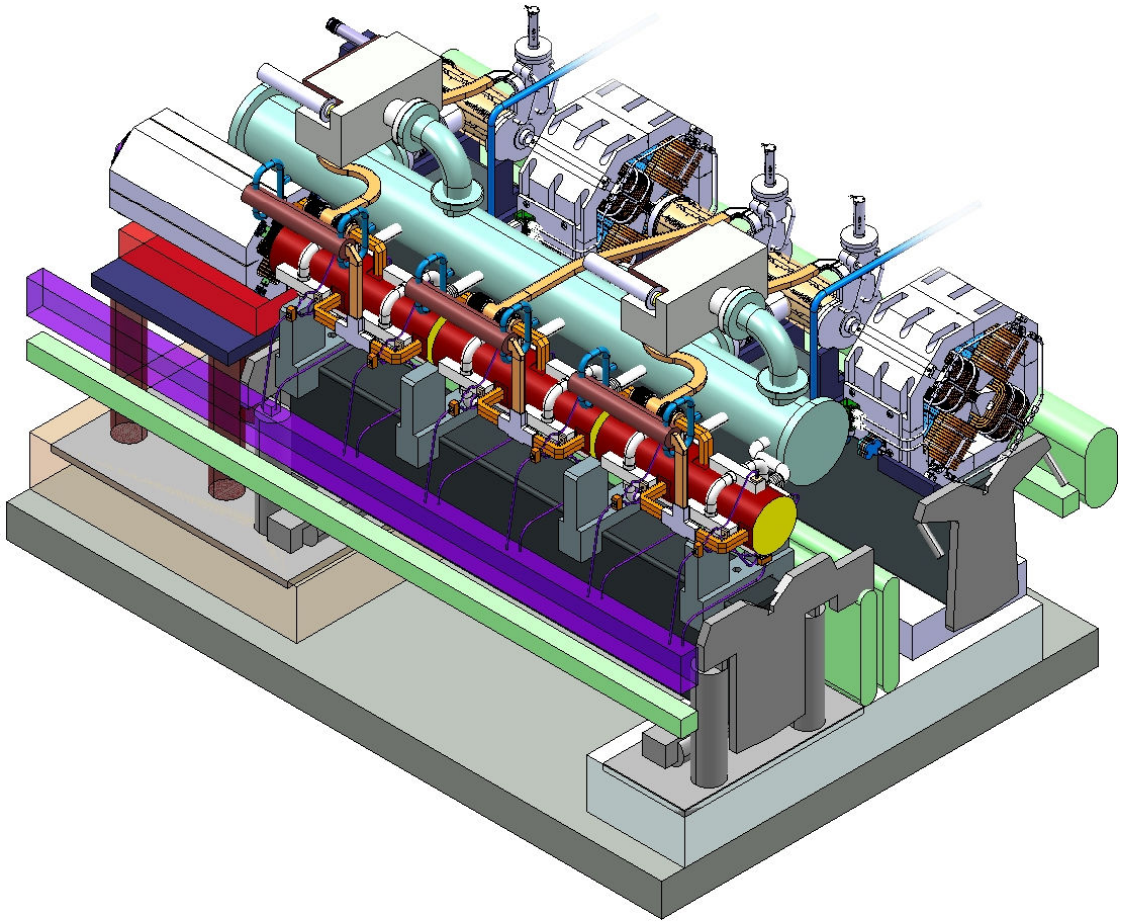
RF aspects of module vacuum system

Riccardo Zennaro CERN

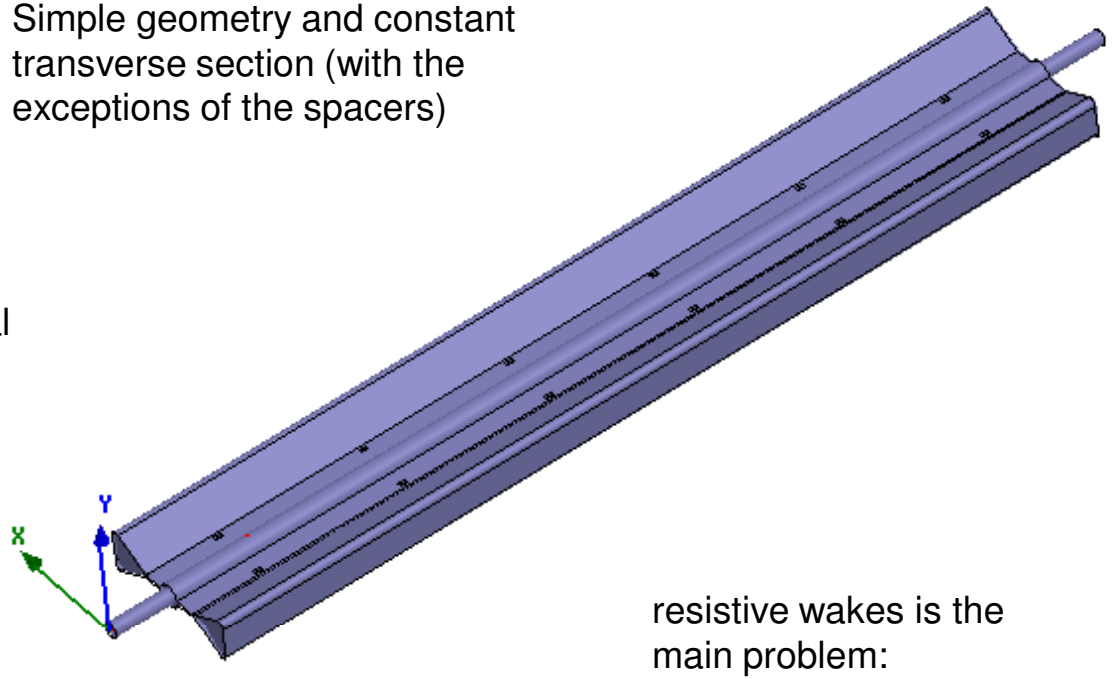
Contents

- ✓Wakefield study in the main linac vacuum chamber
- ✓Wakefile study in the AC-QUAD main linac intramodule interconnection
- ✓Wakefield study in the main linac intermodule interconnection



Problem: resonator in a beam line;
(standing waves excited)

Simple geometry and constant transverse section (with the exceptions of the spacers)

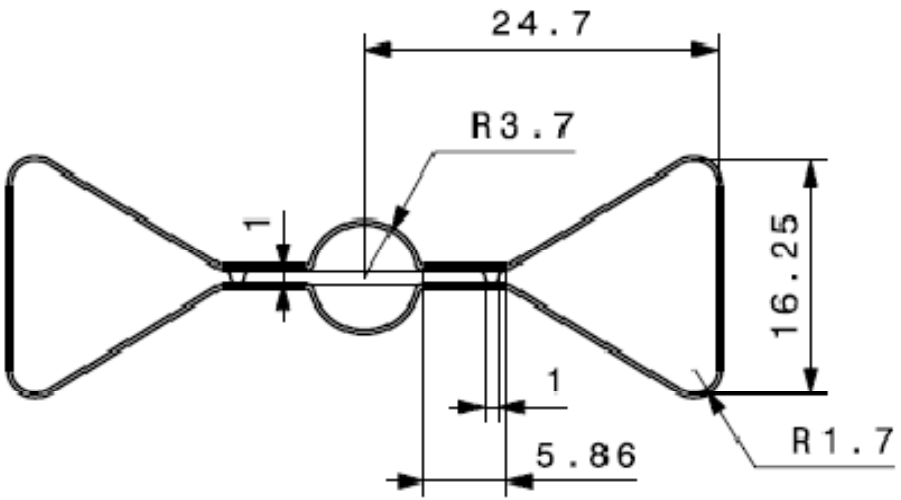


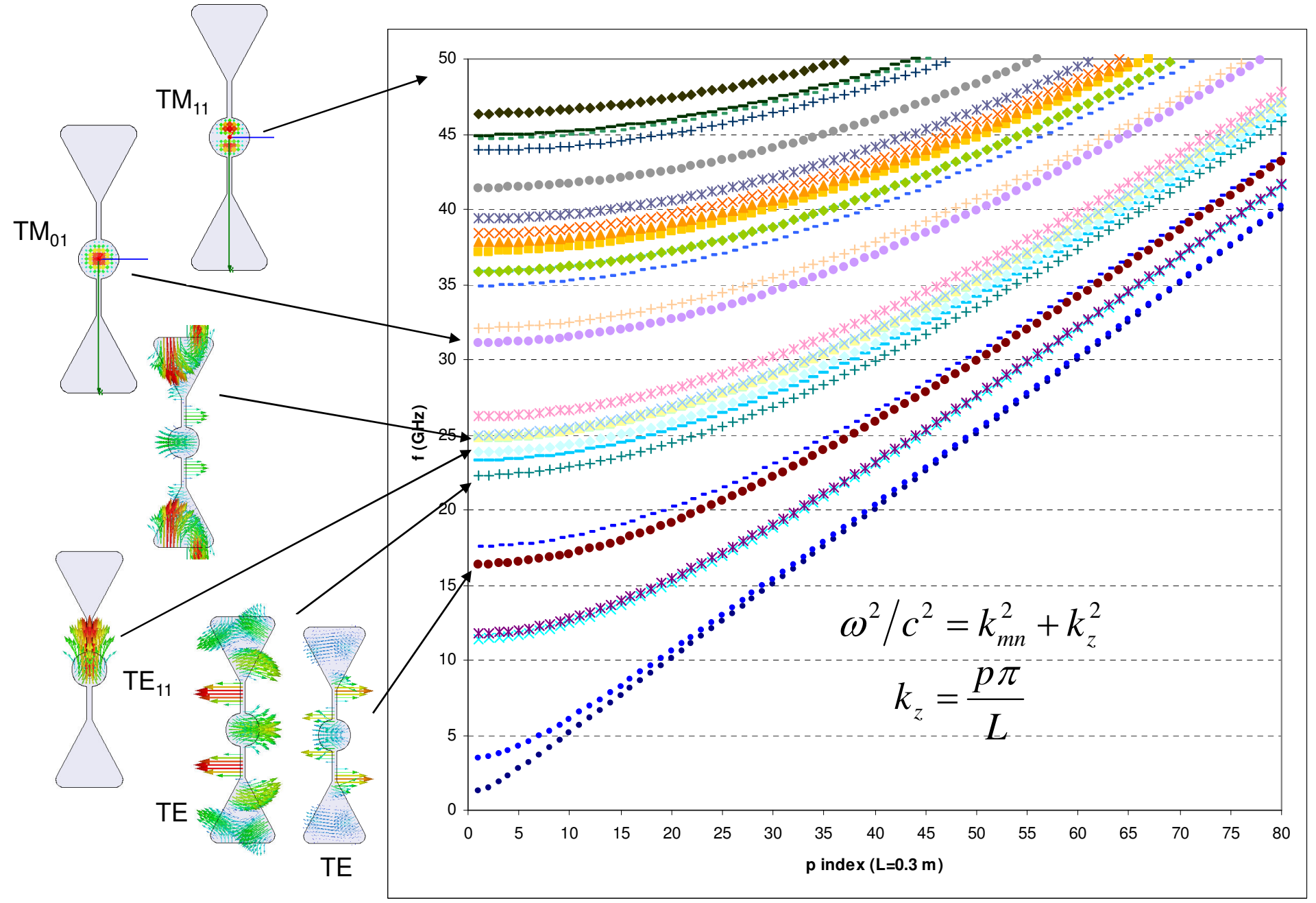
2D problem (HFSS) + longitudinal dependence

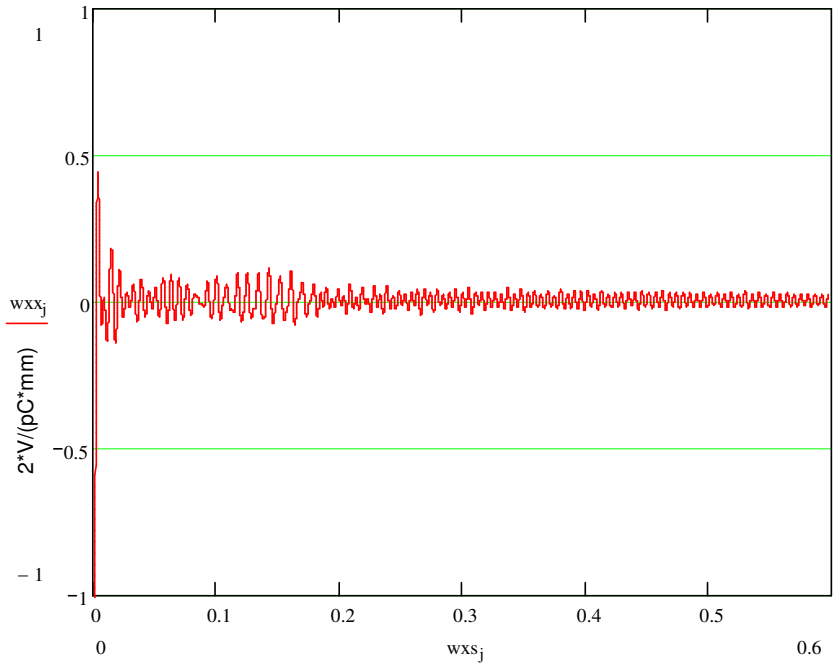
resistive wakes is the main problem:

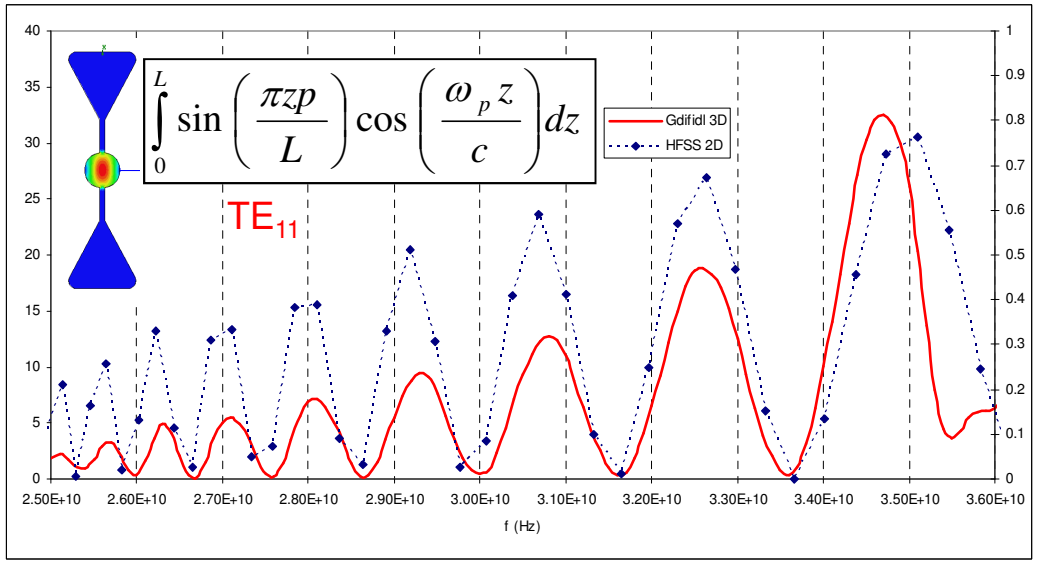
$$W(s) = -\frac{c}{4\pi^{3/2}a}\sqrt{\frac{Z_0}{\sigma}}\frac{1}{s^{3/2}}$$

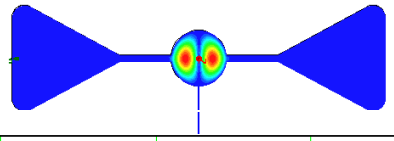
Copper layer




TM11
TM01
TE11
TE
TE
f (GHz)
p index (L=0.3 m)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
$\omega^2/c^2 = k_{mn}^2 + k_z^2$
$k_z = \frac{p\pi}{L}$

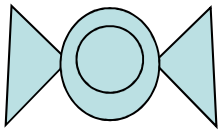


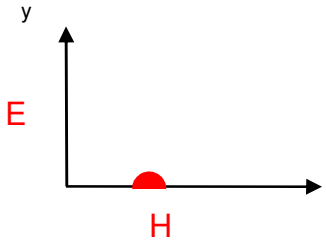


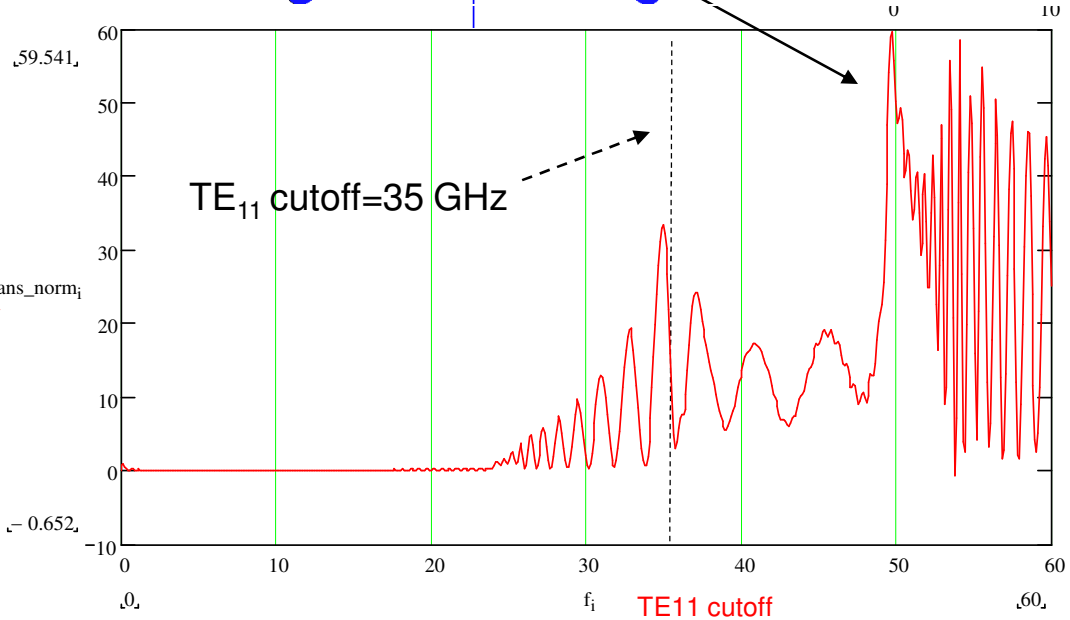


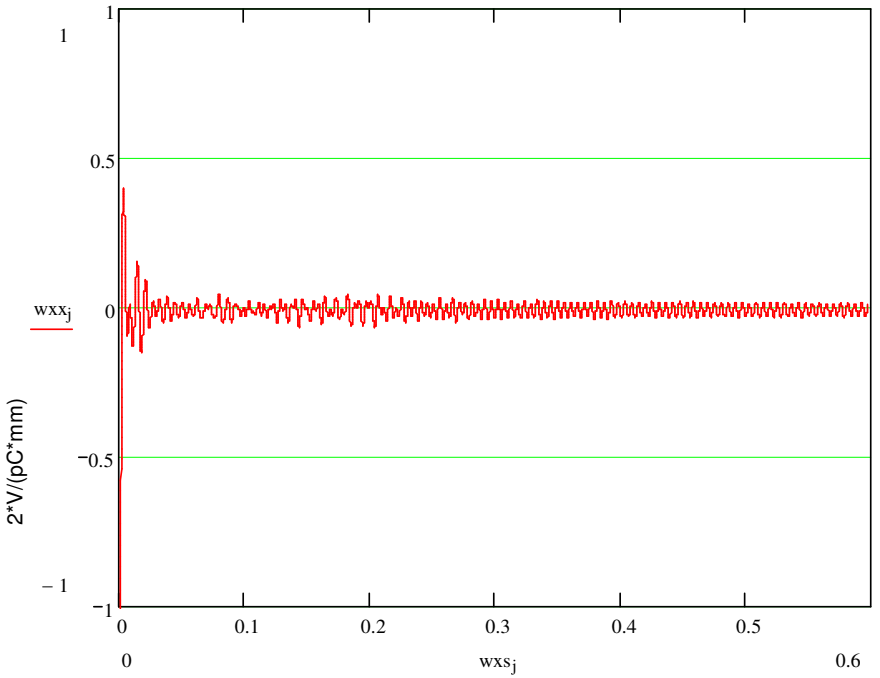
TM11 cutoff=73 GHz

No spacers, r=2.5 mm, dx=1mm

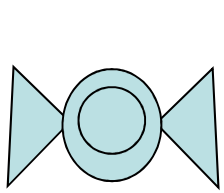






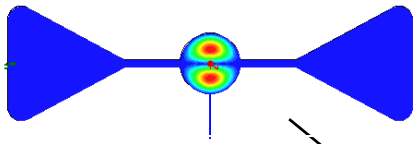


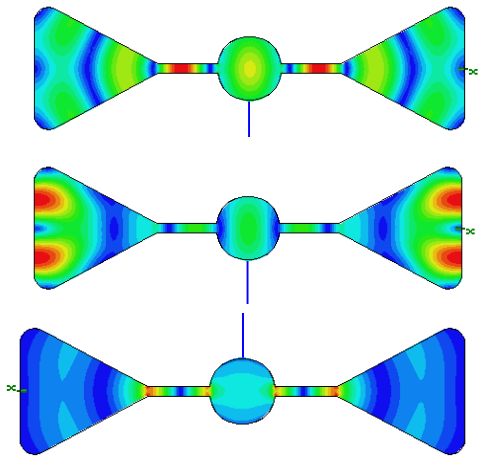
No spacers, r=2.5 mm, dy=1mm

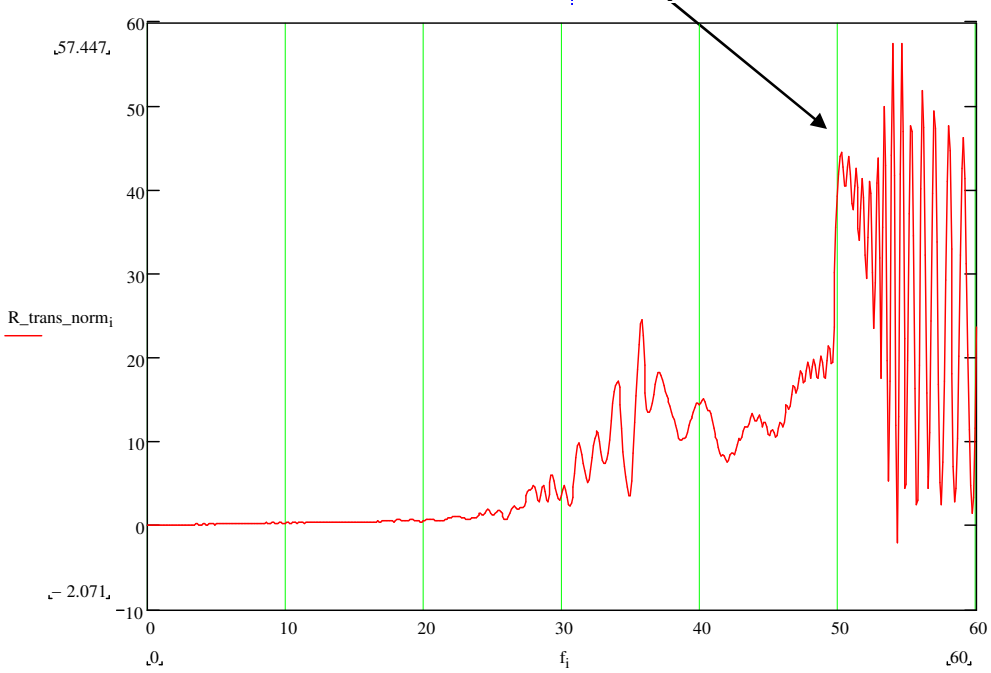


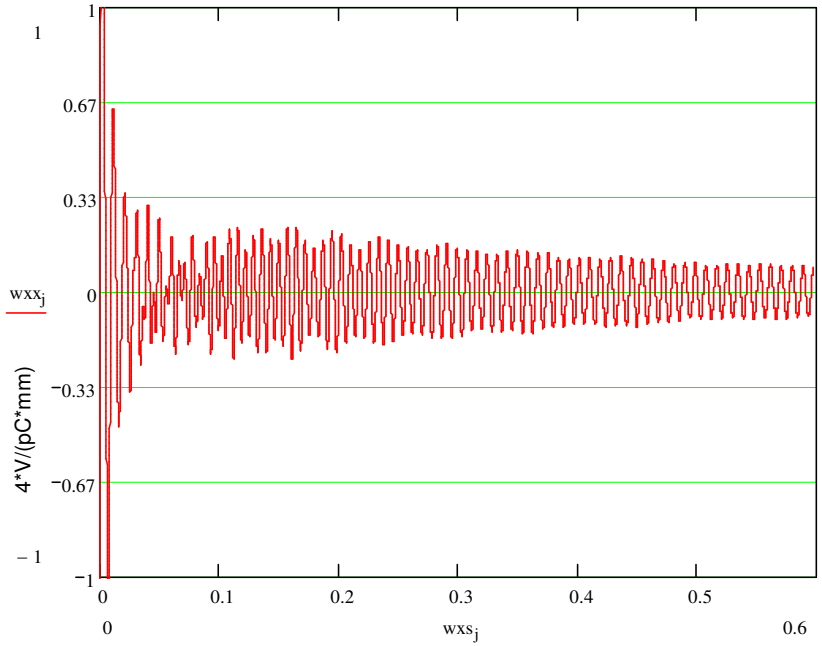
E

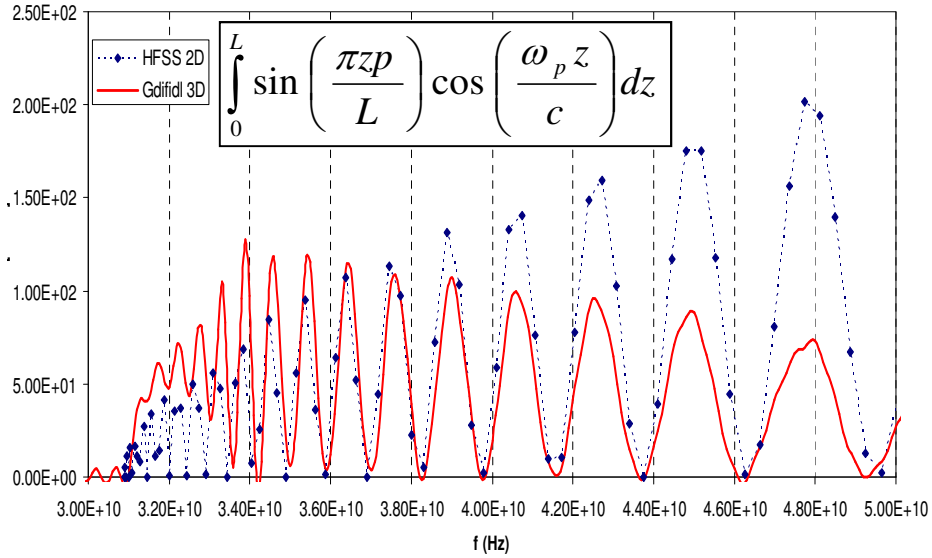
TM_{11}





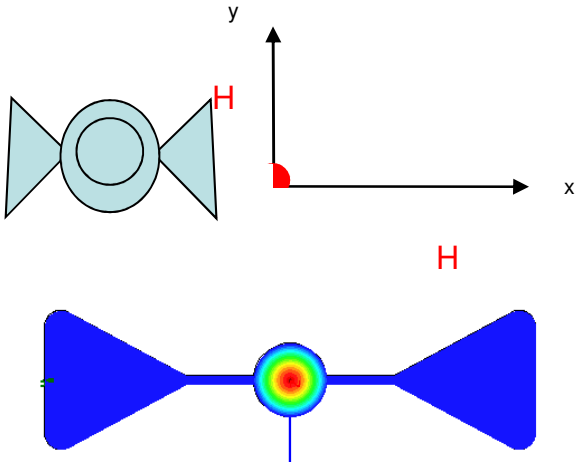




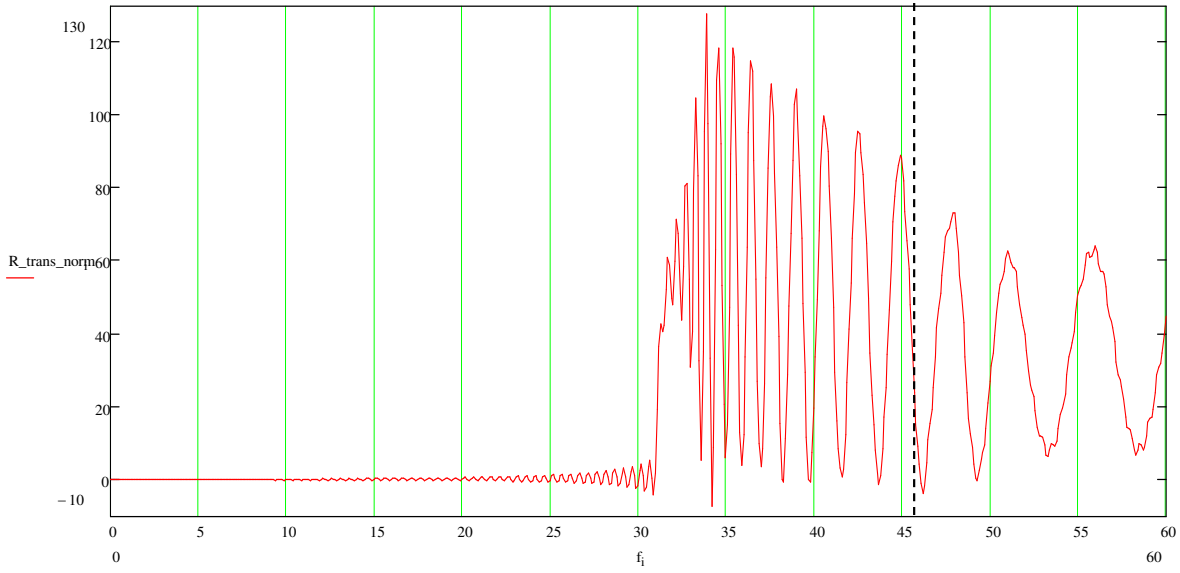


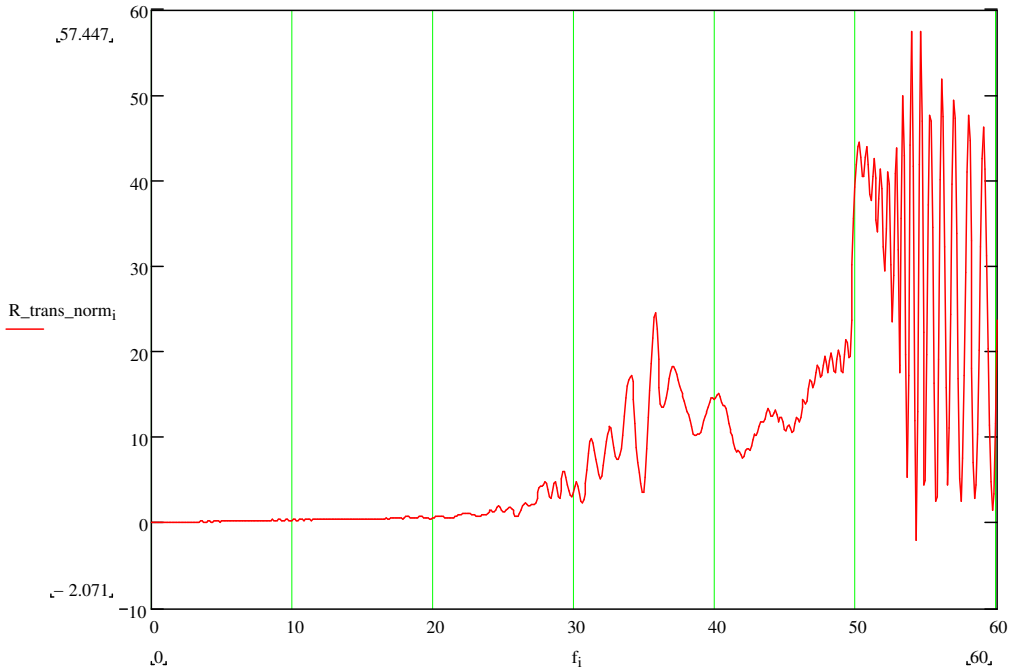
No spacers, r=2.5 mm

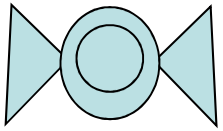
beam on axis

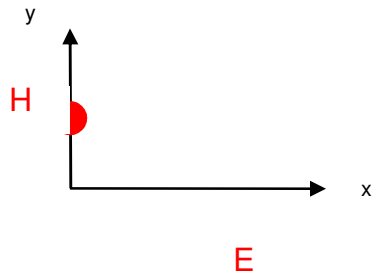


TM_{01} cutoff=46 GHz

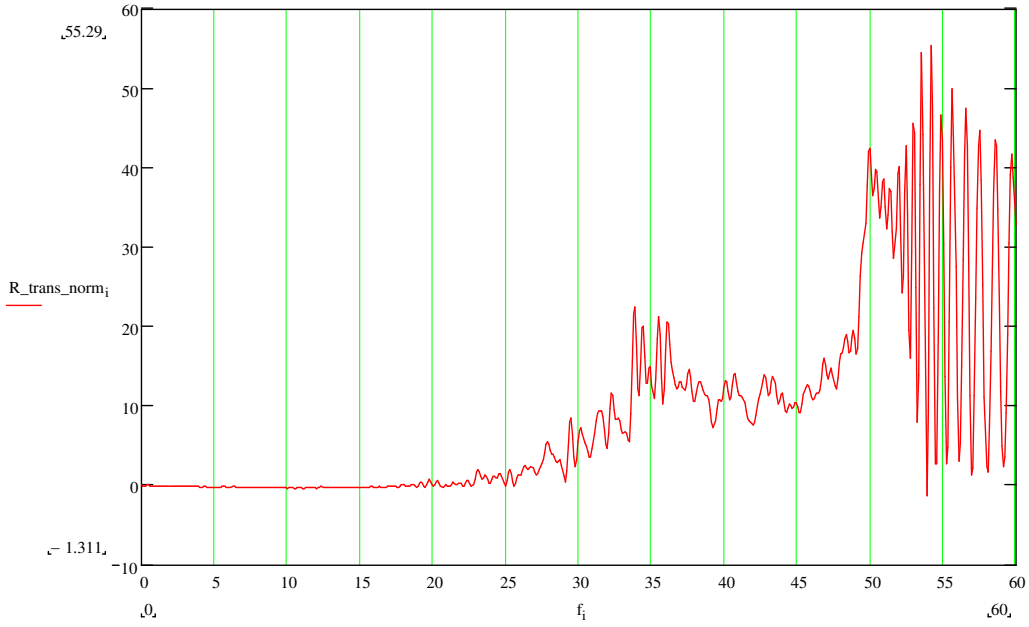




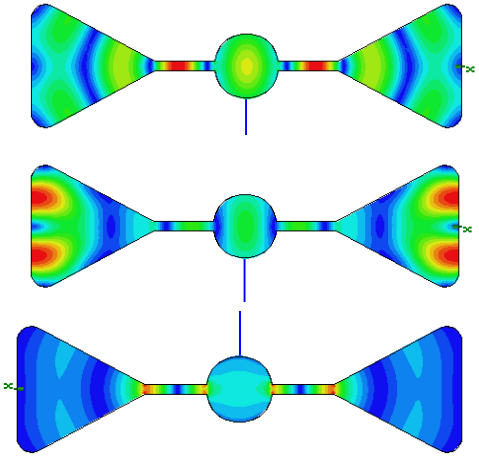


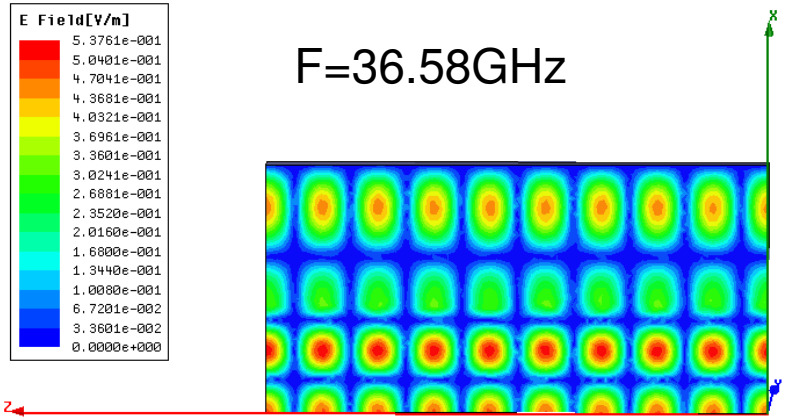


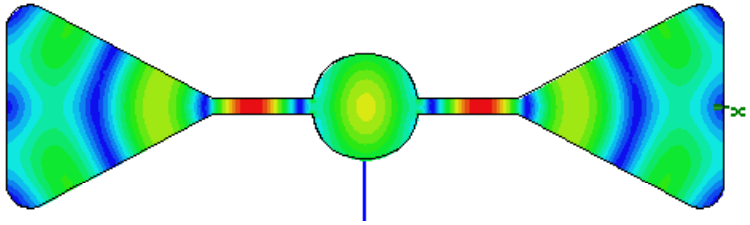
No Spacers

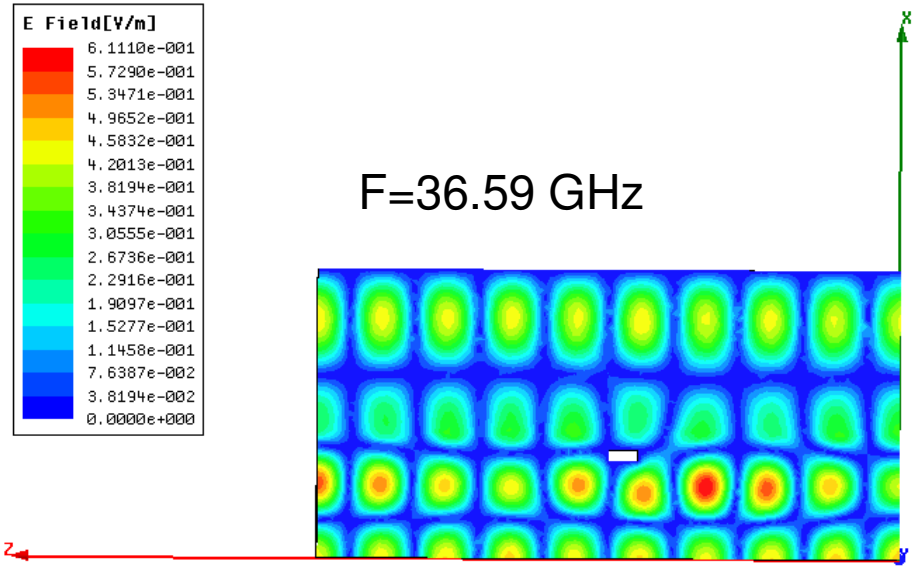


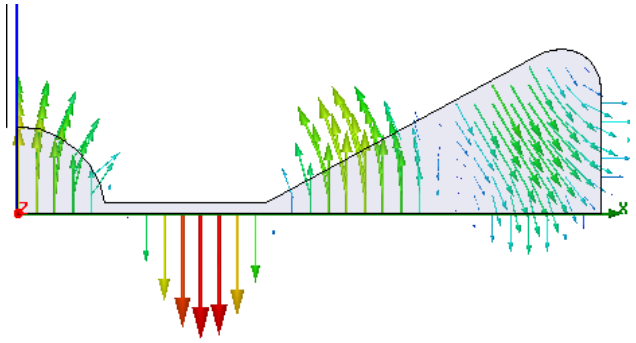
Spacers; periods=50 mm, length=2.5mm

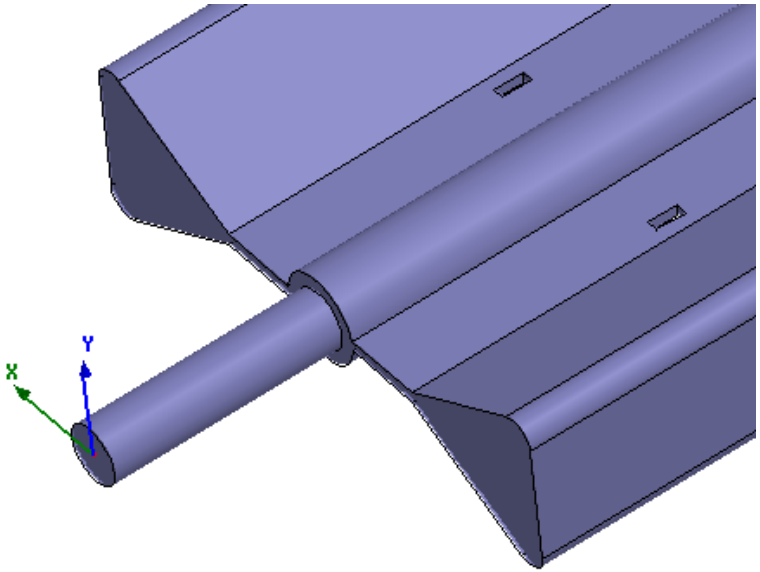



E Field[V/m]
5.3761e-001
5.0401e-001
4.7041e-001
4.3681e-001
4.0321e-001
3.6961e-001
3.3601e-001
3.0241e-001
2.6881e-001
2.3520e-001
2.0160e-001
1.6800e-001
1.3440e-001
1.0080e-001
6.7201e-002
3.3601e-002
0.0000e+000
F=36.58GHz

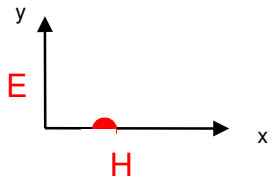



E Field[V/m]
6.1110e-001
5.7290e-001
5.3471e-001
4.9652e-001
4.5832e-001
4.2013e-001
3.8194e-001
3.4374e-001
3.0555e-001
2.6736e-001
2.2916e-001
1.9097e-001
1.5277e-001
1.1458e-001
7.6387e-002
3.8194e-002
0.0000e+000
F=36.59 GHz





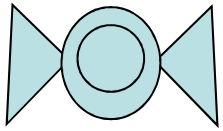
Variation of the beam pipe radius (3.7 mm instead of 2.5 mm)

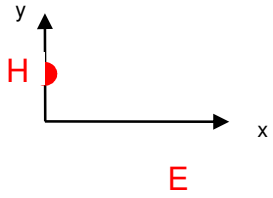


Problem solved

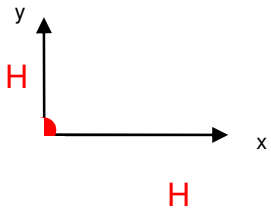
(no trapped modes in the pillbox approximation)

TE_{11} cutoff= from 35 GHz (r=2.5mm) to 24 GHz (r=3.7mm)





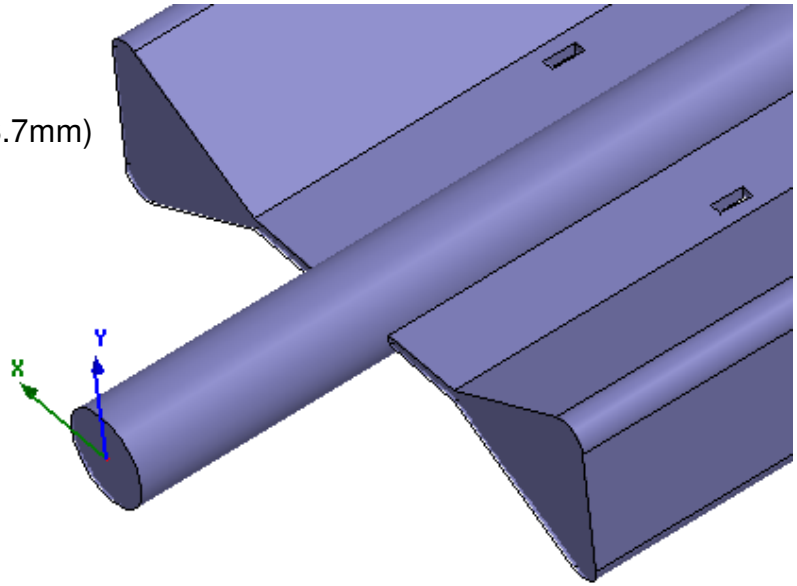
?.. In case damping

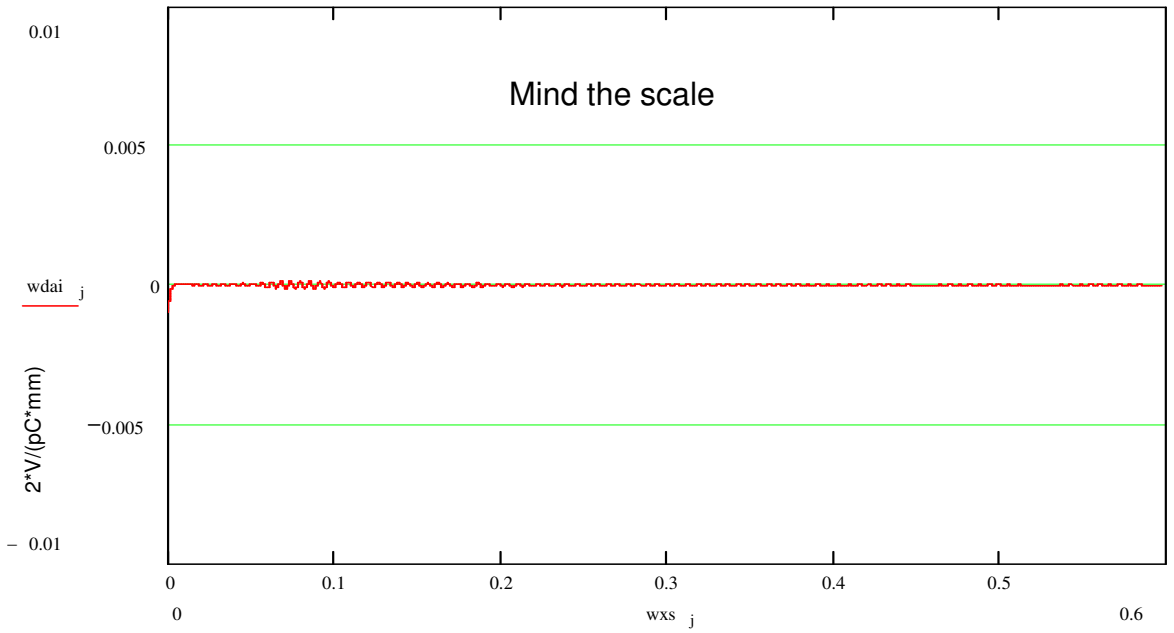


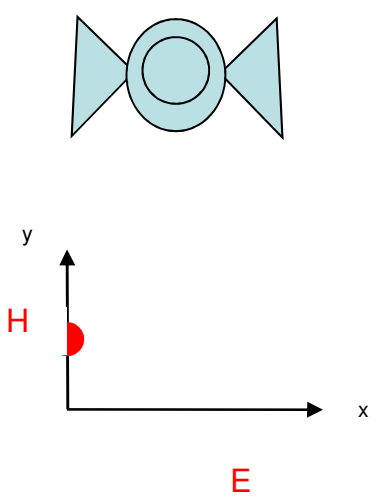
Problem solved

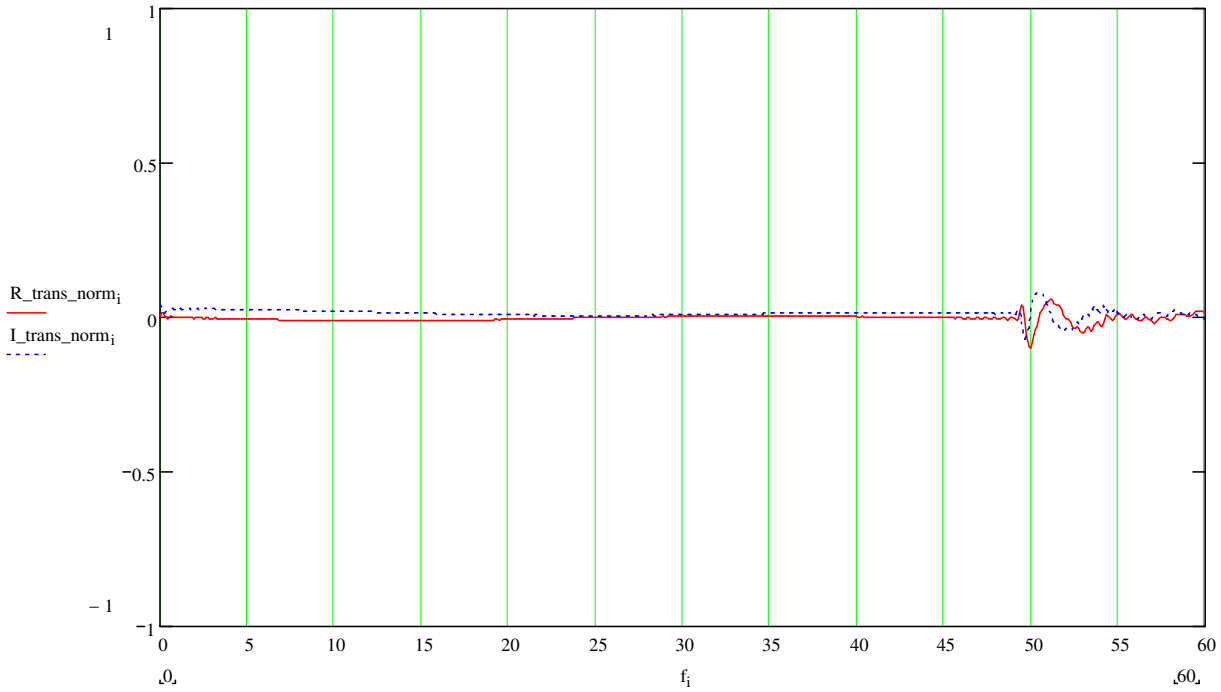
(no trapped modes in the pillbox approximation)

TM_{01} cutoff= from 46 GHz (r=2.5mm) to 31 GHz (r=3.7mm)

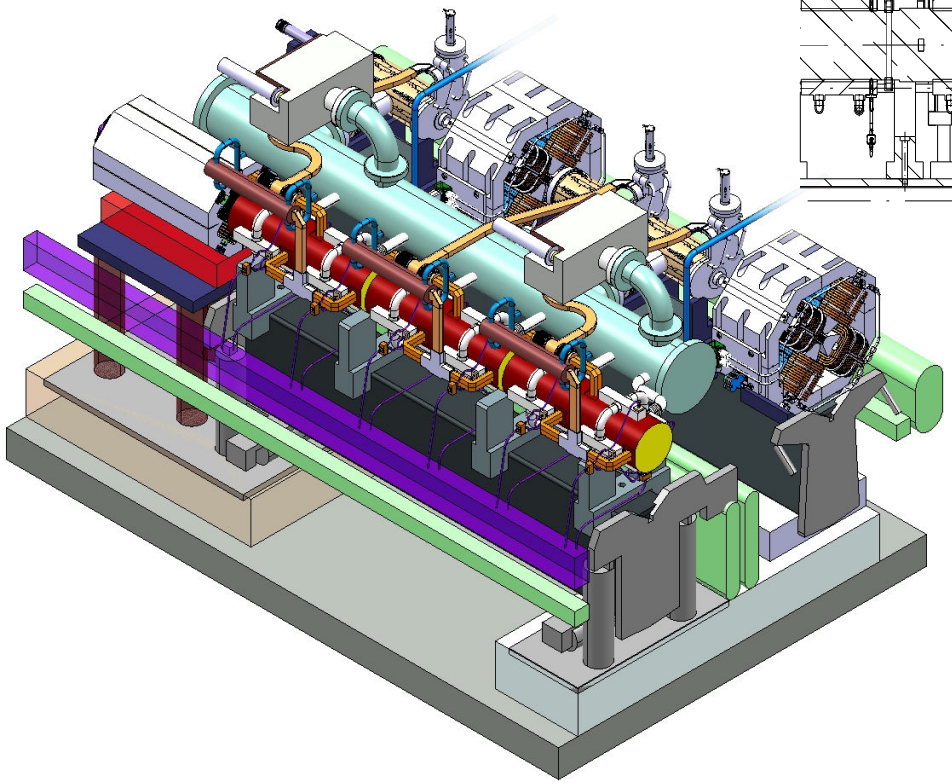


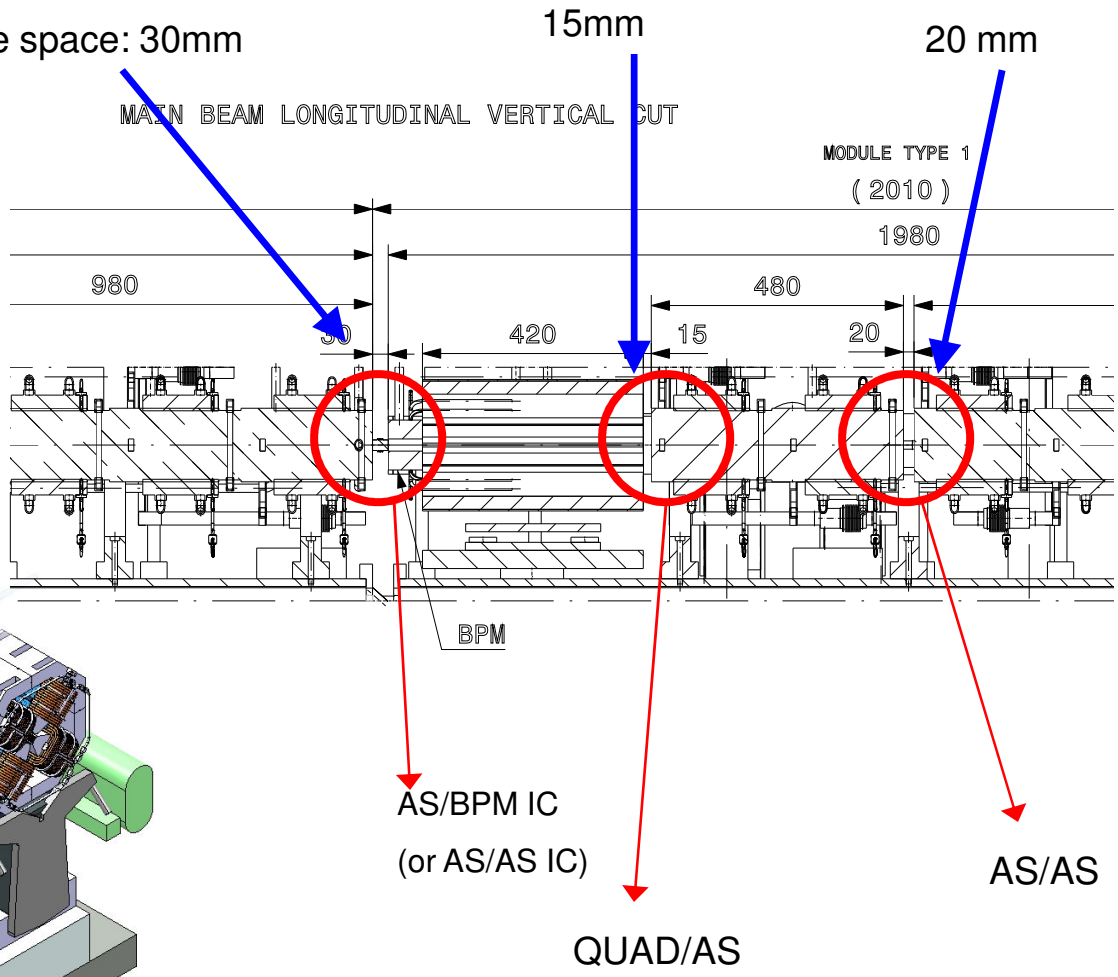

Mind the scale
0.01
0.005
0
−0.005
− 0.01
wdai j
2*V/(pC*mm)
0
0.1
0.2
0.3
0.4
0.5
0.6
wxs j


y
H
x
E


1
0.5
0
−0.5
− 1
R_trans_norm i
I_trans_norm i
0
5
10
15
20
25
30
35
40
45
50
55
60
f i

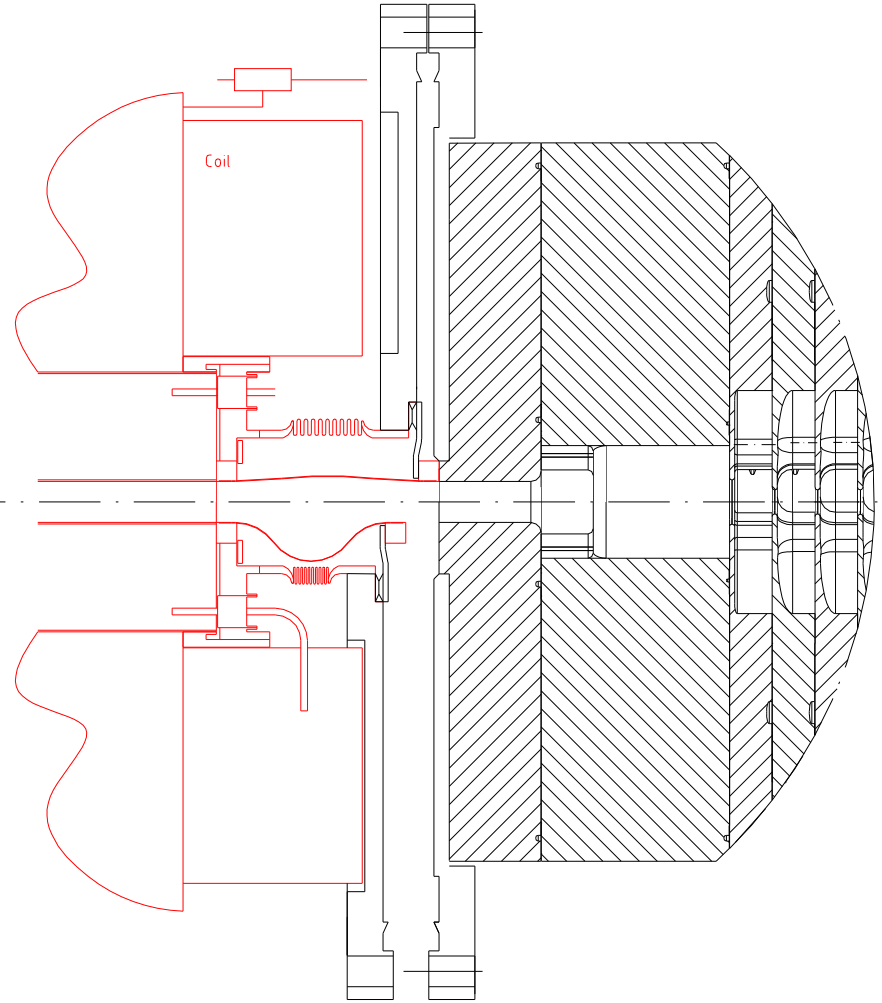
CLIC module



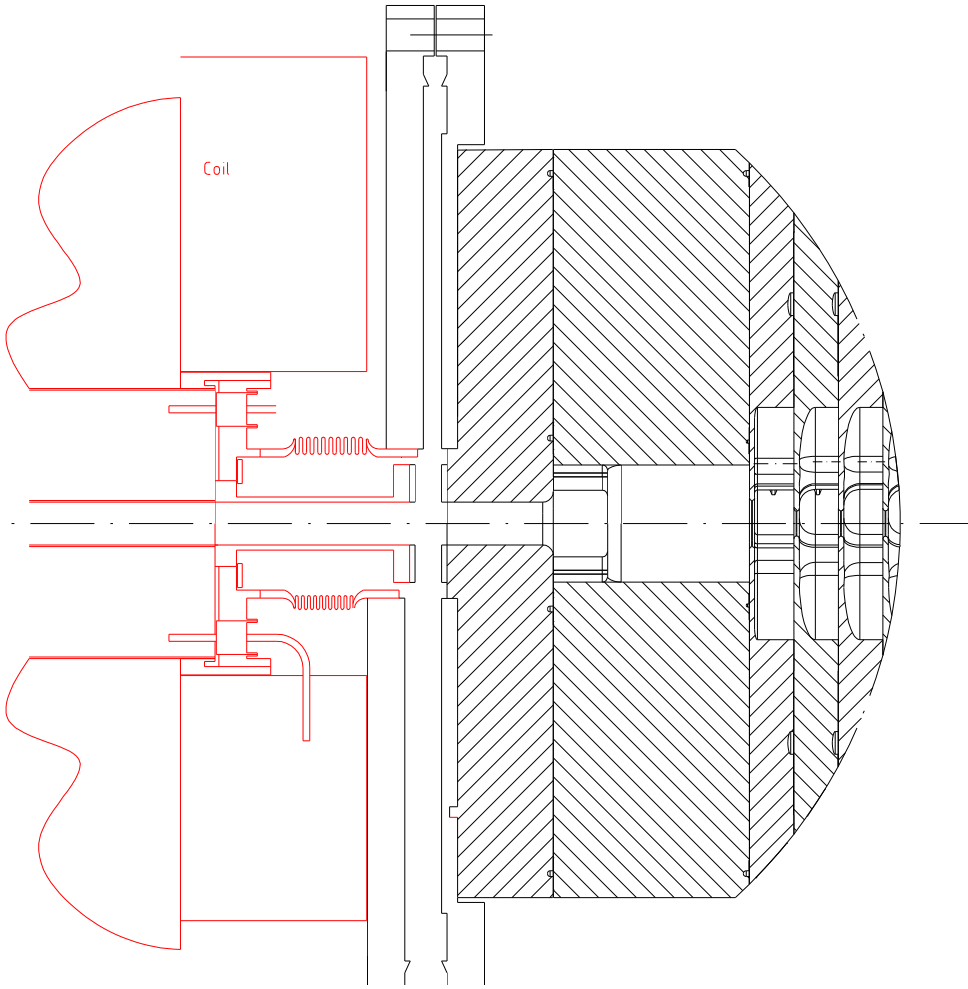

Free space: 30mm
15mm
20 mm
MAIN BEAM LONGITUDINAL VERTICAL CUT
MODULE TYPE 1
(2010)
1980
980
480
30
420
15
20
BPM
AS/BPM IC
(or AS/AS IC)
QUAD/AS
AS/AS

From Cedric: CLIC two beam module review 15/09/09

Main beam – QUAD/AS intramodule (intermodule) interconnections

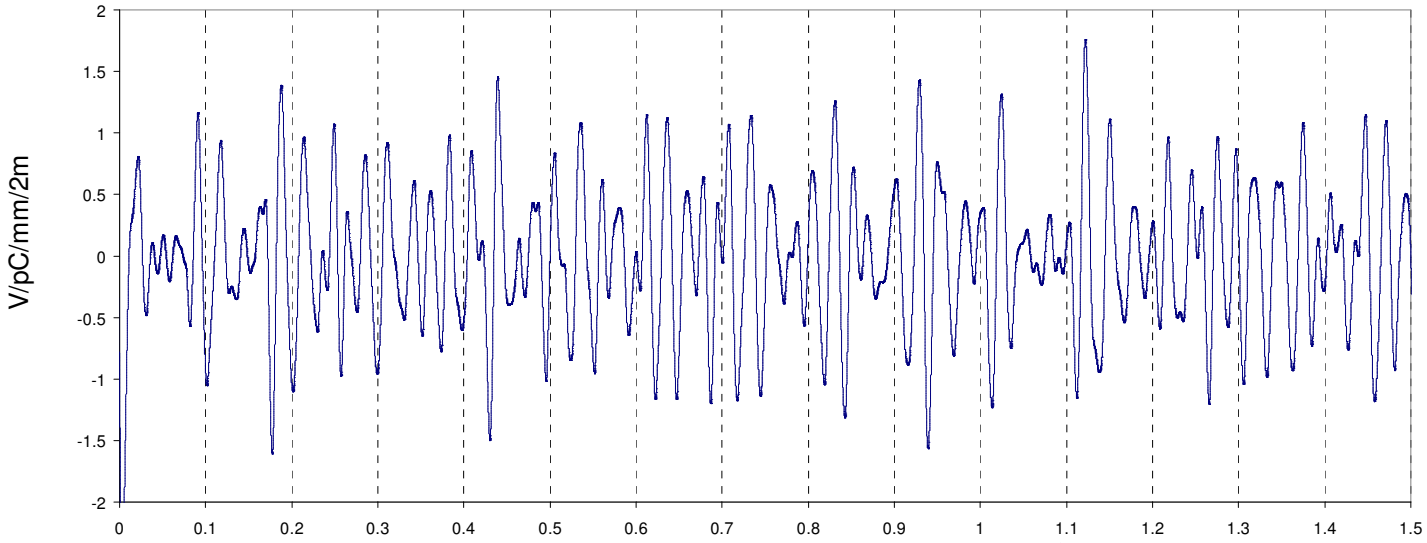


Continuous solution

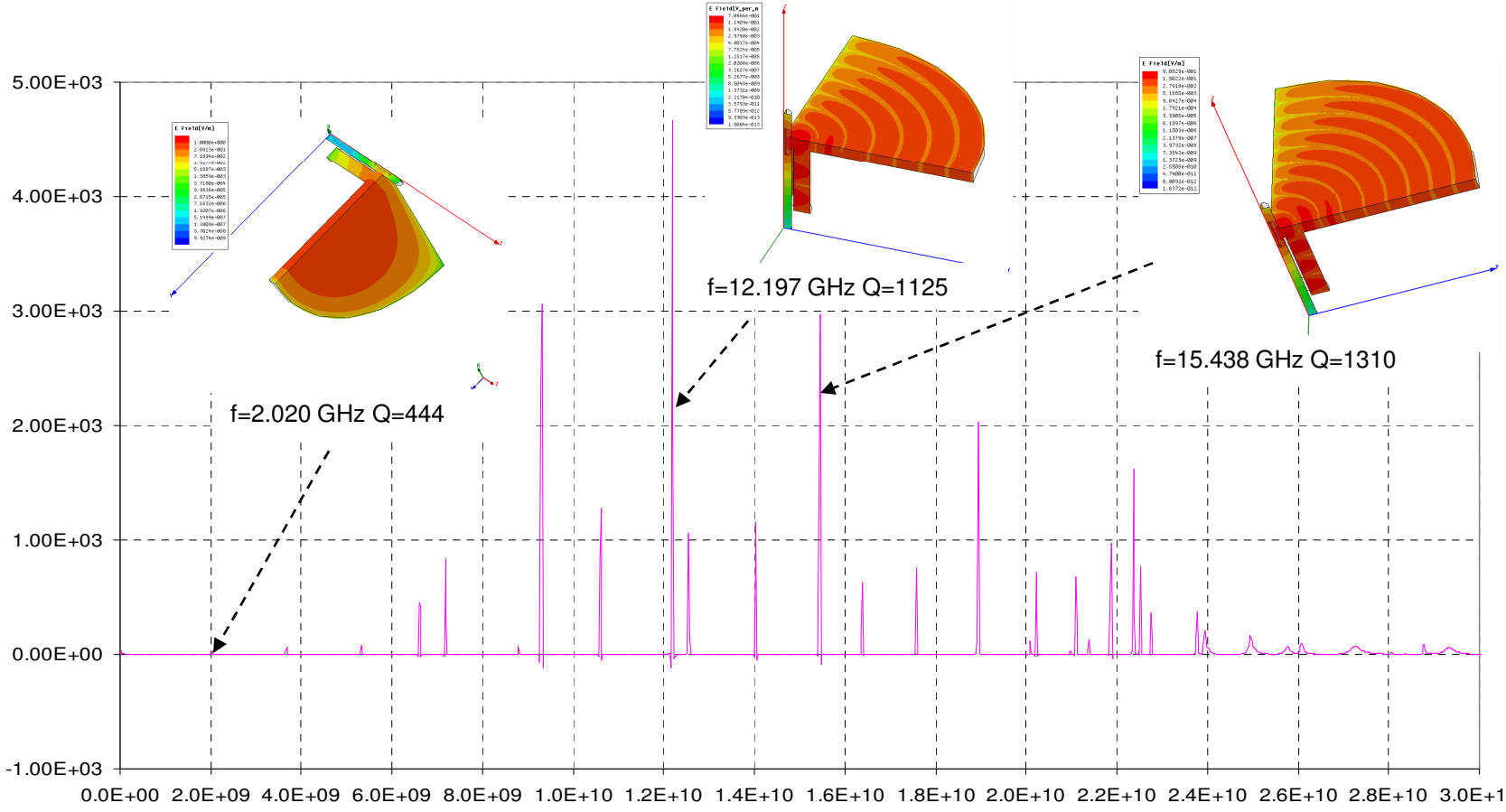


Solution with a gap and damping material (under study)

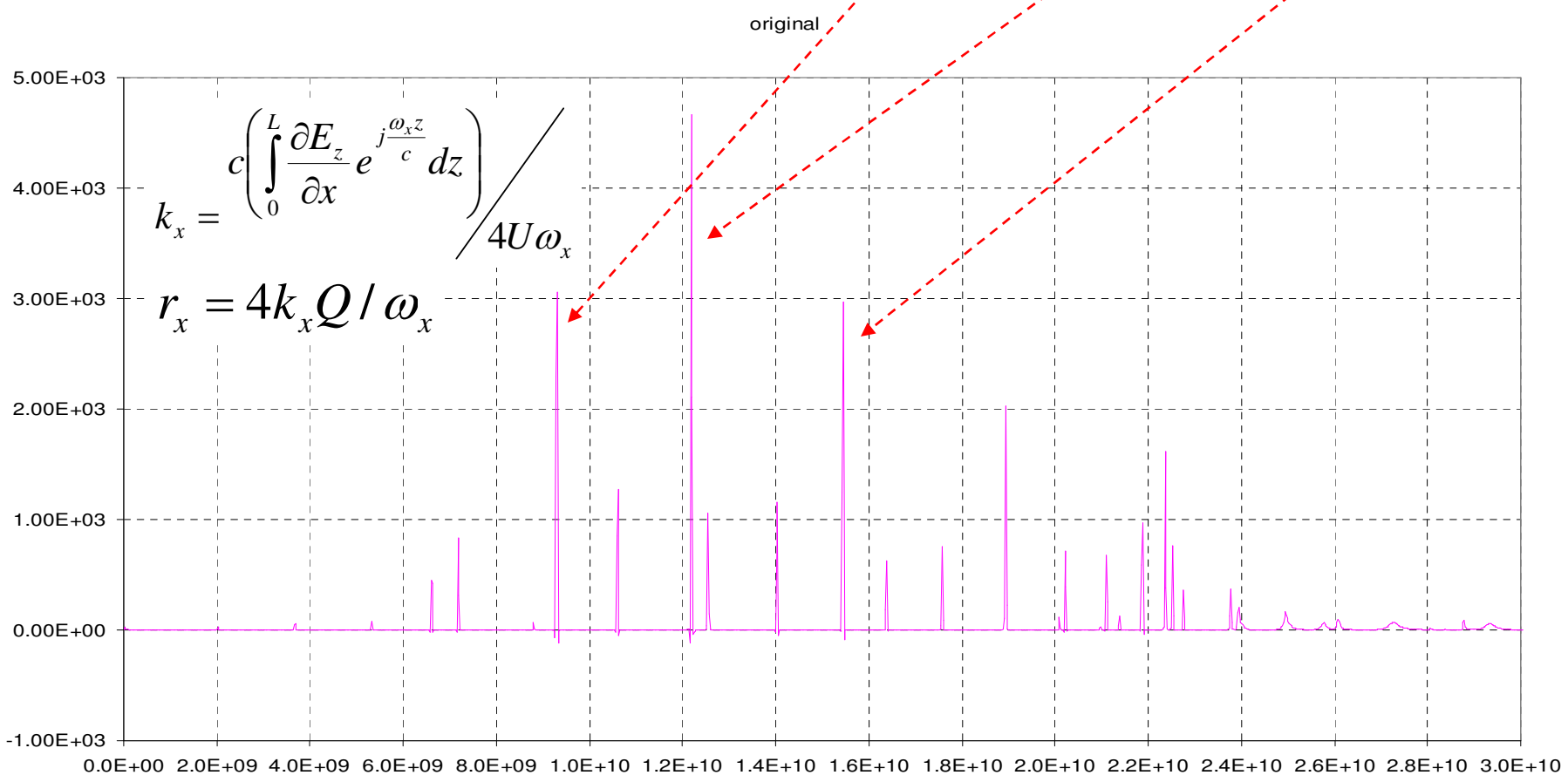
QUAD/AS intermodule is the same with longer bellows and flexible element

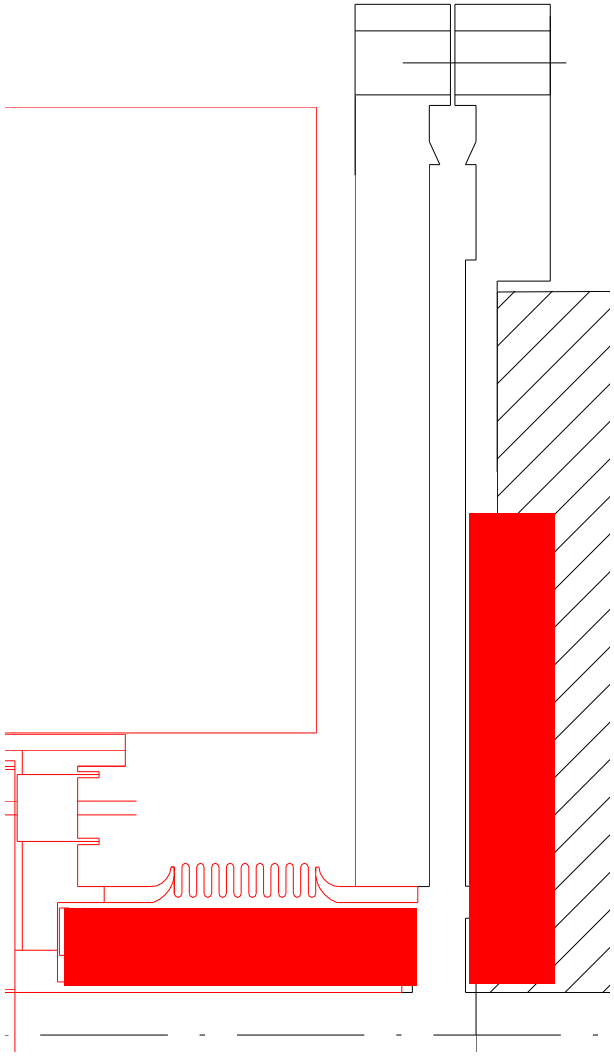


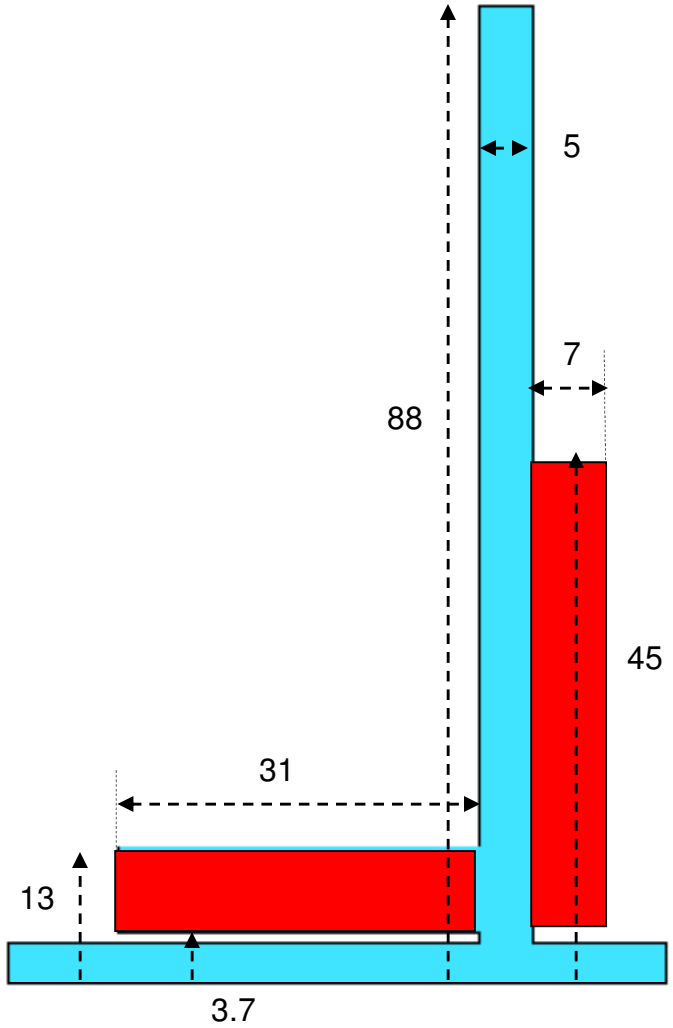
NB: limit at 2nd bunch is 7 V/pc/mm/m



mode	1	2	3	4	5	6	7	8	9	10
F (GHz)	2.020	3.674	5.321	6.628	8.797	9.313	10.597	12.197	14.027	15.438
Q	444	599	721	1012	949	1120	1006	1125	1192	1310
K (V/nC/mm)	3.45	10.2	6.9	48.9	11.5	155.3	44.9	171.9	28.4	96.5
r_x (Ohm/mm)	483	1059	597	4750	787	11888	2716	10093	1534	5212

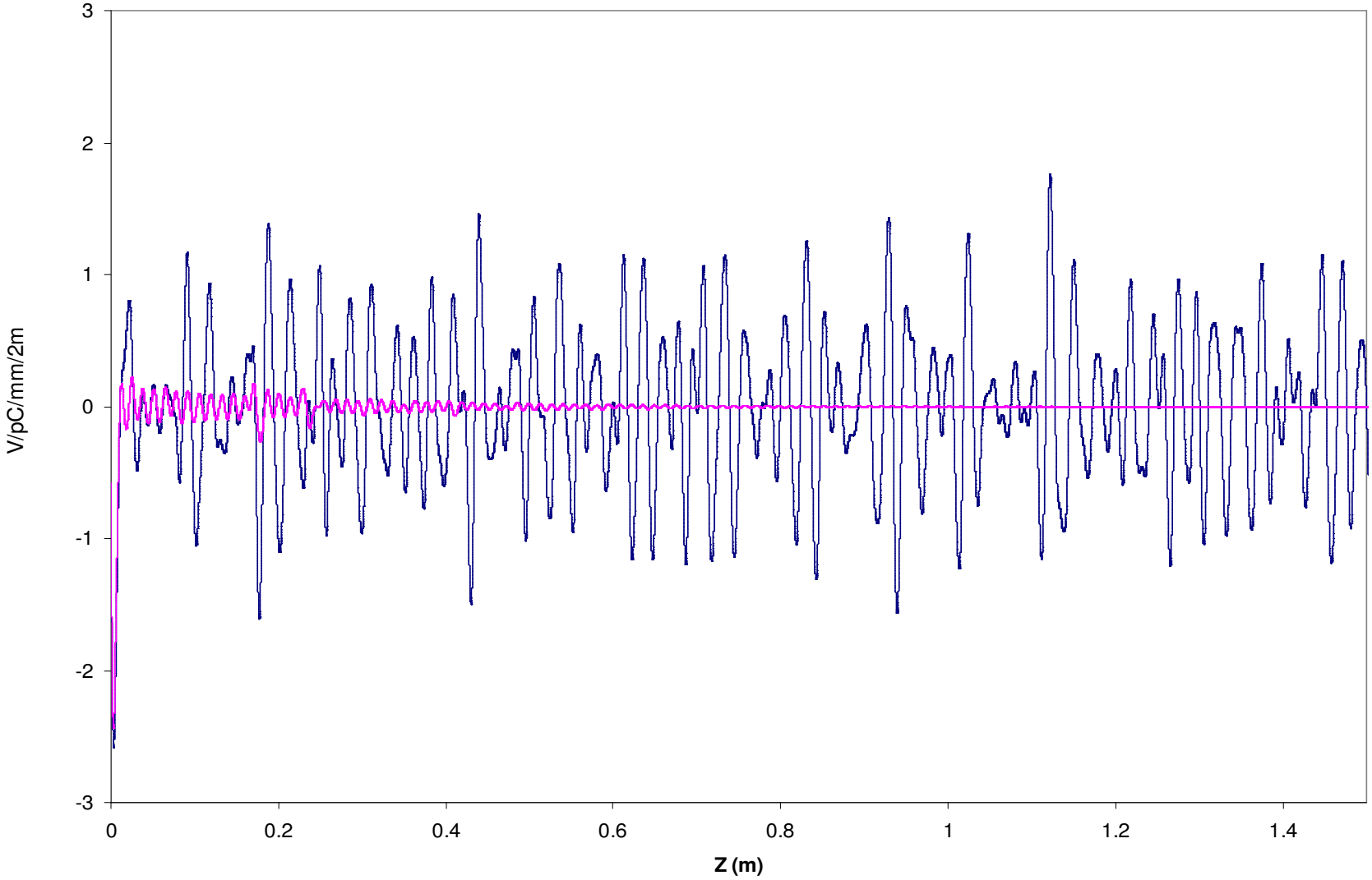






Loads:

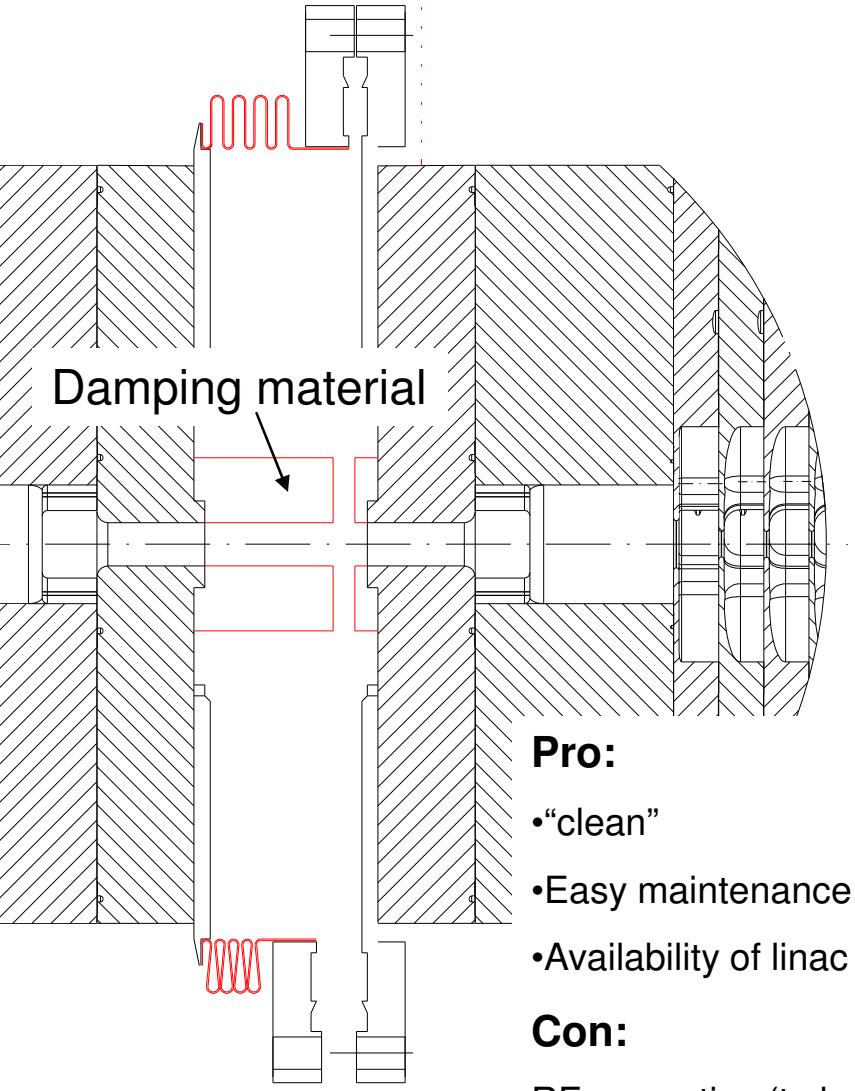
ε_r=20, tgδ=0.2


3
2
1
0
-1
-2
-3
V/pC/mm/2m
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Z (m)

From Cedric: CLIC two beam module review 15/09/09

Main beam – AS/AS (or AS/BPM) intermodule interconnections

Sealed version with gap



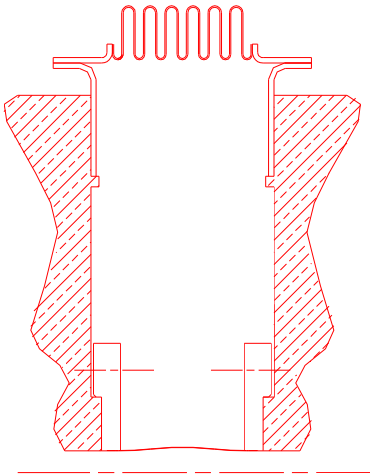
Pro:

- "clean"
- Easy maintenance
- Availability of linac (procedure tbs)

Con:

RF properties (to be checked)

Welded version with flexible element

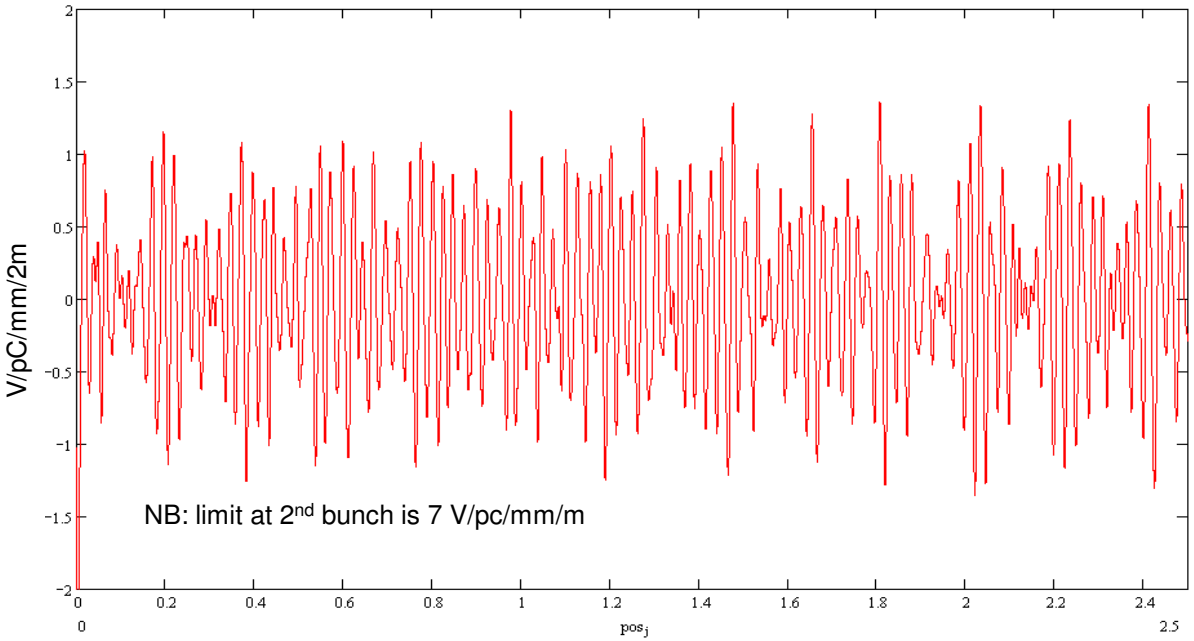


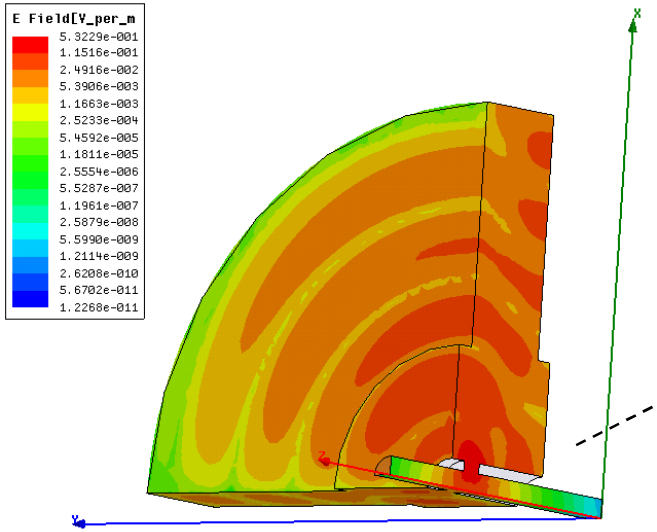
Pro:

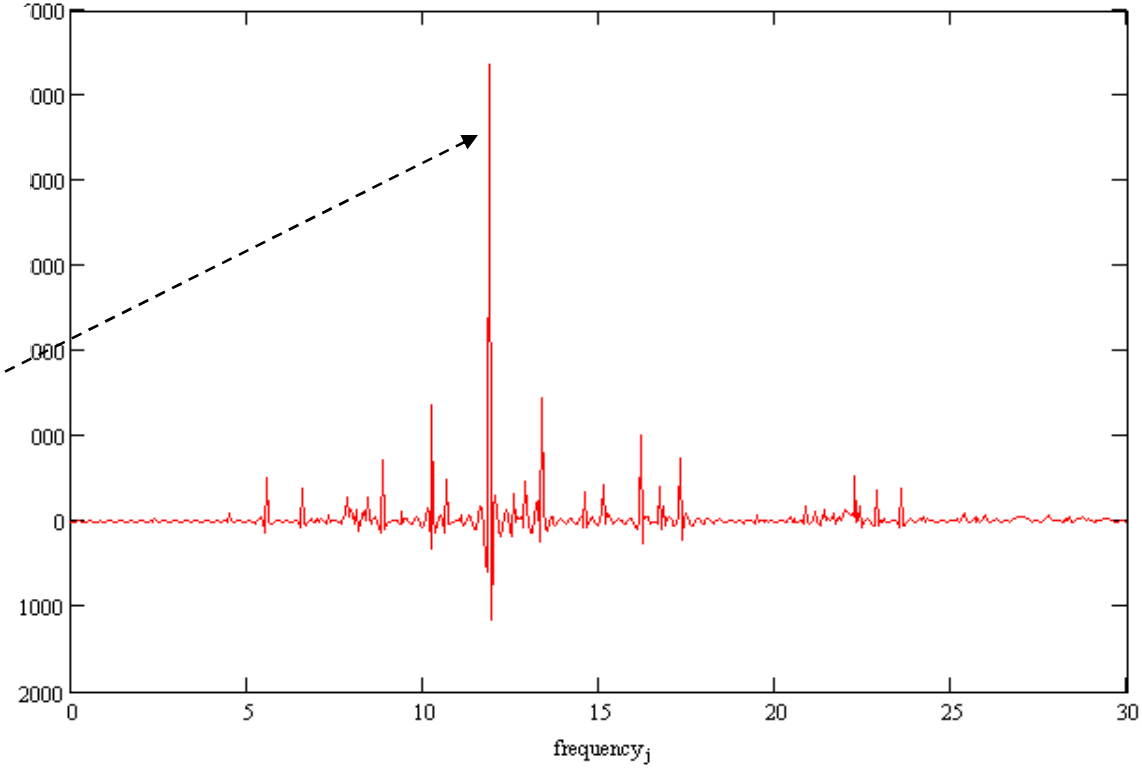
Good RF continuity

Con:

- "dirty"
- Specific tooling (welding and cutting machine)
- Axial and radial space needed



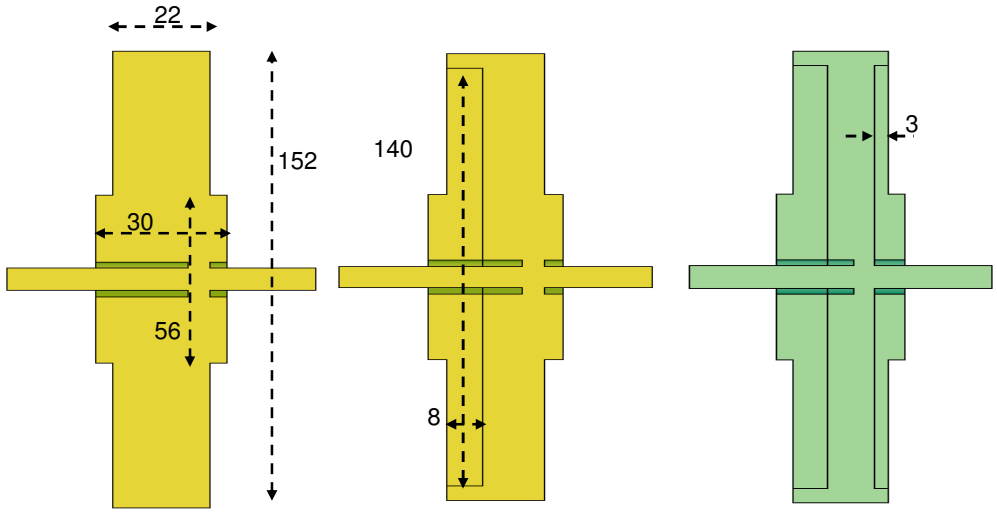


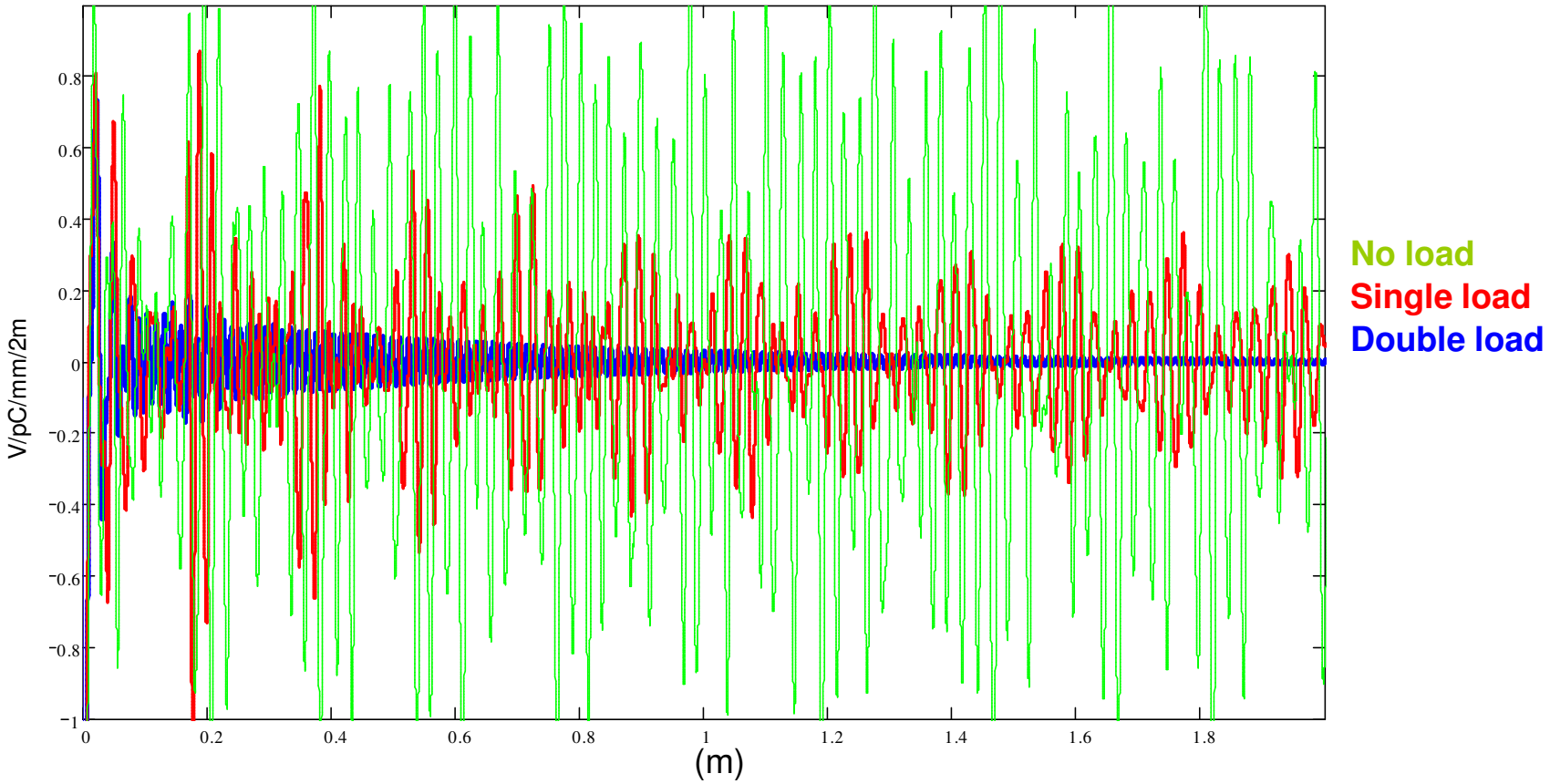


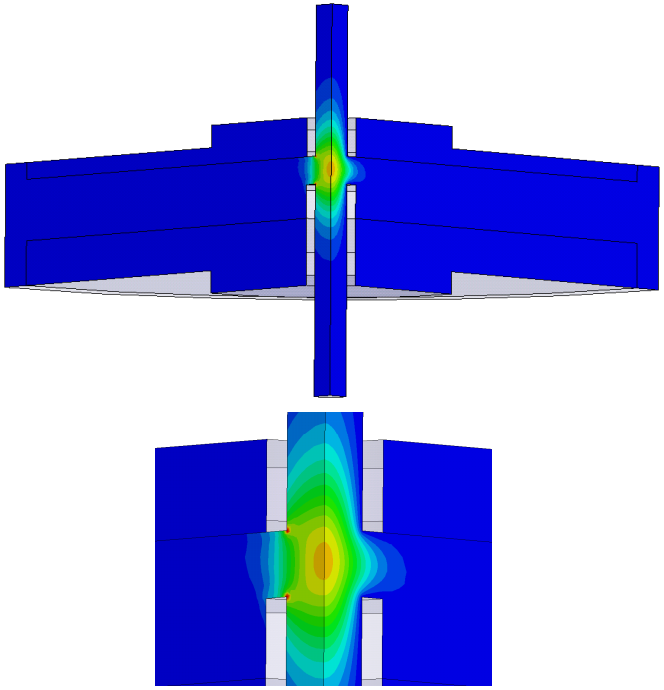
f: 11.882, Q=4279,

kick factor 693 V/nC/mm,

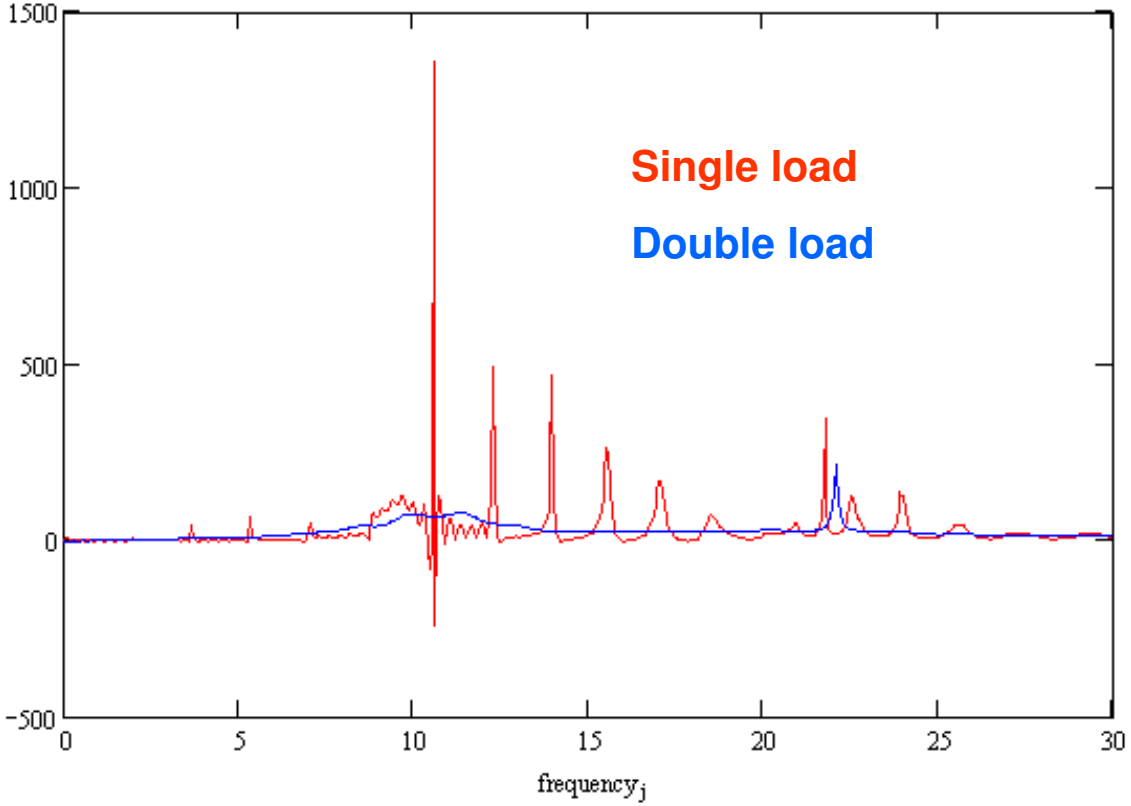
r_x= 159048 Ohm/mm

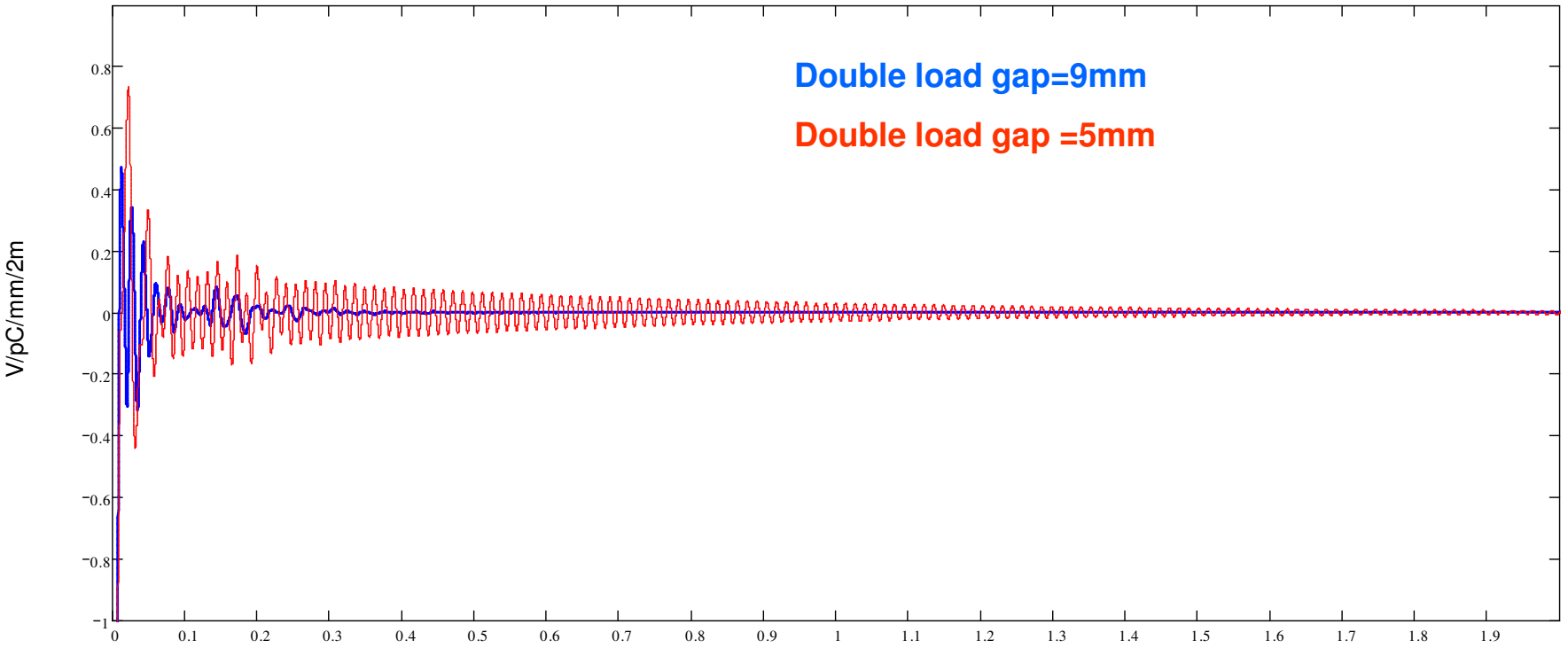

22
152
30
56
140
8
3

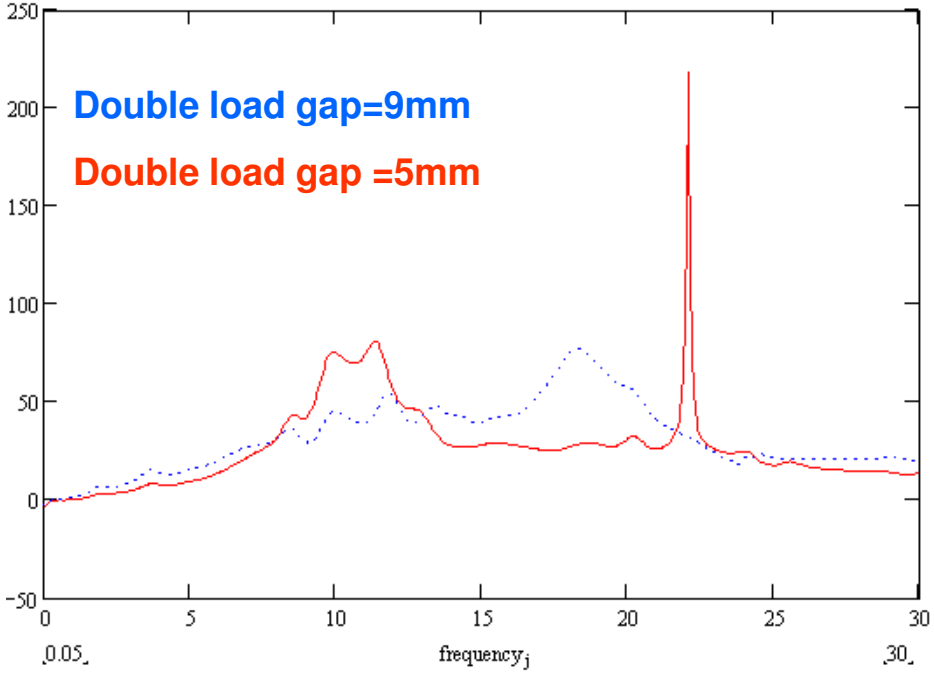

V/pC/mm/2m
(m)
No load
Single load
Double load

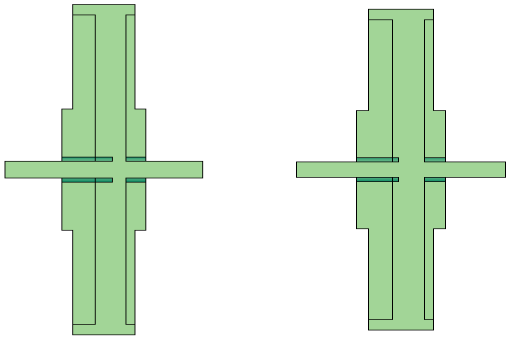


f=22.05 GHz Q~145









Gap=5mm Gap=9mm

Conclusions

Quad vacuum chamber

- ✓Low impedance of the chamber and small wakefield but large Q factor (~9000); problems in case of build-up
- ✓Negligible effects of the spacers
- ✓The geometry can be considered as a simple pillbox for the case of beam on axis or horizontal offset. For this reason the obvious solution is to use a beam pipe of the same radius
- ✓This solutions provides good results also for the other plane

Interconnections

- ✓The transverse wake amplitude due to interconnections seems to be relatively small but, since it is completely undamped (Q~1000), it could be critical (beam dynamics computation to evaluate the criticality).
- ✓Damping is anyway easy to implement and with good results.
- ✓Possible optimization for compactness