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Enhanced energy coupling for indirect-drive fast-ignition fusion targets

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One of the most promising approaches to reach a high gain in inertial confinement fusion is the fast ignition scheme. In this scheme, a relativistic electron beam is generated, which passes through the imploded plasma and deposits parts of its energy in the core. However, the large angular spread of the relativistic electron beam and the poorly controlled compression of the target affect the realization of the fast ignition technique. Here, we demonstrate that indirectly-driven, that is driven by generated X-rays inside a gold hohlraum, implosions with a "high-foot" and a short coast-time of less than 200 ps allow to tightly compress the shell. Furthermore, we show the ability to optimize the symmetry of the imploding shell by changing the hohlraum length, successfully tuning a suitable "tube-shape" shell to compensate for the large angular spread of the relativistic electron beam and to enhance the electron-to-core coupling efficiency via resistive magnetic fields. Benefiting from those experimental techniques, a significantly enhancement in neutron yield was achieved in our indirectly-driven fast ignition experiments. These results pave the way towards high coupling fast ignition experiments with indirectly-driven targets similar to those at the National Ignition Facility.

In this work, we have demonstrated experimentally the indirectly-driven fast ignition scheme for creating a "tube-shape" imploding core as a potential path to the ignition spark formation. Further improvements to the core energy coupling could be achieved by improving the beam quality of REB and increasing the core density. Our work indicates that a better collimated REB can be generated in interaction of high-contrast short pulse laser with double-cone targets. Moreover, a lot of experiments have showed that higher core density (>1.3 g/cm^2) can be achieved by an indirectly-driven high-foot and short coast-time implosion with a higher driven laser energy (~1.8MJ), which allows for REB stopping up to a higher kinetic energy and relaxes the requirement to ignite the fuel. Actually, by assuming the compressed deuterium-tritium fuel has a similar "tube-shape" geometry only with a 10 times higher density (to a value of ρL_x ~ 2.0 g/cm^2 and ρL_y ~ 0.6 g/cm^2), our hybrid simulations show that the ignition may be achieved with an input short pulse laser energy >200 kJ/10ps.

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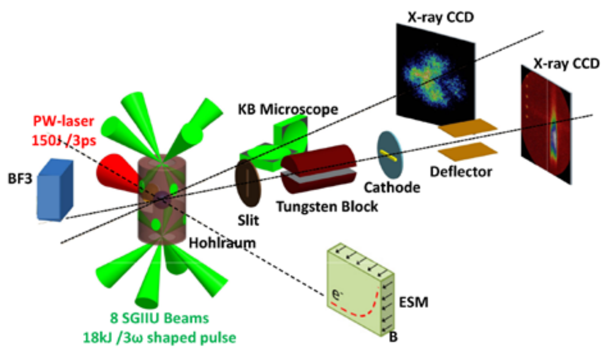

Figure 1. Schematic of an indirect-drive fast ignition experiment. A cone-in-shell target is imploded by soft x-ray radiation produced inside laser-irradiated cylindrical hohlraum at Shenguang-II upgraded laser facility. The short pulse laser irradiates the inner tip of the hollow gold cone to generate relativistic electron beam which serves to heat the compressed fuel.