chapter 2

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1 2.2

(a)Use chapter 1 knowledge:

$$\begin{aligned} E_\mu &= 258.3MeV \\ E_\nu &= 235.7MeV \\ p_\mu &= p_\nu = 235.7MeV/c \end{aligned} \tag{1}$$

(b)

$$\begin{aligned} \sqrt{p_k^2 + m_k^2} &= \sqrt{p_\mu^2 + m_\mu^2} + p_\mu - p_k \\ p_\mu &= 5.011GeV/c \end{aligned} \tag{2}$$

2 2.3

We know second photon must be back direction.

$$\begin{aligned} p_{\gamma 1} + p_{\gamma 2} &= \sqrt{(p_{\gamma 1} - p_{\gamma 2})^2 + m_\pi^2} \\ E_{\gamma 2} &= 30.3MeV \\ \beta_\pi &= 0.66 \end{aligned} \tag{3}$$

3 2.4

$$\begin{aligned} \gamma_1 &= 47.35 \\ \gamma_2 &= 47348.47 \\ l_1 &= 633.6m \\ l_2 &= 0.633m \\ l_1^{'} &= 31.2km \\ l_2^{'} &= 3.12 * 10^7 m \end{aligned} \tag{4}$$

4 2.5

$$\begin{aligned}\gamma_\pi &= \frac{E}{m} = 35.8 \\ l_{rest} &= 0.837km \\ l_{earth} &= 280m\end{aligned} \tag{5}$$

5 2.6

Use the $p = 0.3Br$:

$$\begin{aligned}p_e &= 12MeV/c \\ E_\gamma &= 24MeV\end{aligned} \tag{6}$$

6 2.7

- weak interaction:$K^+ \to \pi^0\pi^+, \mu^- \to e^-\bar{\nu_e}\nu_\mu$
- strong interaction:$\rho_0 \to \pi^+\pi^-, \eta^0 \to \pi^+\pi^-\pi^0$
- electromagnetic interaction:$\pi^0 \to \gamma\gamma$

7 2.8

According to definition:

$$P_c = \frac{dN}{d\Omega_c} = \frac{dN}{2\pi dcos\theta_c} \tag{7}$$

Relativity angle transformation formula

$$cos\theta_c = \frac{-\gamma\beta + \gamma cos\theta_L}{\gamma - \gamma\beta cos\theta_L} \tag{8}$$

Differentiate it:

$$dcos\theta_c = \frac{1-\beta^2}{(1-\beta cos\theta_c)^2} dcos\theta_L \tag{9}$$

Final, we have:

$$P_L = \frac{dN}{2\pi dcos\theta_L} = \frac{dN}{2\pi dcos\theta_c}\frac{dcos\theta_c}{dcos\theta_L} = P_c\frac{1-\beta^2}{(1-\beta cos\theta_c)^2} \tag{10}$$

8 2.9

The Geiger Counter's time resolution is limited(μs), but the pion lifetime is ns.

9 2.10

The magnetic moment of leptons are:

$$\mu = \frac{gqhs}{2m} \tag{11}$$

So we can get:

$$\begin{aligned} \frac{\mu_e}{\mu_\tau} &= 3477 \\ \frac{\mu_e}{\mu_\mu} &= 206 \end{aligned} \tag{12}$$

10 2.11

$$\begin{gathered} \sqrt{m^2 + p_1^2} + \sqrt{m^2 + p_2^2} = \sqrt{16m^2 + (p_2 - p_1)^2} \\ E = 5.6GeV \end{gathered} \tag{13}$$

11 2.13

We know the π^- beam in the hydrogen bubble chamber:

$$\pi^- + p = K^0 + \Lambda^0 \tag{14}$$

There are two kind of neutral particle:$K^0 and \Lambda^0$,followed by the decays:

$$\begin{aligned} &K^0 \to \pi^+ + \pi^- \\ &\Lambda^0 \to p + \pi^- \end{aligned} \tag{15}$$

now we know the negative one is π^-, And $p_{tot} = 1998MeV, E_{\pi^-} = 1905MeV$. If the neutral particle is Λ^0:

$$\begin{aligned} &E = 2303MeV \\ &m_\Lambda = \sqrt{E^2 - p^2} = 1145MeV \end{aligned} \tag{16}$$

If the neutral particle is K^0:

$$\begin{aligned} &E = 2089MeV \\ &m_\Lambda = \sqrt{E^2 - p^2} = 612MeV \end{aligned} \tag{17}$$

So the neutral particle is Λ^0

12 2.14

(1) $\nu_e + n \rightarrow e^- + p$

$$p + m_n = \sqrt{(m_e + m_p)^2 + p^2} \tag{18}$$

No solution,this process can't be happen.
(2) $\nu_\mu + n \rightarrow \mu^- + p$

$$\begin{aligned} &p + m_n = \sqrt{(m_\mu + m_p)^2 + p^2} \\ &E = 110.2MeV \end{aligned} \tag{19}$$

(3) $\nu_\tau + n \rightarrow \tau^- + p$

$$\begin{aligned} &p + m_n = \sqrt{(m_\tau + m_p)^2 + p^2} \\ &E = 3454.0MeV \end{aligned} \tag{20}$$

13 2.17

kinetic energy:

$$k = \sqrt{m^2 + p^2} - m \tag{21}$$

(a)proton:

$$k = 0.28MeV \tag{22}$$

(b)positron:

$$k = 22.5MeV \tag{23}$$