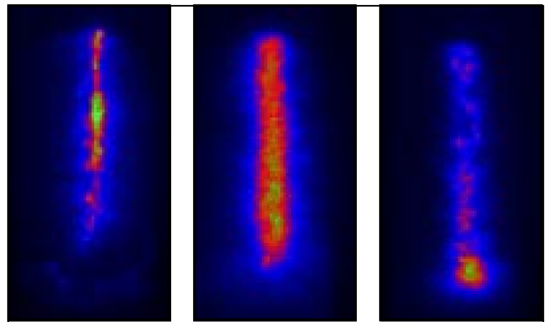
January 1996 Highlights of the Pulsed Power Inertial Confinement Fusion Program



100-ps pinhole camera images of imploding tungsten wires on Saturn shot no. 2224 taken 3 ns apart. Middle image corresponds to time of peak radiated power of 85 TW.

In January we obtained a world-record result with a z-pinch load and determined that impedance loss in ion diodes is not caused by electron avalanche ionization of neutrals. We participated in the U. S. Particle Accelerator School in San Diego and the Physics of High Energy Density in Matter conference in Austria. We are preparing for a Sandia-initiated review of our pulsed power programs on February 21 - 22.

In magnetically-driven implosion experiments on the 2-MV, 20-TW Saturn accelerator, using a tungsten wire array for the plasma radiation source (see figure), we have achieved a total radiated x-ray power of 85 TW. In a separate hohlraum experiment, we have measured an albedo-corrected radiation temperature of 85 eV. The radiated power exceeds the peak electrical power on Saturn by a factor of four. This world-record result with a z-pinch load will have a major impact on application of pulsed power to the science based stockpile stewardship program. The x-ray emission is consistent with LLNL and SNL radiation-hydrodynamics models. The improved x-ray power, with a decrease in pulse width to 4 ns, has been attained by increasing the number of wires (to 120 compared to 40 in earlier experiments). The increased number of wires dramatically improves the azimuthal symmetry of the z-pinch implosion and permits the detailed measurement of features, such as Rayleigh-Taylor bubble/spike structures, to be correlated with radiation-hydrodynamics simulations.

In April we will begin to modify PBFA II to the PBFA-Z mode to enable z-pinch-driven implosions on this higher current, higher voltage accelerator. The required changes to the magnetically insulated transmission lines have been modeled with the two-dimensional, electromagnetic, particle-in-cell code TWOQUICK. The modeling shows that the design is a good one, with the system well insulated by the large magnetic fields. The new Saturn radiation output data described above are being compared with a LANL z-pinch model. The model will then be scaled to the longer current drive time and larger initial load diameter of PBFA Z. A milestone for FY97 is to achieve a 100-eV radiation temperature in a vacuum hohlraum on PBFA Z.

Operation in the ion beam extraction (PBFA-X) mode was curtailed for part of the month by accelerator refurbishment and crane repairs. Tests have begun to evaluate electrode surface cleaning techniques, developed on SABRE in 1994 and 1995, that reduce the current in non-lithium ions. Easy access to the RF discharge cleaning system on PBFA X and experience with that system in 1995 on PBFA II have allowed us rapidly to match the impedance of the cleaning plasma to that of the RF generator. We have modified the anode to the smaller surface area (500 cm^2 vs 1000 cm^2) that is required for the Laser EVaporation Ion Source (LEVIS). LEVIS will be used once the cleaning techniques are implemented.

We have developed a vacuum ultraviolet (VUV) absorption spectroscopy diagnostic for SABRE that explores the physics of impedance loss in the anode-cathode gap of an applied-B ion diode. Fast neutrals generated from charge exchange in a desorbed impurity layer above the anode can cross the gap during the 50-ns power pulse. Such neutrals may be the cause of impedance collapse (i. e., the decrease in voltage faster than diode current decreases). However, visible spectroscopy has shown no significant excited-state neutrals in the gap. The VUV absorption spectroscopy probes directly for ground-state neutrals. The absence of absorption features has set an upper limit of typically 0.1 - 1 x $10^{14}/cm^3$ for various impurity neutrals in the gap. These limits are low enough that electron avalanche ionization of neutrals out in the gap, once considered a likely mechanism for impedance collapse, is not significant in our fast pulses.

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Archived copies of the *Highlights* beginning July 1993 are available at http://www.sandia.gov/pulspowr/hedicf/highlights.