

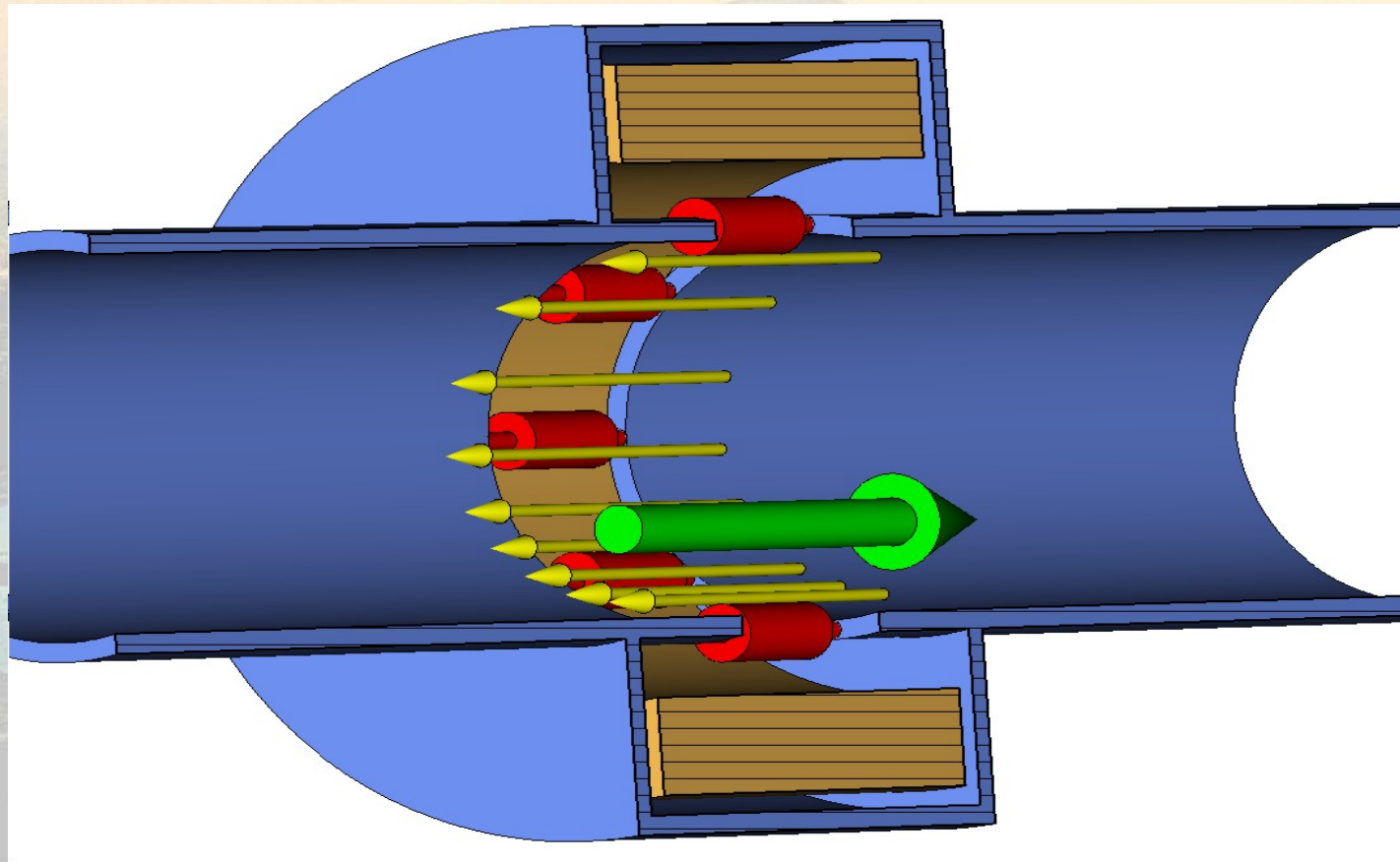
An aerial photograph of a coastal city, likely Genoa, Italy, showing a large bay with a central island, surrounded by mountains. The image is semi-transparent, serving as a background for the text.

Status of the Wall Current Monitor (WCM) design for EUROTeV

Alessandro D'Elia - CERN

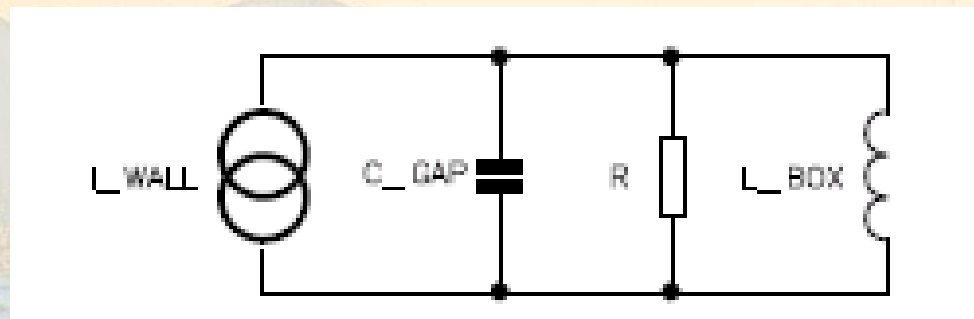
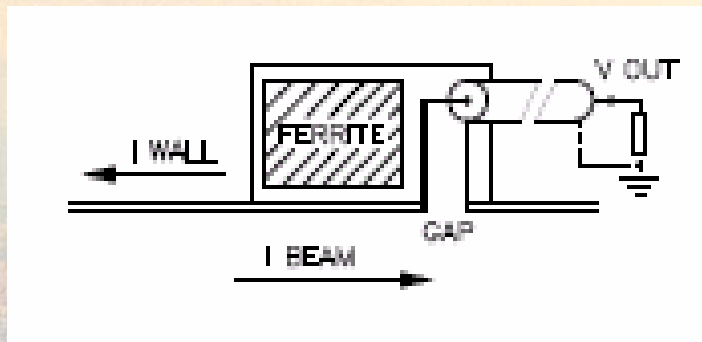
Wall Current Monitors

Wall Current Monitors (WCM) are commonly used to observe the time profile and spectra of a particle beam by detecting its image current.



A first approach using a simple circuit model

The presence of the ferrite is fundamental in order to decrease the low frequency cut-off of the structure



$$F_{lowcut-off} = \frac{1}{2\pi} \frac{R}{L}$$

$$F_{highcut-off} = \frac{1}{2\pi} \frac{1}{RC}$$

Note: When the distance between the WCM elements becomes comparable to the free space wavelength of the propagating fields, the circuit modeling is not reliable and a study of the 3D structure has to be performed by using e-m CAD!

The aim

The 3rd generation of CLIC Test Facility (CTF3) foresees a beam formed by bunches separated of

$\Delta_b = 67 \text{ ps}$ \longrightarrow **WCM h. f. cut-off = 20 GHz**

for a total pulse duration of

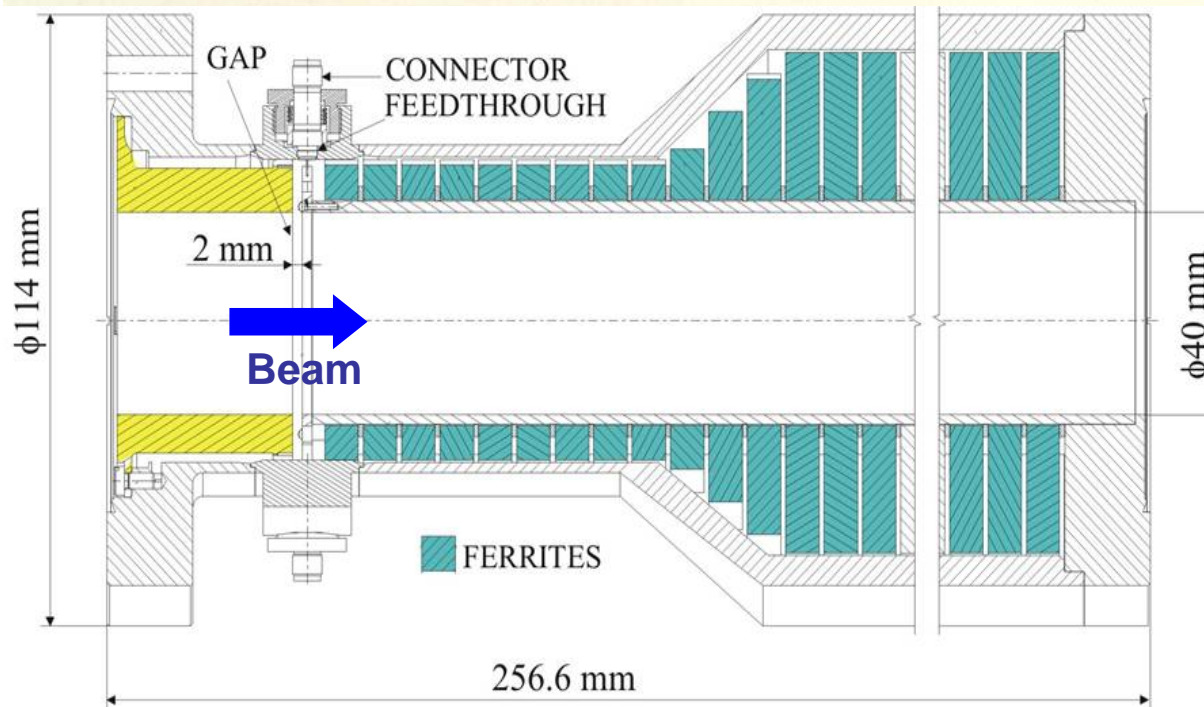
$\tau_r = 1.54 \text{ } \mu\text{s}$ \longrightarrow **WCM l. f. cut-off = 100 kHz**

Furthermore

Bake out temperature:	150 C
Operating temperature:	20 C
Vacuum:	10^{-9} Torr

100kHz-20GHz WB signal transmission over 10-20m.

The existing design

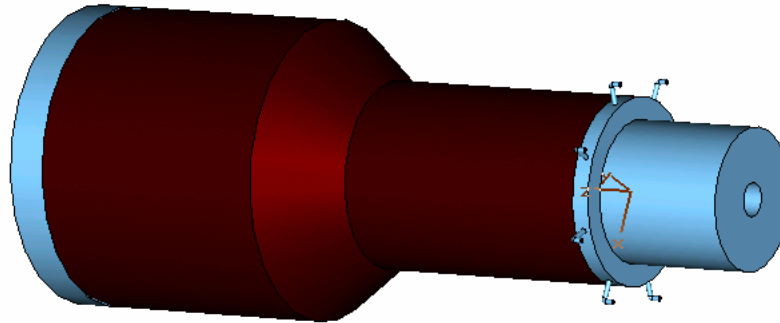


The existing design is based on a previous design for the CTF2
(63 MHz \leq bandwidth \leq 10 GHz)

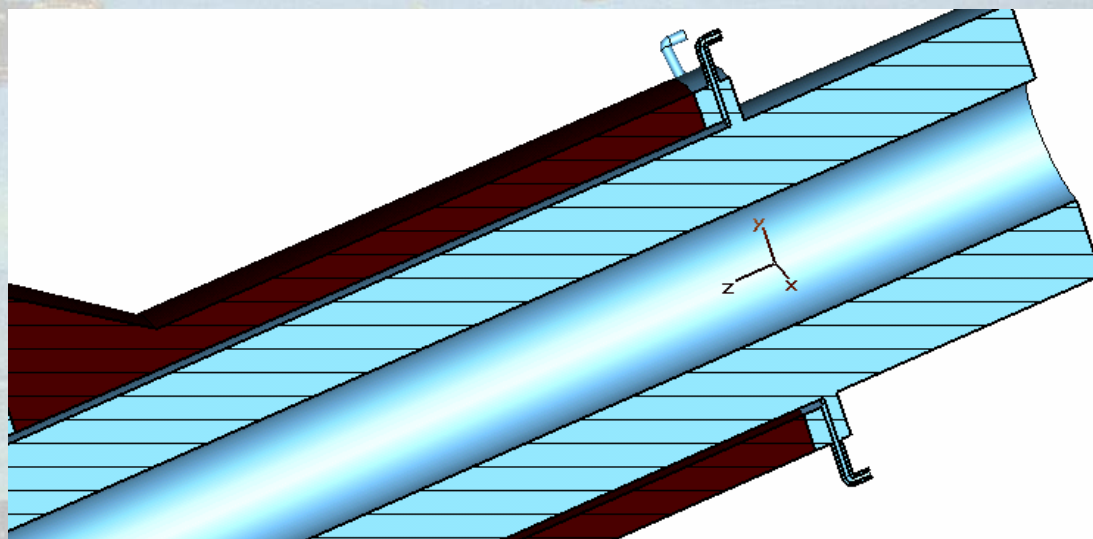
but

- Bigger volume of ferrite in order to lower the l. f. cut-off to 100 kHz
- The miniature feedthrough modified in order to extend their bandwidth beyond 20 GHz

Simulations: geometry parameters

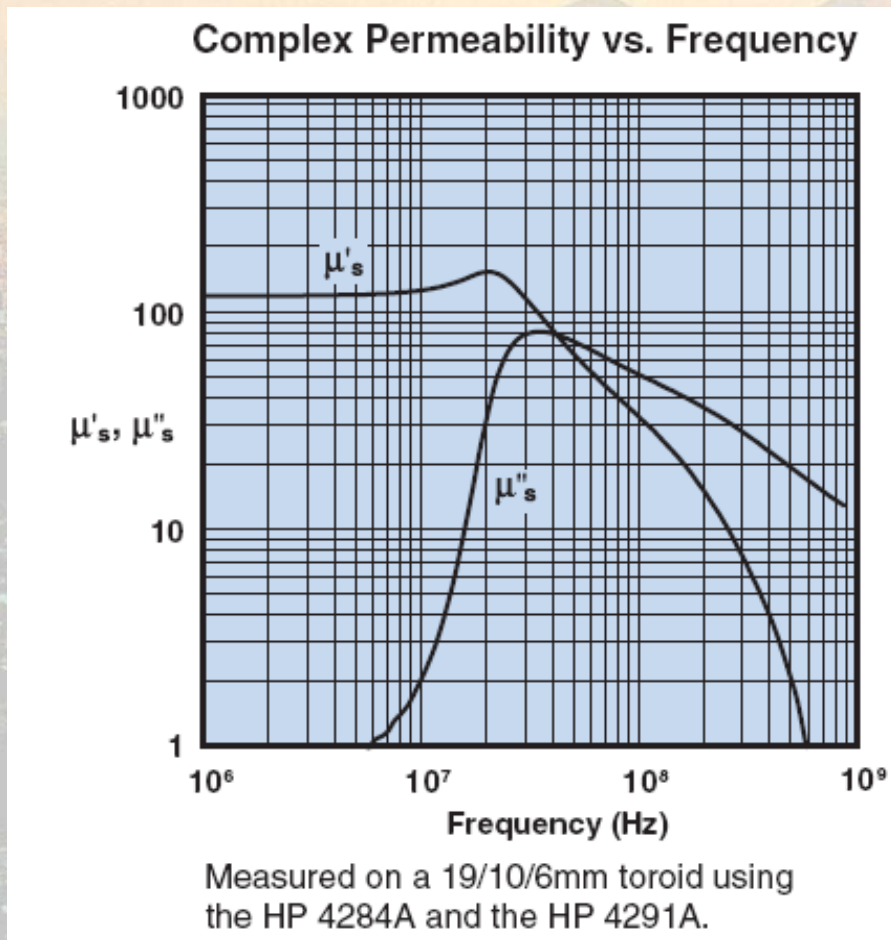


Parameter	mm
$R_{\text{pipe int}}$	20
$R_{\text{pipe ext}}$	25
R_{wire}	8.5
Pipe thickness	1
$R_{\text{feed wire}}$	0.3
$R_{\text{feed ext}}$	0.69
L_{cone}	20
gap	2
R_{ferrite}	20
L_{tot}	205



Simulations: ferrite parameters

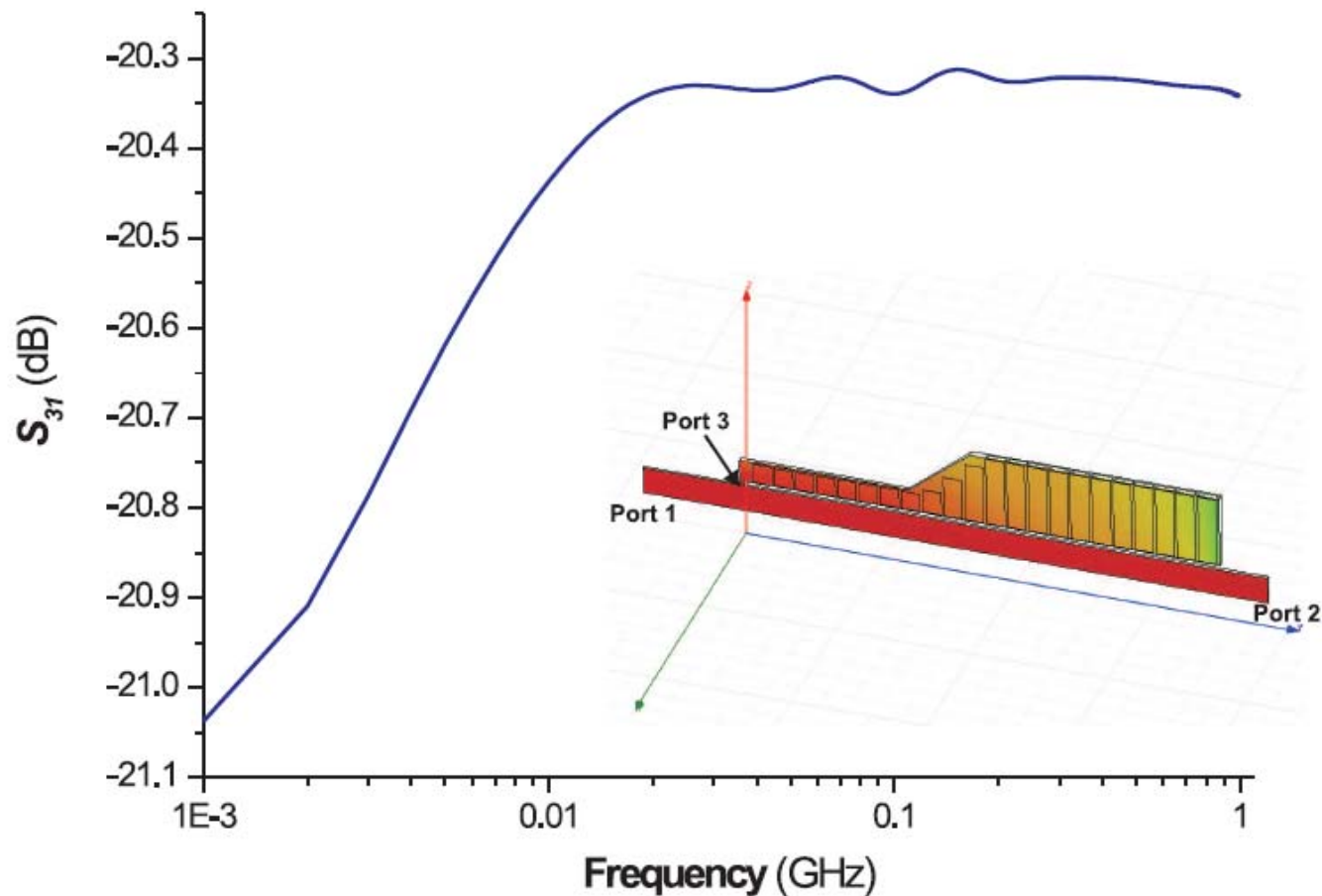
The ferrite used is the Material 61 of Fair Rite Company. From data sheet one finds the curves for complex permeability. Unfortunately the characterization is done only from 1MHz to 1GHz.



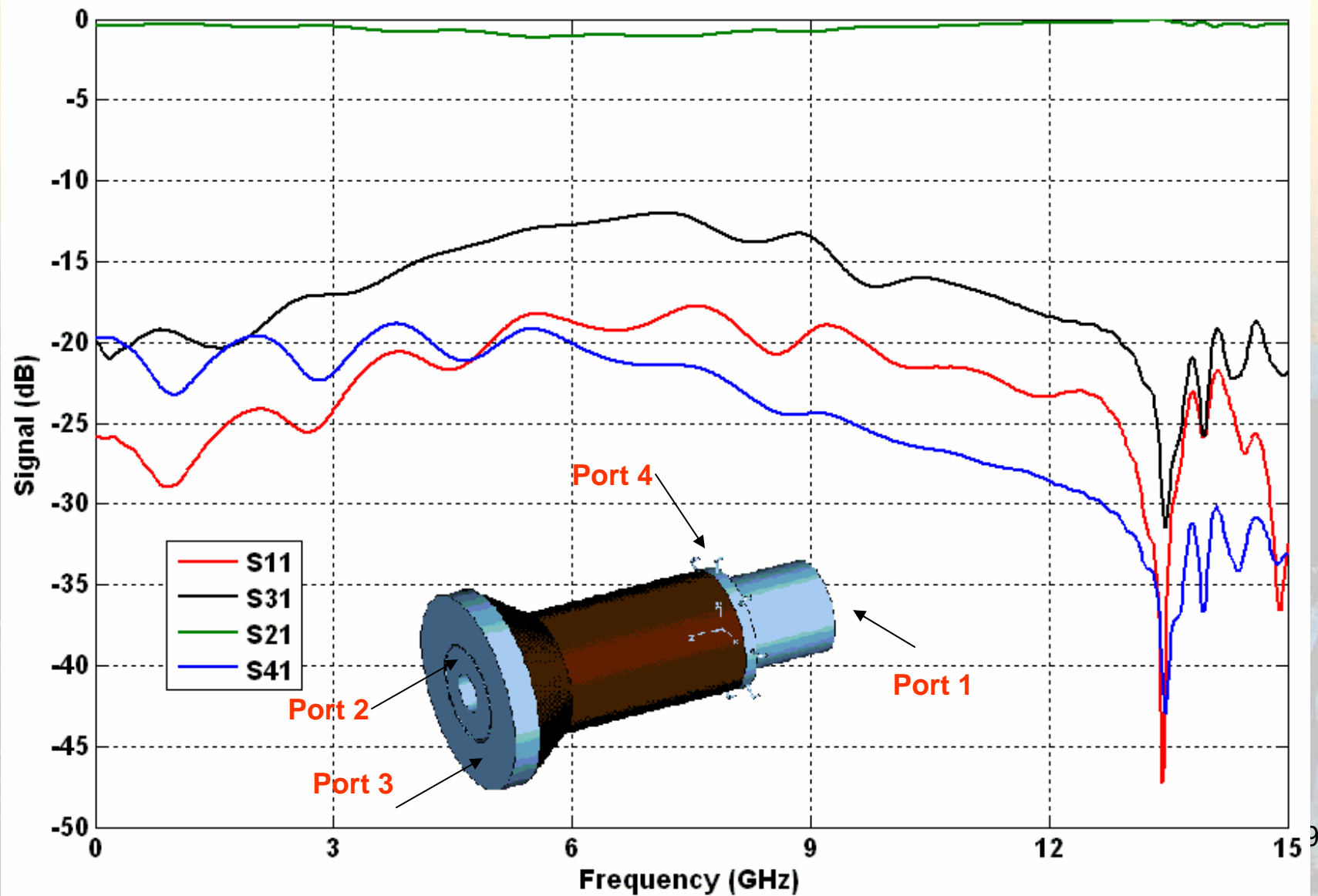
From Fair Rite 61 Material datasheet
(see <http://www.fair-rite.com>)

Simulations: results (1)

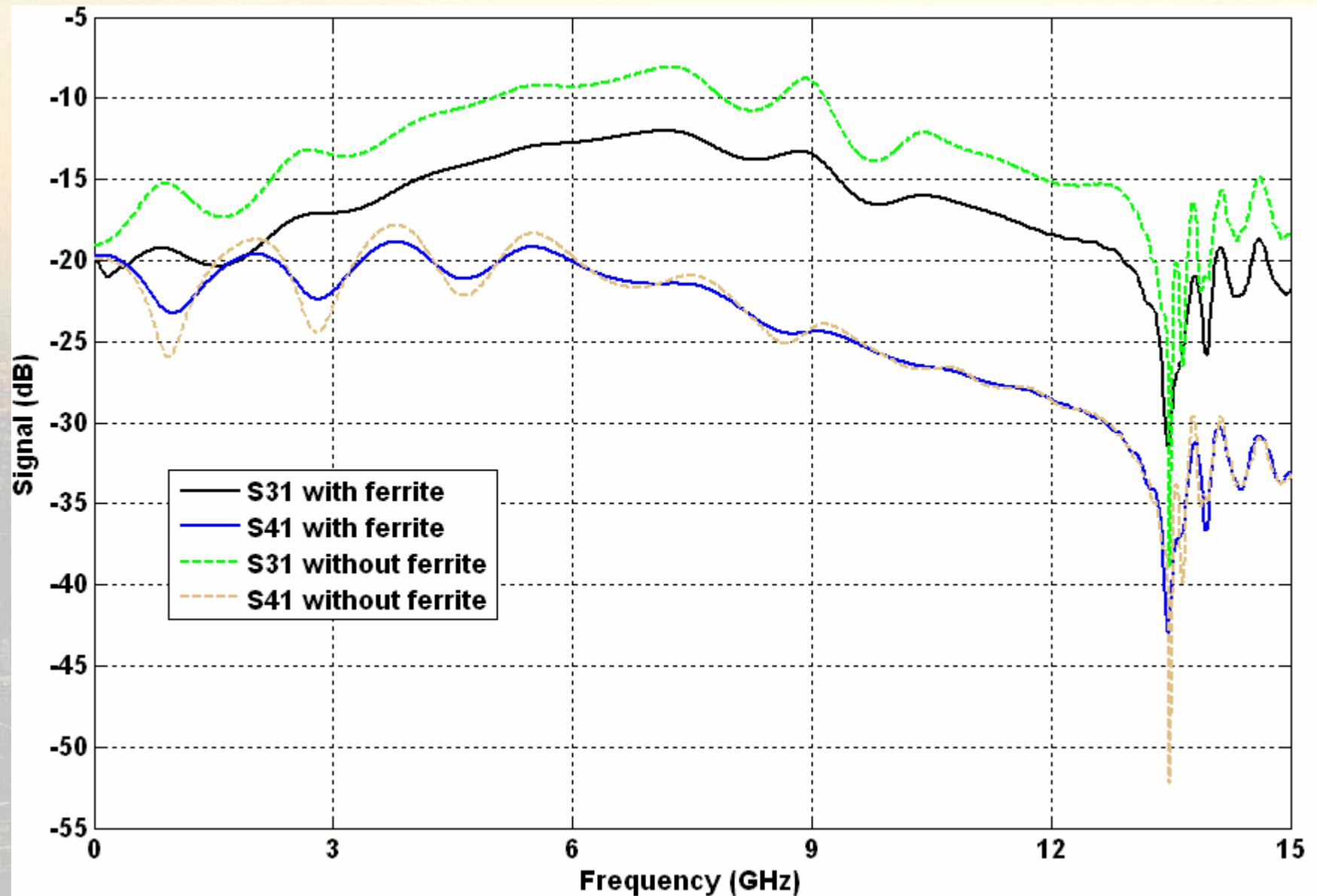
HFSS simulation shows a very good l. f. cut-off



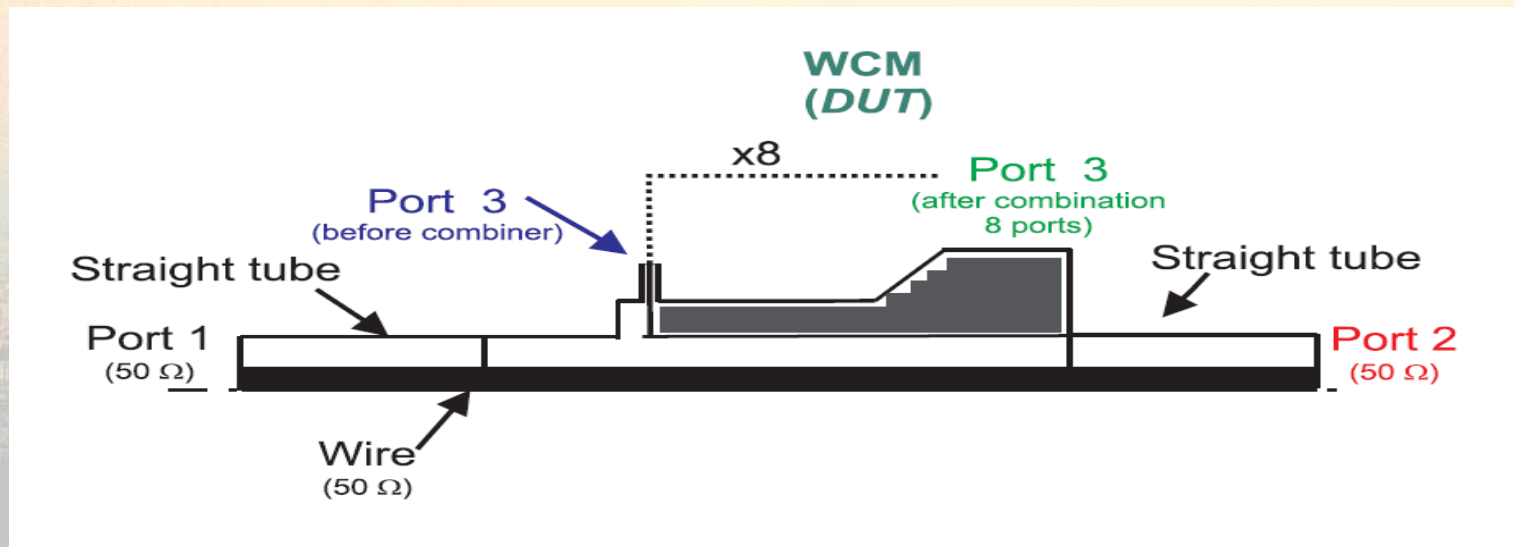
Simulations: results (2)



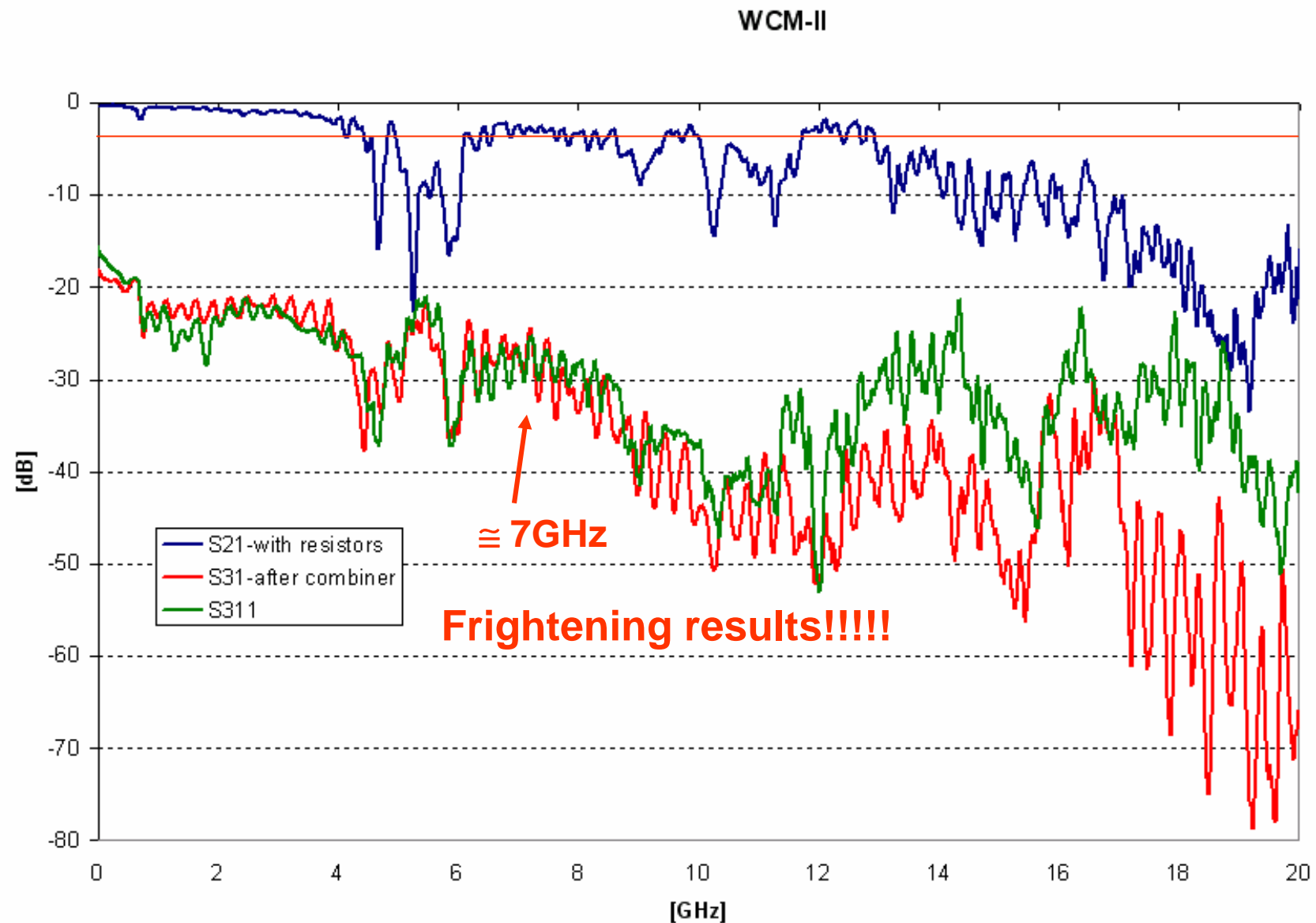
Simulation: results (3)



Experimental setup

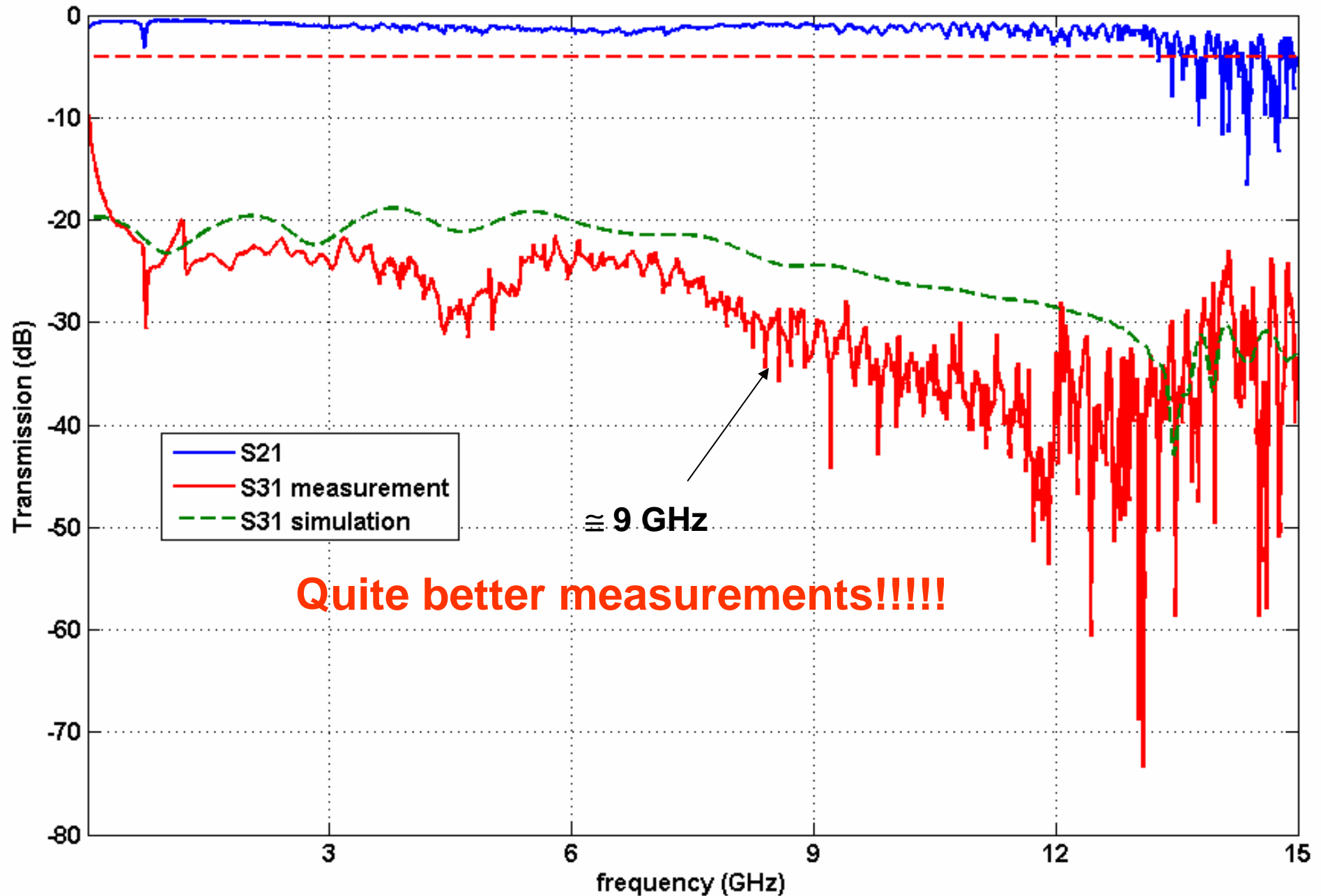


Old measurements (March 2006)

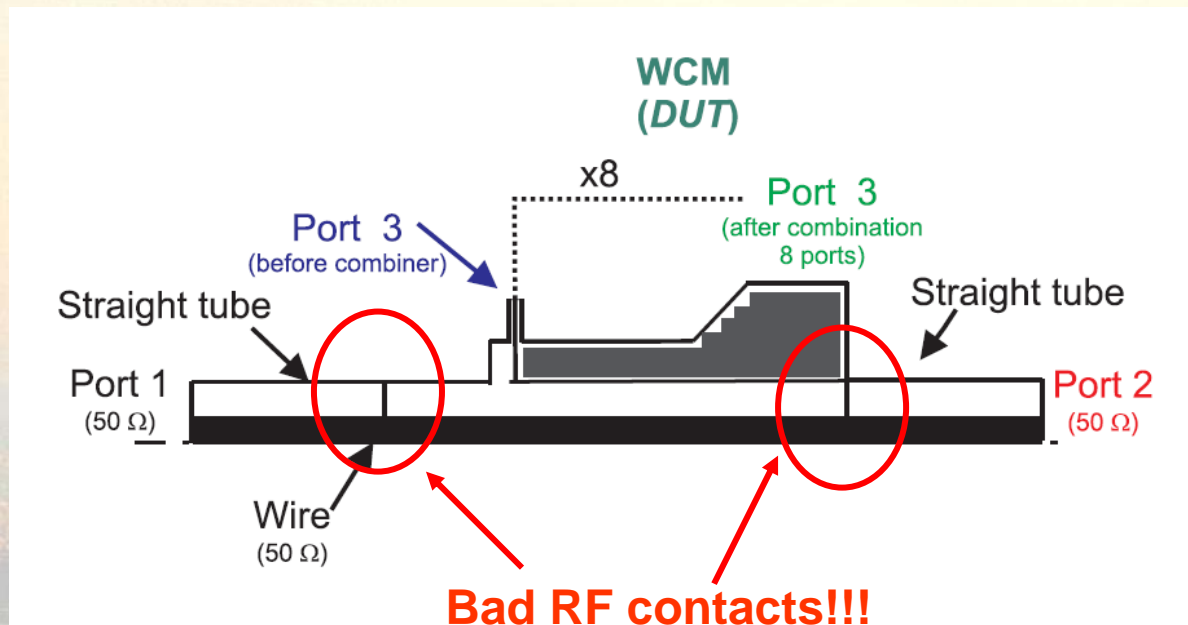


With the courtesy of Lars Soby and Ivan Podadera

New measurements (November 2006)



What was wrong?



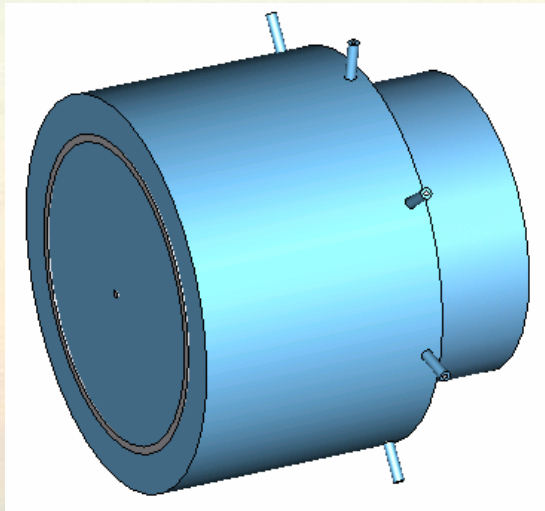
The experimental setup showed very bad RF contacts between WCM and the two external straight tubes. In order to improve the contacts some pasty stripes of conducting material has been used.... Unfortunately it cannot be used in vacuum....

For frequencies higher than 12 GHz it is possible that strong reflections occur because of our SMA connectors are adapted up to 12.5 GHz.

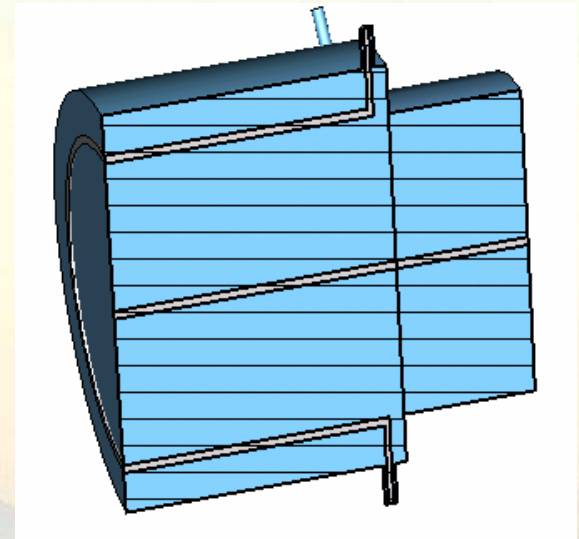
In any case the S31 signal has to be improved (problems with the ferrite? Problems with the feedthrough? Both?)!

Going beyond 10 GHz

Several new structures (biconical structure, several kind of coaxial structures....) were deeply studied in order to extend the frequency bandwidth of the WCM, between them, the one giving the best results, is a structure realized at the cost of few changes in the existing WCM structure.

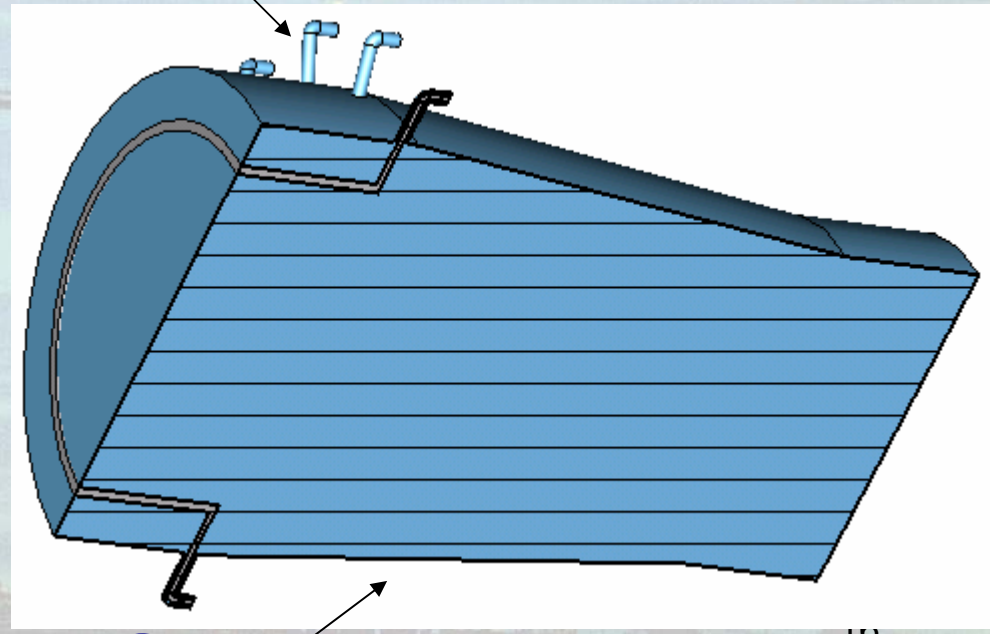
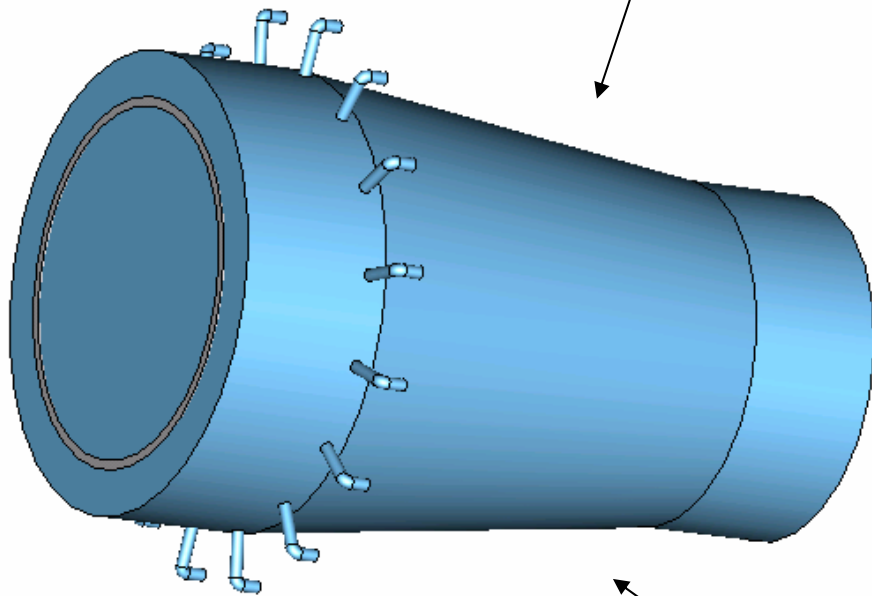


← **Old WCM** →



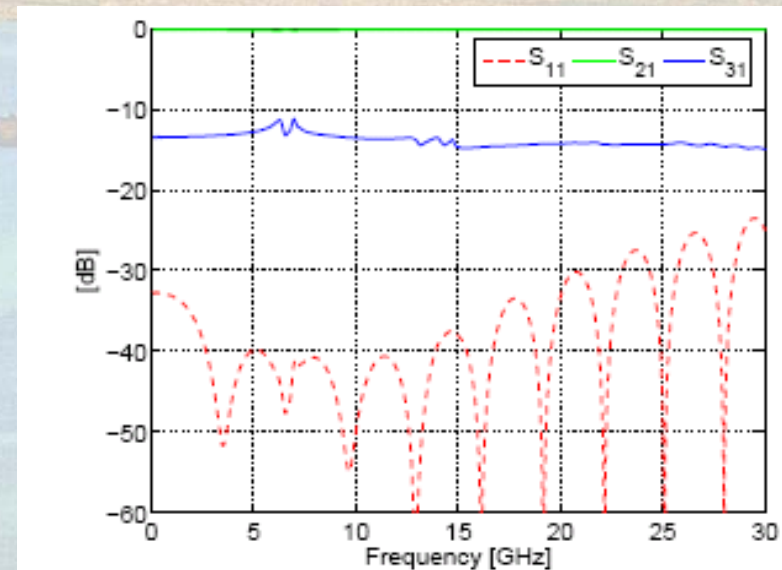
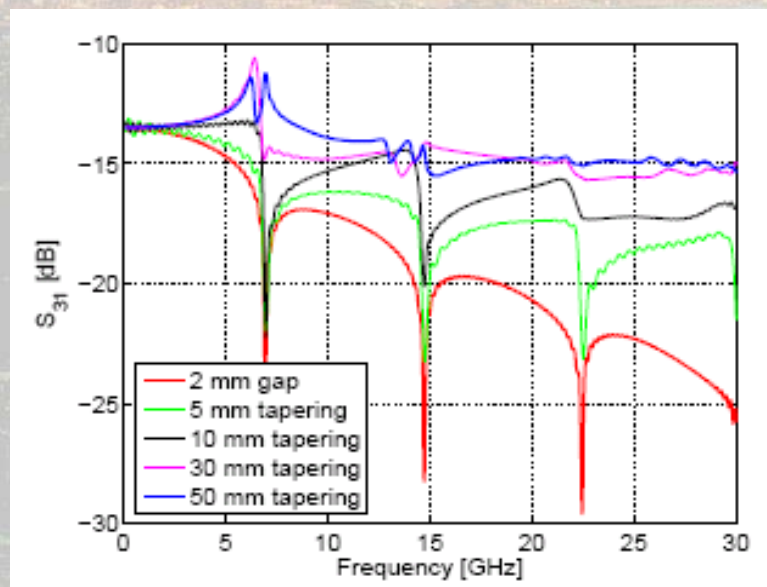
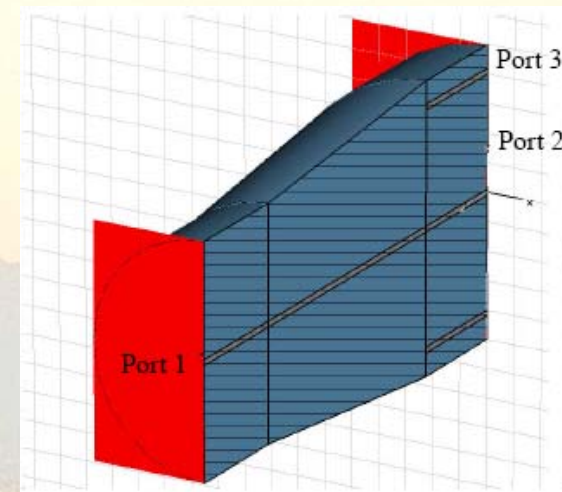
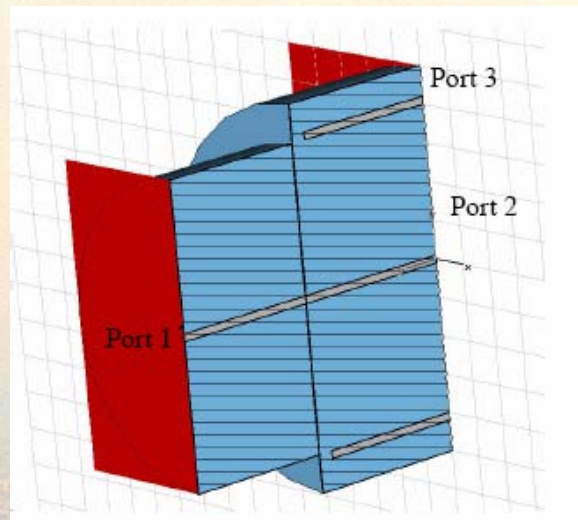
Tapering

16 feedthroughs



← **New WCM** →

The gap resonances



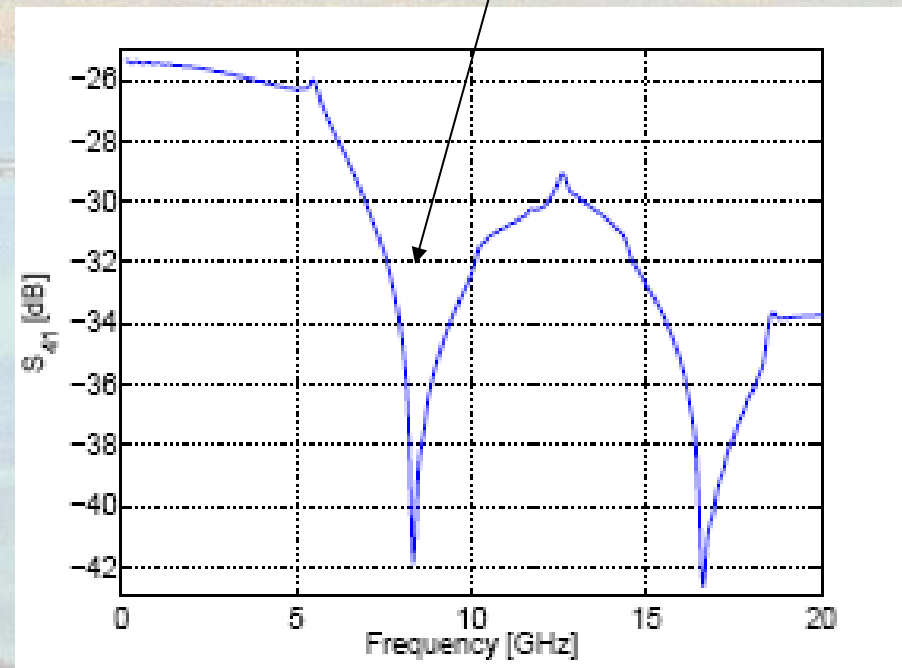
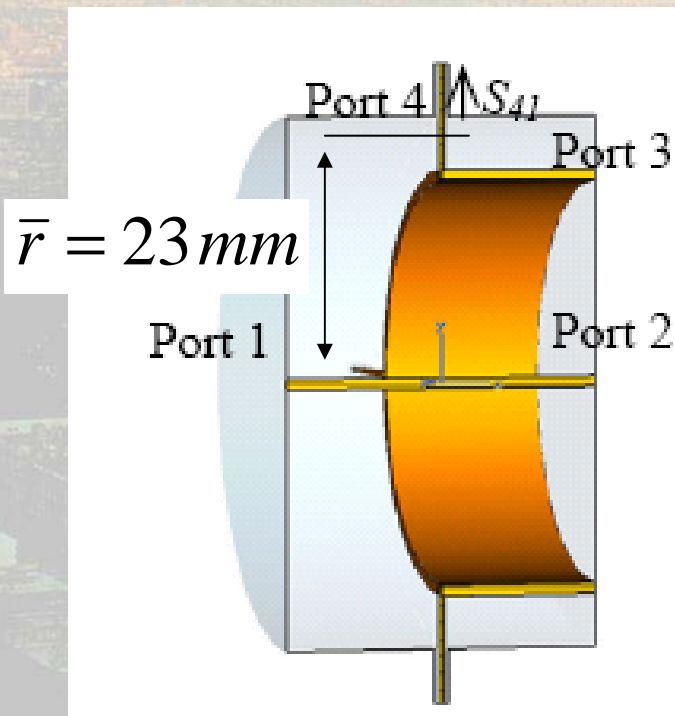
With the courtesy of Tom Kroyer ("A Structure for a Wide Band Wall Current Monitor", AB-Note-2006-040 RF)

Feedthrough resonances

When the distance between two feedthroughs becomes equal to the free space wavelength, the first azimuthal resonance appears in the structure

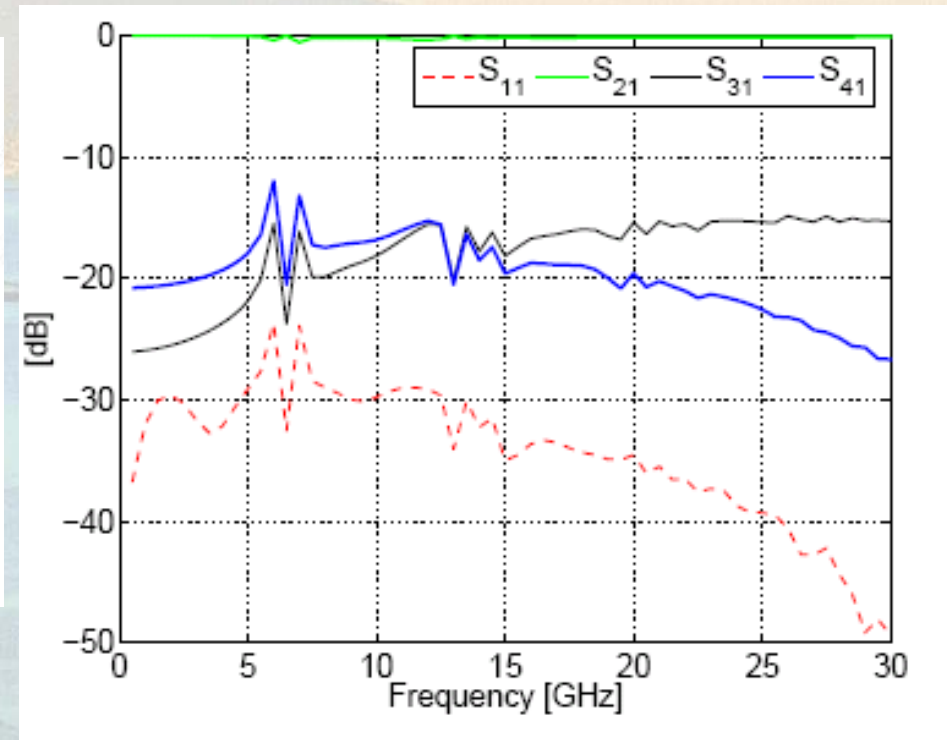
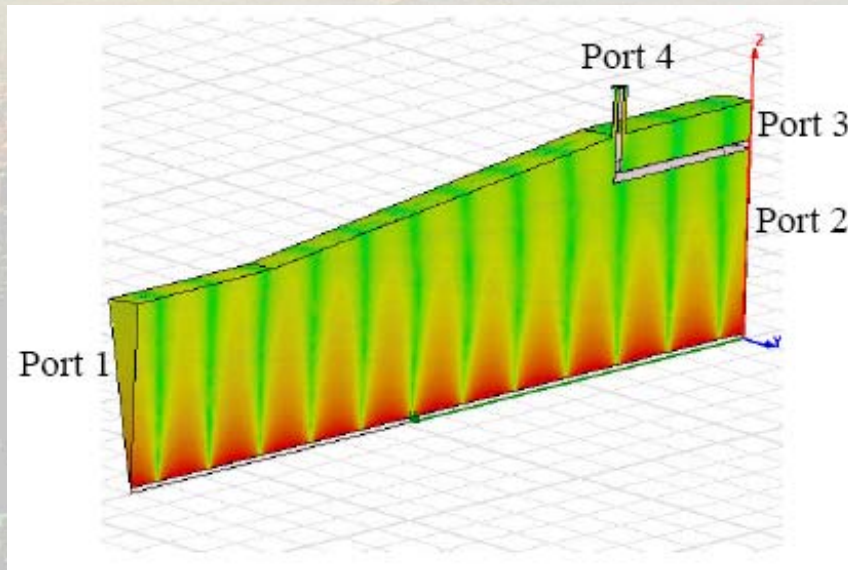
$$F = \frac{c}{2\pi(\bar{r}/n)} \quad n = \text{number of feedthrough}$$

With $n = 4$, one has $F = 8.3 \text{ GHz}$



The whole structure

Therefore to have 16 feedthroughs means to push the previous resonance to ≈ 33 GHz

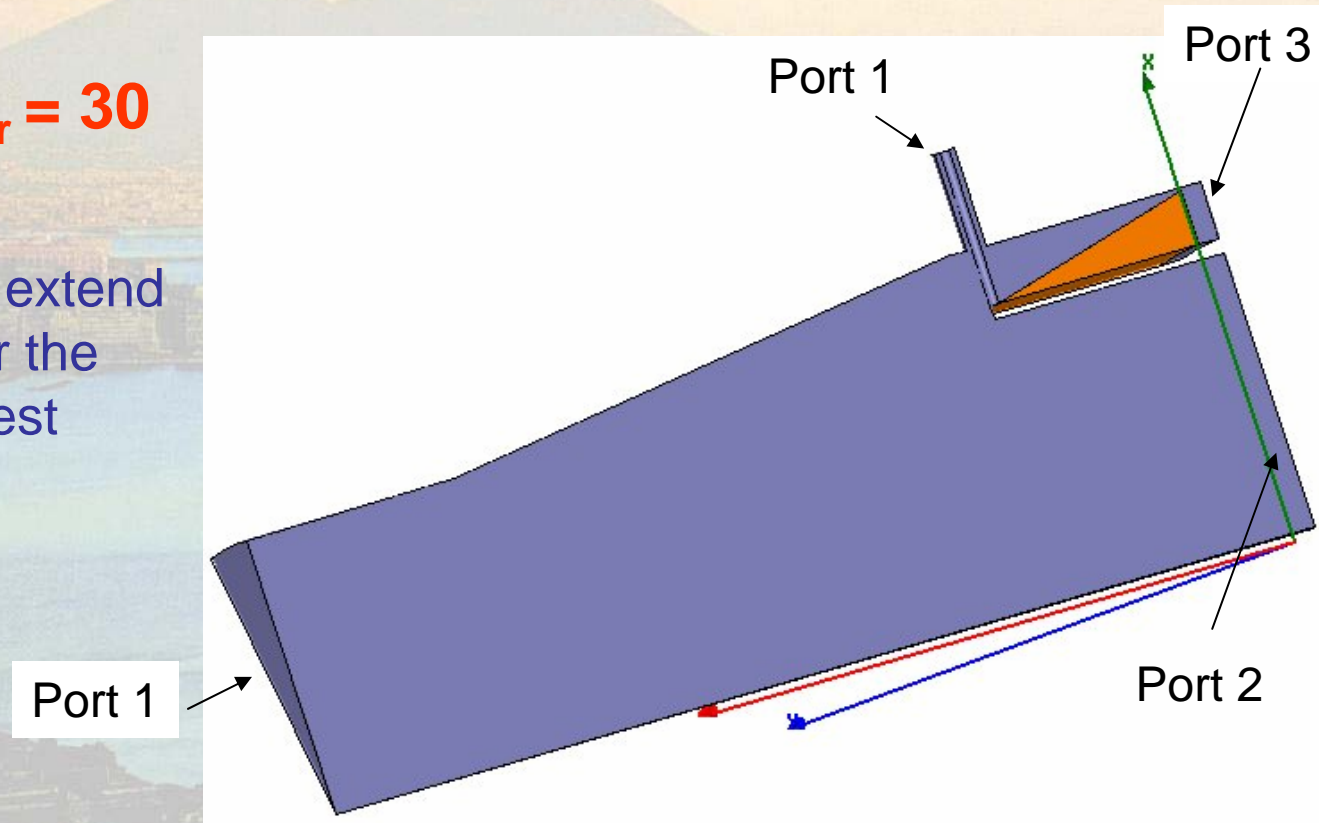


A first simulation with SiC

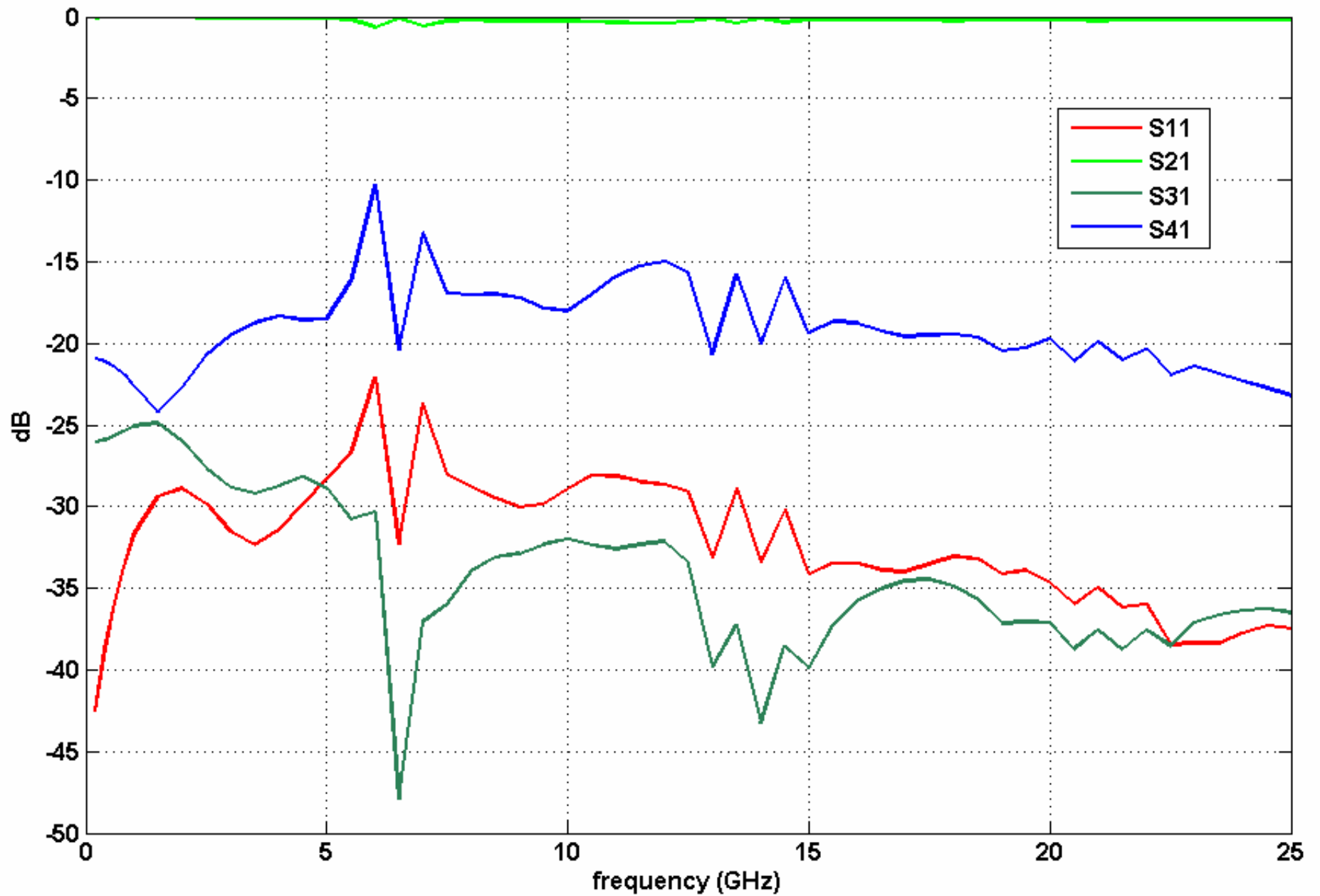
Same geometrical parameters but a cone of SiC has been introduced in the model of a longitudinal length of ≈ 19 mm. The parameters in the range 21GHz-33GHz of SiC are:

$$\text{tang } \delta = 0.3 \quad \epsilon_r = 30$$

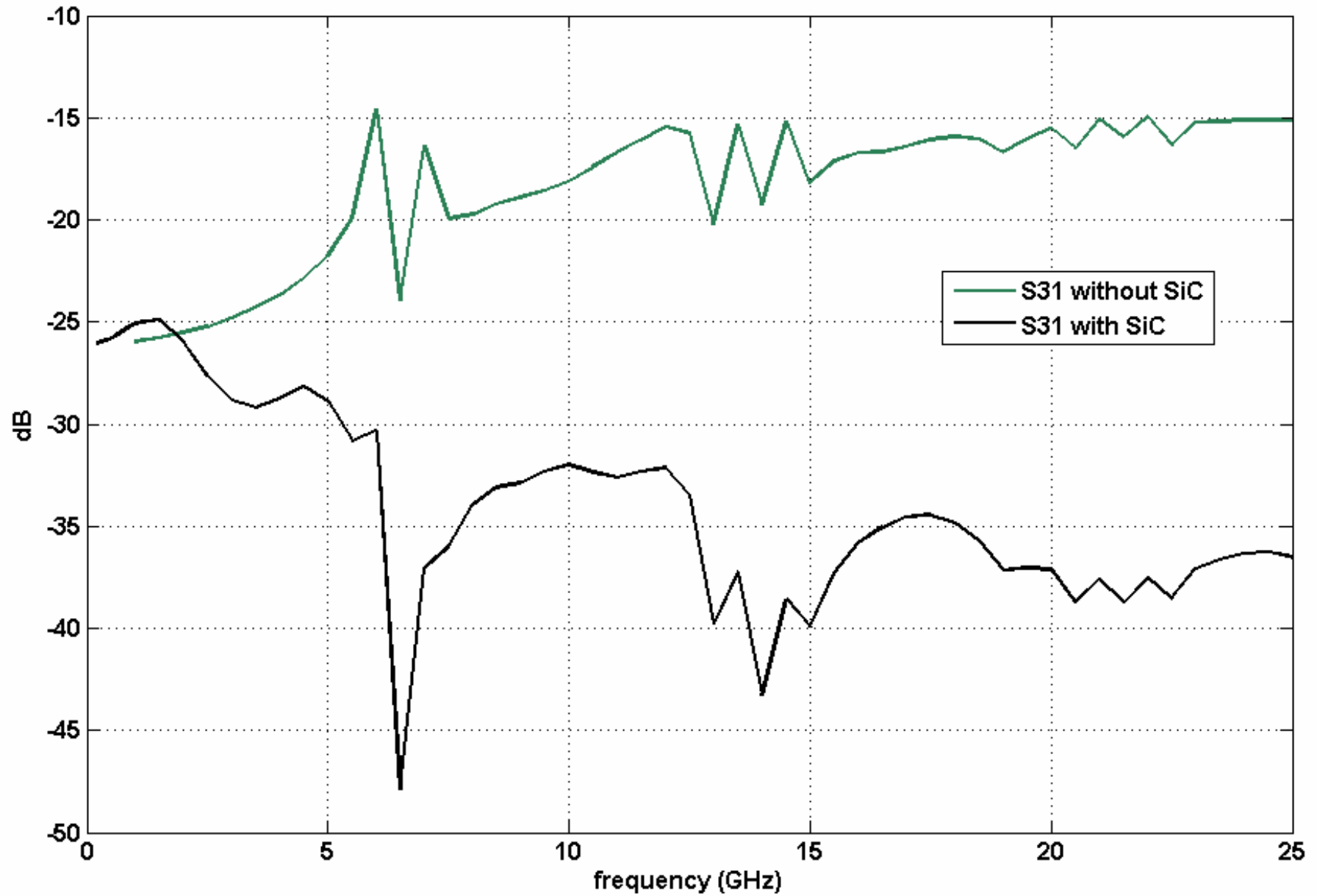
In the simulation we extend these parameters for the whole range of interest (1GHz-25GHz)



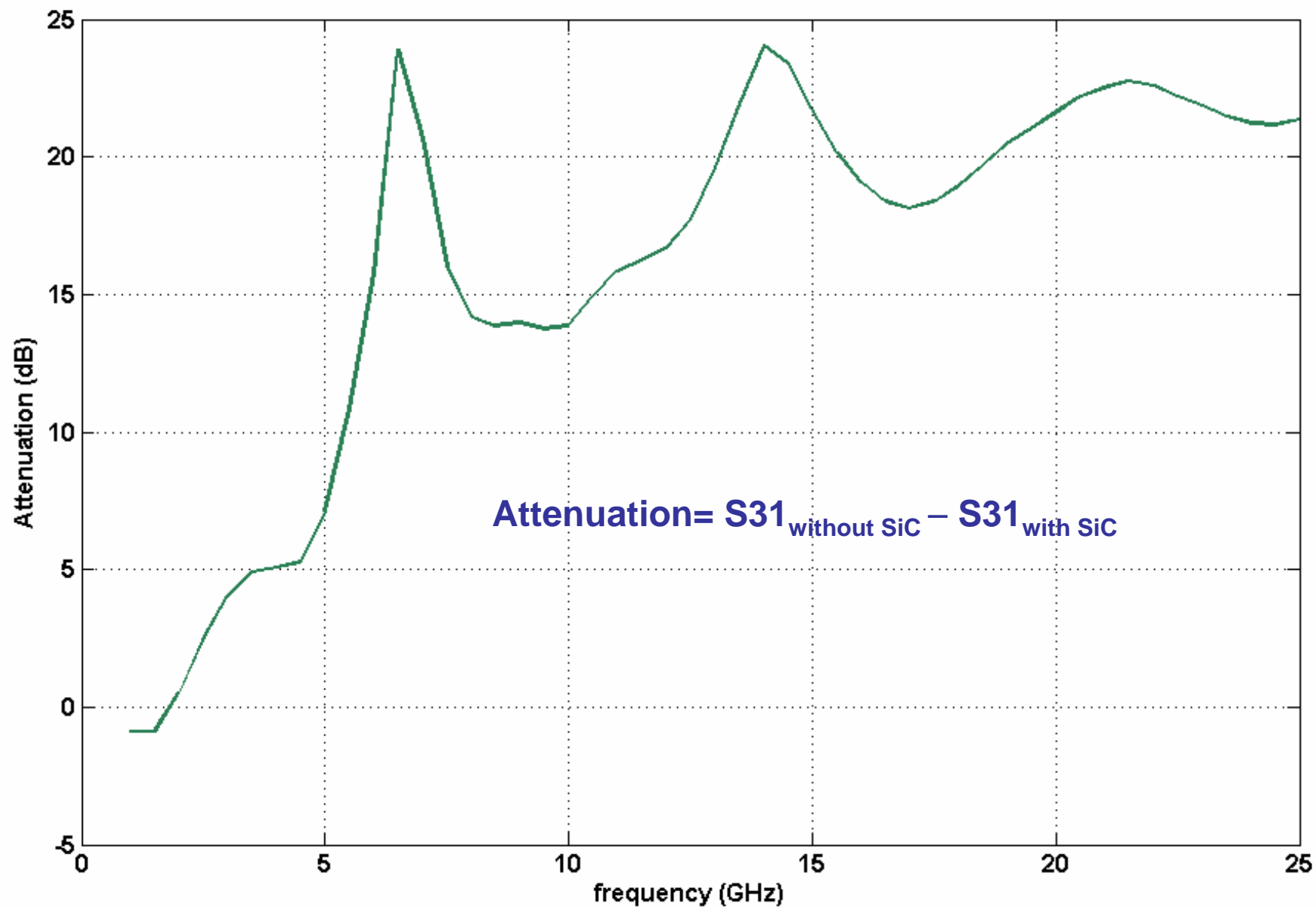
Results



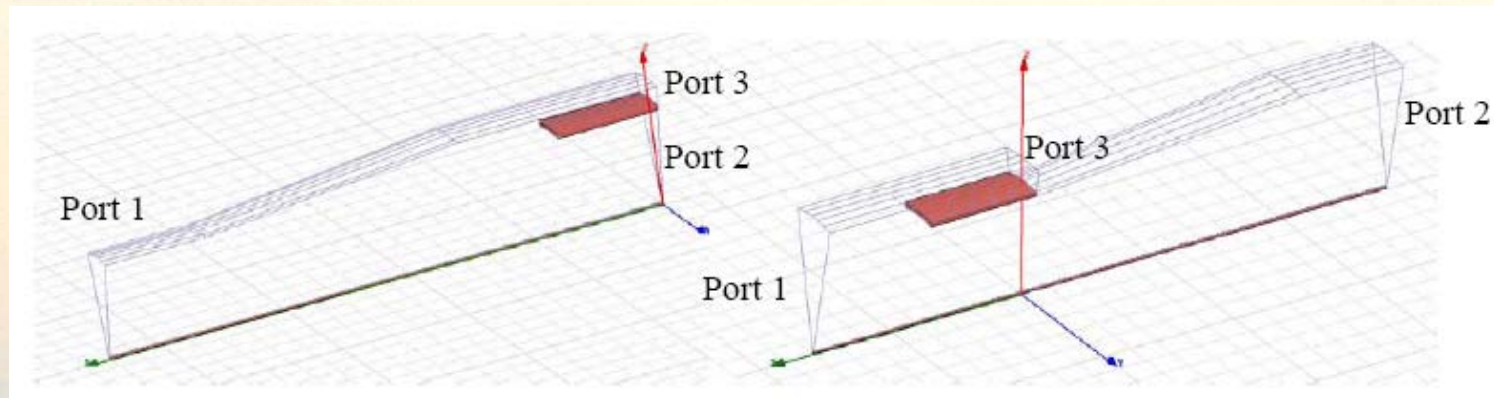
Results



Signal attenuation at Port 3 due to SiC

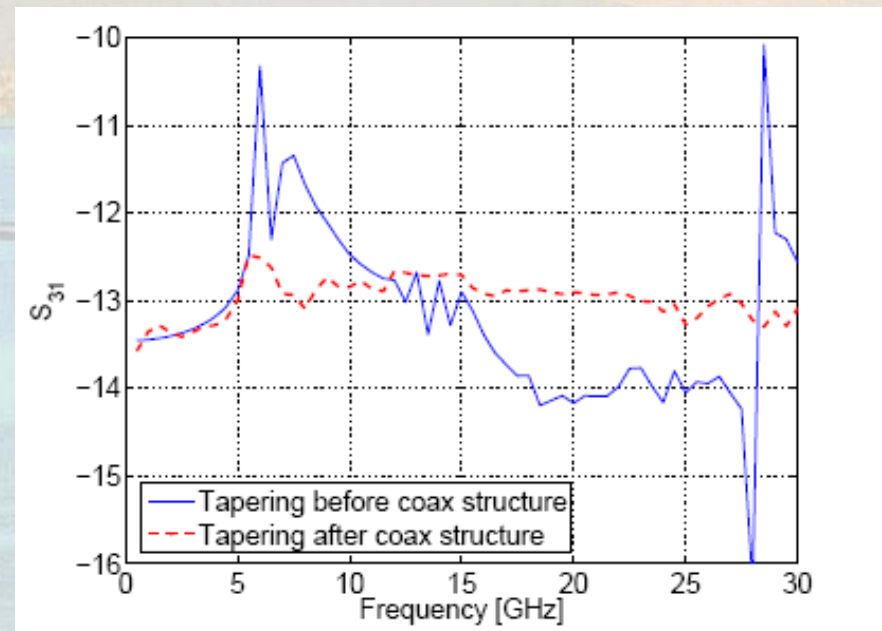


An interesting proposal



If an aperture restriction can be tolerated, the inner pipe may be inserted into the beam pipe and a taper added after the coaxial section.

This structure is advantageous since higher order modes excited at the edge of the inner pipe can run back into the beam pipe without encountering discontinuities, No trapped modes will thus appear.



Conclusions... and a “few” of remaining problems

- The test bench has been improved
- The new proposed geometry at the cost of few changing in the old one shows a quite good response for our aims: apart of the TM01 mode at about 5.5 GHz a quite good flat response it is foreseen up to 25 GHz with the possibility of extending the bandwidth up to 30 GHz for future applications
- More accurate studies on the real feedthrough are needed
- Development of a new testbench only for feedthrough
- Feedthrough vacuum leakage
- Reliable ferrite and SiC models in CST MicroWave and/or HFSS
- We are confident, on February, of producing a preliminary mechanical design