Cryogenic Architecture of LiteBIRD Satellite

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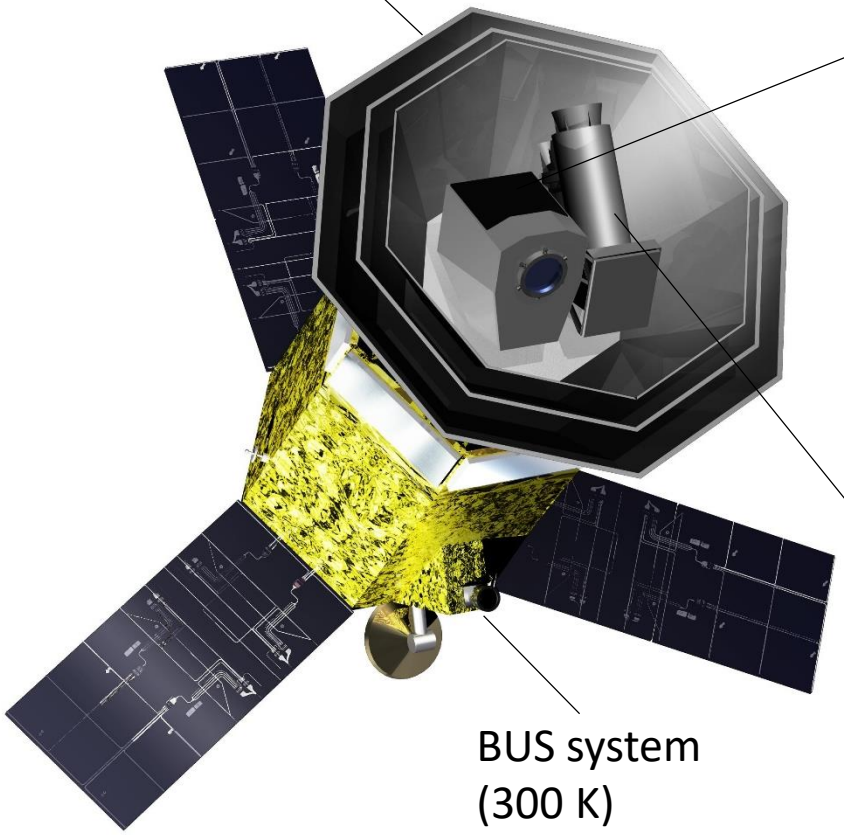
on behalf of LiteBIRD Joint Study Group

Institute of Space and Astronautical Science (ISAS),
Aerospace Exploration Agency (JAXA)

LiteBIRD Instruments

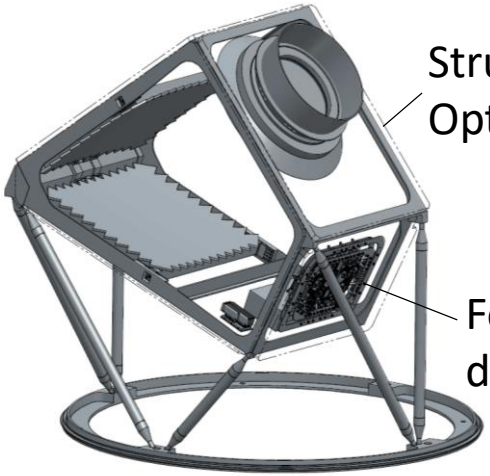
Thermal Shields (30 - 200 K)



BUS system
(300 K)

Solar Array Panels (350 K)

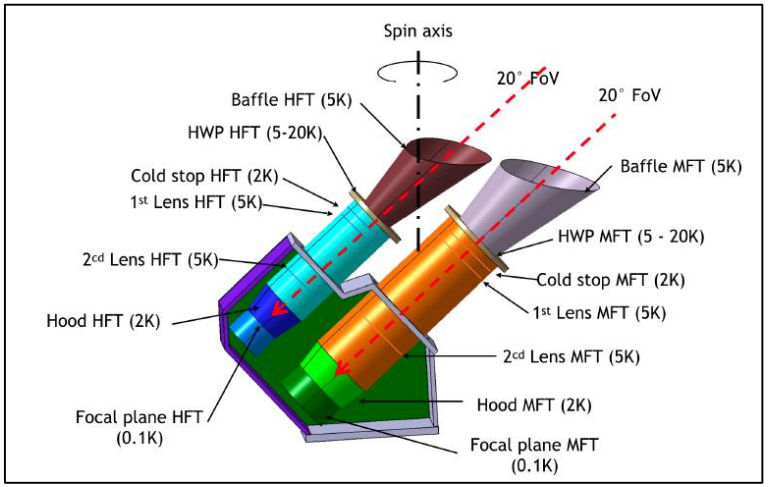
Low Frequency Telescope (LFT)



Structures and
Optics (5K)

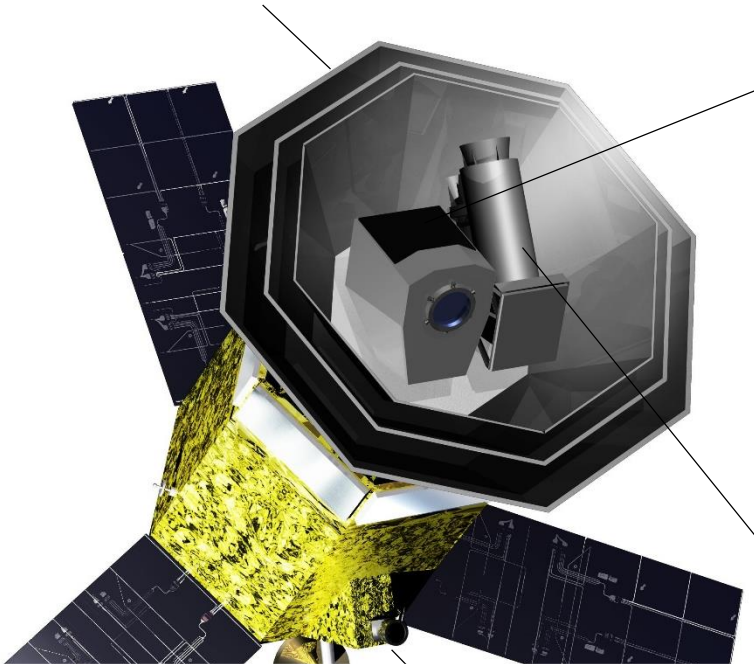
Focal plane
detectors (100mK)

Mid and High Frequency Telescopes (MHFT)

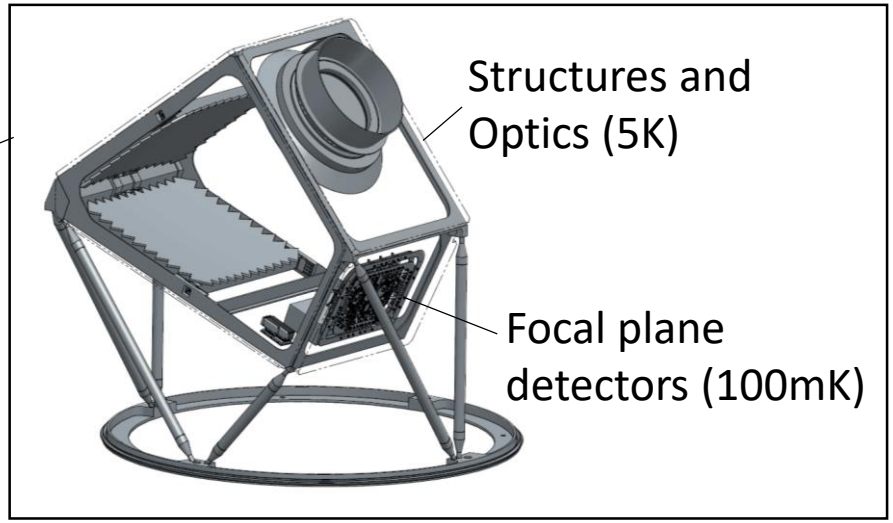


LiteBIRD Instruments

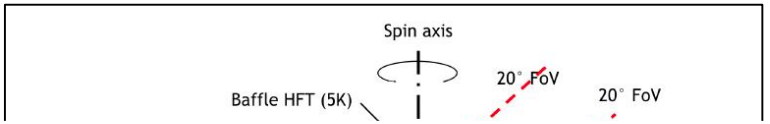
Thermal Shields (30 - 200 K)



Low Frequency Telescope (LFT)

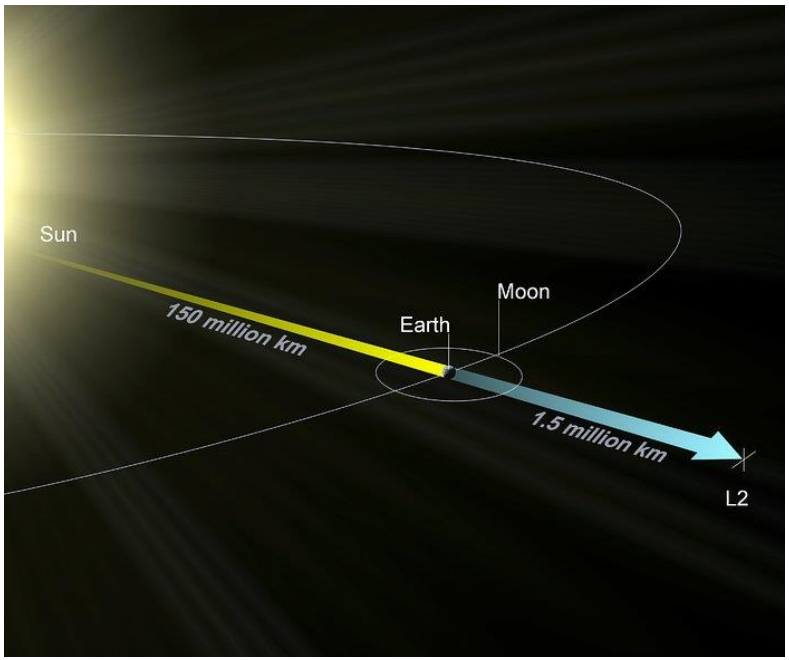


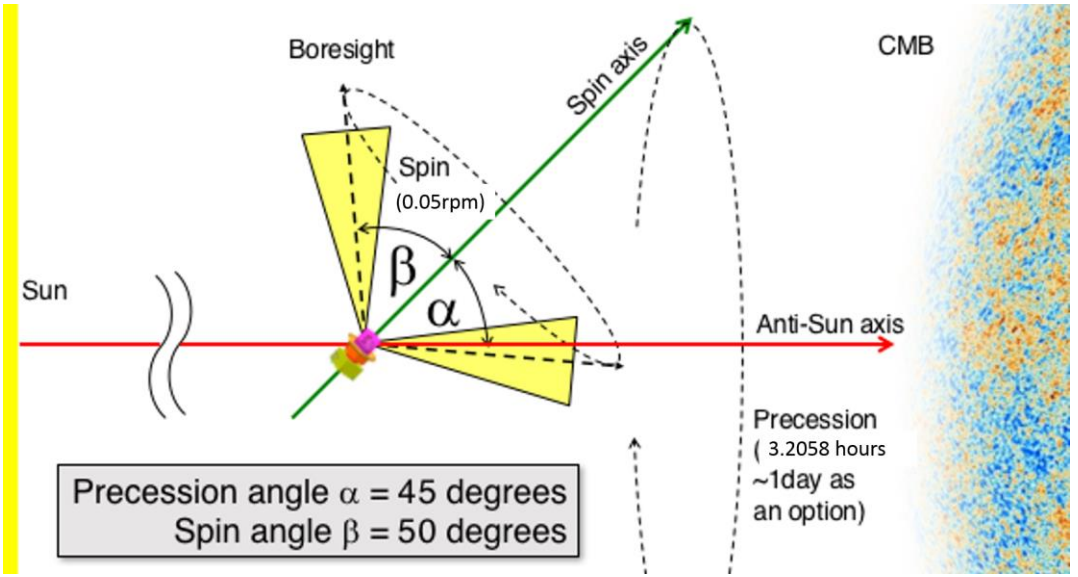
Mid and High Frequency Telescopes (MHFT)



- ~5000 superconducting detectors array (100 mK).
- 5 K telescopes to mitigate radiation noise from instruments.

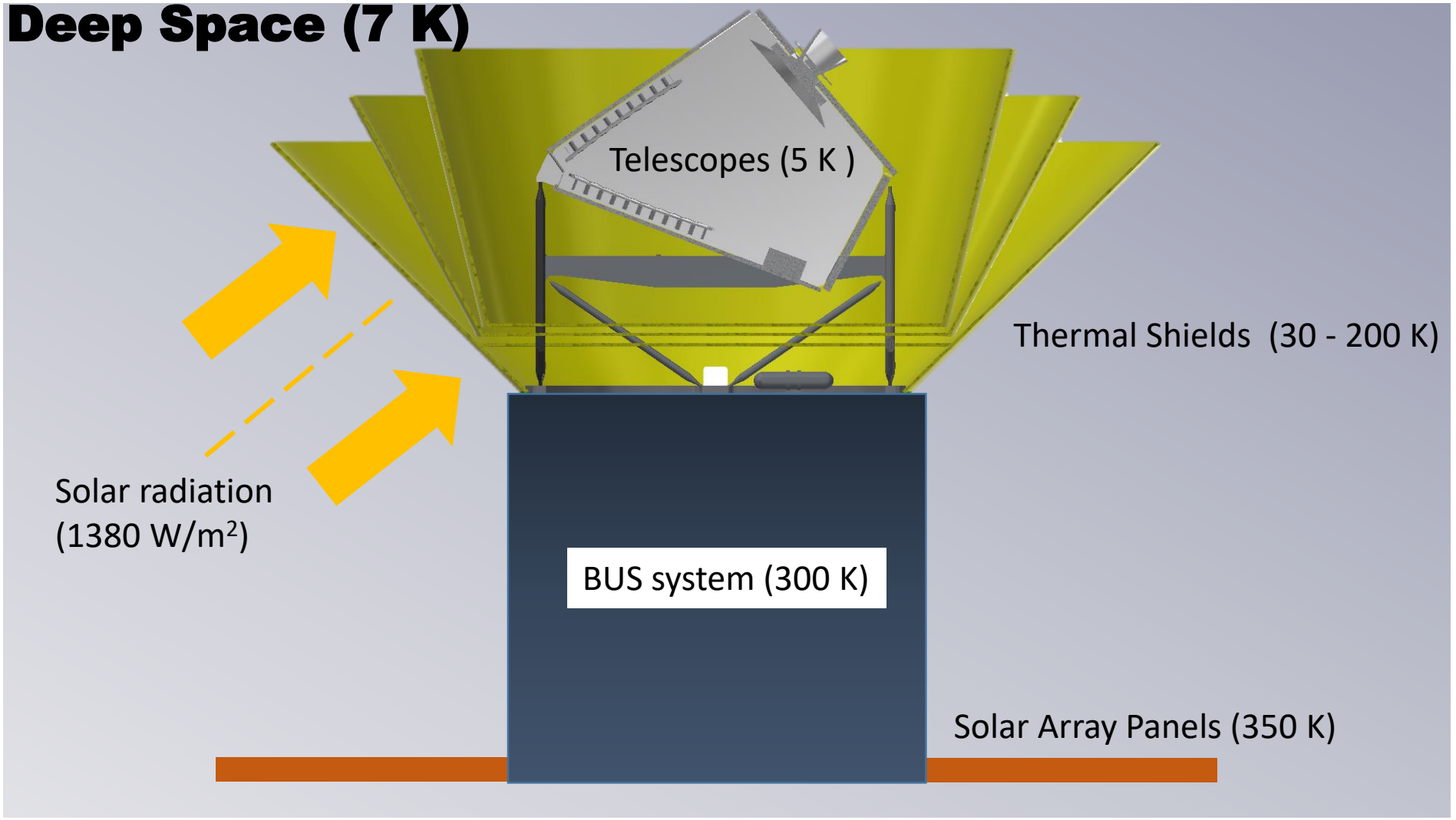
LiteBIRD on L2 Orbit





- Stable thermal environment
- Deep space radiative cooling
- Limited electric power
- Limited cooling power

Thermal Environment



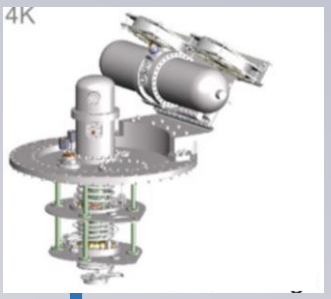
Mechanical Coolers

15K-PT Cooler (EU)

2nd Stage

Telescopes (5 K)

4K-JT Cooler (JP)



1st Stage

T. Prouve et al., Cryogenics 2018

Thermal Shields (30 - 200 K)

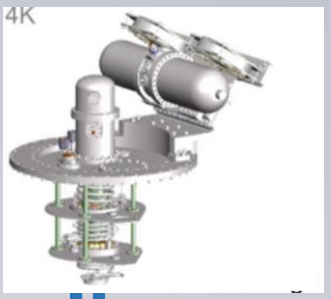
Mechanical Coolers

15K-PT Cooler (EU)

2nd Stage

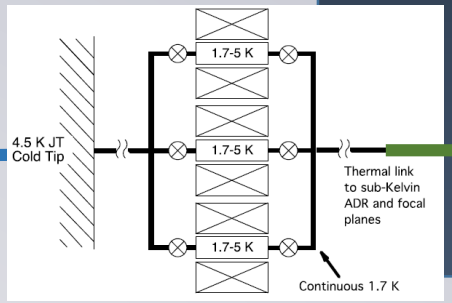
Detectors(0.1 K)

4K-JT Cooler (JP)

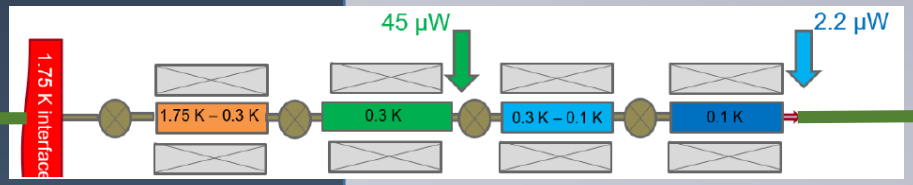


1st Stage

2K ADR (US)

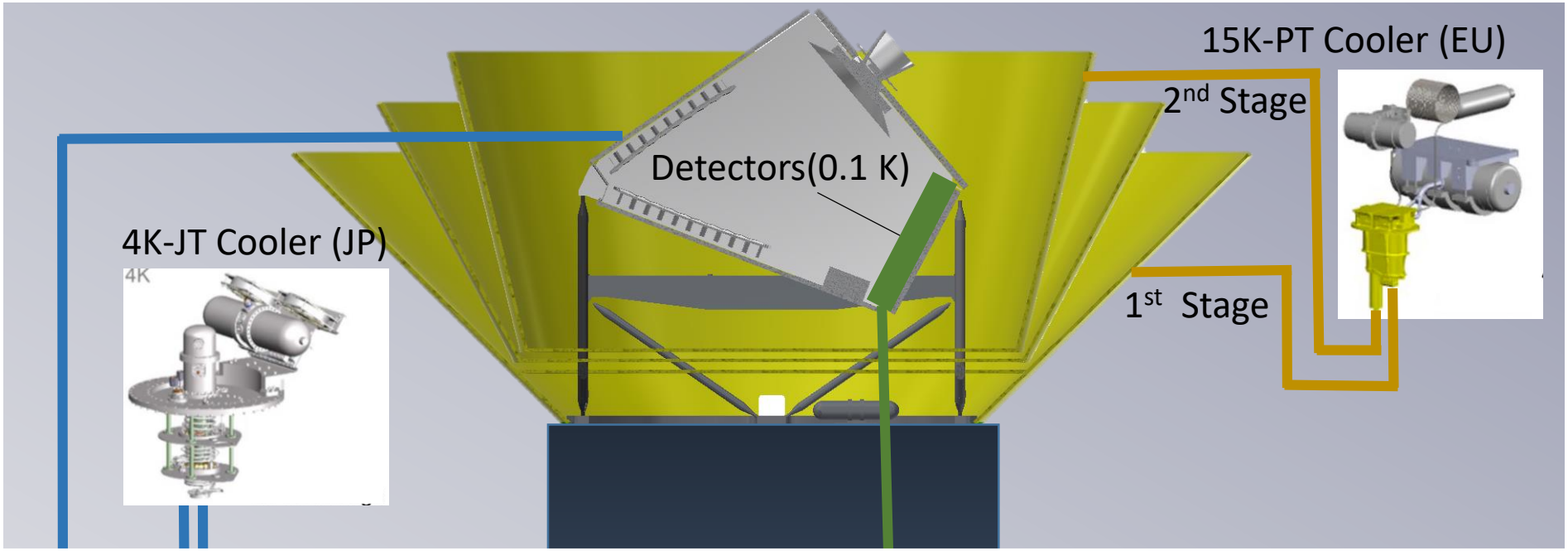


Sub -K ADR (EU)



J.M.Duval et al., JLTP 2020

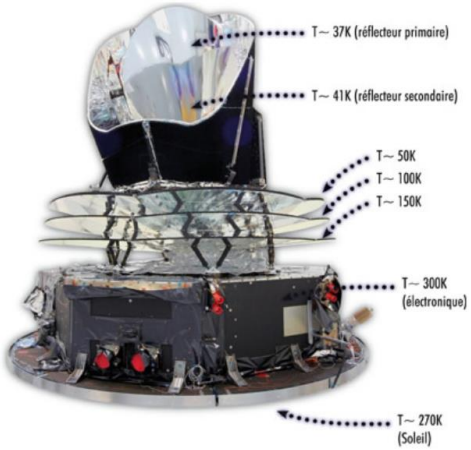
Mechanical Coolers



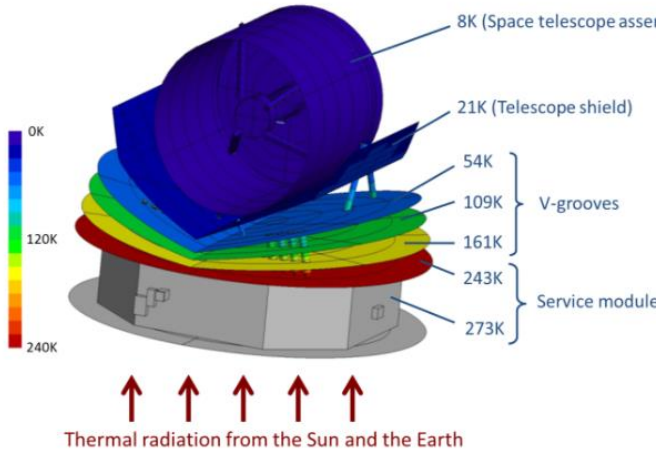
- JP group is responsible for 300 – 5K cryochain.
- 4K-JT cooling power : **40 mW @ 4.5 K**

Radiative Cooling

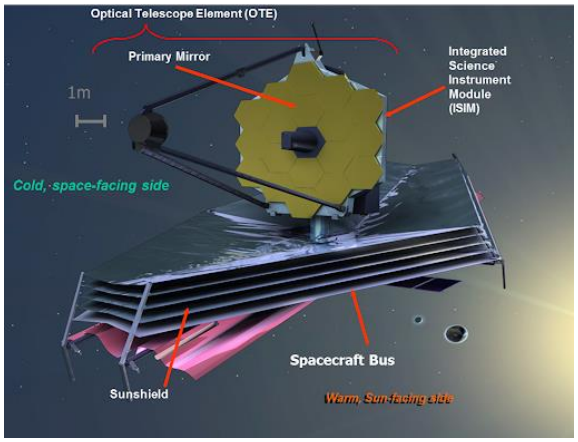
Planck

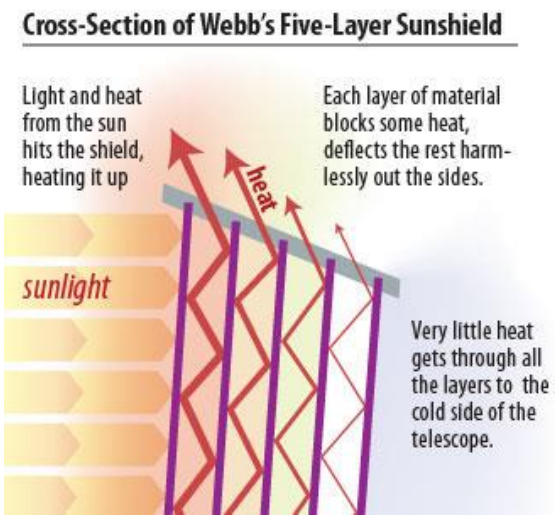


SPICA



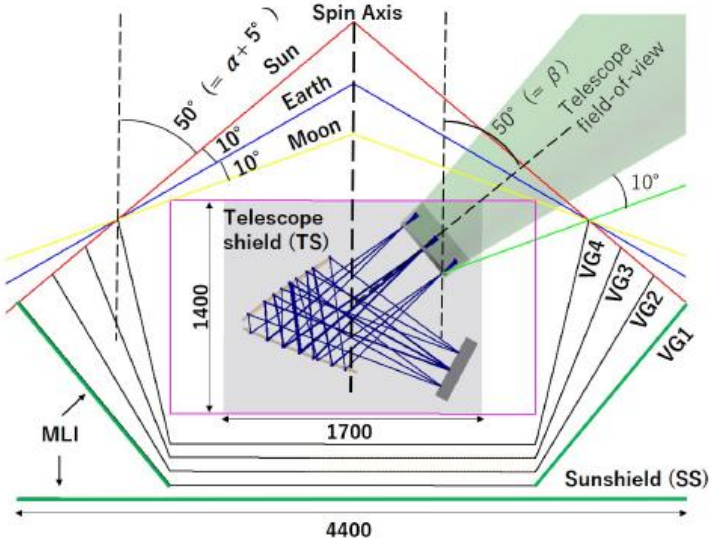
JWST

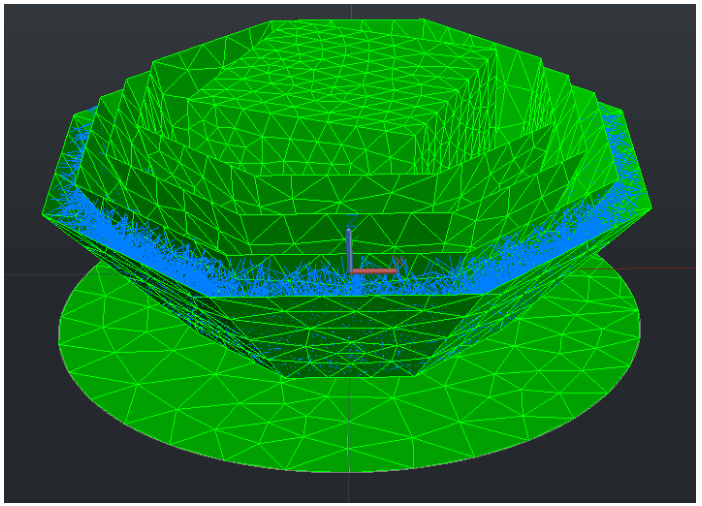


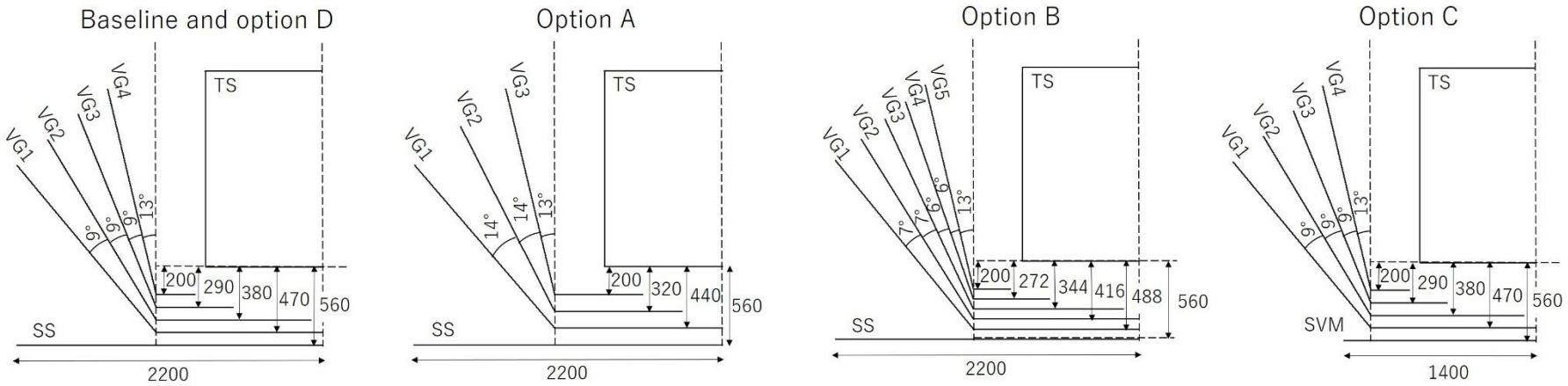


https://jwst.nasa.gov/content/observatory/sunshield.html

Thermal Shield Design

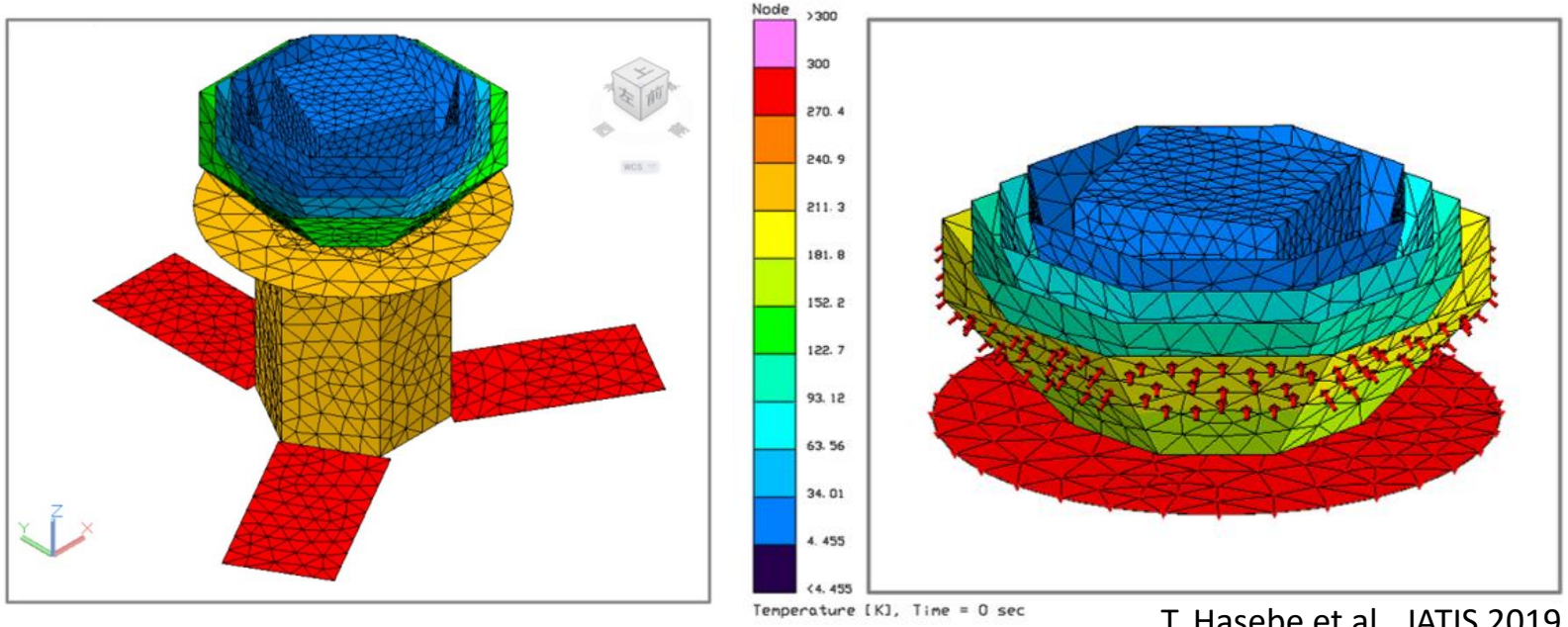






Design optimization has been done

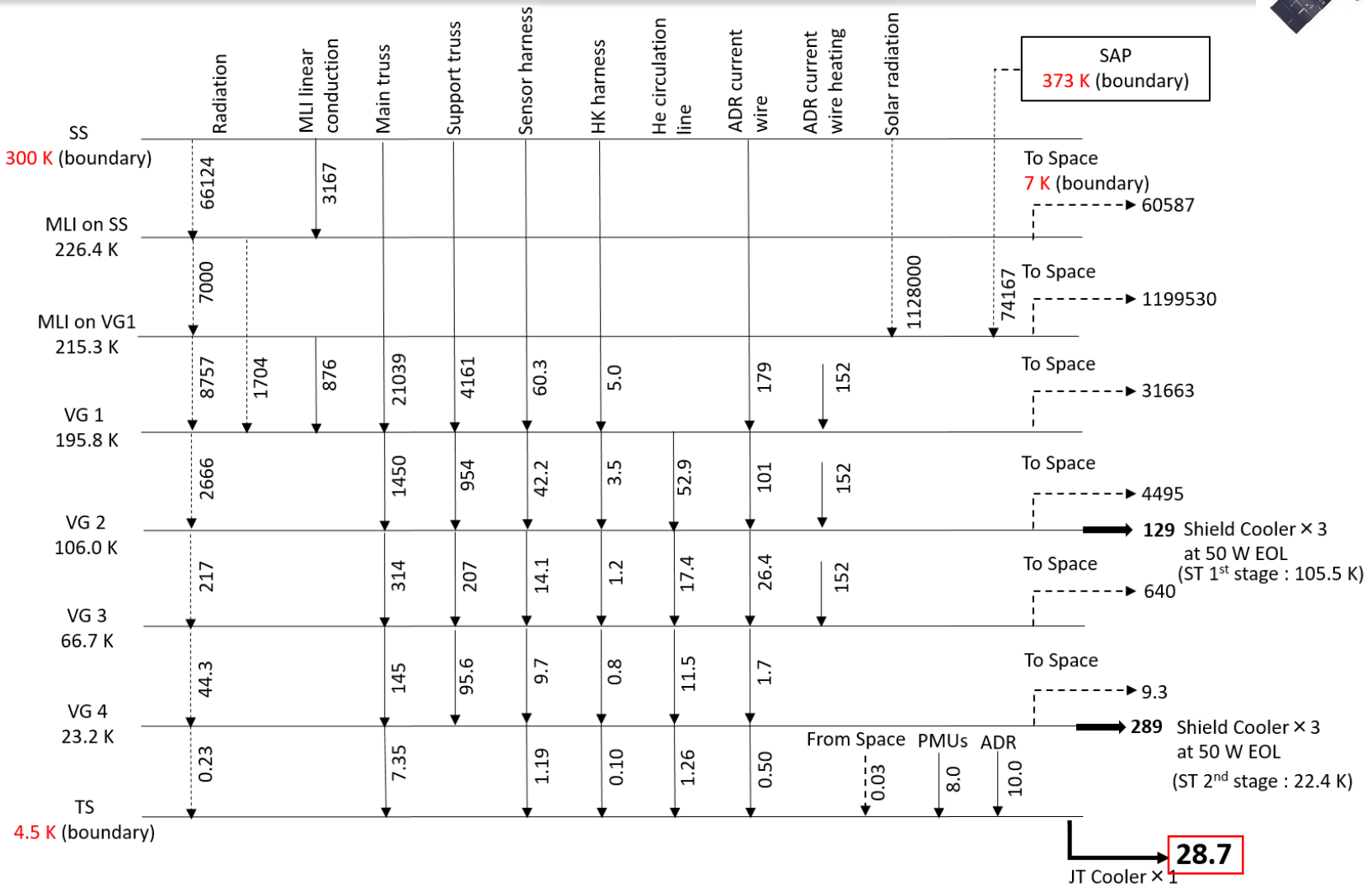
Thermal Simulation



T. Hasebe et al., JATIS 2019

- Radiative heat from the Sun, SAP, BUS system etc…
- Conductive heat from Structures, Harnesses etc…
- Heat inputs from Instruments
- Cooling by Cryocoolers

Heat Flow



Current model achieves 4.5 K with < 30 mW cooling power

Summary

1. Cryogenics is a key technology for high sensitive space science missions.

2. LiteBIRD uses a combination of cryocoolers and radiative cooling to realize the high-performance cooling system.

3. We established a robust thermal architecture during the cosmic acceleration program.