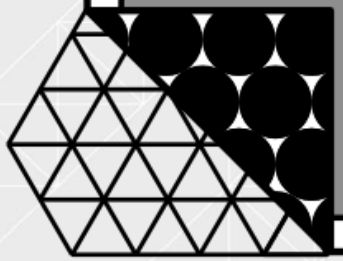
UCL ENGINEERING
Department of Civil, Environmental & Geomatic Engineering (CEGE)
↳3D Imaging, Metrology, Photogrammetry Applied Coordinate Technologies (3DIMPact)



A study into the use of simple holeplates to measure the apparent distortion in the geometry of reconstructed volumes

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3DIMPact
3D Imaging, Metrology & Photogrammetry Applied Coordinate Technologies

EPSRC
Engineering and Physical Sciences Research Council

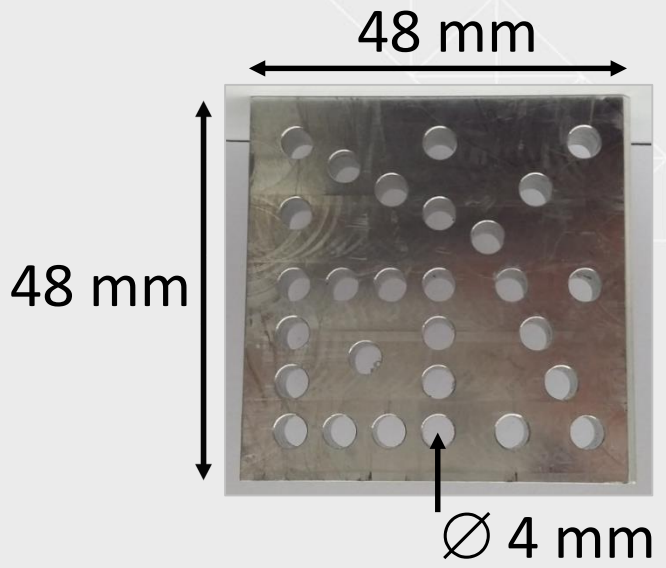
NPL
National Physical Laboratory

Outline

- Background to work
- Experimental work with holeplates
  - Complex
  - Simple
- Simulation results
- Summary and further work

Background to work

- Aluminium, 8 mm holeplate manufactured at NPL, based on a design by PTB/NMIJ[1]
- Complex holeplate previously used to study the effects of beam hardening
- Unidirectional and bidirectional lengths measured
- Central to an emerging ISO standard



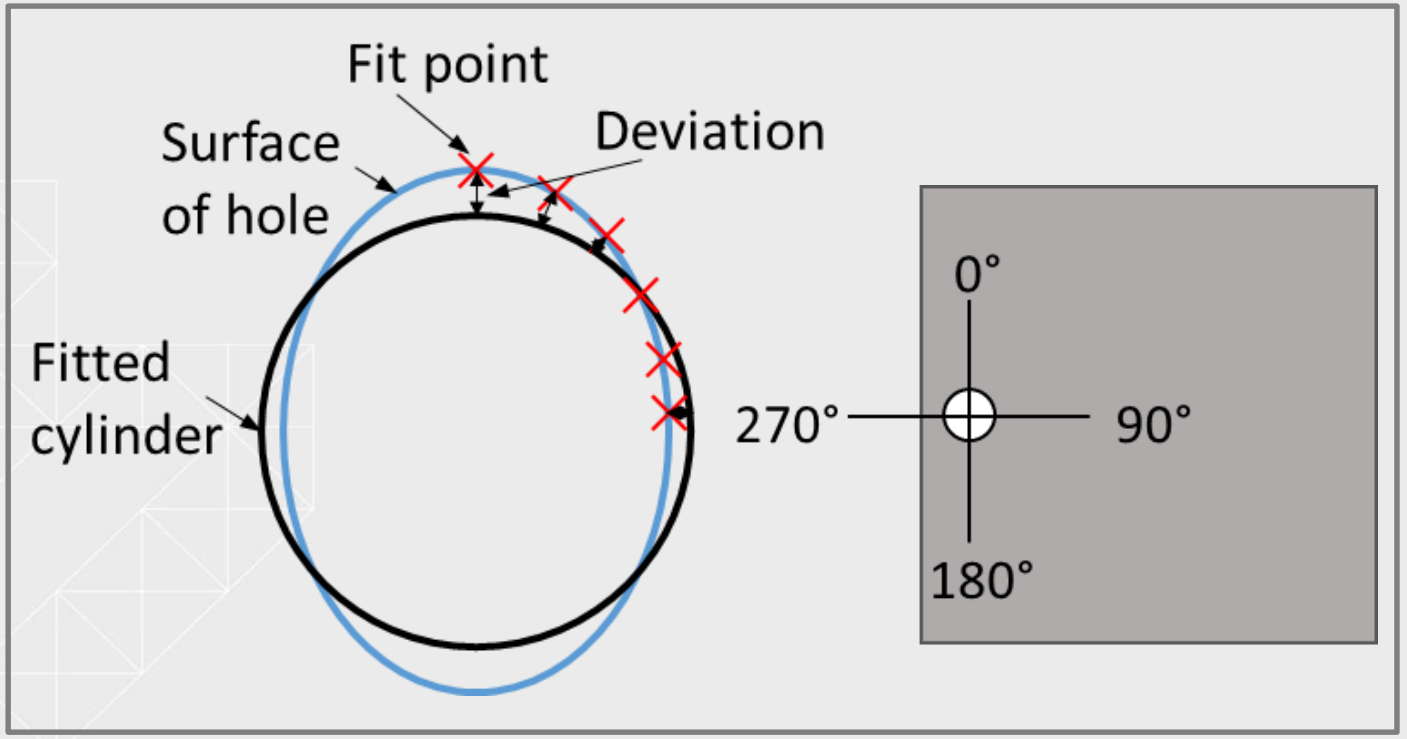
1. Bartscher, M. et al., 2014. Current state of standardization in the field of dimensional computed tomography. *Measurement Science and Technology*, 25(6)

Method

- Commercially available metrology XCT system
  - MPE ± 9.96 µm (manufacturer's specification)
- Constant voltage (170 keV)
- Constant current (60 µA)
- Magnification
  - 1.6x (voxel size = 125 µm)
  - 5x (voxel size = 40 µm)

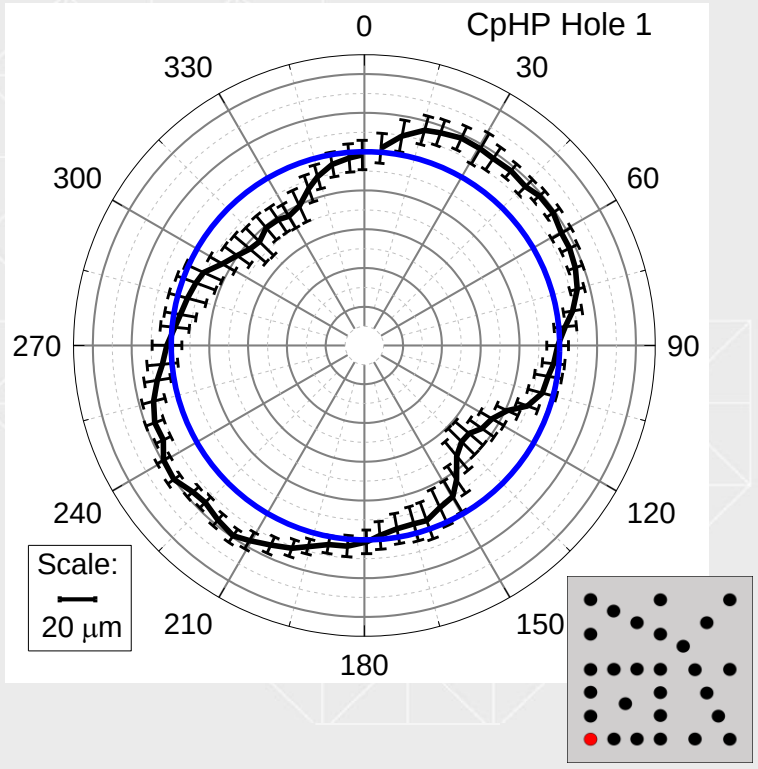
Complex holeplate

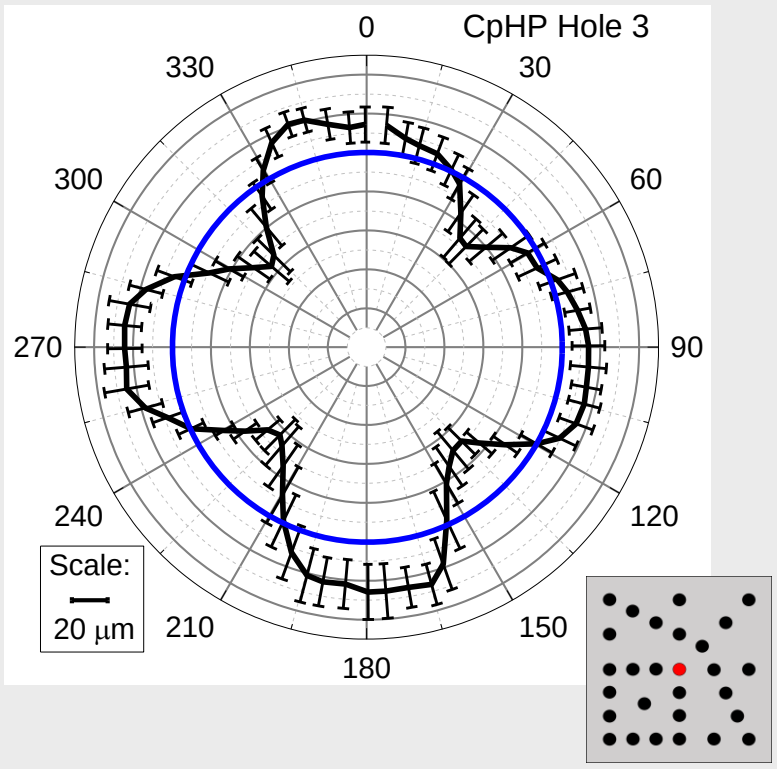
- Apparent deformation of cylinder geometry
  - Dependent on the position of hole within the holeplate

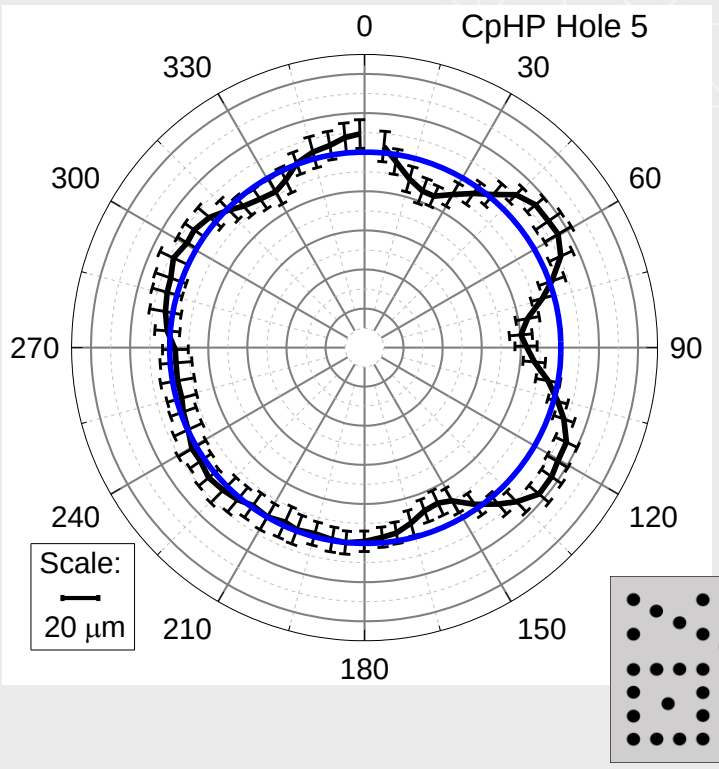


Complex holeplate

- Apparent deformation of cylinder geometry
  - Dependent on the position of hole within the holeplate
  - Maximum deviation from circle 45 µm

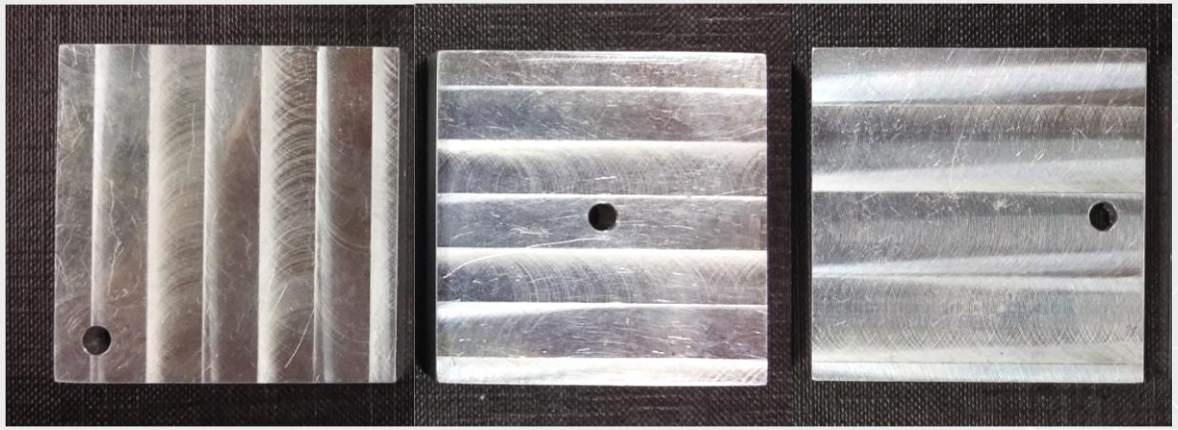




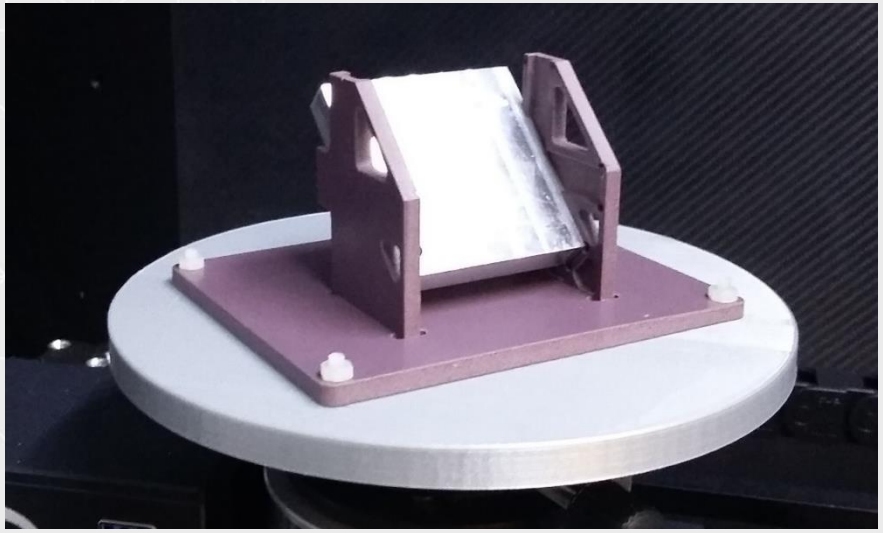


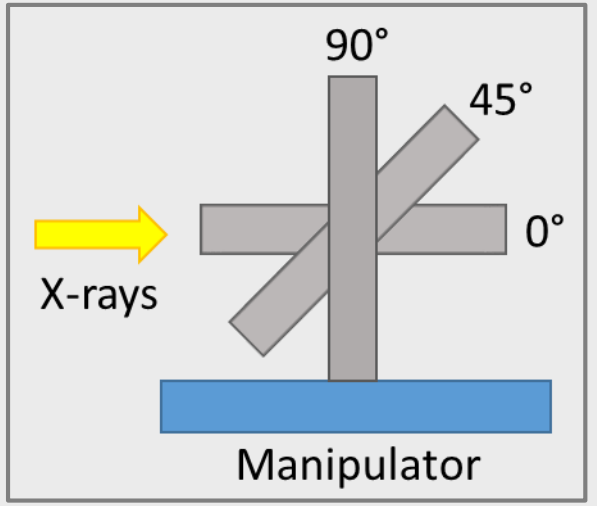
Simple holeplates

- 3 simple holeplates
- CMM: ± 4 µm



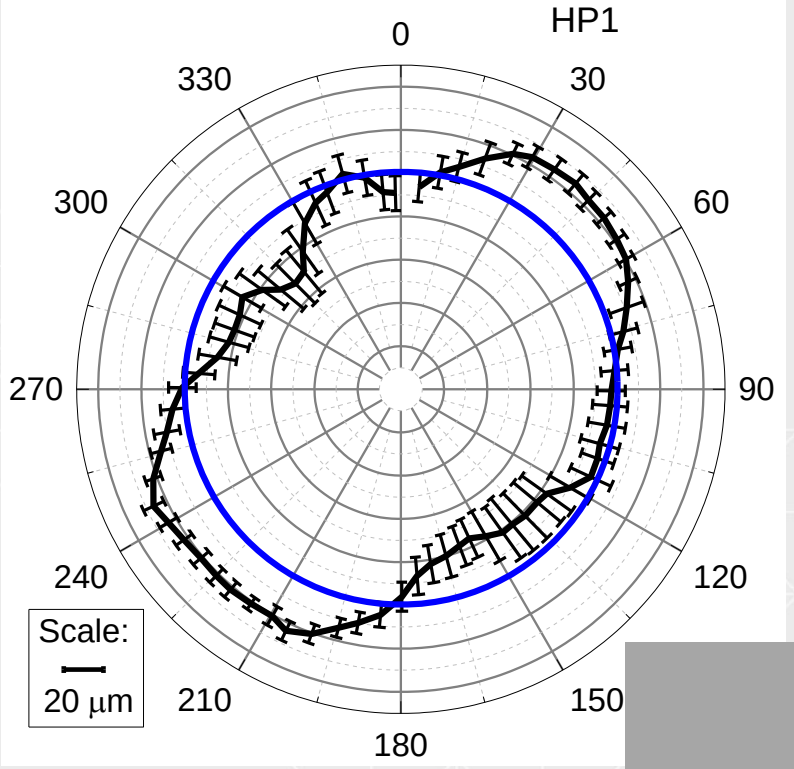
HP1 HP3 HP5

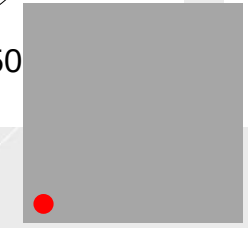


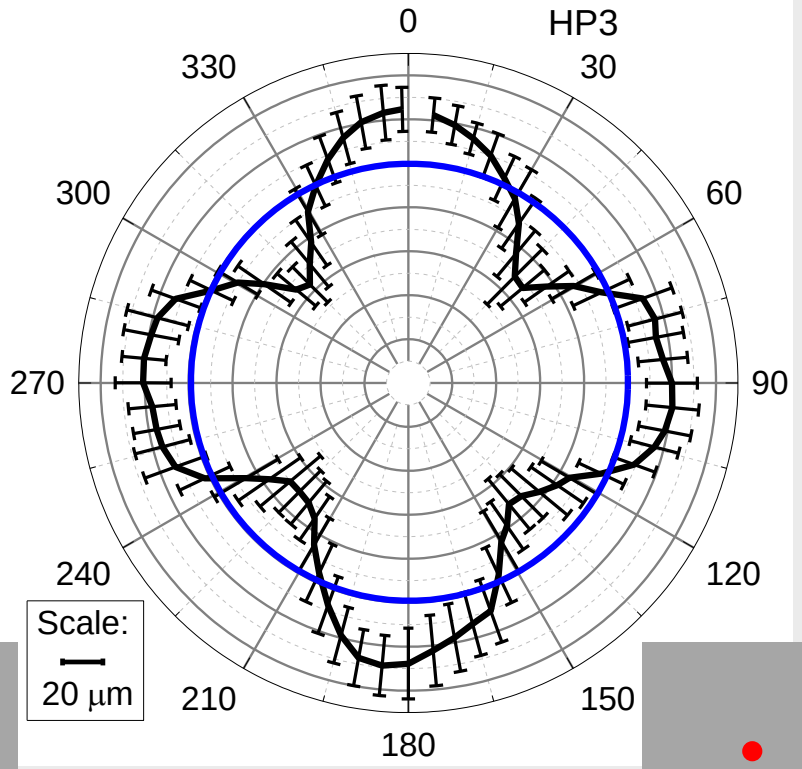


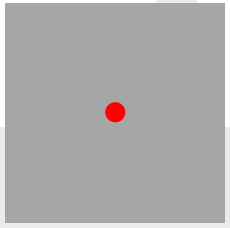
Simple holeplates

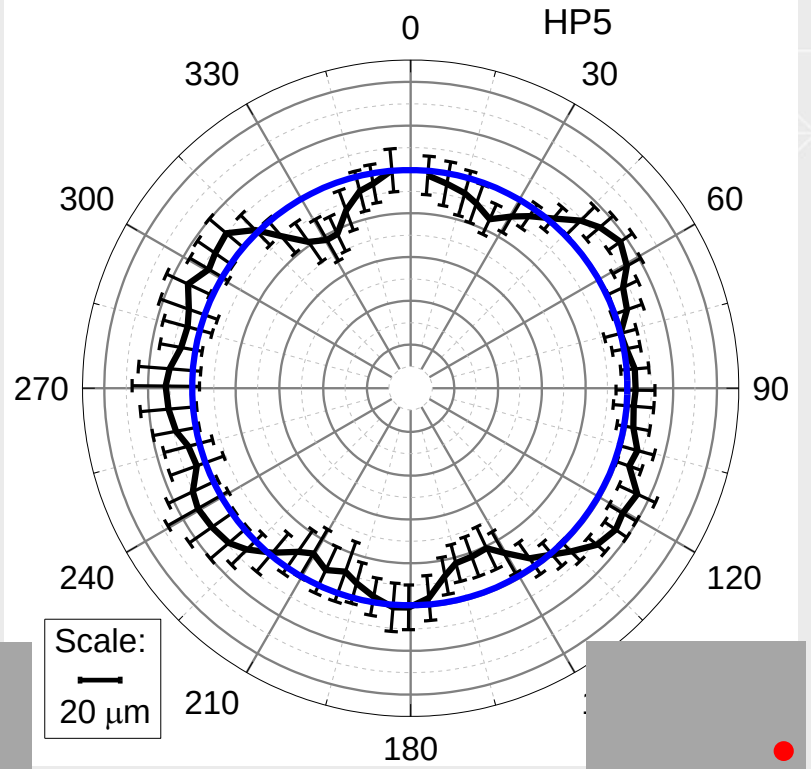
- Imaged at 0°:
  Maximum deviation from circle 37µm



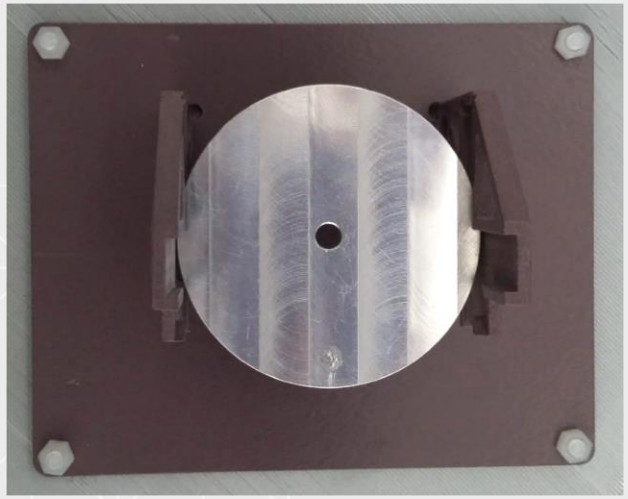


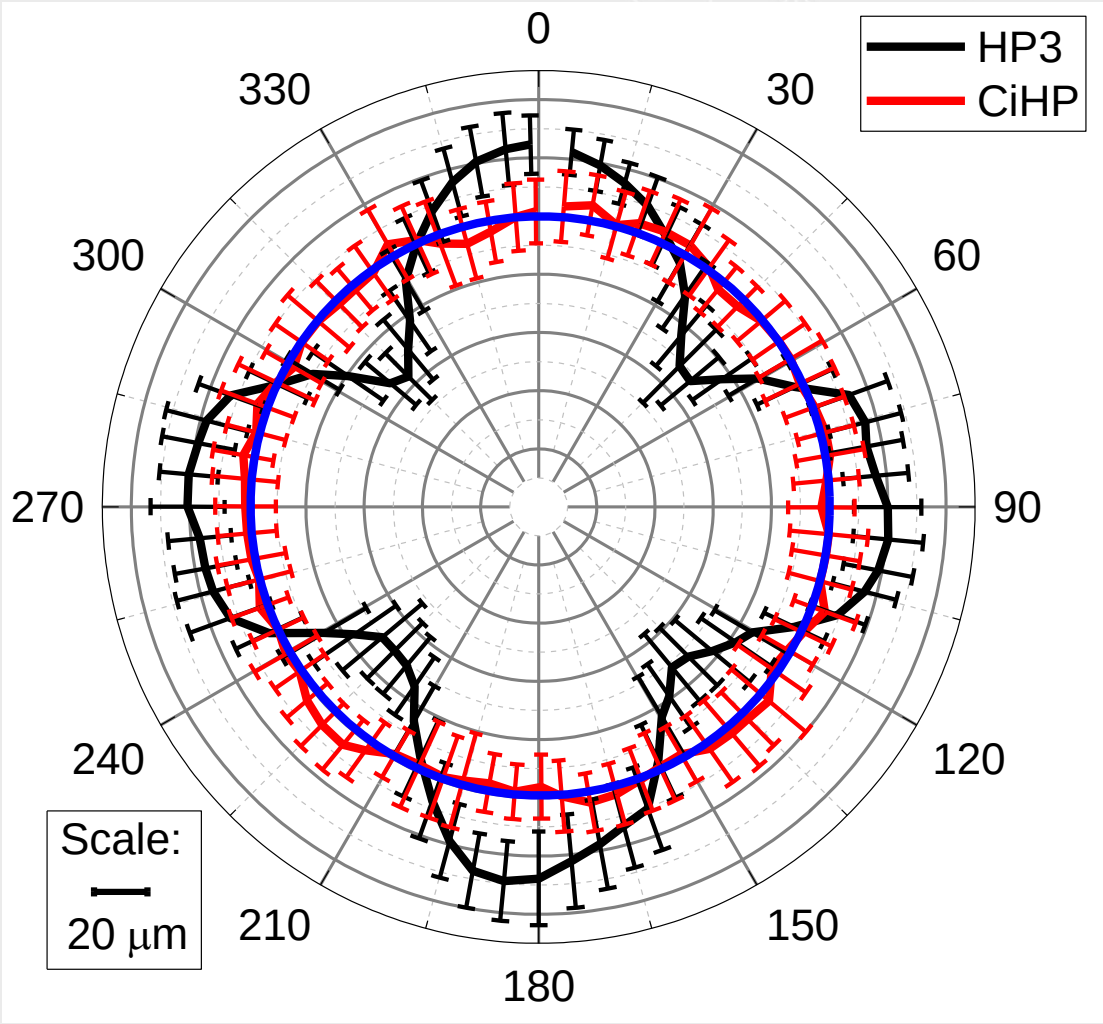






Circular holeplate

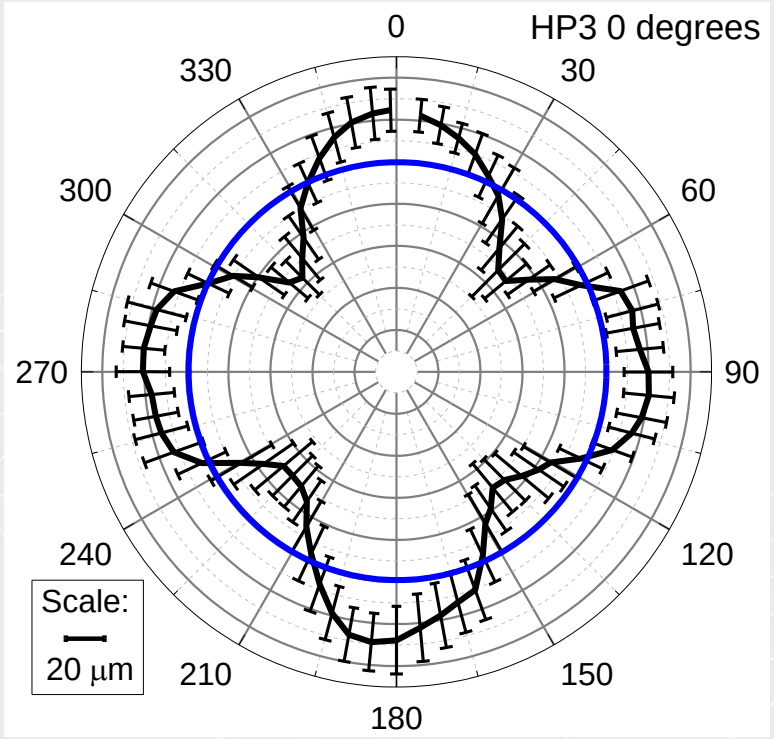


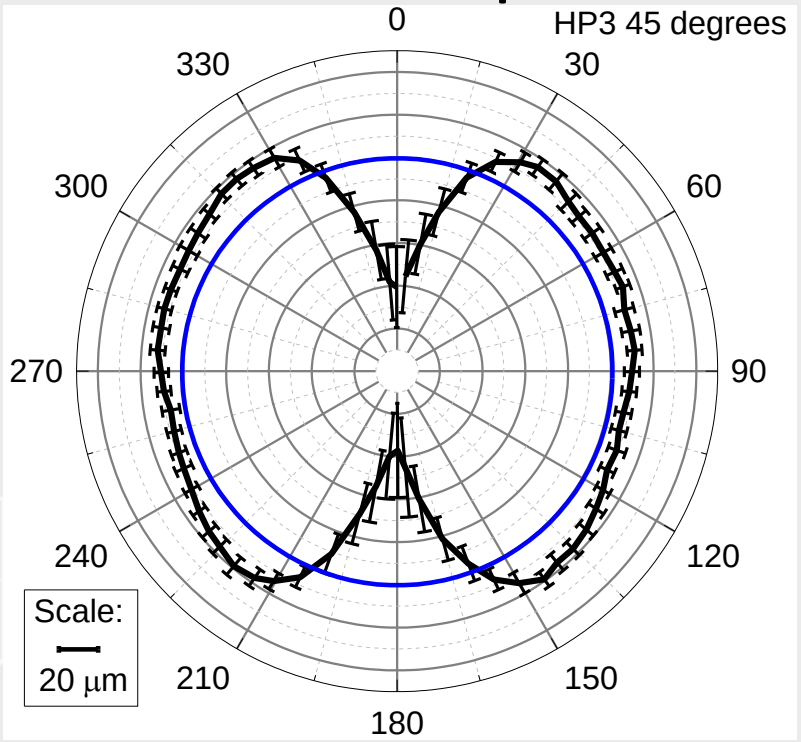


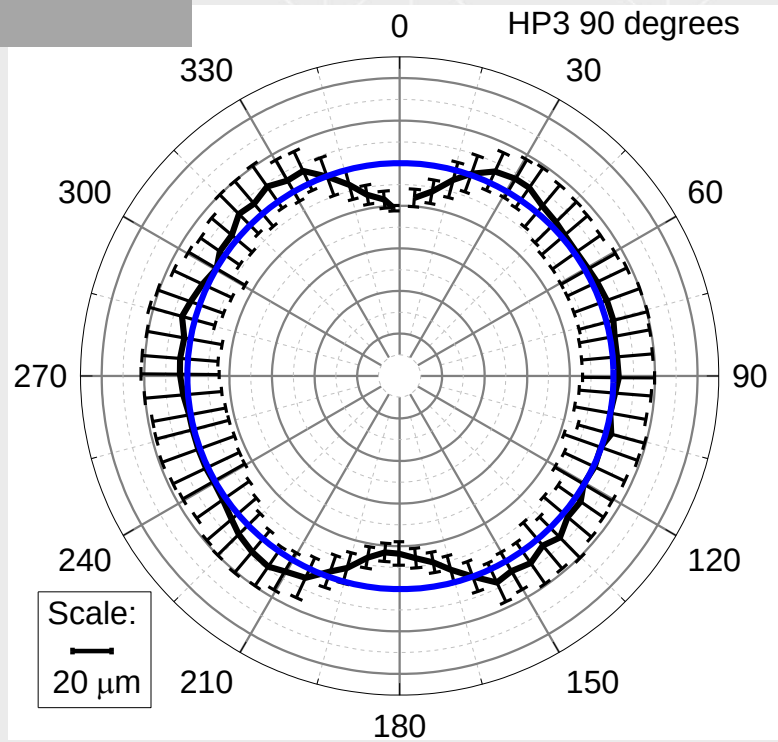
- Circular holeplate imaged at 0°
- Maximum deviation 37 µm

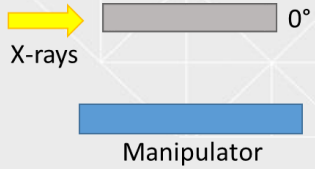
Simple holeplates

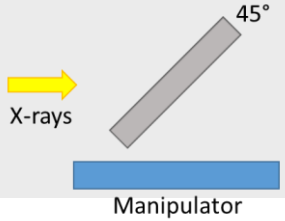
- Orientation during imaging:
  Maximum deviation from circle 60µm

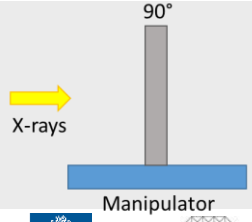






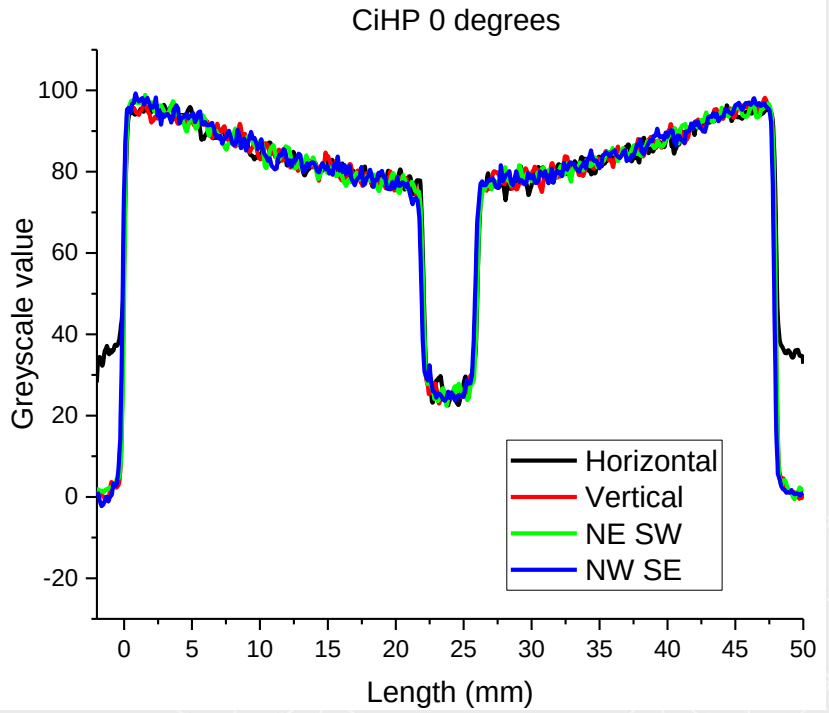


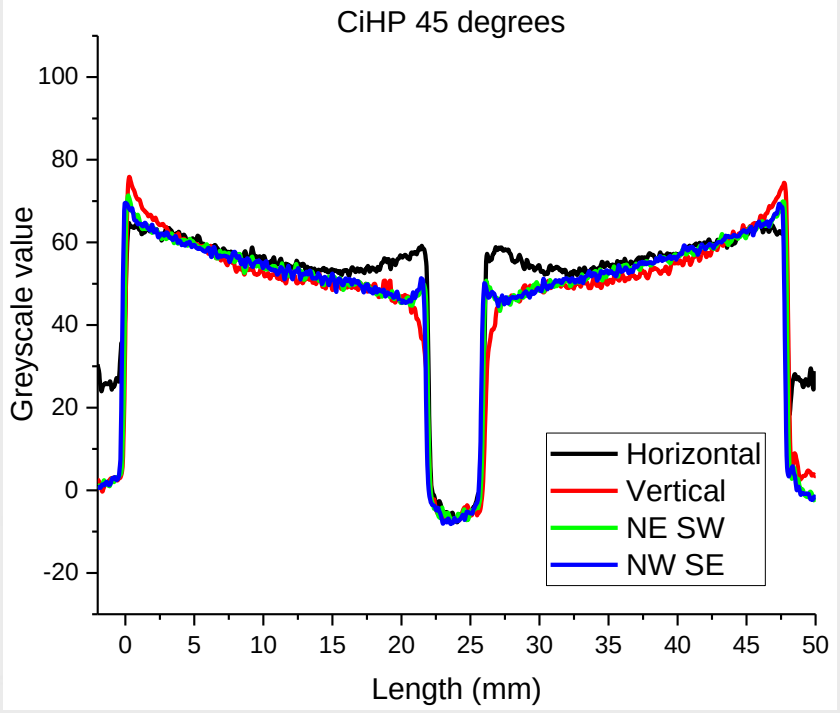


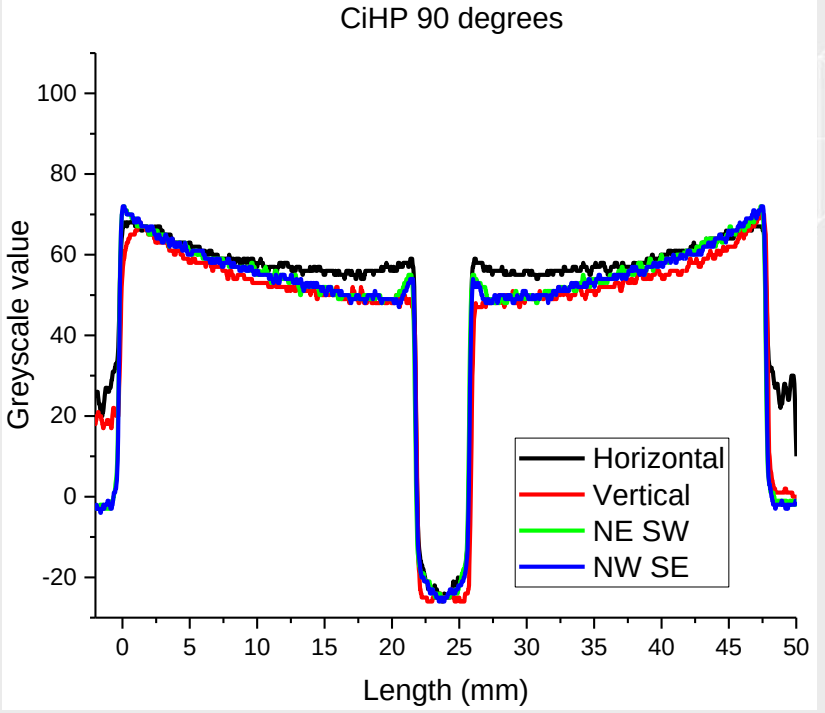


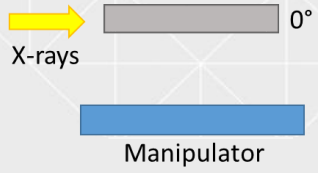
Circular holeplate

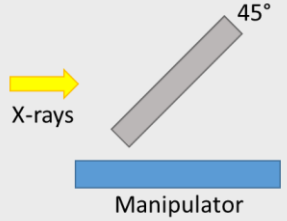
- Greyscale profile through reconstructed volume

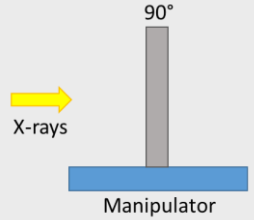






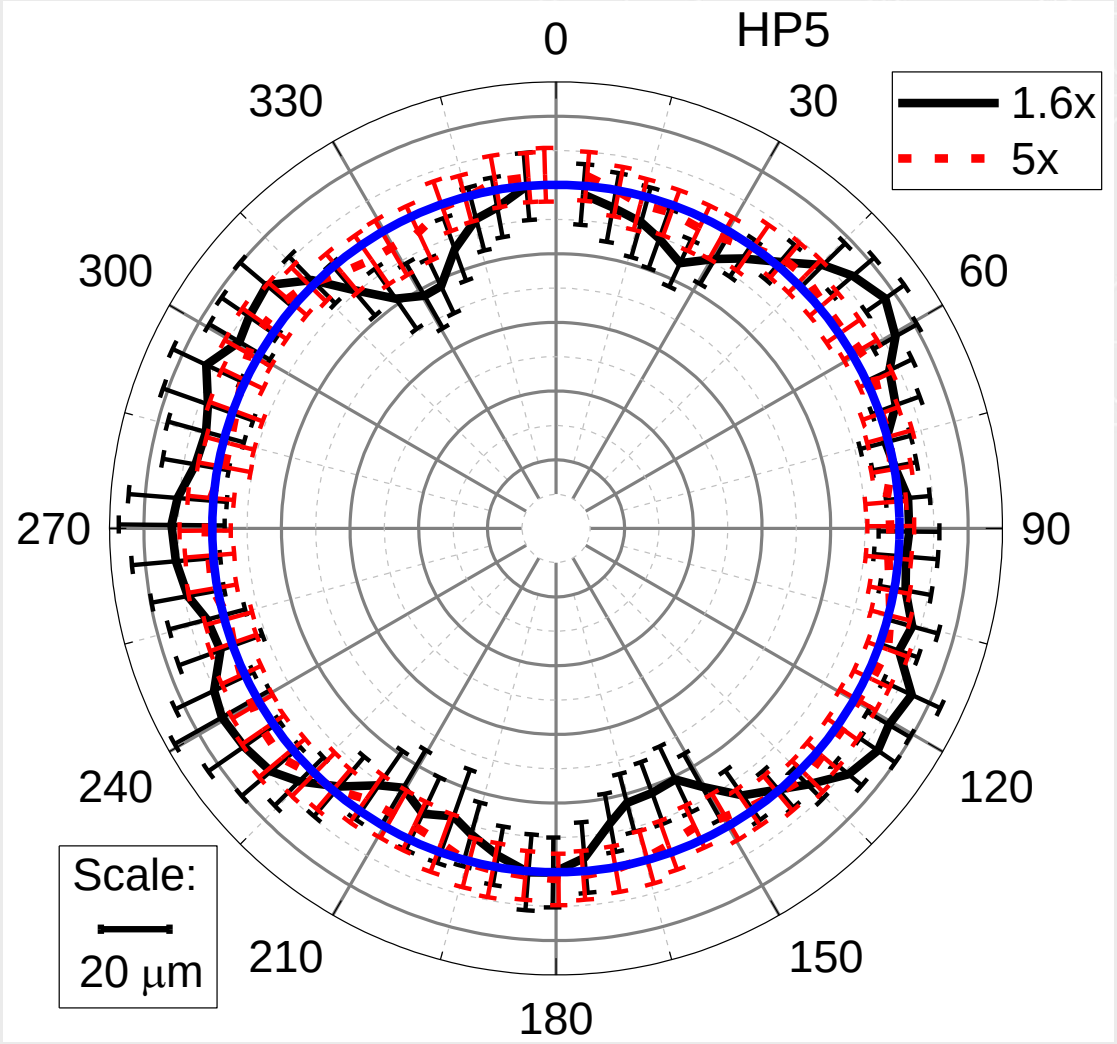






Magnification

- Deformation in geometry has the same systematic variation at both magnifications
- Magnitude of deviation decreases with magnification
- The noise in the deviation decreases with magnification (22 µm to 5 µm)



Simulations

- Simulated a series of 2D images in Matlab
- Intensity of pixel computed from the path length taken by a single central ray for each pixel in the detector
- The sum of attenuation coefficients – weighted for spectrum was used
- Beam hardening not applied
- Reconstructed in CT Pro as usual

Summary and further work

- Experimental X-ray reconstructions of simple and complex holeplates demonstrate systematic deviations in recovered hole geometry of the order of 60µm
- Simulation of holeplate radial deformation based on X-ray path length shows a close correlation to experimental data with maximum deviations of up to 90 µm
- Position of hole within the holeplate effects the apparent geometry of the hole
  - Away from centre of object and rotation
- The orientation of the holeplate during imaging effects the apparent geometry
  - Extremes in path lengths depending on the projection
- Beam hardening has yet to be added to the simulation

Thank you for your attention.

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