Spherical Crystal X-ray Imaging for MTW, OMEGA, and OMEGA EP

C.STOECKL, G. FISKEL, R. K. JUNGQUIST, P. M. NILSON, AND W. THEOBALD

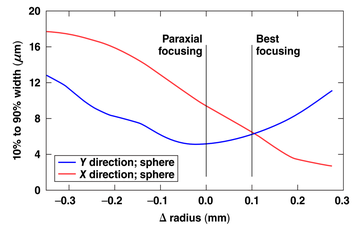
University of Rochester, Laboratory for Laser Energetics

Spherical Crystal Imaging (SCI) Systems Have Been Installed on MTW, OMEGA and OMEGA EP

- An SCI system has a number of unique capabilities
  - narrow spectral width
  - high throughput
  - high spatial resolution
- SCI systems have been installed on all of the LLE laser facilities
  - MTW: Cu K_α and Zr K_α emission, Al He_β and Si He_α backlighting
  - OMEGA EP: Cu K_α emission
  - OMEGA: Cu K_α emission, Si He_α backlighting
- Three major improvements are planned for the Si-SCI on OMEGA
  - aspheric crystal to reduce the astigmatism
  - time-resolved recording system using an x-ray framing camera (XRFC)
  - fast target insertion system for compatibility with CRYO

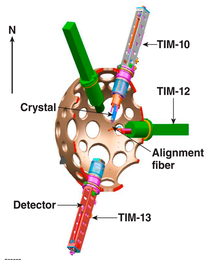
E20905

A 5-μm Resolution is Predicted for the Cu K_α Imaging System



E18862a

The OMEGA EP Crystal Imager Uses Two TIM's in Shot Mode and Three TIM's in Alignment Mode

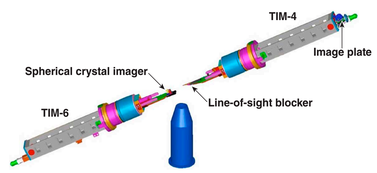


- The crystal is located in TIM-10 285 mm from the target at a 1.3° angle of incidence
- The IP detector in TIM-13 is placed at 2.7 m from crystal for a magnification of ~9.5

C. Stoeckl *et al.*, Rev. Sci. Instrum. 83, 033107 (2012).

E20907

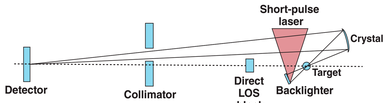
The OMEGA Spherical Crystal Imager is Based on the OMEGA EP Design Using Two Opposing TIM's



- The crystal is located in TIM-6, 267 mm from the target at a 1.3° angle of incidence
- The IP detector in TIM-4 is placed 3.6 m from the crystal for a magnification of ~13

E20912

High-Quality Backlit Images of Implosions can be Obtained with a Crystal Imaging System

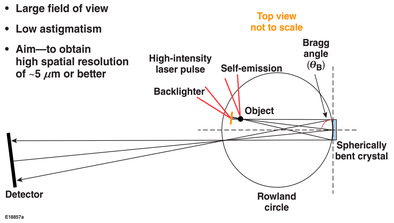


- The backlighter foil is not in the focus of the imaging system, so the backlighter uniformity does not depend on the laser-intensity distribution
- A collimator blocks the line-of-sight (LOS) to the backlighter, minimizing the background from short-pulse laser
- A direct LOS block shields the detector from background produced by the implosion target

E20916

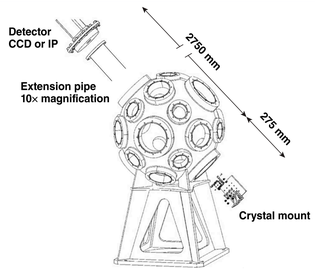
A Spherical Crystal Imager Can Work Either in Self-emission or Backlighting Mode

- Near-normal incidence
- Large field of view
- Low astigmatism
- Aim—to obtain high spatial resolution of ~5 μm or better



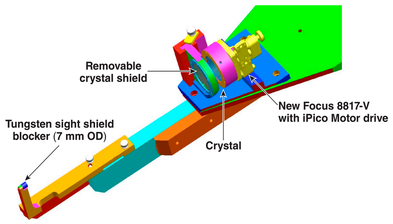
E18857a

The Spherical Crystal Imager on MTW Uses a Manual Crystal Mount and Either CCD or IP Detectors



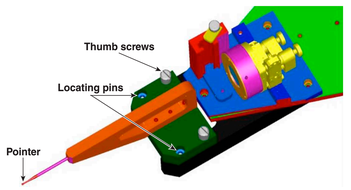
E18860a

The Crystal Holder Assembly Includes a Removable Blast shield and a Direct Line-of-Sight Shield



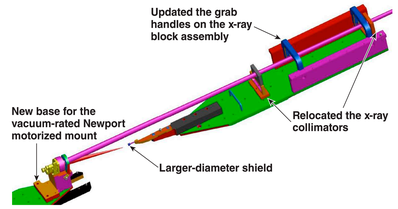
E20909

A Pointer on the Crystal Mount Assembly is Used to Locate the Crystal at the Desired Distance from TCC



E20913

The OMEGA SCI Setup was Recently Modified to a Si He_α Backlighting Configuration



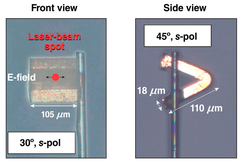
E20917

Different Crystals Are Used for the Different Wavelength Requirements of the Applications

Emission line	Si He_α	Cu K_α	Zr K_α
Wavelength (Å)	6.65	1.541	0.790
Energy (keV)	1.865	8.048	15.691
Quartz	1011	2131	2354
Reflection order	1	2	2
Bragg angle (°)	83.9	88.7	87

E18859a

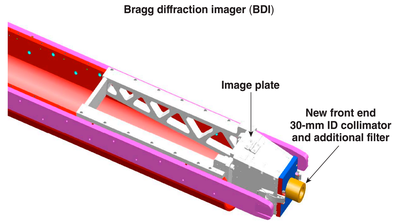
Wedge Targets Are Used to Study the Fast-Electron Conversion Efficiency



- One-piece Cu targets with ~100 × 100 × 40-μm^3 volume and 30°, 45°, and 60° opening angles
- Radius of curvature (~1 μm) smaller than the focal-spot diameter
- Wedge target orientation sets laser polarization

E17223a

The Image-Plate Detector Assembly is Based on a LLNL Design with an Additional Collimator and Filter Mount



E20910

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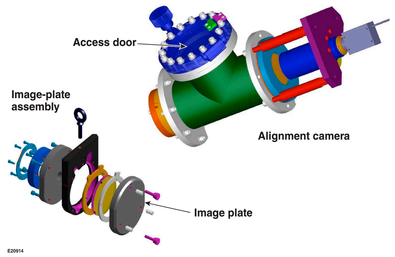

E20914

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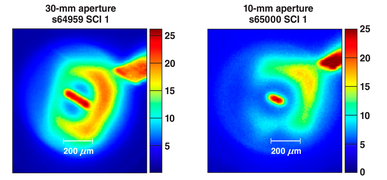
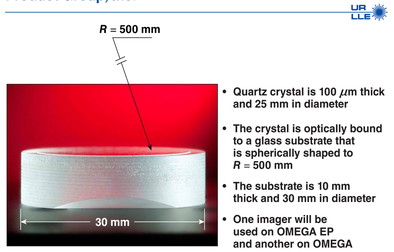


The astigmatism of the imager is reduced with the smaller aperture.

E20918

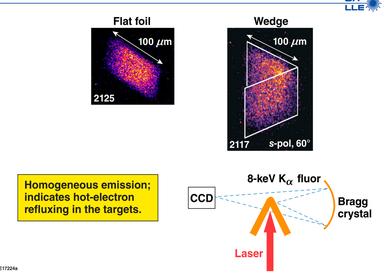
Two Imagers Have Been Fabricated by Photonics Product Group, Inc.



- Quartz crystal is 100 μm thick and 25 mm in diameter
- The crystal is optically bound to a glass substrate that is spherically shaped to R = 500 mm
- The substrate is 10 mm thick and 30 mm in diameter
- One imager will be used on OMEGA EP and another on OMEGA

E20906

A Spherical Bragg Crystal Imager Recorded the Spatially Resolved Cu K_α Emission



E17224a

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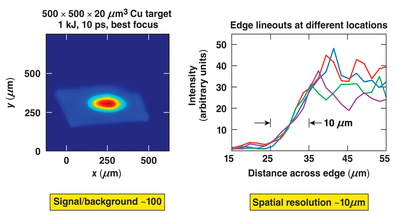
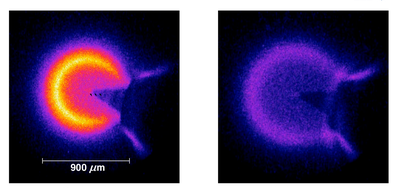


E20911

The SCI Recorded Images from Cu-Doped, Cone-in-Shell Fast-Ignitor Targets



Images courtesy of M. Wei, General Atomics

E20915

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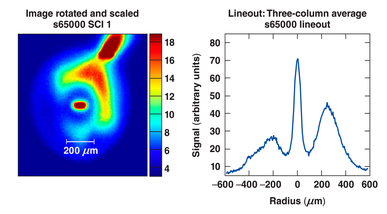

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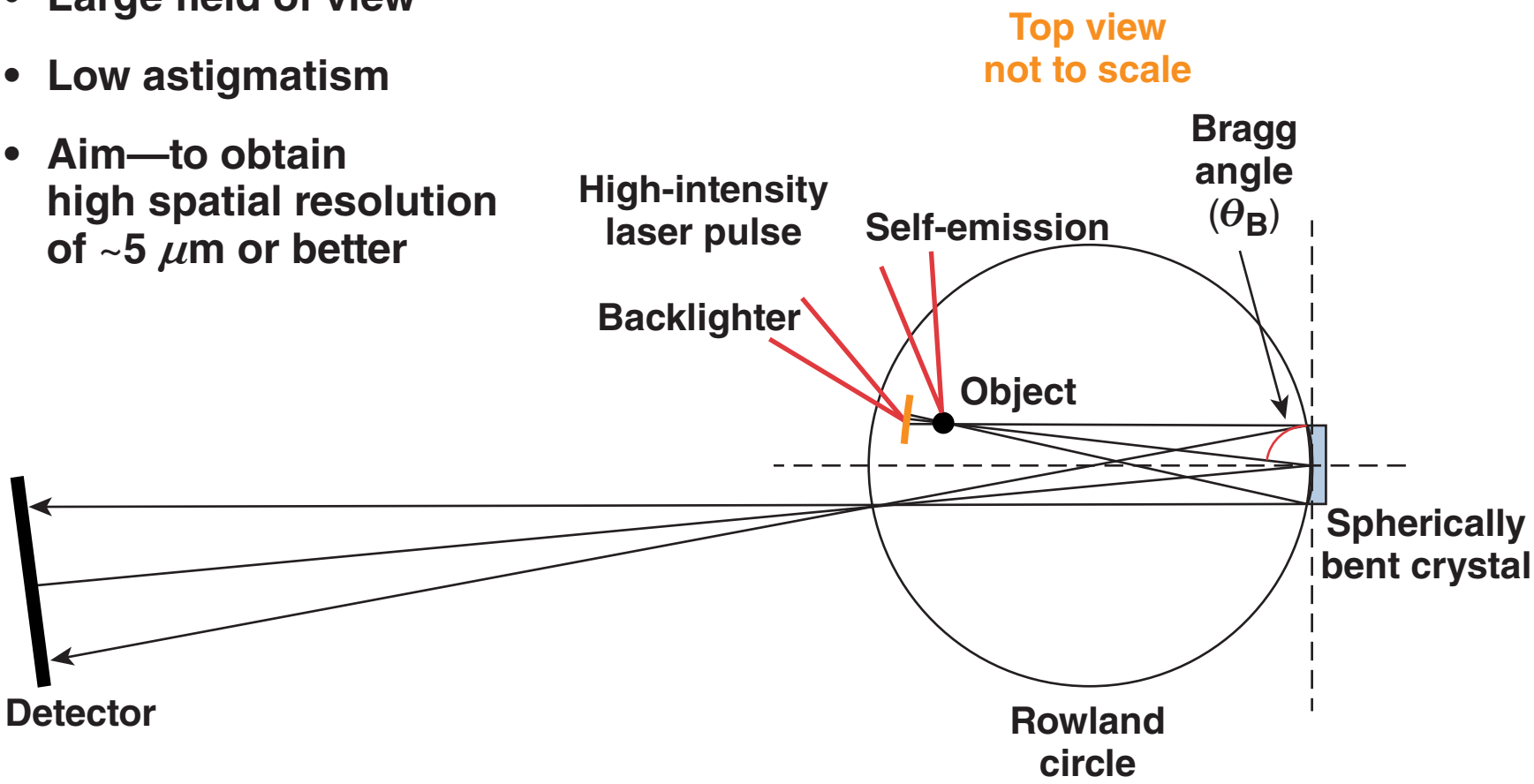

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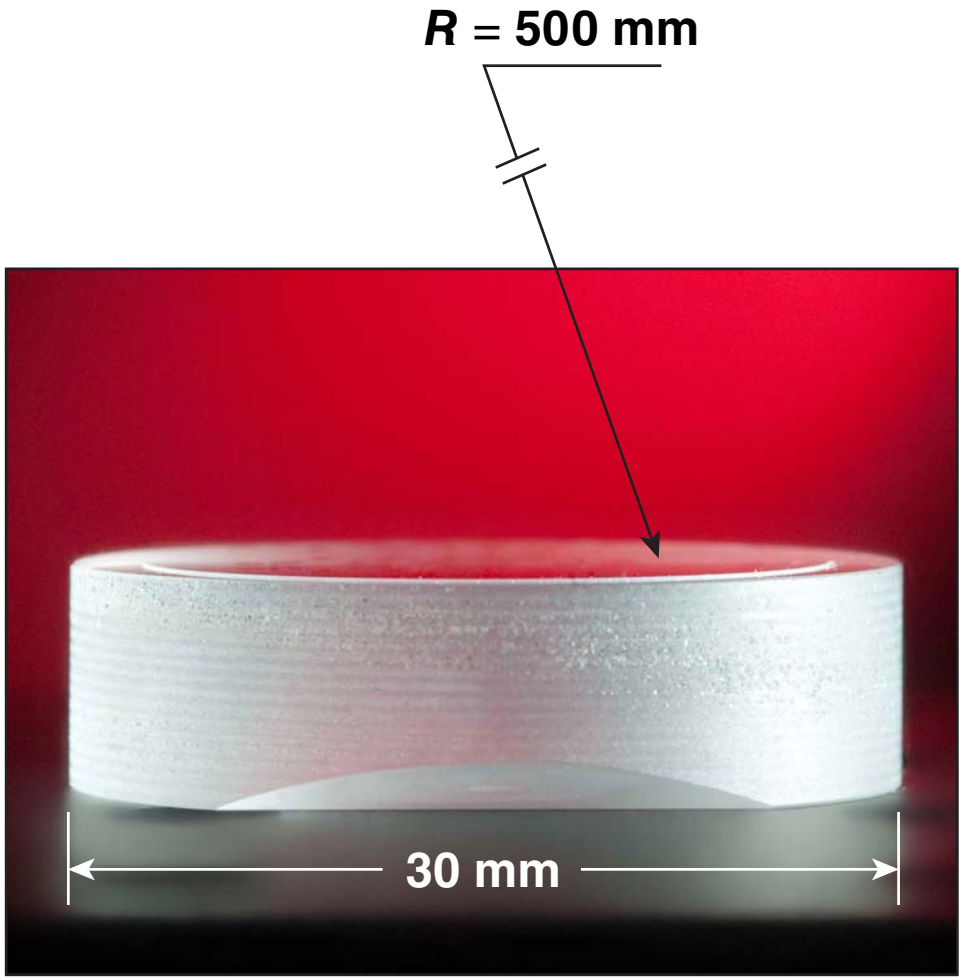

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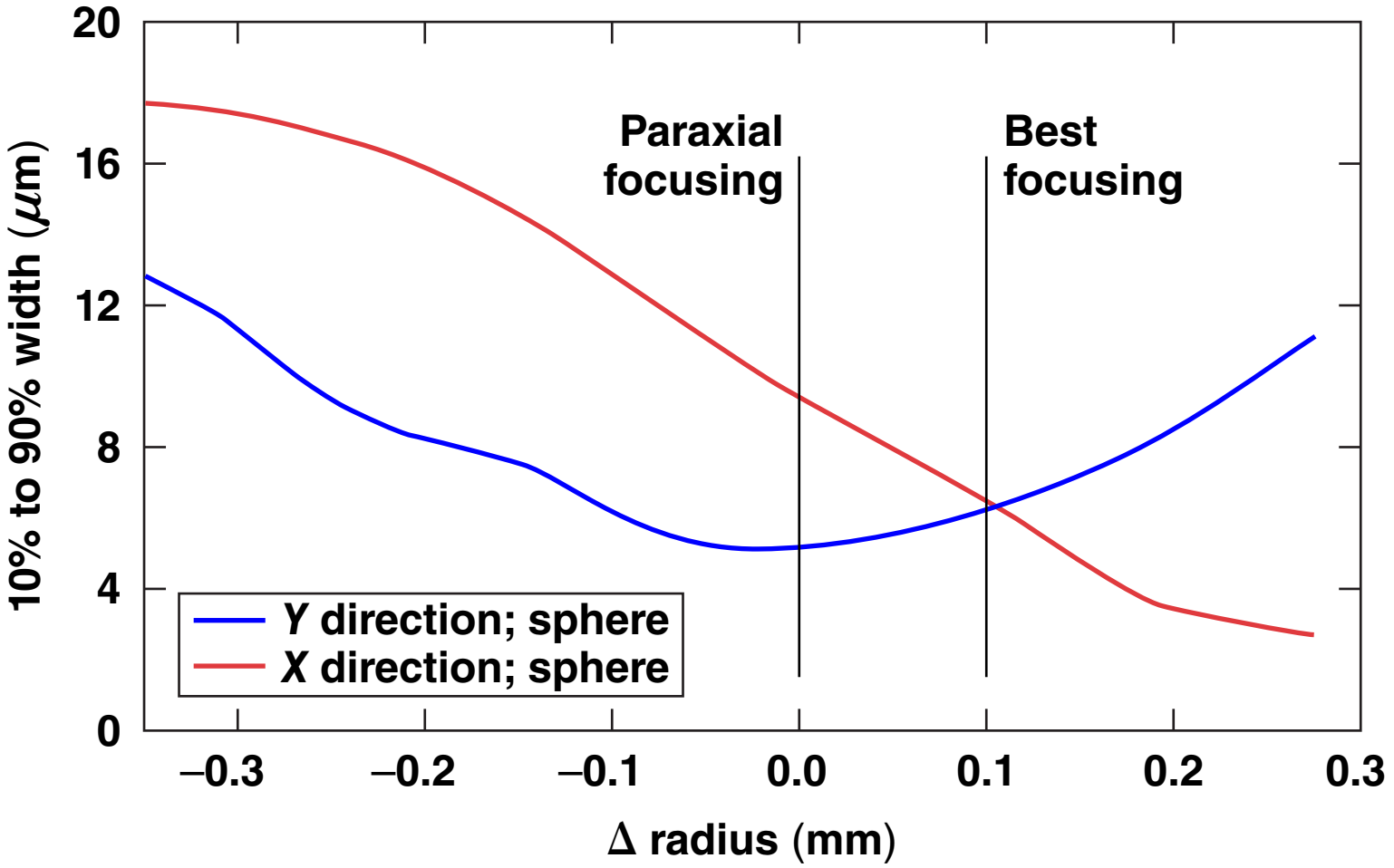

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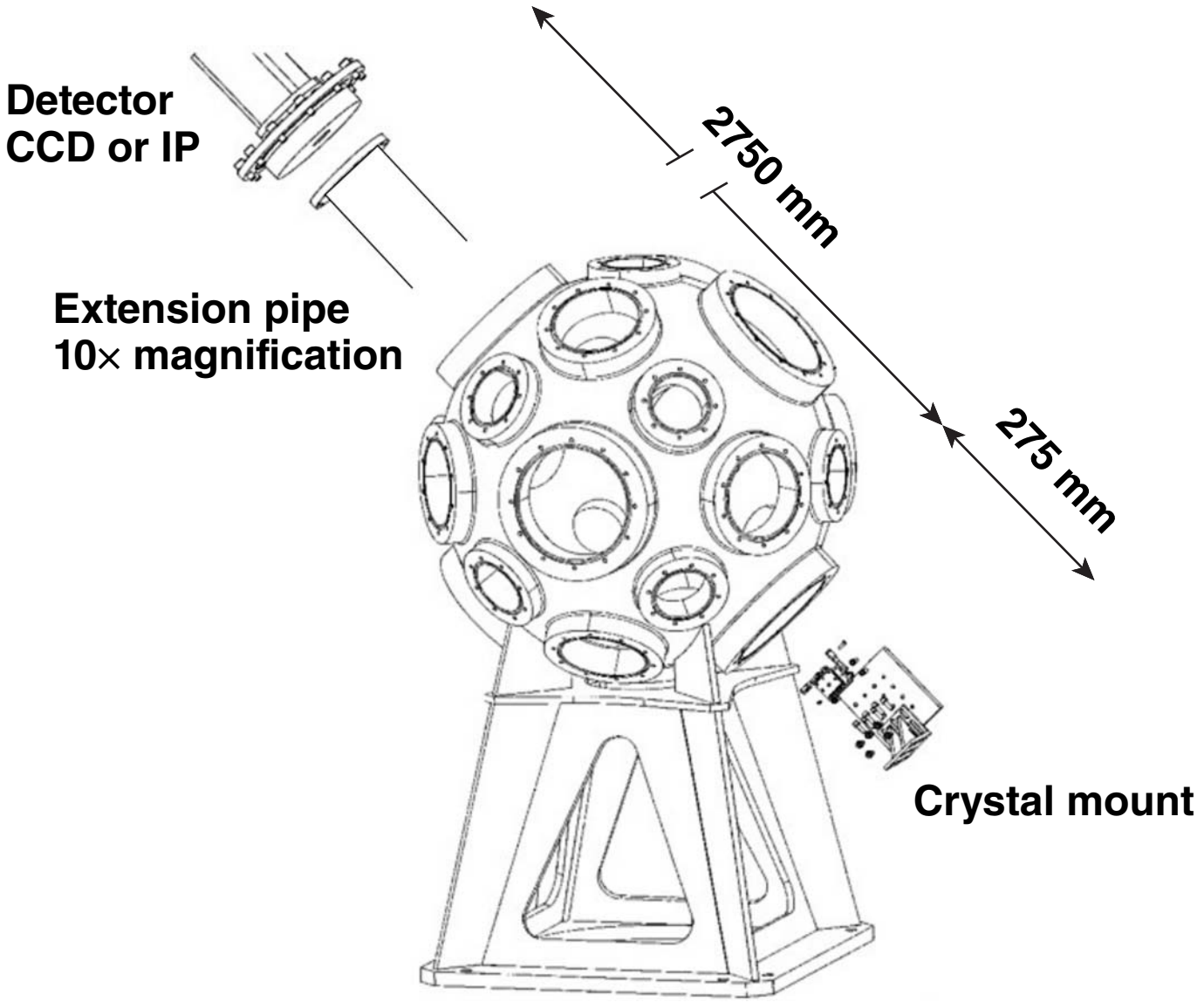

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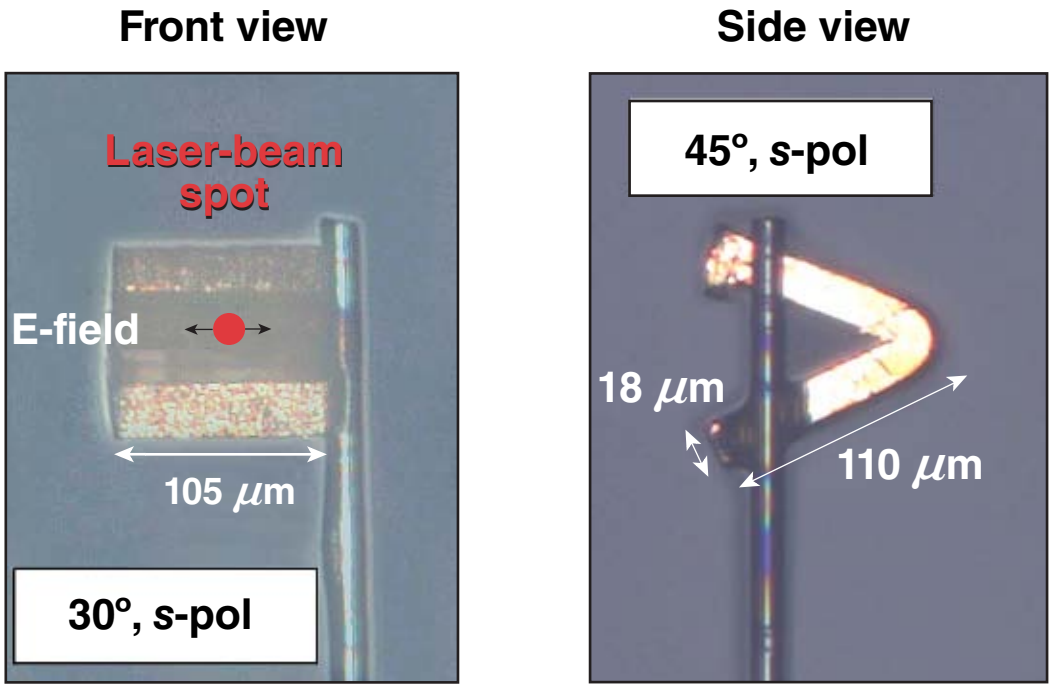

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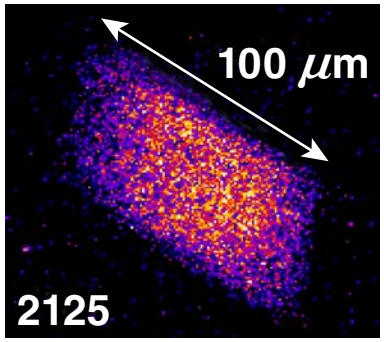
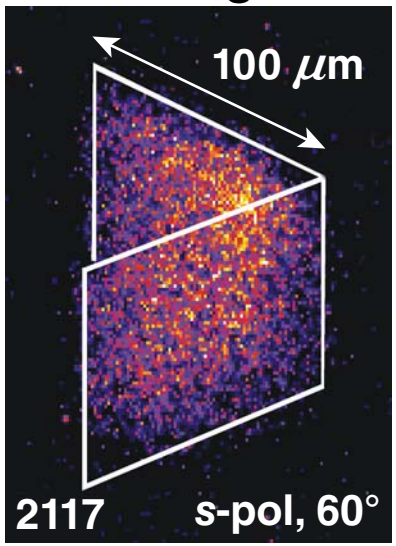
UR LLE

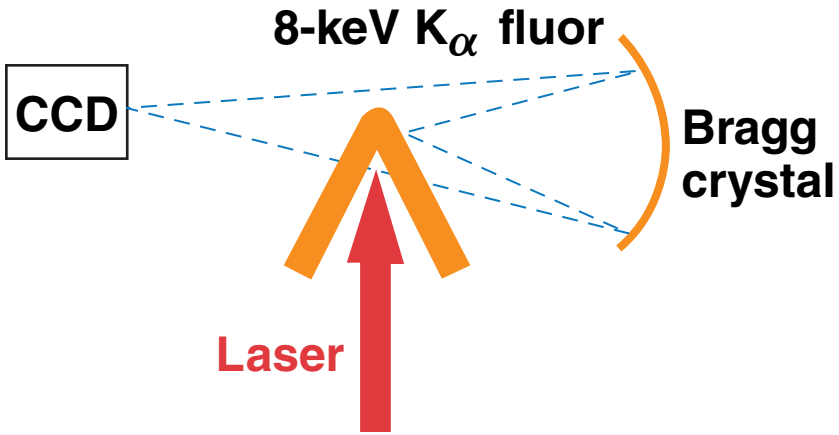
Flat foil



Wedge



Homogeneous emission; indicates hot-electron refluxing in the targets.



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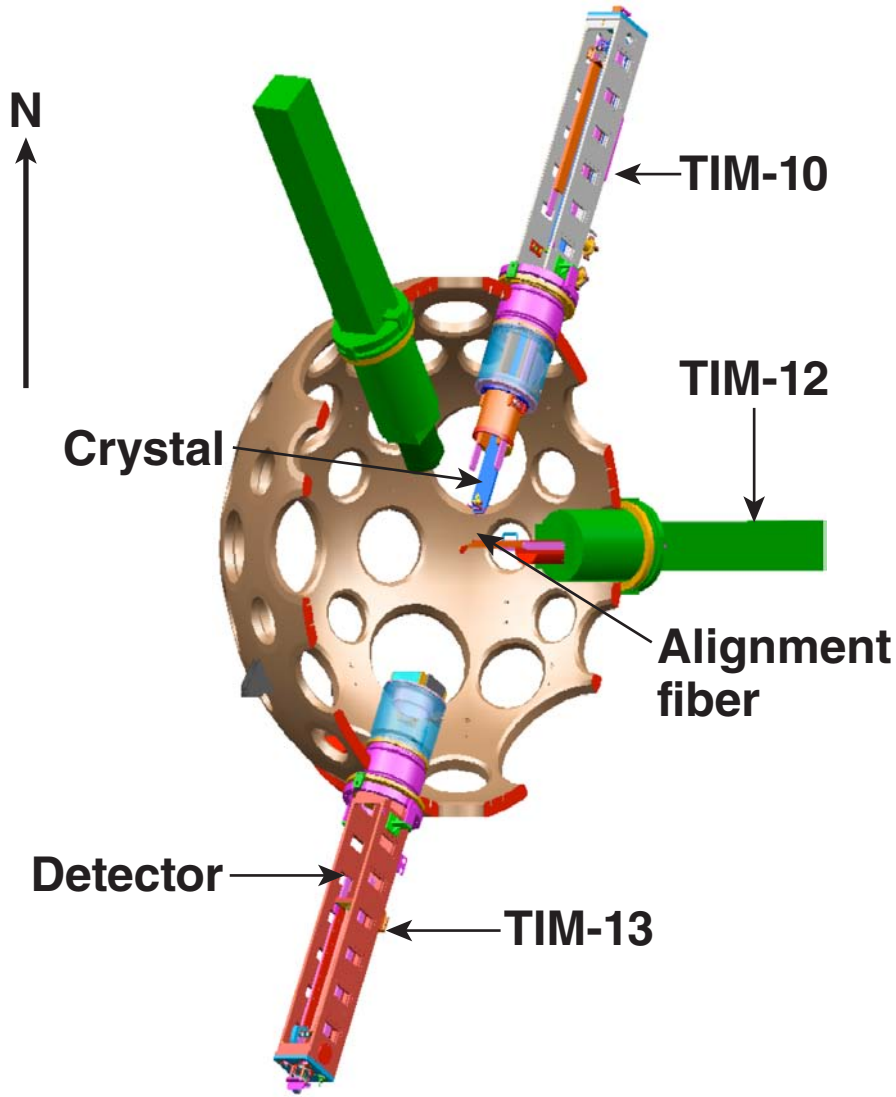

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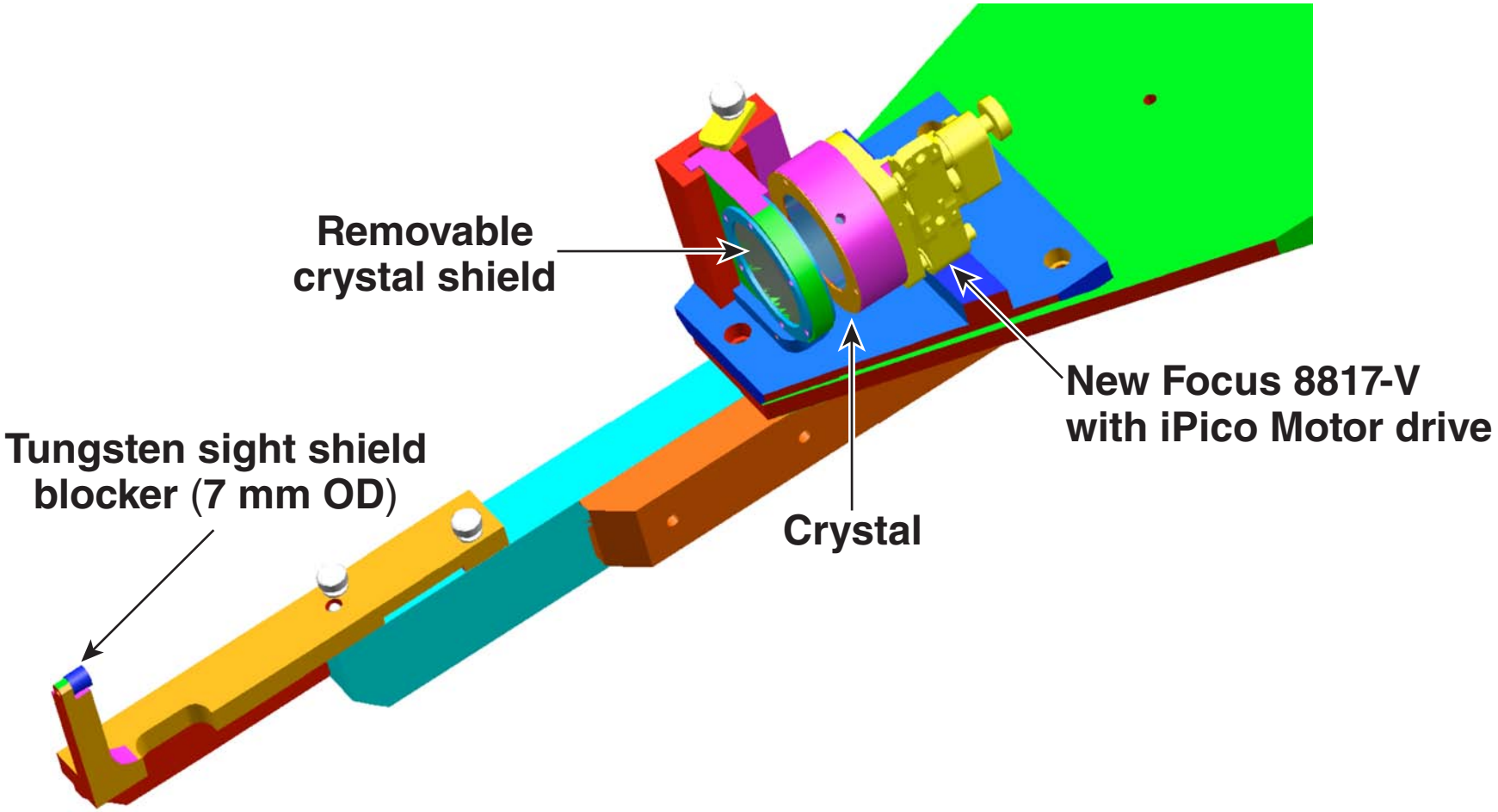

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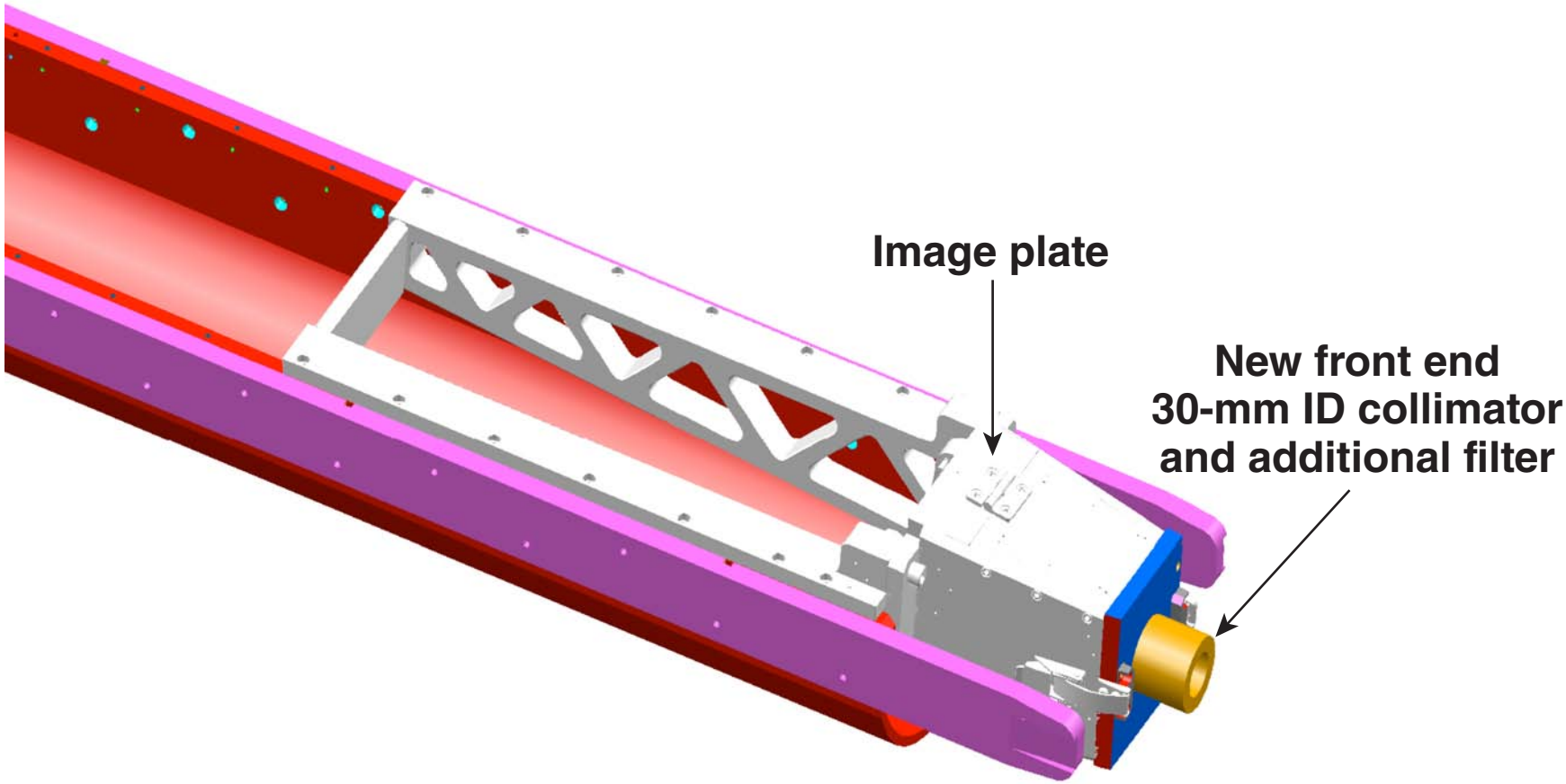
UR LLE

Bragg diffraction imager (BDI)



E20910

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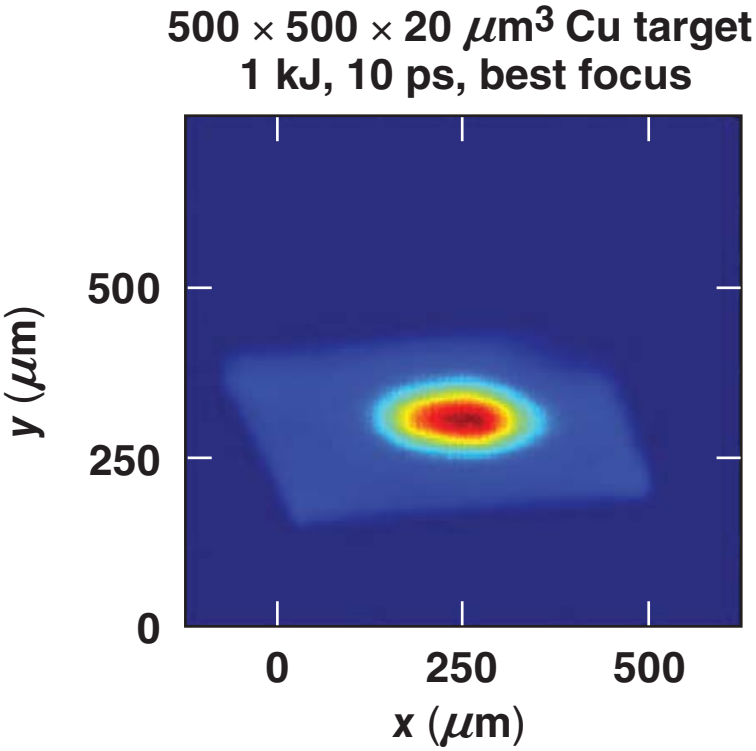

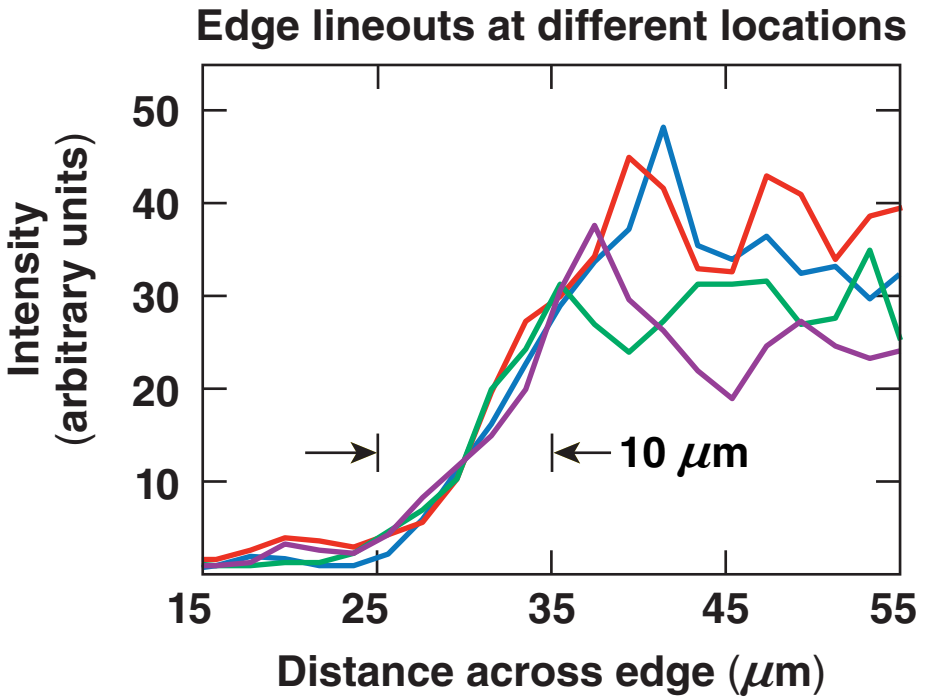

Signal/background ~100

Spatial resolution ~10μm

E20911

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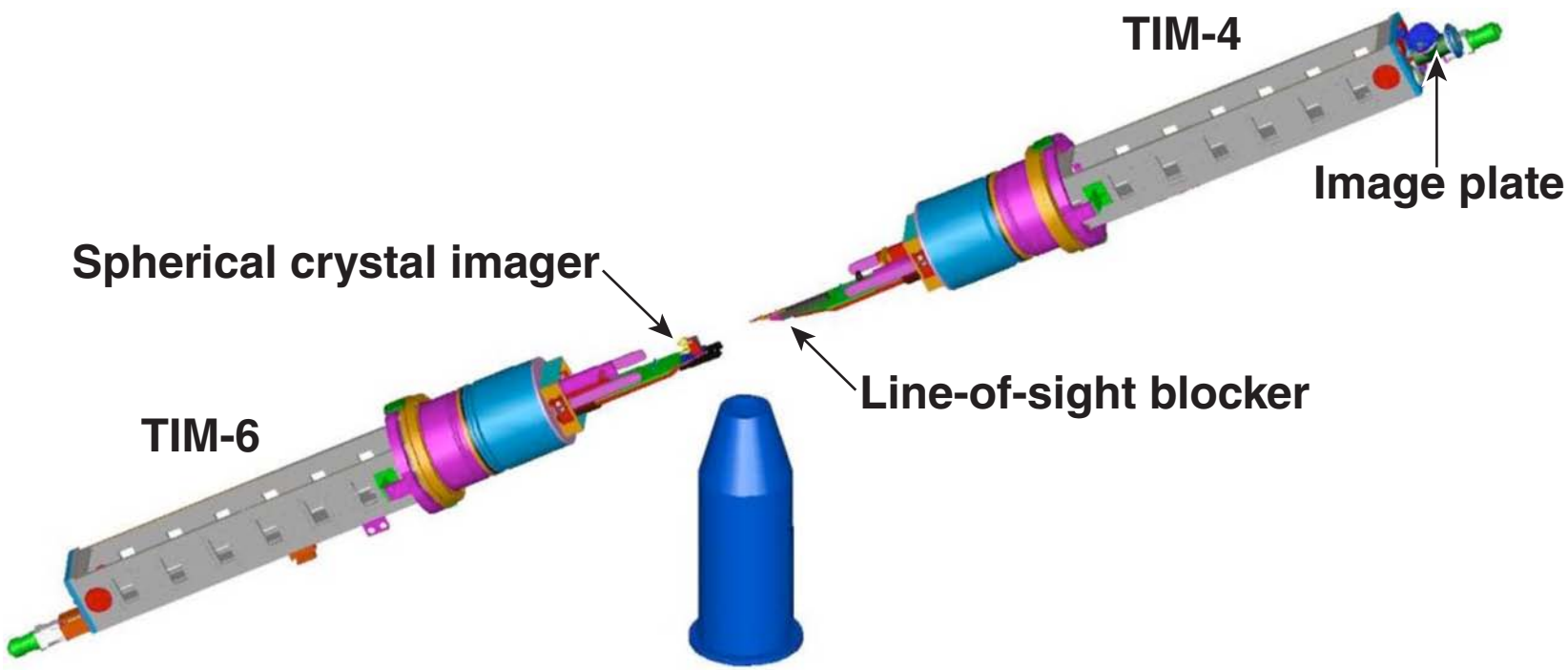

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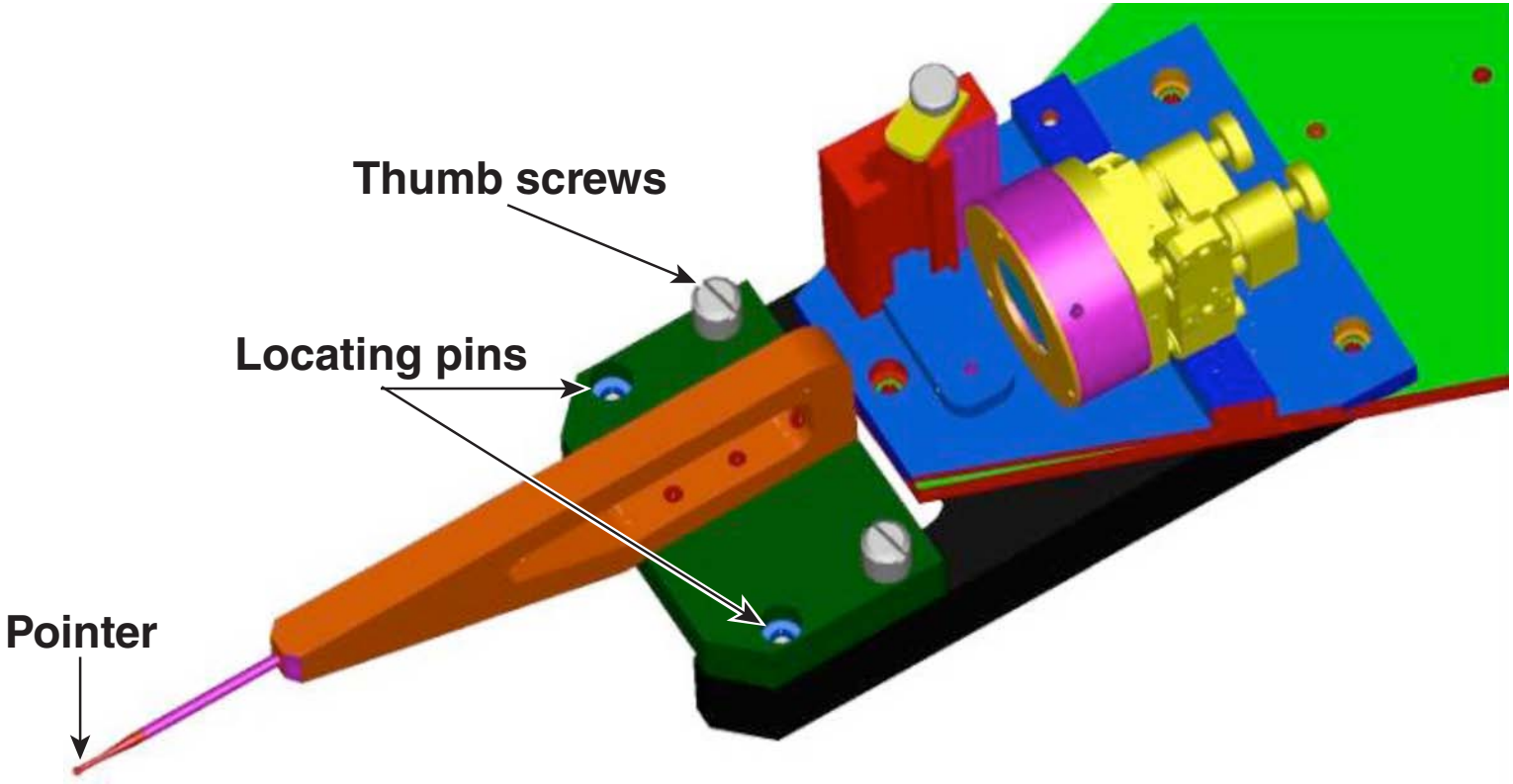

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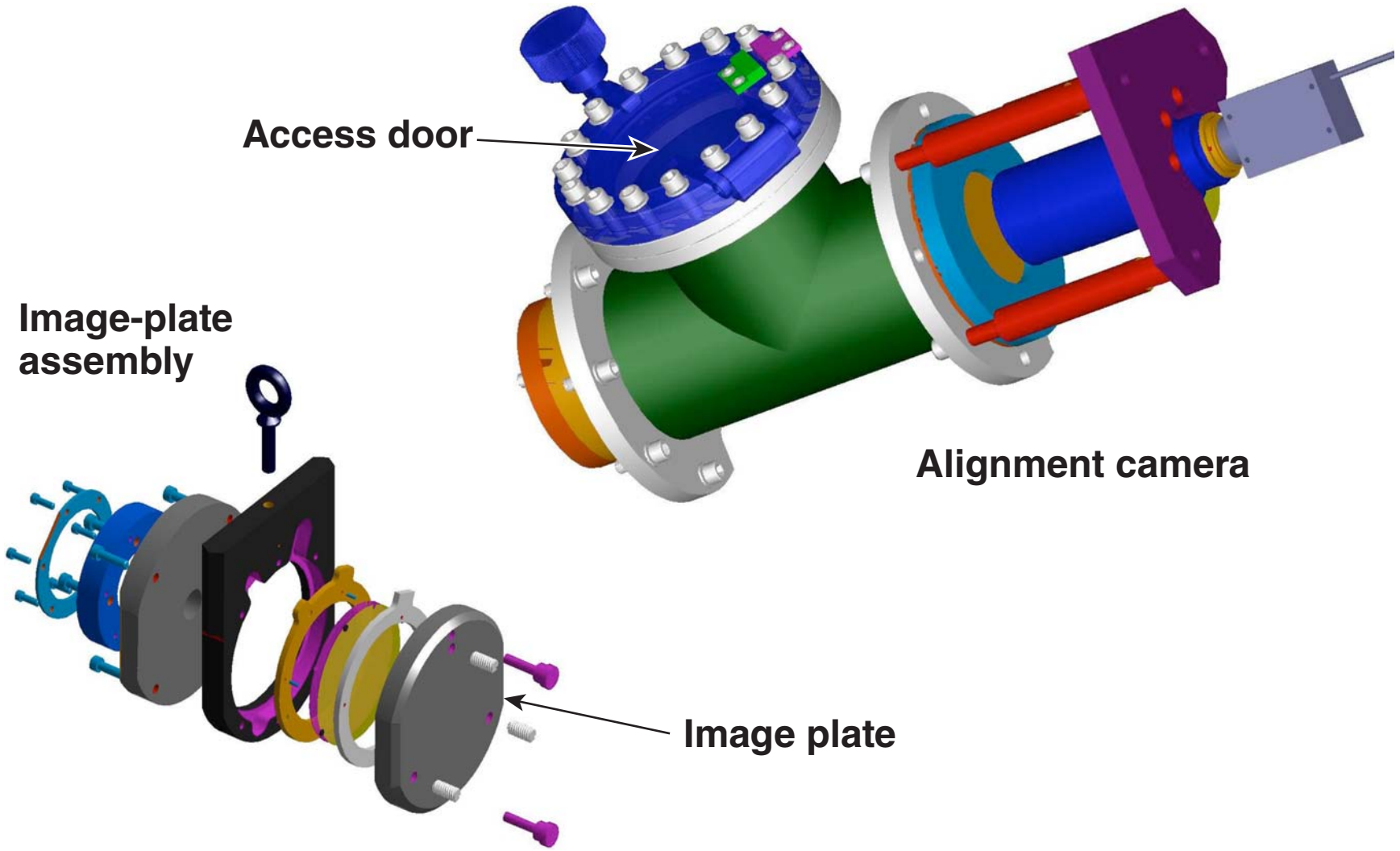
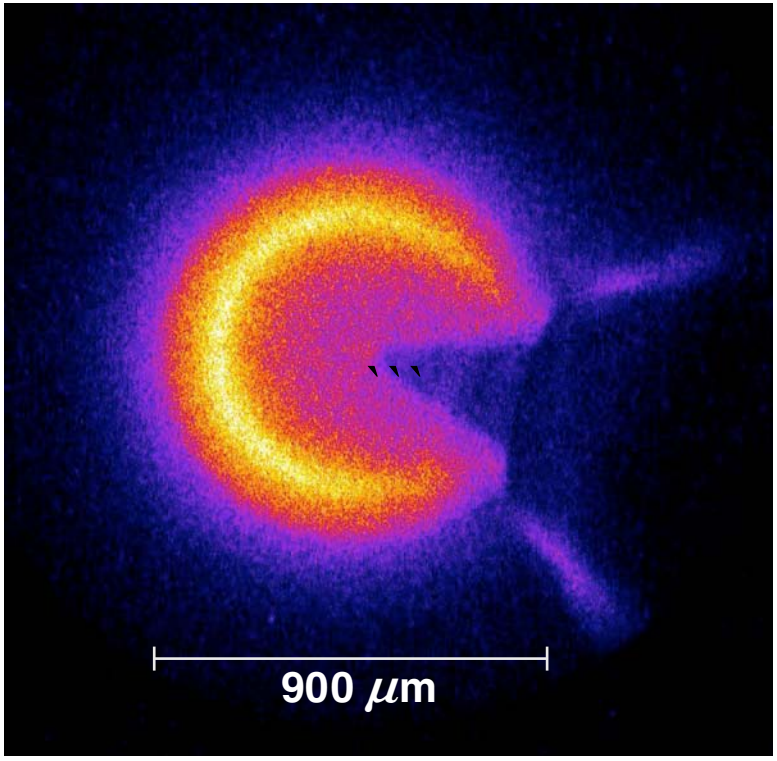
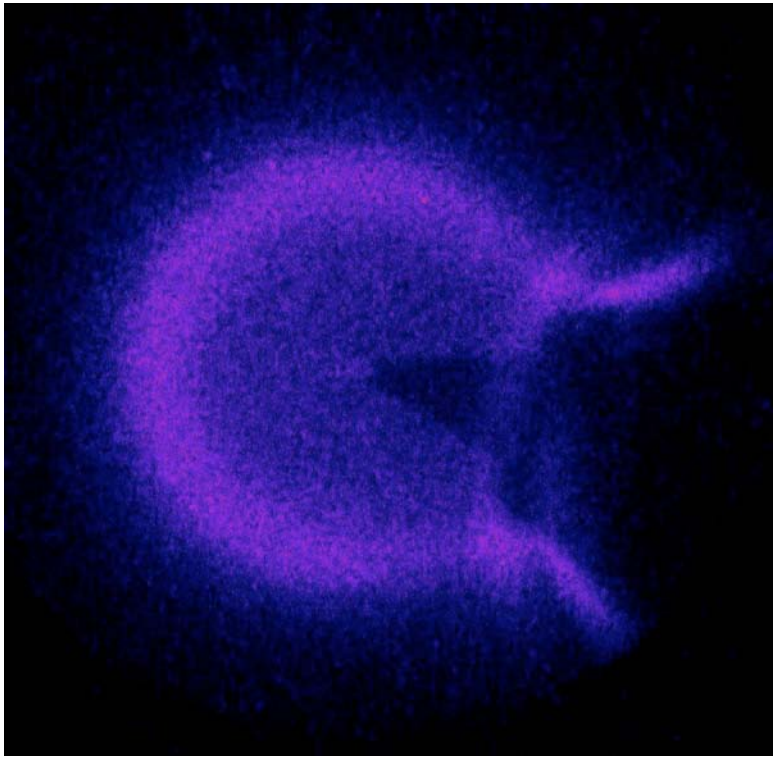


E20914

The SCI Recorded Images from Cu-Doped, Cone-in-Shell Fast-Ignitor Targets



Cu-doped shell
OMEGA UV beams only



Undoped shell
OMEGA UV beams only

GENERAL ATOMICS

UCSD CER Center for Energy Research

E20915

Images courtesy of M. Wei, General Atomics

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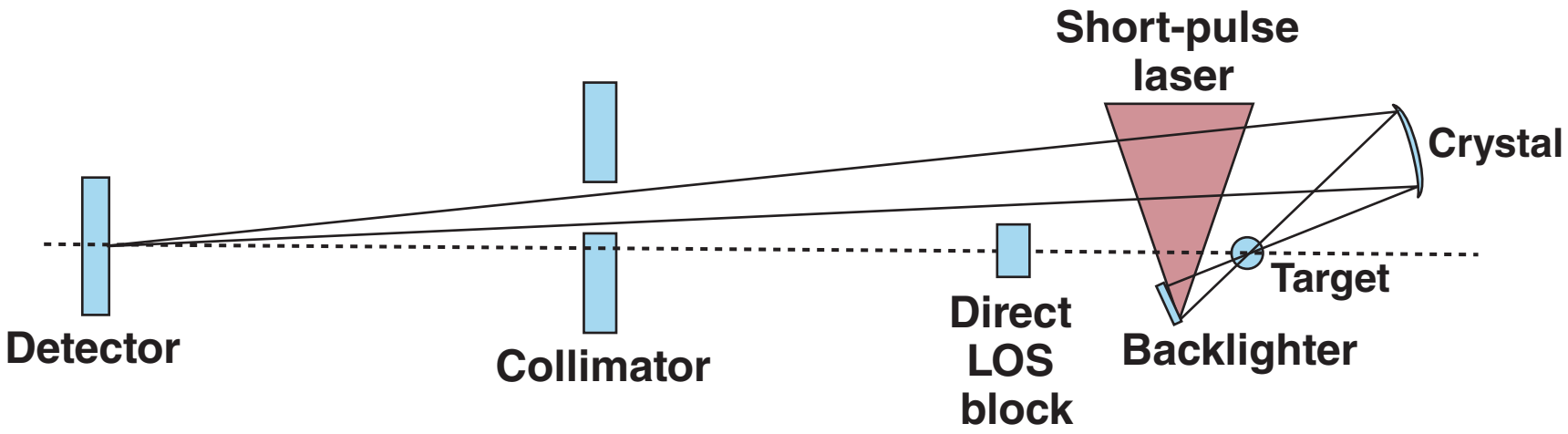

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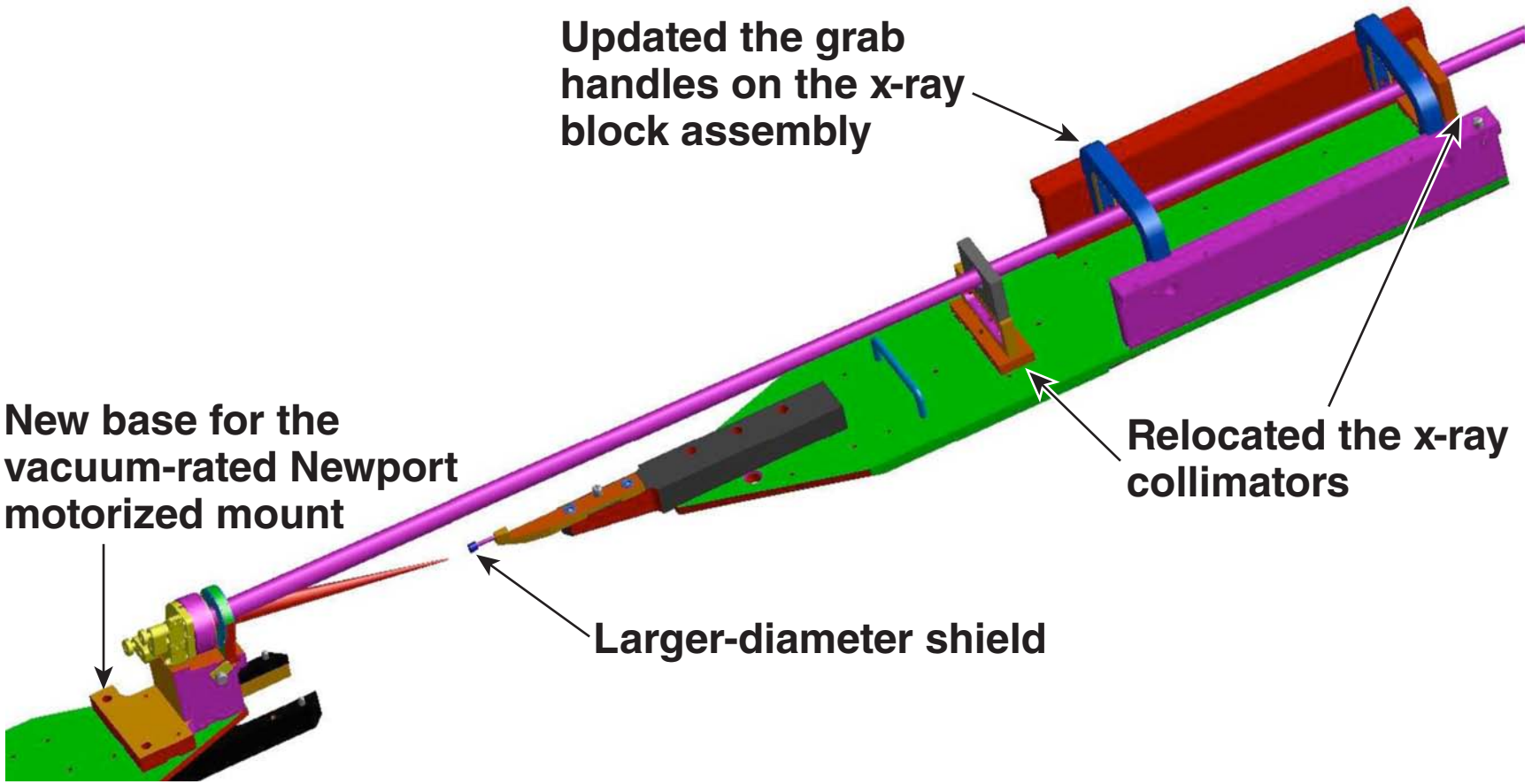

E20917

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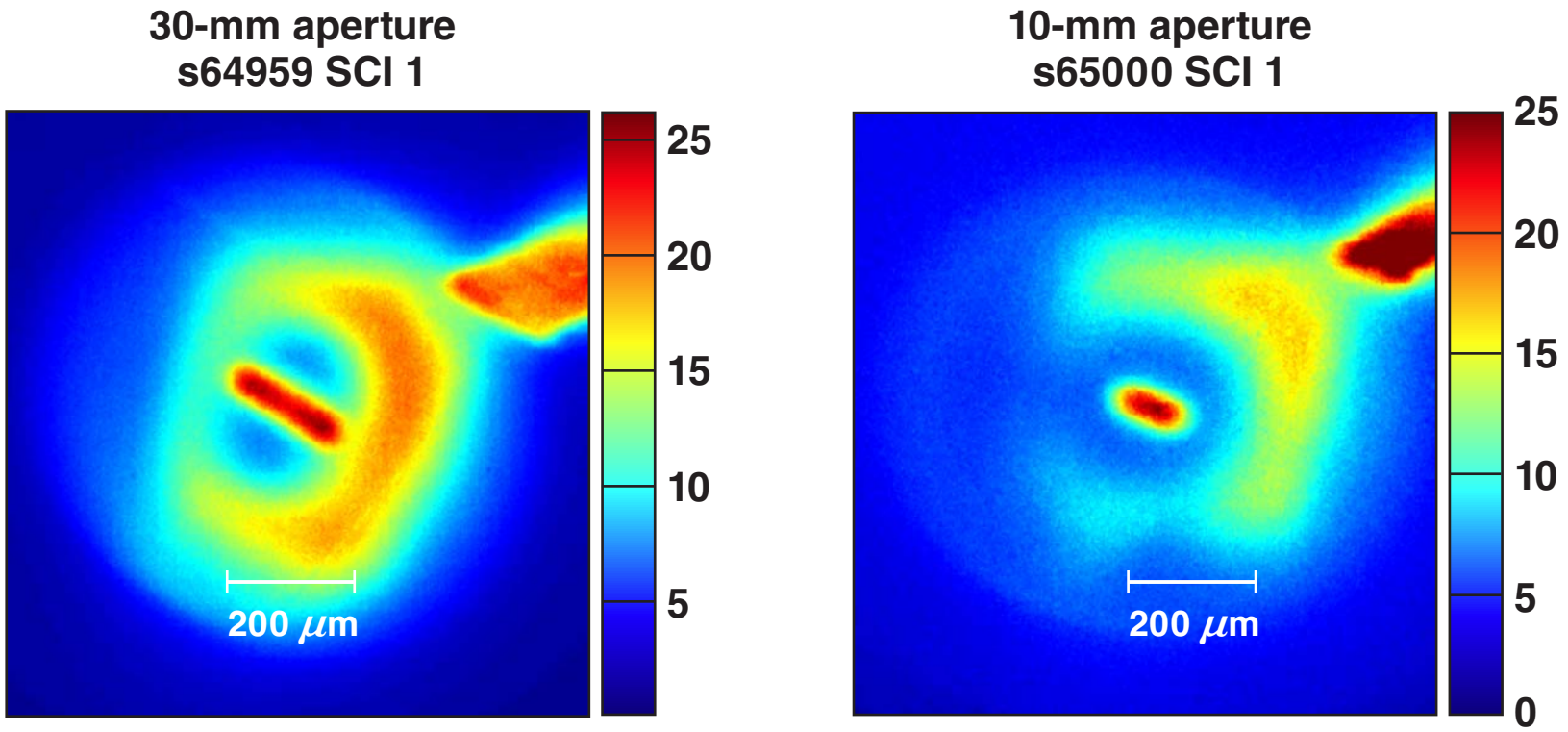

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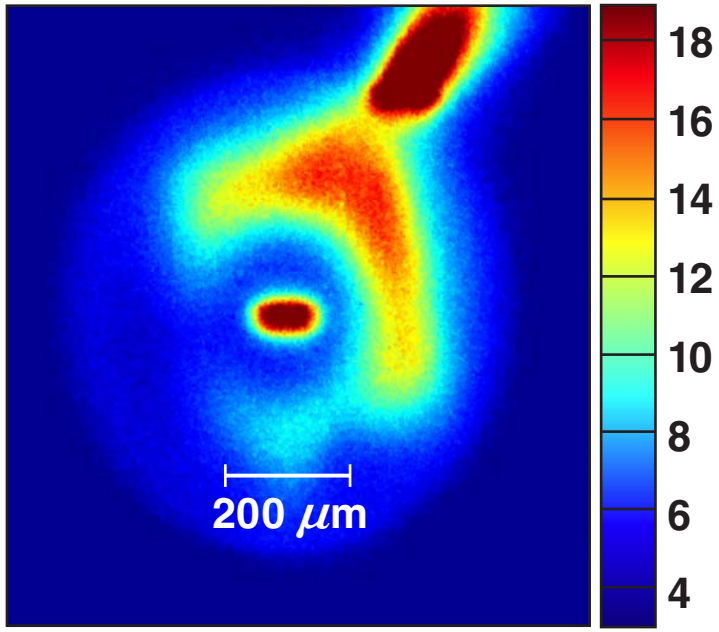
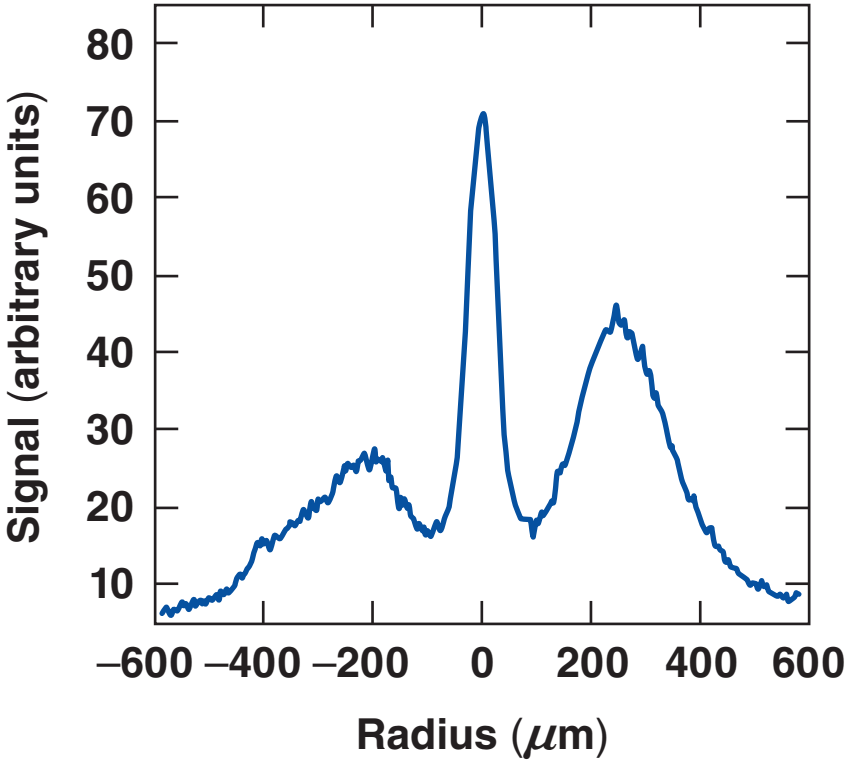
UR LLE

Image rotated and scaled
s65000 SCI 1



Lineout: Three-column average
s65000 lineout



E20919