MC4LHC - SUSY Decay Packages

Introduction & Brainstorm

SUSY Interface and SM/BSM decay tables.

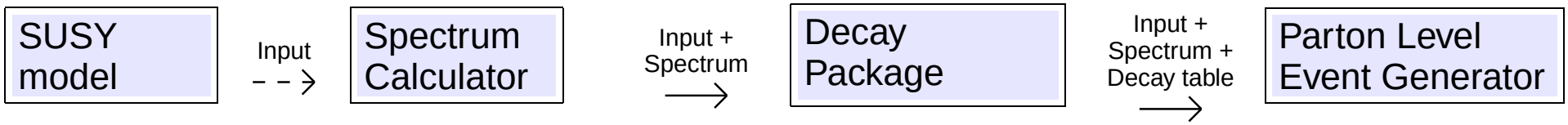
P. Skands (Lund).

1. Aims & scope.
2. The Les Houches Accord (#3).
3. Input for (minimal) spectrum calculations.
4. Decay tables (SUSY + SM + other BSM?)
5. Extended models and/or Higher orders.

Aims & scope

SUSY INTERFACE

Les Houches Accord #3



SUGRA
GMSB
AMSB
NMSSM
RPV
CPV
ESSM
...

(FeynHiggs)
ISASUSY ✓
(PYTHIA ✓)
SOFTSUSY✓
SPHENO ✓
SUSPECT
...

HDECAY
SDECAY ✓
+ OTHER BSM?
...

COMPHEP
GRACE
HDECAY
HERWIG (✓)
ISAJET (✓)
PROSPINO
PYTHIA ✓
SUSYGEN (✓)
...

The Les Houches Accord

General Structure:

- Particles are identified by PDG code:

  $\tilde{t}_1$ = 1000006, $\tilde{e}_R$ = 2000011, ...

- Spectrum File and Decay Table(s), divided into named blocks:

  BLOCK MASS, BLOCK STOPMIX, BLOCK NMIX, DECAY 1000006, ...

- A unique set of conventions for input/output, necessary for unambiguous interpretation of parameters.

  CP $\Longrightarrow$ Real mixing matrices, $m_{\tilde{t}_1} < m_{\tilde{t}_2}$, ...

- Running parameters: a grid of values may be provided, for logarithmic interpolation.

  BLOCK GAUGE Q= 1.00000000E+02, BLOCK GAUGE Q= 1.00000000E+03, ...

- All the gory details in the Les Houches Summary:

  http://www.thep.lu.se/~zeiler/projects/lhs.ps.gz

```
# SoftSusy − SUSY Les Houches Accord − MSSM spectrum
Block MODSEL  # Select model
    1    1  # sugra
Block MINPAR  # Input parameters
  101   1.000000000e+02  # m0
  102   2.500000000e+02  # m12
  103   1.000000000e+01  # tanb
  104   1.000000000e+00  # sign(mu)
  105  −1.000000000e+02  # A0
#
Block MASS  # Mass spectrum
#PDG code      mass               particle
         25    1.096471686e+02  # h0
         35    3.905646065e+02  # H0
         36    3.849267509e+02  # A0
         37    3.963987424e+02  # H+
    1000001    5.537379281e+02  # ~d_L
    1000002    5.480648005e+02  # ~u_L
    1000003    5.536689385e+02  # ~s_L
    1000004    5.479950083e+02  # ~c_L
    1000005    4.990864878e+02  # ~b_1
    1000006    3.866681125e+02  # ~t_1
    1000011    2.005077001e+02  # ~e_L
    1000012    1.844822029e+02  # ~snue_L
    1000013    2.005050044e+02  # ~mu_L
    1000014    1.844792730e+02  # ~snumu_L
    1000015    1.339969762e+02  # ~stau_1
    1000016    1.836242253e+02  # ~snu_tau_L
    1000021    5.934756712e+02  # ~g
    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  # ~d_R
    2000002    5.311251030e+02  # ~u_R
    2000003    5.269652151e+02  # ~s_R
    2000004    5.309795680e+02  # ~c_R
    2000005    5.257115262e+02  # ~b_2
    2000006    5.704560875e+02  # ~t_2
    2000011    1.430886701e+02  # ~e_R
    2000013    1.430810123e+02  # ~mu_R
    2000015    2.043832731e+02  # ~stau_2
# Higgs mixing
Block hmix Q= 4.520624648e+02  # Higgs mixing parameters
    1   −1.146864127e−01  # alpha
    2    3.439934743e+02  # mu
Block stopmix  # stop mixing matrix
  1  1    5.443784304e−01  # O_{11}
  1  2    8.388397490e−01  # O_{12}
```



```
  2  1    8.388397490e−01  # O_{21}
  2  2   −5.443784304e−01  # O_{22}
Block sbotmix  # sbottom mixing matrix
  1  1    9.355024721e−01  # O_{11}
  1  2    3.533201449e−01  # O_{12}
  2  1   −3.533201449e−01  # O_{21}
  2  2    9.355024721e−01  # O_{22}
Block staumix  # stau mixing matrix
  1  1    2.810947184e−01  # O_{11}
  1  2    9.596800297e−01  # O_{12}
  2  1    9.596800297e−01  # O_{21}
  2  2   −2.810947184e−01  # O_{22}
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  1   −6.143190096e−02  # N_{3,1}
  3  2    9.173963120e−02  # N_{3,2}
  3  3    6.949466769e−01  # N_{3,3}
  3  4    7.105343608e−01  # N_{3,4}
  4  1   −1.192995029e−01  # N_{4,1}
  4  2    3.308313851e−01  # N_{4,2}
  4  3    6.421788575e−01  # N_{4,3}
  4  4   −6.811200615e−01  # N_{4,4}
Block Umix  # chargino U mixing matrix
  1  1    9.084497528e−01  # U_{1,1}
  1  2   −4.179940750e−01  # U_{1,2}
  2  1    4.179940750e−01  # U_{2,1}
  2  2    9.084497528e−01  # U_{2,2}
Block Vmix  # chargino V mixing matrix
  1  1    9.691507874e−01  # V_{1,1}
  1  2   −2.464685606e−01  # V_{1,2}
  2  1    2.464685606e−01  # V_{2,1}
  2  2    9.691507874e−01  # V_{2,2}
Block yatop Q= 4.520624648e+02  # (SUSY scale)
    1    8.944749998e−01  # Yt(Q)MSSM DRbar
    2   −4.713090005e+02  # At(Q)MSSM DRbar
Block yabot Q= 4.520624648e+02  # (SUSY scale)
    1    1.454916965e−01  # Yb(Q)MSSM DRbar
    2   −6.039636586e+02  # Ab(Q)MSSM DRbar
Block yatau Q= 4.520624648e+02  # (SUSY scale)
    1    9.977348866e−02  # Ytau(Q)MSSM DRbar
    2   −2.513543943e+02  # Atau(Q)MSSM DRbar
Block SPINFO          # Program information
    1    SOFTSUSY    # spectrum calculator
    2    1.8         # version number
```

3. Spectrum output blocks

Block MASS	- Pole mass spectrum.
Block NMIX	- –’’–
Block UMIX	- –’’–
Block VMIX	- –’’–
Block STOPMIX	- EW scale sfermion mixing.
Block SBOTMIX	- –’’–
Block STAUMIX	- –’’–
Block HMIX Q=...	- α and μ at scale Q.
(Block GAUGE Q=...	- g', g, and g_3 at scale Q.)
Block YATOP Q=...	- Trilinear coupling and Yukawa at scale Q.
Block YABOT Q=...	- –’’–
Block YATAU Q=...	- –’’–
Block YAMU Q=...	- –’’–
Block SPINFO	- Spectrum calculator program and version number.

Need to consider: RPV, CPV, NMSSM, ...

Input for (minimal) spectrum calculations

- mSUGRA, mGMSB, mAMSB GUT parameters.

  Already there?

- Boundary conditions / assumptions.

  I.e. top mass, $\alpha_s(m_Z)$, $\sin^2\theta_W$, ... Different values / interpretations $\Rightarrow$ inconsistencies. Not essential for discovery tools, but will be important for subsequent precision studies.

- Options for the calculation.

  E.g. number of loops in RGE's. What is needed by subsequent calculators that is not above? Can it be standardized?

- Extended model inputs.

  Phases, NMSSM, RPV, etc. $\rightarrow$ next workshop?

Decay Tables

- Nothing “SUSY” about a decay table + more than 1 standards is not a standard $\Rightarrow$ should agree with SM + other BSM people on this.

- At present: using PDG numbers + comments in a format like:

```
DECAY   1000021  WIDTH= 1.017523300E+01   # gluino decays
#          BR          NDA     ID1       ID2
     4.183132700E-02    2     1000001        -1   # BR( g -> ~d_L dbar)
     1.555876400E-02    2     2000001        -1   # BR( g -> ~d_R dbar)
     3.913909700E-02    2     1000002        -2   # BR( g -> ~u_L ubar)
     1.743581800E-02    2     2000002        -2   # BR( g -> ~u_R ubar)
     ...
Block DCINFO          # Program information
     1    SDECAY       # Decay package
     2    1.0          # version number
```

- First character = control character (same as spectrum).
  Thus, more information about one chanel, e.g. helicity structure etc., may be added on subsequent lines (using “+” as the £rst character on such lines).

4. Issues Remaining – tentative(!)

1. **Input to the spectrum calculators.**

2. **Decay tables (SUSY + other BSM?).**
   Tue. 15/7, 09:00 – 12:00; Salle A.

3. **Non-minimal models (input & output).**

4. **Higher orders / Hi $\leftrightarrow$ Lo RGE precision?**

5. **Other issues? Agenda will be £xed now!**

Mon. 14/7, 16:00 – 18:00; Salle A.
Tue. 14/7, 09:00 – 12:00; Salle A.
Tue. 14/7, 14:00 – 18:00; Salle A.
Wed. 14/7, 09:00 – 12:00; Salle A.
(Wed. 14/7, 14:00 – 18:00; Salle A.)