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Publication Date
2010-01-21

HIFAN 1752a

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The Heavy Ion Fusion Science Virtual National Laboratory (a collaboration of LBNL, LLNL, and PPPL) is using intense ion beams to heat thin foils to the "warm dense matter" regime at 1 eV, and is developing capabilities for studying target physics relevant to ion-driven inertial fusion energy. The need for rapid target heating led to the development of plasma-neutralized pulse compression, with current amplification factors exceeding 50 now routine on the Neutralized Drift Compression Experiment (NDCX). Construction of an improved platform, NDCX-II, has begun at LBNL with planned completion in 2012. Using refurbished induction cells from the Advanced Test Accelerator at LLNL, NDCX-II will compress a ~500 ns pulse of Li+ ions to ~1 ns while accelerating it to 3-4 MeV over ~15 m. Strong space charge forces are incorporated into the machine design at a fundamental level. We are using analysis, an interactive 1D PIC code (ASP) with optimizing capabilities and centroid tracking, and multi-dimensional Warp code PIC simulations, to develop the NDCX-II accelerator. This paper describes the computational models employed, and the resulting physics design for the accelerator.

This work was supported by the Director, Office of Science, Office of Fusion Energy Sciences, of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231 and by LLNL under Contract DE-AC52-07NA27344.