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Leonardo Space

Thermal Balance Test and Thermal Model Correlation of FLORIS PFM

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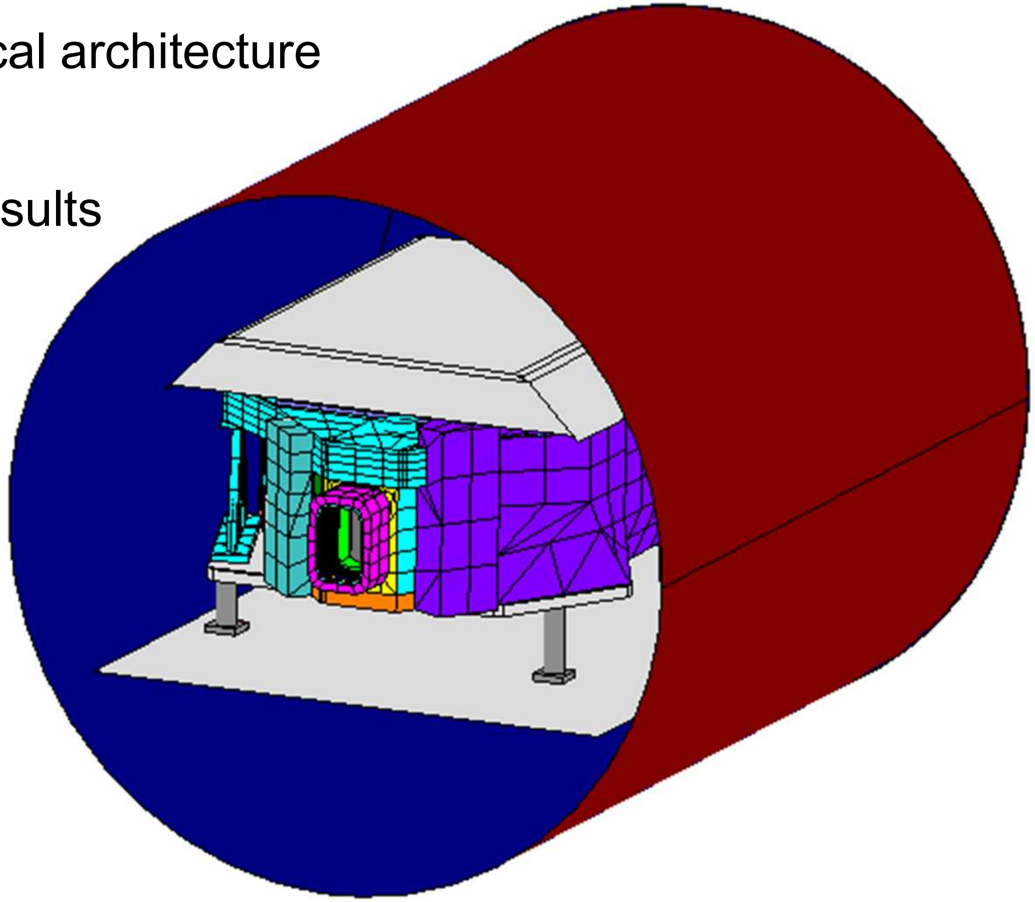
ESTEW 2025 – 10/09/2025

Summary

- FLORIS Thermo-mechanical architecture
- Thermal Balance Test
- Correlation process and results
- Lessons Learnt



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FLORIS Thermo-Mechanical Architecture

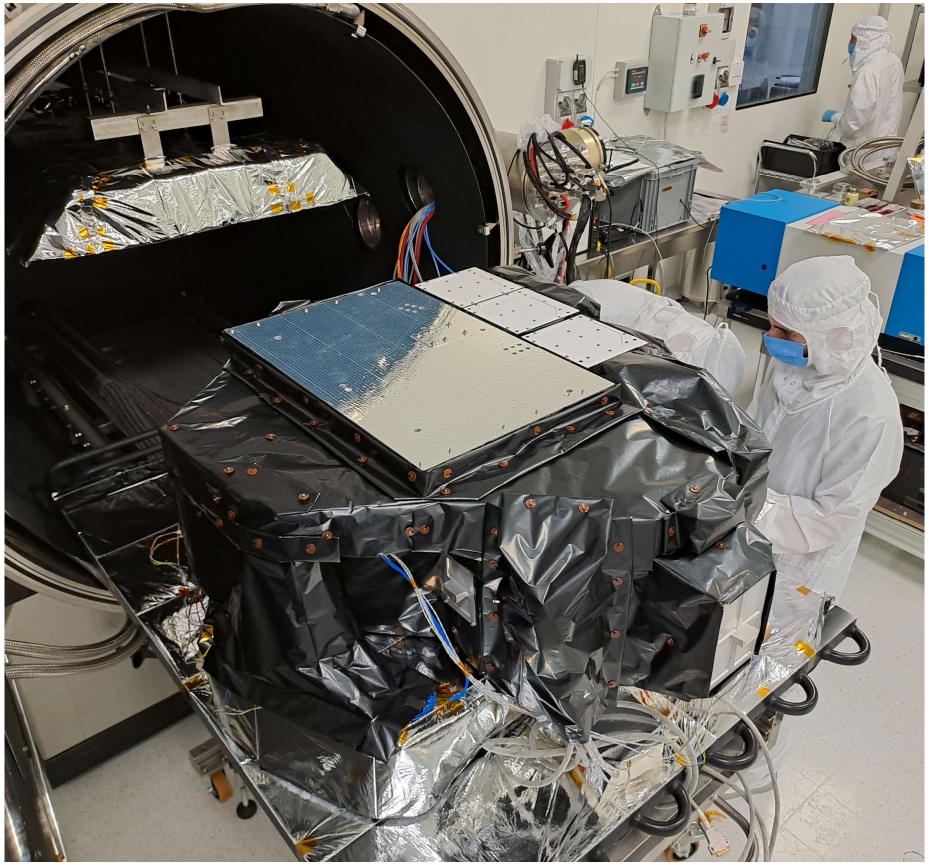
FLORIS

- **Single Instrument** of mission **FLEX**:
  - an imaging spectrometer that detects visible light
  - ICU (Instrument Control Unit)

- **Mission Objective**: Quantitative measurements of the solar induced **vegetation fluorescence**

- **Satellite** prime contractor: **TASF**

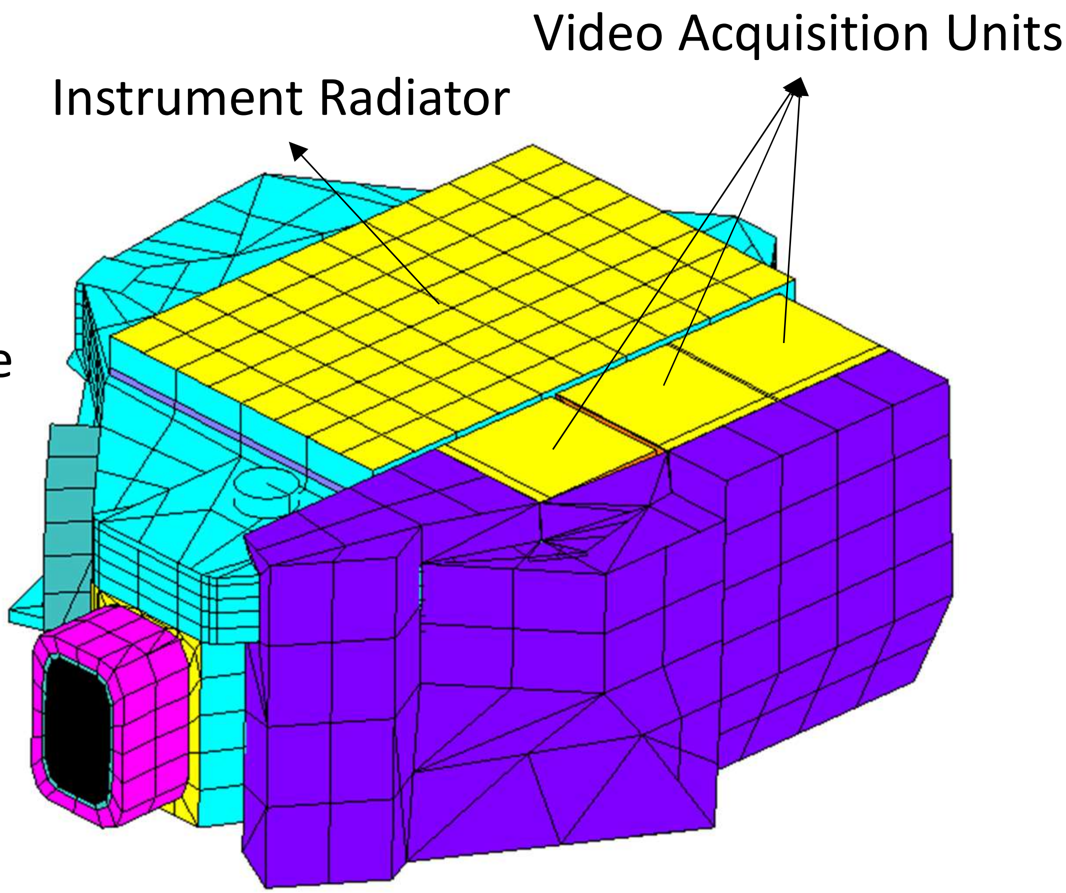
- **Instrument** contractor: **LEONARDO**



FLORIS main thermal features /1

Exterior elements charachteristics:

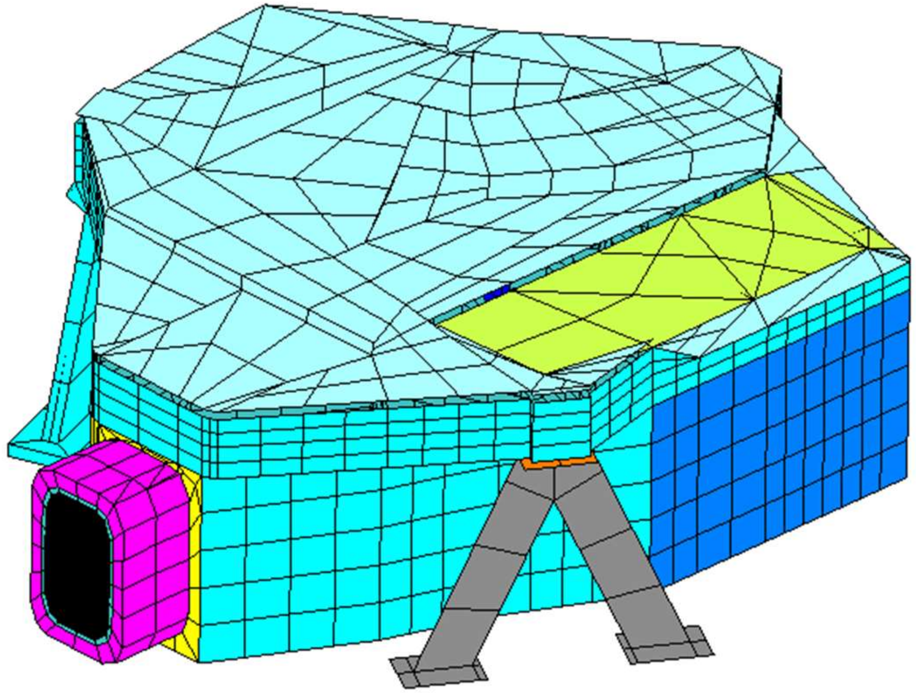
- MLI: Black Kapton
- Instrument Radiator: Teflon Silicate Tape
- VAUs radiator: White Paint



FLORIS main thermal features /2

MLI blanket between OB and radiator:

- Surface towards radiator: Black Kapton
- Surface towards OB: VDA Kapton



FLORIS main thermal features /3

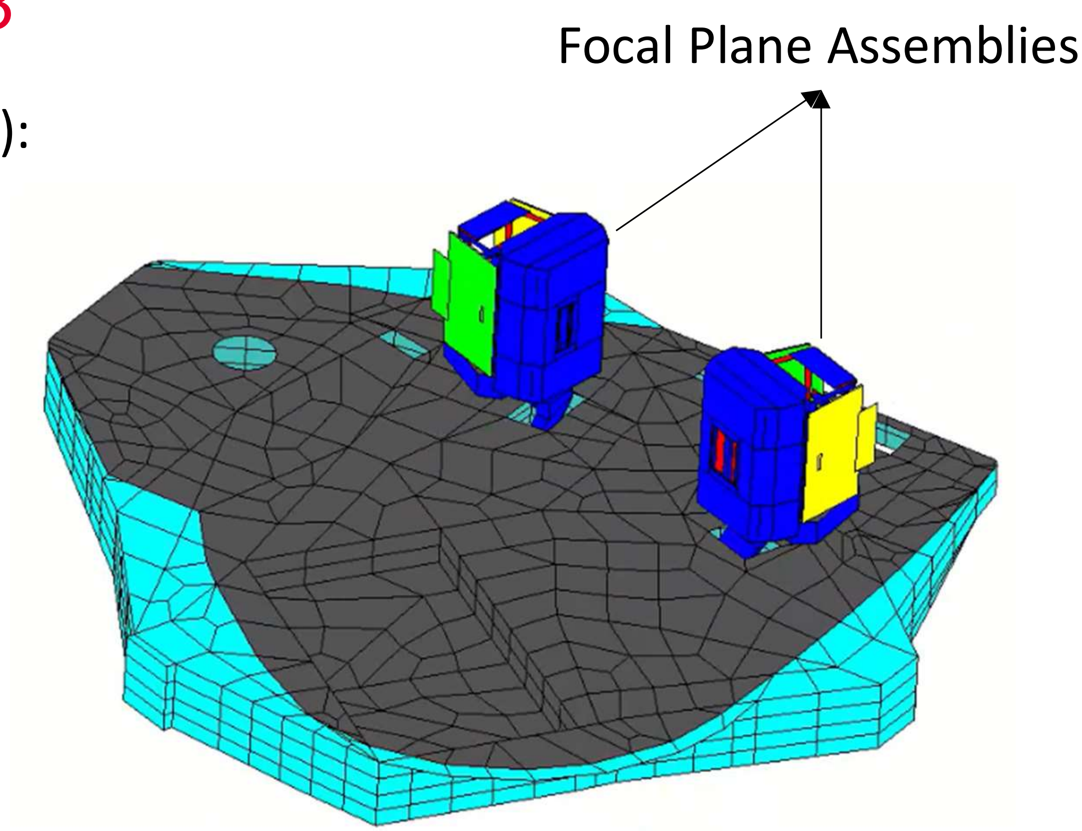
OB and FPAs thermal control (PI regulation):

Operative

- OB: 5 heater lines (7 RER per line)
- FPAs: 1 heater each

Survival

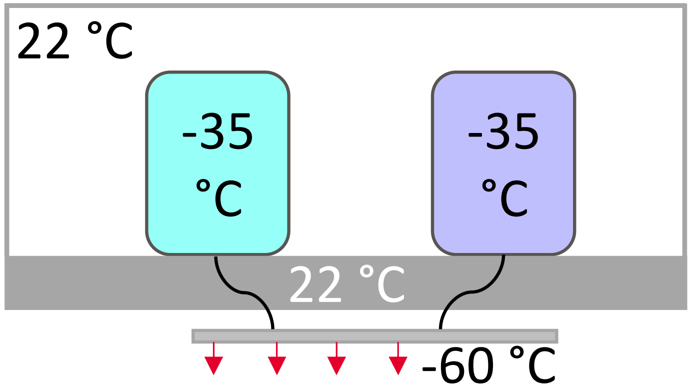
- OB: 1 heater line (9 RER)
- FPAs: 1 heater each
- Radiator: 1 heater line (12 RER)
- VAUs: 1 heater foil each



FLORIS main thermal features /4

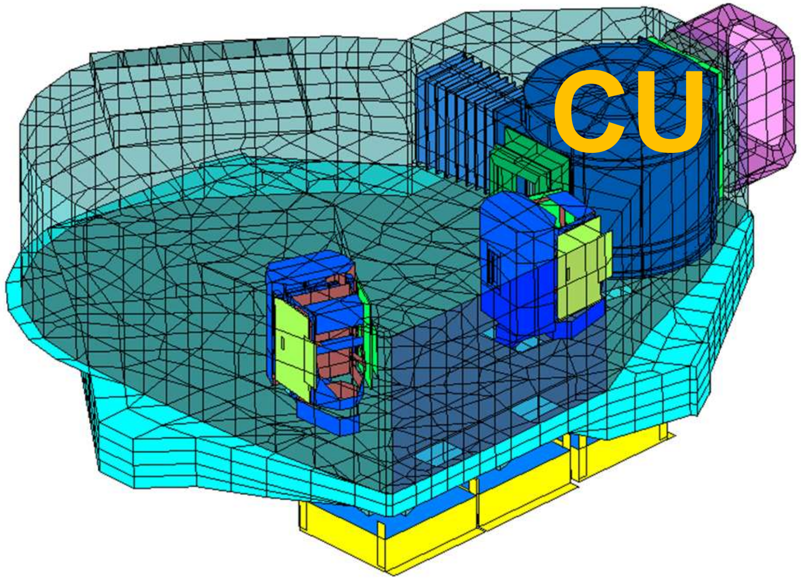
Temperatures

Subsystem	Operative	Non Operative
Detectors Unit	-35 °C	< -50 °C
Optical Bench	22 °C	1 °C
Radiator	< -60 °C	< -60 °C



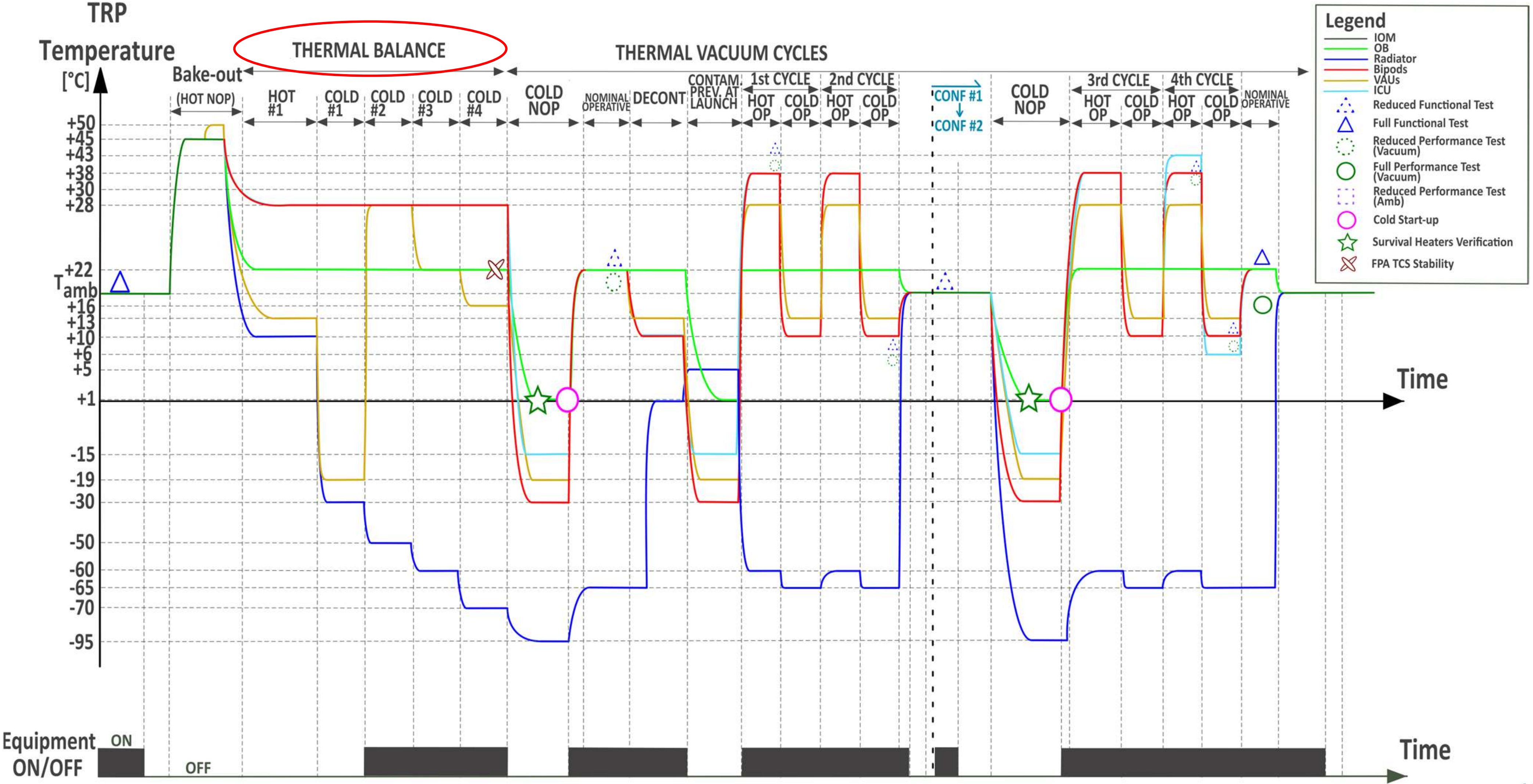
Active elements:

- 3 x VAU (Video Acquisition Unit)
- 3 x CCD (Charge Coupled Device)
- 3 x FPPE (Focal Plane Proximity Electronics)
- Calibration Unit



Thermal Balance Test

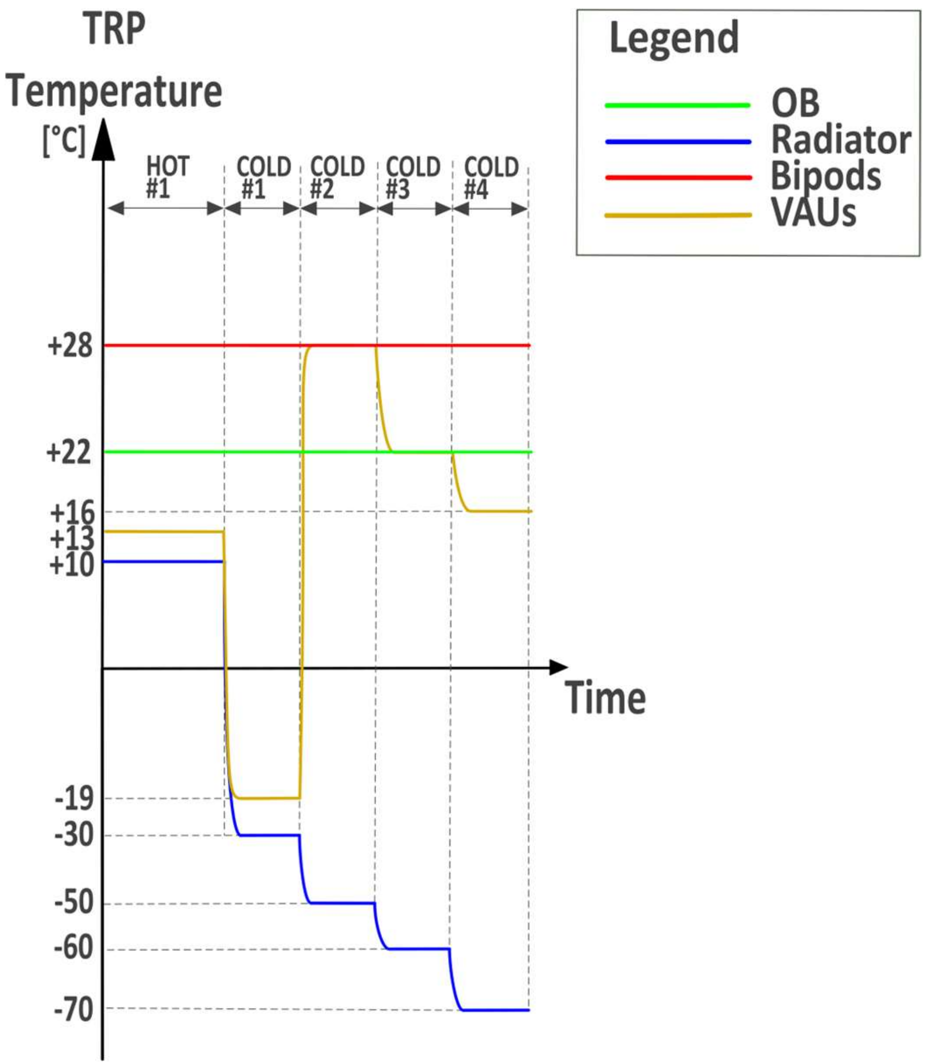
Thermal Balance Test



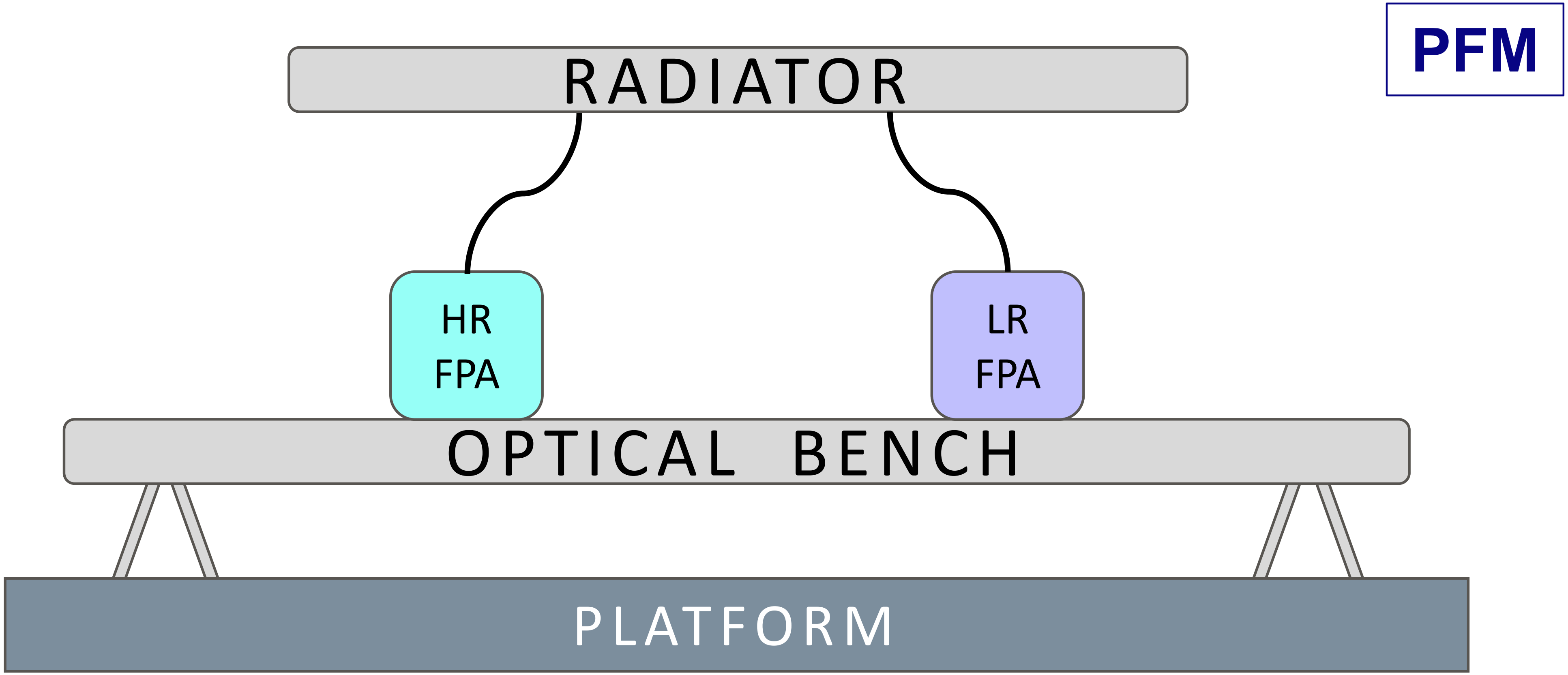
Test Overview and Goals

The **planned** profile foresaw **5 phases**:

- **1 hot non operative**
- **1 cold non operative**
- **3 cold operative**

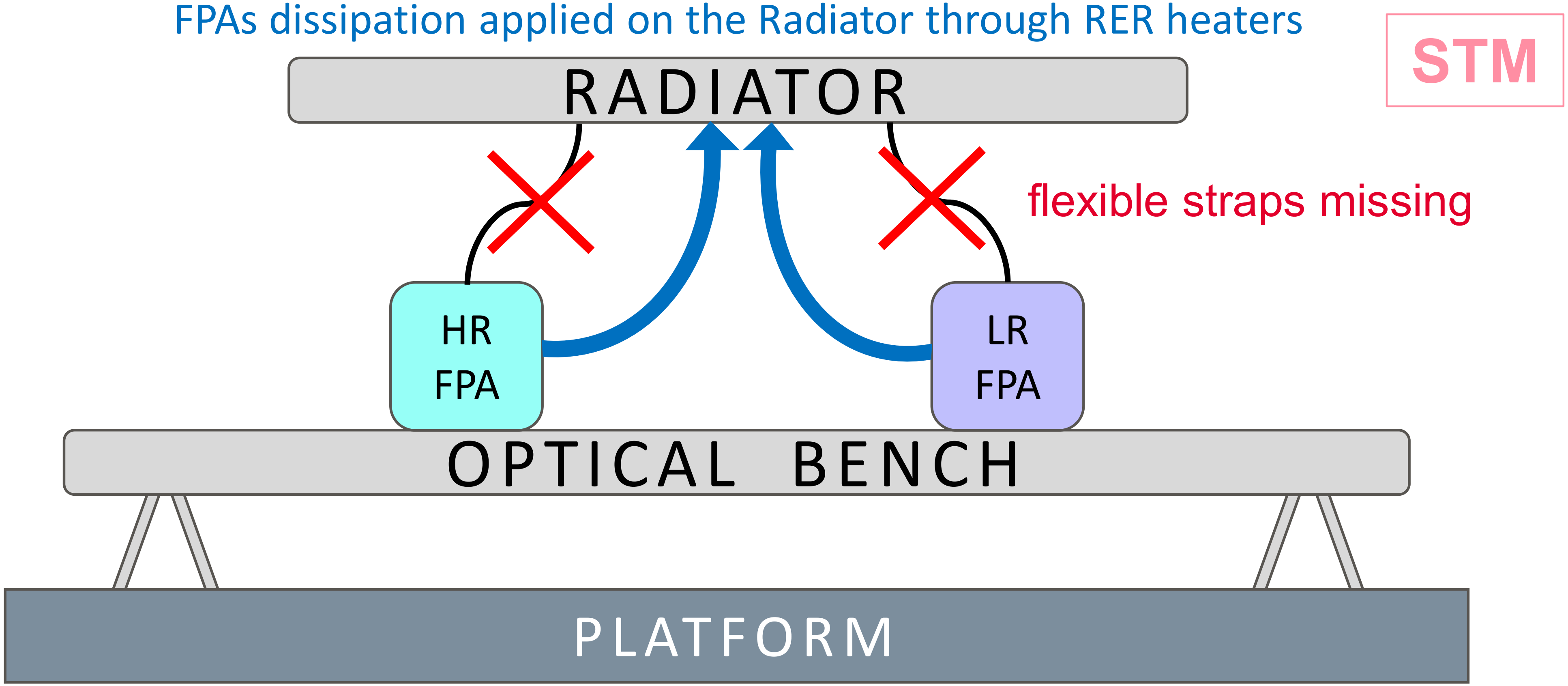


STM vs PFM Thermal Balance Test /1



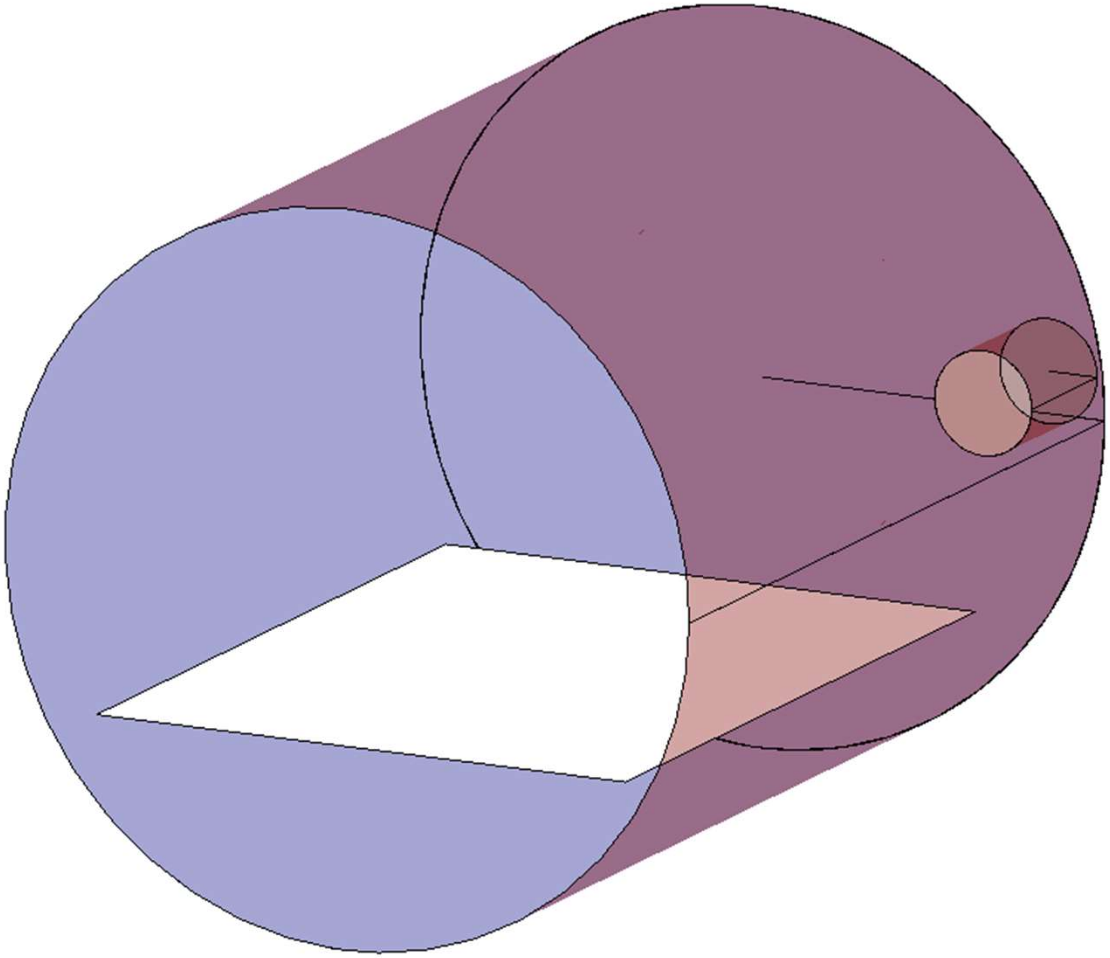
STM vs PFM Thermal Balance Test /2

FPAs dissipation applied on the Radiator through RER heaters



Test Setup /1

The test chamber is equipped with a **baseplate** and a **shroud** controlled in temperature.

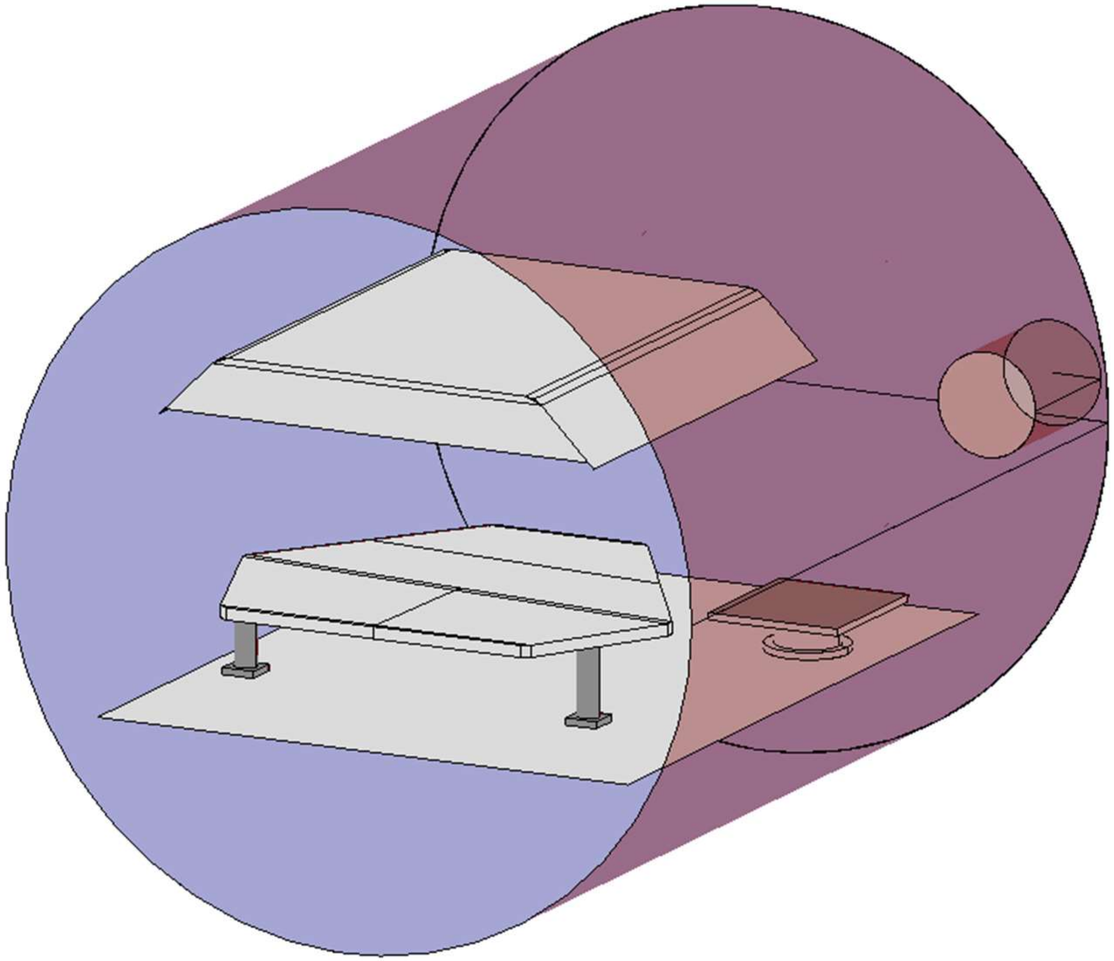


Test Setup /2

For this thermal vacuum test the following TGSE were installed:

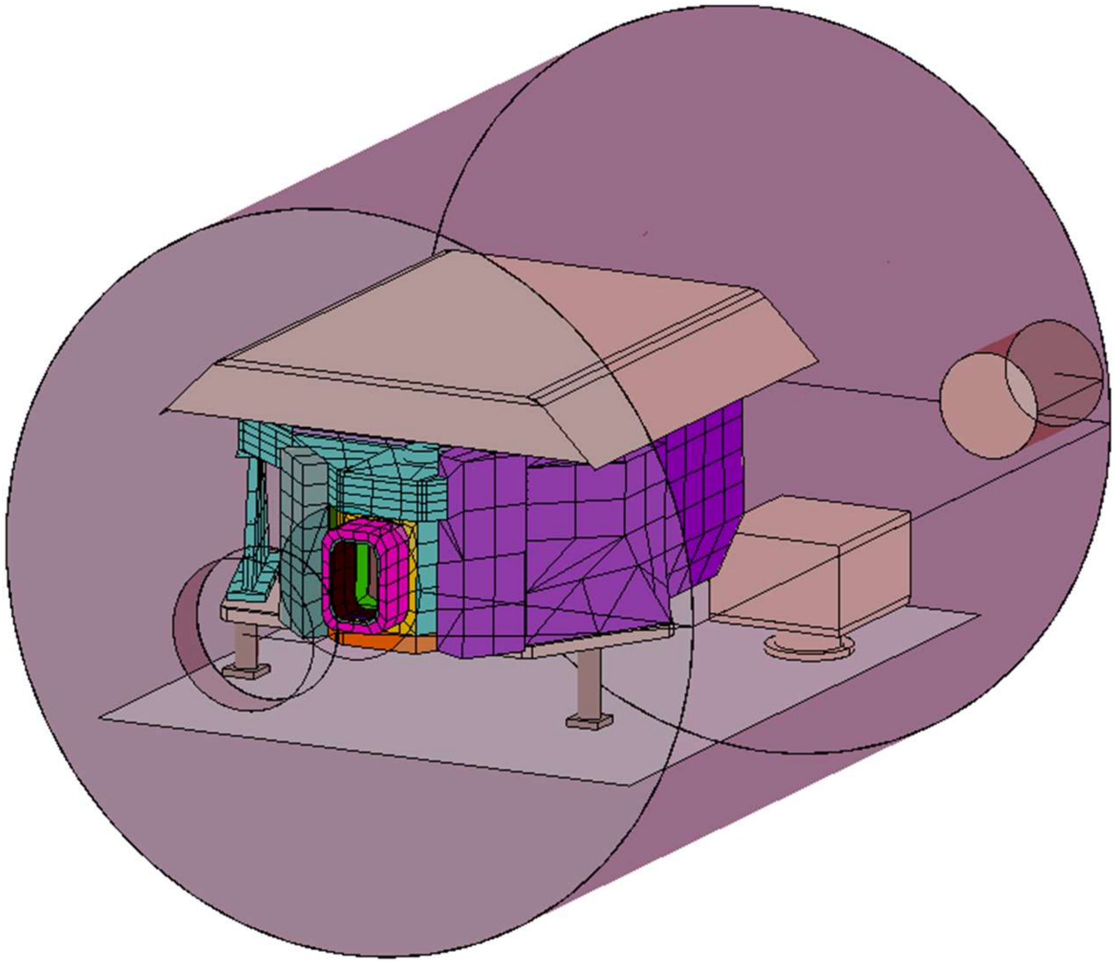
- an additional **shroud**
- A **plate** for the **instrument** supported by three columns
- A **small plate** for the **ICU** supported by a column

All these elements were covered with test MLI blankets



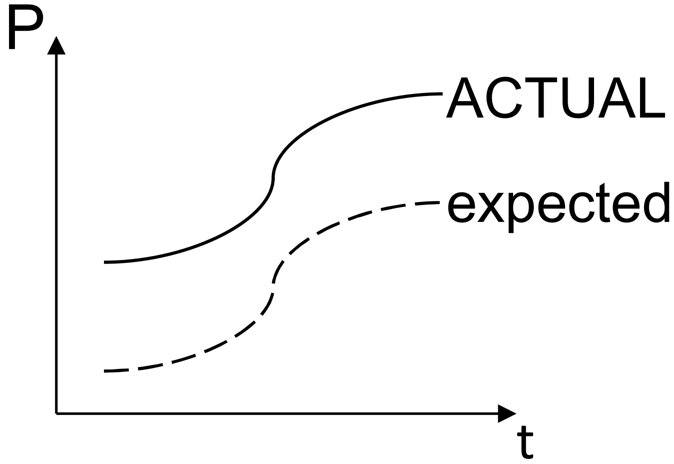
Test Setup /3

Between the instrument and the plate on which it is mounted, a **test MLI** blanket was placed. This **simulates** the flight configuration in which there is the **platform MLI** below the instrument.



Major discrepancies and way forward /1

- During the first phase of the thermal balance the **actual dissipation** of the heater lines resulted **greater** than expected due to an unexpected functioning of the I-EGSE.
- The control loop of the test heater installed to regulate the heat leak of the harness was too unstable.



SOLUTION

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- The control was switched from fixed power to PI with fixed temperature.
- Since the control was too dangerous, due to its high delay, it was shut down.

Major discrepancies and way forward /2

The comparison between test predictions and measurements highlighted the following **major discrepancies**:

- **VAUs colder** than predicted
- **OB** heater lines power **dissipation greater** than predicted
- **FPAs** heater lines power **dissipation greater** than predicted

SOLUTION

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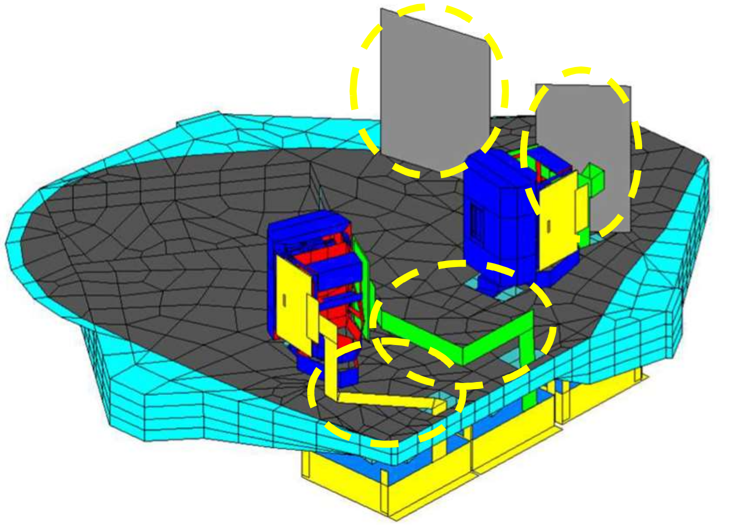
- **2 cold operative** additional phases were performed
- Two **TVAC** phases were also used for the correlation activity:
  - Cold Non operative
  - Nominal

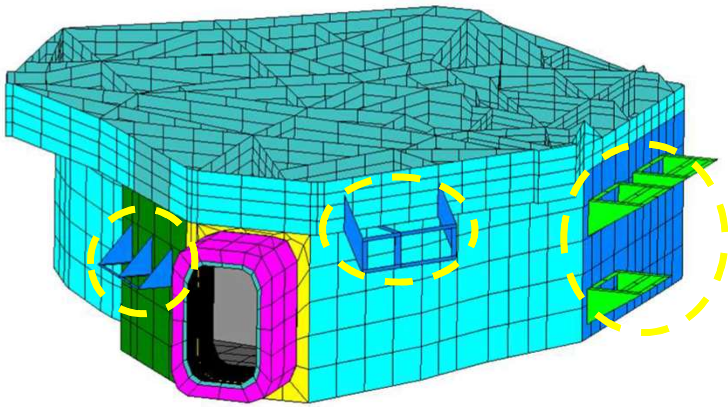
Correlation process and results

Geometrical Mathematical Model update



The update of the GMM included **changes** to both the **chamber** and the **instrument** model, in particular:

- OB assembly: internal shields and connectors bracket added
- FPAs: detail of electrical connections added
- Radiator: detailed including stiffeners

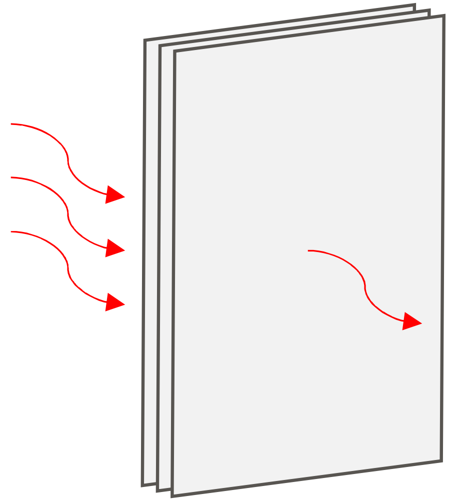


The objective was to **increase** the **radiative flux** exchanged between the OB and various subsystems, and the OB and the environment.

Thermal Mathematical Model update /1

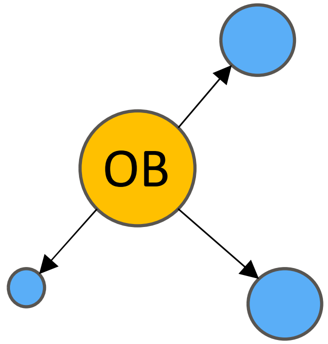
The update of the TMM mainly focused on the **OB temperature** that above all was **very far from** the one obtained in the **test**.

This was ascribed primarily to an **overestimation** of the **MLI efficiency**.



The linear **conductors** between the **OB** and the following **colder subsystems** have been **increased** too:

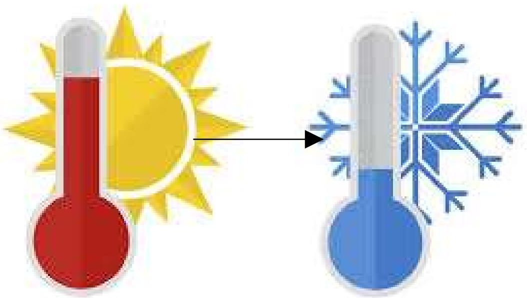
- Bottom Cover
- Radiator
- VAUs



Thermal Mathematical Model update /2

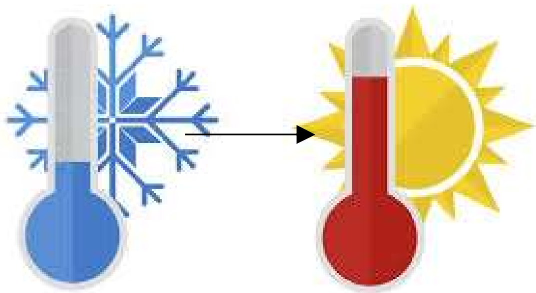
To **reduce** the **VAUs** calculated **temperature**:

- The conductors among their internal nodes have been increased, therefore increasing the heat flux exchanged with the radiator.
- The VAUs dissipation has been lowered to compensate for MLI coverage flaws.
- The conductors between the VAUs and the OB have been reduced.

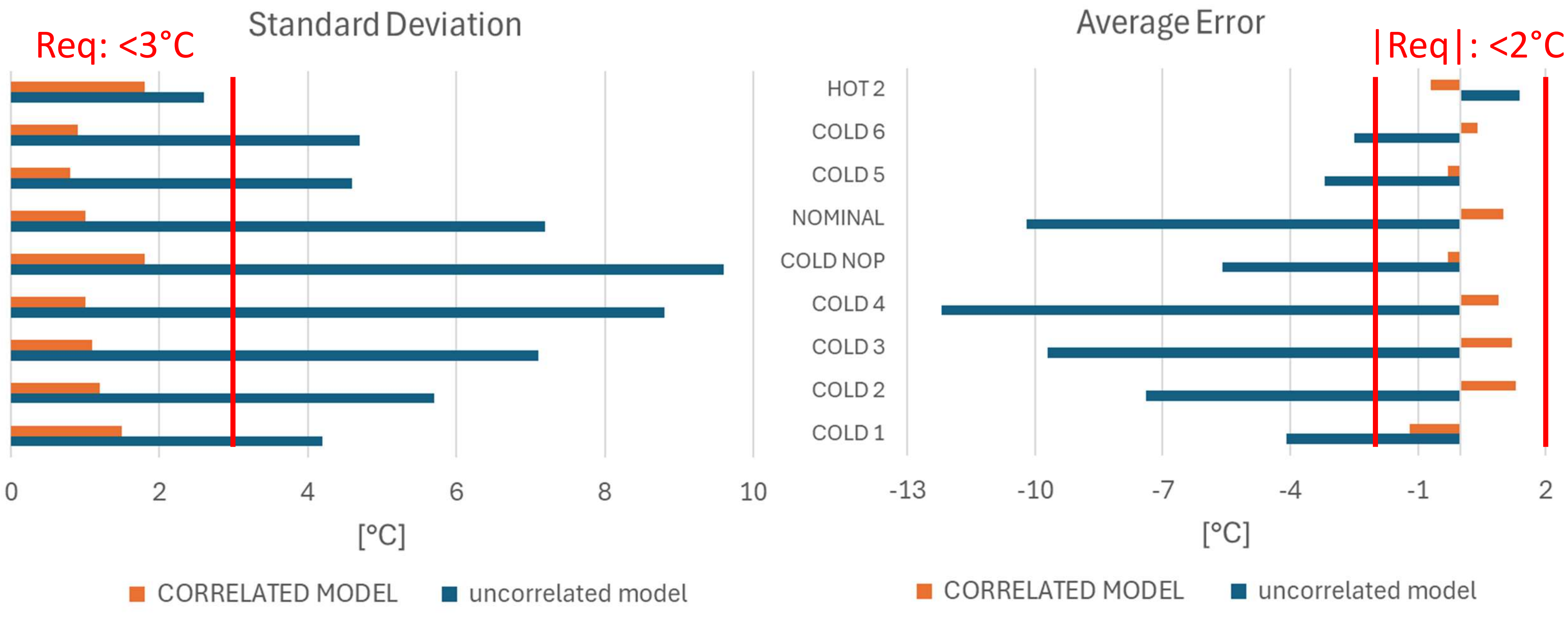


After all the other changes, the **FPAs** calculated **temperature** had to be **increased**, therefore:

- The overall conductance of their straps have been reduced.



Pre and post-correlation comparison



Lessons Learnt

Test preparation and execution

- Need for an appropriate commissioning phase of the test setup
- To verify the functioning of the EGSE logic to check any possible difference between intended and actual dissipations.
- To appropriately design heaters control loop to avoid high delay.
- The more detailed and accurate the emergency procedure the quicker and more efficient the solution will be when something unexpected happens.

- **The importance of great teamwork internally and with all the customers(!):**
  - Late change of the test facility required a redesign of the test set-up which was efficiently performed in close collaboration with the customer chain (TAS-F and ESA).
  - The test required 24/7 support both on-site and remotely, involving many people from the project and outside the project who required specific training.

Thermal model correlation

- A feasible methodology was established to accomplish the correlation avoiding time-consuming iteration process:
  - A general significant contribution was provided by the “macro” parameters, affecting the overall behavior of the system (e.g. MLI efficiency)
  - The refinement of the correlation was accomplished with a local assessment of the individual parameters (e.g. thermal strap conductance)
- Do not trust too much your knowledge of the system! Sometimes the (apparently) less important parameters produce the larger effects.

Thank you
for your attention

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