INFLUENCE OF THE DIFFERENT GEOMETRIC PARAMETERS OF SUPERCONDUCTING ELLIPTICAL CAVITIES ON THE MULTIPACTOR

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Abstract

The results of numerical simulations of multipacting discharge in different superconducting elliptical cavities are presented in this paper. The influence of aperture radius, equator shape, iris shape and frequency and electron trajectories for different geometrical parameters of elliptic structures are considered.

INTRODUCTION

Multipacting simulations were carried out using MultP-M code [1] which provides information about threshold values of accelerating gradient, character and parameters of an electron trajectories and shows the areas of the structure where multipacting discharge occurs. As the result of simulations we obtain a dependence of the of secondary electrons number increase within the cavity vs. accelerating gradient. Example of such graph for various aperture radii is shown in Figure 1.

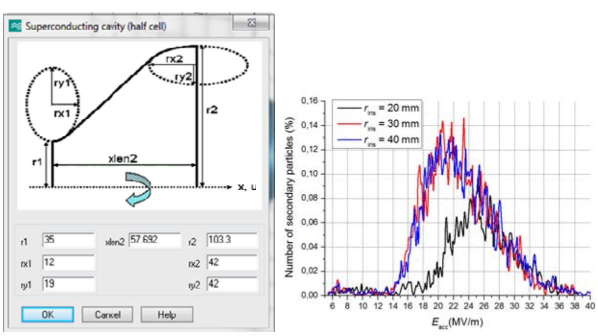

Figure 1: Basic shape of the 1.3 GHz SC cell (left) [2] and the number of secondary electrons as a function of accelerating gradient (right).

This plot doesn't allow obtaining precise values of accelerating gradient when multipacting discharge can occur. The next step of discharge prediction is a detailed analysis of an electron motion.

INFLUENCE OF THE APERTURE RADIUS

Detailed investigation of an electron motion shows that stable multipacting trajectories (1st order at equator region) are obtained in a wide range of an accelerating gradients from 4.3 to 38 MV/m. One can see from Figure 2 that the range of accelerating gradient becomes narrower for larger iris aperture dimensions..

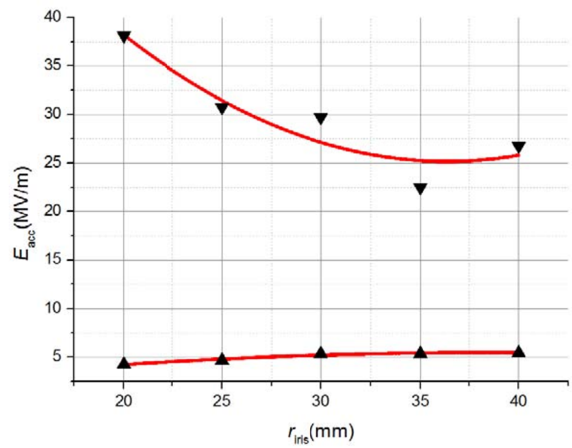

Figure 2: Threshold values of Eacc for various radii.

Q-curve plot (Fig.3) obtained during the vertical test of the standard cell geometry with r_{iris}= 35 mm shows that Q-value starts decreasing at 5-6 MV/m of accelerating gradient which is close to the simulation result.

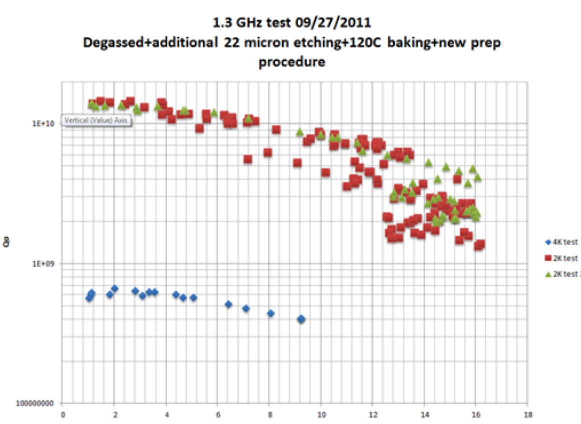

Figure 3: Experimental Q-curve for the standard geometry riris=35 mm. Courtesy of TRIUMF [3].

An example of stable 1st order trajectory is shown in Figure 4. Dependence of main parameters of such trajectories (energy and amplitude) as functions of. accelerating gradient for various aperture radii is presented in Figures 5 and 6.

ISBN 978-3-95450-170-0

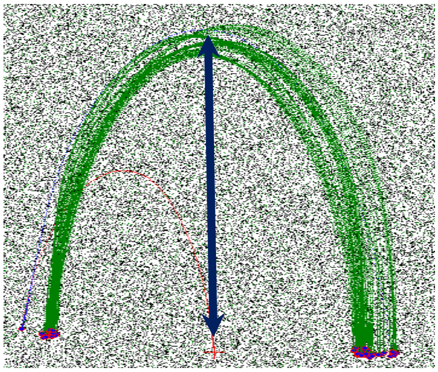

Figure 4: Trajectory amplitude.

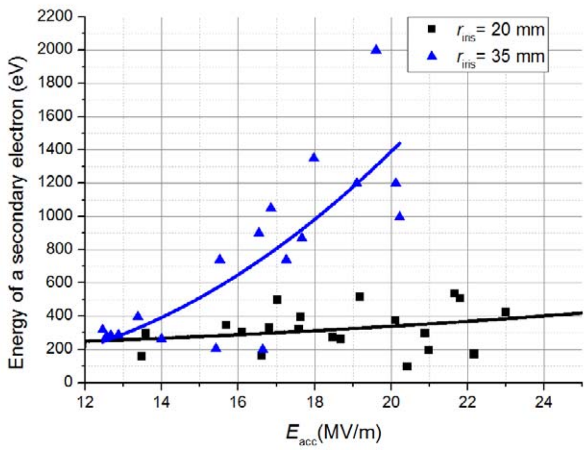

Figure 5: Energies of a secondary electrons as a function of accelerating gradient for aperture radii 20 and 35 mm.

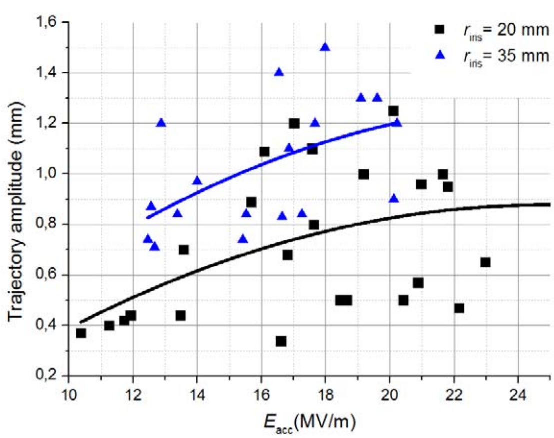

Figure 6: Trajectory amplitudes as a function of accelerating gradient for aperture radii 20 and 35 mm.

One can see that the larger is aperture radius, the higher is energy of an electron and bigger is trajectory amplitude. This fact explains narrow multipacting region for large apertures.

INFLUENCE OF THE EQUATOR SHAPE

We have obtained the dependence of the cell's equator shape on multipacting discharge development for 3 types of cells: standard cell, Low Loss cell, and standard cell with equator dome radii $r_{x2} = r_{y2} = 43$ mm.

The results of simulations show that standard geometry undergoes multipacting in the most narrow region of the accelerating gradient due to the higher electron energy.

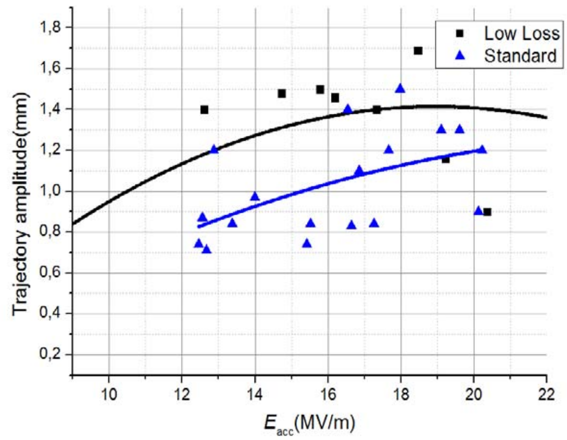

Figure 7: Trajectory amplitudeas a function of accelerating gradient for Low Loss and standard geometries.

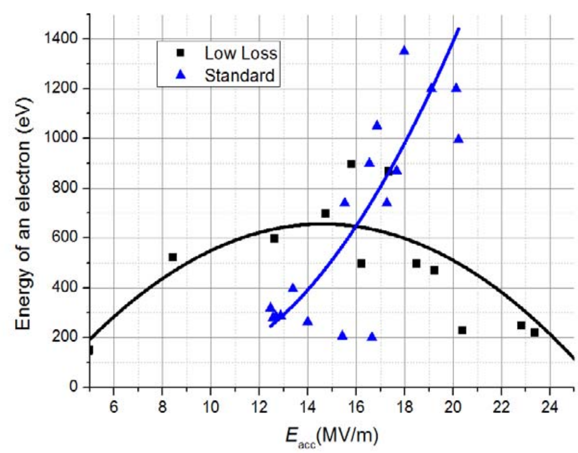

Figure 8: Energy of secondary electrons as a function of accelerating gradient for Low Loss and standard geometries.

INFLUENCE OF THE IRIS SHAPE

We have done simulations for structures with various radii of the iris ellipse: r_{x1} = 12 mm, r_{y1} = 19 mm (standard), r_{x1} = 12.5 mm, r_{y1} = 21 mm and r_{x1} = 10 mm, r_{y1} = 21 mm. The results show that r_{x1} has practically no influence on multipacting ranges. Lower threshold values are almost the same for all structures. Upper threshold value of accelerating gradient is higher for the structure with $r_{y2=}$21 mm.

ISBN 978-3-95450-170-0

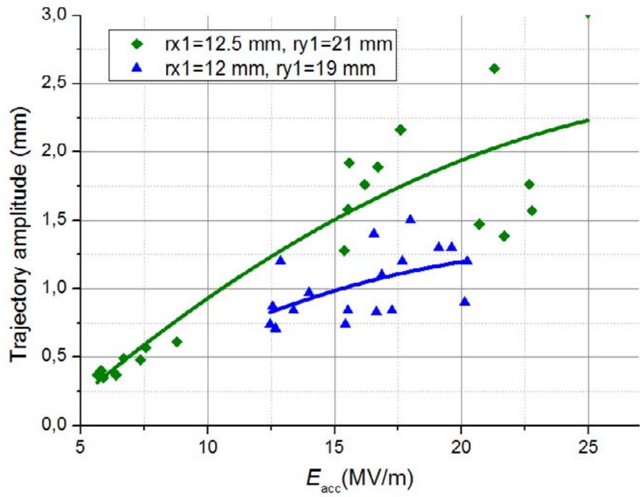

Figure 9: Trajectory amplitude as a function of. accelerating gradient for Low Loss and standard geometries.

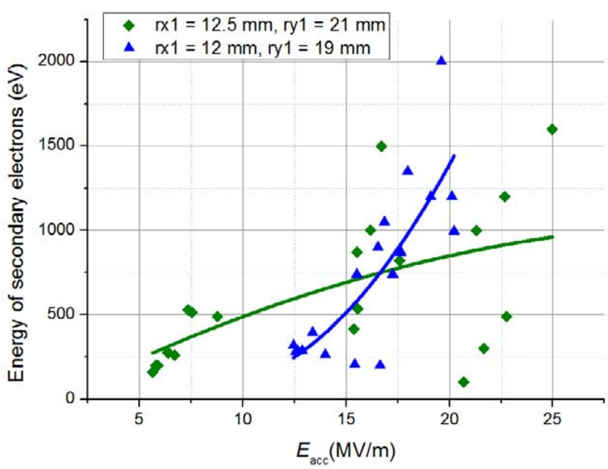

Figure 10: Energy of secondary electrons as a function of accelerating gradient for Low Loss and standard geometries.

SUMMARY

We were able to obtain stable 1st order multipacting trajectories in SC elliptical cells in a wide region of accelerating gradient, roughly at 5-30 MV/m.

The smaller is the aperture radius, the wider is the range of accelerating gradient at which cell suffers from multipactor discharge.

Low Loss cavity and cavity with a wider equator ($r_{x2}=r_{y2}=43$ mm) suffers from multipacting discharge in a wider range (4.7–29.3 MV/m in comparison with 5.4-22.5 for regular cell).

Larger radii of the iris ellipse have little influence on the multipacting discharge development.

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