February 1998 Highlights of the Pulsed Power Inertial Confinement Fusion Program

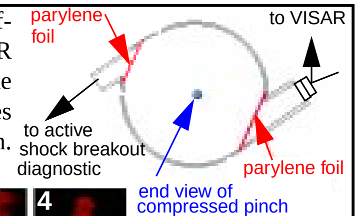

Fig. 1. Primary hohlraum, off-axis secondaries, and VISAR sample on Shot 189. Parylene burn-through foil eliminates effect of run-in radiation.

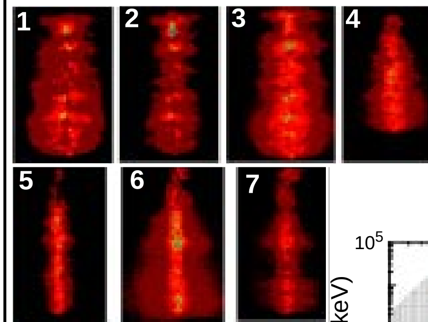

Fig. 2. Pinhole images on nested Shot 180 at 1-ns intervals; pinch compression is 40:1

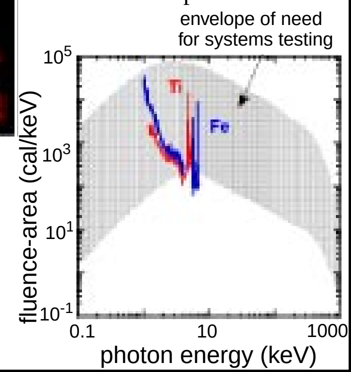

Fig. 3. Fluence-area vs energy for data obtained in fall 1997 on Z relative to national needs for effects testing. Warm (> 10 keV) x rays within needs envelope would be possible with X-1.

We are continuing to optimize z-pinch sources, develop diagnostics, and study indirect drive on Z. Of the 17 February shots, two were with nested arrays, two for equation-of-state (EOS) data, three for weapons effects, four to measure radiation temperature in a vacuum hohlraum, four to measure x rays as an array strikes a central Cu sleeve and stagnates on axis, and two LANL weapons physics shots. The on-axis hohlraum shots with the Cu sleeve had the largest number of wires to date (480 each).

On the EOS shots, a velocity interferometer (VISAR) is mounted at the end of an off-axis secondary hohlraum (Fig. 1). The average radiation temperature in the secondary, uncorrected for hole closure or wall absorption, was 80 eV. The temperature in the 5 cm^3 primary was not measured; on earlier shots with the same configuration, it was 135 eV. The pressure in the aluminum/LiF VISAR sample was 1.2 Mbars. Because of success in measuring the pressure profile and the secondary temperature, the VISAR was fielded on the LANL weapons physics shots and will be fielded on most future Z shots.

On nested array shots, the number and mass of wires in the arrays are varied as well as the wire length in order to optimize the radiated power. The x-ray images on Shot 180 (Fig. 2) show the the achievement of the tightest pinch yet on Z (1 mm diameter). The x-ray data also indicate that the inner array expands somewhat before the inner edge of the outer array reaches the inner array. The low (2.5-kA) current measured per inner wire with a Bdot monitor implies that most of this inner array expansion is not from current preheat and is more likely caused by radiation preheat. This expansion will need to be modeled accurately on the 2D magnetohydrodynamics codes.

We began to test on Z, using titanium wire arrays developed with DSWA, the radiation hardness of actual stockpile components for the neutron generator program. The fluence-area possible on Z has increased the national soft x-ray nuclear weapons effects testing capability by a factor of ten (Fig. 3), accessing an area within the needs envelope.

The initial dynamics of z pinches is being studied at Troitsk, NRL, and Cornell with optical and x-ray diagnostics. On one Angara-5 module and at NRL, individual wires have been exploded at a current rate of rise equivalent to the Z prepulse (25 - 50 kA/µs per wire) and imaged by laser shadowgraphy and interferometry to observe evolving asymmetries. At Troitsk, the dynamics of cylindrical segments containing a number of wires has also been imaged. At Cornell, plasma formation and merging of multi-wire (planar) z pinches are backlit, at >1-µm spatial resolution, with x-rays from x pinches on the XP pulser and imaged with a pinhole camera. All data are being compared with models by Sandia, Imperial College, NRL, and others to treat the coalescence of wires and adjacent wire arrays.

We completed the analysis of the radiation temperatures in two series of dynamic hohlraum shots from last fall. Using the time-resolved, five-channel, reflection grating spectrometer, a peak temperature of 170 eV and a “useful” (i.e., for driving end-on weapons physics experiments) temperature of 140 eV was measured on LLNL shots in which a tungsten wire array implodes onto a beryllium sleeve that is surrounded by one or two foam annuli at larger radius. The same 140 eV temperature, useful for ICF capsule compression in this case, was obtained on Sandia-designed shots, using x-ray diodes to diagnose the radiation temperature. On these shots, the wire array struck a plastic foil annulus or a uniform-density foam cylinder. More shots in both series are scheduled for March through May, with the goal of reaching a useful temperature of 150 eV.

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