Nuclear Radiation detectors:

All the nuclear measurements require specialized devices to detect and record the different types of nuclear radiation. These devices known as radiation detectors, which used to specify the types of radiation, amount of radiation, and determine its energy.

The type of detectors depends on:

1. Type of particles or radiations which require to detect (heavy charged particles, electrons, x-ray and Gamma rays)
2. Energy of radiation.
3. Intensity of radiation

The principle of radiation detection on many detectors depends on ionization phenomena or excitation of radiation to the atoms and molecules of the material when the radiation passes through it. Other types of detectors depend on its work on some chemical changes in its material, and by measuring these changes the amount of radiation can be measured.

The gas detectors:

The principle of gas detectors depend on collect the electrical charged (electrons and ions) resulted from ionization of atom or gas molecules when the ionized radiation pass through it. By measuring the resulted electrical charge or current, the detection of radiation through gases can detected. The gas detectors can be classify into three types:

1. Ionization chamber.
2. Proportional counter
3. Geiger- Muller counter

Introduction to Geiger Counters

A Geiger counter (Geiger-Muller tube) is a device used for the detection and measurement of all types of radiation: alpha, beta and gamma radiation. The Geiger – Müller counter takes advantage of the fact that radioactive decay produces high-energy particles that can ionize the matter through which they pass.

- Basically it consists of a pair of electrodes surrounded by a gas.
- The electrodes have a high voltage across them.
- The gas used is usually Helium or Argon.
- When radiation enters the tube it can ionize the gas.
- The ions (and electrons) are attracted to the electrodes and an electric current is produced.
- A scaler counts the current pulses, and one obtains a "count" whenever radiation ionizes the gas.
- The apparatus consists of two parts, the tube and the (counter + power supply).
- The Geiger-Mueller tube is usually cylindrical, with a wire down the center.
- The (counter + power supply) have voltage controls and timer options. A high voltage is established across the cylinder and the wire as shown in the figure below.

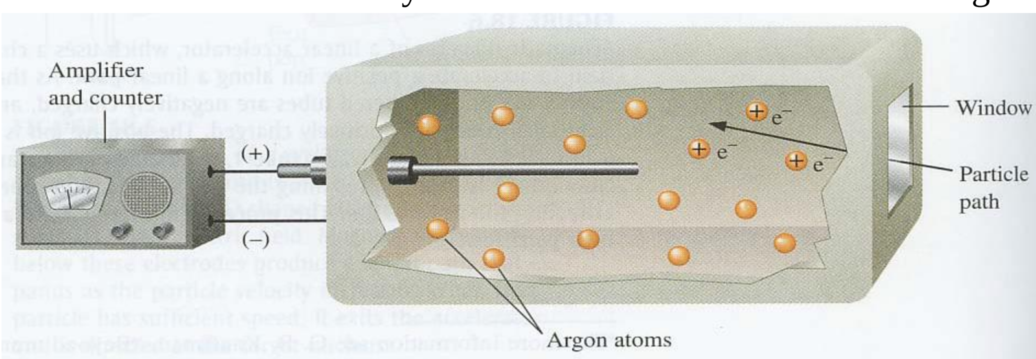

Figure 1. Aschematic representation of a Geiger-Muller counter. The high energy radioactive particle enters the window and ionizes argon atoms along its path. The resulting ions and electrons produce a momentary curent pulse, which is amplified and counted.

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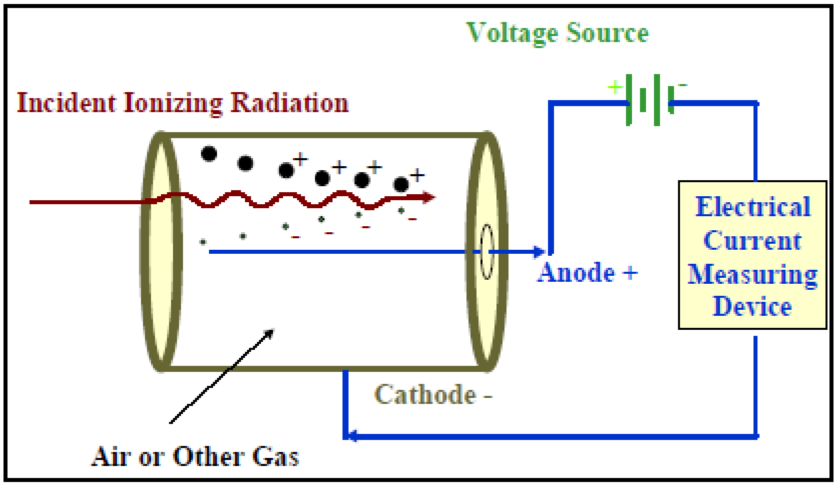


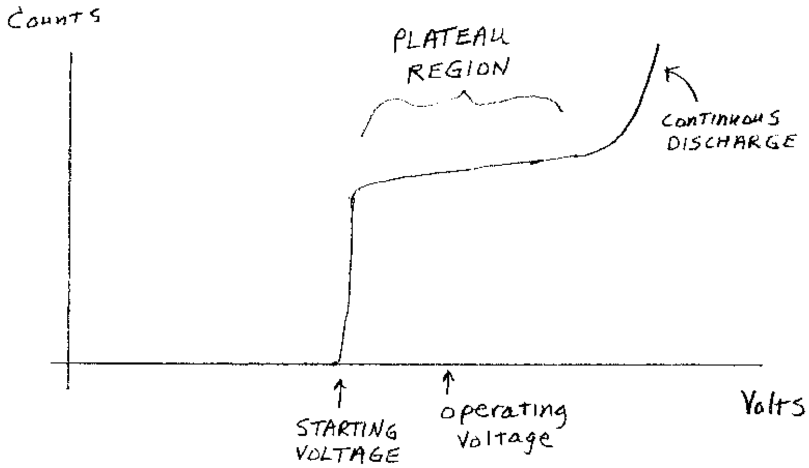
When ionizing radiation such as an alpha, beta or gamma particle enters the tube, it can ionize some of the gas molecules in the tube. From these ionized atoms, an electron is knocked out of the atom, and the remaining atom is positively charged.

The high voltage in the tube produces an electric field inside the tube. The electrons that were knocked out of the atom are attracted to the positive electrode, and the positively charged ions are attracted to the negative electrode. This produces a pulse of current in the wires connecting the electrodes, and this pulse is counted.

After the pulse is counted, the charged ions become neutralized, and the Geiger counter is ready to record another pulse. In order for the Geiger counter tube to restore itself quickly to its original state after radiation has entered, a gas is added to the tube.

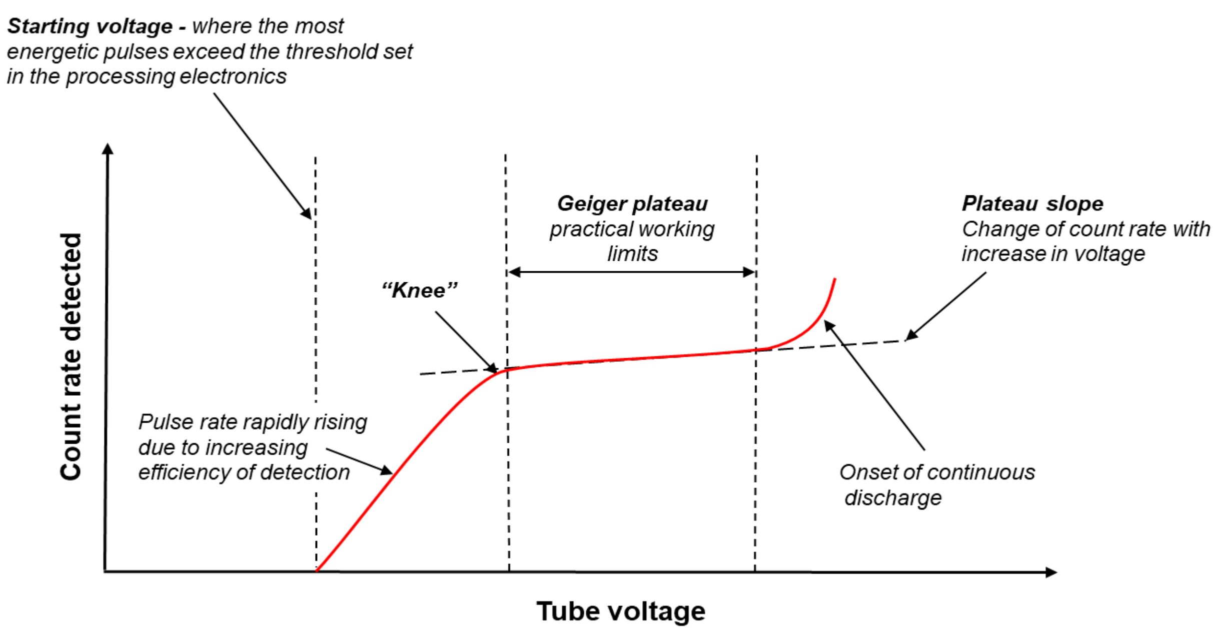
For proper use of the Geiger counter, one must have the appropriate voltage across the electrodes:

- If the voltage is too low, the electric field in the tube is too weak to cause a current pulse.
- If the voltage is too high, the tube will undergo continuous discharge, and the tube can be damaged.
- Usually the manufacture recommends the correct voltage to use for the tube.
- Larger tubes require larger voltages to produce the necessary electric fields inside the tube.
- For low voltages, no counts are recorded. This is because the electric field is too weak for even one pulse to be recorded. As the voltage is increased, eventually one obtains a counting rate. The voltage at which the G-M tube just begins to count is called the *starting potential*. The counting rate quickly rises as the voltage is increased.
- The rise in potential is so fast, that the graph looks like a "step" potential. After the quick rise, the counting rate levels off. This range of voltages is termed the "**plateau**" region.
- Eventually, the voltage becomes too high and we have continuous discharge. The *threshold* voltage is the voltage where the plateau region begins.
- Proper operation is when the voltage is in the plateau region of the curve. For best operation, the voltage should be selected fairly close to the threshold voltage, and within the first 1/4 of the way into the plateau region.
- In the plateau region the graph of counting rate vs. voltage is in general not completely flat. The plateau is not a perfect plateau. In fact, the slope of the curve in the plateau region is a measure of the quality of the G-M tube. For a good G-M tube, the plateau region should rise at a rate less than 10 percent per 100 volts. That is, for a change of 100 volts, (Δcounting rate)/(average counting rate) should be less than 0.1. An excellent tube could have the plateau slope as low as 3 percent per 100 volts



The Geiger Plateau Curve

Showing the characteristic curve of a GM tube with a constant radiation source with change in tube voltage



Efficiency of the Geiger-counter:

The efficiency of a detector is given by the ratio of the (number of particles of radiation detected)/ (number of particles of radiation emitted):

$$\varepsilon \equiv \frac{number\ of\ particles\ of\ radiation\ detected}{number\ of\ particles\ of\ radiation\ emitted}$$

Some of the advantages of using a Geiger Counter are:

a)They are relatively inexpensive

b)They are durable and easily portable

c)They can detect all types of radiation

Some of the disadvantages of using a Geiger Counter are:

a) They cannot differentiate which type of radiation is being detected.

b) They cannot be used to determine the exact energy of the detected radiation

c) They have a very low efficiency