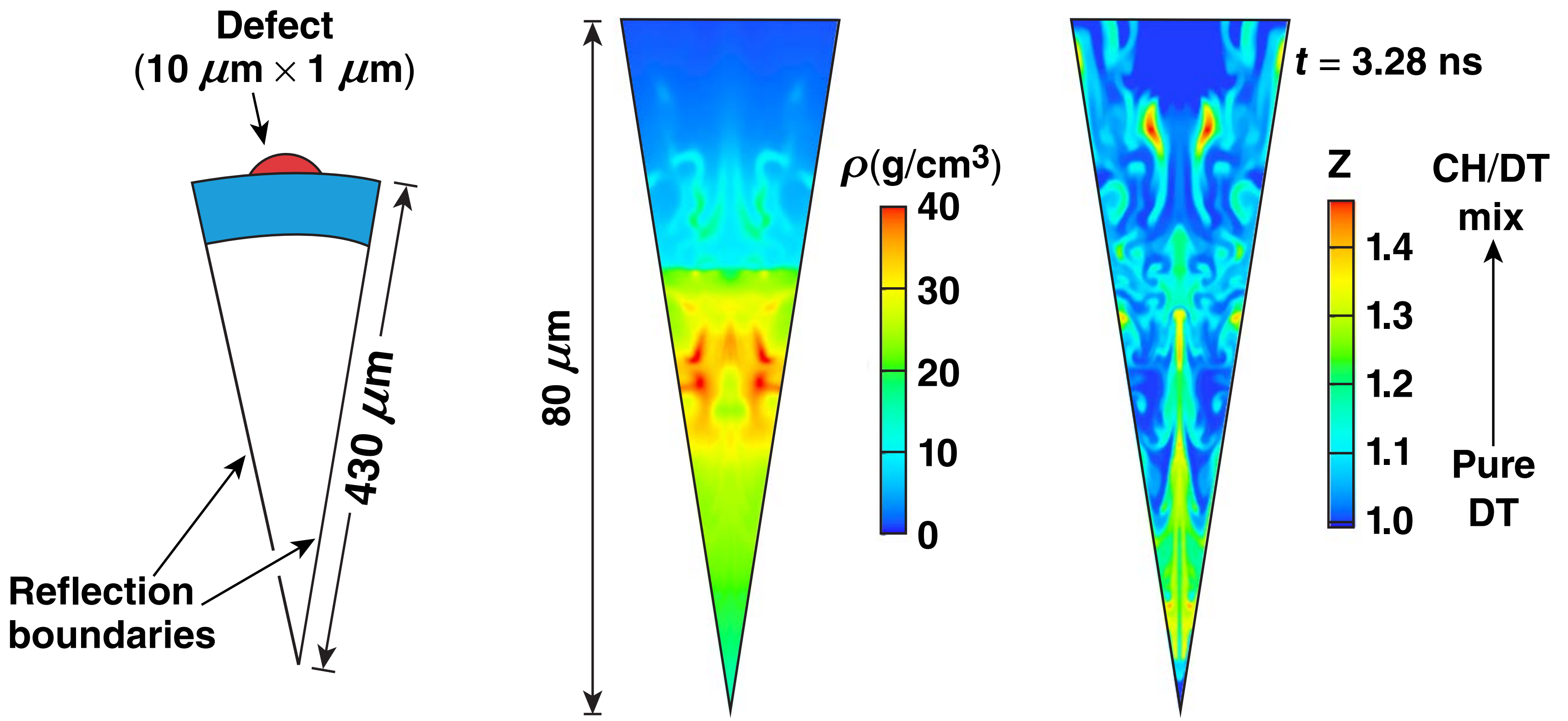
Fuel–Ablator Mix from Surface Nonuniformities in Directly Driven Implosions

Cryogenic target implosion with surface defects



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Summary

Fuel–ablator mix induced by surface defects limits the performance of low-adiabat cryogenic implosions on OMEGA

- Pre-shot evaluation of cryogenic targets typically reveals a significant number (from several tens to hundreds) of surface debris/condensates with the dimensions from <1 μm and up to 50 μm*
- 2-D hydrodynamic simulations show that such defects can develop perturbations, which produce holes in implosion shells and result in injection of ablator inside targets
- Predicted performance of low-adiabat (α < 2.5)** OMEGA implosions with fuel–ablator mix in the core is consistent with measurements

*T. C. Sangster, N12.00002, this conference.
**α is the ratio of the gas pressure to Fermi degenerated pressure

TC10302

Collaborators

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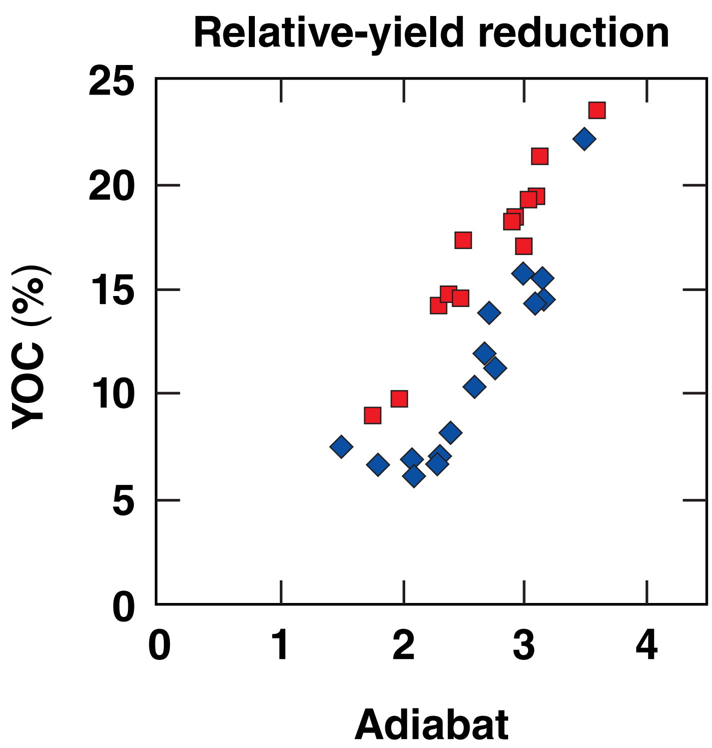
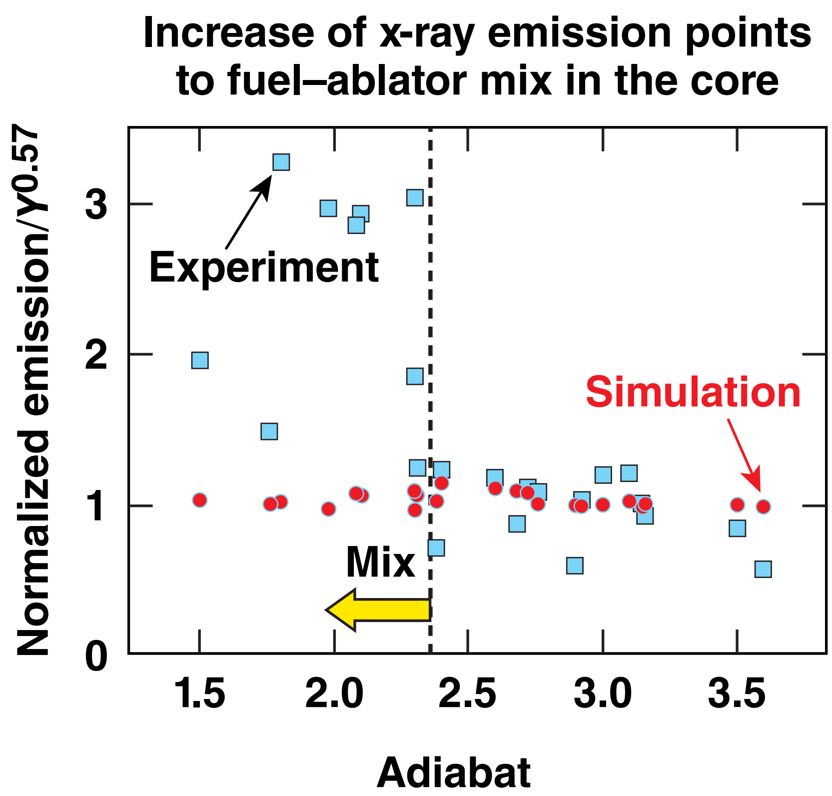
Low-adiabat ($\alpha < 2.5$) cryogenic OMEGA implosions consistently underperform with respect to 1-D predictions*





Outer surface defects most probably cause the performance degradation.

TC10380

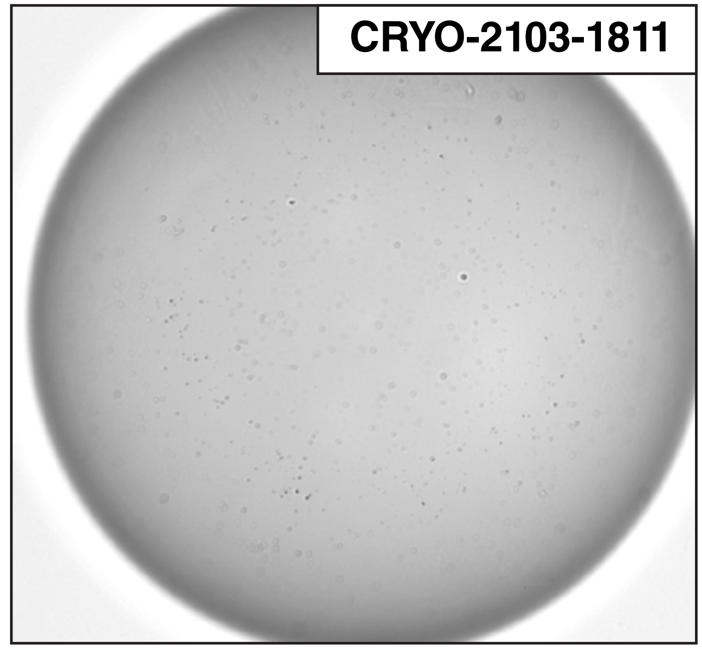
*V. N. Goncharov, JO4.00002, this conference.

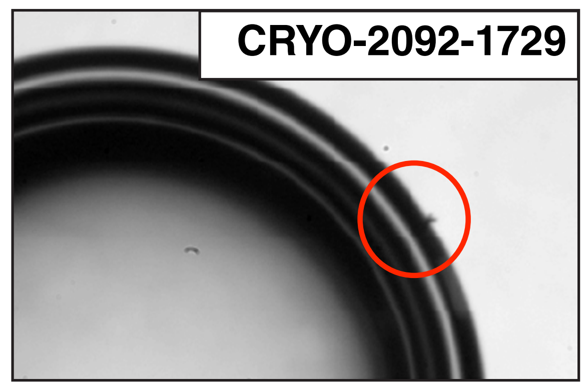
Various surface defects in cryogenic targets are developed during manufacturing/ice-shell forming process

Most-damaging defects:

Condensates	Radiolytic CH_4, N_2, ... Diameter ~20 μm, h >3 μm
Debris	Particles (Al, Mo,...) Diameter <1 μm to ~50 μm

- Several tens to hundreds of defects are typically observed
- Submicron defects are not observable, but can be damaging

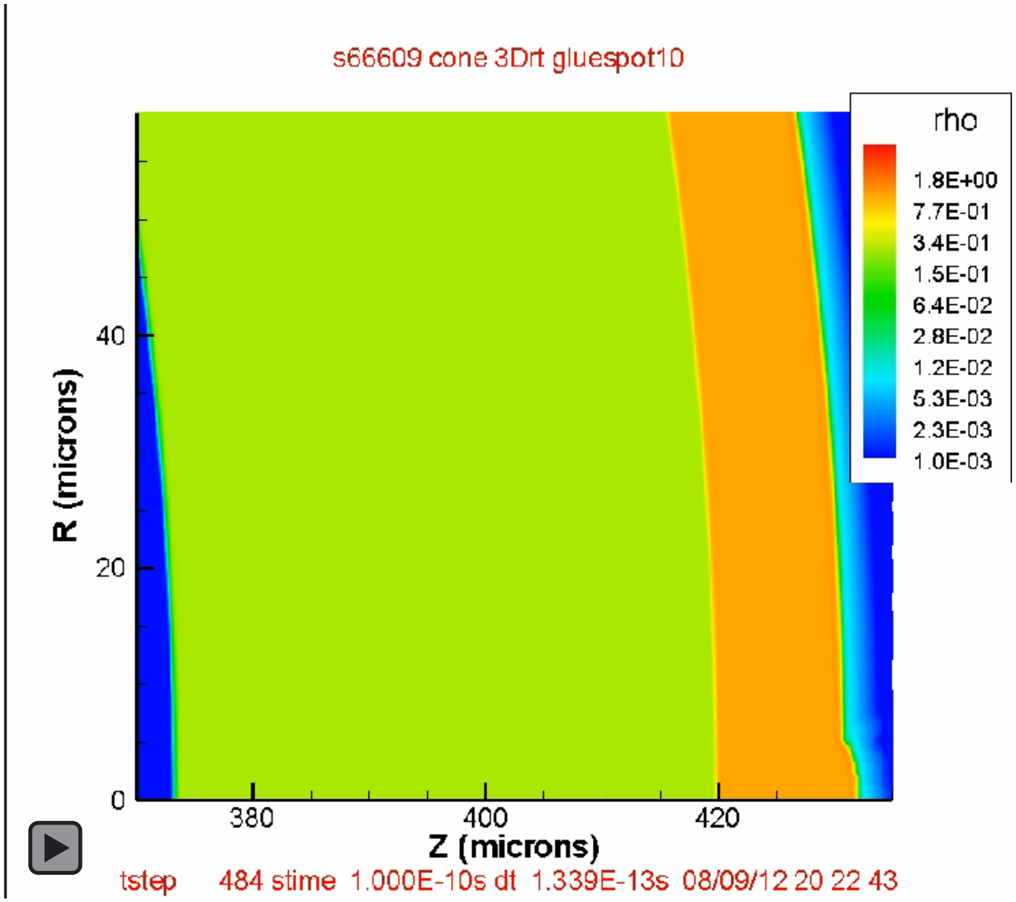




TC10304

~10-μm-size surface defects can result in injection of ablator inside implosion targets

Cryogenic target with a surface spot (10 μm × 1 μm)

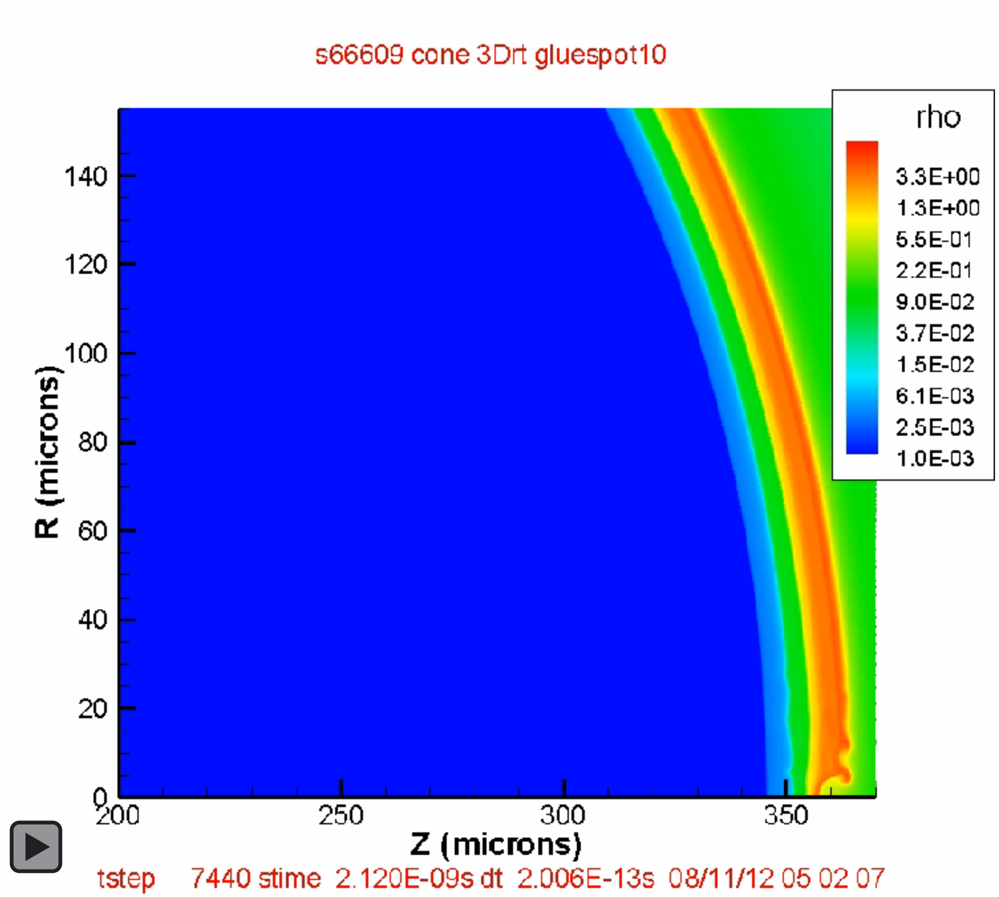


- **Earlier time evolution shows perturbations in shocks***

*T. R. Boehly, JO4.00014, this conference.

~10-μm-size surface defects can result in injection of ablator inside implosion targets (continued)

Cryogenic target with a surface spot (10 μm × 1 μm)



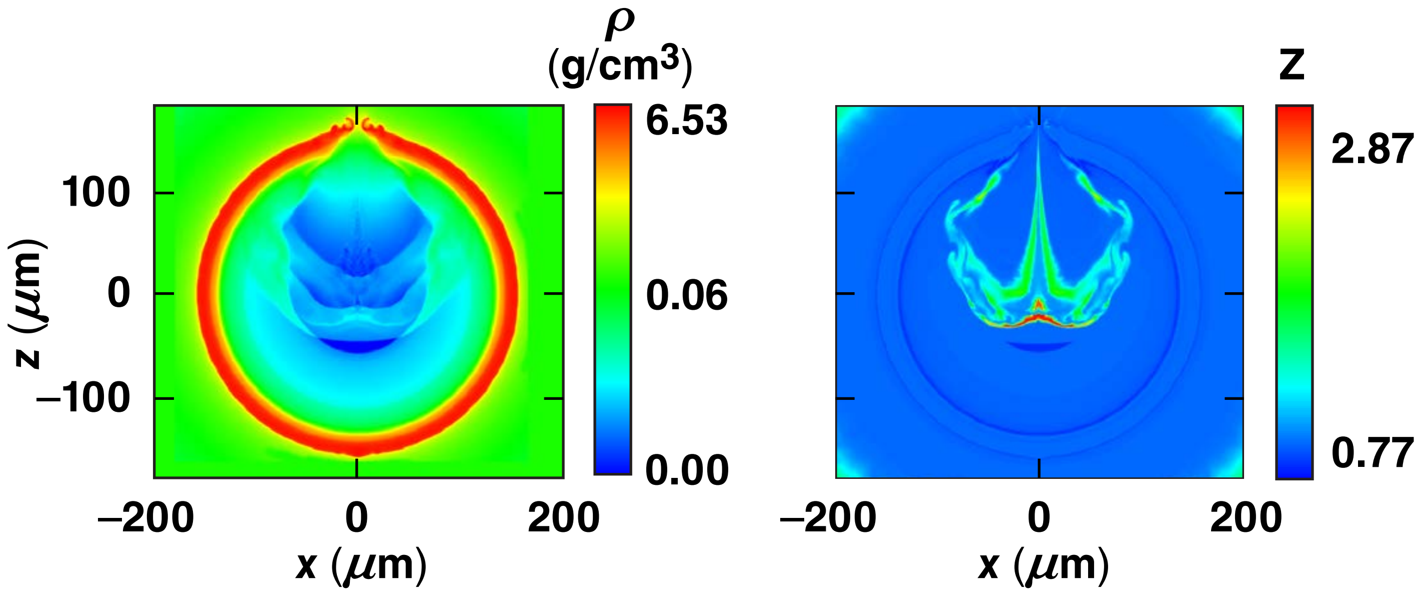
- **Hole is developed in the accelerated shell**
- **Ablator material is injected inside**

TC10384

Significant perturbations of target shells and interior are predicted from one defect

Cryogenic target with a single 20-μm-diam defect

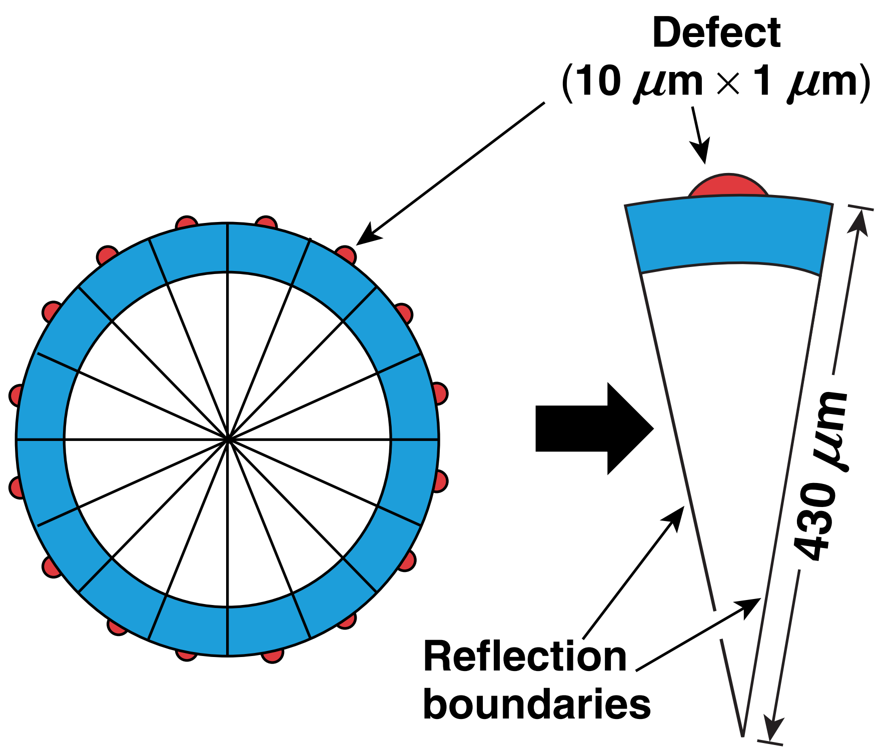
at t = 3.8 ns (end of pulse)



- Ablator material is driven through the hole by the ablation pressure
- Self-generated magnetic fields enhance the injection

TC10306

Two-dimensional simulations in a narrow cone mimic the large number of debris/condensates in real implosions

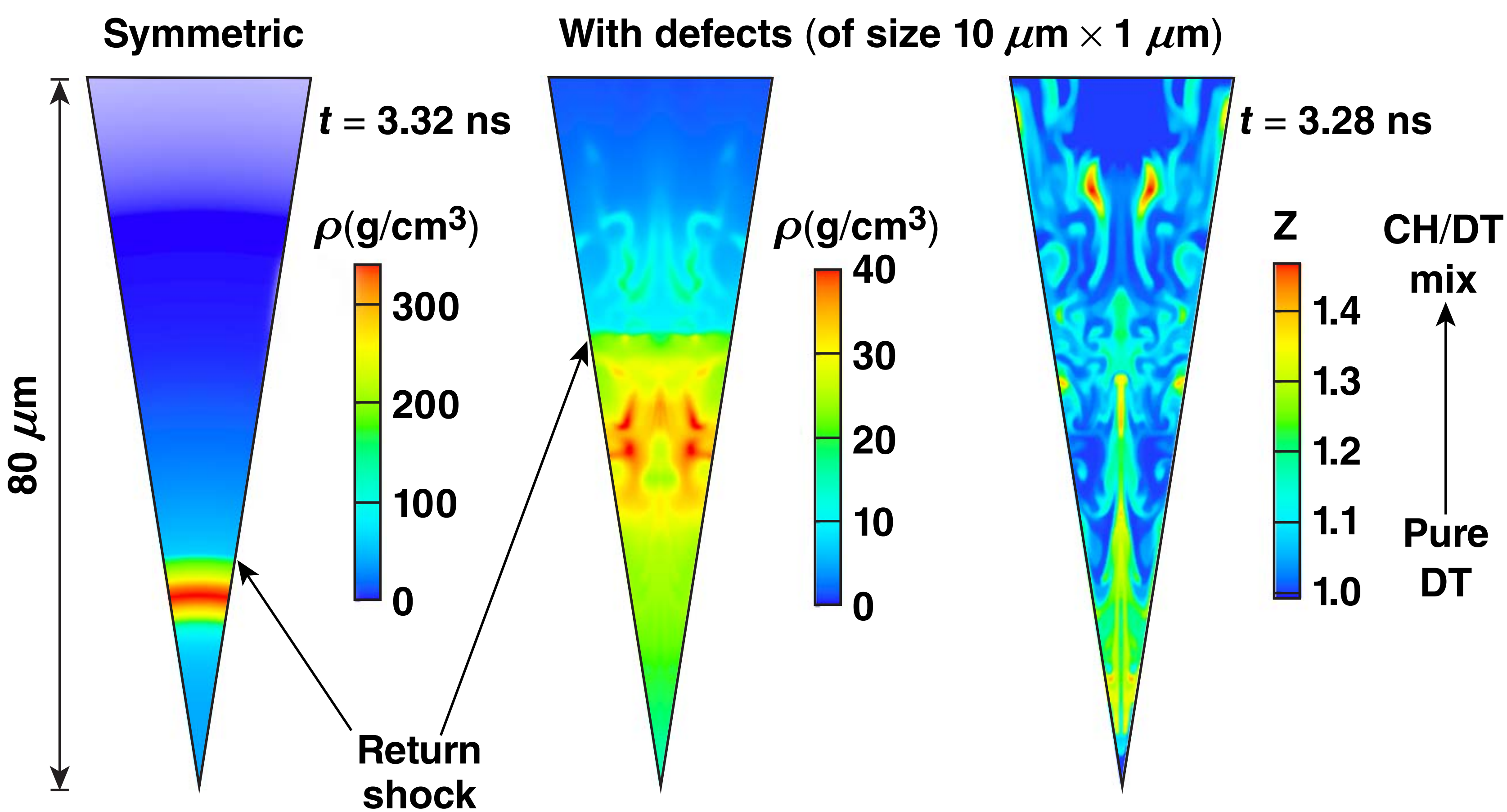


- Effect of multiple defects is accounted using reflection boundaries
- Assumed cone angle $\pi/10$ (~150 surface defects)
- 3-D effects caused by different defect sizes and placements are not addressed

TC10307

Simulations of low-adiabat ($\alpha < 2.5$) implosions with multiple defects show significant fuel–ablator mix in the core

Simulated implosion (OMEGA shot 66613) at peak neutron production



- The broken shell stagnates at a larger radius → reduced ρR
- Radiative cooling reduces T_i in the mixed core

TC10308

Predicted performance of low-adiabat implosions with fuel–ablator mix is consistent with measurements

Shot 66613	Neutron yield	ρR (mg/cm^2)	T_i (keV)
Experiment	5.5×10^{12}	130	2.2
Simulations/symmetric	1.0×10^{14}	324	3.18
Simulations/defects	3.1×10^{12}	120	2.38

- Simulations of five different low-adiabat ($\alpha \sim 2$) implosions with defects show similar agreements

Summary/Conclusions

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