# Compton Scattering Logbooks

## Lab 2 – February 13th, 2025

Firstly, the electronic gates were configured through connecting wires to the corresponding ports and the lay out is as pictured below in Figure 1.

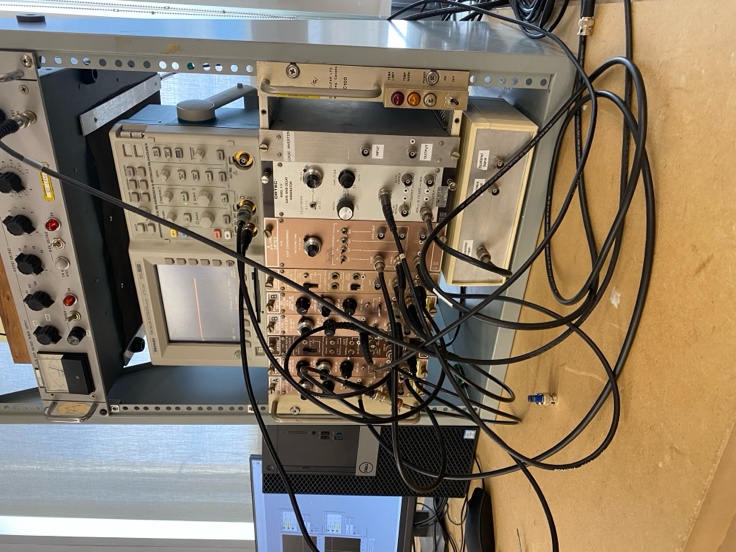


Figure 1: Power source along with the electronic gate wire setup with the oscilloscope powered on.

The high voltage source was powered on and the oscilloscope was activated for data collection. The Cobalt 60 source was checked out and placed into the pre-set lead block setup as seen in the figure below.

A stack of grey bricks

Description automatically generated

Figure 2: The lead structure containing the source, incident detector, and beam collimator set at an angle of around 110 degrees.

The oscilloscope was then tuned to view and calibrate the signals being received from the incident detector. It was observed that the oscilloscope was receiving signals therefore confirming that the electronic setup was receiving data. However, only channel 2 while connected seemed to be receiving signals from the source, while channel 1 remained mostly noise. After adjusting the electronic gate connections, channel 1 was resolved and signals were beginning to be received. The predominant result was a on and off square wave appearing on the oscilloscope with slight phase shifts back and forth. The channel 2 signal displayed a much longer square wave that appeared less frequently on the oscilloscope.

A close up of a device

Description automatically generated

Figure 3: Snapshot of the oscilloscope output for a Co-60 source after electronics were configured for data collection.

After calibrating the oscilloscope such that signals were being received, the oscilloscope was disconnected so the team may proceed with exploring and testing the Compton Scattering LabVIEW program. While trying to connect the setup to LabVIEW, only noise was being recognized despite our promising results on the oscilloscope. Restarting LabVIEW resolved this issue.

The Co-60 source we used initially was a weaker and older source, starting data collection on LabVIEW took a long time because of this. Co-60 is supposed to be high energy, so we expect to see a curve at a higher voltage on the x-axis. It was determined this would not be a good calibration source for the program because this peak will be so much higher than the Cs-137 source, we plan to use for our data collection, and Compton scattering data will bring the peak even lower. Therefore, the team changed our calibration sources to Na-22, Cs-137, Ba-133, and Am-241 to ensure reliable data collection on LabVIEW.

A graph of a voltage

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A graph of a voltage

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Figure 4,5,6,7: LabVIEW outputs for data calibration for Na-22, Cs-137, Ba-133, and Am-241 sources, plotting event counts against voltage.

Table 1: The calibration source and gain.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Source | Ba-133 | Cs-137 | Na-22 | Am-241 |
| Peak energies (observed) in keV | 80.998, 276.397-302.851, 356-384? | 661.638 | 511.006 | 59.537 |
| Gain | 40 C + 4-20 F (was it 20?) | 10 C + 4-20 F | 10 C + 4-20 F | 10 C + 4-20 F |

A close-up of a black and white text

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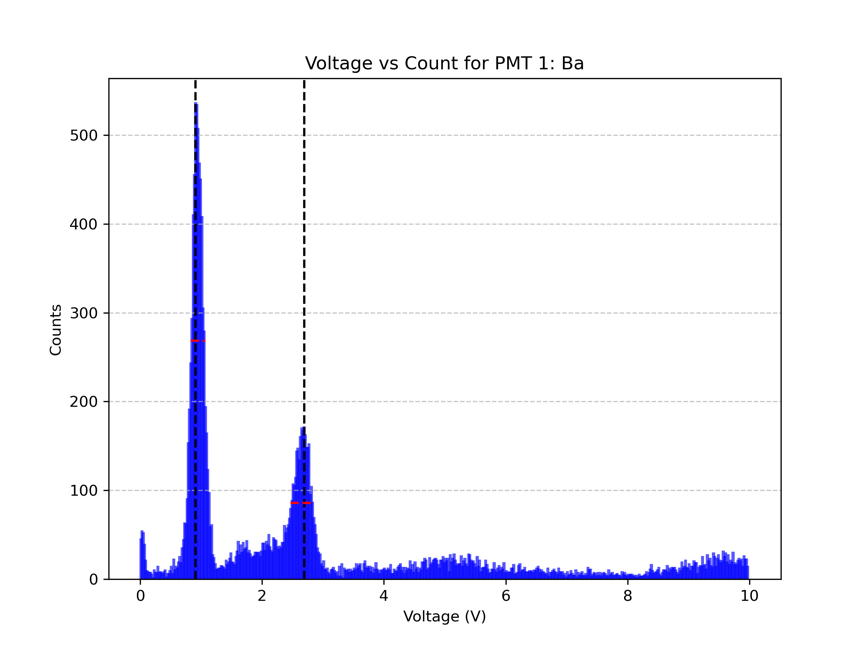
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## Lab 3 – February 25th, 2025

**2:30 – 3:00 pm**

Python was used to perform data analysis to find the linear regression slope and intercept values of the relationship between voltage and energy of PMT 1. The four source histograms from the previous lab were analyzed using Scipy (a statistical python library) to find the peaks and the FWHM values. These are seen below, along with the relationship between the voltages and energies.

A graph of a voltage

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A graph of a voltage

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Figure 5: The fitted histogram data for each calibration source for the first PMT. The coarse voltage gain is 10 for each source except Ba, for which it is 40.

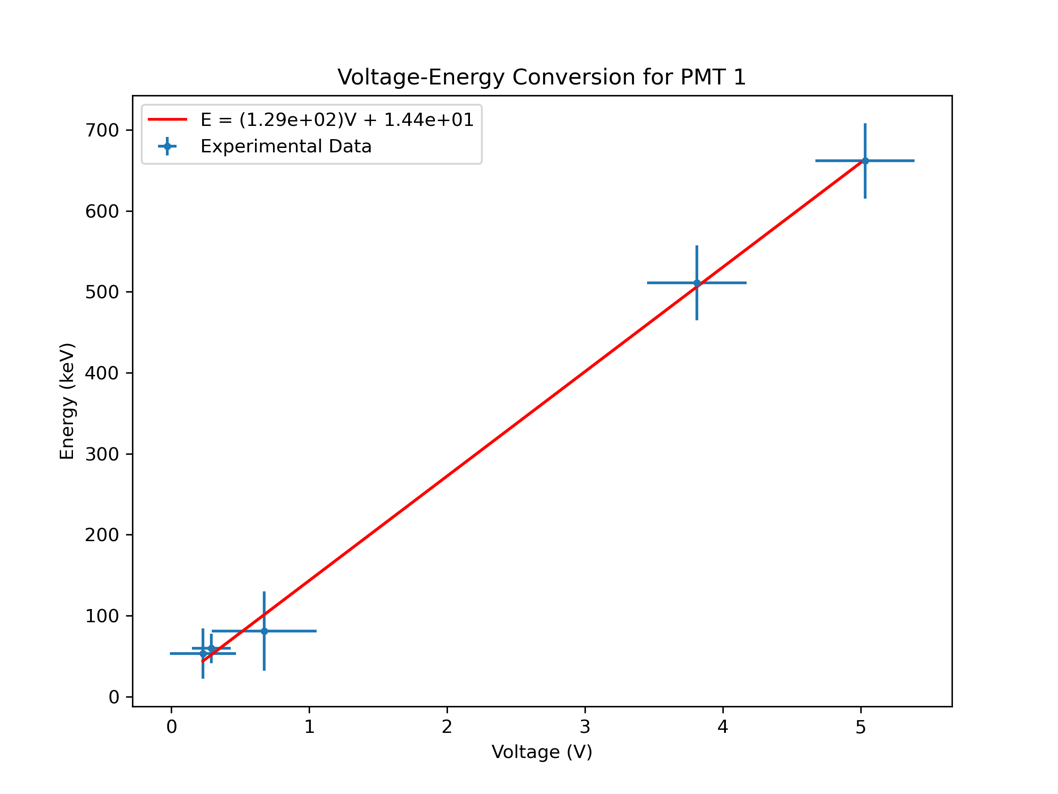


Figure 6: The energy-voltage relationship fit with a linear regression for PMT 1 (scatterer). Error is included from FWHM values.

The error in each energy value is calculated with:

Where denotes error, and is the calculated FWHM of each peak. The regression value was calculated to be:

The propagated error values are shown in the following table.

Table 2: The propagated errors in peak voltage and energy.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| [V] | 0.24 | 0.38 | 0.36 | 0.36 | 0.14 |
| [keV] | 30.97 | 49.04 | 46.46 | 46.46 | 18.07 |

**3:00-4:00 pm**

The calibration of the second (target) PMT was started and followed the same process as the first PMT calibration. The sources used to calibrate, their observed energy peaks, and the gain setting as shown below.

Table 3: The target PMT calibration sources and their gains.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Source | Ba-133 | Cs-137 | Na-22 | Am-241 |
| Peak energies (observed) in keV | 53.12, 80.998, 276.397-302.851 | 661.638 | 511.006 | 59.537 |
| Gain | 10 C + 4-20 F (was it 20?) | 10 C + 4-20 F | 10 C + 4-20 F | 10 C + 4-20 F |

A graph of a voltage

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AI-generated content may be incorrect.A graph with a line

AI-generated content may be incorrect.The four source histograms for the second PMT were analyzed in the same fashion as the first. These are seen below, along with the relationship between the voltages and energies.

Figure 7: The fitted histogram data for each calibration source for the second PMT. The coarse voltage gain is 10 for each source.

A graph of a voltage

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A graph of a voltage

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Figure 8: The energy-voltage relationship fit with a linear regression for PMT 2 (detector). Error is included from FWHM values.

The regression value was calculated to be:

The propagated error values are shown in the following table.

Table 4: The propagated errors in peak voltage and energy.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| [V] | 0.08 | 0.12 | 0.22 | 0.32 | 0.28 | 0.1 |
| [keV] | 12.79 | 19.19 | 35.18 | 51.17 | 44.77 | 15.99 |

The analysis code is available on Github:

<https://github.com/clarastones/compton_scattering/blob/76db107858c5b9d23b0b8b90070d240e027e8cad/calibration.py>

**4:00-5:00 pm**

The time calibration was started with the Na-22 source placed between the two detectors to find coincident events. Na-22 was chosen for this because it emits two gamma rays at the same time in opposite directions, which is ideal when calibrating the timing of the two detections. Eventually, the oscilloscope was calibrated such that the channel 1 signal happened in coincidence with the channel 2 signal, at different amplitudes, but same phase.

**5:00-5:20pm**

The next step in the timing calibration is to find optimal delay values for each PMT signal to maximize the counts. To perform this, 9 permutations of delay values will be tested from each signal. For each value of delay on PMT 1 of 0.1, 0.2, and 0.3 microseconds, three values will be tested for each delay on PMT 1 of 0.1, 0.3, and 0.5 microseconds. The goal is to plot counts vs PMT 2 delay for each delay on PMT 1 and hopefully observe a parabolic output that will allow to find the highest count delay.

## Lab 4 – February 27th, 2025

**2:30-3:00**

The calibration code was updated for the second (target) PMT to remove the outlying points. The resulting relationship is seen below, and is described by:

A graph of a voltage

AI-generated content may be incorrect.

Figure 9: The energy-voltage relationship fit with a linear regression for PMT 2 (detector). Error is included from FWHM values.

To perform the timing calibration, a high activity source is placed between both PMT’s. The objective is to find the delay values on the timing SCA modules to optimize the number of counts from each PMT. This process involves trying nine unique permutations of delay values, three for each module. All counts will be summed, and three plots will be generated for each unique value of PMT 1. The expected behaviour will be three data points on each plot that exhibit a parabolic curve, therefore proving which timing SCA delay values correspond to a max number of counts for the experiment.

**3:00-4:00**

Nine datasets were collected for each permutation of PMT delay generating the three plots. The table below displays each combination that was collected.

Table 5: Delay settings on the electronic gates corresponding to PMT 1 and 2 respectively.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PMT 1 delay (left sca) ( | PMT 2 delay 1 () | PMT 2 delay 2 () | PMT 2 delay 3 () | PMT 2 delay 4 () |
| **0.1** | 0.1 | 0.3 | 0.5 | 0.7 |
| **0.2** | 0.1 | 0.3 | 0.5 | 0.7 |
| **0.3** | 0.1 | 0.3 | 0.5 | 0.7 |

**4:00-5:30**

It was determined by the repeated trials that the most effective delay configuration for the PMTs was PMT 1 set at 0.1 delay and PMT 2 set at 0.3 delay. From here, the trial with this setting was reset and completed for 20 000 counts.

Upon trying to convert the voltage to energy