MEBT Cavities

16 January 2013

RAL

MEBT Re-bunching cavity engineering design:

Different cavities for the MEBT have been considered

The objective is to keep the target frequency 324 MHz and high efficiency value while allowing space for ports on the circumference of the cavities.

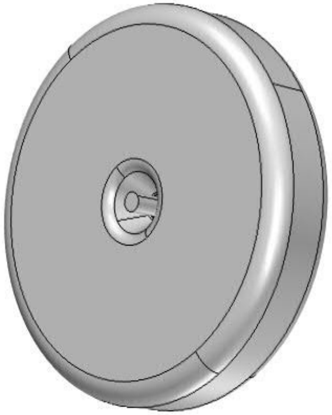
F=324 MHz

Q=28284

Model 51

Baseline model with no ports

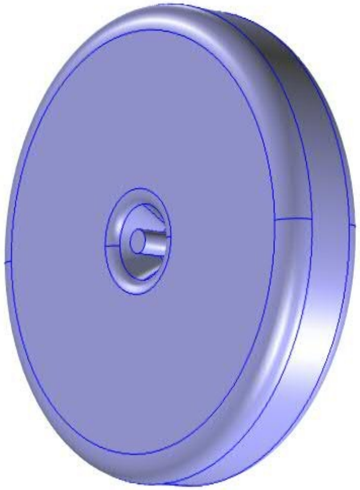
f=315.68 MHz, Q=27963



Modle_71
ReBunchingCavity7_R=36mm_D=606mm_InnerVolume

To investigate effect of 36mm internal radius allowing for CF40 flange

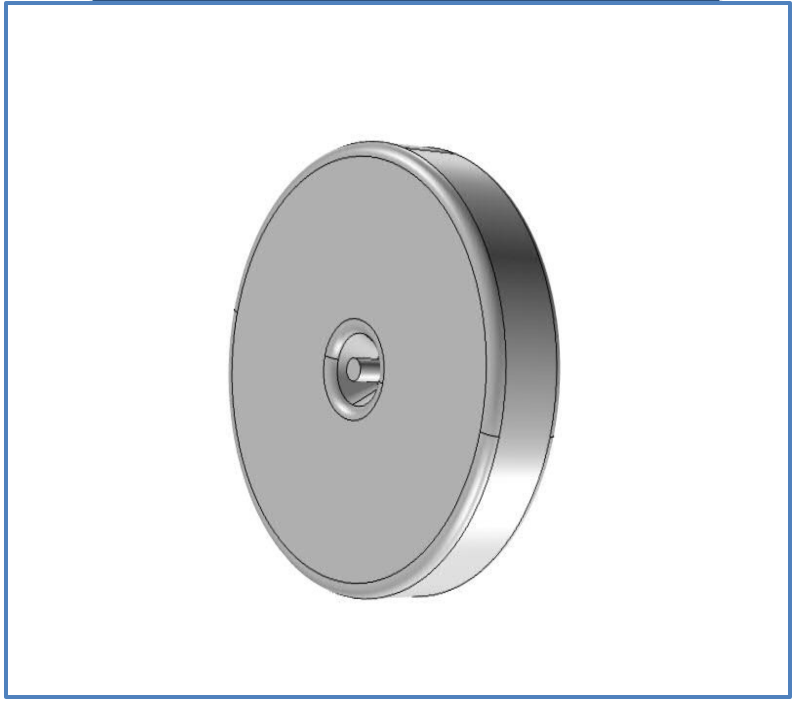
f=321.17 MHz, Q=27900



Model_72
ReBunchingCavity7_R=36mm_D=591mm_InnerVolume

Reduced diameter to bring frequency up

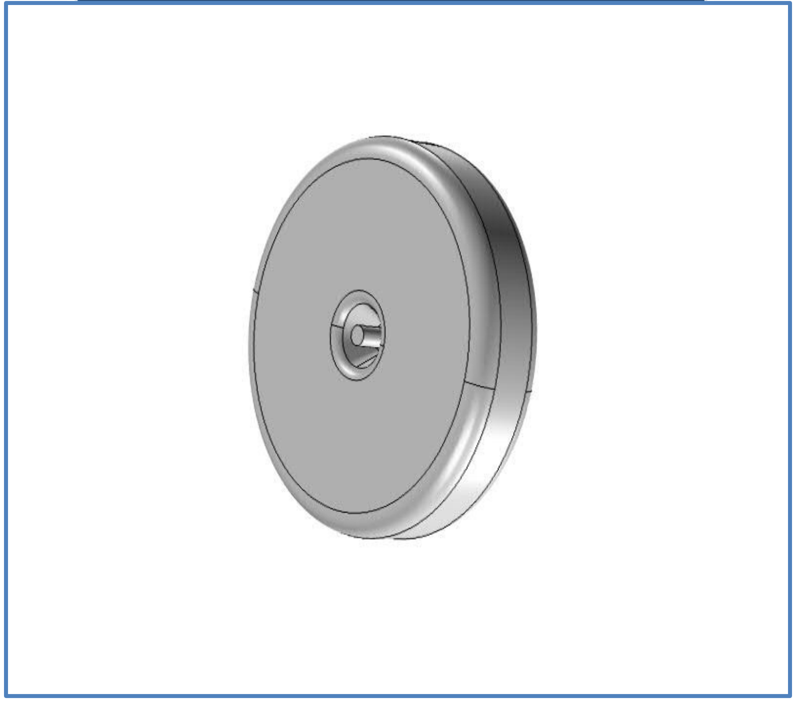
f=321.85 MHz, Q=27496



Modle_73
ReBunchingCavity7_R=20mm_D=584mm_InnerVolume

To investigate effect of 20 mm internal radius allowing for CF75 flange

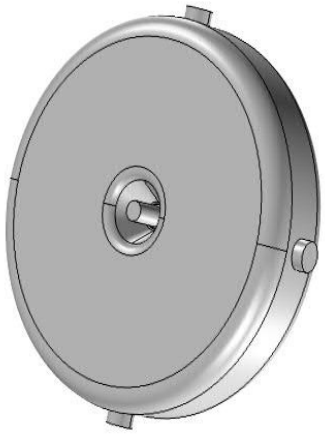
f=324.17 MHz, Q=27861



Modle_74
ReBunchingCavity7_R=36mm_D=583mm_InnerVolume

To bring the frequency to 324MHz

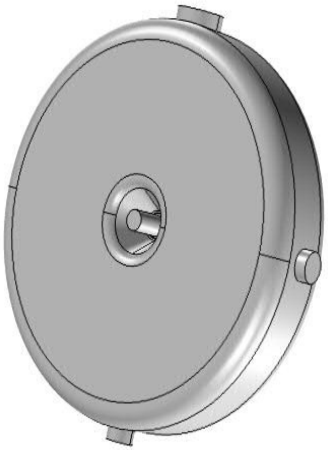
f=324.06 MHz , Q=27745



Model_75
ReBunchingCavity7_R=36mm_D=583mm_Ports=45mm

Model 74 with 4 diameter 45mm ports

f=323.97 MHz, Q=27712



Modle_76
ReBunchingCavity7_R=36mm_D=583mm_Port=77mm

Model 75 with 1 port enlarged to 77mm diameter

No cavity shows drastic drop in Q value

Model	Inner radius	**Frequency**	**Q**	Q change %	Diameter	Max port size	Purpose
	(mm)	**(MHz)**		(w.r.t. Model 51)	(mm)	diam (mm)	
51	72	**323.95**	**28284**	0	606	0	Baseline model with no ports
71	36	**315.68**	**27963**	1.15	606	45	To investigate effect of 36mm internal radius
72	36	**321.17**	**27900**	1.38	591	45	Reduced diameter to bring frequency up
73	20	**321.85**	**27496**	2.87	584	77	To investigate effect of 20mm internal radius
74	36	**324.17**	**27861**	1.52	583	45	To bring the frequency to 324MHz
75	36	**324.06**	**27745**	1.94	583	45	Model 74 with 4 diameter 45mm ports
76	36	**323.97**	**27712**	2.06	583	3*45+1*77	Model 75 with 1 port enlarged to 77mm diameter

MEBT Cavities Power and Voltage (Normalization)

Parameter	SF	HSFF	MWS
Frequency (MHz)	324.0	323.961	324.103
Q	27815	27812	28150
Shunt Impedance(M Ohm)	6.0427	5.987	5.984
Power Dissipation (kW)	11.26	10.32	11.13
Stored Energy(J)	0.154	0.141	0.154
Axial Voltage (kV)	260.85	248.62	258.06
Effective Voltage (kV)	160.0	152.5	158.3

Note that R/Q=217.24

COMSOL Simulation and Normalization

F=3.2395e8+5729.59i (Hz)
Q=28284
V=18.19 (v)
W=7.4888 x 10^{-10} (J)
$R/Q=V^2/\omega W=217.26$
R=6.144981 (MΩ)

It's obvious that if we consider W=0.154 (J) then through $V^2=(R/Q)\omega W$
we will have: V=260 (kV)
Which is consistent with the other software results.

The results with COMSOL showed comparable values with the other software results. It remains how the value of 260 kV relates to the values used in GPT for particle tracking.

Estimate for our RF Amplifiers specifications from GPT		
Frequency(MHz)	*Old lattice (scheme A)*	*New lattice (scheme Z+1)*
	324	324
Number of Cavities	4	3
Voltage(kV)	V_1=94.600	V_1=94.600
	V_2=81.700	V^2=86.000
	V_3=68.800	V_3=81.700
	V_4=53.750	
Shunt impedance(MOhm)	R=6.04275*(Ciprian-Super-Fish)*	R=6.04275*(I assumed Ciprian value)*
Power Dissipated(kW)	V_1^2/r=1.48	V_1^2/r=1.48
	V_2^2/r=1.1046	V_2^2/r=1.22
	V_3^2/r=0.7833	V_3^2/r=1.10
	V_4^2/r=0.4781	

E_z=M sin(ωt+φ-k_zz) $I_0(k_t r)$
M=(3 x $3^{0.5}$/2π)E_{zef}

E_{zef} is used in GPT simulation
Typical value for E_{zef} in our simulation is about 4.4x10^6 V/m.
Which means M=3.6x10^6 V/m and therefore E_{z_axial}=M=3.6x10^6 V/m.

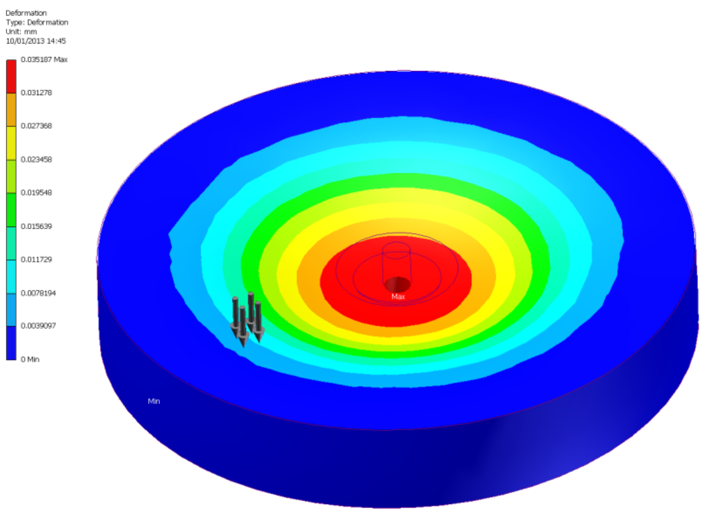
With a gap of g=21.5 mm, we will have
V_{axail}=Eg=77.400 kV!

Is transit time factor missing ?
Is the transit time factor about 160/260=0.61?

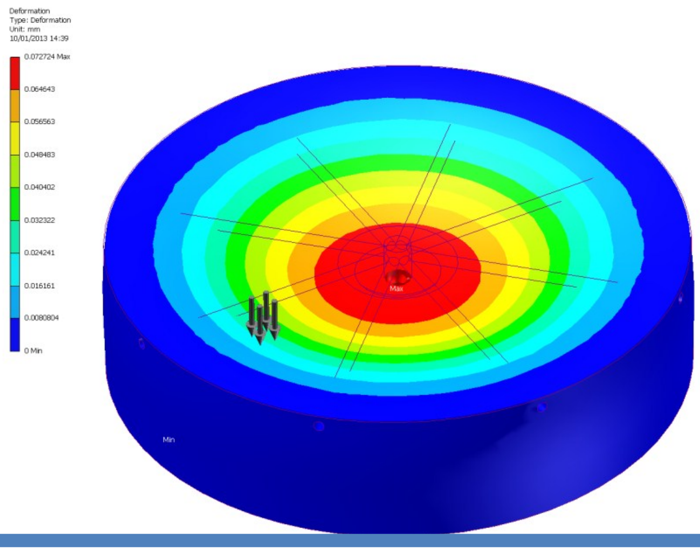
There is a factor of 2 roughly missing between the 160 kV from EM simulation and 77.4 kV from GPT. Has this anything to do with different definitions, for example linac definition for p:
$p=V_1^2/2r$

Effect of vacuum loading on MEBT rebunching cavity

72mm inner rad
Cooling channels NOT present
Wall thickness = 25mm
Pressure = 100,000 Pa
Material: Copper
Max equivalent stress = 5.2MPa
Safety Factor = 15
Maximum deformation = 0.035mm



20mm inner rad
Cooling channels present
Wall thickness = 25mm
Pressure = 100,000 Pa
Material: Copper
Max equivalent stress = 7.7MPa
Safety Factor = 15
Maximum deformation = 0.07mm



Conclusion:
Nose to nose gap will reduce from 16mm by approx 0.14mm
Inner volume will reduce by a small amount
Should not reduce wall thickness below 25mm. The deformation is not very significant

Thank you