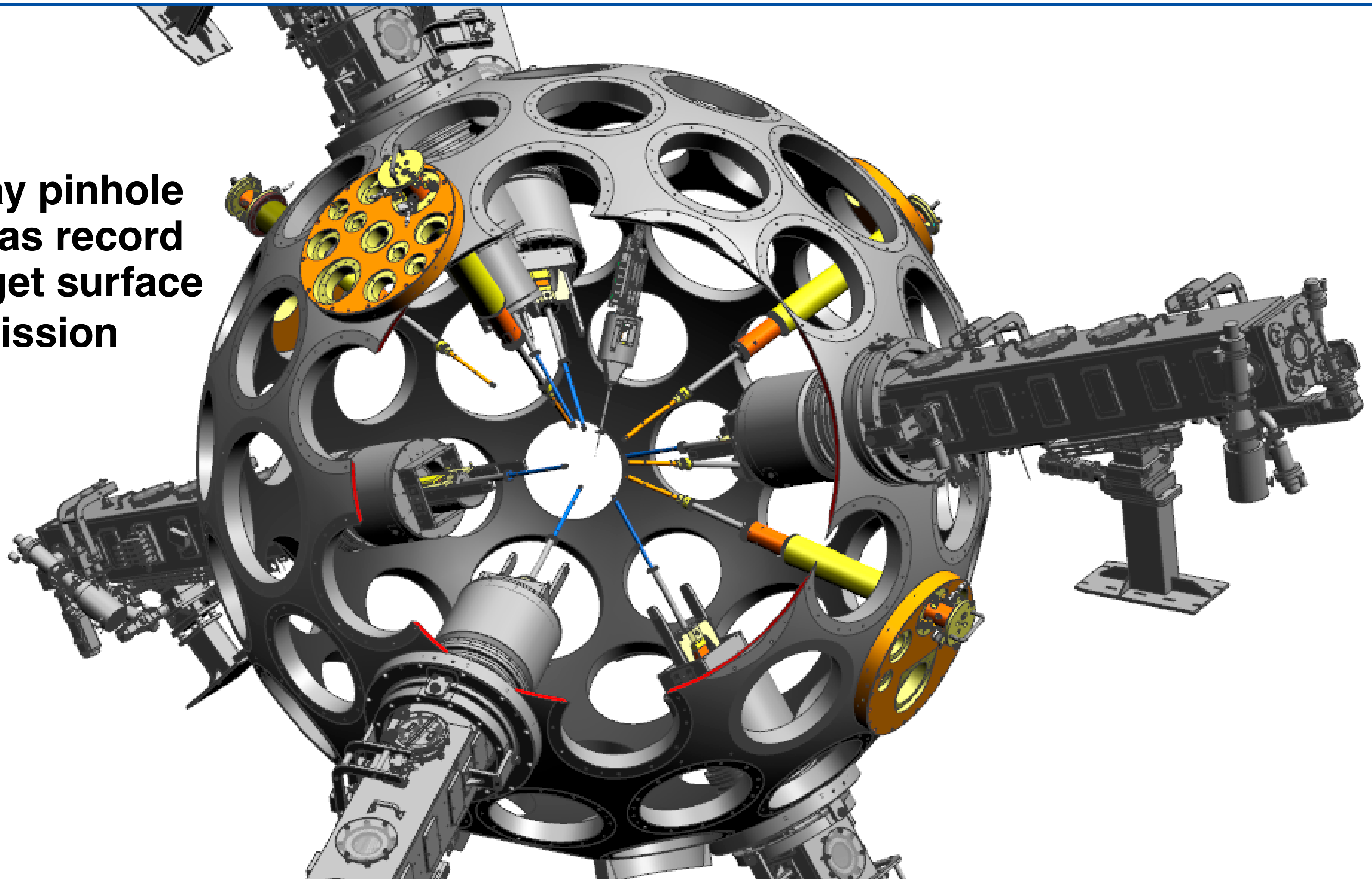
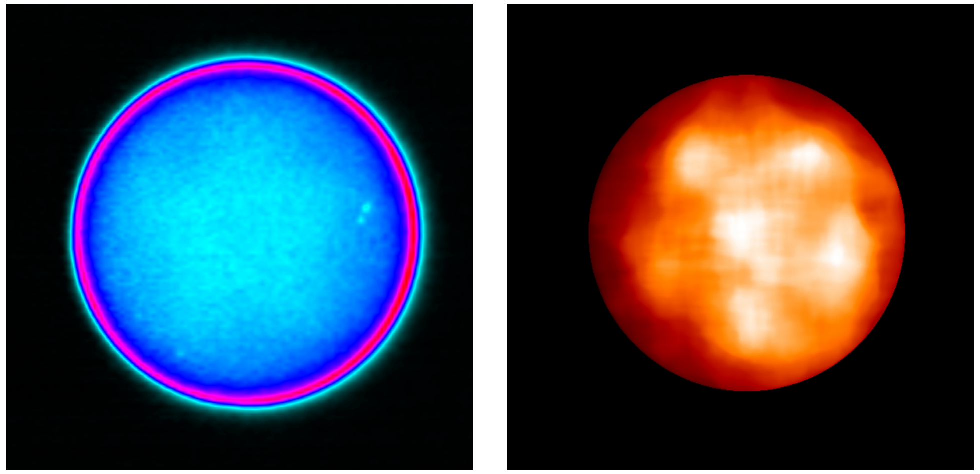
In-Situ Measurements of Direct-Drive Illumination Uniformity on OMEGA



11 x-ray pinhole cameras record the target surface emission

X-ray image of Au-coated sphere

Image after correction for limb brightening



1.2 × 1.2-mm regions

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Summary

Experiments performed on the OMEGA Laser System have measured the 60-beam, direct-drive illumination uniformity

- The Legendre modes ($\ell < 30$) UV illumination variations are inferred from images of x-ray emission from Au-coated spherical targets (at $I \approx 7 \times 10^{14}$, 100-ps pulses)
- Inference of illumination uniformity has been performed under best current conditions (clean debris shields, precision pointing, good beam balance)
- Beam-overlap illumination variation and stalk shadowing have both been observed with this method
- The σ_{rms} uniformity for standard-size targets (860-μm diam) approaches 1% (with less than 1% in all low ℓ-modes above $\ell = 2$, individually and combined)

E28006

Collaborators

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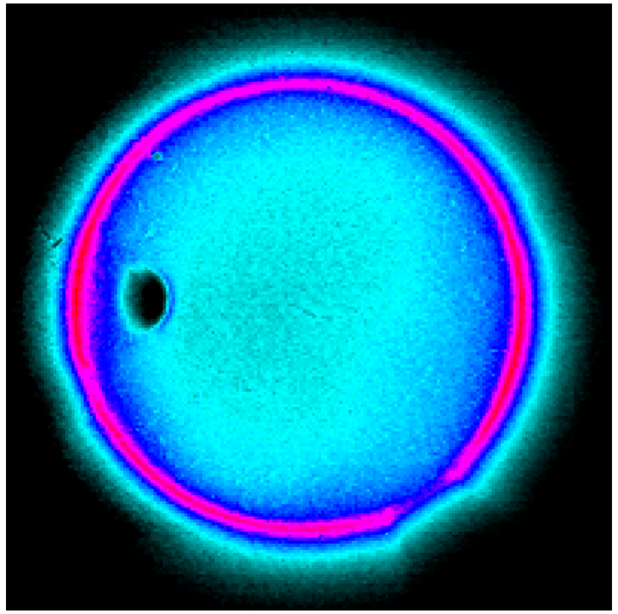
The emission from spherical, Au-coated targets is corrected for limb brightening* to infer the local x-ray surface flux

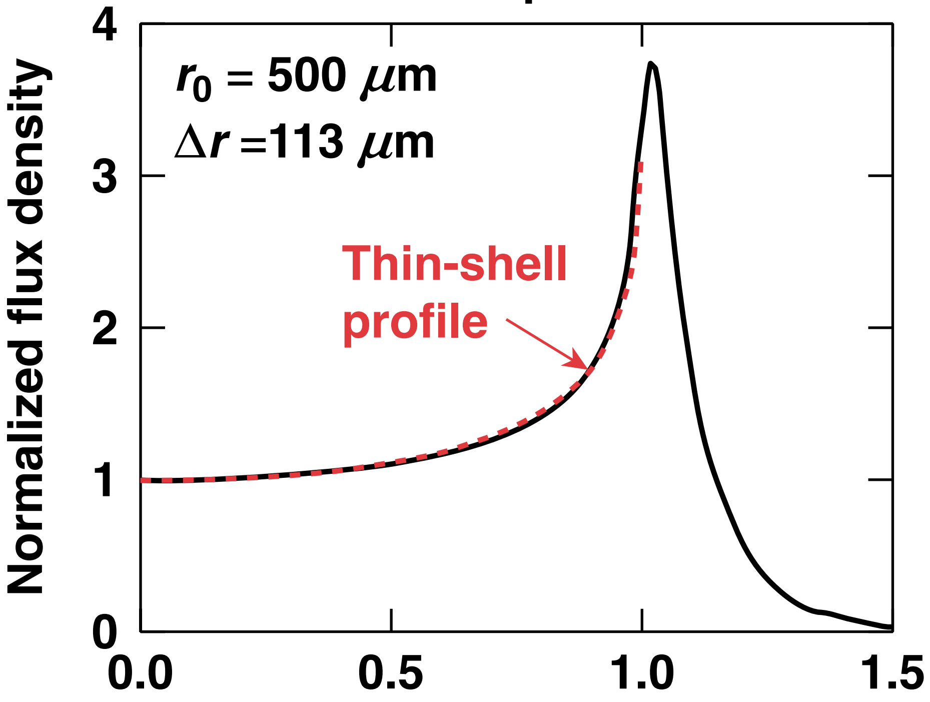
OMEGA shot 21608

CID image (H9 view)



1-mm-diam
Au-coated sphere

Radial profile



$$I_x = I_x(0) \times f(r)$$

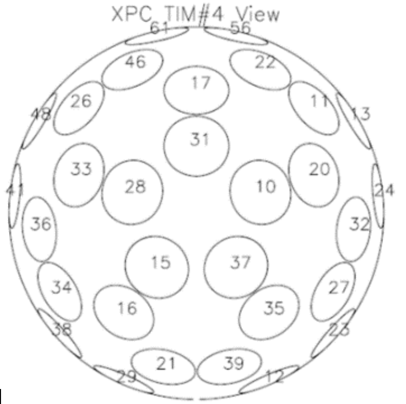
For a thin shell:

$$f(r) = (r_0/\Delta r)\left[\sqrt{(1+\Delta r/r_0)^2 - (r/r_0)^2} - \sqrt{1-(r/r_0)^2}\right]$$

*F. J. Marshall *et al.*, Phys. Plasmas 11, 251 (2004); R. A. Forties and F. J. Marshall, Rev. Sci. Instrum. 76, 073505 (2005).
CID: charge-injection device

E11296a

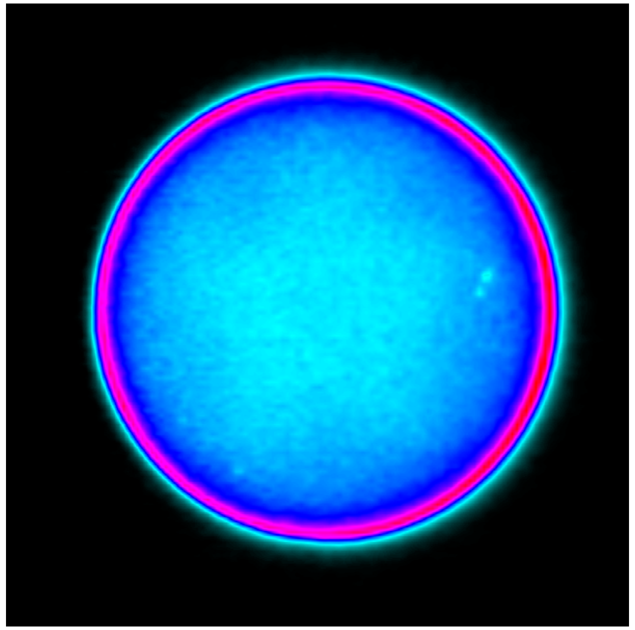
When corrected for limb brightening, the x-ray images reveal peaks at the beam overlaps and low mode variation



Example Au-uniformity image
Shot 87280 (100-ps pulse)
TIM-4 XRPHC CID image
860-μm-diam Au-coated sphere

Normalized x-ray intensity

Min  Max



Limb-brightened image (uncorrected)

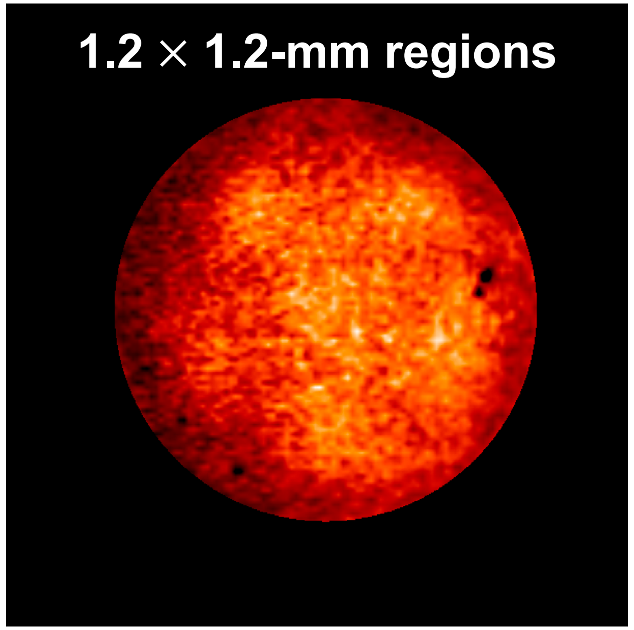
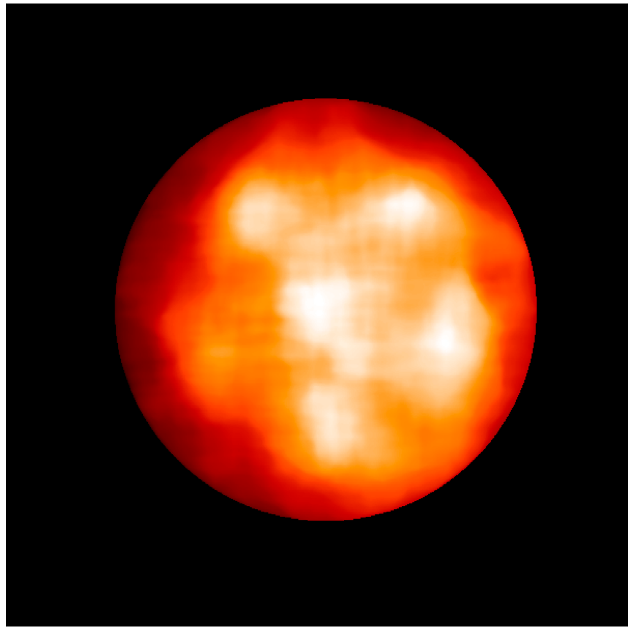


Image corrected for limb brightening

Normalized x-ray intensity

Min  Max

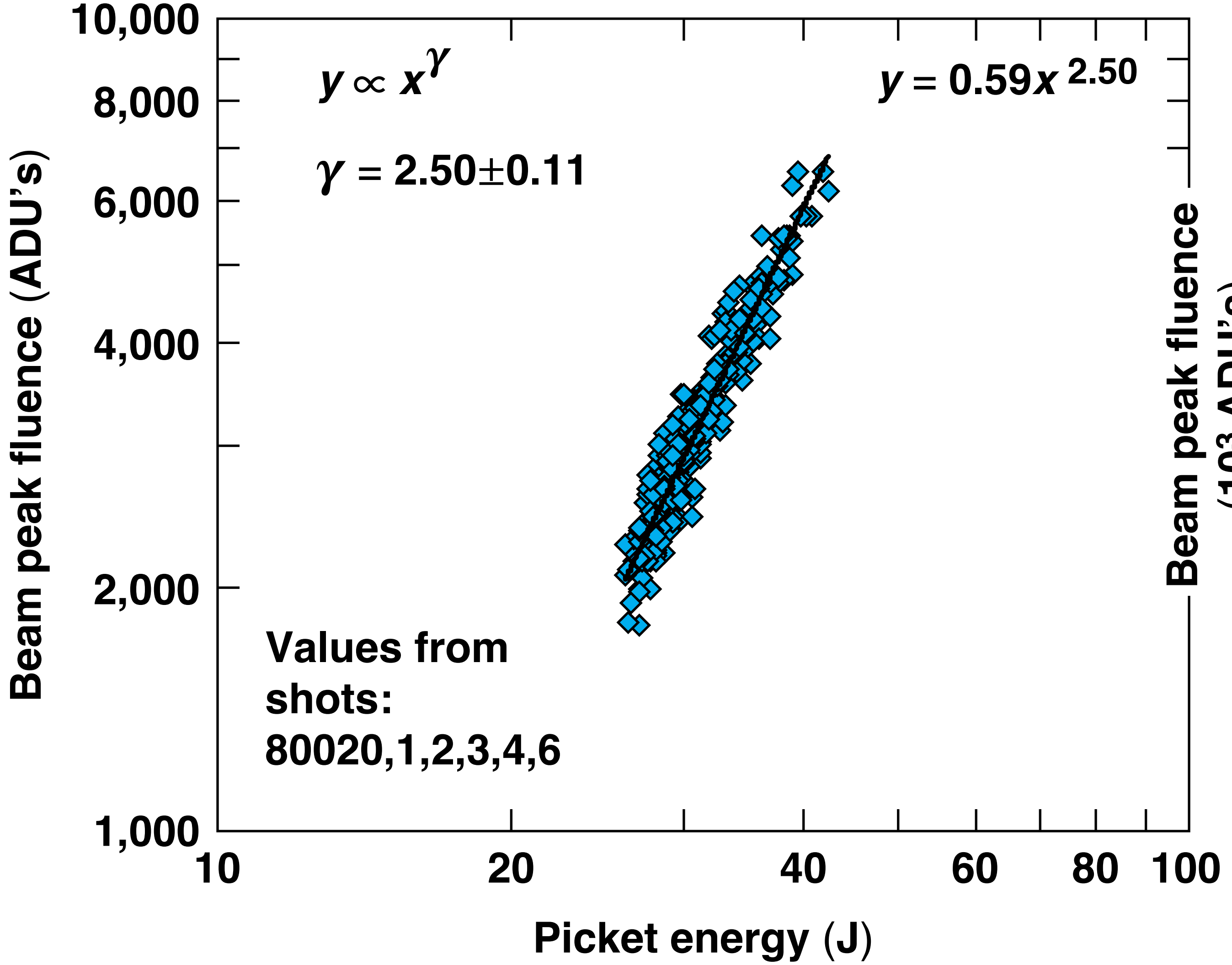


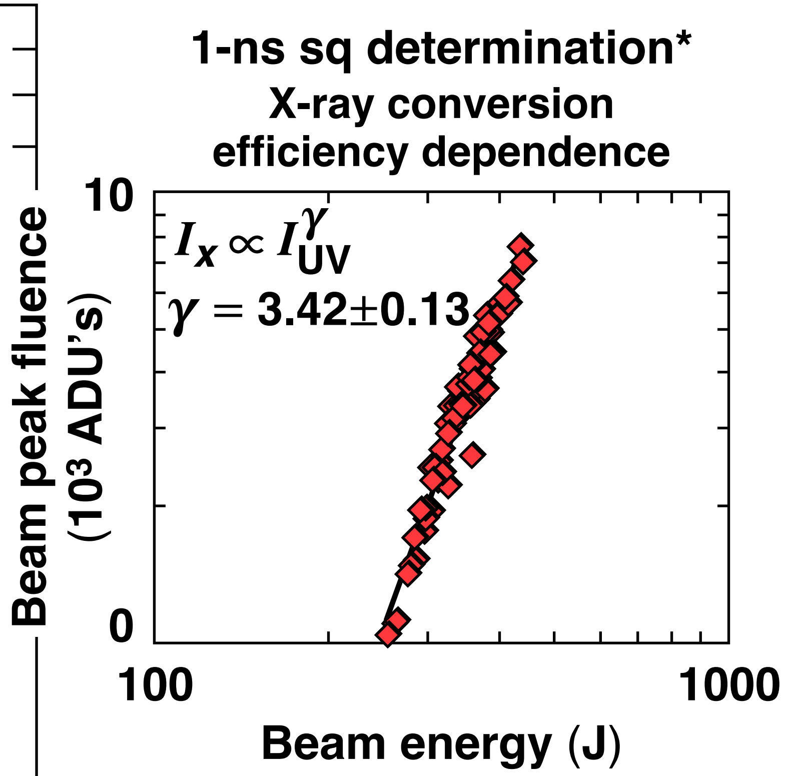
Median filtered 60-μm region

TIM: ten-inch manipulator
XRPHC: x-ray pinhole camera

E28007

The inferred UV illumination variation is determined from the x-ray emission variation using a power law

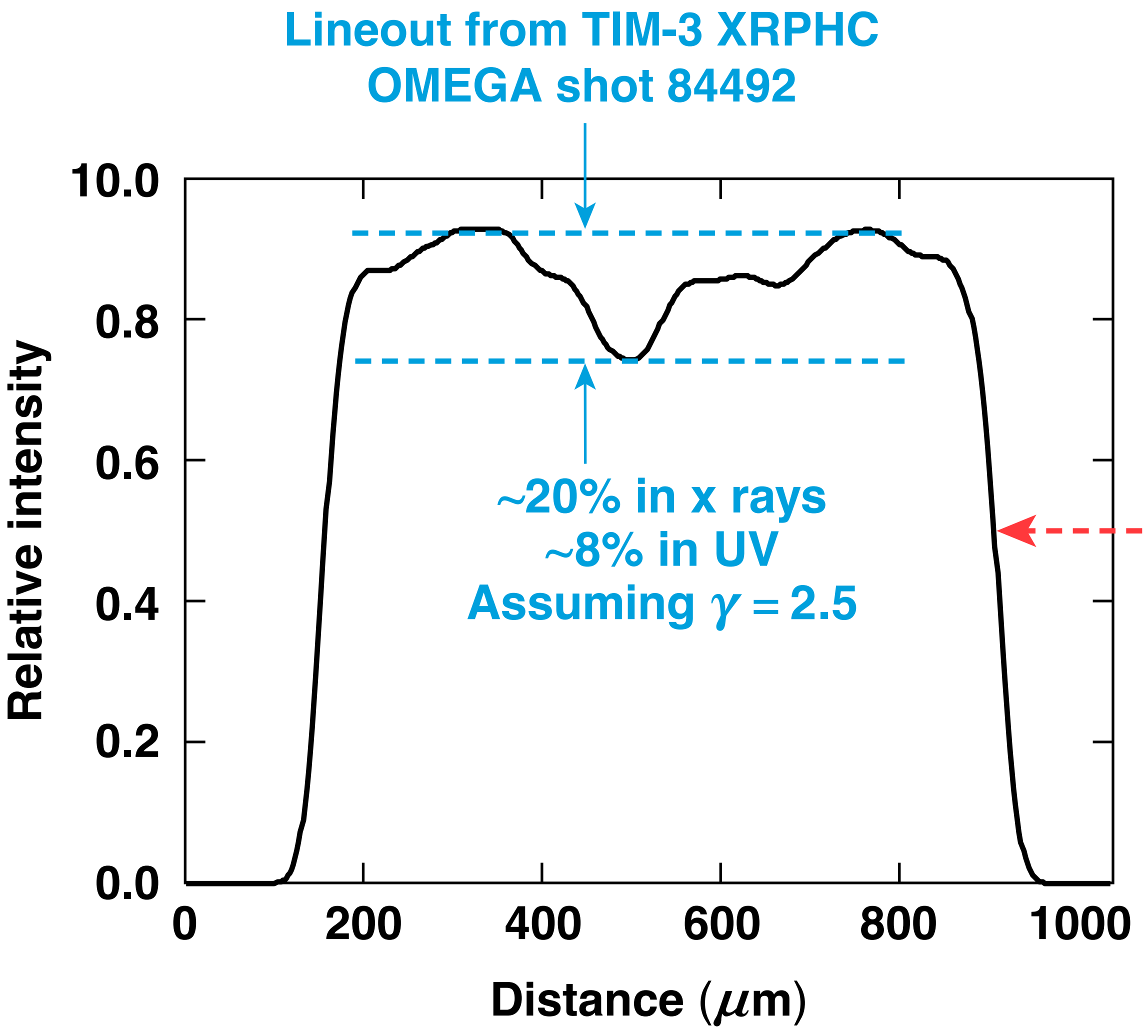


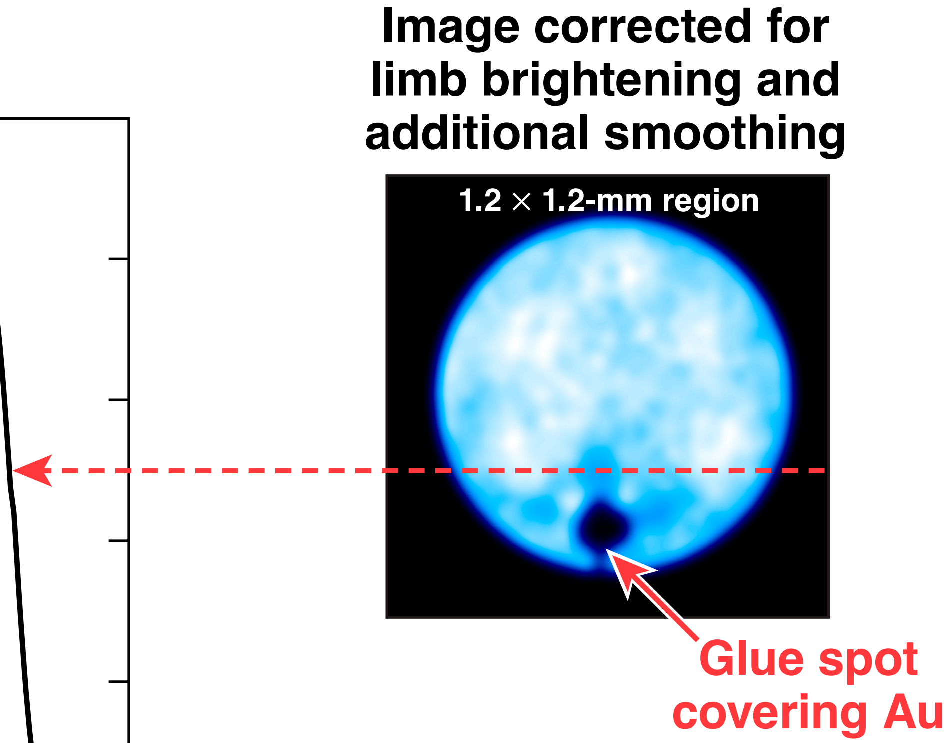


*F. J. Marshall *et al.*, Phys. Plasmas 11, 251 (2004).

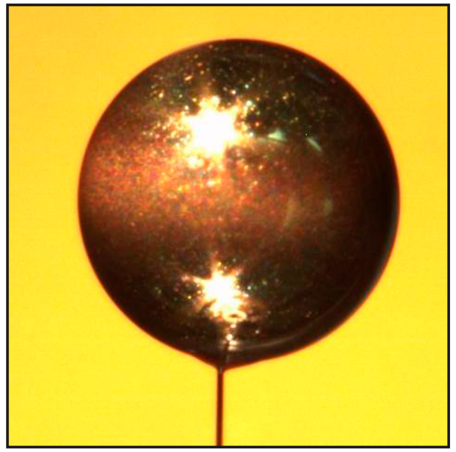
E28008

The depth of a stalk shadow is inferred from the assumed power law correspondence





Viewing camera image of target



This target stalk is in the same direction as current cryogenic targets.

E28009

Corrected images must be reprojected and combined to infer the illumination variation over the target surface

$$I_x(\theta,\varphi) = \frac{\sum f_{x_i}(\theta,\varphi)\, w_i(\theta,\varphi)}{\sum w_i(\theta,\varphi)}$$

where $I_x(\theta,\varphi)$ is the relative intensity at (θ,φ), f_{x_i} is the contribution from the ith x-ray camera, and w_i is the weight

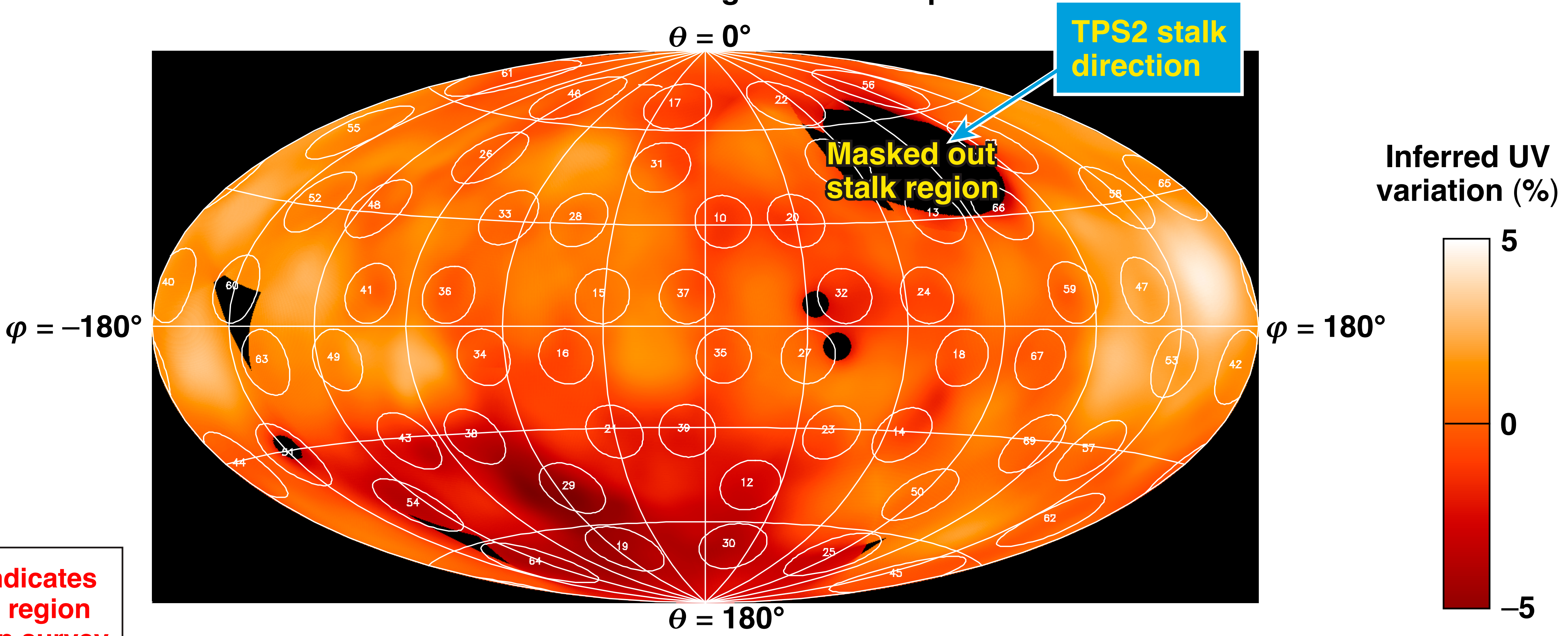
The cameras are cross-calibrated, the images reprojected and combined, after which the UV intensity variation is inferred using the power law correspondence

$$I_{\mathrm{UV}} \propto \left(I_x\right)^{(1/\gamma)}$$

The ten nearly identical CID-based XRPHC images (six TIM based, four fixed) are used to compute the full-sphere illumination uniformity.

Multiple XRPHC CID images of Au-coated targets are combined to determine the inferred UV illumination uniformity

OMEGA shot 87286, uniformity target, 858-μm-diam, Au-coated sphere
10 XRPHC-CID-image derived map



Black indicates masked region or gap in survey

25 J/beam, 100-ps pulse, 3.5% rms beam-to-beam (HED values)

TPS: Target Positioning System
HED: high-energy diode

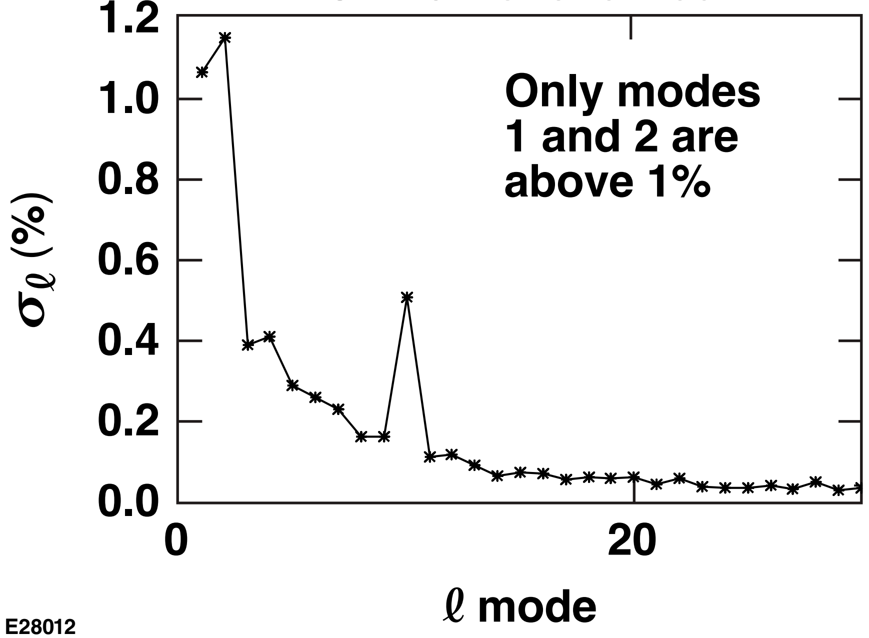
E28011

OMEGA direct-drive illumination uniformity inferred from x-ray images of Au-coated sphere emission approaches 1% rms

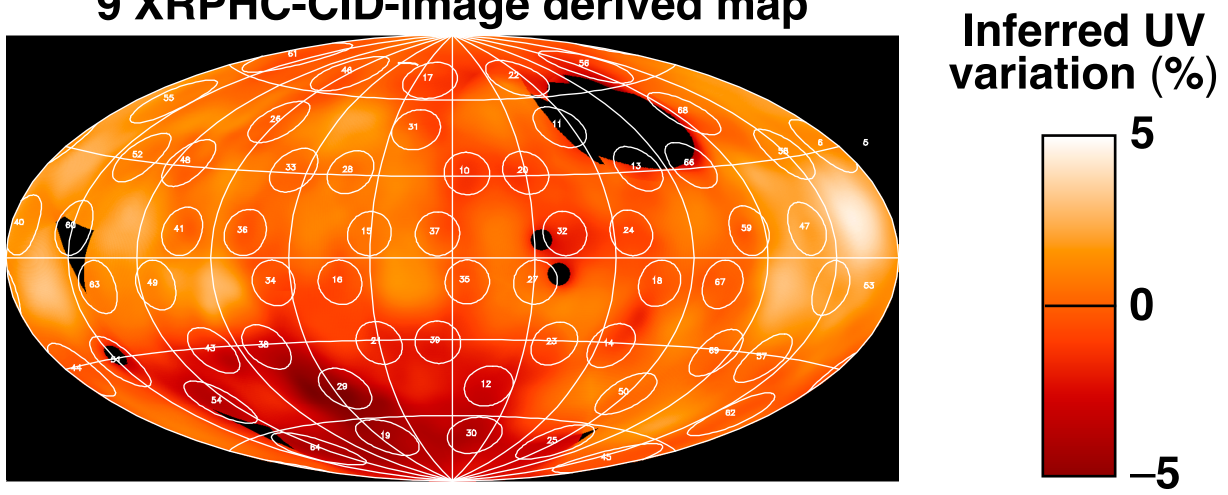
OMEGA shot 87286, uniformity target
858-μm-diam, Au-coated sphere

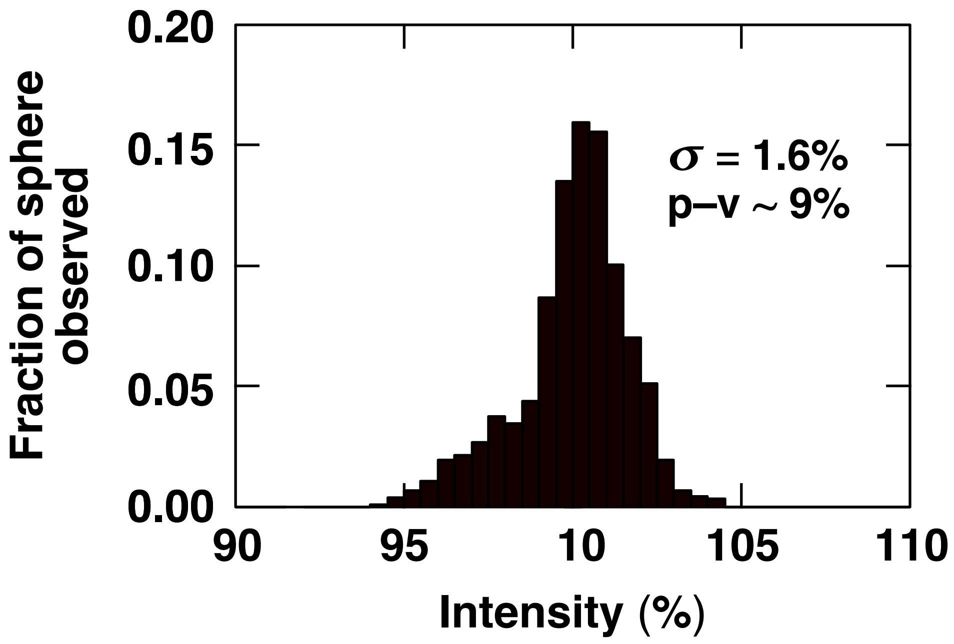
Conditions:
60 UV beams, 100-ps pulse
SG5 DPP's, 0.3-THz SSD, 3-color cycle
25 J/beam, 3.5% rms (beam-to-beam)

The ℓ = 10 mode is clearly evident



9 XRPHC-CID-image derived map

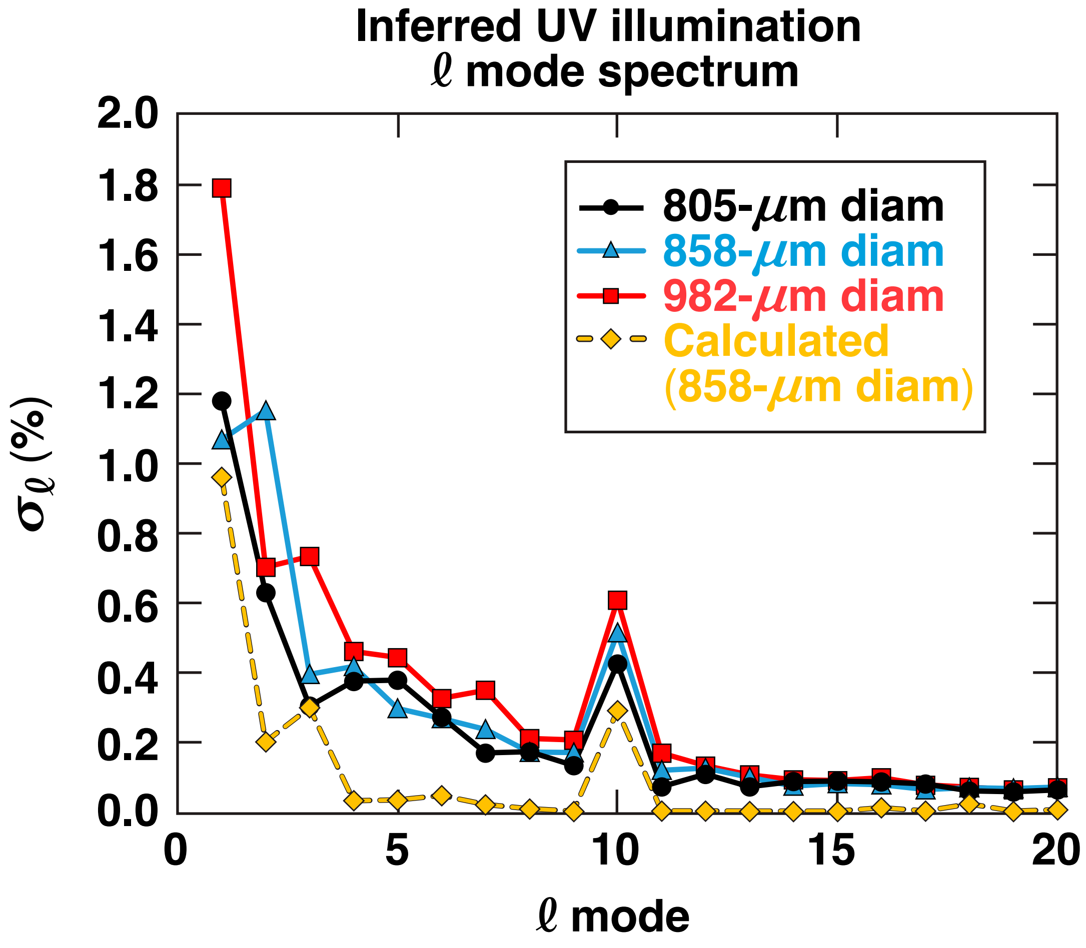


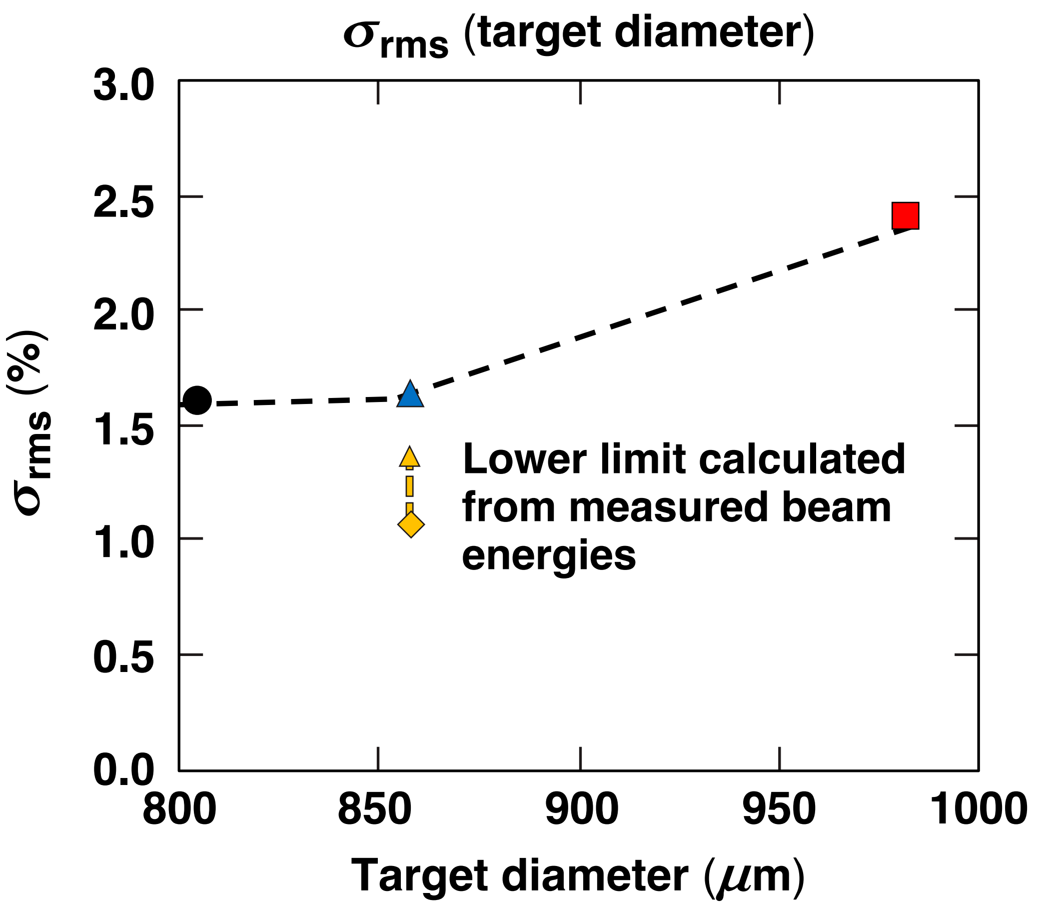


DPP: distributed phase plate
SSD: smoothing by spectral dispersion
p–v: peak-to-valley

E28012

The inferred low-mode OMEGA direct-drive illumination uniformity has no significant contributions above $\ell = 2$





The x-ray inferred low-mode uniformity approaches that calculated from the measured beam energies, varying slowly with target diameter.

E28089

UNIVERSITY of ROCHESTER

Experiments performed on the OMEGA Laser System have measured the 60-beam, direct-drive illumination uniformity

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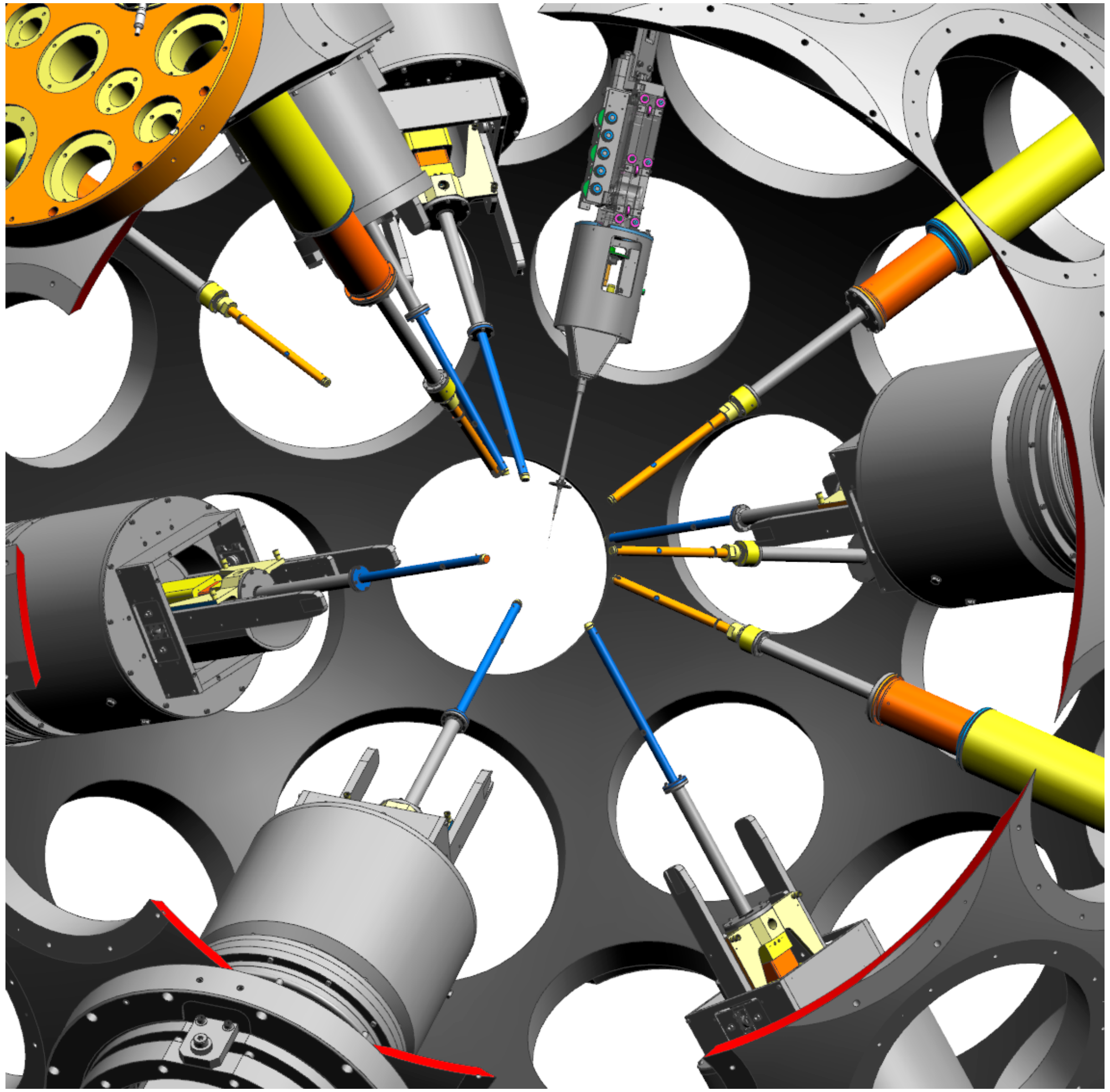
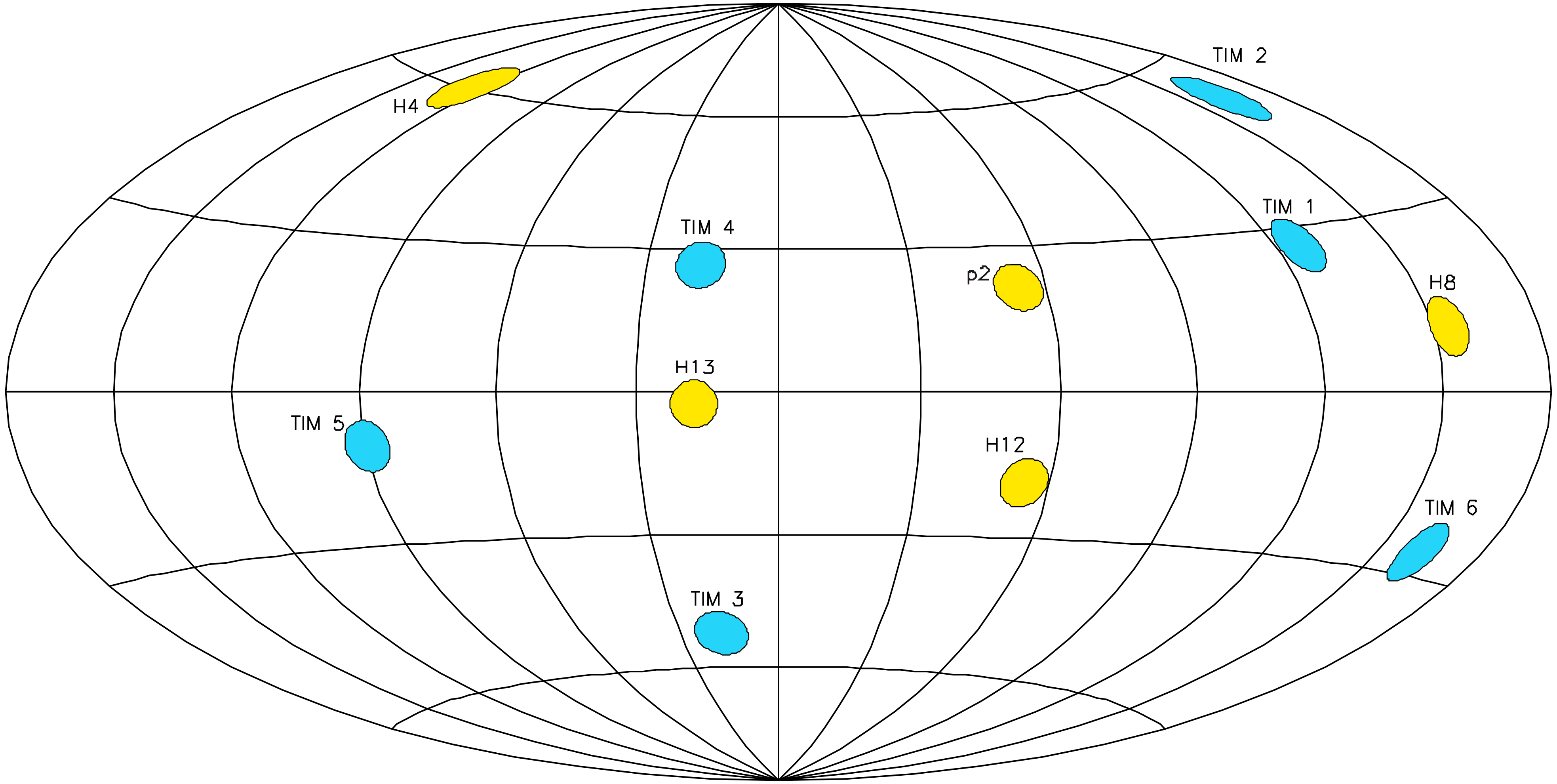
Backup

Isometric drawing of the interior of the OMEGA target chamber showing five fixed (yellow noses) and six TIM-based (blue noses) XRPHC's



E28090

Hammer–Aitoff projection of the OMEGA target chamber showing XRPHC locations: five fixed (yellow), 6 TIM-based (blue) XRPHC's



11 digitally recorded x-ray pinhole cameras record the target surface emission

E28091