Indications of Bulk Fluid Motion in Direct-Drive Implosions

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The neutron time-of-flight (nTOF) spectrum is now used to measure bulk flows on OMEGA implosions

- Inertial confinement fusion (ICF) implosions with low-mode asymmetries induce bulk flows in the capsule, leading to residual kinetic energy not transferred into heat energy
- Bulk flows manifest themselves in the nTOF spectrum as shifts in the neutron kinetic energy from their nominal peak values
- Measurements of the neutron spectrum on OMEGA indicate bulk flows as large as $60 \pm 20 \text{ km/s}$

Summary

Future work will extend this analysis to multiple lines of sight.
Collaborators


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Bulk motion of the capsule reduces performance by leaving residual kinetic energy (KE) in the shell and hot spot.

Residual fuel KE = 68 J
Residual KE fraction ≈ 3%

Residual fuel KE = 120 J
Residual KE fraction ≈ 6%

The moments of the neutron spectrum encode essential diagnostic information about the reactants.

\[ \langle E \rangle = E_0 + E_{th} + \Delta E_{V_{cm}} \]

\[ \langle (E - \langle E \rangle)^2 \rangle \propto T \]
The petal detector* is used to measure the neutron spectrum.

The small scintillator volume results in a very narrow instrument response function.

*V. Yu. Glebov et al., CO8.00001, this conference.
Absolute timing calibration is achieved with an optical fiducial along with x-ray timing shots

- The optical fiducial\(^*\) enables accurate placement of the laser pulse and bang time on the time axis.

\(t_\gamma\) \hspace{1cm} \(t_{\text{delay}}\)

\(t_{14\text{ MeV}}\) \hspace{1cm} \(t_{\text{delay}}\)

The x-ray calibration shot allows us to quantify the inherent delay and determine an absolute timing axis.

\(^*\)LLE Review Quarterly Report 88, 171 (2001)
The forward-fitting procedure* is used to infer the first and second moments of the neutron spectrum.

\[ m(t) = I[e(t)] \left| \frac{dE}{dt} \right| \otimes R(t) \]

Observed variation in the neutron kinetic energy peak in DT cryogenic implosions imply bulk fluid velocities as large as $60 \pm 20$ km/s.
Summary/Conclusions

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