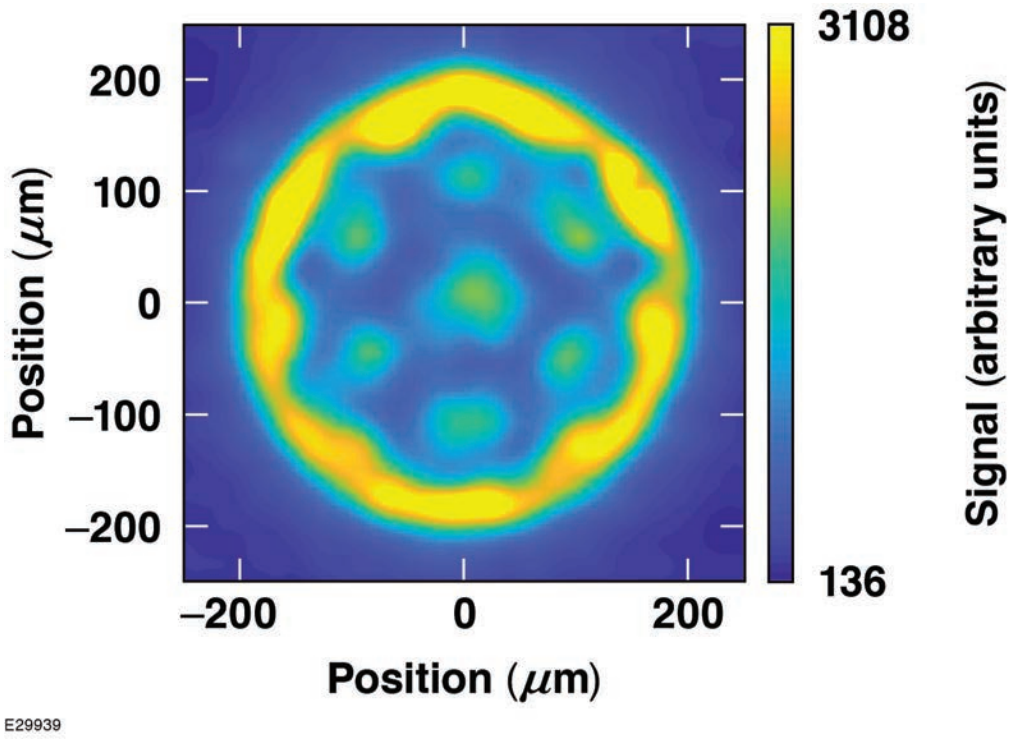
# Analysis of Modulations Observed in X-Ray Self-Emission Images of OMEGA Direct-Drive Inertial Confinement Fusion Implosions

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Summary

# Nonuniform emission modulations observed in x-ray self-emission images show greater contrast than in simulations

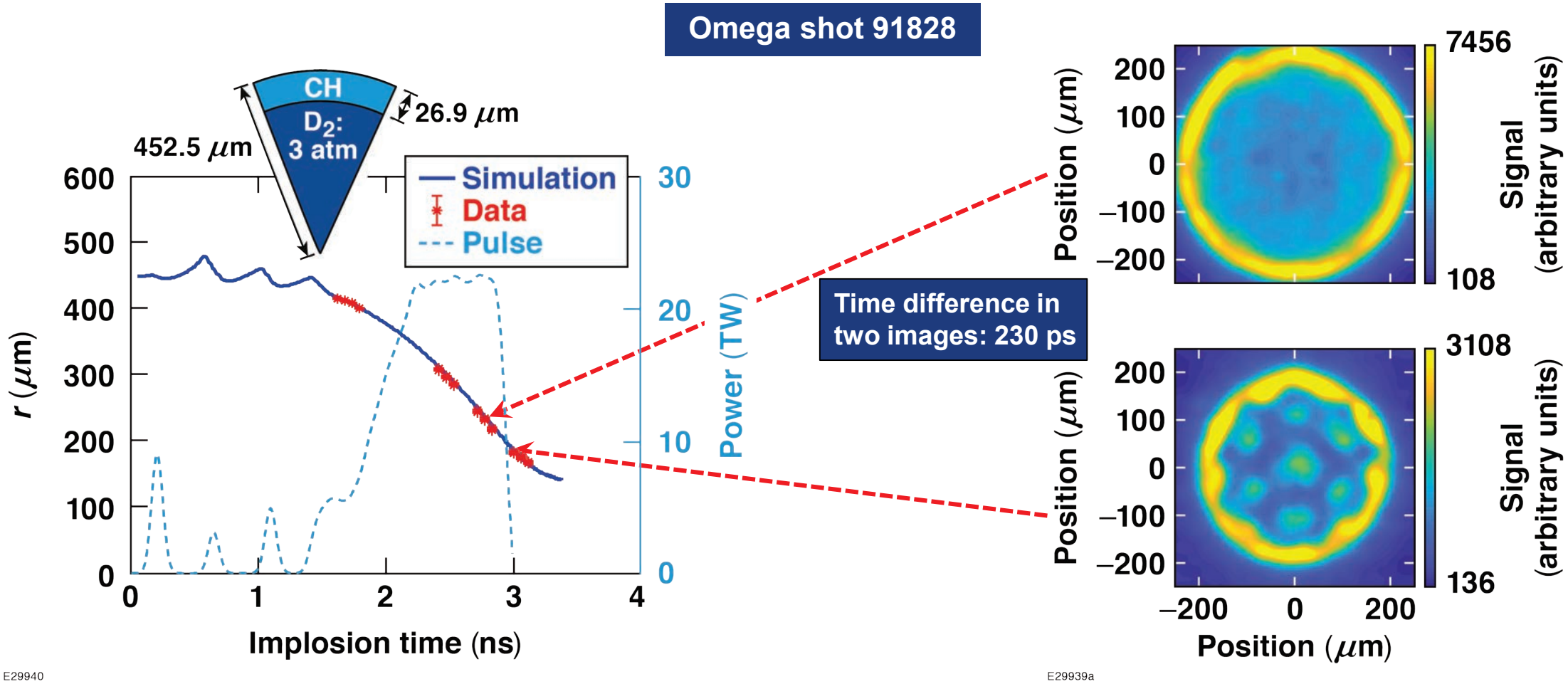
- Modulations are generated from the laser beam port geometry on OMEGA spherical direct-drive implosions using small-spot distributed phase plates
  - the nonuniform emission patterns in the images arise from the x-ray self-emission around the ablation-front region
- State-of-the-art 3-D *ASTER* simulations show qualitatively similar patterns in the self-emission images
  - inclusion of imprint in the simulations did not resolve the discrepancy
- The results suggest the beam-mode–induced hydrodynamic perturbations may be underestimated

# Collaborators

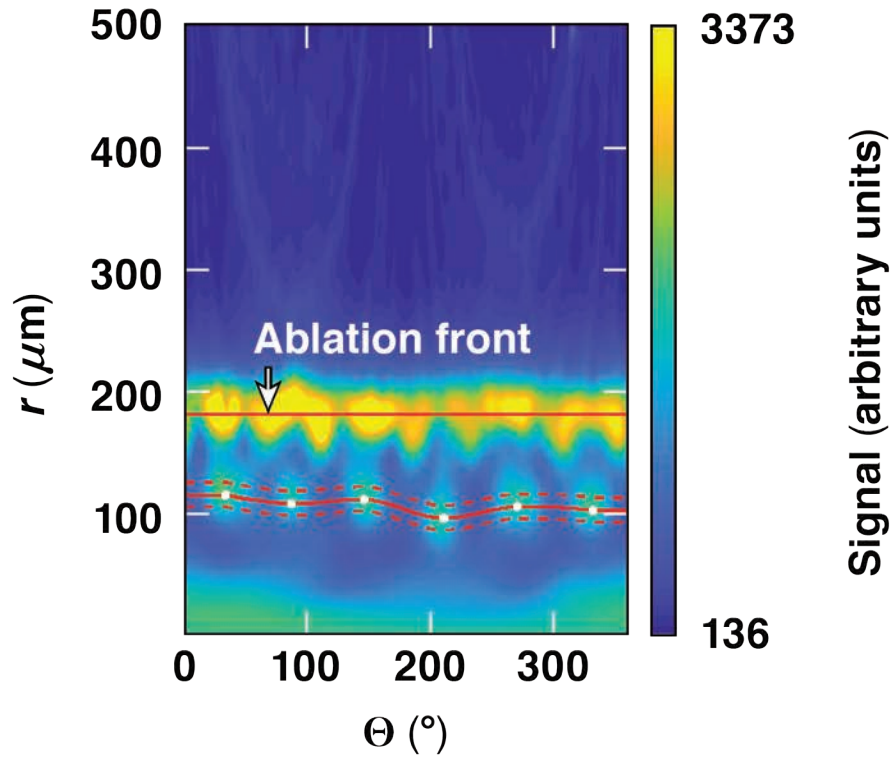
**R. C. Shah, W. Theobald, I. V. Igumenshchev, J. Baltazar, D. Cao, and S. P. Regan**

**University of Rochester**
**Laboratory for Laser Energetics**

# Observations of emission modulations in x-ray self-emission images late in the implosion time



# Extraction of intensity profiles from the intensity modulations in the self-emission image

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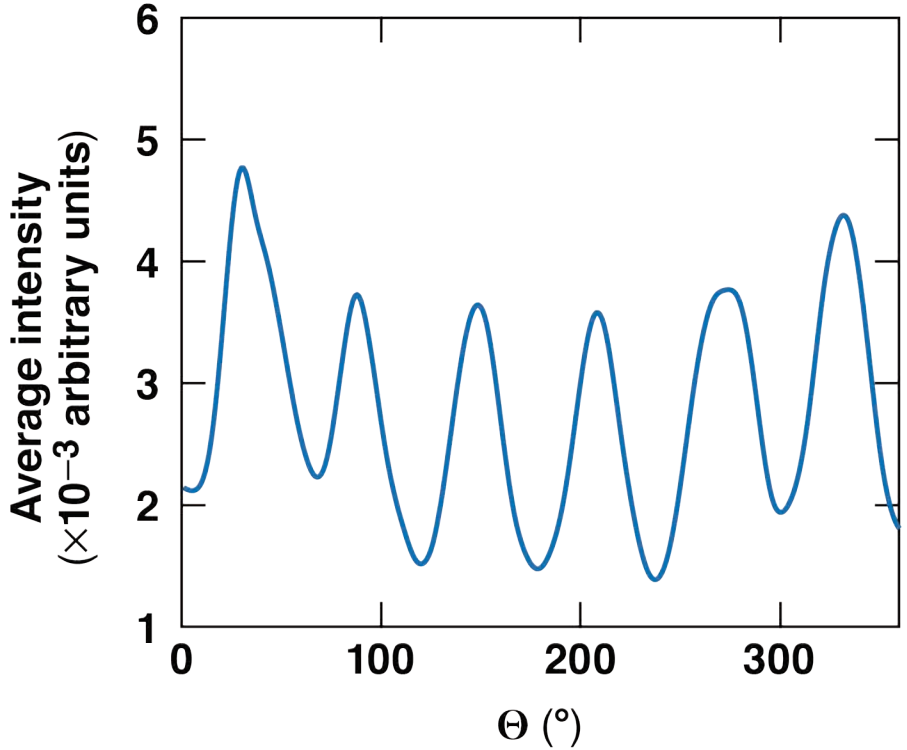
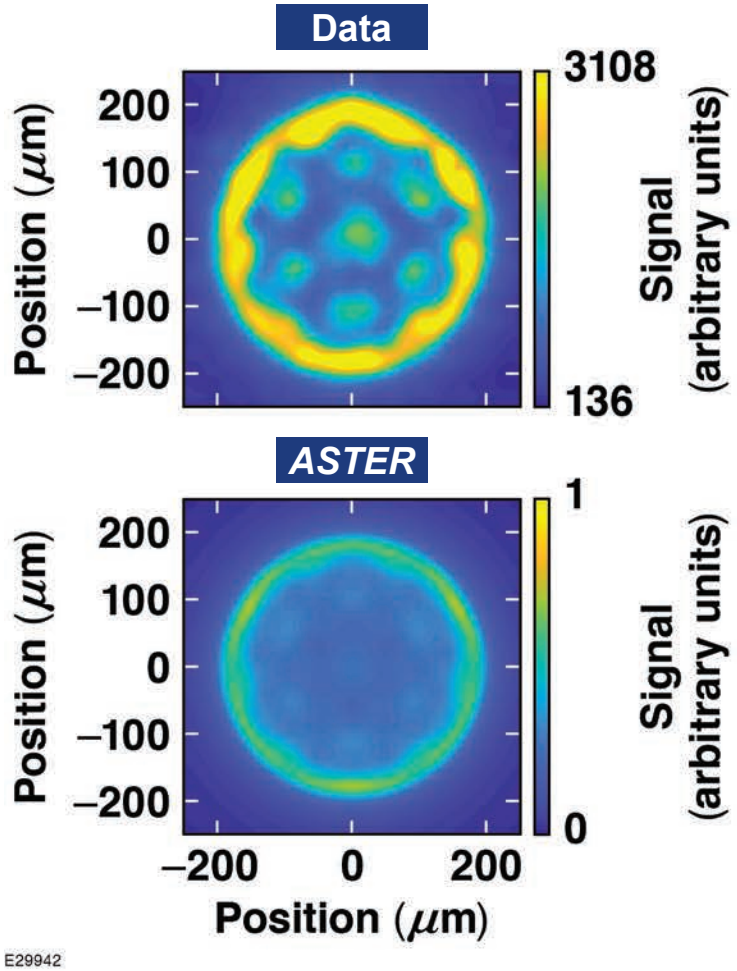
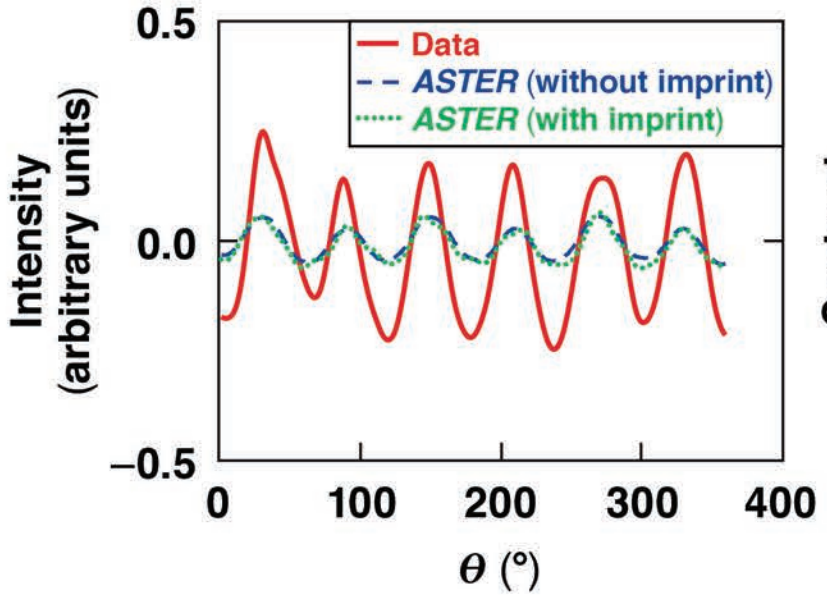
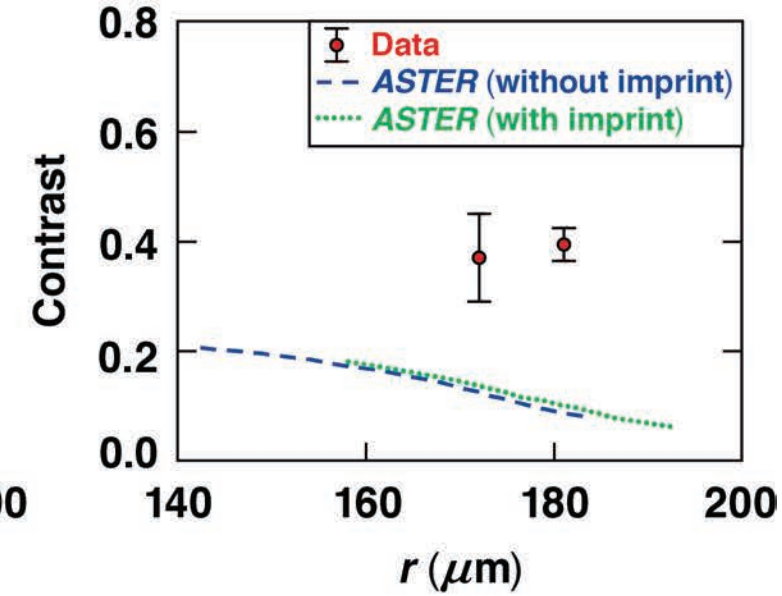


# X-ray self-emission images from *ASTER* also shows emission modulations

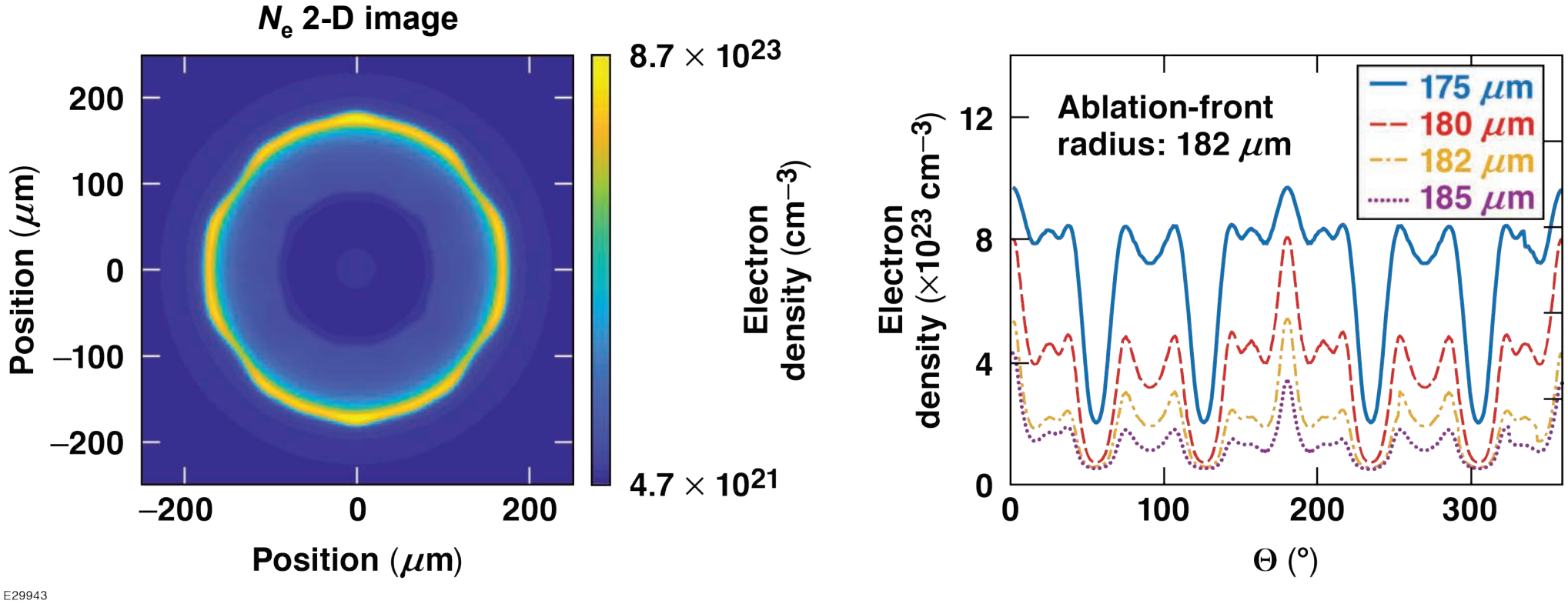


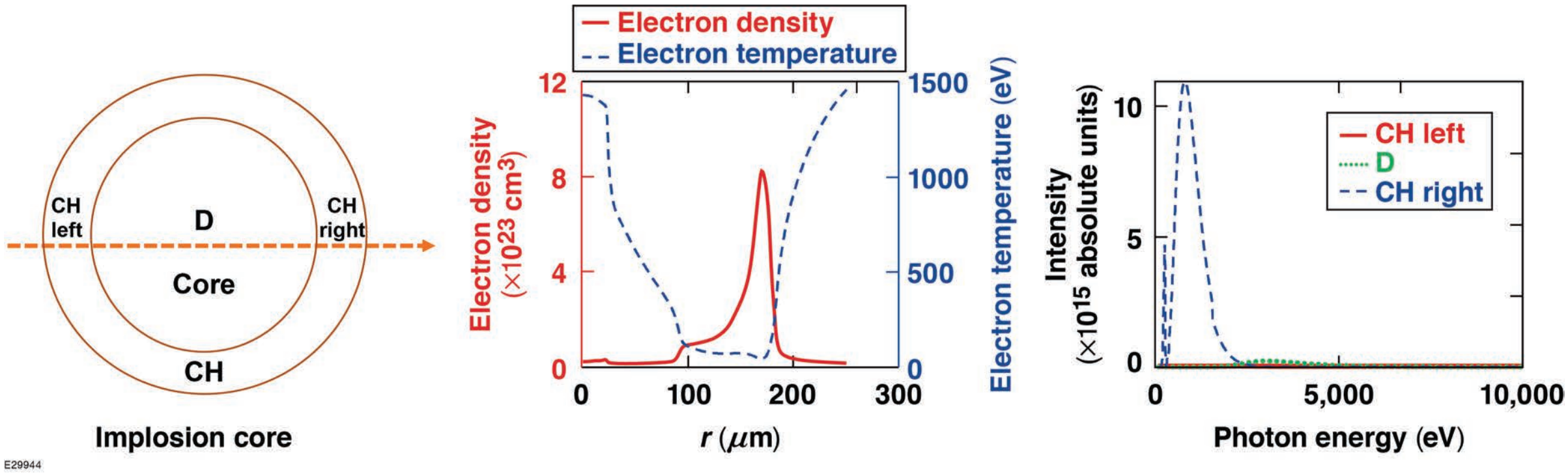

***ASTER* x-ray self-emission images show smaller contrast compared to the data.**

# Two-dimensional slice of electron density in the simulated implosion core show modulations




Two-dimensional slices of electron temperature and effective charge in the simulated implosion core also show similar modulations

# A radiation transport model is used to understand the source of the emission




**Intensity-weighted photon energy: ~1000 eV**

**Due to soft x rays, the model shows that the modulations arise from the surface closest to the view.**

# Plasma conditions for maximum and minimum emissions are predicted to differ

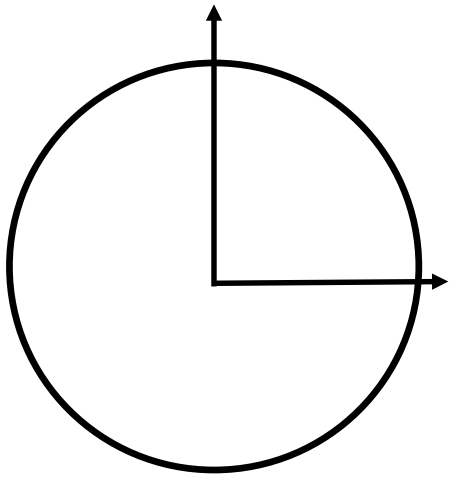
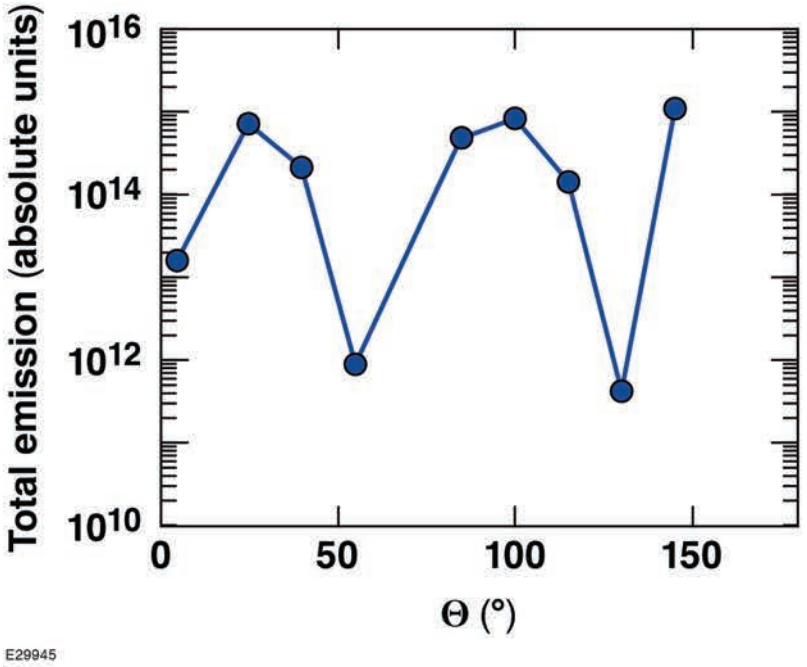
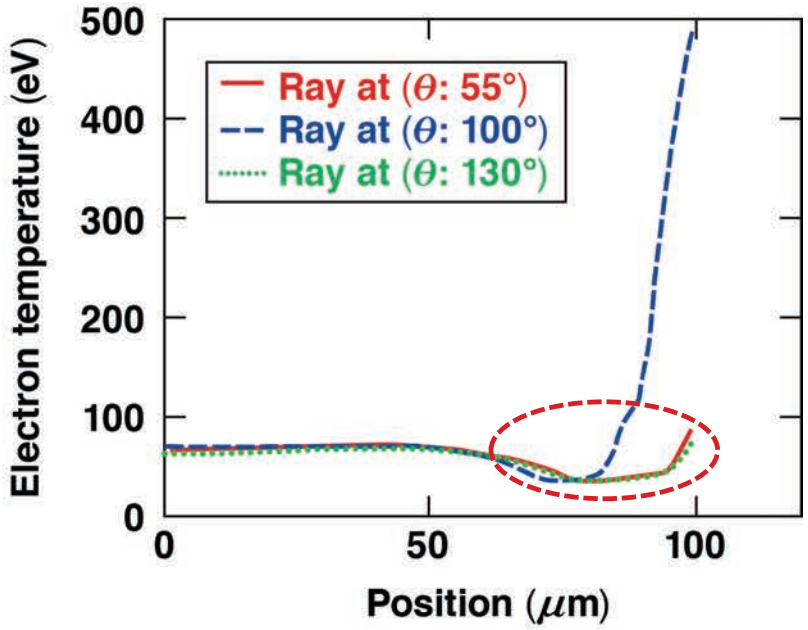


Image Plane

Line integrated emission




Spatial profile of elec. temp. for max. and min. emission



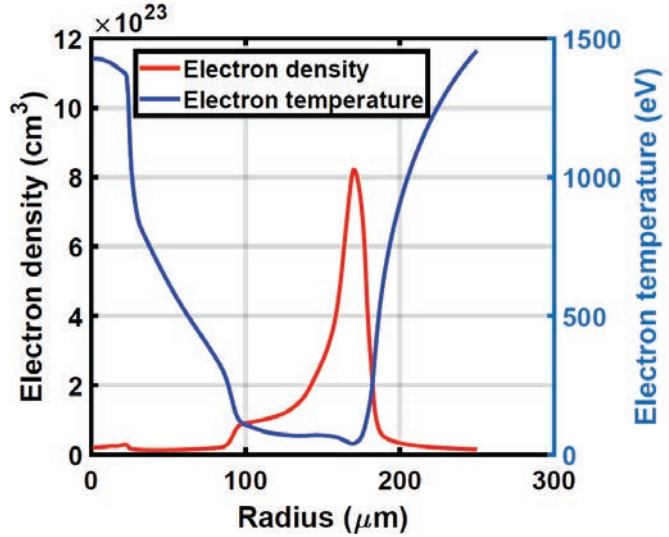

**Difference in plasma conditions around ablation front region causes emission modulations in the x-ray self-emission image**

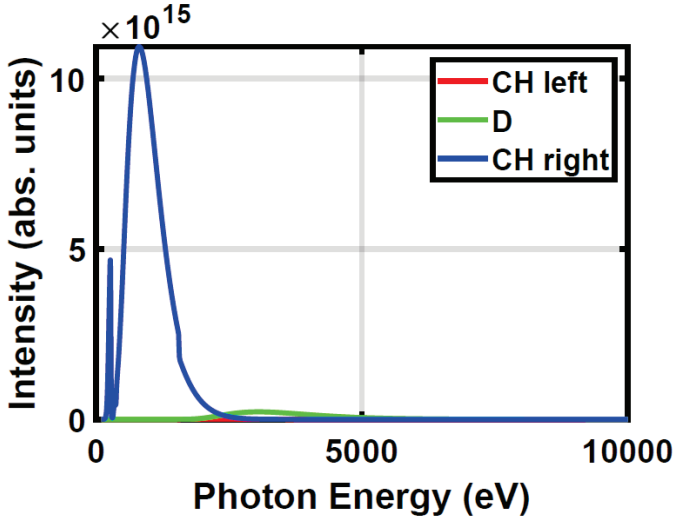
Summary/Conclusions

# Nonuniform emission modulations observed in x-ray self-emission images show greater contrast than in simulations

- Modulations are generated from the laser beam port geometry on OMEGA spherical direct-drive implosions using small-spot distributed phase plates
  - the nonuniform emission patterns in the images arise from the x-ray self-emission around the ablation-front region
- State-of-the-art 3-D *ASTER* simulations show qualitatively similar patterns in the self-emission images
  - inclusion of imprint in the simulations did not resolve the discrepancy
- The results suggest the beam-mode–induced hydrodynamic perturbations may be underestimated

# Emission from the shell along the line-of-sight shows much higher emission




**Intensity weighted photon energy:**

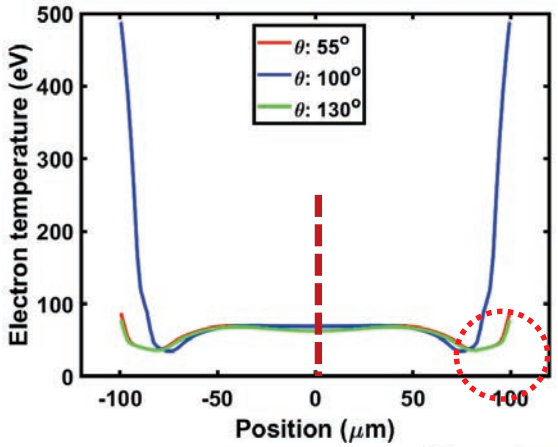
$$I_{av} = \frac{\sum_{i=hv}^{n} hv_i \,.\, I_i}{\sum I_i}$$

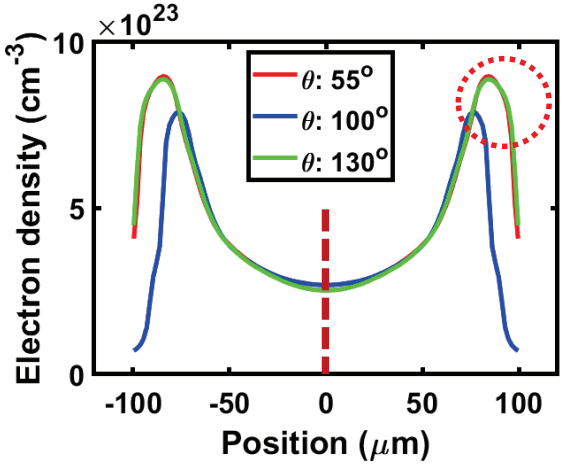
$$\approx 1000\ eV$$

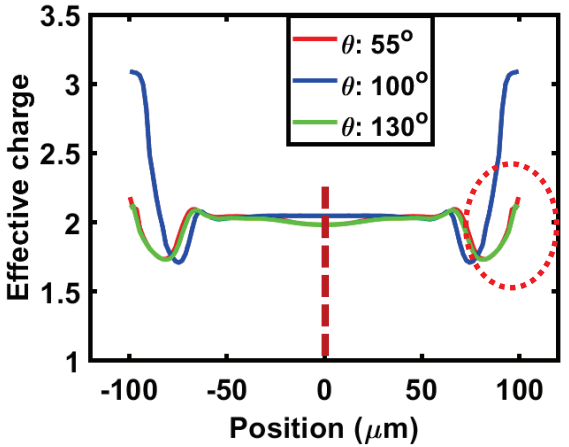
**At ~ 1000 eV intensity:**

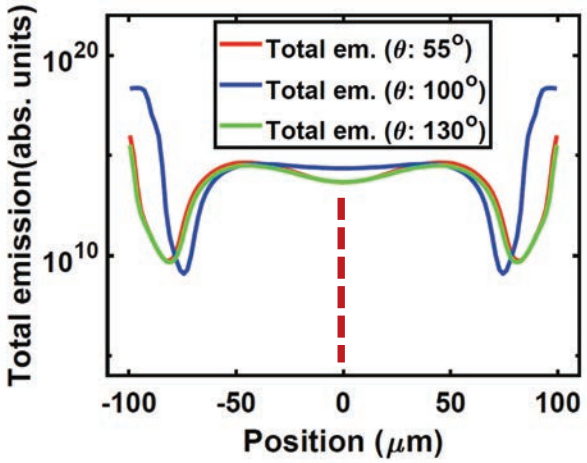
**CH left ~ 1.5e$^2$ abs. units**
**D ~ 1.3e$^2$ abs. units**
**CH right ~ 1.0e$^{16}$ abs. units**

# Different plasma conditions around ablation front region cause emission modulations in the x-ray self-emission image

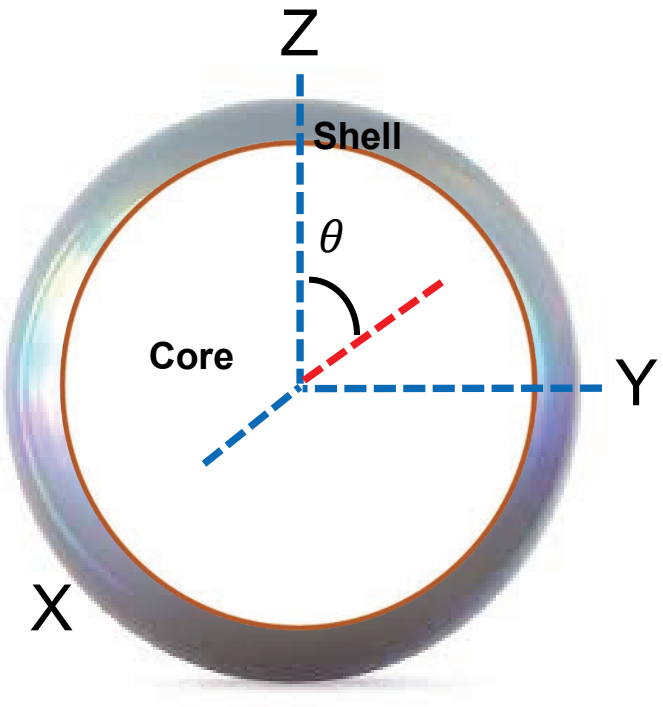



Plasma conditions are different only in the ablation front region (see red dotted circles)


Z
Shell
θ
Core
Y
X