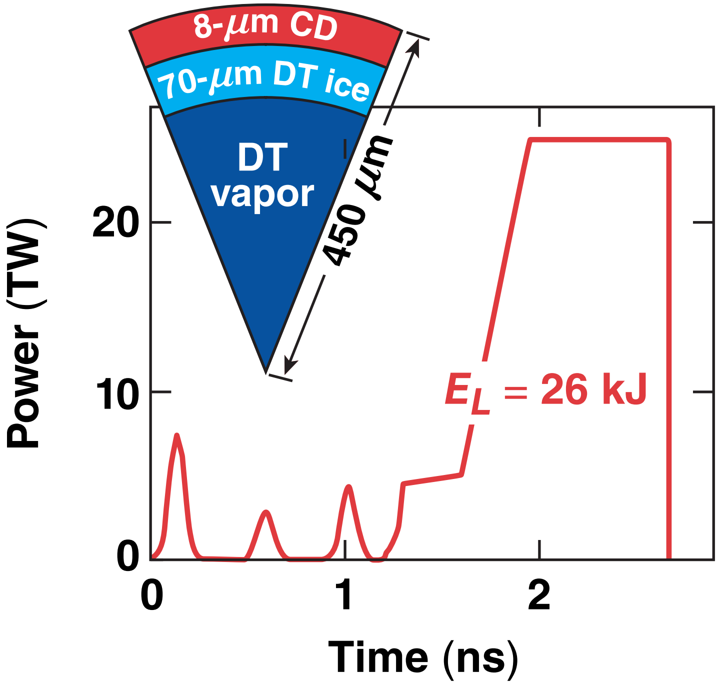
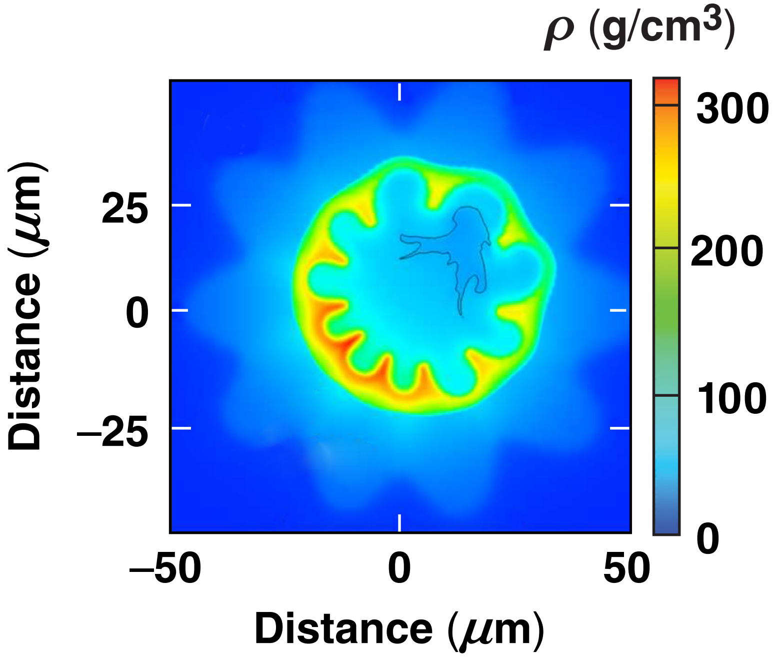
High-Performance Cryogenic Designs for OMEGA and the NIF

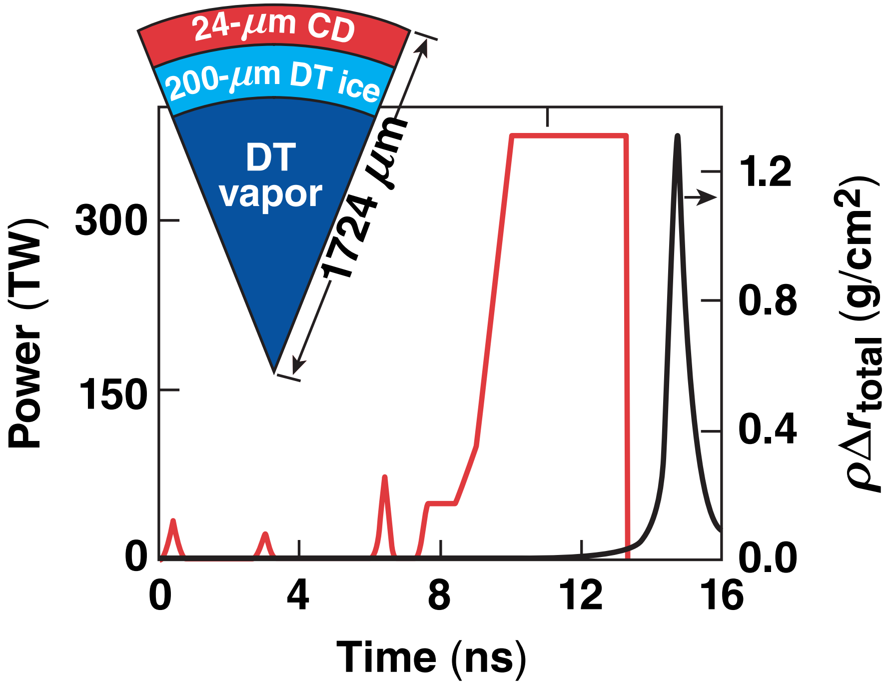
Ignition hydroequivalent OMEGA design, $R_b/R_t = 0.75$ (R75)



ASTER simulation
OMEGA R75



SDD NIF R75 design
E_L = 1.6 MJ



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58th Annual Meeting of the
American Physical Society
Division of Plasma Physics
San Jose, CA
31 October–4 November 2016

Summary

Reducing cross-beam energy transfer (CBET) losses improves stability properties of ignition spherical direct-drive (SDD) designs at the National Ignition Facility (NIF)

- Hot-spot energy in direct-drive (DD) implosions is a factor of 5 or more larger than that of indirect-drive (ID) implosions
  - the required hot-spot pressure in an igniting NIF-scale DD design must exceed 120 Gbar (350 Gbar in ID)
- Without CBET mitigation, SDD designs on the NIF have in-flight aspect ratios in excess of 30
  - CBET mitigation in hydroequivalent designs on OMEGA involves reducing beam size relative to the target size* to $R_b/R_t = 0.75$
  - high-yield and ignition SDD designs on the NIF require both beam-size reduction and wavelength detuning**

* I. V. Igumenshchev, Phys. Plasmas 17, 122708 (2010);
I. V. Igumenshchev, CI3.00002, this conference (invited).
** J. A. Marozas *et al.*, NO5.00009 and P. B. Radha *et al.*, NO5.00005, this conference.

Collaborators

T. J. B. Collins, J. A. Marozas, S. P. Regan, P. B. Radha,
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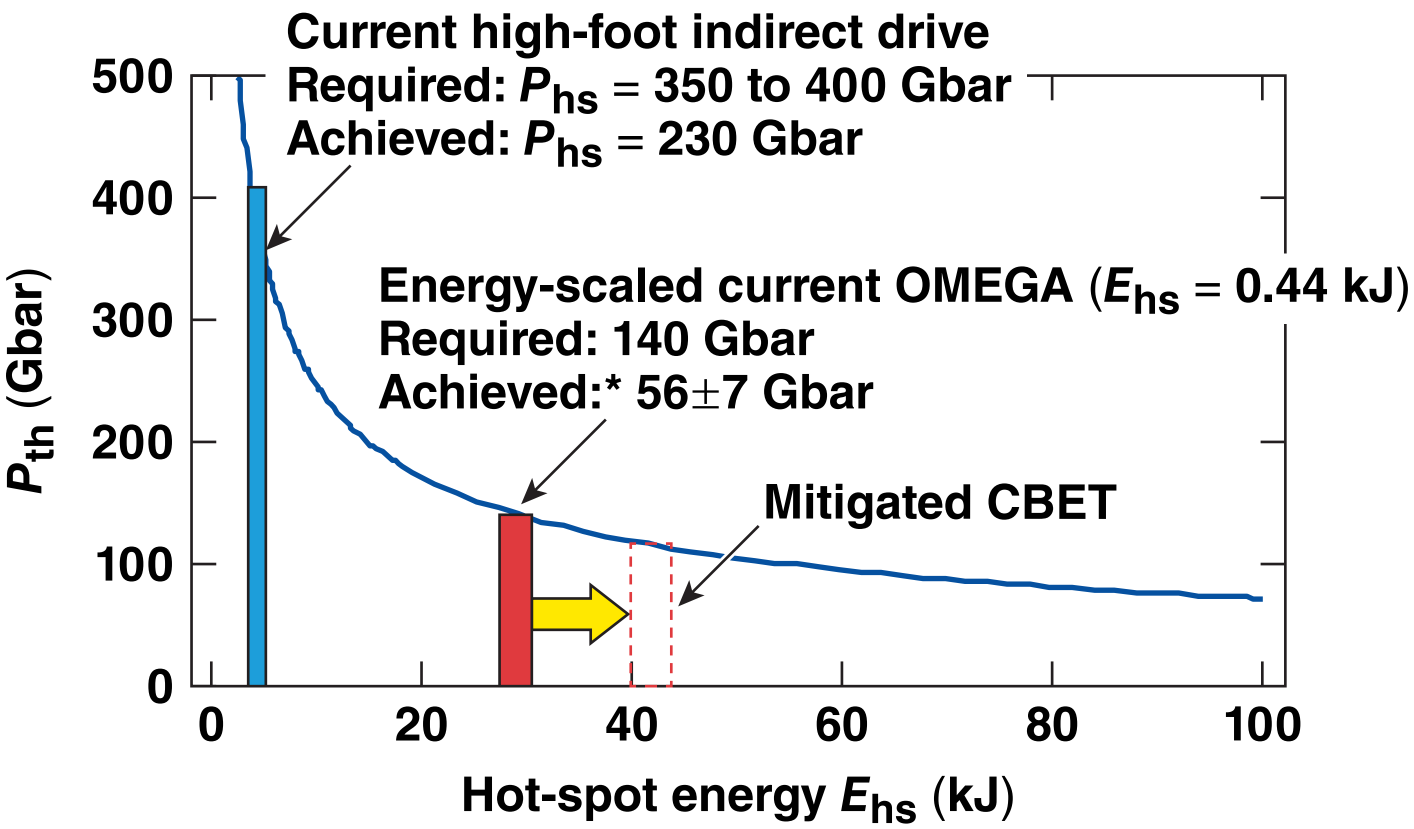
The hot-spot pressure in an ignition design must exceed a threshold value



- Pressure threshold for ignition

$$P_{th} \sim 1/\sqrt{E_{hs}}$$

- For direct drive

$$P_{hs} \sim V_{imp}^{10/3} P_{a}^{1/3} \Big/ \alpha \sim P_{a}\,\mathrm{IFAR}^{5/3}$$

Direct-drive designs are in a less-challenging hydrodynamic regime with CR $\lesssim$ 22 and P_{hs} > 120 Gbar; indirect-drive–ignition targets require CR = 30 to 40 and P_{hs} > 350 Gbar.

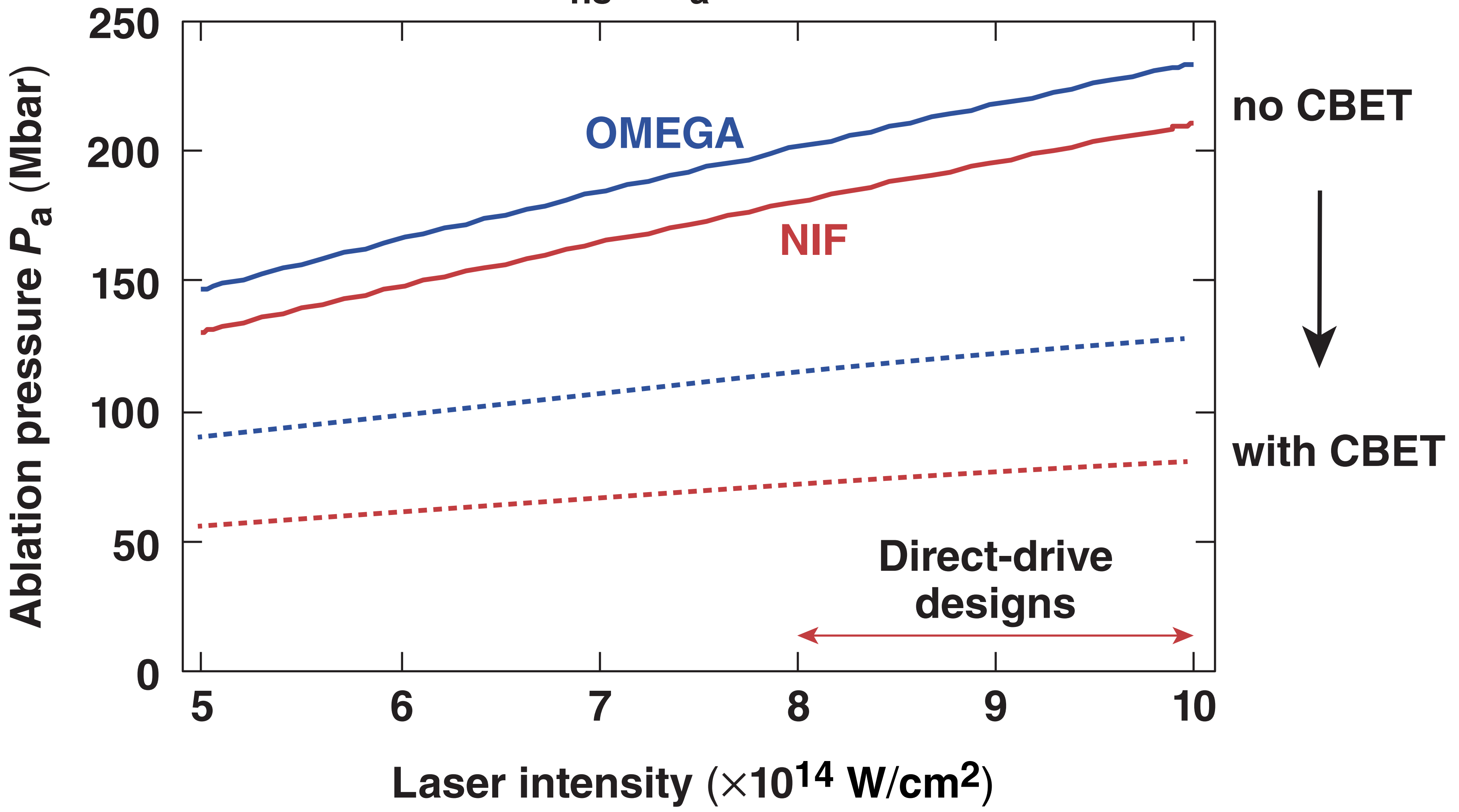
IFAR: in-flight aspect ratio

*S. P. Regan *et al*., Phys. Rev. Lett. 117, 025001 (2016).

TC12311e

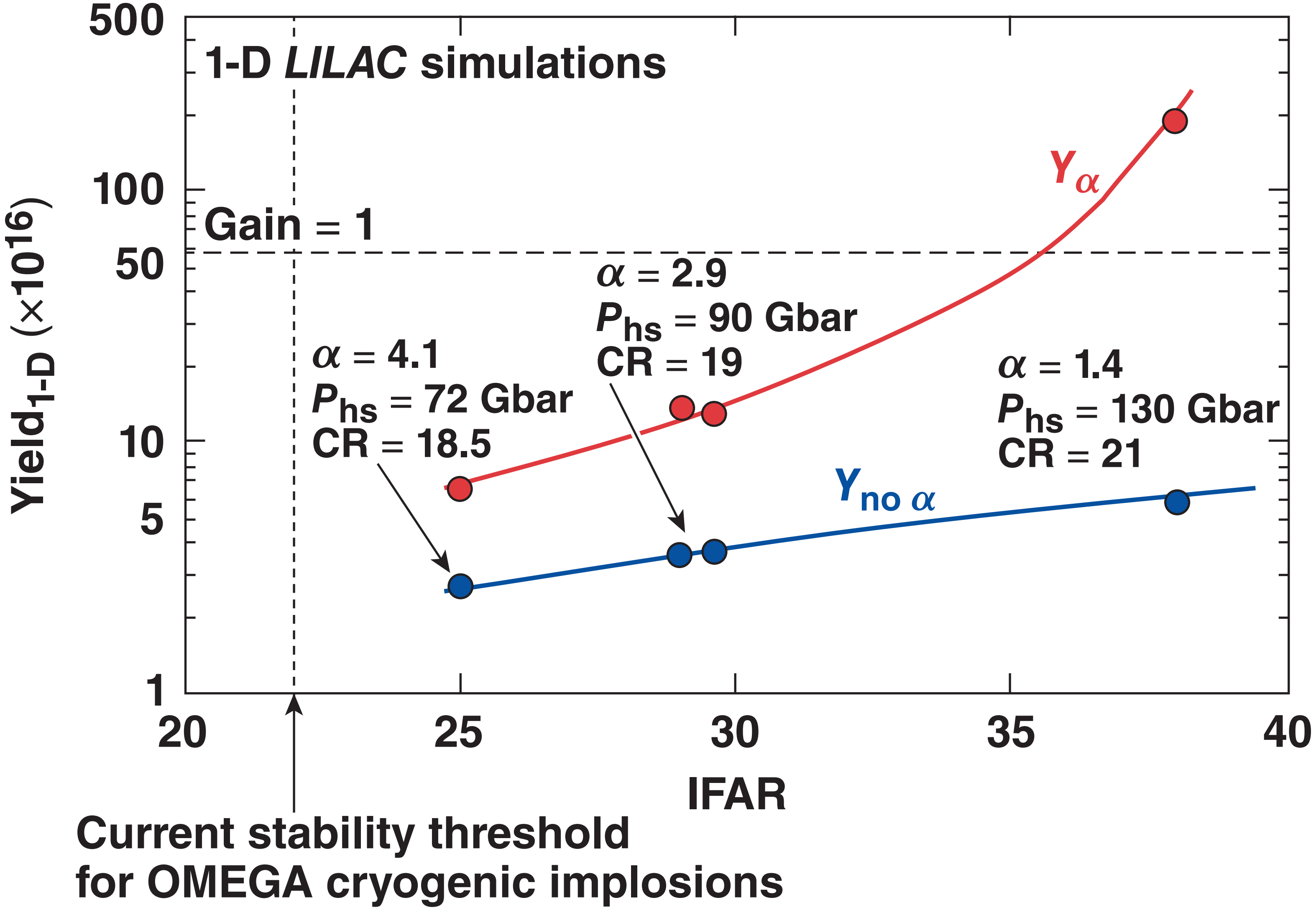
Coupling losses caused by CBET are larger on the NIF-scale targets because of longer density scale length

$P_{hs} \sim P_a \mathrm{IFAR}^{5/3}$



TC12872a

CBET losses make ignition target designs too unstable during acceleration

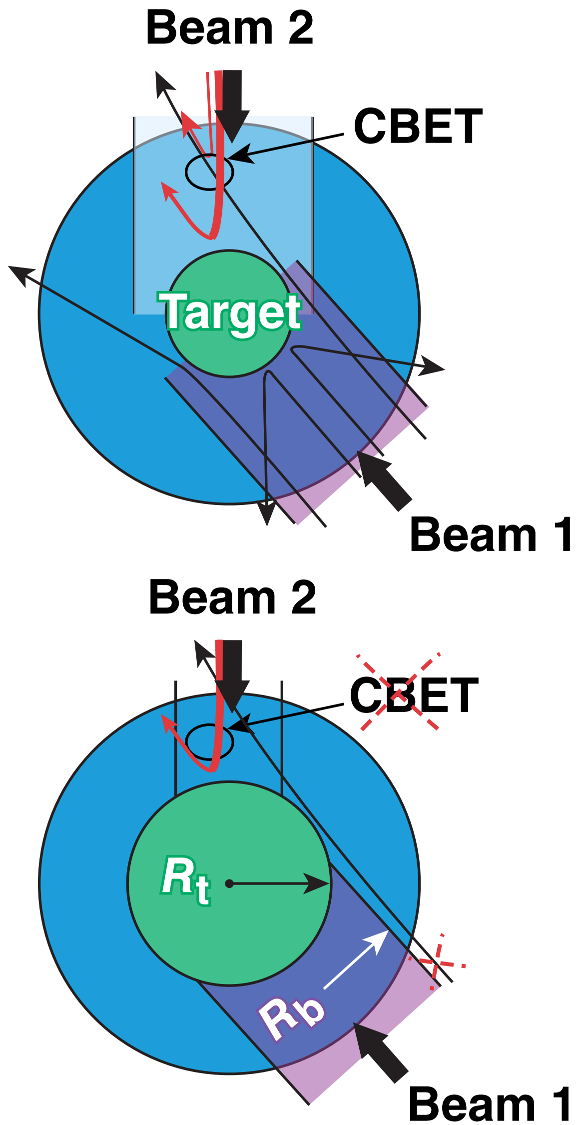


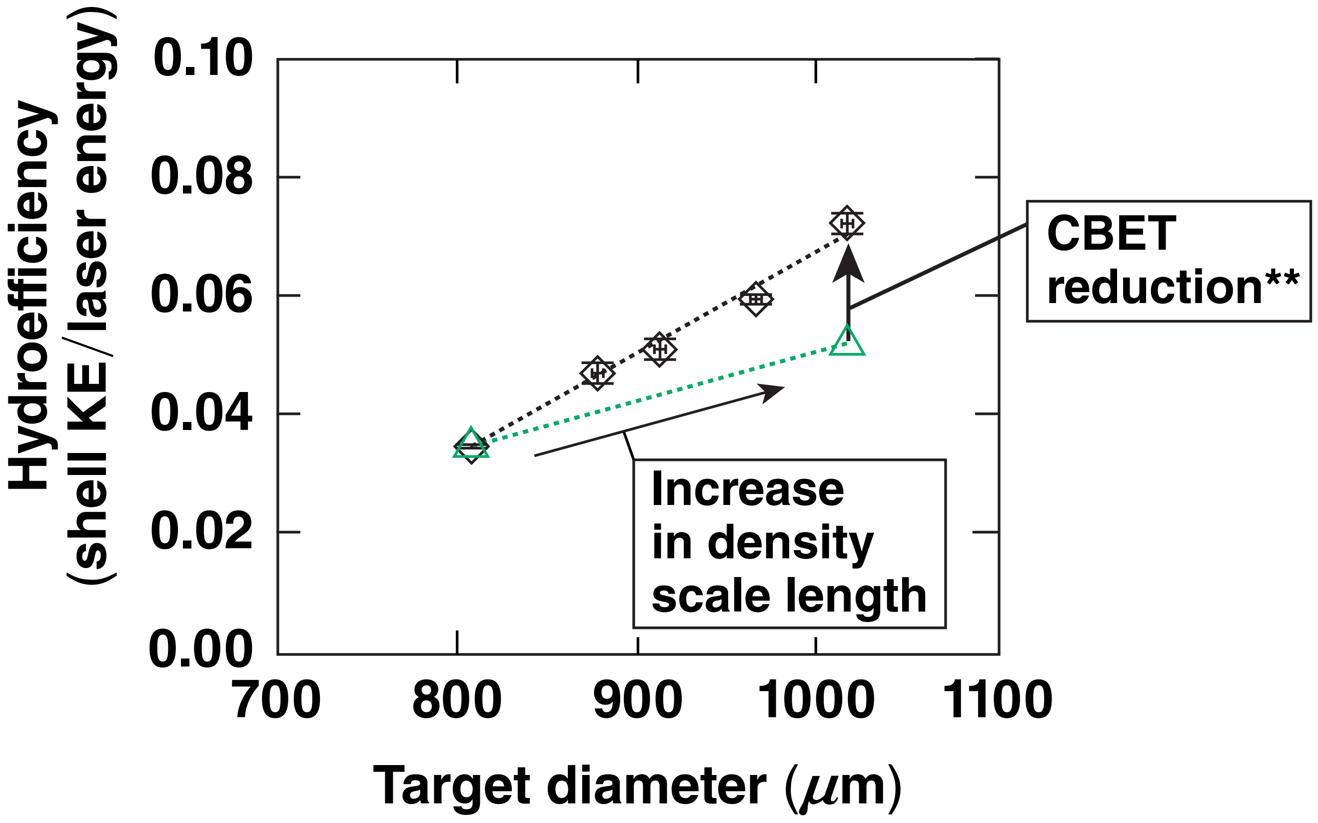
NIF SDD designs
$V_{imp} = 3.8 \times 10^7$ cm/s
Full CBET, P_a = 90 Mbar

TC13056

CR: convergence ratio

CBET reduction* and improved laser coupling have been demonstrated on OMEGA by reducing R_{beam}/R_{target}





The performance of larger shells is limited by drive asymmetries. The near-term goal is to quantify and reduce laser power imbalance (part of the "100-Gbar" campaign).

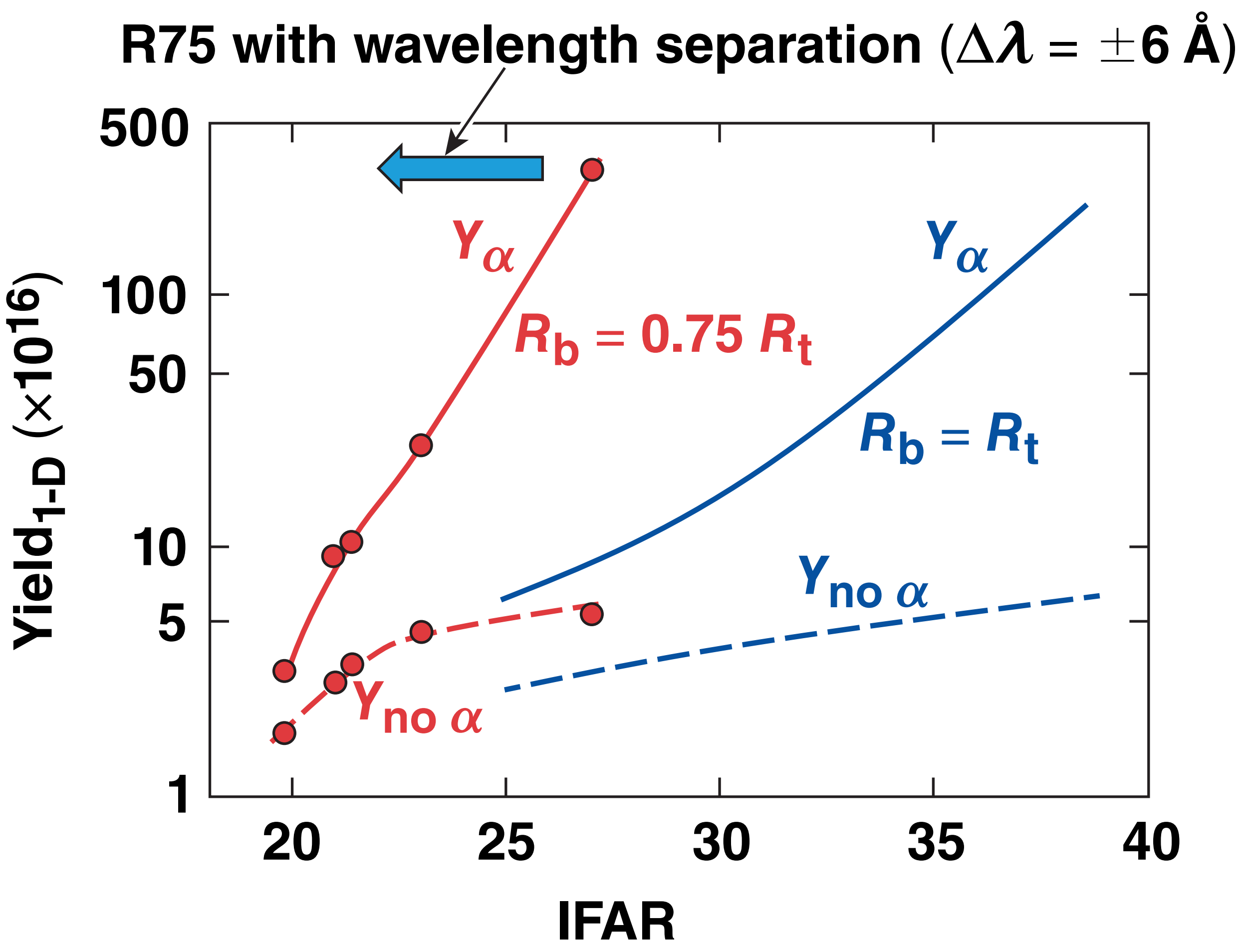
KE: kinetic energy

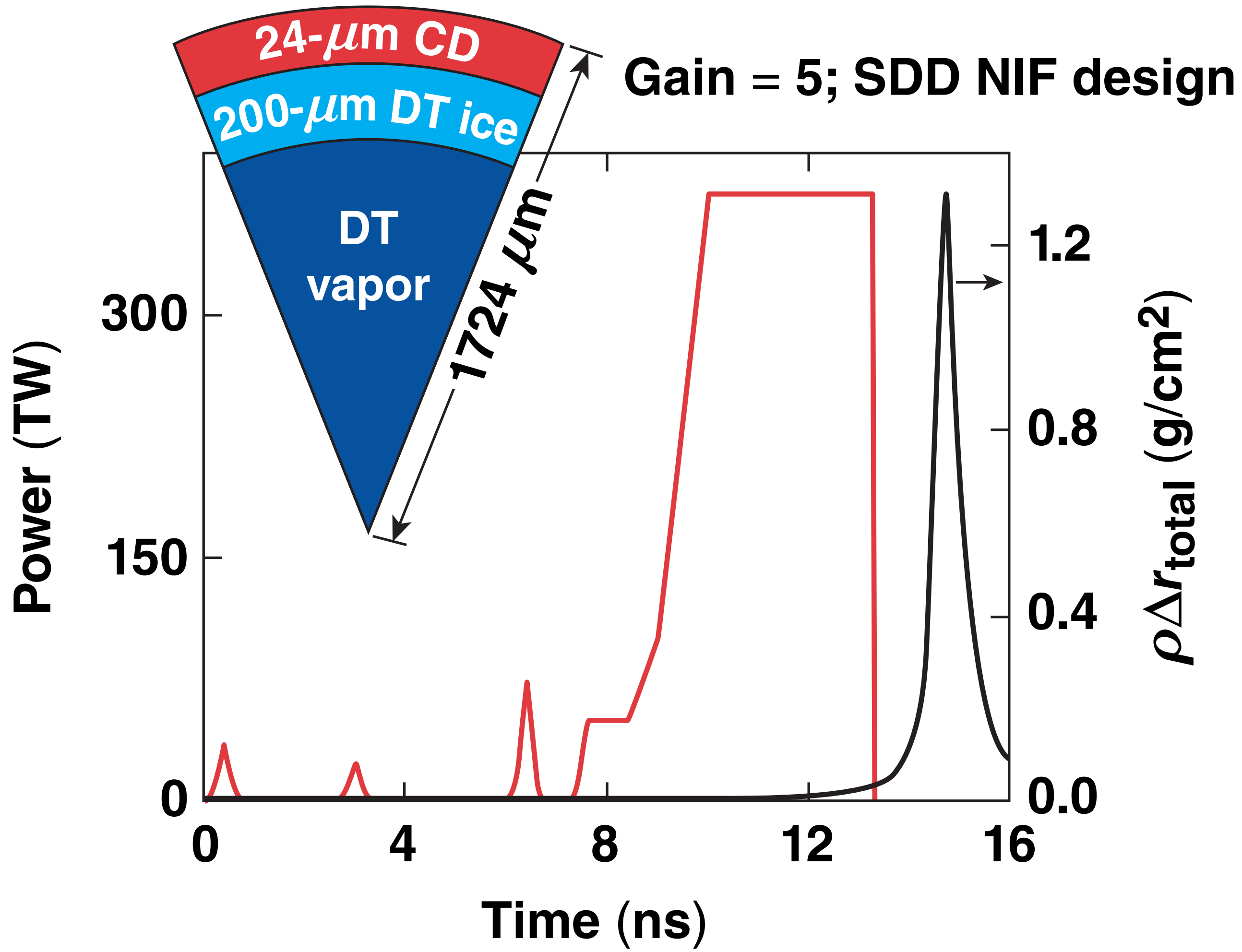
* I. V. Igumenshchev, Phys. Plasmas 17, 122708 (2010); D. H. Froula *et al.*, Phys. Rev. Lett. 108, 125003 (2012).

** V. N. Goncharov *et al.*, J. Phys. Conf. Ser. 717, 012008 (2016); S. P. Regan *et al.*, presented at the 57th Annual Meeting of the APS Division of Plasma Physics, Savannah, GA, 16–20 November 2015 (CI3.00005) (invited).

TC13057

Combination of $R_b/R_t < 1$ and wavelength detuning leads to robust high-yield SDD designs on the NIF



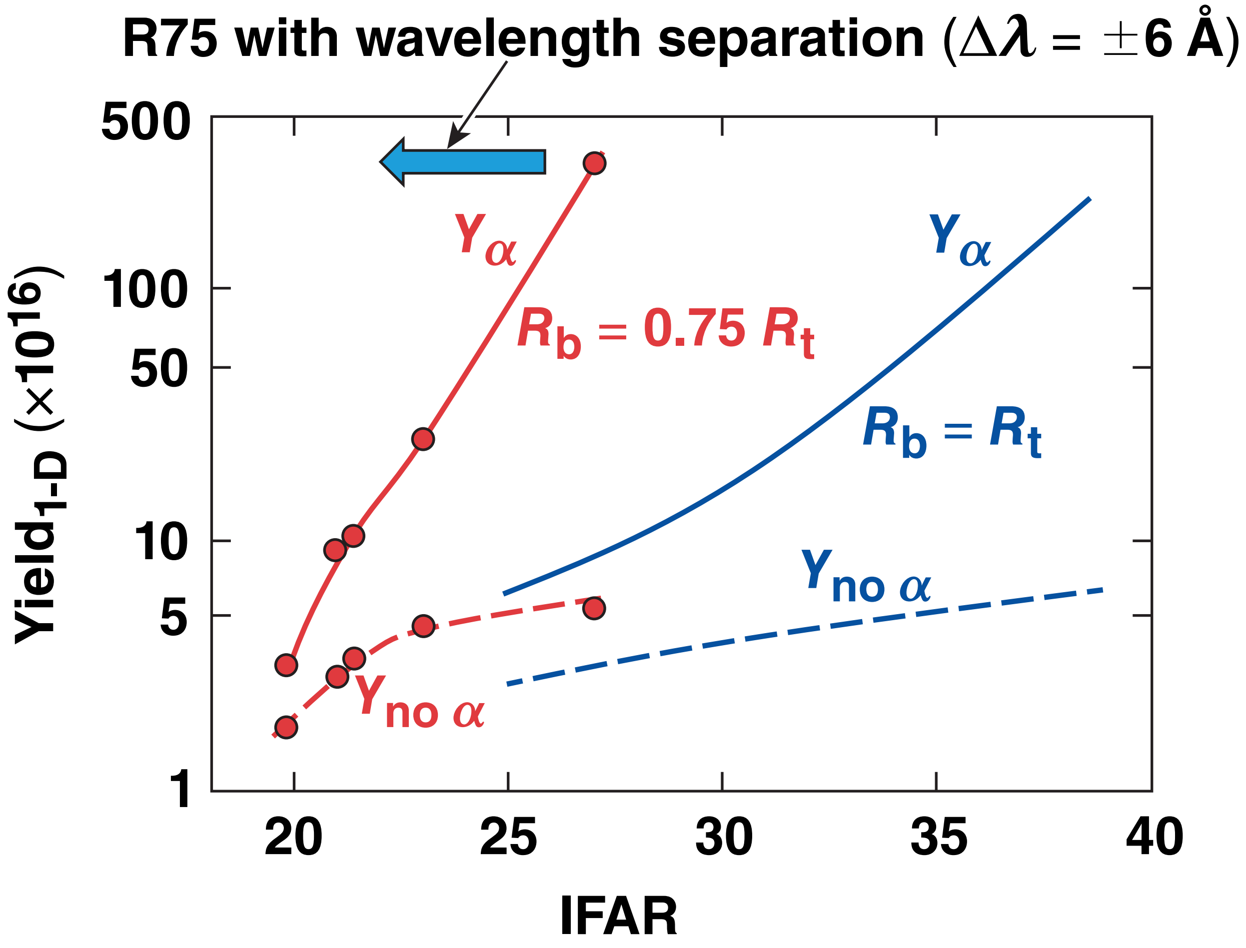


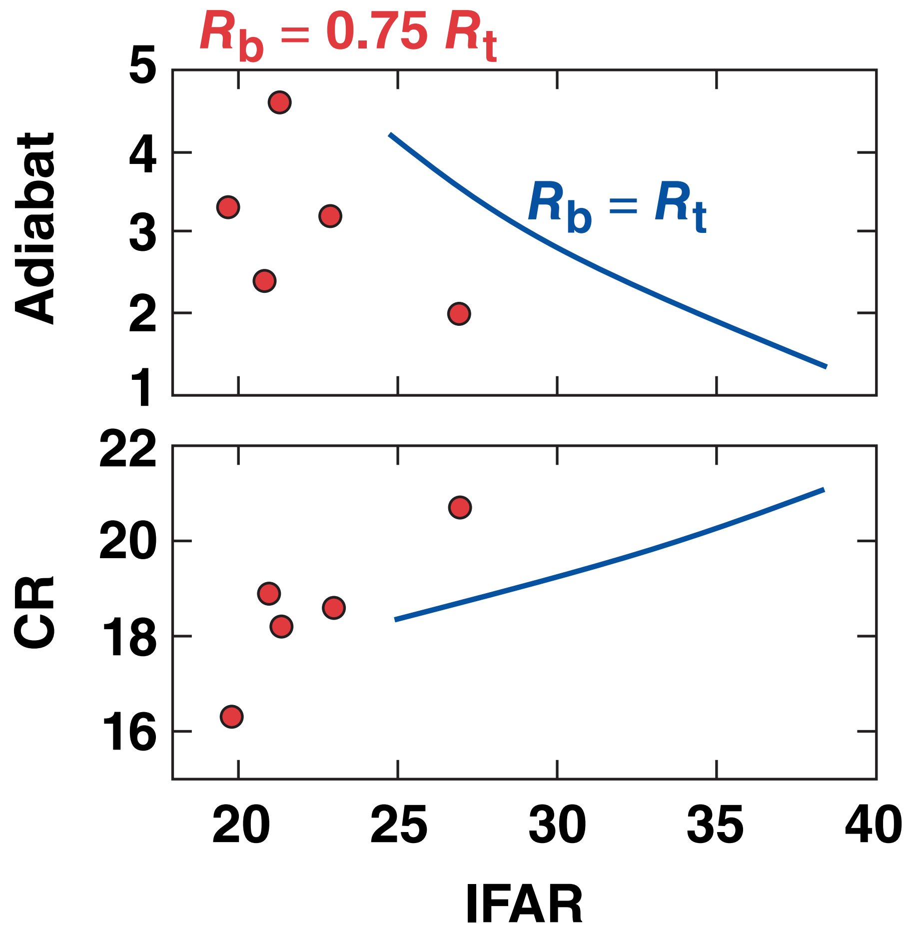
Initial experiments on the NIF with $\Delta\lambda = \pm 2.3$ Å confirmed predicted CBET reduction.*

*J. A. Marozas *et al.*, NO5.00009, this conference.

TC13025

Combination of $R_b/R_t < 1$ and wavelength detuning leads to robust high-yield SDD designs on the NIF

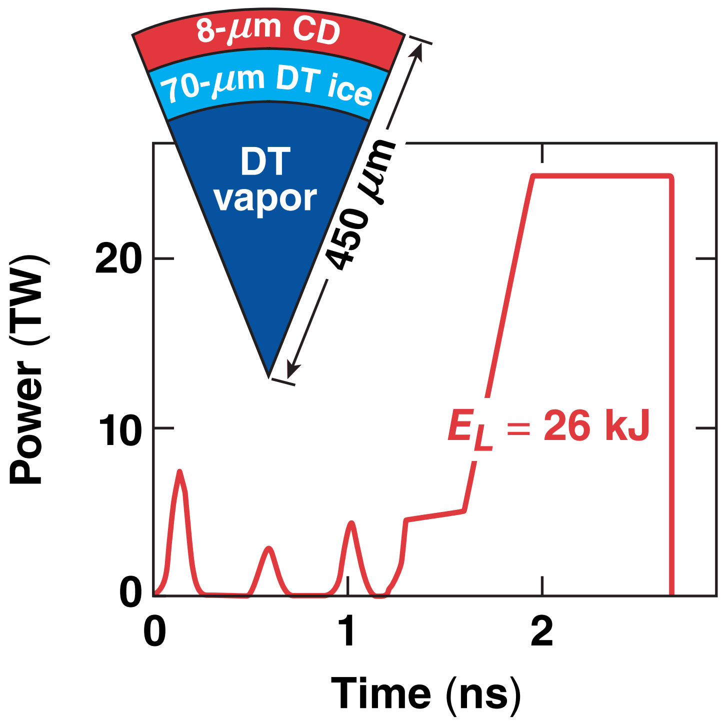




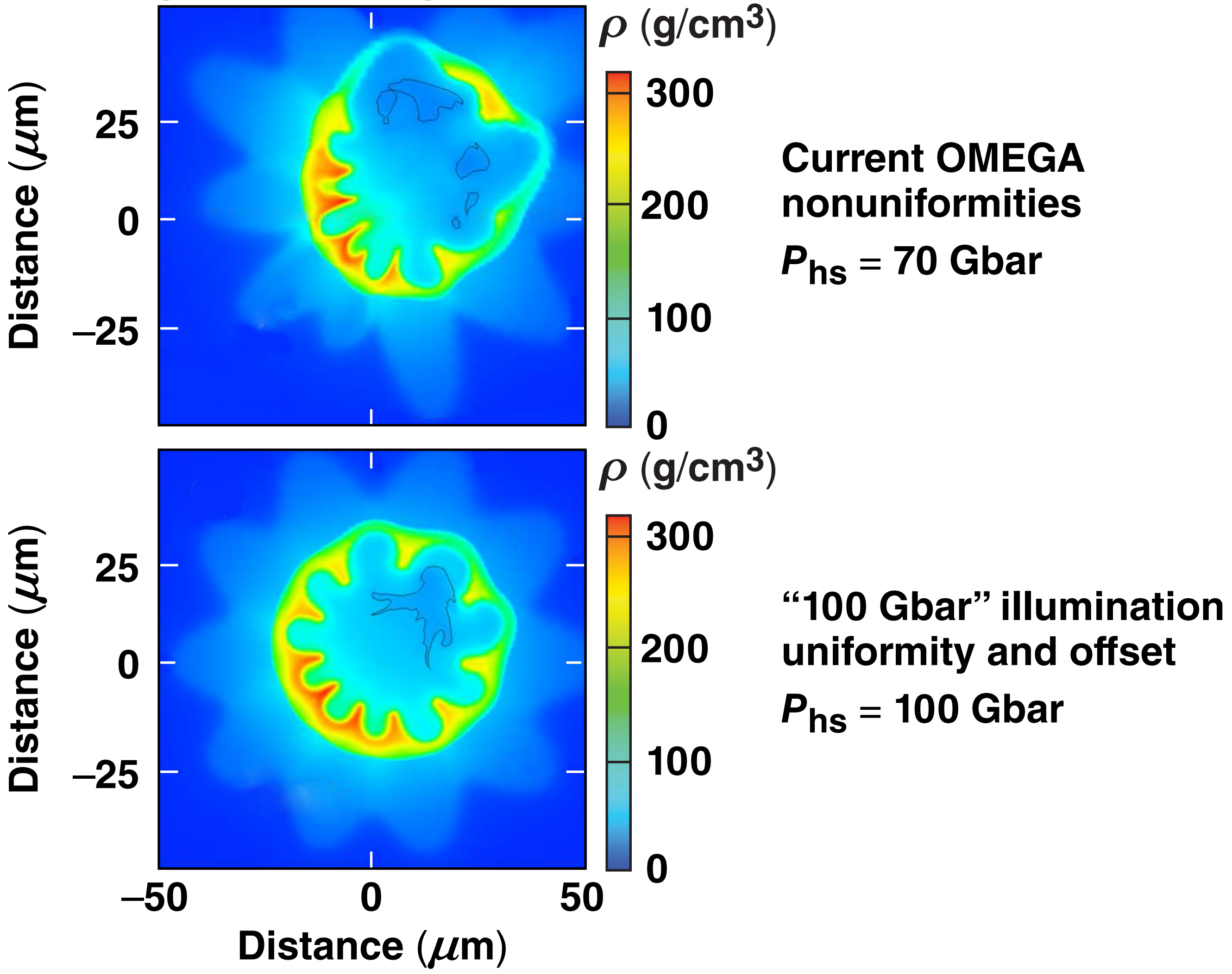
TC13058

The effect of improved laser coupling on target performance will be tested using an R75 design on OMEGA with improved power balance

- The effect of CBET is smaller on OMEGA because of shorter scale lengths
- Ignition hydroequivalent OMEGA design
  $R_b/R_t = 0.75$, IFAR = 21.8, $\alpha = 3$
  $V_{imp} = 3.7 \times 10^7$ cm/s



3-D *ASTER** simulations at peak neutron production



*I. V. Igumenshchev *et al.*, Phys. Plasmas 23, 052702 (2016).

TC13059

Summary/Conclusions

Reducing cross-beam energy transfer (CBET) losses improves stability properties of ignition spherical direct-drive (SDD) designs at the National Ignition Facility (NIF)

UR LLE

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I. V. Igumenshchev, CI3.00002, this conference (invited).
** J. A. Marozas *et al.*, NO5.00009 and P. B. Radha *et al.*, NO5.00005, this conference.

TC13024