An Implosion-Velocity Survey for Shock Ignition on the NIF

\[ \text{ITF} = \frac{E_{\text{kin}}}{E_{\text{ign min}}} \]

![Graph showing ITF as a function of \( V_{\text{imp}} \times 10^7 \text{ cm/s} \)]

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55th Annual Meeting of the American Physical Society
Division of Plasma Physics
Denver, CO
11–15 November 2013
A survey of implosion velocity for shock ignition at the National Ignition Facility (NIF) indicates best performance and stability at velocities below $3 \times 10^7$ cm/s

**Summary**

- A parameter study was performed varying the implosion velocity and quantifying target robustness in 1-D and 2-D for plastic-ablator cryogenic capsules
- This study used polar-drive beam geometry to evaluate long-wavelength perturbations and laser imprint to study short wavelengths
- The target margin in 2-D with polar drive was relatively constant with implosion velocity
- Low-velocity capsules showed less sensitivity to laser imprint
Collaborators

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Shock ignition separates the fuel-assembly phase from the ignition phase using a single laser system.

The late-time shock amplifies the hot-spot pressure.

The target margin is quantified using the ignition threshold factor (ITF)\(^*\)

\[
\int_{V_{\text{clean}}} \langle \sigma V \rangle dV \approx \int_{V_{1-D}} \langle \sigma V \rangle dV \frac{V_{\text{clean}}^{3-D}}{V_{1-D}} \approx \int_{V_{1-D}} \langle \sigma V \rangle dV \times \text{YOC}
\]

Minimum YOC required for ignition (MYOC)

\[\text{ITF; MYOC}^{-1.5}\]

*D. S. Clark et al., Phys. Plasmas 15, 056305 (2008);
P. Y. Chang et al., Phys. Rev. Lett. 104, 135002 (2010);
Three targets were analyzed; the velocities were varied by changing the target thickness.

![Diagram showing target thicknesses and velocities](image)

<table>
<thead>
<tr>
<th>Velocity (cm/s)</th>
<th>$2.6 \times 10^7$</th>
<th>$2.8 \times 10^7$</th>
<th>$3.0 \times 10^7$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain (1-D)</td>
<td>69</td>
<td>62</td>
<td>58</td>
</tr>
<tr>
<td>ITF (1-D)</td>
<td>2.5</td>
<td>3.5</td>
<td>4.2</td>
</tr>
<tr>
<td>IFAR$_{2/3}$</td>
<td>14</td>
<td>17</td>
<td>20</td>
</tr>
</tbody>
</table>

$E_{\text{Laser}} = 700 \text{ kJ}$
The previous shock-ignition* design for the NIF showed the highest sensitivity to polar-drive beam geometry and laser imprint.

\[ \nu_{\text{imp}} = 3.1 \times 10^7 \text{ cm/s} \]

ITF (1-D) = 4.1

IFAR = 22

\[ \nu \]

\[ \text{No imprint, ITF} = 2.8 \]

\[ \text{With imprint, ITF} = 1.1 \]

\[ \text{Density (g/cm}^3\text{)} \]

Robustness to long-wavelength modes was evaluated using polar-drive nonuniformities and to short-wavelength modes using laser imprint.

Polar drive
Beams are repointed toward the equator to ensure adequate symmetry.

Generates long-wavelength perturbations, $\ell \leq 20$

Generates short-wavelength perturbations, $\ell > 20$

Single-beam speckle from phase plate

Radial lineout of laser intensity

Laser intensity (arbitrary units)

Beam spot lineout ($\mu$m)

Laser imprint modeled using multi-FM SSD*

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*A. Shvydky et al., YO4.00006; M. Hohenberger et al., YO4.00007, this conference.
The margin in 2-D polar-drive simulations was relatively independent of implosion velocity.
Low-velocity, low-IFAR targets show less susceptibility to imprint

ITF analysis with laser imprint is in progress.
Summary/Conclusions

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