LAB 1: Plotting a GM Plateau and Introduction to Statistical Distribution

This lab will have two sections, **A and B**.

Students are supposed to write separate lab reports on section A and B, and submit the report at the beginning of the next lab to your lab T.A.

A. Plotting a GM Plateau

Objective:

In this experiment, you will determine the plateau and optimal operating voltage of a Geiger-Muller counter.

[All the GM counters do not operate in the exact same way because of differences in their construction. Hence, each GM has a different high voltage that must be applied to obtain optimal performance from the instrument. Hence, **stay on the same table the whole semester for all other labs**, as the data/information we obtain in this lab will be used in other labs as well. Also note the GM tube number that is used in your table for future reference.]

Equipment:

Set up ST-360 counter with GM Tube and stand (Counter box, power supply transformer, GM tube, shelf stand, serial cable, and a source holder for the Stand) as shown in figure 1.

Radioactive source: (e.g. Cs-137, Sr-90, or Co-60).

Procedure:

1. (Should have already been done for this lab, but if not……….) Plug in the transformer/power supply into any normal electricity outlet and into the back of the ST-360 box. Place the GM Tube in to the top of the shelf stand with the window down and the BNC connector facing upward. Connect the BNC cable from the GM to the ST-360 and a serial port on the back of your PC.
2. Turn the ST-360 power switch on. Turn on the computer ON and double click on "ST360", program located in the desktop. You should see a blue control panel appear in the screen. Put the radioactive source on the source holder of the shelf stand. Keep the source stand on the second level from top of the shelf.
3. Go to Setup menu and select the HV setting option. In the Set High Voltage window, start with 700 Volts. Similarly in the "Setup", set Step Voltage to 20, and select "ON". In the Preset menu, select "Time" and enter 30 for number of

seconds and press OK. Also in the Preset menu, choose “Number of Runs”, and set it to 26.

4. You should see a large screen with a large window for the number of counts and data for all the runs on the left half of the screen. On the right half, you should see a window for the preset time, elapsed time, runs remaining, and HV and step voltages. If not, go to the view option and select counts.
5. Make sure there are no previous data by choosing the erase button (last one on the right). Then select the green “diamond” to start taking data.
6. When all the runs are taken, choose the File menu and Save as. (Create a group folder in the desktop, so that you can locate this file later). Then you may save the data file. The output file is a text file that is tab delimited, which means that it will load into most spreadsheet programs. Also, record your data in the “Data Sheet I” included in this manual.

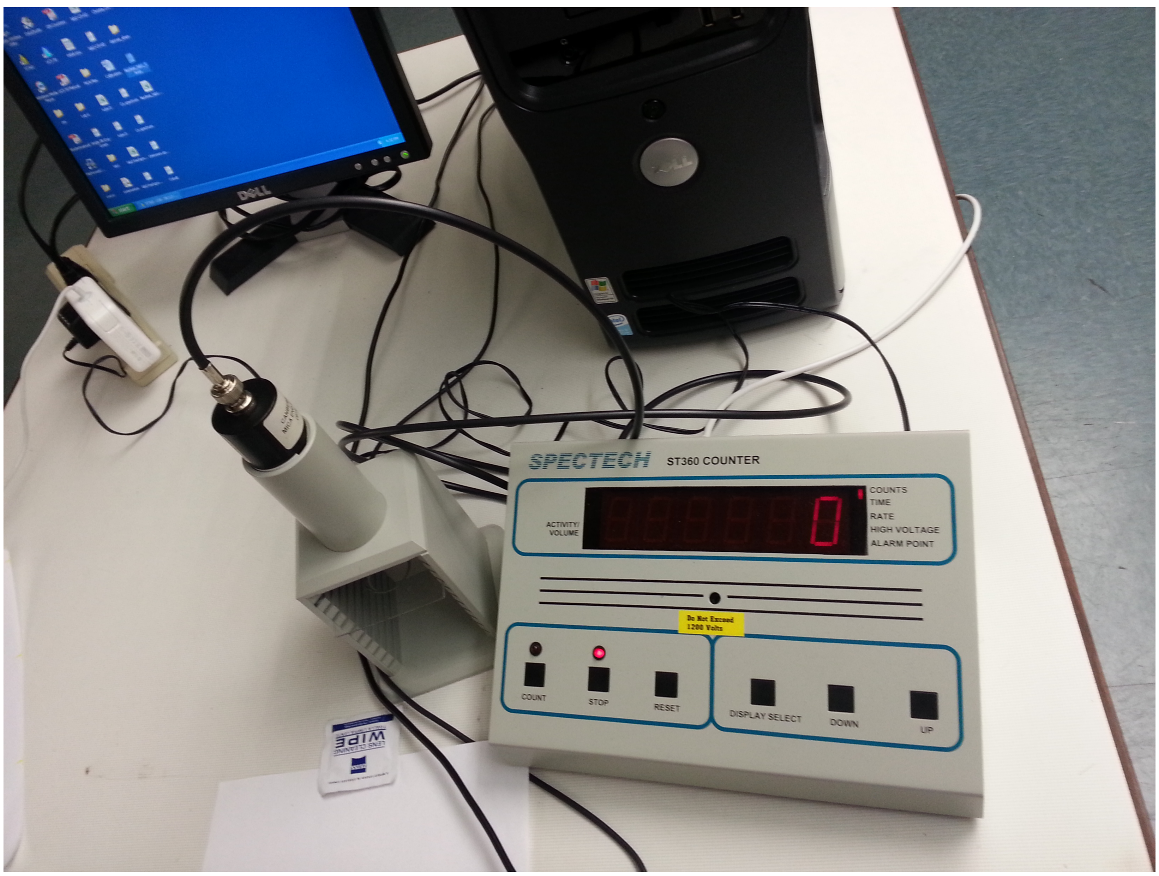


Figure 1: GM tube setup using a ST-360 Counter

Data Analysis:

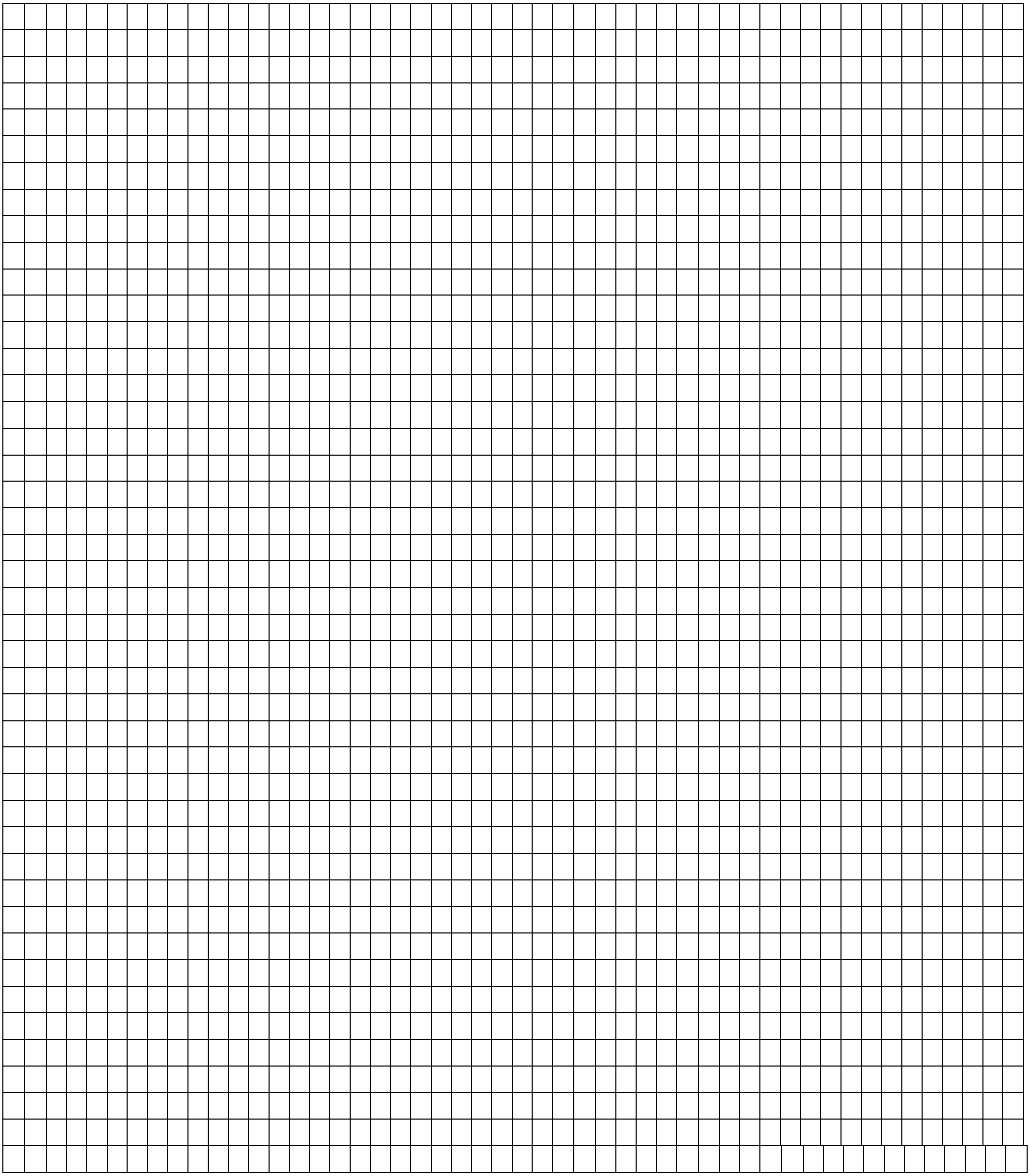
Use the graph paper to plot the graph (There is a graph page on this manual). Please label the graph properly with Voltage on X- and counts on Y-axis. Remember that colleting the data is a group work, whereas everyone should be plotting the graph for final submission to your T.A. during your final lab report.

DATA SHEET I

Name: 1000-ID:
Date: Table No:

Data Table for GM Plateau Lab:
Tube #:

Voltage	Counts		Voltage	Counts



B. Statistics

Objective:

To learn how to apply Poisson and Gaussian distribution methods to statistical data using Excel

Background counts:

The Geiger- Müller tube is susceptible to natural background radiation as well as to the radiation emitted from the source and cannot differentiate between the two. For any meaningful data to be taken and analyzed, the background radiation should be known and taken into consideration.

Statistics of Counting:

Any radioactive disintegration is a spontaneous phenomenon, and hence is completely random as well as unpredictable. Hence in counting experiments, it is quite natural that the counts will vary for the same interval of time. Once cannot afford to predict any results based on such fluctuating data. At the same time we cannot ignore this data as completely deceptive because it will contain valuable information.
Statistical analysis is the solution in analyzing this data to obtain overall sense of data to make predictions over measurements. In this section, you will be going to use "Poisson distribution" and "Gaussian or Normal Distribution" to study the radioactivity phenomena.

The Poisson distribution is a probability distribution over a fixed interval of time using a single parameter, this parameter being the known expected value, usually the mean value of any specific occurrence within a fixed time frame. The number of nuclear disintegrations detected by a Geiger counter can be appropriately modeled using this method.

The Poisson probability of event value of x to occur during the same time frame as the mean value $\bar{x}$ is determined using

$$P(x) = \frac{e^{-\bar{x}}\bar{x}^{x}}{x!}$$

where $\bar{x}$ is the mean value of the occurrence during a fixed time frame and x is the value of which you desire to know the probability for its occurrence.

For large values of $\bar{x}$ the Poisson distribution can become difficult to use as the x! value and $\bar{x}^x$ value becomes unmanageable for programs such as Excel to use.

You should be familiar with the Normal or Gaussian distribution and its characteristic bell curve. The Gaussian distribution is given by

$$P(n) = \frac{1}{\sigma\sqrt{2\pi}} exp\left[-\frac{(x-\bar{x})^2}{2\sigma^2}\right]$$

From this equation, the mean and standard deviation equations in which you are familiar are derived.

Procedure

1. From the previous experiment you have determined an optimal operating voltage for the GM tube. This voltage will be used during the duration of the experiment. Setup the counter for the following.

HV	determined from your last experiment
Preset Time	10s
Runs	120
Step voltage	0 volts or disabled

2.Run a data set with no source under or near the Geiger- Müller tube. This will be your background count. Try to move the source as far away possible from the GM tube to getter better background reading.
3. Gather a set of data using each source Cs-137 and/or Co-60. Save your data for each source in the computer. Record this data in the data sheet below.
4. Take the data back home for further analysis and fitting. Process to fit the distribution in excel is given at the end of this lab manual.

Name: 1000-ID: Source:

Runs	Background Count	Source Count	Runs	Background Count	Source Count	Runs	Background Count	Source Count
1			41			81		
2			42			82		
3			43			83		
4			44			84		
5			45			85		
6			46			86		
7			47			87		
8			48			88		
9			49			89		
10			50			90		
11			51			91		
12			52			92		
13			53			93		
14			54			94		
15			55			95		
16			56			96		
17			57			97		
18			58			98		
19			59			99		
20			60			100		
21			61			101		
22			62			102		
23			63			103		
24			64			104		
25			65			105		
26			66			106		
27			67			107		
28			68			108		
29			69			109		
30			70			110		
31			71			111		
32			72			112		
33			73			113		
34			74			114		
35			75			115		
36			76			116		
37			77			117		
38			78			118		
39			79			119		
40			80			120		

Name: 1000-ID: Source:

Runs	Background Count	Source Count	Runs	Background Count	Source Count	Runs	Background Count	Source Count
1			41			81		
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3			43			83		
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7			47			87		
8			48			88		
9			49			89		
10			50			90		
11			51			91		
12			52			92		
13			53			93		
14			54			94		
15			55			95		
16			56			96		
17			57			97		
18			58			98		
19			59			99		
20			60			100		
21			61			101		
22			62			102		
23			63			103		
24			64			104		
25			65			105		
26			66			106		
27			67			107		
28			68			108		
29			69			109		
30			70			110		
31			71			111		
32			72			112		
33			73			113		
34			74			114		
35			75			115		
36			76			116		
37			77			117		
38			78			118		
39			79			119		
40			80			120		

<u>Tips for fitting the Poisson and Normal distribution in Excel: (To be done back home)</u>

4. Using MS excel or some equivalent type of program enter your data for the counts into a column. In another column subtract the average background counts from the collected counts for each run.
5. Into another column divide the corrected count data by the duration, in seconds, of the trial you now have a cps series of data.
5. Create within the spreadsheet cells for Average, Minimum, Maximum and Standard deviation in the adjacent cell enter in the appropriate function to perform the calculation.
6. Create columns headings for N, frequency, Poisson and Gaussian.
7. Under the N heading create bins 1 count apart from the minimum to the maximum value. Under frequency us e Excel's Frequency function. First select the area to be filled, this area should be the same number of rows as the N data column. Next select Insert function and select Frequency. A window will appear where you can enter the appropriate information. Data array is where the corrected data is stored, for example d:11:d131. The bin array is from the column label N. **WAIT**, do not simple select enter this will only fill one cell. The trick in filling the frequency column is to press and hold CTRL-SHIFT then select OK.

		N	frequency	Poisson	Gaussian
Average	390.81	374	1		
Minimum	374	375	0		
maximum	406	376	0		
StdDev	6.23	377	0		
		378	0		
		379	1		
		≈			
		389	6		
		390	10		
		391	4		
		≈			
		402	2		
		403	5		
		404	6		
		405	2		
		406	0		

7. The Poisson and Gaussian calculations can be computed by hand but more efficiently by using the built in functions that Excel provides. Again help for each function can be found within the excel program. Each of these functions has a

logical argument which needs to be set as FALSE, to provide the necessary numerical data. The value should also be multiplied by the number of trials used to better correspond to the frequency values when you graph the data.

8. Graph a Frequency vs. Counts graph also include the Poisson and Gaussian distribution fits on the same graph page. Make a separate graph for each source. An example is shown below.