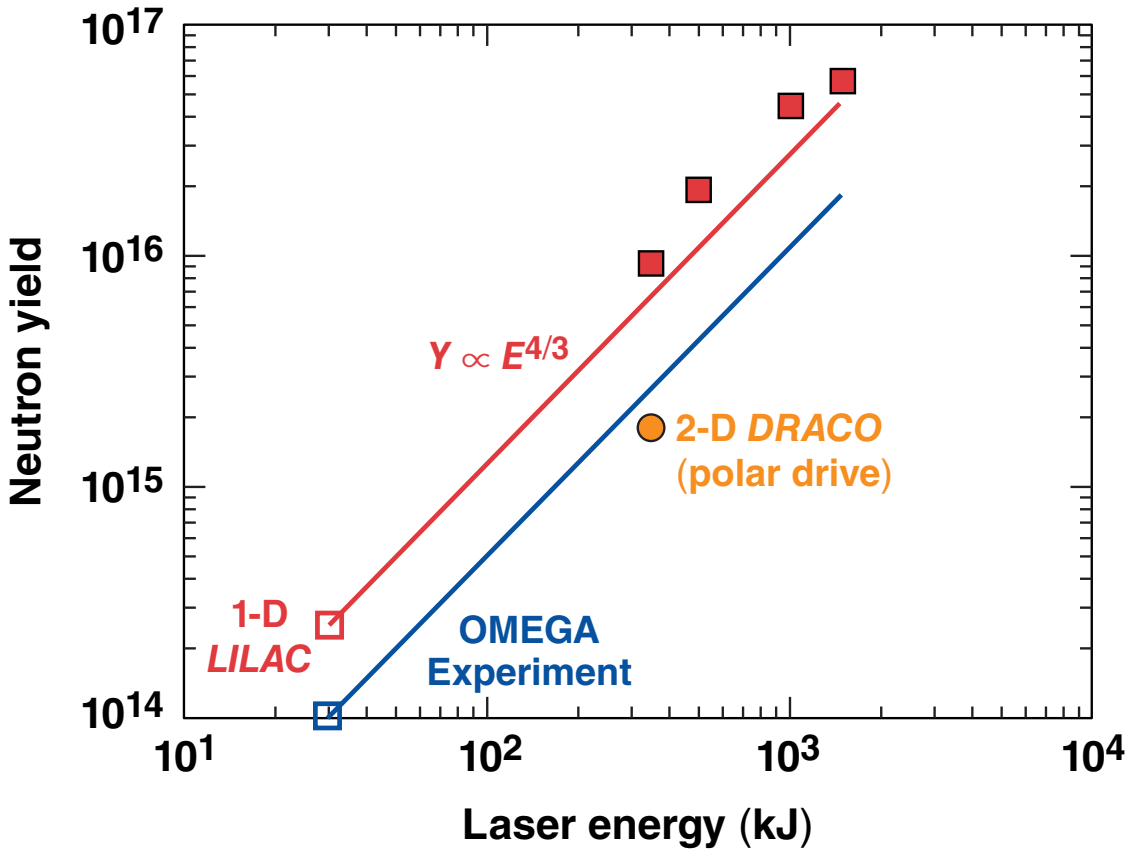
Simulations of Polar-Drive NIF Targets Optimized for High Neutron Yields



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Summary

Polar-drive designs meet the neutron diagnostic development requirement for the NIF

UR LLE

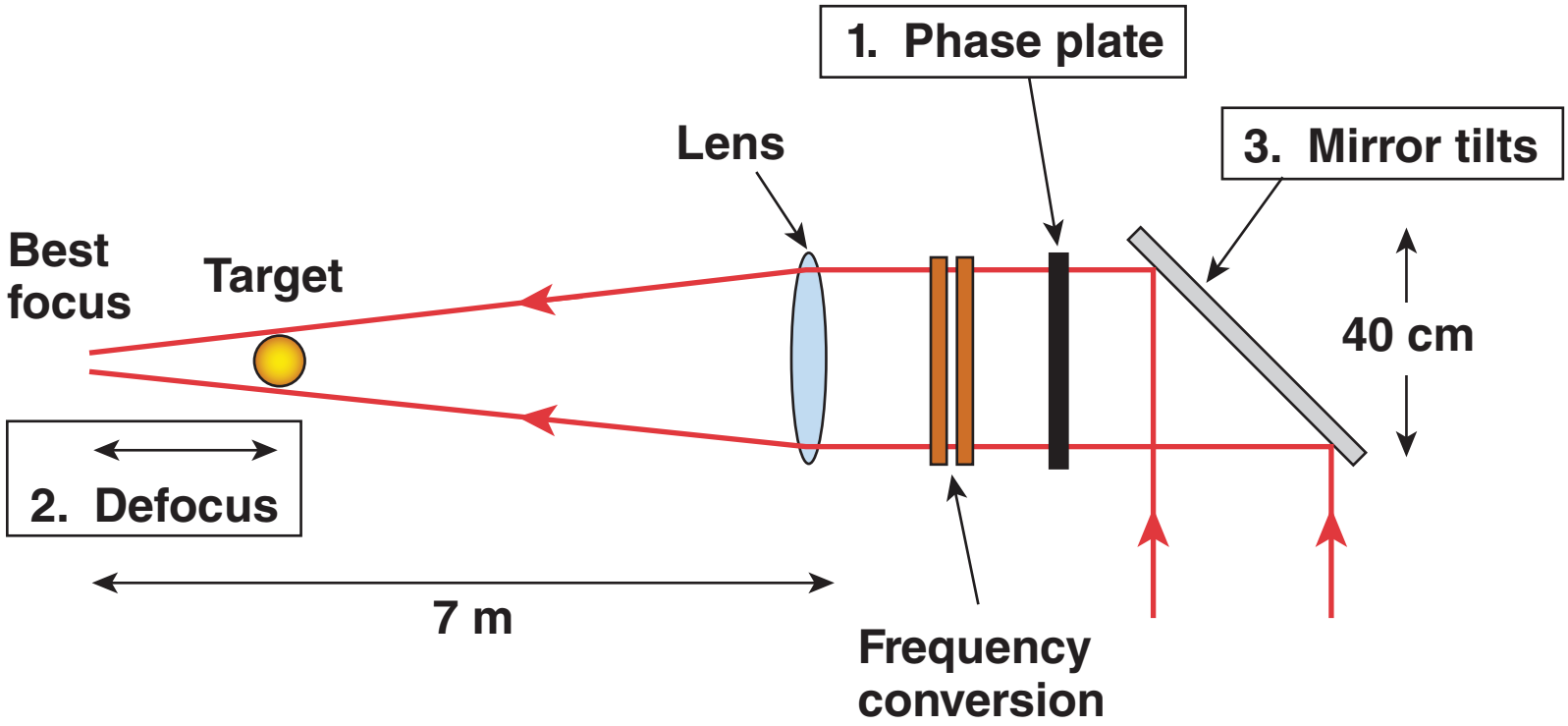
- High neutron yields are produced from room-temperature targets
- Uniform drive is possible using existing NIF hardware
  - defocus the beams
  - repoint the beams
  - spread the beams within a quad
- The designs are insensitive to the phase-plate details but sensitive to the ablator material
- Yields around 10^{16} are expected for 1-MJ laser energy

Three hydrodynamic codes are being used to develop the designs

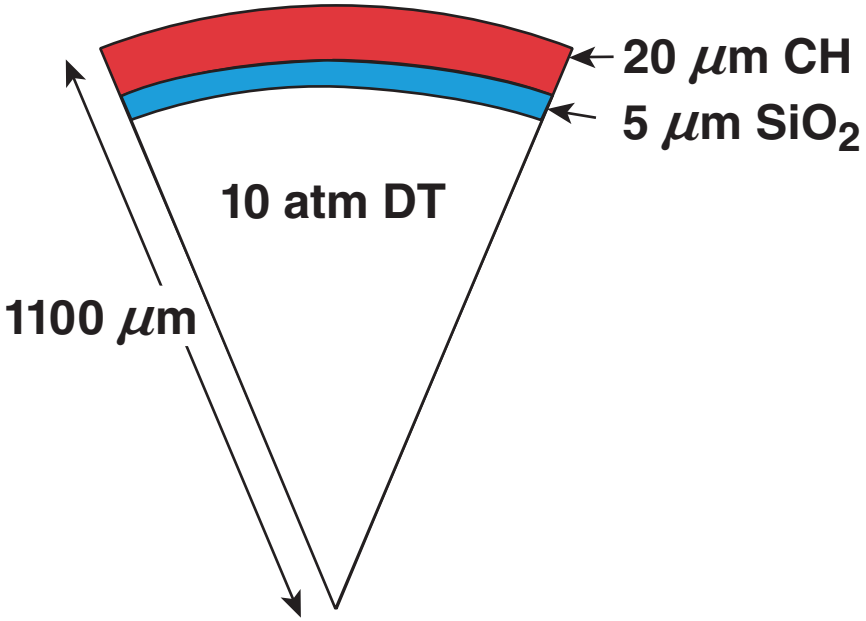
UR LLE

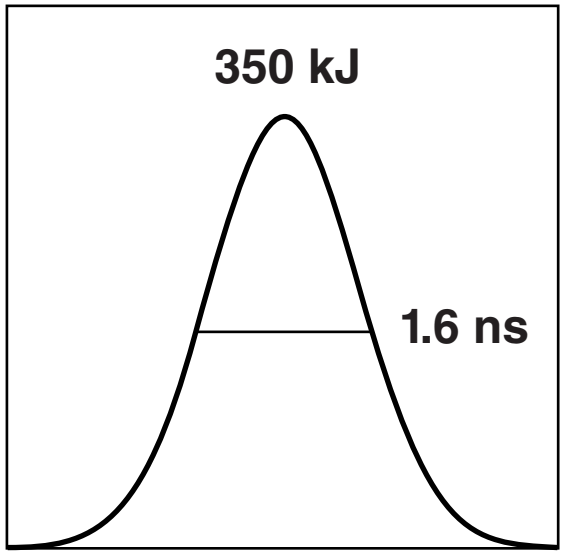
- *SAGE* is used to identify uniform irradiation conditions
- *LILAC* is used to optimize the 1-D design
  - from 350 kJ to 1.5 MJ
- *DRACO* is used for full 2-D simulations
  - initially focus on 350 kJ

The polar-drive designs use only readily available capabilities on the NIF



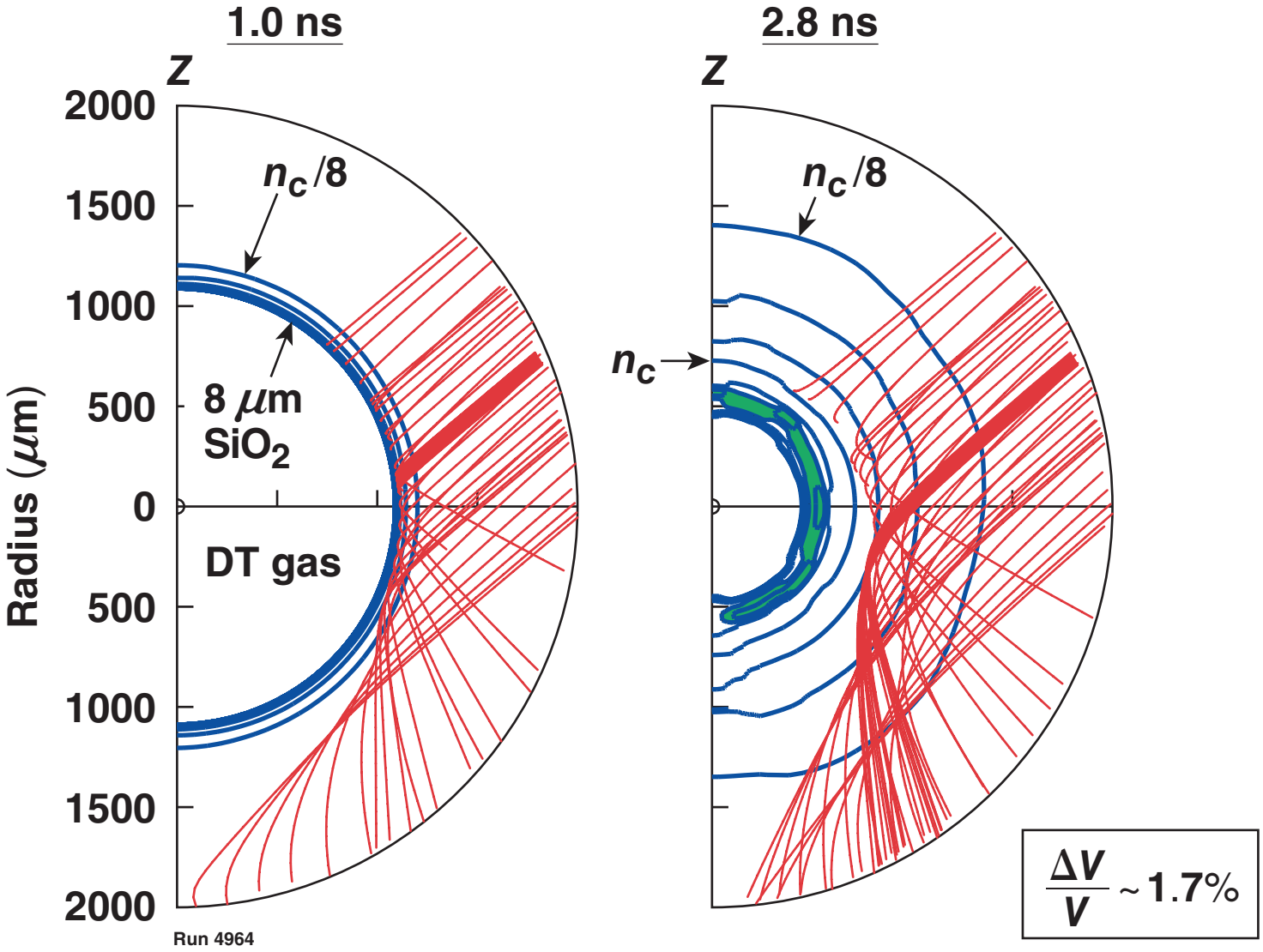
The designs use thin-shell targets irradiated with short laser pulses





For higher energy E, scale radius and time as $E^{1/3}$.

The shell implodes with a high degree of uniformity

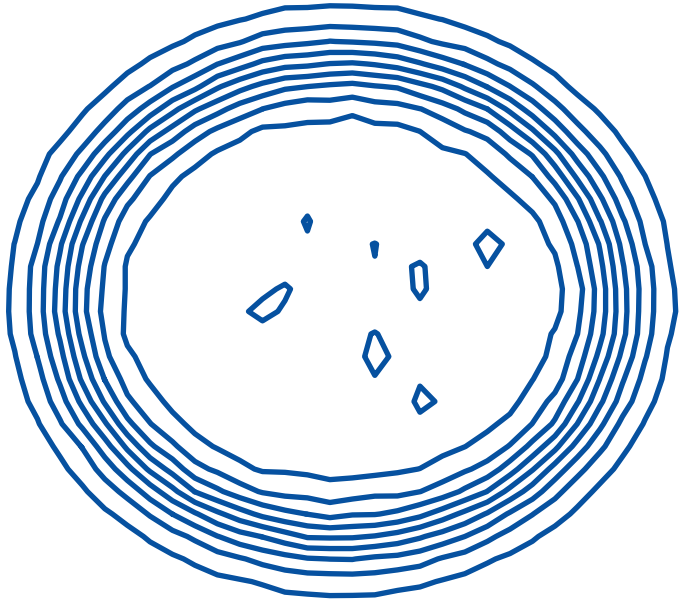


TC7885

The original and Rev. 1 inner-cone designs are significantly different

UR LLE

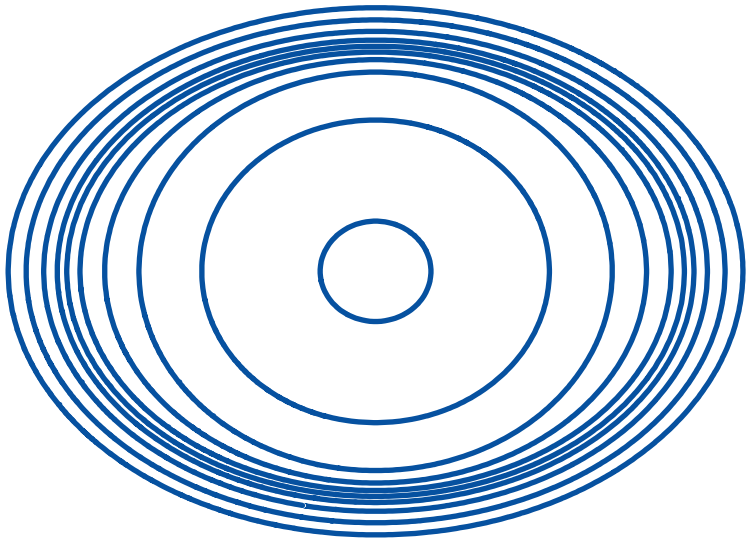
Original
(a, b) = (739, 636) μm



1.0 mm

D. Munro "Scoping model"

Rev. 1
(a, b) = (824, 590) μm



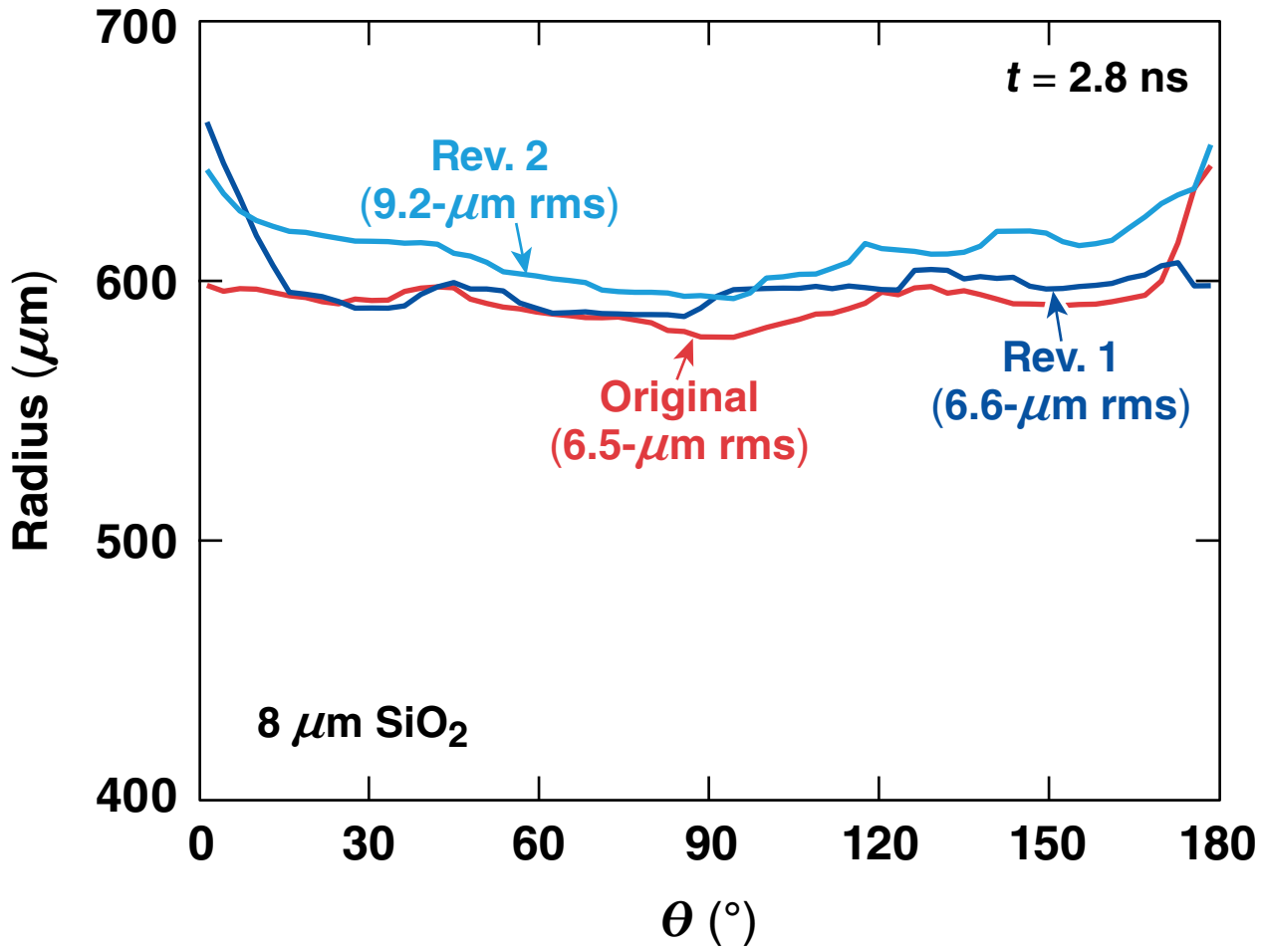
1.0 mm

D. Munro "Ellipse model"

Sub 41, Sub 42

TC8157

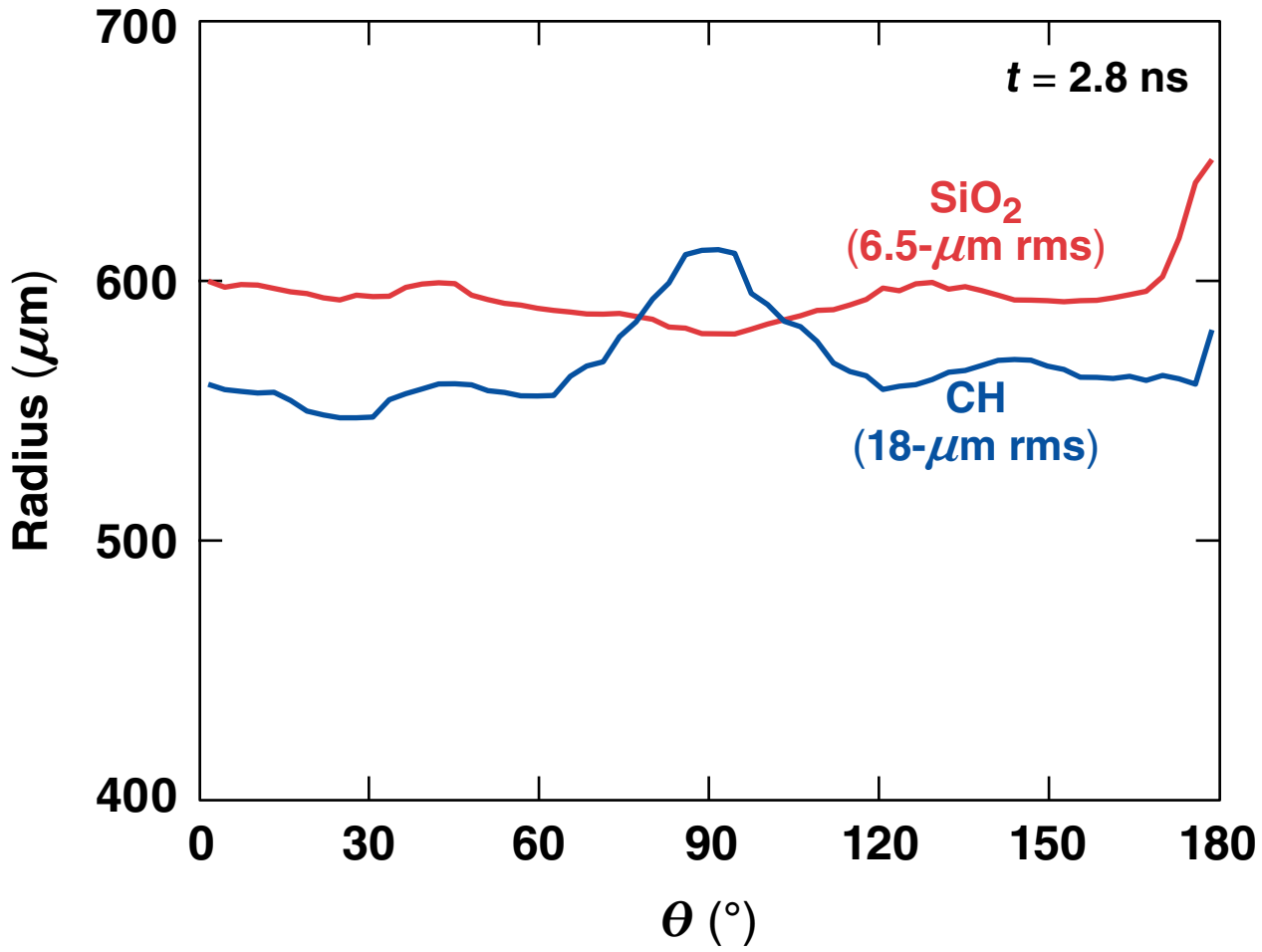
Substituting the Rev. 1 or Rev. 2 phase plates in the original design makes little difference to uniformity



Runs 4964,5030,5031

TC8158

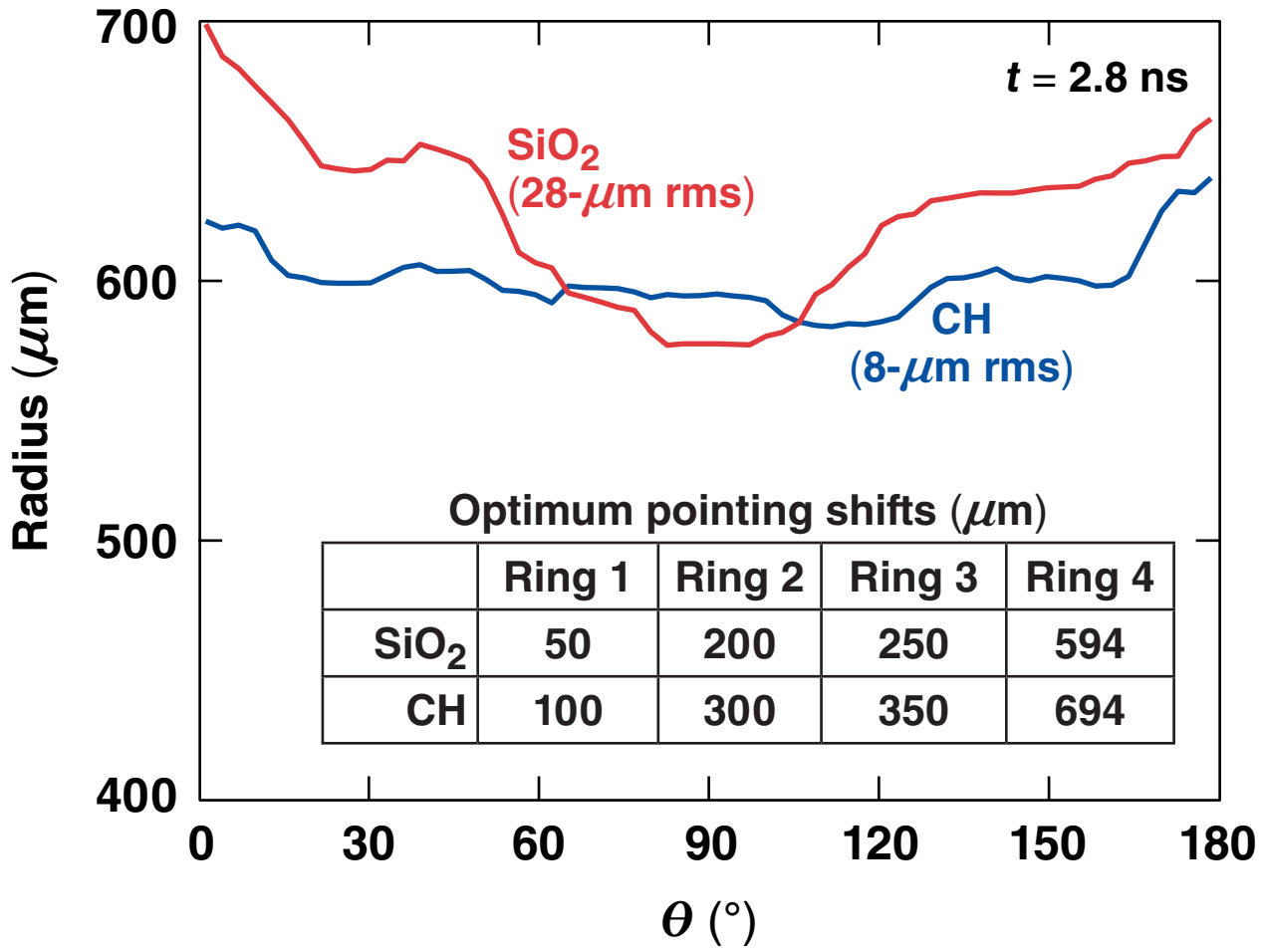
With the beam pointings optimized for SiO_2, a CH target with equivalent mass is underdriven at the equator



Runs 4964,5157

TC8159

The beam pointings can be adjusted to be optimum for CH



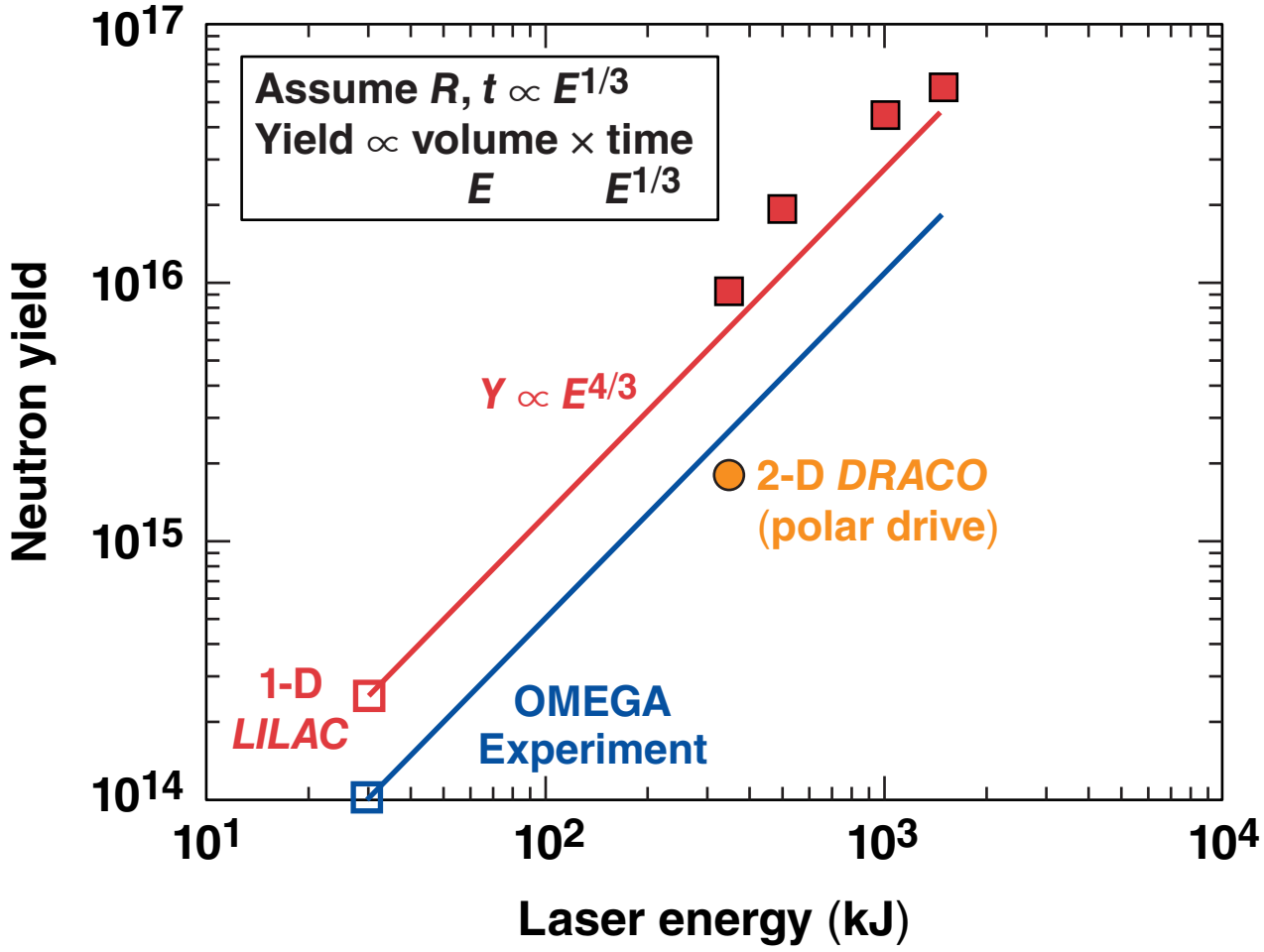
Optimum pointing shifts (μm)

	Ring 1	Ring 2	Ring 3	Ring 4
SiO_2	50	200	250	594
CH	100	300	350	694

Runs 5110,5152

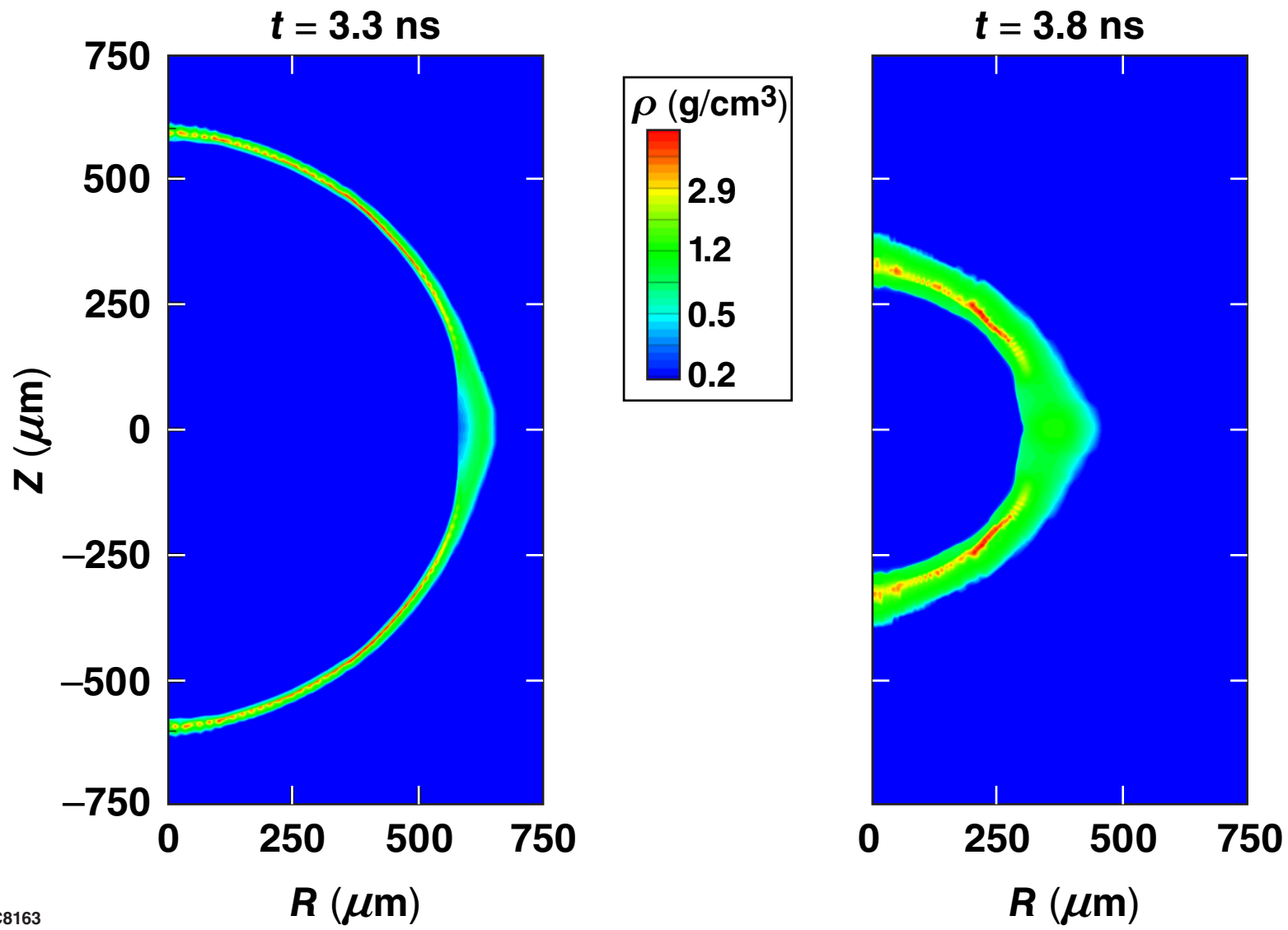
TC8160

The anticipated yields are consistent with OMEGA results and a very simple scaling model



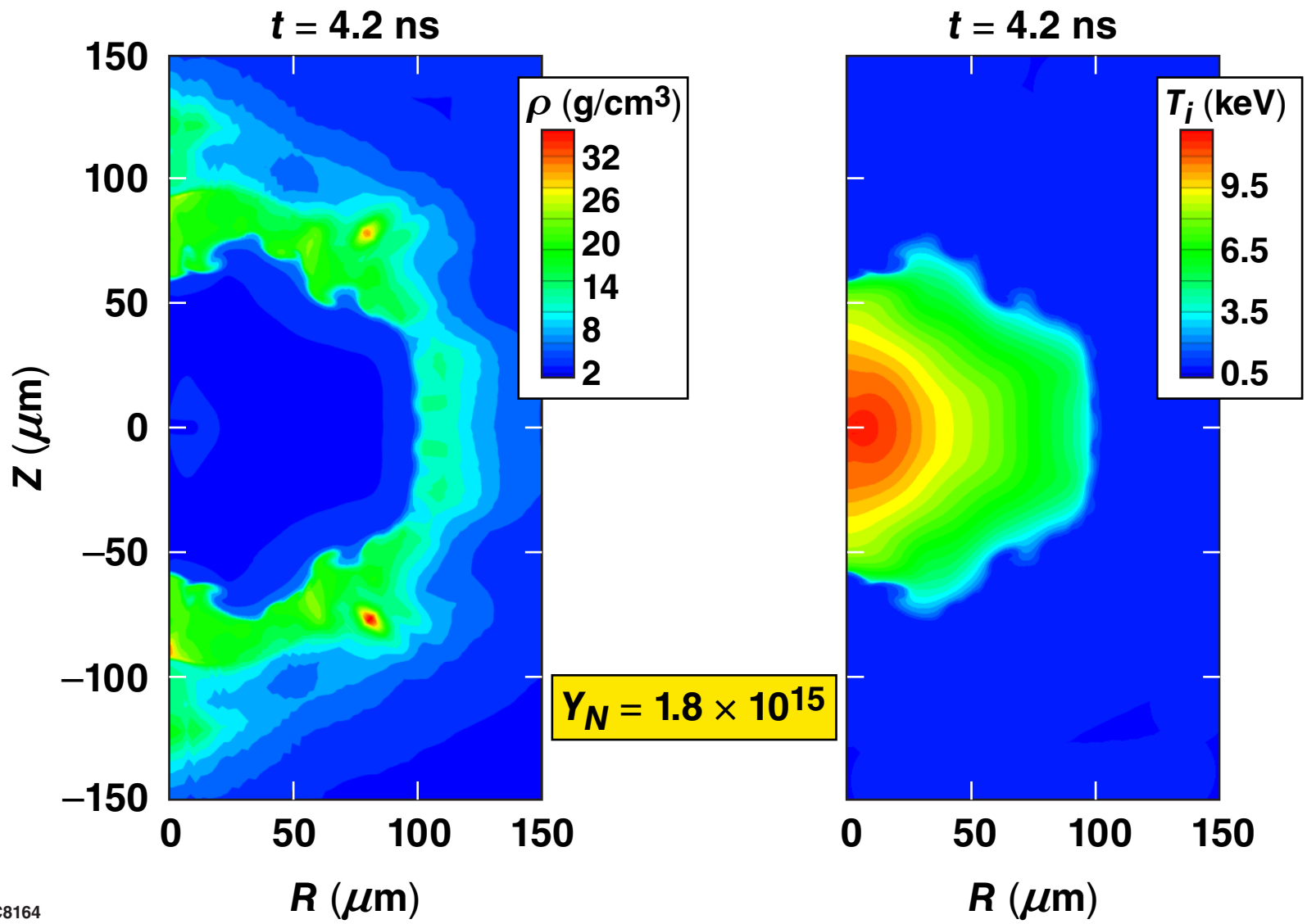
TC8162

The 2-D *DRACO* simulation shows a fairly uniform implosion but with a weaker drive at the equator



TC8163

At peak neutron production the shell is nonuniform but there is a region of ~10-keV ion temperature



TC8164

Summary/Conclusions

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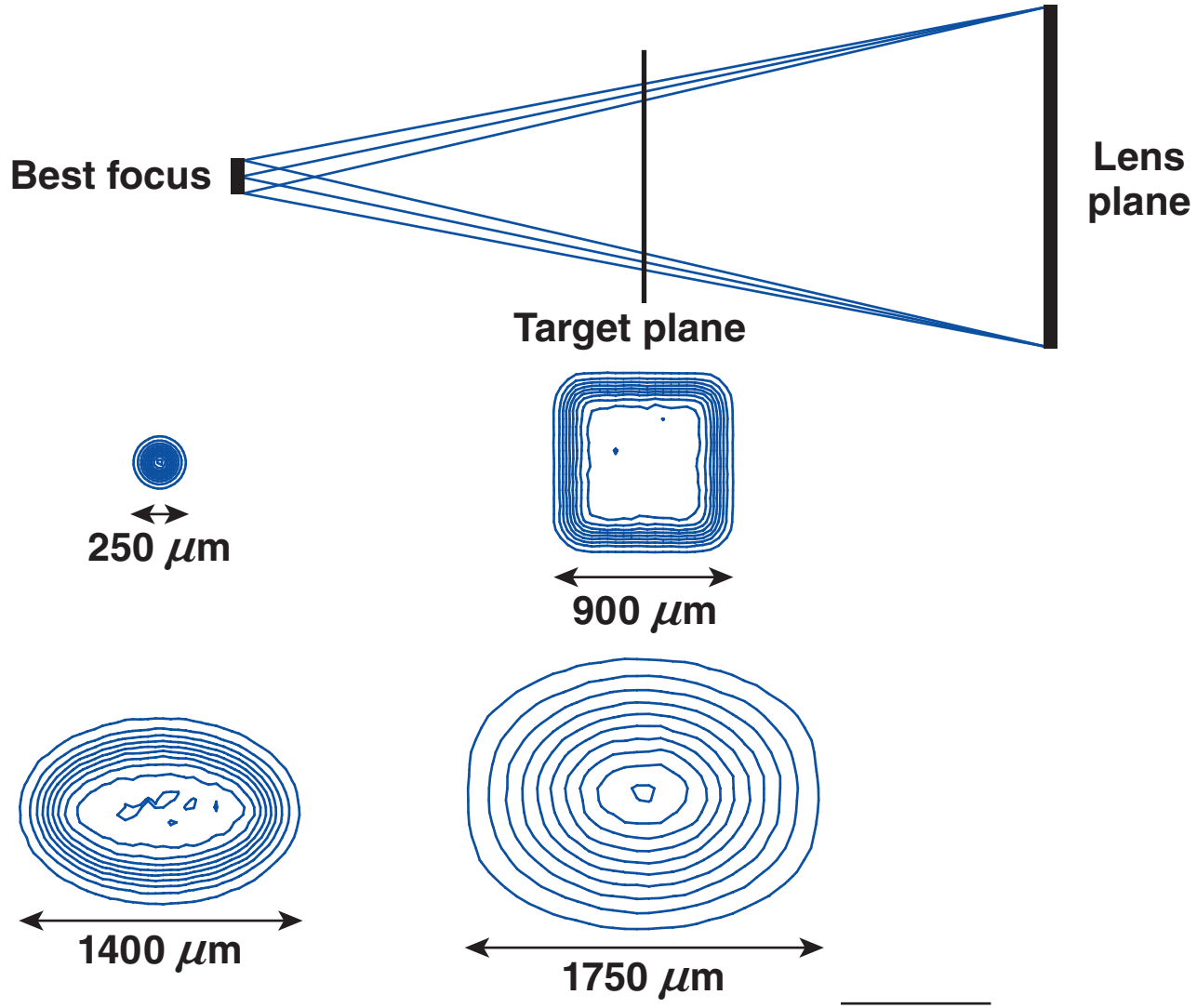
Focal distributions are calculated using a simple geometrical-optics model



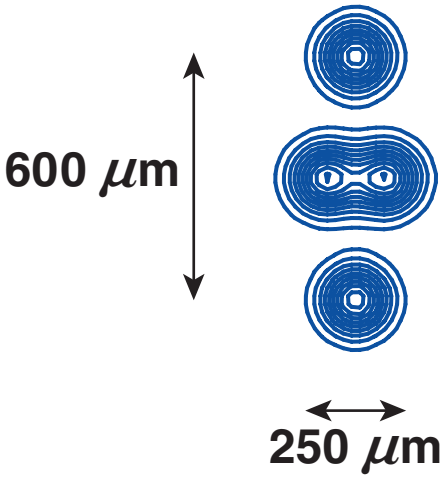
*D. Munro parameterization

TC7884

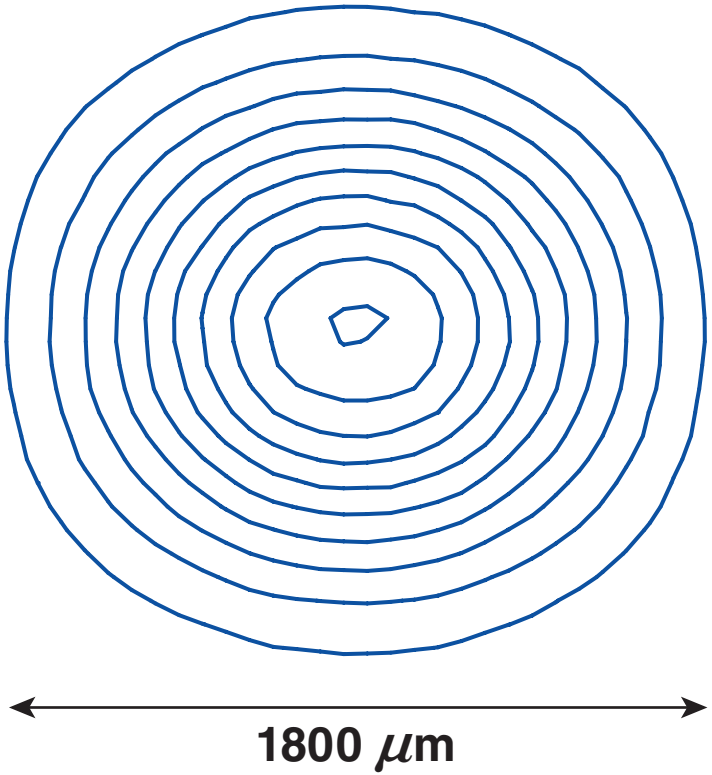
More-spatially broadened target-plane profiles can be obtained using split-quad focusing*

UR LLE

No phase plate, best focus



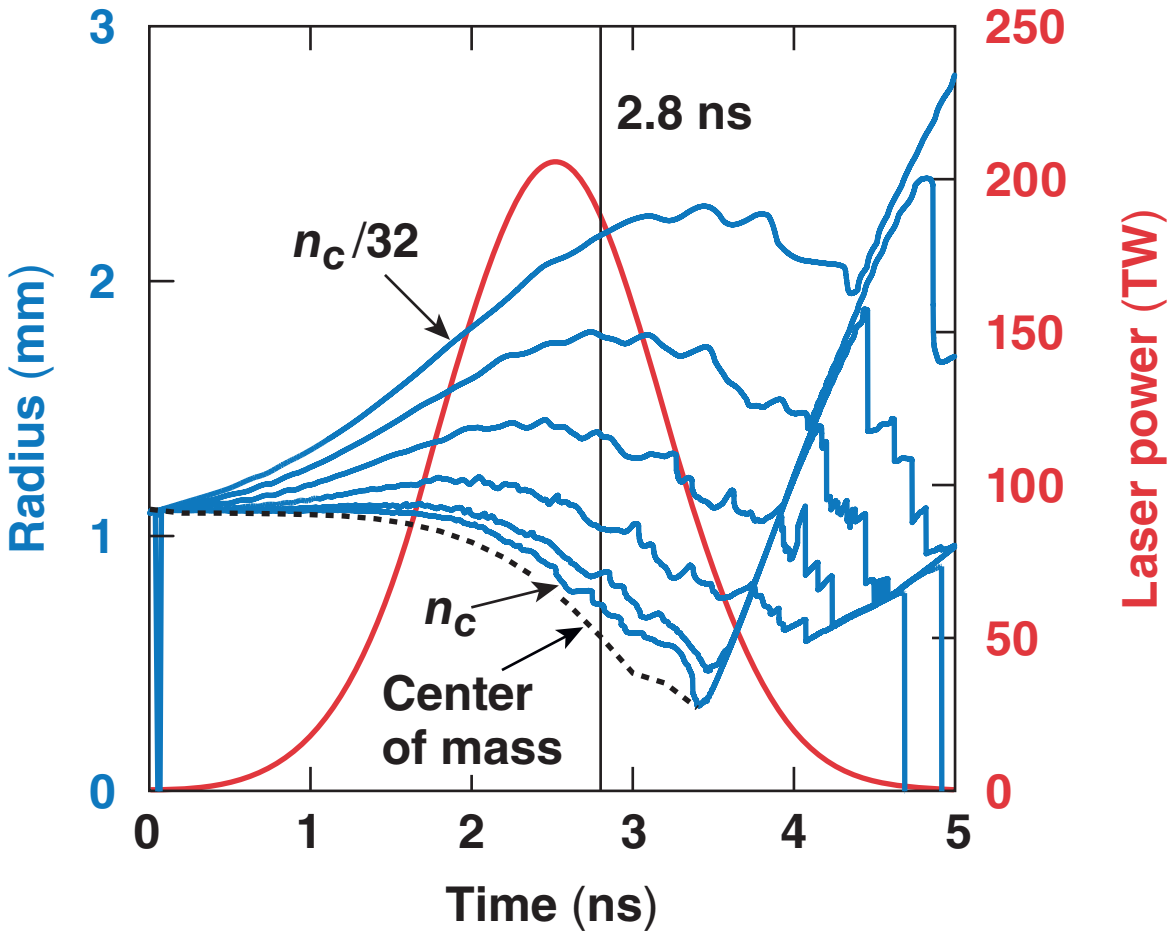
Phase plate, defocused



TC7884a

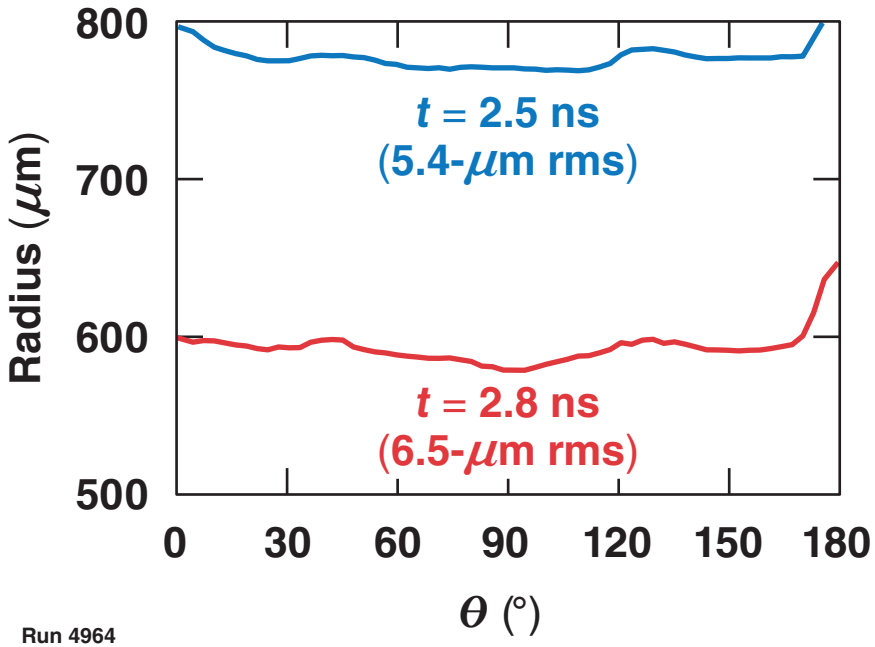
*Suggested by E. Moses

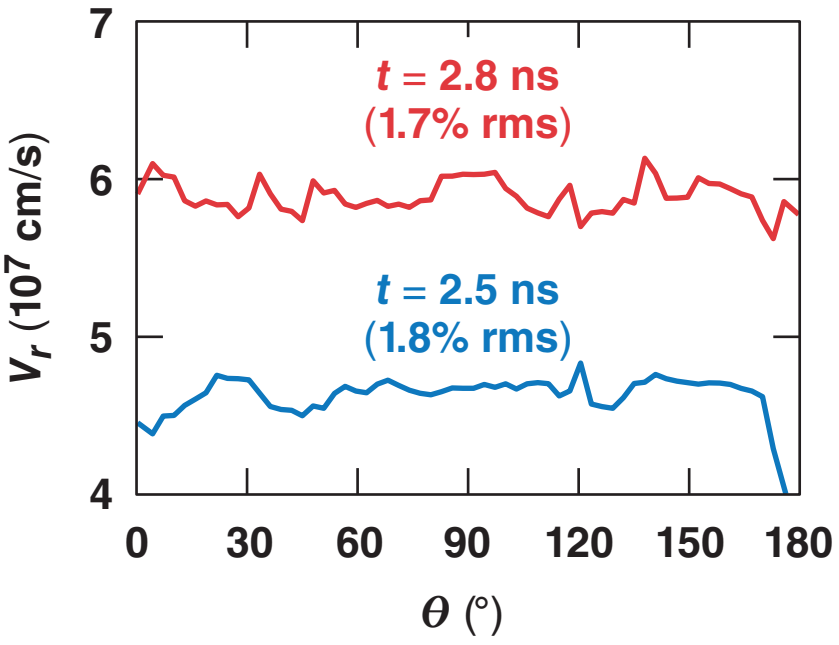
The 350-kJ design is diagnosed at 2.8 ns, just before peak neutron production



E15384

At 2.8 ns the center-of-mass radius is 600±6.5 μm and its velocity is 6 × 10^7 cm/s ±1.7%





Run 4964

TC7886

The final NIF phase-plate design is uncertain

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Outer cone

Profile #	(a, b) μm	
1	(593, 343)	Original*
5	(593, 343)	Rev. 1 (300 eV)*
7	(697, 403)	Rev. 2 (285 eV)

Inner cone

Profile #	(a, b) μm	
3	(739, 636)	Original
6	(824, 590)	Rev. 1 (300 eV)
8	(968, 693)	Rev. 2 (285 eV)

*Under fabrication