Experiment 1: Geiger Counter Experiments

In this introductory lab on the Geiger Counter, we will perform a number of experiments with our Geiger counters. We have three different types of Geiger counters, and you will get a chance to try out each type. In addition, we will use the Geiger counters to examine the statistical properties of nuclear decay. The three Geiger counters are 1) Cal Poly "home made", 2) variable voltage Geiger counter, and 3) fixed voltage Geiger counter. Below is an outline of the experiments done with the first two:

A. Cal Poly Home-Made Geiger tube set-up

Our home-made Geiger setups are built on an electronic "bread board". A 9 volt battery is connected to a DC-DC voltage amplifier, which increases the voltage by a factor of 100. There is a dial, which allows you to vary the voltage to the amplifier from 0-9 volts. Thus, the output voltage will vary from 0 to 900 volts. We will have just a few setups in the class, but BE CAREFUL WHERE YOU PUT YOUR FINGERS. A voltmeter is connected across the input so the voltage can be measured.

The high voltage is connected across a Geiger-Muller tube and a large resistor, $10^7\Omega$, in series. An oscilloscope is connected across the $10^7\Omega$ resistor, so we can observe the discharge.

a) Together, we will place a source under the Geiger-Mueller tube. Then we will slowly turn the dial to increase the voltage until we observe a pulse on the oscilloscope.

b) Note the voltage at which a pulse is produced. Once a nice pulse is produced, make a sketch of the pulse, with the axes properly labeled.

c) In class we will discuss what is meant by "dead time", and go over how to calculate the number of electrons released during a discharge.

B. Variable Voltage Geiger Counter

For some of the Geiger Counters in class, the voltage across the Geiger-Mueller tube can be varied. For these detectors we will vary the voltage and measure the count rate.

a) Place a source under the Geiger counter tube.

b) Set the timer to count for ten minutes or longer.

c) Set the voltage to zero first, then slowly turn up the voltage until the counter starts to record counts. This is the "starting voltage".

d) Take 1 minute readings, increasing the voltage by about 10 or 20 volts each time. Keep increasing the voltage up to around 150 Volts above the starting voltage. Don't increase the voltage above 1000 Volts. Make a table of your data.

Note: to prevent damaging the tube, **do not increase the voltage more than 150 volts beyond the starting voltage, and certainly not more than 1000 volts.**

e) Graph your results using Excel or on linear graph paper. Label on your graph the **starting voltage** and **the plateau region**. Also label the proper **operating voltage** on the graph. From your graph, do you think your Geiger counter tube is operating properly? Why or why not?

C. Statistics of Nuclear Decay

For this experiment, we will examine the statistical properties of radiation detection. You will take ≈ 50 one minute recordings with one of the commercial Geiger counters. Each group will take their data with different counting rates to investigate how the standard deviation of the counts changes with total counts.

a) With the Geiger Counter set at the proper operating voltage, take 50 one minute recordings with your sample at an appropriate distance from the detector. We will call the i'th recording x_i.

Note: Parts b) and c) below can be done with the Excel spreadsheet.

b) Find the average number of counts, x_{ave} from the 50 values.

$$x_{ave} \equiv \frac{\sum_{i=1}^{50} x_i}{50} \tag{1}$$

c) Find the "experimental" standard deviation, σ_{exp}, of the number of counts.

$$\sigma_{exp} \equiv \sqrt{\frac{\sum_{i=1}^{50}(x_i - x_{ave})^2}{50}} \tag{2}$$

d) What is the reliability factor R for your data?

$$R \equiv \frac{\sqrt{x_{ave}}}{\sigma_{exp}} \tag{3}$$

Comment on your value of R.

e) If there is enough good class data, make a graph of σ_{exp} (on the vertical axis) versus x_{ave} (on the horizontal axis) using the data from the groups in the class. Is there a power law relationship? If so, what is the power?

Report writeup for Experiment 1

1. (3 points) Discuss briefly what you observed with the home-made Geiger tube setup. Include your sketch of the discharge pulse, and your estimate of the dead time. Show your calculation for determining the number of electrons discharged.

2. (4 points) Make a table and graph of Counts vs. voltage for the variable voltage Geiger counter tube. Label on your graph the starting voltage, operating voltage, and the plateau region.

3. (6 points) Turn in your data and the excel spreadsheet of the calculation of your average and standard deviation of your 50 one minute recordings.

4. (3 points) Turn in your calculation for the reliability factor R, and discuss the significance of your value for R. Do you think your Geiger Counter is working properly? Discuss.

5. (2 points) Make a graph of the class results of standard deviation vs. average number. Discuss if the experimental results of the class follow what is expected theoretically.

6. (2 points) Add up the total number of counts that you recorded for the 50 "one minute" readings and consider this a single counting experiment for 50 minutes. For

this single counting experiment for 50 minutes, what is the count rate and statistical uncertainty in counts/min?