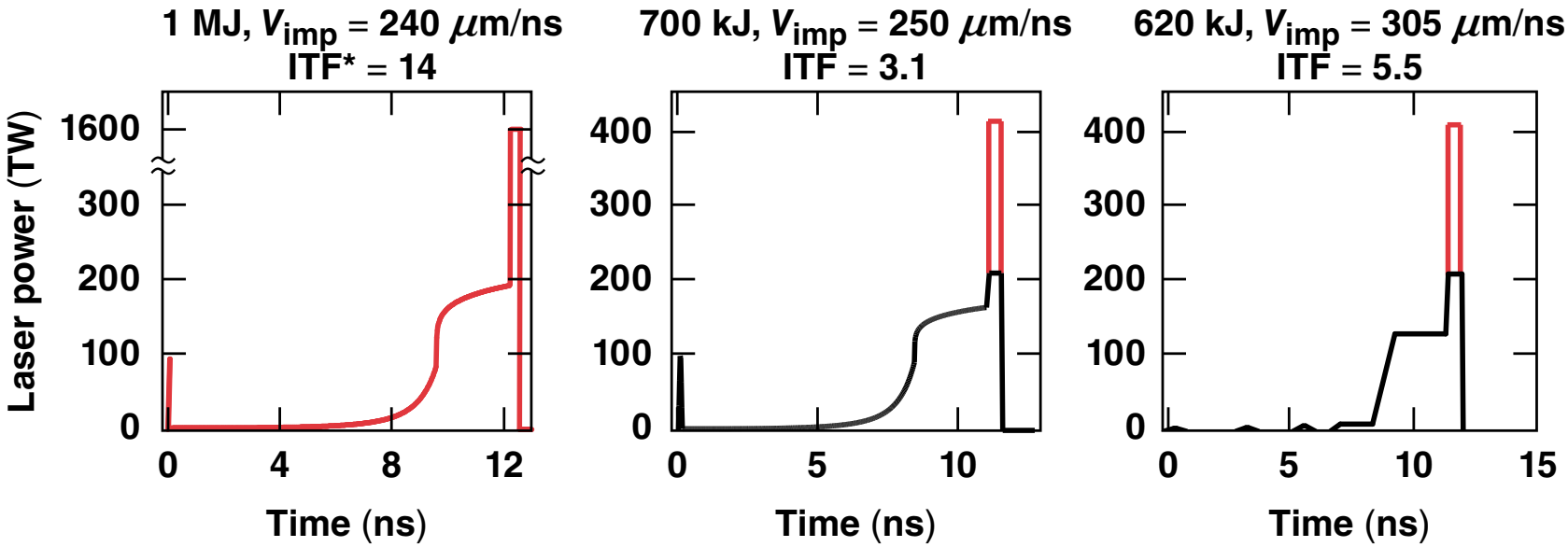
Simulations of Shock-Ignition Targets for the NIF



*ITF = ignition threshold factor

K. S. Anderson, *et al.*
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Division of Plasma Physics
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Summary

Shock ignition at higher implosion velocities (~300 μm/ns) is being explored as a method of increasing margin on the NIF

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- A high-implosion-velocity target at 305 μm/ns exhibits a higher ignition threshold factor (ITF) of 5.5, compared to a slow target (250 μm/ns) with an ITF of 3.1
- Two-dimensional simulations of a high-velocity target indicate excellent robustness to ice roughness up to 4× NIF specification
- NIF polar-drive simulations show gain of 50; initial imprint simulations are approaching marginal ignition

Collaborators

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Ideal shock-ignition designs at full NIF energy are not feasible because of maximum laser power constraints

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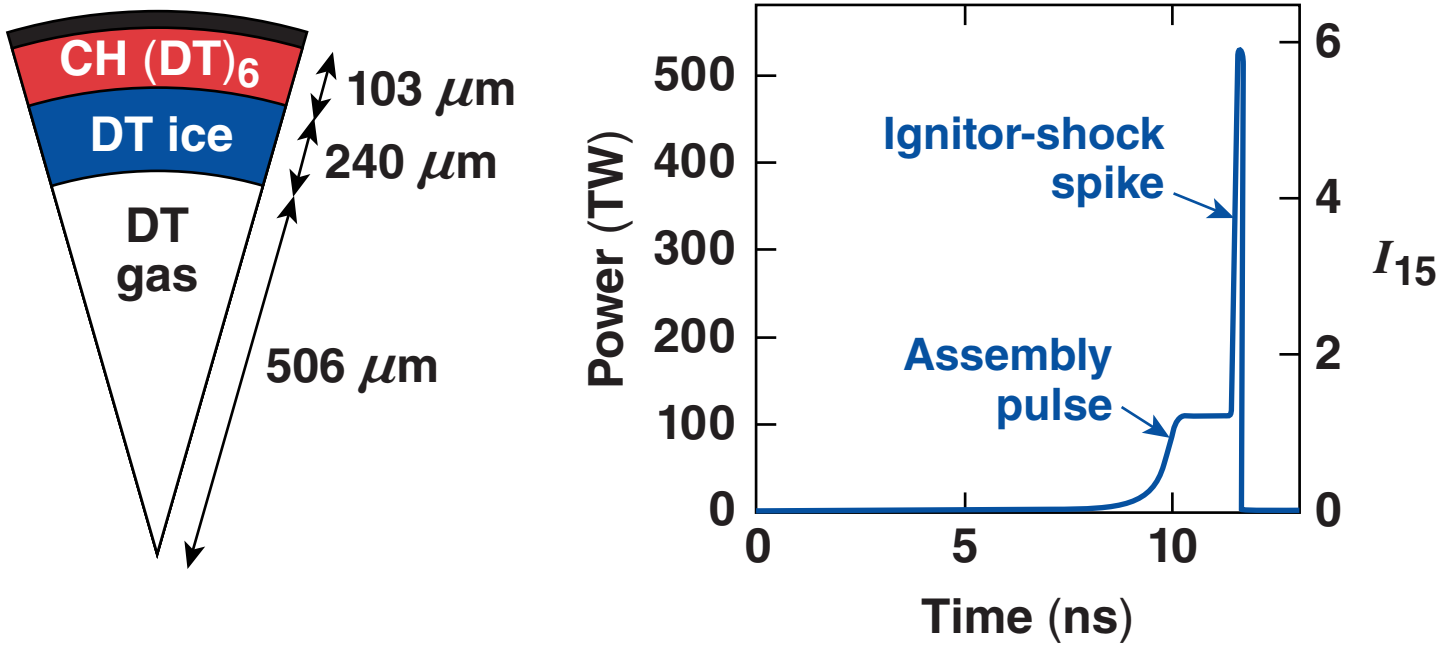
Original, marginally igniting 290-kJ design*



Scaling from 290 kJ to 1 MJ requires a spike laser power of >1 PW!

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*Betti, *et al.*, Phys. Rev. Lett. 98, 155001 (2007).

For shock ignition to be feasible on the NIF, more hot-spot energy must come from the fuel-assembly pulse

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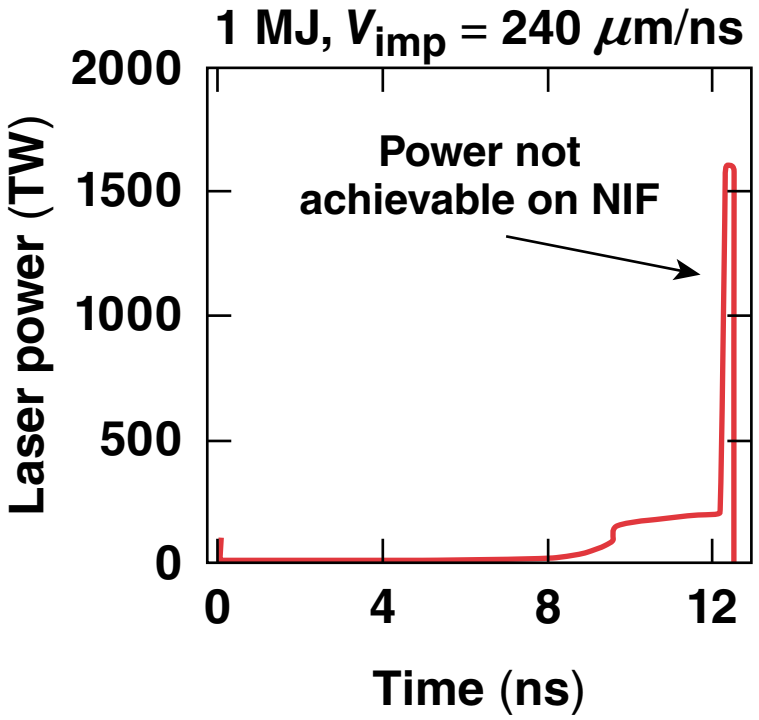
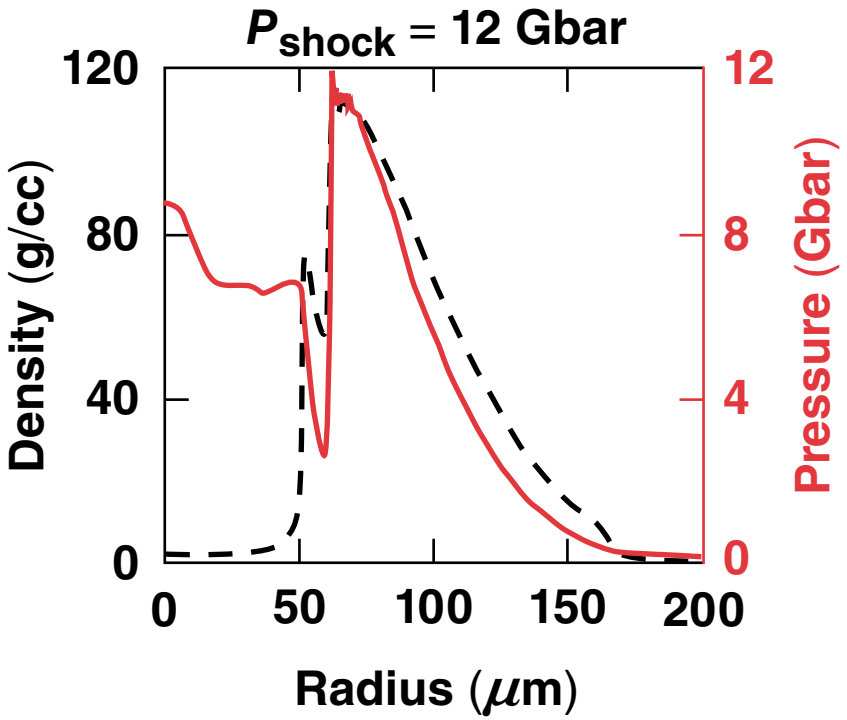
- Shock-ignition targets lose substantial margin at the reduced laser spike powers attainable on the NIF
- Targets gain additional margin by increasing the velocity of the fuel assembly
- The target design must carefully balance the contribution of the main pulse and spike pulse to the hot-spot energy

The NIF-scaled version of the original shock-ignition design requires unfeasible power requirements





ITF = 14

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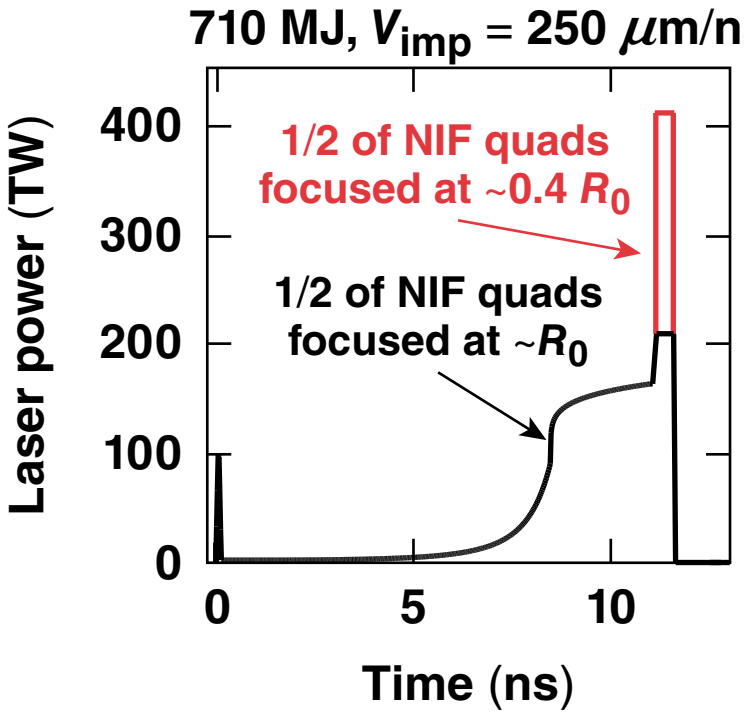
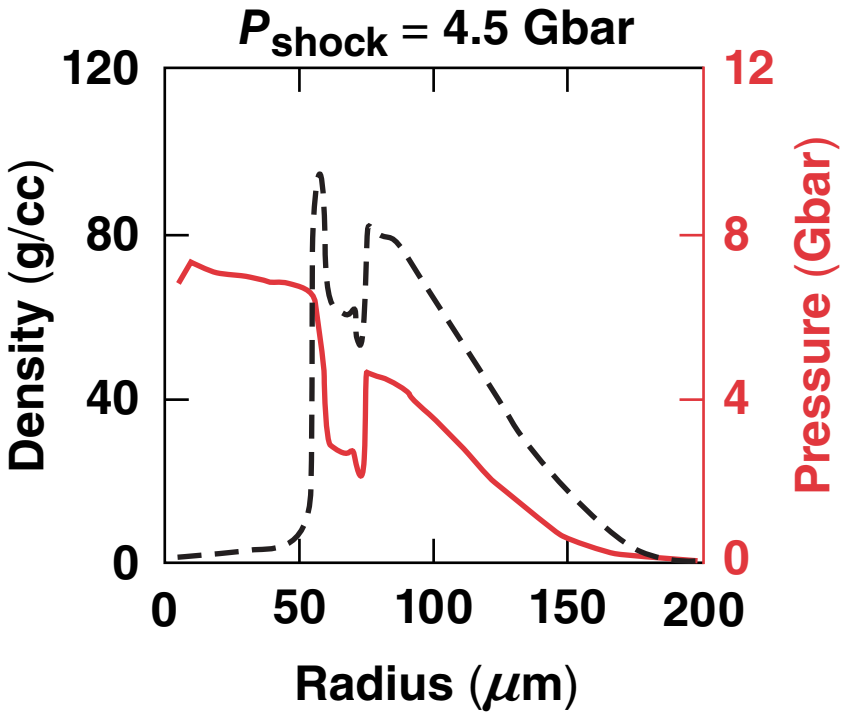
At laser powers that are achievable on the NIF, the shock pressure is much lower, and margin is degraded





ITF = 3.1

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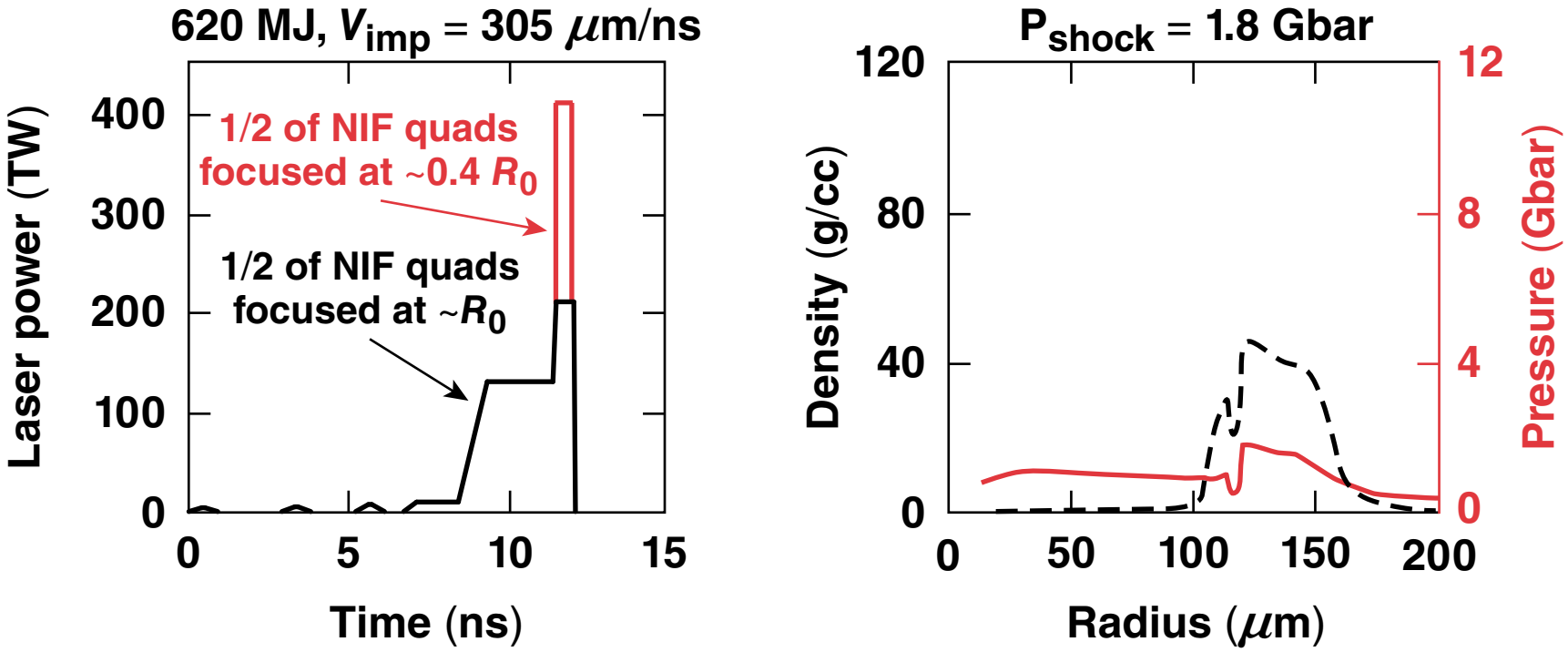
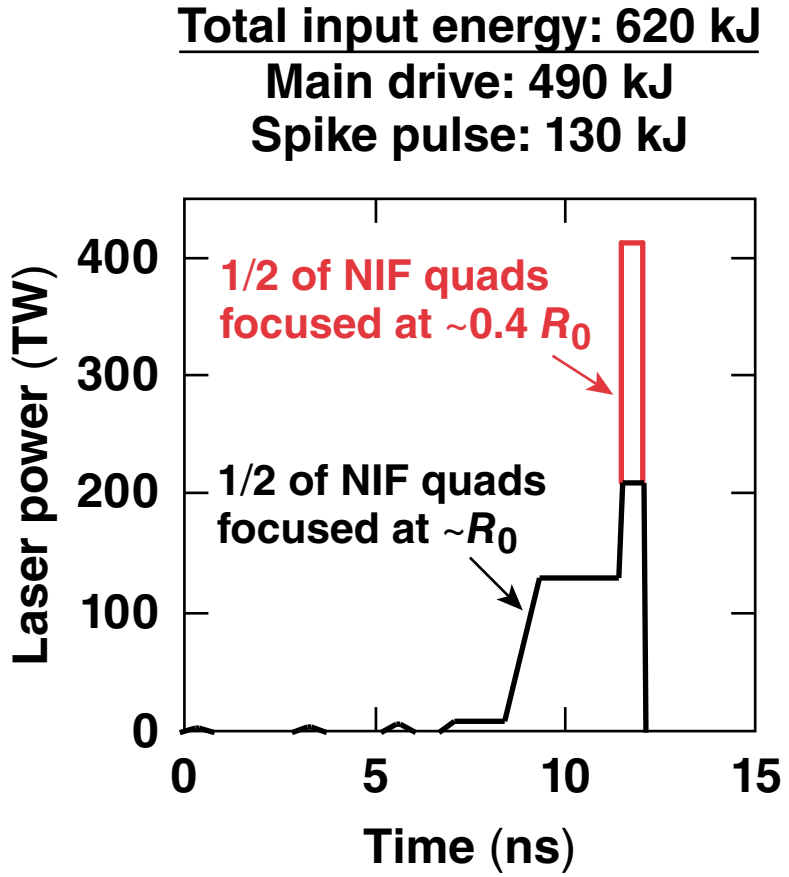
Sizeable margin is recovered by decreasing the target thickness, thereby increasing the velocity of the fuel assembly

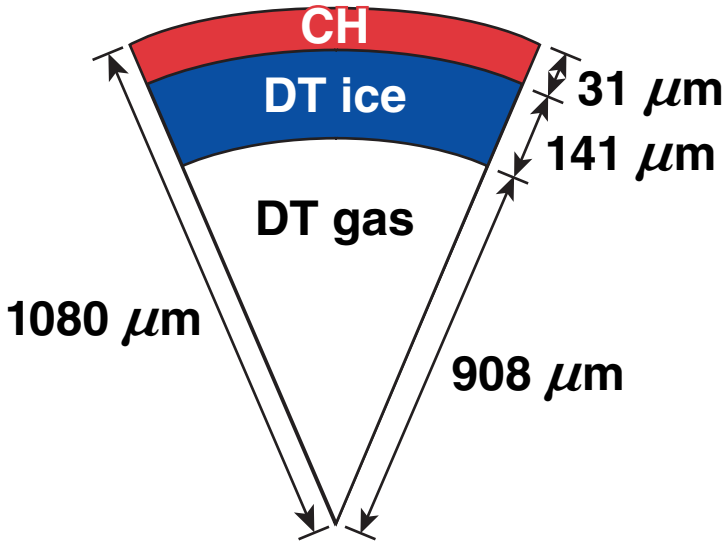


ITF = 5.5

The effect of the spike shock is diminished, but ITF still increases.

The faster implosion at 620 kJ attains higher 1-D margin at the expense of a higher in-flight aspect ratio (IFAR)





Gain (1-D)	55
ρR (g/cm^2)	1.7
V_{imp} (μm/ns)	305
$IFAR_{2/3}$	29
Adiabat	1.0

$ITF_{1\text{-}D} = 5.5$

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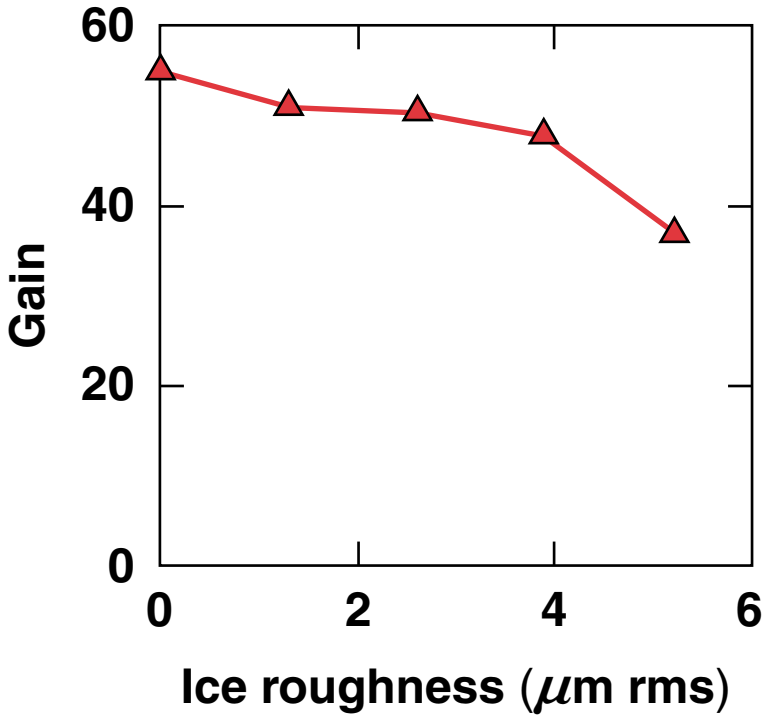
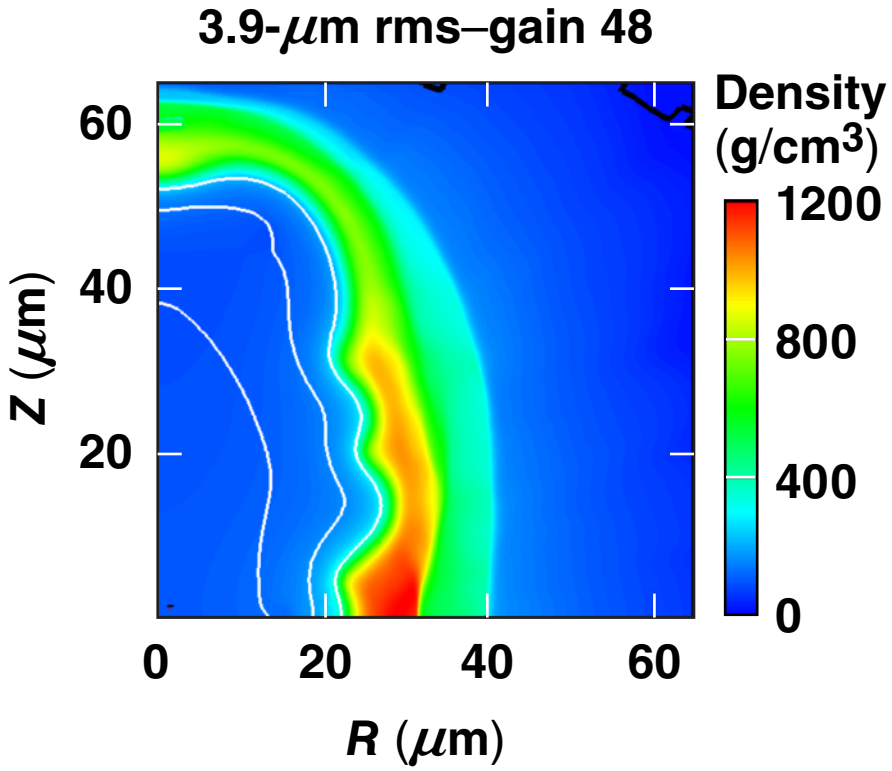
High-implosion-velocity target performance in 2-D is insensitive to ice roughness up to ~4× NIF specifications





The target still ignites with a gain of 37 at 5.2-μm rms.

Initial imprint simulations have achieved near-ignition; polar-drive achieves gain 50 within NIF specifications

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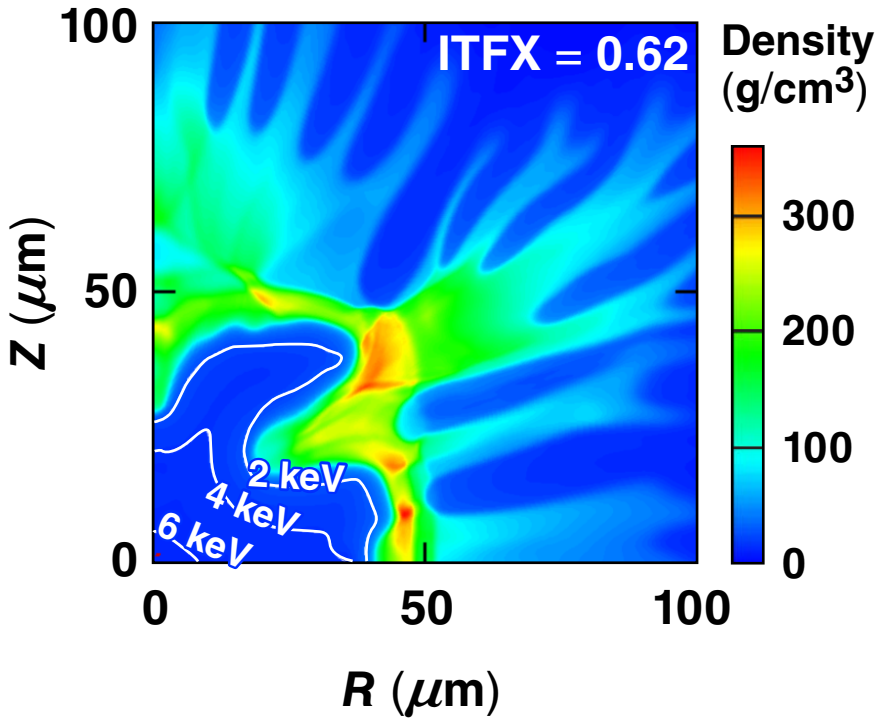
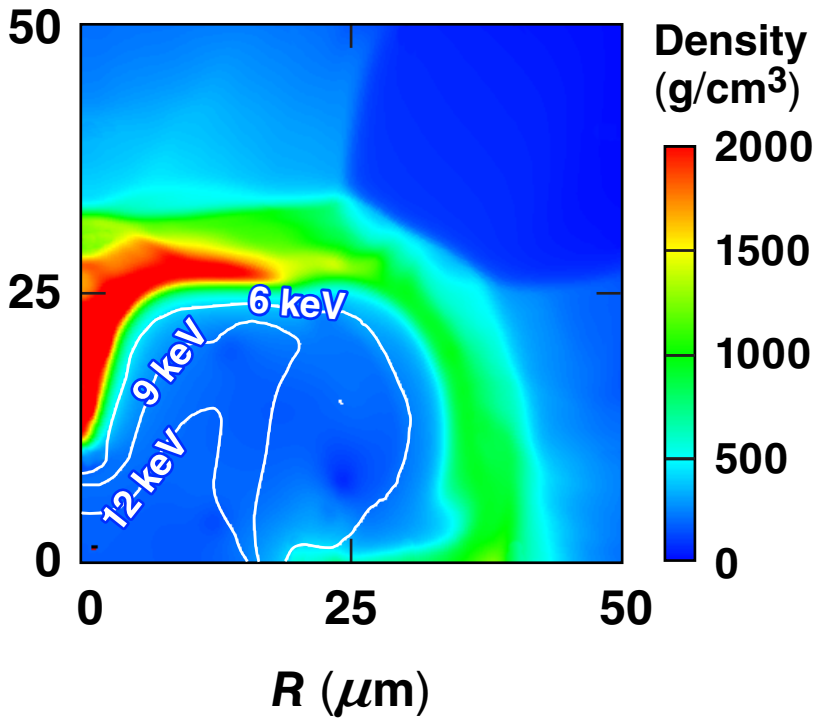
Direct-drive port geometry
Imprint modes ℓ = 2 to 100, MFM-SSD*
~200 ps before 1-D bang time



PD simulation
(730-kJ laser energy)
Gain = 50



*LLE Review Quarterly Report 114, 73 (2008).
J. A. Marozas, J. D, Zuegel, and T. J. B. Collins, Bull. Am. Phys. Soc. 55, 294 (2010).

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Summary/Conclusions

Shock ignition at higher implosion velocities (~300 μm/ns) is being explored as a method of increasing margin on the NIF

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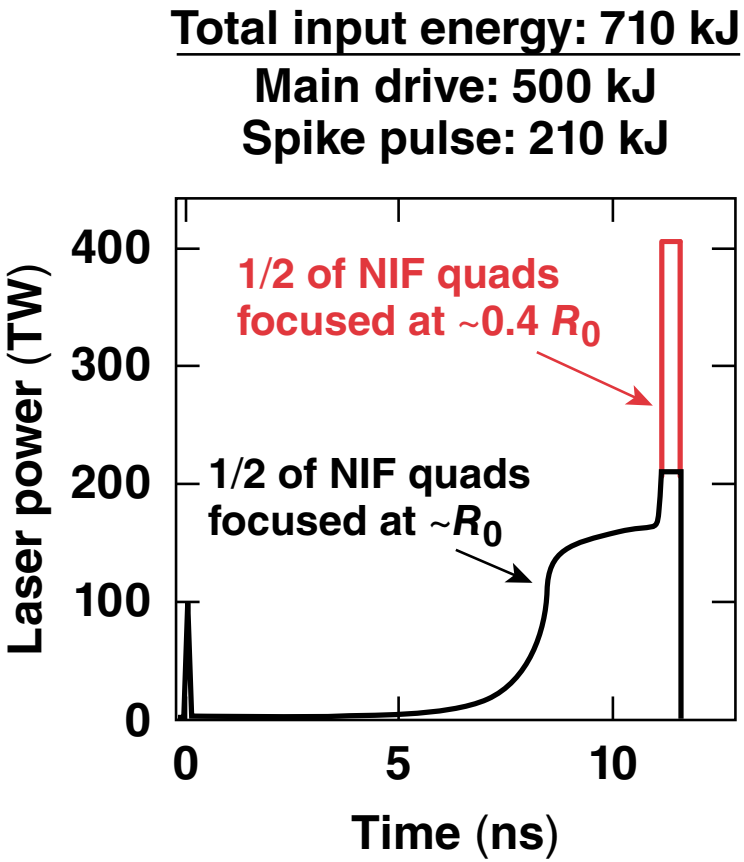
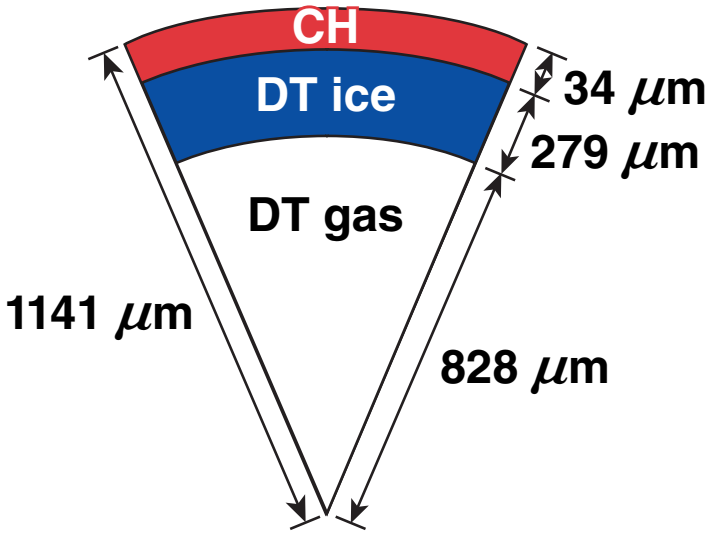
- A high-implosion-velocity target at 305 μm/ns exhibits a higher ignition threshold factor (ITF) of 5.5, compared to a slow target (250 μm/ns) with an ITF of 3.1
- Two-dimensional simulations of a high-velocity target indicate excellent robustness to ice roughness up to 4× NIF specification
- NIF polar-drive simulations show gain of 50; initial imprint simulations are approaching marginal ignition

A low-velocity an alternate design exhibits lower 1-D margin, but has a lower IFAR



$ITF_{1\text{-}D} = 3.1$



	Fast design	This design
Gain (1-D)	55	87
ρR (g/cm^2)	1.7	2.9
V_{imp} (μm/ns)	305	250
$IFAR_{2/3}$	29	17
Adiabat	1.0	1.0

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