VIOLAZIONE DELLA PARITA'

$$P: \vec{r} \to -\vec{r}$$

$\theta - \tau$ puzzle

si osservano (1953)

- $\theta^+ \to \pi^+ + \pi^0$ HA PARITA' +
- $\tau^+ \to \pi^+ + \pi^+ + \pi^-$ $(J^P = 0^-)$

OGGI SAPPIAMO

$$K^+ \to \pi^+ \pi^0$$
$$\pi^+ \pi^+ \pi^-$$

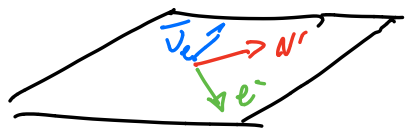
CONSIDERO IL DEC. β

$$N \to N' + e^- + \nu_e$$

- io ricostruisco $\vec{P}_{N'}, \vec{P}_e, \vec{P}_\nu$

- posso usare $\vec{P}_e \cdot \vec{P}_{N'}$? No (scalare)
- posso $\vec{P}_{N'} \cdot (\vec{P}_e \times \vec{P}_\nu)$

PSEUDO-SCALARE



MA vale sempre 0 (sono coplanari)

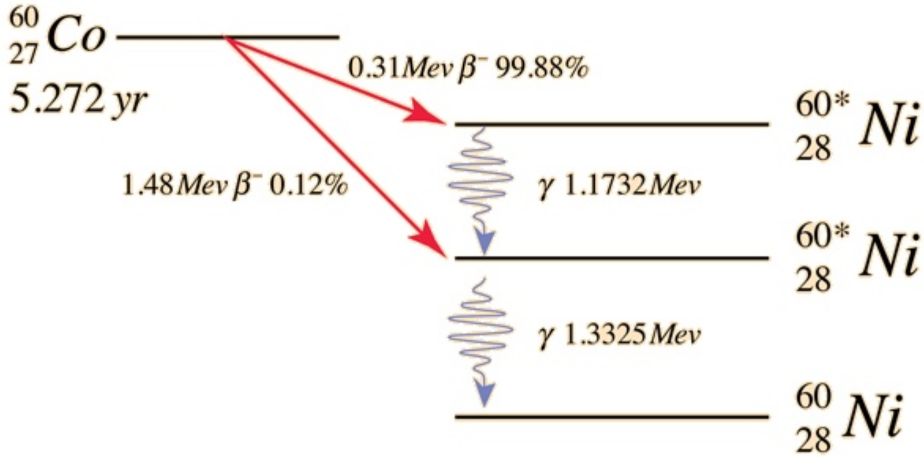
- uso uno pseudovettore

POLARIZZAZIONE

- $\langle \vec{J} \rangle \neq \vec{0}$
- MISURO $\langle \vec{J} \rangle \cdot \vec{P}_e$

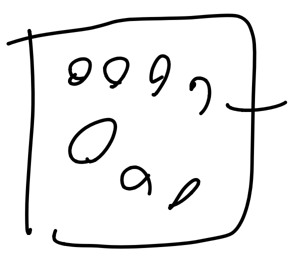
$$^{60}_{27}Co \rightarrow {}^{60}_{28}Ni^{*} + e^- + \bar{\nu}_e$$

↳ DECADE ALLO STATO FOND. emettendo 2γ



IDEA:

$$\vec{\mu} = -\frac{e}{2m}\vec{S}$$



^{60}Co

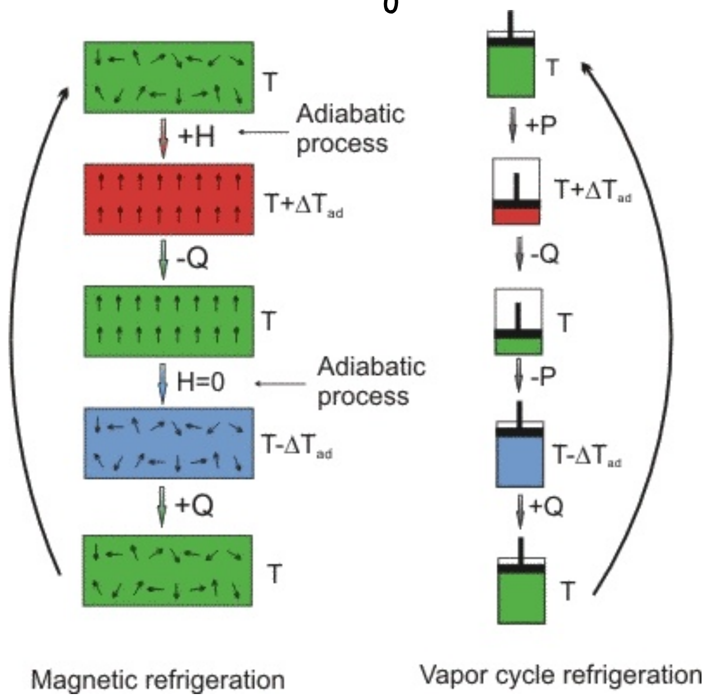
LA PROB. DI RIUSCIRE A ORIENTARE CON $\vec{B}$ I NUCLEI

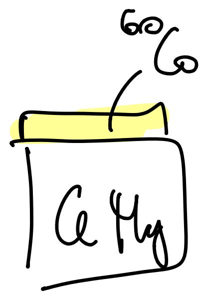
$$P(\langle\vec{\mu}\rangle) = e^{-\frac{\vec{\mu}\cdot\vec{B}}{kT}}$$

serve $T \sim 3\ mK$

B elevato $(\sim 1 \div 10\ T)$

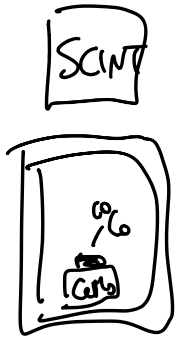
SALE PARAMAGNETICO CeMg

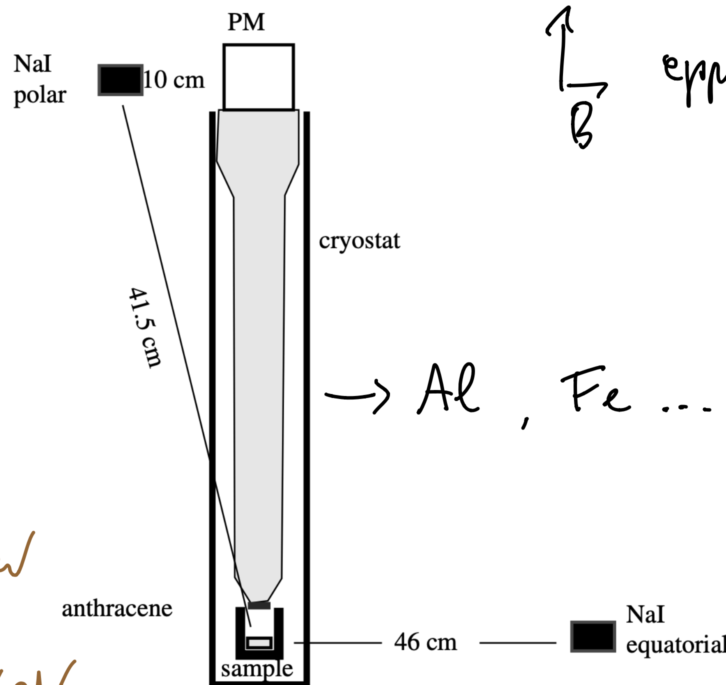




- raggiungo 3mK
- ottengo, grazie al fatto che ho allineato gli e^-, $\vec{B}_{locale} \sim 10T$

$\uparrow B$ eppure $\downarrow B$





→ Al , Fe ...

$E_c(Al) \sim 42\,MeV$

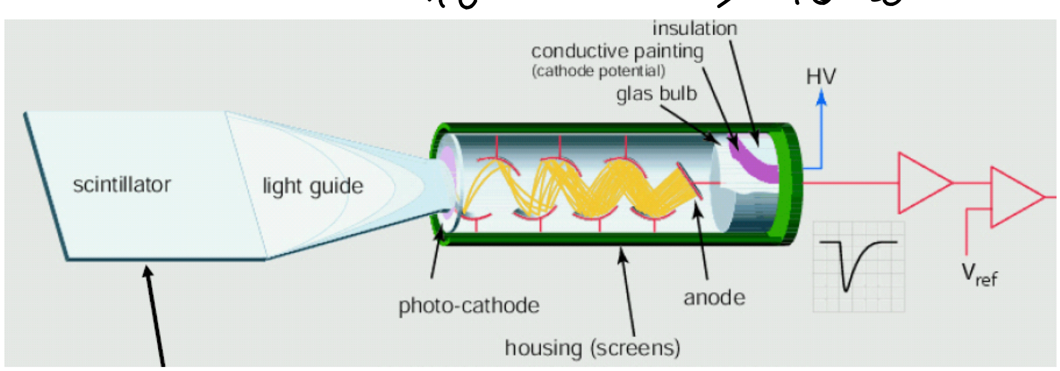
$E_{e^-} \sim 300\,keV$

MIP: $\rho \sim 3\,g/cm^3$

$1.6\,MeV/g/cm^2$

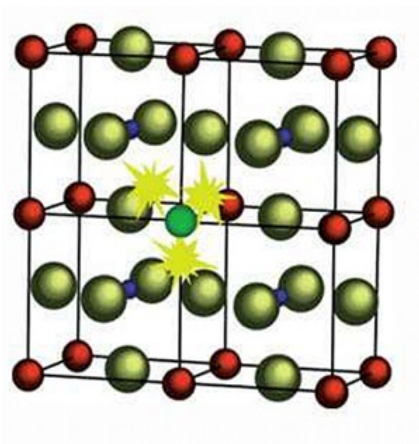
$\rightarrow 4\,MeV/cm$

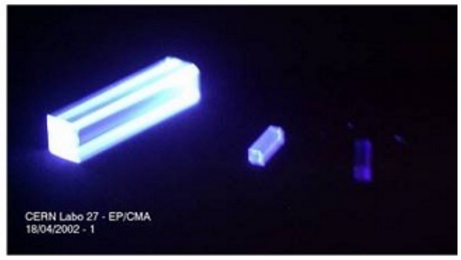
$1e^- \longrightarrow 10^6 e^-$



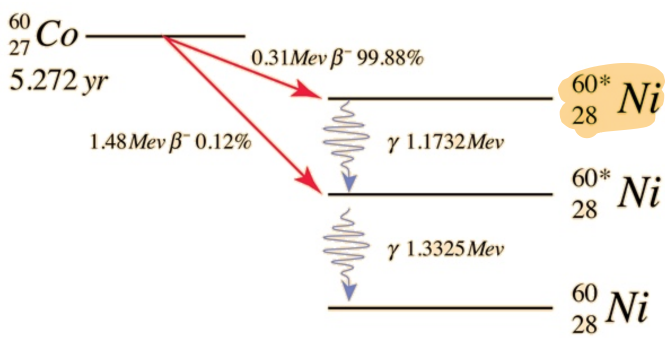
FOTOCATODO

$\gamma + e^- + \gamma + e^-$





COME MISURO $\langle \vec{\mu} \rangle$!



$J^P(Co-60) = 5^+$

$J^P(Ni-60) = 4^+$

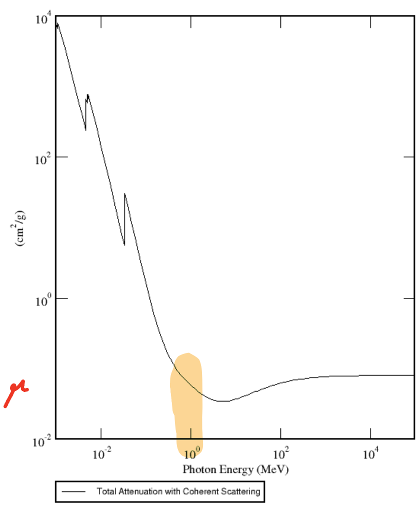
$\uparrow {}^{60}_{27}Co\ (J^P = 5^+) \longrightarrow \uparrow {}^{60}_{28}Ni^{**}\ (J^P = 4^+) + e^- + \bar{\nu}_e$

SPIN ($\vec{\mu}$)

$^{60}_{28}Ni^{**} \longrightarrow \uparrow {}^{60}_{28}Ni^{*}\ (J^P = 2^+) + \gamma$ (1.2 MeV)

$^{60}_{28}Ni^{*} \longrightarrow \uparrow {}^{60}_{28}Ni\ (J^P = 0^+) + \gamma$ (1.3 MeV)

→ I FOTONI SONO EMESSI ANISOTROPICAMENTE

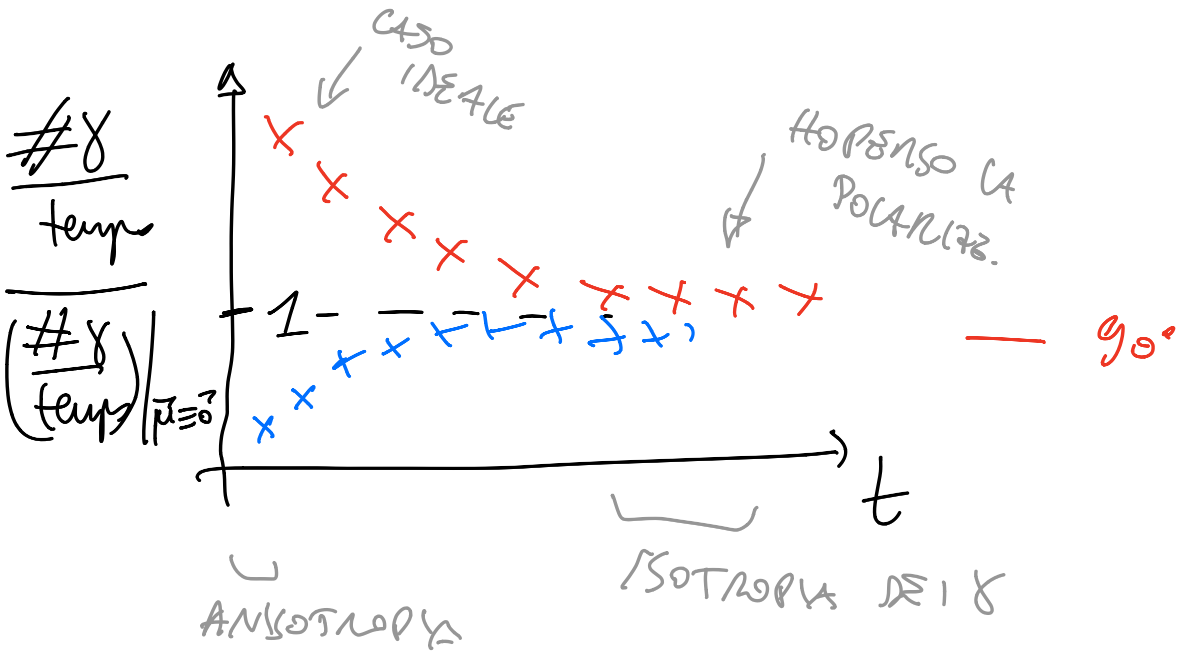


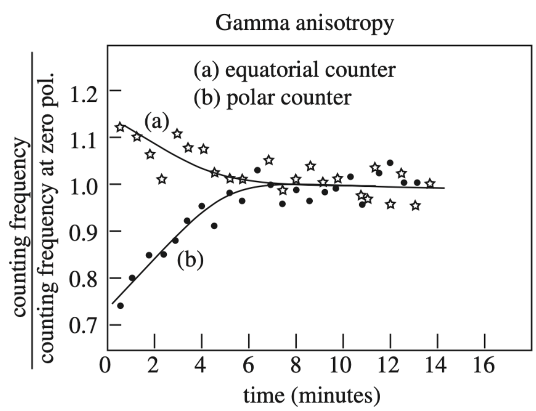
$\frac{1}{\sigma M_{Ae}} \sim \mu \sim \frac{1}{\lambda}$

MISURO IL GRADO DI POLARIZZAZIONE MISURANDO I γ

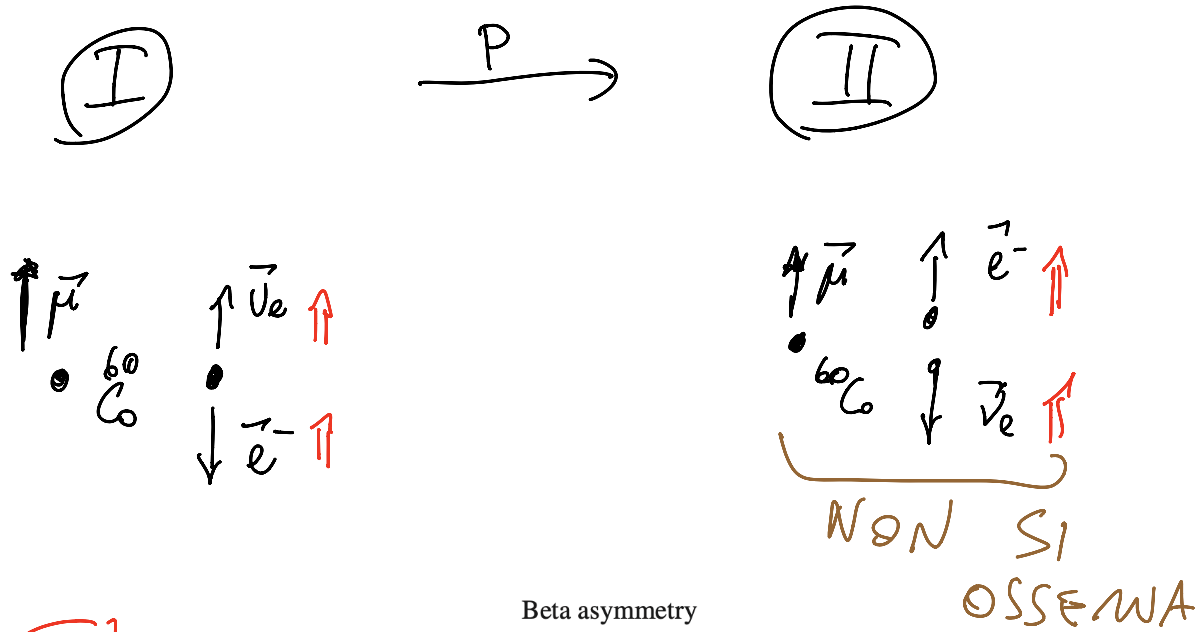
$$\varepsilon_\gamma \equiv \frac{W_\gamma(90^\circ) - W_\gamma(0^\circ)}{W_\gamma(90^\circ) + W_\gamma(0^\circ)}$$

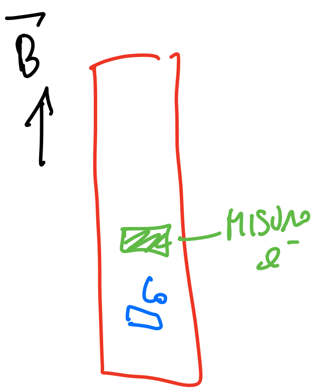
$$W \equiv \frac{\#\ \text{fotoni}}{\text{secondo}}$$

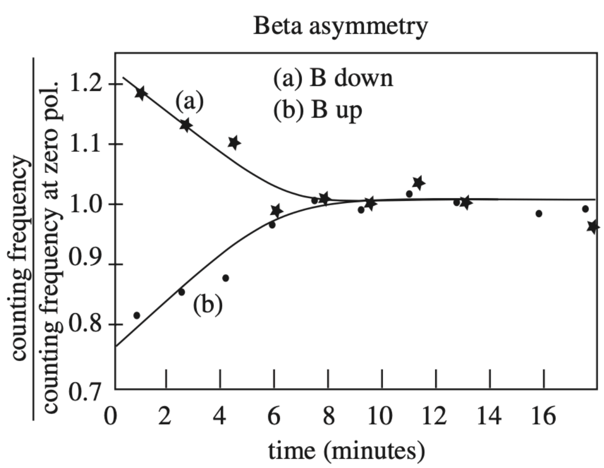


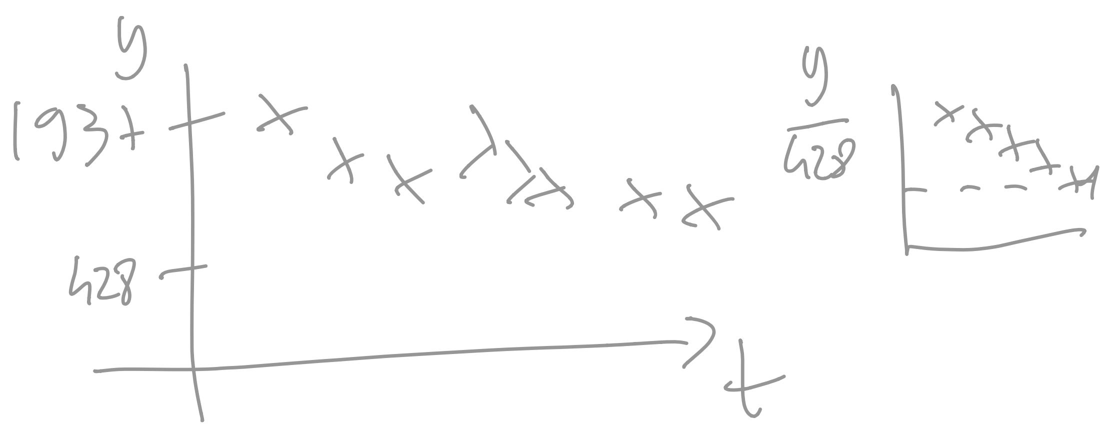


Se misuro gli e^-, cosa vedo?


I
P
II
$\vec{\mu}$
^{60}Co
$\vec{\nu}_e$
$\vec{e}^-$
NON
SI
OSSERVA


$\vec{B}$
MISURO e^-
Co


Beta asymmetry
(a) B down
(b) B up
(a)
(b)
counting frequency / counting frequency at zero pol.
1.2
1.1
1.0
0.9
0.8
0.7
0
2
4
6
8
10
12
14
16
time (minutes)


y
1937
428
t
y/428

DECADIM. β INVERSO & PRINCIPIO DEL BILANCIO DETTAGLIATO

se $A + B \to C + D$

allora $A \to \bar{B} + C + D$

(A). ho già calcolato

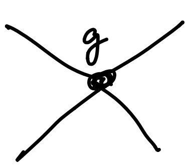
$$^{A}_{Z}X \to {}^{A}_{Z-1}Y + e^+ + \nu_e$$

(B). posso calcolare facilmente

$$^{A}_{Z}X + \bar{\nu}_e \to {}^{A}_{Z-1}Y + e^+$$

$$\text{"p"} + \bar{\nu}_e \to \text{"n"} + e^+$$

(A) $$\langle f | H_I | i \rangle = \frac{g}{V} \int d\vec{r}\, \psi_Y^*(\vec{r})\, O_X\, \psi_X(\vec{r})$$



$$\equiv \frac{g}{V} \cdot M_{fi} \equiv \frac{G_F (\hbar c)^3}{V} M_{fi}$$

$$\Gamma = \frac{\hbar}{\tau} = \frac{G_F^2}{2\pi^3} |M_{fi}|^2 f(\pm Z, Q) (m_e c^2)^5$$

$$f(\pm Z, Q) = \frac{1}{(m_e c^2)^5} \int_0^Q E_\nu (p_\nu c)(p_e c)(T_e + m_e c^2) \times F(\pm Z, T_e)\, dT_e$$

(B) $\langle f | H_I | i \rangle$ sarà calcolato allo stesso modo!

se $M_{fi\,(A+B \to C+D)} = f(\vec{p}_A, \vec{p}_B, \vec{p}_C, \vec{p}_D)$

allora $M_{fi\,A \to \bar{B} + C + D} = f(\vec{p}_A, -\vec{p}_B, \vec{p}_C, \vec{p}_D)$

Vogliamo (scegliamo $n_A = 1$, $n_B = 1$)

$$\sigma = \frac{\lambda}{N_B \cdot \phi} = \frac{\lambda}{1 \cdot n_A v_A} = \frac{\lambda}{v_A}$$

$$\lambda = \frac{2\pi}{\hbar} |\langle f | H_I | i \rangle|^2 \rho(E_i)$$

$$|\langle f|H_I|i\rangle|^2 = \left|\frac{G_F(\hbar c)^3}{V} M_{fi}\right|^2$$

$$= \frac{G_F^2(\hbar c)^6}{V^2} \cdot \frac{\hbar}{\tau} \cdot \frac{2\pi^3}{G_F^2} \frac{1}{f(\pm Z, Q)(m_e c^2)^5}$$

$V \equiv 1$

$$= \frac{\hbar}{\tau}(\hbar c)^6 \, 2\pi^3 \frac{1}{f(\pm Z, Q)(m_e c^2)^5}$$

$$\rho(E_i) = ?$$

$\bar{\nu}_e + p \to n + e^+$

$$\rho(E_i) \equiv \left.\frac{dn}{dE_f}\right|_{E_f = E_i}$$

$$= \left.\frac{dn}{dp_e} \cdot \frac{dp_e}{dE_f}\right|_{E_i = E_f} = \frac{p_e^2 \, dp_e \cdot 4\pi}{dp_e (2\pi\hbar)^3}$$

$$\times \frac{dp_e}{dE_f}$$

$$E_i = E_\nu + m_x c^2$$

$$= E_y + E_e$$

$$\simeq m_y c^2 + E_e$$

$$= m_y c^2 + \sqrt{p_e^2 c^2 + (m_e c^2)^2}$$

$$\frac{dE_f}{dp_e} = \frac{1}{2} \cdot \frac{2 p_e c^2}{\sqrt{(p_e c)^2 + (m_e c^2)^2}}$$

$$= \frac{p_e c^2}{E_e}$$

$$= \rho(E_i) = \frac{p_e^2 \cdot 4\pi}{(2\pi\hbar)^3} \cdot \frac{E_e}{p_e c^2}$$

$$= \frac{p_e \cdot 4\pi}{(2\pi\hbar)^3} \cdot \frac{E_e}{c^2}$$

$$= \frac{p_e c \cdot 4\pi \cdot E_e}{(2\pi\hbar c)^3}$$

$$\beta_e = \frac{p_e c}{E_e}$$

$$= \frac{4\pi\, p_e E_e^2}{(2\pi \hbar c)^3}$$

$$\lambda = \frac{2\pi}{\hbar} |\langle f | H_I | i \rangle|^2 \rho(E)$$

$$= \frac{2\pi}{\hbar} \cdot \frac{\hbar}{\tau} (\hbar c)^6 \frac{2\pi^3}{f(\pm Z, Q)(m_e c^2)^5}$$

$$\times \frac{4\pi\, p_e E_e^2}{(2\pi \hbar c)^3}$$

$$= 2\pi^2 \cdot (\hbar c)^3 \cdot \frac{E_e^2\, p_e}{\left[\tau f(\pm Z, Q) \times (m_e c^2)^5\right]}$$

$$\sigma = \frac{\lambda}{N_B \cdot \sigma} = \frac{\lambda}{\phi_\nu} = \frac{\lambda}{c}$$

$$= 2\pi^2 \cdot (\hbar c)^2 \cdot \frac{\hbar}{\tau} \cdot \frac{E_e^2 \beta_e}{f(\pm Z, Q)(m_e c^2)^5}$$

$$= \sigma_{\bar{\nu}_e + p \to n + e^+}$$

$$\bar{\nu}_e + X \to Y + e^+$$

se $E_e \sim 1$ MeV

$\beta_e \sim 0.86$

$f \equiv 1$

$\tau \equiv 800s$ (neutrone)

ho $\sigma \sim 10^{-43} cm^2$