Constraints on the phenomenological MSSM from the LHC Higgs Results

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in collaboration with A Arbey, A Djouadi and F Mahmoudi
pMSSM Scans

R-parity conservation;
real soft SUSY breaking parameters;
diagonal sfermion mass matrices and trilinear coupling matrices;
universal first and second generation sfermions;
neutralino LSP;

19 parameters flat scans

\[
1 \leq \tan \beta \leq 60,
50 \text{ GeV} \leq M_A \leq 3 \text{ TeV},
-10 \text{ TeV} \leq A_f \leq 10 \text{ TeV},
50 \text{ GeV} \leq m_{\tilde{f}_L}, m_{\tilde{f}_R}, M_3 \leq 3.5 \text{ TeV},
50 \text{ GeV} \leq M_1, M_2, |\mu| \leq 2.5 \text{ TeV}
\]
Higgs Mass in the MSSM

One loop SUSY corrections to $M_h$

\[ \frac{3 \, \bar{m}_t^4}{2 \pi^2 v^2 \sin^2 \beta} \left[ \log \frac{M_S^2}{\bar{m}_t^2} + \frac{X_t^2}{2 \, M_S^2} \left( 1 - \frac{X_t^2}{6 \, M_S^2} \right) \right] \]
\( \mu_{XX} = \frac{\sigma(h) \times BR(h \rightarrow XX)}{\sigma(H_{SM}) \times BR(H_{SM} \rightarrow XX)} \)

Constraints

Limits from Z lineshape, LEP-2 and Tevatron searches, LHC searches: jets + MET (CMS), leptons + MET, b-jets + MET (ATLAS)

\[
\text{BR}(B^0_s \rightarrow \mu^+\mu^-) = (3.2^{+1.5}_{-1.2}) \times 10^{-9}
\]

\[
10^{-4} < \Omega_\chi h^2 < 0.155
\]

\[
123 \text{ GeV} \leq M_h \leq 129 \text{ GeV}
\]
H/A → ττ
$B^0_s \to \mu\mu$

$\mu A_t \frac{\tan^3 \beta}{(1 + \epsilon_b \tan \beta)^2} \frac{m_t^2}{m^2_t} \frac{m_b m_\mu}{4 s_w^2 M_W^2 M_A^2}$


Arbey, MB, Mahmoudi, EPJC 72 (2012) 1906
Direct DM Searches

\[ \tilde{\chi}_1^0 \rightarrow \tilde{\chi}_1^0 \]

\[ h^0, H^0 \]

\[ q \rightarrow q \]
SUSY Effects to Higgs Rates

Modification of Higgs width through bb suppression/enhancement

$$\Delta_b \approx \mu \tan \beta.$$  

Vanishing coupling regime

$$g_{hbb} \approx 1 - \Delta_b / (\tan \alpha_{\text{eff}} \tan \beta)$$

Chargino contribution to $h \rightarrow \gamma\gamma$

Stau contribution to $h \rightarrow \gamma\gamma$

$m_{\tau}^2 X_{\tau}^2 / m_{\tau_1}^2 m_{\tau_2}^2$

Arbey, MB, Djouadi, Mahmoudi, JHEP 1209 (2012) 107
Statistical analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>$M_h$</td>
<td>126±2 GeV</td>
</tr>
<tr>
<td>$\mu_{\gamma\gamma}$</td>
<td>1.66±0.33</td>
</tr>
<tr>
<td>$\mu_{ZZ}$</td>
<td>0.93±0.28</td>
</tr>
<tr>
<td>$\mu_{WW}$</td>
<td>0.85±0.23</td>
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<tr>
<td>$\mu_{b\bar{b}}$</td>
<td>1.28 ± 0.45</td>
</tr>
<tr>
<td>$\mu_{\tau\tau}$</td>
<td>0.71 ± 0.42</td>
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$$\chi^2 = \frac{(M_h(LHC) - M_h(i))^2}{\delta^2[M_h(LHC)] + \delta^2[M_h(th)]} + \sum_j \frac{(\mu_j(LHC) - \mu_j(i))^2}{\delta^2[\mu_j(LHC)] + \delta^2[\mu_j(th)]}$$

Higgs Data @ 90% C.L.  25%
Higgs Data @ 68% C.L.  5.5%
Higgs Data @ 68% C.L. (no syst.)  0.3%
$[M_A, \tan \beta]$
$[X_i, M_i] \ (i = t, b, \tau)$

$\left[ M_1, \mu \right]$ 

$\left[ M_2, \mu \right]$
### ICHEP 2012

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<tr>
<td>$M_H$</td>
<td>125.7±2.1 GeV</td>
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<td>$\mu_{\gamma\gamma}$</td>
<td>1.66±0.33</td>
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<tr>
<td>$\mu_{ZZ}$</td>
<td>0.99±0.38</td>
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<td>0.95±0.35</td>
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<tr>
<td>$\mu_{b\bar{b}}$</td>
<td>&lt;1.64 (95% C.L.)</td>
</tr>
<tr>
<td>$\mu_{\tau\tau}$</td>
<td>&lt;1.06 (95% C.L.)</td>
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### HCP 2012

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Arbey, MB, Djouadi, Mahmoudi, JHEP 1209 (2012) 107
Higgs Results and Direct DM Searches

XENON 100 - 225 live days limit coverage of accepted pMSSM points

All accepted 28%
Higgs Data @ 90% C.L. 24%
Higgs Data @ 68% C.L. 15%
What have we learned so far?

Higgs mass and signal strengths provide significant constraints on SUSY parameters if we interpret 126 GeV signal as lightest SUSY h state;

Data on μ values not settled yet, discrepancies between experiments cover range of SUSY effects;

Possible enhancement of γγ rate interesting for its implications on Γ_h and/or chargino/stau contributions;

Data on bb and ττ channels essential for constraining width and understanding origin of (possible) enhancements;

Present data support SUSY in decoupling regime with heavy pseudo-scalar A^0, confirmed by limits of direct H/A → ττ searches;

Important interplay of Higgs results with flavour physics (B_s → μμ) and dark matter direct detection experiments.
any thanks for the hospitality!