Abstract for an Invited Paper
for the DPP06 Meeting of
The American Physical Society

Developing high energy, stable laser wakefield accelerators: particle simulations and experiments

CAMERON GEDDES, LBNL

Laser driven wakefield accelerators produce accelerating fields thousands of times those achievable in conventional radiofrequency accelerators, and recent experiments have produced high energy electron bunches with low emittance and energy spread. Challenges now include control and reproducibility of the electron beam, further improvements in energy spread, and scaling to higher energies. We present large-scale particle in cell simulations together with recent experiments towards these goals. In LBNL experiments the relativistically intense drive pulse was guided over more than 10 diffraction ranges by plasma channels. Guiding beyond the diffraction range improved efficiency by allowing use of a smaller laser spot size (and hence higher intensities) over long propagation distances. At a drive pulse power of 9 TW, electrons were trapped from the plasma and beams of percent energy spread containing $>$ 200pC charge above 80 MeV with normalized emittance estimated at < 2 π-mm-mrad were produced. Energies have now been scaled to 1 GeV using 40 TW of laser power. Particle simulations and data showed that the high quality bunch in recent experiments was formed when beam loading turned off injection after initial self trapping, creating a bunch of electrons isolated in phase space. A narrow energy spread beam was then obtained by extracting the bunch as it outran the accelerating phase of the wake. Large scale simulations coupled with experiments are now under way to better understand the optimization of such accelerators including production of reproducible electron beams and scaling to energies beyond a GeV. Numerical resolution and two and three dimensional effects are discussed as well as diagnostics for application of the simulations to experiments. Effects including injection and beam dynamics as well as pump laser depletion and reshaping will be described, with application to design of future experiments. Supported by DOE grant DE-AC02-05CH11231 and by an INCITE computational award.