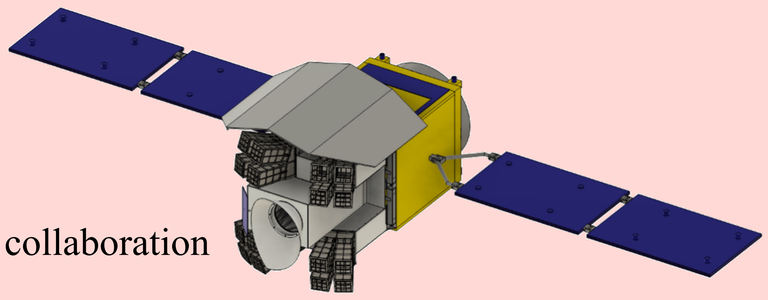
Thermal analysis of the near-infrared telescope on board the HiZ-GUNDAM satellite



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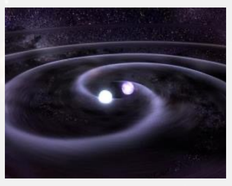
1. Purpose of HiZ-GUNDAM satellite

■ Exploration in the early universe



The gamma-ray burst (GRB) which is the biggest explosion in the universe can be observed in the early universe.

→ Star formation rates and reionization processes in the early universe can be understood.

■ Moment of the birth of a black hole

Gamma-ray bursts and kilonova occurs by a neutron star marger as the birth of a black hole.

→ Black holes and heavy element formation processes can be understood.

■ Observation methods

Current methods

1. A Satellite detects GRBs and notifies the ground.
   ↓ **~ 1 hour**
2. Observing GRBs with small telescopes.
   ↓ **a few hours – 1 day**
3. Estimating the distance of GRBs with medium size telescopes.
   ↓ **~ 1 day**
4. Spectroscopic observation of high-z GRBs with large telescopes.

HiZ-GUNDAM

Automatic on-board follow-up within 300 seconds

Within a half-hour

GRB afterglow has faded by the time the large telescopes observe.

Accelerates the process from GRB discovery

2. Thermal problems of this satellite

Thermal requirement:
Telescope body: < 200 K & IR detector: < 120 K
Radiative cooling (no mechanical cooler)

- A previous study has succeeded in temperature requirements.
  Telescope body: <165 K & IR detector: <105 K
- But temperature changes due to attitude change may degrade imaging performance.

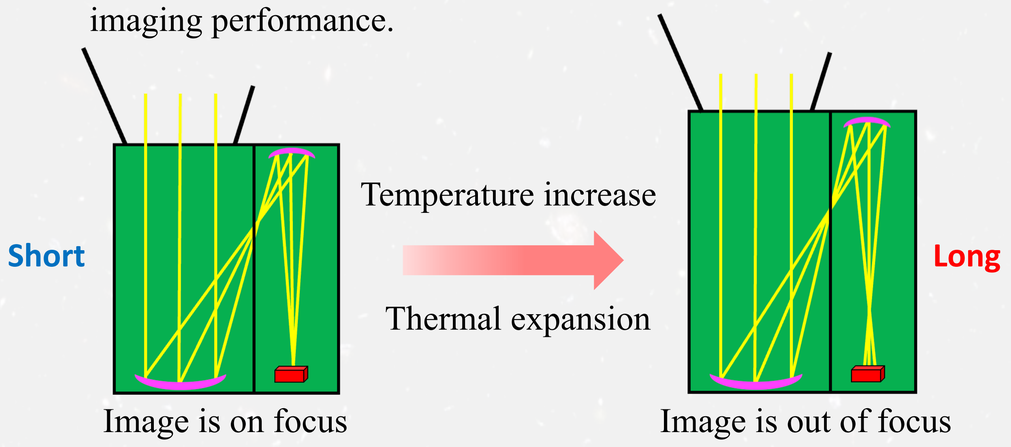


Table 1:
Allowable expansion and Actual expansion in the previous study.

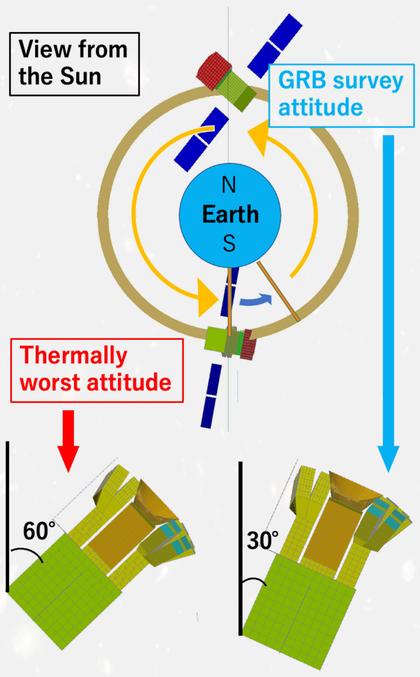
	Previous study
Allowable expansion	18 μm
Actual expansion	34.0 μm

■ Purpose of this study

Verify thermal feasibility in new optical designs.

3. Methods of thermal analysis

■ Conditions of thermal analysis

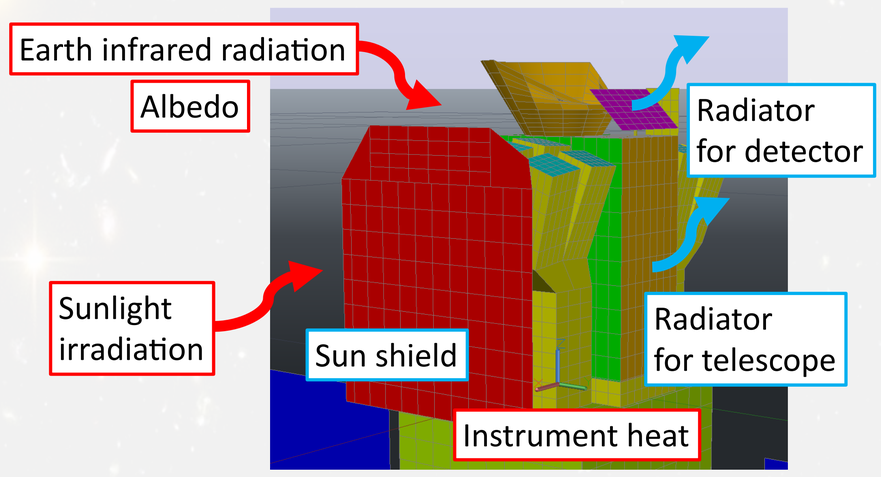


【Orbit】
A sun-synchronous polar orbit on the day-night boundary (Dawn-Dusk orbit)

【Attitude】
- GRB survey attitude:
  - Tilt toward the anti-solar direction: 30 deg
  - Tilt toward the direction of travel: 50 deg
- GRB tracking attitude (Thermally worst):
  - Tilt toward the anti-solar direction: 60 deg
  - Tilt toward the direction of travel: 80 deg

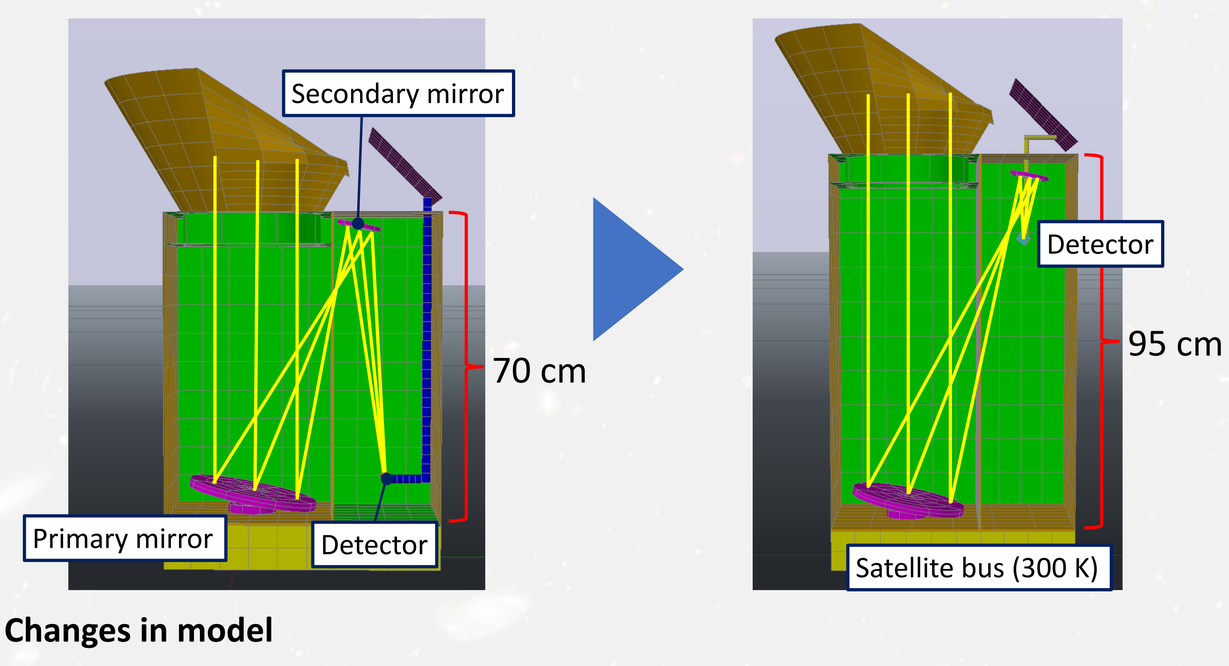
Consider the case of transition to the thermally worst attitude over Antarctica on the winter solstice, when thermal conditions are at the worst.

■ Thermal model



- Science instruments (NIRT + WFXMs + others) are modeled for thermal analysis by Thermal Desktop.
- The finite element method is used for thermal analysis.

4. Thermal model change



■ Changes in model

① Telescope enclosure extended vertically to extend the focal length of the primary mirror.
② Focal point is moved to the top, so the detector is placed at the top.

■ Benefits

① Longer focal lengths allow for greater displacement tolerance due to thermal deformation.
② The detector to be cooled has been moved from the satellite bus to the position closer to the radiator.

5. Analysis results

Table 2:Allowable expansion and actual expansion for previous and new models.

	Allowable expansion	Actual expansion
Previous model	18 μm	34.0 μm
New model	**40 μm**	**27.0 μm**

Table 3:Requirement and achieved temperature of temperature and detector.

	Telescope	Detector
Requirement	200 K	120 K
Previous model	164.5 K	104.1 K
New model	**164.5 K**	**96.9 K**

- Tolerances have been relaxed to meet the requirements.
- Actual expansion is within the allowable expansion.
- Telescope and detector temperatures also remained below the required values.

6. Future Prospect

- The results of the manufacturer's conceptual study are also incorporated to further refine the thermal model and improve accuracy.