Low-Adiabat, Polar-Drive-Implosion Experiments on OMEGA

OMEGA shot 52136, Saturn target, 15-atm-D\textsubscript{2}-filled, 24-\textmu m CH shell, LA1501 pulse shape

![Experiment]

![DRACO/Spect3D]

Ti backlit images
\(~4.7\text{ keV}~

View angle $\theta_v = 63^\circ$

F. J. Marshall
University of Rochester
Laboratory for Laser Energetics

50th Annual Meeting of the American Physical Society
Division of Plasma Physics
Dallas, TX
17–21 November 2008
Summary
Low-adiabat, polar-drive experiments on OMEGA are validating the NIF designs

- Shaped pulses are used to keep the main fuel layer on a low adiabat (~3).
- Beam repointing is used to optimize the implosion symmetry on both standard and Saturn-type targets.
- Measurements of implosion core size and shape determined from framed x-ray radiographs compare favorably to 2-D DRACO simulations.
- Inferred areal densities agree with values determined from D³He proton spectra.

Recent publications:

Related Talk:
A. Shvydky (TO5.00007).
Collaborators


University of Rochester
Laboratory for Laser Energetics

J. A. Frenje, C. K. Li, R. D. Petrasso, and F. H. Séguin

Massachusetts Institute of Technology
Plasma Fusion Center
Forty OMEGA beams are used to emulate the NIF 192 beam (48 quad) indirect-drive configuration.

- The OMEGA beams, in six rings from 21° to 59°, are used to emulate the NIF geometry.
- Additional OMEGA beams are used for x-ray backlighting.
Comparison of low- and high-energy backlit images reveals details of the evolution of the fuel and shell.

OMEGA shot 49331, polar-driven standard target, 15-atm-D\textsubscript{2}-filled, 24-\(\mu\)m CH shell, LA1501 pulse shape

<table>
<thead>
<tr>
<th>Time (ns)</th>
<th>Image Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.11</td>
<td>Ti backlit images</td>
</tr>
<tr>
<td>2.22</td>
<td>~4.7 keV</td>
</tr>
<tr>
<td>2.35</td>
<td>View angle (\theta_v = 63^\circ)</td>
</tr>
<tr>
<td>2.40</td>
<td>Au backlit images</td>
</tr>
<tr>
<td>2.46</td>
<td>2.2 to 2.5 keV</td>
</tr>
<tr>
<td></td>
<td>View angle (\theta_v = 63^\circ)</td>
</tr>
</tbody>
</table>

The higher-energy backlighter more clearly delineates the shell and fuel at stagnation.
Standard targets require a larger beam offset to optimize implosion symmetry

Polar-driven standard target, 15-atm-D\textsubscript{2}-filled, 24-\textmu m CH shell, LA1501 pulse shape

$\text{t} = 2.16$ ns
$\text{t} = 1.99$ ns

Shot 49331
90,150,150-\textmu m offset pointing Ti backlit images
$\sim$4.7 keV

Shot 52135
90,120,120-\textmu m offset pointing Sc backlit images
$\sim$4.3 keV

$400 \times 400\text{-}\textmu m$ regions

(\textless 0 is emission)

Opacity

View angle $\theta_v = 63^\circ$

Saturn-target implosion symmetry is achieved with a smaller beam offset relative to standard targets*

Polar-driven Saturn target, 15-atm-D$_2$-filled, 24-$\mu$m CH shell, LA1501 pulse shape

Shot 49333
90,150,150-$\mu$m offset pointing Ti backlit images
$\sim$4.7 keV

Shot 52136
90,120,120-$\mu$m offset pointing Sc backlit images
$\sim$4.3 keV

Opacity

View angle $\theta_v = 63^\circ$

X-ray radiographs and 2-D DRACO simulations* show good agreement of both shape and size of the core.

OMEGA shot 49333, polar-driven Saturn target, 15-atm-D₂-filled, 24-μm CH shell, LA1501 pulse shape.

400 × 400-μm regions
View angle $\theta_v = 63°$

$\text{Ti backlit images} \sim 4.7 \text{ keV}$

DRACO/Spect3D

Simulated backlit images

Prolate implosion

E17405

* A. Shvydky (TO5.00007).
Identifying the fuel/shell interface and the outer edge of the shell allows the areal density to be estimated from the x-ray radiographs.

\[
\rho R_{\text{shell}} = 3 \rho_0 r_0^2 \frac{(\Delta r_0 - \Delta r_{\text{abl}})}{(r_{\text{out}}^3 - r_{\text{in}}^3)} \times (r_{\text{out}} - r_{\text{in}})
\]

\[
\rho R_{\text{fuel}} = \rho_0 \left( \frac{r_0}{r_{\text{in}}} \right)^3 r_{\text{in}},
\]

- \(r_0\) = initial radius
- \(\rho_0\) = initial density
- \(\Delta r_0\) = initial shell thickness
- \(\Delta r_{\text{abl}}\) = ablated shell thickness
- \(r_{\text{in}}\) = final fuel/shell interface radius
- \(r_{\text{out}}\) = final shell outer radius
Determination of $\rho R$ from radiographs compares favorably with values determined from proton spectra.

OMEGA shot 49331, polar-driven standard target

<table>
<thead>
<tr>
<th>$\rho R$ values (mg/cm$^2$)</th>
<th>$\rho R$ values (mg/cm$^2$)</th>
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<tbody>
<tr>
<td>$t = 2.40$ ns</td>
<td>$t = 2.46$ ns</td>
</tr>
<tr>
<td>$\rho R_{CH} = 50 \pm 5$</td>
<td>$\rho R_{CH} = 54 \pm 5$</td>
</tr>
<tr>
<td>$\rho R_{D2} = 5 \pm 1$</td>
<td>$\rho R_{D2} = 7 \pm 1$</td>
</tr>
<tr>
<td>$\rho R_{total} = 55 \pm 5$</td>
<td>$\rho R_{total} = 61 \pm 5$</td>
</tr>
</tbody>
</table>

$\langle \rho R \rangle_p = 58 \pm 7$
$\rho R_{LILAC} = 88$

The values determined at the two times bracket the value determined from D$^3$He protons.\(^*\)

Summary/Conclusions

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