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Unforeseen advantage of looser focusing in vacuum laser acceleration

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Acceleration of electrons in vacuum directly by intense laser fields holds great promise for the generation of high-charge, ultrashort, relativistic electron bunches. While the energy gain is expected to be higher with tighter focusing, this does not account for the reduced acceleration range, which is limited by diffraction. Here, we present the results of an experimental investigation that exposed nanotips to relativistic few-cycle laser pulses. We demonstrate the vacuum laser acceleration of electron beams with 100s pC charge and 15 MeV energy. Two different focusing geometries, with normalized vector potential a_0 of 9.8 and 3.8, produced comparable overall charge and electron spectra, despite a factor of almost ten difference in peak intensity. The experimental findings are in good agreement with 3D particle-in-cell simulations performed using SMILEI code, which indicate the importance of dephasing.

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