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Stable 1.5 GeV range electron beams in a centimeter pre-formed axiparabola driven plasma waveguide with a 50 TW laser power

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Today's laser-plasma accelerators produce electric fields of ~100 GV/m —over 1000 times those in conventional accelerators —shrinking their size from large facilities to compact tabletop laboratories. Recent LWFA advances have demonstrated high-quality femtosecond relativistic electron bunches accelerated to GeV energies within a few centimeters of plasma. Research on plasma waveguides to sustain large accelerating fields over longer distances is advancing rapidly, offering new prospects for scaling up energy and beam quality.

We present results on generating stable multi-GeV electron beams using laser wakefield acceleration assisted by a pre-formed axiparabola-driven plasma waveguide. Experiments at Weizmann Institute of Science accelerated electrons to peak energies exceeding 1.5 GeV using a 50 TW Ti:Sapphire laser power. We achieved reproducible stable high-energy continuous electron spectra and quasi-monoenergetic beams at 1 GeV, maintained over multiple days. A detailed investigation revealed strong dependence of energy and stability on key parameters, including the guiding channel's density gradient profile matched to the laser spot size, channel length, and injection mechanism. We discuss these results in light of theoretical models for laser guiding and wakefield evolution, highlighting strategies to optimize plasma channel design for next-generation laser-driven electron accelerators.

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