2-Loop Higgs Mass Corrections in Effective Potential Approach

Cargèse Summer School 2014

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Introduction

$$m_h = 125.36 \pm 0.41\,\text{GeV (ATLAS)}$$

- Tree-level:
  $m^2_{h,H} = \frac{1}{2}\left(m^2_A + m^2_Z \mp \sqrt{(m^2_A - m^2_Z)^2 + 4m^2_Z m^2_A \sin^2(2\beta)}\right)$
- $m_h \leq m_Z\,|\cos(2\beta)|$
- large 1 loop corrections ($\approx 34\,\text{GeV}$)
- 2 loop dominant: $\alpha_s\alpha_{t,b}, (\alpha_t + \alpha_b)^2, \alpha_\tau\alpha_b, \alpha^2_\tau$ corrections ($\approx$ GeV) $\quad (\alpha_s = g^2_3/(4\pi))$

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  - $V_{\text{eff}} =$ vacuum diagrams
  - calculate $\frac{\partial^2 V_{\text{eff}}}{\partial v_i \partial v_j}$ at minimum $\rightarrow \Delta \mathcal{M}_h{}^2$
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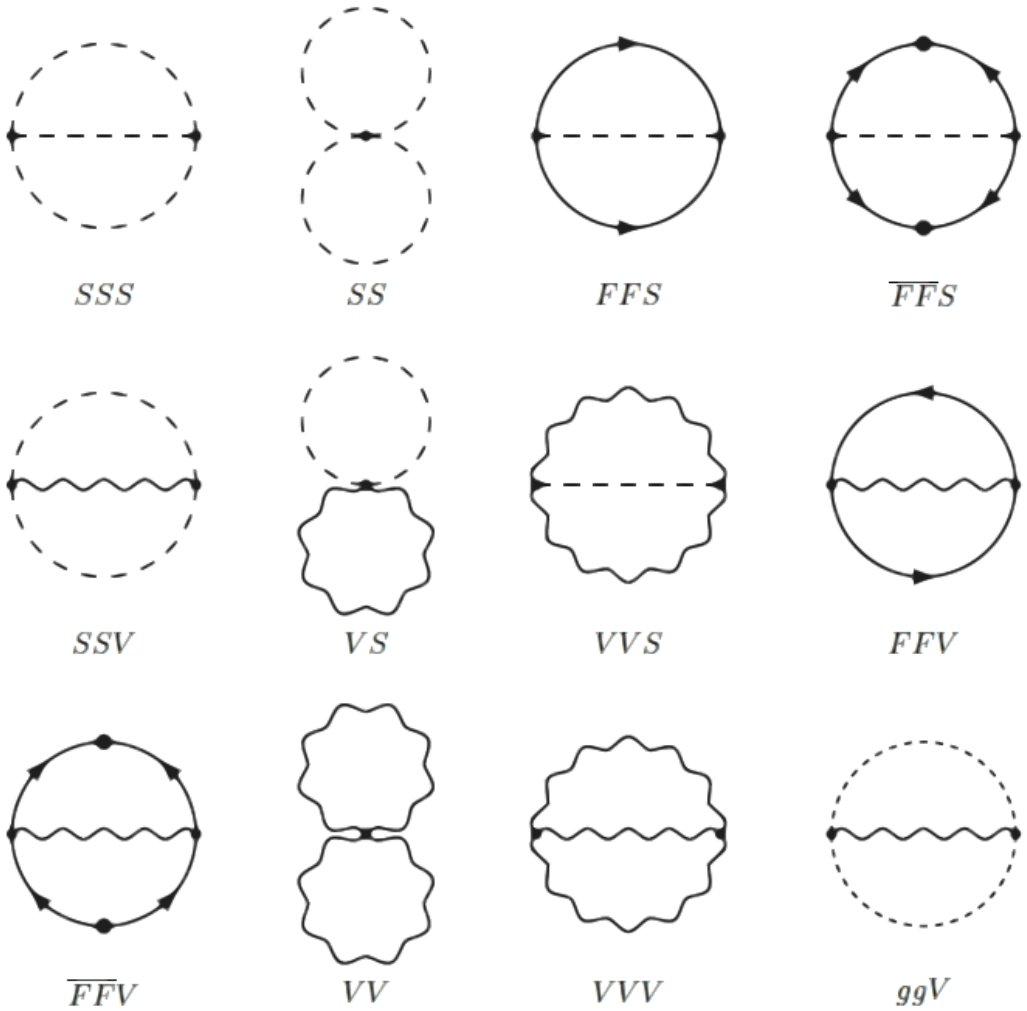
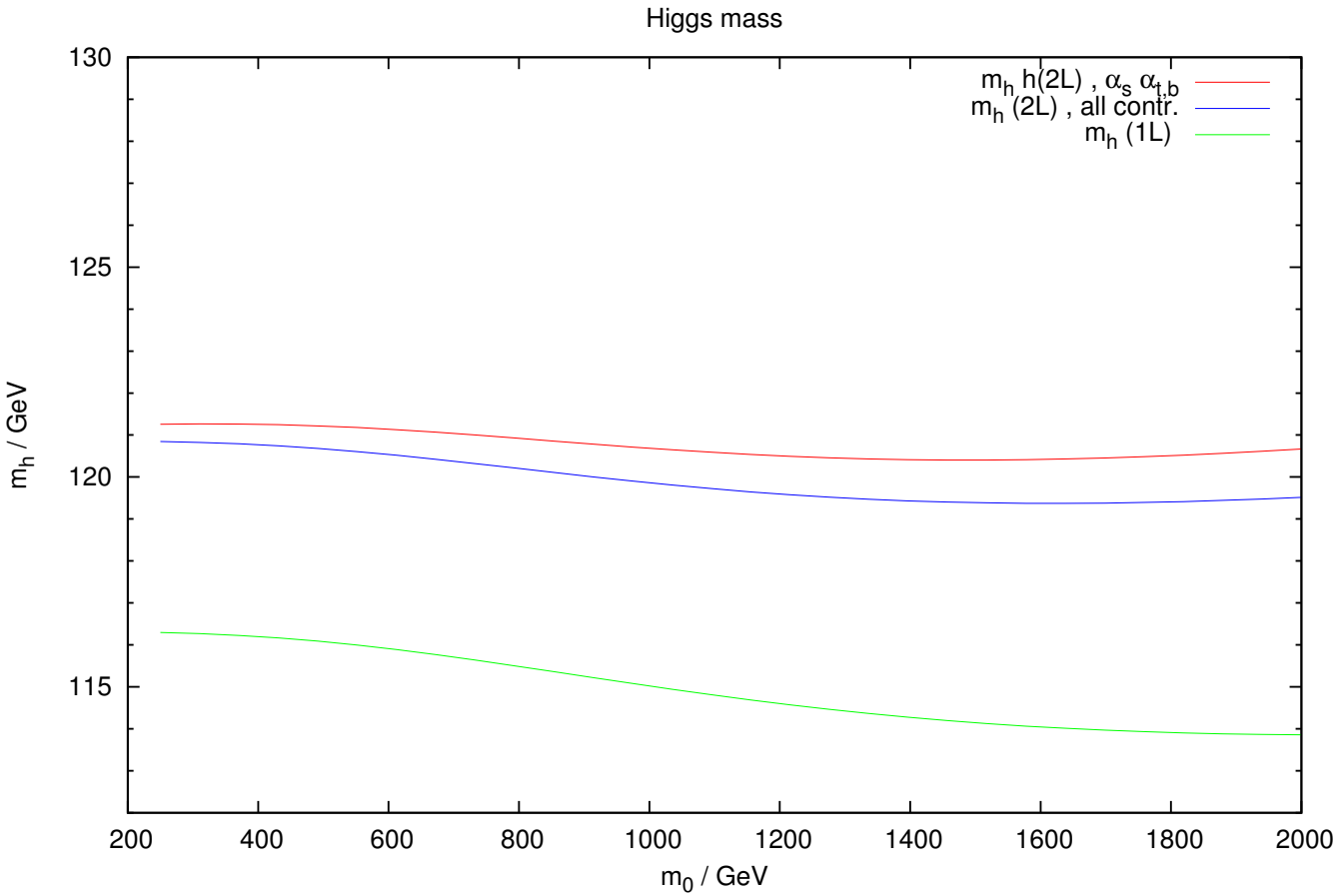
- Renormalization Group Equations (RGE)
  - use running of gauge couplings to obtain Higgs self-couplings at m_Z
  - large logarithms are resummed

Effective Potential Approach



S. Martin, [arXiv:0111209v2]

Higgs mass contributions



Higgs mass m_h corrections in CMSSM with SPheno 3.2.4
($m_{1/2} = 500\,\text{GeV}, A_0 = -1.4\,\text{GeV}, \tan\beta = 10, \text{sgn}(\mu) = 1$)

2L $\alpha_s\alpha_{t,b}$, 2L all dominant, 1L

Summary

- EP approach is easy method (extendable) for m_h at 2-loop
- will be part of SPheno (via SARAH)
- equivalent to diagrammatical for $p^2 = 0$
- Goldstone problem: $m_G = 0$ (Landau gauge)
- currently: p^2 dependent $\mathcal{O}(\alpha_t \alpha_s)$ (1)
- 3-Loop MSSM (2)

(1) S. Borowa, T. Hahn, S. Heinemeyer, G. Heinrich, W. Hollik, arXiv:1404.7074

(2) P. Kant, R.V. Harlander, L. Mihaila, M. Steinhauser, arXiv:1005.5709