TUPB029

Wakefield studies for the step structure and the skin depth

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INTRODUCTION

FEL lasing performance largely depends on the quality of electron bunches. While the wakefield generated by the electron bunch always destroys its phase space, which leads to a decrease of lasing performance. The step structure wakefield even contributes half of the total wakefield. Therefore, the study of the step structure wakefield is important for FEL. In this paper, we calculate and analyse the step structure wakefield in different situation and initially list its characteristics comprehensively.

In our study of the wakefield in the kicker of the SHINE, we found that the skin depth issue in wakefield calculations is still unsolved. Different teams presented different perspectives. In this paper, we proposed the conception of "effective skin depth" from the perspective of the accumulation of free charges and the attenuation of the surface current. We calculate the effective skin depth using our own simulation code. The results demonstrate the feasibility of the development of this conception in the future.

STEP WAKE

◆ *Short Bunch Situation*

Table 1: Parameters of Wakefield Simulation

Aperture 1[mm]	Aperture2[mm]	Bunch length [GeV]	Charge [pC]
14	24	8	100

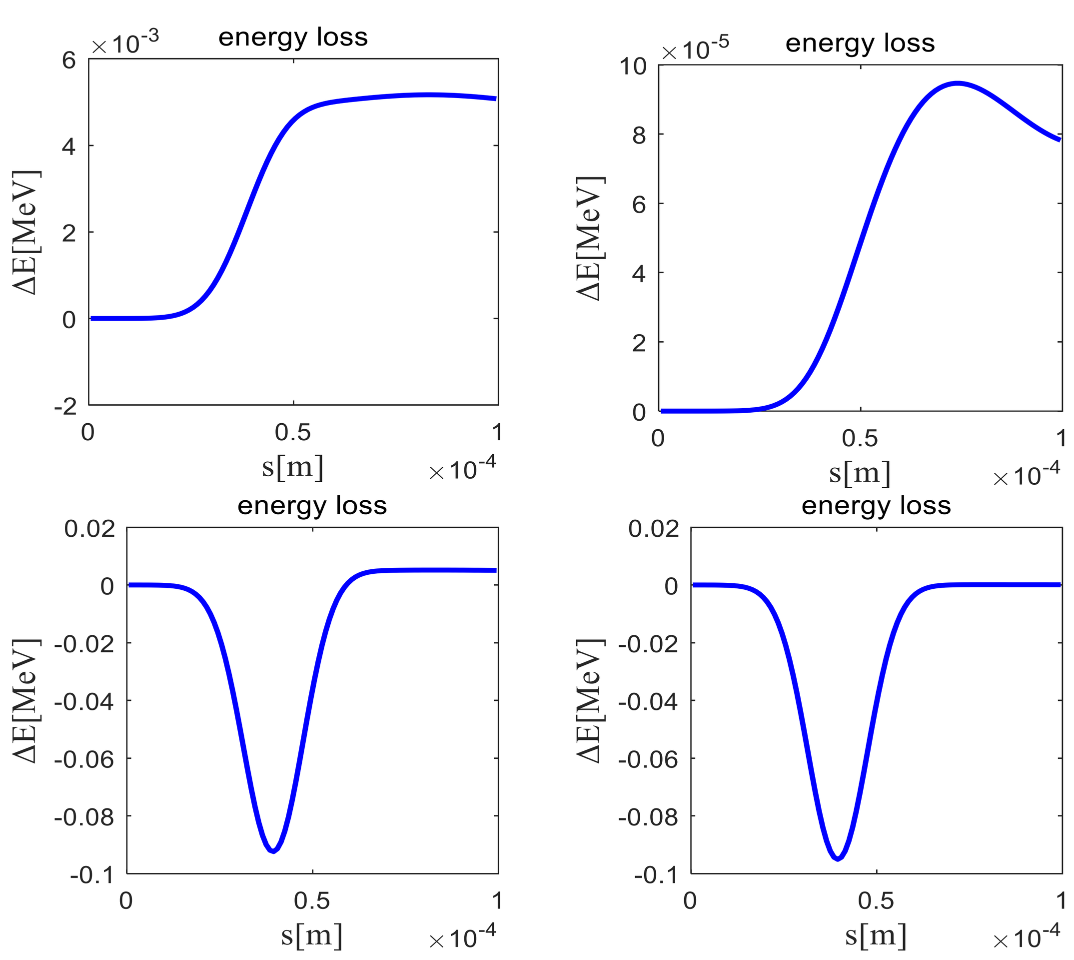

Fig.1 Simulation results of step structure wakefields in short bunch situation

◆ *Long Bunch Situation*

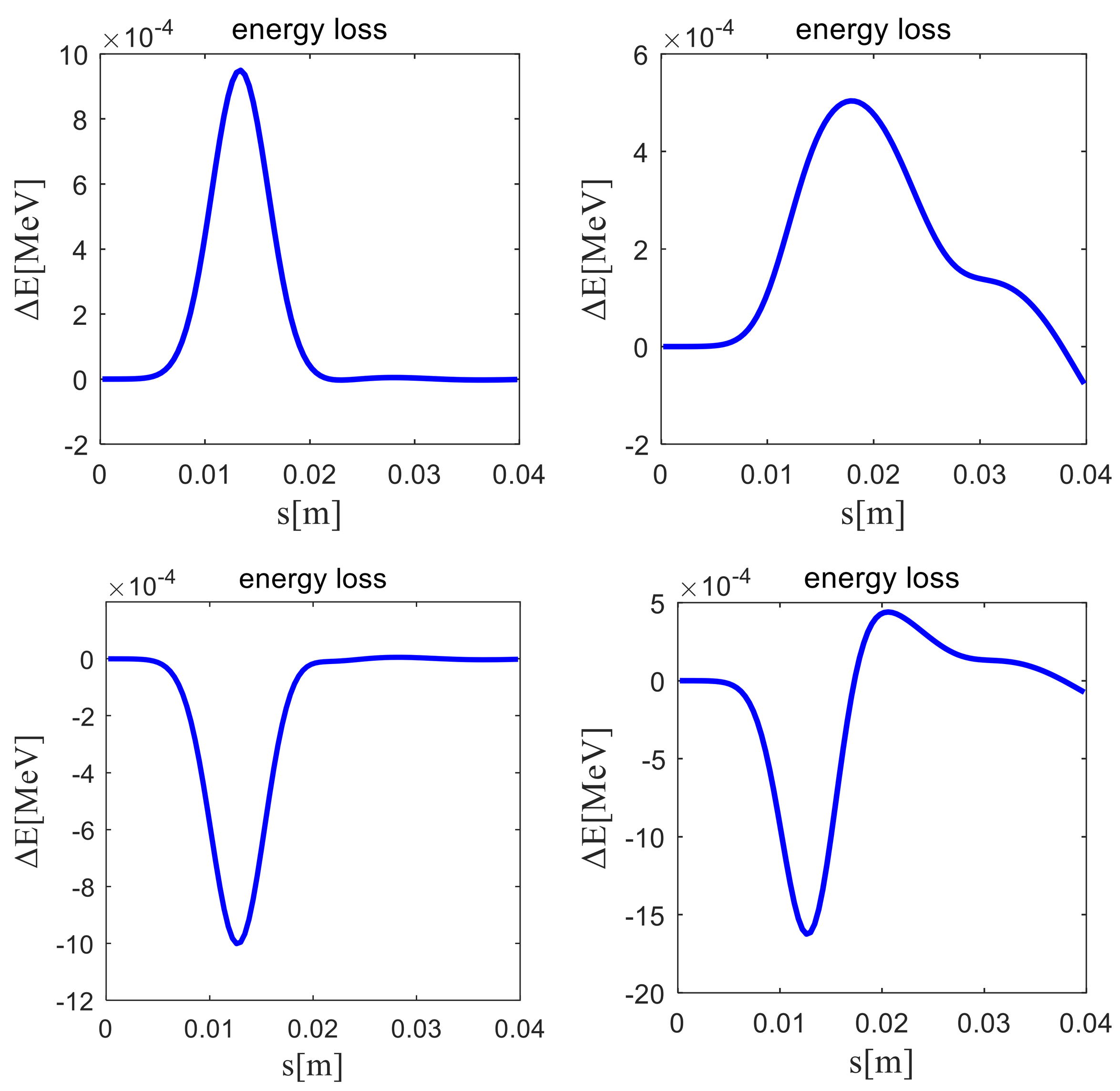

Fig.2 Simulation results of step structure wakefields in long bunch situation

- The wakefield of step-in is positive, which means an energy compensation. This part of energy comes from the energy lost by the electron bunch itself at the position of step-out.
- In the case of ultra-short bunch and hard connections, the wakefield of step-in is extremely small. It is several orders of magnitude smaller than that of step-out.
- As the electron bunch becomes longer and the slope of the step structure becomes smaller, the low-frequency part of the impedance spectrum increases, resulting in a larger step-in wakefield and a smaller step-out wakefield. Ultimately, the absolute values of the two gradually approach. For a infinitely long bunch and an infinitely flat slopes, the sum of the wakefields of step-in and step-out is 0.
- The length of the electron bunch is the main factor that dominates the high and low frequency proportion of the impedance spectrum of the step structure.
- The value of the wakefield discussed above refers to the total wakefield from the beginning to the end of the step structure. In the case of ultra-short beam clusters, although the total wakefield cannot be obviously changed by a tapering connection, it can be distributed across the entire slope, which is helpful in weakening the thermal effect of the wakefield.

SKIN DEPTH

The kicker in the SHINE employs a metal coated dielectric tube as its vacuum chamber.

kicker's magnetic field → **thin coating**

kicker's wakefield → **thick coating**

⇨ **Effective Skin Depth**

1. *Accumulation of Free Charges*
2. *Accumulation of Free Charges*

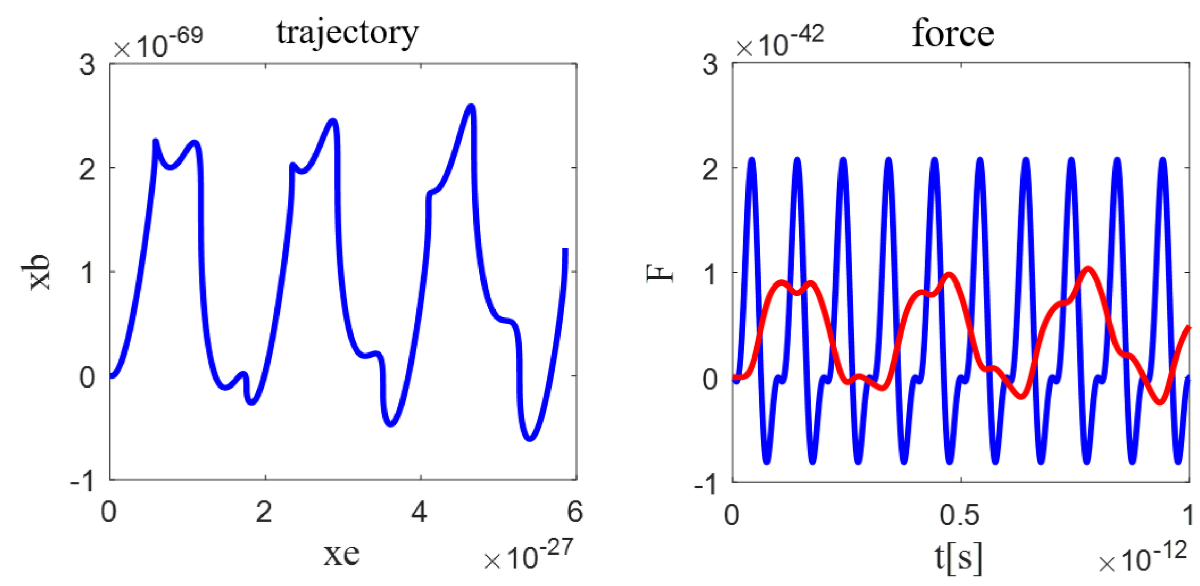

Fig.3 The trajectory and force of electron motion reaching equilibrium state

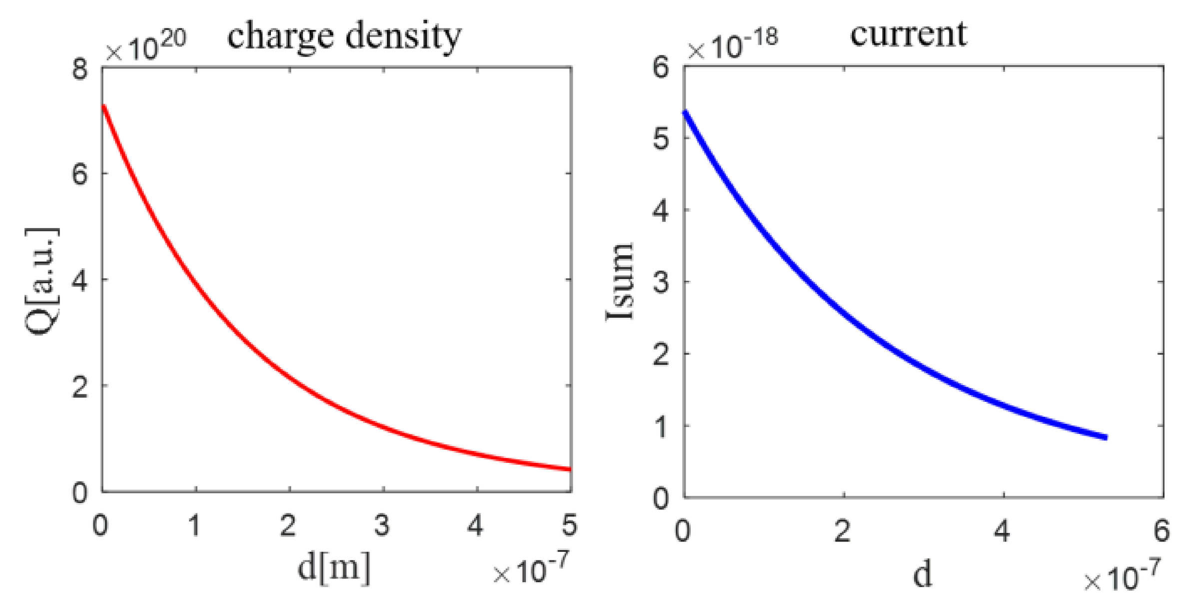

Fig.4 Attenuation curve of total charge density and surface current distribution under multi frequency superposition field

$\delta_{eff} = 162nm$ $\delta_{eff} = 272nm$

CONCLUSIONS

We systematically summarized the wakefield characteristics of the step structure. The conclusion could be helpful for related research. In addition, we proposed the conception of "effective skin depth" from two different perspectives. Although the simulation code is rough, we believe these methods could provide new mentalities for related research in the future.