LLNL-PROC-403811

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X-Ray Digital Radiography and Computed Tomography Characterization of Targets

J. D. Sain, W. D. Brown, D. J. Chinn, H. E. Martz Jr., K. E. Morales, D. J. Schneberk, E. O. Updike

May 13, 2008

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Disclaimer

Lawrence Livermore National Laboratory

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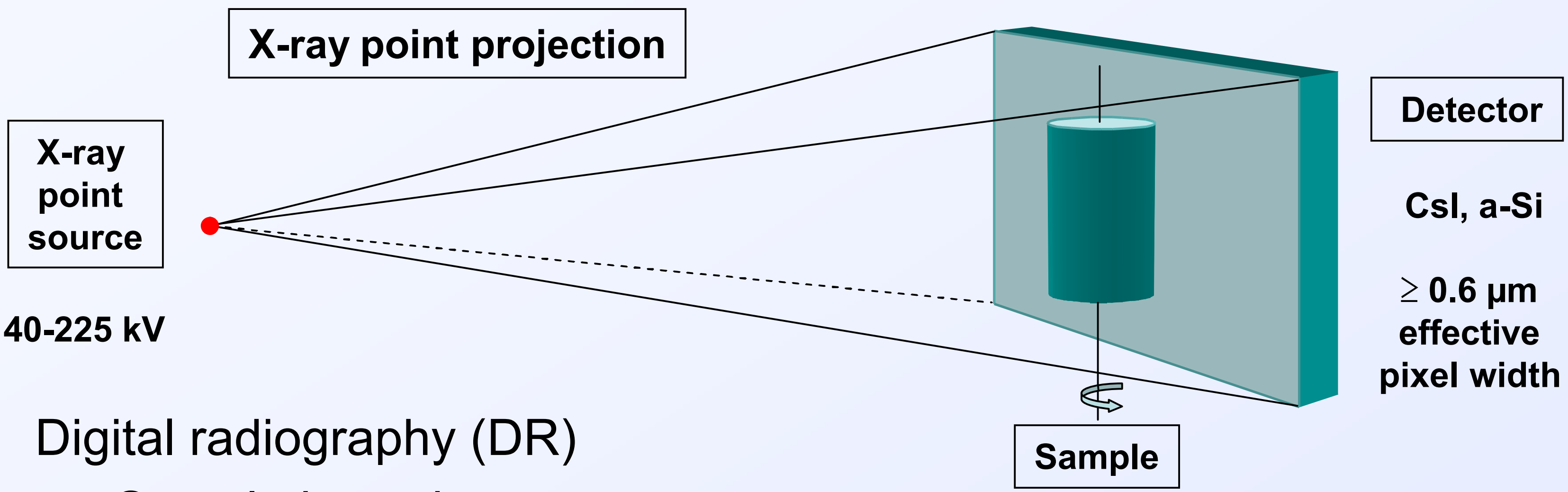
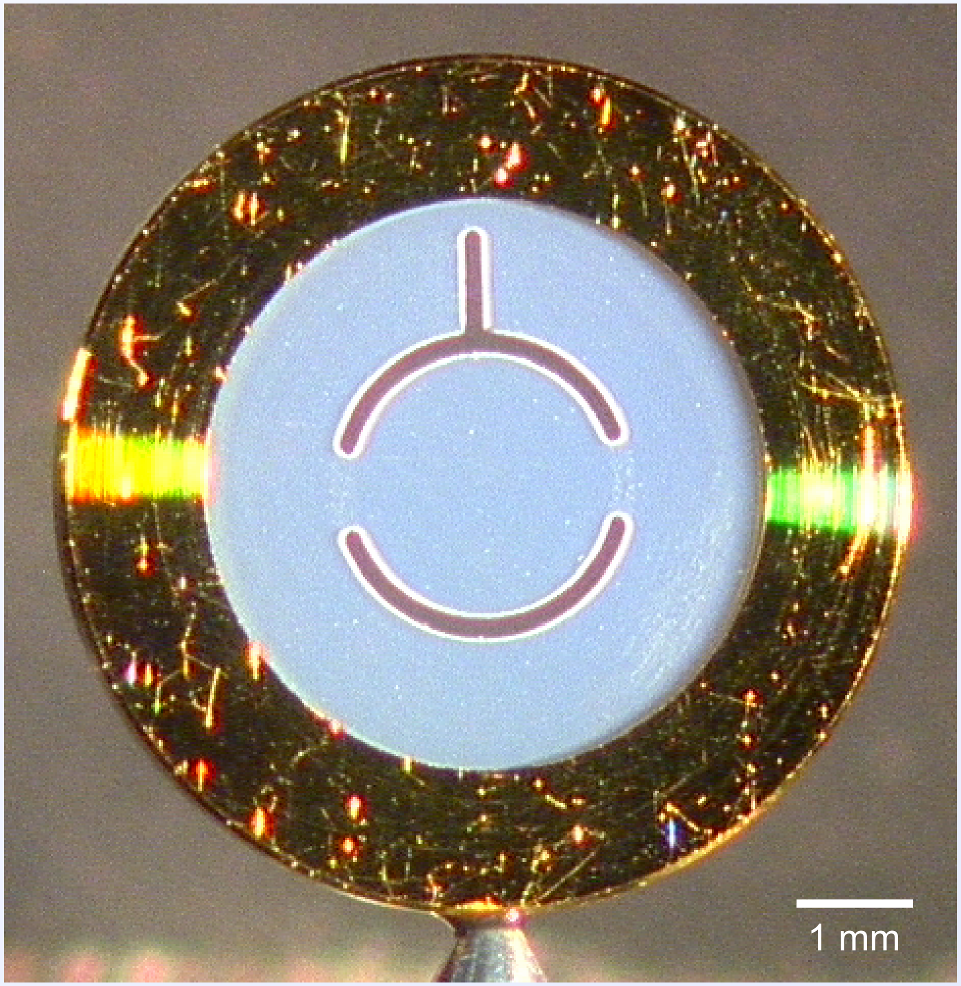
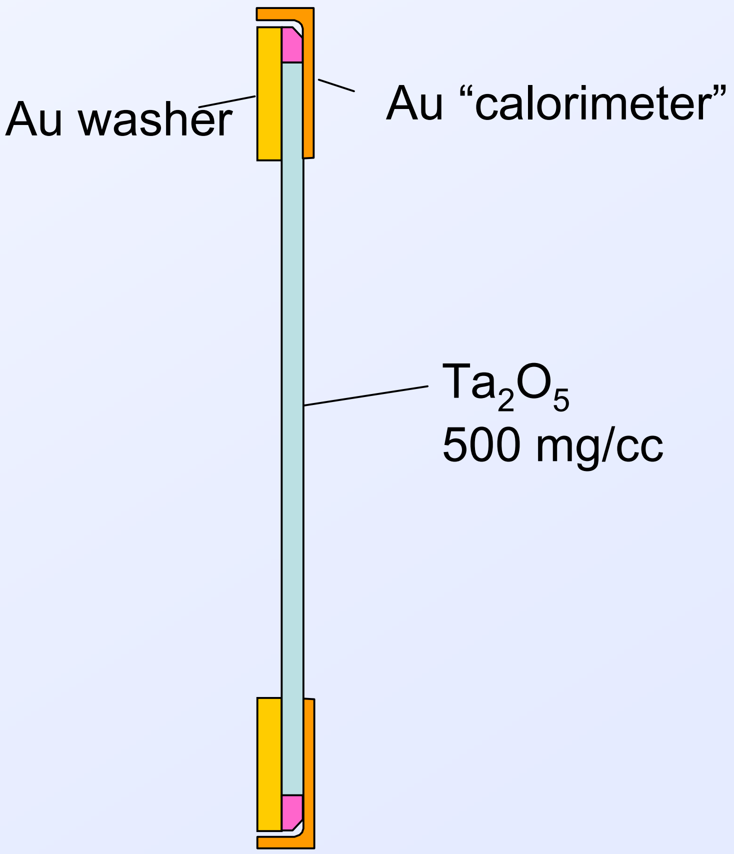
X-ray imaging capabilities can measure features that are important for target fabrication.



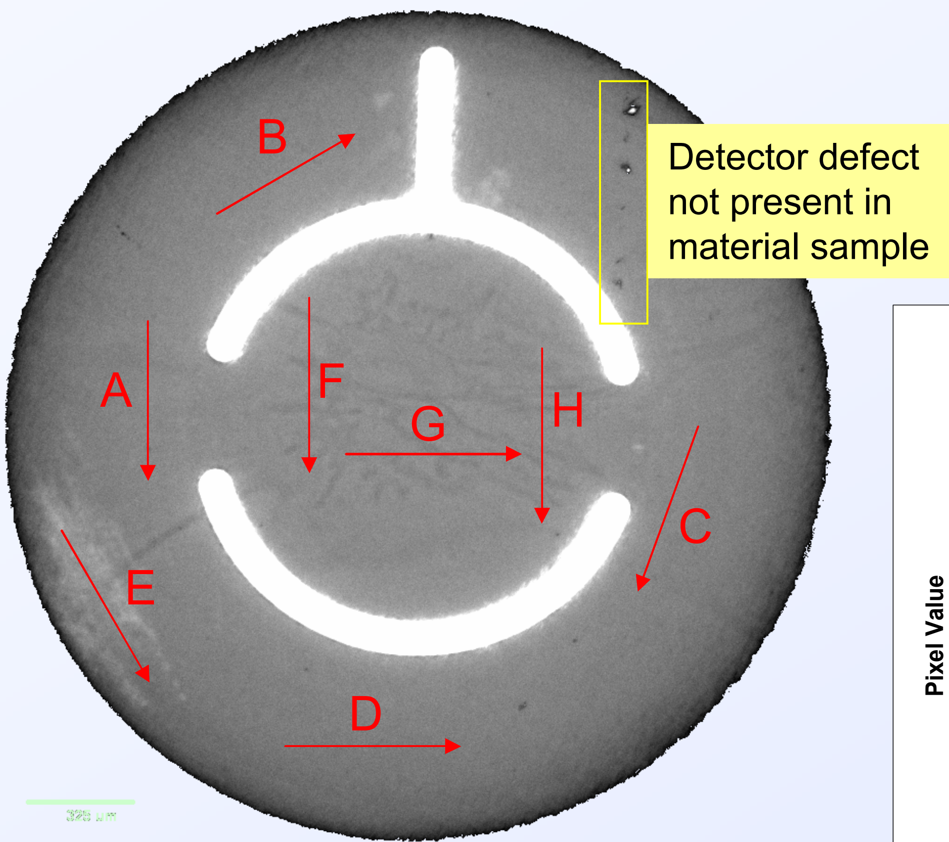
- Digital radiography (DR)
  - Sample is stationary
  - 3-D object is compressed to 2-D projection (radiograph).
- Computed tomography (CT)
  - Sample is rotated 180° /360° .
  - Many 2-D projections are acquired.
  - 2-D projections are used to compute 3-D representation of object.
  - Cross-sectional views (i.e. “slices”) are available.

The uniformity of μL is an important specification for radiation transport targets.





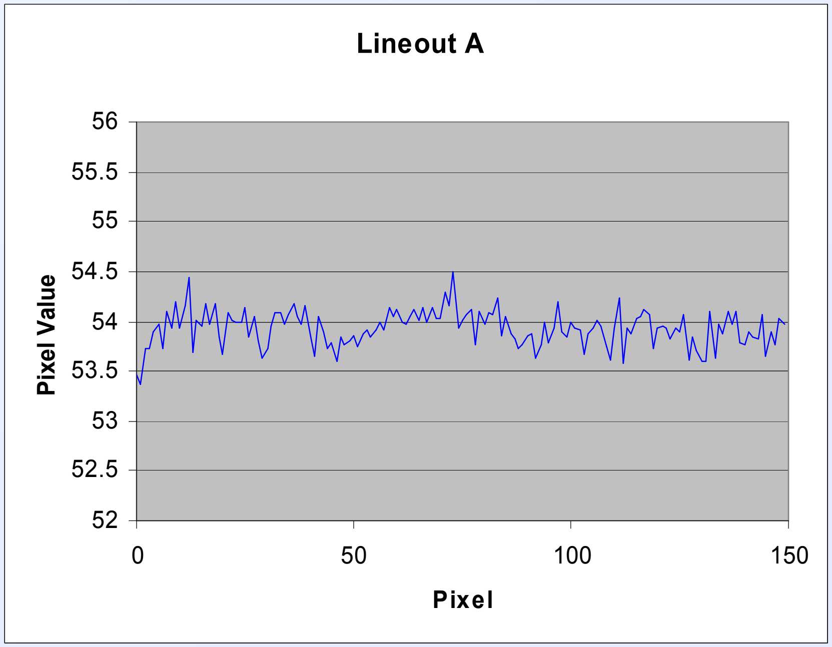
The measurement of µL as a function of position shows that the target meets design specifications.



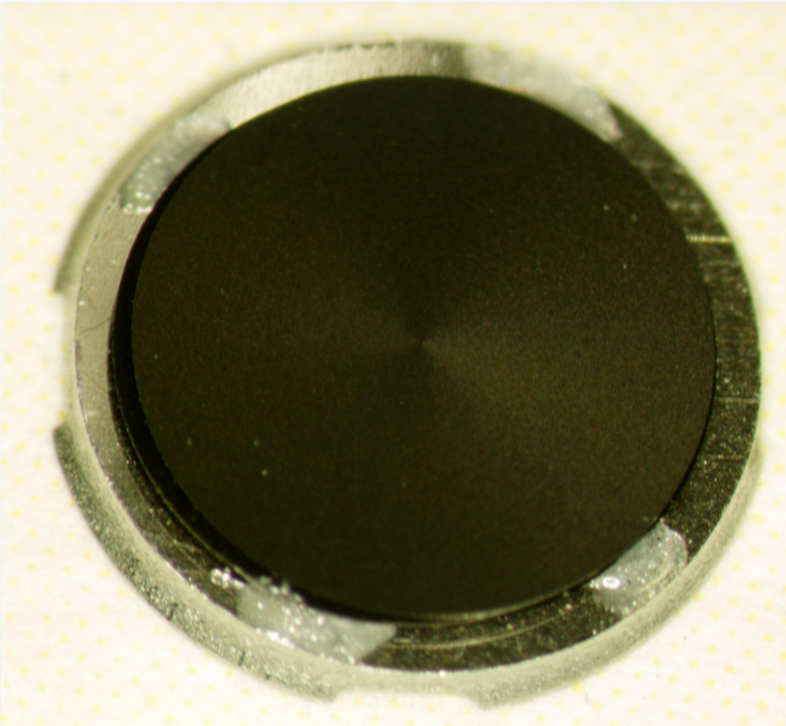
Xradia Micro XCT system
E = 50 kV, I = 40 uA, t = 50 s

Mean = 53.93
Std Dev = 0.18

SNR = 299.61

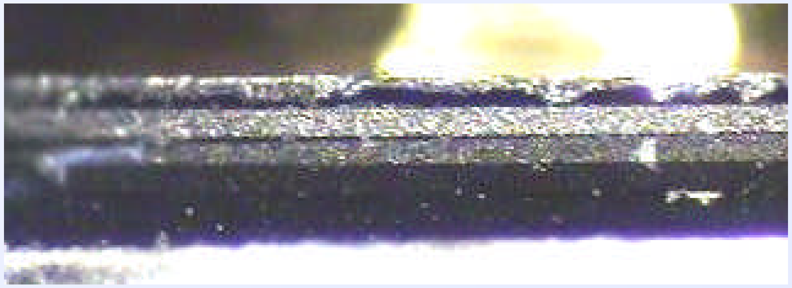


The thickness and spacing of CRF layers are important specifications for these graded density reservoirs.



Top view

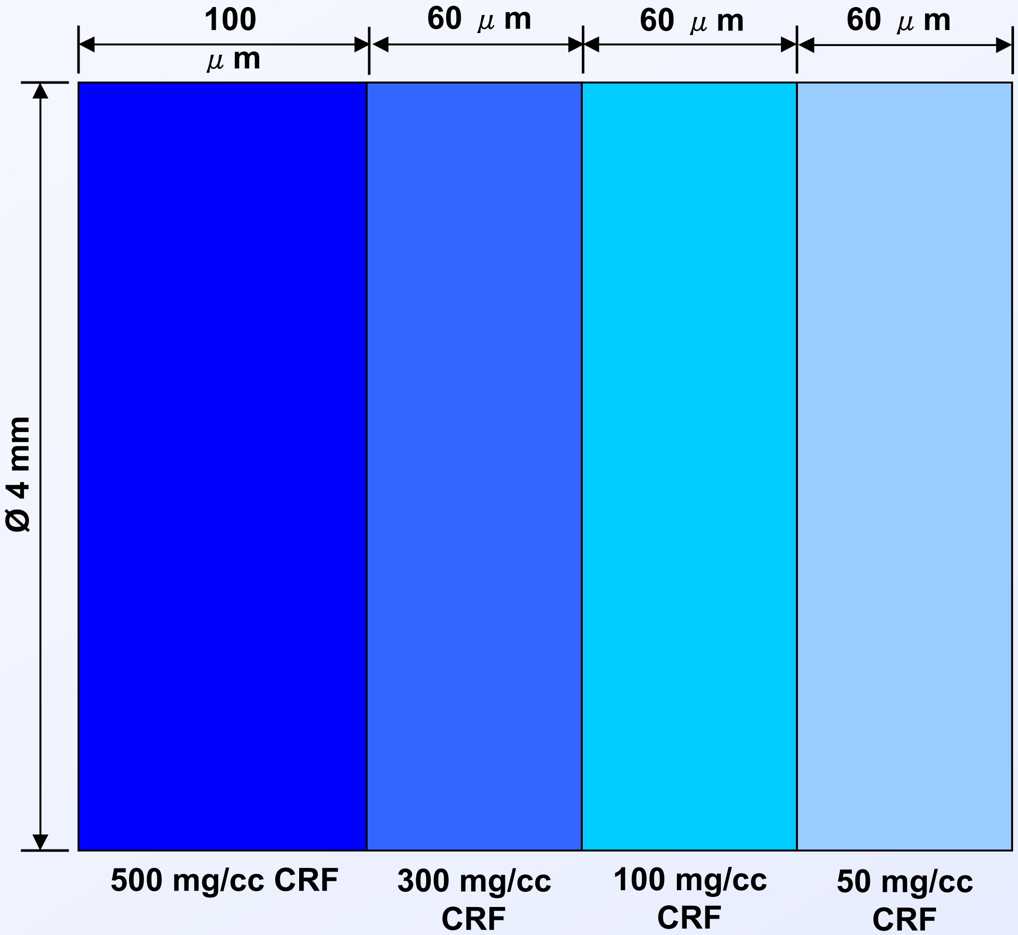
Stack of four CRF wafers mounted on a washer.

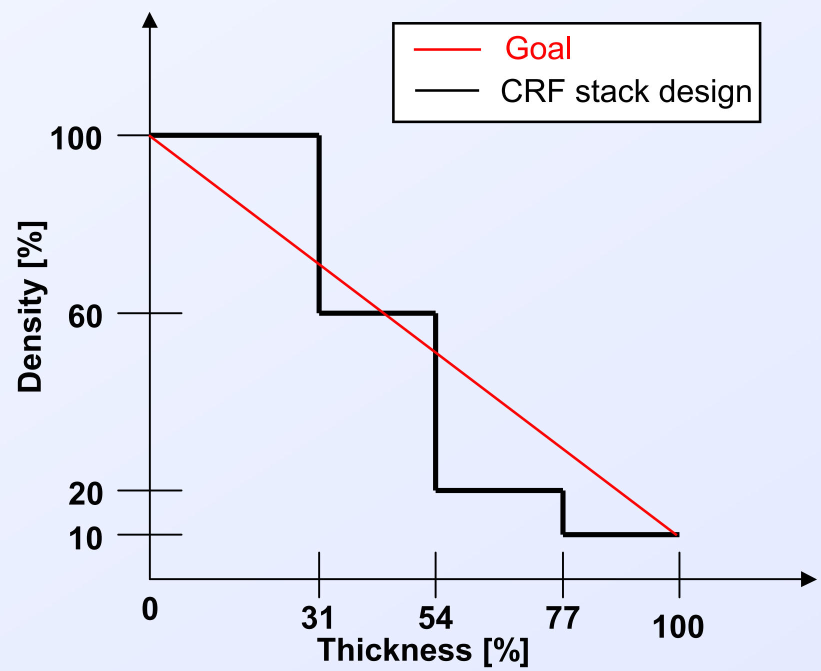


Side view

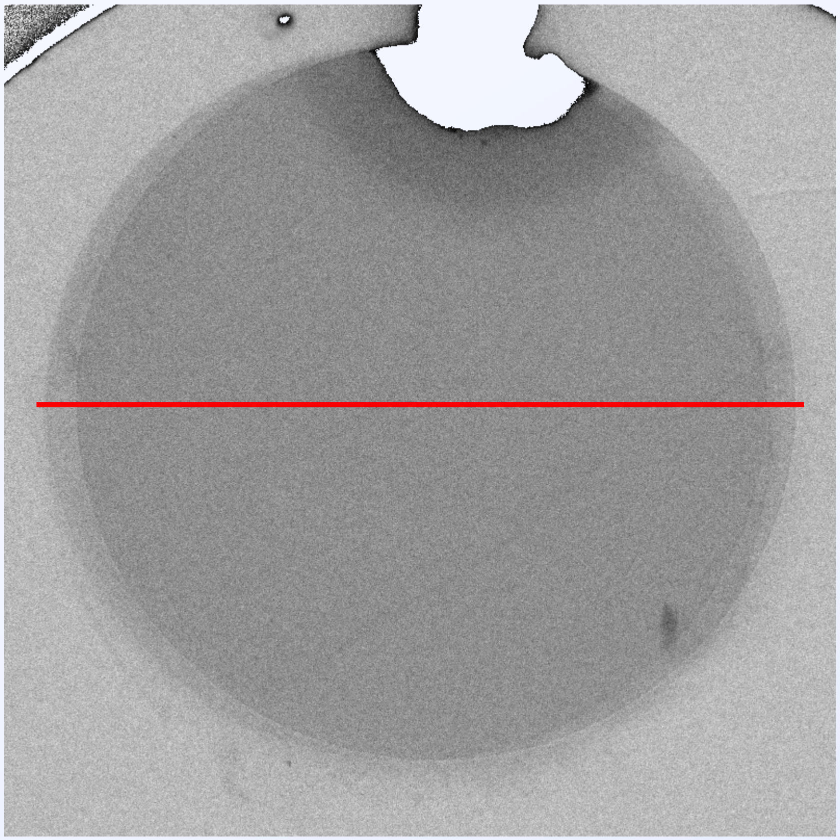
Carbon Resorcinol Foam (CRF)

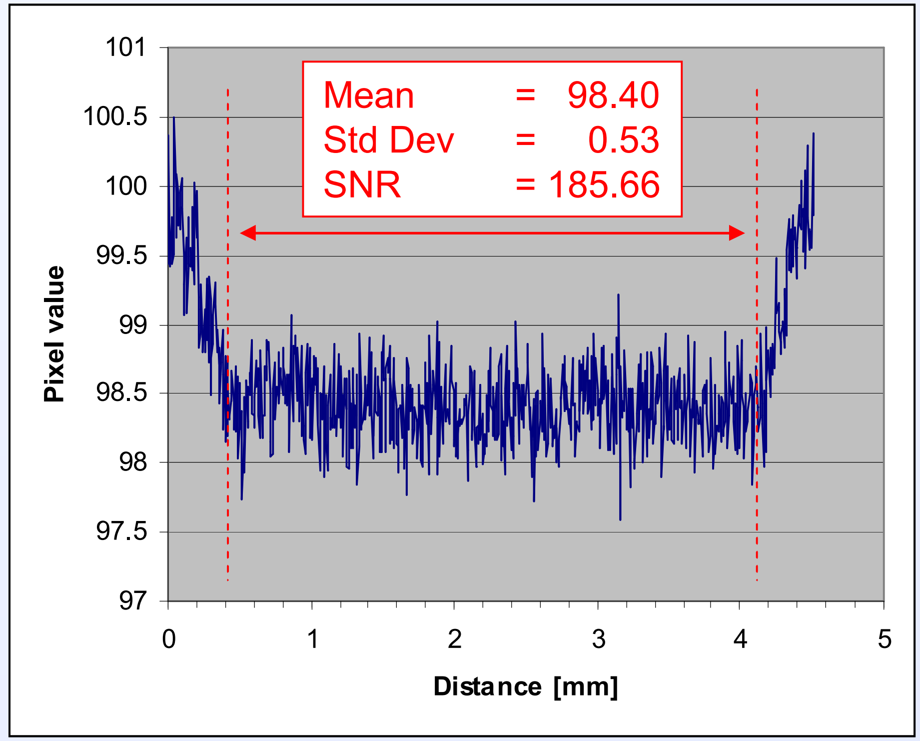
The measurement of the density gradient is a challenge that can be met by x-ray characterization.





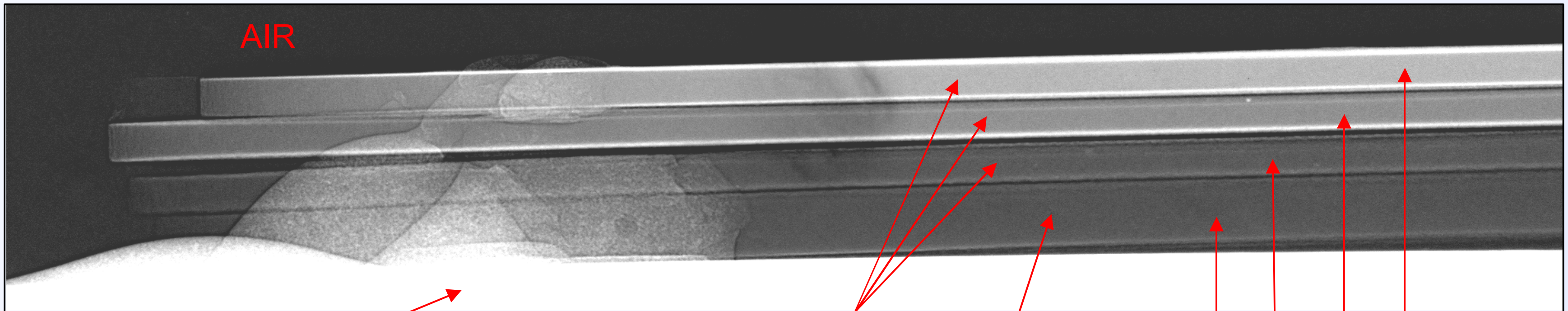
A face-on digital radiograph shows the uniformity of µL as a function of position for the stacked CRF layers.

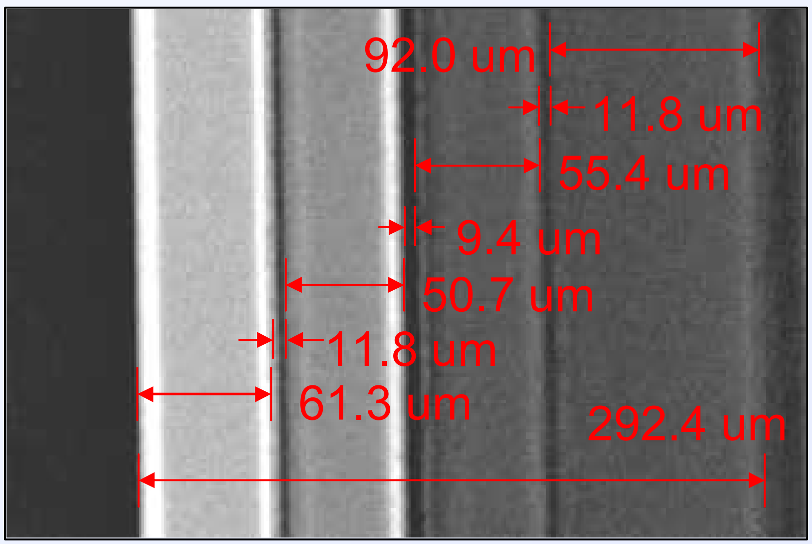




E = 50 kV
I = 40 uA
4 x 60-sec frame-averaged images
10X magnification

An edge-on digital radiograph reveals the layer and gap thicknesses and uniformity for the stacked CRF layers.

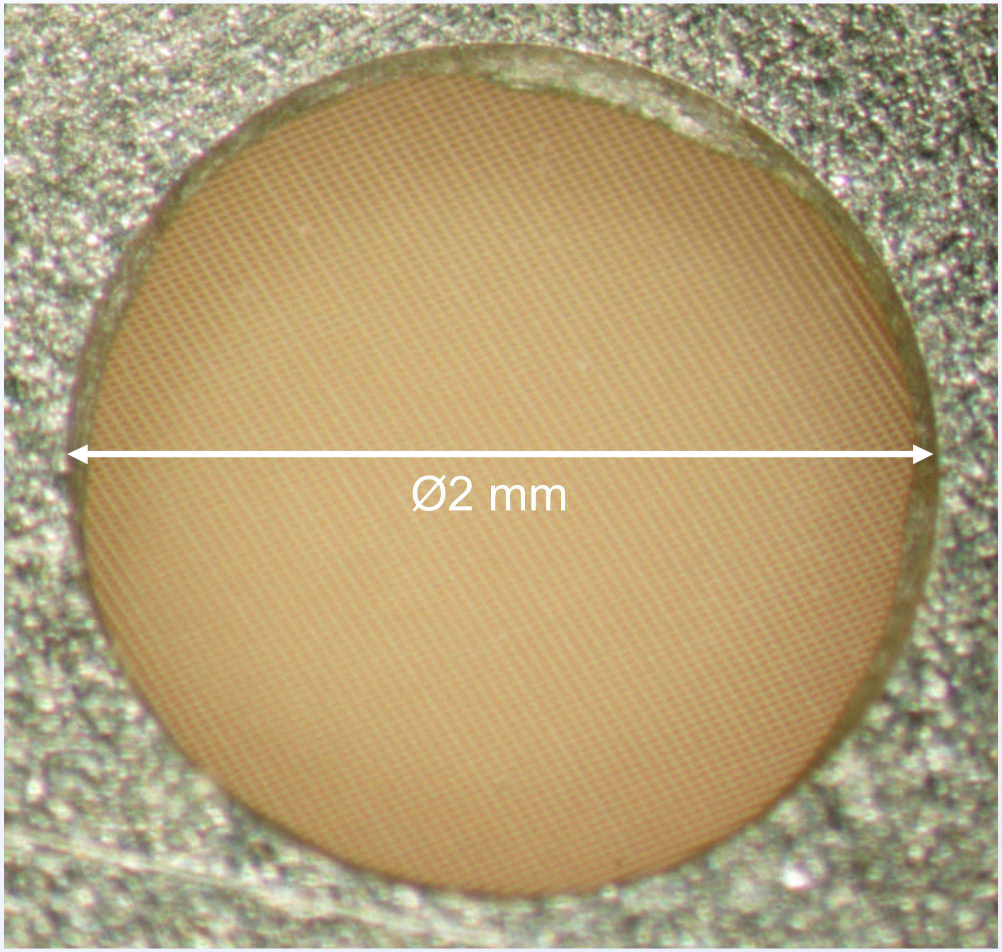


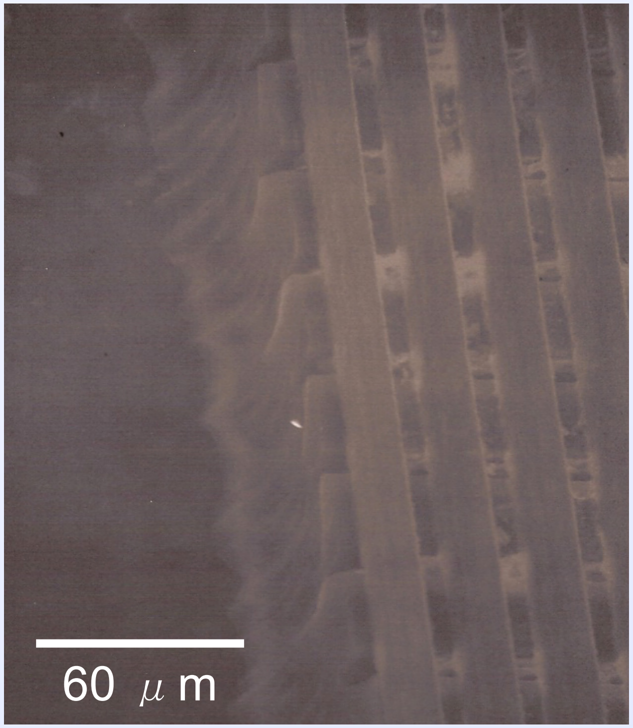


Physics requires that the gaps between CRF layers be less than 10 µm. These images of early test assemblies showed potential gaps of up to 12 µm.

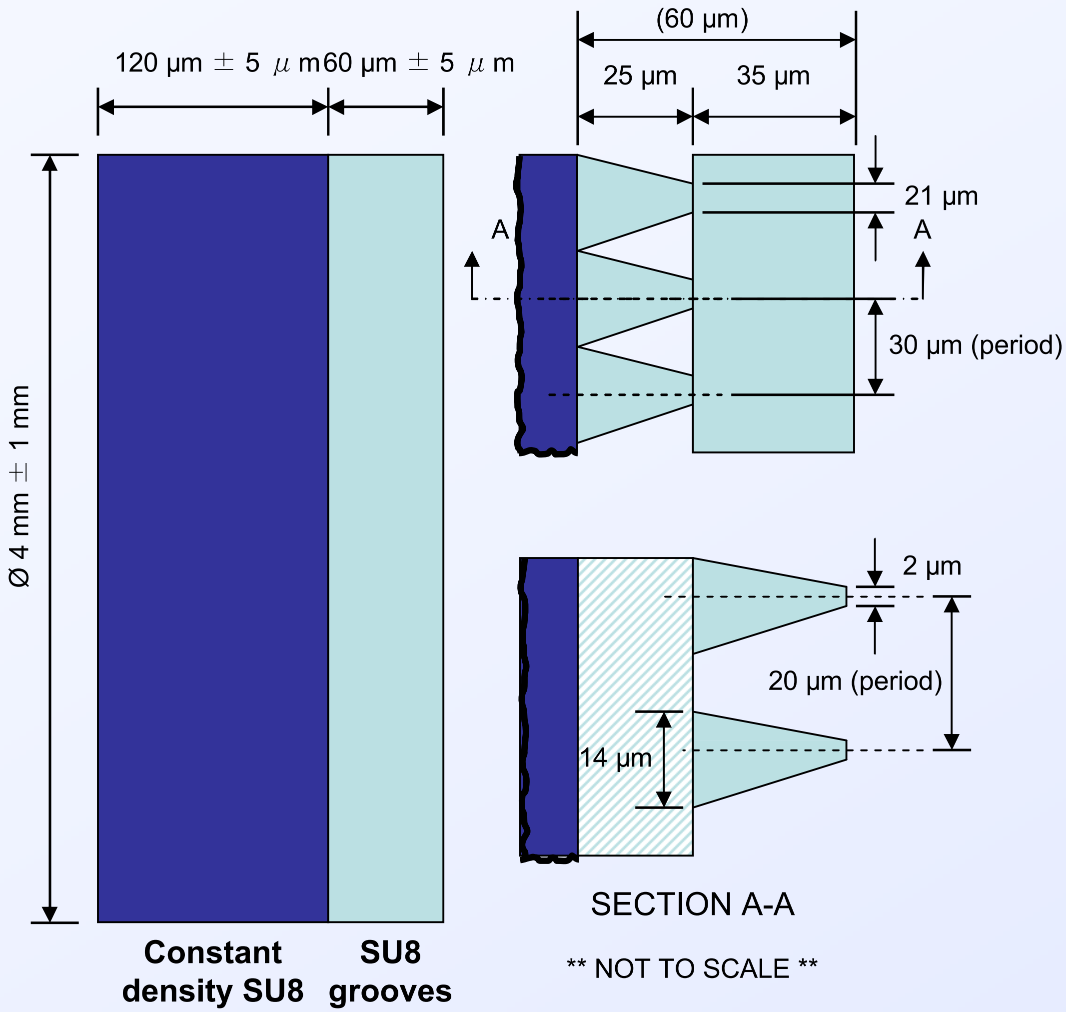
Fabrication procedures were modified to correct this alignment error, and subsequent stacks meet design specifications.

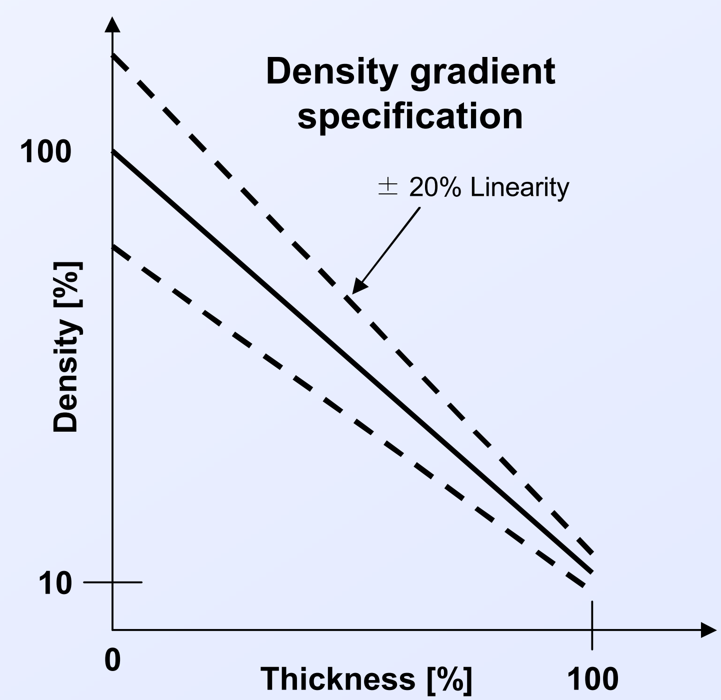
The dimensions of the layered machined SU8 grooves are important specifications for these graded density reservoirs.



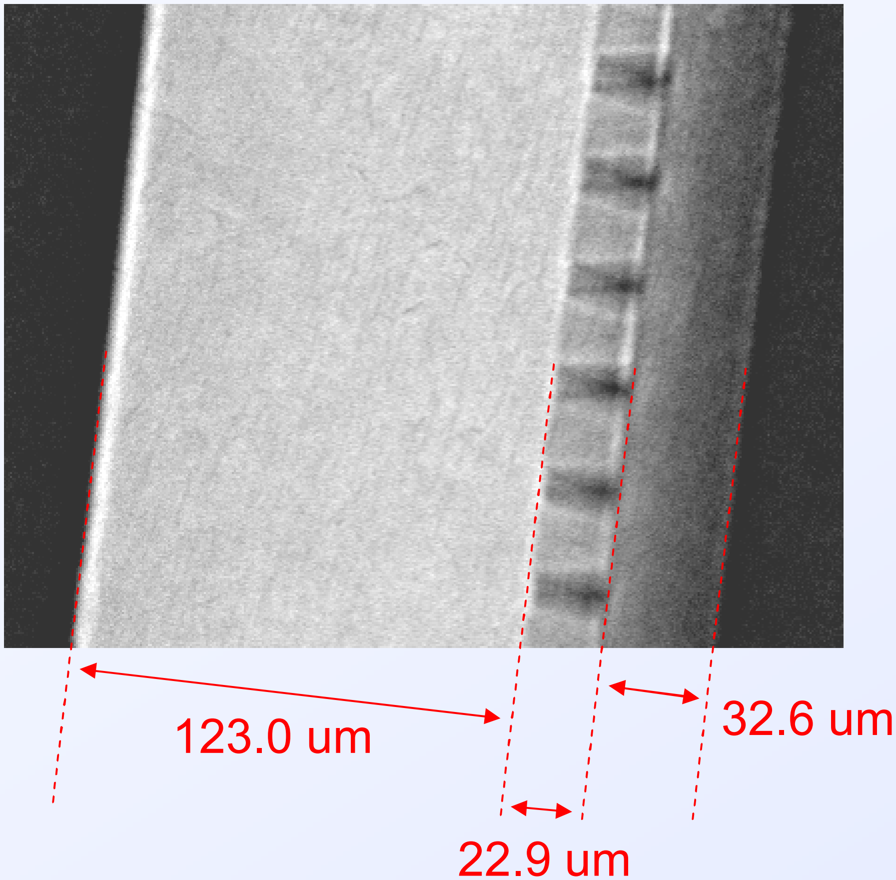


Both digital radiography and computed tomography were used to characterize the structural features of the SU8 layers.



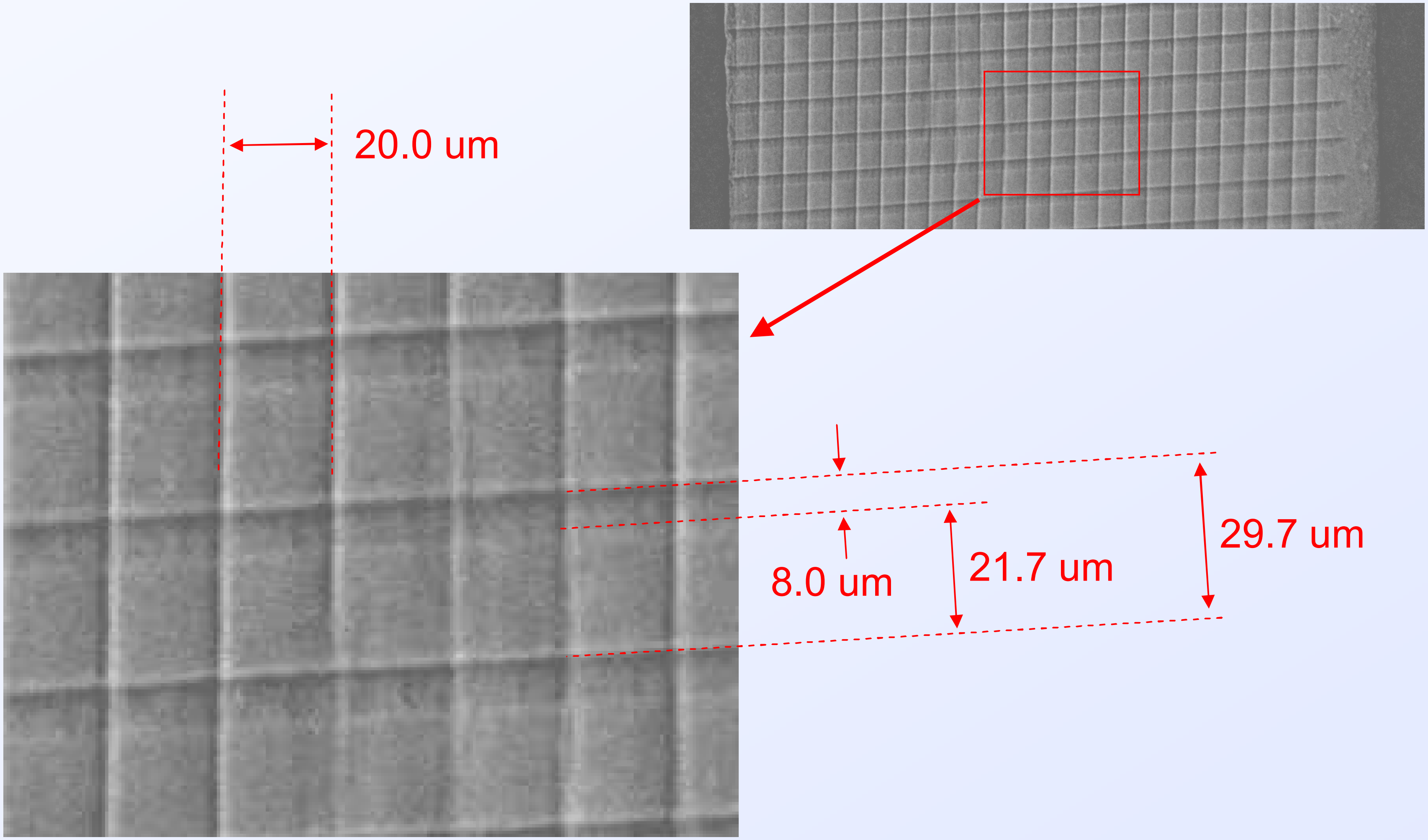


A side-on digital radiograph shows that the layer thicknesses meet the design specifications.

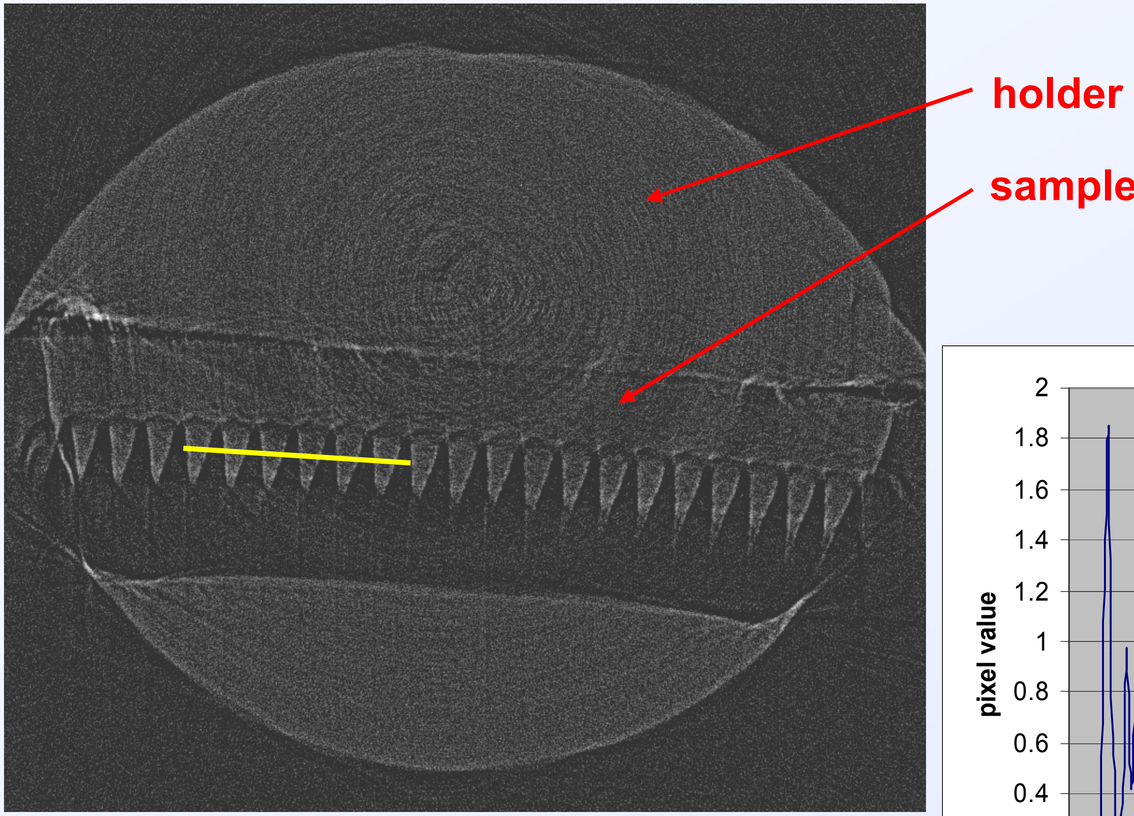


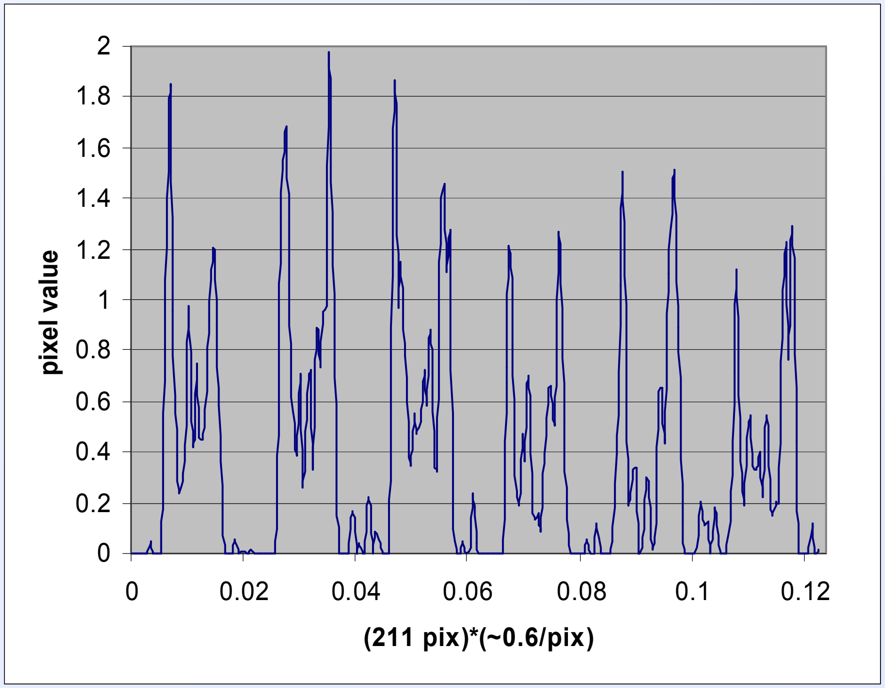
Note: This projection is slightly rotated – 0.25 degree – about the vertical axis. So the image shows a small amount of overlap between structural layers.

A face-on digital radiograph shows that the layer features meet the design specifications as well.

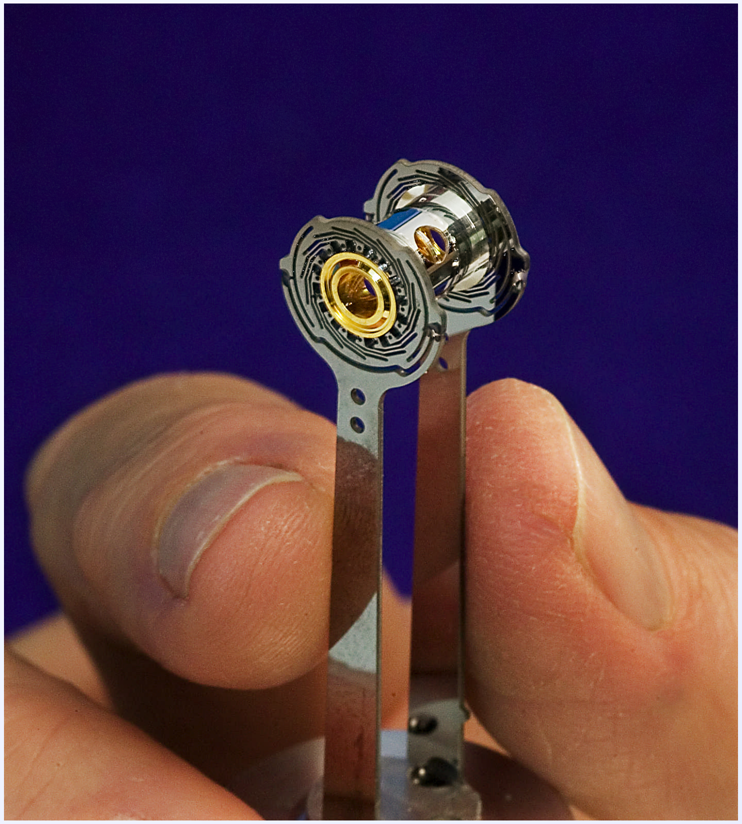


A tomographic slice shows the spacing and shape of the grooves within one layer of the structure.



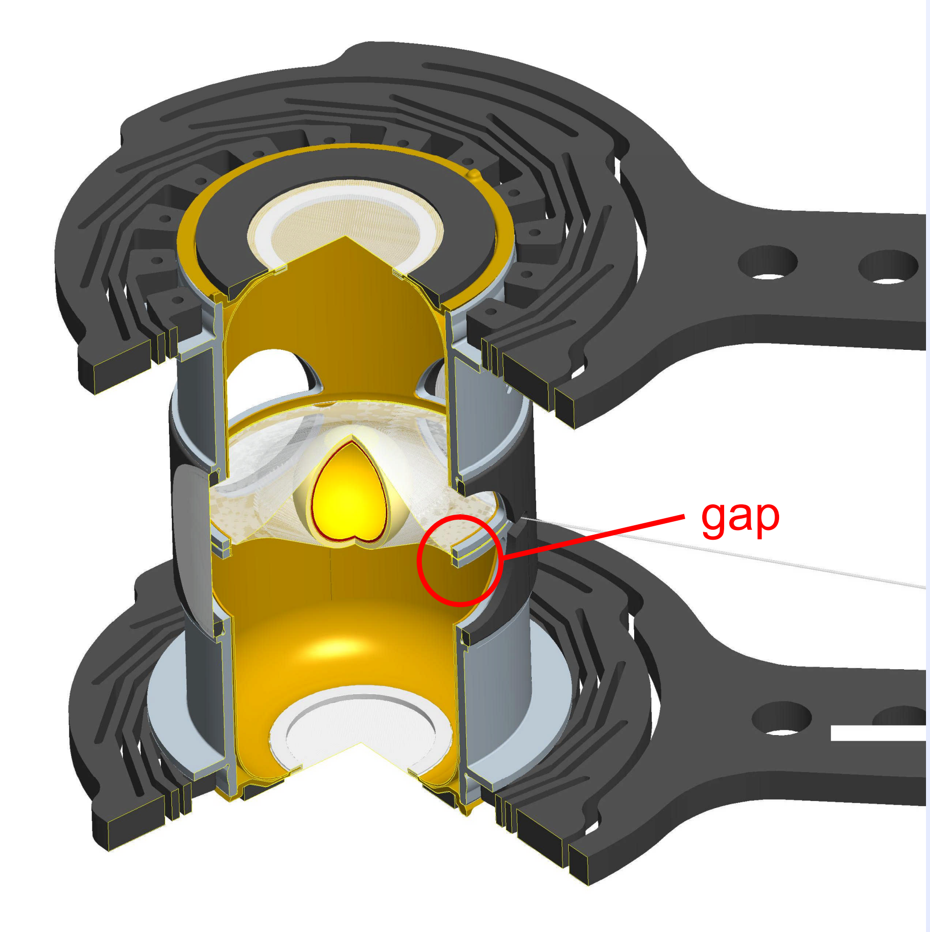


X-ray computed tomography can provide accurate metrology of hohlraum assembly components.

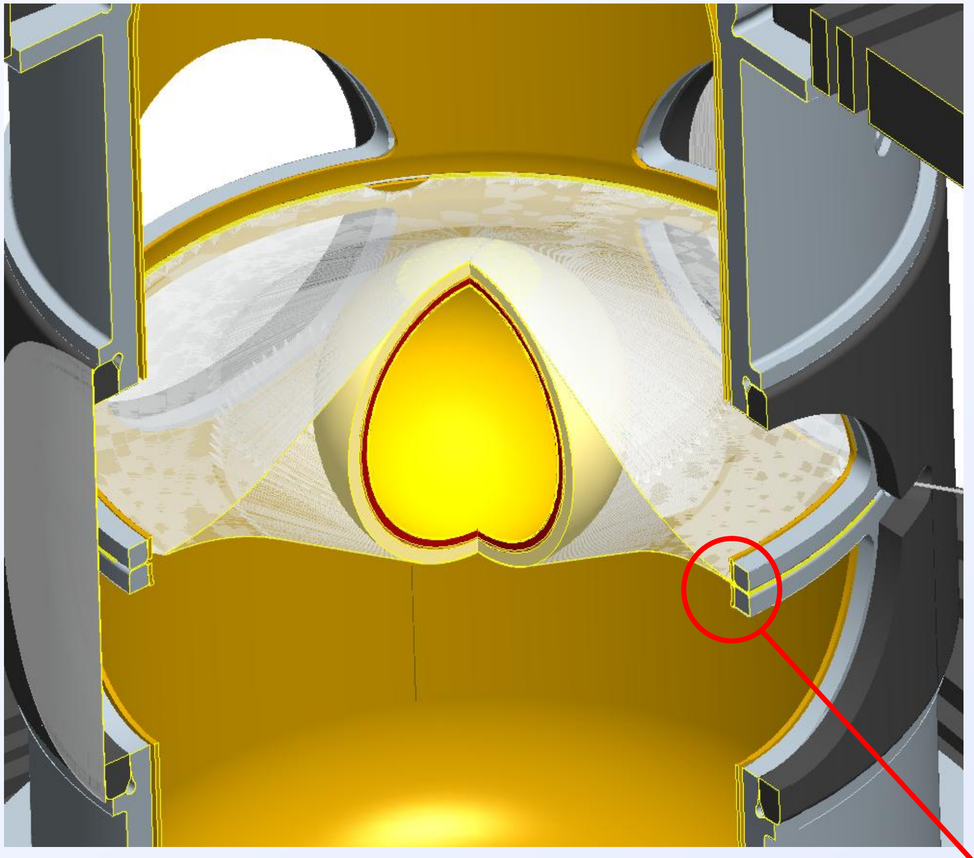


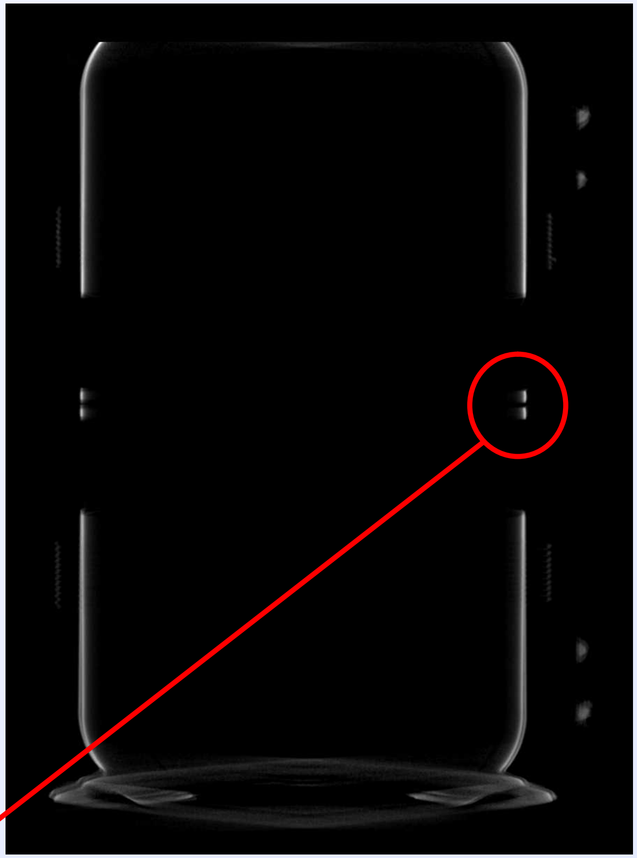
Computed tomography may provide the best metrology of the size of gaps between hohlraum halves.

- The designed-in gap between hohlraum halves allows for tolerance accommodation and cryogenic contraction of materials.
- The resulting gap is a compilation of multiple component and assembly tolerances.
- The direct measurement of the assembled target will be important to final shot fidelity.



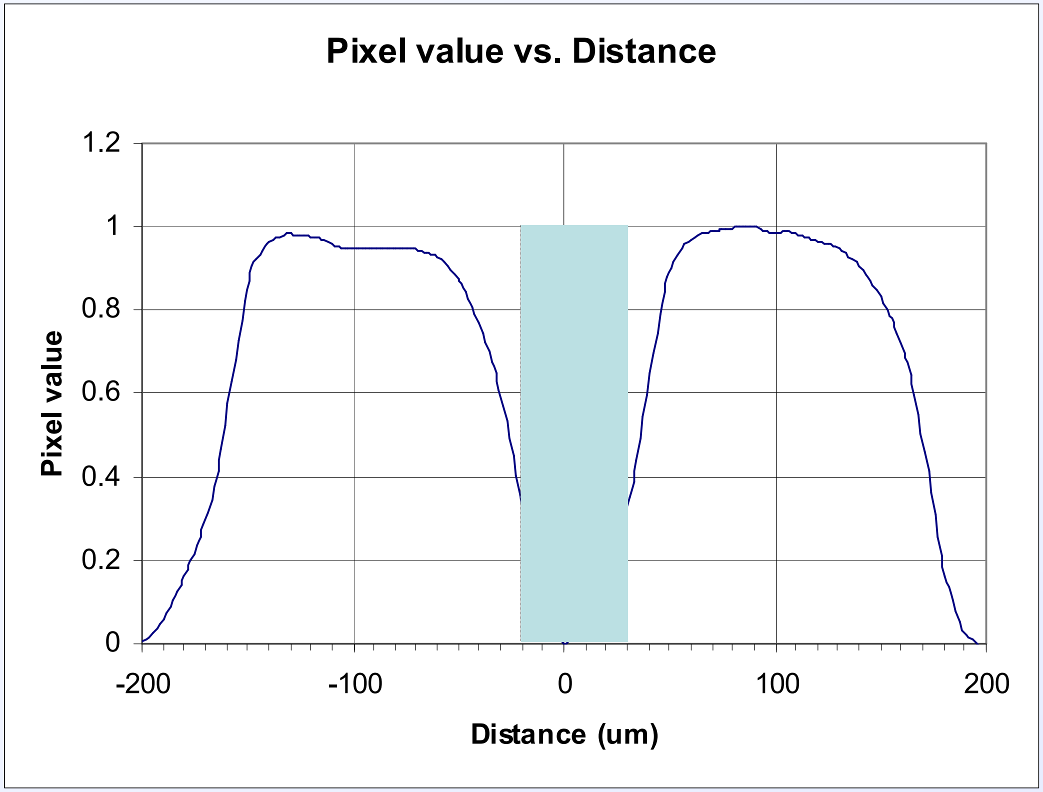
A tomographic slice clearly shows the gap between the hohlraum halves.

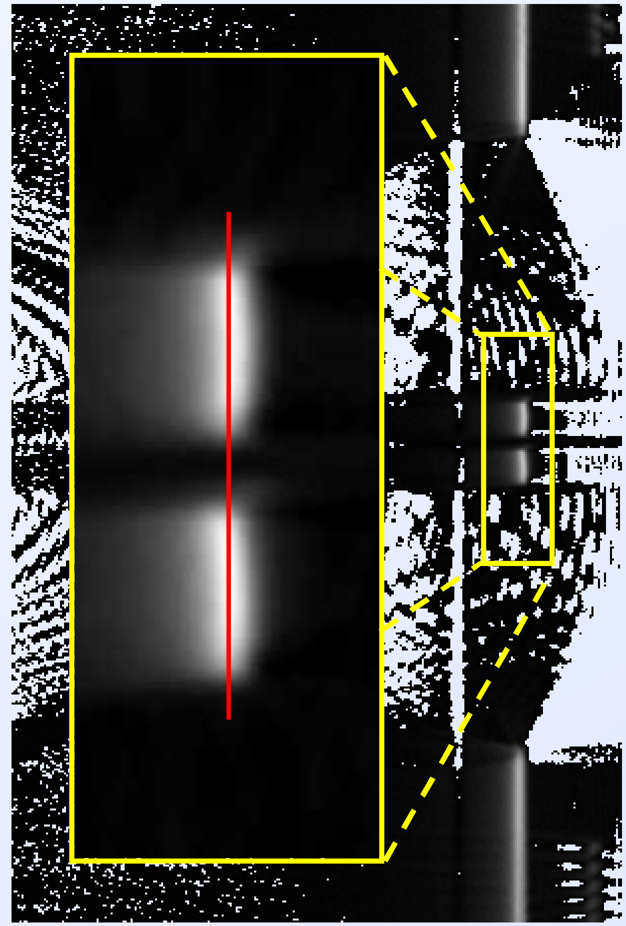




Gap between hohlraum halves

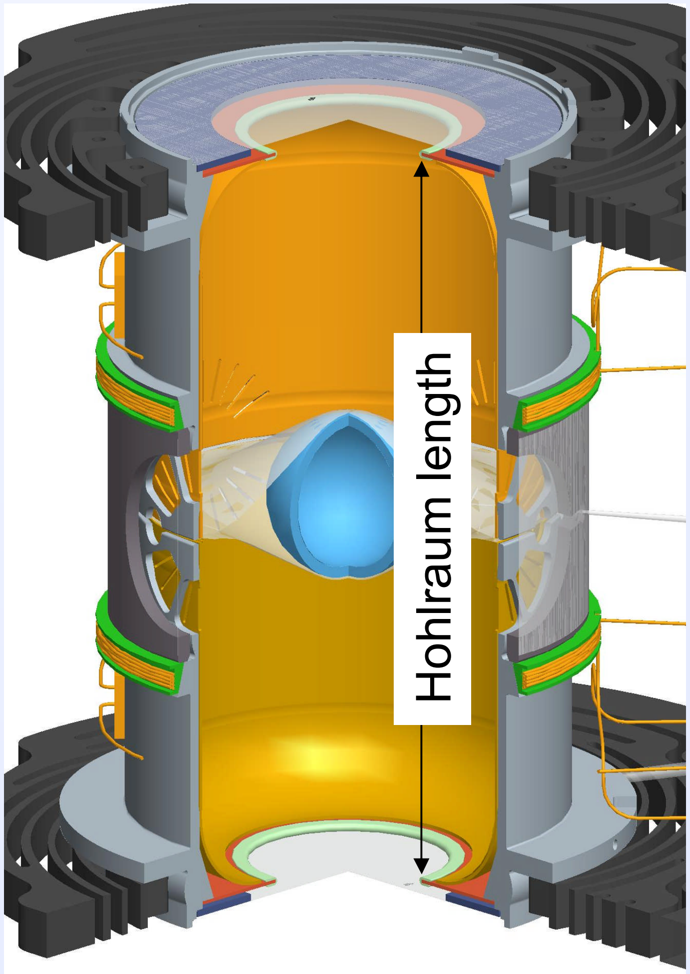
A lineout from the tomographic image demonstrates that the gap spacing meets the design specification.



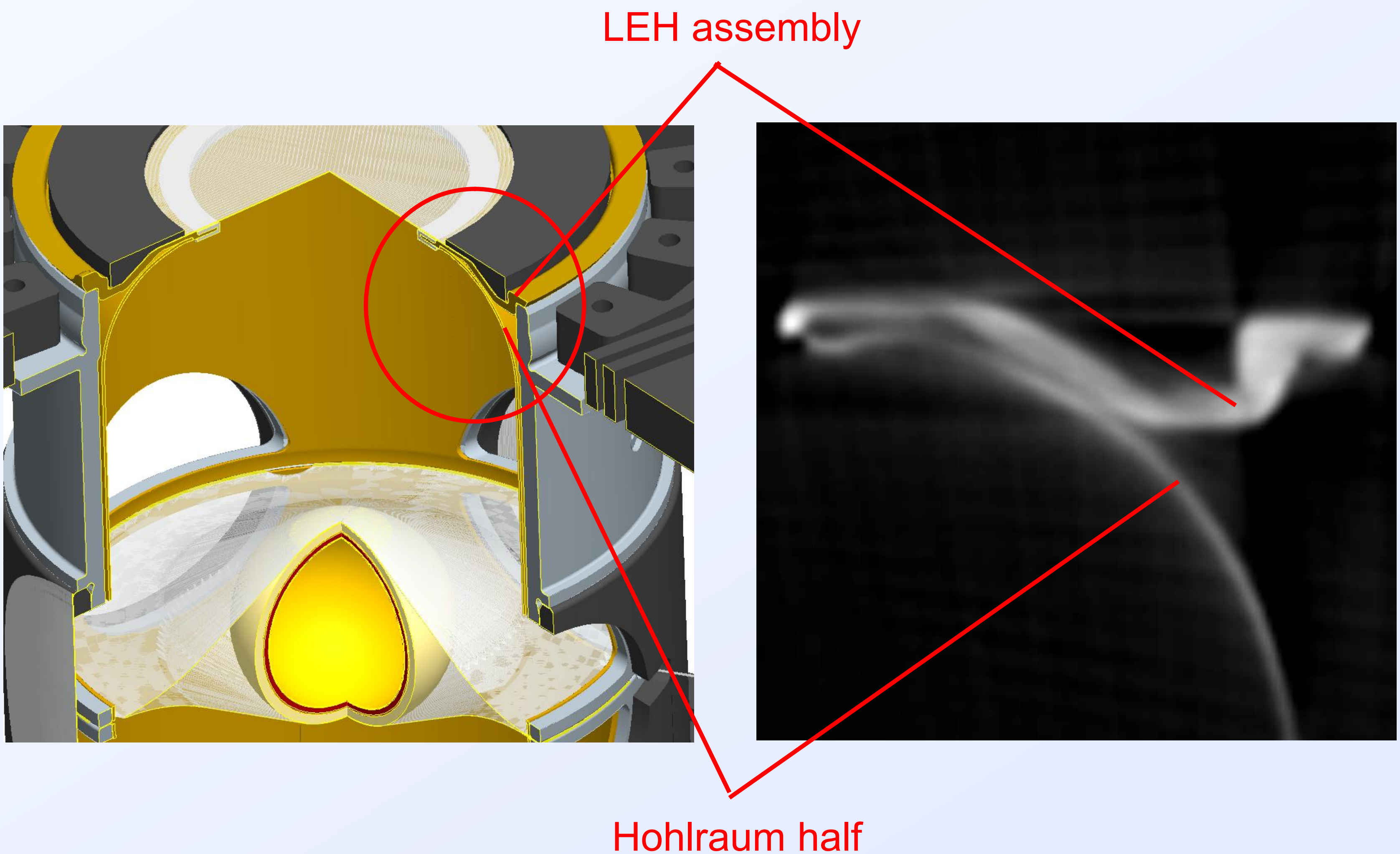


Computed tomography can provide excellent metrology of the structural dimensions of the LEH component.

- The hohlraum length is defined by the distance between the inner LEH apertures.
- This distance is the composite of many component tolerances.
- A direct measurement is only likely with x-ray metrology.



A tomographic slice shows the cross-sectional dimensions of the LEH component.



Summary

- The Xradia Micro XCT and LLNL CCAT x-ray systems are used to nondestructively characterize a variety of materials, assemblies, and reference standard components.
- The digital radiograph (DR) and computed tomography (CT) image data may be used for metrology, quality control, and defect detection.
- The ability to detect and characterize imperfections leads to improvements in the manufacturing processes for assemblies.
- Special thanks to LLNL's Bill Brown, George Langstaff, Matt Bono, and Jeff Klingman, all of whom provided some of the graphical content for this presentation.