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Fast Ignition Realization Experiment with High-Contrast Kilo-Joule Peta-Watt Laser "LFEX" and Strong External Magnetic Field[1]

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We report on progresses of the Fast Ignition Realization Experiment (FIREX) project that has been curried out at the Institute of Laser Engineering to assess the feasibility of high density core heating with a high-power, short-pulse laser including the construction of the Kilo-Joule, Petawatt class LFEX laser system. Our recent studies identify three scientific challenges to achieve high heating efficiency in the fast ignition (FI) scheme with the current GEKKO and LFEX laser systems: (i) control of energy distribution of relativistic electron beam (REB), (ii) guiding and focusing of REB to a fuel core, and (iii) formation of a high areal-density core. The control of the electron energy distribution has been experimentally confirmed by improving the intensity contrast of the LFEX laser up to $>10^9$ and an ultra-high contrast of 10^{11} with a plasma mirror. After the contrast improvement, 50% of the total REB energy is carried by a low energy component of the REB, which slope temperature is close to the ponderomotive scaling value ($\sim$ 1 MeV). To guide the electron beam, we apply strong external magnetic field to the REB transport region. Guiding of the REB by 0.6 kT field in a planar geometry has already been demonstrated at LULI 2000 laser facility in a collaborative experiment lead by CELIA-Univ. Bordeaux. Considering more realistic FI scenario, we have performed a similar experiment using the Kilo-Joule LFEX laser to study the effect of guiding and magnetic mirror on the electron beam. A high density core of a laser-imploded 200 μm-diameter solid CD ball was radiographed with picosecond LFEX-produced K-alpha backlighter. Comparisons of the experimental results and integrated simulations using hydrodynamic and electron transport codes suggest that 10% of the efficiency can be achievable with the current GEKKO and LFEX laser system with the success of the above challenges.

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