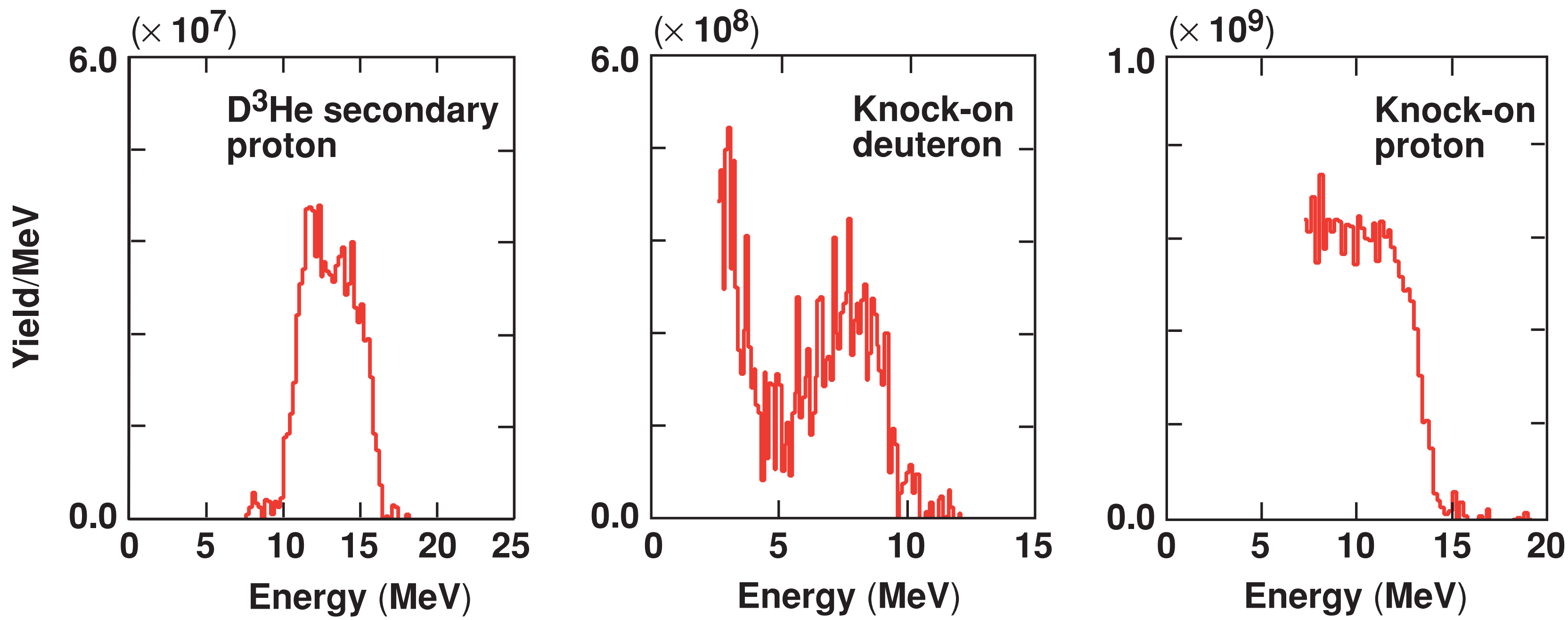
Effects of Fuel–Shell Mix upon Direct-Drive Spherical Implosions on OMEGA



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Summary

Fuel–shell mix and its relationship to target performance of direct-drive implosions on OMEGA are systematically studied using nuclear diagnostics

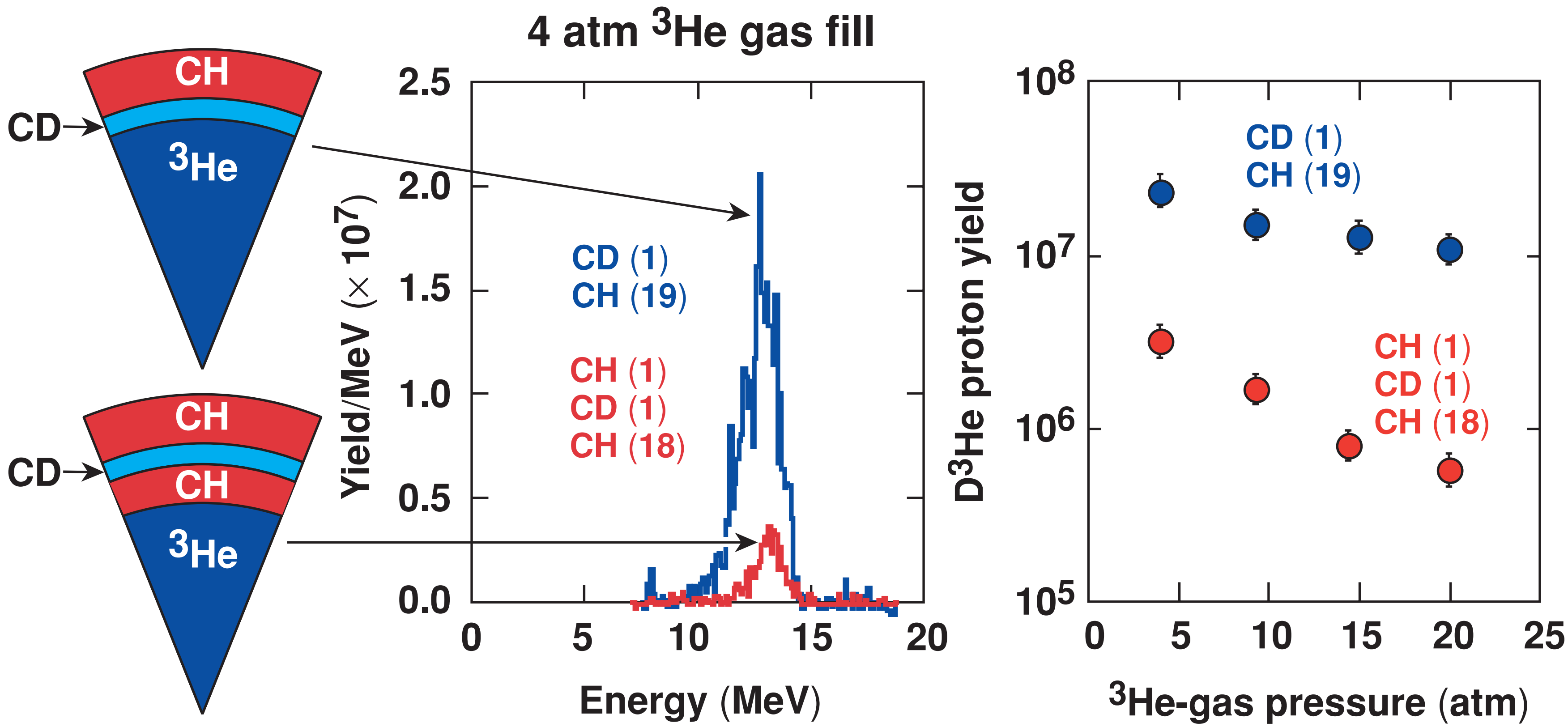
- Implosions of pure ^{3}He gas capsules with CD shell layer demonstrate the existence of fuel–shell mix and its extent.
- Convergence ratios (CR) of ~11 were obtained irrespective of fill pressures from 3 to 15 atm.
- Target performance degradations relative to 1-D predictions were demonstrated to be strongly correlated with mix.
- The implications of the mix effects are less serious for cryogenic targets (including future ignition targets) because of less cooling by bremsstrahlung and no dilution of fuel.

Outline

- Presence of fuel–shell mix
- Effects of mix upon spherical implosions
- Modeling of mix with a simple static model
- Implication of mix for cryogenic targets

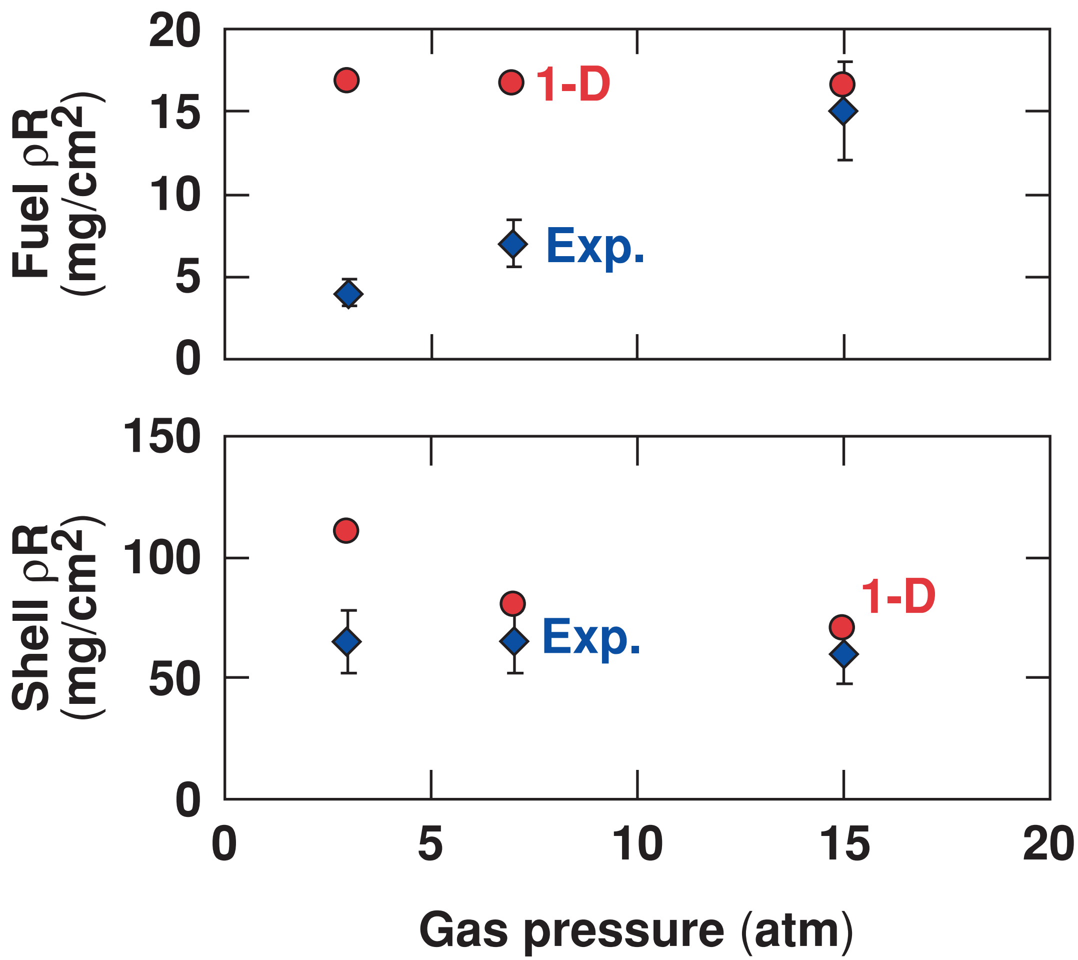
The increasing D^3He yield with decreasing fill pressure suggests more-severe mix with lower fill pressures

- The D^3He yield increases as the gas-fill pressure decreases (indication of more mixing) and falls off rapidly as the CD layer is offset from the ^3He fuel.



E11195

Implosions of 15-atm capsules achieve ~85% of 1-D predictions for both ρR_{fuel} and ρR_{shell}, while 3-atm capsules achieve ~25% for ρR_{fuel} and ~60% for ρR_{shell}



E11124

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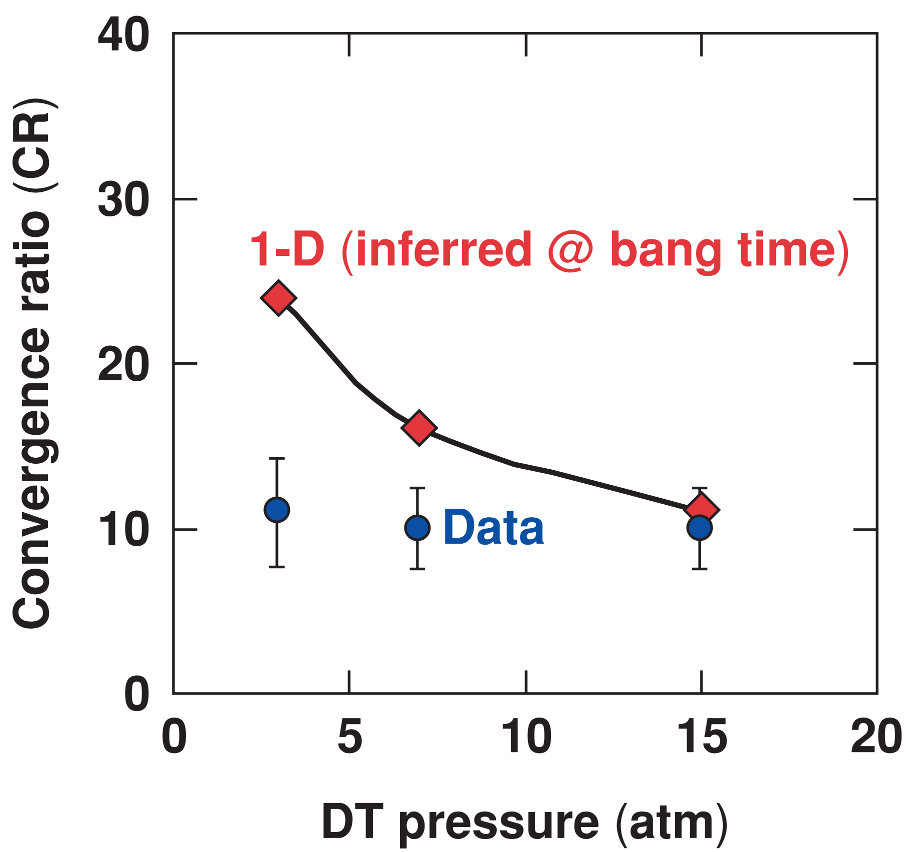
While 1-D simulations predict high convergence ratios for 3-atm capsule implosions (CR ~ 25), the implosions achieve ~45% of 1-D predicted values (CR ~ 11, similar to the 15-atm case)



CR is determined by either ρR_{fuel} or ρR_{shell} measurements:

Fuel

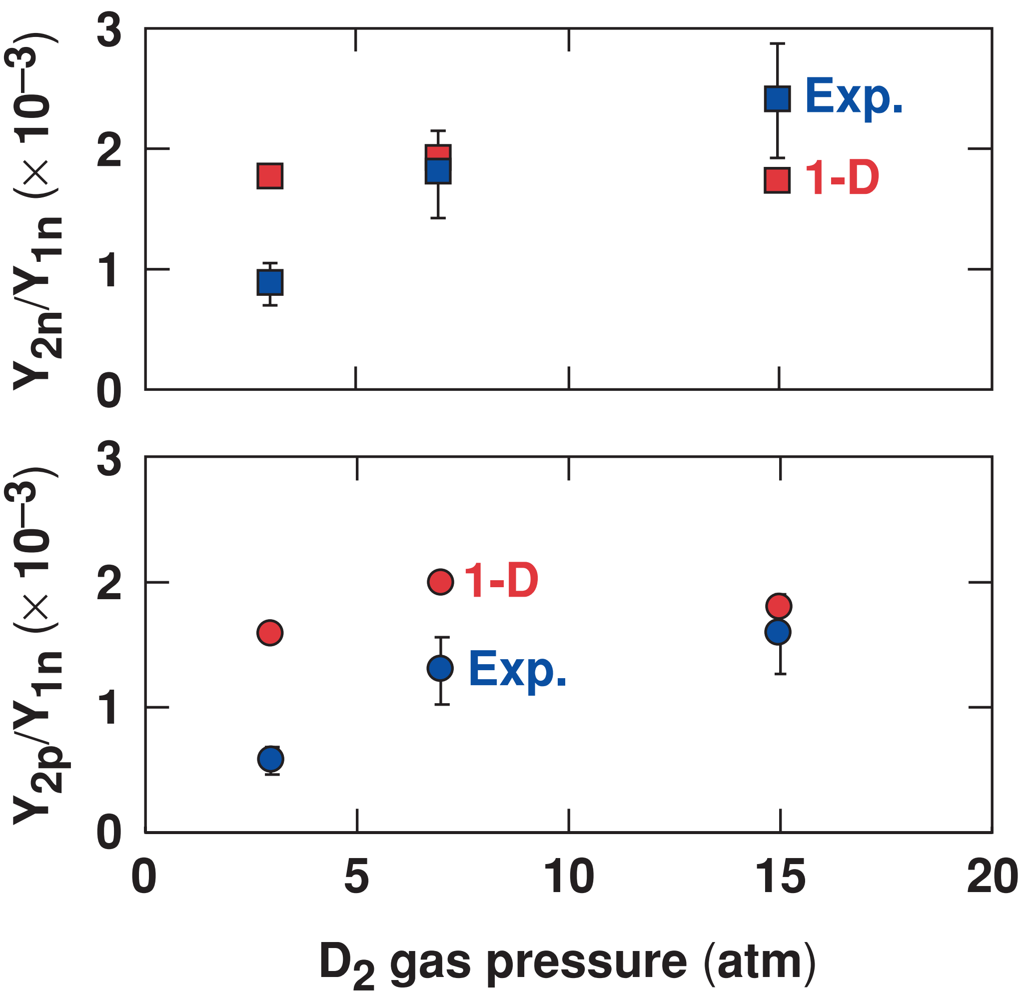
$$CR = \sqrt{(\rho R_{fuel}/\rho R_{fi})}$$

Shell

$$CR = \sqrt{3(\rho \Delta R_{shell}/\rho \Delta R_{si})}$$

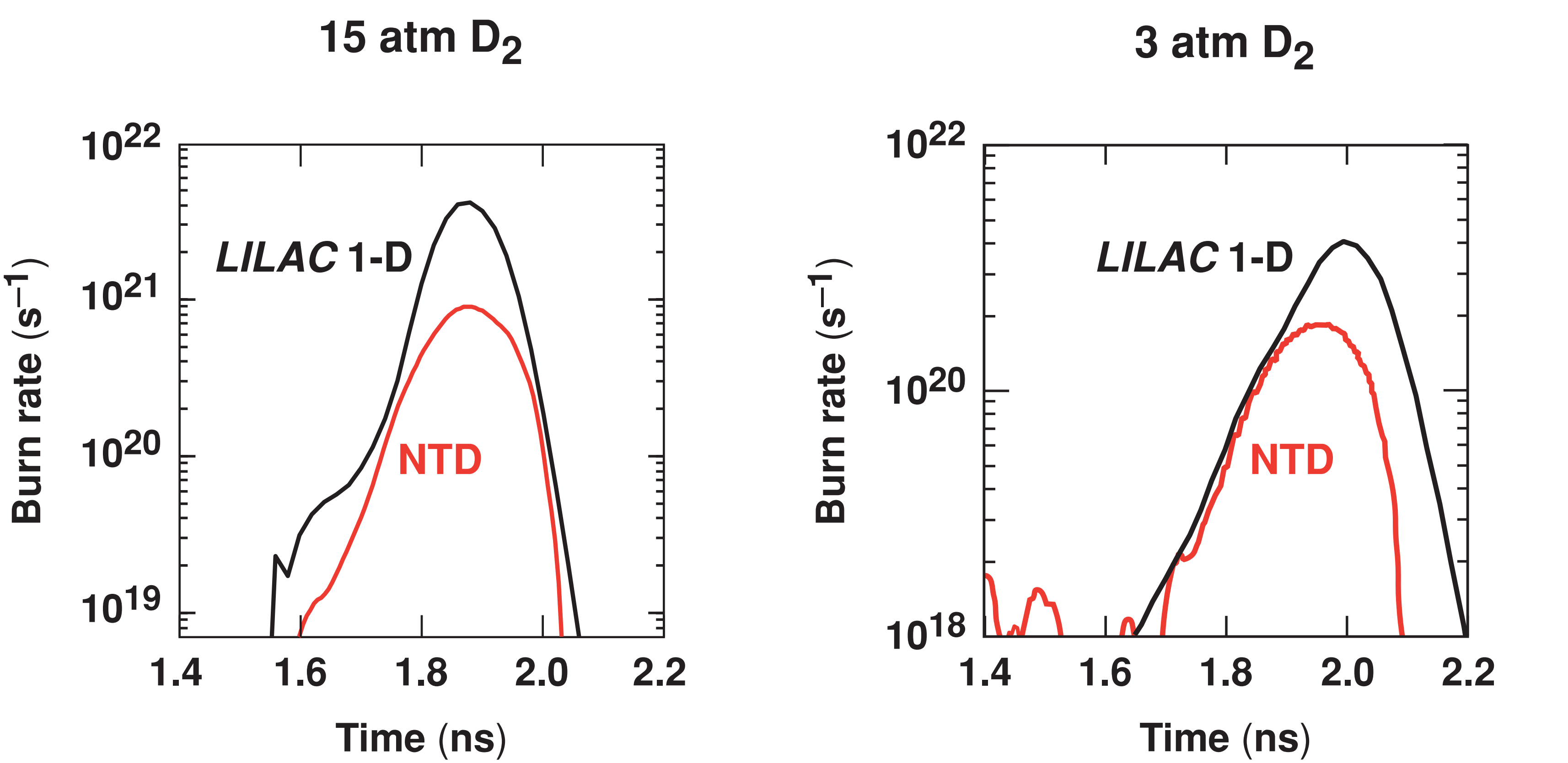
E11125

The ratios (Y_{2n}/Y_{1n}, Y_{2p}/Y_{1n}) indicate that mix is more severe for 3-atm implosions



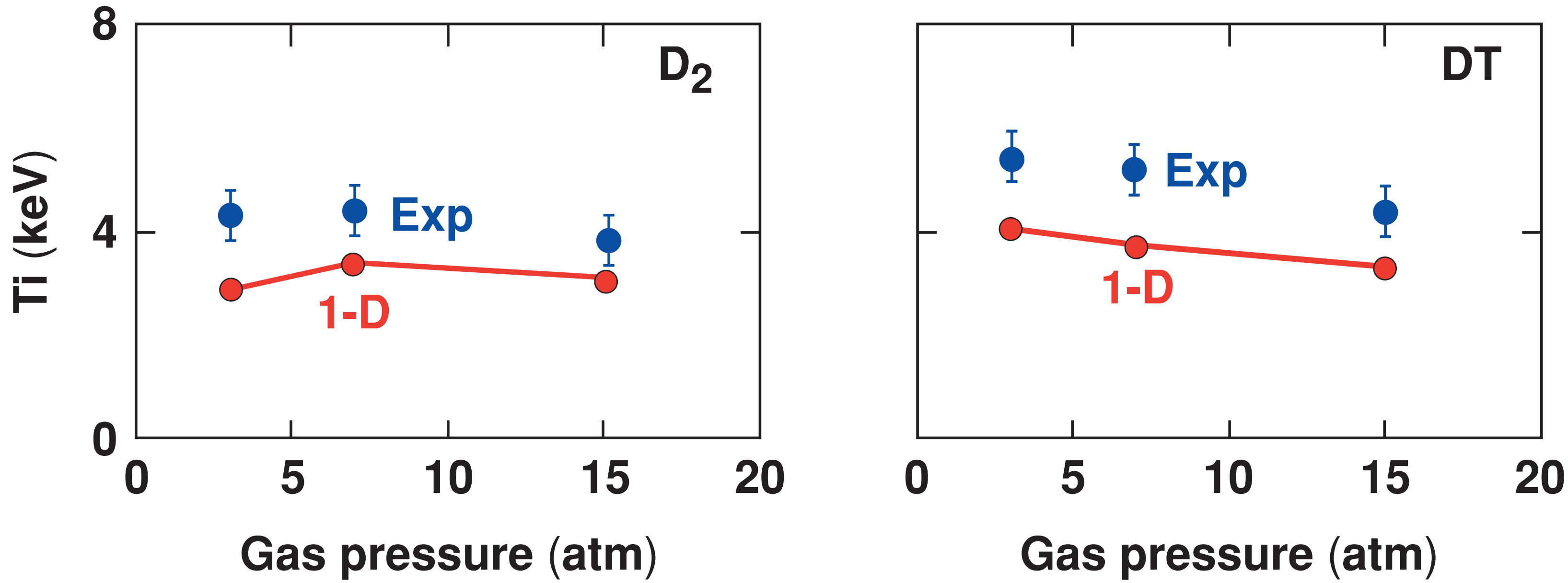
E11123

Experiments with a 1-ns square laser pulse show no truncation of burn for 15-atm implosions, but ~20% truncation of burn for 3-atm implosions



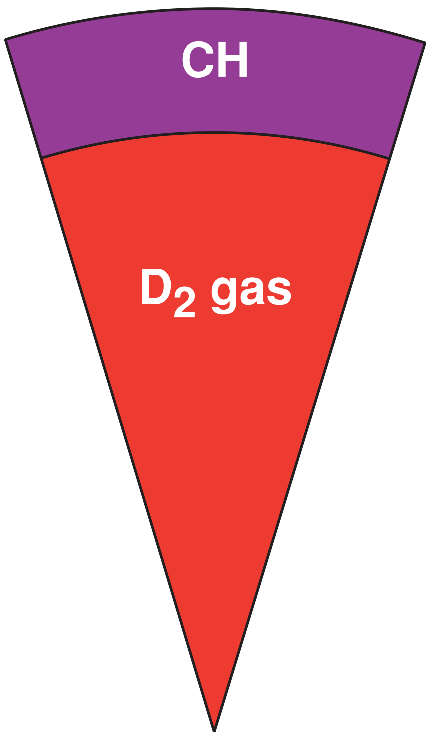
E11751

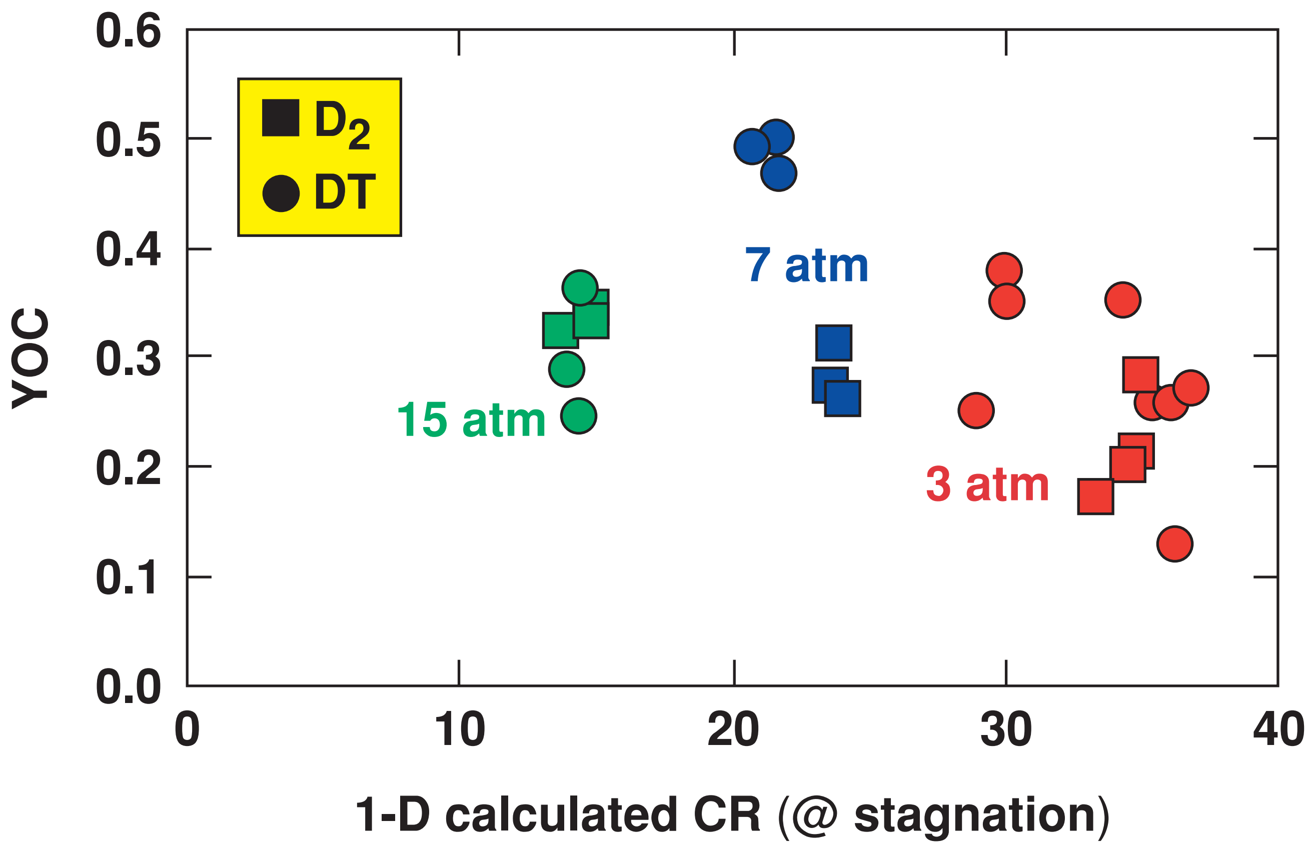
The measured ion temperatures (yield averaged) are generally higher than 1-D predictions



E11427a

The overall core performances are characterized by comparisons between the experimental data and the 1-D calculations





E11194

More fuel–shell mix is inferred for 3-atm implosions

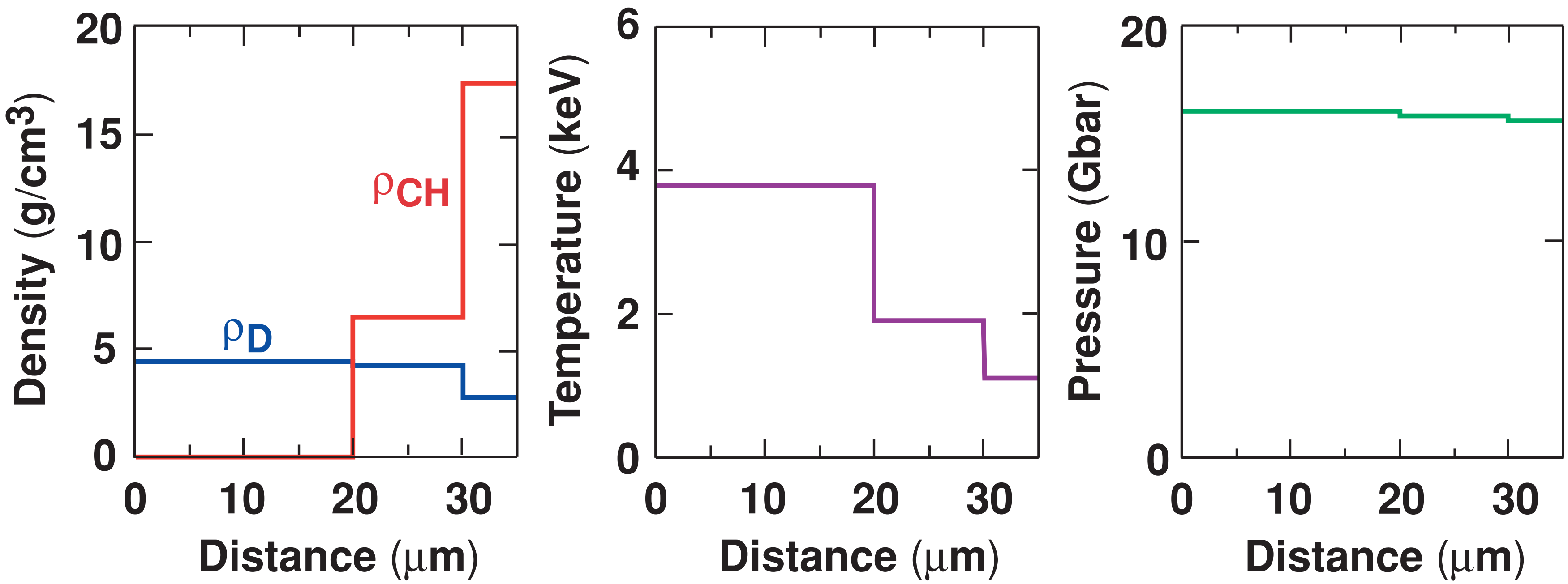
$$Y_n \approx \frac{4\pi}{3} R_b^3 n^2 <\sigma v> t_b \propto \left(\frac{R_b}{R}\right)^3 (CR)^3\, T_i^m t_b$$

15-atm implosions: $\frac{R_b}{R} \sim 0.65$ Outer core

3-atm implosions: $\frac{R_b}{R} \sim 1$ Entire core

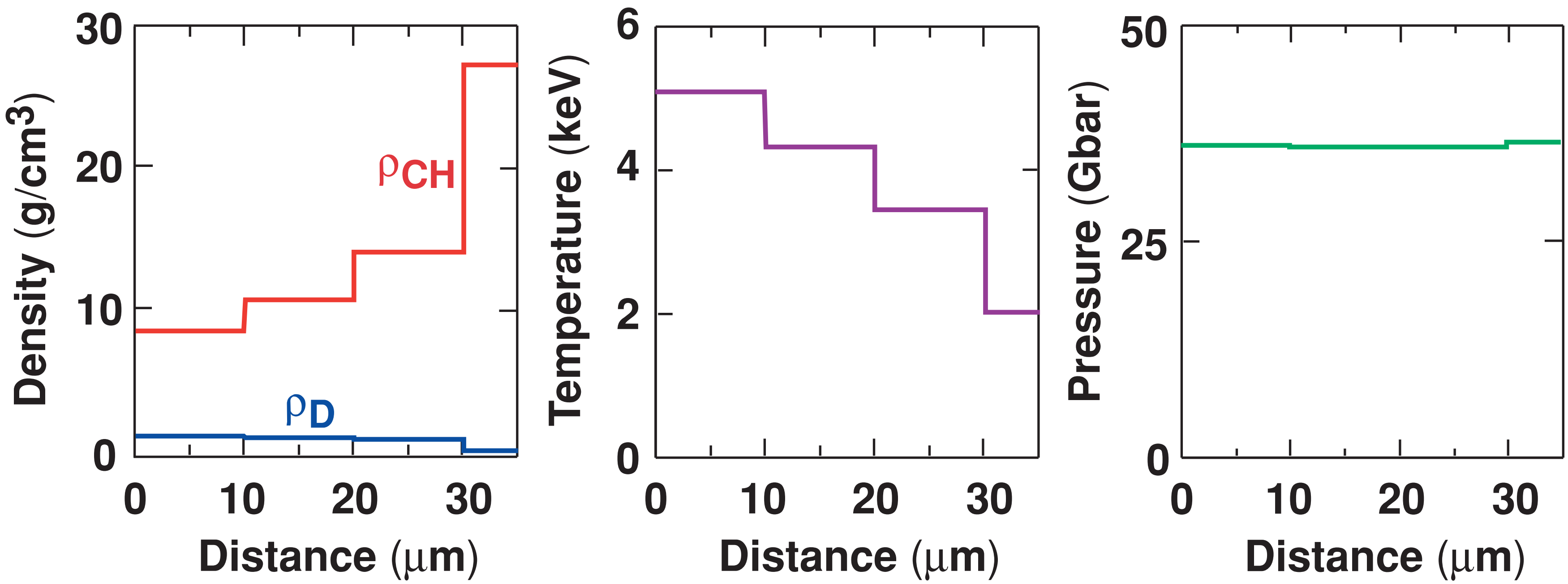
E11784

Modeling of 15-atm implosions indicates that ~0.5 μm of the original inner CH shell mixes into the outer part of the fuel



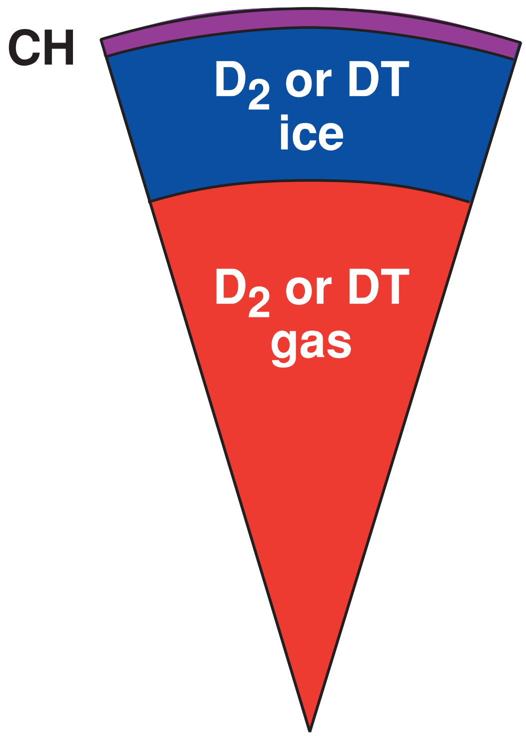
E11129

Modeling of 3-atm implosions indicates that ~0.9 μm of the original inner CH shell mixes into the entire core



E11130

The implications of the mix effects are less serious for cryogenic targets (including future ignition targets)



D_2 or DT "shell" instead of CH shell

- Mix doesn't dilute fuel (fuel and "shell" are same material)
- Lower Z results in less cooling by bremsstrahlung (Z = 1 instead of Z = 3.5)

Summary/Conclusion

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