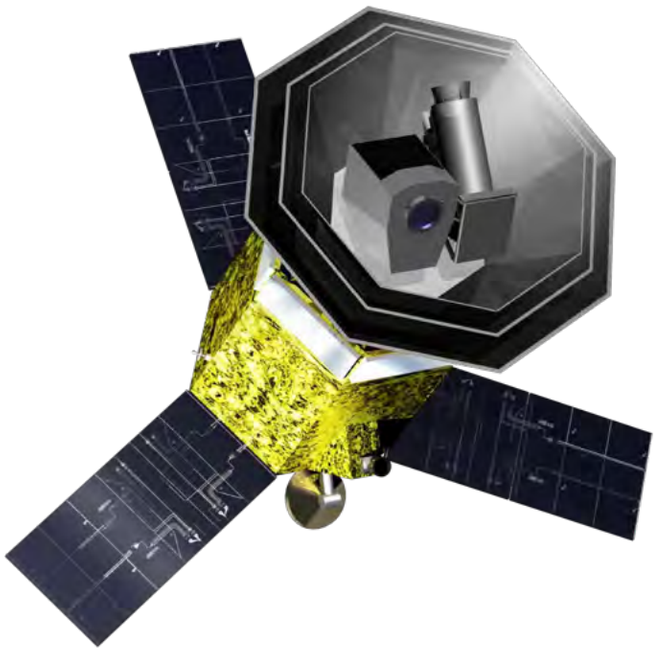
LiteBIRD
leading role of JAXA

2019-07-02

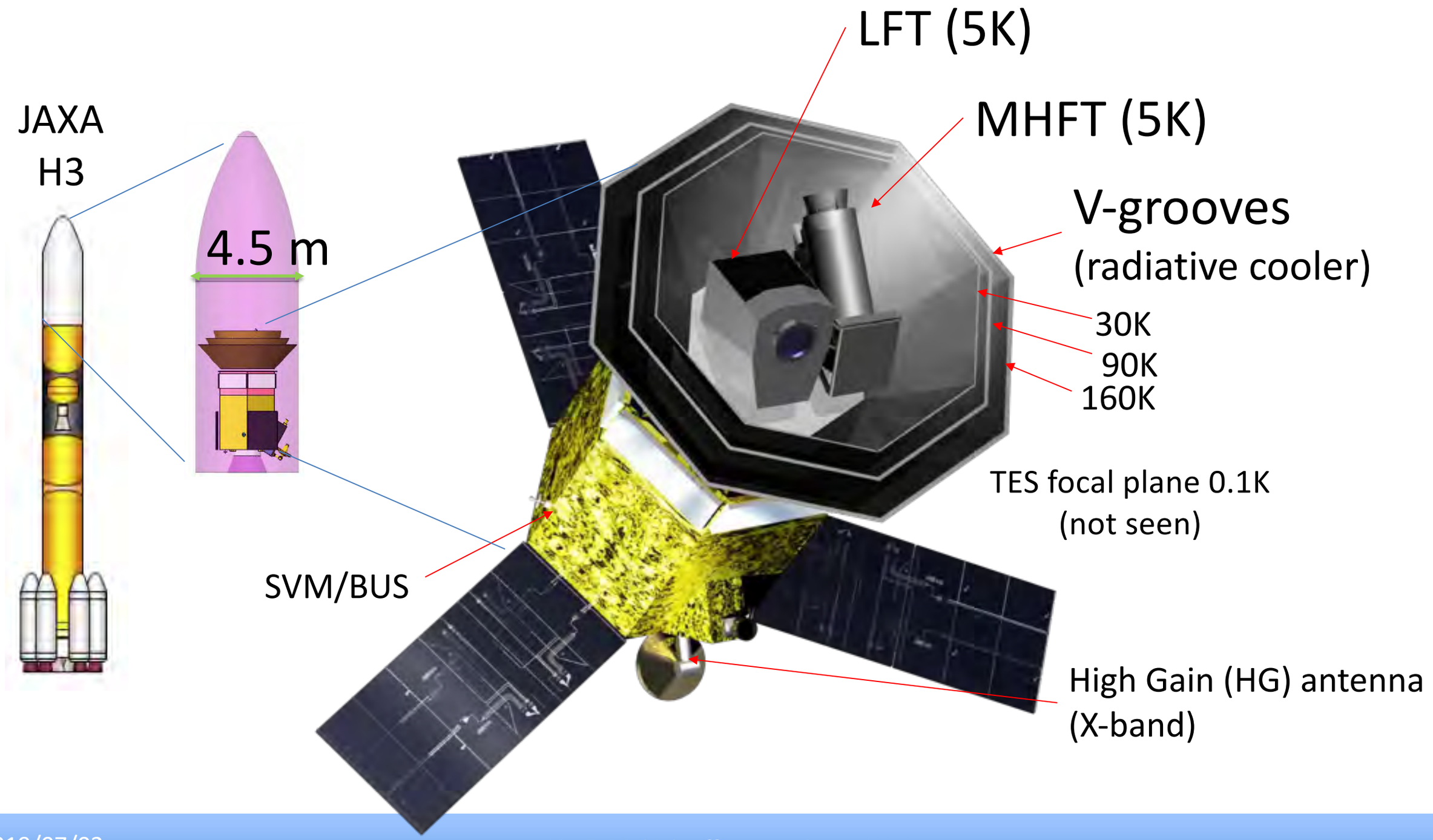


Yutaro Sekimoto, Tadayasu Dotani, Masahiro Tsujimoto,
Ken Ebisawa, Takashi Hasebe, Masashi Hazumi, Toru Kaga,
Kazuhisa Mitsuda, Norio Okada, Yasuhiro Murata, Yoichi Sato,
Keisuke Shinozaki, Hayato Takakura, Yoichi Takeda, Noriko Yamasaki
Japan Aerospace Exploration Agency (JAXA)

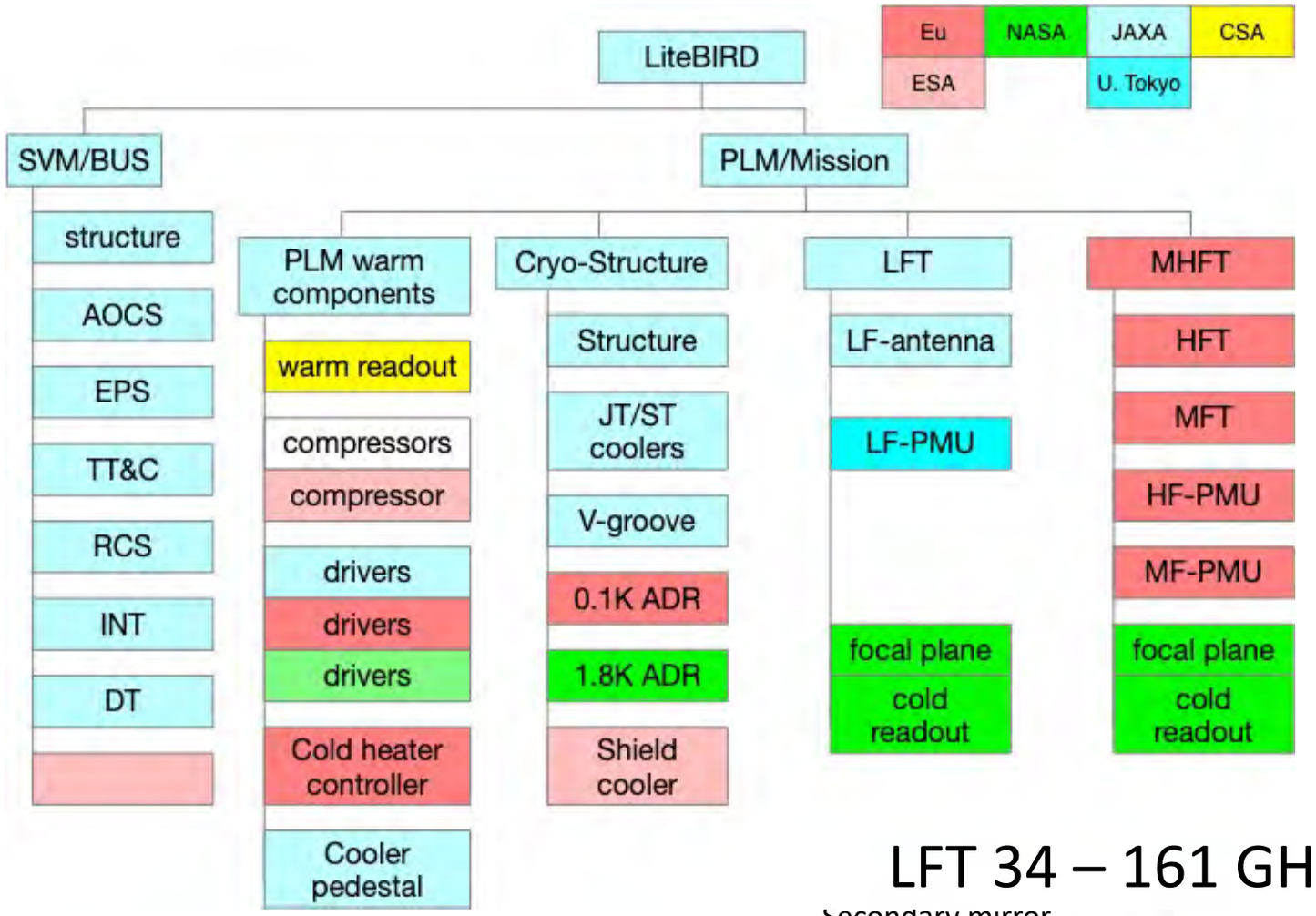
Spacecraft

LFT (Low frequency telescope) 34 – 161 GHz : Synchrotron + CMB

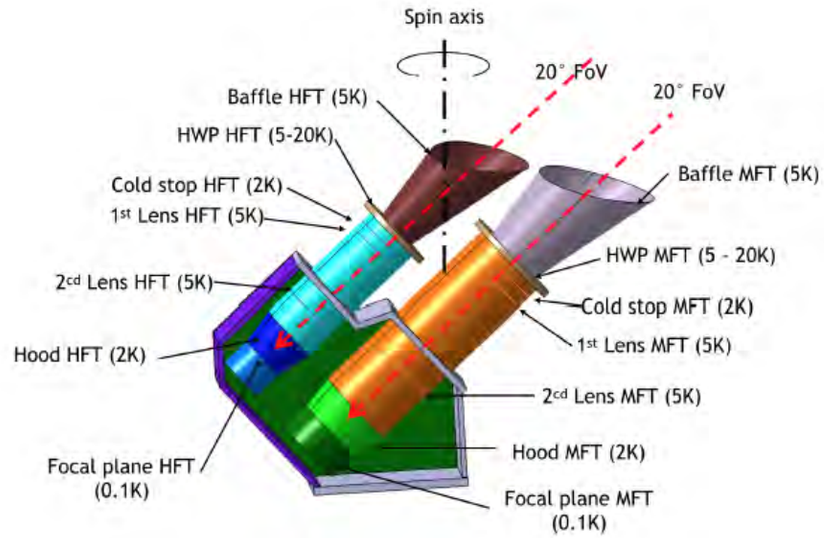
MHFT (middle and high frequency telescopes) 89 – 448 GHz : CMB + Dust



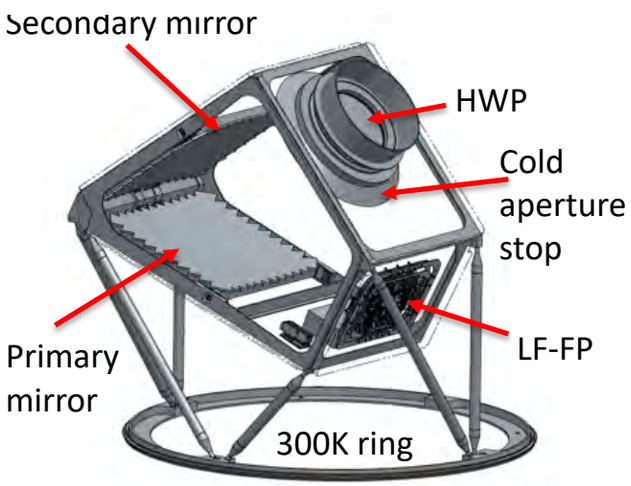
LiteBIRD product tree



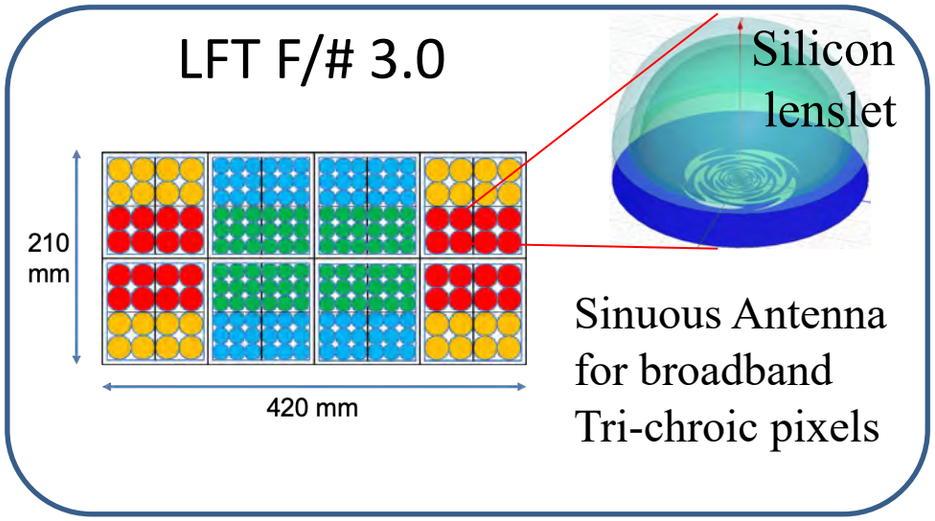
MHFT 89 – 448 GHz



LFT 34 – 161 GHz



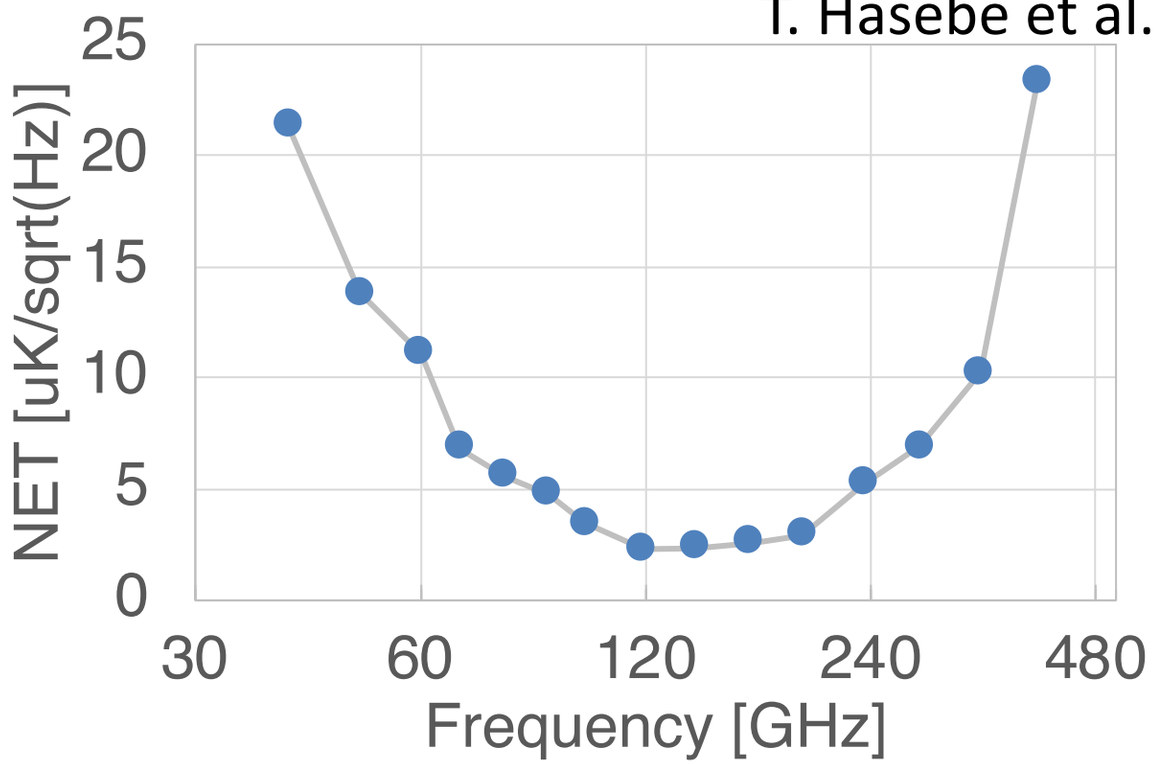
LFT F/# 3.0



LiteBIRD basic parameters

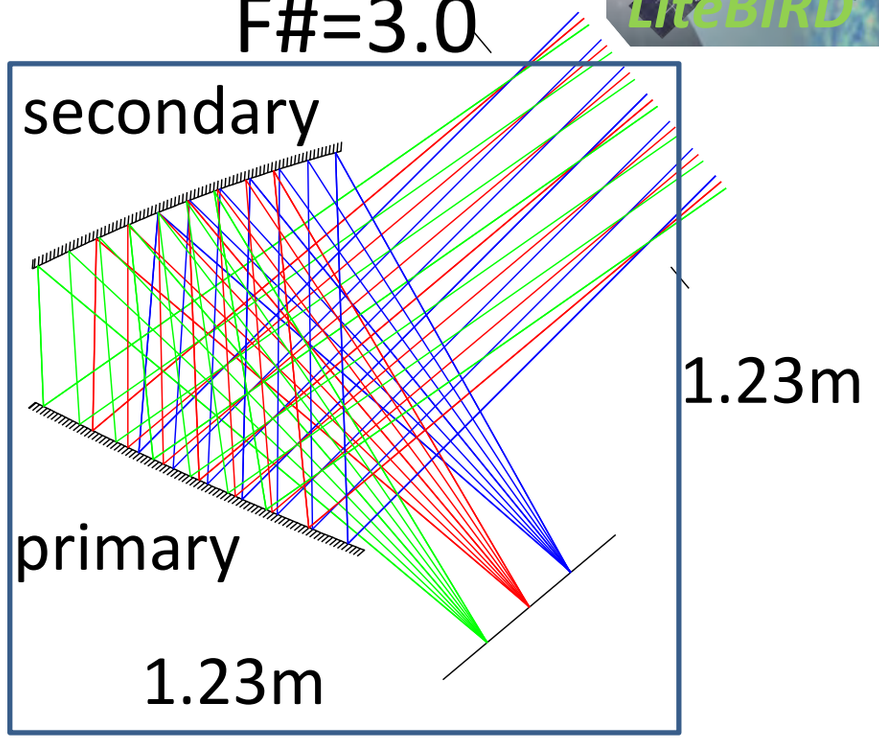
	Low Frequency Telescope (LFT)	Middle & High Frequency Telescope (MHFT)
Frequency	34 ~ 161 GHz	89 ~ 448 GHz
field of view	20 deg ×10 deg	ϕ 28 deg
aperture diameter	400 mm	300 mm
angular resolution	20 ~ 70 arcmin	18 ~ 42 arcmin
rotational HWP	88 rpm	170 rpm
number of detectors	1248	3428
Uncertainty of r	δr < 1 × 10^(−3)	
Observation period	3 years	
Scan	L2 Lissajous, precession angle 45 deg, spin angle 50 deg (0.1 rpm)	
Sensitivity	2 μK·arcmin	
pointing knowledge	< 2.1 arcmin	
focal plane array	bath temperature 100 mK	
	f_{knee} < 20 mHz	
data transfer	10 GByte/day	
mass	2.6 ton	
electrical power	3.0 kW	

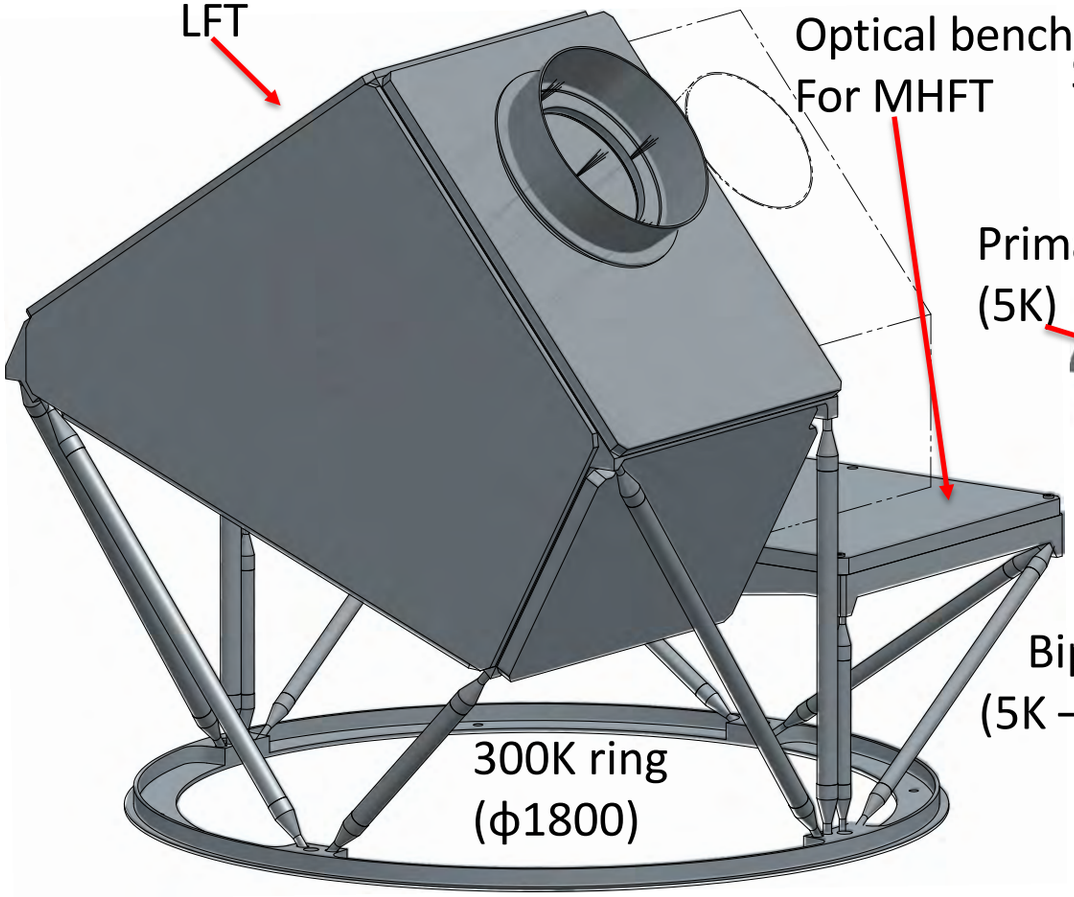
T. Hasebe et al.

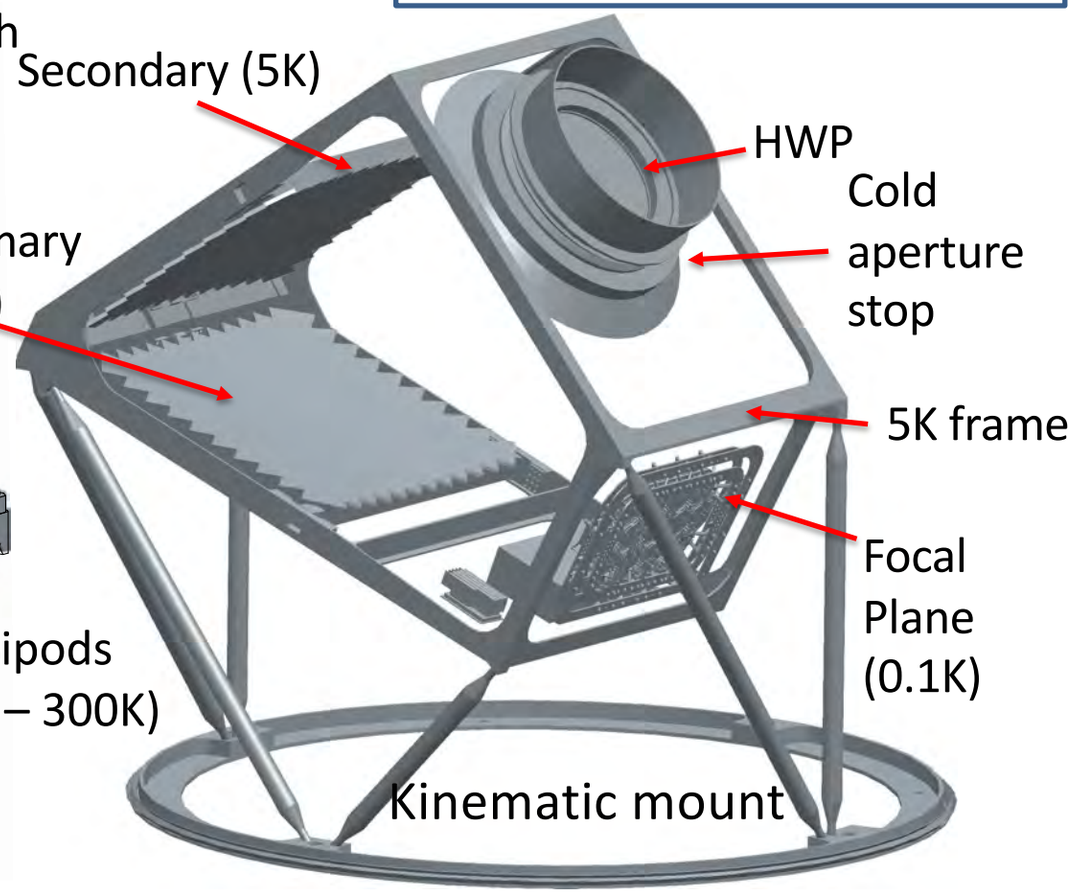


Opt-Cryo-Mechanical design of Low frequency telescope (LFT)

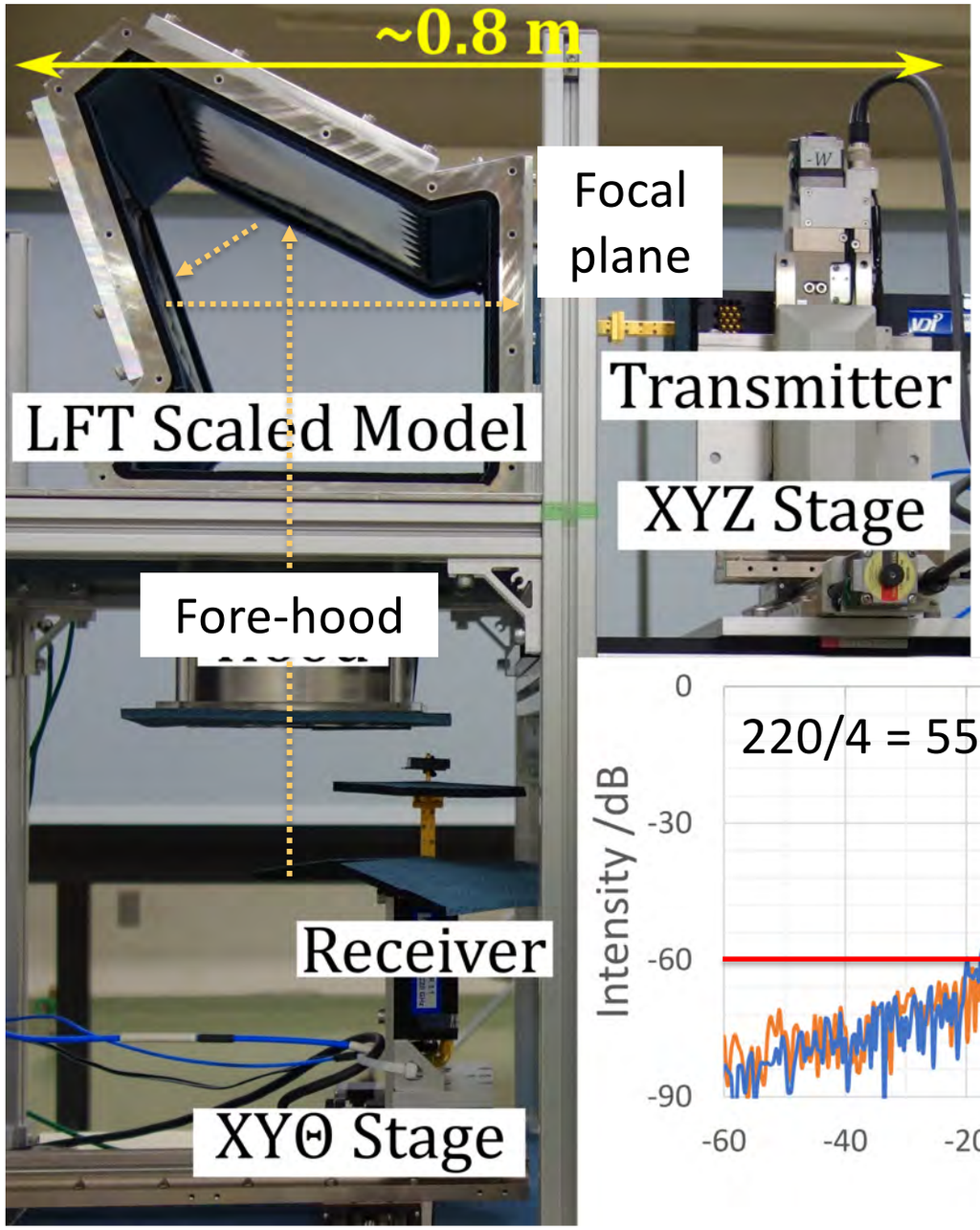
- Aperture diameter 400 mm
- Field of view 20 deg x 10 deg
- F#3.0 & crossed angle of 90 degree
- All 5K parts are made of Aluminum
- S. Kashima et al. 2018 Appl. Optics
- Y. Sekimoto et al. 2018 SPIE

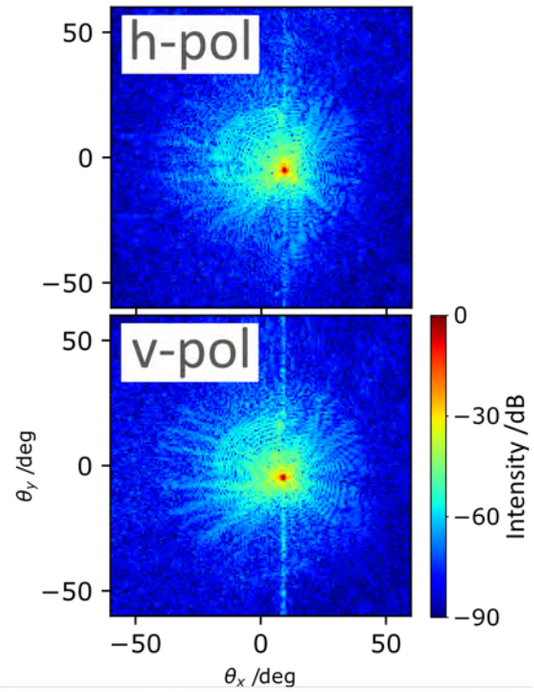


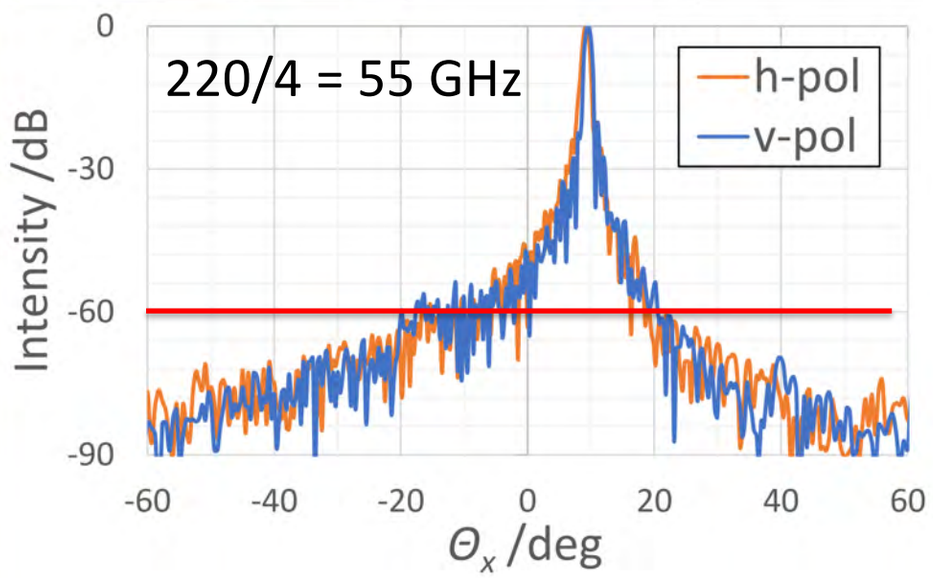




LFT ¼ scaled model far sidelobe measurements





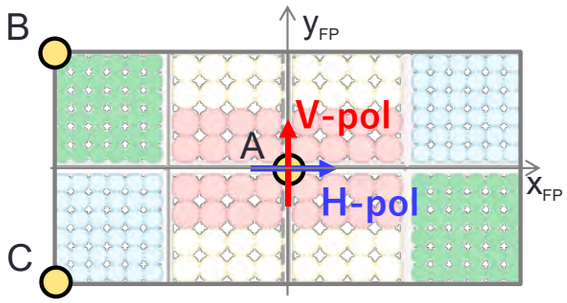


A frame structure and mirrors have been designed and machined by Advanced Machine shop of ISAS/JAXA

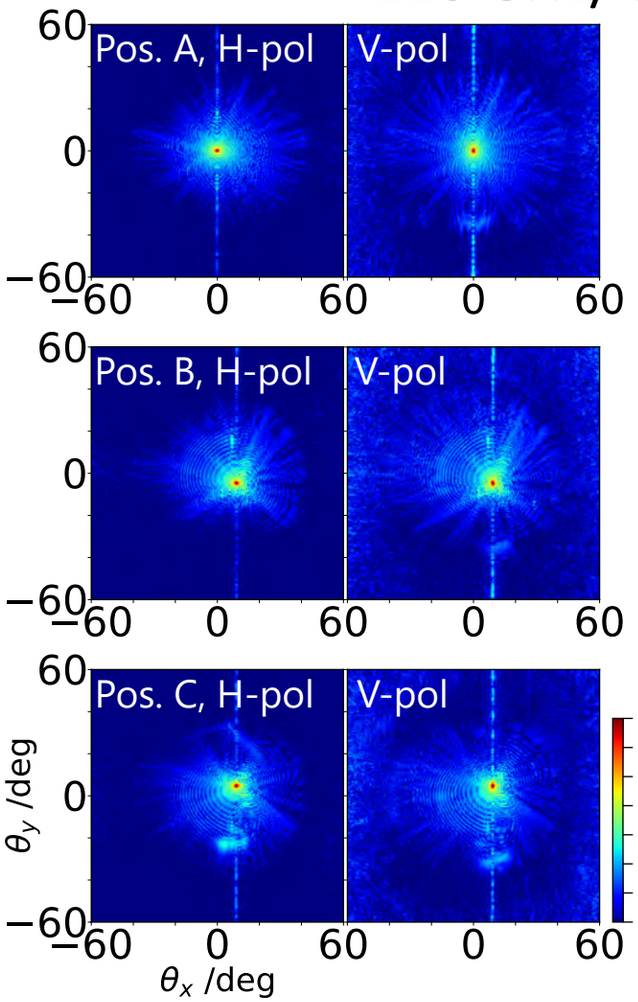
Far sidelobe of LFT has been measured to be less than -60 dB even at the outer edge of the field of view (the edge of the focal plane).

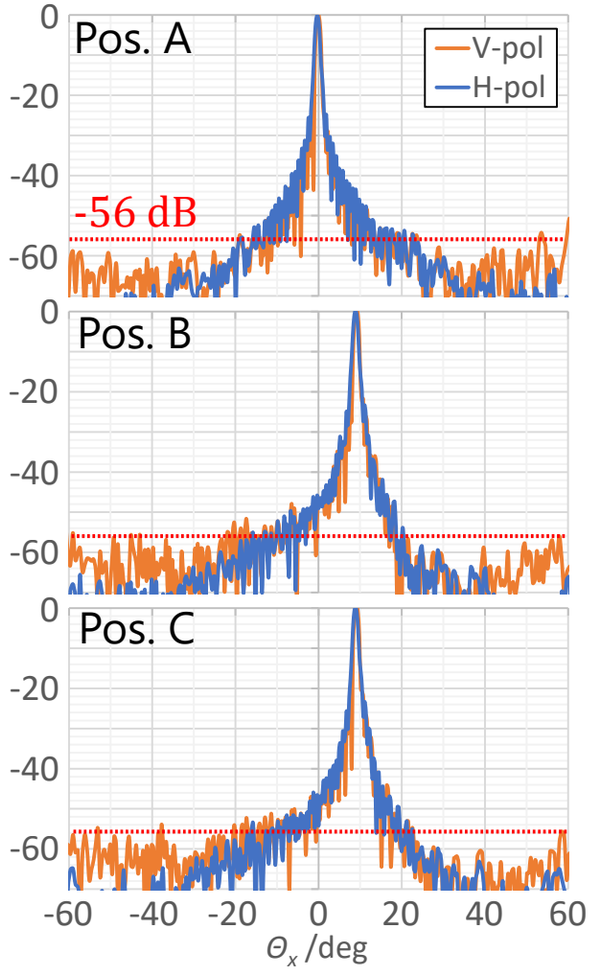
H. Takakura et al. 2019 IEEE TST submitted

Far sidelobe measurements

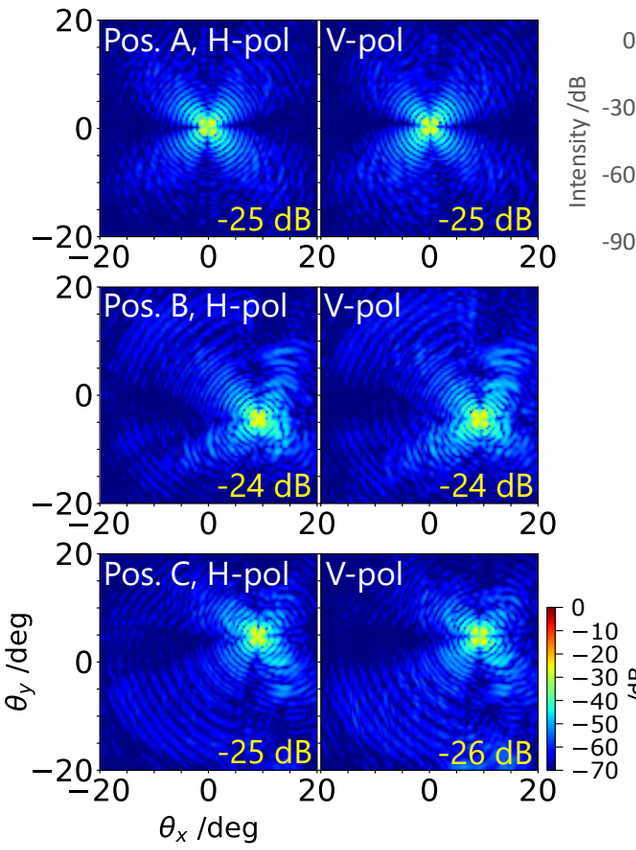


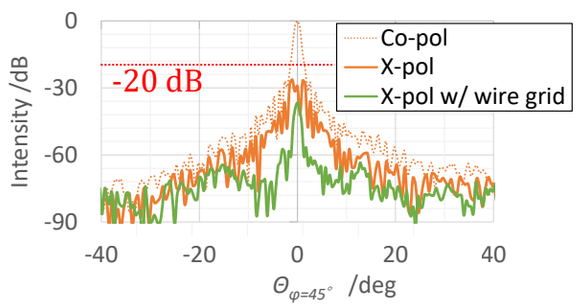
220 GHz/4 = 55 GHz



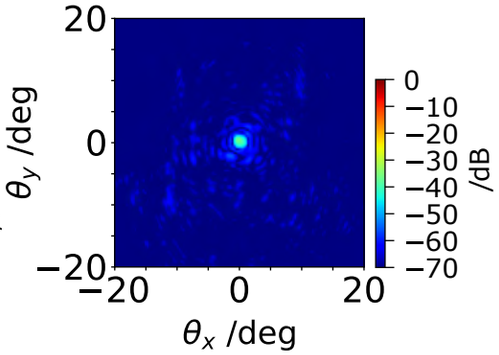


Cross polarization





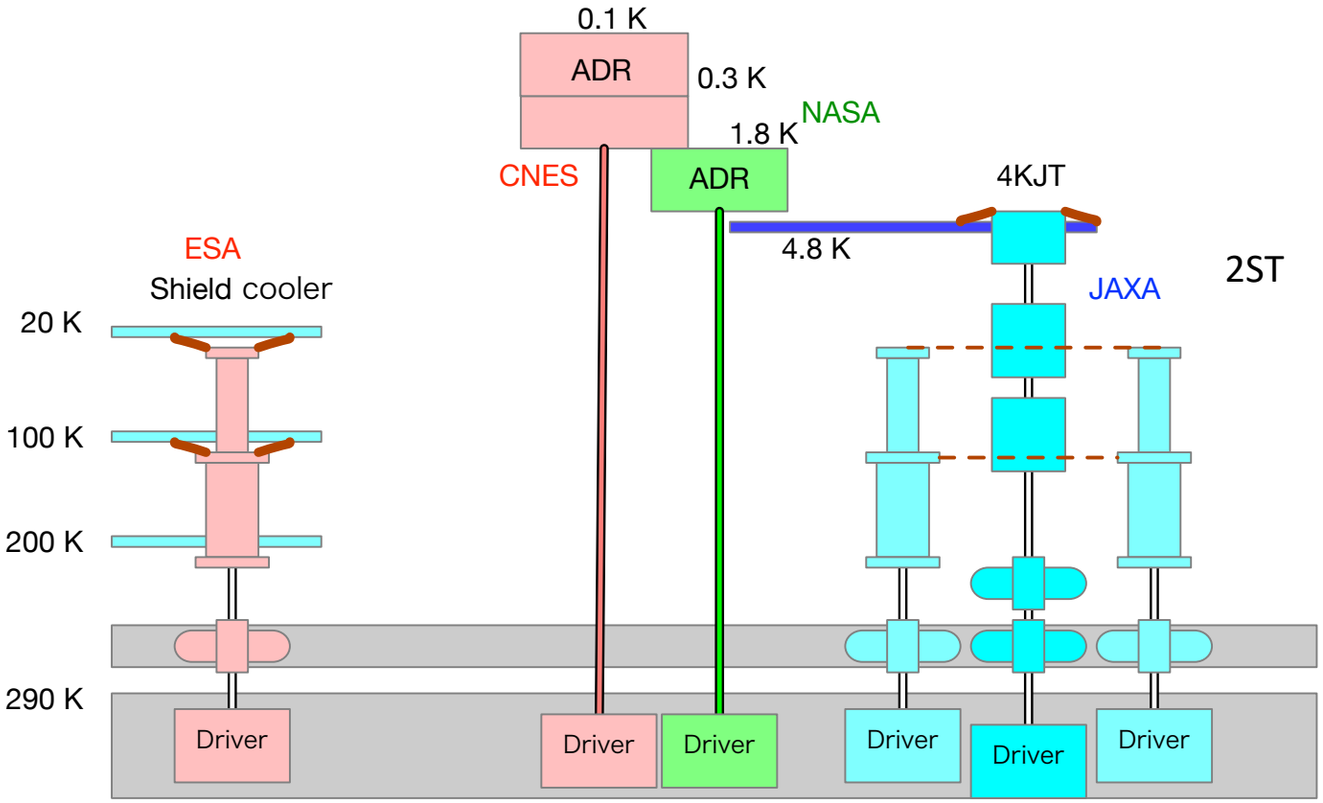
With wiregrid



H. Takakura et al. 2019 IEEE TST submitted

Cryo-coolers

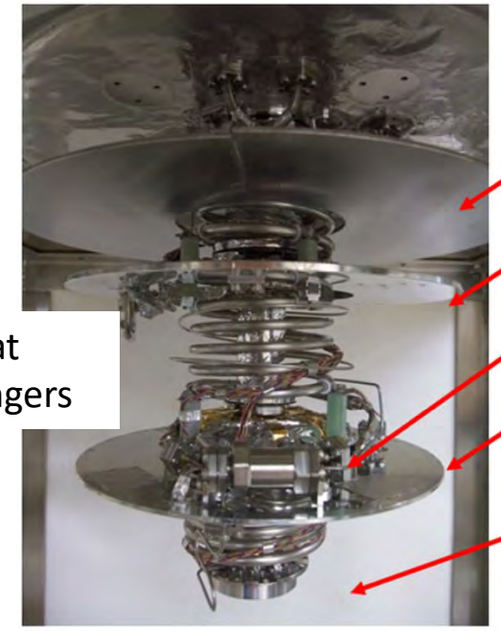
- 4K Joule-Thompson cooler (4K-JT)
  - Cooling power : 40 mW at 4.5 K
  - Smiles, Hitomi, XRISM, SPICA, Athena
- 2 stage Stirling cooler (2ST)
  - Cooling power: 200 mW at 20K
  - Akari, Smiles, Hitomi, XRISM, SPICA
- Cooling chain – core technology program (CC-CTP)
  - Collaboration with CEA for Athena, SPICA, LiteBIRD



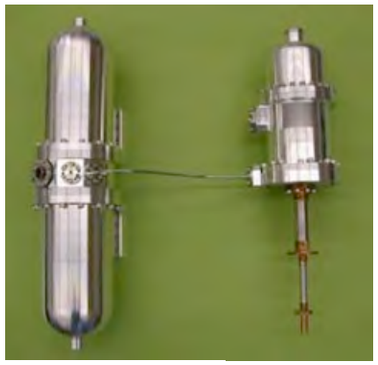
ADR : Adiabatic Demagnetization Refrigerator

4K-JT

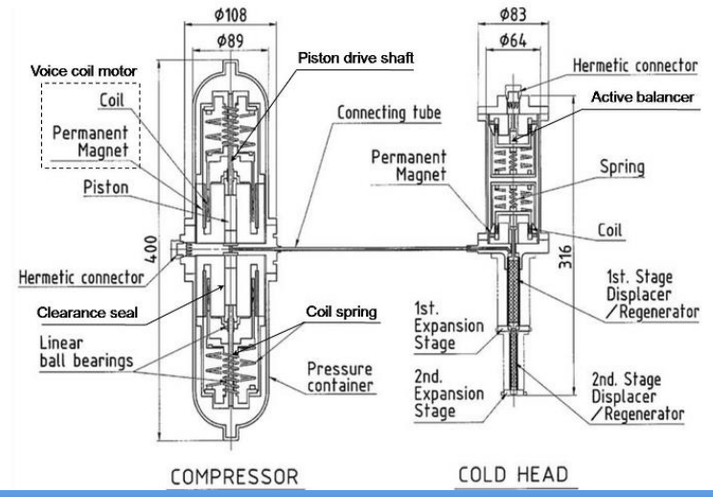
Y. Sato et al. Cryogenics 2014



2ST

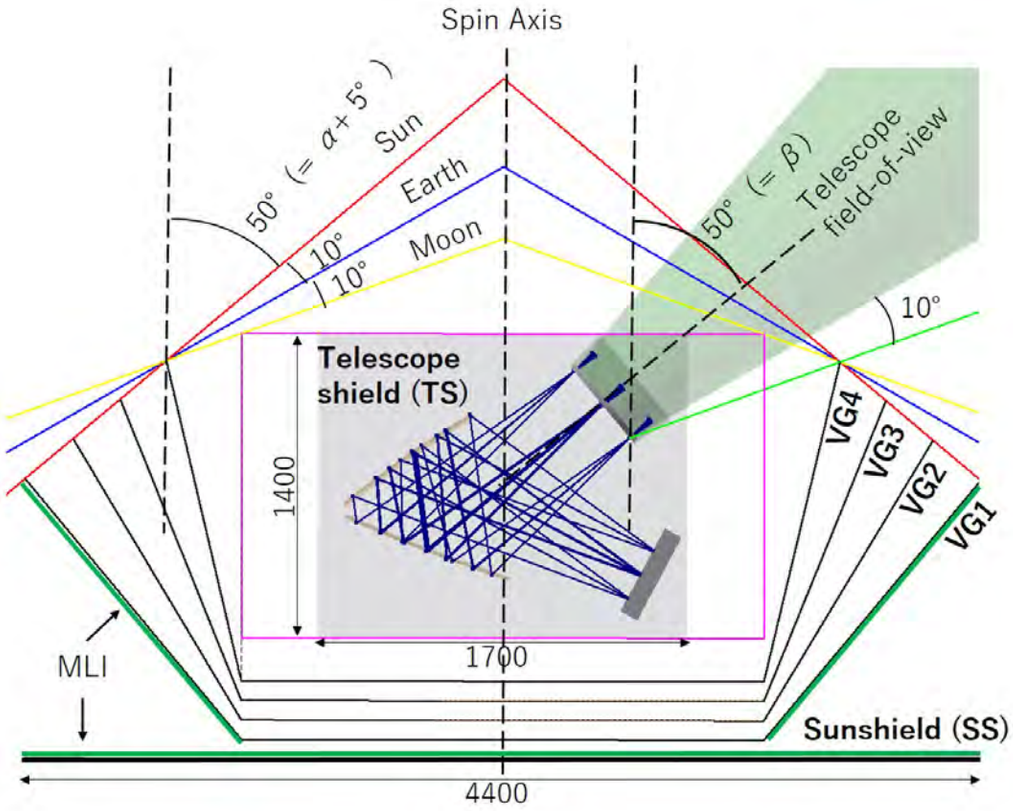


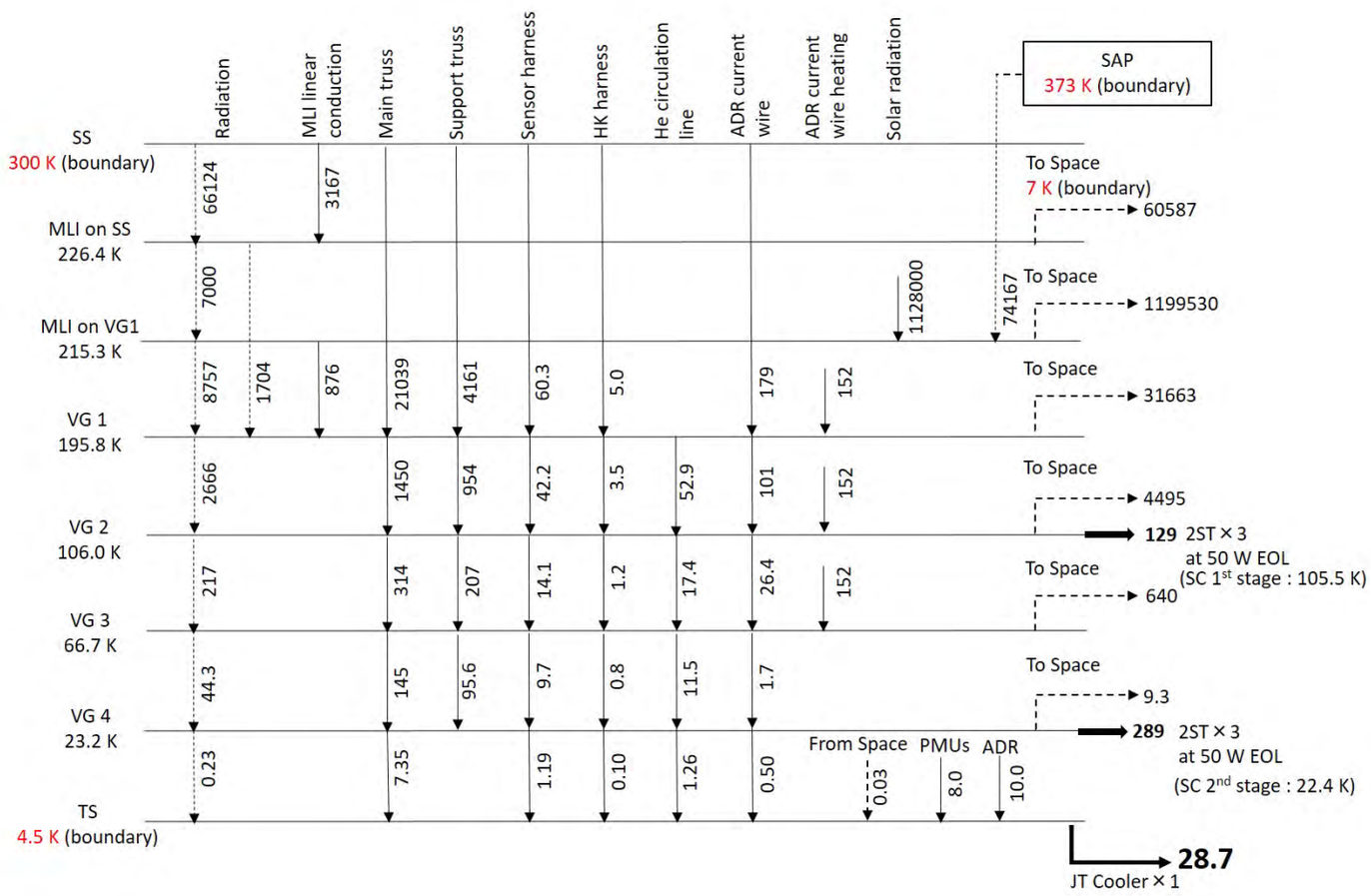
Y. Sato et al. Cryogenics 2012

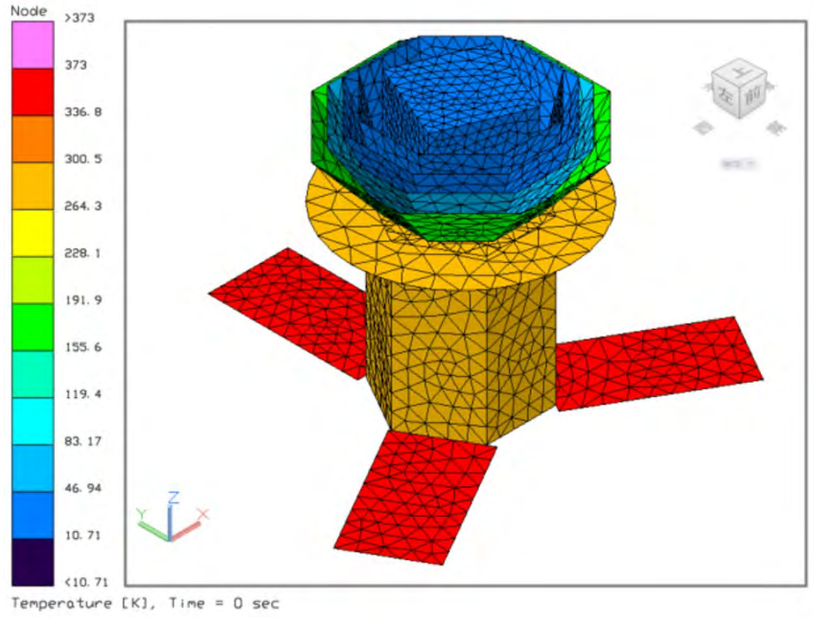


PLM thermal design with V-groove

T. Hasebe et al. 2019 JATIS submitted

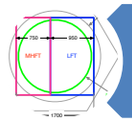


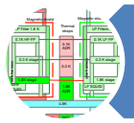




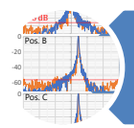
Interfaces

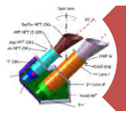
- System requirements (RPR-LB16003A)
- Payload joint study group (PLM JSG)

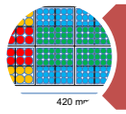

Mechanical I/F


Thermal I/F

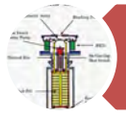

Electrical I/F

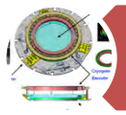

Optical I/F


MHFT

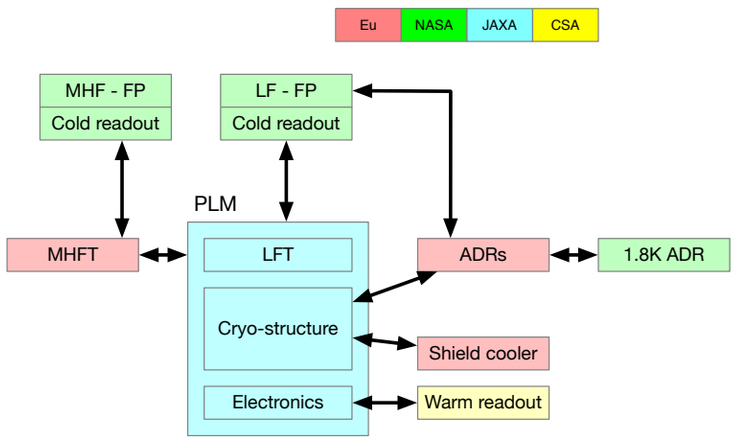

LF-Focal plane


Warm Electronics

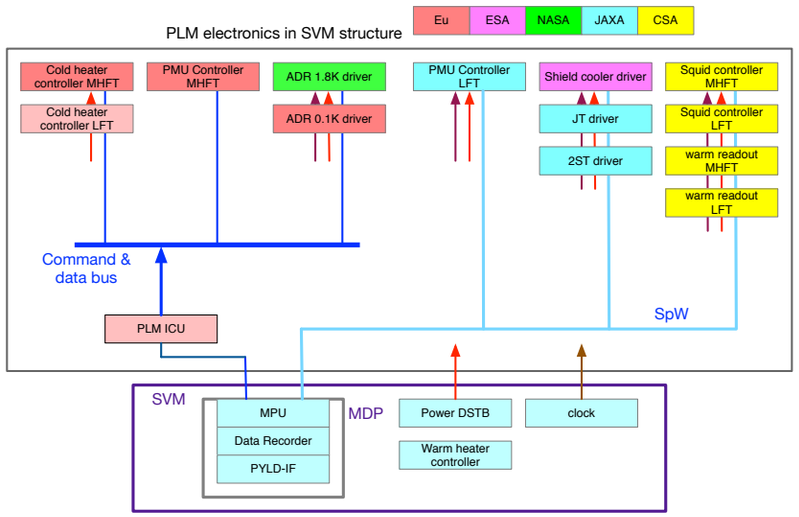

Sub-Kelvin coolers (ADRs)


LF-PMU (HWP)

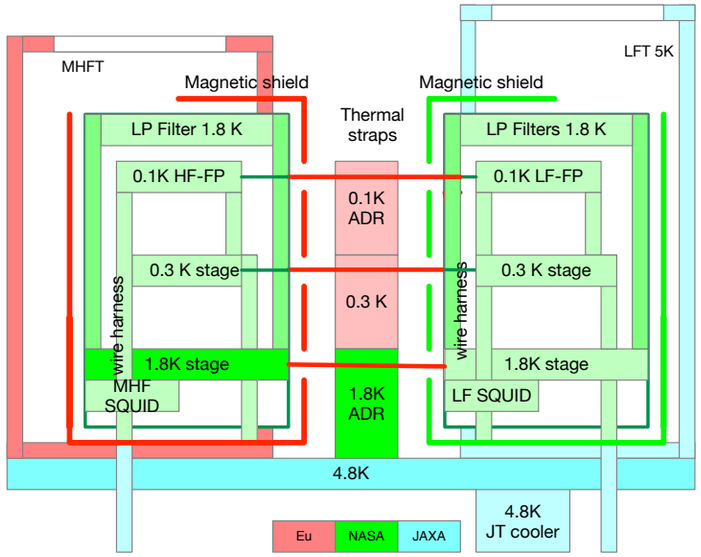
JAXA interfaces



Electronical interfaces

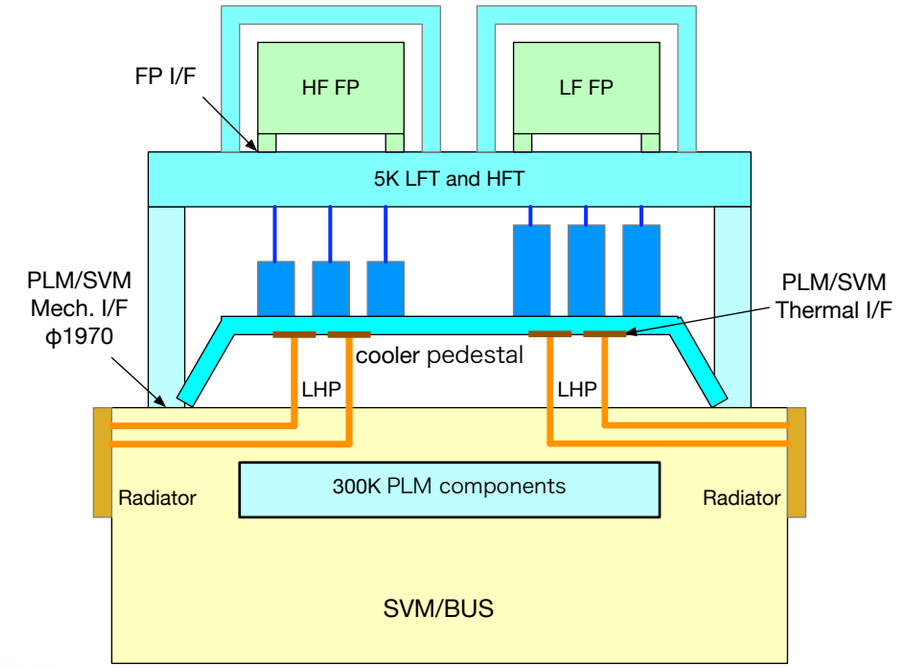


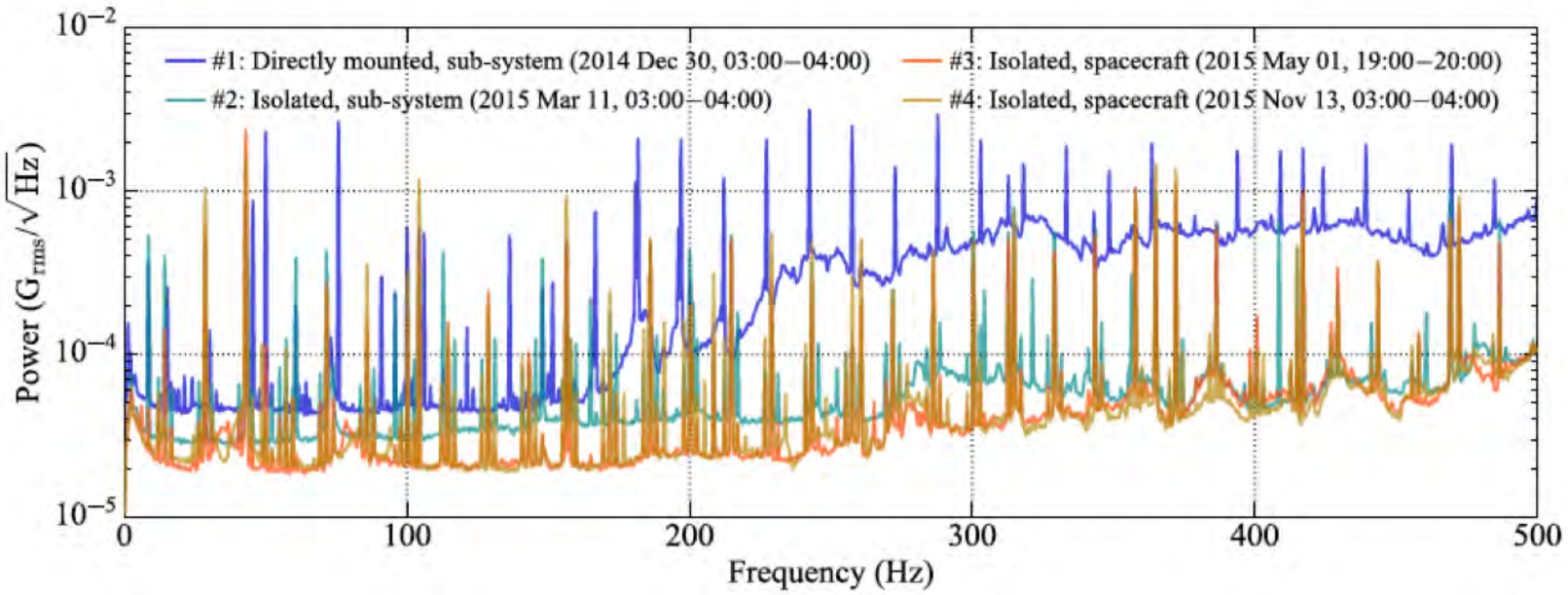
Thermal interfaces



Stability and Risk mitigation

- Microphonic vibration
- Temperature stability
- EMC/EMI
- Pointing stability





Power spectrum of micro-phonic vibration of Hitomi

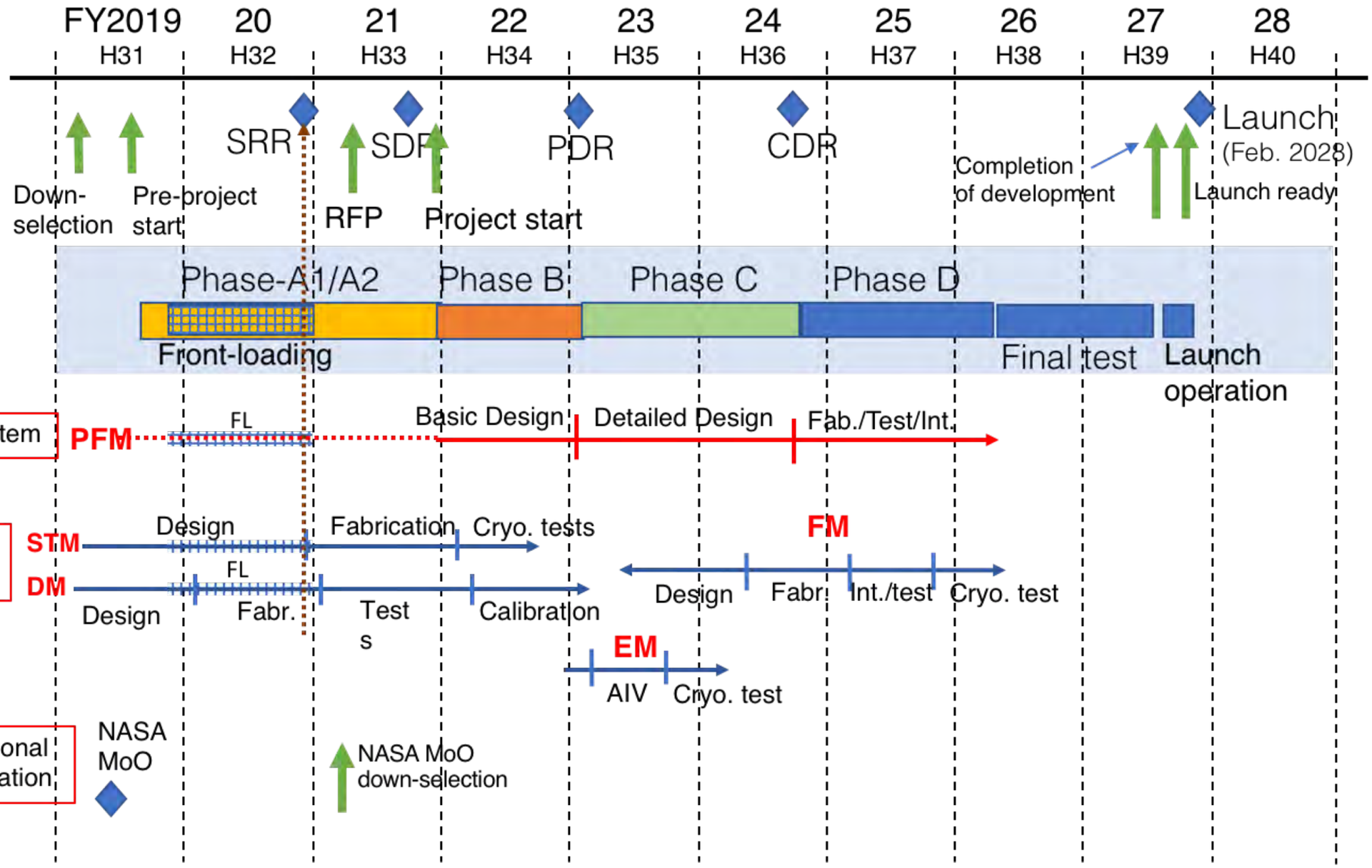
Y. Takei et al. 2018 JATIS

Global Schedule

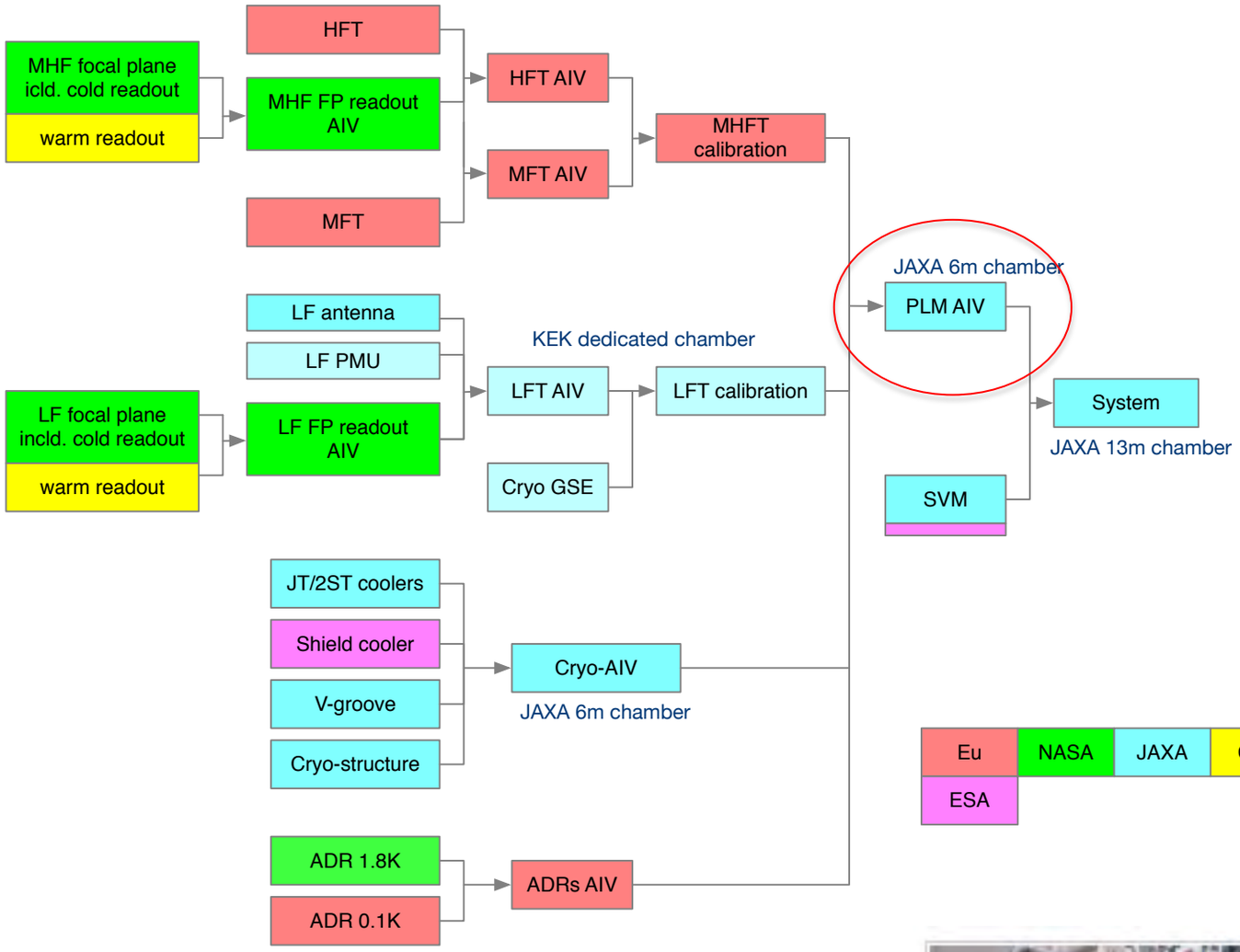
--- before launch ---

Preliminary version, subject to change

Japanese fiscal year (JFY, April 1 – Mar 31)



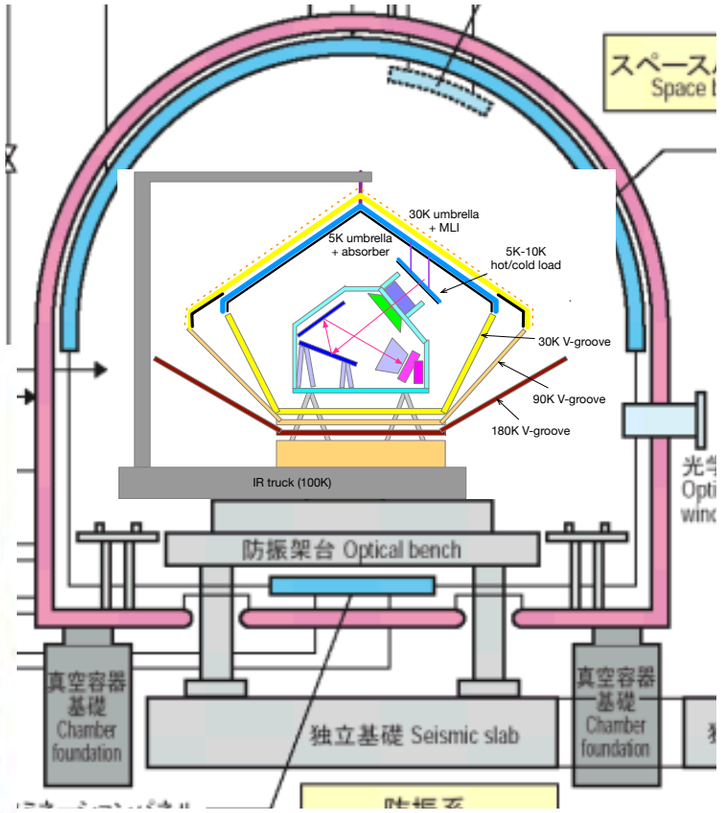
PLM Integration and Verification



- Microphonic vibration
- Temperature stability
- 1/f noise
- EMC/EMI

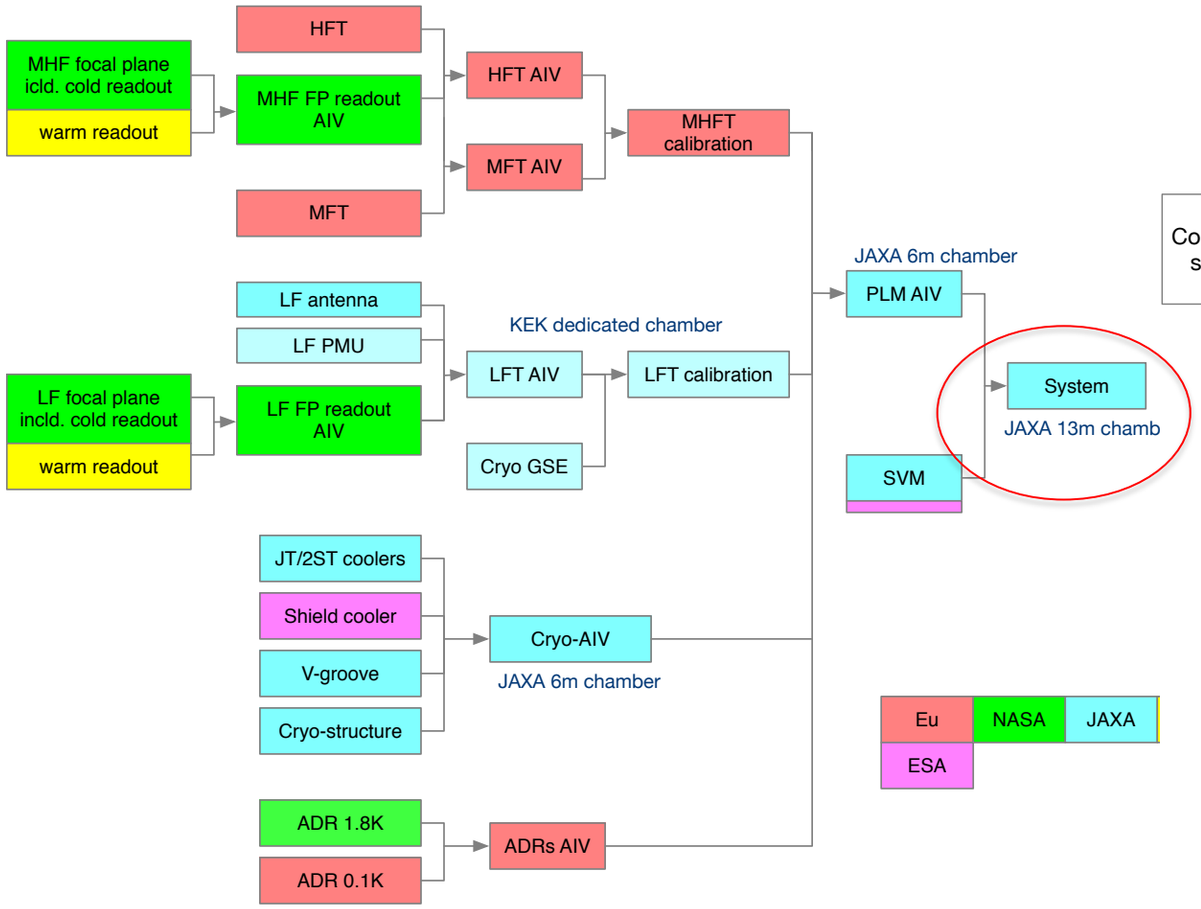
PLM Verification with Cryogenic Umbrella in JAXA 6-m diameter space chamber

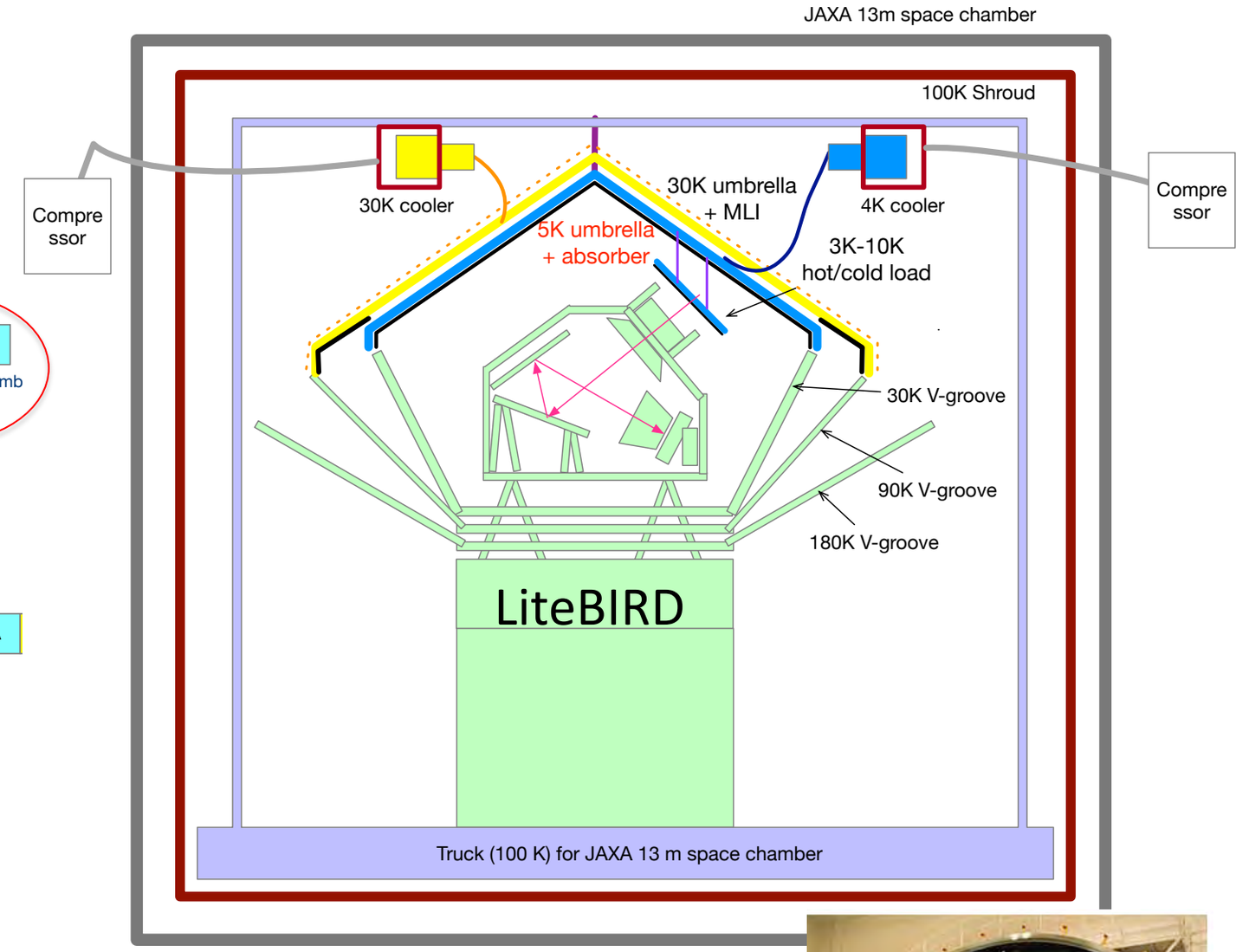
Eu NASA JAXA CSA ESA



AIV : assembly, integration, verification

System Cryogenic Verification

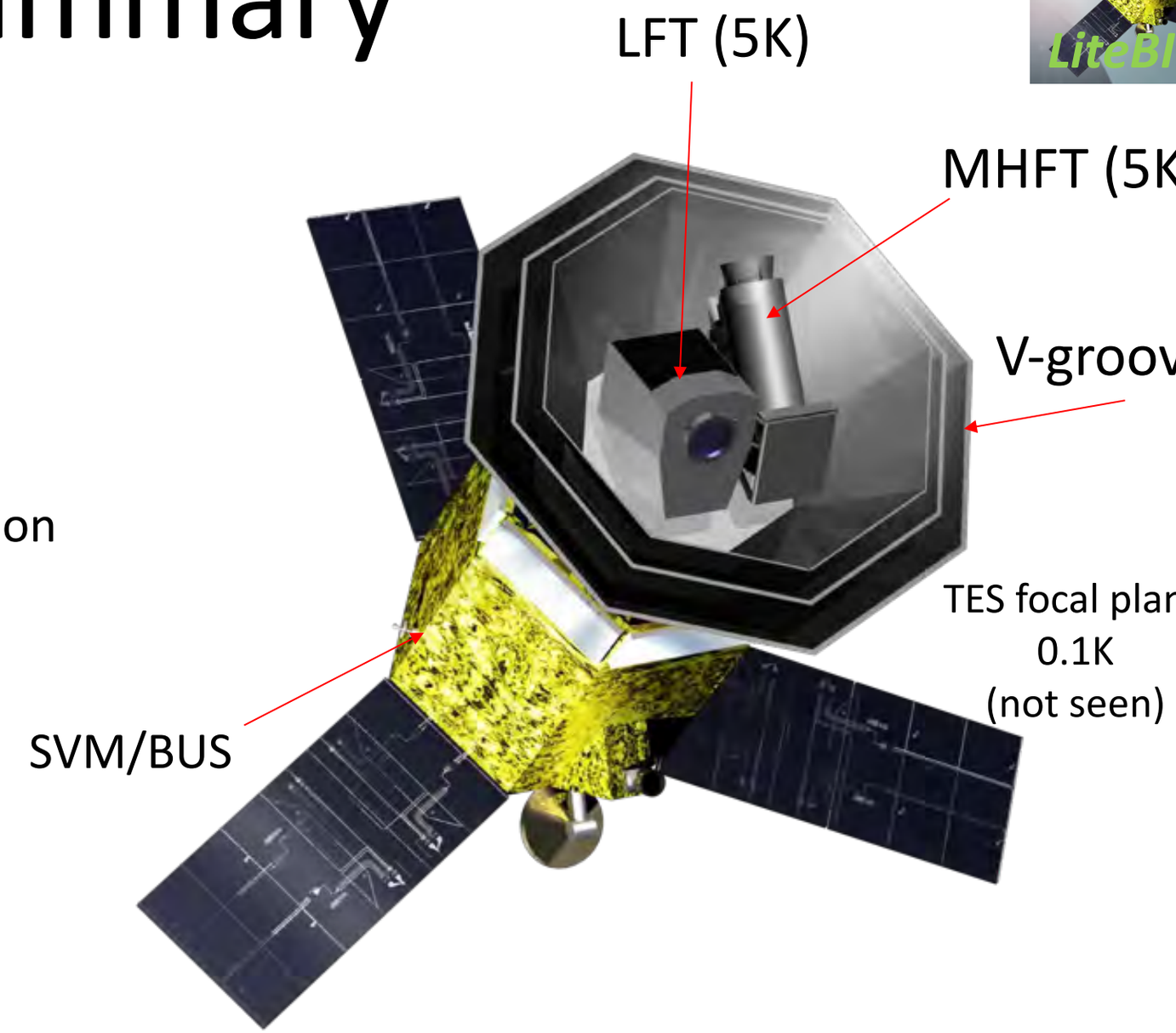




End-to-End verification

- Microphonic vibration
- Temperature stability
- 1/f noise
- Optical efficiency
- EMC/EMI

Summary



JAXA is responsible for

- System integration and verification
- SVM/BUS
- PLM/mission integration
- Low Frequency Telescope
- Cryo-structure
- Launch and Satellite Operation

In collaboration with

- NASA, CNES, ESA, CSA, ASI, DLR, UK-SA, NOSA, SRON, INTA, INFN, SNSA
- IPNS/KEK, Kavli IPMU/U. Tokyo, Okayama U., Nagoya U., Kitasato U.,
- Industrial partners