Z34 - Properties of Germanium Semiconductor Detector and a Scintillation Crystal

Physics Laboratory II – academic year 2017/2018
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The aim of the exercise is to compare the properties of germanium semiconductor detector Ge(Li) and a scintillation crystal NaI(Tl) used for registration of gamma radiation. The following detector properties will be studied: energy resolution, energy calibration and gain sensitivity to count rate changes of registered radiation.

Preparatory questions

1. Gamma radiation. radioactive decay - selection rules for gamma transitions [1].
2. Decay schemes for ^{22}Na, ^{60}Co, ^{133}Ba and ^{137}Cs radioactive sources[3].
3. Interaction of gamma radiation with matter – three basic processes [1].
4. Operation principle of semiconductor and scintillation detectors [1, 2].
5. The parameters characterizing the detection system: resolving power, efficiency, energy calibration, dead time [2].

Computational assignments

Calculate the ratio of the number of particles recorded by the detector when you change the distance between the source and the detector from d to $3d$.

Apparatus and materials

Experimental setup consists of:

- Scintillation detector $NaI(Tl)$ with high voltage power supply and preamplifier.
- Semiconductor detector $Ge(Li)$ with high voltage power supply and preamplifier.
- Amplifier.
- Analog-to digital converter and multi-channel analyzer (ADC+MCA).
- Computer.
- Ruler.
- Radioactive sources.

Experiment

1. Set-up the measurement with scintillation detector $NaI(Tl)$: switch on power to investigate on the oscilloscope the pulses coming directly from the preamplifier and amplifier, selection of gain, registration of the energy spectrum using the ADC+MCA interfaced via the Tukan program on a PC. In the following sections, you cannot change any settings of electronics and photo-multiplier high voltage.
2. Performing the measurement of spectra for all available radioactive sources at low count rate in the detector. Those results will be used for energy calibration of the detection system.
3. Execution of a series of several measurements by setting the source ^{60}Co and ^{137}Cs at different distances from the detector: $1cm$ to $25cm$.
4. Carry out similar measurements using semiconductor detector $Ge(Li)$. The entire procedure is identical to that for the scintillation detector, except applying different high voltage.

Data analysis

1. For each measurement determine positions of specific source peaks. Note that the peaks are always imposed on the background, and sometimes registered peaks overlap. Therefore in order to determine the peak positions it is necessary to fit the Gaussian function (or a combination of two Gaussian functions) describing the location of the peak and the second-degree polynomial describing the background.
2. Perform energy calibration of the detection system. The measured peak positions (as defined in the channels) should be assigned to the corresponding energies of gamma quanta. Fit linear dependence to measured position of the peak as a function of corresponding gamma energy.
3. Use the energy calibration to calculate the resolving power of the detector for each measured en-

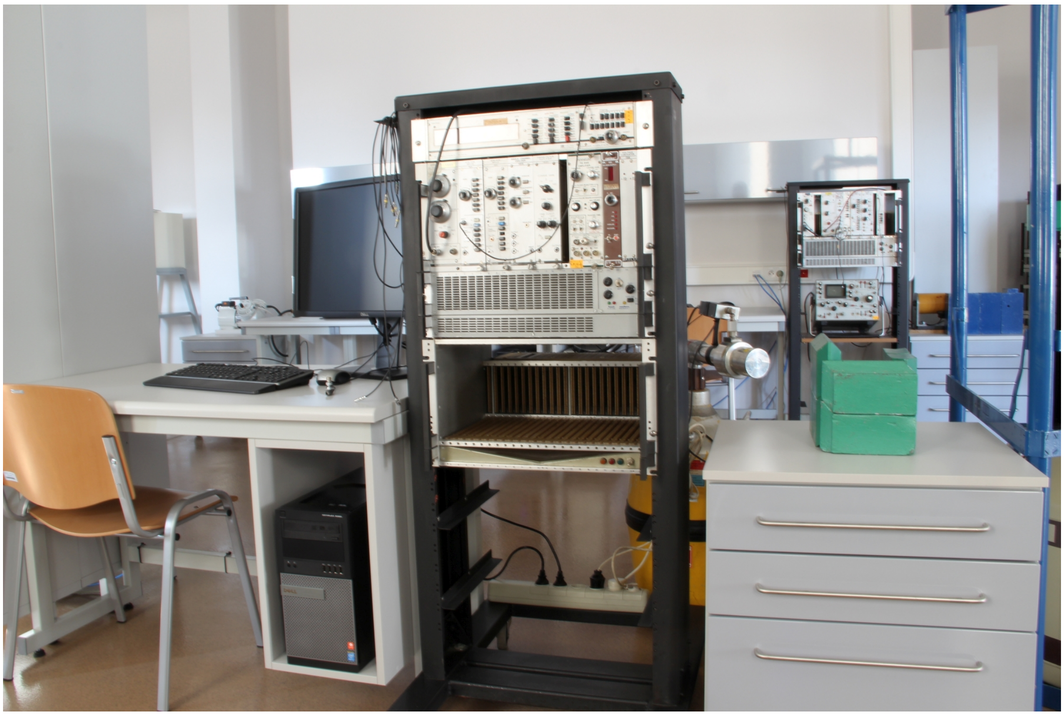

Figure 1: Experimental setup

ergy. Plot the energy resolution as a function of energy.

4. Plot the measured number of counts in the peak as a function of the square of the distance from the source to the detector.

5. Plot the energy and width of the peaks as a function of count rate in the whole measured spectrum (number of counts in the spectrum normalized to measurement time).

References

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

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

[3] K. Siegbahn, *Alpha-, Beta- and Gamma-Ray Spectroscopy*, North-Holland Publishing Co., Amsterdam 1965.