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High power terahertz Cherenkov free electron laser from a waveguide with a thin dielectric layer by a near-relativistic electron beam

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Abstract: Corrugated and dielectric structures have been widely used for producing accelerator based terahertz radiation source. Recently, the novel schemes of the sub-terahertz free electron laser (FEL) from a metallic waveguide with corrugated walls and a normal dielectric loaded waveguide driven by a near-relativistic (beam energy of a few MeV) picosecond electron beam were studied respectively. Such a beam is used for driving resonant modes in the waveguide, and if the pipe is long enough, the interaction of these modes with the co-propagating electron beam will result in micro-bunching and the coherent enhancement of the wakefield radiation. It offers a promising candidate for compact accelerator-based high power terahertz source which can be realized with relatively low energy and low peak-current electron beams. However the choices of the waveguide above is less effective in order to obtain high power with frequency around 1THz. In this paper, we propose to use the waveguide with a thin dielectric layer instead, and high power radiation (>~10 MW) around 1 THz is expected to obtain in the proposed structure according to the simulation results.

Wakefield of a single particle

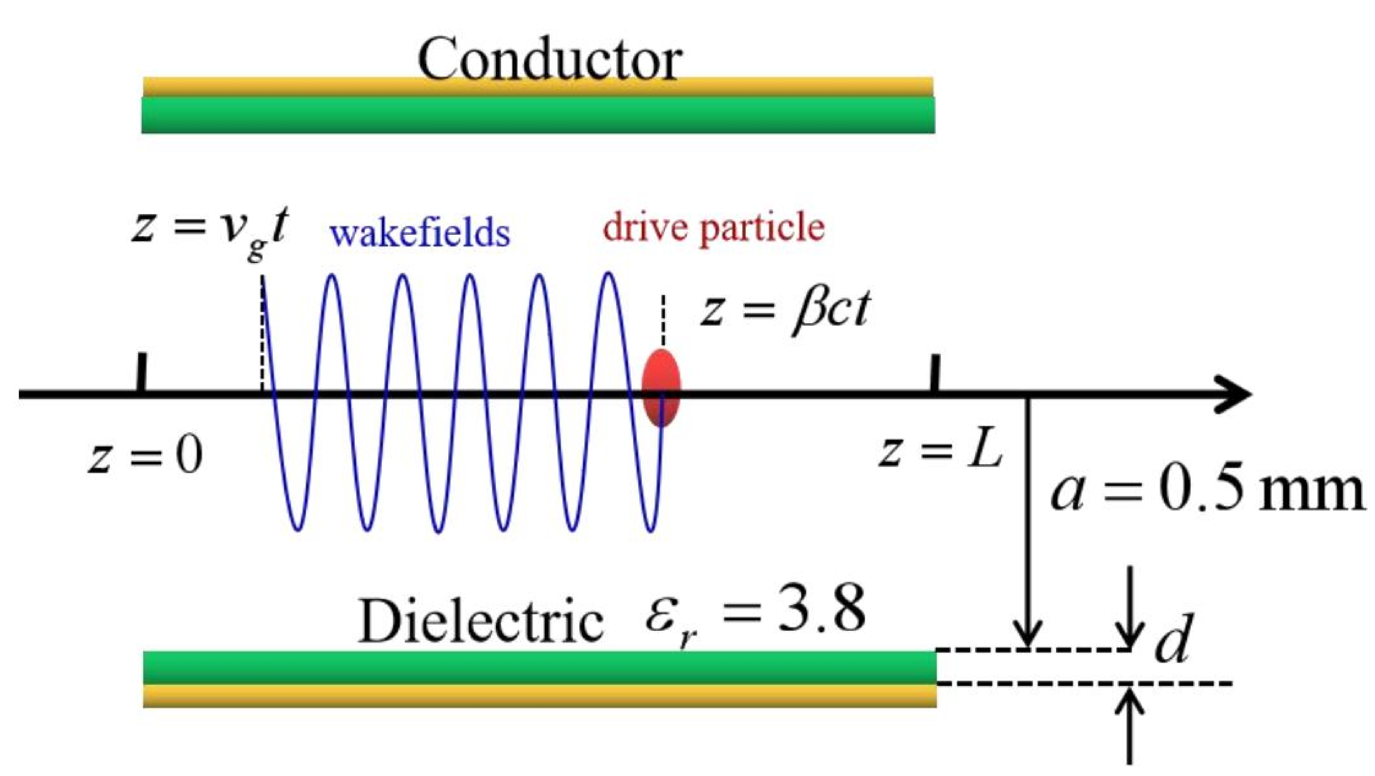

Fig. 1 Definition of the geometry

$$E_z(r,z,s)=2\kappa q I_0\left(\frac{kr}{\beta\gamma}\right)\cos\left(\frac{k}{\beta}(s-z)\right)e^{-\alpha_c(s-z)} \text{ when } s\left(1-\frac{v_g}{\beta c}\right)<z<s$$

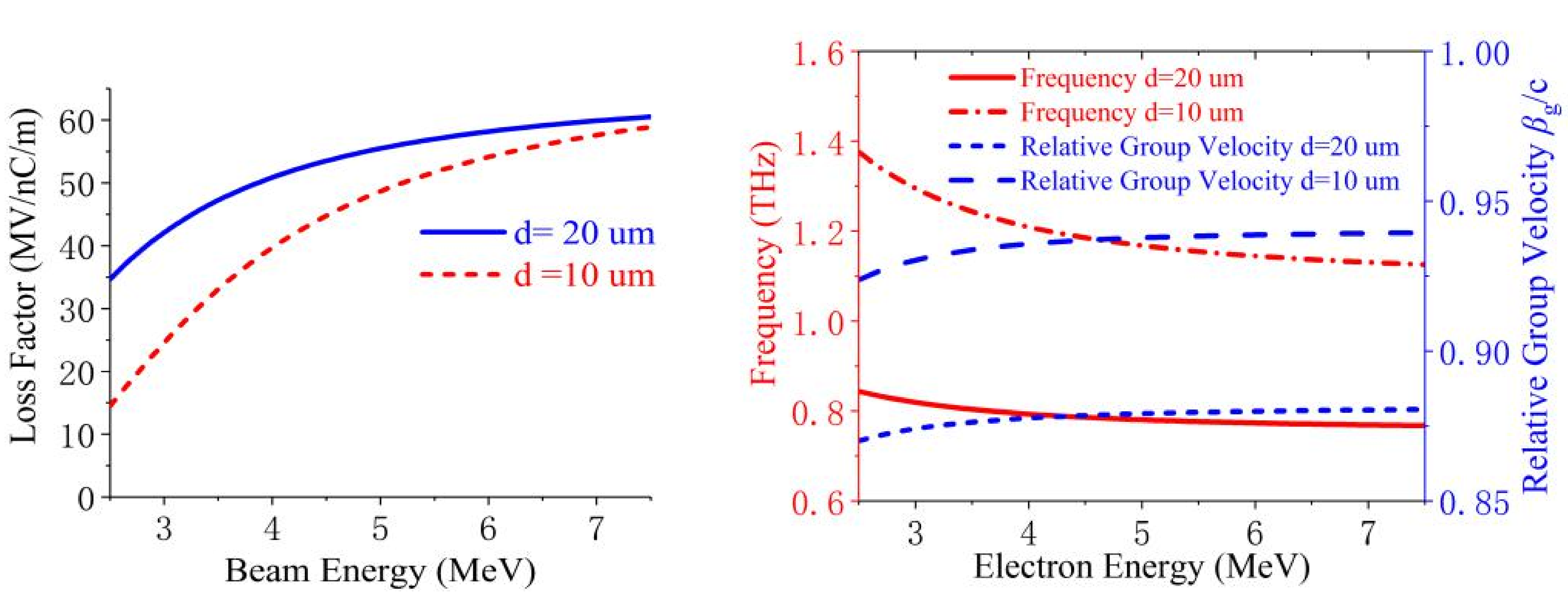

Fig.2 Loss factor, frequency and the group velocity as function of beam energy

Electron Beam

uniform temporal distribution 10ps,100A @5.4 MeV

Dielectric waveguide

dielectric loss tangent 3×10^{-3}, conductor: Cu

Simulation method

Details: W. Li *et al.*, NIMA 931.75 (2019)

Results

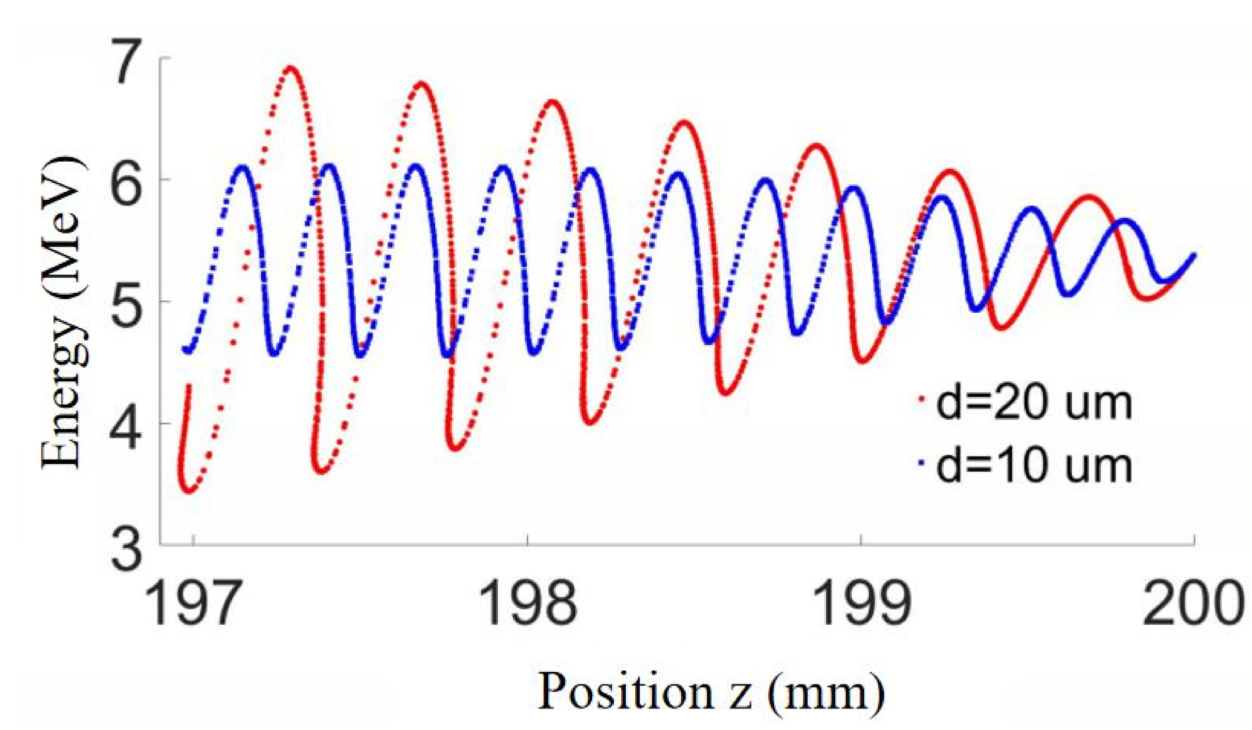

Fig.3 Beam phase space distribution @ time=0.2 m/c

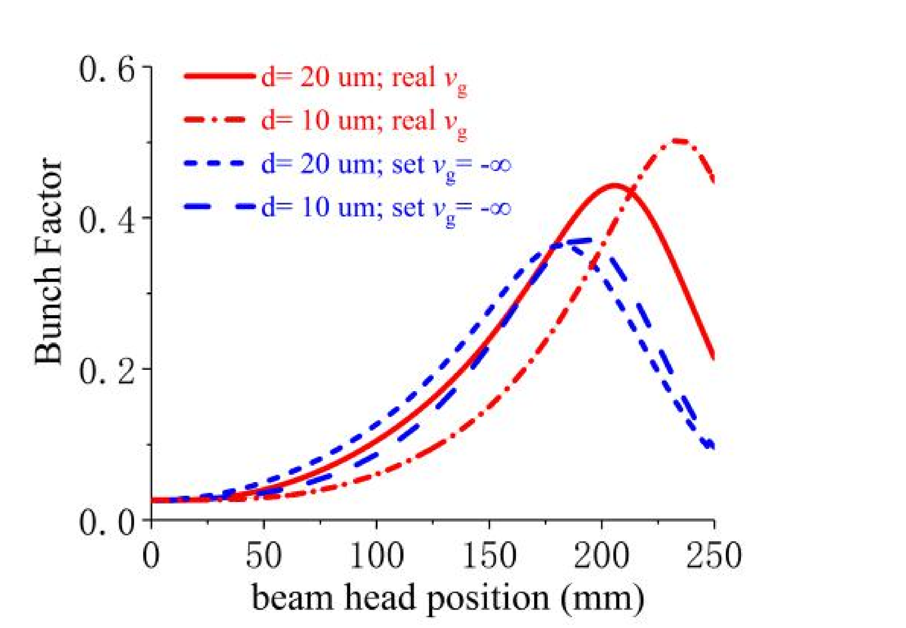

Fig. 4 Bunch form factor evolution as with the advancement of the beam

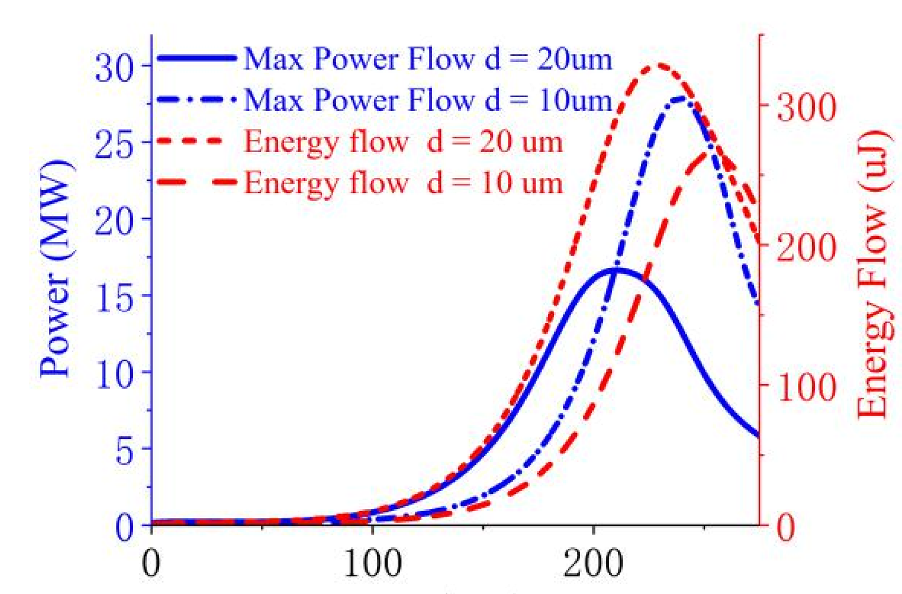

Fig. 5 The max power flow and the total energy flow versus the the longitudinal position

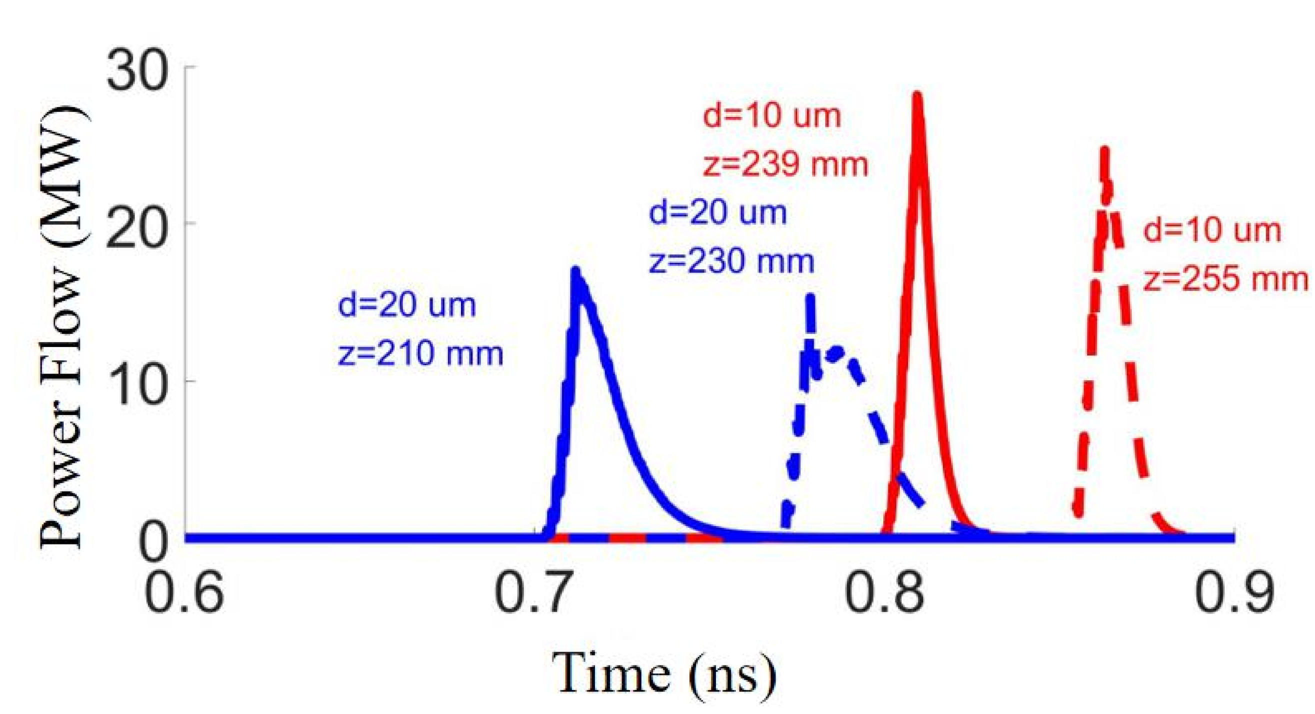

Fig.6 Power flow vs time at different cross sections

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