LA-UR- 04-2994

*Approved for public release; distribution is unlimited.*

*Title:* Calculations for NIF first quad gas-filled hohlraum experiments testing beryllium microstructure growth and laser plasma interaction physics

*Author(s):* S. Robert Goldman, X-1
Juan C. Fernandez, P-24
Nelson M. Hoffman, X-1
Joseph M. Kindel, X-1
A. Bruce Langdon, Lawrence Livermore National Lab

*Submitted to:* 34th Annual Anomalous Absorption Conference
Gleneden Beach, Oregon
May 2-7, 2004



Los Alamos
NATIONAL LABORATORY

*34th[d] Annual Anomalous Absorption Conference*
*Gleneden Beach, Oregon*
*May 2-7, 2004*

# Calculations for NIF first quad gas-filled hohlraum experiments testing beryllium microstructure growth and laser plasma interaction physics*

S. R. Goldman, J. C. Fernandez, N. M. Hoffman, and J. M. Kindel

*Los Alamos National Laboratory*

A.B. Langdon

*Lawrence Livermore National Laboratory*

The first quad of the NIF provides four nearly collinear f/20 laser beams, which can be treated as a single f/8 beam of maximum energy 16 kJ. We are designing experiments on halfraums in which the composite beam is focused in the plane of the (single) halfraum laser entry hole (LEH) with its symmetry axis collinear with the halfraum symmetry axis. For most of the calculations, the halfraum diameter is 1.6mm, the LEH is 1.2mm, and axial length is 3.0mm. The incident laser power consists of an early foot followed by a final peak. Peak radiation temperatures for this relatively narrow hohlraum are greater than for wider hohlraums of the same length. Plasma conditions within the halfraum are calculated with Lasnex using azimuthally symmetric, (r,z) geometry, taking into account a polyimide membrane which contains the fill gas ($CH_2$) within the halfraum. Estimates for microstructure growth due to the volume crystalline structure within a beryllium slab mounted in the halfraum sidewall are obtained by a post-processor, which applies plasma conditions within the halfraum to an ablatively accelerated, two-dimensional beryllium slab. We present a detailed simulation of the hohlraum conditions resulting from a laser spot of diameter 500μm, with peak intensity at $3.5\times10^{15}$ W/cm$^2$, a comparison with a simulation with the same power-time profile at an intensity about ¼ as great, and a comparison with a simulation with more detailed attention to hydro coupling between the gold and gas-fill regions of the hohlraum. We are currently attempting to model the consequences of possible beam filamentation during the pulse.

*Work supported by USDOE

# CALCULATIONS FOR NIF FIRST QUAD GAS-FILLED HOHLRAUM EXPERIMENTS TESTING BERYLLIUM MICRO-STRUCTURE GROWTH AND LPI PHYSICS

S. R. Goldman, J. C. Fernandez, N. M. Hoffman and J. M. Kindel
Los Alamos National Laboratory
and
A. B. Langdon
Lawrence Livermore National Laboratory

Anomalous Absorption Conference, May 2004

NNSA

Los Alamos

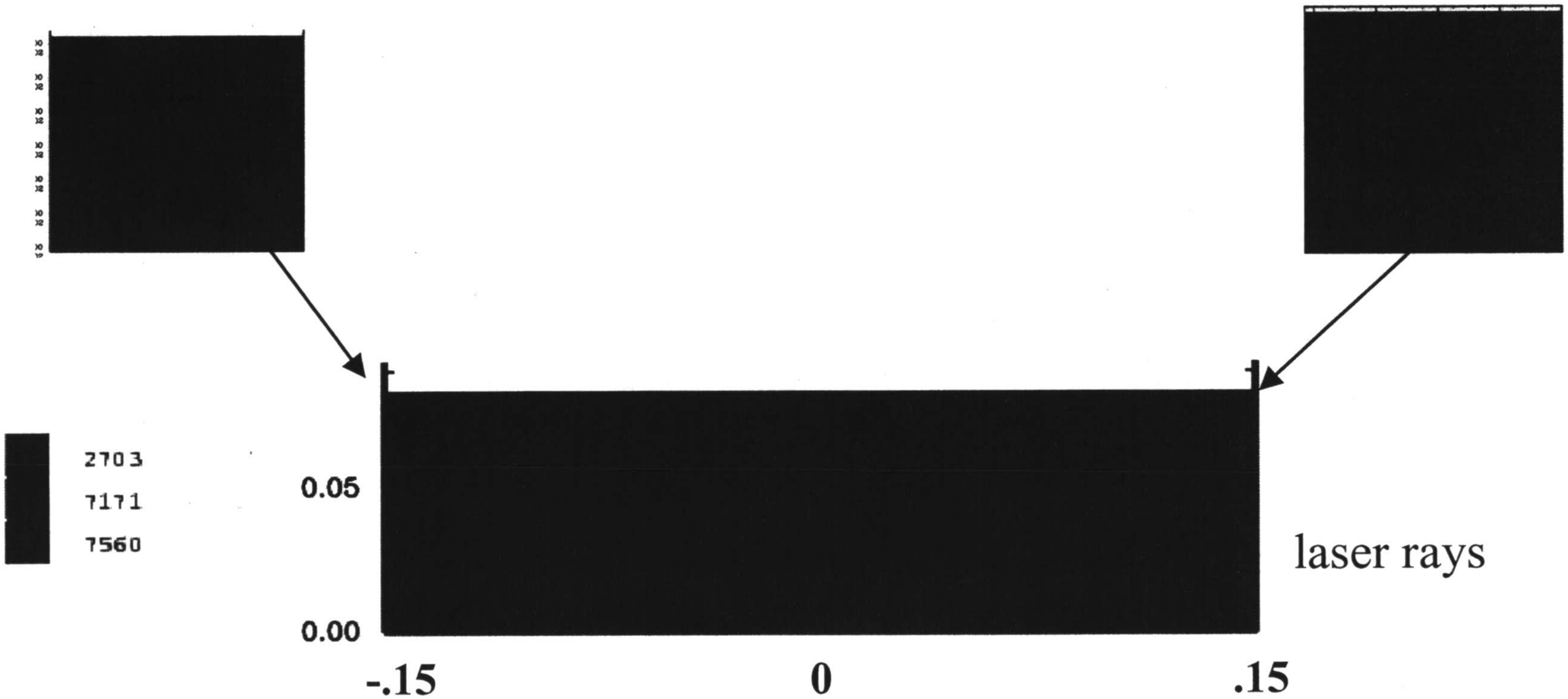
# Outline

plasma results for a gas-filled NIF first quad halfraum of size (in mm) [1.2 (LEH diameter), 1.6 (hohlraum diameter), 3.0 (axial length)], with laser spot 0.5 mm (diameter) and polyimide membrane over LEH of thickness 0.5μm

comparison with results for the same hohlraum geometry, but with laser spot size about twice as great (laser spatial profile is different) and membrane thickness 1.0μm

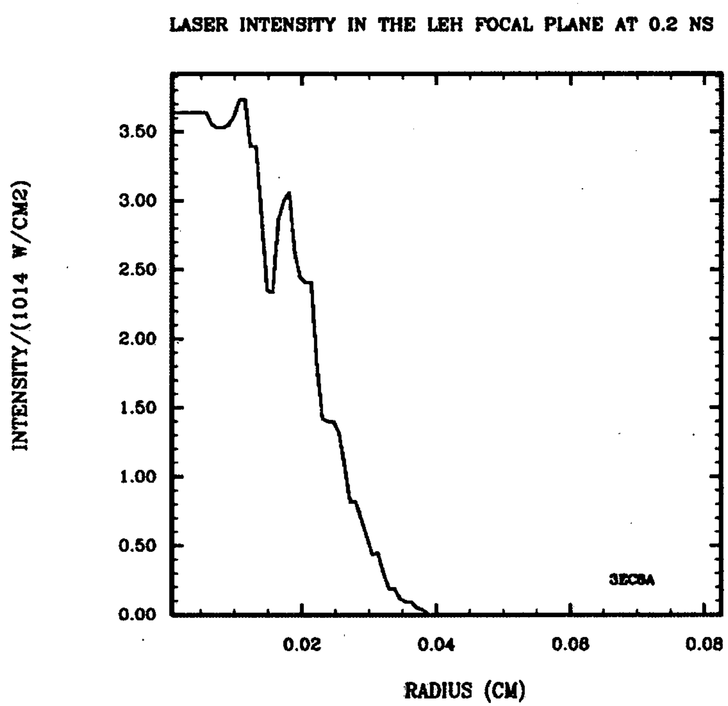
comparison of the first result with a calculation using a more detailed hydrodynamics treatment

The halfraum geometry has a laser entry hole (LEH) of diameter 1.2mm, hohlraum inner radius of 1.6mm and axial length of 3.0mm



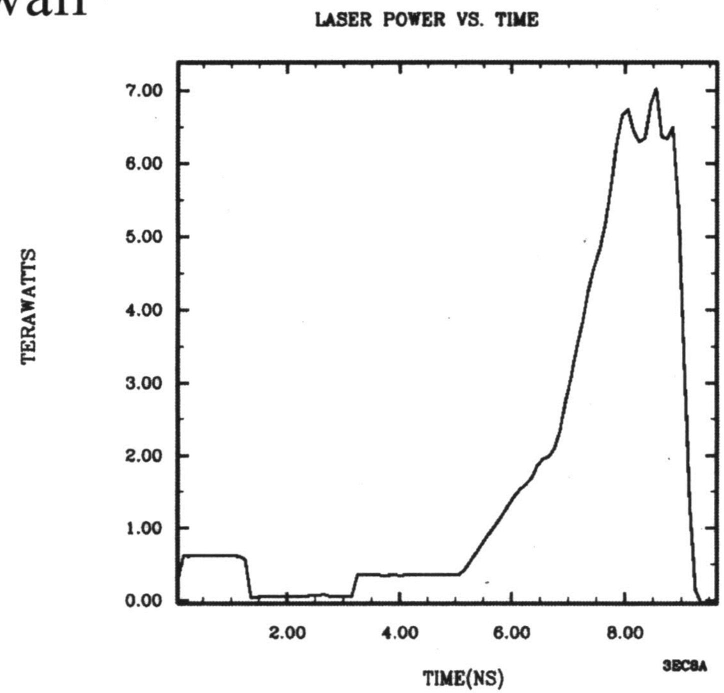

Gas fill is $CH_2$ at density $1.3 \times 10^{-3}$ g/cm$^3$, so that $n_e(max)/ncrit = 0.05$, with a gas retaining polyimide cover (blue) over the LEH

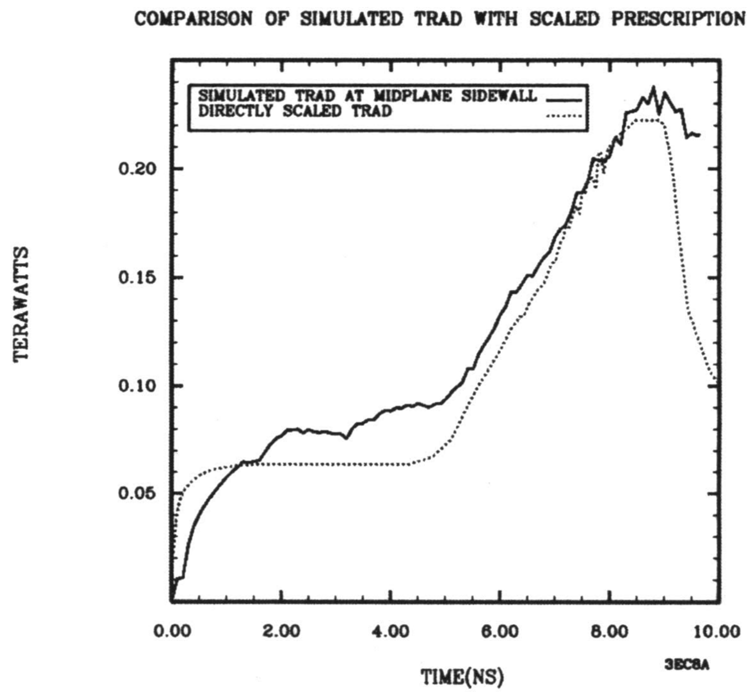
The first quad of the NIF provides four nearly collinear f/20 beams which can be treated as a single f/8 beam of maximum energy 16kJ
The composite beam can be focused in the plane of the halfraum laser entry hole (LEH) with its symmetry axis collinear with the halfraum symmetry axis
The beams are directed so as to form a focal spot of diameter 500mm in the focal plane




**at a power of 7 Terawatts, the peak laser intensity would be $3x10^{15}W/cm^2$**

# The foot of the laser pulse was designed to provide a sustained precursor of 1 Mbar pressure drive in the midplane of the hohlraum sidewall



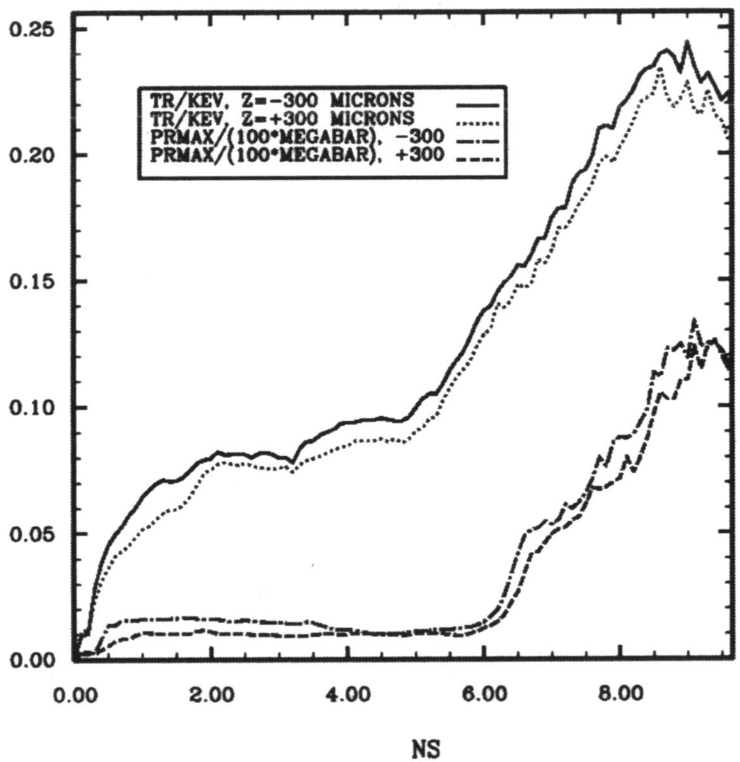



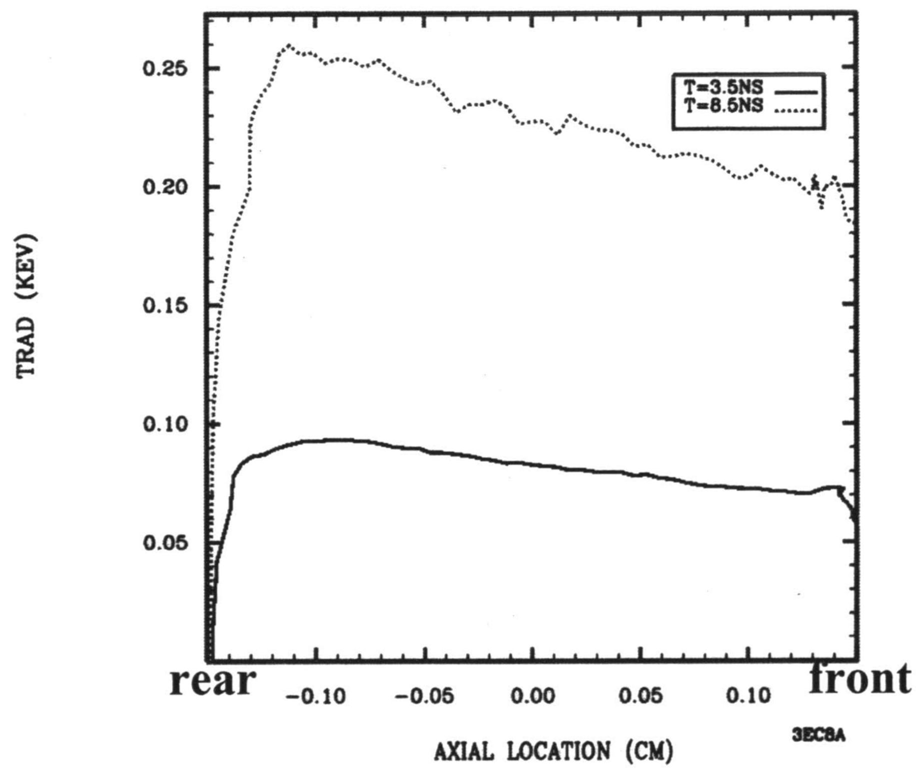

- the latter part of the drive from 5.1 to 9.7ns came from a hohlraum radiation temperature history for a 16 kJ pulse interpolated between the 5 kJ BAMS pulse on Omega and a calculated full NIF ignition capsule drive
- the power source necessary to maintain this profile in a 1D cylindrical hohlraum with our spatial dimensions was obtained through a Lasnex simulation
- the simulated radiation temperature after 5.1ns is generally close to the prescription

NNSA

Los Alamos

Around the hohlraum midplane, over a typical diagnostic distance of 600μm the variation in radiation temperature along the sidewall is about 7% and the time integrated peak pressure in the sidewall varies by about 20%



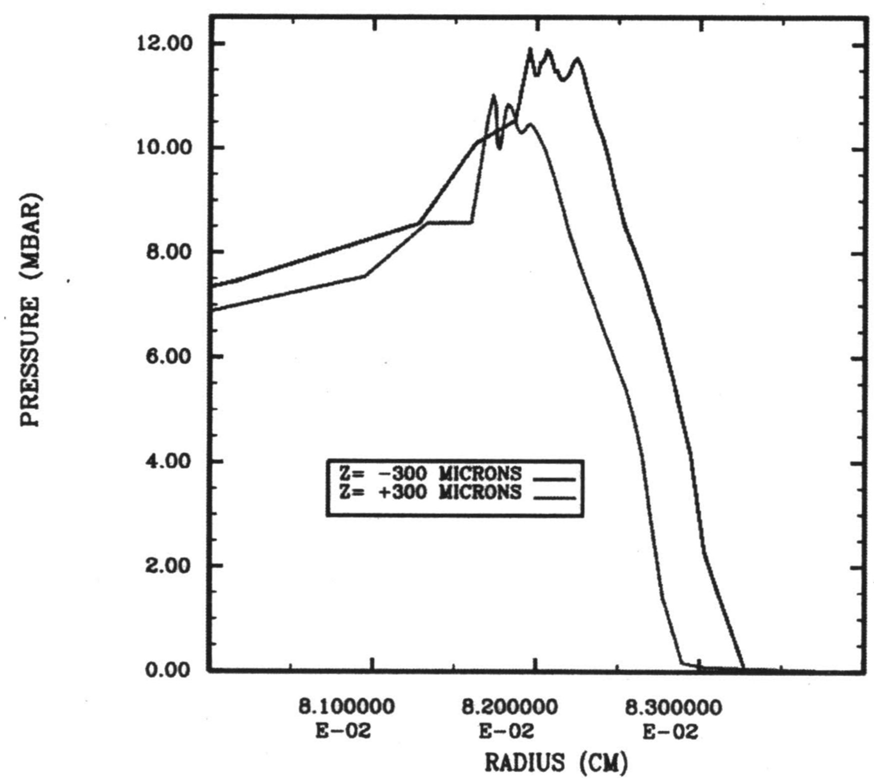

•asymmetry between the front and rear of the hohlraum is similar over time

NNSA

Los Alamos

At a time of 9.0ns, close to the end of the laser pulse, the peak shock pressure is about 9% higher 600μm closer to the rear wall, and the shock is about 10% more advanced

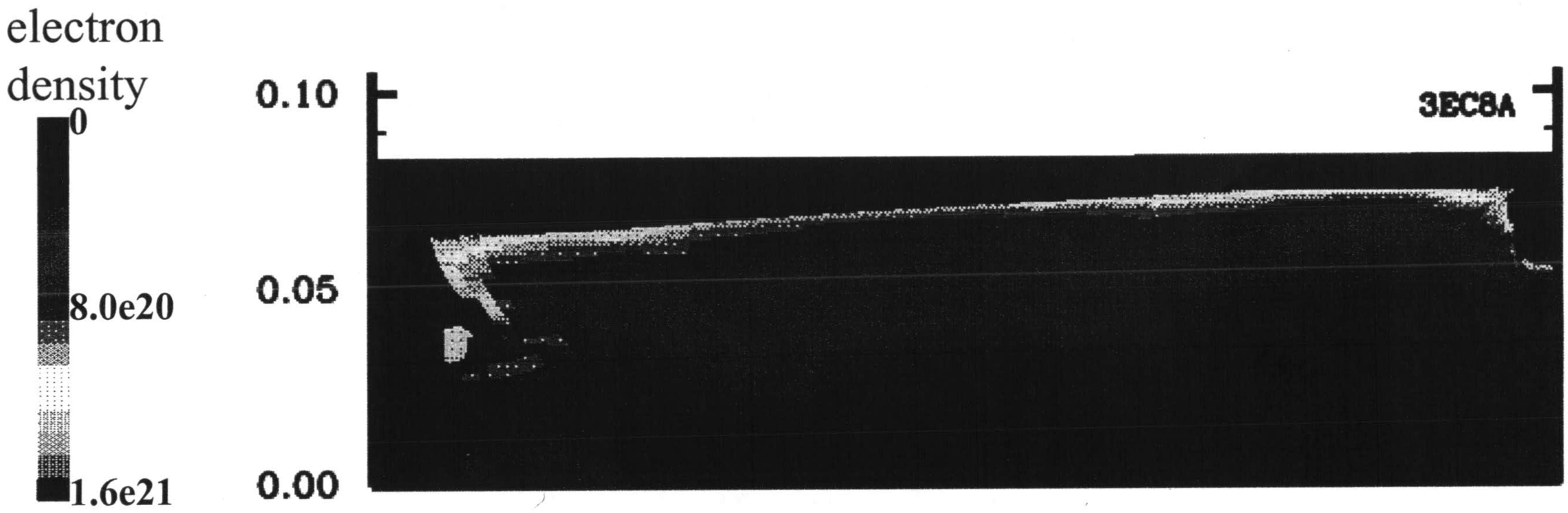
**Sidewall pressure profiles, t=9.0ns**

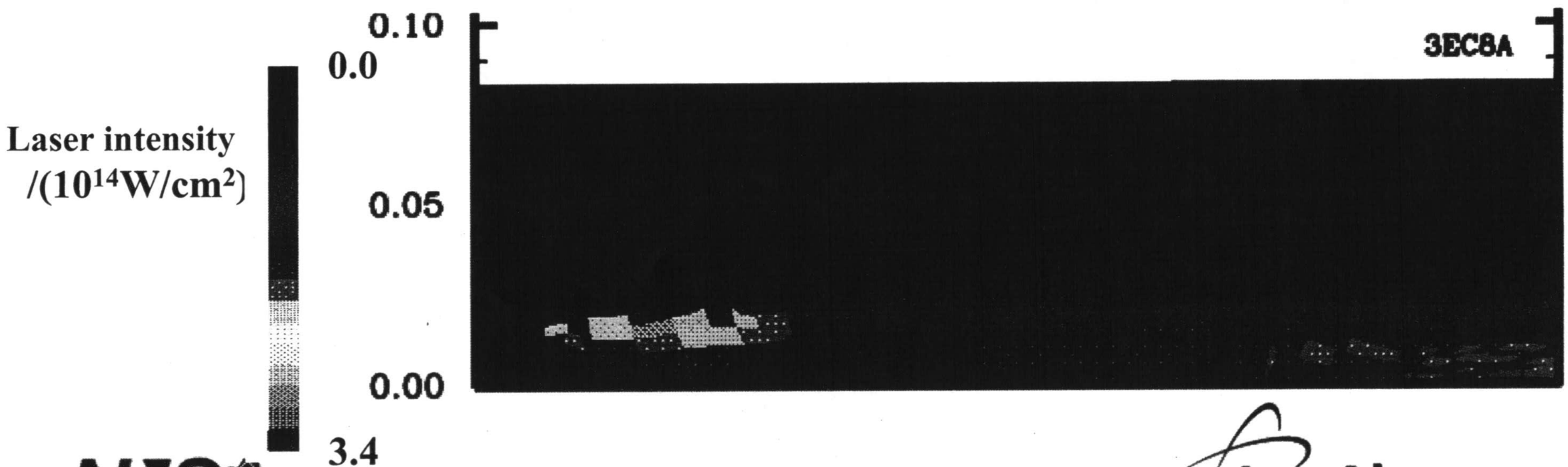



NNSA

Los Alamos

# Some variables at 3.5 ns (center of 1 Mbar drive period)

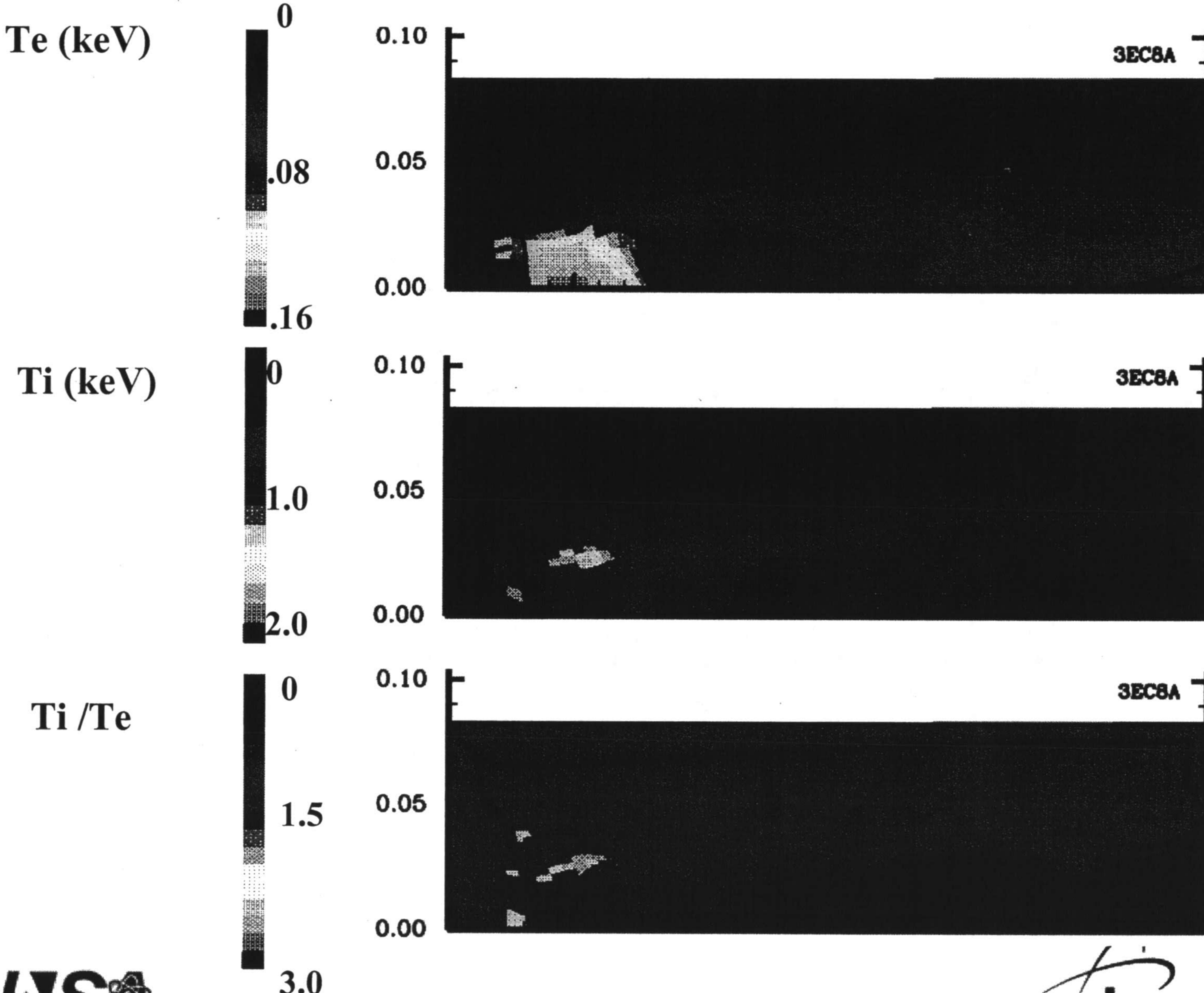



NNSA

Los Alamos

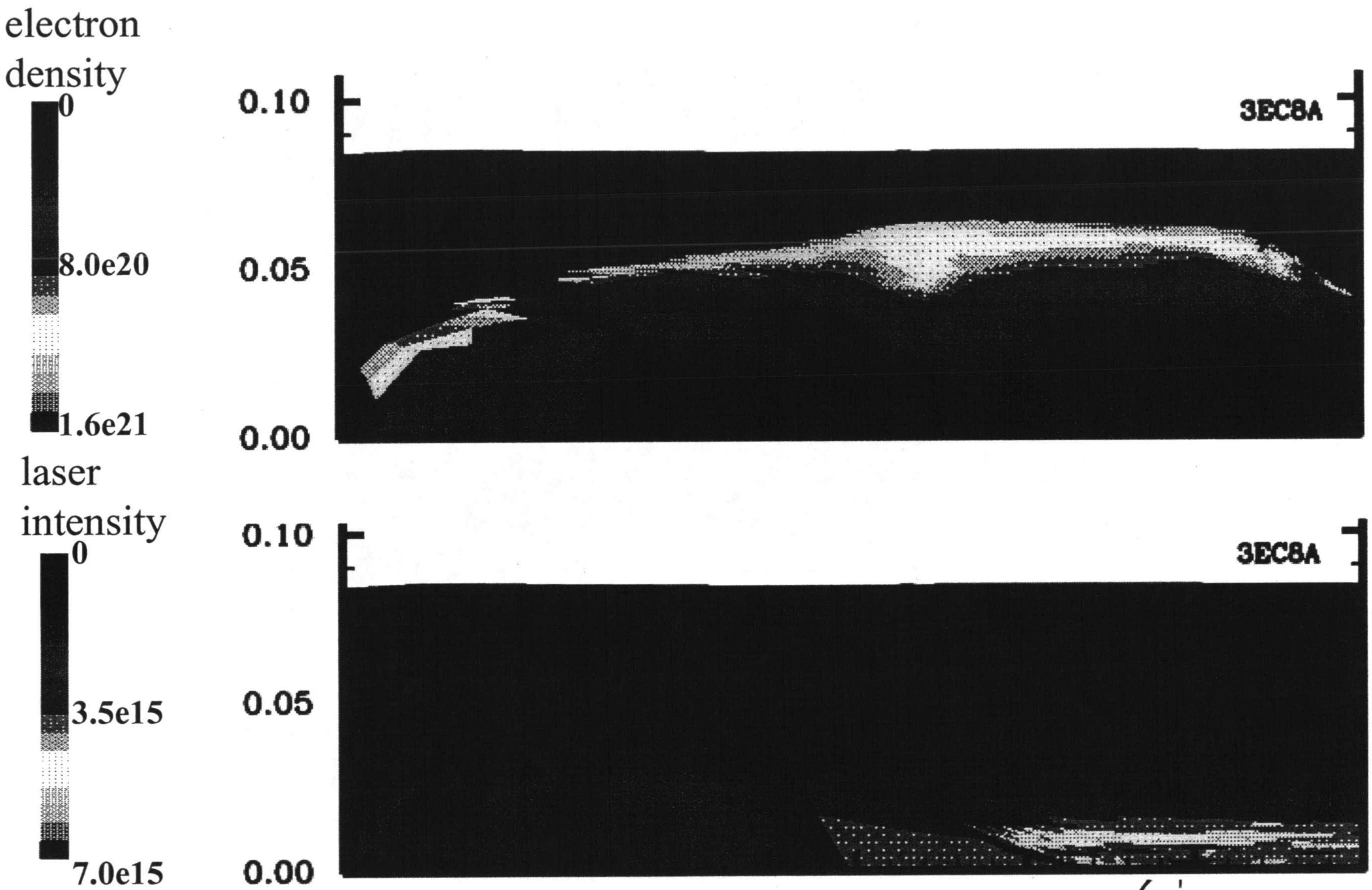
# Some variables at 3.5 ns (center of 1 Mbar drive period) - 2




NNSA

Los Alamos

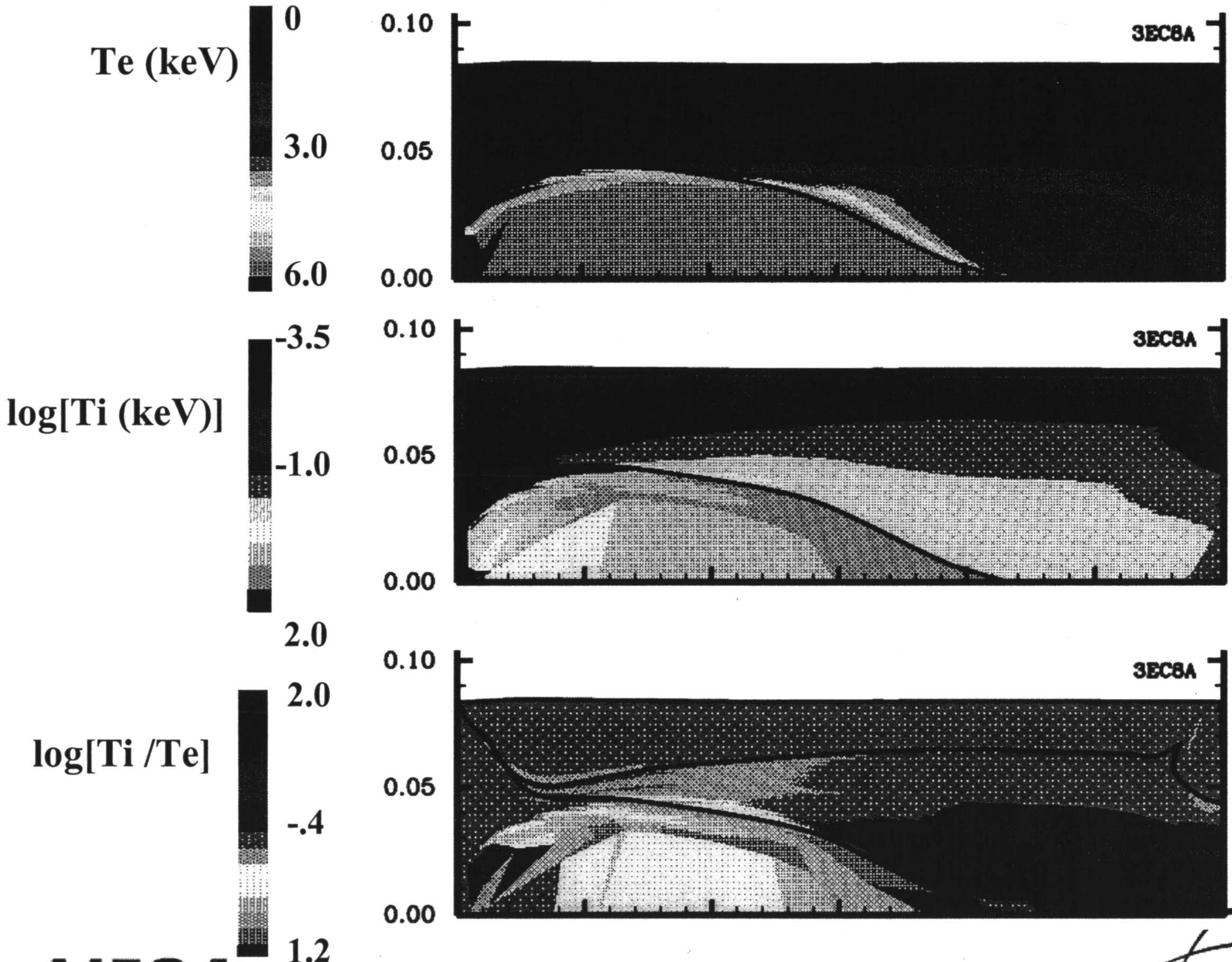
# Some variables at 8.5 ns (end of peak drive period)




NNSA

Los Alamos

# Some variables at 8.5 ns (end of peak drive period) - 2




NNSA

Los Alamos

Comparison lower intensity calculation

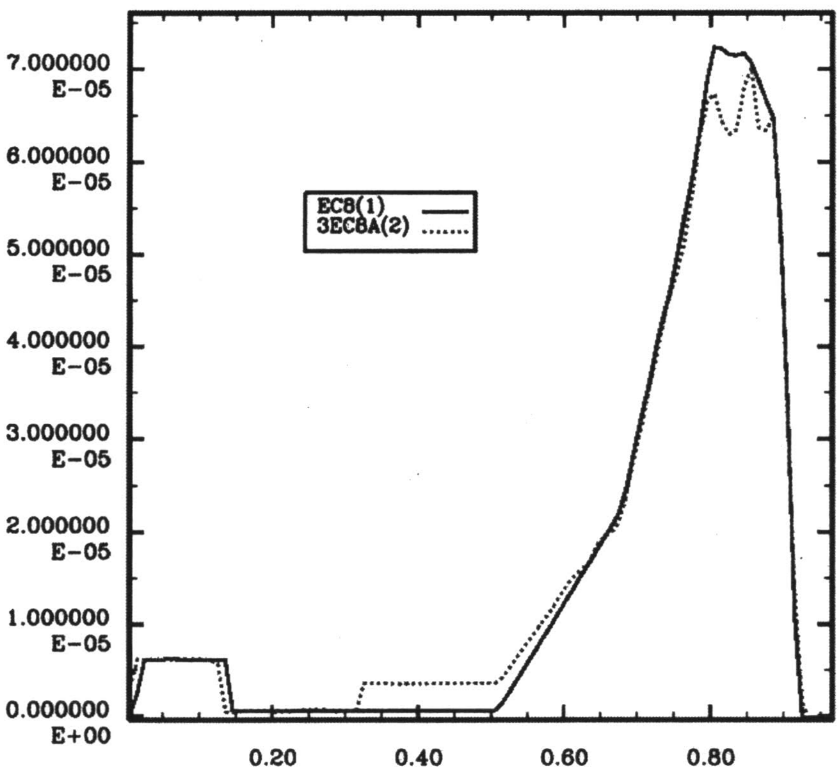
- same hohlraum can
- thicker polyimide membrane
- spot size ≈ 1mm

Some differences in hohlraum variables but shock drive appears very similar

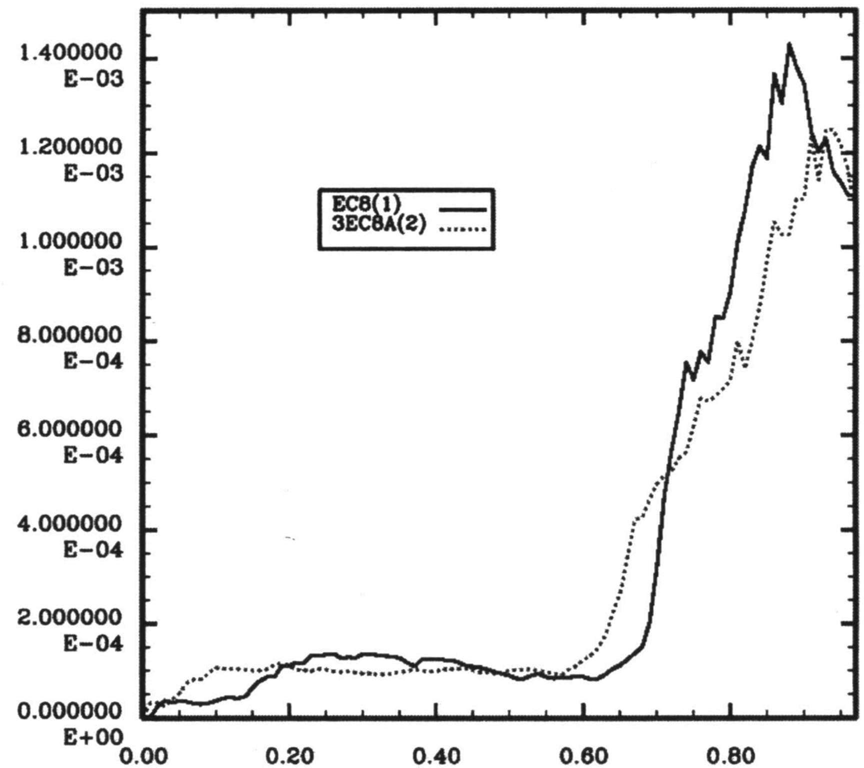
Illustration of rad-hydro sensitivity to intensity

# Power profiles to give a sustained 1Mbar pressure near the hohlraum mid-plane in the first part of the pulse are not a sensitive function of the decreased intensity

**maximum pressure in wall at z=0.03 vs time**




**input power vs time**



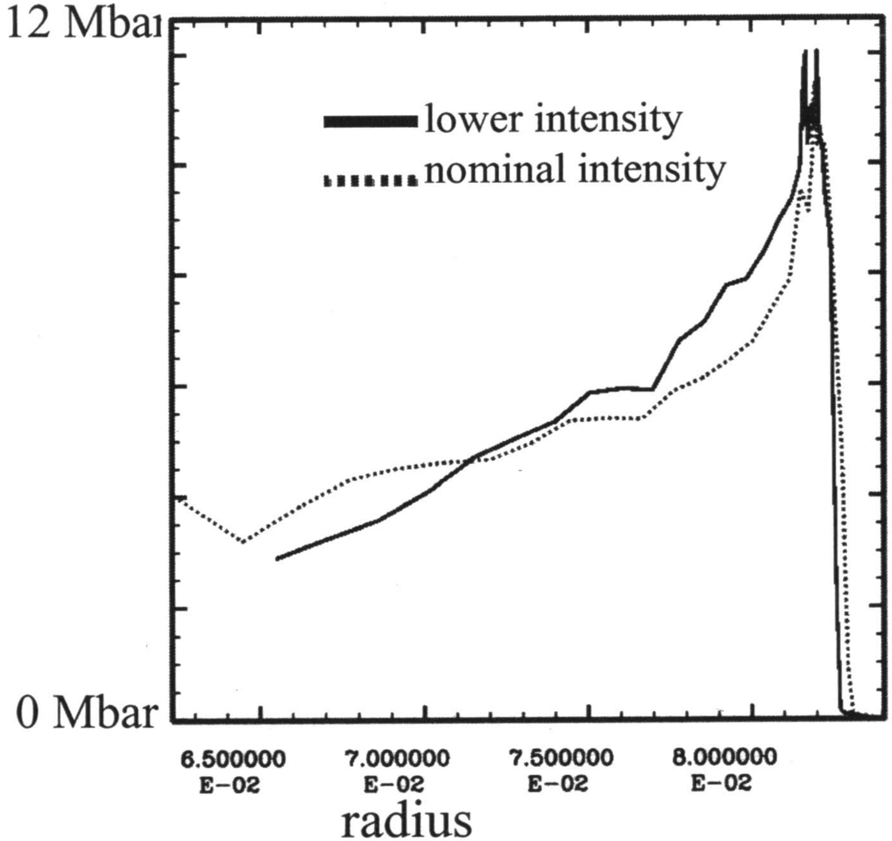

but pressure variations are more marked at later times

NNSA

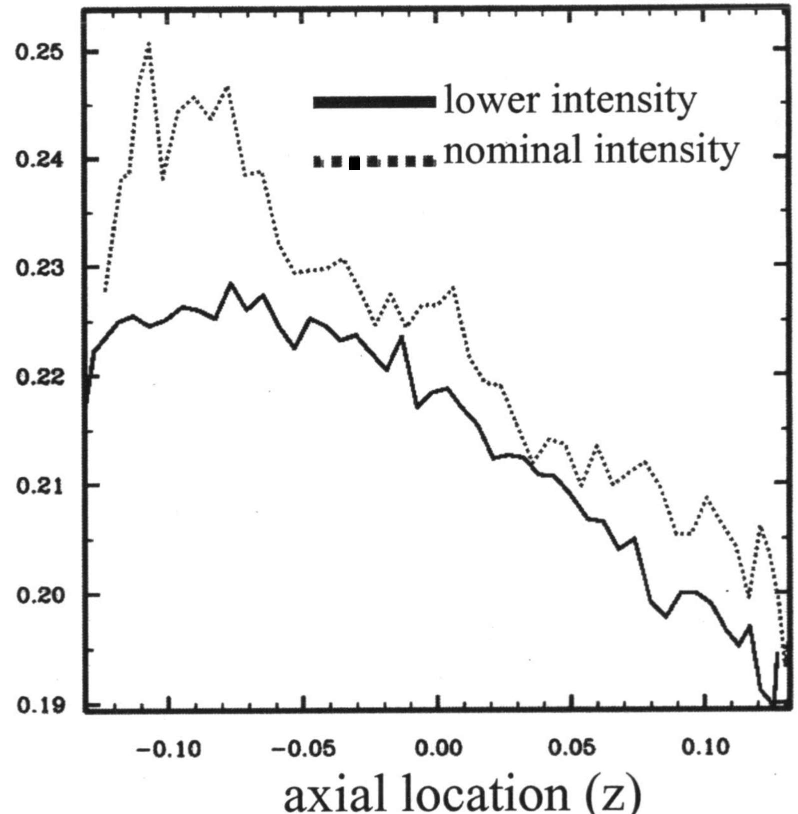
Los Alamos

# Although there are substantial differences in pressures with time, radiation drive and shock location along the front section of the hohlraum sidewall do not vary markedly by the end of the drive

Pressure vs position, t=9.2ns, z=0.03cm




Radiation temperature vs. axial location at hohlraum interface, t=9.2ns




NNSA

Los Alamos

A more careful hydro calculation of the first part of the nominal Problem

Mass matching between the gold zones in the rear hohlraum wall And the gas-fill

Differences in pressures at the sidewall at the 1 Mbar level

# Mass matching has a substantial effect at early times