Additional practise exercises for the exam

A

The critical energy of the electromagnetic shower development in iron is E_C = 24 MeV, and one radiation length is X_0 = 1.76 cm.
Estimate the smallest needed thickness of a calorimeter that uses iron as an absorper, if the initial electrons have energies not exceeding E_0 = 100 MeV.

B

A secondary particle beam can consist of several types of different particles. Separators are used to select the type of particle required. The separator consists of two parallel plates with a high potential between them. The beam passes between the plates and then through a deflecting magnet an slit system. Show that the difference in angular deflection, $\Delta\theta$, of two relativistic partilces with momentum p and masses m_1 and m_2, after traversing an electric field of strength E and length L, is:

$$\Delta\theta = \frac{eEL(m_1^2 - m_2^2)}{2p^3}$$

C

The decay $B^+ \to e^+\nu_e + \pi^0/D^0$ was used to set limits on the V_{cb} coupling. The branching ratio is 0.12, the B^+ lifetime is 1.4×10^{-12} s and the relative decay widths $\frac{\Gamma(b\to u)}{\Gamma(b\to c)}$ is less than 0.08.

1) Draw leading Feynman diagrams for the decays
2) The decay $\mu^+ \to e^+\nu_e\bar{\nu}_\mu$ is described as: $\Gamma_\mu = \frac{1}{\mu\,\text{lifetime}} = km_\mu^5$. Using this as an analogy, use Γ_{B^+} to derive a value for $|V_{cb}|$.
3) What is the largest allowed value of $|V_{ub}|$?

D

Suppose a detector can for each event measure a quantity x with $0 \leq x \leq 1$ for with the probability density functions for signal (s) and background (b) are:

$$f(x|s) = 3(1-x)^2$$

$$f(x|b) = 3x^2$$

1) The background hypothesis is rejected if the observed value of x is smaller than a specified cut value, x_{cut}. Find the value of x_{cut} such that the probability to reject the background hypothesis if it is background is $\alpha = 0.05$.
2) What is then the probability to accept an event with $x < x_{cut}$ given that it is signal?
3) Suppose the expected number of background events is $b_{tot} = 100$ and for a given signal model we expect $s_{tot} = 10$ events. Find the expected number of events s and b of signal and background events that will satisfy $x < x_{cut}$ using the value $x_{cut} = 0.1$.