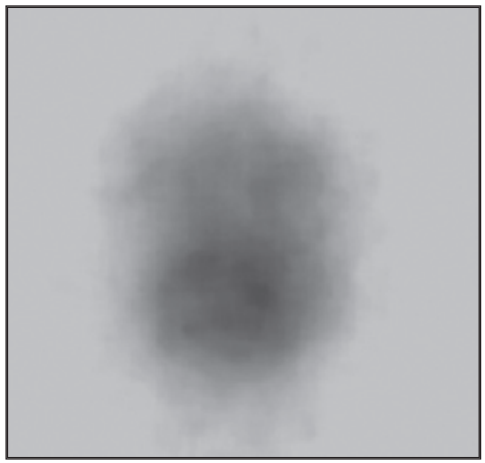
Numerical Investigation of X-Ray Core Images from OMEGA Implosions Driven with Controlled Polar Illumination

UR LLE

OMEGA Shot 34668, PDD, D_2(15)CH[20], 40 beams, 15.4 kJ

DD yield
2.9×10^{10}



KB3 time-integrated x-ray image

100 μm

DD yield
4.1×10^{10}

DRACO/Spect3D

R. Epstein, *et al.*
University of Rochester
Laboratory for Laser Energetics

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Fajardo, Puerto Rico
27 June–1 July 2005

Summary

2-D DRACO/Spect3D* simulated x-ray images show good agreement with images of imploded cores from polar direct drive experiments

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- Successfully attributing the low-order asymmetry of implosion images to controlled polar drive in OMEGA experiments supports ongoing PDD (polar direct-drive) design work.
- The size, asymmetry, and history of observed images are reproduced by
  - 2-D hydrodynamic simulation
  - radiation-transport postprocessing
- Additional image asymmetry can be attributed to the viewing angle in some cases, rather than unintended illumination imbalance.

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Collaborators

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Laboratory for Laser Energetics

Simulated images are obtained from 2-D hydrodynamic simulation and 3-D radiation transport postprocessing

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- *DRACO* hydrocode
  - 2-D Lagrangian hydrodynamics with interface tracking
  - PDD irradiation simulated with 2-D ray tracing
- Spect3D* radiation-transport postprocessing
  - Full 3-D straight-line integration of the equation of transfer
  - Tabulated LTE opacities valid for intended application
  - Camera filtering, response, and viewing angles included

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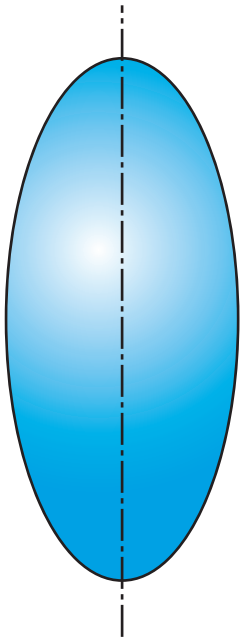
OMEGA experiments show the effects of known polar nonuniformities on the shape of compressed cores

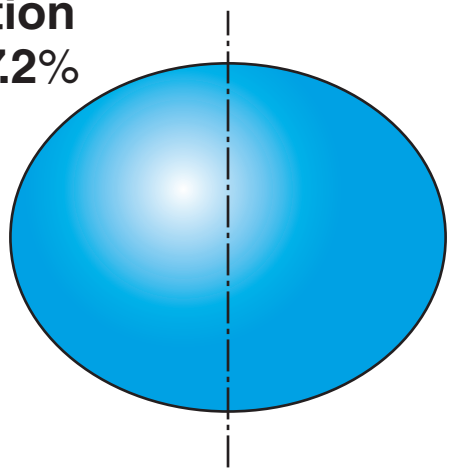


Shot 35173, prolate energy distribution

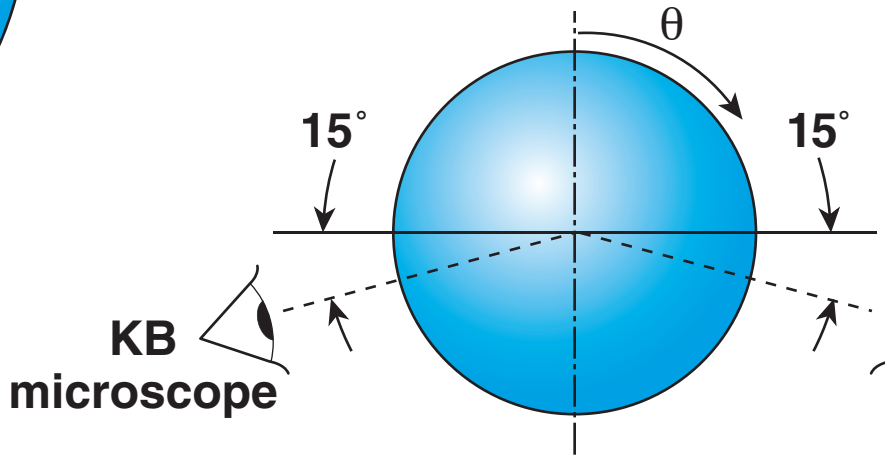
$\sigma_{\ell = 2} = -13.2\%$

Shot 35174, prolate energy distribution

$\sigma_{\ell = 2} = 7.2\%$



$$I_{laser}(\theta) = I_0\left[1 + \sigma_2 \hat{P}_2(\cos\theta)\right]$$



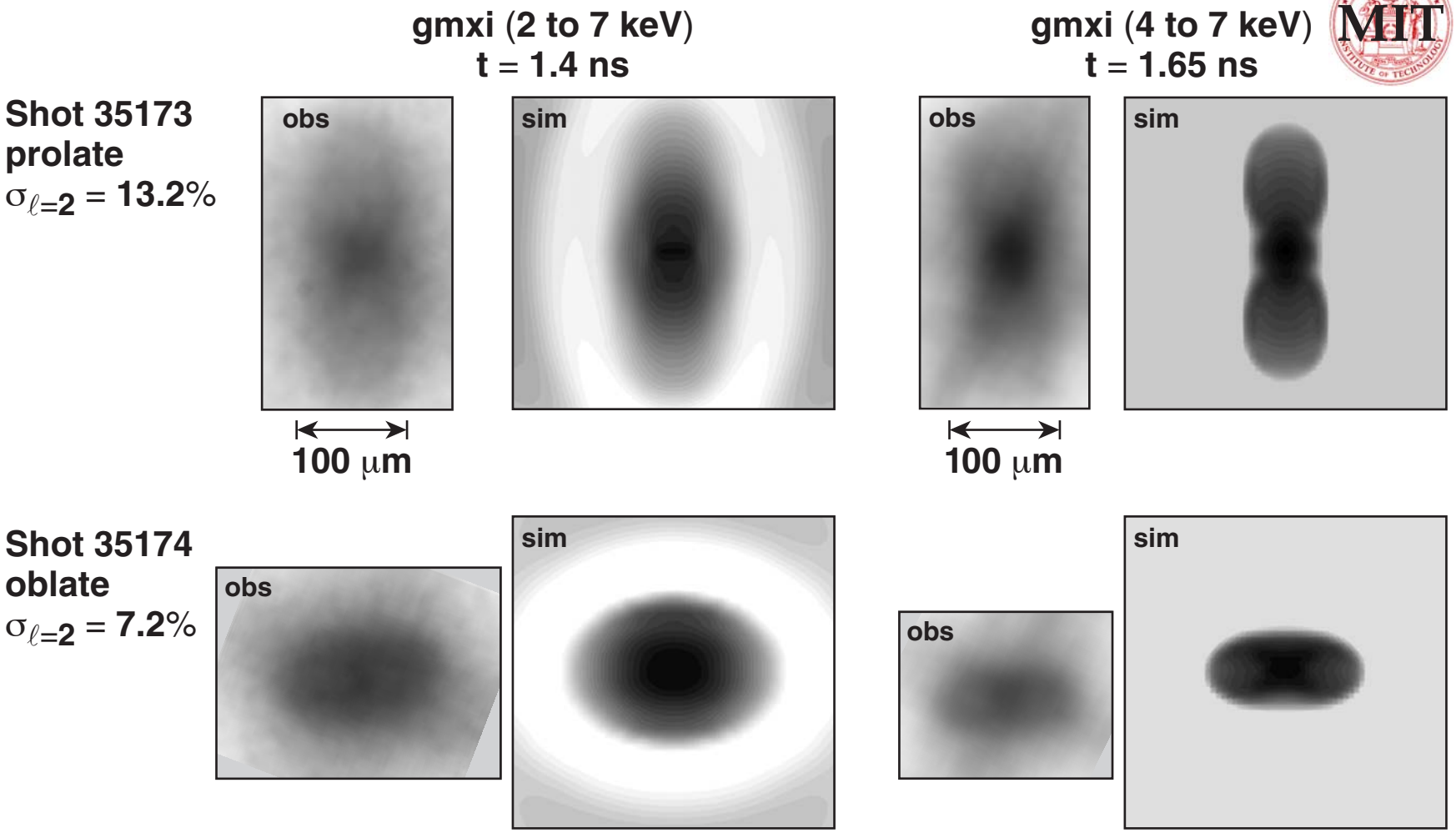
Viewing geometry

TC6785a

Target cores imploded with controlled polar asymmetry match the size and shape of 2-D *DRACO* and Spect3D* simulations

UR LLE

MIT



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TC6786a

Image distortion parameters are estimated by fitting data with noncircular intensity contours

- **Find image intensity contours:**
  $r(\theta) = \rho(1 + a_1 \cos\theta + a_2 \cos 2\theta + a_4 \cos 4\theta)$, **such that** $I(x,y) \approx I(\rho)$

Shot 35173, prolate

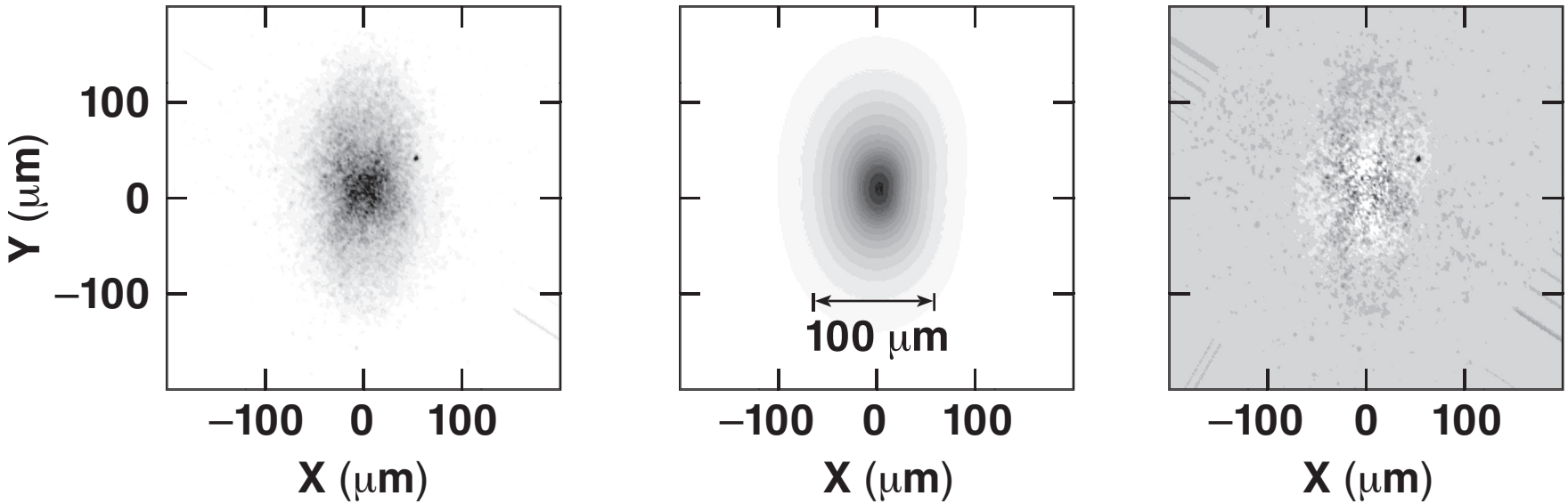
$\sigma_{\ell=2}$ **= 13.2% P2 drive nonuniformity:**
$I(x,y)$ **data**

gmxi (2 to 7 Kev)

a_2 **= 0.20**
fit to $I(\rho)$ **contour map**

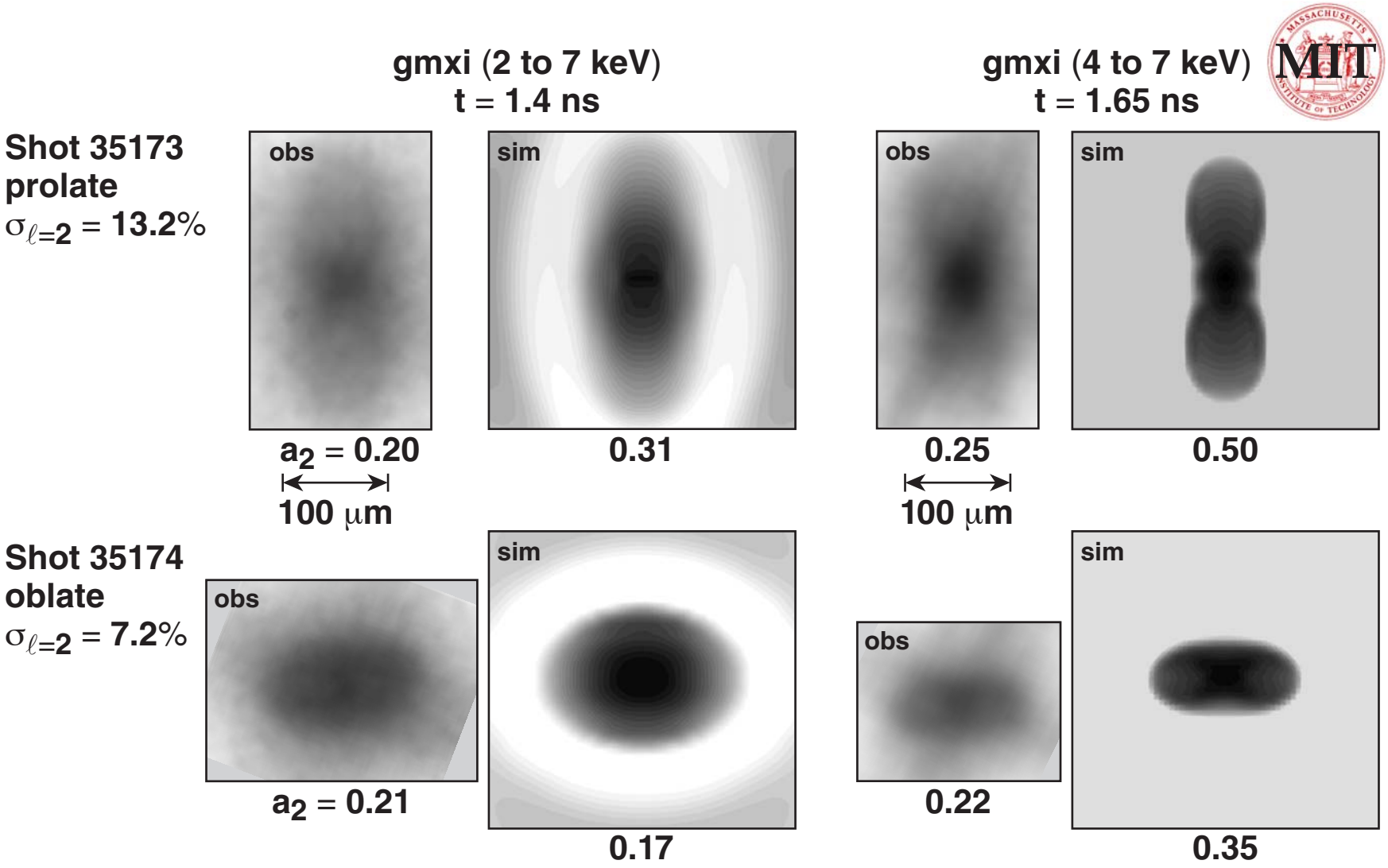
t = 1.4 ns

Fit residual



TC6986

Target cores imploded with controlled polar asymmetry match the size and shape of 2-D *DRACO* and Spect3D* simulations



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TC6786b

A measured prolate core-image sequence with equatorial stagnation is reproduced with 2-D *DRACO* and Spect3D*

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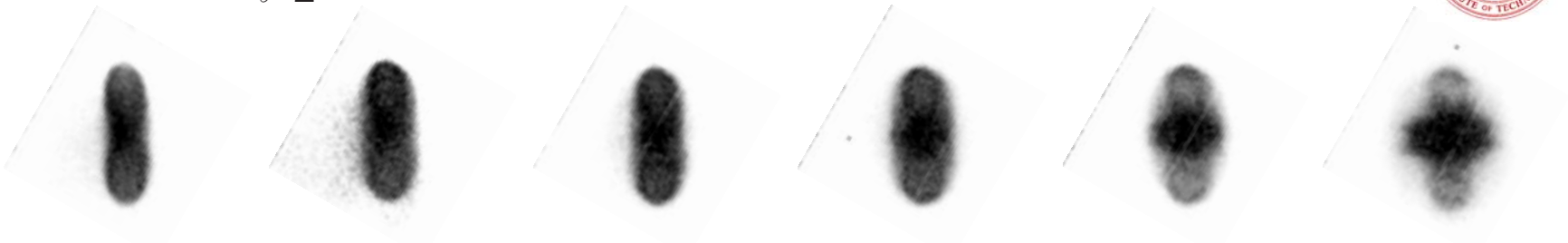
Shot 35173, prolate drive
Δt = 58 ps, $\sigma_{\ell=2}$ = –13.2%, xrfc, Be filter

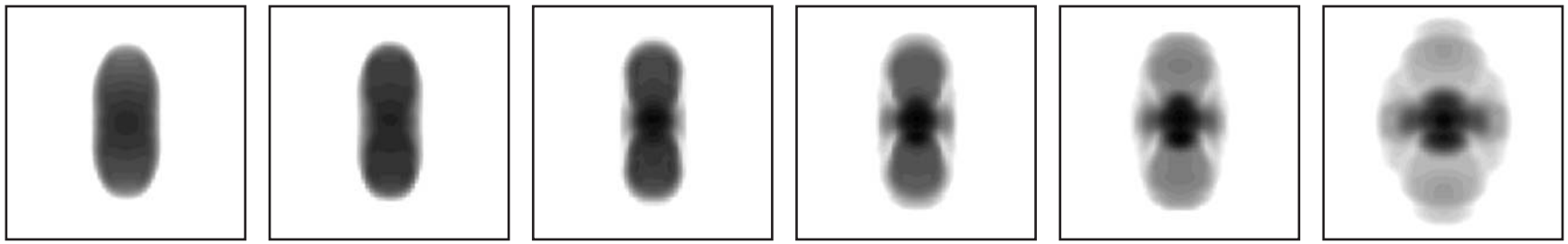


a_2 = 0.58 | 0.44 | 0.48 | 0.38 | 0.27 | 0.10

200 μm

Peak compression

DRACO* and Spect3D



a_2 = 0.38 | 0.45 | 0.46 | 0.37 | 0.27 | 0.16

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TC6787a

The observed time-resolved P2 harmonic distortion parameter of the prolate stagnation sequence is reproduced with a 2-D *DRACO* and Spect 3D* simulation

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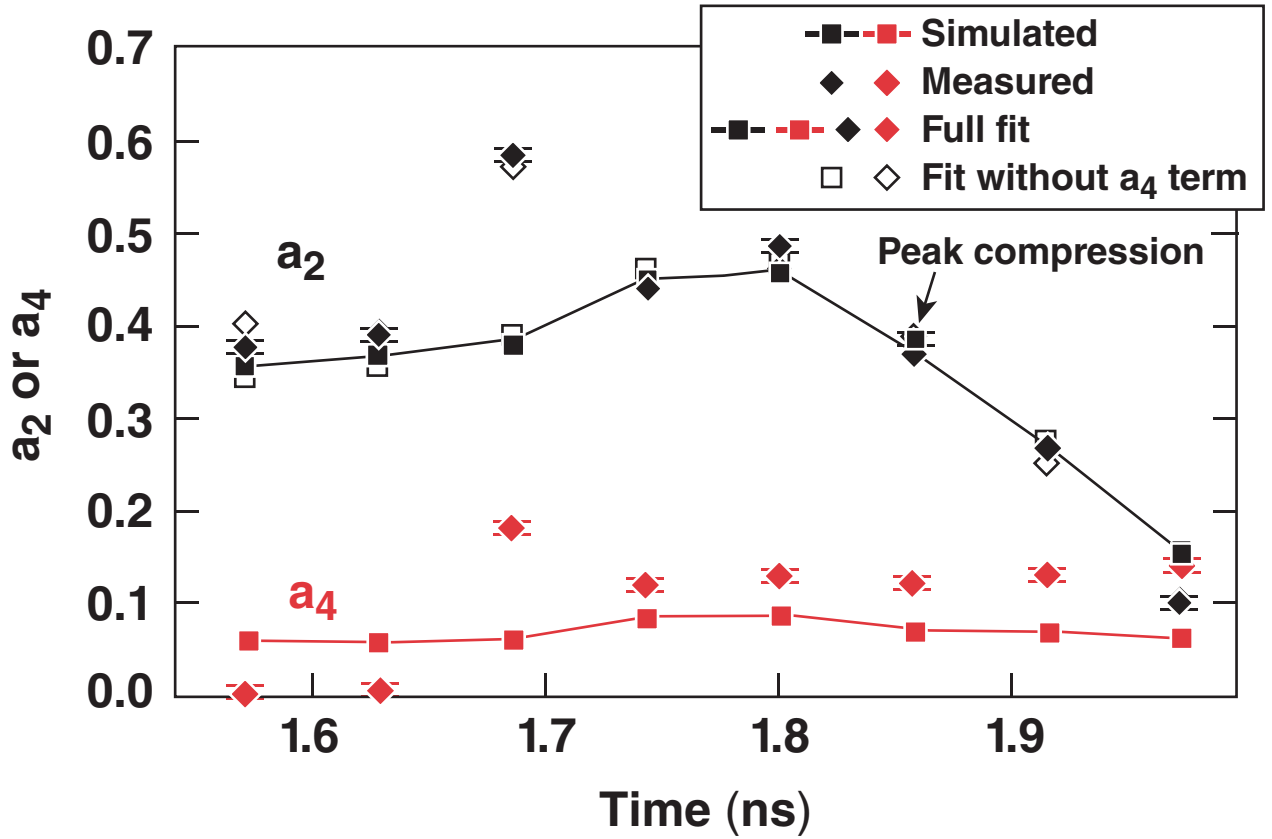
Shot 35173, prolate drive, $\sigma_{\ell = 2}$ = 13.2%, xrfc, Be filter

Intensity contours: $I(x,y) = I(\rho)$, $r(\theta) = \rho(1 + a_2\cos 2\theta + a_4\cos 4\theta)$



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OMEGA PDD Configuration

The NIF 48-quad PDD configuration was simulated on OMEGA by repointing 40 beams

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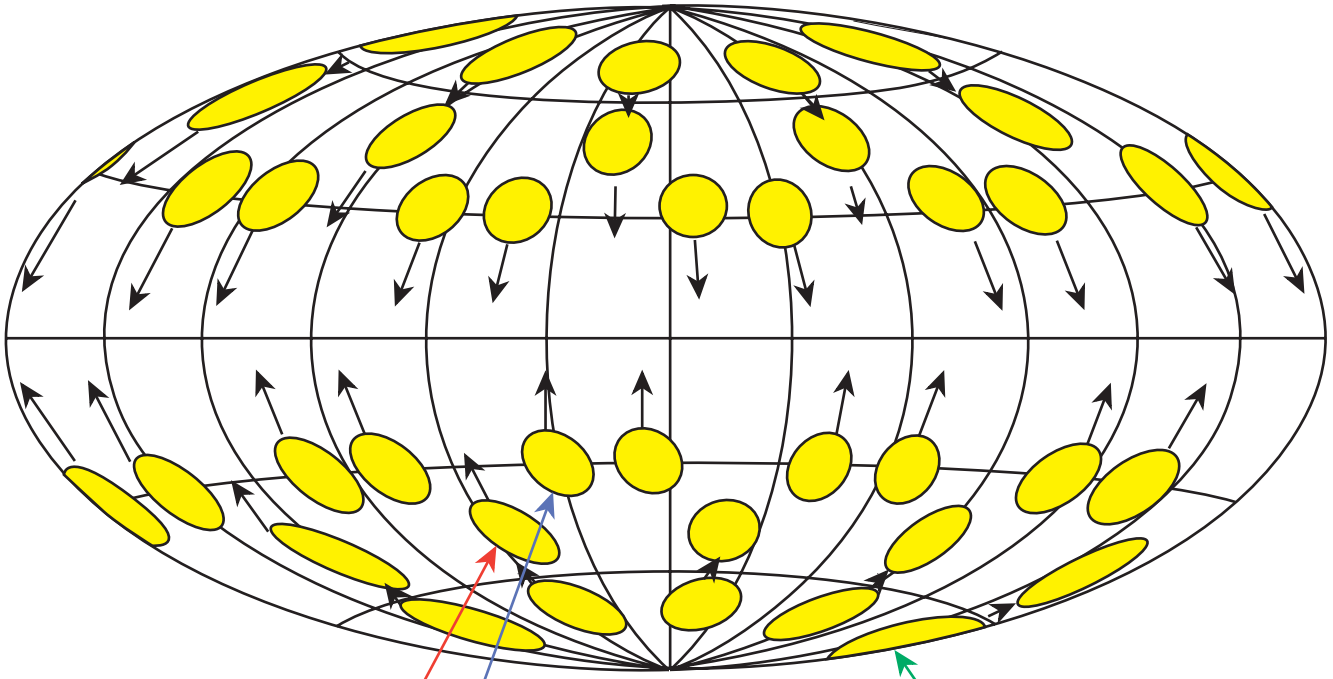

42° beams moved to 66.6°

58.8° beams moved to 83.5°

21° beams moved to 33.4°

The core-stagnation symmetry is affected by the illumination configuration

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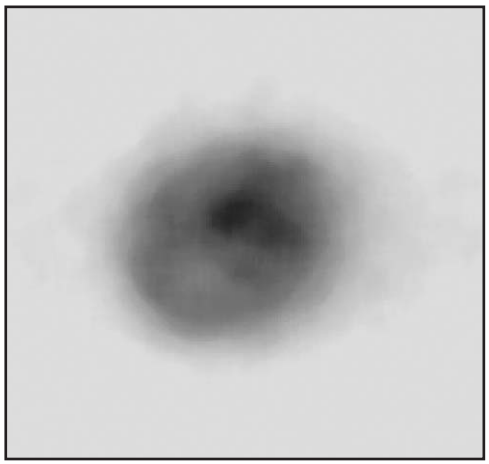
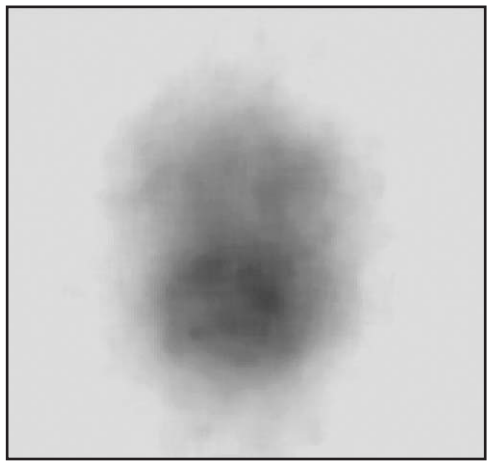
Time-integrated KB microscope images

	60 beams TCC 15.6 kJ $Y_{DD} = 8.4 \times 10^{10}$	40 beams PDD 15.4 kJ $Y_{DD} = 2.9 \times 10^{10}$
Shot 34644 / Shot 34668		

100 μm

TC6533

DRACO simulations of the PDD experiments reproduce the qualitative shape of the compressed core

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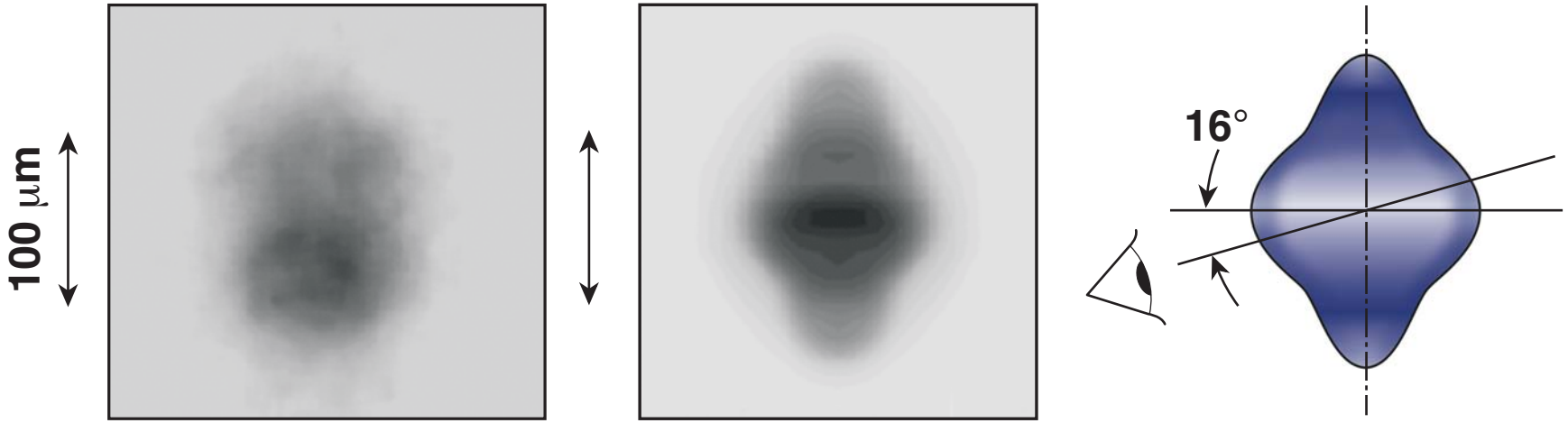
OMEGA implosions at 15-atm, D_2-filled, 20-μm-thick CH shells

40 beams
PDD shot 34668
15.4 kJ

40 beams
PDD simulation*
shot 34668

KB microscope view



DD yield
2.9×10^{10}

DD yield
4.1×10^{10}

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TC6638a

PDD x-ray image asymmetry is due to the oblique viewing angle and absorption by the shell

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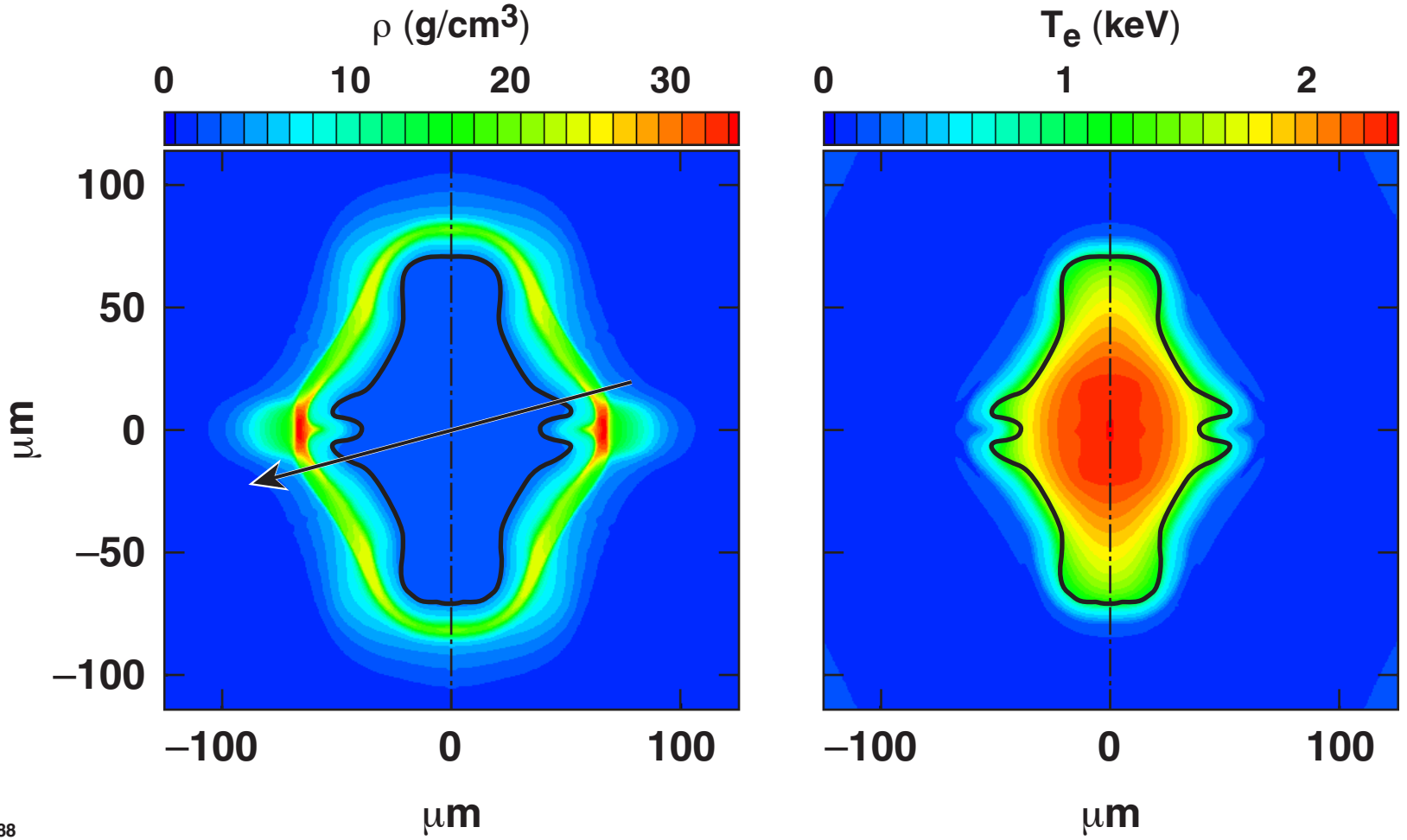
Mass density and electron temperature near peak compression
Shot 34668, t = 2.2 ns



TC6788

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