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A parametric study for enhanced electron beam quality in laser wakefield accelerators

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The path for Laser Wakefield Accelerator (LWFA) systems to emerge as reliable sources of electrons on a large scale necessitates a significant improvement in the electron beam's quality. This demand encompasses a comprehensive analysis of beam dynamics, from its generation in the plasma to the end user, while also considering the magnetic components of the transport line. This study presents a parametric investigation through Particle-in-Cell (PIC) simulations to identify the optimal laser-plasma setup. As a result, the potential for creating a highly charged (>100 pC) and energetic electron beam (>150 MeV) is demonstrated, with maintained high quality, marked by low emittance (<2 µm) and narrow energy spread (<2%). Moreover, using TraceWin (a beam dynamics code), a compact transfer and focus line is proposed to uphold beam quality up to the user. This work contributes to the EARLI project, which aims to design a high-quality, standalone LWFA electron for the AWAKE collaboration. In the design phase, the project currently employs methods derived from conventional accelerators applied to LWFA physics.

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