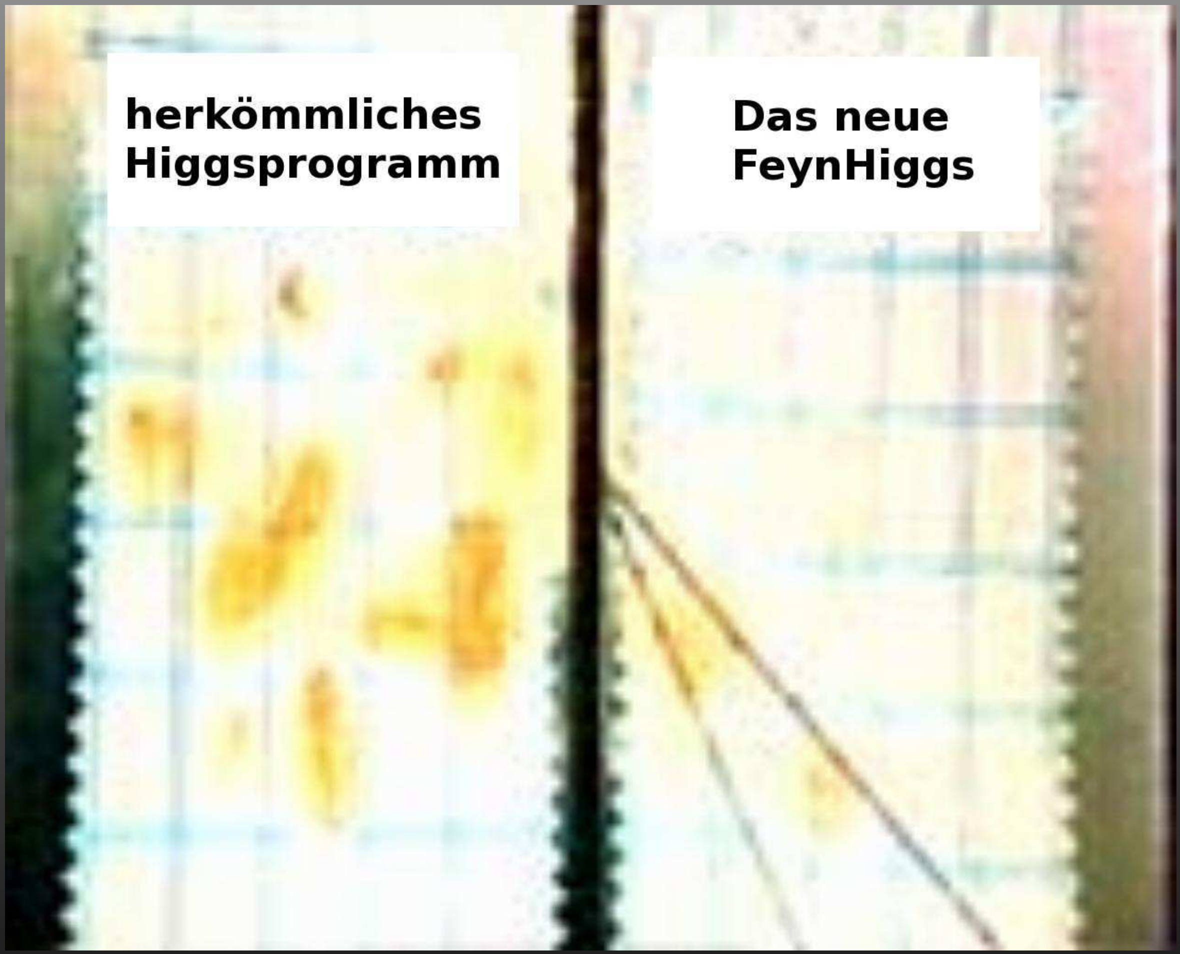
FeynHiggs 2.7 and More



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Executive Summary

- $h_i \rightarrow f_j\,\bar{f}_k$ at one-loop precision.
- Improved treatment of NMFV corrections (sfermion section completely revamped).
- Better computation of Δ_b.
- Inclusion of ΔM_s at one-loop level in NMFV.
- Many small additions and bug-fixes.

Higgs Mass Matrix

The Higgs mass matrix has the form

$$\mathcal{M}^2 = \begin{pmatrix} q^2 - M_h^2 + \hat{\Sigma}_{hh} & \hat{\Sigma}_{hH} & \hat{\Sigma}_{hA} \\ \hat{\Sigma}_{Hh} & q^2 - M_H^2 + \hat{\Sigma}_{HH} & \hat{\Sigma}_{HA} \\ \hat{\Sigma}_{Ah} & \hat{\Sigma}_{AH} & q^2 - M_A^2 + \hat{\Sigma}_{AA} \end{pmatrix}$$

The physical Higgs states h_1, h_2, h_3 diagonalize this matrix:

$$\begin{pmatrix} h_1 \\ h_2 \\ h_3 \end{pmatrix} = U \begin{pmatrix} h \\ H \\ A \end{pmatrix} \quad \textbf{where} \quad U\mathcal{M}^2U^\dagger = \begin{pmatrix} M_{h_1}^2 & 0 & 0 \\ 0 & M_{h_2}^2 & 0 \\ 0 & 0 & M_{h_3}^2 \end{pmatrix}$$

Observe: $\mathcal{M}^2$ is symmetric but not Hermitian.

Corrections included in FeynHiggs 2.7

$$\begin{pmatrix} q^2 - M_h^2 + \hat\Sigma_{hh}^{\bullet\bullet\bullet} & \hat\Sigma_{hH}^{\bullet\bullet\bullet} & \hat\Sigma_{hA}^{\bullet\bullet} \\ \hat\Sigma_{Hh}^{\bullet\bullet\bullet} & q^2 - M_H^2 + \hat\Sigma_{HH}^{\bullet\bullet\bullet} & \hat\Sigma_{HA}^{\bullet\bullet} \\ \hat\Sigma_{Ah}^{\bullet\bullet} & \hat\Sigma_{AH}^{\bullet\bullet} & q^2 - M_A^2 + \hat\Sigma_{AA}^{\bullet\bullet} \end{pmatrix}, \quad \hat\Sigma_{H^+H^-}^{\bullet\bullet}$$

- **Leading $\mathcal{O}(\alpha_s \alpha_t)$ two-loop corrections in the cMSSM.**

  Heinemeyer, Hollik, Rzehak, Weiglein 2007

- **Leading $\mathcal{O}(\alpha_t^2)$ + subleading $\mathcal{O}(\alpha_s \alpha_b, \alpha_t \alpha_b, \alpha_b^2)$ two-loop corrections in the rMSSM (phases only partially included).**

  Degrassi, Slavich, Zwirner 2001
  Brignole, Degrassi, Slavich, Zwirner 2001, 02
  Dedes, Degrassi, Slavich 2003

- **Full one-loop evaluation (all phases, q^2 dependence).**

  Frank, Heinemeyer, Hollik, Weiglein 2002

Treatment of Phases

A flag controls the treatment of phases in the part of the two-loop corrections known only in the rMSSM so far:

- all corrections ($\alpha_s\alpha_t$, $\alpha_s\alpha_b$, $\alpha_t\alpha_t$, $\alpha_t\alpha_b$) in the rMSSM,
- only the cMSSM $\alpha_s\alpha_t$ corrections,
- the cMSSM $\alpha_s\alpha_t$ corrections combined with the remaining corrections in the rMSSM, truncated in the phases,
- the cMSSM $\alpha_s\alpha_t$ corrections combined with the remaining corrections in the rMSSM, interpolated in the phases [default].
  New in 2.7: choice of interpolation in A_t/X_t, A_b/X_b.

FeynHiggs thus not only has the most precise evaluation of the Higgs masses in the cMSSM available to date, but also a method to obtain a reasonably objective estimate of the uncertainties due to the rMSSM-only parts.

Masses

FeynHiggs performs a numerical search for the complex roots of $\det \mathcal{M}^2(q^2)$.

The Higgs masses are thus determined as the real parts of the complex poles of the propagator.

Complex contributions to the Higgs mass matrix ($\mathrm{Im}\,\hat\Sigma$) are taken into account.

The diagonalization routines are available as a stand-alone package: http://feynarts.de/diag

Hahn 2006

Mixings

FeynHiggs returns two different 'mixing' matrices.

- UHiggs is a 'true' mixing matrix in the sense of being unitary and hence preserving probabilities. This matrix must be used for internal Higgs bosons.

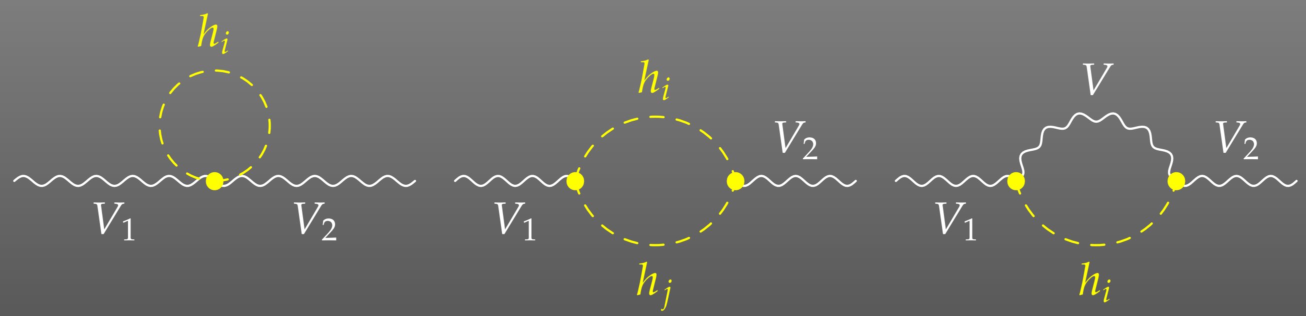
  Note: To obtain a unitary matrix, it is mathematically a necessity that $\mathcal{M}^2$ has no imaginary parts - making it Hermitian. This of course constrains the achievable quality of approximation.

- ZHiggs is a matrix of Z-factors. It guarantees on-shell properties for external Higgs bosons.

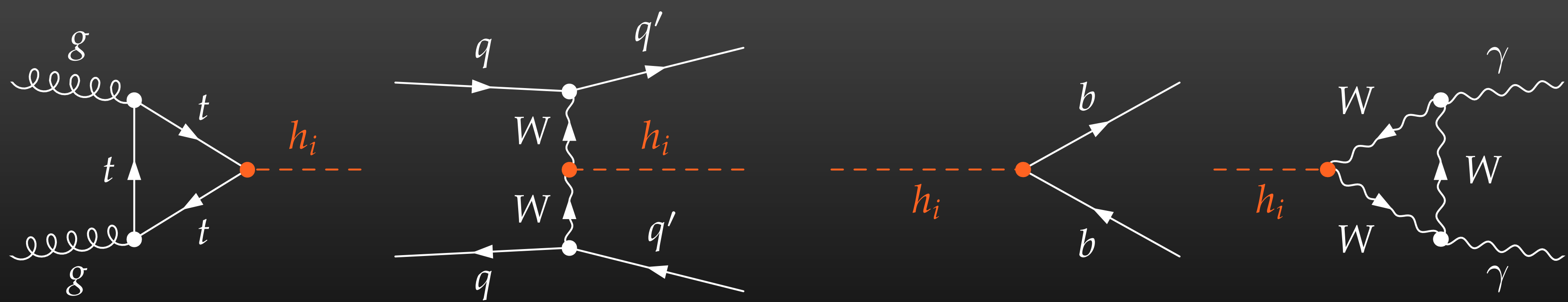
It is important to understand that ZHiggs and UHiggs are two objects with physically and mathematically distinct properties. Neither is universally 'better' than the other.

Examples of Internal and External Higgs Bosons

Internal Higgs bosons:



External Higgs bosons (production and decay):



UHiggs

FeynHiggs offers two approximations for `UHiggs`:

- q^2 **on-shell**

  meaning $\hat{\Sigma}_{ii}(q^2 = m_i^2)$,
  $$\hat{\Sigma}_{ij}(q^2 = \tfrac{1}{2}(m_i^2 + m_j^2)).$$

- $q^2 = 0$

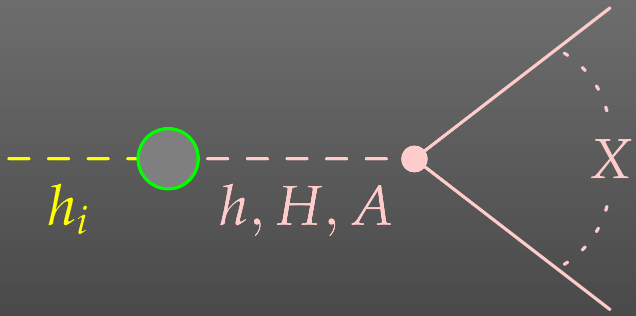
  In this limit, `UHiggs` corresponds to the effective potential approach and coincides with `ZHiggs`$(q^2 = 0)$.

  In the absence of ~~CP~~ effects (i.e. 2×2 mixing only), this is identical to the α_{eff} description.

ZHiggs

`ZHiggs` **is engineered to deliver the correct on-shell properties of an external Higgs boson, but is not necessarily unitary.**

$$\Gamma_{h_1} = \sqrt{Z_h}(\Gamma_h + Z_{hH}\Gamma_H + Z_{hA}\Gamma_A)$$
$$\Gamma_{h_2} = \sqrt{Z_H}(Z_{Hh}\Gamma_h + \Gamma_H + Z_{HA}\Gamma_A)$$
$$\Gamma_{h_3} = \sqrt{Z_A}(Z_{Ah}\Gamma_h + Z_{AH}\Gamma_H + \Gamma_A)$$



- $\Gamma_{h,H,A}$ **- amplitude for** $h, H, A \to X$,
- $\sqrt{Z_h}$ **- sets residuum of the external Higgs boson to 1,**
- Z_{hH}, Z_{hA} **- describe the transition** $h \to H, A$.

ZHiggs

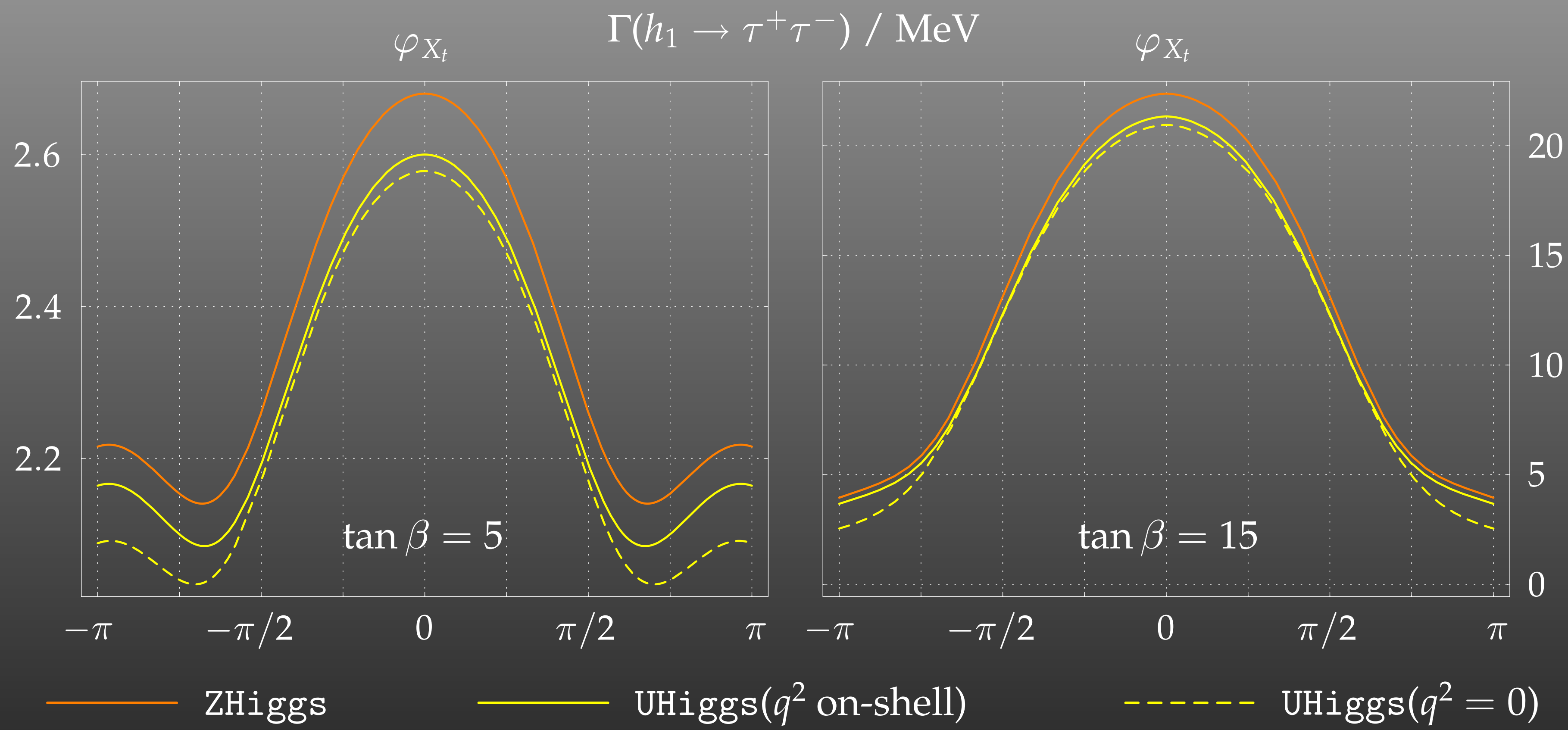
For convenience, the Z factors can be arranged in matrix form:

$$\texttt{ZHiggs} = \begin{pmatrix} \sqrt{Z_h} & \sqrt{Z_h}\, Z_{hH} & \sqrt{Z_h}\, Z_{hA} \\ \sqrt{Z_H}\, Z_{Hh} & \sqrt{Z_H} & \sqrt{Z_H}\, Z_{HA} \\ \sqrt{Z_A}\, Z_{Ah} & \sqrt{Z_A}\, Z_{AH} & \sqrt{Z_A} \end{pmatrix}$$

In this guise, `ZHiggs` can be used very much like `UHiggs`, even though its theoretical origin is quite different.

Reassuringly, `ZHiggs` and `UHiggs` coincide in the limit $q^2 = 0$.

Phenomenological Effects



[$M_{\text{SUSY}} = M_3 = M_2 = 500$ GeV, $\mu = 1000$ GeV, $M_{H^+} = 150$ GeV, $X_t = 700\, e^{i\varphi_{X_t}}$ GeV]

UHiggs(q^2 on-shell) **gives results closer to the full result than** UHiggs($q^2 = 0$) **with deviations at the few-percent level.**

Mixing Matrix Overview

- **Internal** Higgs boson: use `UHiggs`.
  Two approximations:
  - q^2 on-shell,
  - $q^2 = 0$ = effective potential approximation.
- **External** Higgs boson: use `ZHiggs`.

Choice of mixing matrices in all Higgs production and decay channels through `FHSelectUZ` (default: `ZHiggs`).

Non-Minimal Flavour Violation

In NMFV, the sfermion flavours are allowed to mix with each other, i.e. the mixing is 6×6 rather than 2×2:

NMFV	MFV	NMFV	MFV
$\tilde u_i = R^{\mathrm{u}}_{ij} \begin{pmatrix} \tilde u_L \\ \tilde c_L \\ \tilde t_L \\ \tilde u_R \\ \tilde c_R \\ \tilde t_R \end{pmatrix}_j$	$\tilde u_i = U^{\mathrm{u}}_{ij} \begin{pmatrix} \tilde u_L \\ \tilde u_R \end{pmatrix}_j$ $\tilde c_i = U^{\mathrm{c}}_{ij} \begin{pmatrix} \tilde c_L \\ \tilde c_R \end{pmatrix}_j$ $\tilde t_i = U^{\mathrm{t}}_{ij} \begin{pmatrix} \tilde t_L \\ \tilde t_R \end{pmatrix}_j$	$\tilde d_i = R^{\mathrm{d}}_{ij} \begin{pmatrix} \tilde d_L \\ \tilde s_L \\ \tilde b_L \\ \tilde d_R \\ \tilde s_R \\ \tilde b_R \end{pmatrix}_j$	$\tilde d_i = U^{\mathrm{d}}_{ij} \begin{pmatrix} \tilde d_L \\ \tilde d_R \end{pmatrix}_j$ $\tilde s_i = U^{\mathrm{s}}_{ij} \begin{pmatrix} \tilde s_L \\ \tilde s_R \end{pmatrix}_j$ $\tilde b_i = U^{\mathrm{b}}_{ij} \begin{pmatrix} \tilde b_L \\ \tilde b_R \end{pmatrix}_j$

Technical remark: FeynHiggs 2.7 keeps the MFV arrays U exactly ‘on top’ of the NMFV R ones.

Non-Minimal Flavour Violation

The mixing matrices R diagonalize the mass matrices

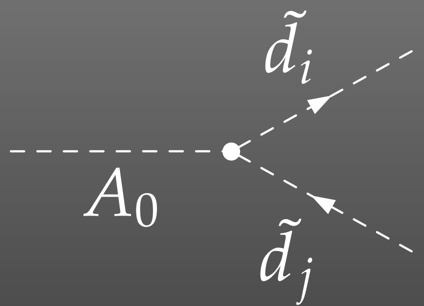
$$M^2_{u,d} = \left(\begin{array}{ccc|ccc} M^2_{\tilde L,i} & 0 & 0 & m_i X_i & 0 & 0 \\ 0 & M^2_{\tilde L,j} & 0 & 0 & m_j X_j & 0 \\ 0 & 0 & M^2_{\tilde L,k} & 0 & 0 & m_k X_k \\ \hline m_i X_i^* & 0 & 0 & M^2_{\tilde R,i} & 0 & 0 \\ 0 & m_j X_j^* & 0 & 0 & M^2_{\tilde R,j} & 0 \\ 0 & 0 & m_k X_k^* & 0 & 0 & M^2_{\tilde R,k} \end{array}\right) + \Delta_{u,d}$$

$$M^2_{\tilde L,q} = M^2_{\tilde Q,q} + m_q^2 + \cos 2\beta\,(T_3^q - Q_q s_W^2) m_Z^2 \qquad X_q = A_q - \mu \tan^{-2T_3^q}\beta$$

$$M^2_{\tilde R,q} = M^2_{\tilde U/\tilde D,q} + m_q^2 + \cos 2\beta\, Q_q s_W^2 m_Z^2$$

NMFV Effects

The most immediately notable effect comes from the LR(RL) sector, as the A^f_{ij} enter the couplings directly, e.g.



$$\propto \sum_{g,g'} \Big[m_{d_{g'}} R^{d*}_{i,g+3} R^{d}_{j,g'} (\delta_{gg'}\mu + A^{d*}_{g'g} \tan\beta) - m_{d_g} R^{d*}_{i,g} R^{d}_{j,g'+3} (\delta_{gg'}\mu^* + A^{d}_{gg'} \tan\beta) \Big]$$

This enters the Higgs masses through the A_0 self-energy and can lead to sizable effects.

Main constraints from low-energy observables.
Currently included in FeynHiggs are $b \to s\gamma$ and ΔM_s, both at one-loop including NMFV effects, with more to follow.

Benchmark Scenarios

FeynHiggs has long included **Benchmark Scenarios** which are useful in the search for the MSSM Higgs bosons:

- Vary only M_A and $\tan\beta$,
- Keep all other SUSY parameters fixed.

$m_h^{\max}$ scenario
Yields conservative $\tan\beta$ exclusion bounds ($X_t = 2\,M_{\text{SUSY}}$).

gluophobic Higgs scenario
Looks at a small hgg coupling, such that a main LHC production mode vanishes.

no-mixing scenario
No mixing in the scalar top sector ($X_t = 0$).

small α_{eff} scenario
Explores $\alpha_{\text{eff}} \to 0$ where the $hb\bar{b}$ coupling $\sim \sin\alpha_{\text{eff}}/\cos\beta$ and thus a main decay mode and important search channel vanishes.

Carena, Heinemeyer, Wagner, Weiglein 2002

But: constraints such as CDM so far ignored.
Wanted: M_A-$\tan\beta$ planes in agreement with CDM.

Parameter Planes

Moreover, models like the NUHM* introduce non-trivial relations between parameters, which thus cannot be scanned naively by independent loops.

FeynHiggs offers the Parameter Table format to deal with such cases.

*Non-universal Higgs mass model:
assumes no unification of sfermion and Higgs parameters at the GUT scale.

Parameter Tables

Input parameters can either be given in an input file (as before) or interpolated from a table, in almost any mixture.

The table format is pretty straightforward:

```
MT      MSusy  MA0    TB    At      MUE ...
171.4   500    200    5     1000    761
171.4   500    210    5     1000    753
...
171.4   500    200    6     1000    742
171.4   500    210    6     1000    735
```

For **two given inputs** (typically M_A and $\tan\beta$) the four **neighbouring grid points** are searched in the table and the other parameters are **interpolated** from those points.
An error is returned if the inputs fall outside of the table boundaries (i.e. no extrapolation).

Tables and Records

Four predefined **NUHM M_A-$\tan\beta$ planes** can be downloaded from **feynhiggs.de.**

Definition of new planes by the user is possible.

The Table is actually embedded in the concept of the **FeynHiggs Record.** This is a data type which captures the entire content of a FeynHiggs parameter file.

Using a Record, the programmer can process FeynHiggs parameter files independently of the frontend.

Higgs Decays

The Higgs decays to fermions, $h_i \to f_j \bar{f}_k$ **are now available at one-loop precision.**

Weiglein, Williams 2007

The real gluon (photon) which cancels the IR pole is treated fully inclusive.

Braaten, Leveille 1980

The (phenomenologically important) resummed Δ_b corrections are still taken into account, with the corresponding one-loop contribution subtracted to prevent double counting.

Output of FeynHiggs 2.7

- `FHHiggsCorr` - **All Higgs-boson masses and mixings:** M_{h_1}, M_{h_2}, M_{h_3}, $M_{H^\pm}$, $\alpha_{\rm eff}$, `UHiggs`, `ZHiggs`, ...
- `FHUncertainties` - **Uncertainties of masses and mixings.**
- `FHCouplings`
  - **Couplings and Branching Ratios for the channels**

    $$\begin{array}{llll} h_{1,2,3} \to & f\bar f', \gamma\gamma, ZZ^*, WW^*, gg & H^\pm \to f\bar f' & t \to W^+ b \\ & h_i Z^*, h_i h_j, H^+ H^- & \quad\;\; h_i W^{\pm *} & \quad\;\; H^+ b \\ & \tilde f_i \tilde f_j, & \quad\;\; \tilde f_i \tilde f'_j, & \\ & \tilde\chi^\pm_i \tilde\chi^\pm_j, \tilde\chi^0_i \tilde\chi^0_j & \quad\;\; \tilde\chi^0_i \tilde\chi^\pm_j & \end{array}$$

  - **Branching Ratios of an SM Higgs with mass M_{h_i}:**

    $$h^{\rm SM}_{1,2,3} \to f\bar f, \gamma\gamma, ZZ^*, WW^*, gg$$

Output of FeynHiggs 2.7

- `FHHiggsProd` - Higgs production-channel cross-sections:
  (SM: most up-to-date, MSSM: effective coupling approximation)
  - $gg \to h_i$ - gluon fusion.
  - $WW \to h_i$, $ZZ \to h_i$ - gauge-boson fusion.
  - $W \to Wh_i$, $Z \to Zh_i$ - Higgs-strahlung.
  - $b\bar{b} \to b\bar{b}h_i$ - Yukawa process.
  - $b\bar{b} \to b\bar{b}h_i,\, h_i \to b\bar{b}$, one b tagged.
  - $t\bar{t} \to t\bar{t}h_i$ - Yukawa process.

Note: Not all are available for $\sqrt{s} \neq 2, 14$ TeV at present.

Output of FeynHiggs 2.7

- FHConstraints - **Electroweak precision observables:**
  - $\Delta\rho$
    at $\mathcal{O}(\alpha, \alpha\alpha_s)$ including NMFV effects.
  - M_W, s_w^{eff}
    via SM formula + $\Delta\rho$.
  - $(g_\mu - 2)_{\text{SUSY}}$
    full one-, leading/subleading two-loop SUSY corrections.
    Heinemeyer, Stöckinger, Weiglein 2004
  - EDMs of electron (Th), neutron, Hg.
- FHFlavour - **Flavour observables:**
  - $\text{BR}(b \to s\gamma)$
    Hahn, Hollik, Illana, Peñaranda 2006
  - ΔM_s
    Hahn, Illana 2009

Download and Build

- Get the FeynHiggs tar file from feynhiggs.de.
- Unpack and configure:

```
tar xfz FeynHiggs-2.7.0.tar.gz
cd FeynHiggs-2.7.0
./configure
```

- Type make to build the Fortran/C++ part only.
  Type make all to build also the Mathematica part.
  Build takes about 75 sec on a Macbook Air.
- Type make install to install the package.
- Type make clean to remove unnecessary files.

Build tested on Linux, Tru64 Unix, Mac OS, Windows (Cygwin).

Usage

Four operation modes:

- **Library Mode:** Invoke the FeynHiggs routines from a Fortran or C/C++ program linked with `libFH.a`.
- **Command-line Mode:** Process parameter files in FeynHiggs or SLHA format at the shell prompt or in scripts with the standalone executable `FeynHiggs`.
- **Web Mode:** Interactively choose the parameters at the FeynHiggs User Control Center (FHUCC) and obtain the results on-line.
- **Mathematica Mode:** Access the FeynHiggs routines in Mathematica via MathLink with `MFeynHiggs`.

All programs and subroutines are documented in man pages.

Library Mode

- Static Fortran 77 library `libFH.a`.
- All **global symbols prefixed** to prevent symbol collision.
- Uses **only subroutines** (no functions):
  No include files needed (except for couplings).
  C/C++ users include `CFeynHiggs.h` for prototypes.
- Detailed **debugging output** can be turned on at run time.
- Main routines:
  `FHSetFlags` - set the flags of the calculation,
  `FHSetPara` - set the MSSM input parameters,
  `FHHiggsCorr` - compute Higgs masses and mixings,
  `FHUncertainties` - estimate their uncertainties,
  `FHCouplings` - compute the Higgs couplings and BRs,
  `FHHiggsProd` - estimate Higgs production cross-sections,
  `FHConstraints` - evaluate additional constraints.

Command-line Mode

Input File

```
MT          178
MB          4.7
MW          80.450
MZ          91.1875
MSusy       975
MA0         200
Abs(M_2)    332
Abs(MUE)    980
TB          50
Abs(At)     -300
Abs(Ab)     1500
Abs(M_3)    975
```

Command

FeynHiggs *file [flags]* →

Screen Output

```
------------------- HIGGS MASSES -------------------
| Mh0    =   116.022817
| MHH    =   199.943497
| MA0    =   200.000000
| MHp    =   216.973920
| SAeff  =  -0.02685112
| UHiggs =   0.99999346  -0.00361740   0.00000000 \
|            0.00361740   0.99999346   0.00000000 \
|            0.00000000   0.00000000   1.00000000

-------------- ESTIMATED UNCERTAINTIES -------------
| DeltaMh0  =  1.591957
| DeltaMHH  =  0.004428
| DeltaMA0  =  0.000000
| DeltaMHp  =  0.152519
  ...
```

- **Mask off details with**
  FeynHiggs *file [flags]* | grep -v %
- table **utility converts to machine-readable format, e.g.**
  FeynHiggs *file [flags]* | table TB Mh0 > outfile

Access to Tables

Input File "normal"

```
MT          170.9
MB          4.7
MW          80.392
MZ          91.1875
MSusy       975
MA0         200
Abs(M_2)    332
Abs(MUE)    980
TB          50
Abs(At)     -300
Abs(Ab)     1500
Abs(M_3)    975
```

"table"

```
MT          170.9
MB          4.7
MW          80.392
MZ          91.1875
MA0         200
TB          50
table file.dat MA0 TB
```

"inline table"

```
MT          170.9
MB          4.7
MW          80.392
MZ          91.1875
MA0         200
TB          50
table - MA0 TB
MA0  TB  At    MUE ...
200  5   1000  761
210  5   1000  753
...
```

Loops over parameter values possible (parameter scans).

- MA0 200 400 50 - linear: 200, 250, 300, 350, 400,
- TB 5 40 $*2$ - logarithmic: 5, 10, 20, 40,
- TB 5 50 $/6$ - # of steps: 5, 14, 23, 32, 41, 50.

Command-Line Mode Scripted

```
#! /bin/sh

make || exit 1

FHDEBUG=2 ./build/FeynHiggs - ${1:-400202113} << _EOF_
MT              173.1
MSusy           3000
MA0             1000
Abs(M_2)        2500
Abs(MUE)        2000
TB              5
Abs(Xt)         1000
Abs(M_3)        2000
_EOF_
```

Command-Line Mode Scripted

```
#! /bin/sh
```

Shell “Magic”

```
make || exit 1

FHDEBUG=2 ./build/FeynHiggs - ${1:-400202113} << _EOF_
MT              173.1
MSusy           3000
MA0             1000
Abs(M_2)        2500
Abs(MUE)        2000
TB              5
Abs(Xt)         1000
Abs(M_3)        2000
_EOF_
```

Command-Line Mode Scripted

```
#! /bin/sh

make || exit 1
```

exit if make fails

```
FHDEBUG=2 ./build/FeynHiggs - ${1:-400202113} << _EOF_
MT              173.1
MSusy           3000
MA0             1000
Abs(M_2)        2500
Abs(MUE)        2000
TB              5
Abs(Xt)         1000
Abs(M_3)        2000
_EOF_
```

Command-Line Mode Scripted

```
#! /bin/sh

make || exit 1

FHDEBUG=2 ./build/FeynHiggs - ${1:-400202113} << _EOF_
MT              173.1
MSusy           3000
MA0             1000
Abs(M_2)        2500
Abs(MUE)        2000
TB              5
Abs(Xt)         1000
Abs(M_3)        2000
_EOF_
```

env. variable

Command-Line Mode Scripted

```
#! /bin/sh

make || exit 1

FHDEBUG=2 ./build/FeynHiggs - ${1:-400202113} << _EOF_
MT              173.1
MSusy           3000
MA0             1000
Abs(M_2)        2500
Abs(MUE)        2000
TB              5
Abs(Xt)         1000
Abs(M_3)        2000
_EOF_
```

default flags
(if arg #1 not given)

Command-Line Mode Scripted

```
#! /bin/sh

make || exit 1

FHDEBUG=2 ./build/FeynHiggs - ${1:-400202113} << _EOF_
MT              173.1
MSusy           3000
MA0             1000
Abs(M_2)        2500
Abs(MUE)        2000
TB              5
Abs(Xt)         1000
Abs(M_3)        2000
_EOF_
```

stdin

begin “here” document

end “here” document

SUSY Les Houches Accord Format

Input File

```
BLOCK MODSEL
    1    1
BLOCK MINPAR
    1   0.100000000E+03  # m0
    2   0.250000000E+03  # m12
    3   0.100000000E+02  # tanb
    4   0.100000000E+01  # Sign(mu)
    5  -0.100000000E+03  # A
BLOCK SMINPUTS
    4   0.911870000E+02  # MZ
    5   0.425000000E+01  # mb(mb)
    6   0.175000000E+03  # t
  ...
```

Command

`FeynHiggs` *file [flags]* →

file`.fh`

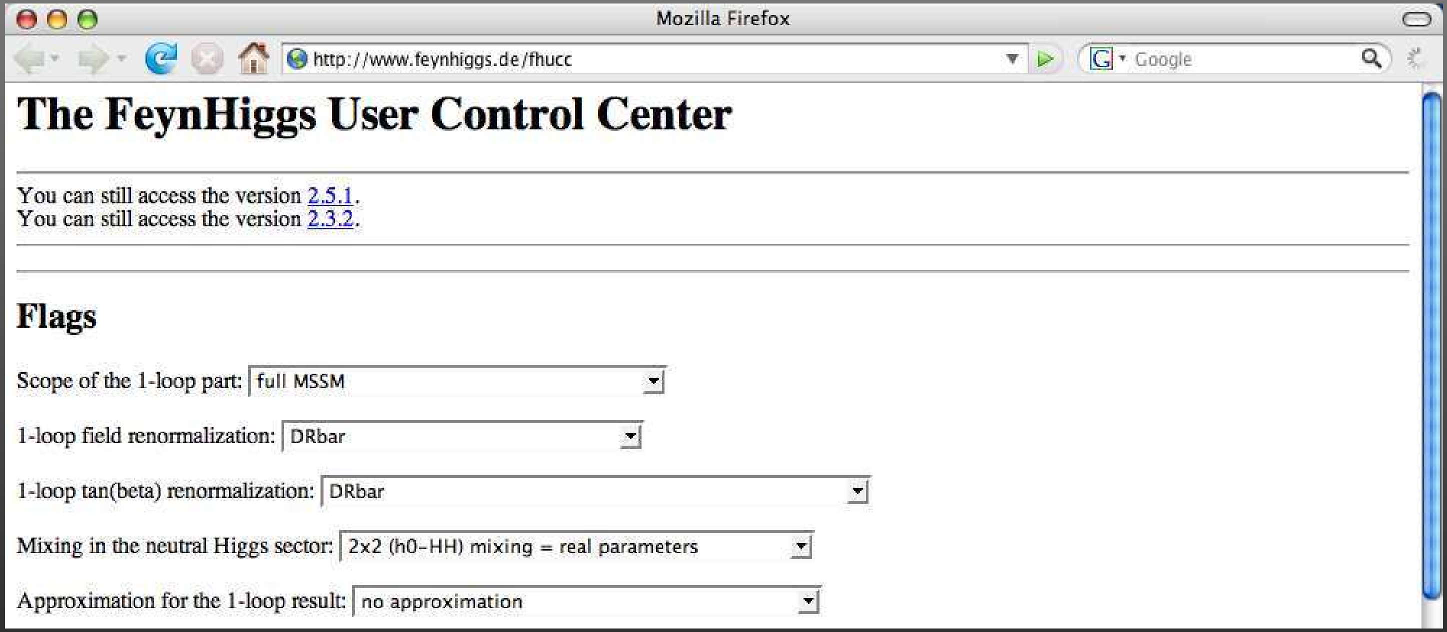
```
BLOCK MASS
   25   1.12697840E+02   # Mh0
   35   4.00145460E+02   # MHH
   36   3.99769788E+02   # MA0
   37   4.08050556E+02   # MHp
  ...
BLOCK ALPHA
       -1.10658125E-01   # Alpha
  ...
```

- **Uses the SLHA 2.**
- **SLHA can also be used in Library Mode with `FHSetSLHA`.**
- **FeynHiggs tries to read each file in SLHA format first. If that fails, fallback to native format.**

Web Mode

The FeynHiggs User Control Center (FHUCC) is on-line at

http://feynhiggs.de/fhucc



FHUCC is a Web interface for the Command-line Frontend. The user gets the results together with the input file for the Command-line Frontend.

Mathematica Mode

Provides the FeynHiggs functions in Mathematica, e.g.

```
In[1]:= Install["MFeynHiggs"];

In[2]:= FHSetFlags[...];

In[3]:= FHSetPara[...];

In[4]:= FHHiggsCorr[]

Out[4]= {MHiggs -> {117.184, 194.268, 200., 212.67},
>         SAeff -> -0.37575,
>         UHiggs -> {{0.994782, 0.102021, 0},
>                    {-0.102021, 0.994782, 0},
>                    {0, 0, 1.}}}
```

- Can use all Mathematica functions on the results (e.g. `ContourPlot`, `FindMinimum`).
- Convenient interactive mode for FeynHiggs.

Summary

- Higgs masses are the **real part of the complex pole.**
- **Two kinds of 'mixing' matrices** (`UHiggs`, `ZHiggs`).
- Inclusion of the **full cMSSM two-loop $\alpha_s\alpha_t$ corrections** in highly optimized form.
- Inclusion of **full one-loop NMFV effects.**
- Possibility to **interpolate parameters from data tables.** M_A-$\tan\beta$ **planes** in agreement with CDM constraints.
- All important **Higgs decay channels.** New: $h_i \to f_j \bar{f}_k$ **at one-loop.**
- Estimates of Higgs **production cross-sections.**
- Precision **EW and flavour observables** as constraints.