Pylab 5 - Random Number Analysis

Adams, Jake
jake.adams@mail.utoronto.ca
1003847377

Jiang, Hansen
hansen.jiang@mail.utoronto.ca
1003192403

October 2018

Introduction

The purpose of this lab was to analyze the radioactive count from a Fiesta plate containing low amounts of Uranium Oxide using Python analysis of random radioactive decays. The data in this experiment was pre-acquired and thus the extent of the work was done predominantly in the programming/analysis.

Methods and Materials

- Geiger counter
- Fiesta Plate
- Geiger counter software

Experimental Procedure

The data recording portion of this experiment was conducted by a lab technologist in demonstration, rather than by individual experimentation. The device was used to detect the background radiation of the laboratory. The device collected 60 points of data, with equal intervals of 20 seconds. Then, it was used to detect the radiation of the plate. Similarly, the device remained unmoved and collected 60 data points, with equal intervals of 20 seconds. After these two data sets were collected, they were made available for analysis.

Results

The Fiesta plate's measured distribution is plotted as follows, using the range of measured values as the range of the histogram, and an appropriate number of bins. Changing the bin size based on the range for integer-sized intervals changes the results, as can be noted in Figure 4

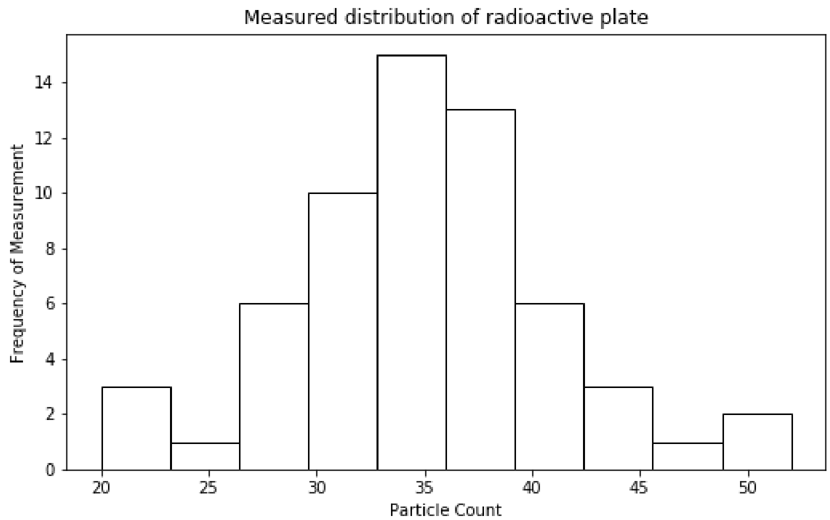

Figure 1: histogram of plate's count data

Following the provided equations, the true radiation of the plate is calculated by subtracting the average background radiation from the measured radiation. The uncertainty is calculated by taking the square root of the addition of the measured radiation and the background radiation.

Because we are using discrete random variables, the Poisson probability mass function was used to qualitatively fit the data. The average value of the count data was used for the value of μ and is plotted over top the histogram. Additionally, the Gaussian distribution was added for the sake of comparison against the Poisson distribution, where the mean value was μ and the standard deviation was $\sigma = \sqrt{\mu}$.

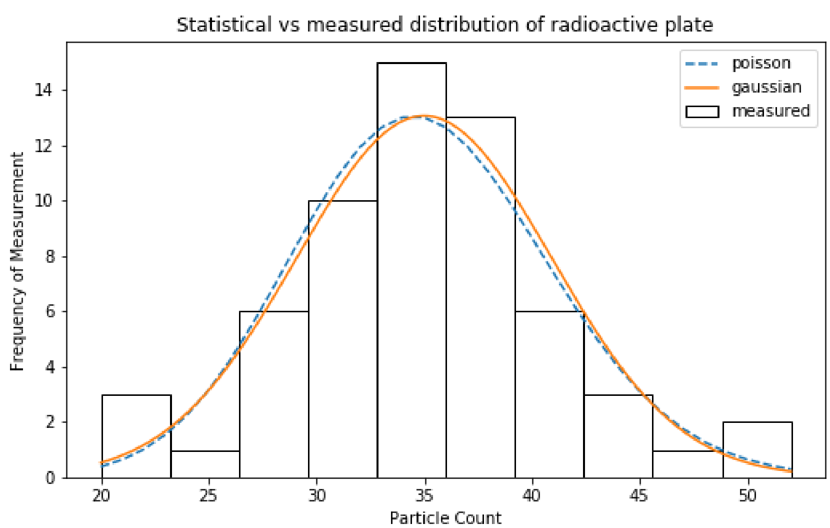

Figure 2: histogram of plate count including both distribution functions

The same analysis was performed on the data of the background radiation within the lab room. As previously stated, we had used the data to find the mean background radiation in order to subtract that value from the plate data to find the plate radiation alone. The background radiation distribution is plotted as follows.

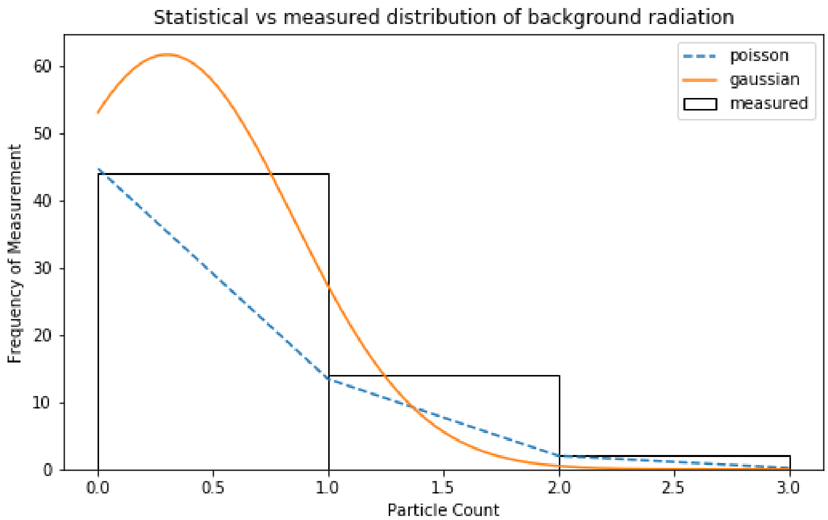

Figure 3: histogram of background count including both distribution functions

Discussion

From examining the data plot of Figure 2, it is true to say that the Poisson and Gaussian functions both fit the data adequately. Moreover, given the size of the data set (60 sample numbers), it is reasonable to understand how both functions appear similar, as (by the Central Limit Theorem) a distribution will have an approximate normal distribution when enough data points are present.

This result can be verified further by changing the number, and therefore size, of the histogram bins, as follows. The bin count is changed to be a factor of the range, so that bin edges are integers rather than floats.

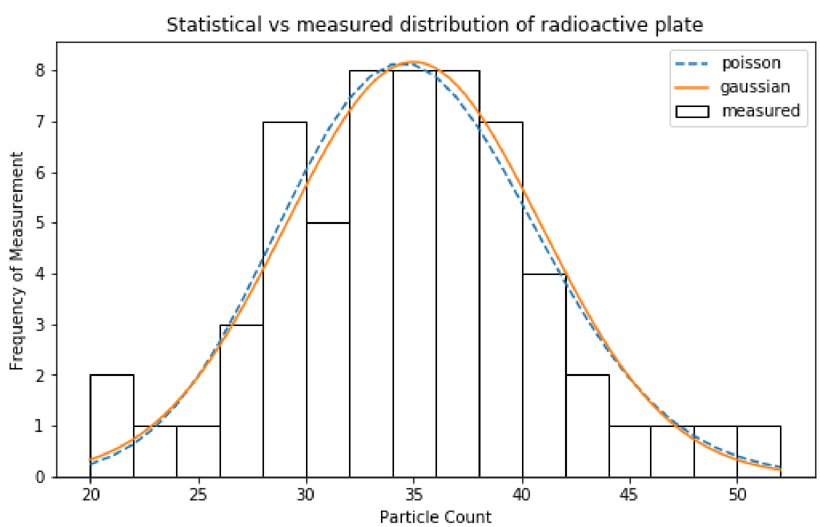

Figure 4: histogram of plate count including both distribution functions

The discrepancy between the peaks of the histogram and the peaks of the probability distribution functions, as seen in Figure 2, is reduced in this plot. Other differences arise in different areas of the distribution, notably in the 28-30 bin. While there is correlation, this data suggests that a larger sample size would result in a closer fit with the normal distribution function. However, both the Poisson and Gaussian functions fit the data adequately.

With regards to the background data alone, the same can not be said. While the data set is of the same size (again, 60 samples), the diversity in the values of the counts is to blame for the appearance of the distribution. In a data set that ranges in counts from 0 to 2, there is very little actual data to display. Furthermore, the majority of the count data is of value zero. This is to be expected; we do not expect to record large counts of background radiation to display a well rounded bell curve. It is reasonable to believe that the majority will be zero counts, and in comparison to an actively decaying element, we should expect to see a distribution of the sort we gathered in this experiment.

Conclusion

For sets of data with many measurements, the Poisson distribution function tends towards the Gaussian distribution function, where both distributions become strong models of natural random variable data. The correlation becomes stronger with greater ranges of data and smaller histogram bin sizes, as the frequency tends towards a continuous function.