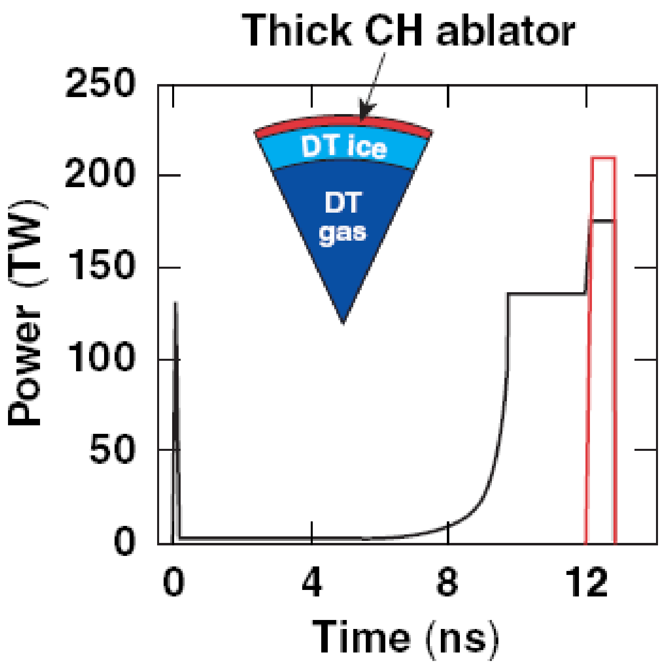
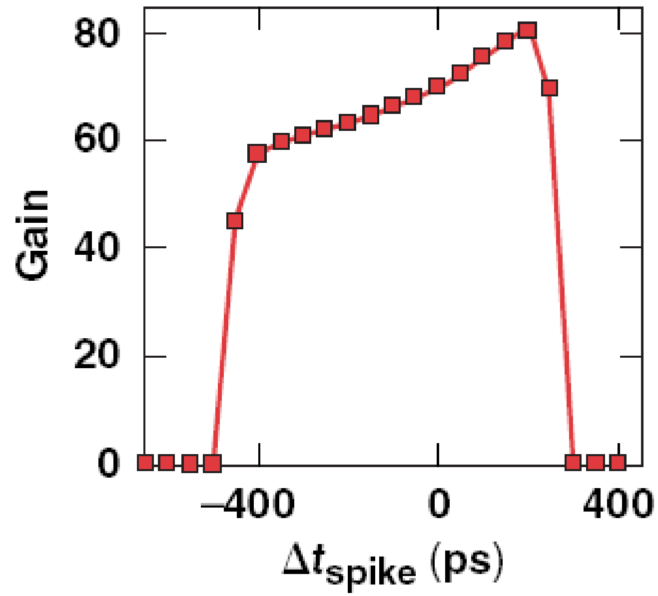
Shock Ignition with Plastic-Ablator Cryogenic Shells on the NIF





K. S. Anderson, *et al.*
University of Rochester
Laboratory for Laser Energetics
Fusion Science Center for Extreme States
of Matter and Fast Ignition

International Workshop
on ICF Shock Ignition
Rochester, NY
8—10 March 2011

Summary

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- Targets are tested for robustness using a 1-D, clean-volume model to determine the minimum yield-over-clean (MYOC) required for ignition.
- Implosions at 600 to 700 kJ are predicted to be robust to
  - Spike pulse mistiming of 700ps.
  - Hot-electron energy deposition in the shell.
  - Ignition threshold factor (ITF) for this target is 3.0.
- 2-D DRACO simulations indicate robustness to rms ice roughness up to 3.5 μm.
- Polar-Drive pointing schemes are currently being investigated in DRACO

Collaborators

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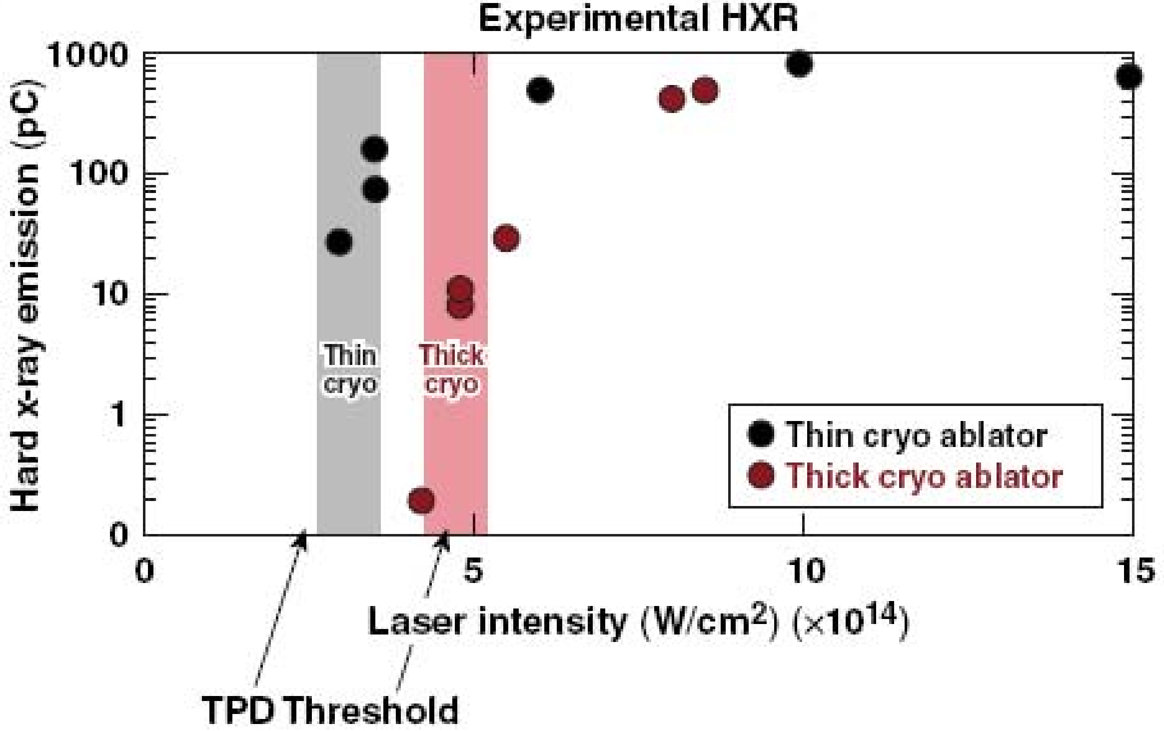
Large hard x-ray signals in OMEGA experiments may indicate preheat from LPI-generated hot electrons

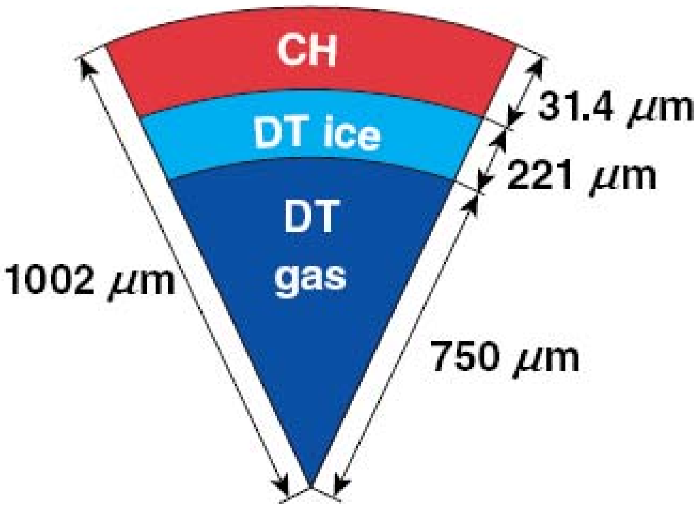


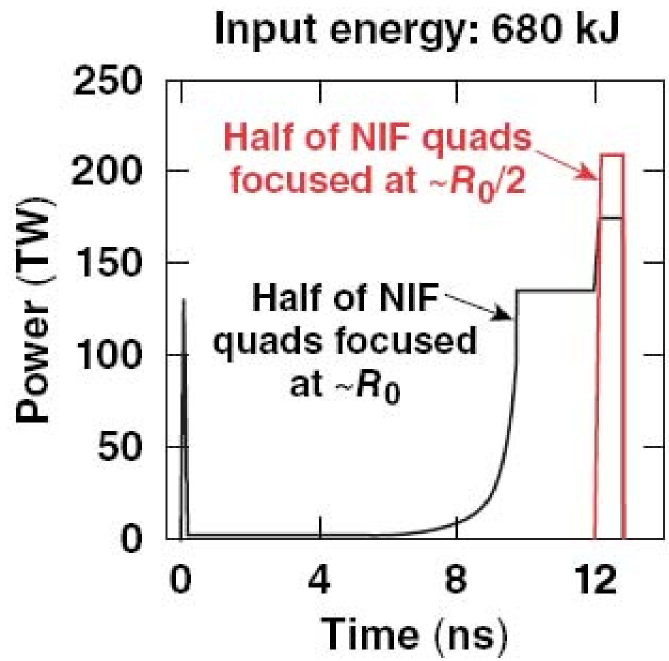
OMEGA implosions with thick plastic ablators produce fewer hard x rays from hot electrons.

TC8036f

A. V. Maximov *et al.*, Bull. Am. Phys. Soc. 52, 195 (2007).

A thick plastic-ablator shock-ignition target for the NIF has been designed using existing NIF phase plates





Gain (1-D)	70
ρR (g/cm^2)	2.6
V_{imp} (μm/ns)	300
$IFAR_{2/3}$	30

$$IFAR_{2/3} = \frac{R}{\Delta R} \text{ at } R = \frac{2}{3}R_0$$

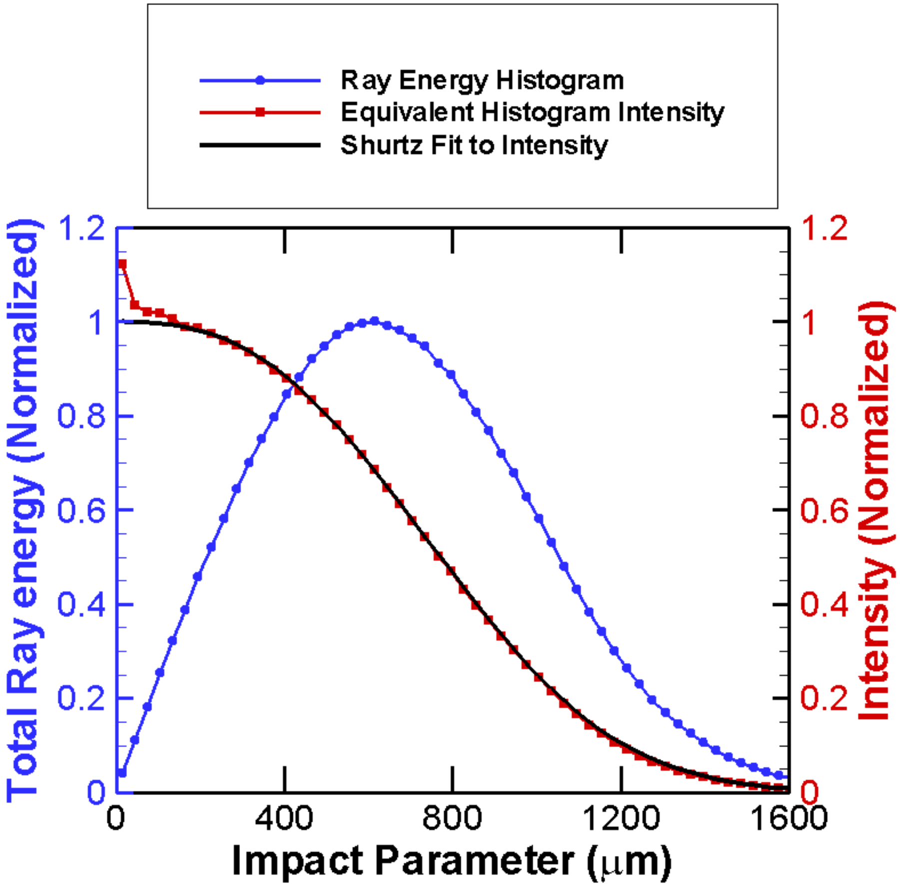
1-D beam profiles approximate polar drive.

TC9109

In one dimension, polar drive energy losses are approximated by using a fit to 3-D ray histogram of ray impact parameters

- Ray energy is binned using a 3-D raytrace in SAGE*
- NIF indirect-drive phase plates were used with defocusing
- Fit function is given by†

$$I(r) = I_0 e^{-(r/885)^{2.66}}$$



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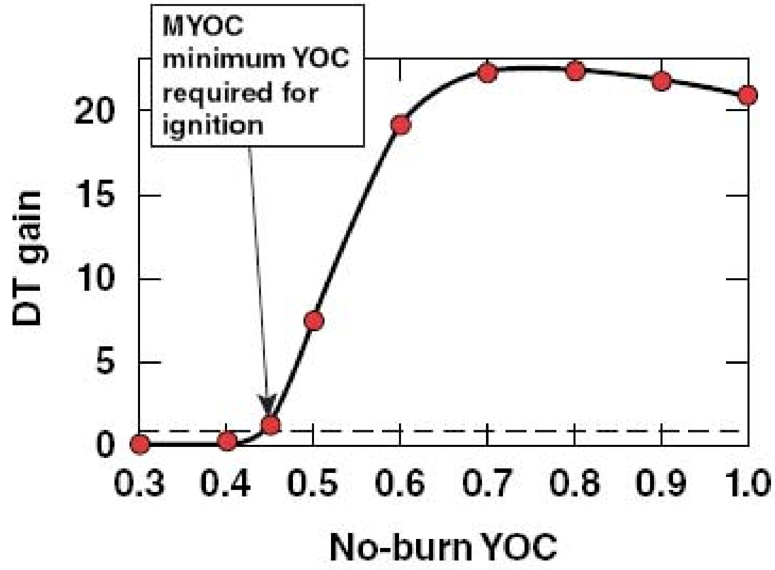
*R. S. Craxton

†G. Schurtz

The 1-D ignition-threshold factor (ITF) can be calculated from the minimum yield-over-clean (MYOC) required for ignition

- Varying the YOC† as an input parameter, one finds the minimum YOC required for ignition



†YOC for non-igniting targets is controlled by modifying <σv>

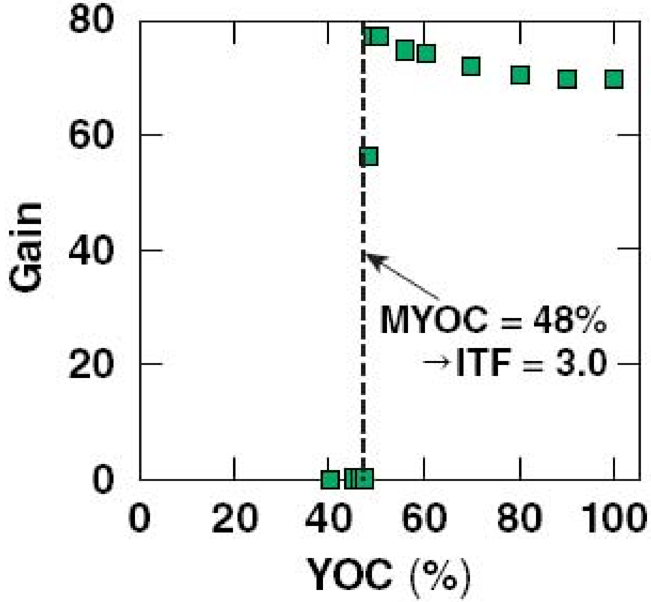
$$\mathrm{ITF\,(1\text{-}D)} = \frac{1}{\mathrm{MYOC}^{1.5}}$$

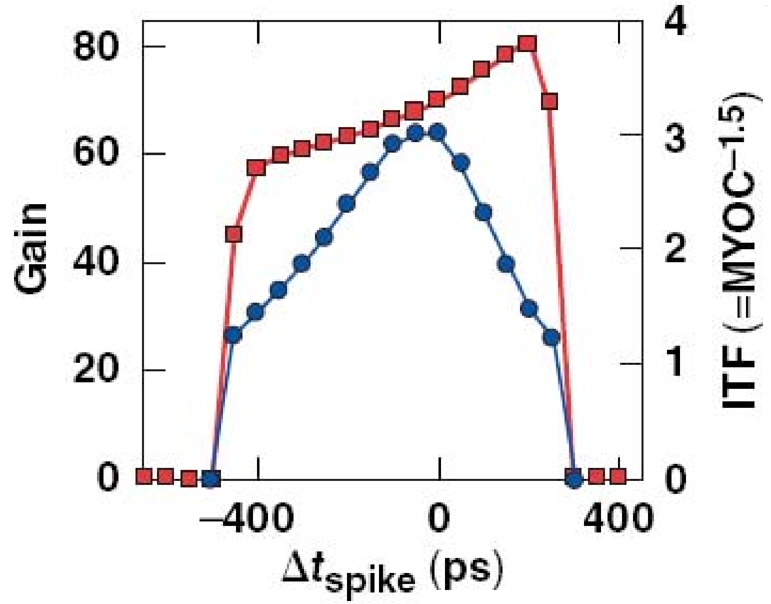
- 2-D *DRACO* simulations have validated this model for other designs*

*K. S. Anderson *et al*., Bull. Am. Phys. Soc. 54, 306 (2009).
P. Chang, K. Anderson, and R. Betti, Bull. Am. Phys. Soc. 54, 260 (2009).

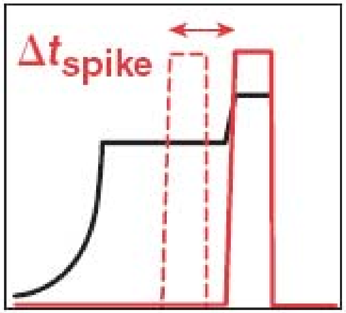
TC8570a

Plastic-ablator shock-ignition targets are robust to shock timing and reduced clean volumes





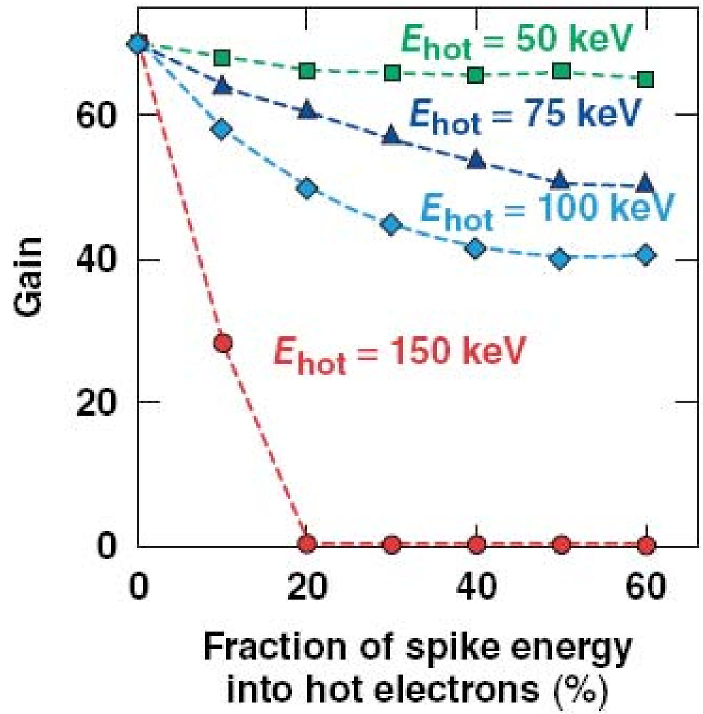
ITF for indirect-drive point design* is ~5.3 (MYOC = 33%) at 1 MJ.



*J. Lindl, presented to the JASON Review Committee Study #JSR-09-330, San Diego, CA, 14–16 January 2009.

TC9110

The plastic-ablator SI design is robust to hot electrons up to 100 keV at 60% of laser energy during the spike pulse

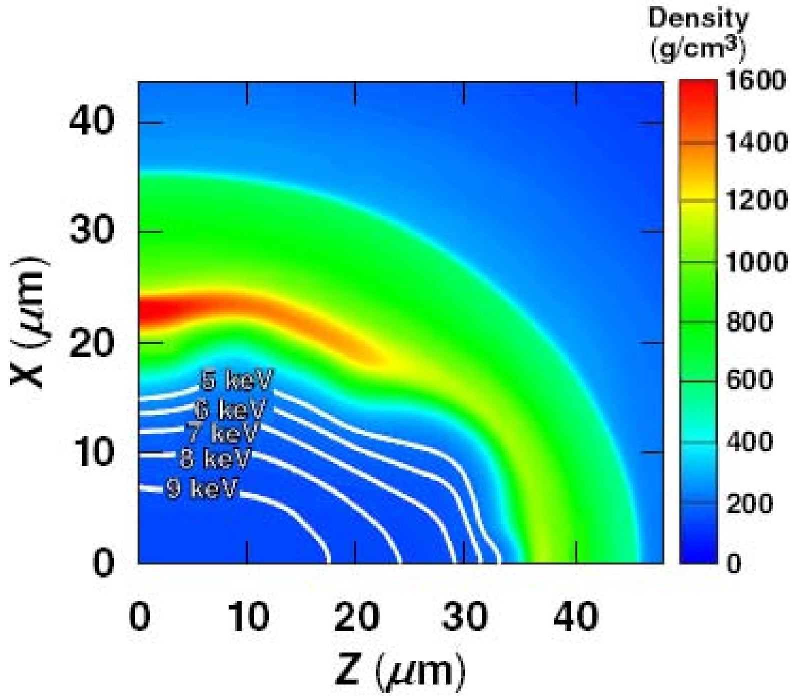


- Straight-line hot-electron-transport model by A. A. Solodov
- Future work will investigate hot-electron transport during the main pulse

TC9111

Symmetric 2-D *DRACO* simulations performed with similar targets indicate robustness to ice roughness >3.5-μm rms

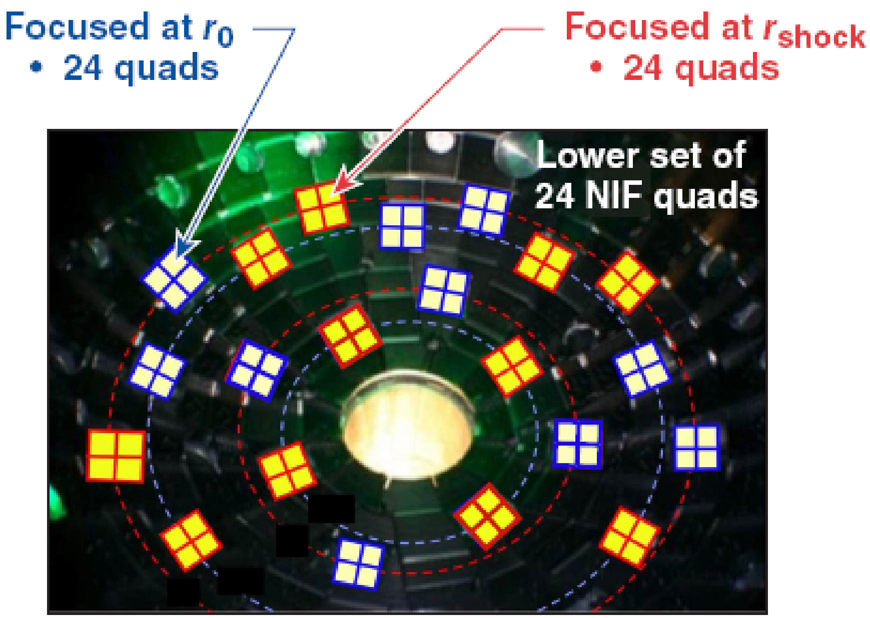
- Symmetric laser irradiation
- *DRACO* simulations with 3.5-μm-rms roughness in modes ℓ = 2 to 50
- Target ignites with full gain
- Upper limit on robustness to ice modes not yet explored
- Other nonuniformity studies to follow (imprint, target offset, polar drive, etc.)



TC9112

Beam pointing schemes are being explored for Polar Drive Shock Ignition on the NIF

- **Focusing separate shock beams at a smaller radius late in time allows better coupling of energy to the target.**
- **A scheme with split quads would allow best irradiation uniformity on target, but requires time-consuming "rewiring" of NIF seed pulses.**
- **Another scheme employing full quads, half for the main drive and half for the shock pulse was recently proposed* by Steve Craxton**



*Craxton, et al., APS-DPP 2010

Current beam pointings uses ring 1 for the main drive, ring 2 for the spike, and divides quads in rings 3 and 4 between the main drive and spike.

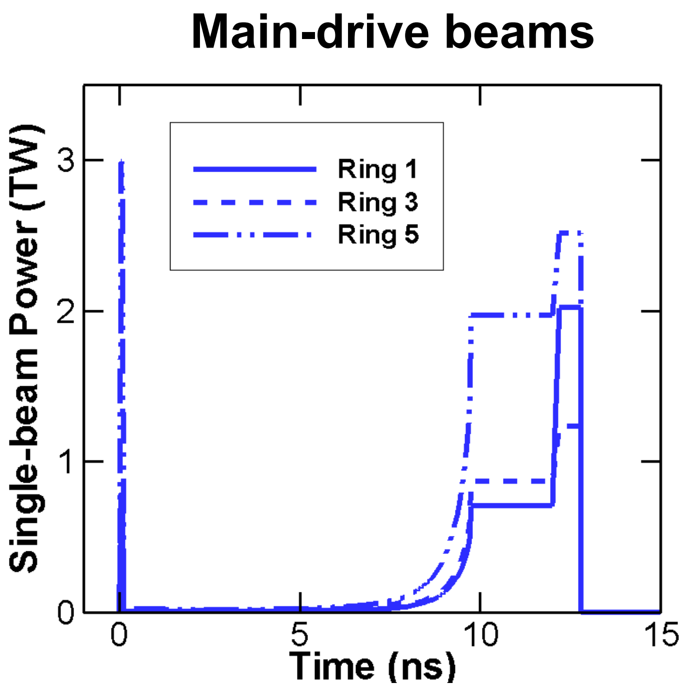
		Pointing Angles	
	Port Angle (θ)	Main	Spike
Ring 1	23.5	24.5	
Ring 2	30.0		30.0
Ring 3	44.5	47.0	50.0
Ring 4	50.0	79.0	75.0

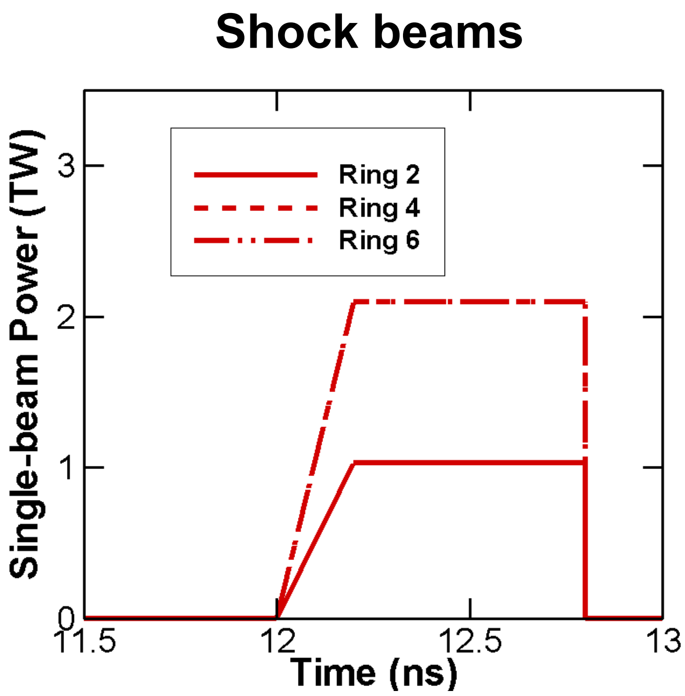
- **Phase plates for rings 1, 2 and 3, are circular spots; Ring 4 is a convolution of a circular and elliptical spot***

DRACO simulations are continually refining these pointings to improve uniformity

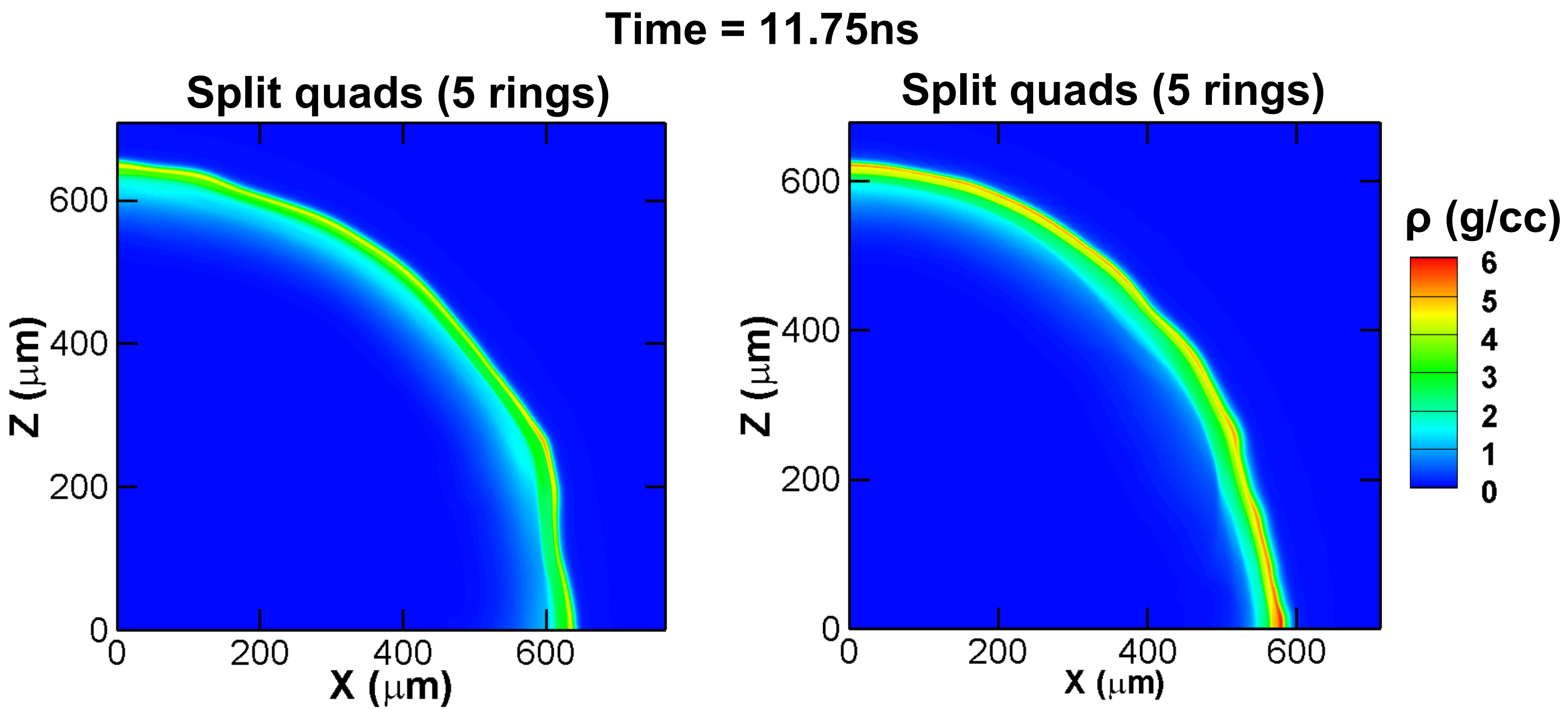
*see T. J. B. Collins' talk tomorrow

Preliminary DRACO Polar-Drive Shock-Ignition simulations use six pulseshapes, three for compression and three for the shock pulse





Preliminary DRACO Polar-Drive Shock-Ignition simulations indicate reasonable uniformity, but refinements are needed



Laser imprint studies are also in progress

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