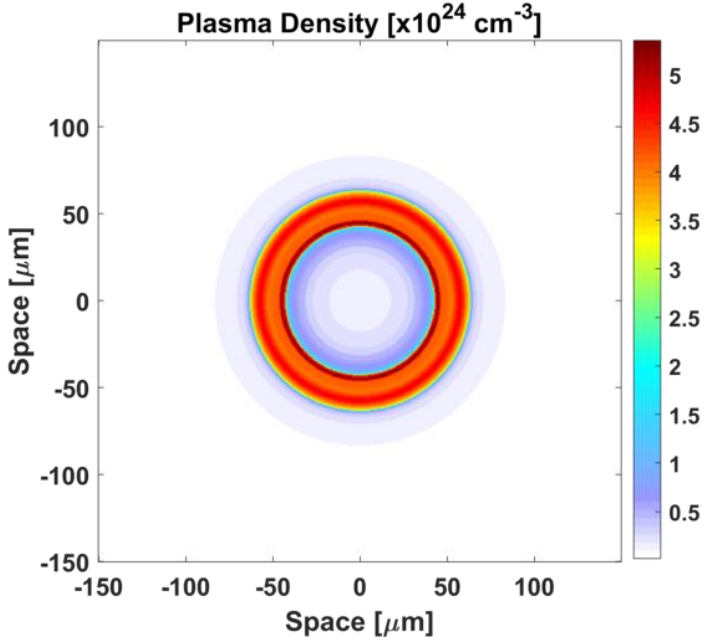
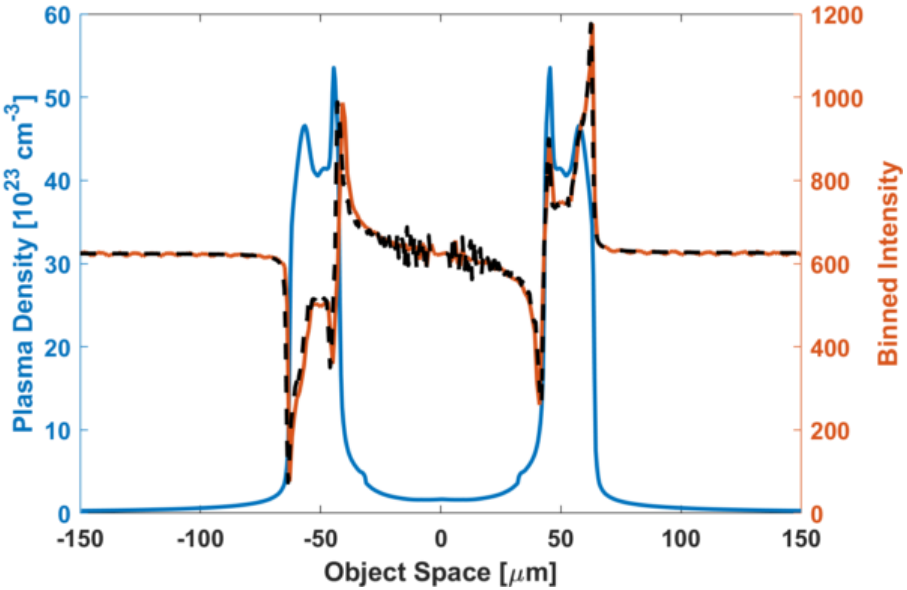
Schlieren Refraction Measurements of Implosion Density Profiles





Summary

Schlieren refraction imaging could be an informative diagnostic for plasma density profiles in-flight and near stagnation

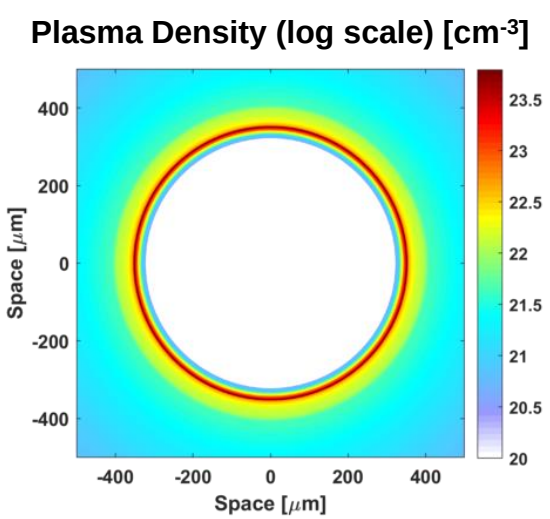
- The density profile on the inner side of a driven ICF target can have detrimental affects on implosion dynamics
  - Indirect evidence of this has been seen in early hot spot emission
- An x-ray refraction measurement could uncover details of this density profile thus far unseen by x-ray radiography and refraction enhanced imaging
- A knife-edge schlieren system is being designed for the measurement of a refraction map
  - Initial testing can take advantage of the existing crystal imaging system on OMEGA-EP for diagnostic development and OMEGA for warm/cryo measurements

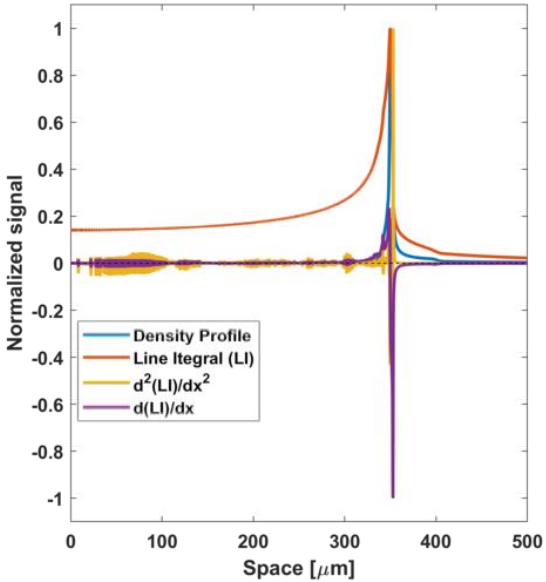
The motivation for a refraction diagnostic is to gain more information about the density profile inside the shell through its first derivative

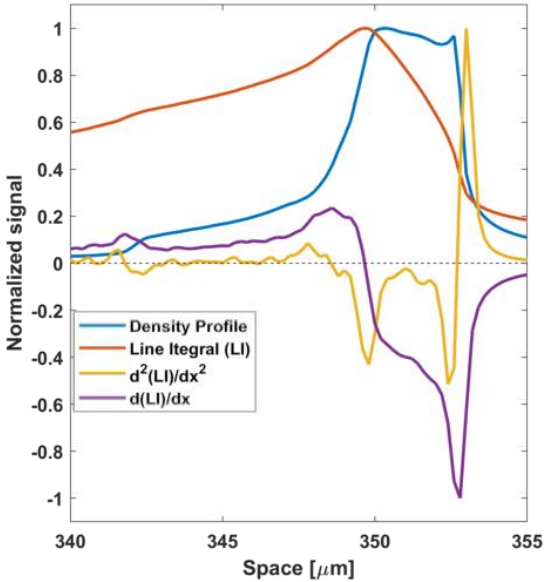
Line Integral (LI) : Radiography

$d(LI)/dx$: AFR or Schlieren (refraction)

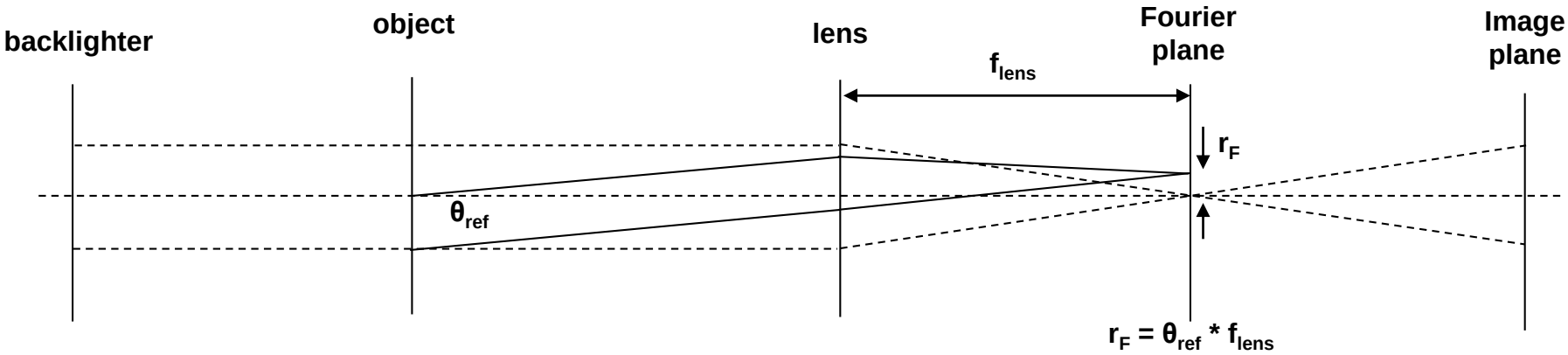
$d^2(LI)/dx^2$: RER (shadowgraphy)







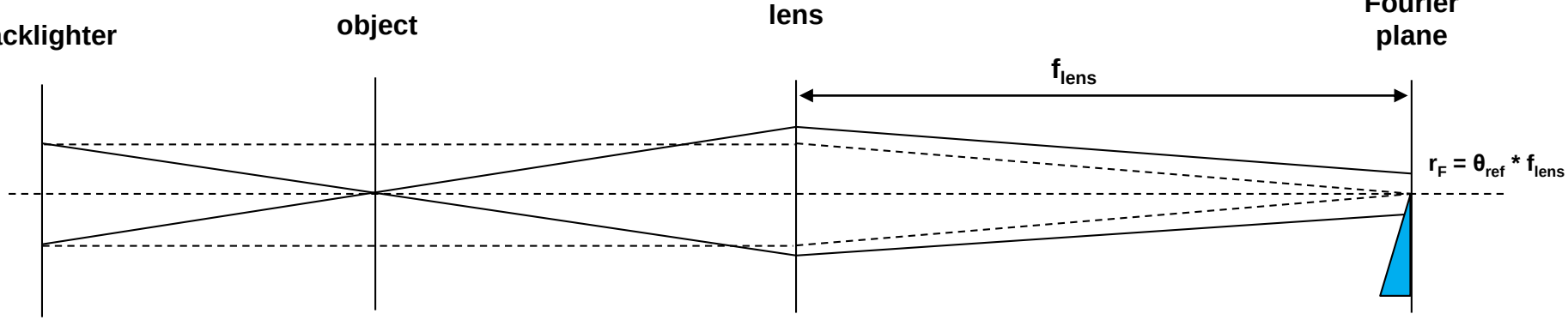
Access to the refraction angle is obtained in the far field of the imaging object where the angle is mapped to space (spatial Fourier transform)



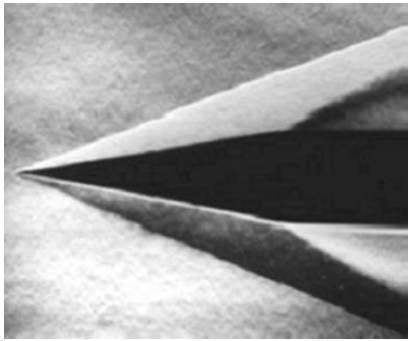
Note : A Fresnel zone plate or Crystal imager is required. Pinhole imaging does not work

A filter is used at the Fourier plane to encode information about θ_{ref} that can be interpreted in the image plane

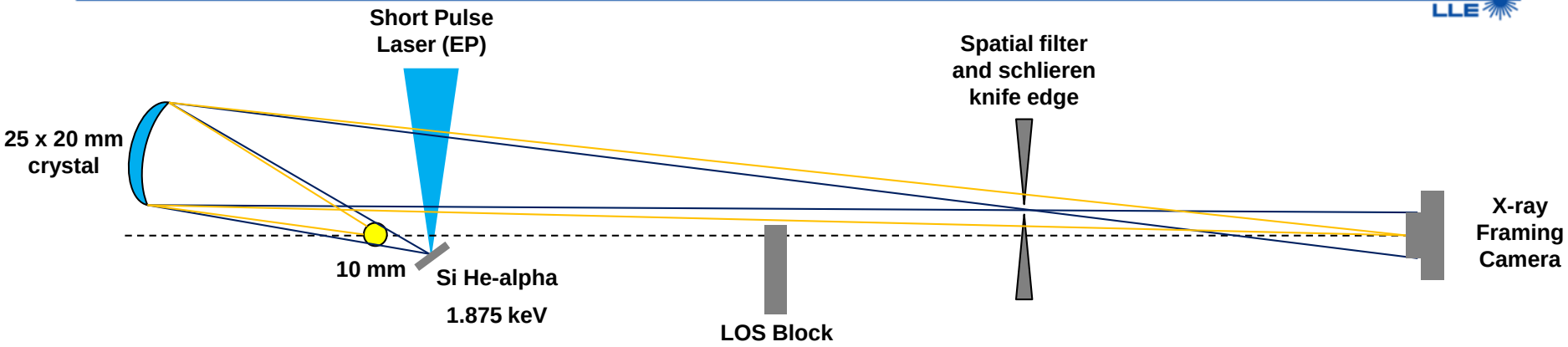
A schlieren diagnostic takes advantage of the spatial bandwidth of the backlighter using a knife edge to image the amount of refraction



- The most common schlieren stop is a knife edge cutting half of the k-vectors resulting in a 50% transmission
- Refraction vertically up passes more light beyond the knife : increased intensity
- Refraction vertically down passes less light beyond the knife : decreased intensity
- A refraction map versus space is directly read at the image plane (assuming background free!)
- The dynamic range of the measurement is 0% to 100% intensity modulation

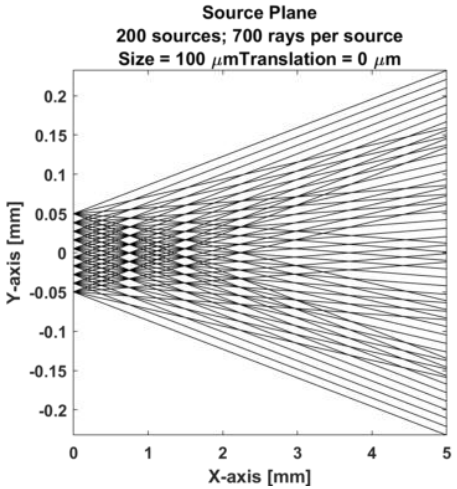


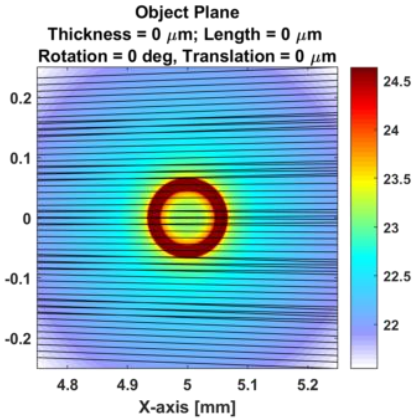
The current crystal imaging system on OMEGA is considered for a schlieren diagnostic

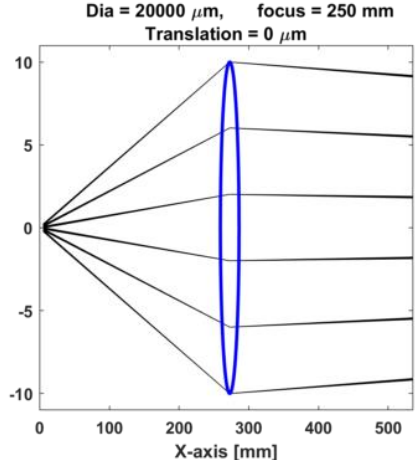


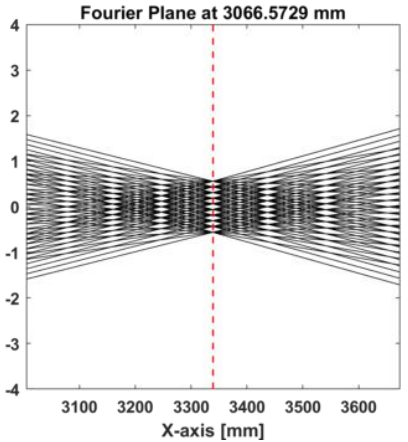
- Magnification = 15
- Resolution = 10 μm (limited by crystal aberrations)

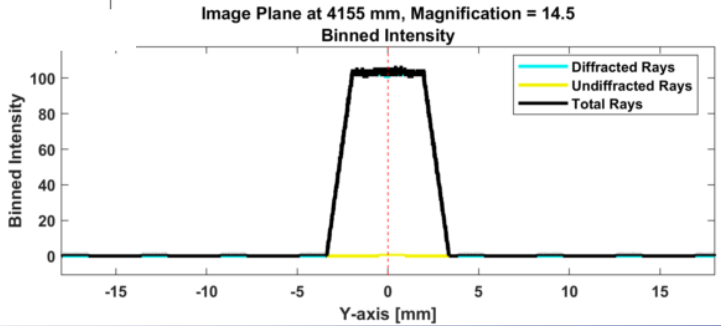
A ray trace program was set up to investigate the features of a schlieren imaging system



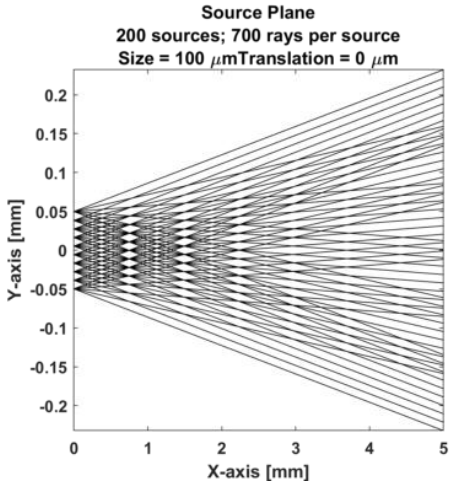


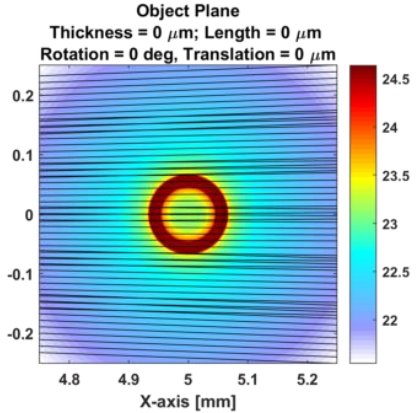


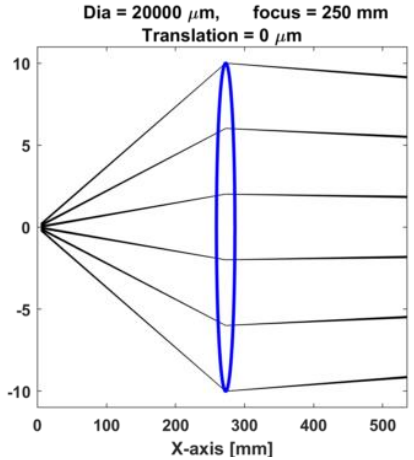


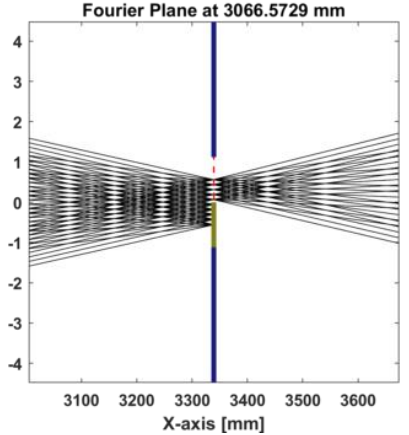


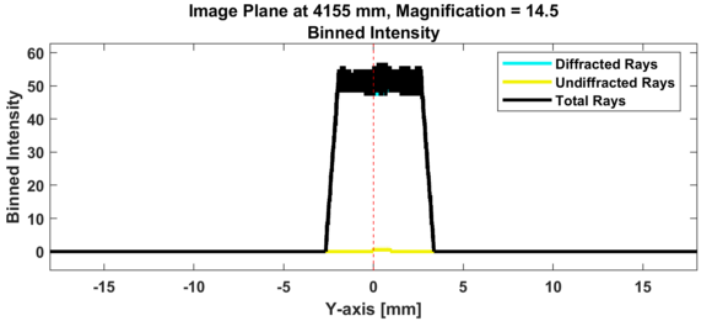
Adding a 50% schlieren stop cuts the signal in half but doesn't affect the profile in the image plane



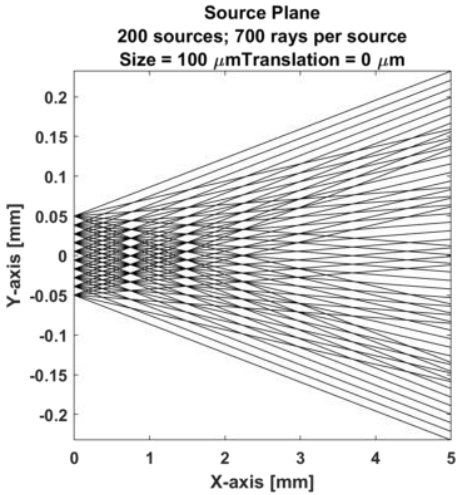


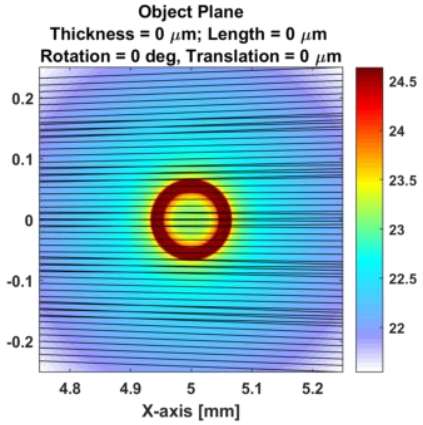


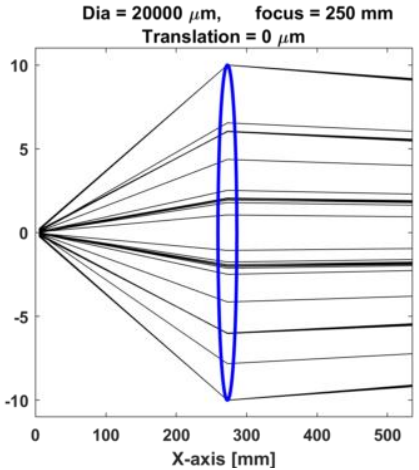


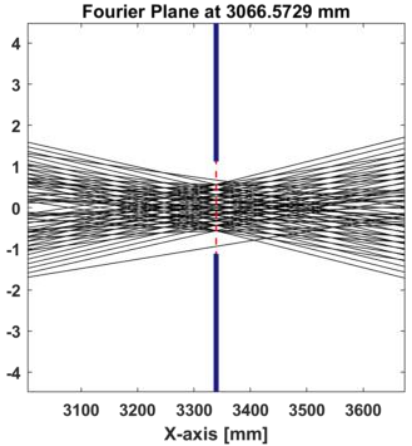


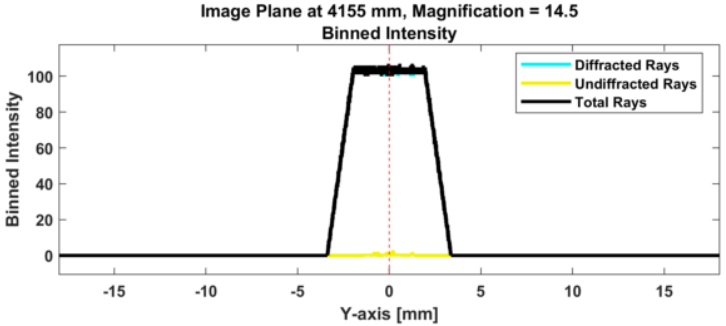
Removing the schlieren stop, and turning on refraction shows a flat image plane, as expected



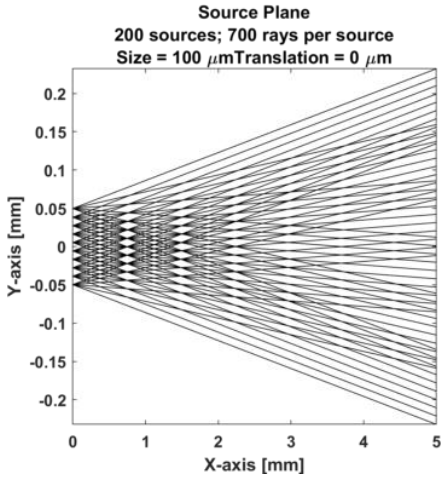


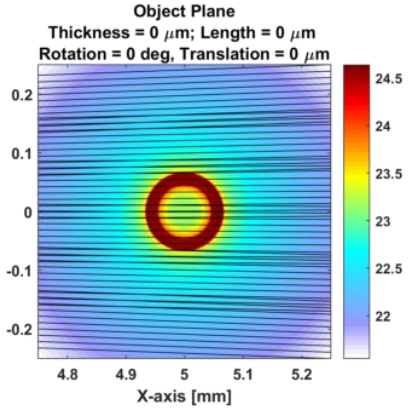


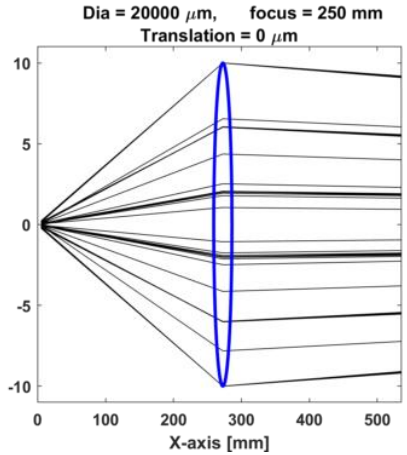


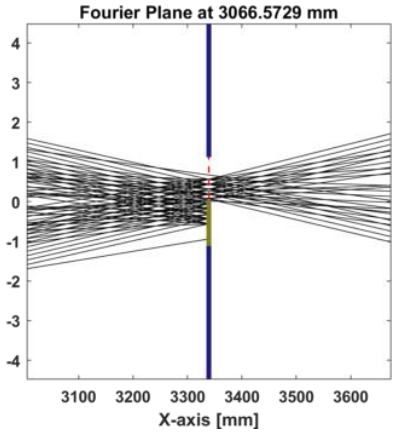


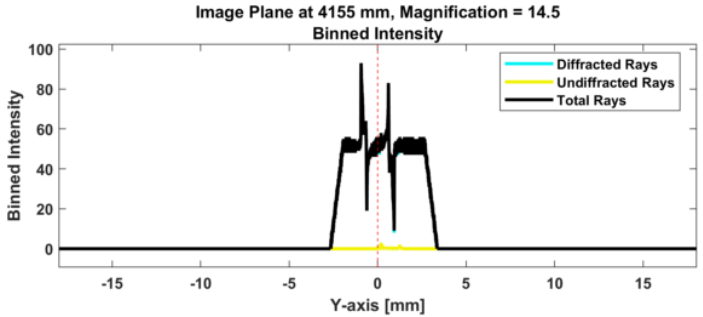
Re-inserting the schlieren stop uncovers a refraction profile



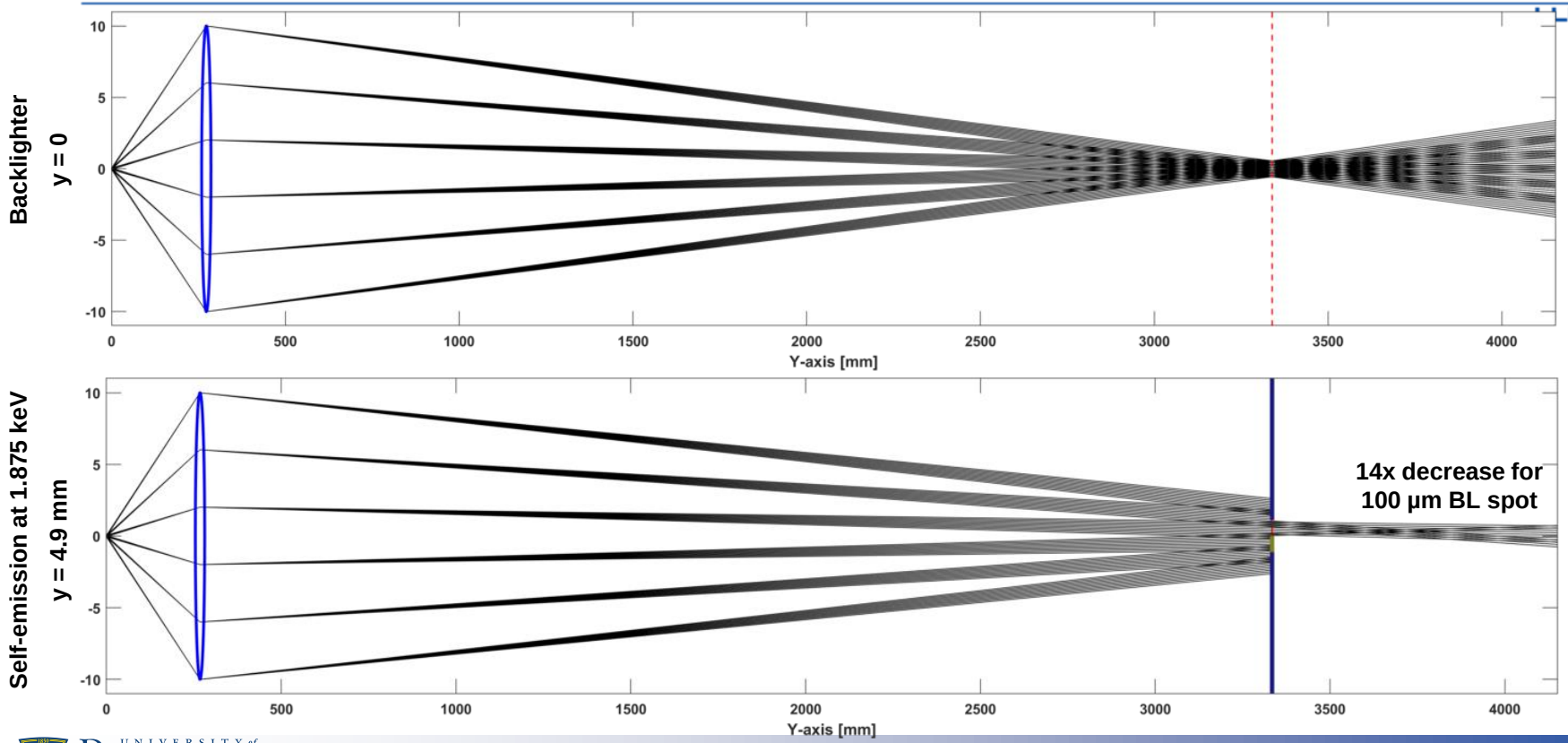








The full system view shows additional filtration of the imploding target's self-emission due to the schlieren stop



During the acceleration/deceleration phases of an implosion, we may be able to obtain more information about the extent of the inner surface

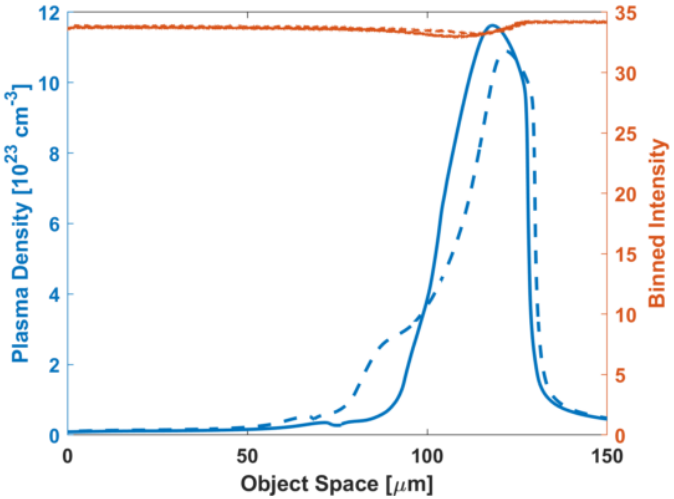
LILAC Simulations

2500 ps

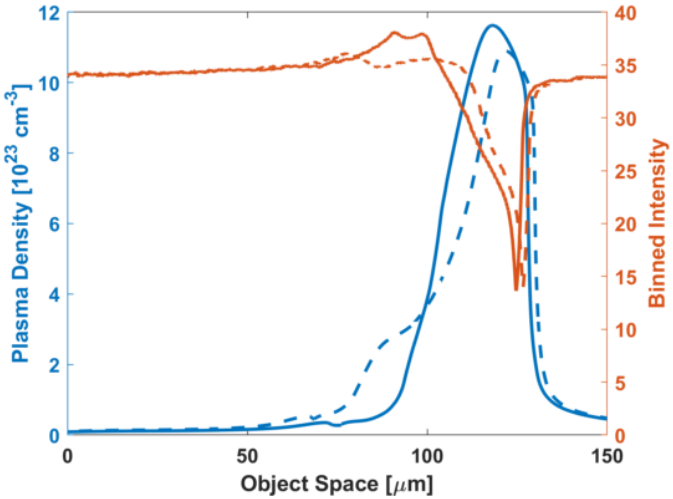
Solid Line : Standard

Dashed Line : 10J energy deposited on inner surface

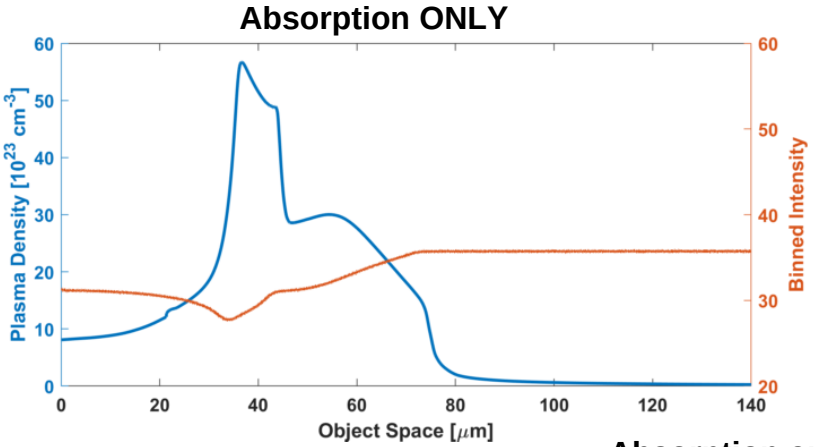
Absorption ONLY

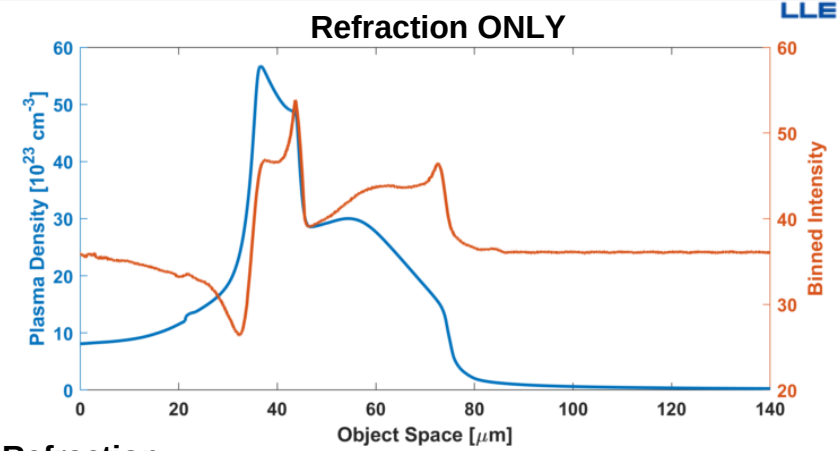


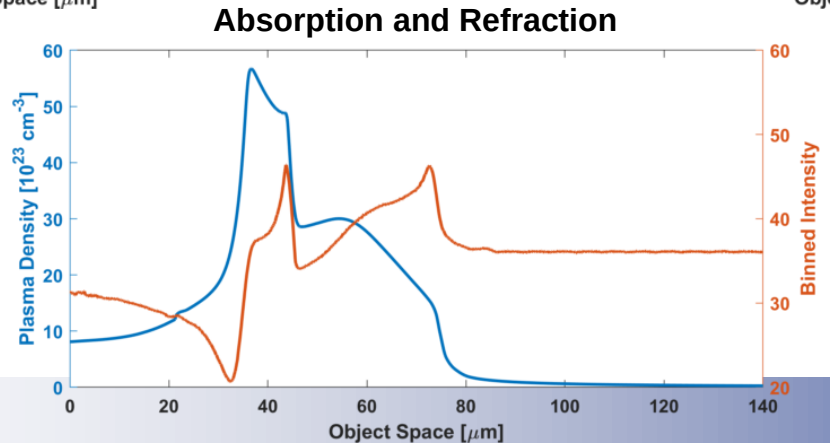
Refraction ONLY



Closer to stagnation, the refraction and absorption are combined giving more information about the density profile







LILAC Simulations

2900 ps

Schlieren refraction imaging could be an informative diagnostic for plasma density profiles in-flight and near stagnation

- The density profile on the inner side of a driven ICF target can have detrimental affects on implosion dynamics
  - Indirect evidence of this has been seen in early hot spot emission
- An x-ray refraction measurement could uncover details of this density profile thus far unseen by x-ray radiography and refraction enhanced imaging
- A knife-edge schlieren system is being designed for the measurement of a refraction map
  - Initial testing can take advantage of the existing crystal imaging system on OMEGA-EP for diagnostic development and OMEGA for warm/cryo measurements