Optimization of Uniformity for Current Polar-Direct-Drive Implosion Experiments at the National Igintion Facility

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Summary

Two new designs have been developed to improve polar-direct-drive uniformity at the National Ignition Facility (NIF)

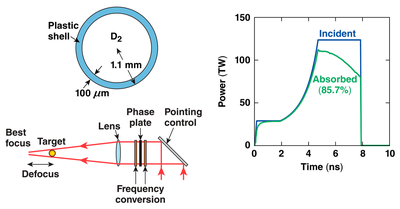
- Self-emission and x-ray backlighting images of current polar-direct-drive implosions show deviations from uniformity
- The "defocused" design uses larger defocuses and slight changes in aim point from the current design, improving the center-of-mass rms nonuniformity from 1.30% to 0.64%
- The "oblique" design uses large pointing shifts for all beams to compensate for the imprint caused by laser speckle, giving a nonuniformity of 0.57%

Both new designs are straightforward to test on the NIF.

TC12089

Current Experments

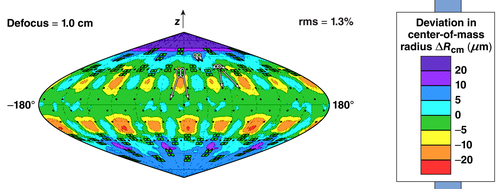
Thick plastic shells are imploded using a shaped laser pulse



Run G1001
TC12091

Current Design

The current NIF design uses a small defocus for all beams

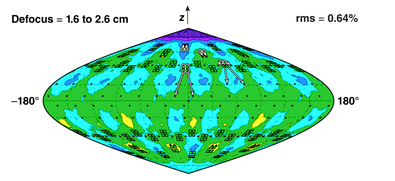


- The dominant nonuniformity is an azimuthal mode around $\theta = 60°$

Run G1001
TC12094

Defocused Design

The defocused design uses larger defocuses to improve uniformity

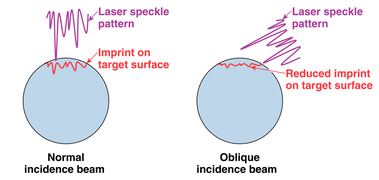


- Energy is increased by 7% to compensate for the lower absorption

Run G1123
TC12097

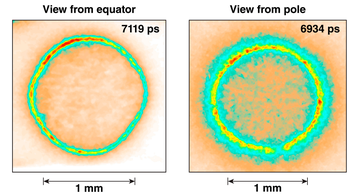
Oblique Design

Having beams encounter the target obliquely may reduce the effects of laser speckle on uniformity



TC12100

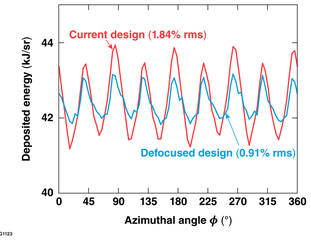
Self-emission images* viewed from the equator show less symmetry than images from the pole



*D. T. Michel *et al.*, Rev. Sci. Instrum. 83, 10E530 (2012).

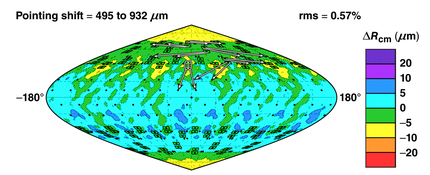
TC12092

Azimuthal variations around $\theta = 60°$ are reduced by a factor of 2 using the defocused design



Runs G1001, G1123
TC12095

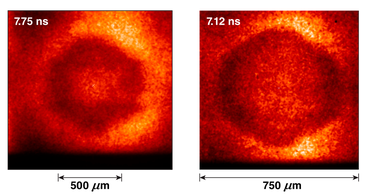
The oblique design also produces good uniformity



- Energy is increased by 25% to compensate for the lower absorption

Run G1209
TC13191

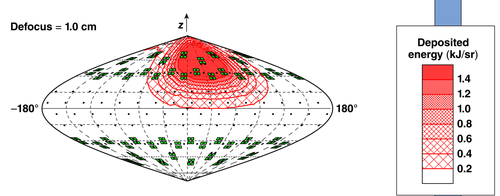
X-ray backlit images* viewed from the equator show significant nonuniformity in the high-density shell



*F. J. Marshall (unpublished).

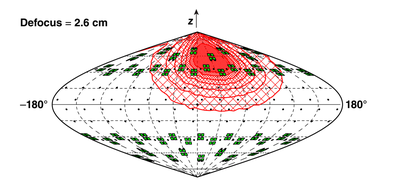
TC12093

The energy deposition pattern for a single beam shows closely spaced contours



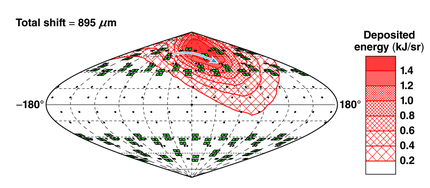
Run G1154
TC12096

The contours are more spread out for a defocused beam



Run G1156
TC12098

The majority of a beam's energy is deposited far from the beam port



Run G1221
TC13192

Abstract

Two alternative designs for the current series of polar-direct-drive implosions[1,2] at the National Ignition Facility have been developed using the hydrodynamics simulation code *SAGE*. The current design produces implosions that are close to spherical but still show some nonuniformities. They are calculated to have an rms center-of-mass nonuniformity of 1.3% averaged over the entire sphere when the shell has compressed to approximately half its initial diameter. The first alternative design—the "defocused" design—utilizes greater defocuses than the current design on all of the beams along with small changes to the pointing shifts and has a lower nonuniformity of 0.64%. The second alternative design—the "oblique" design—uses large pointing shifts so that all beams encounter the target at oblique incidence with a minimum pointing shift of 45% of the target radius. It is speculated that these large pointing shifts may help to reduce the nonuniformity associated with laser speckle that is not modeled in the simulations. The oblique design has an rms nonuniformity of 0.57%.

[1] P. B. Radha *et al.*, Phys. Plasmas 20, 056306 (2013).
[2] M. Hohenberger *et al.*, "Polar-Direct-Drive Experiments on the National Ignition Facility," to be published in Physics of Plasmas.

TC12090

Pointing and focusing parameters

		Current Design			Defocused Design			Oblique Design		
Quad	Beam	Defocus (cm)	θ (°)	$\Delta\phi$ (°)	Defocus (cm)	θ (°)	$\Delta\phi$ (°)	Defocus (cm)	θ (°)	$\Delta\phi$ (°)
23.5°	1	1.0	23.5	0	2.4	20	0	3.0	23	70
1, 2	2	1.0	23.5	0	2.4	20	0	3.0	23	115
3, 4	3	1.0	23.5	0	2.4	20	0	3.0	23	−115
	4	1.0	23.5	0	2.4	20	0	3.0	23	−70
30.0°	5	1.0	35	0	2.6	35	0	2.7	39	70
5, 6	6	1.0	35	0	2.6	35	0	2.7	39	115
7, 8	7	1.0	35	0	2.6	35	0	2.7	39	−115
	8	1.0	35	0	2.6	35	0	2.7	39	−70
44.5°	9	1.0	46	−11.25	2.0	46	−11.25	1.8	48	35
9, 10	10	1.0	46	11.25	2.0	46	11.25	1.8	48	60
11, 12	11	1.0	69	−11.25	2.0	69	−11.25	1.8	68	−60
	12	1.0	69	11.25	2.0	69	11.25	1.8	68	−35
50.0°	13	1.0	83	−11.25	1.8	84	−11.25	1.8	81	−11.25
13, 14	14	1.0	83	11.25	1.8	84	11.25	1.8	81	11.25
15, 16	15	1.0	83	−11.25	1.6	84	−11.25	1.8	81	−11.25
	16	1.0	83	11.25	1.6	84	11.25	1.8	81	11.25
	17 to 32	All parameters are a reflection of upper hemisphere								

TC12099

Summary

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UR LLE

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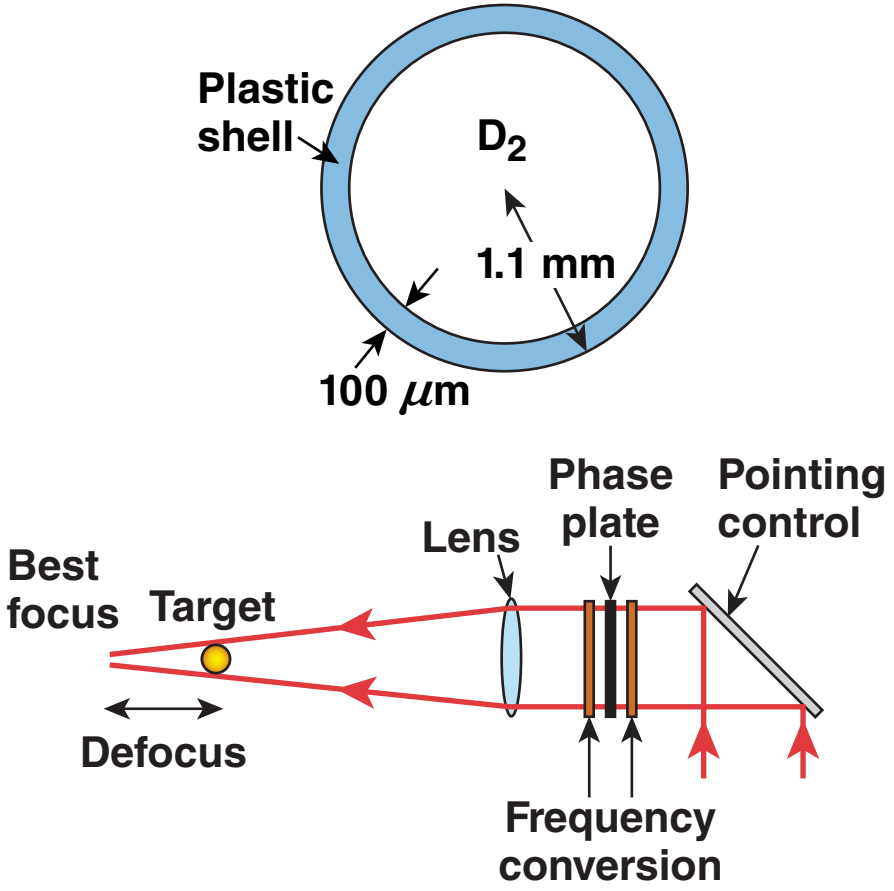
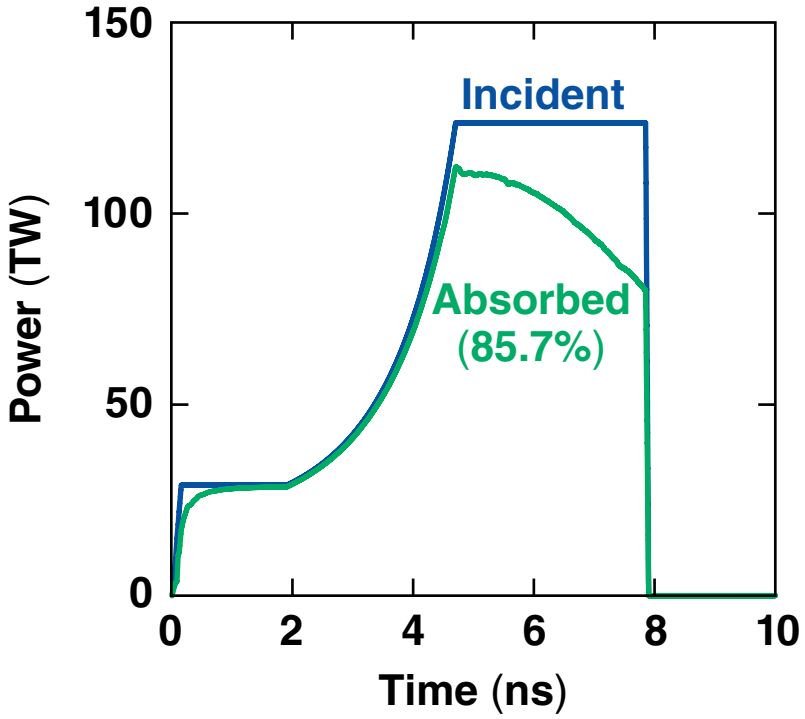
Thick plastic shells are imploded using a shaped laser pulse



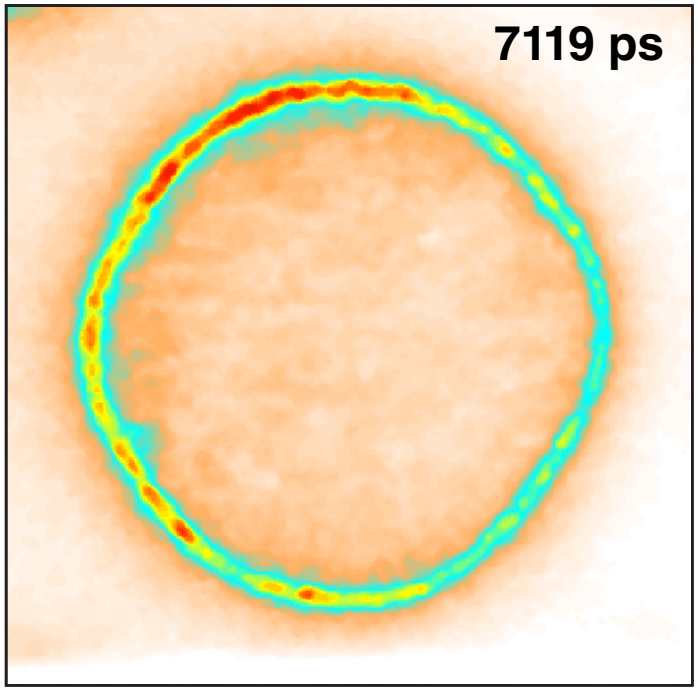


Run G1001
TC12091

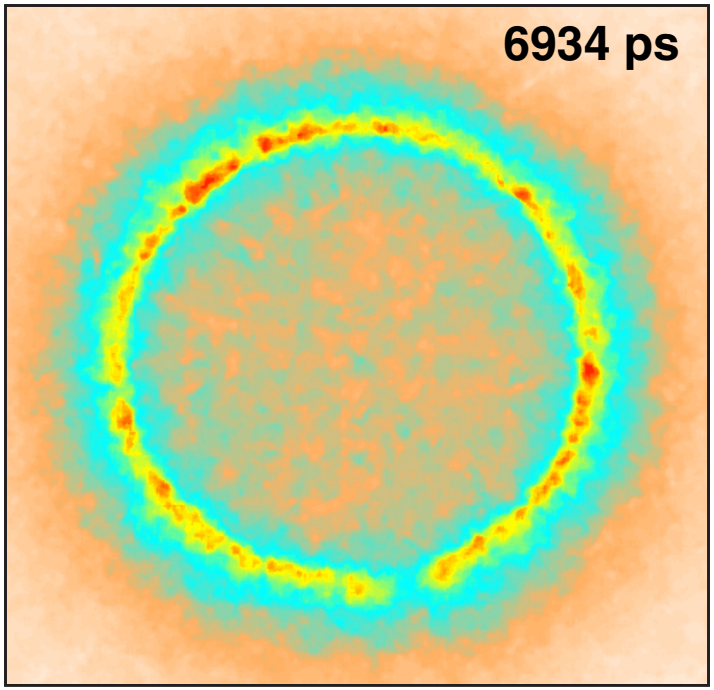
Self-emission images* viewed from the equator show less symmetry than images from the pole

UR LLE

View from equator



View from pole



Shot N140228-003

*D. T. Michel *et al.*, Rev. Sci. Instrum. 83, 10E530 (2012).

TC12092

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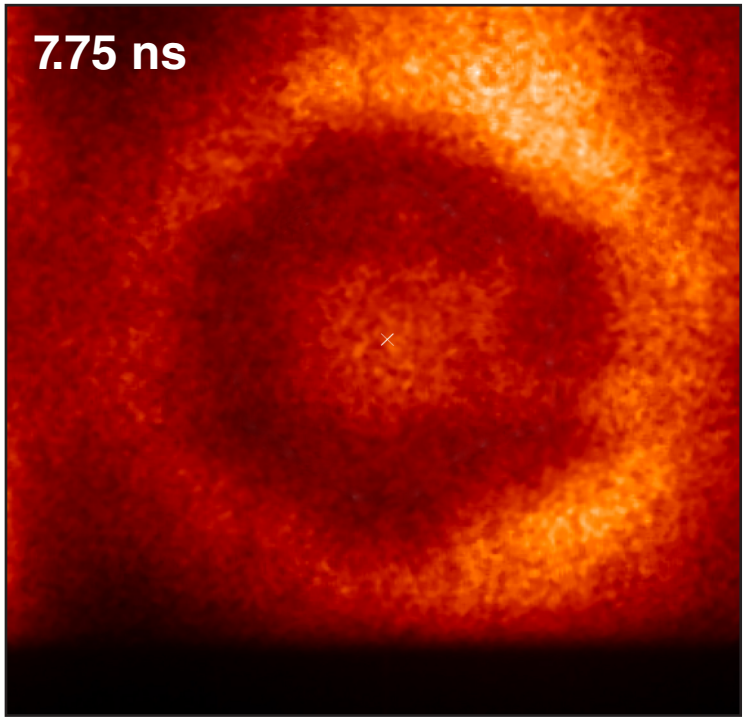
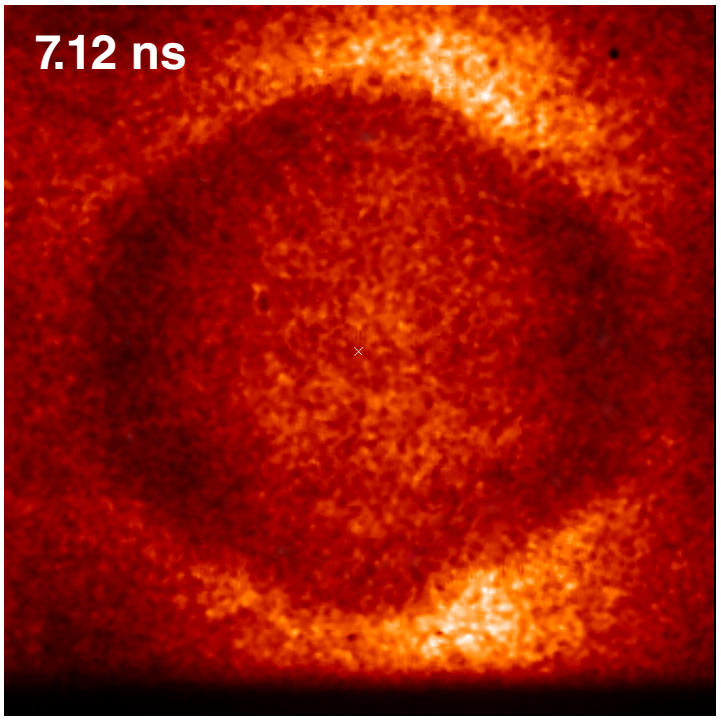


500 μm

Shot N140612-001



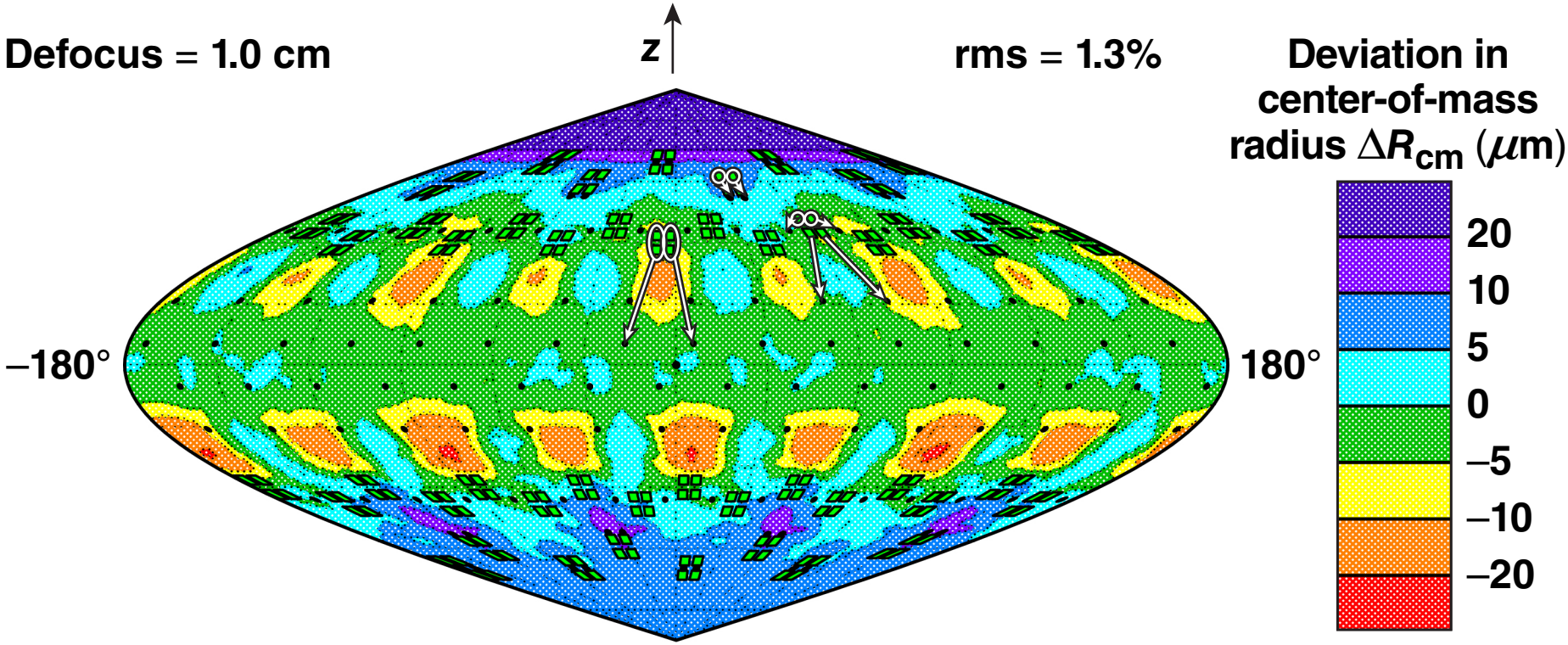
750 μm

Shot N150118-002

*F. J. Marshall (unpublished).

TC12093

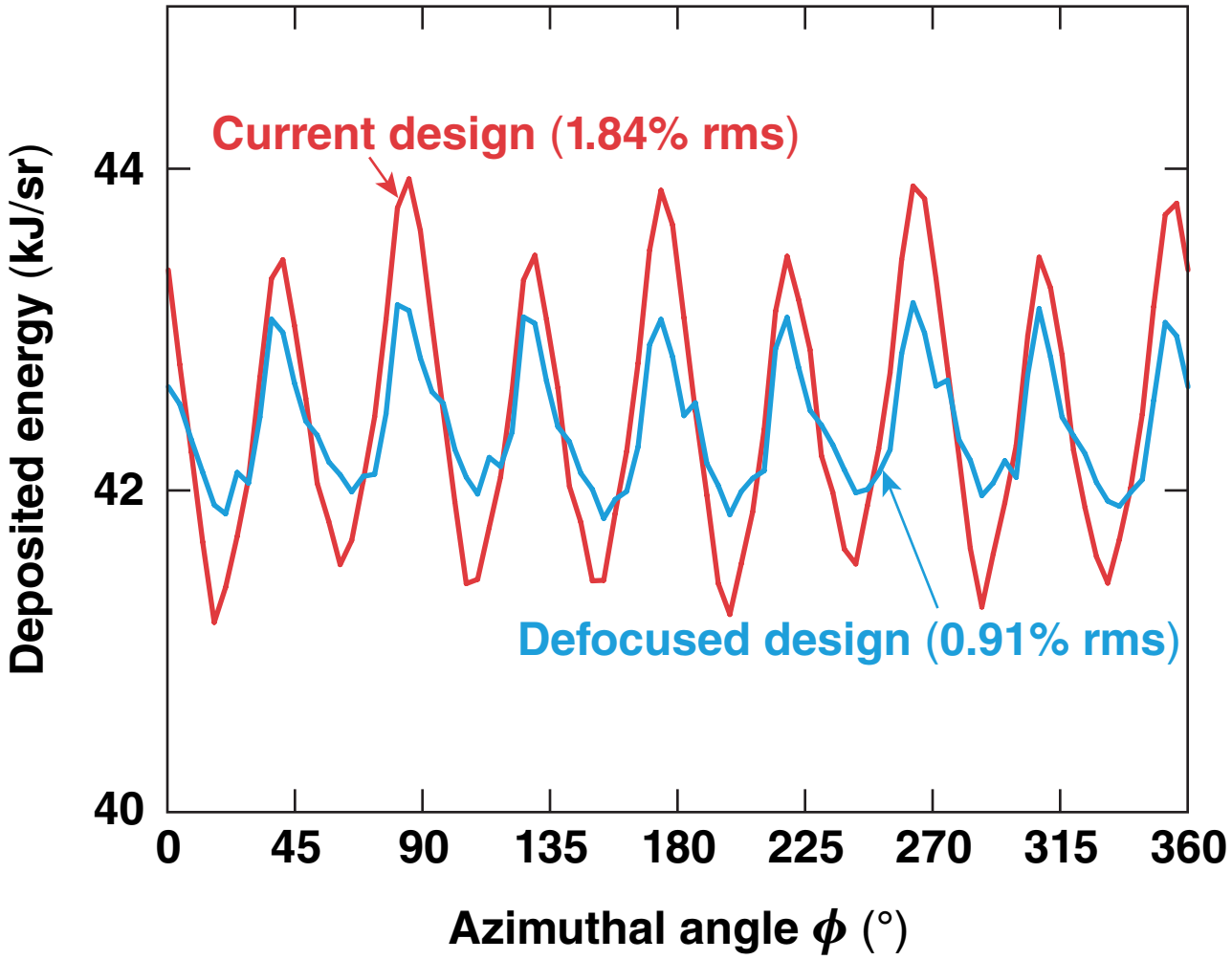
The current NIF design uses a small defocus for all beams



- The dominant nonuniformity is an azimuthal mode around $\theta = 60°$

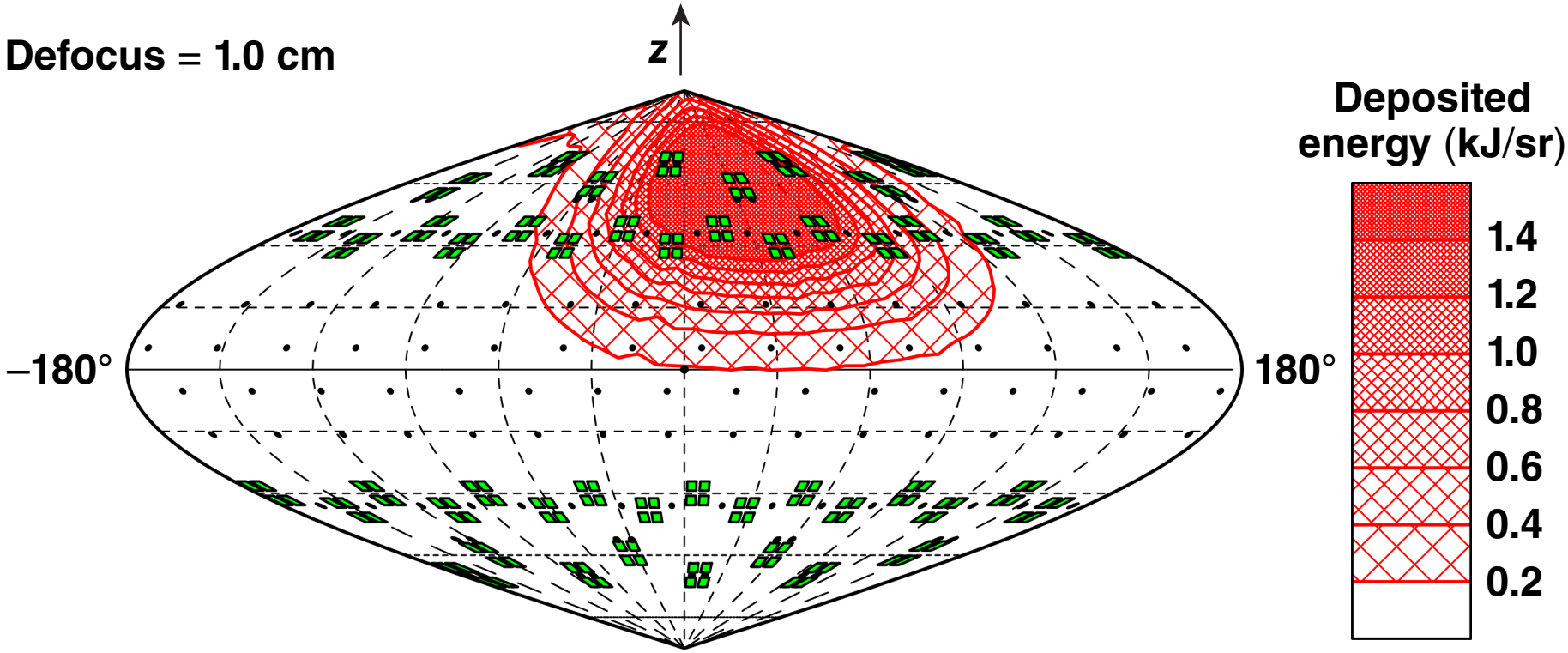
Run G1001
TC12094

Azimuthal variations around $\theta = 60°$ are reduced by a factor of 2 using the defocused design



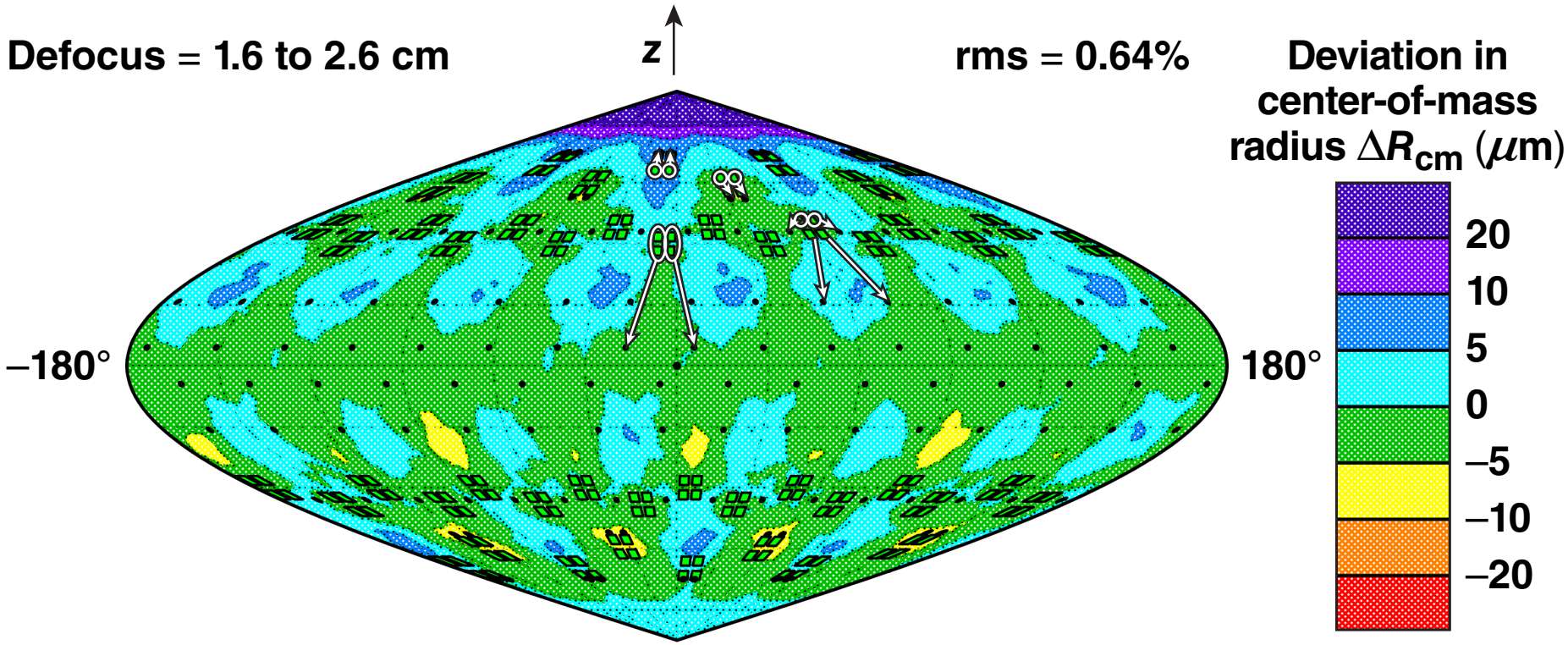
Runs G1001, G1123
TC12095

The energy deposition pattern for a single beam shows closely spaced contours



Run G1154
TC12096

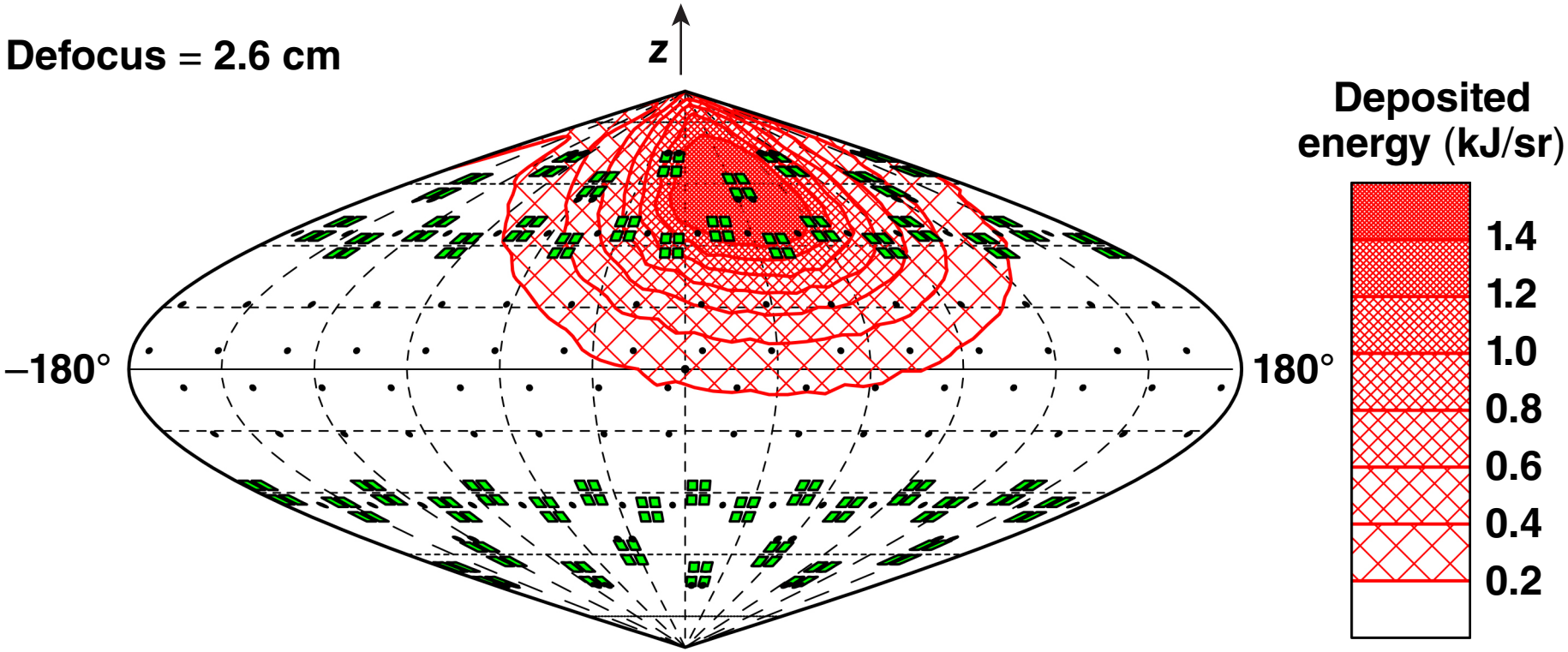
The defocused design uses larger defocuses to improve uniformity



- Energy is increased by 7% to compensate for the lower absorption

Run G1123
TC12097

The contours are more spread out for a defocused beam



Run G1156
TC12098

Pointing and focusing parameters

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	2	1.0	23.5	0	2.4	20	0	3.0	23	115
	3	1.0	23.5	0	2.4	20	0	3.0	23	–115
	4	1.0	23.5	0	2.4	20	0	3.0	23	–70
30.0° 5, 6 7, 8	5	1.0	35	0	2.6	35	0	2.7	39	70
	6	1.0	35	0	2.6	35	0	2.7	39	115
	7	1.0	35	0	2.6	35	0	2.7	39	–115
	8	1.0	35	0	2.6	35	0	2.7	39	–70
44.5° 9, 10 11, 12	9	1.0	46	–11.25	2.0	46	–11.25	1.8	48	35
	10	1.0	46	11.25	2.0	46	11.25	1.8	48	60
	11	1.0	69	–11.25	2.0	69	–11.25	1.8	68	–60
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50.0° 13, 14 15, 16	13	1.0	83	–11.25	1.8	84	–11.25	1.8	81	–11.25
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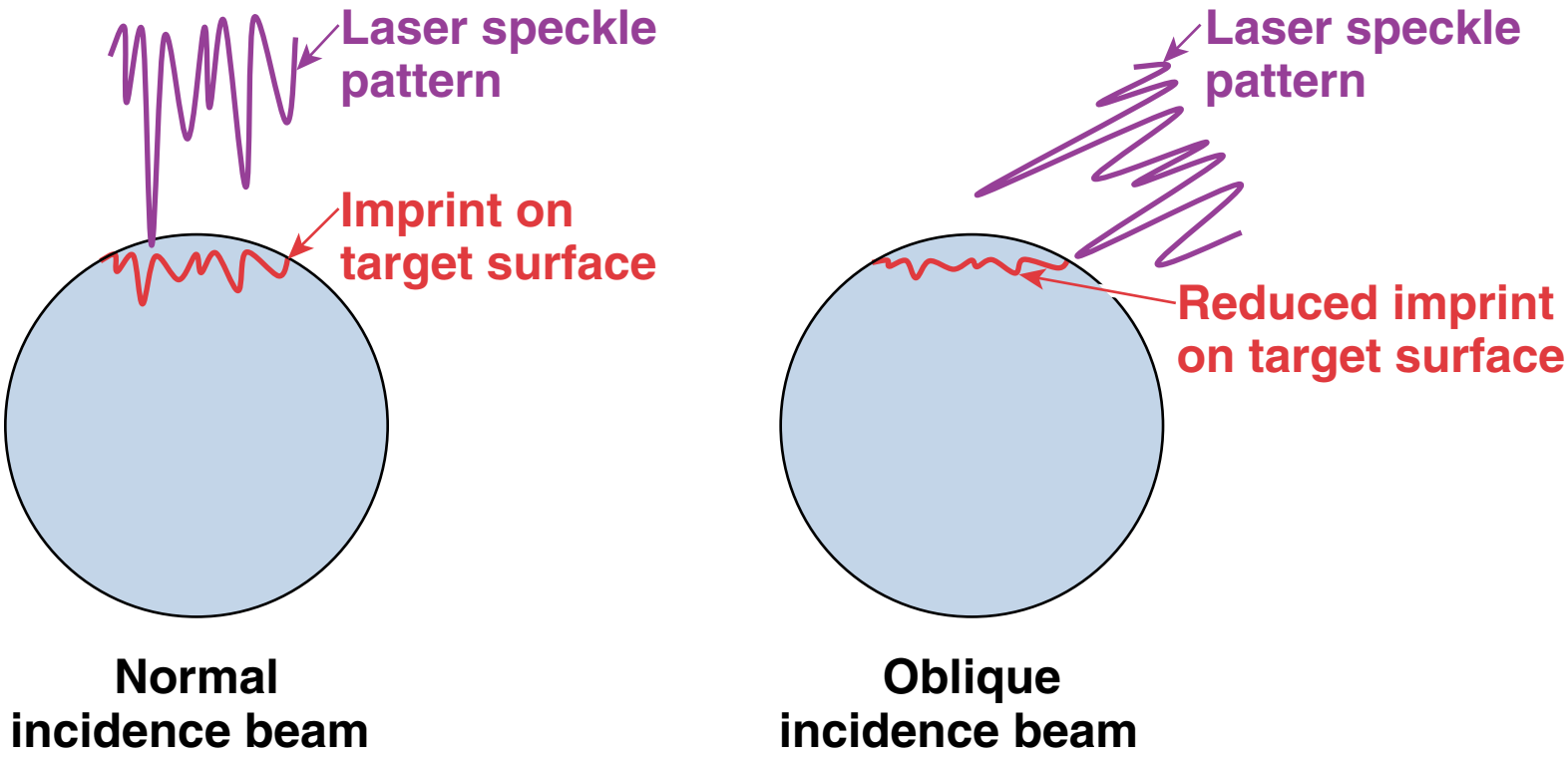
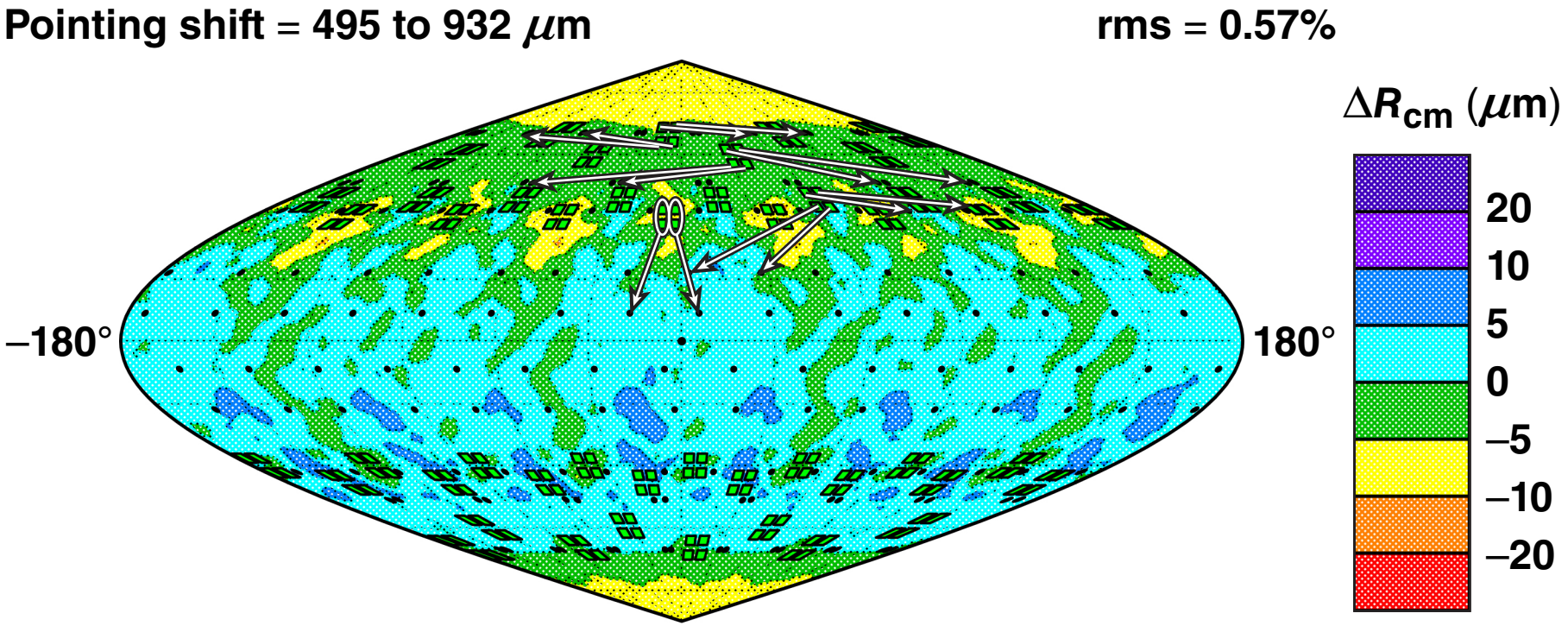
	17 to 32	All parameters are a reflection of upper hemisphere								

TC12099

Having beams encounter the target obliquely may reduce the effects of laser speckle on uniformity



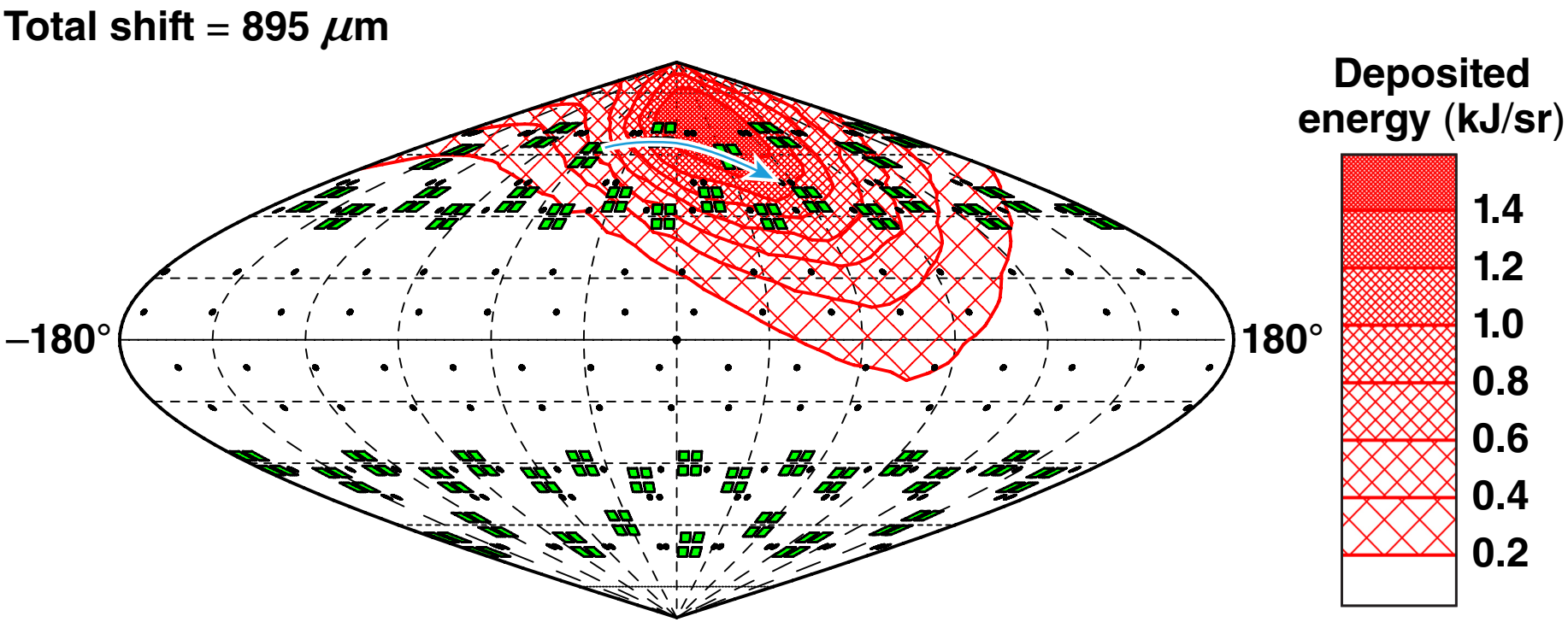
The oblique design also produces good uniformity



- Energy is increased by 25% to compensate for the lower absorption

Run G1208
TC12101

The majority of a beam's energy is deposited far from the beam port



Run G1221
TC12102