New accelerator to examine heavy-ion-beam approach

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An overhead view of the NDCX-II. Photo by Roy Kaltschmidt/Lawrence Berkeley National Laboratory

The Department of Energy's Heavy Ion Fusion Science Virtual National Laboratory (HIFS-VNL), whose member institutions include LLNL, Lawrence Berkeley National Laboratory (LBNL) and the Princeton Plasma Physics Laboratory, has recently completed a new accelerator designed to study an alternate approach to inertial fusion energy.

Housed at LBNL, NDCX-II is a compact machine designed to produce a high-quality, dense beam that can rapidly deliver a powerful punch to a solid target. Research with NDCX-II will introduce advances in the acceleration, compression and focusing of intense ion beams that can inform and guide the design of major components for heavy-ion fusion energy production.

NDCX-II is an induction accelerator that can handle compact pulses of some 200 billion positively charged lithium ions, shaping each pulse as it is accelerated, and making sure that almost all the ions are delivered to the target within a nanosecond. But when they start from the injector, the ions are spread out in a 500-nanosecond pulse; the first task of the accelerator is to set the pulse's tail moving faster than its head. Then, during the initial acceleration, the overall pulse length shortens to less than 70 nanoseconds.

After further acceleration, the pulse enters a drift tube filled with plasma, which neutralizes the mutually repulsive charge of the positive ions and allows the pulse to compress, as its faster-moving tail closes the final distance to the head while focusing on the target. This process of neutralized drift compression gives the machine its name.

LLNL's HEDLP/Heavy Ion Fusion group within Physics Division's Fusion Energy Sciences Program developed most of the physics design for NDCX-II, under an $854,600 subcontract to LBNL. LLNL also provided the accelerating cells, which were previously used for its Advanced Test Accelerator (ATA), and the Blumleins, which are 250,000-volt, pulsed-power sources that provide the rapid final acceleration.

In addition to providing the ATA cells and Blumlein power sources, LLNL led the development of the beam dynamics prescription and the "acceleration schedule" (sequence of shaped accelerating waveforms, including specification of their shapes, amplitudes, timing and placement of the active accelerating cells on the beamline). Lab scientists also contributed to other aspects of the machine, such as the prescription for locating the beam "steering" components and establishment of the optimal beam-pipe size.

"NDCX-II represents the first conversion of electron induction accelerator components into a pulse-compressing ion accelerator," said Alex Friedman, the project's beam acceleration task area leader. "It would not have been possible without the tri-lab collaboration of the HIFS-VNL. With NDCX-II we will be able to study fusion-relevant intense-beam physics, ion-heated matter properties and elements of target physics for ion-beam-driven inertial fusion energy."

Provided by Lawrence Livermore National Laboratory