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Increased Efficiency of Short-Pulse Laser Generated Proton Beams from Novel Flat-Top Cone Targets[1]

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Ion-driven Fast Ignition (IFI) may have significant advantages over electron-driven FI (EFI) due to a large reduction in the ignitor beam and laser driver energy requirements. Recent experiments at the LANL Trident facility, using novel flat-top cones made by Nanolabz in Reno Nevada, have yielded a 4 fold increase in laser-ion conversion efficiency, a 13 fold increase in the number of ions above 10 MeV, and a two fold increase in the maximum proton energy as compared to Au flat-foil targets. If efficiencies scale with intensity, in accordance with flat-foils, then IFI would have an even bigger advantage over EFI. At a modest intensity of 10^{19} W/cm^2 with 20 Joules in 600 fs protons with at least 30 MeV were observed from the cone targets. Particle in Cell (PIC) simulations show that the maximum cutoff energy could have been as high as 40 MeV. The simulations indicate that the observed energy and efficiency increase can be attributed to the cone's ability guide and focus the laser, allowing more laser-light to be absorbed into the electrons. The cone's geometry then funnels the electrons to the flat-top. The small size also limits the number of electrons, allowing more to be heated to high temperatures, creating a hotter, denser sheath. The PIC simulations elucidate the critical parameters in obtaining superior proton acceleration such as the dependence on laser contrast/preplasma-fill and longitudinal and transverse laser pointing. In addition, these cones have the potential to revolutionize ICF target design and fabrication via mass production.

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