Higgs mass prediction in BSM models with FlexibleSUSY using an automatized EFT approach

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Contents

Contents

FlexibleSUSY = spectrum generator generator

FlexibleSUSY

Generating a spectrum generator

model definition
$\mathcal{L}(\tilde{t}, \tilde{b}, \tilde{g}, \ldots; g_i, y_f, \ldots)$

↓ SARAH

$M_{\tilde{t}}$, $\Sigma_{\tilde{t}}$, β_{g_i}, ...
(Mathematica)

↓ **FlexibleSUSY**

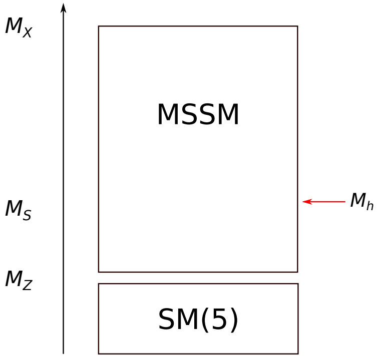
spectrum generator
(C++)

Available models with MSSM high-scale origin

Model	RGEs	h self-energy contributions	matching conditions to the MSSM
MSSM ("full model")	3L	$1\text{L} + 2\text{L}\ O((\alpha_t+\alpha_b)\alpha_s)$ $+ 2\text{L}\ O((\alpha_t+\alpha_b)^2)$	–
THDM	2L	1L	$1\text{L}\ \lambda_i\ O((\alpha_t+\alpha_b+\alpha_\tau)\alpha_i)$ $+ 2\text{L}\ \lambda_i\ O(\alpha_t^2\alpha_s)$ [1508.00576]
THDM + $\tilde{h}_i$	2L	1L	$1\text{L}\ \lambda_i\ O((\alpha_t+\alpha_b+\alpha_\tau)\alpha_i)$ $+ 2\text{L}\ \lambda_i\ O(\alpha_t^2\alpha_s)$ [1508.00576]
THDM + split	2L	1L	$1\text{L}\ \lambda_i\ O((\alpha_t+\alpha_b+\alpha_\tau)\alpha_i)$ $+ 2\text{L}\ \lambda_i\ O(\alpha_t^2\alpha_s)$ [1508.00576]
SM + split	2L	$1\text{L} + 2\text{L}\ O(\alpha_t(\alpha_s+\alpha_t))$ $+ 3\text{L gluino}\ O(\alpha_t\alpha_s^2)$	$1\text{L}\ \tilde{g}_{ij}\ O(\alpha_t+\alpha_i)$ $+ 1\text{L}\ \lambda\ O((\alpha_t+\alpha_i)^2)$ $+ 2\text{L}\ \lambda\ O(\alpha_s\alpha_t^2)$ [1407.4081]
SM ("EFT")	3L	$1\text{L} + 2\text{L}\ O(\alpha_t(\alpha_s+\alpha_t))$	$1\text{L}\ \lambda\ O((\alpha_t+\alpha_i)^2+\alpha_b^2+\alpha_\tau^2)$ $+ 2\text{L}\ \lambda\ O((\alpha_s+\alpha_t)\alpha_t^2)$ [1407.4081, 1504.05200]
SM ("automatic EFT")	3L	1L	$1\text{L}\ \lambda + O(p^2/M_S^2)$ terms

Contents

Full model approach



Idea: Calculate M_h in the MSSM as a function of the $\overline{\mathrm{DR}}$ parameters:

$$g_i,\ y_{ij}^f,\ v_i,\ \mu,\ B\mu,\ m_{H_i}^2,\ m_{\tilde{f},ij}^2,\ M_i,\ T_{ij}^f$$

Full model approach

Fixed by observables:

Input				Output
$\alpha_{\text{em}}^{\text{SM}(5)}(M_Z)$	$\to$	$\alpha_{\text{em}}^{\text{MSSM}}(M_Z)$	$\to$	$g_1^{\text{MSSM}}(M_Z)$
G_F	$\to$	$\sin\theta_W^{\text{MSSM}}(M_Z)$	$\to$	$g_2^{\text{MSSM}}(M_Z)$
$\alpha_{\text{s}}^{\text{SM}(5)}(M_Z)$			$\to$	$g_3^{\text{MSSM}}(M_Z)$
M_Z	$\to$	$m_Z^{\text{MSSM}}(M_Z)$	$\to$	$v^{\text{MSSM}}(M_Z)$
M_t	$\to$	$m_t^{\text{MSSM}}(M_Z)$	$\to$	$y_t^{\text{MSSM}}(M_Z)$
$m_b^{\text{SM}(5)}(m_b)$	$\to$	$m_b^{\text{MSSM}}(M_Z)$	$\to$	$y_b^{\text{MSSM}}(M_Z)$
M_τ	$\to$	$m_\tau^{\text{MSSM}}(M_Z)$	$\to$	$y_\tau^{\text{MSSM}}(M_Z)$

Fixed by 2 EWSB conditions: $m_{H_u}^2$, $m_{H_d}^2$

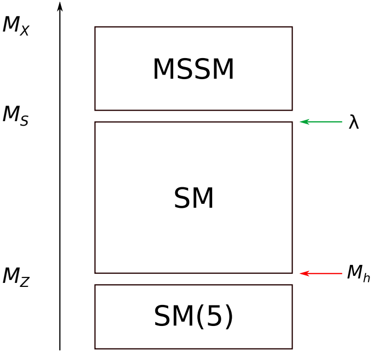
Free parameters: $\tan\beta$, μ, $B\mu$, $m^2_{\tilde{f},ij}$, M_i, T^f_{ij}

Full model approach

$$(M_h^{\text{MSSM}})^2 = \text{smallest eigenvalue of} \\ \left[(m_h^{\text{MSSM}})^2 - \Sigma_h^{\text{MSSM}}(p^2 = (M_h^{\text{MSSM}})^2, Q = M_S)\right]_{ij}$$

Advantage: includes terms $O(p^2/M_S^2)$
Disadvantage: suffers from large logarithms $\propto \log(M_Z/M_S)$ if $M_S \gg M_Z$

EFT approach



Idea: Calculate M_h in the SM as a function of the $\overline{\text{MS}}$ parameters:

$$g_i,\ y^f_{ij},\ v,\ \mu^2,\ \lambda$$

EFT approach

Fixed by observables:

Input				Output
$\alpha_{\text{em}}^{\text{SM}(5)}(M_Z)$	$\rightarrow$	$\alpha_{\text{em}}^{\text{SM}}(M_Z)$	$\rightarrow$	$g_1^{\text{SM}}(M_Z)$
G_F	$\rightarrow$	$\sin\theta_W^{\text{SM}}(M_Z)$	$\rightarrow$	$g_2^{\text{SM}}(M_Z)$
$\alpha_s^{\text{SM}(5)}(M_Z)$			$\rightarrow$	$g_3^{\text{SM}}(M_Z)$
M_Z	$\rightarrow$	$m_Z^{\text{SM}}(M_Z)$	$\rightarrow$	$v^{\text{SM}}(M_Z)$
M_t	$\rightarrow$	$m_t^{\text{SM}}(M_Z)$	$\rightarrow$	$y_t^{\text{SM}}(M_Z)$
$m_b^{\text{SM}(5)}(m_b)$	$\rightarrow$	$m_b^{\text{SM}}(M_Z)$	$\rightarrow$	$y_b^{\text{SM}}(M_Z)$
M_τ	$\rightarrow$	$m_\tau^{\text{SM}}(M_Z)$	$\rightarrow$	$y_\tau^{\text{SM}}(M_Z)$

Fixed by 1 EWSB condition: μ^2

Free parameter: λ

EFT approach: matching all $\Gamma_{\phi_1,\ldots,\phi_n}(Q = M_S)$

Determine $\lambda(M_S)$ from mathching all $\Gamma_{\phi_1,\ldots,\phi_n}(Q = M_S)$:

$$\frac{\partial}{\partial p^2}\Gamma^{\text{SM}}_{hh}(p^2 = 0, Q = M_S) = \frac{\partial}{\partial p^2}\Gamma^{\text{MSSM}}_{hh}(p^2 = 0, Q = M_S)$$
$$\Gamma^{\text{SM}}_{hhhh}(p^2 = 0, Q = M_S) = \Gamma^{\text{MSSM}}_{hhhh}(p^2 = 0, Q = M_S)$$

$\Rightarrow$

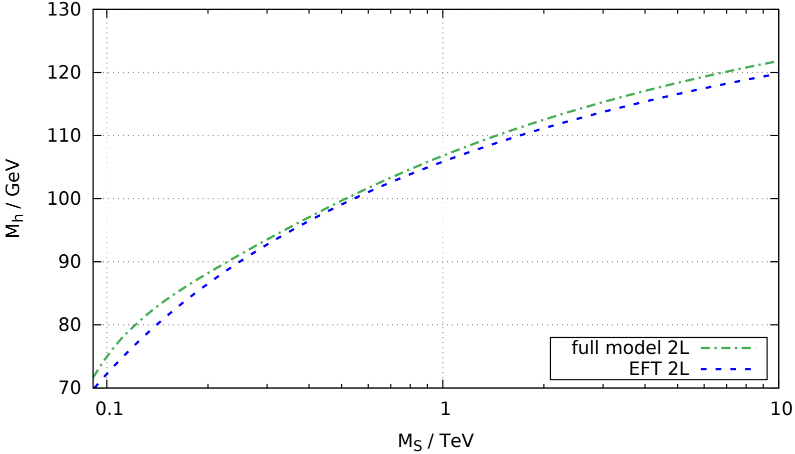
$$\lambda(M_S) = \frac{1}{4}\left[g_Y^2 + g_2^2\right]\cos^2 2\beta + \Delta\lambda$$

RG running to $Q = M_Z \Rightarrow$

$$(M_h^{\text{SM}})^2 = \lambda(M_Z)v^2(M_Z) - \Sigma_h^{\text{SM}}(p^2 = (M_h^{\text{SM}})^2, Q = M_Z)$$

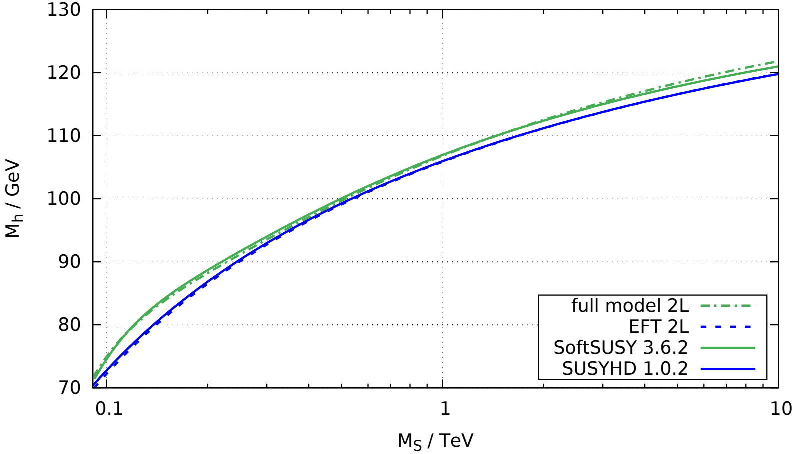
Advantage: resums large logarithms $\propto \log(M_Z/M_S)$
Disadvantage: difficult to automatize; neglects terms $O(p^2/M_S^2)$ from SUSY particles if performed at 1L-level only

Comparison full model vs. EFT approach



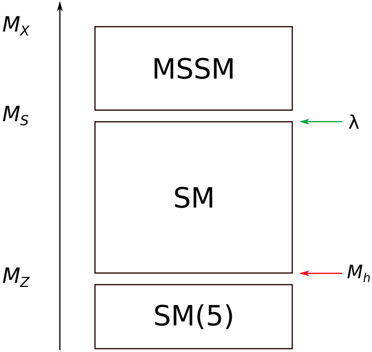
$\tan\beta = 5,\ X_{t,b,\tau} = 0$

Comparison full model vs. EFT approach



$\tan\beta = 5$, $X_{t,b,\tau} = 0$

Automatic EFT approach



Idea: Calculate M_h in the SM as a function of the $\overline{\text{MS}}$ parameters:

$$g_i,\ y_{ij}^f,\ v,\ \mu^2,\ \lambda$$

where $\lambda(M_S)$ is determined numerically by the 1L matching condition $M_h^{\text{SM}} \stackrel{!}{=} M_h^{\text{MSSM}}$

Automatic EFT approach: matching M_h

$$M_h^{\text{SM}} \stackrel{!}{=} M_h^{\text{MSSM}} \quad \text{at} \quad Q = M_S, 1L$$

$\Rightarrow$

$$\lambda(M_S) = \frac{1}{v^2(M_S)}\Big[(M_h^{\text{MSSM}})^2 + \Sigma_h^{\text{SM},1L}(p^2 = (M_h^{\text{SM}})^2, Q = M_S)\Big]$$

where

$$\begin{aligned} (M_h^{\text{SM}})^2 &= \lambda(M_S)v^2(M_S) - \Sigma_h^{\text{SM},1L}(p^2 = (M_h^{\text{SM}})^2, Q = M_S) \\ (M_h^{\text{MSSM}})^2 &= \text{smallest eigenvalue of} \\ &\qquad \Big[(m_h^{\text{MSSM}})^2 - \Sigma_h^{\text{MSSM},1L}(p^2 = (M_h^{\text{MSSM}})^2, Q = M_S)\Big]_{ij} \end{aligned}$$

Automatic EFT approach: matching M_h

Next step: RG running to $Q = M_Z$
$\Rightarrow$

$$(M_h^{\mathrm{SM}})^2 = \lambda(M_Z) v^2(M_Z) - \Sigma_h^{\mathrm{SM},1L}(p^2 = (M_h^{\mathrm{SM}})^2, Q = M_Z)$$

Equivalence EFT and automatic EFT approach $O(\hbar y_t^4)$

$$M_h^{\text{SM}} \stackrel{!}{=} M_h^{\text{MSSM}} \quad \text{at} \quad Q = M_S, 1L$$

where

$$(M_h^{\text{SM}})^2 = \lambda v^2 - \Sigma_h^{\text{SM}} + t_h^{\text{SM}}$$
$$t_h^{\text{SM}} = -6(y_t^{\text{SM}})^2 A_0(m_t)/(4\pi)^2$$

and [neglecting stop mass mixing $O(m_t X_t/M_S^2)$]

$$(M_h^{\text{MSSM}})^2 = \frac{1}{4}(g_Y^2 + g_2^2)(v_u^2 + v_d^2)c_{2\beta}^2 - \Sigma_h^{\text{MSSM}} + t_h^{\text{MSSM}}$$
$$\Sigma_h^{\text{MSSM}} = \Sigma_h^{\text{SM}} \frac{c_\alpha^2}{s_\beta^2} + 3\frac{(y_t^{\text{SM}})^2}{(4\pi)^2}\frac{c_\alpha^2}{s_\beta^2}\Big\{A_0(m_{Q_3}) + A_0(m_{U_3})$$
$$+ 2m_t\big[B_0(m_{Q_3}, m_{Q_3}) + B_0(m_{U_3}, m_{U_3})\big]\Big\}$$
$$t_h^{\text{MSSM}} = -3\frac{(y_t^{\text{SM}})^2}{(4\pi)^2}\frac{c_\alpha^2}{s_\beta^2}\Big[2A_0(m_t) - A_0(m_{Q_3}) - A_0(m_{U_3})\Big]$$

Equivalence EFT and automatic EFT approach $O(\hbar y_t^4)$

in SM limit $\frac{c_\alpha^2}{s_\beta^2} \to 1$
$\Rightarrow$

$$
\begin{aligned}
\lambda &= \frac{1}{4}(g_Y^2 + g_2^2)c_{2\beta}^2 \\
&\quad - 3\frac{(y_t^{\mathrm{SM}})^4}{(4\pi)^2}\Big[B_0(p^2, m_{Q_3}, m_{Q_3}) + B_0(p^2, m_{U_3}, m_{U_3})\Big] \\
&= \frac{1}{4}(g_Y^2 + g_2^2)c_{2\beta}^2 \\
&\quad - 3\frac{(y_t^{\mathrm{SM}})^4}{(4\pi)^2}\Big[- \log\frac{m_{Q_3}^2}{Q^2} + \frac{p^2}{6m_{Q_3}^2} + O\Big(\frac{p^4}{m_{Q_3}^4}\Big) \\
&\qquad\qquad\qquad - \log\frac{m_{U_3}^2}{Q^2} + \frac{p^2}{6m_{U_3}^2} + O\Big(\frac{p^4}{m_{U_3}^4}\Big)\Big] \\
&= [\text{Bagnaschi et. al. 2014}] + O\Big(\frac{p^2}{m_{Q_3}^2}\Big) + O\Big(\frac{p^2}{m_{U_3}^2}\Big)
\end{aligned}
$$

Summary of automatic EFT approach

Advantages:

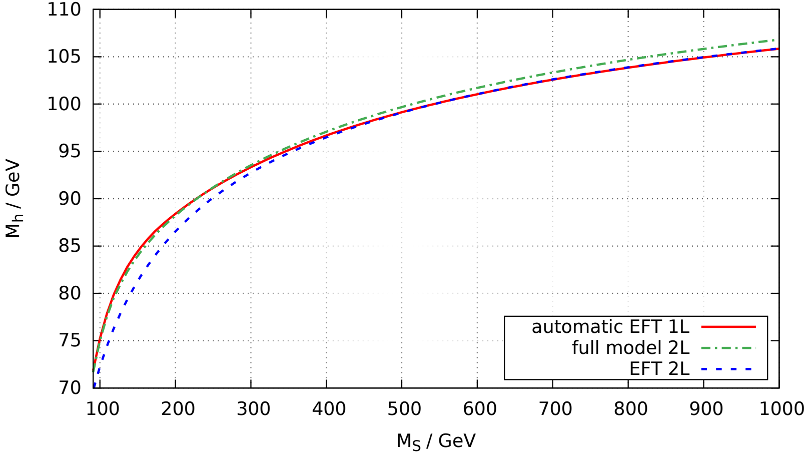
- easily automatizable
- resums large logarithms $\log(M_Z/M_S)$ due to RG running
- includes 1L terms $O(p^2/M_S^2)$ from SUSY particles
- incorporates SUSY particle mixings

Disadvantage:

- large logs in matching cancel only in SM limit $\cos(\beta - \alpha) \to 0$
- only 1L calculation so far

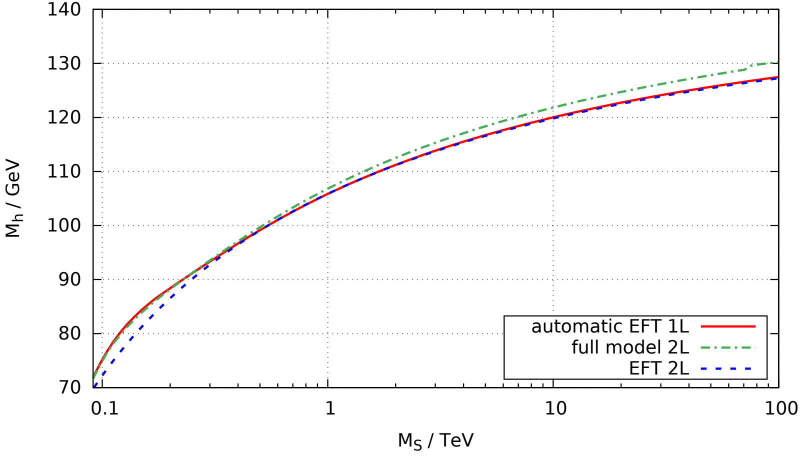
Contents

Comparison full vs. EFT vs. automatic EFT approach



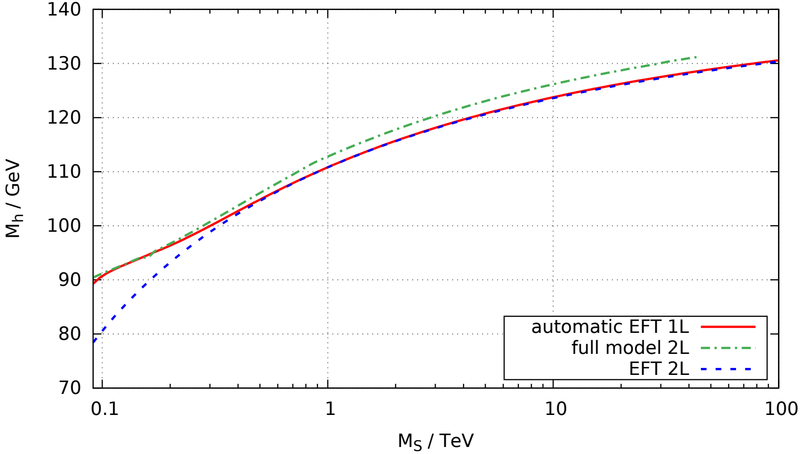
$\tan\beta = 5,\ X_{t,b,\tau} = 0$

Comparison full vs. EFT vs. automatic EFT approach



$\tan\beta = 5$, $X_{t,b,\tau} = 0$

Comparison full vs. EFT vs. automatic EFT approach



$\tan\beta = 20,\ X_{t,b,\tau} = 0$

Summary

Summary:

- full model approach suffers from large logs $\propto \log(M_Z/M_S)$ if $M_S \gg M_Z$
- EFT approach resums large logs, but difficult to automatize (also misses 1L terms $O(p^2/M_S^2)$ if performed at 1L-level only)
- "automatic EFT" approach
  - can be automatized easily $\rightarrow$ incorporation into FlexibleSUSY
  - resums large logs $\propto \log(M_Z/M_S)$
  - includes terms $O(p^2/M_S^2)$ at 1L
  - handles SUSY particle mixings
  - large logs cancel only in SM limit

Todo:

- perform matching and calculation of M_h at 2-loop level
- test non-SUSY and non-minimal SUSY models

Backup

Determination of MSSM parameters

Determination of $g_3^{\mathsf{MSSM}}(M_S)$

$$\alpha_s^{\mathsf{MSSM}}(M_S) = \frac{\alpha_s^{\mathsf{SM}}(M_S)}{1 - \Delta\alpha_s(M_S)}$$

with

$$\Delta\alpha_s(Q) = \frac{\alpha_s}{2\pi}\left[\frac{1}{2} - \sum_{\text{SUSY particle } f} T_f \log\frac{m_f}{Q}\right]$$

$\Rightarrow$

$$g_3^{\mathsf{MSSM}}(M_S) = \sqrt{4\pi\alpha_s^{\mathsf{MSSM}}(M_S)}$$

Determination of $v_i^{\mathrm{MSSM}}(M_S)$

$$M_Z^{\mathrm{SM}} = M_Z^{\mathrm{MSSM}}$$

$\Rightarrow$

$$\begin{aligned}(m_Z^{\mathrm{MSSM}}(M_S))^2 &= (M_Z^{\mathrm{SM}})^2 + \Pi_Z^{\mathrm{MSSM},1L}(Q = M_S)\\ (M_Z^{\mathrm{SM}})^2 &= \frac{1}{4}\left[(g_Y^{\mathrm{SM}})^2 + (g_2^{\mathrm{SM}})^2\right](v^{\mathrm{SM}})^2 - \Pi_Z^{\mathrm{SM},1L}(Q = M_S)\end{aligned}$$

$\Rightarrow$

$$v^{\mathrm{MSSM}}(M_S) = \frac{2 m_Z^{\mathrm{MSSM}}(M_S)}{\sqrt{(g_Y^{\mathrm{MSSM}})^2 + (g_2^{\mathrm{MSSM}})^2}}$$

$\Rightarrow$

$$\begin{aligned}v_u^{\mathrm{MSSM}}(M_S) &= v^{\mathrm{MSSM}}(M_S)\sin\beta(M_S)\\ v_d^{\mathrm{MSSM}}(M_S) &= v^{\mathrm{MSSM}}(M_S)\cos\beta(M_S)\end{aligned}$$

Determination of $y_i^{\mathrm{MSSM}}(M_S)$

$$M_f^{\mathrm{SM}} = M_f^{\mathrm{MSSM}}$$

$\Rightarrow$

$$\begin{aligned} m_f^{\mathrm{MSSM}}(M_S) &= M_f^{\mathrm{SM}} + \Sigma_f^{\mathrm{MSSM},1L}(Q = M_S) \\ M_f^{\mathrm{SM}} &= \frac{\sqrt{2} m_f^{\mathrm{SM}}}{v_i^{\mathrm{SM}}} - \Sigma_f^{\mathrm{SM},1L}(Q = M_S) \end{aligned}$$

$\Rightarrow$

$$y_f^{\mathrm{MSSM}}(M_S) = \frac{\sqrt{2} m_f^{\mathrm{MSSM}}(M_S)}{v_i^{\mathrm{MSSM}}(M_S)}$$

Determination of SM parameters

Determination of $g_3^{\mathrm{SM}}(M_Z)$

Input: $\alpha_s^{\mathrm{SM}(5)}(M_Z) = 0.1185$

$\rightarrow$

$$\alpha_s^{\mathrm{SM}}(M_Z) = \frac{\alpha_s^{\mathrm{SM}(5)}(M_Z)}{1 - \Delta\alpha_s(M_Z)}$$

with

$$\Delta\alpha_s(Q) = \frac{\alpha_s}{2\pi}\left[-\frac{2}{3}\log\frac{m_t}{Q}\right]$$

$\Rightarrow$

$$g_3^{\mathrm{SM}}(M_Z) = \sqrt{4\pi\alpha_s^{\mathrm{SM}}(M_Z)}$$

Determination of $y_t^{\mathrm{SM}}(M_Z)$

$$y_t^{\mathrm{SM}}(M_Z) = \frac{\sqrt{2}\, m_t^{\mathrm{SM}}(M_Z)}{v(M_Z)}$$

where

$$\begin{aligned}
m_t^{\mathrm{SM}}(Q) &= M_t + \mathrm{Re}\,\Sigma_t^S(M_Z) + M_t\Big[\,\mathrm{Re}\,\Sigma_t^L(M_Z) \\
&\quad + \mathrm{Re}\,\Sigma_t^R(M_Z) + \Delta m_t^{1L,\mathrm{gluon}} + \Delta m_t^{2L,\mathrm{gluon}}\Big] \\
\Delta m_t^{1L,\mathrm{gluon}} &= -\frac{g_3^2}{12\pi^2}\left[4 - 3\log\left(\frac{m_t^2}{Q^2}\right)\right] \\
\Delta m_t^{2L,\mathrm{gluon}} &= \left(\Delta m_t^{1L,\mathrm{gluon}}\right)^2 \\
&\quad - \frac{g_3^4}{4608\pi^4}\left[396\log^2\left(\frac{m_t^2}{Q^2}\right) - 2028\log\left(\frac{m_t^2}{Q^2}\right)\right. \\
&\quad \left. - 48\zeta(3) + 2821 + 16\pi^2(1+\log 4)\right]
\end{aligned}$$

Determination of v^{SM}

The VEV v^{SM} is calculated from the running Z mass at $Q = M_Z$:

$$v^{\mathrm{SM}}(M_Z) = \frac{2m_Z^{\mathrm{SM}}(M_Z)}{\sqrt{g_Y^2 + g_2^2}}$$

$$m_Z^{\mathrm{SM}}(M_Z) = \sqrt{M_Z^2 + \Pi_Z^{1L}(p^2 = M_Z^2, Q = M_Z)}$$

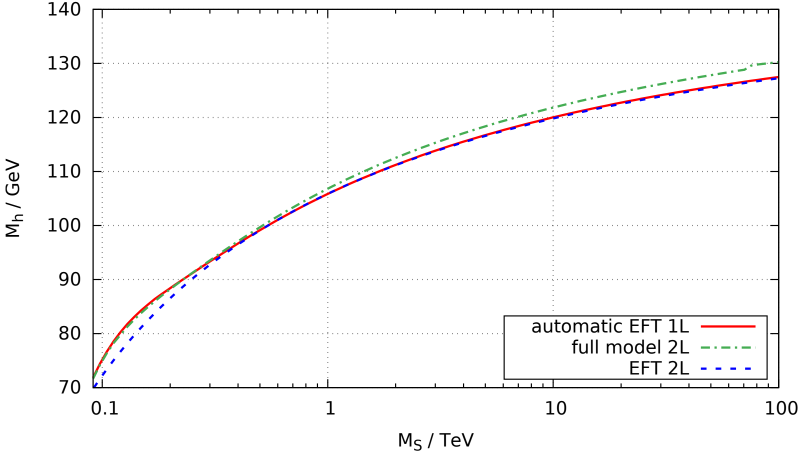
v^{SM} evolves under RG running according to
[Sperling, Stöckinger, AV, 2013, 2014]

X_t dependence

(default algorithm: $1L$ matching SM $\rightarrow$ MSSM)

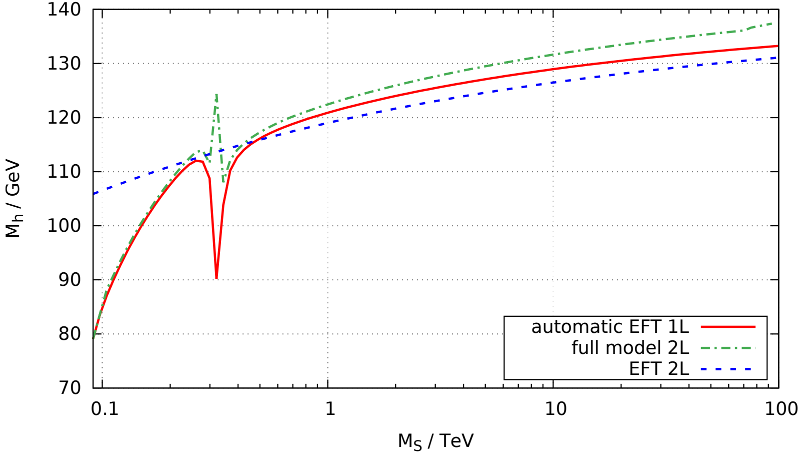
$$\tan\beta = 5$$

Comparison full vs. EFT vs. automatic EFT approach



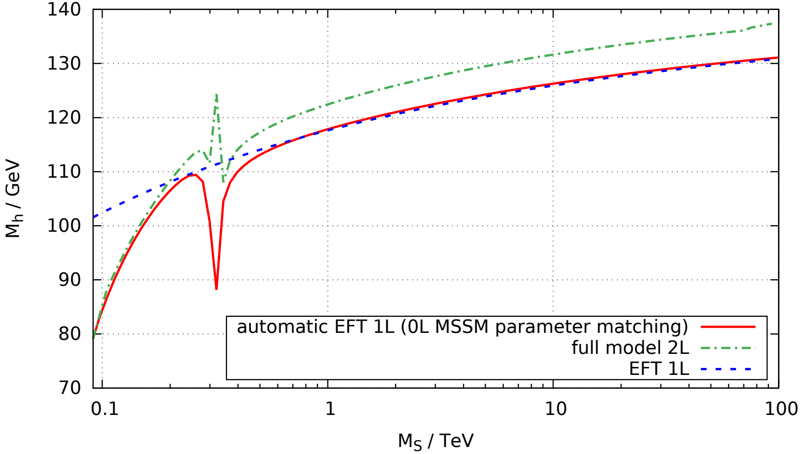
$\tan\beta = 5$, $X_{t,b,\tau} = 0$

Comparison full vs. EFT vs. automatic EFT approach



$\tan\beta = 5$, $X_t = \sqrt{6}$, $X_{b,\tau} = 0$

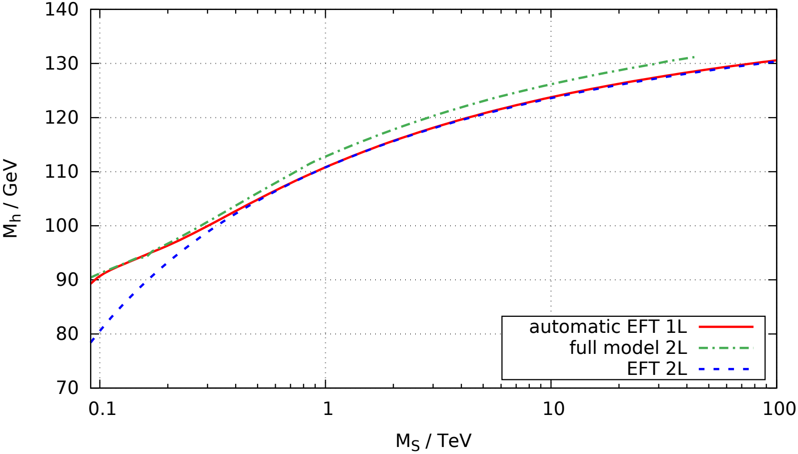
Comparison full vs. EFT vs. automatic EFT approach



$\tan\beta = 5$, $X_t = \sqrt{6}$, $X_{b,\tau} = 0$ ($0L$ matching SM $\to$ MSSM)

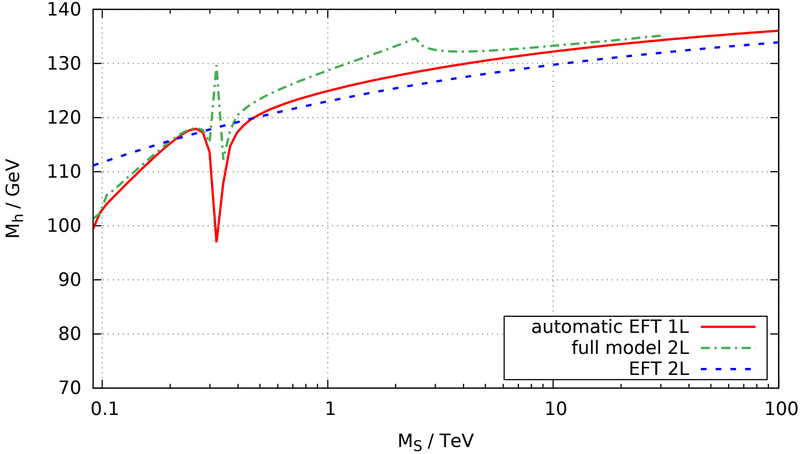
$\tan\beta = 20$

Comparison full vs. EFT vs. automatic EFT approach



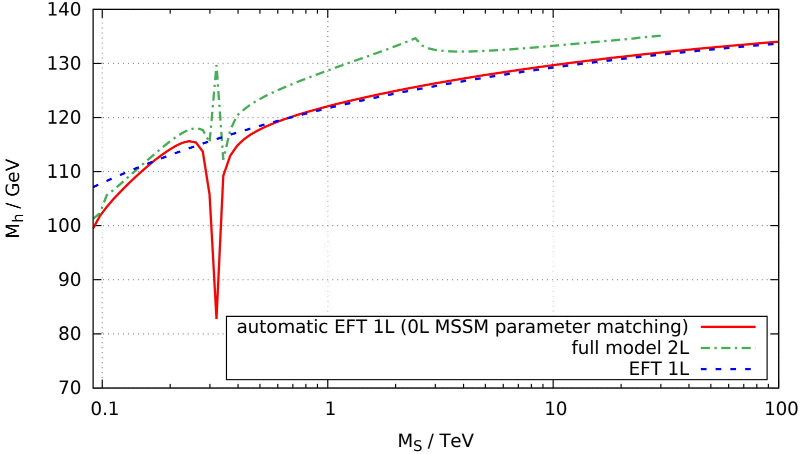
$\tan\beta = 20$, $X_{t,b,\tau} = 0$

Comparison full vs. EFT vs. automatic EFT approach



$\tan\beta = 20$, $X_t = \sqrt{6}$, $X_{b,\tau} = 0$

Comparison full vs. EFT vs. automatic EFT approach

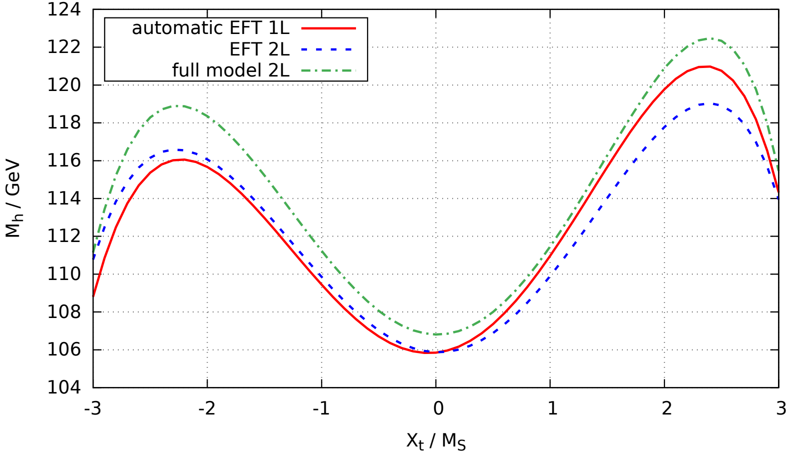


$\tan\beta = 20$, $X_t = \sqrt{6}$, $X_{b,\tau} = 0$ ($0L$ matching SM $\rightarrow$ MSSM)

X_t dependence

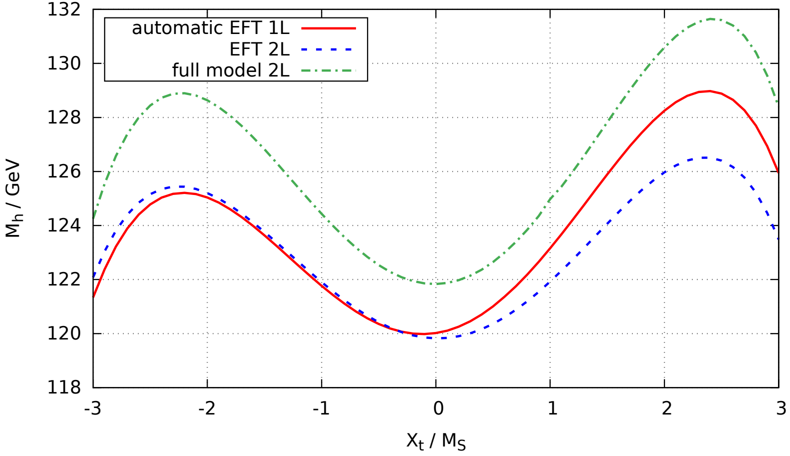
(default algorithm: $1L$ matching SM $\to$ MSSM)

Comparison full vs. EFT vs. automatic EFT approach



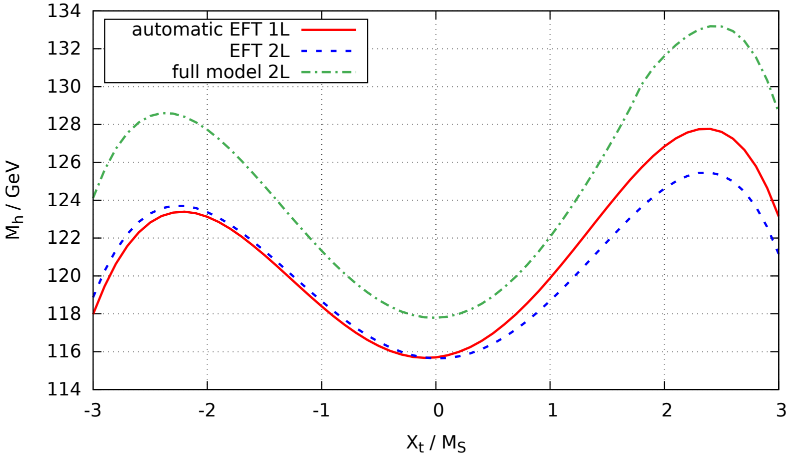
$\tan\beta = 5,\ X_{b,\tau} = 0,\ M_S = 1\,\text{TeV}$

Comparison full vs. EFT vs. automatic EFT approach



$\tan\beta = 5,\ X_{b,\tau} = 0,\ M_S = 10\,\text{TeV}$

Comparison full vs. EFT vs. automatic EFT approach

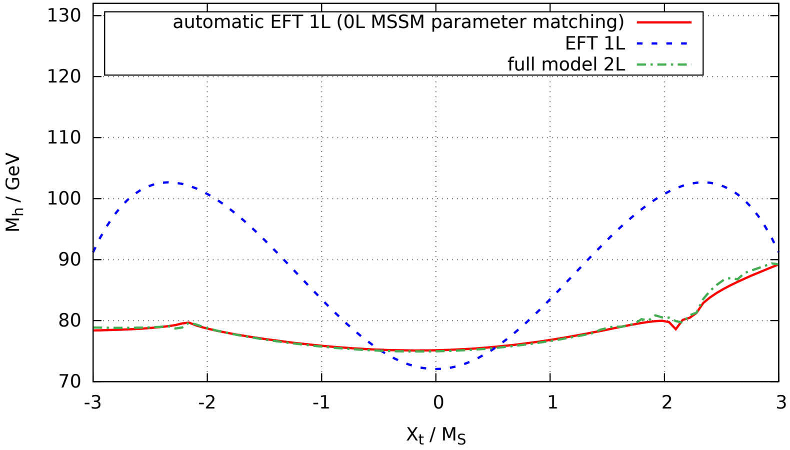


$\tan\beta = 20,\ X_{b,\tau} = 0,\ M_S = 2\,\text{TeV}$

X_t dependence

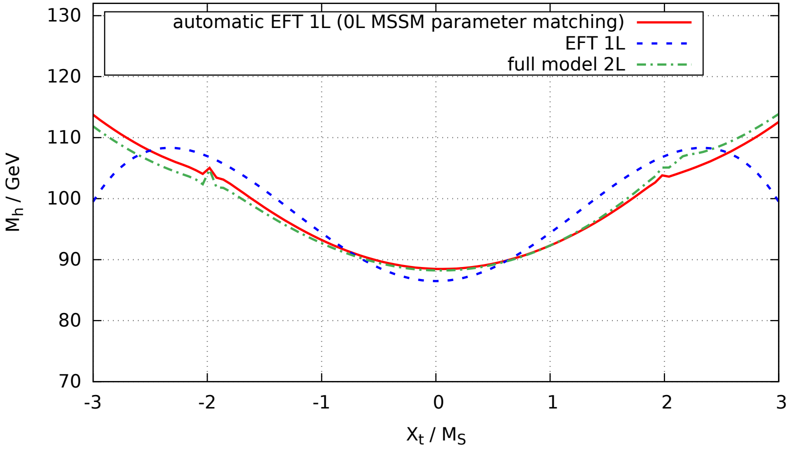
(0L matching SM $\to$ MSSM)

Comparison full vs. EFT vs. automatic EFT approach



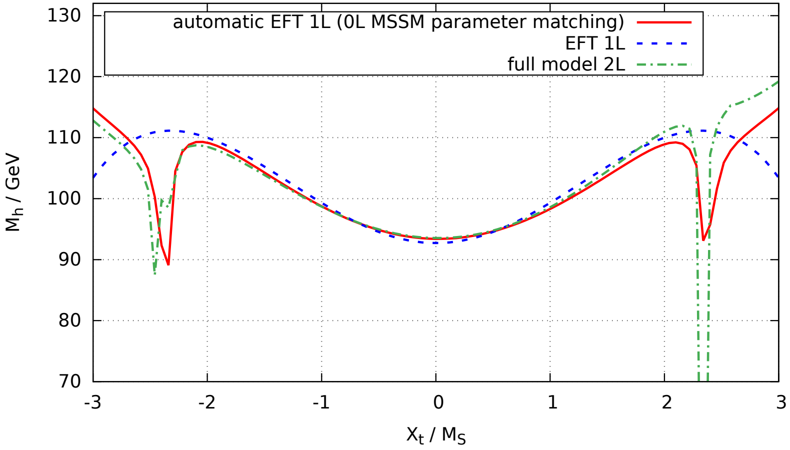
$\tan\beta = 5$, $X_{b,\tau} = 0$, $M_S = 100\,\text{GeV}$ ($0L$ matching SM $\to$ MSSM)

Comparison full vs. EFT vs. automatic EFT approach



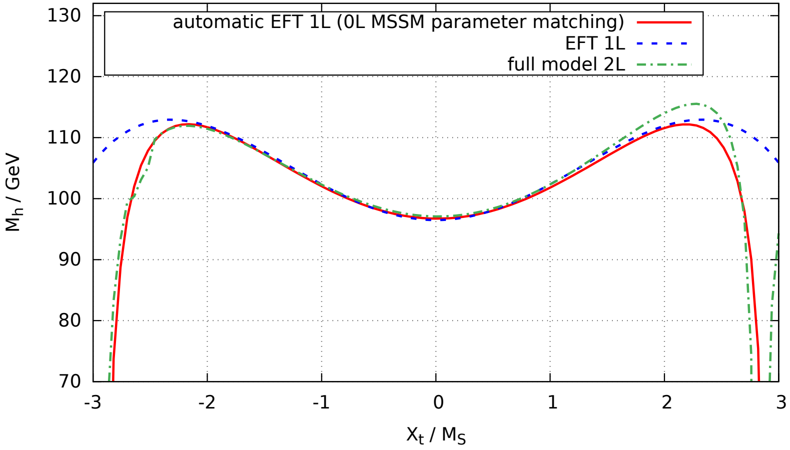
$\tan\beta = 5,\ X_{b,\tau} = 0,\ M_S = 200\,\text{GeV}$ ($0L$ matching SM $\to$ MSSM)

Comparison full vs. EFT vs. automatic EFT approach



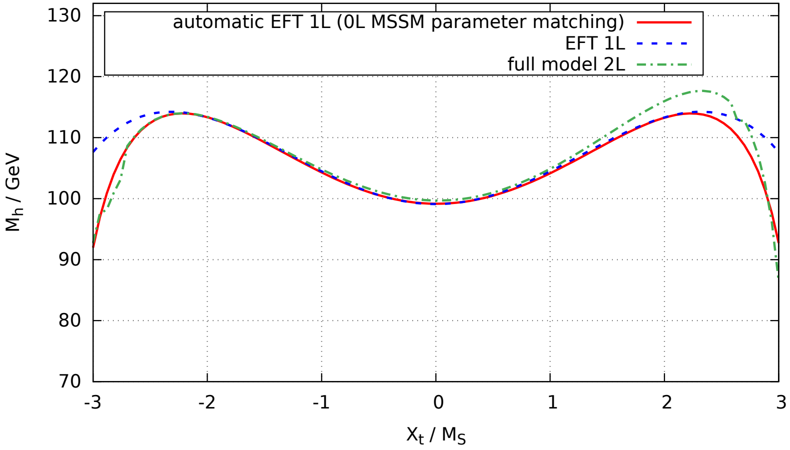
$\tan\beta = 5,\ X_{b,\tau} = 0,\ M_S = 300\,\text{GeV}$ (0L matching SM $\to$ MSSM)

Comparison full vs. EFT vs. automatic EFT approach



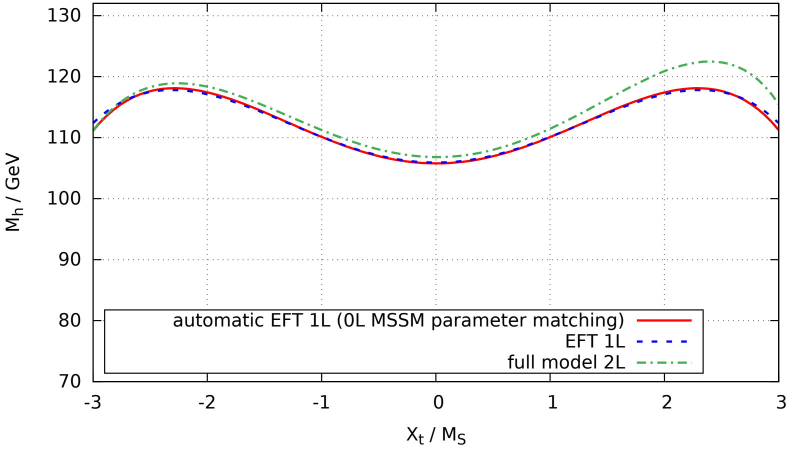
$\tan\beta = 5,\ X_{b,\tau} = 0,\ M_S = 400\,\text{GeV}$ ($0L$ matching SM $\to$ MSSM)

Comparison full vs. EFT vs. automatic EFT approach



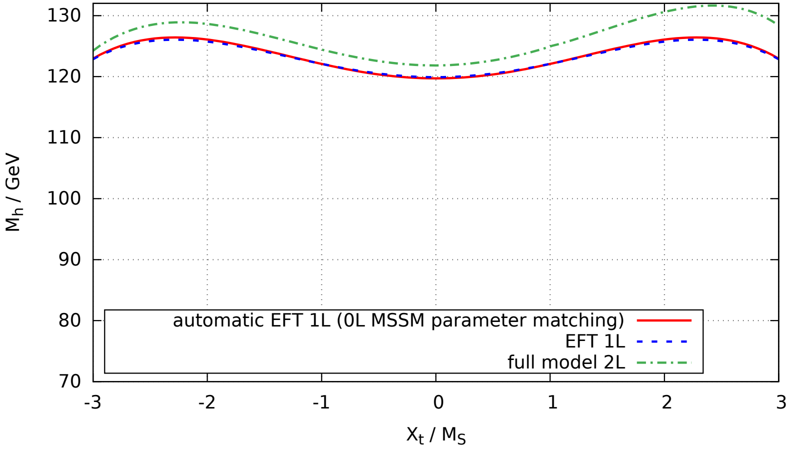
$\tan\beta = 5$, $X_{b,\tau} = 0$, $M_S = 500\,\text{GeV}$ ($0L$ matching SM $\to$ MSSM)

Comparison full vs. EFT vs. automatic EFT approach



$\tan\beta = 5,\ X_{b,\tau} = 0,\ M_S = 1\,\text{TeV}$ ($0L$ matching SM $\to$ MSSM)

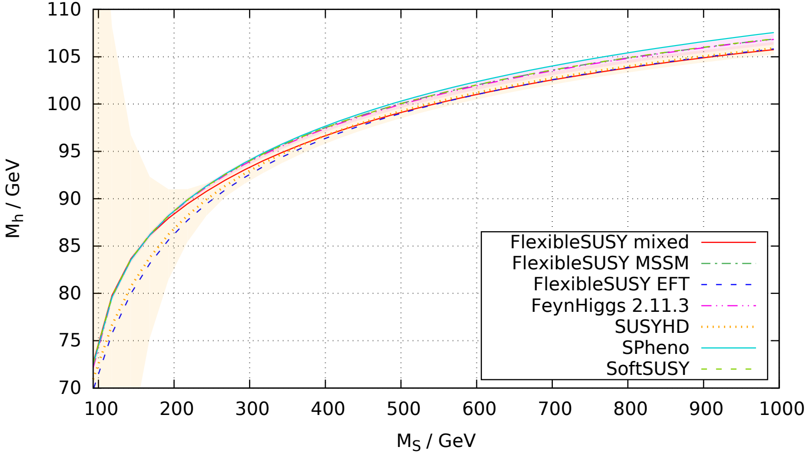
Comparison full vs. EFT vs. automatic EFT approach



$\tan\beta = 5,\ X_{b,\tau} = 0,\ M_S = 10\,\text{TeV}$ ($0L$ matching SM $\to$ MSSM)

Comparison with other spectrum generators

Comparison full vs. EFT vs. automatic EFT approach



$\tan\beta = 5$, $X_{t,b,\tau} = 0$

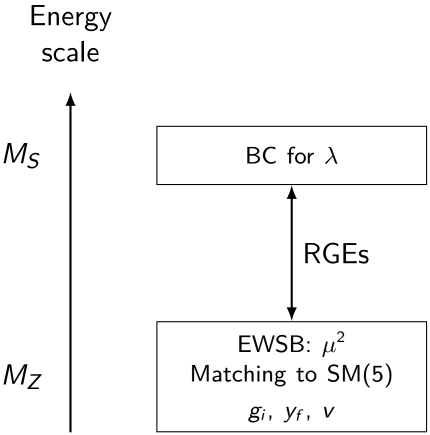
FlexibleSUSY's Weltanschauung

- Model is defined in terms of Lagrangian parameters:
  g_i, y_{ij}, v_i, ... in the $\overline{\text{MS}}/\overline{\text{DR}}$ scheme

- Input parameters:
  $\alpha_{\text{em,SM}}^{(5),\overline{\text{MS}}}(M_Z)$, $\alpha_{\text{s,SM}}^{(5),\overline{\text{MS}}}(M_Z)$, M_Z, M_t, G_F, ...

- Output parameters:
  m_h, M_h, ...

Physical problem statement for the SM



Algorithm to calculate the model parameters consistent with all BCs