TITLE: # 4KRL adhesive thermal cycle facility

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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
1.0		All	First issue of this document	

TABLE OF CONTENTS

1 SCOPE

1.1 Purpose

The 4KRL unit will provide a stable reference signal to the LFI radiometers. It is fully described in RD 1. Each RT will be bonded to the mounting structure using an epoxy adhesive. Details on the adhesives under study can be found in RD 3, RD 4.
Before being tested as in RD 4, samples are submitted to thermal cycles to cryogenic temperature. This will ensure tat the operating conditions during ground tests and space operation are simulated.

1.2 Document Overview

This document will describe the cryo facility designed for sample thermal cycling.

1.3 TERMS and ACRONYMS

4K RL	4K Reference Load
CMB	Cosmic Microwave Background
EBB	Elegant Bread Board
FEM	Front End Module
FM	Flight Model
FPU	Focal Plane Unit
FS	Flight Spare
HFI	High Frequency Instrument
I/F	Interface
IL	Insertion Loss
LFI	Low Frequency Instrument
MS	Mounting Structure
N/A	Not Applicable
PD	Prototype Demonstrator
QM	Qualification Model
RH	Reference Horn
RL	Return Loss
RT	Reference Target
SS	Spin-Synchronous
TBC	To Be Confirmed
TBD	To Be Defined
TBR	To Be Refined
ThL	Thermal Link
WG	Waveguide

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

AD 1: FIRST/Planck Instrument Interface Document, Part A (SCI-PT-IIDA-04624, 2/0)
AD 2: FIRST/Planck Instrument Interface Document, Part B (SCI-PT-IIDB/LFI-04142, 2/0)
AD 3: LFI Interface Control Document (PL-LFI-PST-ID-010, 2.0)
AD 4: LFI/HFI Interface Document (PL-LFI-PST-ID-001, 1.0)
AD 5: LFI Specification (PL-LFI-PST-SP-001, 3.0)
AD 6: Planck LFI Instrument Design and Development Plan (PL-LFI-PST-PL-002, 2.0)
AD 7: Planck LFI Product Assurance Plan (PL-LFI-PST-PL-003, 3.0)
AD 8: Planck LFI Assembly Integration & Verification Plan (PL-LFI-PST-Pl-004, 3.0)
AD 9: FIRST/Planck Operations Interface Requirements Document (SCI-PT-RS-07360, 2/1)
AD 10: LFI Configuration and Data Management CADM Plan (PL-LFI-PST-PL-001, 3.0)
AD 11: LFI Instrument Deliverable Documentation List (DDL) (PL-LFI-PST-LI-007, 1.0)
AD 12: 4K Reference Load Requirement Specification (PL-LFI-TES-SP-001, 1.0)

2.2 Reference documents

RD 1: 4K Reference Load Design Report (PL-LFI-TES-RP-001, 2.0)
RD 2: Planck LFI Mechanical Design (PL-LFI-LAB-RP-001, 3.0)
RD 3: Adhesive data for the 4KRL (PL-LFI-TES-TN-002, 1.0)
RD 4: 4KRL a proposal for mechanical test on adhesives for the LFI 4K Reference Load Collaboration TeSRE-ESA (PL-LFI-TES-TN-006, 0.1)

3 Introduction

The reference load of LFI instrument consists of fine-shaped Eccosorb blocks contained in aluminium MS, thermally linked to the 4 K stage of HFI instrument. We are testing cryogenic properties of adhesives, commercially available, to bond Eccosorb to aluminium in their flight configuration. So we are interested in carrying on thermal tests of samples to verify the efficiency of adhesives during both thermal shocks and long period thermal cycles.

4 Thermal cycles requirement and setup

We prepared a cryostat to implement a cycle from 300 to 77 K and back by means of nitrogen fillings. The requirement we imposed was of a temperature gradient of about 30K/hour, which implies duration of about 10 hours of the cooling and a symmetric heating of the same duration. We had to use a two stage cryostat consisting of two tanks for cryogenic liquids connected with two flanges over which we had to mount our Eccosorb samples. Of course, the cooling of the flanges is almost instantaneous. So we decided to mount our samples on a brass flange thermally isolated from the cold flange by means of a low conduction struts.

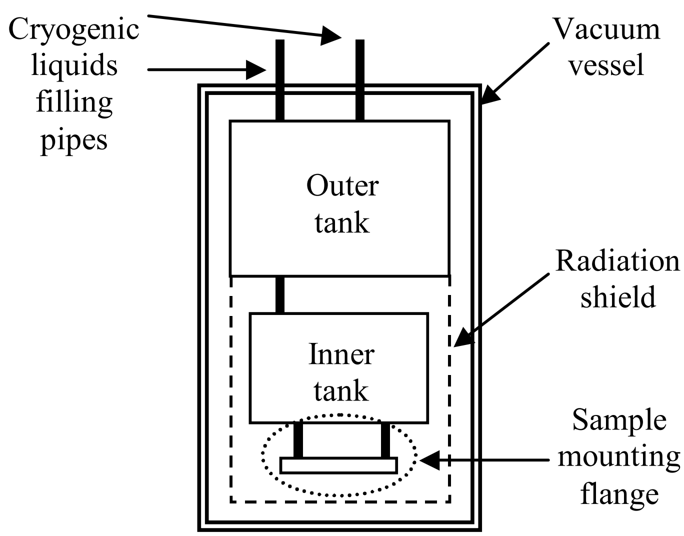

Figure 1: Sketch of the cryostat used for thermal cycles. Mounting flange is illustrated in Figure 2.

5 Thermal design

In order to evaluate the better screw material for an insulation matching our requirement, we built a simple thermal model of the setup discussed above.

We selected three isolating materials (nylon, teflon and stainless steel) and considered their mean thermal properties, in the range of temperatures of our cycle, as input to the model. Data used are reported in Table 1.

	Nylon	Teflon	Stainless steel	Brass
Thermal conductivity (W/m K)	0.339	0.259	12.3	81
Specific heat (J/Kg K)	984	227	300	300

Table 1: Thermal properties of the materials used in the model

5.1 Thermal model description

We considered the flange linked to the nitrogen tank as a thermal source at 77 K. Then a set of four struts are modelled as follows, the total length of 3 cm is divided in 5 nodes. A grid of 3 X 3 nodes models the brass flange (Fig. 1). These parts starts from the room temperature of 300 K. A radiative link to the source at 77 K represents the aluminium shields in the cryostat.

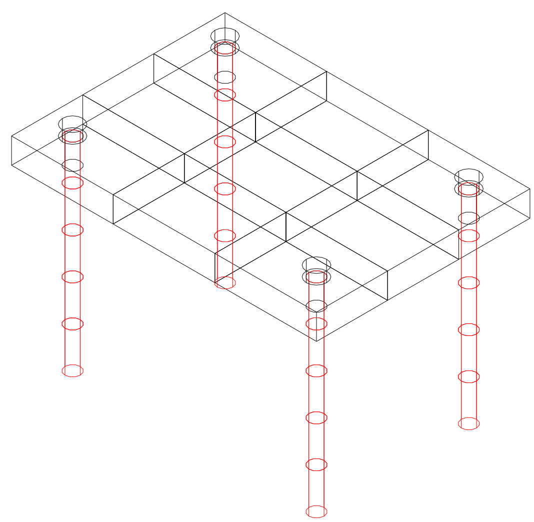

Figure 2 :The nodes partition in the thermal model. The struts are split into five nodes and the brass flange in nine nodes

Dimensions of the flange and struts are reported in Table 2.

Screw length	30 mm
Flange length	80 mm
Flange width	40 mm
Flange thickness	5 mm

Table 2: Relevant dimensions used in the model

5.2 Thermal model results

The results are shown in Figure 3, Figure 4 and Figure 5. They show the behaviour of the node on the struts closer to the nitrogen flange, the central node in the struts, the interface between the

screws and the brass flange, the central node in the brass flange. Because of the good brass conductivity the last two nodes are nearly coincident, as evident in the figures.
Considering as a reference the temperature of the central node in the brass flange, our choice to use stainless steel struts sounds optimal.

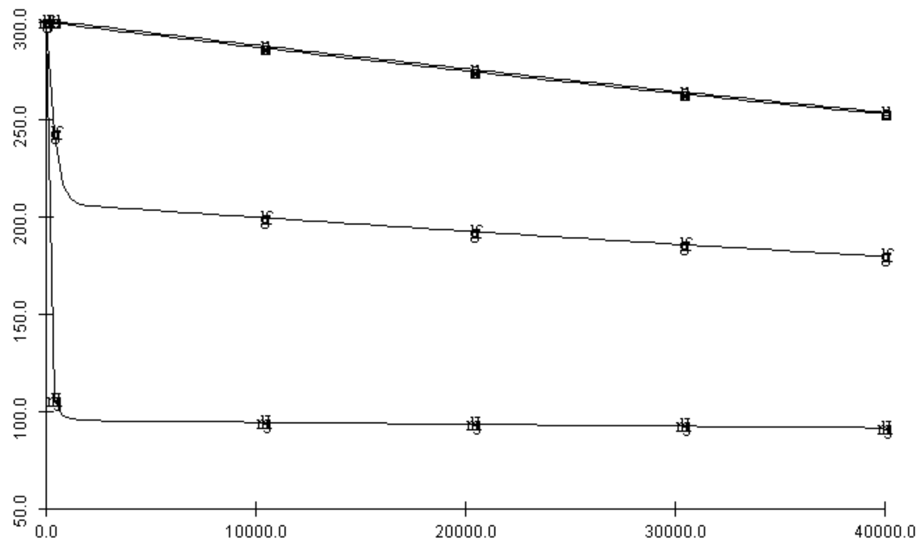

Figure 3 Temperature vs time of our system using Nylon cylinders

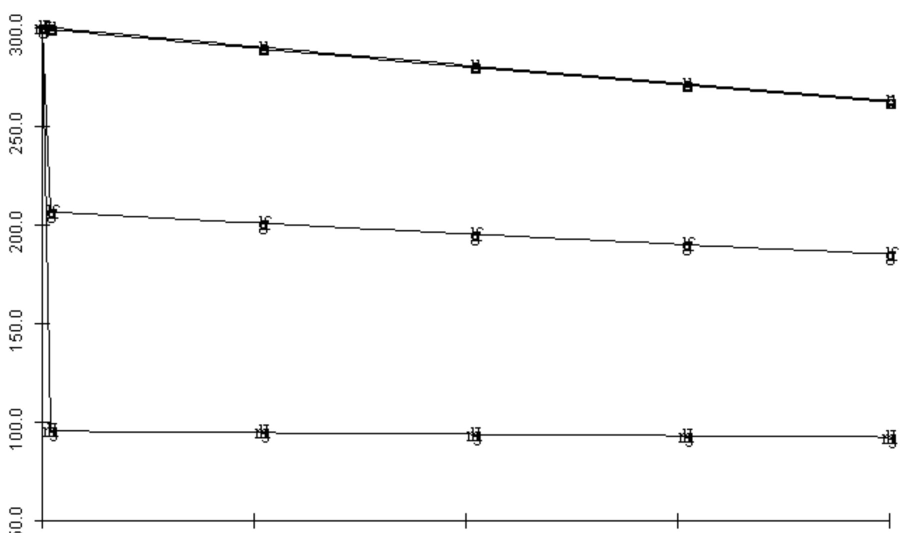

Figure 4 Temperature vs time of our system using Teflon cylindrical struts

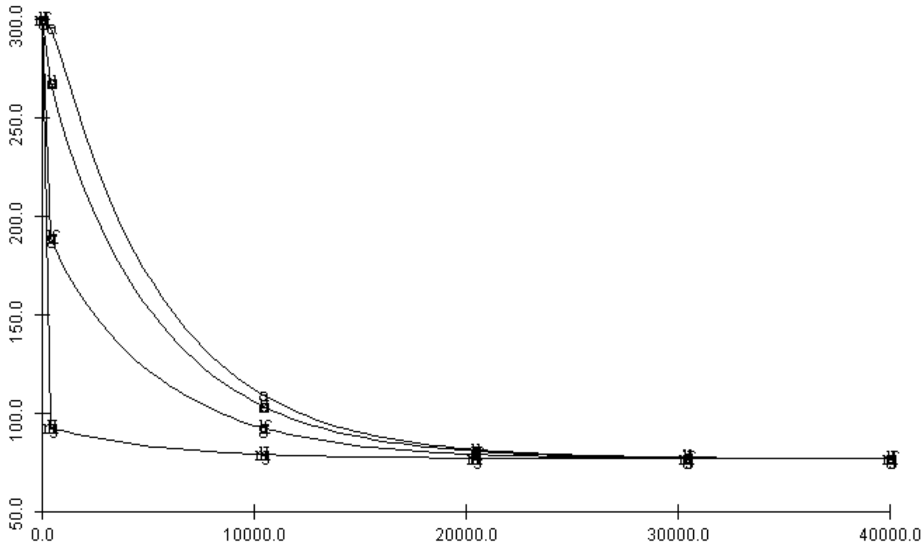

Figure 5 Temperature vs time of our system using stainless steel struts

6 Manufacturing

The flange was manufactured according to the drawing in Figure 6.

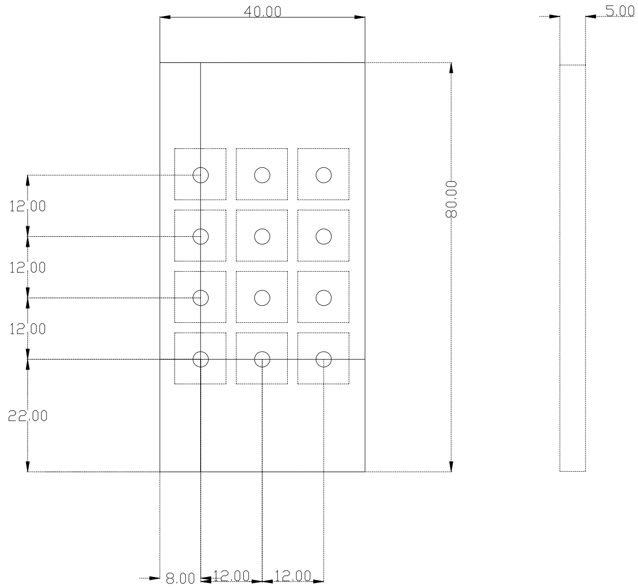

Figure 6: Drawing of the brass flange

As insulating struts, stainless steel screws are used. The flange, with samples mounted on it, is illustrated in Figure 7.

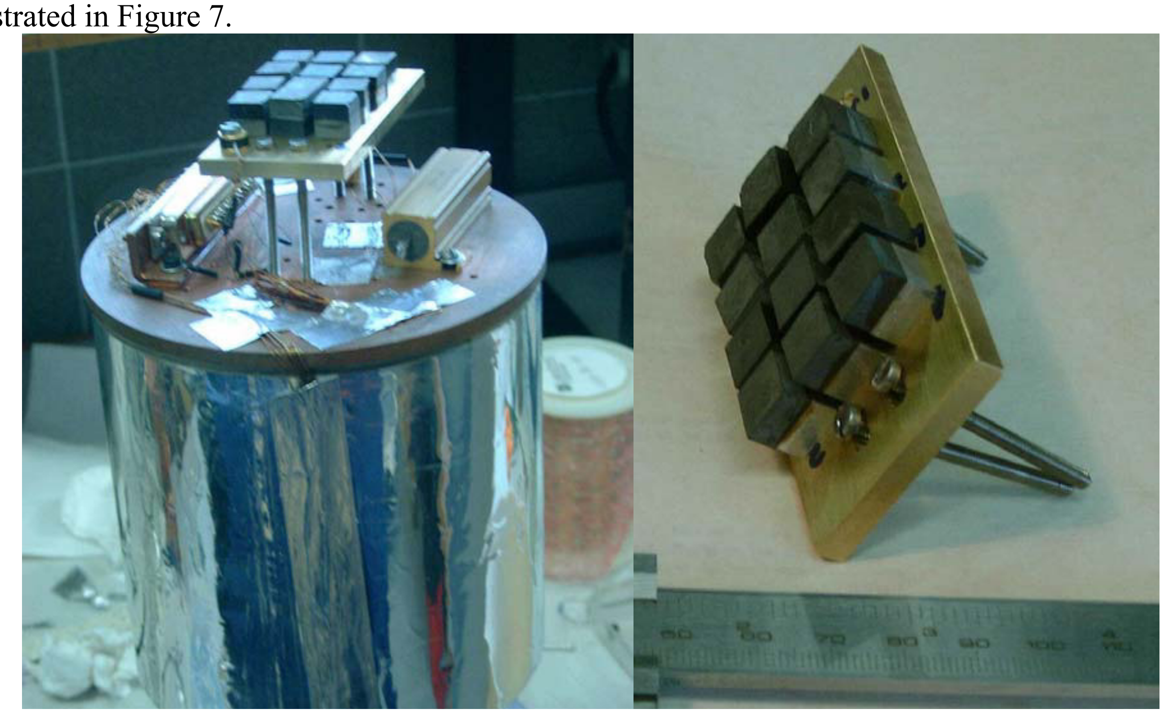

Figure 7: Right – The brass flange with samples mounted. The stainless steel struts (screws) are also visible. Left - The cryostat used for thermal cycles with the flange on the cold plate. Temperature sensors and the heater are also visible.

6.1 *Temperature sensors*

We used two LakeShore DT-470 silicon diodes read by a LakeShore controller 340. From the LakeShore datasheet we have a mean sensitivity for our temperature range of 5 mK and an accuracy of 60 mK. One sensor is mounted over the nitrogen tank and the other upon the brass flange (Fig. 7)

7 Experimental verification test

In order to verify this thermal behaviour I made a cooling monitoring the temperature at the center of the brass flange, together with the reference temperature on the nitrogen flange (Fig. 8 and 9).

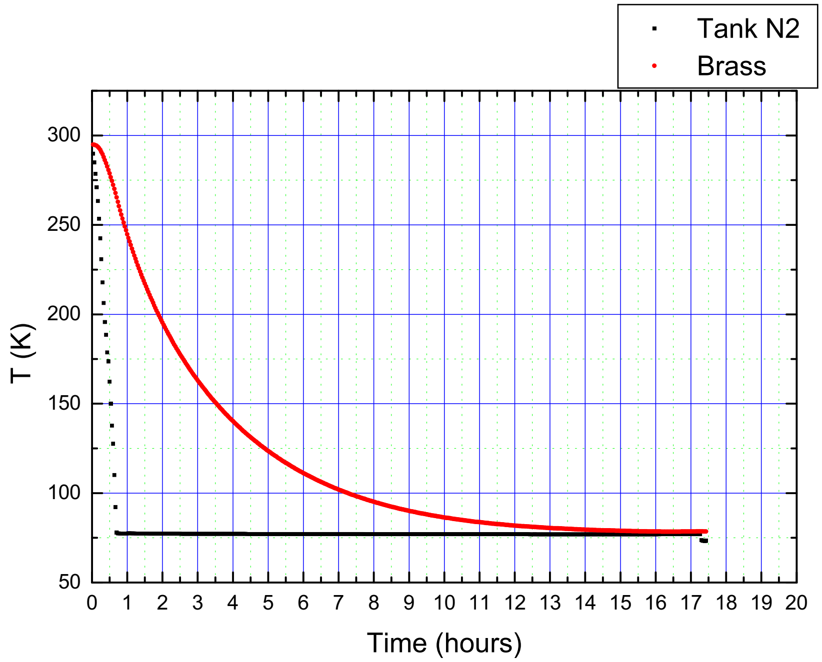

Figure 8 Time behavior in the cooling of our cryogenic systems (experimental data).

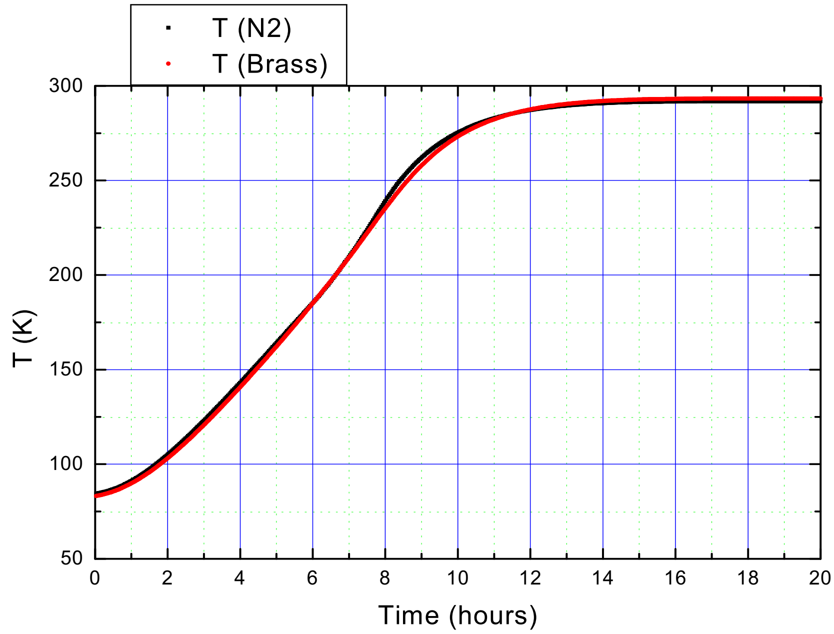

Figure 9 Time behavior in the heating of our cryogenic systems (experimental data)

We filled the cryostat tanks with liquid nitrogen and then, after the thermalization of the brass flange at 77 K, we emptied the containers and let the system temperature spontaneously warm back to room temperature.

The results are quite well matching the simulations. Longer timescales measured are explained taking into account different combined effects. First of all a delay is simply due to the finite duration of the cryogenic liquid filling, which is about 40 minutes as evident in the Fig. 8. It is important to consider that in the model we used approximated values of thermal properties (averages upon the temperature range). Finally, the struts used are a little longer (about 1 cm) and this increases the insulation.

It is important to stress that in the final configuration the cooling and warming period will be slower because the thermal inertia of the system is increased by Eccosorb samples mounted on the brass flange. So we are going to mount a heater in the main flange to drive the temperature back to room's according to our requirements.

8 Conclusions

Test results are in good agreement with the thermal model. We can therefore conclude that the realized cryo facility satisfies the requirements. It will be used for thermal cycle of the samples.