The signal strengths of CP-odd spin zero states in the Model of Electroweak-scale Right-handed Neutrinos at the LHC

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(Nucl. Phys. B,877 190, and arXiv:1412.0343)

Pheno 2015
University of Pittsburgh

May 5, 2015

Outline

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- A large parameter space satisfies the Electroweak precision measurements
- The $125 - GeV$ SM-like Higgs boson can be accommodated into the model in two very different scenarios
- The signal strengths of CP-odd spin zero states are at the same order or below the upper limits of ATLAS/CMS

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- Dirac mass:

$$\mathcal{L}_S = g_{sl} \bar{l}_l \phi_S l_R^M + h.c.$$

$$\phi_S(1, \frac{Y}{2} = 0)$$

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- The highest scale of the EWν_R model is Λ_{EW}.

In the scalar sector.

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  - H_1^0 couple to both SM and mirror fermions so:

$$\frac{\sigma(gg \to H_1^0)}{\sigma(gg \to H_{SM})} \approx \frac{|\sum_Q F(\tau_Q)|^2}{|F(\tau_{top})|^2} \approx \frac{7^2}{cos^2\theta_H}$$

$\Rightarrow$ Can't compensated by branching ratios.

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  - $\phi_S \rightarrow e^{-i(\alpha_{MF}-\alpha_{SM})}\phi_S$
  - All other fields are singlets under $U(1)_{SM} \times U(1)_{MF}$

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  Both give signal strengths well within 1σ region.
- There are two neutral pseudo-scalars in the model, H_3^0, H_{3M}^0.

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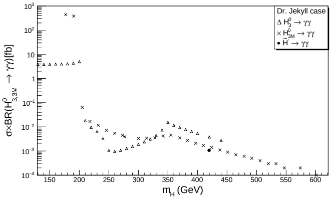

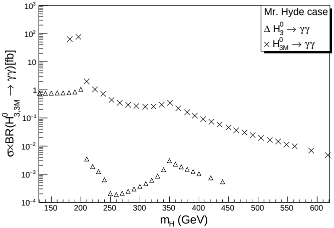

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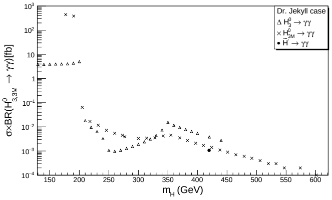

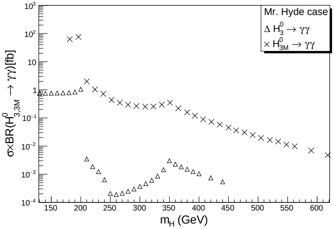

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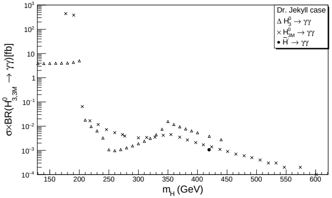

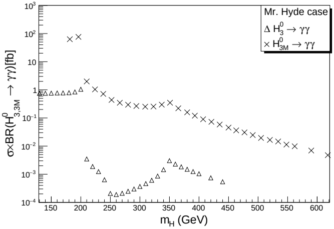

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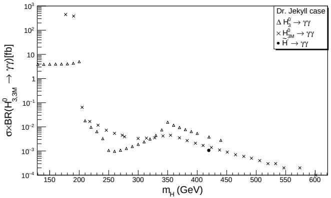

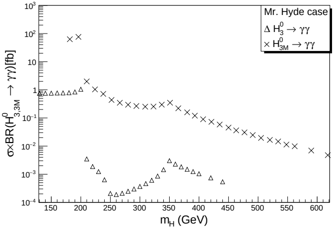

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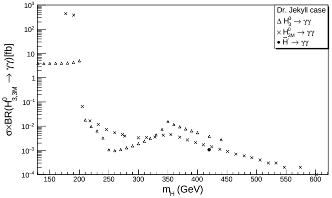

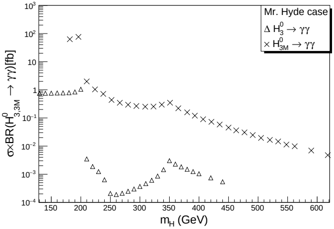

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- As $m_{H^0_3}$ increasing, The total width of $H^0_{3,3M}$ increases. So both signal strengths are below the limit.

$\sigma(gg \to H^0_{3,3M}) \times BR(H_{3,3M} \to \tau\tau)$

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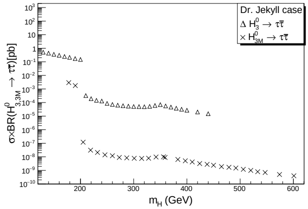

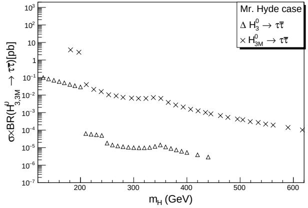

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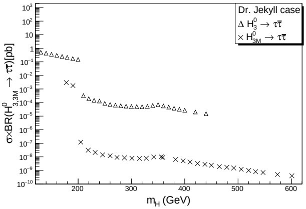

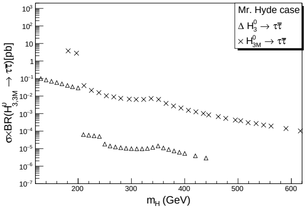

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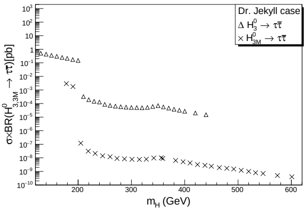

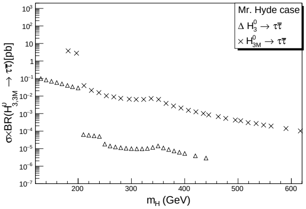

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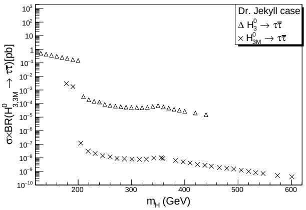

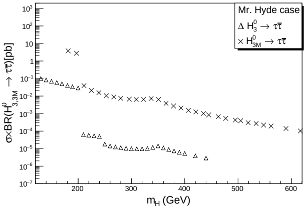

- In both cases, the signal strength can exceed the upper limit from ATLAS and CMS before the thresholds of mirror fermions, here is 204 GeV.
- After passing the first threshold, the signal strengths of both $H_{3,3M} \to \tau\bar{\tau}$ decrease rapidly. And the signal strengths of both $H_{3,3M}$ are well below the upper limits.

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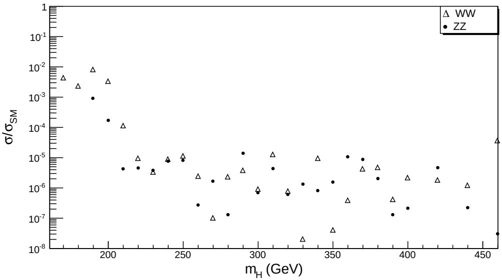
- Here we plot the ratio of signal strength H_3^0 vs H_{SM}:

$$\sigma/\sigma_{SM} = \frac{\Gamma(H_3^0 \to gg)Br(H_3^0 \to WW/ZZ)}{\Gamma(H_{SM} \to gg)Br(H_{SM} \to WW/ZZ)}$$



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- We also put a "rough" limit on the mass range of the pseudo scalars, $H^0_{3,3M}$, in certain parameter spaces.

Thank You!!!

Two strange case of Dr. Jekyll and Mr. Hyde

We consider two example corresponding to the dual nature of the 125 *GeV* Higgs impostor.

- When H_1^0 is dominant in $\tilde{H}_1^0$ (*Dr. Jekyll*) $m_{q_1^M} = m_{q_2^M} = m_{l^M} = 102\ GeV; m_{\nu_R} = 50\ GeV; m_{q_3^M} = 120\ GeV; sin\theta_2 = 0.92; sin\theta_M = 0.36, sin\theta_{2M} = 0.16.$

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- In analogy to previous comparisons, we define a ratio of signal strength:
  $\mu^l = \frac{\sigma(gg \to H_3^0) Br\left(H_3^0 \to \bar{l}^M l^M\right) Br\left(l^M \to l\phi_S\right)}{\sigma(gg \to H_{sm}) Br(H \to W^+W^-) Br(W \to l\nu)}$

$(H_3^0 \to \bar{l}^M l^M)/(H_{sm} \to WW)$

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- We can set an upper limit $\mu^l(H_3^0 \to \bar{l}\phi_S l\phi_S^*) \leq 1$. Consequently, $g_{sl} \leq 10^{-3}$.

Mixing states

$$
\begin{aligned}
v &= \sqrt{v_2^2 + v_{2M}^2 + 8 v_M^2} \\
s_2 &= \frac{v_2}{v}\,,\ s_{2M} = \frac{v_{2M}}{v}\,,\ s_M = \frac{2\sqrt{2}\ v_M}{v}\,, \\
c_2 &= \frac{\sqrt{v_{2M}^2 + 8 v_M^2}}{v}\,,\ c_{2M} = \frac{\sqrt{v_2^2 + 8 v_M^2}}{v}\,, \\
c_M &= \frac{\sqrt{v_2^2 + v_{2M}^2}}{v}\,.
\end{aligned}
\tag{1}
$$

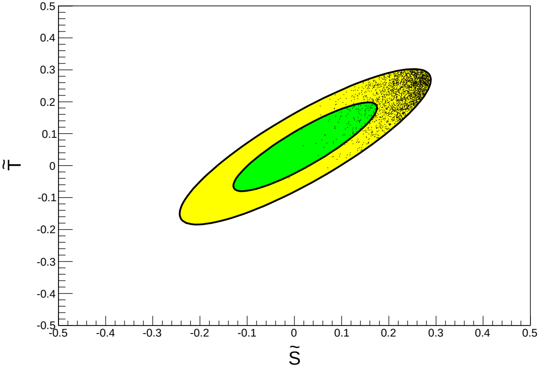
Mixing states

$$\phi_2^0 \equiv \frac{1}{\sqrt{2}}\left(v_2 + \phi_2^{0r} + \imath\phi_2^{0\imath}\right),$$
$$\phi_{2M}^0 \equiv \frac{1}{\sqrt{2}}\left(v_{2M} + \phi_{2M}^{0r} + \imath\phi_{2M}^{0\imath}\right),$$
$$\chi^0 \equiv v_M + \frac{1}{\sqrt{2}}\left(\chi^{0r} + \imath\chi^{0\imath}\right);$$
$$\psi^\pm \equiv \frac{1}{\sqrt{2}}\left(\chi^\pm + \xi^\pm\right), \quad \zeta^\pm \equiv \frac{1}{\sqrt{2}}\left(\chi^\pm - \xi^\pm\right) \tag{2}$$

Mixing states

$$
\begin{aligned}
H_5^{++} &= \chi^{++},\ H_5^{+} = \zeta^{+},\ H_5^0 = \frac{1}{\sqrt{6}}\left(2\xi^0 - \sqrt{2}\chi^{0r}\right), \\
H_3^{+} &= -\frac{s_2 s_M}{c_M}\phi_2^{+} - \frac{s_{2M} s_M}{c_M}\phi_{2M}^{+} + c_M\psi^{+}, \\
H_3^{0} &= \imath\left(\frac{s_2 s_M}{c_M}\phi_2^{0i} + \frac{s_{2M} s_M}{c_M}\phi_{2M}^{0i} + c_M\chi^{0i}\right), \\
H_{3M}^{+} &= -\frac{s_{2M}}{c_M}\phi_2^{+} + \frac{s_2}{c_M}\phi_{2M}^{+}, \\
H_{3M}^{0} &= \imath\left(-\frac{s_{2M}}{c_M}\phi_2^{0i} + \frac{s_2}{c_M}\phi_{2M}^{0i}\right), \\
H_1^0 &= \phi_2^{0r},\ H_{1M}^0 = \phi_{2M}^{0r}, \\
H_1^{0\prime} &= \frac{1}{\sqrt{3}}\left(\sqrt{2}\chi^{0r} + \xi^0\right)
\end{aligned}
\qquad (3)
$$

ST


0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
$\tilde{T}$
-0.5
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
$\tilde{S}$

$$\rho = \frac{\sum [T(T+1) - T_3^2]_i v_i^2 c_{T,Y}}{2 \sum T_{3i}^2 v_i^2}$$

$c_{T,Y} = 1$ for complex multiplet.
$c_{T,Y} = 1/2$ for real multiplet.
One complex triplet will give $\rho = 1/2$.
Any complex doublet will give $\rho = 1$.