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Title:

Gated X-Ray Framing Camera Image of a Direct-Drive Cylindrical Implosion

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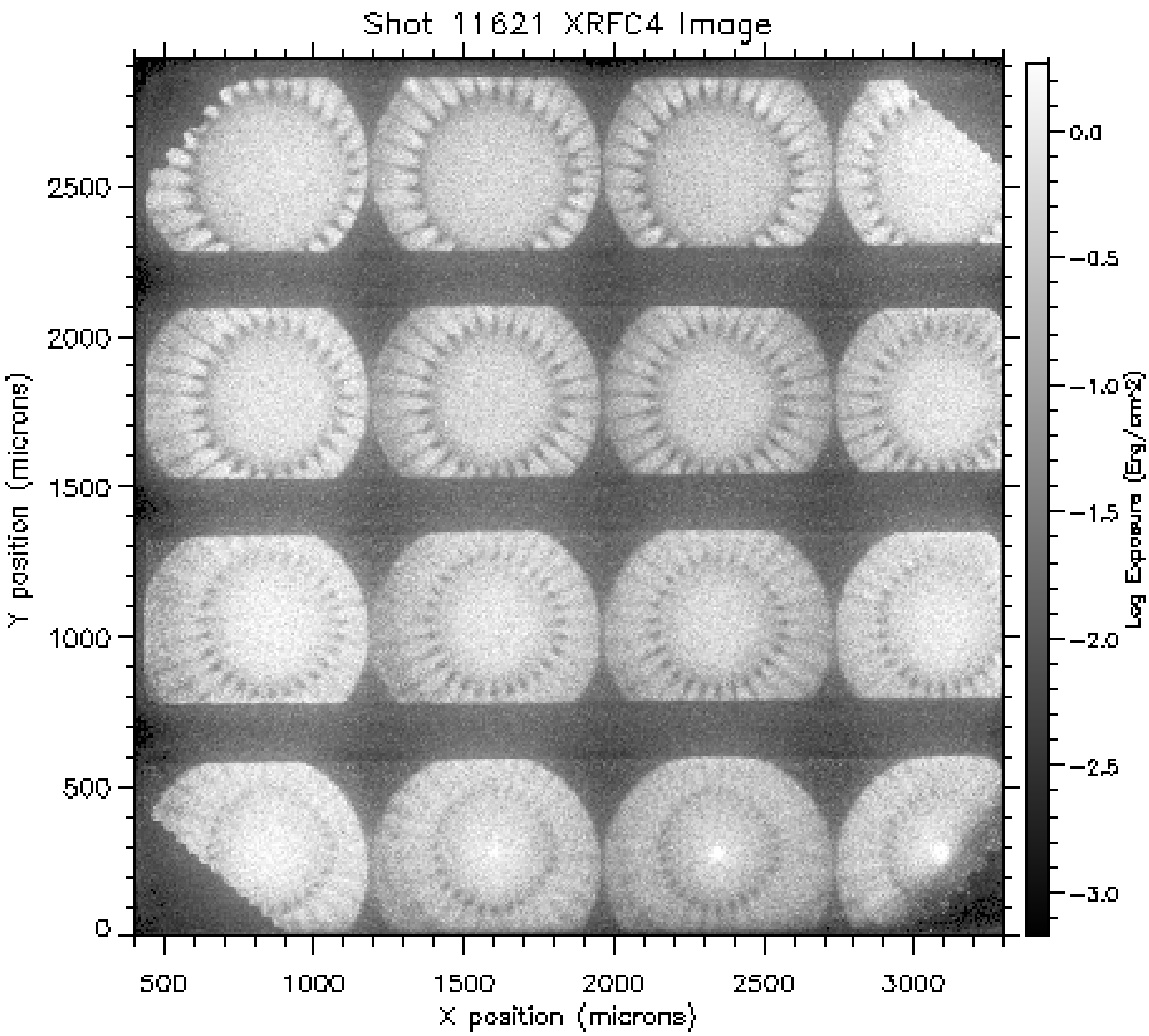

Fig. 1. Gated x-ray framing camera image of a direct drive cylindrical implosion. The image is magnified by 12X. Time runs from top left to bottom right. Initial m=28 1.5 μm machined perturbations are observed to grow from the ablative Rayleigh-Taylor instability.

***Abstract*—Gated x-ray images of laser-driven implosions can provide movies of typically 16 frames with ~80 psec time resolution and 10 μm spatial resolution. Cylindrical implosions allow study of convergent hydrodynamics but with excellent diagnostic access down the axis of the cylinder. This example from a recent cylindrical implosion campaign on the OMEGA laser provides quantitative data on the growth of ablative Rayleigh-Taylor instabilities in convergent geometry.**

Studies of convergent hydrodynamics in cylindrical geometry are being conducted at the OMEGA laser facility at the Laboratory for Laser Energetics at the University of

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Rochester. Polystyrene cylinders 2.25 mm long and 0.9 mm diameter with 60 mg/cc polystyrene foam are directly illuminated with 19 kJ from 50 laser beams in a 2.5-nsec linear ramp pulse shape. The imploding cylinder is then radiographed from the x-rays generated using 5 laser beams to illuminate a titanium foil normal to the cylinder along its axis. (The experimental configuration is described in detail in Reference [1], and initial physics results in Reference [2].) This image is an example of the high time and spatial resolution data available from such hydrodynamic experiments.

The x-ray framing camera[3] number 4 (XRFC4) is positioned for imaging down the axis of the cylinder. A 4 X 4 array of 10 μm diameter pinholes is used at the nose of the camera to create 16 separate images with 12X magnification. A leaded-acrylic washer on the end of the cylinder provides a 750 μm inner diameter aperture that separates the view of each pinhole while blocking x rays from outside the aperture from overlapping. The view is imaged onto a microchannel plate (MCP) which acts as an image intensifier. The MCP has four electronic microstrips across its face. A pulse is sent down a microstrip, gating on the image under each pinhole only when the pulse is present at that location on the MCP. The full width half maximum of the gating pulse for each image is ~80 psec, and the time between images (determined by the speed of the electrical pulse) is 58 psec. The images start at the top left corner of this photo and move to the right, going down through the strips, each one fired approximately as the previous ended. The time of the first image is centered at 2.28 nsec and the last image is at 3.15 nsec. The intensified images are then detected by film. After development, the film is digitized and analyzed, including corrections for nonlinear film response. This was the tenth shot of this experimental campaign, by which time the alignment and timing of the camera had been determined and corrected.

The 50 laser beams of the direct-drive illumination are pointed to concentrate their intensity along the central region of the cylinder, causing the implosion to pinch the cylinder down in an hourglass shape along its axis. In this central region, under the initial ablator thickness of 16 μm of plain polystyrene, is a 4 μm thick, 250 μm long layer of dichloropolystyrene. This chlorinated shell with its higher opacity to x rays serves as a marker layer for the region of uniform hydrodynamic drive. As the sequence of images shows, the average diameter of the cylinder decreases in time during the implosion. The target has sinusoidal perturbations machined along its entire length on the outside with mode number m=28 and initial 1.5 μm amplitude. These initial perturbations on the outside of the cylinder grow at the ablation front by the ablative Rayleigh-Taylor instability. This instability "feeds-in" to the marker layer[4] and make observable perturbations 15-20 μm amplitude. Late in time the growth stabilizes and the perturbations reduce in amplitude. The low intensity "plumes" emanating from the evolving spikes arise from perturbations fabricated beyond the ends of the marker. Each spike has the hourglass shape of the imploding target as if the view were down the fluted mouth of a trombone. The darkest spikes from the central region with doped marker are still clearly visible. Finally, at late times (starting at the second image of the fourth row) x-ray self-emission from the hot, stagnating shock converging at the axis is seen in the center of the image. Several of these features of the individual frames of the image are annotated on a single frame shown in Figure 2.

We thank the operations staff of the OMEGA facility, and Tom Ortiz and Pete Walsh of LANL for their excellent technical support of this experiment. The Los Alamos target fabrication team did an outstanding job fabricating and metrologizing these complicated targets. This work performed under the auspices of the U.S. Department of Energy under contract W-7405-ENG-36.

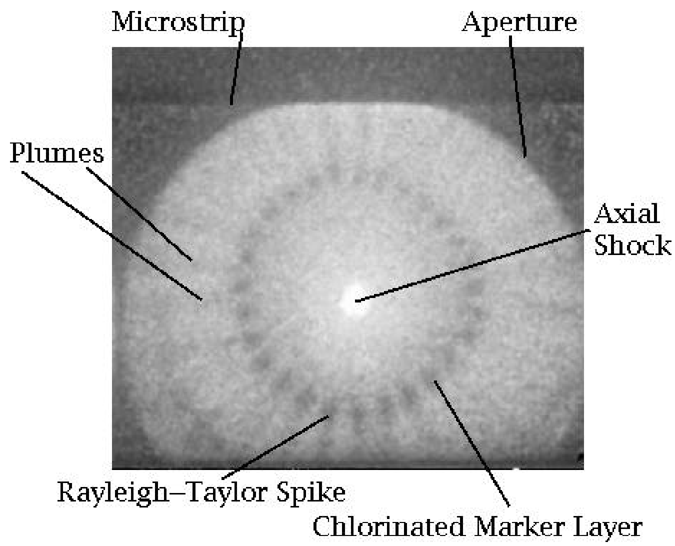

Figure 2: A single annotated frame from the image of Fig. 1.

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