

# KUTS paper – Chapter 4 Hybrid

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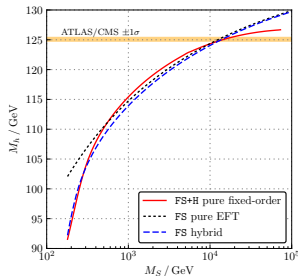
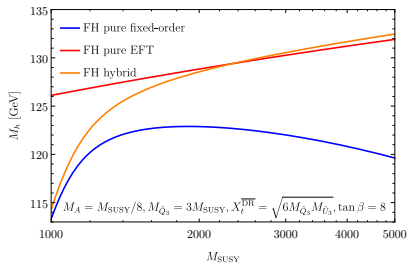
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# 1 Motivation

approach	$M_S \lesssim 1\text{--}2\text{ TeV}$	$M_S \gtrsim 1\text{--}2\text{ TeV}$
fixed order	✓	✗
EFT	✗	✓
hybrid	✓	✓

To illustrate position of “intermediate region”, show:



## 2 Methods

- FeynHiggs: [1312.4937, 1608.01880, 1706.00346]

$$M_h^2 = (M_h^2)_{\text{fixed-order}} - (M_h^2)_{\text{logs}} + (M_h^2)_{\text{resummed logs}}$$

- ✓ Pro: 2L accuracy available, complex parameters
- ✗ Contra: currently only MSSM

- FlexibleEFTHiggs and SARAH/SPheno:

[1609.00371, 1703.03267, 1710.03760]

$$\begin{aligned} (M_h^2)_{\text{SM}} &\stackrel{!}{=} (M_h^2)_{\text{MSSM}} \quad \text{at } Q = M_S \\ \Rightarrow \lambda(M_S) &= \frac{1}{v^2} \left[ (M_h^2)_{\text{MSSM}} - (\Delta m_h^2)_{\text{SM}} \right] \end{aligned}$$

- ✓ Pro: not restricted to MSSM
- ✗ Contra: tricky to extend to NNLO + NNLL level

## 3 Status

Currently available corrections:

- FeynHiggs
  - Fixed-order: full LO + NLO +  $O(\alpha_s\alpha_t, \alpha_s\alpha_b, (\alpha_t + \alpha_b)^2)$
  - EFT: full LL + NLL + NNLL  $O(\alpha_s, \alpha_t)$ ; gaugino threshold
- FlexibleEFTHiggs
  - Fixed-order: full LO + NLO
  - EFT: full LL + NLL
- SARAH/SPheno
  - Fixed-order: full LO + NLO +  $O(\alpha_s\alpha_t, \alpha_s\alpha_b, (\alpha_t + \alpha_b)^2)$   
[to be checked]
  - EFT: full LL [+ NLL?]

## 4 Advances during KUTS

- FeynHiggs:
  - EW contributions, gaugino thresholds, NNLL resummation [1608.01880]
  - investigation of large differences to other codes [1706.00346]
  - refinement of hybrid method [1706.00346]
- FlexibleEFTHiggs:
  - implementation of hybrid method [1609.00371]
  - improved to NLL accuracy [1710.03760]
- SARAH/SPheno:
  - implementation of hybrid method [1703.03267]

## 5 Theoretical uncertainties

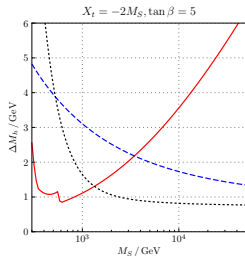
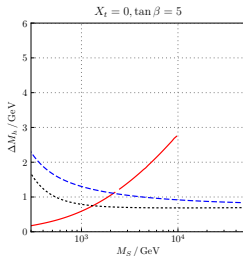
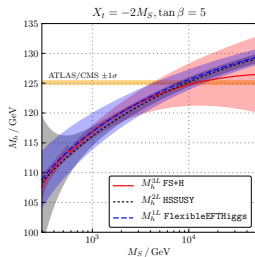
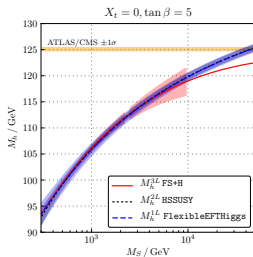
Give prescription and estimate of uncertainties of:

- fixed-order calculation
- EFT calculation
- hybrid calculation

### **Expectations:**

- fixed-order uncertainty increases with  $M_S$
- EFT calculation more precise than fixed-order for  $M_S \gtrsim 1\text{--}2\text{ TeV}$
- hybrid uncertainty is smaller or similar to EFT / fixed-order

# 5 Theoretical uncertainties





## 6 Prospects

- Advance FlexibleEFTHiggs to NNLO + NNLL
- Improvement on theoretical uncertainties
- Further low-energy models (not only SM as EFT)
- Further high-energy models (not only MSSM as UV theory)