Direct-Drive Implosion Experiments with Enhanced Beam Balance on the OMEGA Laser

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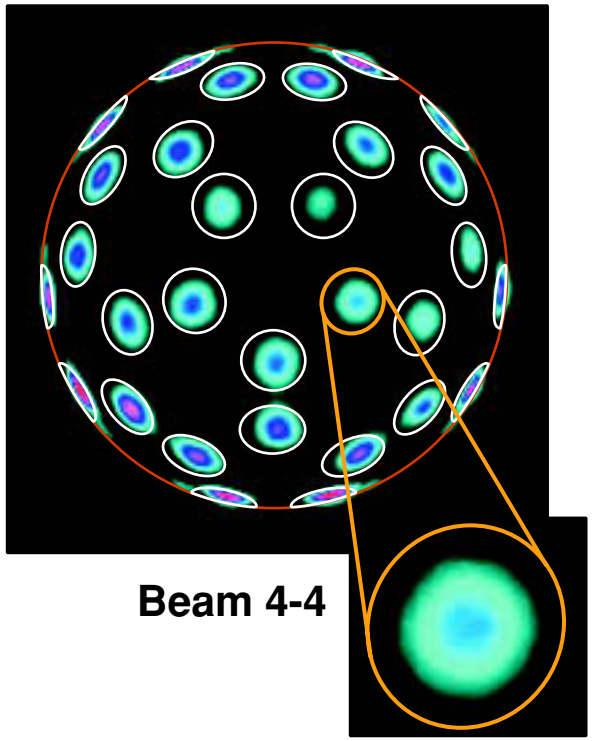
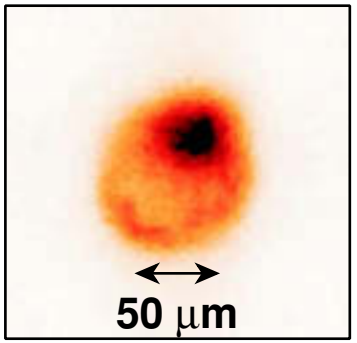
TIM 6 CID x-ray image

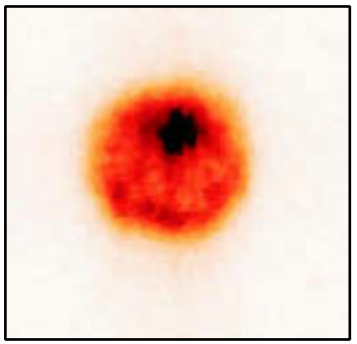


15-atm-D_2-filled CH shells

Standard balance (24119)



Enhanced balance (24121)



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Summary

A method to enhance the OMEGA laser system's on-target beam balance has been developed

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- The on-target beam intensities are determined by analysis of x-ray images of laser–plasma generated by non-overlapping beams.
- The measurements have been used to reduce the beam peak intensity variations from ~6% (rms) to ~2% (rms).
- Experiments have been performed with enhanced beam balance, demonstrating improved implosion symmetry.
- Fusion performance (Y_n, ρR_{fuel}) is not significantly improved, however, by enhanced beam balance, implying that other factors such as beam shape or target imperfections may be more important.

A method to determine the on-target-beam-intensity variation has been developed

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- All 60 beams of OMEGA irradiate a 4-mm-diam Au-coated sphere.
- The x-ray emission from each beam spot is corrected for conversion efficiency and view-angle effect to determine the beam-to-beam intensity variations.

$$I_x \propto I_{UV}^{\gamma} \quad \text{(power-law x-ray conversion dependence)}$$

$$I_x(\theta) = I_x(0) f(\theta) \quad \text{(view-angle effect)}$$

- Once the individual-beam-intensity variations are determined, adjustments are made to the last amplifier of each beam to improve on-target balance.

Each OMEGA pointing shot image is simulated to determine the beam peak intensities

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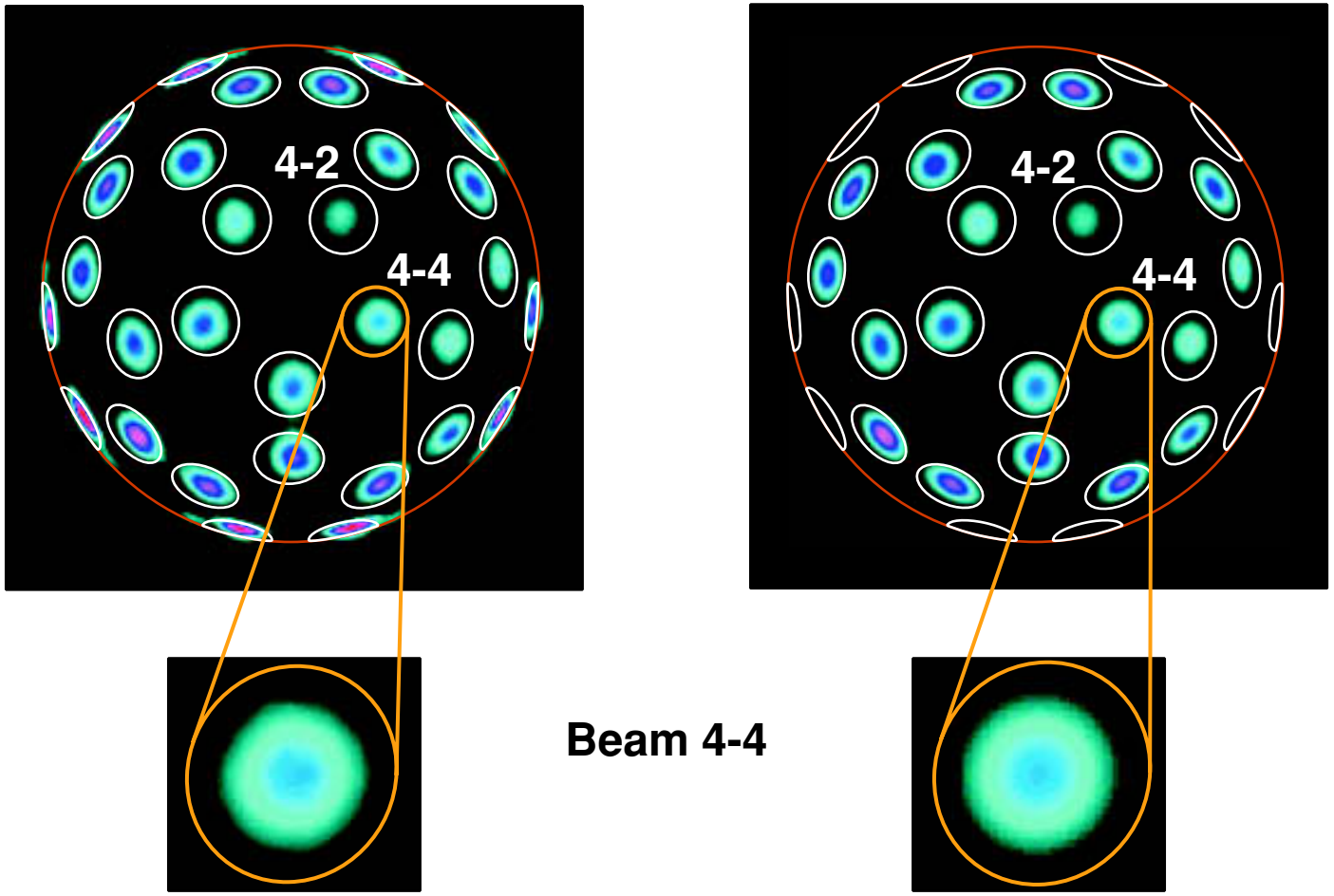
Shot 24628

TIM 6 CID x-ray image

Simulation



Beam 4-4

E11294

The x-ray beam spots are fit to super-Gaussian intensity patterns corrected for view angle

$$I(\text{x ray}) = I_0\{\exp - [(x - x_0)/r_0]^{\eta}\}^{\gamma}$$

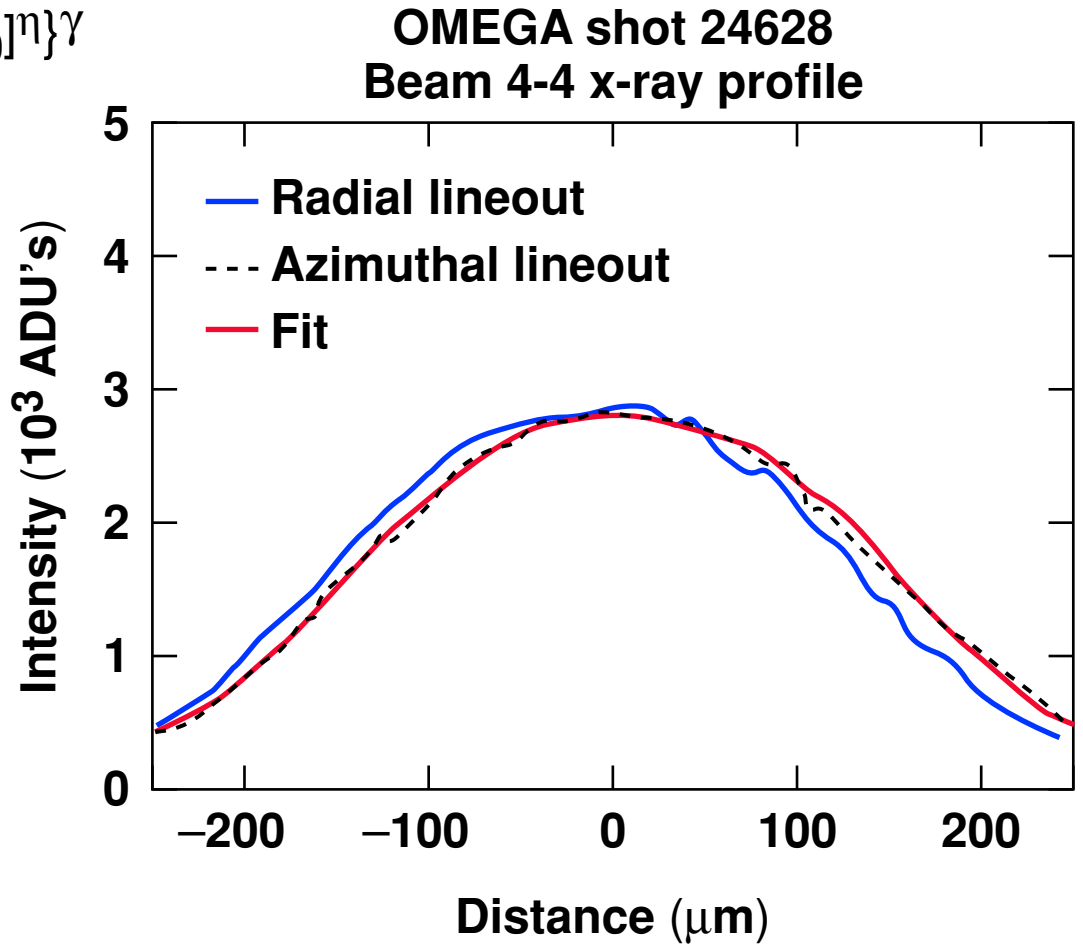
γ = 3.7 (assumed)

r_0 = 306 μm

η = 2.57

I_0 = 2844 ADU's

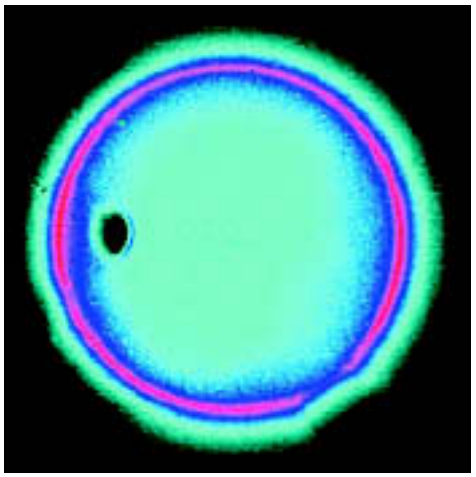
ADU = analog to digital unit



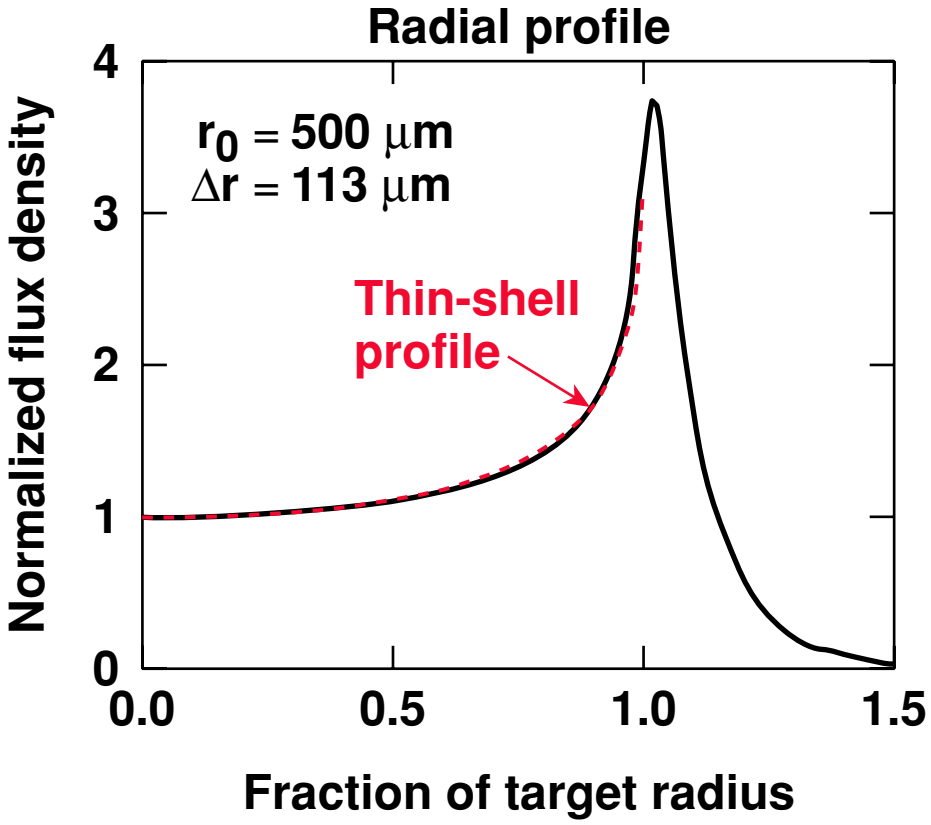
The effect of view angle can be accurately modeled by x-ray emission from an optically thin plasma shell

OMEGA shot 21608

CID image (H6 view)



1-mm-diam
Au-coated sphere



$$I_x = I_x(0) \times f(r)$$

For a thin shell:

$$f(r) = (r_0/\Delta r)\left[\sqrt{(1 + \Delta r/r_0)^2 - (r/r_0)^2} - \sqrt{1 - (r/r_0)^2}\right]$$

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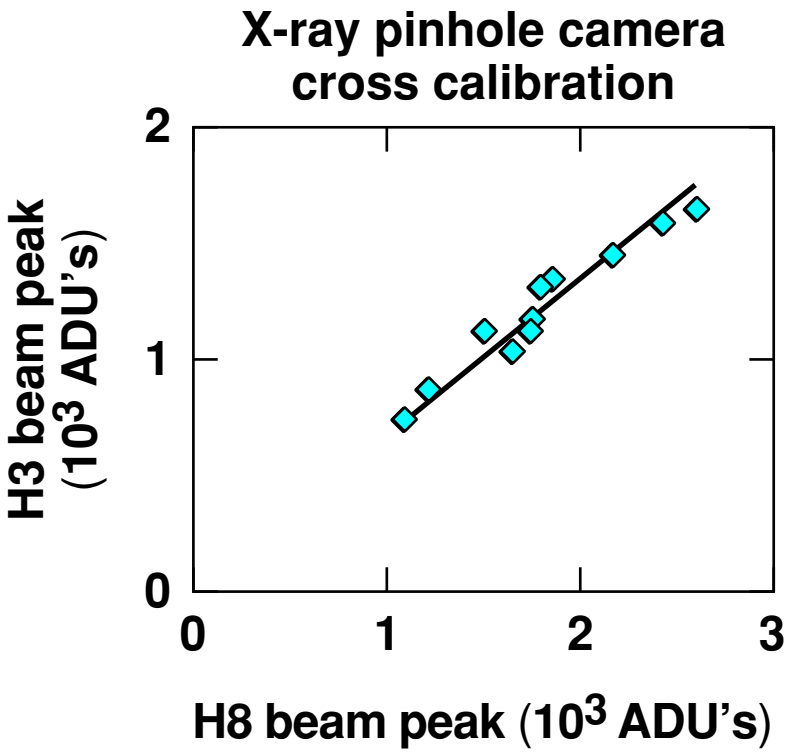
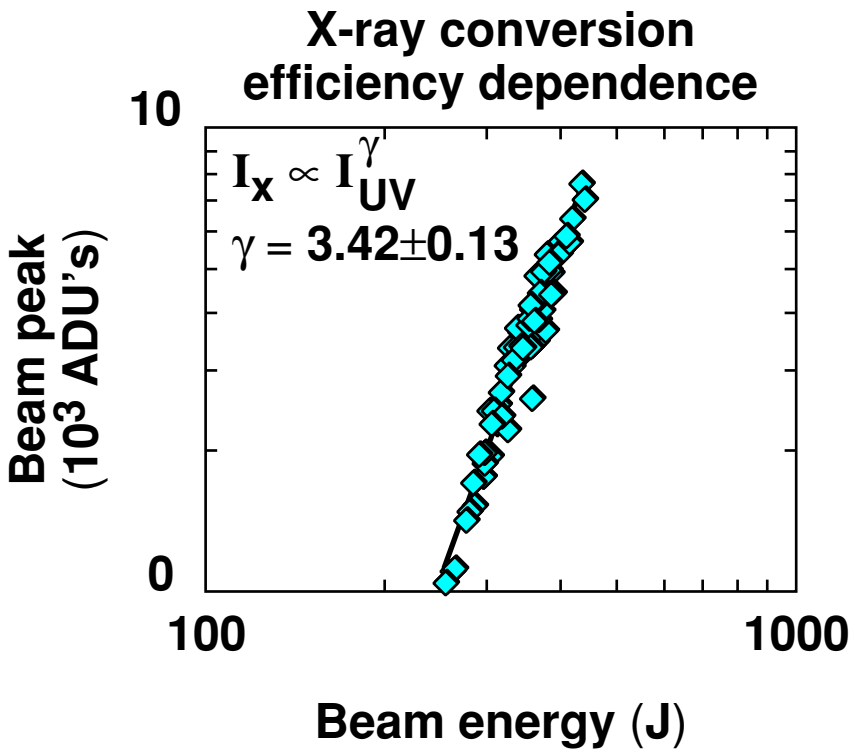
Up to eight cross-calibrated x-ray cameras (XPHC's) are used to determine the beam's peak





The beam-to-beam intensity variations are reduced with enhanced balance

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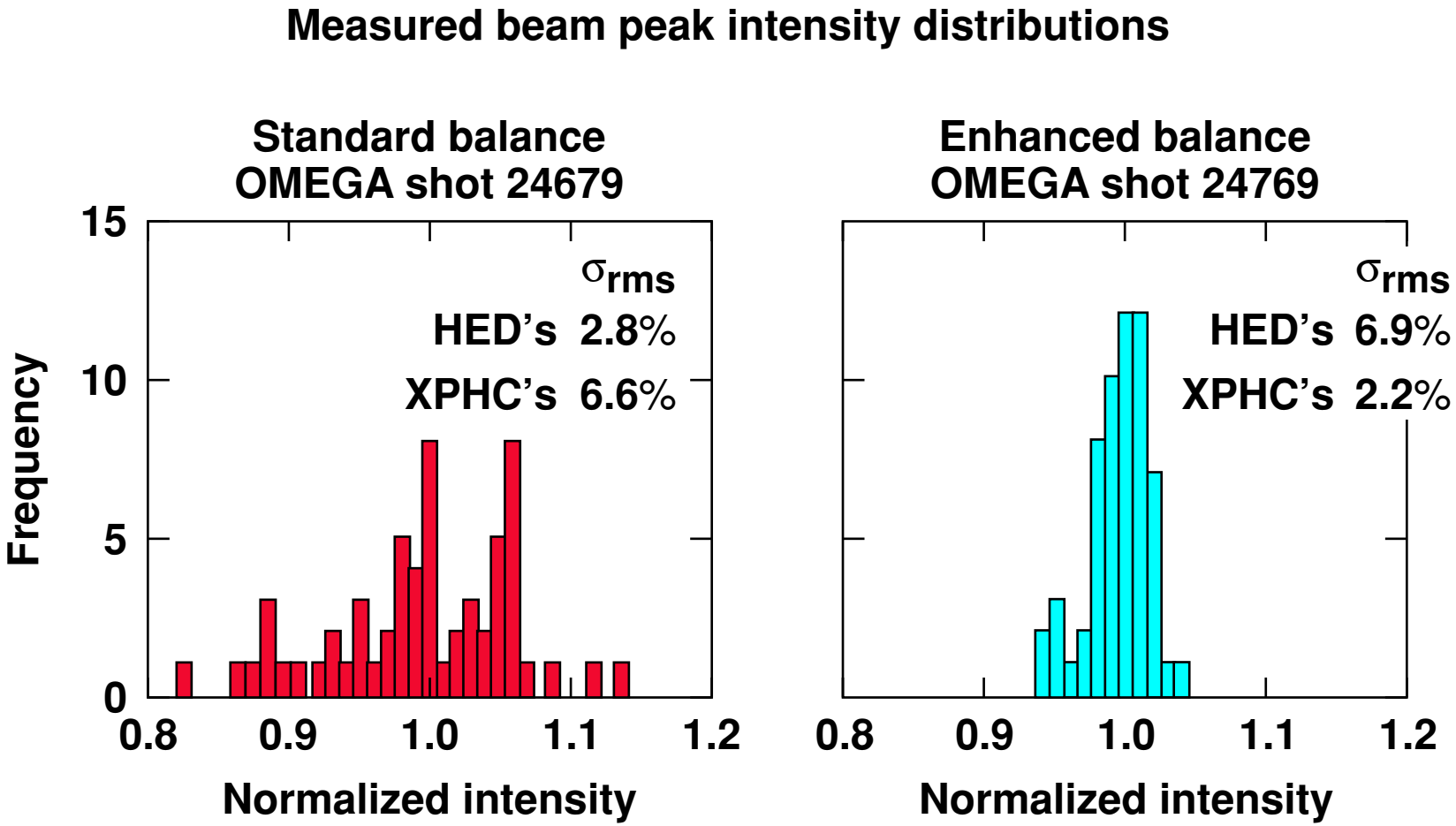

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Enhanced balance implosions obtain more spherically shaped cores

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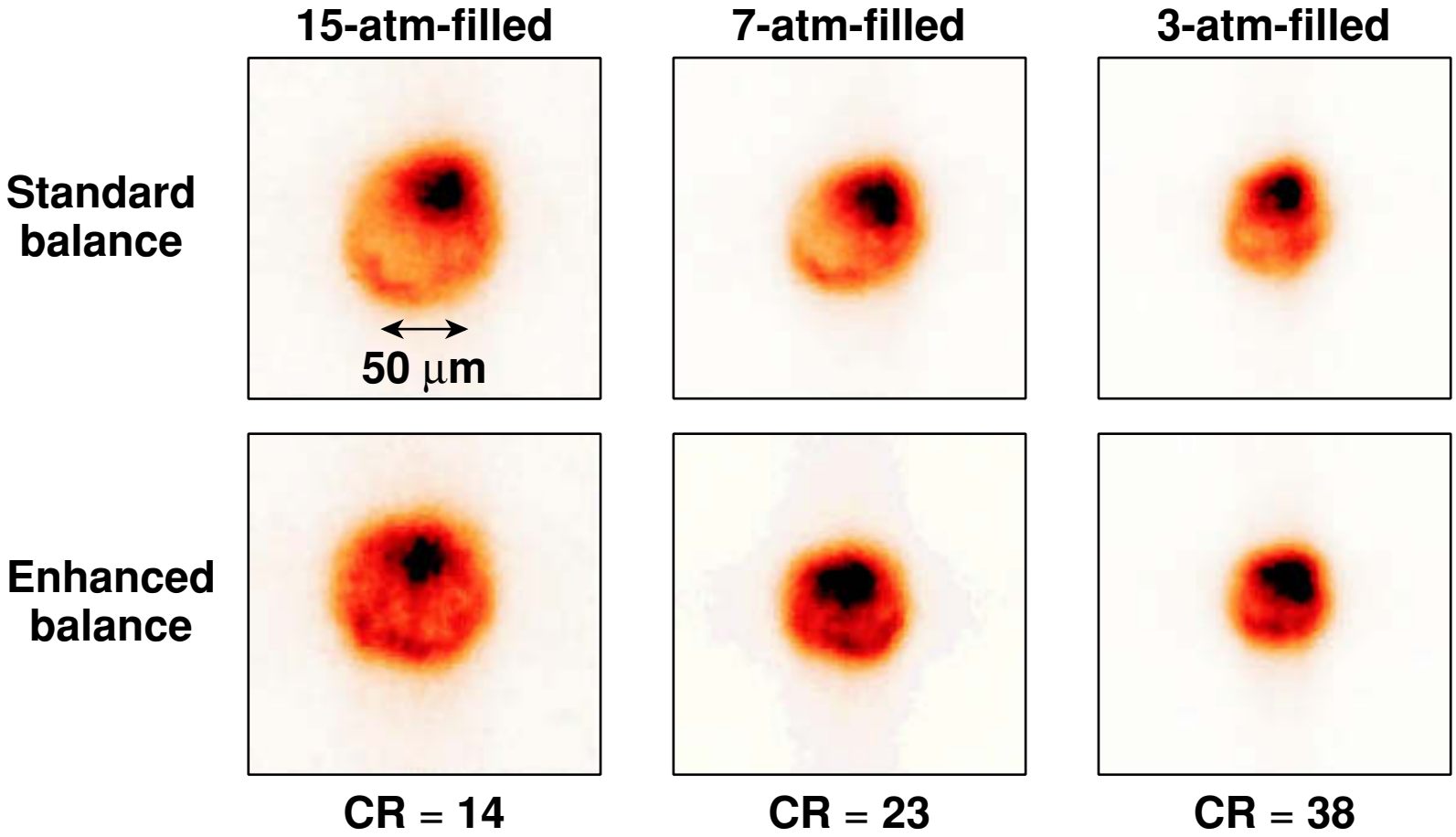
OMEGA direct-drive, D_2-filled, 18.5-μm-thick-CH-shell implosions



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The orientation of perturbations seen in the implosions is consistent with the inferred on-target uniformity

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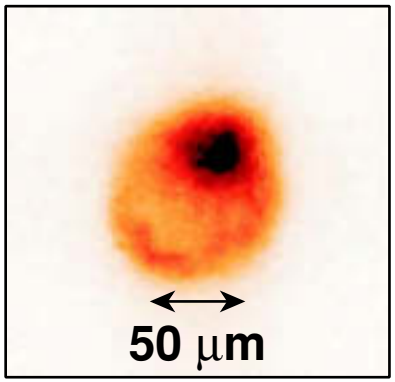
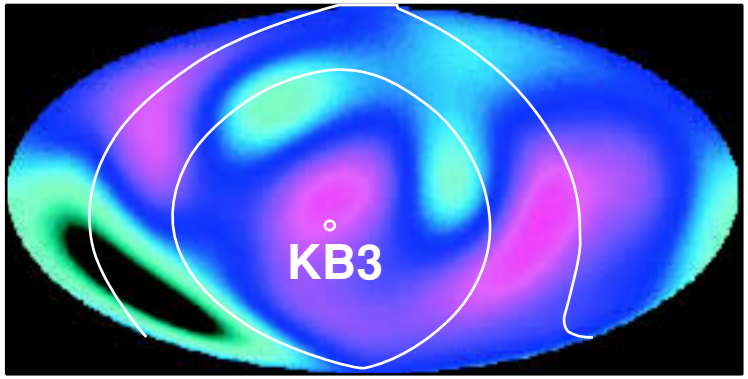
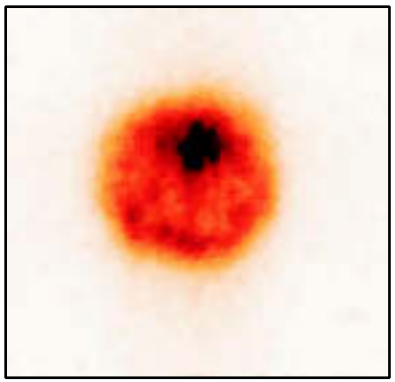
OMEGA direct-drive, D_2-filled-CH-shell implosions

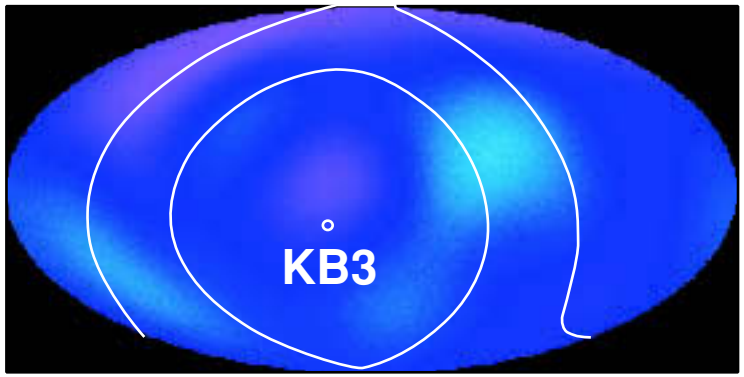
Standard balance (24119)

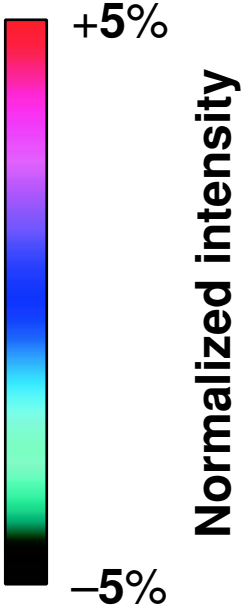




Enhanced balance (24121)







E11300

Target performance is not significantly affected by beam balance with current beam smoothing

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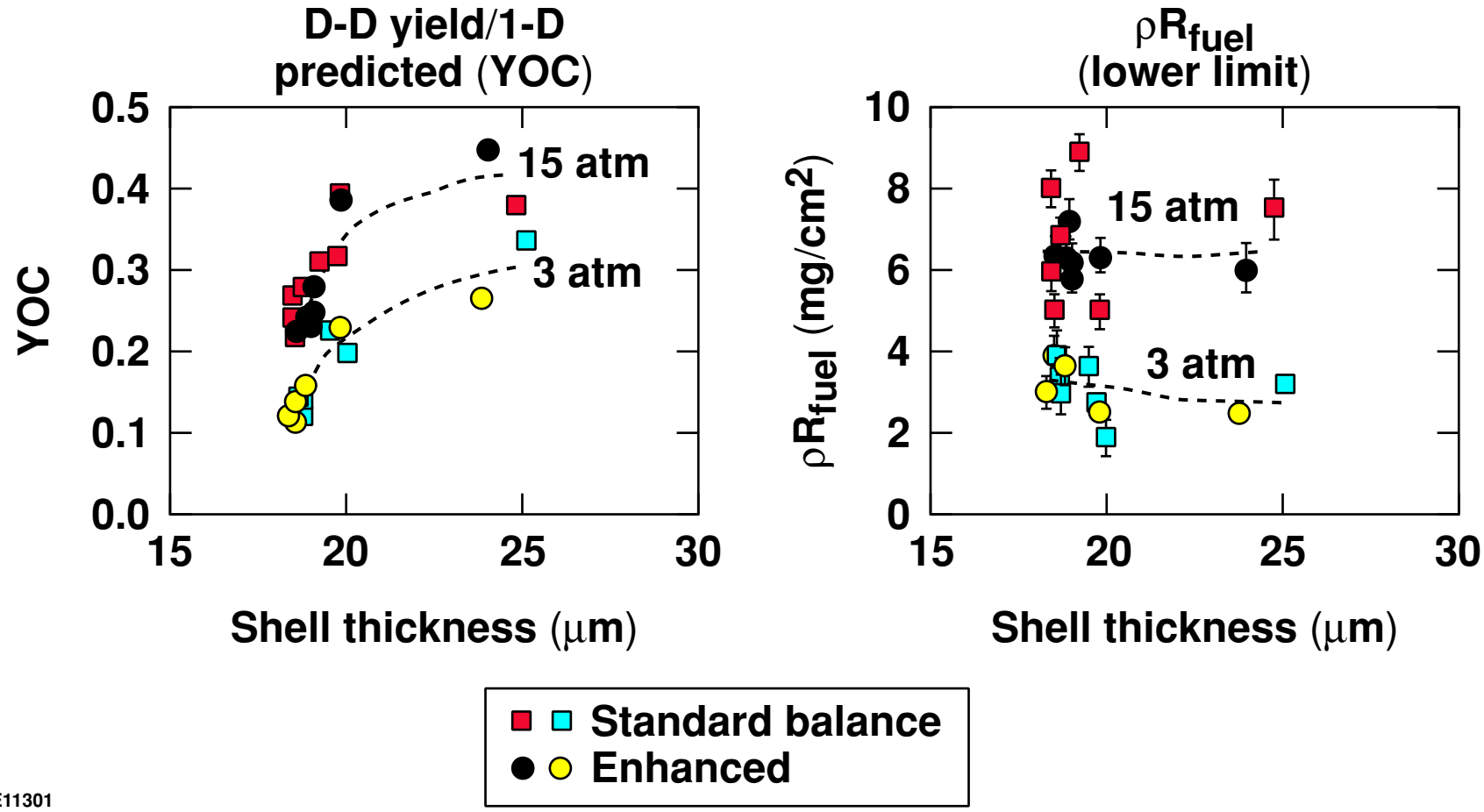
OMEGA, 1-THz SSD with PS, 1-ns square pulse implosions, D_2-filled CH shells



E11301

Summary/Conclusions

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