Viability of Minimal Neutrinophilic two-Higgs-Doublet Models
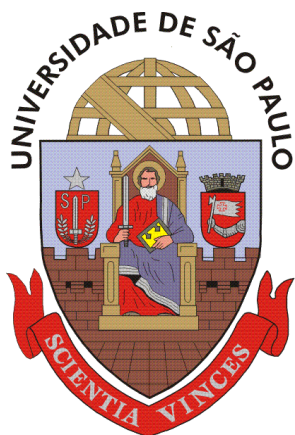
Yuber F Perez G*

Instituto de Física, Universidade de São Paulo, Brasil

Neutrinophilic two-Higgs-doublets Models (ν2HDM)

Neutrinophilic two-Higgs-doublets Models (v2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

Neutrinophilic two-Higgs-doublets Models (v2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

⬇

See-saw

Neutrinophilic two-Higgs-doublets Models (ν2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

See-saw ⟶ Majorana neutrinos

Neutrinophilic two-Higgs-doublets Models (v2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

⬇

2HDM?

Neutrinophilic two-Higgs-doublets Models (ν2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

$\downarrow$

2HDM? $\longrightarrow$ Majorana or Dirac neutrinos

Neutrinophilic two-Higgs-doublets Models (ν2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

⬇

2HDM? ➡ Majorana or Dirac neutrinos

- Second Higgs Doublet $\quad\quad \Phi_2 \quad\quad (1,2)_{+\frac{1}{2}}$

Neutrinophilic two-Higgs-doublets Models (v2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

$\downarrow$

2HDM? $\longrightarrow$ Majorana or Dirac neutrinos

- Second Higgs Doublet $\qquad \Phi_2 \qquad (1,2)_{+\frac{1}{2}} \qquad\qquad \mathcal{O}(\langle \Phi_2 \rangle) \sim [\mathrm{eV}]$

Neutrinophilic two-Higgs-doublets Models (ν2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

$\downarrow$

2HDM? $\longrightarrow$ Majorana or Dirac neutrinos

- Second Higgs Doublet $\qquad \Phi_2 \qquad (1,2)_{+\frac{1}{2}} \qquad\qquad \mathcal{O}(\langle \Phi_2 \rangle) \sim [\mathrm{eV}]$

- Right-handed neutrinos $\qquad \nu_R \qquad (1,1)_0$

Neutrinophilic two-Higgs-doublets Models (v2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

$\downarrow$

2HDM? $\longrightarrow$ Majorana or Dirac neutrinos

- Second Higgs Doublet $\qquad \Phi_2 \qquad (1,2)_{+\frac{1}{2}} \qquad\qquad \mathcal{O}(\langle \Phi_2 \rangle) \sim [\mathrm{eV}]$

- Right-handed neutrinos $\qquad \nu_R \qquad (1,1)_0$

$$-\mathcal{L}_{\mathrm{Y}} = \bar{e}_R Y_E \Phi_1 \ell_L + \boxed{\bar{\nu}_R Y_N \tilde{\Phi}_2 \ell_L} + \bar{e}_R Y_{2E} \Phi_2 \ell_L + \bar{\nu}_R Y_{1N} \tilde{\Phi}_1 \ell_L$$

Neutrinophilic two-Higgs-doublets Models (v2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

$$\Downarrow$$

2HDM? $\Longrightarrow$ Majorana or Dirac neutrinos

- Second Higgs Doublet $\qquad \Phi_2 \qquad (1,2)_{+\frac{1}{2}} \qquad\qquad \mathcal{O}(\langle\Phi_2\rangle) \sim [\mathrm{eV}]$

- Right-handed neutrinos $\qquad \nu_R \qquad (1,1)_0$

$$-\mathcal{L}_Y = \bar{e}_R Y_E \Phi_1 \ell_L + \bar{\nu}_R Y_N \tilde{\Phi}_2 \ell_L \boxed{+\, \bar{e}_R Y_{2E} \Phi_2 \ell_L + \bar{\nu}_R Y_{1N} \tilde{\Phi}_1 \ell_L} \longrightarrow \boxed{\text{Unwanted terms}}$$

Neutrinophilic two-Higgs-doublets Models (ν2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

$\downarrow$

2HDM? $\longrightarrow$ Majorana or Dirac neutrinos

- Second Higgs Doublet $\qquad \Phi_2 \qquad (1,2)_{+\frac{1}{2}} \qquad\qquad \mathcal{O}(\langle\Phi_2\rangle) \sim [\mathrm{eV}]$

- Right-handed neutrinos $\qquad \nu_R \qquad (1,1)_0$

$$-\mathcal{L}_{\mathrm{Y}} = \overline{e}_R Y_E \Phi_1 \ell_L + \overline{\nu}_R Y_N \tilde{\Phi}_2 \ell_L$$

Neutrinophilic two-Higgs-doublets Models (ν2HDM)

Is it possible to explain the smallness of the neutrino masses without having small Yukawas?

$$\downarrow$$

2HDM? $\longrightarrow$ Majorana or Dirac neutrinos

- ## Second Higgs Doublet $\qquad \Phi_2 \qquad (1,2)_{+\frac{1}{2}} \qquad\qquad \mathcal{O}(\langle\Phi_2\rangle) \sim [\text{eV}]$

- ## Right-handed neutrinos $\qquad \nu_R \qquad (1,1)_0$

$$-\mathcal{L}_{\text{Y}} = \bar{e}_R Y_E \Phi_1 \ell_L + \bar{\nu}_R Y_N \tilde{\Phi}_2 \ell_L$$

$\mathbb{Z}_2$ scenario
Gabriel-Nandi [ArXiv:hep-ph/0610253]

U(1) scenario
Davidson-Logan [ArXiv:hep-ph/0906.3335]

Scalar spectrum $h, H, A, H^{\pm}$

Scalar spectrum $h, H, A, H^\pm$

$\mathbb{Z}_2$ scenario

H $\longrightarrow$ LHC particle ≈ SM Higgs Boson

$m_h \sim \mathcal{O}(v_2) \ll v$
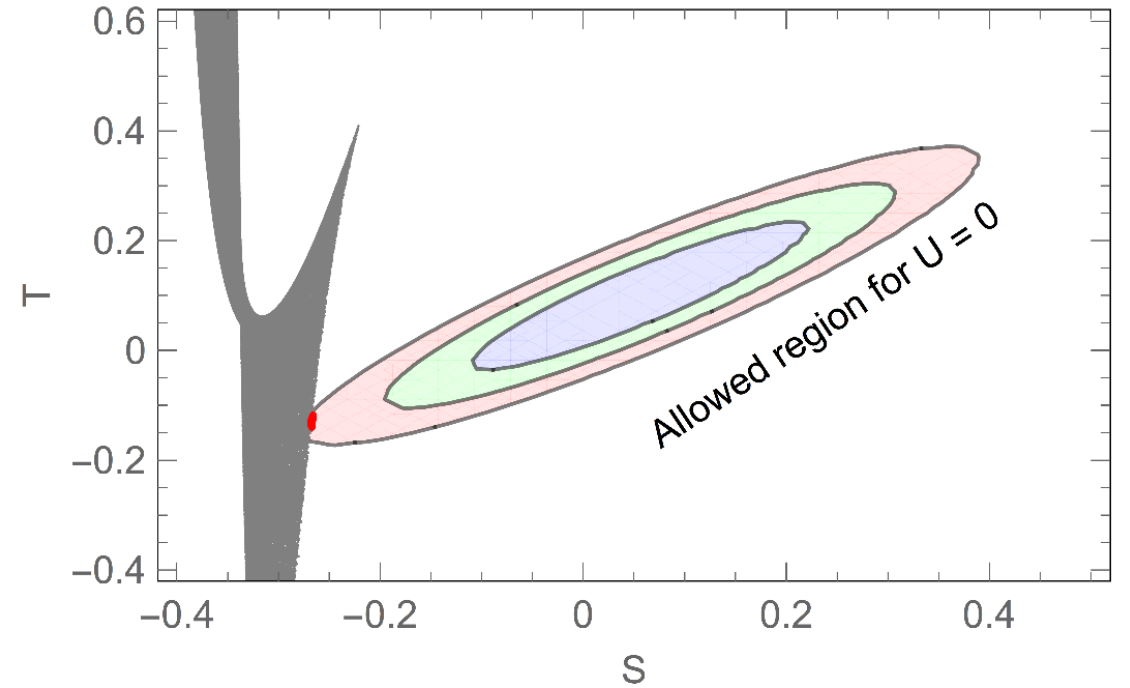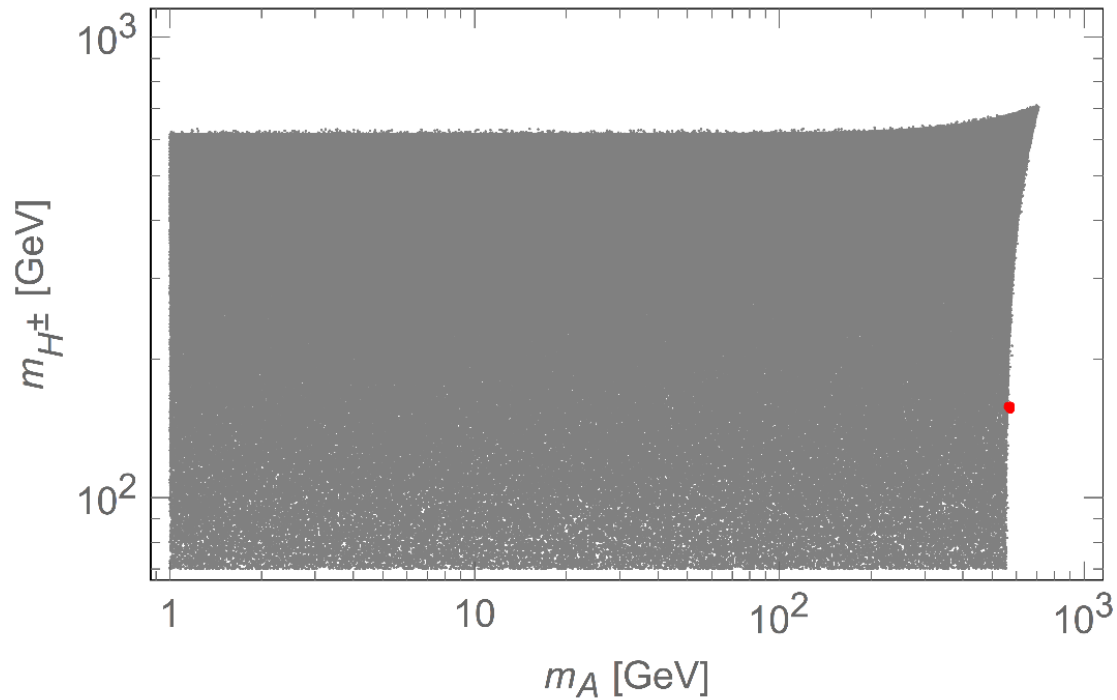
$m_{H^\pm} \sim m_A \gtrsim v$

U(1) scenario

H $\longrightarrow$ LHC particle ≈ SM Higgs Boson

$m_h \approx m_A \sim \mathcal{O}[\mathrm{GeV}]$

Scalar spectrum $h, H, A, H^{\pm}$

$\mathbb{Z}_2$ scenario

H ⟶ LHC particle ≈ SM Higgs Boson

$m_h \sim \mathcal{O}(v_2) \ll v$

$m_{H^\pm} \sim m_A \gtrsim v$

U(1) scenario

H ⟶ LHC particle ≈ SM Higgs Boson

$m_h \approx m_A \sim \mathcal{O}[\text{GeV}]$

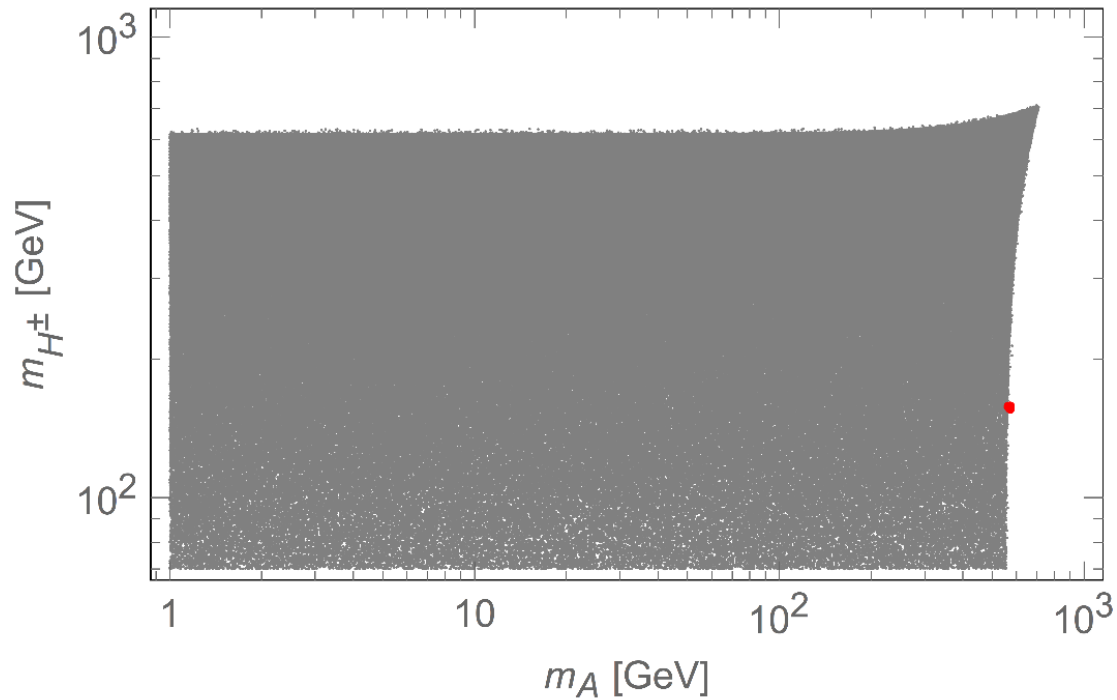We studied theoretical and phenomenological constrains to these minimal models.
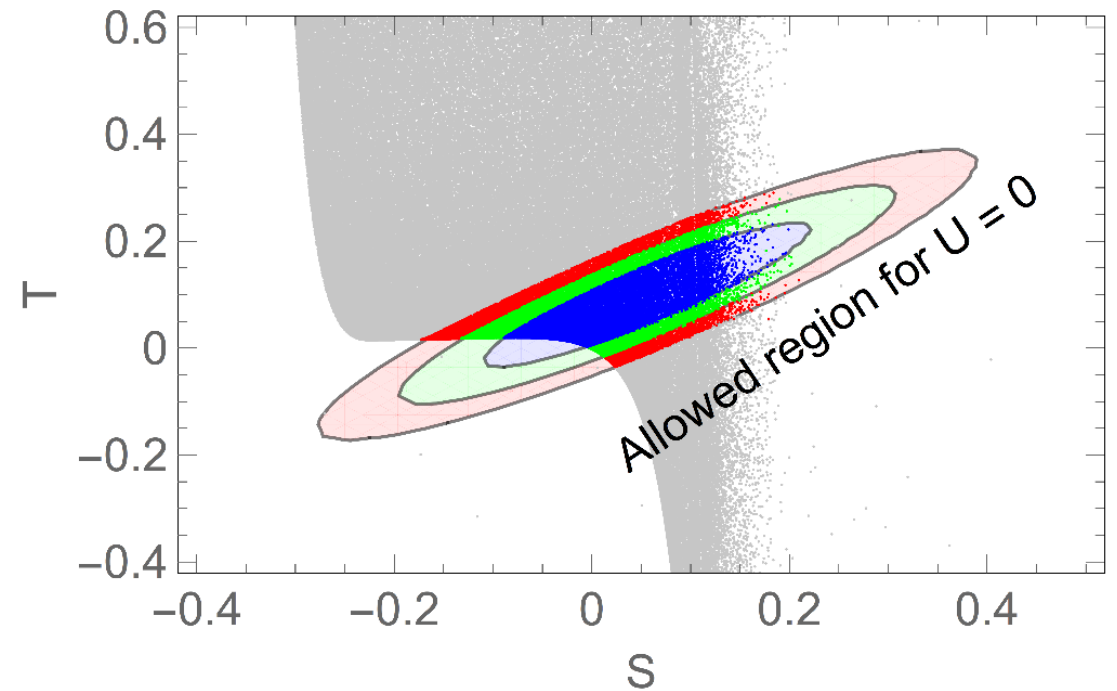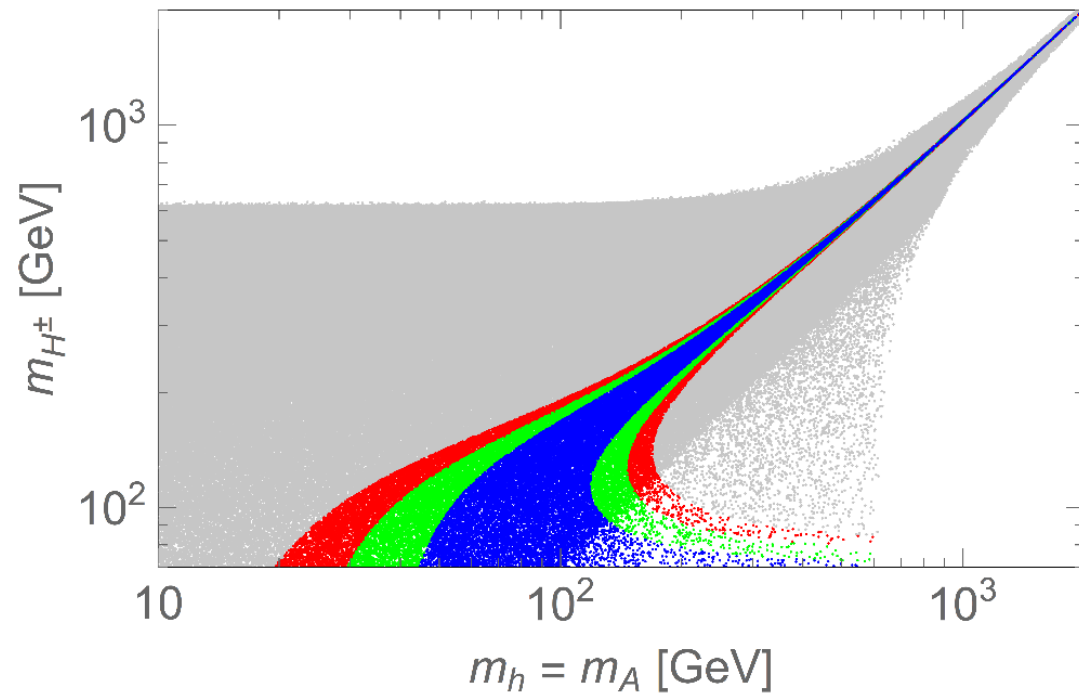
Results for $\mathbb{Z}_2$

Results for $\mathbb{Z}_2$

Gray points allowed by theoretical constrains; blue, green red points allowed by S,T,U at 1σ, 2σ, 3σ, respectively.

Results for $\mathbb{Z}_2$
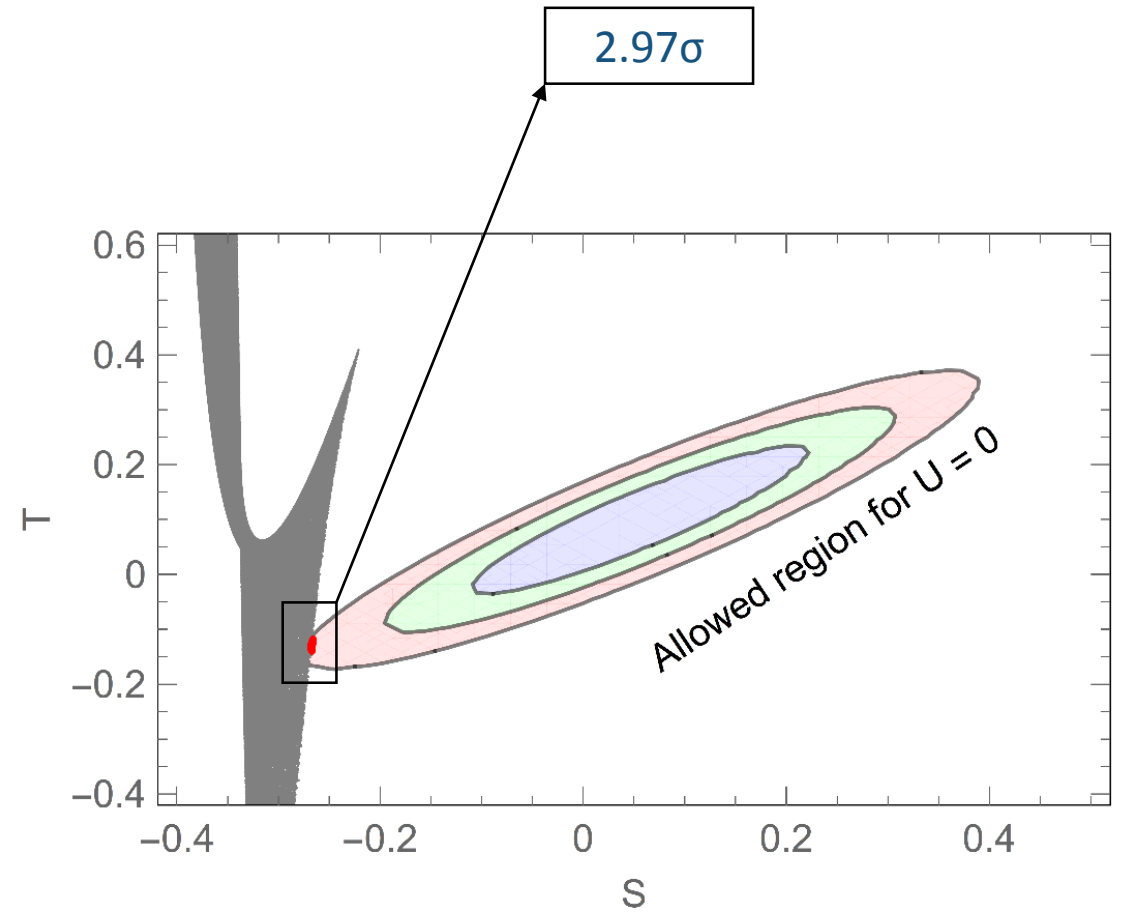
Gray points allowed by theoretical constrains; blue, green red points allowed by S,T,U at 1σ, 2σ, 3σ, respectively.

Results for U(1)

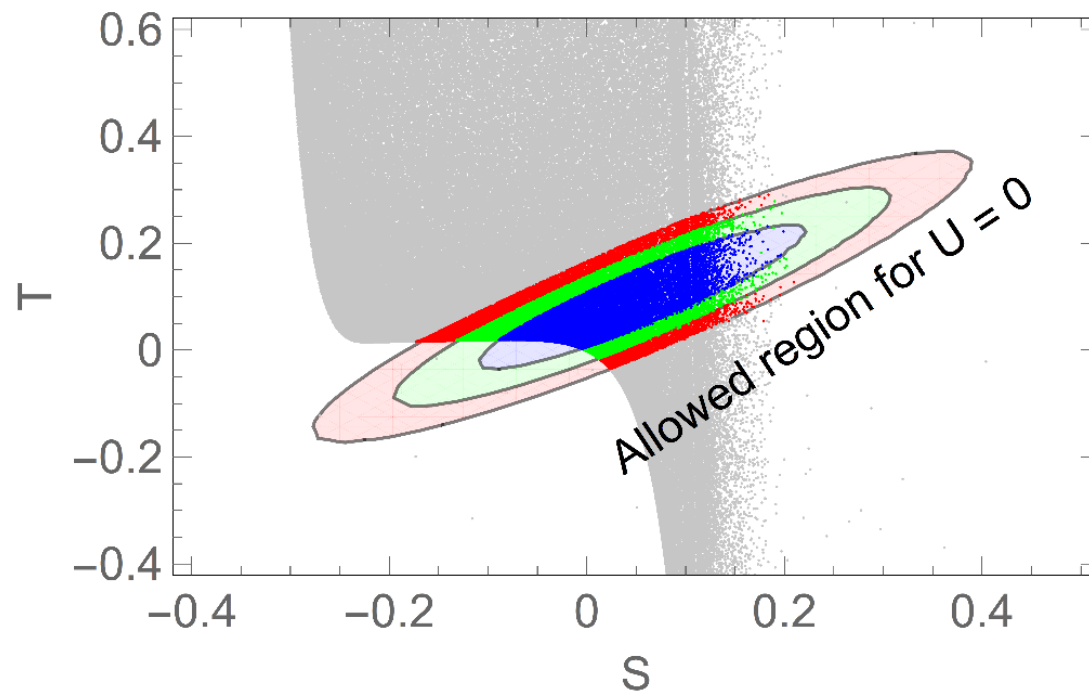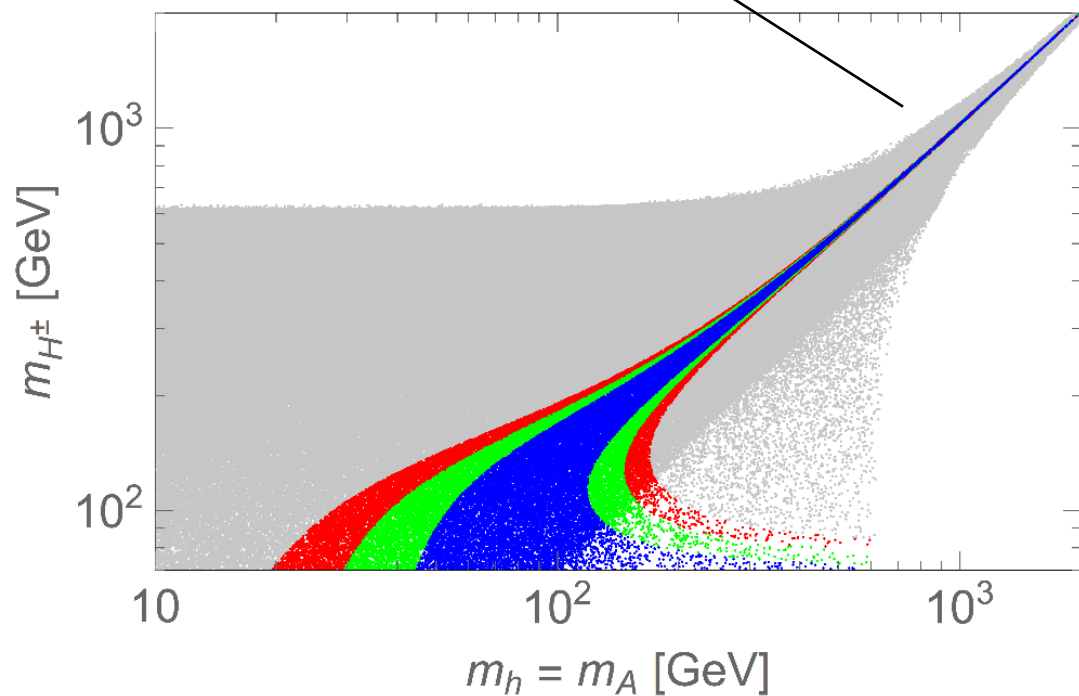# Results for U(1)

Gray points allowed by theoretical constrains; blue, green red points allowed by S,T,U at 1σ, 2σ, 3σ, respectively.

Results for U(1)

Degenerated spectrum

Gray points allowed by theoretical constrains; blue, green red points allowed by S,T,U at 1σ, 2σ, 3σ, respectively.

Conclusions

- The $\mathbb{Z}_2$ model is excluded by EWPT.

- The U(1) model is allowed but the spectrum is quite constrained.

- In any case, neutrinophilic 2HDM can have rich signatures at LHC.

Thanks for your attention! For more details, come
to see my Poster today!