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.

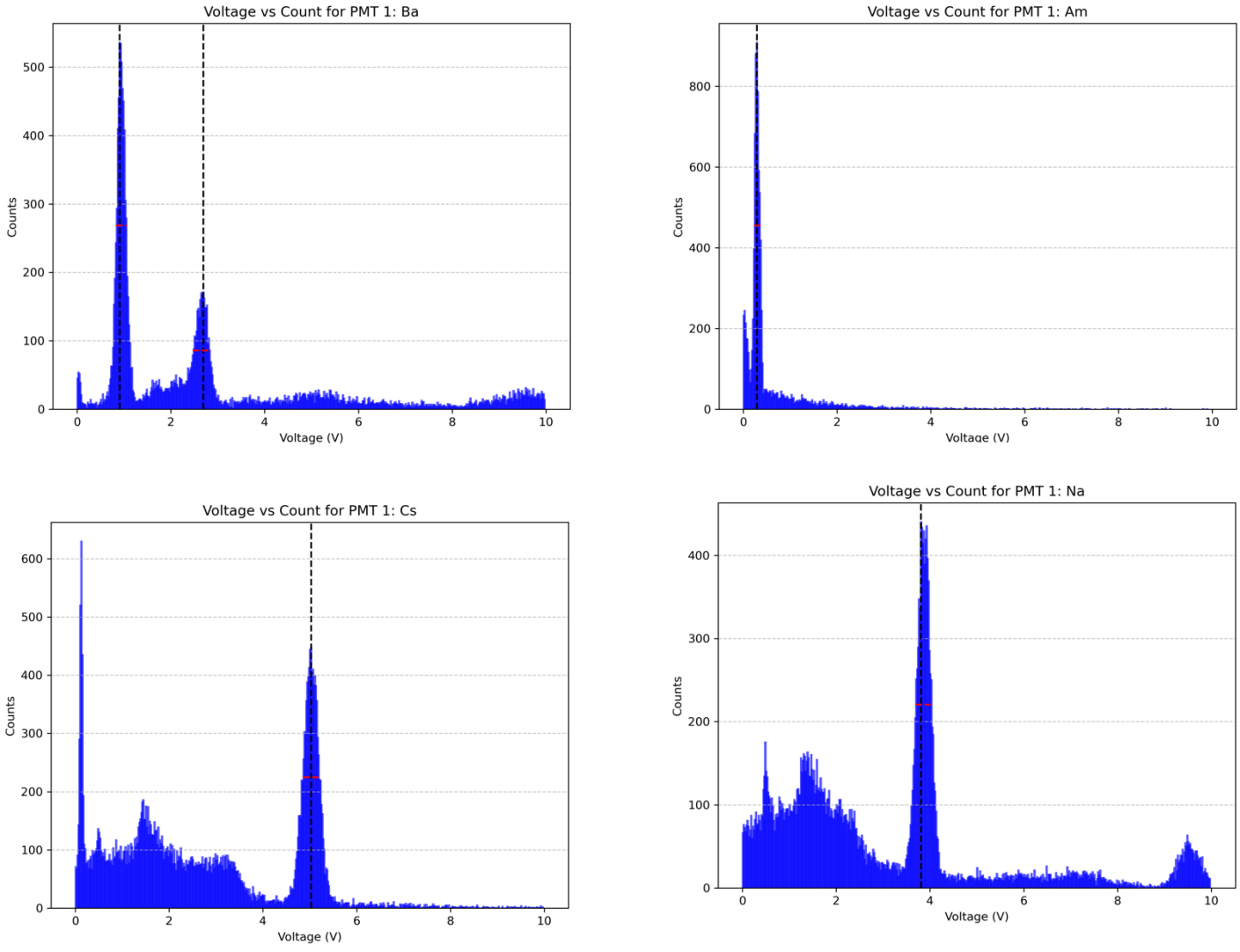

Figure 1: The fitted histogram data for each calibration source for the first PMT. The coarse voltage gain is 10 for each source except Ba, for which it is 40.

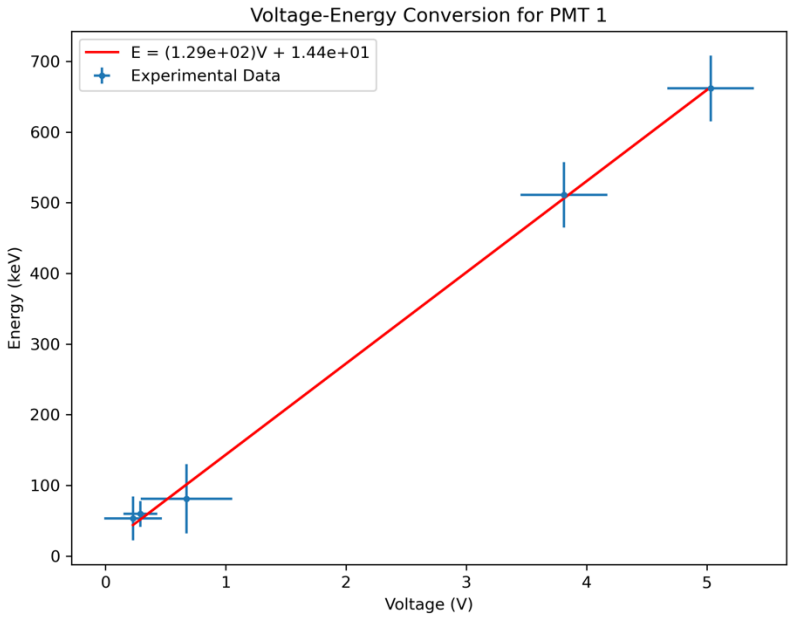

Figure 2: The energy-voltage relationship fit with a linear regression for PMT 1 (scatterer). Error is included from FWHM values.

The error in each energy value is calculated with:

$$\sigma_E = \left|\frac{dE}{dV}\right| \cdot \sigma_V \quad (1)$$

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

$$E = (129.1 \pm 3.1) + (14.4 \pm 8.8)\ keV$$

The propagated error values are shown in the following table.

Table 1: The propagated errors in peak voltage and energy.

σ_V [V]	0.24	0.38	0.36	0.36	0.14
σ_E [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 2: 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

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.

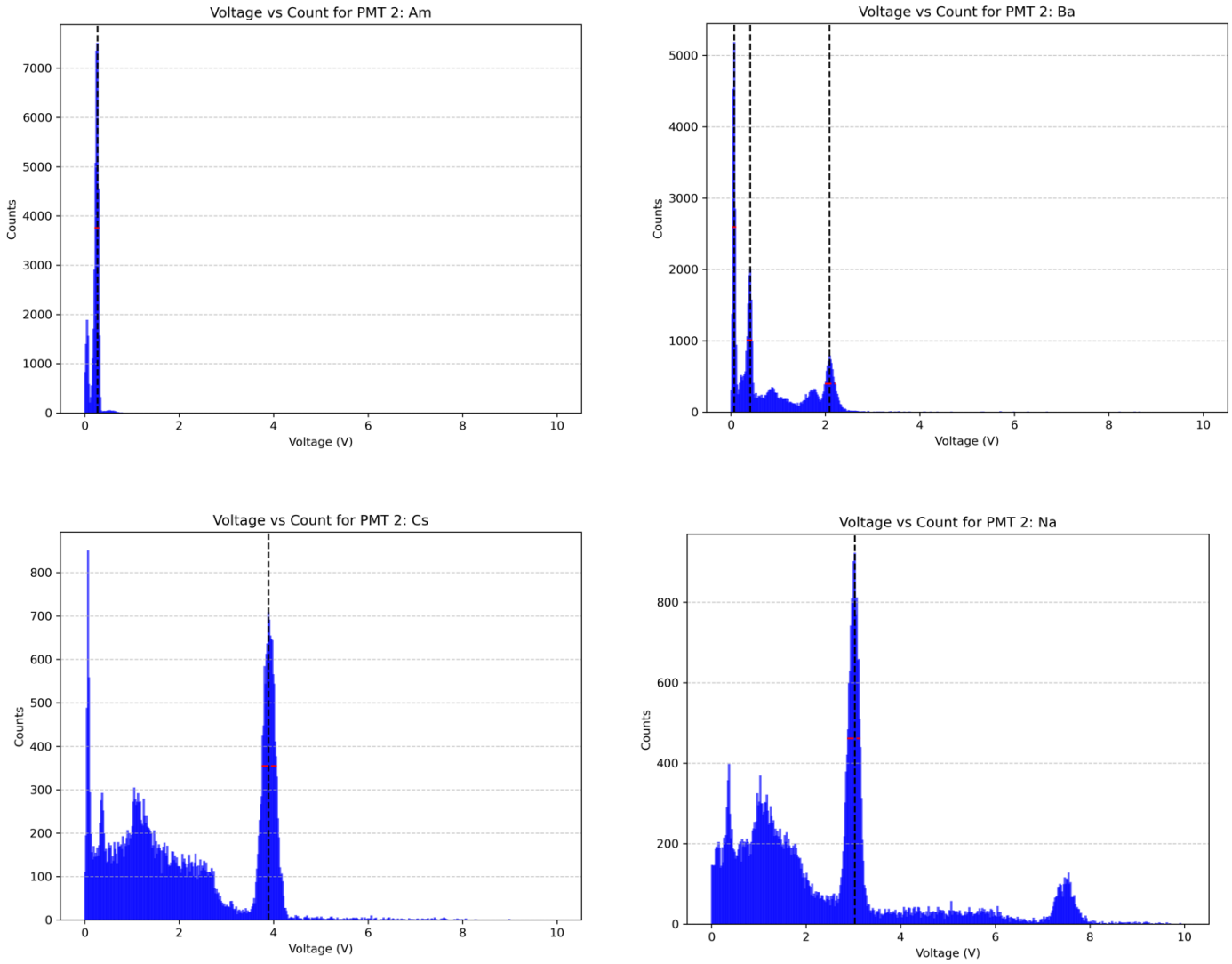

Figure 3: The fitted histogram data for each calibration source for the second PMT. The coarse voltage gain is 10 for each source.

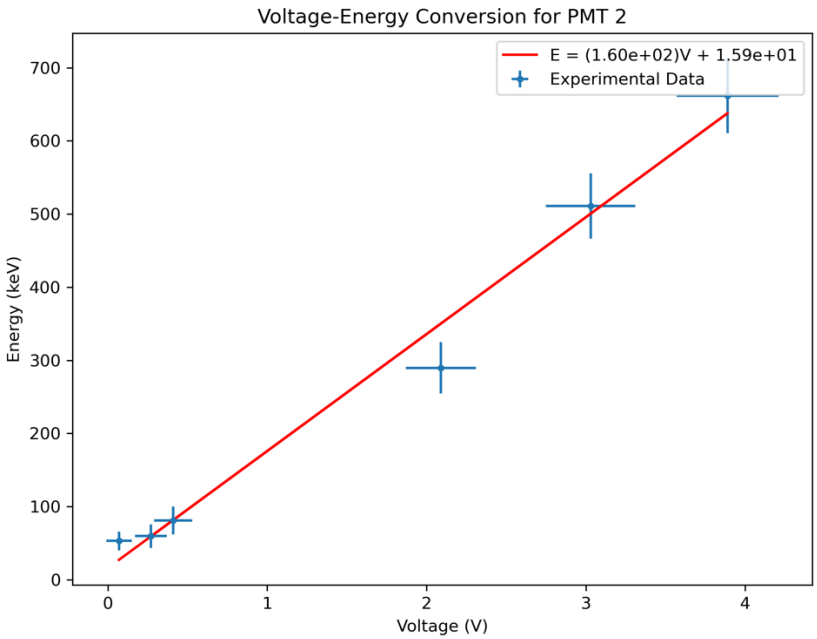

Figure 4: The energy-voltage relationship fit with a linear regression for PMT 2 (detector). Error is included from FWHM values.

The regression value was calculated to be:

$$E = (159.9 \pm 9.8) + (16 \pm 22)\ keV$$

The propagated error values are shown in the following table.

Table 3: The propagated errors in peak voltage and energy.

σ_V [V]	0.08	0.12	0.22	0.32	0.28	0.1
σ_E [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.