Anomaly-free implementations of 2HDM-U(1) with two generations of right-handed neutrinos

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NuPhys2019, London, 17th of December

Motivation

Why is a classification of 2HDM-U(1) useful?

- **Popular extension to the SM**
- **Previous studies covers only a subset of the allowed models**
- **Catalogue for future studies**

Result - 16 models in total (example below)

$$\Gamma_2 : \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ \times & \times & 0 \end{pmatrix}, \quad \Gamma_1, \Delta_1 : \begin{pmatrix} \times & \times & 0 \\ \times & \times & 0 \\ 0 & 0 & \times \end{pmatrix}, \quad \Delta_2 : \begin{pmatrix} 0 & 0 & \times \\ 0 & 0 & \times \\ 0 & 0 & 0 \end{pmatrix}$$

$$\Pi_1 : \begin{pmatrix} \times & \times & 0 \\ \times & \times & 0 \\ 0 & 0 & \times \end{pmatrix}, \Pi_2 : \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ \times & \times & 0 \end{pmatrix}, \Sigma_1 : \begin{pmatrix} \times & 0 \\ \times & 0 \\ 0 & \times \end{pmatrix}, \Sigma_2 : \begin{pmatrix} 0 & \times \\ 0 & \times \\ 0 & 0 \end{pmatrix}$$

$$A : \begin{pmatrix} \times & 0 \\ 0 & 0 \end{pmatrix}, \quad B : \begin{pmatrix} 0 & \times \\ \times & 0 \end{pmatrix}, \quad C : \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix},$$

with

$$\begin{aligned} -\mathcal{L}_{\text{Yukawa}} = {} & \overline{q_L^0} \Gamma_a \Phi_a d_R^0 + \overline{q_L^0} \Delta_a \tilde{\Phi}_a u_R^0 + \overline{\ell_L^0} \Pi_a \Phi_a e_R^0 \\ & + \overline{\ell_L^0} \Sigma_a \tilde{\Phi}_a \nu_R + \frac{1}{2} \overline{\nu_R^c} \left(\mathrm{A} + \mathrm{B} S + \mathrm{C} S^* \right) \nu_R + \mathrm{h.c.} \end{aligned}$$

Inverted ordering agreeing better with data

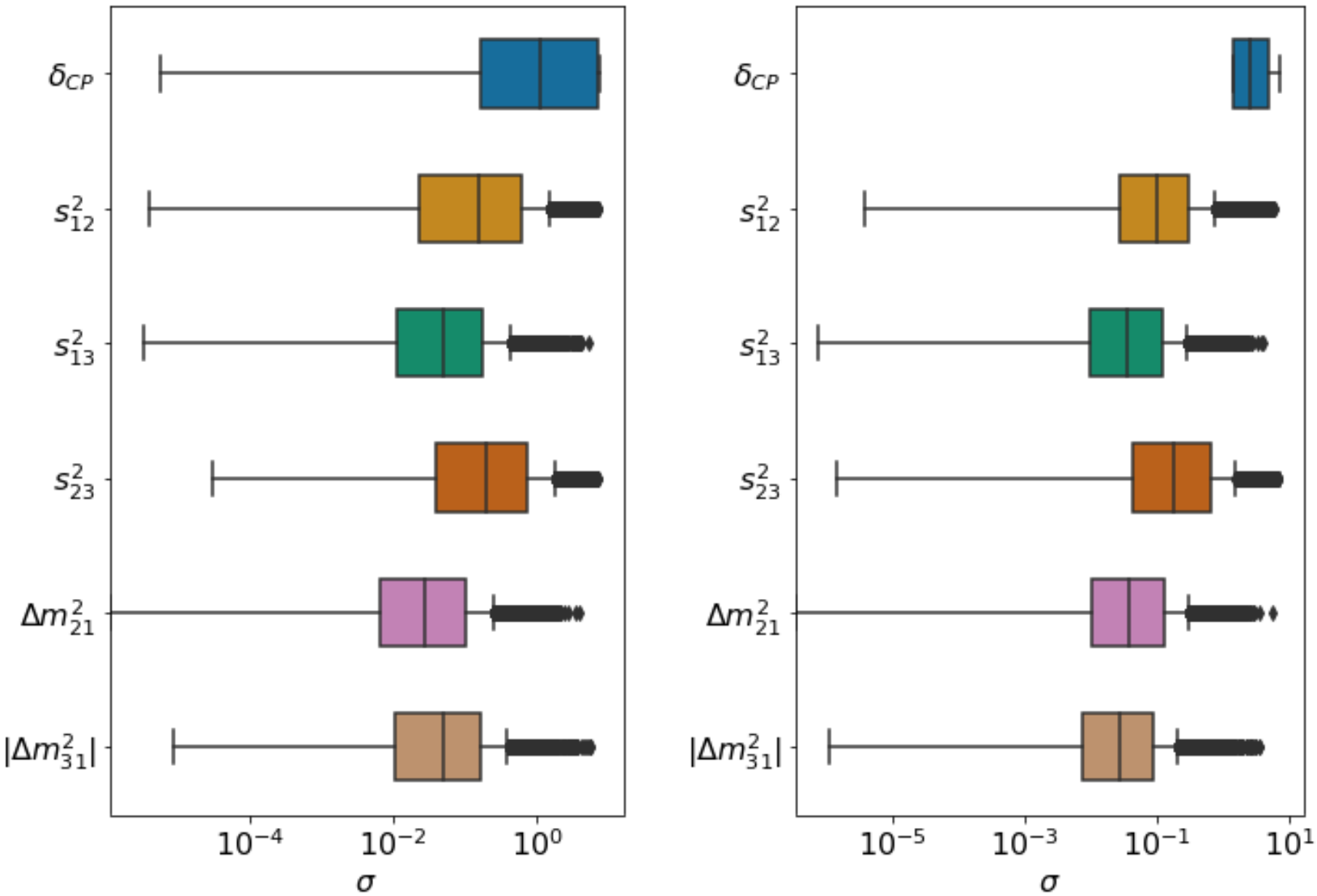

Figure: *Inverted ordering (left) and normal ordering (right)*

Conclusions

- 16 valid models, out of which the majority are previously unexplored
- The previously unexplored models agree equally well with data
- These models deserve further attention

Thank you for listening!