Counting radioactive decay events using a GM Tube

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1 Introduction

In this experiment, we show that there exist circumstances in which the Geiger Muller Tube can be used to reliably count the number of beta decay events. We also explain theoretically (qualitatively only) why the aforesaid circumstances are necessary and justify the observed behavior when they are altered.

2 Theory

A Gieger Muller tube is a device filled with gas which counts individual ionisation events. It consists of an anode surrounded by a metal cylinder that is the cathode. The gas filled in the tube is a mixture of rare gases and a quenching agent. The quanta entering the tube and colliding with the gas molecules initiate the ionising events.

Quenching is the termination of the ionisation of the current pulse in the GM tube.

Plateau Threshold Voltage is the starting voltage applied to the GM tube at which pulses just appear and the apparatus starts counting.

Plateau is the part of the GM characteristic curve over which the counts are predominantly independent of the applied voltage.

Plateau Length is the range of applied voltage over which the plateau region extends.

Upper Threshold Voltage is the highest voltage upto which the plateau region remains, beyond which counts increase substantially with applied voltage.

Plateau Slope is the slope of the curve in the plateau region, which quantifies the change in counts with the change in applied voltage, expressed in percentage.

Operating Voltage is the voltage at which the apparatus should be preferably used, is taken to be at the middle of the plateau region.

Background Counts are the counts registered without the source, which may be due to cosmic rays and other surrounding sources.

3 Procedure

The GM Tube described in the previous section is powered using a 220V source. A radioactive source (Cs; a β and γ source) was placed about 2 cm from the window of the Tube. An electronic device designed to count the number of detection events was initialized to count for 60 seconds. The voltage being applied to the GM Tube was varied from 350V to 650V. These numbers were determined by the following two procedures.

The voltage was increased continuously but slowly while ensuring that the counts display on the electronic device reads zero. The voltage at which the first count is found gives a rough estimate of where to start; in this case 350V.

The other value of the voltage was found by noting that the counts suddenly shoot up at around this value. Going beyond this risks reduction in the life of or permanent destruction the tube.

After the determination of appropriate range of operation, three sets of counts were noted twice for voltage values incremented in steps of 30V. Once with the source, and once without. The background thus found was subtracted and a graph of voltage versus counts was plotted and various regions identified.

4 Observations

Listing 1: Experimental Observations

Background Subtracted Counts

Voltage(V)	Count	Count	Count
350	0	0	0
380	971	977	982
410	975.33	955.33	956.33
440	966.66	980.66	973.66
470	953.66	1008.66	1007.66
500	986	1000	1004
530	967.33	995.33	979.33
560	952	978	974
590	1009.33	993.33	977.33
620	1447	1687	1759
650	2003.33	2053.33	2048.33

The plateau threshold voltage was observed to be at 380V.

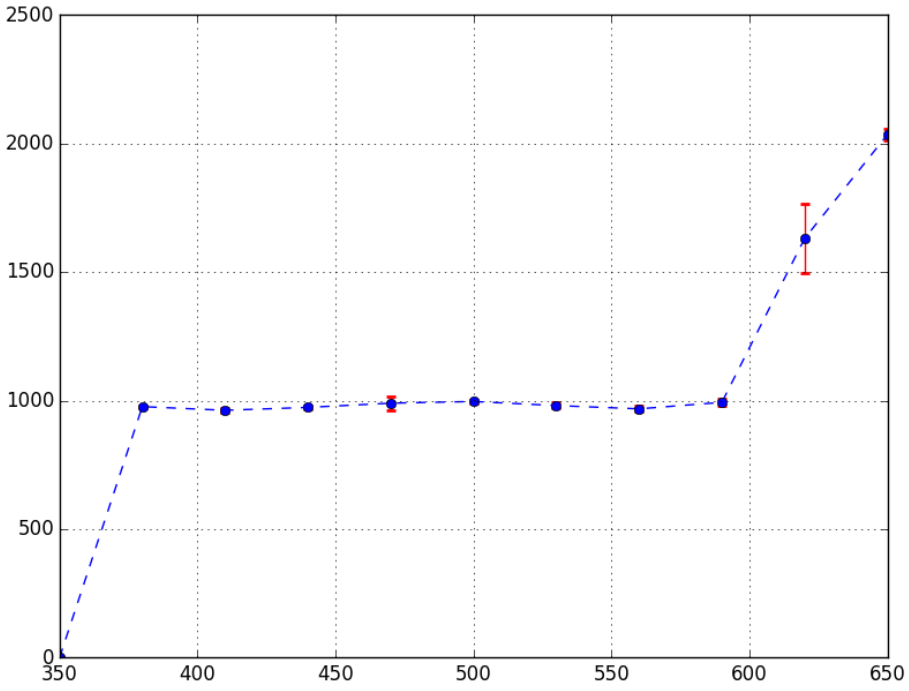


Figure 1: Voltage (V) vs Counts (in 60 sec)

The plateau region extends upto 590 V after which a sharp beginning of the discharge region can be noticed.

The plateau length is thus $(590 + 380)V = 210V$

The operating voltage V_0 is defined as the average of the plateau region voltages, thus

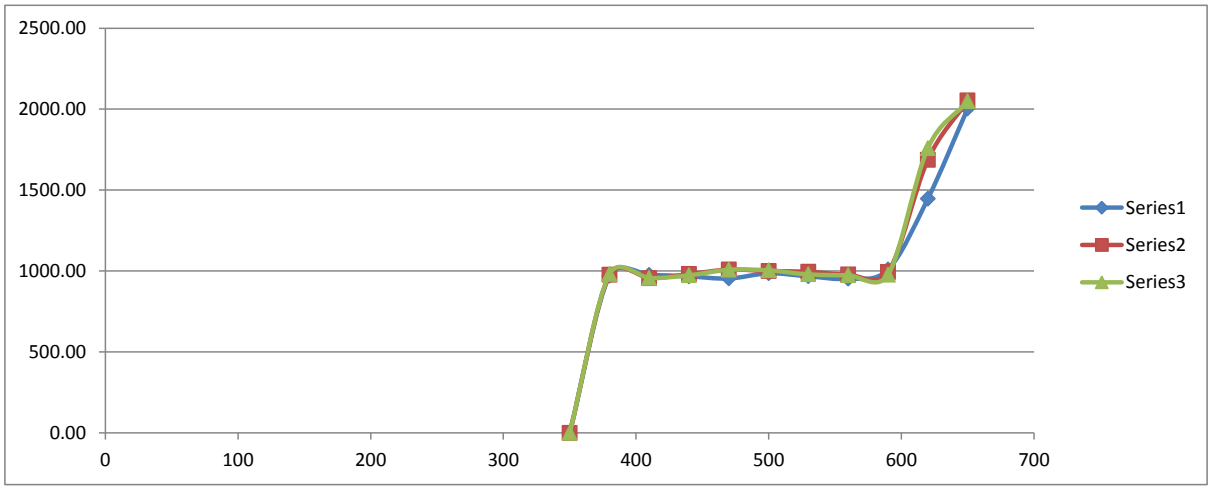
$$V_0 = \frac{1}{2}(590 + 380) = 485V$$

The slope of the plateau is given as

$$\frac{N_2 - N_1}{V_2 - V_1} \times 100 = \frac{16.67}{100} \times 100 = 7.93\%$$

Detailed observations have been listed below

	background				cs source		counts(30sec)			
volt (V)	counts(30sec)			avg background	counts1	without back1	counts2	without back2	count3	without back3
350	2	0	0	0.67	0	0.00	0	0.00	0	0.00
380	8	16	21	15.00	986	971.00	992	977.00	997	982.00
410	9	19	10	12.67	988	975.33	968	955.33	969	956.33
440	11	14	15	13.33	980	966.67	994	980.67	987	973.67
470	7	12	9	9.33	963	953.67	1018	1008.67	1017	1007.67
500	11	10	12	11.00	997	986.00	1011	1000.00	1015	1004.00
530	11	16	14	13.67	981	967.33	1009	995.33	993	979.33
560	8	19	18	15.00	967	952.00	993	978.00	989	974.00
590	10	11	17	12.67	1022	1009.33	1006	993.33	990	977.33
620	9	16	20	15.00	1462	1447.00	1702	1687.00	1774	1759.00
650	20	45	33	32.67	2036	2003.33	2086	2053.33	2081	2048.33
680	20	34	29	27.67	1986	1958.33				
710	31									
740										
770										
800										
830										



5 Results

The graph plotted, appropriately shows the plateau region, with a length of 210V. Thus the operation voltage was found to be 485V.