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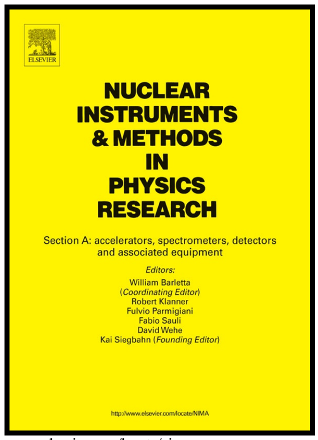

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Simulation of 3-D effects in THz-based phase space manipulation☆

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Abstract

We simulate "zero-slippage" phase space manipulation driven by a guided THz pulse using the 3-D General Particle Tracer code and compare our results to analytical predictions for bunch compression and angular deflection. With the beam parameters available at the UCLA PEGASUS laboratory for a proof-of-concept experiment, we simulate compression by nearly a factor of 10. We compare two deflection mechanisms for transverse streaking with an emphasis on the 3-D effects introduced by the undulator field.

Keywords: THz, beam control, IFEL

Introduction

The length scale of the THz frequency regime presents an opportunity for high resolution phase space manipulation such as beam compression or transverse streaking [1, 2, 3]. However, the limited power and efficiency of today's THz sources can make practical implementation in beam interactions a formidable challenge [4, 5]. Using the General Particle Tracer (GPT) code [6], we simulate a "zero-slippage" interaction that extends the duration of efficient coupling to a near-single cycle THz pulse for the applications of bunch compression and angular deflection and compare our results to analytical predictions [7]. In this scheme, a waveguide is used to reduce the group velocity of the THz pulse to match the propagation of the electron beam and to support a mode profile which, when coupled to the transverse momentum of the electrons oscillating in an undulator field, can induce an energy chirp or a transverse deflection along the beam.

THz IFEL for bunch compression

A single cycle THz pulse produced by optical rectification will outrun electrons propagating in free space, precluding any sustained interaction. One solution to this problem is a "zero-slippage" interaction, in which the group velocity of the THz pulse is reduced to match the electron bunch propagation using a waveguide [8]. We examine here a velocity-matched THz inverse free electron laser (IFEL) which uses this technique to achieve bunch compression and improve the timing synchronization of the accelerated beam to the external laser pulse that generates both the THz pulse and electron beam [7].

In this scheme, the beam co-propagates with the THz pulse in a waveguide that is nested between an array of undulator magnets. The waveguide controls the THz group velocity; the magnets cause the beam to wiggle in the vertical direction. When the phase synchronism condition for resonant interaction is satisfied, the

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