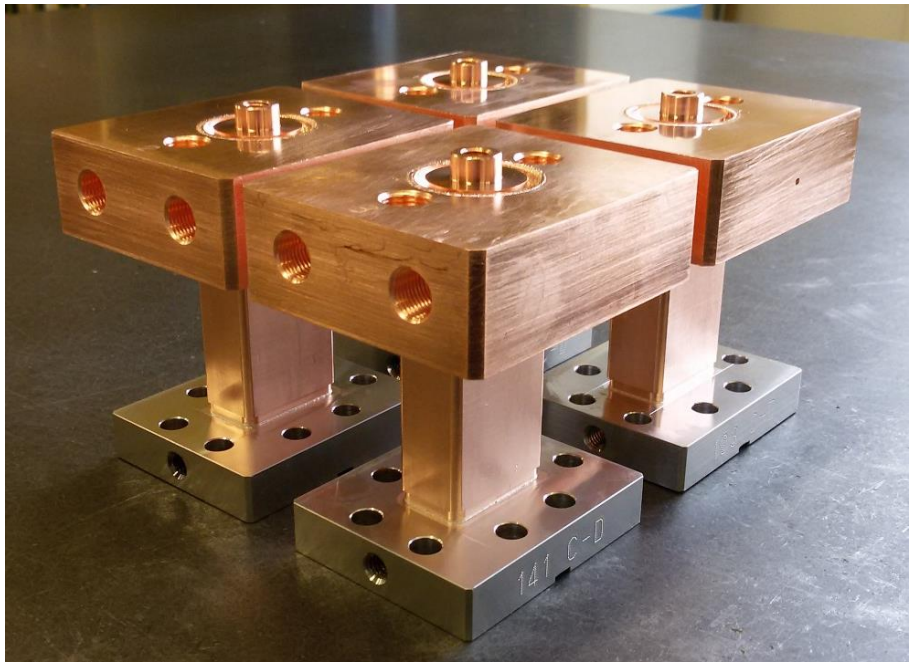


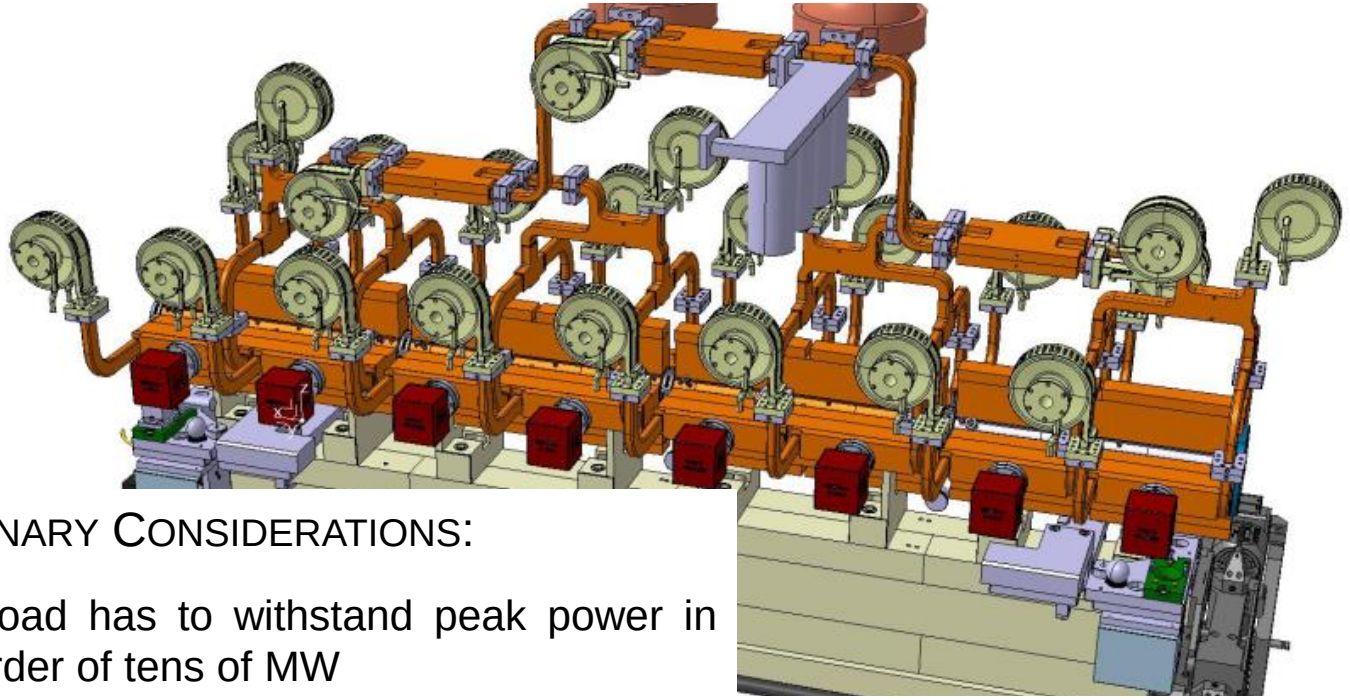
RF Terminator: compact RF load from SiC

A. Grudiev, Y. Cuvet, C. Serpico, N. Shafqat

HG2018, Shanghai, June 2018

MOTIVATION

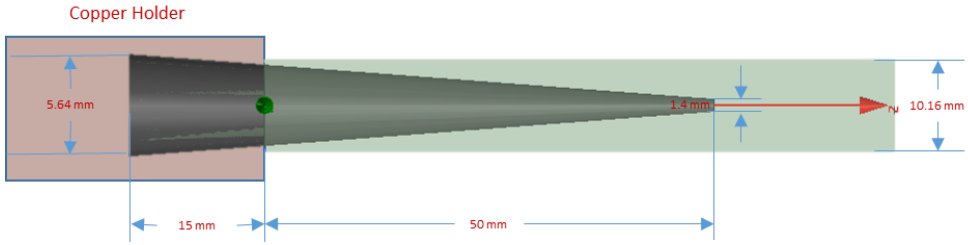
In the CLIC klystron-based solution, each module comprises **8 hybrids**. **Each hybrid** has to be equipped with a **load** which, in case of arcing, will absorb part of the power traveling back to the klystron.



PRELIMINARY CONSIDERATIONS:

- The load has to withstand peak power in the order of tens of MW
- If installed on the 4th port of an hybrid, very low average power will be dissipated
- The RF design should be easily scalable in order to handle higher average power

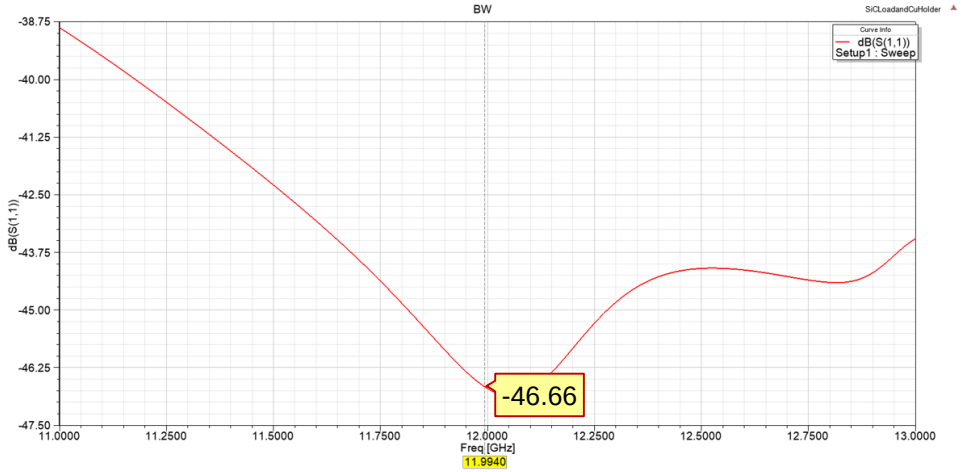
RF DESIGN

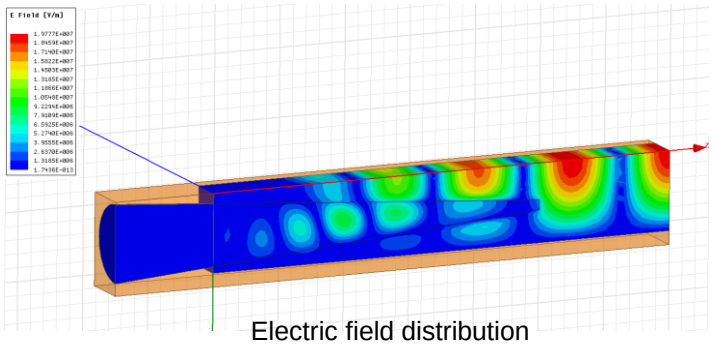


- 2 EKasicP cones are placed in a standard rectangular waveguide.
- A water cooling channel is machined in the holding plate.

This design can be easily scaled. For example, if we intend to double the power we can move to a double-height rectangular waveguide

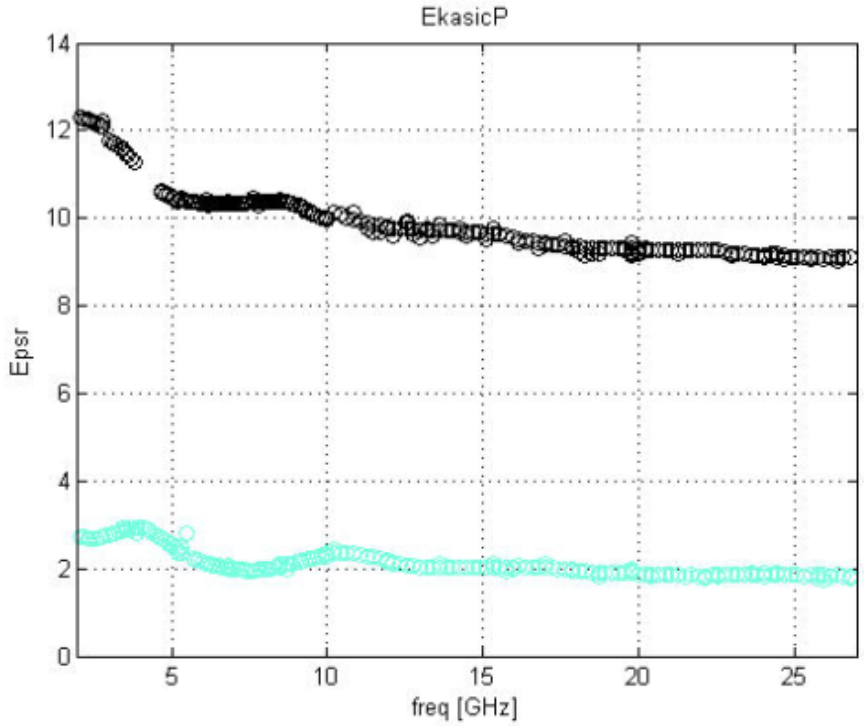
BANDWIDTH





Electric field distribution

MATERIAL PROPERTY



Ref.: G. De Michele, Wakefield Simulations and Measurements for the CLIC RF Accelerating Structure, PhD Thesis, 2014

Relative permittivity for CerasicB1, EkasicF and EkasicP measured with the transmission method.

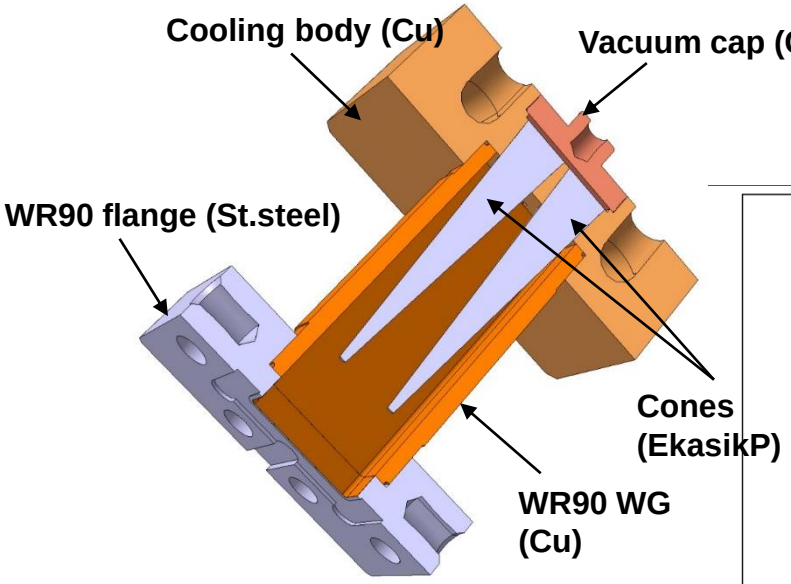
Black circles: real part; blue circles: imaginary part.

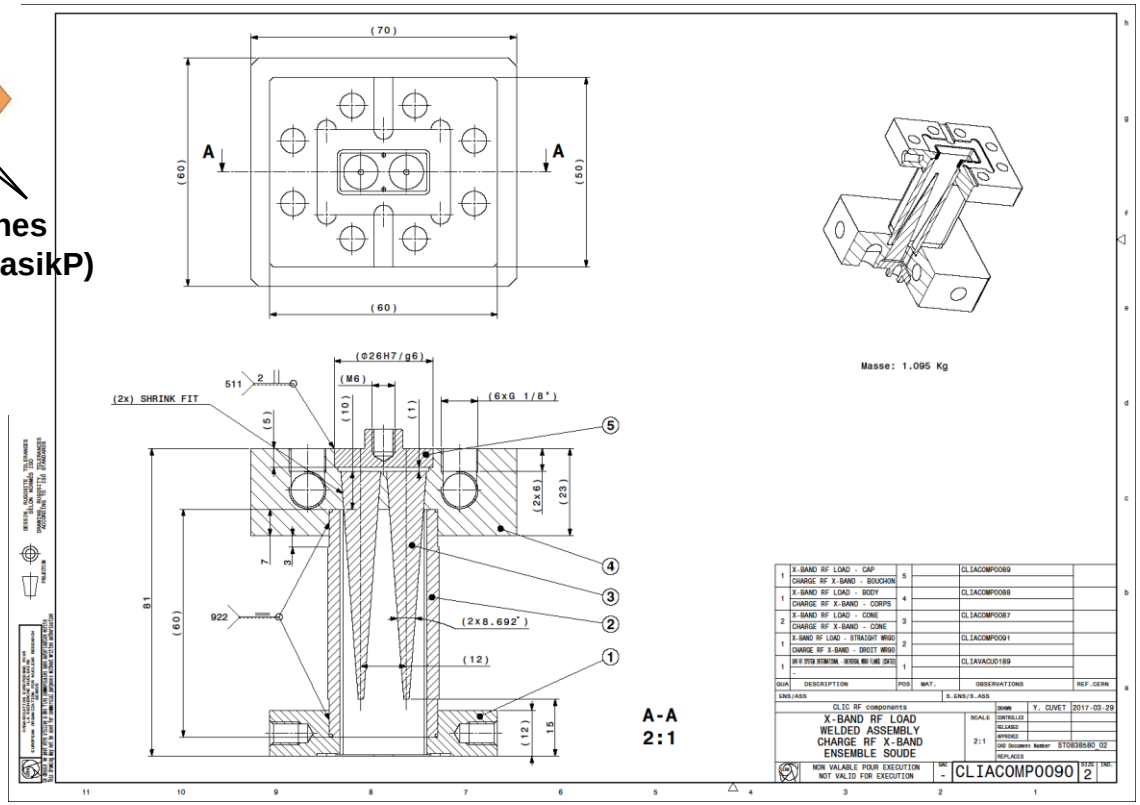
EkasicP material has been chosen as absorbing material

EkasicP Material Properties

f_0	12	GHz
$Re\{\varepsilon_r\}$	10	
tanδ	0.2	

MECHANICAL DESIGN

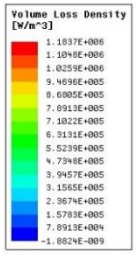




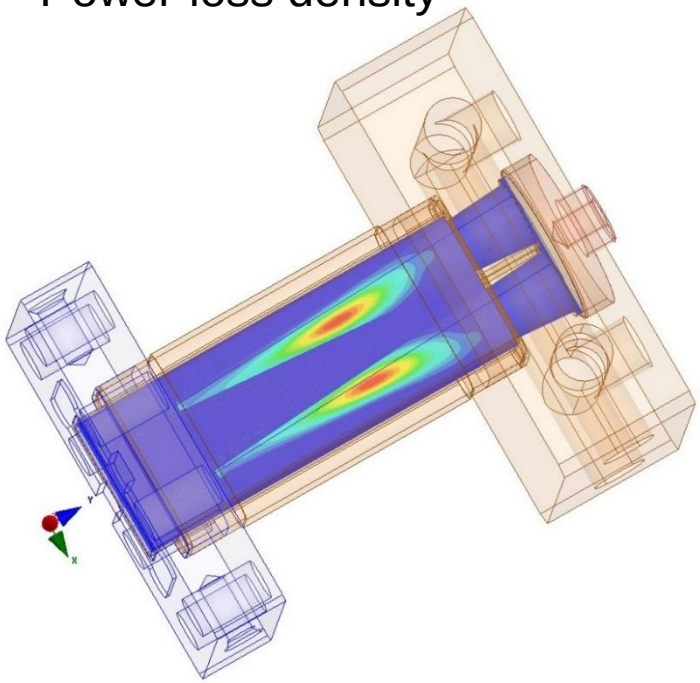
- Compact design
- Just 6 pieces
- Shrink fit cones technology
- Brazing/shrink fit in the same operation
- Simplified cooling

HEAT LOAD

Ansys HFSS simulation with 150w RF load



Power loss density



RF Power Dissipation

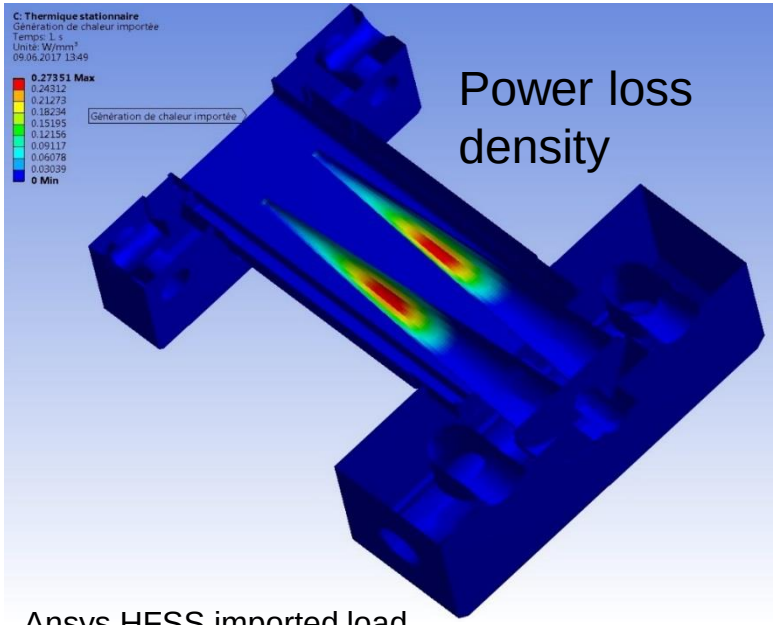
Structure	CLIC-G	CLIC-G*	CLIC380	Klystron (K)
f_{rep} [Hz]	50	50	50	50
Efficiency: η [%]	27.7	28.5	39.8	38.7
Rise time: tr [ns]	22.4	22	13.1	20.3
Filling time: tf [ns]	62.9	65.5	55.4	62.7
Efficient beam loading time: tb [ns]	155.5	155.5	175.5	242
Pulse length: tp [ns]	240.8	243	244	325
P_{in} [MW]	63.8	62.3	59.7	41.7
$P_{out}^{unloaded}$ [MW]	29.7	26.5	27.6	17.9
P_{out}^{loaded} [MW]	11.9	9.76	6.2	4.5
P_{beam} [MW]	27.367	27.747	33.035	21.673
Thermal dissipation [W]: $<P_{dissipated}^{unloaded}>$, $<P_{dissipated}^{loaded}>$	410.564, 336.181	434.970, 349.394	391.620, 289.526	386.750, 286.649
Mean power in the load [W]: $<P_{load}^{unloaded}>$, $<P_{load}^{loaded}>$	357.588, 219.193	321.975, 191.822	336.720, 148.935	290.875, 128.735
Mean power to the beam: $<P_{beam}>$ [W]	212.778	215.729	289.879	262.241

X. X. Huang 5/04/17

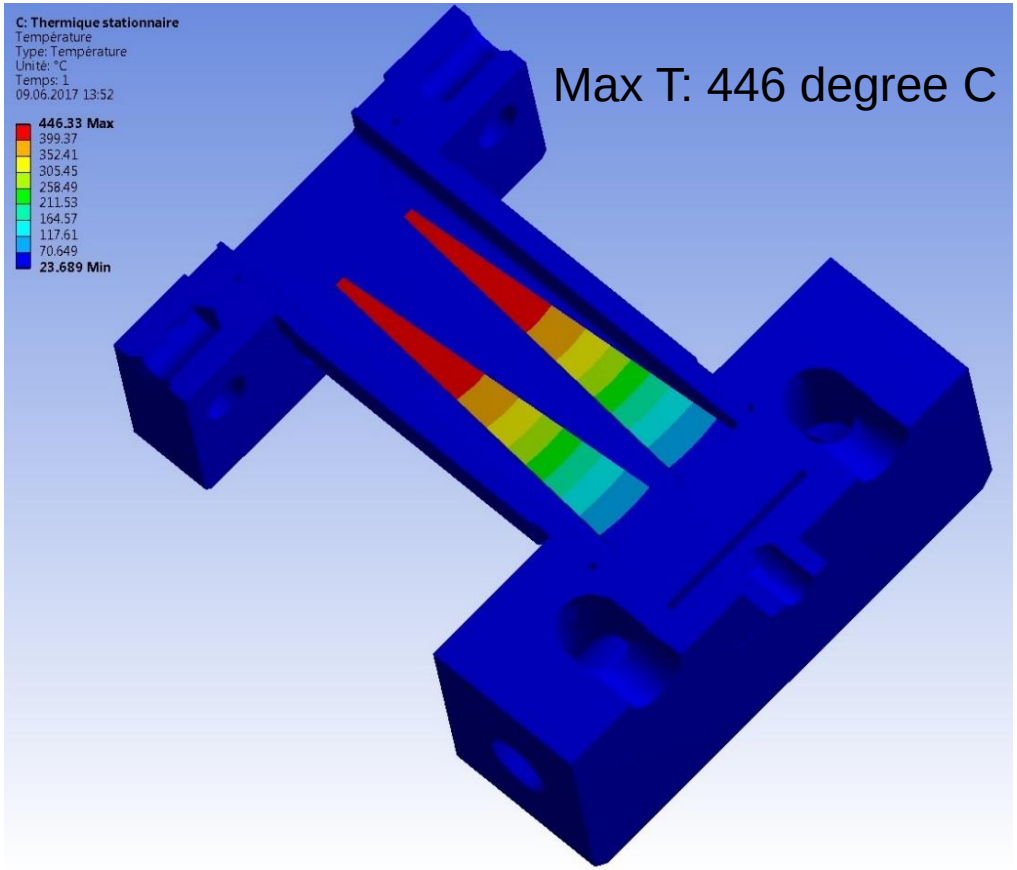
CLIC Implementation Civil Engineering and Infrastructure - 5th May2017 10

Power for 1 structure (2 loads)

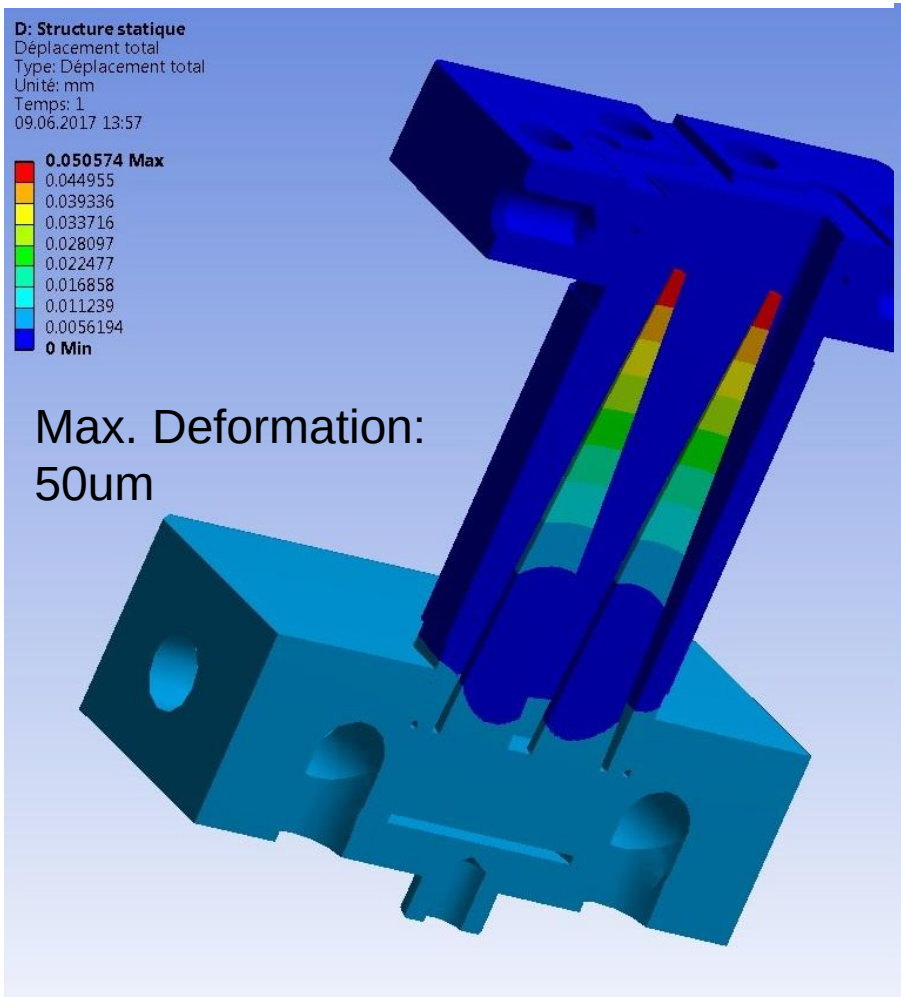
Static Thermal simulation for 150 W average input power

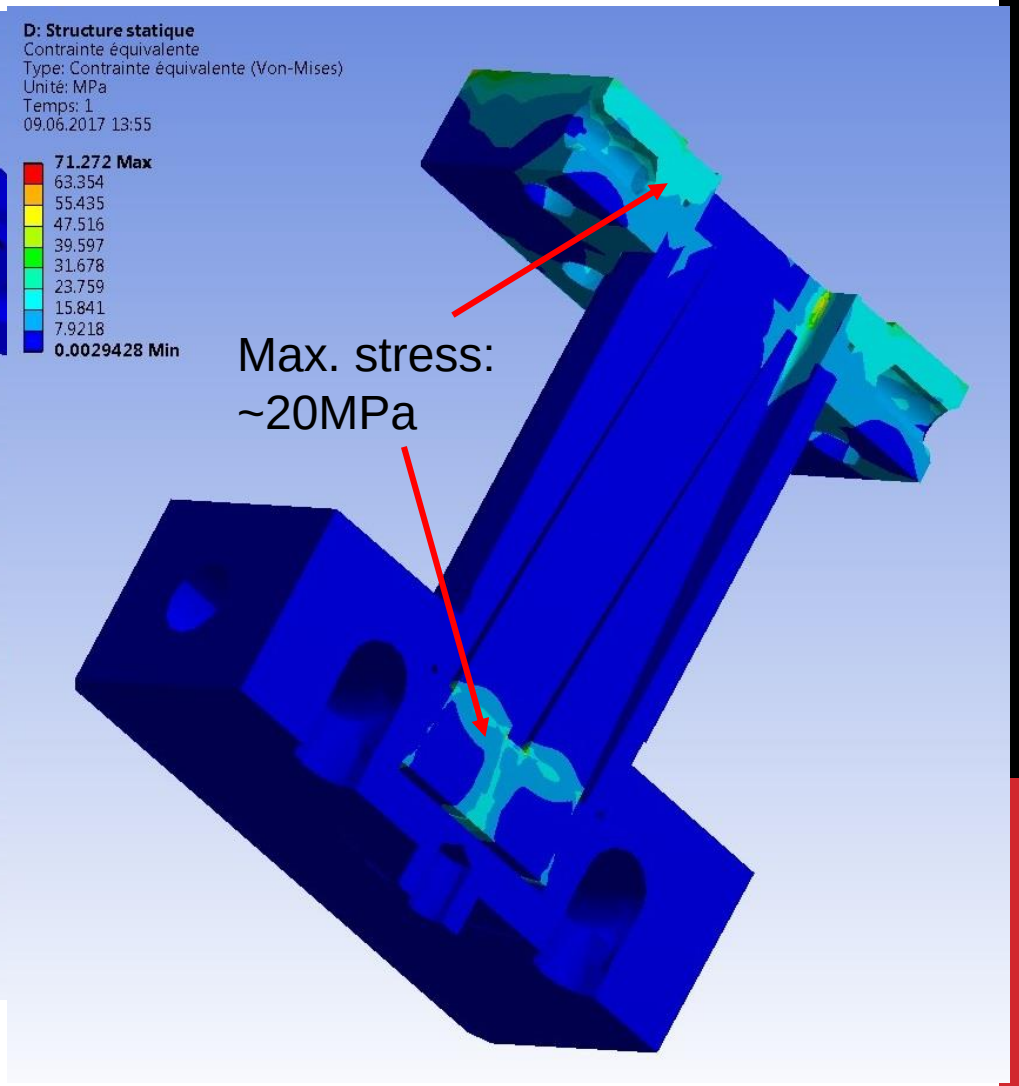


Ansys HFSS imported load

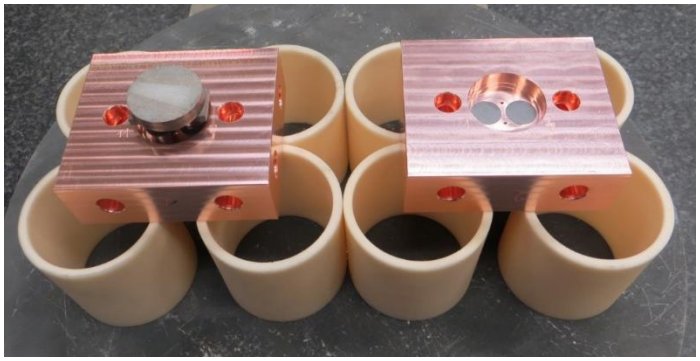


Static Strutural simulation





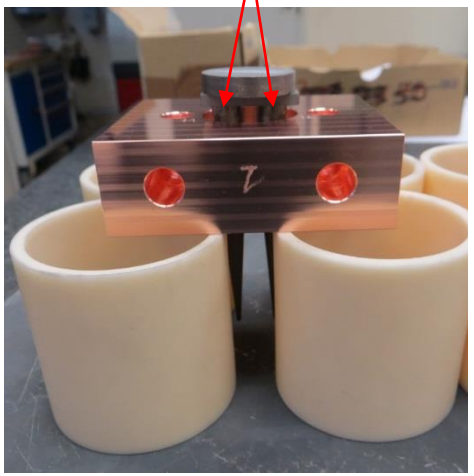
Schrink fit test samples



2 samples:

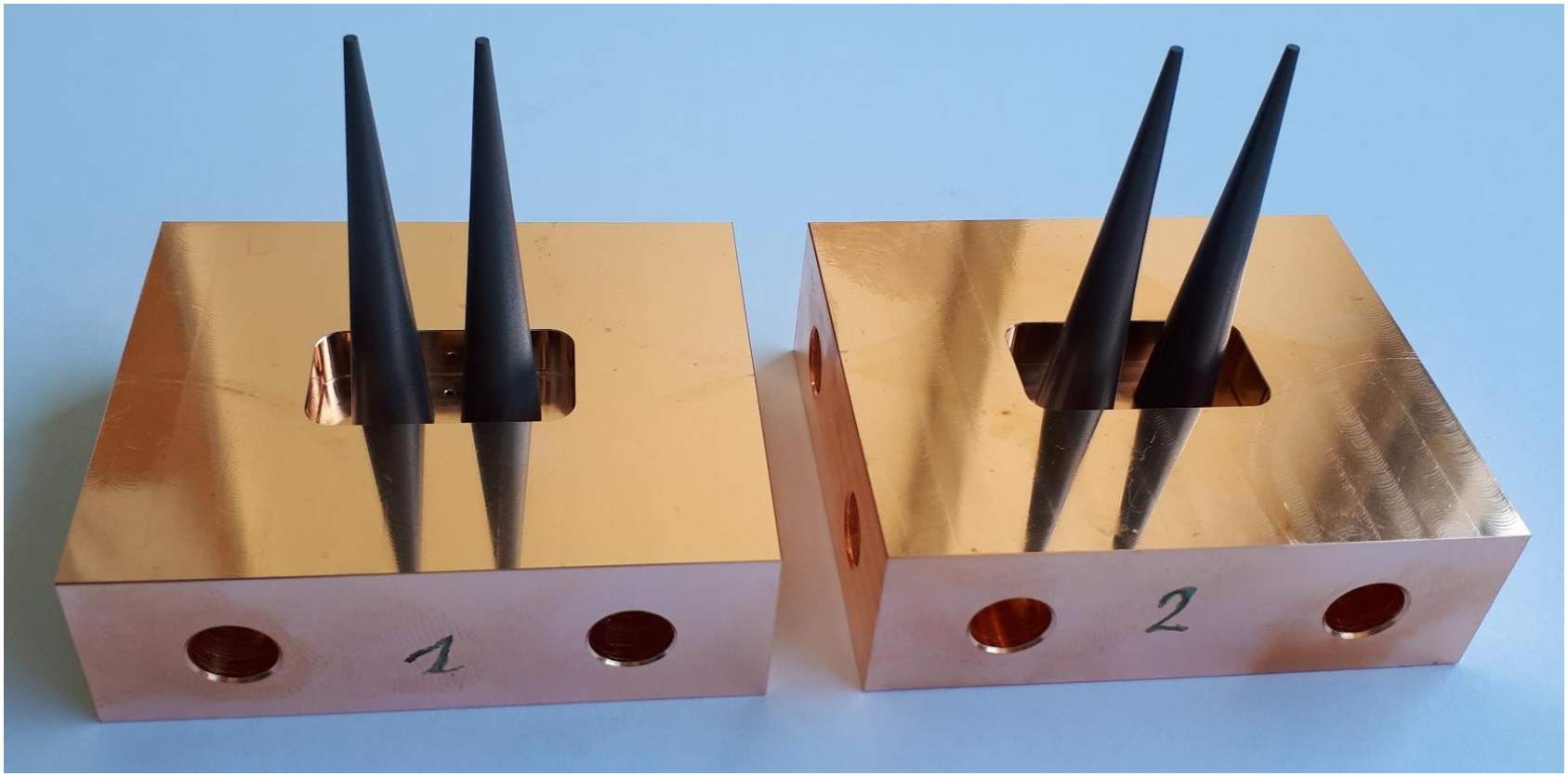
- **1 with cones «MICROPIERRE» supplier**
- **1 with cones «CERATEC» supplier**

Tungstène mass



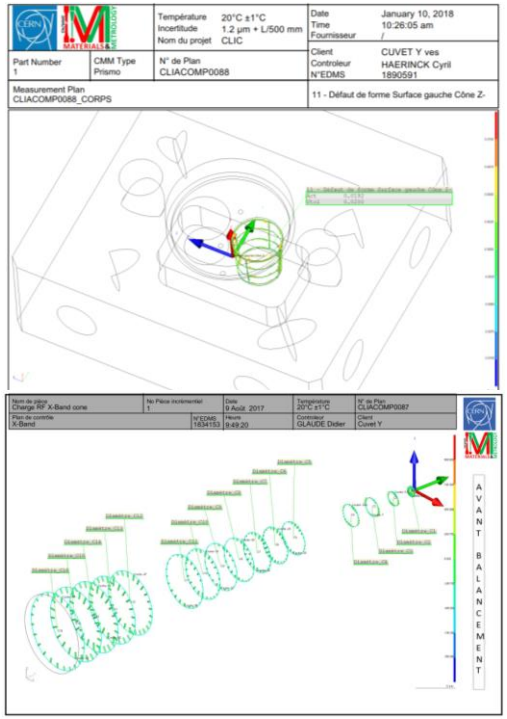
Tooling for shrink fit

Results of the shrik fit test- OK



No breaks on cones!

4 prototypes manufacturing steps



Metrology body/cone

Brazing/shrink fit
(815°C/5 min.)

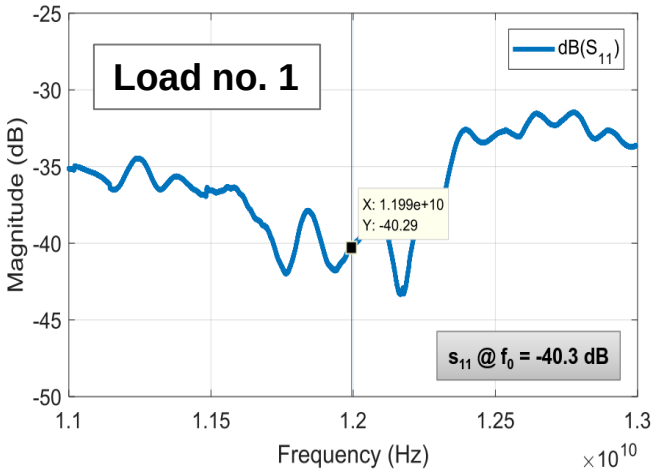
EB welding vacuum cap

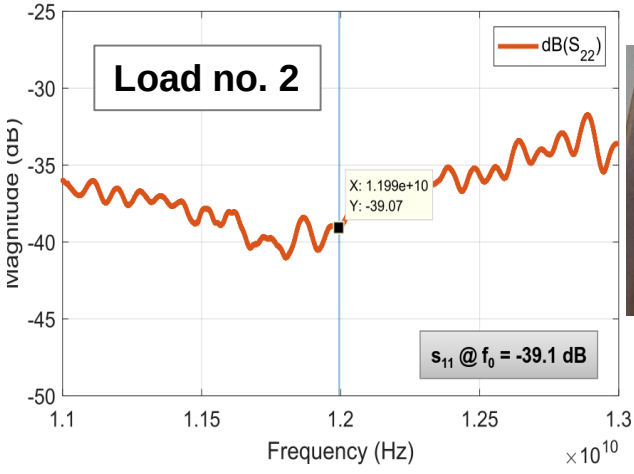
4 prototypes manufactured

«MICROPIERRE» supplier

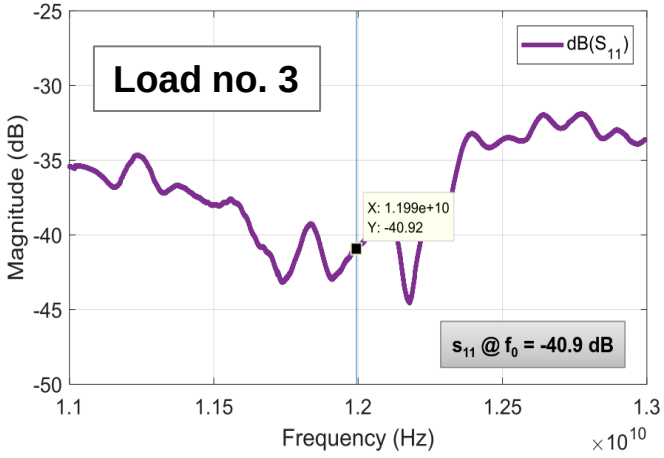
«CERATEC» supplier

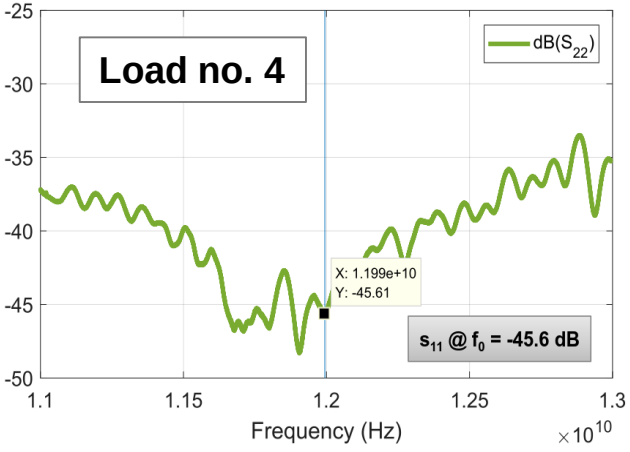
RF COLD TESTS





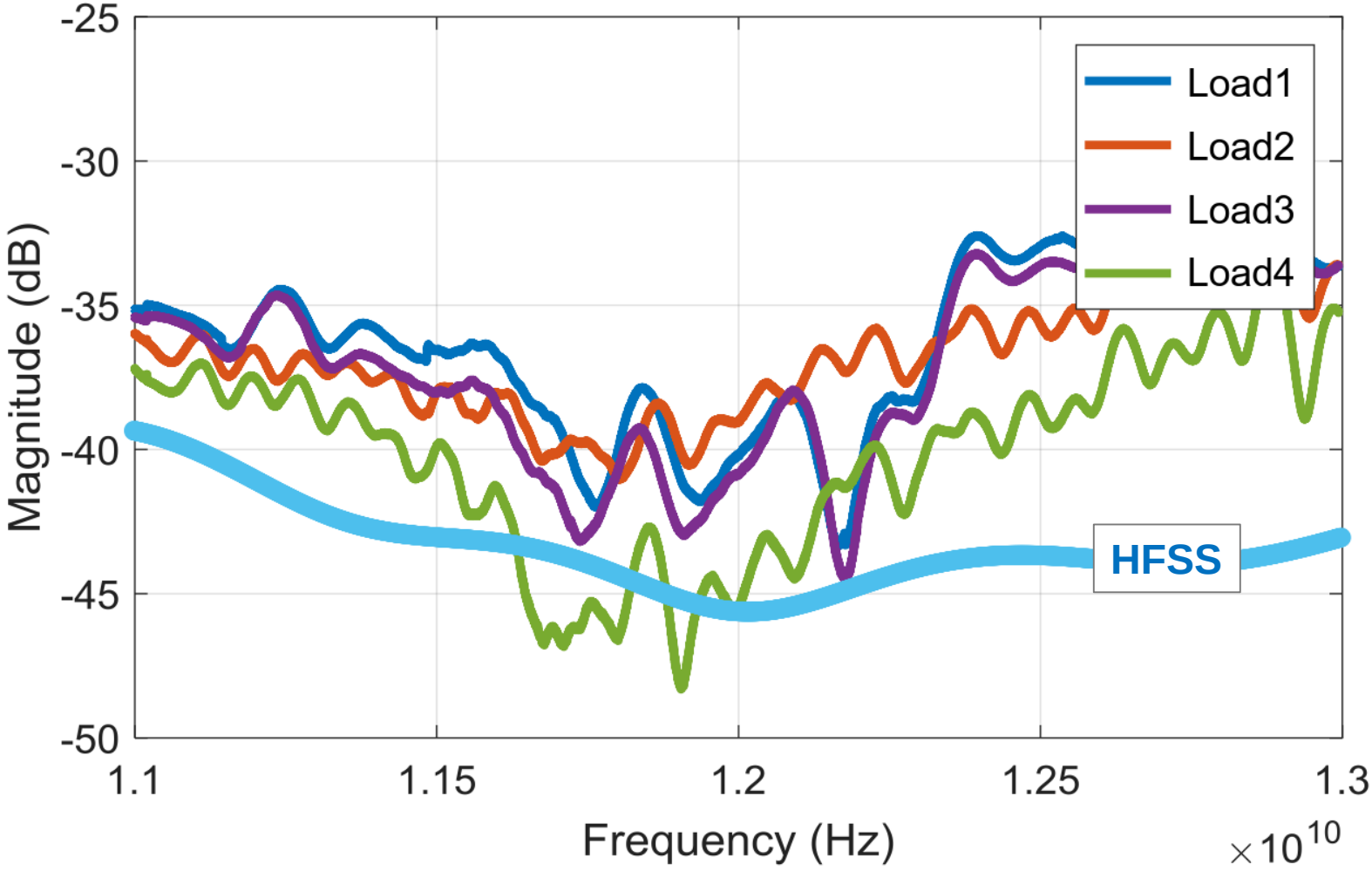
RF Terminators in the lab for the measurements. Each load is labelled





Load no.	S_{11} @ f_0 [dB]
1	-40.4
2	-39.1
3	-41.9
4	-45.6

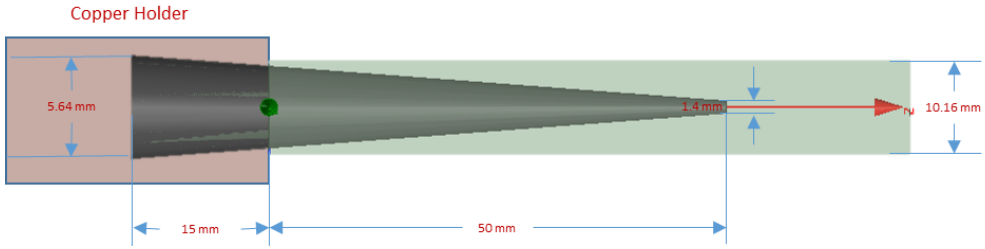
COMPARISON


-25
-30
-35
-40
-45
-50
Magnitude (dB)
1.1
1.15
1.2
1.25
1.3
Frequency (Hz)
×10^10
Load1
Load2
Load3
Load4
HFSS

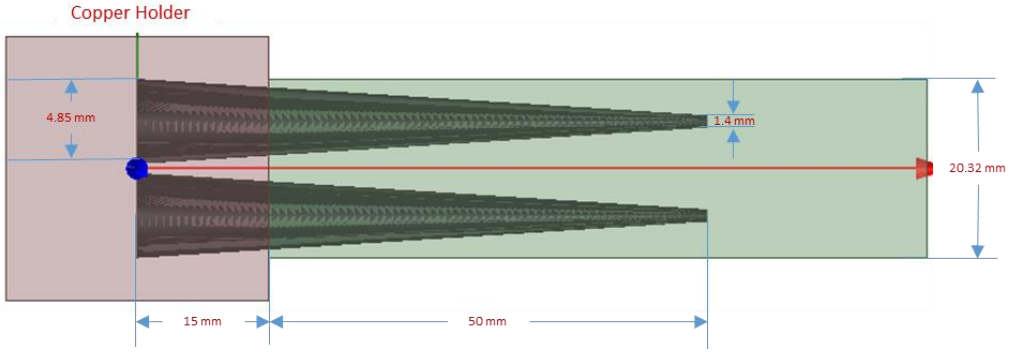
DOUBLE-HEIGHT WAVEGUIDE DESIGN

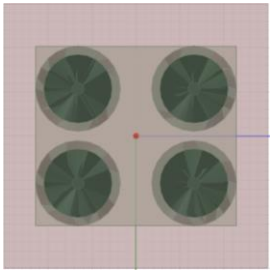
In order to double the power handling capability, the height of the waveguide can be simply doubled to host 4 cones

STANDARD WR90



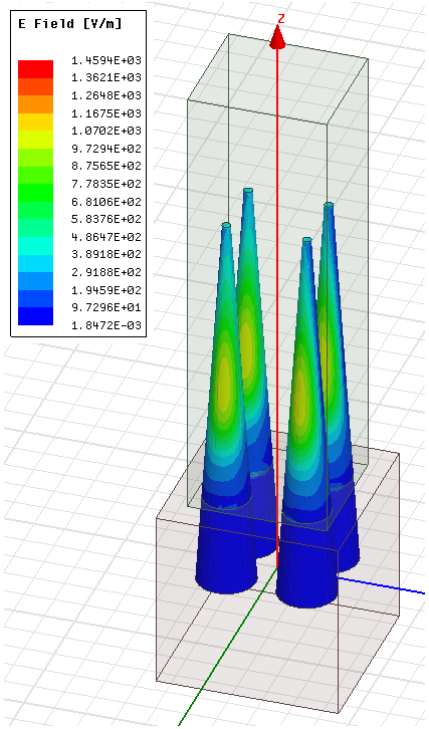
DOUBLE-HEIGHT WR90



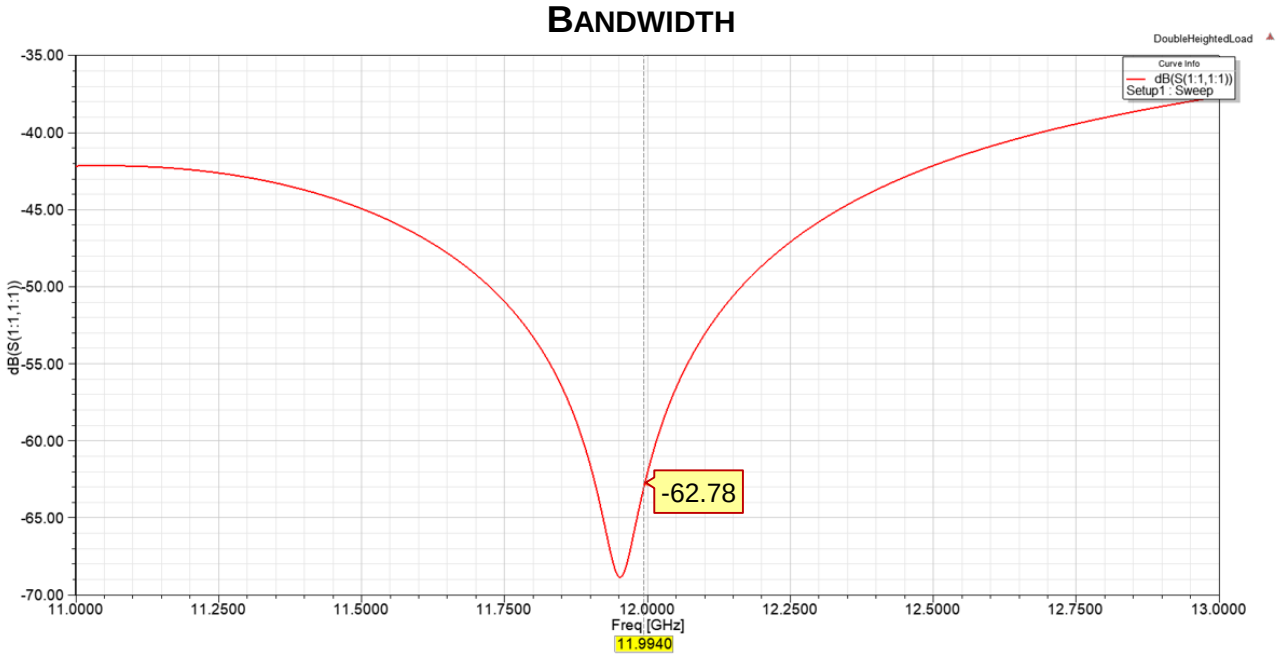


- Diameter of the base has been reduced to fit in the copper holder.
- Diameter of the tip has not been changed.
- Length of the cones has not been changed.

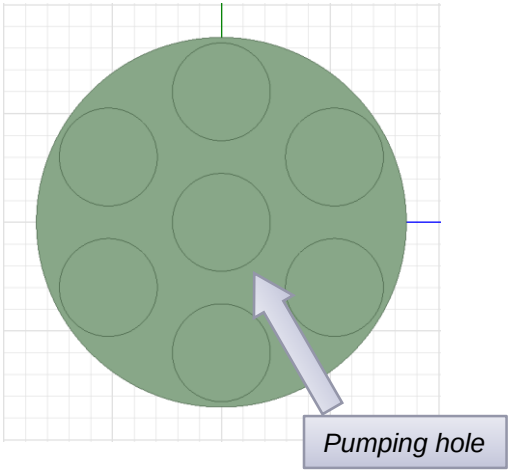
DOUBLE-HEIGHT WAVEGUIDE DESIGN



Electric field distribution

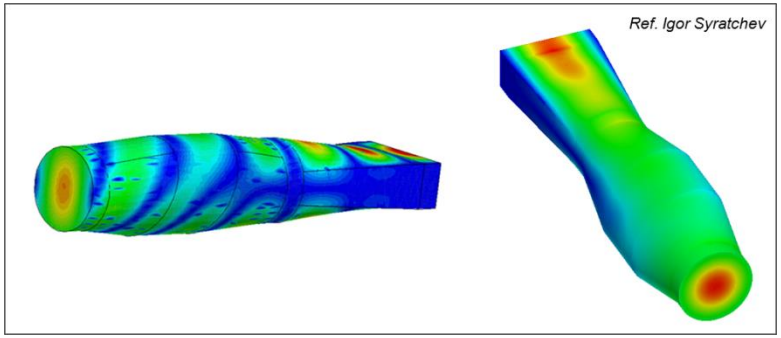


NOVEL RF DESIGN

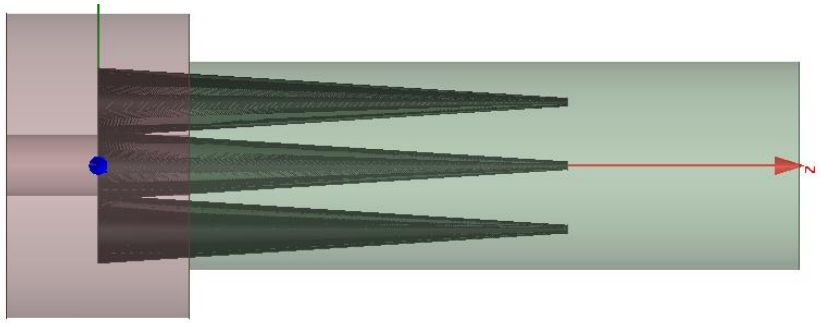


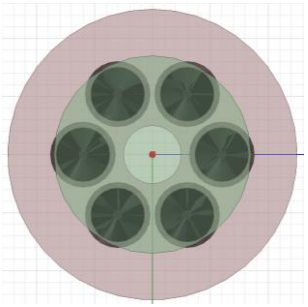
Solution		
Number of cones	6	
Radius circular waveguide	17	mm

- A circular waveguide will host 6 cones.
- A mode conversion, from TE_{10} (rectangular wg) to rotating TE_{11} (circular wg), is necessary to get a more uniform distribution of the fields.
- A section of elliptical waveguide will be used to get the mode conversion

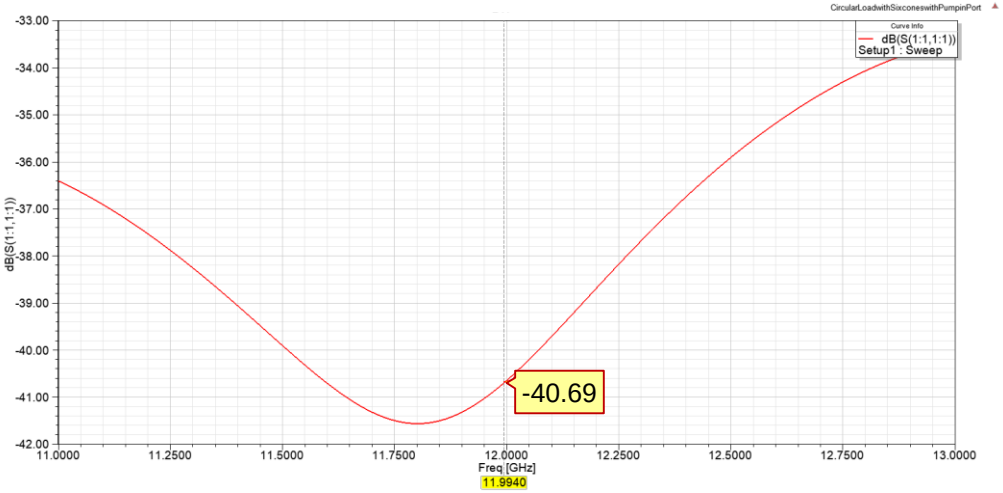


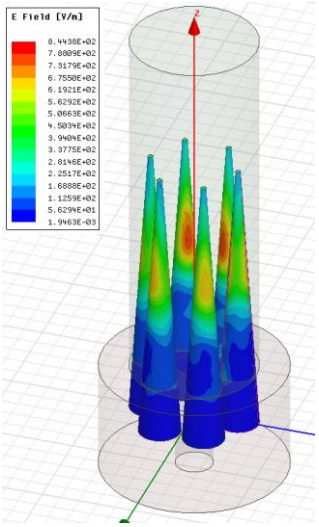
NOVEL RF DESIGN





BANDWIDTH





CONCLUSION

- 4 RF terminators (with 2 EkasicP cones) have been built and measured sucefully.
- High power tests shall be performed to prove the power handling capability of the RF terminators.