$\mathcal{L} = i\bar{\psi}\gamma_\mu\partial^\mu\psi - m\bar{\psi}\psi$

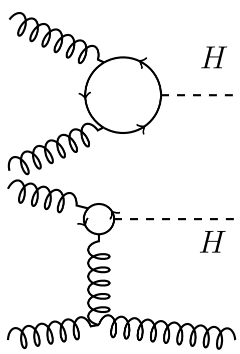
$U(1)$ symmetry: $\psi(x) \to \psi' = e^{i\alpha}\psi$, $\alpha \in \mathbb{R}$

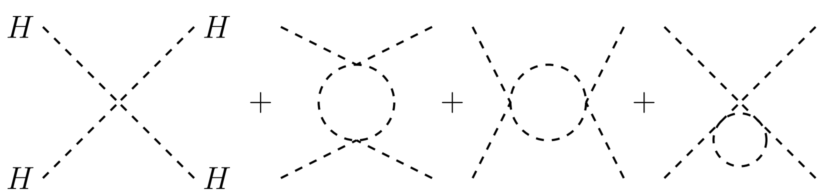
$\mathcal{L} = \mathcal{L}' \quad \Rightarrow \quad \partial_\mu j^\mu = \partial_\mu(-e\bar{\psi}\gamma^\mu\psi) = 0 \quad \Rightarrow \quad Q = \int d^3x j^0$ conserved

$$\phi = \begin{pmatrix} \phi^+ \\ \phi^0 \end{pmatrix} \to \frac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ v + H \end{pmatrix}$$

$$g\bar{\psi}^L\phi\psi_R \to \frac{g}{\sqrt{2}}v\bar{\psi}^L\psi_R + \frac{g}{\sqrt{2}}H\bar{\psi}^L\psi_R$$

$$|D\phi|^2 - V(\phi) \to v^2e^2\mathcal{A}_\mu\mathcal{A}^\mu + \frac{1}{2}\left[(\partial_\mu H)^2 - m_H H^2\right] + \mathcal{A}_\mu H \,\text{interactions}$$





(1)

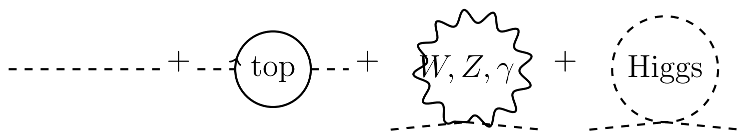
$$\frac{1}{\lambda(v)} - \frac{1}{\lambda(Q)} = \frac{3}{4\pi^2}\ln(Q^2/v^2) \tag{2}$$

$$\lambda(Q) = \frac{\lambda(v)}{1 - \frac{3\lambda(v)}{4\pi^2}\ln(Q^2/v^2)} \tag{3}$$

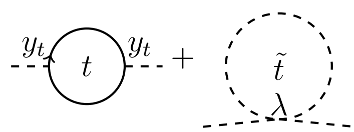
$$m_H^2 < \frac{8\pi^2 v^2}{3\ln(\Lambda^2/v^2)} \tag{4}$$

$$\mathcal{L}_H = \quad m_H^2\phi^\dagger\phi \quad - \quad \lambda(\phi^\dagger\phi)^2 \quad + \; Y^{ij}\Psi_L^i\Psi_R^j\phi \tag{5}$$

$$\begin{array}{ccc} \downarrow & \downarrow & \downarrow \\ \text{Naturalness} & \text{Metastability} & \text{Hierarchy} \end{array}$$

$m_H^2(\text{physical}) \simeq$  (6)

$$m_H^2(\text{bare}) \qquad -\tfrac{3}{8\pi^2}\lambda_t^2\Lambda^2 \qquad -\tfrac{9}{64\pi^2}g^2\Lambda^2 \qquad -\tfrac{1}{16\pi^2}\lambda^2\Lambda^2$$

$\delta m_H^2 \;\simeq$  (7)

$$\delta m_H^2|_{\text{top}} \qquad \delta m_H^2|_2 \qquad \delta m_H^2|_3$$

$$\delta m_H^2|_{\text{top}} = \frac{N_C|y_t|^2}{8\pi^2}\left[-\Lambda^2 + 3m_t^2 \ln\left(\frac{\Lambda^2 + m_t^2}{m_t^2}\right) + ...\right] \tag{8}$$

$$\delta m_H^2|_2 = \frac{\lambda N}{16\pi^2}\left[2\Lambda^2 - 3m_{\tilde{t}}^2 \ln\left(\frac{\Lambda^2 + m_{\tilde{t}}^2}{m_{\tilde{t}}^2}\right) + ...\right] \tag{9}$$

$$\delta m_H^2|_3 = \frac{N}{16\pi^2}\left[-\mu^2 \ln\left(\frac{\Lambda^2 + m_{\tilde{t}}^2}{m_{\tilde{t}}^2}\right) + ...\right] \tag{10}$$

$$\tag{11}$$

$$\Gamma(H \to f\bar{f}) = N\frac{G_F m_H m_f^2}{4\pi\sqrt{2}}\left(1 - x_f\right)^{3/2} \tag{12}$$

$$\Gamma(H \to VV) = \frac{G_F m_H^3}{8\pi\sqrt{2}}\sqrt{1 - x_V}\left(1 - x_V + \frac{3x_V}{4}\right)\left(\frac{1}{2}\right)_Z \tag{13}$$

$$\mathcal{P}_{\text{event}} = \mathcal{P}(\Delta\theta_{3\text{D},1}, p_{\tau,1}) \times \mathcal{P}(\Delta\theta_{3\text{D},2}, p_{\tau,2})$$