

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

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## 1 Introduction

Charged particle's interaction with matter has been experimentally studied since the very beginning of nuclear physics. Understatement of this phenomenon was necessary to develop detection methods and form basis for the nuclear physics research. In this exercise we will focus on the basic parameters of this process: particle range and straggling, depending on their energy and matter properties. We shall use the method described by publication [1], closely following the described therein 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 average energy and straggling on depth;
  - d) range of heavy charged particles;
  - e) range straggling.
2. Heavy charged particle 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

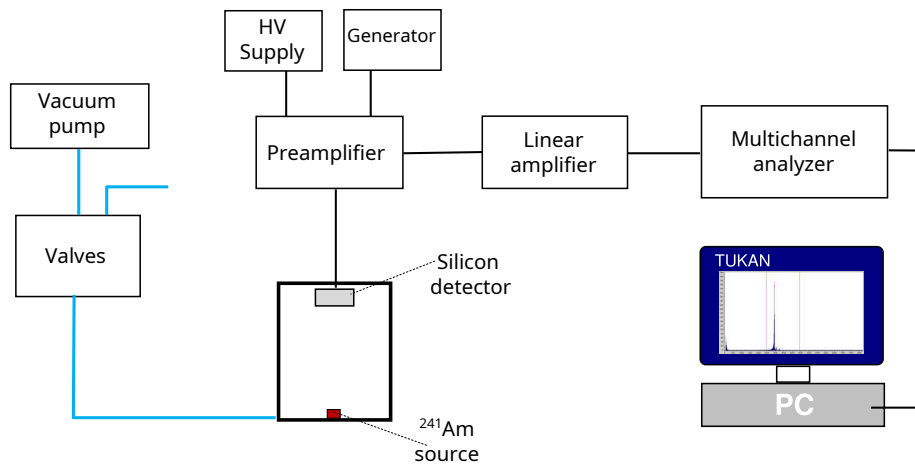


Figure 1: Overview of the experimental setup

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  $\alpha$  spectrum at selected pressure values

### 4 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. Calibration of the pressure sensor
2. Calibration of the silicon detector
3. Determination of  $\alpha$  particles range
4. Determination of  $\alpha$  particles energy in function of air thickness
5. Determination of stopping power in function of air thickness
6. Determination of energy straggling in the 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/](http://www.nndc.bnl.gov/nudat3/)