$\sigma(p+C) = 330\ mb$ $\quad \underline{\underline{E}}$

$I_p = 1\ nA$

① $g: C,\ \rho = 2.1\ \underline{\underline{g/cm^3}},\ A = 12$

$d_g = 1\ mm$

$\underline{\underline{p+C}}$

$\dot{N}_r = ?$

$$\dot{N}_r = \sigma\, \dot{N}_p\, n_g\, d_g$$

$$\dot{N}_p = \frac{I_p}{e} = \frac{1 \cdot 10^{-9}}{1.6 \cdot 10^{-19}} = 6.25 \cdot 10^{9}\ s^{-1}$$

$$n_g = \frac{N_A\, \rho_g}{A} = \frac{6.022 \cdot 10^{23} \cdot 2.1}{12} = 1.05 \cdot 10^{23}\ cm^{-3}$$

$$\Rightarrow \dot{N}_r = \sigma \cdot \dot{N}_p\, n_g\, d_g =$$

$$= (330 \cdot 10^{-3} \cdot 10^{-24})(6.25 \cdot 10^{9}) \cdot$$

$$\cdot (1.05 \cdot 10^{23}) \cdot \underset{\substack{\uparrow \\ d_g}}{(0.1)} = 2.17 \cdot 10^{7}\ s^{-1}$$

② spessore polietilene

$$C_2H_4 \quad \rho = 0.9 \ g/cm^3$$

per avere stesso $\dot{N}_r$?

$$\dot{N}_r = \sigma \, \dot{N}_p \, n_{C_2H_4} \, d_{C_2H_4}$$

[illegible]

fascio

processo

$$n_{C_2H_4} = 2 \cdot \frac{N_A \cdot \rho_{C_2H_4}}{A_{C_2H_4}} = 2 \cdot \frac{6.022 \cdot 10^{23} \cdot 0.9}{28} =$$

$$= \underline{3.88 \cdot 10^{23} \ cm^{-3}}$$

$$A_{C_2H_4} = 2 \cdot A_C + 4 \cdot A_H = 2 \cdot 12 + 4 \cdot 1 = 28$$

$$d_{C_2H_4} = \frac{\dot{N}_r}{\sigma \, \dot{N}_p \, n_{C_2H_4}} = \frac{2.17 \cdot 10^7}{330 \cdot 10^{-27} \cdot 6.25 \cdot 10^9 \cdot 3.88 \cdot 10^{23}} =$$

$$= 0.27 \ cm = \underline{2.7 \ mm}$$

(3) Corrente residua

bersaglio grafite da 10 cm

$$I(x) = I_0 \, e^{-\mu x}$$

$$\mu = \underline{\sigma} \, \underline{n_b} = 330 \cdot 10^{-27} \cdot 1.05 \cdot 10^{23} =$$

$$= 0.034 \ \mathrm{cm}^{-1}$$

$$I(x = 10\,\mathrm{cm}) = I_0 \, e^{-\mu \cdot 10\,\mathrm{cm}} =$$

$$= 1 \cdot 10^{-9} \cdot e^{-0.034 \cdot 10}$$

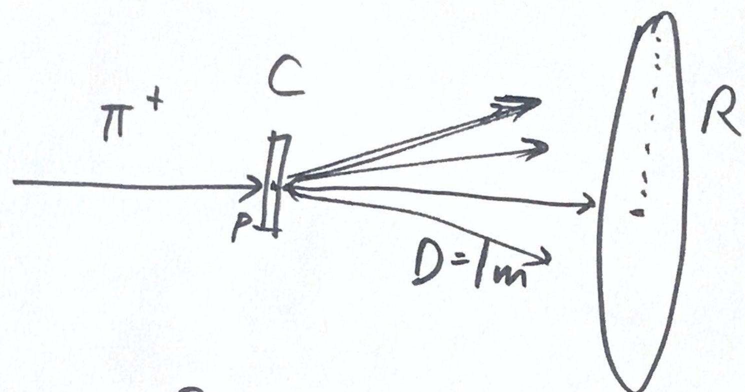
$$= 0.71 \ \mathrm{nA}$$

$\boxed{\text{EX}}$ fascio pioni

bersaglio grafite C, $A=12$, $Z=6$, $\rho = 2.1\ g/cm^3$

spessore $d = 1\ cm$

$$\pi^+ p \rightarrow \Sigma^+ \underline{\underline{K}}^+$$



(a) $E_{soglia} = ?$

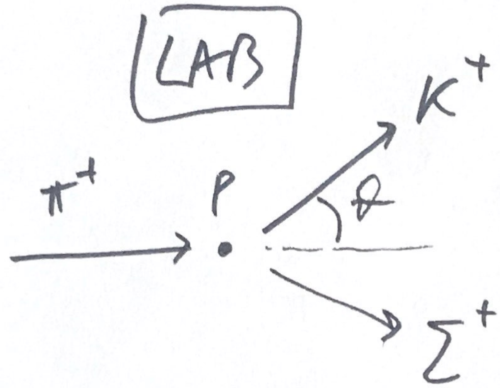
$$E_{\pi,soglia} = \frac{(m_\Sigma + m_K)^2 - (m_\pi^2 + m_p^2)}{2 m_p} =$$

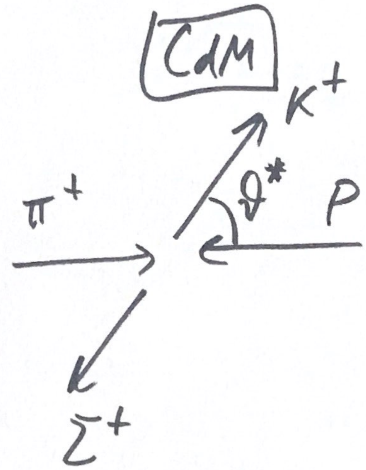
$$= \frac{(1189 + 494)^2 - (140^2 + 938^2)}{2 \cdot 938} =$$

$$= 1030\ MeV$$

$$\cancel{\Rightarrow E_{\pi,soglia} = K_{\pi,soglia} + \overset{140}{m_\pi} = 1170\ MeV}$$

$E_\pi = 2.1$ GeV $>$ $E_{soglia,\pi} = 1.17$ GeV





$\pi: (E_\pi, \vec{p}_\pi)$

$p: (m_p, \vec{0})$

$$\sqrt{s}\Big|_{LAB} = \sqrt{(E_\pi + m_p)^2 - p_\pi^2} =$$

$$= \sqrt{E_\pi^2 + m_p^2 + 2E_\pi m_p - p_\pi^2} =$$

$$= m_\pi^2$$

$$= \sqrt{m_\pi^2 + m_p^2 + 2E_\pi m_p} = 1775 \text{ MeV}$$

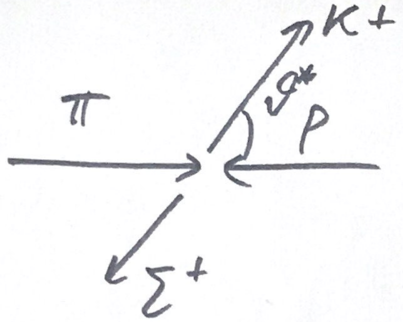
$\boxed{M} \rightarrow m_1\, m_2$

$\uparrow$

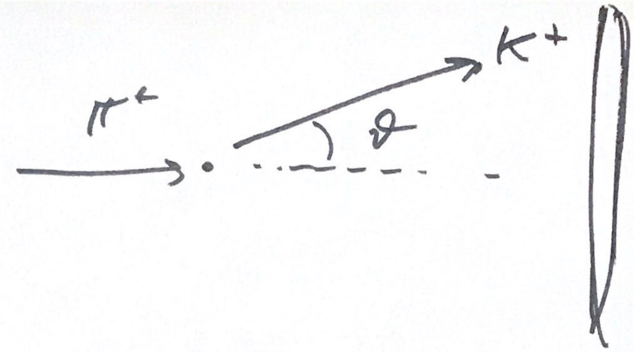
$\sqrt{s}$

$$E_K^* = \frac{s + m_K^2 - m_\Sigma^2}{2\sqrt{s}} = 558 \text{ MeV}$$

$$p_K^* = \sqrt{E_K^{*2} - m_K^2} = 260 \text{ MeV}$$



CdM



LAB

$$\tan\vartheta_{MAX} = \frac{\beta_K^*}{\gamma_{cm}\sqrt{\beta_{cm}^2 - \beta_K^{*2}}}$$

$\exists\, \vartheta_{MAX}$ se $\beta_{cm} > \beta_K^*$

$$\beta_K^* = \frac{p_K^*}{E_K^*} = 0.466$$

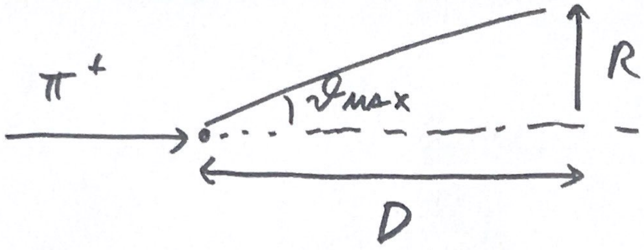
$p_\pi = \sqrt{E_\pi^2 - m_\pi^2} = 1.19$ GeV

$$\beta_{cm} = \frac{p_{TOT}^{LAB}}{E_{TOT}^{LAB}} = \frac{p_\pi}{E_\pi + m_p} = \frac{1.19}{1.2 + 0.938} = 0.56$$

$$\beta_{cm} > \beta_K^* \Rightarrow \exists\, \vartheta_{MAX} \neq 180°$$

$$\gamma_{cm} = \frac{1}{\sqrt{1-\beta_{cm}^2}} = 1.2$$

$$\Rightarrow \tan\vartheta_{MAX} = 1.26$$



$$\frac{R_{min}}{D} = \tan \vartheta_{MAX}$$

$$\rightarrow R_{min} = \tan \vartheta_{MAX} \cdot D = 1.26\ m$$

(c) corrente di pioni

$$\dot{N}_r = 1\ kHz \qquad \sigma = 0.1\ mb$$

$$d = 1\ cm$$

$$\dot{N}_r = \sigma\, \dot{N}_\pi\, n_b \cdot d$$

$$n_b = Z \frac{N_A \cdot \rho}{A} = 6\, \frac{6.022 \cdot 10^{23} \cdot 2.1}{12} =$$

$$= 6.3 \cdot 10^{23}\ cm^{-3}$$

$$\dot{N}_\pi = \frac{\dot{N}_r}{\sigma \cdot n_b \cdot d} = \frac{1000}{0.1 \cdot 10^{-3} \cdot 10^{-24} \cdot 6.3 \cdot 10^{23} \cdot \underbrace{1}_{=d}} =$$

$$= 1.58 \cdot 10^{7}\ s^{-1}$$

$$I_\pi = \dot{N}_\pi e = 1.58 \cdot 10^{7} \cdot 1.6 \cdot 10^{-19} =$$

$$= 2.54 \cdot 10^{-12}\ A = 2.54\ pA$$

$\boxed{\text{EX}}$

$$p \rightarrow \cdots\cdots \rightarrow \mu^+$$

bersaglio di Tungsteno $A = 184$, $Z = 74$

$$p + p \rightarrow \pi^+ + n + p$$

$$\pi^+ \rightarrow \underline{\mu^+} + \nu_\mu$$

(A) $I_p = 0.05\ mA$

$S = 10\ cm^2$ — inutile

$\rho = 0.0193\ Kg/cm^3 = 19.3\ g/cm^3$

$d = 2\ cm$

$$\sigma(pp \rightarrow \pi n p) = 1.5\ mb$$

$$\dot{N}_\pi = ?$$

$$\dot{N}_\pi = \sigma\ \dot{N}_p\ n_b\ d$$

$$\dot{N}_p = \frac{I_p}{e} = \frac{0.05 \cdot 10^{-3}}{1.6 \cdot 10^{-19}} = 3.12 \cdot 10^{14}\ s^{-1}$$

$$n_b = Z\frac{N_A \rho}{A} = 74\ \frac{6.022 \cdot 10^{23} \cdot 19.3}{184} = 4.67 \cdot 10^{24}\ cm^{-3}$$

$\dot{N}_\pi = \sigma \dot{N}_p n_s d = 4.37 \cdot 10^{12} \, s^{-1}$

$I_\pi = \dot{N}_\pi \cdot e = 4.37 \cdot 10^{12} \cdot 1.6 \cdot 10^{-19} = 0.70 \, \mu A$

(B) $\langle \beta_\pi \rangle = 0.98$

lunghezza tunnel = ?

t.c. $I_\mu = 0.5 \, \mu A$

$\tau_\pi = 2.6 \cdot 10^{-8} \, s$

$$\pi^+ \longrightarrow \begin{matrix} \mu^+ \\ \nu_\mu \end{matrix} \qquad I_{tot}(t) = I_\pi(t) + I_\mu(t) = \text{cost.}$$

$$= I_\pi(t=0) = 0.70 \, \mu A$$

$\exists t : \quad I_\mu(t) = 0.5 \, \mu A$

$\Rightarrow \underline{I_\pi(t) = 0.2 \, \mu A}$

nel $\underline{\text{CdM}}$ $\quad \exists t^* : \quad I_\pi(t^*) = I_\pi(0) \, e^{-t^*/\tau_\pi}$

$$\frac{I_\pi(t^*)}{I_\pi(0)} = \frac{0.2}{0.7} = 0.286 = e^{-t^*/\tau_\pi}$$

$\Rightarrow t^* = -\tau_\pi \ln(0.286) = 3.25 \cdot 10^{-8} \, s$

$$t^* \longrightarrow t = \gamma_\pi \cdot t^*$$

$$\beta_\pi = 0.98 \Rightarrow \gamma_\pi = \frac{1}{\sqrt{1-\beta_\pi^2}} = 5$$

$$t = 5 \cdot t^* = 16.25 \cdot 10^{-8} s = 162.5 \, ns$$

$$d = v \cdot t = (\beta_\pi c) \cdot (\gamma_\pi t^*) =$$

$$= 0.98 \cdot 3 \cdot 10^8 \cdot 162.5 \cdot 10^{-9} =$$

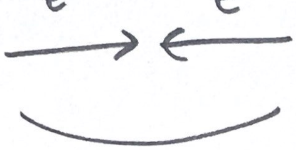
$$= 47.8 \, m$$

J/ψ $\quad m(J/\psi) = (3.15\ \text{GeV}) = ?$

CALIFORNIA

RICHTER

S.L.A.C.



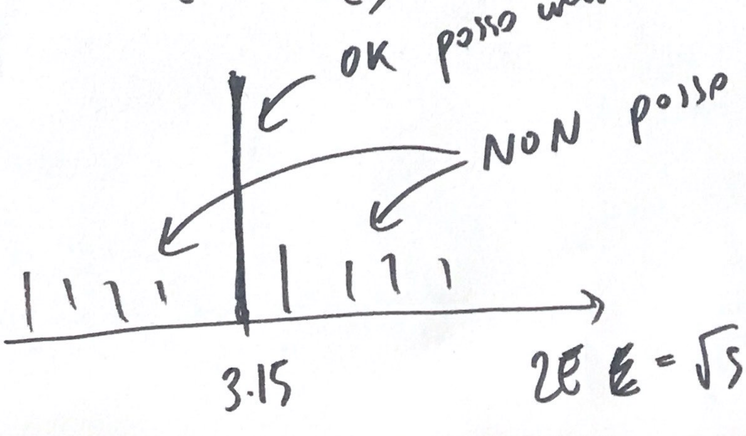
$\boxed{e^+e^- \to J/\psi} \Rightarrow$

$E_+ = E_- = E$

$\sqrt{s} = m_{J/\psi}$

$\sqrt{s} = 2E$

$(E \gg m_e)$



vs

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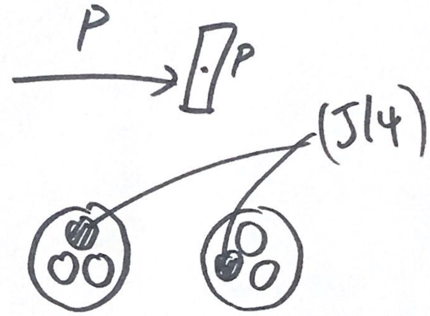


$E_q = f_q \cdot E_p$

$f_q \sim 0.2\text{-}0.3$

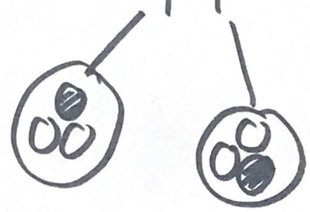
$0 < \sqrt{s}_{\text{eff}} < \sqrt{s}_{\text{nomin.}}$

$$e^+e^- \to J/\psi$$

$$\sqrt{s} = 2E$$

$$E = \frac{m_{J/\psi}}{2}$$

$$q\bar{q} \to J/\psi$$



$$E_q = f_q E_p$$

$$E_{\bar{q}} = f_q' \cdot E_p'$$

$$\sqrt{s} = 2\sqrt{E_q E_{\bar{q}}}$$