Q 1

1)

אנחנו מתחילים מפה:

$$\sigma = \frac{S}{4 m_2 |\bar{P}_1|} \frac{1}{\;} \int |M|^2 \delta^4(P_1 + P_2 - P_3 - P_4) \frac{d^3 P_3}{2\sqrt{\bar{P}_3^2 + m_3^2}} \frac{d^3 P_4}{2\sqrt{\bar{P}_4^2 + m_4^2}}$$

$$\delta(E_1 + \cancel{E_2}^{\,m_2} - E_3 - E_4) \qquad \delta^3(\bar{P}_1 + \cancel{\bar{P}_2}^{\,0} - \bar{P}_3 - \bar{P}_4)$$

$$P_1 = (E_1, \bar{P}_1) \quad P_2 = (m_2, 0) \quad P_3 = (E_3, \bar{P}_3) \quad P_4 = (E_4, \bar{P}_4)$$

$$\frac{d\sigma}{d\Omega} = \frac{S}{m_2 |\bar{P}_1|} \int |M|^2 \frac{\delta\left(E_1 + m_2 - \sqrt{\bar{P}_3^2 + m_3^2} - \sqrt{(\bar{P}_1 - \bar{P}_3)^2 + m_4^2}\right)}{\sqrt{\bar{P}_3^2 + m_3^2}\sqrt{(\bar{P}_1 - \bar{P}_3)^2 + m_4^2}} |P_3|^2 dP_3$$

$$(P_1 - P_3)^2 = P_1^2 + P_3^2 - 2 P_1 P_3 \cos\theta$$

$$\frac{dz}{dP_3} = \frac{|\bar{P}_3|}{\sqrt{P_3^2 + m_3^2}} + \frac{|\bar{P}_3| - |\bar{P}_1|\cos\theta}{\sqrt{P_1^2 + P_3^2 - 2P_1P_3\cos\theta + m_4^2}}$$

$$= \frac{|\bar{P}_3|\sqrt{\quad} + \sqrt{\quad}\,|P_3| - \sqrt{\quad}\,|\bar{P}_1|\cos\theta}{\sqrt{\quad}\sqrt{\quad}}$$

$$= \frac{|\bar{P}_3| z - \sqrt{\quad}\,|\bar{P}_1|\cos\theta}{\sqrt{\quad}\sqrt{\quad}}$$

$$\frac{d\sigma}{d\Omega} = C \frac{S}{m_2 |\bar{P}_1|} \int |M|^2 \delta(E_1 + m_2 - z) \frac{|\bar{P}_3|^2}{|P_3| z - \underbrace{\sqrt{P_3^2 + m_3^2}}_{E_3} |P_1| \cos\theta} dz$$

$$= C \frac{S}{m_2 |\bar{P}_1|} |M|^2 \frac{|\bar{P}_3|^2}{|\bar{P}_3|(E_1 + m_2) - |\bar{P}_1| E_3 \cos\theta}$$

$$\hookrightarrow \frac{1}{4} \cancel{(2\pi)^4} \quad \cancel{(2\pi)^2} \quad \frac{1}{(2\pi)^6} \quad \frac{1}{4} \quad \cancel{(2\pi)^2} \quad \cancel{(2\pi)^5}$$

של δ^4 ... ; של δ on-shell ; $d^4 P_4$; אינטגרל של θ

$$E_1 E_3 (E_1 + m_2 - \cos\theta)$$

2) 

$|\bar{P}_1| = E_1$

$|\bar{P}_3| = E_3$

$P_1 = (E_1, |P_1|)$ $P_2 = (E_2, -|\bar{P}_1|)$

$P_3 = ($

Q2

$$c\tau_{\pi^+} = 7.8\ m$$

$$d = \frac{pc}{m_{\pi^+}c^2}c\tau$$

$$p = \frac{d\cdot m_{\pi^+}c^2}{c\cdot c\tau} = \frac{5\cdot10^4\ m\cdot \overbrace{139\ MeV}^{2.23\cdot10^{-11}\ \frac{kg\ m^2}{s^2}}}{3\cdot10^8\ \frac{m}{s}\cdot 7.8\ m} = 4.76\cdot10^{-16}\ \frac{kg\cdot m}{s}$$

$$pc = 891\ GeV$$

$$cm^{-2} = 10^{-24}\ b^{-1} =$$

Q3

1) $L = \mathcal{L}\cdot 1yr = 10^{34}\cdot 3\cdot 10^{7} = 3\cdot10^{41}\ cm^{-2} = 3\cdot10^{17}\ fb^{-1}$

2) $N = L\sigma = 3\cdot10^{17}\cdot10^{-15}\ b^{-1}\cdot10^{-11}\ b = 3\cdot10^{-9}$

$17\ -26$

Q4

Fe COM

1) $flux\ \left[\frac{N}{A\cdot s}\right] = \frac{nV}{At} = \frac{nx}{t} = \frac{\rho_{\tau} V_n}{m}$

2) $\frac{\rho}{dx} = n\sigma_0 = \frac{\rho}{m}\sigma_0 = \frac{N_{events}}{dx}$

$$\frac{N_{events}}{dx} = N(x)\frac{\rho}{m}\sigma_0$$

לפס ה״כ

3) $N_{no-scaterr} = -N(x)$

$$\Rightarrow \lambda = \frac{\rho}{m}\sigma_0$$

4) $\frac{\rho}{m}\sigma_0 = \frac{7.9\cdot g\ cm^{-3}}{56\cdot 1.6\cdot10^{-24}\ g}\ 10^{-38}\cdot 200\ GeV\ cm^2 = 17.64\cdot10^{-14}\ cm^{-1}$

מסה של אטום
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5) $N(x) = N_0 e^{-\lambda x}$

6) $N(x)$ מספר הפיזורים, לכן מס' האינטראקציות $N_0 - N(x)$

$$\Rightarrow 10^{-9} = \frac{N_0 - N(x)}{N_0} = 1 - e^{-\lambda x} \Rightarrow e^{-\lambda x} = 1 - 10^{-9} \Rightarrow -\lambda x = -10^{-9}$$

$$x = \frac{10^{-9}}{\lambda} = 5880\ cm$$

Q5

$$\Theta(p^0_{1a})\,\delta^4(p_a^2 - m_a^2) = \frac{1}{2\sqrt{\bar{p}_a^2 + m_a^2}}\,\delta\left(p_a^0 - \sqrt{\bar{p}_a^2 + m_{1a}^2}\right)$$

תנעים הפוכים בCOM $\bar{p}_1 = -\bar{p}_2$

$$\Rightarrow \quad (p_1 \cdot p_2)^2 = (E_1 E_2)^2 = E_1^2 E_2^2 = (m_1^2 + p_1^2)(m_2^2 + p_2^2)$$

$$\cancel{m_1^2 m_2^2} + p_1^2 m_2^2 + p_2^2 m_1^2 + p_1^2 p_2^2 - \cancel{m_1^2 m_2^2}$$