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Beam driven wakefield characteristics probed by femtosecond-scale shadowgraphy

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High peak current electron beams from laser wakefield accelerators (LWFA) are capable to drive a particle driven wakefield (PWFA) in a subsequent stage. The intrinsic short duration of these driver beams opens the possibility for PWFA studies in a higher density regime of the order of $10^{18} \cdot \mathrm{cm}^{-3}$. Since optical probing provides a reasonable contrast at this density range, direct insight into the particle-driven wakefields is possible. Here we present the results of femtosecond optical probing of such beam driven wakefields, showing pronounced differences in the morphology of beam driven plasma waves when surrounded by either neutral gas or a broad pre-generated plasma channel. Moreover, the shape and size of the first cavity of the wakefields correlates with the driver beam charge. The experimental results are supported by 3D particle-in-cell simulations performed with PIConGPU. This method can be extended to a detailed study of driver charge depletion by probing the evolution of the wakefield as it propagates through the plasma. This is an important step for further understanding and optimization of high energy efficiency PWFAs.

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