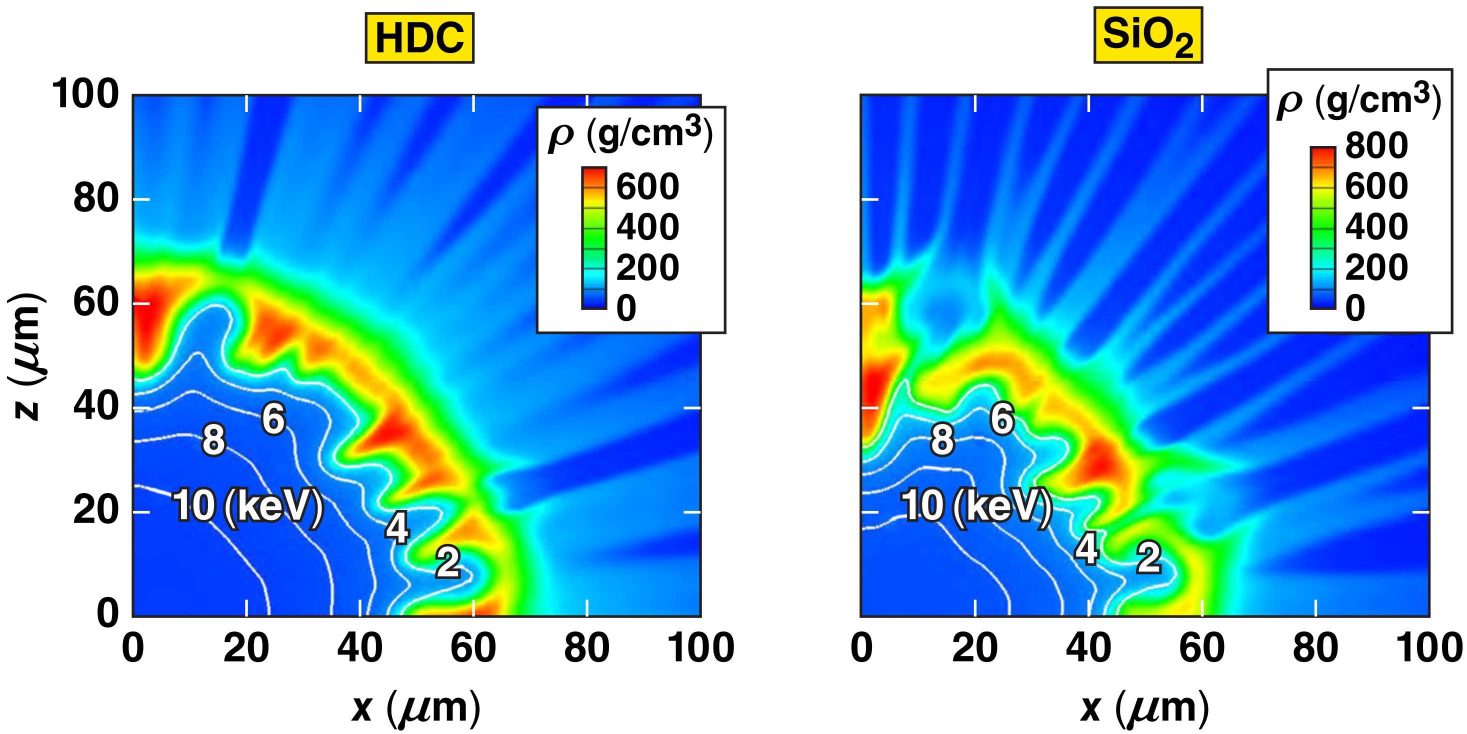
Direct-Drive–Ignition Designs with Moderate-Z Ablators



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55th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Denver, CO
11–15 November 2013

Summary

Moderate-Z ablator materials are studied as an alternative to CH for mitigating the effect of laser–plasma instabilities

- Cryogenic targets with higher *Z* than plastic have a higher two-plasmon–decay (TPD) intensity threshold and possibly less hot-electron preheat
- Ignition targets using mid-*Z* ablators can be designed in one dimension with cross-beam energy transfer (CBET)
- Ignition designs using mid-*Z* ablators are developed and simulated in one and two dimensions for direct-drive and polar-drive configurations

Collaborators

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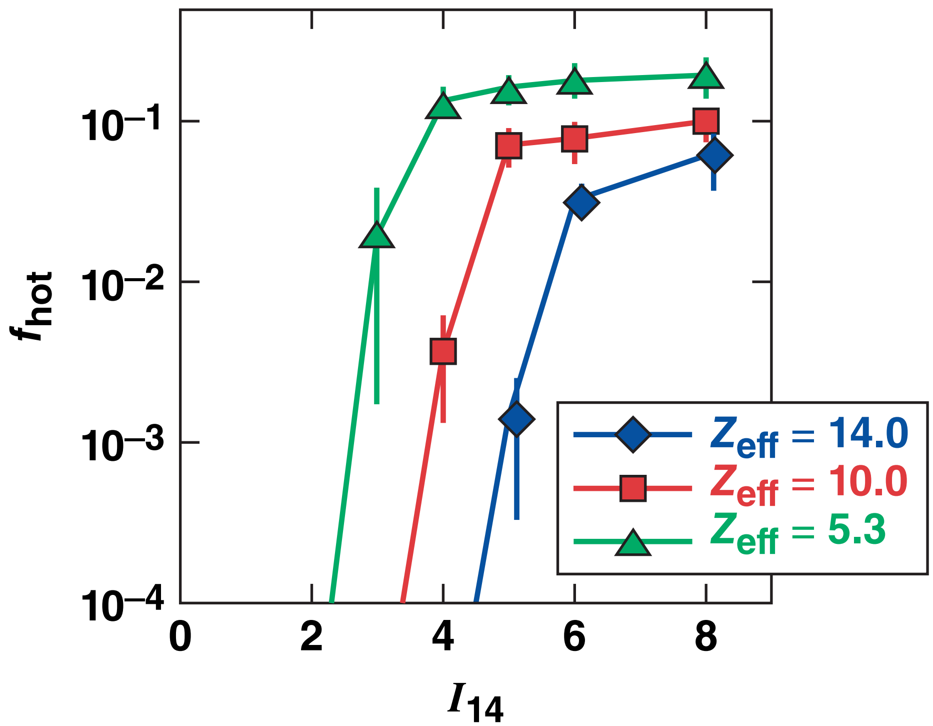
Moderate-Z materials are predicted to mitigate the generation of hot electrons caused by the TPD instability

- The TPD threshold parameter* is defined as

$$\eta = \frac{I_{14} L_{\mu m}}{230\, T_{keV}}$$

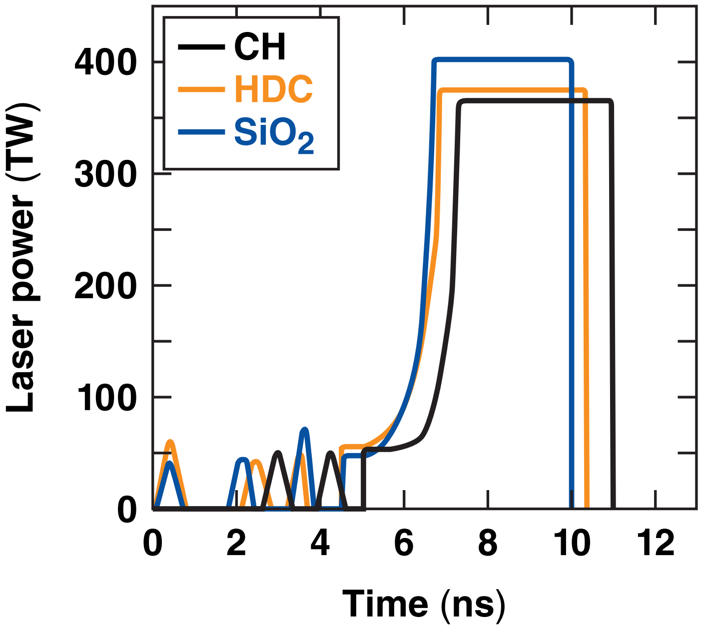
- Moderate-Z ablator materials may help reduce the TPD instability at quarter-critical density because of
  - higher electron temperature
  - better absorption leading to lower intensity
  - higher collisional damping
  - lower damping of ion-acoustic waves (IAW's)

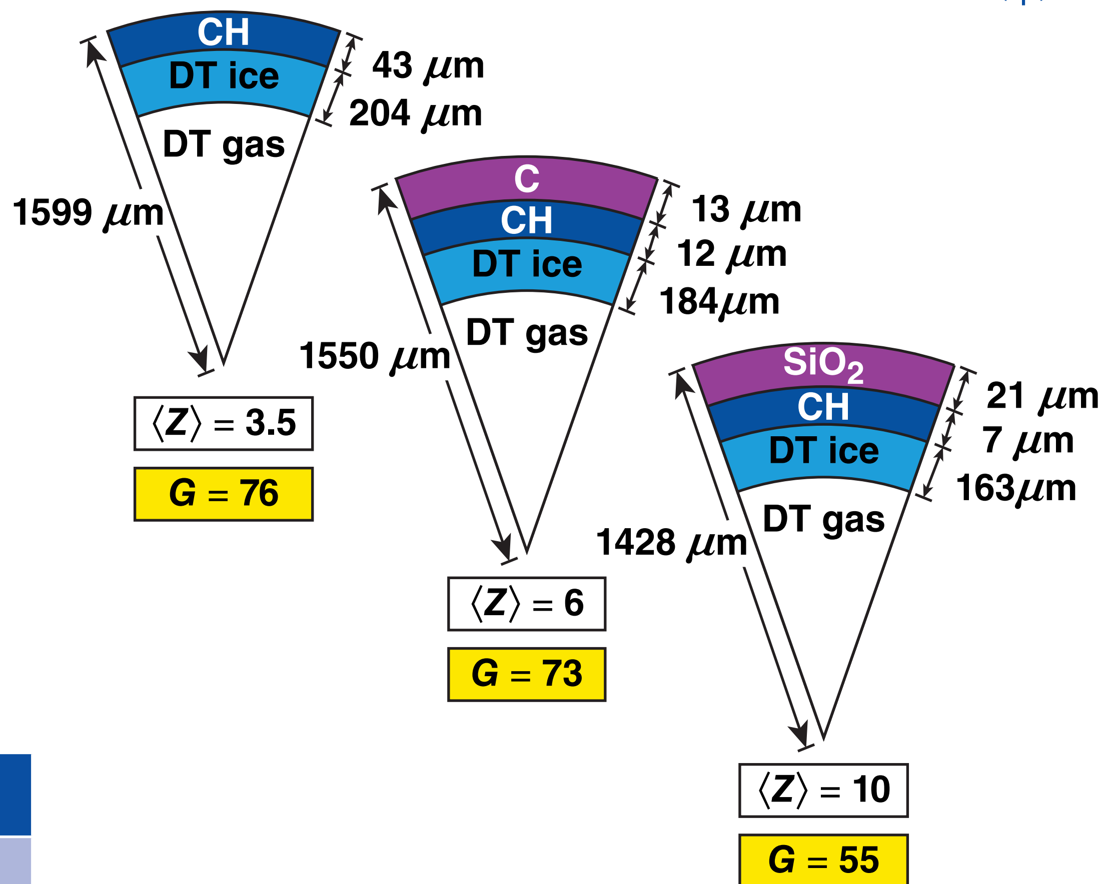


J. F. Myatt *et al*., Phys. Plasmas 20, 052705 (2013).
*A. Simon *et al*., Phys. Fluids 26, 3107 (1983).

TC10891

Hydro-equivalent ignition targets have been designed for the NIF using CH, HDC, and SiO_2 ablators





Flux limiter $f = 0.06$

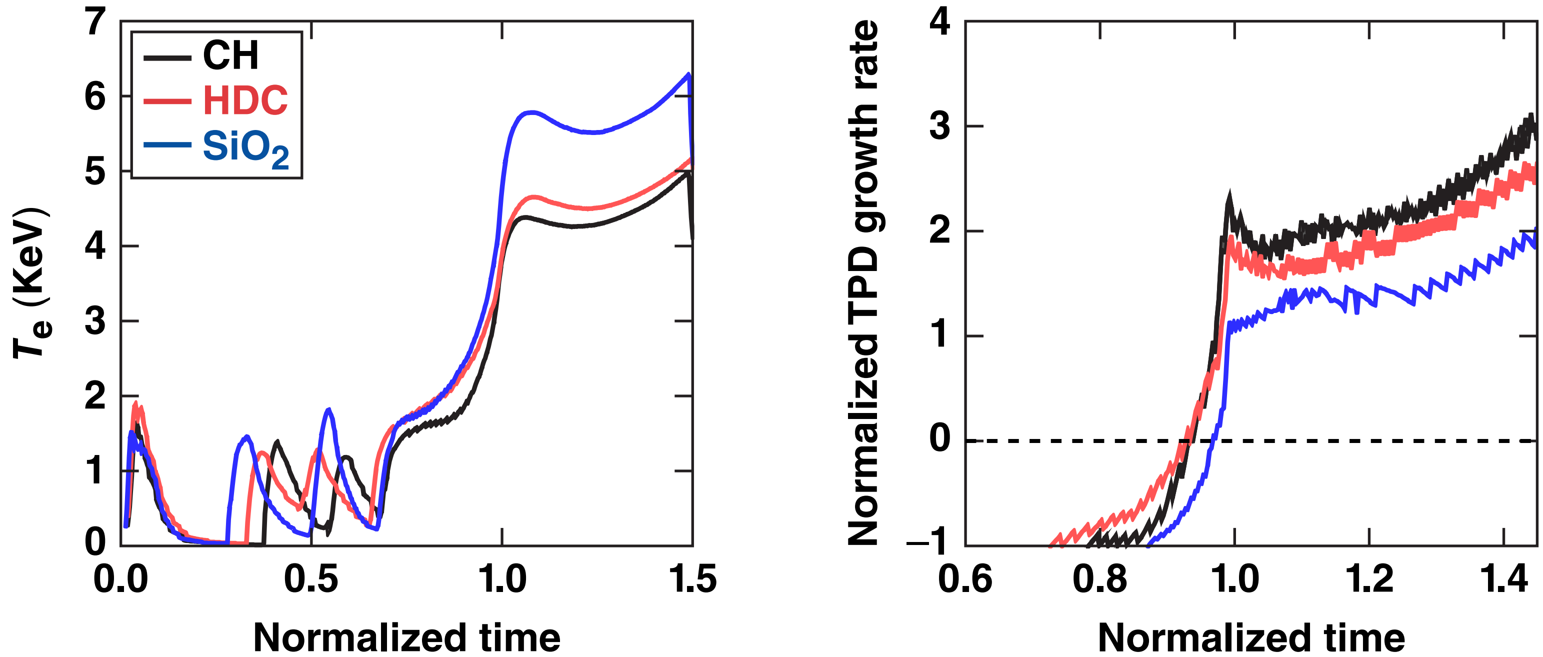
v_{imp} (km/s)	~360
E_L (MJ)	~1.6
Adiabat	~2.0
I_L (W/cm^2)	$\sim 1.2 \times 10^{15}$
ITF*$_{1\text{-}D}$	~4.0

T. J. B. Collins *et al.*, Phys. Plasmas 19, 056308 (2012).
*Ignition threshold factor

TC10892

Mid-Z ablators exhibit lower TPD linear growth rates

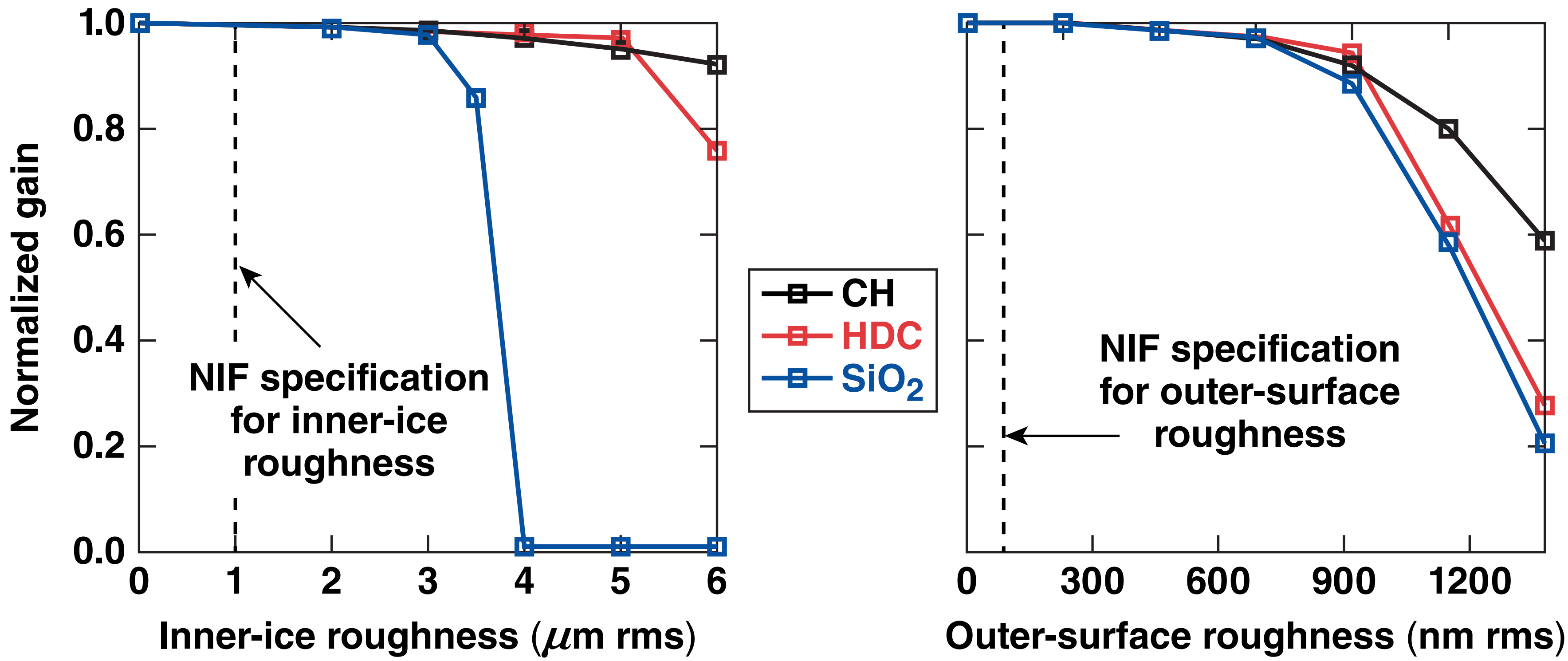
- The normalized TPD growth rate* is $\hat{\gamma} = \frac{L_{\mu m} I_{14}}{230\, T_{keV}} - 1 - \frac{0.3\, Z_{eff} L_{\mu m} \sqrt{I_{14}}}{230\, T_{keV}^{5/2}}$



Mid-Z materials present higher coronal temperature and more collisional damping, leading to higher TPD threshold.

*A. Simon *et al.*, Phys. Fluids 26, 3107 (1983).

All three ignition designs are robust to several times the inner-ice and outer-surface roughness NIF specifications



Mid-Z ablator designs tolerate over 3-μm rms and 1-μm rms, respectively, for inner-ice roughness and outer-surface roughness.

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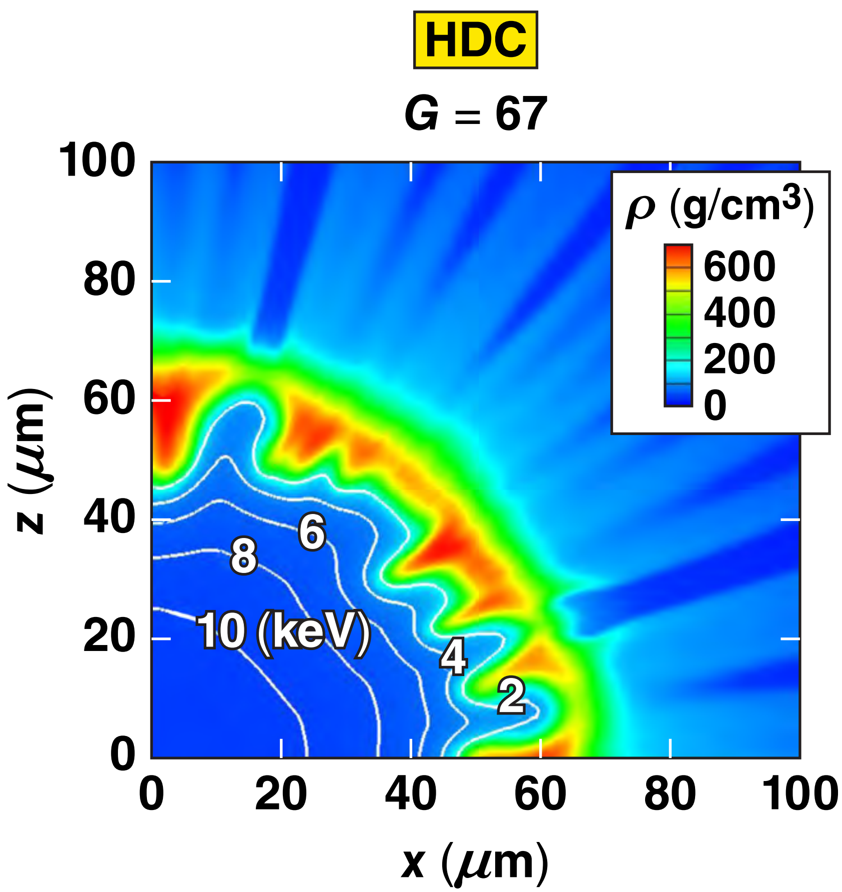
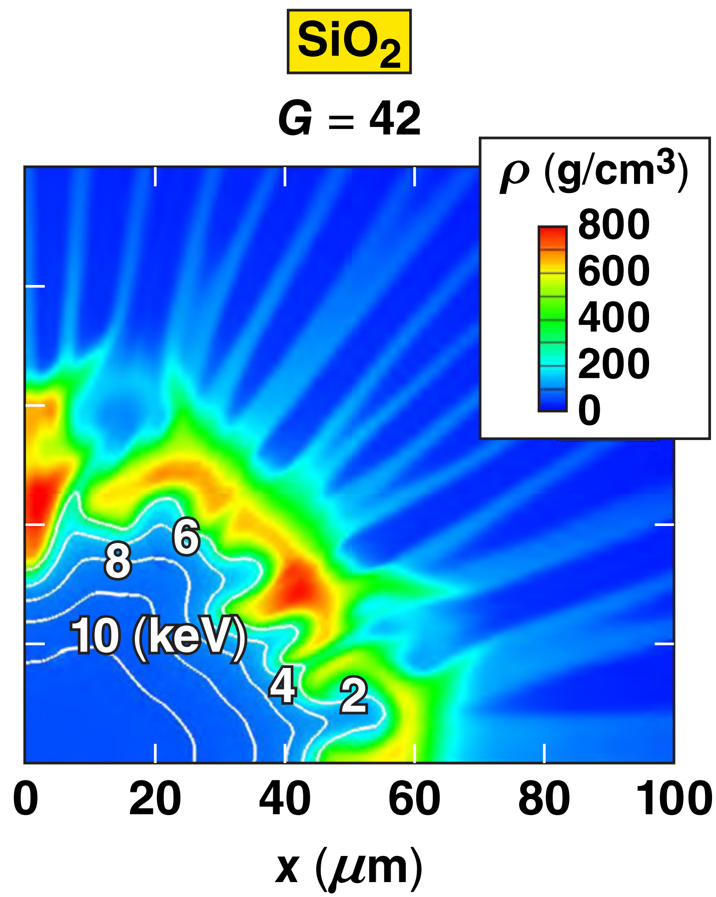
Both high-density carbon (HDC) and glass designs still produce high gains under laser-imprint perturbations

- Density at onset of ignition for laser-imprint simulations with ℓ <100 (2-D SSD*)

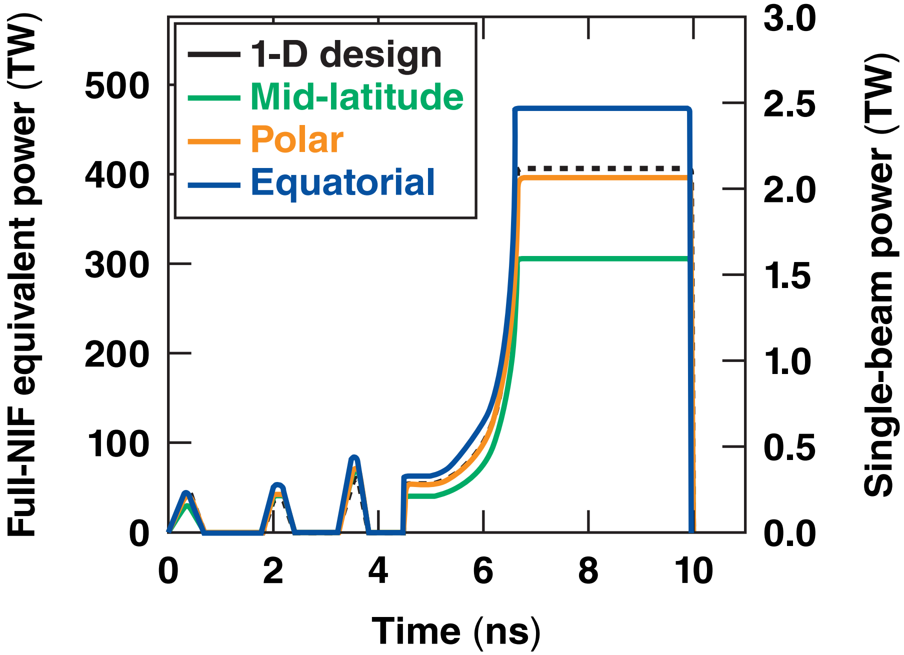




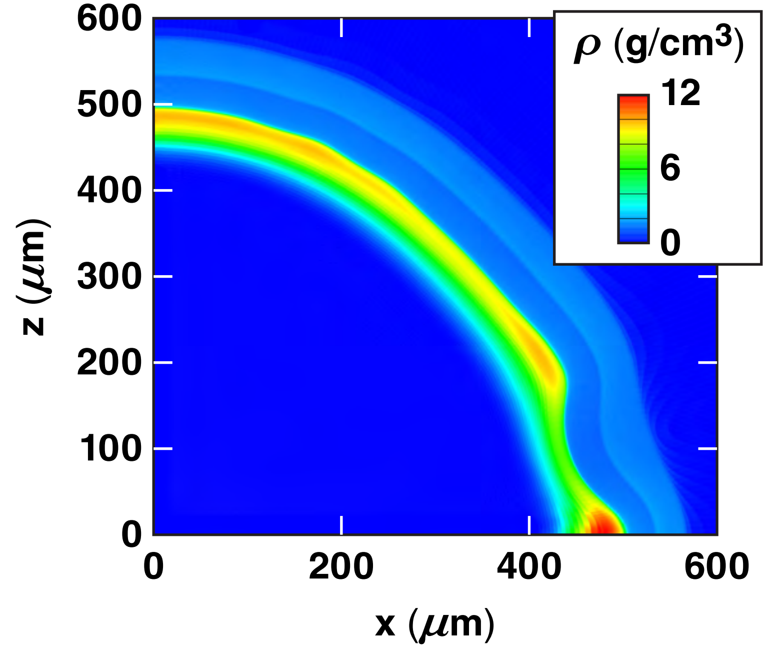
*Smoothing by spectral dispersion

TC10898

The robustness of mid-Z designs is currently investigated using the polar-drive configuration



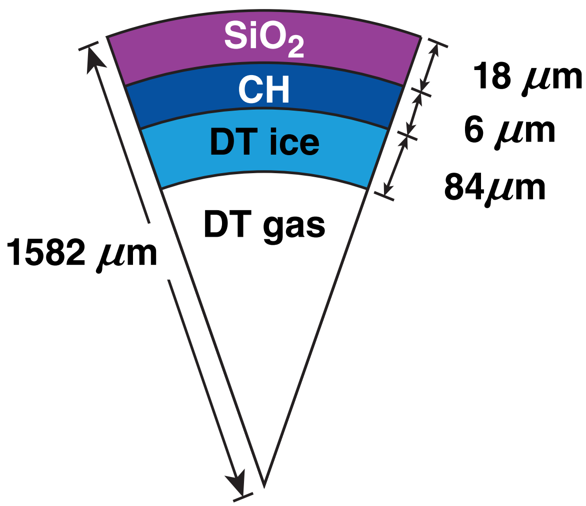
Density at the end of the laser pulse

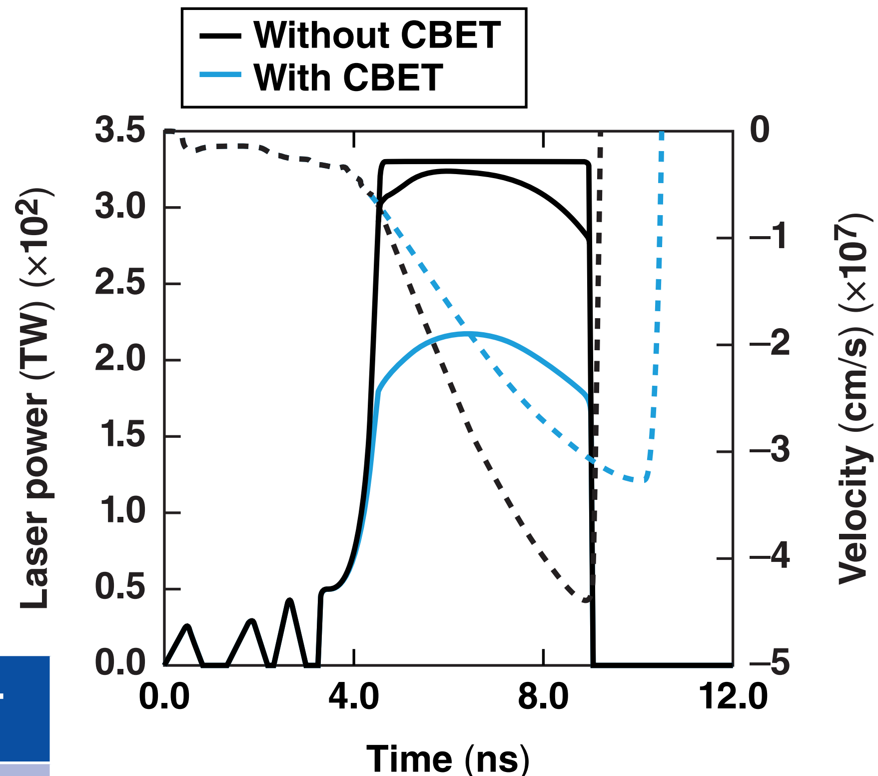


S. Skupsky *et al*., Phys. Plasmas 11, 2763 (2004).

TC10900

A glass target ignites with cross beam energy transfer (CBET) in 1-D, giving a gain of 30





	Without CBET	With CBET
η_{abs} (%)	95	65
V_{imp} (km/s)	440	327
$IFAR_{2/3}$*	61	40
Gain	20	30

*In-flight aspect ratio

TC10897

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