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# Boosting Laser-Driven Proton Beams to Relativistic Energies with Hollow-Channel Magnetic Vortex Acceleration and Readily Available Petawatt Laser Pulse Energy

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Laser-driven proton acceleration can provide ultra-short, high-charge, low-emittance bunches. Despite extensive research, current laser-ion sources fall short of delivering the desired energies for pivotal applications, like proton tumor therapy. Moreover, the generated non-relativistic beams cannot be injected into high-$\beta$ accelerator elements for further acceleration and use in high-energy physics applications. Relieving the requirements for a single laser-ion source, we introduce a proof-of-principle concept that boosts a proton beam into the desired energy regime within a few compact laser-plasma stages. Our approach is based on magnetic vortex acceleration, using near-critical density target stages with a pre-formed hollow channel. Each individual booster stage accepts an incident proton bunch whose arrival is temporally matched to the driving laser pulse. With 3D particle-in-cell simulations using the exascale code WarpX, we showcase the approach's robustness in bunch acceptance (temporal and spatial), transport, energy boost, and bunch quality preservation. While our approach unveils a multi-parameter design space for future optimization and in-situ tuning, the scheme can be operated with presently available laser pulse parameters.
Arxiv preprint describing the work planned to be presented: https://arxiv.org/abs/2308.04745

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