

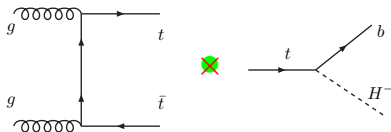
Charged Higgs boson production at the LHC: update of the 4FS calculation

Michael Krämer (CERN-TH & RWTH Aachen)

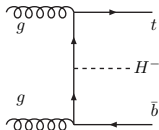
with Stefan Dittmaier, Michael Spira and Manuel Walser (arXiv:0906.2648)

Introduction: charged Higgs production at the LHC

- ▶ $pp \rightarrow t\bar{t}$ with $t \rightarrow bH^\pm$ for $M_{H^\pm} \lesssim m_{\text{top}}$



- ▶ $pp \rightarrow tbH^\pm$ for $M_{H^\pm} \gtrsim m_{\text{top}}$



alternative production mechanisms like $q\bar{q}' \rightarrow H^\pm$, $pp \rightarrow H^\pm + \text{jet}$,
 $pp \rightarrow H^\pm W^\mp$, or Higgs pair production are suppressed...

Status of (MSSM) calculations

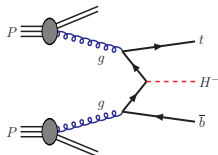
- ▶ 5FS NLO SUSY-QCD [Plehn; Berger et al.]
- ▶ 5FS in MC@NLO [Weydert et al.]
- ▶ 5FS NNLL/NNLO_{approx.} [Kidonakis]
- ▶ 5FS SUSY-EWK [Jin et al., Belyaev et al., Beccaria et al.]
- ▶ 4FS NLO SUSY-QCD [Peng et al.; Dittmaier et al.]
- ▶ LO 4 and 5FS matched [Borzumati et al.; Alwall, Rathsmann]

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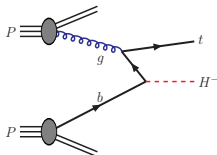
Associate tbH^\pm production: two calculational schemes

4-flavour scheme



- + exact $g \rightarrow b\bar{b}$ splitting & mass effects
- no summation of $\ln(M_H/M_b)$ terms

5-flavour scheme



- + summation of $\ln(M_H/M_b)$ terms
- LL approximation to $g \rightarrow b\bar{b}$ splitting

The 4- and 5-flavour schemes

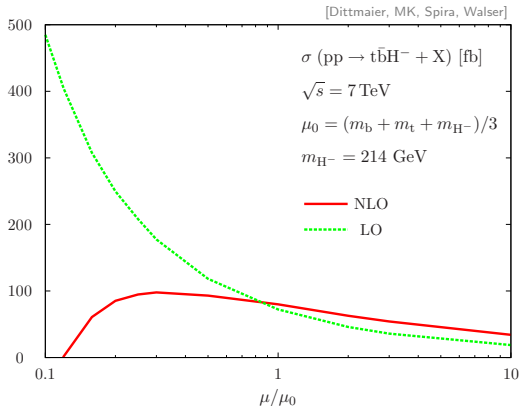
- are both theoretically consistent & well-defined
- represent different ways of ordering perturbation theory
- should agree at sufficiently high order
- do not match exactly at finite order

Associate tbH^\pm production: 4FS calculation at NLO

- ▶ new results for the inclusive cross section at 7 TeV using the Higgs WG inputs & MSTW 2008 4F pdfs
- ▶ some old results on the impact of SUSY corrections
- ▶ some old results on distributions
- ▶ a relatively new 4FS and 5FS comparison with MSTW08 pdfs

Associate tbH^\pm production: 4FS calculation at NLO

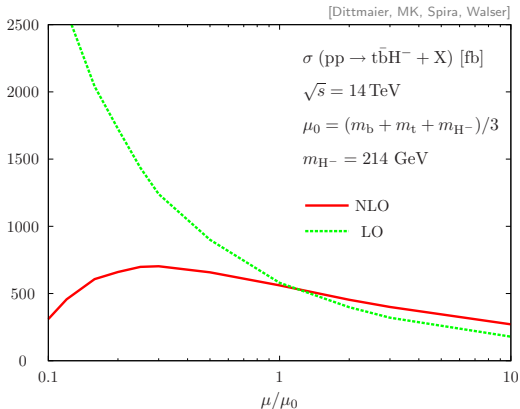
- ▶ scale dependence at 7 TeV (here and in the following we use SPS1b)



- choose $\mu_0 = (m_b + m_t + m_H)/3$
with scale variation $\mu/3 \leq \mu \leq 3\mu_0$

Associate tbH^\pm production: 4FS calculation at NLO

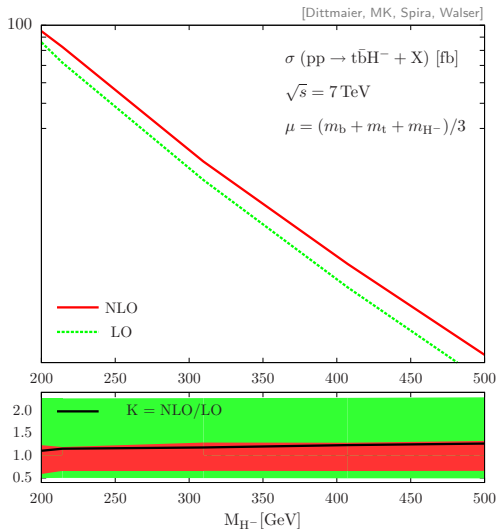
- ▶ scale dependence at 14 TeV



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Associate $t\bar{b}H^\pm$ production: 4FS calculation at NLO

- ▶ total cross section at 7 TeV



Associate tbH^\pm production: 4FS calculation at NLO

- ▶ **total cross section (still 14 TeV...):** individual NLO contributions:

$$\sigma_{\text{NLO}} = \sigma_0 \times (1 + \delta_{\text{SUSY-QCD}}^{\text{tan } \beta\text{-resum.}}) \times (1 + \delta_{\text{QCD}} + \delta_{\text{SUSY-QCD}}^{\text{remainder}})$$

M_{H^\pm} [GeV]	σ_0 [fb]	δ_{QCD}	$\delta_{\text{SUSY-QCD}}^{\text{tan } \beta\text{-resum.}}$	$\delta_{\text{SUSY-QCD}}^{\text{remainder}}$
214	512	0.55	-0.30	-0.001
310	223	0.61	-0.30	-0.001
407	106	0.62	-0.30	-0.001

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- ▶ partial cancellation between QCD and SUSY-QCD corrections
- ▶ dominant SUSY-QCD (non-decoupling) contributions from corrections to bottom-Higgs Yukawa coupling:

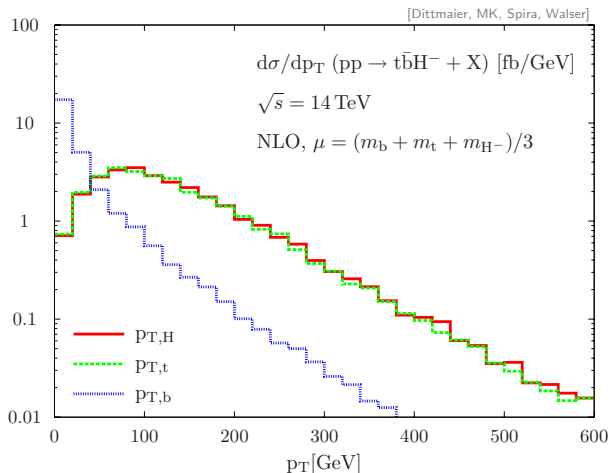
$$\frac{M_b \tan\beta}{v} \rightarrow \frac{M_b \tan\beta}{v} \frac{1}{1 + \Delta M_b}$$

where $\Delta M_b = \frac{C_F}{2} \frac{\alpha_s}{\pi} m_{\tilde{g}} \mu \tan\beta \times I(m_{\tilde{b}_1}, m_{\tilde{b}_2}, m_{\tilde{g}})$

[Hall, Rattazzi, Sarid, ...; Carena, Garcia, Nierste, Wagner; ... Noth, Spira]

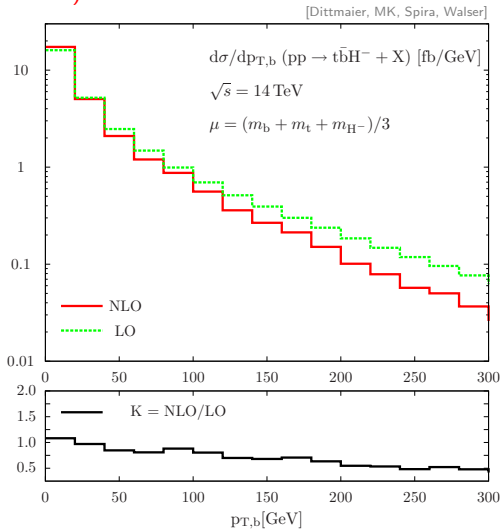
Associate tbH^\pm production: 4FS calculation at NLO

- ▶ transverse momentum distribution (still 14 TeV...)



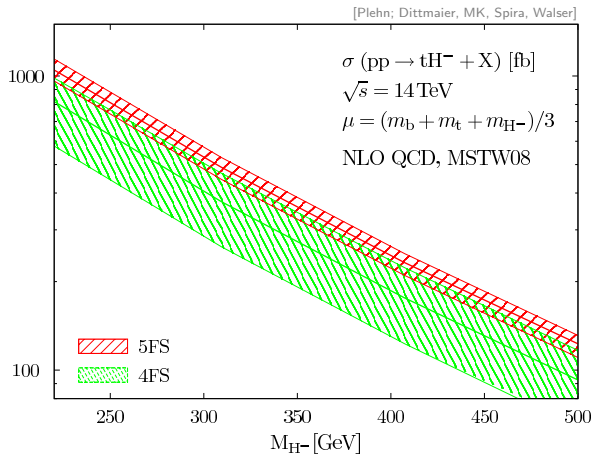
Associate $t\bar{b}H^\pm$ production: 4FS calculation at NLO

- ▶ bottom transverse momentum distribution at LO/NLO
(still 14 TeV...)



Comparison of 4 and 5FS calculations at NLO

► total cross section



Summary

- ▶ NLO (SUSY-) QCD corrections available in 4FS and 5FS; higher-order SUSY effects can be absorbed in ΔM_b
- ▶ two schemes for calculating Higgs+top cross sections at the LHC
 - should agree at sufficiently high order
 - significant differences observed at NLO
- ▶ EWK corrections may be significant for light MSSM spectrum
- ▶ implementation in MC@NLO of 5FS NLO calculation available

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Plans

- ▶ complete 4FS and 5FS numerics for 7 TeV
- ▶ more systematic comparison of 4FS and 5FS NLO calculations
- ▶ match 4FS calculation with parton shower [Powheg]