Polar-Direct-Drive Experiments on OMEGA

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Spoke-mounted Saturn target

\[ t = 1.21 \text{ ns} \]

\[ t = 1.46 \text{ ns} \]

\[ t = 1.71 \text{ ns} \]

~15.3 kJ, 1-ns square

D-D neutron yield \((\times 10^{10})\)

Shell thickness (\(\mu\text{m}\))

- 60 beams TCC
- Saturn (repointed)
- Standard PDD
- Saturn (original)

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Contributors

Summary

Polar-direct-drive (PDD) experiments on OMEGA have achieved up to 75% of symmetric yields using Saturn targets

- PDD is being tested on OMEGA with 40 beams arranged to emulate the 48 NIF indirect-drive beam configuration.

- X-ray radiography is used to measure the effects of beam pointing and Saturn ring size on the implosion symmetry.

- Implosions with better symmetry produce higher fusion yields.

- Future experiments will attempt to further optimize implosion symmetry and address target mount effects.

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40 of the OMEGA beams are used to emulate the NIF 48 beam 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.
Silk-mounted and spoke-mounted Saturn targets have been shot on OMEGA.

- **OMEGA shot 38500**
  - Time-integrated pinhole camera (2 to 5 keV)

- **OMEGA shot 37430**
  - X-ray pinhole camera image (2 to 5 keV)

- **OMEGA shot 39281**
  - X-ray pinhole camera image (2 to 5 keV)

- **“Silk” mount**

- **“Spoke” mount**
PDD implosions show nearly 1-D behavior until just before stagnation.

Standard PDD target implosion
OMEGA shot 34669
20-μm-thick CH shell, filled with 15-atm D₂

![Graph showing the relationship between radius (μm) and time (ns) with LILAC 1-D simulation lines and framed images marked with Imaging streak and Framed images labels.]
Core stagnation symmetry is affected by the direct-drive illumination configuration

X-ray pinhole camera images (2 to 5 keV)

60 beam implosion

<table>
<thead>
<tr>
<th>PDD 40 beam implosions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard target</td>
</tr>
<tr>
<td>Saturn target</td>
</tr>
</tbody>
</table>

OMEGA shot 37419
15.8 kJ, \( Y_n = 6.9 \times 10^{10} \)

OMEGA shot 37427
15.2 kJ, \( Y_n = 2.1 \times 10^{10} \)

OMEGA shot 39285
15.6 kJ, \( Y_n = 5.9 \times 10^{10} \)

865 \( \mu \text{m} \)

Ring shadow
The radiographs are fit with ideal Legendre modes to determine the deviations from spherical symmetry.

Standard PDD implosion of D$_2$(15)CH[20] target
OMEGA shot 38502

<table>
<thead>
<tr>
<th>Pointing</th>
<th>Ring</th>
<th>Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>90 µm</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>120 µm</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>120 µm</td>
</tr>
</tbody>
</table>
Different beam pointing results in a different modal structure, as seen by the framing cameras.

Standard PDD target $\ell$-mode pattern at $t = 1.7$ ns

Ring 1, 2, 3 offsets (\(\mu\)m)
37427 \ldots (90, 180, 180)
38502 \ldots (90, 120, 120)
The symmetry of the imploding shell depends on beam pointing for Saturn targets as well.

<table>
<thead>
<tr>
<th>Rings 1, 2, 3 offsets ((\mu m))</th>
<th>(90, 120, 120)</th>
<th>(90, 150, 150)</th>
<th>(30, 60, 120)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shot 38501</td>
<td>(t = 1.52) ns</td>
<td>(Y_n = 2.8 \times 10^{10})</td>
<td>(Y_n = 2.2 \times 10^{10})</td>
</tr>
<tr>
<td>Shot 38508</td>
<td>(t = 1.65) ns</td>
<td>(Y_n = 3.3 \times 10^{10})</td>
<td>(Y_n = 2.2 \times 10^{10})</td>
</tr>
<tr>
<td>Shot 38512</td>
<td>(t = 1.46) ns</td>
<td>(Y_n = 2.2 \times 10^{10})</td>
<td>(Y_n = 2.2 \times 10^{10})</td>
</tr>
</tbody>
</table>

Saturn ring
2.2-mm diam
0.3-mm thick
The best Saturn targets achieve fusion yields that are \( \sim 75\% \) of symmetrically irradiated targets.
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