
SUSY-HIT (SUSpect-SdecaY-Hdecay-Interface)

MMM,Djouadi,Spira, hep-ph/0609292

Milada Margarete Mühlleitner
(CERN, Geneva)

GDR Tools

CERN

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Introduction

- **SUSY particle properties:** precision of a few % at the LHC and $\lesssim 1\%$ at future e^+e^- colliders

⇒ Need programs for the calculation of the

- SUSY particle spectrum
- SUSY particle production cross sections
- SUSY particle total widths and branching ratios

with high precision, also including higher order effects

- **Existence of several programs wanted:**

- test of the programs
- estimate of the theoretical errors

- **On the market:**

SUSY particle spectrum:

ISASUSY Baer et al. SOFTSUSY Allanach
SuSpect Djouadi et al. SPHENO Porod ...

Production cxns and BR's:

ISASUSY Baer,... (S)HERWIG Corcella,...
SPYTHIA Sjostrand,...;Mrenna,... SUSYGEN Ghodbane ...
PROSPINO Beenakker et al. MICROMEGAS Bélanger et al.
GRACE GRACE Coll. . . .

Creation of SUSY-HIT

- High precision measurements \Rightarrow
SUSY particle spectrum and decay programs must include corrections at the highest possible level
- Beyond leading order results depend on choice of renormalization scheme, definition of input parameters, ... \Rightarrow
Inherently consistent package to cover whole program of spectra calculation and new particle decays **at higher order** highly wishful

\Rightarrow creation of Fortran package SUSY-HIT:

HDECAY - Calculation of decay widths and BR's of MSSM Higgs bosons
SDECAY - Calculation of decay widths and BR's of SUSY particles
SUSPECT - Spectrum calculator, linked by default*

- * Can be replaced by any spectrum calculator using the SUSY Les Houches Accord [Skands et al.](#)

Spectrum Calculator - example SuSpect

- **Implementation of the MSSM**

- minimal gauge group, $SU(3)_C \times SU(2)_L \times U(1)_Y$
- minimal particle content
- minimal set of couplings imposed by R-parity
- minimal set of soft SUSY breaking parameters

(i) soft SUSY breaking parameters are real

(ii) matrices for sfermion masses and trilinear couplings are diagonal

(iii) sfermions of the first and second generation are universal at low energy

- **General algorithm:** - RGE of parameters back and forth between LE and HE scale

- Consistent implementation of (radiative) EWSB

- Calculation of pole masses of the Higgs bosons and SUSY particles

- **Necessary files:**

- input file `suspect2.in` (select model, algorithm accuracy, SM masses and gauge couplings)

- main routine `suspect2.f`

- routine `twoloophiggs.f` (calculation of Higgs boson masses)

- routine `bsg.f` (calculates $BR(b \rightarrow s\gamma)$)

- **Generation of output file in the SLHA format** which can be read in by SDECAY, HDECAY.

Fortran code HDECAY

- **Implemented decays:** Calculation of SM and MSSM Higgs particle decays
 - All relevant HO QCD corrections to decays into quarks and to quark loop mediated $\gamma\gamma/gg$ decays.
 - Double off-shell decays of CP-even Higgs bosons into massive gauge bosons, subsequently decaying into four massless fermions.
 - All important below-threshold or 3-body decays.
 - Complete rad. corr. in the eff. potential approach (full mixing in stop/sbottom sectors), RG improved Higgs masses & couplings \rightarrow extract Higgs self-couplings.
 - All decays into SUSY particles and inclusion of all SUSY particles in the loop mediated $\gamma\gamma$ and gg decay channels. Here QCD corr. to quark and squark loops implemented. **New:** Full squark mass dependence in QCD corr. to squark loops. MMM,Spira
- **Updates: Implementation of the SLHA:**
 - HO in SDECAY in $\overline{\text{MS}}$ scheme \rightsquigarrow scale dependent parameters from SLHA input in $\overline{\text{DR}}$ scheme transformed in $\overline{\text{MS}}$ scheme.
 - Higgs self-couplings (not provided by SLHA input) calculated in eff. potential approach \rightsquigarrow not completely consistent with HO Higgs masses from SLHA input.

Fortran code SDECAY

- **Implemented decays:** Calculation of SUSY particle decays
(MSSM implementation as in SuSpect)
 - 2-body decays of sfermions and gauginos. In GMSB, 2-body decays into LSP gravitino.
 - SUSY-QCD corrections to 2-body decays involving coloured particles!
 - 3-body decays of gauginos, gluino, stops, sbottoms (if 2-body decays are closed).
 - Loop-induced decays of \tilde{t}_1 , NLSP neutralino, gluino.
 - 4-body decays of \tilde{t}_1 if 3-body decays closed.
 - Top decays within MSSM.
- **Updates:**
 - Now only non-zero BRs in the SLHA output file.
 - Creation of common blocks for BRs and partial widths of the various SUSY particles.

The program package SUSY-HIT

Necessary files:

• Spectrum files:

- Taken from any spectrum calculator \rightsquigarrow must provide SLHA input file, named `slhaspectrum.in`.
- `slhaspectrum.in` created by SuSpect: need `SuSpect` files.

• Decay files: For HDECAY the file `hdecay.f`, for SDECAY the file `sdecay.f`.

• Input file: HDECAY and SDECAY input files merged into one short input file `susyhit.in`.

Flags of previous input files hard-coded:

- SDECAY by default HO corrs. to coloured 2-body decays; the multi-body, loop-induced, top and in GMSB models the NLSP decays.
- HDECAY by default HO corrs. and off-shell decays and all SUSY final state decays.

Input file:

- Choice: (i) spectrum from SuSpect
(ii) from any spectrum calculator providing SLHA output file.
- Setting of some parameters related to HDECAY.

Example of the input file

* SUSpect-SdecaY-Hdecay-InTerface options:

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- (1) link SuSpect-Sdecay-Hdecay and take the input parameters from SuSpect
 - (2) link Sdecay-Hdecay, not SuSpect, take the input parameters from any SLHA input, called slhaspectrum.in

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* Choice of the output, SLHA format (1) or simple (0):

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* HDECAY input parameters:

MSBAR(1) = 0.190D0

MC = 1.40D0

MMUON = 0.105658389D0

1/ALPHA = 137.0359895D0

GAMW = 2.080D0

GAMZ = 2.490D0

VUS = 0.2205D0

VCB = 0.04D0

VUB/VCB = 0.08D0

Changes/How the package works

- **SDECAY:** Main program, calls HDECAY, passes necessary parameters from `susyhit.in` to HDECAY. Calls SuSpect if spectrum taken from there. SLHA spectrum input file `slhaspectrum.in` read in by SDECAY and HDECAY. Creates output file `susyhit_slha.out/susyhit.out` (simple format) at each run.
- **HDECAY:** Subroutine, called by SDECAY. Not needed routines taken out. No creation of output file.
- **SuSpect:** Some name changes in `two loophiggs.f` to avoid clashes with HDECAY.
- **Remarks:**
 - SLHA input gives $mb(mb)\overline{MS}$. SDECAY, HDECAY, SuSpect calculate internally b quark pole mass. Differences $< 3\%$.
- **Web page:**

<http://lappweb.in2p3.fr/~muehlleitner/SUSY-HIT/>

Download all necessary files; `makefile` for compilation; short instructions; updates/changes file; examples of output files.

Suggestions from experimentalists/theorists are highly welcome.