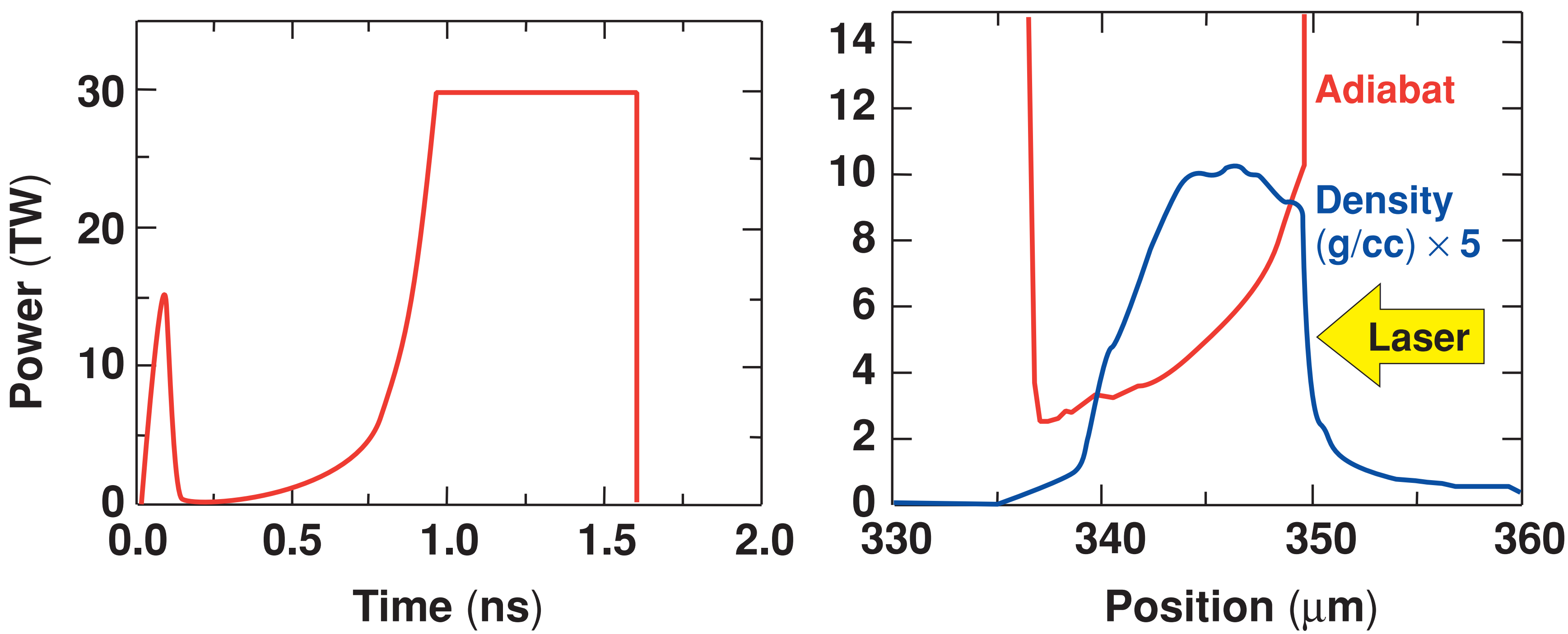
Adiabat Shaping in Direct-Drive ICF Implosions Using the Intensity Picket



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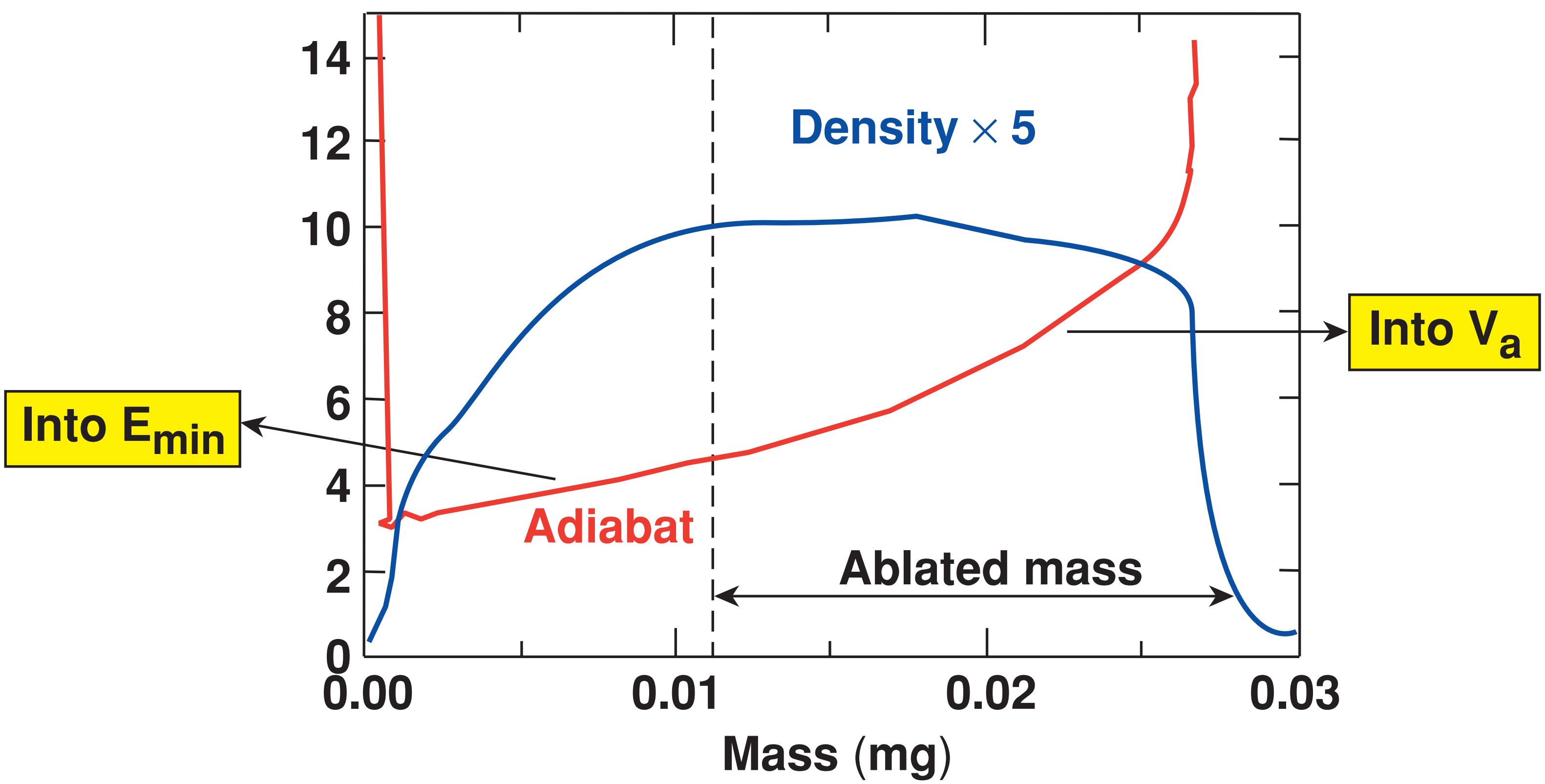
Summary

Perturbation growth can be significantly reduced by adiabat shaping

- A technique is proposed to reduce the perturbation growth without compromising the target yield.
- Shaping the adiabat of the main fuel and ablator reduces both seeding and the growth of the Rayleigh–Taylor instability.
- The adiabat is shaped using an intensity picket that launches a decaying shock into the shell. The shock places the outer portion of the shell (ablator) on the higher adiabat, keeping the inner part (main fuel) on the lower adiabat.
- The stabilizing effect of the adiabat shaping is confirmed both numerically and experimentally.

Shell stability and compressibility depend on the adiabat

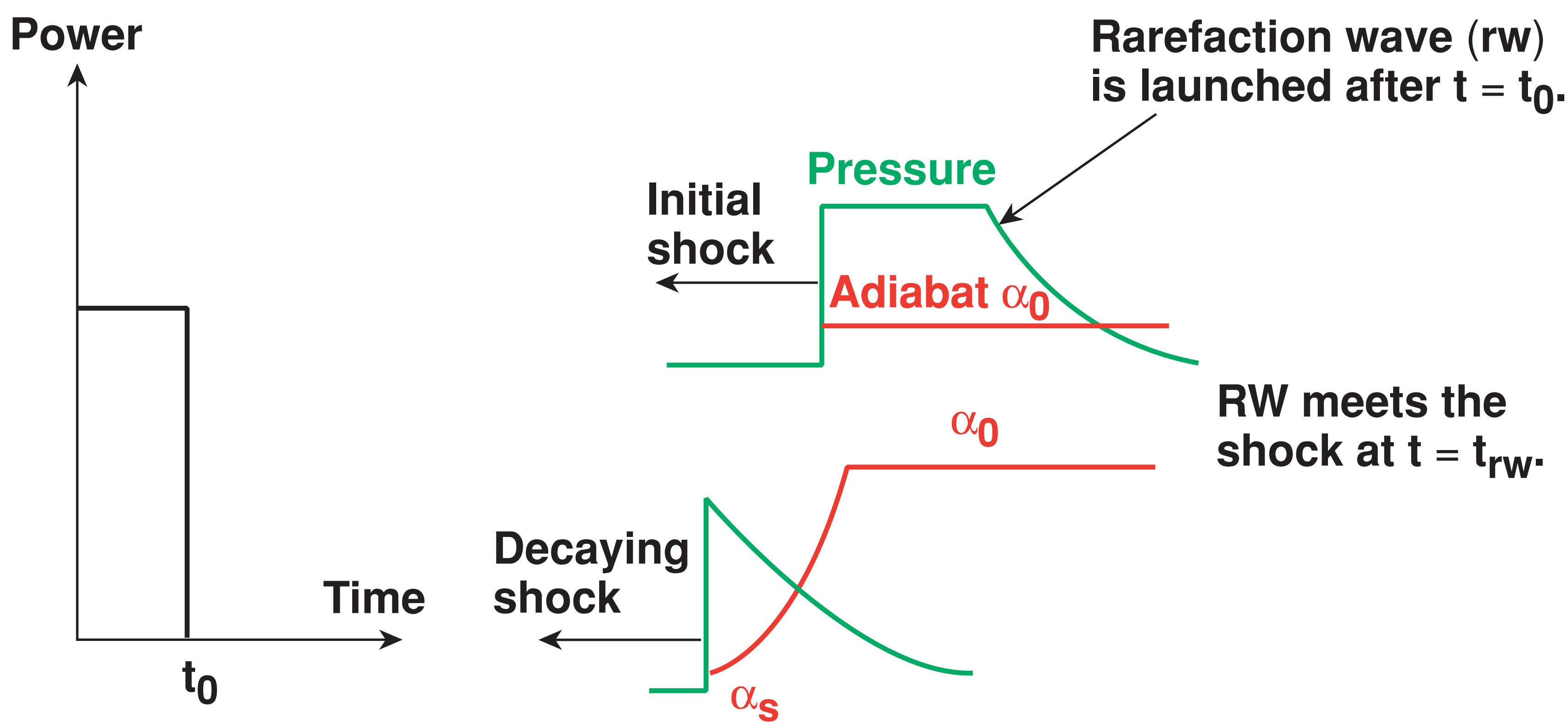
- Mimimum energy required for ignition:[1,2] $E_{min} \sim \alpha^{1.88}$ $\alpha = P/P_{Fermi}$
- Rayleigh–Taylor instability growth $\gamma = \alpha_{RT}(kg)^{1/2} - \beta_{RT}kV_a$ $V_a \sim \alpha^{3/5}$



[1]M. Herrmann *et al.*, Phys. Plasmas 8, 2296 (2001).
[2]R. Betti *et al.*, Phys. Plasmas 9, 2277 (2000).

TC5950

Adiabat shaping is done using an intensity picket



Calculations show $\dfrac{p_s}{p_0} \approx \dfrac{\alpha_s}{\alpha_0} \approx \left(\dfrac{t - t_0}{t_{rw} - t_0}\right)^{-\frac{\sqrt{2\gamma(\gamma-1)}}{2\gamma-1}}$ valid for $\gamma > 1.2$.

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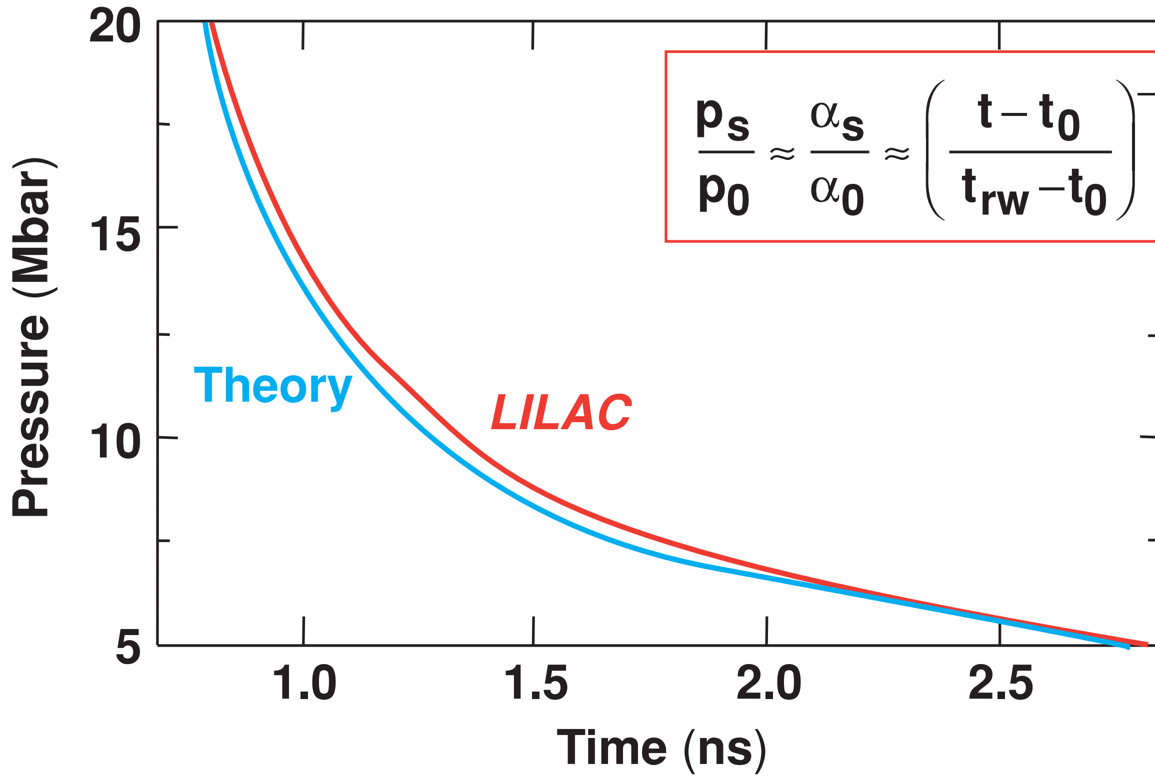
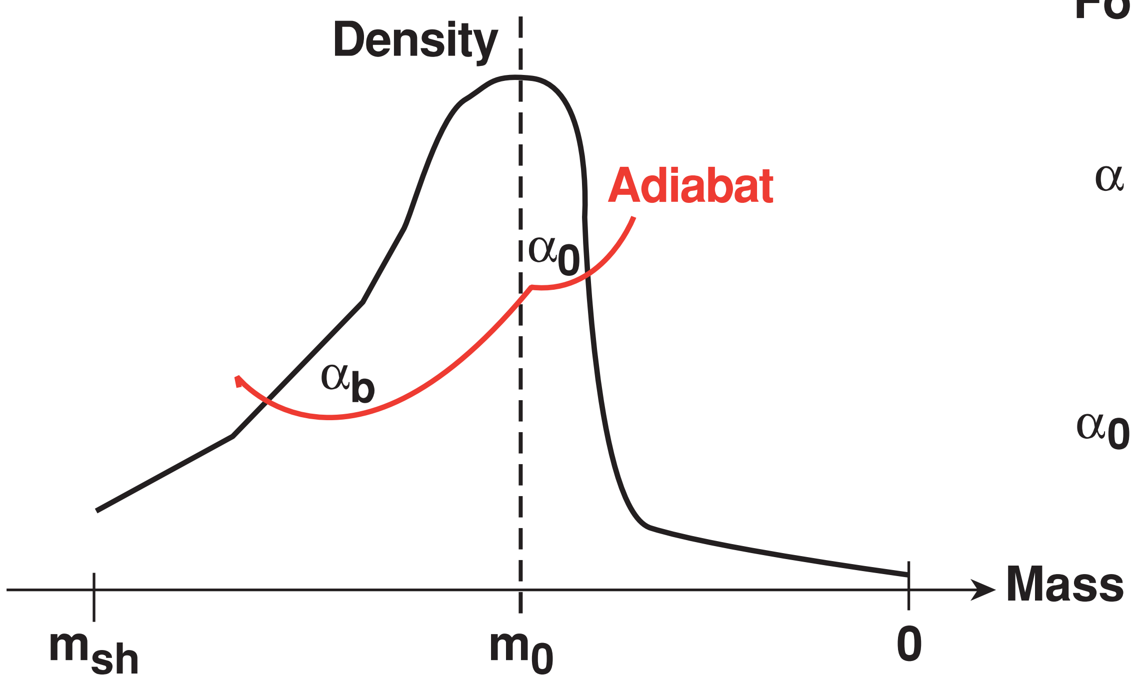
Numerical simulations confirm the shock-decaying rate

The 300-μm-DT foil is driven by 500-ps, 100-TW square pulse.



$$\frac{p_s}{p_0} \approx \frac{\alpha_s}{\alpha_0} \approx \left(\frac{t - t_0}{t_{rw} - t_0}\right)^{-0.64}, \; \gamma = 5/3$$

The adiabat at the ablation front depends on the picket intensity and picket width



For $\gamma = 5/3$:

$$\alpha = \alpha_0 \left[1.5 \left(\frac{m}{m_0} - 1 \right) + 1 \right]^{-0.94}$$

$$\alpha_0 = \alpha_b \left[1.5 \left(\frac{m_{sh}}{m_0} - 1 \right) + 1 \right]^{0.94}$$

$$m_0 = \rho_0 U_{sh} \left(t_0 + t_{rw} \right)$$

Optimum adiabat shaping requires narrow (<100-ps) high-intensity pickets.

TC5953

Stabilizing effects of the adiabat shaping were numerically tested on the "all-DT," α = 3 OMEGA target design

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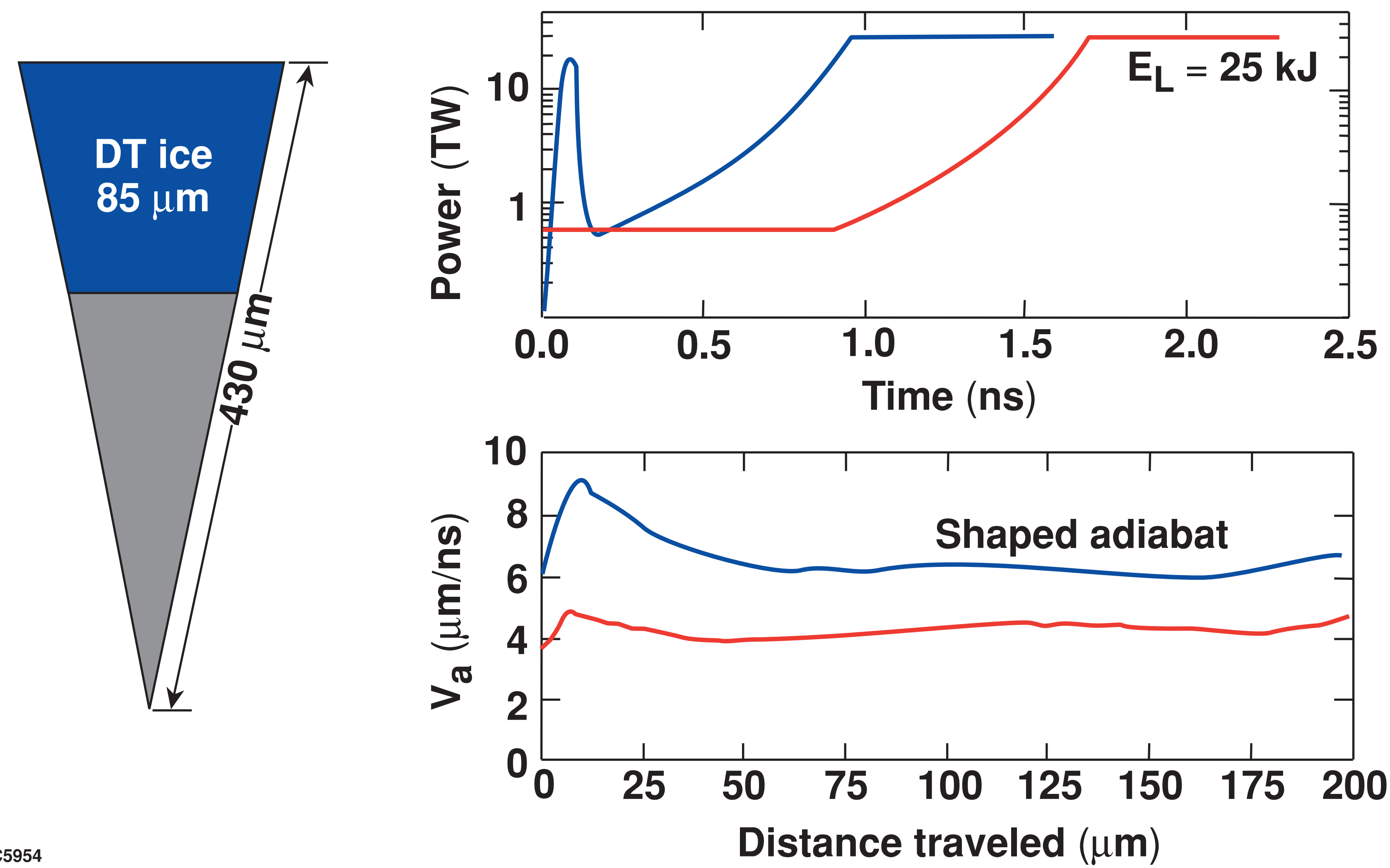
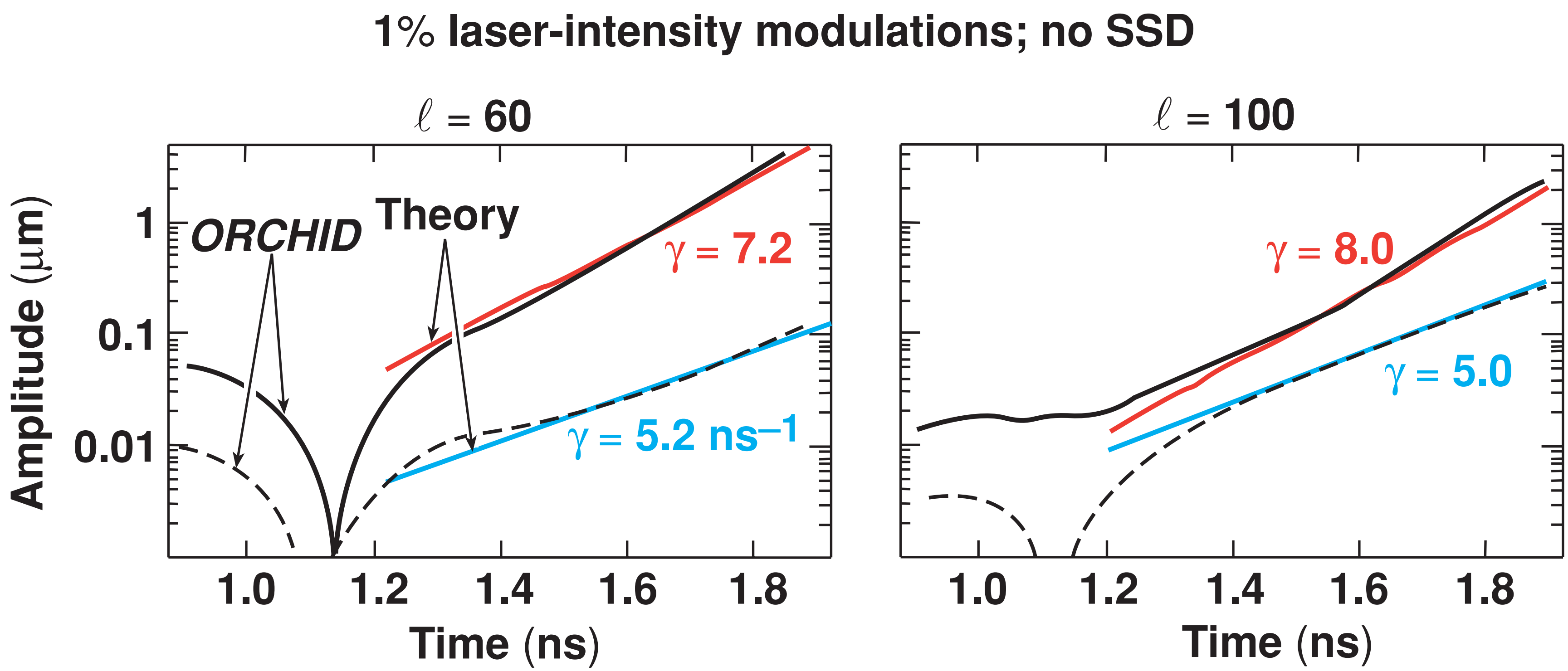
Two pulse shapes were considered



TC5954

The intensity picket reduces both the growth rate and laser imprint

- Imprint simulation using 2-D lagrangian code *ORCHID*

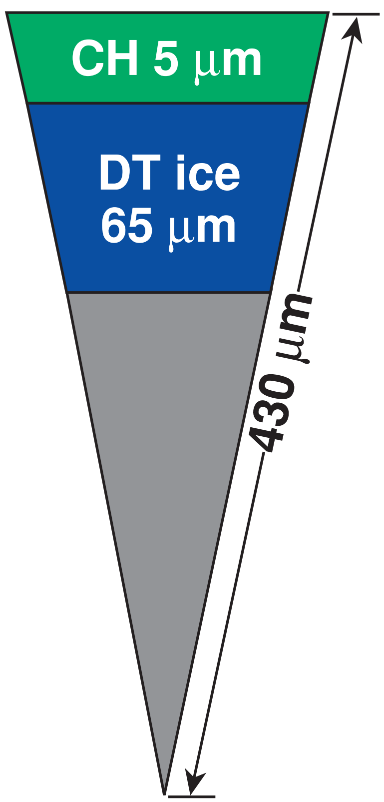


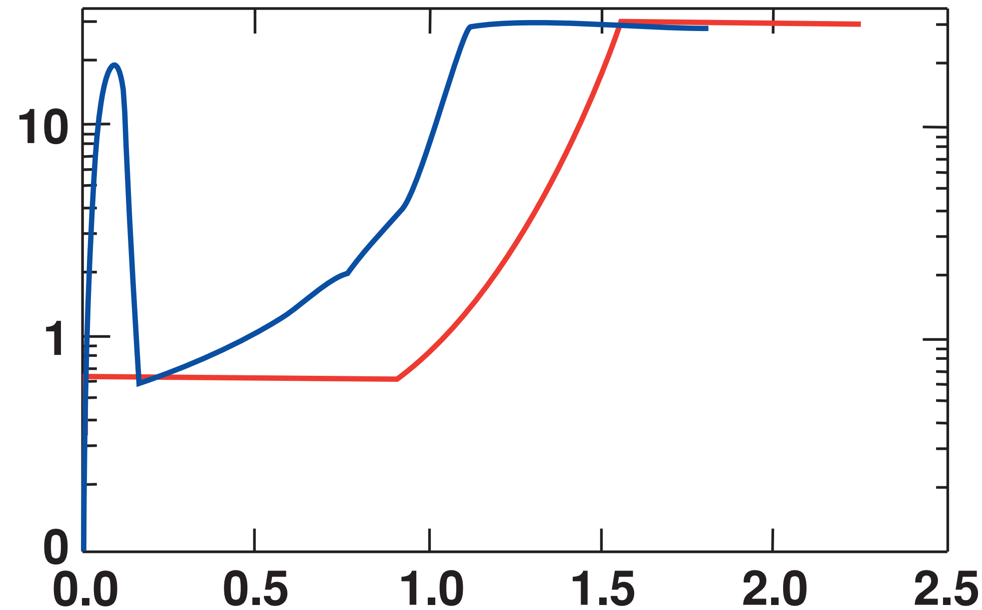
For DT foils:[1] $\gamma = 0.94\sqrt{kg} - 2.6\ kV_a$

[1]R. Betti *et al.*, Phys. Plasmas 5, 1446 (1998).

TC5955

Greater shell stability is predicted for high-performance OMEGA cryogenic target designs with an intensity picket





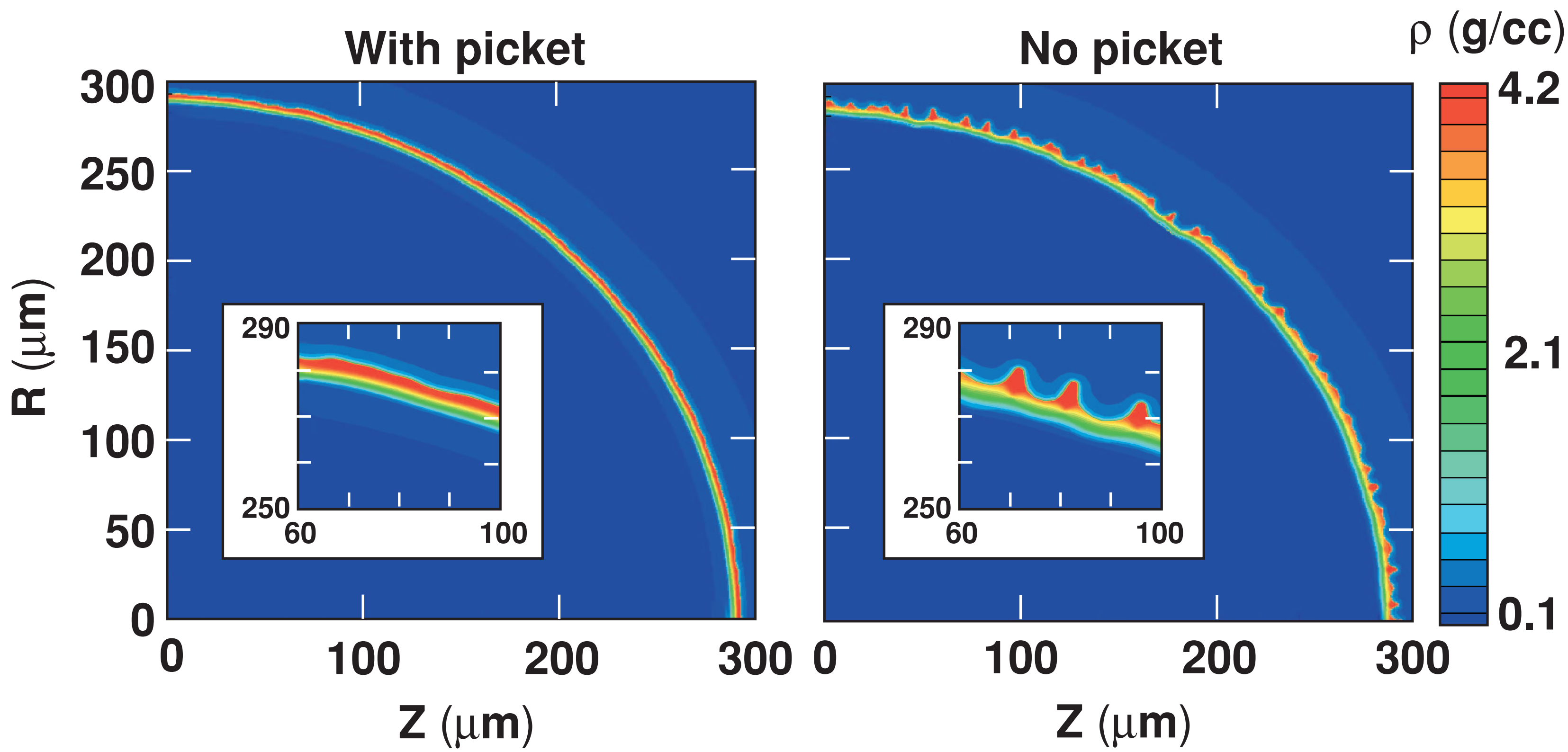
		Picket
ρR (mg/cm^2)	330	305
Y ($\times 10^{14}$)	6.5	6
A_{bubble}/Th (%)[1]	>100	55

[1]V.N. Goncharov *et al.*, Phys. Plasmas 7, 5118 (2000)

TC5956

Multimode *ORCHID* simulations demonstrate greater the stability of the shaped-adiabat design

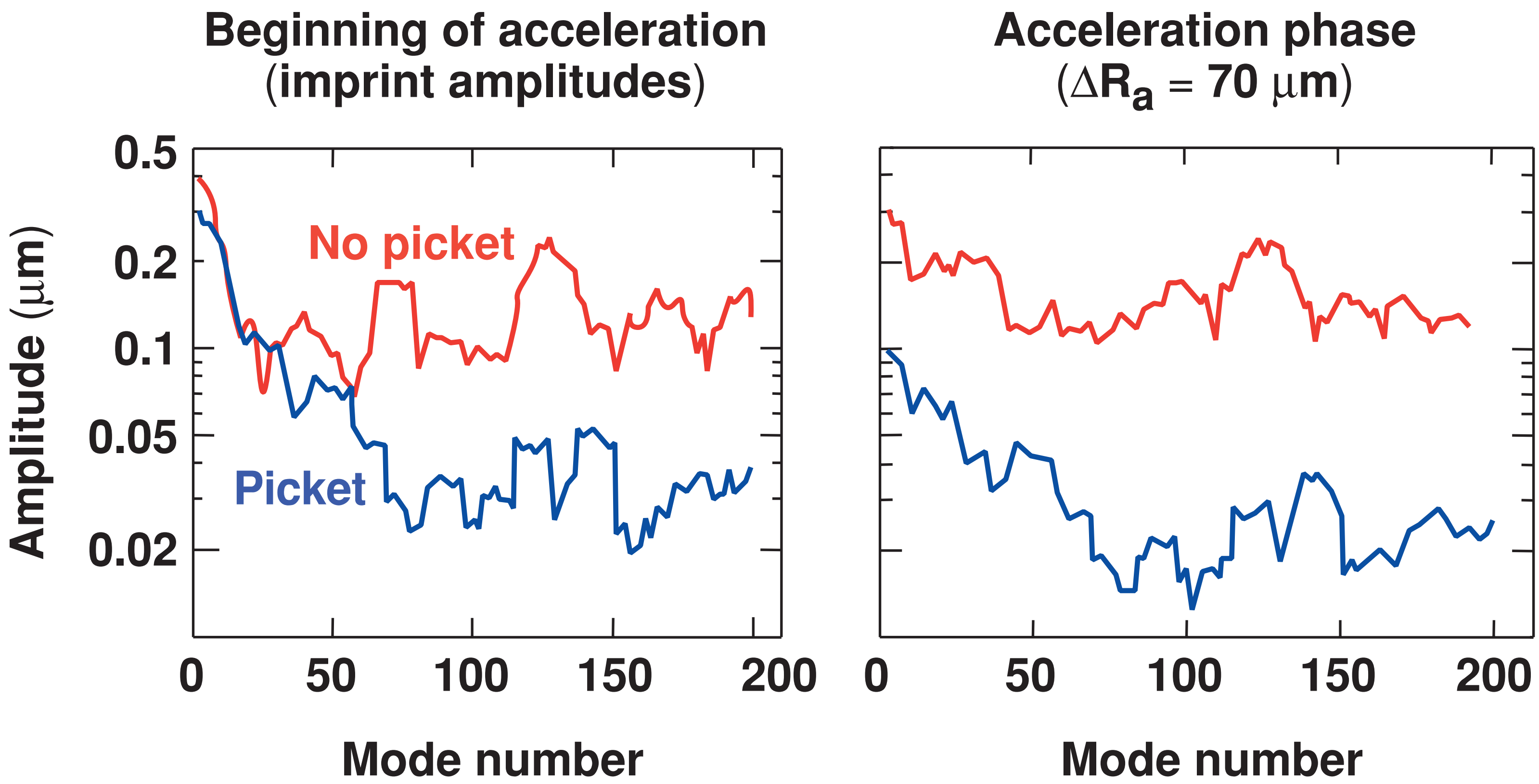
Imprint simulations: ℓ = 2–200, DPP + PS, 1-THz SSD



Shell is significantly less distorted in the picket design.

TC5957

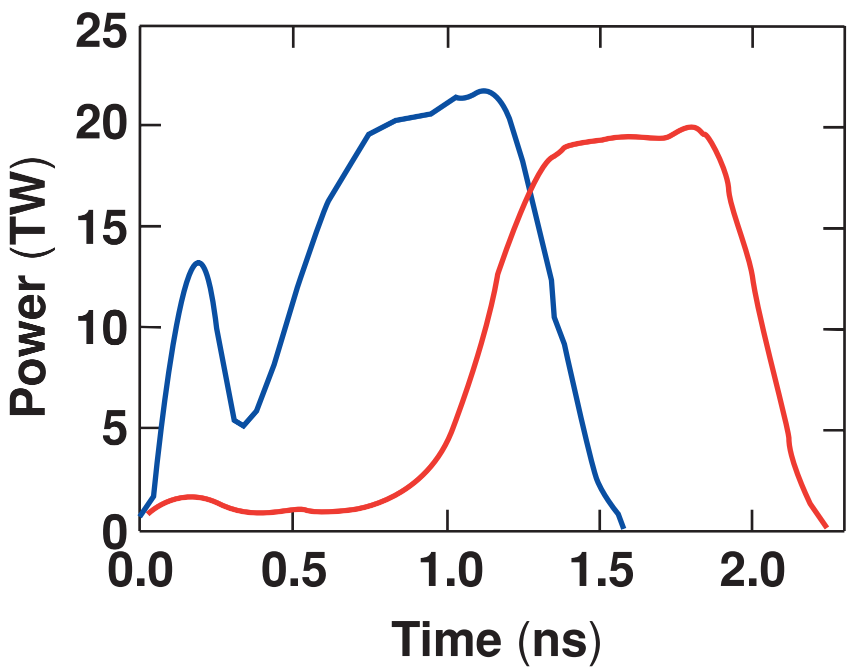
Mode decomposition shows the effect of the picket on the imprint amplitudes and growth rates

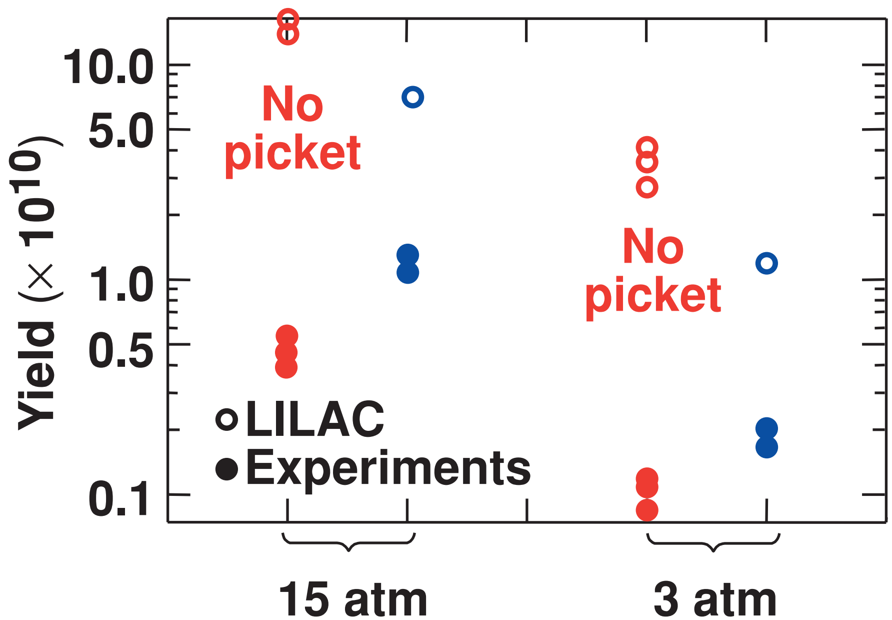


TC5958

The stabilizing effect of the adiabat shaping was studied experimentally using D_2-filled plastic shells

33-μm-CH shells filled with 3 atm and 15 atm D_2 gas





$Y_{exp} / Y_{1\text{-}D}$ (%)	4	18	3	15

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