Blatt 1 Exphy 6 Julian Bergmann

Nr. 1

a) $E_{cm} = 2\underbrace{\sqrt{(m_p c^2)^2 + (p_p c)^2}}_{E_p} \stackrel{!}{=} m(\eta_c)c^2 = 2{,}980\,\mathrm{GeV}$

$\Rightarrow E_p = \frac{m(\eta_c)c^2}{2} = 1{,}49\,\mathrm{GeV}$

$\Rightarrow p_p = \sqrt{\left(\frac{m(\eta_c)c^2}{2}\right)^2 - (m_p c^2)^2} \cdot \frac{1}{c} = \frac{1}{c}\cdot\sqrt{(1{,}49\,\mathrm{GeV})^2 - (0{,}93827\,\mathrm{GeV})^2}$

$= 1{,}157\,\mathrm{GeV}/c$

b) $P_{cm} = (E/c\,;\,p_x\,;\,p_y\,;\,p_z)^{-1} = (1{,}49\,\frac{\mathrm{GeV}}{c}; 0; 0; \pm 1{,}157\,\frac{\mathrm{GeV}}{c})^{-1}$

$P_{lab} = L\,P_{cm} = \begin{pmatrix} \gamma & 0 & 0 & \beta\gamma \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \beta\gamma & 0 & 0 & \gamma \end{pmatrix} \begin{pmatrix} E/c \\ p_x=0 \\ p_y=0 \\ p_z \end{pmatrix} = \begin{pmatrix} \gamma E/c + \beta\gamma\, p_z \\ 0 \\ 0 \\ \beta\gamma E/c + \gamma\cdot p_z \end{pmatrix}$

$P_{lab,1} = \left(\frac{5}{3}\cdot 1{,}49\,\frac{\mathrm{GeV}}{c} + \frac{4}{3}\cdot 1{,}157\,\frac{\mathrm{GeV}}{c}; 0; 0; \frac{4}{3}\cdot 1{,}49\,\frac{\mathrm{GeV}}{c} + \frac{5}{3}\cdot 1{,}157\,\frac{\mathrm{GeV}}{c}\right)$

$= \left(4{,}026\,\frac{\mathrm{GeV}}{c}; 0; 0; 3{,}915\,\frac{\mathrm{GeV}}{c}\right)$

$P_{lab,2} = \left(\frac{5}{3}\cdot 1{,}49\,\frac{\mathrm{GeV}}{c} - \frac{4}{3}\cdot 1{,}157\,\frac{\mathrm{GeV}}{c}; 0; 0; \frac{4}{3}\cdot 1{,}49\,\frac{\mathrm{GeV}}{c} - \frac{5}{3}\cdot 1{,}157\,\frac{\mathrm{GeV}}{c}\right)$

$= \left(0{,}941\,\frac{\mathrm{GeV}}{c}; 0; 0; 0{,}0583\,\frac{\mathrm{GeV}}{c}\right)$

$\Rightarrow T_1 = E_1 - m_0 c^2 = 4{,}026\,\mathrm{GeV} - 938{,}27\,\mathrm{MeV} = 3{,}088\,\mathrm{GeV}$

$T_2 = E_2 - m_0 c^2 = 0{,}941\,\mathrm{GeV} - 938{,}27\,\mathrm{MeV} = 2{,}73\,\mathrm{MeV}$

$\Rightarrow$ nur pos. z-Richtung!

c) $P_{cm} = (E/c\,; \pm p_c\,; 0; 0)$

$P_{lab} = L_z P_{cm} = (\gamma E/c\,; \pm p_x; 0; \gamma\beta E/c)$

$= \left(2{,}48\,\frac{\mathrm{GeV}}{c}; \pm 1{,}157\,\frac{\mathrm{GeV}}{c}; 0; 1{,}99\,\frac{\mathrm{GeV}}{c}\right)$

$\alpha_{p_1} = -\alpha_{p_2} = \arctan\left(\frac{p_x}{p_z}\right) = \arctan\left(\frac{1{,}157}{1{,}99}\right) = 30{,}17°$

Nr 2

a) $w_c = \frac{e}{m_*} B_z = \frac{e}{m_p + 2m_e} B_z = \frac{c^2 \cdot 1T}{939{,}292 MV} = 95{,}68 MHz$

$w_{c,rel} = w_c \gamma = w_c \cdot \frac{m_0 c^2}{T + m_0 c^2} = 95{,}68 MHz \cdot \frac{1}{1{,}013} = 94{,}59 MHz$

b) $\frac{12 MeV - 200 keV}{800 eV} = 147{,}5 \approx 148$ Schritte

c) $R_i = \frac{m}{eB} v_i$ (i: Umläufe)

$\Rightarrow \Delta R_{74} = \frac{m}{eB} \sqrt{\frac{2}{m}} \left(\sqrt{T_{148}} - \sqrt{T_{146}}\right) = \frac{\sqrt{2m}}{eB} \left(\sqrt{12{,}04 MeV} - \sqrt{12{,}04 MeV - 1{,}6 keV}\right)$

$= 3{,}34 mm$

Nr 3

a) $\Delta E = \frac{ec^2 B}{2\pi \nu_{HF}} = \frac{ec^2 \cdot 1T}{2\pi \cdot 2{,}45 GHz} = 5{,}84 MeV$

b) $\Delta R_i = \frac{1}{ec^2 B} \left(v_i E_i - v_{i-1} E_{i-1}\right) \approx \frac{1}{ecB} \cdot 5{,}85 MeV = 0{,}0194 m$

$v_i, v_{i-1} \approx c$

c) $\Delta t = kT = \frac{2(\pi R + d)}{v_{\approx c}} \approx \frac{2\pi E_0}{ec^2 B} + \frac{2d}{c} \Rightarrow d = \frac{1}{2} kTc - \frac{\pi}{ecB} E_0$