Abstract Submitted
for the DPP07 Meeting of
The American Physical Society

Laser wakefield simulation using a speed-of-light frame envelope model[1] BENJAMIN COWAN, DAVID BRUHWILER, AMMAR HAKIM, PETER MESSMER, PAUL MULLOWNEY, Tech-X Corporation, ERIC ESAREY, Lawrence Berkeley National Laboratory — Simulation of laser wakefield accelerator (LWFA) experiments is computationally highly intensive due to the disparate length scales involved. Current experiments extend hundreds of laser wavelengths transversely and thousands in the propagation direction, making explicit PIC simulations enormously expensive and requiring massively parallel execution in 3D. We can substantially improve the performance of laser wakefield simulations by modeling the envelope modulation of the laser field rather than the field itself. This allows for much coarser grids, since we need only resolve the plasma wavelength and not the laser wavelength, and therefore larger timesteps. Thus an envelope model can result in savings of several orders of magnitude in computational resources. Secondly, coherent transition radiation (CTR) from an electron bunch exiting the plasma region of an LWFA is a useful experimental diagnostic, and we wish to investigate the dependence of CTR properties on the bunch properties. Modeling the laser envelope separately from the fields due to the plasma particles allows examination of the CTR, making systematic studies possible. Finally, previous simulations evolving the envelope in the lab frame showed distortions when the laser pulse was propagated over long distances in a plasma. By propagating the laser envelope in a Galilean frame moving at the speed of light, these distortions can be avoided and simulations over long distances become possible. Here we describe the model and its implementation, and show simulations of laser wakefield phenomena such as trapping, acceleration, and CTR using the model.

[1]Work supported by the U.S. DOE Office of Science, Office of High Energy Physics, under grant DE-FG02-04ER84097.

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Date submitted: 20 Jul 2007 Electronic form version 1.4