Effects of Fuel-Shell Mix in Implosions of Plastic Capsules on OMEGA

Johan Frenje
MIT - Plasma Science and Fusion Center

44th Annual Meeting of the Division of Plasma Physics
Orlando, FL, Nov 11-15, 2002
Collaborators

C. K. Li, F. H. Séguin, S. Kurebayashi, R. Rygg, B. Schwartz
and R. D. Petrasso*
Plasma Science and Fusion Center
Massachusetts Institute of Technology

J. Delettrez, J. M. Soures, V. Yu. Glebov, J. Knauer,
D. D. Meyerhofer, S. P. Regan, P. B. Radha, S. Roberts,
T. C. Sangster and C. Stoeckl
Laboratory for Laser Energetics
University of Rochester

N. Hoffman and D. Wilson
Los Alamos National Laboratory

* Visiting senior scientist at LLE
Summary

Fuel-shell mix has been studied using nuclear diagnostics

• Implosions of pure $^3\text{He}$ gas filled capsules with CD shell layer have further quantified levels of fuel-shell mix.

• For 4-atm implosions mix decreases for increasing shell thickness.

• For 20-atm implosions mix is independent of shell thickness.

• For 27-µm thick shells mix is independent of gas fill pressure from 4 to 20 atm.

• Target performance of hydrodynamically similar $\text{D}_2$ implosions relative to 1-D predictions confirms $^3\text{He}$-CD data.
Related work

Recent related papers:

D. Wilson et al., submitted to Phys. Plasmas
S. P. Regan et al., Rev. Letters 89 (2002) 085003

Related talks at this conference:

S. P. Regan et al., BO2.002
R. Epstein et al., BO2.001
Outline

• Presence of fuel-shell mix.

• Effects of mix in spherical implosions of 20, 24 and 27 μm thick shells at various fill pressures.

• Modeling of fuel-shell mix.

• Target performance of hydrodynamically similar D₂ implosions relative to 1-D predictions.

• Summary

• Future work.
Implosions of $^3$He gas filled capsules with CD shells have further quantified levels of mix.

\[ D + ^3\text{He} \rightarrow p (14.7 \text{ MeV}) + \alpha (3.6 \text{ MeV}) \]
D$^3$He proton yield decreases as shell thickness increases.

Does increased mix explain the reduced D$^3$He yield for thicker shells?
Mix decreases for increasing shell thickness for 4-atm implosions, while mix is independent of shell thickness for 20-atm implosions.

Similar levels of mix are observed for 27-μm thick shells irrespective of fill pressure.
Modeling of fuel-shell mix

- Assume isobaric conditions at bang time.
- Match experimental results: $<T_i>_{Doppler}$, $<T_i>_{Ratio}$, $Y_{1p}$, $Y_{1n}$, $\rho R_{fuel}$, and burn time
~0.5-0.9 \( \mu \text{m} \) of original shell mixes into fuel for 4-atm implosions, while ~0.5 \( \mu \text{m} \) of shell mixes into fuel for 20-atm implosions irrespective shell thickness.
Target performance of hydrodynamically similar D$_2$ implosions relative to 1-D predictions confirms the $^3$He-CD data

3-atm implosions - mix varies with shell thickness.
15-atm implosions - mix independent of shell thickness.
The dependency of $Y_{2p}/Y_{1n}$ relative to 1-D for D$_2$ implosions also confirms the $^3$He-CD data.

3-atm implosions - mix varies with shell thickness.
15-atm implosions - mix independent of shell thickness.
Summary

- Implosions of pure $^3$He gas filled capsules with CD shell layer have further quantified levels of fuel-shell mix.
- For 4-atm implosions mix decreases for increasing shell thickness.
- For 20-atm implosions mix is independent of shell thickness.
- For 27-$\mu$m thick shells mix is independent of gas fill pressure from 4 to 20 atm.
- Target performance of hydrodynamically similar D$_2$ implosions relative to 1-D predictions confirms $^3$He-CD data.
Future work

• Study fuel-shell mix for different laser-pulse shapes.

• Study time resolved fuel-shell mix using a proton temporal diagnostic (PTD), which is now under development.