Thermal Mathematical Models Correlation.

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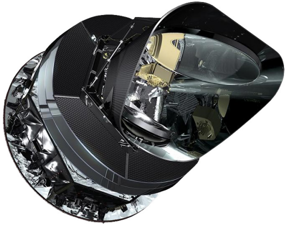
MUSE IDR-UPM-ETSIAE

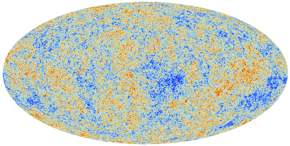
Outline

Introduction

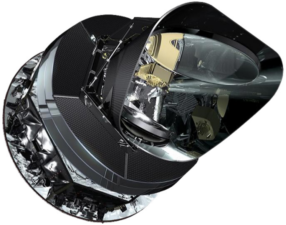
State of the art

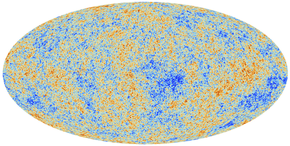
- Thermal mathematical model of the UPMSat 3 in ESATAN.
- $\approx$ 1150 nodes
- Two steady cases defined by the mission requirements:
  1. Steady hot with all the payloads active (PL1 Case).
  2. Steady Cold, latency case, minimum power consumption.





Objectives





- Develop thermal TVAC test cases in ESATAN.
- Run the models on pycanha and compare the results with the ones from ESATAN.
- Determine and compare the most influent parameters in the thermal model on flight and TVAC.
- Optimize sensor placement for the TVAC test and the Flight cases.
- Correlate the model with the test cases.

Pycanha model validation

ESATAN vs Pycanha

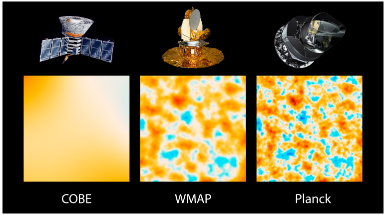
- HFI environment temperature ¡ 2K.
- LFI environment temperature ¡ 60K.
- 0.5 W heatlift in the LFI.

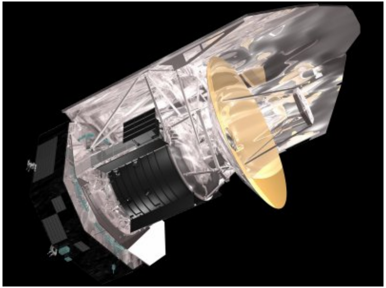
Other requirements

- No deployables.
- No optical elements such as windows with warm edges between the feed horns and telescope
- 1.5 yr minimum total lifetime.
- A spinning spacecraft.

Precedents

Background



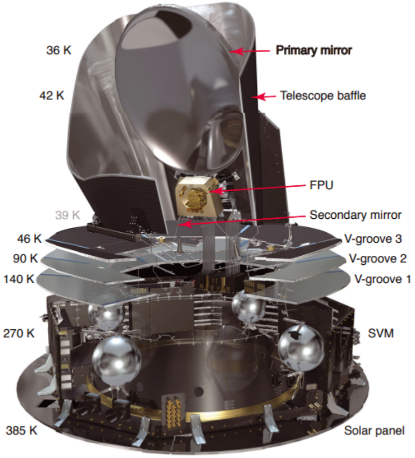


- COBE ($T = 2.725$K): used a 650 l He cryostat to cool the IR spectro-photometer to 2 K .
- WMAP ($T = 90$K): used passive cooling. A lot simpler, but unable to reach sub-Kelvin operating temperatures.
- Herschel ($T = 1.65$K): used 2 He cryostats of 2300 l each to cool the HIFI.

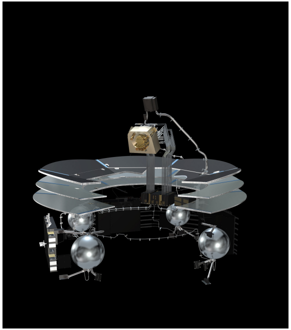
Thermal control instruments

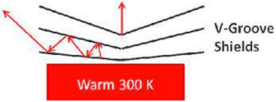
Thermal control instruments

1. Passive Elements
   - Telescopic Baffle: provided radiative shield.
   - 3 V-groove radiators.
2. Active Elements
   - Hydrogen sorption cooler.
   - Helium Joule Thompson expansion cooler.
   - He-He dilution cooler.



Passive elements

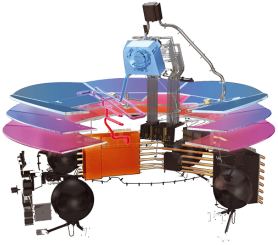




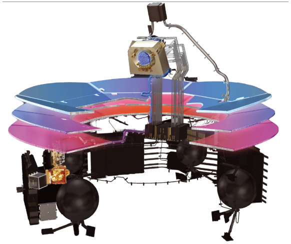
- Telescopic Baffle: provided radiative shield.
- 3 V-groove radiators: provided thermal isolation and radiative cooling

Allows to reach the precooling temperature ≤ 60K.

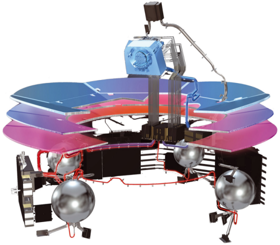
Active elements



H-Sorption cooler

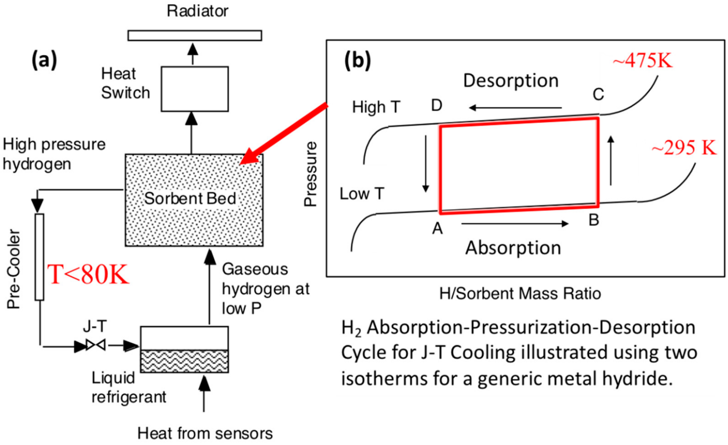


He-JT Expansion cooler



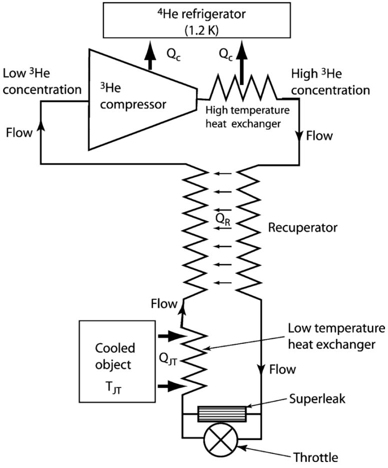
He-He dilution cooler

Active elements: H-Sorption Cooler



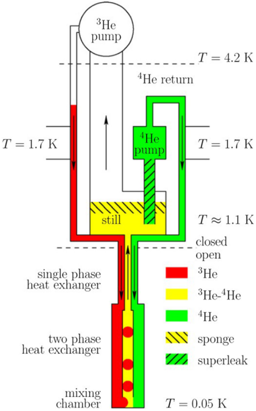
Functioning of an sorption cooler

Active elements: He-JT cooler



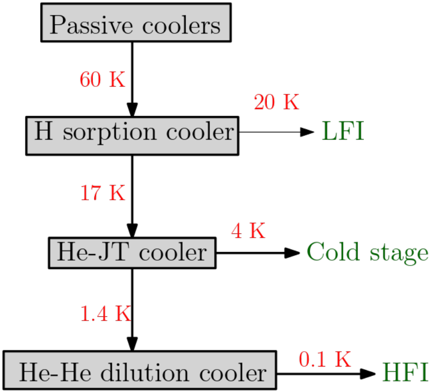
- JT He cooler works by expanding helium gas through a small orifice, resulting in a temperature drop.
- Cold He recirculates through a heat exchanger to cool down a target object.
- He is compressed back to its original pressure to start the cooling cycle again.

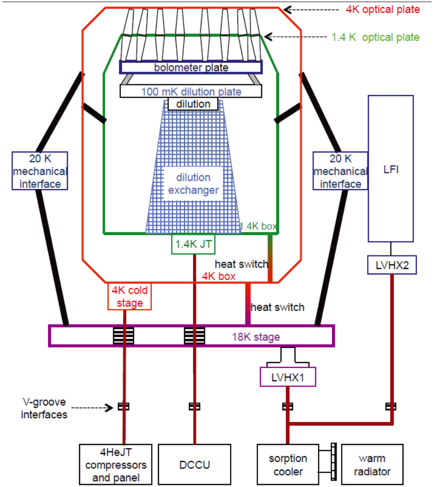
Active elements: He-He Dilution cooler



- Cooling medium is a mixture of Helium-3 and Helium-4 gradually cooled down to temperatures approaching 0 K.
- Uses the superfluid helium-4 to carrying heat away from the target object, as it flows without any resistance.
- Can achieve extremely low temperatures, down to a few millikelvin.

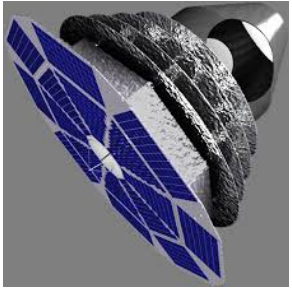
Complete system



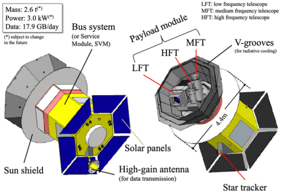


Future missions

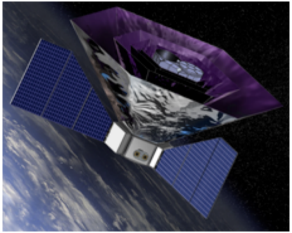
Active Elements



COrE+
Cosmic Origins Explorer, ESA



LiteBird
Primordial B modes mission, JAXA



Pixie Absolute Spectrophotometer, NASA

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Thank you for attending

Questions?