Exercise J14 - Measurement of range, range straggling, stopping power, and energy straggling of alpha particles in air

1 Introduction

Charged particles interaction with matter are experimentally studied since the very beginning of nuclear physics. Understatement of this phenomenon was necessary to develop detection methods and basic nuclear physics research. In measurements of that type we focus on particles range and straggling, depending on their energy and matter properties, and this will be studied in the following exercise. We shell use the method described by publication [1], closely following the described procedure.

2 Required reading

1. Heavy charged particles interaction with matter ([2]-2.I):
   a) energy losses, Bethe equation, dependency on particle charge and energy, and matter properties;
   b) shape of energy losses along the particle track (Bragg curve);
   c) dependency of an average energy and straggling on depth;
   d) range of heavy charged particles;
   e) range straggling.
2. Heavy charged particles detection with semiconductor detectors. ([2]-11.IV.2) Principles of operation ([3]-14.1, 14.2, [2]-16.III, 18-III) of
   a) surface barrier silicon detector
   b) charge preamplifier,
   c) linear amplifier,
   d) multichannel analyzer.
3. Statistical and systematical uncertainties in radiation measurements ([2]-3.II).
4. Read publication [1]. How is the air thickness being changed? Why such a method was selected? What is the range of air thicknesses measured?

3 Outline

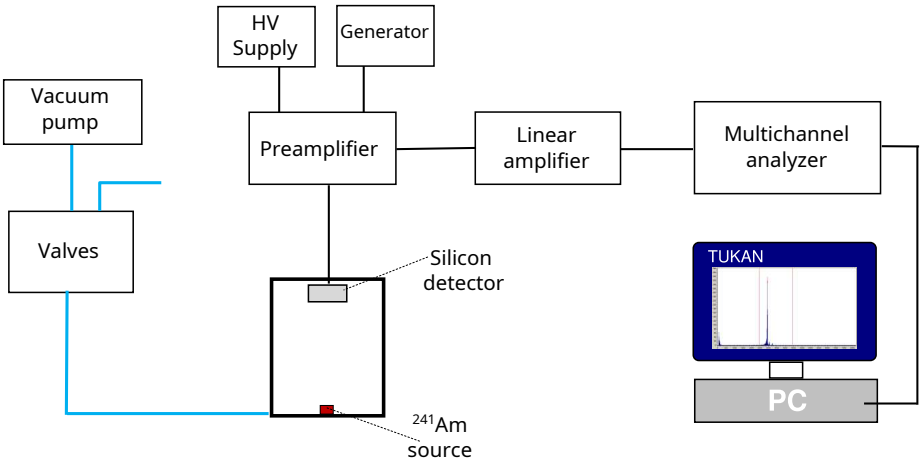

Figure 1: Overview of the experimental setup

1. Introduction to experimental setup: pressure valves, detector, HV power supplies, amplifiers, analyzer and computer program.
2. Calibration of pressure sensor
3. Calibration of silicon detector
4. Measurement of α spectrum at selected pressure values

4 Analysis

Laboratory report is a kind of an essay, and it should be written with correct spelling and grammar. It should follow a logic reasoning, having 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. Introduction should define the purpose of the experiment, put possible hypothesis to be tested, refer to previous studies, and shortly describe the method to be used. The main part, consisting of more detailed description of 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 main component of uncertainty, if something could be improved, etc.

Main analysis steps

1. Calibration of the pressure sensor

2. Calibration of the silicon detector
3. Determination of α particles range
4. Determination of α particles energy in function of air thickness
5. Determination of stopping power in function of air thickness
6. Determination of energy straggling in function of air thickness
7. Comparison of the results with literature data and discussion

References

[1] P.J. Ouseph and A. Mostovych, American Journal of Physics 46 (1978) 7

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

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

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

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