Higgs Boson Production from Bottom Quarks

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in collaboration with

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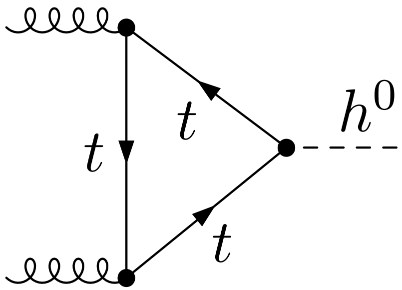
Outline

- b quark Yukawa coupling : SM vs. MSSM
- organizing the calculation: 4FNS and 5FNS
- scale uncertainties
- SUSY-QCD corrections
- electroweak MSSM corrections

Higgs Production

SM production modes:

- gluon fusion (via closed top loop)



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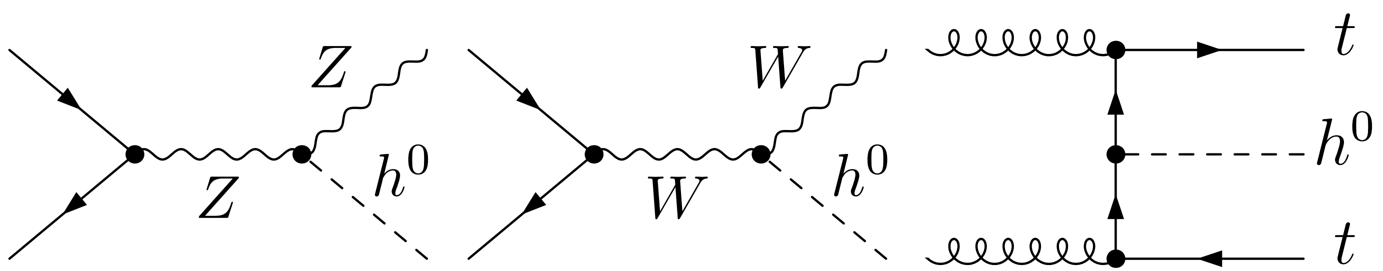

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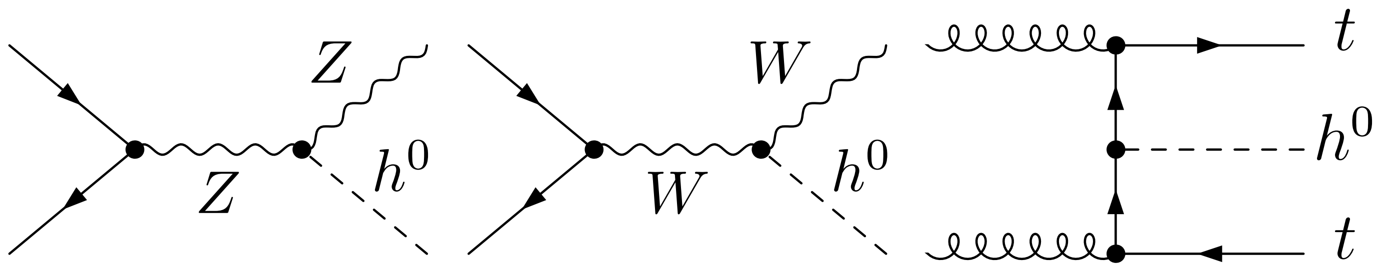

- in association with bottom quarks?

Bottom Yukawa Coupling

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  - $v^2 = v_u^2 + v_d^2\,; \quad \tan\beta = v_u/v_d$

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$\Rightarrow$ important for large $\tan\beta$

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but: $s_\alpha / c_\beta \sim \mathcal{O}(1)$ for large M_A

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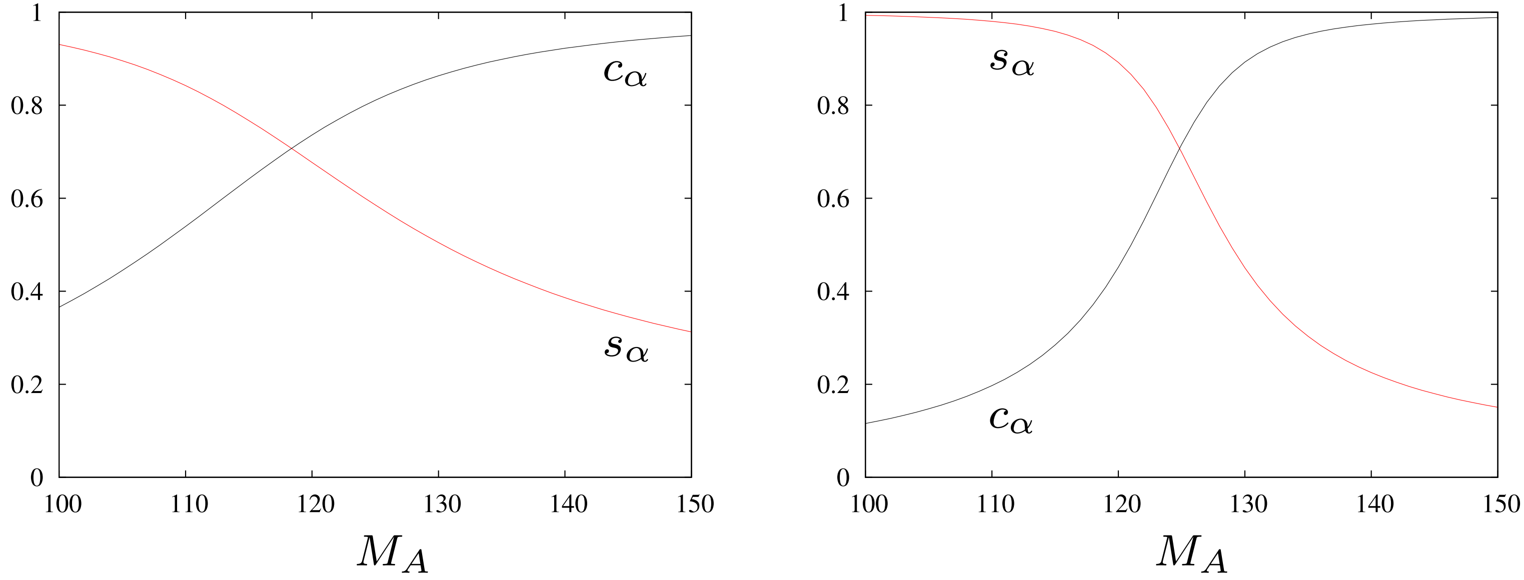
Bottom Yukawa Coupling

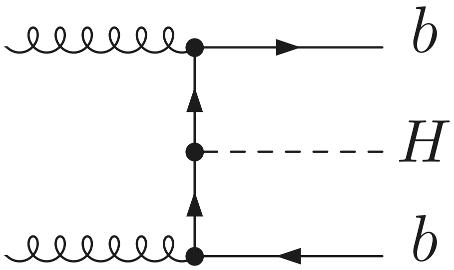
The mixing angle α for the CP even Higgs bosons:

$\tan\beta = 10$ (SPS1a) $\qquad$ $\tan\beta = 30$ (SPS1b)



Basic Process

basic process at gluon collider:



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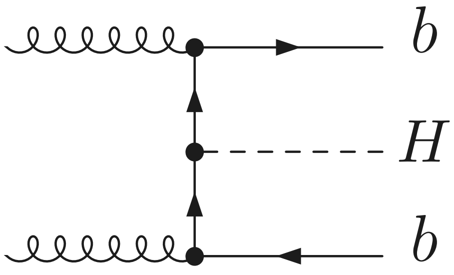

gluon splitting: large logs from collinear b quarks

$\Rightarrow$ expansion in $\log \frac{\mu_F}{m_b} \alpha_s$

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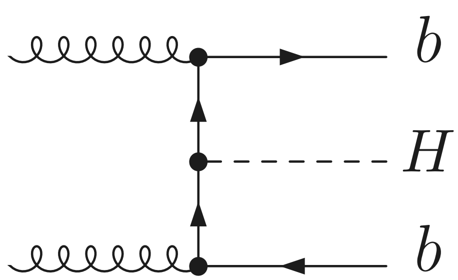

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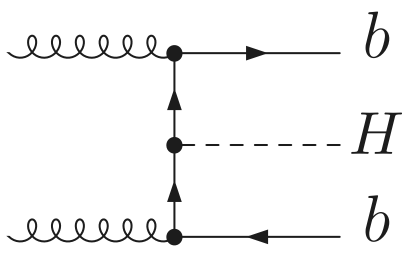
possible resummation:

introduce PDF for b quarks in the proton

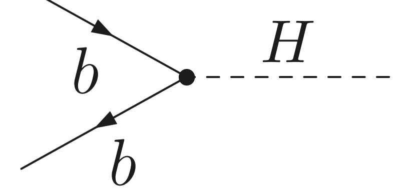
massless approximation $m_b \to 0$ ($\log \frac{\mu_F}{m_b} \to 1/\epsilon$)

collinear $1/\epsilon$ poles absorbed in PDF

4FNS and 5FNS

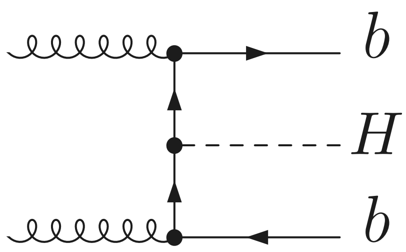


$\Leftrightarrow$



4 flavors in proton $\Leftrightarrow$ 5 flavors in proton

4FNS and 5FNS



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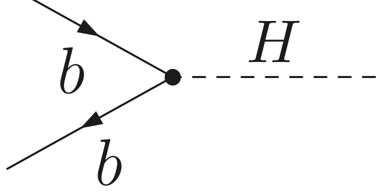
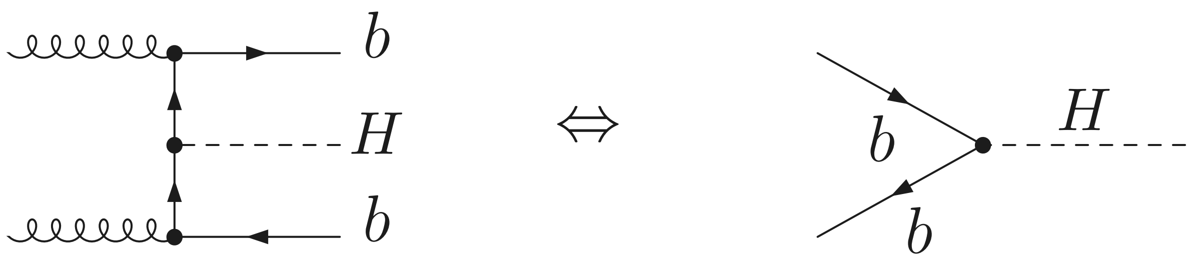


4 Flavor
Number Scheme

$\Leftrightarrow$

5 Flavor
Number Scheme

4FNS and 5FNS



4FNS: exclusive $b\bar{b}H$ final state

known to NLO (Dittmaier, Krämer, and Spira Phys.Rev. D70 (2004) 074010
Dawson, Jackson, Reina, and Wackeroth Phys. Rev. Lett. 94 (2005) 031802)

5FNS: resummed logs

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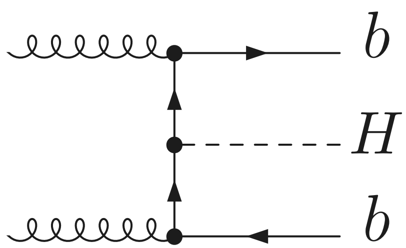
4FNS and 5FNS



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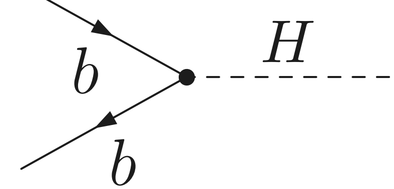

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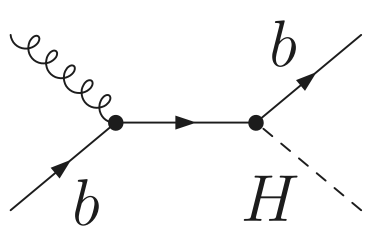

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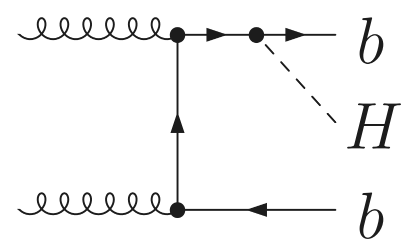

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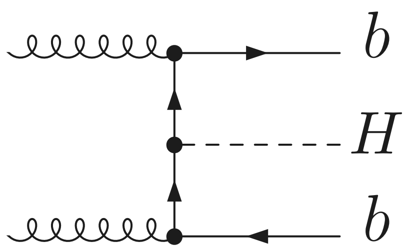

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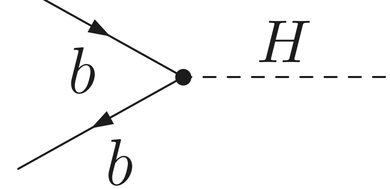

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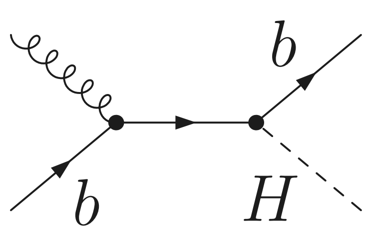
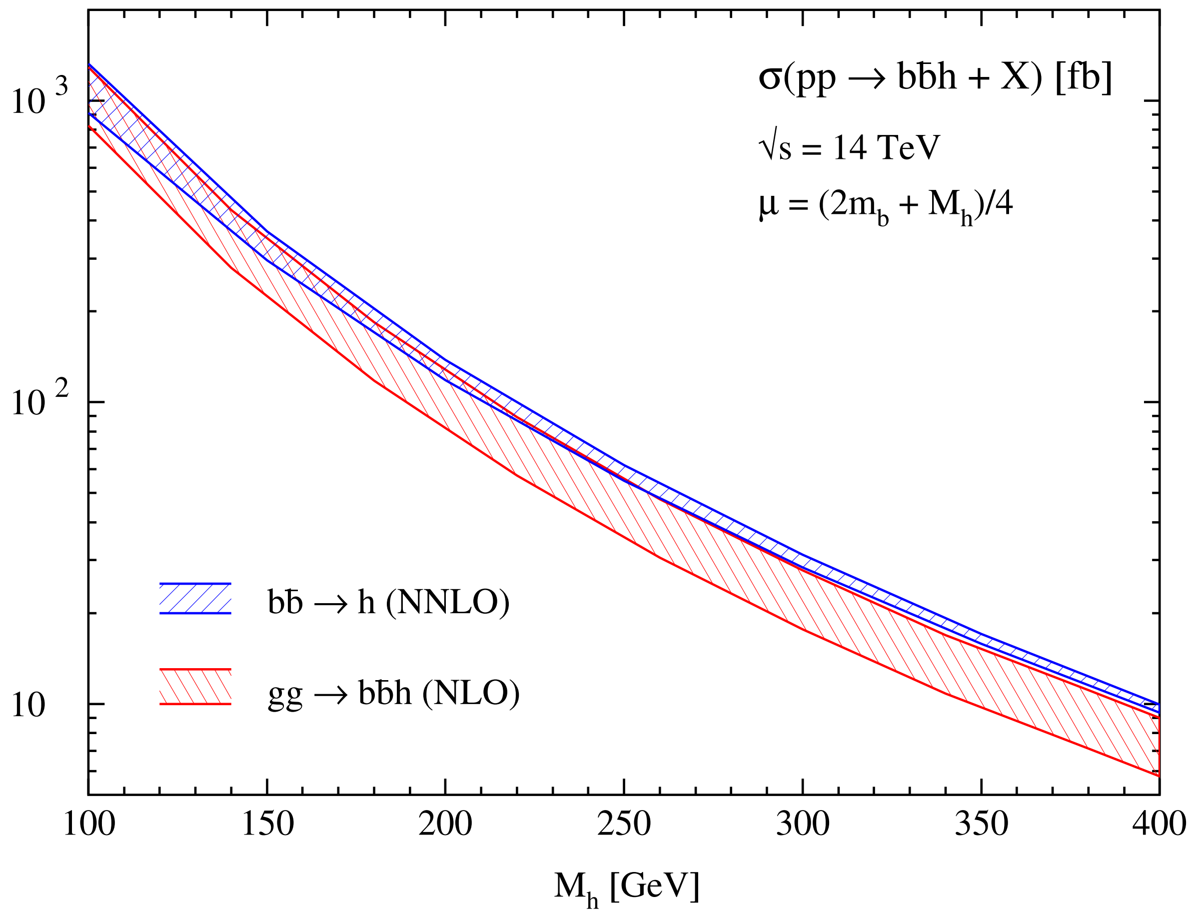


$\sim\ 1/\log\frac{\mu_F}{m_b}$

4FNS and 5FNS



Campbell et al., hep-ph/0405302

Scale Dependence

- fact. scale μ_F dependence of PDFs
- ren. scale μ_R dependence of running m_b and α_s

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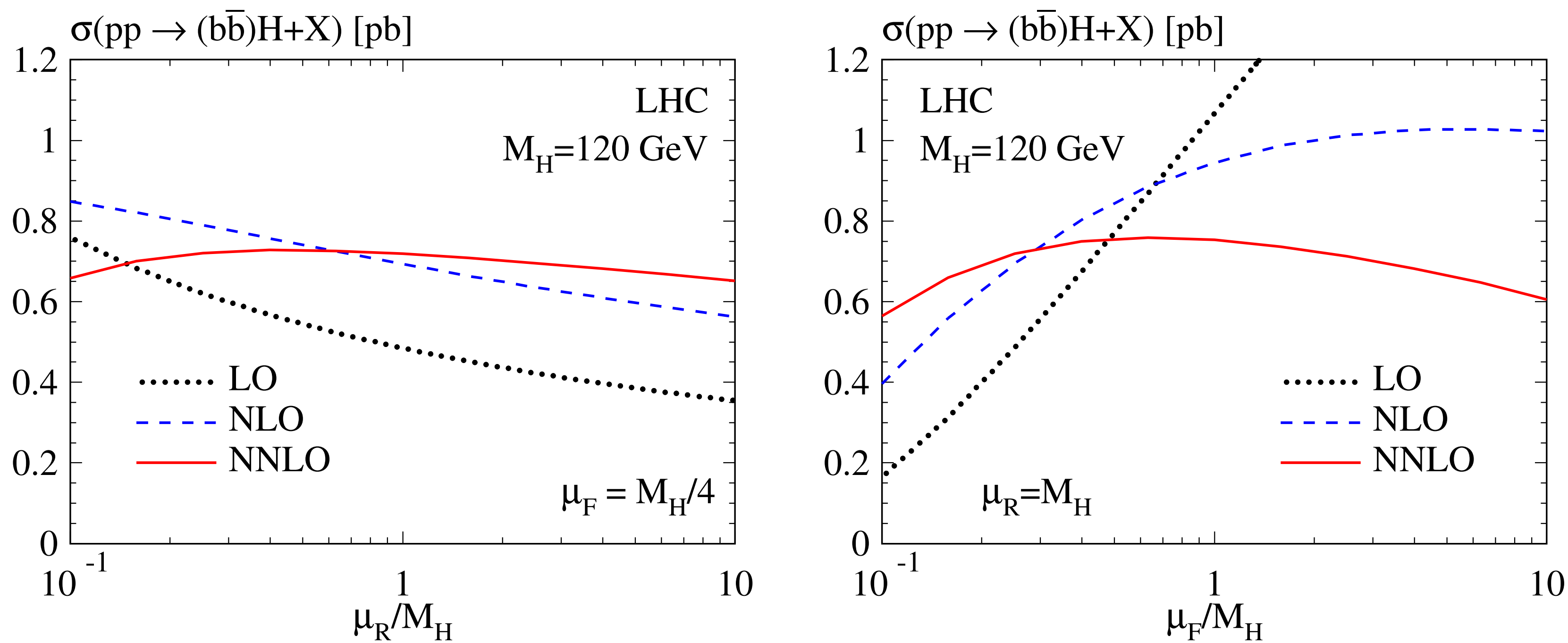

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Uncertainties

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AACHEN

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What about weak corrections?

weak SM corrections: $\sim$4% (in $\alpha(m_Z)$ scheme)

scheme dependence: $\sim$1% (between $\alpha(m_Z)$ and $\alpha(0)$ scheme)

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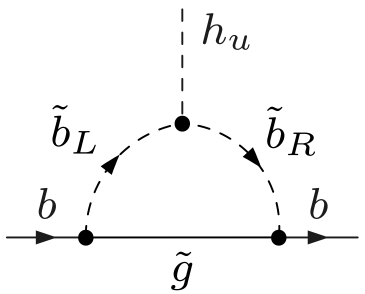
photon contribution: $<$1% (coll. sing. absorbed in photon PDF $\rightarrow$ MRST QED PDF)

SUSY-QCD

effective $b\bar{b}H_u$ coupling:



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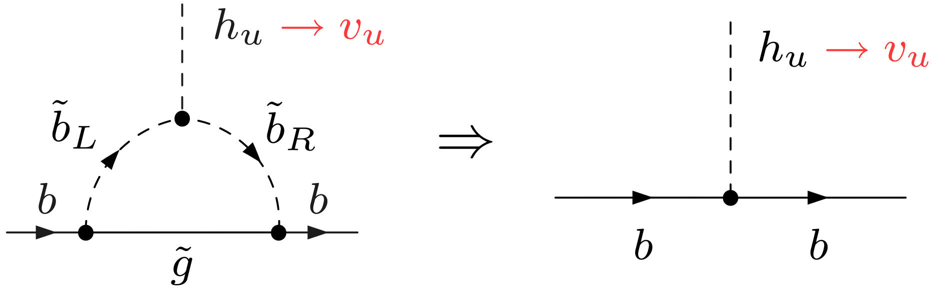

effective field theory: $m_b \to m_b(1 + \Delta_b)$

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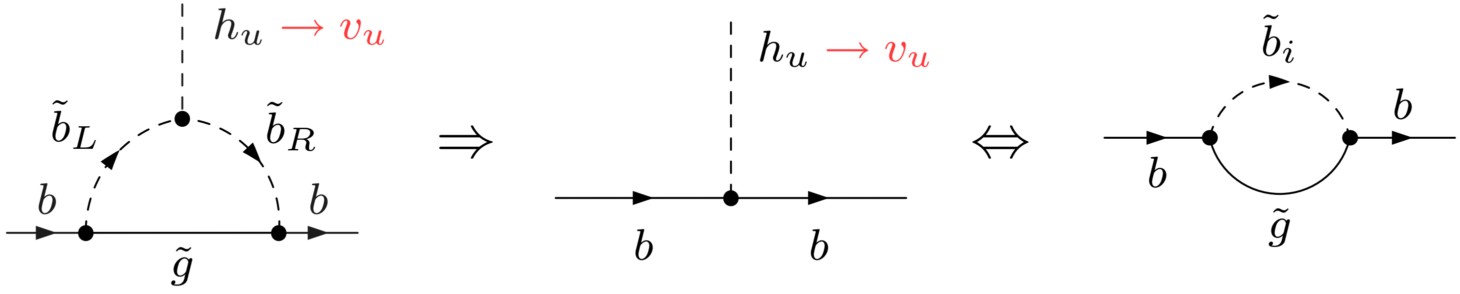

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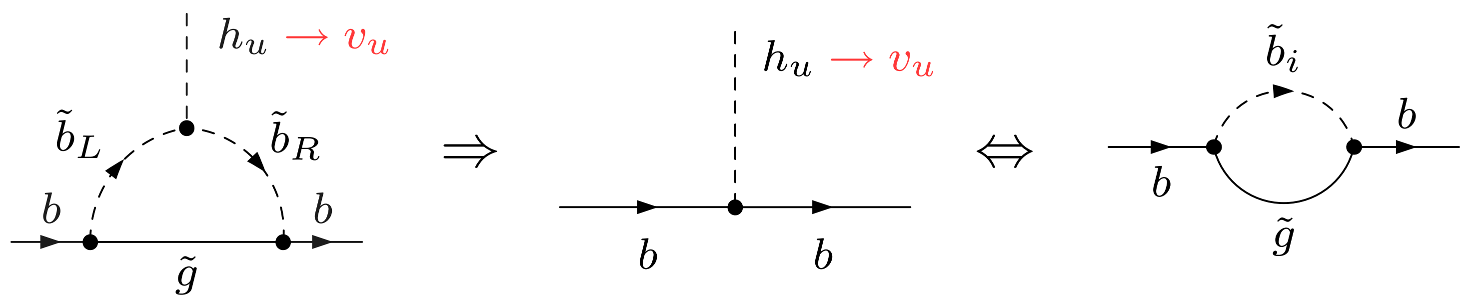
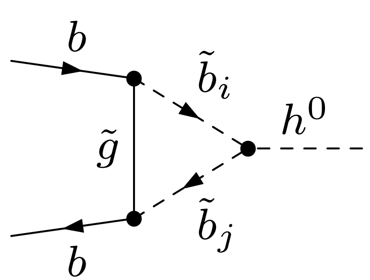


effective field theory: $m_b \to m_b(1+\Delta_b)$

effective vertex correction:

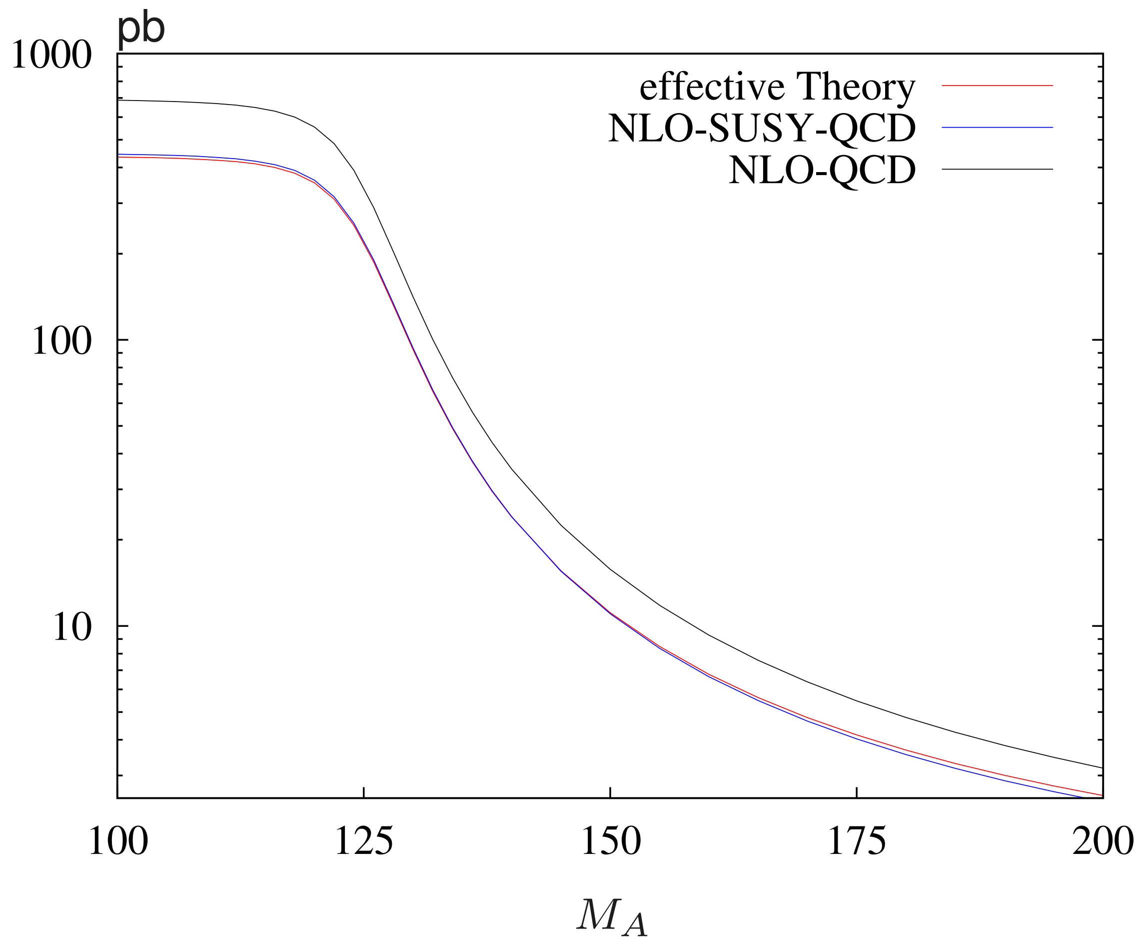


$$\Rightarrow \lambda_b^{h^0} = -\lambda_b^{\mathrm{SM}} \frac{1}{1+\Delta_b}\left(\frac{s_\alpha}{c_\beta} - \Delta_b \frac{c_\alpha}{s_\beta}\right)$$

SUSY-QCD

effective theory vs. full one loop result:

(SPS1b, $\tan\beta = 30$)



EW MSSM corrections

usually:

- large chargino-stop loop contributions treated like gluino-sbottom loops
- radiatively corrected mixing angles

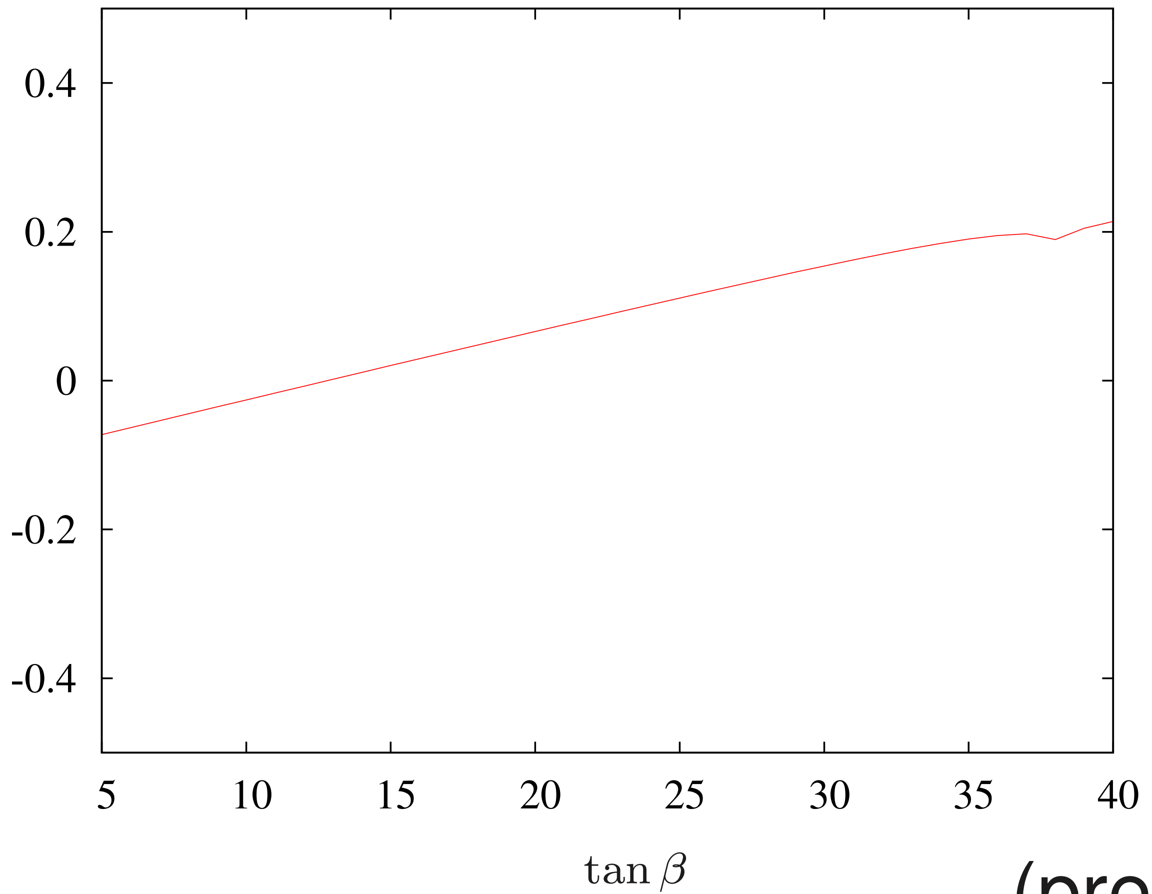
full one-loop calculation:

- using FeynArts and FormCalc
- diagrammatic calculation completed (DCPR scheme)
- starting phenomenology

EW MSSM corrections

SPS1a with varying $\tan\beta$:

(including chargino-stop loops, Higgs mixing)



(preliminary)

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Summary and Outlook

Higgs production from b quarks:

- important production channel for large $\tan\beta$
- under good theoretical control
  - different schemes agree (4FNS $\Leftrightarrow$ 5FNS)
  - scale and pdf uncertainties $\sim$ 10-20%
- calculating full 1-loop EW MSSM corrections

outlook:

- phenomenological analysis
- similar processes: slepton prod. in RPV SUSY