Planck-LFI
4K reference Load

TARGET DESIGN ANALYSIS AND TEST

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Introduction

The RF (Radio Frequency) characterisation of the Planck-LFI 4K reference load [10,11,13]is reported. It is a black body located in front of each reference horn of the LFI radiometers. The load is located 2 mm away from the horn mouth as a baseline distance. For its characterization we measure R.loss (ratio of the intensity radiation reflected by the load to the one reflected by a metal plate surface) and the Leakage (power reaching the radiometer's reference arm from sources external out to the load) [8,9].

We want to evaluate, by means of measures of R.loss and Leakage, the role carried out by the target's geometry and by materials utilized.
We measure the different RF responses when the target, starting from its complete configuration (Cfr Fig 2) is deprived of each one of its costituent elements.
It will be valued the weigh of the pyramidal geometry in the central area of the target: the pyramid will be substituted by a cone of height equal to that one of the pyramid having as base a circle inscribed in the squared base of the pyramid.
It will be checked also the dependance of R.loss and Leakage on the accuracy in machining the tip of the cone.
Variations of Rloss and Leakage with the material which the cones are made of (MF-110, MF-117, MF-124) will be verified.

For the purpose of the tests , two horns will be used: the EBBA@44GHz (with a choke) and the EBB@44GHz , whose dimensions (relative to the models in pictures 1 and 2) are reported in table-1 [12,14]

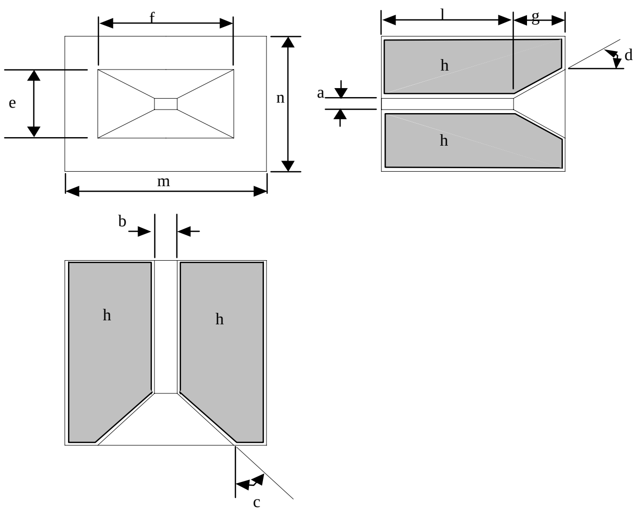


fig 1- Horn EBB @44Ghz

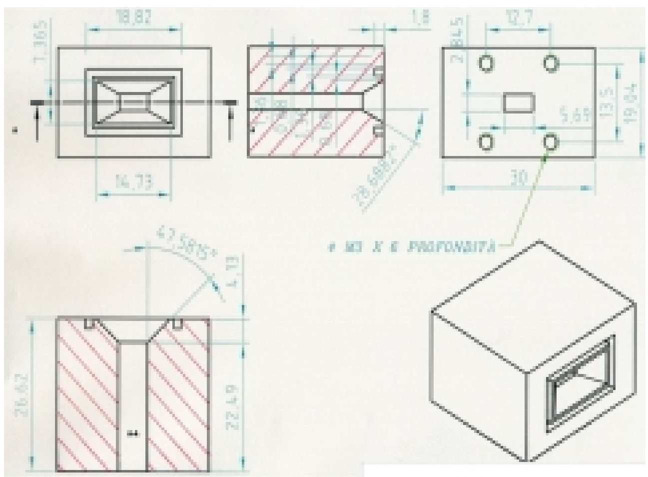


fig 2- Horn EBBA 44GHz

	A	B	c	D	e	f	G	M	n
EBB@44GHz	2.845	5.69	47.569	28.680	7.365	14.730	4.13	30	19.04

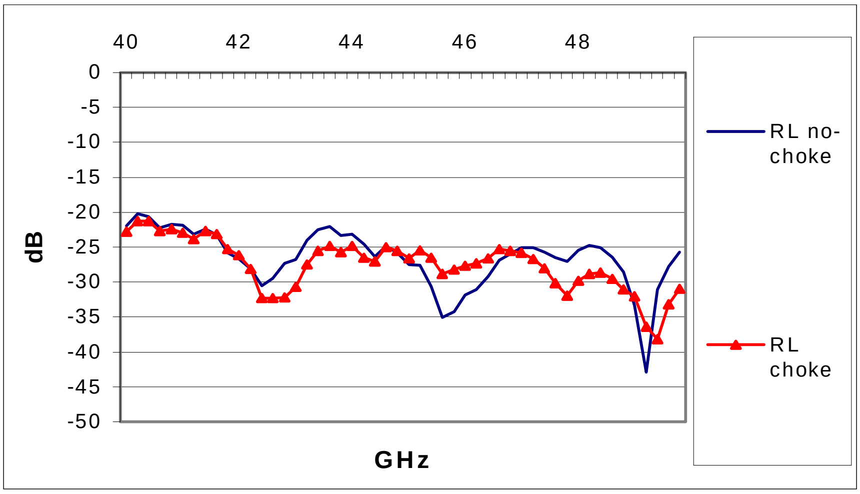
Tab 1- Measures for the EBB and EBBA horns (choke's measures are not considered)

Results are sensitive to large effects only. Small differences are mainly due to the measure set-up repeatability .

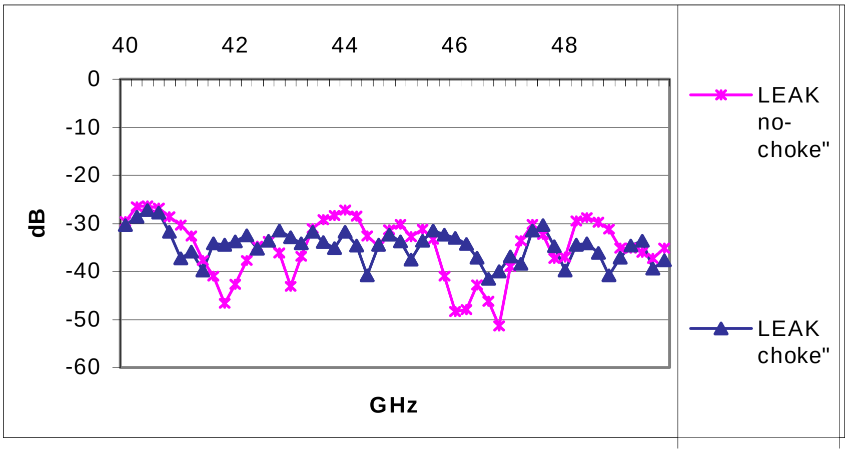
In the following graphic is represented the comparison between the two horn models, with and without choke, when matched to the same load. Measures have been taken matching the horns to a 'perfect load': it is made of a Eccosorb CV panel located in front of each horn at a distance of 50 cm from it and with an inclination forming an angle of 45 degree with the line of sight of the horn [9] (Fig. 1-bis).

All measures and instrumental calibrations has been performed inside a anechoic chamber [14] (mean attenuation of 40dB) as to reduce the R.loss and Leakage contributes due to the surrounding environment.

Graphs H- Comparison between the two horn models, with and without choke



Graph H-a R.Loss



Graph. H-b Leakage

The horn performances are similar within measurement accuracy.

The scheme of the target in its start configuration is the one in the figure 2. It is composed by a back part, made of Eccosorb CR117, a central pyramid made of Eccosorb CR110 (techn. bulletin n°1-210), a ring (cross) made of CR110 too.

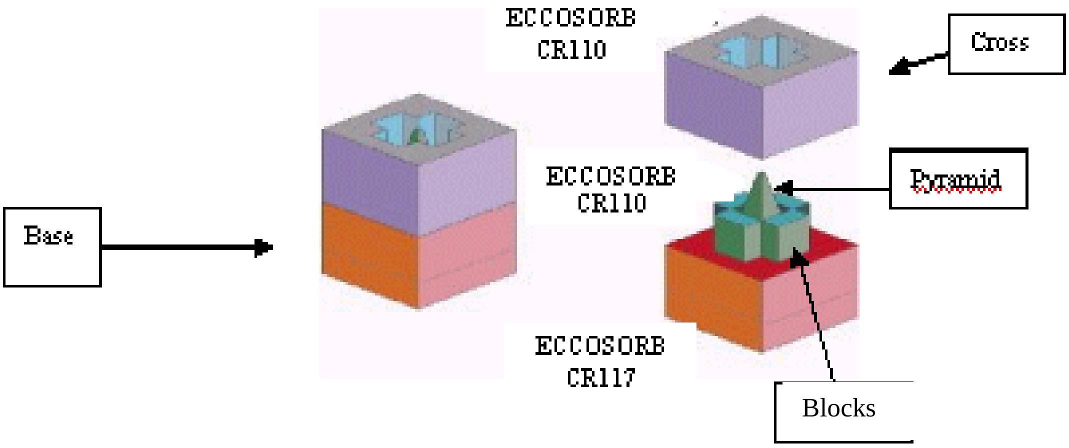
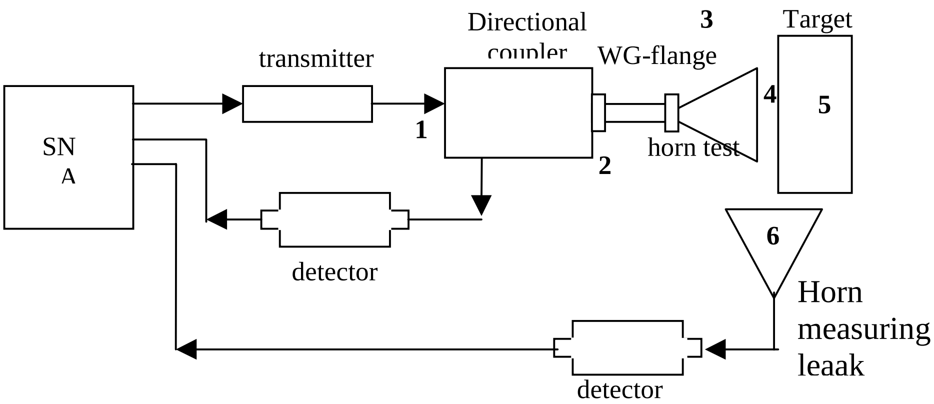


Fig 2: start configuration of the target

Experimental setup

Data have been acquired by means of a RF circuit assembled like the scheme in fig 3-. A scalar analyzer has been employed. Data has been taken in anechoich chamber.

Fig. 3- RF circuit assemby



Measures have been taken at the Temperature of 300K and at the distance of 2mm calculated from the horn’s mouth to the target’s front.

Measures

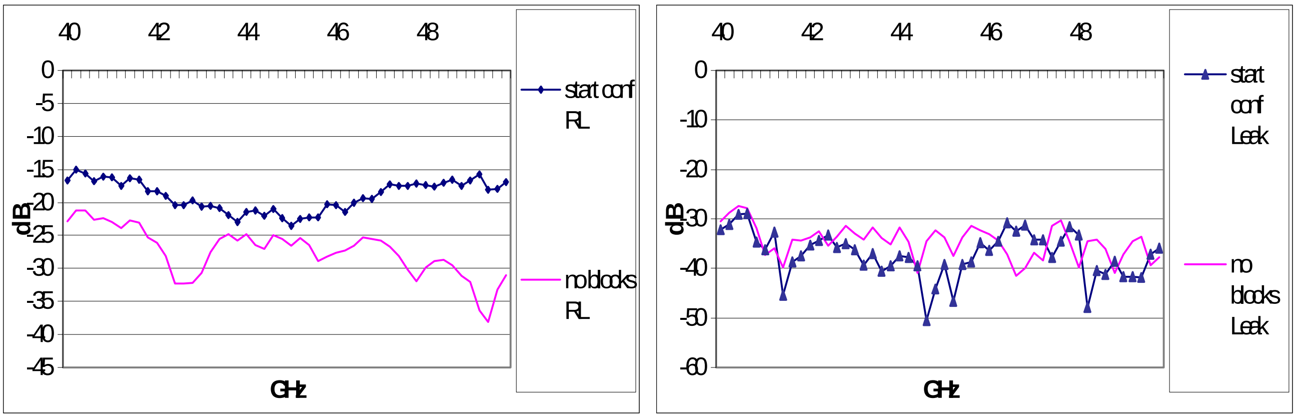
We compare with the “start-assembly” the following configurations:

- target without blocks (conf 1)
- target without CR117 base (conf 2)
- target without pyramid (conf 3)
- target without cross (conf 4)
- target without pyramid and without cross. The base alone has been put in the Al box (conf 5)

CONFIG.	BASE	CROSS	PYRAMID	BLOCKS
0 start	✔	✔	✔	✔
1 no blocks	✔	✔	✔	
2 without base		✔	✔	
3 alone base	✔			
4 without cross	✔		✔	
5 without pyramid	✔	✔		

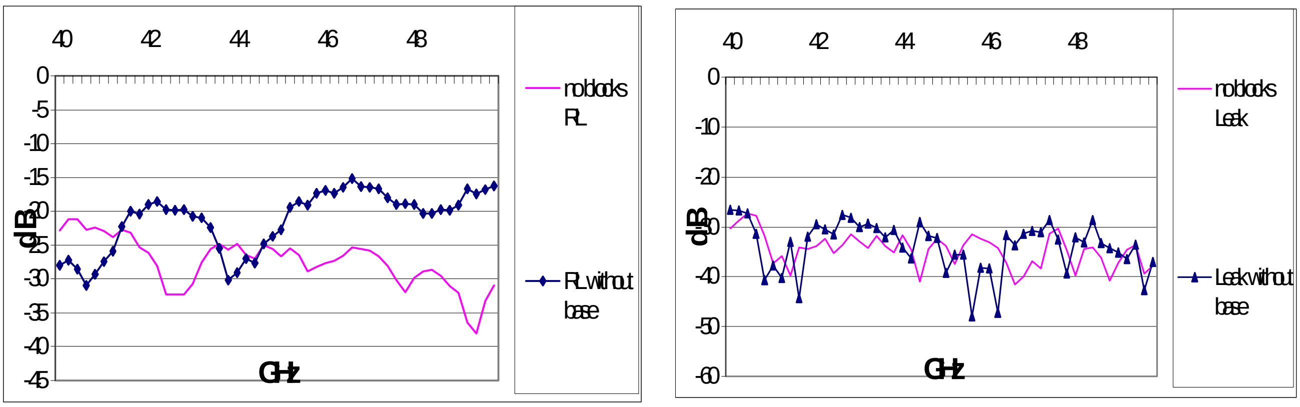
Configuration 1

graph 1-comparation between initial configuration 0) (triangle) and without blocks configuration (-) 1)



The R.loss of Conf-1 is lower than the initial Conf –0 and the leakage is comparable. From now on, we’ll compare others configurations with the ‘no-blocks’ configuration

Configuration 2

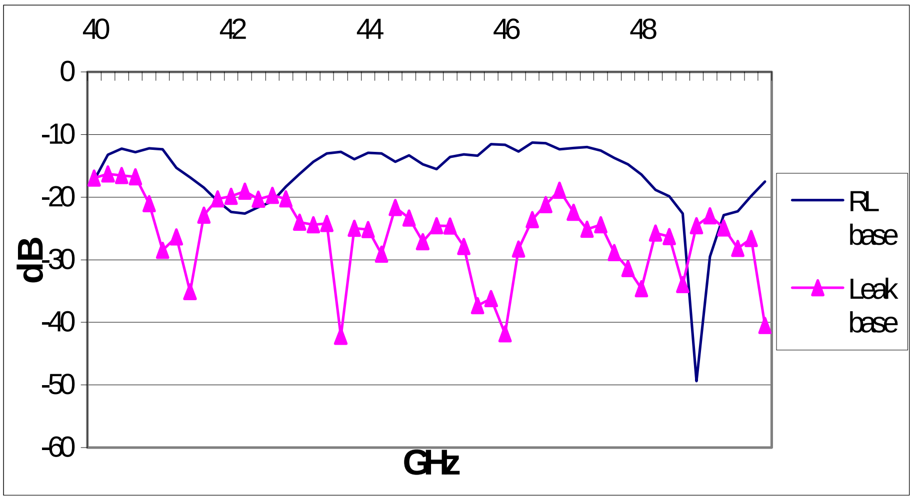


Graph 2- comparison between no-blocks configuration (-) and without base conf (triangle).

As it was foreseeable, the Leakage is almost independent on the presence of the base.

Configuration 3

We can evaluate also the contribute offered to the absorption by the presence of only the CR117 base (Conf.-3)placed into the Aluminium box.

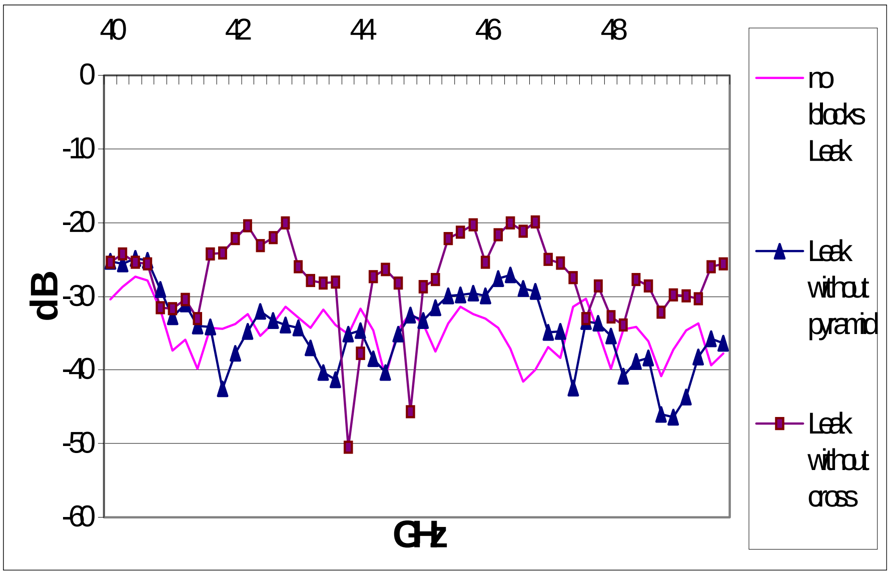


Graph 3- R.loss and Leakage of the "only base" configuration

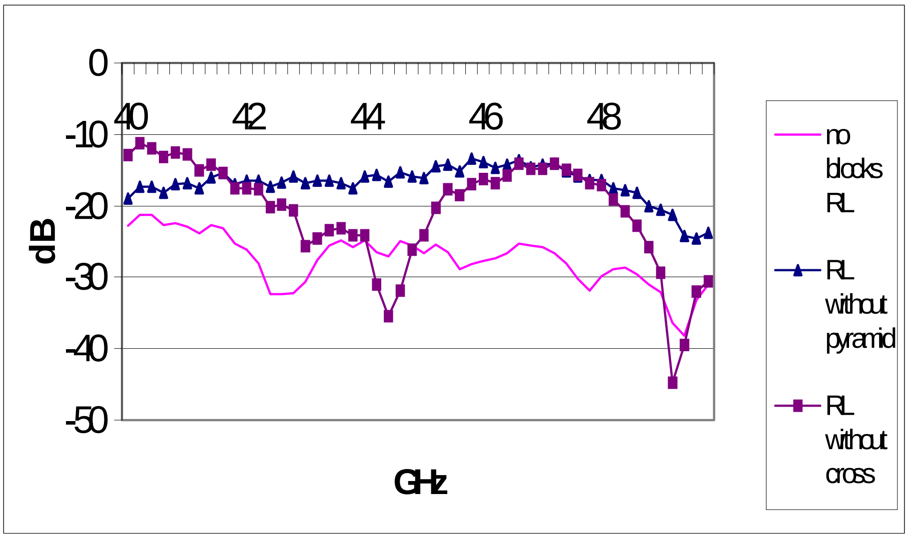
We estimate the RL average 15.41 dB and the average Leak 24.42 dB (We calculated the mean power over the whole wave band (± 10% of the nominal frequency); we calculated the standard deviation; we calculated again the mean value for powers into 1σ). The contribute of the CR117 base is relevant to increase the target absorption: it makes increase sensibly the average absorption. Now we want to evaluate R.loss and Leakage changing due to the insertion of the cross and of the pyramid:

Configurations 4-5

Graph 4: comparison between no-blocks configuration (–1) and no-cross (-4) and no-pyramid (5) configurations: R-Loss (fig 4-A) and Leakage (fig. 4-B) measures are shown.



Graph. 4a Leakage

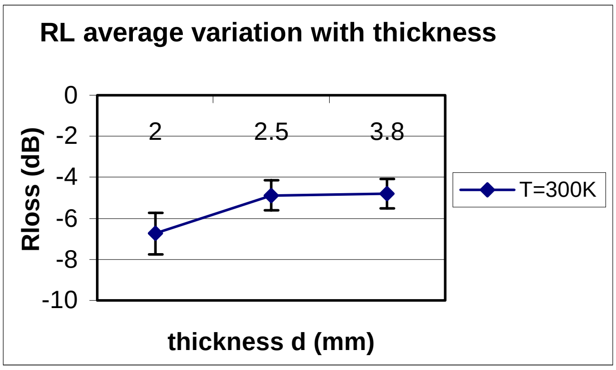


Graph 4-b R.Loss

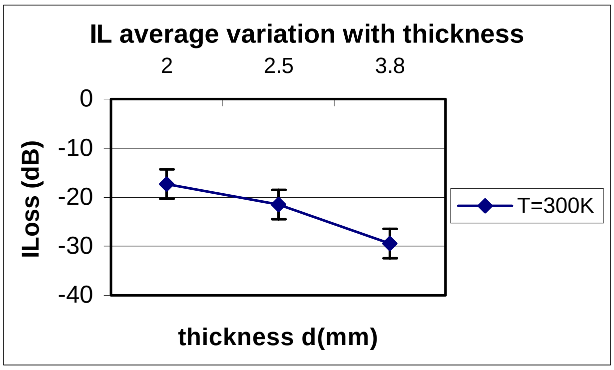
The presence of the pyramid improves the RL, the cross reduces the leakage: the R.loss reduction due to the pyramid alone is only apparent; in fact, radiation, after multiple reflections over the CR117 base and over the Aluminium box walls, come out as Leakage radiation.

DATA ANALYSIS

The best configuration is the no-blocks (-1) one (Cfr. graph 2).
The presence of the CR117 base is determinant for the absorption; however the base's tickness could be lowered according with the test on materials. Actually the base is 5mm thick: measures of R.loss and I.Loss variations with thickness on CR117 samples (Cfr. graphs. 5 and 6) show that the average R.loss stabilises from 2,5 mm thickness on and I.loss for a sample's thickness of 2.5mm is already lower than –20dB: note (Cfr graph2) that after the radiation passes trough the pyramid and the cross it is reduced by 15 dB about.
The pyramid lowers the R.loss from –16.4 dB average (Conf 5) to –27.1 dB average (Conf 1) [Cfr graph 4]
The CR110 cross (see Conf 1 and Conf 4) attenuates the incident radiation causing a changing in Leakage from –27,2 dB average to –34.2 dB on the average.



Graph 5- Rloss variations with thickness in a CR117 sample



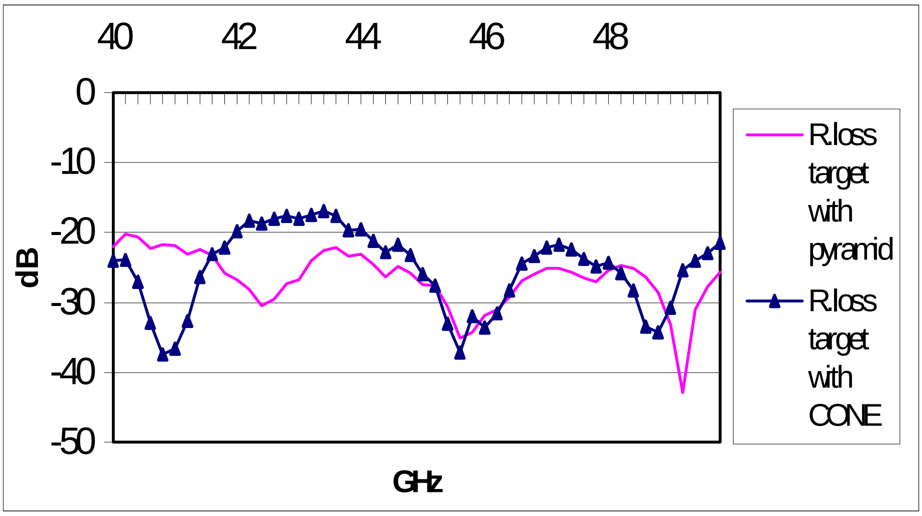
Graph 6- Iloss variations with thickness in a CR117 sample

Role of the pyramidal geometry

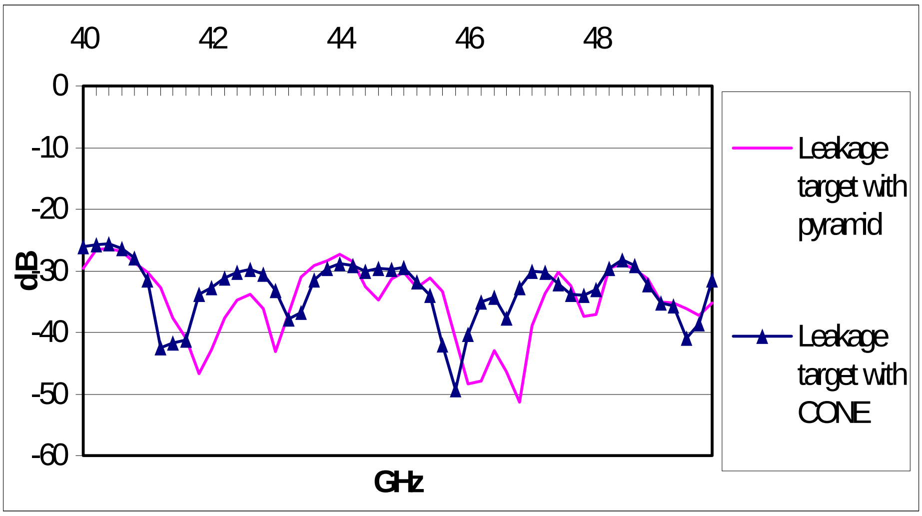
We now evaluate the effect in changing the central pyramid with different cones: they have the same height of the pyramid and a base inscribed in the squared base of the pyramid.

The horn used for the measures is the EBB: like the previous, but it has not any choke around the aperture (Cf. fig 2_).
From now on, all measures presented will be relative to the horn EBB without choke.

Graph. 7- effect of the pyramidal and conical shape on R.Loss (7a) and Leakage (7b)

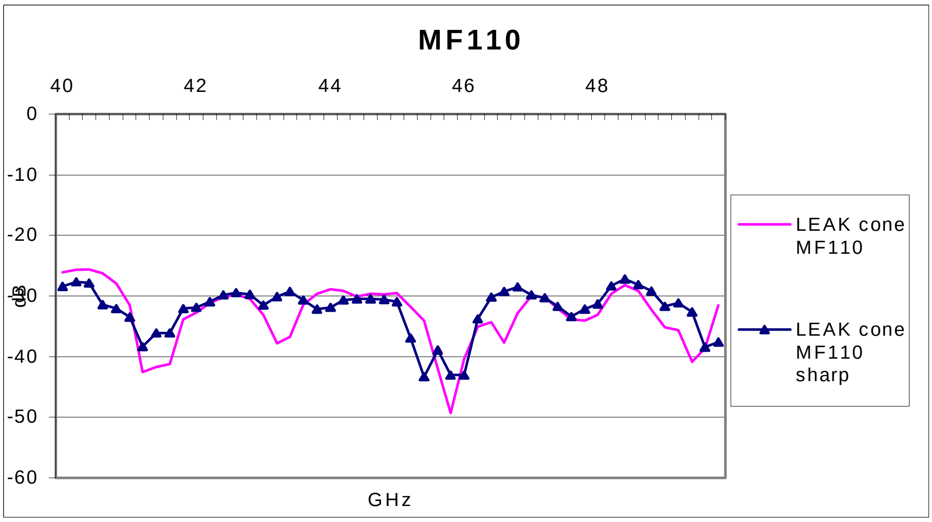


Graph. 7-a



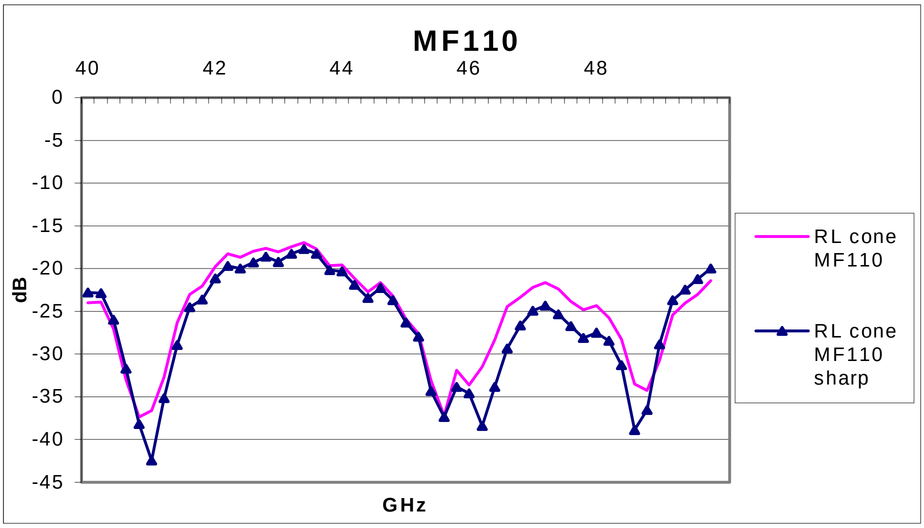
Graph. 7-b

It is evident that the substitution of the pyramid with the cone produces variations in R.loss and Leakage values: the average RL changes from -27.1 (pyramid) to -23.9 (cone); average Leakage from –34.2 (pyramid) to –31.9 (cone): so pyramidal and conical geometry appear to be quite different. Some difference can be attributed also to the geometrical mismatching of the cone in the square hole originally performed to lodge the pyramid and to the shaping of the cone, as can be seen from the comparison of two cones: the former is the one presented in the graph 7, the latter is one identical to the former but machined with a very sharp tip. Comparisons are reported in Graph 8 (for MF110 cones) and in Graph 9 (for MF117 cones).



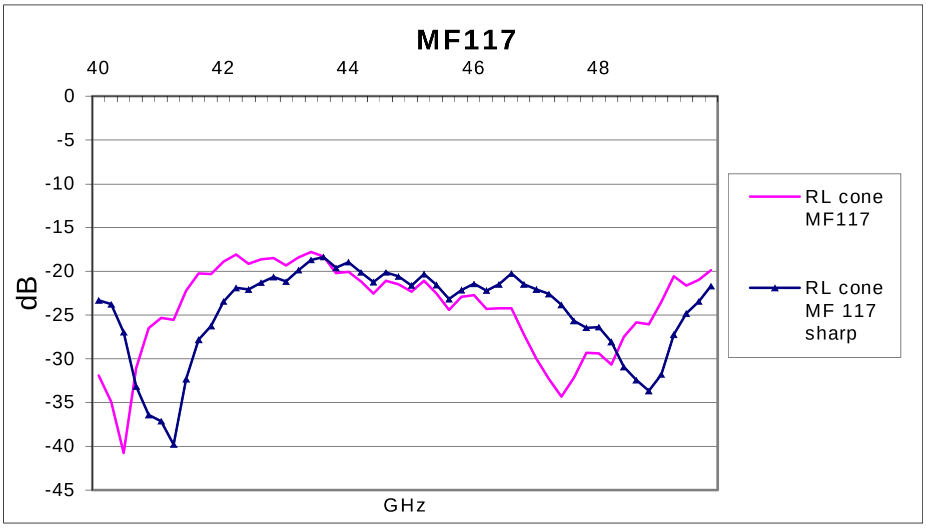
Graphs 8: effect of the tip on R-loss and Leakage in target provided with MF 110 cones

Graph. 8-a: Leakage

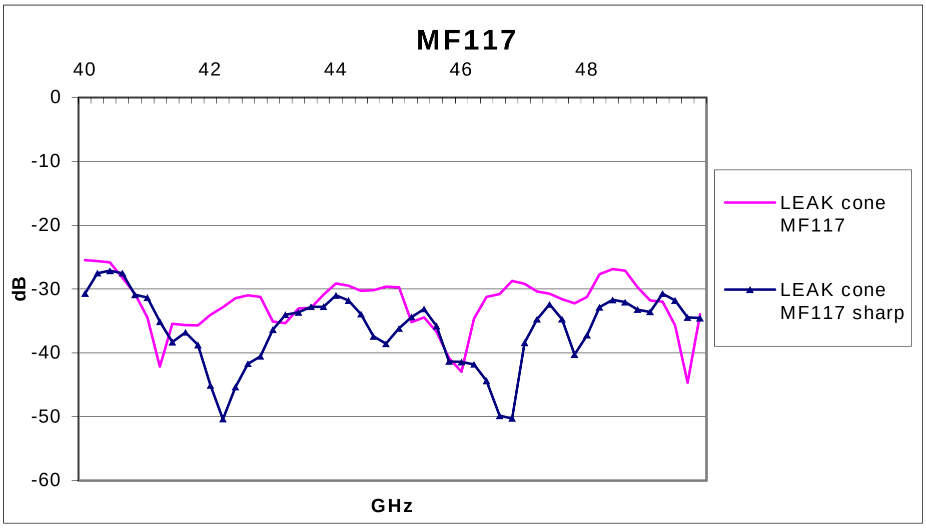


Graph. 8-b R.loss

Graphs 9- : effect of the sharpness of the tip in MF 117 cones



Graph. 9-a Rloss



Graph. 9-b Leakage

The effect of the tip seems to be more evident with reflective materials: however we can see just a little improvement in Leakage data relative to the MF117 sharp cone.
Average values are:

		Normal	sharp
MF110:	RL :	-25.182	-26.759
	Leak:	-33.076	-32.271
MF117:	RL :	-24.249	-24.635
	Leak:	-32.315	-36.200

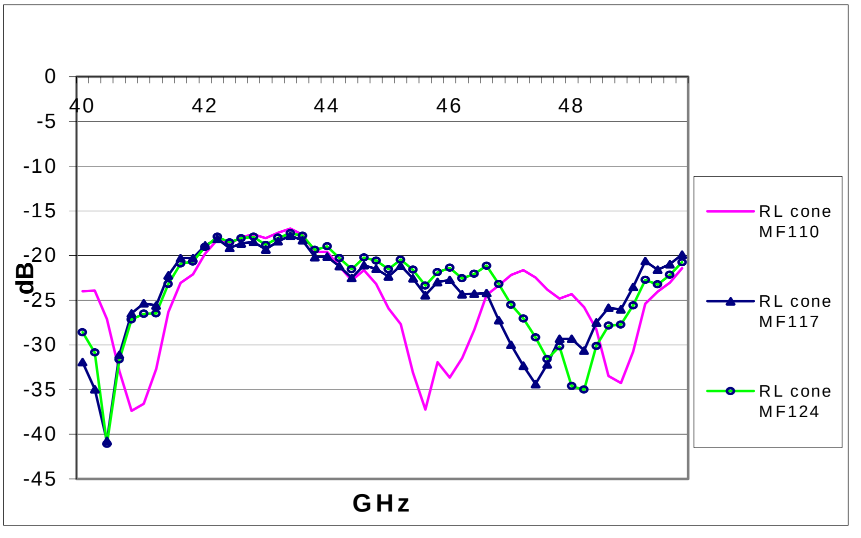
Tab.2: effect of the tip in MF110 and MF117 samples

Role of the material in the central absorber

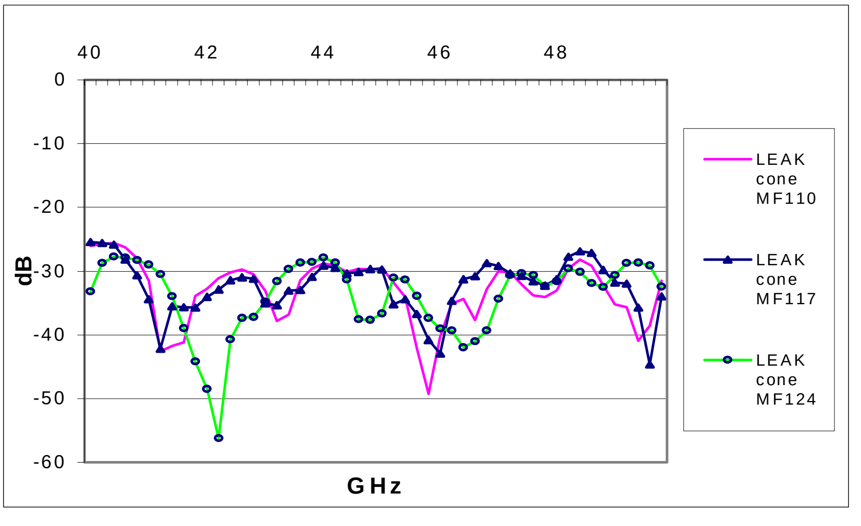
We compare the three cases in wich the central absorber is a cone of MF 110 , MF117, MF 124 series.

Graph.10: comparison between MF 110 MF117 MF 124 cones

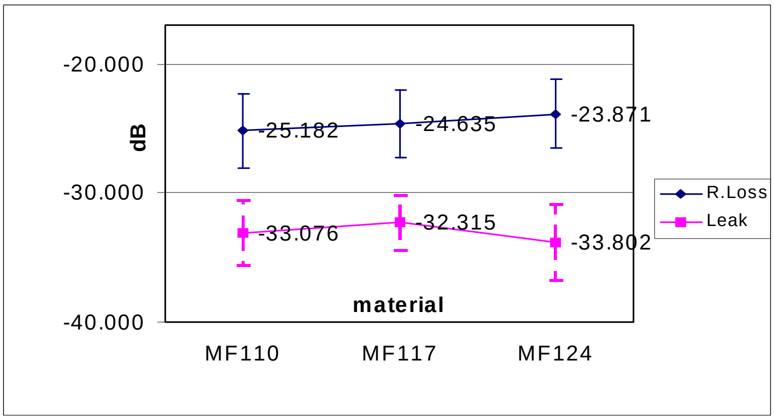
Graph. 10-a R-Loss for different materials



Graph.10-b Leakage for different materials



The graphics show that R.Loss and Leakage are quite independent from the material of the central absorber: this can be summarized in the following graphic in which changes due to the material are shown.



Graph.11 Average R.Loss and Leakage variation with the material for a same geometry of the sample. The Standard deviations values relative to each material's data are also shown.

Conclusions

We measured the behaviour of different configurations in the reference loads: they differed in assembly and materials.
From our data the best performances (in both Return loss and Leakage) are obtained with the 'no blocks Conf.' (-1). However the thickness of the back part (CR117 plate) can probably be reduced without affecting the performances.
Comparing pyramidal and conical absorbers we deduced that they are not equivalent. The best choice seems to be that one with the pyramid.
A perfect machining of the tip is as much important as the material used is reflective: however the measurement approach does not allows us to derive robust results. This effect is probably more important at highest frequencies.
The geometry of the central absorber is more important than the material used: different materials produced similar behaviours when machined in the same shape.

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