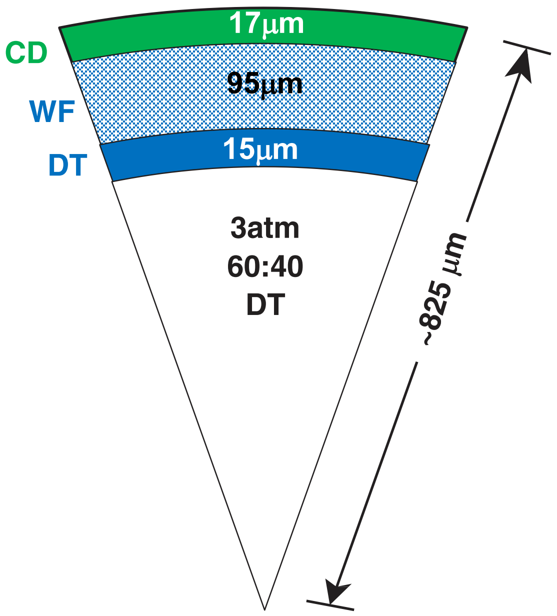
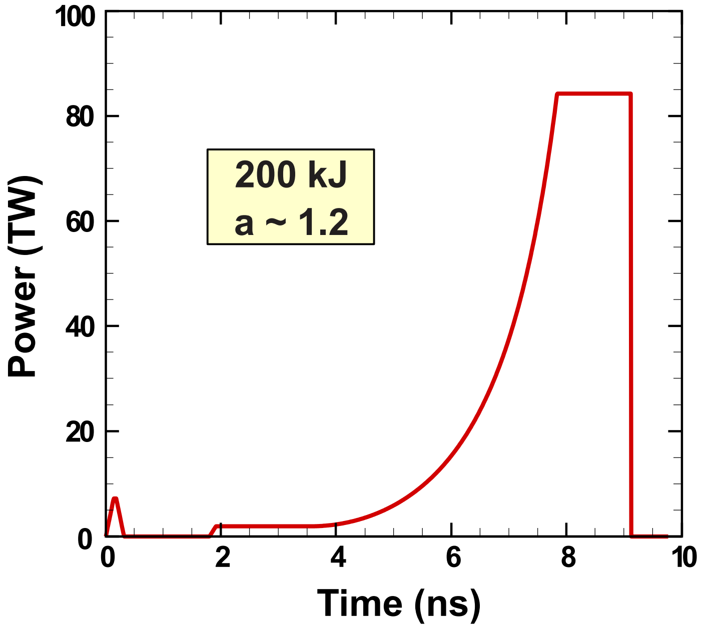
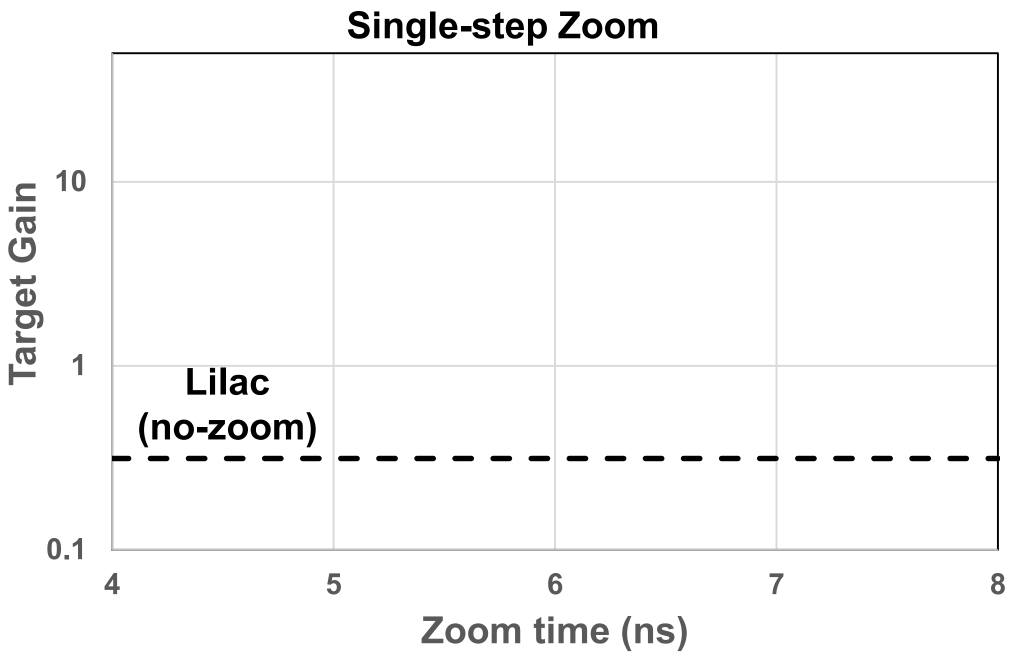
Evaluation of the Effects of Laser-Beam Zooming on OMEGA-Next, Wetted-Foam Target Designs



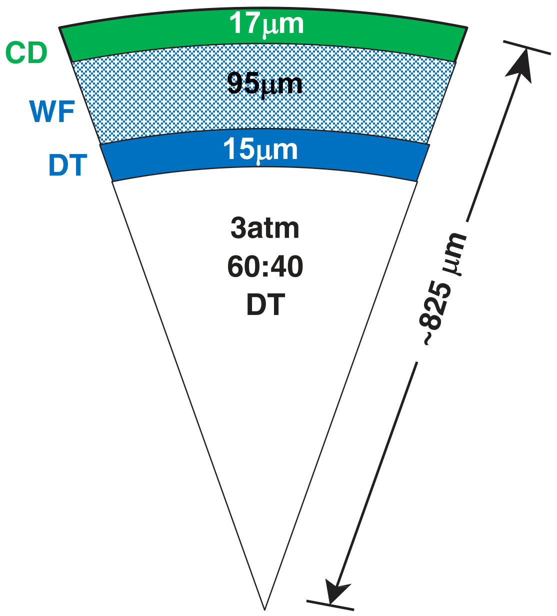


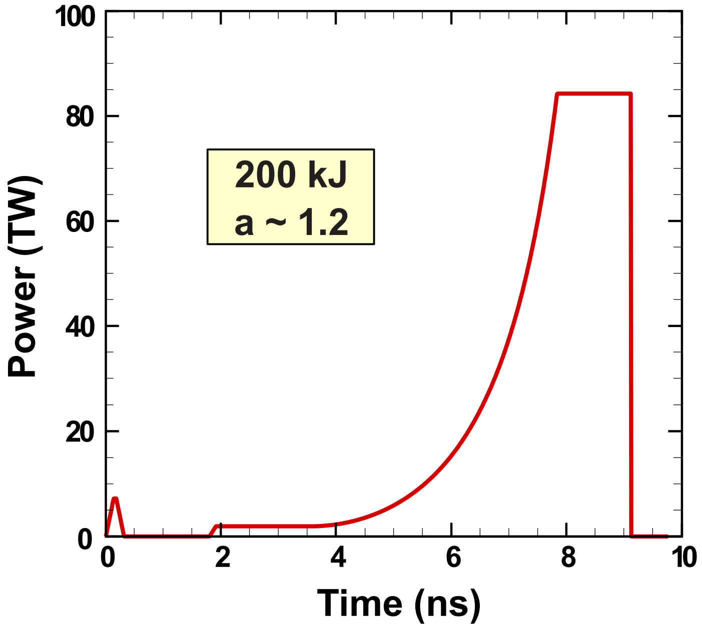


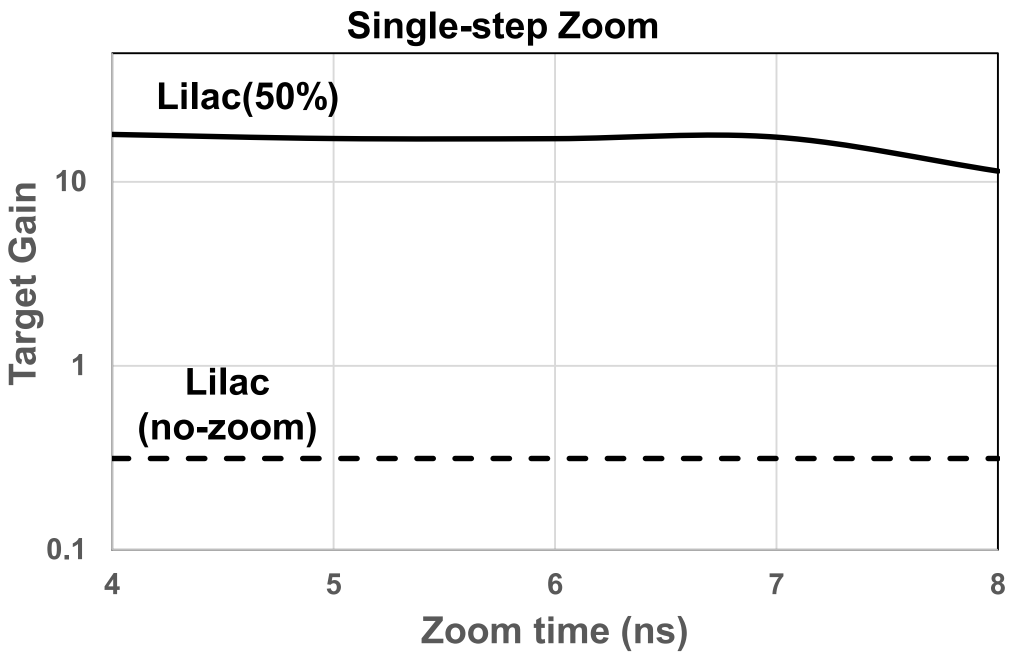
P. W. McKenty
Laboratory for Laser Energetics
University of Rochester

64th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Spokane, WA
17 - 21 October, 2022

Evaluation of the Effects of Laser-Beam Zooming on OMEGA-Next, Wetted-Foam Target Designs



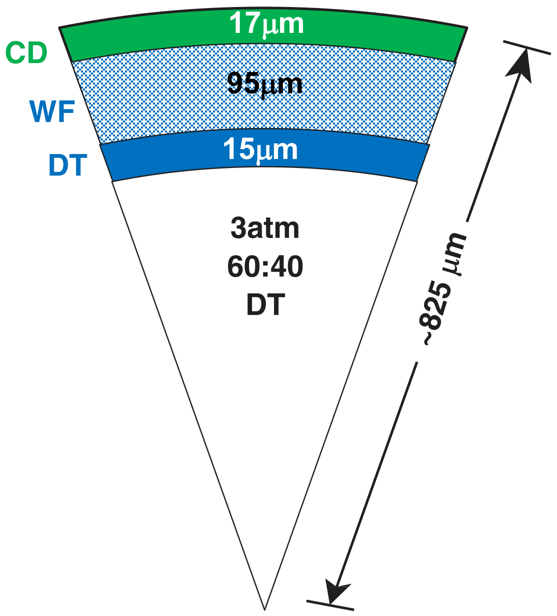


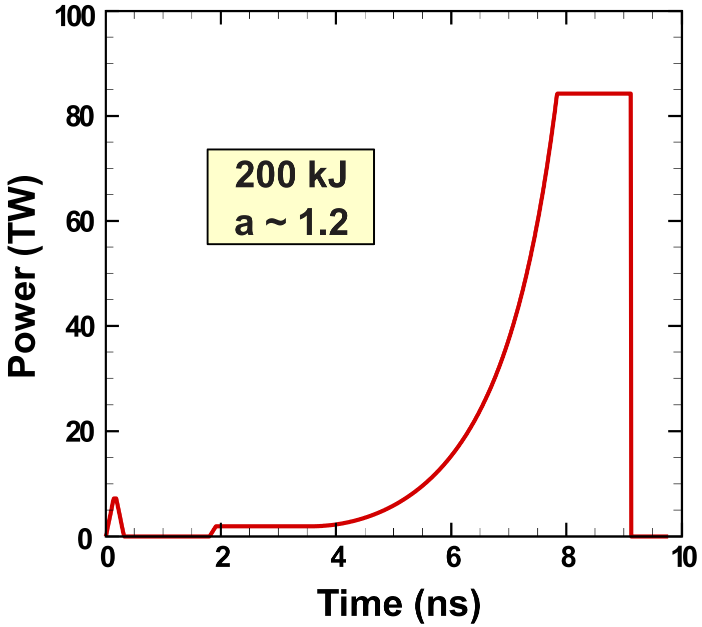


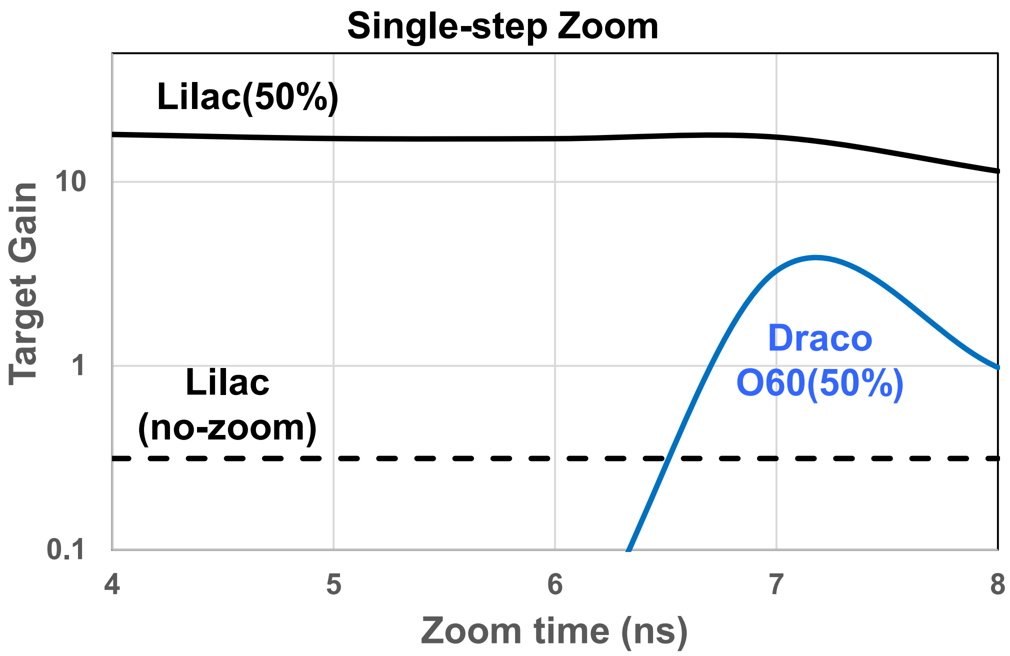
P. W. McKenty
Laboratory for Laser Energetics
University of Rochester

64th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Spokane, WA
17 - 21 October, 2022

Evaluation of the Effects of Laser-Beam Zooming on OMEGA-Next, Wetted-Foam Target Designs



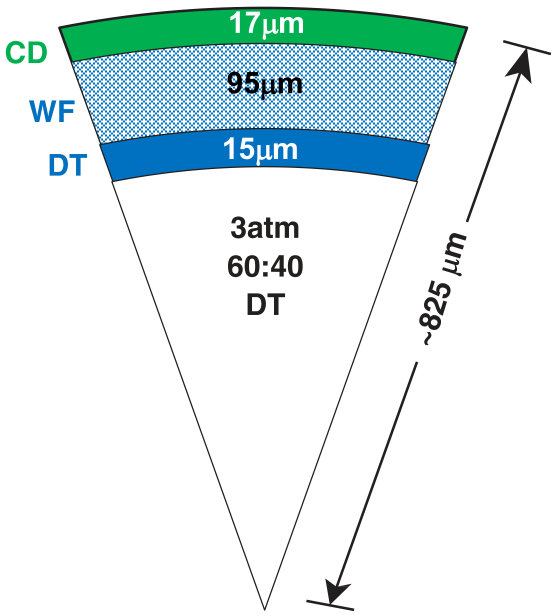


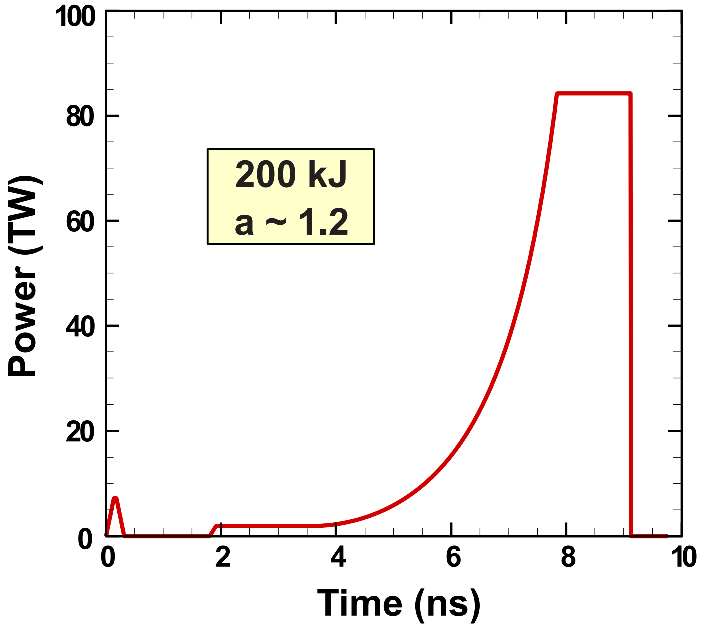


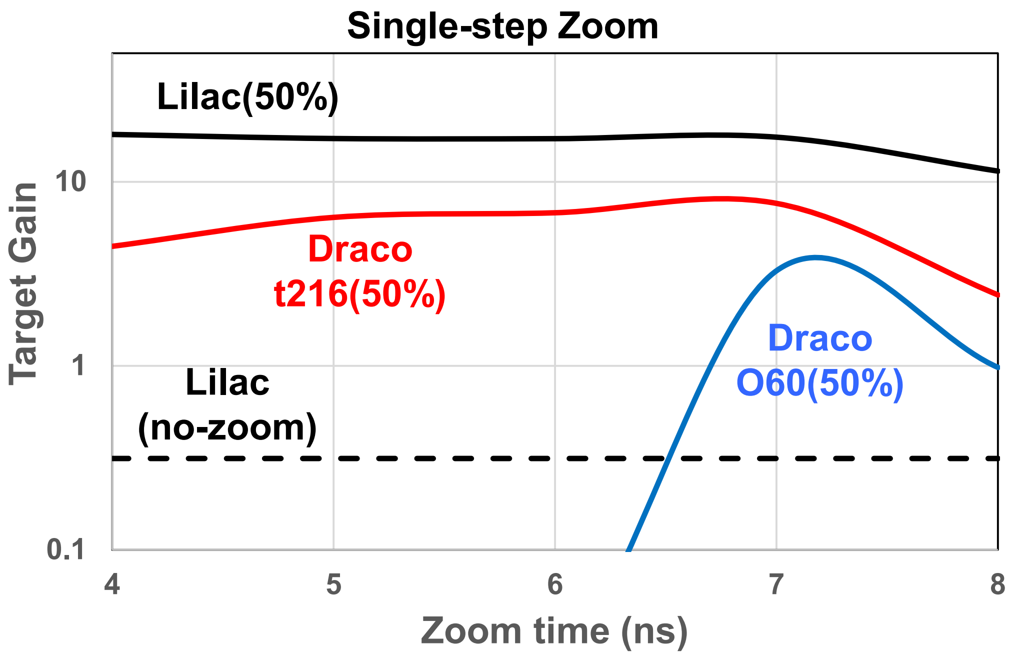
P. W. McKenty
Laboratory for Laser Energetics
University of Rochester

64th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Spokane, WA
17 - 21 October, 2022

Evaluation of the Effects of Laser-Beam Zooming on OMEGA-Next, Wetted-Foam Target Designs



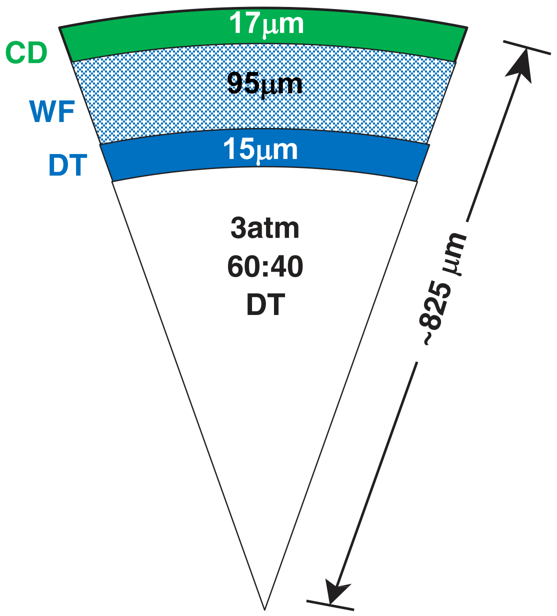


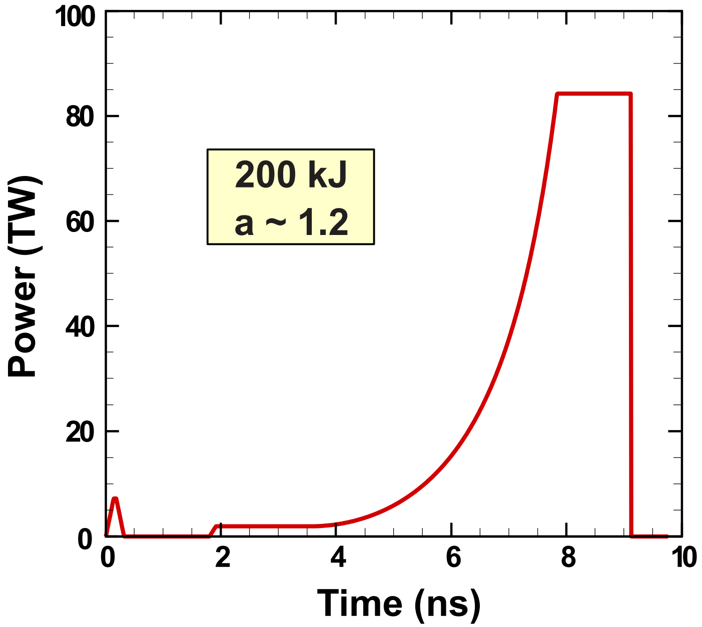


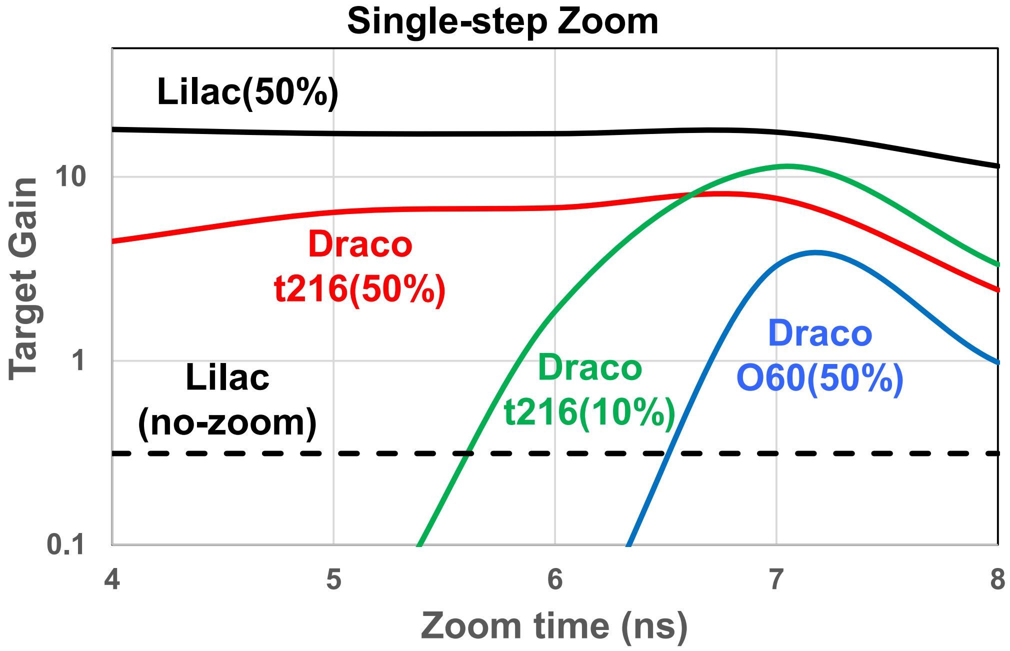
P. W. McKenty
Laboratory for Laser Energetics
University of Rochester

64th Annual Meeting of the
American Physical Society
Division of Plasma Physics
Spokane, WA
17 - 21 October, 2022

Evaluation of the Effects of Laser-Beam Zooming on OMEGA-Next, Wetted-Foam Target Designs







64th Annual Meeting of the American Physical Society Division of Plasma Physics
Spokane, WA
17 - 21 October, 2022

P. W. McKenty
Laboratory for Laser Energetics
University of Rochester

Laser beam zooming provides a path to ignition for OMEGA-Next, low-adiabat target designs at energies in the 200-kJ range

UR LLE

- **Enhanced laser engineering will significantly relax the constraints of both imprint and CBET for OMEGA-Next implosions.**

- **Wetted-foam targets provide a low cost and easily fabricated and deployed target platform when compared to conventional, layered cryogenic targets.**

- **One-dimensional simulations capture the energy coupling of zooming, but 2D simulations are required to adequately account for drive perturbations growing during the implosion.**

- **Two-dimensional simulations of 200kJ, wetted-foam ignition targets, employing single-step zooming and enhanced Spherical *t-design* pointings*, show G ~ 11, about half the 1D result.**

* **A. Shvydky et al**., *Spherical t-designs for Symmetric Laser Direct Drive Inertial Confinement Fusion,* **(submitted for publication)**

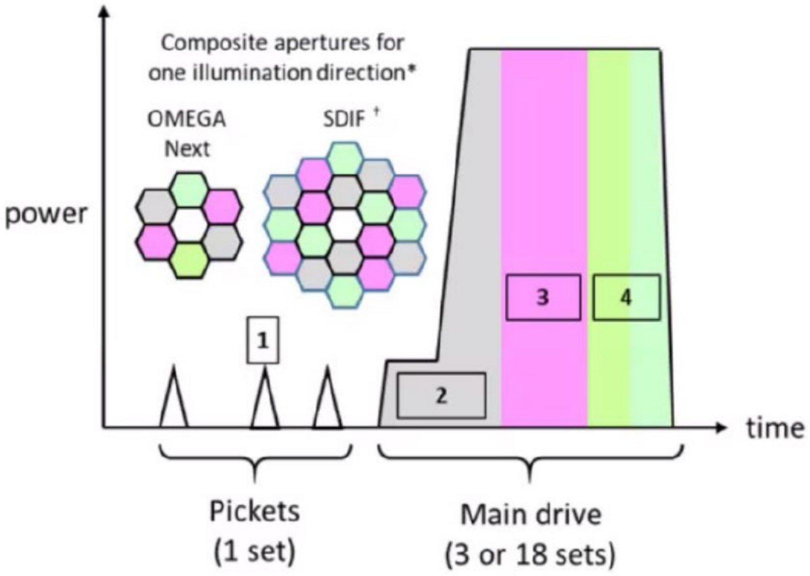
Collaborators

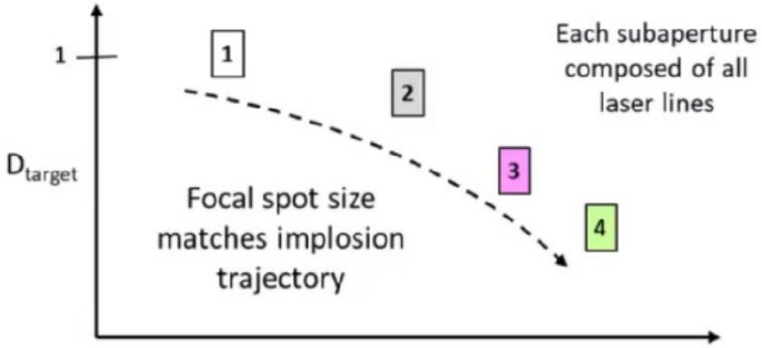
D. Cao, A. Shvydky, J. A. Marozas, T. J. B. Collins, W. Trickey,
J. Carroll Nellenbeck, and V. N. Goncharov

Laboratory for Laser Energetics

University of Rochester

OMEGA-Next will provide a generational platform, able to investigate Direct-drive laser and target concepts in pursuit of an IFE Reactor

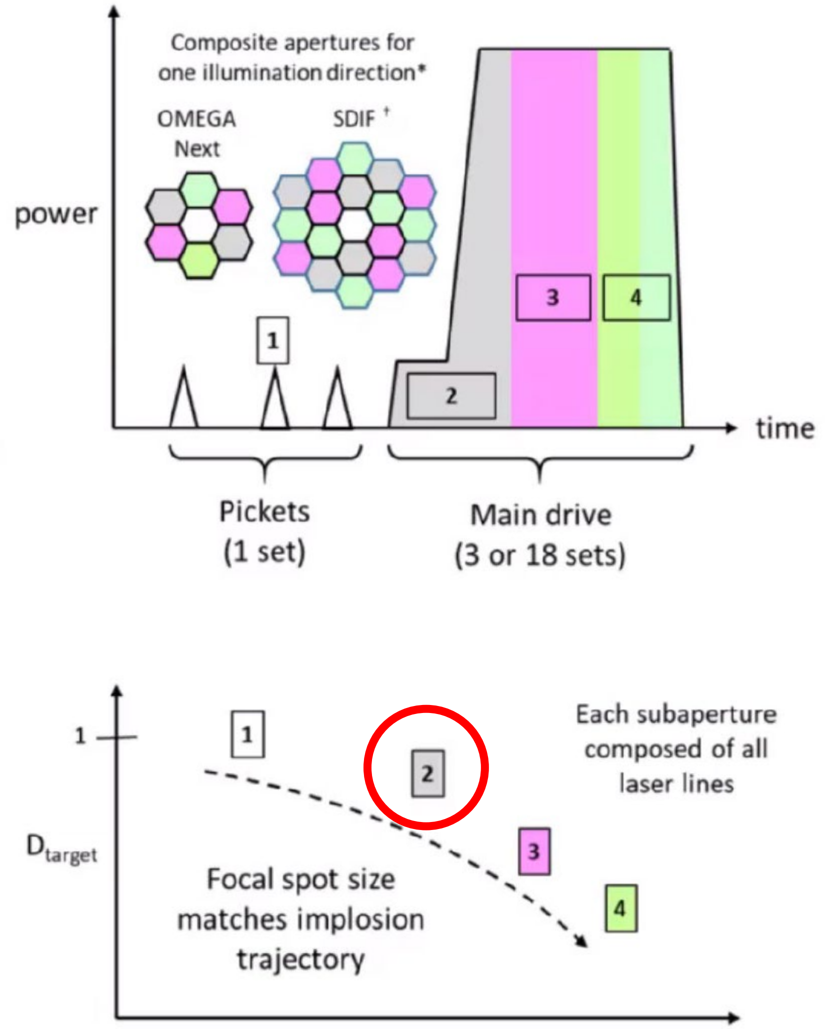




- **StarDriver**-based use of small beamlets clustered in a reasonable number of ports ~ 100 – 200**
- **Mosaic pattern of incoherent sources, which permits use of multiple wavelengths and enables multi-step "zooming"**
- **Each beamlet has bandwidth ($\Delta\lambda/\lambda$~3.5%) *and* a discrete centroid wavelength**
- **Power balance σ_{rms} ~ 1% rms**

*J. Zuegel (private communication)
** D. Eimerl et al., J Fusion Energy, 33, 476-488 (2014).

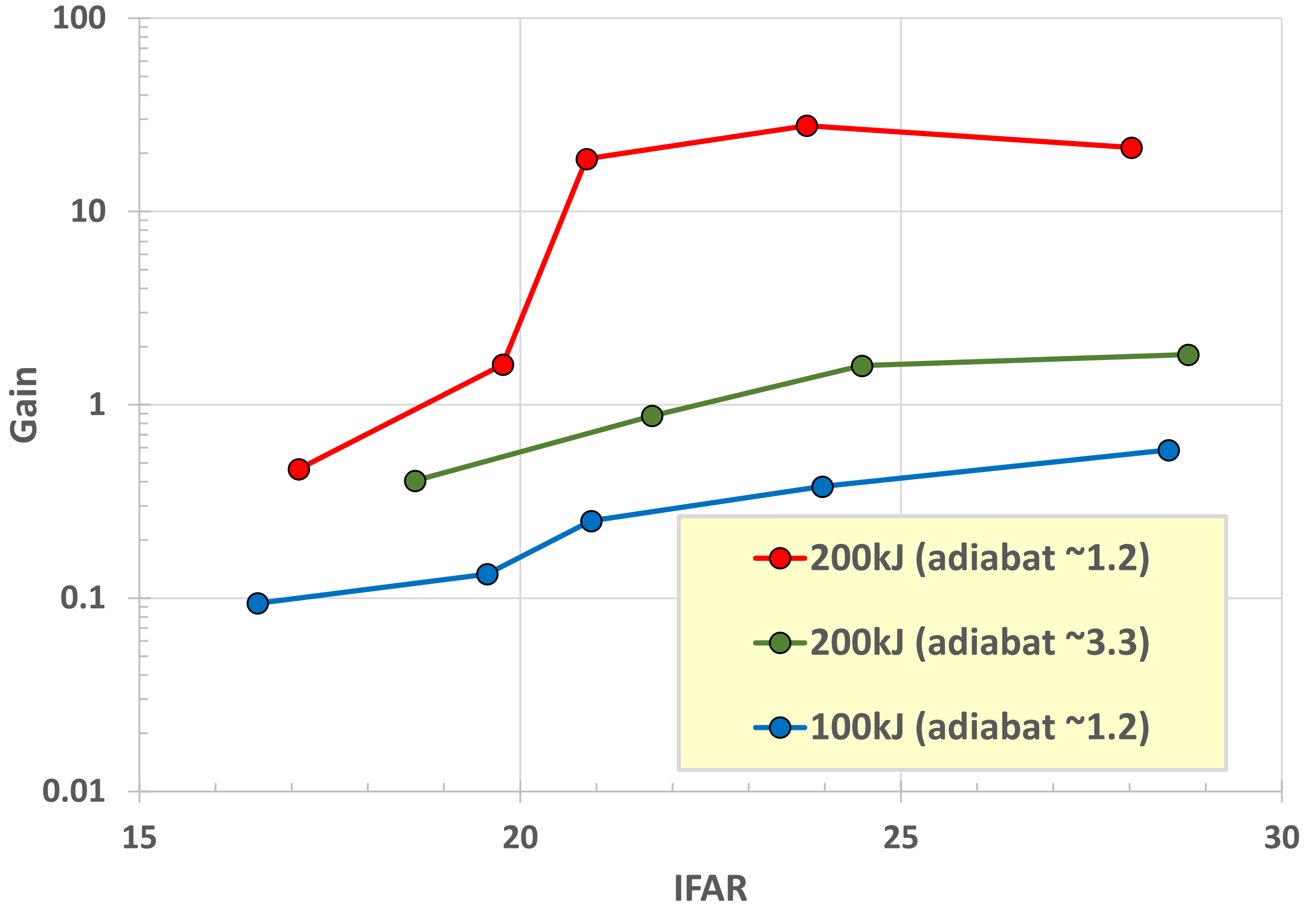
OMEGA-Next will provide a generational platform, able to investigate Direct-drive laser and target concepts in pursuit of an IFE Reactor



- **StarDriver**-based use of small beamlets clustered in a reasonable number of ports ~ 100 – 200**
- **Mosaic pattern of incoherent sources, which permits use of multiple wavelengths and enables multi-step "zooming"**
- **Each beamlet has bandwidth ($\Delta\lambda/\lambda$~3.5%) *and* a discrete centroid wavelength**
- **Power balance σ_{rms} ~ 1% rms**

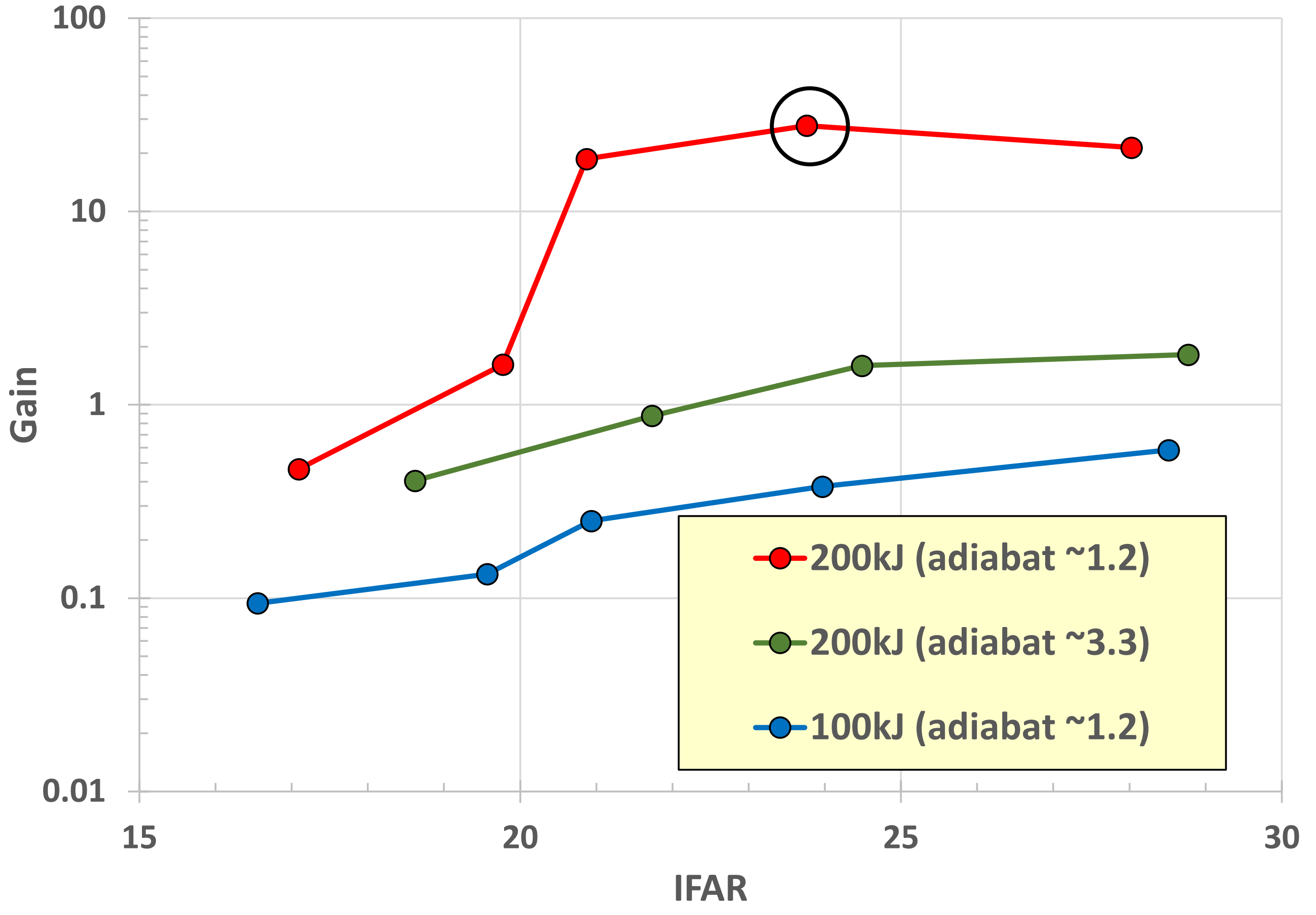
*J. Zuegel (private communication)
** D. Eimerl et al., J Fusion Energy, 33, 476-488 (2014).

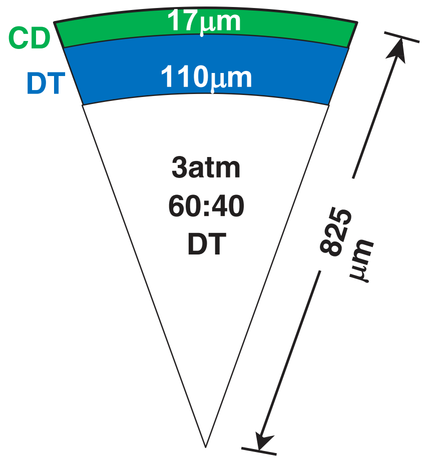
Multiple series of 1D LILAC runs optimized single-step-zoomed target performance as a function of IFAR for energies of 100-200kJ*

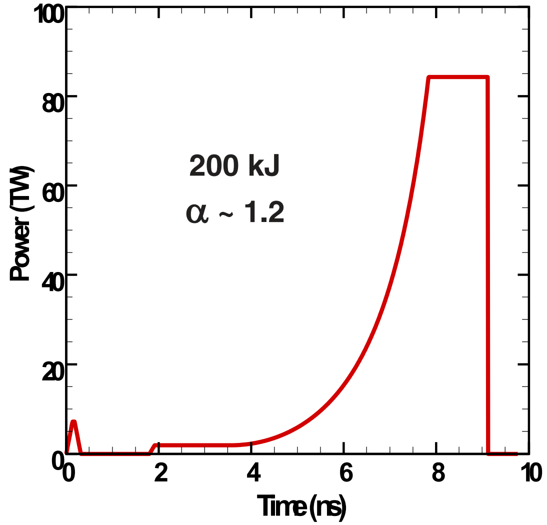


* D. Cao, (private communication)

Multiple series of 1D LILAC runs optimized single-step-zoomed target performance as a function of IFAR for energies of 100-200kJ*



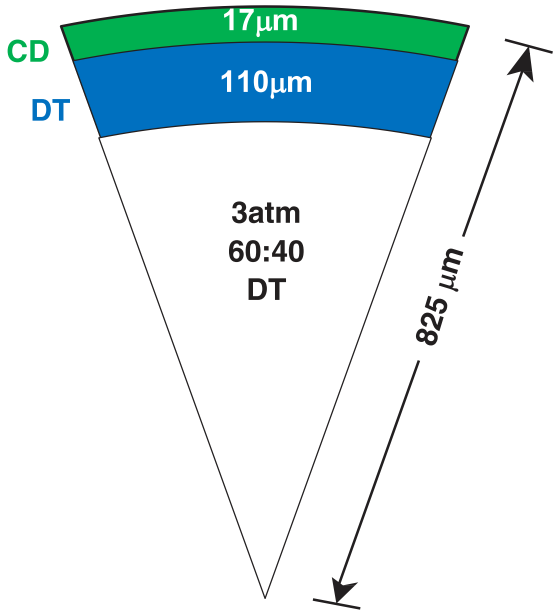




* D. Cao, (private communication)

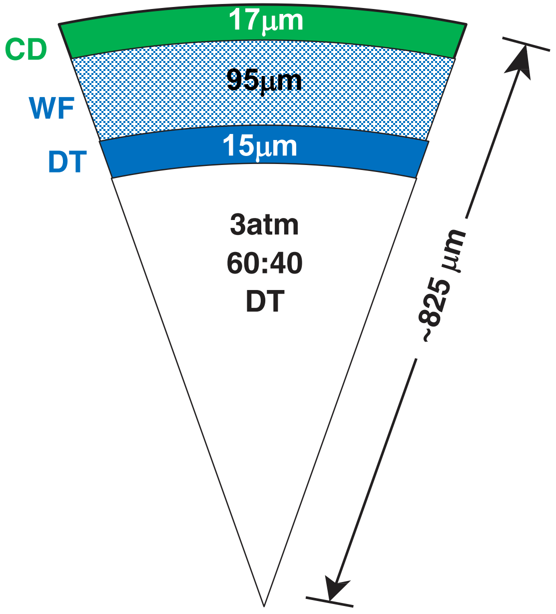
OMEGA-Next, given its 10-minute shot rate, will require a significant number of low-cost and easily-fabricated/deployed ignition targets

Baseline CD/DT



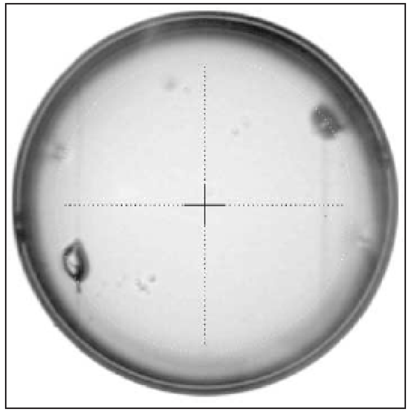
Adiabat	
1.21	0.92
Convergence ratio	
29.01	29.39
IFAR	
23.56	23.44
Gain - no zoom	
0.11	0.14
Gain - 1 step zoom	
27.44	17.44

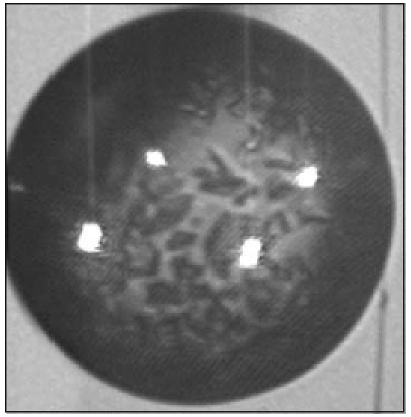
Wetted foam

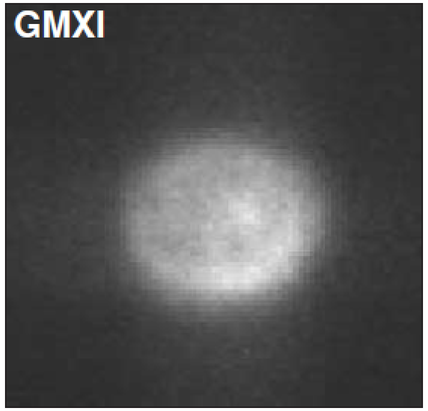


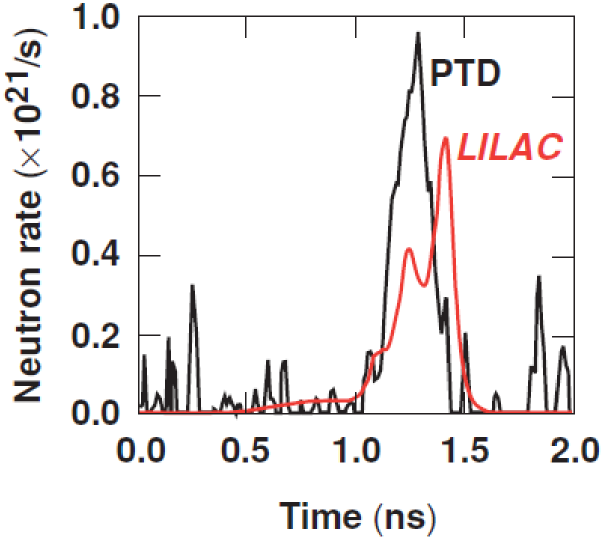
Target fabrication will play a dominate role in the success of OMEGA-Next

LLE is no stranger with deploying wetted-foam implosion targets with first experiments taking place in 2003









Experiment:

Y_{1n} = 1.74E11

Y_{2n} = 3.52E08

T_{ion} = 5.2 keV

LILAC

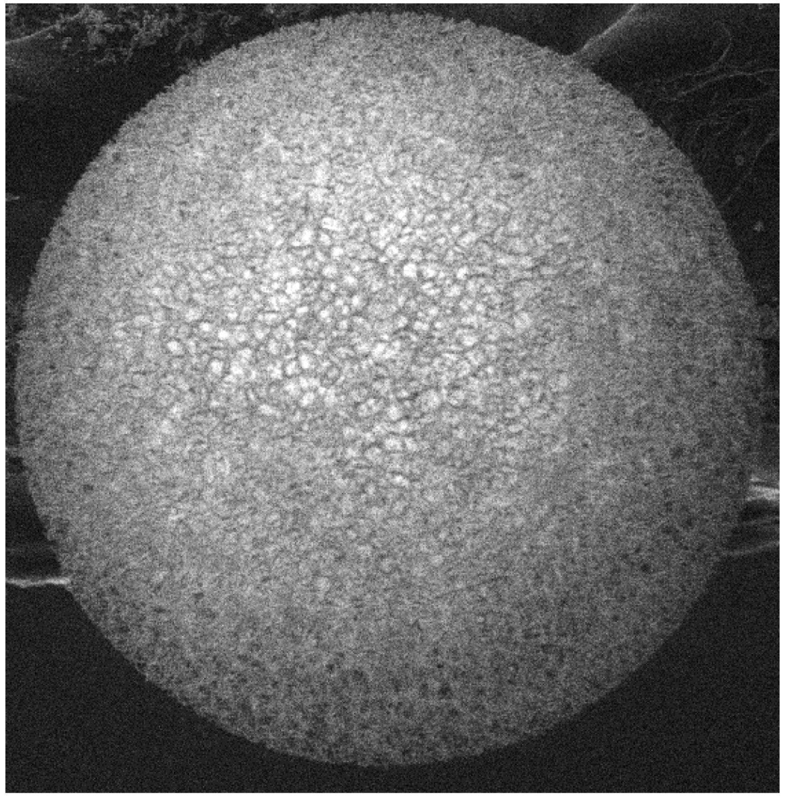
$Y_{1n} = 1.5^3 \times 10^{11}$

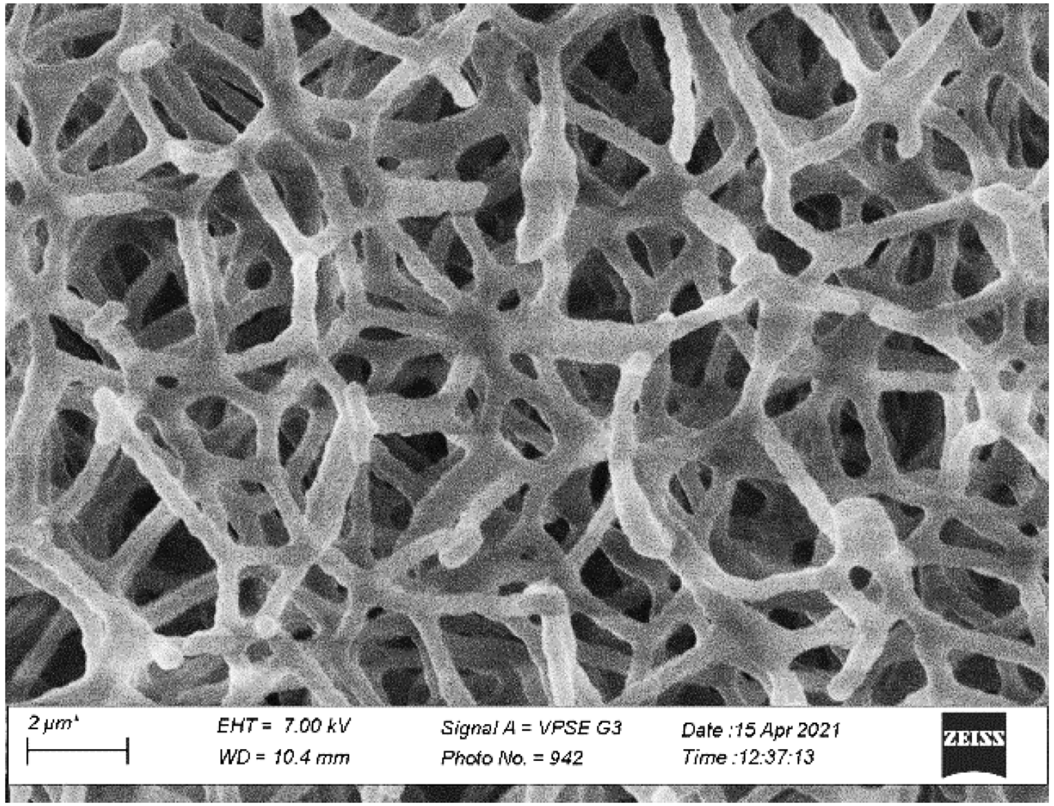
$Y_{2n} = 1.18 \times 10^9$

T_{ion} = 2.7 keV

TC6460

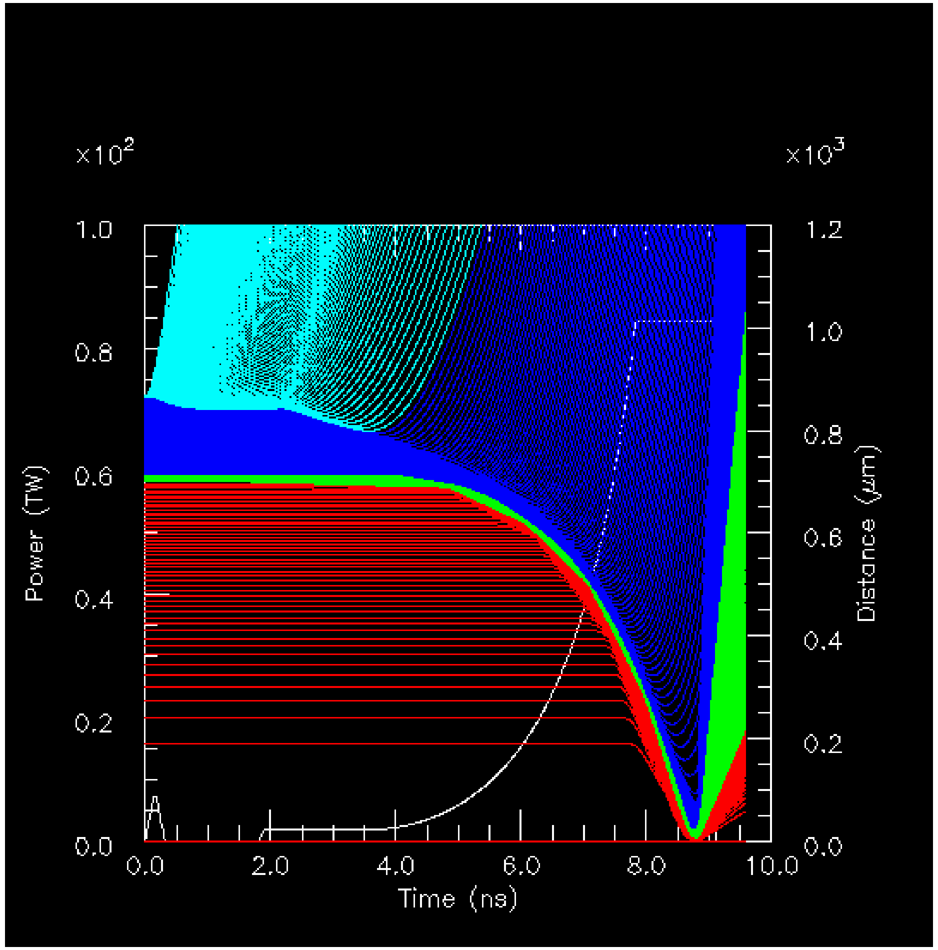
In August of this year, LLE produced and imploded several 3-D printed foam shells approaching OMEGA-Next specifications





* D. Harding et al.,*8th Target Fabrication Workshop,* September 2022

A series of 1D runs, scanning zoom fractions and times, indicates that gain is relatively constant if zooming is implemented before a CR of 2



Target gain vs zoom parameters

t_{zoom}(ns)

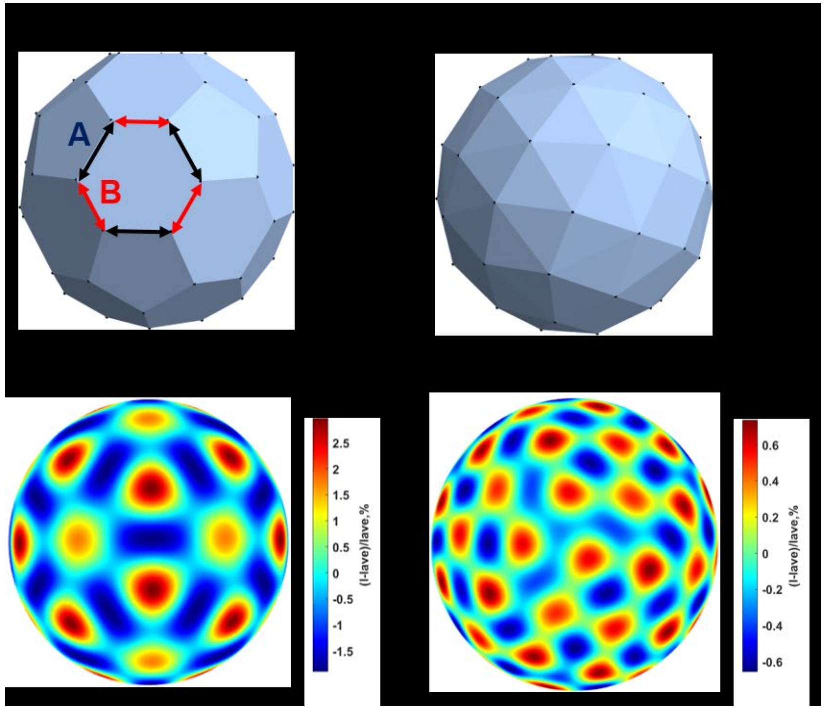
Zoom fraction	4	5	6	7	8
0.10	23.91	22.71	22.63	22.31	16.05
0.25	22.62	21.52	21.54	21.3	15.04
0.50	18.05	17.15	17.12	17.44	11.41
0.75	6.08	5.71	6.23	6.91	3.80
0.90	0.85	0.87	0.92	0.97	0.69

Two-dimensional DRACO simulations examine the effects of early-time zooming, late-time zoom fractions, and several laser configurations

1D Target gain vs zoom parameters

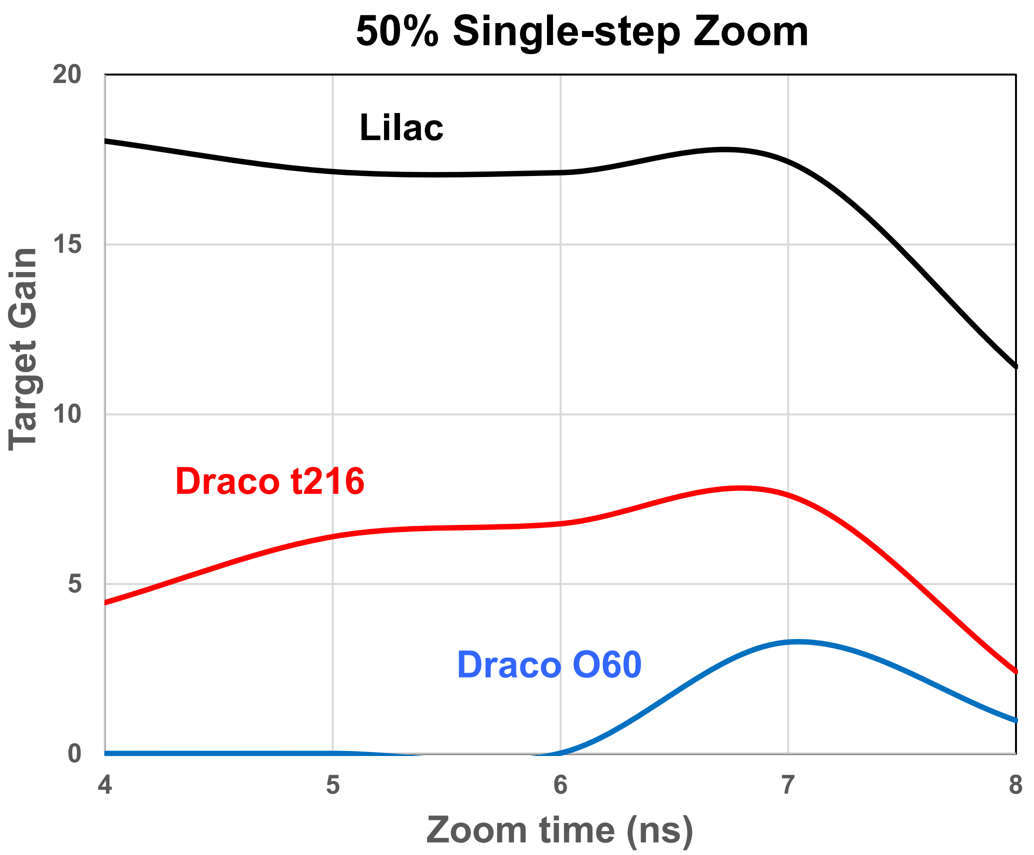
Zoom fraction \ t_{zoom}(ns)	4	5	6	7	8
0.10	23.9	22.71	22.63	22.31	16.05
0.25	22.62	21.52	21.54	21.3	15.04
0.50	18.05	17.15	17.12	17.44	11.41
0.75	6.08	5.71	6.23	6.91	3.8
0.90	0.85	0.87	0.92	0.97	0.69

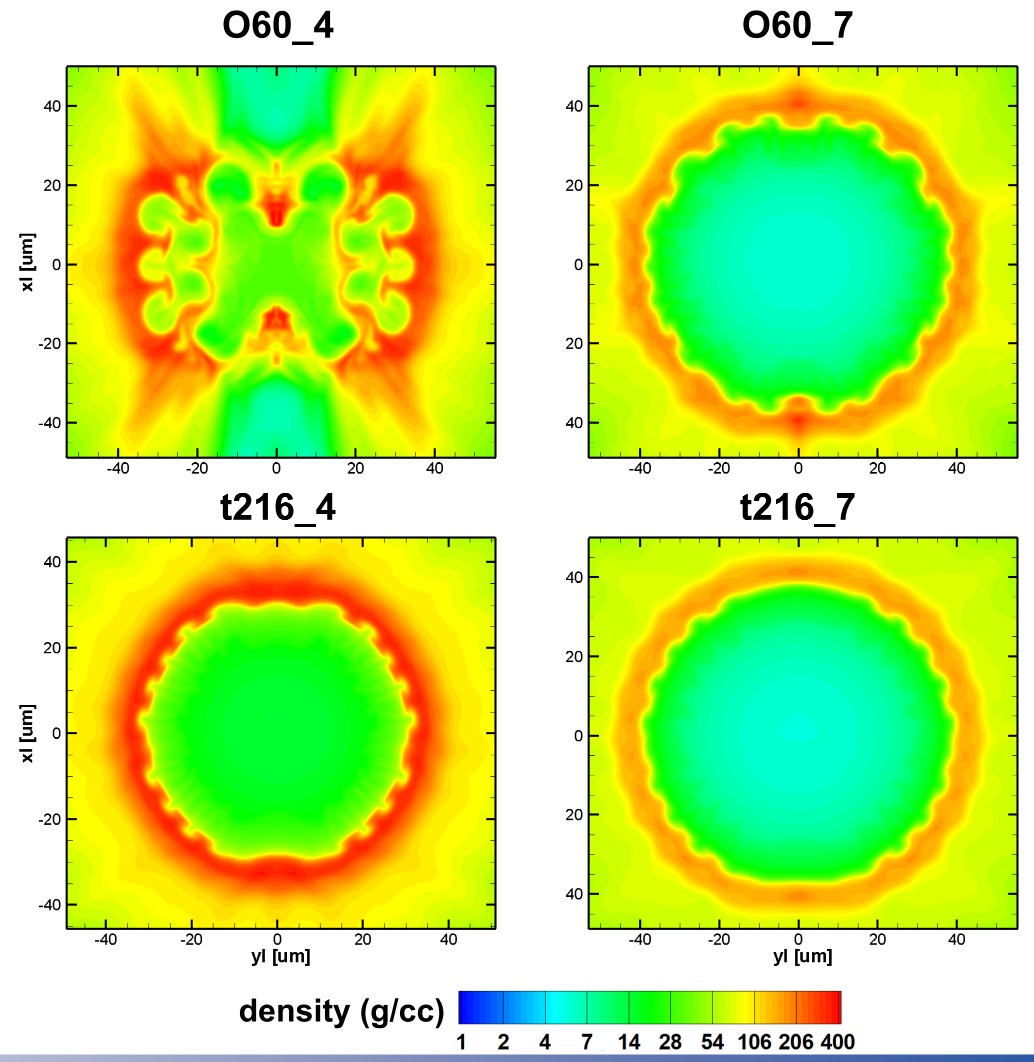
OMEGA-60 (O60) — **Spherical *t*-designs* (*t*60 – *t*216)**



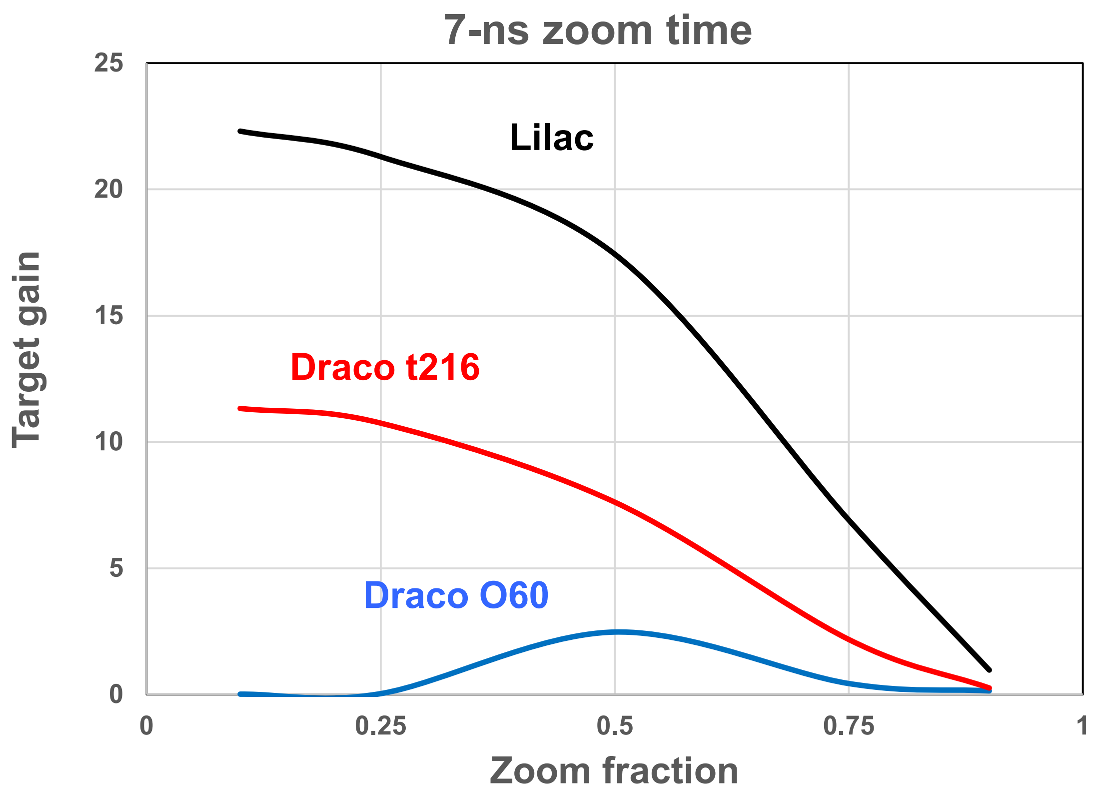
* **A. Shvydky et al.**, *Spherical t-designs for Symmetric Laser Direct Drive Inertial Confinement Fusion*, **(submitted for publication)**

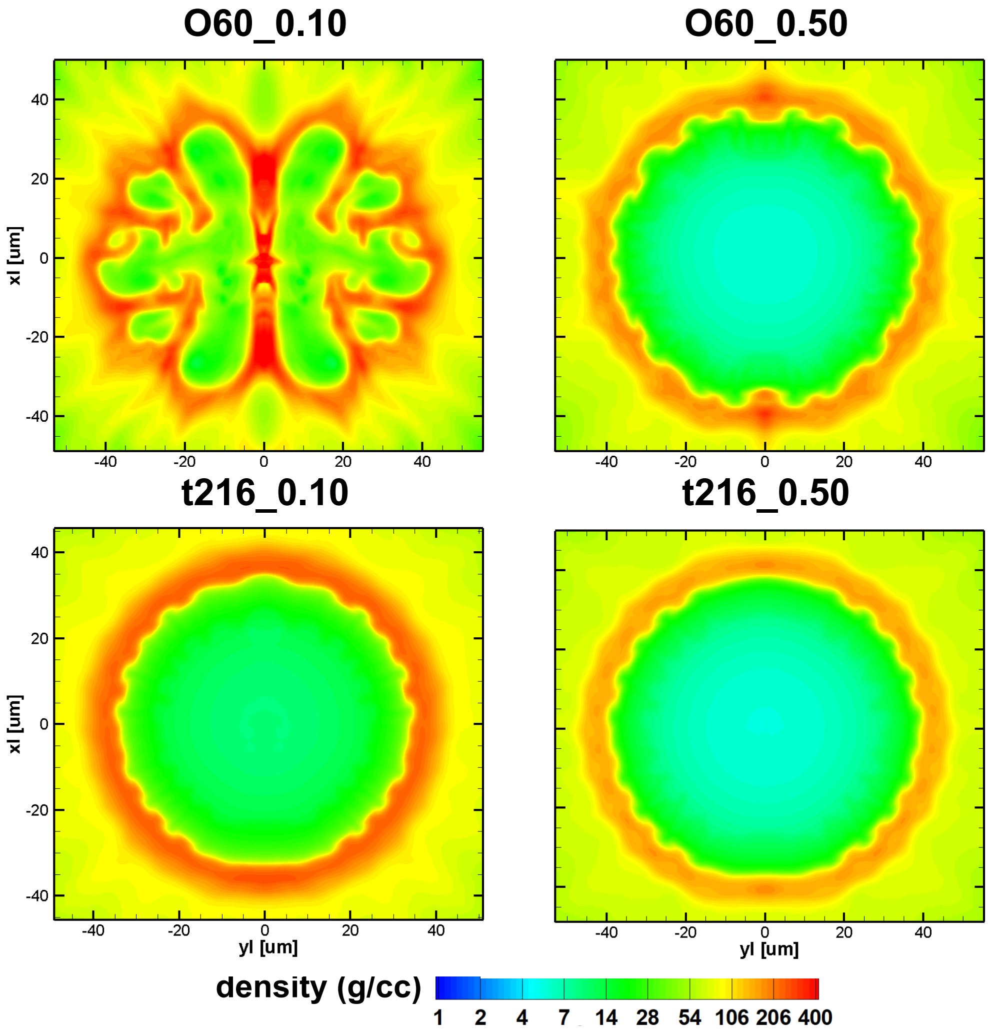
DRACO simulations indicate that target performance becomes more robust with single-step zooming as more ports are employed





DRACO simulations also indicate that port configurations with a higher number of beams begin to mimic 1D LILAC performance





Laser beam zooming provides a path to ignition for OMEGA-Next, low-adiabat target designs at energies in the 200-kJ range

UR LLE

- Enhanced laser engineering will significantly relax the constraints of both imprint and CBET for OMEGA-Next implosions.

- Wetted-foam targets provide a low cost and easily fabricated and deployed target platform when compared to conventional, layered cryogenic targets.

- One-dimensional simulations capture the energy coupling of zooming, but 2D simulations are required to adequately account for drive perturbations growing during the implosion.

- Two-dimensional simulations of 200kJ, wetted-foam ignition targets, employing single-step zooming and enhanced Spherical *t-design* pointings, show G ~ 11, about half the 1D result.

Similar talk - CO04.00015 J. A. Marozas et al.