Estimating the theoretical uncertainties in FeynHiggs

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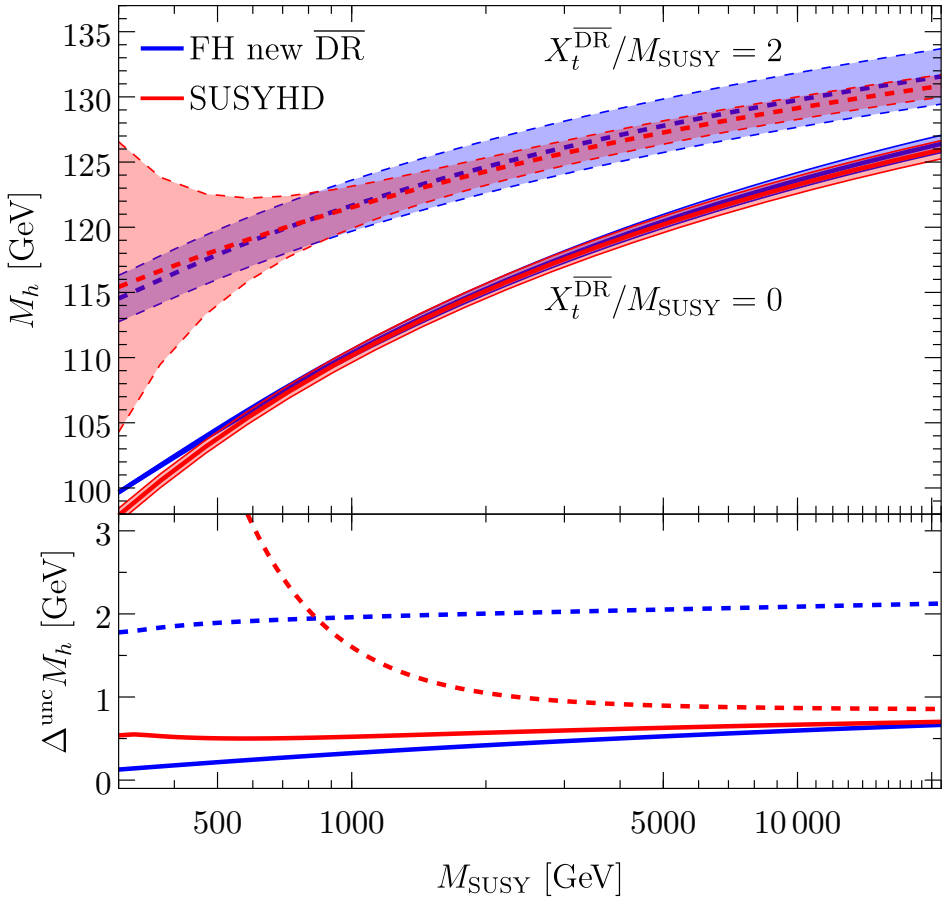
Remember KUTS VII in Karlsruhe, lots of discussion about this plot...

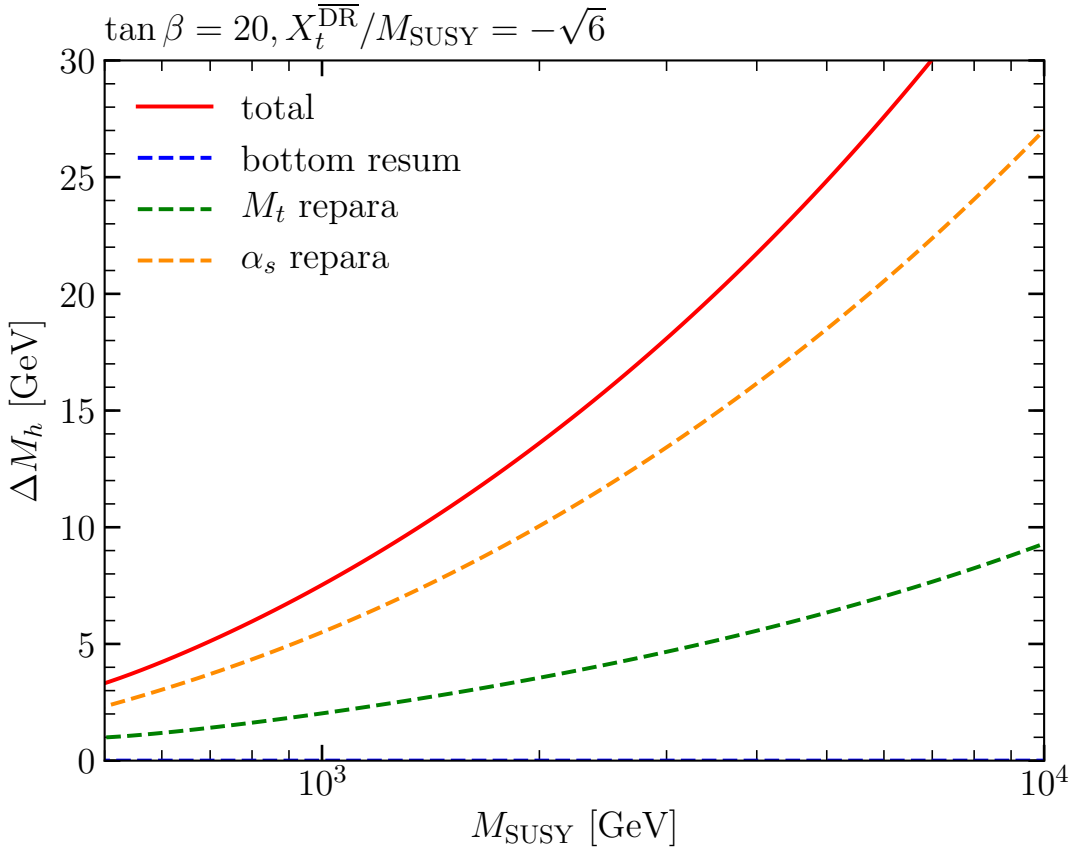


Pietro's intro talk: "For high SUSY scales not only the central value but also the uncertainty estimate should agree."

Uncertainty estimate of FO calculation I

- Switching between different parametrizations of the top mass (OS top-quark mass and SM $\overline{\text{MS}}$ top-quark mass),
- Deactivating the resummation of the bottom-Yukawa coupling for large $\tan\beta$,
- Evaluating the strong gauge coupling at the scales M_t and M_{SUSY}.

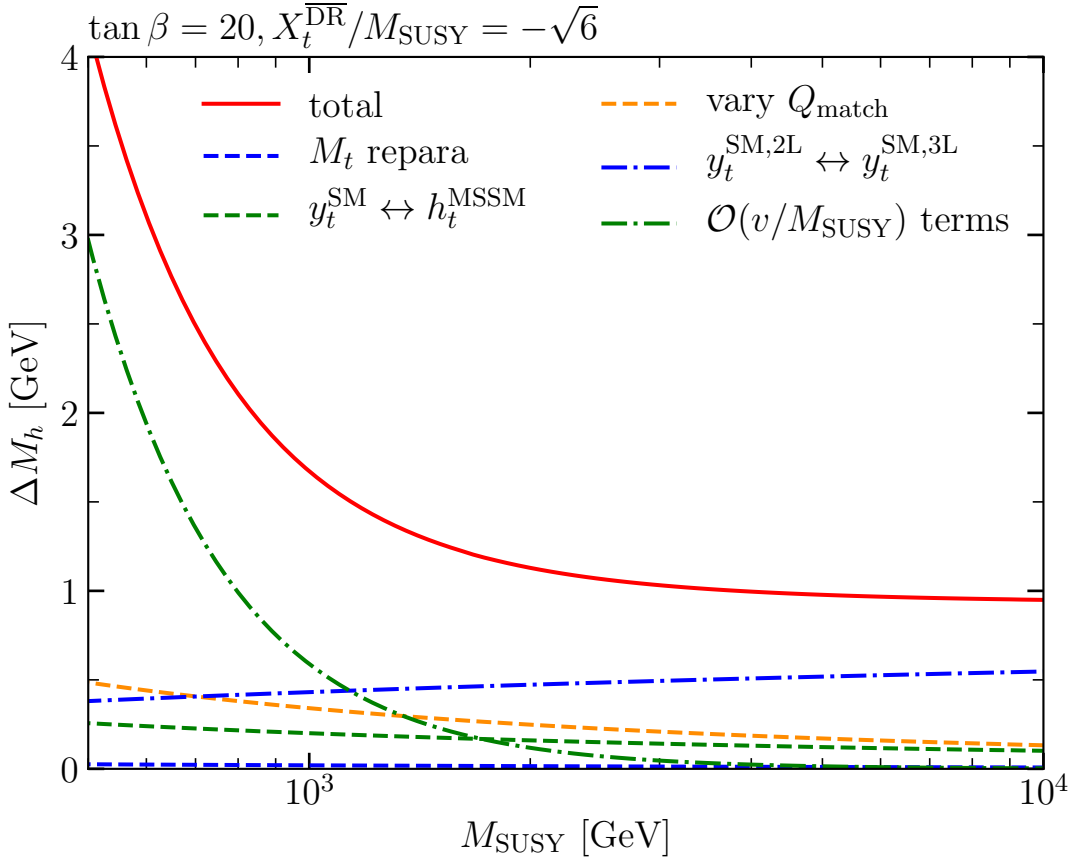
Uncertainty estimate of FO calculation II



Uncertainty estimate EFT calculation I

- High-scale uncertainty:
  - Varying the high-energy matching scale Q_{match} between $[M_{\text{SUSY}}/2, 2M_{\text{SUSY}}]$
  - Reparametrizing the threshold corrections in terms of the MSSM top Yukawa coupling
- Low-scale uncertainty:
  - Switching between an extraction of the SM $\overline{\text{MS}}$ top Yukawa coupling at the two- and three-loop level
  - Finding the Higgs pole mass employing either the OS top mass or the SM $\overline{\text{MS}}$ top mass
- Uncertainty from $\mathcal{O}(v/M_{\text{SUSY}})$ terms:
  - Multiplying the one-loop threshold correction by $v^2/{M_{\text{SUSY}}}^2$

Uncertainty estimate EFT calculation II



Uncertainty estimate of hybrid calculation I

Hybrid approach: basic idea

EFT result + $\mathcal{O}(v/M_{\rm SUSY})$ terms of FO calculation

'Old' approach for estimating uncertainty:

- Estimate uncertainty of fixed-order calculation without logs

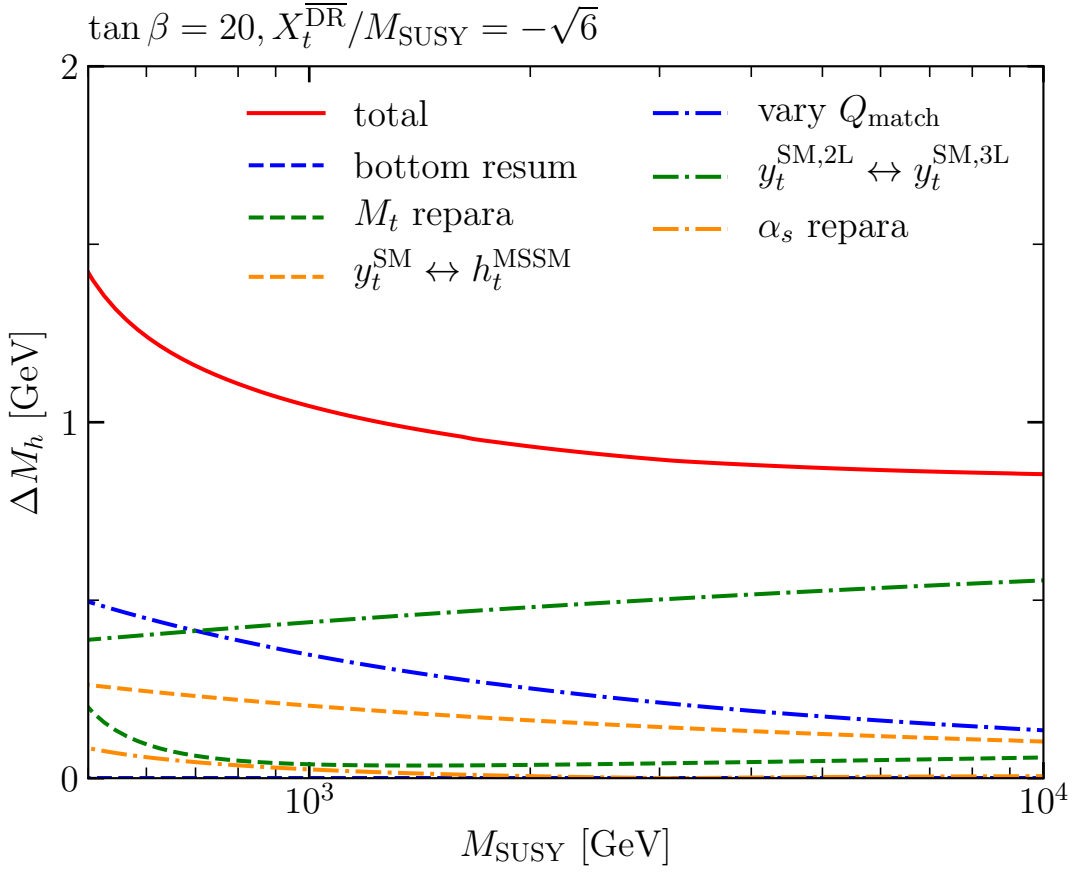
'New' approach for estimating uncertainty:

- Estimate uncertainty of EFT part as for pure EFT calculation (apart of $\mathcal{O}(v/M_{\rm SUSY})$ terms)
- Estimate uncertainty of $\mathcal{O}(v/M_{\rm SUSY})$ terms as for FO calculation

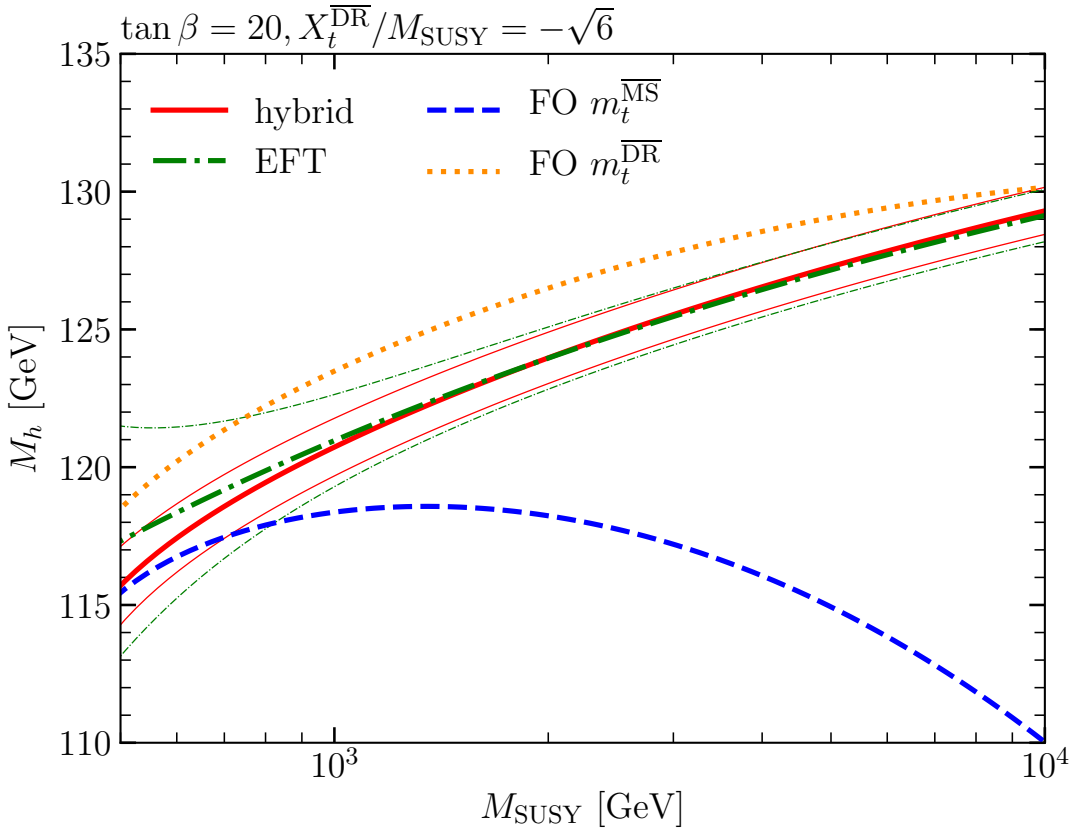
Uncertainty estimate of hybrid calculation II

- High-scale uncertainty (estimated in the EFT part):
  - Varying the high-energy matching scale Q_{match} between $[M_{\text{SUSY}}/2, 2M_{\text{SUSY}}]$
  - Reparametrizing the threshold corrections in terms of the MSSM top Yukawa coupling
- Low-scale uncertainty:
  - Switching between an extraction of the SM $\overline{\text{MS}}$ top Yukawa coupling at the two- and three-loop level
  - Finding the Higgs pole mass employing either the OS top mass or the SM $\overline{\text{MS}}$ top mass
- Uncertainty from $\mathcal{O}(v/M_{\text{SUSY}})$ and $\mathcal{O}(\alpha_b)$ terms (estimated in the fixed-order part):
  - Switching between different parametrizations of the top mass (OS top-quark mass and SM $\overline{\text{MS}}$ top-quark mass),
  - deactivating the resummation of the bottom-Yukawa coupling for large $\tan\beta$,
  - Evaluating the strong gauge coupling at the scales M_t and M_{SUSY}.

Uncertainty estimate of hybrid calculation III

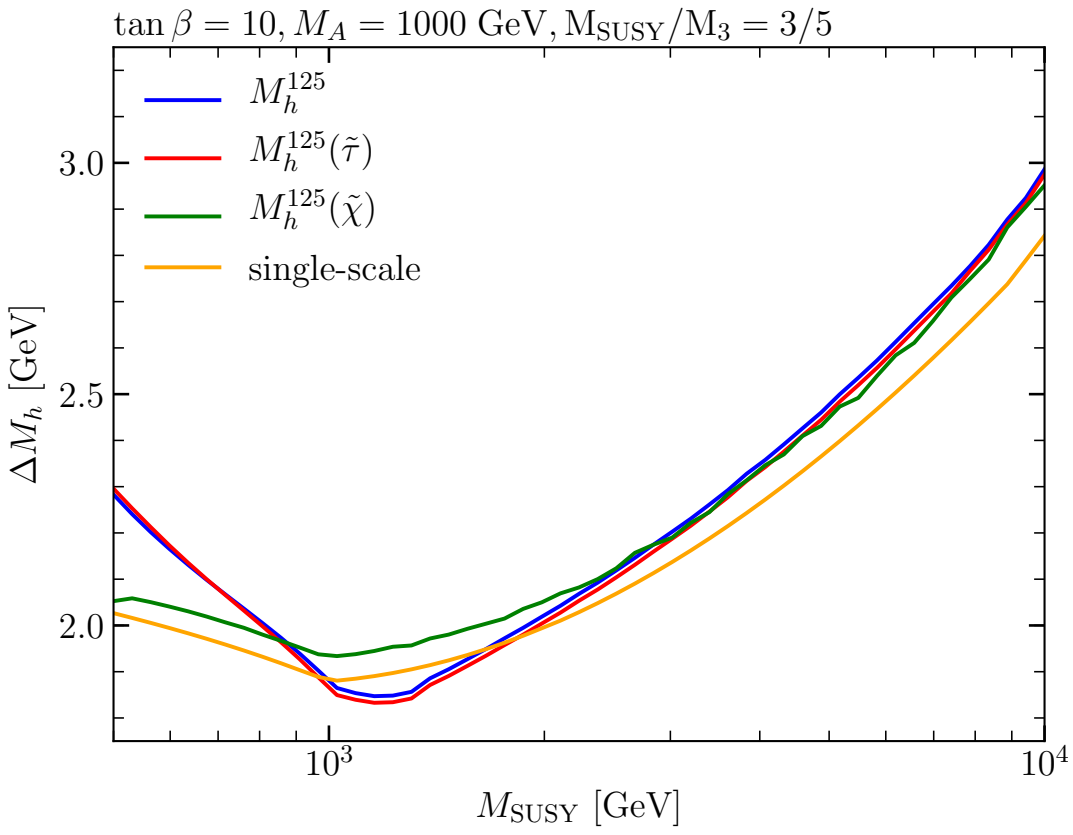


Comparison in single scale scenario



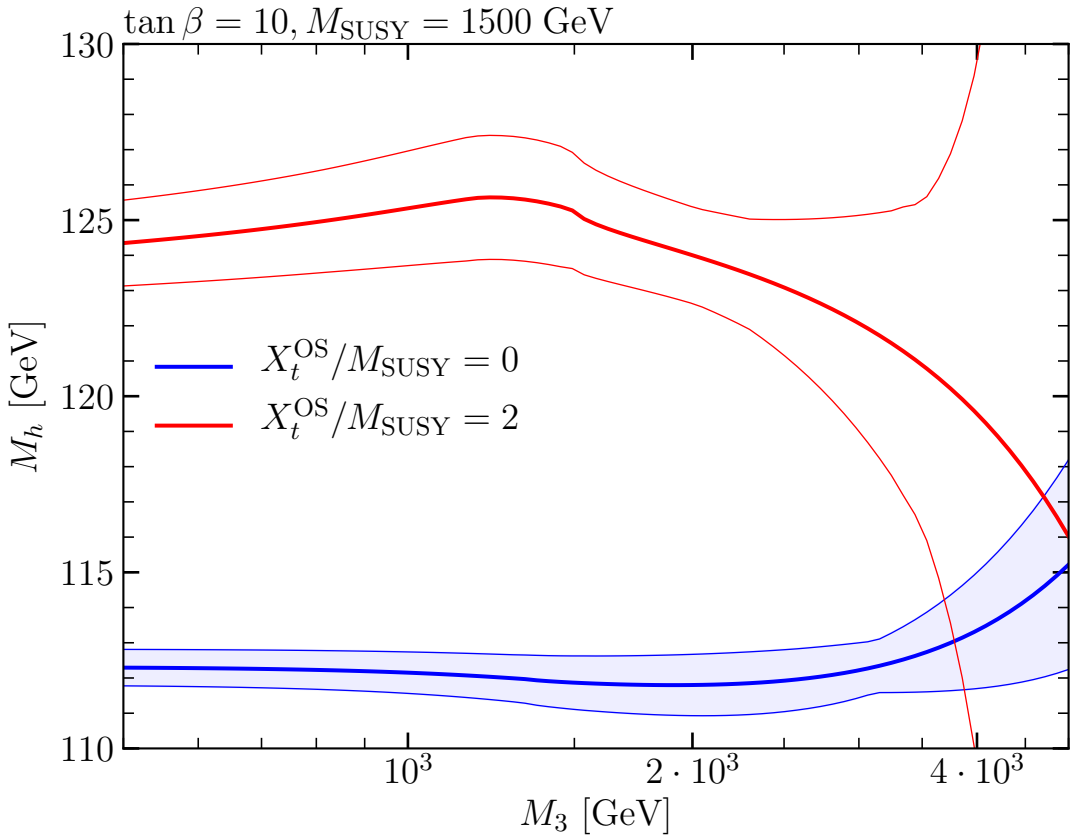
$\rightarrow$ good agreement between hybrid and EFT for high scales

Higgs benchmark scenarios



Benchmark scenarios defined using simple ± 3 GeV estimate.

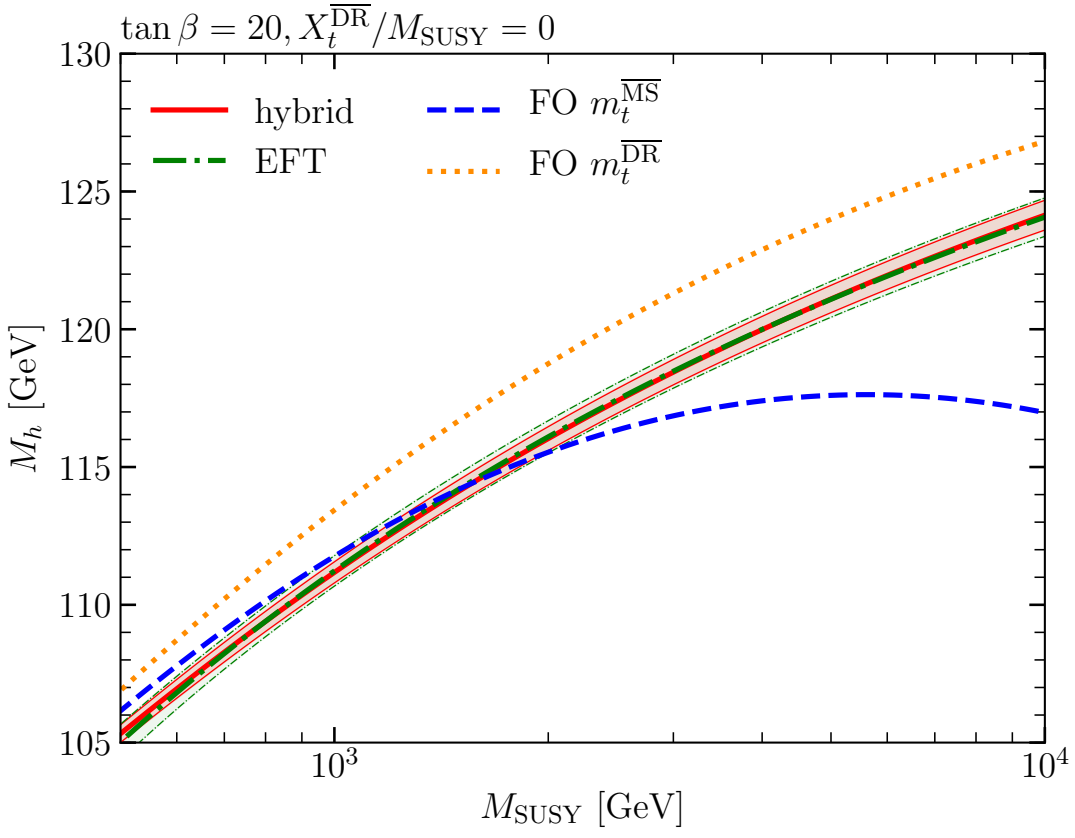
Varying the gluino mass

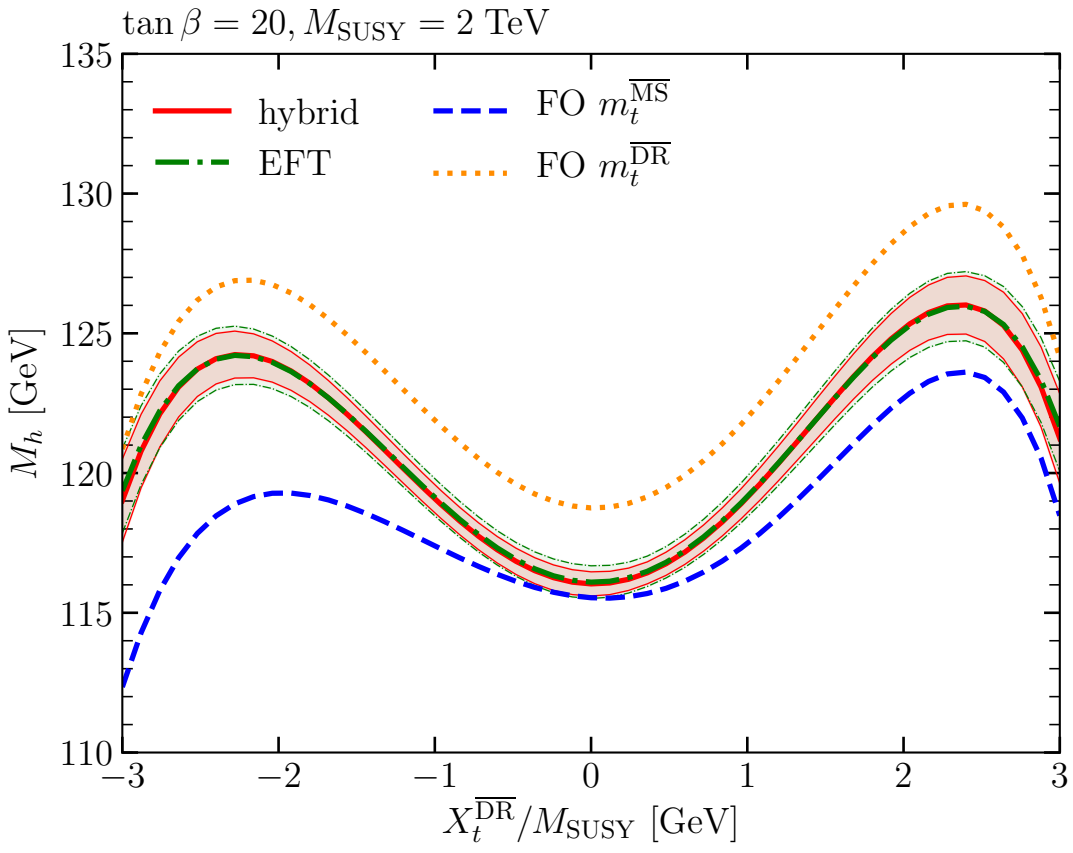


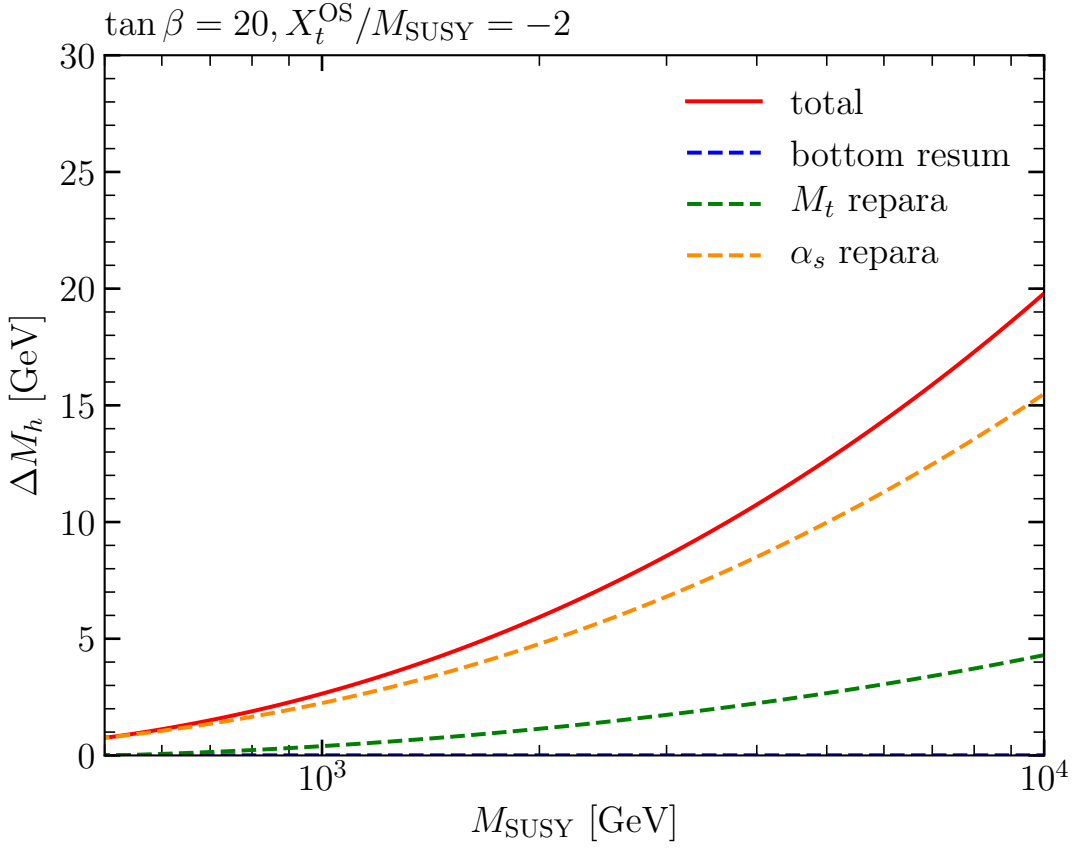
$\rightarrow$ large logs in $\mathcal{O}(\alpha_s \alpha_t)$ threshold correction

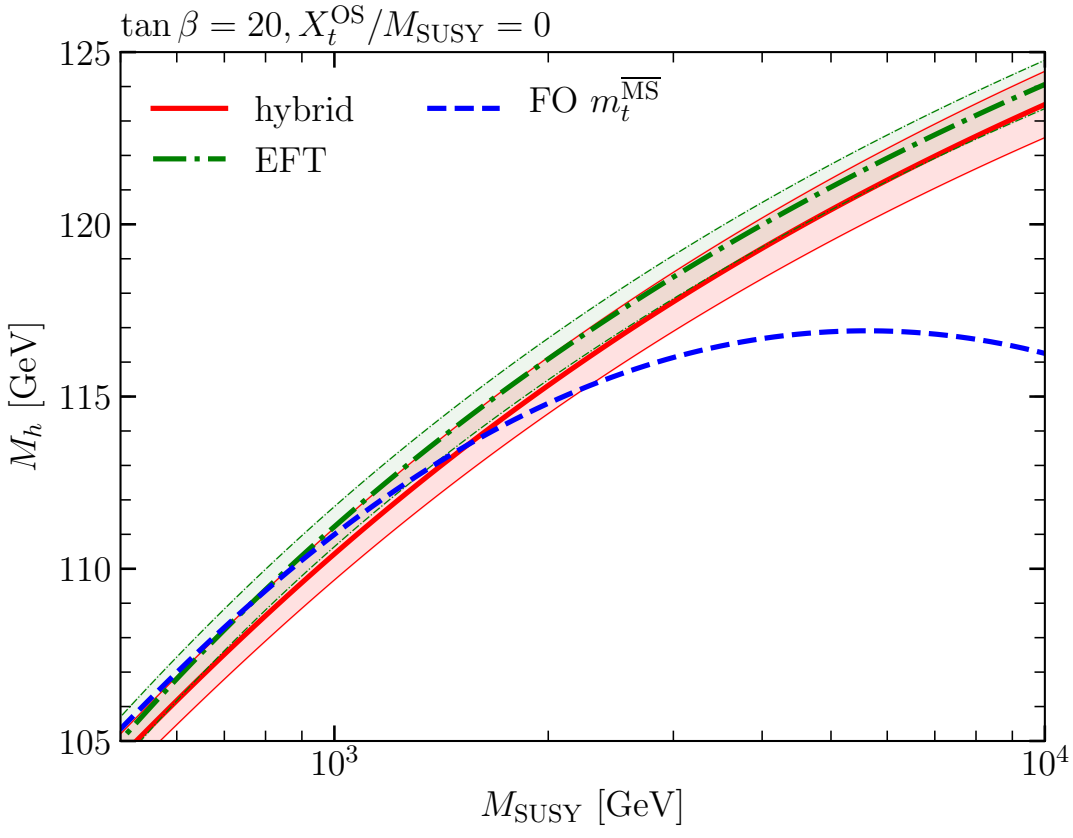
Conclusions

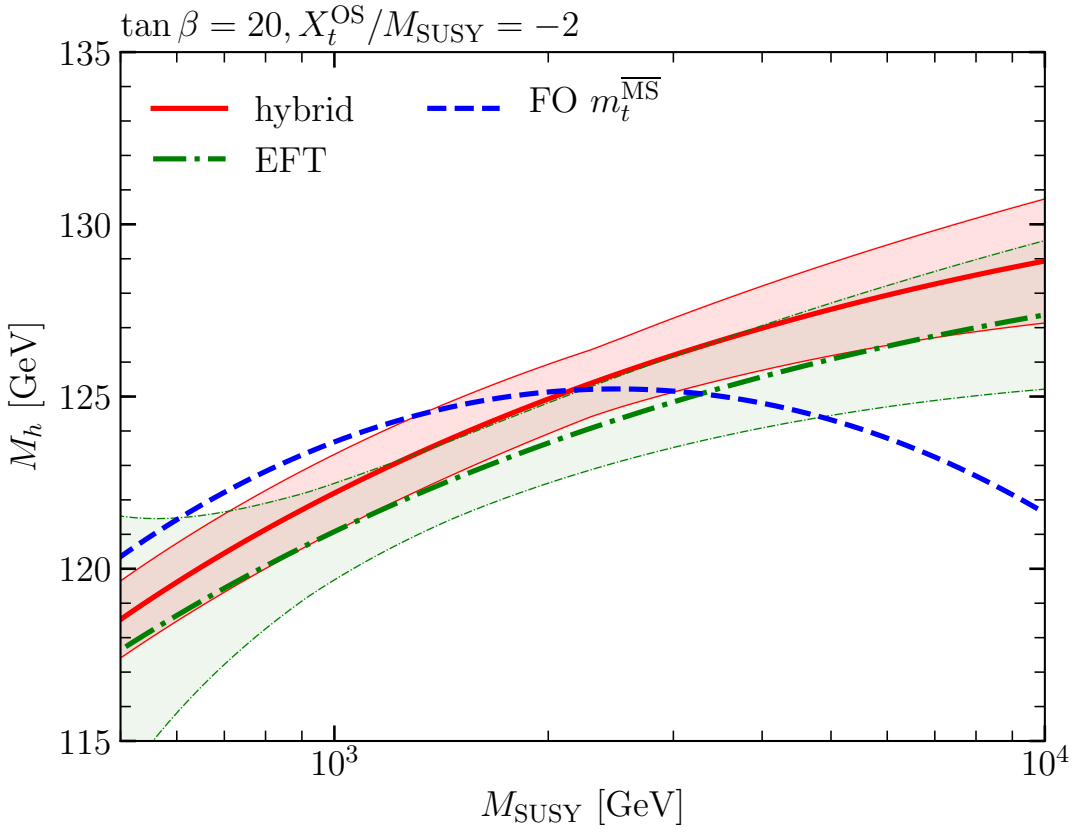
- Presented new uncertainty estimates for the FO, EFT and hybrid calculation implemented in `FeynHiggs`
- Good agreement between EFT and hybrid uncertainty estimate for high SUSY scales
- Heavy gluino results in large uncertainty estimates


$\tan\beta = 20, X_t^{\overline{\rm DR}}/M_{\rm SUSY} = 0$
hybrid
EFT
FO $m_t^{\overline{\rm MS}}$
FO $m_t^{\overline{\rm DR}}$
130
125
120
115
110
105
M_h [GeV]
10^3
10^4
$M_{\rm SUSY}$ [GeV]


$\tan\beta = 20, M_{\rm SUSY} = 2$ TeV
hybrid
EFT
FO $m_t^{\overline{\rm MS}}$
FO $m_t^{\overline{\rm DR}}$
M_h [GeV]
$X_t^{\overline{\rm DR}}/M_{\rm SUSY}$ [GeV]
135
130
125
120
115
110
−3
−2
−1
0
1
2
3


$\tan\beta = 20, X_t^{\rm OS}/M_{\rm SUSY} = -2$
30
25
20
15
10
5
0
10^3
10^4
ΔM_h [GeV]
$M_{\rm SUSY}$ [GeV]
total
bottom resum
M_t repara
α_s repara


$\tan\beta = 20, X_t^{\rm OS}/M_{\rm SUSY} = 0$
hybrid
FO $m_t^{\overline{\rm MS}}$
EFT
125
120
115
110
105
10^3
10^4
M_h [GeV]
$M_{\rm SUSY}$ [GeV]


$\tan\beta = 20, X_t^{\rm OS}/M_{\rm SUSY} = -2$
hybrid
FO $m_t^{\overline{\rm MS}}$
EFT
135
130
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120
115
10^3
10^4
M_h [GeV]
$M_{\rm SUSY}$ [GeV]