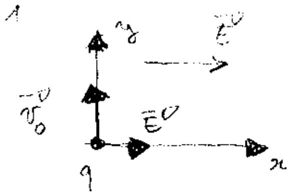
PC : * $\|\vec v\| = cte$; $\vec F = \frac{d\vec p}{dt} = \frac{d}{dt}(\gamma m \vec v) = \gamma m \frac{d\vec v}{dt}$; $\gamma = cte$ $\boxed{\vec F = \gamma m \vec a}$ champ $\vec B$

* $\vec v = cte$; $\vec F = \gamma m \frac{d\vec v}{dt} + m\vec v \frac{d\gamma}{dt}$; $\frac{d\gamma}{dt} = \frac{d\gamma}{dv}\cdot\frac{dv}{dt} = \gamma^3 \frac{v}{c^2}\frac{dv}{dt} \Rightarrow \vec v \frac{d\gamma}{dt} = \underbrace{\gamma^3\beta^2}_{\gamma(\gamma^2-1)} \frac{d\vec v}{dt}$

$\Rightarrow \vec F = \gamma m \vec a + m\gamma(\gamma^2-1)\vec a \Rightarrow \boxed{\vec F = \gamma^3 m \vec a}$ champ $\vec E$

* $R = \frac{\gamma m v}{qB} = \frac{\|\vec p\| c}{qBc} = \frac{1}{qBc} \times \sqrt{E^2 - m^2c^4} = \frac{\sqrt{(5.10^9)^2 - (0,511\times10^6)^2} \times 1,6.10^{-19}}{1,6.10^{-19} \times 10 \times 3.10^8} = 1,66.10^{-3}\ m$

$E = \gamma m c^2 \Rightarrow \boxed{\gamma = 9,78}$ et $\beta = \sqrt{1 - \frac{1}{\gamma^2}} = 0,994$! $\boxed{R = \frac{\gamma\beta m c}{qB} = 1,66.10^{-3}\ m}$

1) 

$\vec F = \frac{d\vec p}{dt}$ $\begin{cases} qE = dp_x/dt \\ 0 = dp_y/dt \end{cases}$ $p_x = qEt + 0$; $p_y = p_0 = \gamma m v_y$ $\begin{bmatrix} v_x = \frac{qEt}{\gamma m} \\ v_y = \frac{p_0}{\gamma m} \end{bmatrix}$ γ

$p = \gamma m v$
$E = \gamma m c^2 \Rightarrow \boxed{\frac{v}{c^2} = \frac{p}{E}} = \frac{\sqrt{q^2E^2t^2 + p_0^2}}{\sqrt{q^2E^2t^2c^2 + p_0^2c^2 + m^2c^4}}$

$v = c \cdot \frac{1}{\sqrt{1 + \frac{m^2c^4}{q^2E^2t^2c^2 + p_0^2c^2}}} = c \cdot \frac{1}{\sqrt{1 + \frac{t_r^2}{t^2 + \frac{p_0^2}{q^2E^2}}}}$; $\boxed{t_r = \frac{mc}{qE}}$

$$\boxed{\gamma = \frac{E}{mc^2} = \sqrt{\frac{q^2E^2t^2c^2 + p_0^2c^2 + m^2c^4}{m^2c^4}} = \sqrt{\frac{t^2}{t_r^2} + \frac{p_0^2}{m^2c^2} + 1}}$$

$x = \int v_x\, dt$; $y = \int v_y\, dt$

$x(t) = c\int \frac{qEt}{mc\sqrt{\frac{t^2}{t_r^2} + \frac{p_0^2}{m^2c^2} + 1}} \times dt = ct_r \int \frac{t/t_r}{\sqrt{\frac{t^2}{t_r^2} + \frac{p_0^2}{m^2c^2} + 1}}\, d(t/t_r)$

* $\boxed{x(t) = ct_r \times \left[\sqrt{\frac{t^2}{t_r^2} + \frac{p_0^2}{m^2c^2} + 1} - \sqrt{\frac{p_0^2}{m^2c^2} + 1}\right]} = ct_r\sqrt{\frac{p_0^2}{m^2c^2} + 1}\left[\sqrt{\frac{t^2}{t_r^2(\frac{p_0^2}{m^2c^2} + 1)} + 1} - 1\right]$

condition initiale $x = 0$ à $t = 0$

$y(t) = \int v_y\, dt = \int \frac{p_0}{m\sqrt{\frac{t^2}{t_r^2} + \frac{p_0^2}{m^2c^2} + 1}}\, dt = ct_r \int \frac{p_0}{mc\sqrt{\frac{p_0^2}{m^2c^2} + 1}} \frac{1}{\sqrt{1 + \frac{t^2}{t_r^2(\frac{p_0^2}{m^2c^2} + 1)}}}\, dt/t_r$

$y(t) = ct_r \times \frac{p_0}{mc} \int \frac{1}{\sqrt{1 + u^2}}\, du$; $u = \frac{t}{t_r\sqrt{\frac{p_0^2}{m^2c^2} + 1}}$

* $\boxed{y(t) = ct_r \times \frac{p_0}{mc} \times \text{Argsh}\left(\frac{t}{t_r\sqrt{\frac{p_0^2}{m^2c^2} + 1}}\right)}$ $\left[\text{sh}\left(\frac{y}{ct_r\frac{p_0}{mc}}\right) = \frac{t}{t_r\sqrt{\frac{p_0^2}{m^2c^2} + 1}} \right.$

$x(t) = ct_r\sqrt{\frac{p_0^2}{m^2c^2} + 1}\left[\text{sh}\left(\frac{y}{ct_r\frac{p_0}{mc}}\right) - 1\right]$ soit $\boxed{\frac{y}{ct_r\frac{p_0}{mc}} = \text{Argsh}\left[\frac{x}{ct_r\sqrt{\frac{p_0^2}{m^2c^2} + 1}} + 1\right]}$ si $p_0 = 0$ alors $y = 0$ OK

équation trajectoire.

2) $t \ll t_r \Rightarrow$; $x \ll ct_r\sqrt{\frac{P_0^2}{m^2c^2}+1}$ approximation classique.

; $y \ll ct_r \times \frac{P_0}{mc}$.

$x = ct_r\sqrt{\frac{P_0^2}{m^2c^2}+1} \times \left[ch \frac{y}{ct_r \frac{P_0}{mc}} - 1 \right]$ $\quad ch\, u \simeq \frac{e^u + e^{-u}}{2} \simeq \frac{1}{2}\left[1+u+\frac{u^2}{2}+1-u+\frac{u^2}{2}\right]$

$\simeq 1 + \frac{u^2}{2}$

$x \simeq ct_r \underbrace{\sqrt{\frac{P_0^2}{m^2c^2}+1}}_{\simeq 1} \times \frac{1}{2} \cdot \frac{y^2}{c^2t_r^2 \frac{P_0^2}{m^2c^2}}$; $P_0 \ll mc$ (vitesse initiale $\ll c$) $\Rightarrow$

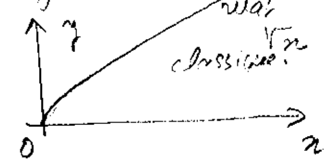
$y^2 \simeq 2x \times \frac{P_0^2}{m^2c^2} \times ct_r \Rightarrow y^2 \simeq 2x \times \frac{P_0^2}{m^2c^2} \times c \times \frac{mc}{qE}$; $t_r \Rightarrow$

$y^2 \simeq \frac{2 P_0^2}{m\, qE} \times x \Rightarrow$ $\quad y = \frac{P_0}{\sqrt{m}} \times \sqrt{\frac{2}{qE}} \times \sqrt{x}$. ; $P_0 = mv_0 \Rightarrow$

$\boxed{y = v_0 \times \sqrt{\frac{2m}{qE}} \times \sqrt{x}}$

vitesse initiale.

trajectoire classique



$$\boxed{\begin{array}{l} x = \frac{qEt^2}{2m} \quad y = v_0 t \Rightarrow \\ y = v_0 \times \sqrt{\frac{2m}{qE}} \times \sqrt{x} \end{array}}$$

Exo 2

$p^+ + p^+ \rightarrow p^+ + p^+ + (\pi^+ + \pi^-)$

1) collision inélastique nombre et nature des particules modifiés.

2) conservation de la quantité de mouvement totale ; conservation de l'énergie totale.

3) CDM $\vec{P}^{\,\prime}_{TOT} = \vec{0}$

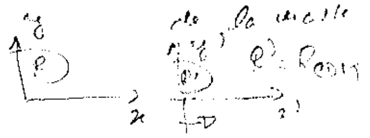
4) particules crées au repos dans le CDM $\Rightarrow$ $\boxed{E_S^* = 4m_pc^2 = 4 \times 938 = 3752\ \text{MeV}}$

5) $M^2_{TOT,av}c^4 = M^2_{TOT,ap}c^4 \Rightarrow (E_1 + m_pc^2)^2 - P_1^2c^2 = 4^2 m_p^2c^4 \Rightarrow 2E_1 m_pc^2 = 14\, m_p^2c^4$

invariance et conservation de la masse totale

$\boxed{E_1 = 7m_pc^2 = 938\ \text{MeV} \times 7}$ $\boxed{E_{k1} = 6m_pc^2}$ 5628 MeV

6)



$P' = \gamma(P + \beta\frac{E}{c})$

$\frac{E'}{c} = \gamma(\frac{E}{c} + \beta P)$.

7) $R' \equiv R_{CDM}$ $\quad \vec{P}'_{TOT} = \vec{0} \Rightarrow \vec{P}'_1 + \vec{P}'_2 = \vec{0} \Rightarrow \vec{P}'_1 = -\vec{P}'_2$ $\quad P'_1 = \gamma(P_1 + \beta E_1/c) \Rightarrow$

$P'_2 = \gamma(0 + \beta \cdot E_2/c)$.

$\cancel{\gamma}(P_1 + \beta E_1/c) + \cancel{\gamma}\beta\, m_p\frac{c^2}{c} = 0 \Rightarrow P_1c + \beta(E_1 + m_pc^2) = 0 \Rightarrow$ $\boxed{\beta = -\frac{P_1c}{E_1 + m_pc^2}}$ R_{CDM}/R.

E_2/c

8) $\boxed{\beta = -\frac{\sqrt{(E_{k1}+m_pc^2)^2 - m_p^2c^4}}{E_{k1} + 2m_pc^2} = -\frac{\sqrt{7^2 - 1^2}\, m_pc^2}{(7+1)m_pc^2} = 0{,}866c}$ $= \frac{\sqrt{3}}{2}c$ $\boxed{\beta = \frac{-P_1c}{E_{k1} + 2m_pc^2}}$

9) $\boxed{P'_1 = \gamma(P_1 + \beta\frac{E_1}{c})}$; $\gamma = \frac{1}{\sqrt{1-\beta^2}}$ avec $\beta = \sqrt{3}/2$, $\gamma = \frac{1}{\sqrt{1-\frac{3}{4}}} = 2$

10) $P'_1c = 2\left(\sqrt{E_1^2 - m_p^2c^4} - \frac{\sqrt{3}}{2} \times E_1\right) = 2\left[\sqrt{7^2 - 1^2} - \frac{\sqrt{3}}{2} \times 7\right] m_pc^2 = 1{,}73\, m_pc^2$

$\boxed{P'_1c = 1625\ \text{MeV}}$