# Chapter = 20

# "Nuclear Radiations" Compiled by: Sir M.Atiq

**Alpha particles:**

1. Due to large mass $\alpha$ particles make very large number of collisions with the atoms and ionize them as it passes through atom.
2. When $\alpha$ particle passes through atom the strong electrostatic attraction force between it and an electron tears the electron off from the atom and ionize it.
3. The range of $\alpha$ particle is small and it is about $7 \times 10^{-2}$ m in air and only $4 \times 10^{-5}$ m in aluminum for the 7.7 Mev $\alpha$ particles.
4. The number of ions produced by an$\alpha$ particle or its range in air is a measure of its energy.
5. Alpha particles produce fluorescence on striking certain substances such as zinc sulphide and bariumplatinocynide.



**Beta particles:**

1. The mass and ionization of $\beta$ is much less than the $\alpha$ particles.
2. Due to its small size the collisions are fewer and farther apart.
3. It can ionize an atom by strong electrostatics repulsion when it passes close to its electron.
4. The range of $\beta$ particles in a medium is very large, nearly 100 times than that of $\alpha$ particles.
5. The ionization is less than the $\alpha$ particles and is one-hundred of that by $\alpha$ particle.
6. $\alpha$ Particles are stopped by an ordinary paper, but the $\beta$ particles may pass through a thick book.
7. Small thickness of a heavy metal rich in electrons is enough to stop the $\beta$ particles e.g. $5 \times 10^{-3}$ m of aluminum.
8. Fluorescence is also produced when $\beta$ particles strike calcium tungstate and barium platinocynide.

**Gamma Rays:**

1. Gamma rays are very high energy electromagnetic radiations of extremely short wavelength emitted from the nuclei of radioactive atoms.
2. They carry no charge and have no rest mass but possess very high energy of the order of several Mev.
3. They penetrate through far greater distance in material media as compared to $\alpha$ and $\beta$ particles.
4. Very energetic gamma rays are capable of penetrating several centimeters of concrete.
5. Gamma rays can produce ionization in three ways e.g. photoelectric effect, Compton's effect and pair production.

6. Substance rich in electrons e.g. lead will stop most of the gamma ray photons and serve as a good shield against gamma rays.



**Protons:**

1. A proton is also a positively charged particle with properties similar to the $\alpha$ particles.
2. Its mass is one-fourth and charge is one half of that of an$\alpha$ particle.
3. It suffers fewer collisions with the atoms of the medium as compared with the $\alpha$ particle and penetrates the medium through a greater distance about (5 to 10 times) before stopping.
4. Its ionizing power is also much less, about one-fifth that of the $\alpha$ particle.

**Neutrons:**

1. A neutron is essentially emitted from the nucleus of an atom. It is so called because it is electrically neutral and carries no charge.
2. Its mass is very nearly equal to that of a proton.
3. It can neither experience nor exert any electrostatic force of attraction or repulsion.
4. When it hits an electron, it knocks it out from the atom (ionization) with practically no charge in its own energy or direction of motion.
5. When it hits a nucleus, appreciable changes in its energy and direction of motion are likely.
6. A neutron is a highly penetrating but very slightly ionizing particle.



**Geiger counter**

A Geiger-Muller tube is one filled with a low pressure inert gas such as helium. The instrument works by ionizing radiation that passes through the tube making the gas molecules to be ionized creating charged ions and electrons. The energy created during the ionization process accelerates the ions to the cathode and the electron towards the anodes. This creates a current that is measured and counted by the device.

**Structure of the Geiger counter**

The main element of a Geiger counter is the Geiger-Muller tube, which is basically a chamber filled with inert gas or a mix of organic vapor and halogens. The tube contains two electrodes, the anode and the cathode, which are usually coated with graphite. The anode is represented by a wire in the center of the cylindrical chamber while the cathode forms the lateral area. One end of the cylinder, through which the radiation enters the chamber, is sealed by a mica window.

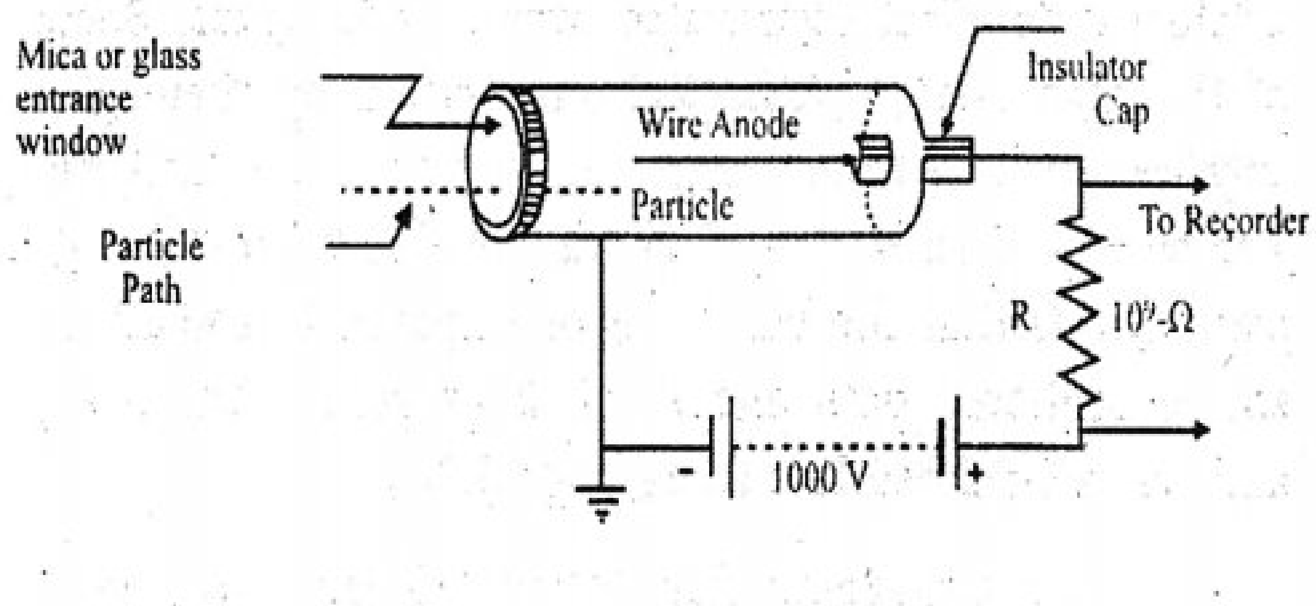



*Fig.20.3 Geiger Counter*

**Working**

As ionizing radiation coming from the surrounding medium passes through the mica window and enters the Geiger-Muller tube, it ionizes the gas inside, transforming it into positively charged ions and electrons. The electrons eventually migrate towards the anode of the tube detector, while the positively charged ions accelerate towards the cathode. As the positive ions move towards the cathode, they collide with the remaining inert gas thus producing more ions through an avalanche effect. When this happens an electrical current is established between the two electrodes. This current can then be easily collected, amplified and measured or counted and played in the form of an acoustic signal made out of clicks (available for most Geiger-Muller counters), each of which should correspond to the detection of a single ion (most of the times prevented by secondary avalanche processes). To improve the detection, multiple discharge stopping techniques can be used, either by removing the high voltage from the electrodes or by inserting additional organic or halogen gases in the inert mix.

**Wilson Cloud Chamber**

It is an instrument used for the detection and identification of the path of subatomic particles. In Wilson Cloud Chamber, paths of subatomic particles or ionized particles can be photographed.

**Structure**

It is consist of a closed cylindrical chamber with the transparent glass top, a movable piston at the bottom. On the sides near the top, the cylinder is provided with a glass window. Inside the cylinder a liquid of low boiling point is placed. The piston can be moved up or down. The whole system is air tight. A strong light source issued to illuminate the chamber while the photograph is taken by the camera.

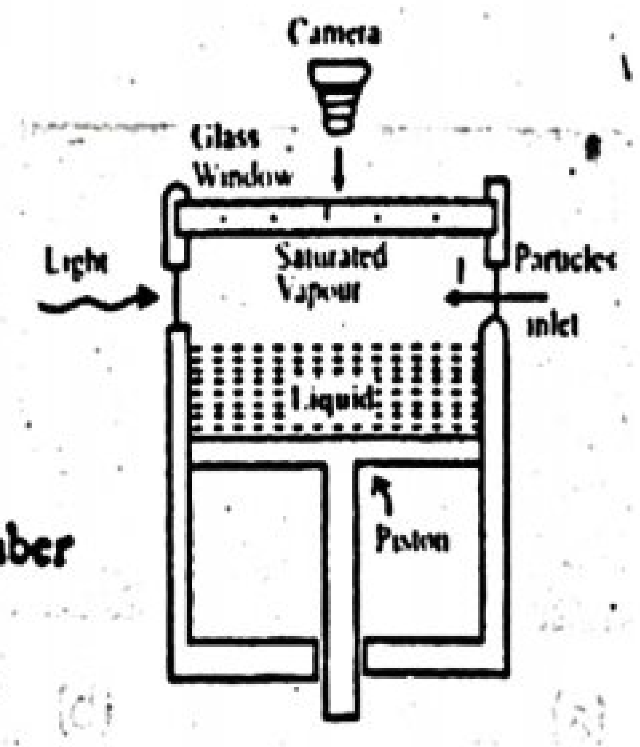



Fig.20.1. Wilson Cloud Chamber

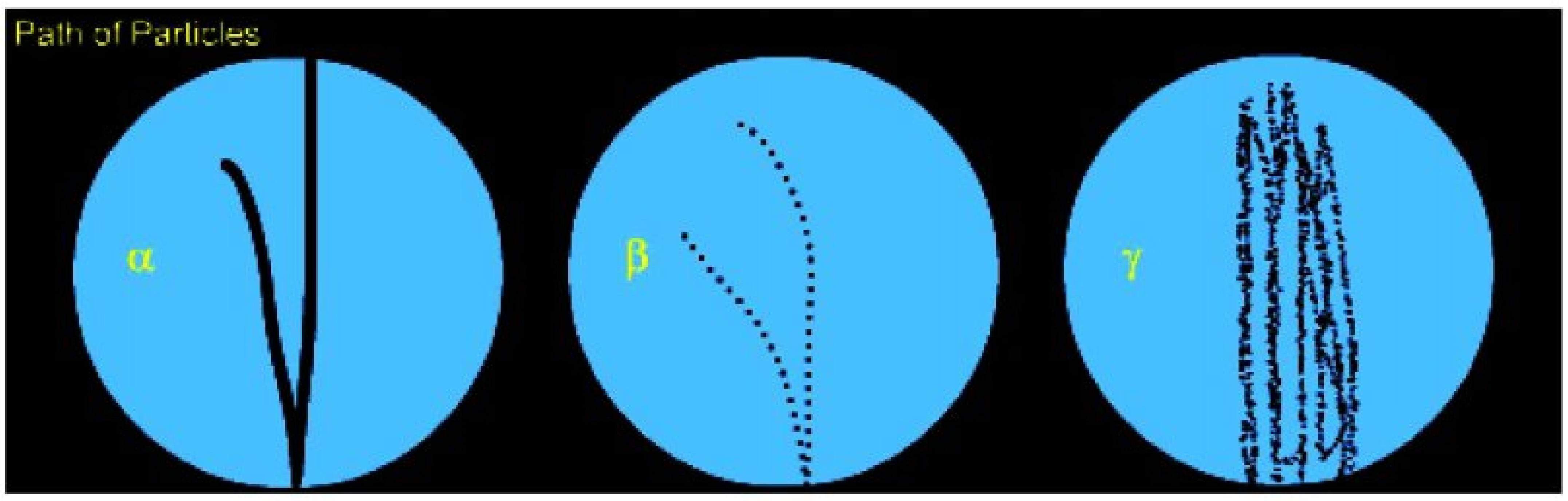
**Working**

Some volatile liquid having low boiling point (methanol $CH_3OH$ or ethanol $C_2H_5OH$) poured on the inner surface of the chamber. The piston first is moved slowly up so the air inside the chamber is cleaned and then it is then moved down, so that the ir pressure is dropped and the air gets vapors of the liquid and becomes supersaturat a fog is observed in the chamber.

At the right moment particles are allowed to enter into the chamber and a powe intense beam of light is used to illuminate the track of the particles and photos taken by the sensitive camera.

If a strong electric or magnetic field is applied to the particles (charged) then t path is altered. By the study of path`s length, thickness, continuity or discontin the influence of magnetic field (curve) .i.e. geometry the e/m ratio can be calcul and hence the particle is detected.

An alpha particle left a broad, straight path of definite length while an electron produced a light path with bends due to collisions. Gamma rays did not produce a visible track since they produce very few ions in air.




**Solid State Detectors:**

These devices basically make use of the solid state semiconductor diodes i.e. the p-n junction. It may be recalled that no current passes through a semiconductor diode when it is reverse biased. However if an energetic particle (or radiation) passes through the p-n junction region, a reverse current pulse passes through the diode due to the ionization of the atoms of the region. The current pulse so produced is then fed into an amplifier and the amplified pulse is applied to a loudspeaker or an electric counter which can register the number of clicks or counts respectively as the Geiger counter.



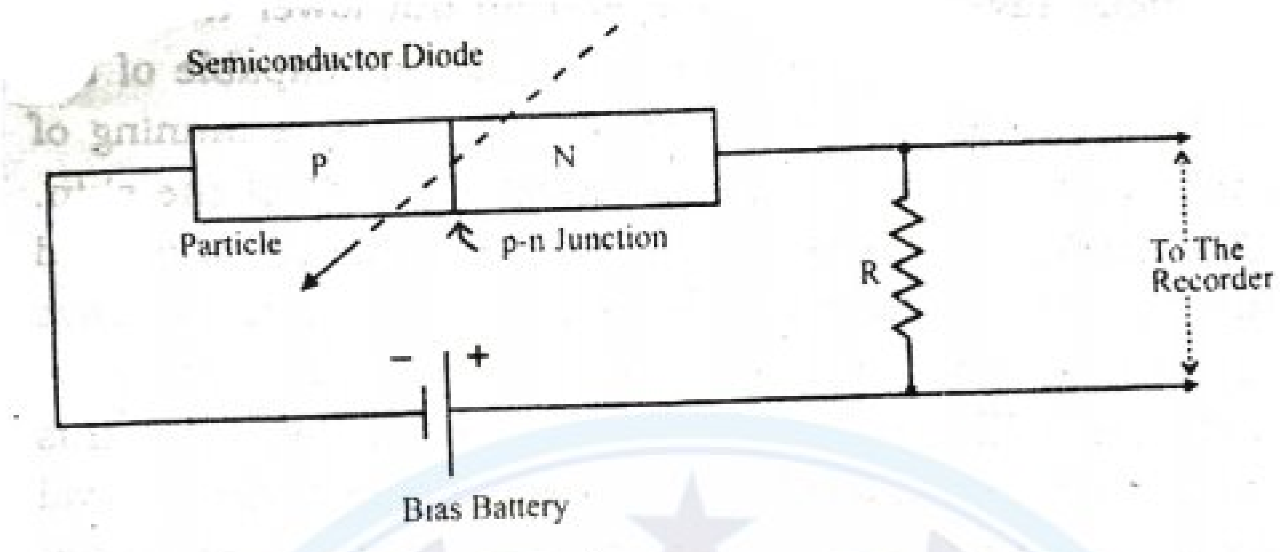


*Fig.20.4 Solid State Detector*

**Advantages:**

1. The advantage of this device over the Geiger counter is that it eliminates the use of Geiger tube, the special gaseous mixture in it and the low pressure it demands.
2. This device works at low potential difference up to 9 volts.
3. It can detect particles having energy only a few electron volts.