# Installing the superinsulation blanket on NOTCam
# Description and recommendations

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**Forewords**

The aim of this report is to provide all the NOTCam people with a description of the insulation blanket that has been used and how this has been done. It will give more indications than what one can guess 'from the outside', i.e. when looking at NOTCam opened. This description, as well as some recommendations of use, is to be taken as general information, but may be of help in case a part of the blanket is damaged and has to be replaced.

**Introduction**

The superinsulation blanket used for NOTCam is made of 15 layers of 5 µm thick aluminised Mylar film, the layers being separated by a net of Nylon (Mylar is a polyester film from DuPont [1]). This type of blanket, which was purchased from a french company called Jéhier [2], is usually employed for space applications. It has been decided that 2 blankets, representing 30 layers, will be used to wrap the cold table and the protection shield.

So one will find in this paper a description of the installation of the superinsulation blanket on the two preceding items, as well as on the light rejection system. Some recommendations of use will follow, in case one wants to refine the insulation or if a part of it has to be replaced because of an important damage. Finally, i have included on the last pages some pictures of the process.

**Description**

Be it for high fashion or for NOTCam, the installation of a material on a given volume requires the following steps :

- drawing and designing the pattern
- tying the pattern and the material together
- cutting the material following the pattern
- installing the material on the volume

These steps have been followed for the components of NOTCam that needed an insulation (cold table and struts, protection shield, light rejection system), sometimes with different techniques.

<u>1) Cold table</u>

This item is the biggest one that requires insulation, and so it is the one i spent most of my time with.

For a better understanding, let's point out that during the installation of the insulation blanket the cold table is upside down compared to its usual position in NOTCam. I then called the side with the two LN2 filling tubes the 'front', the opposite one the 'back', and the remaining two the 'sides'.

*drawing and designing the pattern*

The pattern was drawn on the 1x1 m brown kraft paper that was delivered on top of each 1x1 m insulation blankets (picture 1). The measurements were taken directly from the cold table. The basic volume is a quite simple, but i had to pay attention to some tricky elements such as the holes for the struts. The drawings of NOTCam i got from Niels were not so helpful to find their precise location on the cold table as they don't show a lot of measurements. I found it quicker to mount the struts on the cold table, draw their outline with a pencil and take measurements from the pencil lines, that of course i removed afterwards.

The blanket has been designed in such a way that once it has been cut, the sides of the cold table are of two kinds :

- a-type : the blanket covers the side of the LN2 tank completely, all is needed here is to tape the blanket on it
- b-type : on these sides each layer of the blanket needs to be folded three times (see picture 2) :
  once from the "top" and twice from the "sides".

Even though the "sides" could have simply been cut or folded once with the "top" coming on them, Anton and i chosed to do things differently. In order to have a better insulation, we prefered to fold it layer by layer : the first layer from the side comes first, then the first layer from the top (these layers are actually different parts of the first layer of the blanket), then repeating it folding the second layer from the side and the second layer from the top, etc... That way each layer of the blanket is in contact with "itself" and the layers that come before and after it, i.e. the ones with almost the same temperatures (the inner the layer the colder).

*tying the pattern*

The following step was to tie the pattern and the 15 double layers together. The point is that the pattern must remain tight with the blanket during the cutting, and afterwards the 15 layers must stay as one blanket and not be able to move separately. The solution we found was to use sewing needles : each one will cross the blanket several time in an extra area that is not needed for the covering of the cold table and will be removed when the blanket is completely installed. But while wandering downtown to find some something else caught my attention and i finally purchased a Mikado box. The 41 wooden sticks the box contains are just perfect for the job, and much less expensive than needles (needles would have cost about 200 DKK, the Mikado box is just 10 DKK). Each stick is 18 cm long, so you can have 3 or 4 on each side of the blanket. There are flexible enough to be installed easily and of course they are stiff so they hold the layers together well.

As can be seen on pictures 1, i first put a sticker to strenghten the paper pattern in each place the Mikado sticks were going through, and then made a small slit with the cutter.

*cutting the blanket*

To cut the layers following the pattern i only used scissors, the cutter is not suited at all for large clips. It can only be used for small apertures, like the struts holes, or to start cutting the PTR hole.

*installing the blanket*

This is the part that required the biggest amount of work.

The price to pay for the layer-by-layer insulation is a huge amount of time : on each b-type side one layer of the blanket has to be folded three times and taped 12 times, that makes it 90 folds and 360 pieces of tape (at least) for one blanket. In addition the layers have to be taped with the aluminium tape purchased with the blankets, but it is quite uneasy to cut it directly from the roll. What i used to do is to "tape the tape" on a previously cleaned part of a table, cut it with the cutter and finally untape it and put it on the layers. The drawback of this method is that the tape is not directly transfered from the roll to the layer. On the other hand it is the only solution i found to have pieces of tapes of precise dimensions, and as far as the tape does not remain long on the table it has not enough time to really stick to it and keeps its properties when it is removed.

Therefore, given the time it takes, the installation of the blanket requires a lot a patience and perseverance. It also demands a great bunch of nerve control and calm as you can get quickly upset : the aluminiun layer is very fragile, prone to brake if any extra tension is applied to it, and the Nylon net is elastic so it is never get cut you want it to be. In addition you have to be careful, especially when working on the front of the cold table, of not touching the LN2 tubes that can be bent easily.
Anyway i gained experience from the 4 days spent on the first layer (picture 3) and could install the second one in only 2 days (after trying to see how the second blanket could be affected by the thickness of the first one, i just decided to keep the same dimensions for it and that did well). Then the layers have been fold another time, so that they don't show apparent edges as Peter Hasting suggested in one of his mails [3]. As one can see on picture 4 the blanket is larger than the cold table itself, as it will ultimately be fold perpendicularly to come on the protection shield.
The first layer had its b-type side on the front of the cold table (picture 2), the second one on the side. The same thing was applied to the PTR hole : the 8-branch star pattern used to cut the blanket for the hole has been rotated so that the triangles made that way cover most of the intern anodised surface (picture 5).
For the struts holes, it was possible to cut the blanket in 4 triangles on the a-type sides and fold them (so no tape is visible), but i had to cut them completely on the b-type sides and cover the edges with tape. This is what can be seen on picture 6 for the bottom layer, while the upper one only shows aluminium Mylar.
The design of the blanket wrapped around the struts (only one blanket) is copyright to Anton, who also made the installation (picture 7). Once screwed on the cold table, they fit very well and no anodised surface can be seen (picture 8 and 9).
At last, the layers are fold perpendicularly so they can cover the blankets of the protection shield and the cold table is mounted in NOTCam (picture 10 and 14). As the corners are quite thick due to several folds an electric wire (same as any motor wire) is put all around to make it a bit more tight. This prevent problems when closing NOTCam, where the top of the vessel comes close to the insulation when going down.

<u>2) protection shield</u>

The 2 blankets were delivered pre-cut so they just had to be installed and taped. Two apertures have been made on the side to allow the wires (temperature sensor and motor wires) to go through the blankets of the protection shield; the same thing has been done for the cold table (picture 11, 12 and 13). The apertures have been covered by tape at a later stage to have a minimum anodised surface visible from the outside.

<u>3) light rejection system (LRS)</u>

The light rejection system is basically a cylinder (pic 15), the idea here was to cut a "jacket" that would come and covers the anodised circular plate.
The best way to invesigate how the pattern should look like was to try a paper pattern (pic 16). The insulation blanket was then pinned through the pattern to a wooden plank (pic 17). This was quicker than the Mikado solution, which better suit larger surfaces. The blanket was cut (pic 18) and wrapped around the LRS.
It is just at this moment that i realized that :
a) i did not take into account the thickness of the 15 layers the way i should, as only 3 of the holes were matching the screws
b) we do not need to see the screws from the outiside, and thus the pattern can be done in a much simpler way.
So i tried a blanket sample (from what was left from the cold table), and design a new jacket which was 2 cm longer. It fitted perfectly the LRS (pic 19), which was mounted on the protection shield; almost no anodised surface could then be seen (pic 20).

**Recommendations**

NOTCam is not supposed to be opened more than 2-3 times a year and the cold table should theoretically stay mounted all the time, so hopefully the first part of these recommendations will not be very useful. However, if someone has to use insulation again or in case an important damage happens to NOTCam, the advices i have summed up in the following section may be of help.
The second part is particularly dedicated to the NOT staff that will perfom the installation of optics and detector, the calibration and alignements in La Palma as it concerns the installation and removal of the cold table and the protection shield.

1) dealing with the superinsulation blanket
Some of the following advices may seem really obvious, but sometimes it's good to have them in mind.

*drawing and designing the pattern*
This is the most important phase, so it is not wasted time to think a lot of what will be done. Paper patterns are always useful to investigate the shape the blanket will have, several are sometimes needed to chose among different possibilities (it was the case for the corners of the cold table).

*tying the pattern and the blanket*
The Mikados sticks turned out to be excellent to tie the pattern of the cold table on the blankets, also because it was possible to have them in an area of the blanket that would have been cut anyway (no extra effort to include them).
For smaller part, like the light rejection system, pins were sufficient.
Clamps have also been used, even though they better suit the folding a long edges of blanket.
And last Peter Hasting suggested the use of H-shaped nylon tags; some are already installed on the blankets upon delivery.

*cutting the blanket*
Let's just repeat that cissors are more recommended for long distance, and a cutter for slits.
Keeping the blanket tense will undeniably ease the cutting, especially the nylon net.
It can be useful to keep large piece of blanket that remains after the cutting. For example some of the blanket left from the insulation of the cold table has been used for the design of the LRS jacket.

*installing the blanket*
Here comes the big part, so first it must be remembered that the superinsulation blanket is very fragile, especially the 5 µm thick Mylar film. Hands must be completely dry, as the Mylar film is very prone to stick to wet ones.
In any case installing the blanket will demand time, patience and calm, so it is not necessary at all to try to do it quick. It's better to take time to do it, short breaks each 15/20 minutes help not to get upset.
To repair cracks and tears that WILL happens, use tape for the smallest ones and spare parts of Mylar film, saved from the cutting (see preceding chapter), for the largest ones. A big repaired crack can be seen on the front of the protection shield, above the circular aperture.
It is quite clever to use tools covered with aluminium tape during the installation (ruler, wooden planked to heighten the cold table or to pin the blanket, see picture 17) : it makes a friendly surface for the Mylar film and helps to prevent cracks.

2) installing the cold table and the protection shield

The first thing to do to install the cold table is to screw the struts on the bottom part of the vessel. Keeping them a bit loose, i.e. not screwing them to the maximum, will help to adjust their position on the cold table. Three persons are needed for this operation : two hold the cold table, one pushes/pulls the insulation blanket or the struts to have no blanket stuck between the table and the struts.

Extra attention should be paid to the LN2 filling tube when moving the table down.

Then, after the spectrograph has been mounted the protection shield has to be put on the cold table. One person could be sufficient but three seems to be a better number : one to move the shield down, and one person on each side to make sure that the wires (temperature sensor and motor wires) go in the apertures. If not they will be crush into the table and the shield and may brake. This seems particularly relevant for the temperature sensor wires, thin and fragile.

Then the electric wire used to tight the blanket has to be fasten around the cold table.

The last step are to close NOTCam with the top part of the vessel and to mount the light rejection system. The LRS blanket can be tighten with another electric wire, but it seems that this is not really necessary.

At the time writing NOTCam faces a new problem with the collar that does not fit, so it may turn that after all the LRS blanket won’t be used due to lack of space.

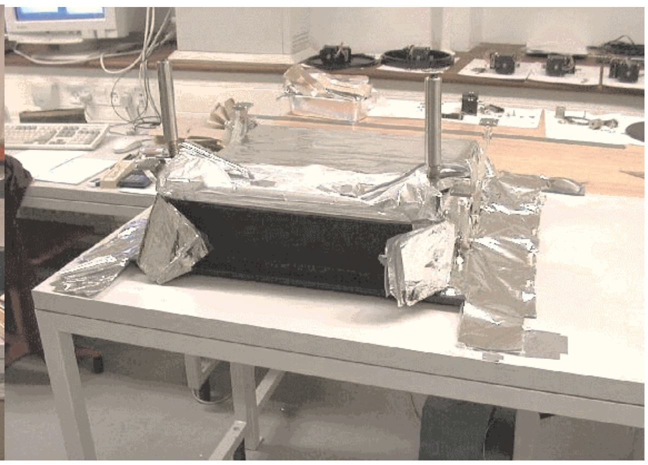
## Conclusion

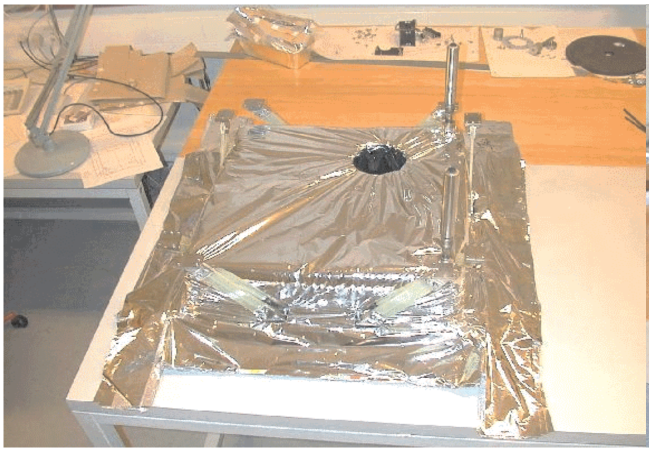
As a conclusion, i hope this report will help those who were wondering how the insulation blanket had been installed and that it will answer most of the questions they might have. Fortunately the insulation blanket will remained undamaged throughout the life of NOTCAm, but if ’something’ goes wrong one will find here some advices to repair it. And in the worst case if the insulation of the cold table has to be done again, let me wish good luck to the person who will do it, he will need it. If this happens, i believe the pattern i used and that should be delivered to La Palma with NOTCam will help to reduce the working time.

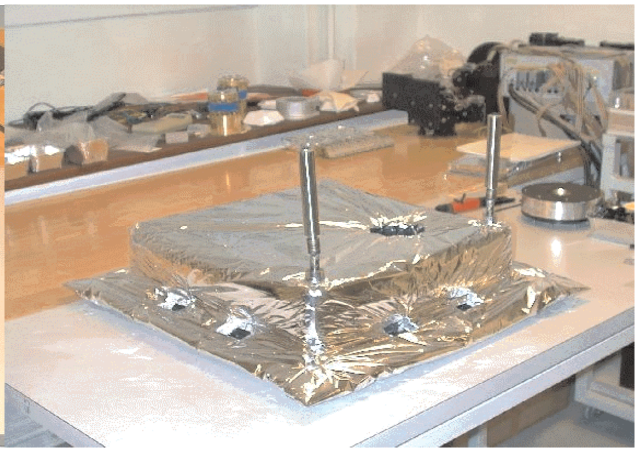
## Some pictures

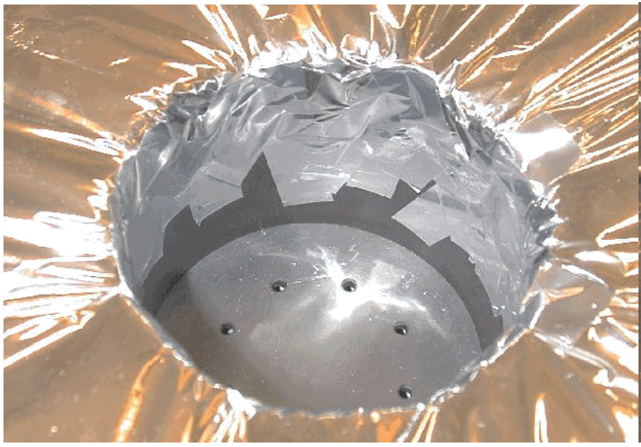
### Cold table


1) Kraft paper model with the Mikado sticks


2) First blanket before folding the layers


3) First blanket after folding the layers

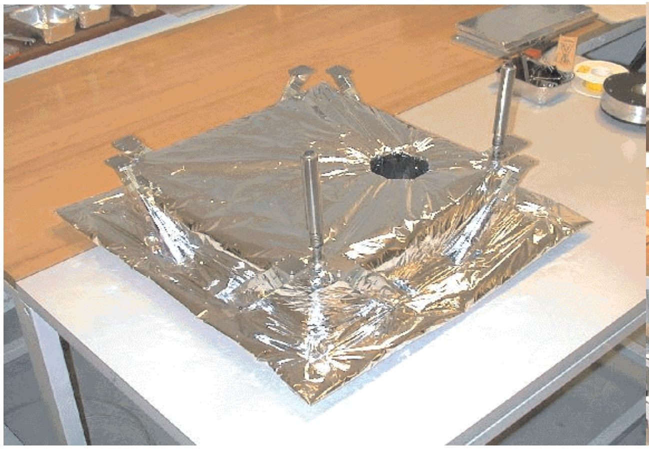

4) Cold table after installing the blankets; no struts

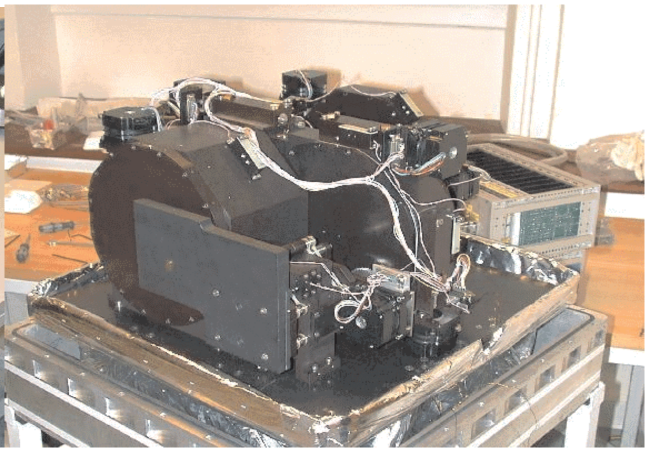

5) Hole for the PTR


6) Hole for a strut

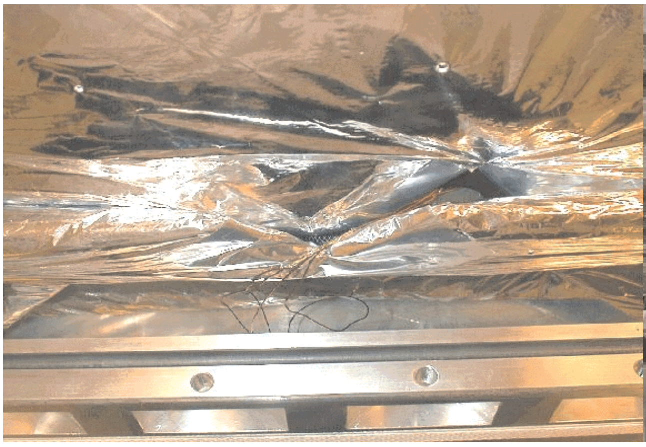

7) Struts with socks


8) Strut screwed on the cold table


9) Cold table with blankets and struts

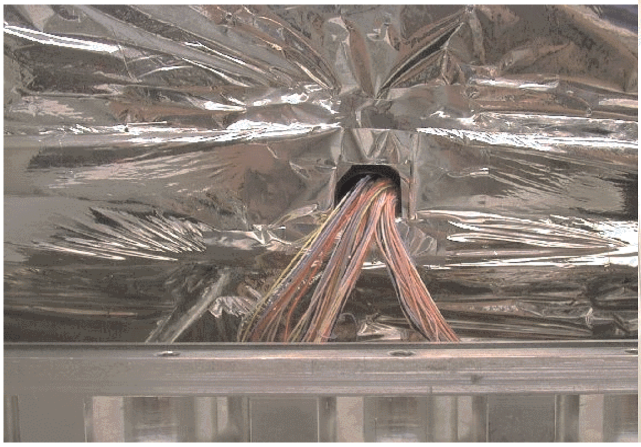

10) Cold table and spectrograph mounted

## Protection shield

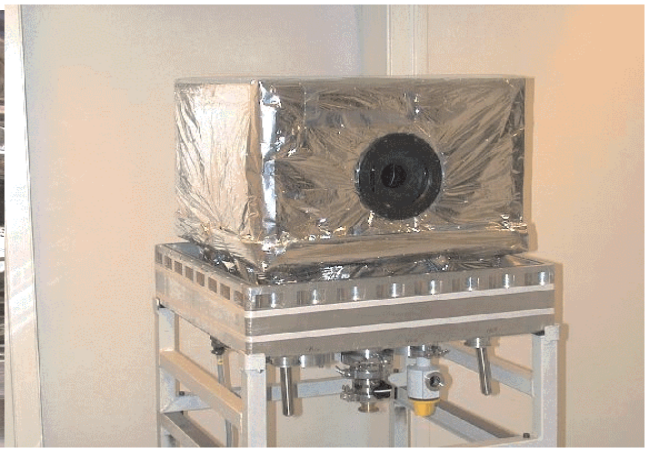


11) 12)

Apertures for temperature sensors wires : view from the top (11) and from the side (12).

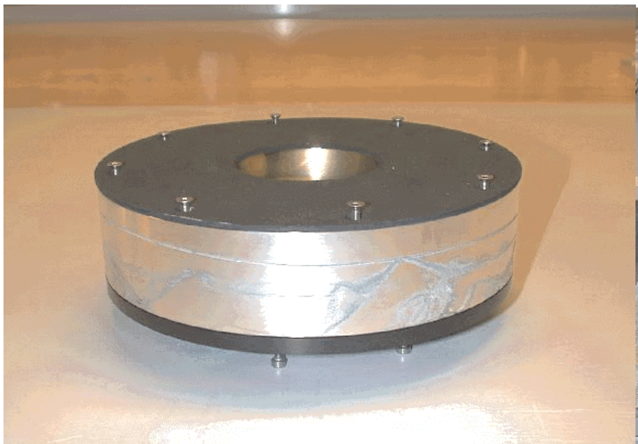


13) Aperture for motor wires

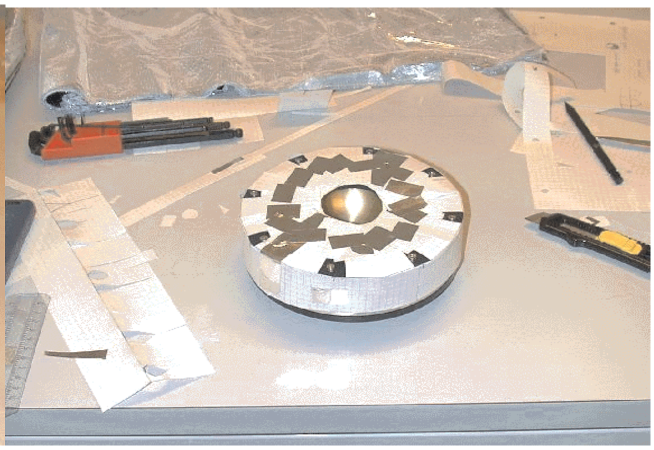


14) Protection shield on the cold table

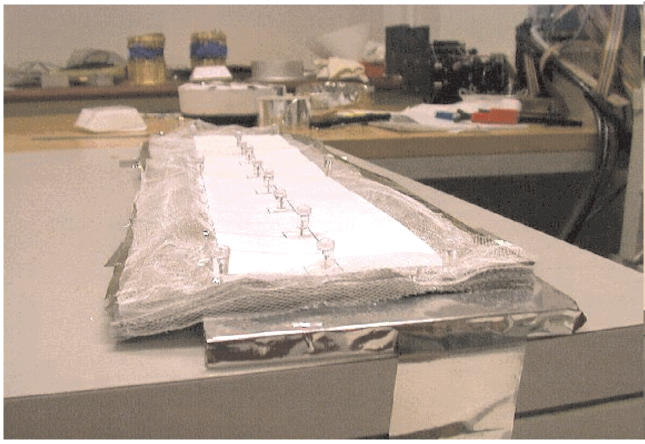
## Light rejection system (LRS)



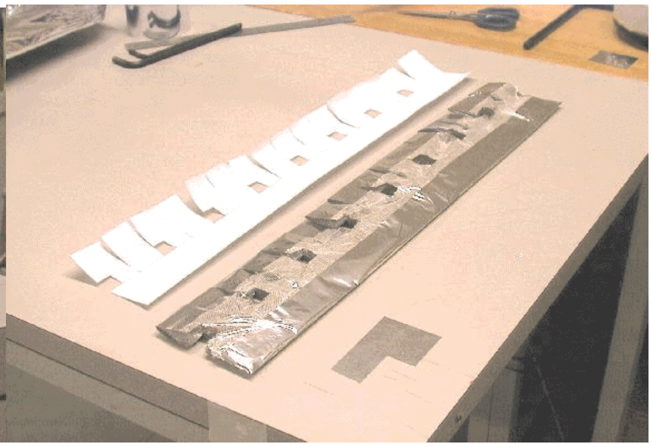
15) LRS



16) Paper model

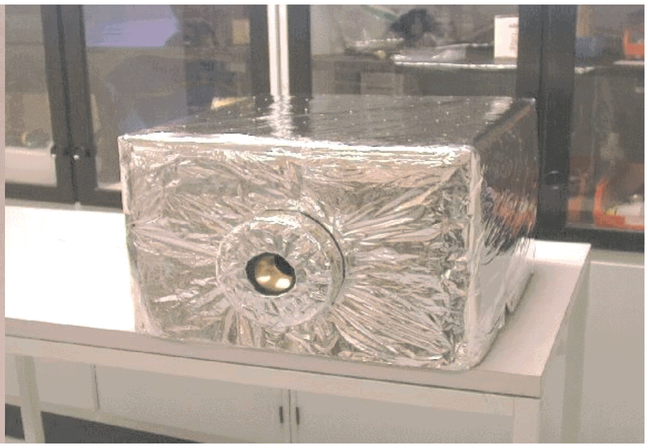


17) Before cutting jacket #1



18) After cutting jacket #1

19) Jacket #2



20) Protection shield and insulated LRS

## References

[1] Mylar :
http://www.dupont.com/polyester/products/mylar/index.html

[2] Jéhier
B.P. 29  F-49120 Chemille
tel   (33) 02 41 64 54 00
fax (33) 02-41-64-54-01

[3] Mail from Peter Hasting, ROE, forward by Colin Aspin on the 5th of January 1999 To Anton, Preben and Jens (Peter was answering to Colin).
This mail is reported on the following pages.

> We have a question about the super-insulation blanket for NOTCam. When I had it made at
> Jehier in la belle France I got one that covered the four sides of the rad shield plus the top but not
> the bottom under the LN2 tanks. I thought that was what we decided upon.

In which case I can't have made myself clear. All the external surfaces ofthe cold hardware need to be superinsulated.

> The people at Copenhagen are wondering if we should have one that covers the bottom of the
> LN2 tank (underneath) also ?

Dead right - it is essential to have as uninterrupted a coverage as possible. In this case it should not be too difficult since the whole instrument is cuboid so wrapping should be fairly easy.

> What would you suggest ? Is it important to minimize rad losses from there also ?

If it were _my_ instrument, I would make two major MLI (multi-layerinsulation) blankets. One would cover the LN2 tank and have many holes in it for the connectors, the truss legs, the Iwatani link etc. This blanket will be time-consuming to make and fit but it will not be disturbed thereafter.

The other blanket will be attached to the radiation shield and has one big hole where the baffle attaches. The collar which the baffle fits onto is designed to secure the blanket at that point and to ensure that the end of the blanket does not look out onto 300K but onto the collar at 65K. There is a similar fitting where the thermal link comes through into the LN2 tank.

**It is desirable that where the blanket is interrupted by a hole or a joint, the edge of the blanket (which has an effective emissivity of 1) looks at a low temperature rather than 300K. This can be achieved by using a collar (as at the baffle and the thermal link) for large holes and by turning a hem at the free edges of a joint.**

300K

________________

________) removeable blanket

________________________________ fixed blanket

70K

In this way the adjacent surfaces of the MLI are at 300K and the cut endsare looking in to 70K rather than out to 300K. It's a bit awkward to formthe inward tuck but it is necessary. The various layers can be secured by the little H-shaped nylon tags that hold the price ticket on your trousers. The layers of MLI should not be pressed together since this leads to thermal shorts. If the blanket is the same thickness as the same number of layers just lying on a flat surface under their own weight then that's OK. A polyester (curtain lining material) cover over the whole blanket keeps it clean and makes it easier to handle.

You'll also have to make socks for the truss legs since they have a significant area but again these will be a semi-permanent feature.

If all goes well than the effective emmisivity of the MLI jacket should be around 3% (i.e. a heat load of 13.7 watts per square metre). This can be checked by a LN2 boil-off measurement without the Iwatani(s) connected and with the hole for the thermal link capped by aluminised Mylar.

Where the wiring (or the legs) pass through the MLI blanket it’s a good idea to allow a longish overlap.

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300K
__________________________
    __________________) removeable blanket
================================================ wires
    -------------------------------------------------- fixed blanket
70K
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I hope all this is clear - if you need any more information just shout.

cheers and best wishes for a happy and succesful New Year to all the NOTCam team.

Peter
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