INAF
IASF-Bologna
LFI Project System Team

Planck LFI

TITLE: **PLANCK OPTICAL SHIELD 2: CRYO TESTS ON REPRESENTATIVE PANELS**

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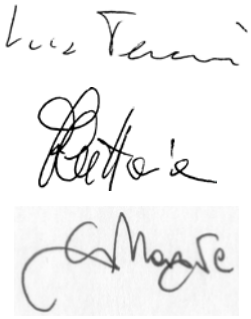
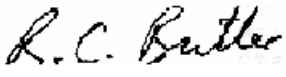
Prepared by	**L. TERENZI** **F. CUTTAIA** **G. MORGANTE**	**Date:** **January 22nd 2008** **Signature:** 
Agreed by	**C. BUTLER** **LFI Program Manager**	**Date:** **January 22nd 2008** **Signature:** 
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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
0.1	17-12-07		1st minireport after 1 cycle	
0.2	21-12-07		2nd minireport after 2 cycles	
0.3	11-01-08		3rd minireport after 9 cycles	

TABLE OF CONTENTS

1 ACRONYMS

AIV	Assembly, Integration, Verification
TBC	To be completed
TBI	To be included
SKL	Sky Load

2 INTRODUCTION

A new sky load simulator was committed by HFI Team, basing on a design agreed with LFI, to characterise some unwanted features observed during HFI calibrations at instrument level. The new sky load requires some changes, respect to the old one, to allocate 3 noise sources. The position and shape of sources comes from HFI and LFI requirements . More details are given in **Errore. L'origine riferimento non è stata trovata.** and RD 1. Changes regard basically two ECCOSORB panels, located in the central region of the Sky Load (SKL) and the metal plate backing panels.
IASF-Bo has taken in charge the responsibility to perform cryogenic tests on two representative panels to verify that are compliant with needs. Tests have been performed on procedure given in AD01, mainly based on the same followed in year 2003 to verify compliance of the original sky load.

2.1 Purpose and Scope

Scope of this document is to show results from cryo tests performed by IASF-Bo , using its own facility in Bologna (AD02).
This document is a collection and integration of the three mini-reports produced by IASF-Bo as update of the activities foreseen to characterise the panels.

2.2 Acknowledgments

This document has been issued as a part of the activity performed under the ASI contract for Planck phase E2.

3 APPLICABLE AND REFERENCE DOCUMENTS

3.1 Applicable Documents

[AD01] "Skyload2 Eccosorb panels Thermal test specification" , SP-PHZW-700402-IAS, 1.0

[AD02] "The 4KRL cryo facility", PL-LFI-TES-TN-010

[AD03] "Thermal test of panels of pyramids manufactured by Officine Pasquali", IASF-BO-IR-04/003

[AD04] "FIRST/Planck Instrument Interface Document IID Part A" , PT-IID-A-04624

3.2 Reference Documents

RD 1. "Planck cold load performance degradation at LFI frequency caused by HFI carbon fibre noise source" , PL-LFI-PST-RP-025

RD 2. TBC: (HFI document describing the shape and position of CFS Carbon fibre sources)

4 TEST PREPARATION

4.1 DEVICES UNDER TEST

As required in AD01, two panels have been tested: they are a 'standard' panel and a 'custom' panel. The 'custom unit modified to lodge sources.
Each panel was provided to IASF-Bo together with its backing metal plate. The metal plate is representative of the shape having the larger one in correspondence of the panel.
This is why, the standard panel is backed by a simply flat metal Aluminium plate while the 'custom' panel is attached to a custom Aluminium plate , shaped in order to lodge the sources.

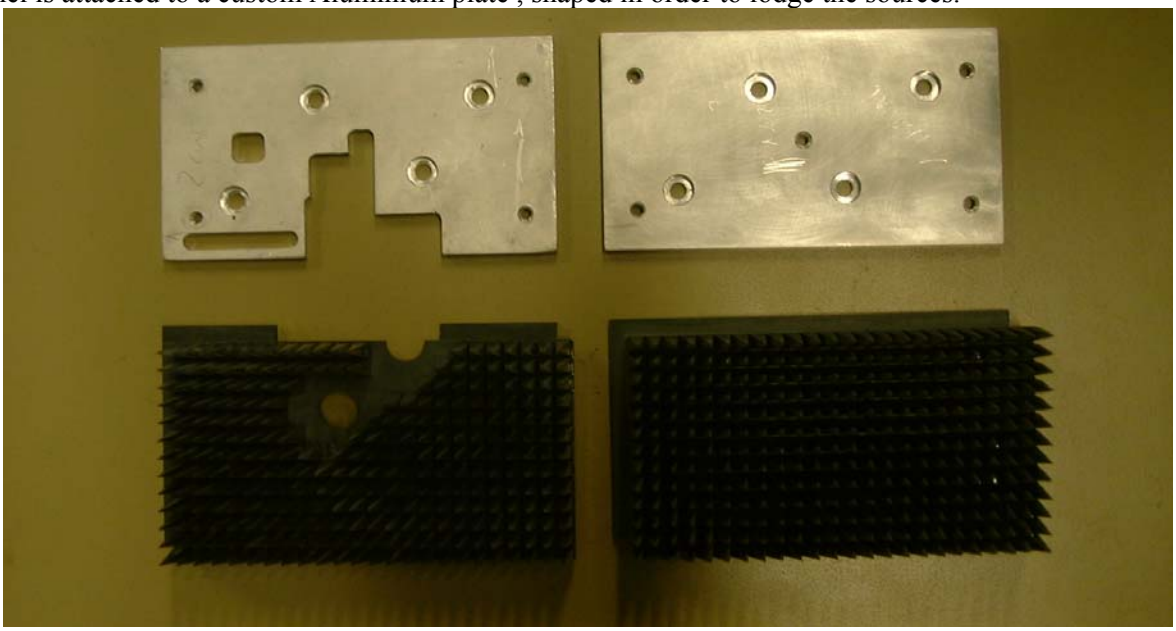


Figure 1 the two panels under test together (above in the picture) with their back metal plate: special panel (left side) and standard panel (right side)

4.2 TEST FACILITY

The test facility is a cryostat cooled by a SUMITOMO cooler. Its characteristics are given in AD02 and are compliant with test requirements (AD01)
The facility has cooling power able to cool the inner flange (where metal supports, sustaining panels, are connected) down to 2.3 K.

4.3 TEST FLOW:

9 complete (cooldown and warmup) cycles are foreseen, basing on procedures described in AD01. They followed this scheme:
1st cycle :
Cryostat opened; visual inspection by naked eye.
2nd to 5th cycle:
Cryostat opened; visual inspection by naked eye; panels dismounted from cryo supports. Torque verified.
6th to 9th cycle:
Cryostat opened; visual inspection by naked eye; panels dismounted from cryo supports. Torque verified. Aluminium plates dismounted from panels; visual inspection by naked eye and by binocular

5 TEST RESULTS

5.1 INCOMING INSPECTION

Panels have undergone a detailed incoming inspection before mounting on the cryo facility. All defects (as broken tips) have been mapped in advance. Many pyramids showed tips partly broken. Main defects have been noted. The material colour was not uniform, showing features probably coming from mechanical workings. Many pictures have been taken in order to check for eventual changes at the end of the last thermal cycle.

5.2 MOUNTING

Screws connecting metal backs to the Eccosorb panels have been tightened with the required torque 0.8 Nm using a dynamometer key.
Panels have been hence mounted on the mounting structure built to interface with the cryo facility. It is the same already used in 2003 to test panels of the old sky load.
Panels have been mounted with pyramids facing the 2.7 K Flange of the cryostat: the two panels are mounted crossed, using two separate supports.
Details of mounting are shown in the figure below.

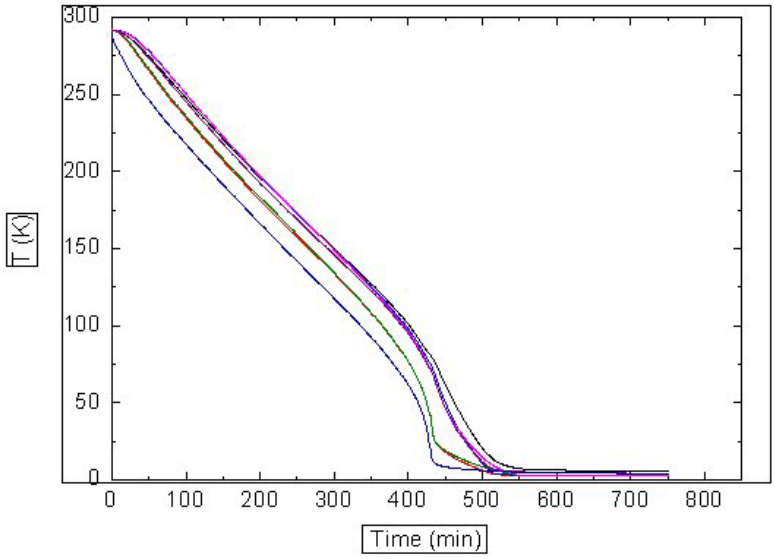
Figure 2 mounting structures inside the cryo facility.

Sensors have been applied in the positions foreseen by procedures (three per panel and one on the cold flange). Sensors on pyramids have been attached using thermofit.
Contact between the metal support and Aluminium plates has been increased using thermal grease .
An Aluminium foil was put on the 2.7 K flange, to collect damaged parts, eventually detached from panels, falling down.

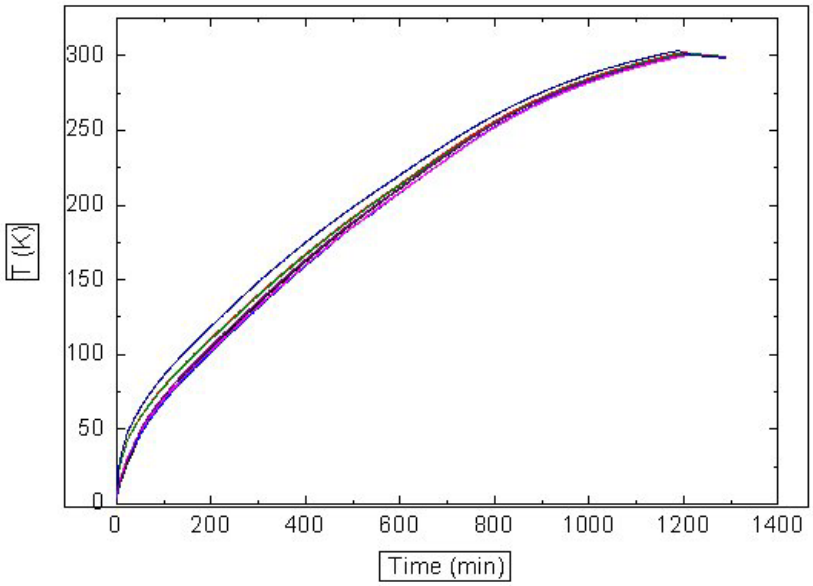
5.3 1ST CYCLE

5.3.1 Thermal curves

The 1st cooldown started on Wednesday 12/12/2007 at 21:00 and finished on 13/12/2007 at 07:00
the 1st warmup started on 13/12/2207 14:30 and finished on Friday 14/12/2207 at 11:30
temperatures in cold state: between 3K and 7K, depending on location of sensors (Req: 5K -3/+5 K)
duration of the flat (< 1K/hr gradient) step in steady state conditions >3 hr (Req 1hr)



Plot 1 cooldown curve 1st cycle



Plot 2 warmup curve

5.3.2 Inspection:

Was performed at the end of the warm up , after opening the cryo facility.
Before dismounting panels from support structures
After removal from cryo facility but without disassembling the metal backing aluminium plate from the ECCOSORB panel.
Both inspections gave no evidence of possible problems or defects ascribable to the cycle.
Torque of screws was not checked, since not foreseen at this level.
Some pictures reporting the mounting setup and the panel status at the end of the warmup are shown below.

Figure 3 detail of the mounting after warmup

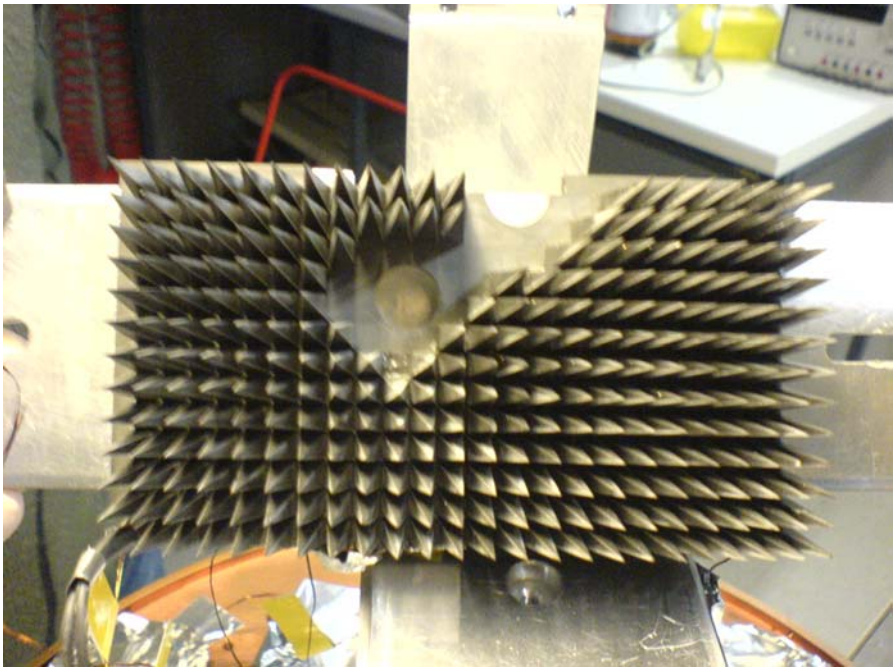


Figure 4 special panel after removal for inspection

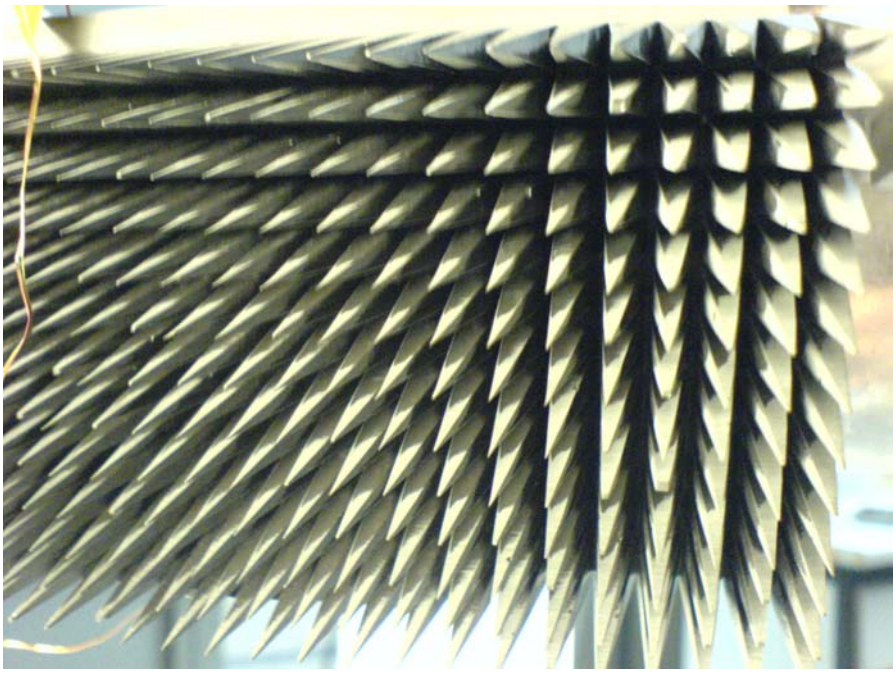


Figure 5 standard panel after removal for inspection

5.4 2ND - 5TH CYCLE

The 5th cycle has been closed on Friday 21-12-2007, as foreseen by schedule.
Everything before opening the facility has gone fine.
Cycles have been performed in accord with specifications, in terms of temperature reached, steady state duration, cooldown and warmup slope and speed.
All the curves, reporting cooldown and warmup for cycles from 2nd to 5th , are displayed below

In the following table , temperatures measured during the steady states, are reported

5.4.1 Cooldown 2-5

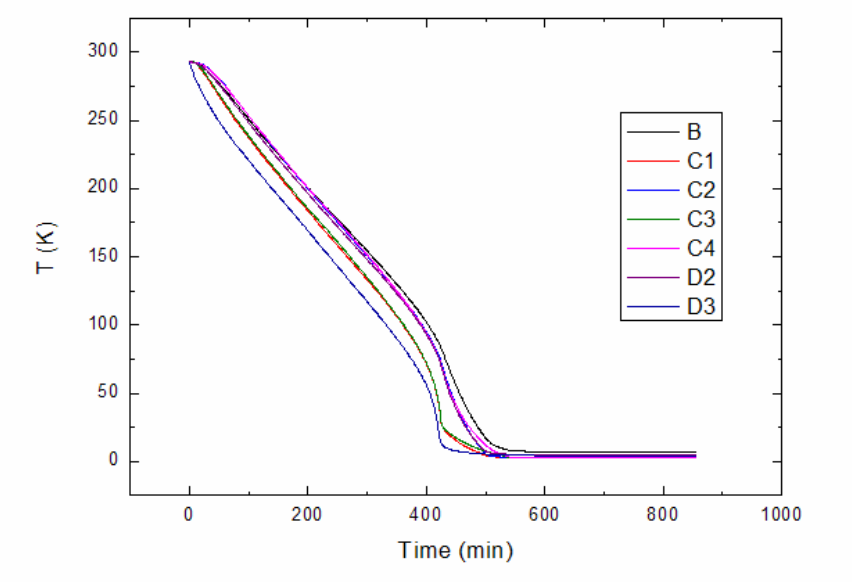


Figure 6 2nd cycle cooldown

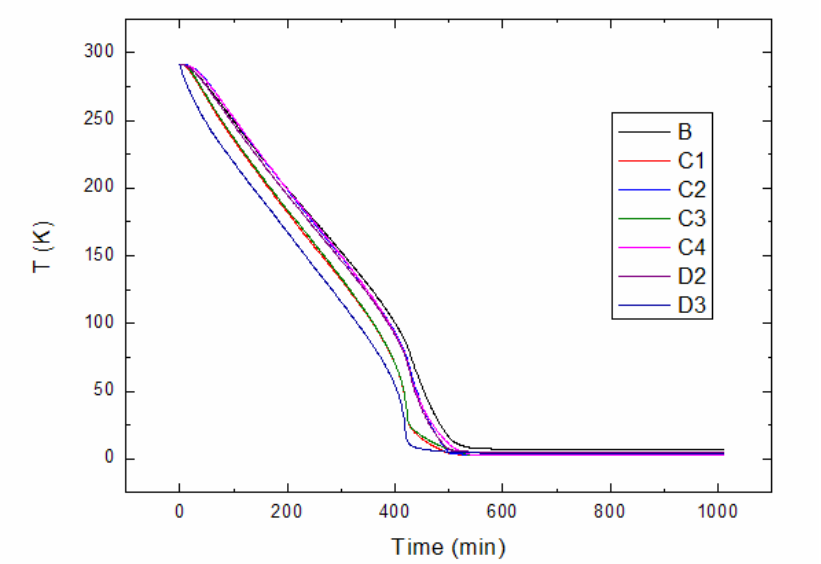


Figure 7 3rd cycle cooldown

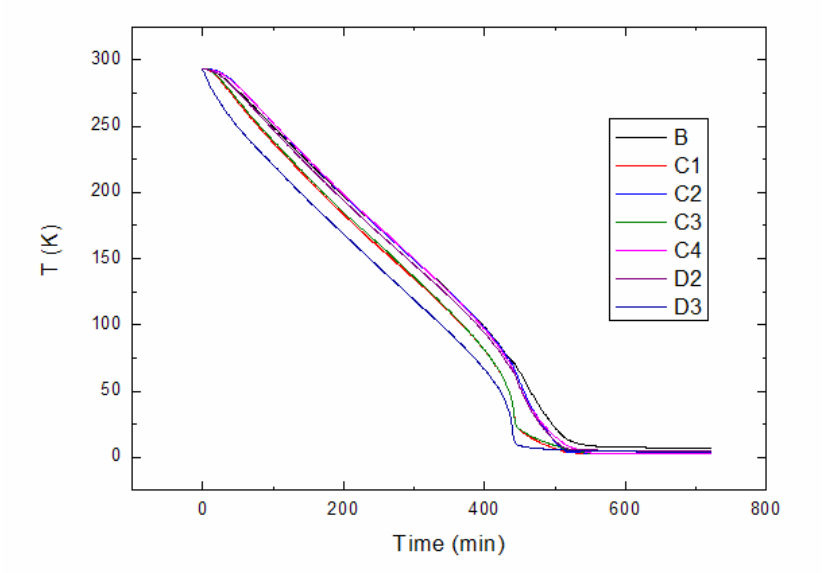


Figure 8 4th cycle cooldown

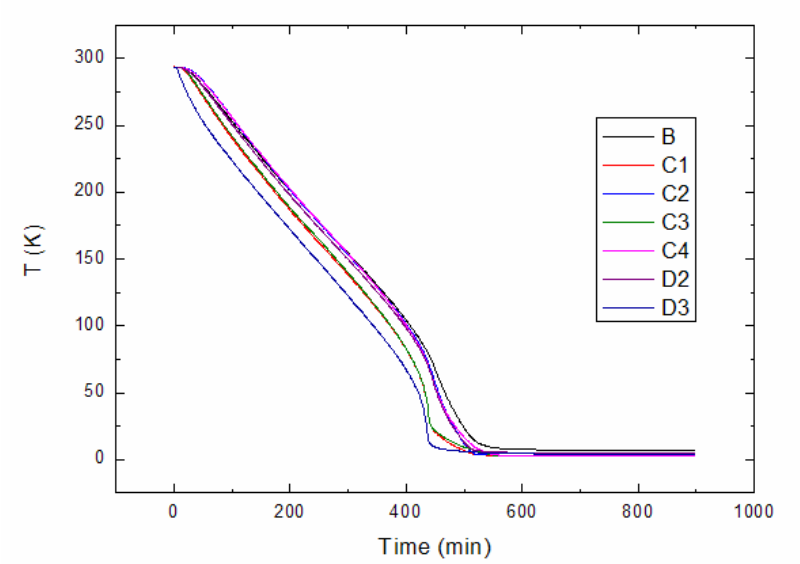


Figure 9 5th cycle cooldown

CYCLE	B	C1	C2	C3	C4	D2	D3	Steady state
2	6.4878	2.5779	2.7171	2.6294	2.7786	4.3489	4.0706	230’
3	6.6109	2.581	2.7163	2.629	2.787	4.3792	3.9389	440’
4	6.8499	2.5839	2.7269	2.6299	2.8071	4.4794	4.0352	180’
5	6.5006	2.5588	2.6932	2.6055	2.768	4.389	3.952	340’

Table 1 summary of the thermal behaviour from 2nd to 5th cycle : cooldown

5.4.2 Warmup 2-5

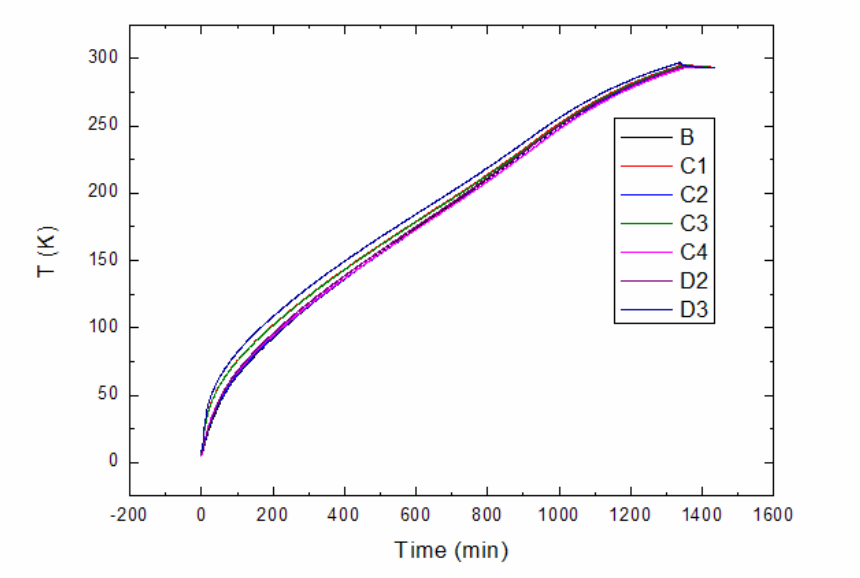


Figure 10 2nd warmup

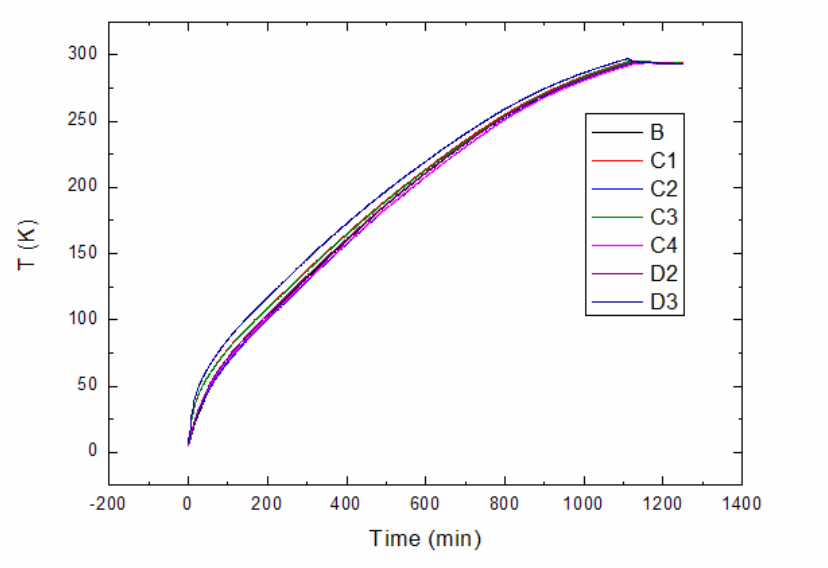


Figure 11 3rd warmup

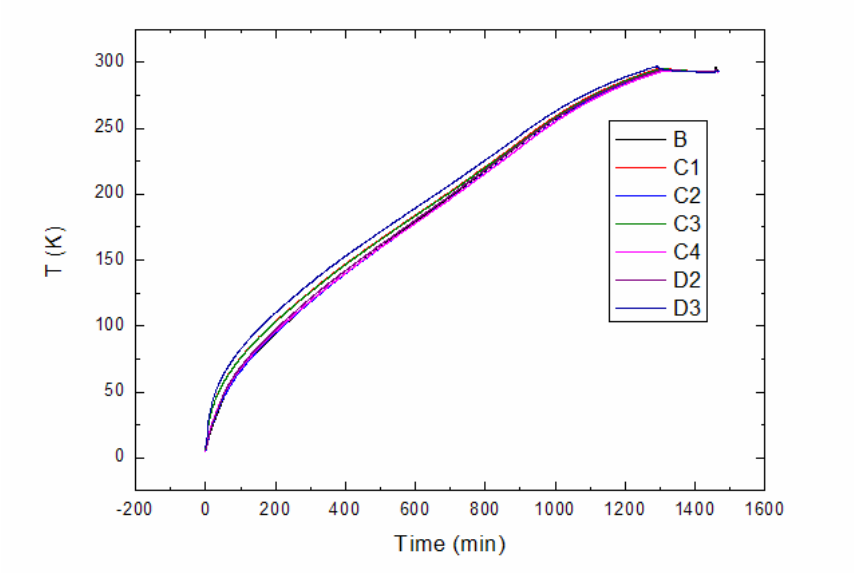


Figure 12 4th warmup

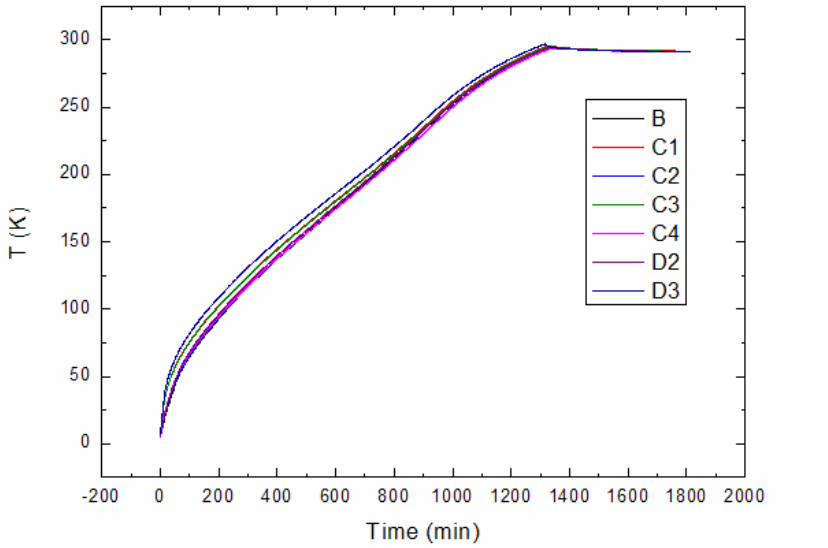


Figure 13 5th warmup

CYCLE	B	C1	C2	C3	C4	D2	D3	Steady state
2	298.964	299.383	299.344	299.35	298.776	299.056	298.471	300’
3	291.443	291.631	291.411	291.547	290.893	291.433	291.189	270’
4	293.558	293.771	293.638	293.698	293.104	293.565	293.211	110’
5	291.941	293.1	292.715	293.073	292.294	292.194	292.562	115’

Table 2 summary of thermal behaviour from cycle 2nd to 5th: warmup

5.4.3 Inspection

An accurate inspection was performed removing panels, without dismounting from their base plates, from the aluminium support structures connecting them to the cryo-flange.
The two panels have been posed on a table , observed by eyes and photographed.
No evidence of change was observed in the panels: no broken parts (example Eccosorb tips) have been found on the aluminium foil put on the flange in order to collect eventual parts falling down from the panels.
Comparison of photograph before the 1st cooldown and after the 5th warmup seems to show that nothing changed due to cycling.

Figure 14 panels after the facility has been opened. Everything looks fine, no broken parts on the aluminium tape covering the cryo 4K flange.

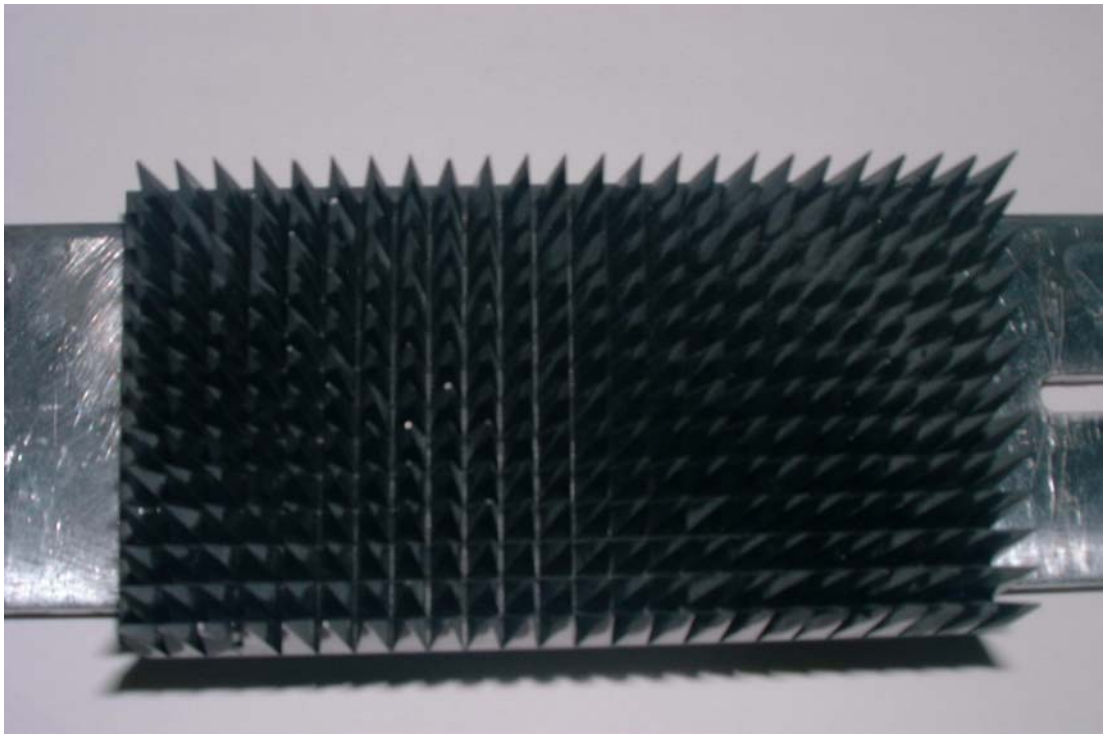


Figure 15 standard panel after dismounting from facility supports

Figure 16 special panel after dismounting from facility supports

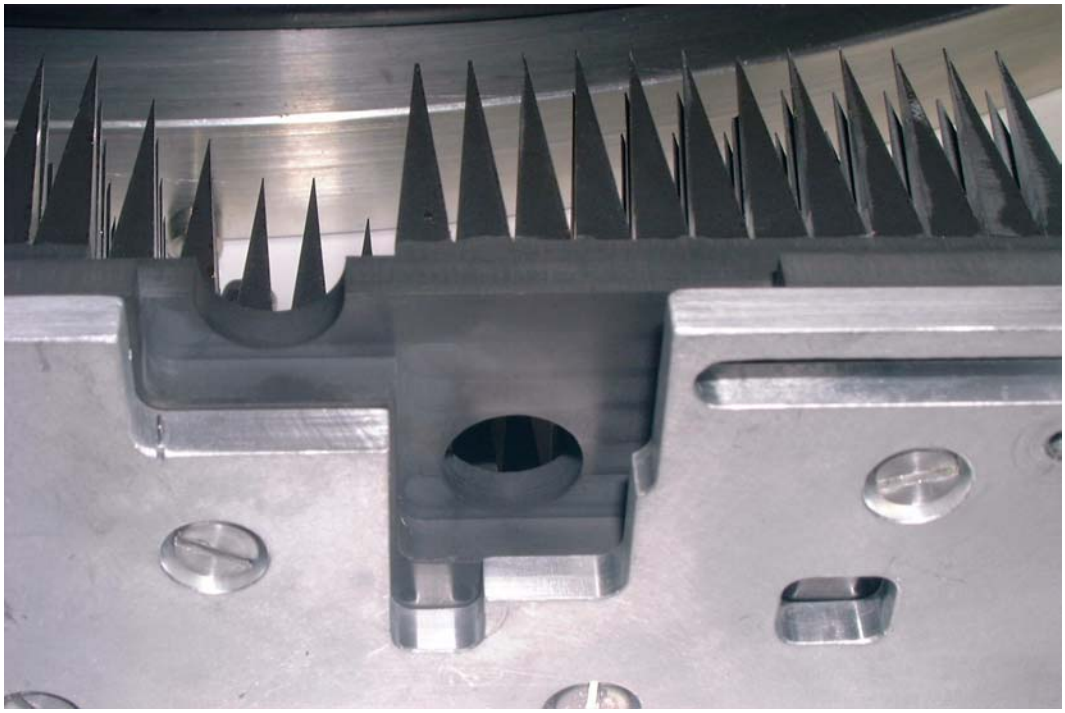


Figure 17 special panel from the back after dismounting from aluminium interface with cryo facility supports.

Figure 18 standard panel from the back after dismounting from aluminium interface with cryo facility supports.

5.4.4 Torque verification

Panels have been completely dismounted from the aluminium support of the facility, in order to check the torque of the 4 screws connecting each panel to its aluminium base plate. Increasing torque have been applied from 0.5 Nm to 0.8 Nm, without observing any rotation of the screws. Until the nominal torque (0.8) was reached, and the verification considered passed, no extra torque was applied more.

5.5 TEST INTERRUPTION

As foreseen in the PLAN, tests have been interrupted by 21-12-2007 up to 03-01-2008 for Christmas Holydays. Interruption does not affect in anything the validity of the full test campaign.

5.6 5^{TH} - 9^{TH} CYCLE

5.7 mounting

Aluminium plates have been remounted on the supports , in the same position having in the previous cycles. The same torque (1.2 Nm) was applied to the interface screws.
Sensors have been mounted in the same places and using the same name convention. A possibly problematic behaviour was observed with the sensor put on the cold flange: soldering with connector was done again and it seemed to work in warm conditions. Due to unavailability of a spare sensor with similar characteristics, and since this sensor is used just to monitor the cryostat flange, it was decided to proceed anyway closing the chamber.

5.7.1 thermal curves

The 6^{th} cycle started on January the 3th 2008; the 9^{th} cycle finished on January the 11^{th} 2008, as foreseen by schedule.
Cycles have been performed in accord with specifications, in terms of temperature reached, steady state duration, cooldown and warmup slope and speed.
All the curves, reporting cooldown and warmup for cycles from 6^{th} to 9^{th} are displayed in the followings.

A non ideal behaviour of the sensor put on the 2.7K flange was recorded: it was probably due to a bad solder in the connector wiring it with the Lakeshore controller. However, since this sensor was put on the coldest part of the facility, and not used to monitor the panels but only the cryostat, this lack did not affect in anything results and full validity of measurements.

5.7.2 Cooldown 6-9

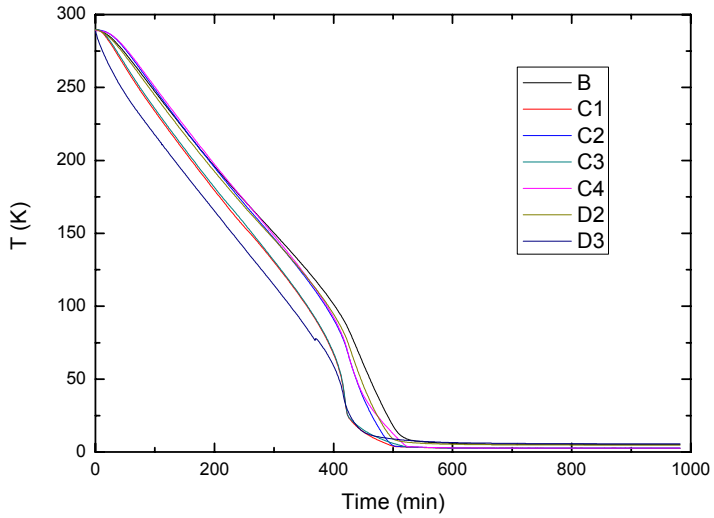


Figure 19 6th cooldown: a problem is evident in one sensor (outermost trace on the left)

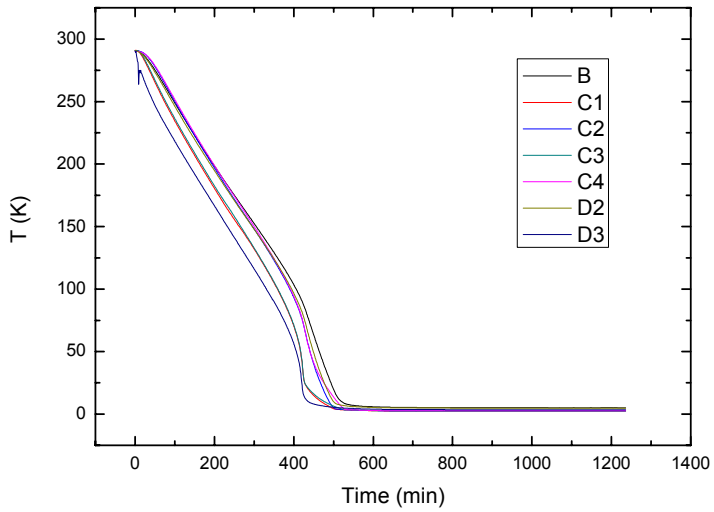


Figure 20 7th cooldown

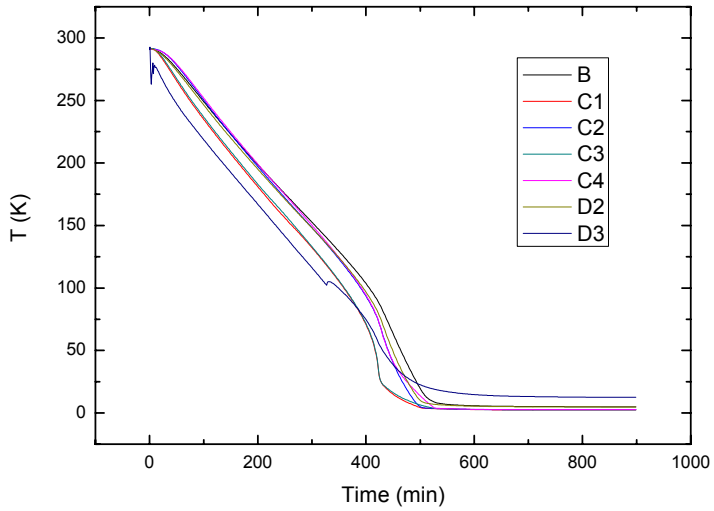


Figure 21 8th cooldown: the suffering sensor put on the flange does not thermalise anymore

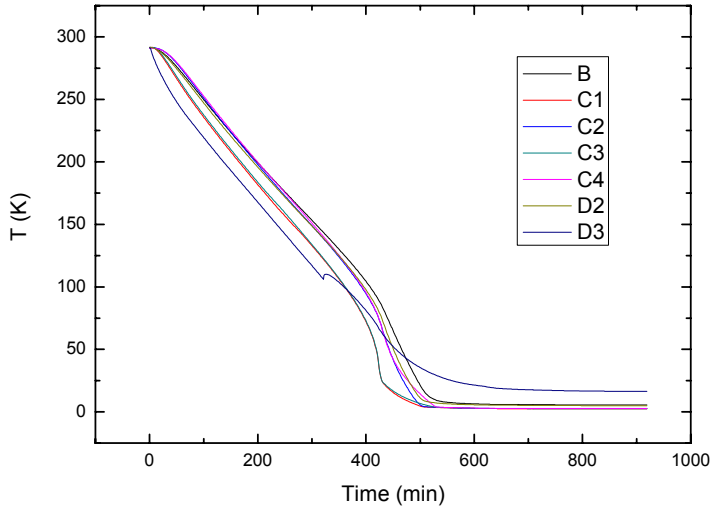


Figure 22 9th cooldown

CYCLE	B	C1	C2	C3	C4	D2	D3	Steady state (min)
6	6.119	2.764	2.911	2.818	2.954	5.420	6.640	392
7	6.041	2.812	2.953	2.866	3.005	5.458	4.087	651
8	5.937	2.820	2.967	2.870	3.023	5.552	**15.069**	309
9	6.479	2.832	2.985	2.889	3.052	5.719	**21.750**	324

Table 3 summary of the thermal behaviour from 6th to 9thcycle: cooldown

5.7.3 Warmup 6-9

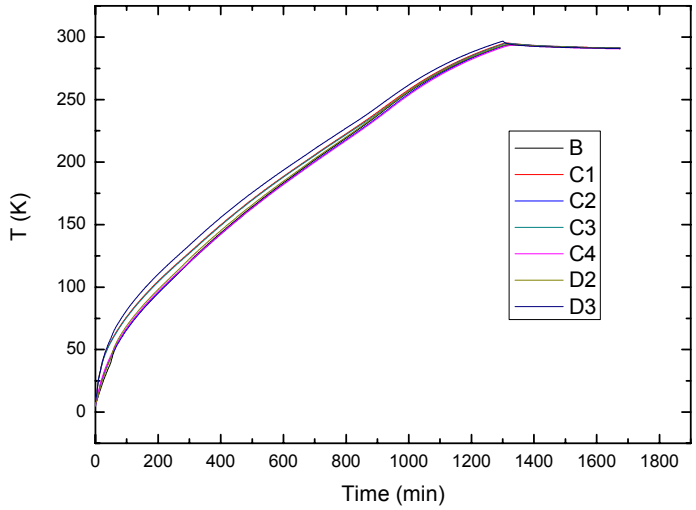


Figure 23 6th warmup

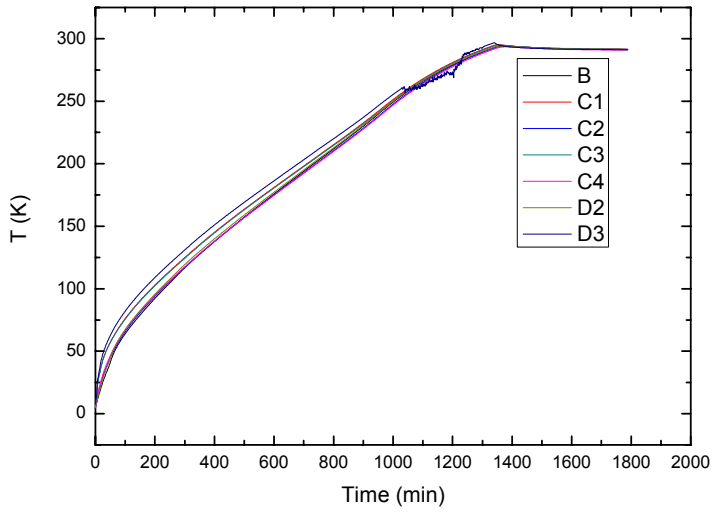


Figure 24 7th warmup

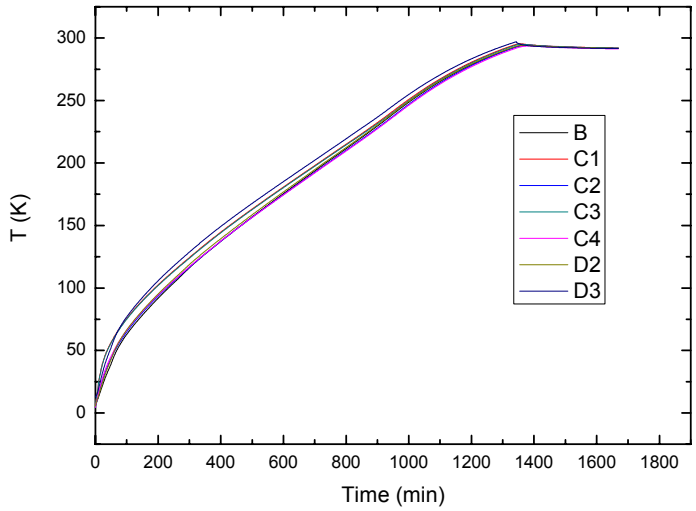


Figure 25 8th warmup

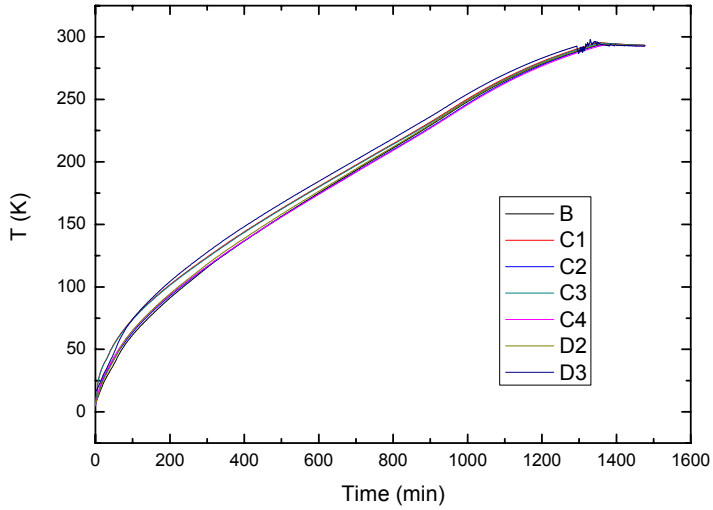


Figure 26 9th warmup

CYCLE	B	C1	C2	C3	C4	D2	D3	Steady state (min)
6	292.122	292.369	292.204	292.307	291.688	292.107	291.790	178
7	292.440	292.697	292.551	292.638	292.035	292.425	292.096	286
8	292.793	293.041	292.906	292.982	292.387	292.777	292.432	183
9	292.064	293.952	291.743	293.414	290.873	292.423	293.695	143

Table 4 summary of thermal behaviour from cycle 6th to 9th: warmup

5.7.4 Preliminary inspection

A first inspection was done just after opening the chamber, with panels still mounted on their supports. Nothing relevant was observed.
The aluminium foil was removed from the cold flange to search for eventual parts detached from panels: nothing was found on the foil.

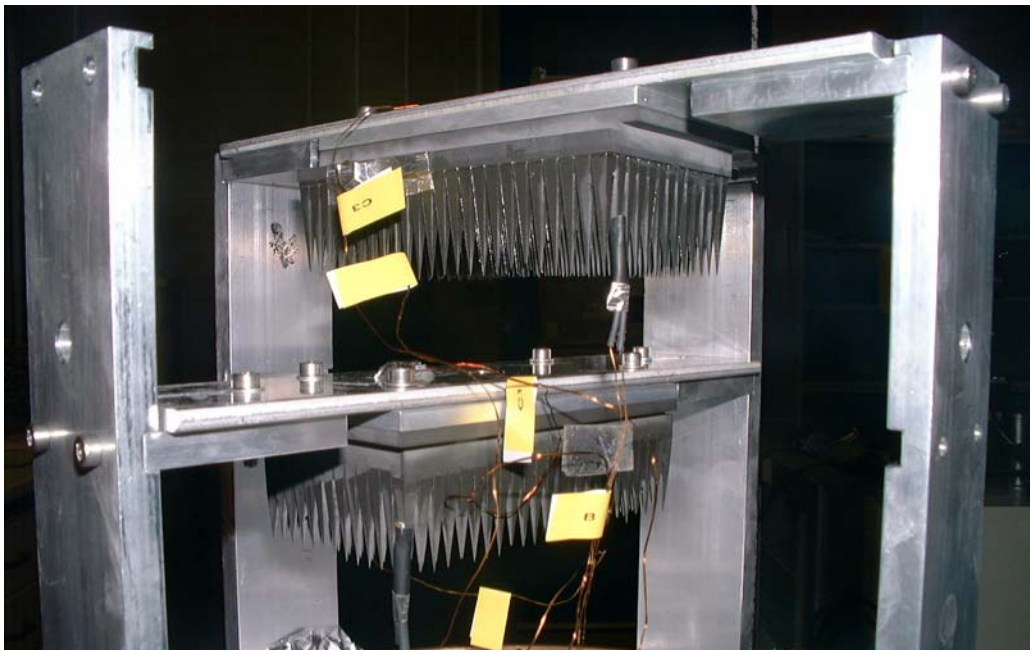


Figure 27 panels mounted on supports before dismounting

Figure 28 aluminium foil put on the cold flange to collect eventual parts detaching from panels: nothing found on it

5.7.5 dismounting and final inspection

The two panels have been then dismounted from the cryo supports.
They have been firstly inspected by naked eye before dismounting from the aluminium back: nothing new, in terms of damages, was observed.
Then torque (see next paragraph) has been checked.
Metal backs have been removed: It allowed to observe the back of ECCOSORB panels for the first time since tests started: everything looked nice, as before cryo tests.
Panels have been then inspected by binocular: nothing new seems to be observed. Comparison with the initial map reporting broken tips and other defects seems to confirm this result.

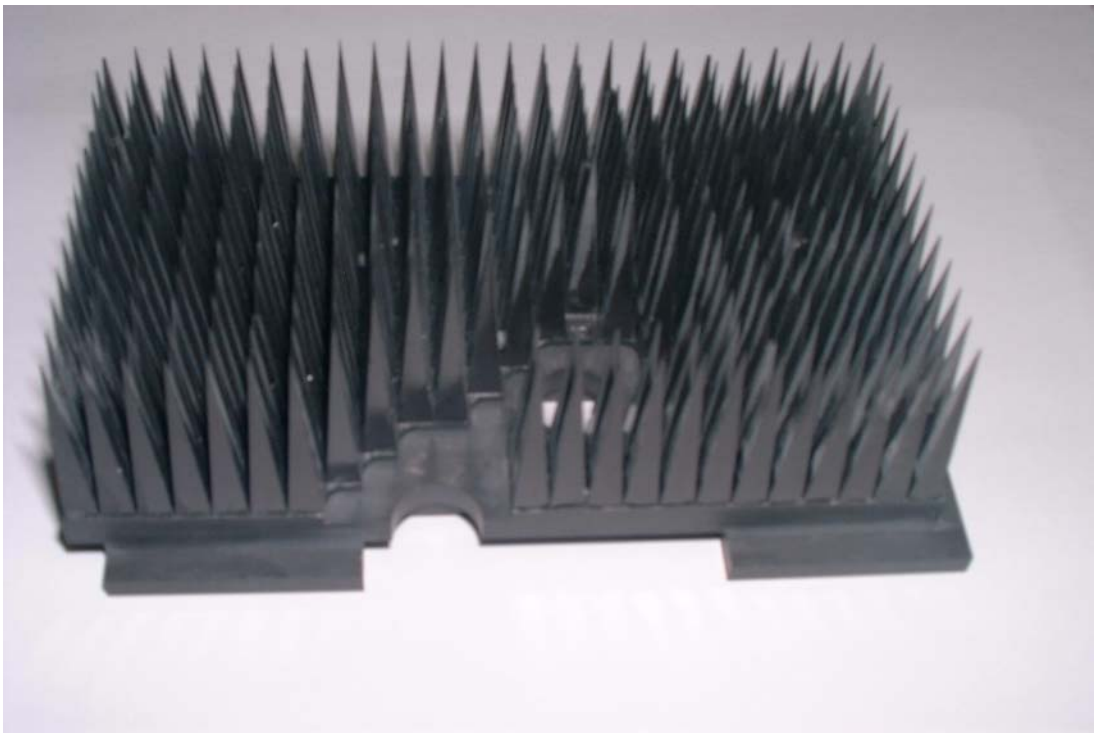


Figure 29 special panel after inspection

Figure 30 special panel (back)

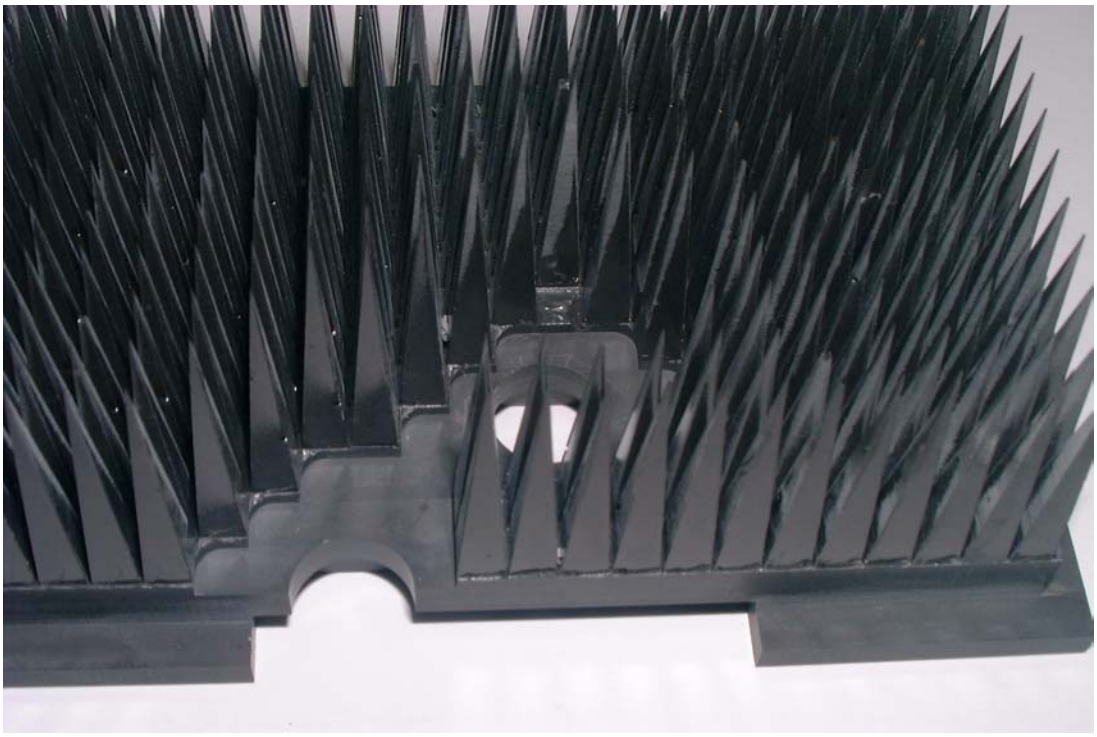


Figure 31 special panel: zoom on the region lodging sources

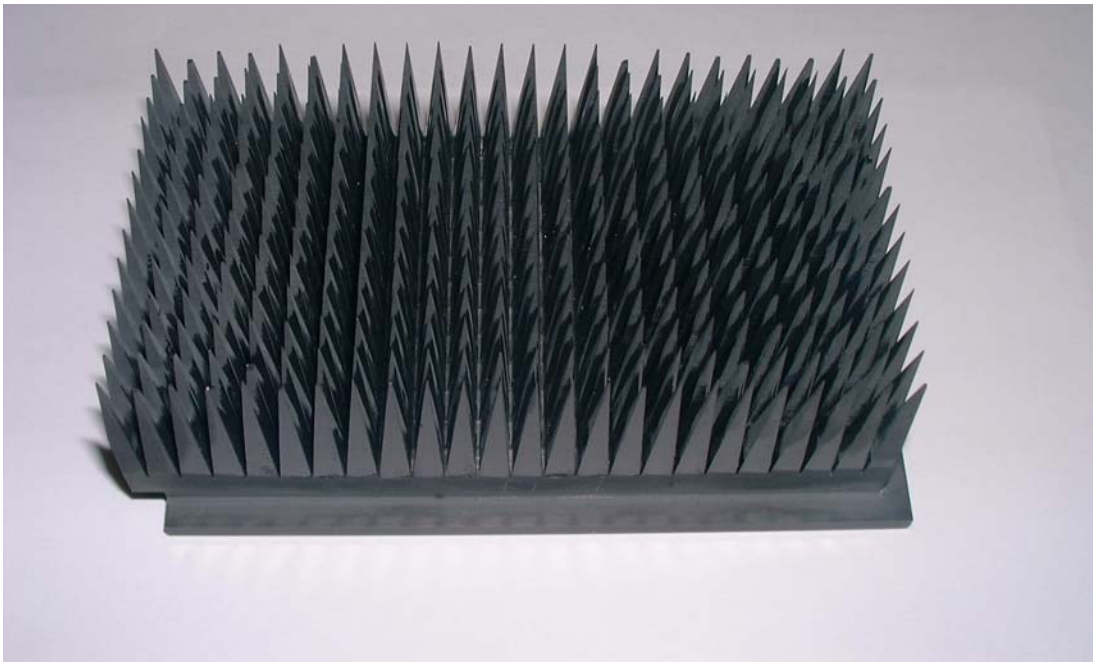


Figure 32 standard panel after inspection

Figure 33 standard panel (back)

5.7.6 Torque verification

Torque was measured for each of the 4 screws fixing the two panels. no changes have been measured with respect to the nominal value (0.8 Nm)

6 CONCLUSIONS

All tests foreseen, basing on procedures, were performed. Tests have been conducted in time with plan and in agreement with procedures. All requirements have been satisfied during the tests, in terms of temperatures reached, steady state duration, slope of the cooldown and warmup curves.
Panels, before being cryo cycled, showed some manufactory defects, however not affecting the validity of the test: defects have been mapped in advance, trying to take also into account the degree of damage.
During cycles, from 7^{th} to 9^{th}, one of the 7 thermal sensors showed instabilities and in the last two cycles did not reach the temperature foreseen. However, this sensor was used just to monitor the cold flange of the cryostat: hence, this failure did not affect the validity of the test.
Results from cryo cycles indicate that panels have passed all the tests foreseen without suffering structural damages visible by thermal behaviour, naked eye and binocular inspections.