Development Path for Z-Pinch IFE

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The goal of z-pinch IFE is to extend the outstanding single-shot z-pinch ICF results on Z to a repetitive-shot z-pinch power plant concept for energy. On Z, the high magnetic field pressures associated with 20-MA load currents implode a wire array z-pinch, generating up to 1.8 MJ of x-rays at powers as high as 230 TW. Using a *double-pinch hohlraum target*, capsule implosions in the ~70 eV hohlraum have been radiographed by 6.7 keV x-rays produced by the Z-Beamlet Laser (ZBL). These experiments demonstrated capsule implosion convergence ratios between 14 and 21 from a radiation drive symmetry that is within 1.6 to 4 times the symmetry required for scaling to high yield. Using a *dynamic hohlraum target*, a 2.1-mm-diameter deuterium-filled CH capsules absorbs up to 35 kJ of x-ray energy from the ~ 220 eV dynamic hohlraum. The capsule convergence ratio is 5-10 and the thermonuclear DD neutron yield is up to 8 $x10^{10}$. These yields approach being a factor of 10 higher than that achieved by any other indirect-drive target experiments.

Based on (1) these demonstrated z-pinch driven target results, (2) the high demonstrated electrical conversion efficiency (~ 15%) on Z from wall-plug to x-rays, and (3) the lowest cost in $/Joule for all IFE drivers, it appears that z-pinches are particularly attractive for IFE provided a suitable method for rep-rated standoff (separation of driver and target) can be developed. The simplest and most robust method is the Recyclable Transmission Line (RTL) concept. In this concept, an RTL is made from a solid coolant (e.g., Flibe), or a material that is easily separable from the coolant (e.g., low activation ferritic steel). The RTL/target assembly is inserted through a single opening at the top of the thick liquid wall power plant chamber. The shot is fired, portions of the RTL are vaporized and end up mixed with the coolant to be recycled, the upper remnant of the RTL is removed, and the cycle is repeated. The present strategy for Z-Pinch IFE is to use high yield (~3 GJ/shot) and low repetition rate per chamber (~0.1 Hz).

A development path for Z-Pinch IFE has been created that complements and leverages the NNSA DP ICF program. This path includes a Proof-of Principle (PoP) phase, an Integrated Research Experiment (IRE) phase, an Engineering Test Facility (ETF) phase, and a Demo phase. Funding by a U.S. Congressional initiative of $4M for FY04 through NNSA DP is supporting assessment and initial research on (1) RTLs, (2) repetitive pulsed power drivers, (3) shock mitigation [because of the high yield targets], (4) planning for a proof-of-principle full RTL cycle demonstration [with a 1 MA, 1 MV, 100 ns, 0.1 Hz driver], (5) IFE target studies for multi-GJ yield targets, and (6) z-pinch IFE power plant engineering and technology development. Initial results from all areas of this research will be discussed.

*In collaboration with G. E. Rochau, S. A. Slutz, T. A. Mehlhorn, M. K. Matzen, J. P. Quintenz, W. B. Gauster, and the Z-Pinch IFE Team.

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