

## Experiment 3

### Introduction to Gamma Detectors

This laboratory session will be done in two parts, each being two hours long. One part will be done in room 8-35, and the other part will be done in room 4-3-567.

### Room 8-35

#### Part I: Identifying the features of the NaI gamma spectrum

In the introduction to this experiment, we discussed the different parts of the NaI gamma spectrum. You will be given a printout of three different gamma spectra taken with one of the NaI detectors in the laboratory. They are from the isotopes:  $Na^{22}$ ,  $Cs^{137}$ , and  $Co^{60}$ . The spectra are also posted just after this writeup on my home page.

a) Identify all the different features of each of the spectra. If the following features are present, be sure to indicate them on the graphs:

- a) photopeak(s)
- b) Compton Region(s)
- c) Compton Edge(s)
- d) Backscattering peak(s)
- e) Characteristic X-rays

#### Part II: Resolution of the NaI Detector

In the introduction to this experiment, we will discuss what is meant by the resolution of the detector and how to measure it. The **F**ull **W**idth at **H**alf **M**aximum (FWHM) is defined as:

$$FWHM \equiv \frac{C_+ - C_-}{C_0} \times 100\% \quad (1)$$

where  $C_0$  is the channel number of the center of the photopeak,  $C_-$  and  $C_+$  are the channel numbers where the counts equal one-half of the peak value, left and right of the photopeak center,  $C_0$ . An easy way to determine the  $FWHM$  is to use the parameters of the Gaussian fit:

$$FWHM = 2\sqrt{\ln(2)} \frac{\sigma}{C_0} \times 100\% \quad (2)$$

where  $\sigma$  is the width parameter.

a) Use the Energy Calibration (Javascript) in the "Virtual Radiation Lab" or the link on the experiment page to determine the resolution of two photopeaks. A commonly measured photopeak is the  $Cs^{137}$  photopeak at 662 KeV. Another interesting photopeak is the 1270 KeV photopeak of  $Na^{22}$ . To do this, fit the photopeaks with the Gaussian peak fitting option and find the channel number of the peak center,  $C_0$ , and the width parameter  $\sigma$ .

### Part III: Energy Calibration of the MCA

Your goal in this part is to calibrate the MCA, determine the energies of the unknown, and identify it. As calibration standards, you can use be  $^{22}Na$ ,  $^{137}Cs$ , and  $^{60}Co$ . The CRC lists the energies of the primary gamma rays of these sources to be:

$^{137}Cs$ : 661.64 KeV
$^{22}Na$ : 511.0034 and 1274.5 KeV
$^{60}Co$ : 1173.237 and 1332.501 KeV

For your analysis, you can assume that the energy increases linearly with the channel number. The data in the Javascript program are:  $^{137}Cs$ ,  $^{22}Na$ ,  $^{60}Co$  and the unknown.

a) Make a calibration graph of energy vs. channel number. You can use Excel, and display the equation on the graph. From the channel numbers of your unknown and the calibration equation, determine the energies of the gamma rays of the unknown. Estimate the uncertainty of the unknown energies by examining the residues of the calibration graph.

b) Use the link on my home page to determine the unknown isotope.

### Room 4-3-567

### Part III: Energy Calibration of the MCA

Here you will carry out part III above with the NaI detector, as well as determining the resolution of the NaI detector for one of the gammas. As before, your goal in this part is to calibrate the MCA for energy, determine the energies of the unknown, and identify it. **Do not change the amplifier setting during this part.** If you do, your calibration will change. Be sure that both peaks of  $Na^{22}$  are present in your spectra before you start. As calibration standards, you will be given  $^{22}Na$ ,  $^{137}Cs$ , and  $^{60}Co$ . The CRC lists the energies of the primary gamma rays of these sources to be:

$^{137}Cs$ : 661.64 KeV
$^{22}Na$ : 511.0034 and 1274.5 KeV
$^{60}Co$ : 1173.237 and 1332.501 KeV

For your analysis, you can assume that the energy increases linearly with the channel number. You will be given only one isotope at a time.

a) Make a calibration graph of energy vs. channel number. You can use Excel, and display the equation on the graph. From the channel numbers of your unknown and the calibration equation, determine the energies of the gamma rays of the unknown. Estimate the uncertainty of the energies of the unknown by looking at the residues of the standards for the calibration graph.

b) Use the link on my home page to determine the unknown isotope.

c) Determine the resolution of the NaI detector for the 662 *KeV* gamma that you detected from  $^{137}\text{Cs}$ .

### Laboratory Writeup for Experiment 2

Your lab writeup will consist of the following:

1) (4 points) Identify the isotopes of the three spectra passed out in class (and also posted on my home page just after this writeup). For each one, point out the different features (photopeak, Compton edge, etc.).

2) (2 points) Show your measurements and calculations for determining the FWHM for the  $\text{Cs}^{137}$  photopeak.

3) (4 points) Turn in your data for the energy calibration and your calibration graph and the calibration equation for the Javascript program.

4) (4 points) Turn in your data for the energy calibration and your calibration graph and the calibration equation for the laboratory data.

5) (6 points) Show how you determined the unknown gamma energies and their uncertainties for both the Javascript data and the lab data. Identify the unknown isotope.