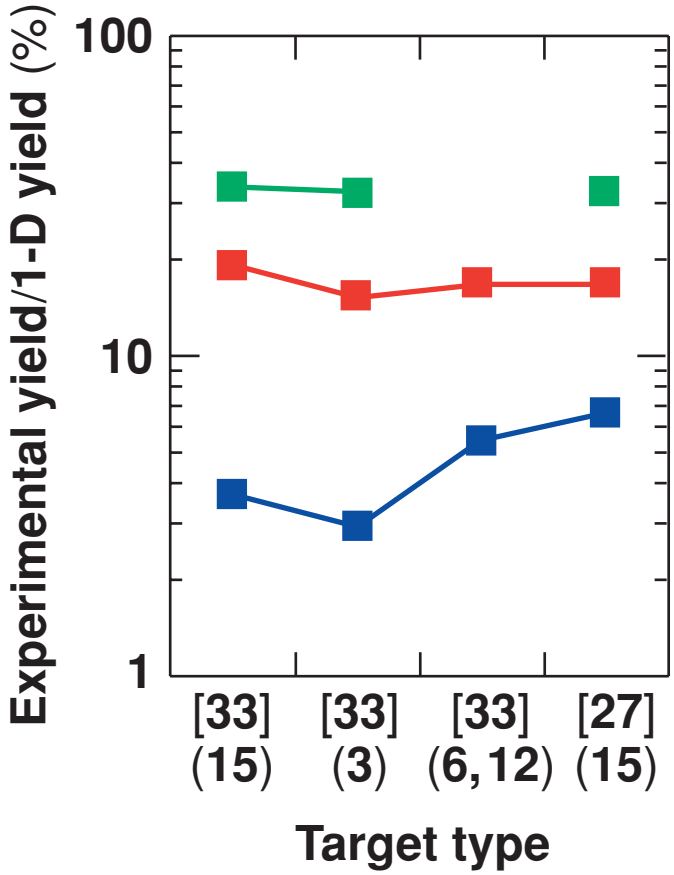
Improved Performance of Direct-Drive Implosions with a Laser-Shaped Adiabat



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Summary

Adding a picket pulse to a shaped drive laser pulse improves the performance of spherical implosions

UR LLE

- A picket pulse shape has been designed that will vary the adiabat inside a CH shell.
- The absolute yield of measured fusion products increases up to a factor of 2.7, and the measured neutron yield/calculated neutron yield (YOC) improves from 3.7% to 18% when a picket pulse is used.
- Measured target compression did not decrease when the picket pulse was added.

Outline

Improved performance of direct-drive implosions with laser-shaped adiabat

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- Design experiment
- Expected adiabat profile
- X-ray measurements
- Fusion product measurements

Shaping the adiabat within the shell results in a more stable and compressible implosion

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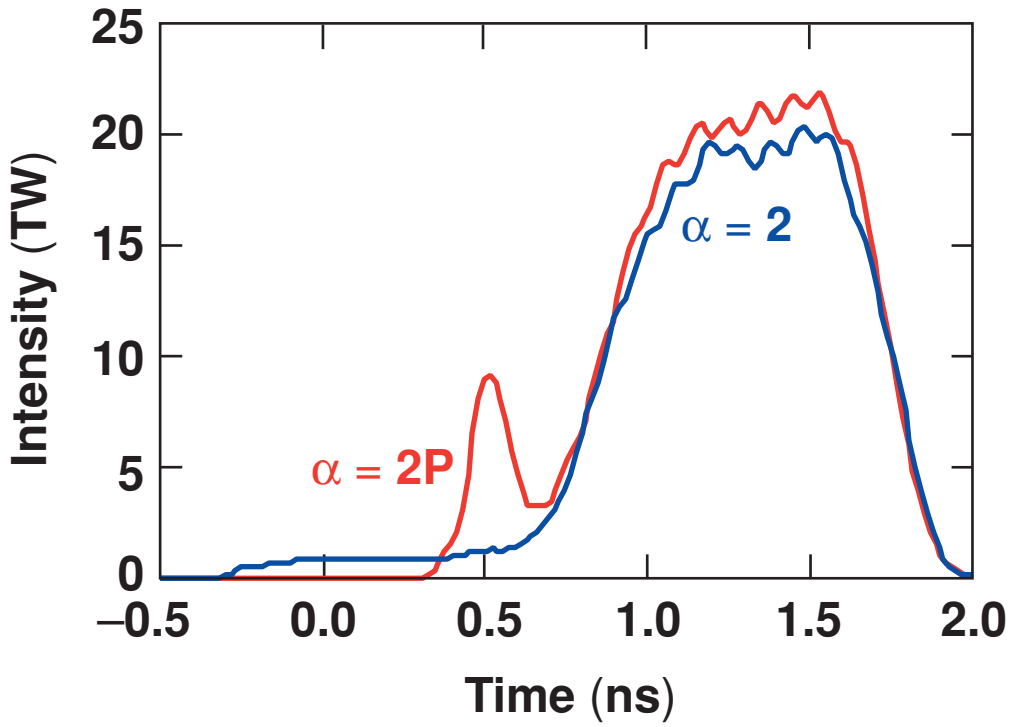
$$\alpha = \frac{P}{P_{Fermi}}$$

$$\gamma = 0.98\sqrt{\frac{kg}{1+kL}} - 1.7\,kV_a$$

$$V_a \propto \alpha_{shell\ (ablation)}^{3/5}$$

$$E_{compression} \propto \alpha_{shell\ (fuel)}^{n} \qquad n = \begin{array}{l} 2.4\ (\text{Betti}) \\ 1.9\ (\text{Herrmann}) \end{array}$$

A picket pulse was added to a drive pulse that implodes a CH target on an $\alpha = 2$ adiabat

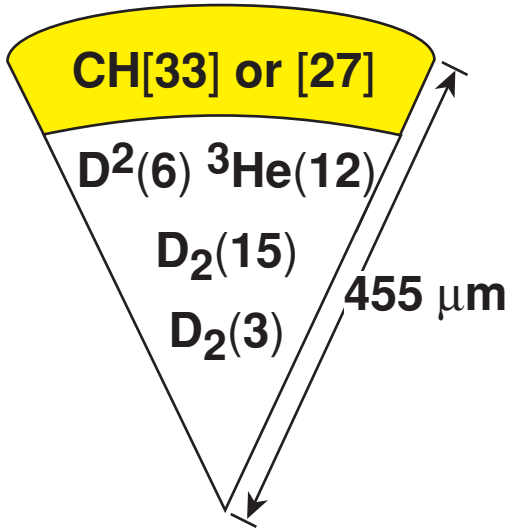


Picket pulse

Width (FWHM) = 120 ps

Amplitude = 0.4 of drive

Position = 340 ps before drive



E11906

The bubble height/shell thickness stays below 0.7 for the drive with the picket pulse

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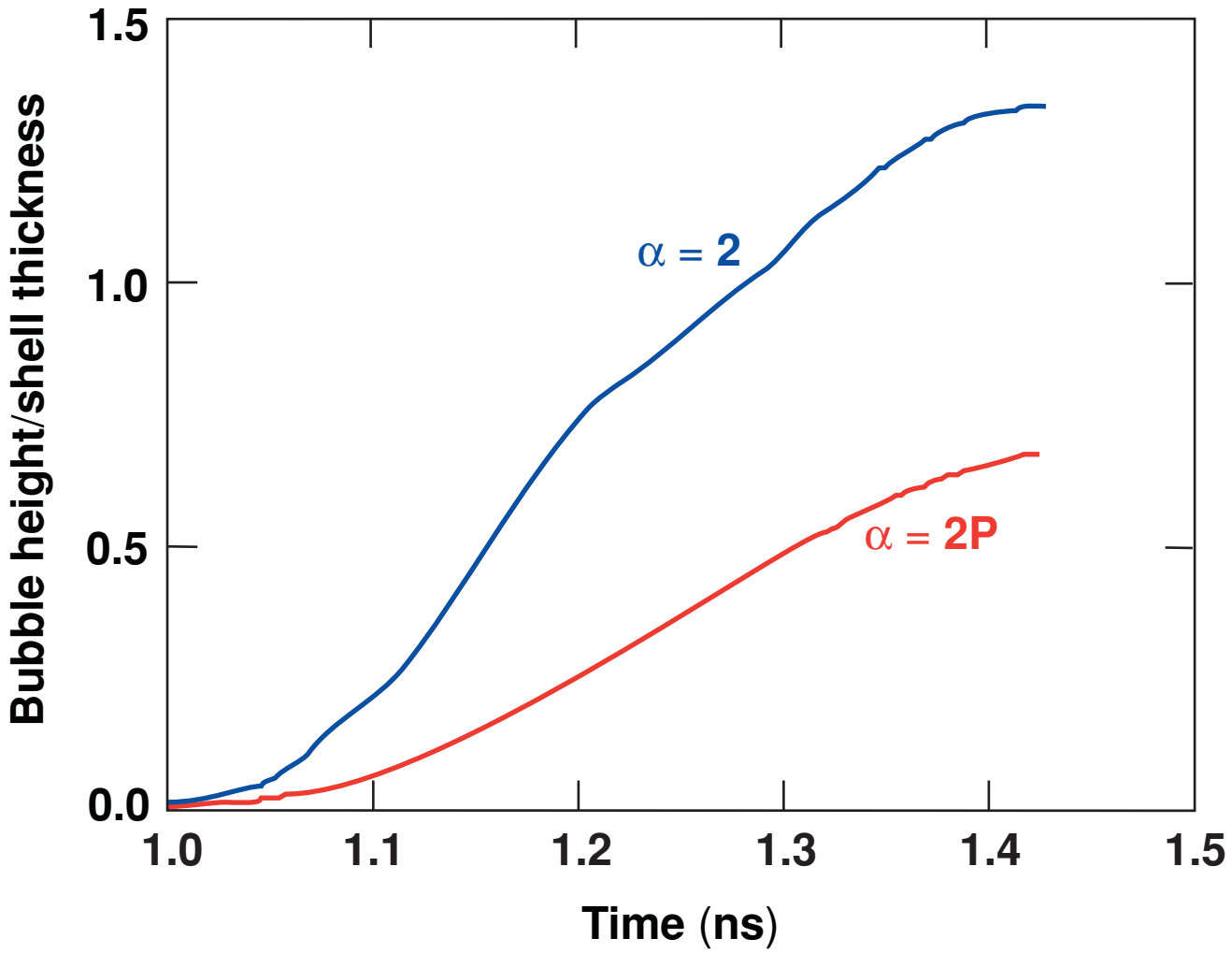
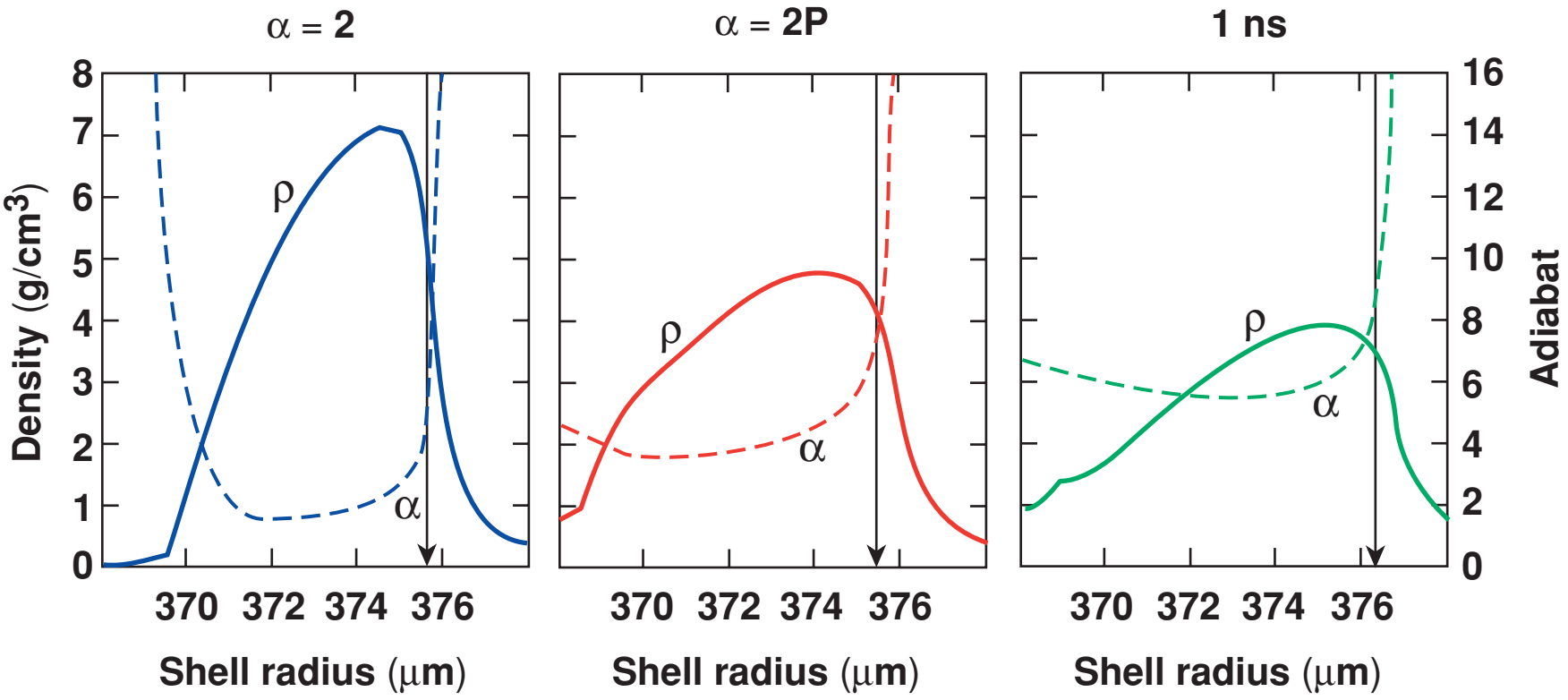
LILAC simulation with stability postprocessor



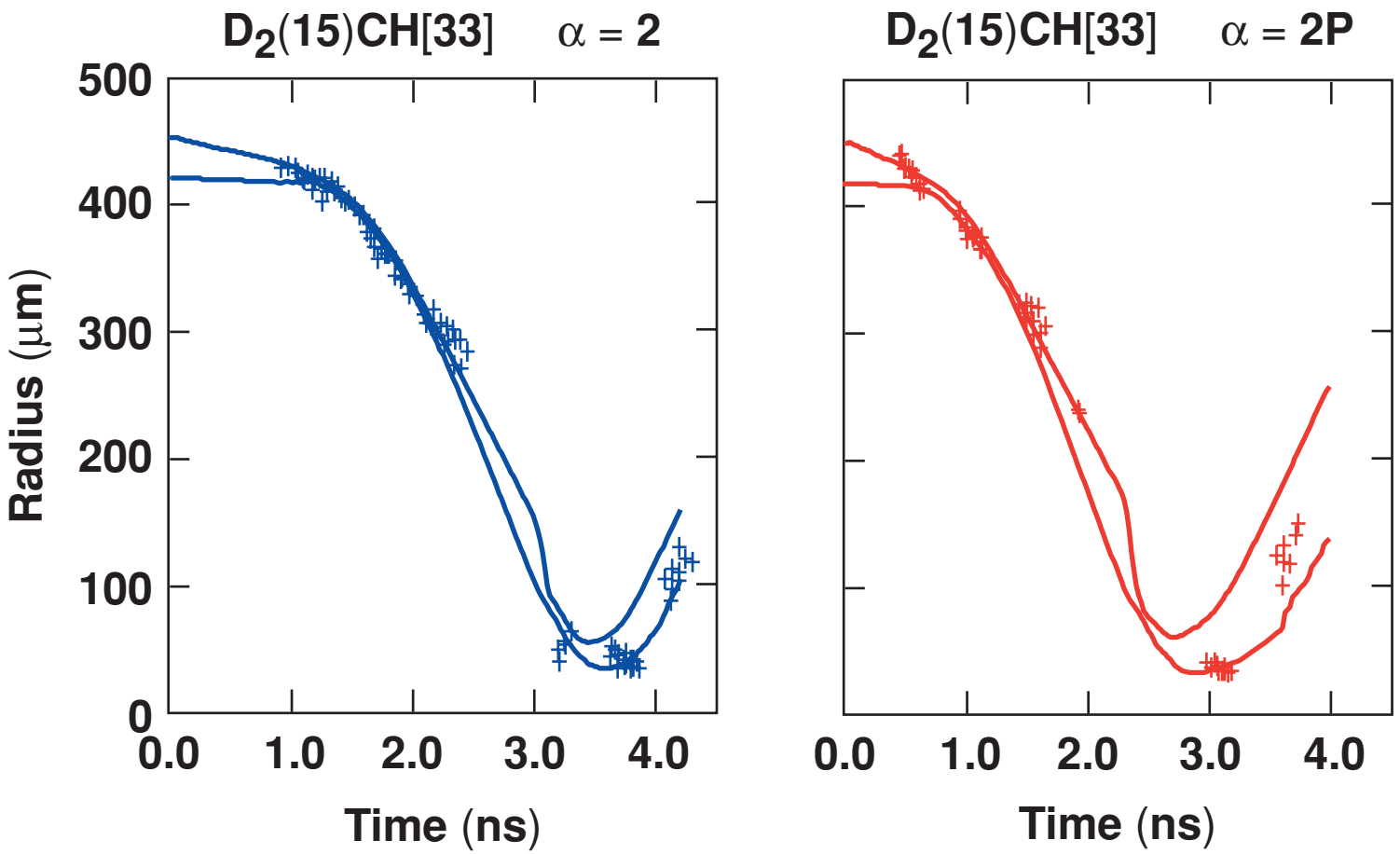
E11907

The adiabat at ablation interface increases from 4 to 6 when a picket is added



E11908

Simulated shell trajectories agree with experimental measurements for pulse shapes



X-ray microscope data show a larger emission region when a picket is used

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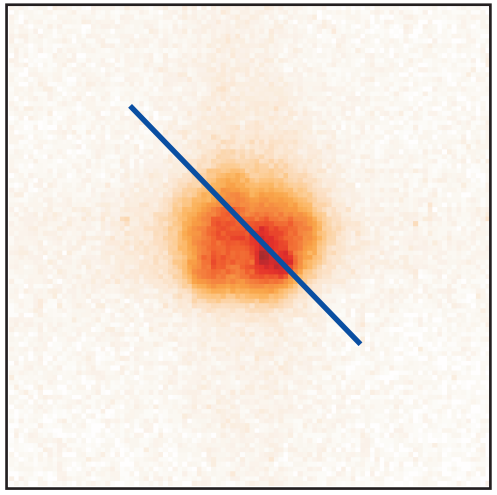
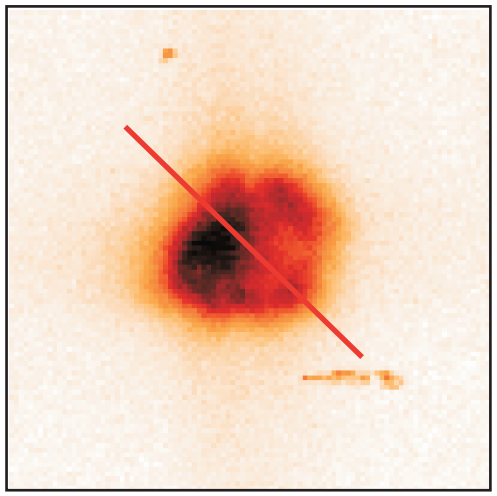
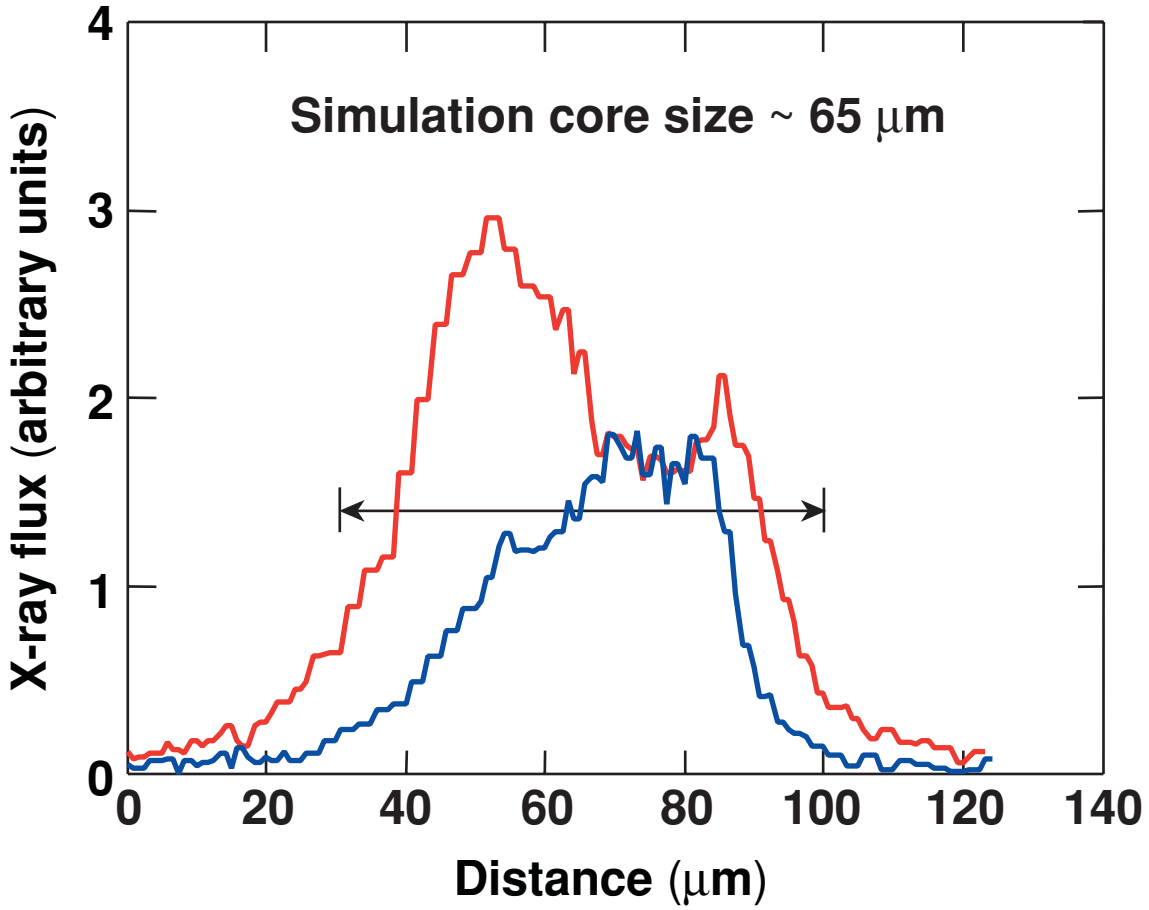
$\alpha = 2$



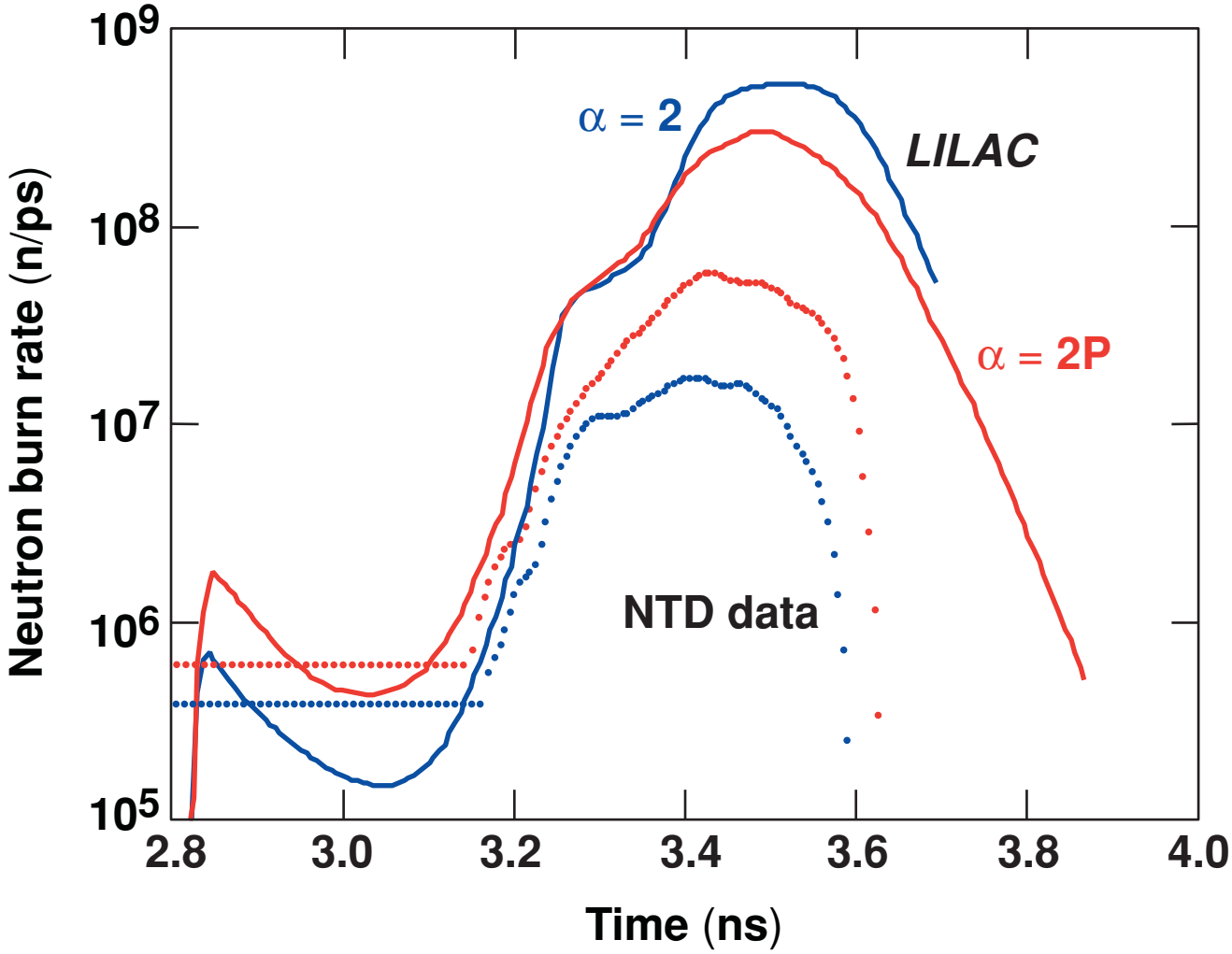
$\alpha = 2P$





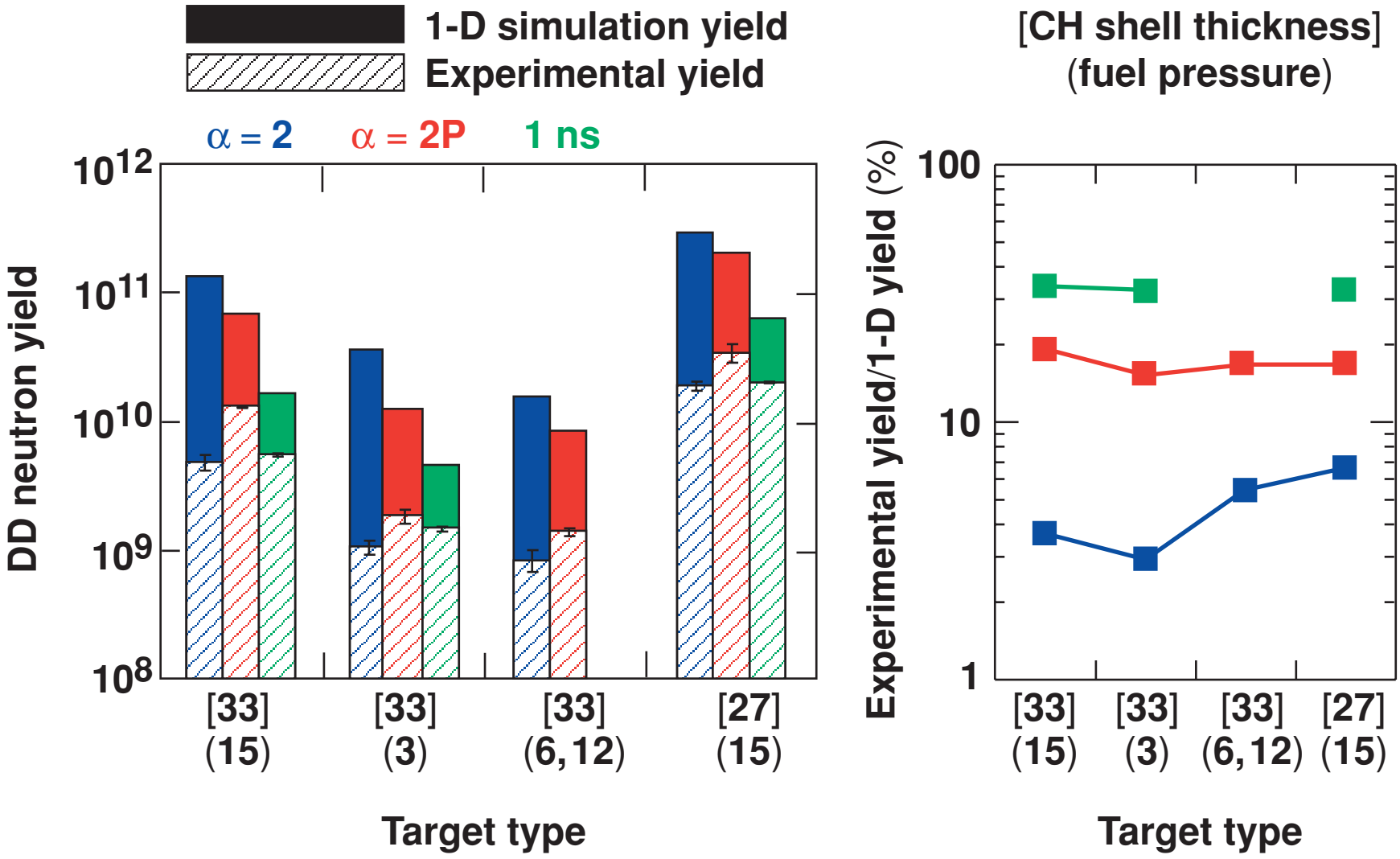
E11910

The neutron burn rate increases when a picket pulse is added to the drive pulse



E11911

Both the experimental yield and the normalized yield increase when a picket pulse is used



E11912

The picket increases the yield from D^{3}He reactions and maintains compressibility

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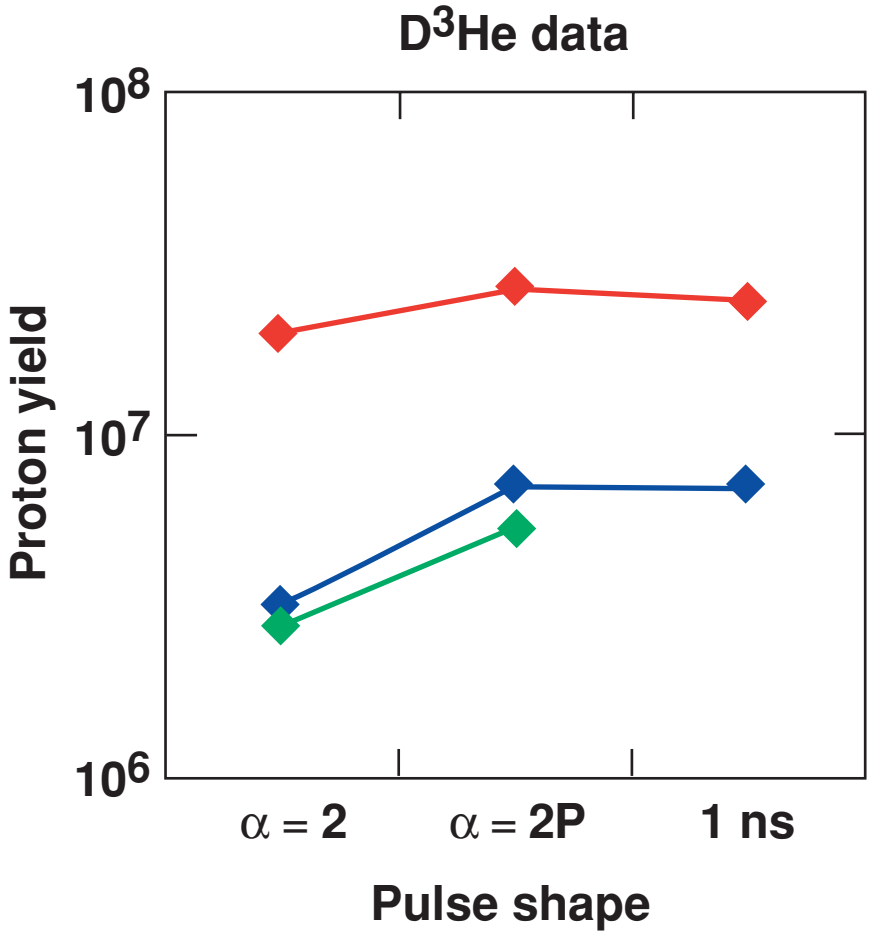
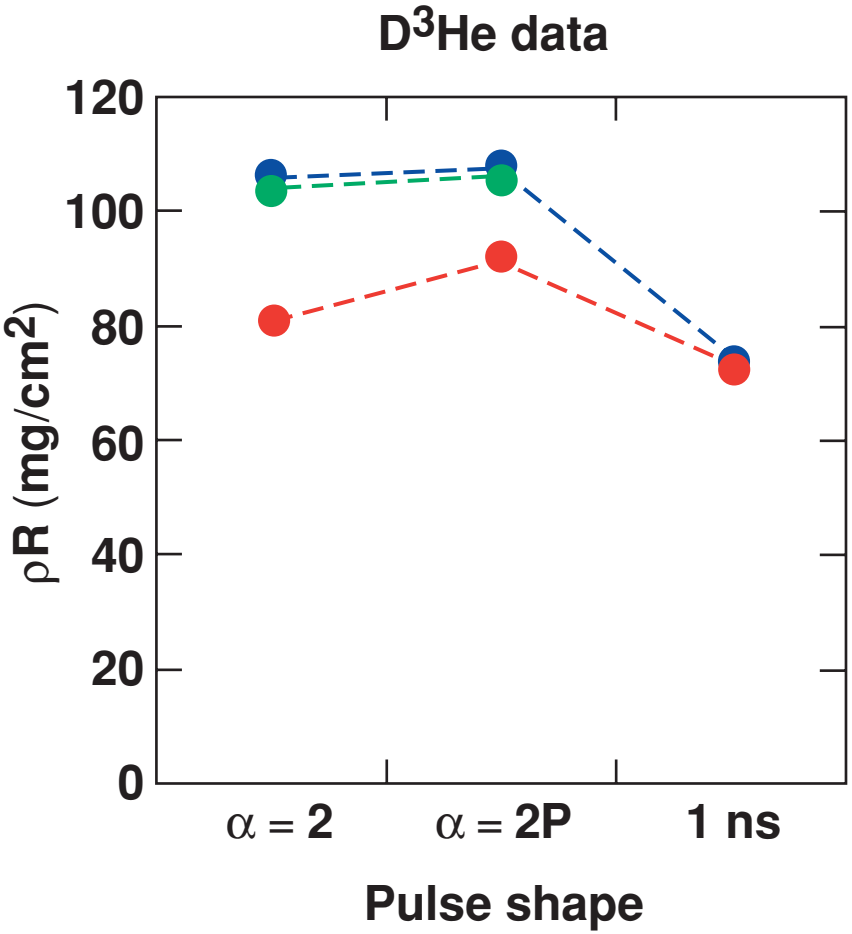
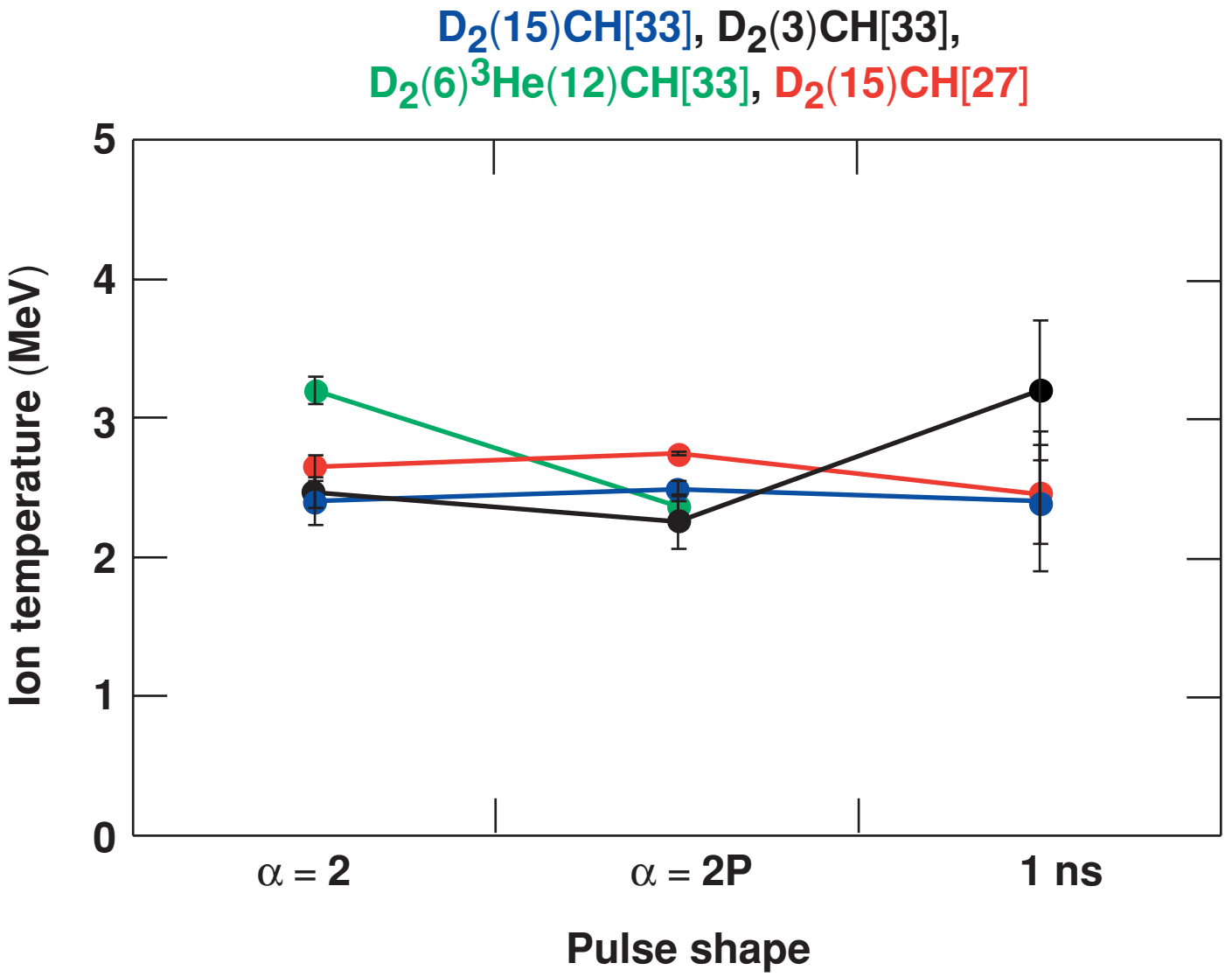
D_2(15)CH[33], D_2(6)^{3}He(12)CH[33], D_2(15)CH[27]





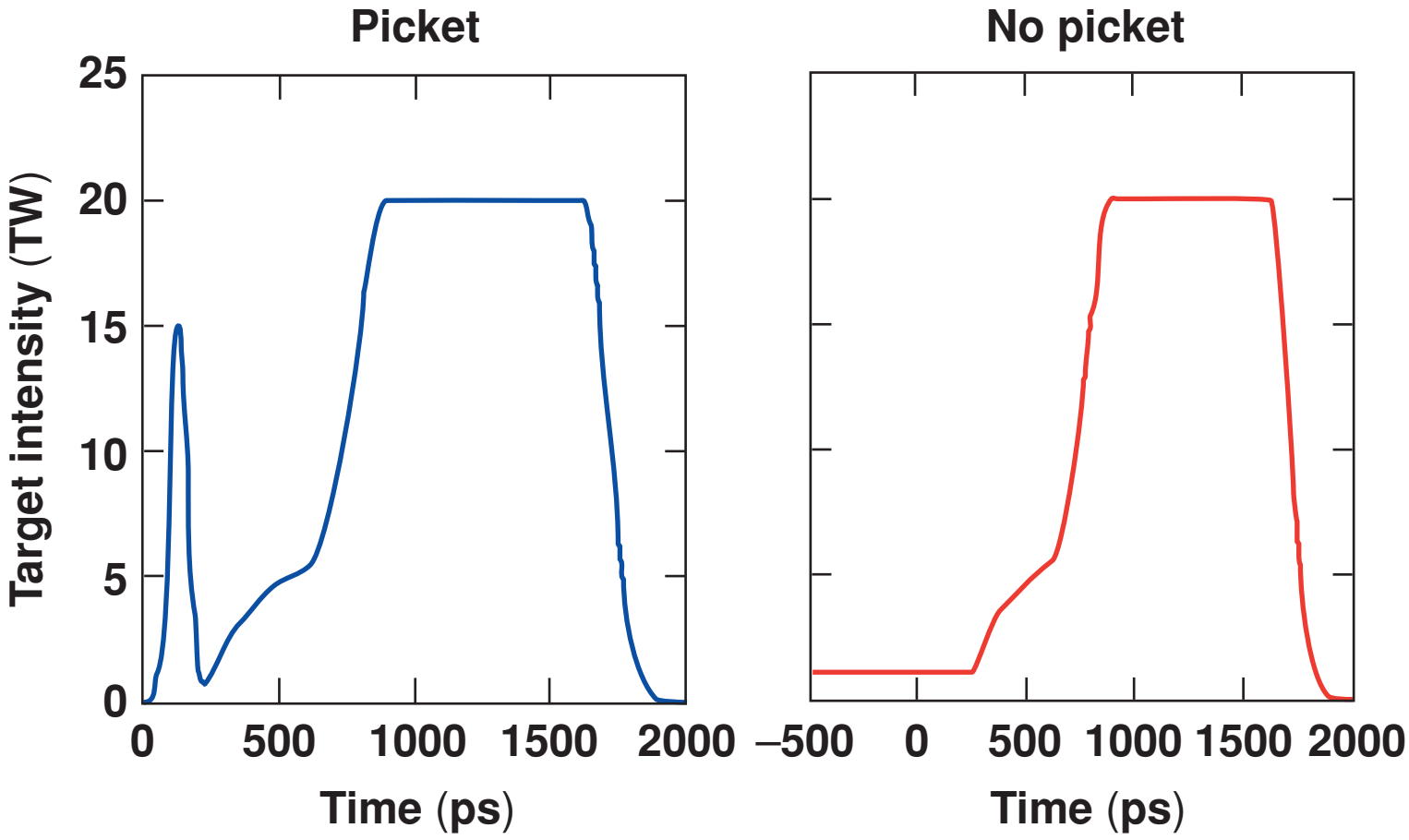
E11913

Measured ion temperature is unaffected by pulse shape



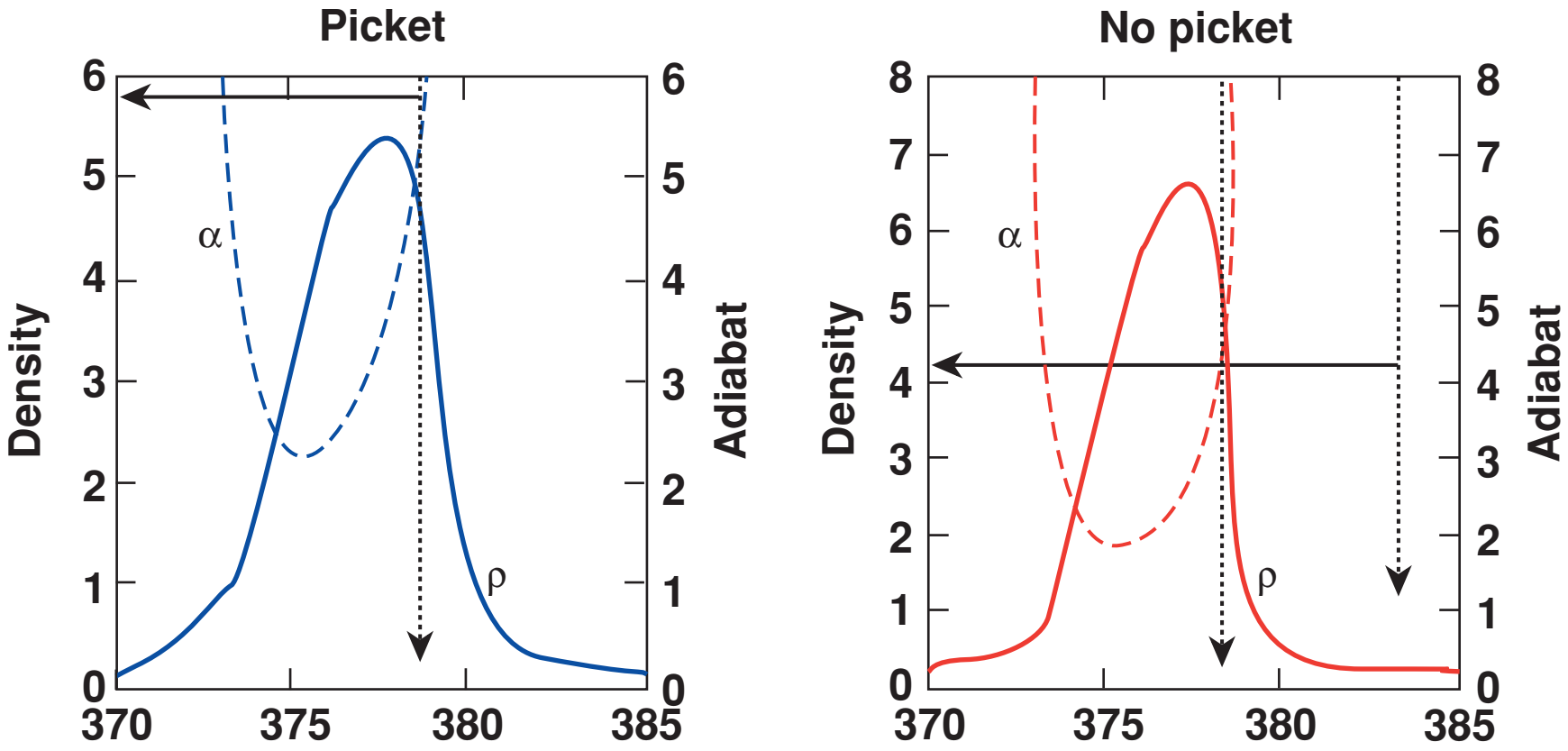
E11914

A new picket pulse shape was designed for the 27-μm-thick targets



E11915

Density and adiabat profiles for 27-μm shells with and without picket



E11916

Summary/Conclusions

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- The absolute yield of measured fusion products increases up to a factor of 2.7, and the measured neutron yield/calculated neutron yield (YOC) improves from 3.7% to 18% when a picket pulse is used.
- Measured target compression did not decrease when the picket pulse was added.
- Experiments are being done with thinner CH shells