

PARTICLE PHYSICS 1 : EXERCISE 3

1) π^0 decays

Treating the π^0 as a $u\bar{u}$ bound state, draw the Feynman diagrams for :

- (a) $\pi^0 \rightarrow \gamma\gamma$
- (b) $\pi^0 \rightarrow \gamma e^+ e^-$
- (c) $\pi^0 \rightarrow e^+ e^- e^+ e^-$
- (d) $\pi^0 \rightarrow e^+ e^-$

By considering the number of QED vertices present in each decay, estimate the relative decay rates taking $\alpha = 1/137$.

2) Prohibited processes in the SM

Explain why it is not possible to construct a valid Feynman diagram using the Standard Model vertices for the following processes :

- (a) $\mu^- \rightarrow e^+ e^- e^+$
- (b) $\nu_\tau + p \rightarrow \mu^- + n$
- (c) $\nu_\tau + p \rightarrow \tau^+ + n$
- (d) $\pi^+ + \pi^- \rightarrow n + \pi^0$

3) Electromagnetic showers

Tungsten has a radiation length of $X_0 = 0.35$ cm and a critical energy of $E_c = 7.97$ MeV. Roughly what thickness of tungsten is required to fully contain a 500 GeV electromagnetic shower from an electron ?

4) Čerenkov detectors for CPLEAR

The CPLEAR detector consisted of : tracking detectors in a magnetic field of 0.44 T, an electromagnetic calorimeter, and Čerenkov detectors with a radiator of refractive index $n = 1.25$ used to distinguish $\pi^\pm$ from $K^\pm$. A charged particle travelling perpendicular to the direction of the magnetic field leaves a track with a measured radius of curvature of $R = 4$ m. If it is observed to give a Čerenkov signal, is it possible to distinguish between the particle being a pion or a kaon ?

5) Particle interactions in detectors

Draw the scheme of interaction of a photon ($\sim$ GeV) and a detector with a magnetic field. Assume that the detector has a typical multi-layer structure with (from the innermost to the outermost subdetector) : tracking detectors, ECAL, HCAL and muon chambers. You can take as an example the CMS detector.

Draw the same scheme also for the other particles : $e^\pm$, p , n , $\pi^\pm$, π^0 , $\mu^\pm$.