CB100 simulations

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Let us answer the following questions:

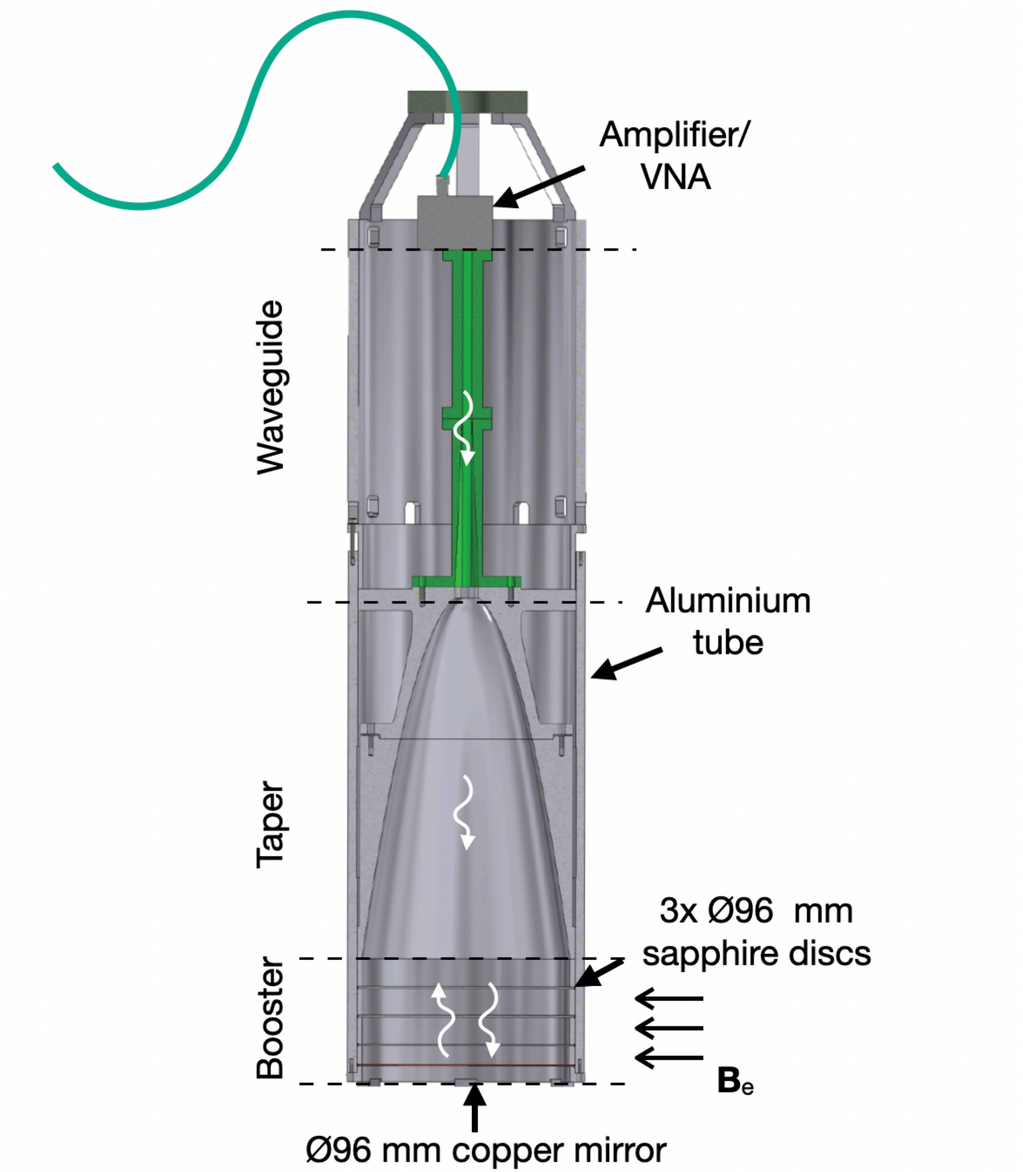
Where do we use simulations?

How could simulations help us understand more?

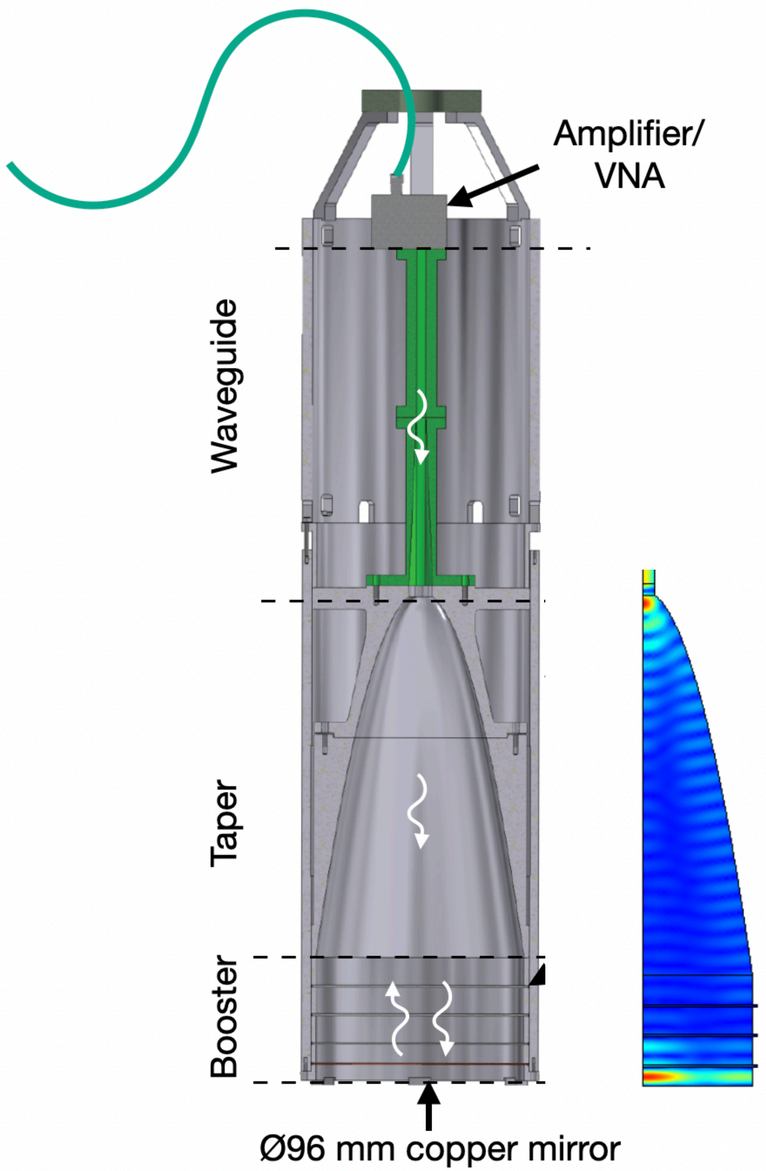
What are the parameters and results for the state of CB100 at CERN?

Do we need simulations for the paper?

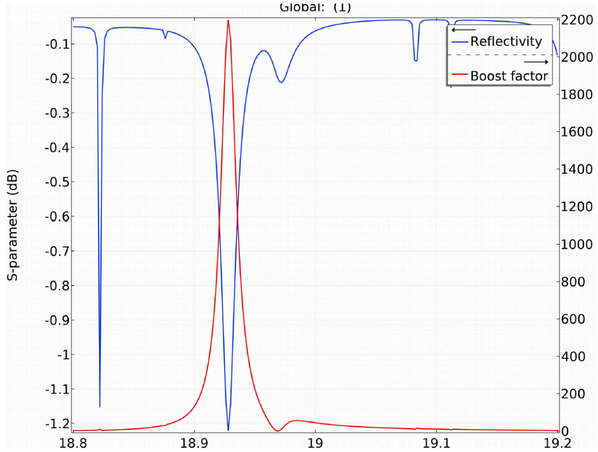
Where do we use simulations?



Where do we use simulations?



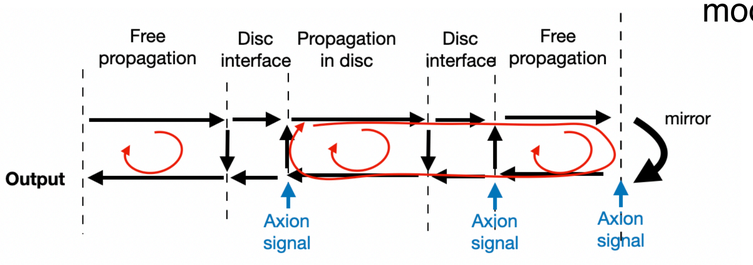
Where we know our assumption for single mode propagation breaks

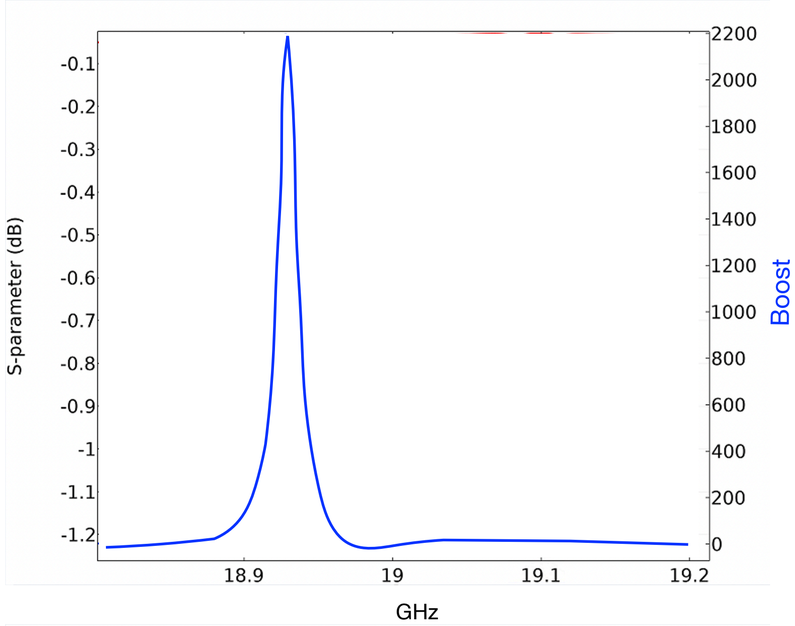


From 1d to COMSOL

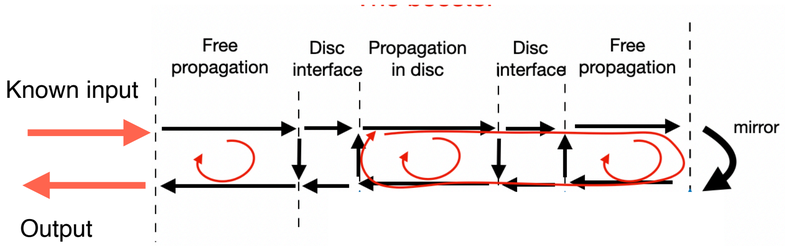
1. Predict the **boost output** — make a 1D model of wave propagation (cylindrical wave)

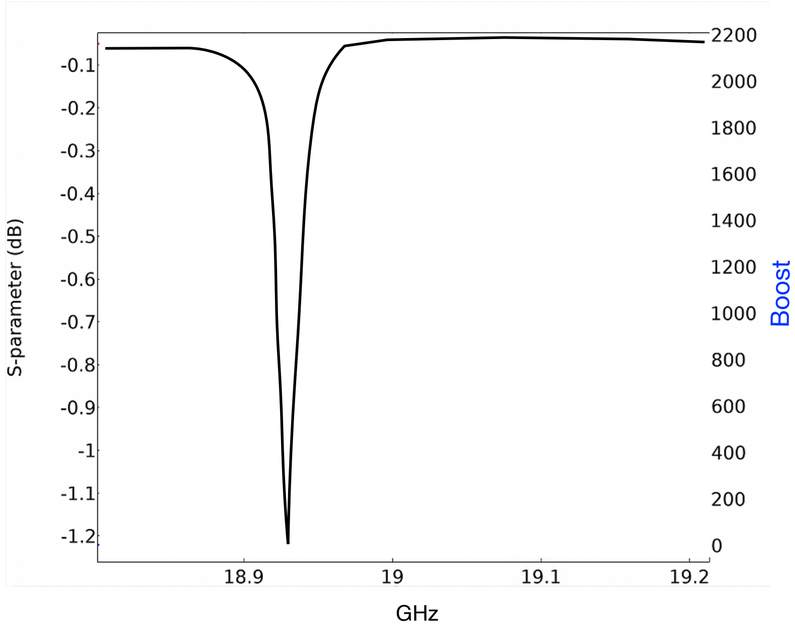
Assuming the mode is known





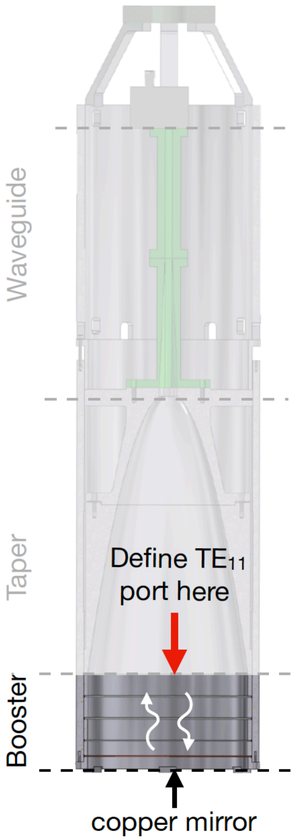
2. Predict the **reflectivity output** you expect for the booster curve (our diagnostic curve)

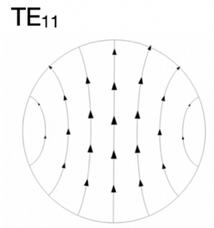


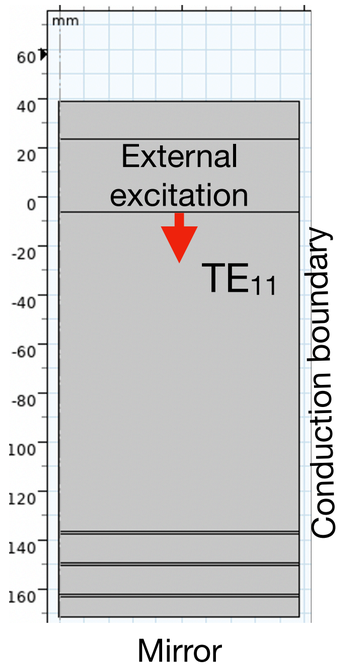


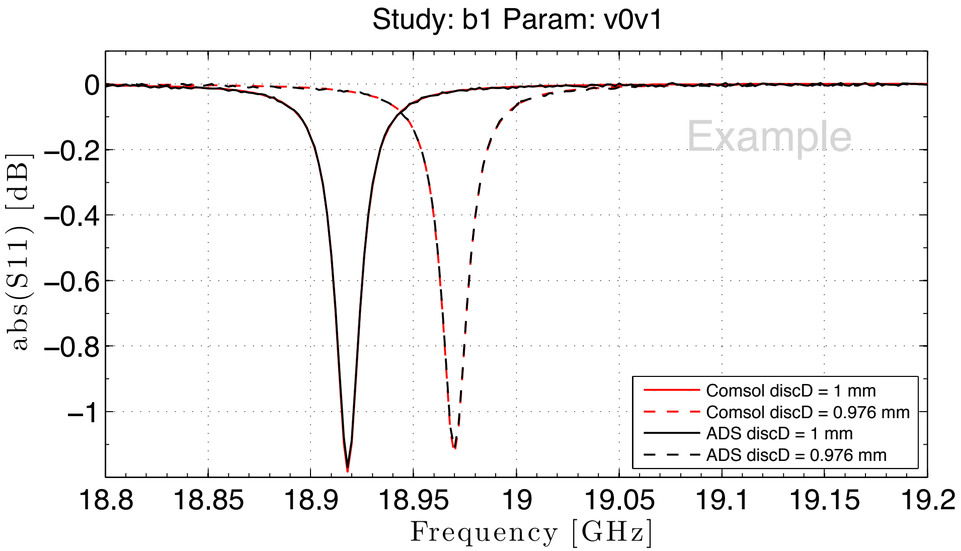
From 1d to COMSOL

3. Build a **minimalist 3D** and use 1D to validate reflectivity and field distribution

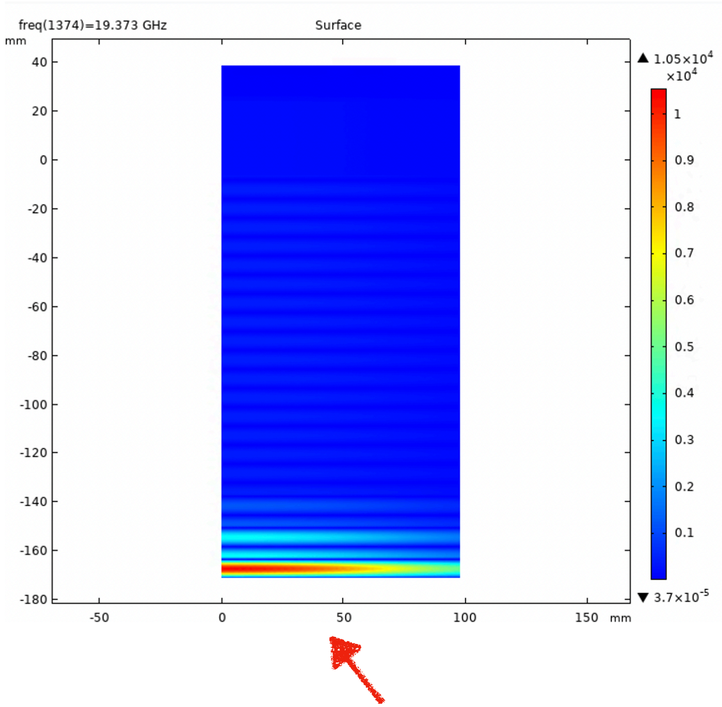








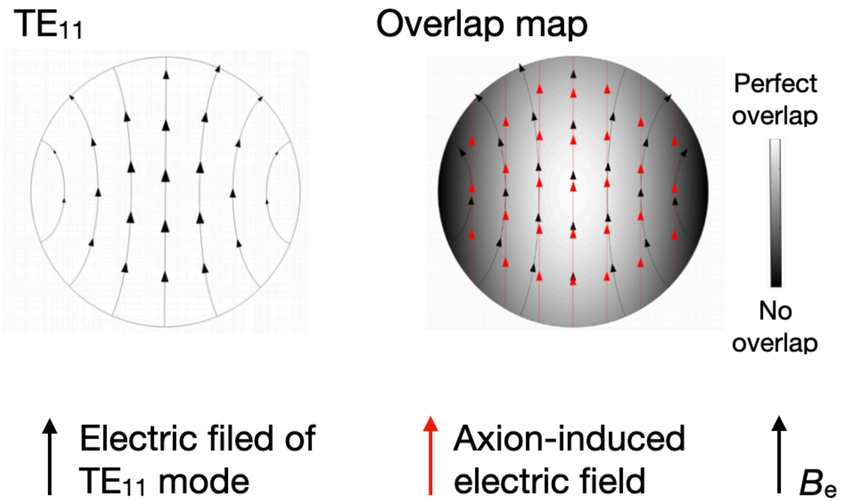
How the field will look

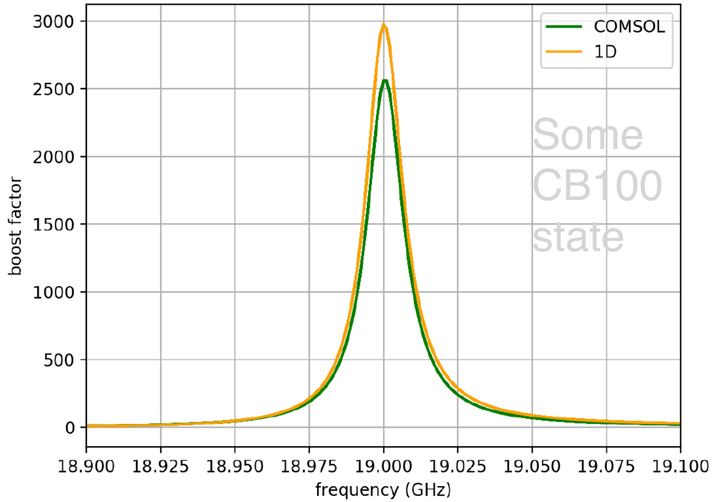


Strong field near the mirror

Overlap and form factor

4. Implement the axion field and account for **form factor effects**

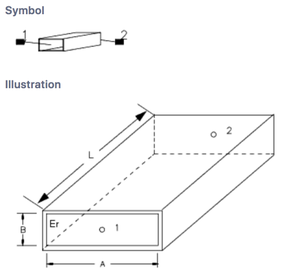


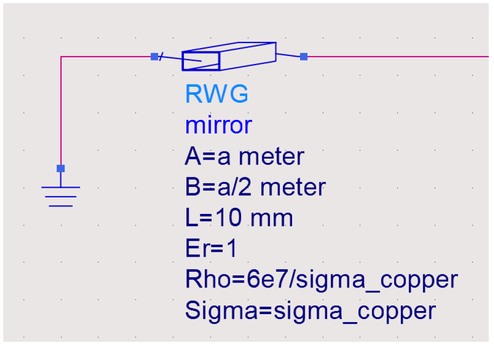


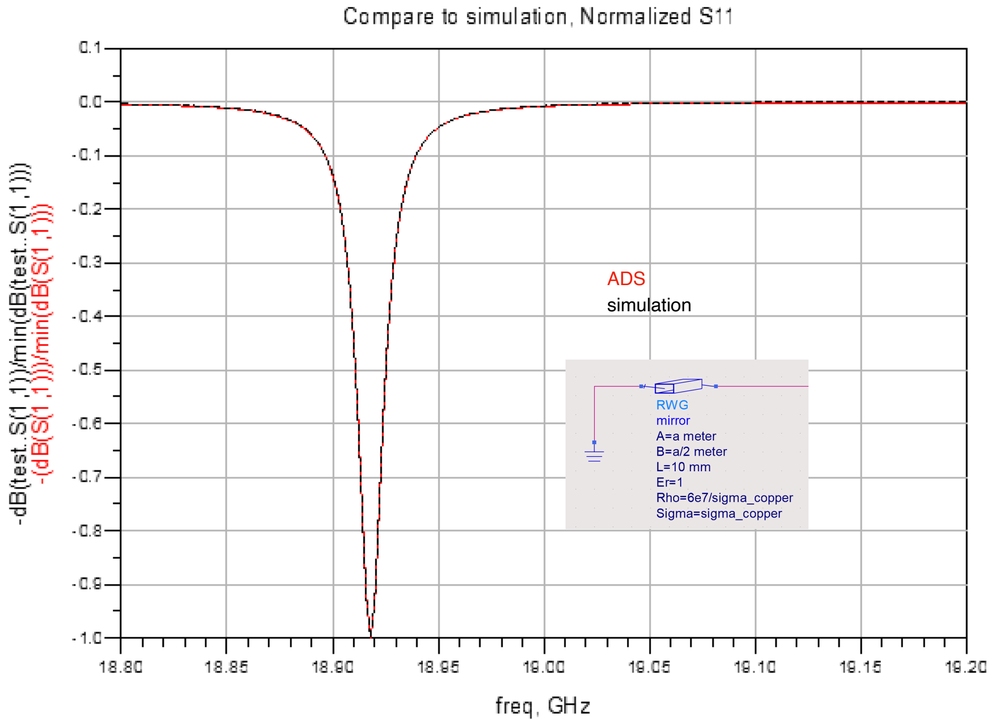
Answer the question how boost factor is reduced when you make the system finite in size

Benchmark the mirror model

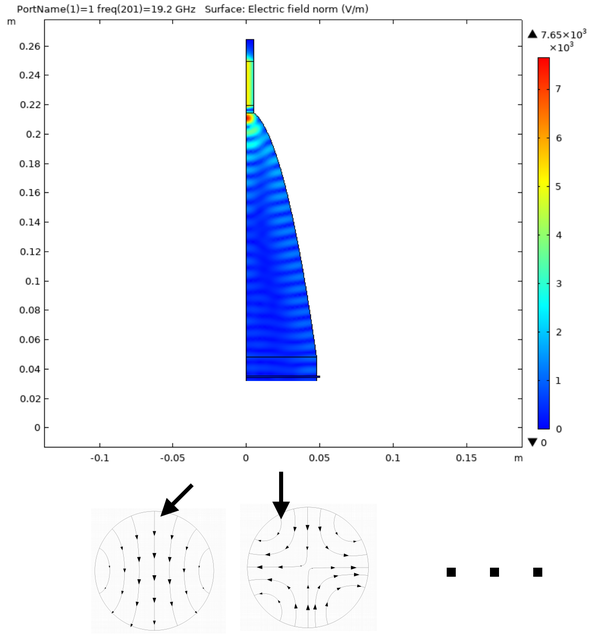
5. Benchmark the mirror model of ADS

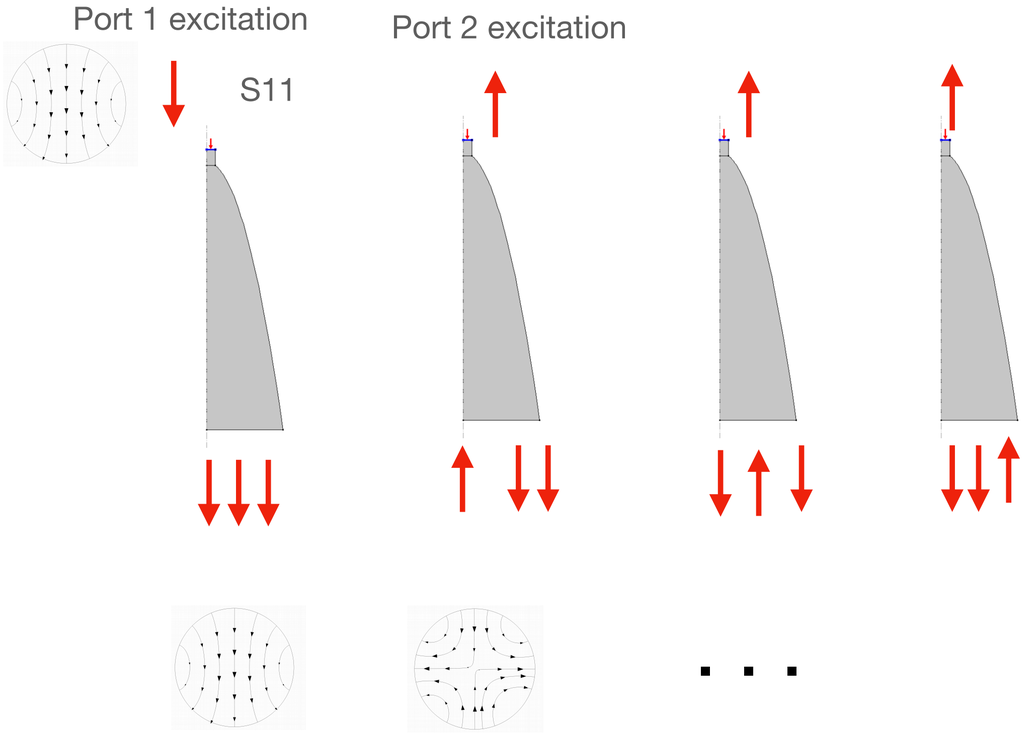




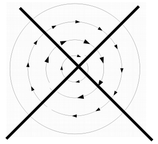


Excitation of higher order modes and the taper





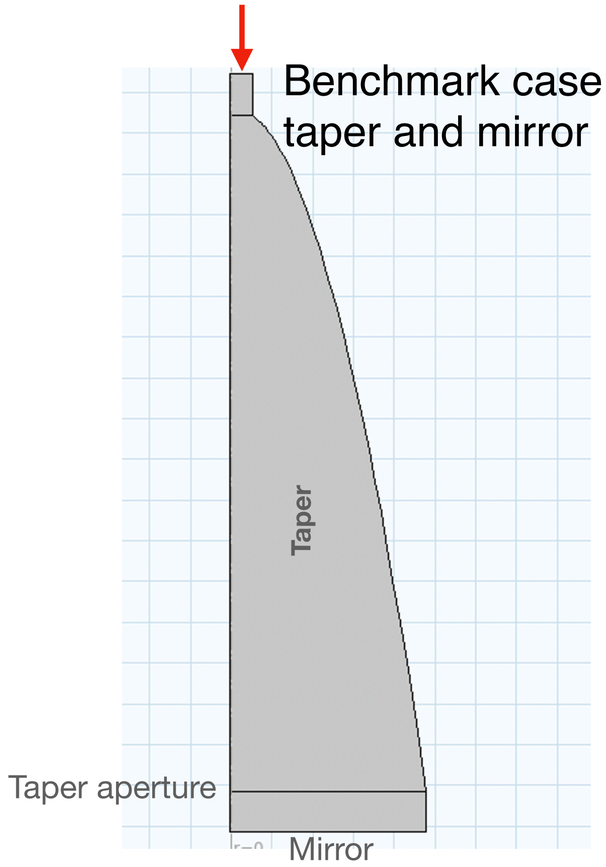
Modes we do not account for

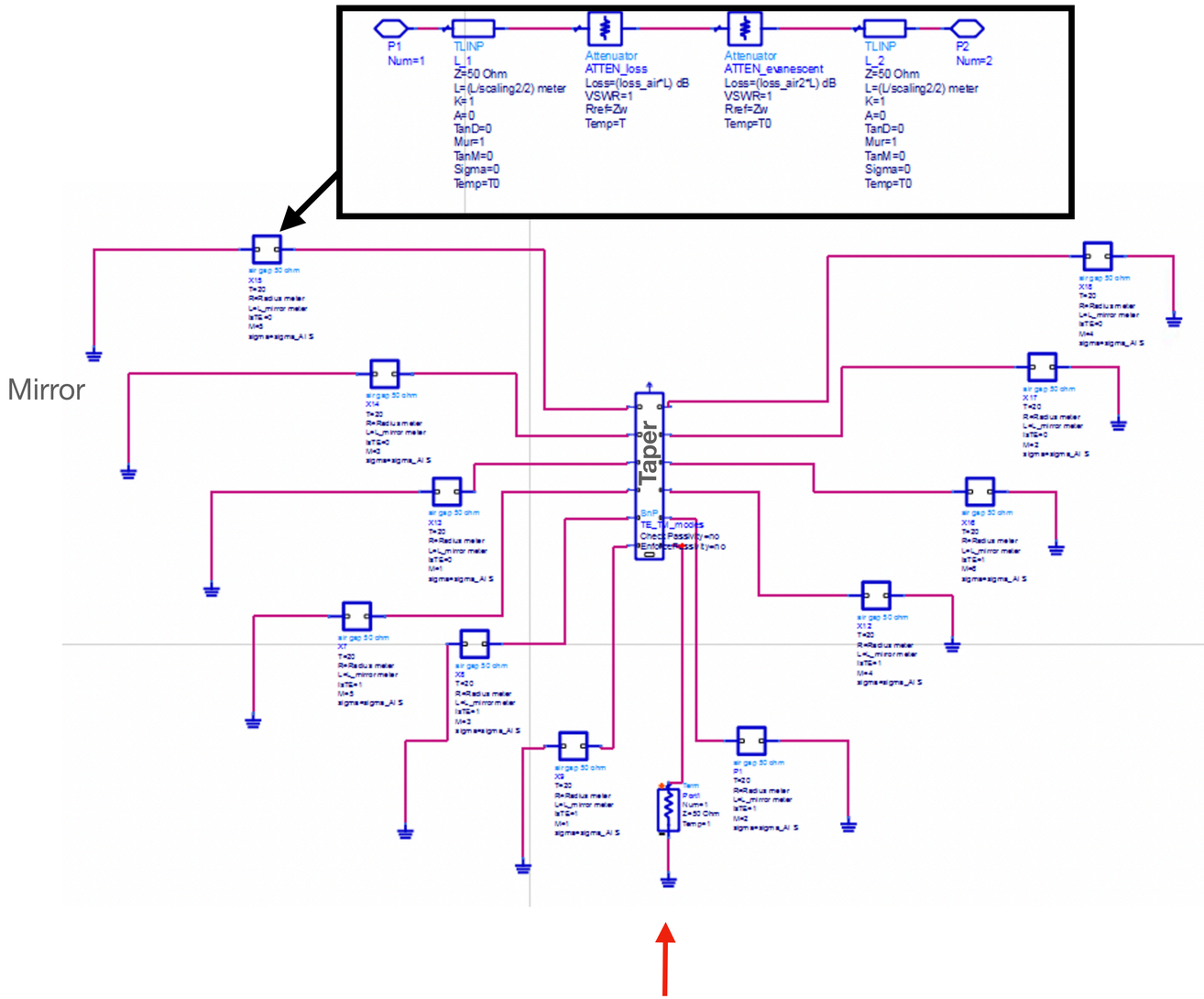


Assemble the GSM matrix (4 port example):

$$\begin{pmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{pmatrix}$$

Higher order modes in ADS

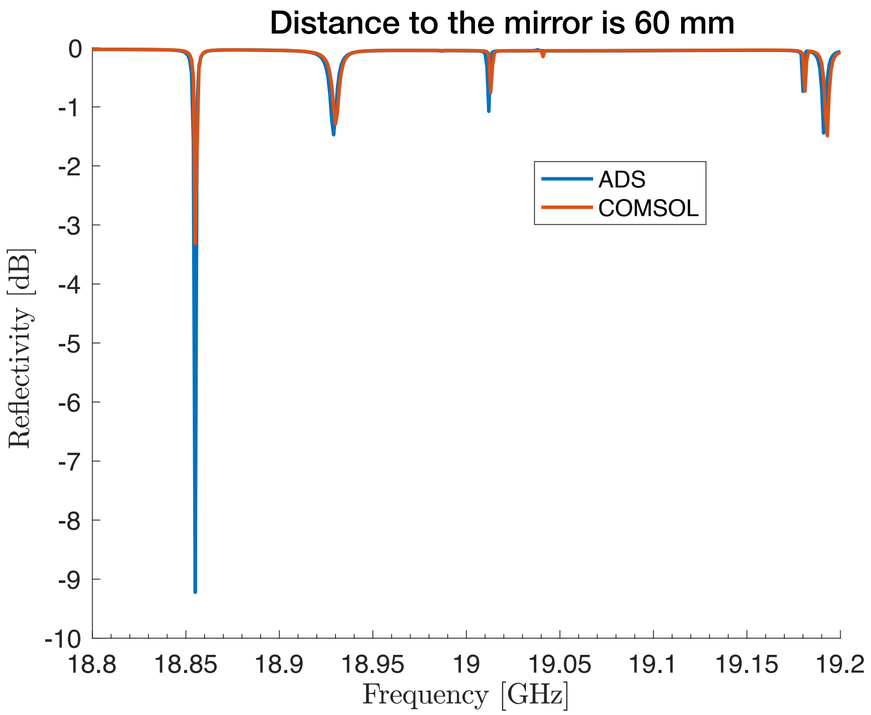


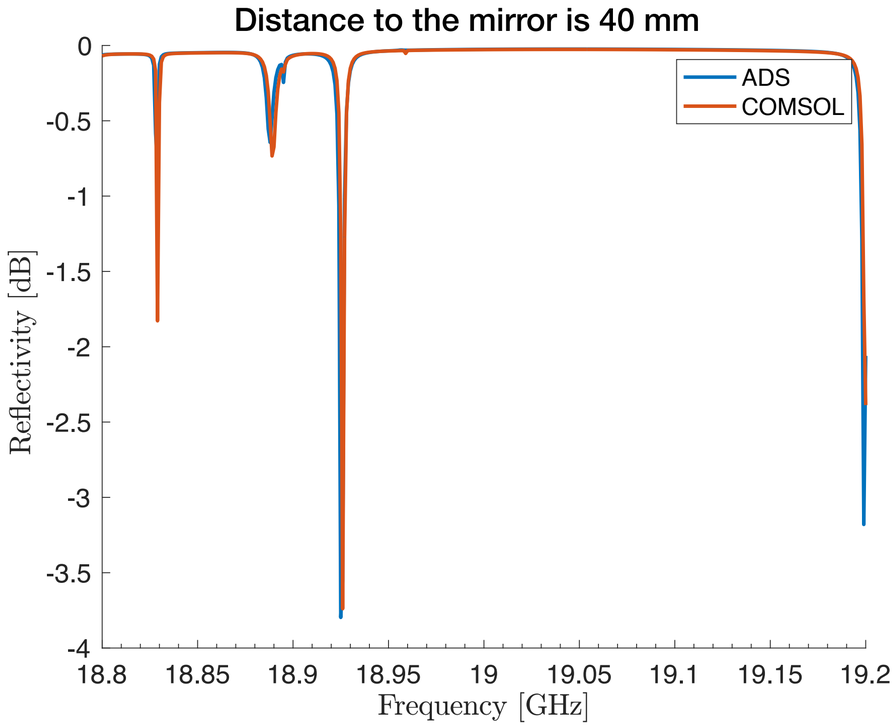


Physically: 2 port device

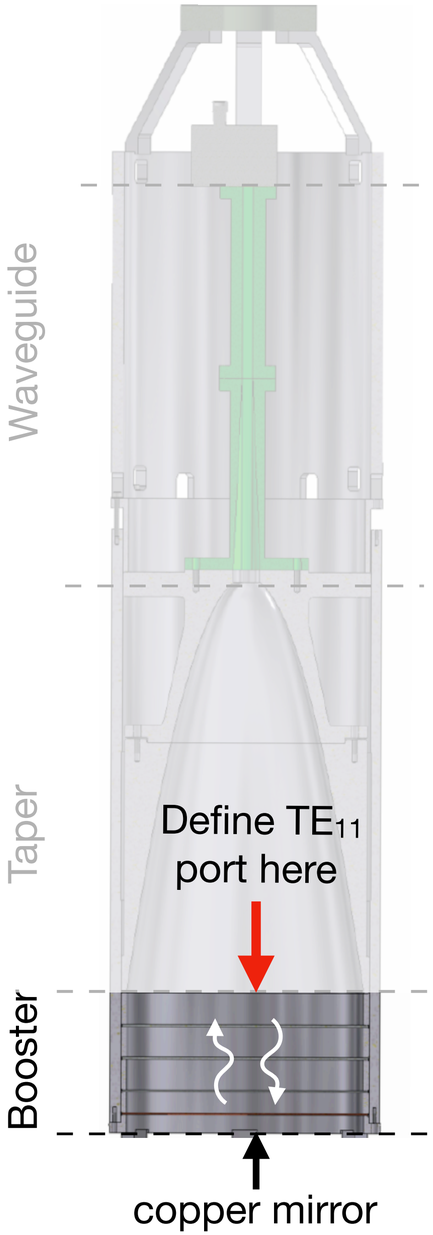
Conceptually: multi-port device

Can ADS predict more of the peaks?

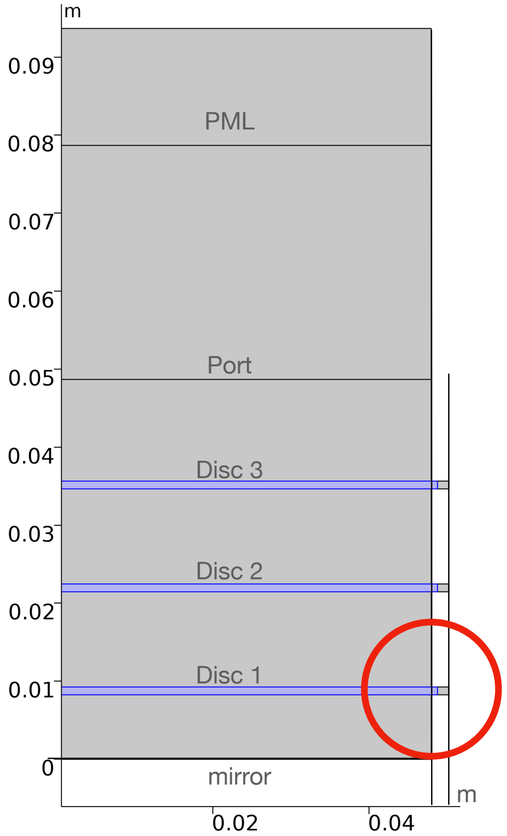


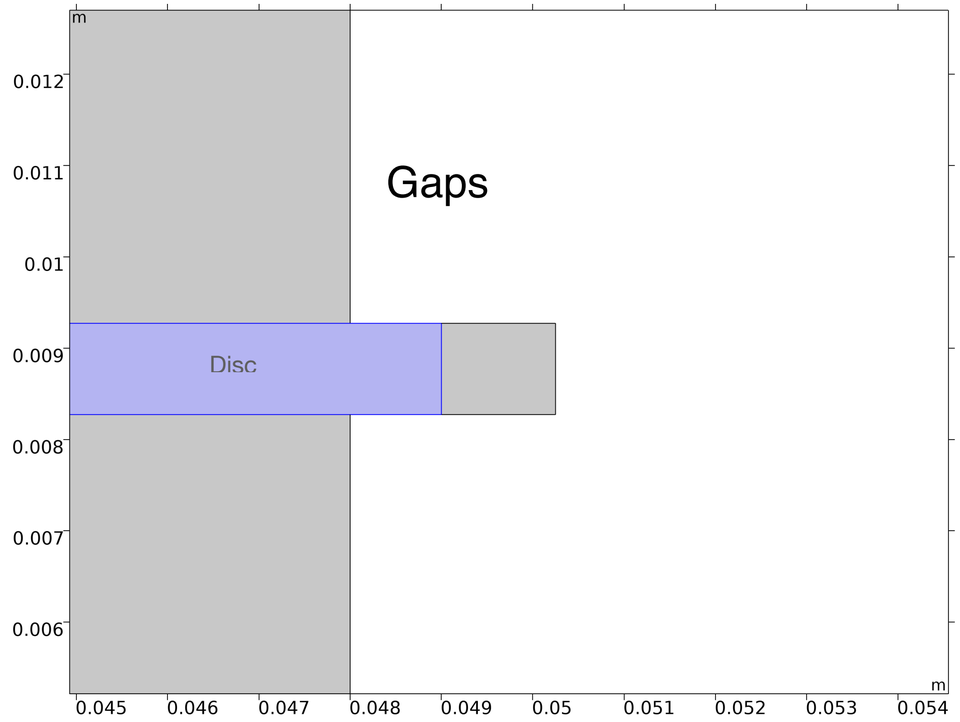


Transverse mode excitation in the booster



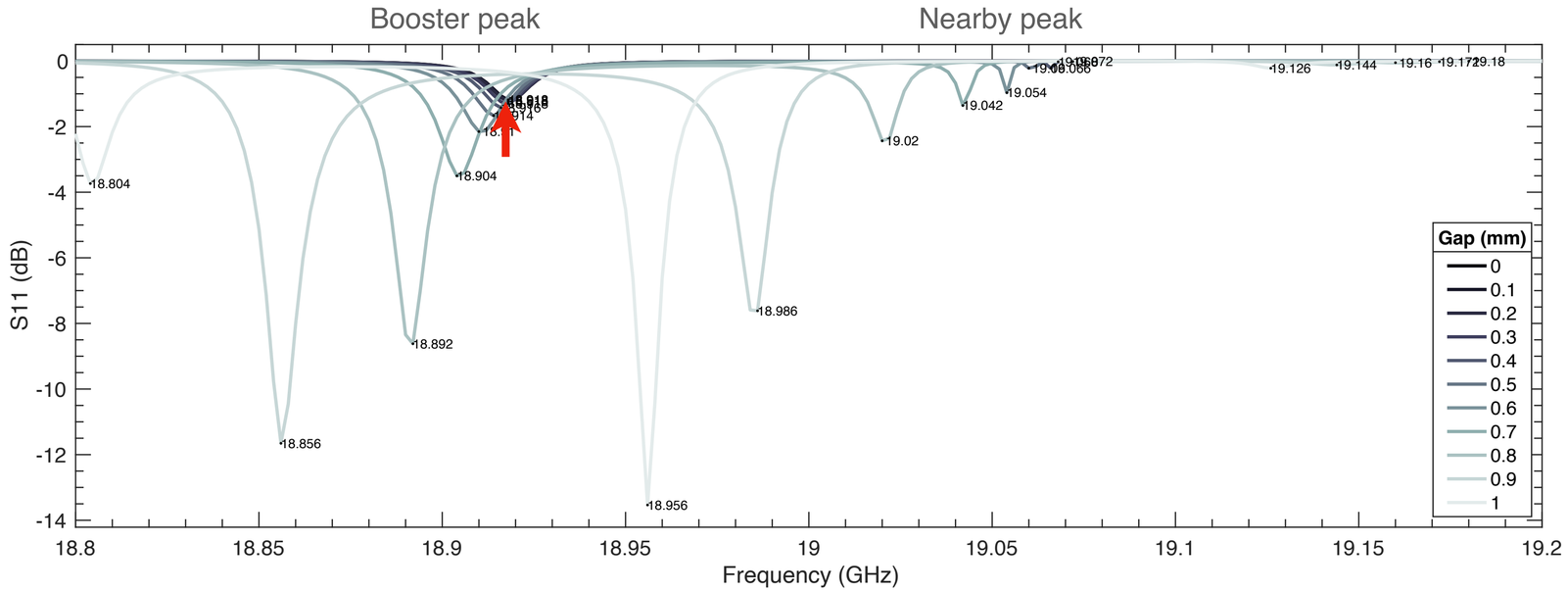
Only tiny geometrical deviation from the 1D-like case

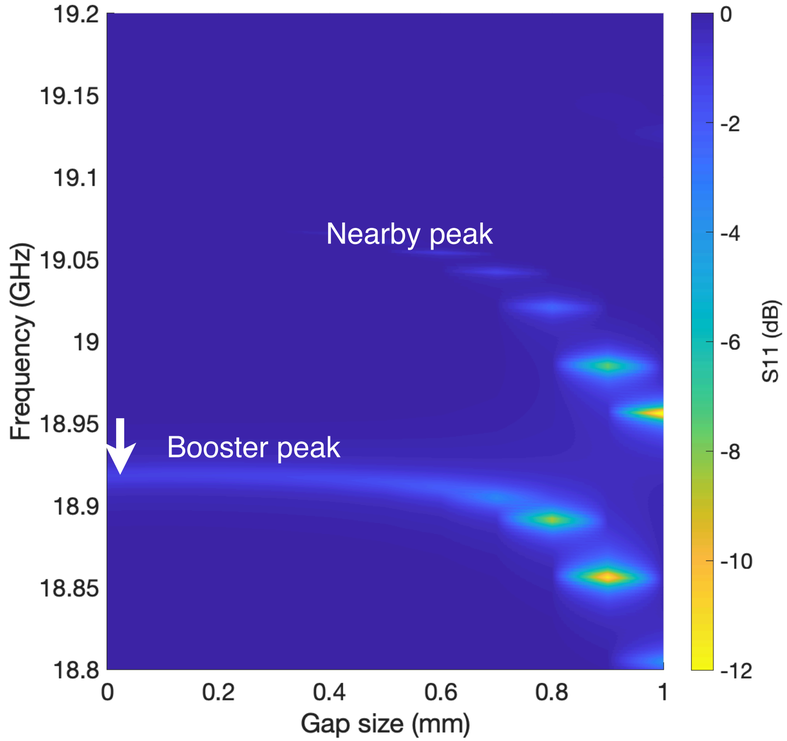


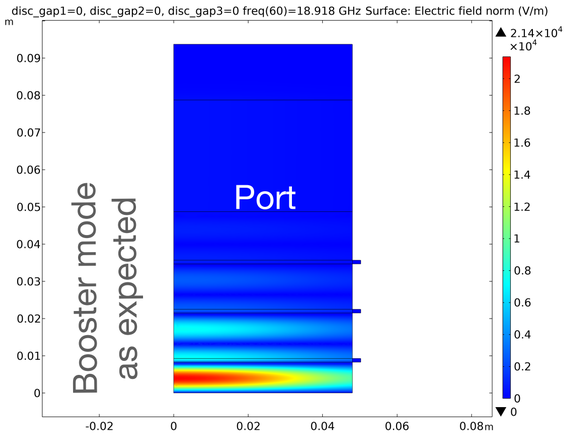


Transverse mode excitation in the booster

- Reflectivity for a sweep of the the **bottom** gap







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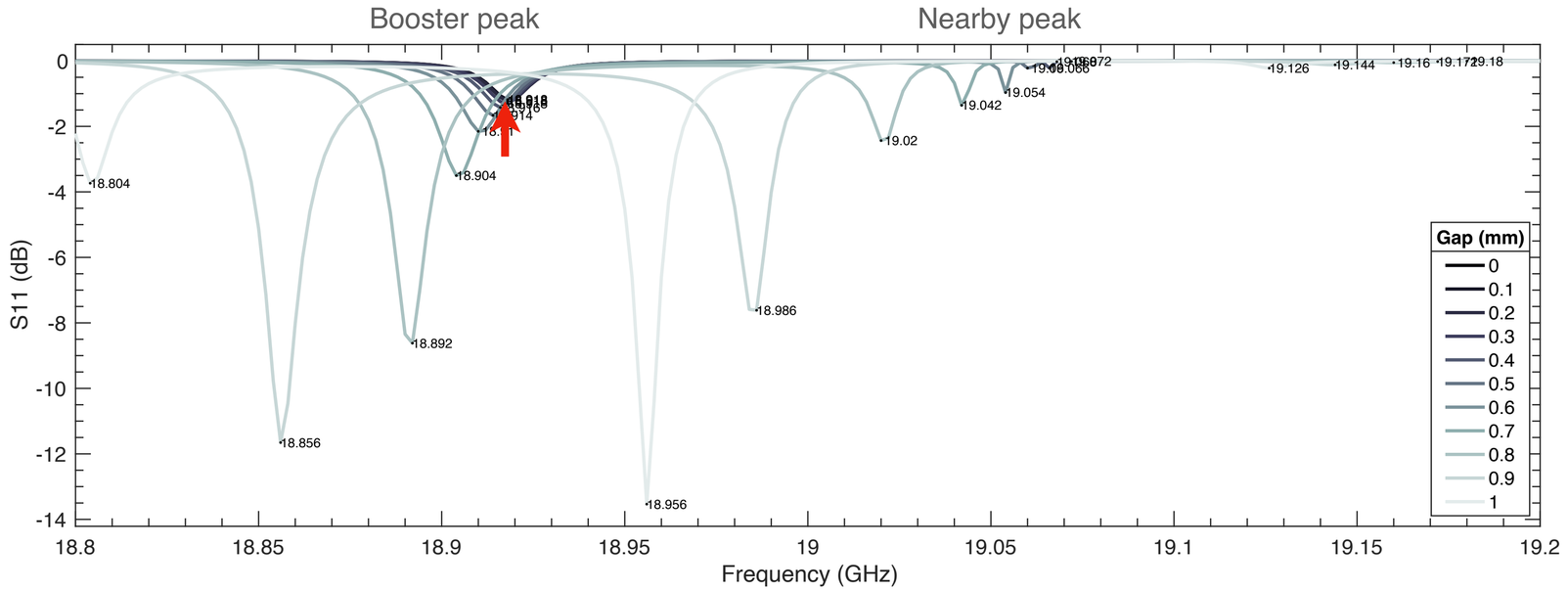

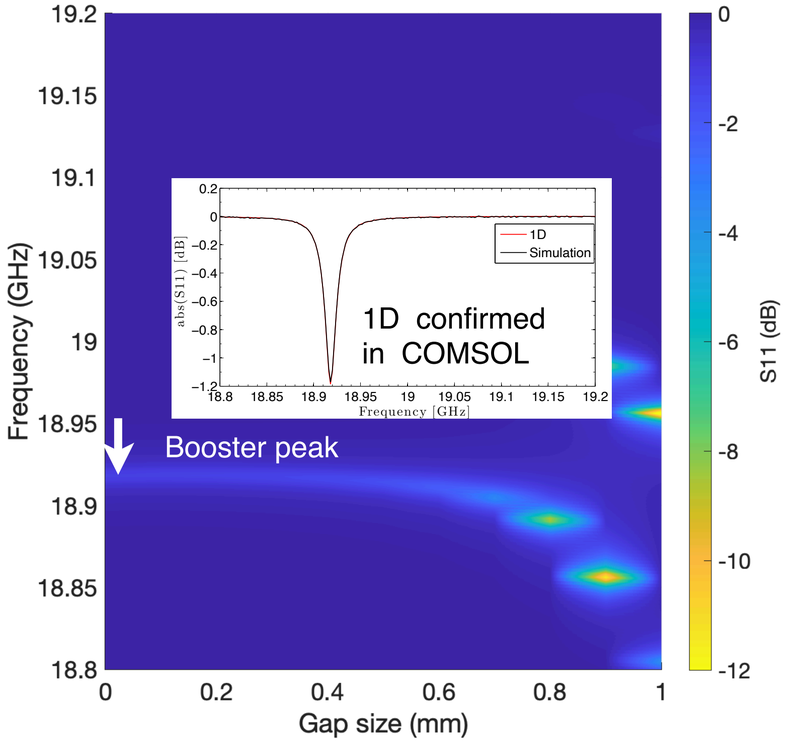

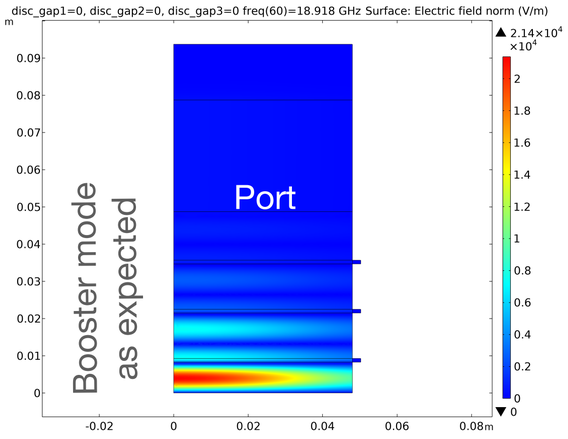

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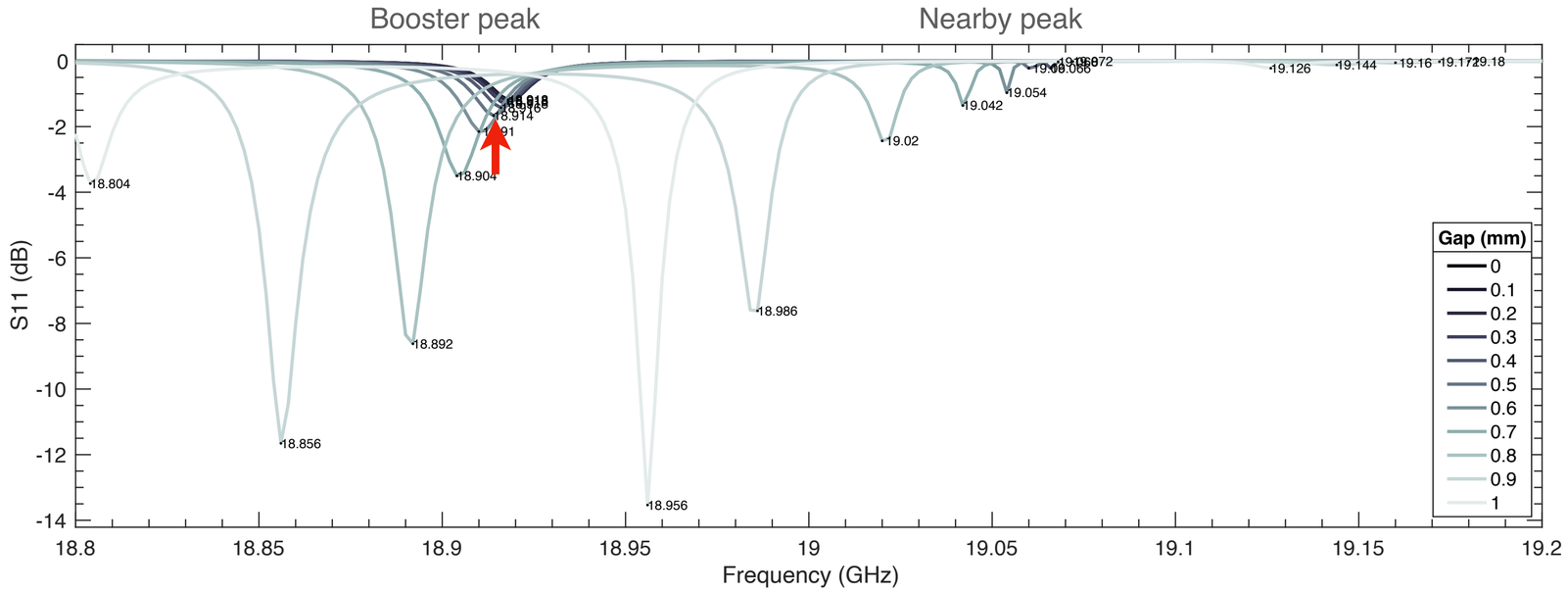

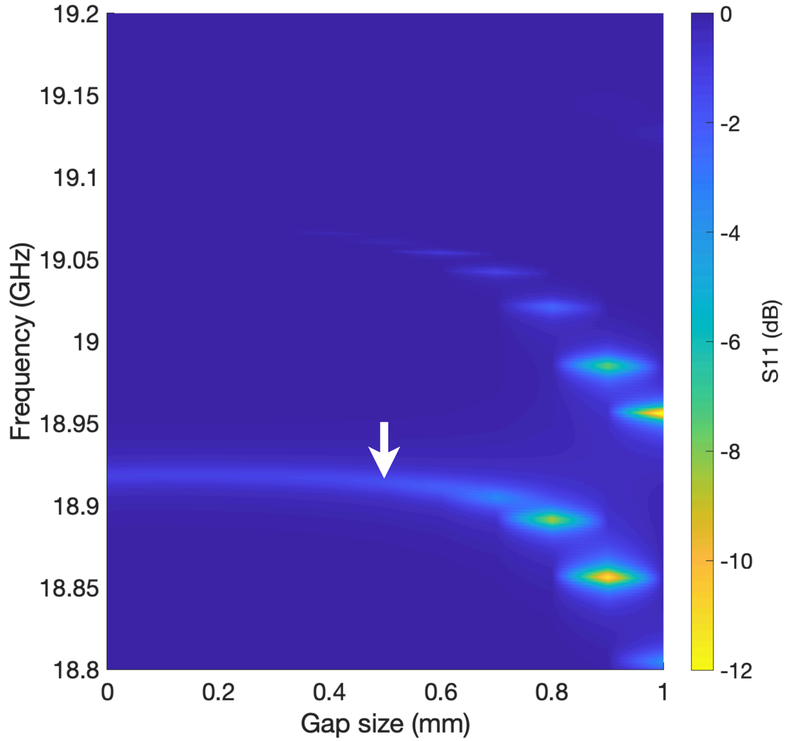

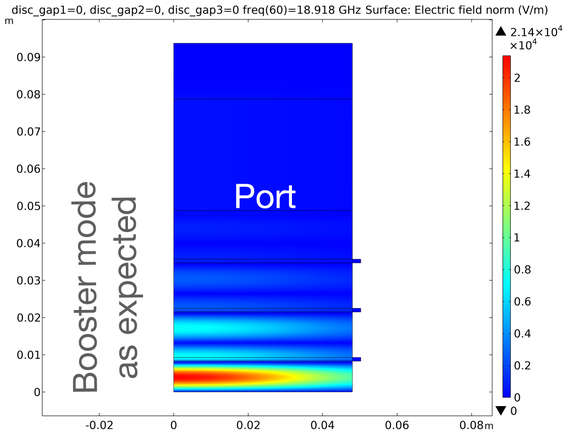

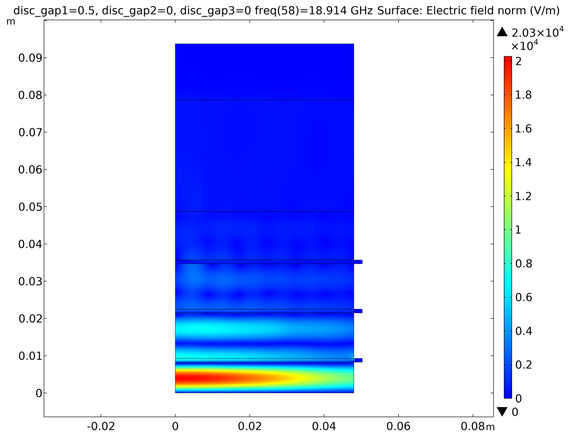

Transverse mode excitation in the booster

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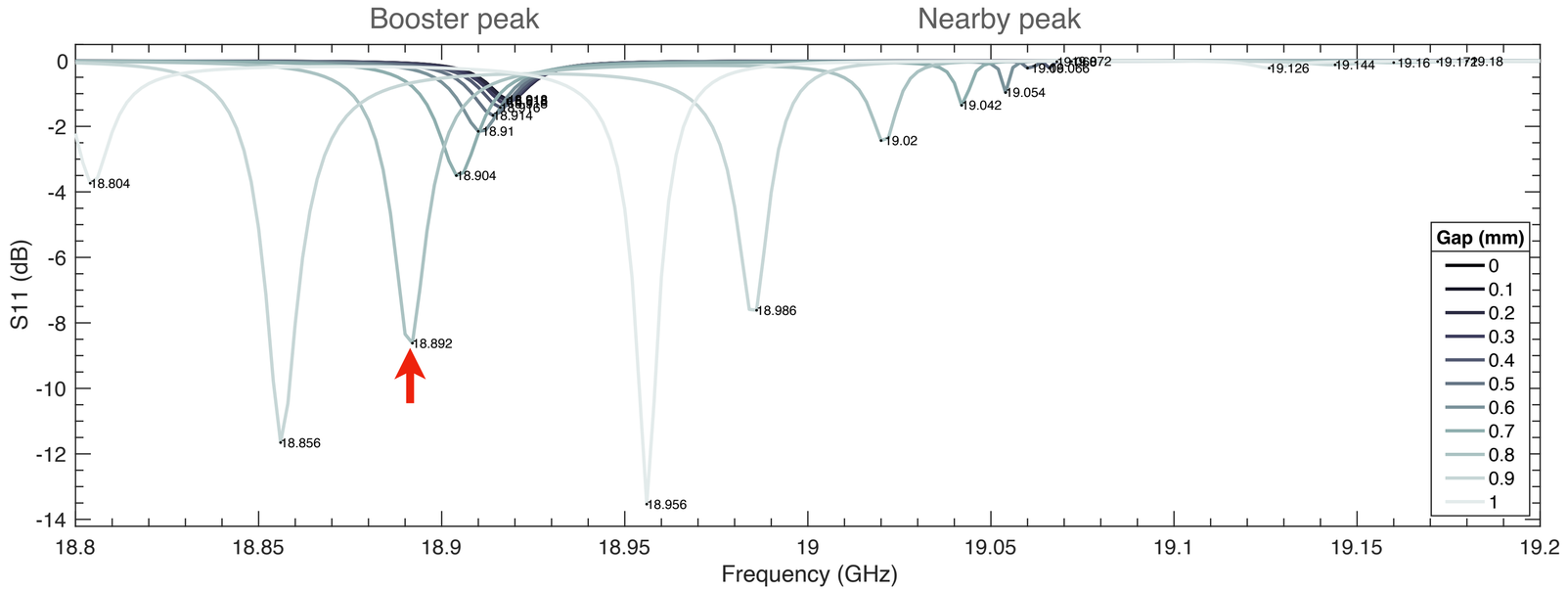
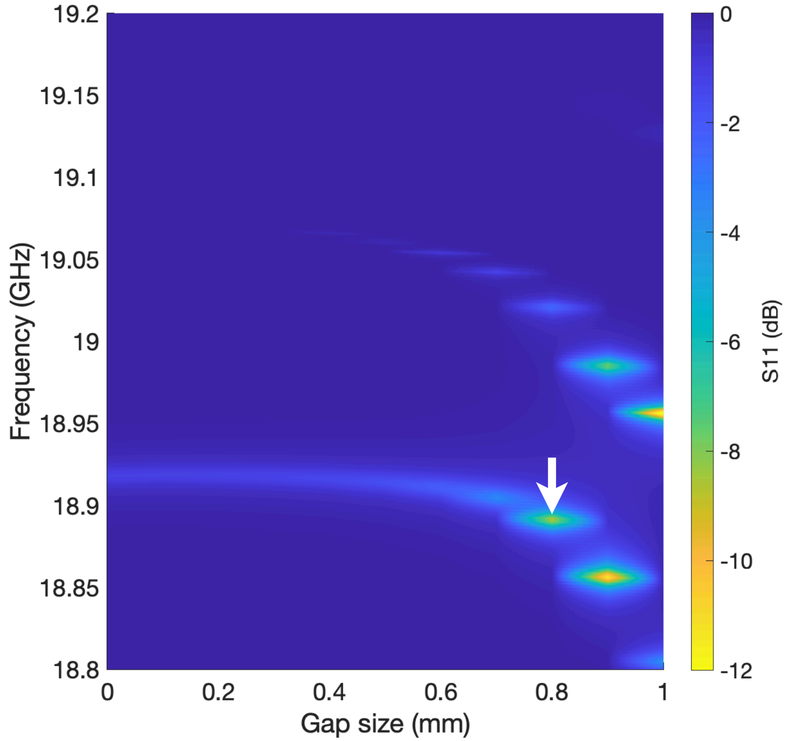
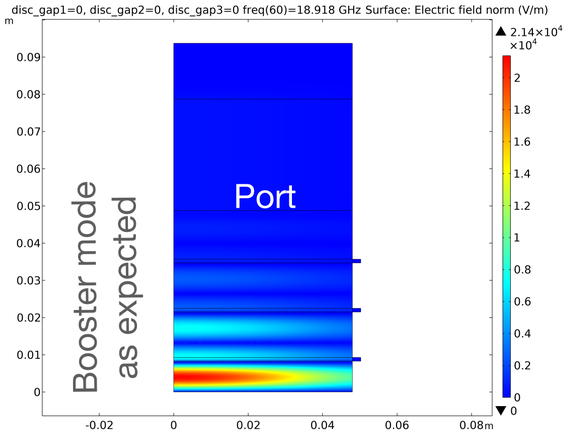
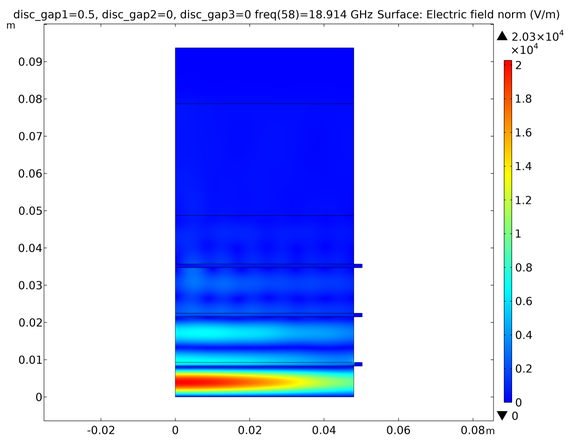
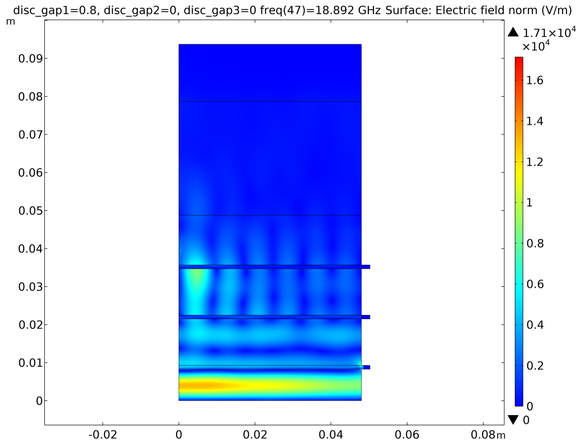




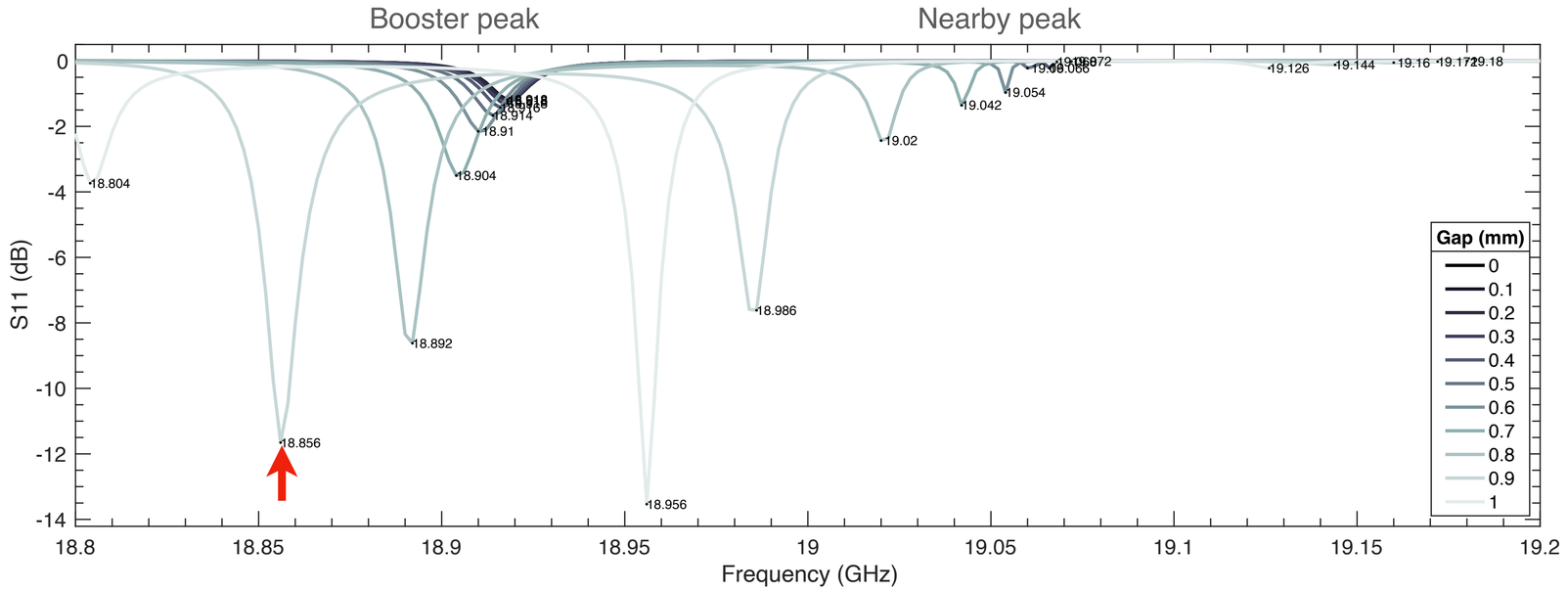


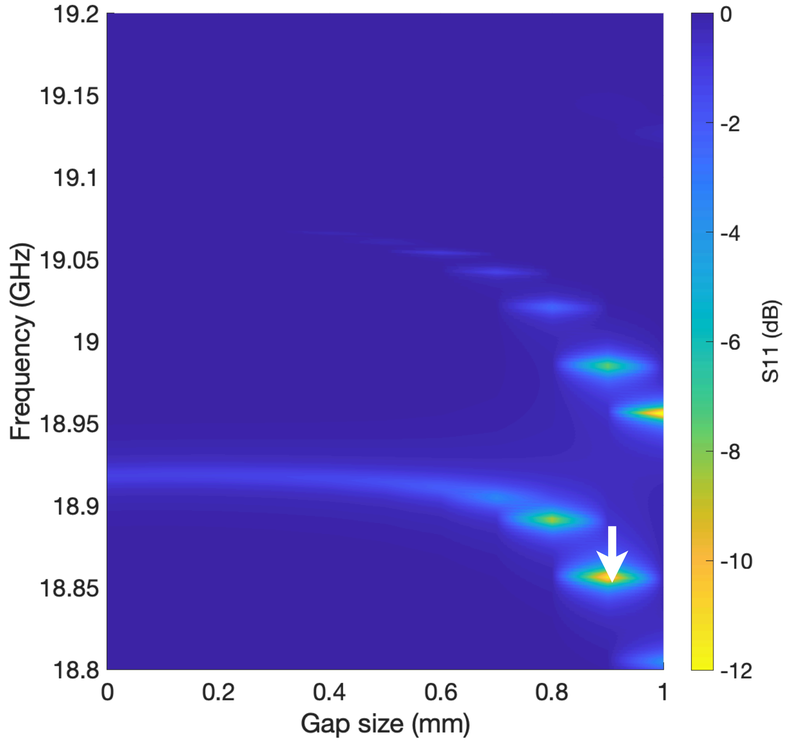


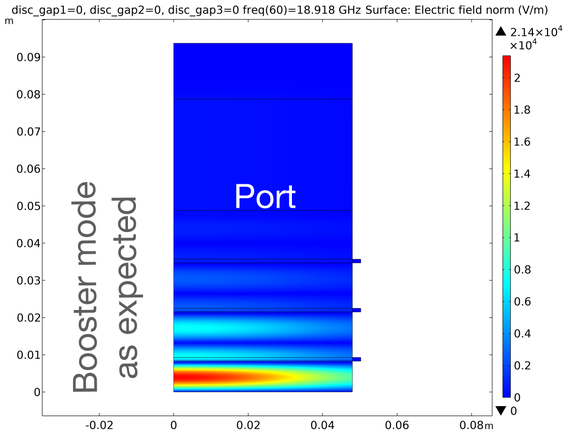


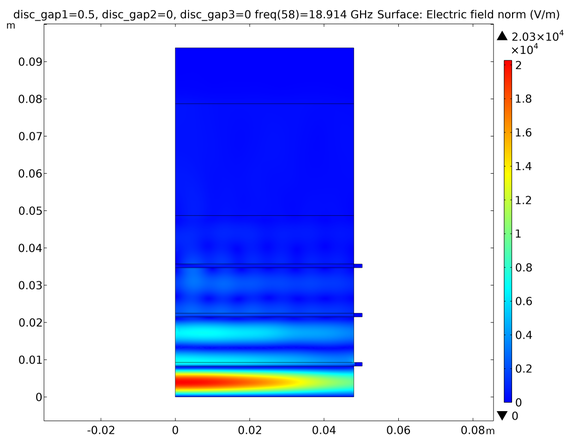
Transverse mode excitation in the booster

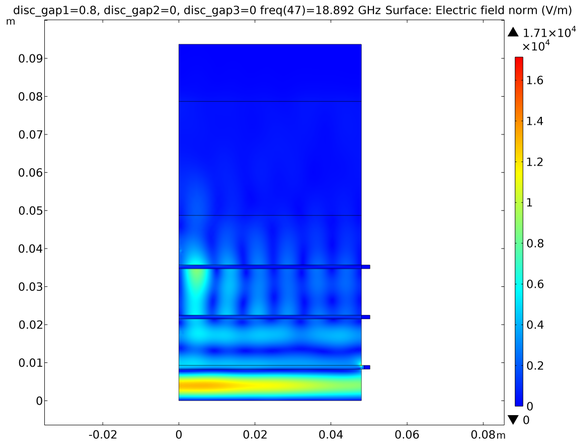
- Reflectivity for a sweep of the the **bottom** gap

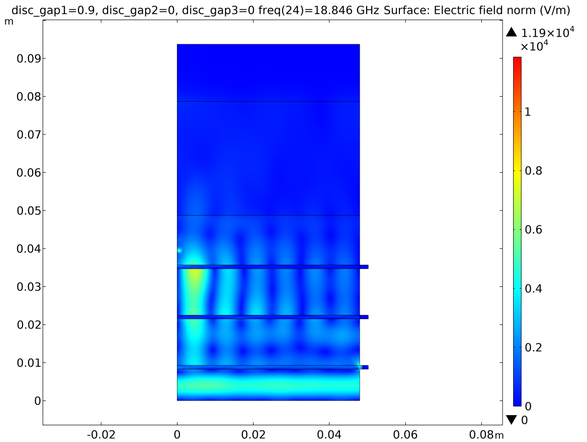




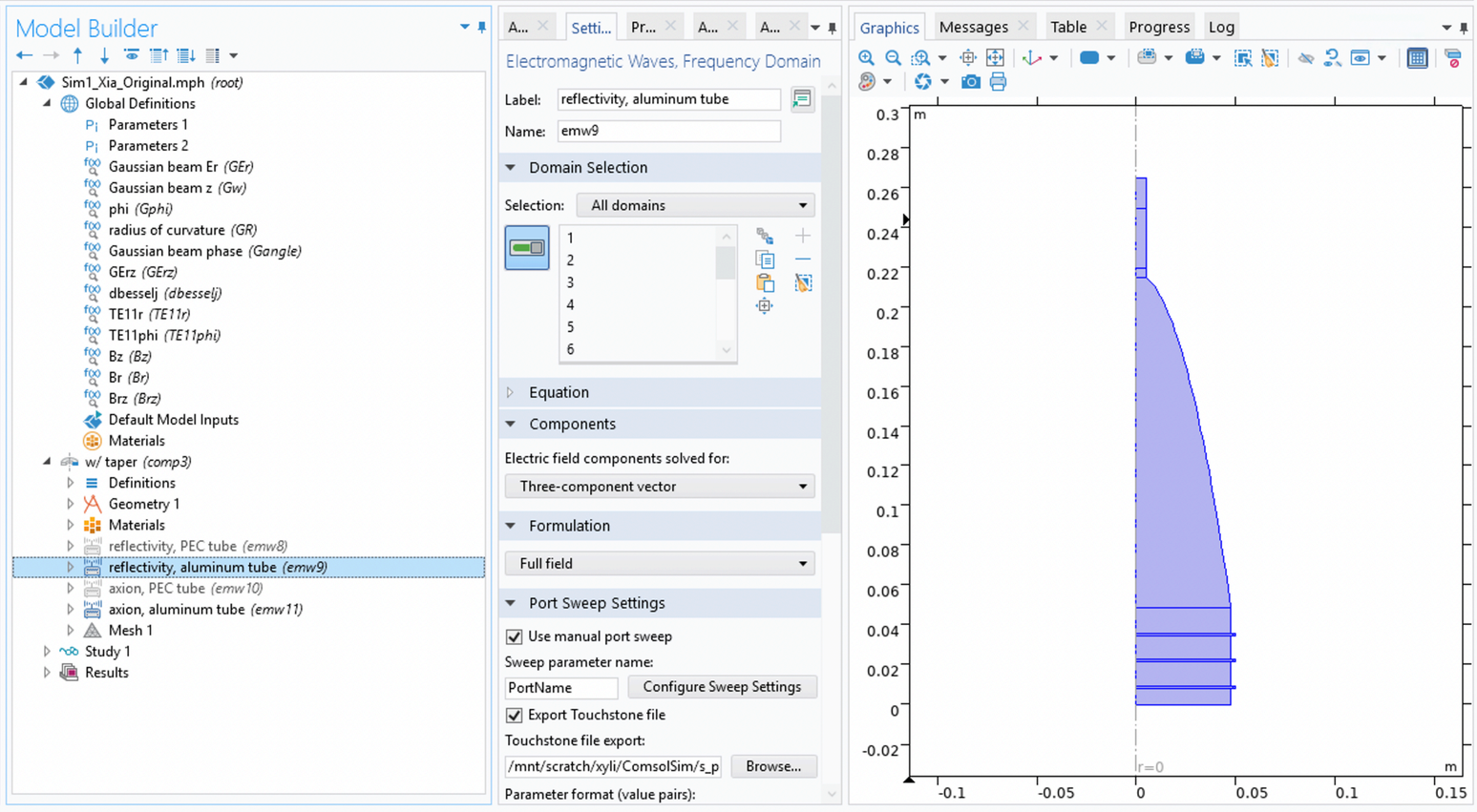




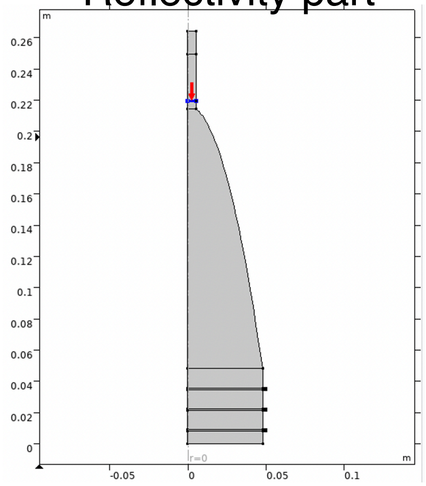




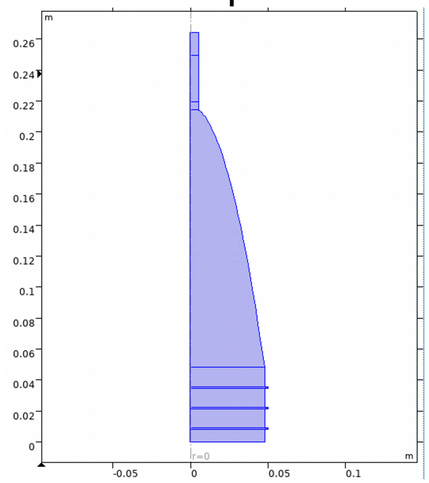
What is the file that we use?

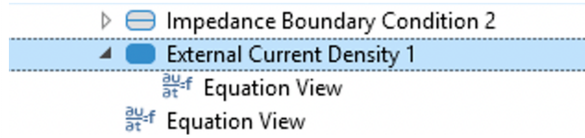


Reflectivity part



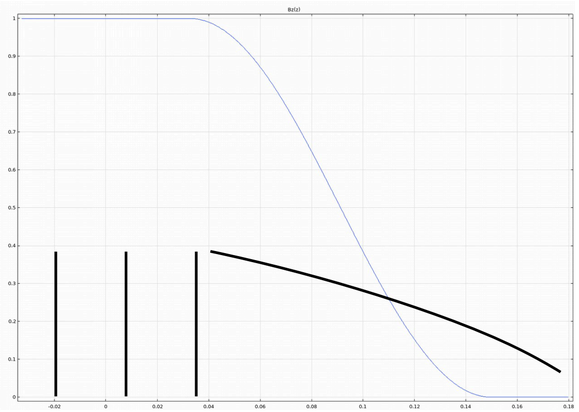
Axion part





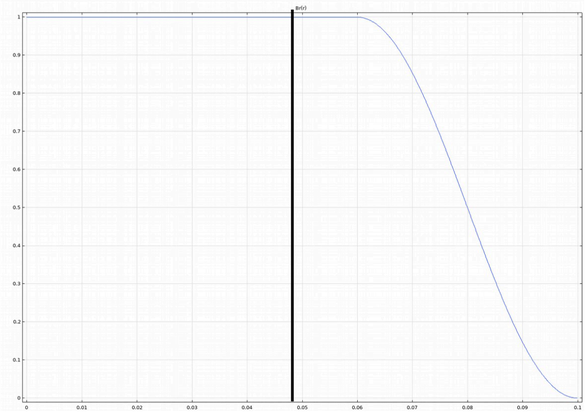
How is B0 introduced?

Tapering function along z



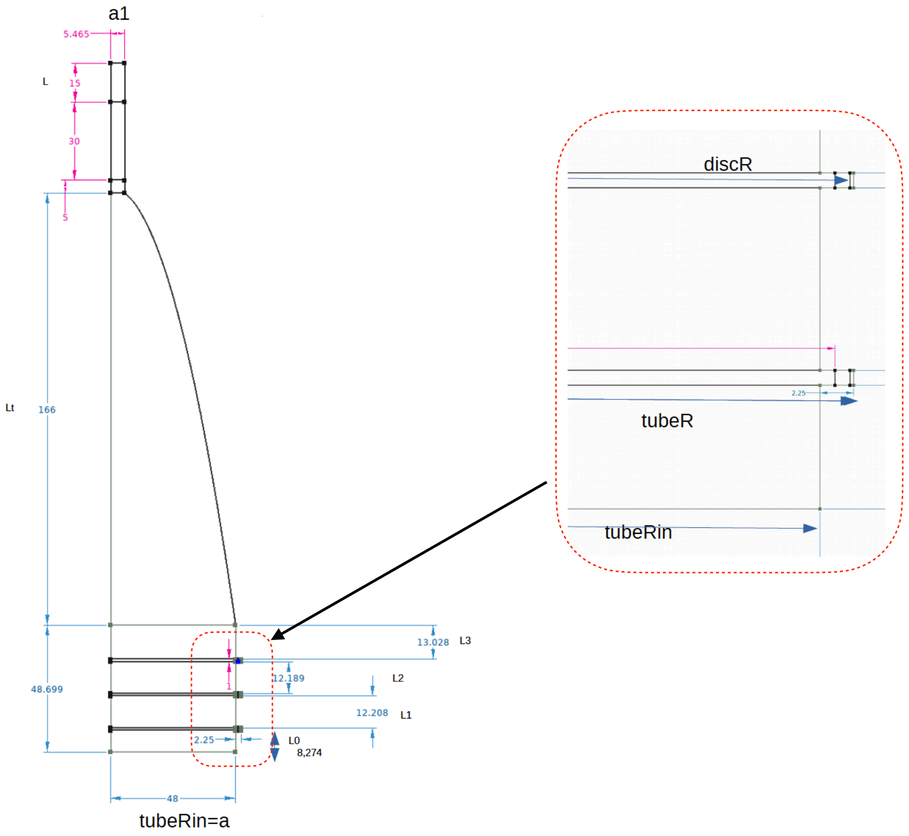
discs

Tapering function along r



Booster radius

Dimensions and parametrisation



Sim0

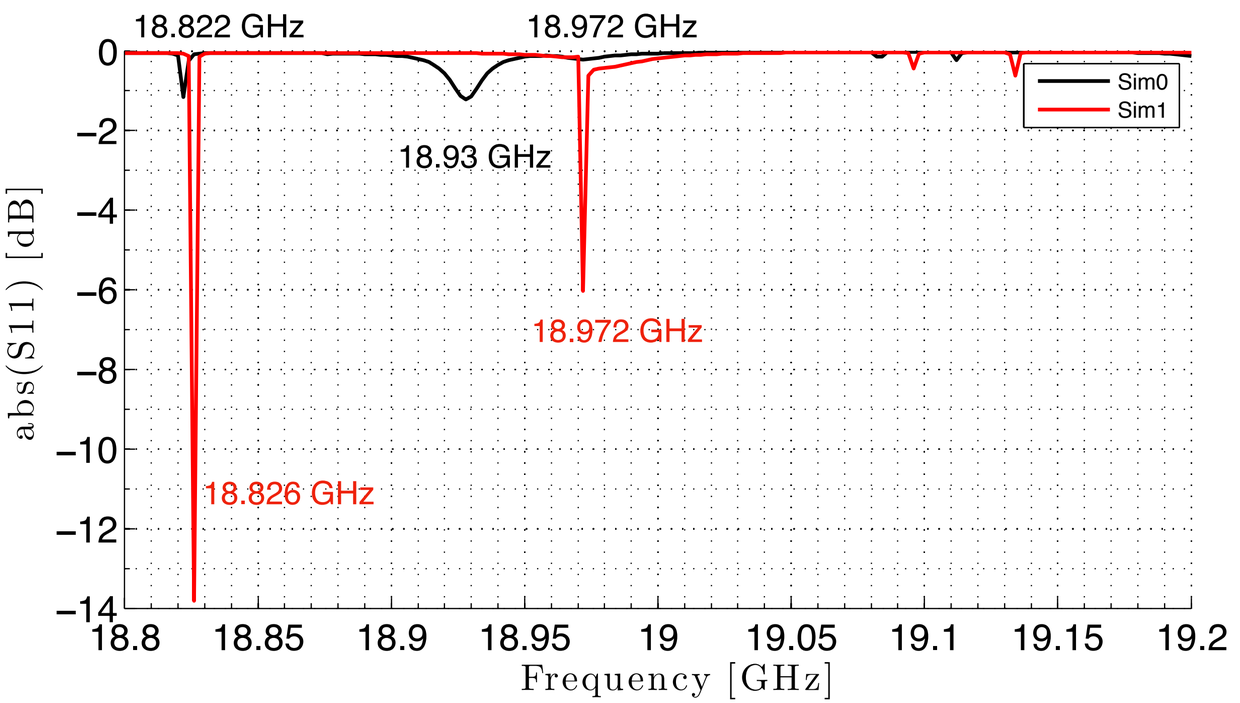
discR	5[cm]*(1-shrink_s)	0.05 m
L0	8.274[mm]	0.008274 m
L1	12.208[mm]	0.012208 m
L2	12.189[mm]	0.012189 m
discD	1[mm]*(1-shrink_s)	0.001 m
L	15[cm]	0.15 m
SimR	a*3	0.144 m
SimZ		0.18 m
epsilon	9.35	9.35
tanD_s	3E-05	3E-05
disp	1[mm]	0.001 m
bScaling	(1[A/m^2])^2/ (2*c_const*omega^2*mu0_const*epsilon0_const^2)*pi*discR^2	9.3296E-6 W
L_tot	L0+L1+L2	0.032671 m
L3	13.028[mm]	0.013028 m
Lt	166[mm]	0.166 m
a1	10.93[mm]/2	0.005465 m
F	(a^2-a1^2)/2/Lt	0.0068498 m
PortName	1	1
eps_air	1	1
shrink	0.004*0	0
shrink_s	0.0001*0	0
copper_sigma	5.9E+07	5.9E+07
al_sigma	3.77E+07	3.77E+07
tubeR	100.5[mm]/2	0.05025 m
tubeRin	a	0.048 m

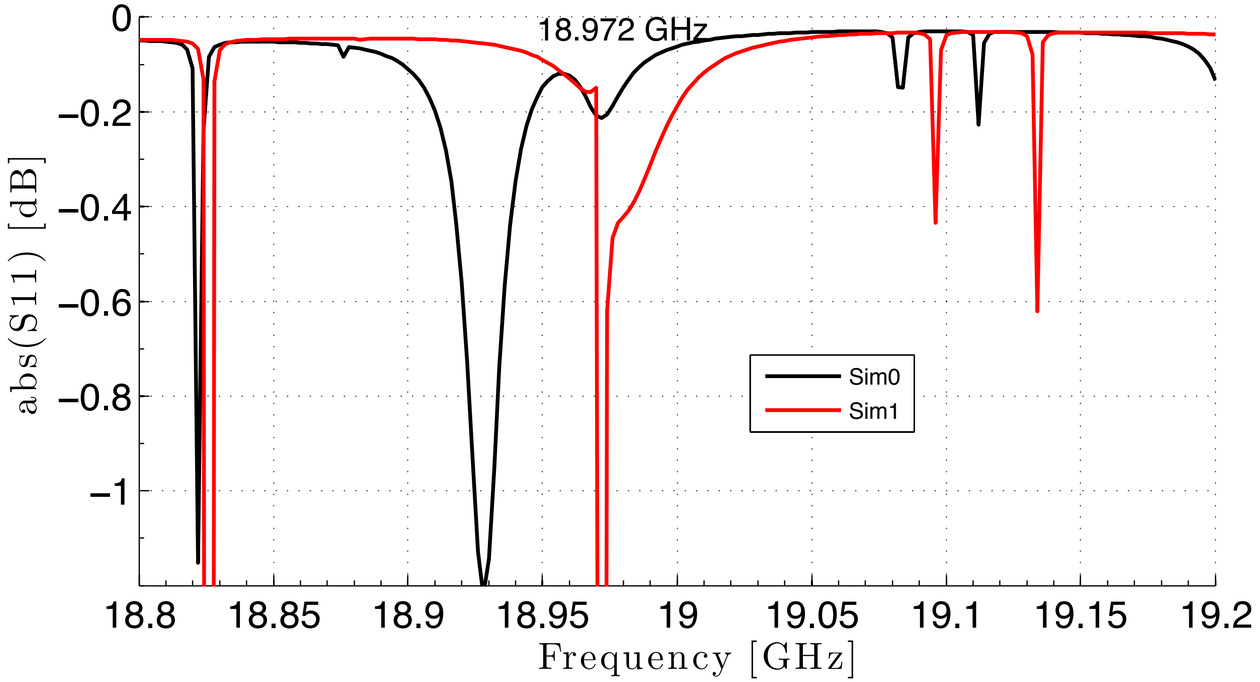
Parameters as obtained from Xia Li's file

Sim1

discR	5[cm]*(1-shrink_s)	0.05 m
L0	8.2745[mm]	0.0082745 m
L1	12.208[mm]	0.012208 m
L2	12.189[mm]	0.012189 m
discD	0.976[mm]*(1-shrink_s)	9.76E-4 m
L	15[cm]	0.15 m
SimR	a*3	0.144 m
SimZ	L+3[cm]	0.18 m
epsilon	9.35	9.35
tanD_s	3E-05	3E-05
disp	1[mm]	0.001 m
bScaling	(1[A/m^2])^2/ (2*c_const*omega^2*mu0_const*epsilon0_const^2)*pi*discR^2	9.3296E-6 W
L_tot	L0+L1+L2	0.032672 m
L3	13.028[mm]	0.013028 m
Lt	166[mm]	0.166 m
a1	10.93[mm]/2	0.005465 m
F	(a^2-a1^2)/2/Lt	0.0068498 m
PortName	1	1
eps_air	1	1
shrink	0.004*0	0
shrink_s	0.0001*0	0
copper_sigma	5.9E+07	5.9E+07
al_sigma	3.77E+07	3.77E+07
tubeR	100.5[mm]/2	0.05025 m
tubeRin	a	0.048 m
m_angular	1	1

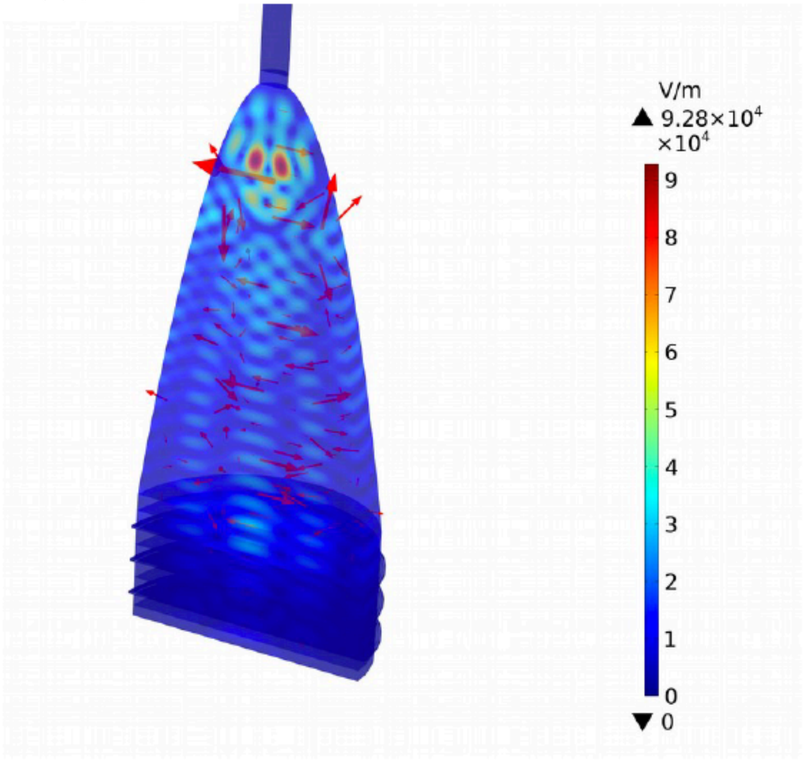
Parameters as given by Olaf


18.822 GHz
18.972 GHz
18.93 GHz
18.972 GHz
18.826 GHz
Sim0
Sim1
abs(S11) [dB]
Frequency [GHz]
0
−2
−4
−6
−8
−10
−12
−14
18.8
18.85
18.9
18.95
19
19.05
19.1
19.15
19.2

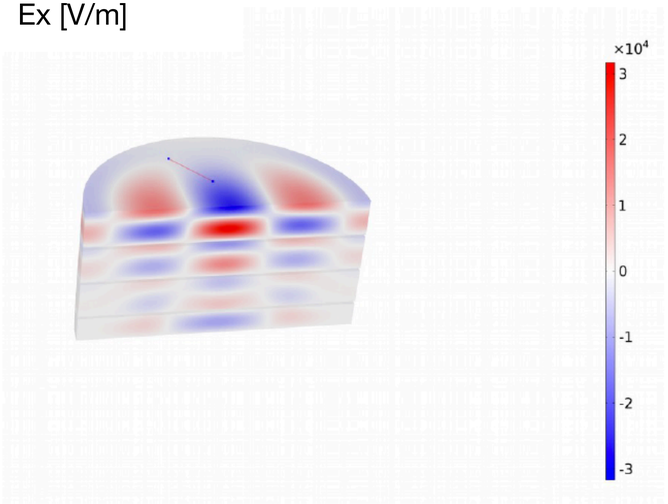

18.972 GHz
Sim0
Sim1
abs(S11) [dB]
Frequency [GHz]
0
−0.2
−0.4
−0.6
−0.8
−1
18.8
18.85
18.9
18.95
19
19.05
19.1
19.15
19.2

18.826 GHz

abs(E) [V/m]



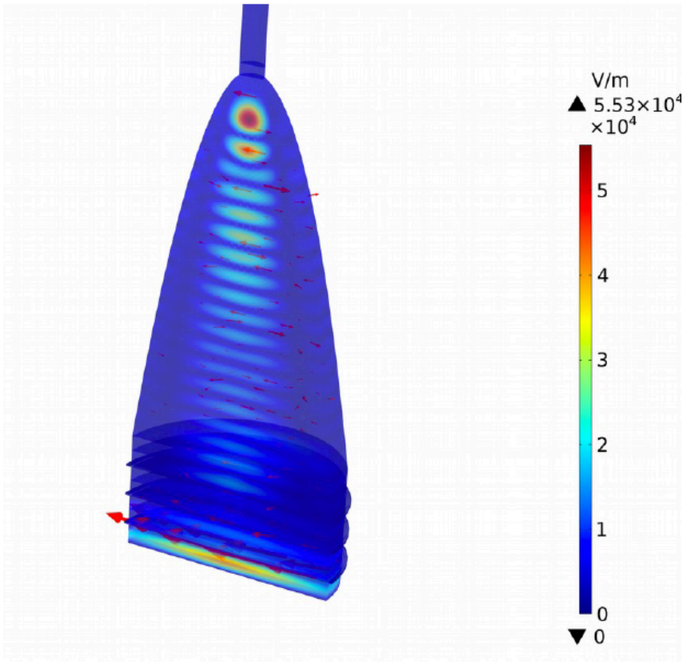
Ex [V/m]



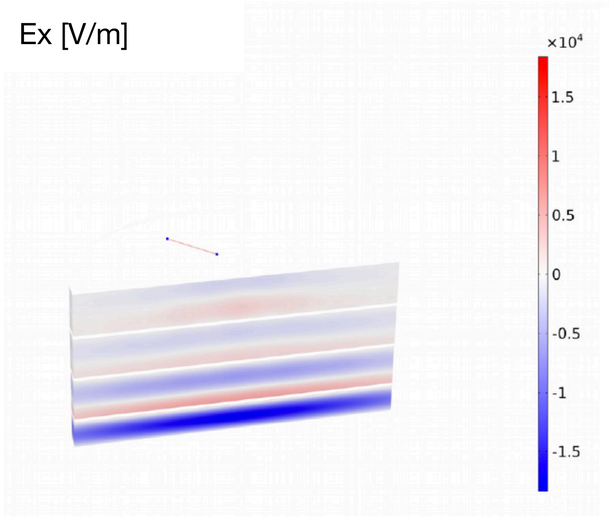
Looks like 18.822 GHz from Sim0

18.972 GHz

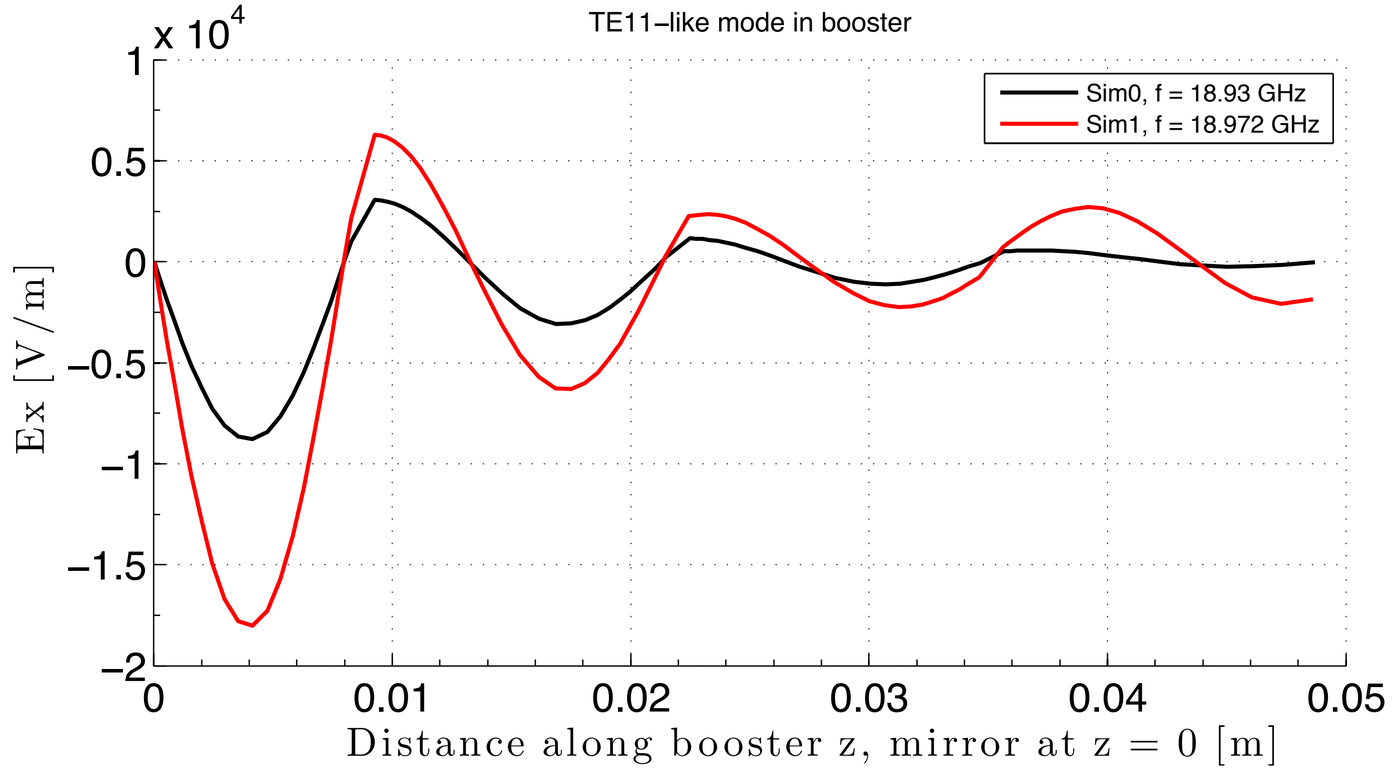
abs(E) [V/m]



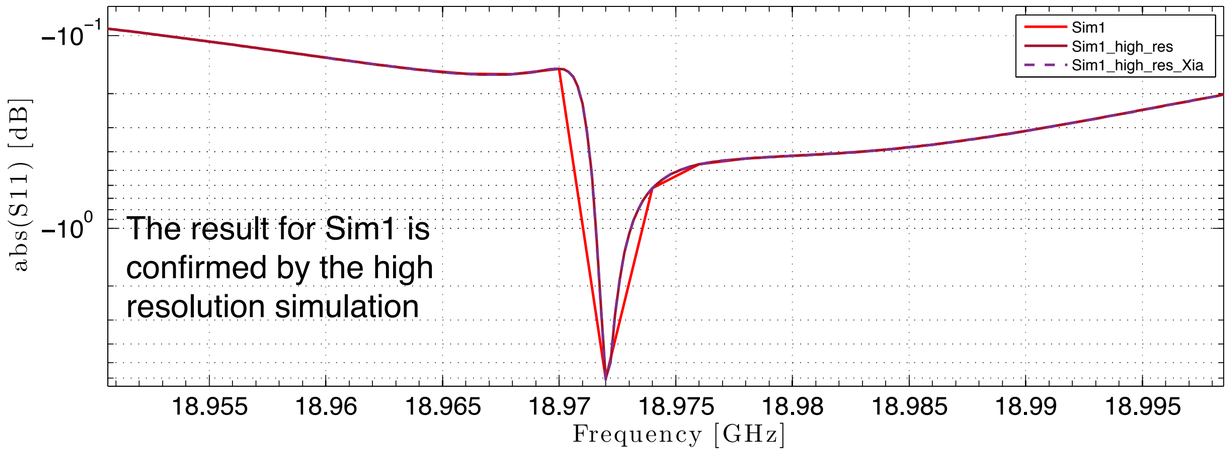
Ex [V/m]



Looks like a combination of 18.93 and 18.972 GHz from Sim0


TE11–like mode in booster
x 10^4
1
0.5
0
−0.5
−1
−1.5
−2
0
0.01
0.02
0.03
0.04
0.05
Ex [V/m]
Distance along booster z, mirror at z = 0 [m]
Sim0, f = 18.93 GHz
Sim1, f = 18.972 GHz

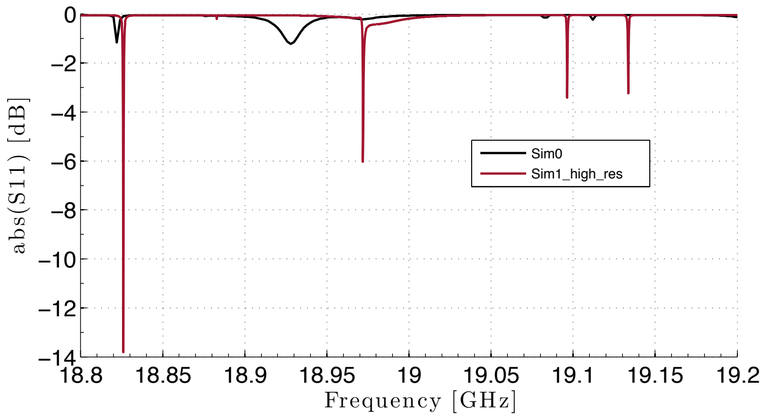
Increasing the resolution for Sim1



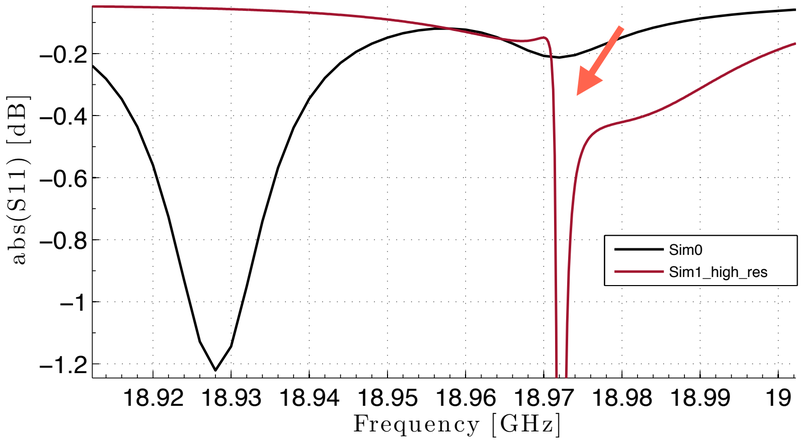
Sim1 -> Δf = 2 MHz
Sim1_high_res -> Δf = 0.2 MHz
(cold_booster_taper_goldring13mm_revolution)

Sim_high_res_Xia -> Δf = 0.2 MHz
(Sim1_Xia_Original.mph)

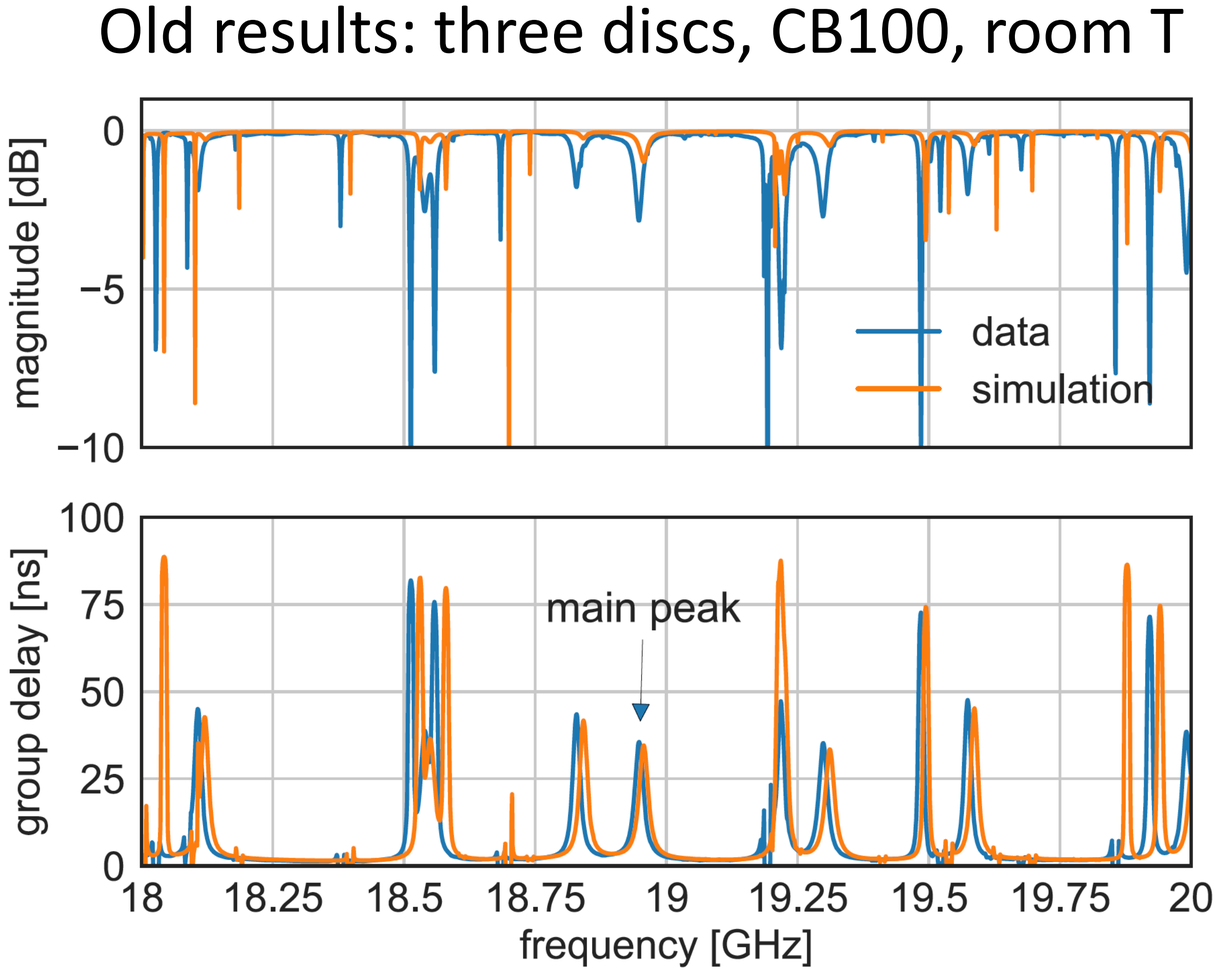
Below, Sim0 and Sim1 are compared, the results are with high resolution



This seems to be physical



Do we trust COMSOL at all?



Open discussion

Let us answer the following questions:

Where do we use simulations?

How could simulations help us understand more?

What are the parameters and results for the state of CB100 at CERN?

Do we need simulations for the paper?