By now we have studied several particles, specially we have discussed various ~~pa~~ radiations like $\beta^{\pm}$, α, γ, ~~and~~ and neutron. On top of this we also know that there are proton ~~II~~ Pions, Kaons, neutrinos, muons etc. By now there are more than 180 particles have been discovered. ~~beg~~ While we will discuss about them in our particle physics lecture at this stage we limit to few (only those which can be seen by detector at present technologies. lets ~~ta~~ categorize them based on ~~their~~ particle properties.

$\boxed{\text{Type of radiation/particle}}$.

- $\boxed{\text{Charged particle}}$
  - Heavier
    - α (He^{2+}
    - $p^{\pm}$
    - $\pi^{\pm}$
    - $K^{\pm}$
    - Recoil nuclieds
    - Fission fragments
    - μ^+, μ^-
  - Lighter
    - β^+, β^- e^+, e^-, ~~μ^+~~, ~~μ^-~~
- $\boxed{\text{Neutral particle}}$
  - Neutrons
  - π^0
  - K^0
  - γ (gamma)

(radiation)

what happens when these particles passes through a material?? To answer this question we need to look into molecular, rather atomic level of the material in which radiation is passing through. and the properties of incoming particles. Thus interaction of ~~ioni~~ radiation with matter can be described at the molecular process like absorption, scattering etc. Therefore following parameters are important to note for these analysis:

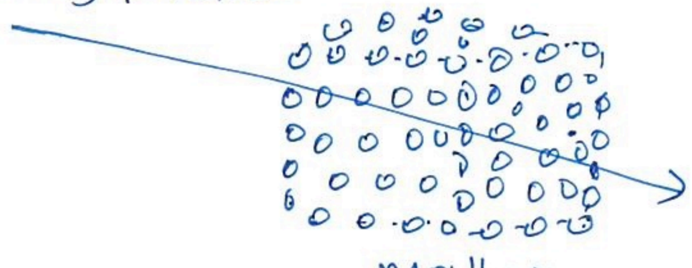
Incoming Particle →
- mass
- charge
- speed
- kinetic energy
- spin.

} ~~de~~ deacceleration, decrease of energy, ~~dec~~ fragmentation, decaying.

matter.
- atomic mass
- what atom (z.)
- number of electrons per volume
- density
- ionization potential

} physical effects, chemical effects, biological effect, structural changes.

incoming particle



matter.

It is obvious that when a particle passes through a matter it undergoes multiple scattering (this depends on the cross sections). All these scattering depends on the four interaction, through which these scatterings happens. Due to these scattering some energy gets transfer to the material & the incoming particle looses its energy. Therefore the strength of these interaction plays an important role in radiation interaction with matter.

- at atomic level only electromagnetic & ~~gravitat~~ gravitational interactions have sizable strength.

-> Electromagnetic strength is ~40 order of magnitude stronger than that of gravity.

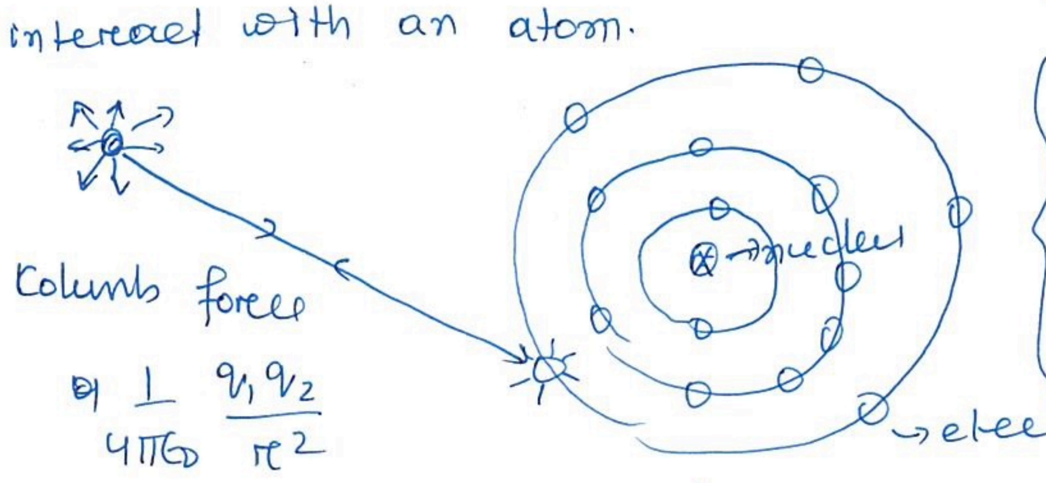
-> at the size of proton, the strong force turn on and it becomes ~100 times stronger than electromagnetic strength

-> At distance much smaller than nucleonic size (1/1000 of proton size) weak force turns on.

-> Quarks are not isolable

considering all these facts, it is clear that, at atomic or molecular level, we should concentrate only on electromagnetic interaction level. This is due to a combination of ~~their~~ their strength and reach make them the primary responsible for the energy loss in matter. For neutral particle other effects enters.

Let's discuss what happens when a charge particle interact with an atom.



atom

Also it can interact to nucleus. Which is less probable as it depends on incoming energy.

The colomb force increases (wheather it is attraction or repulsion decided by charge state). If the kinetic energy of incoming particle is higher, this will have bigger effect on the electron in the atom. Eventually some energy will transfer to the electron in atom (this is called electromagnetic scattering). Now what happen to the electron in atom which has ~~ee~~ recieved some energy: either of the following ~~thing~~ effect will happen to the electron:

1. if the energy recieved is higher that binding energy of this electron to the atom, then the electron will be able to completely separate from the atom, producing an electron-ion pair.

2. if the energy recieved by electron in atom is smaller than the atomic binding energy then the electron will jump to an excited state & drops back to original shell by emitting a photon.

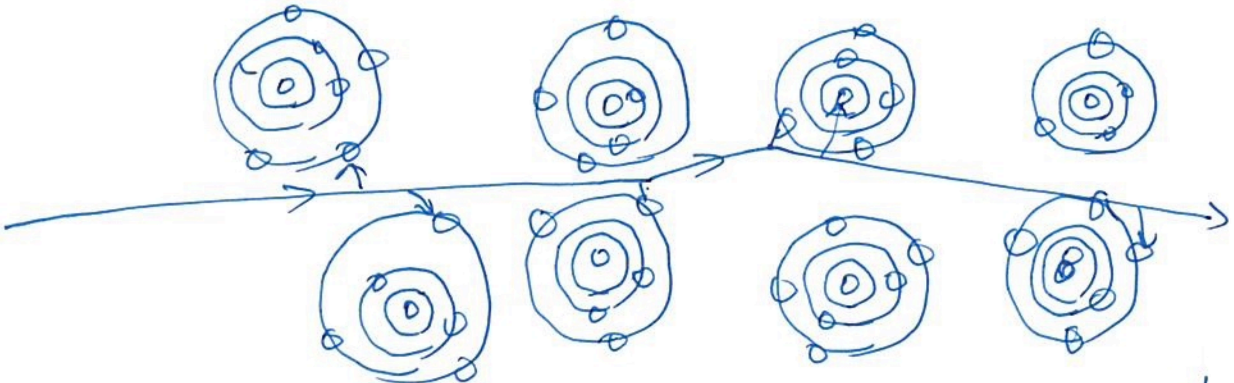
Therefore if we some how manage to characterize the ejected electron (case-1) or photon (case-2) then we can ~~g~~ quantify the ~~et~~ energy loss of the incoming particle. This is where a detector is needed to measure those out going particles. However, before going to the detail of the detector let's do an analysis on the scattering ... loss of particle passing through the matter. The neeutral radiation (n, γ) are not subjected to the columb force. Thus when they passes through the matter they processes charged particle through the scattering, & then those charged particles are used to characterise the energy loss.

Interaction of charged particle with matter:

A charge particle losses its energy of deflect from the matter roughly by following processes.

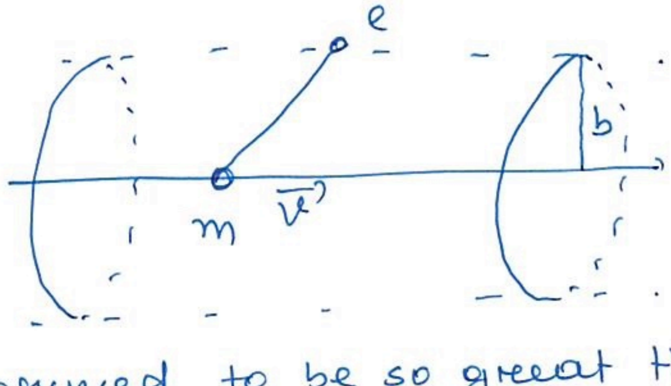
1. Elastic collion with atomic electron: usually <100eV
2. Inelastic collision with electron in atom: This is a dominated process through which incoming particle losses lot of kinetic energy in the matter
3. Elastic Collision with atomic nuclei: These are less frequent process. This is sometime happen only to conserve momentum of the process.
4. Inelastic collision with atomic nuclei: Collion of these types are even less probable then the elastic collion & most of time these are neglected These are are treated as very special case of interaction:
5. Another form of radiative loss is the cerenkov radiation which arises from the longitudinal polarization of a transparent medium whenever a charge particle passes through it at a velocity exceeding the phase velocity of the light medium.

To calculate the energy loss we shall first consider the interaction of charged particle with one electron and then sum the effects for all the electrons with which the particle is interacts.



(interaction with atomic electrons, atomic nuclei, the incoming particle losses energy & also undergoes deflection)

Now let's consider a particle with mass m, charge ze, velocity v interact with the atomic electron at a distance b from the particle trajectory.



The velocity v is assumed to be so great that in most cases the electron has to appreciably changed position before the particle has passed by it. Thus the transfer of momentum to the electron is Δp, or the impulse can be calculated as

$$F = \frac{dp}{dt} \qquad \Delta P = \int dP = \int F dt$$

$$\Delta P = I$$

$$\Rightarrow I = \Delta P = \int F dt = \int e E_{\perp} dt = e \int E_{\perp} \frac{dx}{v}$$