Introduction to Computed Tomography (CT)

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Tomography

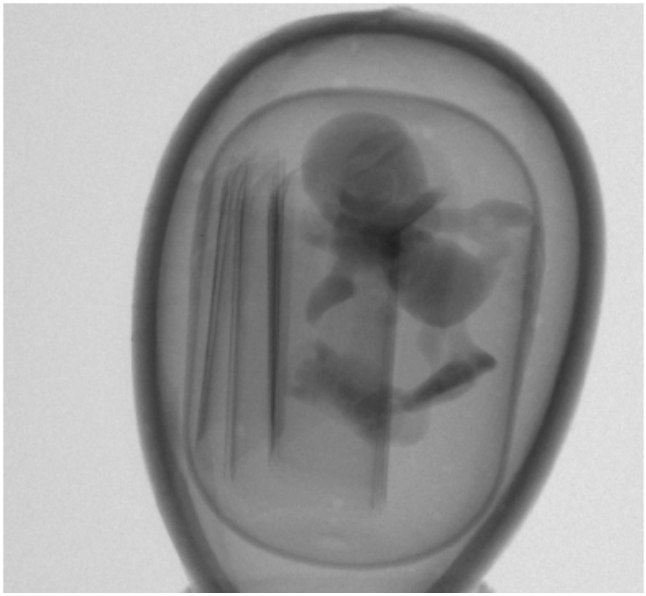
What is tomography?

- From Greek: *Tomos*, a section or slice; *Graphos*, to describe.
- Imaging of slices of an object—without actually slicing it!
- These days not just slices but 3D images can be obtained.
- To see the inside, need information obtained from the outside.
- Some applications of tomography . . .

Look inside Kinder Surprise Egg without opening it!











Tomographic reconstruction: Projections $\rightarrow$ 3D interior model

Medical Imaging





Non-Destructive Inspection and Testing

Production, security, metrology, etc.

Example: airport luggage scanner for threat detection.

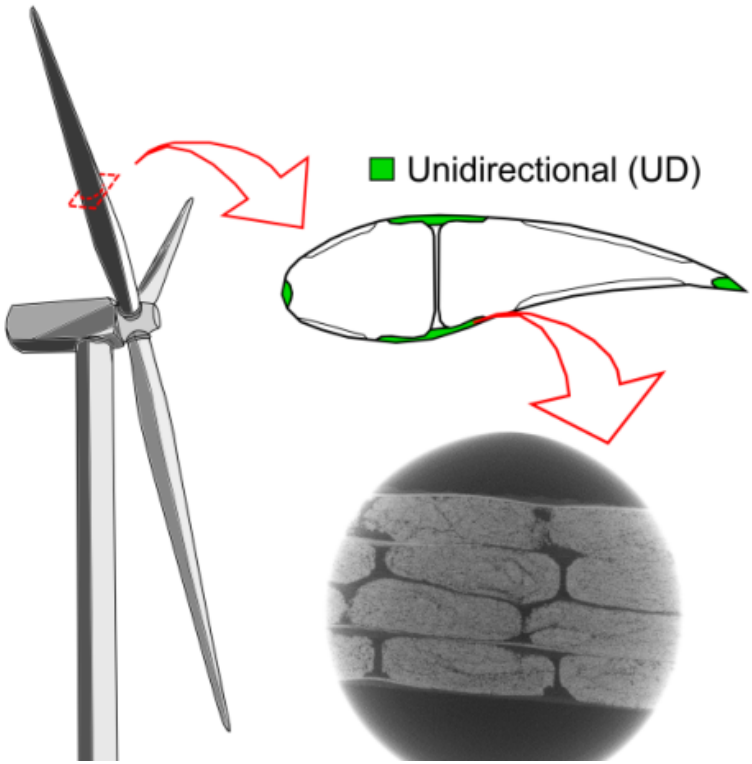


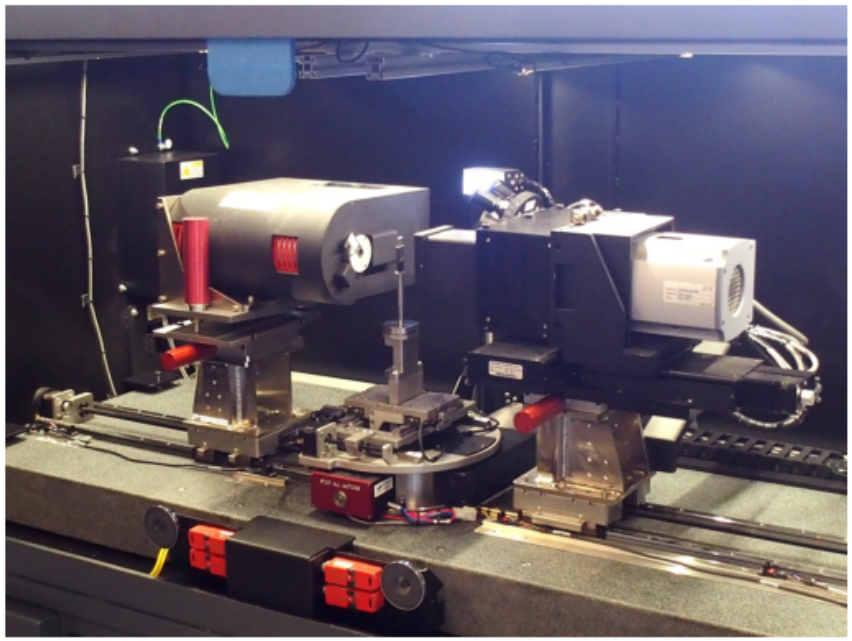
Materials Science

Development of advanced materials requires understanding their properties at the micro and nano scale.

Example: maximize strength of glass fibre for wind turbine blades.

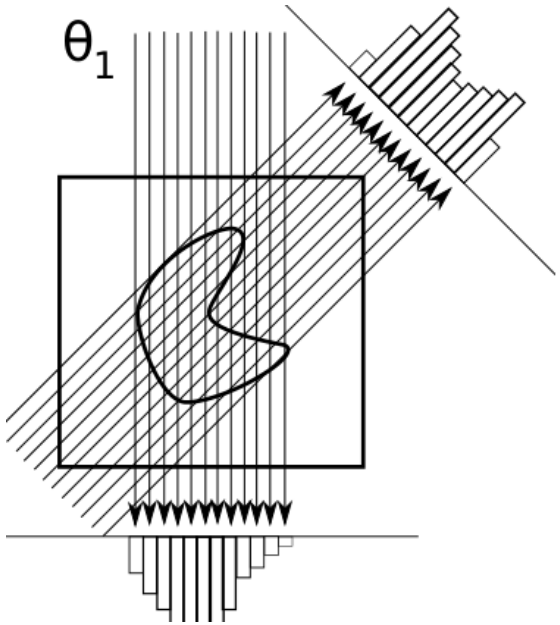
Laboratory micro-CT scanners and large-scale synchrotron facilities.





X-Ray Tomography: imaging from projections

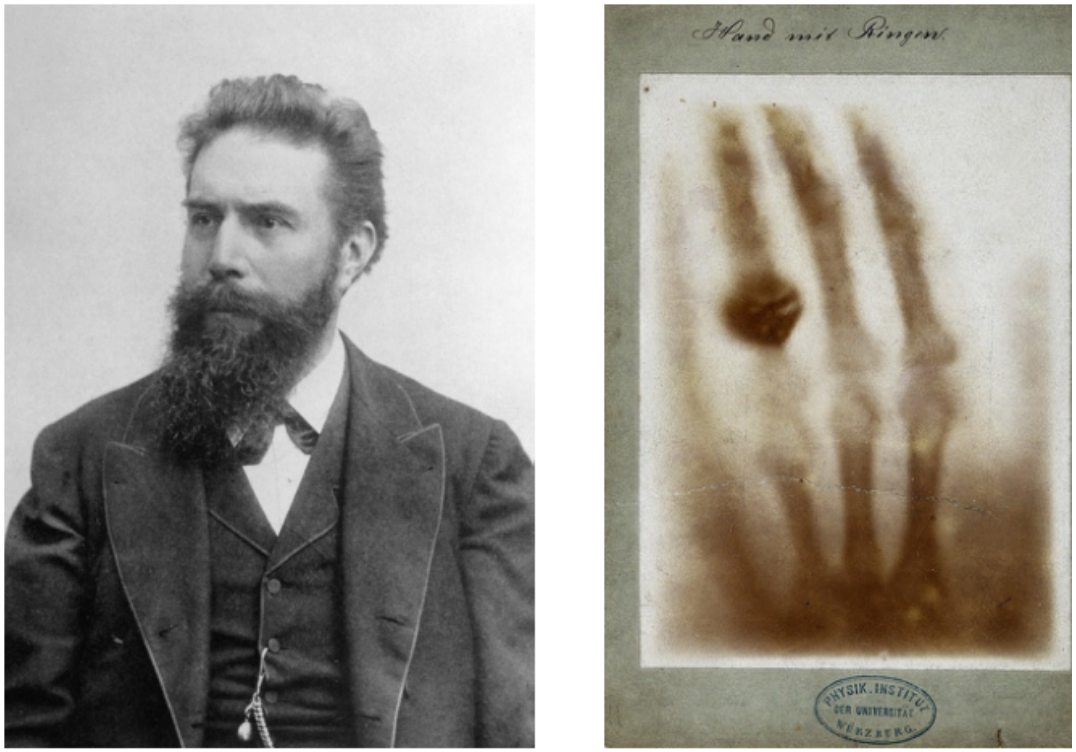
- Projections are measured around an object using X-rays.
- Goal is to reconstruct the object from the projections.
- Simplest is 2D parallel beam geometry, which we focus on.
- Used in early scanners and in large-scale synchrotron facilities.



Contrast mechanism: X-Ray attenuation

"Heavier" matter attenuates X-rays more: air–tissue–bone–metal.

Quantified by the linear attenuation coefficient μ.



Wilhelm Conrad Röntgen and the first X-ray image showing his wife's hand (1895).

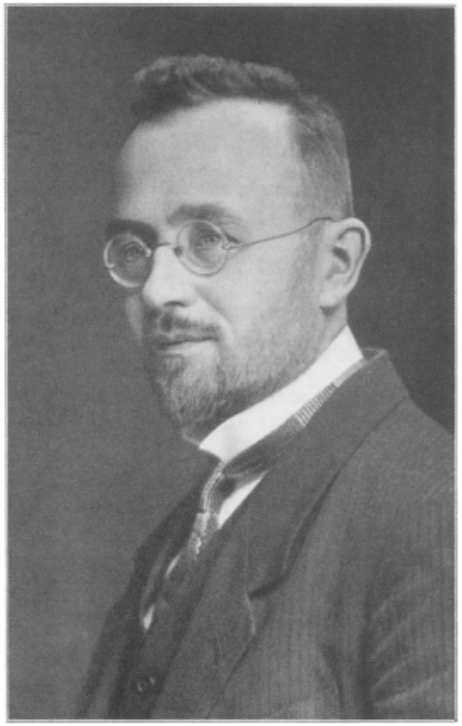
The (abstract) origin of Tomographic Reconstruction

Original reference:

Über die Bestimmung von Funktionen durch ihre Integralwerte längs gewisser Mannigfaltigkeiten.

(Johann Radon, 1917)

An object can be reconstructed **perfectly** from a full set of line integrals.





The (proper) origin of Tomographic Reconstruction

Applications of Radon's work

- Allan Cormack's 1963 and 1964 papers:
  e.g., determination of a variable X-ray absorption coefficient in two dimensions
- Godfrey Hounsfield built and experimental X-ray tomography system:
  tested on a patient in 1971



Joint Nobel prize in Physiology or Medicine in 1979.