Poisson Statistics

Bilal Samil Okan

2008203057
Partner: Murat Can Gokceaslan

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1 Abstract

In nature lots of radioactive events happen. In this experiment we are going to observe ^{137}Cs to radiate which is a random process. Measurements of the particle can be different in equal time frames. We would like to find from standard normal or Gaussian distribution to Poisson distribution which is special case of Binomial Distribution. Poisson distribution can be applied to results of experiments measuring independent events in a given time period.

2 Theory

Poisson Distribution formula given below:

$$P(\mu, n) = \frac{\mu^n e^{-\mu}}{n!} \tag{1}$$

P_p is the probability μ is the mean n is of counts in a distribution with μ.

The standard deviation of the Poisson distribution is equal to the square root of the its mean:

$$\sigma^2 = \mu \tag{2}$$

If the mean μ goes larger and Poisson distribution approaches to Gaussian distribution increases, so distribution approximates to the Gaussian Distribution. Normalized Gaussian behaves as below:

$$P_G(\mu, \sigma, n) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \tag{3}$$

The probability of observing n counts during a time interval t is given by the equation;

$$P_q(\alpha, t, n) = \frac{(\alpha t)^n e^{-\alpha t}}{n!} \tag{4}$$

where

$$\mu = \alpha t \tag{5}$$

3 Apparatus

The apparatus we used in this experiment are listed below:

- Geiger (Muller tube) Counter with a Scaler
  Gaseous ionization detector uses Townsend avalanche phenomenon to detect electronic pulse. It is used for gamma radiation but also can be modified to detect neutrons.
- Various Gamma-Ray Sources(^{137}Cs for our experiment)
- Sample Holder

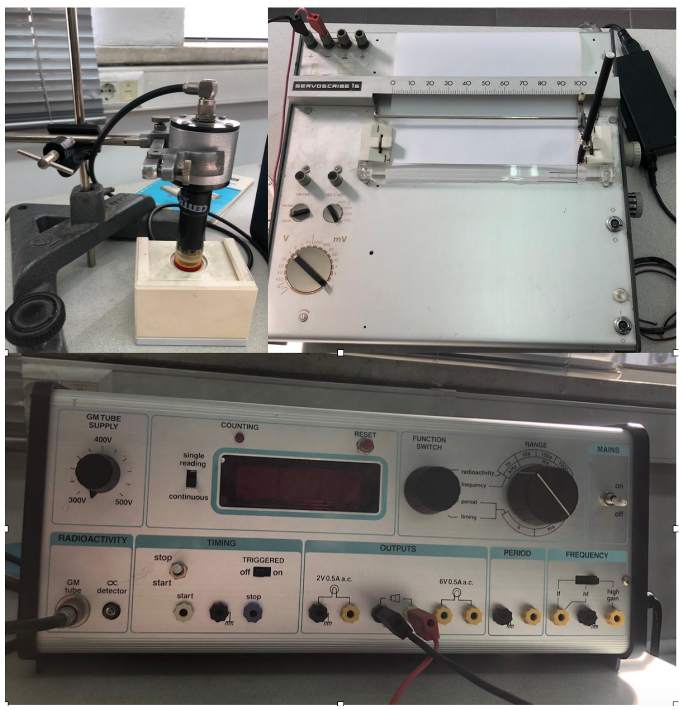

Figure 1: Poisson Statistics Experiment Setup

Voltage	Number of Counts
300	0
320	0
340	0
360	993
380	998
400	1022
420	1078
440	1016
460	1031
480	1087
500	**1107**

- Chart Recorder
- Lead Absorbers

First we set the limit voltage of geiger counter. From 300 V to 500 V we took data with 20 V differences for 100 seconds. To continue the experiment we repeat it until get a better value. 440 is good point for this choice.

Geiger tube is determined to get data 10 s interval in continuous mode. With the Gamma-ray source(^{137}Cs) we got 100 counts. Following the same routine for each one recorded in 10 second intervals and the counter is set to 1 s interval and the same recording process is repeated.Thus, we got 4 sets of data that are used to created histograms.

Second, we took a chart recorder to get data, a bunch of data given within some small time interval.Measuring the distance between peaks for $n = 0$ and $n = 1$

4 Data and Data Analysis

$$P(0+1,t) = \frac{(\alpha t)^0 e^{-\alpha t}\alpha}{0!} = \alpha e^{-\alpha t} \tag{6}$$

$$P(1+1,t) = \frac{(\alpha t)^1 e^{-\alpha t}\alpha}{1!} = \alpha^2 t e^{-\alpha t} \tag{7}$$

By using equations above, which are mentioned in theory part, and α values which are found on Python;

$$n = 0 \ \rightarrow \alpha = 0.923 \tag{8}$$

$$n = 1 \ \rightarrow \alpha = 0.460 \tag{9}$$

In this experiment, we observed two set of examples. We could try to fit our data to Poisson statistics model. As seen from the data radioactive decay can be modeled for this sort of continuous independent process. We compared the results of both Poisson and Gaussian fit chart. Poisson Distribution seems more efficient to describe the data.

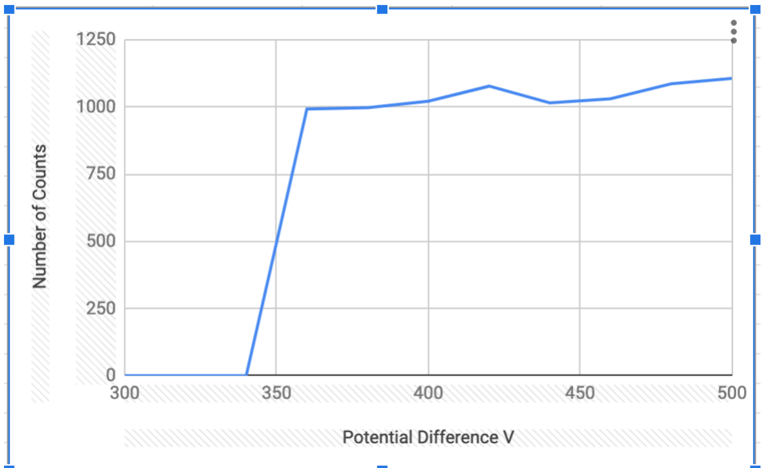

Figure 2: Voltage versus Number of Counts chart

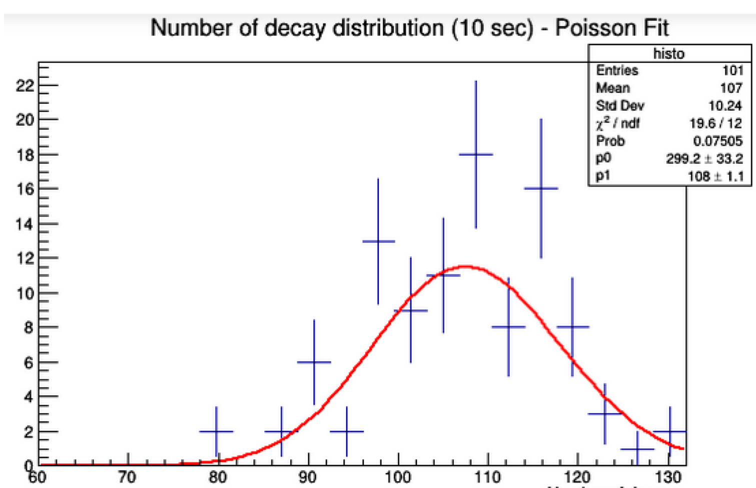

Figure 3: Poisson chart 10s

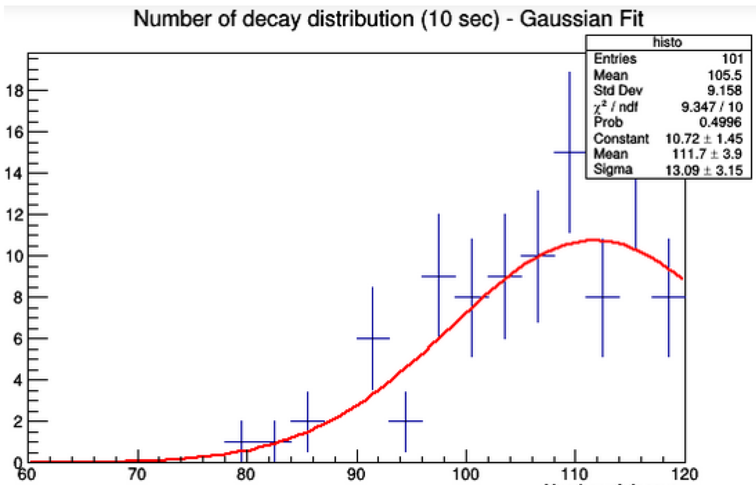

Figure 4: Gaussian chart 10s

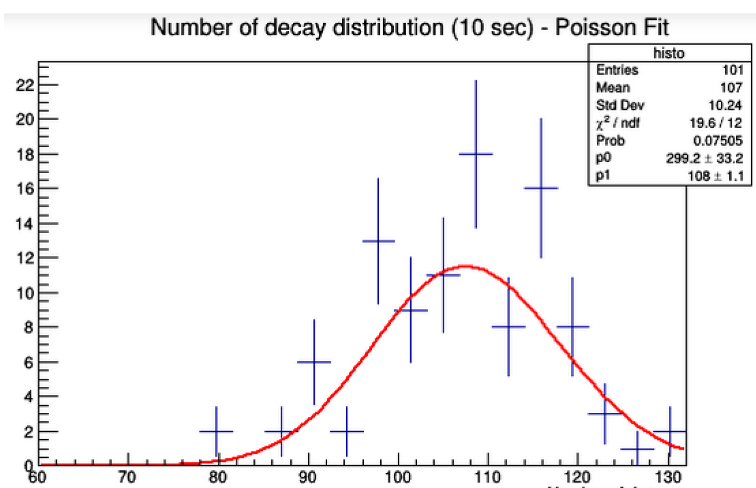

Figure 5: Poisson chart2 10s

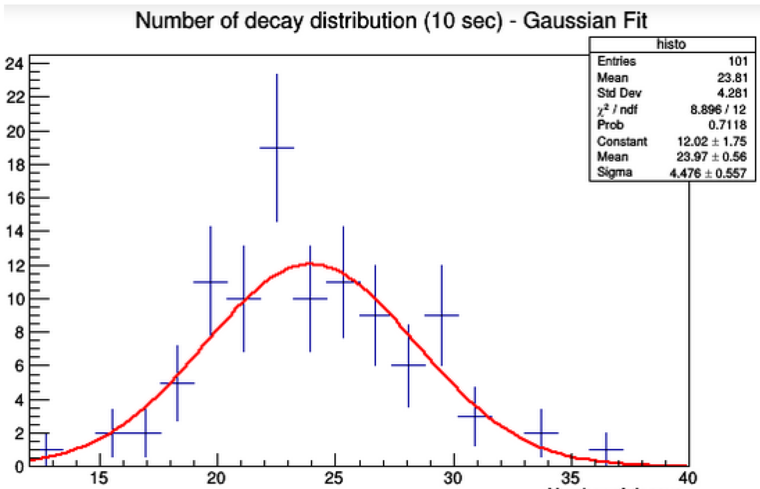

Figure 6: Gaussian chart2 10s

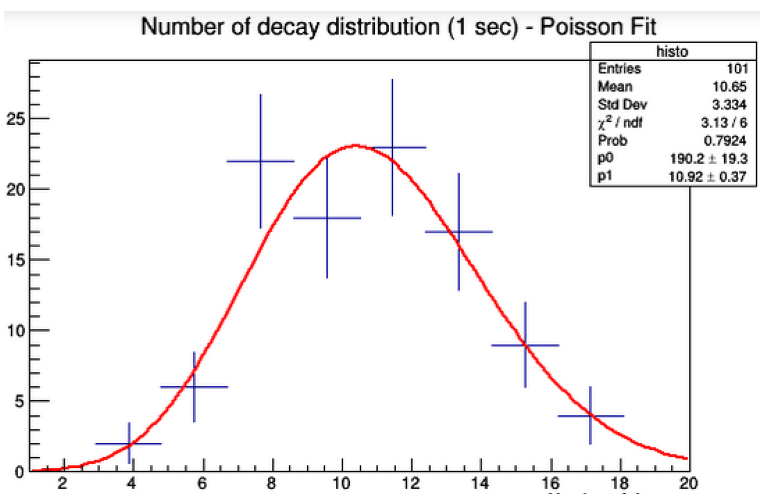

Figure 7: Poisson chart1 1s

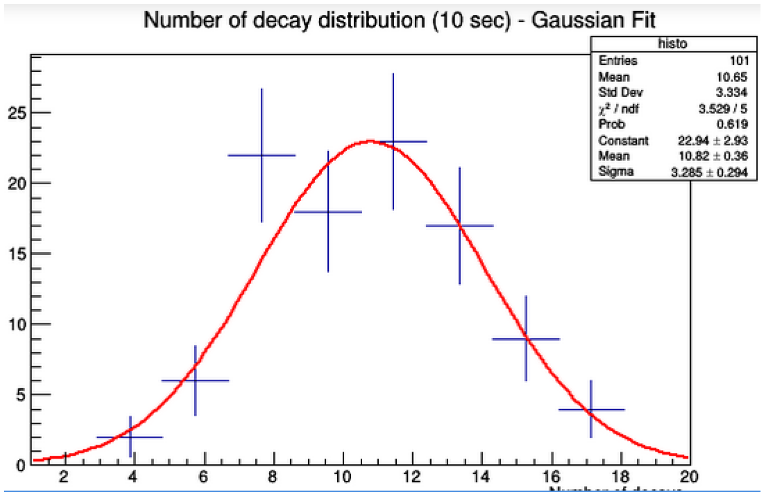

Figure 8: Gaussian chart1 1s

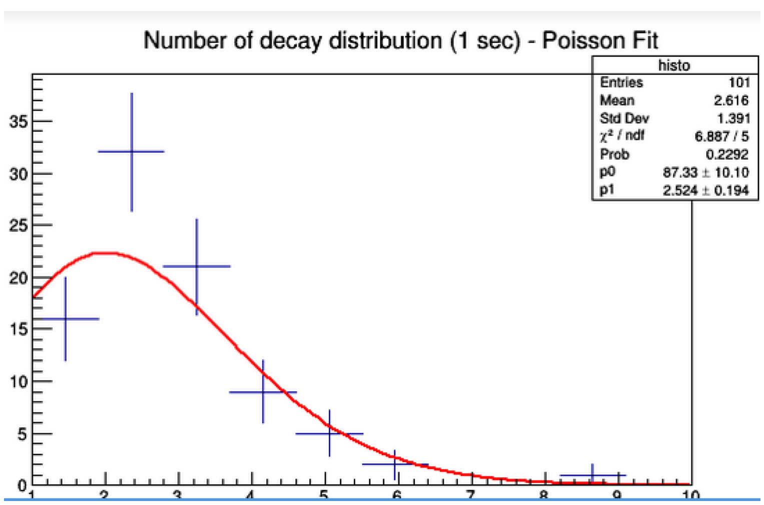

Figure 9: Poisson chart1 1s

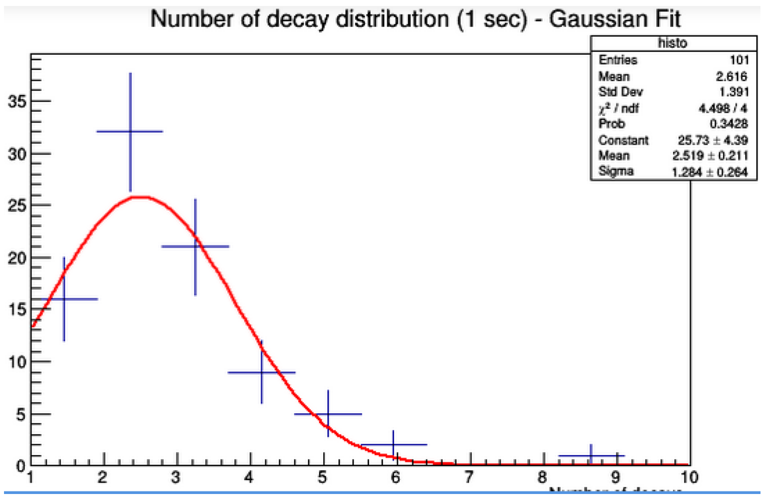

Figure 10: Gaussian chart1 1s

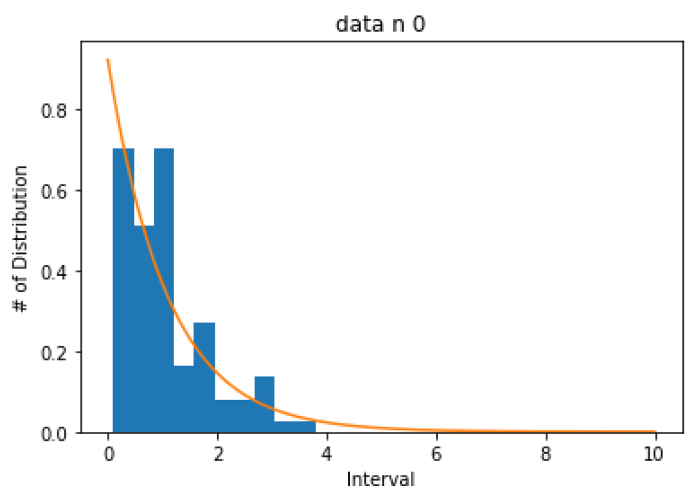

Figure 11: Poisson fitting n 0

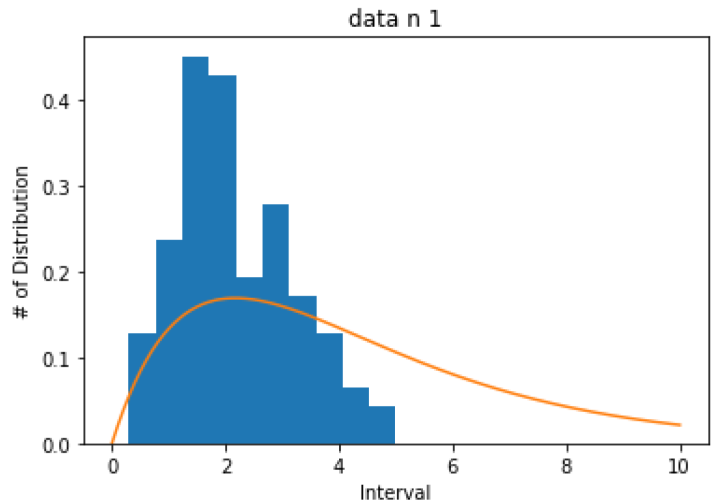

Figure 12: Poisson fitting n 1

5 Reference

- E. Gulmez, ”Advanced Physics Experiment”, Istanbul, Bogazici University Publication, 1999
- http://www.wikiwand.com/en/Poisson_distribution

A Appendix

Data and codes are link below
https://github.com/samilokan/442.git