Counting radioactive decay events using a GM Tube

Vivek Sagar, Prashansa Gupta and Atul Singh Arora

November 3, 2014

1 Introduction

Here we show that there exist circumstances in which the Geiger Muller Tube can be used to reliably count the number of beta decay events.

2 Theory

A Gieger Muller tube is a device filled with gas which counts individual ionising events. It consists of 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.

A characteristic curve can thus be plotted for the given GM tube, using voltage and counts.

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.

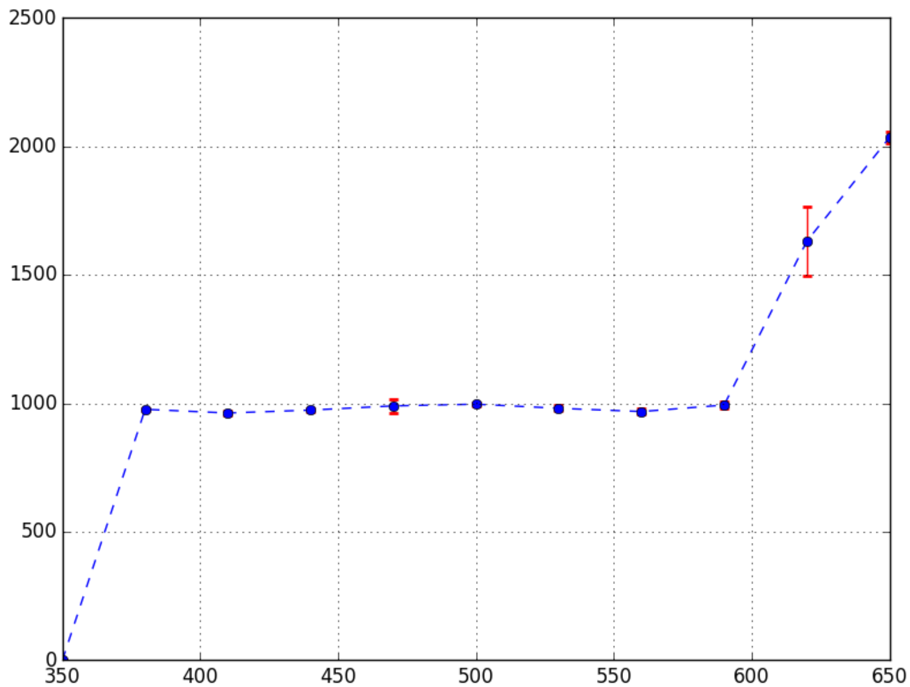
After the determination of appropriate range of operation, three sets of counts were noted twice for voltage values incremented in steps of 30V. Once with the source, and once without. The background thus found was subtracted and a graph of voltage versus counts was plotted and various regions identified.

4 Observations

Listing 1: Experimental Observations

```
Voltage          Count Rate                 Count Rate       Count Rate
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.



The plateau region extends upto 590V 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_O is defined as the average of the plateau region voltages, thus

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

The slope of the plateau is given as

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

5 Results

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