DYNAMIC ANALYSIS OF X-BAND DAW (DISK-AND-WASHER) ACCELERATING STRUCTURE

Yuan Hu*, Chuanxiang Tang, Yuzheng Lin
Tsinghua University, Beijing 100084, PR. China

Abstract

Although disk-and-washer accelerating structure has many merits such as high quality factor and effective shunt impendence, it still has problems. HOMs in DAW cavity have large influence to the dynamic stability of the accelerated particles. In this passage we proceeded the simulation calculation with the TS3 of MAFIA to analyse the relation between the wakefield and the beam parameter such as beam peak current and pulse length. The distribution of momentum and position of the accelerated particles was studied. The wakefield in cavity was monitored and analysed.

1 INTRODUCTION

Disk-and-washer standing wave accelerating structure has outstanding features include high effective shunt impendence and high stability[1,2,3]. Yet some problems still remain with this type of structure such as mode overlay. The passbands of some HOMs are close to the operating frequency[4], which influences the dynamic stability of the accelerated particles[5]. The emittance and energy spread of the beam are increased and the quality of beam is decreased for the problem.

The HOMs in DAW cavity are mainly generated by the wakefield excited by the accelerated particles. As the increment of beam peak current and pulse length, the strength of wakefield can also be increased and so do the influence to the following accelerated particles.

2 SIMILATION

2.1 Simulation Model

The simulation model contained one and a half DAW cavity shown in Fig.1. The accelerating mode of DAW, TM02-like mode, was added as the initial field in the cavity and the frequency was f_{TM02}, the resonant frequency of TM02-like mode in the cavity calculated by modus E of MAFIA400. The injected electron bunch was distributed as a gaussian function. The time gap between each bunch is $1/f_{TM02}$. Each bunch contains 4000 macro particles. When the macro particles vanished, its position and momentum(β∗γ) was recorded. The variation of electric field at the observation point was also recorded simultaneously.

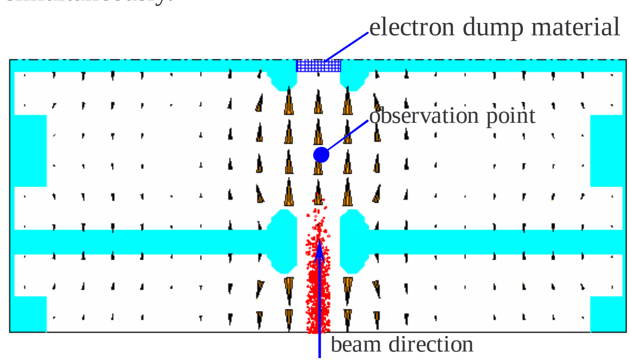
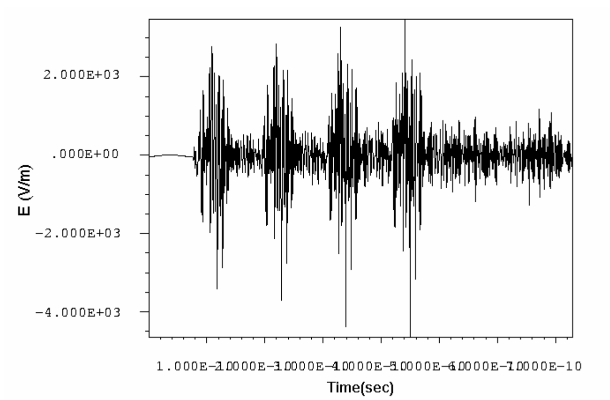


Figure 1 simulation model

2.1 The simulation on different pulse current

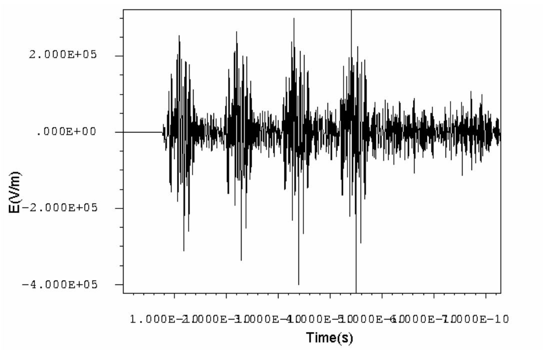
The maximum electric field density at the z-axis of the DAW cavity was fixed about 7.5MV/m. Simulation calculation was preceded separately when the pulse current reached 50mA, 500mA and 5A. In each simulation, a 4-bunch macro pulse pass through the cavity and the initial energy of the beam is 6MeV.

As the distance that the particles passes is only one and a half cavity length, the distribution of position between the bunch in a macro pulse was similar to each other. As the increment of the peak current, the radial electric field intensity at the observation point was also increased, which was shown in Fig 2. The radial electric field that was excited by accelerated particles persisted for a rather long time after the macro pulse had passed.



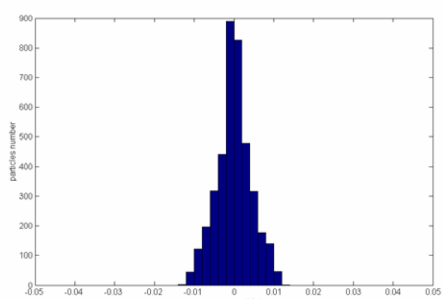
(a) Variation of electric field in x direction (I_{peak}=50mA)

* hy01@mails.tsinghua.edu.cn

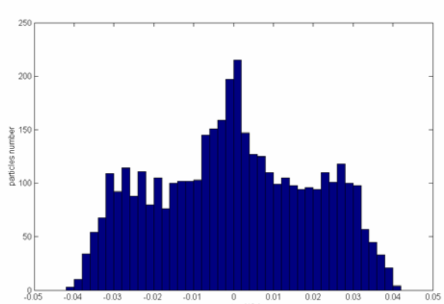


(b) Variation of electric field in x direction (I_{peak}=5A)
Figure 2 radial electric field intensity at observation point in the condition of different peak current

In one macro pulse, the wakefield made the radial momentum distribution of macro particles in different bunch different. As the beam peak current changed, the degree of difference changed also. When the peak current was equal to 50 mA, the radial momentum distribution of macro particles in each bunch was nearly the same; when the peak current changed to 500mA, the difference could be seen; and when the peak current reached 5A, the difference was obvious(shown in Fig.3).



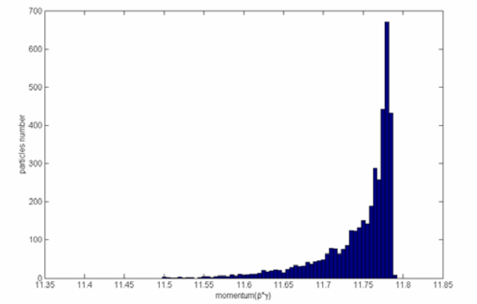
(a) The first bunch



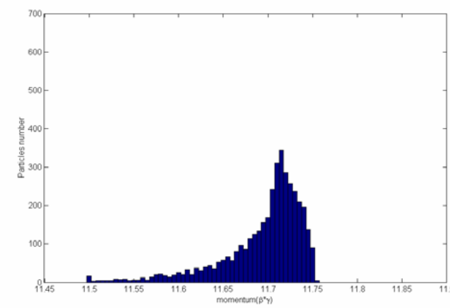
(b) The fourth bunch
Figure 3 the radial momentum distribution of the macro particles (I_{peak}=5A)

The radial momentum distribution of later bunch is much more dispersive than the earlier. As the increment of beam intensity, the emittance of the beam increased.

The axial momentum distribution is also different between bunches in one macro pulse. When the peak current was 50mA and 500mA, the difference was small, and when the peak current was changed to 5A, the difference was obvious(shown in Fig 4).



(a) The first bunch



(b) The fourth bunch
Figure 4 the axial momentum distribution of the macro particles (I_{peak}=5A)

As the beam intensity increased, the the axial momentum distribution of macro particles became more dispersive, and the energy gained from the accelerating electric field became smaller.

In DAW accelerating structure, the influence of HOMs becomes larger and larger following the peak current of the beam. If the peak current is smaller than a threshold value, the influence can be omitted.

2.3 Simulation of pulse with more bunches

As the increment of the number of bunches contained in a macro pulse, the influence of wakefield will become larger and larger. The following simulation was proceeded when a 20-bunch macro pulse passed the DAW cavity. The peak current of the beam was 5A.

The radial momentum distribution became more and more dispersive as the increment of the sequence number of the bunch in macro pulse. Correspondingly, the peak value of the axial momentum distribution moved to lower value. Figure 5 shows the distribution of momentum in x direction of the whole macro particles in the macro pulse. The peak of the distribution also became wider than the lower peak current.

With the increment of beam peak current, the emittance and the energy spread became larger. In DAW accelerating structure, the quality of beam decreased as the increment of peak current and length of macro pulse.

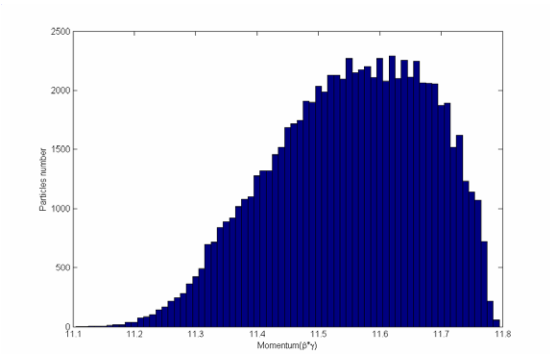
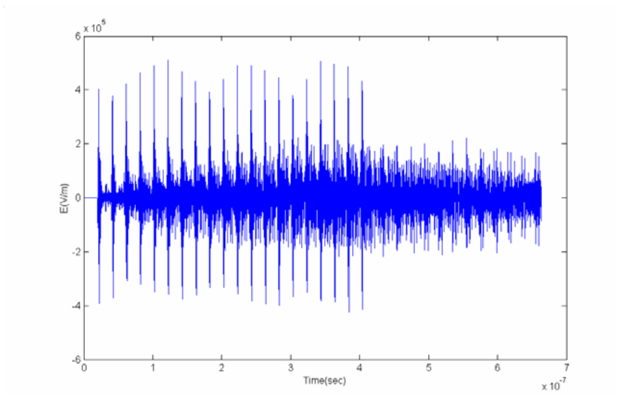
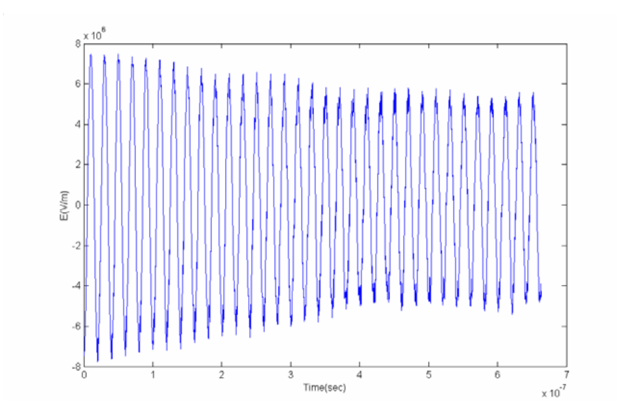


Figure 5 distribution of axial momentum of the whole macro particles in 20-bunch macro pulse

Fig.6 shows the variation of electric field at the observation point. As the pulse passed the point, the radial electric field excited by the beam became stronger and stronger. The wakefield still remained for a rather long time after the pulse ended and would influent the following bunches that might pass by. The axial electric field became weaker as the pulse went by and did not recover after the pulse went by.



(a) variation of electric field in x direction



(b) variation of electric field in z direction

Figure 6 variation of electric field at the observation point as the 20-bunch macro pulse passed by

Wakefield can exist in accelerating cavity for a long time, which makes the decrement of axial electric field. This makes that the following particles can not be accelerated effectively and the energy spread increased.

3 SUMMARY

In DAW accelerating structure, the HOMs excited by wakefield has large influence to the dynamic stability of the accelerated particles and decrease the quality of beam. The beam intensity and pulse length are important factors for the problem. Changes of these factors can adjust the influence of HOMs in DAW accelerating structure.

4 REFERENCES

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