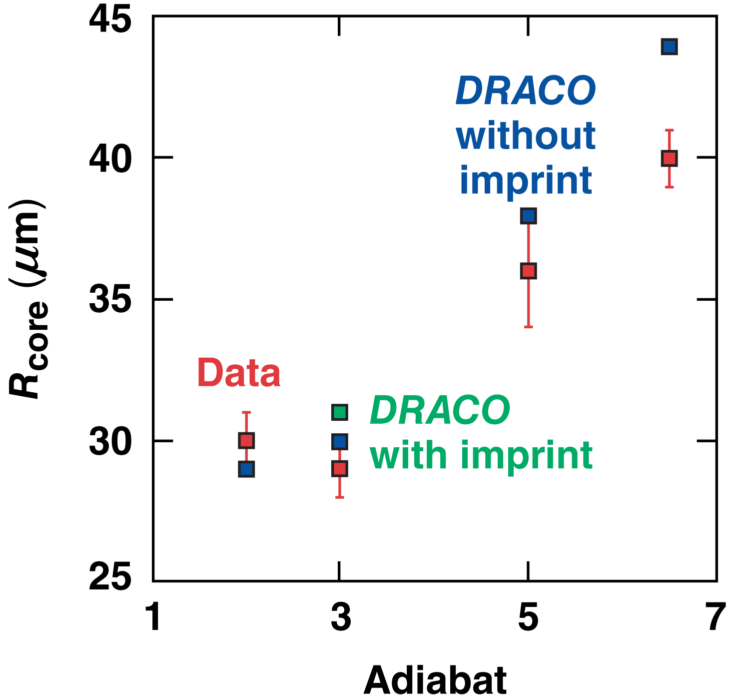
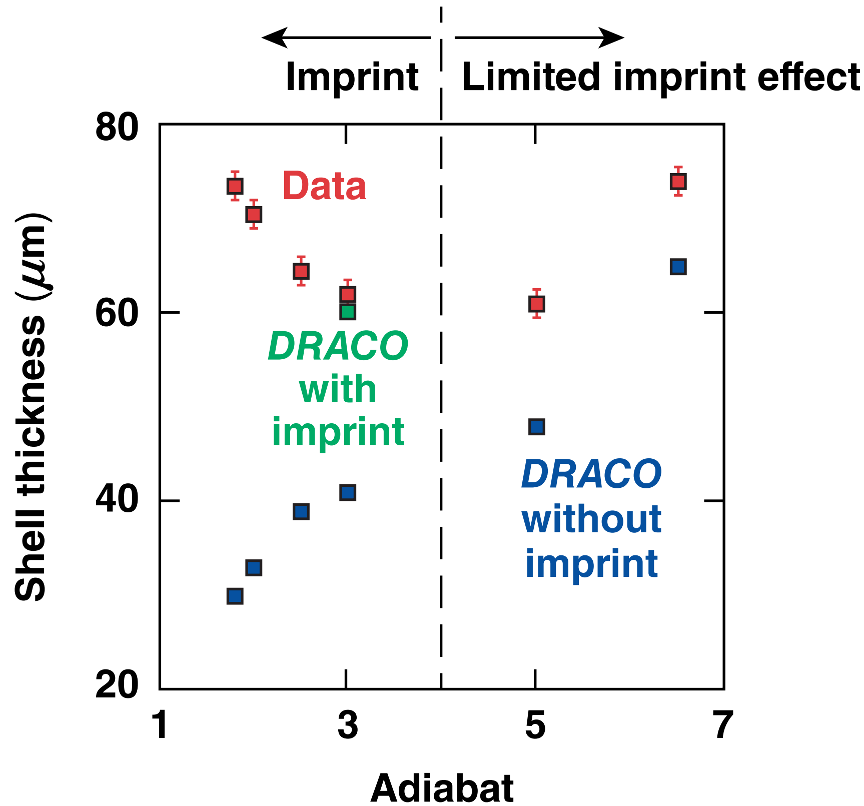
Measurements of the Effect of Adiabat on the Shell Thickness in Direct-Drive Implosions on OMEGA





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46th Annual Anomalous Absorption Conference
Old Saybrook, CT
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Summary

For adiabat implosions below ~4, the laser imprint is shown to decompress the shell by a factor of 2.5

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- For high-adiabat ($\alpha > 4$) implosions, the measured shell thicknesses and neutron yields are in agreement with 1-D simulations
- For lower-adiabat ($\alpha < 4$) implosions, significant shell decompression and reduced neutron yield are observed
- The core size was measured to decrease consistently with reducing the adiabat from 6.5 to 1.8
- Two-dimensional simulations with laser imprint reproduce the measured shell decompression

In warm implosions, mitigating imprint should improve performance by preventing the shell decompression in low-adiabat implosions.

Collaborators

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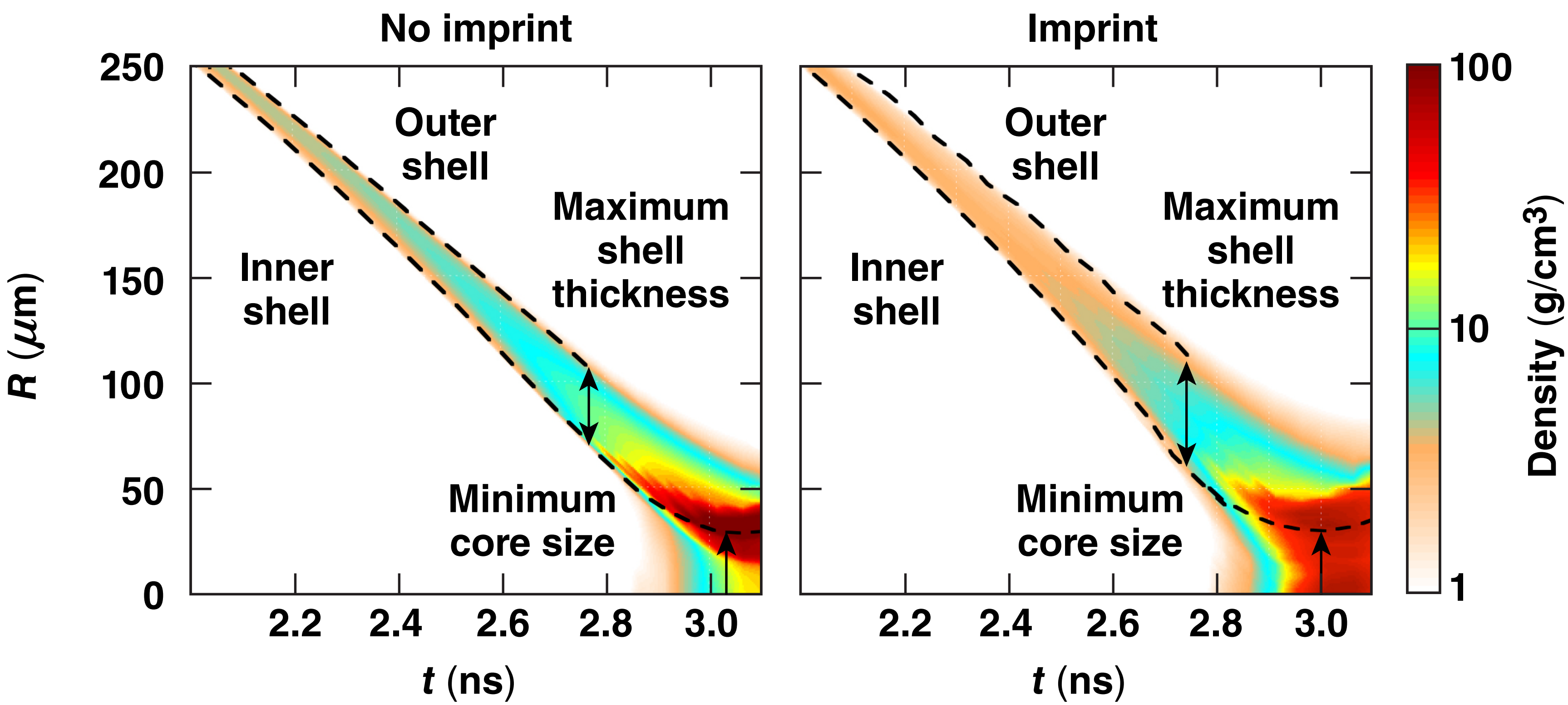
During the acceleration of the capsule, the Rayleigh–Taylor growth of the laser imprint results in large nouniformities



Nonuniformities increase the thickness of the shell but not the minimum core size.

E25052

An experiment was performed on OMEGA to measure the shell thickness for various shell adiabats

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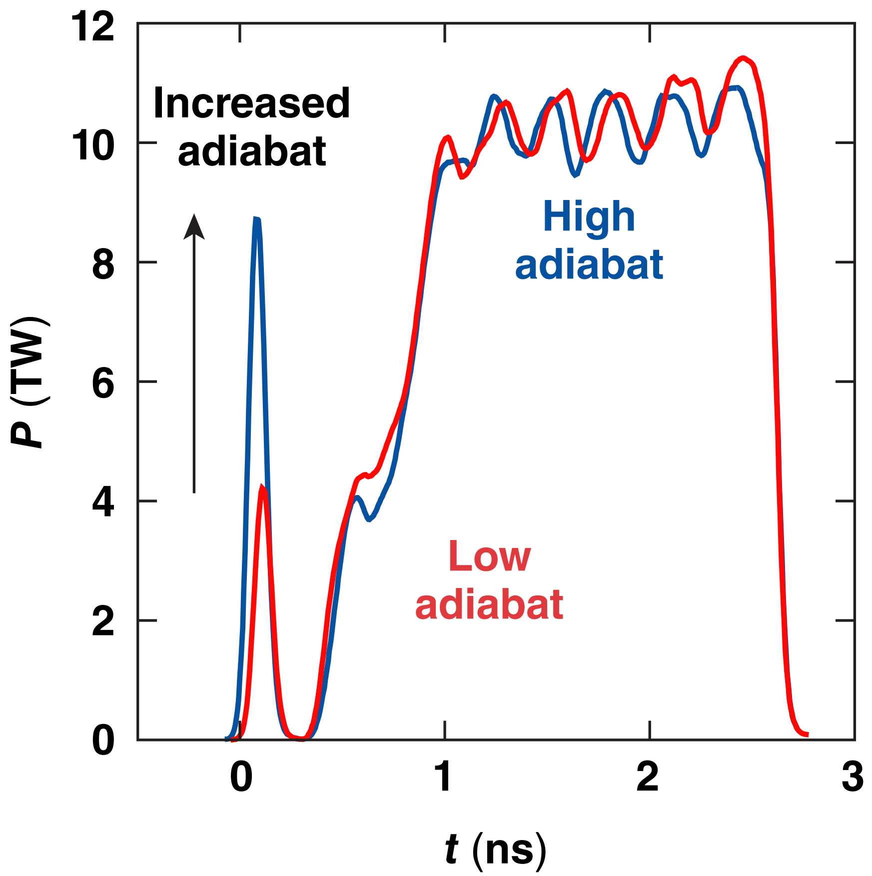

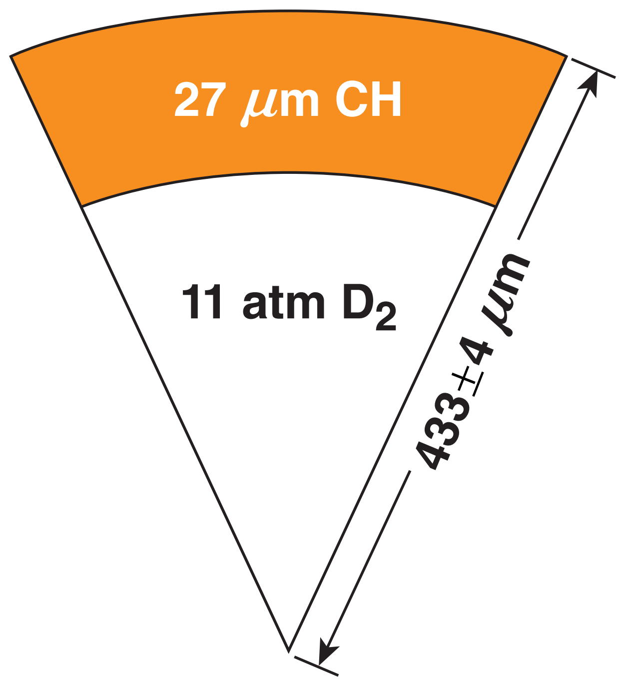

The shell adiabat varied between 1.8 and 6 by changing the energy of the picket.

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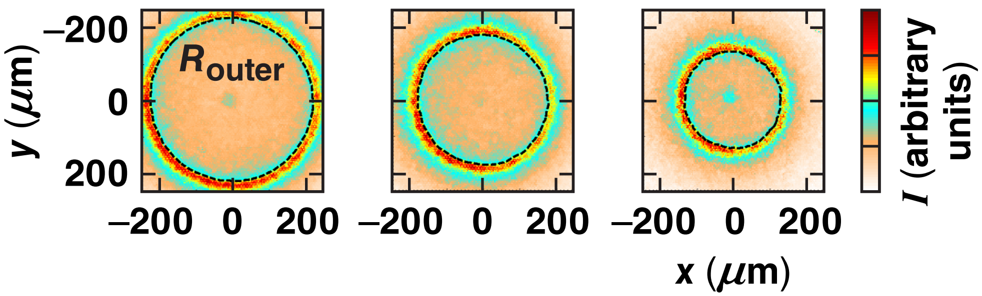
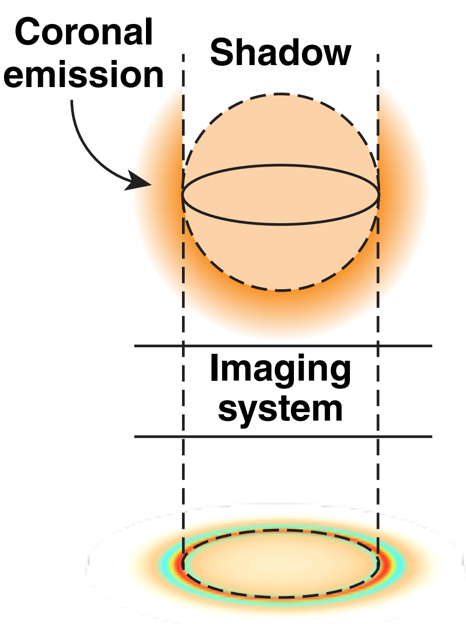
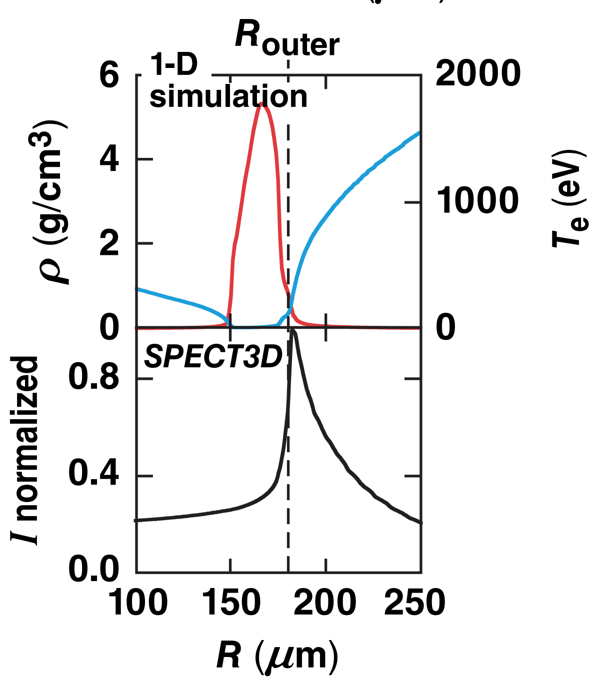
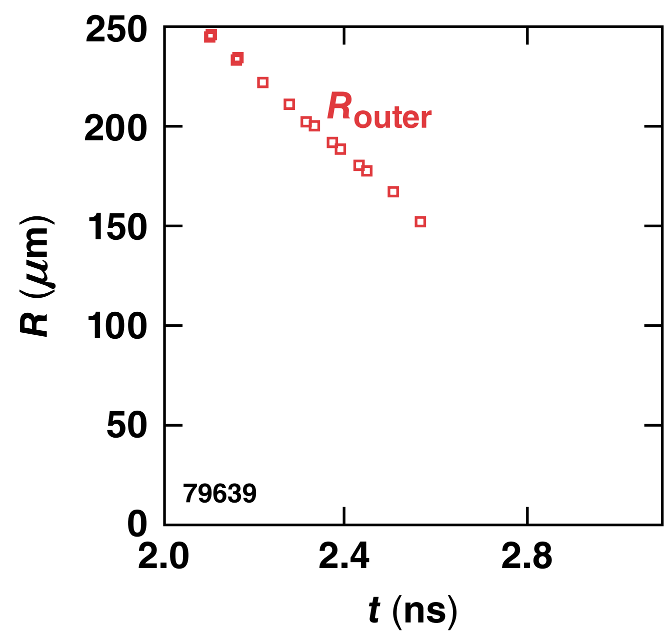
The outer and inner surfaces of the shell are measured from self-emission images within ±0.2 μm* and ±2.0 μm, respectively









*Self-emission shadowgraphy: D. T. Michel *et al.*, Rev. Sci. Instrum. 83, 10E530 (2012); D. T. Michel *et al.*, High Power Laser Science and Engineering 3, e19 (2015).

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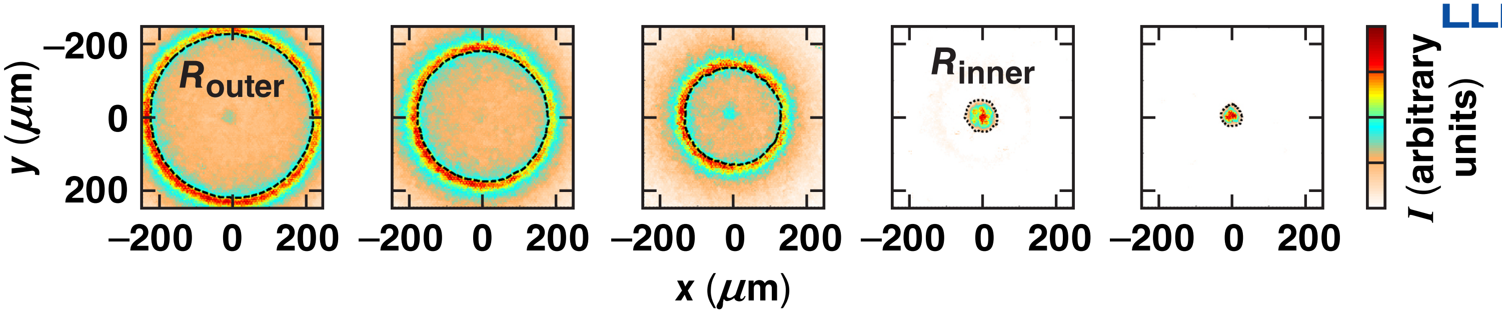

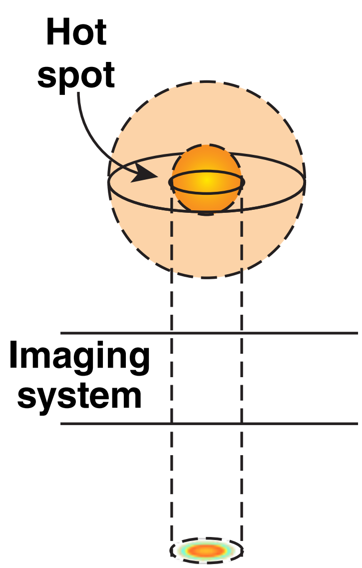

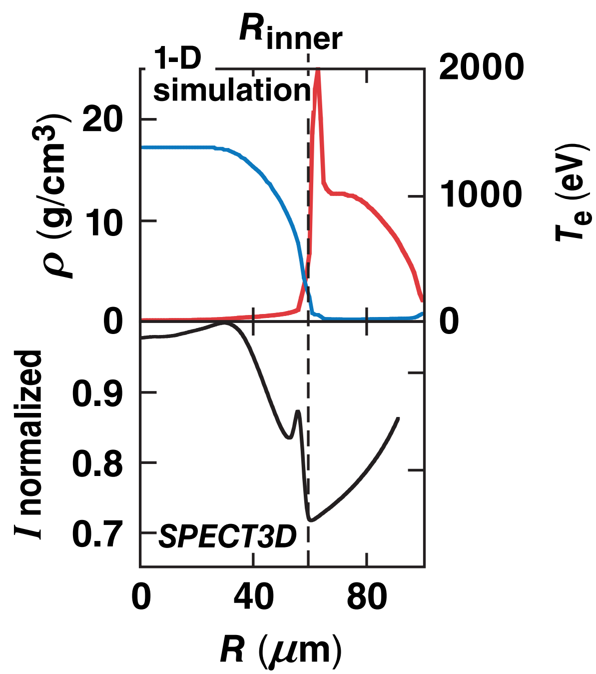

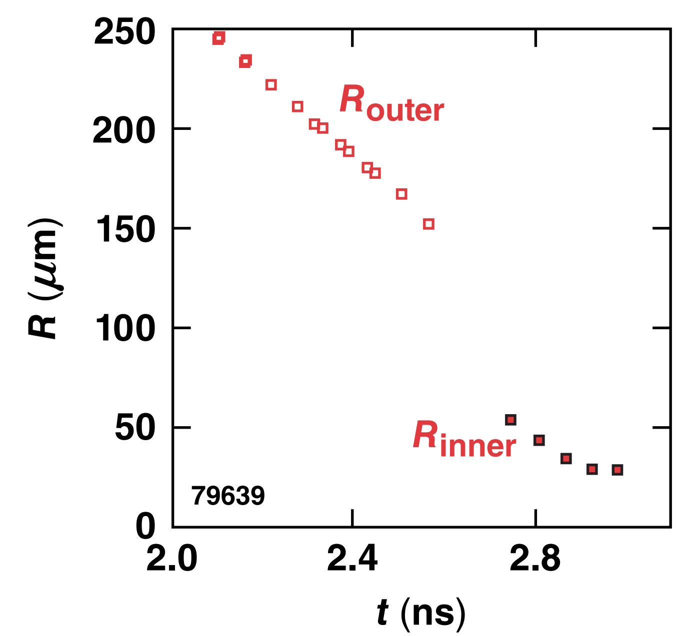

E25055

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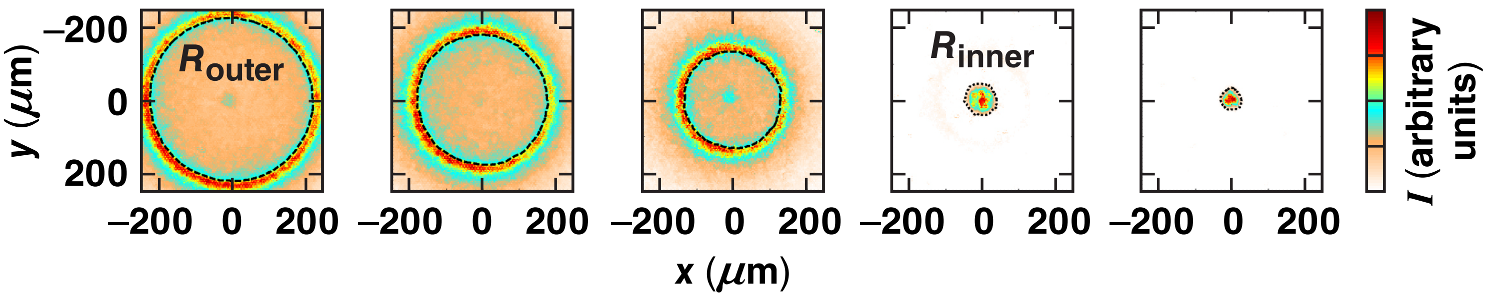
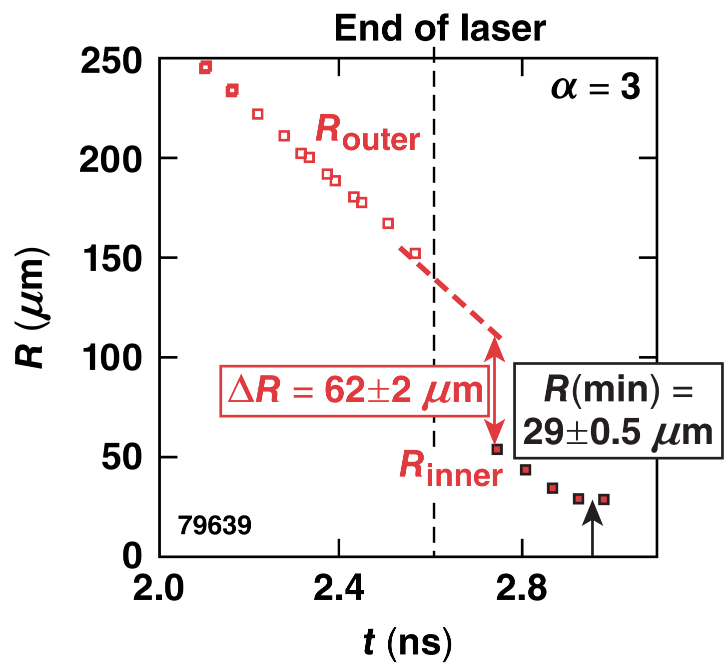
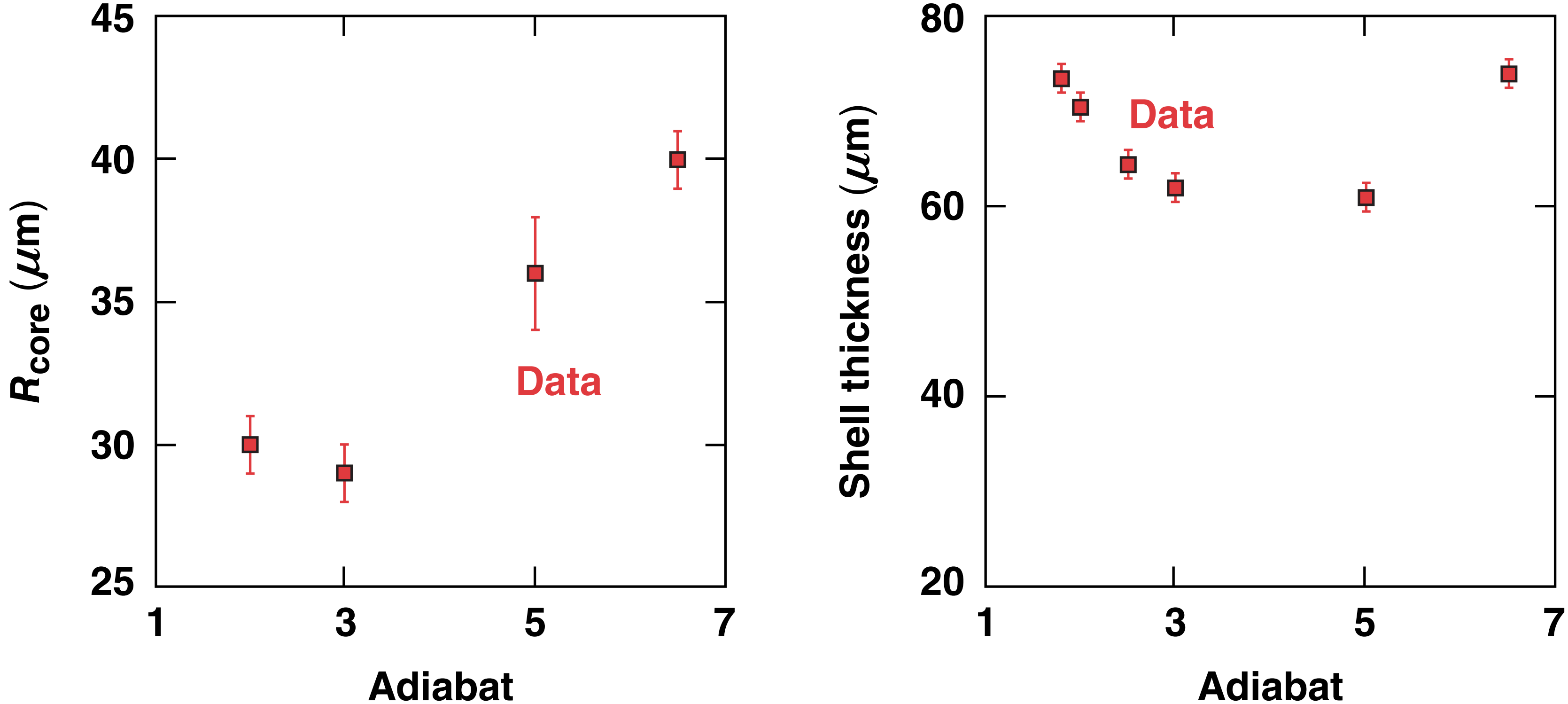
The outer and inner surfaces of the shell are measured from self-emission images within ±0.2 μm and ±2.0 μm, respectively





E25056

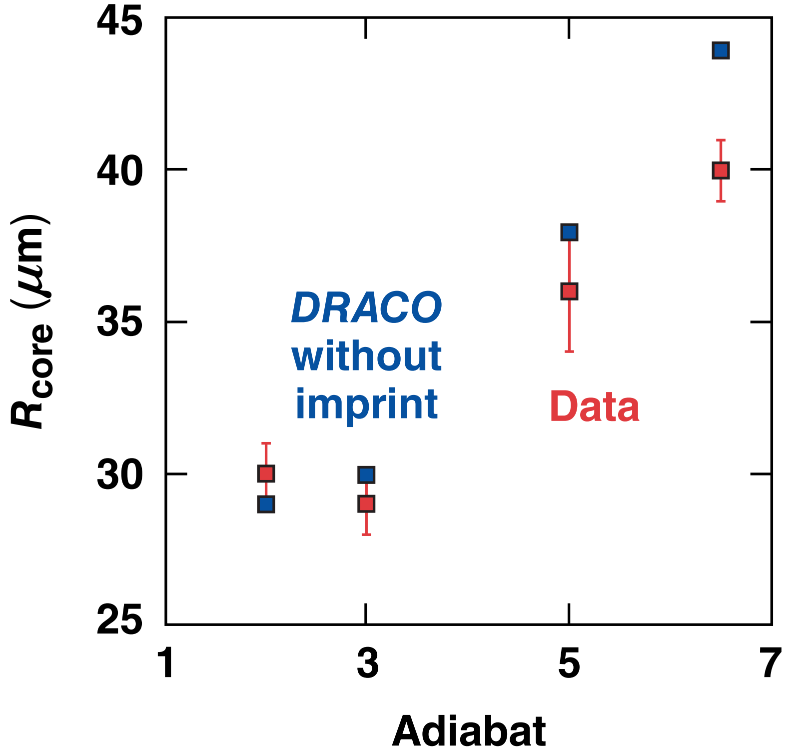
The core size was measured to decrease when reducing the adiabat, while the shell thickness increased for an adiabat less than 3

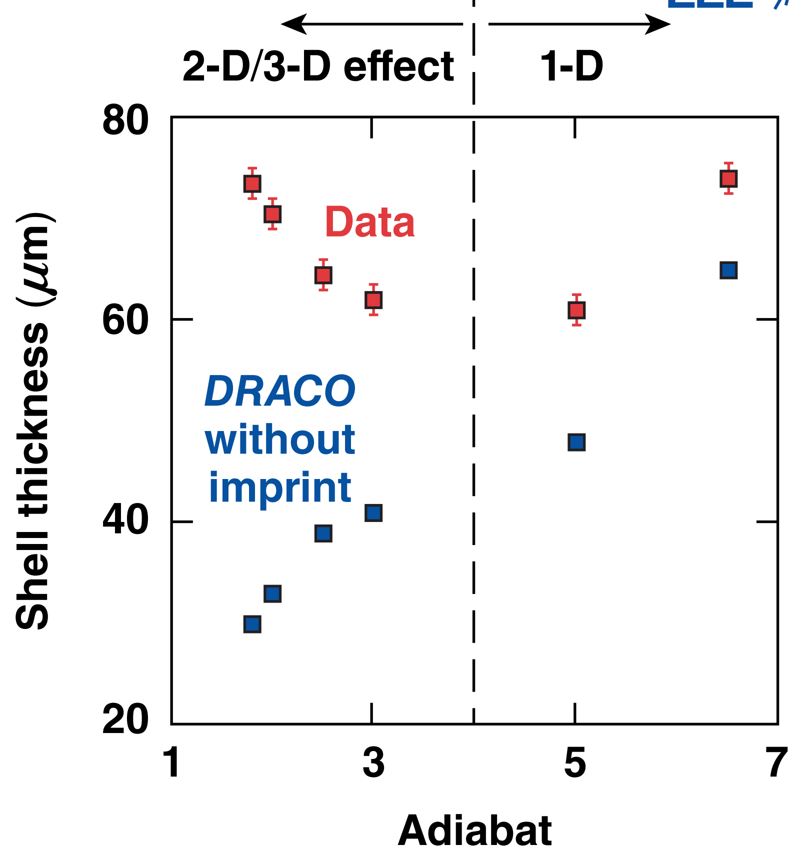


This shows that the shell decompression observed for a low adiabat is not caused by an error in the adiabat calculation.

E25057

For a high adiabat ($\alpha > 4$), the measured shell thickness and yield are in reasonable agreement with 1-D simulations





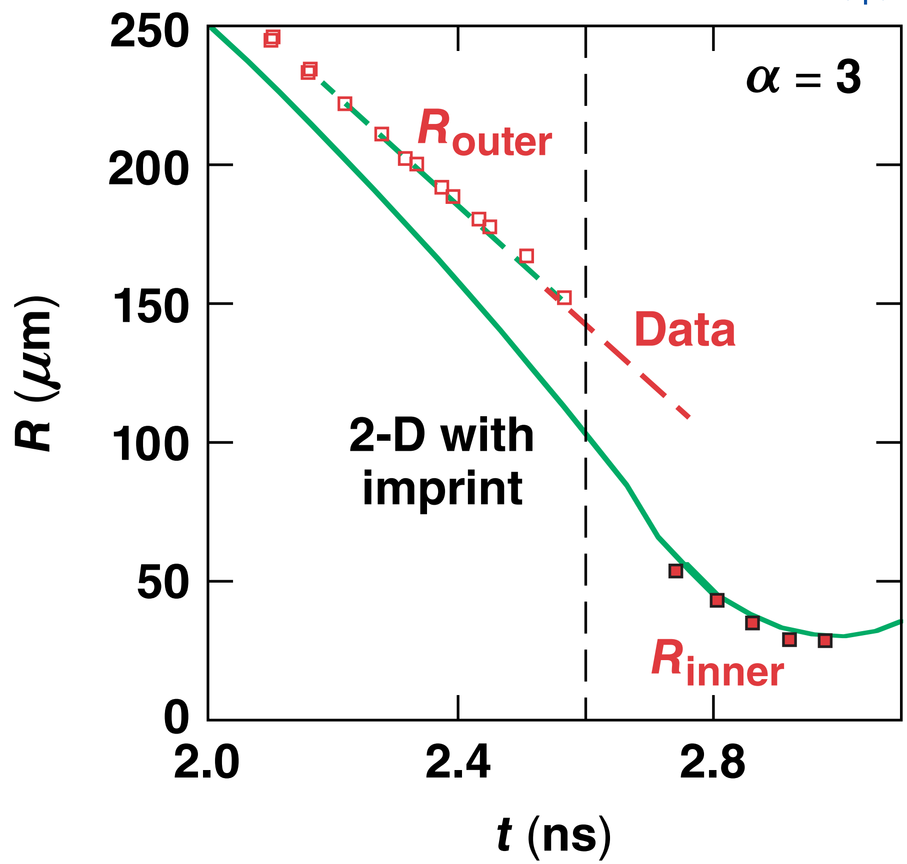
For a lower adiabat ($\alpha < 4$), significant shell decompressions are observed because of 2-D/3-D effects.

E25057a

A 2-D *DRACO* simulation with laser imprint was performed with CBET and NL to correctly model the Rayleigh–Taylor growth*

The simulation included

- Nonlocal (NL) thermal-transport model
- Cross-beam energy transfer (CBET) model
- Laser imprint up to the ℓ = mode 200

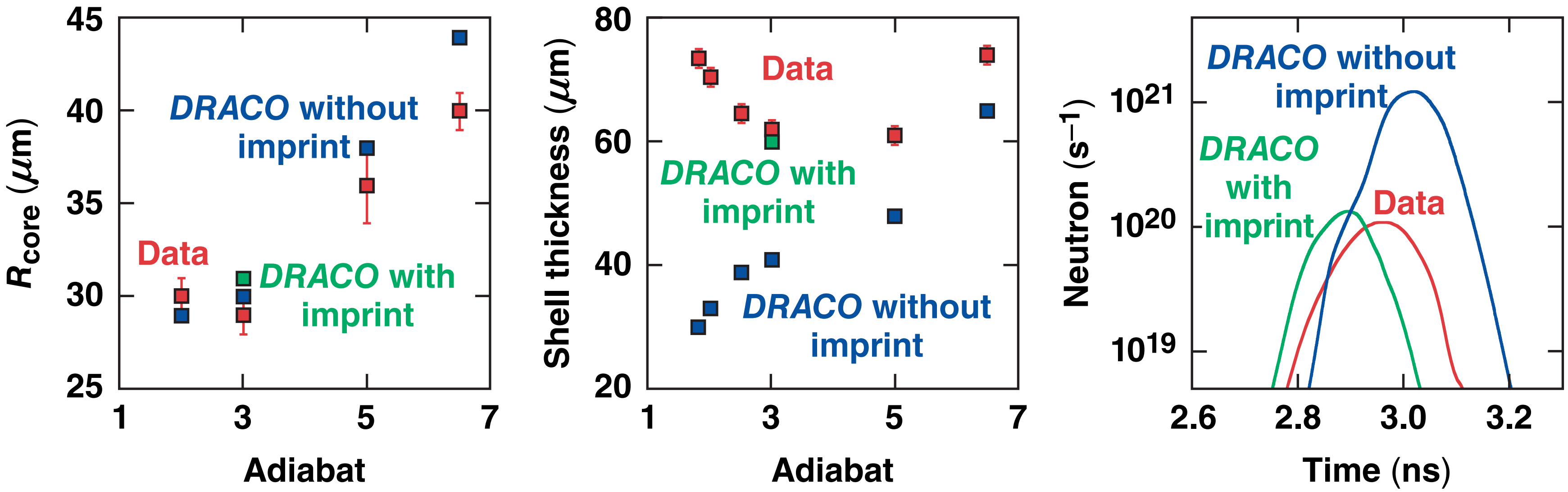


The simulation reproduced the shell thickness and deceleration.

E25058

*D. T. Michel *et al*., Phys. Rev. Lett. 114, 155002 (2015).

A 2-D *DRACO* simulation with laser imprint was in excellent agreement with all experimental observables



E25059

Summary/Conclusions

For adiabat implosions below ~4, the laser imprint is shown to decompress the shell by a factor of 2.5

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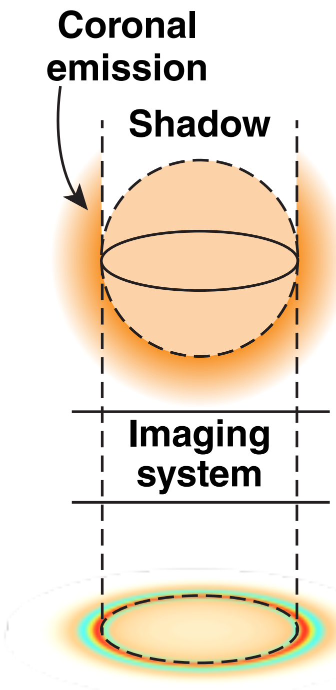
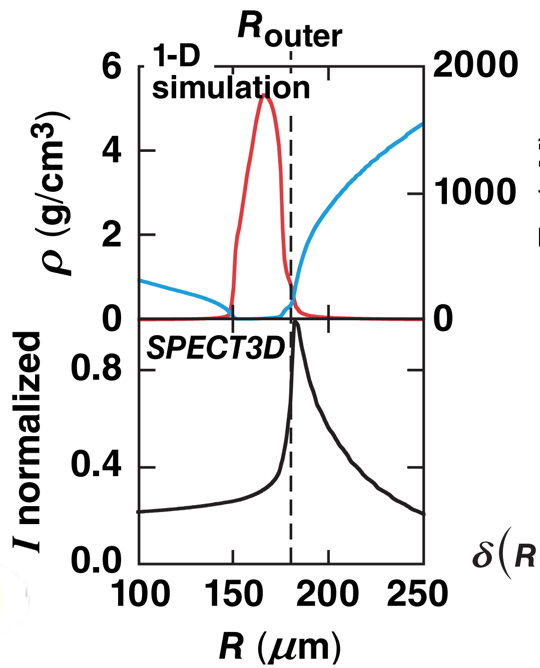
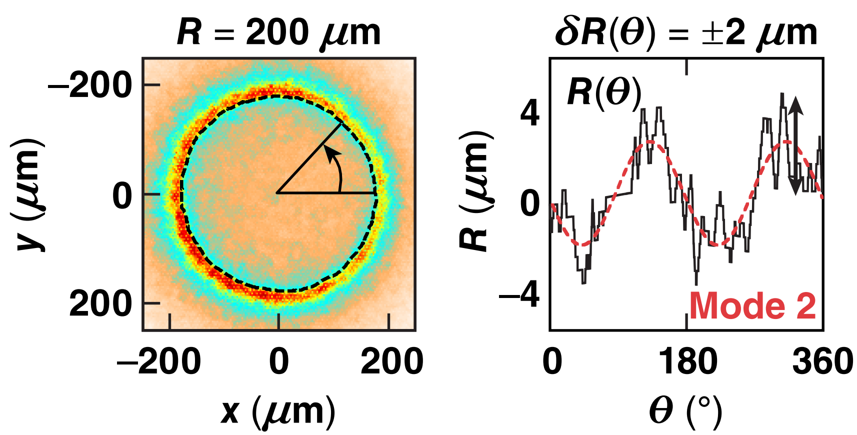
In warm implosions, mitigating imprint should improve performance by preventing the shell decompression in low-adiabat implosions.

E25051

The combination of the limb and shadow effect provide a step inner edge in the coronal emission that allows the outer edge of the shell to be measured within ±0.2 μm*







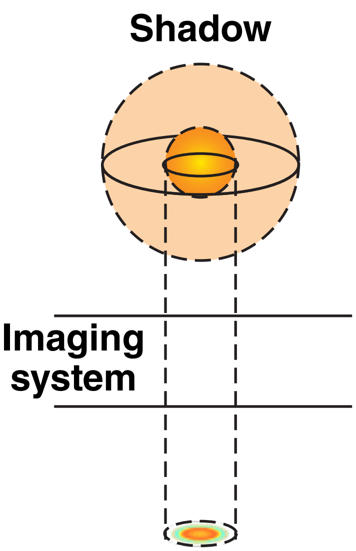
$$\delta(R) = \frac{\delta[R(\theta)]}{N_{R(\theta)}} = \frac{\delta[R(\theta)]}{\sqrt{2\pi R / \text{PSF}^{**}}} = \frac{\pm 2\ \mu\text{m}}{\sqrt{2\pi 200\ \mu\text{m} / 10\ \mu\text{m}}} \approx \pm 0.2\ \mu\text{m}$$

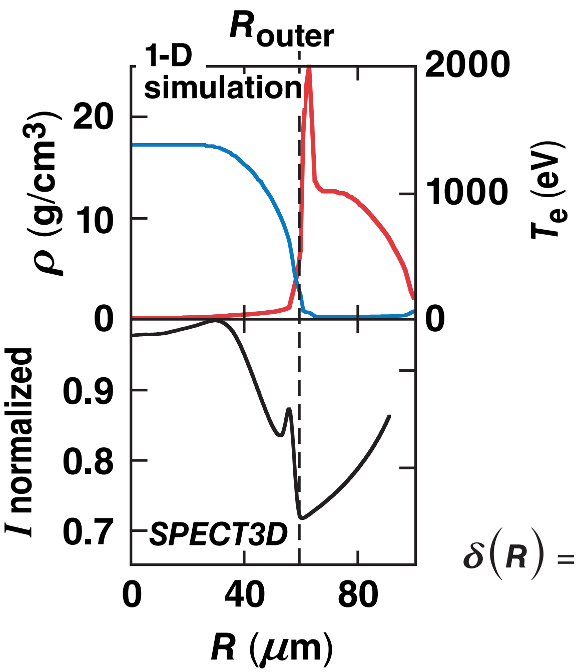
The shadow effect prevents the emission coming from the back of the shell from reaching the diagnostic, reducing the emission by a factor of 2 just after the outer edge of the shell.

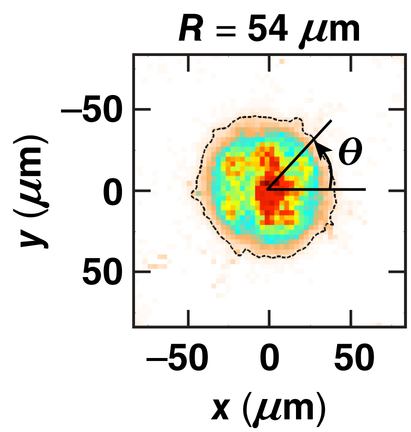
E25061

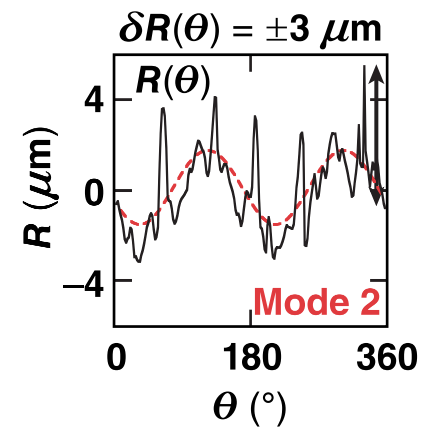
* D. T. Michel *et al*., High Power Laser Science and Engineering 3, e19 (2015).
** PSF: point spread function

When the shell begins to decelerate, the temperature inside the shell increases and the core starts to emit x rays







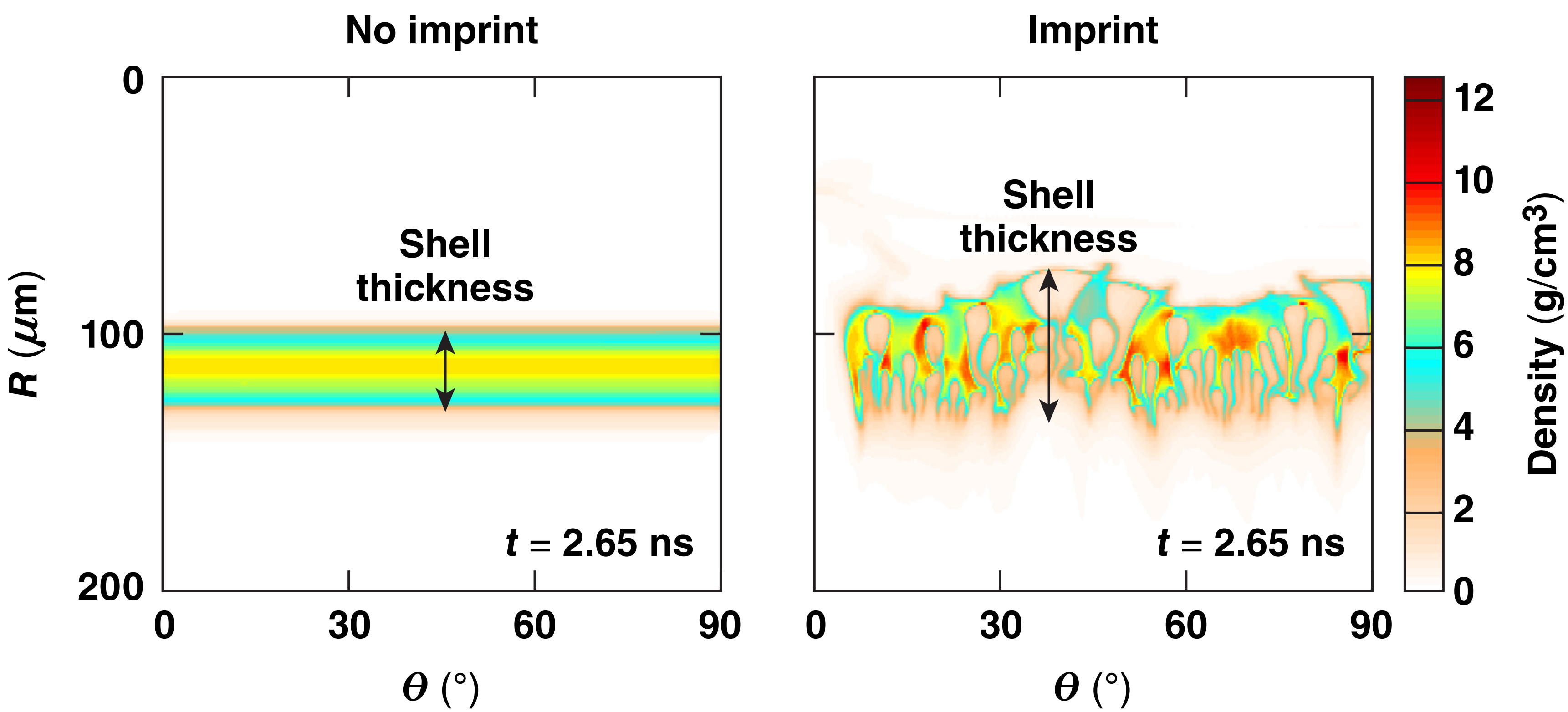


$$\delta(R) = \frac{\delta[R(\theta)]}{N_{R(\theta)}} = \frac{\delta[R(\theta)]}{\sqrt{2\pi R/\text{PSF}}} = \frac{\pm 3\ \mu\text{m}}{\sqrt{2\pi 54\ \mu\text{m}/10\ \mu\text{m}}} \approx \pm 0.5\ \mu\text{m}$$

The outer surface of the core emission makes it possible to determine the inner surface of the cold shell within ±0.5 μm.

During the acceleration of the capsule, the Rayleigh–Taylor growth of the laser imprint results in larger nouniformities that decompress the shell

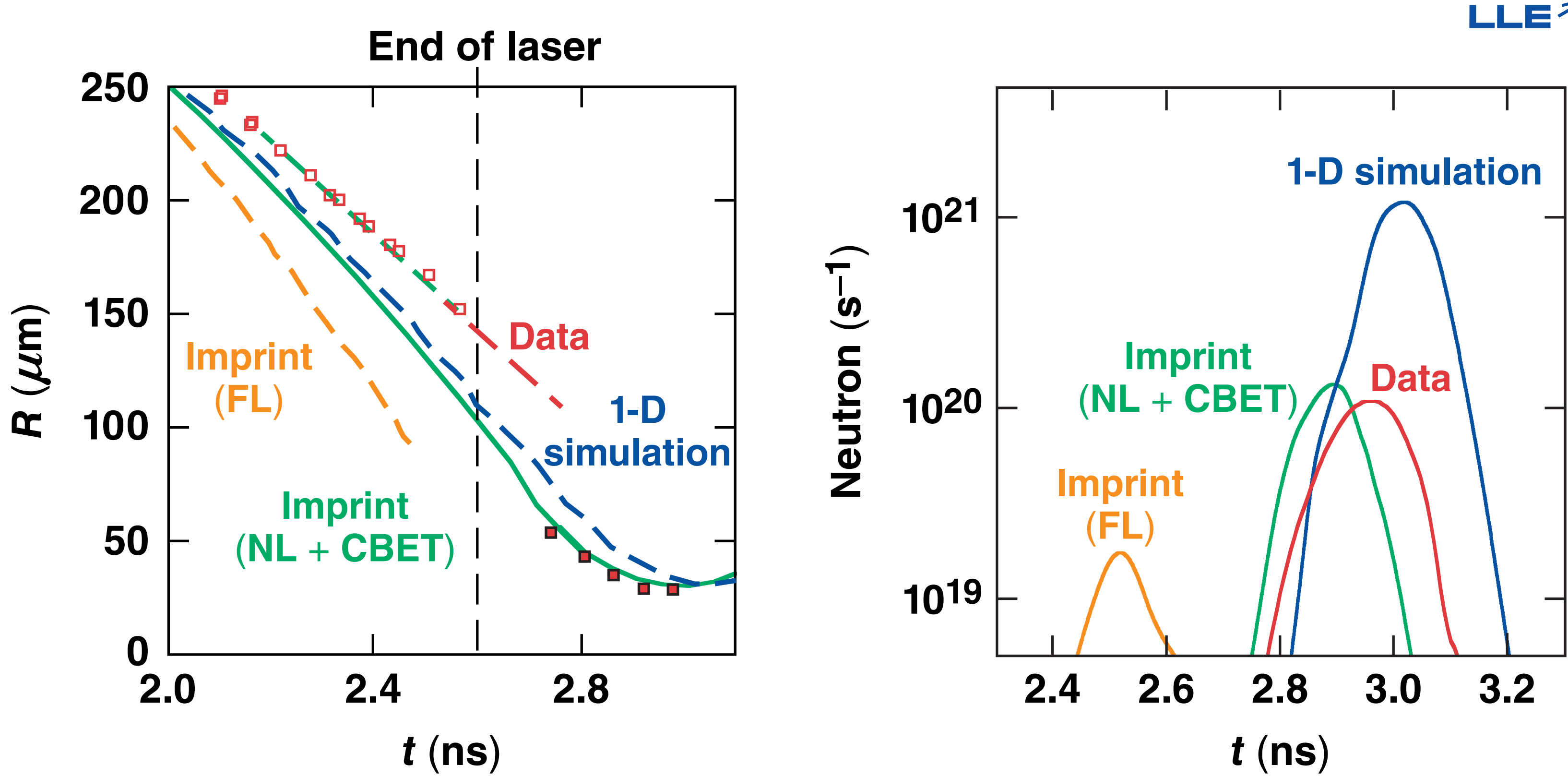
UR LLE



The decompression of the shell reduces the shell pressure and the implosion performances.

E25063

When using a time-dependent flux limiter (FL) adapted to match trajectory, the shell decompression was significantly overestimated



The larger decompression is likely caused by an overestimate of the Rayleigh–Taylor growth as a result of the underestimate of the mass ablation rate previously observed.*

E25064

* D. T. Michel *et al.*, Phys. Rev. Lett. 114, 155002 (2015).