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Overview of Fusion Research at Sandia National Laboratories*

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Sandia's flagship is the Z facility, which was refurbished in 2007 to improve its energy, power (~80 TWe), reliability, and precision. We are now routinely performing one experiment per day, obtaining load currents as high as 26 MA to create high magnetic fields (> 1000 Tesla) and pressures (10s of Mbar). In a z-pinch configuration, the magnetic pressure supersonically implodes a plasma created from a cylindrical wire array or liner, which at stagnation generates a plasma with energy densities as high as 10 MJ/cm^3 and temperatures exceeding 1 keV at 0.1% of solid density. These plasma implosions can produce over 3 MJ of x-ray energy at powers over 300 TW for Inertial Confinement Fusion (ICF), radiation hydrodynamics, radiation-material interaction, Inertial Fusion Energy (IFE), and astrophysics experiments. In an alternate configuration, the large magnetic pressure is used to directly drive Isentropic Compression Experiments (ICE) to pressures greater than 6 Mbar or accelerate flyer plates to velocities as high as 45 km/s for equation of state experiments at pressures as high as 20 Mbar.

Significant progress has been made in the target physics for pulsed-power-driven approaches to ICF. Earlier experiments focused on the traditional hot-spot ignition approach to ICF, where z-pinch-produced x-rays are used to implode a fusion capsule. While these experiments and state-of-the-art 3D radiation magnetohydrodynamics simulations showed a promising path for meeting the key requirements for the radiation symmetry, pulse shaping, and scaling of the x-ray output as a function of current, we recently began focusing on an alternate approach that uses the magnetic pressure from the high current to directly compress the fusion fuel to ignition conditions. This Magnetized Liner Inertial Fusion (MagLIF) concept increases the efficiency of coupling energy into the fusion fuel by as much as an order-of-magnitude over the x-ray-drive approach. While this direct-drive concept is less mature, the higher coupling efficiency has the potential to greatly reduce the pulsed-power-driver requirements for ignition and high yield.

This research and development is performed in collaboration with many other research groups from laboratories and universities around the world.

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