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IFE/P6-08: Focusing Protons Beams for Fast Ignition

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The Fast Ignition (FI) concept [1] has the potential for higher gains and smaller energy requirements as compared to conventional central hot spot (CHS) IFE. A hollow cone inserted in the side of the compressed fuel may be used to maintain a clear path for an ultra-short-pulse ignition laser to generate energetic particles that travel into and ignite the dense fuel. In the proton/ion FI concept [2], the ignition laser impinges upon a hemispherical target inside the cone, which generates a proton plasma jet with multi-MeV proton energies that is focused to a spot in the fuel. Optimizing the target's conversion efficiency and beam focus are key issues. Focusing has been demonstrated and studied using freestanding curved targets [3-5]. However, integration into full FI geometry will require the understanding of additional effects including interaction with fields associated with charging of surrounding structures, such as the cone. Experiments were conducted to examine these effects using curved targets with and without surrounding structure [6]. The focused waist diameter was found to be 50% smaller for the structured cases as compared to the freestanding cases. It was <40 microns for all measured energies. The focal position was also deeper for the conical structure case, but conversion efficiency was lower. Hybrid Particle-In-Cell (PIC) simulations identified connections between structure charging, beam focusing, and conversion efficiency [7] that can explain the focusing behavior observed experimentally in [6] and the conversion efficiency trends in subsequent experiments. Our findings show that targets with a cone structure result in non-ballistic focusing of proton beams to the diameter required for proton FI experiments. This effect could play an important role in controlling proton focusing and conversion efficiency in full-scale proton FI studies. This work was performed under the auspices of the U.S. DOE contract DE-SC0001265.

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