Title: Defect Implosion Experiment (DIME)


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Defect Implosion Experiment (DIME)

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Statement of the Problem

For an ICF implosion, we want to learn the effect of an equatorial-plane defect on the capsule.

- Accurate modeling is needed for predicting the effects of capsule/fuel cracks and capsule joints (e.g. Be hemi’s).
- The DIME campaign involves perturbed spherical implosions, driven by 60 OMEGA beams with uniform, symmetrical illumination (~24 kJ). D-T-filled CH-shell targets with equatorial-plane defects are designed to produce a non-spherical neutron burn region.
The objectives of the DIME series are to use the neutron imaging system NIS to observe non-spherical burn for defect targets and to successfully simulate the physics of the neutron and x-ray production with such perturbations.

Outline:

I. - Objective
II. - Targets and technique
III. - Simulations
IV. - Diagnostic
V. - Results
VI. - Future plans – NIF and Applications of Ignition
II. DIME Targets and Technique

General Atomic defect targets

- With uniform laser drive, the equatorial-plane defect (width and depth) may be modified to study the effect.
- 865-μm-diameter CH shells, 15- or 8-μm thick
- The key is to have enough neutrons for an image.
III. Simulations Show Defect Pathology

Thick-wall: No defect

- 30 x 2 μm
- 30 x 8 μm

Neutrons

200 μm

X Rays

• 1- & 2-D AMR Eulerian code
• Energy sourced into thin layer
• The grove is modeled as a symmetric equatorial band.
• The source thickness is adjusted to match the correct energy and bang time.

See Magelssen, BO5-3
IV. Diagnostics: Yield and Imaging

- NTOF – LLE’s neutron time of flight diagnostic that together with their NTS (neutron temporal scanner) gives us yield, bang time, burn time, and ion temperature $T_i$

- NIS – LANL’s neutron imager similar to the NIF NIS, ... Resolution $\sim 35 \mu m$

- QXI – LANL’s gated-x-ray imager, qualified for DT operation – It produced $0^{th}$-order hydrodynamic images of imploding capsules with/without defects with $\sim 60$ ps time resolution
V. Results: Neutron Yield Agreement

- In agreement with simulations, yield is reduced with defect depth.
- Yield is lower for thick-walled targets.
- The most recent targets were a year old and did not perform as well.
- Results show that for small defects, we have enough neutrons for a NIS image.
V. Results – Neutron Imaging

- Small pinhole for Shot 59520

Raw data Minimal processing
- Diamond-shaped pinhole
- Nominal resolution $\sim 35 \, \mu m$
- Alignment must be correct to $\pm 100 \, \mu m$, else…
- Pointing-correction algorithms are needed to correct images
- Data are preliminary; the correction is a work in progress.

See Fittinghoff et al. CO5-8 and Grim, et al. CO5-9
V. Results – X-Ray 0th-order Hydro

QXI data for perfect, thick-walled targets
First light
Neutron bang-time is ~1570 ps for both 514 and #520.
V. Results – Defect Pathology

Defect: 30 μm wide, 8-μm deep – thick-walled target

59516F2 @ 1.44 ns

- Legendre analysis: $P_2/P_0 > 25\%$ with other higher modes
- Note deficit of x rays along equatorial plane; ≤ bang time
V. Results – Defect Pathology

30 x 8 μm channel, thin
~1 ns after bang time

20 x 2 μm channel, thick
slightly after bang time

*A variety of x-ray asymmetries exist.*
VI. Future Plans

• Applications-of-Ignition shots begin soon on Omega and NIF to address the overarching goal of measuring the enhancement of convergent mix caused by defect-induced perturbed shocks and its effect on ICF material morphology and fusion burn.

• For future NIF shots, we must verify that polar direct-drive is equivalent to normal direct drive to determine the effects of defects on capsule yield.

See also Schmitt (next talk); Bradley, T05-2; Tregellis, NP9-125; and Finnegan, PO6-13
DIME Summary

The objectives of the DIME series were to use the neutron imaging system NIS to observe non-spherical burn for defect targets and to successfully simulate the physics of the neutron and x-ray production with such perturbations.

- Neutron images were obtained; analysis continues.
- X-ray images show defect modification of implosions.
- Simulations support defect reduction of neutron yield.
- We are prepared to demonstrate the utility of polar drive at Omega for experiments at NIF.