Numerical Evaluation of Subtangential Focusing in OMEGA Target Implosions

Beam 3
Center-beam ray
Crossed-beam energy transfer
Beam 2
Edge-beam ray
Narrow beam
Full beam
Beam 1

P. W. McKenty
University of Rochester
Laboratory for Laser Energetics

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Summary

Direct-drive phase plates require precise design to achieve the necessary imprint and laser–plasma interaction (LPI) mitigation

- Subtangential focusing leads to higher laser absorption
- Hydrodynamic instabilities are enhanced by reduced target illumination uniformity
- Bifocal phase plates are being examined to evaluate their applicability to OMEGA and NIF experimental platforms
Collaborators


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University of Rochester
Laser absorption can be increased by implementing subtangential focusing

**Positives**
- Decreased refraction
- Reduced crossed-beam energy transfer

**Negatives**
- Enhanced overlap nonuniformity
- Reduced imprint smoothing
Subtangential-focus experiments are drawn from previous OMEGA capsule implosions.

**Graphs:**
- **Focus parameter ($F/R$) vs. Neutron yield:**
  - The graph shows a plot of neutron yield versus focus parameter ($F/R$).
  - Two focus parameters are highlighted: $F = 2R$ and $F = 8R$.
  - The neutron yield values range from $10^{10}$ to $10^{11}$.
  - The data points are color-coded to indicate different diameters: >700-μm diam and 500- to 650-μm diam.

- **Calculated convergence ratio (at stagnation):**
  - The calculated convergence ratio is plotted against calculated convergence ratio (at stagnation).
  - The graph includes data points for 1-ns square, 23-kJ, D$_2$-filled shells, 1-THz, one-color-cycle SSD and PS targets.
  - The convergence ratios are labeled with diameters and pressures: 27 μm, 20 atm; 20 μm, 15 atm; 20 μm, 7 atm; and 20 μm, 3 atm.

**Notes:**
- The focus parameter $F = 2R$ and $F = 8R$ are shown on the graph.
- The calculated convergence ratio at stagnation is indicated for different pressures and diameters.
- The graph includes 37 shots at 20 μm, 15 atm.
Subtangential-focus experiments showed a relative yield improvement at tighter focus but 2× reduction in yield performance overall.
Defocused phase plates lead to higher levels of imprint nonuniformities and lower target performance.
**DRACO simulations of an** $F = 0.8$ OMEGA cryogenic implosion show degraded target performance

**Density contours at peak burn**

- $F = 1.0$
  - Yield over clean 30%
  - $\rho R$ over clean 92%

- $F = 0.8$
  - Yield over clean 21%
  - $\rho R$ over clean 70%

**Geometric nonuniformity (% rms)**

- $F = 0.8$
- $F = 1.0$

**Effective number of overlapping beams**

- $F = 0.8$
- $F = 1.0$
Single-focus phase plates can only straddle the desired regions of imprint and LPI control.
Bifocal phase plates, coupled with co-propagation of spliced pulses, can deliver two-step laser zoom

- Two-state phase modulation yields efficient energy transfer
- Sensitivity to focal-spot shape and profile is reduced
- Smaller focal spot decreases CBET for the main laser pulse
- Reduced phase gradients lower laser-damage probability
Two-step zooming can provide both imprint and LPI mitigation while maintaining target performance.
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