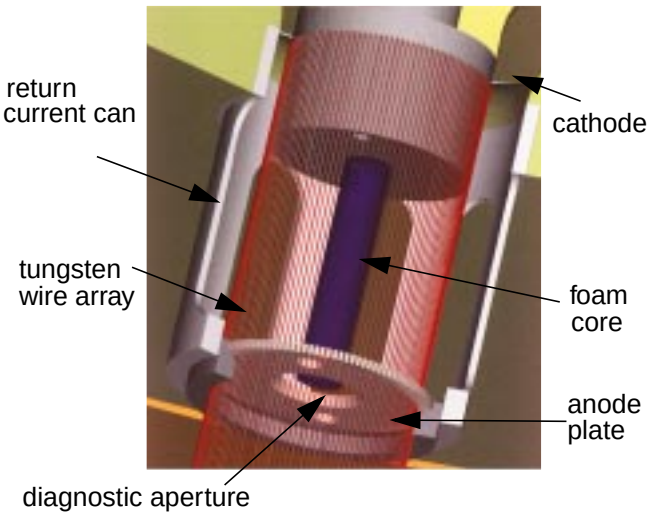
February 1997 Highlights of the Pulsed Power Inertial Confinement Fusion Program

This month, the tungsten wire array diameter was varied from 1.75 to 3.5 cm in 12 radiation source shots on PBFA Z. We obtained radiated energy and power of 1.4 MJ and 140 TW with a 3-cm-diameter wire array on February 26. The accelerator was shut down after this shot to replace an insulator in the vacuum stack that had cracked. Electron loss may be causing load Bdot current monitors to fail on shots with small-diameter wire arrays and fast implosion times. For these high inductance loads, we are developing a new Bdot, offset from the transmission line, that will be shielded from electron flow.



Pictorial view of Saturn wire array on foam core geometry. Mass from the foam could pass through the open anode and fill the volume seen by the end-on viewing aperture. On PBFA Z, the geometry is inverted, with aperture and anode at the top.

We are evaluating the asymmetries and surface and internal chemistry of the tungsten wire stock with scanning electron microscopy (SEM), electron dispersion spectrometry, and Auger emission spectroscopy. The 8-to-20-μm-thick wires are about 1/6th the width of a human hair. They are extremely parallel with faint nodules composed chiefly of machine oil contamination introduced during fabrication. Profilometry shows no evidence that the tungsten wire stretches, even if weights are applied a week before the load hardware is used. At the beginning and end of each spool of wire, the wire diameter can differ as much as 1 μm. Hence, wire at the beginning and end of a spool is not used. SEM data indicate that the wire diameter is typically 5 to 10% larger than the manufacturer's specification. Since z-pinch performance is sensitive to total wire mass, we are assisting the manufacturer in determining actual wire size.

New analysis of 1996 Saturn z-pinch experiments with aluminum wire arrays reveals a sharp transition in the peak radiated power as a function of total array mass and the size of an individual wire. This transition is observed in all photon energy channels and is more dramatic for higher energy ones. In particular, the full width at half maximum of the K-shell radiation pulse decreased a factor of two as total wire array mass was decreased from 1.9 to 1.3 mg (corresponding to a decrease in individual wire diameter from 15 to 13 μm). We are using this information to design the z-pinch load configuration on PBFA Z that will produce the maximum aluminum K-shell yield.

The presence of an axial plasma jet in dynamic hohlraum experiments can affect our interpretation of the radiation temperature within the hohlraum. We expect to see a jet on PBFA Z, after the tungsten wire array implodes and strikes the inner annular foam target. If this jet is created by the radiation from the wires heating the outer edge of the foam, analytic calculations suggest it will have a negligible effect on the transmitted soft x-ray spectrum. However, creation or modification of a plasma jet by accelerator prepulse, magnetohydrodynamic instabilities, or electrode effects could affect our analysis of the spectral data as seen through the end-on viewing aperture (see schematic). These issues are being addressed in detailed computer simulations. Characterization of such a jet, including measurement of its mass density, is planned on upcoming PBFA-Z experiments.

Electron loss to the anode is an indicator of the instability state of an ion diode, with a low level of loss correlating with low divergence. A new electron loss diagnostic has been developed for SABRE that shows a much earlier and larger electron loss than our present QUICKSILVER simulations predict. Our objective is to understand the cause of this early electron loss by studying the sensitivity of diode behavior to anode and cathode perturbations with QUICKSILVER, and then to modify the experiments to avoid the early loss.

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