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SPheno, a program for calculating supersymmetric spectra, SUSY particle decays and SUSY particle production at e^+e^- colliders

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[illegible]

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Abstract

SPheno is a program that accurately calculates the supersymmetric particle spectrum within a high scale theory, such as minimal supergravity, gauge mediated supersymmetry breaking, anomaly mediated supersymmetry breaking, or string effective field theories. An interface exists for an easy implementation of other high scale models. The program solves the renormalization group equations numerically to two–loop order with user-specified boundary conditions. The complete one–loop formulas for the masses are used which are supplemented by two–loop contributions in case of the neutral Higgs bosons and the μ parameter. The obtained masses and mixing matrices are used to calculate decay widths and branching ratios of supersymmetric particles as well as of Higgs bosons, $b \to s\gamma$, $\Delta\rho$ and $(g-2)_\mu$. Moreover, the production cross sections of all supersymmetric particle as well as Higgs bosons at e^+e^- colliders can be calculated including initial state radiation and longitud

[illegible]

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[1] SPheno stands for **S**upersymmetric **Pheno**menology

[illegible]. D [illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible] .26 7[illegible])- 0[illegible]

[illegible] Y[illegible] [illegible] fo[illegible] no[illegible]

$$L_{soft,1} \quad \frac{1}{2}\left(M_1\tilde{B}\tilde{B} + M_2\tilde{W}_a\tilde{W}^a + M_3\tilde{g}_\alpha\tilde{g}^\alpha\right) + h.c. \; , \qquad 2)$$

[illegible] tt [illegible]

$$\begin{aligned} L_{soft,2} \quad & -M^2_{H_1}H^*_{1a}H^a_1 - M^2_{H_2}H^*_{2a}H^a_2 - M^2_{\tilde{L},ij}\tilde{L}^*_{ia}\tilde{L}^a_j - M^2_{\tilde{E},ij}\tilde{E}^*_i\tilde{E}_j \\ & -M^2_{\tilde{Q},ij}\tilde{Q}^*_{ia}\tilde{Q}^a_j - M^2_{\tilde{U},ij}\tilde{U}^*_i\tilde{U}_j - M^2_{\tilde{D},ij}\tilde{D}^*_i\tilde{D}_j \qquad) \end{aligned}$$

[illegible] tt [illegible]

$$\begin{aligned} L_{soft,3} \quad & -\epsilon_{ab}\left(A^L_{ij}\tilde{L}^a_iH^b_1\tilde{E}^*_j + A^D_{ij}\tilde{Q}^a_iH^b_1\tilde{D}^*_j + A^U_{ij}\tilde{Q}^b_iH^a_2\tilde{U}^*_j - B\mu H^a_1H^b_2\right) \\ & +h.c. \qquad 4) \end{aligned}$$

2.2 Masses and Mixing Matrices

[illegible] Y[illegible] v_i [illegible] v_i $< H^0_i >$. [illegible] β v_2/v_1. [illegible]

$$m^2_W \quad \frac{1}{4}g^2(v^2_1 + v^2_2), \qquad m^2_Z \quad \frac{1}{4}(g^2 + g'^2)(v^2_1 + v^2_2) \qquad)$$

N[illegible]

$$m_{u_i} \quad \frac{1}{\sqrt{2}}Y^U_{ii}v_2, \qquad m_{d_i} \quad \frac{1}{\sqrt{2}}Y^D_{ii}v_1, \qquad m_{l_i} \quad \frac{1}{\sqrt{2}}Y^L_{ii}v_1 \qquad 6)$$

fo[illegible]-q[illegible] -q[illegible] [illegible]

2 [illegible] 6 .8 4 .26 2)0.97 4)-2.26269)0.9720 6 06 4769)- 7.8)2.92482 o)-2.26 996)66

[illegible] N:

$$M_{D,\tilde{\chi}^0} \quad N^* Y N^\dagger . \qquad ([illegible]0)$$

[illegible] (H_1^0, H_2^0) [illegible] α [illegible] (h^0, H^0) [illegible]:

$$\begin{pmatrix} h^0 \\ H^0 \end{pmatrix} \quad \begin{pmatrix} -\sin\alpha & \cos\alpha \\ \cos\alpha & \sin\alpha \end{pmatrix} \begin{pmatrix} H_1^0 \\ H_2^0 \end{pmatrix} \qquad ([illegible])$$

[illegible] $m_{h^0} < m_{H^0}$. [illegible]

$$m^2_{A^0} \quad B\mu\,(\tan\beta + \cot\beta)\,, \qquad m^2_{H^+} \quad m^2_{A^0} + m^2_W \qquad ([illegible]2)$$

[illegible].

[illegible]:

$$M^2_{\tilde{\nu}_i} \qquad M^2_{\tilde{L}_i i} + \frac{1}{2} m_Z^2 \cos 2\beta \qquad ([illegible])$$

[illegible] 2 [illegible] 2 [illegible]:

$$M^2_{\tilde{l},i} \quad \begin{pmatrix} M^2_{\tilde{L},ii} - \left(\frac{1}{2} - s_W^2\right) c_{2\beta} m_Z^2 + m^2_{l,i} & \frac{1}{\sqrt{2}}\left(v_1 A^L_{ii})^* - \mu Y^L_{ii} v_2\right) \\ \frac{1}{\sqrt{2}}\left(v_1 A^L_{ii} - \mu Y^L_{ii})^* v_2\right) & M^2_{\tilde{E},ii} - s_W^2 c_{2\beta} m_Z^2 + m^2_{l,i} \end{pmatrix} \qquad ([illegible]4)$$

$$M^2_{\tilde{u}} \quad \begin{pmatrix} M^2_{\tilde{Q},ii} + \left(\frac{1}{2} - \frac{2}{3} s_W^2\right) c_{2\beta} m_Z^2 + m^2_{u,i} & \frac{1}{\sqrt{2}}\left(v_2 A^U_{ii})^* - \mu Y^U_{ii} v_1\right) \\ \frac{1}{\sqrt{2}}\left(v_2 A^U_{ii} - \mu Y^U_{ii})^* v_1\right) & M^2_{\tilde{U},ii} + \frac{2}{3} s_W^2 c_{2\beta} m_Z^2 + m^2_{u,i} \end{pmatrix} \qquad ([illegible])$$

$$M^2_{\tilde{d}} \quad \begin{pmatrix} M^2_{\tilde{Q},ii} - \left(\frac{1}{2} - \frac{1}{3} s_W^2\right) c_{2\beta} m_Z^2 + m^2_{d,i} & \frac{1}{\sqrt{2}}\left(v_1 A^D_{ii})^* - \mu Y^D_{ii} v_2\right) \\ \frac{1}{\sqrt{2}}\left(v_1 A^D_{ii} - \mu Y^D_{ii})^* v_2\right) & M^2_{\tilde{D},ii} - \frac{1}{3} s_W^2 c_{2\beta} m_Z^2 + m^2_{d,i} \end{pmatrix} \qquad ([illegible]6)$$

[illegible] $c_{2\beta}$ [illegible] $\cos 2\beta$ [illegible] s_W^2 [illegible] $\sin^2\theta_W$. [illegible] 2 [illegible] 2 [illegible] $R_{\tilde{f},i}$ [illegible]

$$m^2_{\tilde{f}} \quad R_{\tilde{f}} M^2_{\tilde{f}} R^\dagger_{\tilde{f}} \qquad ([illegible]7)$$

[illegible] $\tilde{e}_1$, $\tilde{e}_2$, $\tilde{\mu}_1$, $\tilde{\mu}_2$, $\tilde{\tau}_1$, $\tilde{\tau}_2$ [illegible]

2.3 High scale models

[illegible] SPheno [illegible] $|\mu|$ [illegible]:

$$|\mu|^2 \quad \frac{1}{2}\left[\tan 2\beta \left(M^2_{H_2} \tan\beta - M^2_{H_1} \cot\beta\right) - m_Z^2\right] . \qquad ([illegible]8)$$

[illegible] μ [illegible] $\tan\beta$.

2.3.1 Minimal Supergravity

[illegible] (M_{GUT}) [illegible] $M_{1/2}$, [illegible] M_0, [illegible] A_0:

$$M_i(M_{GUT}) = M_{1/2} \tag{19}$$

$$M_j^2(M_{GUT}) = M_0^2 \tag{20}$$

$$A_i(M_{GUT}) = A_0 Y_i(M_{GUT}) \tag{21}$$

2.3.2 Minimal Supergravity including right handed neutrinos

[illegible] m_{ν_R}, [illegible] m_{ν_i} ($i = 1, 2, 3$), [illegible] m_{ν_R} [illegible] $Y_{\nu,i} = \sqrt{m_{\nu_R} m_{\nu_i}}/v_2$. [illegible] m_{ν_R} [illegible] M_{GUT}

[illegible] $SU(3)$, $SU(2)$ [illegible] $U(1)_Y$ [illegible] $Y = 2(Q - I_3)$ [illegible] [10]

$$
f(x) = \frac{1+x}{x^2}\left[\log(1+x) - 2\,\mathrm{Li}_2\left(\frac{x}{1+x}\right) + \frac{1}{2}\,\mathrm{Li}_2\left(\frac{2x}{1+x}\right)\right] + (x \to -x) \tag{27}
$$

[illegible] $\Lambda \ll M_M$ [illegible] (26) [illegible] M_M [illegible] A [illegible] M_M [illegible] A_0 [illegible]

2.3.4 Anomaly Mediated Supersymmetry Breaking

[illegible] (AMSB) [illegible] [1] [illegible]

$$
M_a = \frac{1}{g_a}\beta_a m_{3/2} \tag{28}
$$

$$
A_i = \beta_{Y_i} m_{3/2} \tag{29}
$$

$$
M_j^2 = \frac{1}{2}\dot{\gamma}_j m_{3/2}^2 \tag{30}
$$

[illegible] β_a [illegible] β_{Y_i} [illegible] γ_j [illegible] $m_{3/2}$ [illegible] (30) [illegible] [1] [illegible] M_0 [illegible] (30) [illegible]

$$
M_j^2 = M_0^2 + \frac{1}{2}\dot{\gamma}_j m_{3/2}^2 \tag{31}
$$

[illegible]

2.3.5 String Effective Field Theories

[illegible] S [illegible] T_m [illegible] S [illegible] T_m [illegible] [2,].

[illegible] m [illegible] T [illegible] [2,]. [illegible] $m_{3/2}$.

[illegible] [ ] [illegible] OII [illegible] t A and B of . on . on n [ ] n OI p . on . of the OI p . on . f . q. .2) – .2) of [ ]:

$$M_i \quad -g_i^2 m_{3/2}\left\{\sqrt{\ } \,\mathrm{n}\,\theta + \left[b_i + s\sqrt{\ }\,\mathrm{n}\,\theta g_s^2\left(C_i - \sum_j C_i^j\right)\right.\right.$$
$$\left.\left. + 2t\,\mathrm{o}\,\theta\, G_2\, t)\left(\delta_{\rm GS} + b_i - 2\sum_j C_i^j + n_j)\right)\right]/16\pi^2\right\} \qquad 2)$$

$$M_j^2 \quad m_{3/2}^2\left\{\left(1 + n_j\,\mathrm{o}^2\,\theta\right) + 2\sqrt{\ }\,s\,\mathrm{n}\,\theta\left[\sum_i \gamma_j^i g_i^2 - \frac{1}{2s}\sum_{km}\gamma_j^{km}\right]\right.$$
$$\left. +\gamma_j + 2t\,\mathrm{o}\,\theta\, G_2\, t)\sum_{km}\gamma_j^{km}\, n_j + n_k + n_m + \ )\right\} \qquad)$$

$$A_{jkm} \quad m_{3/2}\Big[-\sqrt{\ }\,\mathrm{n}\,\theta - 2t\,\mathrm{o}\,\theta\, n_j + n_k + n_m + \ )G_2\, t) + \gamma_j + \gamma_k + \gamma_m\Big] \qquad 4)$$

s $\langle S\rangle$ p on of . t $\langle T\rangle/m_{3/2}$ p on of $G_2\, t)$ $2\zeta\, t) + 1/2t$ non- o. n nf on ζ no δ_{GS} p t. of n- on t. γ_j n on of tt. γ_j^i and γ_j^{km} Y p t p C_i, C_i^j q C op f o op G_i, p n n t p n on n n tt p n on i, j, k no t H_1, H_2, $\tilde{E}$, $\tilde{L}$, $\tilde{D}$, $\tilde{U}$ and $\tilde{Q}$. A-p t f n n :

$$A_{e,n}\, GUT) \quad Y_{e,nn}\, GUT) A_{\tilde{E}_n\tilde{L}_nH_1} \qquad)$$
$$A_{d,n}\, GUT) \quad Y_{d,nn}\, GUT) A_{\tilde{D}_n\tilde{Q}_nH_1} \qquad 6)$$
$$A_{u,n}\, GUT) \quad Y_{u,nn}\, GUT) A_{\tilde{U}_n\tilde{Q}_nH_2} \qquad 7)$$

n no t n on.

n of the OII p . on . no n q. 11) of [ ]:

$$M_i \quad -g_i^2 m_{3/2}\left\{\frac{\sqrt{\ }\,\mathrm{n}\,\theta}{2k_{s\bar{s}}^{1/2}} + \frac{1}{16\pi^2}\left[2t\,\mathrm{o}\,\theta G_2\, \delta_{\rm GS} + b_i) + b_i\right.\right.$$
$$\left.\left. + \frac{\sqrt{\ }\,g_s^2\,\mathrm{n}\,\theta}{2k_{s\bar{s}}^{1/2}}\, C_i - \sum_j C_i^j)\right]\right\}. \qquad 8)$$

o f on p t p n t o of on on : t A) p f f o q. 1) and 19) of [ ]:

$$M_i^2 \quad m_{3/2}^2\left\{\,\mathrm{n}^2\,\theta + \gamma_i + \frac{\sqrt{\ }\,\mathrm{n}\,\theta}{k_{s\bar{s}}^{1/2}}\Big[\sum_a \gamma_i^a g_a^2 + \frac{1}{2}\sum_{jk}\gamma_i^{jk}\, k_s + k_{\bar{s}})\Big]\right\}, \qquad 9)$$

$$A_{ijk} \quad m_{3/2}\left\{\gamma_i + \gamma_j + \gamma_k - \frac{\sqrt{\ }\,k_s\,\mathrm{n}\,\theta}{k_{s\bar{s}}^{1/2}}\right\} \qquad 40)$$

[illegible] B) [illegible] p [illegible] f [illegible] q [illegible] 6) and [illegible] .20) of [ ]:

$$M_i^2 \quad m_{3/2}^2\Big\{\frac{\sqrt{\ }\ \mathrm{n}\,\theta}{k_{s\bar{s}}^{1/2}}\Big[+ 2t\ \mathrm{o}\ \theta G_2\Big]\Big[\sum_a g_a^2\gamma_i^a + \frac{}{2}\sum_{jk}\gamma_i^{jk} k_s + k_{\bar{s}})\Big]$$

$$+ \ \mathrm{n}^2\,\theta\Big[+ \gamma_i + \mathrm{n}\,[2t|\eta\ t)|^4 \sum_a \gamma_i^a + 2\sum_{jk}\gamma_i^{jk}) - \sum_a \gamma_i^a \mathrm{n}\ g_a^2)\Big]$$

$$-\frac{9\ \mathrm{n}^2\,\theta}{k_{s\bar{s}}}\Big[\sum_a \gamma_i^a\left(\frac{g_a^4}{4}\right)\left(\mathrm{n}\ g_a^2) + -\right)$$

$$+\mathrm{n}[\ t+\bar{t})|\eta\ t)|^4 \sum_a \gamma_i^a \frac{g_a^4}{4}) + - \sum_{jk}\gamma_i^{jk}k_s k_{\bar{s}})\Big]\Big\}, \qquad 4)$$

$$A_{ijk} \quad m_{3/2}\Big\{\gamma_i + \gamma_j + \gamma_k)\Big[+ 2t\ \mathrm{o}\ \theta G_2\Big]$$

$$+\frac{\sqrt{\ }\ \mathrm{n}\,\theta}{k_{s\bar{s}}^{1/2}}\Big[k_s + \sum_a \frac{g_a^2}{2}\gamma_i^a + \gamma_j^a + \gamma_k^a) - \mathrm{n}\ g_a^2))$$

$$-\mathrm{n}\Big[\ t+\bar{t})|\eta\ t)|^4\Big] \sum_a g_a^2\ \gamma_i^a + \gamma_j^a + \gamma_k^a)$$

$$-\sum_{lm} k_s\ \gamma_i^{lm} + \gamma_j^{lm} + \gamma_k^{lm}))\Big]\Big\}. \qquad 42)$$

[illegible] $\tilde{\mu}_i$) [illegible] $\tilde{\mu}_i$ [illegible]).

2.3.6 General High Scale Model

[illegible] $M_{1/2}[U\ ]$, $M_{1/2}[SU\ 2)]$, $M_{1/2}[SU\ \ )]$; [illegible]: $M^0_{\tilde{E},ii}$, $M^0_{\tilde{L},ii}$, $M^0_{\tilde{D},ii}$, $M^0_{\tilde{U},ii}$, $M^0_{\tilde{Q},ii}$; [illegible] $M^0_{H_1}$ and $M^0_{H_2}$; [illegible] $A_{0,e,ii}$, $A_{0,d,ii}$ and $A_{0,u,ii}$ [illegible] ii [illegible] [4] [illegible] [ ] [illegible] RA.

2.3.7 General MSSM at low energies

[illegible] on 2.2.0 [illegible] M_{EWSB} [illegible] M_{EWSB} [illegible] M_1 and M_2, [illegible] $m_{\tilde{g}}$; [illegible] μ, $\tan\beta$, [illegible] m_A; [illegible] $M_{\tilde{E},ii}$, $M_{\tilde{L},ii}$, $M_{\tilde{D},ii}$, $M_{\tilde{U},ii}$, $M_{\tilde{Q},ii}$, $A_{u,ii}$, $A_{d,ii}$, [illegible] $A_{l,ii}$ [illegible] Appendix B.[illegible].8.

3 Decays of supersymmetric particles and Higgs bosons

[illegible] $\tilde{\chi}_1^+ \to \tilde{\chi}_1^0 W^+$) BR($W^+ \to \nu l^+$) [illegible] $\tilde{\chi}_1^+ \to \tilde{\chi}_1^0 \nu l^+$) [illegible] $\tilde{\chi}_1^+ \to \tilde{\chi}_1^0 W^+$ [illegible]

[illegible]:

$$\tilde{f}_i \to f\,\tilde{\chi}_k^0,\ f'\,\tilde{\chi}_l^\pm \quad (4[illegible])$$

$$\tilde{f}_i \to \tilde{f}_j\,Z^0,\ \tilde{f}'_j\,W^\pm \quad (44)$$

$$\tilde{f}_i \to \tilde{f}_j\,(h^0, H^0, A^0),\ \tilde{f}'_j\,W^\pm \quad (4[illegible])$$

[illegible] [[illegible]7, [illegible]8, [illegible]9]:

$$\tilde{t}_1 \to c\,\tilde{\chi}_{1,2}^0 \quad (46)$$

$$\tilde{t}_1 \to W^+ b\,\tilde{\chi}_1^0,\ H^+ b\,\tilde{\chi}_1^0 \quad (47)$$

$$\tilde{t}_1 \to b\,\nu\,\tilde{l}_i^+,\ b\,l^+\,\tilde{\nu} \quad (48)$$

[illegible] $l = e, \mu, \tau$ [illegible] SPheno [illegible] [[illegible]8] [illegible] $\tilde{G}$ [illegible]:

$$\tilde{l}_i \to l\,\tilde{G} \quad (49)$$

[illegible] [29].

[illegible] [40] [illegible] [4[illegible]] [illegible]

[illegible]:

$$\tilde{\chi}_i^0 \to Z^0\,\tilde{\chi}_j^0,\ W^\pm\,\tilde{\chi}_k^\mp \quad ([illegible]0)$$

$$\tilde{\chi}_i^0 \to (h^0, H^0, A^0)\,\tilde{\chi}_j^0,\ H^\pm\,\tilde{\chi}_k^\mp \quad ([illegible]1)$$

$$\tilde{\chi}_i^0 \to f\bar{\tilde{f}}_j,\ \bar{f}\tilde{f}_j \quad ([illegible]2)$$

$$\tilde{\chi}_k^+ \longrightarrow Z^0\,\tilde{\chi}_s^+,\; W^+\,\tilde{\chi}_j^0 \qquad (53)$$
$$\tilde{\chi}_k^+ \longrightarrow (h^0, H^0, A^0)\,\tilde{\chi}_s^+,\; H^+\,\tilde{\chi}_j^0 \qquad (54)$$
$$\tilde{\chi}_k^+ \longrightarrow f\,\tilde{f}_i' \qquad (55)$$

[illegible] :

$$\tilde{\chi}_i^0 \longrightarrow f\,\bar{f}\,\tilde{\chi}_j^0,\; f\,f'\,\tilde{\chi}_k^\mp \qquad (56)$$
$$\tilde{\chi}_i^0 \longrightarrow q\,\bar{q}\,\tilde{g} \qquad (57)$$
$$\tilde{\chi}_k^+ \longrightarrow f\,\bar{f}\,\tilde{\chi}_s^+,\; f\,f'\,\tilde{\chi}_j^0 \qquad (58)$$
$$\tilde{\chi}_k^+ \longrightarrow q\,q'\,\tilde{g} \qquad (59)$$

[illegible] [16, 42] [illegible] [4]. [illegible] loop [illegible]

$$\tilde{\chi}_i^0 \longrightarrow \tilde{\chi}_j^0\,\gamma \qquad (60)$$

[illegible] [44] [illegible] :

$$\tilde{\chi}_1^0 \longrightarrow \gamma\;\tilde{G} \qquad (61)$$
$$\tilde{\chi}_1^0 \longrightarrow Z^0\;\tilde{G} \qquad (62)$$
$$\tilde{\chi}_1^0 \longrightarrow h^0\;\tilde{G} \qquad (63)$$

[illegible] [29].

[illegible] :

$$\tilde{g} \longrightarrow q\,\tilde{q}_i \qquad (64)$$

[illegible] $q = u, d, c, s, t, b$. [illegible] :

$$\tilde{g} \longrightarrow \tilde{\chi}_i^0\,q\,\bar{q} \qquad (65)$$
$$\tilde{g} \longrightarrow \tilde{\chi}_j^\pm\,q'\,\bar{q} \qquad (66)$$
$$\tilde{g} \longrightarrow \bar{b}\,W^-\,\tilde{t}_1,\, b\,W^+\,\tilde{t}_1^* \qquad (67)$$

[illegible] [4]. [illegible]

$$\tilde{g} \longrightarrow \tilde{\chi}_i^0\,g \qquad (68)$$

[illegible] [44, 46] [illegible].

[illegible] :

$$\phi \longrightarrow f\,\bar{f} \qquad (69)$$
$$\phi \longrightarrow \tilde{f}_i\,\bar{\tilde{f}}_j \qquad (70)$$
$$\phi \longrightarrow \tilde{\chi}_k^0\,\tilde{\chi}_l^0 \qquad (71)$$

$$\phi \to \tilde{\chi}^+_r \, \tilde{\chi}^-_s \tag{72}$$
$$h^0 \to Z^0 \, Z^{0*}, \; W^+ W^{-*}, \; W^{+*} W^- \tag{73}$$
$$h^0 \to g \, g \tag{74}$$
$$H^0 \to g \, g \tag{75}$$
$$H^0 \to Z^0 \, Z^0, \; W^+ W^- \tag{76}$$
$$H^0 \to h^0 \, h^0 \tag{77}$$
$$A^0 \to h^0 \, Z^0 \tag{78}$$
$$H^+ \to f \, \bar{f}' \tag{79}$$
$$H^+ \to \tilde{f}_i \, \bar{\tilde{f}}'_j \tag{80}$$
$$H^+ \to \tilde{\chi}^0_k \, \tilde{\chi}^-_s \tag{81}$$
$$H^+ \to h^0 \, W^+ \tag{82}$$

ϕ h^0, H^0, A^0 f $\nu_i, e, \mu, \tau, u, d, c, s, t, b$. ... loop ... [47, 48, 49]. ... QCD ... [47] ... $g\,g$ ... SPheno ... HDECAY [ ] ...

4 Production of supersymmetric particles and Higgs bosons

... :

$$e^+ e^- \to \tilde{f}_i \, \tilde{f}_j \quad (f = l, \nu, q) \tag{83}$$
$$e^+ e^- \to \tilde{\chi}^0_k \, \tilde{\chi}^0_n \tag{84}$$
$$e^+ e^- \to \tilde{\chi}^+_r \, \tilde{\chi}^-_s \tag{85}$$
$$e^+ e^- \to h^0 \, Z, \; H^0 Z \tag{86}$$
$$e^+ e^- \to h^0 \, A^0, \; H^0 A^0 \tag{87}$$
$$e^+ e^- \to H^+ H^- \tag{88}$$

... [49] ... QCD ... P_{e^-} ... P_{e^+} ... P_{e^-} ... [−1, 1] ... {−1, 0, 1} ... 100% ... 100% ...

[illegible] $P_{e^-} = -0.8$, $P_{e^+} = -0.8$) [illegible] 80% [illegible] 20% [illegible].

5 Low Energy Constraints

[illegible]

6 Details of the Calculation

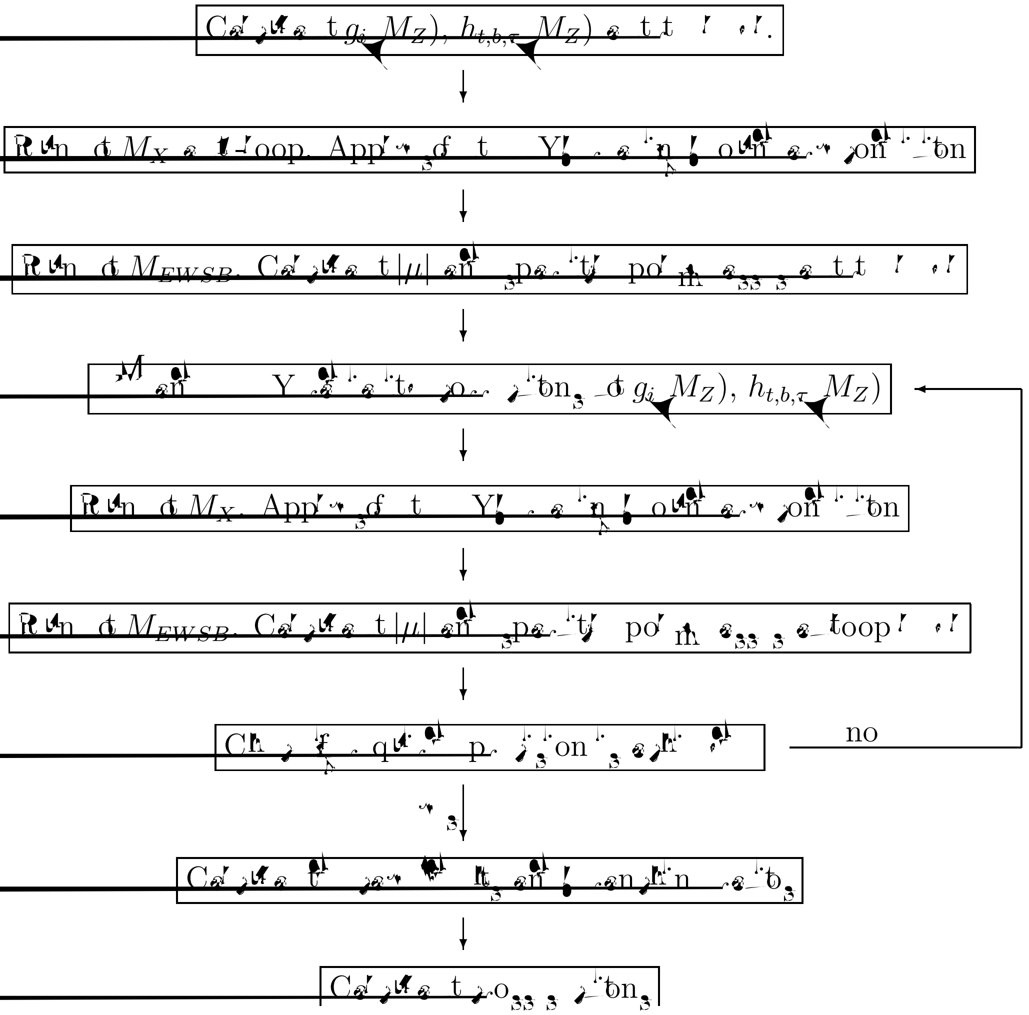
[illegible]

6.1 First rough calculation of SUSY and Higgs boson masses

[illegible]

6.2 Main loop for the calculation of SUSY and Higgs boson masses

[illegible] $\Delta\alpha_{lep} + \Delta\alpha_{had} = 0.06907$ [64]. [illegible]


no

formulae [6]

$$m_W^2 = m_Z^2\rho\left(\frac{1}{2}+\sqrt{\frac{1}{4}-\frac{\alpha^{\overline{DR}}(m_Z)\pi}{\sqrt{2}G_F m_Z^2\rho(1-\Delta r)}}\right) \quad (89)$$

$$\rho = \frac{1}{1-\Delta\rho} \quad (90)$$

$$\Delta\rho = Re\left(\frac{\Pi^T_{ZZ}(m_Z^2)}{\rho m_Z^2}-\frac{\Pi^T_{WW}(m_W^2)}{m_W^2}\right) \quad (91)$$

$$\Delta r = \rho\frac{\Pi^T_{WW}(0)}{m_W^2}-\frac{\Pi^T_{ZZ}(m_Z^2)}{m_Z^2}+\delta_{VB} \quad (92)$$

Π^T_{VV} ... δ_{VB} ... non- ... μ ... two-loop ... formulae of [66] ... [2]. ... formulae of ... δ_{VB} ... [67, 68]. ... loop ... top-quark ... 2-loop ... on- ... loop ... formulae ... of the ... formulae ... Appendix D of [2]. ... α_s ... of m_Z ... 4-loop ... [69] ... [70]. ... $\overline{MS}$ ... m_Z ... $\overline{DR}$ ... formulae ... [71, 72], ...:

$$m_{b',\overline{DR}}(m_Z) = m_{b,\overline{MS}}(m_Z)\left(1-\frac{\alpha_s}{\pi}-\frac{23\alpha_s^2}{72\pi^2}+\frac{4g_2^2}{128\pi^2}-\frac{13g'^2}{1152\pi^2}\right) \quad (93)$$

... α_s ... $\overline{DR}$ ... of α_s^2 ... of [72]. ... Appendix D of [2] ... no ... $\Delta m_{b,SUSY}(m_Z)$ ... m_Z ... $\Delta m_{b,SUSY}(m_Z)$ ... [7]

$$m_{b,\overline{DR}}(m_Z) = \frac{m_{b',\overline{DR}}(m_Z)}{1-\frac{\Delta m_{b,SUSY}(m_Z)}{m_{b,\overline{DR}}(m_Z)}} \quad (94)$$

... top-quark ... m_t ... formulae ... [2] ... $m_t^{\overline{DR}}(m_Z)$ ... of [2] ... 2-loop ... 2-loop formulae ... [71]:

$$\Sigma_t^{2l} = -\left(\frac{\alpha_s(m_Z)}{\pi}\right)^2\left(\frac{8\pi^2}{9}+\frac{2011}{18}+\frac{16\pi^2\ln 2}{9}-\frac{8\zeta(3)}{3}+\frac{246}{3}L+22L^2\right) \quad (95)$$

$$L = \log\left(\frac{m_Z^2}{m_t^2}\right) \quad (96)$$

6.3 Calculation of the other observables

[illegible] M_{EWSB} [illegible]

[illegible] e^+e^- [illegible]

[illegible] : $BR(b \to s\gamma)$, [illegible] a_μ [illegible] $\Delta\rho$ [illegible] M_{EWSB} [illegible] m_Z [illegible] m_Z [illegible] $BR(b \to s\gamma)$ [illegible] C_7 [illegible]

$$C_7(W^+) = -\frac{K_{ts}K_{tb}x_{tW}}{4\,m_W^2}\left(\frac{2}{3}F_1(x_{tW}) + F_2(x_{tW})\right) \tag{99}$$

$$\begin{aligned} C_7(H^+) = & -\frac{K_{ts}K_{tb}}{4\,m_{H^+}^2}\left[\frac{Y_t^2\cos^2\beta}{4}\left(\frac{2}{3}F_1(x_{tH^+}) + F_2(x_{tH^+})\right)\right. \\ & \left. -\frac{Y_bY_t\cos\beta\sin\beta m_t}{m_b}\left(\frac{2}{3}F_3(x_{tH^+}) + F_4(x_{tH^+})\right)\right] \end{aligned} \tag{100}$$

$$\begin{aligned} C_7(\tilde{\chi}^+) = & \sum_{i,j=1}^{2}\frac{K_{ts}K_{tb}}{4\,m_{\tilde{t}_i}^2}\left[C_{R,ij}^2\left(\frac{2}{3}F_2(x_{\tilde{\chi}_j^+\tilde{t}_i}) + F_1(x_{\tilde{\chi}_j^+\tilde{t}_i})\right)\right. \\ & \left. -C_{L,ij}C_{R,ij}\left(\frac{2}{3}F_4(x_{\tilde{\chi}_j^+\tilde{t}_i}) + F_3(x_{\tilde{\chi}_j^+\tilde{t}_i})\right)\right] \end{aligned} \tag{101}$$

$$C_{L,ij} = Y_bR_{\tilde{t},i1}U_{j2} \tag{102}$$

$$C_{R,ij} = -gR_{\tilde{t},i1}V_{j1} + Y_tR_{\tilde{t},i2}V_{j2} \tag{103}$$

[illegible] Y_i [illegible] U [illegible] V [illegible] K [illegible] $R_{\tilde{t}}$ [illegible] $x_{ab} = m_a^2/m_b^2$ [illegible] F_i [illegible] [17]. [illegible] C_8 [illegible] $C_{7,8}$ [illegible] [19] [illegible]

$$BR(b \to s\gamma) = 1.258 + 0.382 r_7^2 + 0.017 r_8^2 + 1.89 r_7 + 0.161 r_8 + 0.08 r_7 r_8 \tag{104}$$

[illegible] $r_7 = C_7/C_7(W^+)$ [illegible] $r_8 = C_8/C_8(W^+)$. [illegible] $\tan\beta$ [illegible] $b \to s\gamma$ [6].

[illegible] MSSM Data [illegible]

[illegible]	
e^{φ_μ}	`complex(dp) :: phase_mu`
$\tan\beta$	`real(dp) :: tanb`
M_1, M_2, M_3	`complex(dp) :: Mi(3)`
M_E^2, M_L^2	`complex(dp), dimension(3,3) :: M2_E, M2_L`
M_D^2, M_Q^2, M_U^2	`complex(dp), dimension(3,3) :: M2_D, M2_Q, M2_U`
A_l, A_d, A_u	`complex(dp), dimension(3,3) :: A_l, A_d, A_u`
μ	`complex(dp) :: mu`
$B\mu$	`complex(dp) :: B`
M_H^2	`real(dp) :: M2_H(2)`
g', g	`real(dp) :: gp, g`
Y_l, Y_d, Y_u	`complex(dp), dimension(3,3) :: Y_l, Y_d, Y_u`
v_1, v_2	`real(dp) :: vevSM(2)`
g', g, g_s	`real(dp) :: gauge(3)`

7 A sample example

[illegible] SPheno.f90. [illegible]

```
Call ReadingData(kont)
```

[illegible] SPheno.f90 [illegible] LesHouches.in [illegible] Control.in [illegible] StandardModel.in [illegible] HighScale.in [illegible] Messages.out [illegible]

[illegible] CalculateSpectrum [illegible]

```
! Call SetGUTScale(2.e16_dp)   ! please put the GUT scale
! Call SetRGEScale(1.e3_dp**2) ! please put the scale M_EWSB squared
```

[illegible] g_1 [illegible] g_2 [illegible] M_{EWSB} [illegible] M_{EWSB} [illegible] $\sqrt{m_{\tilde t_1} m_{\tilde t_2}}$.

[illegible]

[illegible] 2: [illegible] CalculateSpectrum [illegible] MSSM Data [illegible]

$m_{\tilde{g}}$	Real(dp) :: mGlu
$e^{\varphi_{\tilde{g}}}$	Complex(dp) :: PhaseGlu
$m_{\tilde{\chi}^+_i}$	Real(dp) :: mC(2)
U, V	Complex(dp) :: U(2,2), V(2,2)
$m_{\tilde{\chi}^0_j}$	Real(dp) :: mN(4)
N	Complex(dp) :: N(4,4)
m_{h^0}, m_{H^0}	Real(dp) :: mS0(2)
R_α	Real(dp) :: RS0(2,2)
m_{G^0}, m_{A^0}	Real(dp) :: mP0(2)
R_β	Real(dp) :: RP0(2,2)
m_{G^+}, m_{H^+}	Real(dp) :: mSpm(2)
R'_β	Complex(dp) :: RSpm(2,2)
$m_{\tilde{\nu}}$	Real(dp) :: mSneut(3)
$R_{\tilde{\nu}}$	Complex(dp) :: RSneut(3,3)
$m_{\tilde{l}}$	Real(dp) :: mSlepton(6)
$R_{\tilde{l}}$	Complex(dp) :: RSlepton(6,6)
$m_{\tilde{u}}$	Real(dp) :: mSup(6)
$R_{\tilde{u}}$	Complex(dp) :: RSup(6,6)
$m_{\tilde{d}}$	Real(dp) :: mSdown(6)
$R_{\tilde{d}}$	Complex(dp) :: RSdown(6,6)

```
delta = 1.e-4_dp
WriteOut = .False.
n_run = 20
If (kont.Eq.0) Call CalculateSpectrum(n_run, delta, WriteOut, kont, tanb     &
    & , vevSM, mC, U, V, mN, N, mS0, mS02, RS0, mP0, mP02, RP0, mSpm, mSpm2   &
    & , RSpm, mSdown, mSdown2, RSdown, mSup, mSup2, RSup, mSlepton, mSlepton2 &
    & , RSlepton, mSneut, mSneut2, RSneut, mGlu, PhaseGlu, gauge, Y_l, Y_d    &
    & , Y_u, Mi, A_l, A_d, A_u, M2_E, M2_L, M2_D, M2_Q, M2_U, M2_H, mu, B     &
    & , A_l_save, A_u_save, A_d_save, m_GUT)
```

[illegible] Rslepton [illegible]

- **delta**: [illegible] on [illegible] delta, [illegible] Sugra [illegible] loop.
- **m_GUT**: [illegible]
- **kont**: [illegible] 0 [illegible] /o. [illegible] /o. [illegible] Messages.out.
- **WriteOut**: [illegible] True. [illegible] Messages.out.
- **n_run**: [illegible] loop. [illegible] delta [illegible] n_run [illegible]

No [illegible] M_{EWSB}. [illegible] [2] [illegible] μ [illegible] loop [illegible] [26, 27].

In [illegible] L_BR=.TRUE. [illegible] kont.eq.0:

```
If ((L_BR).And.(kont.eq.0)) Then
 epsI = 1.e-5_dp
 deltaM = 1.e-3_dp
 CalcTBD = .False.
 ratioWoM = 0._dp
 Couplings_At_Mi = .True.
 Call CalculateBR(gauge, mGlu, PhaseGlu, mC, U, V, mN, N, mSneut           &
    & , mSlepton, RSlepton, mSup, RSup, mSdown, RSdown, mS0, RS0            &
    & , mP0, RP0, mSpm, RSpm, Y_d, A_d, Y_l, A_l, Y_u, A_u, mu, vevSM       &
    & , Fgmsb, m32 , epsI, deltaM, ratioWoM , CalcTBD, Couplings_At_Mi      &
    & , kont, gP_Sl, gT_Sl, BR_Sl, gP_Sn, gT_Sn, BR_Sn, gP_Sd, gT_Sd, BR_Sd &
    & , gP_Su, gT_Su, BR_Su, gP_C, gT_C, BR_C, gP_N, gT_N, BR_N             &
    & , gP_Glu, gT_Glu, BR_Glu, gP_P0, gT_P0, BR_P0, gP_S0, gT_S0, BR_S0    &
    & , gP_Spm, gT_Spm, BR_Spm)
 End If
```

[illegible] gP_ gT_ [illegible] BR_ [illegible] Real(dp) [illegible] Sl, Sn, Sd [illegible] Su [illegible] 4, [illegible] 6 [illegible] 7 [illegible] 8. [illegible]

Table : Components ... for ... on ... (continued) ... $\tilde t_1$ ...

	$\tilde l$	$\tilde\nu$	$\tilde d$	$\tilde u$	$\tilde t_1$
$\tilde f_i \to f\tilde\chi^0_k$	1-4	1-4	1-4	1-4	1-4
$\tilde f_i \to f'\tilde\chi^\pm_j$	-6	-6	-6	-6	-6
$\tilde f_i \to f\tilde g$	-	-	7	7	7
$\tilde f_i \to W^\pm \tilde f'_j$	7	7-8	8-9	8-9	8-9
$\tilde f_i \to H^\pm \tilde f'_j$	8	9-10	10-11	10-11	10-11
$\tilde f_2 \to Z^0 \tilde f_1$	9	-	12	12	-
$\tilde f_2 \to A^0 \tilde f_1$	10	-	1	1	-
$\tilde f_2 \to h^0 \tilde f_1$	11	-	14	14	-
$\tilde f_2 \to H^0 \tilde f_1$	12	-	1	1	-
$\tilde l_1 \to l\tilde G$	1	-	-	-	-
$\tilde t_1 \to c\tilde\chi^0_{1,2}$	-	-	-	-	- 6
$\tilde t_1 \to W^+\bar b\tilde\chi^0_1$	-	-	-	-	7
$\tilde t_1 \to \bar b e^+\tilde\nu_e$	-	-	-	-	8
$\tilde t_1 \to \bar b \mu^+\tilde\nu_\mu$	-	-	-	-	9
$\tilde t_1 \to \bar b \tau^+\tilde\nu_\tau$	-	-	-	-	60
$\tilde t_1 \to \bar b \nu_e\tilde e^+_{1,2}$	-	-	-	-	61-62
$\tilde t_1 \to \bar b \nu_\mu\tilde \mu^+_{1,2}$	-	-	-	-	6 -64
$\tilde t_1 \to \bar b \nu_\tau\tilde \tau^+_{1,2}$	-	-	-	-	6 -66

- Fgmsb and m32 : the F parameter and the ... M ... B ... 62]69) .0862 2)0.9700 4)0.647 7)0.9700

Table 4: Co[illegible]pon[illegible]n[illegible] [illegible] [illegible]n [illegible] [illegible]on[illegible] [illegible]n[illegible] fo[illegible] [illegible]no p[illegible] [illegible] [illegible] [illegible]n[illegible]n [illegible]) [illegible]n [illegible] [illegible]

[illegible]	[illegible] (gP_C, BR_C)
$\tilde\chi^+_i \to \tilde l^+_{m,k}\, \nu_m$	1-6
$\tilde\chi^+_i \to \tilde\nu_m\, l^+_m$	7-9
$\tilde\chi^+_i \to \tilde{\bar d}_{m,k}\, u_m$	10-1[illegible]
$\tilde\chi^+_i \to \tilde u_{m,k}\, \bar d_m$	16-21
$\tilde\chi^+_i \to \tilde\chi^0_j\, W^+$	22-2[illegible]
$\tilde\chi^+_i \to \tilde\chi^0_j\, H^+$	26-29
$\tilde\chi^+_2 \to \tilde\chi^+_1\, Z^0$	[illegible]0
$\tilde\chi^+_2 \to \tilde\chi^+_1\, A^0$	[illegible]1
$\tilde\chi^+_2 \to \tilde\chi^+_1\, h^0$	[illegible]2
$\tilde\chi^+_2 \to \tilde\chi^+_1\, H^0$	[illegible]
$\tilde\chi^+_i \to \tilde\chi^0_j\, u_m\, \bar d_m$	64-7[illegible]
$\tilde\chi^+_i \to \tilde\chi^0_j\, l^+_m\, \nu_m$	76-87
$\tilde\chi^+_i \to \tilde g\, u_m\, \bar d_m$	88-90
$\tilde\chi^+_2 \to \tilde\chi^+_1\, u_m\, \bar u_m$	91-9[illegible]
$\tilde\chi^+_2 \to \tilde\chi^+_1\, d_m\, \bar d_m$	94-96
$\tilde\chi^+_2 \to \tilde\chi^+_1\, l_m\, l^+_m$	97-99
$\tilde\chi^+_2 \to \tilde\chi^+_1\, \nu_m\, \bar\nu_m$	100-102

- Couplings_At_Mi : [illegible] .TRUE. [illegible] Q [illegible] M_i [illegible] M_i [illegible] .False. [illegible] Q [illegible] m_{EWSB} [illegible].

[illegible] L_CS = .TRUE. [illegible] kont = 0:

```
 If ((L_CS).and.(kont.eq.0)) then
  Call CalculateCrossSections(Ecms, Pm, Pp, ISR                    &
             & , mSup, RSup, mf_u, mSdown, RSdown, mf_d, mglu     &
             & , SigSup, SigSdown, mSlepton, RSlepton             &
             & , mSneut, RSneut, SigSle, SigSn, mC, U, V, mN, N  &
             & , SigC, SigChi0, mS0, RS0, vevSM, mP0, RP0, mSpm  &
             & , RSpm, SigS0, SigSP, SigHp )
 End If
```

[illegible] fo[illegible]o[illegible]n [illegible] np[illegible]t[illegible]n[illegible]:

- Ecms : [illegible]
- Pm, Pp : [illegible] po[illegible] [illegible] [illegible]n [illegible]n [illegible] [illegible]on [illegible] po[illegible]on, [illegible]p [illegible]
- ISR : [illegible] .TRUE. [illegible]n [illegible] [illegible] [illegible] n [illegible] fo[illegible] [illegible]n [4]

[illegible]

[illegible]	[illegible] BR_N)
$\tilde\chi_i^0 \longrightarrow \tilde l^+_{m,k}\, l_m$	1-12
$\tilde\chi_i^0 \longrightarrow \tilde\nu_m\, \nu_m$	1 -18
$\tilde\chi_i^0 \longrightarrow \bar{\tilde u}_{m,k}\, u_m$	19- 0
$\tilde\chi_i^0 \longrightarrow \tilde d_{m,k}\, \bar d_m$	1-42
$\tilde\chi_i^0 \longrightarrow \tilde\chi_j^\pm\, W^\mp$	4 -46
$\tilde\chi_i^0 \longrightarrow \tilde\chi_j^\pm\, H^\mp$	47- 0
$\tilde\chi_i^0 \longrightarrow \tilde\chi_j^0\, Z^0$	1- 24+)
$\tilde\chi_i^0 \longrightarrow \tilde\chi_j^0\, A^0$	2 +)- 2 +2)
$\tilde\chi_i^0 \longrightarrow \tilde\chi_j^0\, h^0$	26+)- 22+)
$\tilde\chi_i^0 \longrightarrow \tilde\chi_j^0\, H^0$	27+)- 21 +4)
$\tilde\chi_i^0 \longrightarrow \gamma\, \tilde G$	6
$\tilde\chi_i^0 \longrightarrow Z^0\, \tilde G$	64
$\tilde\chi_i^0 \longrightarrow h^0\, \tilde G$	6
$\tilde\chi_i^0 \longrightarrow \gamma\, \tilde\chi_j^0$	6 +
$\tilde\chi_i^0 \longrightarrow \tilde\chi_j^\pm\, q_m\, \bar q'_m$	69 - 80
$\tilde\chi_i^0 \longrightarrow \tilde\chi_j^\pm\, l_m^\mp\, \nu_m$	81 - 92
$\tilde\chi_i^0 \longrightarrow \tilde G\, u_m\, \bar u_m$	9 - 9
$\tilde\chi_i^0 \longrightarrow \tilde G\, d_m\, \bar d_m$	96 - 98
$\tilde\chi_{i>1}^0 \longrightarrow \tilde\chi_1^0\, u_m\, \bar u_m$	99 - 101
$\tilde\chi_{i>1}^0 \longrightarrow \tilde\chi_1^0\, d_m\, \bar d_m$	102 - 104
$\tilde\chi_{i>1}^0 \longrightarrow \tilde\chi_1^0\, l_m^+\, l_m^-$	10 - 107
$\tilde\chi_{i>1}^0 \longrightarrow \tilde\chi_1^0\, \nu_m\, \bar\nu_m$	108 - 110
$\tilde\chi_{i>2}^0 \longrightarrow \tilde\chi_2^0\, u_m\, \bar u_m$	111 - 11
$\tilde\chi_{i>2}^0 \longrightarrow \tilde\chi_2^0\, d_m\, \bar d_m$	114 - 116
$\tilde\chi_{i>2}^0 \longrightarrow \tilde\chi_2^0\, l_m^+\, l_m^-$	117 - 119
$\tilde\chi_{i>2}^0 \longrightarrow \tilde\chi_2^0\, \nu_m\, \bar\nu_m$	120 - 122
$\tilde\chi_4^0 \longrightarrow \tilde\chi_3^0\, u_m\, \bar u_m$	12 - 12
$\tilde\chi_4^0 \longrightarrow \tilde\chi_3^0\, d_m\, \bar d_m$	126 - 128
$\tilde\chi_4^0 \longrightarrow \tilde\chi_3^0\, l_m^+\, l_m^-$	129 - 1 1
$\tilde\chi_4^0 \longrightarrow \tilde\chi_3^0\, \nu_m\, \bar\nu_m$	1 2 - 1 4

6: Co... pon... n... for ... no p...) ... No t... ... n.

	BR
$\tilde{g} \to \tilde{d}_{m,k}\, d_m$	[illegible]2
$\tilde{g} \to \tilde{u}_{m,k}\, \bar{u}_m$	[illegible]-24
$\tilde{g} \to \tilde{t}_1\, \bar{c}$	2 -26
$\tilde{g} \to \gamma\, \tilde{\chi}^0_j$	26 + [illegible]
$\tilde{g} \to \tilde{\chi}^0_1\, u_m\, \bar{u}_m$	[illegible]-
$\tilde{g} \to \tilde{\chi}^0_1\, d_m\, \bar{d}_m$	4- 6
$\tilde{g} \to \tilde{\chi}^0_2\, u_m\, \bar{u}_m$	7- 9
$\tilde{g} \to \tilde{\chi}^0_2\, d_m\, \bar{d}_m$	40-42
$\tilde{g} \to \tilde{\chi}^0_3\, u_m\, \bar{u}_m$	4 -4
$\tilde{g} \to \tilde{\chi}^0_3\, d_m\, \bar{d}_m$	46-48
$\tilde{g} \to \tilde{\chi}^0_4\, u_m\, \bar{u}_m$	49-[illegible]
$\tilde{g} \to \tilde{\chi}^0_4\, d_m\, \bar{d}_m$	2- 4
$\tilde{g} \to \tilde{\chi}^\pm_i\, q_m\, \bar{q}'_m$	-66
$\tilde{g} \to \tilde{t}_i\, W^-\, \bar{b}$	67-68

γ b...

... CrossSections.in ... Sig ... 9. ... no t ... f ... on ... p ...

Table 7: Co[illegible] pon[illegible] n[illegible] t[illegible] n[illegible] f o[illegible] p[illegible] [illegible]) [illegible] BR 0) [illegible] BR 0) f o[illegible] p[illegible] [illegible]) [illegible] C[illegible] o on[illegible] h^0, H^0) [illegible] C[illegible] o on A^0). [illegible] 0 BR 0) [illegible]) [illegible] no t[illegible] h^0 H^0). [illegible] ϕ [illegible] f o[illegible] h^0, H^0 [illegible] A^0. [illegible]

[illegible]	h^0	H^0	A^0
$\phi \to l_m^+ \, l_m^-$	1-	1-	1-
$\phi \to d_m \, \bar{d}_m$	4-6	4-6	4-6
$\phi \to u_m \, \bar{u}_m$	7-9	7-9	7-9
$H^0 \to \tilde{e}_1^+ \, \tilde{e}_1^-$	-	10	-
$\phi \to \tilde{e}_1^\mp \, \tilde{e}_2^\pm$	-	11-12	11-12
$H^0 \to \tilde{e}_2^+ \, \tilde{e}_2^-$	-	1	-
$H^0 \to \tilde{\mu}_1^+ \, \tilde{\mu}_1^-$	-	14	-
$\phi \to \tilde{\mu}_1^\mp \, \tilde{\mu}_2^\pm$	-	1 -16	1 -16
$H^0 \to \tilde{\mu}_2^+ \, \tilde{\mu}_2^-$	-	17	-
$H^0 \to \tilde{\tau}_1^+ \, \tilde{\tau}_1^-$	-	18	-
$\phi \to \tilde{\tau}_1^\mp \, \tilde{\tau}_2^\pm$	-	19-20	19-20
$H^0 \to \tilde{\tau}_2^+ \, \tilde{\tau}_2^-$	-	21	-
$H^0 \to \tilde{\nu}_m \, \overline{\tilde{\nu}}_m$	-	21 +m	-
$H^0 \to \tilde{d}_1^+ \, \tilde{d}_1^-$	-	2	-
$\phi \to \tilde{d}_1^\mp \, \tilde{d}_2^\pm$	-	26-27	2 -24
$H^0 \to \tilde{d}_2^+ \, \tilde{d}_2^-$	-	28	-
$H^0 \to \tilde{s}_1^+ \, \tilde{s}_1^-$	-	29	-
$\phi \to \tilde{s}_1^\mp \, \tilde{s}_2^\pm$	-	0- 1	27-28
$H^0 \to \tilde{s}_2^+ \, \tilde{s}_2^-$	-	2	-
$H^0 \to \tilde{b}_1^+ \, \tilde{b}_1^-$	-		-
$\phi \to \tilde{b}_1^\mp \, \tilde{b}_2^\pm$	-	4-	1- 2
$H^0 \to \tilde{b}_2^+ \, \tilde{b}_2^-$	-	6	-
$H^0 \to \tilde{u}_1^+ \, \tilde{u}_1^-$	-	7	-
$\phi \to \tilde{u}_1^\mp \, \tilde{u}_2^\pm$	-	8- 9	- 6
$H^0 \to \tilde{u}_2^+ \, \tilde{u}_2^-$	-	40	-
$H^0 \to \tilde{c}_1^+ \, \tilde{c}_1^-$	-	41	-
$\phi \to \tilde{c}_1^\mp \, \tilde{c}_2^\pm$	-	42-4	9-40
$H^0 \to \tilde{c}_2^+ \, \tilde{c}_2^-$	-	44	-
$H^0 \to \tilde{t}_1^+ \, \tilde{t}_1^-$	-	4	-
$\phi \to \tilde{t}_1^\mp \, \tilde{t}_2^\pm$	-	46-47	4 -44
$H^0 \to \tilde{t}_2^+ \, \tilde{t}_2^-$	-	48	-
$\phi \to \tilde{\chi}_r^0 \, \tilde{\chi}_s^0$ (r s)	49- 8	49- 8	46-
$\phi \to \tilde{\chi}_1^+ \, \tilde{\chi}_1^-$	9	9	6
$\phi \to \tilde{\chi}_1^\pm \, \tilde{\chi}_2^\mp$	60-61	60-61	7- 8
$\phi \to \tilde{\chi}_2^+ \, \tilde{\chi}_2^-$	62	62	9

[illegible]	h^0	H^0	A^0
$H^0 \to Z^0 \, Z^0$	-	6	-
$H^0 \to W^+ \, W^-$	-	64	-
$H^0 \to h^0 \, h^0$	-	70	-
$A^0 \to h^0 \, Z^0$	-	-	6
$h^0 \to W^+ W^{-*}$	70	-	-
$h^0 \to W^{+*} W^-$	71	-	-
$h^0 \to Z^0 Z^{0*}$	72	-	-
$\phi \to gg$	80	80	-

Table 8: Co[illegible]pon[illegible] [illegible] the [illegible] for the partial [illegible] (array [illegible]) of the [illegible] and the [illegible] (array [illegible] BR_[illegible]) and [illegible] of partial [illegible].

[illegible]	[illegible]
$H^+ \to l_m^+ \, \nu_m$	1-[illegible]
$H^+ \to u_m \, \bar{d}_m$	4-6
$H^+ \to \tilde{e}_i^+ \, \tilde{\nu}_e$	7-8
$H^+ \to \tilde{\mu}_i^+ \, \tilde{\nu}_\mu$	9-10
$H^+ \to \tilde{\tau}_i^+ \, \tilde{\nu}_\tau$	11-12
$H^+ \to \tilde{u}_i \, \bar{\tilde{d}}_j$	12 + 2*([illegible]-1) + [illegible]
$H^+ \to \tilde{c}_i \, \bar{\tilde{s}}_j$	16 + 2*([illegible]-1) + [illegible]
$H^+ \to \tilde{t}_i \, \bar{\tilde{b}}_j$	20 + 2*([illegible]-1) + [illegible]
$H^+ \to \tilde{\chi}_l^+ \, \tilde{\chi}_s^0$	24 + 4*([illegible]-1) + [illegible]
$H^+ \to h^0 \, W^+$	4[illegible]

Table 9: Co[illegible]pon[illegible] [illegible] the p[illegible] [illegible] and the [illegible] in the p[illegible].

p[illegible]	[illegible] na[illegible] and [illegible]
$e^+ e^- \to \tilde{u}_i \, \tilde{u}_j$	[illegible]p) :: [illegible]p(6,6)
$e^+ e^- \to \tilde{d}_i \, \tilde{d}_j$	[illegible]p) :: [illegible]o[illegible]n(6,6)
$e^+ e^- \to \tilde{l}_i \, \tilde{l}_j$	[illegible]p) :: [illegible](6,6)
$e^+ e^- \to \tilde{\nu}_i \, \tilde{\nu}_j$	[illegible]p) :: [illegible]n(6,6)
$e^+ e^- \to \tilde{\chi}_k^0 \, \tilde{\chi}_n^0$	[illegible]p) :: [illegible]C[illegible]0(4,4)
$e^+ e^- \to \tilde{\chi}_l^+ \, \tilde{\chi}_s^-$	[illegible]p) :: [illegible]N(4,4)
$e^+ e^- \to h^0 \, Z, \; H^0 Z$	[illegible]p) :: [illegible]0(2)
$e^+ e^- \to h^0 \, A^0, \; H^0 A^0$	[illegible]p) :: [illegible](2)
$e^+ e^- \to H^+ H^-$	[illegible]p) :: [illegible]p

```
! output according to SUSY Les Houches Accord
 Call LesHouches_Out(HighScaleModel, M_GUT, BRbtosgamma, a_mu, Delta_Rho &
      & , Ecms, Pm, Pp, ISR, SigSup, SigSdown, SigSle, SigSn, SigChi0    &
      & , SigC, SigS0, SigSP, SigHp)

! output according to orginal SPheno style
 Call WriteOutPut0(11,  kont, HighScaleModel, M_GUT, BRbtosgamma, a_mu    &
       & , Delta_Rho, Ecms, Pm, Pp, ISR, SigSup, SigSdown, SigSle , SigSn &
       & , SigChi0, SigC, SigS0, SigSP, SigHp)
```

[illegible] SetWriteMinBR [illegible] SetWriteMinSig [illegible] LesHouches_Out [illegible] [28] [illegible] WriteOutPut0 [illegible] SPheno [illegible] App [illegible] D. [illegible]

```
call closing() ! closes the files
```

8 Conclusions

[illegible] SPheno [illegible] e^+e^- [illegible] e^+e^- [illegible] $BR(b \to s\gamma)$, [illegible] a_μ [illegible] ρ [illegible] 2.2.0 SPheno [illegible] [28].

[illegible] QCD [illegible]

Acknowledgments

[illegible]

[illegible] No. 209 [illegible]

A Switches

[illegible]

1. [illegible] M_{EWSB}, [illegible] $M_{EWSB} = \sqrt{m_{\tilde{t}_1} m_{\tilde{t}_2}}$. [illegible]

```
Call SetRGEScale(1.e3_dp**2)
```

M_{EWSB} [illegible] 10^3 [illegible] SetRGEScale [illegible]

2. [illegible] B, [illegible] $g_1 = g_2$. [illegible]

```
Call SetGUTScale(2.e16_dp)
```

M_{GUT} [illegible] $2 \cdot 10^{16}$ [illegible] SetGUTScale [illegible] $g_1 = g_2$ [illegible] B.

[illegible] g_3 [illegible] g_1 [illegible] g_2 [illegible] [78]. [illegible]

```
test = SetStrictUnification(.TRUE.)
```

[illegible] test [illegible] .FALSE.. [illegible] 2.2.0 [illegible] C.

B Input files

[illegible] HighScale.in [illegible] Control.in, CrossSections.in [illegible] StandardModel.in [illegible] B.1, B.2 [illegible] B.4. [illegible] SPheno [illegible] C.

B.1 Control.in

[illegible]:

```
0             ! ErrorLevel
.True.        ! Calculation of branching ratios
.True.        ! Calculation of cross sections
```

[illegible] Control.in [illegible] ErrorLevel [illegible] [-2,2] [illegible]:

-2 [illegible]

-1 [illegible]

0 [illegible]

1 [illegible]

2 [illegible]

A [illegible]

B.2 CrossSections.in

[illegible]:

```
500.          ! c.m.s. energy in GeV
0.            ! degree of longitudinal polarization of electrons
0.            ! degree of longitudinal polarization of positrons
.True.        ! calculation of initial state radiation if .TRUE.
```

[illegible] CrossSections.in [illegible] 2.2.2 [illegible] 100 [illegible]

B.3 HighScale.in

[illegible] Highscale.in [illegible] Highscale.in [illegible] SPheno. [illegible] A_0 [illegible] Y [illegible] [79]. [illegible] Appendix D [illegible]

B.3.1 mSUGRA

```
mSugra
 250.                        ! M_1/2
 100.                        ! M_0
-100.                        ! A_0
  10.                        ! tan(beta)
   1.                        ! sign of mu
.TRUE.                       ! if 2-loop RGEs should be used
```

B.3.2 mSUGRA including right handed neutrinos

```
mSugra
 250.                        ! M_1/2
 100.                        ! M_0
-100.                        ! A_0
  10.                        ! tan(beta)
   1.                        ! sign of mu
1.e14                        ! m_nu_R
1.e-14 3.e-12 0.06e-9        ! m_nu_i
.TRUE.                       ! if 2-loop RGEs should be used
```

B.3.3 GMSB

```
GMSB
100000.                       ! Lambda
200000.                       ! M_M
1                             ! N_5
0                             ! N_10
0.                            ! A0
15.                           ! tan(beta)
1.                            ! sign of mu
.TRUE.                        ! if 2-loop RGEs should be used
```

B.3.4 AMSB

[illegible]

```
AMSB             ! model
60000.           ! M_3/2
450.             ! M_0
10.              ! tan(beta)
1.               ! sign of mu
.TRUE.           ! if 2-loop RGEs should be used
```

B.3.5 String I

[illegible]

```
String_OI
180.                      ! M_3/2
14.0                      ! <t>
0.5                       ! g_s^2
0.9                       ! sin^2(theta)
 0.                       ! delta_GS
-1 -3                     ! n_E n_L
 1 -2 0                   ! n_D n_U n_Q
-1 -1                     ! n_H1 n_H2
10.                       ! tan(beta)
-1.                       ! phase(mu)
.TRUE.                    ! if 2-loop RGEs should be used
```

B.3.6 String II

[illegible]

```
5.                            ! tan(beta)
1.                            ! phase(mu)
.TRUE.                        ! if 2-loop RGEs should be used
```

[illegible]

```
String_OIIb
300.                          ! M_3/2
14.6                          ! <t>
0.5                           ! g_s^2
0.9                           ! sin^2(theta)
0.                            ! delta_GS
5.                            ! tan(beta)
1.                            ! phase(mu)
.TRUE.                        ! if 2-loop RGEs should be used
```

B.3.7 SUGRA

[illegible] non-[illegible] $M_{1/2}[U(1)]$, $M_{1/2}[SU(2)]$, $M_{1/2}[SU(3)]$, [illegible] $M^0_{\tilde{E},ii}$, $M^0_{\tilde{L},ii}$, $M^0_{\tilde{D},ii}$, $M^0_{\tilde{U},ii}$, $M^0_{\tilde{Q},ii}$; [illegible] $M^0_{H_1}$ [illegible] $M^0_{H_2}$; [illegible] $A_{0,e,ii}$, $A_{0,d,ii}$ [illegible] $A_{0,u,ii}$ [illegible] ii [illegible]

```
Sugra
480. 300. 300.          ! M_1/2_i
150. 150. 150.          ! M0_E_ii
150. 150. 150.          ! M0_L_ii
150. 150. 150.          ! M0_D_ii
150. 150. 150.          ! M0_Q_ii
150. 150. 150.          ! M0_U_ii
150. 150.               ! M0_H_i
0. 0. 0.                ! A0_u_ii
0. 0. 0.                ! A0_d_ii
0. 0. 0.                ! A0_e_ii
10.                     ! tan(beta)
1.                      ! phase(mu)
.TRUE.                  ! if 2-loop RGEs should be used
```

B.3.8 MSSM

[illegible] M_1, M_2 [illegible] M_3, [illegible] $M_{\tilde{E},ii}$, $M_{\tilde{L},ii}$, $M_{\tilde{D},ii}$, $M_{\tilde{U},ii}$, $M_{\tilde{Q},ii}$, 9 [illegible] $A_{e,ii}$, $A_{d,ii}$, $A_{u,ii}$; [illegible] β [illegible] Q [illegible] β, [illegible] μ [illegible]: m_A [illegible] $B\mu/$[illegible] β [illegible] $\beta)$.

```
MSSM
99.13 192.74 580.51                              ! M_1 M_2 M_3
136.23 136.23 133.55                             ! M_E_i
196.64 196.64 195.75                             ! M_L_i
519.53 519.53 516.86                             ! M_D_i
539.86 539.86 495.91                             ! M_Q_i
521.66 521.66 424.83                             ! M_U_i
0. 0. -510.01                                    ! A_u
0. 0. -772.66                                    ! A_d
0. 0. -254.20                                    ! A_e
10. 454.65                                       ! tan(beta) Q
352.39  393.63                                   ! mu m_A
```

[illegible] MSSMtree [illegible] MSSM [illegible]

```
10.                                              ! tan(beta)
352.39  393.63                                   ! mu m_A
```

[illegible] pMSSM [illegible] MSSM:

- m_A [illegible]
- [illegible] β [illegible] m_Z

[illegible] [7].

B.4 StandardModel.in

[illegible]:

```
91.1876                    ! m_Z
2.499.281(4)2.327.687(d)1.94718(54)256(n)1.94411(e)3.56154
2. 0.
66907( T*-66907L T*>.67009(5)1.919.288(m)l-270.6 -14.5199 Td [(3))-519.287(0)2.66958(.)-56
```

```
4.20               ! m_b(m_b)
137.0359998        ! 1./ alpha
0.1172             ! alpha_s(m_Z)
1.16639e-5         !  G_F, Fermi constant
0.224              ! s12 of CKM particle data book 1998, 90%, 0.217-0.222
0.0413             ! s23 of CKM 0.036-0.042
0.00363             ! s13 of CKM 0.0018 - 0.0044
0.                 ! phase of CKM   0.-2 Pi
2.19709e-6         ! life time of muon
3.4e-13            ! life time of tau
```

[illegible] Br [illegible]

C Implementation of SUSY Les Houches Accord

[illegible] version 2.2.0 SPheno [illegible] [28]. [illegible] LesHouches.in [illegible] SPheno.spc [illegible]:

- [illegible] EXTPAR [illegible] SPheno.
- [illegible] SPINFO. [illegible] Messages.out [illegible].

[illegible] MODSEL [illegible] EXTPAR [illegible]

[illegible] SPheno [illegible] SPhenoInput [illegible] SMINPUTS [illegible] 2.2.2 [illegible] 22-26 [illegible] 100 [illegible] 22. [illegible] id value:

1 : [illegible] App[illegible] B.
2 : [illegible] A[illegible] [80]
11 : [illegible]
12 : [illegible]
21 : [illegible]
22 : [illegible] e^+e^- [illegible] 2 -26
23 : [illegible] e^- [illegible]
24 : [illegible] e^+ [illegible]
25 : [illegible] 0
26 : [illegible]
31 : [illegible] 0
32 : [illegible] $g_3(m_{GUT})$ [illegible] $g_1(m_{GUT})$ $g_2(m_{GUT})$;
[illegible] $g_1(m_{GUT})$ $g_2(m_{GUT})$ $g_3(m_{GUT})$ [illegible]
33 : [illegible] Q_{EWSB} [illegible] 0
41 : [illegible] Z [illegible]
42 : [illegible]
51 : [illegible]
52 : [illegible]
61 : [illegible] (u, d, s, c) [illegible]
62 : [illegible]
63 : [illegible]
64 : [illegible]
65 : [illegible]
[illegible] SPheno

1g7(l)2.6J03(i)2.66907(f

1g121d000000E-04-0ri

```
Block SPhenoInput        # SPheno specific input
  1  -1                  # error level
 11   1                  # calculate branching ratios
 12   1.00000000E-04     # write only branching ratios larger than tth2.66907(i)2.g     # w
```

[illegible] SPheno [illegible] SPhenoCrossSections. [illegible] $\sqrt{s}$ [illegible]

```
Block SPhenoCrossSections  # cross sections
XS 11 -11   500.0  0.00  0.00  1  # e+ e- XS, Pe-, Pe+,  including ISR
```

[illegible]:

```
Format("XS 11 -11 ",F7.1," ",F5.2," ",F5.2," ",A)
```

[illegible]

```
#       Sigma [fb]       NDA         ID1      ID2
      2.83574498E+02     2      2000011   -2000011     # ~e_R-       ~e_R+
```

[illegible]

```
Format(3x,1P,e16.8,0p,3x,I2,3x,2(i9,1x),2x," # ",A)
```

[illegible]

```
Block SPhenoCrossSections  # cross sections
XS 11 -11   500.0  0.00  0.00  1  # e+ e- XS, Pe-, Pe+,  including ISR
#       Sigma [fb]       NDA         ID1      ID2
      2.83574498E+02     2      2000011   -2000011     # ~e_R-       ~e_R+
      7.79728001E+01     2      2000011   -1000011     # ~e_R-       ~e_L+
      4.57495061E+01     2      1000011   -1000011     # ~e_L-       ~e_L+
      5.47916441E+01     2      2000013   -2000013     # ~mu_R-      ~mu_R+
      6.00045490E-03     2      2000013   -1000013     # ~mu_R-      ~mu_L+
      1.90114309E+01     2      1000013   -1000013     # ~mu_L-      ~mu_L+
      5.96228076E+01     2      1000015   -1000015     # ~tau_1-     ~tau_1+
      1.26426385E+00     2      1000015   -2000015     # ~tau_1-     ~tau_2+
      1.59684572E+01     2      2000015   -2000015     # ~tau_2-     ~tau_2+
      4.52889205E+02     2      1000012   -1000012     # ~nu_eL      ~nu_eL*
      1.36168303E+01     2      1000014   -1000014     # ~nu_muL     ~nu_muL*
      1.39168830E+01     2      1000016   -1000016     # ~nu_tauL    ~nu_tauL*
      2.75869582E+02     2      1000022    1000022     # chi_10 chi_10
      6.56937491E+01     2      1000022    1000023     # chi_10 chi_20
      7.10141133E+00     2      1000022    1000025     # chi_10 chi_30
      8.27993814E-01     2      1000022    1000035     # chi_10 chi_40
      6.90281358E+01     2      1000023    1000023     # chi_20 chi_20
      1.60903760E+02     2      1000024   -1000024     # chi_1- chi_1+
      2.47077869E+01     2           25         23     # h0 Z
```

[illegible] $BR(b \to s\gamma)$, [illegible] $(g-2)_\mu$ [illegible] $\Delta(\rho)$) [illegible] SPheno [illegible]
SPhenoLowEnergy [illegible]:
1 : $BR(b \to s\gamma)$
2 : [illegible] $(g-2)_\mu$
3 : [illegible] $\Delta(\rho)$
[illegible]:

```
Block SPhenoLowEnergy  # low energy observables
    1    4.55809155E+00   # BR(b -> s gamma)
    2    5.42193822E-09   # (g-2)_muon
    3    1.97608480E-04   # Delta(rho)
```

D Sample output

[illegible] SPheno.out [illegible] HighScale.in [illegible] App[illegible] B. [illegible] Control.in, CrossSections.in [illegible] StandardModel.in.

```
SPheno output file
Version 2.2.2 ,  created: 14.09.2004,  17:14

 mSugra input at the GUT scale   2.4620574378552756E+16
 M_1/2      :     2.5000000000000000E+02
 M_0        :     1.0000000000000000E+02
 A_0        :    -1.0000000000000000E+02
 tan(beta) at m_Z :    10.0000000000000000
 sign(mu) :     1.0000000000000000

 Running masses have been used for the boundary conditions at mZ

 Parameters at the scale    4.8442121445544416E+02

       g'              g              g_3
  3.61098068E-01  6.46530088E-01  1.09487945E+00

      Y_e             Y_mu           Y_tau
  2.88425398E-05  5.96372335E-03  1.00306479E-01

      Y_u             Y_c             Y_t
  8.84588597E-06  3.53835431E-03  8.92075460E-01

      Y_d             Y_s             Y_b
  1.91353683E-04  3.28034867E-03  1.37341541E-01

 Gaugino mass parameters
   1.0155024266722937E+02   1.9167894566112778E+02   5.8533134393167563E+02
```

```
mu, B
  3.5775913791766874E+02   1.6731090082362174E+04

Slepton mass parameters
A_l
 -2.5344637795775390E+02  -2.5344027822464955E+02  -2.5172098902647821E+02
M2_E
  1.8443988295117768E+04   1.8441668307344480E+04   1.7789728306764348E+04
M2_L
  3.8222680589380434E+04   3.8221538628557908E+04   3.7900699251843856E+04

Squark mass parameters
A_d
 -8.5558462724494541E+02  -8.5558116731465941E+02  -7.9140619867408907E+02
A_u
 -6.8014557244910873E+02  -6.8014185758548206E+02  -4.9696697403034966E+02
M2_D
  2.7491167922793247E+05   2.7490965928240586E+05   2.7157606836767372E+05
M2_U
  2.7715958460406726E+05   2.7715762927385850E+05   1.7637959938821895E+05
M2_Q
  2.9720857969470561E+05   2.9720661515585968E+05   2.4639278946889582E+05

Higgs mass parameters
  3.2551122776108325E+04  -1.2811756834297138E+05

Masses and mixing matrices
Gluino :    6.0453116356737542E+02   1.0000000000000000

Charginos
  1.8029681792857122E+02   3.8336666782688877E+02
  U
        -0.91584          0.40153
         0.40153          0.91584
  V
        -0.97278          0.23175
         0.23175          0.97278

Neutralinos
 97.0684422442318606    1.8069642547695042E+02    3.6506776000040759E+02    3.82276404251164
  N
   1    1   (          -0.98582,           0.00000)
   1    2   (           0.05596,           0.00000)
   1    3   (          -0.14856,           0.00000)
   1    4   (           0.05430,           0.00000)
   2    1   (          -0.10355,           0.00000)
```

```
   2   2  (       -0.94298,         0.00000)
   2   3  (        0.27441,         0.00000)
   2   4  (       -0.15735,         0.00000)
   3   1  (        0.00000,         0.06043)
   3   2  (       -0.00000,        -0.09021)
   3   3  (       -0.00000,        -0.69486)
   3   4  (       -0.00000,        -0.71090)
   4   1  (        0.11737,         0.00000)
   4   2  (       -0.31546,         0.00000)
   4   3  (       -0.64792,         0.00000)
   4   4  (        0.68331,         0.00000)

e-sneutrino mass   :    1.8629967789333597E+02
mu-sneutrino mass  :    1.8629643037340736E+02
tau-sneutrino mass :    1.8538056982341820E+02

selectron masses
  1.4394583534020416E+02    2.0249814925123943E+02
 R_e
         0.00009          1.00000
        -1.00000          0.00009

smuon masses
  1.4391005493518603E+02    2.0251437533591726E+02
 R_mu
         0.01958          0.99981
        -0.99981          0.01958

stau masses
  1.3430774918769018E+02    2.0648286202975819E+02
 R_tau
         0.28332          0.95903
        -0.95903          0.28332

u-squark masses
  5.4818625728877964E+02    5.6590020431737230E+02
 R_u
         0.00006          1.00000
        -1.00000          0.00006

c-squark masses
  5.4817448074068113E+02    5.6590853096426122E+02
 R_c
         0.02385          0.99972
        -0.99972          0.02385

t-squark masses
```

```
  3.9989424629928800E+02    5.8682205427167264E+02
 R_t
          0.55322           0.83304
         -0.83304           0.55322

d-squark masses
  5.4791161728759471E+02    5.7129911929796879E+02
 R_d
          0.00058           1.00000
         -1.00000           0.00058

s-squark masses
  5.4790724305571359E+02    5.7129944562180071E+02
 R_s
          0.00999           0.99995
         -0.99995           0.00999

b-squark masses
  5.1564470876393955E+02    5.4769779167739352E+02
 R_b
          0.94719           0.32066
         -0.32066           0.94719

m_A0, m_H+
  3.9982837260329677E+02    4.0811814345802685E+02

m_h0, m_H0
  1.1082357413611736E+02    4.0020427017852177E+02
 R_S0
          0.11369           0.99352
         -0.99352           0.11369


Low energy constraints
 10^4 Br(b -> s gamma) :    0.4581123E+01
 Delta(a_mu)           :    0.5696755E-08
 Delta(rho)            :    0.2001459E-03


 Anti particles are marked with a * in case of
 (s)neutrinos and (s)quarks in the decay section.
                    Decay widths (GeV) and branching ratios

 Selectron_1
  Neutralino_1 e                0.21291502   100.00000000
 Total width :                  0.21291502
```

```
Selectron_2
 Neutralino_1 e               0.12098066    55.98037525
 Neutralino_2 e               0.03480167    16.10348944
 Chargino_1 neutrino          0.06033029    27.91613531
Total width :                 0.21611263


Smuon_1
 Neutralino_1 mu              0.21263340   100.00000000
Total width :                 0.21263340


Smuon_2
 Neutralino_1 mu              0.12115824    55.99761649
 Neutralino_2 mu              0.03482867    16.09731436
 Chargino_1 neutrino          0.06037630    27.90506915
Total width :                 0.21636321


Stau_1
 Neutralino_1 tau             0.14502344   100.00000000
Total width :                 0.14502344


Stau_2
 Neutralino_1 tau             0.15977947    58.63841454
 Neutralino_2 tau             0.04134796    15.17453244
 Chargino_1 neutrino          0.07135516    26.18705302
Total width :                 0.27248259


e-Sneutrino
 Neutralino_1 neutrino        0.14973207    94.94284818
 Neutralino_2 neutrino        0.00211800     1.34299390
 Chargino_1 e                 0.00585751     3.71415792
Total width :                 0.15770758


mu-Sneutrino
 Neutralino_1 neutrino        0.14972554    94.94874820
 Neutralino_2 neutrino        0.00211562     1.34162573
 Chargino_1 mu                0.00584974     3.70962607
Total width :                 0.15769090


tau-Sneutrino
```

Neutralino_1 neutrino	0.14788387	96.53891386
Neutralino_2 neutrino	0.00149472	0.97575508
Chargino_1 tau	0.00380717	2.48533106
Total width :	0.15318576	

Sdown_1

Neutralino_1 d-quark	0.28838606	98.56429027
Neutralino_2 d-quark	0.00269444	0.92090214
Neutralino_3 d-quark	0.00035714	0.12206173
Neutralino_4 d-quark	0.00114758	0.39221887
Total width :	0.29258676	

Sdown_2

Neutralino_1 d-quark	0.12870838	2.41531292
Neutralino_2 d-quark	1.64327451	30.83732443
Neutralino_3 d-quark	0.00857068	0.16083549
Neutralino_4 d-quark	0.08252004	1.54855280
Chargino_1 u-quark	3.23407423	60.68991849
Chargino_2 u-quark	0.23170134	4.34805586
Total width :	5.32884919	

S-strange_1

Neutralino_1 s-quark	0.28839626	98.33512617
Neutralino_2 s-quark	0.00291737	0.99474185
Neutralino_3 s-quark	0.00036637	0.12492215
Neutralino_4 s-quark	0.00114598	0.39074858
Chargino_1 c-quark	0.00045256	0.15431122
Total width :	0.29327899	

S-strange_2

Neutralino_1 s-quark	0.12869979	2.41541244
Neutralino_2 s-quark	1.64305243	30.83648512
Neutralino_3 s-quark	0.00859993	0.16140172
Neutralino_4 s-quark	0.08255413	1.54935962
Chargino_1 c-quark	3.23357116	60.68702822
Chargino_2 c-quark	0.23179659	4.35031288
Total width :	5.32827402	

Sbottom_1

Neutralino_1 b-quark	0.16653332	4.31243760
Neutralino_2 b-quark	1.34625440	34.86172159
Neutralino_3 b-quark	0.01956140	0.50654921

Neutralino_4 b-quark	0.04233574	1.09629870
Chargino_1 t-quark	1.72259277	44.60713339
Stop_1 W-	0.56442035	14.61585951
Total width :	3.86169797	

Sbottom_2

Neutralino_1 b-quark	0.24058254	31.91983477
Neutralino_2 b-quark	0.09329885	12.37863659
Neutralino_3 b-quark	0.04185389	5.55305967
Neutralino_4 b-quark	0.05807690	7.70548478
Chargino_1 t-quark	0.12191203	16.17495579
Stop_1 W-	0.19798439	26.26802841
Total width :	0.75370860	

Sup_1

Neutralino_1 u-quark	1.15420363	98.56401566
Neutralino_2 u-quark	0.01078281	0.92080534
Neutralino_3 u-quark	0.00143143	0.12223802
Neutralino_4 u-quark	0.00460140	0.39293982
Total width :	1.17101929	

Sup_2

Neutralino_1 07(0)2.66907(1)2.66907(4)2.66907(0)-2085.15(0)2.66907(.)2.66907(3)2.66907(

Neutralino_4 c-quark	0.06008384	1.08645601
Chargino_1 s-quark	3.59645144	65.03223042
Chargino_2 s-quark	0.07414186	1.34065776
Total width :	5.53026002	

Stop_1

Neutralino_1 t-quark	0.39786160	19.42136860
Neutralino_2 t-quark	0.24313066	11.86827336
Chargino_1 b-quark	1.37082175	66.91581865
Chargino_2 b-quark	0.01991200	0.97199197
c-quark neutralino_1	0.00040360	0.01970164
c-quark neutralino_2	0.01643838	0.80242915
Total width :	2.04857653	

Stop_2

Neutralino_1 t-quark	0.22193261	3.01781302
Neutralino_2 t-quark	0.64232737	8.73429056
Neutralino_3 t-quark	0.30940040	4.20718955
Neutralino_4 t-quark	1.44196179	19.60762341
Chargino_1 b-quark	1.62955414	22.15848167
Chargino_2 b-quark	1.44485203	19.64692457
Stop_1 Z	1.39455443	18.96298387
Stop_1 h0	0.26950476	3.66469336
Total width :	7.35408754	

Chargino_1

Smuon_1 neutrino	0.00004613	0.28874351
Stau_1 neutrino	0.01510357	94.54518351
Neutralino_1 W	0.00071260	4.46072016
neutralino_1 e^+ nu	0.00003745	0.23441594
neutralino_1 mu^+ nu	0.00003745	0.23441507
neutralino_1 tau^+ nu	0.00003773	0.23615356
Total width :	0.01597497	

Chargino_2

Selectron_2 neutrino	0.13339597	5.23062736
Smuon_2 neutrino	0.13343849	5.23229482
Stau_1 neutrino	0.00064169	0.02516131
Stau_2 neutrino	0.14518928	5.69305830
e-sneutrino e	0.04987592	1.95569876
mu-sneutrino mu	0.04994101	1.95825114
tau-sneutrino tau	0.06840093	2.68208833
Neutralino_1 W	0.16988544	6.66142664
Neutralino_2 W	0.73896629	28.97581836

```
  Chargino_1 Z                   0.60911313   23.88410873
  Chargino_1 h0                  0.45051419   17.66524071
  neutralino_1 b^* t             0.00030103    0.01180365
  neutralino_2 b^* t             0.00003051    0.00119636
  chargino_1 b b^*               0.00054500    0.02137000
 Total width :                   2.55028619

 Neutralino_1 : stable

 Neutralino_2
  Selectron^-_1 e^+              0.00066378    3.07448383
  Selectron^+_1 e^-              0.00066378    3.07448383
  Smuon^-_1 mu^+                 0.00069076    3.19948480
  Smuon^+_1 mu^-                 0.00069076    3.19948480
  Stau^-_1 tau^+                 0.00939369   43.50975897
  Stau^+_1 tau^-                 0.00939369   43.50975897
  neutralino_1 u u^*             0.00000345    0.01599688
  neutralino_1 c c^*             0.00000345    0.01597295
  neutralino_1 d d^*             0.00000459    0.02123795
  neutralino_1 s s^*             0.00000459    0.02123789
  neutralino_1 b b^*             0.00000472    0.02186206
  neutralino_1 nu_e   nu_e^      0.00001768    0.08190096
  neutralino_1 nu_mu  nu_mu      0.00001769    0.08192757
  neutralino_1 nu_tau nu_ta      0.00001944    0.09003518
  neutralino_1 e^-    e^+        0.00000630    0.02919519
  neutralino_1 mu^-   mu^+       0.00000630    0.02917454
  neutralino_1 tau^-  tau^+      0.00000514    0.02379866
 Total width :                   0.02158986


 Neutralino_3
  Selectron^-_1 e^+              0.00245868    0.12468320
  Selectron^+_1 e^-              0.00245868    0.12468320
  Selectron^-_2 e^+              0.00115857    0.05875282
  Selectron^+_2 e^-              0.00115857    0.05875282
  Smuon^-_1 mu^+                 0.00247970    0.12574917
  Smuon^+_1 mu^-                 0.00247970    0.12574917
  Smuon^-_2 mu^+                 0.00120501    0.06110808
  Smuon^+_2 mu^-                 0.00120501    0.06110808
  Stau^-_1 tau^+                 0.00993392    0.50376391
  Stau^+_1 tau^-                 0.00993392    0.50376391
  Stau^-_2 tau^+                 0.01297595    0.65802945
  Stau^+_2 tau^-                 0.01297595    0.65802945
  e-sneutrino nu_e^*             0.00636550    0.32280417
  e-sneutrino^* nu_e             0.00636550    0.32280417
  mu-sneutrino nu_mu^*           0.00636566    0.32281210
  mu-sneutrino^* nu_mu           0.00636566    0.32281210
```

tau-sneutrino nu_tau^*	0.00640970	0.32504561
tau-sneutrino^* nu_tau	0.00640970	0.32504561
Chargino^+_1 W^-	0.58233645	29.53114356
Chargino^-_1 W^+	0.58233645	29.53114356
Neutralino_1 Z	0.22153690	11.23446435
Neutralino_2 Z	0.42050000	21.32417766
Neutralino_1 h0	0.04208071	2.13397535
Neutralino_2 h0	0.02440336	1.23753049
Neutralino_2 photon	0.00002030	0.00102937
Total width :	1.97194005	

Neutralino_4

Selectron^-_1 e^+	0.01003487	0.37554208
Selectron^+_1 e^-	0.01003487	0.37554208
Selectron^-_2 e^+	0.02565497	0.96010376
Selectron^+_2 e^-	0.02565497	0.96010376
Smuon^-_1 mu^+	0.01001475	0.37478909
Smuon^+_1 mu^-	0.01001475	0.37478909
Smuon^-_2 mu^+	0.02572432	0.96269931
Smuon^+_2 mu^-	0.02572432	0.96269931
Stau^-_1 tau^+	0.00708230	0.26504573
Stau^+_1 tau^-	0.00708230	0.26504573
Stau^-_2 tau^+	0.04322619	1.61768406
Stau^+_2 tau^-	0.04322619	1.61768406
e-sneutrino nu_e^*	0.06696143	2.50594432
e-sneutrino^* nu_e	0.06696143	2.50594432
mu-sneutrino nu_mu^*	0.06696288	2.50599874
mu-sneutrino^* nu_mu	0.06696288	2.50599874
tau-sneutrino nu_tau^*	0.06737263	2.52133329
tau-sneutrino^* nu_tau	0.06737263	2.52133329
Chargino^+_1 W^-	0.68286763	25.55543352
Chargino^-_1 W^+	0.68286763	25.55543352
Neutralino_1 Z	0.05548528	2.07646431
Neutralino_2 Z	0.05010799	1.87522654
Neutralino_1 h0	0.18248851	6.82939545
Neutralino_2 h0	0.37208545	13.92481435
Neutralino_2 photon	0.00003496	0.00130835
Total width :	2.67210349	

Gluino

Sup_1 u^*	0.22549273	4.93757980
Sup_1^* u	0.22549273	4.93757980
Sup_2 u^*	0.10927993	2.39288589
Sup_2^* u	0.10927993	2.39288589
S-charm_1 c^*	0.22529588	4.93326946

S-charm_1^* c	0.22529588	4.93326946
S-charm_2 c^*	0.10935220	2.39446832
S-charm_2^* c	0.10935220	2.39446832
Stop_1 t^*	0.23631434	5.17453901
Stop_1^* t	0.23631434	5.17453901
Sdown_1 d^*	0.22758779	4.98345500
Sdown_1^* d	0.22758779	4.98345500
Sdown_2 d^*	0.08161707	1.78715654
Sdown_2^* d	0.08161707	1.78715654
S-strange_1 s^*	0.22761069	4.98395651
S-strange_1^* s	0.22761069	4.98395651
S-strange_2 s^*	0.08162105	1.78724357
S-strange_2^* s	0.08162105	1.78724357
Sbottom_1 b^*	0.51303196	11.23378233
Sbottom_1^* b	0.51303196	11.23378233
Sbottom_2 b^*	0.23942646	5.24268461
Sbottom_2^* b	0.23942646	5.24268461
Stop_1 c^*	0.00526030	0.11518395
Stop_1^* c	0.00526030	0.11518395
neutralino_2 gluon	0.00021864	0.00478751
neutralino_3 gluon	0.00032667	0.00715313
neutralino_4 gluon	0.00037459	0.00820239
neutralino_1 t t^*	0.00008996	0.00196988
neutralino_2 t t^*	0.00009543	0.00208969
chargino^+_1 t^* b	0.00067696	0.01482320
chargino^-_1 t b^*	0.00067696	0.01482320
chargino^+_2 t^* b	0.00030059	0.00658192
chargino^-_2 t b^*	0.00030059	0.00658192
Total width :	4.56686756	

h0

muons	0.00000104	0.03717403
taus	0.00029367	10.49412940
s-quark	0.00000127	0.04524099
b-quark	0.00216519	77.37202572
c-quark	0.00010749	3.84124361
W+ W-*	0.00005707	2.03933591
W+* W-	0.00005707	2.03933591
Z Z*	0.00000615	0.21967100
g g	0.00010946	3.91166457
Total width :	0.00279842	

H0

muons	0.00028046	0.03480344
taus	0.07932609	9.84378583
s-quark	0.00031273	0.03880696

b-quark	0.54671657	67.84351804
t-quark	0.03547964	4.40276284
Selectron 1 1	0.00038368	0.04761235
Smuon 1 1	0.00039169	0.04860540
Smuon 1 2	0.00001977	0.00245370
Smuon 2 1	0.00001977	0.00245370
Stau 1 1	0.00461331	0.57247839
Stau 1 2	0.00404359	0.50178033
Stau 2 1	0.00404359	0.50178033
e-Sneutrino	0.00089263	0.11076927
mu-Sneutrino	0.00089273	0.11078183
tau-Sneutrino	0.00092078	0.11426177
neutralino_1 neutralino_1	0.01634146	2.02785540
neutralino_1 neutralino_2	0.04742007	5.88448299
neutralino_2 neutralino_2	0.01339966	1.66280004
chargino^+_1 chargino^-_1	0.03593261	4.45897405
Z Z	0.00145026	0.17996641
W+ W-	0.00310488	0.38529262
h0 h0	0.00951582	1.18084312
g g	0.00034176	0.04241034
Total width :	0.80584938	

A0

muons	0.00028106	0.02300774
taus	0.07950191	6.50800650
s-quark	0.00031341	0.02565593
b-quark	0.54815429	44.87177335
t-quark	0.11221779	9.18611989
Smuon 1 2	0.00002049	0.00167718
Smuon 2 1	0.00002049	0.00167718
Stau 1 2	0.00594160	0.48637805
Stau 2 1	0.00594160	0.48637805
neutralino_1 neutralino_1	0.02505516	2.05100917
neutralino_1 neutralino_2	0.10779205	8.82383050
neutralino_2 neutralino_2	0.09278079	7.59501200
chargino^+_1 chargino^-_1	0.24090139	19.72012765
h0 Z	0.00267484	0.21896208
Total width :	1.22160158	

H^+

muon neutrino	0.00028679	0.04230494
tau neutrino	0.08112135	11.96655479
s-quark c-quark	0.00026690	0.03937192

b-quark t-quark	0.43329892	63.91775887
Selectron_2 Sneutrino	0.00073931	0.10905855
Smuon_1 Sneutrino	0.00005822	0.00858803
Smuon_2 Sneutrino	0.00073338	0.10818334
Stau_1 Sneutrino	0.01538016	2.26879229
chargino_1 neutralino_1	0.14190050	20.93234365
chargino_1 neutralino_2	0.00107290	0.15826853
h0 W	0.00303784	0.44812476
Total width :	0.67790067	

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