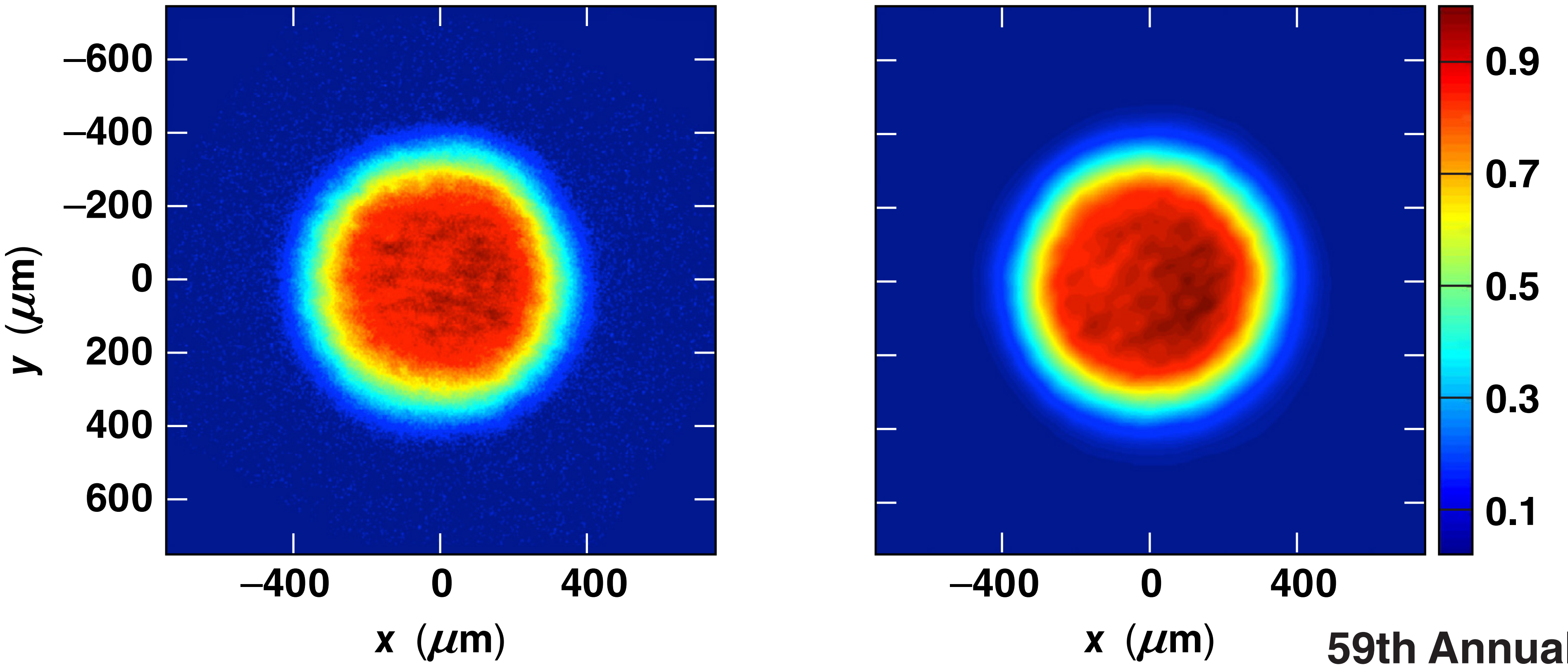
Inferred UV Fluence Focal-Spot Profiles from Soft X-Ray Pinhole-Camera Measurements on OMEGA

UV profile from in-target chamber x-ray measurement

UV profile from pre-target chamber UV ETP measurement



W. Theobald
University of Rochester
Laboratory for Laser Energetics

59th Annual Meeting of the American Physical Society Division of Plasma Physics
Milwaukee, WI
23–27 October 2017

Equivalent-target-plane and in-target chamber x-ray measurements produce UV focal-spot fluence distributions that agree within 5%

- A histogram analysis method of the beam-fluence distribution from two shots with slightly different laser energy provides the relation between UV and x-ray fluence
- The fluence response between x rays and UV photons $\left(F_x \sim F_{UV}^{\gamma}\right)$ has been measured for 100-ps pulses with γ between 0.9 and 2.6 for photons in the 2-keV range
- The relative errors of the x-ray method for the spot radius of 95% encircled energy, the radius of 1/*e* peak fluence, and the super-Gaussian order are estimated to be less than 5%

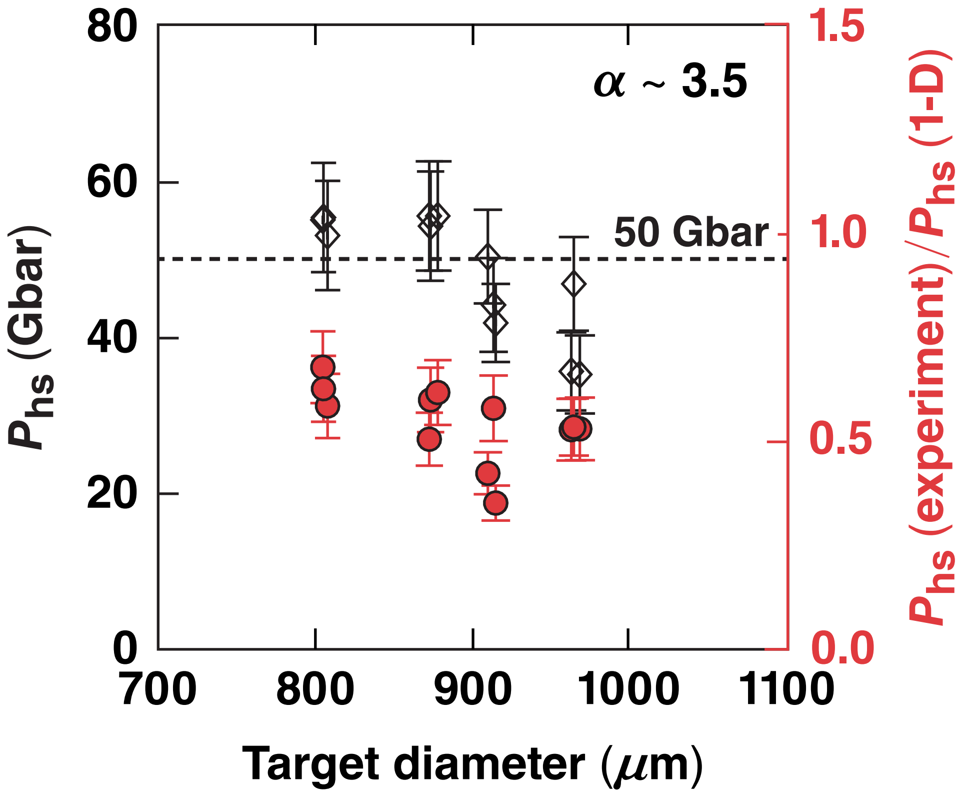
The UV focal-spot fluence measurements at full power must be improved to meet the requirements of the 100-Gbar Project.

Collaborators

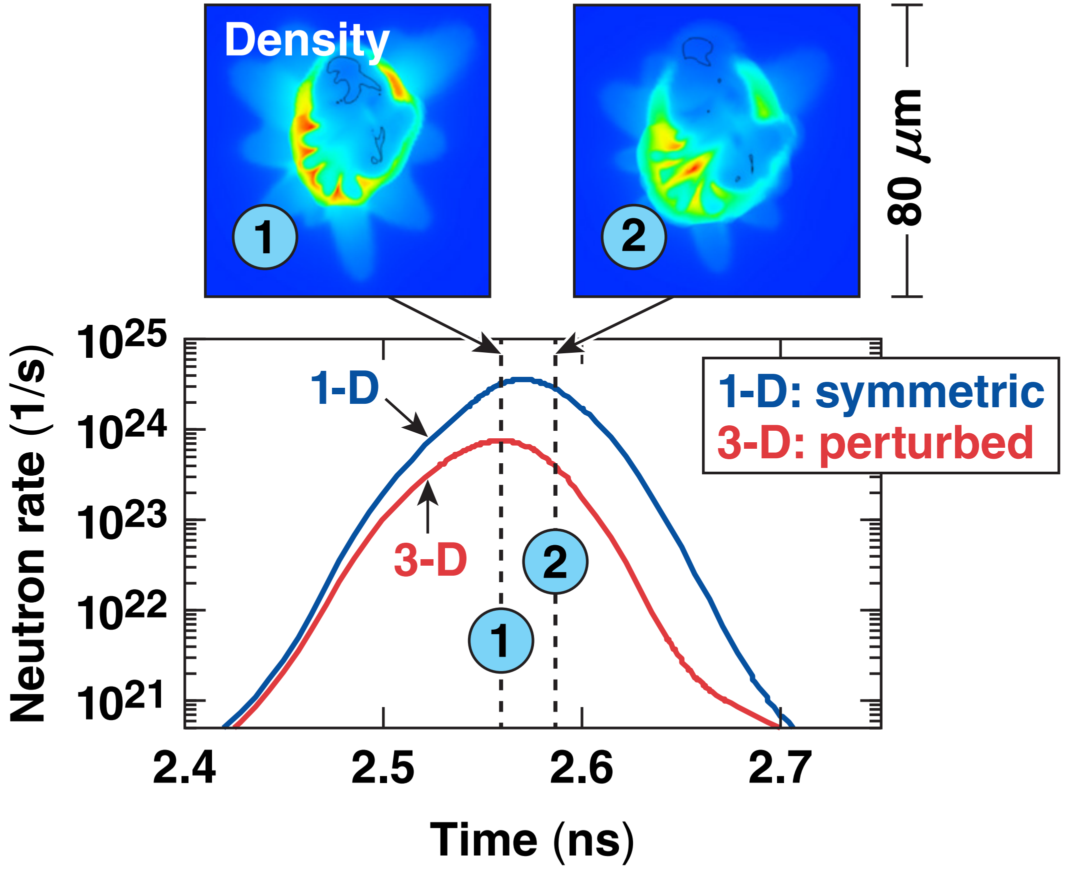
C. Sorce, R. Epstein, R. L. Keck, C. Kellogg, T. J. Kessler,
J. Kwiatkowski, F. J. Marshall, S. P. Regan, W. Seka, R. Shah,
A. Shvydky, C. Stoeckl, and L. J. Waxer

University of Rochester
Laboratory for Laser Energetics

Current cryogenic target implosions on OMEGA achieve hot-spot pressures exceeding 50 Gbar*



3-D *ASTER*** simulations for an 860-μm-outer-diam (OD) target



Hypothesis: Low-mode laser-drive nonuniformity limits the hot-spot pressure.

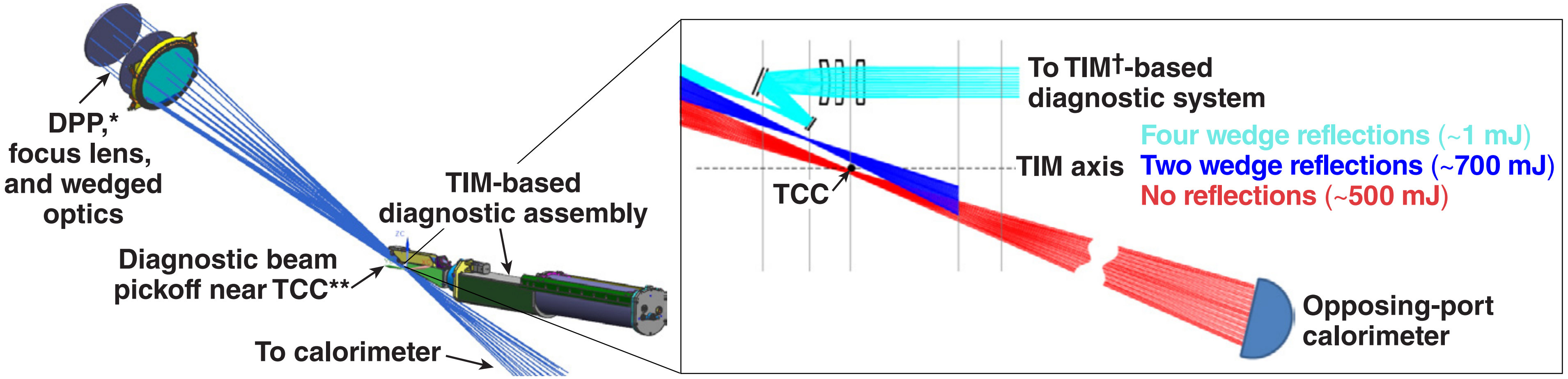
*S. P. Regan *et al.* Phys. Rev. Lett. 117, 025001 (2016); 117, 059903(E) (2016).
** I. V. Igumenshchev *et al.*, Phys. Plasmas 23, 052702 (2016).

I2515b

The required UV intensity balance on target must be better than 1% to meet the 100-Gbar goal

- An accurate knowledge of the UV fluence distribution and the beam energy on target at full power for each of the 60 beams is required
- X-ray data are used to infer the beam UV profile at full energy on target, but this technique is limited in accuracy and dynamic range
- The potential benefit of the x-ray method is that ultimately all 60 beams might be characterized in a single shot

Full-beam, in-tank (FBIT) diagnostic

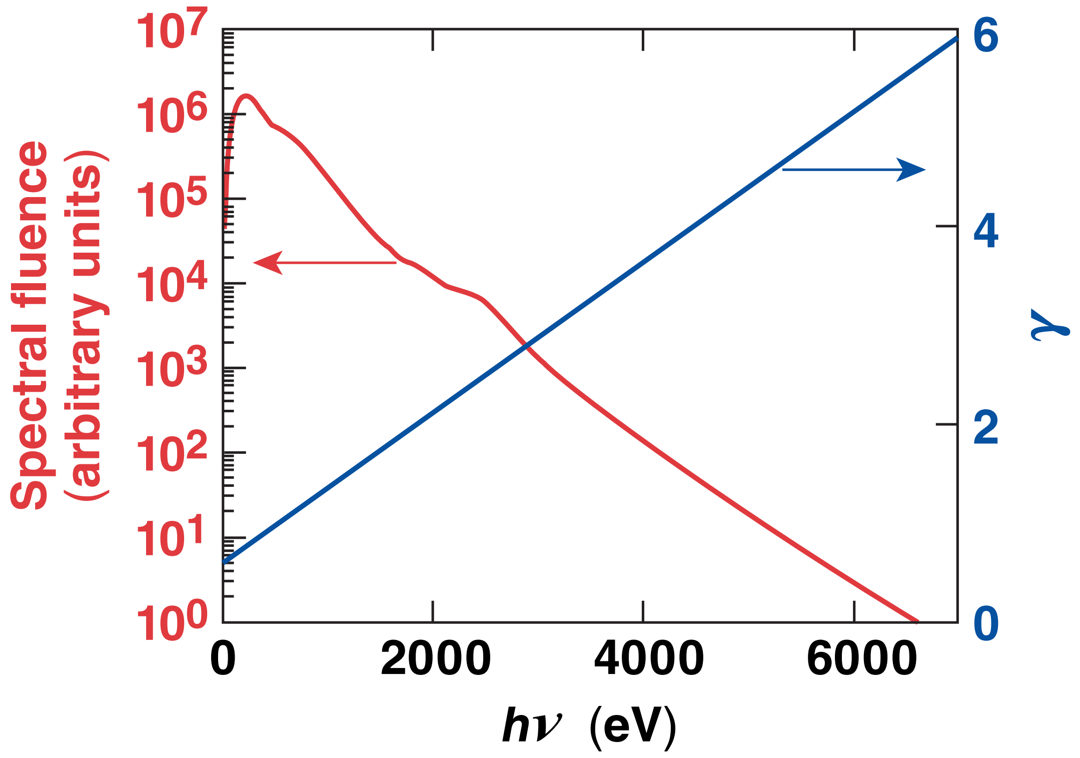


*DPP: distributed phase plate
**TCC: target chamber center
†TIM: ten-inch manipulator

E26657

The fluence response between x rays and UV photons $\left(F_x \sim F_{UV}^{\gamma}\right)$ is more favorable in the soft x-ray range

Calculation for a Au target irradiated with a 100-ps pulse

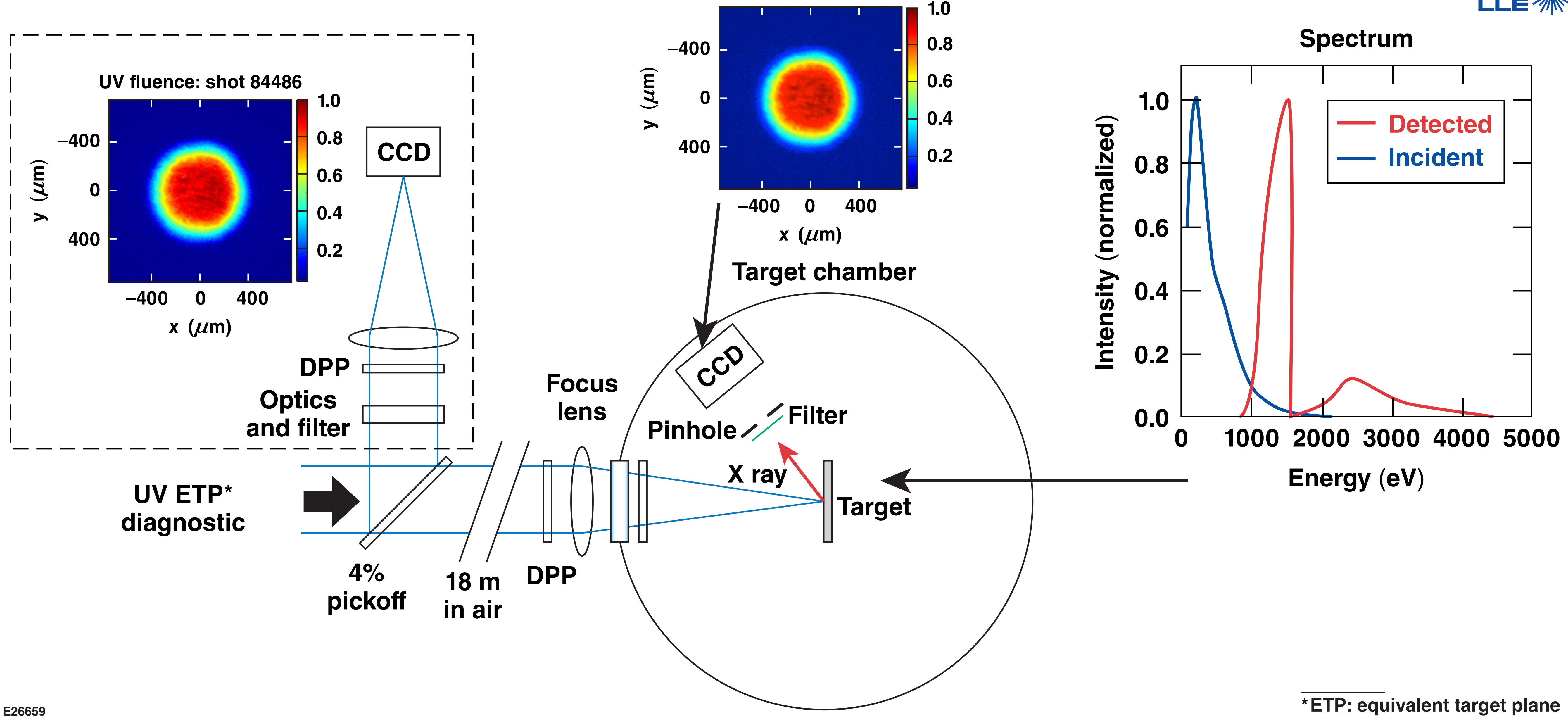


- Current pinhole cameras equipped with charge-injection devices (CID's) record the x-ray emission in the ~3- to 7-keV photon-energy range from Au-coated targets and measured $\gamma = 3.42 \pm 0.13$*
- Using a back-thinned charge-coupled–device (CCD) camera with softer filtration ($E < 2$ keV) will provide a lower γ and, therefore, a larger dynamic range in the inferred UV fluence

*F. J. Marshall *et al.*, Phys. Plasmas 11, 251 (2004).

E26658

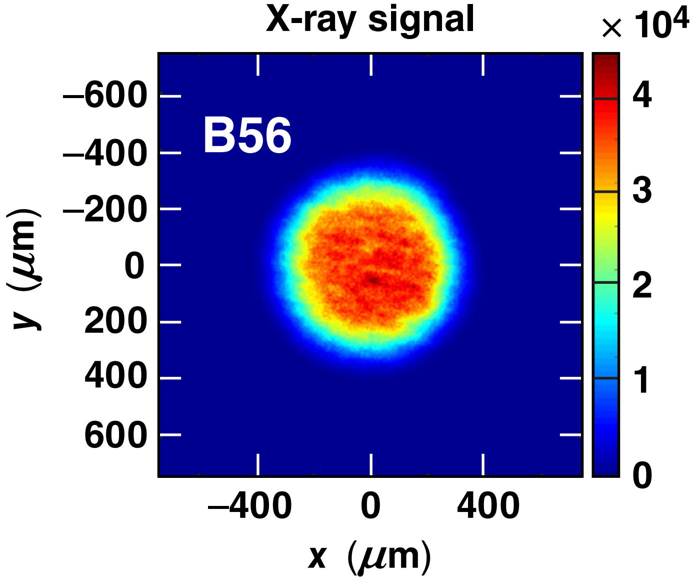
UV beam profiles inferred from x-ray measurements at full laser energy are compared to pre-tank UV measurements



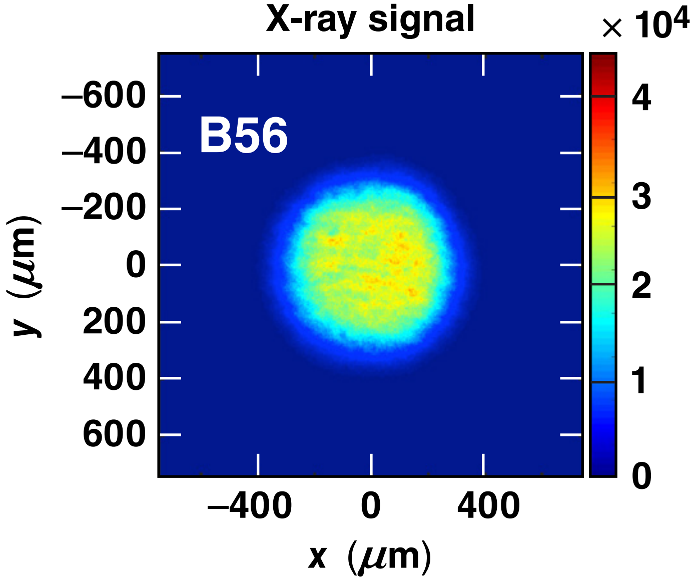
*ETP: equivalent target plane

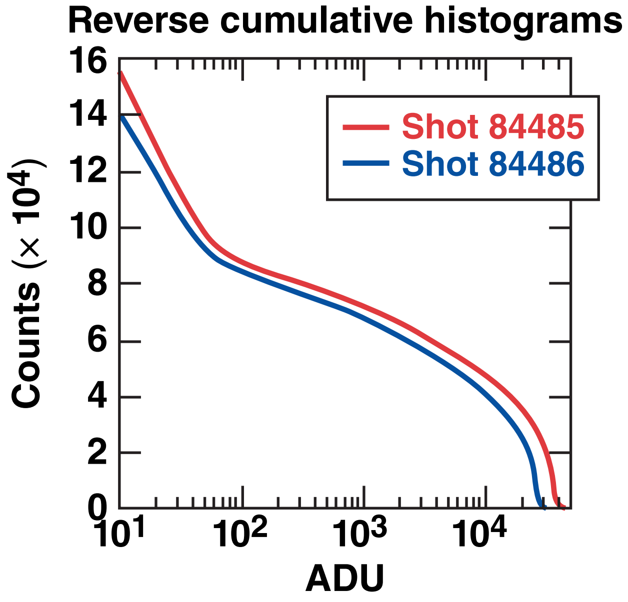
A histogram analysis method* of two shots with slightly different laser energies provides the relation between UV and x-ray fluence

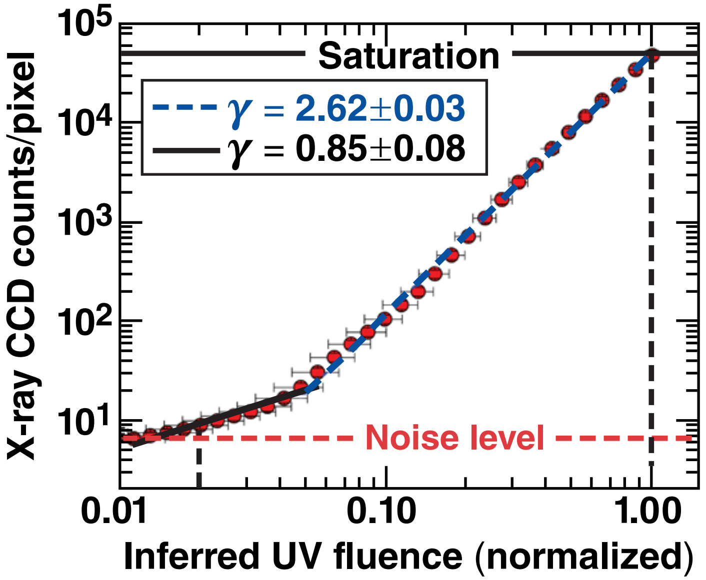
Shot 84485
E_L = 36.61 J



Shot 84486
E_L = 31.68 J



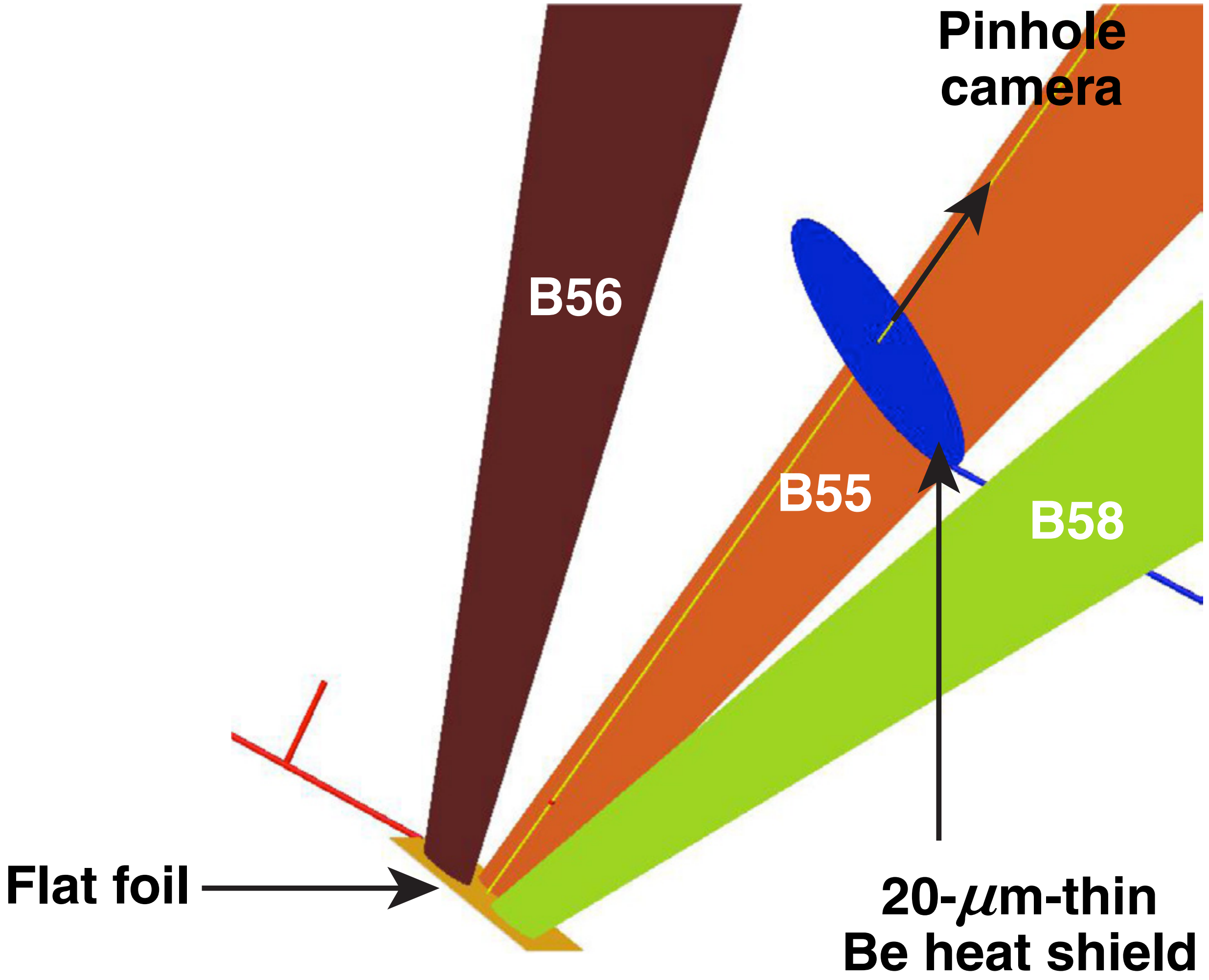


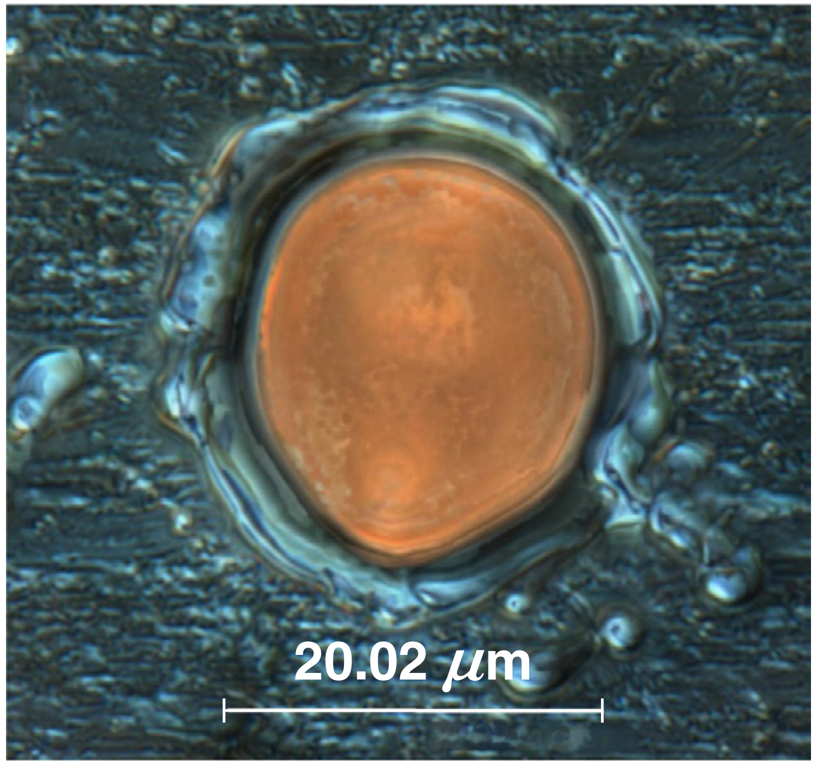


E26660

*LLE Review Quarterly Report 28, 186 (1986).

A thin Be heat shield was used to protect the pinhole from target debris





- The calibration requires that the same pinhole is used for multiple shots
- Each pinhole was well characterized to calculate its throughput

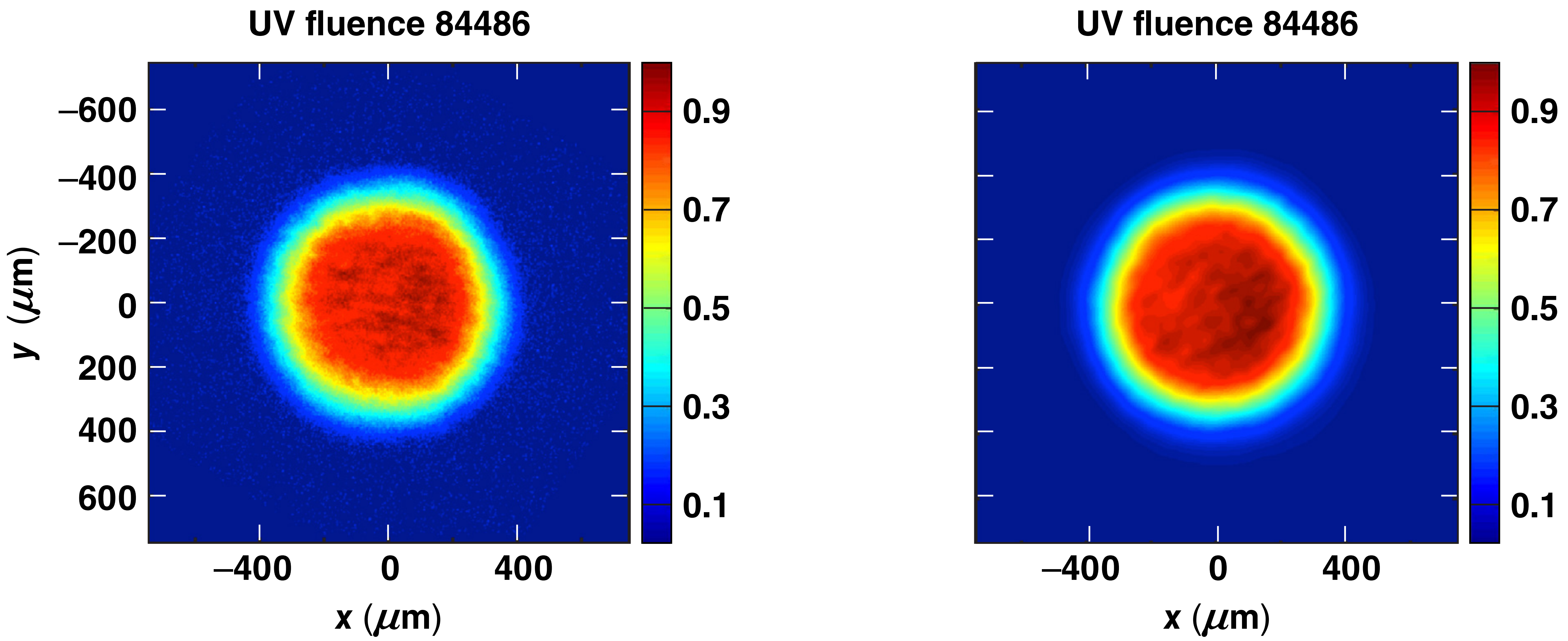
E26661

The UV fluence distribution of Beam 56 was inferred from the x-ray data and compared to the UV ETP data

UR LLE

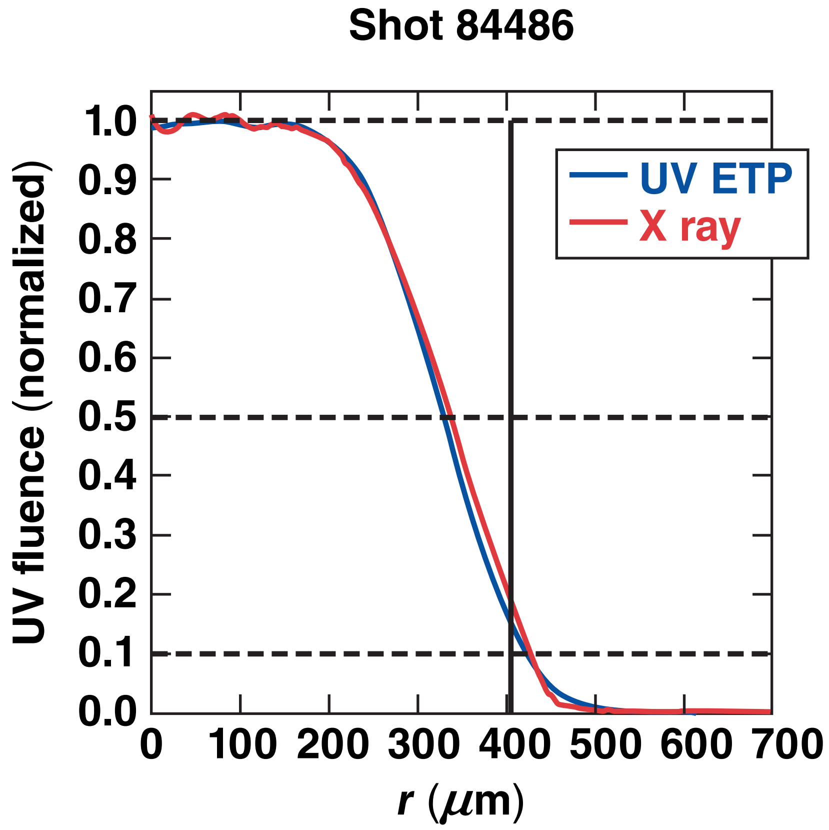
UV profile from in-target chamber x-ray measurement

UV profile from pre-target chamber UV ETP measurement



E26662

The azimuthally averaged data show a very similar distribution



Quantity	Direct UV ETP	X ray inferred
Spot radius of 95% encircled energy—r_{95} (μm)	405±4	402±13
Spot radius of 74% encircled energy—r_{74} (μm)	310±3	313±10
Radius of the 1/e peak fluence—$r_{1/e}$ (μm)	354±2	363±12
Super-Gaussian order n_{SG}	5.2±0.1	5.0±0.1

E26663

The statistical errors were estimated based on shot-to-shot variations

Quantity	Direct UV ETP	Standard deviation over six shots	X ray inferred	Standard deviation over six shots
Spot radius of 95% encircled energy—r_{95} (μm)	409±4	±1%	399±4	±1 %
Radius of the 1/e peak fluence—$r_{1/e}$ (μm)	355±0.5	±0.1%	363±3	±1%
Super-Gaussian order n_{SG}	5.16±0.13	±2.5%	5.1±0.1	±2%

The relative errors of r_{95}, $r_{1/e}$, and n_{SG} from the x-ray inferred method are estimated to be less than 5%.

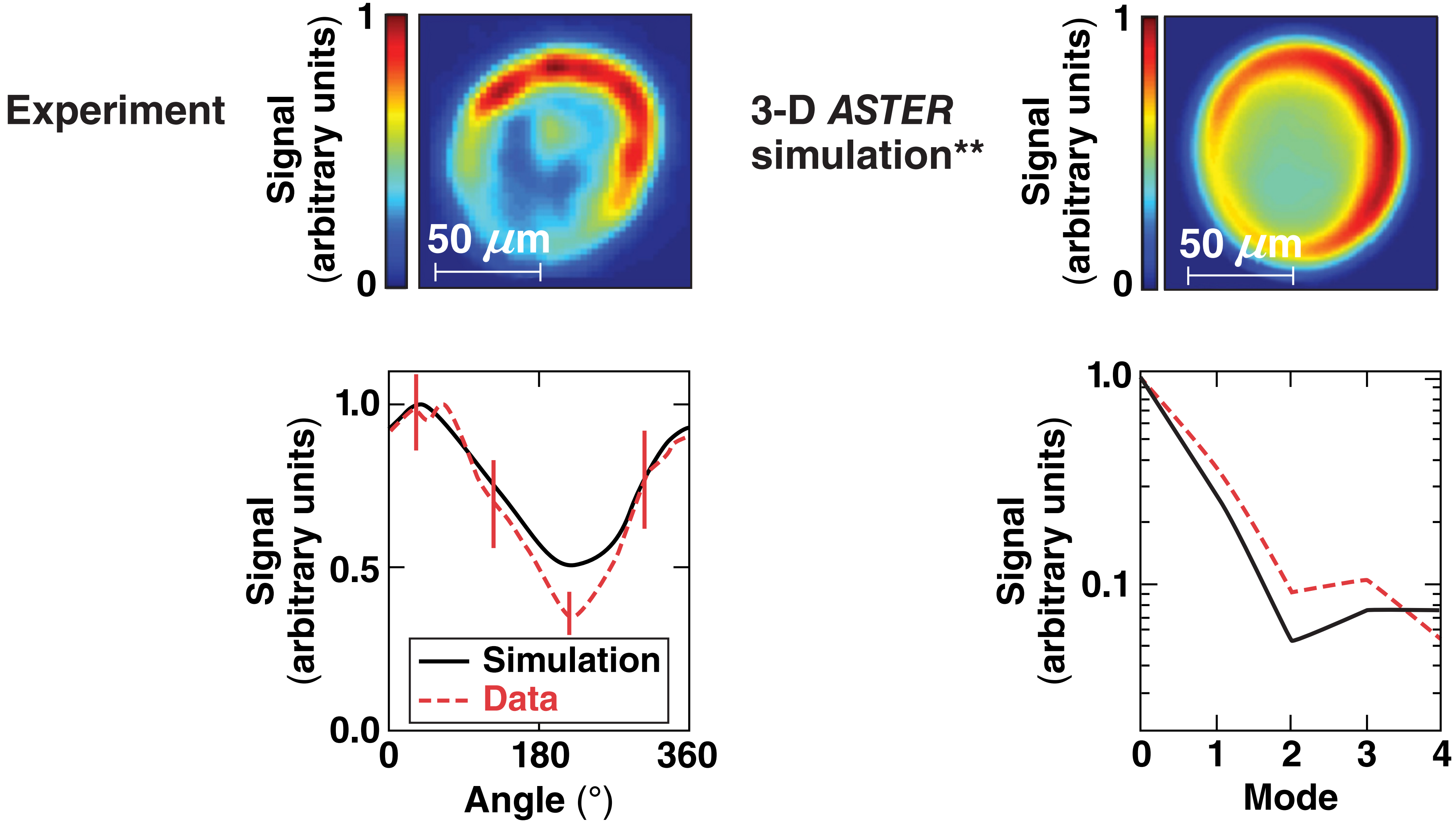
Summary/Conclusions

Equivalent-target-plane and in-target chamber x-ray measurements produce UV focal-spot fluence distributions that agree within 5%

- A histogram analysis method of the beam-fluence distribution from two shots with slightly different laser energy provides the relation between UV and x-ray fluence
- The fluence response between x rays and UV photons $\left(F_x \sim F_{UV}^{\gamma}\right)$ has been measured for 100-ps pulses with γ between 0.9 and 2.6 for photons in the 2-keV range
- The relative errors of the x-ray method for the spot radius of 95% encircled energy, the radius of 1/*e* peak fluence, and the super-Gaussian order are estimated to be less than 5%

The UV focal-spot fluence measurements at full power must be improved to meet the requirements of the 100-Gbar Project.

Recent self-emission x-ray images from titanium tracer layers in imploded targets show significant low-mode asymmetry*



*R. C. Shah *et al.*, Phys. Rev. Lett. 118, 135001 (2017).
**I. V. Igumenshchev *et al.*, Phys. Plasmas 23, 052702 (2016).

E26656