Simulation of Efficient Interaction Between Terahertz Pulse and Electron Beam

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Background

- FEL and IFEL coupling is one of the best options for efficient interaction of electron beam and radiation in the terahertz frequency regime, while the slippage effect will limit the energy efficiency
- We use a curved parallel plate waveguide to match the group velocity of the radiation and average longitudinal velocity of the electron beam to increase the interaction length

Method

- We design a GPT custom element to simulate FEL/IFEL interaction in a waveguide in a self-consistent way
- The TE01 mode in the curved parallel plate waveguide is used to obtain high interaction efficiency

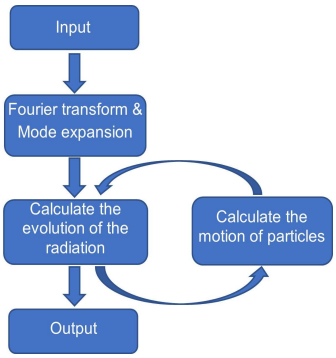

Figure 1: Program flow chart for the GPT custom element

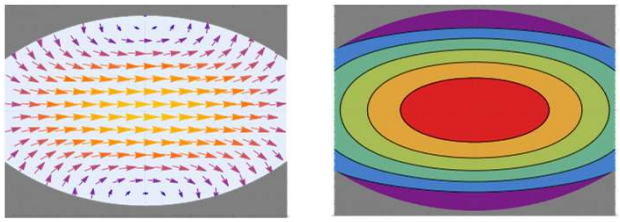

Figure 2: TE01 mode transverse component of the electric field for a curved parallel plate waveguide

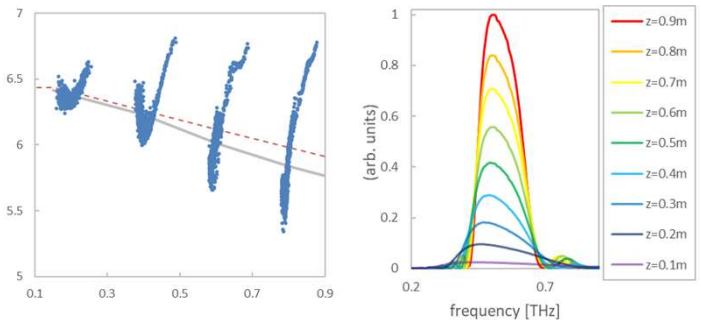

Figure 3: Left: the resonant energy, average energy and the phase space of the electron beam. Right: the evolution of the THz spectrum

FEL interaction

- Using a tapered undulator, our results show generation of radiation in the 0.5~1THz frequency range, with an average efficiency of more than 10%

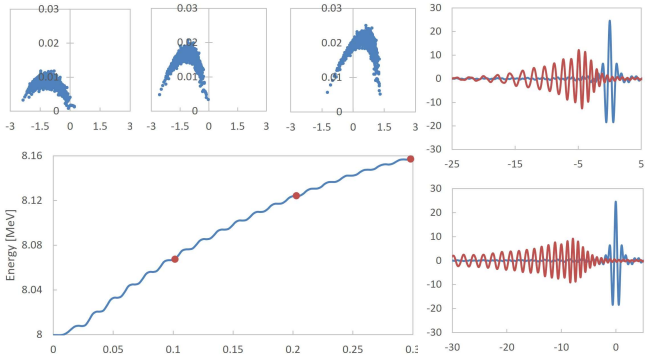

Figure 4: Left: the evolution of the average energy and the phase space of the electron beam. Right: the diffraction of the THz pulse at z = 0.15m and z = 0.3m

IFEL interaction

- IFEL interaction can be used for acceleration and compression of a relativistic electron beam.
- Using a terahertz pulse with an energy of about 1 μJ, our simulation predicts 160keV energy gain of an 8MeV electron beam, while the diffraction of the THz pulse limits the maximum energy gain
- After a 0.3m IFEL interaction and 1.3m drift length, the 1 ps electron beam can be compressed to about 1/3 ps

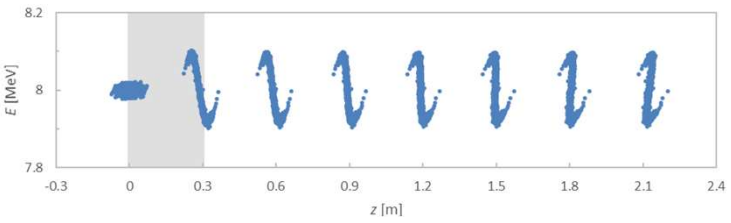

Figure 5: The resonant electron beam in and after a 0.3m long undulator. The longitudinal length reach its minimum at about z = 1.6m

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