Modeling Observables to Diagnose Areal Density in OMEGA Implosions

Secondary proton spectrum
OMEGA cryogenic implosion; $\alpha \sim 2.5$

1. Burn truncation
2. Timing
3. Multidimensional $\rho R$ variations

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Good agreement between measured and simulated areal densities are obtained when non-ideal implosion effects are included.

- Areal density depends crucially on shock timing, preheat, and equation of state.

- Nonuniformities result in burn truncation.
  - preferentially sampling early-time areal density making observed values lower than 1-D simulation by 10 to 20%

- With increasing intensities, sampling effects alone cannot explain the observed degradation in areal densities in OMEGA implosions.

- Shock-timing experiments* indicate that shock mistiming may account for degraded areal densities in cryogenic implosions.

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Areal density is the only implosion observable that provides information on the shell adiabat

\[ \rho R_{\text{max}} = \frac{2.6 (E_L)^{0.33} V_{\text{imp}}^{0.04}}{\alpha^{0.55}} \]  

\[ \alpha = \frac{P}{P_F}; \quad E_L = \text{laser energy} \]
\[ V_{\text{imp}} = \text{implosion velocity} \]

\(^1\text{R. Betti and C. Zhou, Phys. Plasmas 12, 110702 (2005).}\)
Preferential sampling of the areal density due to burn truncation can produce apparent degradation of observed areal densities.

<table>
<thead>
<tr>
<th>Simulated $\rho R$</th>
<th>182 mg/cm$^2$</th>
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<tbody>
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OMEGA cryogenic implosions
Offset <30 $\mu$m
Preferential sampling of the areal density due to burn truncation can produce apparent degradation of observed areal densities.

Simulated $\rho R = 182 \text{ mg/cm}^2$

Inferred $\rho R = 138 \text{ mg/cm}^2$

OMEGA cryogenic implosions
Offset <30 $\mu$m

Primary neutron yield ($Y_{\text{expt}}/Y_{\text{1-D}}$) %

Simulated neutron arrival time
Observed neutron arrival time
Simulated areal density
Better agreement between simulation and observation is obtained when burn truncated is included.
The low-energy tail in the secondary proton spectrum is due to nonuniformities in the compressed shell.

**DRACO simulation**; $\alpha \sim 2.5$

11-\(\mu\)m offset; 3.0-\(\mu\)m rms

- Burn truncation is included in the secondary spectrum calculations.
Including the effects of burn truncation gives better agreement with experiment.

**OMEGA cryogenic implosions**
Offset <30 μm; $\alpha \sim 2$–4

- **Simulated $\rho R$ (mg/cm²)**
- **Observed $\rho R$ (mg/cm²)**

- **Multiple-picket laser pulse**
- **Continuous laser pulse ($I > 5 \times 10^{14}$ W/cm²)**
- **Continuous laser pulse ($I < 5 \times 10^{14}$ W/cm²)**

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Including the effects of burn truncation gives better agreement with experiment

OMEGA cryogenic implosions
Offset <30 μm; α ~ 2–4

Observed ρR (mg/cm²) vs. Simulated ρR (mg/cm²)

Power (TW) vs. Time (ns)

Δ Multiple-picket laser pulse
◆ Continuous laser pulse (I > 5 × 10¹⁴ W/cm²)
◆ Continuous laser pulse (I < 5 × 10¹⁴ W/cm²)

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OMEGA cryogenic implosions
Offset <30 μm; α ~ 2–4

- Multiple-picket laser pulse
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Summary/Conclusions

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