The SUSY Les Houches Accord

Interfacing SUSY Spectrum Calculators, Decay Packages, and Event Generators

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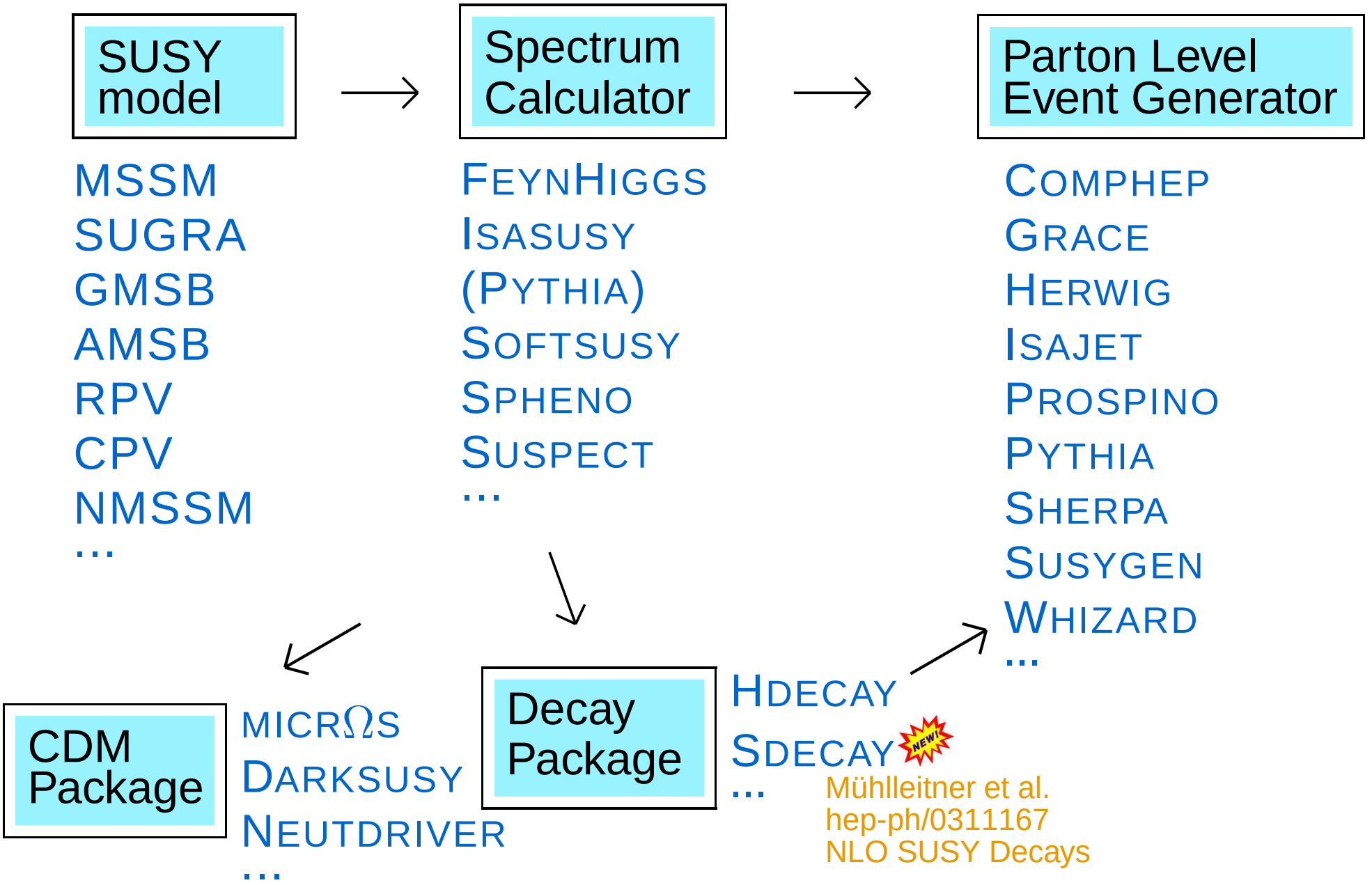
Writeup 10'th Nov:

hep-ph/0311123

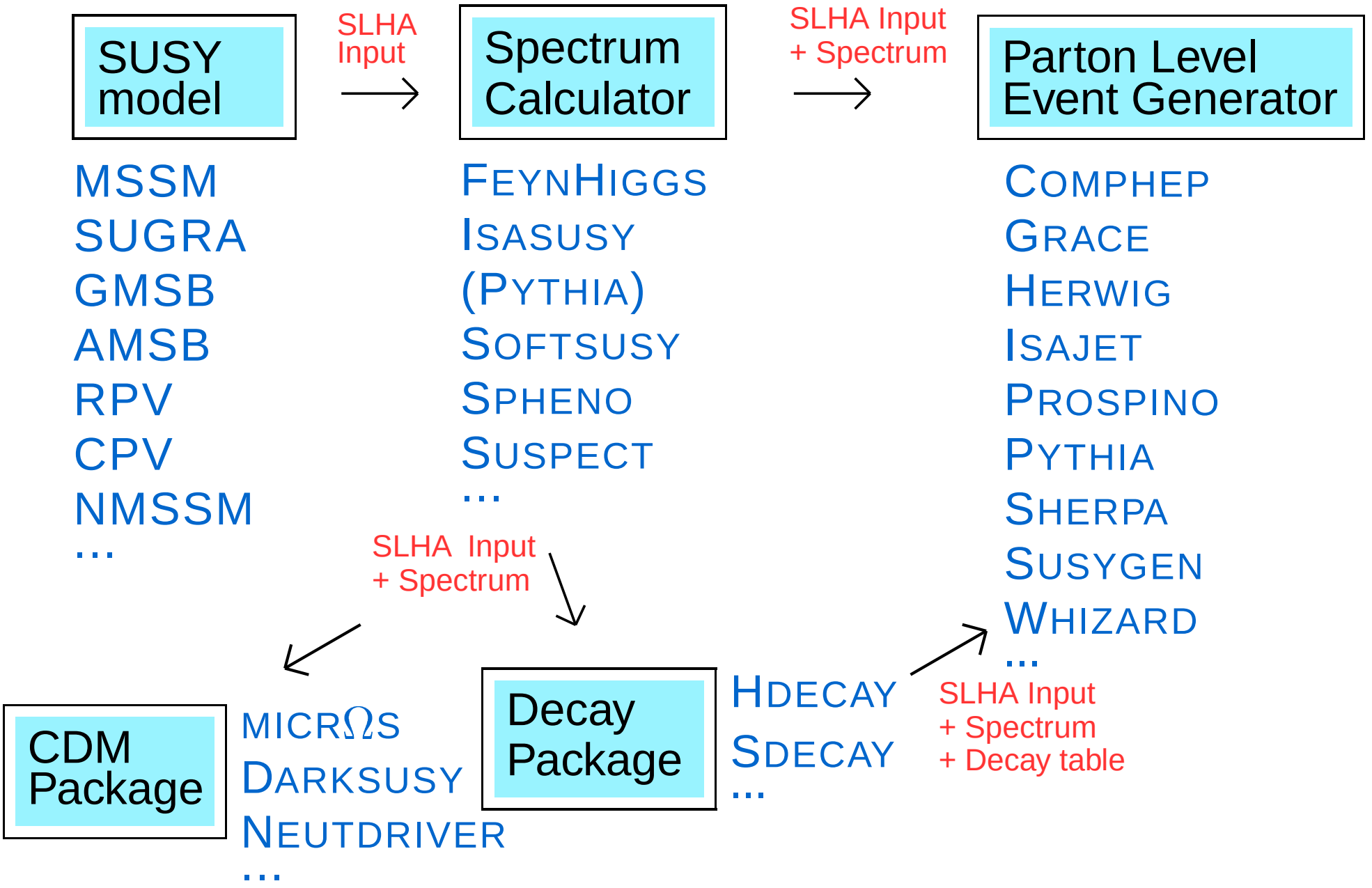
Overview

1. Why?
2. The SUSY Les Houches Accord (v1).
3. Examples.
4. Outlook.

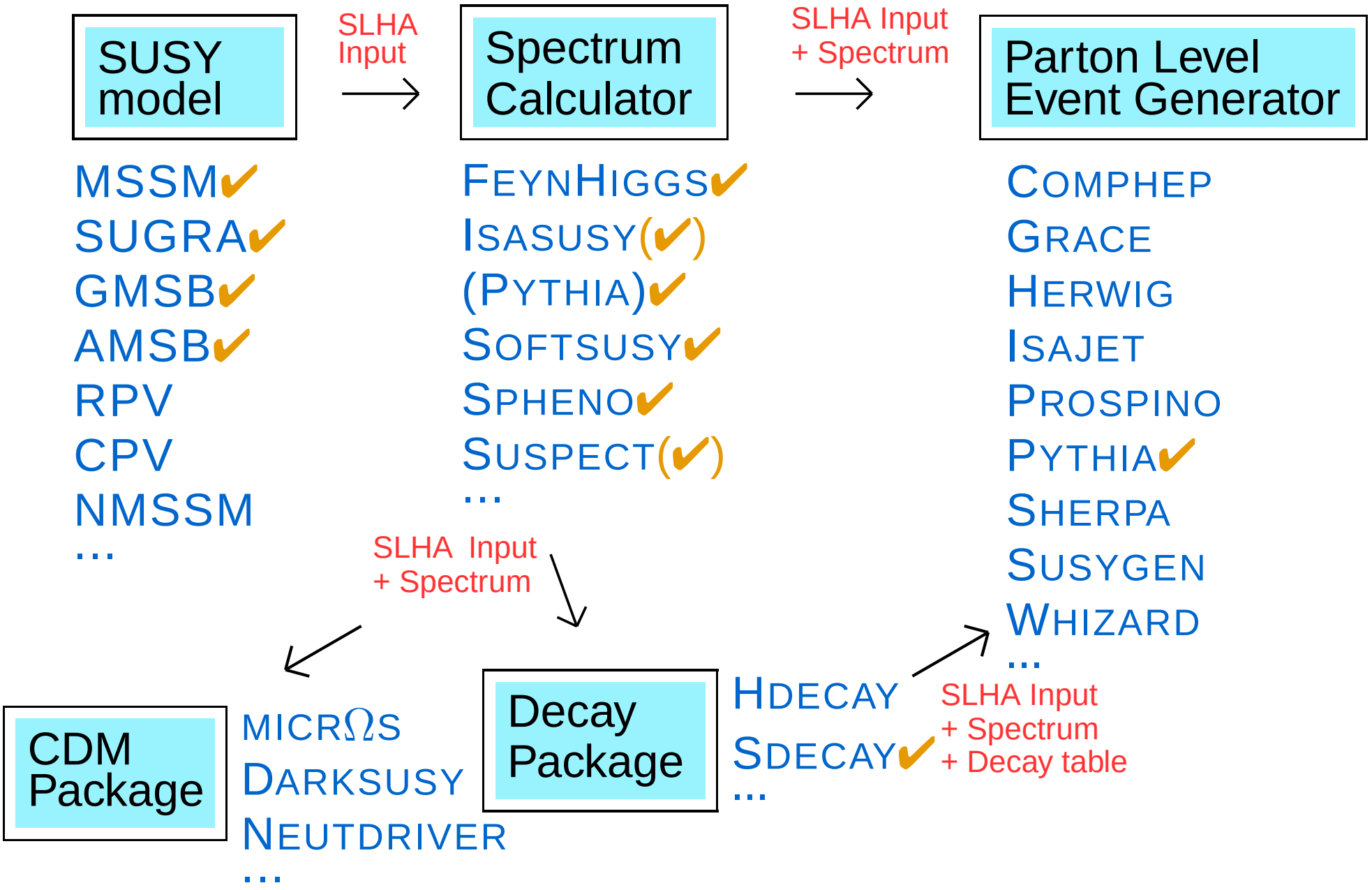
1. Why?


SUSY model
Spectrum Calculator
Parton Level Event Generator
MSSM
SUGRA
GMSB
AMSB
RPV
CPV
NMSSM
...
FeynHiggs
Isasusy
(Pythia)
Softsusy
Spheno
Suspect
...
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 SUSY Decays

1. Why? to make life easier.



1. Why? to make life easier.



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2. The SUSY Les Houches Accord

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

General Structure:

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

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

- Files are organized in named blocks:

  `BLOCK MODSEL, BLOCK MASS, BLOCK STOPMIX, BLOCK NMIX, ...`

- All particles are identified by PDG code:

  h^0 = 25, $\tilde{t}_1$ = 1000006, $\tilde{e}_R$ = 2000011, $\tilde{g}$ = 1000021,...

- Running parameters: a grid of values may be provided.

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

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All the gory details in the writeup:

hep-ph/0311123

2. The SUSY Les Houches Accord

The Input File:

- `BLOCK MODSEL`
  Model selection, e.g. which model of SUSY breaking to use.

- `BLOCK MINPAR`
  Input parameters for a minimal type of the selected model, e.g. m_0, $m_{1/2}$, $\tan\beta$, ...

- `BLOCK EXTPAR`
  Optional parameters for non-minimal/extended models, e.g. M_1, M_2, M_3,...

- `BLOCK SMINPUTS`
  Measured/fitted SM parameters, e.g. $m_b(m_b)$, $\alpha_s(m_Z)$, m_t, ...

2. The SUSY Les Houches Accord

The Spectrum File: (`BLOCK` is implicit)

- `MASS` Mass spectrum.
- `NMIX`, `UMIX`, `VMIX` $\tilde{\chi}^0$ and $\tilde{\chi}^{\pm}$ mixing.
- `STOPMIX`, `SBOTMIX`, `STAUMIX` $\tilde{t}, \tilde{b}, \tilde{\tau}$ mixing.
- `ALPHA` Higgs mixing (α).

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- `HMIX Q=...` Higgs mixing (μ).
- `GAUGE Q=...` Gauge couplings.
- `AU Q=...`, `AD Q=...`, `AE Q=...` Trilinear couplings.
- `YU Q=...`, `YD Q=...`, `YE Q=...` Yukawa couplings.

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- `SPINFO` Info from spectrum calculator, e.g. errors.

2. The SUSY Les Houches Accord

The Decay File:

- For each particle:
  - PDG code
  - Total width.
  - (Human readable translation of PDG code.)
  - + List of decay chanels.
- For each decay chanel:
  - Branching ratio.
  - Number of daughters.
  - PDG codes of daughters.
  - (Human readable translation of PDG codes.)
- + `DCINFO` (just like `SPINFO` above)

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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)
```

Outlook

The SUSY Les Houches Accord (v1):

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

Future Plans:

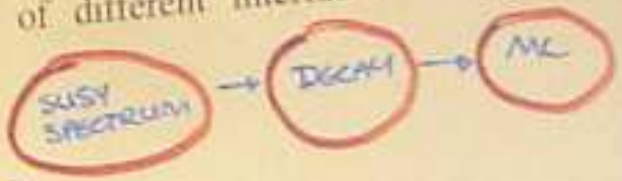
- Higher orders $\Longrightarrow$ more soft parameters.
- CPV, RPV.
- NMSSM, ... ?

The (v1):

- A s or MS
- Def t mass and es.
- Ma SLHA, mo
- Hig eters.
- CP
- NM

Les Houches Discord

- *Les Houches 2001* accord between matrix element generators, Monte-Carlo programs
- Idea is to set same thing up between SUSY spectrum generators and other programs (co-ordinator: P Skands)
- Reduces number of different interfaces from n^2 problem to n



- long discussions
- At *Les Houches 2003*, then implemented one simple case (CMSSM): it **threw up** problems in the interface design
- Design principles: general structure which can be extended, conventions for particular case etc., *higher loops very thorny*