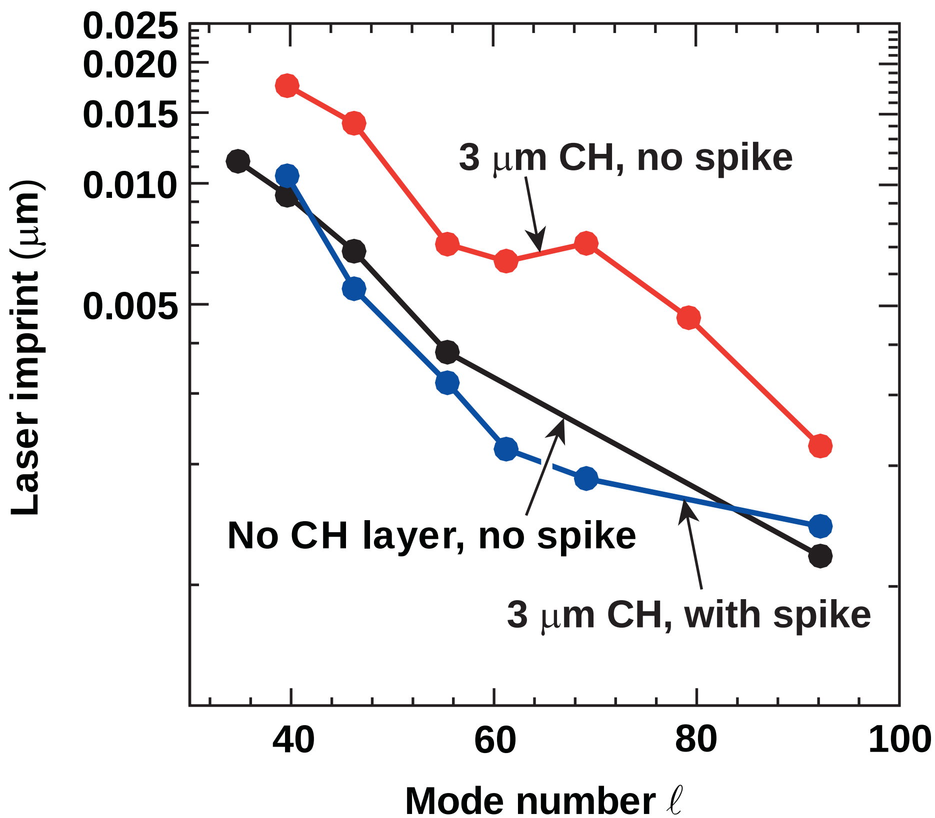
# Imprint Reduction with Shaped Pulses





T. J. B. Collins and S. Skupsky
University of Rochester
Laboratory for Laser Energetics



42nd Annual Meeting of the
American Physical Society
Division of Plasma Physics
Québec City, Canada
23–27 October 2000

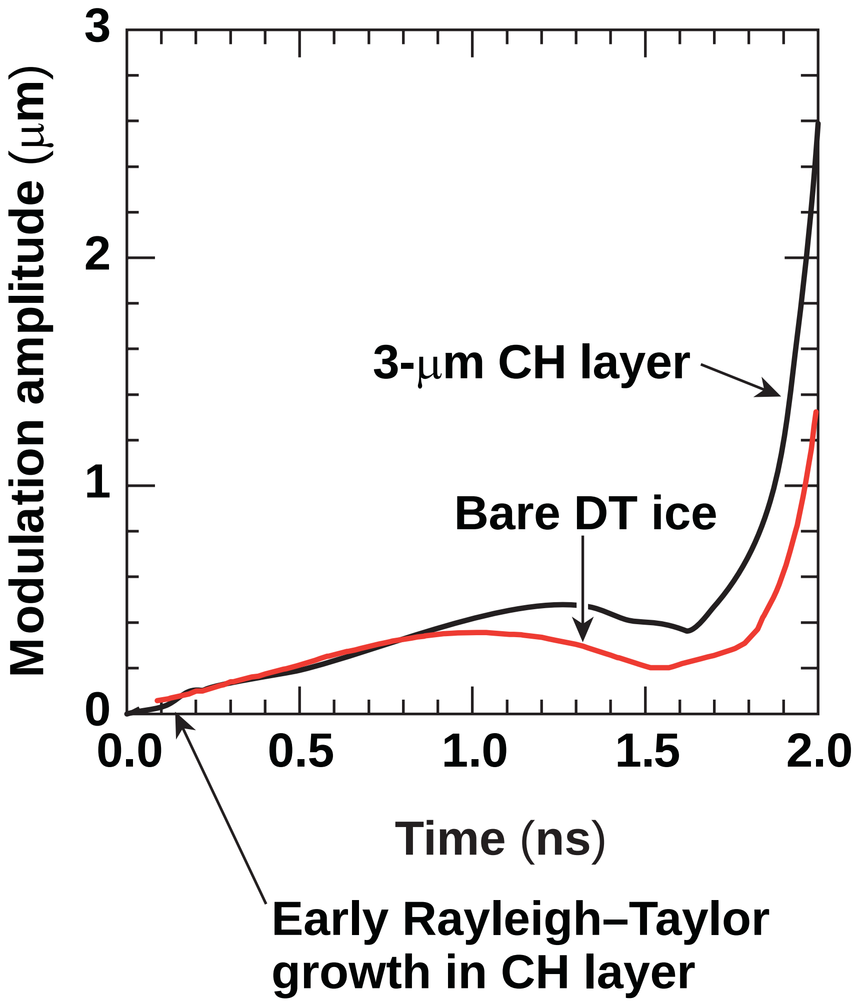
# Imprint Reduction with Shaped Pulses

T. J. B. Collins

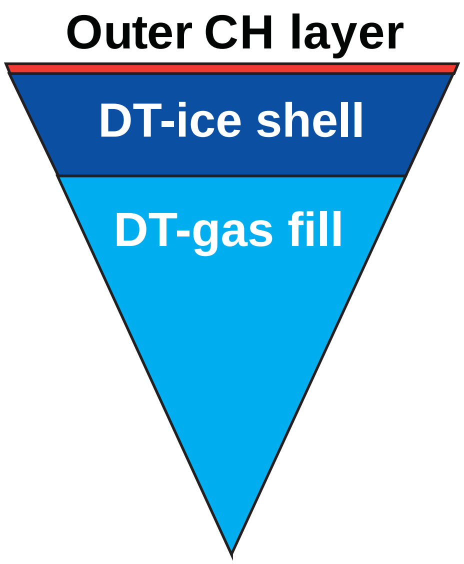
Laboratory for Laser Energetics, U. of Rochester

A novel technique for reducing laser imprint in OMEGA cryogenic targets has been developed. Standard ICF cryogenic targets consist of a shell of DT ice with an thin outer layer of CH. The presence of the CH layer gives rise to a brief period of early-time growth by the Rayleigh-Taylor (RT) instability, which effectively increases the amount of laser imprint by about a factor of 2. Two–dimensional *ORCHID* simulations show that by introducing a short, high-intensity spike at the start of the implosion, this early-time growth can be significantly reduced with only a small change to the calculated 1–D neutron yield. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460.

# The CH outer layer increases imprint




- OMEGA cryo targets have an outer ~1- to 4-μm layer of CH.
- The CH/DT interface causes an additional, brief period of Rayleigh–Taylor growth, early in time.
- This affects the late-time target conditions and increases imprint.

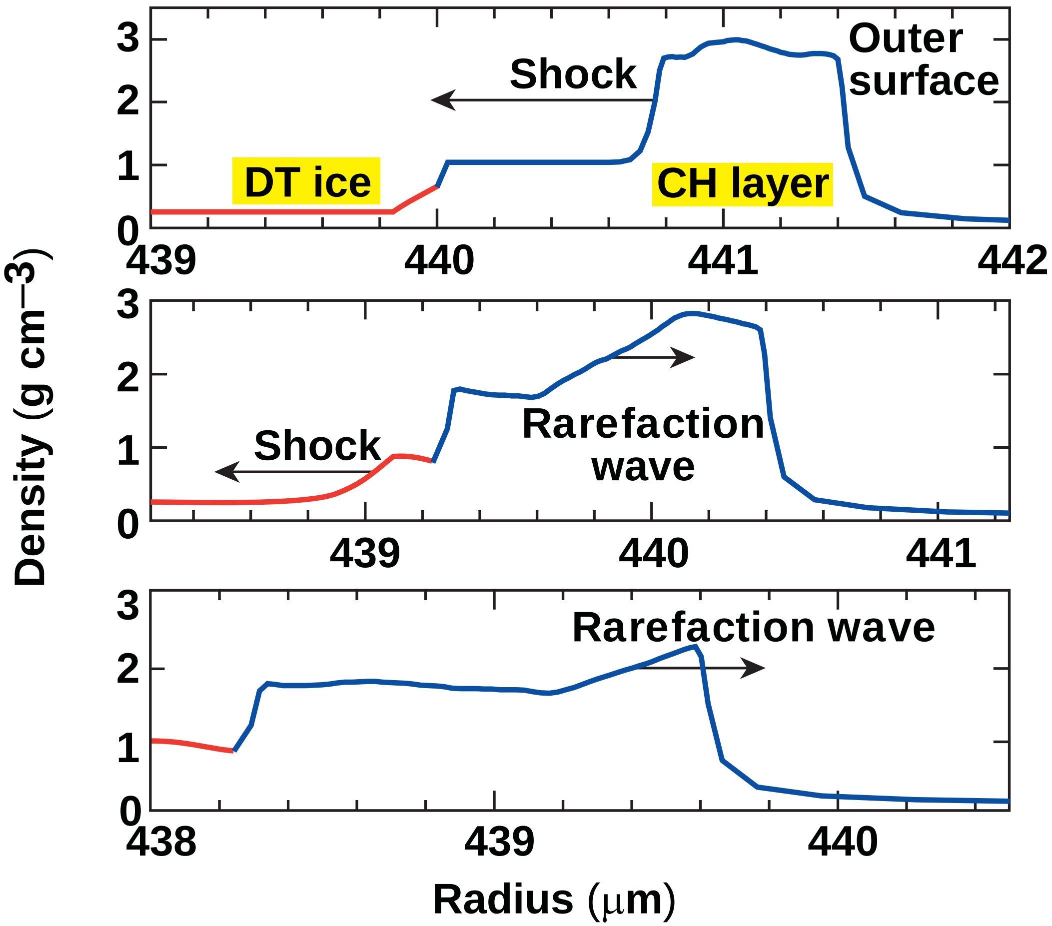



TC5496

# The embedded interface produces a rarefaction wave

UR LLE

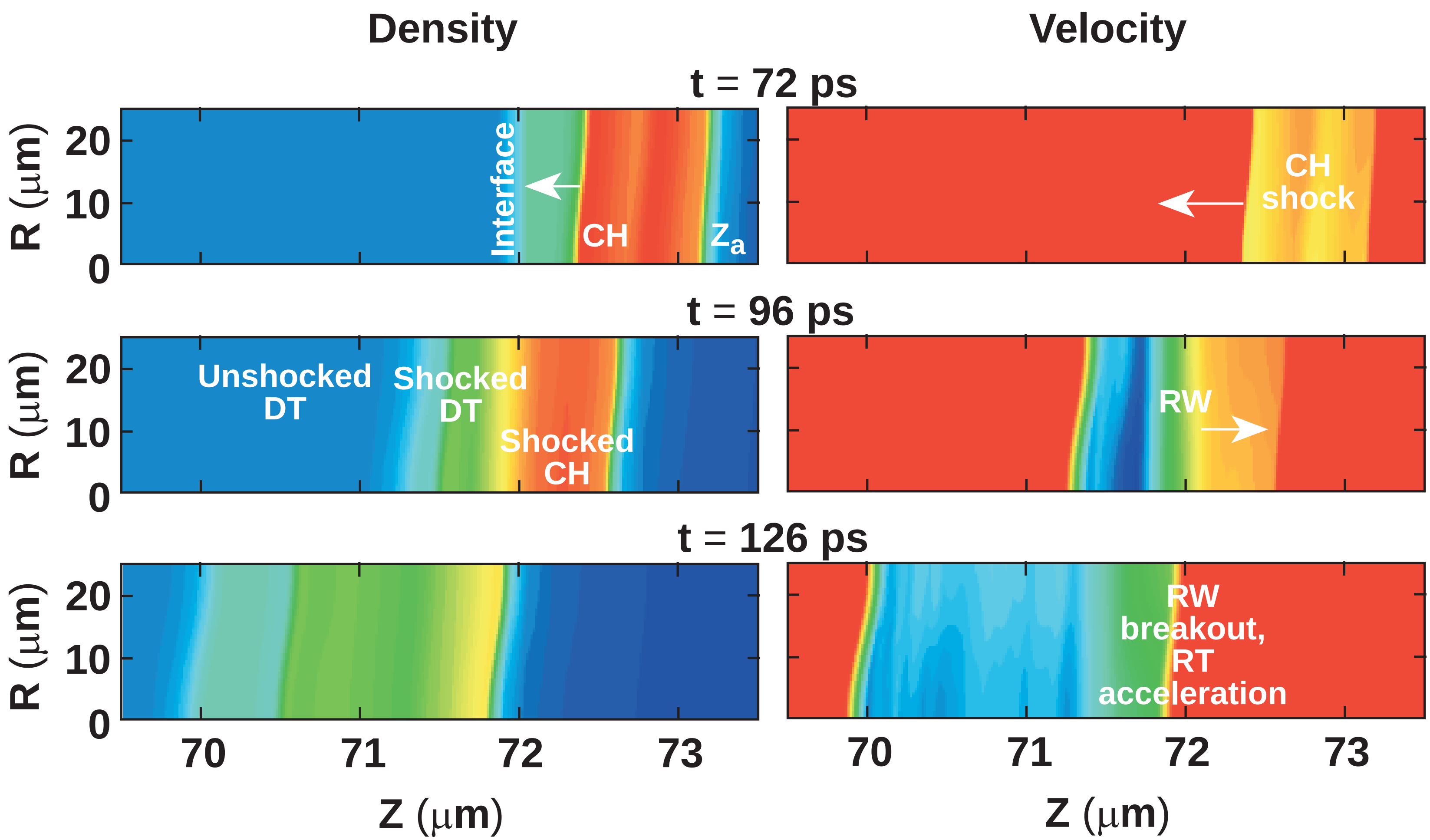
### Three early-time lineouts from an *ORCHID* simulation




- **When the rarefaction wave returns, the CH layer starts to accelerate and initiates early-time Rayleigh–Taylor growth.**

TC5497

# Rarefaction wave accelerates front surface, causing Rayleigh–Taylor growth




TC5526

# The CH/DT interface produces a new, brief period of Rayleigh–Taylor growth

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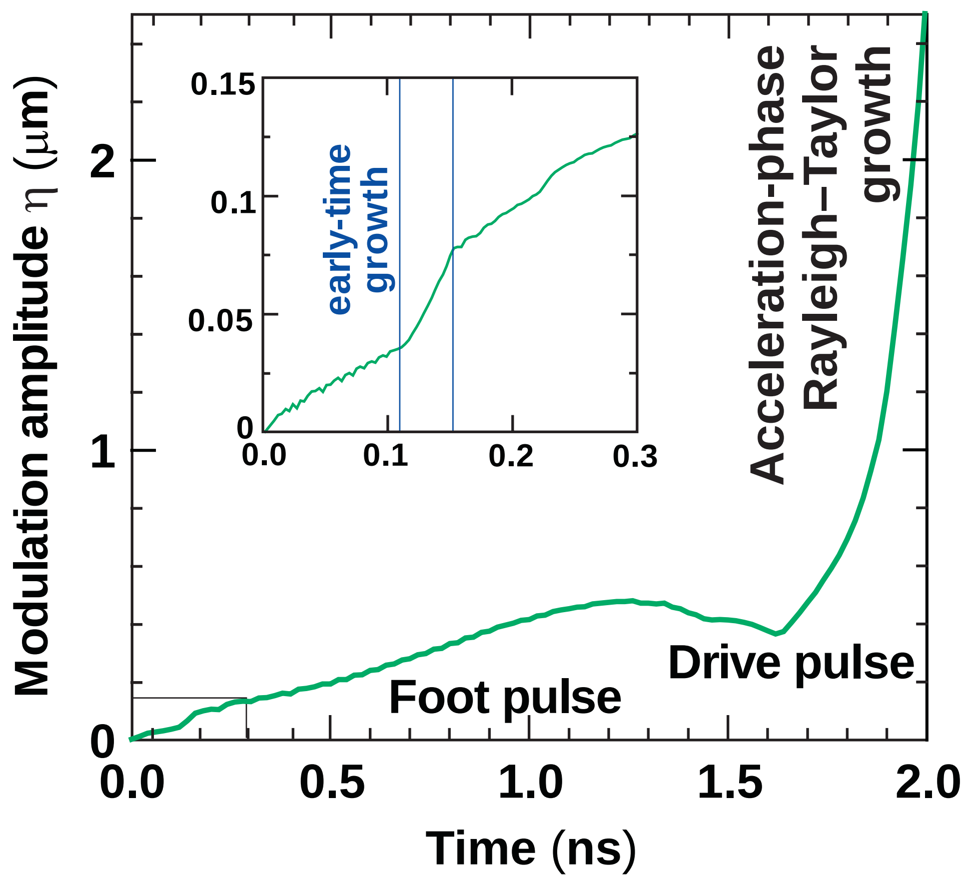


- This growth is greater for OMEGA targets than for NIF targets, *for a given mode number* $\ell$, because smaller R $\Rightarrow$ smaller $\lambda \Rightarrow$ greater $\gamma$.

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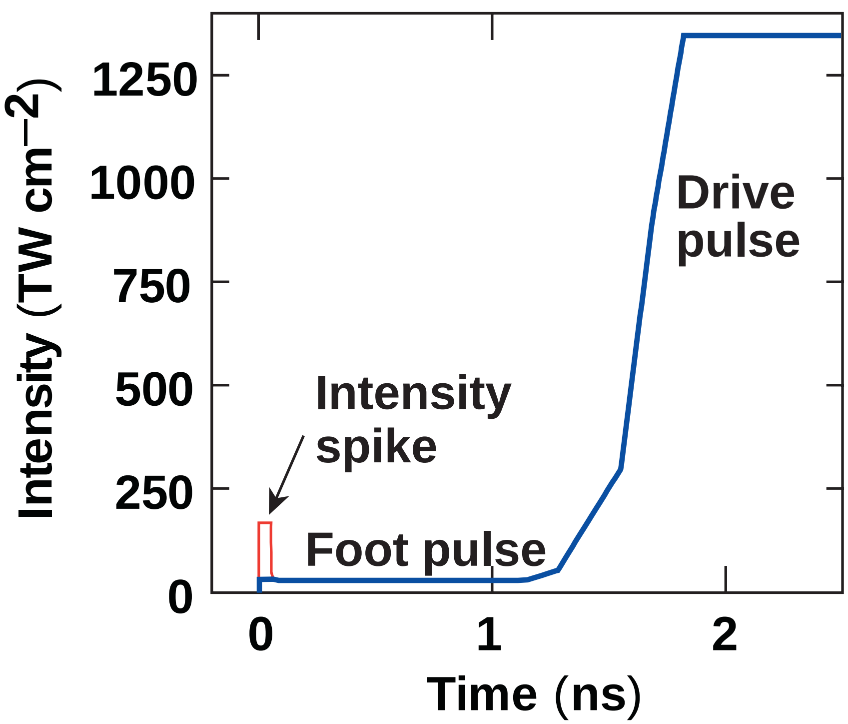
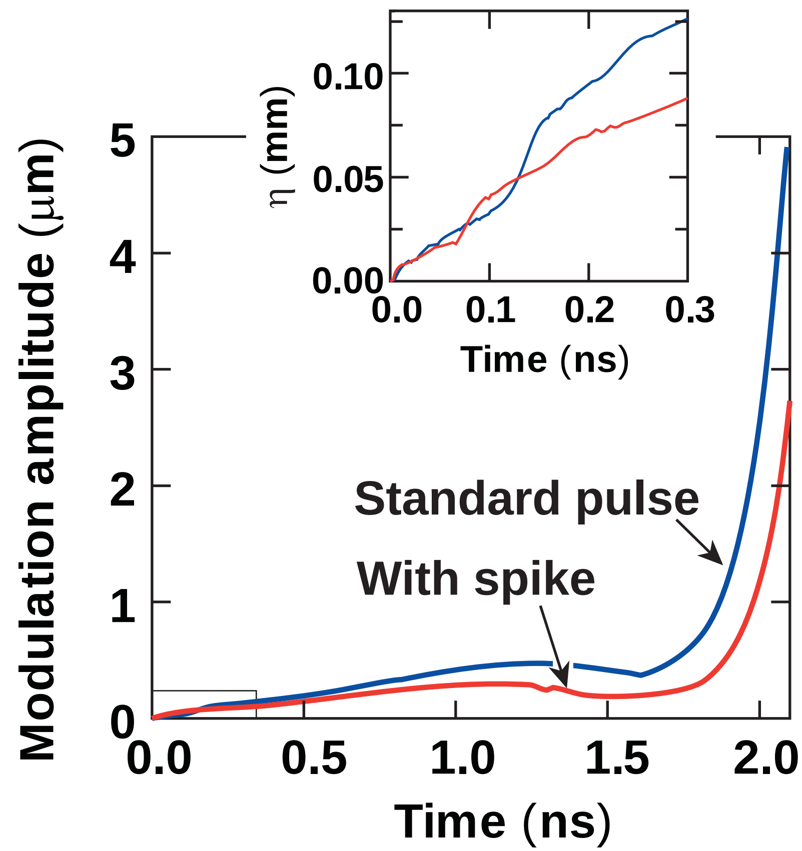
# A brief high-intensity spike at the start of the foot pulse reduces imprint




TC5499

# The intensity spike reduces the effects of CH layer

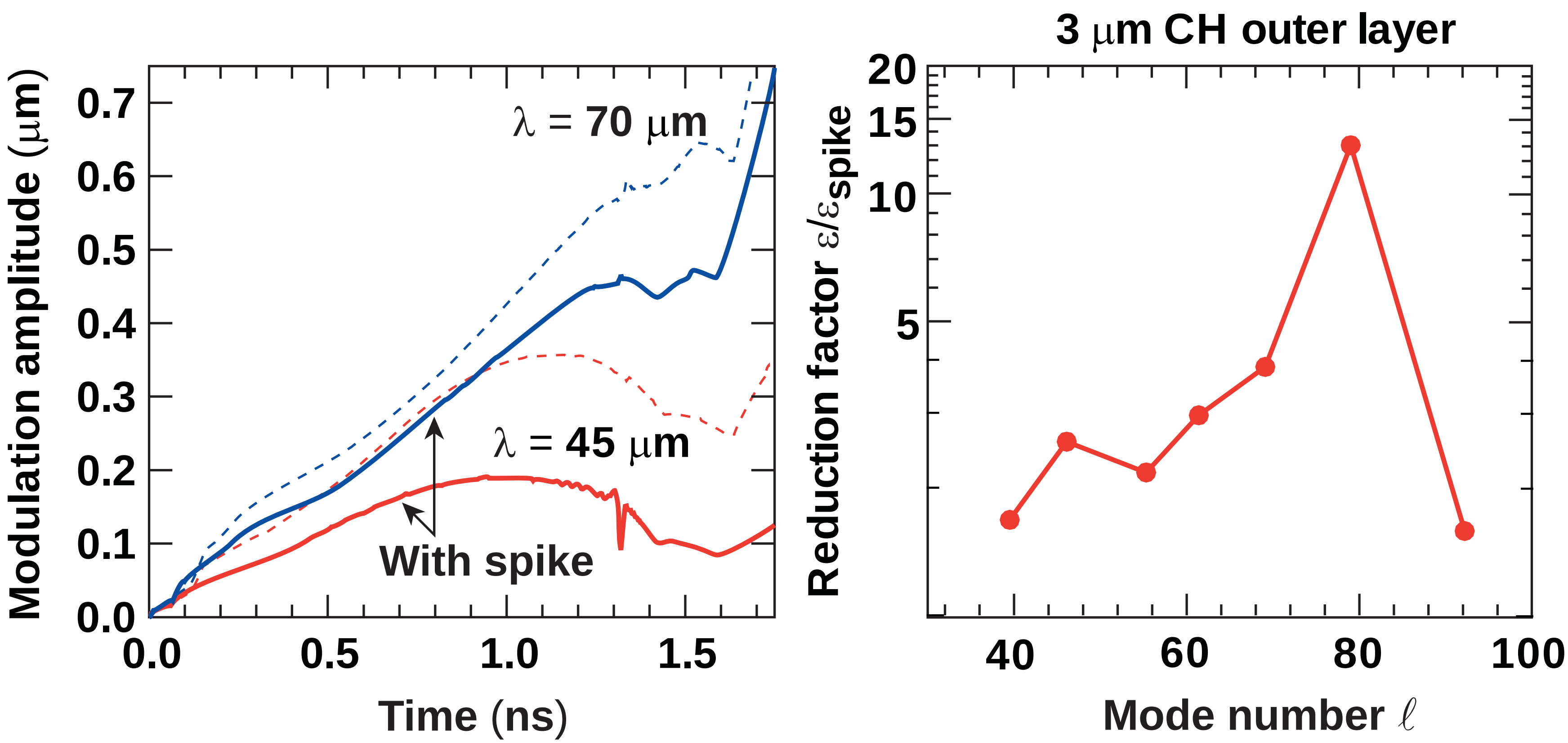
- The intensity spike
  - launches a stronger shock,
  - which reaches the CH/DT interface sooner,
  - and results in a greater post-shock sound speed;
  - the width of the compressed CH is less,
  - so the rarefaction waves returns sooner
  - and is shorter in duration.

- The spike reduces the early Rayleigh–Taylor growth.

- Rayleigh–Taylor growth starts at a lower amplitude.

# Imprint reduction is greater for shorter wavelengths

- Early-time growth is less for greater wavelengths.

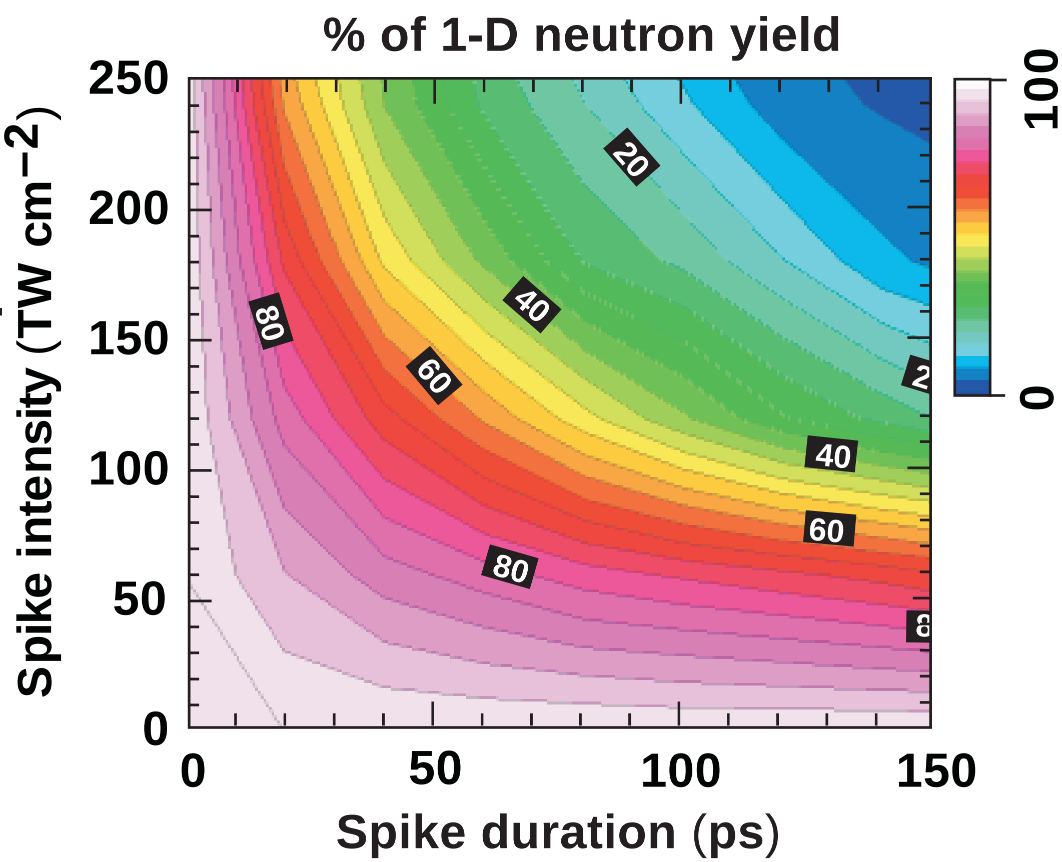



- Phase reversal can counteract reduction at small λ.

TC5501

# The intensity spike can affect the neutron yield

- The effect of the intensity spike on target performance depends on $I \times dt \propto$ the energy in the spike.
- Fuel adiabat is unchanged by the spike due to small spike energy.
- Yield might be raised by retuning.




TC5502

# The imprint reduction is greater for thicker CH layers

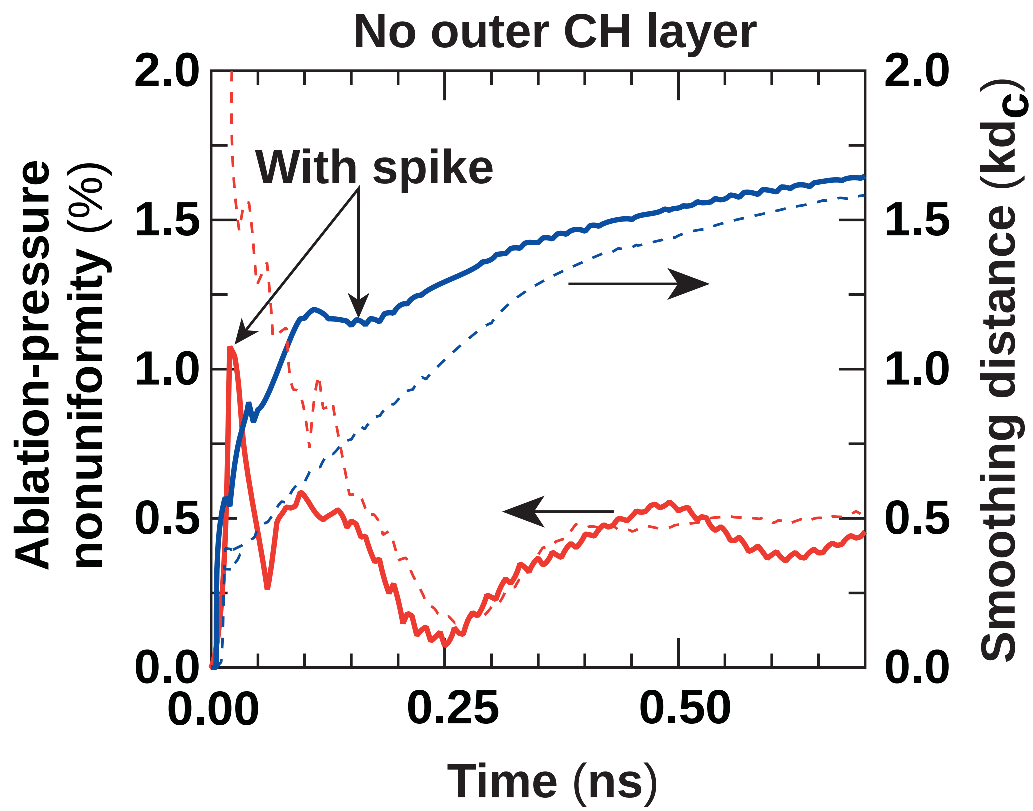
- *Equivalent Surface Finish:* The surface roughness that would, for uniform illumination, produce the same outer-surface modulation amplitude.
- Duration of early-time growth ~$d/\xi c_S$, where d is the CH layer width, $\xi$ is the foot-shock compression, and $c_S$ is the post-shock sound speed.
- Simple average of imprint reduction over mode number is greater for thicker CH layers.

| CH ($\mu$m) | $\langle \varepsilon/\varepsilon_{spike} \rangle$ |
|---|---|
| 0 | 1.2 |
| 1 | 1.7 |
| 2 | 1.9 |
| 3 | 2.7 |

TC5503

# The intensity spike increases thermal smoothing

- Smoothing distance $d_c$ between critical and ablation surfaces increases with laser intensity.
- Pressure nonuniformity decreases exponentially with smoothing distance.
- Thermal smoothing contributes to imprint reduction.




GI3.002

TC5504

**Summary**

# An initial intensity spike reduces imprint in OMEGA cryogenic targets

- Outer CH layer introduces early period of Rayleigh–Taylor growth, increasing imprint.
- Initial intensity spike reduces effects of CH layer.
- Intensity spike also reduces imprint via thermal smoothing.