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A tunable electron beam source using density down-ramp trapping

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One challenge in the development of laser wakefield accelerators is to demonstrate sufficient control and reproducibility of the beam parameters. Many schemes of controlled trapping of electrons have been proposed and implemented, aiming to improve control and reproducibility. Here we report on a numerical study of trapping in density down-ramps, as a continuation of our previous experimental study in which remarkable stability, using this trapping mechanism, was observed.

We demonstrate that trapping using density down-ramps allows for tuning of several electron bunch parameters by varying the properties of the density down-ramp. We show that the electron bunch length is determined by the difference in density before and after the ramp. The transverse emittance of the bunch is controlled by the steepness of the ramp. Finally, the amount of trapped charge depends both on the density difference and on the steepness of the ramp. We emphasize that both parameters of the density ramp are feasible to vary experimentally. This tunable electron accelerator makes it suitable for a wide range of applications, from those requiring short pulse length and low emittance, such as the FELs, to those requiring high-charge, large-emittance bunches to maximize betatron x-ray generation.

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