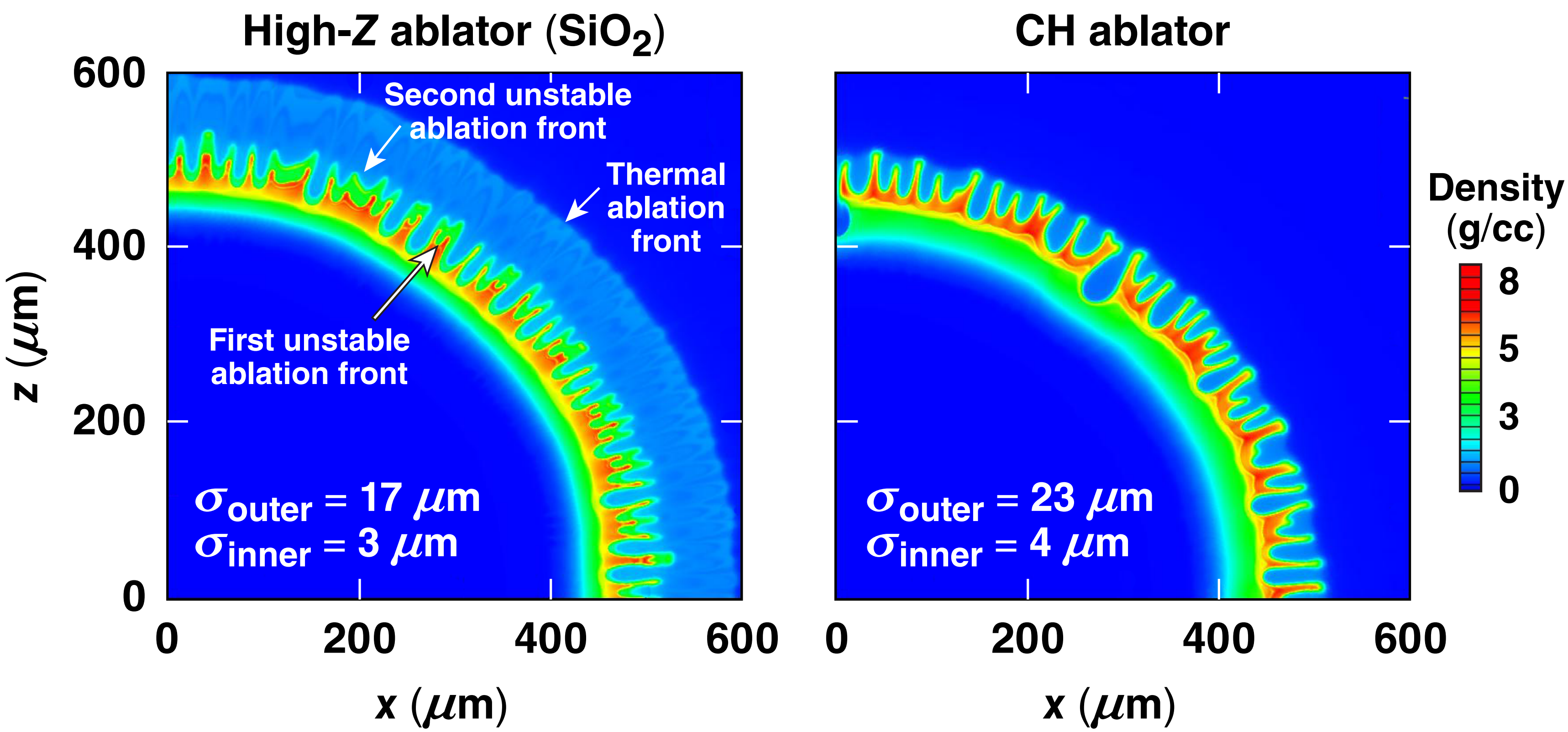
Hydrodynamic Stability of Direct-Drive Targets with High-Z Ablators



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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

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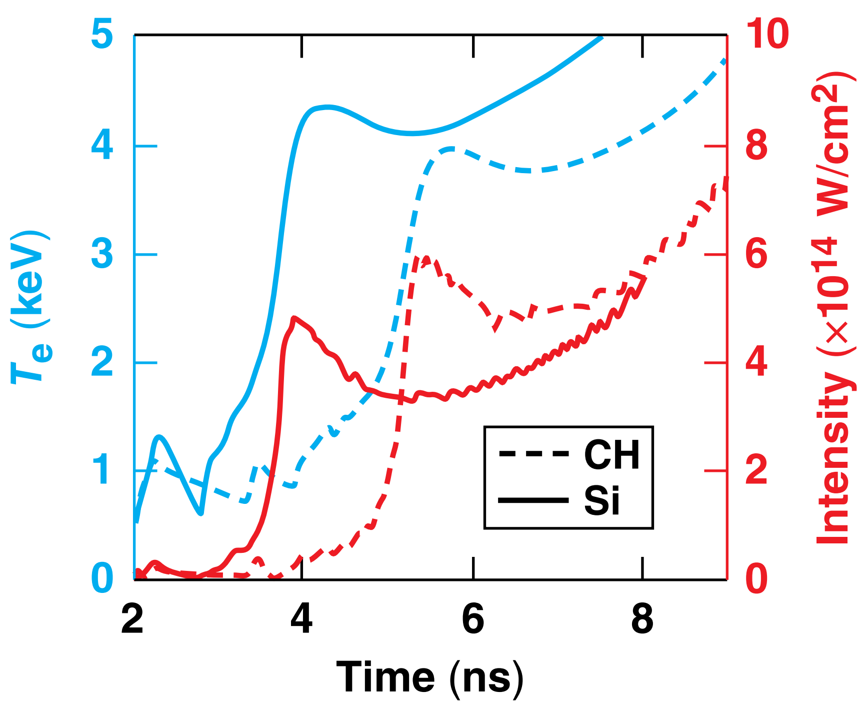
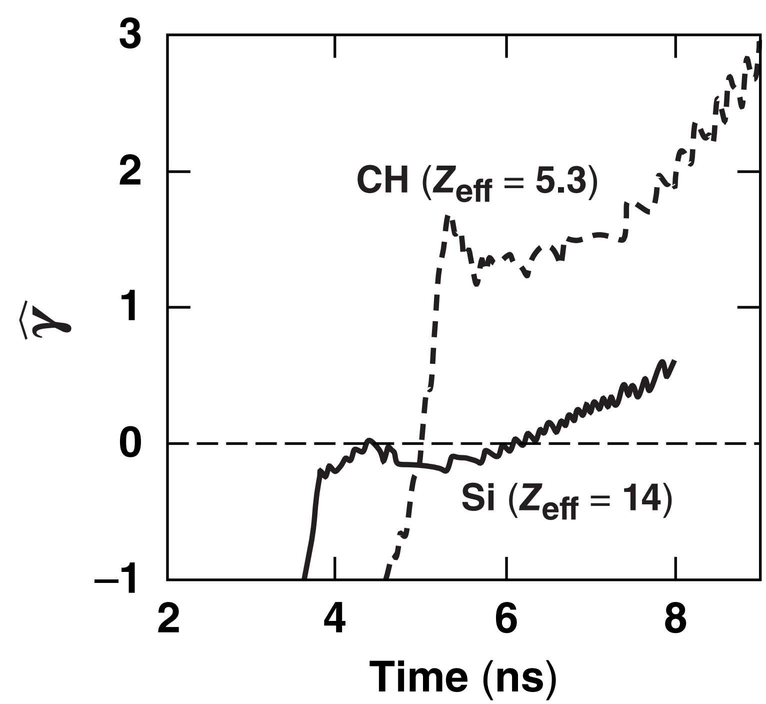
High-Z ablators are expected to reduce the hot-electron preheat caused by TPD instability

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



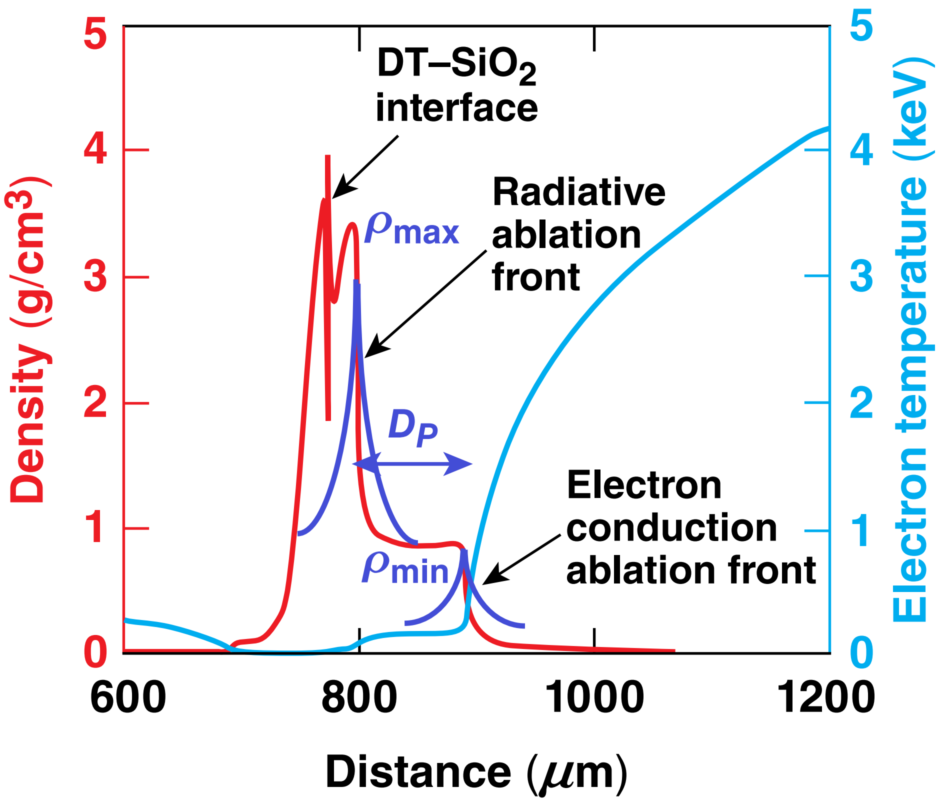


High-Z materials increase the intensity threshold of the TPD instability.

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

TC10273a

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

$$\gamma_{RT} = \sqrt{\frac{A_T kg}{1 + A_T kL}} - 3\,kV_a$$

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

- The thermal front is almost fully stabilized by mass ablation
- The RT instability grows almost classically at the radiative front and the DT–SiO_2 interface

*S. Fujioka *et al.*, Phys. Plasmas 11, 2814 (2004).
**H. Takabe *et al.*, Phys. Fluids 28, 3676 (1985).

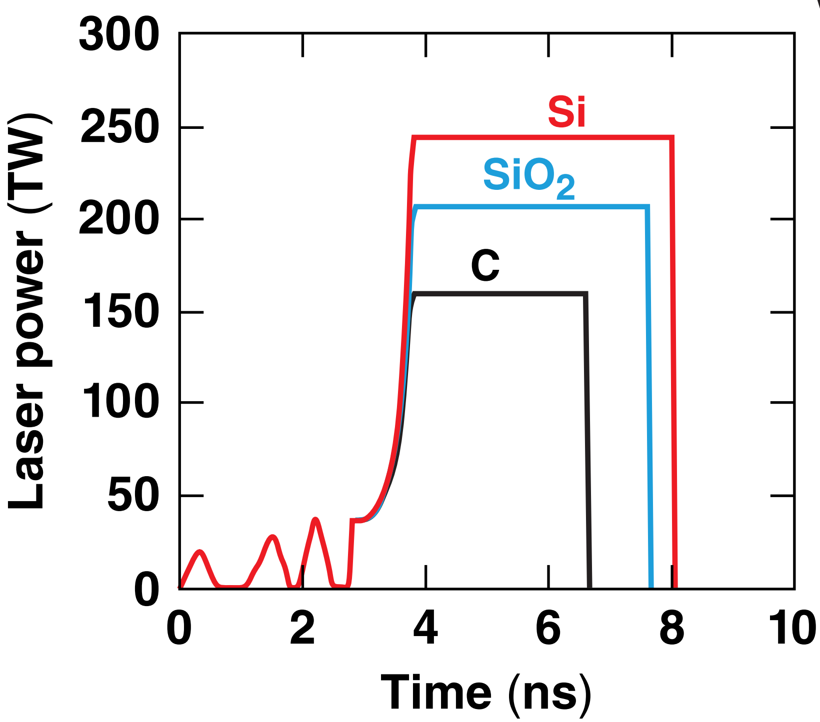
TC10273

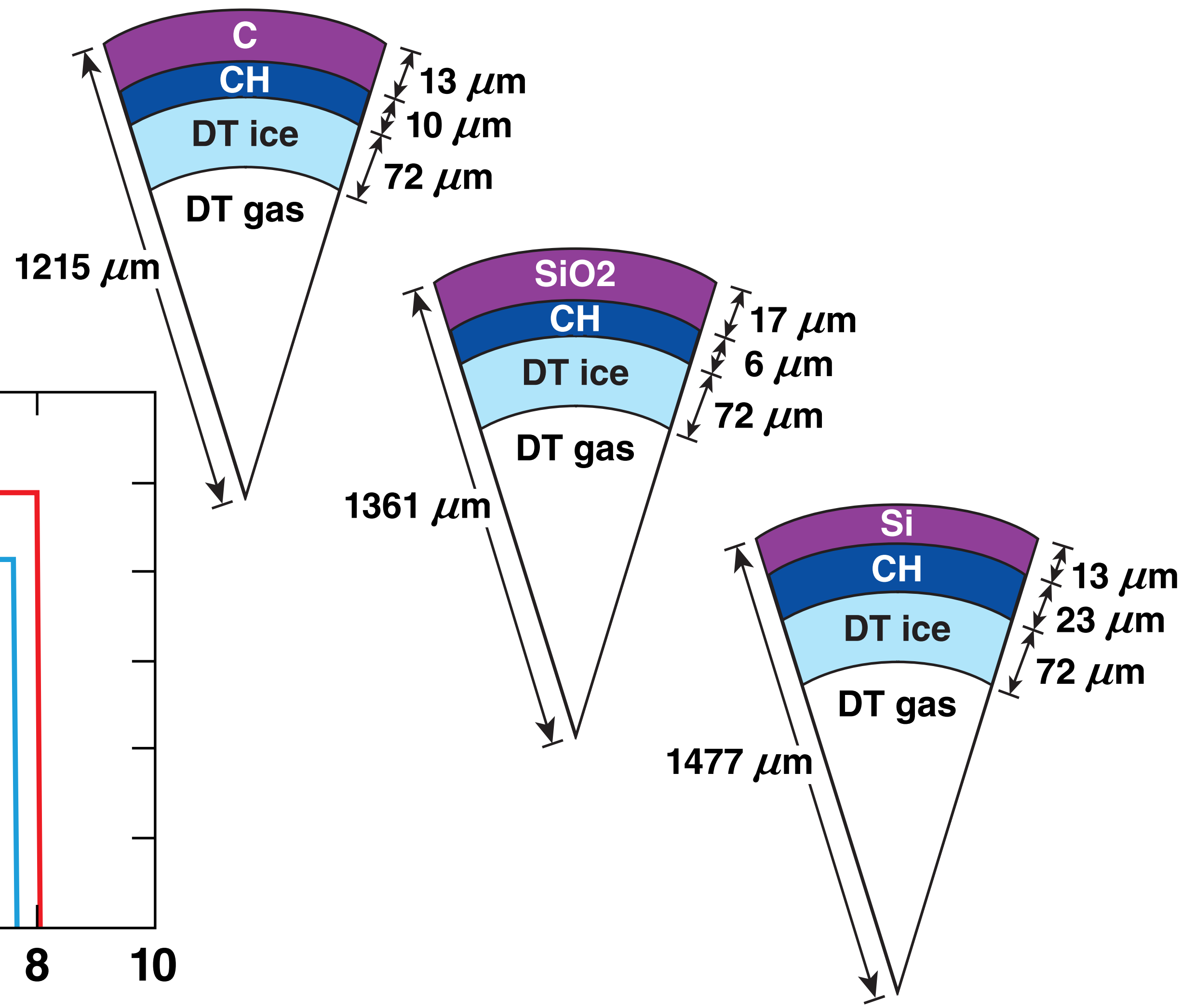
Hydrodynamic stability is studied for different high-Z ablators ranging from carbon to silicon

Peak laser intensity:
9×10^{14} W/cm^2

V_{imp} = 390 km/s

$\alpha \sim 2.5$





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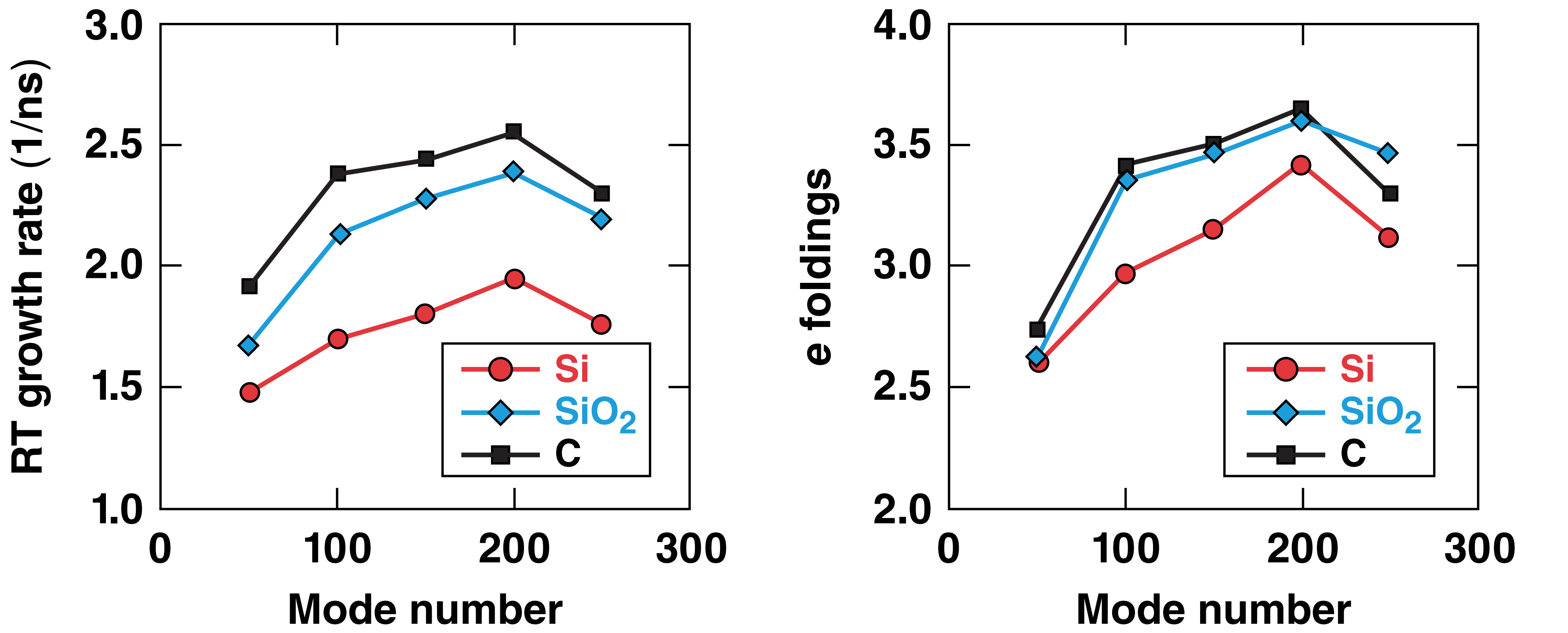
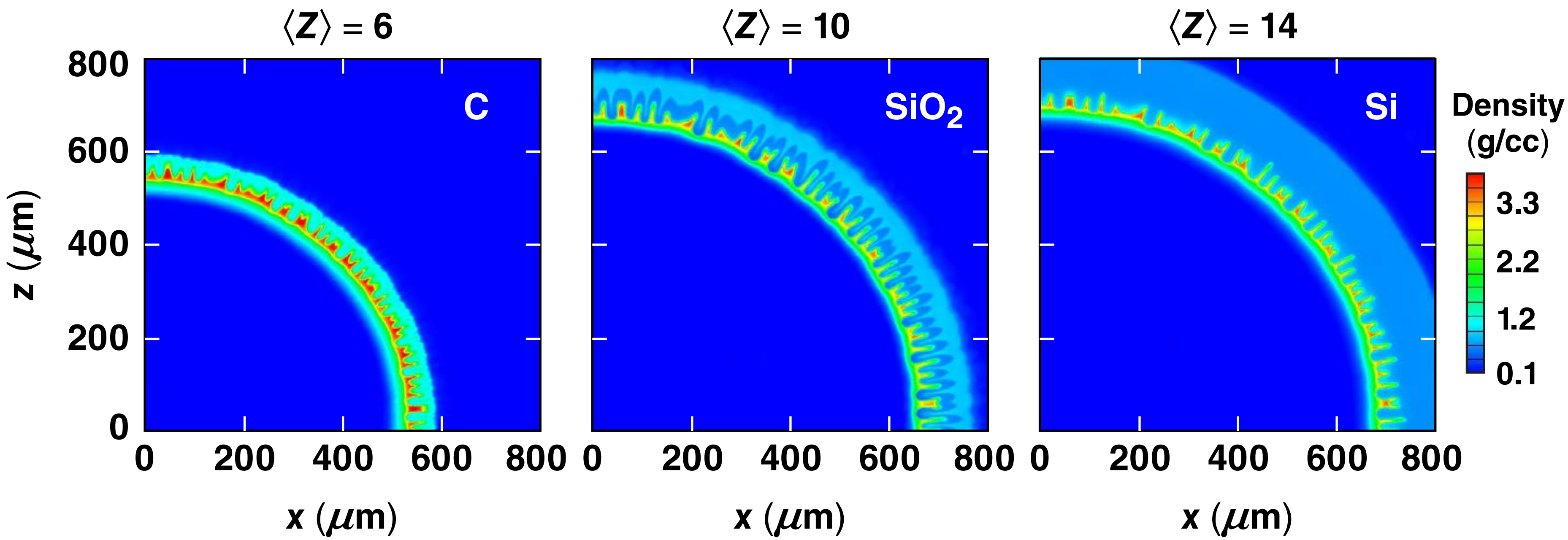
Single-mode simulations show a slightly lower RT instability growth factor for high-Z ablators

- 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 ablators 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

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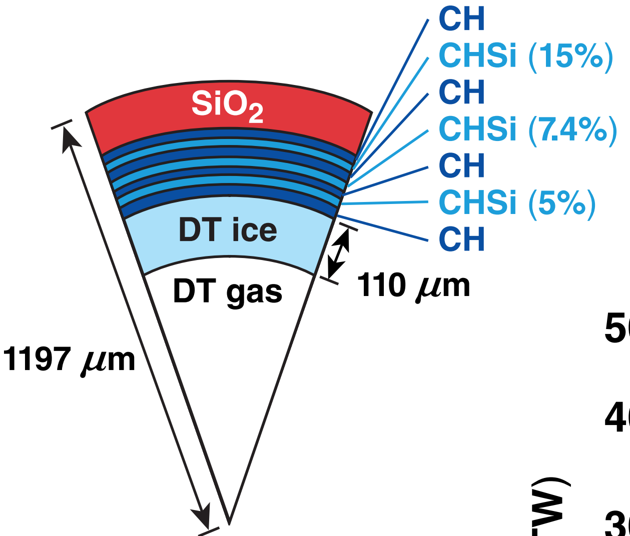
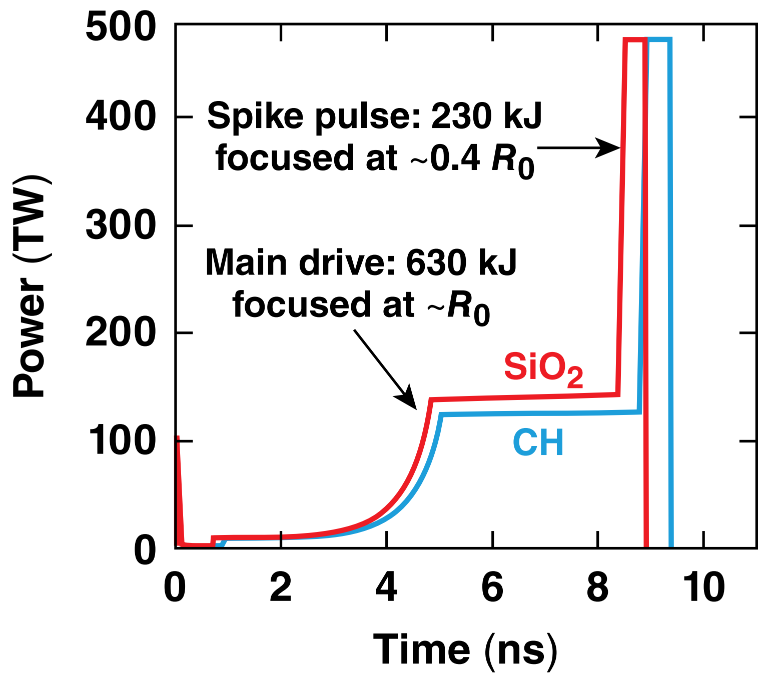
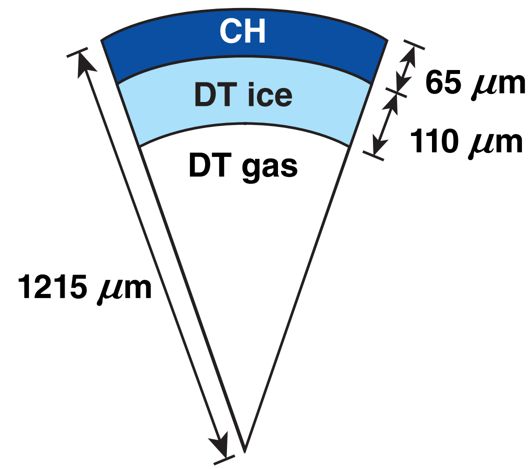
A high-Z ablator target has been designed for shock ignition on the NIF at sub-MJ energies



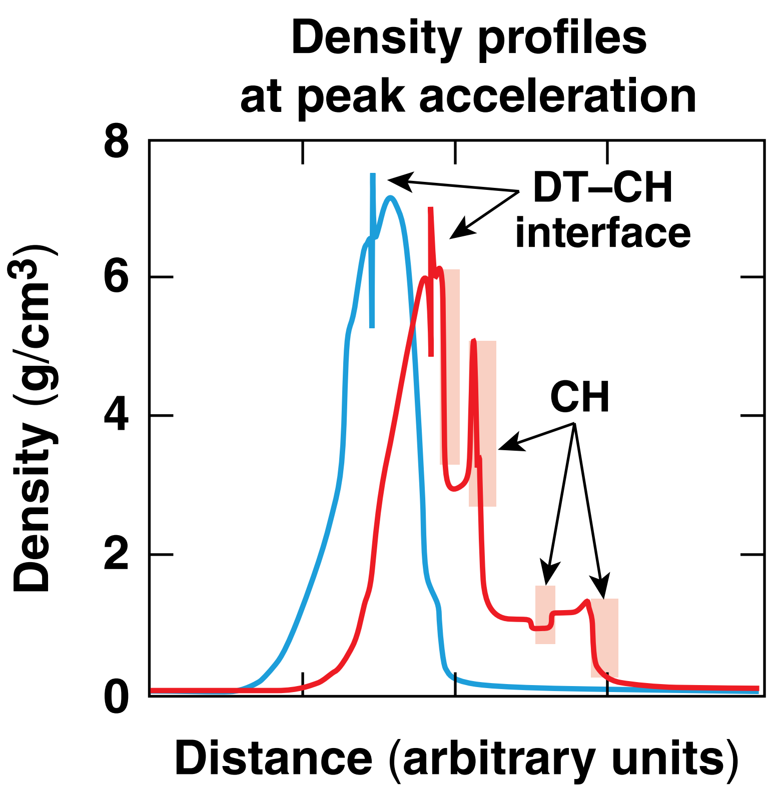
Gain (1-D)	62
V_{imp} (km/s)	260
Adiabat	1.4
$IFAR_{2/3}$	23

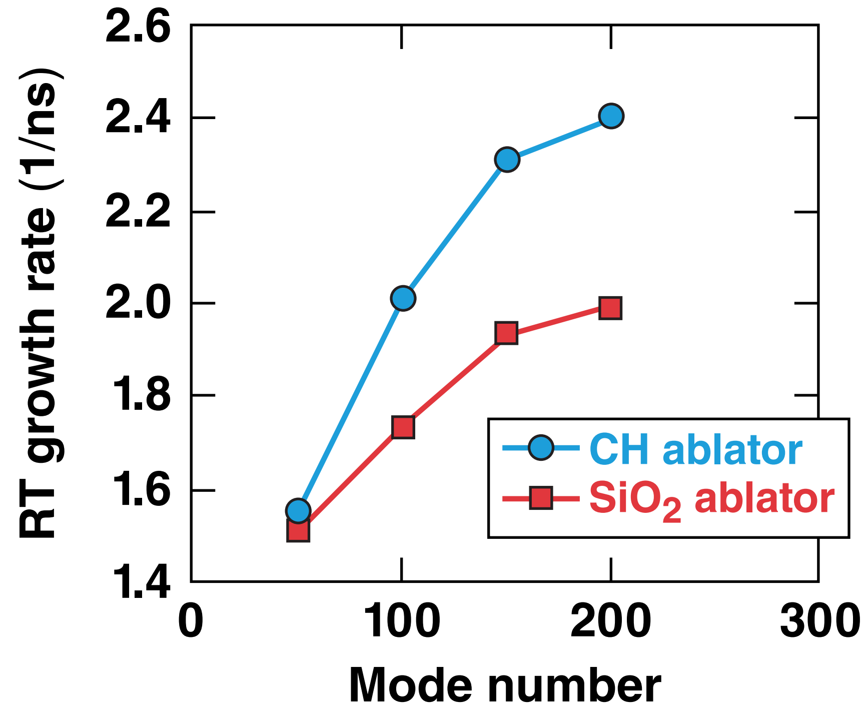




Gain (1-D)	64
V_{imp} (km/s)	262
Adiabat	1.3
$IFAR_{2/3}$	28

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



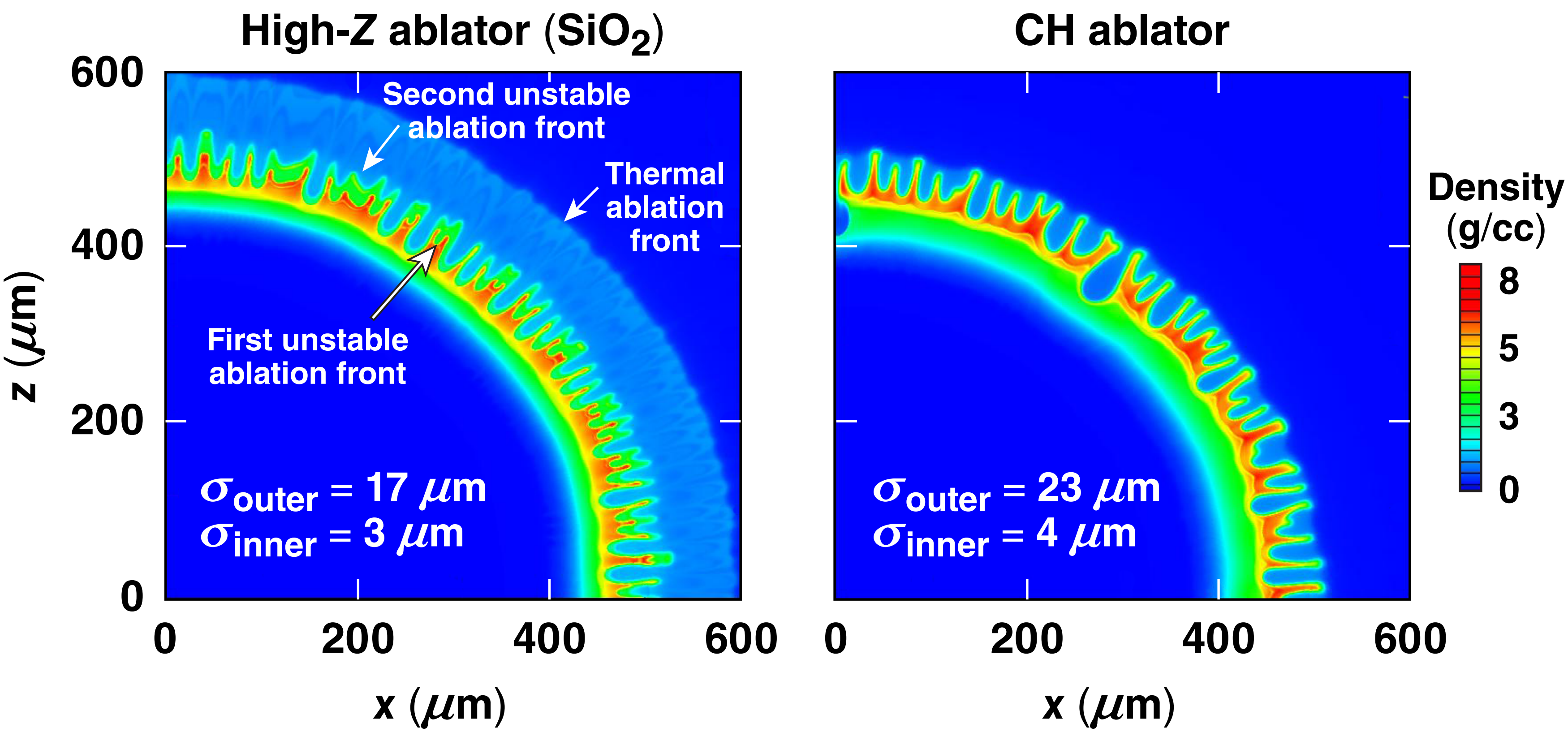


Using graded doping of plastic layers reduces the RT growth in a double-ablation-front structure.

TC10278

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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Summary/Conclusions

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