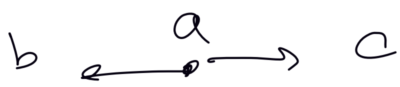
Token 173 554

$a \to b + c$

$a \to b + c + d$



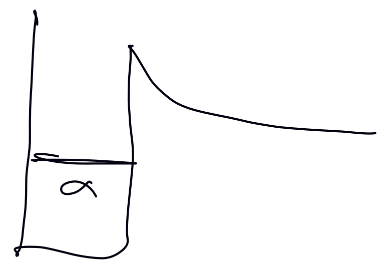
$p_c^* = p_b^* = p$

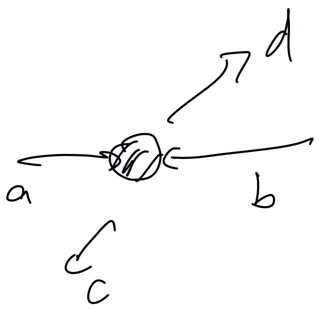
monocromatico

$E^2 = p^2 + m^2$

${}^{A}_{Z}X \to {}^{A-4}_{Z-2}Y + \alpha$

${}^{4}_{2}He$





$\mu^+ \to e^+ + \nu_e + \bar{\nu}_\mu$

conservazione E, $\vec{p}$, Q, mom angolare, num quantici

at $t = 0$ $N(0)$ particelle

@ $t = t'$ $N(t')$

Ipotesi: la prob. di decad.m per unità di tempo.
indip. del tempo t
indip da N.

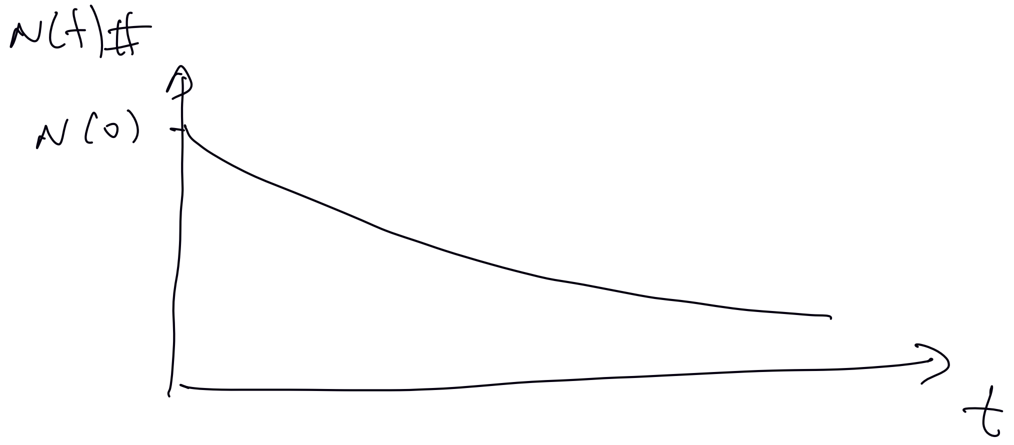
λ: caratt. intrinseca della particella singola

tempo osservazione $dt \Rightarrow$ prob decadim λdt

$$dN = (-\lambda dt) N. \quad @ \; t$$

N particelle dello stesso tipo

$$\frac{dN}{N} = -\lambda dt \Rightarrow N(t) = N(0)\, e^{-\lambda t}$$



$$\frac{N(t)}{N(0)} = e^{-\lambda t} = \underline{P_{soprav.}(t)}$$

singola particella.

$$\langle t \rangle = \frac{\int_0^\infty t\, N(t)\, dt}{\int_0^\infty N(t)\, dt} = \frac{\int_0^\infty t\, e^{-\lambda t}\, dt}{\int_0^\infty e^{-\lambda t}\, dt}$$

$$[\lambda] = [T]^{-1}$$

$$= \frac{1}{\lambda^2}\lambda = \frac{1}{\lambda}$$

$$\langle t \rangle = \frac{1}{\lambda} =: \tau \quad \text{vita media propria}$$

$$N(t) = N(0)\, e^{-t/\tau}$$

$$N(\tau) = N(0)\, e^{-1} \simeq \frac{N(0)}{3} = 37\%$$

$$P_{surv}(\tau) = e^{-1} = \frac{1}{e} = 37\%$$

Fisicamente importante t/τ

$$T_{1/2} : \quad N(T_{1/2}) = \frac{N(0)}{2} = N(0)\, e^{-\frac{T_{1/2}}{\tau}}$$

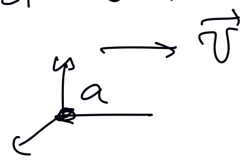
$$\Rightarrow \quad \frac{1}{2} = e^{-\frac{T_{1/2}}{\tau}}$$

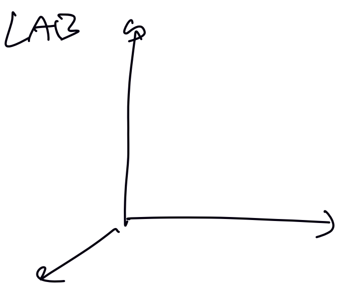
$$\ln\frac{1}{2} = -\frac{T_{1/2}}{\tau} \Rightarrow \boxed{\tau \ln 2 = T_{1/2}}$$

$$\ln 2 \simeq 0.7$$

$$\tau_\mu = 2.2 \times 10^{-6} \text{ sec.}$$

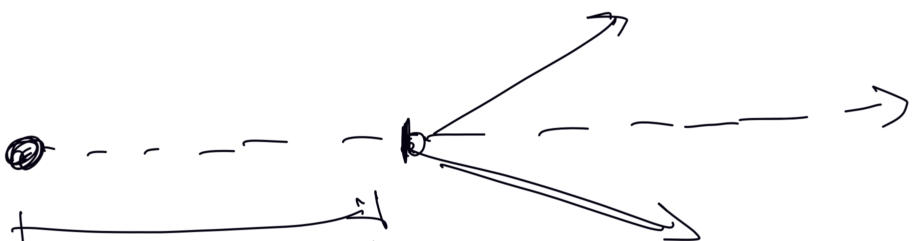
Nel rif. solidale con a $\quad N(t') = N(0)\, e^{-t'/\tau}$





$$\tau_{LAB} = \gamma\tau$$

$$N(t) = N(0)\, e^{-\frac{t_{LAB}}{\gamma\tau}}$$



$$\Delta x = v\, t_{LAB}$$

$$t_{LAB} = \frac{\Delta x}{v} = \frac{\Delta x}{\beta c} \qquad \beta = \frac{p}{E} \qquad \beta\gamma = \frac{p}{m}$$

$$N(t) = N(0)\, e^{-\frac{x_{LAB}}{\beta\gamma c\tau}} \qquad \gamma = \frac{E}{m}$$

$$\beta\gamma = \frac{\beta}{\sqrt{1-\beta^2}} \qquad (\beta\gamma)^2 = \frac{\beta^2}{1-\beta^2}$$

$$\beta = \frac{(\beta\gamma)}{\sqrt{1+(\beta\gamma)^2}} \qquad \beta\gamma = \frac{p}{m}$$

μ: $m = 106\ \text{MeV}$

$p = 10\ \text{GeV}$

$$\beta\gamma = \frac{10\ \text{GeV}}{0.1\ \text{GeV}} = 100$$

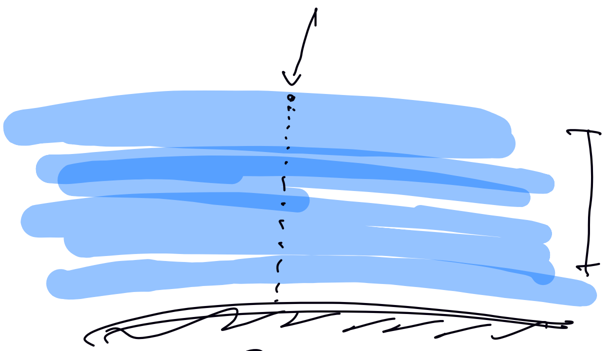
$$E^2 = p^2 + m^2$$

$$(10)^2 + (0.1)^2 \qquad E \simeq p$$

CAB :

$$\beta\gamma c\tau = 100 \times 3\times10^8\ \frac{m}{s}\ 2.2\times10^{-6}\ s$$

$$\simeq 10^4 \times 2.2\times3\ m = 60\ \text{Km}$$

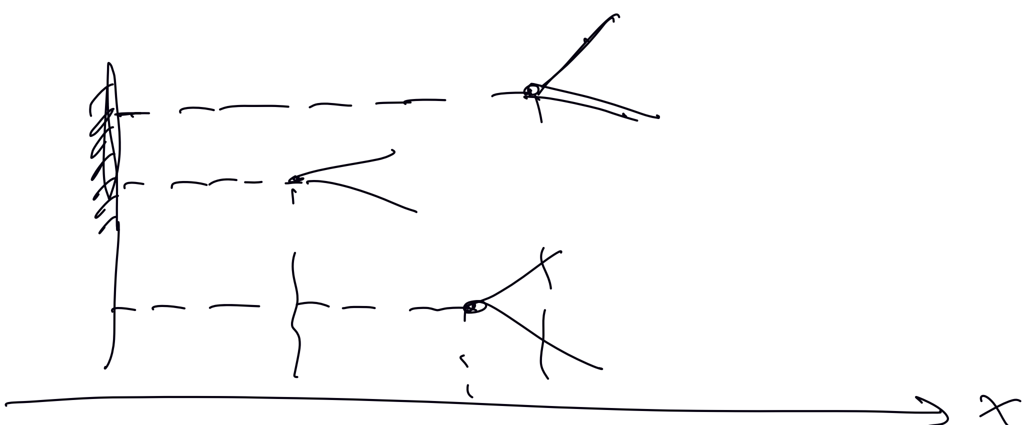


15 Km

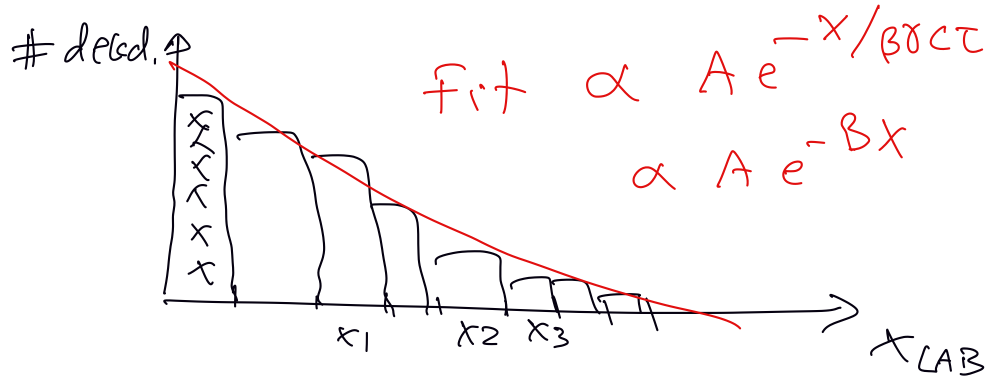
Terra.

$c\tau$ = cammino medio proprio.

$$N(t) = N(0)\, e^{-\frac{x}{\beta\gamma c\tau}}$$



x_1 x_2 x_3 x



Fit $\propto A e^{-x/\beta\gamma c\tau}$

$\propto A e^{-Bx}$

$P_a = P_b + P_c$

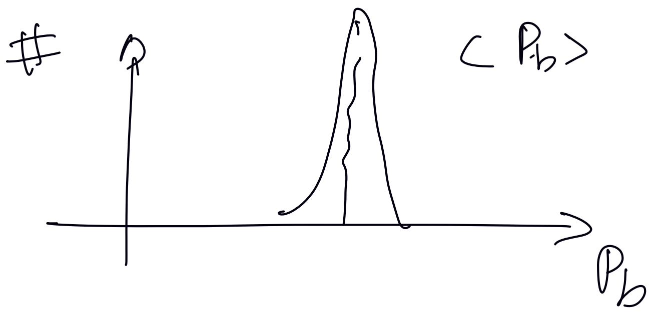
$\vec{P}_a = \vec{P}_b + \vec{P}_c$

misurare τ

$a \to b + c$

① x_1, β_1, γ_1

$\vec{P}_a^{(1)} = \vec{P}_b^{(1)} + \vec{P}_c^{(1)}$



$\langle P_b \rangle$

$|\mu^-\rangle \to |\mu^-\rangle$

$\quad\quad\ \to |e^- \bar{\nu}_e \nu_\mu\rangle$

$\{|\mu^-\rangle, |e^- \bar{\nu}_e \nu_\mu\rangle\}$

$|\mu^-, 0\rangle$ Rif. solidale con μ^-

$E = m_\mu$.

$|\mu^-, t\rangle = e^{-im_\mu t} |\mu, 0\rangle$

$i \frac{d}{dt} |\psi\rangle = H|\psi\rangle$

$H = H^+$

$P(\mu @ t) = |\langle \mu, 0 | \mu^-, t\rangle|^2$

$= 1$

$|\mu^-, t\rangle = a(t) |\mu^-\rangle + b(t) |e^- \bar{\nu}_e \nu_\mu\rangle$

1930 Wigner–Weisskoff

M
Γ si stima
da H_I

$$\boxed{\begin{array}{l} H = \underline{\underline{M}} - \frac{i}{2}\,\underline{\underline{\Gamma}} \\[2ex] H = H_0 + H_I \end{array}}$$

$M = M^\dagger \quad \Gamma = \Gamma^\dagger$

hamiltoniana completa

H_0: particella libera

H_I: causa del decadimento

$$|\mu^-, t\rangle = e^{-im_\mu t}\, e^{-i(-i\frac{\Gamma}{2})t}\,|\mu^-\rangle$$

Sakurai 5.6

$$= e^{-im_\mu t}\, e^{-\frac{\Gamma}{2}t}\,|\mu^-\rangle$$

$$\langle\mu^-|\mu^-, t\rangle = \cancel{e^{-im_\mu t}}\,\cancel{e^{+im_\mu t}}\,e^{-\frac{\Gamma}{2}t}$$

$$P(\mu^- \text{ sopravvive}) = |\langle\mu^-|\mu^-, t\rangle|^2 = e^{-\Gamma t}$$

$$\parallel$$
$$|a(t)|^2$$

$$1 = |a(t)|^2 + |b(t)|^2$$

$$\Leftrightarrow |b(t)|^2 = 1 - e^{-\Gamma t}$$

$$P(\mu^- \to \mu^-) = e^{-\Gamma t} \equiv e^{-t/\tau}$$

$\Gamma \equiv \lambda$

$$\boxed{\Gamma =: \frac{1}{\tau}}$$

larghezza di decadimento.
prob. di decadim per unità di tempo.

Γ si misura in MeV, s^{-1}
τ in s