Rules of work in the educational laboratory of atomic and nuclear physics (2024 spring semester)

Work safety instructions

In some experiments, radioactive samples are used. Although the amount of radioactive material in each sample is very small (much less than one microgram) and the samples are sealed, they should not be held in a hand for a prolonged period of time. This is because of the "inverse-square law": the radiation intensity is inversely proportional to the square of the distance to the source of radiation. Thus, for example, if a person holds a radioactive sample in a hand, then the dose rate (the energy absorbed in unit mass per unit time) in the biological tissues of the hand exceeds the dose rate at a distance of 1 meter by a factor of $10^3 - 10^4$. Consequently, the radioactive samples should be touched only when it is necessary for the experiment, i.e., when putting the sample into its holder, or when removing the sample. Each radioactive sample must be returned to the laboratory supervisor when the sample is no longer needed for further measurements, or immediately after finishing the measurements. Note: Between the laboratory experiments, the samples are kept in another room, in a special safe.

Rules of work

During each semester, each student performs five laboratory experiments. The experiments are done according to a rolling schedule (every two or three weeks). During the week preceding the measurements, the student writes the introductory part of the final report, consisting of the title, the aims of the experiment, and the theoretical introduction. During one or two weeks that follow the measurements, the final report must be written.

When a student arrives to the laboratory for the experiment, the introductory part of the report must be presented to the laboratory supervisor in order to be allowed to perform the measurements (it may be presented either in a printed form, or on a tablet, notebook or laptop computer). In addition, the student must answer a question or two regarding the theory or the measurement procedure of the experiment.

Immediately after finishing the measurements, the student presents the tables with the experimental data to the laboratory supervisor. If the data indicate that the measurements have been performed correctly, the supervisor puts his signature below the tables. If the data were written to one of the computers of the laboratory, then those data may be copied to a USB flash drive or sent by e-mail to any location (there is an Internet connection in the laboratory). But in any case the tables with the "raw" experimental data must be printed (using the printer available in the laboratory), so that they can be signed by the supervisor. The data files must not be deleted from the computer. Later on, those tables (including the signature) will have to be included in the final report.

Preparation for an experiment and writing the introductory part of the report

All the information needed for each laboratory experiment is in a corresponding instruction manual. The links to PDF files with the instruction manuals are available on the web page http://web.vu.lt/ff/a.poskus/nuclear-physics-laboratory/. The reports may be written using a computer (i.e., with a word processor), or by hand (in the work journal).

At the beginning of the report (after the title page), the aims and tasks of the experiment must be listed. After that, there must be an introduction to the theory of the experiment. The introduction must be concise (2 – 4 pages of size A4, if the font size is 12 pt and single-spaced lines are used). The theoretical introduction must contain the definitions of the main terms that are needed for the experiment, as well as statement of the main physical regularities and properties that are investigated during the experiment. Examples of such statements are:

- definition of the term “absorption coefficient” (if one of the aims of the experiment is investigation of absorption of radiation in matter), or “decay half-life” (if one of the aims is investigation of decay curves of radioactive nuclides),
- formulation of the exponential dependence of radiation intensity on thickness of the absorbing material (if one of the aims of the experiment is investigation of absorption of radiation in matter),
- graphs illustrating the mentioned dependences.

There is no need to provide a detailed description of the measurement procedure in the report. Instead, only the main steps of the procedure should be listed. For example: “(a) measure the background, (b) measure the beta radiation intensity using different values of the absorber thickness, (c) measure the alpha radiation intensity at different distances between the source of alpha particles and the detector”.

Writing the final report

During the week that follows the measurements, the experimental data must be processed. This includes calculation of all the quantities that are mentioned in the tasks of the experiment, their uncertainties, creating the graphs illustrating the observed regularities, and the tables with the summary of the results of the analysis. Those calculations, graphs and tables must be presented in the section titled “Analysis of Data”. All the observed regularities and the possible deviations from the predictions of the theory must be discussed in the section titled “Discussion of Results”. The final section of the report is called “Conclusions”. It must contain the final values of the main quantities that were determined during the experiment, and several sentences summarizing the results of the experiment (for example, evaluation of the accuracy of the measurement method, and the reasons of the differences between the obtained results and the predictions of the theory).

A link to a sample report is available on the web page of the laboratory (the mentioned link is https://web.vu.lt/ff/a.poskus/files/2013/10/No08_sample_report.pdf). There is also a link with more detailed guidelines (https://web.vu.lt/ff/a.poskus/files/2013/10/Guide-to-Laboratory-Report-Writing.pdf).

If the student does not have the software needed for the analysis of the measurement data, then the software will be made available for the student.

Evaluation of the laboratory reports and requirements for permission to start a new experiment

In the spring semester of 2024, the students will not be required to “defend” the lab reports, or to provide an oral presentation either of theory or experimental results. Instead, it will be sufficient for the student to send the file with the final report to the laboratory supervisor by e-mail, or share it (using, for example, “Microsoft OneDrive”). Ideally, this should be done during the seven days after the measurements (at any time convenient to the student). The final report may be in a .docx or .pdf file. If it was written by hand, then a scanned or photographed image of it must be sent. In addition to the sections of the report that were mentioned previously (i.e., theoretical introduction, analysis of data, discussion of results, and conclusions), it must contain the “raw” (unprocessed) data of the experiment, i.e., the same data that were presented to the laboratory supervisor for signing. Those data must be included as a scanned or photographed image (the signature of the laboratory supervisor must also be visible).

Each final report is evaluated on a scale of 1 to 10. After reading the report received from a student, the student is sent an email with the final mark for the experiment, and the explanatory remarks. The final mark depends on the quality of the report (including both its contents and its structure) and, to a lesser extent, on the degree of preparation of the student for the experiment before starting the measurements.

In order to be allowed to start a new experiment, there must be no more than one pending final report (i.e., missing report corresponding to an experiment whose measurements have been performed already). If there are two pending reports, then the student will be allowed to proceed with the next experiment only after sending at least one of the pending reports, and if it is sent too late (i.e., with less than one week remaining until the measurements), then the final mark for the experiment will be reduced by one point (excluding the cases when the delay was due to objective reasons). This requirement does not apply when there is only one pending report (for example, after the first experiment): its final mark will not be reduced even if it is sent with less than one week remaining until the measurements of the next experiment (or after them).

After evaluating all five final reports, an average mark is calculated. A part of it is included in the final mark for the exam (the mentioned part is set by the professor who delivers the course of atomic and nuclear physics).