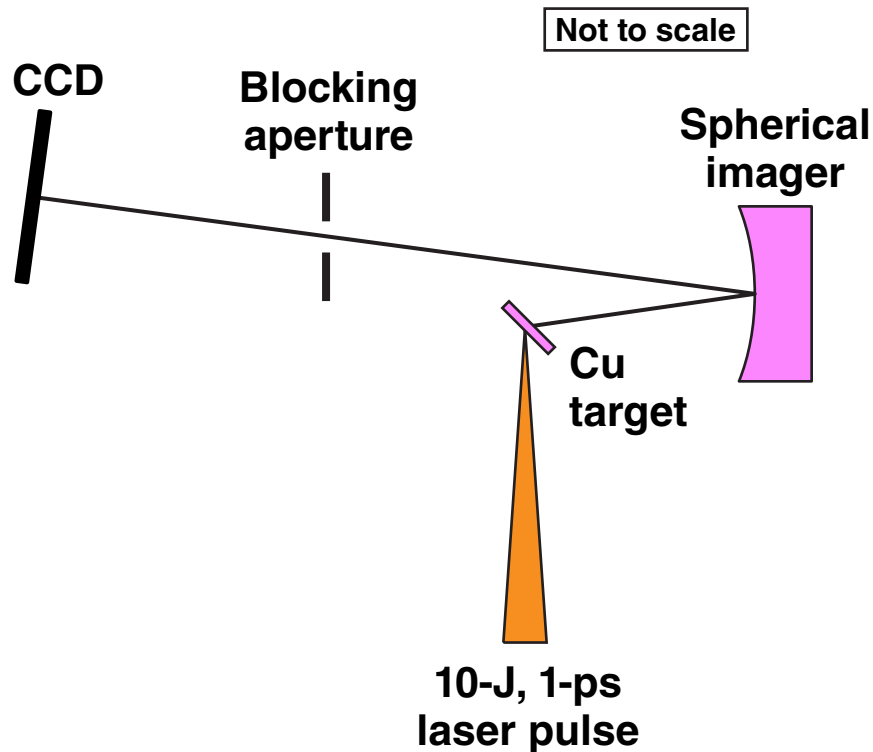
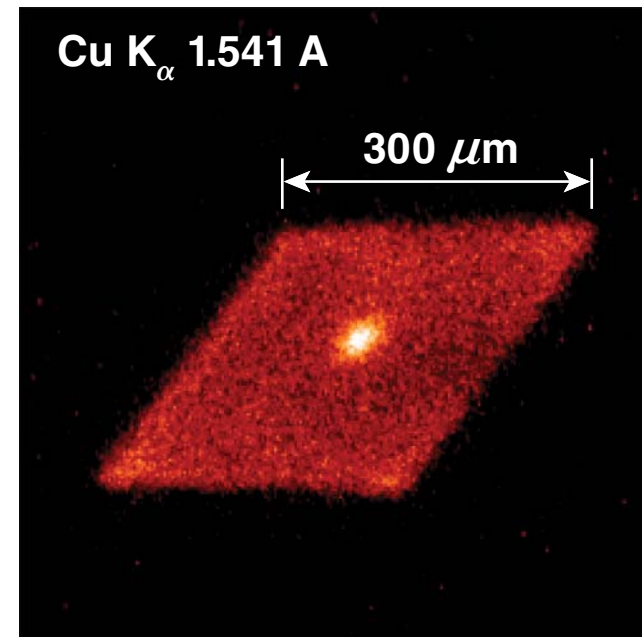


Development of a Spherical Crystal X-Ray Diagnostic for OMEGA EP



X-ray image of a $300 \times 300\text{-}\mu\text{m}$ Cu target



G. Fiksel
University of Rochester
Laboratory for Laser Energetics

52nd Annual Meeting of the
American Physical Society
Division of Plasma Physics
Chicago, IL
8–12 November 2010

Summary

A high-quality spherical crystal x-ray imager for OMEGA EP has been developed, fabricated, and tested



- High-resolution, high-efficiency, 8-keV x-ray imaging has been demonstrated
- The key features are
 - operation wavelength: Cu K_{α} 0.154-nm line emission
 - high spatial resolution: $\sim 6 \mu\text{m}$ (aberration limited)
 - large light-collection area $\sim f/10$
- The imager was tested on a 1-ps/10-J laser system

The imager will be fielded on OMEGA EP in 2011.

Collaborators



**R. Jungquist, C. Mileham, P. M. Nilson,
W. Theobald, and C. Stoeckl**

**University of Rochester
Laboratory for Laser Energetics**

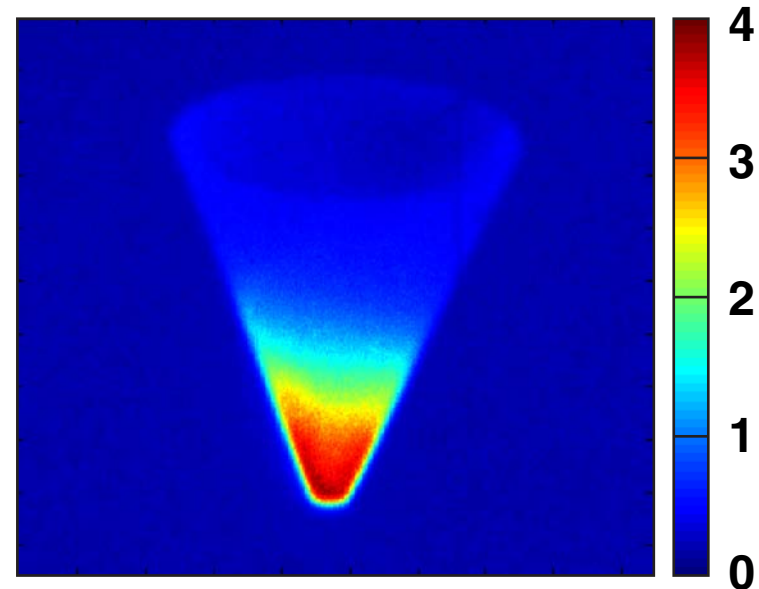
Motivation

A spherical crystal imager will complement the existing x-ray diagnostics on OMEGA EP



- A broad range of applications include
 - self-emission and backlight imaging of fusion targets
 - fast-electron dynamics in fast-ignition experiments
 - hydrodynamic instabilities
- The diagnostic was requested by OMEGA users
- The key features are
 - high spatial resolution $\leq 10 \mu\text{m}$
 - large light collection area $\sim f/10$

8-keV x-ray image of Cu cone obtained with a UCSD crystal imager

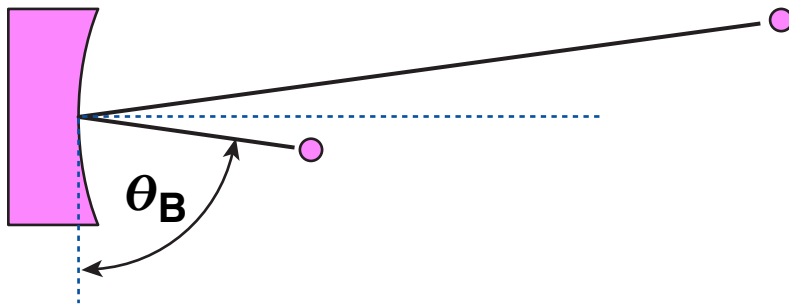


Courtesy of H. Sawada, F. N. Beg, UCSD

The crystal parameters for Cu K_α imaging have been specified

- The emission wavelength, the crystal constant, and the Bragg angle are interrelated

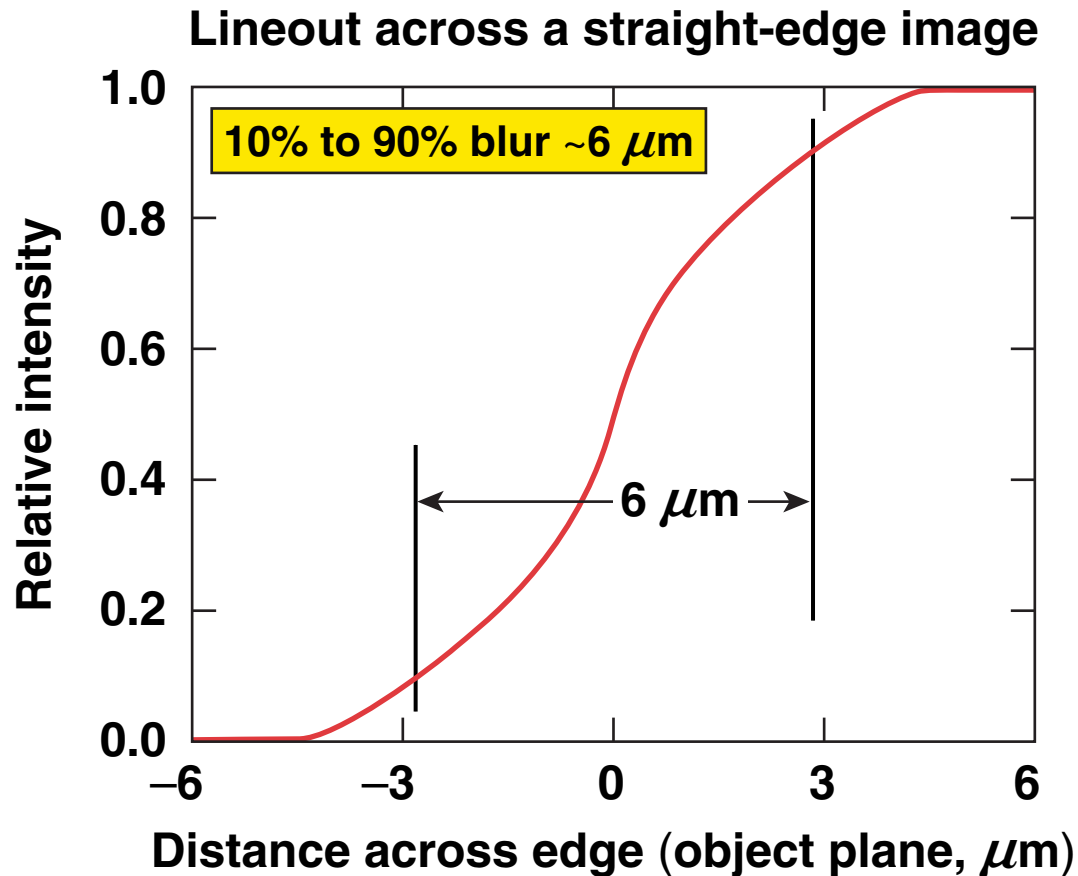
$$n\lambda = 2d \sin(\theta_B)$$



- Spherically shaped crystal acts like a spherical mirror
- Near-normal incidence provides for low aberrations and a narrow bandwidth

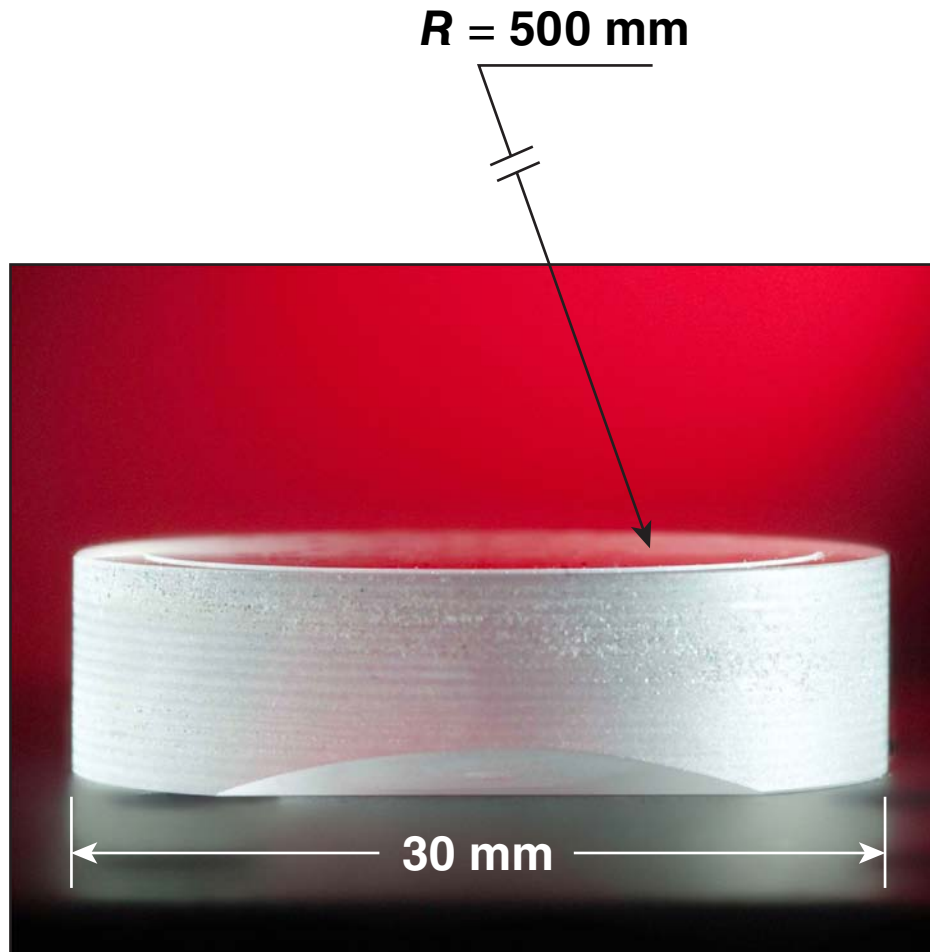
Emission line	Cu K _α 0.154 nm (8.05 keV)
Crystal	Quartz 2131 2d = 0.308 nm
Bragg angle	88.7° (n = 2)
Bending radius Focal distance	500 mm 250 mm
Diameter Light collection	25 mm f/10
Spatial resolution	~6 μm

Ray tracing indicates that the aberration-limited resolution is $\sim 6 \mu\text{m}$



- Coma and astigmatism dominate the aberration
- The resolution can be further improved by reducing the aperture

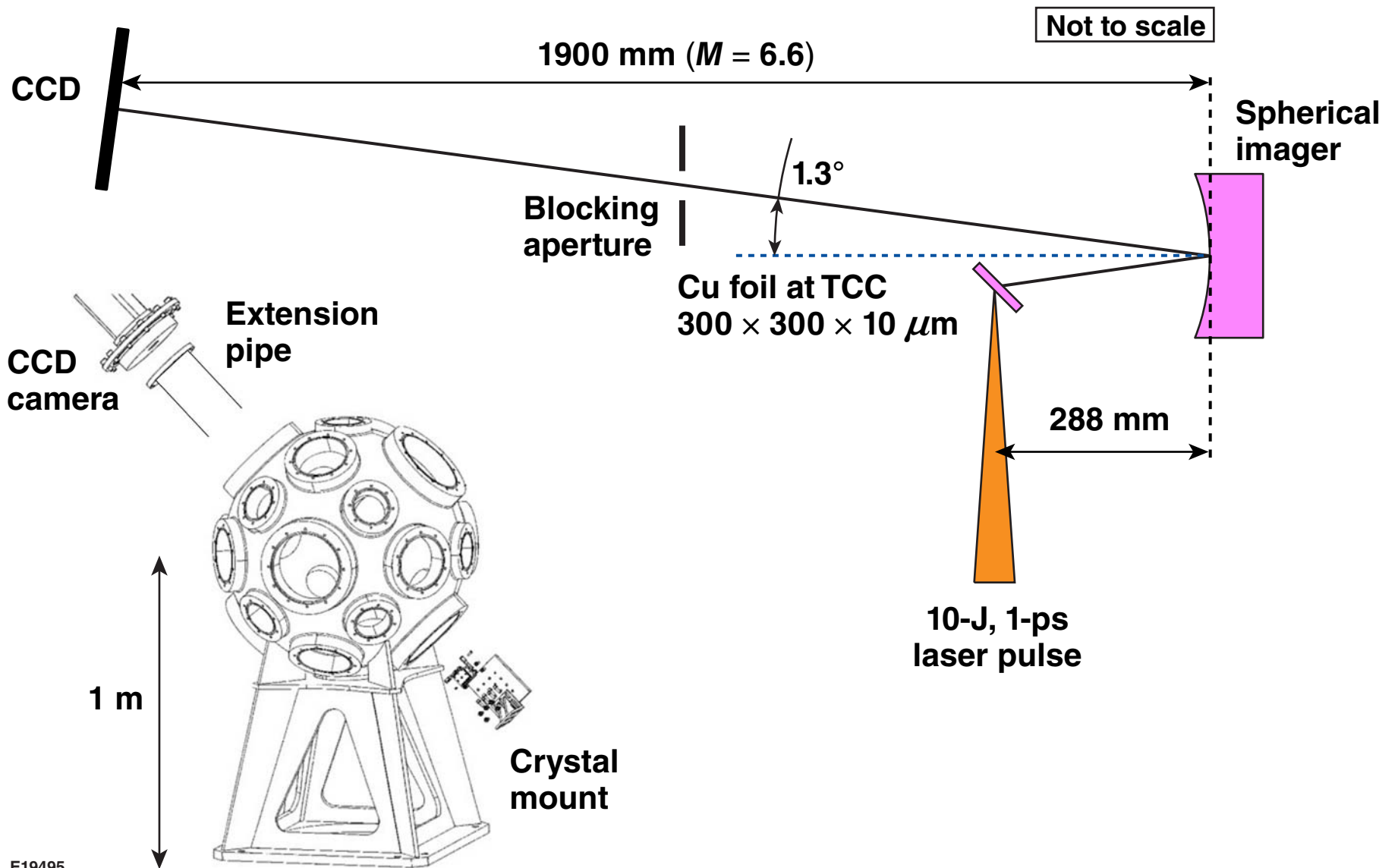
The imager has been fabricated by Photonics Product Group, Inc.



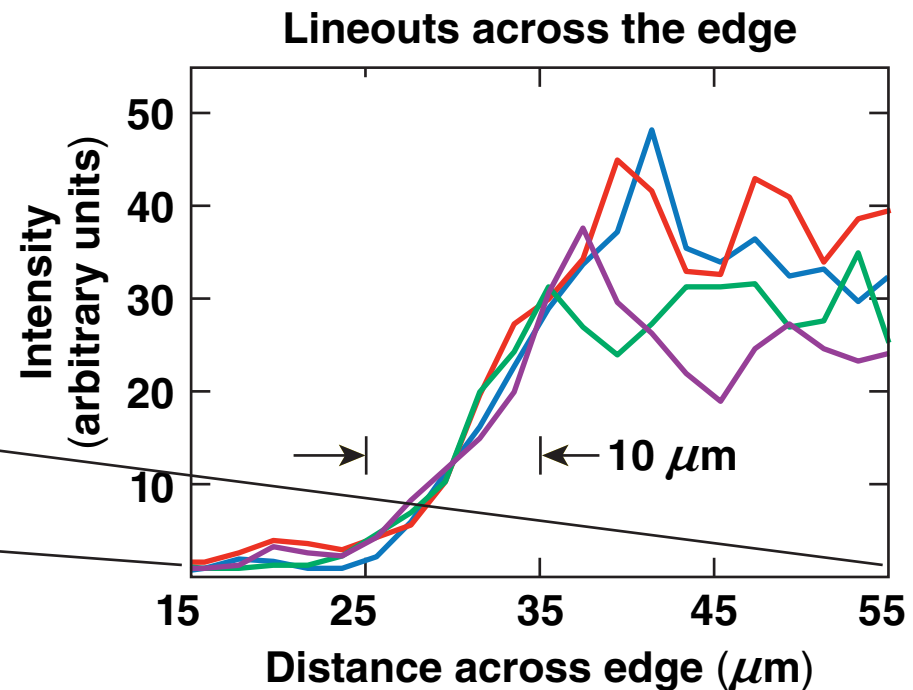
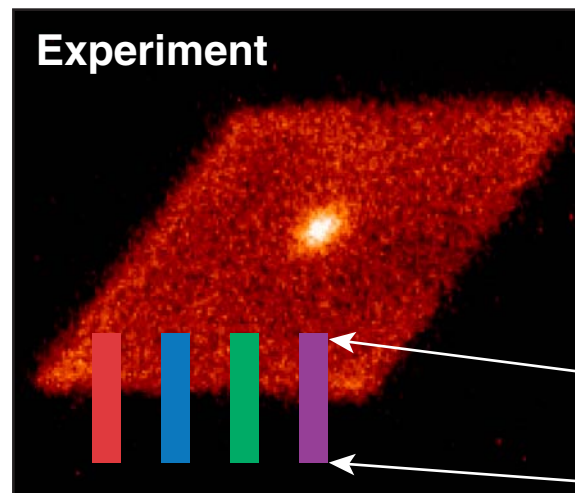
- Quartz crystal is $100\ \mu\text{m}$ thick and 25 mm in diameter
- The crystal constant $2d = 0.308\ \text{nm}$, 2131 cut
- The crystal is optically bound to a glass substrate that is spherically shaped to $R = 500\ \text{mm}$

Photo by E. Kowaluk

The crystal imager was tested on the MTW facility

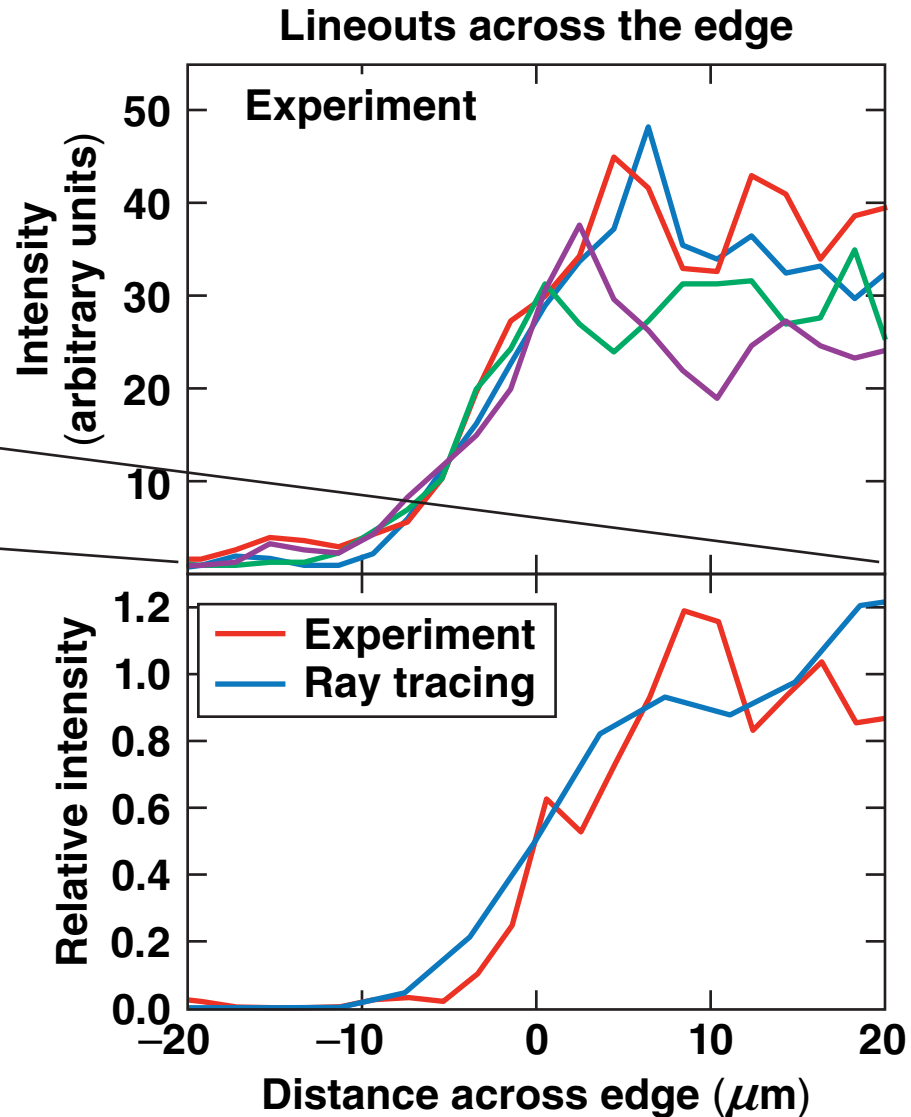
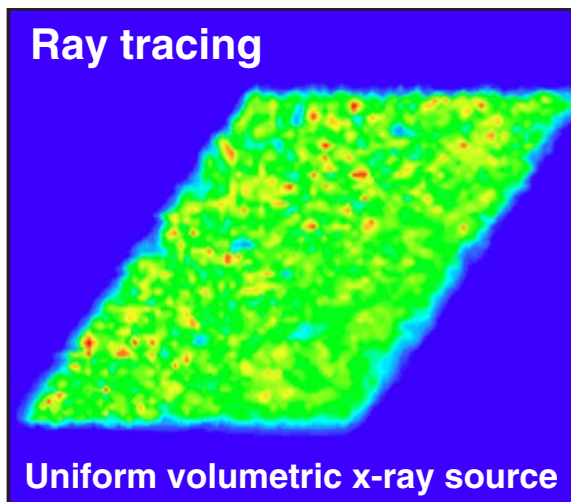
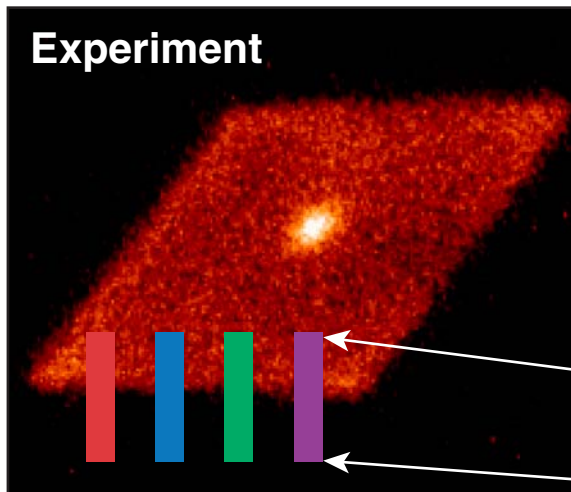


Sharp edges are observed over the entire field of view



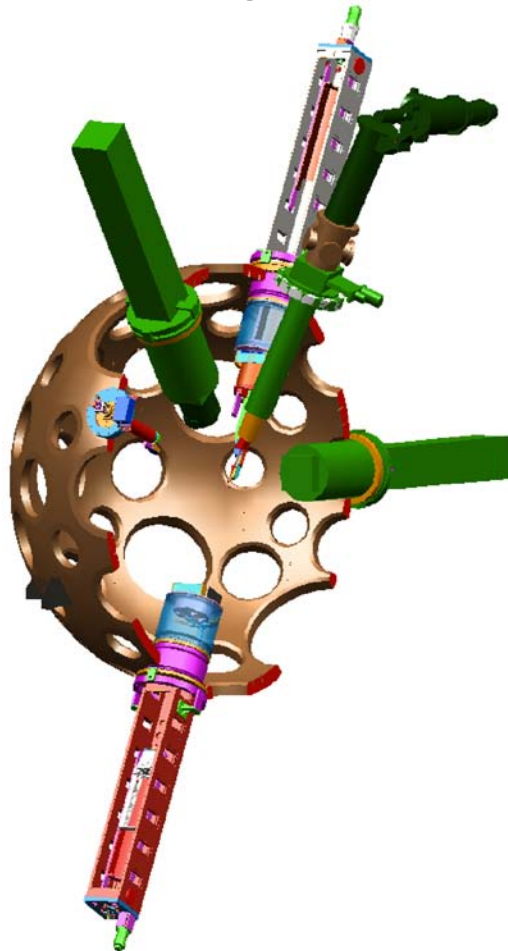
- Sharp edges are observed over the entire field of view
- The $\sim 10\text{-}\mu\text{m}$ edge blur appears to be higher than the $6\text{-}\mu\text{m}$ aberration blur
- A finite foil thickness ($10\ \mu\text{m}$) and 45° tilt increase the apparent blur

Ray tracing that includes a finite target thickness and tilt shows good agreement with the measurements



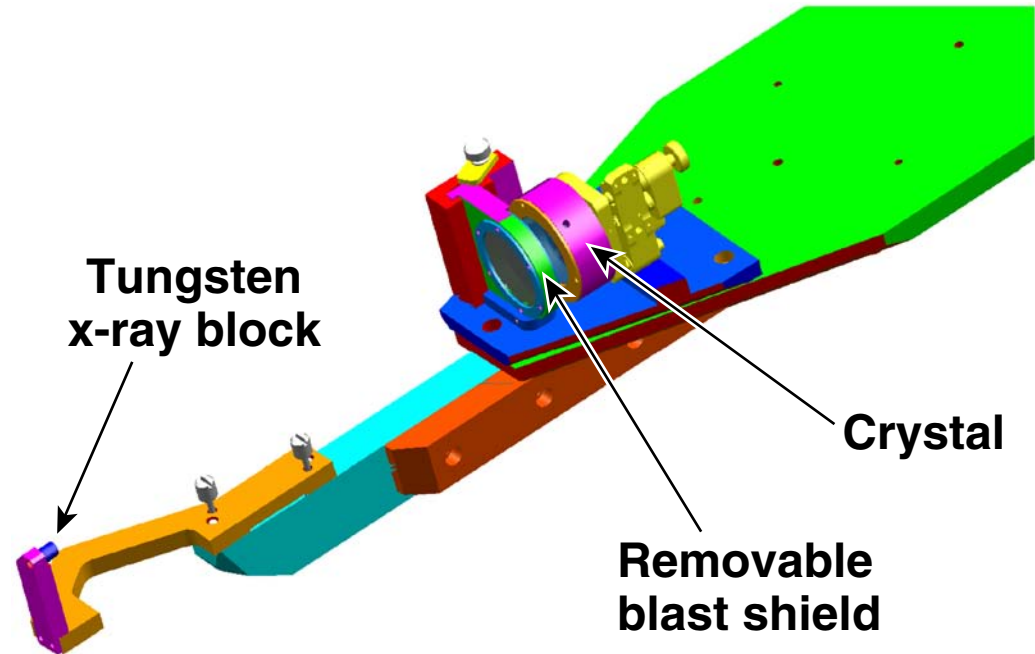
A TIM-based delivery and alignment platform is being developed for OMEGA EP

Crystal TIM



**Imaging TIM
(CCD or IP)**

Crystal TIM



Summary/Conclusions

A high-quality spherical crystal x-ray imager for OMEGA EP has been developed, fabricated, and tested



- High-resolution, high-efficiency, 8-keV x-ray imaging has been demonstrated
- The key features are
 - operation wavelength: Cu K_{α} 0.154-nm line emission
 - high spatial resolution: $\sim 6 \mu\text{m}$ (aberration limited)
 - large light-collection area $\sim f/10$
- The imager was tested on a 1-ps/10-J laser system

The imager will be fielded on OMEGA EP in 2011.