Analysis of a Direct-Drive, 1-MJ, Wetted-Foam Target Design

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Summary

The stability of a 1-MJ wetted-foam design has been examined with respect to power balance and ice roughness.

- This design experiences tolerable gain degradation with a 1.25-\(\mu\)m initial ice roughness.
- Simulations including mistiming and beam-to-beam power imbalance also show modest effects on target gain.
- Preliminary imprint simulations show moderate gain reduction when single-beam nonuniformity modes 10–60 are included.
Collaborators

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Wetted foams have higher absorption allowing a thicker shell and greater stability.

- Foam density is chosen by balancing higher absorption with increased radiative preheat.
- Foam layer thickness is chosen so that foam is entirely ablated.

<table>
<thead>
<tr>
<th>1-MJ designs</th>
<th>All DT</th>
<th>Wetted foam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain</td>
<td>29</td>
<td>39</td>
</tr>
<tr>
<td>Absorption (%)</td>
<td>57%</td>
<td>91%</td>
</tr>
<tr>
<td>$\rho R$ (g/cm²)</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Margin (%)</td>
<td>46%</td>
<td>44%</td>
</tr>
<tr>
<td>Peak IFAR</td>
<td>77</td>
<td>44</td>
</tr>
<tr>
<td>$A/\theta$</td>
<td>27%</td>
<td>9%</td>
</tr>
</tbody>
</table>
The pulse is within the limits of NIF pulse-shaping capabilities

- Pulses on the NIF are decomposed into a series of Gaussian impulses and filtered with a 1-GHz, low-pass Bessel filter.
- The design is robust in 1-D to control-point variation.
The picket is designed to shape the adiabat while maintaining gain and implosion velocity.

- Stability is gauged by the ratio $A/\theta$ of the rms bubble amplitude to the shell thickness.
- The picket has been designed to provide an ablator adiabat of 10 with an ice adiabat of 2, and with an implosion velocity of $4.3 \times 10^7$ cm/s.
This design tolerates a 1.25-μm initial ice roughness

- The ice-roughness spectrum is given by $a_{\ell} = a_0 \ell^{-\beta}$.
- In cryogenic targets fabricated at LLE: $\beta \sim 2$.\(^1\)
- 2-D DRACO simulations including modes $\ell = 2$–50 were performed.

\(^1\)D. Harding and D. Edgell, private communication (2005).
The beam-to-beam imbalance perturbation amplitude is ~1% and the mistiming ~10%, early in time

- Beam port locations contribute a perturbation of ~1% in $\ell = 6$.
- Beam-to-beam imbalance is dominated by modes $\ell = 2–12$, with an amplitude of ~1%.
- Beam mistiming contributes ~5–15% in modes $\ell = 1–3$, primarily during the picket.*

*R. Epstein, FO3.13.
The design is robust to pulse mistiming and beam-to-beam power imbalance

- A number of power-imbalance and mistiming histories\(^1\) with an rms mistiming of 30 ps were simulated in 2-D, including modes \(\ell = 2\text{–}12\).
- The average gain reduction due to these effects was 12%.

1-D and 2-D simulations indicate the design can tolerate single-beam nonuniformity

- A 1-D Rayleigh–Taylor post-processor\(^1\) found a 7% ratio of bubble amplitude to shell thickness.

- Imprint sensitivity is estimated simulating the most dangerous mode, \(\ell = 32\), with the amplitude of modes 10–60 added in quadrature.

- Multimode imprint simulations are underway.

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