Precise Estimates of the Higgs Mass in Heavy SUSY Scenarios

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SUSY 2014 Conference, Univ. of Manchester, July 22, 2014

Lightest SM-like Higgs mass strongly depends on:

* CP-odd Higgs mass m_A
* tan beta
* the top quark mass
* the stop masses and mixing $M^2_{\tilde{t}} = \begin{pmatrix} m_Q^2 + m_t^2 + D_L & m_t X_t \\ m_t X_t & m_U^2 + m_t^2 + D_R \end{pmatrix}$

M_h depends logarithmically on the averaged stop mass scale M_{SUSY} and has a quadratic and quartic dep. on the stop mixing parameter X_t. [and on sbotton/stau sectors for large tanbeta

Haber & Hempfling, Ellis et al, Okada et al '91

For moderate to large values of tan beta and large non-standard Higgs masses

$$m_h^2 \cong M_Z^2 \cos^2 2\beta + \frac{3}{4\pi^2}\frac{m_t^4}{v^2}\left[\frac{1}{2}\tilde{X}_t + t + \frac{1}{16\pi^2}\left(\frac{3}{2}\frac{m_t^2}{v^2} - 32\pi\alpha_3\right)\left(\tilde{X}_t t + t^2\right)\right]$$

$$t = \log(M_{SUSY}^2 / m_t^2) \qquad \tilde{X}_t = \frac{2X_t^2}{M_{SUSY}^2}\left(1 - \frac{X_t^2}{12 M_{SUSY}^2}\right)$$

$X_t = A_t - \mu/\tan\beta \rightarrow$ LR stop mixin

M.Carena, J.R. Espinosa, M. Quiros, C.W.'95
M. Carena, M. Quiros, C.W.'95

Analytic expression valid for $M_{SUSY} \sim m_Q \sim m_U$

Computation with mainly two different Methods

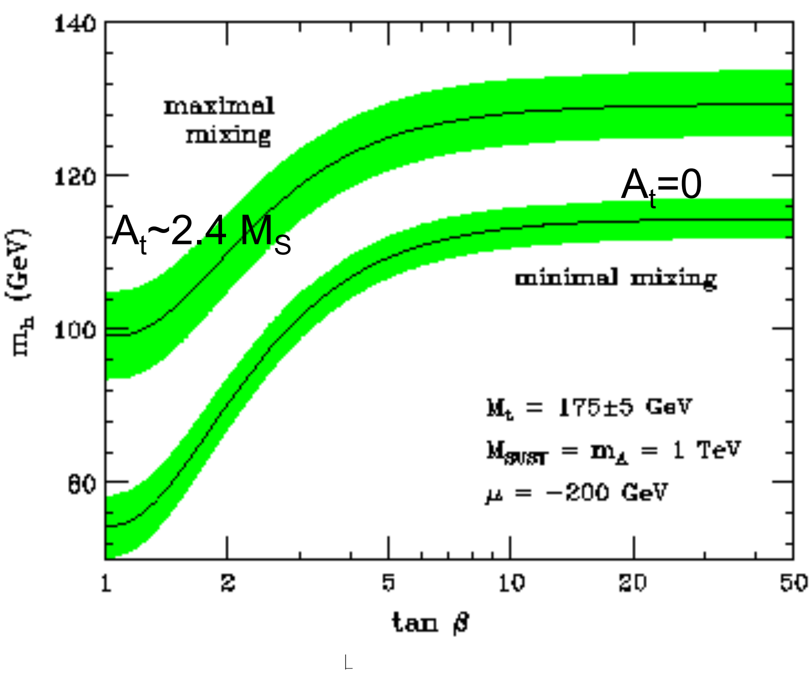
- Diagrammatic Approach : Includes all the one-loop corrections plus the dominant two loop corrections. It preserves the exact dependence on the sparticle spectrum (FeynHiggs)
- Renormalization Group Approach : Includes all the relevant one and two loop corrections at the leading logarithmic level, as well as finite threshold corrections associated with the decouple of heavy sparticles. Leading logarithmic corrections may be included at higher loops, by solving the corresponding RG equations.
- Diagrammatic Approach is expected to be more precise if sparticles are light
- A careful RG approach should lead to all relevant contributions if sparticles are heavy.
- The RG resummation may be cut at different loop levels, and it could be compared with the results of the diagrammatic approach. Inclusion of weak couplings is easy in this approach (this talk)

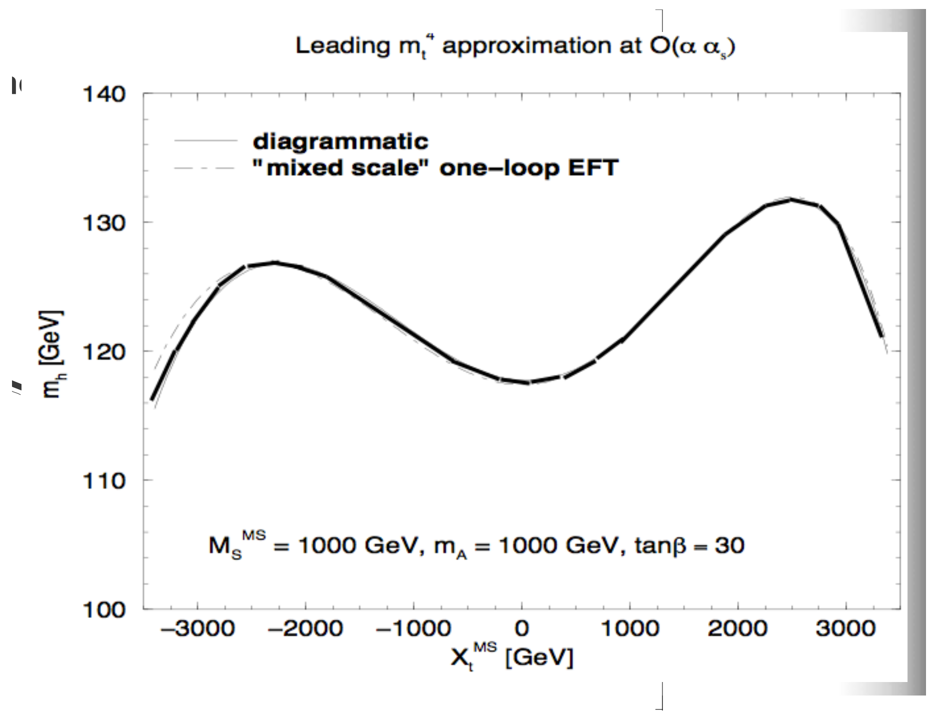
Standard Model-like Higgs Mass

Long list of two-loop computations: Carena, Degrassi, Ellis, Espinosa, Haber, Harlander, Heinemeyer, Hempfling, Hoang, Hollik, Hahn, Martin, Pilaftsis, Quiros, Ridolfi, Rzehak, Slavich, C.W., Weiglein, Zhang, Zwirner

Carena, Haber, Heinemeyer, Hollik, Weiglein, C.W.'00

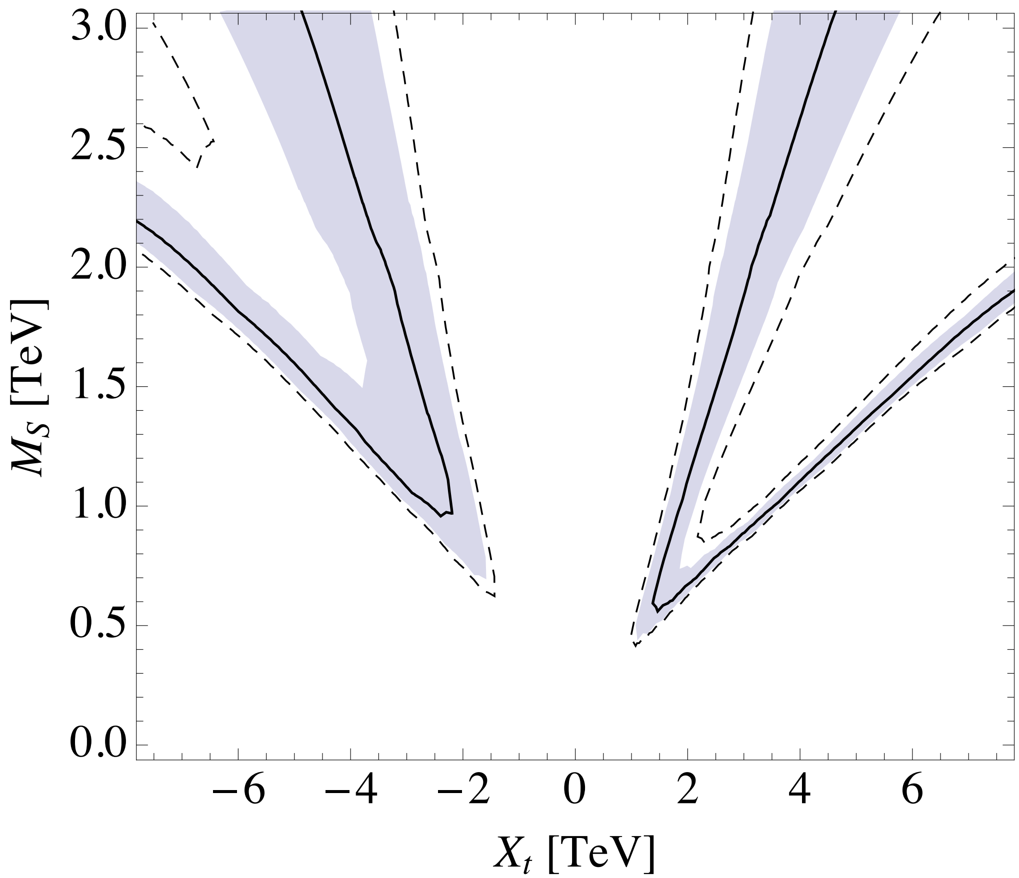
For masses of order 1 TeV, diagrammatic and EFT approach agree well, once the appropriate threshold corrections are included





$$X_t = A_t - \mu/\tan\beta, \qquad X_t = 0 : \text{ No mixing}; \qquad X_t = \sqrt{6} M_S : \text{ Max. Mixing}$$

Large Mixing in the Stop Sector Necessary



P. Draper, P. Meade, M. Reece, D. Shih'11
L. Hall, D. Pinner, J. Ruderman'11
M. Carena, S. Gori, N. Shah, C. Wagner'11
A. Arbey, M. Battaglia, A. Djouadi, F. Mahmoudi, J. Quevillon'11
S. Heinemeyer, O. Stal, G. Weiglein'11
U. Ellwanger'11

Stop Mixing and the Stop Mass Scale

- For smaller values of the mixing parameter, the Stop Mass Scale must be pushed to values (far) above the TeV scale
- The same is true for smaller values of $\tan\beta$, for which the tree-level contribution is reduced
- In these cases, the RG approach allows to resum the large logarithmic corrections and leads to a more precise determination of the Higgs mass than the fixed order computations.
- The level of accuracy may be increased by including weak coupling corrections to both the RG running of the quartic coupling, as well as threshold corrections that depend on these couplings
- One can also use the RG approach to obtain partial results at a given fixed order by the methods we shall describe below

Three Loop Computations

- For many years, the Higgs phenomenology was described by a multiplicity of programs which contain computations of the Higgs mass at the two-loop order.

- The Higgs mass in this computations had a slow increase with the stop mass scale and actually it decreases for sufficiently large values of this scale, when the Higgs mass was expressed as a function of the top quark mass at Mt.

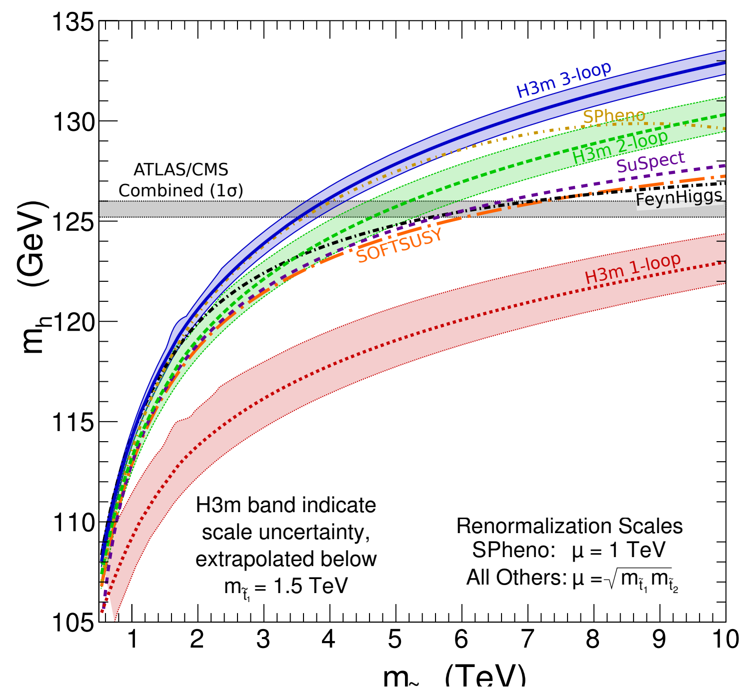
- A partial three-loop diagrammatic computation was performed, including the dominant QCD effects, and showed a faster than expected increase of the Higgs mass.

- Such an increase implies that the stop mass spectrum consistent with the observed Higgs mass was pushed to lower values, within the LHC reach.

- The question remained of what was the effect of the ignored subdominant three-loop corrections that depend on the top-Yukawa coupling and the strong gauge coupling

- Higher loop effects should also be evaluated.

Small Mixing, moderate tanb



Evolution of the quartic Coupling

$$\kappa \equiv \frac{1}{16\pi^2}, \qquad t \equiv \log Q, \qquad \beta_\lambda^{(n,k)}(t) \equiv \frac{\mathrm{d}^k \beta_\lambda^{(n)}}{\mathrm{d}t^k}(t)$$

We want to evaluate the coupling at the weak scale (mt) starting from the stop mass scale. It can be done in two ways, depending on where the couplings are evaluated. Taking $L \equiv \tilde{t} - t = \log(\widetilde{Q}/Q) > 0\,, \quad \beta_\lambda^{(n)} \equiv \beta_\lambda^{(n,0)}.$

$$\lambda(Q) = \lambda(\widetilde{Q}) - \sum_{n=1}^{\infty} \kappa^n \sum_{k=0}^{\infty} (-1)^k \frac{\beta_\lambda^{(n,k)}(\tilde{t})}{(k+1)!} L^{k+1}$$

These two expressions are not equivalent, and represent a different reorganization of the perturbativexpansion. The second one is implemented in CPsuperH. The first one leads to a faster convergence

$$\lambda(\widetilde{Q}) = \lambda(Q) + \sum_{n=1}^{\infty} \kappa^n \sum_{k=0}^{\infty} \frac{\beta_\lambda^{(n,k)}(t)}{(k+1)!} L^{k+1}$$

Details of the Calculation

Tree-level coupling, should be evaluated at the SUSY breaking scale :

$$\lambda_{\rm tree} = \frac{1}{4}(g_Y^2 + g_2^2)c_{2\beta}^2$$

Simplified stop spectrum :

$$\mathcal{M}_{\tilde{t}}^2 = \begin{pmatrix} m_{\tilde{t}_L}^2 + m_t^2 + c_{2\beta}\left(\frac{1}{2} - \frac{2}{3}s_W^2\right)m_Z^2 & m_t X_t \\ m_t X_t & m_{\tilde{t}_R}^2 + m_t^2 + \frac{2}{3}c_{2\beta}s_W^2 m_Z^2 \end{pmatrix}$$

$$\mathcal{M}_{\tilde{t}}^2 = \begin{pmatrix} M_S^2 & m_t X_t \\ m_t X_t & M_S^2 \end{pmatrix}$$

$$m_{\tilde{t}_{1,2}}^2 = M_S^2 \mp |m_t X_t|.$$

This approximation is abandoned at the one-loop level, in the evaluation of the thresholds to the quartic coupling

One loop thresholds to the quartic coupling and Yukawas in the MS scheme

$$\Delta_{\rm th}^{(\alpha_t)}\lambda = 6\kappa h_t^4 s_\beta^4 \widehat{X}_t^2\Big(1-\frac{\widehat{X}_t^2}{12}\Big) + \frac{3}{4}\kappa h_t^2 s_\beta^2 (g_2^2+g_Y^2)\widehat{X}_t^2 c_{2\beta},$$
$$\Delta_{\rm th}^{(\alpha_b)}\lambda = -\frac{1}{2}\kappa h_b^4 s_\beta^4 \hat{\mu}^4,$$
$$\Delta_{\rm th}^{(\alpha_\tau)}\lambda = -\frac{1}{6}\kappa h_\tau^4 s_\beta^4 \hat{\mu}^4,$$

It is important to consider the thresholds to the quartic couplings induced by the D-term, weak gauge couplings contributions to the stop masses, which was ignored before

$$y_t = h_t s_\beta, \qquad y_b = h_b c_\beta, \qquad y_\tau = h_\tau c_\beta;$$

The top, bottom and tau Yukawa couplings have the usual threshold corrections at the scale of supersymmetric particles

$$h_t = \frac{y_t}{s_\beta}\frac{1}{1-\kappa(\Delta h_t + \cot\beta\,\delta h_t)},$$
$$h_b = \frac{y_b}{c_\beta}\frac{1}{1-\kappa(\Delta h_b + t_\beta\,\delta h_b)},$$
$$h_\tau = \frac{y_\tau}{c_\beta}\frac{1}{1-\kappa t_\beta\,\delta h_\tau},$$

Very relevantly, two loop corrections were included to relate the top quark mass to the running mass

$$y_t(Q=M_t) = 0.93697 \pm 0.00550\Big(\frac{M_t}{\rm GeV} - 173.35\Big) - 0.00042\frac{\alpha_s(M_Z)-0.1184}{0.0007},$$
$$g_3(Q=M_t) = 1.1666 + 0.00314\frac{\alpha_s(M_Z)-0.1184}{0.0007} - 0.00046\Big(\frac{M_t}{\rm GeV} - 173.35\Big).$$

Buttazzo et al '13

These threshold corrections include subdominant contributions

$$
\begin{aligned}
\Delta h_t &= \frac{8}{3} g_3^2 m_{\tilde g} X_t \, I(m_{\tilde t_1}, m_{\tilde t_2}, m_{\tilde g}) - h_b^2 \mu \cot\beta X_b \, I(m_{\tilde b_1}, m_{\tilde b_2}, \mu), \\
\delta h_t &= g_2^2 M_2 \mu \Big([c_b^2 I(m_{\tilde b_1}, M_2, \mu) + s_b^2 I(m_{\tilde b_2}, M_2, \mu)] + \frac{1}{2}[c_t^2 I(m_{\tilde t_1}, M_2, \mu) + s_t^2 I(m_{\tilde t_2}, M \ldots \\
&\quad + \frac{1}{3} g_Y^2 M_1 \Big(\frac{2}{3} X_t t_\beta I(m_{\tilde t_1}, m_{\tilde t_2}, M_1) - \frac{1}{2}\mu [c_t^2 I(m_{\tilde t_1}, M_1, \mu) + s_t^2 I(m_{\tilde t_2}, M_1, \mu)] \\
&\quad + 2\mu [s_t^2 I(m_{\tilde t_1}, M_1, \mu) + c_t^2 I(m_{\tilde t_2}, M_1, \mu)] \Big), \qquad (15)
\end{aligned}
$$

The top threshold introduces a dependence on the sign of the gluino mass times the mixing parameter

$$
\begin{aligned}
\Delta h_b &= \frac{8}{3} g_3^2 m_{\tilde g} X_b \, I(m_{\tilde b_1}, m_{\tilde b_2}, m_{\tilde g}) - h_t^2 \mu t_\beta X_t \, I(m_{\tilde t_1}, m_{\tilde t_2}, \mu), \\
\delta h_b &= g_2^2 M_2 \mu \Big([c_t^2 I(m_{\tilde t_1}, M_2, \mu) + s_t^2 I(m_{\tilde t_2}, M_2, \mu)] + \frac{1}{2}[c_b^2 I(m_{\tilde b_1}, M_2, \mu) + s_b^2 I(m_{\tilde b_2}, M_2, \ldots \\
&\quad + \frac{1}{3} g_Y^2 M_1 \Big(-\frac{1}{3} X_b \cot\beta \, I(m_{\tilde b_1}, m_{\tilde b_2}, M_1) + \frac{1}{2}\mu [c_b^2 I(m_{\tilde b_1}, M_1, \mu) + s_b^2 I(m_{\tilde b_2}, M_1, \mu)] \\
&\quad + \mu [s_b^2 I(m_{\tilde b_1}, M_1, \mu) + c_b^2 I(m_{\tilde b_2}, M_1, \mu)] \Big), \qquad (17)
\end{aligned}
$$

$$
\begin{aligned}
\delta h_\tau &= g_2^2 M_2 \mu \Big(I(m_{\tilde \nu_\tau}, M_2, \mu) + \frac{1}{2}[c_\tau^2 I(m_{\tilde \tau_1}, M_2, \mu) + s_\tau^2 I(m_{\tilde \tau_2}, M_2, \mu)] \Big) \\
&\quad - g_Y^2 M_1 \Big(X_\tau \cot\beta \, I(m_{\tilde \tau_1}, m_{\tilde \tau_2}, M_1) + \frac{1}{2}\mu [c_\tau^2 I(m_{\tilde \tau_1}, M_1, \mu) + s_\tau^2 I(m_{\tilde \tau_2}, M_1, \mu)] \\
&\quad - \mu [s_\tau^2 I(m_{\tilde \tau_1}, M_1, \mu) + c_\tau^2 I(m_{\tilde \tau_2}, M_1, \mu)] \Big),
\end{aligned}
$$

$$
I(a,b,c) = \frac{ab\log(a/b) + bc\log(b/c) + ac\log(c/a)}{(a-b)(b-c)(a-c)}
$$

$$
\begin{aligned}
I(1,1,1-\delta) &= \frac{1}{2} + \frac{\delta}{6} + \ldots \qquad (\mu \sim M_S), \\
I(1,1,\delta) &= 1 + \delta(1 + \log\delta) + \ldots \qquad (\mu \ll M_S).
\end{aligned}
$$

Two loop thresholds to the quartic Couplings in the $\overline{\text{MS}}$ scheme

$$\Delta_{\rm th}^{(\alpha_s\alpha_t)}\lambda = 16\kappa^2 h_t^4 g_3^2\Big\{-2\widehat{X}_t^2+\frac{1}{3}\widehat{X}_t^3-\frac{1}{12}\widehat{X}_t^4\Big\},$$

$$\begin{aligned}\Delta_{\rm th}^{(\alpha_t^2)}\lambda = 3\kappa^2 h_t^6\Big\{&-\frac{3}{2}+6\hat\mu^2-2(4+\hat\mu^2)f_1(\hat\mu)+3\hat\mu^2 f_2(\hat\mu)+4f_3(\hat\mu)-\frac{\pi^2}{3}\\ &+\Big[-\frac{17}{2}-6\hat\mu^2-(4+3\hat\mu^2)f_2(\hat\mu)+(4-6\hat\mu^2)f_1(\hat\mu)\Big]\widehat{X}_t^2\\ &+\Big[23+4s_\beta^2+4\hat\mu^2+2f_2(\hat\mu)-2(1-2\hat\mu^2)f_1(\hat\mu)\Big]\frac{\widehat{X}_t^4}{4}-\frac{13}{24}\widehat{X}_t^6 s_\beta^2\\ &+c_\beta^2\Big[-\frac{9}{2}+60K+\frac{4\pi^2}{3}+\Big(\frac{27}{2}-24k\Big)\widehat{X}_t^2-6\widehat{X}_t^4\\ &\quad-(3+16K)(4\widehat{X}_t+\widehat{Y}_t)\widehat{Y}_t+4(1+4K)\widehat{X}_t^3\widehat{Y}_t\\ &\quad+\Big(\frac{14}{3}+24K)\widehat{X}_t^2\widehat{Y}_t^2-\Big(\frac{19}{12}+8K)\widehat{X}_t^4\widehat{Y}_t^2\Big]\Big\}.\end{aligned}$$

The two loop corrections are relevant for the precision calculation

$$K=-\frac{1}{\sqrt{3}}\int_0^{\pi/6}dx\log(2\cos x)\sim -0.1953256,$$

$$\widehat{Y}_t=(A_t-\mu t_\beta)/M_S=\widehat{X}_t+\frac{2\hat\mu}{\sin 2\beta},$$

$$f_1(\hat\mu)=\frac{\hat\mu^2}{1-\hat\mu^2}\log\hat\mu^2,$$

$$f_2(\hat\mu)=\frac{1}{1-\hat\mu^2}\Big[1+\frac{\hat\mu^2}{1-\hat\mu^2}\log\hat\mu^2\Big],$$

$$f_3(\hat\mu)=\frac{-1+2\hat\mu^2+2\hat\mu^4}{(1-\hat\mu^2)^2}\Big[\log\hat\mu^2\log(1-\hat\mu^2)+Li_2(\hat\mu^2)-\frac{\pi^2}{6}-\hat\mu^2\log\hat\mu^2\Big]$$

One and two-loop log corrections

- They reproduced the values in the literature. Weak corrections included
- Light chargino effects resummed at the loop level and provide a dependence on the value of mu, raising the mass for smaller values of mu (we assume gaugino masses at the scale of the mu parameter

$$
\begin{aligned}
\delta_1\lambda = &\Big\{ -12\lambda^2 - \lambda\Big[12y_t^2 + 12y_b^2 + 4y_\tau^2 - 9g_2^2 - \frac{9}{5}g_1^2\Big] + 12y_t^4 + 12y_b^4 + 4y_\tau^4 \\
&\quad - \frac{9}{4}g_2^4 - \frac{9}{10}g_2^2g_1^2 - \frac{27}{100}g_1^4\Big\}L \\
&+ \Big\{ -6\lambda\Big[g_2^2 + \frac{1}{5}g_1^2\Big] + \Big[g_2^2 + \frac{3}{5}g_1^2\Big]^2 + 4g_2^4\Big[1 - 2s_\beta^2c_\beta^2\Big]\Big\}L_\mu, \qquad (45) \\
\delta_2\lambda = &\Big\{144\lambda^3 + \lambda^2\Big[216y_t^2 - 108g_2^2 - \frac{108}{5}g_1^2\Big] + \lambda\Big[-18y_t^4 + 27g_2^4 + \frac{54}{5}g_2^2g_1^2 + \frac{81}{25}g_1^4\Big] \\
&\quad + \lambda y_t^2\Big[-96g_3^2 - 81g_2^2 - 21g_1^2\Big] + y_t^4\Big[-180y_t^2 + 192g_3^2 + 54g_2^2 + \frac{102}{5}g_1^2\Big] \\
&\quad + y_t^2\Big[\frac{27}{2}g_2^4 + \frac{27}{5}g_2^2g_1^2 + \frac{81}{50}g_1^4\Big]\Big\}L^2 \\
&- \Big\{\Big[24\lambda + 12y_t^2 - 9g_2^2 - \frac{9}{5}g_1^2\Big]\Big[6\lambda\Big[g_2^2 + \frac{1}{5}g_1^2\Big]^2 - \Big[g_2^2 + \frac{3}{5}g_1^2\Big]^2 - 4g_2^4\Big[1 - 2s_\beta^2c_\beta^2\Big]\Big]\Big\}LL_\mu \\
&+ \Big\{3\Big[g_2^2 + \frac{1}{5}g_1^2\Big]\Big[6\lambda\Big[g_2^2 + \frac{1}{5}g_1^2\Big]^2 - \Big[g_2^2 + \frac{3}{5}g_1^2\Big]^2 - 4g_2^4\Big[1 - 2s_\beta^2c_\beta^2\Big]\Big]\Big\}L_\mu^2 \\
&+ \Big\{78\lambda^3 + 72\lambda^2y_t^2 + \lambda y_t^2(3y_t^2 - 80g_3^2) - 60y_t^6 + 64g_3^2y_t^4\Big\}L,
\end{aligned}
$$

Draper, Lee, C.W. '13

The analysis of the three-loop corrections show a high degree of cancellation between the dominant and subdominant contributions

$$\delta_3\lambda = \Big\{ -1728\lambda^4 - 3456\lambda^3 y_t^2 + \lambda^2 y_t^2(-576y_t^2 + 1536g_3^2)$$
$$+ \lambda y_t^2(1908y_t^4 + 480y_t^2 g_3^2 - 960g_3^4) + y_t^4(1548y_t^4 - 4416y_t^2 g_3^2 + 2944g_3^4)\Big\} L^3$$
$$+ \Big\{ -2340\lambda^4 - 3582\lambda^3 y_t^2 + \lambda^2 y_t^2(-378y_t^2 + 2016g_3^2)$$
$$+ \lambda y_t^2(1521y_t^4 + 1032y_t^2 g_3^2 - 2496g_3^4) + y_t^4(1476y_t^4 - 3744y_t^2 g_3^2 + 4064g_3^4)\Big\} L^2$$
$$+ \Big\{ -1502.84\lambda^4 - 436.5\lambda^3 y_t^2 - \lambda^2 y_t^2(1768.26y_t^2 + 160.77g_3^2)$$
$$+ \lambda y_t^2(446.764\lambda y_t^4 + 1325.73y_t^2 g_3^2 - 713.936g_3^4)$$
$$+ y_t^4(972.596y_t^4 - 1001.98y_t^2 g_3^2 + 200.804g_3^4)\Big\} L,$$

This is a SM effect, since this is the effective theory we are considering.

This shows that a partial computation of three loop effects is not justified

The cancellation between dominant and subdominant contributions persists at the four loop level !

$$\delta_4\lambda = \Big\{20736\lambda^5 + 51840\lambda^4 y_t^2 + \lambda^3 y_t^2(21600y_t^2 - 23040g_3^2)$$

$$+ \lambda^2 y_t^2(-30780y_t^4 - 18720g_3^2y_t^2 + 14400g_3^4)$$

$$+ \lambda y_t^2(-22059y_t^6 + 28512g_3^2y_t^4 + 10560g_3^4y_t^2 - 10560g_3^6)$$

$$+ y_t^4(-8208y_t^6 + 56016y_t^6g_3^2 - 84576y_t^2g_3^4 + 44160g_3^6)\Big\}L^4$$

$$+ \Big\{48672\lambda^5 + 101808\lambda^4 y_t^2 + \lambda^3 y_t^2(30546y_t^2 - 49152g_3^2y_t^2)$$

$$\lambda^2 y_t^2(-50292y_t^4 - 40896y_t^2g_3^2 + 45696g_3^4)$$

$$+ \lambda y_t^2(-33903y_t^6 + 41376y_t^4g_3^2 + 35440g_3^4y_t^2 - 45184g_3^6)$$

$$+ y_t^4(-15588y_t^6 + 86880y_t^4g_3^2 - 161632y_t^2g_3^4 + 112256g_3^6)\Big\}L^3$$

$$+ \Big\{63228.2\lambda^5 + 72058.1\lambda^4 y_t^2 + \lambda^3 y_t^2(25004.6y_t^2 - 11993.5g_3^2)$$

$$+ \lambda^2 y_t^2(27483.8y_t^4 - 52858y_t^2g_3^2 + 18215.3g_3^4)$$

$$+ \lambda y_t^2(-51279y_t^6 - 5139.56y_t^4g_3^2 + 50795.3y_t^2g_3^4 - 33858.8g_3^6)$$

$$y_t^4(-24318.2y_t^6 + 72896y_t^4g_3^2 - 73567.3y_t^2g_3^4 + 36376.5g_3^6)\Big\}L^2.$$

Three and four loop correction dependence on the stop mass scale.

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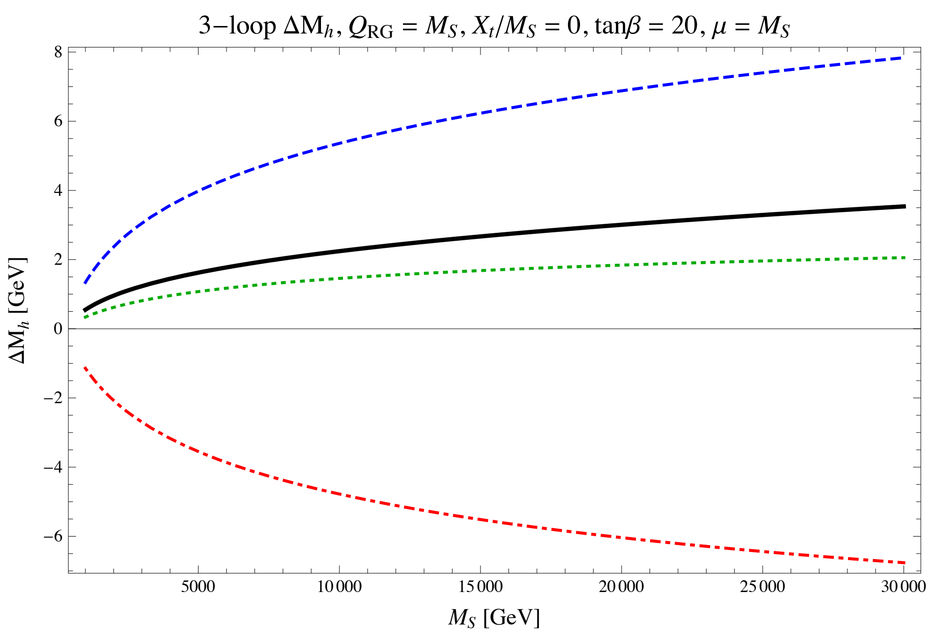

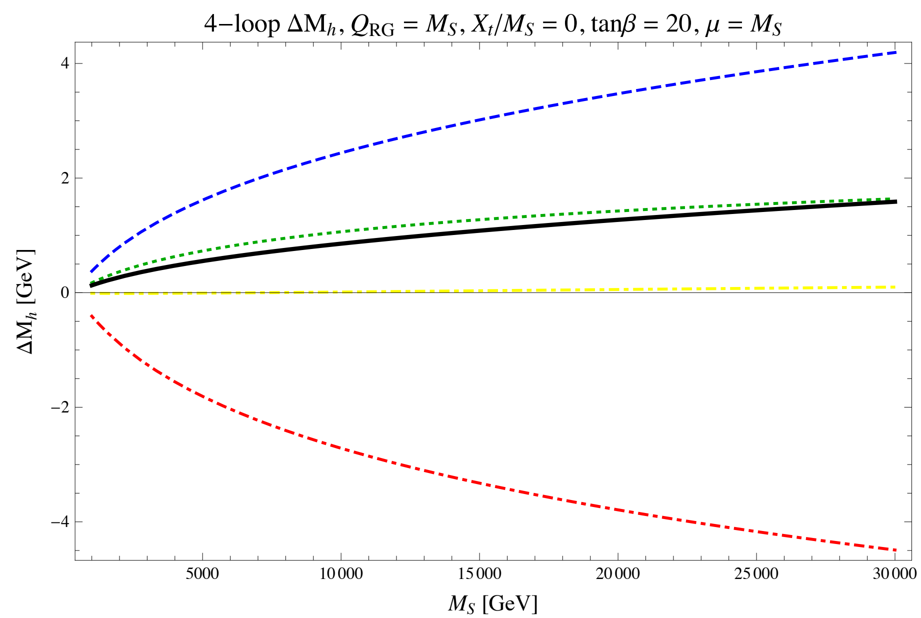

QCD dominant (blue dashed line)
QCD top Yukawa (red dot-dashed line)
Top Yukawa QCD (green dotted line line)
Total Contribution (black line)

Very large cancellations
Three and four loop contributions similar

Higgs Mass in the Maximal Mixing Scenario

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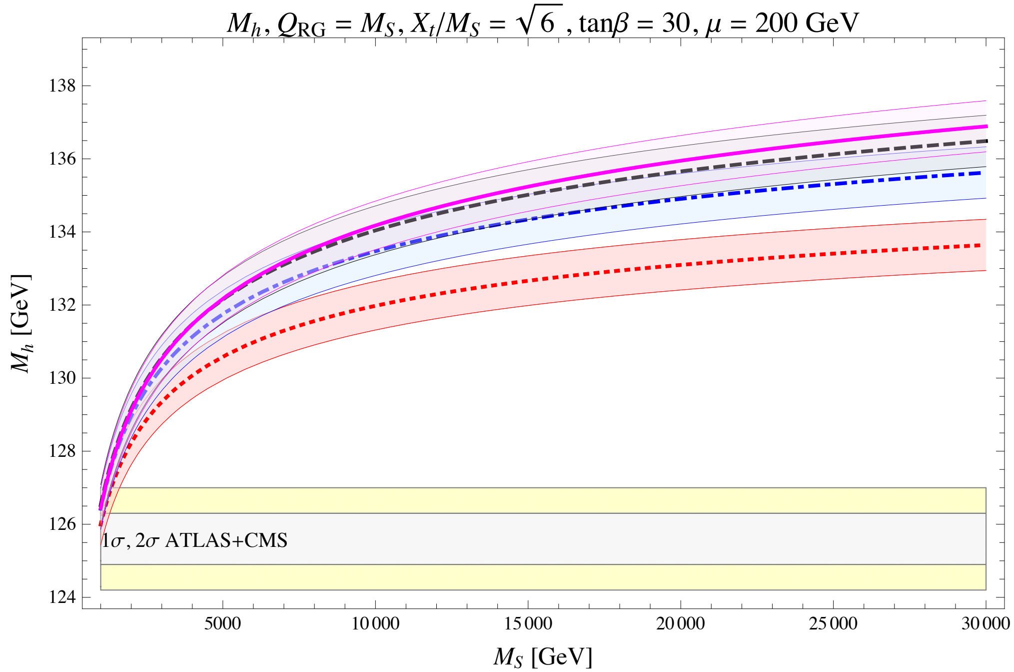
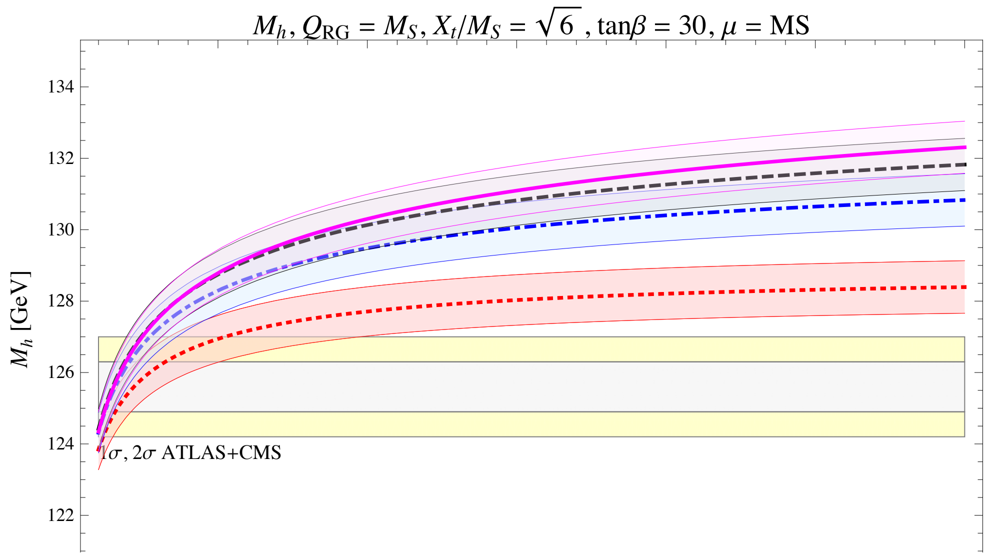
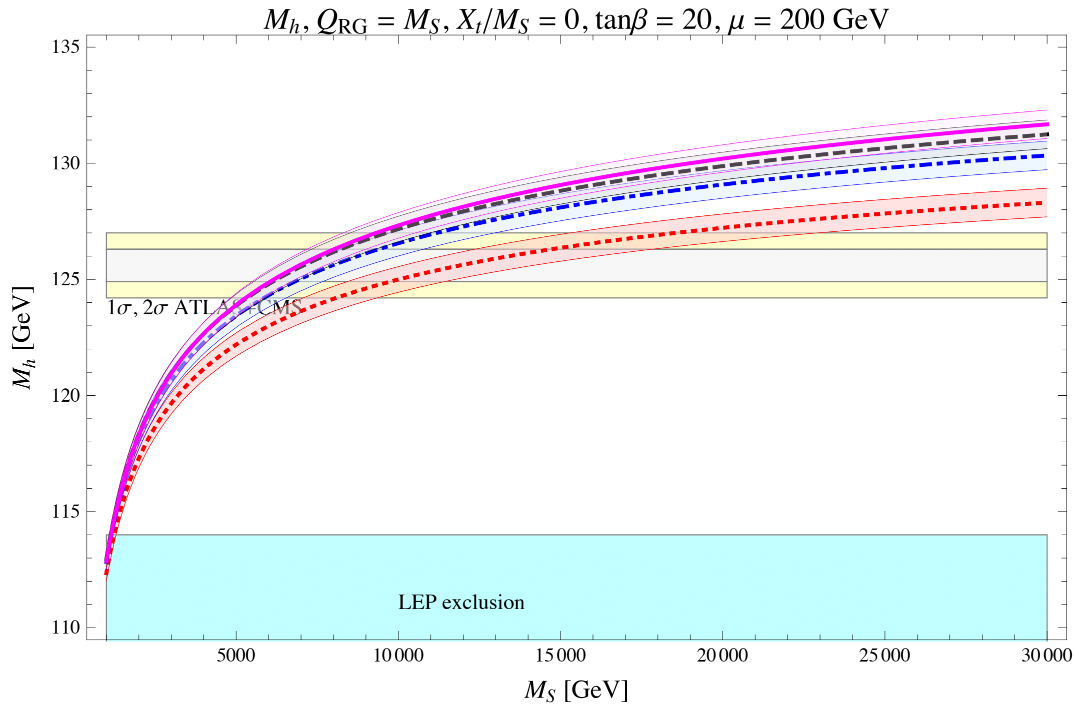
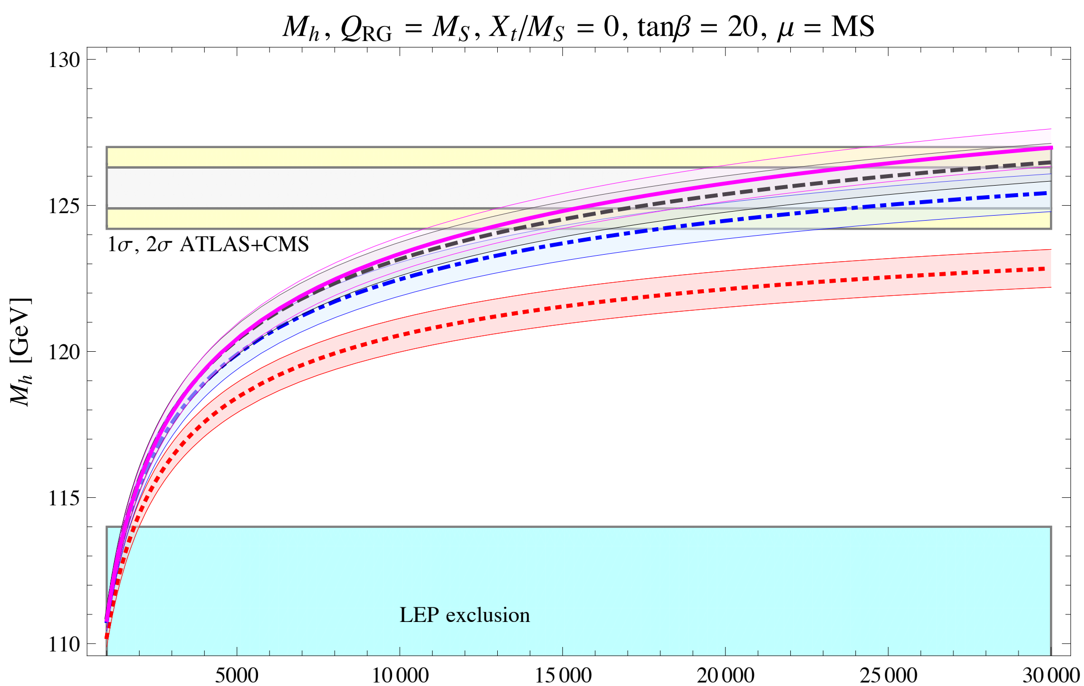


For 1 TeV, mass is 2 GeV smaller than previous calculations, mostly due to the two-loop QCD corrections to the running top quark mass



Still, stops with degenerate stop mass parameters can be as light as 500 GeV





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For zero Mixing, the necessary stop masses go well beyond the LHC reach !

RG approach allow you to get an accurate prediciton of the lightest Higgs mass even in these cases

Higher loop corrections in terms of couplings at the top-quark mass scale

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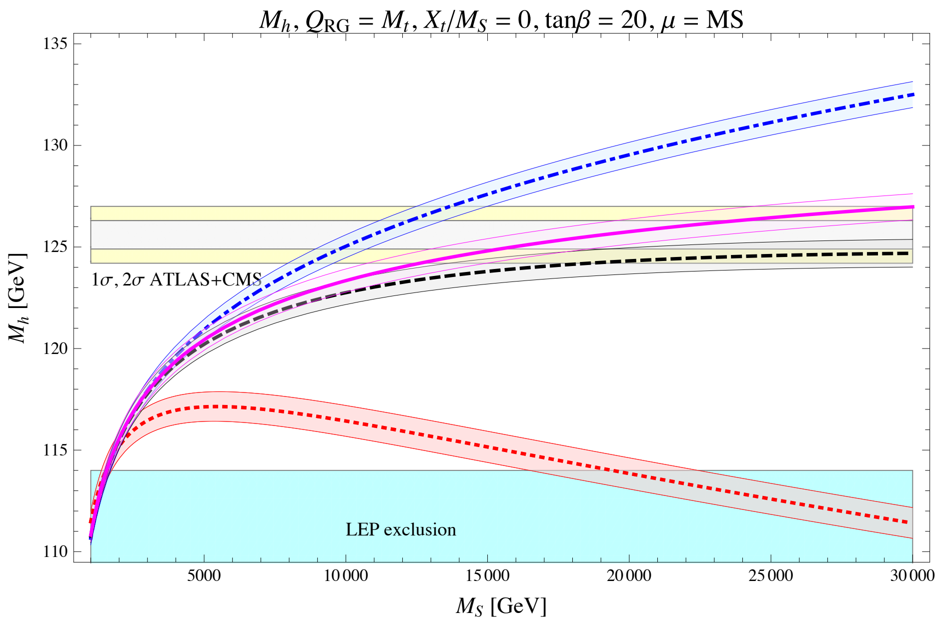
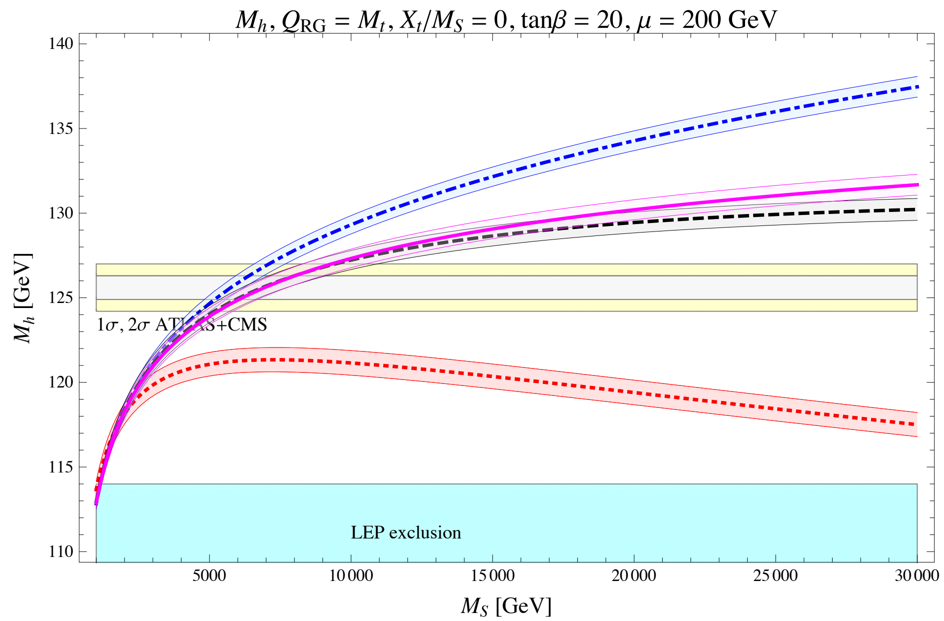
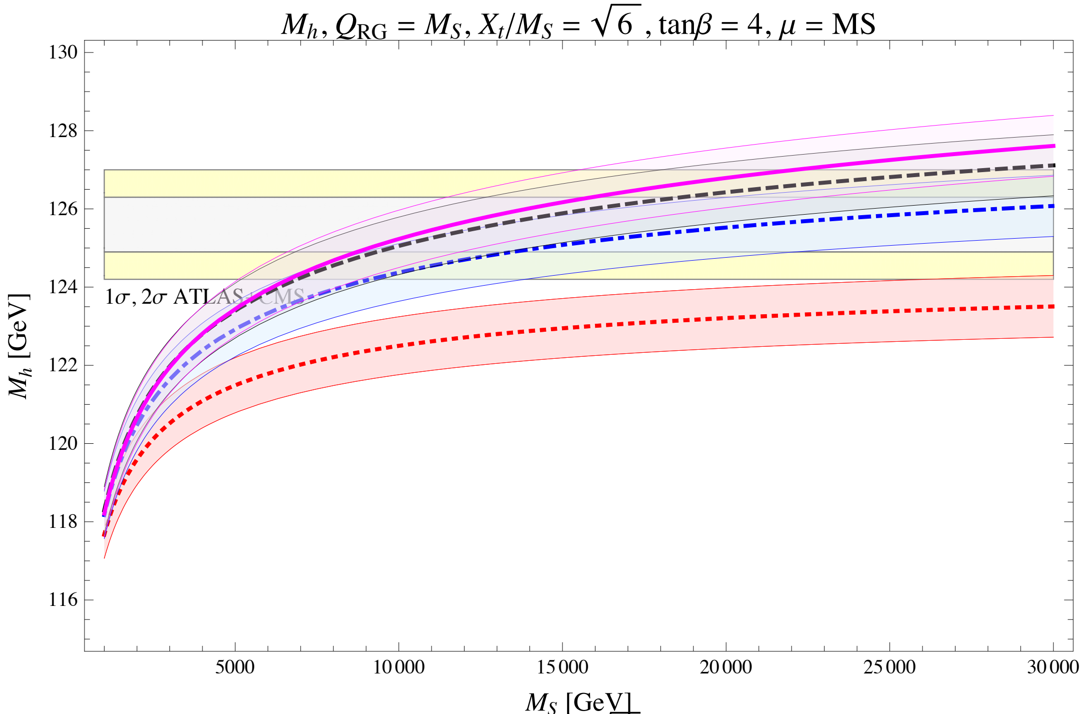




Contributions alternate in sign and converge more slowly than when corrections are expressed in terms of couplings at the MS scale



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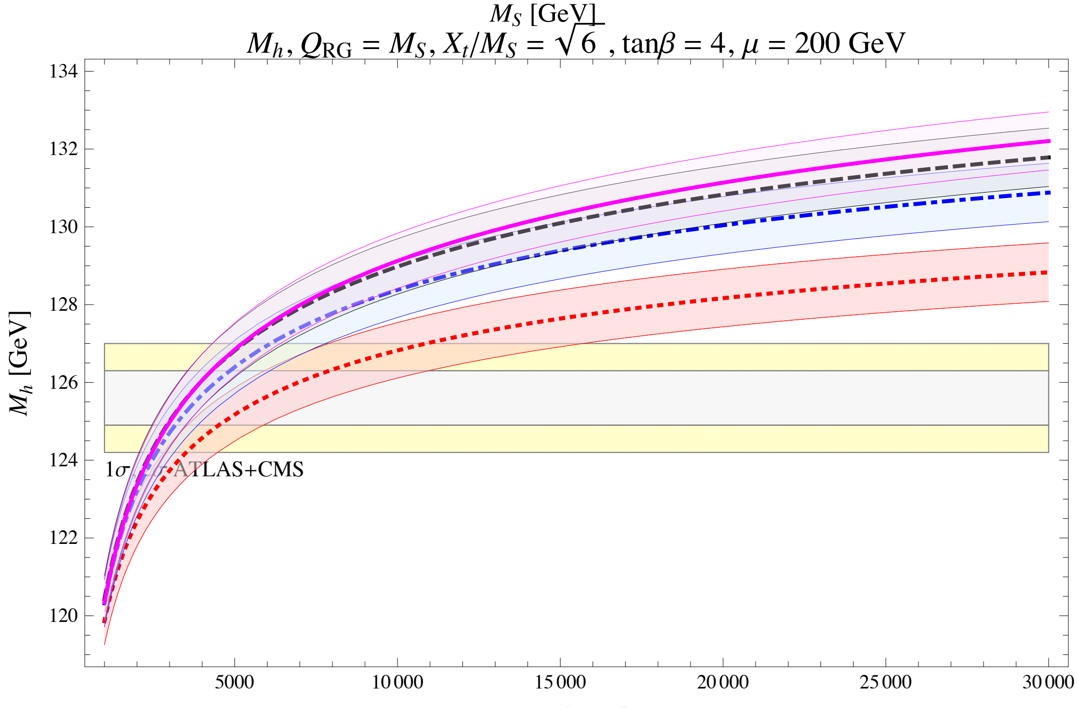
Similar behavior is obtained for large mixing but small values of tanb



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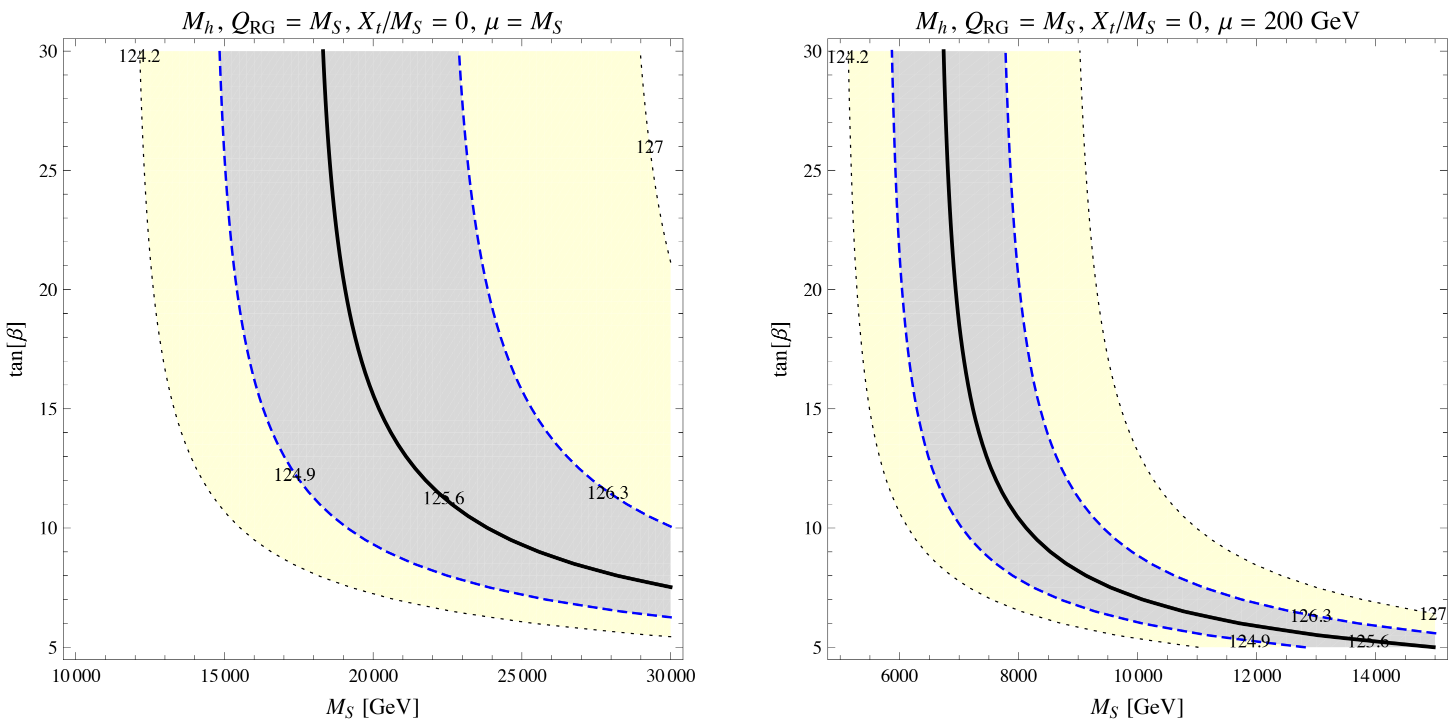
Necessary stop mass values to get the proper Higgs mass for small mixing in the stop sector



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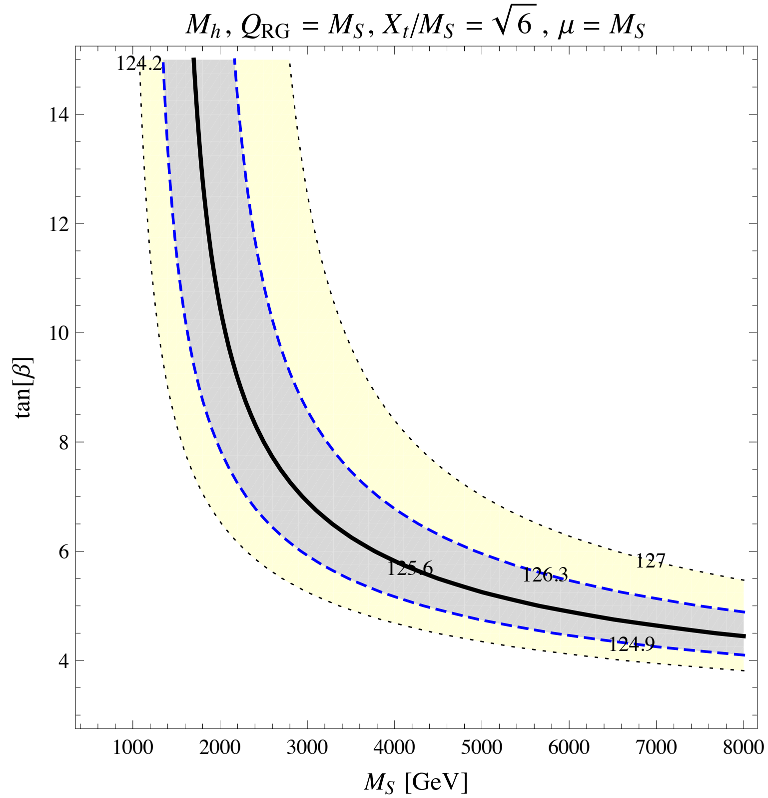
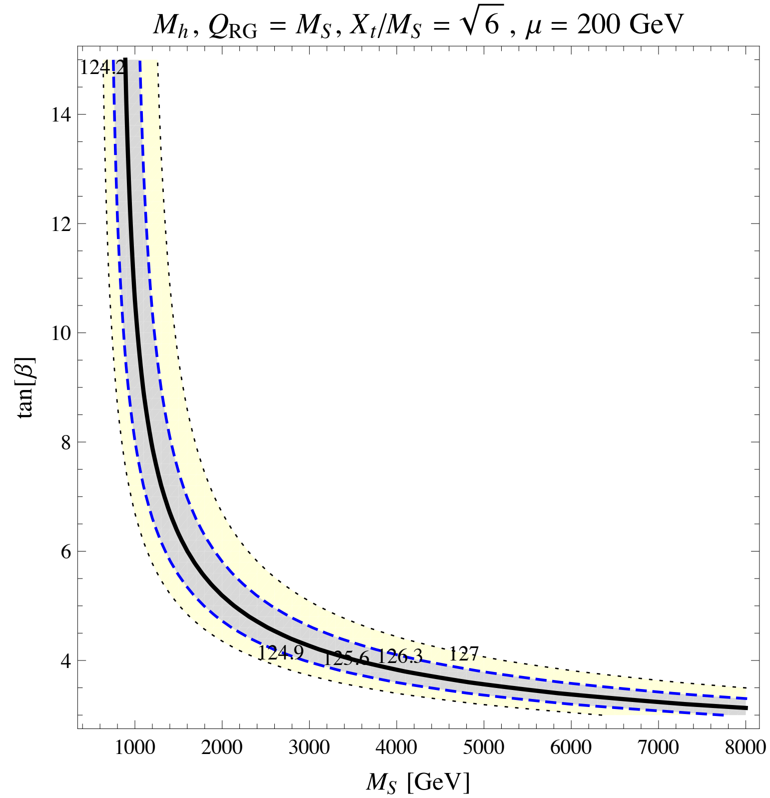
Necessary stop mass values to get the proper Higgs mass for maximal mixing in the stop sector





Conclusions

- Higgs Mass in the MSSM may be computed in terms of the teh gauge boson and sparticle masses
- Radiative corrections depend strongly on the values of the top quark Yukawa and strong gauge couplings, as well as on the SUSY mass scale and stop mixing parameters.
- There is a strong dependence on the mu parameter, that control the electroweakino contributions to the quartic couplings
- Higher loop corrections are very important in controlling the Higgs mass and must be resummed once the supersymmetry particle masses are far above the TeV scale
- There is a large cancellation between dominant and subdominant corrections at the three and four loop level, that make partial calculations unreliable
- Use of the running top quark mass obtained from two-loop QCD corrections has an important impact on the final
- There are few GeV differences between our results and those obtained by FeynHiggs complemented with RG running that must be resolved.

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