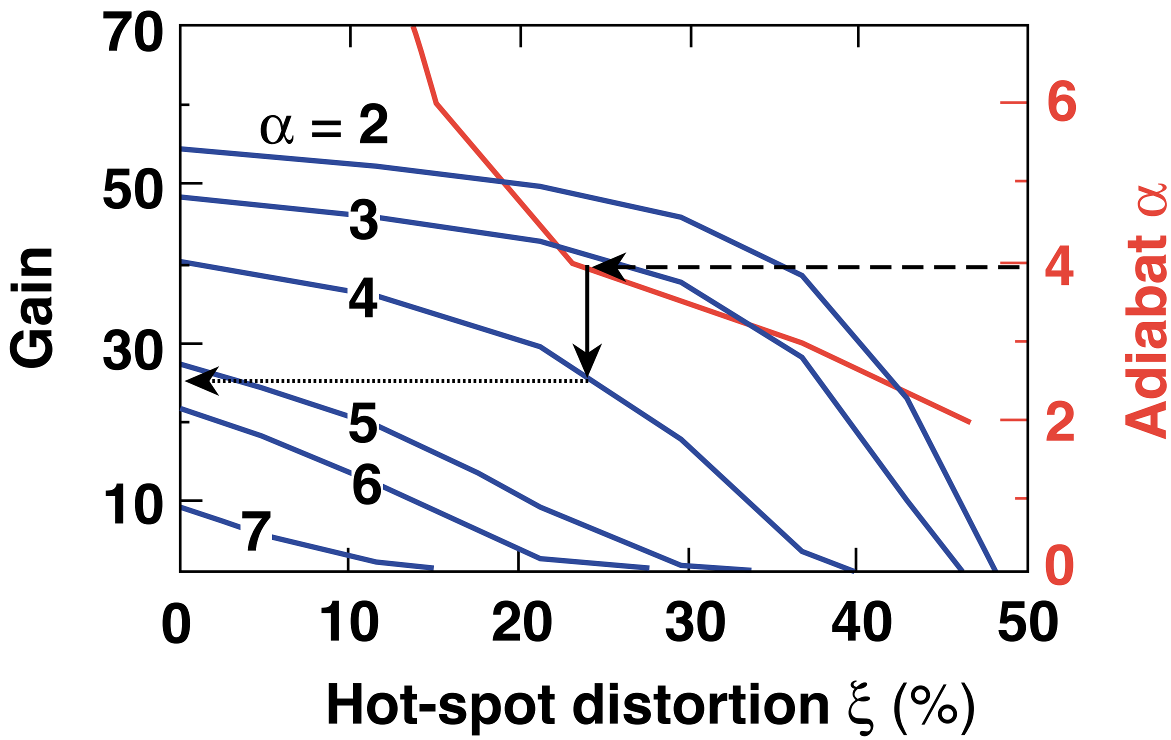
Hydrodynamically stability and gain of moderate-to high-gain direct drive target designs for the NIF



V. N. Goncharov, S. Skupsky, R. Betti,
J. Marozas, P. McKenty and R. Town
University of Rochester
Laboratory for Laser Energetics

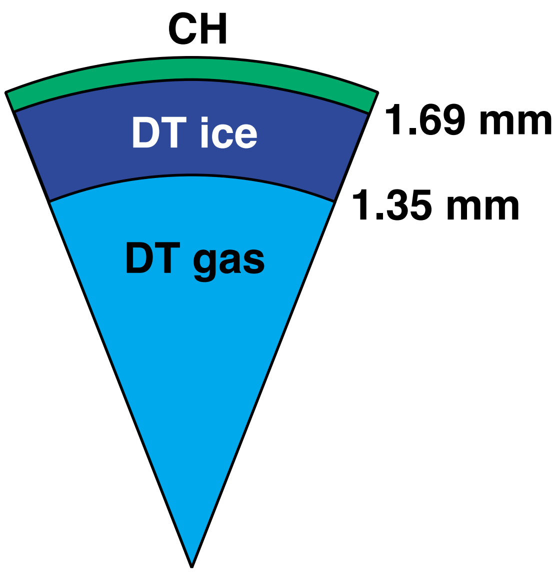
31st Annual Anomalous
Absorption Conference
Sedona, AZ
3–8 June 2001

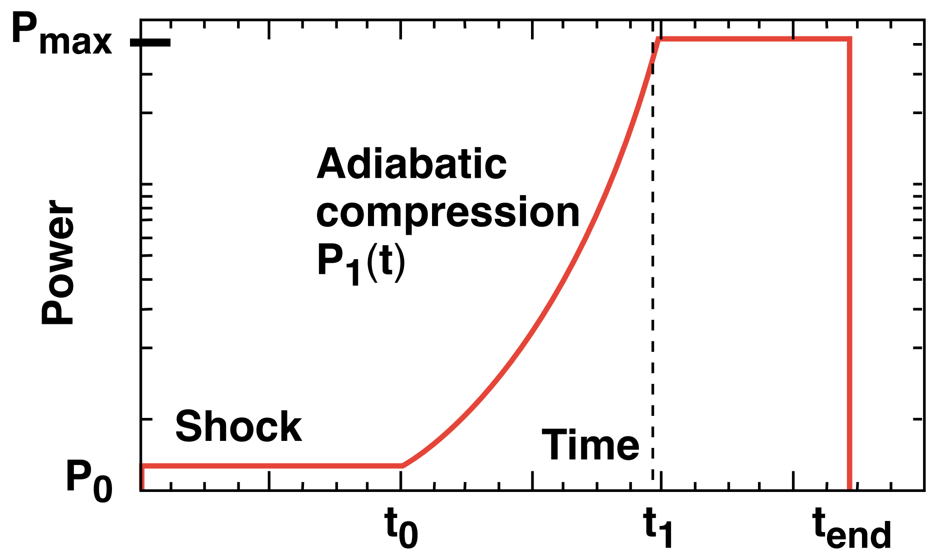
Summary

A model has been developed to optimize NIF DD target designs

- A model has been developed to optimize target gain.
  - The model uses results of a stability postprocessor to calculate shell integrity during the acceleration phase and mode spectrum at shell stagnation.
  - Target gain is calculated by using the obtained mode spectrum and results of 1-D simulations with reduced implosion velocities.
- The model was applied to predict stability and gains for "all-DT" moderate-gain and high-gain foam target designs.
- The results of the model suggest that the maximum gain for the "all-DT" targets can be achieved for $\alpha = 3$ to $\alpha = 4$ designs.

"All-DT" DD NIF targets driven on adiabat up to 7 were considered





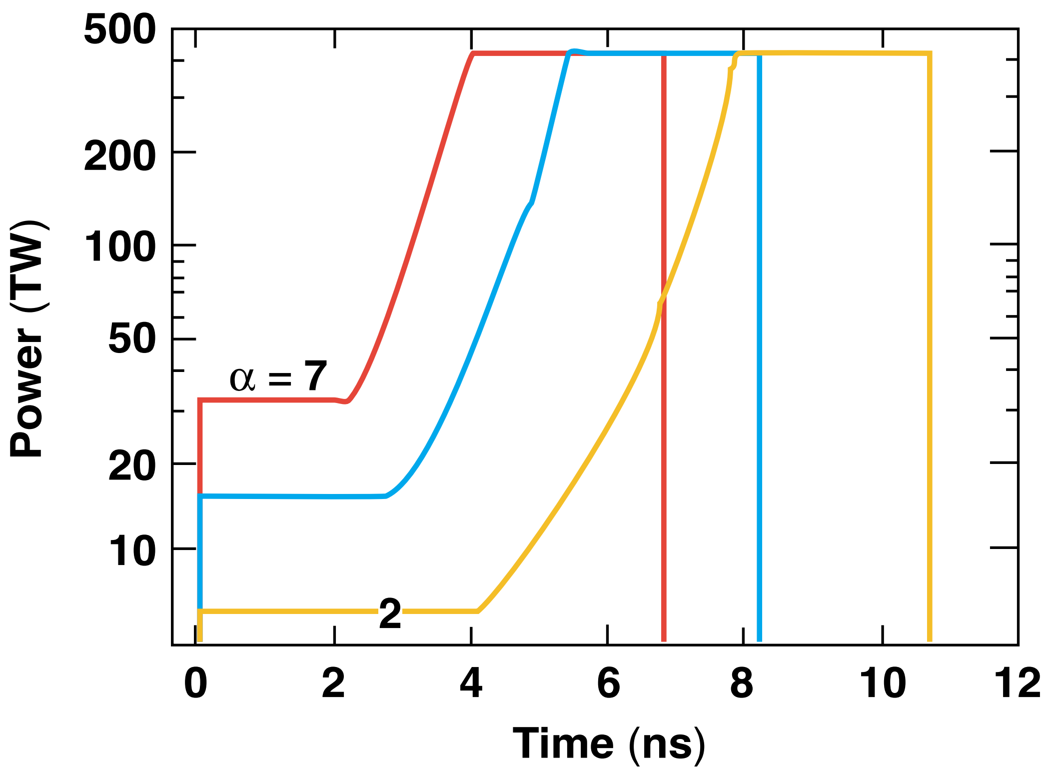
Pressure $p_{kidder} = \dfrac{p_0}{\left[1-(t/\tau)^2\right]^{5/2}}$

Power $P_1 = \dfrac{P_0}{\left[1-(t/\tau)^2\right]^4}$

Parameter	Determined by
P_0	Shell adiabat
P_{max}	Damage threshold, shell stability
t_0	Timing of compression wave and first shock
t_1	Target gain
t_{end}	Laser energy

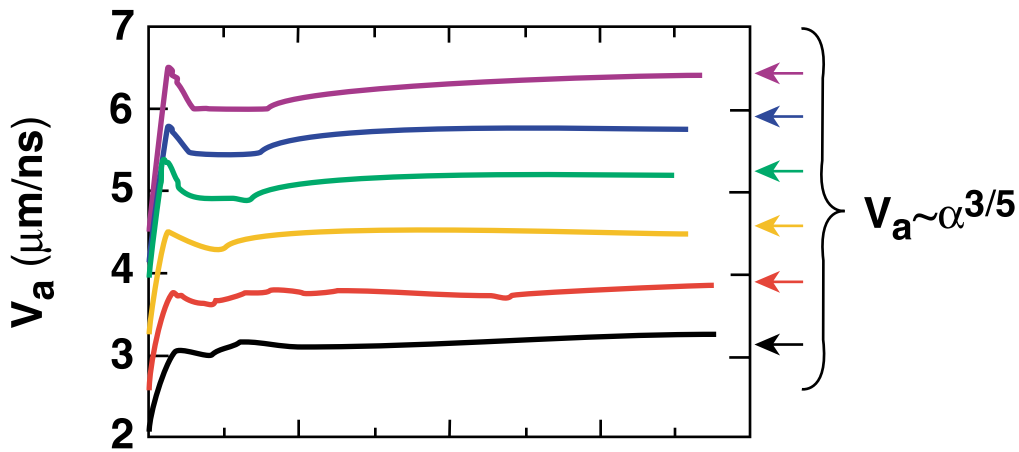
TC5632

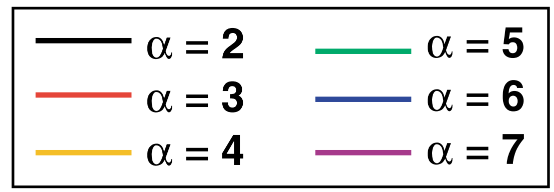
"All-DT" DD NIF targets driven on adiabat up to 7 were considered (continued)



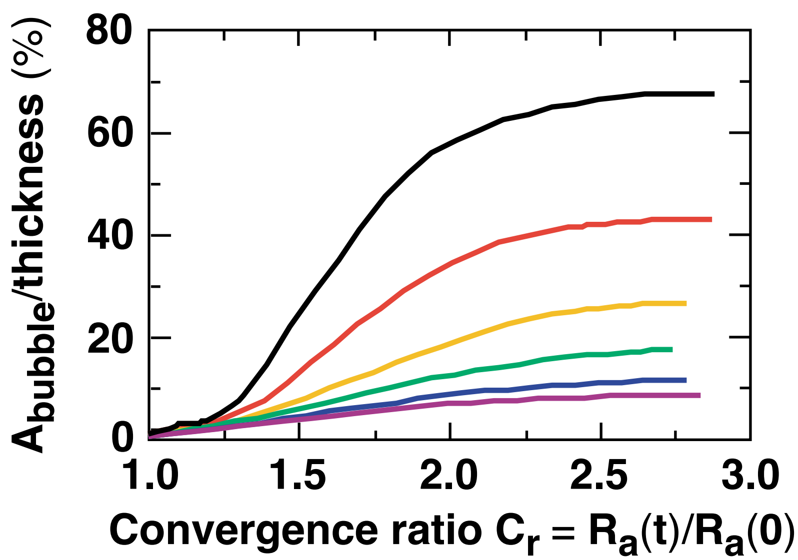
α	ρR_{peak} (g/cm^2)	V_{imp} ($\times 10^7$ cm/s)	Gain
2	1.5	4.17	55
3	1.3	4.27	48
4	1.2	4.34	41
5	1.1	4.42	29
6	1.0	4.42	22
7	0.9	4.45	9

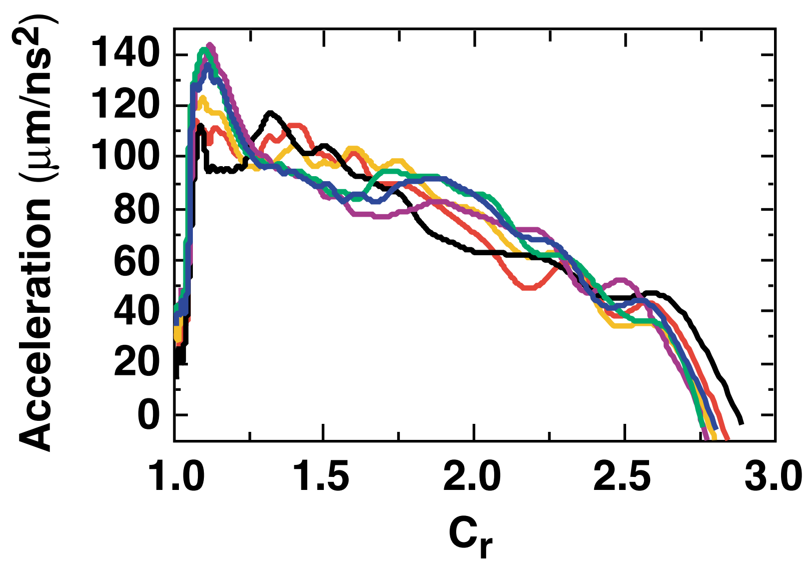
A stability postprocessor[1] was applied to study perturbation evolution of imploding targets during the acceleration, coasting, and deceleration phases





$$GF_{classical} \sim e^{\sqrt{2\ell}\ \mathrm{arc\ sin}\ \sqrt{1-C_r^{-1}}}$$





TC5634

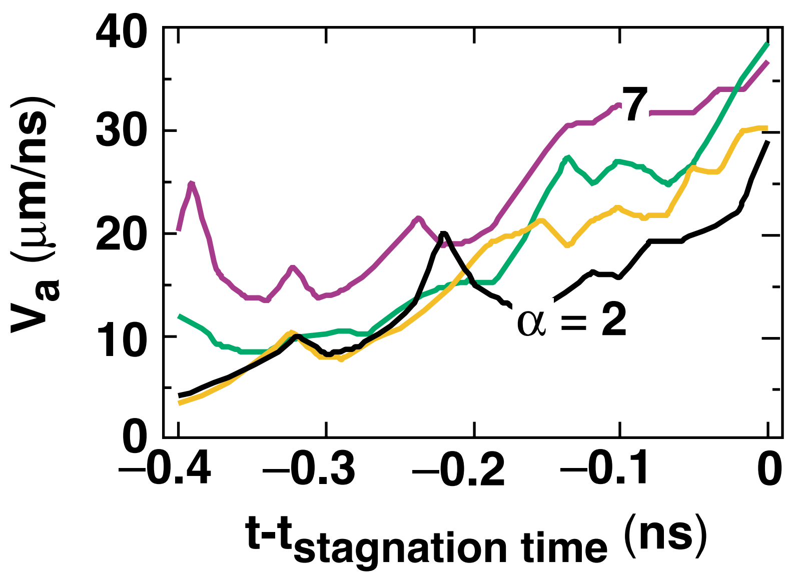
[1]V. Goncharov et al., Phys. Plasmas 7, 5118 (2000).

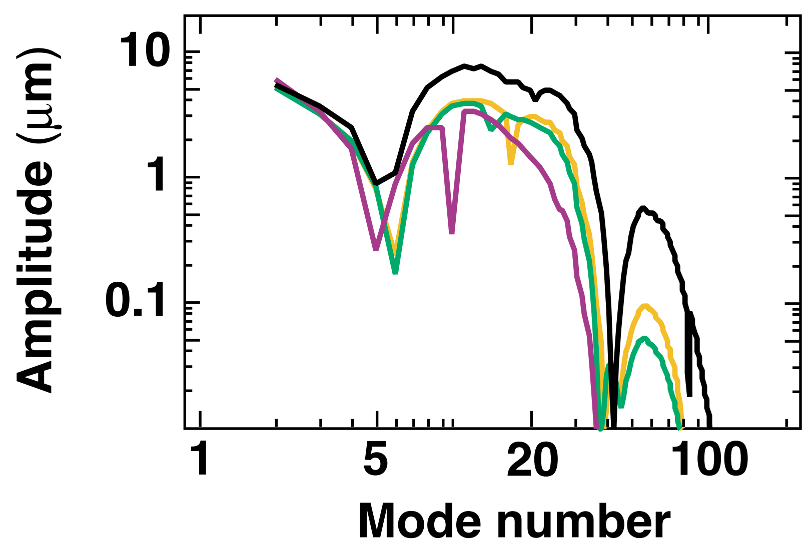
The postprocessor was used to calculate mode spectrum at stagnation

- V_a in decel phase is calculated by using theory of R. Betti[1] et al.

$$V_a \propto \frac{(T_{hs})^{5/2}}{R_{hs}\,\rho_{shell}}$$

- Mode spectrum at the back surface of cold fuel at stagnation (1 THz SSD, 1 μm DT ice roughness, 800Å outer surface finish)





[1]V. Lobatchev and R. Betti, Phys. Rev. Lett., 85, 4522 (2000).

TC5635

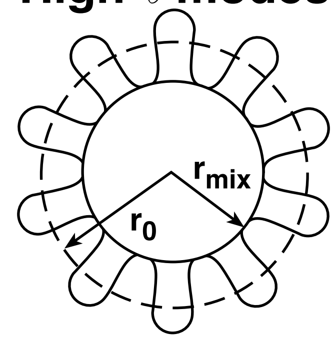
The mode spectrum at stagnation is related to the gain reduction

- According to Levedahl and Lindl[1]

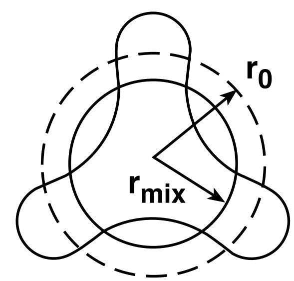
$$\frac{V_{mix}}{V_0} = \left(\frac{r_0}{r_{mix}}\right)^{2/5} \qquad r_{mix} = r_0 - \eta$$

$$\frac{V_{mix}}{V_0} = (1-\xi)^{-2/5} \qquad \xi = \eta / r_0$$

High-ℓ modes



Low-ℓ modes



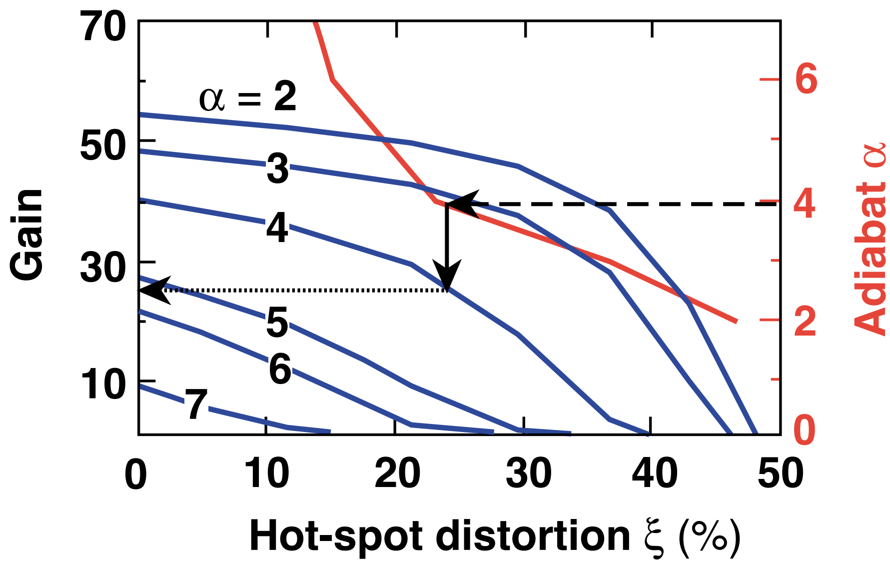
- Perturbation is equivalent to a reduction in 1-D implosion velocity:[2]

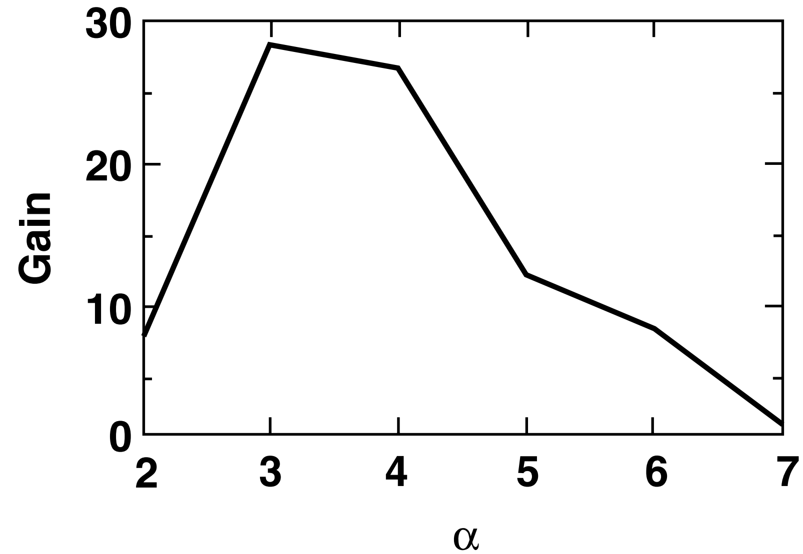
$$\xi = 1 - \left(\frac{V_0 - \Delta V}{V_0}\right)^{5/2}$$

[1] W. Levedahl and J. Lindl, Nuc. Fusion 37, 165 (1997).
[2] Roy Kishony, Ph.D. thesis, 1999.

TC5636

Gain is calculated by using the results of 1-D simulations with reduced V_{imp}





- Target gain is calculated assuming 1-THz, 2-D SSD; 1-μm ice–DT gas roughness; and 800-Å outer surface finish.
- The imprint spectrum is assumed to be the same for different α's.

Summary/Conclusion

A model has been developed to optimize NIF DD target designs

UR LLE

- A model has been developed to optimize target gain.
  - The model uses results of a stability postprocessor to calculate shell integrity during the acceleration phase and mode spectrum at shell stagnation.
  - Target gain is calculated by using the obtained mode spectrum and results of 1-D simulations with reduced implosion velocities.
- The model was applied to predict stability and gains for “all-DT” moderate-gain and high-gain foam target designs.
- The results of the model suggest that the maximum gain for the “all-DT” targets can be achieved for $\alpha = 3$ to $\alpha = 4$ designs.