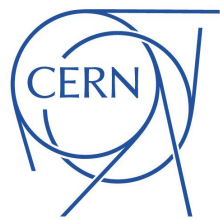


Neutrino

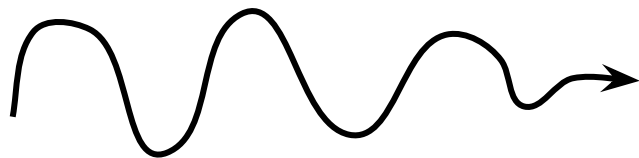
OR ANTI-Neutrino

Nikhef

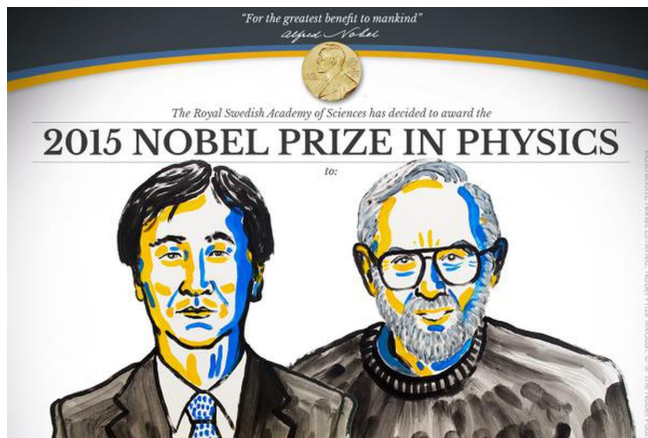


Lera Lukashenko

ν_e



ν_μ



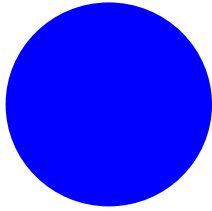
$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} U_{e1} & U_{e2} & U_{e3} \\ U_{\mu1} & U_{\mu2} & U_{\mu3} \\ U_{\tau1} & U_{\tau2} & U_{\tau3} \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

INTERACTION
STATE

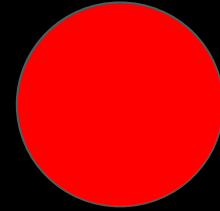
MASS STATE

$$L_{mass} = \frac{1}{2} m^2 \psi^2$$

DIRAC PARTICLE



Neutrino



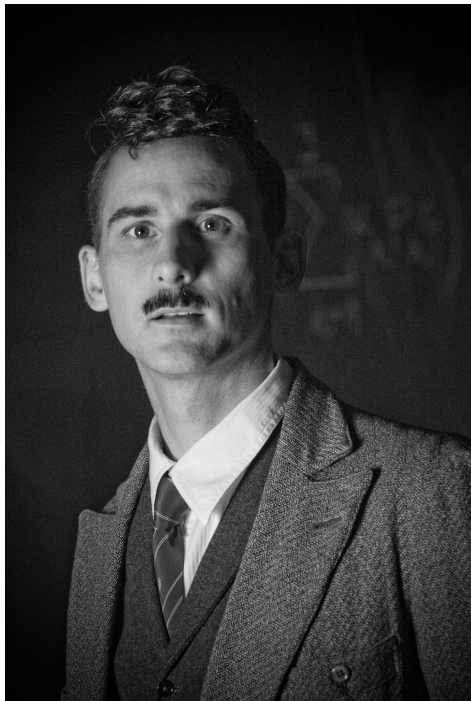
anti-Neutrino

OR

MAJORANA PARTICLE



Neutrino

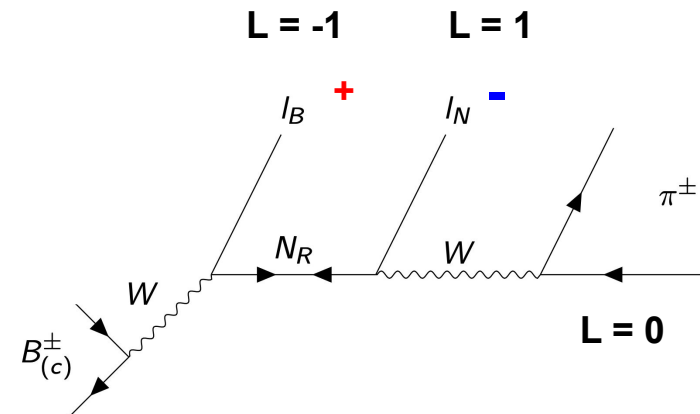


$$\Delta L = 0$$



$$\Delta L = 2$$

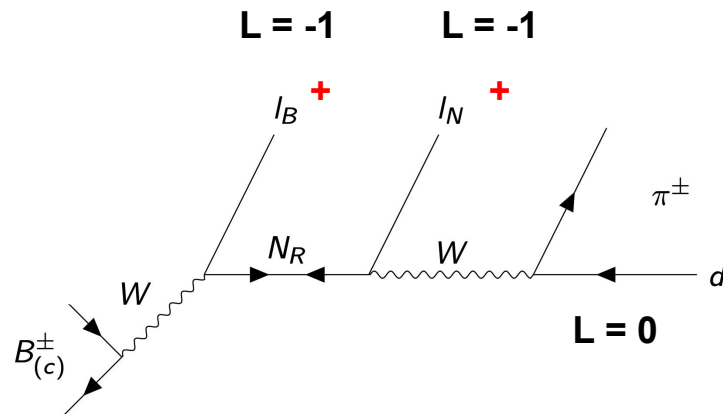
$$\Delta L = 0$$



$$L = 0$$

$$0 = -1 + 1 + 0$$

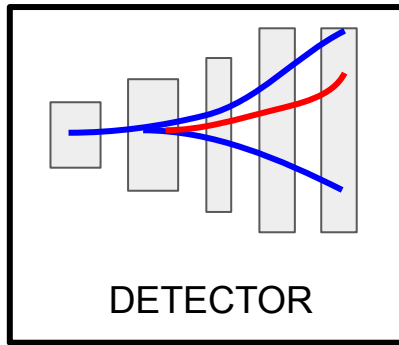
$$\Delta L = 2$$



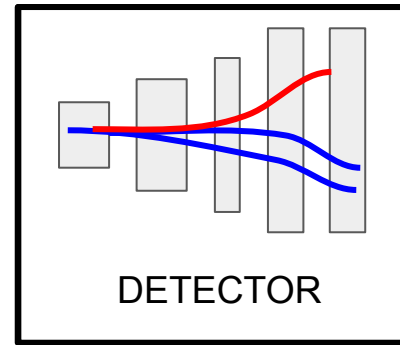
$$L = 0$$

$$0 \neq -1 + -1 + 0$$

DIRAC

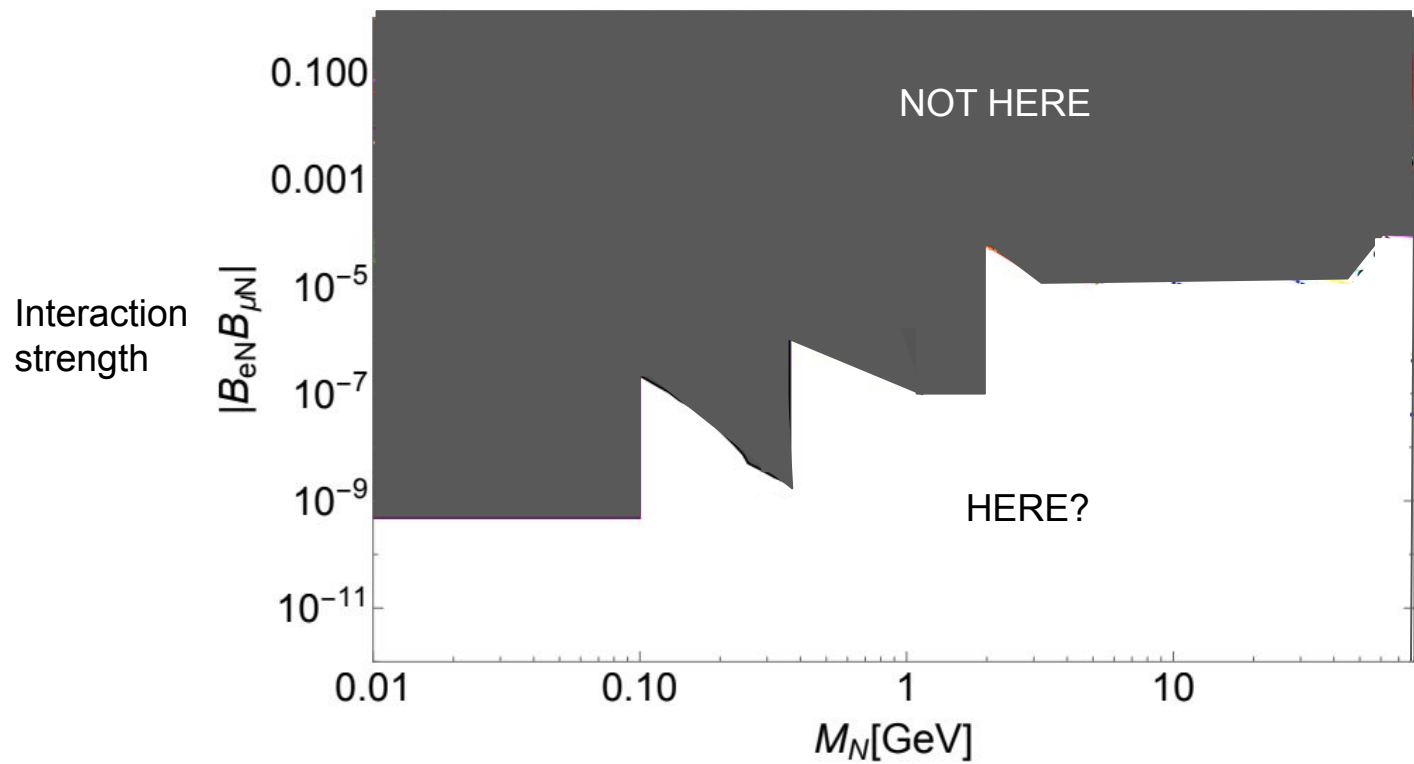


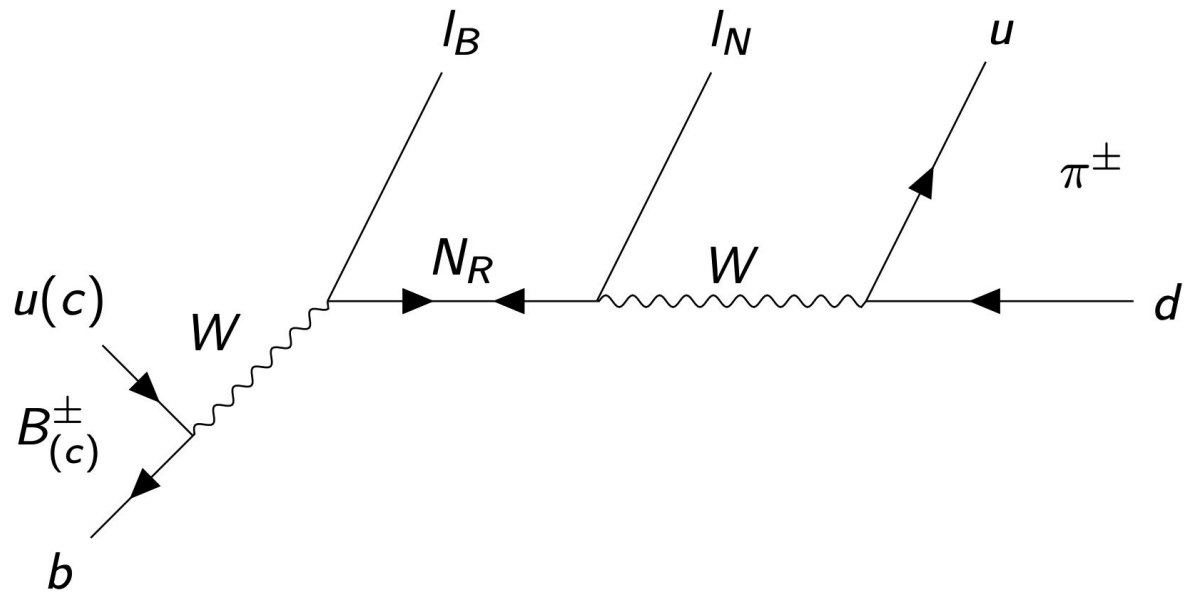
MAJORANA

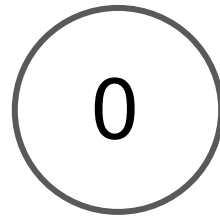


$$-L_{mass} = \begin{bmatrix} \nu_L & N_R \end{bmatrix} \begin{bmatrix} -m_D^2/m_R & 0 \\ 0 & m_R \end{bmatrix} \begin{bmatrix} \nu_L \\ N_R \end{bmatrix}$$





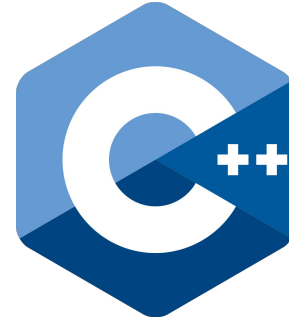
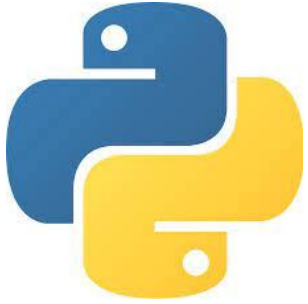




Neutrino

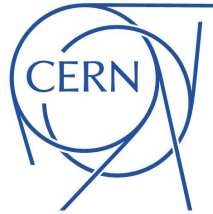


What will you learn?



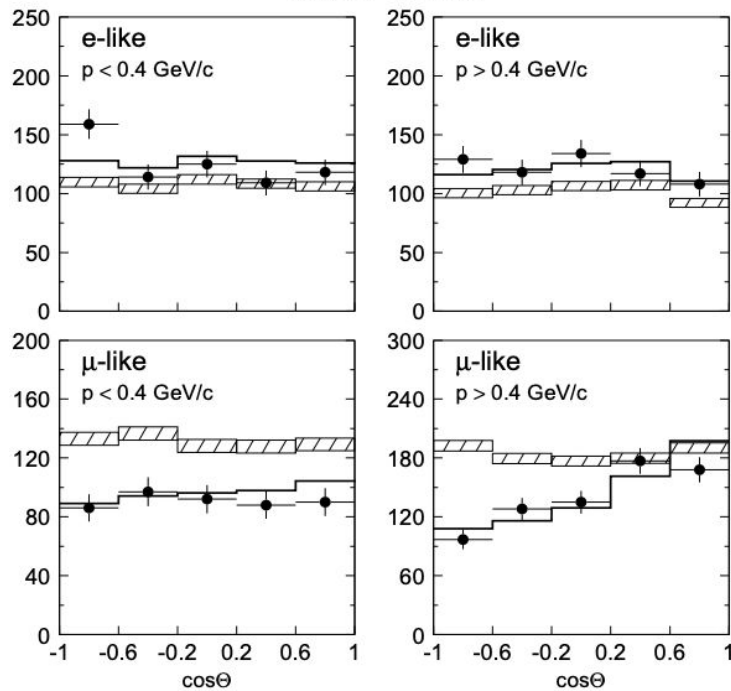
ML

(optional)



HOW DO WE KNOW NEUTRINOS OSCILLATE?

sub-GeV



multi-GeV

