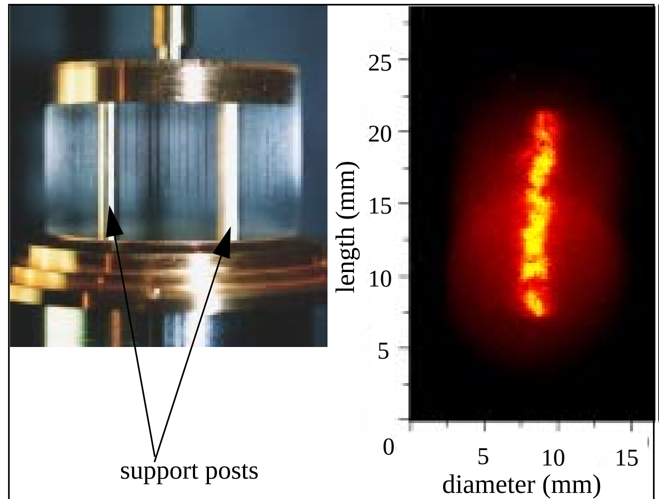
November 1996 Highlights of the Pulsed Power Inertial Confinement Fusion Program



Photograph of annular wire array hardware for 17th radiation shot (PBFA Z Shot 26). Wires are tensioned with copper weights. One of the 240 wires was lost during assembly. Support posts are removed after installation in PBFA Z. Pinhole camera image of imploded plasma stagnated on axis for shot. Total radiated energy was 1.85 MJ, peak x-ray power was ~ 160 TW, and minimum pinch diameter was ~ 1 mm.

On November 1 we achieved the 1.5-MJ radiated energy milestone on PBFA Z and on November 21 we exceeded both the energy and the power milestones (1.5 MJ and 150 TW) on the same shot. We gave talks on imploding z pinches, including a review of z-pinch physics, at the APS Division of Plasma Physics meeting. We hosted the Interlaboratory Pulsed Power Working Group; topics included microsecond (Pegasus at LANL, Shiva at Phillips Laboratory) and submicrosecond (Saturn, PBFA Z) pulsed-power generators, radiography, hydrodynamic instabilities, x-ray backlighters, and future pulsed power generators (Atlas at LANL and X-1 at SNL).

On November 1, 1.6 MJ in soft x rays were produced on PBFA II on the 10th radiation shot in the z-pinch mode. With this x-ray energy--62% of the electrical energy at the vacuum insulator stack--we exceeded the first PBFA-Z milestone of 1.5 MJ x-ray output. An intense, short (~ 8 ns) pulse of soft x rays at a peak power > 110 TW was created when the imploding plasma stagnated on axis. The z-pinch load consisted of 120 10-µm-diameter tungsten wires, configured in a cylindrical array 4 cm in diameter and 2 cm long. X-ray data were taken with x-ray diodes, resistive bolometers, time-integrated and time-resolved spectrometers, and photoconducting detectors. On November 21 we produced 1.85 MJ and ~ 160 TW, thereby exceeding the radiated energy and power milestones (1.5 MJ and 150 TW) on the same shot. The load for this 17th radiation shot was 240 7.5-µm-diameter wires. The x-ray pulse was 6.8 ns wide. The implosion time for both shots (110 ns and 108 ns, respectively) is slightly longer than the 100-ns optimum predicted. We have begun to study energy and power scaling of smaller-diameter wire array loads (1.75 cm diameter instead of 4 cm) that will be used for upcoming hohlraum experiments on PBFA Z.

Because of these successes, PBFA II will be dedicated to z-pinches for the next two to three years. Generation, focusing, and transport of light ions will be assessed on the SABRE accelerator at Sandia, on the new, shallow-focusing extraction ion diode on Gamble II at NRL, and on the newly completed COBRA accelerator at Cornell.

Our near-term SABRE goals are to 1) reproduce and improve the PBFA-X cleaning protocol, 2) study mitigation of anode, cathode, and limiter plasmas by cleaning and coating techniques, and 3) prepare for active ion source experiments for reduced ion divergence. Achieving these goals requires an improved vacuum, higher-power radiofrequency discharges, higher magnetic fields, and new diagnostics. The diode base pressure is now 2×10^{-6} Torr (a factor of 25 better than before on SABRE) without cryogenic cathodes and 7×10^{-7} Torr with them, the lowest ever for the ion diode. A magnetic spectrometer has been installed to measure beam purity and energy vs. time. Electron loss monitors are being designed to provide the time- and space-resolved average electron energy and angle for comparison with QUICKSILVER simulations, and a time-resolved ion divergence diagnostic is being developed.

The first Gamble-II shots have been taken with the extraction diode, including the counterpulse magnetic field and ballistic focusing in 1-Torr air. The counterpulse current positions the separatrix on the ion emission surface at peak ion power, minimizing beam angular momentum and focusing the protons on axis. Pinhole camera images show the counterpulse field decreased angular momentum for counterpulse currents about 1/3 the peak current in the main pulse. DATHETA calculations show that adding less resistive metal at the outer edge of the anode face may improve the focus. Experiments on Gamble II with the most promising transport method for light and heavy ions, self-pinched transport in low-pressure argon, could reduce the ion beam divergence requirement by a factor of two.

Contact: Jeff Quintenz, Inertial Confinement Fusion Program, Dept. 9502, 505-845-7245, fax: 505-845-7464, email: jpquint@sandia.gov
Highlights are prepared by Mary Ann Sweeney, Dept. 9502, 505-845-7307, fax: 505-845-7890, email: masween@sandia.gov.
Archived copies of the *Highlights* beginning July 1993 are available at http://www.sandia.gov/pulspowr/hedicf/highlights.