Analysis of Gamma Ray Spectra from Reference Isotopes with Multi-Channel Analyzers

Oliver Kirkaptrick*, Jackie Sholes†, Anmolpreet Kaur Sodhi‡

March 30, 2023

Aim

In this experiment, we aim to to identify properties of obtained gamma ray spectra provided by known and unkown sampled. Additionally, using this information, we seek to use Full Width Half Maximum (FWHM) of the obtained spectra to estimate the resolution of detector hardware.

1 Relevant Theory

Gamma rays entering the the detector (a Sodium Iodide scintillation detector) will produce electrons via photoelectr effect, compton effect, or pair production.

We can isolate these effects from one another via distributions of energies of the produced electrons. Compton effects should be observed across a wide range of low energy, low relative counts. A significantly large (relative to other effects) counts of higher energy electrons will produce a photopeak, indicating the photoelectric effect. These higher energies are a result of the gamma/x rays giving all their energies to the produced electrons. These photo peaks may also be contributed to by the production of pairs of electrons and positrons.

For a given incident gamma ray of energy E_γ, the energy due to scattering (E'_γ) can be given byx

$$E'_\gamma = \frac{E_\gamma}{1 + (1 - \cos\theta)\left(\frac{E_\gamma}{m_e c^2}\right)}, \tag{1}$$

for a given scatter angle θ. Here the mass energy $m_e c^2$ can be taken as 511 keV.

Inside the distribution of lower energy counts produced by the compton effect, we expect a smaller peak due to backscatter effects. The energies of the gamma rays contributing to this peak can be obtained by setting $\theta = 180°$.

1.1 General Notes

- backscatter implies $\theta = 180°$
- At $E_\gamma \leq 100$ keV, photo electric effect is dominant
- At 100 keV $< E_\gamma \leq 10000$ keV compton scattering is dominant
- At $E_\gamma > 10000$ keV, pair production is dominant

*s3725341@student.rmit.edu.au
†s3785864@student.rmit.edu.au
‡s3838252@student.rmit.edu.au

2 Experiment Setup and Hardware

For this experiment, the following hardware was used, in the configuration depicted in Figure 1:

- NIM Bin and Power Supply
- NaI(Tl) Crystal and Phototube Assembly
- High Voltage Power Supply
- Preamplifier
- Amplifier
- Oscilloscope
- Multi Channel Analyser: Ortec 928 Multi Channel Buffer, USB dual Port Memory cable, PC with Maestro32 spectrum software.
- ^{137}Cs, ^{22}Na, and ^{60}Co gamma sources

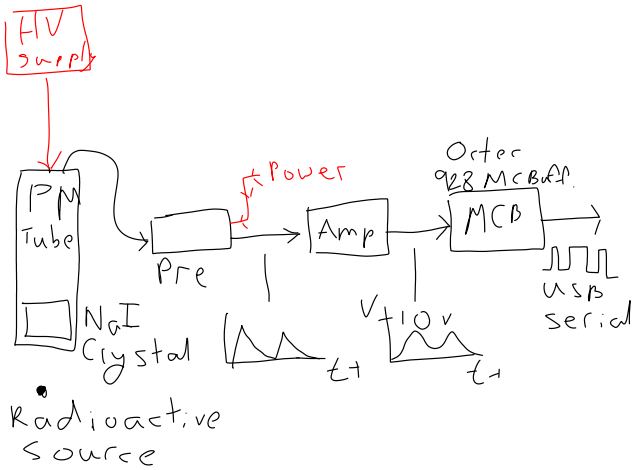

Figure 1: Configuration of hardware for experiment. Raw signals originate at the Photo Multiplier Tube (PM Tube in figure), which is triggered by the radioactive source, which was placed approximately 3 cm in front of the PM Tube. These signals are fed into the Pre-Amplifier, (Pre Amp in figure), before passing into the amplifier. The signal has peaks at approximately 10 Volts after exiting the amplifier, where it is then fed into the Multi-Channel Buffer. Data from the Multi-Channel Buffer is analyzed on a computer via Spectrum32 software.

3 Spectrum Analysis of ^{137}Cs, ^{22}Na, and ^{60}Co

Data saved at:

4 Spectrum and Half-life Measurement of Unknown Sample

Data saved at:

A NIM Setup