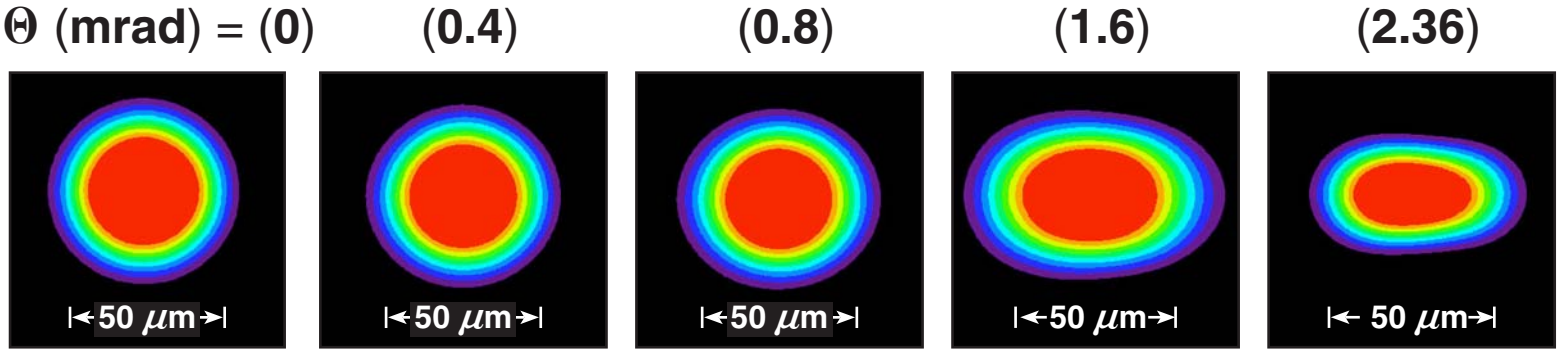
Neutron Detection With Bubble Chambers

UR LLE



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Summary

A neutron imaging (NI) design tool has been used to quantify the effects of aperture fabrication and alignment on reconstructed images

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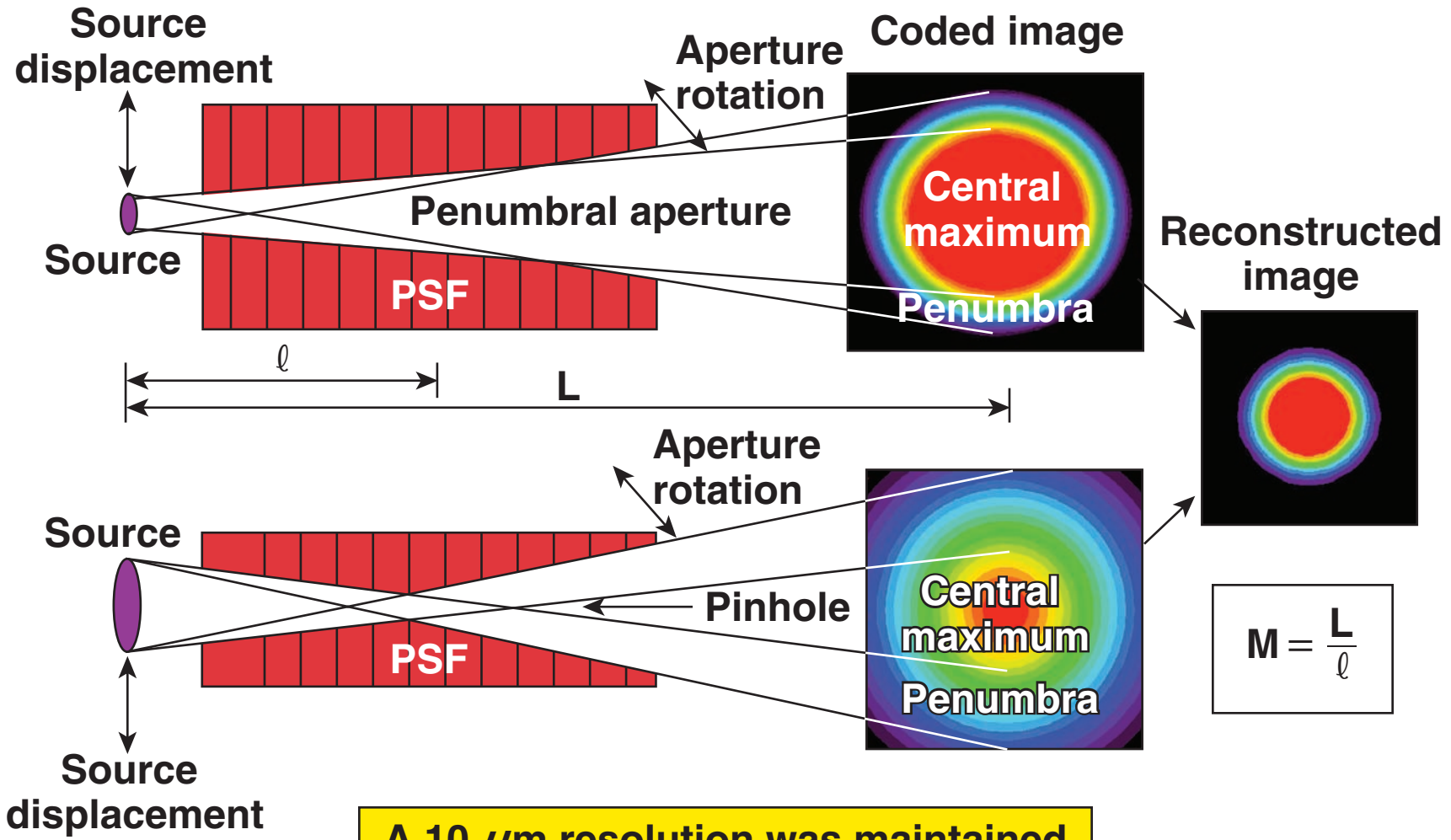
- Alignment tolerances of less than 1 mrad (current precision at OMEGA) introduce measurable features in a reconstructed image.
- Penumbral apertures are several times less sensitive to fabrication errors than pinhole apertures.
- A NI bubble chamber is being assembled at LLE and will be operational in the coming year.

With a design tool we can control the source, aperture, and detector parameters



A 10 μm resolution was maintained within the simulated systems.

E14104

Penumbral Apertures

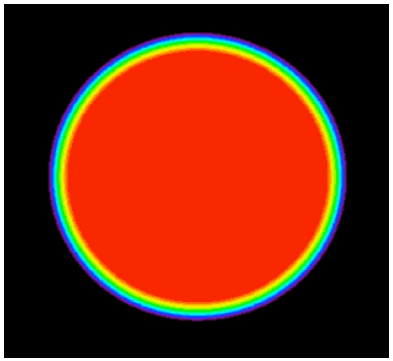
The accuracy of the reconstructed images deteriorates with aperture misalignment

UR LLE

System characteristics

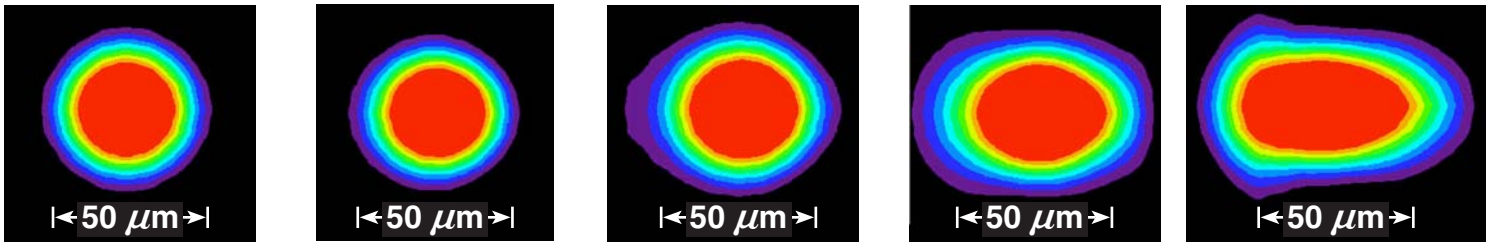
- Flat source image (50 μm)
- Biconic aperture, FOV ~200 μm
  ℓ = 26 cm, L = 800 cm, M = 30.76
- Central diameter = 2 mm
- Thickness = 10 cm

Raw image



Reconstructed images and misalignment angle (mrad)

Θ = (0) (0.2) (0.4) (1.6) (2.36)



A source position off center by 100 μm (edge of the FOV) for an aperture 26 cm from the source is equivalent to a 0.392 mrad aperture rotation.

E14105

Pinhole Apertures

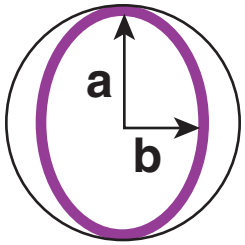
The accuracy of the reconstructed image deteriorates with aperture fabrication errors

UR LLE

System characteristics

- Flat source image (50 μm)
- Biconic aperture, FOV ~200 μm
  ℓ = 26 cm, L = 800 cm, M = 30.76
- Central diameter = 2 mm
- Thickness = 10 cm

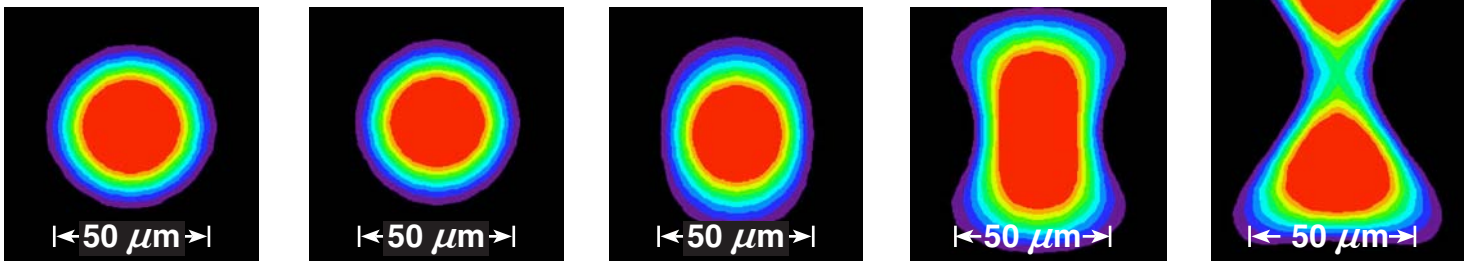
Aperture cross section



$$e = \sqrt{1 - \frac{b^2}{a^2}}$$

Reconstructed images

(e = 0,b/a = 1) (0.1,0.994) (0.15,0.988) (0.2,0.979) (0.3,0.953)



Aperture defects appear to be as important as alignment errors for the accurate reconstruction of an image.

E14106

Pinhole Apertures

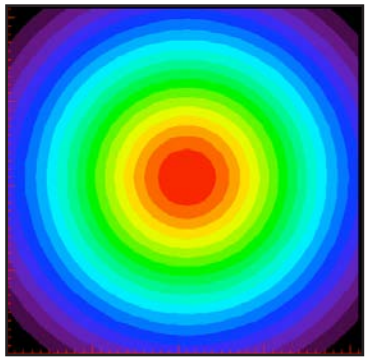
The accuracy of the reconstructed image deteriorates with aperture misalignment

UR LLE

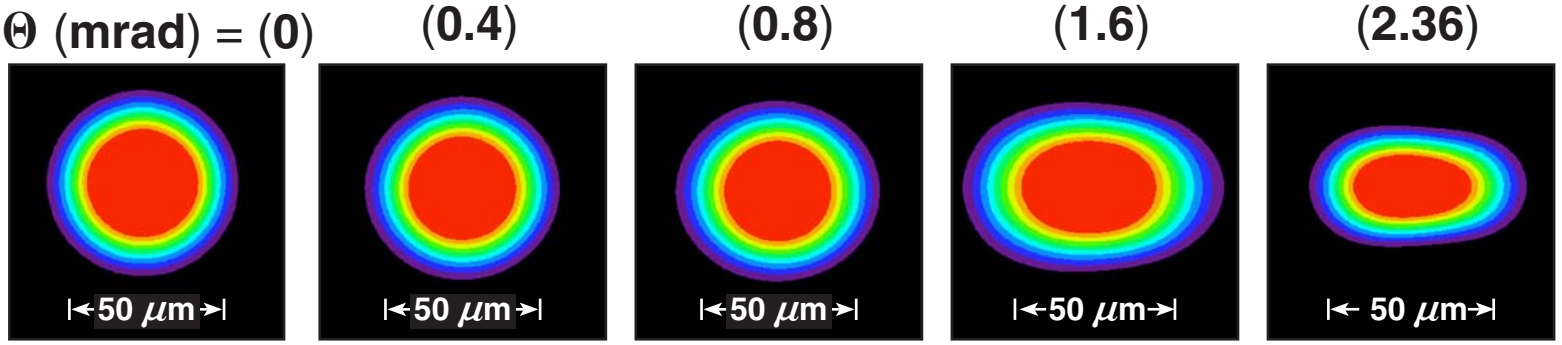
System characteristics

- Flat source image (50 μm)
- Pinhole, FOV ~200 μm
  ℓ = 26 cm, L = 800 cm, M = 30.76
- Central diameter = 10 μm
- Thickness = 10 cm

Raw image



Reconstructed images



A source position off center by 100 μm (edge of the FOV) for an aperture 26 cm from the source is equivalent to a 0.392-mrad aperture rotation

Pinhole Apertures

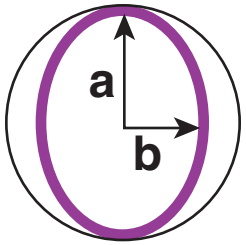
The accuracy of the reconstructed image is less sensitive to pinhole fabrication errors than to misalignment

UR LLE

System characteristics

- Flat source image (50 μm)
- Pinhole, FOV ~200 μm
  ℓ = 26 cm, L = 800 cm, M = 30.76
- Central diameter = 10 μm
- Thickness = 10 cm

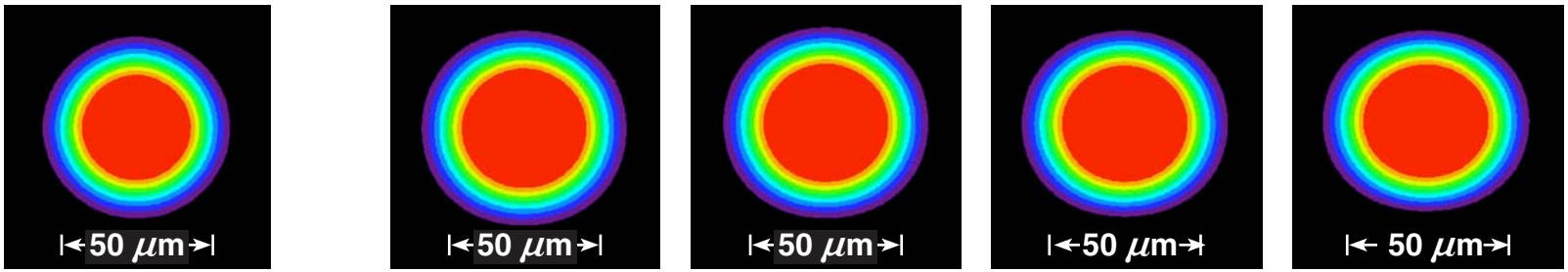
Pinhole cross section



$$e = \sqrt{1 - \frac{b^2}{a^2}}$$

Reconstructed images

(e = 0, b/a = 1) (0.2,0.979) (0.3,0.953) (0.4,0.916) (0.5,0.866)



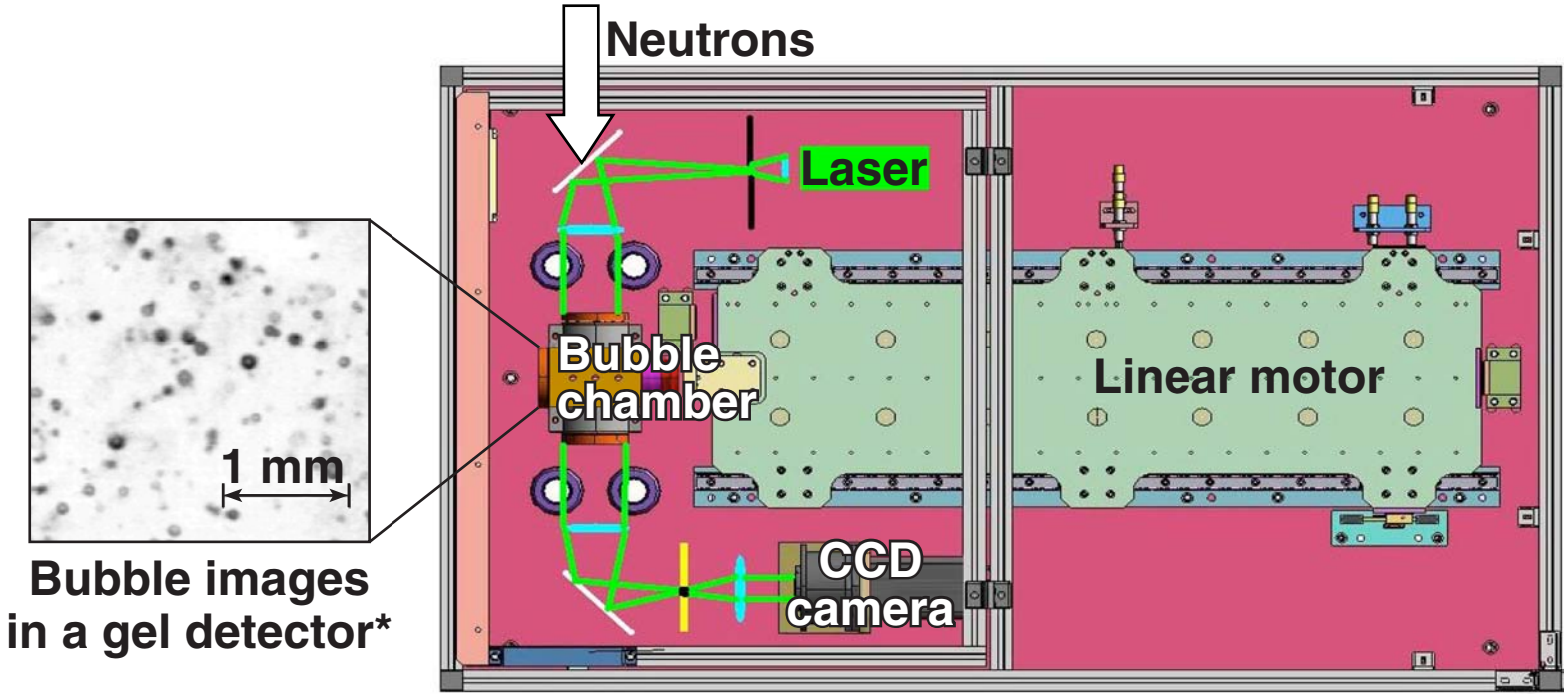
Aperture defects appear to be detectable at b/a = 0.87.

E14108

The alignment and fabrication tolerances to observe 10-μm features have been determined

Penumbral apertures	Pinhole apertures
• Misalignments of 0.4 mrad • Source position off-center by 100 μm • Fabrication eccentricity of 0.15 (i.e., a 1.2% difference between the ellipse axes) or an absolute fabrication error of 24 μm	• Misalignments of 0.8 mrad • Source position off-center by 200 μm • Fabrication eccentricity of 0.5 (i.e., an ~14% difference between the ellipse axes) or an absolute fabrication error of 1.4 μm

The LLE bubble chamber has been designed to measure the column density of bubbles rather than to count individual bubbles as in the original Fisher experiment*



Bubble images in a gel detector*

Schlieren technique will be used for bubble detection

Expect to field on OMEGA within a year

*R. Fisher and R. Lerche, LLNL Monthly Higlights, June/July (2001).

Summary/Conclusions

A neutron imaging (NI) design tool has been used to quantify the effects of aperture fabrication and alignment on reconstructed images

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