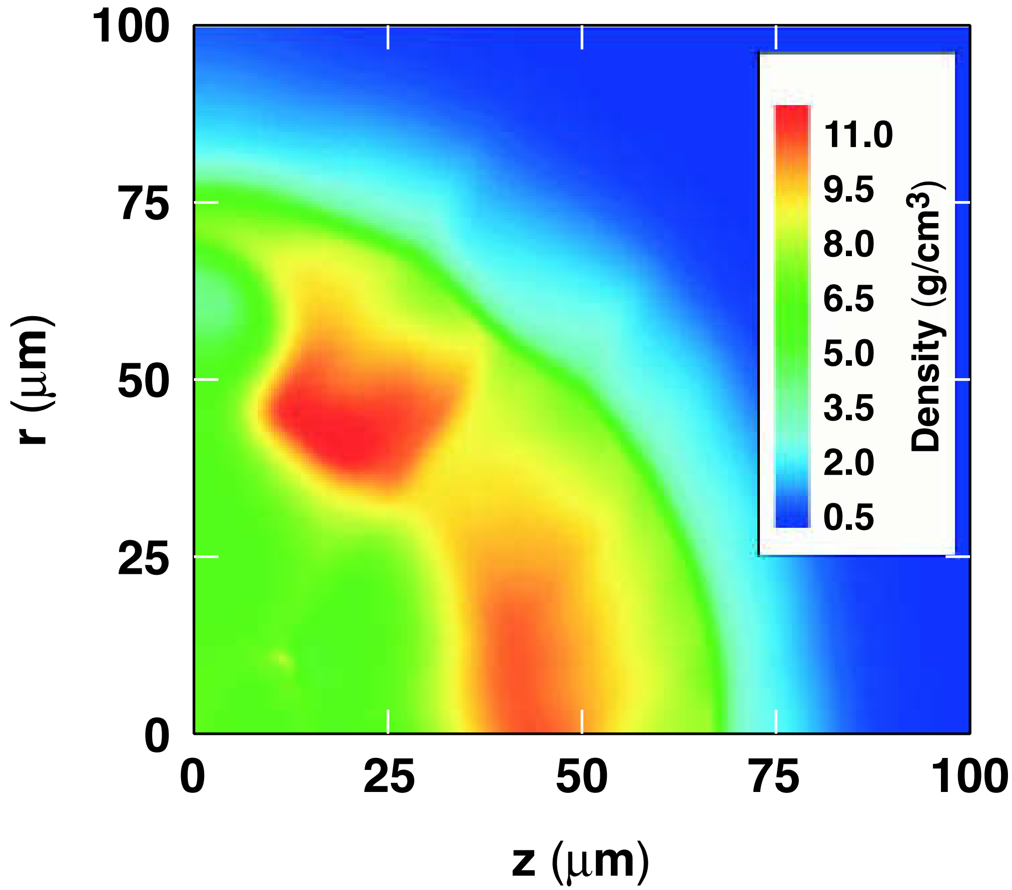
OMEGA Direct-Drive Cryogenic Target Physics



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Summary

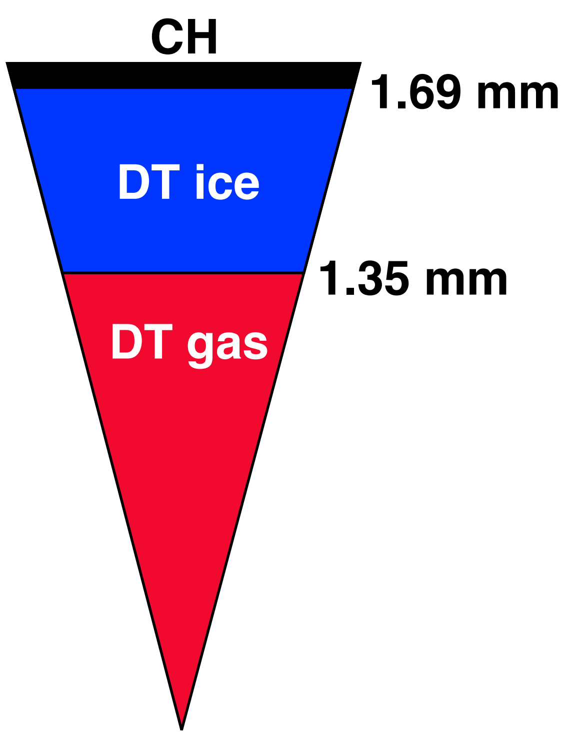
The OMEGA cryogenic target campaign is an important stepping stone to direct-drive ignition on the NIF

- The OMEGA cryogenic targets are energy-scaled versions of the direct-drive ignition targets.
- The OMEGA design's smaller hot spot makes OMEGA designs more sensitive to nonuniformity than NIF designs.
- The first 60-beam cryogenic implosions campaign with higher-adiabat pulses have achieved 30% of 1-D yields.

The base-line direct-drive ignition target is a thick DT-ice layer enclosed by a thin CH shell

- Target designs are characterized by the isentrope parameter α:

$$\alpha = \frac{\text{Electron pressure}}{\text{Fermi-degenerate pressure}}$$



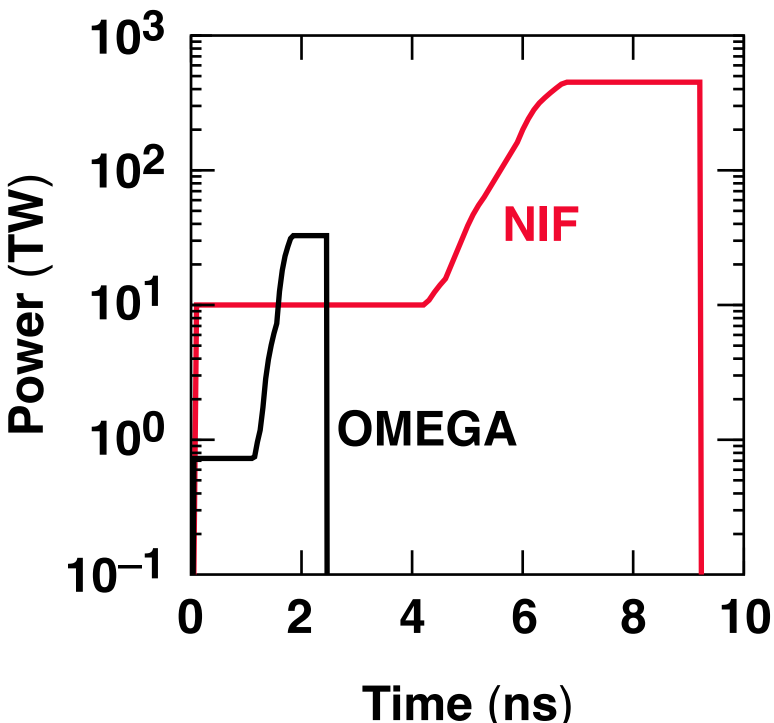
	1.5 MJ, α = 3
Gain	45
Yield	2.5×10^{19}
ρR_{peak}	1.3 g/cm^2
$\langle T_i \rangle_n$	30 keV
Hot-spot CR	28
Peak IFAR	60

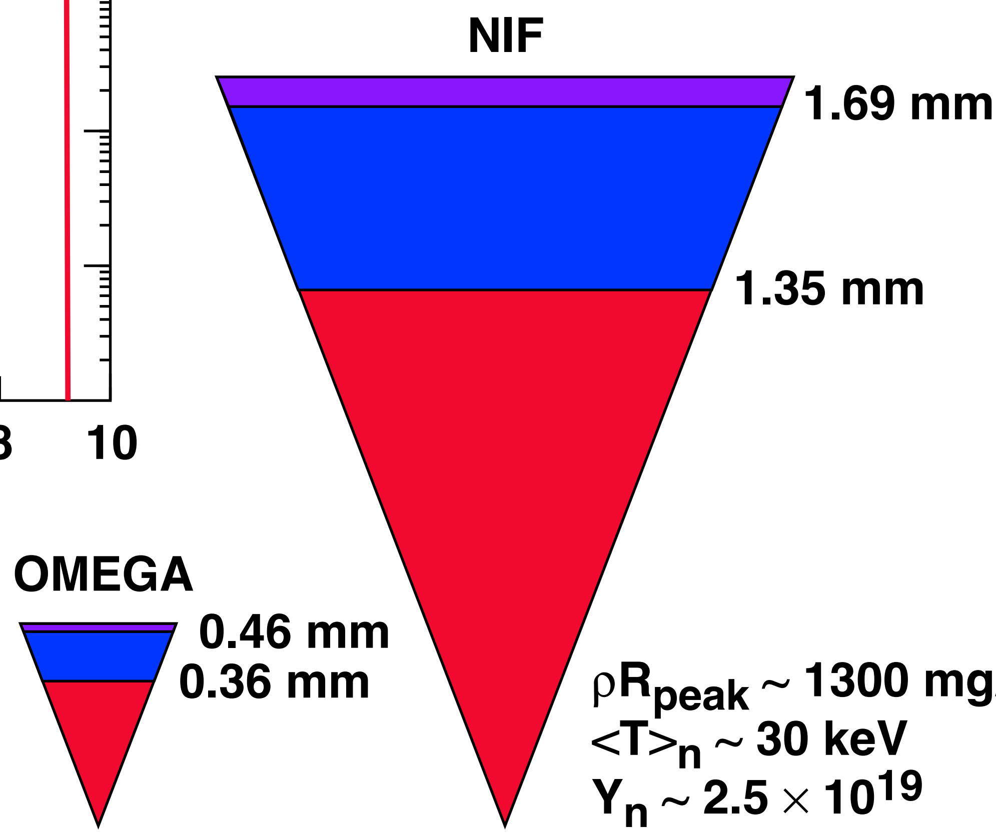
TC4999g

OMEGA cryogenic targets are energy scaled from NIF ignition targets

UR LLE

Energy ~ radius^3, Power ~ radius^2,
Time ~ radius





OMEGA:
$\rho R_{peak} \sim 300$ mg/cm^2
$\langle T \rangle_n \sim 3.9$ keV
$Y_n \sim 1.8 \times 10^{14}$

NIF:
$\rho R_{peak} \sim 1300$ mg/cm^2
$\langle T \rangle_n \sim 30$ keV
$Y_n \sim 2.5 \times 10^{19}$

TC5086

The OMEGA design's smaller hot spot leads to a greater reduction in performance than the NIF design

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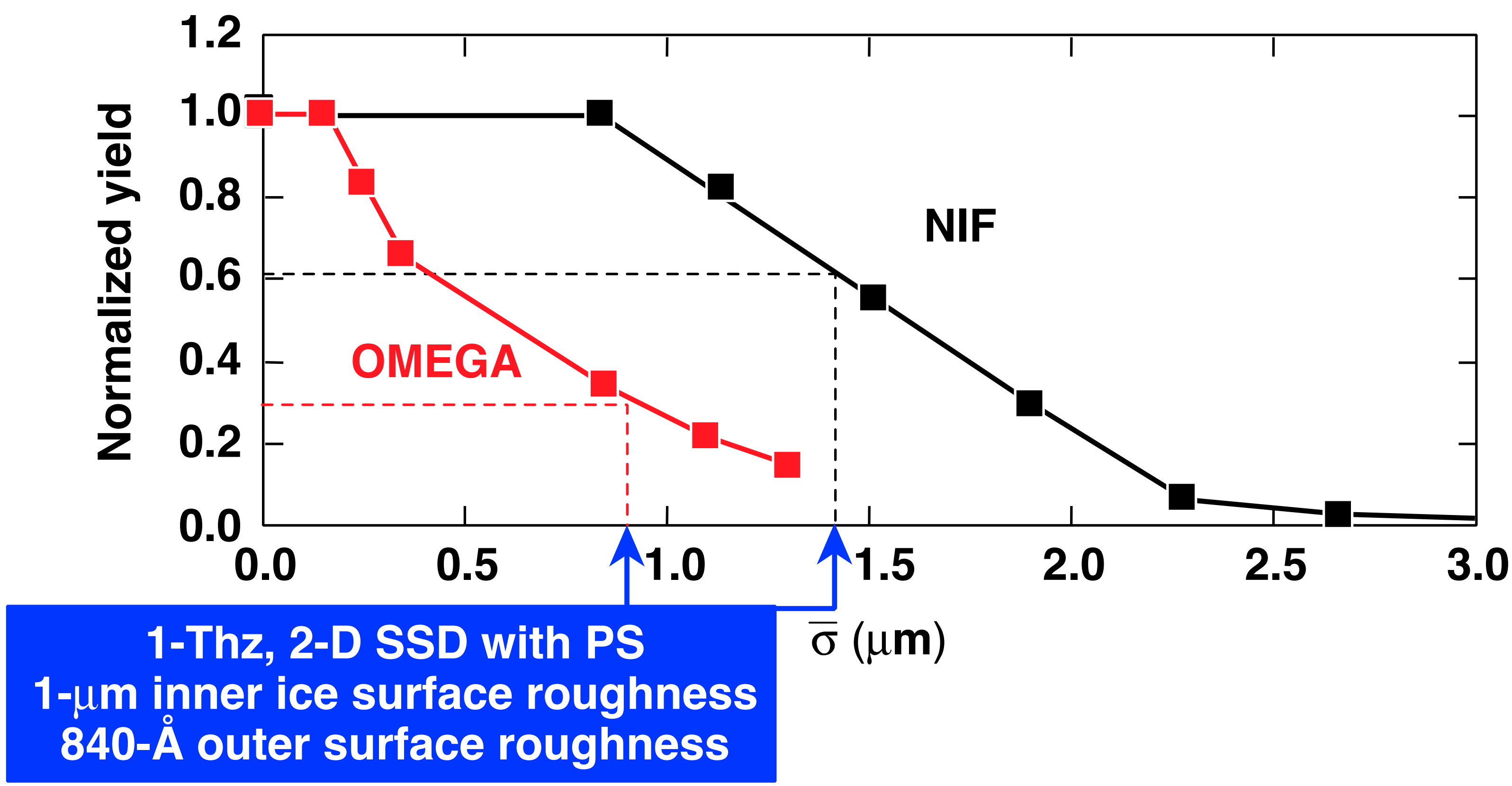
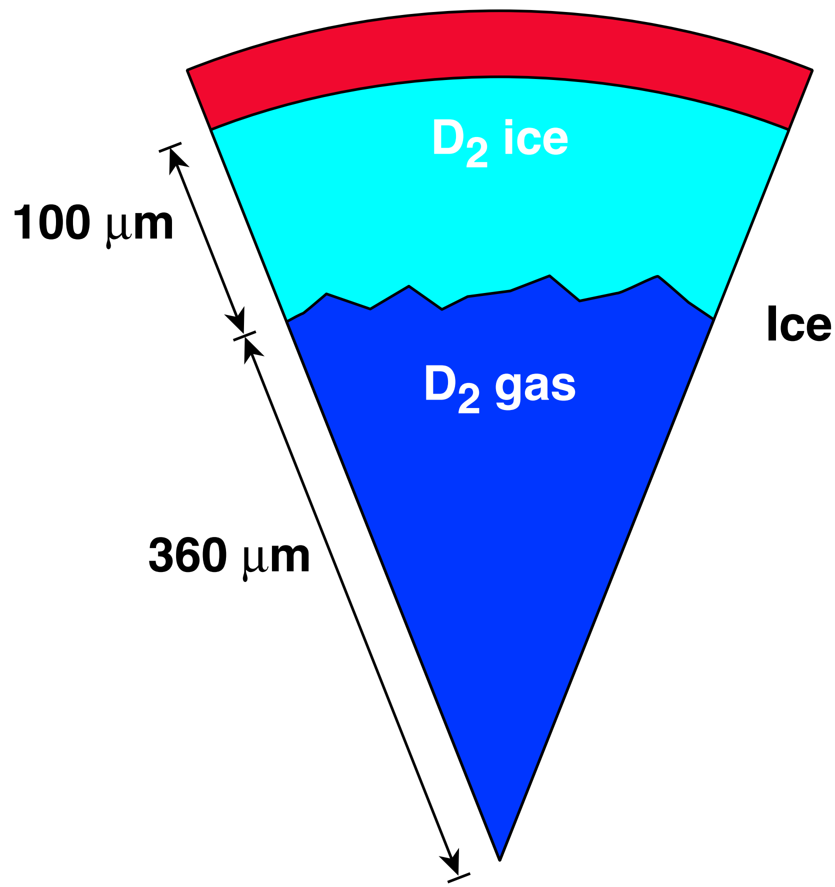
- 2-D ORCHID calculations have shown that the NIF gain* and OMEGA yield can be related to $\bar{\sigma}^2 = 0.06\ \sigma^2_{\ell < 10} + \sigma^2_{\ell \geqslant 10}$.



*Goncharov et al, Proceedings of IFSA 1999.

TC5269a

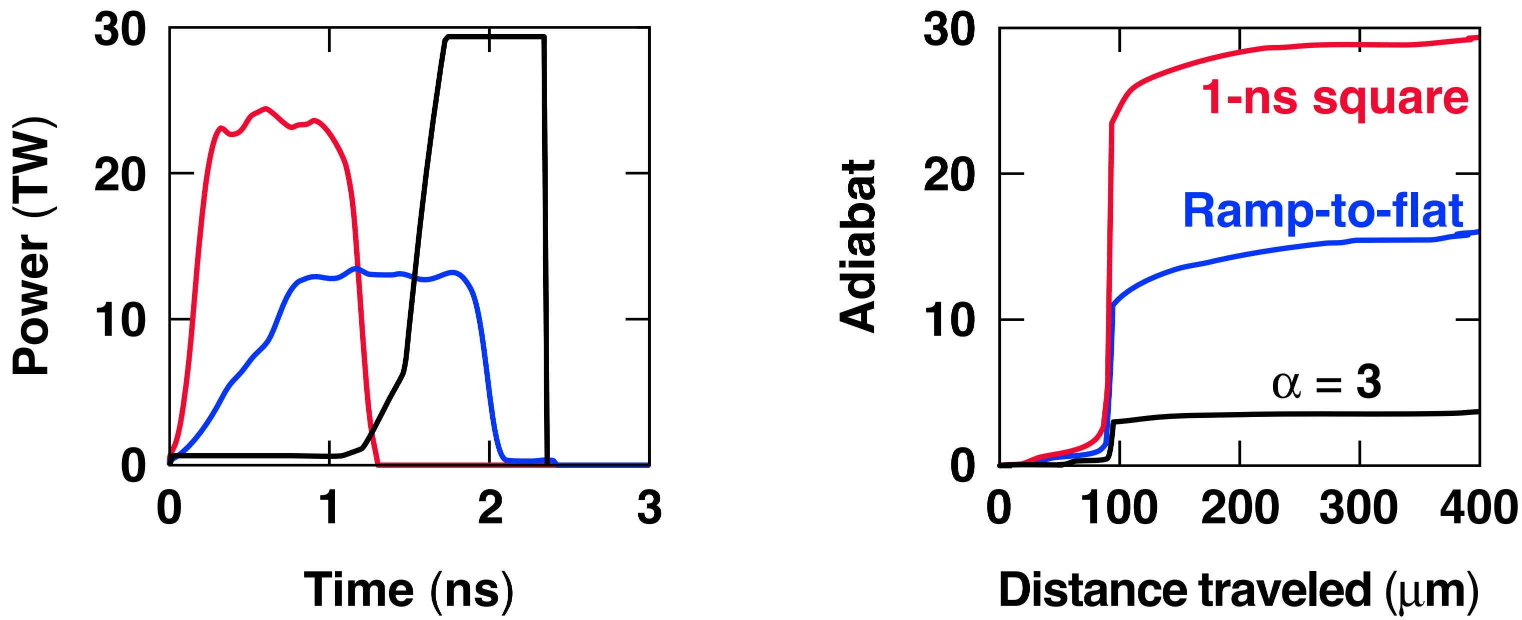
Current OMEGA cryogenic targets use D_2-ice layers



CH thickness ~ 3 μm
(design goal: 1 μm)

Ice roughness ~ 10 μm
(design goal: 1 μm)

Near-term cryogenic experiments use a higher-adiabat laser pulse

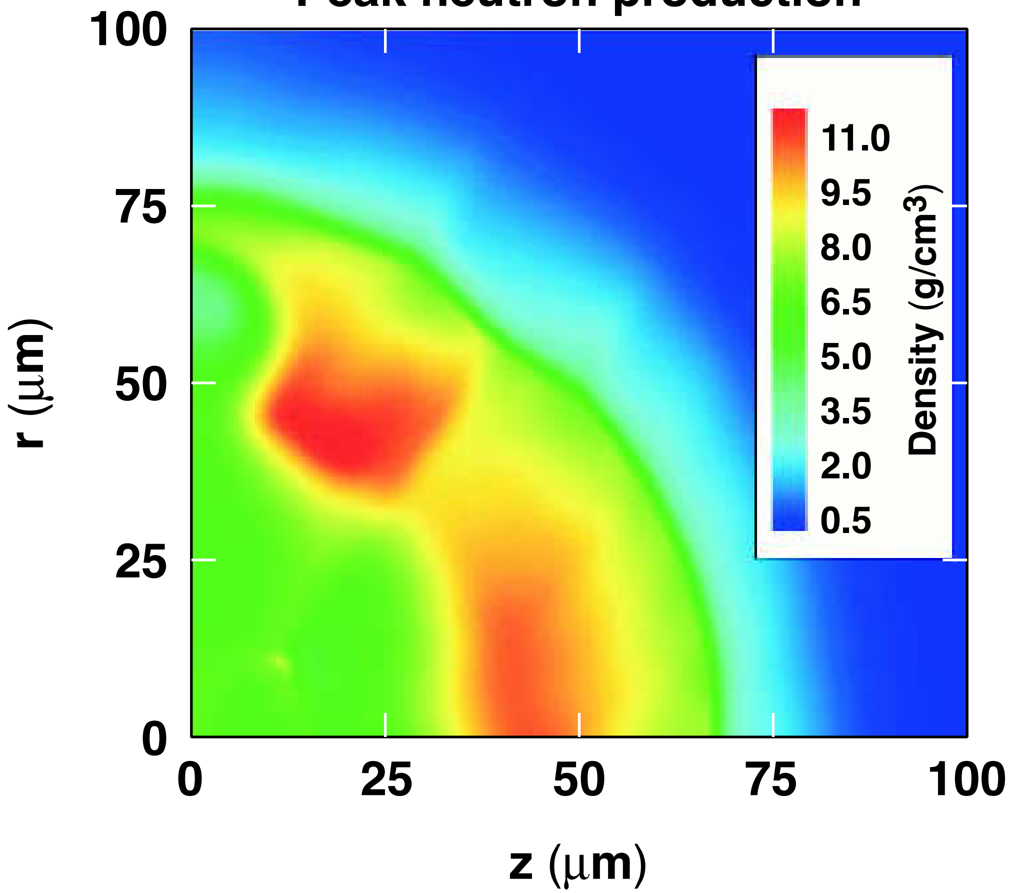


Pulse	ρR_{peak} (mg/cm^2)	Yield
1-ns square	43	1.0×10^{11}
Ramp-to-flat	61	1.2×10^{11}
$\alpha = 3$	212	8.8×10^{11}

TC5714

2-D DRACO calculations with inner ice roughness show a range of areal densities

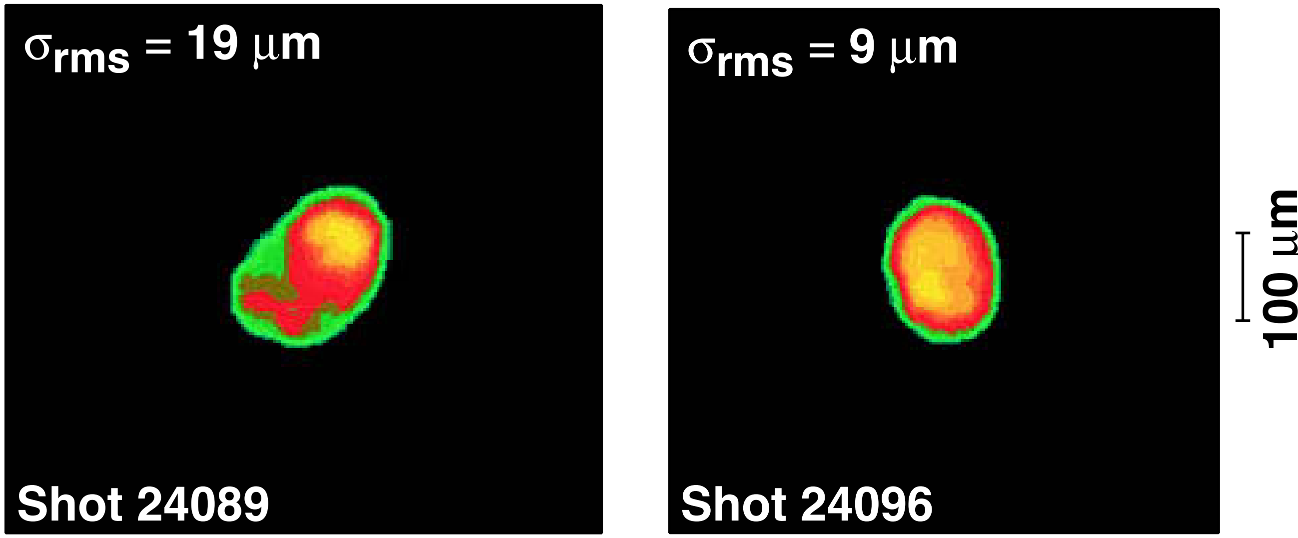
Peak neutron production



- 1-ns square incident on a 100-μm D_2 ice layer with a 9-μm rms inner ice roughness ($\ell < 30$) gave
  - 57% of 1-D yield and
  - 75% to 100% of 1-D areal density.
- Effects of power balance and imprint will be modeled.

TC5728

Cryogenic implosions on OMEGA have shown 30% of 1-D yields



	1-D	24089	24096
Roughness (μm)	—	~ 19	~ 9
Yield	1.0×10^{11}	1.26×10^{10}	3.0×10^{10}
YOC	—	16%	30%
$\langle \rho R \rangle_{total}$ (mg/cm^2)	40	20 - 30 - 58	12 - 25 - 38
Tion (keV)	2.1	2.9±0.5	3.5±0.5
Bang time (ns)	1.8	1.8±0.1	1.7±0.1

F. Seguin et al., FO2.004

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