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Fast and accurate simulations of 10 GeV-scale laser plasma accelerators

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Because of their ultra-high accelerating gradient, laser plasma based accelerators are contemplated for the next generation of high energy colliders and light sources. The upcoming BELLA project will explore acceleration of electron bunches to 10 GeV in a meter long plasma, with a PW-class laser driven wakefield. Simulations of such stages are challenging because of the disparity of length scale between the laser wavelength that needs to be resolved and the simulation length. We report on recent developments of the Laser Envelope Model, a reduced model for laser-plasma interactions that has previously demonstrated orders of magnitude speedup. We present the implementation of the model in cylindrical coordinates, allowing rapid prototyping of laser acceleration stages. We discuss the performance benefits as well as limitations and trade-offs of this model.In parallel, high frequency noise in PIC simulations makes it difficult to accurately represent beam energy spread and emittance. We show that calculating the beam self-fields using a static Poisson solve in the beam frame dramatically reduces particle noise, allowing for more accurate simulation of the beam evolution.
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