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Study of multipacting effect in sub-harmonic buncher of SSRF linac*

ZHANG Meng(张猛)[1,2;1)] ZHAO Ming-Hua(赵明华)[1] WANG Bao-Liang(汪宝亮)[1,2]

1 (Shanghai Institute of Applied Physics, CAS, Shanghai 201800, China)
2 (Graduate University of Chinese Academy of Sciences, Beijing 100049, China)

Abstract During the design process, multipacting effect has been taken into consideration using a 2D simulation code MultiPac and all of the corners are rounded to suppress the multipacting effect in the pill-box cavity. However, unexpected multipacting effect prevents the increase of the input power when the magnetic field of focusing coils is added after adequate conditioning and a novel method is adopted to suppress it by introducing extra coils to counteract the field. This paper focuses on the simulation of multipacting effect in different magnetic field configurations. The experimental observations and simulation results of multipacting effect are presented and details of the multipacting process are also analyzed.

Key words sub-harmonic buncher, multipacting effect, 3D simulation, coil compensation method

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1 Introduction

Multipacting is an undesired, resonant build-up of electrons inside RF-structures operated under vacuum. The disruption induced by multipacting can be in the form of damage to the surface and/or due to absorption of an increasingly significant amount of RF power that becomes unavailable for its original purpose[1]. To prevent the multipacting effect in sub-harmonic buncher of SSRF linac, simulation study has been taken into consideration using a 2D simulation code MultiPac[2].

But when attending to operating the pre-buncher, unexpected multipacting in the cavity starts, as shown in Fig. 1, when the power supplies for the focusing coils are turned on. As a time-consuming process to condition, two coils are rolled around the cavity to compensate the field and the multipacting effect is suppressed well.

In this article, simulation results are presented for different magnetic field configurations. Part 1 is a brief introduction to multipacting in the SSRF sub-harmonic buncher. In Part 2, 2D simulation study is given and the structure is enhanced to prevent the multipacting in simple pill-box cavity. The detailed study of multipacting effect influenced by extra magnetic field is given in the next section of Part 3 and a novel method is adopted to suppress it by introducing extra coils to counteract the field. A brief conclusion is given at the end.

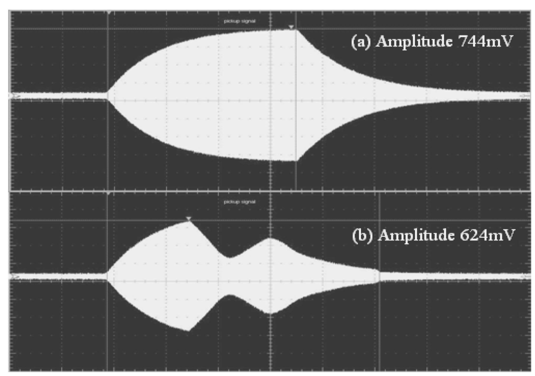

Fig. 1. Pick up signal from coupler. (a) Power supplies are off; (b) Power supplies are on.

2 Comparison between the simple pill-box cavity and the SHB of SSRF linac

During the design process, comparison between

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1) E-mail: zhangmeng@sinap.ac.cn

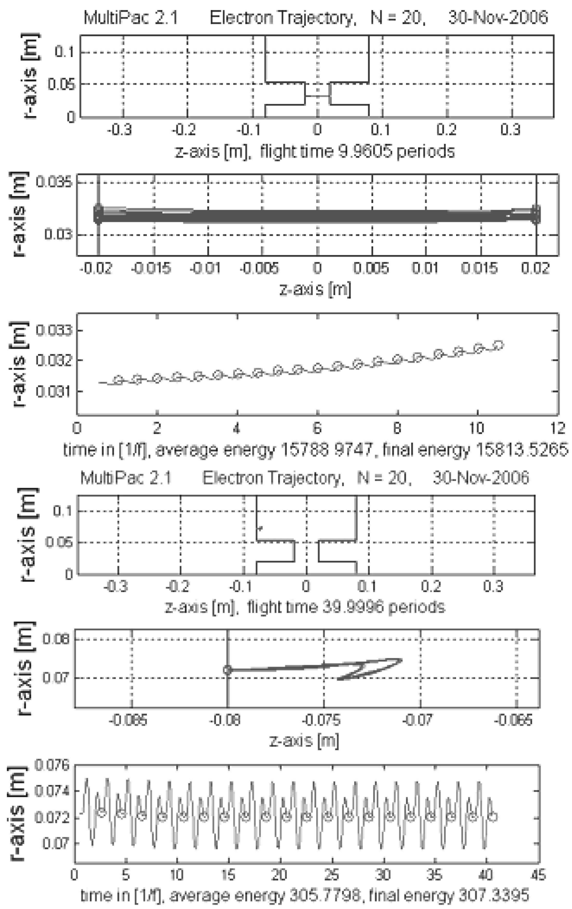

Fig. 2. Results of 2D simulation in pill-box cavity. The upper three figures show the two points multipacting at the nose and the lower three figures show the one point multipacting effect on the wall.

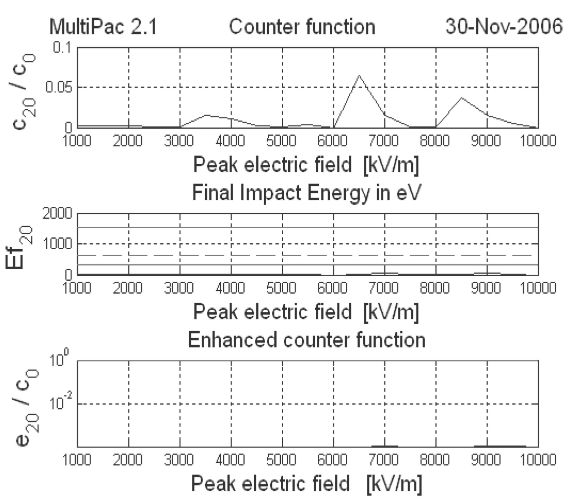

Fig. 3. Results of the SSRF SHB cavity. On the top is the counter function, in the middle is the final impact energy of the electron and on the bottom is the enhanced counter function. The figures show no multipacting, because the enhanced counter function is negligible in this field region.

the simple pill-box cavity and our design shape is carried out to study the multipacting effect using the 2D code MultiPac. As shown in Fig. 2, the two-point multipacting effect happens when the peak electric field on the surface is 1.5 MV/m and the one point multipacting effect takes place at 7.5 MV/m.

On the contrary, these obvious multipacting positions are not found in our design cavity shape and the simulation results are shown in Fig. 3. Using the code further, we find the smooth corners and noses can benefit multipacting suppression.

3 Simulation for different magnetic field configurations

Although the cavity shape is enhanced during design process as described in Part 2, when attending to operating the pre-buncher, unexpected multipacting in the cavity starts when the power supplies for the focusing coils are turned on. This is a 3D problem that should be studied using 3D code, so MultP[3] is applied for this purpose. Compared with the linear multiplication without extra magnetic field, as Fig. 4 shows, the number of particles is growing rapidly after 30 RF cycles when the solenoidal magnetic field is applied.

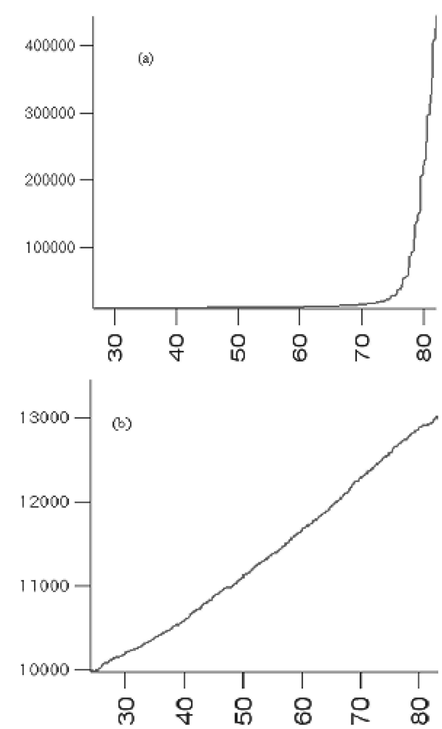

Fig. 4. Multiplication of 10000 randomly distributed electrons, the field E_{acc} = 0.021 MV/m, (a) the focusing coils are turned on, and (b) the focusing coils are turned off.

The typical electron trajectory is the so-called two-point multipacting, as Fig. 5(b) shows, and further study indicates that the most impact points are located at the corner of the outside wall, in a small dimension compared with the cavity size.

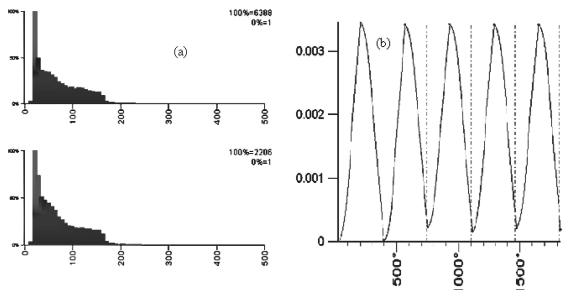

Fig. 5. Typical resonant electron trajectory when the focusing coils are turned on, the field E_{acc} = 0.021 MV/m, (a) the impact energy distribution, and (b) the typical multipacting trajectory.

As a time-consuming process to condition, two coils are rolled around the cavity to compensate the field. After compensating the magnetic field using the two coils, the resonant process is destroyed and the multipacting effect suppressed. For the roughly rolled coils and the inaccurate field configuration, the simulation results need to be further studied.

4 Summary

The multipacting effect is studied in 2D shape to compare with simple pill-box cavity and 3D when the focusing coils are turned on. To get out of the time consuming conditioning process, extra suppression coils are introduced to solve this problem. This method works well during the commissioning process of the SSRF linac.

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