Design of High-Neutron-Yield, Polar-Drive Targets for Diagnostic Activation Experiments on the NIF

Average symmetric D₂ experimental yield = 4.6 × 10⁹

Incident energy (kJ)

Yield-over-clean (%)

Symmetric drive
- YOC (60 beam)

Polar drive
- YOC (40 beam)

Target image at TCC

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Summary

Polar-drive (PD) designs will meet the neutron-diagnostic-development requirements for the NIF.

- High neutron yields are obtained from simple, room-temperature, glass microballoon targets.
- Uniform PD illumination is possible using existing NIF phase plates:
  - defocus the beams
  - repoint the beams
  - spread the beams within certain quads
- OMEGA experiments using NIF targets and PD illumination are producing ~60% of the predicted 1-D yields.
- Yields approaching $10^{16}$ are expected for 1 MJ of incident light on the NIF.
Collaborators

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Original polar-drive designs employed existing NIF ID phase plates to access a wide range of diagnostic yields.

Glass Microballoon Targets

10 atm DT

20 μm CH
5 μm SiO₂

1100 μm

1. Phase plate
2. Defocus
3. Mirror tilts

Best focus Target

Laser energy (kJ)

Neutron yield

Assume \( R, t \propto E^{1/3} \)

Yield \( \propto \) volume \( \times \) time \( E \)

\( Y \propto E^{4/3} \)

OMEGA Experiment

1-D LILAC

SAGE 3-D PD ray trace is employed to demonstrate that the shell implodes with a high degree of uniformity.
The two polar NIF beam rings employ inner-cone phase plates with 2-cm defocus and slight repointing.
The remaining two NIF beam rings employ outer cone phase plates with various defocus and $x/y$ splits coupled with more significant repointing.

**Ring 3—Outer Phase Plate**
- 2.0-cm defocus
- 320/160 $\mu$m, $x/y$ splits
- 235 $\mu$m, z repoint

**Ring 4—Outer Phase Plate**
- 1.0-cm defocus
- 0/0 $\mu$m, $x/y$ splits
- 450 $\mu$m, z repoint

![Graphs showing far field plots for each ring with defocus and split values.]
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 $\frac{E}{E^{1/3}}$

Neutron yield

Laser energy (kJ)

$Y \propto E^{4/3}$

1-D LILAC (polar drive)

OMEGA Experiment

2-D DRACO (polar drive)

All SiO$_2$ with CH ablator
Current target-fabrication capabilities limit 4-μm-wall glass shells to ~1500-μm OD
Pulse clipping and variable tritium fill ratios provide simple levers to achieve desired neutron yields for NIF commissioning shots.
OMEGA shots are underway to test the overall PD defocusing scheme using an actual NIF target.
OMEGA experiments, utilizing a NIF-size target, have demonstrated PD yields of ~60% of 1-D predictions.

- Average symmetric D$_2$ experimental yield = $4.6 \times 10^9$

![Target image at TCC](image)

![Graph showing yield ratio vs. incident energy](graph)
Neutron yields approaching $10^{16}$ will require the largest Hoppe shells manufactured to date.

![Graph showing the relationship between wall thickness and diameter, with stars representing actual shells made and shading indicating very high probability of success.](TC8524b)
Simple PD designs employing accessible Hoppe targets can deliver high neutron yields in May 2010.

Glass Microballoon Targets

- 1050 μm
- 10 atm DT
- 20 to 30 μm CH
- 12 μm SiO₂

Graph showing:
- Power (TW) vs. Time (ns)
- DT yield (×10^16) vs. Time (ns)
- Curves for 1-MJ and 500-kJ incident energy.

TC8641
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