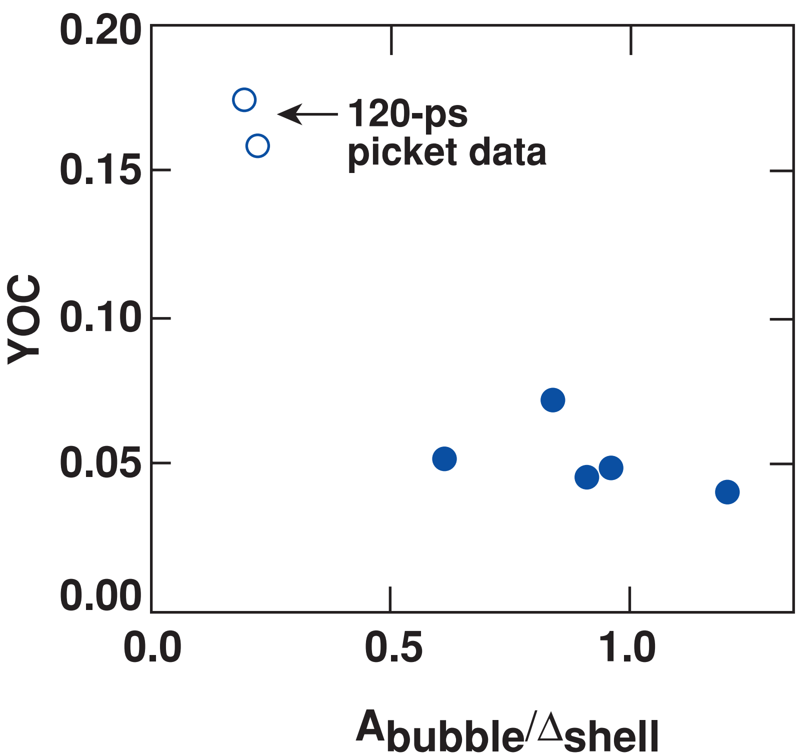
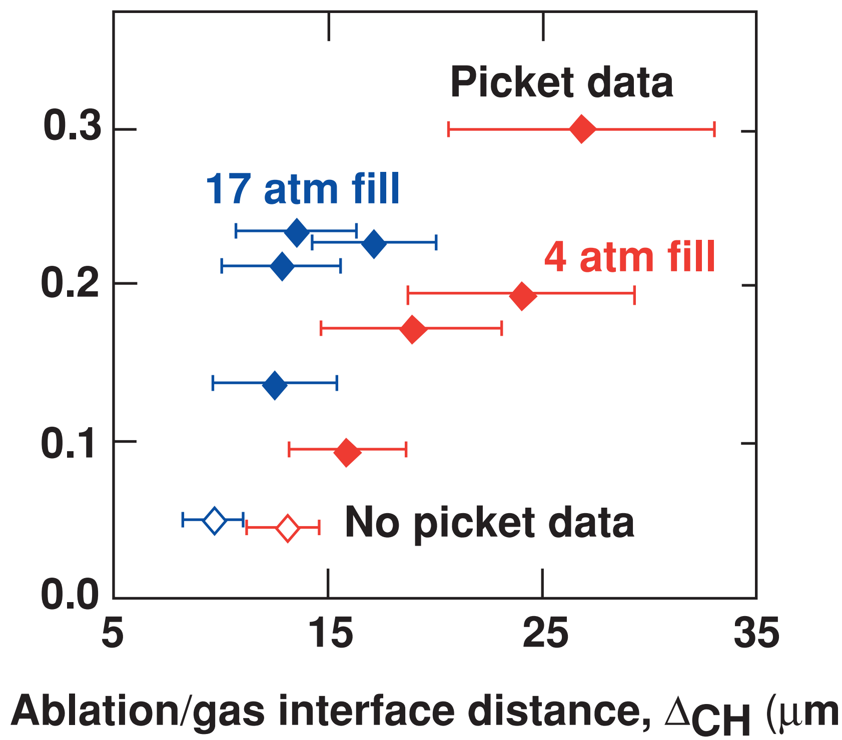
Direct-Drive ICF Implosions with Picket-Fence Pulse Shapes





J. P. Knauer
University of Rochester
Laboratory for Laser Energetics

45th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Albuquerque, NM
27–31 October 2003

Collaborators

V. N. Goncharov, K. Anderson, R. Betti, V. Yu. Glebov, F. J. Marshall, P. W. McKenty, P. B. Radha, S. P. Regan, T. C. Sangster, and C. Stoeckl

University of Rochester
Laboratory for Laser Energetics

J. A. Frenje, C. K. Li, R. D. Petrasso, and F. H. Séguin

Plasma Science and Fusion Center,
Massachusetts Institute of Technology

Summary

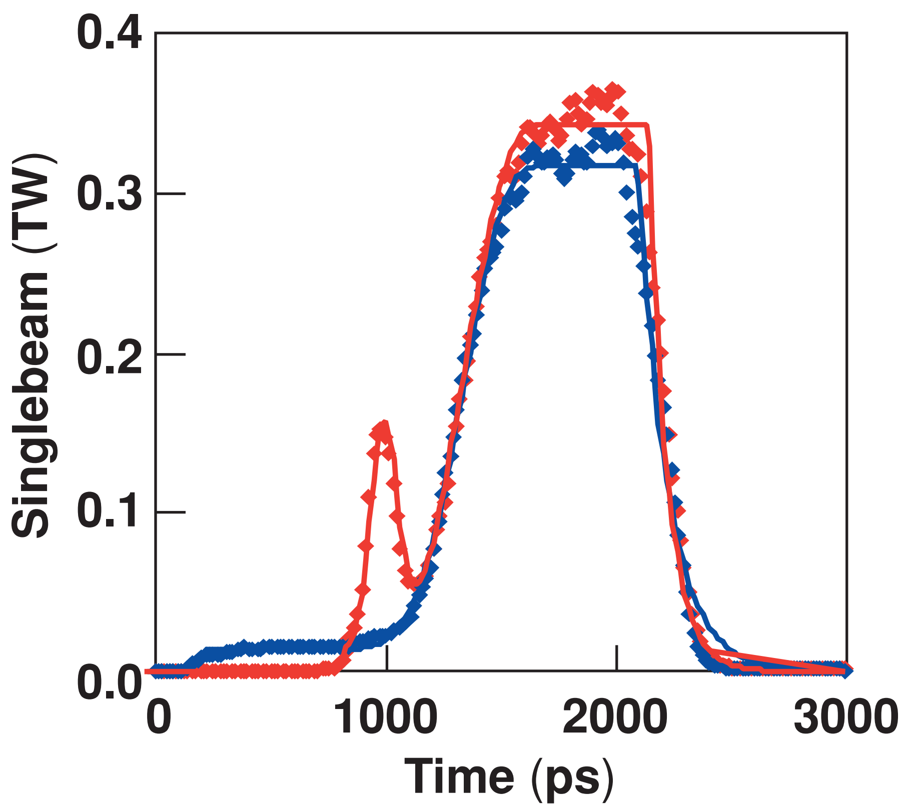
Shaped pulses have been used to control the seed amplitude of the deceleration-phase instability

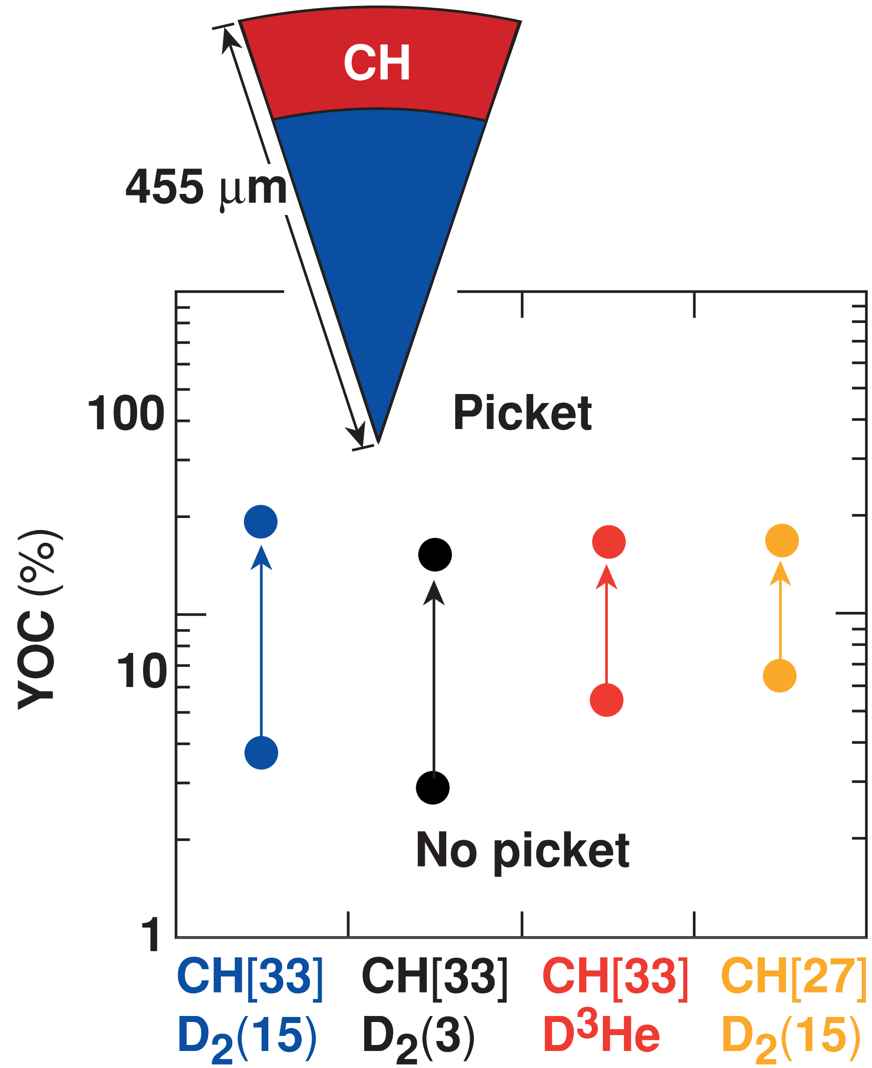
- **First experiments showed significant increase in neutron yield with a picket pulse due to reduction of the deceleration-phase instability initial amplitude.**
- **Experimental yield/1-D simulation yield (YOC) increases with greater separation between the ablation and gas interfaces.**
- **YOC also improves when ablation interface growth is reduced.**

A 120-ps FWHM picket pulse before the drive pulse showed increased fusion yields

<u>Picket pulse</u>

Width (FWHM) = 120 ps
Amplitude = 0.4 of drive
Position = 340 ps before drive

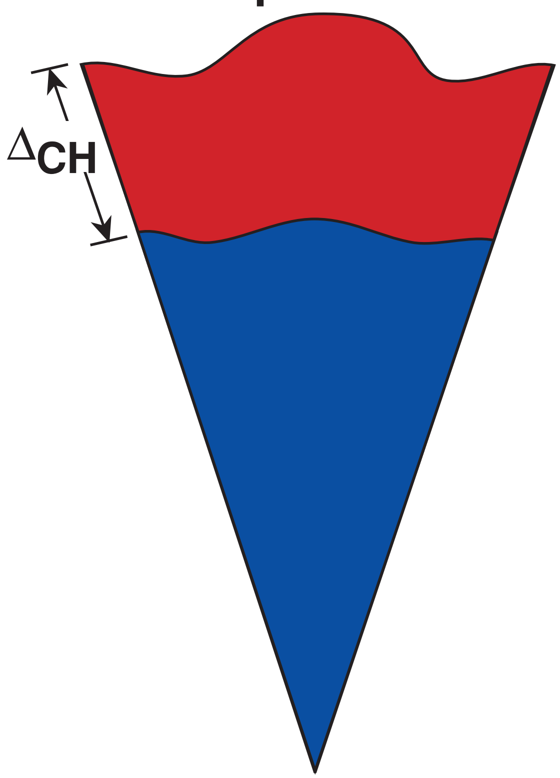




E12598

The Rayleigh–Taylor instability at the shell–gas interface during deceleration strongly affects fusion yield

End of acceleration phase



- Deceleration interface is classically unstable.

$$A = A_{initial} e^{\gamma t}$$

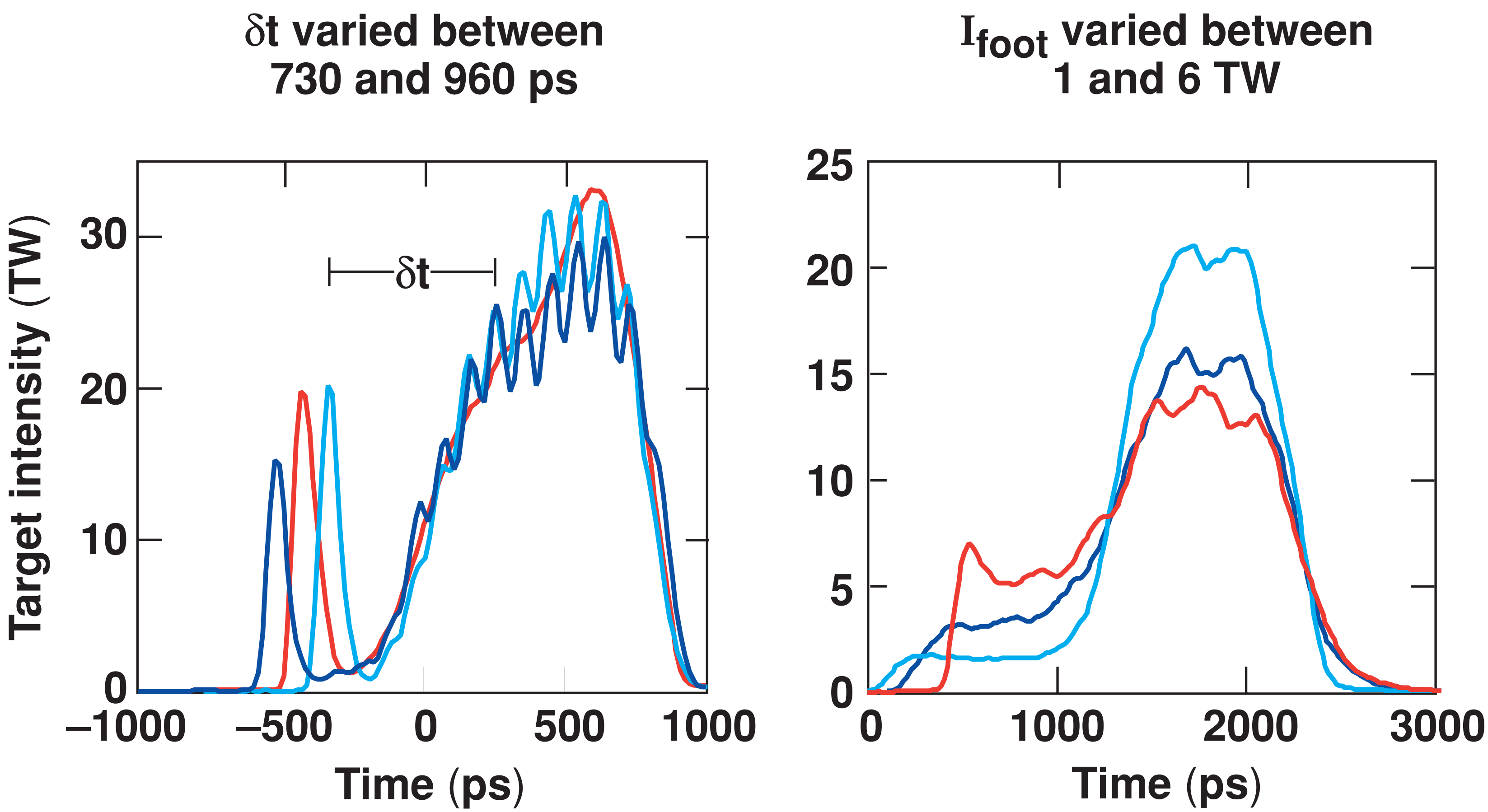
$$A_{initial} = \sqrt{\left(A_{inner}^2 + A_{feedthrough}^2\right)}$$

$$A_{feedthrough} = A_{ablation} e^{-k\Delta_{CH}}$$

- Shaped-pulse implosions will study both $A_{ablation}$ and Δ_{CH}.

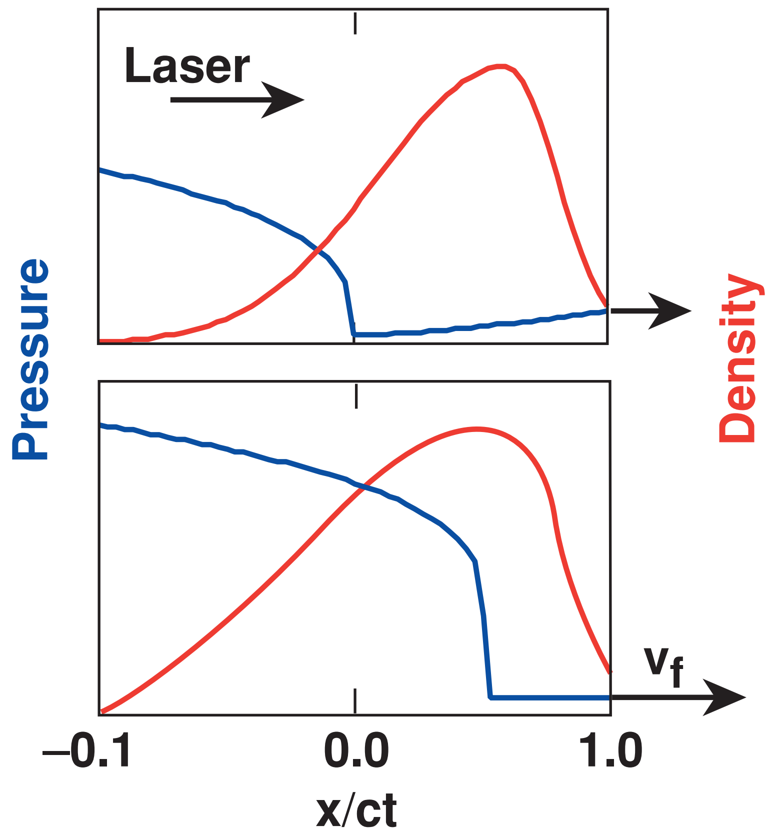
E12599

CH targets were imploded using laser pulse shapes with and without picket pulses



E12600

Picket timing relative to the drive pulse (δt) changes the distance between the ablation and gas interfaces, Δ_{CH}



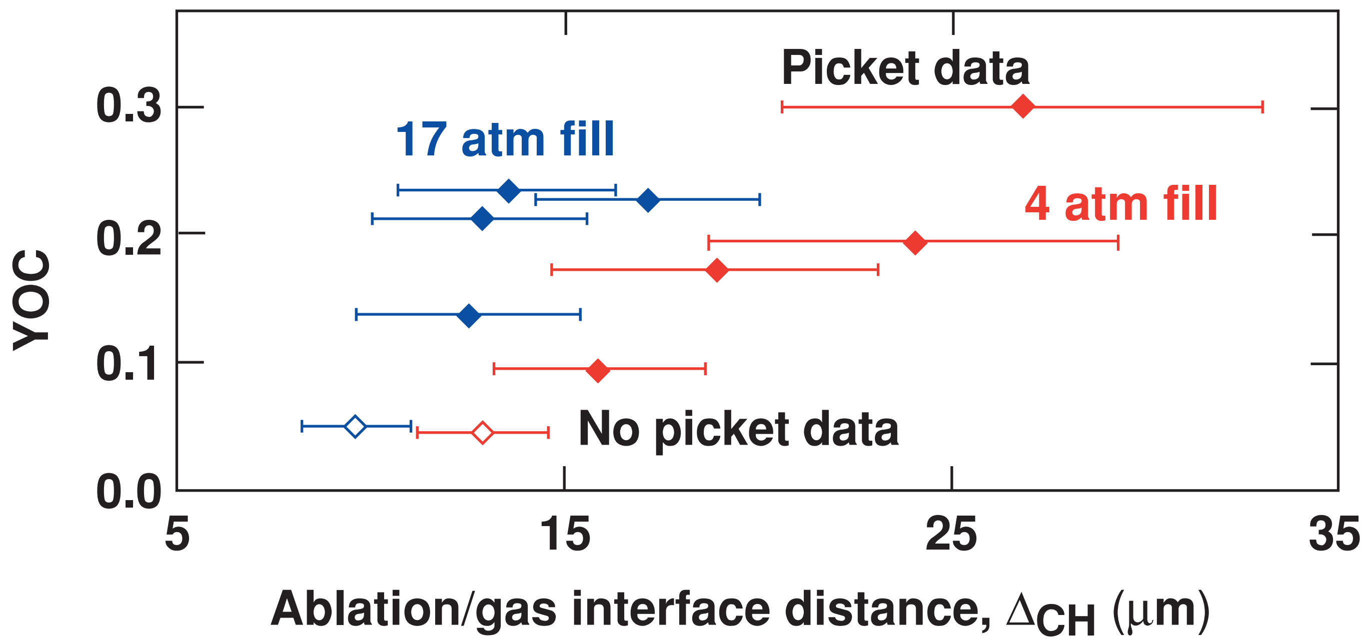
Large δt – Decaying shock wave reaches rear of shell before compression wave

Small δt – Compression wave catches decaying shock wave before rear of shell

- v_f is larger when the compression wave overtakes the decaying shock wave in the shell.
- Δ_{CH} is larger and continues to grow.

E12601

Experimental yield/1-D yield (YOC) is sensitive to the timing of the picket pulse relative to the drive pulse



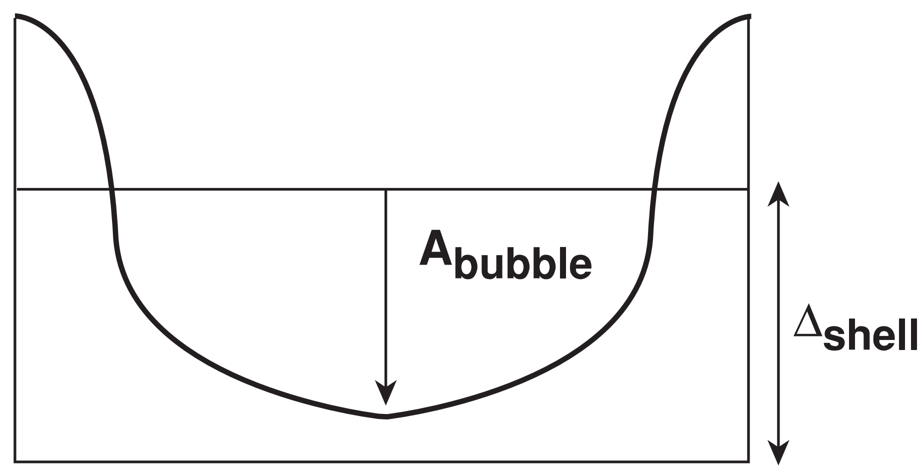
$$\Delta_{CH} \equiv \langle r_{ablation} - r_{gas} \rangle \big|_t$$

- 4-atm-gas-filled targets travel farther during the deceleration phase.

E12602

Both picket and non-picket pulse shapes were used to change the ablation-interface amplitude, $A_{ablation}$

- Separation of ablation and shell–gas interfaces = 18±2 μm



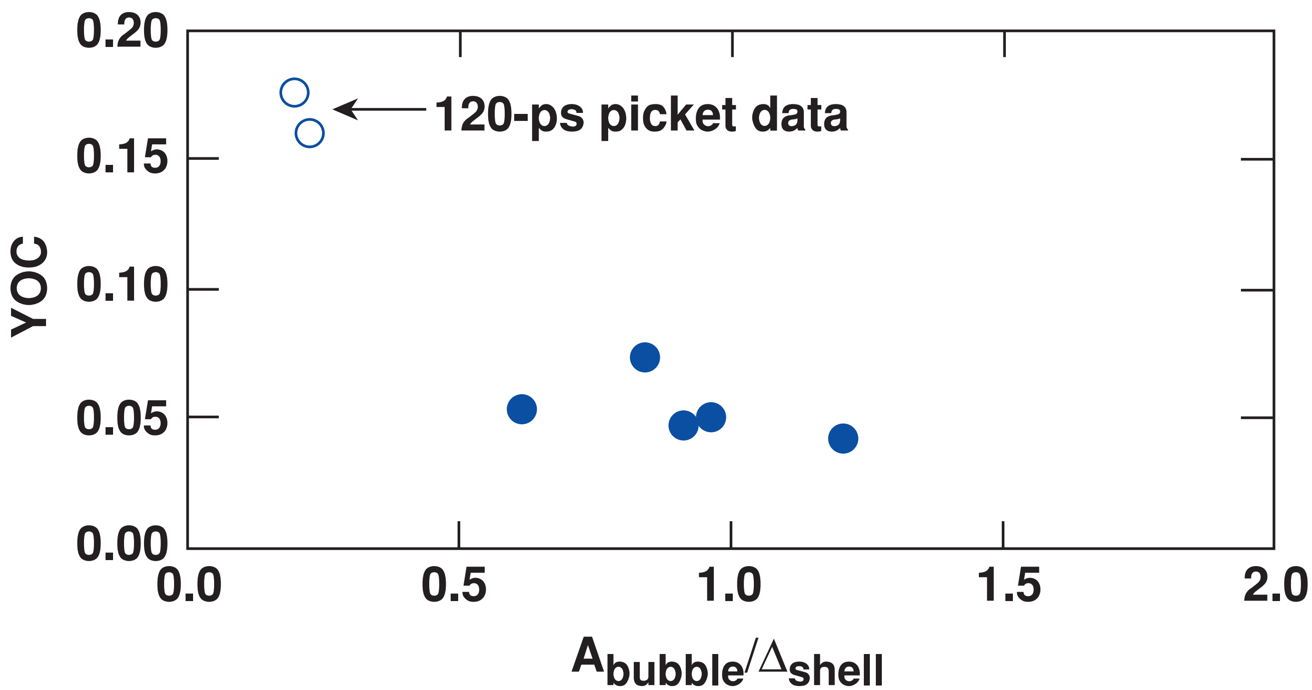
$$A_{bubble} = a_0\, e^{\gamma t}$$

$$\gamma = 0.9\sqrt{[kg/(1+kL)]} - 1.7\, kV_a$$

Acceleration-phase stability growth affects the ratio of the experimental yield to the 1-D simulation yield

UR LLE

- Separation of ablation and shell–gas interfaces, Δ_{CH}, = 18±2 μm



- Bubble amplitude is calculated using postprocessor[1] to 1-D code *LILAC*.
- Calculation includes 1-Thz, 2-D SSD and interface roughness.

E12604

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

Summary/Conclusions

Shaped pulses have been used to control the seed amplitude of the deceleration-phase instability

UR LLE

- First experiments showed significant increase in neutron yield with a picket pulse due to reduction of the deceleration-phase instability initial amplitude.

- Experimental yield/1-D simulation yield (YOC) increases with greater separation between the ablation and gas interfaces.

- YOC also improves when ablation interface growth is reduced.