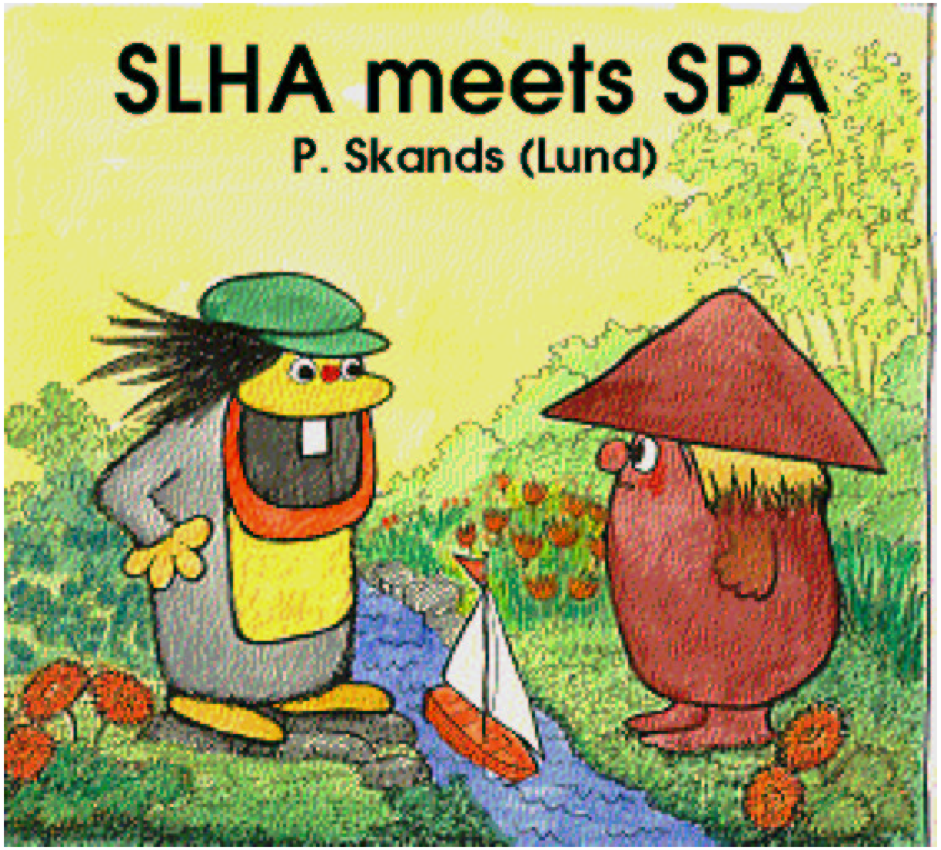

The SUSY Les Houches Accord **hep-ph/0311123**:

P. Skands, B.C. Allanach, H. Baer, C. Balázs, G. Bélanger, F. Boudjema, A. Djouadi, R. Godbole, J. Guasch, S. Heinemeyer, W. Kilian, J. Kneur, S. Kraml, F. Moortgat, S. Moretti, M. Mühlleitner, W. Porod, A. Pukhov, P. Richardson, S. Schumann, P. Slavich, M. Spira, G. Weiglein

Overview

1. SLHA — Why?
2. The SUSY Les Houches Accord.
3. (Examples.)
4. Concluding Remarks.

1. SLHA — Why?

SUSY model

- MSSM
- SUGRA
- GMSB
- AMSB
- RPV
- CPV
- NMSSM
- ...

→ **Spectrum Calculator**

- FEYNHIGGS
- ISASUSY
- (PYTHIA)
- SOFTSUSY
- SPHENO
- SUSPECT
- ...

→ **Parton Level Event Generator**

- COMPHEP
- GRACE
- HERWIG
- ISAJET
- PROSPINO
- PYTHIA
- SHERPA
- SUSYGEN
- WHIZARD
- ...

CDM Package

- MICRΩS
- DARKSUSY
- NEUTDRIVER
- ...

Decay Package

- HDECAY
- SDECAY NEW!
- ...

Mühlleitner et al.
hep-ph/0311167
NLO QCD SUSY Decays

1. SLHA — Why? to make life easier.

SUSY model

MSSM
SUGRA
GMSB
AMSB
RPV
CPV
NMSSM
...

→ SLHA Input →

Spectrum Calculator

FEYNHIGGS
ISASUSY
(PYTHIA)
SOFTSUSY
SPHENO
SUSPECT
...

→ SLHA Input + Spectrum →

Parton Level Event Generator

COMPHEP
GRACE
HERWIG
ISAJET
PROSPINO
PYTHIA
SHERPA
SUSYGEN
WHIZARD
...

SLHA Input + Spectrum → **CDM Package**, **Decay Package**

CDM Package

MICRΩS
DARKSUSY
NEUTDRIVER
...

Decay Package

HDECAY
SDECAY
...

→ SLHA Input + Spectrum + Decay table → Parton Level Event Generator

1. SLHA — Why? to make life easier.

SUSY model → (SLHA Input) → **Spectrum Calculator** → (SLHA Input + Spectrum) → **Parton Level Event Generator**

SUSY model
- MSSM✔
- SUGRA✔
- GMSB✔
- AMSB✔
- RPV
- CPV
- NMSSM
- ...

Spectrum Calculator
- FEYNHIGGS✔
- ISASUSY(✔)
- (PYTHIA)✔
- SOFTSUSY✔
- SPHENO✔
- SUSPECT(✔)
- ...

Parton Level Event Generator
- COMPHEP
- GRACE
- HERWIG
- ISAJET
- PROSPINO
- PYTHIA✔
- SHERPA
- SUSYGEN
- WHIZARD
- ...

Spectrum Calculator → (SLHA Input + Spectrum) → **CDM Package** and **Decay Package**

CDM Package
- MICRΩS✔
- DARKSUSY
- NEUTDRIVER
- ...

Decay Package
- HDECAY
- SDECAY✔
- ...

Decay Package → (SLHA Input + Spectrum + Decay table) → Parton Level Event Generator

Overview

1. SLHA — Why?
2. The SUSY Les Houches Accord.
3. (Examples.)
4. Concluding Remarks.

SLHA — Considerations:

- ## Flexible/Extendable

  Structure should be general enough to *eventually* handle *any* model.

- ## Consistency

  Parameters must be consistently and unambiguously defined.

- ## Easy to implement and use

  Address what is actually on the market, and make sure humans can understand it too.

SLHA — Considerations:

- **Flexible/Extendable**
  Structure should be general enough to *eventually* handle *any* model.

- **Consistency**
  Parameters must be consistently and un-ambiguously defined.

- **Easy to implement and use**
  Address what is actually on the market, and make sure humans can understand it too.

2. The SUSY Les Houches Accord

Conventions & Consistency:

1. Experimental Boundary Conditions
   (measured “SM” couplings & masses).
2. Defining the SUSY model
   (in a form suitable to spectrum calculation programs).
3. Communicating the resulting spectrum
   (in a form suitable for cross section and width calculations).

$\rightarrow$ pretty much ‘theoretician’s definitions’, you start with assumptions about the high scale physics and work out the low scale consequences.

2. The SUSY Les Houches Accord

Conventions & Consistency:

1. Experimental Boundary Conditions

$\alpha_{\rm em}(m_{\rm Z})$	$\frac{\alpha}{1-\Delta\alpha_{\rm lep}(m_{\rm Z})-\Delta\alpha^{(5)}_{\rm had}(m_{\rm Z})-\Delta\alpha_{\rm top}(m_{\rm Z})}$
G_F	The Fermi constant determined from μ decay
$m_{\rm Z}$	The $\rm Z$ boson pole mass
$\alpha_s(m_{\rm Z})^{\overline{\rm MS}}$	The 5–flavour $\overline{\rm MS}$ strong coupling at $m_{\rm Z}$
$m_{\rm b}(m_{\rm b})^{\overline{\rm MS}}$	The $\overline{\rm MS}$ $\rm b$ quark running mass at $m_{\rm b}$
$m_{\rm t}$	Top pole mass
m_τ	Tau pole mass

Note: no SUSY corrections here!

Conventions & Consistency:

2. Defining the SUSY Model

$\mathrm{sgn}(\mu)$	$W_\mu = \epsilon_{ab}\left[-\mu H_1^a H_2^b\right]$, $(\epsilon_{12} = 1)$
$\tan\beta(m_Z)^{\overline{\mathrm{DR}}}$	v_2/v_1 (can also be given at $Q \neq m_Z$)
$V_3(M_{\mathrm{input}})$	$\epsilon_{ab}\sum_{ij}\left[(T_E)_{ij}H_1^a\tilde{L}^b_{i_L}\tilde{e}^*_{j_R} + (T_D)_{ij}H_1^a\tilde{Q}^b_{i_L}\tilde{d}^*_{j_R} + (T_U)_{ij}H_2^b\tilde{Q}^a_{i_L}\tilde{u}^*_{j_R}\right] + \mathrm{h.c.}$, $A_{ij} = T_{ij}/Y_{ij}$
$V_2(M_{\mathrm{input}})$	$m^2_{H_j}H^*_{j\,a}H^a_j + \tilde{Q}^*_{i_L a}(m^2_{\tilde{Q}})_{ij}\tilde{Q}^a_{j_L} + \tilde{L}^*_{i_L a}(m^2_{\tilde{L}})_{ij}\tilde{L}^a_{j_L} + \tilde{q}_{i_R}(m^2_{\tilde{q}})_{ij}\tilde{q}^*_{j_R} + \tilde{e}_{i_R}(m^2_{\tilde{e}})_{ij}\tilde{e}^*_{j_R} - (m_3^2\epsilon_{ab}H_1^a H_2^b + \mathrm{h.c.})$
	○ Either $(m^2_{H_1}, m^2_{H_2})$ or $(\mu, m_A^2 = \frac{m_3^2}{\sin\beta\cos\beta})$
$\mathcal{L}_G(M_{\mathrm{input}})$	$\frac{1}{2}\left(M_1\tilde{b}\tilde{b} + M_2\tilde{w}^A\tilde{w}^A + M_3\tilde{g}^X\tilde{g}^X\right) + \mathrm{h.c.}$

2. The SUSY Les Houches Accord

Conventions & Consistency:

3. Communicating the Spectrum: $\overline{\mathrm{DR}}$ parameters

$W(Q_i)^{\overline{\mathrm{DR}}}$	$\epsilon_{ab}\left[(Y_E)_{ij}H_1^aL_i^b\bar{E}_j + (Y_D)_{ij}H_1^aQ_i^b\bar{D}_j + (Y_U)_{ij}H_2^bQ_i^a\bar{U}_j - \mu H_1^aH_2^b\right]$
$\tan\beta(Q_i)^{\overline{\mathrm{DR}}}$	v_2/v_1
$g_j(Q_i)^{\overline{\mathrm{DR}}}$	g', g, and g_3: gauge couplings
$A_j(Q_i)^{\overline{\mathrm{DR}}}$	Soft breaking trilinear couplings
$(v_j(Q_i)^{\overline{\mathrm{DR}}})$	$\sqrt{2}\langle H_j^0\rangle$, so $v^2=(v_1^2+v_2^2)=(246$ GeV$)^2$
$(M_j(Q_i)^{\overline{\mathrm{DR}}})$	Soft breaking gaugino masses
$(m_j(Q_i)^{\overline{\mathrm{DR}}})$	Soft breaking sfermion masses
$(m_A(Q_i)^{\overline{\mathrm{DR}}})$	Running A mass.

In hep-ph writeup / Being included, before journal submission

Conventions & Consistency:

3. Communicating the Spectrum: mixing matrices

- mixing angles avoided, matrix elements given instead.
- No consensus on best scheme $\rightarrow$
  Effective 'best choice' definitions, at the discretion of each spectrum calculator.

E.g. α: Diagonalizes loop–corrected mass matrices, but not a $\overline{\mathrm{DR}}$ or $\overline{\mathrm{MS}}$ parameter. Still, not scale independent. On–shell scheme has scale fixed by renormalization conditions, and external propagators still carry some momentum, which momentum?

Overview

1. SLHA — Why?
2. The SUSY Les Houches Accord.
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4. Concluding Remarks.

3. Examples

```
# SUSY Les Houches Accord 1.0
# Example input file - Snowmass point 1a
Block MODSEL   # Model selection
     1     1      # SUGRA model
Block SMINPUTS # SM parameters
     5     4.25   # mb(mb)
     6   173.8    # t pole mass
Block MINPAR   # Model Parameters
     1   100.     # m0
     2   250.     # m12
     3    10.     # tanbeta
     4     1.     # sgnmu
     5  -100.     # A0
```

3. Examples

```
# SUSY Les Houches Accord 1.0
# Example spectrum file - Snowmass point 1a
Block SPINFO          # Program information
     1   SOFTSUSY     # spectrum calculator
     2   1.8          # version number
Block MODSEL  # Select model
     1   1  # sugra
Block MINPAR  # Input parameters
     1   1.000000000e+02  # m0
     2   2.500000000e+02  # m12
     3   1.000000000e+01  # tanb
     4   1.000000000e+00  # sign(mu)
     5  -1.000000000e+02  # A0
Block SMINPUTS # SM parameters
     1   1.289700000e+02  # 1/alpha(MZ)[OS]
     2   1.166390000e-05  # Gmu [GeV**-2]
     3   1.120000000e-01  # alphas(MZ)[MSbar]
     4   9.118760000e+01  # Z pole mass
     5   4.250000000e+00  # mb(mb)[MSbar]
     6   1.738000000e+02  # t pole mass
     7   1.776990000e+00  # tau pole mas
Block MASS  # Mass spectrum (pole masses)
        25     1.096471686e+02  # h0
        35     3.905646065e+02  # H0
        36     3.849267509e+02  # A0
        37     3.963987424e+02  # H+
   1000001     5.537379281e+02  # sd(L)
   1000002     5.480648005e+02  # su(L)
   1000003     5.536689385e+02  # ss(L)
   1000004     5.479950083e+02  # sc(L)
   1000005     4.990864878e+02  # sb(1)
   1000006     3.866681125e+02  # st(1)
   1000011     2.005077001e+02  # se(L)
   1000012     1.844822029e+02  # snue(L)
   1000013     2.005050044e+02  # smu(L)
   1000014     1.844792730e+02  # snumu(L)
   1000015     1.339969762e+02  # stau(1)
   1000016     1.836242253e+02  # snu(tau(L))
   1000021     5.934756712e+02  # gluino
   1000022     9.701573617e+01  # neutralino(1)
   1000023     1.788864799e+02  # neutralino(2)
   1000024     1.782649096e+02  # chargino(1)
   1000025    -3.536102287e+02  # neutralino(3)
   1000035     3.733417082e+02  # neutralino(4)
   1000037     3.736128390e+02  # chargino(2)
   2000001     5.269676664e+02  # sd(R)
   2000002     5.311251030e+02  # su(R)
   2000003     5.269652151e+02  # ss(R)
   2000004     5.309795680e+02  # sc(R)
   2000005     5.257115262e+02  # sb(2)
   2000006     5.704560875e+02  # st(2)
   2000011     1.430886701e+02  # se(R)
   2000013     1.430810123e+02  # smu(R)
   2000015     2.043832731e+02  # stau(2)
Block alpha # Effective Higgs mixing angle alph
         -1.146864127e-01  # alpha
Block hmix Q= 4.520624648e+02  # DRbar Higgs mi
     1     3.439934743e+02  # mu
Block stopmix  # stop mixing matrix
  1  1     5.443784304e-01  # O(1,1)
  1  2     8.388397490e-01  # O(1,2)
  2  1     8.388397490e-01  # O(2,1)
  2  2    -5.443784304e-01  # O(2,2)
Block sbotmix  # sbottom mixing matrix
  1  1     9.355024721e-01  # O(1,1)
  1  2     3.533201449e-01  # O(1,2)
  2  1    -3.533201449e-01  # O(2,1)
  2  2     9.355024721e-01  # O(2,2)
Block staumix  # stau mixing matrix
  1  1     2.810947184e-01  # O(1,1)
  1  2     9.596800297e-01  # O(1,2)
  2  1     9.596800297e-01  # O(2,1)
  2  2    -2.810947184e-01  # O(2,2)
# Gaugino-higgsino mixing
Block nmix  # neutralino mixing matrix
  1  1     9.849417415e-01  # N(1,1)
  1  2    -5.795970738e-02  # N(1,2)
  1  3     1.526931274e-01  # N(1,3)
  1  4    -5.670314904e-02  # N(1,4)
  2  1     1.090115410e-01  # N(2,1)
  2  2     9.374300545e-01  # N(2,2)
  2  3    -2.852021039e-01  # N(2,3)
  2  4     1.673354023e-01  # N(2,4)
...
```

3. Examples

```
# SUSY Les Houches Accord 1.0
# Example decay file - Gluino decays
Block DCINFO      # Program information
     1    SDECAY    # Decay package
     2    1.0       # version number
#         PDG            Width
DECAY   1000021    1.01752300e+00   # gluino decays
#           BR          NDA       ID1         ID2
     4.18313300E-02    2      1000001          -1   # BR(sg -> sd(L) dbar)
     1.55587600E-02    2      2000001          -1   # BR(sg -> sd(R) dbar)
     3.91391000E-02    2      1000002          -2   # BR(sg -> su(L) ubar)
     1.74358200E-02    2      2000002          -2   # BR(sg -> su(R) ubar)
     4.18313300E-02    2      1000003          -3   # BR(sg -> ss(L) sbar)
     1.55587600E-02    2      2000003          -3   # BR(sg -> ss(R) sbar)
     3.91391000E-02    2      1000004          -4   # BR(sg -> sc(L) cbar)
     1.74358200E-02    2      2000004          -4   # BR(sg -> sc(R) cbar)
     1.13021900E-01    2      1000005          -5   # BR(sg -> sb(1) bbar)
     6.30339800E-02    2      2000005          -5   # BR(sg -> sb(2) bbar)
     9.60140900E-02    2      1000006          -6   # BR(sg -> st(1) tbar)
     0.00000000E+00    2      2000006          -6   # BR(sg -> st(2) tbar)
     4.18313300E-02    2     -1000001           1   # BR(sg -> sdbar(L) d)
     1.55587600E-02    2     -2000001           1   # BR(sg -> sdbar(R) d)
     3.91391000E-02    2     -1000002           2   # BR(sg -> subar(L) u)
     1.74358200E-02    2     -2000002           2   # BR(sg -> subar(R) u)
     4.18313300E-02    2     -1000003           3   # BR(sg -> ssbar(L) s)
     1.55587600E-02    2     -2000003           3   # BR(sg -> ssbar(R) s)
     3.91391000E-02    2     -1000004           4   # BR(sg -> scbar(L) c)
     1.74358200E-02    2     -2000004           4   # BR(sg -> scbar(R) c)
     1.13021900E-01    2     -1000005           5   # BR(sg -> sbbar(1) b)
     6.30339800E-02    2     -2000005           5   # BR(sg -> sbbar(2) b)
     9.60140900E-02    2     -1000006           6   # BR(sg -> stbar(1) t)
     0.00000000E+00    2     -2000006           6   # BR(sg -> stbar(2) t)
```

Concluding Remarks

The SUSY Les Houches Accord:

- A set of self–consistent conventions for MSSM models.
- Definite file structures for model input, mass and coupling spectra, and decay tables.
- Many programs already implemented SLHA, more on the way.

Concluding Remarks

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- A set of self–consistent conventions for MSSM models.
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To do:

- CPV, RPV. NMSSM ... ?

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- [SPA: fill in wish list here]