Imaging of Compressed Pure-CH Shells and CH Shells with Titanium-Doped Layers on OMEGA

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The compressed shell integrity of spherical targets has been studied using the 60-beam, 30-kJ UV, OMEGA laser system. The emission from the hot core has been imaged through the cold shell at two narrow, x-ray energy bands, absorbing and nonabsorbing by the shell, allowing nonuniformities in the core emission and the cold shell areal density to be measured. Images of the target have been obtained using a pinhole-array with K-edge filters. The x-ray energies used are around 2.8 and 4.5 keV for pure-CH shells, and around 4.5 and 6 keV for titanium-doped layers. Additional images of the shell are obtained with a framed monochromatic x-ray microscope and a time-integrated crystal-spectrometer/pinhole-array combination. We will present measurements of the compressed shell integrity at the stagnation stage of spherical implosions by varying the position of the titanium-doped layer within the shell, by varying the thickness of the CH shell, and by using two different laser pulse shapes. The experimental results will be compared with 2-D (*ORCHID*) hydrodynamic simulations. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority.

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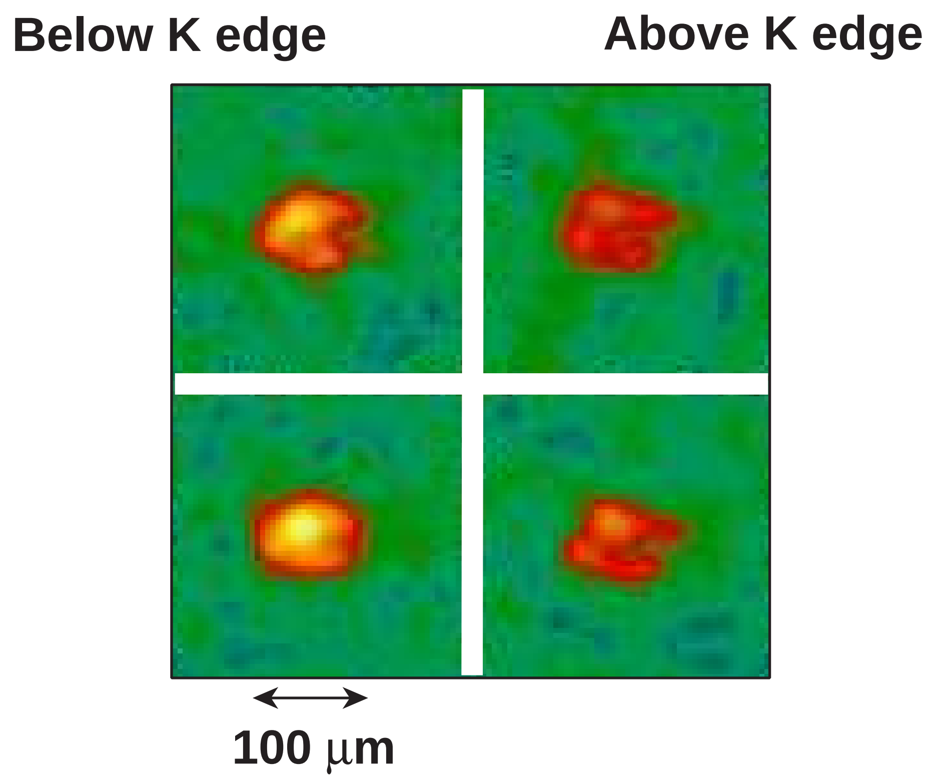

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Summary

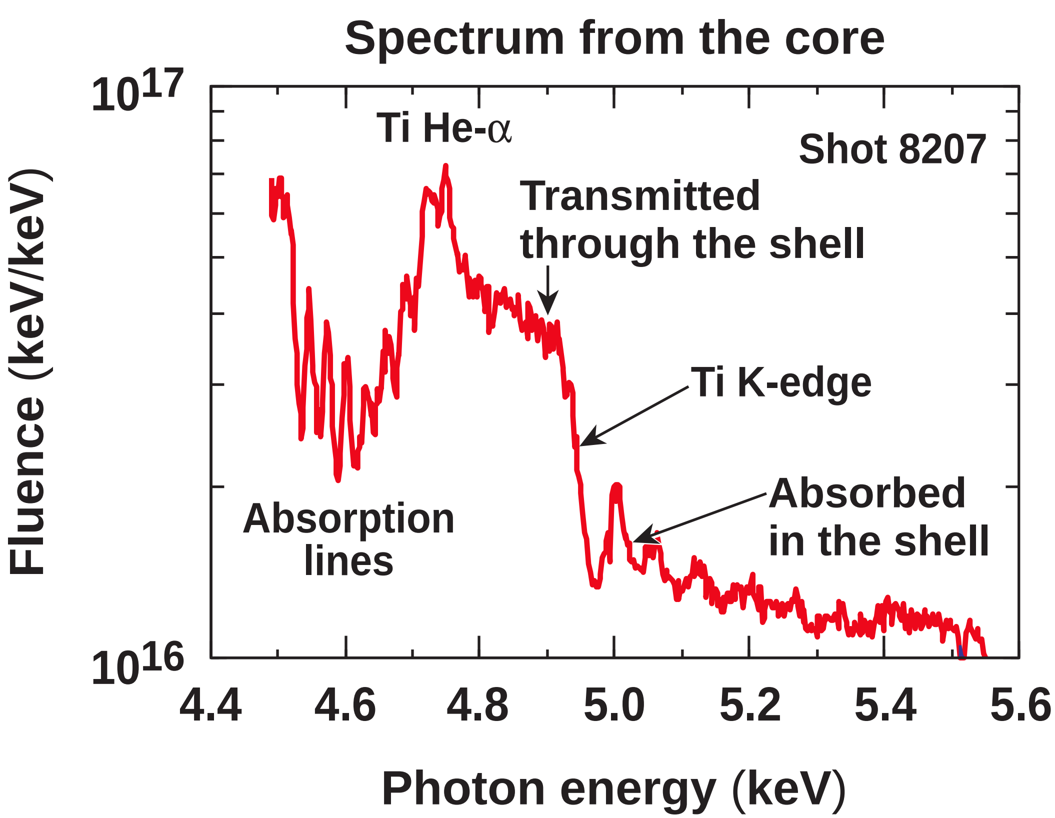
Measured levels of shell-areal-density modulations are about 20% to 50%

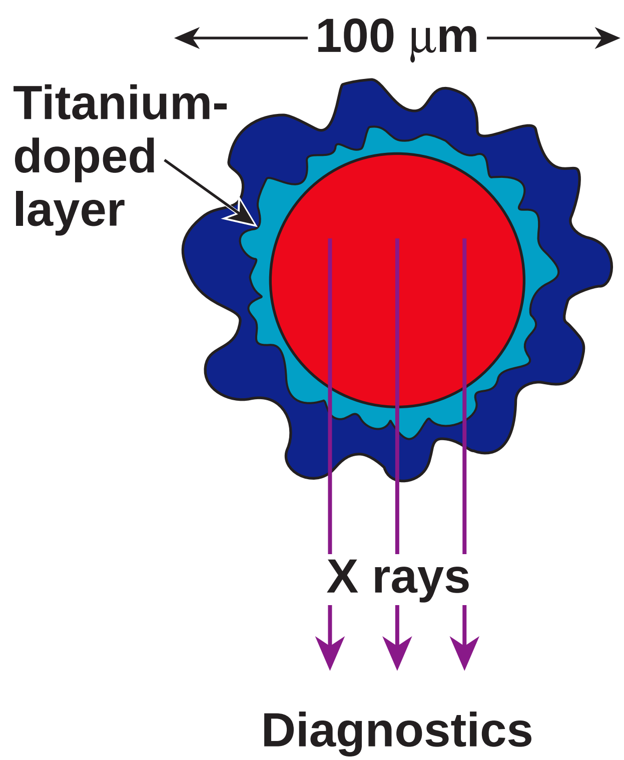
- Method: Core images at two x-ray energies, highly absorbing and nonabsorbing by the shell, are used to measure the shell integrity.
- A pinhole-array spectrometer is used for monochromatic imaging of titanium-doped targets.
- For low-signal implosions, a pinhole array with narrow-band filters is used for quasi-monochromatic imaging.
- Measured levels of nonuniformity in areal density are in the range of 20% to 50% and are dominated by low spatial frequencies.

Outline

- Experimental method
- Measurements of nonuniformities in Ti-doped layers of CH shell.
- Measurments of nonuniformities in pure CH shell.
- Conclusions

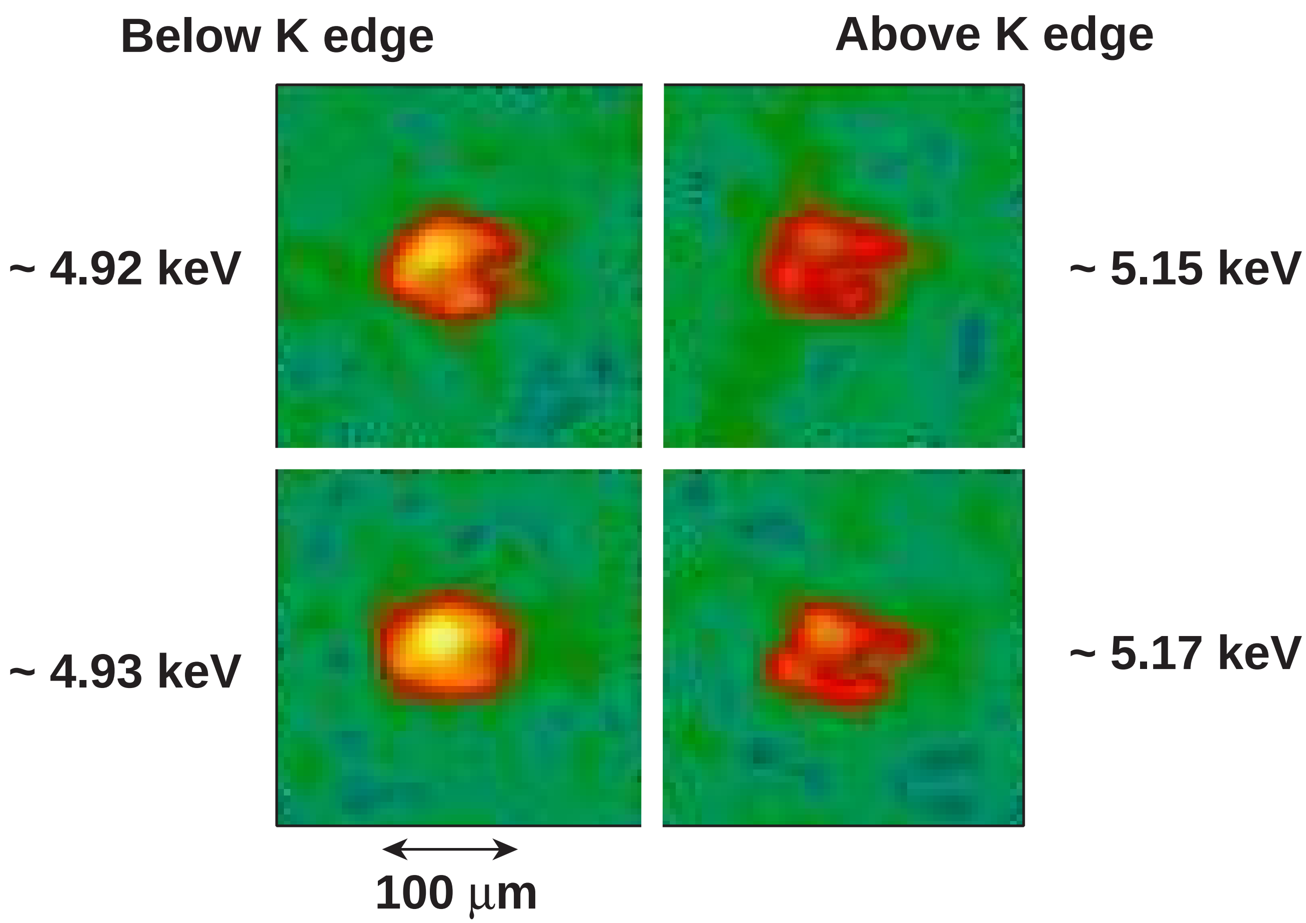
Core images at two x-ray energies, highly absorbing and nonabsorbing by the shell, are used to measure the integrity of the inner portion of the shell





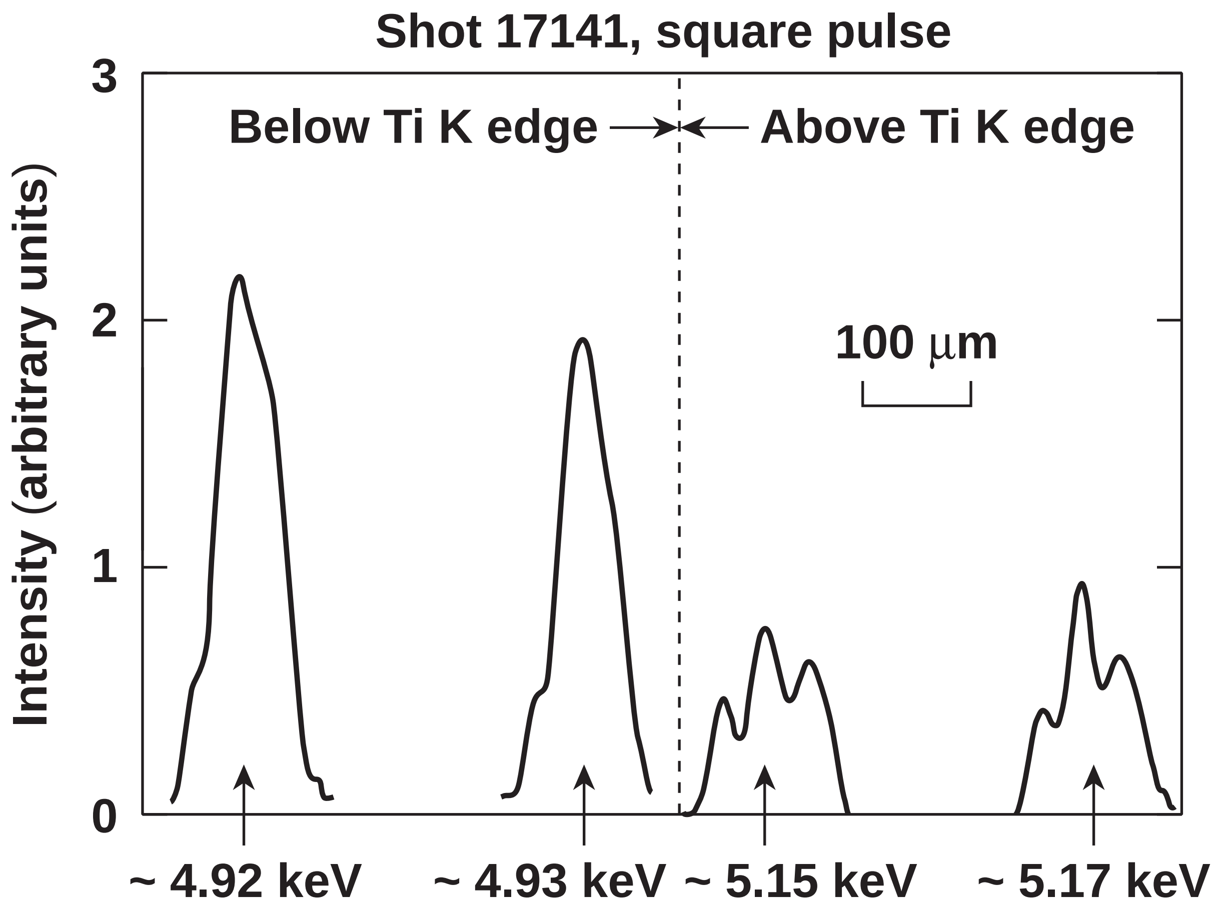
E10053

The ratio of target images below and above the Ti K edge yields the images of cold-shell areal density



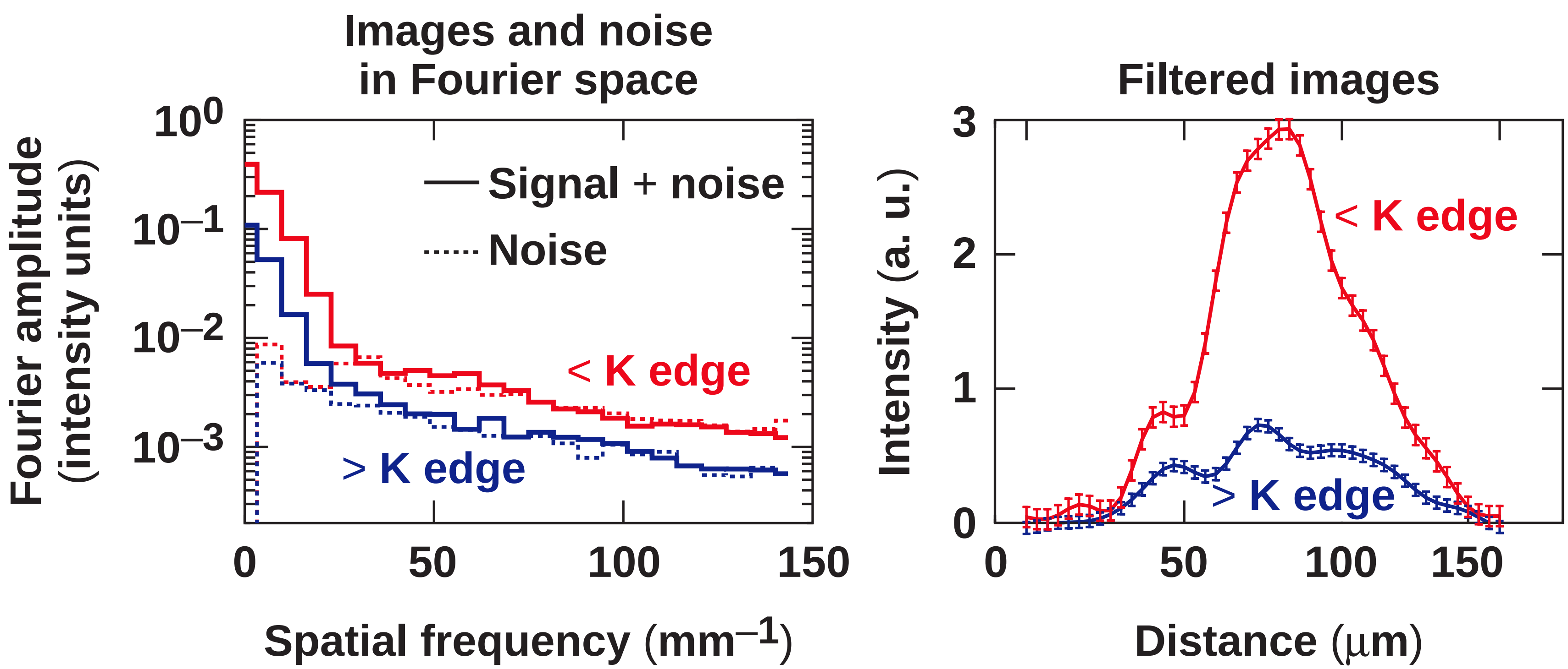
$$\ln[I(< E_K)/I(> E_K)] = [\mu(> E_K) - \mu(< E_K)]\rho\Delta R$$

Images above Ti K edge show structure due to shell ρΔR modulations, not seen in images below the edge



E10055

Fourier analysis and Wiener filtering separate noise from the image of a backlit shell

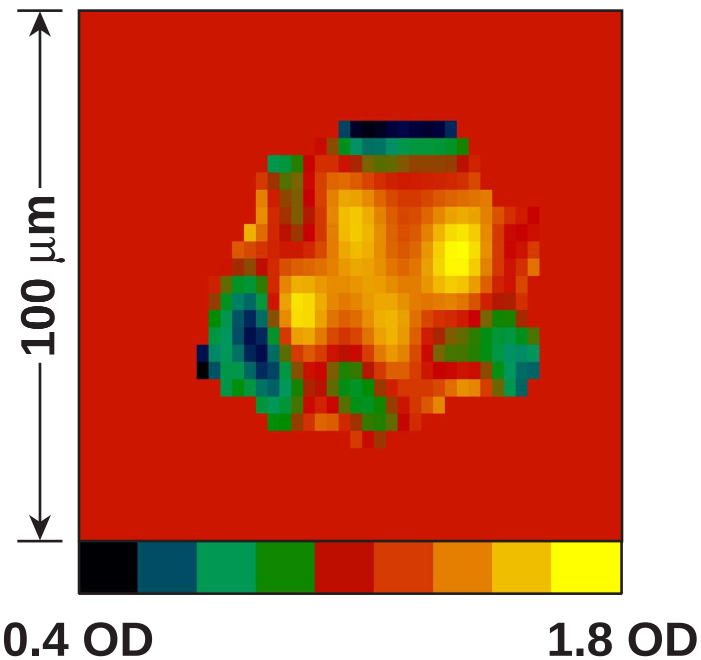


$$R(f) = \frac{C(f)}{MTF} \frac{|C(f)|^2 - |\langle N(f) \rangle|^2}{|C(f)|^2}$$

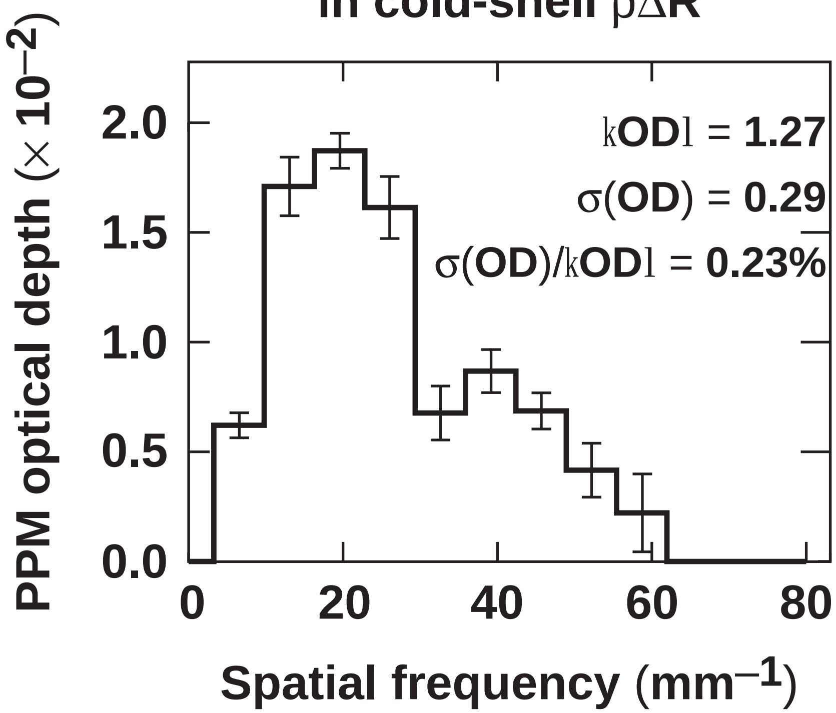
E9967

The ratio of images below and above Ti K edge shows 23% modulation in cold shell ρΔR

Image of cold-shell opacity (or ρΔR)

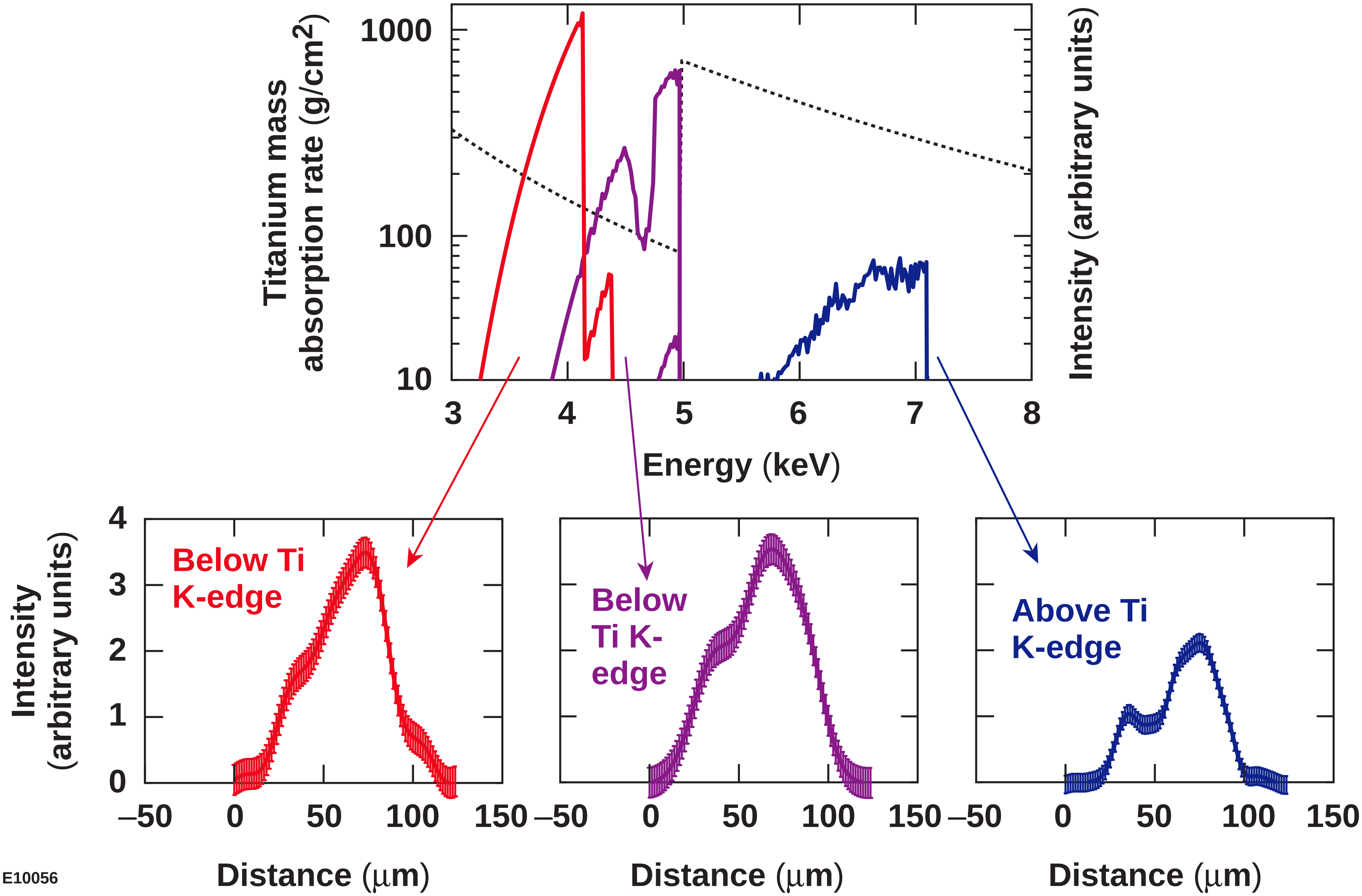


Spectrum of modulation in cold-shell ρΔR



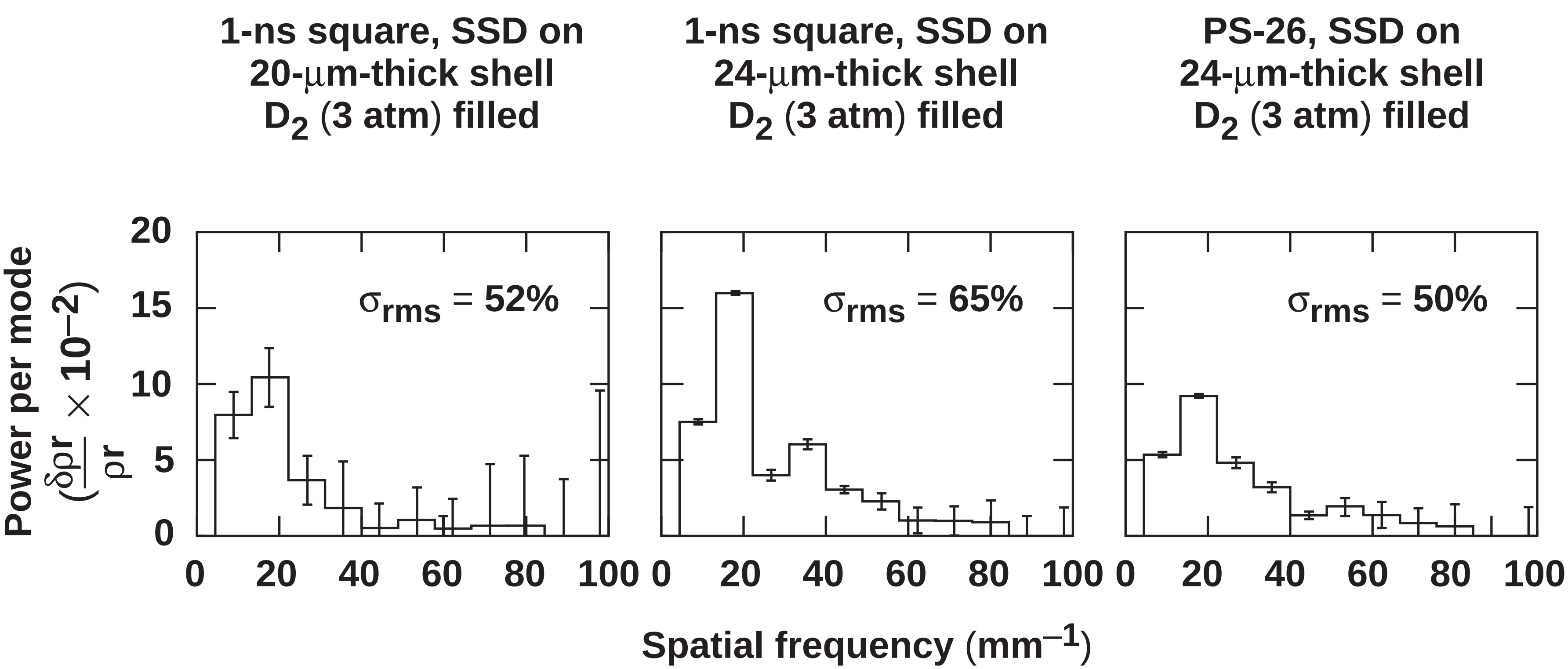
E9986

Pinhole arrays with narrow-band filters allow measurements for lower-signal targets with Ti



E10056

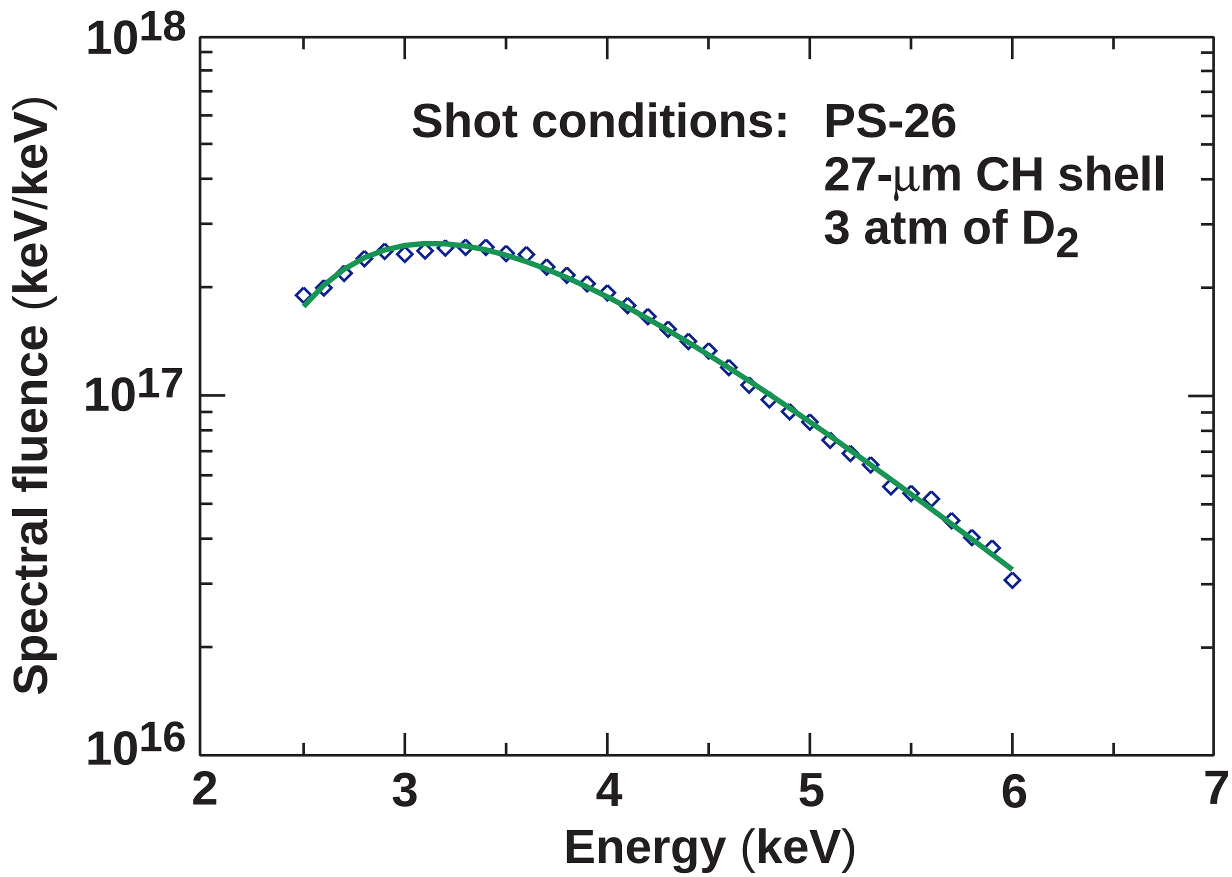
Low spatial frequencies dominate the nonuniformity spectrum for both 1-ns square-pulse shapes and PS-26



2-μm-thick, Ti-doped inner layer

E10057

Imaging at 2.5 to 3.0 keV allows measurement of nonuniformities in full pure-CH shells

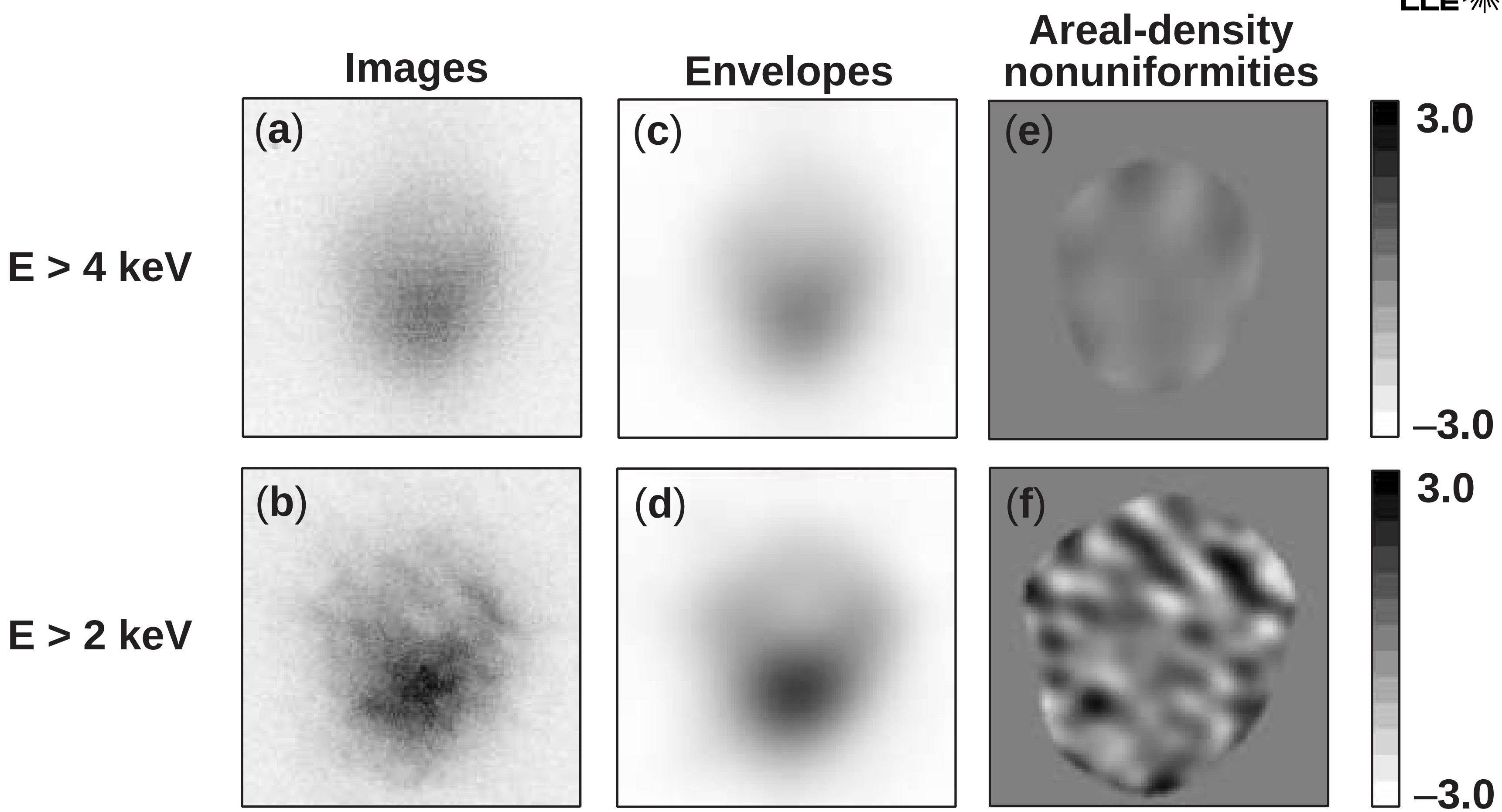


Measured $\langle \rho r \rangle_{cold} = 15 \frac{mg}{cm^2}$

Measured T_e = 0.96 keV

E9797

Low-energy (2.8-keV) imaging allows detection of nonuniformities in the CH shell



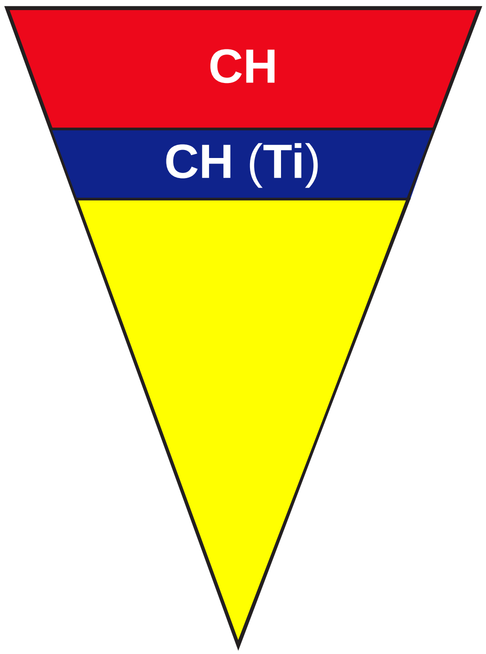
Measured shell $\langle \rho r \rangle = 15 \frac{mg}{cm^2}$

$\delta \langle \rho r \rangle \frac{mg}{cm^2}$

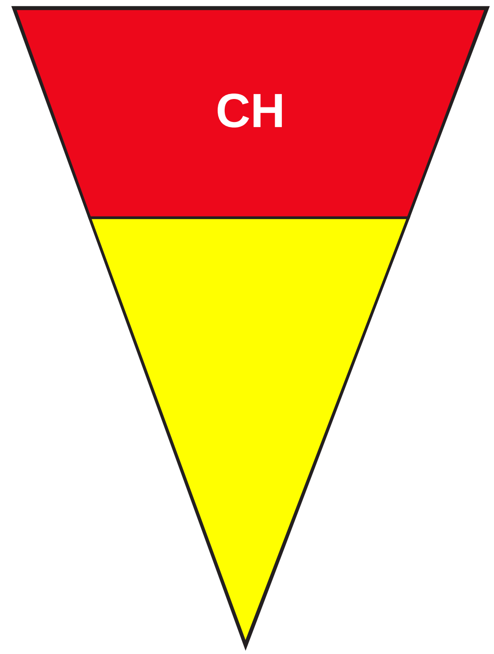
Modulations in shell $\langle \rho r \rangle$ are about $\sigma_{rms} \cdot 2 \frac{mg}{cm^2}$

E9798

The inner layer of the shell is dominated by nonuniformities with $\lambda \sim 50$ μm; the full shell with $\lambda \sim 30$ μm



- **Inner shell (Ti doped) for 20- to 24-μm-thick targets**
- **Nonuniformity peaks at ~ 50 μm**
- **Core size ~ 80-μm diameter**
- **Corresponds to l ~ 5**



- **Full shell (Ti doped) for 27-μm-thick targets**
- **Nonuniformity peaks at ~ 30 μm**
- **Core size ~ 80-μm diameter**
- **Corresponds to l ~ 8**

E10182