Rutherford Scattering

1 INTRODUCTION

To use the Rutherford scattering phenomenon which is caused by Coulomb interaction to find a relationship between the scattering angle and the counting rate. This is represented by the following equation,

$$\dot{N}_0 = \frac{C}{\sin\frac{\theta-\theta_0}{2}}$$

Our goal is to verify Rutherford Scattering. Our experimental set-up consists of a vacuum chamber, a sheet of gold foil which is set-up on a rotatable apparatus to adjust the angle between an α-particle source and a detector. To clarify, the gold foil and particle source are both on the rotatable apparatus and any adjustments will result in a different angle with respect to the detector. This will allow us to measure different rates for different angles. After taking a series of measurements for the count rate at different angles we will have enough data to determine C and θ 0 , this will be done by graphing the logarithm graph.

$$ln(\dot{N}_0) = ln(C) - 4ln(sin(\frac{\theta-\theta_0}{2})$$

Which should result in a linear relationship between the count rate and the scattering angle leading to an offset equal to the ln of the constant and a way to solve for θ 0 because we will be measuring θ in two different directions and we will see a difference in the two directions which will correspond to θ 0 . We will also find that there is a minimum scattering angle in our experiment this means no count rate will be observed in a certain range of angles.

2 UNCERTAINTIES

2.0.1 Counts $\sigma_{\dot{N}}$

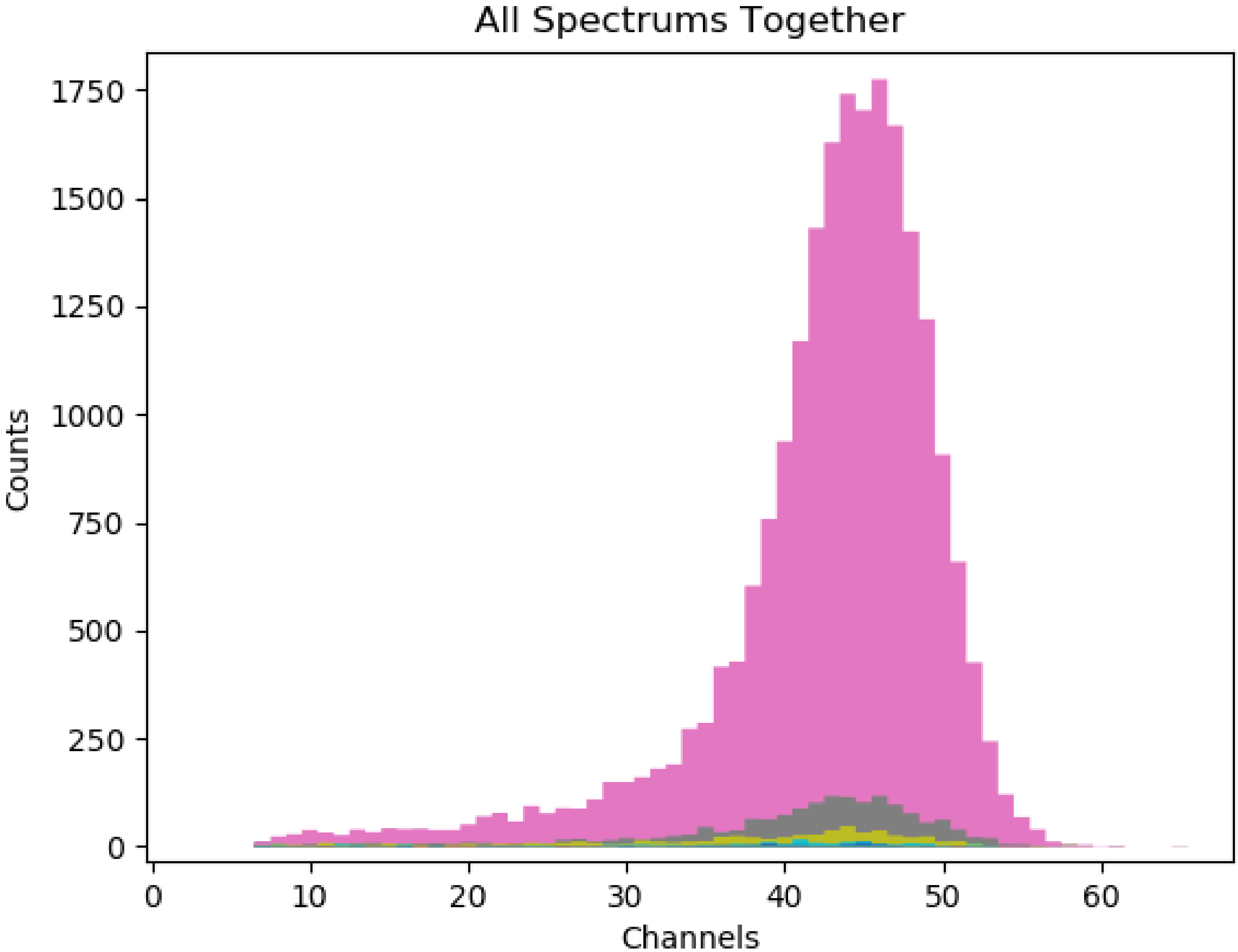
The integration of the counts has an uncertainty, the uncertainty is given by the standard,

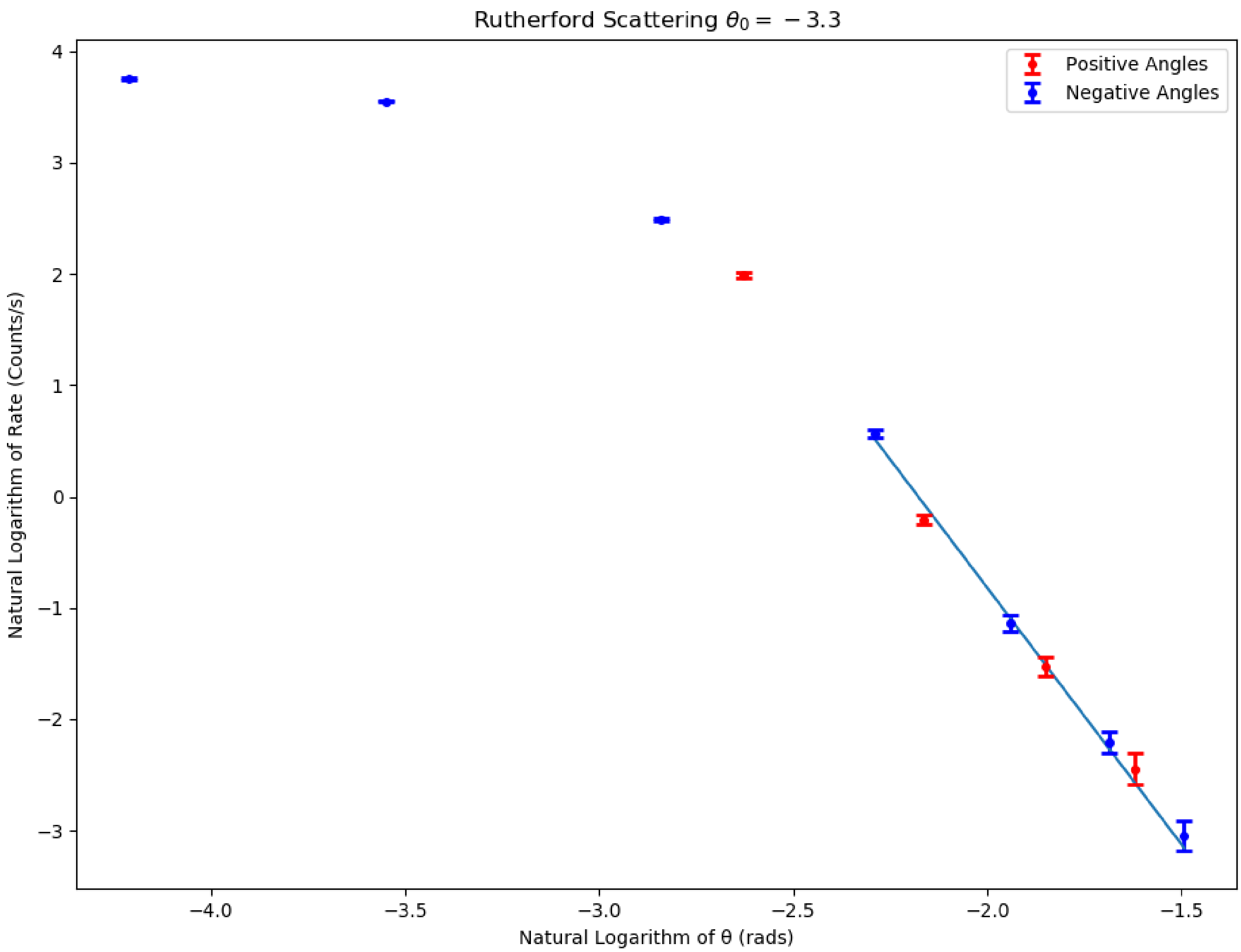
$$\sigma_{\dot{N}} = \frac{\sqrt{\dot{N}_0}}{t}$$

2.1 Uncertainties Unaccounted for

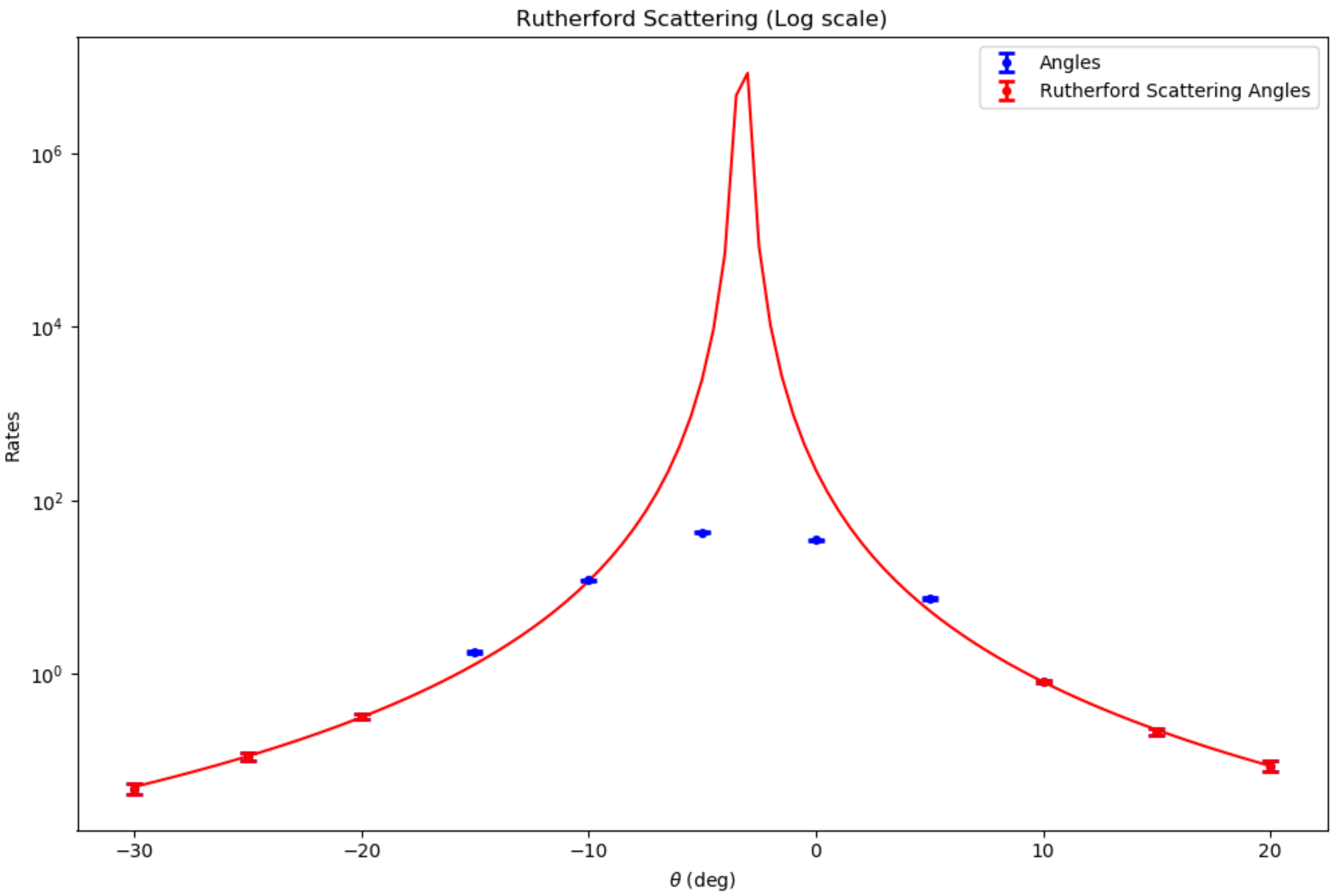
The detector could have false positives or false negatives due to a number of factors including cosmic rays. The pre-amplifier, amplifier and the electronics have numerous possibilities for false counts as well, the analog to digital has always has a borderline between determining a 1 or 0 and signals that lie in between that are quasi-randomly chosen, statistically this has no real significance but it is worth to mention.

3 DATA


All Spectrums Together
Counts
1750
1500
1250
1000
750
500
250
0
0
10
20
30
40
50
60
Channels



Rutherford Scattering $\theta_0 = -3.3$
Positive Angles
Negative Angles
Natural Logarithm of Rate (Counts/s)
Natural Logarithm of θ (rads)
4
3
2
1
0
−1
−2
−3
−4.0
−3.5
−3.0
−2.5
−2.0
−1.5



4 DATA ANALYSIS

In the second graph with positive angles and negative angles we can see a linear relationship for some values of x, this represents the values that experience Rutherford scattering, the slope of this line should represent the exponent of sin shown in the introduction, it was very close to a value of -4.21 with an uncertainty of ± 0.145 Now the offset of this line should be representative of the ln(C), after exponentiation we arrive at a value for C of, $9.03 \cdot 10^{-05} \pm\ 2.60 \cdot 10^{-05}$ which was calculated by using the error propagation,

$$f = e^{A}; \sigma_f \approx |f||\sigma_A|$$

The last graph is partially fitted with Rutherford's equation, the Rutherford Scattering Angles marked in red represent the angles that represent Rutherford Scattering and the ones in blue represent the angles that "do not". The peak should tend to infinity because as you get to smaller and smaller angles you get a more and more direct path. At those angles represented in blue you get more significant effects by different types of scattering which is why we have a Gaussian looking curve.

5 CONCLUSION

We determined for what angles Rutherford scattering occurs for our data set to be, [-30, -25, -20, 10, 15, 20] degrees. Our fit represented in the last graph shows what angles Rutherford scattering occurs as well. We recorded a value for C of $9.03 \cdot 10^{-05} \pm\ 2.60 \cdot 10^{-05}$, a value for the exponent of -4.21 with an uncertainty of ± 0.145. I would consider the experiment successful as we successfully verified Rutherford's equation for large angles.