

MSSM CHARGED HIGGS

Michael Spira (PSI)

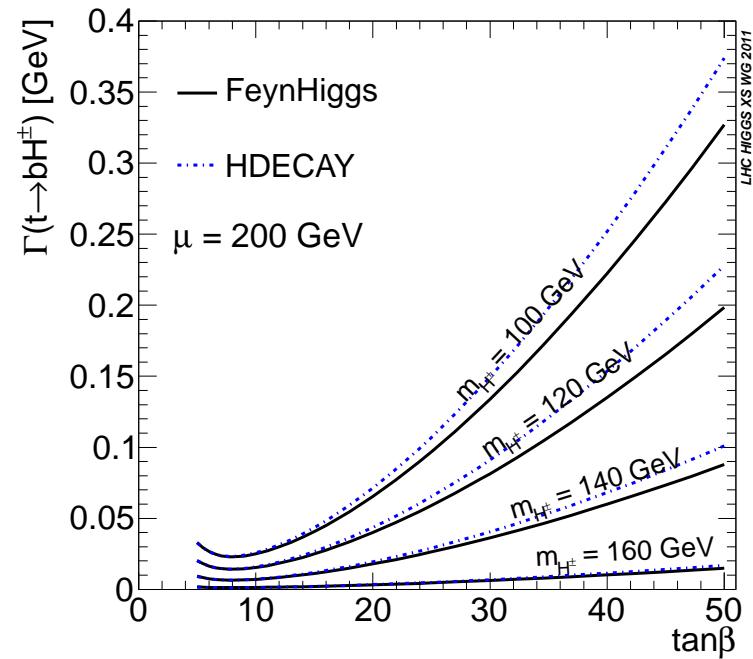
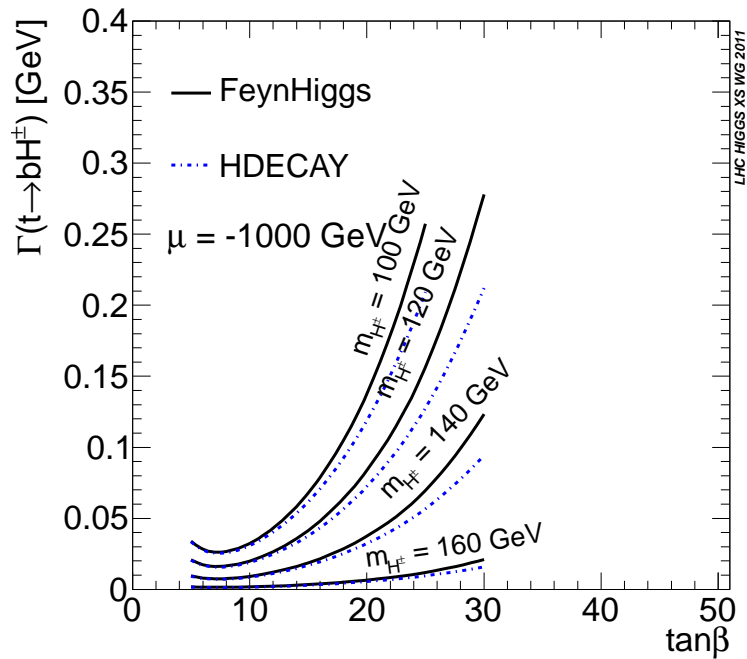
Theory convenors: Robert Harlander, Michael Krämer, Pietro Slavich,
Michael Spira

Experimental convenors: Monica Vazquez Acosta (CMS), Martin Flechl
(ATLAS), Sami Lehti (CMS), Trevor Vickey (ATLAS)

Group members: M. Flechl, R. Harlander, S. Heinemeyer, R. Klees,
M. Krämer, J.S. Lee, S. Lehti, M. Spira, M. Ubiali

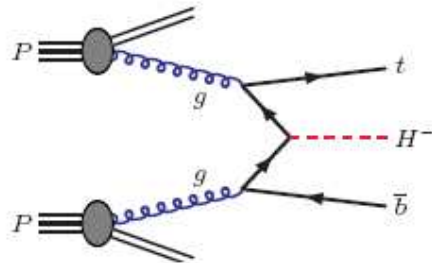
$pp \rightarrow t\bar{b}H^- + X$

- $M_{H^\pm} < m_t - m_b$: $\sigma_{t\bar{b}H^-} = \sigma_{t\bar{t}} \times BR(\bar{t} \rightarrow \bar{b}H^-)$
- off-shell effects? threshold effects? sufficient for exclusion?

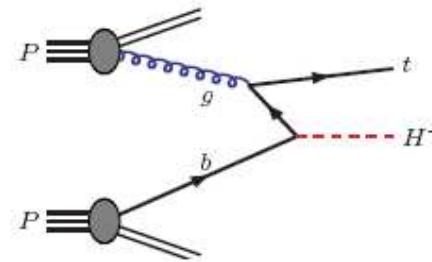


- ▶ There are **two** calculational schemes

$$4\text{FS: } gg \rightarrow tbH^\pm$$

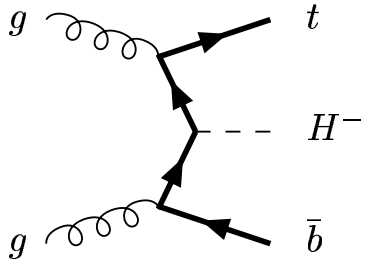


$$5\text{FS: } gb \rightarrow tH^\pm$$



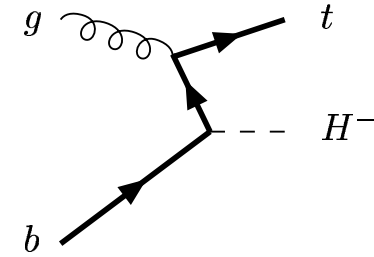
which represent different ways of ordering perturbation theory

- ▶ Both calculations are available in **NLO-SUSY QCD**
[Plehn PRD67 (2003) 014018; Dittmaier, Krämer, Spira, Walser (PRD83 (2011) 055005)]
- ▶ The two schemes can be combined according to the **Santander matching** [Harlander, Krämer, Schumacher, CERN-PH-TH/2011-134]
- ▶ The scale in the 5FS calculation has been set according to the scheme proposed by Maltoni, Ridolfi, Ubiali (JHEP 1207 (2012) 022)
- ▶ Theoretical uncertainties include scale variation as well as pdf, m_b and α_s uncertainty, evaluated according to the PDF4LHC and Higgs cross section working group recommendations



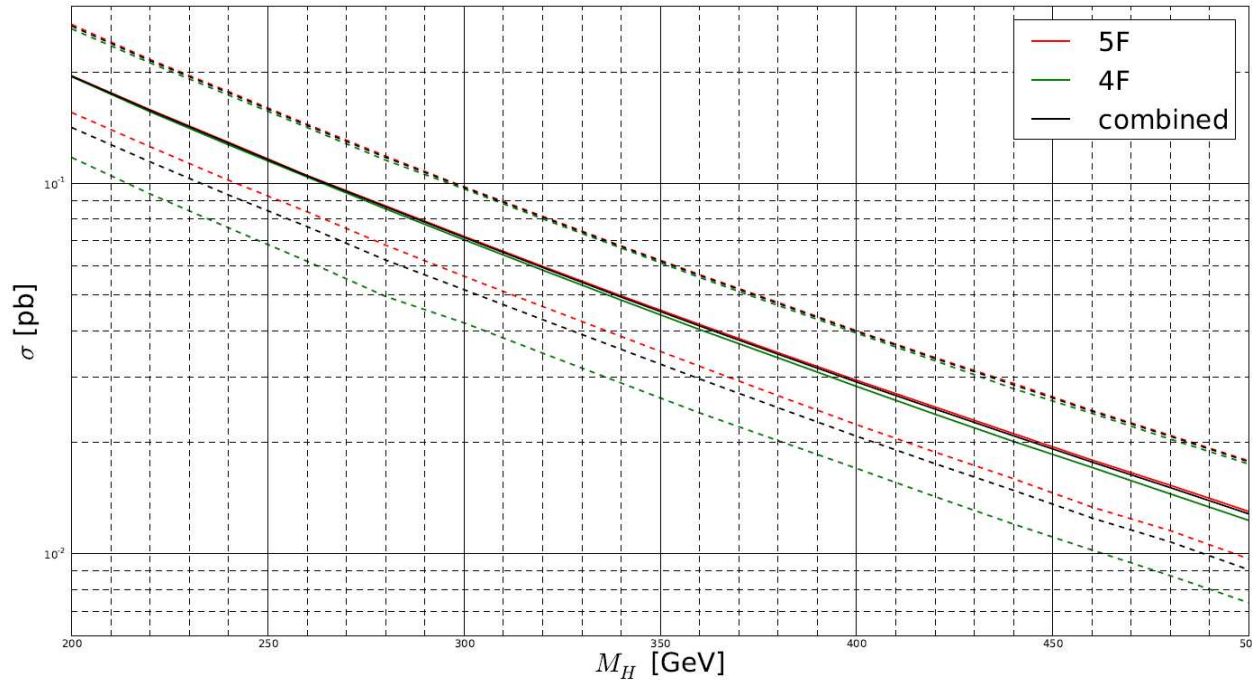
NLO

exact $g \rightarrow b\bar{b}$ splitting & mass/off-shell effects
 no resummation of $\log M_{H^\pm}^2/m_b^2$ terms



NNLO

massless/on-shell b 's, no p_{Tb}
 resummation of $\log M_{H^\pm}^2/m_b^2$ terms



[dynamical scale choice [Maltoni, Ridolfi, Ubiali](#)]

Santander matching:

$$\sigma = \frac{\sigma^{4FS} + w\sigma^{5FS}}{1 + w}$$

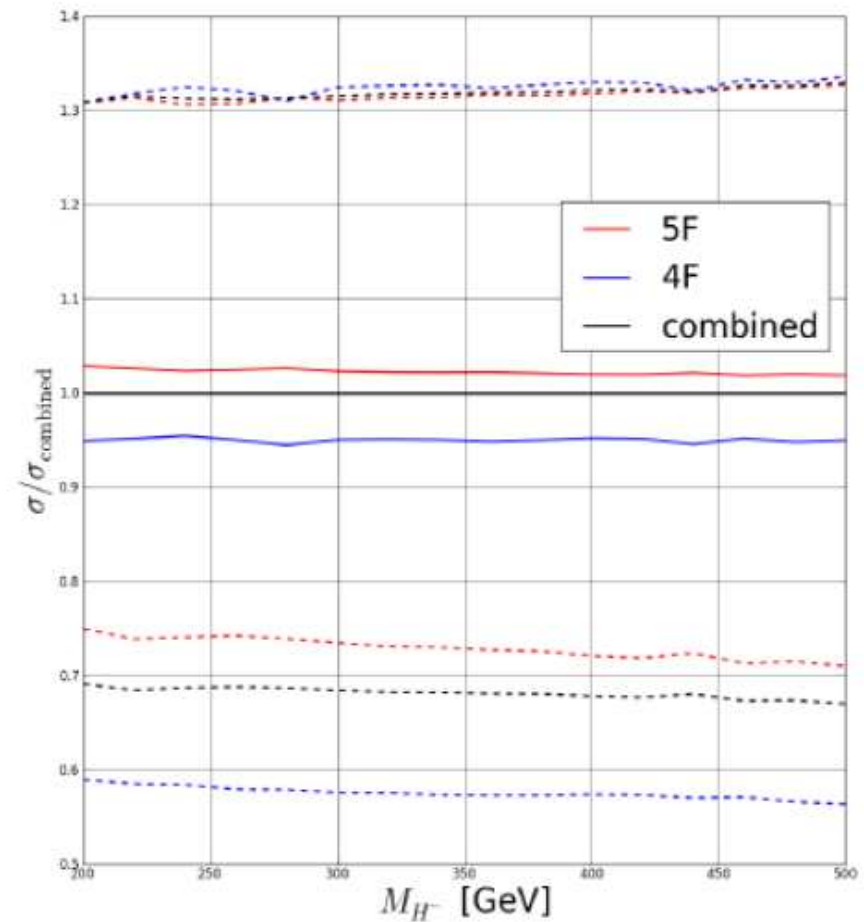
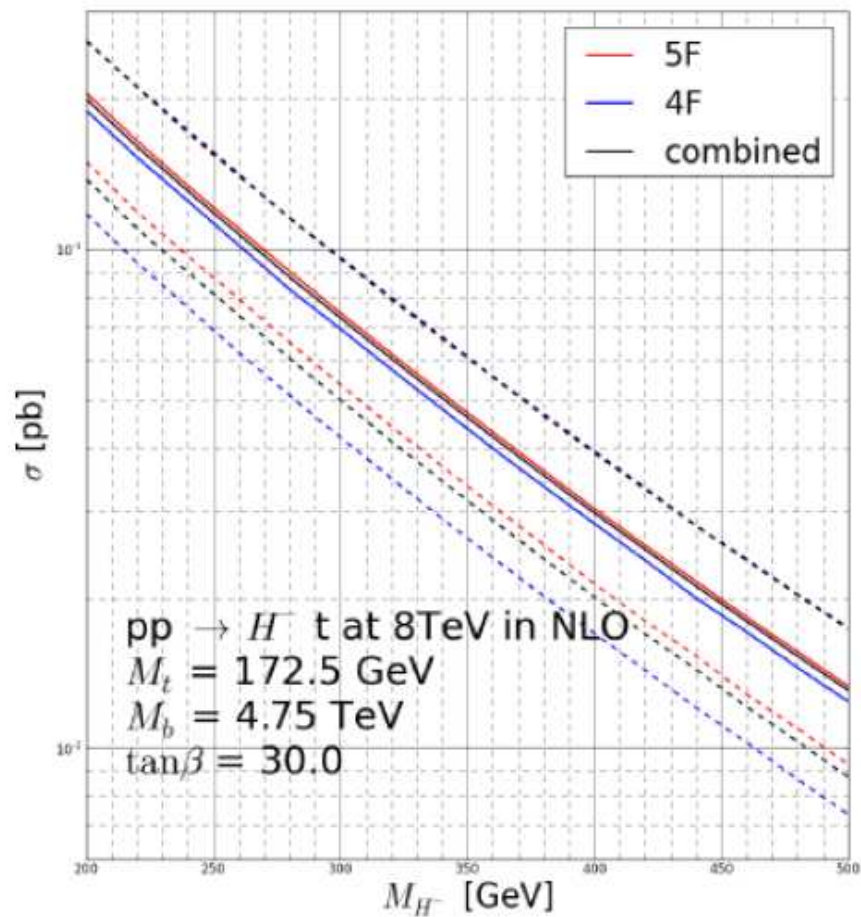
$$w = \log \frac{M_{H^\pm}}{m_b} - 1$$

[Harlander, Krämer, Schumacher](#)

[Dittmaier, Krämer, S., Walser](#)
[Plehn](#)
[Klees, Ubiali](#)

► Cross section @ 8 TeV (PDF4LHC)

[Klees, Krämer, Ubiali]



- rescale with Yukawa coefficients

SUSY-QCD Corrections to $b\bar{b}\phi^0$

$$\mathcal{L}_{eff} = -\frac{m_b/v}{1 + \Delta_b} \bar{b} \left[g_b^h \left(1 - \frac{\Delta_b}{\text{tg}\alpha \text{tg}\beta} \right) h + g_b^H \left(1 + \Delta_b \frac{\text{tg}\alpha}{\text{tg}\beta} \right) H - g_b^A \left(1 - \frac{\Delta_b}{\text{tg}^2\beta} \right) i\gamma_5 A \right] b$$

$$\Delta_b = \frac{2}{3} \frac{\alpha_s}{\pi} m_{\tilde{g}} \mu \text{tg}\beta I(m_{\tilde{b}_1}^2, m_{\tilde{b}_2}^2, m_{\tilde{g}}^2) \quad I(a, b, c) = \frac{ab \log \frac{a}{b} + bc \log \frac{b}{c} + ca \log \frac{c}{a}}{(a-b)(b-c)(a-c)}$$

⇒ resummed Yukawa couplings

Carena, Garcia, Nierste, Wagner
Guasch, Häfliger, S.

- NNLO: $\mathcal{O}(10\%)$, $\mu = M_{SUSY}$

Noth, S.
Mihaila, Reisser

- approximation of NLO SUSY-QCD corrections $< 1\%$ @ large $\text{tg}\beta$

Dittmaier, Krämer, S., Walser

- analogous for charged Higgs: $\tilde{g}_b^{H^\pm} = \frac{\text{tg}\beta}{1 + \Delta_b} \left(1 - \frac{\Delta_b}{\text{tg}^2\beta} \right)$

$pp \rightarrow t\bar{b}H^- + X$

$$\sigma_{NLO} = \sigma_{LO}|_{g_b^{H^\pm} \rightarrow \tilde{g}_b^{H^\pm}} \times \left\{ 1 + \delta_{QCD} + \delta_{SQCD}^{rem} \right\}$$

$\text{tg}\beta$	δ_{SUSY}^{rem} [%]
3	-5.7%
5	-7.9%
10	-4.8%
30	-0.13%

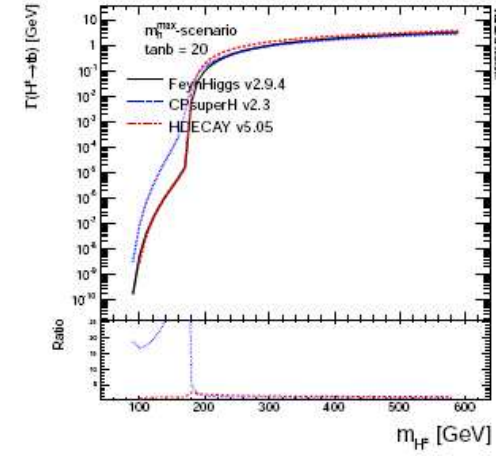
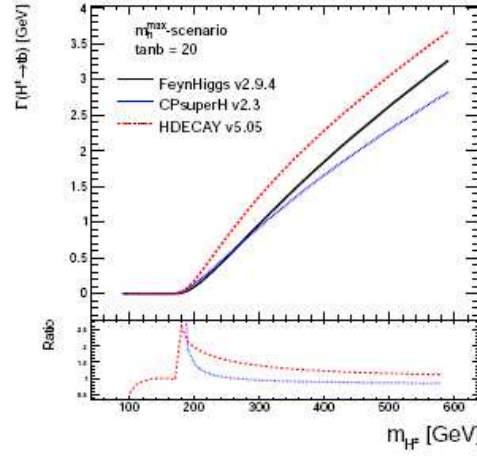
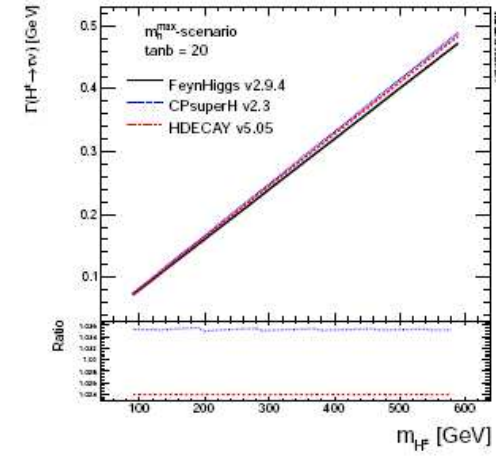
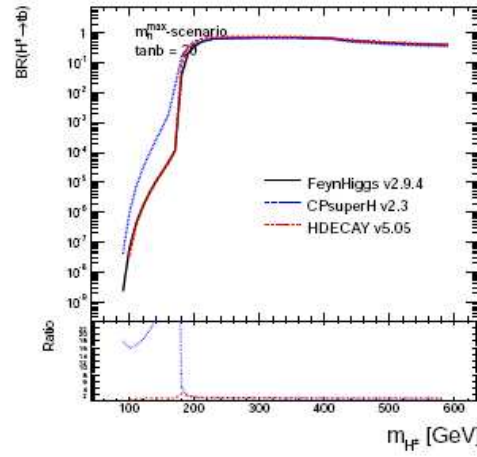
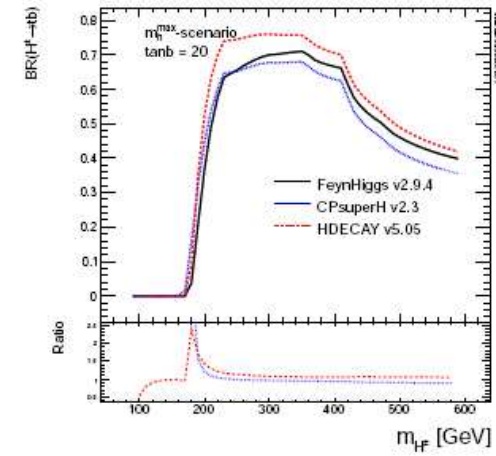
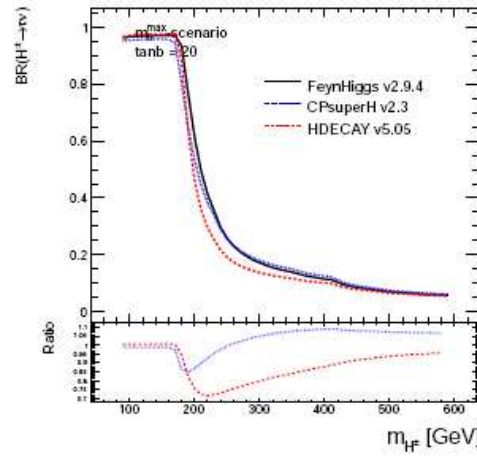
Dittmaier, Krämer, S., Walser

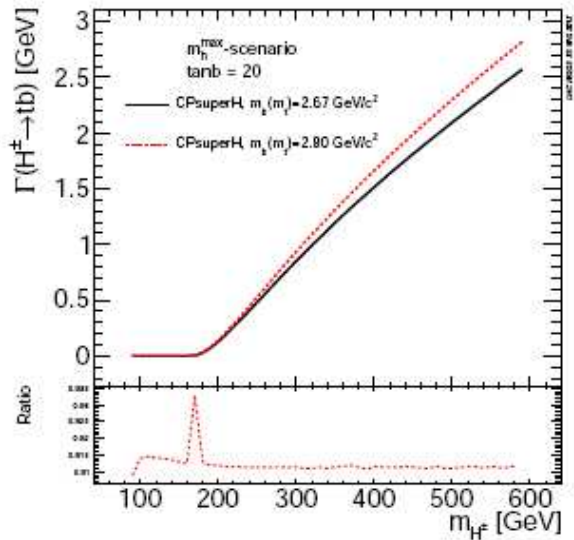
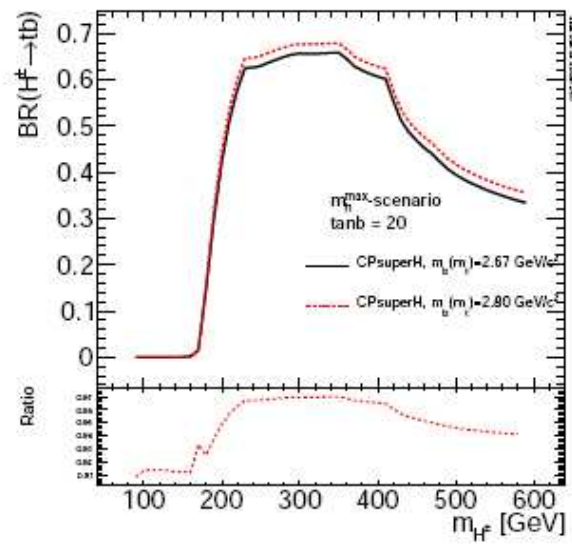
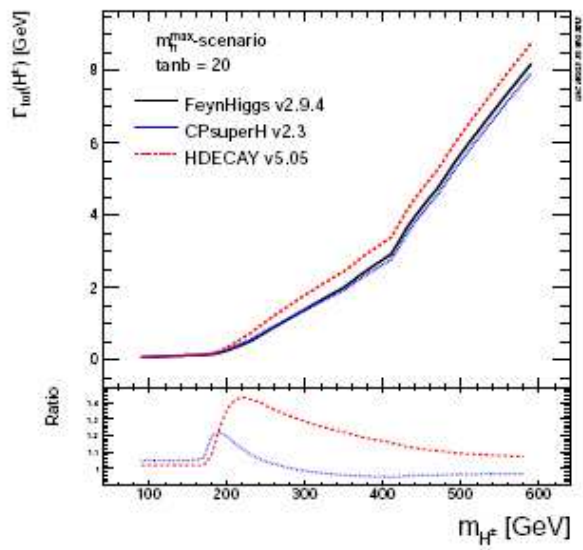
Branching Ratios

FeynHiggs 2.9.4

HDECAY 5.05

CPSuperH 2.3





- differences: $\bar{m}_b(M_{H^\pm})$, treatment of (SUSY-)QCD corrections, off-shell effects below threshold, ...

⇒ to be studied in detail

SUMMARY

$t\bar{b}H^-$

- 4FS: QCD corrections $\lesssim 60\%$ for total cxn
 $\Rightarrow \Delta \lesssim 20\%$ [only scale]
- SUSY-QCD corrections: small after resummation [Δ_b] for large $\tan\beta$
- grids for 4FS central + scale error to be generated [work in progress...]
- 5FS: QCD corrections moderate for total cxn
 $\Rightarrow \Delta \lesssim 20\%$ [scale+PDF+ α_s]
- differences in BR calculations to be understood