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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
0.1	04-06-08		1st issue : analysis and results from measurements	

TABLE OF CONTENTS

1 ACRONYMS

AIV	Assembly, Integration, Verification
TBC	To be completed
TBI	To be included
SKL	Sky Load Simulator
BT	Blank test
OS	Optical Shield

2 APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable Documents

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

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

2.2 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)

RD 3. RP-CSL-PSPA-07001

RD 4. Localisation of the Optical Shied centre Vs ORDP Product Code : 200000, H-P-3-ASP-TN-1445

RD 5. Short Note On Measurements In Iasf-Bo Labs, Cuttaia- A. De Rosa, 210208

RD 6. MEMO: Reference procedure for measuring the wires displacement in pulleys installed in CSL Focal-5. F. Cuttaia, A. De Rosa, IASF-Bo, 200308

RD 7. PL-IASFBo-08-004_R1.0, De Rosa, Cuttaia, Morgante

3 INTRODUCTION

The design of the new sky load simulator used in the CSl cryo facility for FM test campaign set very tight requirements on the accuracy of positioning w..r.t. the FPU (LFI and HFI feeds). A thermo mechanical contraction of structures supporting the SKL is expected when going in cold conditions (optical shield at 4 K, environment between 20 K and 60 K), causing a wrong displacement w.r.t. the nominal position.
A thermo mechanical CAD model was prepared by AMOS , to evaluate by FEM simulations the expected displacement. It can be accounted in warm conditions to correct in advance the SKL position before going to cryo.
A test was prepared to verify the expected displacement during the Planck Blank test (March 2008) using simple devices, described in (RD 7) .
The test was successfully performed in CSL and here follow the main results.

3.1 Acknowledgments

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

We thank Isabelle Domken and CSL people involved in the test for the great help and the patience shown

3.2 Purpose and Scope

Scope of the test was to characterise the Optical shield (SKL) displacement when going from warm to cryogenics conditions.

3.3 Description

The method used to evaluate the SKL displacement bases on 5 devices mounted in opposite sides of the cryo chamber (top, bottom and lateral panels , and Beam stainlessteel bar) . Each device is made of two pulleys holding a wire each tensioned with a weel defined torque and connected on the other side on a common nut on the optical shield.
Pulleys have been mounted in CSL by CLS and LFI personnel .
This is a blind test, since it is not possible in advance to know in which direction the SKL moves and results from measurement can be checked just once gone back to warm conditions after opening the chamber.
The tests consists in measuring the unrolling of wires when the SKL moves in one direction or in the opposite way. This is done using two devices put in opposite points w.r.t. the SKL (as documented by Figure 5) . Each device has two pulleys and two wires in order to be redundant in the case of possible failures. The opportune points where connecting devices on the chamber have been individuated by CSL people using nuts already present on honeycomb panels inside the chamber.
Wires have been connected to a common screw with nut on the optical shield structure , by practicing knots (Figure 1) at the terminal of each wire. On the other end, wires have been fixed on pulleys using screws and knots. (Figure 4)
Wires have been put in tension using a dynamometric key acting on load and pre load nuts on the pulleys, then by hand (each pulley has been rotated until the wire goes back unrolling the pulley itself). The method for mounting and regulating devices was previously described , checked and agreed with other parts (RD 6)
Once mounted, for each wire were measured:
The length (from a reference on the pulley to the nut on the SKL)

The angle with two reference planes . Especially this operation was critical because performed just using manual instruments.
Markers have been put on wires and pulleys, allowing to measure unrolling at the end of the Blank test.
Two kinds of markers have been defined:

One on wires using aluminium tape as reference.

One on each pulley by signing with a colour marker the reference position of the pulley in warm conditions before BT.

In this way, we have a double check by simultaneously measuring unrolling and rotations for each pulley in the case of failure.

A table have been provided by CSL people containing results form this warm measurement (1st step results) . This table is reported in (Table 1) together with results from unrolling measurements at the end of the BT.

At the end of BT the SKL is again in warm conditions, and the effect of thermo-mechanic contraction disappears. The only remnant of the displacement exhibited in cryo is given by the unrolling of some wires that is permanent, since pulleys have not any return spring. From this unrolling it is possible to reconstruct the maximum movement of the SKL during the thermal cycle warm – cryo – warm.

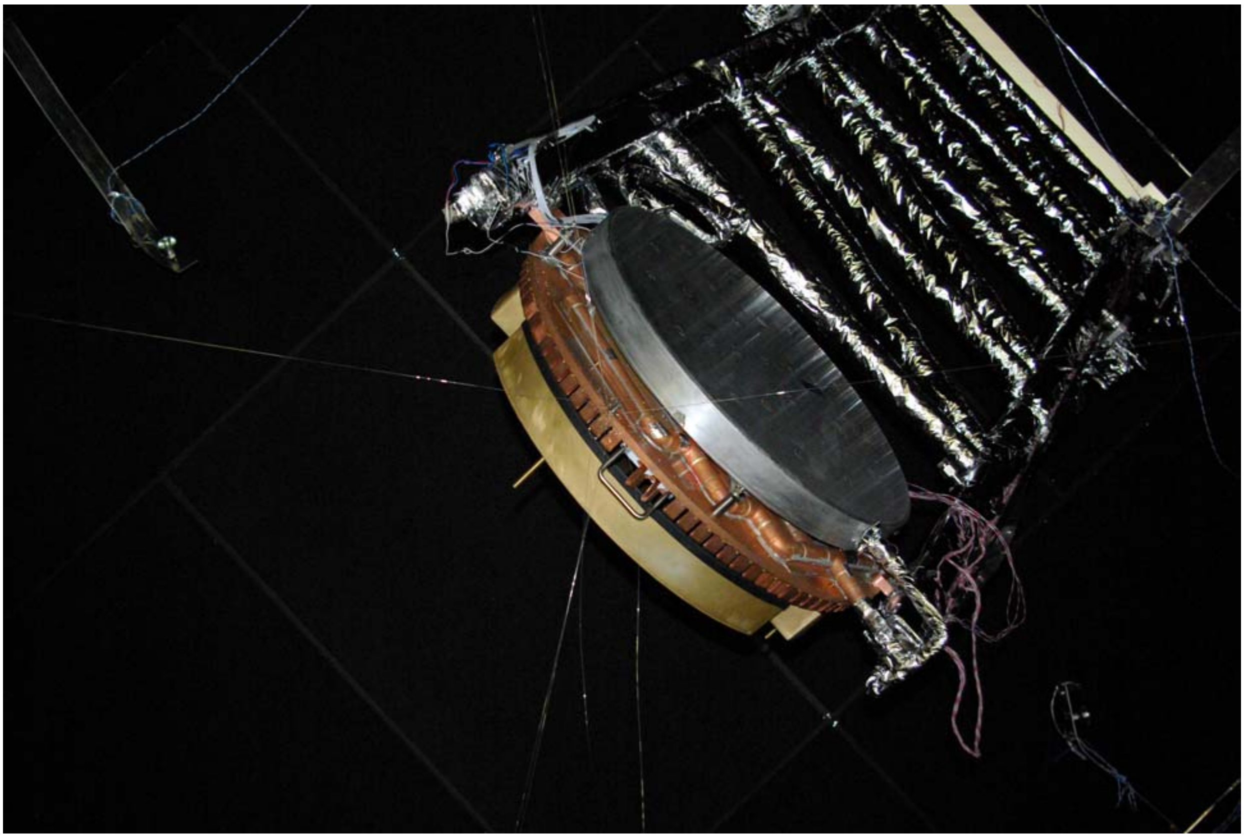

Figure 1 wires connected on the SKL screw and tensioned from pulleys.

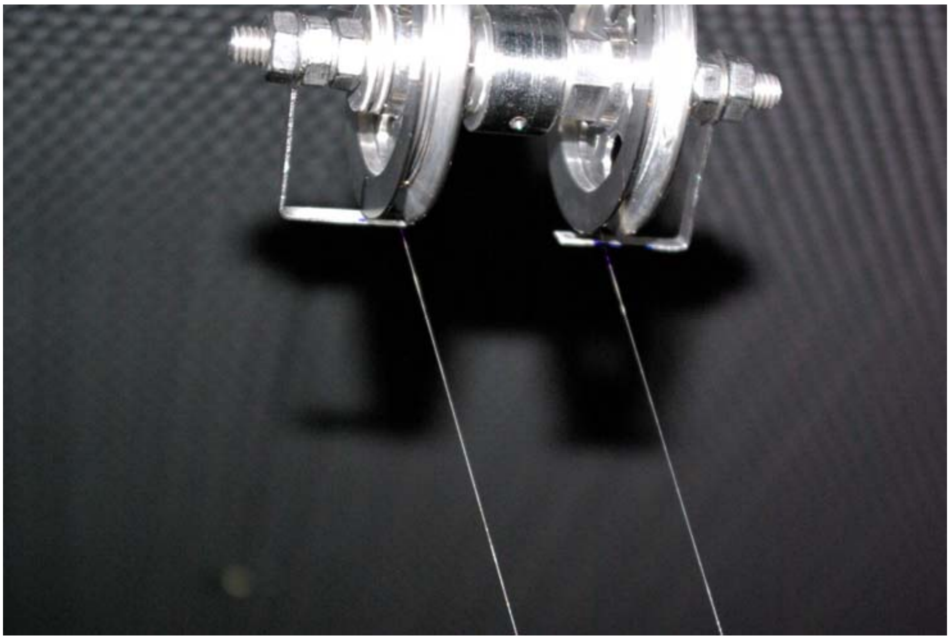

Figure 2 reference marker on the wires (further substituted by aluminium tape)

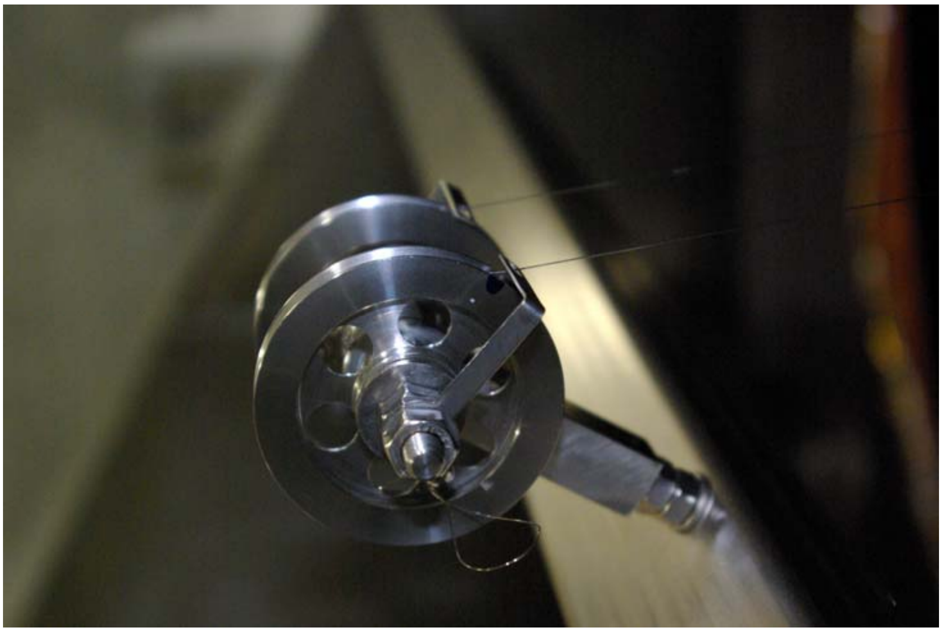

Figure 3 pulley on the focal beam direction (X_CSL axis)

Figure 4 knot on the terminal of wire joining it to pulley by screw.

3.4 Analysis of measurements

Results from measurements have been used to construct a simple CAD model : it has been projected on the CATIA model of the focal 5 provided by CSL. This was done as check to verify that angles and wire lengths measured were compatible with the design of the chamber and with the position of the SKL.
From table 1 it appears that just wires belonging to three pulleys suffered unrolling . These belong to pulley 1, 2, 5
The new point (P') comes from the intersection of the three spheres centred in the pulleys 1, 2, 5 (Figure 7) . It means that , looking the focal 5 facility from the beam direction, it is compatible with a SKL displacement in directions top >> bottom and left >> right. .
Just for one pulley (n°1) the two wires measured very different values (a few mm against more than hundred millimetres) . However, for both pulleys belonging to device (n° 1) the rotation angles are consistent and in agreement with the smaller unrolling It is hence supposed that some failure in the knot attached to the screw occurred.
The P' so found is about 8.2 mm far from the P point in warm conditions.
What is interesting is the projection of this vector on two reference systems :

CSL axis reference system

ORDP axis system.

We passed from one to the other using the 2 rotation matrix provided by Thales (RD 4)
In order to allow a double check from Thales people here are reported both results, in CSL and 0RDP coordinates.

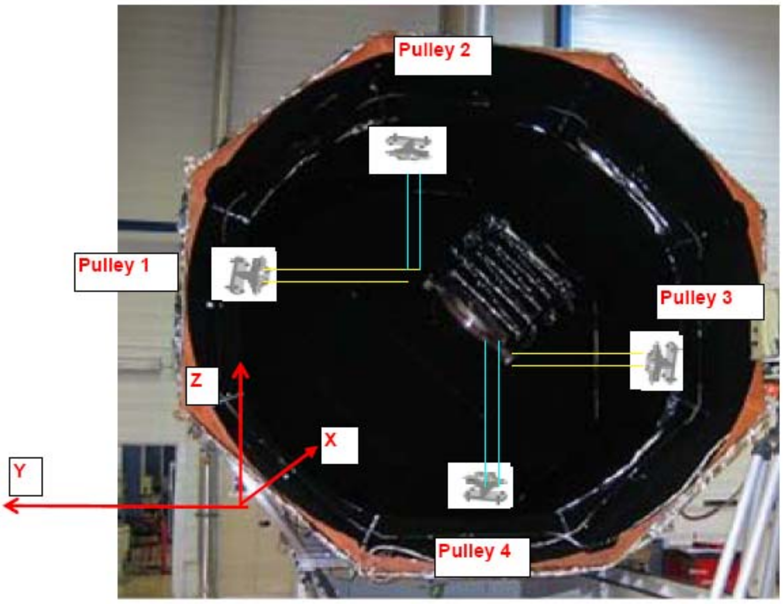

Figure 5 reference system from CSL document

Pulley	Lenght L [mm]		angle in the XZ plan [°]		angle in the XY plan [°]		height H [mm]
	laser measurement	LFI/CSL measurement	laser measurement	LFI/CSL measurement	laser measurement	LFI/CSL measurement	LFI/CSL measurement
pulley 1	/	(-X wire/+X wire) 1850/1840	/	9,5	/	8	88,5
pulley 3	1991,9	1885/1880	7,99	10	6,64	7	90

Pulley	Lenght L [mm]		angle in the XZ plan [°]		angle in the YZ plan [°]		height H [mm]
	laser measurement	LFI/CSL measurement	laser measurement	LFI/CSL measurement	laser measurement	LFI/CSL measurement	LFI/CSL measurement
pulley 2	1852,62	(-Y wire/+Y wire) 1740/1750	5,82	6,5	11,87	14	87,7
pulley 4	/	1980	/	5	/	9,5	94

Pulley	Lenght L [mm]		angle in the XZ plan [°]		angle in the XY plan [°]		height H [mm]
	laser measurement	LFI/CSL measurement	laser measurement	LFI/CSL measurement	laser measurement	LFI/CSL measurement	LFI/CSL measurement
pulley 5	2431,08	2270	7,01		0,54		

Pulley Position	P1(n°1)	P2(n°5)	P3(n°2)	P4(n°3)	P5(n°6)
1st wire elongation (mm)	6,05	4,7	0 (non measurable)	0 (non measurable)	6,38
2nd wire elongation (mm)	124,5 (?)	4,2	0 (non measurable)	0 (non measurable)	5,25

Table 1 results from length and angle measurements at warm (1st step) before BT and after BT (2nd step)

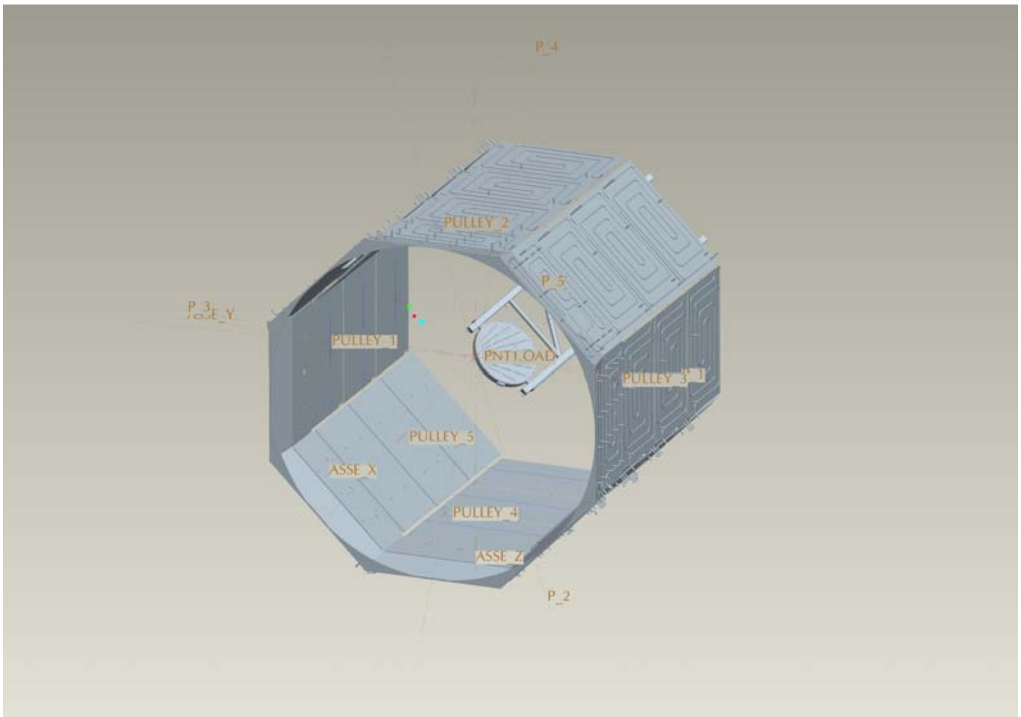

Figure 6 position of pulleys from CSL measurements when projected on the CATIA model

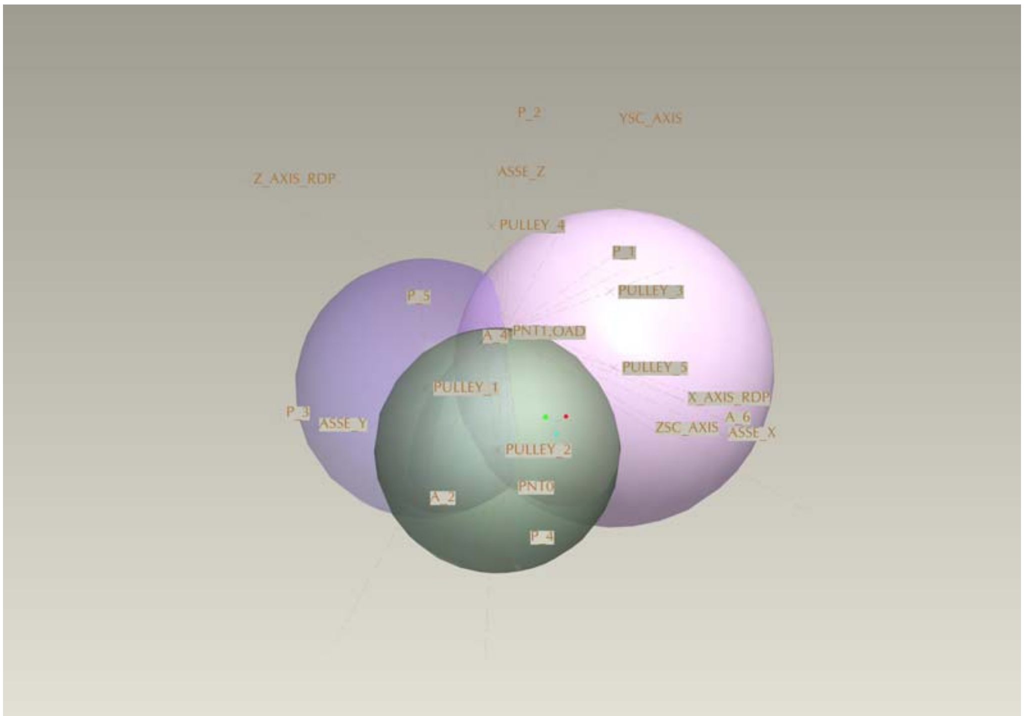

Figure 7 intersection of the three spheres determining the new point P' (displacement of point P at cryo)

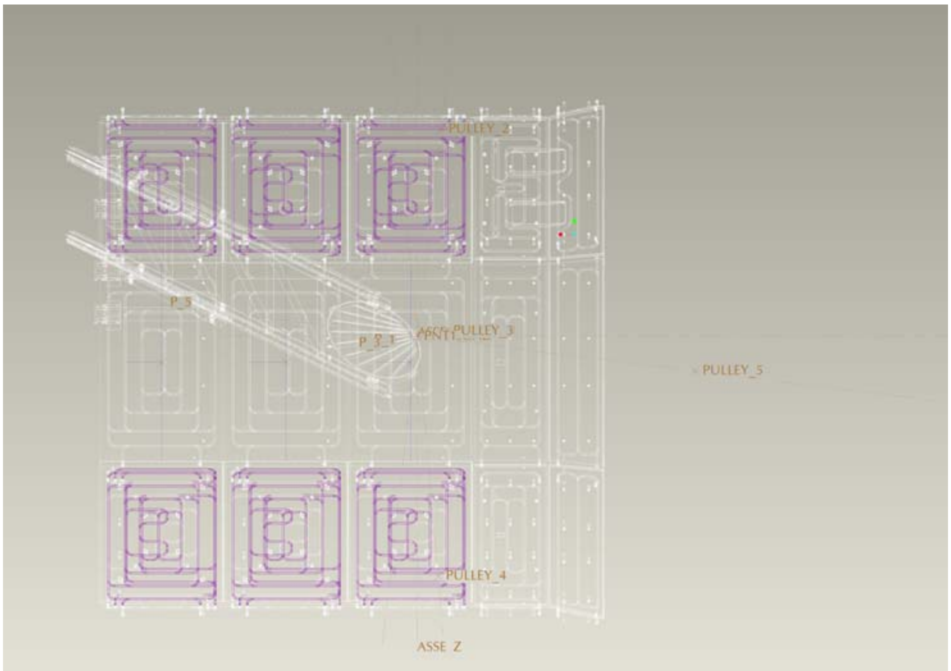

Figure 8

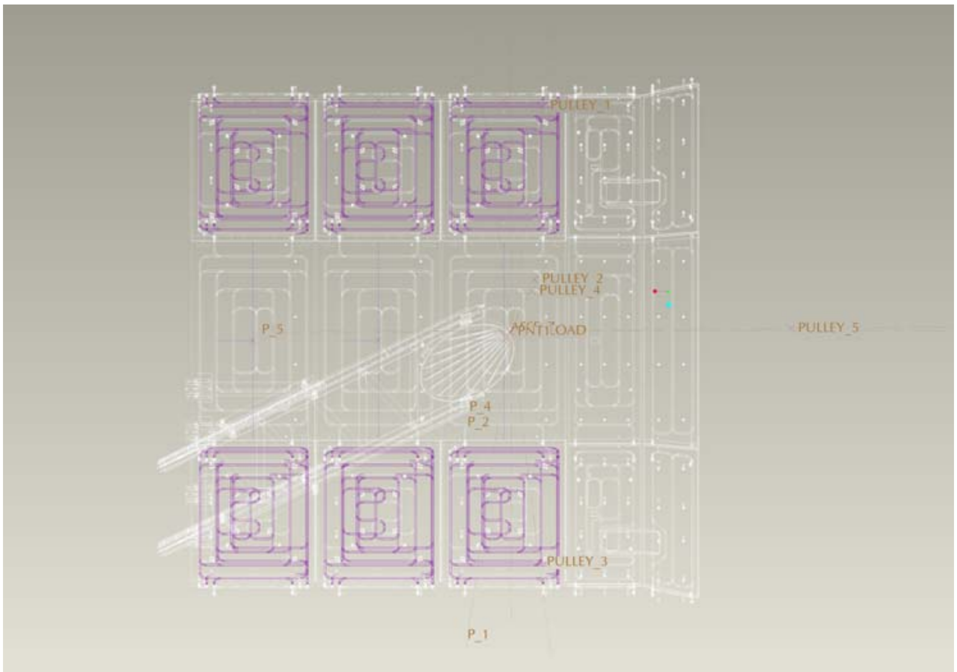

Figure 9

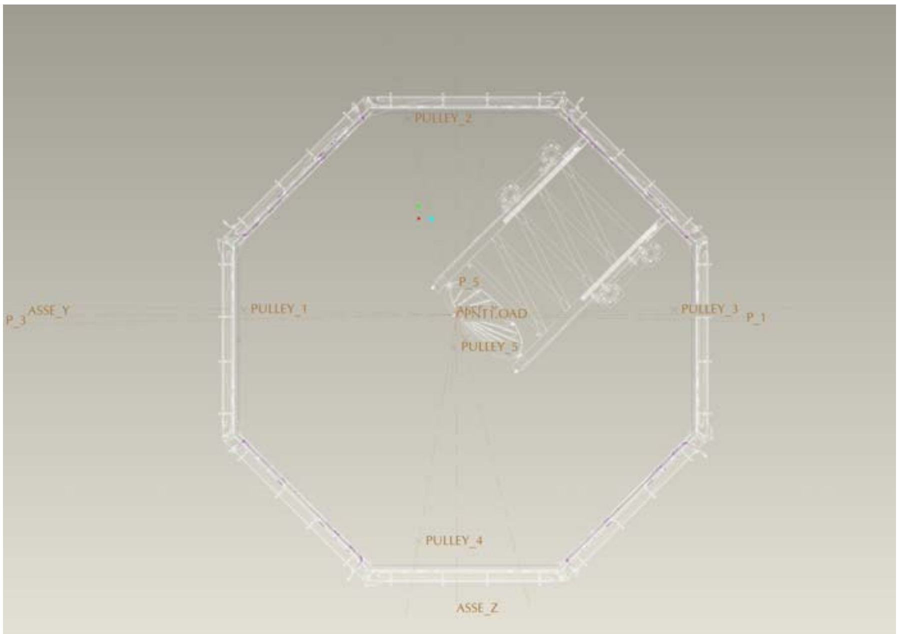

Figure 10

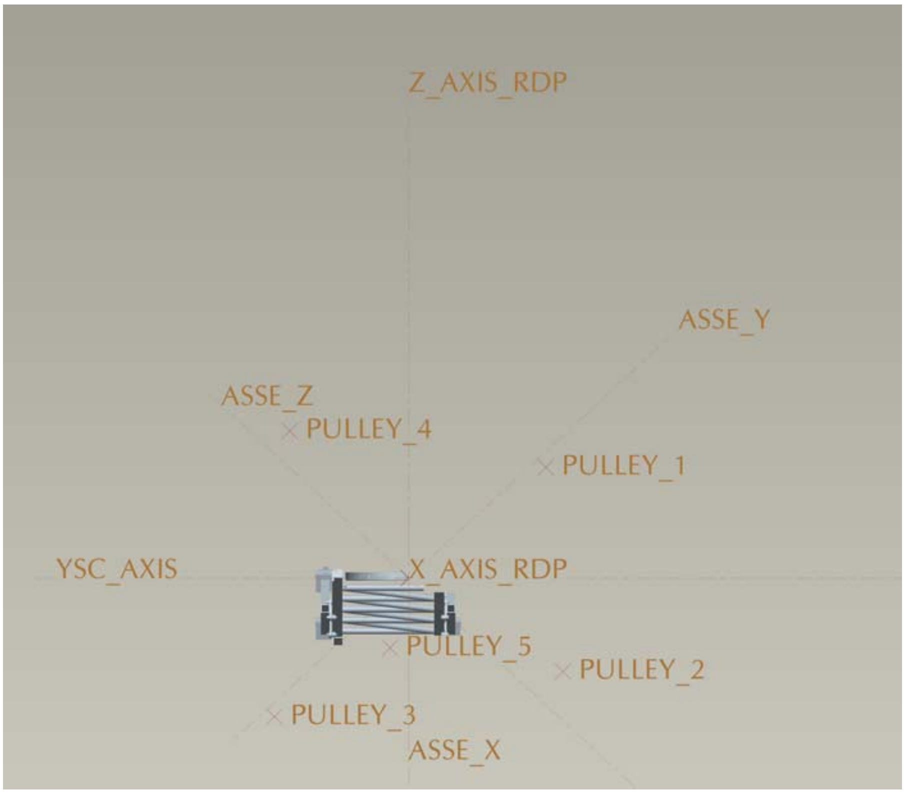

Figure 11

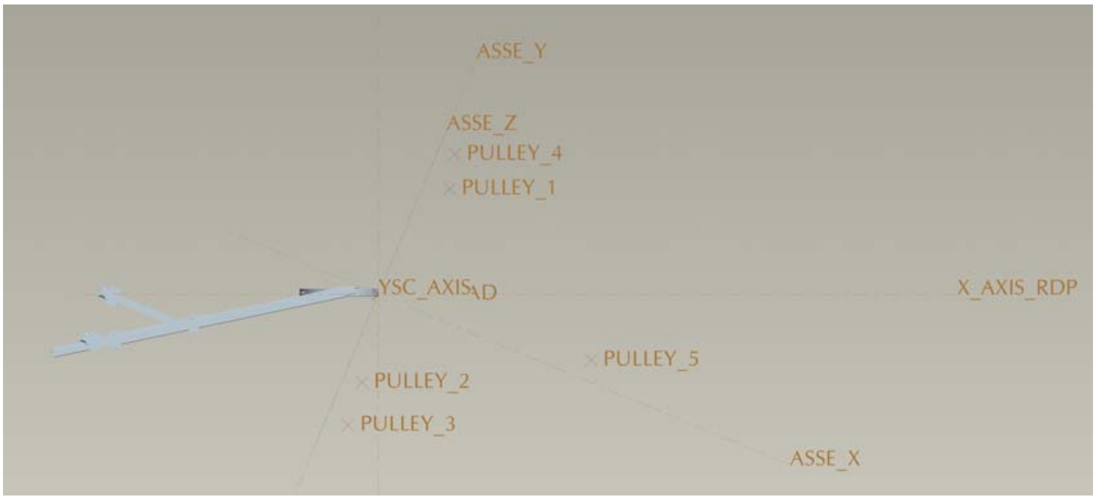

Figure 12

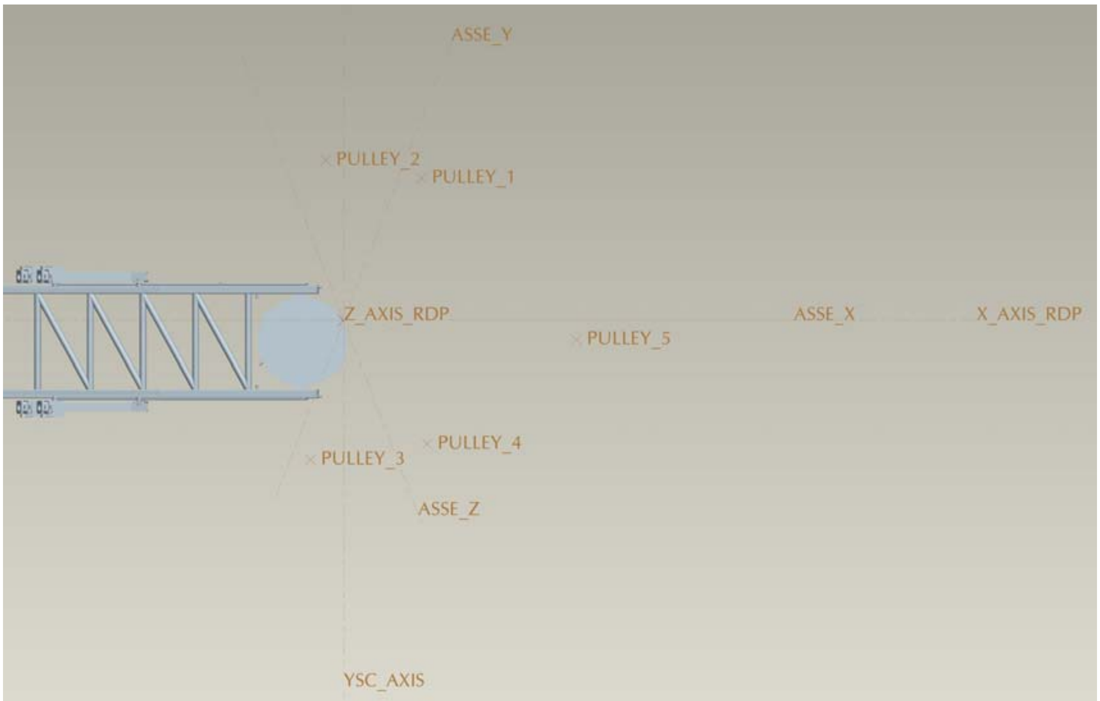

Figure 13

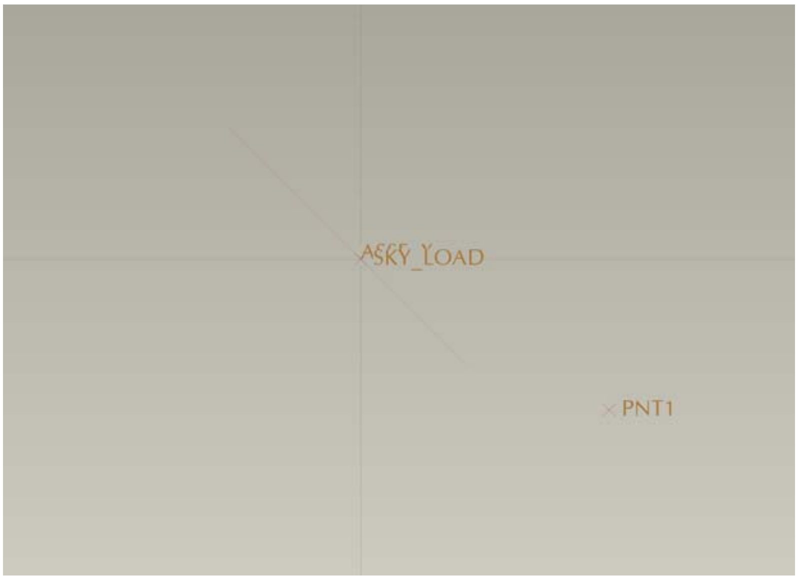

Figure 14 new position (after dieplacement at cryo) of point P' (PNT1) w.r. to its previous one (X SKY_LOAD) when seen from pulley 5 .

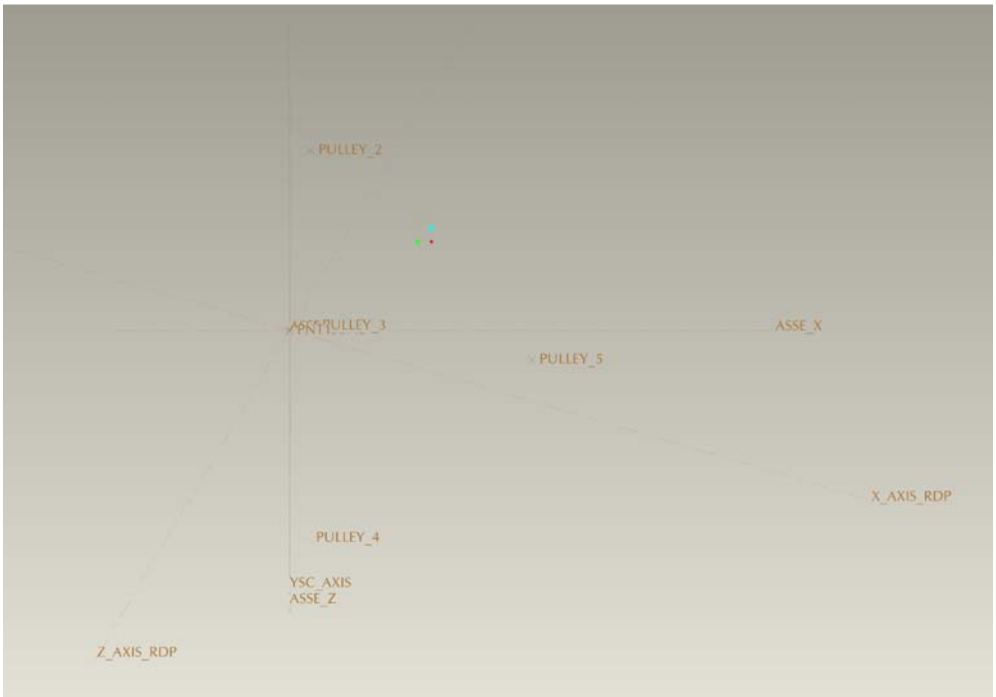

Figure 15 reference system positions: RDP system w.r.t CSL system. (when seen from laterl side left of focal 5)

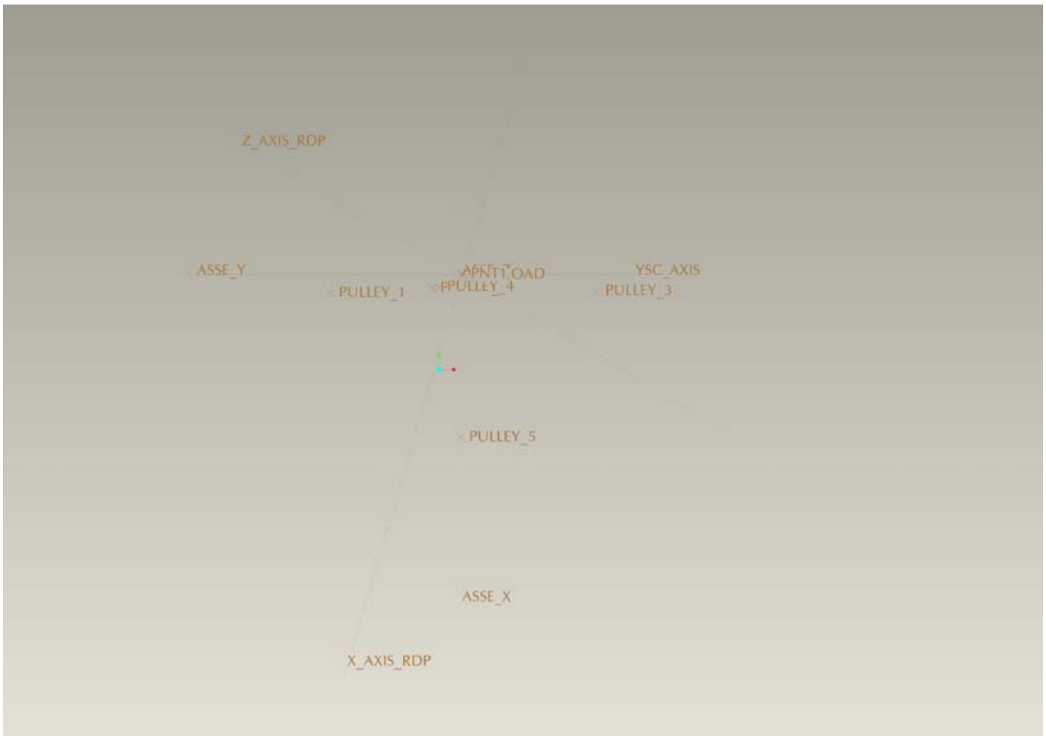

Figure 16 reference system positions: RDP system w.r.t CSL system. (when seen from top side of focal 5)

3.5 Results

Results from projection of the displacement vector on CSL and 0RDP reference systems are reported in the table below.

REF SYSTEM	X mm	Y mm	Z mm
CSL SYSTEM	6.33	- 4.46	- 2.71
ORDP SYSTEM	6.32	- 5.07	- 1.28

Figure 17 results from displacement projection onto CSL and ORDP axis

The uncertainty related with measurements can be estimated in +/- 2 mm for each component: this number comes out as worst case (double) of the length uncertainty of the wires measured in IASF LABs using the optical bench (it was +/-1 mm) .
Obviously it does not take into account possible systematics introduced when mounting the devices: in any cases, these should have been taken into account, at least roughly, using the redundancy of wires.

3.6 Comparison with FEM model from AMOS

Given the many versions of documents circulated the last Summer 2007 concerning the extimation of possible displacements using FEM models, this numerical comparison is left empty and demanded, at least for this draft version of the document, to people having under control the updates of this documentation.
We guess here just a qualitative comparison using data in our hands from RD 4, where the following table is taken from. The reference system for comparison is here the CSL reference system. Apart for a 2 mm difference in the Y component estimation, results from measurements and simulations seem to be in very good agreement.

Optical shield centre displacements in cold conditions		
X	Y	Z
6,31 mm	-2,95 mm	3,00 mm

Table 2 results from AMOS simulation (to be checked with last updated numbers)

4 CONCLUSIONS

Measurements have been successfully done giving final results that look believable because of the method used and the redundancy of units mounted inside the focal 5 (pulley devices) .
These measurements were supposed to be a rough method to verify the validity of the FEM model implemented by AMOS , since it was never tested before.
Results, also within uncertainties related with the method used, show a good agreement with the model and hence a small displacement of the SKL (also within the LFI and HFI requirements) w.r.t. its nominal warm position.
A double check is here expected from TAS people to verify the correctness of numbers coming from AMOS model here used for the comparison.