Optimization of Neutron Yields on the NIF from Room-Temperature DT Targets

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Progress is being made toward designing high-neutron-yield polar-drive targets for the NIF

- Primary motivation is neutron diagnostic development
  - also test polar drive on the NIF

- Uniform drive is possible using existing NIF hardware
  - defocus the beams
  - repoint the beams
  - spread the beams within a quad

- The optimum target employs an SiO$_2$ shell with a CH ablator

- Yields around $10^{16}$ are expected for 1 MJ
Three hydrodynamic codes are being used iteratively

- **SAGE** is used to identify uniform irradiation conditions
- **LILAC** is used to optimize the 1-D design
  - from 350 kJ to 1.5 MJ
- **DRACO** is used for full 2-D simulations
  - initially focus on 350 kJ
The polar-drive designs use only readily available capabilities on the NIF

1. Phase plate
2. Defocus
3. Mirror tilts

Target

Best focus

7 m

40 cm

Frequency conversion
Target-plane distributions out of best focus are calculated using a simple geometrical-optics model. 

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*D. Munro parameterization
Target-plane profiles with greater spatial broadening can be obtained using split-quad focusing*

*Suggested by E. Moses
The 350-kJ design is diagnosed at 2.8 ns, just before peak neutron production.
At 2.8 ns the shell is imploding with a high degree of uniformity.
The original and Rev. 1 inner-cone designs are significantly different

Original
(a, b) = (739, 636) $\mu$m

Rev. 1
(a, b) = (824, 590) $\mu$m

D. Munro “Scoping model”

D. Munro “Ellipse model”
Substituting the Rev. 1 or Rev. 2 phase plates in the original design makes little difference to uniformity.
With the beam pointings optimized for SiO$_2$, a CH target with equivalent mass is underdriven at the equator.
The beam pointings can be adjusted to be optimum for CH

![Graph showing beam pointings and optimum shifts](image)

**SiO$_2$ (28-μm rms)**

**CH (8-μm rms)**

**Optimum pointing shifts (μm)**

<table>
<thead>
<tr>
<th></th>
<th>Ring 1</th>
<th>Ring 2</th>
<th>Ring 3</th>
<th>Ring 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO$_2$</td>
<td>50</td>
<td>200</td>
<td>250</td>
<td>594</td>
</tr>
<tr>
<td>CH</td>
<td>100</td>
<td>300</td>
<td>350</td>
<td>694</td>
</tr>
</tbody>
</table>

**t = 2.8 ns**

Runs 5110,5152

TC8160
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The anticipated yields are consistent with OMEGA results and a very simple scaling model.

Assume $R, T \propto E^{1/3}$
Yield $\propto volume \times time$ }
The 2-D DRACO simulation shows a fairly uniform implosion but with a weaker drive at the equator.
At peak neutron production the shell is nonuniform but there is a region of $\sim$10-keV ion temperature.
Progress is being made toward designing high-neutron-yield polar-drive targets for the NIF

Summary/Conclusions

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The chances of finding improved designs are good.
At 2.8 ns the center-of-mass radius is $600 \pm 6.5 \, \mu\text{m}$ and its velocity is $6 \times 10^7 \, \text{cm/s} \pm 1.7\%$.
The final NIF phase-plate design is uncertain

### Outer cone

<table>
<thead>
<tr>
<th>Profile #</th>
<th>(a, b) μm</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>(593, 343)</td>
<td>Original*</td>
</tr>
<tr>
<td>5</td>
<td>(593, 343)</td>
<td>Rev. 1 (300 eV)*</td>
</tr>
<tr>
<td>7</td>
<td>(697, 403)</td>
<td>Rev. 2 (285 eV)</td>
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</tbody>
</table>

### Inner cone

<table>
<thead>
<tr>
<th>Profile #</th>
<th>(a, b) μm</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>(739, 636)</td>
<td>Original</td>
</tr>
<tr>
<td>6</td>
<td>(824, 590)</td>
<td>Rev. 1 (300 eV)</td>
</tr>
<tr>
<td>8</td>
<td>(968, 693)</td>
<td>Rev. 2 (285 eV)</td>
</tr>
</tbody>
</table>

*Under fabrication
The optimum pointing for SiO$_2$ appears to be not quite optimum for CH.

- Re-optimization for the actual target design is required.