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OVERVIEW OF U.S. HEAVY ION FUSION SCIENCE PROGRAM

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During the past two years, the U.S. heavy ion fusion science program has made significant experimental and theoretical progress in simultaneous transverse and longitudinal beam compression, ion-beam-driven warm dense matter targets, high-brightness beam transport, advanced theory and numerical simulations, and heavy ion target physics for fusion. First experiments combining radial and longitudinal compression of intense ion beams propagating through background plasma resulted in on-axis beam densities increased by 700X at the focal plane. With further improvements planned in 2008, these results should enable initial ion beam target experiments in warm dense matter to begin within a year. We are assessing how these new techniques may apply to higher-gain direct-drive targets for inertial fusion energy.

The success of strong transverse and longitudinal beam compression in neutralizing plasma enables the application of heavy ion beams to direct drive in the ablative rocket regime. A simple analytic implosion model with a heavy-ion dE/dx deposition model, together with hydrodynamic implosion calculations using both LASNEX and HYDRA, have been used to explore the characteristic beam requirements for heavy ion direct drive in the ablative regime, for small, 1 MJ-drive, DT targets as well as for larger, tritium-lean (> 90% DD) targets needing 5 MJ drive energy. Overall beam-to-compressed-fuel coupling efficiencies of 15%, twice as high as for laser direct drive, have been found in LASNEX calculations, and up to 25 % in analytic calculations. A candidate modular induction driver for 1MJ heavy ion direct drive has been identified that appears to meet direct drive target requirements for power, pulse shape and symmetry, ramping-up of ion range during the drive pulse, and final focus in neutralized chambers with focal spot sizes that zoom-in during the implosion drive.

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