Polar Drive Backlighting

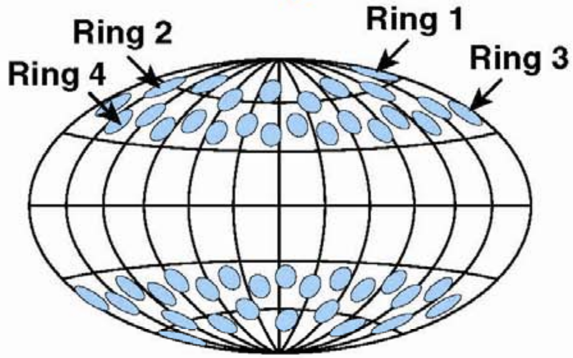
Backlighting of Polar Driven implosions on OMEGA have led to precise comparisons with 2-D simulations

UR LLE

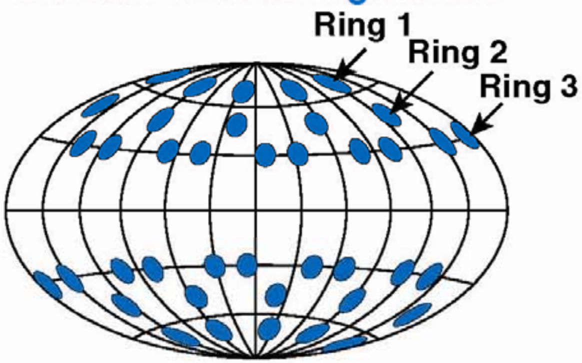
- Low mode perturbations of the shell, due principally to illumination nonuniformity, are easily measured with time-resolved x-ray backlighting.
- 2-D DRACO simulations match the observed shell perturbations in time and shape with some small differences in mass distribution.
- Using beam pointing alone the L=2 perturbations have been minimized leaving only L=4 and higher harmonics.

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

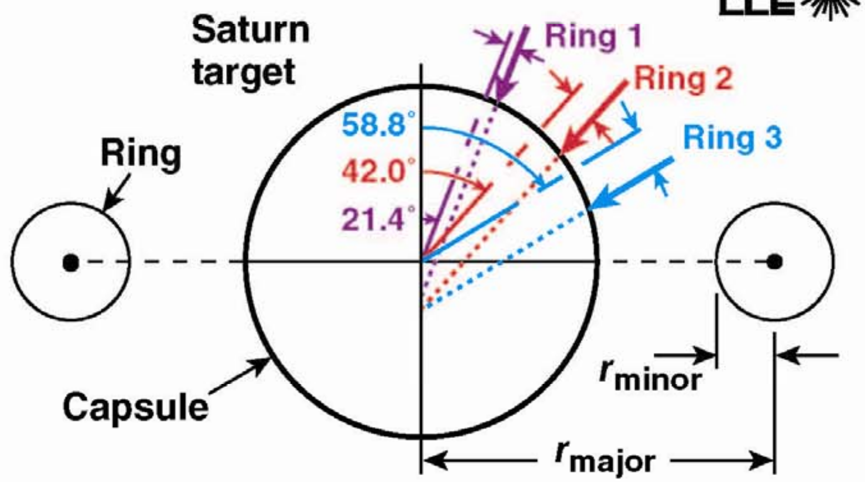
NIF configuration

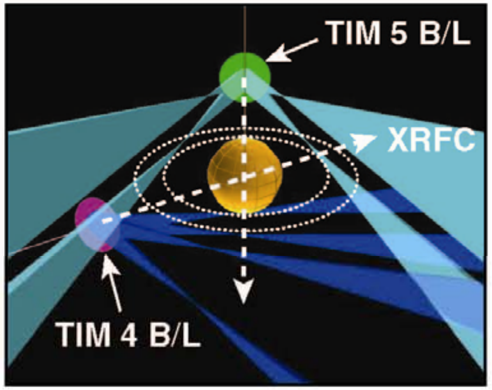


OMEGA PDD configuration



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





Backlighters

Au (2.5 to 4 keV)
Ti (4.7 to 5 keV)
Fe (6.7 to 7 keV)

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

E14113

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

$$I = I_0 \exp\left[-\int \kappa(E,r)\,\mathrm{d}z\right].$$

The inverse Abel transform gives the radially dependent opacity

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

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

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

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

$$M_{\mathrm{shell}} = \int \rho(r)\,\mathrm{d}V = 4\pi\int \frac{\kappa(E,r)}{\mu_{\mathrm{eff}}(E)} r^2\,\mathrm{d}r.$$

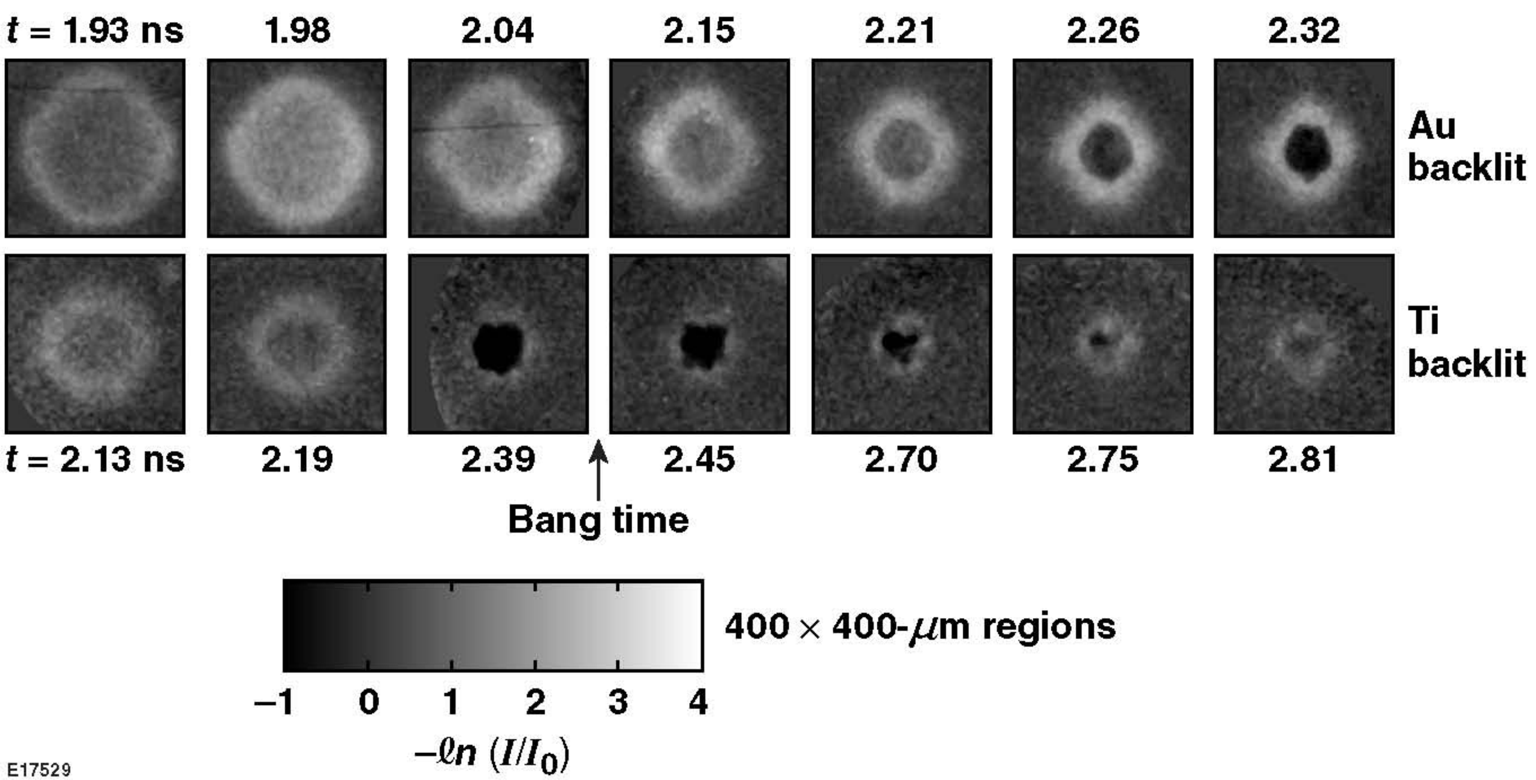
E18411

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

Low adiabat α~3, median convergence ratio c_r~13

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

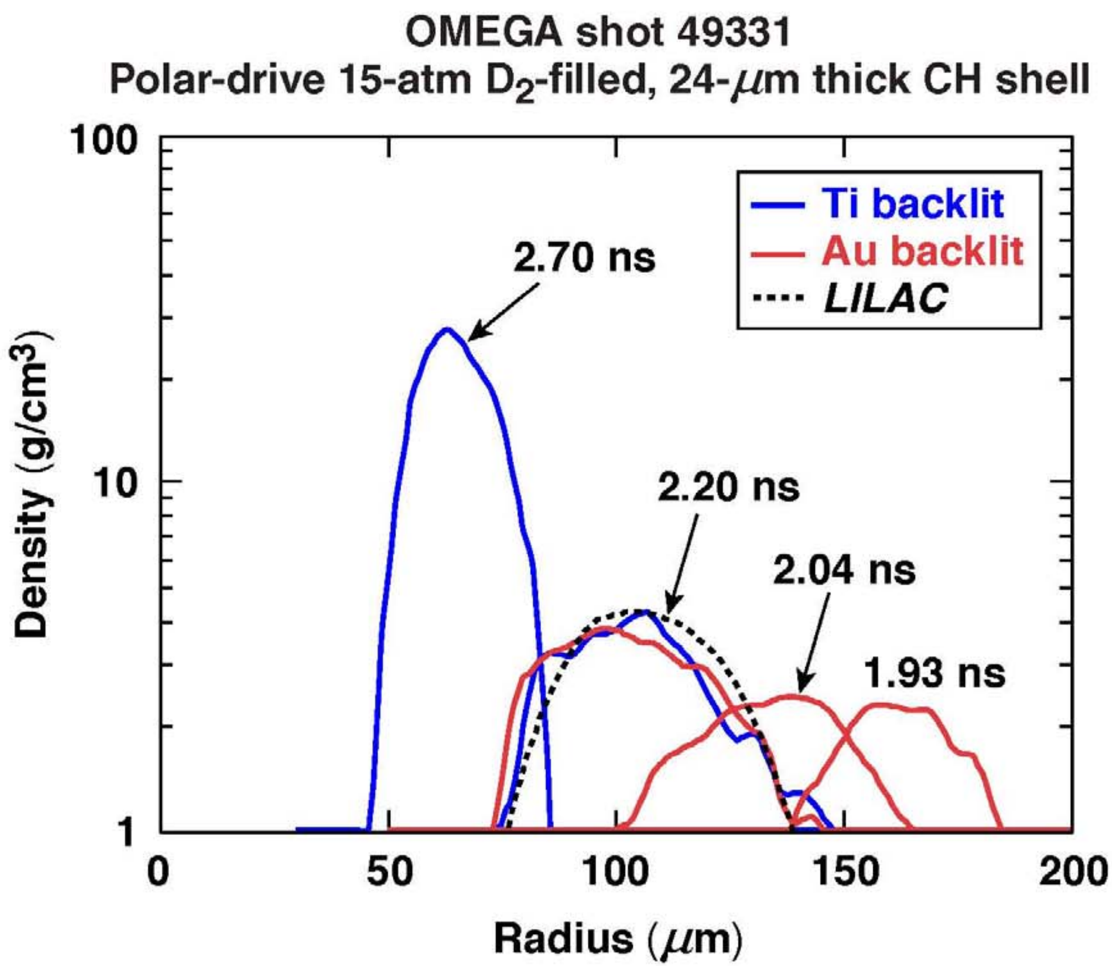
X-ray radiographs from OMEGA shot 49331
Polar-driven 15-atm D_2-filled, 24-μm thick CH shell



E17529

Low adiabat α~3, median convergence ratio c_r~13

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



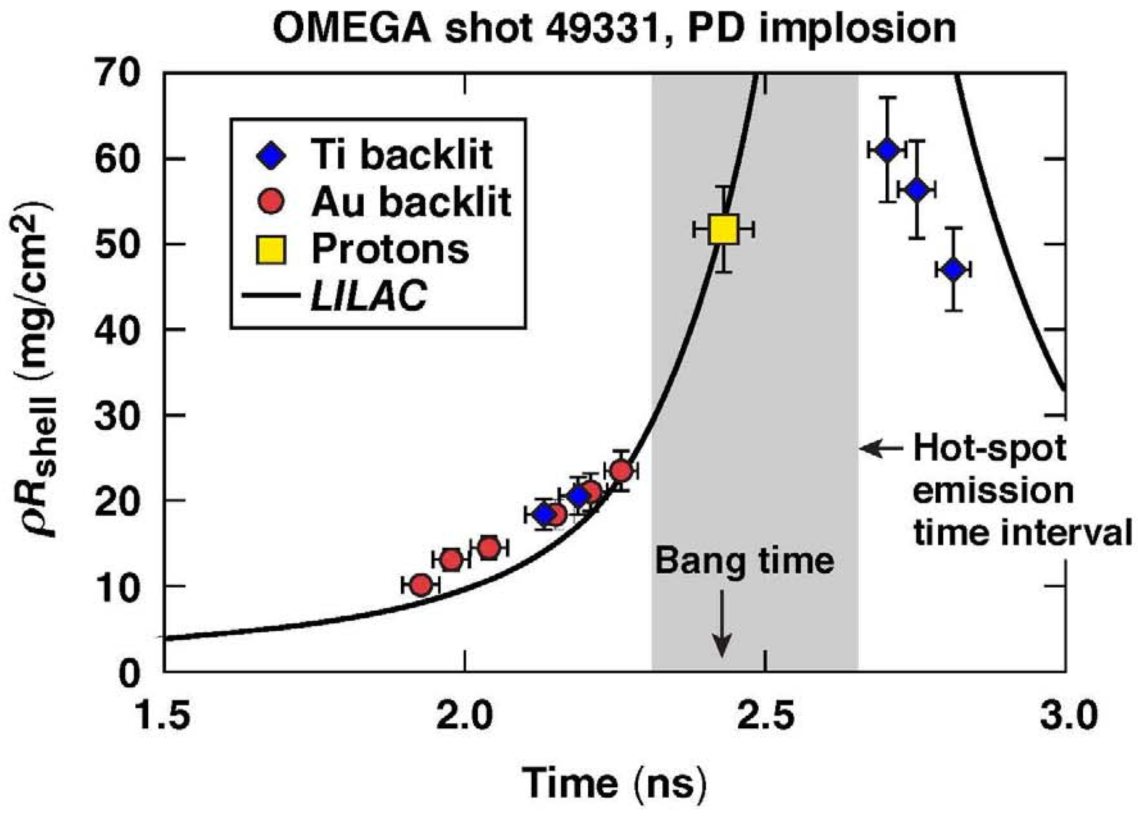
E17531

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

Low adiabat α~3, median convergence ratio c_r~13

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

UR LLE



E17532

Low convergence ratio c_r~10

For the pointing cases with no azimuthal variation the polar-drive implosions varied from oblate to prolate

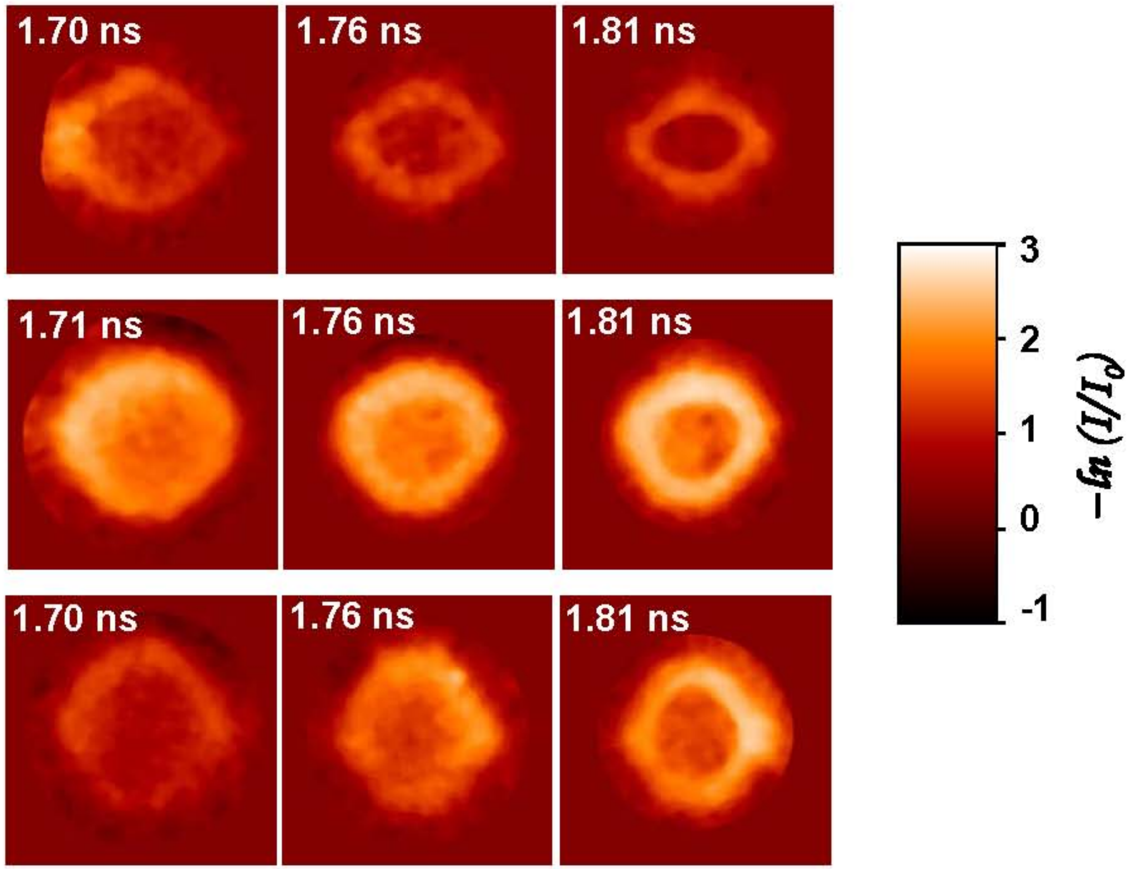
UR LLE

Au-backlit radiographs* (~3 to 4 keV)

Case 1, (90,120,120)
OMEGA shot 38502
TIM 5 view, (θ_v= 101°)
OBLATE

Case 2, (90,150,150)
OMEGA shot 42935
TIM 4 view, (θ_v= 67°)
BEST SYMMETRY

Case 3, (90,180,180)
OMEGA shot 37427
TIM 5 view, (θ_v= 101°)
PROLATE



500 × 500 μm regions

E19517

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

Low convergence ratio c_r~10

Framed backlit images and *DRACO* simulations agree well for oblate- to prolate-shaped PD implosions

UR LLE

Case 1, (90,120,120)
OMEGA shot 38502
TIM 5 view, (θ_v= 101°)
OBLATE

Case 2, (90,150,150)
OMEGA shot 42935
TIM 4 view, (θ_v= 67°)
BEST SYMMETRY

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OMEGA shot 37427
TIM 5 view, (θ_v= 101°)
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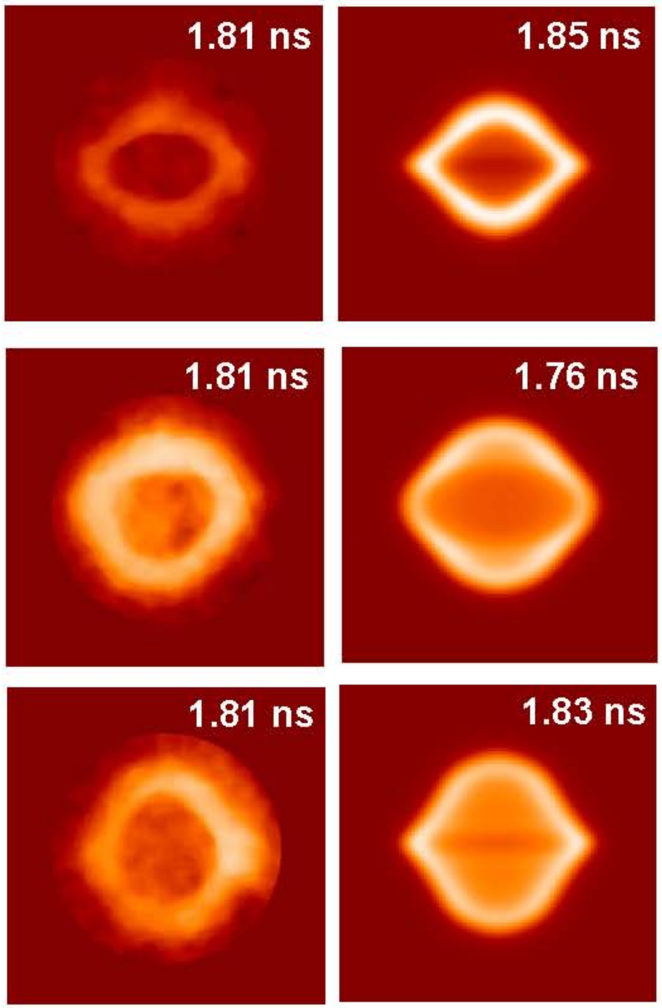
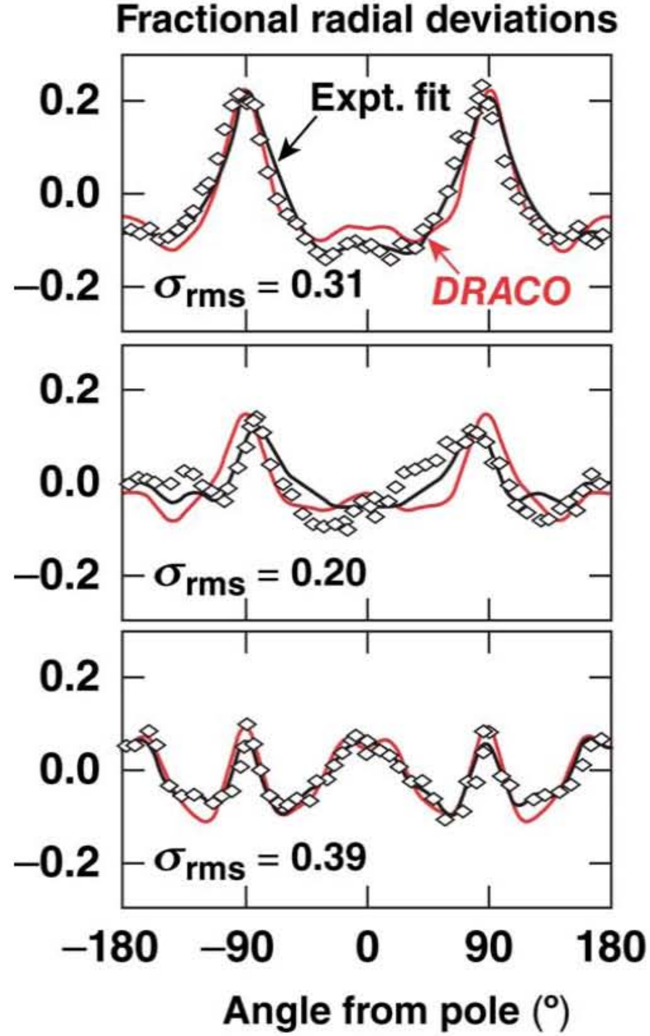


500 × 500 μm regions

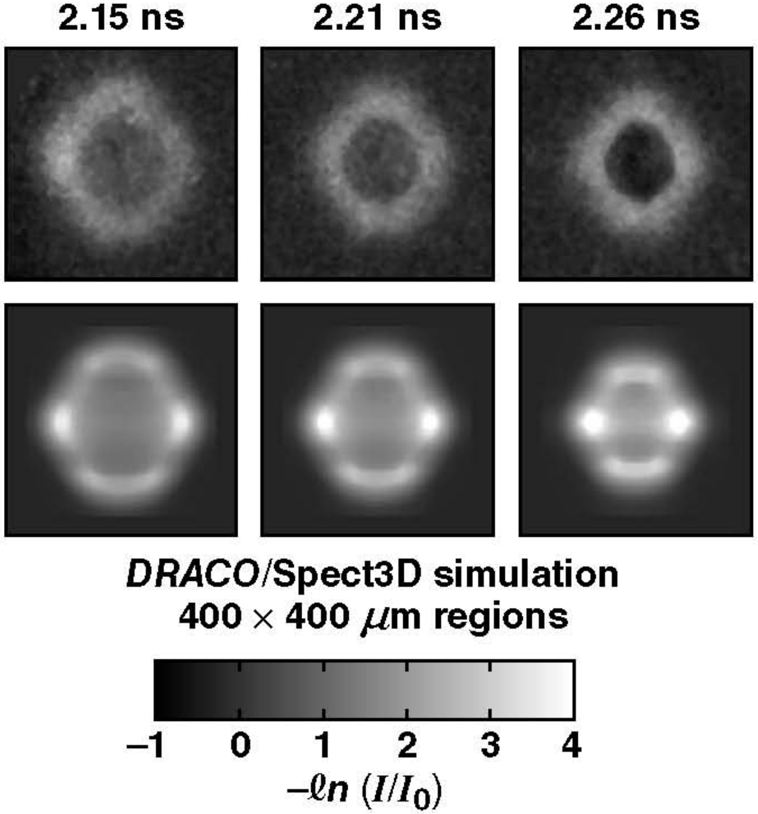


E19520

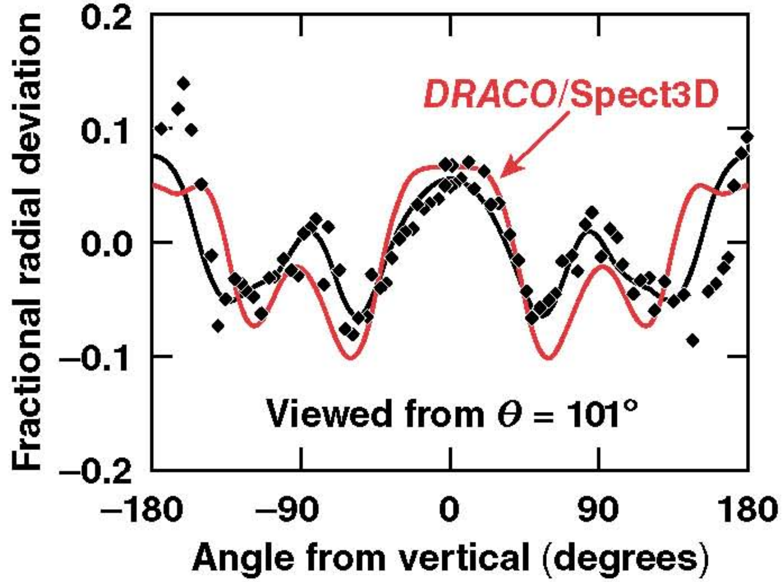
Low adiabat α~3, median convergence ratio c_r~13

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



Shell shape compared to simulation (t = 2.21 ns)

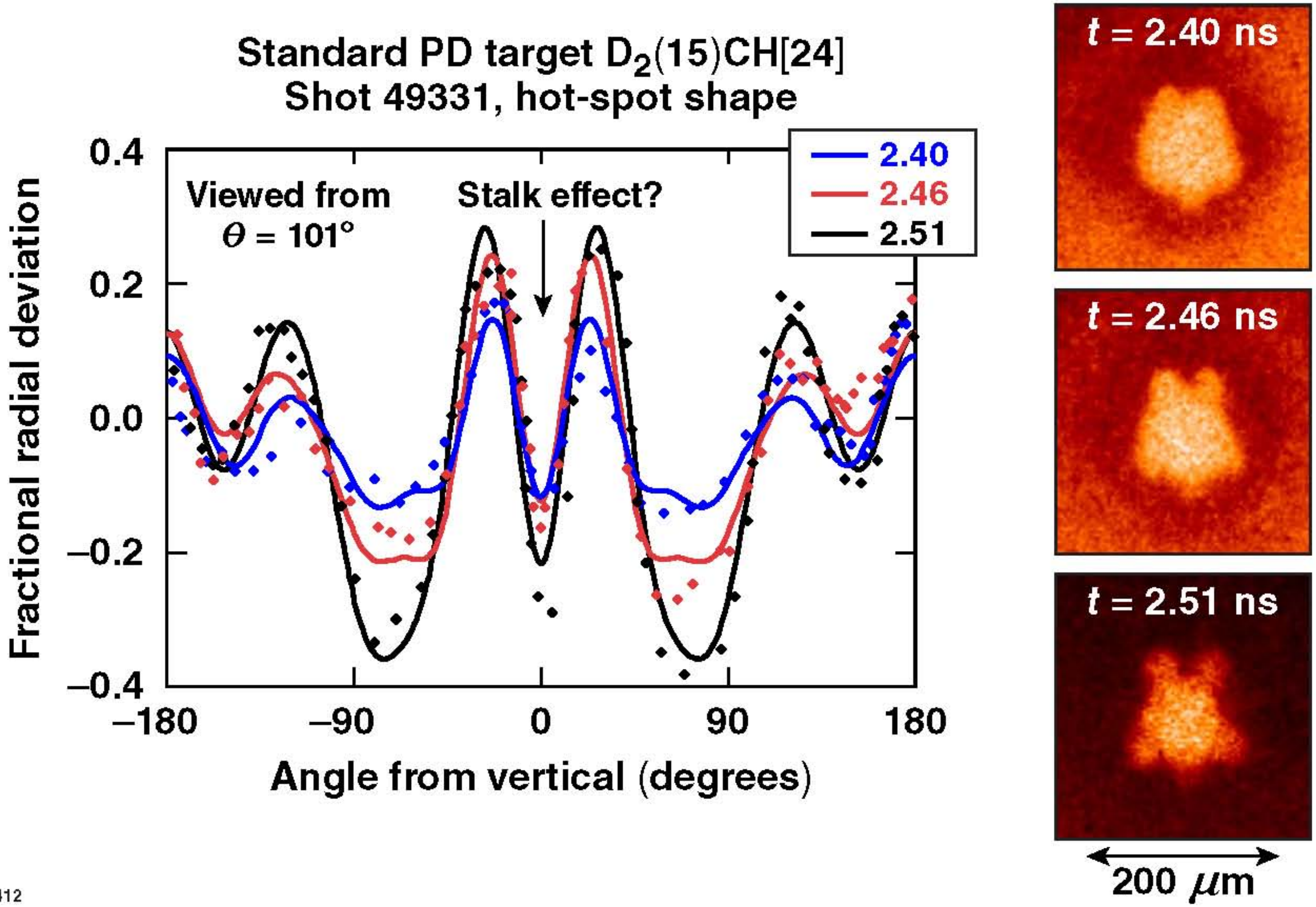


E18413

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

Low adiabat α~3, median convergence ratio c_r~13

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



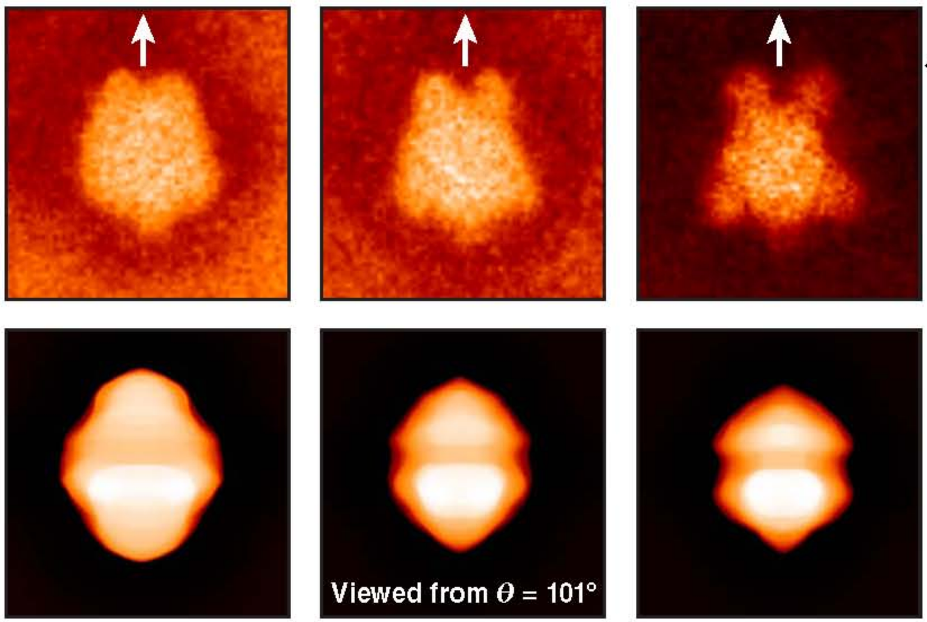
E18412

Low adiabat α~3, median convergence ratio c_r~13

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

2.40 ns | 2.46 ns | 2.51 ns



← 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.

DRACO/Spect3D simulation

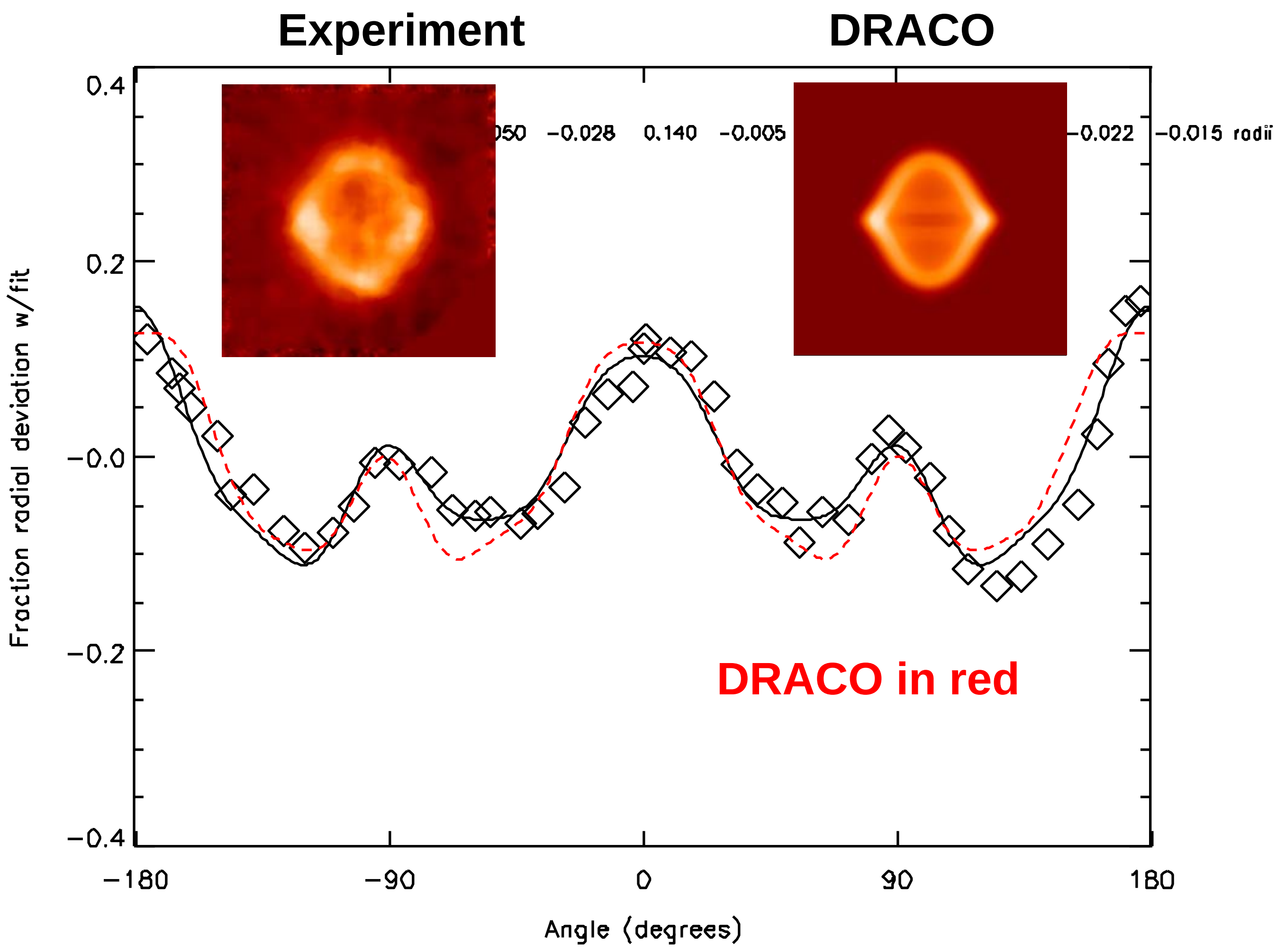
↔ 100 μm

E18423

High convergence ratio c_r~18, slight L=2 (prolate)

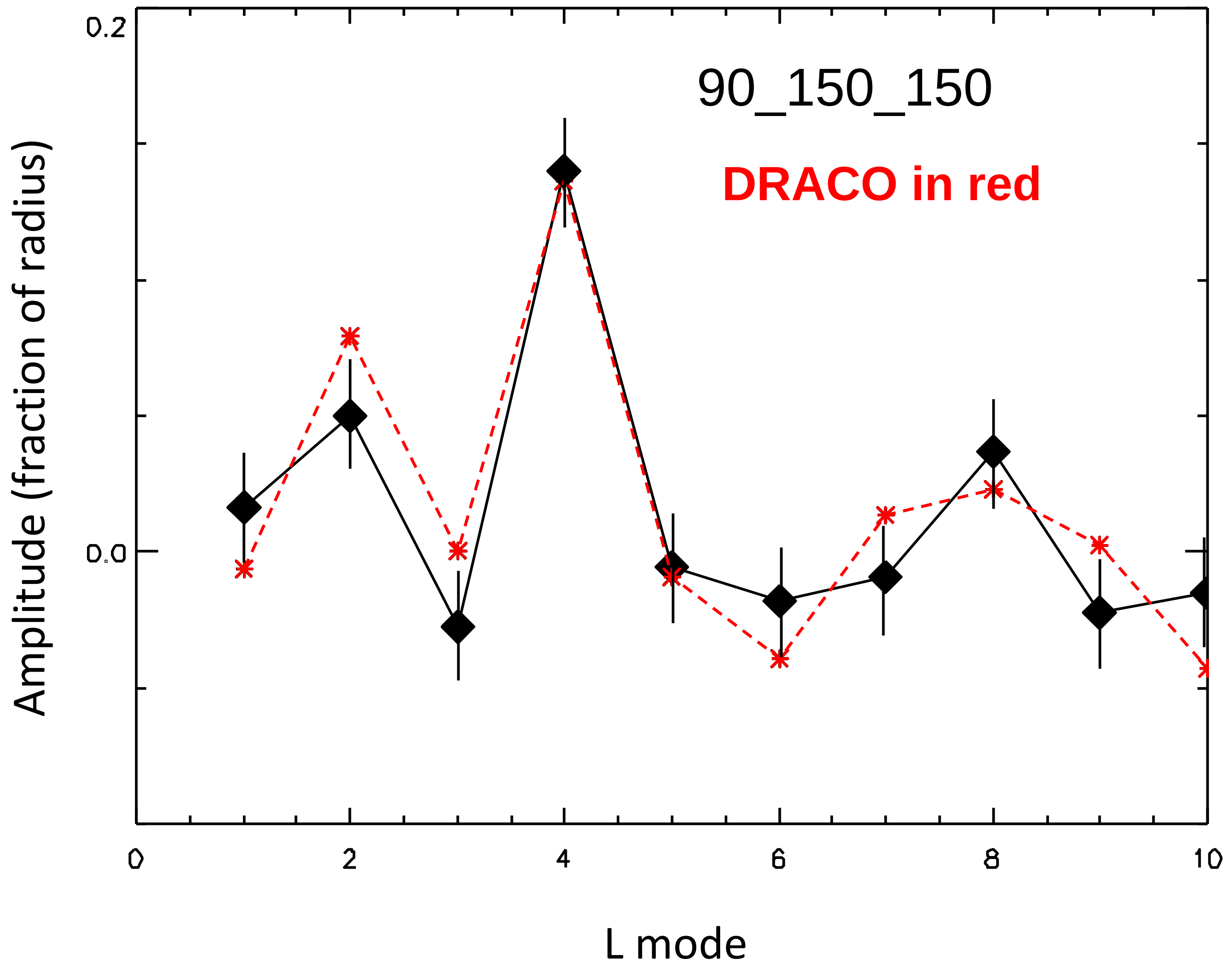
First experiments and simulations indicated that an L=2 component was present in the implosions

UR LLE



High convergence ratio c_r~18, slight L=2 (prolate)

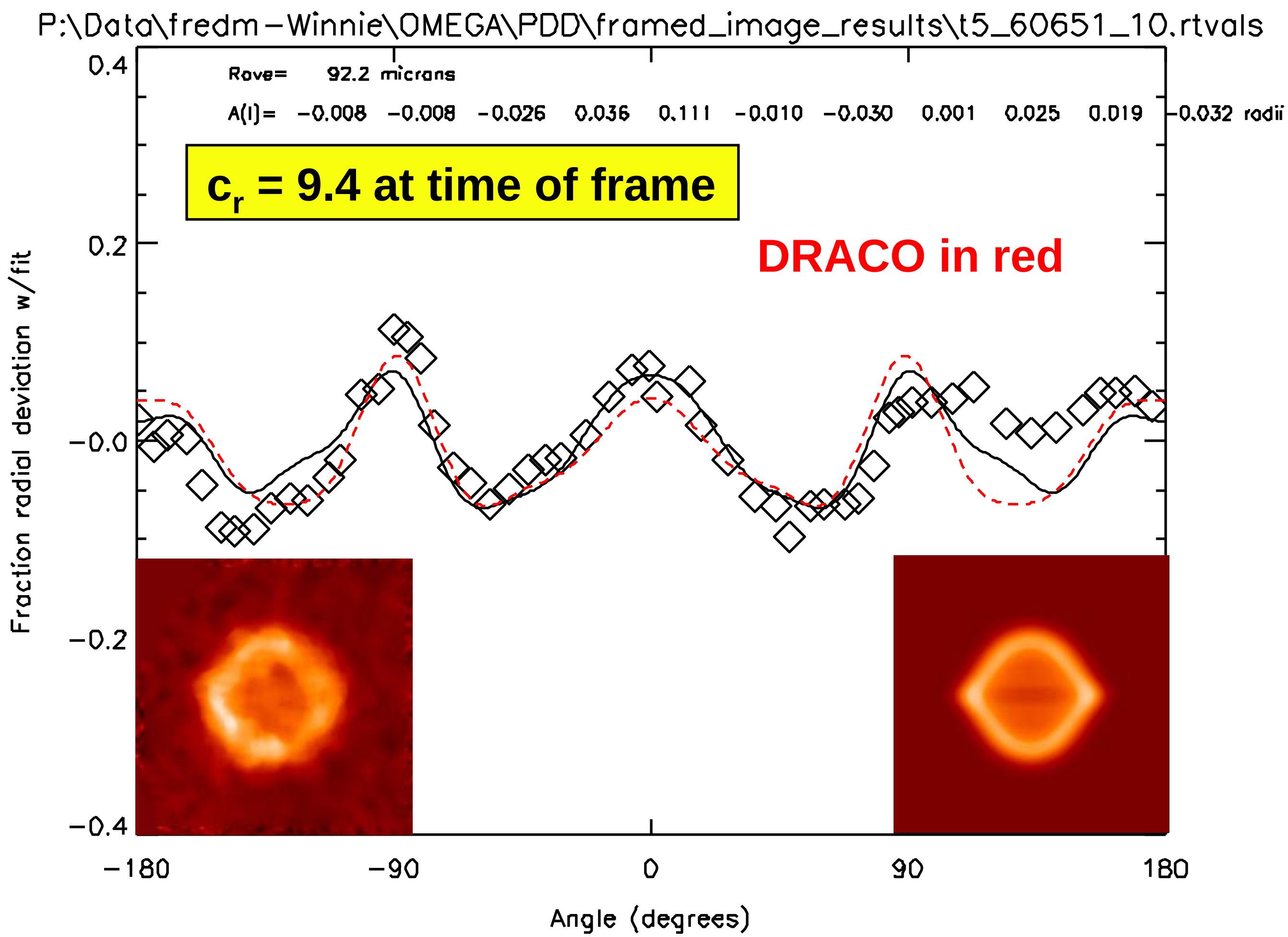
Modal decomposition of the results and simulations indicated both a small L=2 and a larger L=4 component



59649,
frame 7,
3.35 ns

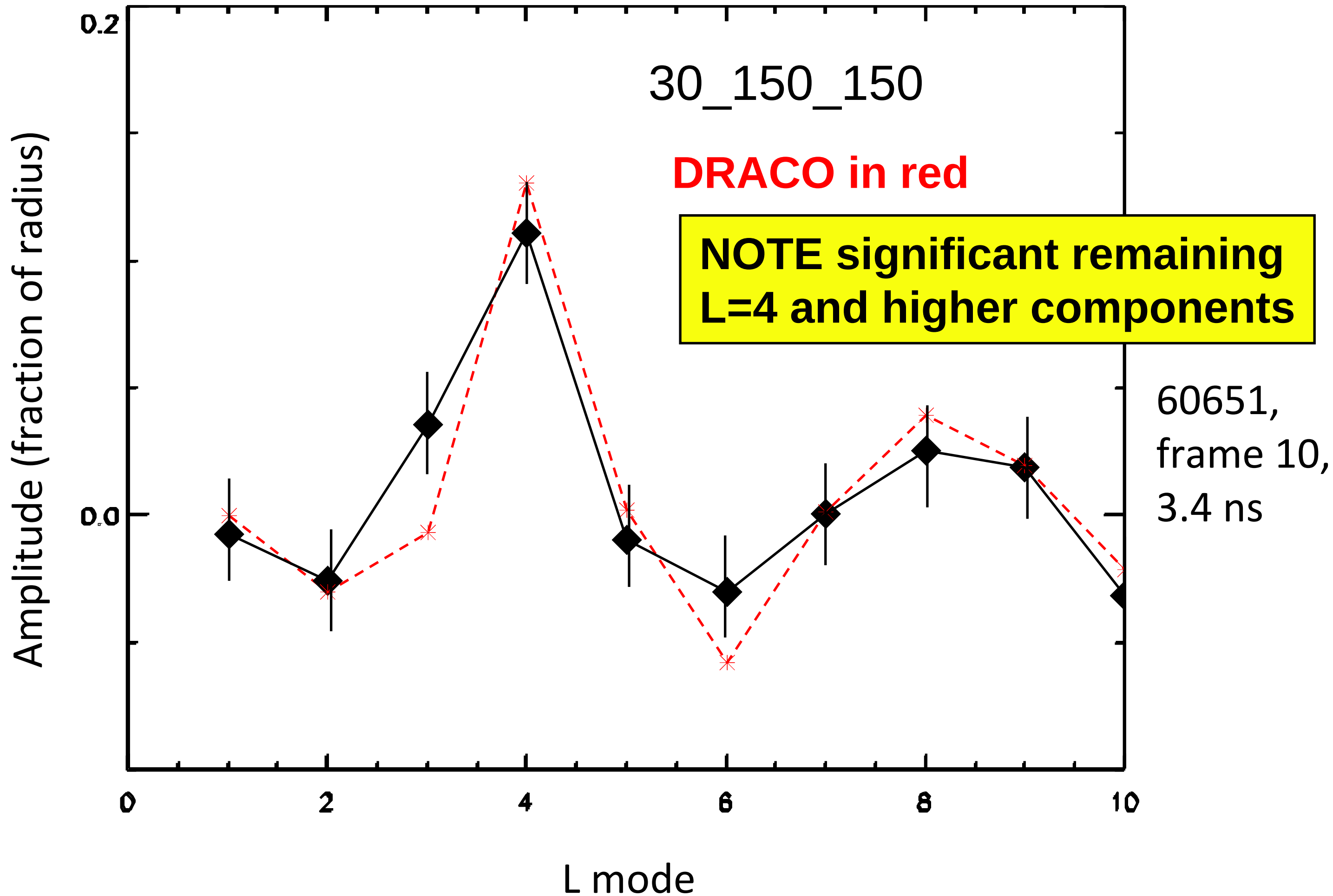
High convergence ratio c_r~18, minimum L=2

The measured and simulated radiographs exhibit nearly identical shapes for the 30,150,150 beam pointing case



High convergence ratio c_r~18, minimum L=2

The modal decomposition of 30,150,150 pointing case agrees well with the DRACO simulation



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