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Collisionless Shock Wave Acceleration of Narrow Energy Spread Ion Beams Using Ultraintense 1 m Lasers[1]

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The quest for a compact laser-based source of high energy and mono-energetic proton beams is an active field of research. Such a source can have a high impact in many applications such as injectors for traditional linear accelerators, high precision measurements of field structures and potentially allow for the broadening of access to treatments with high societal impact. Traditionally, laser produced beams of ions have been generated using the TNSA mechanism, which produces a continuous exponentially decreasing spectrum with cut off energies limited to ˜100 MeV using current laser systems. This work overviews our experimental and numerical results on production of narrow energy spread beams from acceleration via a different mechanism electrostatic collisionless shockwave driven in near critical density plasmas by 1 m wavelength lasers. Shock waves driven by high intensity 1 m wavelength laser systems in CH targets produced beams of protons with peak energies of 10-45 MeV and narrow energy spreads of 10-35%. The number of protons within the narrow distribution was observed to be up to ˜1x10ˆ9, a 10ˆ4X increase over our previous work when using 10 m wavelength laser systems. Coincident with these proton beams was the observation of a narrow distribution of C^{6+} ions that were accelerated to a similar velocity as the proton beam consistent with acceleration by the moving potential of a shock wave. Particle-in-cell simulations show shock accelerated beams with narrow energy distributions of ions consistent with the experiments. Simulations also indicate the plasma profile determines the trade-off between the beam charge and energy and that with additional target optimization narrow energy spread beams exceeding 100 MeV/amu can be produced using the currently available laser systems.

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