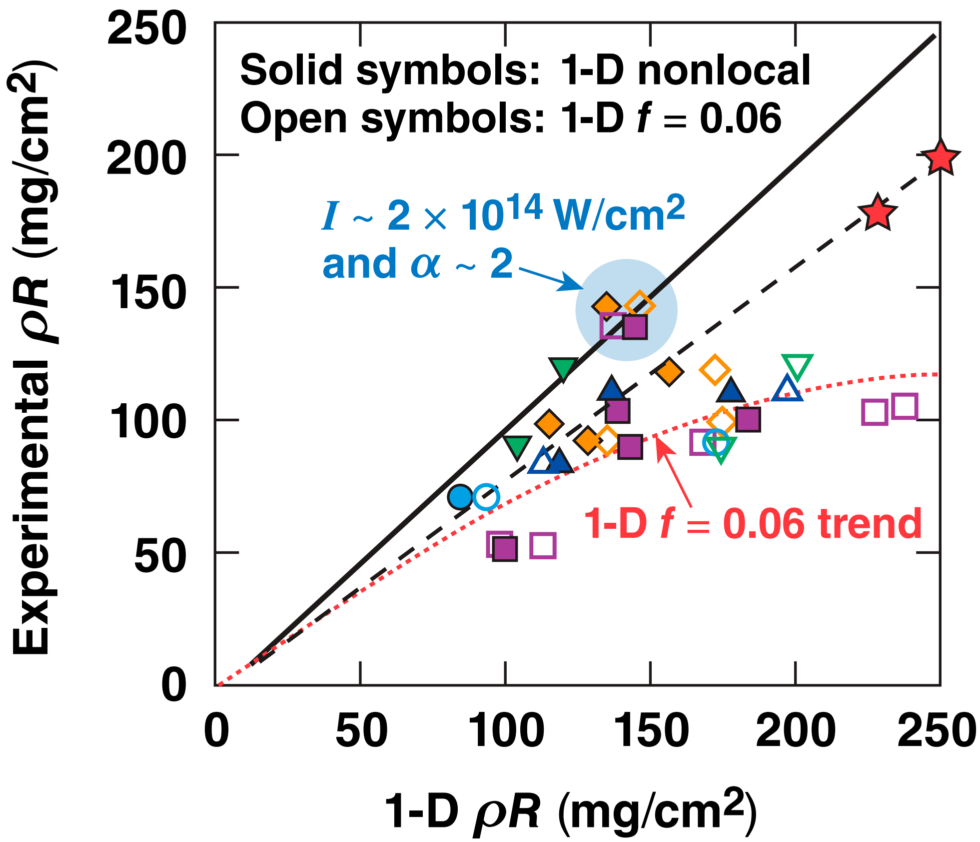
High-Areal-Density Cryogenic D_2 Implosions on OMEGA



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Summary

High areal density ($\langle \rho R \rangle_n$ > 200 mg/cm^2) at an ignition-relevant adiabat has been achieved on OMEGA*

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- ρR degradation relative to 1-D is a combination of shock heating, hot-electron preheating, and burn-weighted sampling of the ρR distribution.
- High areal densities are achieved by using a nonlocal thermal-transport model for the target design and by mitigating hot-electron preheat.
- 1-D simulations using a nonlocal thermal-transport model agree with the measured fuel compression in low-adiabat cryogenic implosions.

The implied adiabat control with the measured 1-D areal densities is important for ignition target design.

*Additional details in the following talks:
P. B. Radha (JO3.00002), J. A. Delettrez (JO3.00003), F. J. Marshall (JO3.00004), R. Epstein (JO3.00005), and S. Skupsky (JOP3.00006).

E16265

Collaborators

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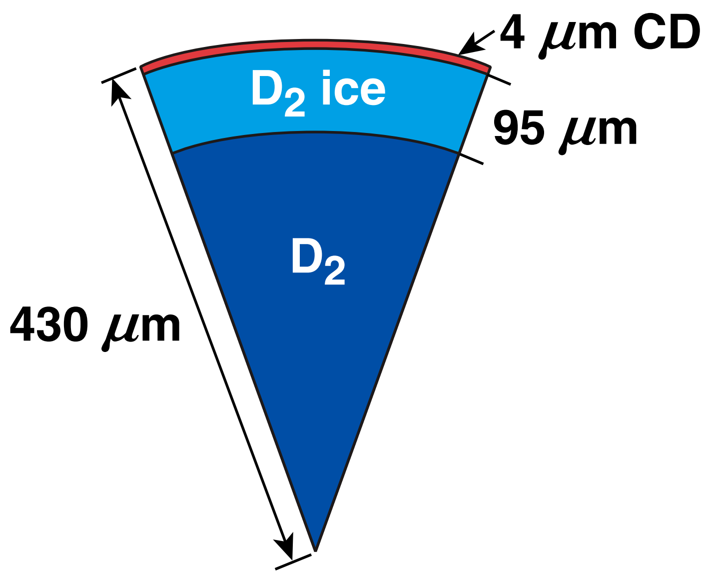
Significant $\langle \rho R \rangle_n$ degradation has been inferred at ignition-relevant drive intensities (~10^{15} W/cm^2)

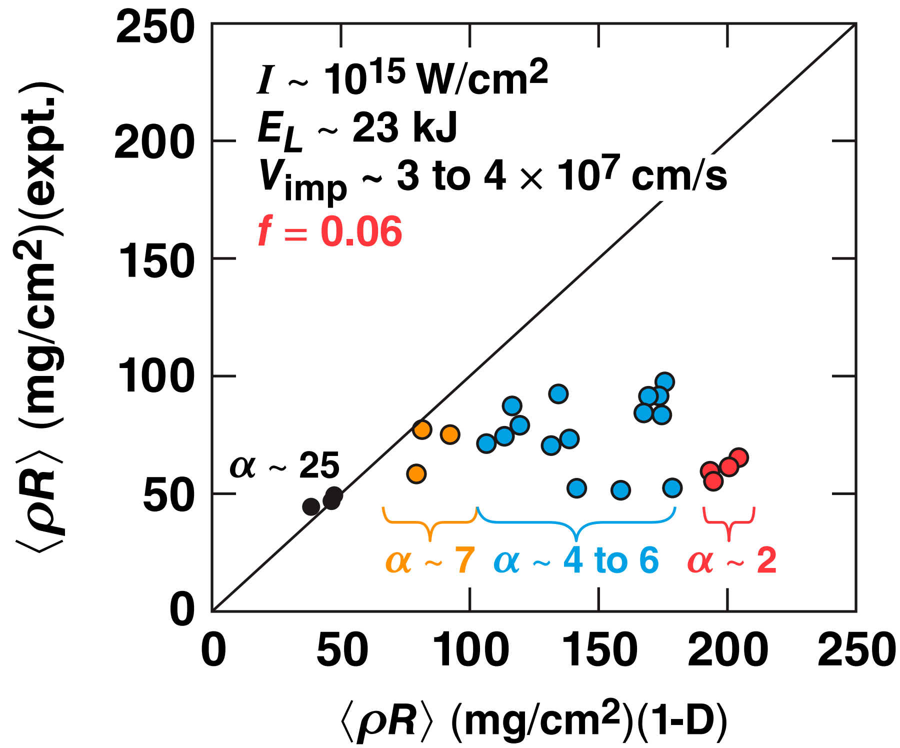
"Standard target"



$\rho R \sim E_L^{1/3}/\alpha^{0.54}$ **

Degradation suggests that the fuel adiabat is not as designed

$\langle \rho R \rangle_n$ inferred from the energy loss of secondary protons*



*F. H. Séguin *et al*., Rev. Sci. Instrum. 74, 975 (2003).
**R. Betti and C. Zhou, Phys. Plasmas 12, 110702 (2005).

There are several possible sources for adiabat degradation

- Hydrostability of the imploded shell
  - mid-α/high-I and low-α/mid-I implosions are predicted to be stable
- Shock mistiming due to absorption discrepancies and nonlocal thermal transport
  - degradation depends on design and can be significant (>50%)
- Radiation preheating
  - D_2 is almost transparent to thermal x rays so ΔT < few eV
- Hot electrons from plasma instabilities (two plasmon and SRS)
  - hard-x-ray signal suggests f_{hot} ~ 0.1% and T_{hot} ~ 100 keV
- Nonlocal thermal electrons and fast electrons from resonance absorption
  - T_e ~ 2 to 5 keV so penetration is < 25 μm $\ll$ $\Delta R(D_2)$

Shock timing and hot electrons from two-plasmon decay are the most likely sources.

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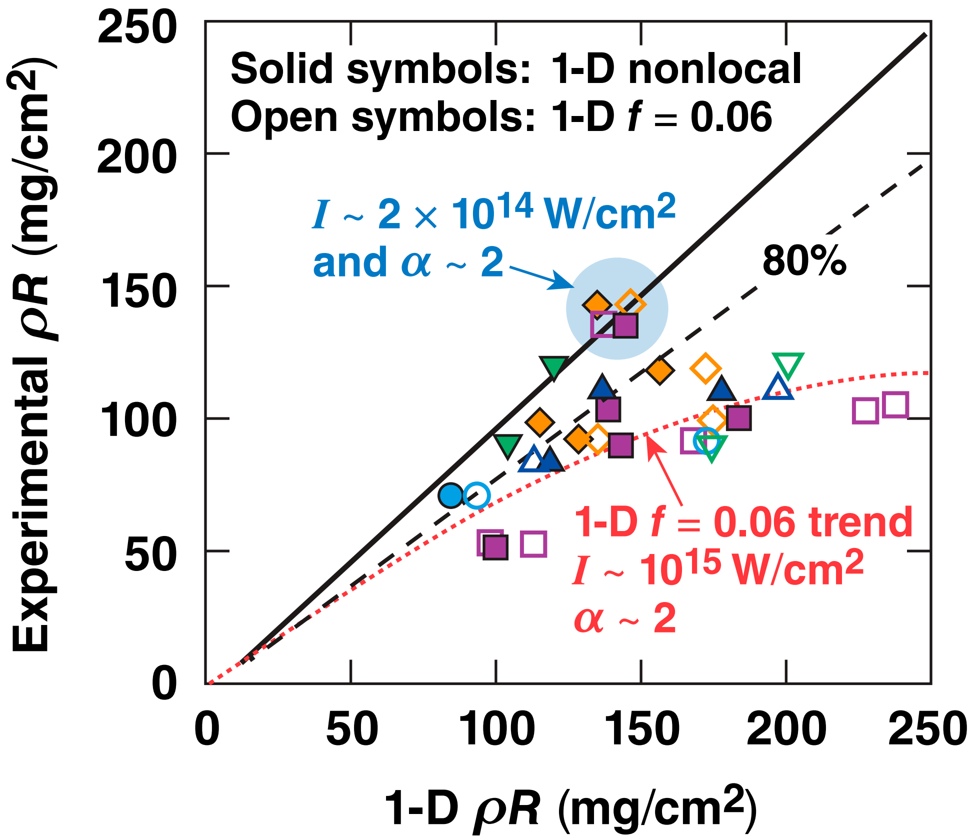
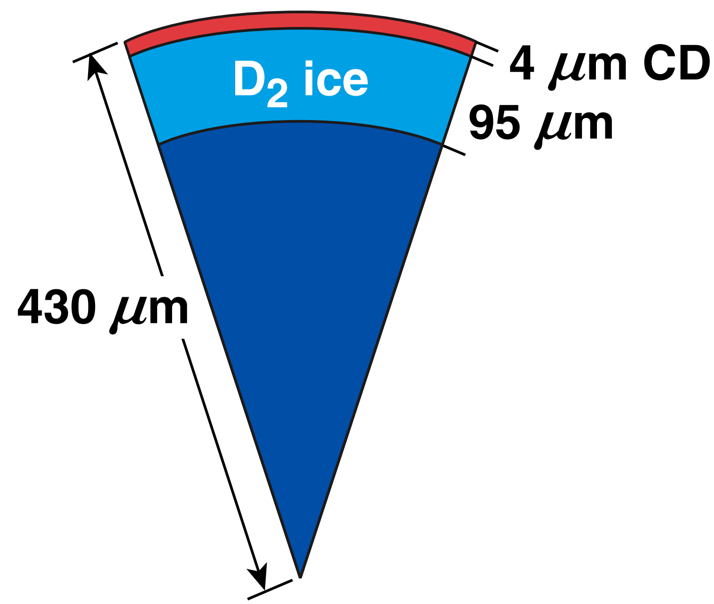
W. Seka (GI1.00003), V. N. Goncharov (GI1.00001), and J. A. Delettrez (JO3.00003)

1-D predications of past shots using a new nonlocal model* are within ~80% of the experimental $\langle \rho R \rangle_n$





The remaining ~20% degradation is likely a combination of preheating and burn-weighted sampling of the ρR distribution

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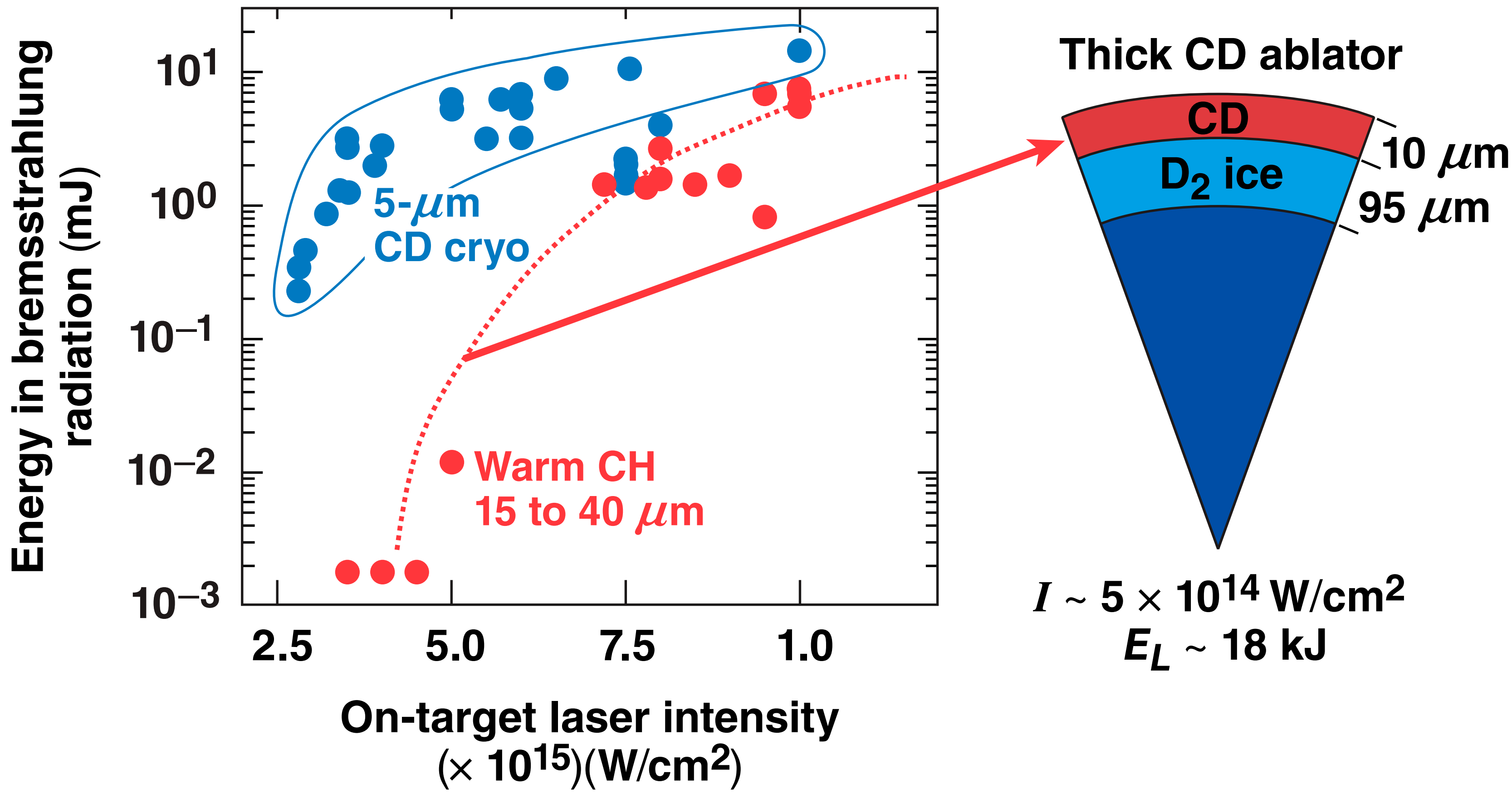
*V. N. Goncharov (GI1.00001).

Warm CH implosions suggest that preheat is minimized with a thick CD ablator at ~5 × 10^{14} W/cm^2



For a thick (10-μm) CD ablator, the preheat is negligible at drive intensities of 5 × 10^{14} W/cm^2

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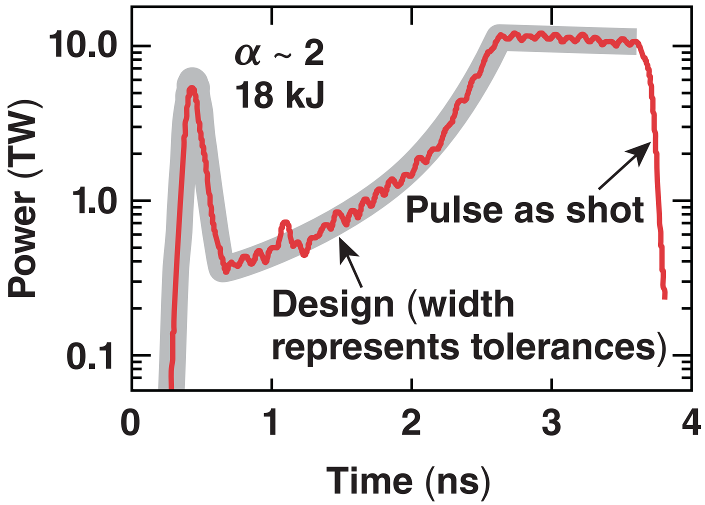
Using an optimal pulse shape*, the thick ablator-fuel assembly proceeded according to the 1-D simulations



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*V. N. Goncharov (GI1.00001)

Using an optimal pulse shape*, the thick ablator-fuel assembly proceeded according to the 1-D simulations

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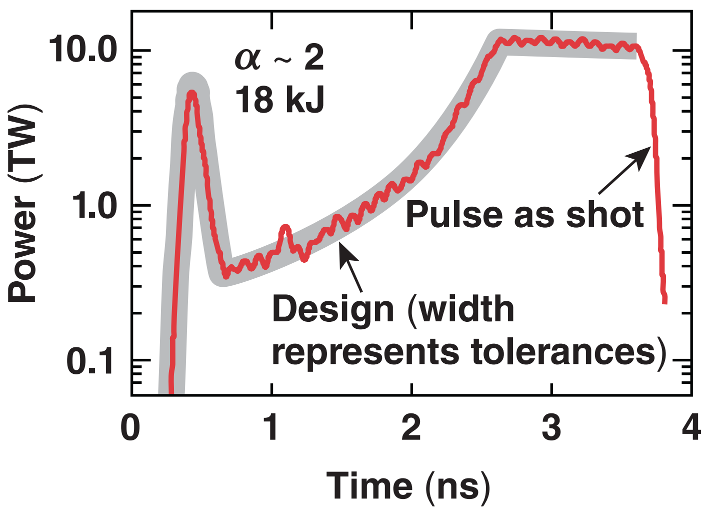
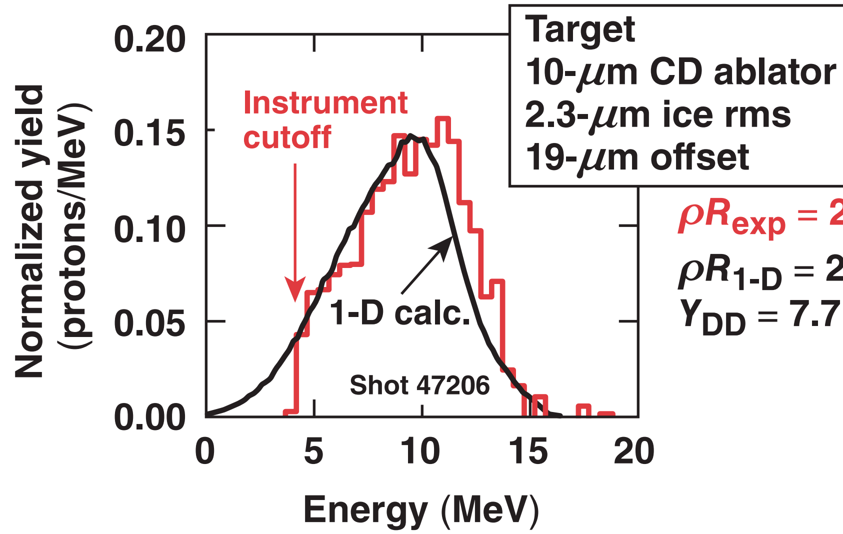




ρR_{exp} = 202 mg/cm^2

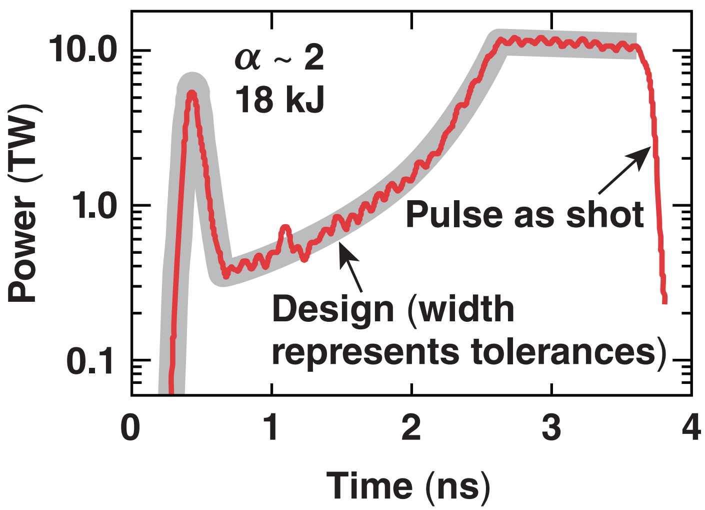
$\rho R_{1\text{-}D}$ = 247 mg/cm^2

$Y_{DD} = 7.7 \times 10^9$ (5.1%)

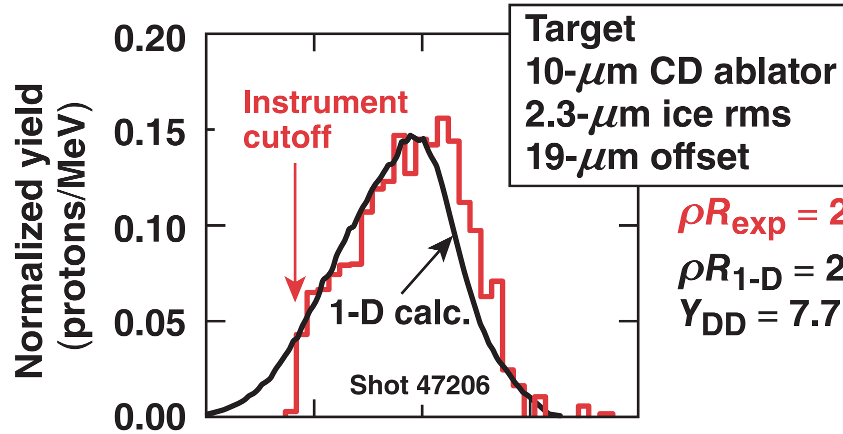
T2368a-2

*V. N. Goncharov (GI1.00001)

Using an optimal pulse shape*, the thick ablator fuel assembly proceeded according to the 1-D simulations



Changing the timing of the picket by 200 ps reduced the areal density in the measurements and simulations



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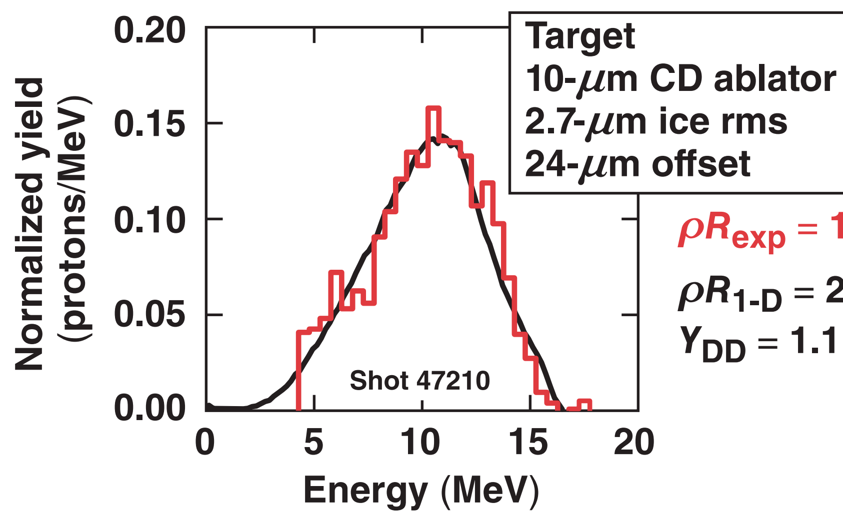

ρR_{exp} = 182 mg/cm^2

$\rho R_{1\text{-}D}$ = 224 mg/cm^2

$Y_{DD} = 1.1 \times 10^{10}$ (7.3%)

These are the highest fuel areal densities yet measured in ignition-relevant laboratory implosions

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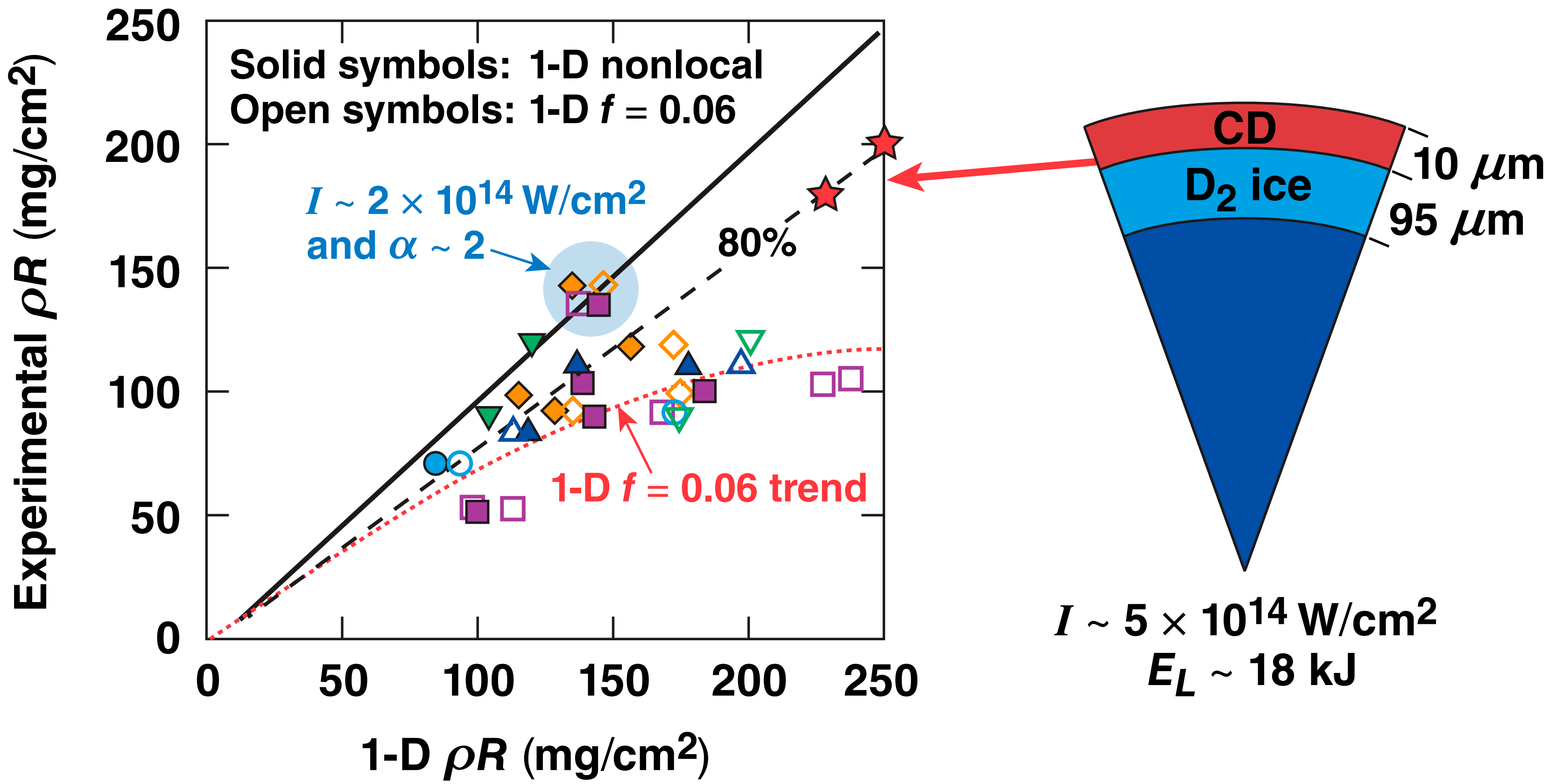
*V. N. Goncharov (GI1.00001)

Targets designed with the nonlocal model gave approximately 80% of the 1-D prediction



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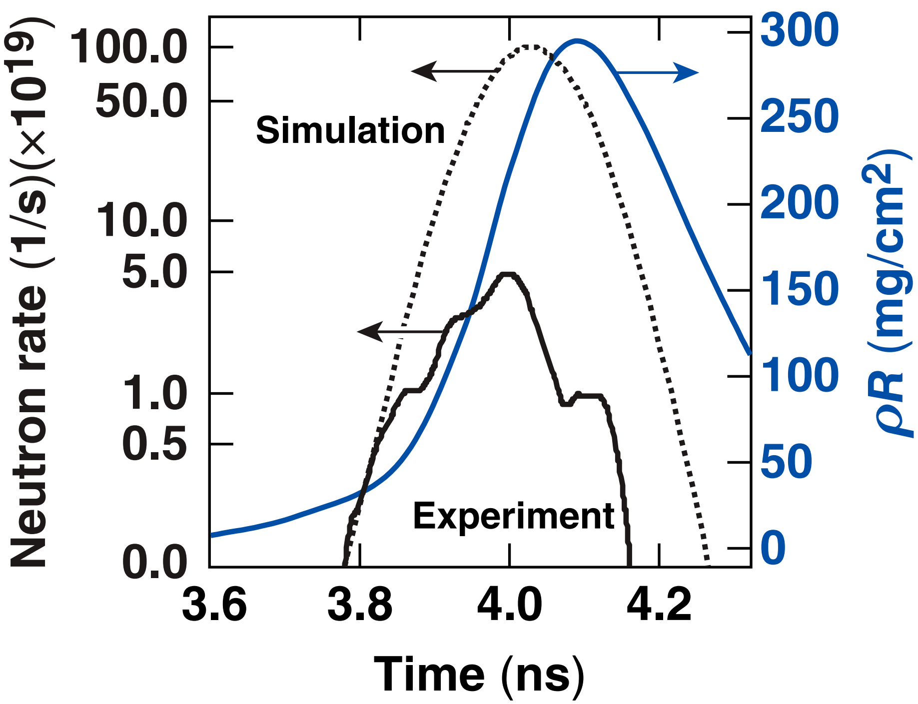
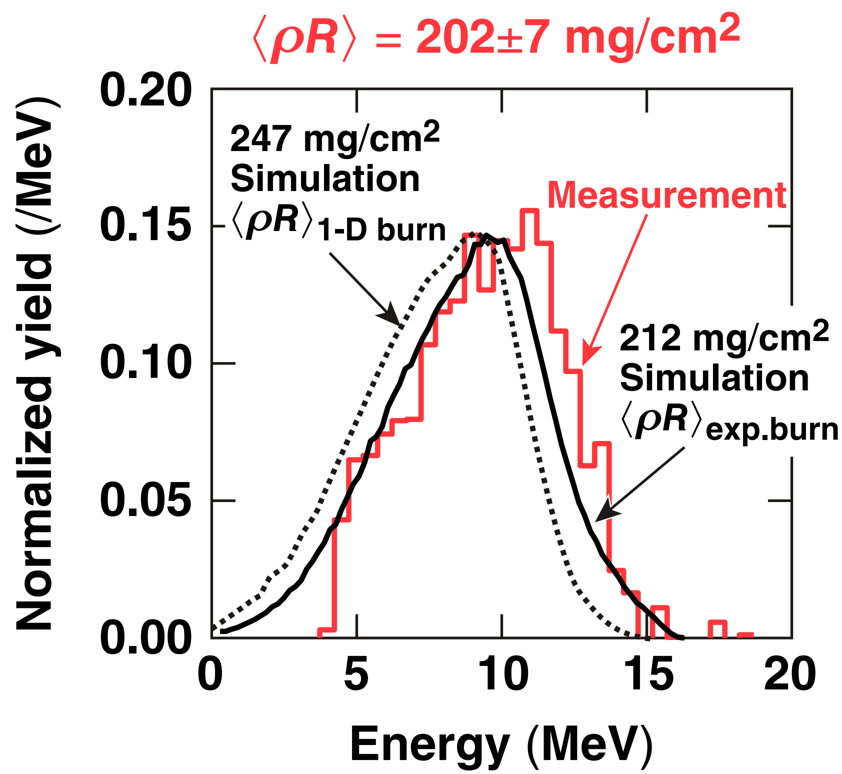
Burn-weighted sampling brings the predicted areal density to within 5% of the experimental value





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Burn-weighted sampling of the brings the predicted areal density to within 5% of the experimental value

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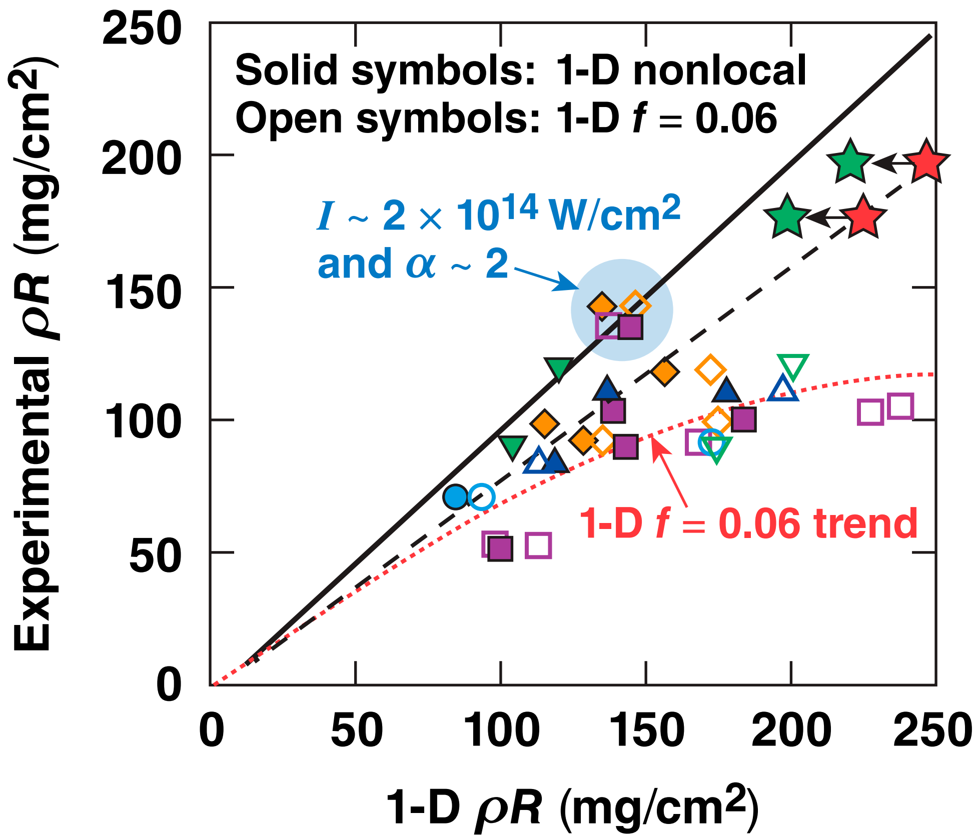

The next stage* is to develop techniques to mitigate preheat at $I \sim 1 \times 10^{15}$ W/cm^2 and achieve $V_{imp} \sim 3$ to 4×10^7 cm/s

E16321

*P. B. Radha (JO3.00002), and J. P. Knauer (PO6.00010)

Summary/Conclusions

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