Experimental Results from the High-Adiabat Cryogenic Implosion Campaign on OMEGA

![Graph showing the relationship between LILAC implosion velocity and DT yield.]

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Summary

High-adiabat implosions have proven to be a valuable technique to extend the performance of cryogenic target experiments

- Implosion velocities >500 km/s are achieved by lowering target mass and improving coupling
  - 330 km/s < implosions velocity < 520 km/s
- High-adiabat implosions show 1-D–like trends
  - ion temperature shows the expected 1-D scaling with implosion velocity
- The highest neutron yield achieved was $1.34 \times 10^{14}$
Collaborators


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*R. Betti, T12.00001, this conference (invited).
**V. Gopalaswamy et al., CO8.00010, this conference.
The target outer diameter and mass were varied to change the implosion velocity

- Target outer diameters (laser coupling*)
  - 860-µm minimum to 980-µm maximum
- Shells
  - CH: 8 µm thick
  - CD: 7.5 µm thick
- Cryogenic layer thickness
  - 53-µm maximum to 40.2-µm minimum
- 330 km/s < implosion velocity < 520 km/s

Single-picket laser pulse shapes were adjusted to match target parameters and study preheat

Picket height and width

Fixed pulse-shape adjustments

1. Timing of the drive relative to picket - set adiabat through shock timing
2. Height of the drive step - fine-tuned shock structure
3. Drive intensity - study preheat caused by “hot” electrons
4. Drive duration - tuned total energy of the drive
5. SSD* on/off - changed initial imprint seed

* SSD: smoothing by spectral dispersion
Ion temperature versus implosion velocity is explained by a 1-D scaling formula*

Best fit of Zhou–Betti formula to date

\[ kT_{\text{Zhou}} = \frac{2.96}{\alpha^{0.15}} \cdot \left( \frac{V_{\text{imp}}}{300} \right)^{1.25} \]

\[ \alpha = 5.3 \pm 1.0 \]

Average from LILAC 1-D hydrodynamic simulation

\[ \alpha = 5.5 \pm 0.9 \]

Ion temperatures show the expected scaling.

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Neither yield nor ion temperature are affected by SSD
The measured areal density decreases when SSD is off

Imprint may compromise the cold fuel layer but not the “hot spot.”

*GMXI: gated monochromatic x-ray imager
Yields $<10^{14}$ are correlated with reactivity calculated at the nTOF* ion temperatures

\[ Y = f_T f_D n_{DT}^2 \sigma_{DT} V_{HS} t_b \]

for yield $>10^{14}$

DT $kT_i$ may not be the thermal temperature

or

\[ n_{DT}^2 V_{HS} t_b \]

is not constant

*nTOF: neutron time of flight
High-adiabat implosions show little residual kinetic energy*

The $T_i$ ratio indicates that the temperature measurement reflects the thermal temperature.

The maximum center-of-mass speed projected along the 13.4-m nTOF line of sight* is $98 \pm 21 \text{ km/s}$

Higher implosion velocities show higher speeds except for two outlying shots.

*O. M. Mannion et al., CO8.00003, this conference.
The measured yield scales as the fourth power of the implosion velocity up to 500 km/s.

The maximum yield was $1.34 \times 10^{14}$ neutrons.
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Future experiments will use 1-D model to improve target $\rho r$ keeping yield high.