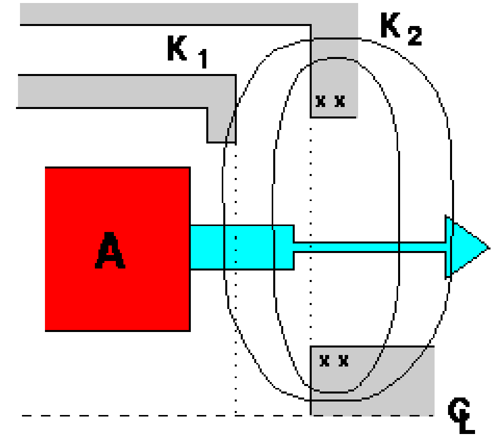
December 1996 Highlights of the Pulsed Power Inertial Confinement Fusion Program



Components of two-stage extraction ion diode: A, anode, K_1, cathode in first stage, and K_2, cathode in second stage. If the current in the second stage is controlled by the current injected from the first stage, independent control of the voltage is possible in the second stage.

Scheduled maintenance of PBFA Z was done in December. The overhead crane, which has hampered operations, is now repaired. After studying radiated energy and power scaling in z-pinch implosions for large-diameter (4-cm) wire arrays on PBFA Z, we are beginning to evaluate scaling for smaller diameters. Ion research is emphasizing methods to control ion focusing in single- and multi-stage diodes and electrode surface cleaning techniques to enhance lithium ion production.

On PBFA Z we have begun to measure the x-ray energy and power for annular wire arrays of smaller diameter than those (4 cm) with which we achieved our radiated energy and power design goals in November. We will use smaller-diameter (~ 1.75 cm) wire arrays within a vacuum hohlraum in upcoming z-pinch experiments because, at a given power level, these should produce higher hohlraum temperature. However, since the radiated power will decrease with diameter, we must determine the optimum wire array diameter for the hohlraum experiments. A potential application of this hohlraum environment is to study ablator physics. For example, 1-D radiation hydrodynamics simulations predict that a 100-eV hohlraum temperature in a 7-ns radiation pulse will generate shocks in material samples of up to 3 Mbars for equation of state and shock wave experiments.

Achieving uniform ion current density across the anode is essential to proper operation of high-power extraction diodes. We participated in initial experiments on the KALIF accelerator at FZK in Karlsruhe, Germany, to evaluate our two-dimensional analytic model for improving the ion current density uniformity. Using independently-driven magnetic field coils for the inner and outer cathode, the experiments confirm that the theoretically-determined magnetic fields can improve the uniformity and also suggest a reduction in the fluctuation amplitude of electromagnetic instabilities that contribute to ion divergence. During the next two months, detailed data on ion divergence will be obtained, and scaling of current density uniformity and divergence vs magnetic field configuration and amplitude will be studied. Sensitivity of diode performance to anode and cathode misalignment will also be measured.

In a single-stage extraction diode, ion focusing is controlled by curving the magnetic flux surface in the vicinity of the virtual cathode to the approximate shape of the anode surface. (The virtual cathode is the sheath region above the solid cathode surface that is filled with electrons.) In the second stage of a multi-stage diode (see figure), however, no anode may be present; hence, the magnetic flux surface can be significantly bowed by the ion pressure. A new analytic theory and 2-D calculations indicate that the degree of bowing of the virtual-cathode flux surface after the ions are accelerated may be acceptable. Hence, a foil or grid may not be necessary to control the shape of the virtual cathode. Instead, a preformed plasma could be used to charge neutralize the ion beam. The two-stage diode concept could therefore be tested on the COBRA accelerator at Cornell University with protons.

The multi-stage results were featured at a tri-laboratory (SNL, LBL, LLNL) workshop that we hosted to review areas of common interest in target, transport, and accelerator research for light and heavy ions and to discuss the possible use of a middle-weight ion for high yield, since a middle-weight ion would require multiple stages. We also hosted a workshop to evaluate the role of electrode cleaning techniques in the operation of SABRE, PBFA X, and Decade (a Defense Special Weapons Agency accelerator for studying weapons effects).

Performance of the prototype NIF power conditioning module has been characterized during hundreds of shots at full charge voltage. The evaluation will be completed during the next quarter by testing the module to 10,000 shots.

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