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IFE/P6-06: Study of Fast Electron Generation and Transport for Fast Ignition

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In cone-guided fast ignition (FI), a high intensity short pulse laser interacts with the cone tip to generate relativistic electrons that travel through the cone tip and deposit their energy in a preassembled high density fuel outside the tip to initiate the fusion spark. Energy coupling to the fuel depends on laser-plasma-interaction (LPI) produced electron source characteristics (laser-to-electron energy conversion, electron energy and divergence). A series of experiments evaluated the energy coupling dependence on target material, geometry, preformed plasma scale length, and laser pulse length using the Titan laser (150 J, 0.7 ps) at LLNL and the OMEGA EP laser (300-1500 J, 1-10 ps) at LLE. Targets were multilayered foils in both planar and buried cone geometries consisting of Au or Al (either as the transport material or as the cone tip material) and a Cu layer buried ~100 mu m deep in the target. Fast electrons were characterized by measuring the induced Cu K_alpha radiation, bremsstrahlung x-rays, and the escaped electron spectrum at various angles.
Important findings include: i) Buried cone geometry improved energy coupling by 2X compared to the flat, however with an increased electron divergence. High Z Au cone resulted in a large diverged electron beam, which we attribute to the extended preplasma inside the Au cone. ii) Electron divergence is reduced (for 1 ps pulse) with a thin high-Z transport layer a few mu m beneath the Al front layer compared to the pure Al transport target. 2D collisional particle-in-cell (PIC) modeling including dynamic ionization and radiation cooling suggest strong resistive B-fields in the high-Z transport target collimate fast electron beam. iii) Preliminary experiments with 10 ps pulses showed irregular, variable shapes in the electron beam; 2-3 distinct spots were observed with a separation distance of ~100 mu m, which suggest the growth, over a few ps, of widely separated, stable filaments either in the LPI region or inside the solid target. The experiments are modeled using collisional PIC and hybrid PIC codes. Detailed experimental and simulations results will be discussed. Understanding of these dependences is important for optimization of FI cone target design to achieve high energy coupling to the fuel core.

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