Lab 2: Counting Statistics

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Abstract

The purpose of this lab is to experiment with the concept of Poisson and Gaussian probability distributions in the context of ionizing radiation sources. We will learn some statistical analysis techniques using Google Sheets and Python to analyze, graph, and compare results from a geiger counter being used on Strontium-90 and Cesium-137.

Methodology

In this lab we used a geiger counter to measure ionizing radiation from different radioactive sources. We used Strontium-90 for a Poisson distribution analysis, and we used Cesium-137 for a Gaussian distribution analysis. To collect this data; we connected the geiger counter to the associated software on our lab computer and set the voltage to 800 V with 1000 runs at 1 second intervals. For the Poisson distribution, we collected data for a period of 1000 seconds and saved that into an excel file. We repeated that process with the Cesium-137 for a period of 2500 seconds instead to find a Gaussian distribution.

Data Analysis

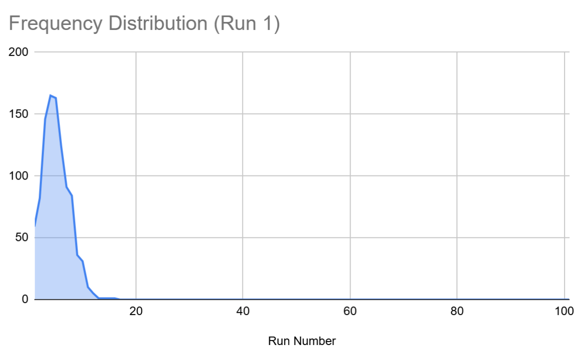

Figure 1, a graph displaying the Frequency Distribution of our data from our Strontium-90 during Run 1.

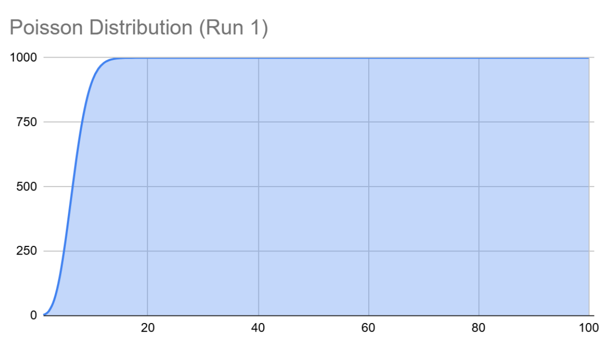

Figure 2, a graph displaying the Poisson Distribution of our data from our Strontium-90 during Run 1.

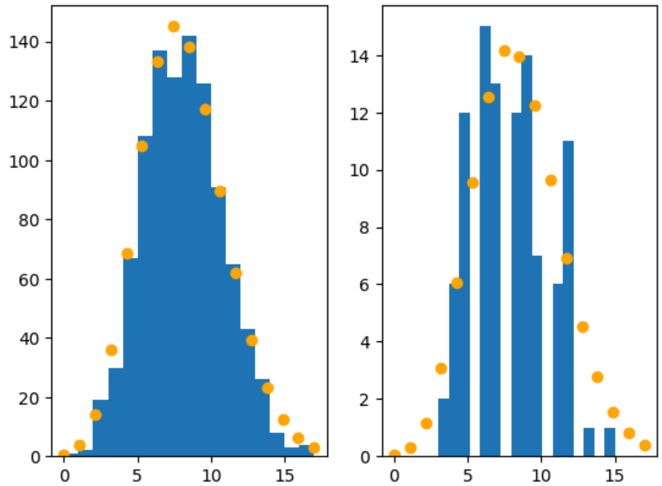

Figure 3, a graph displaying our frequency distribution for Run 1 using a Python script.

We processed and analyzed the data within our excel files and the given python scripts. We started with the Poisson distribution by computing the average number of counts using the formula $\bar{n} = \frac{1}{m}\sum_{i=1}^{m} n_i$. We then created a histogram of the recorded frequency counts. Next, we used the Poisson formula: $P(n) = \frac{\bar{n}^n e^{-\bar{n}}}{n!}$ to compute the Poisson probability and compare it with our histogram we created earlier.

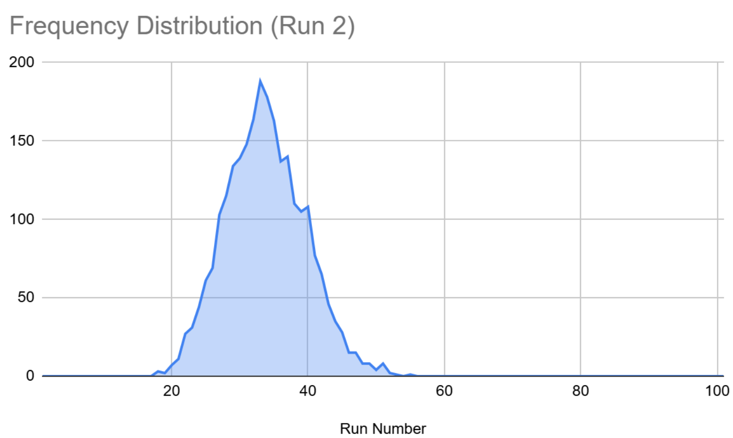

Figure 4, a graph displaying the Frequency Distribution of our data from our Cesium-139 during Run 2.

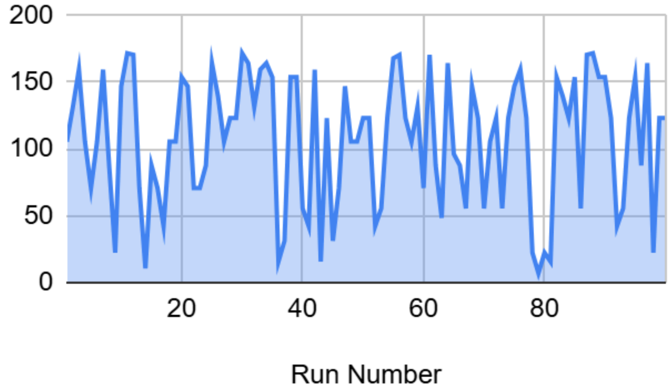

Figure 5, a graph displaying the Gaussian Distribution of our data from our Cesium-139 during Run 2.

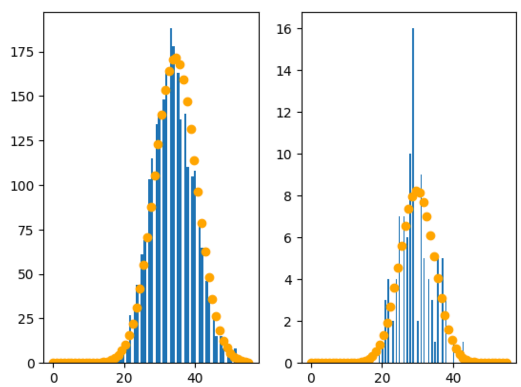

Figure 6, a graph displaying our frequency distribution for Run 2 using a Python script.

As for the Gaussian distribution; we started by computing the average count rate of the 2500 second sample. We then used the Gaussian probability formula $P(n) = \frac{1}{\sigma\sqrt{2\pi}}e^{\frac{-(n-n)^2}{2\sigma^2}}$ and multiplied that by 2500 like before to find the theoretical Gaussian distribution. This was then compared with the histogram we created earlier. As shown in Figure 5, our Gaussian distribution doesn't have the proper bell curve shape, which we postulate that it was because of an extreme number of outliers in our data.

Discussions

Compare your data by overlaying it on the same graph as the frequency plot. Is it different?

The frequency plot looks very similar.

What happens if you truncate your data such that you collected data for only 100 seconds? Does your distribution change? Does the average number of counts change?

There are larger deviations with a smaller number of counts. This also results in a slightly different average number of counts.

What is the average number of counts for your distribution

7.63 counts.

If you binned your data into 2 second intervals, how would your data change?

Our total number of bins would go from 1000 to 500. The frequency distribution would be different as well because there would be less data points. The histogram would be a similar shape but smoother because of less data.

Does your histogram change if you truncate your data to 100 runs?

Yes the histogram would change as well because there would be less data.

Now add an aluminum attenuator between the Sr 90 source and the Geiger counter. This will reduce the number of counts/second. How do your results change? Is your distribution skewed to the right?

The distribution changes because there are less counts per second. Yes, the distribution is skewed to the right due to less counts.

What happens if you truncate your data such that you collected data for only 100 seconds? Does your distribution change? Does the average number of counts change?

The histogram will be less smooth with less points. The gaussian shape will also be less accurate due to the smaller amount of data points. Thus, the distribution changes. I would imagine that since we are only capping the time, and not the amount of counts, that the average number of counts would not change very much at all if we assume that radiation is emitted at a somewhat constant rate.

Approximate the full-width half-maximum of your distribution.

The full-width half-maximum seems to be around 90.

What is the average number of counts for your distribution?

33.4 counts.

If you binned your data into 2 second intervals, how would your data change?

The histogram shape would be smoother but the bell curve would probably be roughly the same.

Does your histogram change if you truncate your data to 100 runs?

Yes, the histogram would change as well because there would be less data.

Conclusion

In this lab we analyzed the statistical nature of radioactive decay by studying the Poisson and Gaussian distributions of two different materials using a geiger counter. Our graphs fit well when compared to the python analysis graphs from the original data. This experiment demonstrated the role of probability distributions in the process of radioactive decay, which goes along with our learning of quantum tunneling in class right now.