Exercise J13 - Measurement of neutron flux

March 25, 2025

1 Introduction

The purpose of this exercise is to measure neutron flux from Pu-Be neutron source at several distances, using Lithium Iodine europium activated scintillator, and compare results with those obtained with activation method involving tungsten sample and a HPGe detector.

2 Required reading

1. Pu-Be neutron source, neutron moderation ([1]-1.V).
2. Interaction of γ-rays with matter: photoelectric absorption, Compton scattering, pair production ([1]-2.III.A).
3. Interaction of neutrons with matter and their detection ([1]-14, [1]-15).
4. Electronic signal processing (preamplifier, amplifier, multichannel analyzer) ([2]-14.1, 14.2, [1]-16.III, 18-III).
5. Energy resolution, energy calibration, efficiency calibration ([1]-4.V, 4.VI)
6. Statistical and systematical uncertainties in radiation measurements ([1]-3.II).
7. Decay schemes ([2]-1.1, 1.3).
8. Biological effects of ionizing radiation and dosimetry ([2]-3).

3 Outline

1. Introduction to experimental setup: neutron source, calibration sources, detectors, HV power supplies, amplifiers, analyzer and computer program.
2. Determination of measurement conditions (resolution optimization) of LiI detector

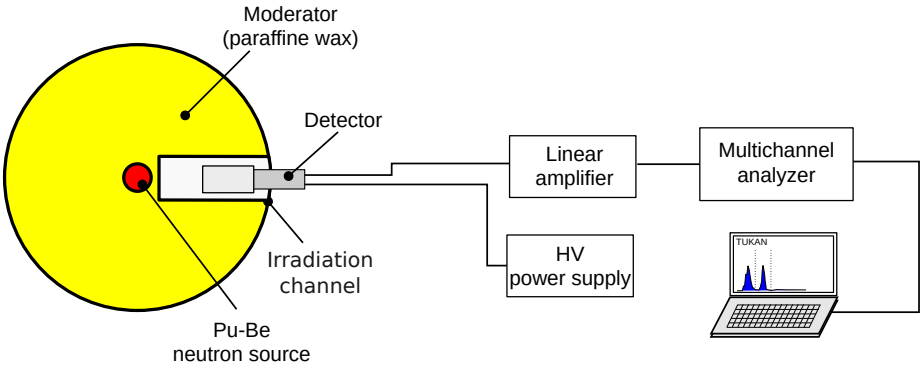

Figure 1: Overview of the experimental setup (scintillation detectors).

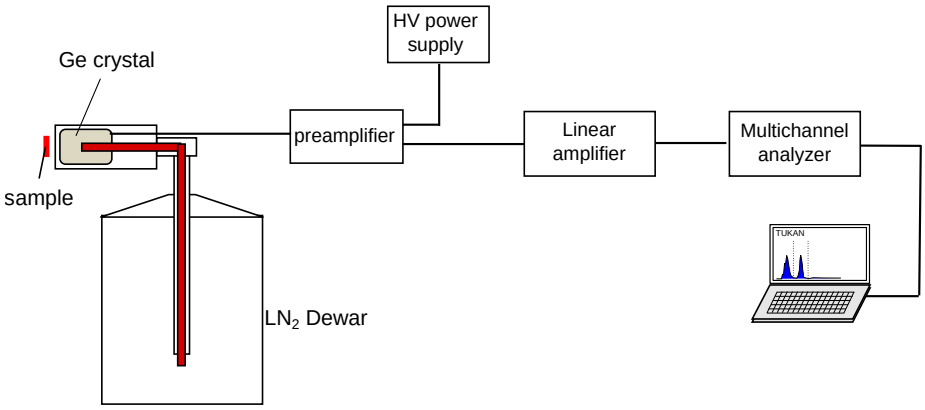

Figure 2: Overview of the experimental setup (Ge detector)

3. Measurement of radiation with LiI detector:
   - unshielded detector,
   - with lead shielding,
   - with light material shielding.
4. Energy calibration of NaI detector with standard sources
5. Measurement of radiation with NaI detector:
   - unshielded detector,
   - with lead shielding,
   - with light material shielding.
6. Measurement of neutron flux in the function of distance to the source
7. Activation of a tungsten sample in the neutron source
8. Optimization of the Ge detector setup with ^{137}Cs source

9. Energy and efficiency calibration of the Ge detector with ^{152}Eu source
10. Measurement of the activated tungsten sample decay spectrum with the Ge detector

4 Data analysis

A laboratory report is a kind of essay, and it should be written with correct spelling and grammar. It should follow logical reasoning, keeping in mind that a person that never done the exercise before, should understand what were the objectives, methods and results.

It should be structured with sections like introduction, methods, results, and conclusions. The introduction should define the purpose of the experiment, put possible hypotheses to be tested, refer to previous studies, and briefly describe the method to be used. The main part, consisting of a more detailed description of the procedure and results, should include figures, and schemes, clearly presented, including labels, legends, units, and other elements. It is not needed to copy textbook knowledge, instead, it is better to select the key information on used methods and equipment and focus on the actual experiment and results. Numerical values should be presented with uncertainties. In the conclusions, one should discuss whether the result confirms expectations or predictions, how it compares to the literature, what is the source of discrepancies, or the main component of uncertainty, if something could be improved, etc.

Main analysis steps

1. Energy calibration of the detectors (NaI, LiI, Ge)
2. Analysis of statistical and systematical uncertainties of calibration
3. Determination of the gamma background and other features of the LiI detector spectrum.
4. Analysis of the neutron flux in 6 positions in respect to the neutron source
5. Analysis of the neutron flux with activation method (tungsten sample)
6. Comparison of the results with expected values and discussion

References

[1] G. Knoll "Radiation detection and measurement", ed. III or IV, J. Wiley and Sons

[2] C. Leo, "Techniques for Nuclear and Particle Physics Experiments" ed. II, Springer 1994

[3] S. Brandt "Data analysis", ed. IV, Springer 2014

[4] Chart of Nuclides, www.nndc.bnl.gov/nudat3/