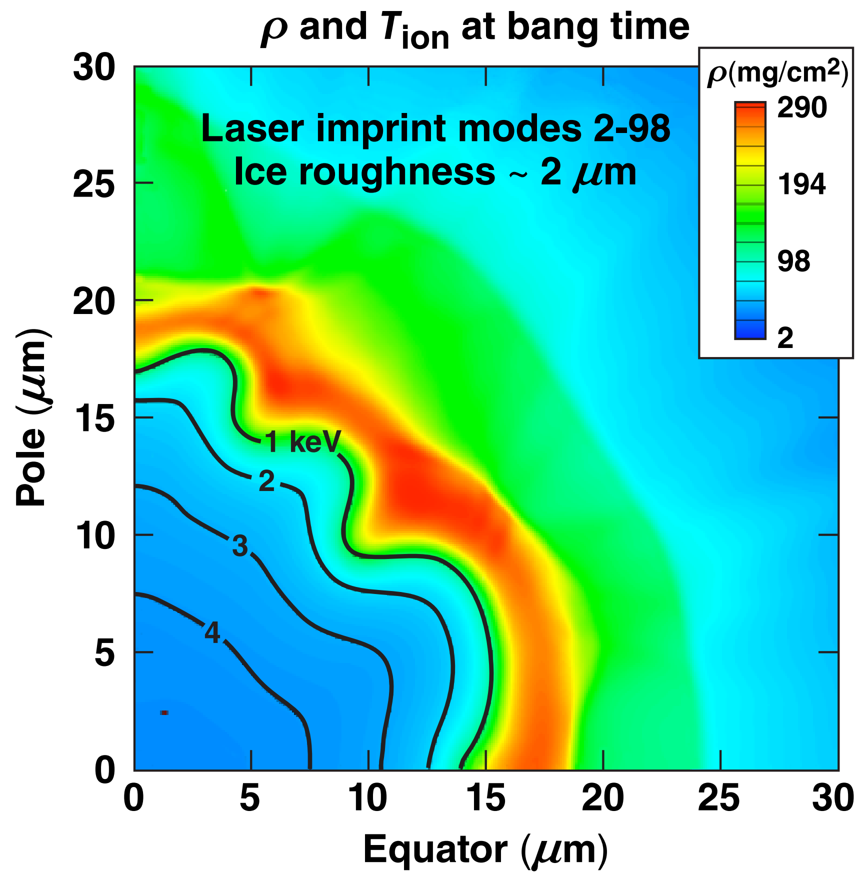
# Cryogenic Shock-Ignition Target Designs for OMEGA





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53rd Annual Meeting of the
American Physical Society
Division of Plasma Physics
Salt Lake City, UT
14–18 November 2011

Summary

# A new triple-picket design has been optimized for cryogenic shock-ignition targets on OMEGA

- Early shock ignition (SI) targets had a neutron yield over clean (YOC) of ~12%
- A new triple-picket design will facilitate experimental shock tuning
- 1-D *LILAC* predicts yields of $5 \times 10^{13}$ and a peak $\rho R$ of 450 mg/cm$^2$
- 2-D *DRACO* shows good stability to laser imprinting and ice roughness
- New cryogenic implosion experiments will begin early next year

# Collaborators

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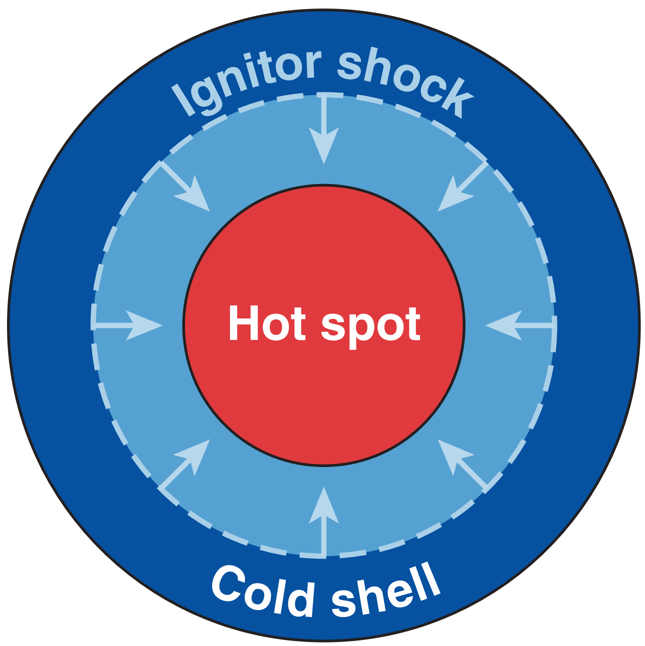
# Shock ignition decouples the compression and ignition stages to achieve ignition*

- SI uses thick, slow massive targets which exhibit small in-flight aspect ratios (IFAR's)
- Targets have a reduced susceptibility to Rayleigh–Taylor (RT) instabilities
- The ignitor shock couples additional kinetic energy into the hot spot to achieve ignition
- Performance metrics: areal density and YOC

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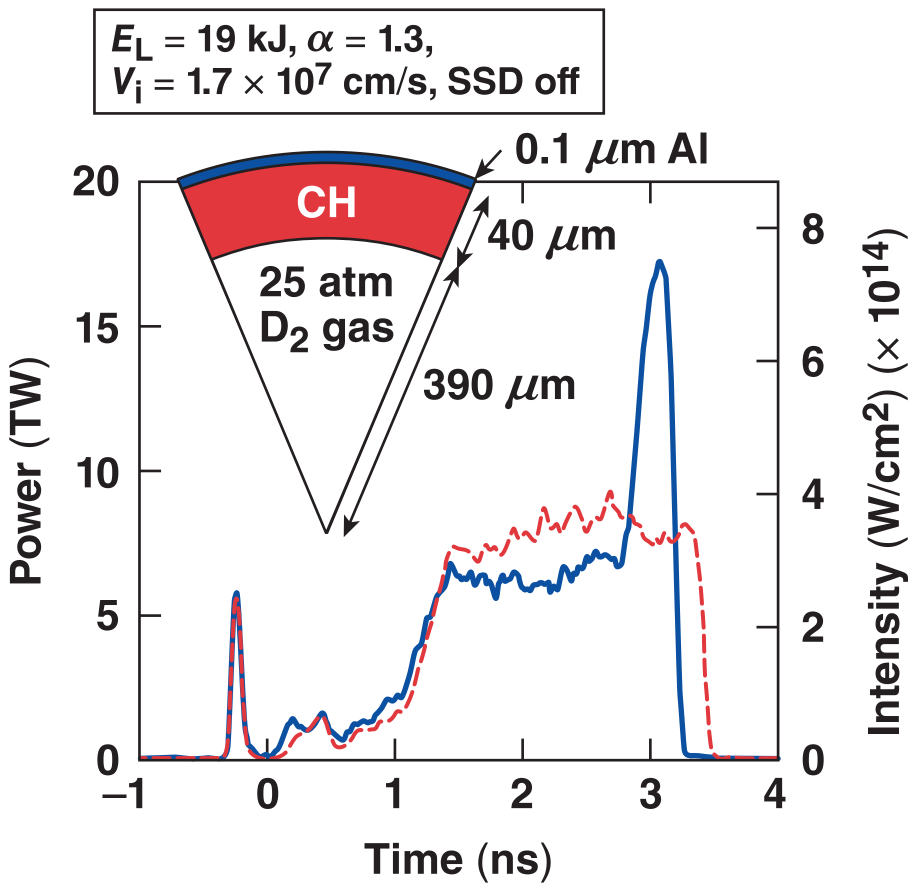
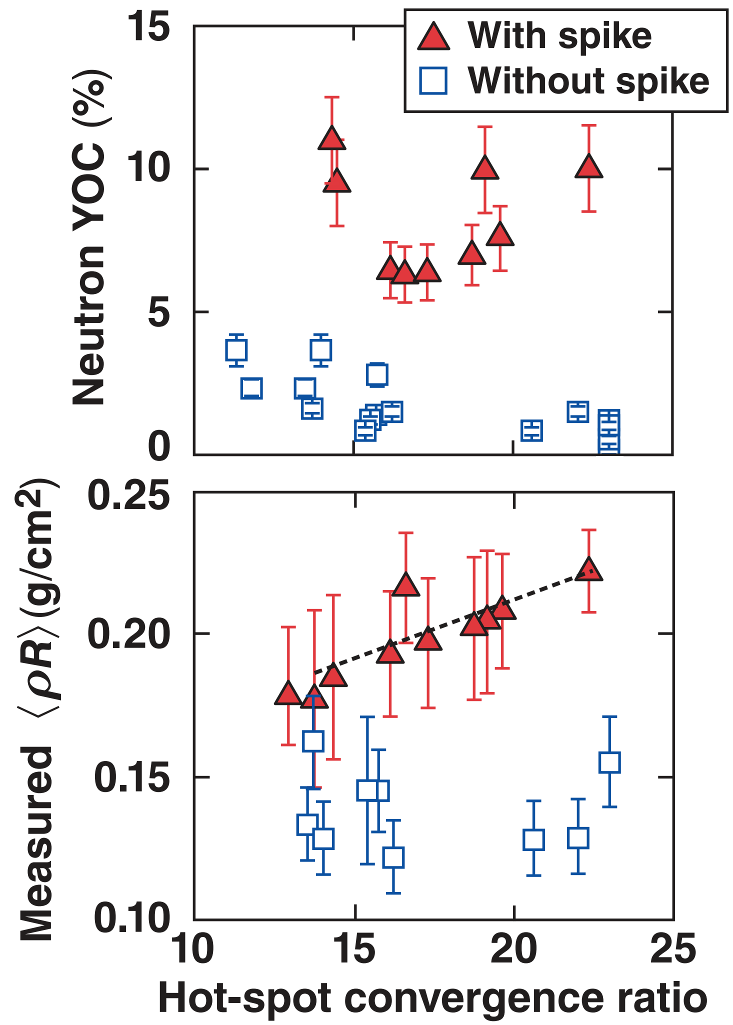
*R. Betti *et al*., Phys. Rev. Lett. 98, 155001 (2007).

# Warm targets have been imploded on OMEGA to test the performance of SI pulse shapes*




$Y_n = 2\pm0.2 \times 10^9$

$Y_n = 8\pm0.8 \times 10^9$

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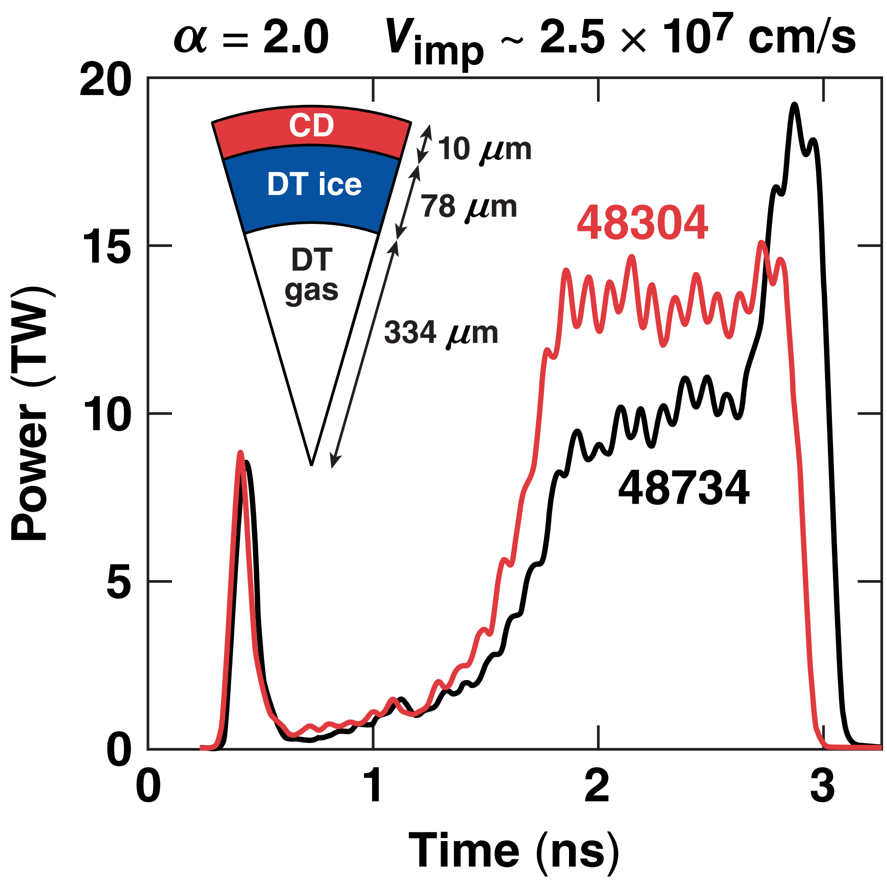
*W. Theobald *et al.*, Phys. Plasmas 15, 056306 (2008).

# There is no database for cryogenic SI experiments




| Shot number | 48304 | 48734 |
|---|---|---|
| $E_{laser}$ (kJ) | 19.3 | 17.9 |
| $Y_n$ | 1.60 × $10^{12}$ | 1.43 × $10^{12}$ |
| YOC (flux) | 9.8% | 12.3% |
| $\langle \rho R \rangle_{exp}$ (g/cm$^2$) | — | 0.205 |
| $T_{ion}$ (keV) (exp) | 2.5 | 1.9 |
| Ice layer ($\mu$m) | 0.7 | 0.9 |
| Target offset ($\mu$m) | — | 10±5 |

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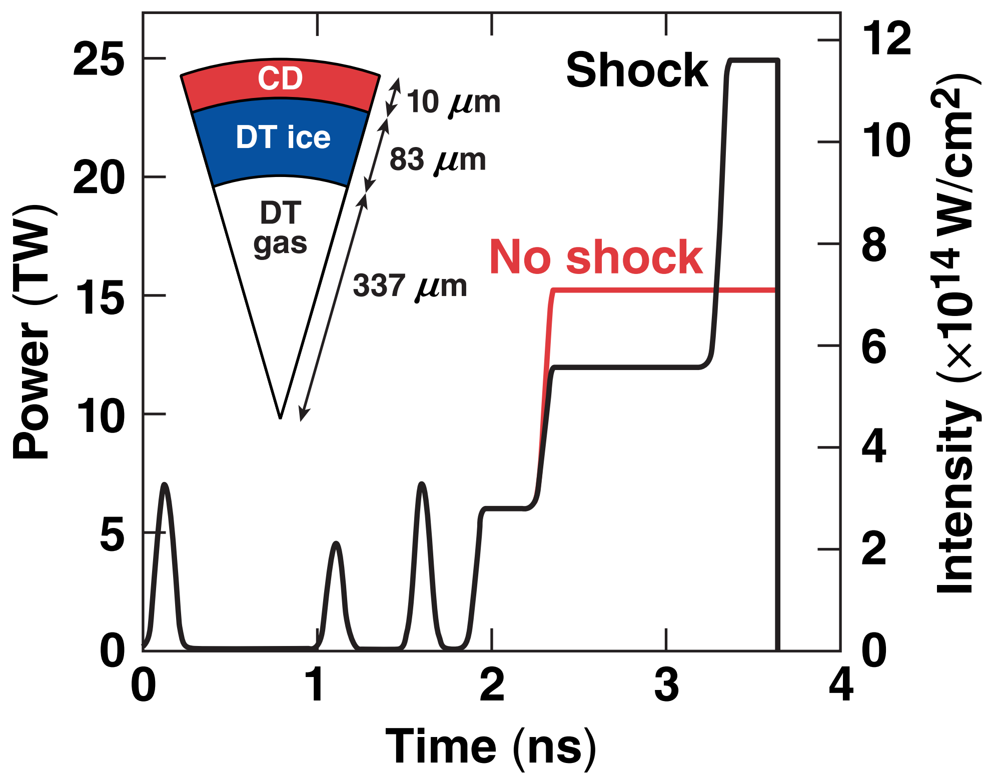
W. Theobald *et al*., Phys. Plasmas 15, 056306 (2008).

# A new triple-picket configuration will provide a better performing and experimentally tunable design*

Switching from a single- to a triple-picket configuration will

- increase the maximum UV laser energy on target
- reduce hydrodynamic instabilities
- allow the adiabat to be experimentally tunable

This design still has a lower than optimal ignitor shock strength

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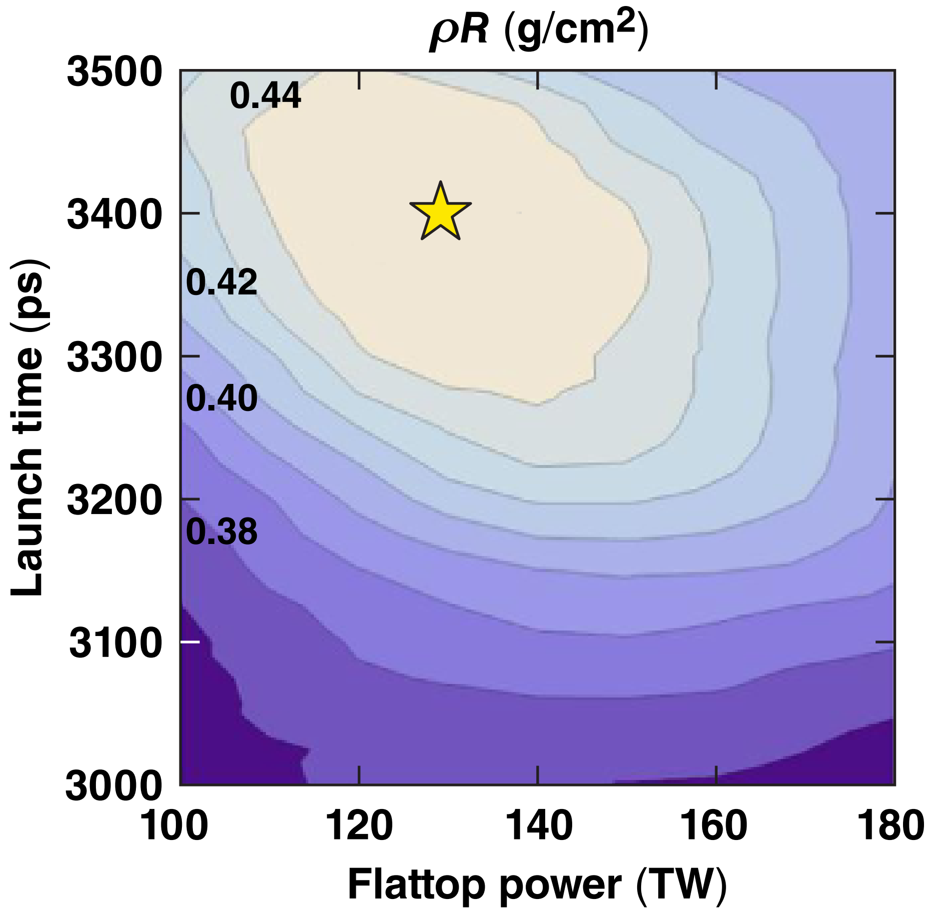
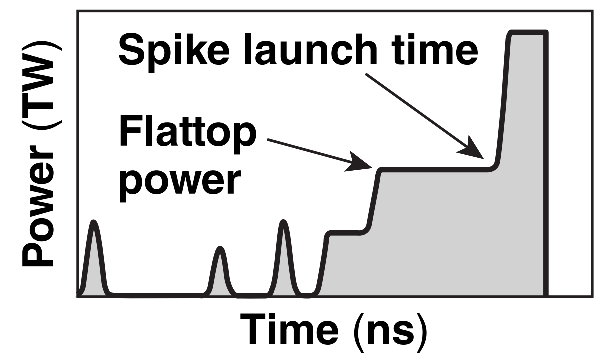
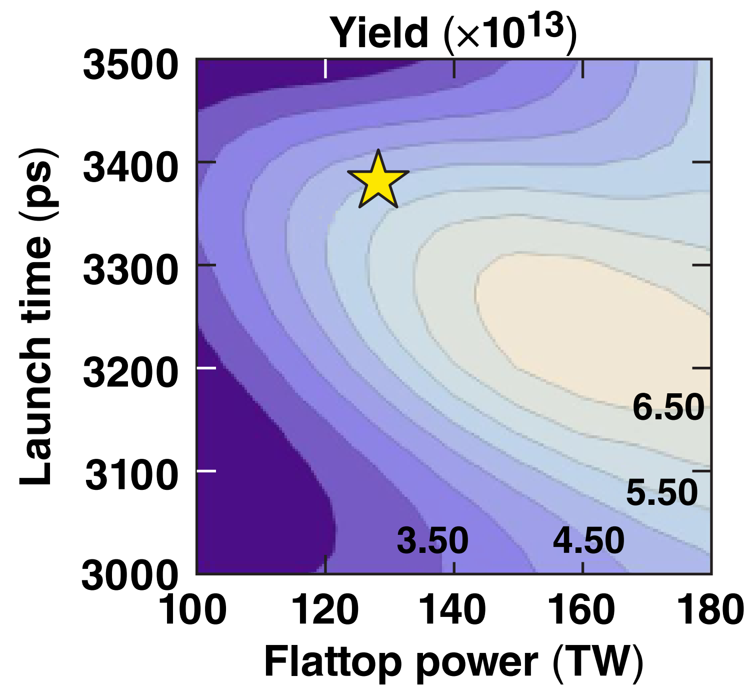
*V. N. Goncharov *et al*., Phys. Rev. Lett. 104, 165001 (2010).

# The triple-picket design is optimized for the OMEGA constraints of 25 kJ and 25 TW






- Design chosen to maximize the areal density

$$\mathrm{ITFX} \sim \chi_{\mathrm{Lawson}}^{2.2} \sim \rho R^2\, Y_n$$

# *DRACO* simulations of the proposed SI design (25 kJ) shows moderately improved performance

<u>Target parameters</u>

$IFAR_{2/3}$: 13

$V_{imp}$: $2.7 \times 10^7$ cm/s

$\alpha_{min}$: 1.7

<u>No shock</u>

1-D yield: $3.6 \times 10^{13}$

YOC: 52%

$\rho R$: 0.40 g/cm$^2$

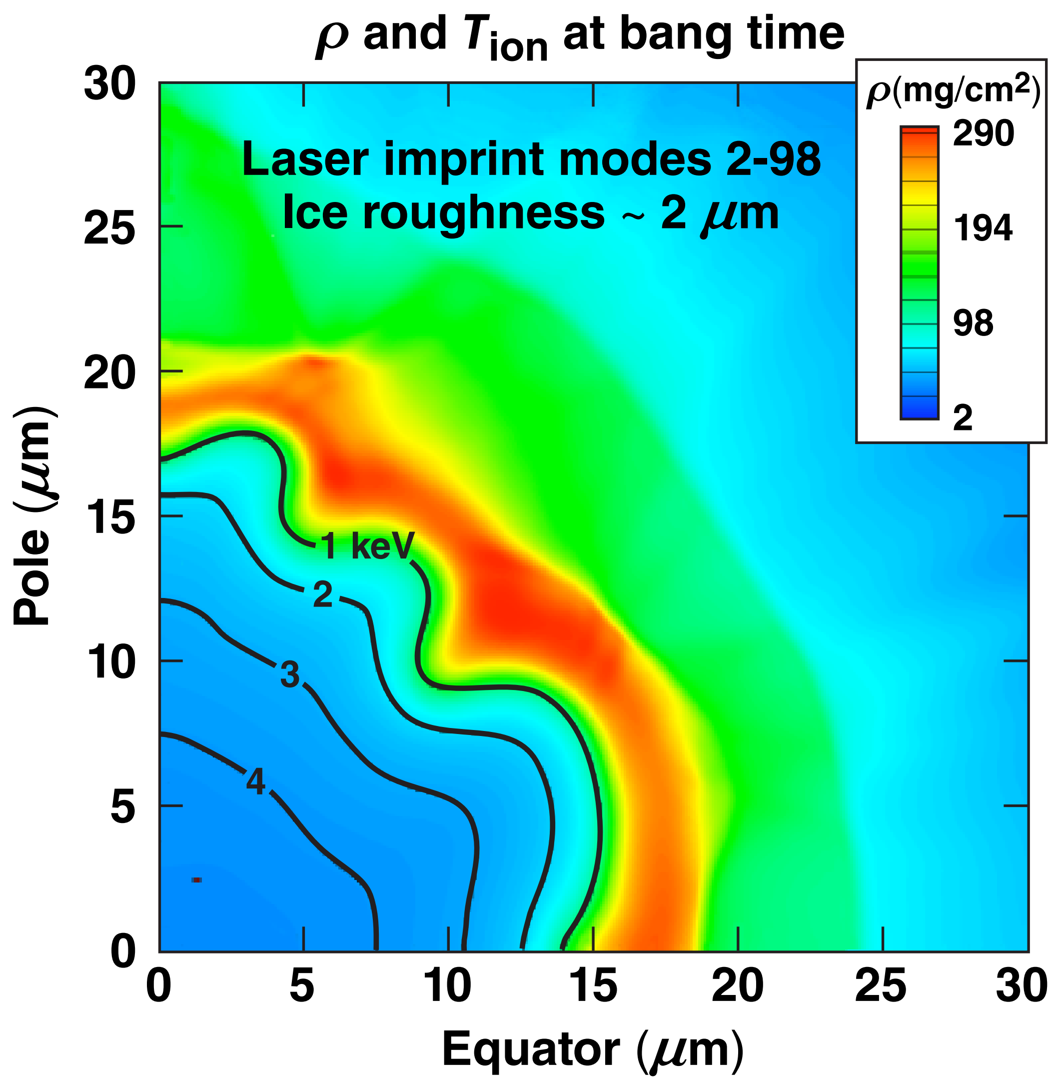
<u>Shock</u>

1-D yield: $5.0 \times 10^{13}$

YOC: 61%

$\rho R$: 0.45 g/cm$^2$

- Simulations do not include beam power imbalance or target offset

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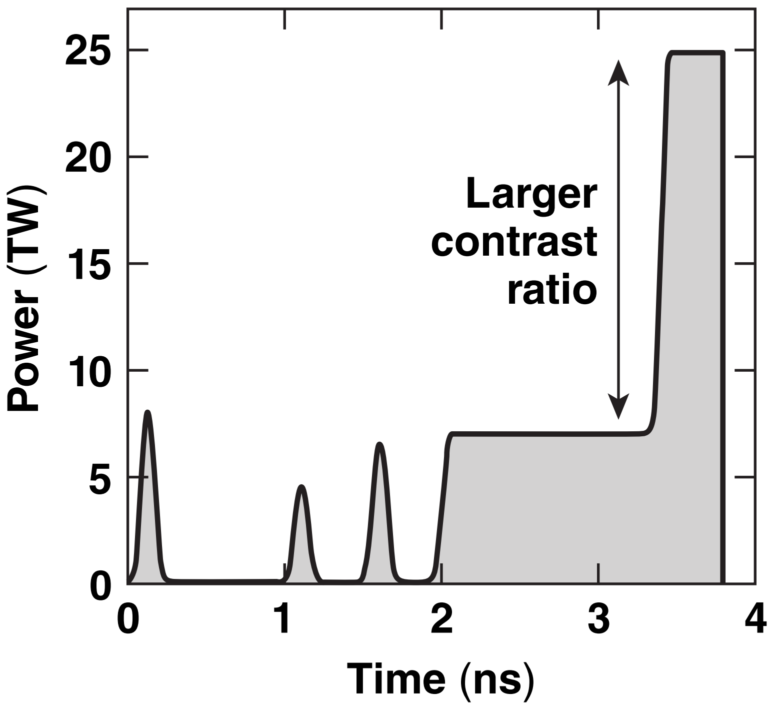
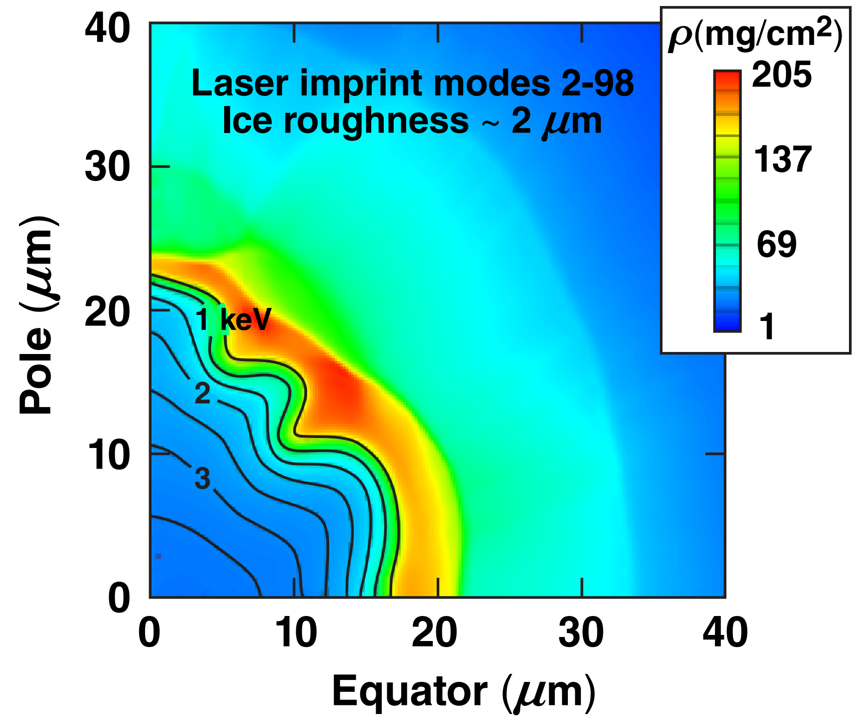
# A second design (21 kJ) with a stronger shock but weaker drive is also under consideration




$\rho$ and $T_{ion}$ at bang time




- Nonpropagating test shot of the previous design predicts a weak ignitor shock
- Reduced but extended drive improves shock strength at the expense of the assembly pulse

*LILAC* yield: $1.71 \times 10^{13}$

YOC: 74%

IFAR: 8

$V_{imp}$: $2.3 \times 10^7$ cm/s

$\rho R$: 0.34 g/cm$^2$

$\alpha_{min}$: 2.0

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Summary/Conclusions

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