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A mid-beta booster for proton beams

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Acceleration of proton beams in laser-driven plasma waves is challenging, owing to the difficulty of trapping the slow velocity protons in the relativistic plasma wave. In a laser-plasma accelerator, the phase velocity of the plasma wave is approximately the group velocity of the laser driver propagating in the underdense plasma. Due to their high rest mass, protons only reach comparable velocities with multi-GeV kinetic energies. However, the typical proton energy obtained from a compact laser-solid source is 10s to $\sim$ 100 MeV. Here, we explore the possibility of post-accelerating a proton beam produced in a compact laser-based source using the "snow-plow"field of an intense laser pulse propagating in a near-critical density target [B. Liu, et al., PRL 129, 274801 (2022)]. The electron sheet that accumulates in front of the laser pulse generates an electric field on the order of $\geq$ 10TV/m, that yields GeV energy gains within a 100 μm target, eventually reaching an energy sufficient for a subsequent beam injection into a laser-plasma accelerator.

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