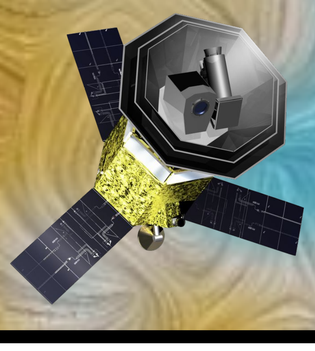


LiteBIRD cryogenic chain: 100 mK cooling with mechanical coolers and ADR

Team

Jean-Marc Duval[1] • Thomas Prouvé[1] • Peter Shirron[2] • Keisuke Shinozaki[3] • Yutaro Sekimoto[4]• Takashi Hasebe[4]•Gerard Vermeulen[5] • Jérome André[7]• Masashi Hasumi[6]•Ludovic Montier[8]• Baptiste Mot[8]

[1] *CEA, UGA, IRIG-DSBT, F-38000 Grenoble (France)*
[2] *NASA-Goddard*
[3] *JAXA, Tsukuba(Japan)*
[4] *JAXA, ISAS, Sagamihara (Japan)*
[5] *Institut Néel, CNRS, F-38000 Grenoble (France)*
[6] *KEK (Japan)*
[7] *CNES, F-31000 Toulouse (France)*
[8] *CNRS-IRAP, F-31000 Toulouse (France)*

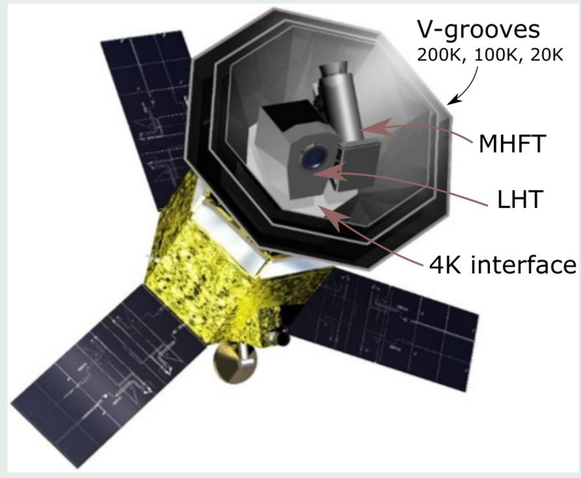
LiteBIRD Mission

Cosmic Microwave background measurements

334 GHz to 440 GHz measured on 15 bandwidth
2 instruments : LFH and MHFT
Tes detectors, operating at 100 mK

Orbiting on the L2 Lagrange point it benefit from a favourable radiative environment

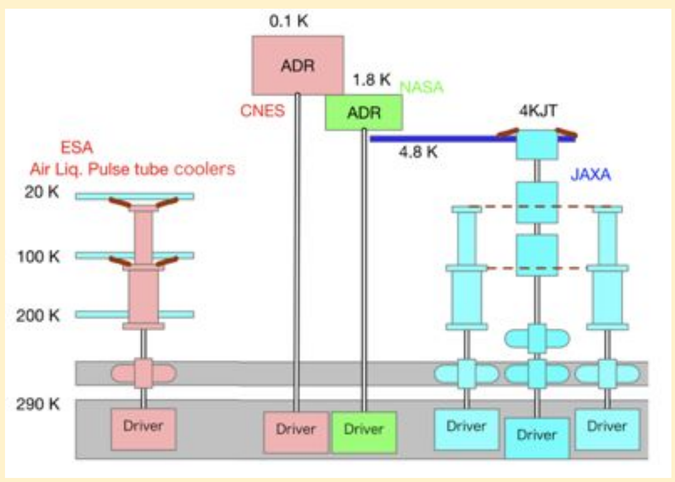
3 radiations shield (V-Groove) to cool the structure of the payload

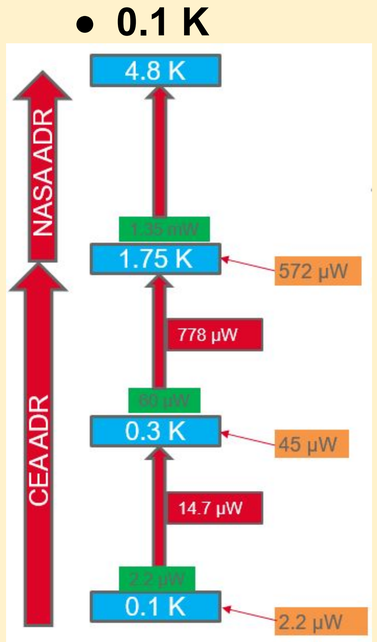


Thermal architecture

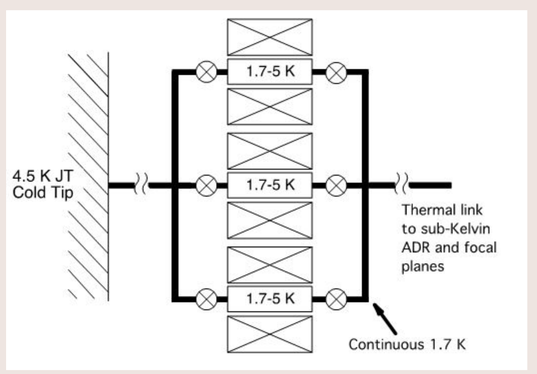
Active Mechanical coolers maintains a 4.75 K environment for the cryogenic instruments
4K-class JAXA coolers precooled by 2 stage Stirling coolers operates at 4.5 K
AL-AT 15 K coolers provides shield cooling at 100 and 20 K

Multistage ADR:
- **1.75 K**
- **0.3 K**
- **0.1 K**





5 K - 2 K ADR



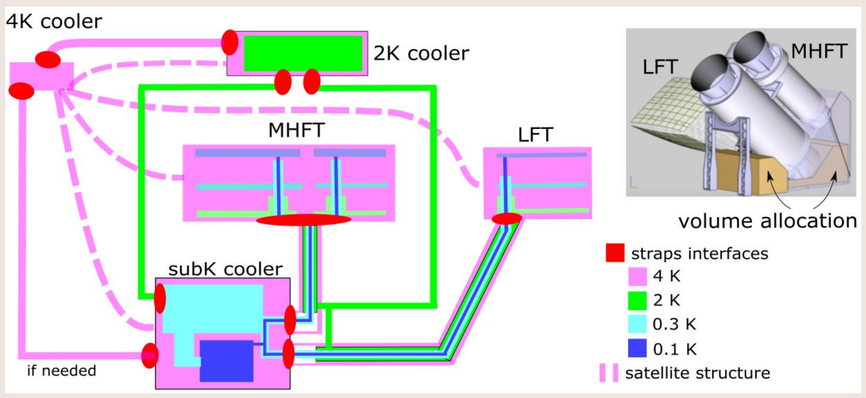
- 2K CADR produces continuous cooling at nominally 1.7 K
- Using 3 ADR stages enables continuous cooling and continuous heat rejection
  - At any given time, one stage is absorbing heat at 1.7 K, another stage is rejecting heat at 4.5 K, and the remaining stage is transiting between 1.7 K and 4.5 K
  - Critical for achieving ~1 mW heat lift at 1.7 K with an average heat reject rate of 10 mW at 4.5 K

ADR stages will build up cooling capacity which is used when the sub-kelvin ADR recycles

Instrument cooling architecture

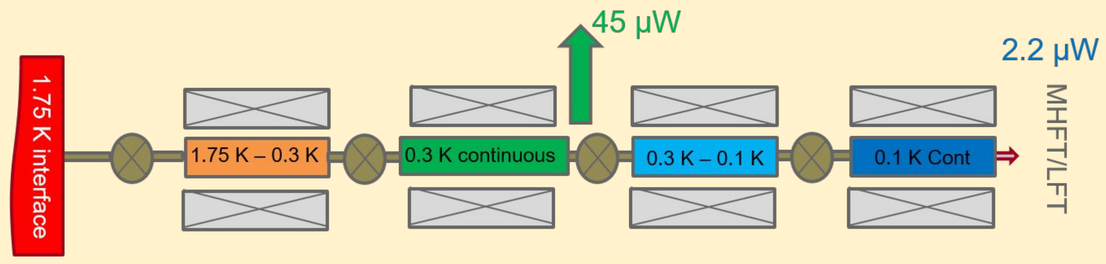
Mechanical stage of the instrument at 4.5 K
Heat distributed at the instrument from a single cooler system

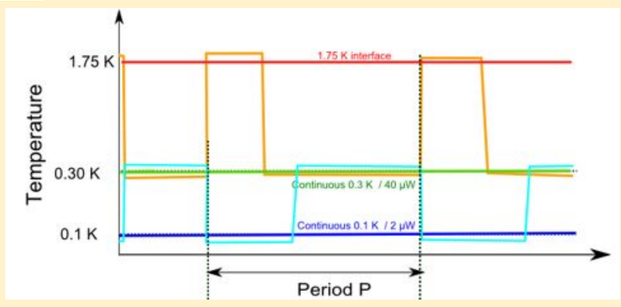
High conductivity 2 K thermal link
Thermal straps distribute heat to both instruments



2 K - 100 mK ADRs

Continuous stage at 300 mK and 100 mK
40 µW cooling power at 300 mK
Heat dissipated on the 1.75 K interface (<0.8 mW)





M < 10 kg
Volume allocation:
200 mm* 175 mm * 260 mm

Conclusion

High cooling requirements for the LiteBIRD mission
4.5 K instruments with 100 mK detectors
Reduced redundancy on cryocoolers lead to efficient cooling chain
High instrument mass (~100 kg) at 4.75 K

Cryogenic design proposed and evaluated for LiteBIRD cooling
- Radiation cooling with V-Groove
- Simplified active mechanical coolers chain for 4K cooling
- ADR multistage coolers for 4.5 K - 100 mK cooling
  - 3 continuous stages : 1.75 K, 300 mK and 100 mK)