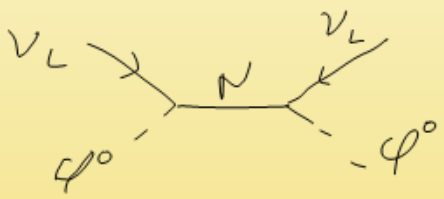
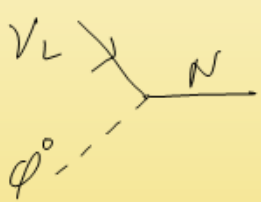
Type-I seesaw $N$

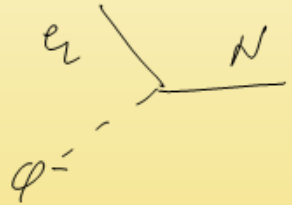
$$\mathcal{L} \sim -y_D \bar{l} \phi^c N \longrightarrow (1,0)$$

$\bar{l}$: $(2,1)$, $\phi^c$: $(2,-1)$

$$-y_D (\bar{\nu}_L \ \bar{e}_L) \begin{pmatrix} \phi^{0*} \\ -\phi^- \end{pmatrix} N \rightarrow -y_D \bar{\nu}_L \phi^{0*} N + y_D \bar{e}_L \phi^- N$$



Proton

$u \quad d \quad \bar{u} \quad \bar{d}$

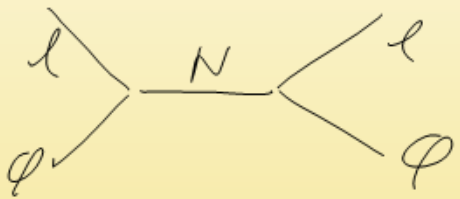
$u - \bar{u} = 2$

$d - \bar{d} = 1$

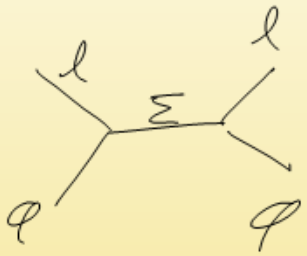
$p = uud$

# Seesaw

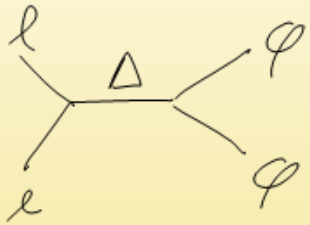
$\ell\ell\phi\phi$




Type I




Type III




Type II

$$\bar{l}_L \, l_L^c \, h_-$$

$$(\bar{\nu}_L \;\; \bar{e}_L) \begin{pmatrix} e_L^c \\ -\nu_L^c \end{pmatrix} h_-$$

$$\bar{\nu}_L \, e_L^c \, h_- \; - \; \bar{e}_L \, \nu_L^c \, h_-$$

$SU(2)_L \times U(1)_Y \rightarrow U(1)_Q$

$SU(2)_L \times SU(2)_R \times U(1)_{B-L} \rightarrow SU(2)_L \times U(1)_Y$