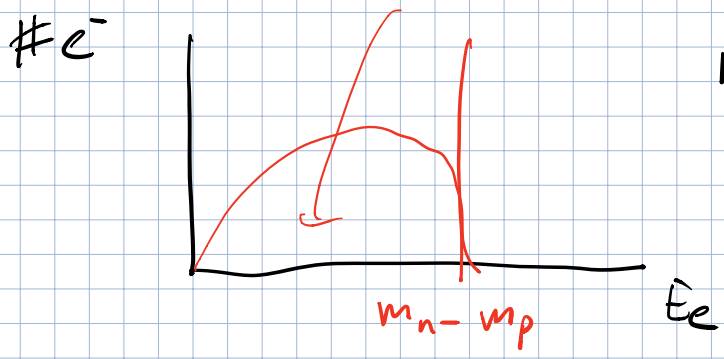
$$n \longrightarrow p + e^- + \bar{\nu}_e$$



$$E_e + E_\nu + m_p = m_n \quad \rightarrow \text{et vost}$$

$$\begin{pmatrix} e^- \\ \nu_e \end{pmatrix} \quad \begin{pmatrix} \mu^- \\ \nu_\mu \end{pmatrix} \quad \begin{pmatrix} \tau^- \\ \nu_\tau \end{pmatrix}$$

$$L\,H\,\nu_R \equiv L\,H\,e_R$$

$m_\nu\,\bar{\nu}\,\nu$

$m_e\,\bar{e}\,e$

$\lambda_{ij}\ L_i\ H\ \nu_{R\,j}$

$i, j = 1, 2, 3$

↳ generation indeces

$M_{ij}\ \bar{\nu}_i\ \nu_j$

Yukawa matrix

W^- — $\bar{\nu}_e$

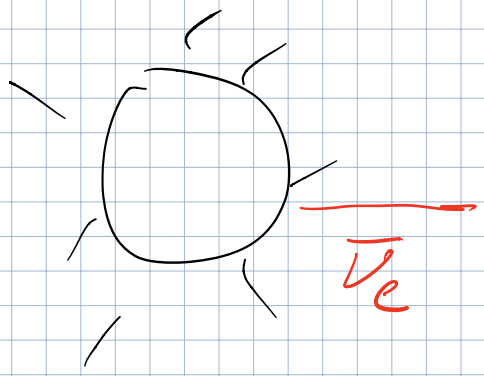
e^-

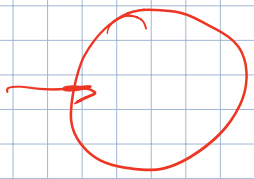
$\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$ e μ τ

$M \cdot \nu$

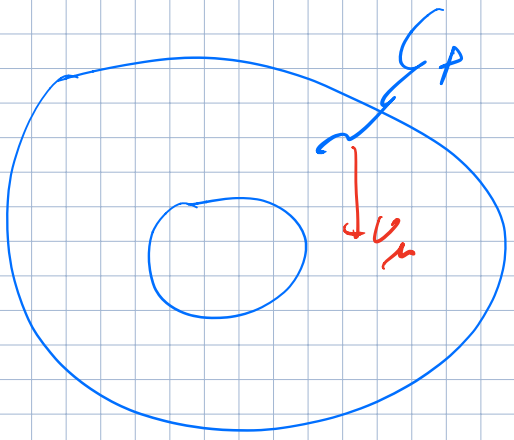
$\begin{pmatrix} m_{\nu_e} & m_{\nu_\mu} & m_{\nu_\tau} \end{pmatrix} \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \rightarrow m_{\nu_e} \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$

$\begin{pmatrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{pmatrix} \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \not\rightarrow \neq \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$

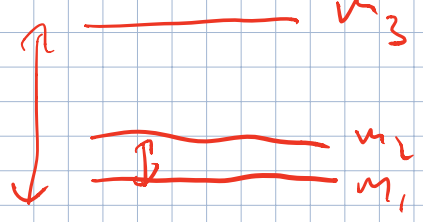




60% ν_e



M_{ij} → diagonal $\begin{pmatrix} m_1 & & \\ & m_2 & \\ & & m_3 \end{pmatrix}$



$Z \to \bar{\nu}_j \nu_i$ $\quad W^- \to e^- \bar{\nu}_1$ $\bar{\nu}_2$ $\bar{\nu}_3$

$Z \to \bar{\nu}_e \nu_e$

$\bar{\nu}_\mu \nu_e$

$\bar{\nu}_\tau \nu_\tau$

Dirac mass

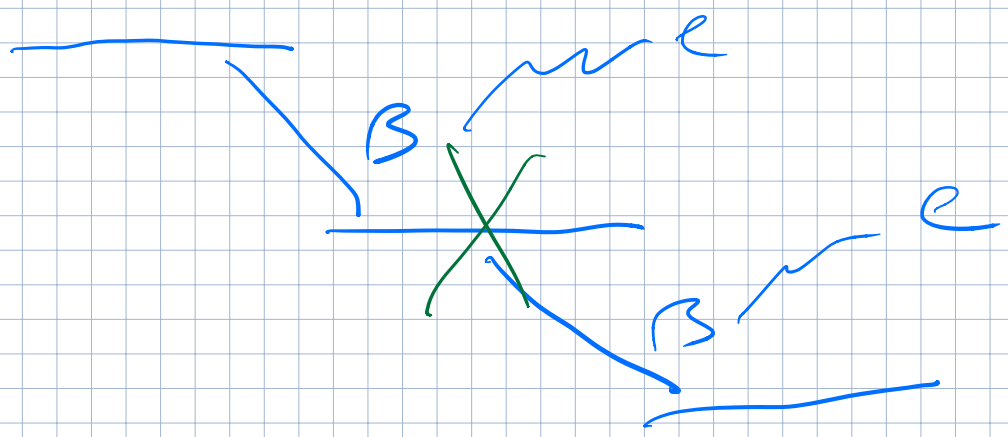
$m_\nu \bar{\nu} \nu$ $(\equiv m_e \bar{e} e)$

$M_{ij} \bar{\nu}_i \nu_j$

Majorana mass:

$m_\nu \; \nu\nu$

$0\nu\beta\beta$



$N \longrightarrow W^- \nu' \longrightarrow W W^- \nu''$