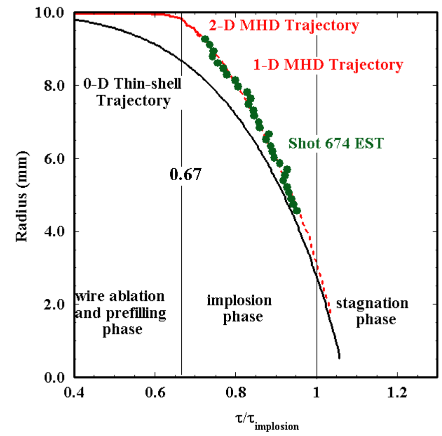
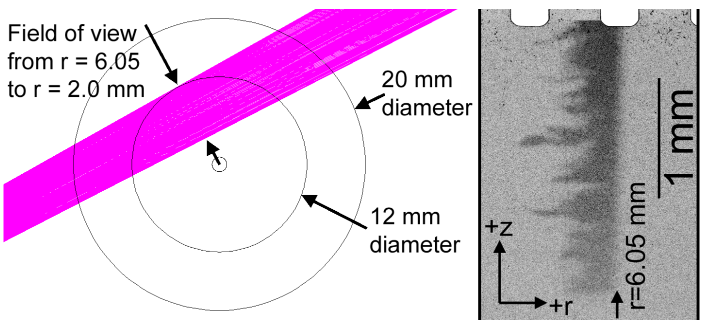
1673 News Notes: August 2002 Edition

X-ray backlighting of wire-array z-pinch implosions

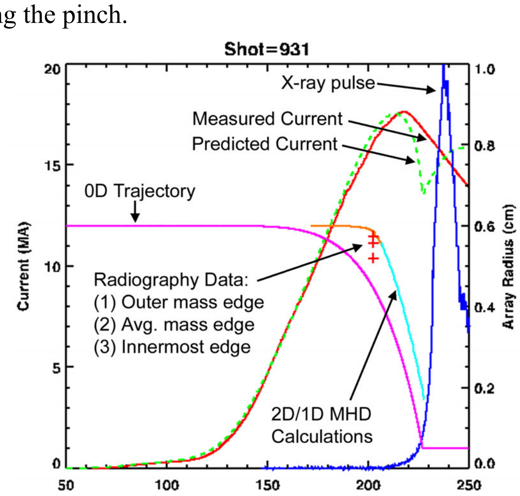


Recent experiments by Michael Cuneo (mecuneo@sandia.gov) and Daniel Sinars (dbsinar@sandia.gov) have begun looking at techniques to vary the temporal shape of the radiation produced by z pinches. The design of radiation pulse-shaping techniques requires an understanding of the trajectory of the imploding wire-array plasma. Simple "zero-dimensional" (0D) models for the trajectory treat arrays as thin shells that implode uniformly to the axis. These models can successfully predict the start time of the radiation pulse. However, recent data from Imperial College, Angara-5 in Russia, and Sandia suggest that the implosion trajectories are not 0D, but that the arrays begin moving later than predicted. In the graph shown above, a delayed trajectory relative to the 0D model was measured by Mike Cuneo *et al.* (in collaboration with Sergey Lebedev and Jerry Chittenden of Imperial College in London) by looking at the optical emission from the wire-array mass as it moved. The measured trajectory, however, is inconsistent with 100% of the wire-array mass participating in the implosion, which suggests that some of the array mass does not participate in the main radiation power pulse and arrives on-axis later. In the case of 20 mm diameter arrays, as much as 30% of the original wire array mass may not contribute to the radiation pulse, based on the delayed trajectory calculation by Jerry Chittenden shown above. Empirically, as the wire-array diameter decreases (and becomes more massive), the array starts moving later in the current pulse. Fits to the delayed trajectories suggest that longer delays may be consistent with increased mass fractions arriving on-axis after the peak radiation pulse.

The recent experiments attempted to directly measure the position of the wire-array mass using an x-ray backlighting diagnostic built by Dan Sinars and Dave Wenger. They obtained the first two-dimensional x-ray backlighting image of an imploding wire array on Z. The x-ray source was a silicon foil irradiated by the Z-Beamlet laser. After passing through the wire array, the x rays reached a spherical crystal mirror that only reflected 1.865 keV x rays so that none of the low- and high-energy x-ray background produced by the z-pinch reached the x-ray film. The backlighter was designed to have three fields of view through a 20 mm diameter array, but a 12 mm diameter array was used during the first test and only allowed one of the three fields of view (shown below). The high x-ray absorption of this heavy array only permitted measuring the mass distribution at the edge of the array. The portion of the film containing the outer boundary is shown. The dark regions on the film correspond to x rays that reached the film, so the ragged boundary on the left side of the image corresponds to regions where the wire-array mass attenuated the x rays below the detection limit of the film. The straight edge on the right was made by a slot edge in the return-current can surrounding the pinch.



It is clear from the x-ray image that the imploding wire array is both axially and radially non-uniform. Furthermore, if we superimpose the radial position of features in this radiograph on a plot of the 0D trajectory for this array, it is apparent that there is a significant amount of mass (our initial estimates suggest about 30-50% of the total mass) lagging behind the 0D trajectory. A delayed trajectory calculation made by Jerry Chittenden is shown for comparison. The analysis of the backlighting data is ongoing. Additional x-ray backlighting measurements of imploding wire arrays will be made during Z-machine experiments in October. The backlighting data obtained during these experiments should greatly enhance our understanding of how wire-array z-pinches implode.



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Sandia is a multiprogram laboratory operated by the Sandia Corporation, a Lockheed Martin Co., for the United States Department of Energy under Contract No. DE-AC04-94AL85000.