

Zero Higgs Doublet Model

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Work in progress in collaboration with K. Tsumura

Introduction

The minimal Standard Model

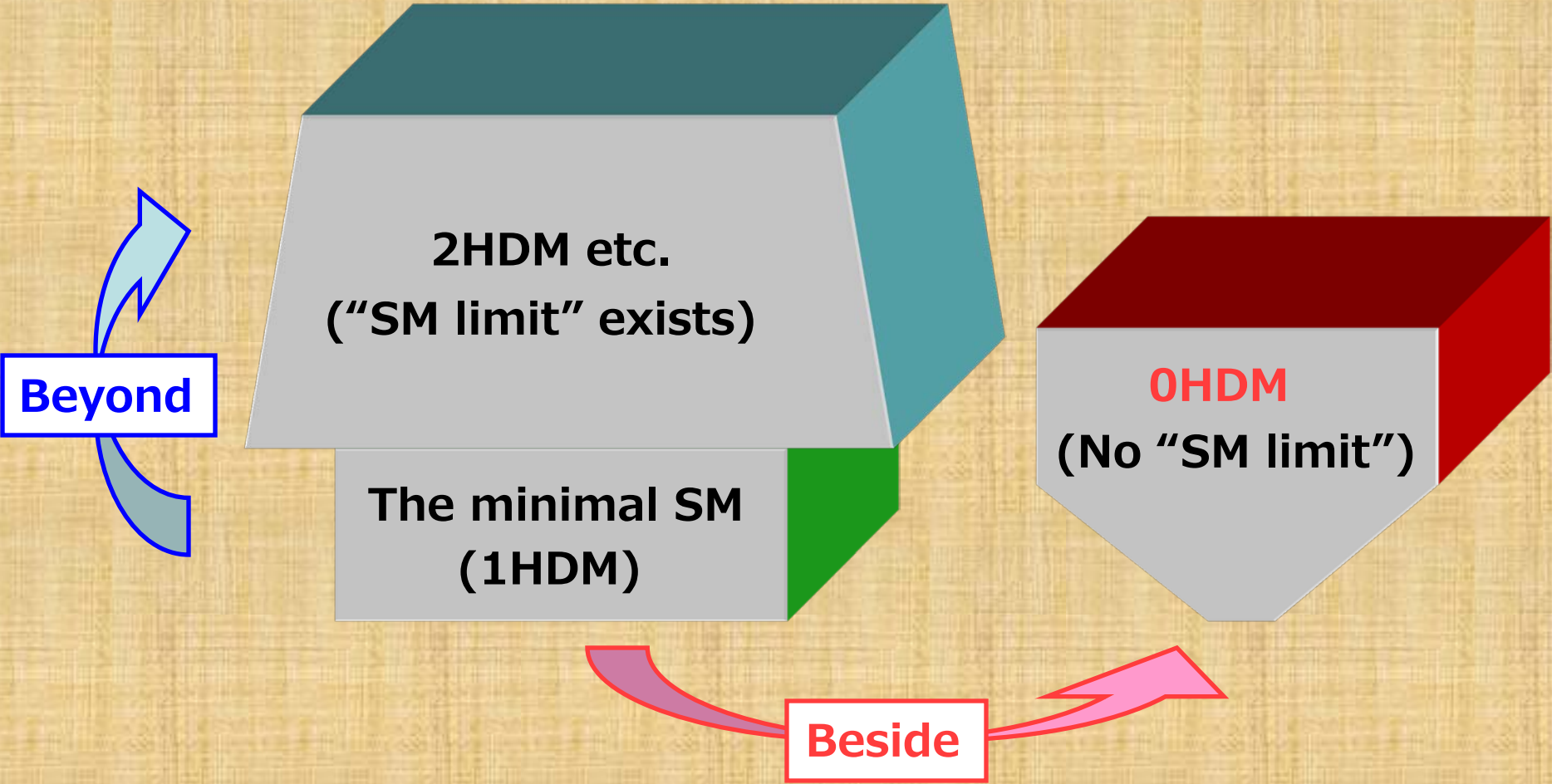
Only a Higgs doublet Φ ← Minimal Higgs sector

Beyond the minimal SM - Non-minimal Higgs sector -

Doublet + Singlet	Gauged $U(1)_{B-L}$
Doublet + Doublet	{ MSSM Two Higgs Doublet Model
Doublet + Triplet	
⋮	

Non-minimal Standard Model ?

~~Doublet~~ + "Higgs fields" ← Zero Higgs Doublet Model



SU(2)_L × U(1)_Y breaking

~~Singlet~~ ← Useless

~~Doublet~~ ← Rule of this game

Triplet ← "The minimal one"

⋮

$\underline{\mathfrak{3}}_0$ or $\underline{\mathfrak{3}}_1$ (\underline{N}_Y : N-plet with hypercharge Y)

Questions

Fermion masses without Higgs doublets ?

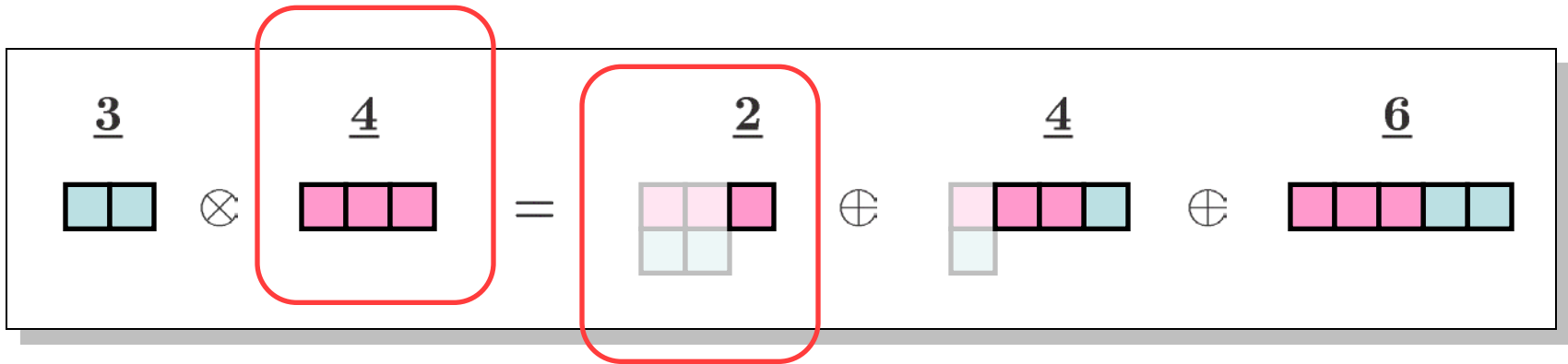
Rho parameter without Higgs doublets ?

LHC results for **Higgs decays** ?

Fermion Masses

“Effective” Higgs doublet

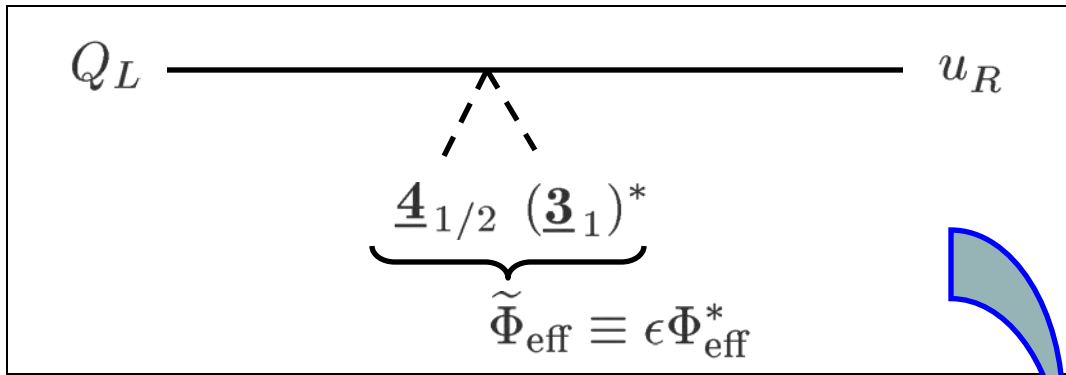
Quadruplet in addition to triplet



Doublet

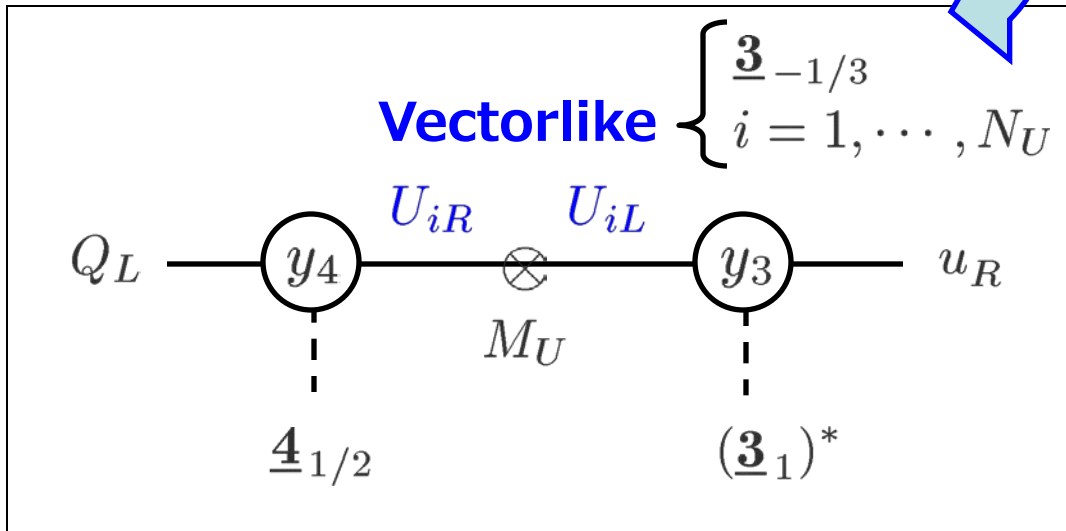
$$\left. \begin{array}{l}
 \underline{\mathbf{3}}_0 \otimes \underline{\mathbf{4}}_{1/2} \\
 \underline{\mathbf{3}}_1 \otimes (\underline{\mathbf{4}}_{1/2})^* \\
 (\underline{\mathbf{3}}_1)^* \otimes \underline{\mathbf{4}}_{3/2}
 \end{array} \right\} \rightarrow \Phi_{\text{eff}} : \underline{\mathbf{2}}_{1/2}$$

“Effective” Yukawa Int.



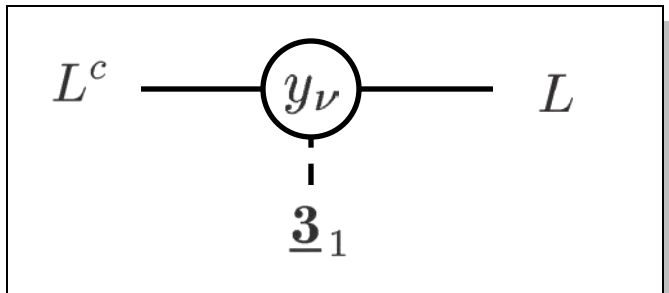
$$(\tilde{\Phi}_{\text{eff}})_i = \epsilon_{ij} (\mathbf{3}_1)^*_{kl} (\mathbf{4}_{1/2})^{jkl}$$

Example of Decomposition



$$m_u = \frac{y_3 y_4 v_3 v_4 N_U}{2M_U}$$

Neutrino mass



$$m_\nu = \sqrt{2} y_\nu v_3$$

(The same as Higgs Triplet Model)

Rho Parameter

“Effective” Higgs doublet

$$\begin{array}{l}
 \underline{\mathbf{3}}_0 \otimes \underline{\mathbf{4}}_{1/2} \\
 \underline{\mathbf{3}}_1 \otimes (\underline{\mathbf{4}}_{1/2})^* \\
 (\underline{\mathbf{3}}_1)^* \otimes \underline{\mathbf{4}}_{3/2}
 \end{array}
 \left. \vphantom{\begin{array}{l} \underline{\mathbf{3}}_0 \\ \underline{\mathbf{3}}_1 \\ (\underline{\mathbf{3}}_1)^* \end{array}} \right\} \Phi_{\text{eff}} : \underline{\mathbf{2}}_{1/2}$$

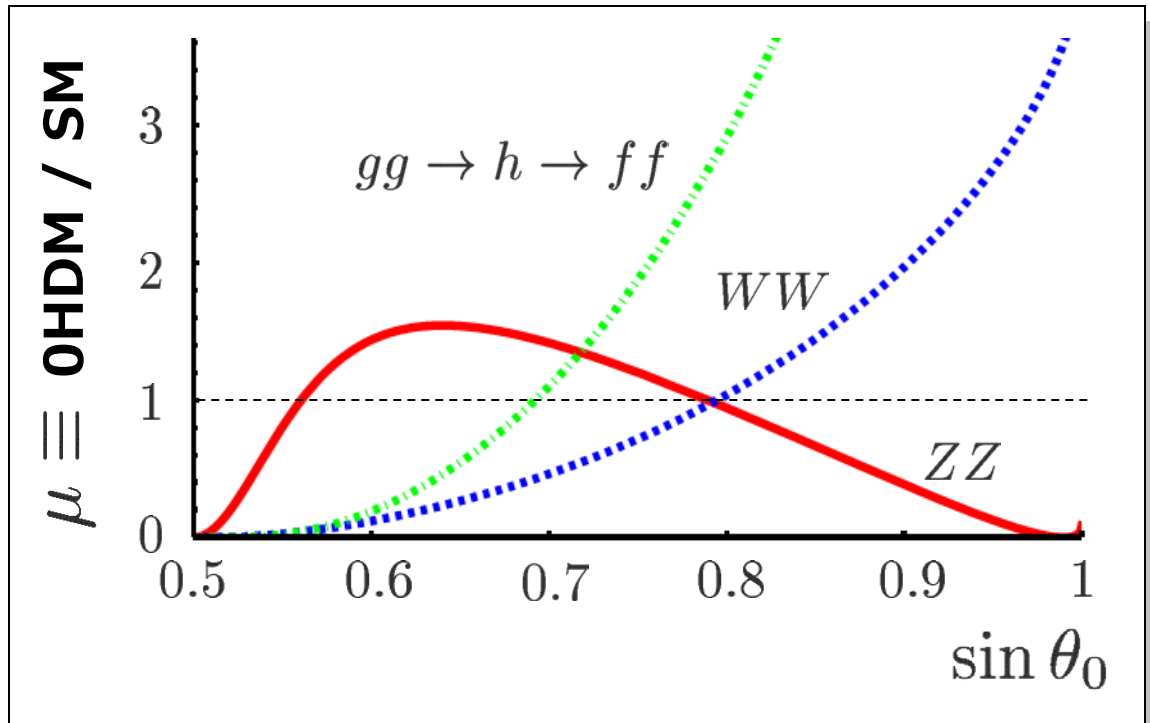
Rho parameter

$$\rho = \frac{m_W^2}{c_W^2 m_Z^2}$$

Experiment : $\rho \simeq 1$

$$\begin{array}{l}
 \underline{\mathbf{3}}_0 \otimes \underline{\mathbf{4}}_{1/2} \longrightarrow \rho \geq 7 \\
 \underline{\mathbf{3}}_1 \otimes (\underline{\mathbf{4}}_{1/2})^* \longrightarrow \rho = 1 \text{ for } v_3 = \sqrt{3} v_4 \\
 (\underline{\mathbf{3}}_1)^* \otimes \underline{\mathbf{4}}_{3/2} \longrightarrow \rho \leq 1/2
 \end{array}
 \left\{ \begin{array}{l} v_3 \simeq 118 \text{ GeV} \\ v_4 \simeq 68 \text{ GeV} \end{array} \right.$$

Higgs Decays



is possible although $\rho = 1$

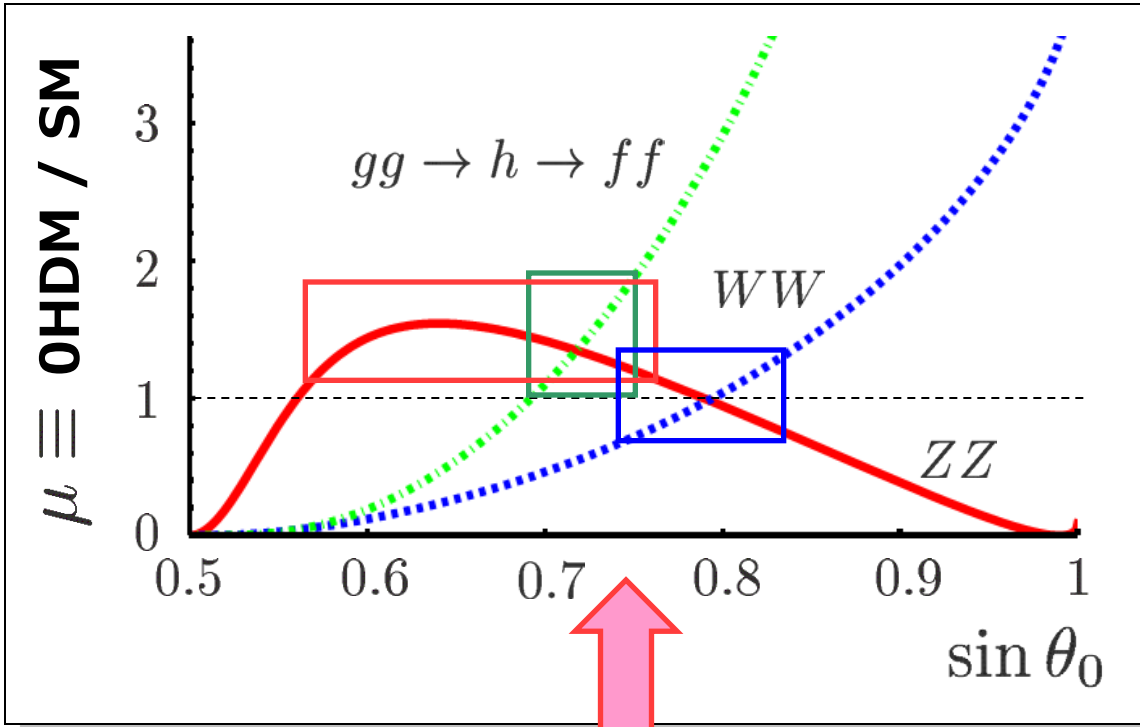
Characteristic feature in OHDM

**Mixing angle
for CP-even scalars**

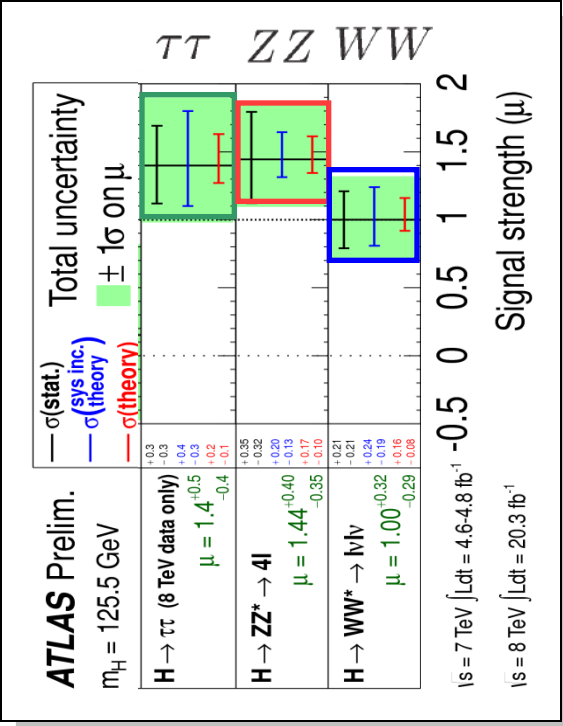
$$\sin \theta_0 = 1$$

$$\Rightarrow h = \sqrt{2} \text{Re}[(\underline{4})^0]$$

Higgs Decays



$\sin \theta_0 \simeq 0.75$ explains data



ATLAS-CONF-2014-009

Summary



Minimal Zero Higgs Doublet Model (0HDM)

$$\underline{\mathbf{3}}_1 \otimes (\underline{\mathbf{4}}_{1/2})^* \longrightarrow \Phi_{\text{eff}} : \underline{\mathbf{2}}_{1/2}$$

No limit to the minimal SM (1HDM)

Fermion masses

$$\rho = 1 \quad \text{for} \quad v_3 = \sqrt{3} v_4$$

Consistent with $gg \rightarrow h \rightarrow \tau\tau, WW, ZZ$



If experiments show $\mu_{WW} \neq \mu_{ZZ} \Rightarrow$ **This model ?**
 $(\mu_{WW} < \mu_{ZZ})$

Doublet or Doubt ?