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Pathway to a lower cost high-repetition IFE ignition facility

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We have identified an attractive path to develop the science and technology for fusion energy based on direct-drive pellet designs that substantially reduce the needed laser energy. A power plant based on laser fusion will require pellet energy gains of about 100 to overcome inefficiencies in the laser and power generation. For directly-driven targets this probably requires energies of at least one MegaJoule. However, many of the key science and engineering tasks could be accomplished with ignition and lesser gains. If one increases the pellet implosion velocity from the nominal 300 km/sec in high gain designs to 400 to 500 km/sec, one can obtain ignition and moderate gains at substantially reduced laser energy. This higher velocity can be obtained by increasing the distance over which the pellet shell is accelerated. But this approach leads to thin large-diameter pellet shells and the implosion is more likely to be disrupted by hydrodynamic instability. One can alternately obtain higher velocity by increasing the laser irradiance and thereby produce higher ablation pressure. This approach allows high-velocity implosion of relatively thick-shelled smaller-diameter targets that are much more resistant against hydrodynamic instability. The Krypton Fluoride (KrF) laser has substantial advantages towards implementing this approach. Its 248 nm deep-UV wavelength and very broad bandwidth suppress the laser-plasma instability that limits usable peak irradiance. The short laser wavelength also gives higher pressure and more efficient absorption. Our one-dimensional simulations using a KrF driver predict energy gains of 20 with 250 kJ laser energy and gains above 50 at 500 kJ. These pellet designs employ mechanisms that increase hydrodynamic stability. This approach opens the opportunity for a relatively small high-repetition KrF-based laser fusion facility that would be useful for developing and testing fusion energy science and technologies. Progress in the analysis of the pellets and implications for a faster-track IFE program will be discussed. This work was supported by the U.S. Department of Energy, NNSA. Work in collaboration with the researchers in the NRL Laser Fusion Program and the High Average Power Laser (HAPL) Program.