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IFE/P6-07: Self-consistent Integrated Modeling for Proton Fast Ignition

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The demonstration of the efficient energy conversion from laser to electrons then to protons via the Target Normal Sheath Acceleration (TNSA) mechanism on the Nova PW laser experiments [1] has opened a door to new regimes of high energy density sciences with the laser produced high energy proton beams either as heating sources or probes. One of the most important potential applications is to use proton beams as an ignitor [2,3] to initiate fusion spark in the fast ignition (FI) scheme [4] of inertial fusion energy. Large-scale hybrid particle-in-cell (PIC) simulations using the LSP code [5] with self-consistent laser-plasma interaction (LPI) package have been carried out in an integrated fashion for the proton FI scheme. Unlike modeling previously considered [6], the environment has been included; the thin hemispherical target is attached to the inside of a conical structure, which in turn is surrounded by an imploded fuel configuration for the DT plasma. The respective physical processes occurring in the proton FI scheme, including the proton beam source production, focusing and transport of proton beam from the proton source foil into dense plasma, stopping and deposition of the proton beam energy in hot spot of DT fuel, have been analyzed. The energy delivered by the proton beam to the DT fuel will be compared to Atzeni's ignition conditions [7] and to current results on electron-driven fast ignition scheme. This work also has important implication to other applications of laser produced proton beams because the proton beam dynamics during transitions analyzed here –of a high current proton beam transitioning from the source foil into vacuum and further towards the solid (cone tip),–is of critical importance to virtually all uses of proton beams, whether as probes or heaters.

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