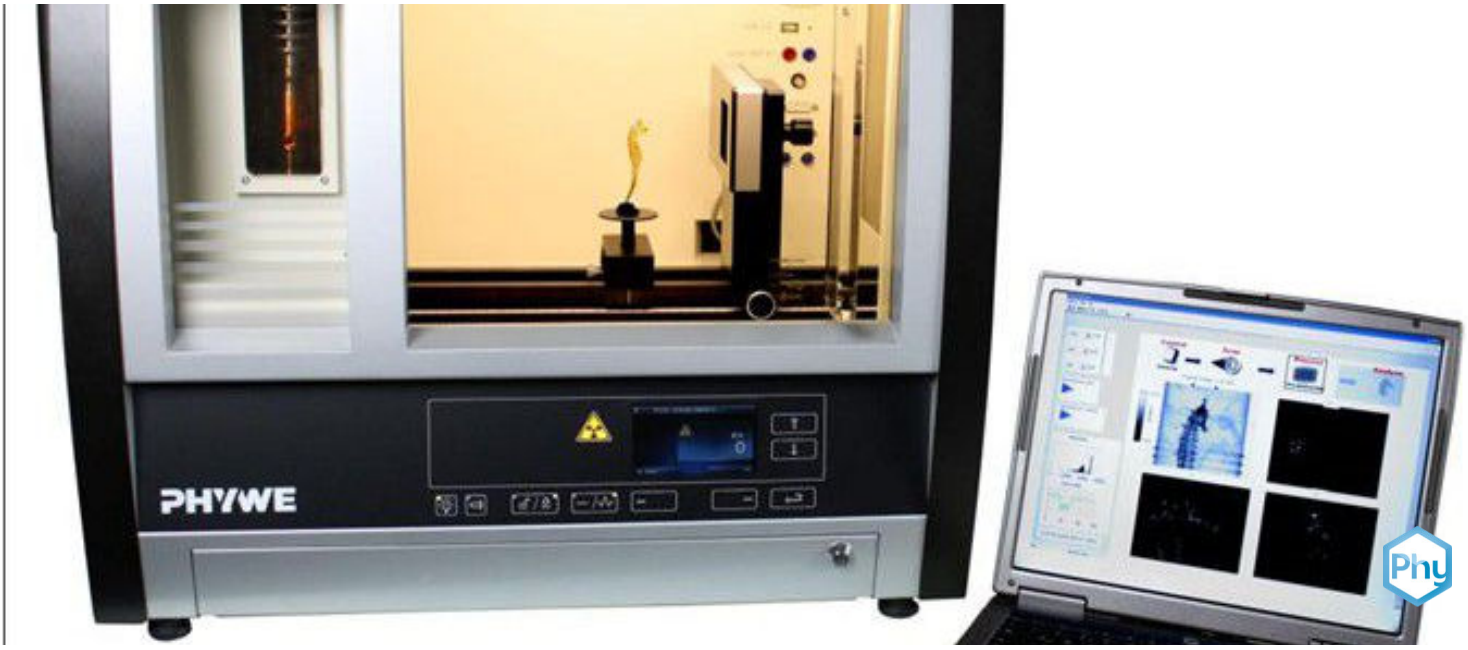
Computed tomography



Physics > Modern Physics > Production & use of X-rays

Difficulty level	Group size	Preparation time	Execution time
hard	2	45+ minutes	45+ minutes

This content can also be found online at:

http://localhost:1337/c/5f9860d76ae01200034530d1

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General information

Application

Computer Tomography is widely used in the medical sector in helping with the identification of wounds and illnesses. Using X-rays detailed pictures of organs can be produced.

Setup

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Other information (1/2)

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Prior knowledge

The prior knowledge for this experiment is found in the Theory section.

Main principle

The CT principle is demonstrated with the aid of simple objects. In the case of very simple targets, only a few images need to be taken in order to achieve a good result. The more complicated the objects are, the more images are necessary in order to show all the details. In addition, special samples are used to demonstrate how artefacts are generated and what causes beam hardening.

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Other information (2/2)

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Learning objective

The goal of this experiment is to get to know the principles behind computer tomography

Tasks

1. Record a CT scan of the simple objects. While doing so, vary the number of steps.
2. Record a CT scan of the metal samples and analyse the result in view of beam hardening.

Theory (1/4)

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Computed tomography (CT) is a procedure for creating superposition-free sectional images of a body or object. It enables doctors to see the inside of their patients. This makes it indispensable for medical diagnostics. However, computed tomography goes beyond medical applications. As a non-destructive method, it is also used in numerous ways in material testing applications.

Nowadays, volume images of the test objects can be created with modern computer programs. Apart from computed tomography, other important imaging techniques are magnetic resonance imaging (MRI) and ultrasound tomography (UST). These techniques differ from each other more or less strongly in terms of the actual method as well as in terms of their application in various medical fields. CT, for example, is often used to visualise the "hard" elements of the body, e.g. bones, whereas magnetic resonance imaging is more suitable for the visualisation of soft tissues.

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Theory (2/4)

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X-ray imaging is the projection of a three-dimensional object on a two-dimensional plane:

- Inner structures are superimposed.
- The exact position of different organs is difficult to determine.

During a CT scan, sectional images are created based on two-dimensional images and with the aid of special algorithms. Fundamental principles of the image acquisition during computed tomography. The technique is based on the so-called "filtered back projection" (the method is based on Johann Radon).The computer divides the object into a square matrix. This matrix corresponds to the pixels of the image.

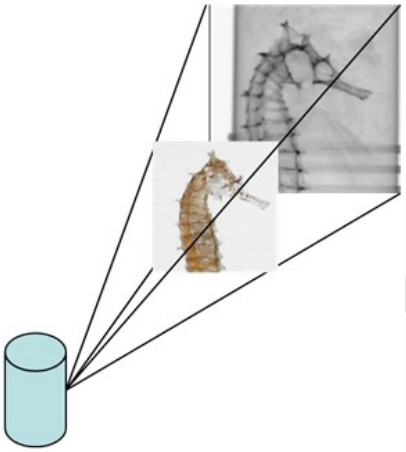

Fig. 1: Principle of an X-ray scan

Theory (3/4)

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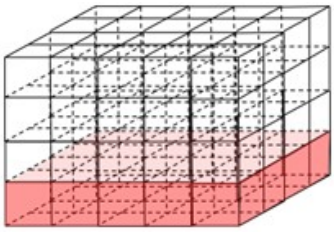
The measured intensity is converted into levels of grey and then entered into this square matrix along the beam path. It is not known where exactly the attenuation occurred. Let us take only one section of the 3D object:



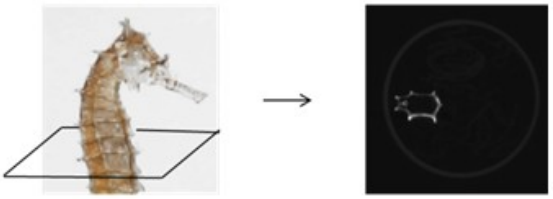


Fig. 2: Principle of a CT scan

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Equipment

Position	Material	Item No.	Quantity
1	XR 4.0 expert unit, 35 kV	09057-99	1
2	XR4 X-ray plug-in W tube	09057-81	1
3	XR 4.0 X-ray Computed Tomography upgrade set	09185-88	1

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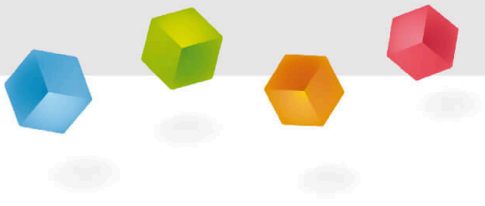

Setup and Procedure

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Setup

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- Connect the rotary stage XRstage to the corresponding connector in the experiment chamber (see the marking in Fig. 3). Connect the X-ray camera XRIS directly to the PC by way of a USB cable. The PC and X-ray unit are connected by way of the data cable and via the USB port (the corresponding connector on the X-ray unit is marked in Fig. 4). Fasten the rotary stage to the motor with the aid of the small knurled screw. Ensure that the selected object is securely connected to the stage and that it cannot change its position during the scan.

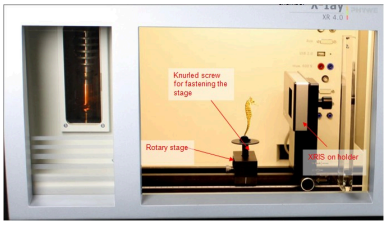

Fig. 5: Set-up in the X-ray unit

Fig. 3: Connectors in the experiment chamber

Fig. 4: Connection of the multi-channel analyser

Procedure (1/3)

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- Start the "measure CT" program. The program displays a dialog box requesting the user to calibrate the camera. Remove any objects located between the camera and the X-ray source. Lock the door and click the "Calibrate" button (1) in the software.

1st mode: "Live image and settings", Fig. 6

- Adjust the distance between the source and the object (2) or between the source and the camera (3). Select 200 projections per 360° (4).
- Now, place an object in front of the active area of the camera and click "Play" (5). In order to interrupt the live mode, click "Play" again. Check the position of your sample and click the next status "CT scan" (6) when you want to start a scanning process.

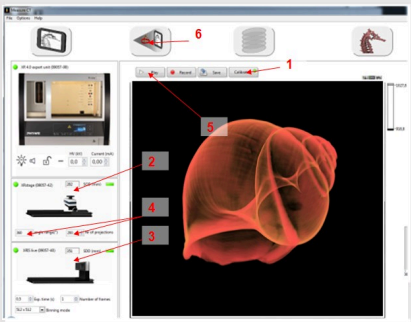

Fig. 6: Screenshot in the mode "Live image and settings"

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Procedure (2/3)

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2nd mode: "CT scan", Fig. 7

- 2nd mode: "CT scan", Fig. 6

3rd mode "Reconstruction", Fig. 8

Click "Select data" (9) in order to open the correct folder. Click "Current folder". Change the COR value (centre of rotation) (10) until the sectional image (11) is satisfactory.

Then, click "Reconstruct volume" (12). It will now take approximately 3 minutes for the reconstructions to be complete.

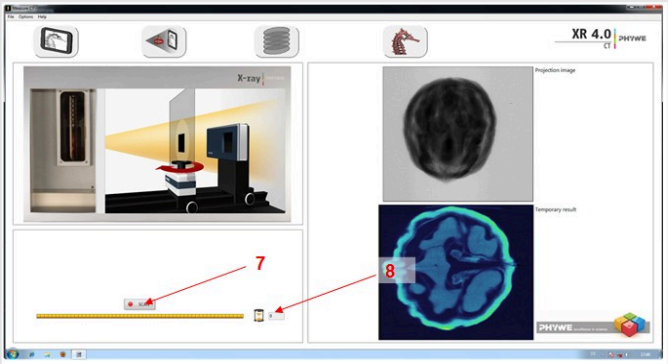

Fig. 7: Screenshot in the "CT scan" mode

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