A More General MSSM Parameter Scan

### Table 1: Ranges of SUSY parameters at the electroweak scale used for independent benchmarks

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_{0}$</td>
<td>$0 - 2000$ GeV</td>
</tr>
<tr>
<td>$m_{A}$</td>
<td>$0 - 2000$ GeV</td>
</tr>
<tr>
<td>$m_{h}$</td>
<td>$0 - 2000$ GeV</td>
</tr>
<tr>
<td>$A_{0}$</td>
<td>$0 - 2000$ GeV</td>
</tr>
<tr>
<td>$\tan \beta$</td>
<td>$0 - 2000$</td>
</tr>
</tbody>
</table>

For some parameter combinations, the branching ratio into a pair of neutralinos is forbidden, and by $\Delta \epsilon /\Lambda$, for small $\tan \beta$, $m_{h}$ is given in $\text{GeV}$. The MSSM contributions are considered, and the experimental limits on Higgs bosons are also used.

The calculations are performed with the full diagrammatic calculations (FDC) approach, which account for all radiative corrections. The benchmark scan of section 8.3 is extended, and the following constraints have been considered:

- Confining and neutralino mass limits from direct searches.
- Additional contributions from supersymmetric particles and Higgs bosons.
- The ratio of the Higgs boson decays.
- The following constraints have also been considered:
  - Additional constraints from supersymmetric particles and Higgs bosons.
  - The rate of the Higgs boson decays.
  - The experimental limits on Higgs bosons.
  - The MSSM contributions are considered, and the experimental limits on Higgs bosons are also used.

The parameters shown in Table 1 are the input parameters for the calculations of the physical Higgs, chargino, neutralino, and squark masses and production rates.
SUSY parameter sets in the ranges defined in Table 1 are excluded at more than 95% confidence level after combining all search channels using the likelihood ratio method. The figures show three regions:

- the 95% CL excluded region (light grey),
- the theoretically not allowed region (dark),
- the allowed region (white),

and Fig. 1 also shows the region excluded by the benchmark scan (dotted line): the region excluded by the more general scan is smaller. In particular, the benchmark limits of 82.6 GeV/c^2 on the h mass and 84.1 GeV/c^2 on the A mass are reduced to 75 GeV/c^2 and 78 GeV/c^2, respectively. Comparison of the FDC cross sections used here and the RGE calculations used for the benchmark scan confirms that this is due to the reduced production cross-sections allowed by the extended parameter range, not due to differences between the FDC and RGE calculations. As illustrated in Table 2, low unexcluded m_h values are typically obtained for large mixing in the stop sector (large A_t, large |μ|). In conclusion, the scan over a larger parameter region reduces the mass limits given in sections 8.3 and 9 by 8 GeV/c^2 for the scalar and by 6 GeV/c^2 for the pseudoscalar Higgs boson.

<table>
<thead>
<tr>
<th>m_A</th>
<th>m_{1/2}</th>
<th>tan β</th>
<th>M_S</th>
<th>M_0</th>
<th>μ</th>
<th>A/M_S</th>
<th>X^{FD}_{FD}</th>
<th>m_{1/2}</th>
<th>m_{2/2}</th>
<th>σ_{h-&gt;hh}^{189}</th>
<th>σ_{h-&gt;hA}^{189}</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>78</td>
<td>8</td>
<td>1000</td>
<td>200</td>
<td>500</td>
<td>2</td>
<td>1938</td>
<td>979</td>
<td>1048</td>
<td>0.07</td>
<td>0.09</td>
</tr>
<tr>
<td>85</td>
<td>80</td>
<td>12</td>
<td>200</td>
<td>1000</td>
<td>-500</td>
<td>1</td>
<td>242</td>
<td>162</td>
<td>333</td>
<td>0.00</td>
<td>0.06</td>
</tr>
<tr>
<td>85</td>
<td>80</td>
<td>10</td>
<td>1000</td>
<td>1000</td>
<td>500</td>
<td>2</td>
<td>1950</td>
<td>824</td>
<td>1174</td>
<td>0.03</td>
<td>0.04</td>
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<tr>
<td>90</td>
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<td>4.4</td>
<td>1000</td>
<td>200</td>
<td>-100</td>
<td>-2</td>
<td>-1977</td>
<td>824</td>
<td>1174</td>
<td>0.11</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Table 2: Examples of unexcluded parameter combinations in the more general MSSM scan. Cross-sections for Higgs boson bremsstrahlung and pair-production are given for \( \sqrt{s} = 189 \) GeV. All masses are given in GeV/c^2 and cross-sections in pb.

References

Figure 1: MSSM exclusion based on all DELPHI data from $\sqrt{s} = 161$ GeV to 189 GeV in the framework of the more general parameter scan. The region excluded at 95% CL (light grey), the unexcluded region (white) and the theoretically forbidden region (dark grey) are shown. The dotted line marks the allowed region obtained with the benchmark scan under the assumption of maximal mixing in the stop sector.
Figure 2: MSSM exclusion based on all DELPHI data from $\sqrt{s} = 161$ GeV to 189 GeV in the framework of the more general parameter scan. The region excluded at 95% CL (light grey), the unexcluded region (white) and the theoretically forbidden region (dark grey) are shown.
Figure 3: MSSM exclusion based on all DELPHI data from $\sqrt{s} = 161$ GeV to 189 GeV in the framework of the more general parameter scan. The region excluded at 95% CL (light grey) and the unexcluded region (white) are shown.