report is about this issue.

Problems around geometry (1)

- Proprietary design
  - Most of spacecraft components are designed by contractors: details are often proprietary and they want to keep them secret.
  - Space science mission data and software are basically open to public: how MC software can keep a part of geometry secret?
- Solution
  - Current approach: proprietary parts are removed or replaced by simplified models by hand before converted to MC geometry.
  - Alternative approach: all the simulation will be carried out on JAXA computers via web interface.
  - Anyway, **better method is strongly required**.

Problems around geometry (2)

- STEP to Geant4 geometry conversion
  - STEP interface is not supported by the latest Geant4: alternatives are
    1. Make geometry by hand,
    2. Try to import very old Geant4 code to the latest one, or
    3. Convert STEP to GDML.
  - ASTRO-H is studying #3 approach.

GDML-based geometry (1)

- Multiple geometries can be easily combined, regardless of Geant4-code or STEP-file origin.
  - by a text editor.
  - Good XML editor or sophisticated tool may do better work.
- Geant4 geometry can be easily converted to GDML by Geant4 itself.
  - Existing geometries, such as detectors designed by scientists, can be reused.
- There are some commercial software to convert STEP to GDML, but...

GDML-based geometry (2)

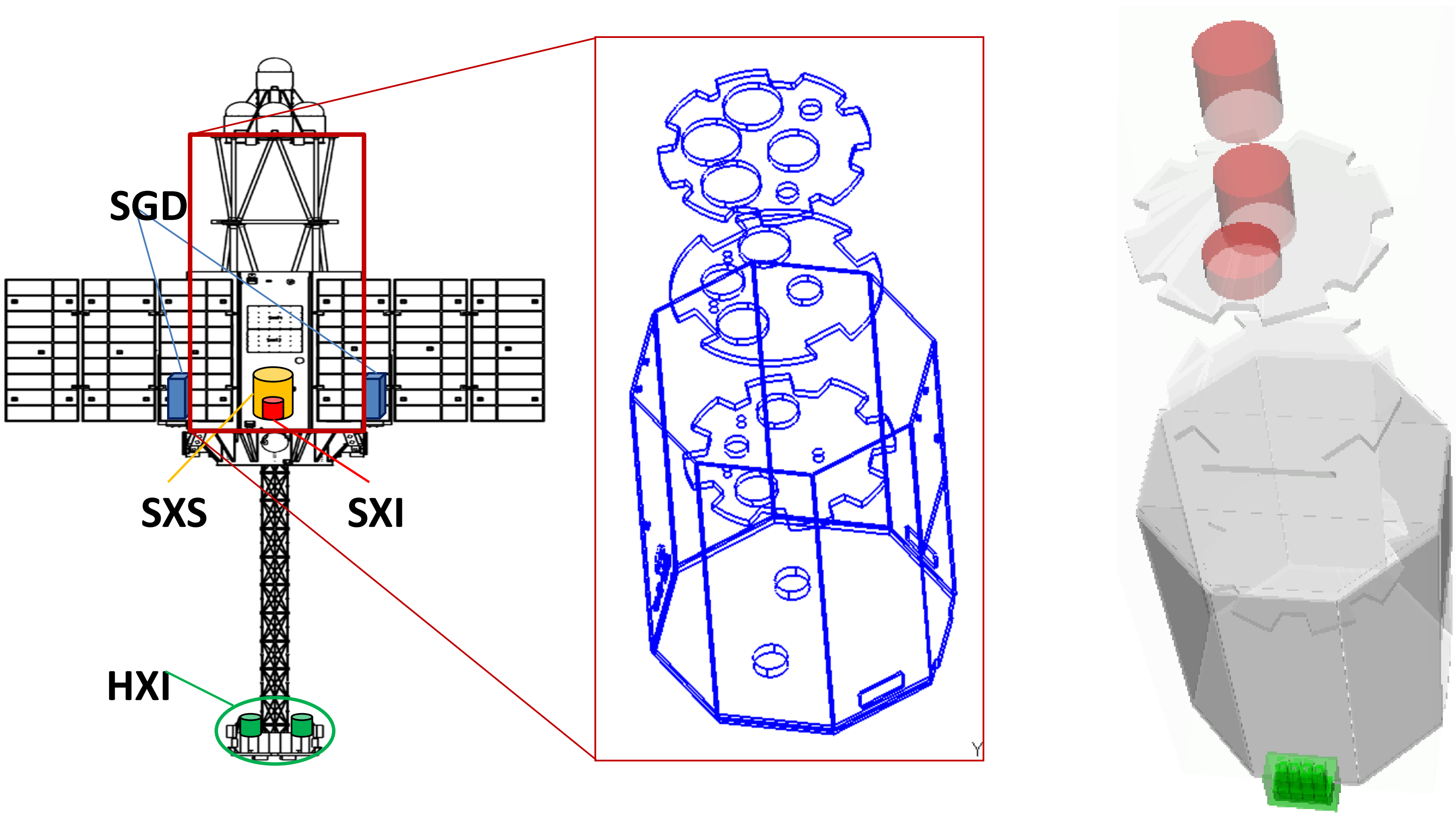
- There are some commercial software to convert STEP to GDML.
  - However, there are concerns:
    - **Evaluation**: it is not clear if each software can convert all the necessary components at once unless trying.
    - **Support**: once we chose a software, we want to use it during the mission life (10 years or so). Can they support us?
      - Even DEC, SGI and Sun disappeared...
  - Thus, open source software may be preferable.
  - Anyway, conversion is not straightforward:
    - GDML does not support BREP, for now.
    - Sometimes solid must be represented by tessellated solid.

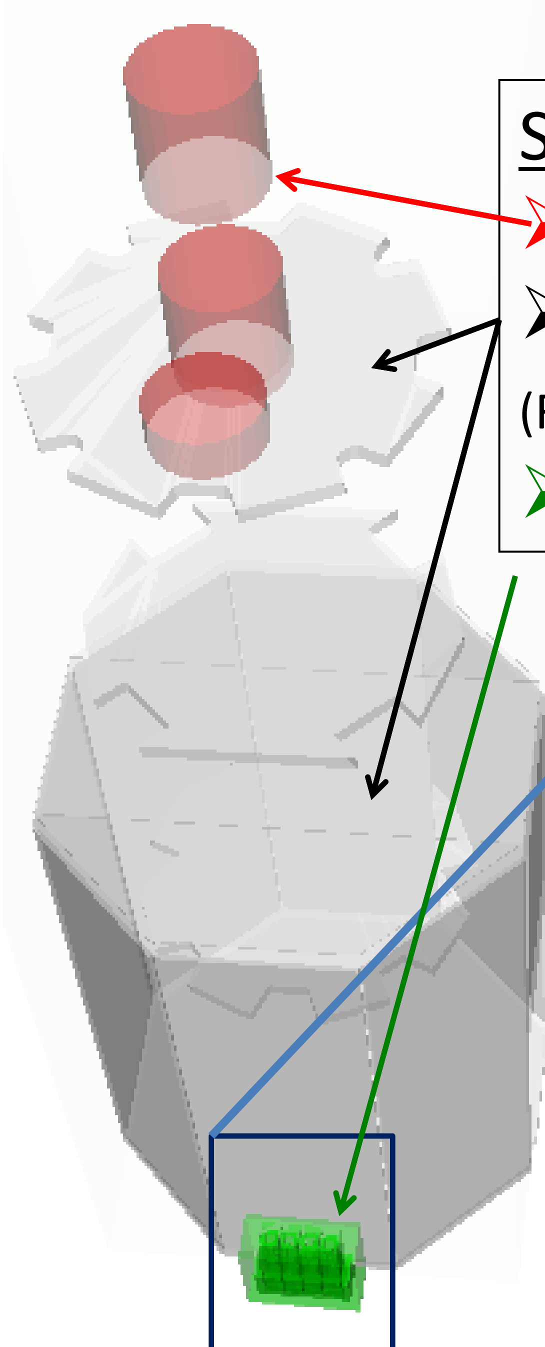
ASTRO-H GDML model trial

- Simplified X-ray telescopes and a precise SGD geometry was generated by Geant4.
- Simplified spacecraft structure was generated from a STEP file.
  - Only the structure panels were represented, and the extended optical bench was omitted.
  - Gmsh (http://geuz.org/gmsh/) with STEP handling library was used for data structure analysis, and its output was converted to GDML by a text editor. All the curved structure was omitted.
  - The result was embedded to the Geant4-output GDML above.
- SXS STEP file could not be converted due to Gmsh crash.
  - Probably the model is too complicated or the source file size is too large: it exceeds 100 MB.

From the original design to G4 model

Original | **Simplified Gmsh** | **Final GDML**



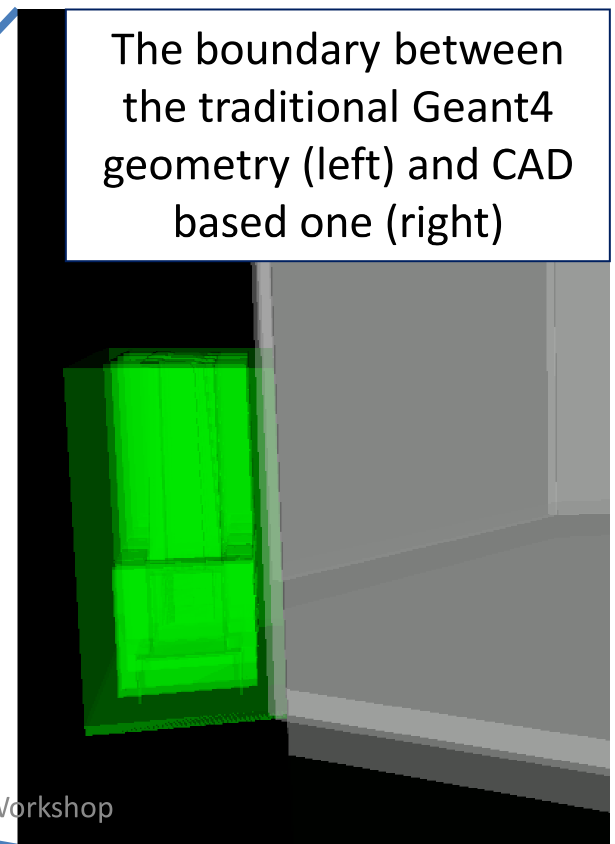


Simple ASTRO-H mass model

- Part of X-ray telescopes
- Some satellite structures

(FOB Panels, Base Panel, Side Panels...)

- SGD



The boundary between the traditional Geant4 geometry (left) and CAD based one (right)

Obtained tips about geometry

- GDML is a good core to combine multiple geometries to one. They can be easily fixed by a text editor or other sophisticated tools and no recompilation is required for the software.
- Supporting the following might make it easier to convert spacecraft STEP model to GDML:
  - BREP in GDML
  - Circle and spline in extruded solid

Summary

- Among JAXA missions, space-science ones tend to use Geant4 deeply.
- Next X-ray observatory mission (ASTRO-H) is studying to generate CAD-based full-satellite geometry.
  - Importing CAD based geometry of contractor origin has several issues.
  - GDML seems to be a good stage to integrate multiple geometries, including STEP based one.