Ionization Chamber

It is a device for detection of ionizing radiation by measuring the electric current generated when radiation ionizes the gas in the chamber.

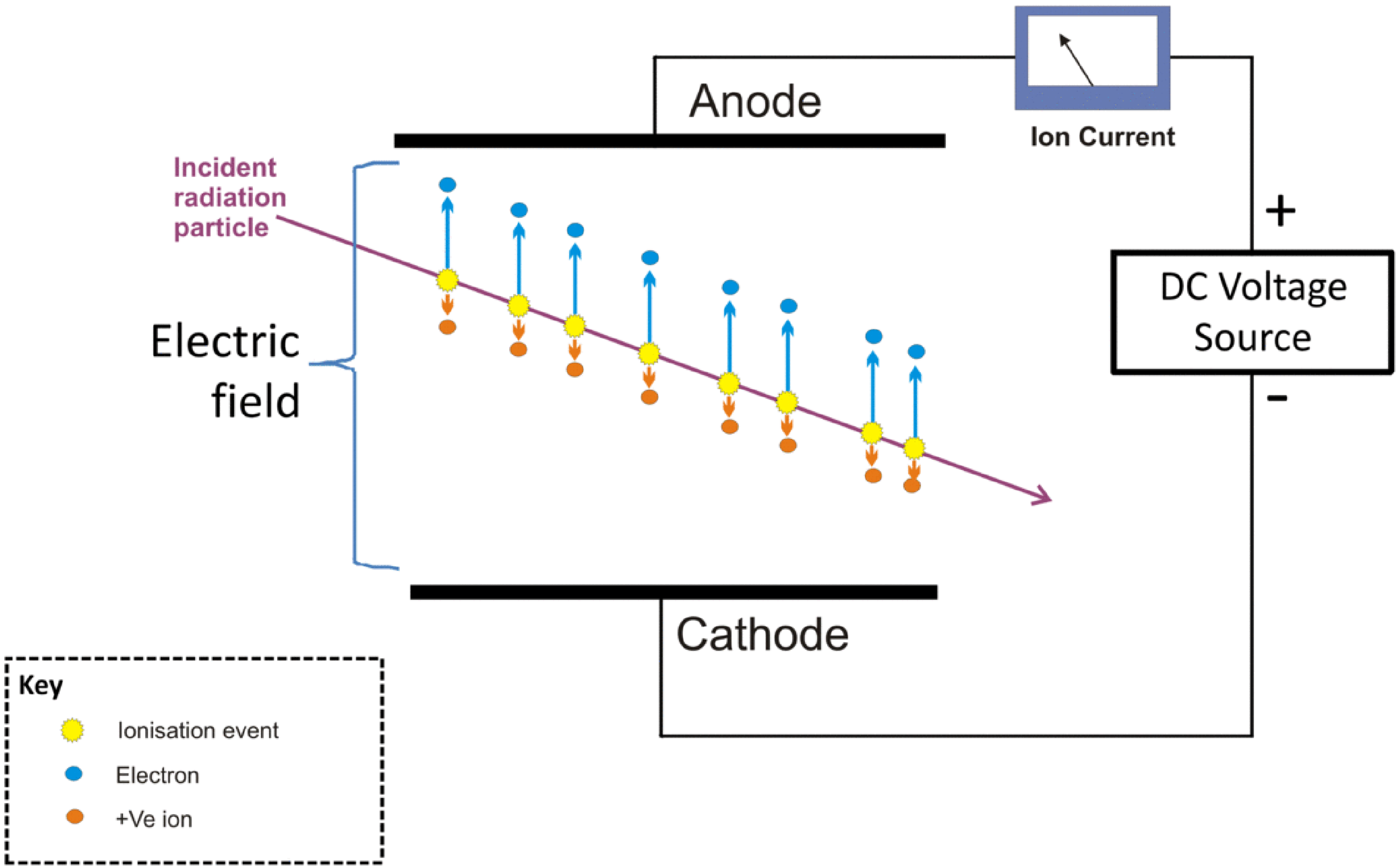
In this detector ions produced by an incident particle are collected by an electrostatic field. An inert gas at suitable pressure is filled inside the chamber. The inert gas like Ar is used to minimize the losses of ions by recombination. When an energetic particle enters the chamber through window, ions are produced.

Ionization Chamber (cont.)

An ionization chamber essentially consists of a closed vessel having an inert (argon) in which ions have rather long life time and two electrodes maintained at a moderate (few hundred to few thousand) voltage.

Commonly used chambers posses either parallel plate geometry or cylindrical geometry. While in the former class two parallel plates are separated by a distance, in the latter a cylindrical conducting shell with a coaxial insulated metallic wire (dia ~1 mm) acts as electrodes.

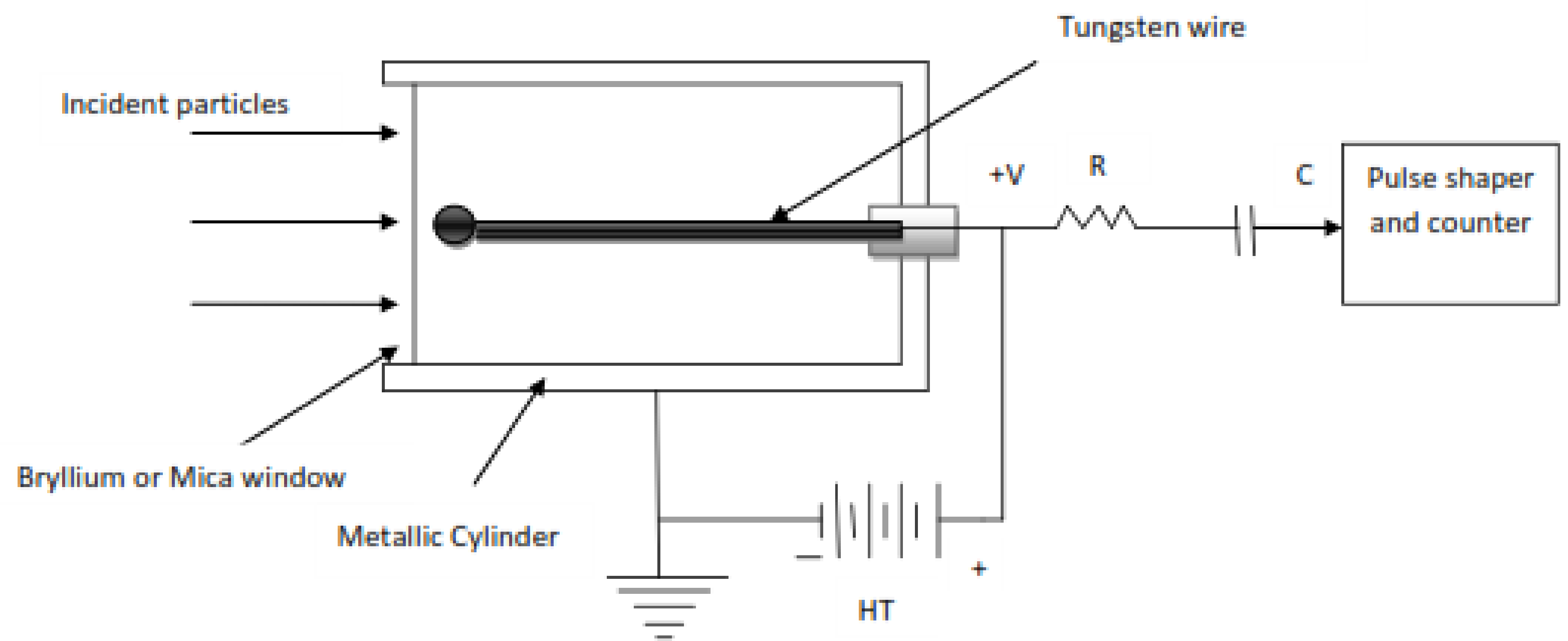
Parallel Plate Ionization Chamber



Gas-filled detector

The performance of this type of detectors depends on the electric pulse of current produced when ions are formed by the passage of a charged particle between two electrodes maintained a sufficient potential difference. These detectors are usually called gas-filled detectors.

Cylindrical Ionization Chamber



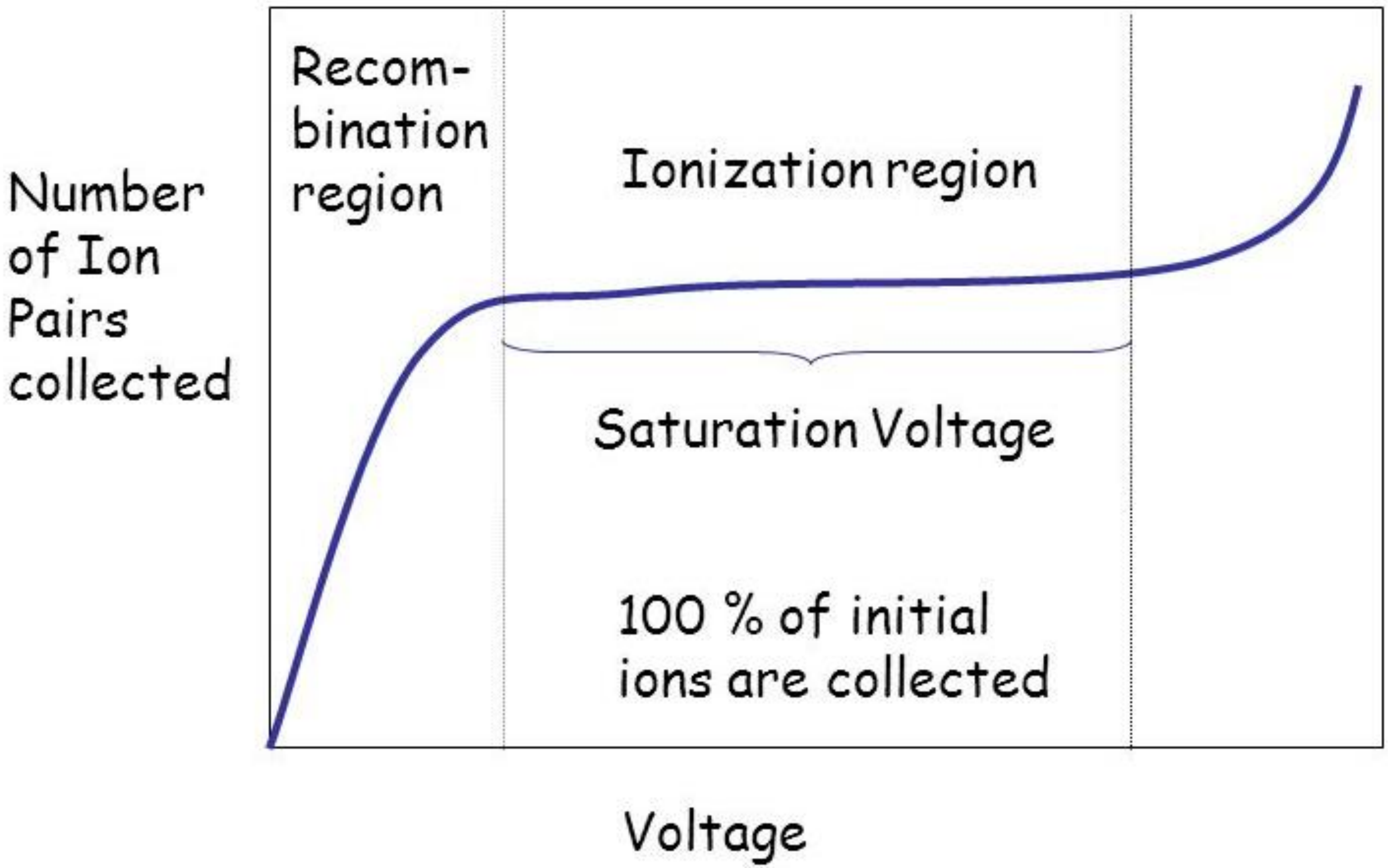
One of the electrodes is the outer metal cylinder connected to the –ve terminal of a dc-power supply and the other electrode is the central straight wire connected in series to a resistor R to the +ve terminal of the power supply (220 V).

Cylindrical Ionization Chamber (cont.)

The gas inside the chamber is maintained under some pressure to enhance the sensitivity of the instrument by providing more targets for the incoming colliding particles. A thin mica window W allows photons or charged particles to enter the chamber and ionize the gas inside.

For instant, if the alpha particle passes through the chamber, it will produce a number of +ve ions and electrons in its path. The electron will drift in the direction opposite to the filed with a mean speed 10^6 m/s, collision with gas molecules stop them from accelerating. The positive ions drifts the other way (-ve electrodes), typically with 100 times slower.

Voltage pulse vs. Ion pairs collected



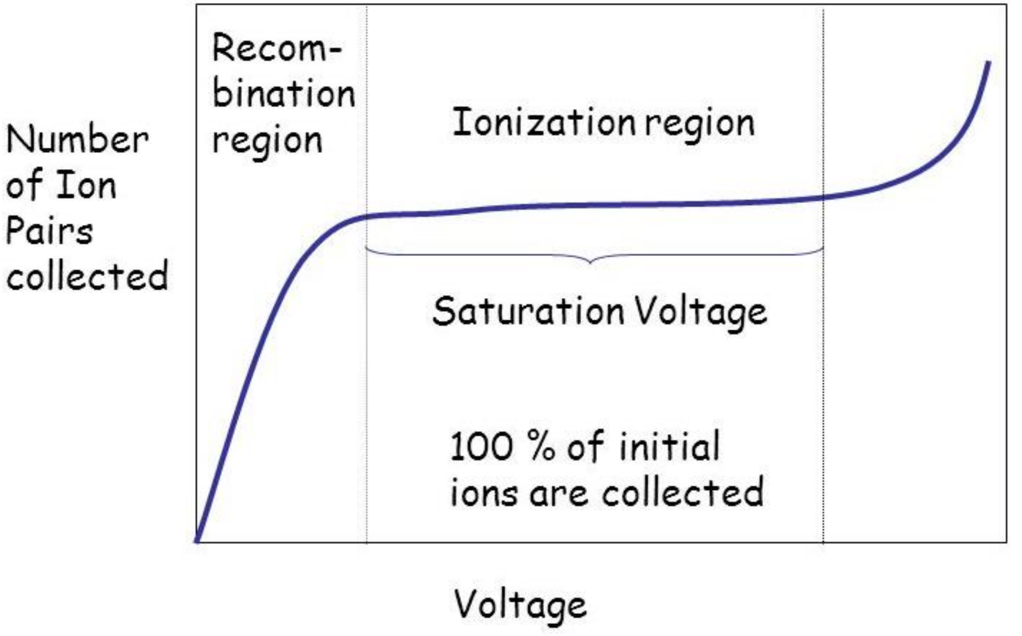
Ion-pairs formation graph

In the ionization region, all the ions produced by incident radiation are collected by electrodes. The pulse height of the ionization region of the figure is independent with applied voltage. So the chamber does not measure the energy of the incoming particles as the energy deposition is, however, proportional to the number of ions produced and is a measure of charge and velocity of the particle. These are the quantities that ionization chamber measures.

The above features of voltage pulse vs. ion pair collected can be explained as follows:

Ion count graph

Let the ions be generated uniformly and at a constant rate. Since the gas is neutral, the number of positive charges and electrons are equal. The ions of opposite sign are having tendency to recombine. This recombination neutralizes the charges and produces neutral atoms.



Ion count graph (cont.)

When potential difference (the filed) is small, very few ions could reach the electrodes, because they recombine. The increase of potential difference increases the number of ions arriving at the electrodes. So long there is enough supply of ions, the proportional increase of pulse is maintained. This corresponds to the initial increase of the graph.

As potential difference if further increased, the velocity of ions is so great that their recombination in the short interval is negligible and all the ions produced reach the electrodes. Thus there is no further increase of pulse even if potential difference increases. It corresponds to the saturation (steady state) condition.

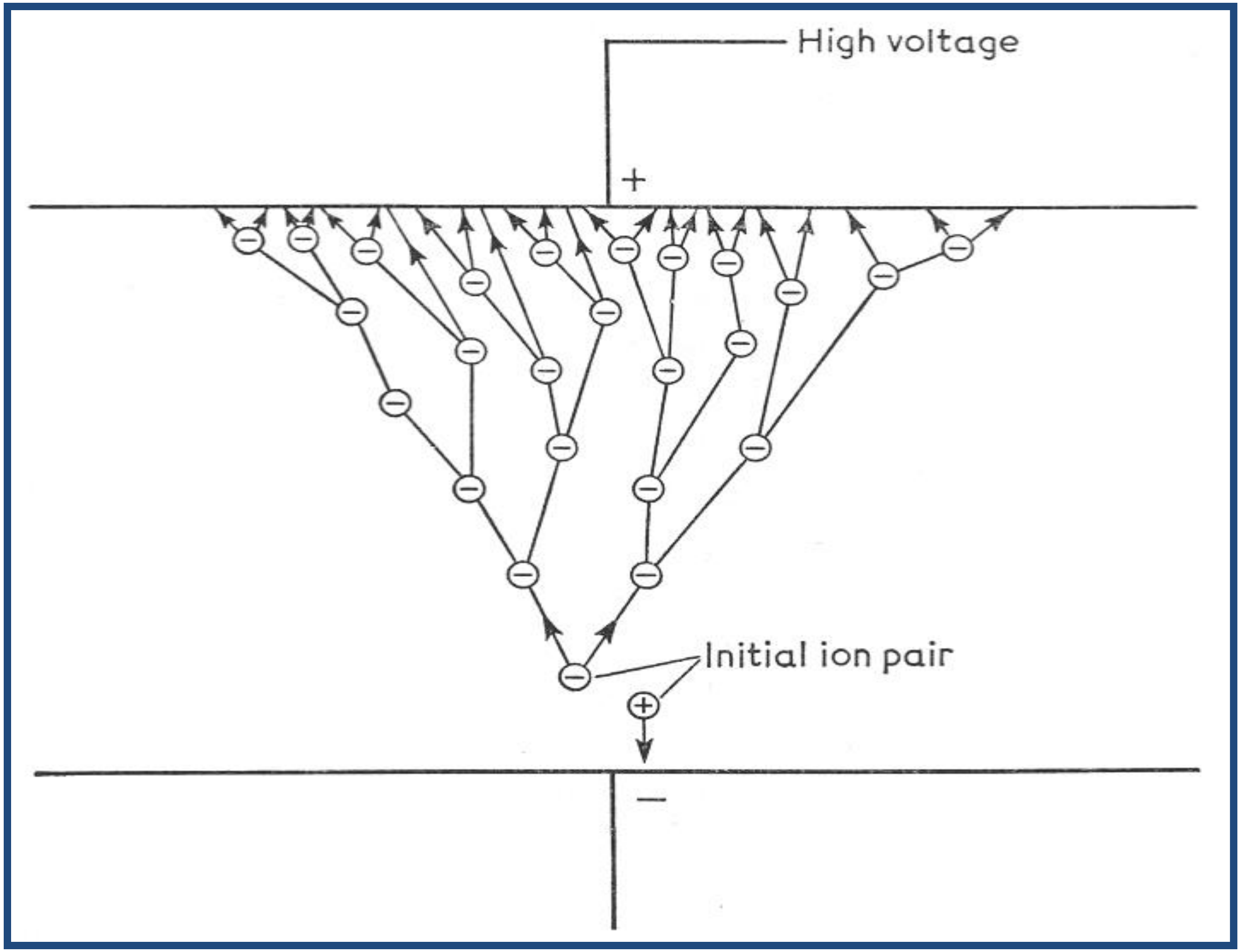
Ion count graph (cont.)

On further increase of potential difference, the ions moving towards the electrodes acquire sufficiently high voltage to ionize other neutral molecules by collision. The rate of this fresh ion-formation by collision far exceeds the rate of ion-formation by ionizing radiation. This results in the step increase of the pulse as given by the end part of the graph. Beyond a certain value of potential difference, a spark passes between the electrodes.

Proportional Counter

A second type of gas-filled detector, derived from the ionization chamber, is the proportional chamber. Low energy of ionizing particles cannot be detected by a ionization chamber since the voltage pulse they produce have very small amplitude. If the filed between the electrodes, it is possible to produce pulse of higher amplitude with such particle using gas multiplication. This is done in proportional counter.

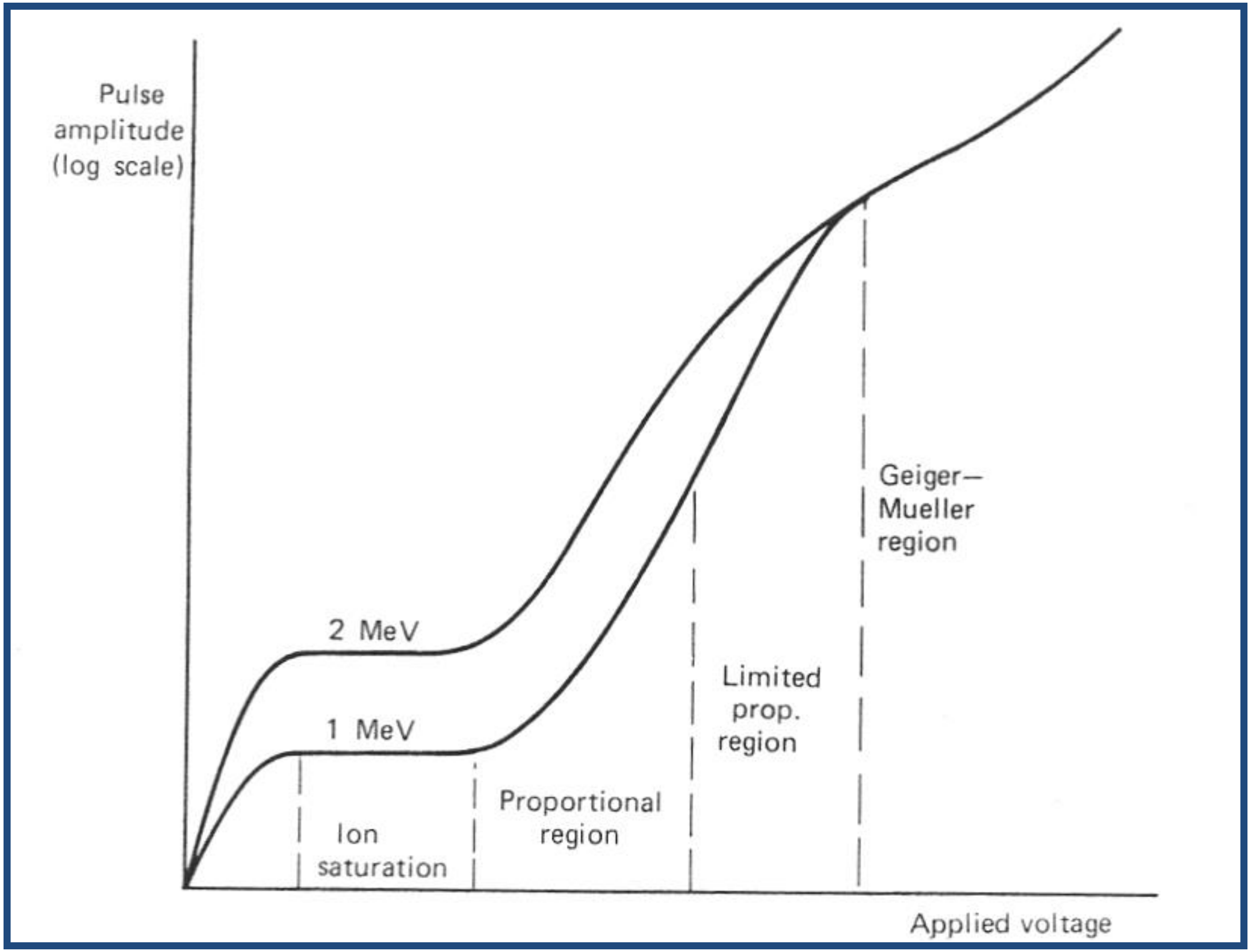
Proportional Mechanism



Proportional Counter (cont)

In this counter, a voltage of 250 – 800 V is applied between electrodes and so the original gas ions produced by particle are accelerated to sufficient kinetic energy to produce secondary ions by collision with neutral gas molecules. The total amount of charge collected for each particle is greater than the original charge produced. The intensities of the electrical pulses are proportional to the number of ions formed by the ionizing radiation. Thus the counter is called proportional counter.

Pulse amplitude vs. Applied voltage



Proportional counter (cont.)

In the proportional region, the pulse height is proportional to the energy of the incident particle. If the pulses are fed into an oscilloscope, the pulse height could measure the energies of the ionization radiation. Such information is of great importance in the study of nuclear disintegration.

With the help of such counter, it is easy to distinguish alpha particle from beta rays and protons by the larger voltage pulses they produce due to greater electric charge.

Therefore, the proportional counter not only counts incoming particles but also measure energy of particles.