Laser-plasma acceleration beyond the diffraction and dephasing limits

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Laser-plasma acceleration allows for producing ultra-relativistic electrons by taking advantage of the ability of plasma to carry arbitrarily intense fields [1]. In practice, three phenomena limit the acceleration length, and thus the beam energy, in a laser-plasma accelerator: pump depletion, diffraction, and dephasing. Pump depletion, i.e., the laser energy transfer to the plasma wave, and laser diffraction tend to decrease the laser intensity during its propagation down to a level from which it can no more drive a steady plasma wave. Dephasing originates from the difference in velocity between the electron bunch and the laser, which results in a progressive shift of the electron beam towards a decelerating phase of the electric field.

Here we discuss several approaches for tackling these limitations and increasing the beam energy: the rephasing technique, which extends the effective dephasing length [2], the acceleration in a laser-plasma waveguide, which prevents diffraction [3], and a dephasing-less, diffraction-free acceleration scheme that solves all three issues at once [4]. We will notably present the first demonstration of acceleration of quasi-monoenergetic electron beams at the GeV level in a plasma waveguide (see Fig. 1) [5].

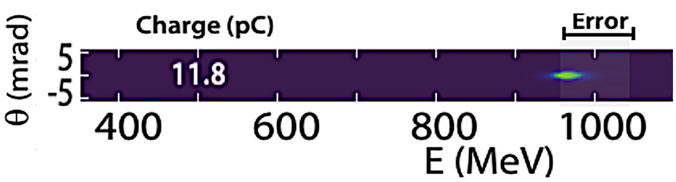

Figure 1: *Mono-energetic electron beam at 1 GeV*

References

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