ASTRID ELECTRON CAVITY STUDY

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Abstract

An accelerating cavity of ASTRID (Aarhus Univ.). Electron Storage Ring[1] was studied. The cavity was simulated with two 3D numerical codes MAFIA[2] and GdfidL[3]. The HOM influence on the cavity components was investigated.

1 INTRODUCTION

Some parameters of ASTRID Electron Storage Ring related to RF system are presented in Table 1. The accelerating cavity is a capacitively loaded coaxial TEM cavity (Fig. 1).

Table 1: Some ASTRID Electron Synchrotron Parameters.

Energy	100–600	MeV
Circumference	40	m
Revolution Frequency	7.4948	MHz
RF Frequency	104.927	MHz
Designed Acc. Voltage	50	kV

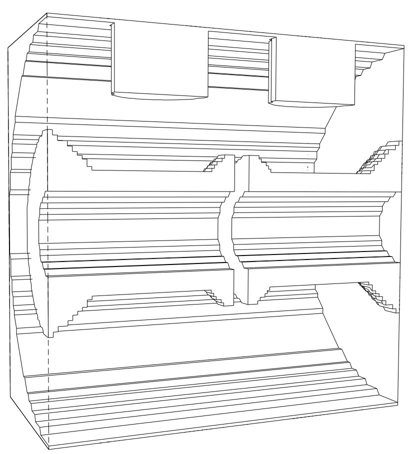

Figure 1: Cavity Geometry.

An electrical field is concentrated in the accelerating gap and a magnetic field is circulating around beam pipes in the same direction for the whole cavity length. Two plungers, placed symmetricaly to the midplane, are used for a magnetic tuning to compensate a beam loading during a beam injection.

RF-spring contacts are used electrical isolation of the plunger housing from the cavity[4].

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2 3D CAVITY SIMULATION

To simulate this cavity with the plunger structure two 3D MAFIA and GdfidL codes were used. On Fig. 1 a half part of the cavity geometry is shown as it was generated by MAFIA mesh generator. The results of 3D MAFIA simulation for two plunger positions are given in Table 2. The plunger position is measured from the cavity tank circumference. The modes 1 and 3 are essentially the fundamental and its second harmonic. The modes 2 and 4 are the first and second harmonics of the transverse mode.

Table 2: 3D Cavity Simulation.

	xplunger = 0.0 mm		
mode	f_0/MHz	Q	R_{sh}/Ohm
1	102.5032654	20414	1763470
2	509.9479675	18997	0
3	546.9269409	40925	64615
4	632.9127808	28986	0
5	689.9231567	54431	0
6	727.2523804	37248	7845
	xplunger = 98.0 mm		
1	103.4529190	19197	1637202
2	437.5782166	24244	10936
3	526.5858154	22095	14694
4	584.1299438	25730	14325
5	658.9996948	38795	1145
6	703.0874023	32683	3833

2.1 Shunted Inductive Loop

The plunger of the ASTRID electron cavity is moved in its full length (90–100 mm) during injection and acceleration of the beam. A plunger insertion changes field distribution causing the HOM's B-field to circulate around it. It means that one of the possible solution to damp HOMs can be a shunted inductive loop (Fig. 2), installed close to the plunger body. The square of such loop should be parallel to the fundamental mode magnetic field and it will be perpendicular to HOM's magnetic fields. The result of such loop use is shown on Fig. 3. The shunting simulation can be done by an electrical conductivity change of a small part of the loop where it connects with the ground. Since we don't know the conductivity value to shunt resistance relationship the simulation has been done for a series of the conductivity values.

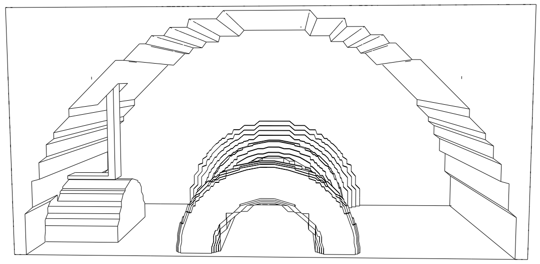

Figure 2: Cavity with Inductive Loop.

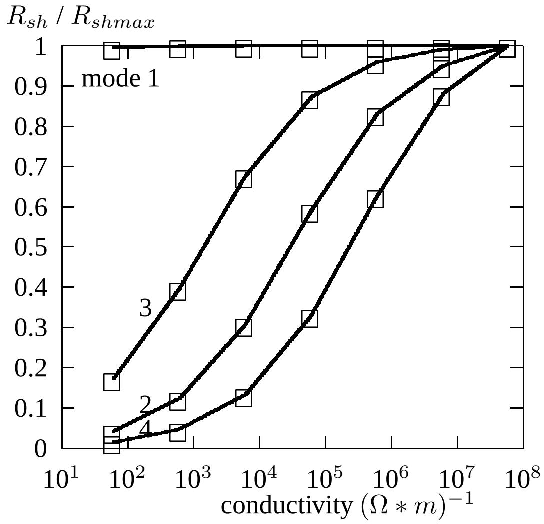

Figure 3: Cavity Shunt Impedance with Shunted Loop.

2.2 Shunted Capacitive Load

The only disadvantage of the proposed above inductive shunted loop is that in order to install it in the working cavity some additional holes should be made in the cavity walls. To avoid that we looked into the possibility of using already exsisting holes. There are some vacant holes in the cavity end flange. These holes can be used for the installation of a capacitive load (Fig. 4) which in the simulation represents a rod with 20 x 10 mm^2 cross section.

The results of the cavity simulation with capacitive load are shown in Fig. 5. To provide an experimental test a 10 mm diameter rod connected to a water cooled 50 Ohm load was installed. Experimental results are summarized in Table 3.

2.3 Z – Plungers

Considering the field distributions in the cavity, a plunger position in the end flange (Fig. 6) is preferable. Firstly, because the magnetic field strength is highest close to this wall and second, the magnetic field of the cavity transversal mode is parallel to the plunger which will not result in the current induction flowing along the plunger.

Simulating with such z-plungers, keeping volumes unchanged and comparing to an x-plunger simulation, gives

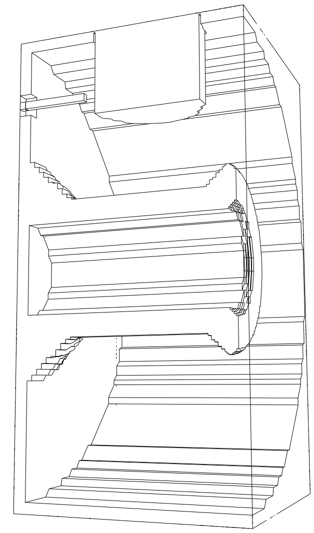

Figure 4: Cavity with Capacitive Load.

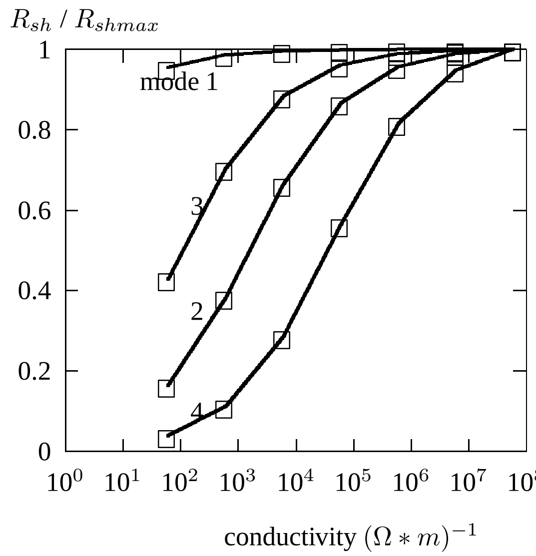

Figure 5: Cavity Shunt Resistance with Capacitive Load.

the results shown in Figs. 7–8. As expected, the frequency change is much bigger now and if one stays with such structure, the different working plunger position also results in a shunt resistance gain.

3 CONCLUSIONS

- The best solution for the higher order mode damping in this cavity is the shunted inductive loop.
- The capacitive shunted load can be very practical option for the HOM damping in this cavity in the situation, when no big mechanical modifications in the cavity can be done.
- Z-Plunger(s) are stronger in terms of the cavity frequency change and preferable compared to x-plungers. But the HOM damping system should be considered in this case, too.

Table 3: HOM Damping Results.

mode	f_0/MHz	Q	Q_l
	MHz		
1	105.027	6327	6484
2	443.696	3872	—
2-3	486.483	1986	231
3	527.075	6230	663
4	583.088	329	125
5	654.985	4043	602

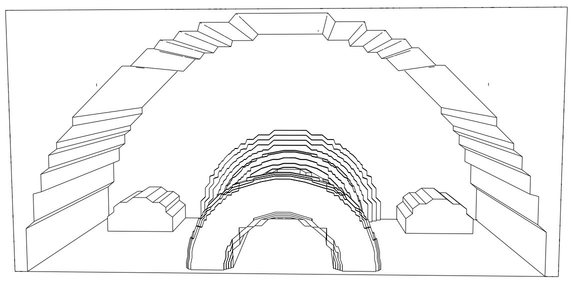

Figure 6: Cavity with Z-Plungers.

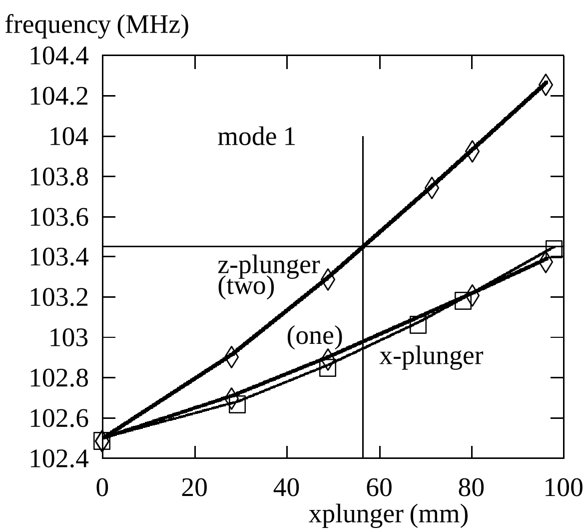

Figure 7: Cavity Fundamental Mode Frequency with Z-Plungers.

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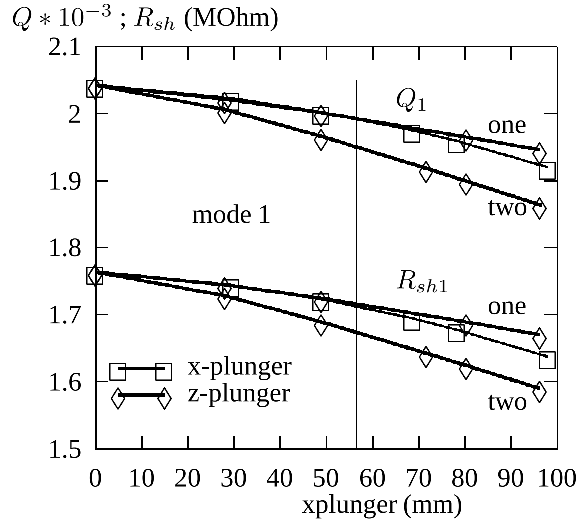

Figure 8: Cavity Parameters with Z-Plungers.

5 REFERENCES

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