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Laser Wakefield Acceleration in the Self-Guided Regime

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Recent experimental results of laser wakefield acceleration demonstrate self-guiding as means to achieve GeV scale electron energies. Experimental results using Helium gas jet and gas cell targets ranging in length from 3 mm to 14 mm produced electron energies to beyond 700 MeV. Energy measurements relied on a unique two-screen method to eliminate error due to angular deviation of the electron beam. To achieve such high-energy electrons in the self-guided regime, a 200 TW 60 fs laser pulse was focused to a spot size of 15 microns and propagated through underdense plasmas with densities ranging from 10^{18} to 10^{19}cm^{-3}. The power threshold for self-trapping of electrons was found to be a strong function of the laser pulse power compared with the critical power for relativistic self-focusing in plasmas. Full 3D Particle-In-Cell simulations show excellent agreement with experimental results. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344 and a Department of Energy Grant No. DEFG02-92ER40727 and was partially funded by the Laboratory Directed Research and Development Program under tracking code 06-ERD-056.