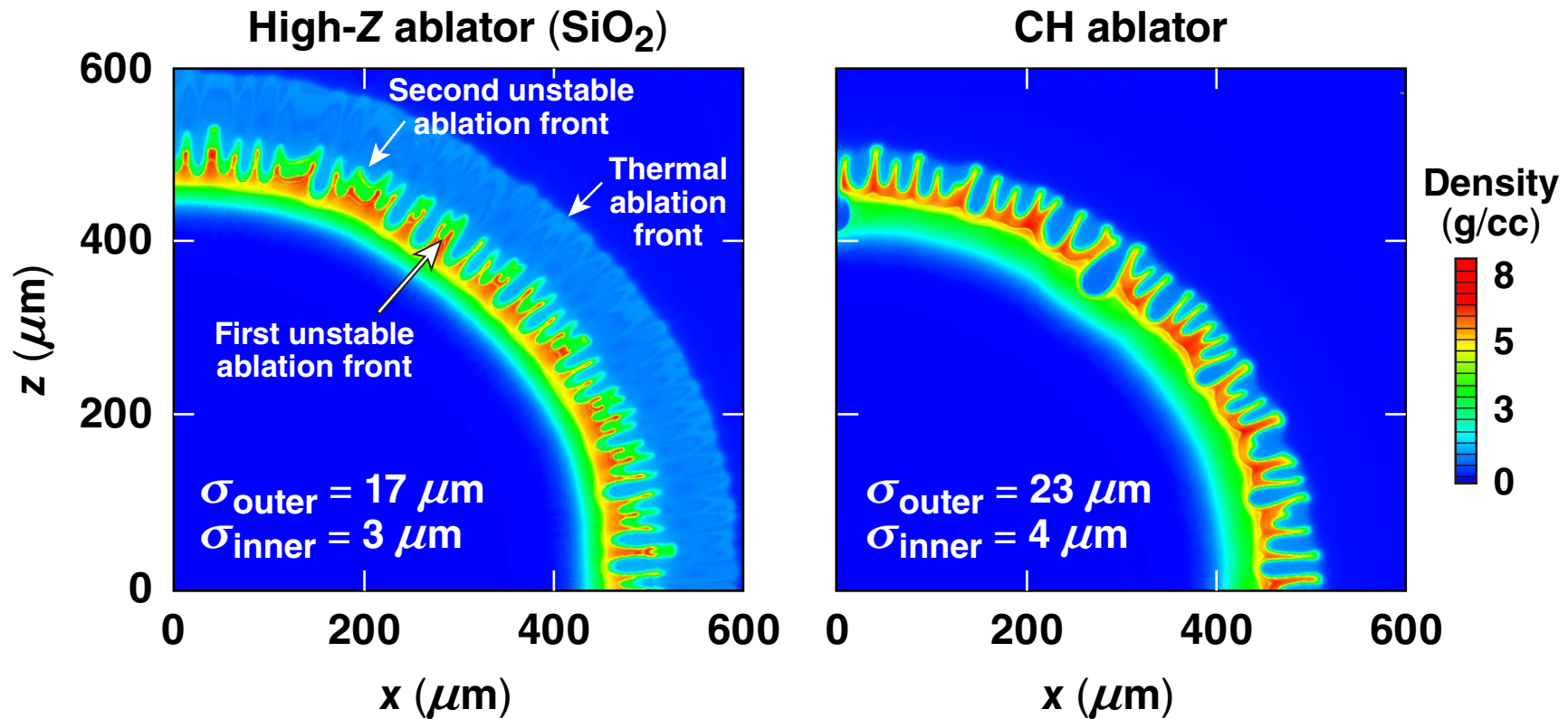


Hydrodynamic Stability of Direct-Drive Targets with High-Z Ablators



Summary

The use of high-Z ablators in direct-drive implosions is promising



- **Cryogenic targets using ablators with a Z higher than plastic have higher two-plasmon–decay (TPD) intensity thresholds, decreasing the shell preheat caused by hot electrons**
- **Hydrodynamic simulations using ablators ranging from carbon to silicon show similar Rayleigh–Taylor (RT) instability growth**
- **A multilayer target, designed for sub-MJ shock ignition on the NIF, employs a graded-Z ablator and exhibits slightly improved stability in comparison with plastic-ablator targets**

Collaborators



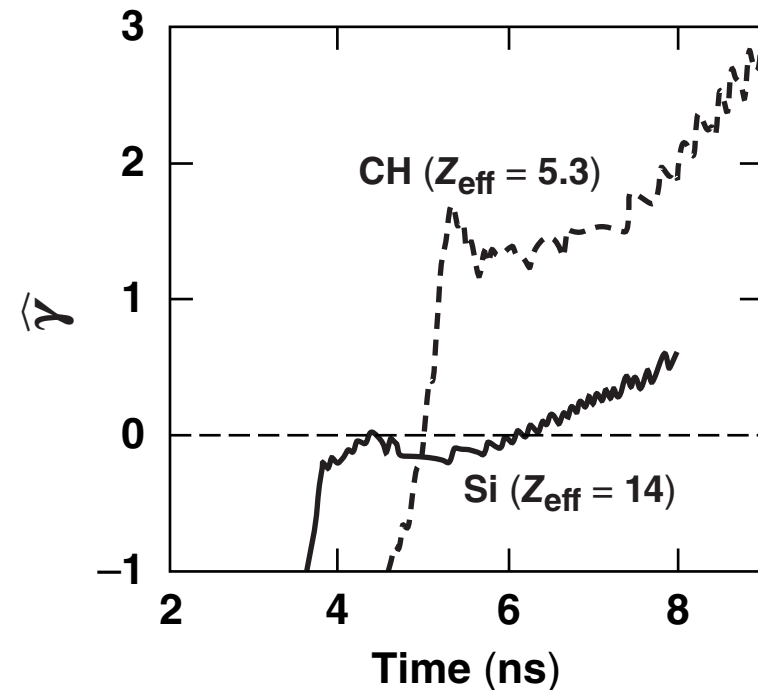
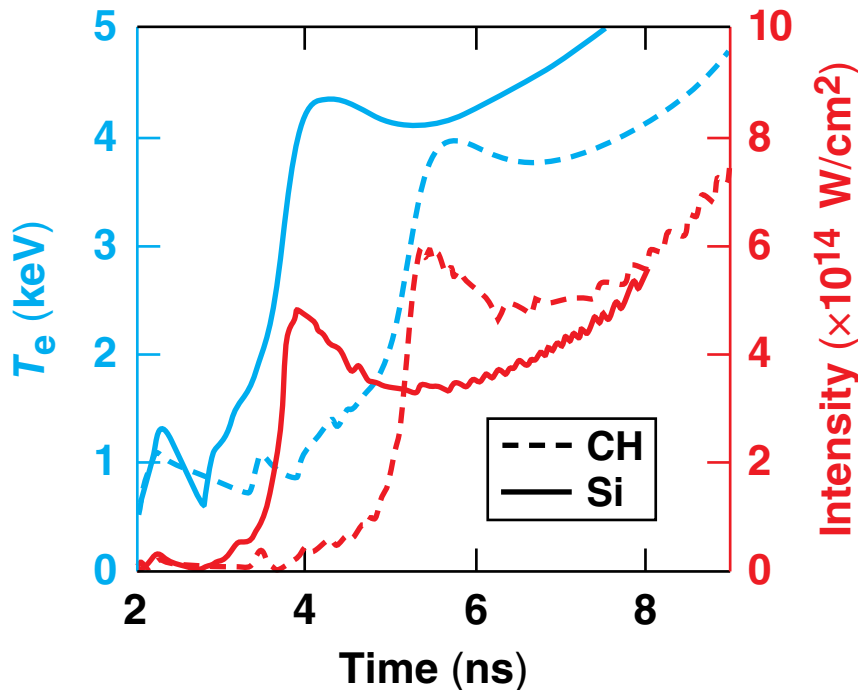
R. Nora[†], K. S. Anderson, and R. Betti[†]

**Laboratory for Laser Energetics
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[†]also Fusion Science Center for Extreme States of Matter

High-Z ablatators are expected to reduce the hot-electron preheat caused by TPD instability

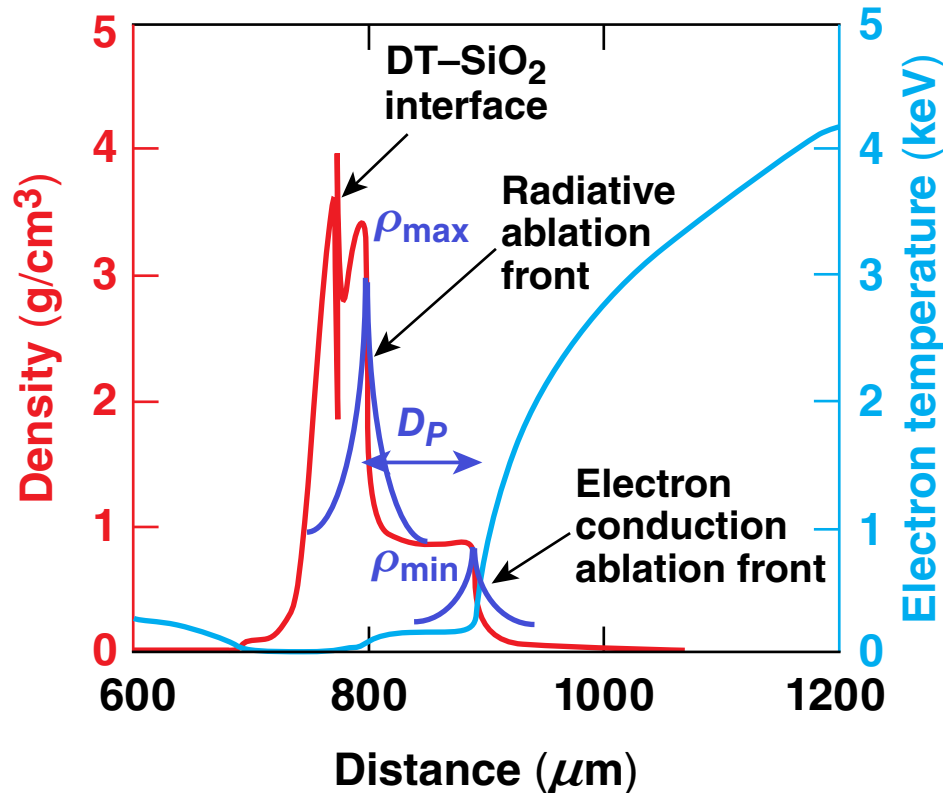
- The TPD growth rate* is $\hat{\gamma} = \frac{L_{\mu\text{m}} I_{14}}{230 T_{\text{keV}}} - 1 - \frac{0.3 Z_{\text{eff}} L_{\mu\text{m}} \sqrt{I_{14}}}{230 T_{\text{keV}}^{5/2}}$



High-Z materials increase the intensity threshold of the TPD instability.

*A. Simon *et al.*, Phys. Fluids **26**, 3107 (1983).
R. Betti, JO4.00005, this conference.
J. Myatt, TO5.00005, this conference.

High-Z ablator targets exhibit a double ablation front* and a classical interface



- Modulations of density grow exponentially with a linear growth rate** given by

$$\gamma_{RT} = \sqrt{\frac{A_T k g}{1 + A_T k L}} - 3 k V_a$$

$$\text{with } A_T = \frac{\rho_{max} - \rho_{min}}{\rho_{max} + \rho_{min}}$$

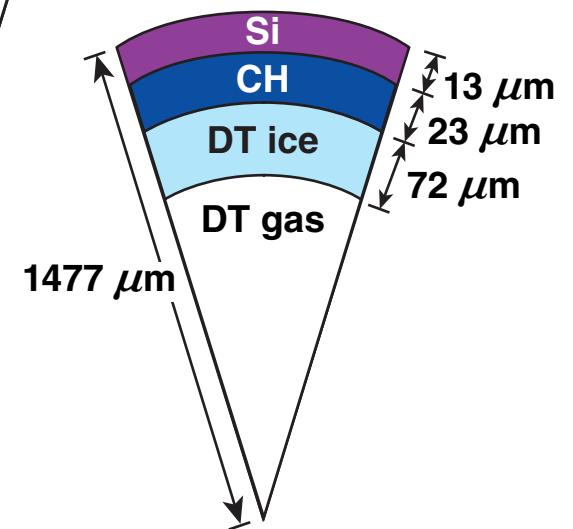
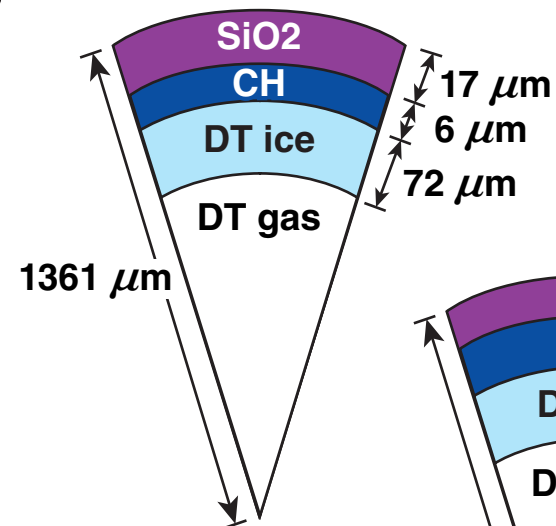
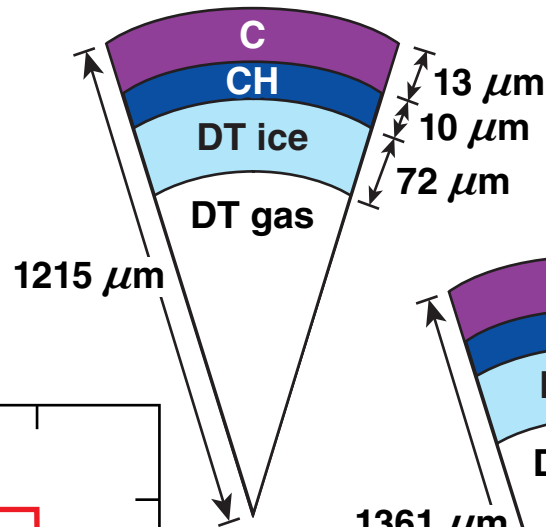
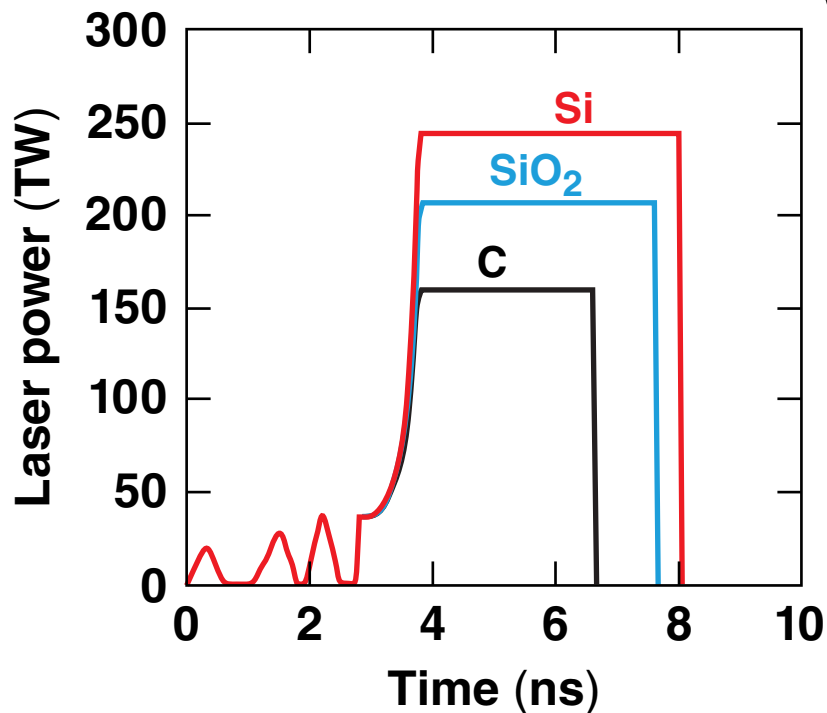
- The thermal front is almost fully stabilized by mass ablation
- The RT instability grows almost classically at the radiative front and the DT-SiO₂ interface

*S. Fujioka *et al.*, Phys. Plasmas **11**, 2814 (2004).

H. Takabe *et al.*, Phys. Fluids **28, 3676 (1985).

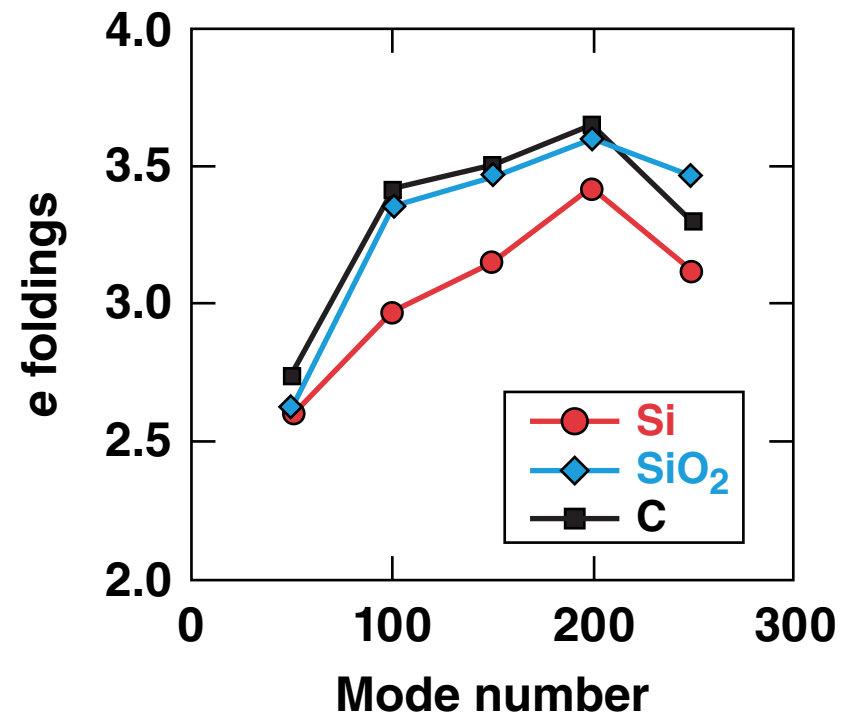
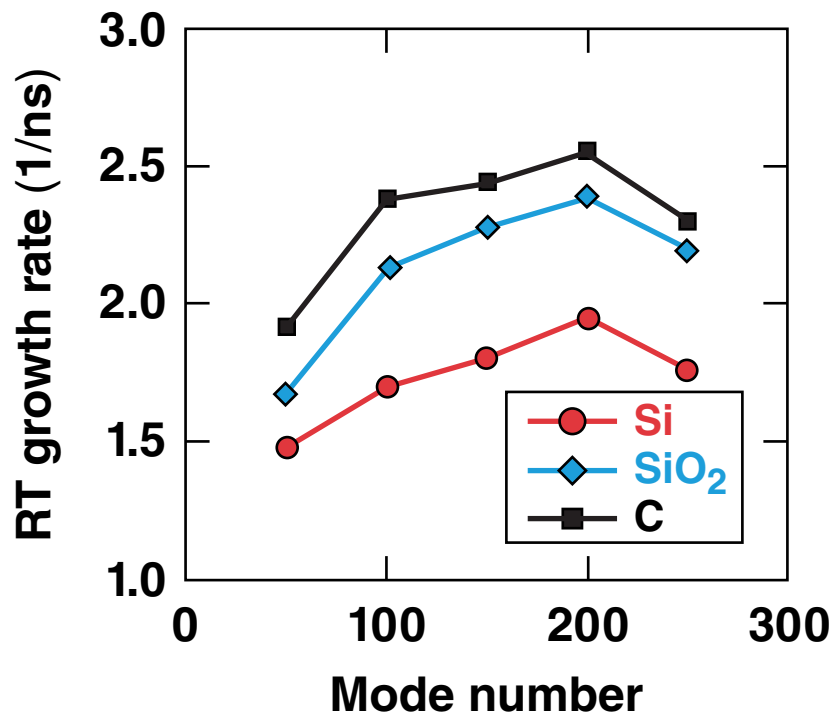
Hydrodynamic stability is studied for different high-Z ablaters ranging from carbon to silicon

Peak laser intensity:
 $9 \times 10^{14} \text{ W/cm}^2$
 $V_{\text{imp}} = 390 \text{ km/s}$
 $\alpha \sim 2.5$



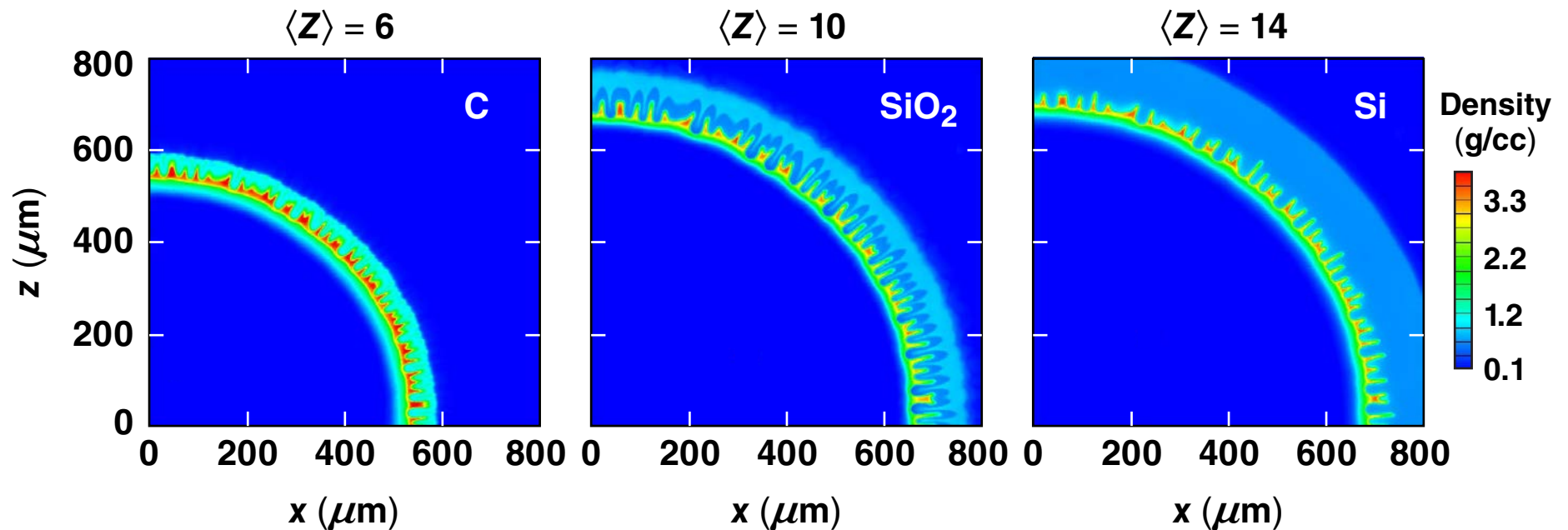
Single-mode simulations show a slightly lower RT instability growth factor for high-Z ablaters

- During the linear phase, the RT instability grows as $e^{\gamma t}$, where γ is the growth rate and γt is the number of e foldings



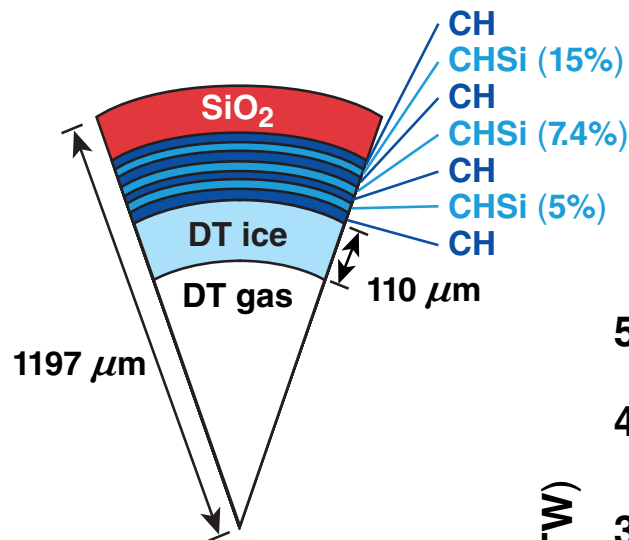
High-Z ablaters exhibit similar perturbations of the shell during the acceleration phase

Imprint simulations with $\ell < 200$ at $R = R_0/2$

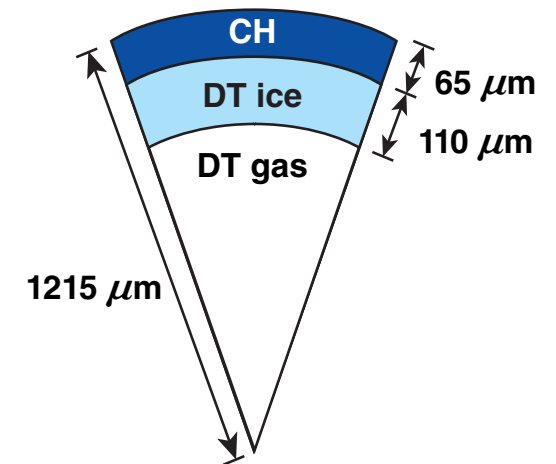
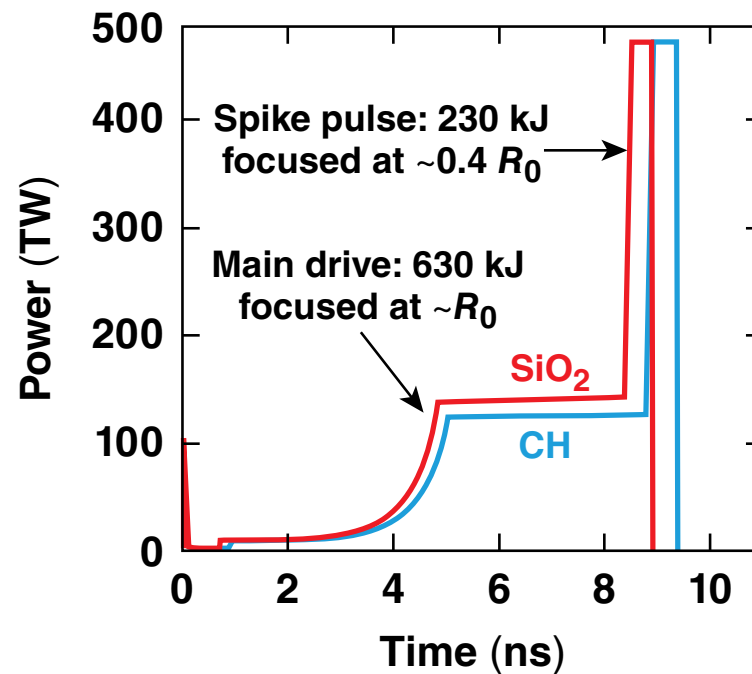


- The plateau length D_P is longer for higher-Z material
- High- ℓ modes develop at the radiative front

A high-Z ablator target has been designed for shock ignition on the NIF at sub-MJ energies

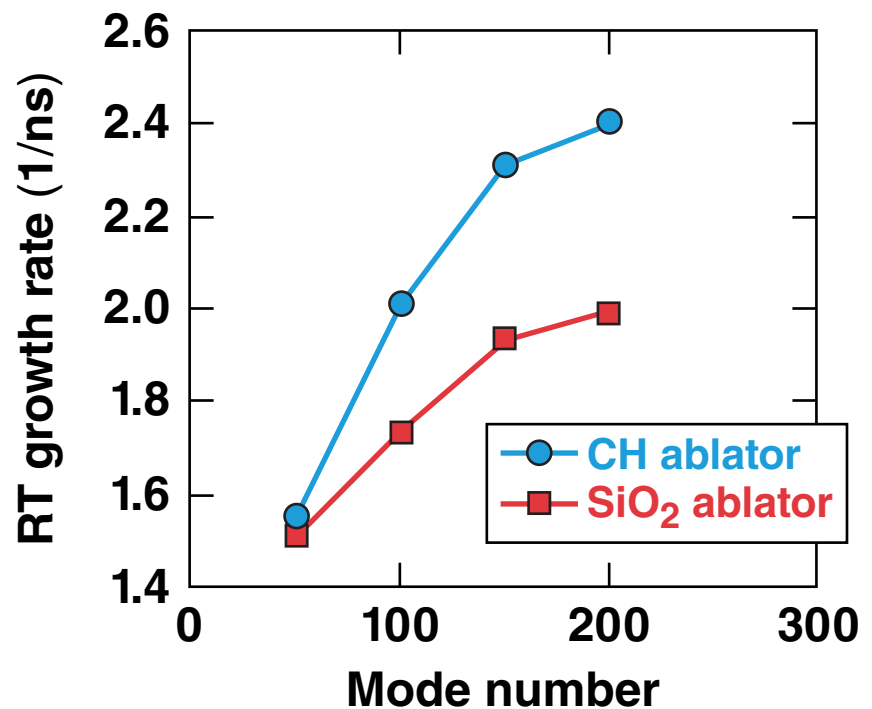
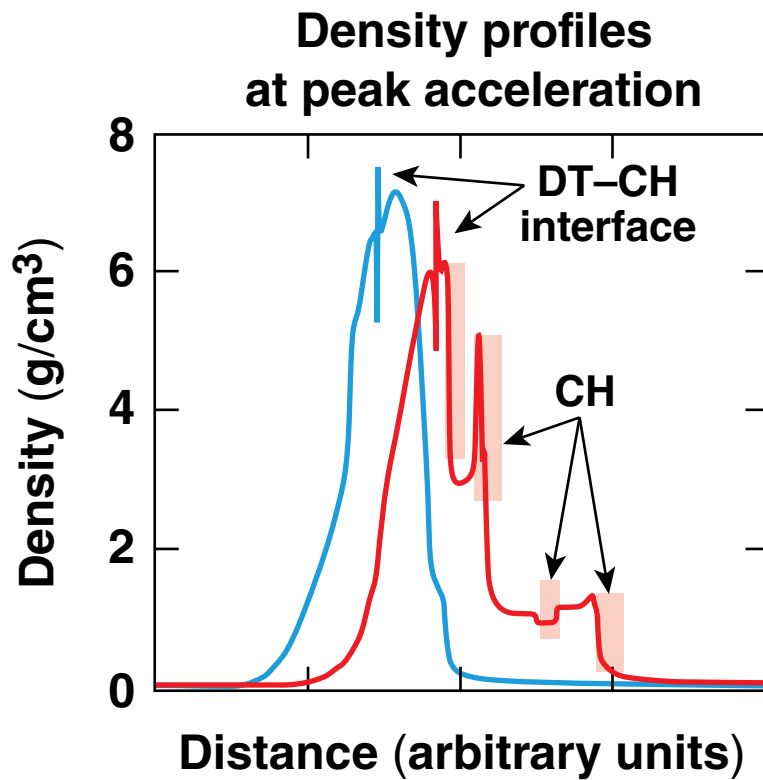


Gain (1-D)	62
V_{imp} (km/s)	260
Adiabat	1.4
IFAR _{2/3}	23



Gain (1-D)	64
V_{imp} (km/s)	262
Adiabat	1.3
IFAR _{2/3}	28

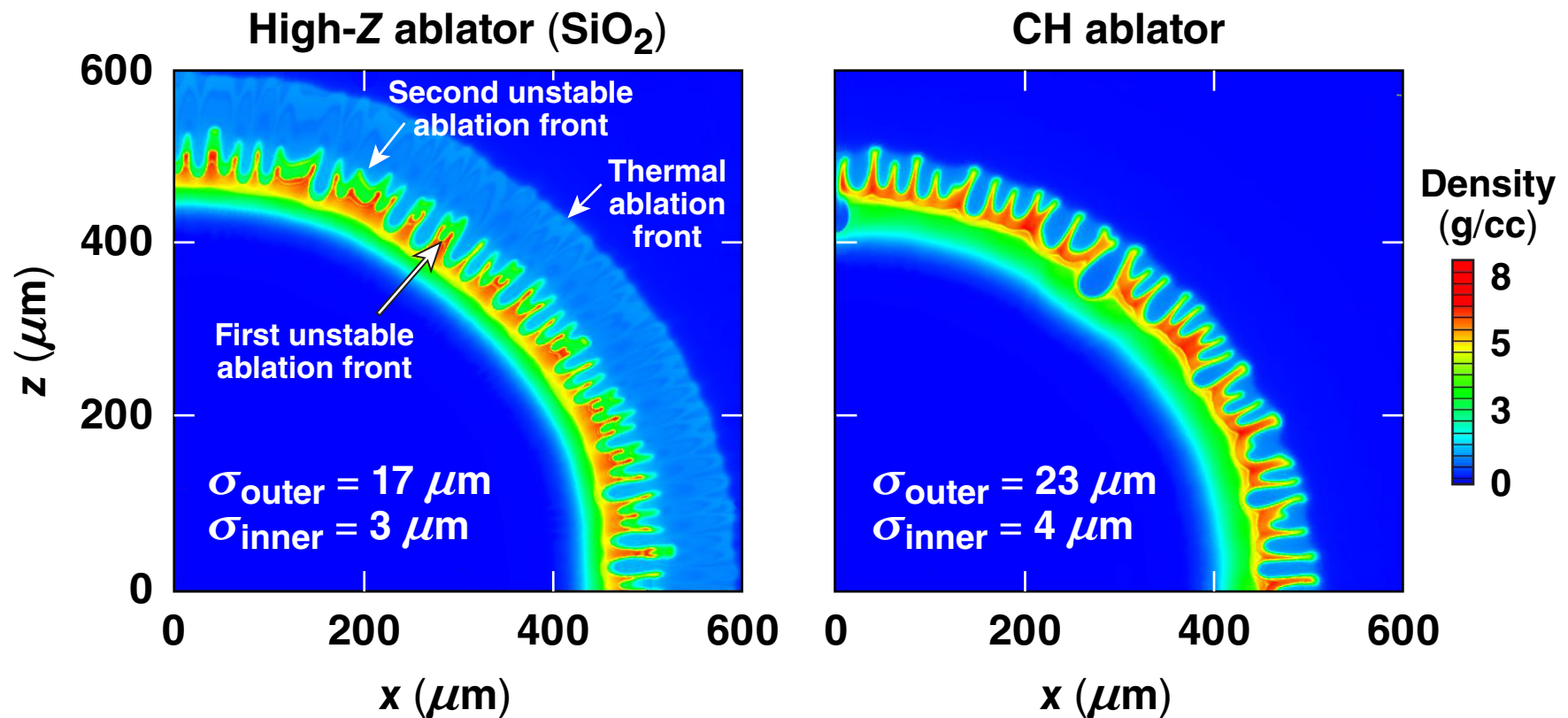
The RT growth is mitigated by finite density gradients generated by multiple layers of doped plastic



Using graded doping of plastic layers reduces the RT growth in a double-ablation-front structure.

The high-Z ablator design exhibits a slightly improved stability over the plastic ablator target

Imprint simulations with $\ell < 200$ at the end of the acceleration phase



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