

## National Physical Laboratory

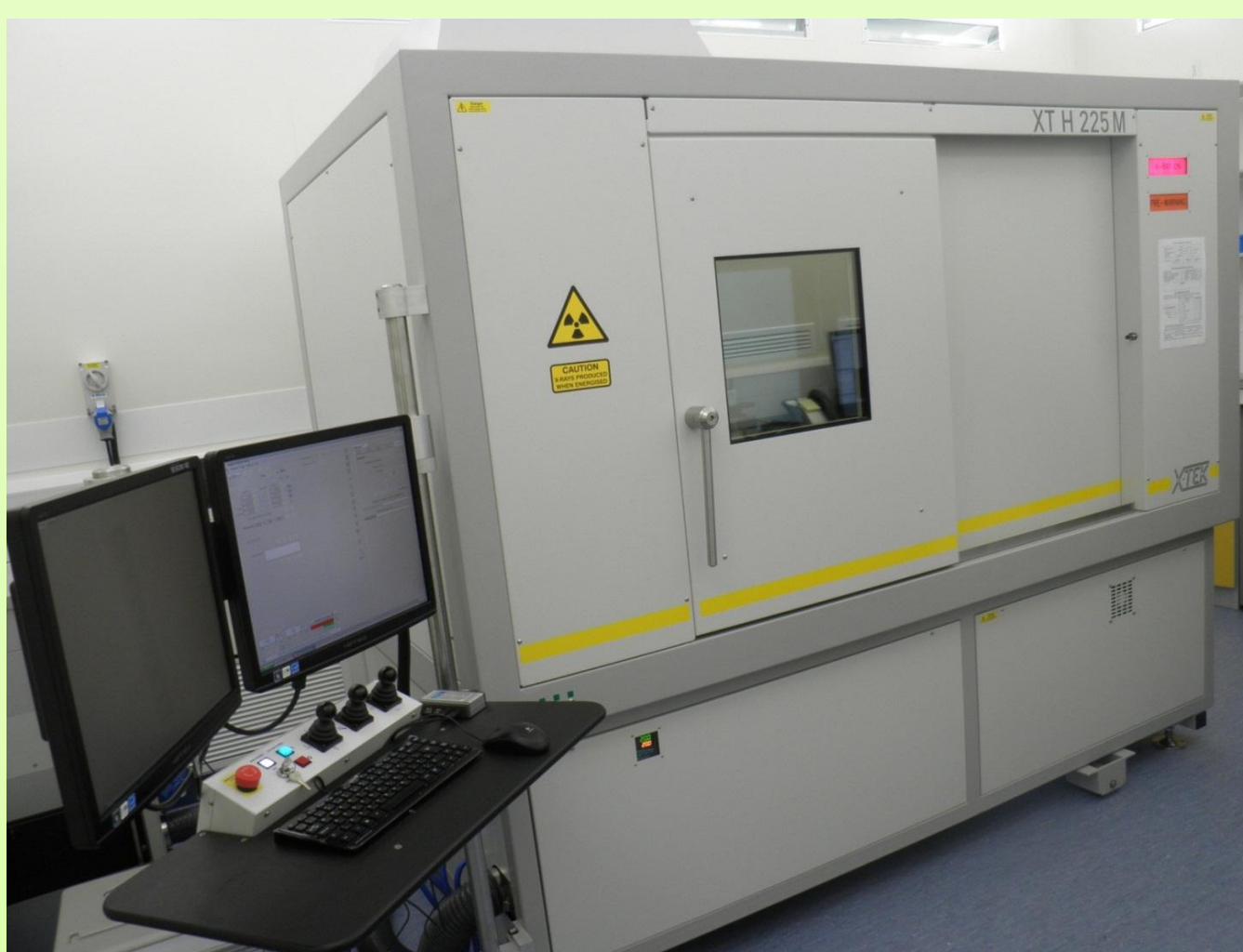
The National Physical Laboratory (NPL) is the national measurement institute of the United Kingdom. NPL has developed and maintained the nation's primary measurement standards for more than a century.

NPL has developed comprehensive measurement solutions for surface topography measurements, and provides a wide range of contact and non-contact instruments for both industry and academic applications. These instruments have the highest accuracy (up to sub-nanometre) and direct traceability to the metre for the most demanding measurement applications.

## X-ray Computed Tomography Development at NPL

NPL has been working in x-ray computed tomography (XCT) since 2010. Recently, we have acquired one of Nikon's first XT H 225 M machines, designed for dimensional metrology. Details of the machine are given below:

- X-ray source: 225 kV/225W open tube
- Minimum spot size 3  $\mu\text{m}$
- Reflection target
- Error mapping using laser interferometer
- High resolution detector 200  $\mu\text{m}$  pixel size
- Precision manipulator
- High resolution encoders
- Temperature controlled



XT H 225M

## Terminology

### Performance verification

*provision of objective evidence that a given item fulfils specified requirements*

### Calibration

*operation that, under specified conditions, in a first step, establishes a relation between the **quantity values** with **measurement uncertainties** provided by **measurement standards** and corresponding **indications** with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a **measurement result** from an indication*

## Current and Future Projects

Currently, NPL is working on investigation of the fundamental principles of XCT measurement, both hardware and software. The work will carry out the basic research that will lead to a traceability infrastructure for XCT measurements. Sources of error will be studied and mathematical models will be addressed. The project will also develop performance verification and calibration objects that can be used in industry.

### Performance verification of XCT

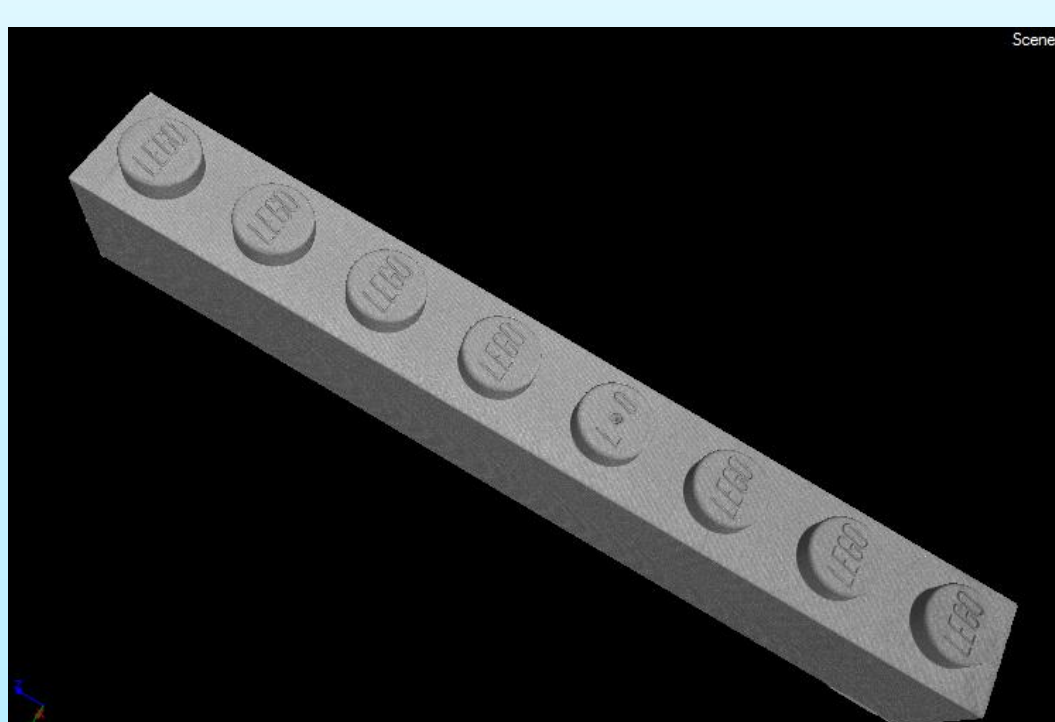
- Verification of XT H 225M machine
- CIA-CT international comparison
- Development of reference objects

### Calibration of XCT

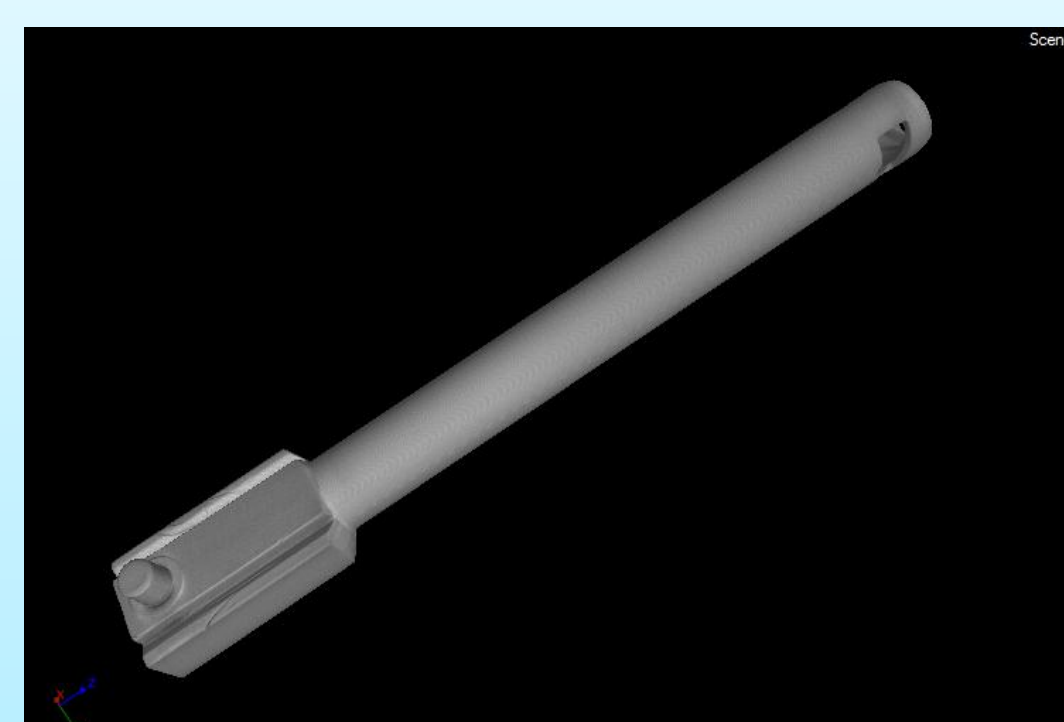
- Investigation of X-ray source (focal spot drift, spectrum, intensity distribution)
- MTF and resolution (PhD with University of Southampton)
- Investigation of CMM errors (PhD with KU Leuven)
- Study of interaction of object and X-rays (PhD with MTC and Loughborough University)
- Verification of reconstruction algorithms (PhD with Nikon and University of Southampton)

### Collaboration with industry and universities

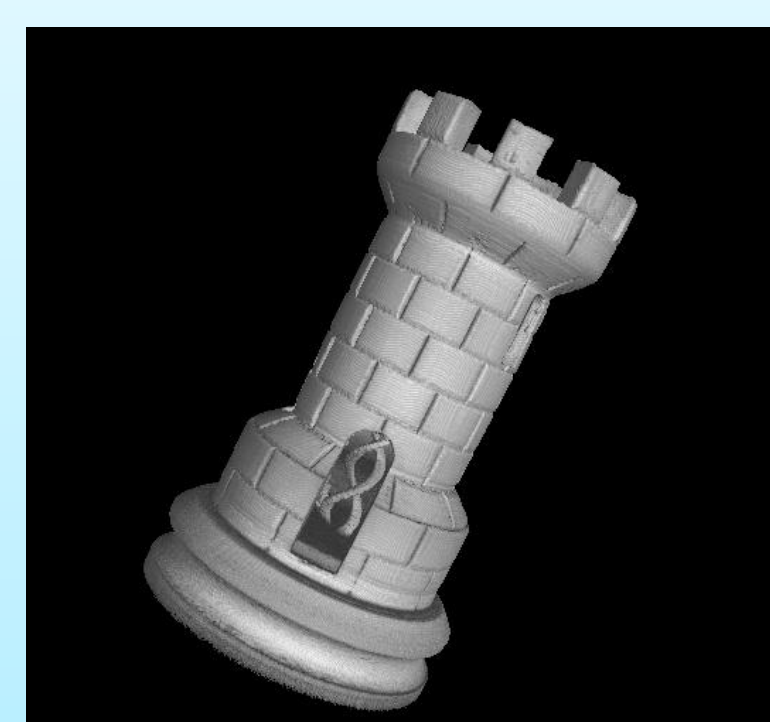
- Leading UK XCT focus group
- UK XCT initiative on calibration involving NPL, Loughborough University, University of Southampton, Nikon, Manufacturing Technology Centre, Rolls Royce
- Strong collaboration with international organisation/universities



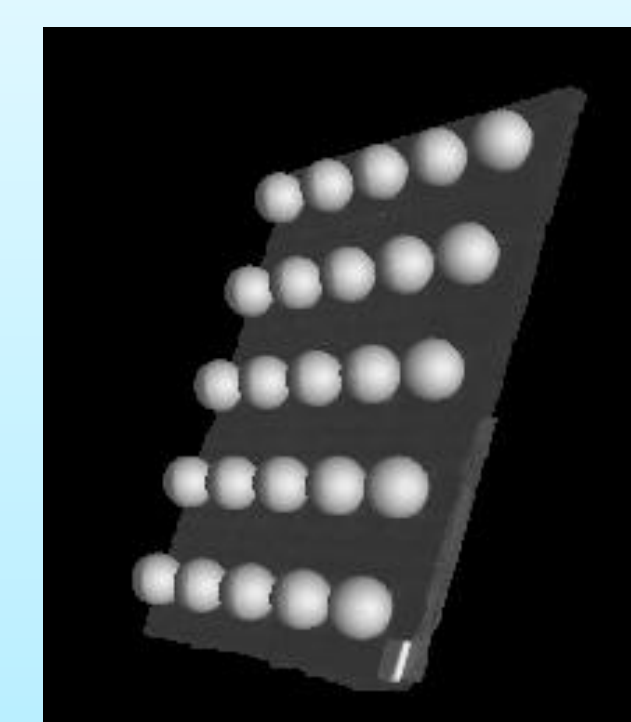
Lego sample measured by XT H 225M system at NPL. Sample courtesy of CIA-CT consortium.



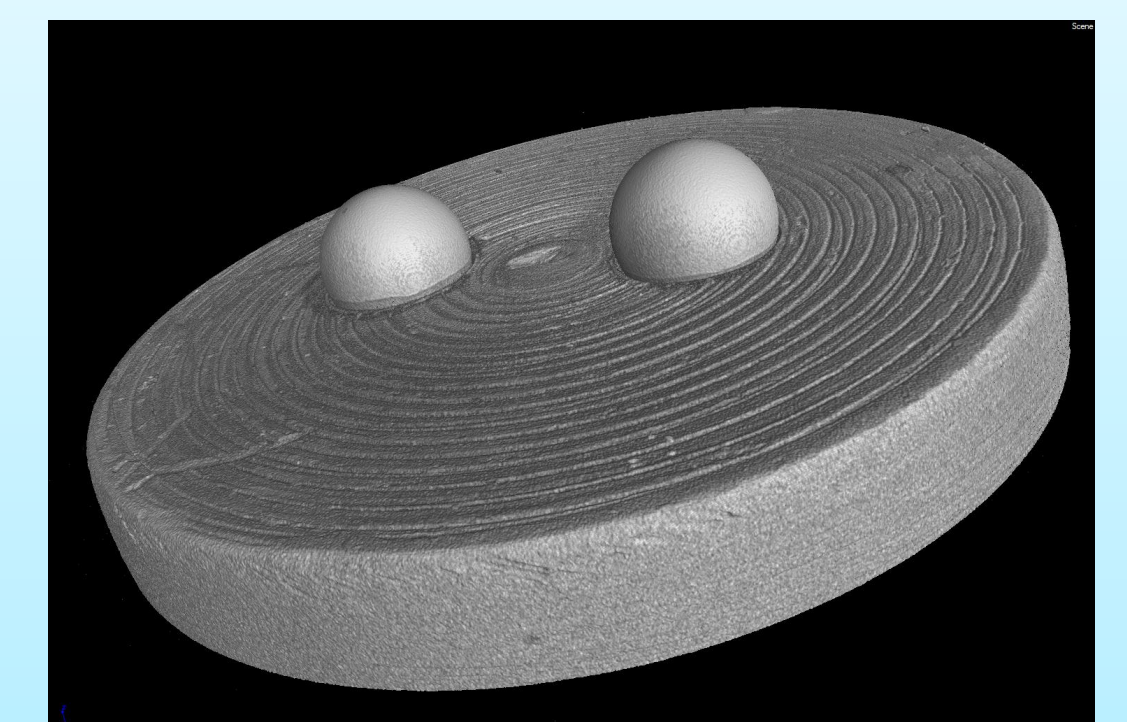
Metal part measured by XT H 225M system at NPL. Sample courtesy of CIA-CT consortium.



DNA castle measured by XT H 225M system at NPL. Sample courtesy of the additive manufacturing and 3D printing research group, University of Nottingham.



CT ball plate measured by XT H 225M. Sample courtesy of University of Padova and Technical University of Denmark.



NPL Calibrated Two Spheres Reference measured by XT H 225M. (sphere diameter is 0.5mm, centre to centre distance is 1 mm.)