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Los Alamos Pinhole Camera (LAPC): A New Flexible X-Ray
Pinhole Camera

Author(s):

J. A. Oertel, P-24
C. G. Peterson, P-23

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Los Alamos Pinhole Camera (LAPC): A new flexible x-ray pinhole camera.

J. A. Oertel and C. G. Peterson

Los Alamos National Laboratory, Los Alamos, New Mexico 87545

We have recently designed, built and fielded a versatile, multi-channel x-ray pinhole camera. The LAPC was designed to fit into any six inch manipulator (SIM) which is a standardized target chamber diagnostic tube. There are currently compatible SIMs available at the Trident, Omega, and NOVA laser systems. The camera uses 9 pinholes in a 3x3 array to produce images at the film plane. The film housing is designed to hold multiple sheets of stacked x-ray film which also uses a dark-slide to protect the film before exposure. Magnifications of 12, 8, 4 and 2X are selected by slip-on nosecones, which support pinholes, collimators, and blast shields. Individual channel filtering is provided by a 3x3 filterpack containing 9 separate filter sub-packs. Spatial resolution is limited by the pinhole diffraction limit and field of view is dependent on magnification and filterpack diameter.

I. INTRODUCTION

Imaging x-rays with pinholes has long been the diagnostic method of choice in the Inertial Confinement Fusion program (ICF).^{1,2} X-ray pinhole cameras are imaging devices capable of providing two-dimensional views of laser heated targets. Utilizing foil filtration to select x-ray energies per individual channels provides valuable information on target symmetry, laser pointing and other implosion dynamics. Typical shot cycles for ICF laser facilities can be less than one hour. It is important that the diagnostics be "operationally friendly" so that the shot rate is not limited by diagnostics and that instruments are easy to configure for last minute changes. We introduce a new time integrated pinhole camera that is an "operationally friendly", nine channel x-ray imager, designed to insert into any six inch manipulator (SIM). SIM's are re-entrant diagnostic tubes, compatible with Los Alamos National Laboratory's Trident³, University of Rochester's Omega⁴, and Lawrence Livermore National Laboratory's NOVA⁵ laser systems. The Los Alamos Pinhole Camera (LAPC) is designed around and interchangeable with, the standard front-end of a Gated X-ray Imager (GXI).^{6,7} Figure 1 shows a picture of LAPC with several magnification and filter attachments.

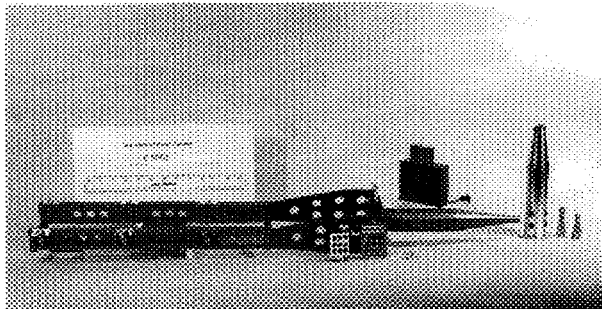


FIG. 1 The Los Alamos Pinhole Camera with magnification and filter attachments.

II. INSTRUMENT DESCRIPTION

The LAPC images x-rays with laser drilled or wire plunge EDM constructed, 5 to 10 μm diameter, pinholes. The pinholes are arranged in a (3x3) nine channel pinhole array and constructed of Tantalum to attenuate out unwanted hard x-rays in the area outside the pinholes. Pinhole arrays typically have thickness to pinhole diameter aspect ratios of 5:1. To further reject hard x-rays and improve signal to noise ratios a 750 μm thick Tantalum collimator with matched 250 μm holes, is located behind the pinhole array. The pinhole array is protected from target debris by a blast shield made of 0.02" Beryllium and is replaced on each shot. The film plane to object distance is fixed at 15" and magnification is varied by moving the position of the pinhole array relative to the object plane. Magnification snouts of 12X and 8X are selected by sliding the snouts over the end of a fixed 4X nosecone and 2X magnification is selected by a separate nosecone. A slip-in filterpack with a 3x3 filter array is located near the image plane where the images are separated by 11.6 mm. Figure 2 shows a disassembled filterpack with one of the nine sub-packs placed off to the side. A sub-pack breaks into two halves to sandwich a sheet of filter material. Once a sub-pack is assembled it should never have to be replaced, allowing an experimenter to calibrate a specific filter. The filterpack was designed to give experimenter's flexibility in filtering each of the nine channels differently allowing views of nine different x-ray energies of the same image simultaneously. Experimenters have the versatility of quickly changing filterpacks and magnification snouts between shots with no effect on laser shot rate. The filmpack shown in figure 3 is made up of a filmpack body, dark-slide, loading door, and retaining pins. Five separate sheets of round x-ray film can be loaded into the filmpack allowing for a bracketed exposure for each of the nine channels. This feature is useful if the predicted x-ray flux is uncertain. X-ray film is loaded in a darkroom

with the dark-slide closed and film door secured on top of the film stacks. The LAPC is usually prepared for a shot on a bench where the filmpack, magnification snout, pinhole array, and filterpack are loaded. The instrument is then loaded into a SIM and the dark-slide is removed. The camera travels into the target chamber inside the SIM and is aligned with an opposing port telescope.

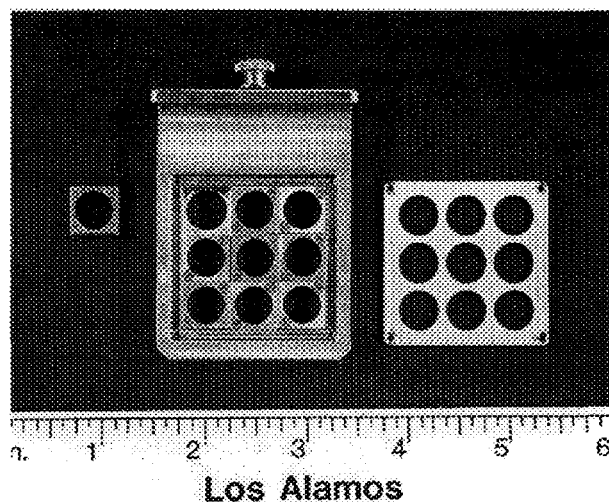


FIG. 2 Filterpack for the Los Alamos Pinhole Camera.

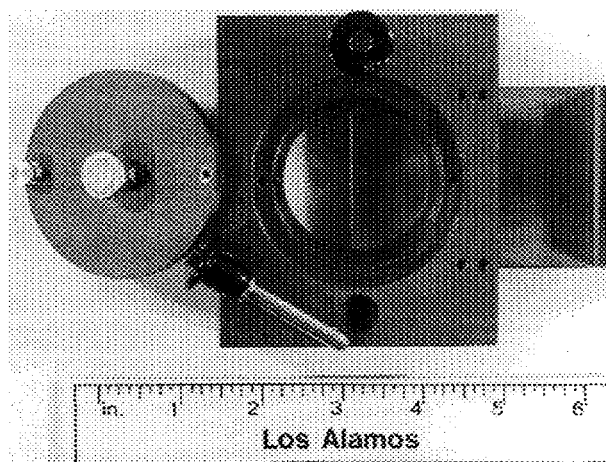


FIG. 3 Filmpack for the Los Alamos Pinhole Camera.

III. SPATIAL RESOLUTION AND FIELD OF VIEW

Before this camera could be sent to a remote facility, we qualified the spatial resolution with test shots at the Trident laser facility. A wire screen with wire diameters of $7\text{ }\mu\text{m}$ and spacings of $25\text{ }\mu\text{m}$ was

backlit by x-ray radiation from a Gold disk. The Gold disk was illuminated with a single beam of 2ω Nd: Glass laser light with 1 ns duration, 50 J, and $150\text{ }\mu\text{m}$ spot size. Figure 4 shows an example exposure of a backlit grid at 12X magnification with CX film. The camera easily resolves the $7\text{ }\mu\text{m}$ wire and diffraction theory predicts resolutions $<5\text{ }\mu\text{m}$ are possible with $5\text{ }\mu\text{m}$ pinholes.⁸ The circular field of view is limited by the 9.54 mm hole diameter in the filter sub-pack. Field of views at the object plane for 12X is $795\text{ }\mu\text{m}$, for 8X is $1193\text{ }\mu\text{m}$, for 4X is $2385\text{ }\mu\text{m}$, and for 2X is $4770\text{ }\mu\text{m}$.

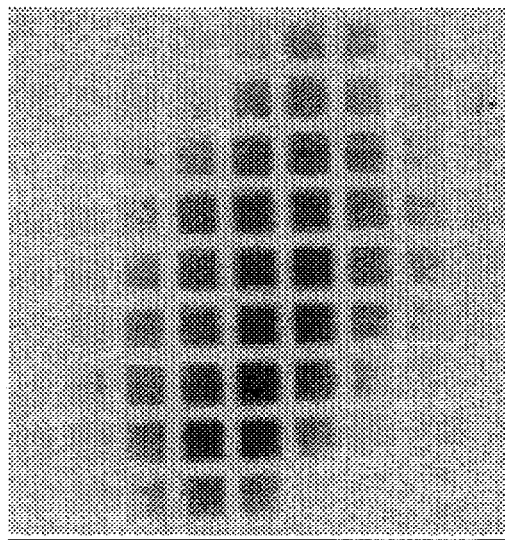


FIG. 4 Backlit grid taken at LANL's Trident laser system. Wire diameters of $7\text{ }\mu\text{m}$ and spacings are $25\text{ }\mu\text{m}$ apart. LAPC was using a 12X magnification with CX film.

IV. CONCLUSIONS

The LAPC has been tested on the Trident laser system and implemented on the NOVA laser system. The x-ray pinhole camera is considered operationally friendly in that it is easy to set up and flexible in configuration. Spatial resolution is limited by diffraction effects with parameters of pinhole diameter, wavelength, distance to object, and magnification. This diagnostic is now in daily usage at the NOVA laser facility and is compatible with Trident and Omega laser facilities.

V. ACKNOWLEDGMENTS

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- ² A.A.Hauer, "Design of X-ray Instrumentation for the Zeta Six Beam laser System," University of Rochester, Laboratory for Laser Energetics Annual Report, 1977.
- ³ Information on the Trident laser system can be found at <http://harry.lanl.gov/PlasmaPhysics/trident.html>.
- ⁴ Information on the Omega laser system can be found at <http://www.lle.rochester.edu/>.
- ⁵ Information on the NOVA laser system can be found at <http://www-lasers.llnl.gov/lasers/target.html>.
- ⁶ J.A. Oertel, T. Archuleta, S. Evans, J. Jimerson, T. Sedillo, R.G. Watt, "Gated X-ray Images of NOVA Hohlraums," Defense Research Review Journal, Vol 6 Number 1&2 Jan-July 1994 UCRL#53880-6-1&2.
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