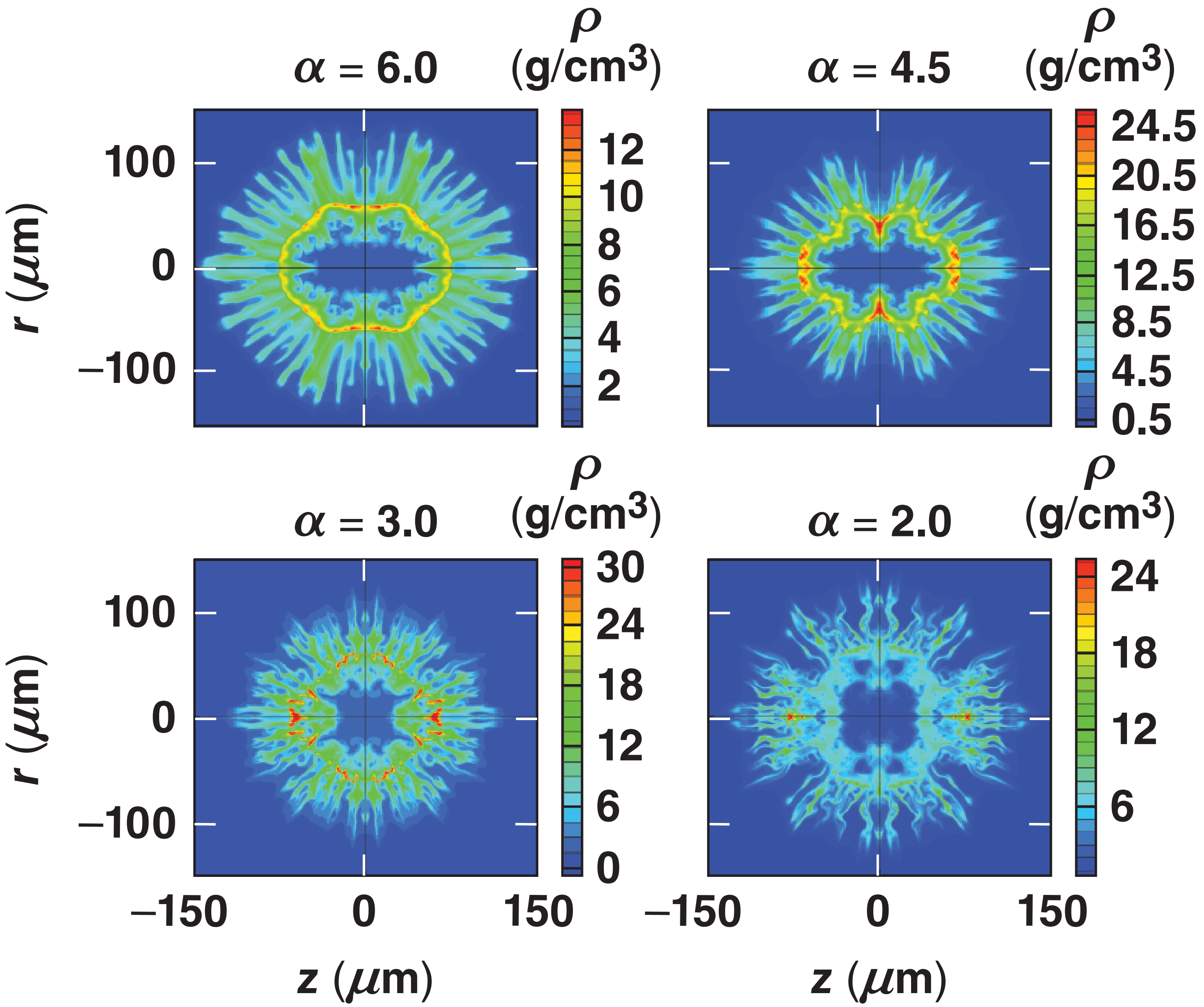
Understanding Laser-Imprint Effects on Plastic Target Implosions on OMEGA with New Physics Models



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Division of Plasma Physics
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Summary

DRACO simulations and experiments have indicated that laser imprint is a major source degrading $\alpha \leq 3$ warm-target implosion performance on OMEGA

- A systematic study of laser-imprint effects on warm-target implosions of different α has been performed using both experiments and *DRACO* simulations
- The x-ray self-emission imaging technique enables us to measure emissions from both ablation front and hot spot, from which the thickness of an imploding CH shell can be inferred
- The state-of-the-art *DRACO* simulations use the new physics models of nonlocal thermal transport, cross-beam energy transfer (CBET), and first-principles equation of state (EOS)
- Most of the measured laser-imprint features (earlier hot-spot emission, “decompressed” shell, and yield reduction) have been well reproduced by our *DRACO* simulations with laser imprint up to mode $\ell = 200$

Mitigating laser imprint is important for the success of direct-drive–ignition attempts.

TC12977

Collaborators

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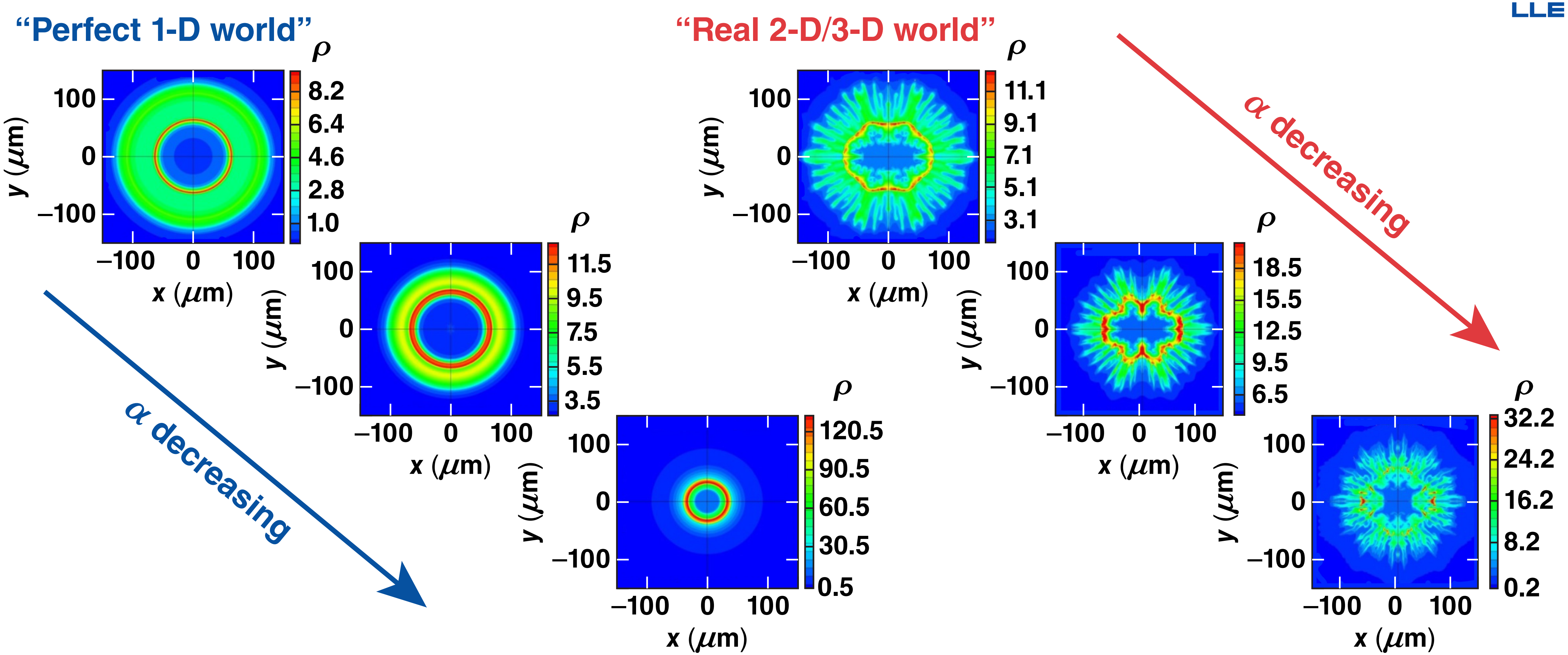
Laser imprint* can seed the Rayleigh–Taylor instability endangering the success of direct-drive–ignition attempts



*R. Ishizaki and K. Nishihara, Phys. Rev. Lett. 78, 1920 (1997); V. A. Smalyuk *et al*., Phys. Rev. Lett. 81, 5342 (1998); V. N. Goncharov *et al*., Phys. Plasmas 7, 2062 (2000); S. Fujioka *et al*., Phys. Rev. Lett. 92, 195001 (2004); P. B. Radha *et al*., Phys. Plasmas 12, 056307 (2005); V. A. Smalyuk *et al*., Phys. Rev. Lett. 103, 105001 (2009); S. X. Hu *et al*., Phys. Rev. Lett. 108, 195003 (2012); G. Fiksel *et al*., Phys. Plasmas 19, 062704 (2012); A. Casner *et al*., Phys. Plasmas 21, 122702 (2014); M. Karasik *et al*., Phys. Rev. Lett. 114, 085001 (2015).

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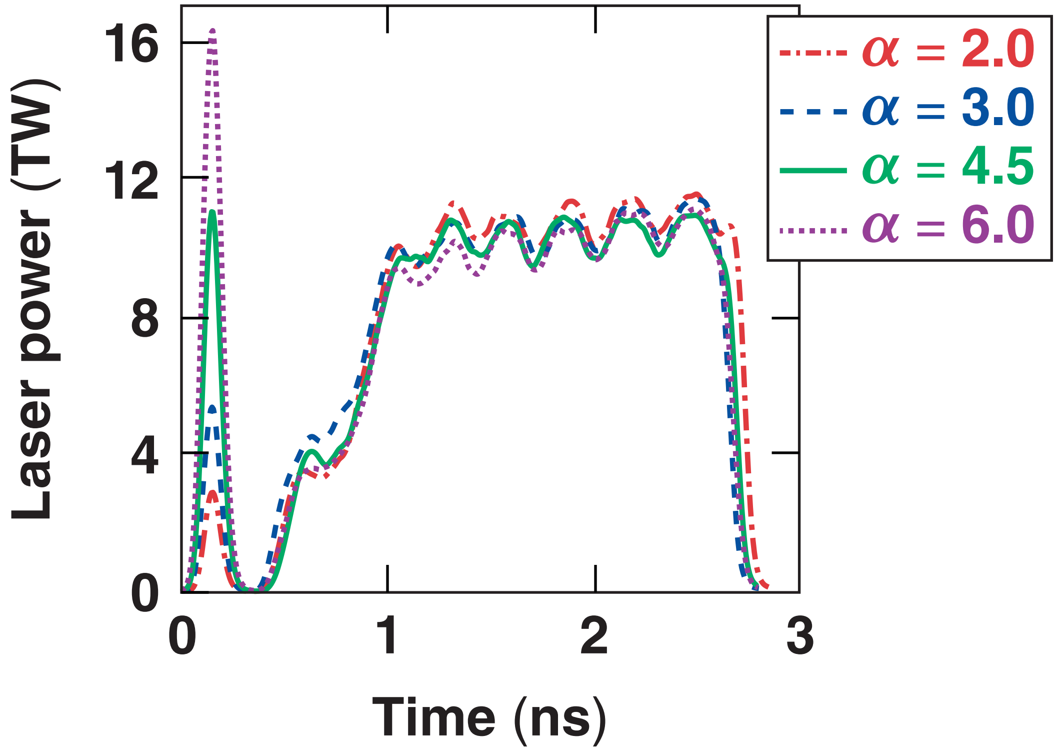
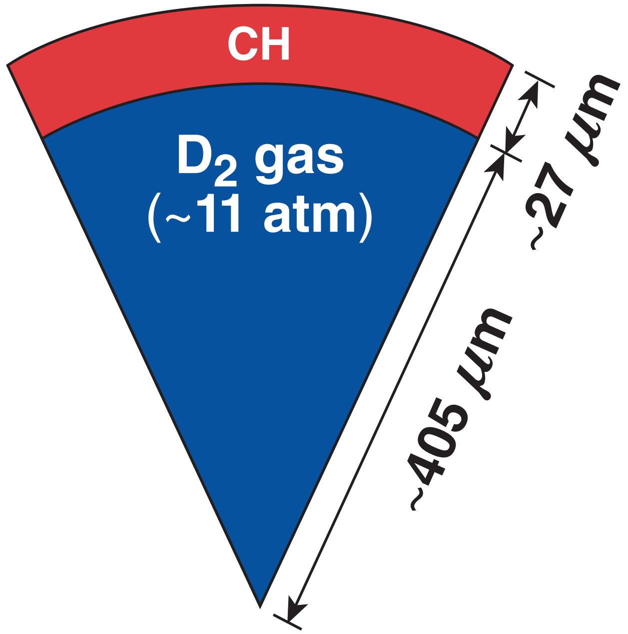
Warm CH-target implosions with different adiabats (α = 2 to 6) have been conducted to assess the laser-imprint effects on OMEGA

SG-5 phase plates and SSD on/off





To understand laser-imprint effects for these implosions, the state-of-the-art physics models, including the nonlocal thermal transport [improved Schurtz-Nicolai-Busquet (iSNB)], cross-beam energy transfer (CBET), and first-principles equation of state (FPEOS), are used in our *DRACO* simulations.

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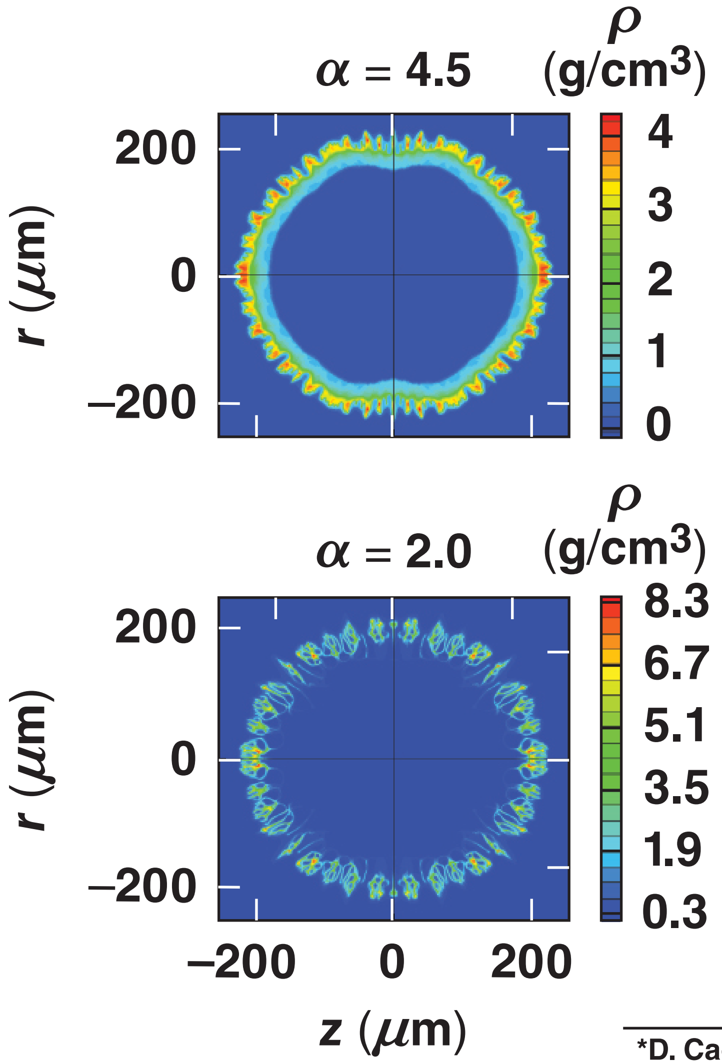
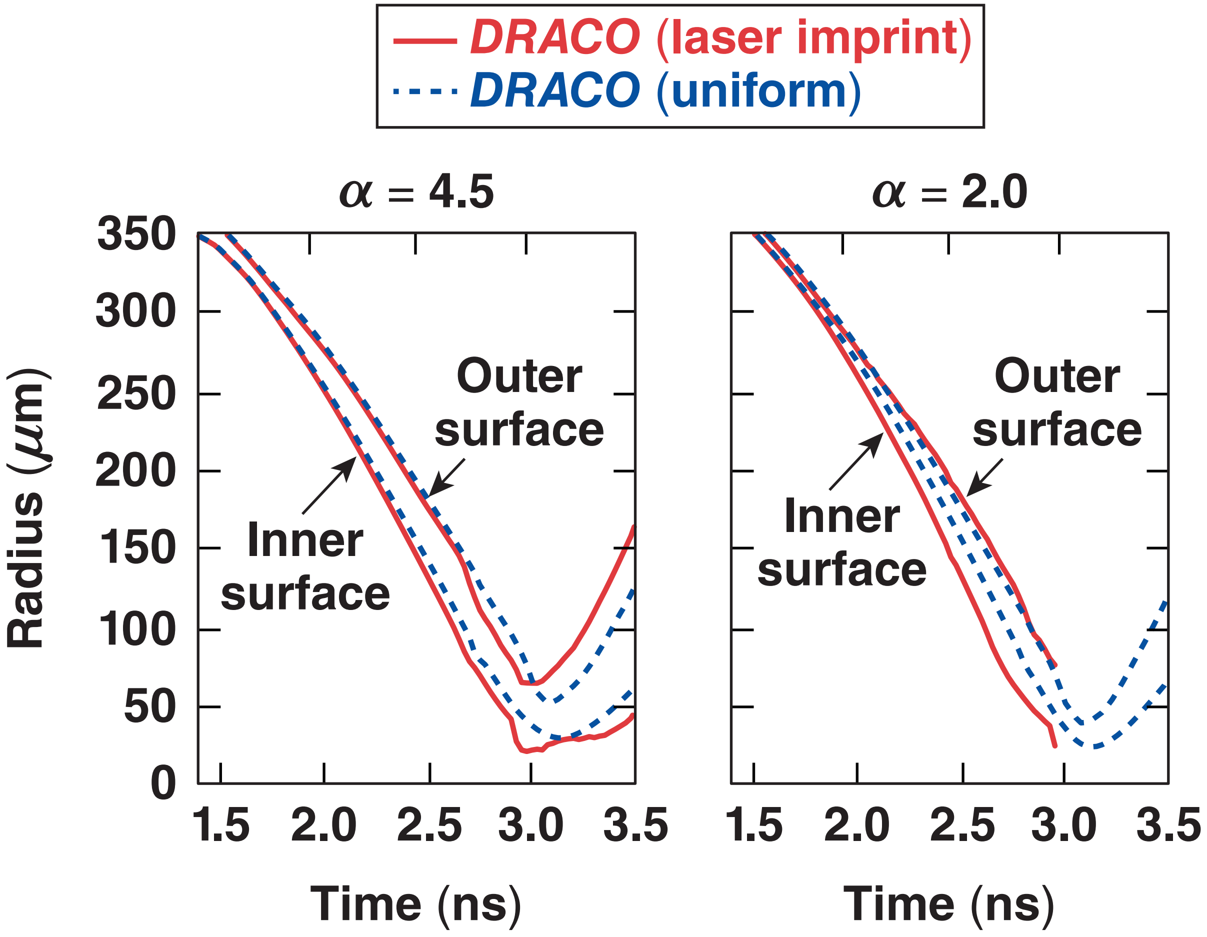
DRACO simulations with new physics models (iSNB,* CBET,** FPEOS†) predicted significant distortions for low-α implosions caused by laser imprint (up to mode $\ell = 200$)

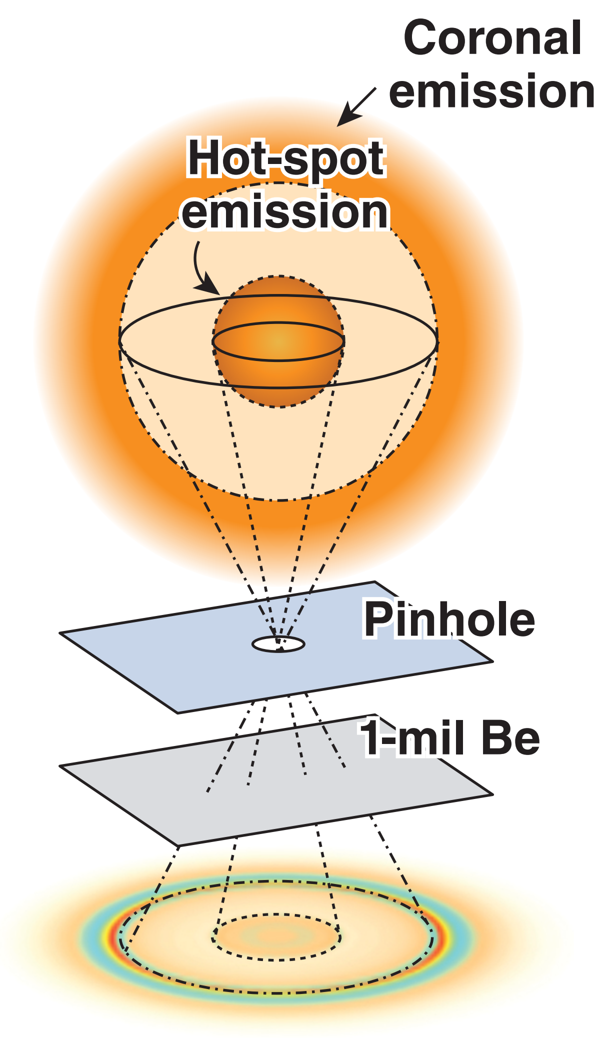


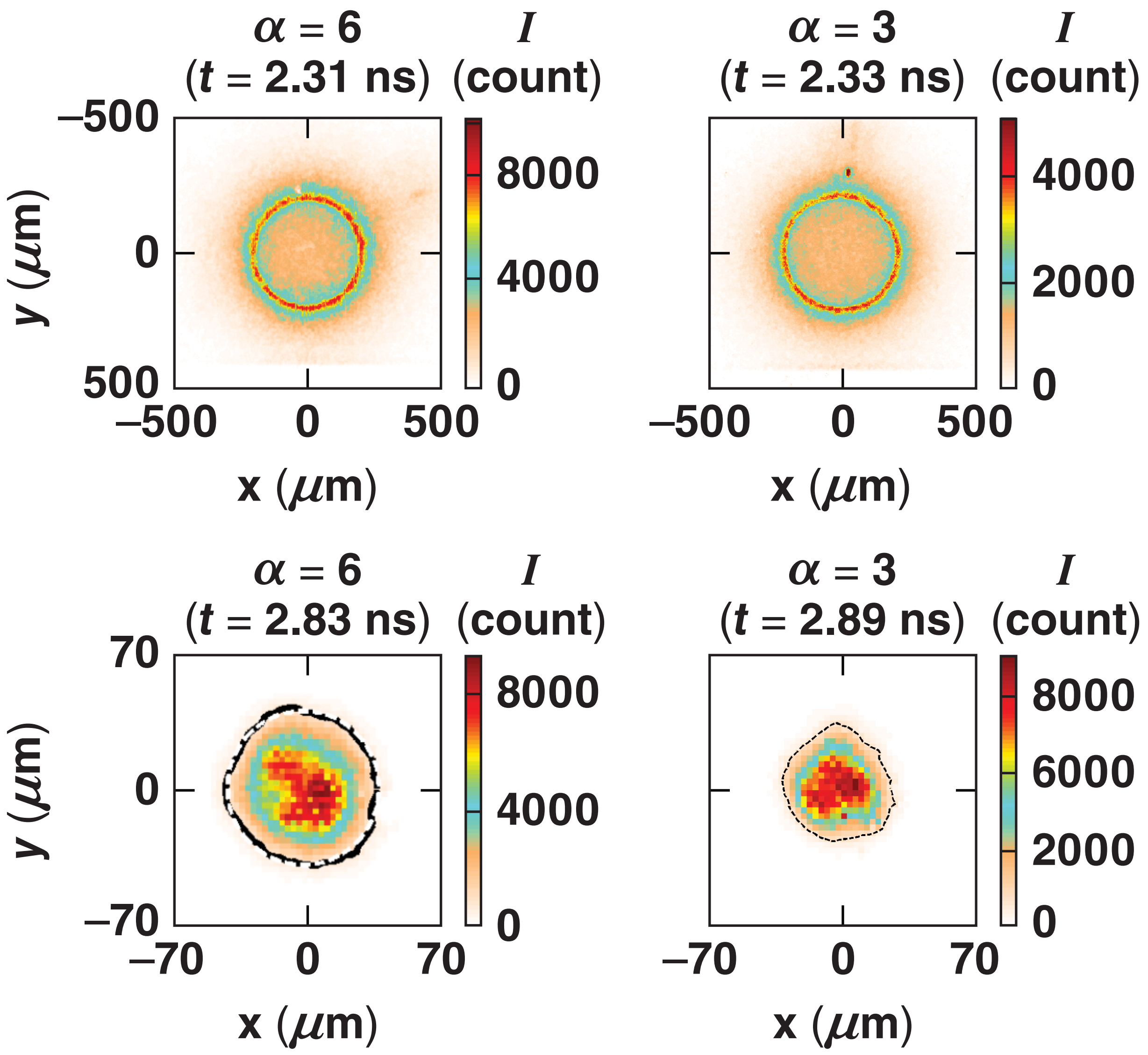


*D. Cao, G. Moses, and J. Delettrez, Phys. Plasmas 22, 082308 (2015).
**I. V. Igumenshchev *et al.*, Phys. Plasmas 17, 122708 (2010); J. A. Marozas and T. J. B. Collins, Bull. Am. Phys. Soc. 57, 344 (2012).
†S. X. Hu *et al.*, Phys. Rev. Lett. 104, 235003 (2010); Phys. Rev. B 84, 224109 (2011); Phys. Rev. E 92, 043104 (2015).

TC12900

The x-ray self-emission imaging technique* is used to simultaneously measure emissions from both corona and hot spot





*D. T. Michel *et al*., Rev. Sci. Instrum. 83, 10E530 (2012).

TC12951

Earlier hot-spot emission and a thicker CH shell are consequences of laser-imprint–induced decompression for low-α shots

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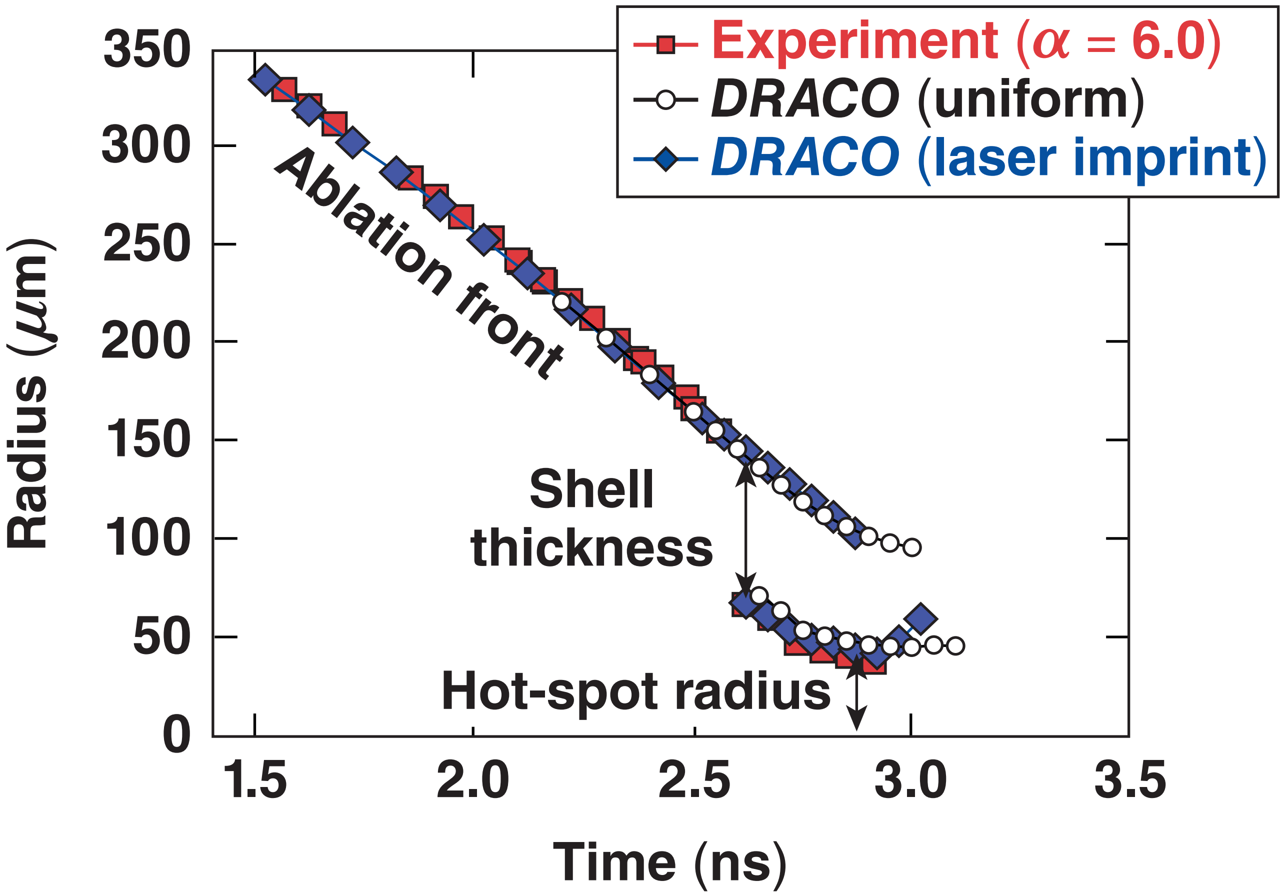
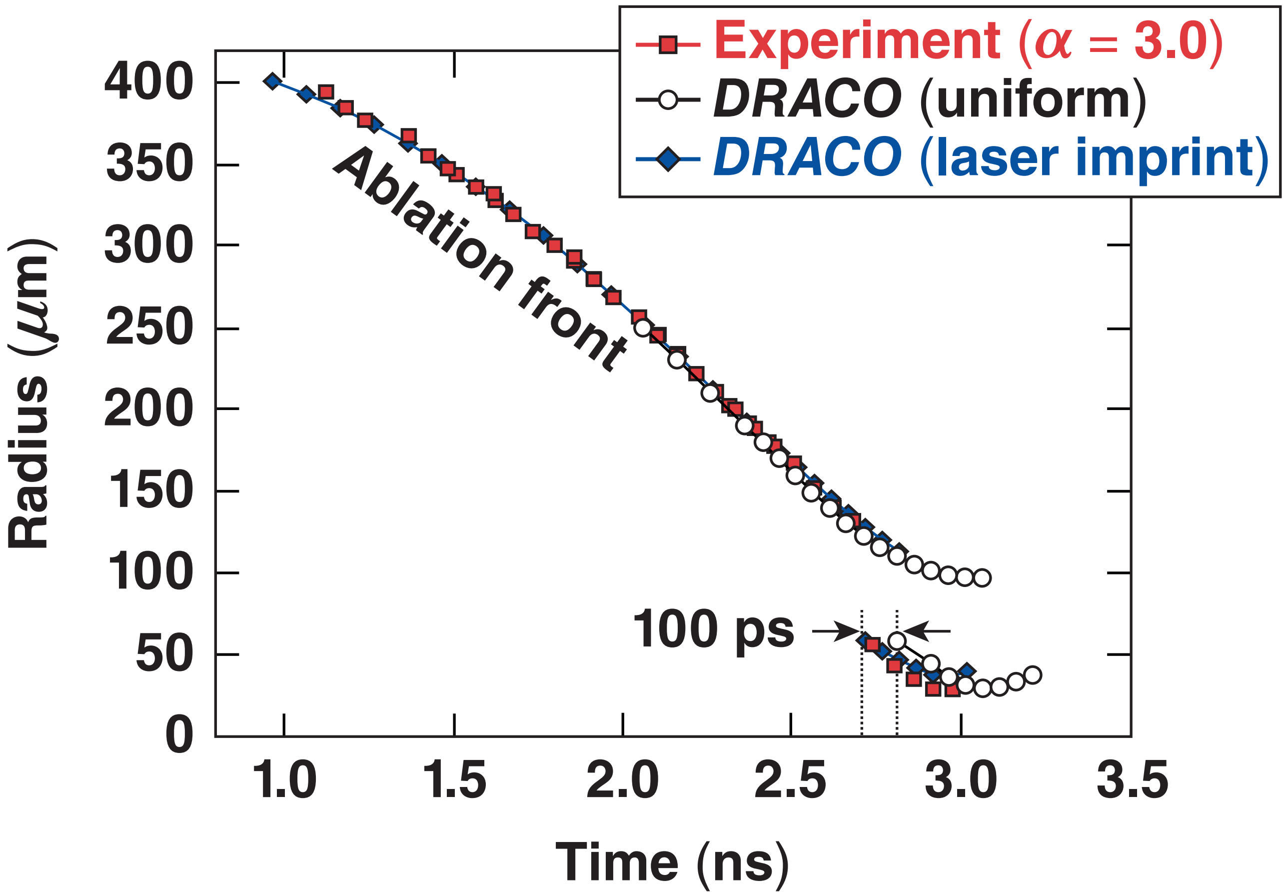


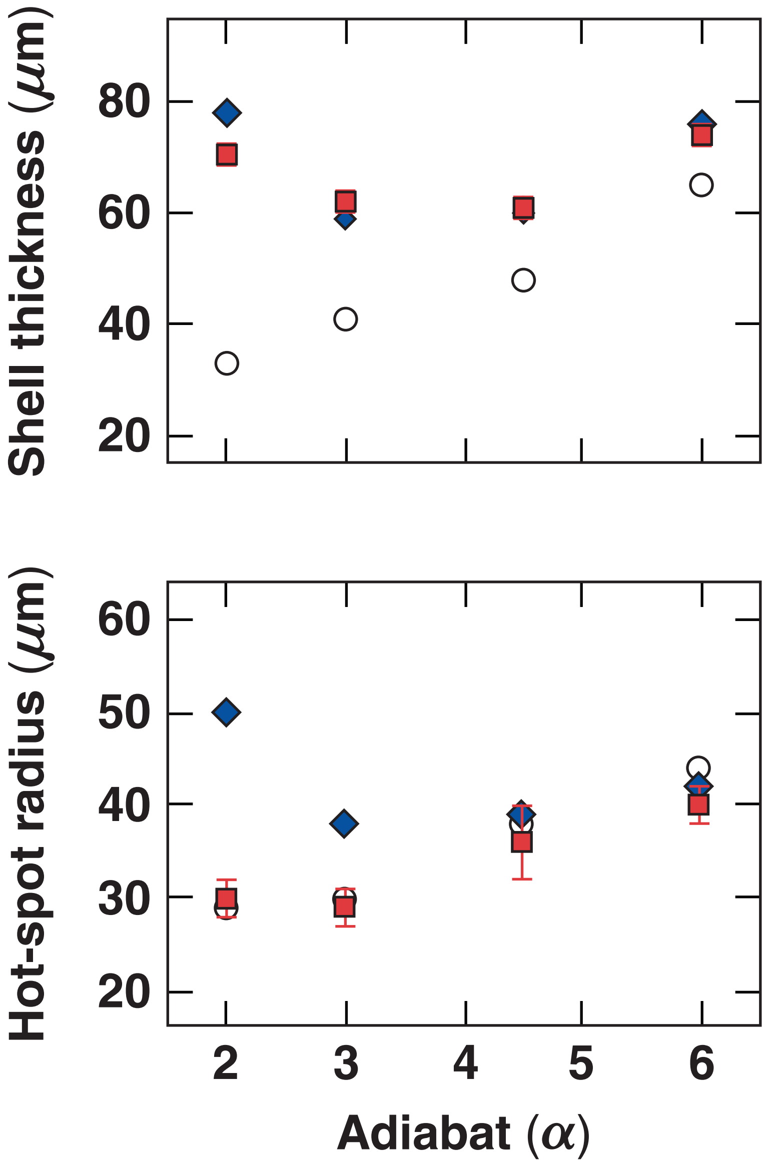


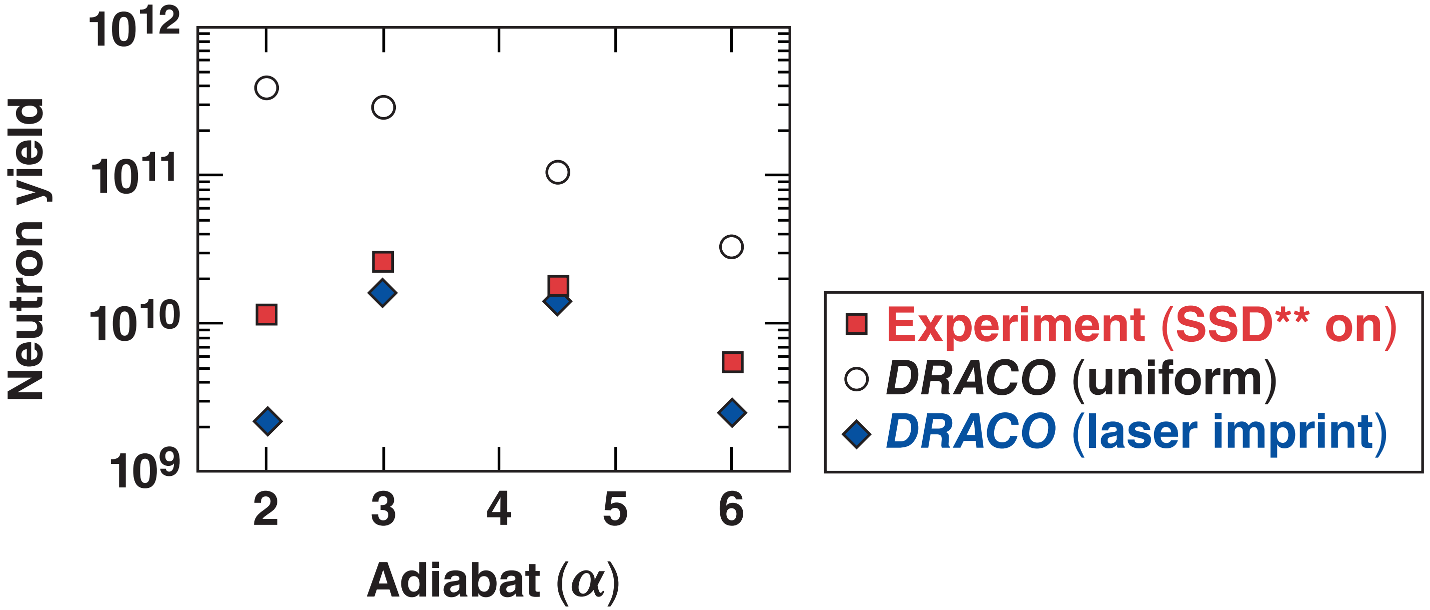
DRACO* simulations with laser imprint reproduced features observed in experiments.

*D. T. Michel *et al*., "Measurements of the Effect of Adiabat on Shell Decompression in Direct-Drive Implosions on OMEGA," submitted to Physical Review Letters.
D. T. Michel *et al*., TO5.00006, this conference.

TC12901

DRACO simulations* with laser imprint reproduced most of the experimental observables (shell thickness, neutron yields, and hot-spot size)



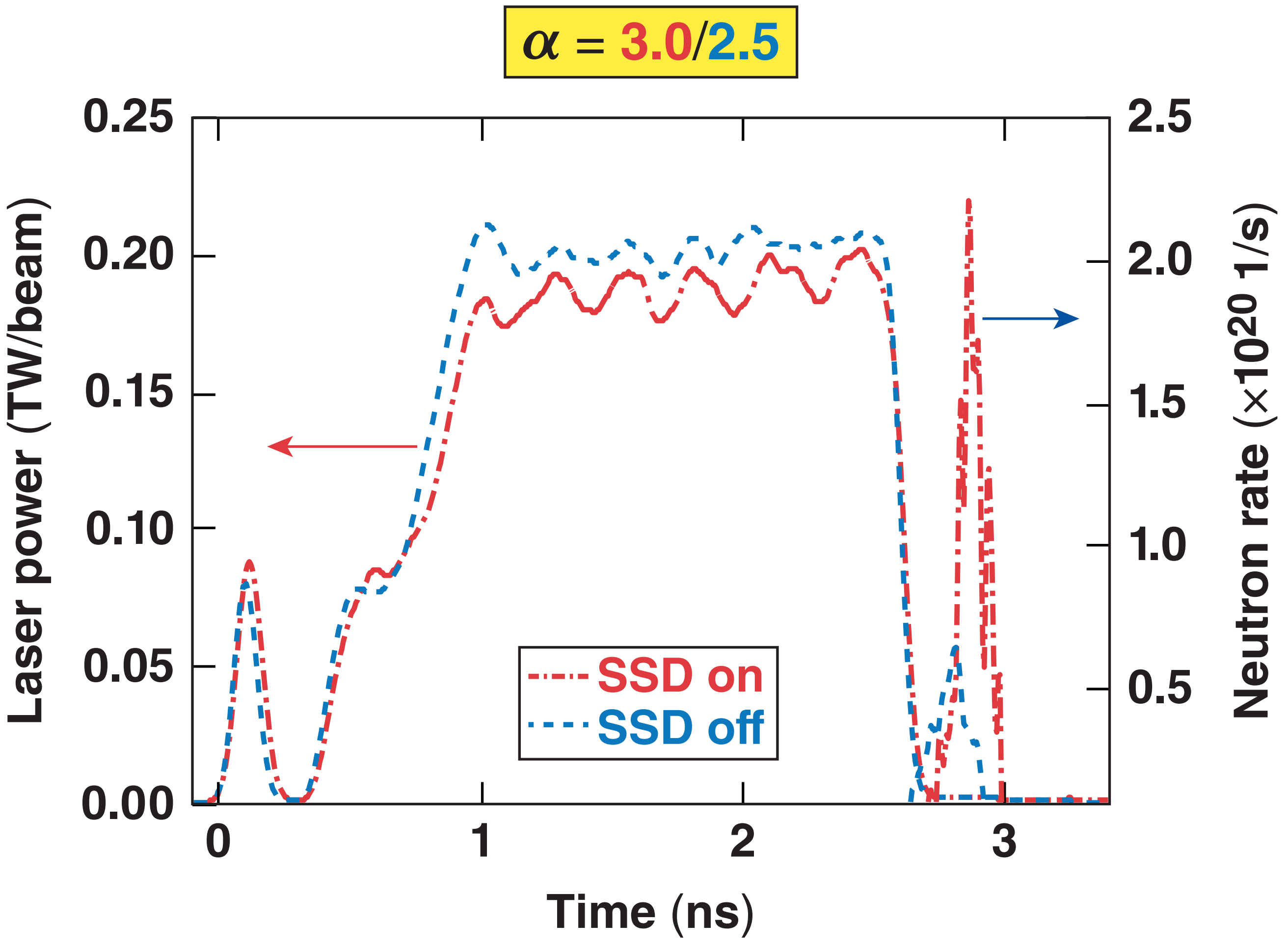


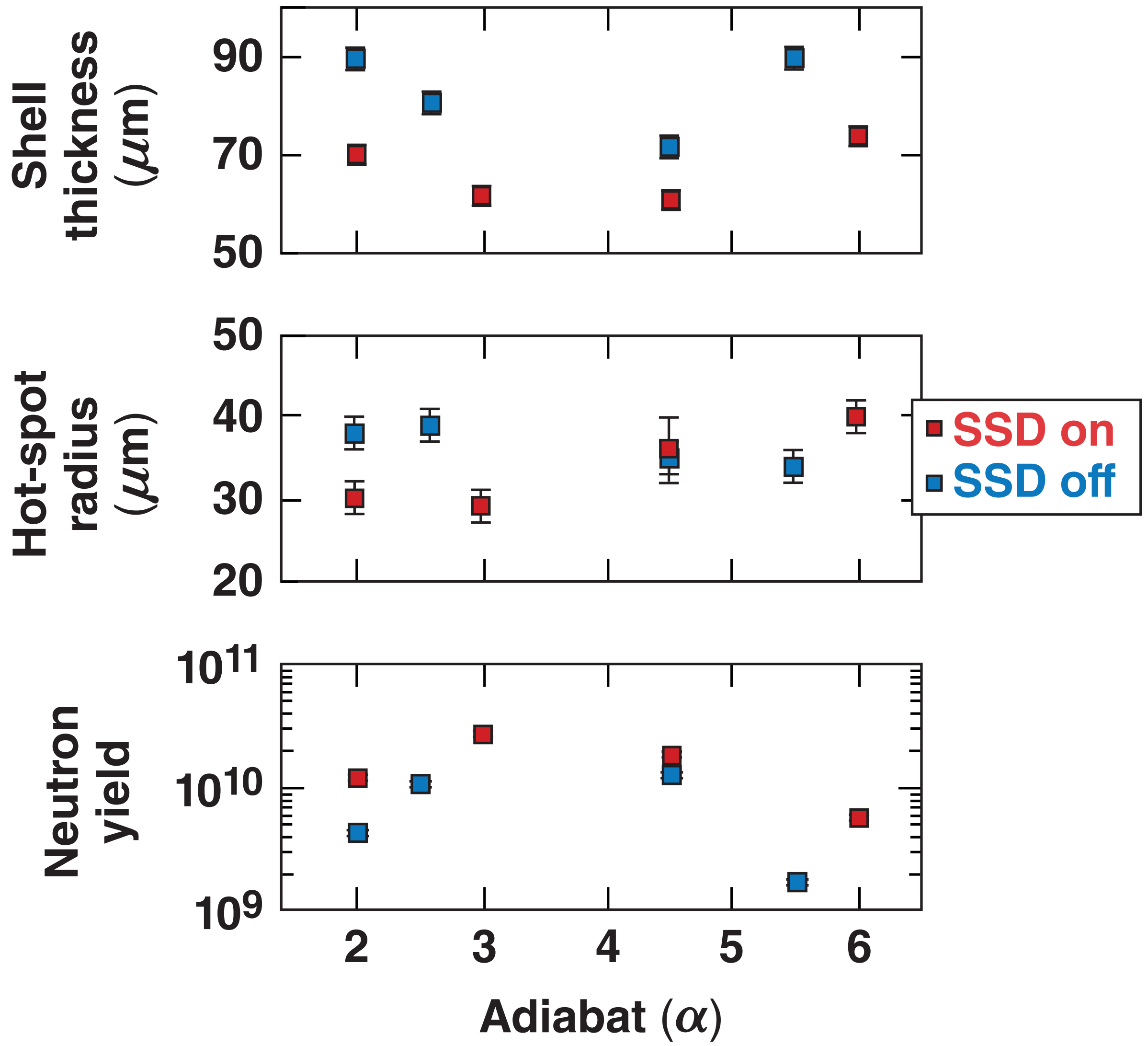
The 2-D nature of *DRACO* simulations has overestimated laser-imprint effects for the lowest-α shot (α = 2).

*S. X. Hu *et al.*, Phys. Plasmas 23, 102701 (2016).
**SSD: smoothing by spectral dispersion

TC12903

Increasing the laser-imprint level (by turning off SSD) further degrades the target performance in experiments: thicker shell, larger hot spot, and less neutron yield





TC12907

DRACO simulations and experiments have indicated that laser imprint is a major source degrading $\alpha \leq 3$ warm-target implosion performance on OMEGA

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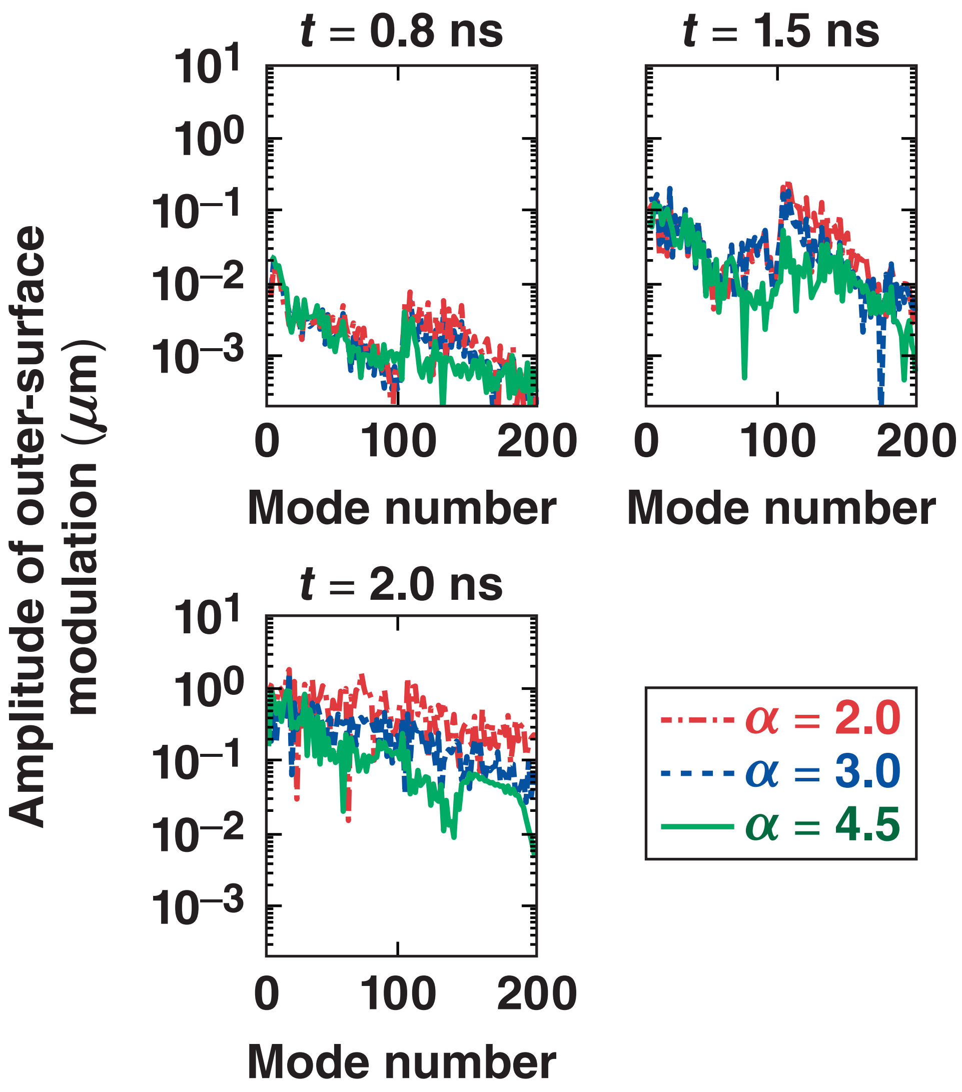
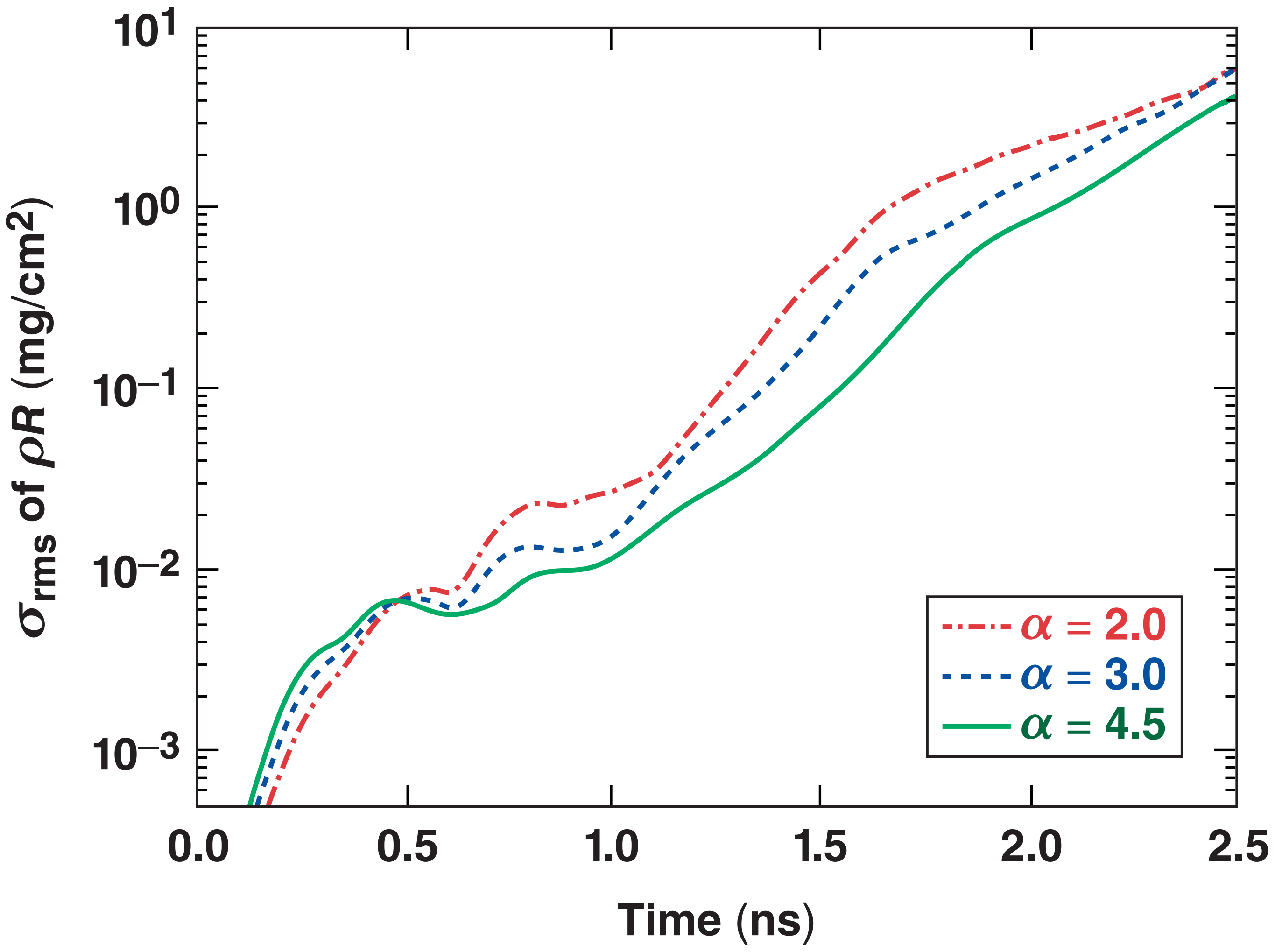
Thank you

Rayleigh–Taylor growth comparison for different adiabat shots

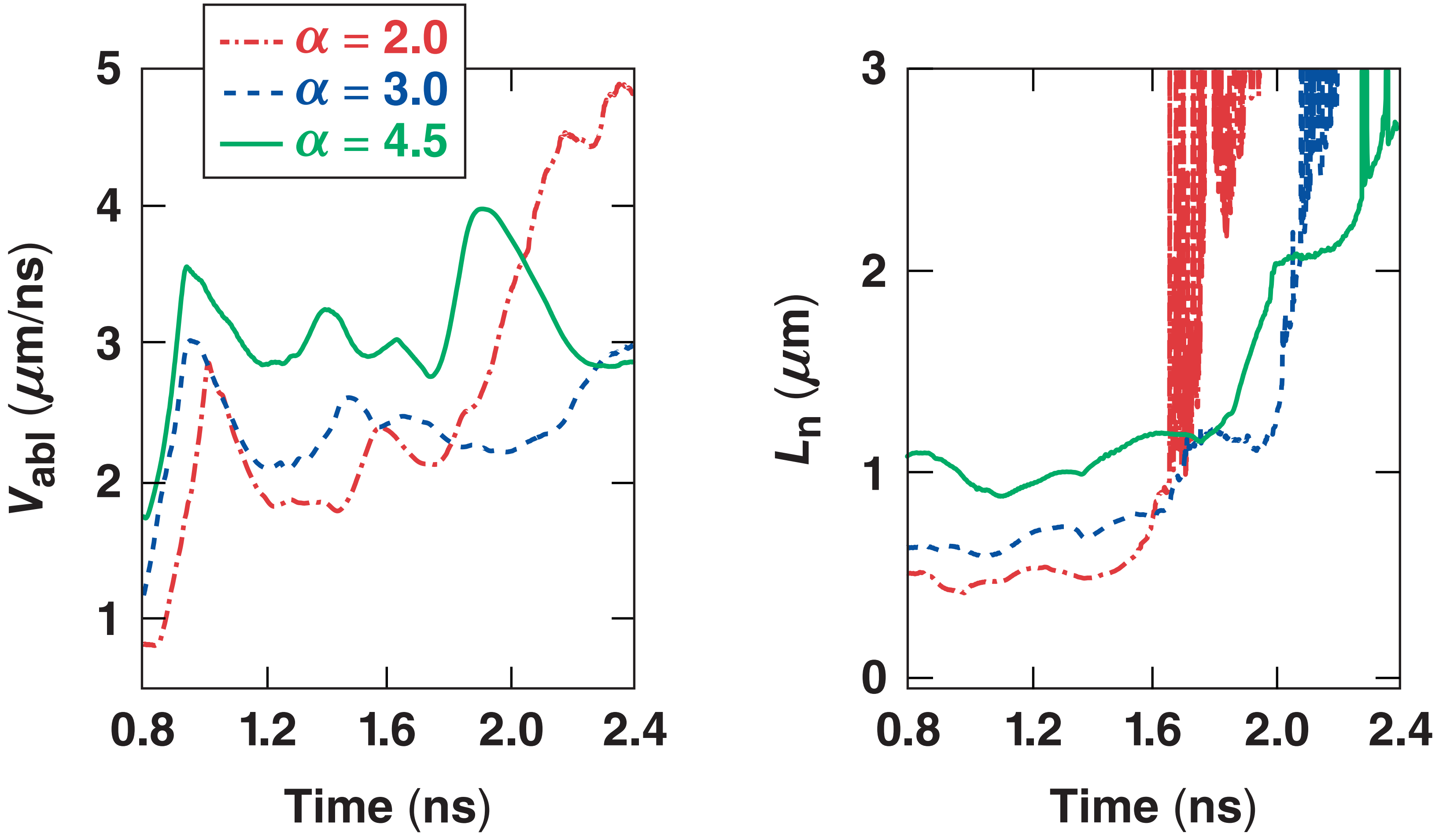




TC12899

Why high-α shots grow less?

$$\gamma = 0.94 \times \sqrt{\frac{kg}{1 + kL_n}} - 1.5 \times kV_{abl}$$



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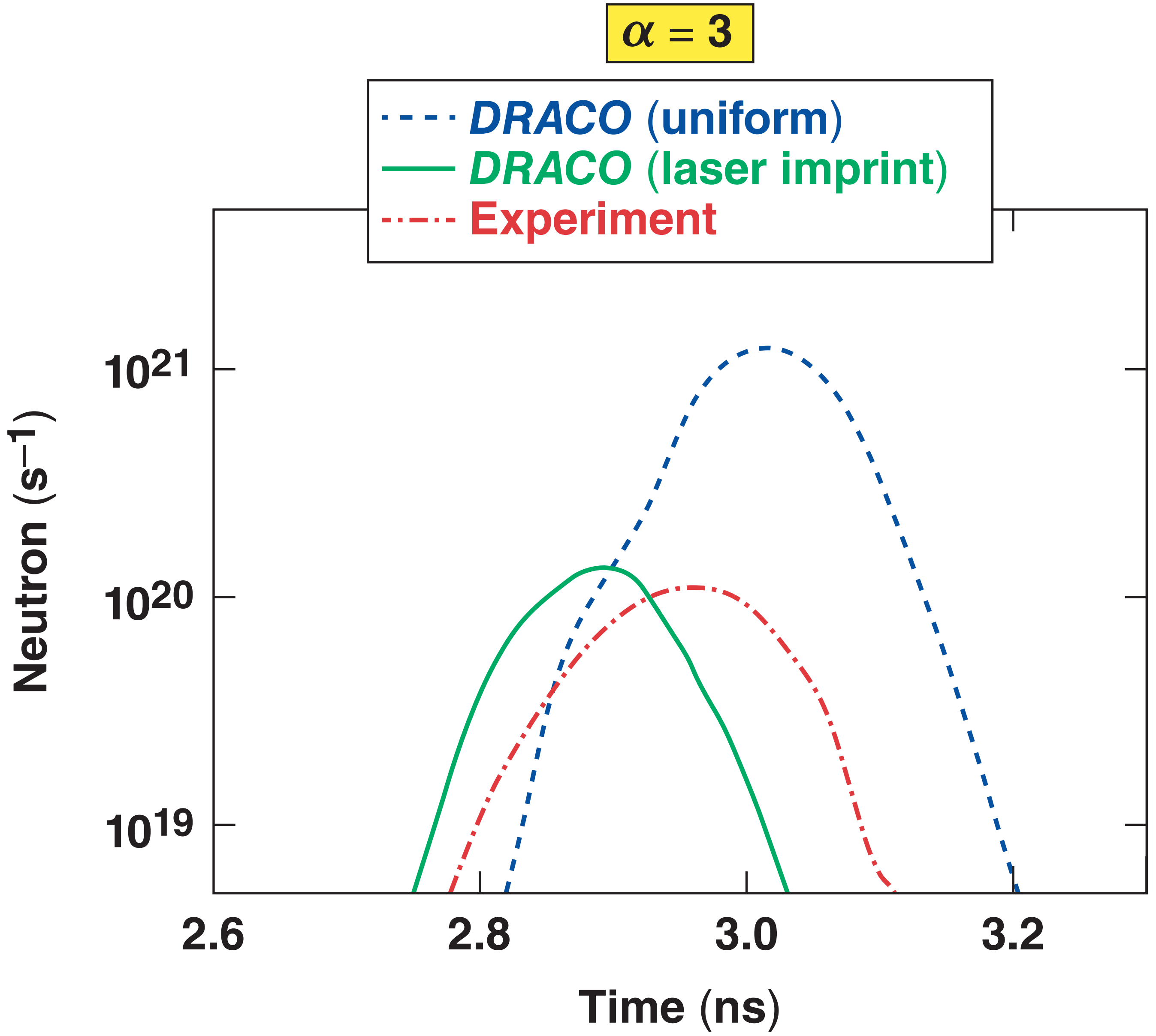
Neutron-rate comparison between experiment and simulations



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