We add two real scalar fields, $\phi^1$ and $\phi^2$. They are singlets under all SM gauge groups. Their mass terms are[1]:

$$\mathcal{L}_{\text{s.m.}} = -\frac{m_1^2}{2}\phi_1^2 - \frac{m_2^2}{2}\phi_2^2 - m_{12}^2\phi_1\phi_2 \,. \tag{1}$$

We will call mass eigenstates $\Phi_1$ and $\Phi_2$, and their eigenmasses $M_1$ and $M_2$, respectively, and we will assume that $M_1 < M_2$.

We add two Dirac fermion fields, $U$ and $E$. Their SM quantum numbers are those of the SM $u_R$ and $e_R$, respectively. These fields have mass terms

$$\mathcal{L}_{\text{f.m.}} = M_U \bar{U} U + M_E \bar{E} E \,. \tag{2}$$

They interact with scalars via

$$\mathcal{L}_{\text{Yuk}} = \lambda_1 \phi_1 \bar{U} P_R u + \lambda_2 \phi_2 \bar{U} P_R u + \lambda_1' \phi_1 \bar{E} P_R e + \lambda_2' \phi_2 \bar{E} P_R e \,, \tag{3}$$

where $u$ and $e$ are the SM up-quark and electron fields. Note that there is a $\mathcal{Z}_2$ symmetry under which all fields we added ($\phi_{1,2}$, $U$, $E$) flip sign, while all SM fields do not, so the new particles must be pair-produced and the lightest new particle (LNP) is stable. This same $\mathcal{Z}_2$ also forbids $U-u$ and $E-e$ mixing via Yukawas with the SM Higgs.

We will assume the following ordering of masses:

$$M_U > M_2 > M_L > M_1 \,, \tag{4}$$

so that $\Phi_1$ is the LNP. Not having any SM interactions, it appears as MET in the detector. The goal of the tutorial is to simulate the process

$$pp \to \bar{U} U \,, \tag{5}$$

at a 8 TeV LHC, and the subsequent $U$ decays:

$$U \;\to\; u\Phi_1 \,, \tag{6}$$

$$U \;\to\; u\Phi_2 \,, \quad \Phi_2 \to eE \,, \quad E \to e\Phi_1 \,. \tag{7}$$

[1] All Lagrangian parameters, here and below, are assumed to be real