THE IMPORTANT ROLE OF THE CONE IN INTENSE PROTON BEAM-DRIVEN FAST IGNITION [*]

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Proton fast ignition (pFI), a possible route to high gain inertial confinement fusion, was proposed [1] immediately following the unexpected high efficiency proton acceleration on the Nova Petawatt laser [2]. Today, significant progress has been made in characterizing laser-driven proton beams from intermediate to large-scale systems (<1 kJ). The studies to date indicate that a short-pulse-laser-driven proton beam created with high conversion efficiency [3], and focused [4], remains a promising fast ignitor candidate [5].

To study the behavior of a beam with parameters more closely related to pFI than previous studies (but still with far less energy than full-scale pFI requirements) we conducted experiments with a 1250 J, 10 ps pulse at the OMEGA EP facility. The laser irradiated spherically curved diamond (C) targets with three target mounting configurations including a freestanding target and two variations of a conductor meant to emulate the shielding cone in the pFI scheme. The proton beam resulting from the laser interaction passed by the conductors and through various foils meant to emulate the cone tip. The spectrum of these protons was measured by two means. Additionally, K-shell x-ray fluorescence, caused by collisions of the beam protons and electrons with atoms of the foil, was imaged with the Spherical Crystal Imager.

The K-α emission was localized and brighter by a factor of 8 for targets with the cone compared to freestanding curved targets. With the cone, the beam density upon entry into the foils is estimated to be 10^{18} cm^{-3}. This demonstrates a possible benefit of the cone; its effect on the proton spectrum is also presented. Furthermore, the proton spectra showed higher than expected energy loss in the foils according to particle-in-cell simulations including a collisional stopping module designed to model the rapidly-heated foil. The findings suggest field effects and intense proton beam transport phenomena should be considered when choosing the cone-tip material in the pFI scheme.

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