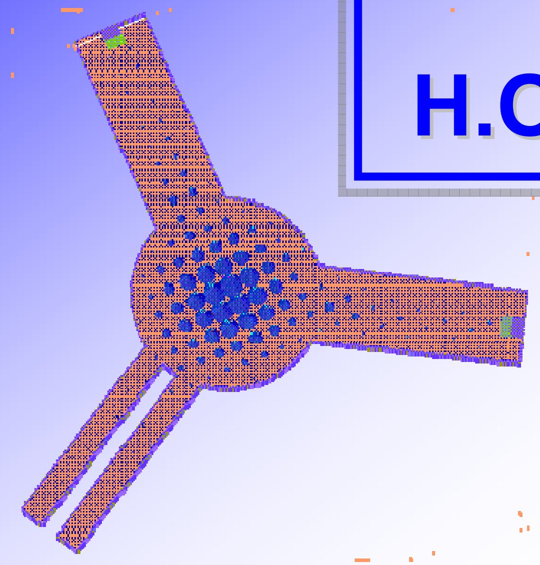
E.S.L.S Radio Frequency Meeting
Aarhus, DENMARK – Sept 2005

SIMULATION OF : H.O.M DAMPED CAVITIES



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ESRF

Grenoble - FRANCE

TARGET OF SIMULATIONS AT E.S.R.F

DEVELOPPING A PROTOTYPE OF NORMAL CONDUCTING CAVITY *(at 352.2 MHz)*
TO ATTENUATE HIGHER ORDER MODES WITH RIDGE WAVEGUIDE DAMPERS
<u>INCLUDING FERRITE</u>

BASED ON R&D OF
*"**<u>EU PROJECT</u>**"*

DELTA

MAX-lab

BESSY

SRS DARESBURY LABORATORY

國立清華大學
National Tsing Hua University
(NTHU)

SUMMARY

1- OPTIMISATION OF THE BODY *(Naked Cavity)*

2- OPTIMISATION OF THE FERRITE LOADED RIDGE WAVEGUIDE

3- SIMULATION OF THE GLOBAL CAVITY : BODY + 3 DAMPERS

4- COMPARISON : MAFIA / GDFIDL FOR SIMULATION OF
THE BESSY II CAVITY *(a design which doesn´t use Ferrite)*

1 - FIRST STEP : OPTIMIZATION OF THE BODY*

- *Superfish (2D) calculates Eigenvalues and main parameters of RF symmetrical cavities*
- *GDFIDL (3D) is used as Eigenvalue or Time domain solver for arbitrary RF structures*

TYPE OF CAVITY	SIMULATION TOOLS	f_{RF} (MHz)	Q	R/Q (Ohms)	R (k Ohms)
Scaled BESSY II Cavity Optimised	SUPERFISH	352.222	49844	148.981	7426
	GDFIDL	352.171	51180	149.140	7633
Scaled BESSY II Cavity Not Optimised	SUPERFISH	352.078	46039	128.196	5902
LEP Model Cavity / ESRF	URMEL *[Dr H.Henke / Dr T.Weiland - 1984]*	353.5	47300	142.4	6736
	SUPERFISH	352.182	47864	138.309	6620
BESSY II	MAFIA *[Dr F.Marhauser / Bessy - 2000]*	499.842	38018	128.139	4872
	SUPERFISH	499.726	38651	128.147	4953
	GDFIDL	499.256	40553	128.535	5212

(PERFECT BODY WITHOUT HOLE)*

A- GDFIFL AS EIGENVALUE SOLVER FOR H.O.M STUDY OF THE BODY

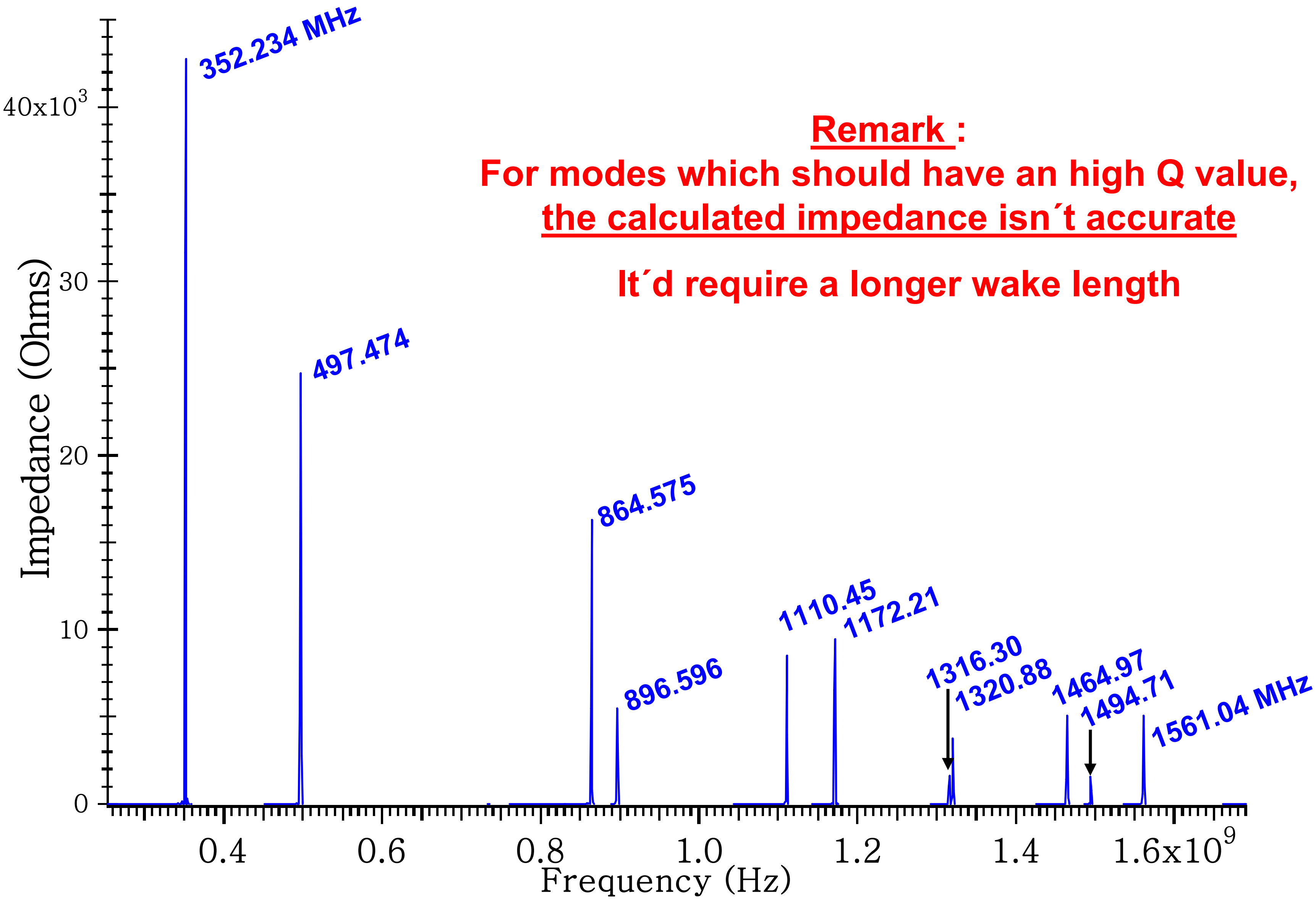
GDFIDL is a Finite Difference solver for the Maxwell and Helmholz equations.
Can be used as Eigenvalues or Time domain solver for arbitraries rf structures.

LIST OF THE MOST INFLUENTIALS LONGITUDINAL MODES TILL 1.3 GHz

MODE TYPE	FREQUENCY (MHz)	Q	R (kΩ)	R/Q (Ω)
0-E-1	352.171	51180	7633	149
0-M-1	498.524	42533	554	13
0-M-2	865.408	40758	109	3
0-E-3	896.959	94489	586	6
0-E-4	1111.37	50231	418	8
0-M-3	1173.40	82536	490	6

- ✓ *Conditions : simulation of half cavity with electric or magnetic boundary for a meshing of 2 mm.*
- ✓ *Notations : m-E-n or m-H-n, m for azimuthal dependency, n as sequential index.*

B- GDFIDL AS FINITE DIFFERENCES IN TIME DOMAIN SOLVER (FDTD) FOR THE BODY



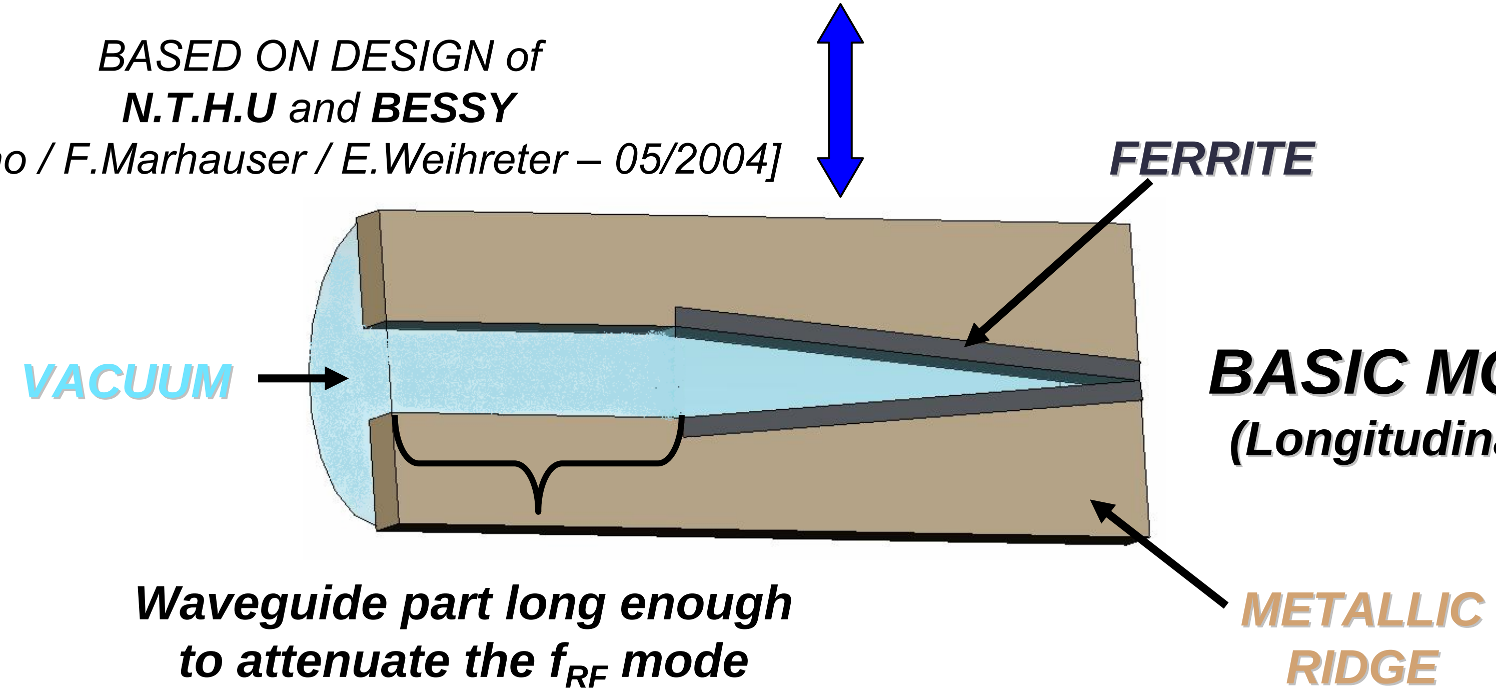
✓ ***Conditions : Simulation on only 200 meters of half the cavity with magnetic boundary for a meshing of 2 mm. (No offset on transverse plane)***

2 - SECOND STEP : OPTIMIZATION OF FERRITE LOADED RIDGE WAVEGUIDE

WITH 3D SIMULATION SOFT : ***High Frequency Structure Simulator (HFSS®)***

HFSS is based on a Finite Element Method with adaptive mesh refinement.
Eigenmodes of arbitrary RF strucutres are solved, including materials losses.

BASED ON DESIGN of
N.T.H.U *and* ***BESSY***
[P.Z Rao / F.Marhauser / E.Weihreter – 05/2004]

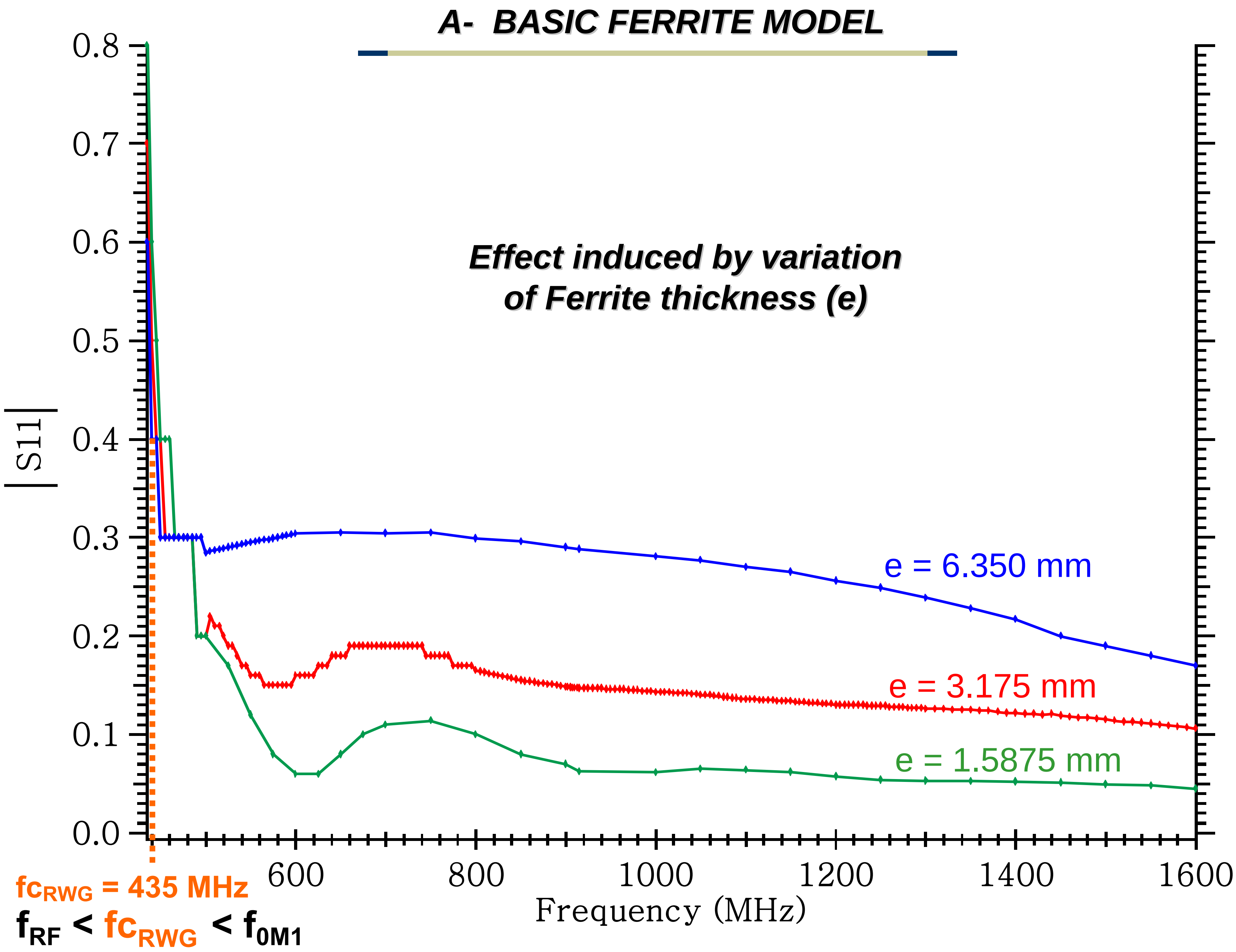


BASIC MODEL
(Longitudinal cut)

Waveguide part long enough to attenuate the f_{RF} mode

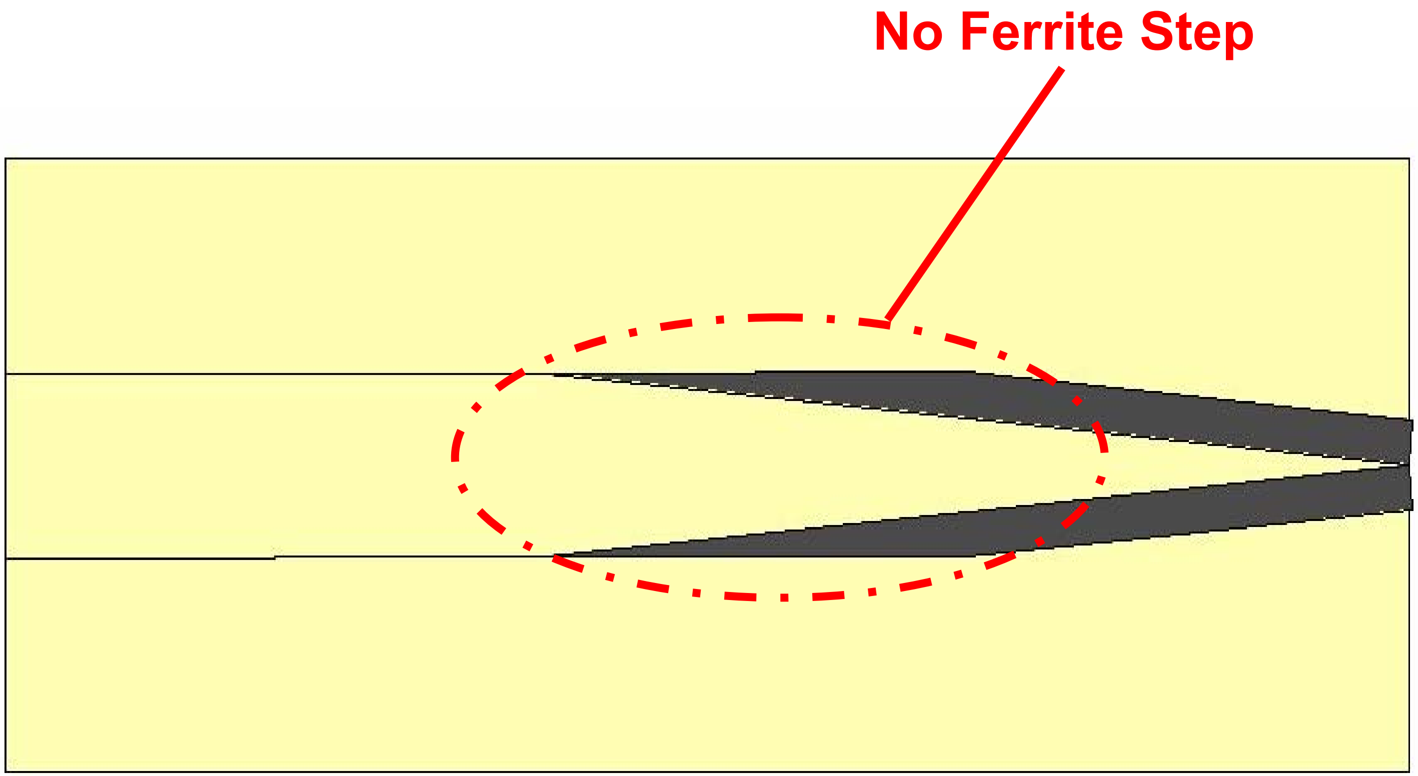
$$P/P_o = \exp\left[-(4.\pi.Z / \lambda).\left(1-(\lambda_c / \lambda)^2 \right)^{1/2} \right]$$

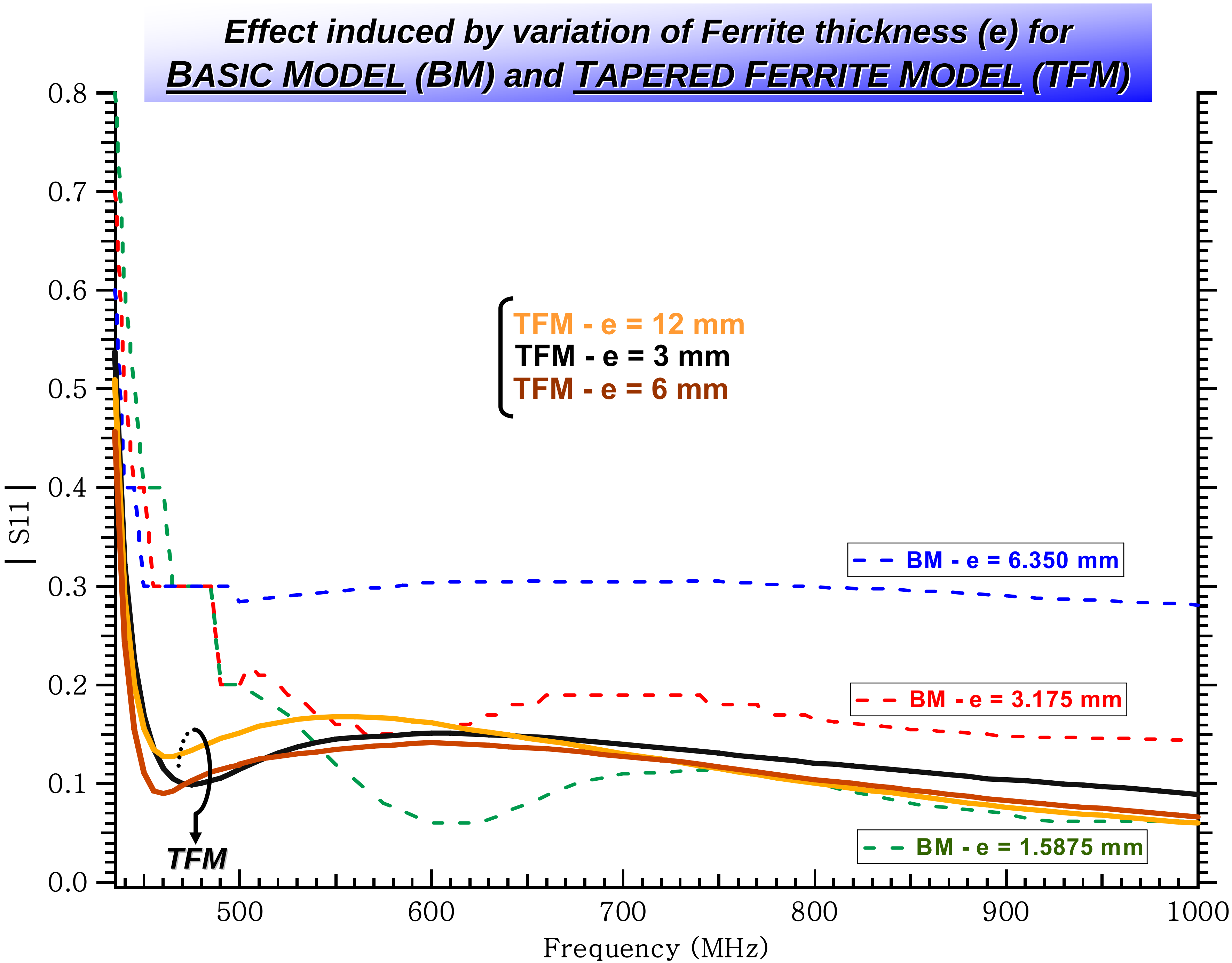
Here, for : $\begin{cases} z = 0.25\ m & \Rightarrow P/P_o \approx 0.07 \\ f_c = 435\ MHz \end{cases}$



A- BASIC FERRITE MODEL
Effect induced by variation
of Ferrite thickness (e)
|S11|
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
e = 6.350 mm
e = 3.175 mm
e = 1.5875 mm
600
800
1000
1200
1400
1600
Frequency (MHz)
fcRWG = 435 MHz
fRF < fcRWG < f0M1

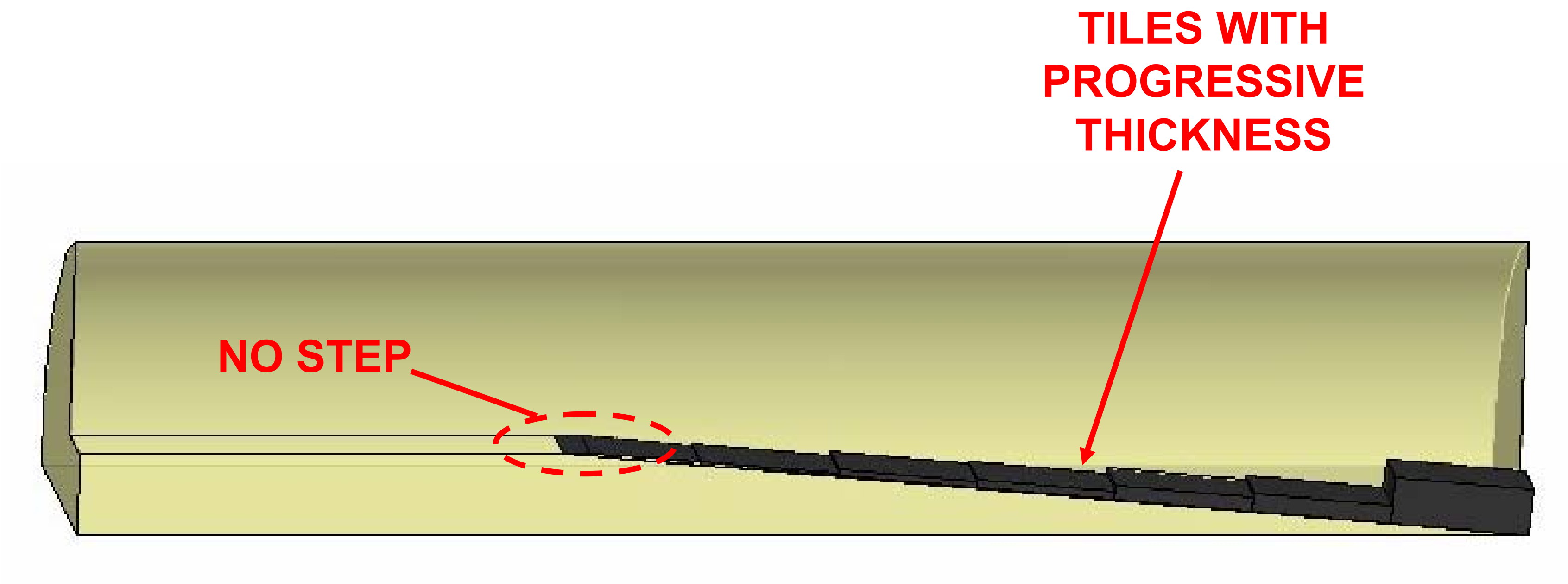
B- TAPERED FERRITE MODEL



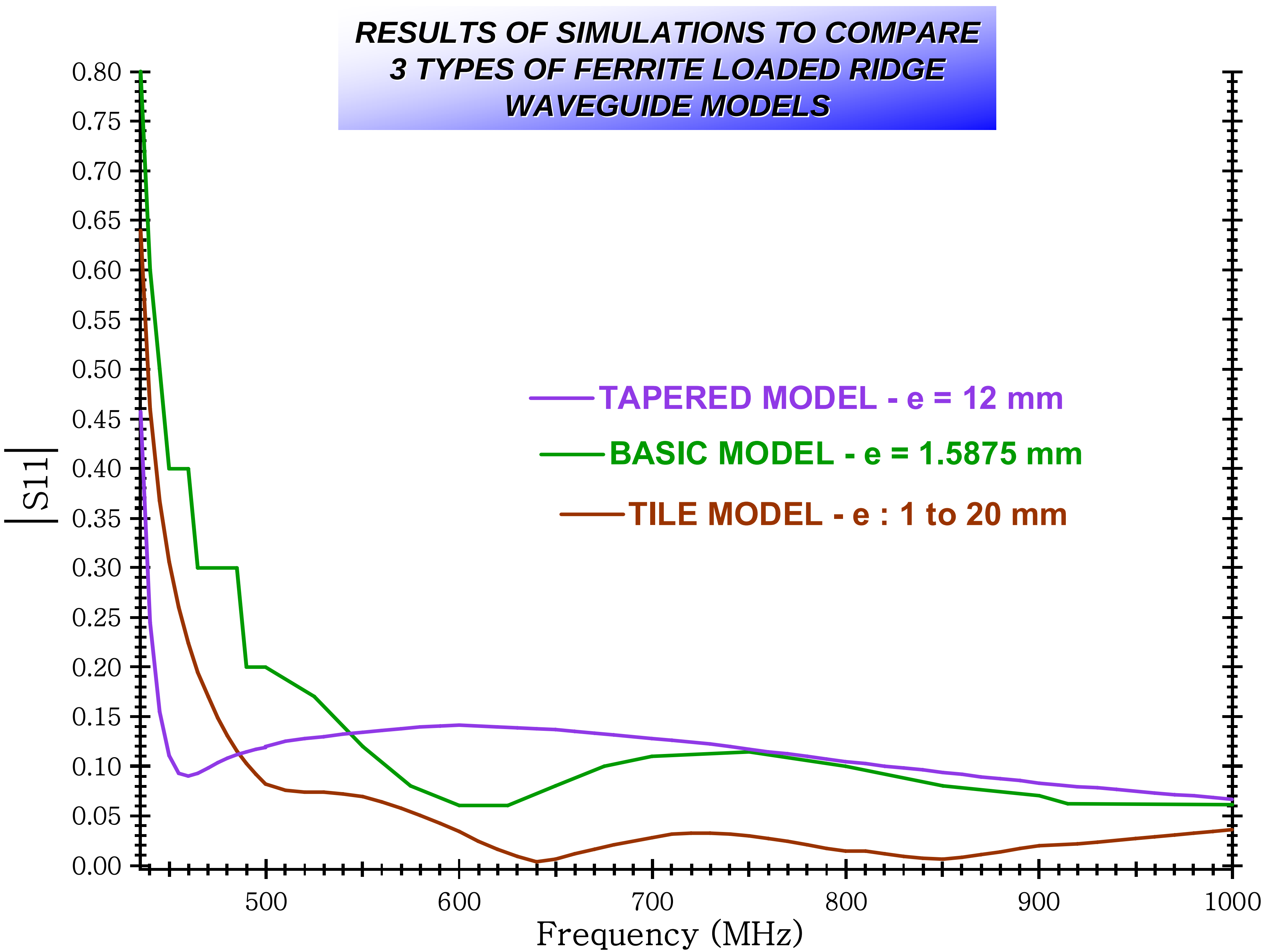


Effect induced by variation of Ferrite thickness (e) for
BASIC MODEL (BM) and TAPERED FERRITE MODEL (TFM)
TFM - e = 12 mm
TFM - e = 3 mm
TFM - e = 6 mm
BM - e = 6.350 mm
BM - e = 3.175 mm
BM - e = 1.5875 mm
TFM
| S11 |
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
500
600
700
800
900
1000
Frequency (MHz)

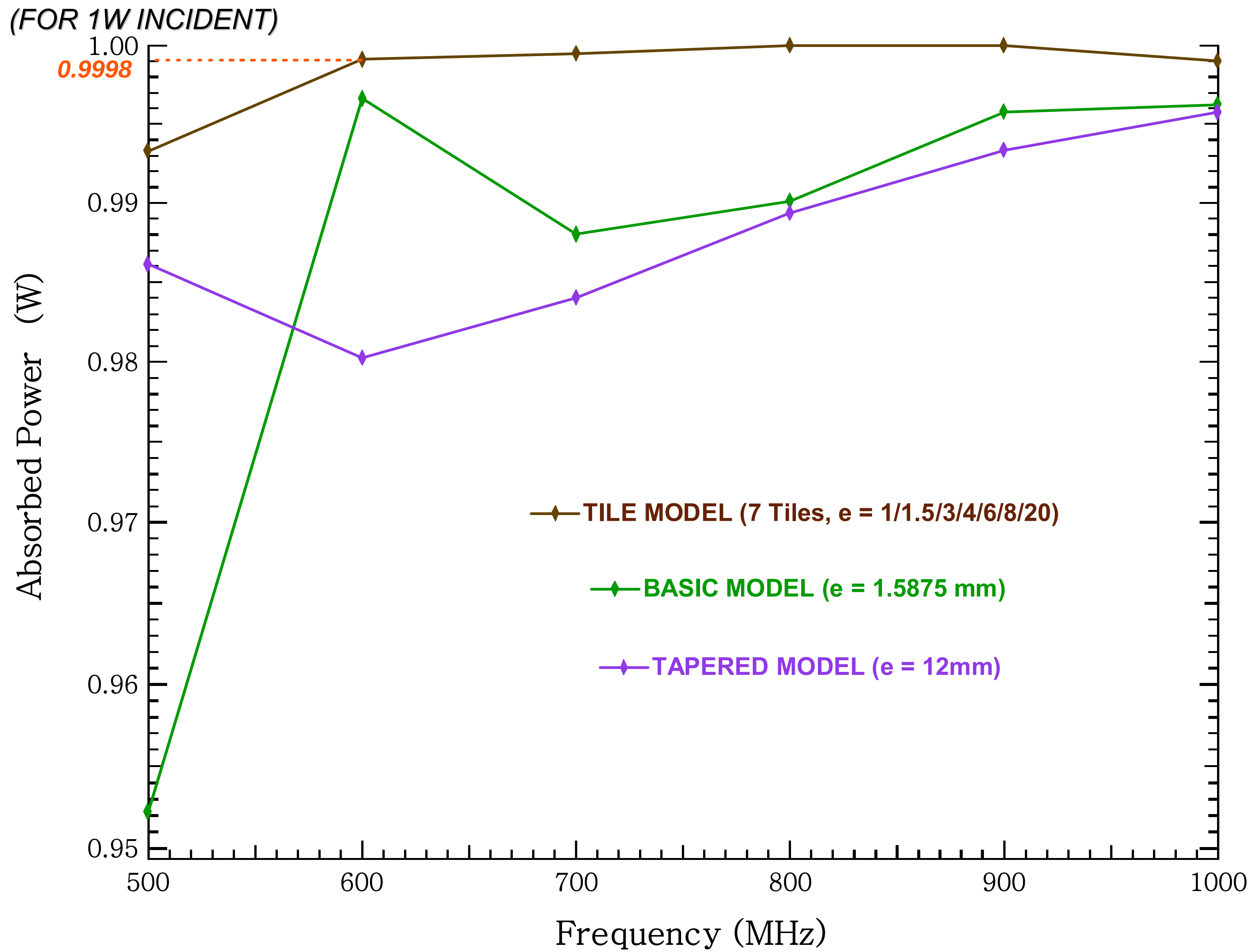
C- TILE FERRITE MODEL



⇒ TO OBTAIN AN HOMOGENEOUS REPARTITION OF THE ABSORBED POWER


RESULTS OF SIMULATIONS TO COMPARE
3 TYPES OF FERRITE LOADED RIDGE
WAVEGUIDE MODELS
TAPERED MODEL - e = 12 mm
BASIC MODEL - e = 1.5875 mm
TILE MODEL - e : 1 to 20 mm
|S11|
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
500
600
700
800
900
1000
Frequency (MHz)

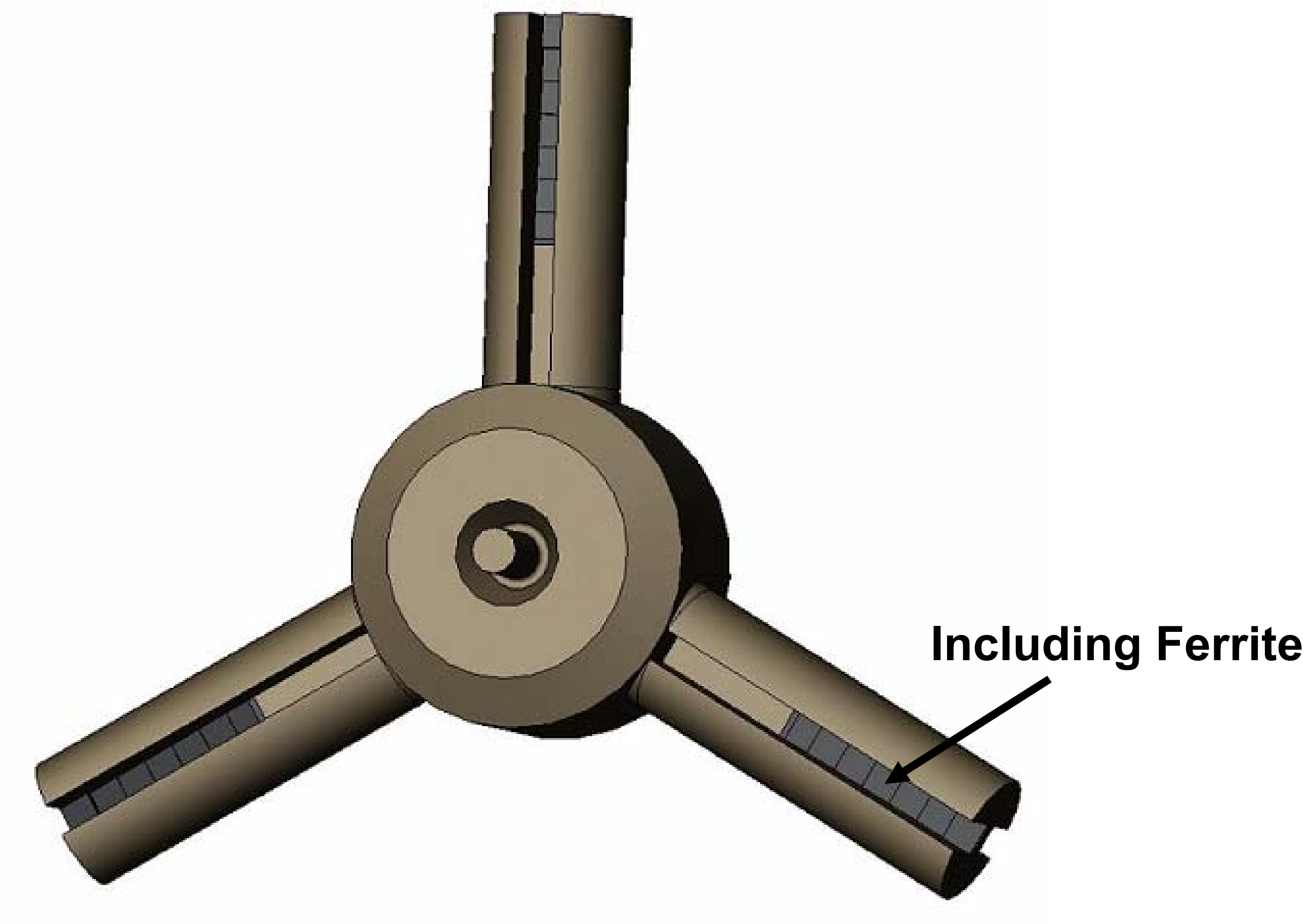
EVOLUTION OF DENSITY POWER ABSORBED BY FERRITE
FOR 3 MODELS : BASIC, TAPERED, TILE



3 - THIRD STEP : THE GLOBAL CAVITY

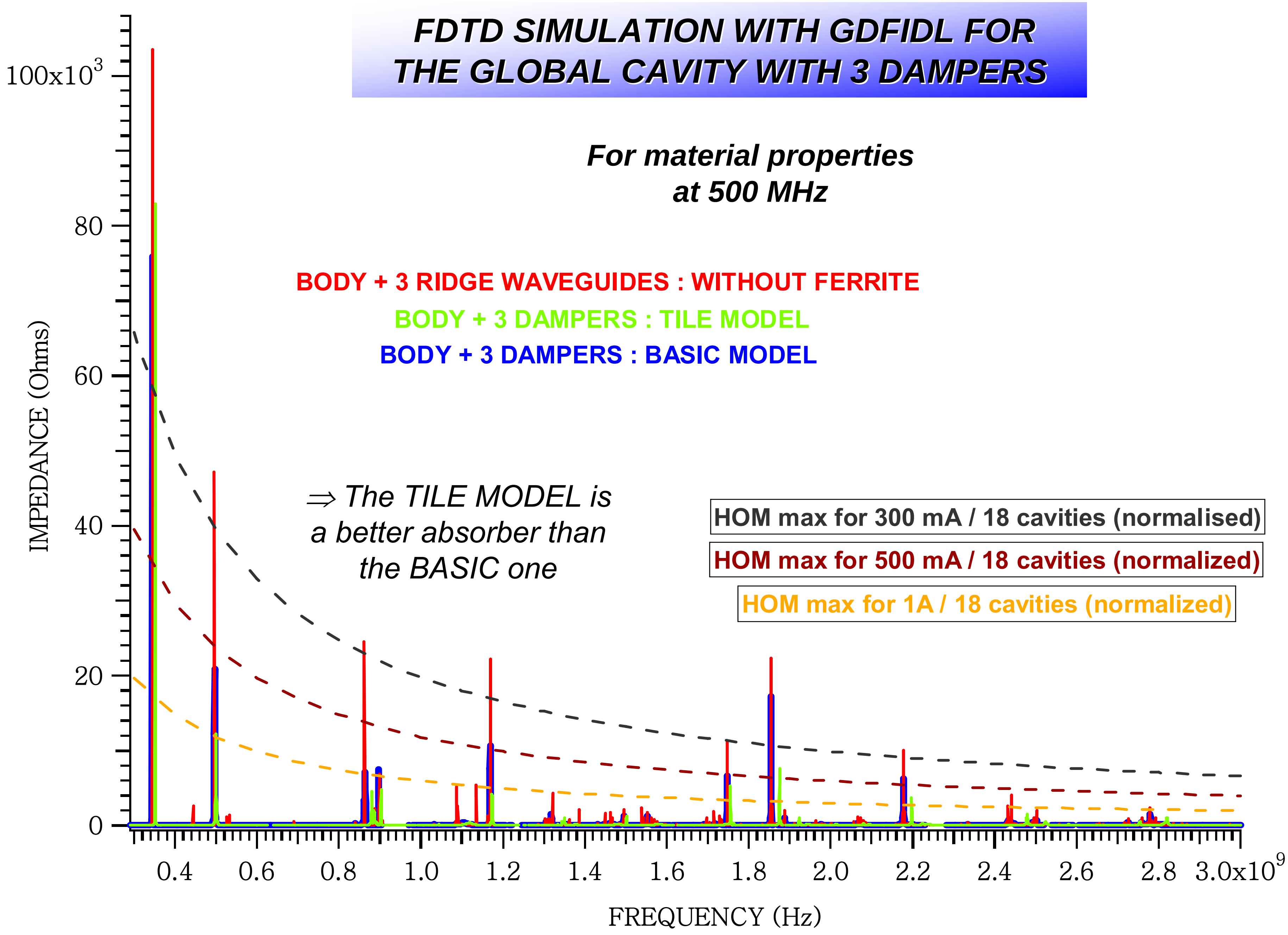
- Body + 3 Dampers -

⇒ ***With GDFIDL only***



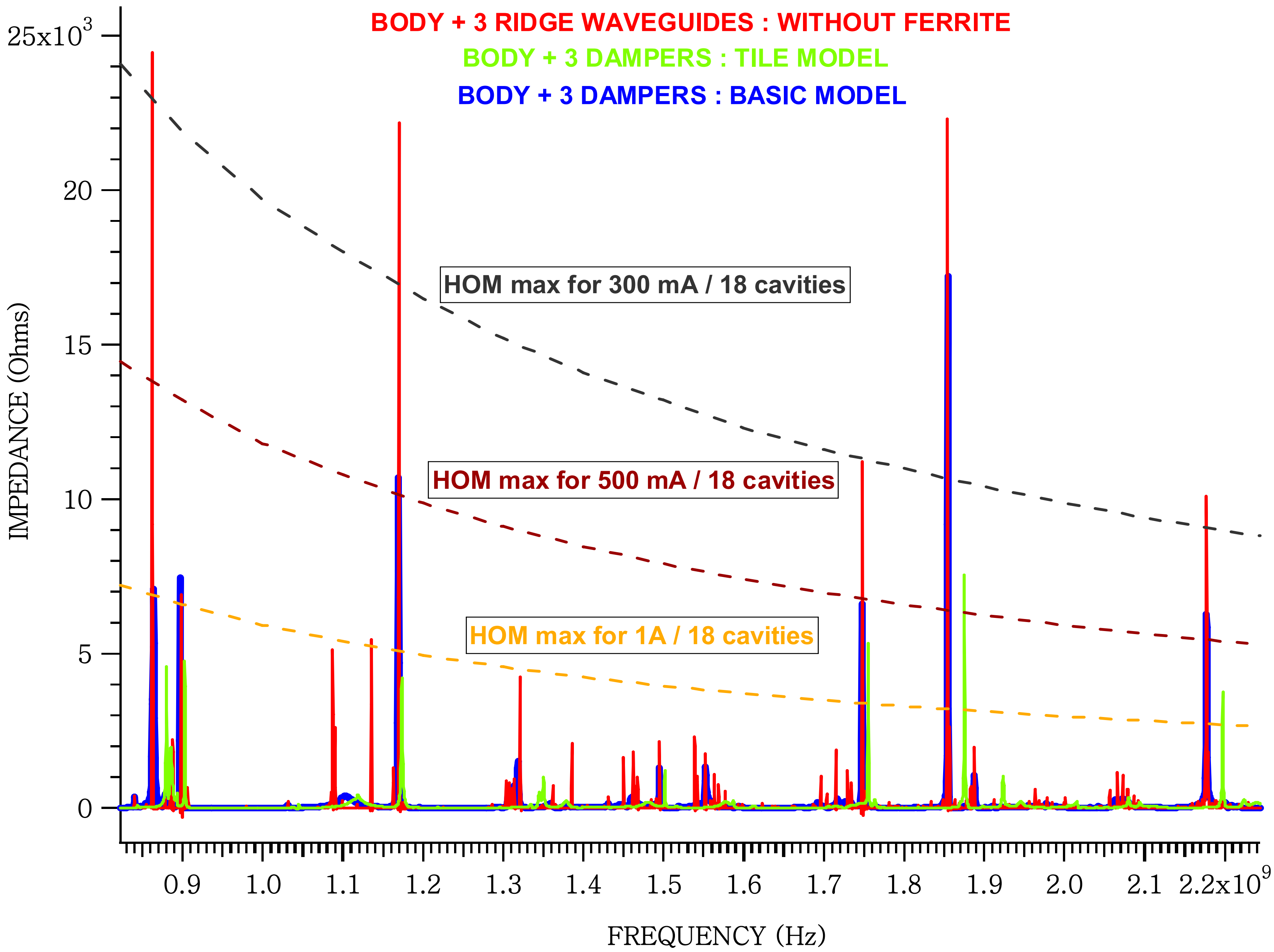
VIEW OF THE WHOLE CAVITY

FDTD SIMULATION WITH GDFIDL FOR THE GLOBAL CAVITY WITH 3 DAMPERS



✓ ***Conditions : Simulation on 600 meters and 2 mm meshing. (No offset on transverse plane)***

ZOOM ON BANDWITH : 0.9 to 2.2 GHz



GDFIDL AS EIGENVALUE SOLVER FOR THE GLOBAL CAVITY

Study of the fundamental mode only - 2 mm meshing			
Parameters	**BODY**	**BODY + 3 WAVEGUIDES : WITHOUT FERRITE**	**BODY + 3 DAMPERS : BASIC FERRITE MODEL**
f_{RF} (MHz)	**352.222**	**345.676***	**345.584**
Q	**49844**	**46645**	**46084**
R/Q (Ω)	**148.981**	**145.923**	**145.130**
R (k Ω)	**7426**	**6807**	**6688**

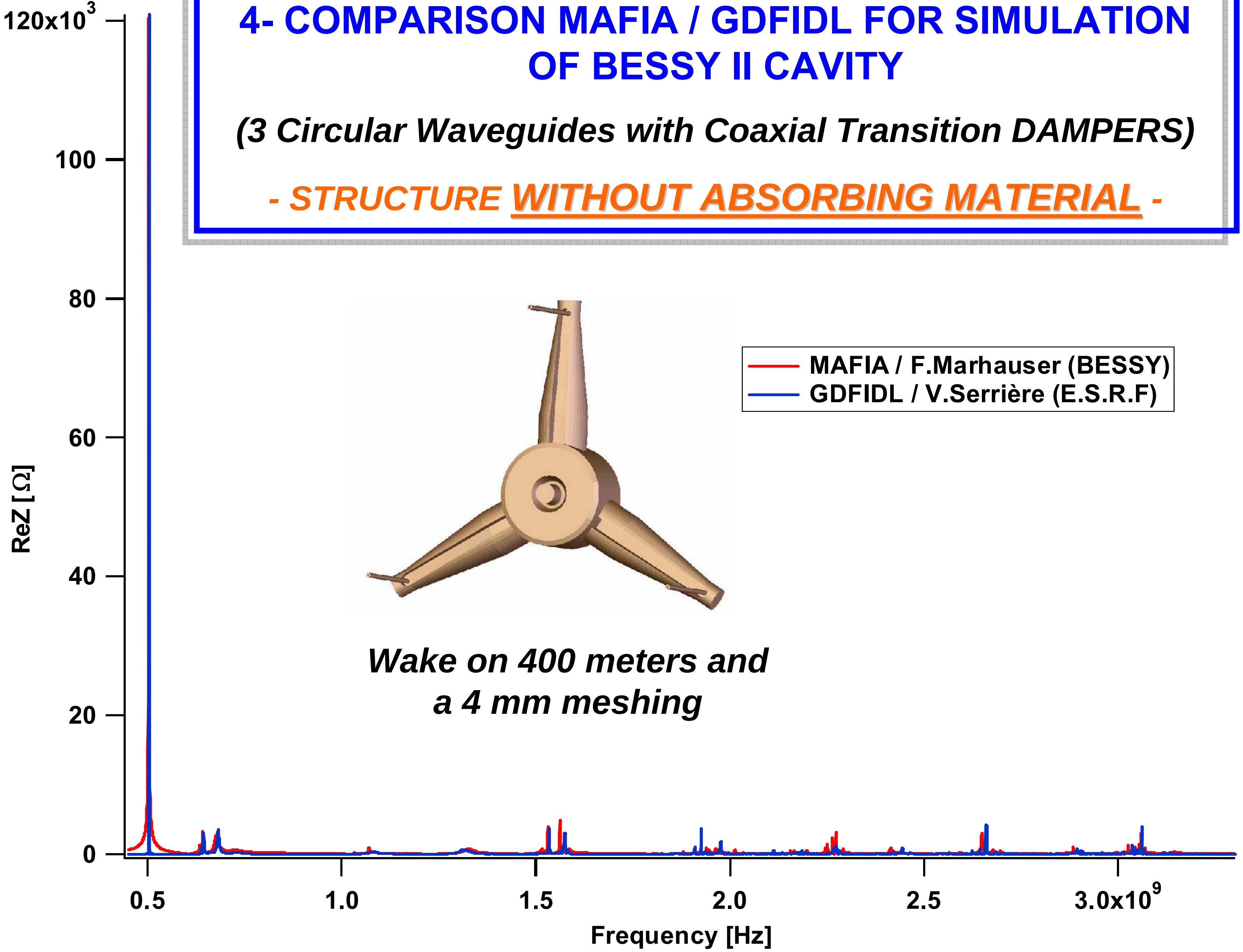
*<u>*Remark*</u> :

Insertion of Ridge Waveguides had induced a huge shift on the fundamental frequency

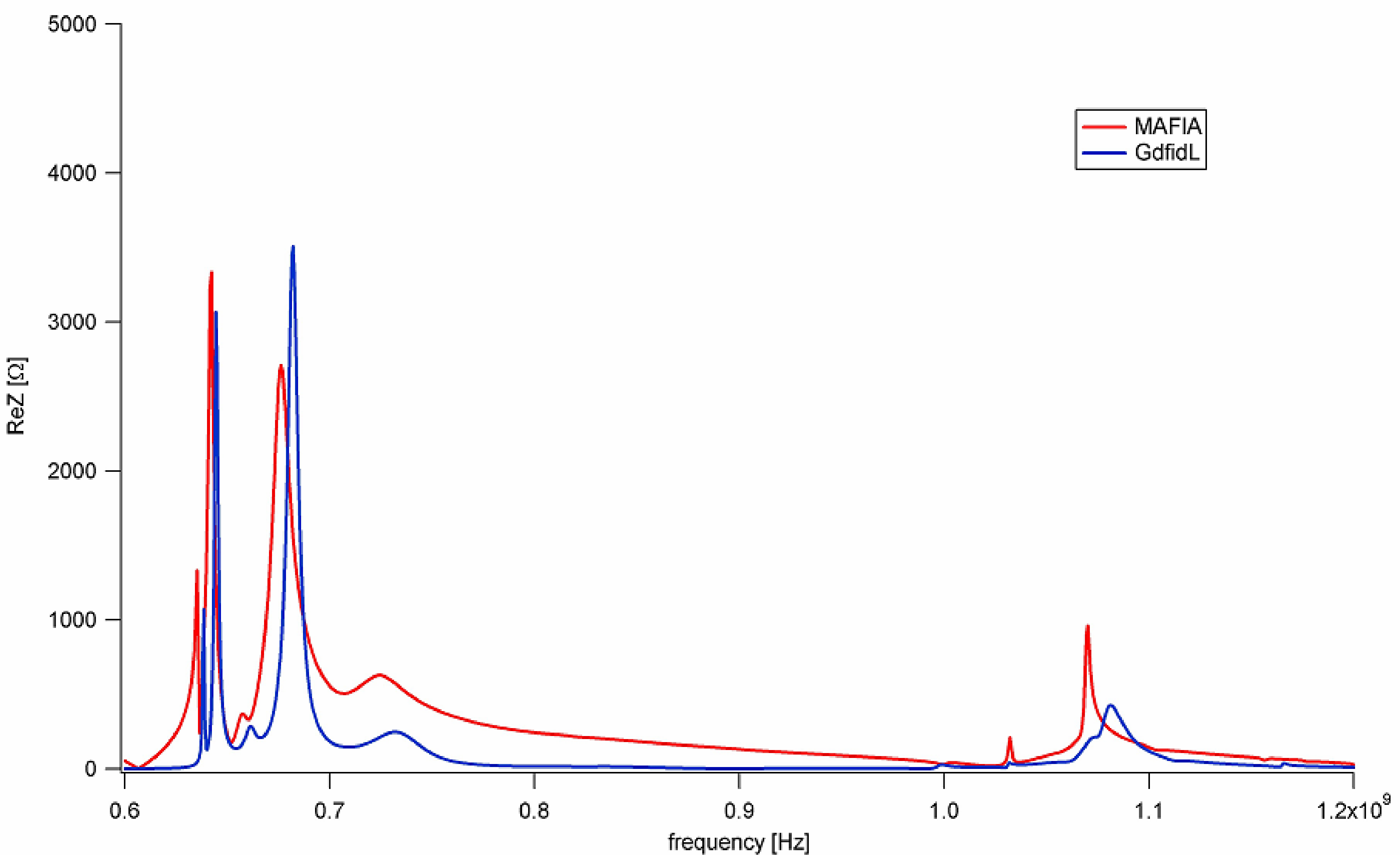
4- COMPARISON MAFIA / GDFIDL FOR SIMULATION OF BESSY II CAVITY

(3 Circular Waveguides with Coaxial Transition DAMPERS)

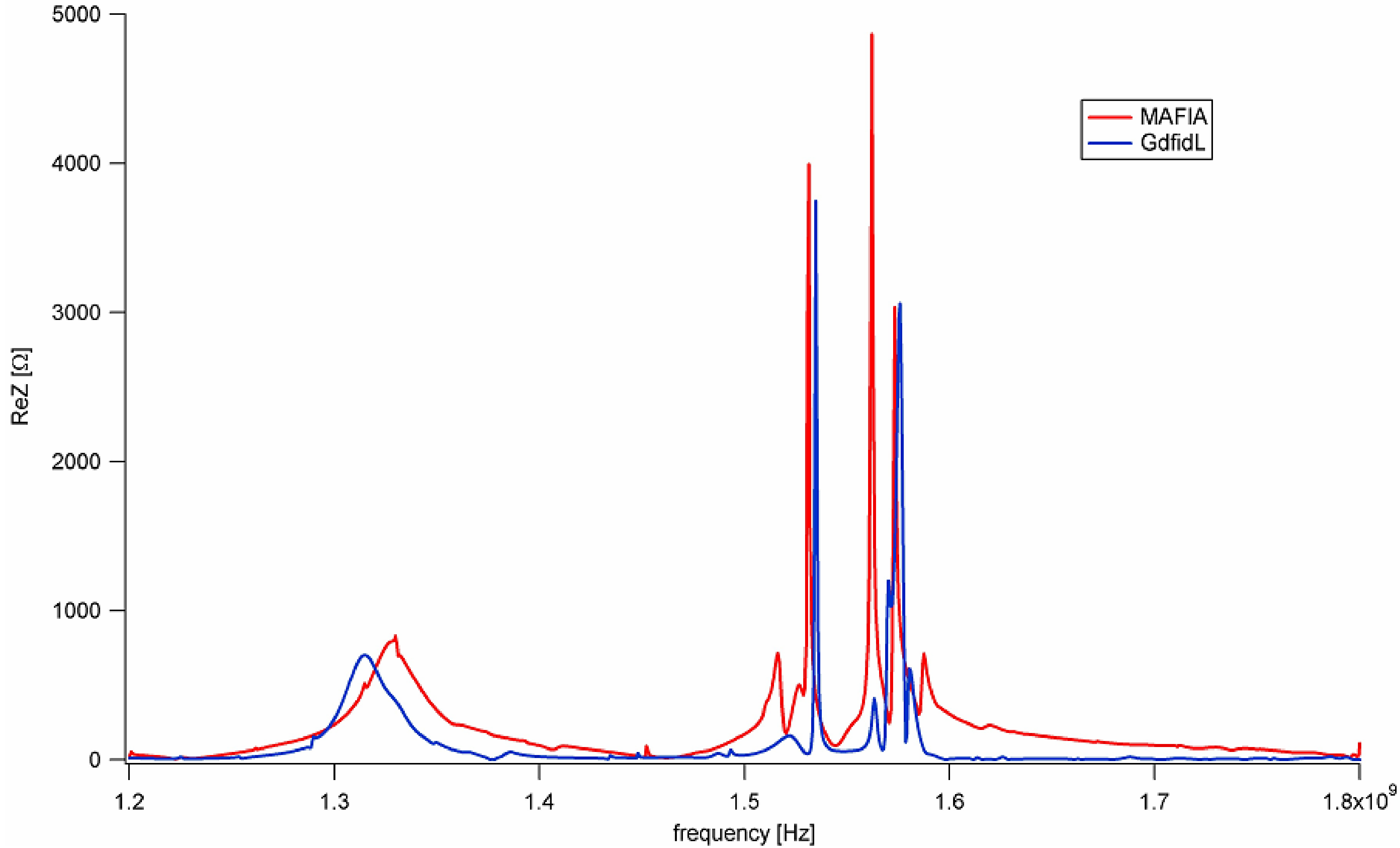
*- STRUCTURE **WITHOUT ABSORBING MATERIAL** -*



ZOOM ON BANDWITH : 0.6 to 1.2 GHz



zoOM ON ON BANDWITH : 1.2 to 1.8 GHz



CONCLUSION ON SIMULATION TOOLS AND RESULTS

1) ASPECTS ALREADY DEALED WITH :

✓ **SIMULATIONS WITH 3 RF SIMULATION SOFTS HAS BEEN DONE :**

. ***SUPERFISH*** **: Perfect for optimisation of simple symmetrical Body**

. ***HFSS*** **: Adapted for S parameters studies (even including absorbing materials)**

. ***GDFIDL*** **: Usefull for H.O.M studies of complex Cavities <u>even including ferrite</u>**

✓ **THE MAIN ELEMENTS OF THE CAVITY HAVE BEEN STUDIED GLOBALY : BODY, RIDGE, FERRITE**

2) … POINTS TO DO :

✓ **STUDY OF TRANSVERSE H.O.M**

✓ **OPTIMISE THE “TILE” MODEL AGAIN TO ABSORB SUFFICIENTLY H.O.M WITHOUT THE FUNDAMENTAL ONE (by changing width and gap of the ridge and the length of the waveguide)**

✓ **OBTAIN A FUNDAMENTAL MODE WITH A FREQUENCY CLOSER TO 352.2 MHz**

✓ **THERMAL STUDY OF THE CAVITY**

✓ **…**

The End - Thank You !

QuestionS ? ...