Interaction of particles with matter

IPM Tutorial

1 - Exercise 1

1. Give the formula of the maximal kinetic energy that can be transferred to an atomic electron in the regime where $\beta\gamma$ reduced to β, expressing, in this approximation, the energy in the center of mass of the incoming particle and the atomic electron.

2. Write the Bethe and Bloch formula in this regime neglecting the atomic shell and density corrections.

3. Explain how charged and low-energy heavy particles of the same velocity could be separated by measuring the energy loss in a thin detector.

4. For particles moving with the same velocity, show that if the detector is thin enough the average energy loss of a particle of charge z is given by $\Delta E_z = z^2 \Delta E_{proton}$

5. Write the relativistic equation that links β^2, the kinetic enegy, T, and m.

6. Compute the energy loss in hydrogen for protons and α particles of T=100 and T=200 MeV (take the proton mass m_p =1 GeV and m_α = 4 GeV).

7. How could these results be used to identify heavy-charge particles ?

2 - Exercise 2

An accelerator produces 100 MeV protons and deuterons

1. Show that both particles satisfy the low-energy condition $2\gamma\frac{m_e}{m_0} \ll 1$.

2. Compute the time of flight of both particles over a 10 m distance.

4. Compute the average specific energy loss in a plastic scintillator made of CH_x (specific mass = 1.03 g cm^{-3}) for both particles, where x = 1.1 is the equivalent molecular H/C ratio. We will neglect the density and atomic shell corrections.

5. Compute for both particles the average energy loss ΔE in a 1-cm thick detector D1 made of CH_x.

6. What should be the apporximate thickness of a second detector D2 located downstream of D1, if one wants to stop both protons and deuterons inside and measure their energies ?

7. If D1 is separate from D2 by 10 m what should be the signal time difference between D1 and D2 for protons and deuterons ?

8. Could you use that to separate protons from deuterons ?

3 - Exercise 3

1. What is the maximum kinetic energy of delta rays produced by 10 GeV/c K^- mesons in liquid hydrogen ?

2. How many delta rays with kinetic energy greater than 100 MeV are produced in 2 m ? The specific mass of liquid hydrogen is 0.071 g/cm^3.