Z39(X4) - X-rays Imaging

Physics Laboratory II – academic year 2017/2018
Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University

The aim of the exercise is to gain quantitative and qualitative knowledge of the fundamental physical phenomena used in X-rays imaging. The X-rays absorption coefficients for different materials are measured, and radiographic images of various objects are studied.

Preparatory questions

1. X-ray sources, X-rays production mechanism [1, 2].
2. Spectral lines of atoms and their relation to electron shells [1].
3. X-rays absorption [1, 3, 4, 5].
4. Geiger-Müller detector – characteristics, construction, energy resolution [2].

Computational assignments

Calculate the thickness of a lead plate for which the absorption of X-rays is the same as for an aluminum plate of a predetermined thickness x_0.

Apparatus and materials

Experimental setup presented in Fig. 1A consists of:

1. X-ray unit with with replaceable X-ray tubes made of Cu or Mo.
2. Goniometer mounted inside the X-ray unit.
3. Geiger-Müller detector for X-rays detection.
4. LiF crystal for the analysis of X-rays energy.
5. Absorption foils made of various materials.
6. Computer.

Experimental set-up presented in Fig. 1B consists of:

1. X-ray unit with W tube.
2. Photographed object (as eg. implant model shown in the figure).
3. Fluorescent screen.
4. Digital camera.

Experiment

1. Energy spectra calibration using direct X-rays from Cu and Mo X-ray tubes.
2. Mount Cu tube and LiF crystal at an angle of 20.4^o. Measure X-rays spectrum. For absorption foils made of various materials measure count rate in the peak as a function of foil thickness.
3. Mount Mo tube and LiF crystal at an angle of 21.5^o. Repeat measurements as in point 2.
4. Dismount goniometer, mount W tube. Place fluorescent screen at the end of X-ray unit chamber and mount digital camera outside the chamber.
5. Just before the screen place the photographed object. Take pictures at different settings of voltage and current of X-ray tube. Move the object farther from the screen and then take the pictures again.
6. Set the implant model just before the screen. For the maximum voltage and current of X-ray tube take pictures by turning the implant model three times by 90^o.

Data analysis

1. Perform energy calibration for the measured X-ray spectra.
2. Determine the X-ray energy for the observed peak measured with the crystal.
3. Plot the dependence of the number of counts N as a function of the foil thickness x for various materials. Fit this relationship using a function $N(x) = N_o e^{-\mu x}$. Compare the determined absorption coefficients m for the various foil materials and X-rays energy.
4. Determine for which X-ray tube working conditions the optimum contrast and focus of the photographed object is obtained. Check how the magnification depends on the distance of the object from the screen.
5. Determine the shape, location and size of the object hidden in the implant model.

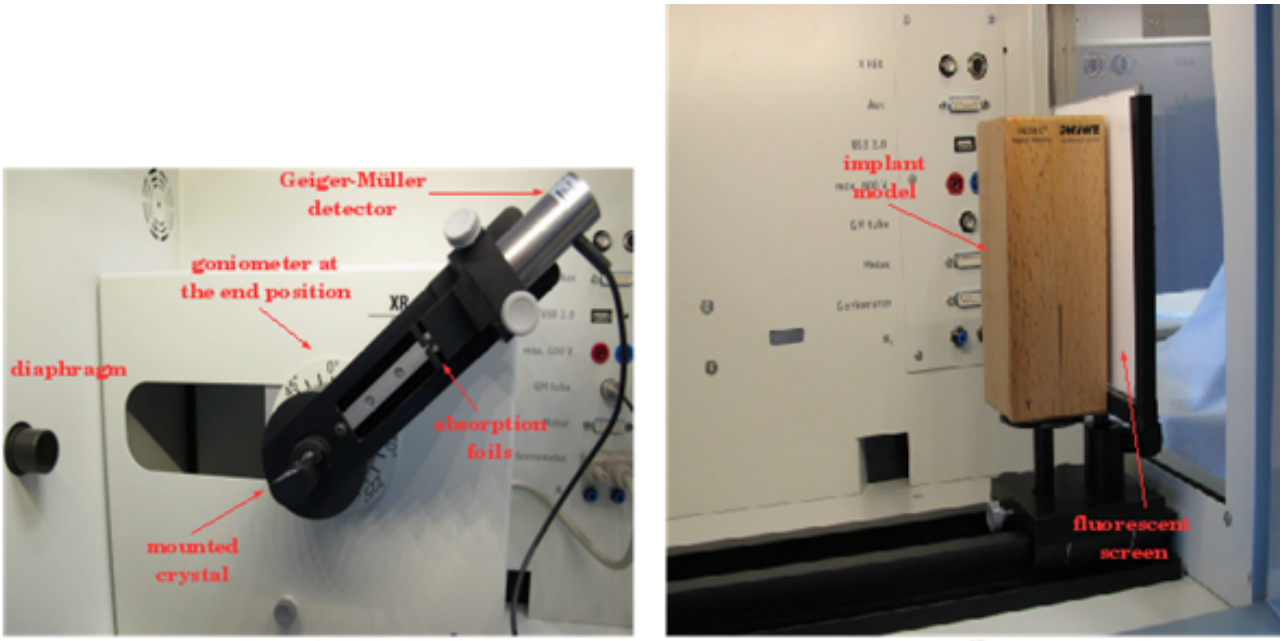

Figure 1: Experimental setup

References

[1] K. S. Krane, *Introductory Nuclear Physics*, John Wiley & Sons.

[2] W.R. Leo, *Techniques for nuclear and particle physics experiments*, S.-Verlag 1987.

[3] repository.phywe.de/files/versuchsanleitungen /p2540020/e/p2540020e.pdf

[4] repository.phywe.de/files/versuchsanleitungen /p2542001/e/p2542001e.pdf

[5] repository.phywe.de/files/versuchsanleitungen /p2541101/e/p2541101e.pdf