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Simulated Particle-in-Cell Results Demonstrating Multi-GeV Energy Quasi-monoenergetic Electron Beams and Adjustable Charge

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Recent experiments [1] have demonstrated laser wakefield acceleration (LWFA) of quasi-monoenergetic electron bunches with energy up to 5 GeV, bunch charge up to tens of picocoulombs, and beam divergence down to milliradians using 20 cm long, low density ionization-injected plasma waveguides [2] using 240 TW peak power laser drive pulses. We present 3D particle-in-cell simulation results that expand the technique used in [1,2] to a longer (40 cm) low density plasma waveguide with the added features of a density up-ramp to mitigate dephasing and a narrowed (4 mm) injection section, demonstrating ~12 GeV electron beam with a charge of 8 pC and <20% energy spread. We also present results using the same laser parameters, delivering a 10X higher bunch charge of 83 pC in a quasi-monoenergetic 5 GeV beam with <5% energy spread. Such LWFA modules are key to the development of a multi-stage electron accelerator.

[1] B. Miao et al., Multi-GeV electron bunches from an all-optical laser wakefield accelerator, Phys. Rev. X 12, 031038.

[2] L. Feder et al., Self-waveguiding of relativistic laser pulses in neutral gas channels, Phys. Rev. Res. 2, 043173 (2020).

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Primary author: ROCKAFELLOW, Ela (University of Maryland College Park)

Co-authors: MIAO, Bo; SHROCK, Jaron (University of Maryland, College Park); Prof. MILCHBERG, Howard (University of Maryland, College Park)

Presenter: ROCKAFELLOW, Ela (University of Maryland College Park)

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