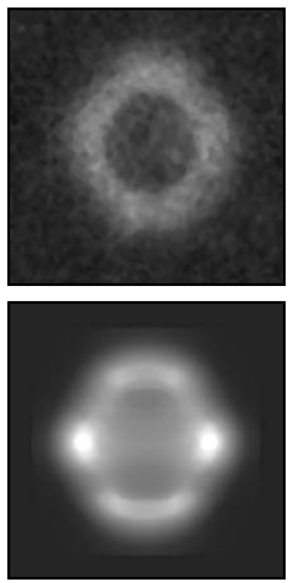
Polar-Driven, Direct-Drive Implosions on OMEGA: Observations and Simulations of Low-Mode Perturbations in the Main Fuel Layer and Hot Spot

Framed x-ray radiograph of OMEGA shot 49331 (polar drive)

t = 2.21 ns

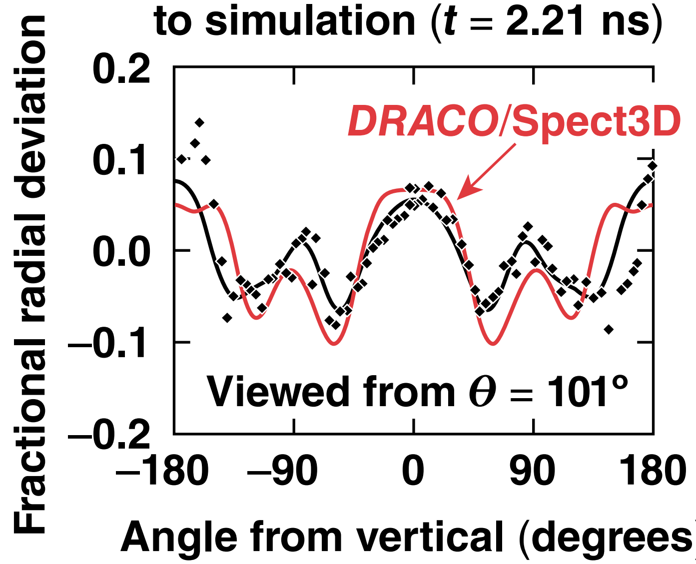
Experiment

DRACO/Spect3D simulation



400 × 400-μm regions

Shell shape compared to simulation (t = 2.21 ns)



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Summary

Low adiabat, directly driven polar-drive (PD) experiments on OMEGA validate our ability to predict low-mode perturbations expected for the NIF PD point design

- Low adiabat, directly driven implosions are being performed on OMEGA emulating the configuration of the NIF beams.
- The implosions follow the 1-D simulations up to shell stagnation as evidenced by x-ray radiography and particle measurements.
- Low mode perturbations of the shell, due principally to illumination nonuniformity, are well reproduced by 2-D simulations.
- Perturbations of the hot spot depart from 2-D simulations and may have contributions from the target stalk not included in the simulations.

Collaborators

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Abel inversion can be used to determine the plasma density from x-ray radiographs*

Absorption of backlighter x rays along a path follows the relation

$$I = I_0 \exp\left[-\int \kappa(E,r)\,dz\right].$$

The inverse Abel transform gives the radially dependent opacity

$$\kappa(E,r) = \frac{1}{\pi}\int_r^\infty \frac{d}{dy}\left\{\ln\left[\frac{I(y)}{I_0}\right]\right\}\frac{dy}{\sqrt{y^2 - r^2}}.$$

If the mass absorption coefficient is approximately constant through the plasma, as is the case for bound-free absorption by inner-shell electrons, then

$$\rho(r) = \kappa(E,r)/\mu_{\text{eff}}(E),$$

where $\mu_{\text{eff}}(E)$ is the mass absorption coefficient averaged over the effective energy band of the radiograph, and can be determined as follows:

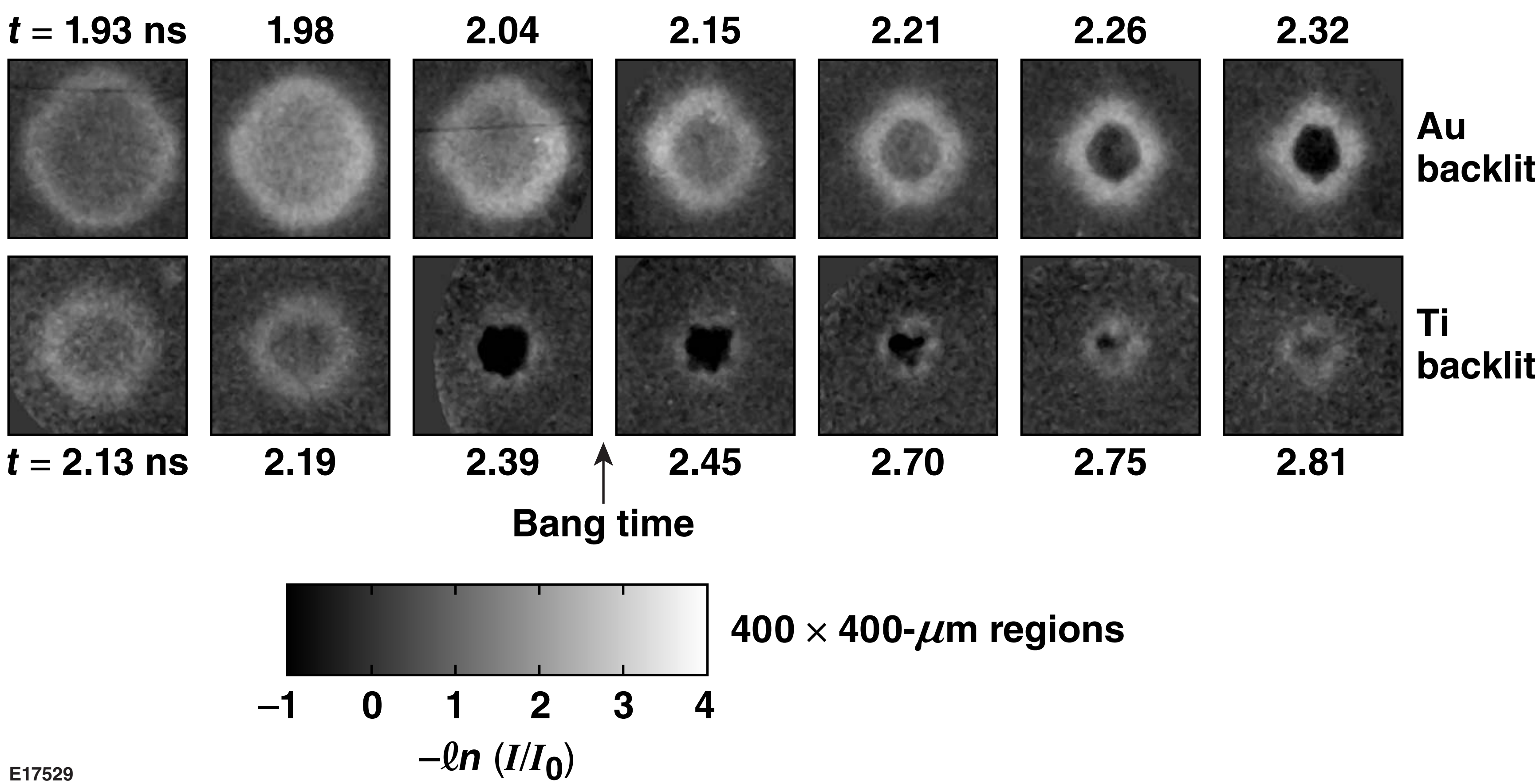
$$M_{\text{shell}} = \int \rho(r)\,dV = 4\pi \int \frac{\kappa(E,r)}{\mu_{\text{eff}}(E)} r^2\,dr.$$

E18411

*F. J. Marshall *et al.*, Phys. Rev. Lett. 102, 185004 (2009).

Abel inversion is used to compute the density profiles from framed x-ray radiographs of a polar-driven, direct-drive implosion

X-ray radiographs from OMEGA shot 49331
Polar-driven 15-atm D_2-filled, 24-μm thick CH shell



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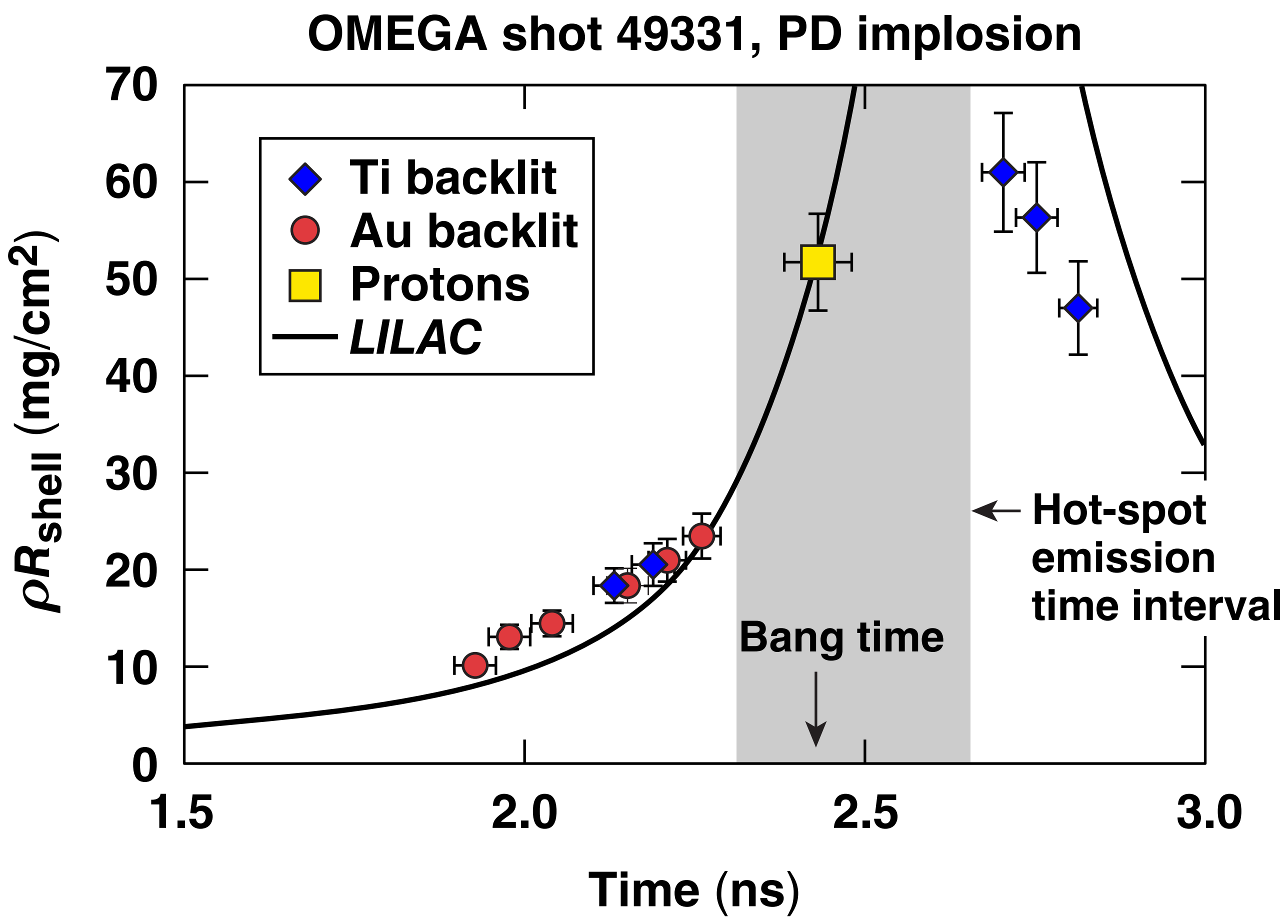
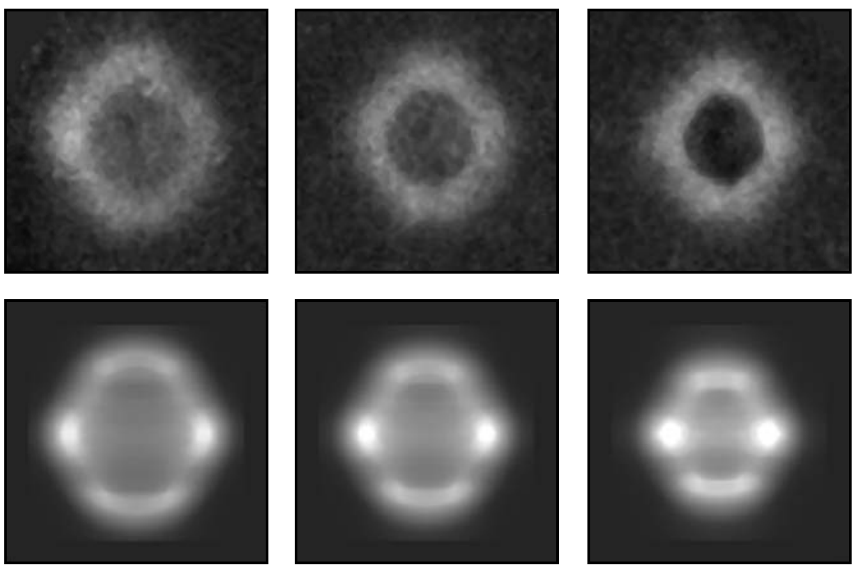
The measured areal-density time history is consistent with 1-D simulations up to bang time



The observed shell perturbations are accurately reproduced by *DRACO* 2-D simulations

OMEGA shot 49331, PD implosion
Framed x-ray radiographs,
2.5 to 4-keV backllighter

2.15 ns 2.21 ns 2.26 ns

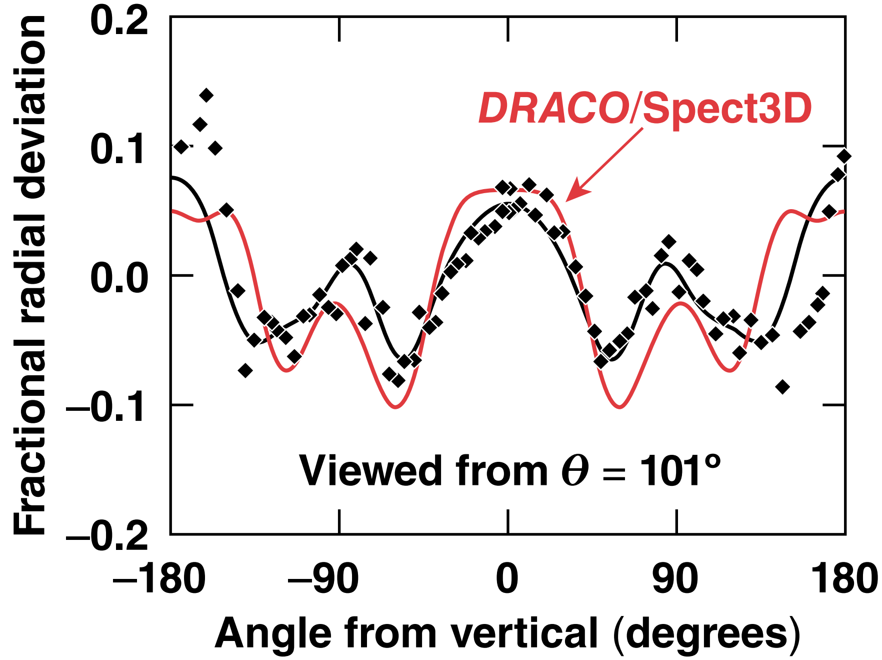


DRACO/Spect3D simulation
400 × 400 μm regions

–1 0 1 2 3 4

$-\ell n\ (I/I_0)$

Shell shape compared
to simulation (t = 2.21 ns)



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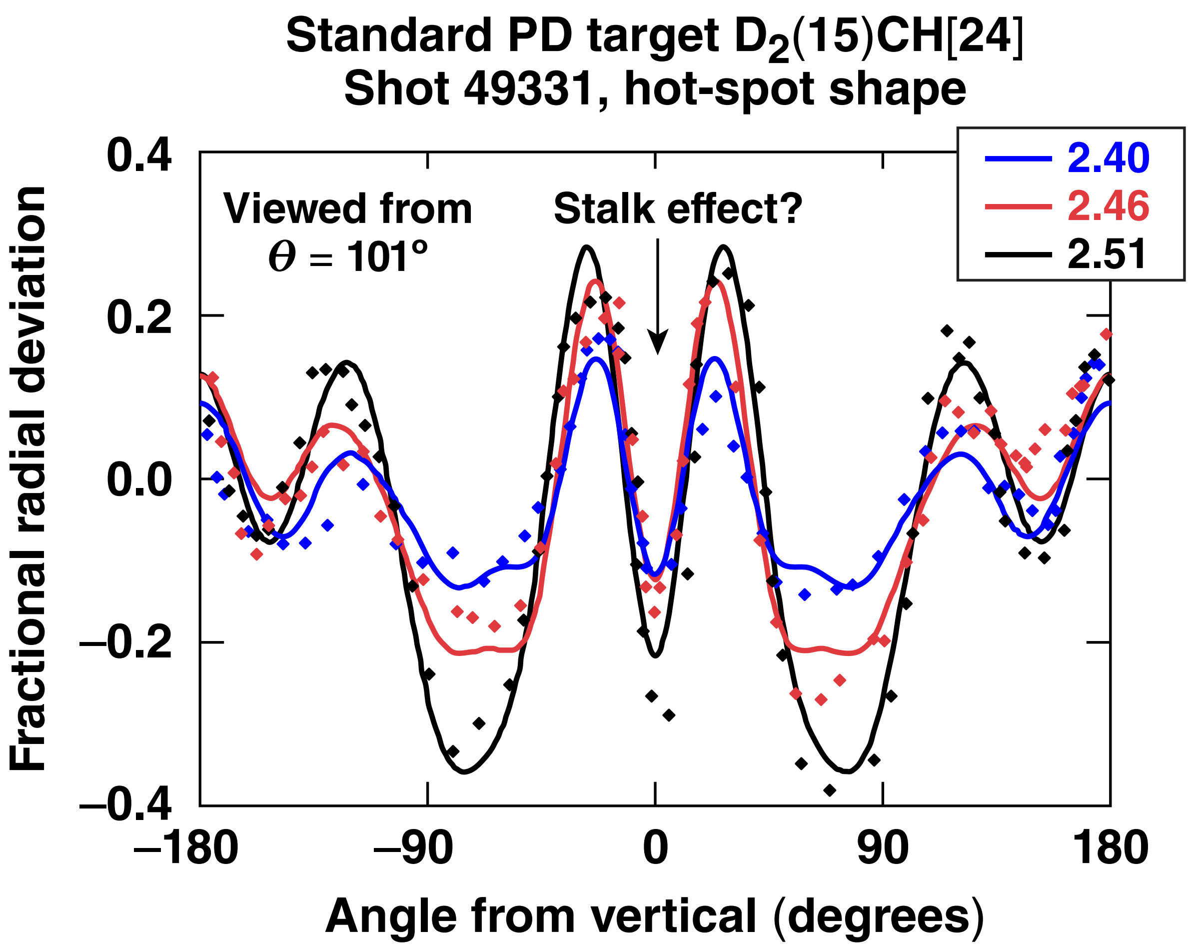
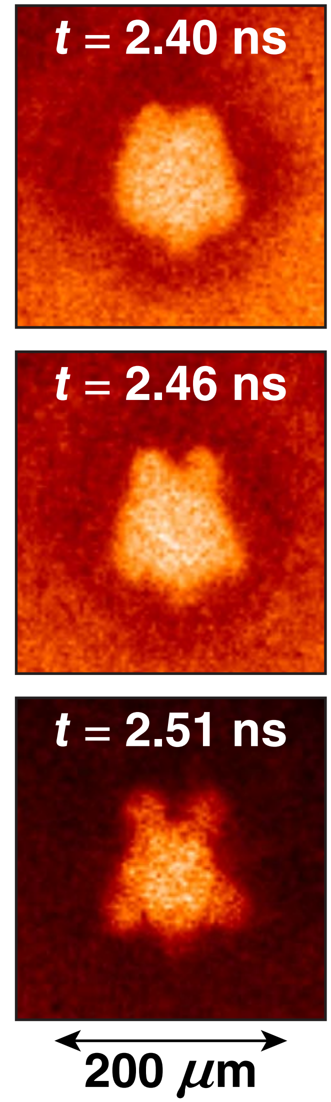
F. J. Marshall *et al*., J. Phys. IV France 133, 153 (2006).

Low-mode perturbations of the hot spot are determined from framed x-ray images of target self-emission





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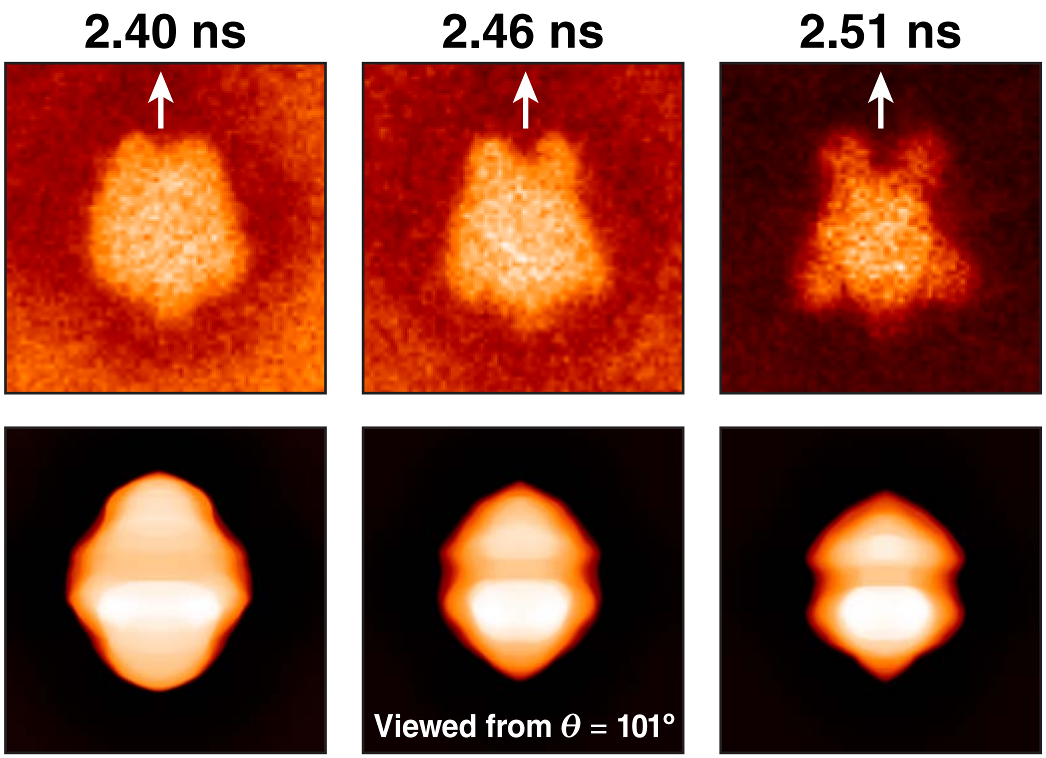
The observed hot-spot perturbations deviate significantly from *DRACO* 2-D simulations

OMEGA shot 49331, PD implosion
Framed x-ray images 2- to 4-keV emission



***DRACO*/Spect3D simulation**

100 μm

Stalk direction indicated with arrows

The differences in measured and simulated shapes may be due to the stalk, whose effect is not included in the simulations.

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Summary/Conclusions

Low adiabat, directly driven polar-drive (PD) experiments on OMEGA validate our ability to predict low-mode perturbations expected for the NIF PD point design

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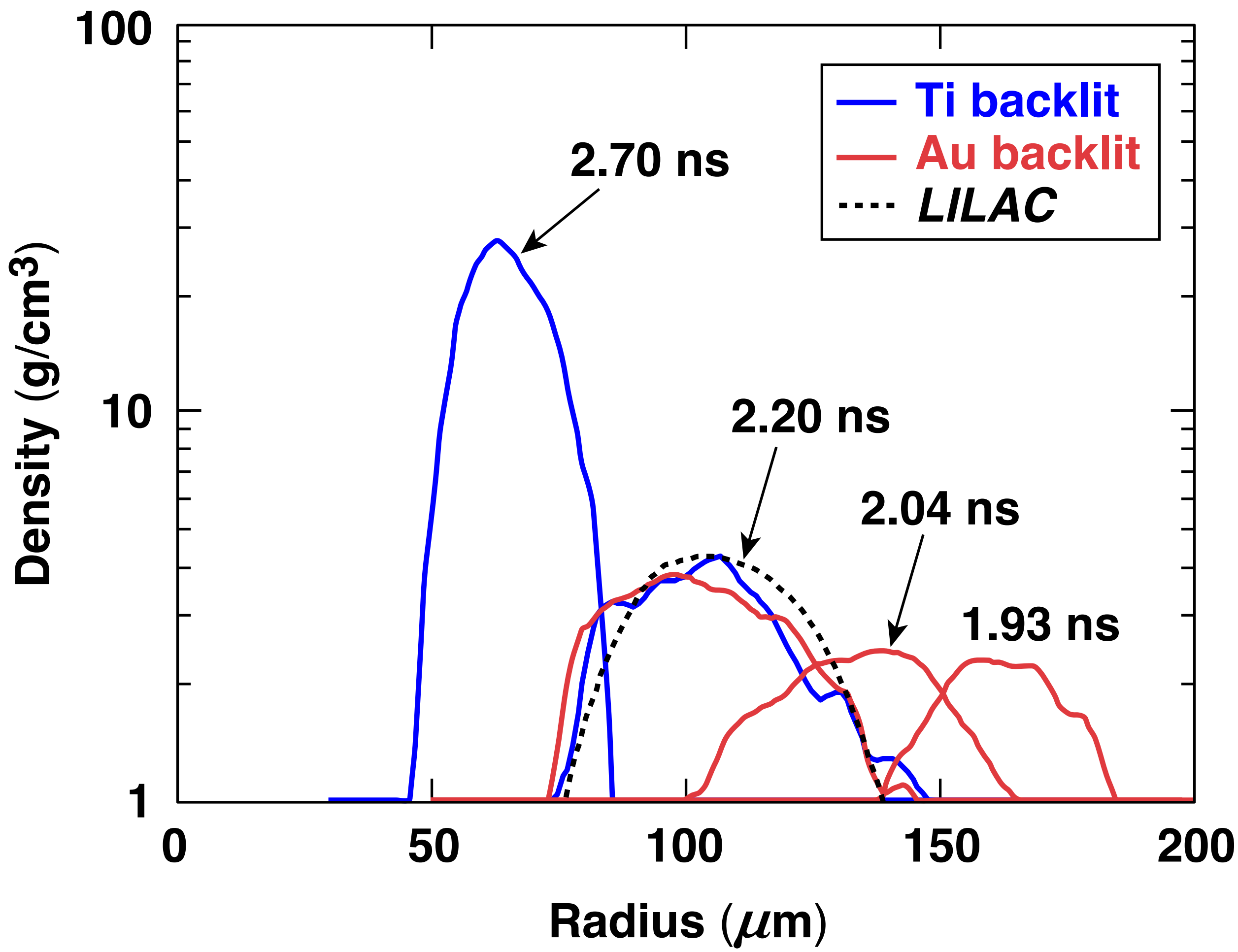
- **Low adiabat, directly driven implosions are being performed on OMEGA emulating the configuration of the NIF beams.**
- **The implosions follow the 1-D simulations up to shell stagnation as evidenced by x-ray radiography and particle measurements.**
- **Low mode perturbations of the shell, due principally to illumination nonuniformity, are well reproduced by 2-D simulations.**
- **Perturbations of the hot spot depart from 2-D simulations and may have contributions from the target stalk not included in the simulations.**

The density distributions are determined for each time from the radiographs and can be compared to simulation

OMEGA shot 49331
Polar-drive 15-atm D_2-filled, 24-μm thick CH shell



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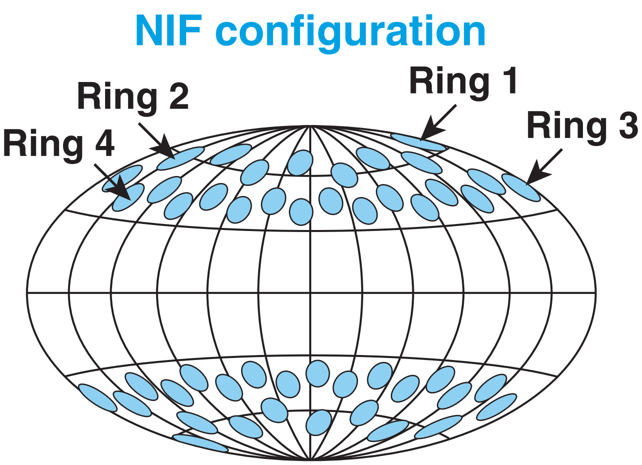
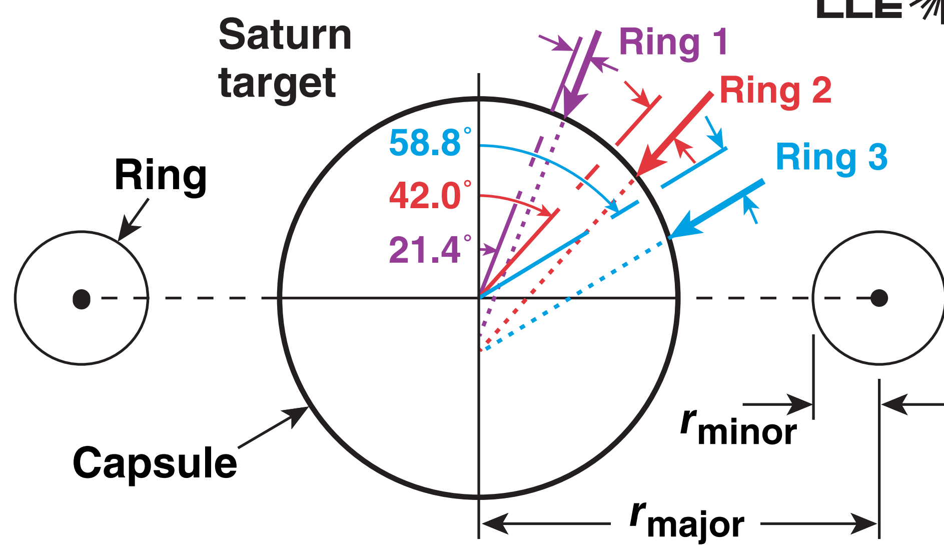
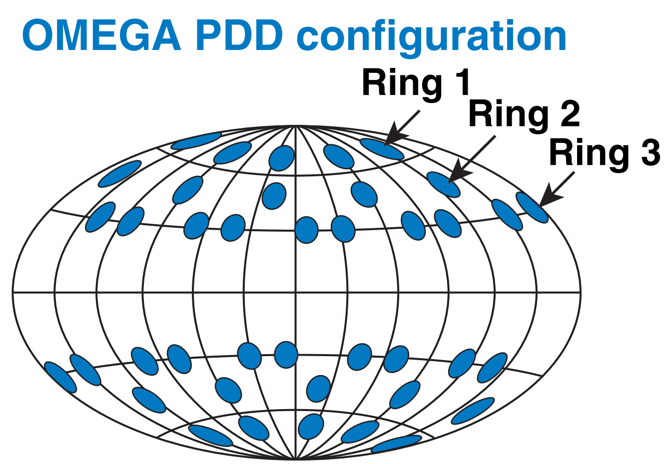
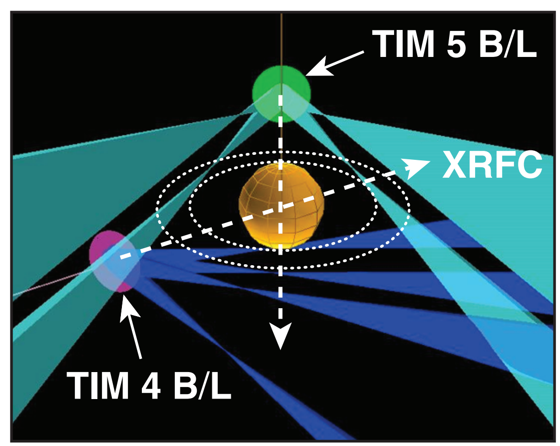
*F. J. Marshall *et al*., Phys. Rev. Lett. 102, 185004 (2009).

40 of the OMEGA beams are used to emulate the NIF 48 beam indirect-drive configuration









- The OMEGA beams, in six rings from 21° to 59°, are used to emulate the NIF geometry.

- Additional OMEGA beams are used for x-ray backlighting.

E14113