MASTER

PREPRINT UCRL- 79780

CONF-771136--18

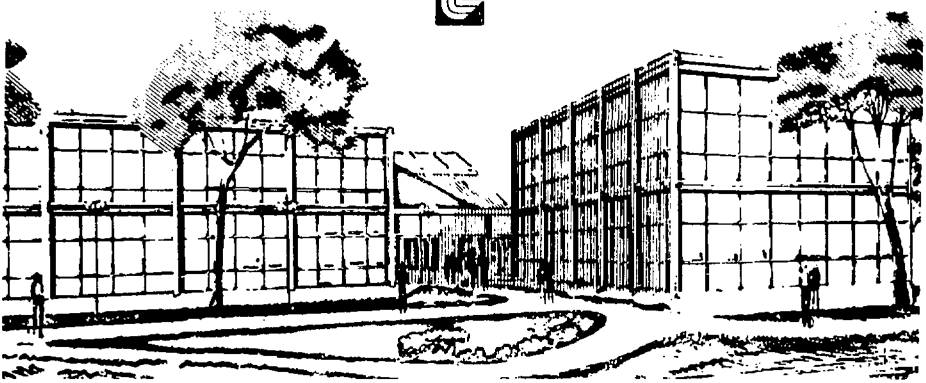
Lawrence Livermore Laboratory

PINHOLE IMAGING OF LASER-PRODUCED THERMONUCLEAR ALPHA PARTICLES

Kenneth M. Brooks, Natale M. Ceglio, Vincent W. Slivinsky, Harlow G. Ahlstrom,
Erik K. Storm, Harry N. Kornblum and George R. Leipelt

November 1, 1977

This paper was prepared for submission to the APS Plasma Physics Meeting of
the American Physical Society, Atlanta, Georgia, November 5-11, 1977



Abstract Submitted

for the APS Plasma Physics Meeting of the

American Physical Society

November 5-11, 1977

Physics and Astronomy Classification Scheme Number 52

Bulletin Subject Heading in which Paper should be placed

Laser Fusion

Pinhole Imaging of Laser-Produced Thermonuclear Alpha Particles. Kenneth M. Brooks, Natale M. Ceglio, Vincent W. Slivinsky, Harlow G. Ahlstrom, Erik K. Storm, Harry N. Kornblum and George R. Leipelt, Lawrence Livermore Laboratory.**--Results of pinhole images of thermonuclear alpha particles generated by exploding pusher targets in the Argus laser facility are reviewed. Recorded images indicate that the reactions occur within a 25 to 30 micron region with twelve micron resolution for ten micron pinholes and thirty micron resolution for twenty-five micron pinholes. These results are in good agreement with LASNEX computer predictions and are confirmed by Zone Plate imaging of the burn conducted by Natale M. Ceglio at LLL. Planned three-dimensional imaging of the burning D-T gas in the Shiva laser facility using seven micron pinholes is discussed. Higher yields ($\sim 5\times10^{10}$ reactions) and three orthogonal images of the burn will provide a data base for analysis using an Algebraic Reconstruction Technique to provide a higher resolution (9 micron), three-dimensional view of the burn.
**Supported by U. S. ERDA Contract W-7405-ENG-48

Submitted by

Kenneth M. Brooks
University of California
Lawrence Livermore Laboratory
P. O. Box 808, L-549
Livermore, CA 94550

REA

PINHOLE IMAGING OF LASER-PRODUCED THERMONUCLEAR ALPHA PARTICLES

Kenneth M. Brooks, Natale M. Ceglio, Vincent W. Slivinsky
Harlow G. Ahlstrom, Erik K. Storm, Harry N. Kornblum and George R. Leipelt

Alpha Particle Imaging Results

Slide #1

Schematic of the Argus laser system -

a) Describe experimental parameters.

b) Describe results - exploding pusher giving 6 x 10^8 reactions.

Slide #2

Primary exploding pusher emissions -

a) Brief run-through of emissions.

b) Experiments to image burning D-T gas using 3.52 MeV α particles first completed in November 1977. Preliminary report of those results were given at last year's APS meeting.

Slide #3

Photo of one pinhole camera apparatus -

a) Describe significant parts - pinhole array of 10 and 25 μm pinholes.

b) 2/10 mil Tantalum filter.

c) 6 μm thick CN.

Slide #4

Filter - detector response to Argus exploding pusher emissions -

a) point out ion, electron, x-ray, α, neutron and photon distributions - and describe how each is absorbed and/or passed in/through the detector-filter system.

Slide #5

Imaging geometry -

a) allows determination of R_0, the object radius, from R_1, the observed image radius even though a large pinhole is used.

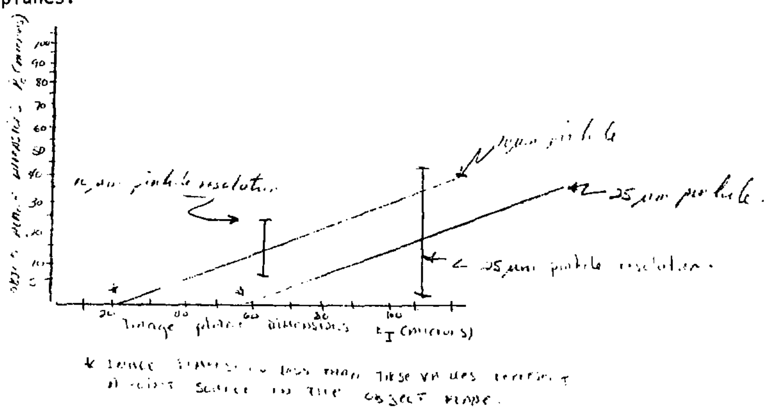
b) resolution of the system is defined as s/m where s is the possible spread of α particle tracks in the image plane that originated from a point source in the object plane.

c) resolution for 10 micron pinholes with a magnification of four is 125 microns and for 25 micron pinholes in the same camera is 31 microns.

Slide #6

Lines representing the spatial transformation from image to object planes for 10 and 25 micorn pinholes in a camera with m = 4.

a) Emphasize that although the transformation is linear, it is displaced and there is no one-to-one spatial mapping from image to object planes.



Slide #7

Photo of an Imaged Hyperion target -

a) point out the low background.

b) tracks have very definite characteristics and are easily distinguished from background noise such as film scratches.

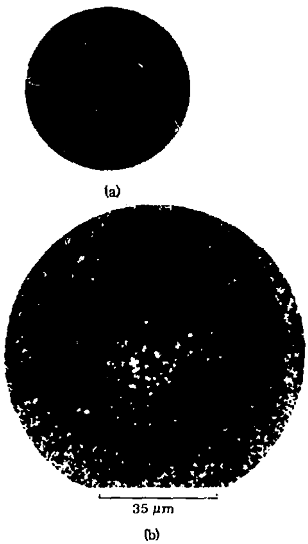
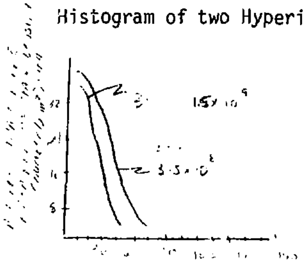


FIG. 3. α-particle tracks (a) without pinhole and (b) with pinhole. The diameter of the α-particle image is referenced to the object plane.

Slide #8

Histogram of two Hyperion targets -

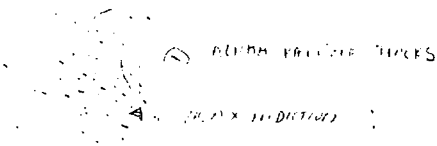


a) note the measured smaller diameter for the higher yield shot (25 μm) at 1.5×10^9 neutrons compared with the 30 micron diameter core for the shot with a lower yield of 3×10^8 neutrons.

Slide #9

Superposition of the recorded alpha image for the high yield shot (361209 07) and the Lasnex calculation for the burn at approximately the same angle.

a) The Lasnex calculation has been spatially transformed into image plane space.



b) Resolution at this yield and pinhole size does not allow us to see detail in the object.

Slide #10

Picture of Shiva -

a) next step will be to reduce the pinhole size to 7 microns in Shiva which is expected to produce > 10^{10} reactions.

Slide #11

What comes out of Shiva

a) x-ray spectra is from Lasnex 2-D calculations.

b) we will absorb 1/10 Joule of energy in the filter which will raise its temperature to 86° K which will not decrease its sensitivity significantly.

c) All other emissions, though greater in magnitude, will be absorbed/ passed in the same manner as those encountered on Argus.

d) Using three of these cameras placed on orthogonal axes, we hope to produce a three-dimensional image of the burn with a nominal resolution of 9 microns. This will be accomplished using an Algebraic Reconstruction Technique such as described by Huebel and Tuntz in UCRL 77450.

ARGUS SYSTEM GEOMETRY FOR LASER FUSION EXPERIMENTS

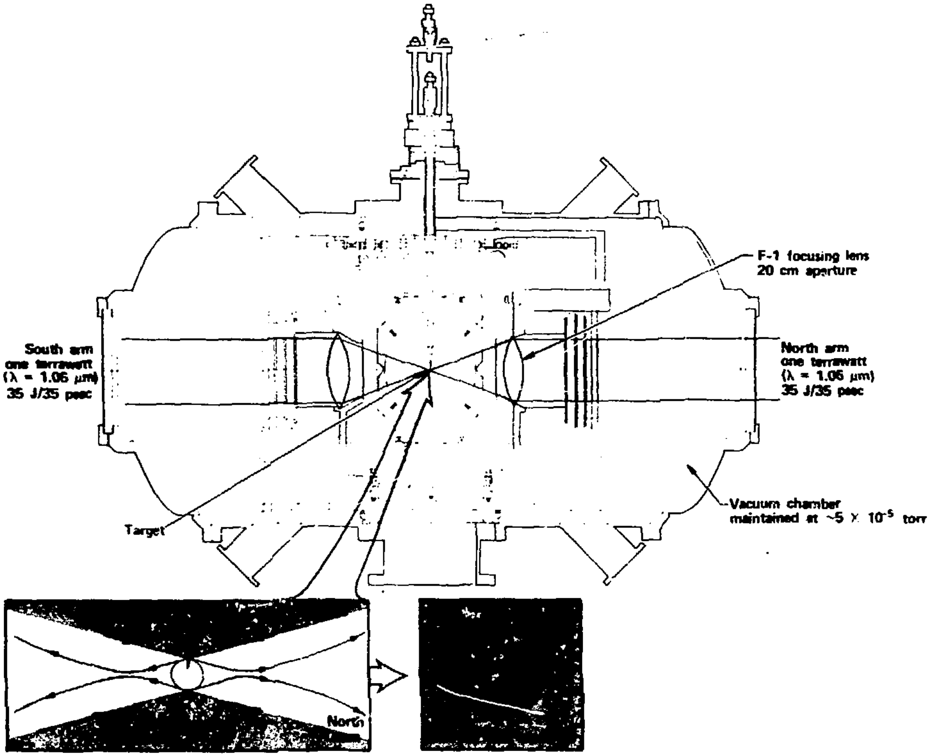


Figure 1

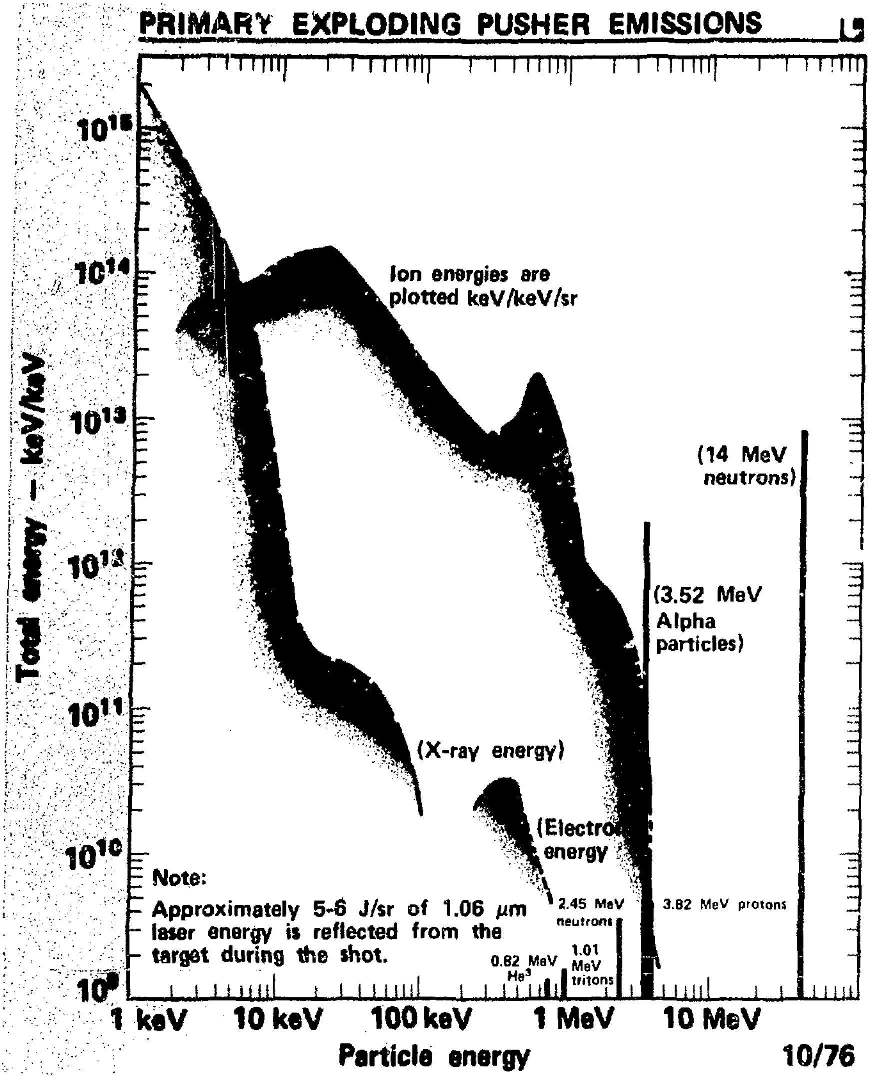
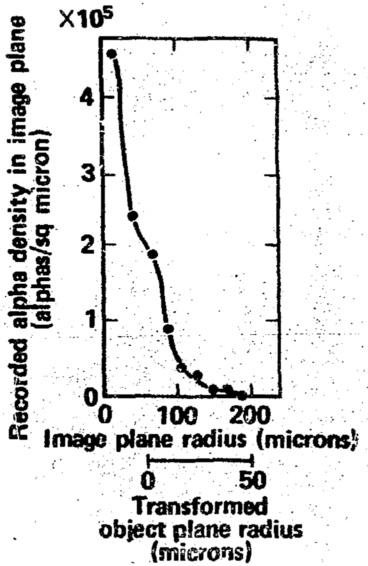
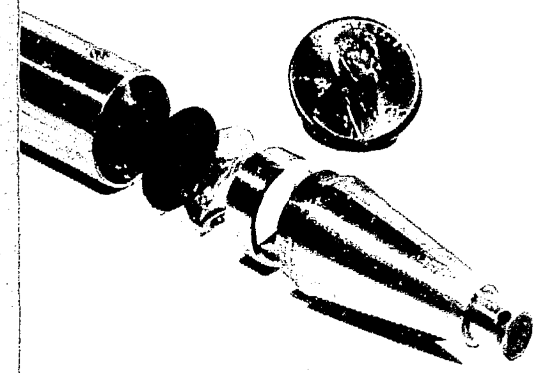

PRIMARY EXPLODING PUSHER EMISSIONS
Ion energies are plotted keV/keV/sr
(14 MeV neutrons)
(3.52 MeV Alpha particles)
(X-ray energy)
(Electron energy)
Note:
Approximately 5-6 J/sr of 1.06 μm laser energy is reflected from the target during the shot.
2.45 MeV neutrons
3.82 MeV protons
1.01 MeV tritons
0.82 MeV He3
Total energy — keV/keV
10^15
10^14
10^13
10^12
10^11
10^10
10^9
1 keV
10 keV
100 keV
1 MeV
10 MeV
Particle energy
10/76

Figure 2

ALPHA PIN HOLE IMAGE OF HYPERION TARGET





5/77

Figure 3

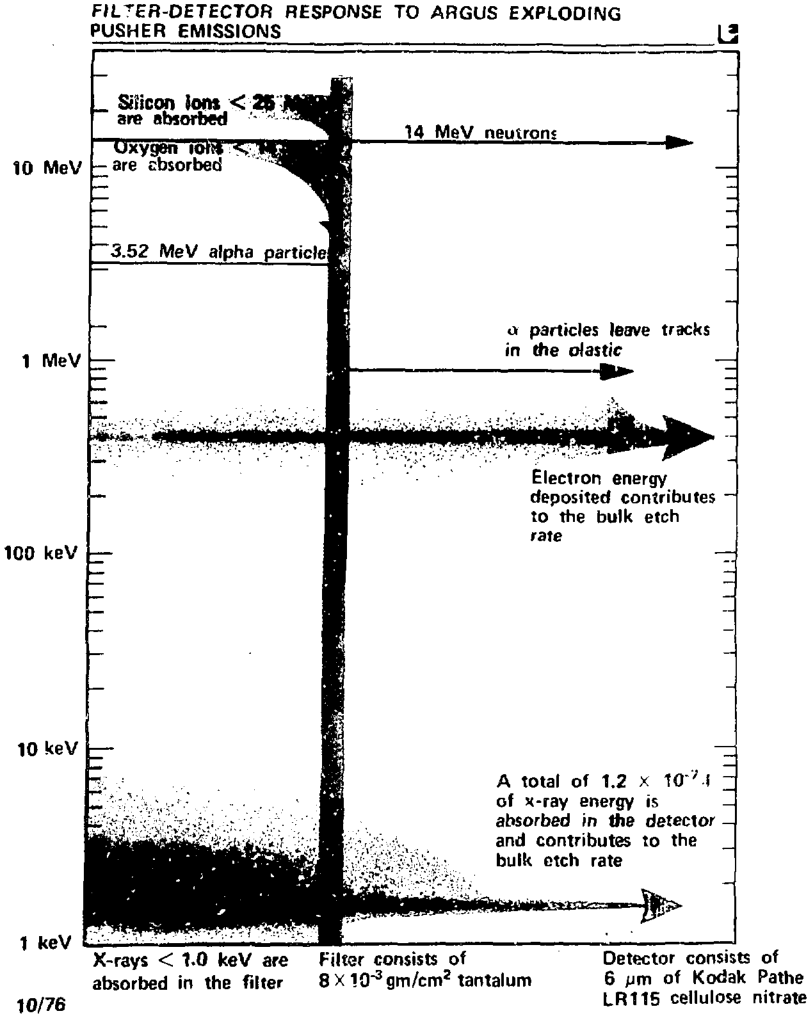
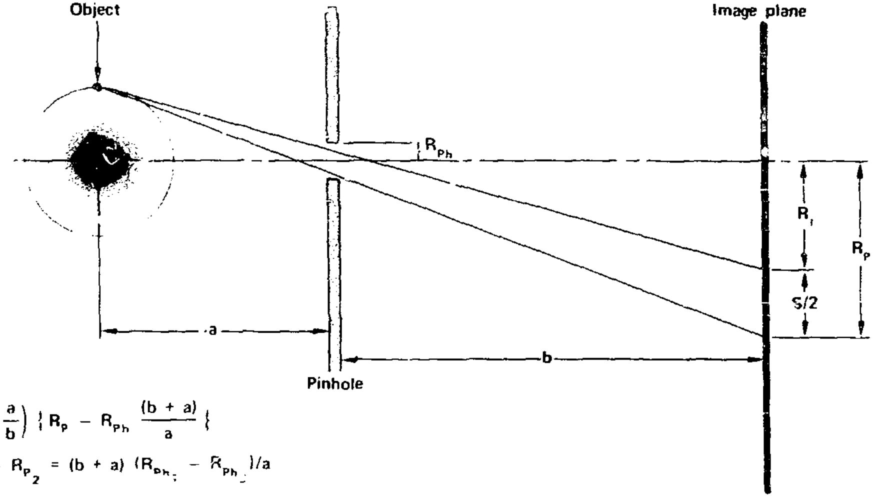

FILTER-DETECTOR RESPONSE TO ARGUS EXPLODING PUSHER EMISSIONS
Silicon ions < 25
are absorbed
14 MeV neutrons
Oxygen ions <
are absorbed
10 MeV
3.52 MeV alpha particle
α particles leave tracks in the plastic
1 MeV
Electron energy deposited contributes to the bulk etch rate
100 keV
10 keV
A total of 1.2 × 10
of x-ray energy is absorbed in the detector and contributes to the bulk etch rate
1 keV
X-rays < 1.0 keV are absorbed in the filter
Filter consists of 8 × 10^-3 gm/cm^2 tantalum
Detector consists of 6 μm of Kodak Pathe LR115 cellulose nitrate
10/76

Figure 4

ALPHA IMAGING GEOMETRY



$$(1)\quad R_0 = \left(\frac{a}{b}\right) \left\{ R_p - R_{Ph} \frac{(b + a)}{a} \right\}$$

$$(2)\quad R_{p_1} - R_{p_2} = (b + a)\,(R_{Ph_1} - R_{Ph_2})/a$$

$$(3)\quad (R_{Ph1} / R_{Ph2})^2 = (\text{alpha density}_1 / \text{alpha density}_2)$$

Geometry for determining the spread (s) of alpha particles in the image plane originating at a point source in the object plane where:

a = object distance
b = image distance
R_{Ph} = pinhole radius
R_i = true image radius for an infinitely small pinhole

S = the spread of a point source in the object plane projected onto the image plane
R_p = the radius of the expected image
R_0 = the true object radius

10 76

Figure 5