Cross-sections and Branching Ratios for H^+ Searches

André Sopczak

Lancaster University / Uppsala University

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Introduction

- In preparation of the experimental search for charged Higgs bosons at the LHC precise expected charged Higgs boson production cross-sections and decay branching ratios at $\sqrt{s}$=14 TeV are required.
- In the mass regime below the top quark mass the expected production cross-sections are discussed using two computer packages based on the decay top to H^+b.
- For higher masses, Next-to-Leading-Order (NLO) calculations have been used, and particular attention has been given to the intermediate mass region.
- The decay branching ratios have been studied with the computer packages FeynHiggs, as well as with HDecay.
- Higher order corrections (Delta_b corrections) in the MSSM are consistently taken into account. Two benchmark scenarios are considered, one of them, the so-called `mhmax'.

MSSM

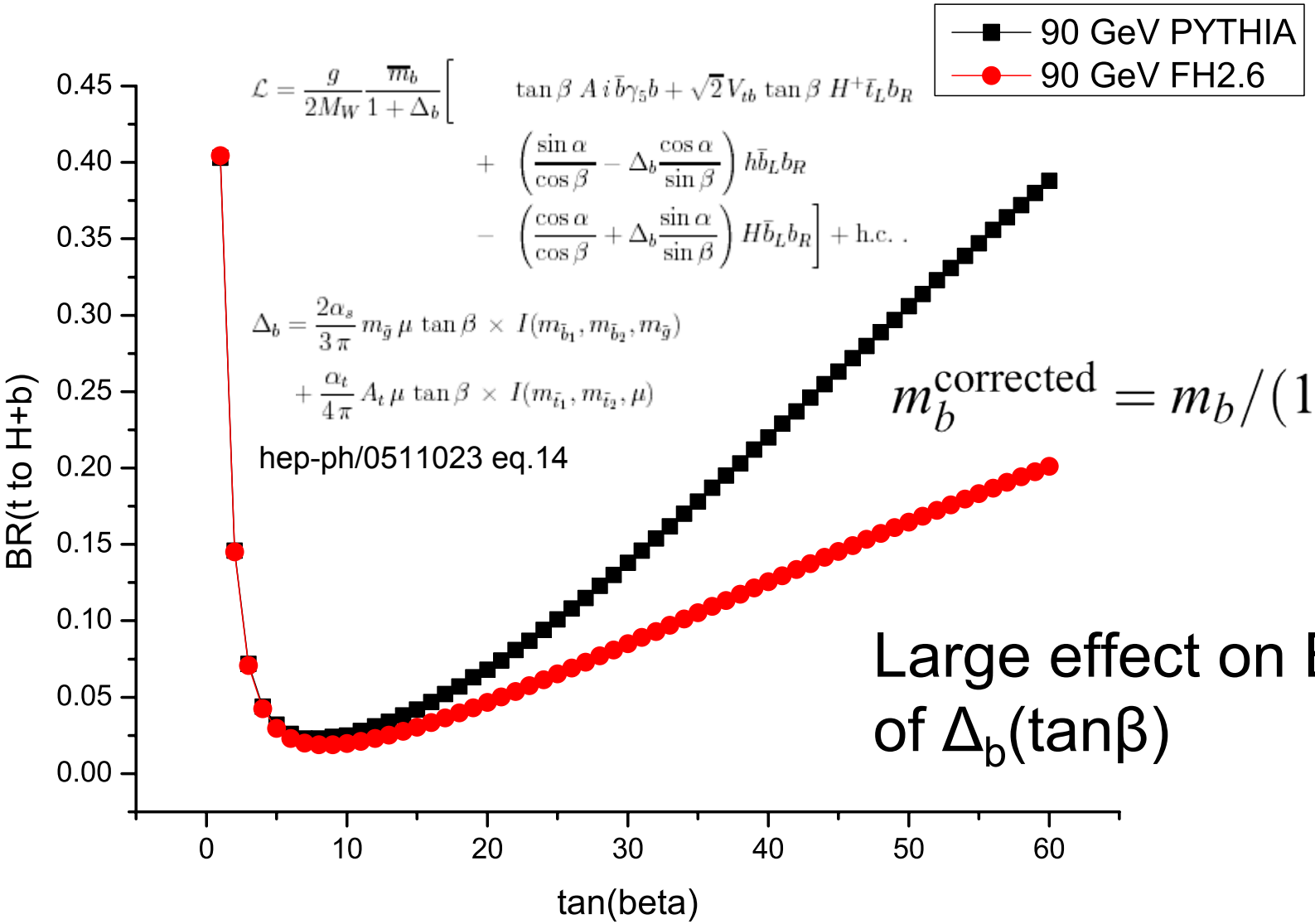
Scenario A
(heavy SUSY)

- M(top) = 175 GeV
- MSusy = 500 GeV
- Abs(At) = 1000 GeV
- Abs(M_2) = 200 GeV
- Abs(μ) = 1000 GeV
- Abs(M_3) = 1000 GeV

Scenario B
(mhmax)

- M(top) = 175 GeV
- MSusy = 1000 GeV
- Abs(Xt) = 2000 GeV
  (At =2000+μ/tanβ)
- Abs(M_2) = 200 GeV
- Abs(μ) = 200 GeV
- Abs(M_3) = 800 GeV

BR(t→H⁺b) PYTHIA vs FH



$$\mathcal{L} = \frac{g}{2M_W}\frac{\overline{m}_b}{1+\Delta_b}\Big[\tan\beta\, A\, i\,\bar{b}\gamma_5 b + \sqrt{2}V_{tb}\tan\beta\, H^+\bar{t}_L b_R + \left(\frac{\sin\alpha}{\cos\beta} - \Delta_b\frac{\cos\alpha}{\sin\beta}\right) h\bar{b}_L b_R - \left(\frac{\cos\alpha}{\cos\beta} + \Delta_b\frac{\sin\alpha}{\sin\beta}\right) H\bar{b}_L b_R\Big] + \text{h.c.}\,.$$

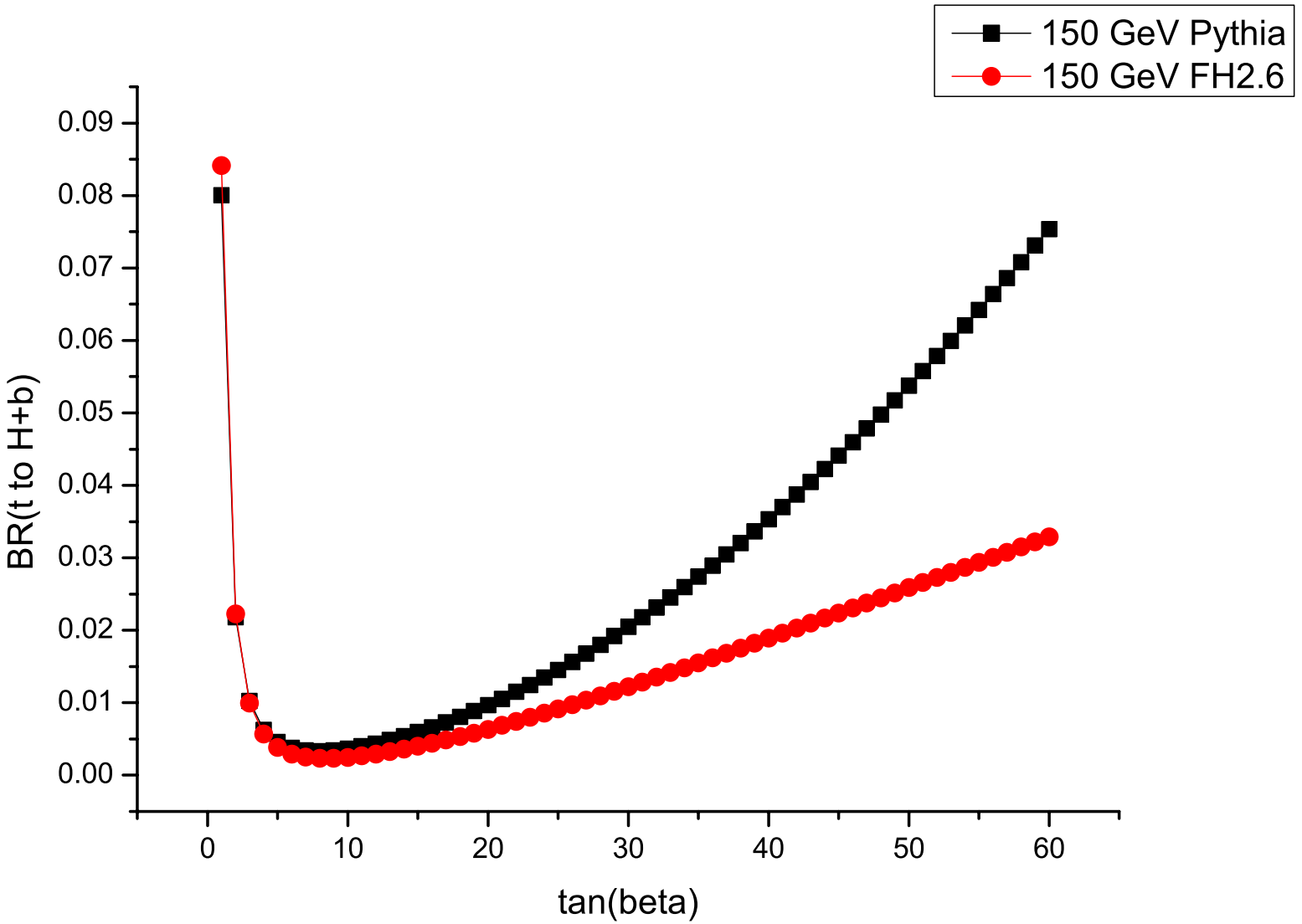
$$\Delta_b = \frac{2\alpha_s}{3\pi} m_{\tilde{g}}\,\mu\,\tan\beta \times I(m_{\tilde{b}_1}, m_{\tilde{b}_2}, m_{\tilde{g}}) + \frac{\alpha_t}{4\pi} A_t\,\mu\,\tan\beta \times I(m_{\tilde{t}_1}, m_{\tilde{t}_2}, \mu)$$

hep-ph/0511023 eq.14

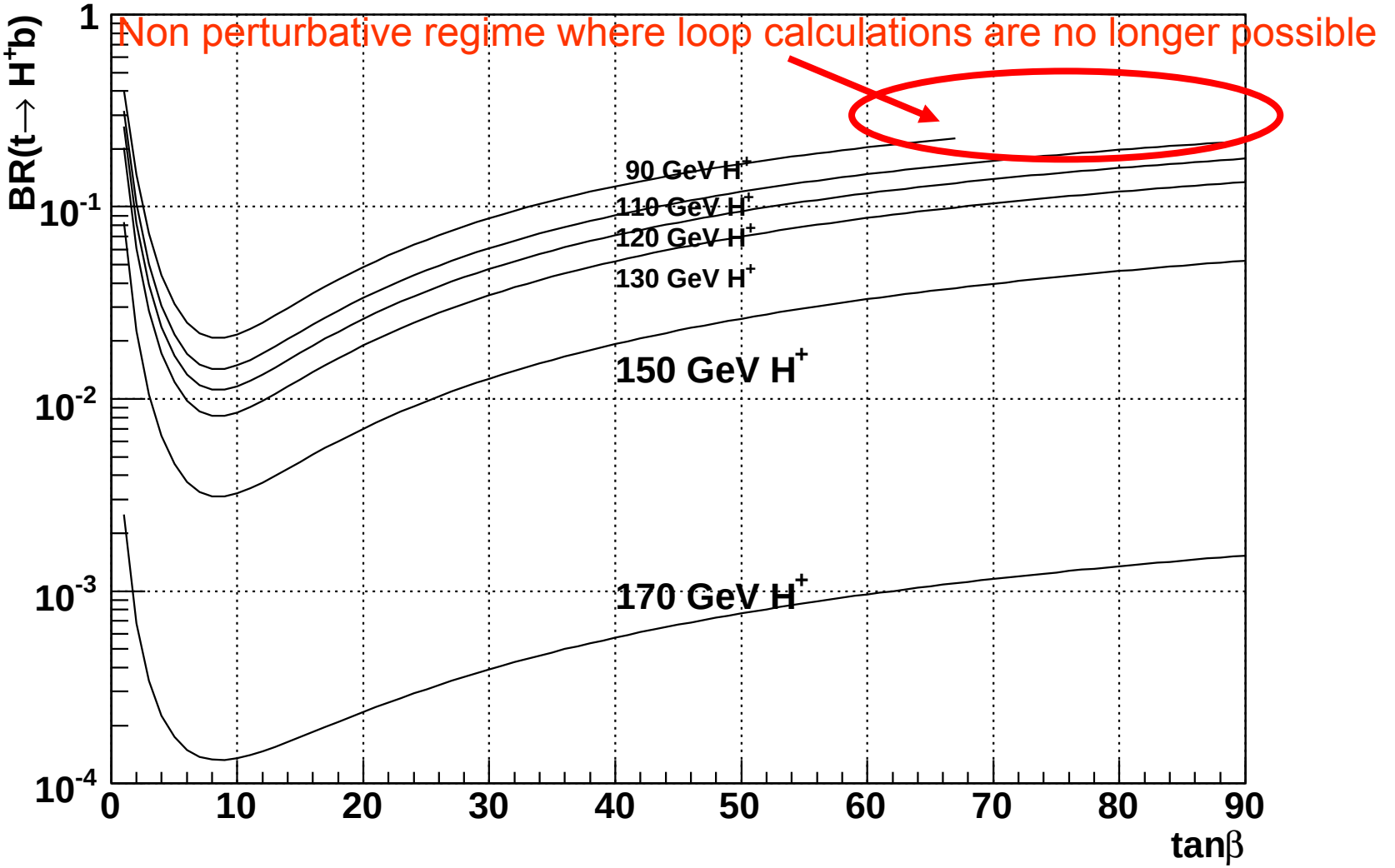
$$m_b^{\text{corrected}} = m_b/(1+\Delta_b)$$

Large effect on BR of $\Delta_b(\tan\beta)$

BR(t→H⁺b) PYTHIA vs FH



BR(t→H⁺b) MSSM Scenario A



Low-mass H^+ Cross-section

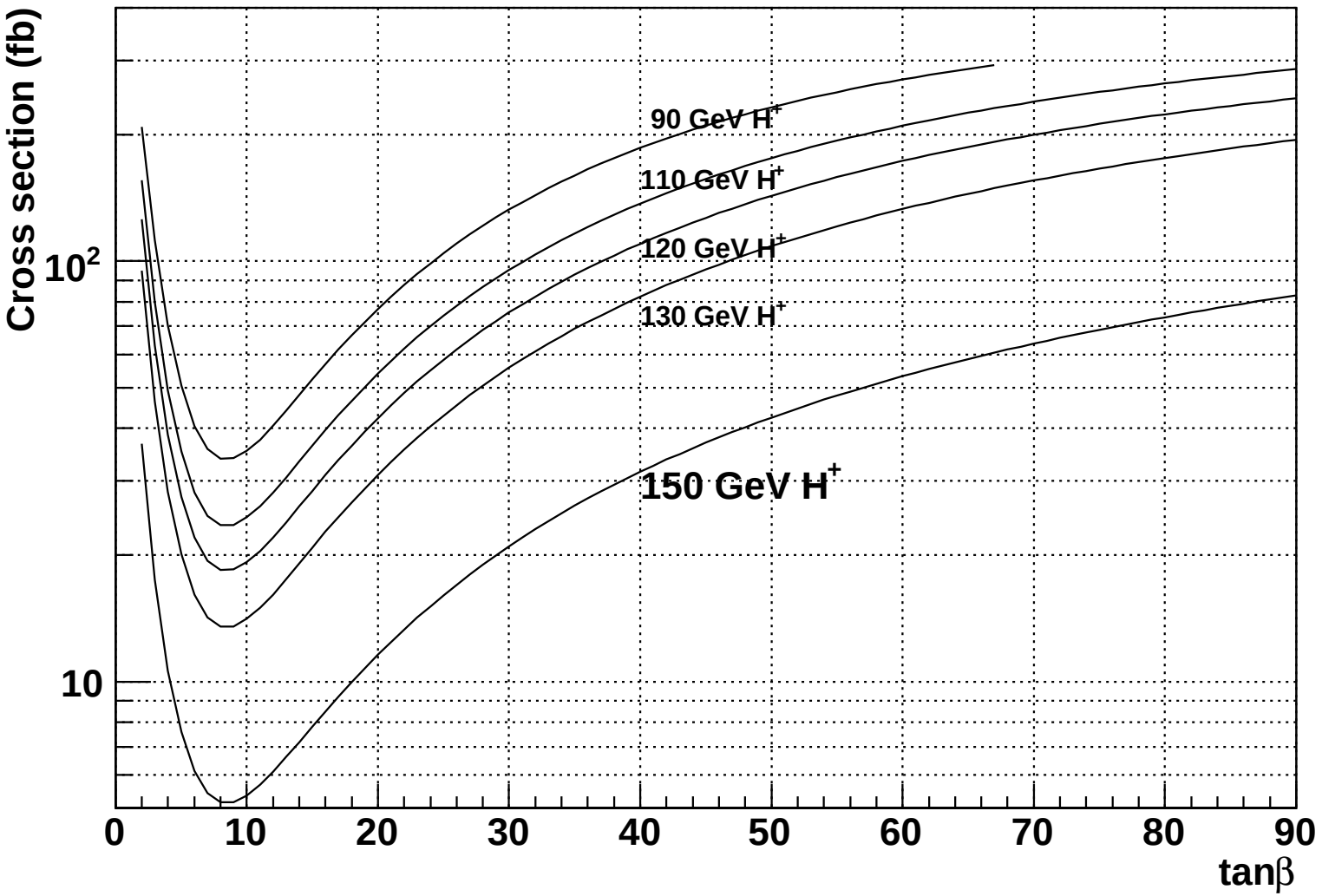
Using the ttbar production cross-section

$$\sigma_{t\bar{t}} = 833 \text{ pb}$$

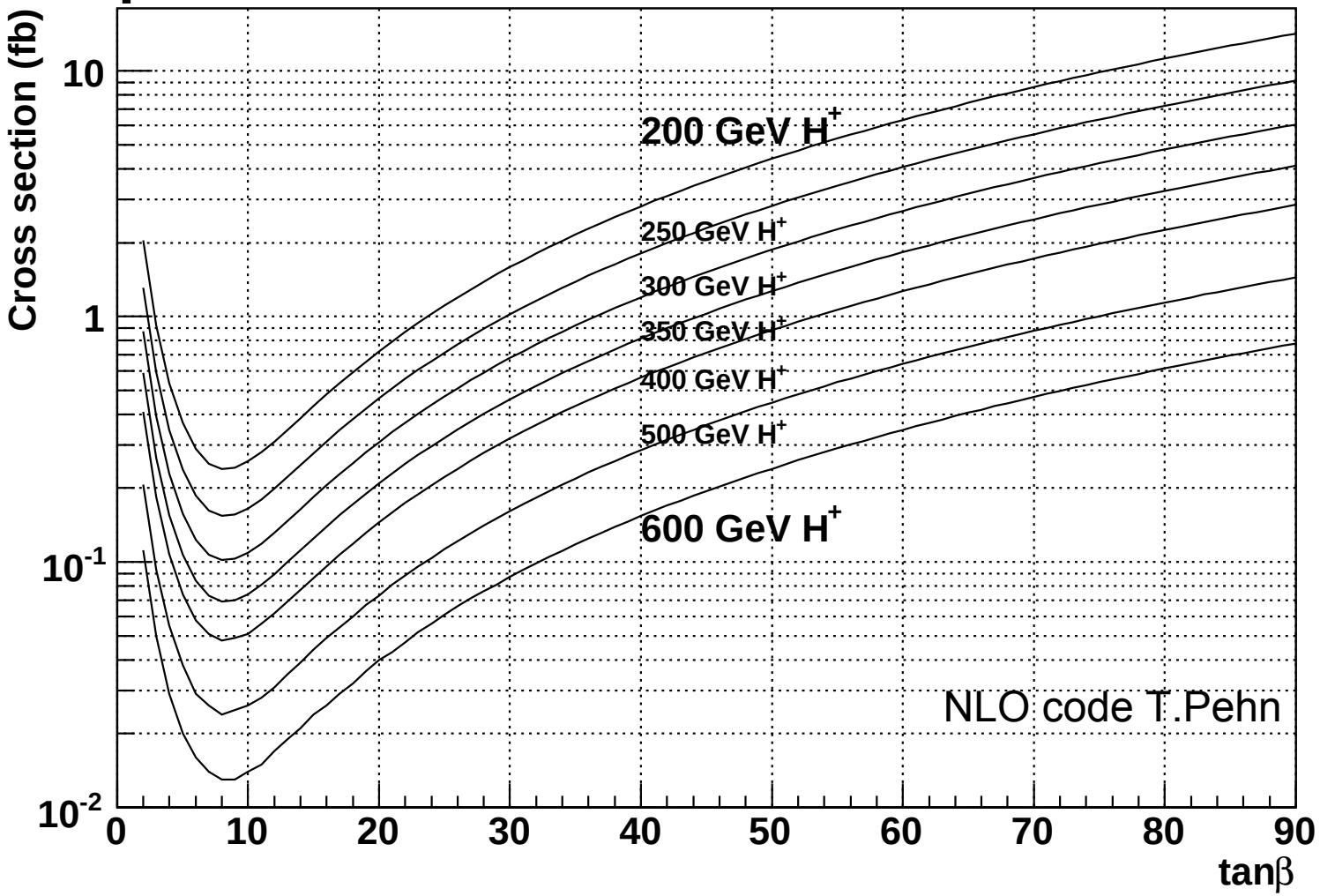
the H^+ production cross-section is determined:

$$\sigma_{tbH^+} = 2 \cdot \sigma_{t\bar{t}} \text{BR}\left(t \to H^+ b\right)\left[1 - \text{BR}\left(t \to H^+ b\right)\right]$$

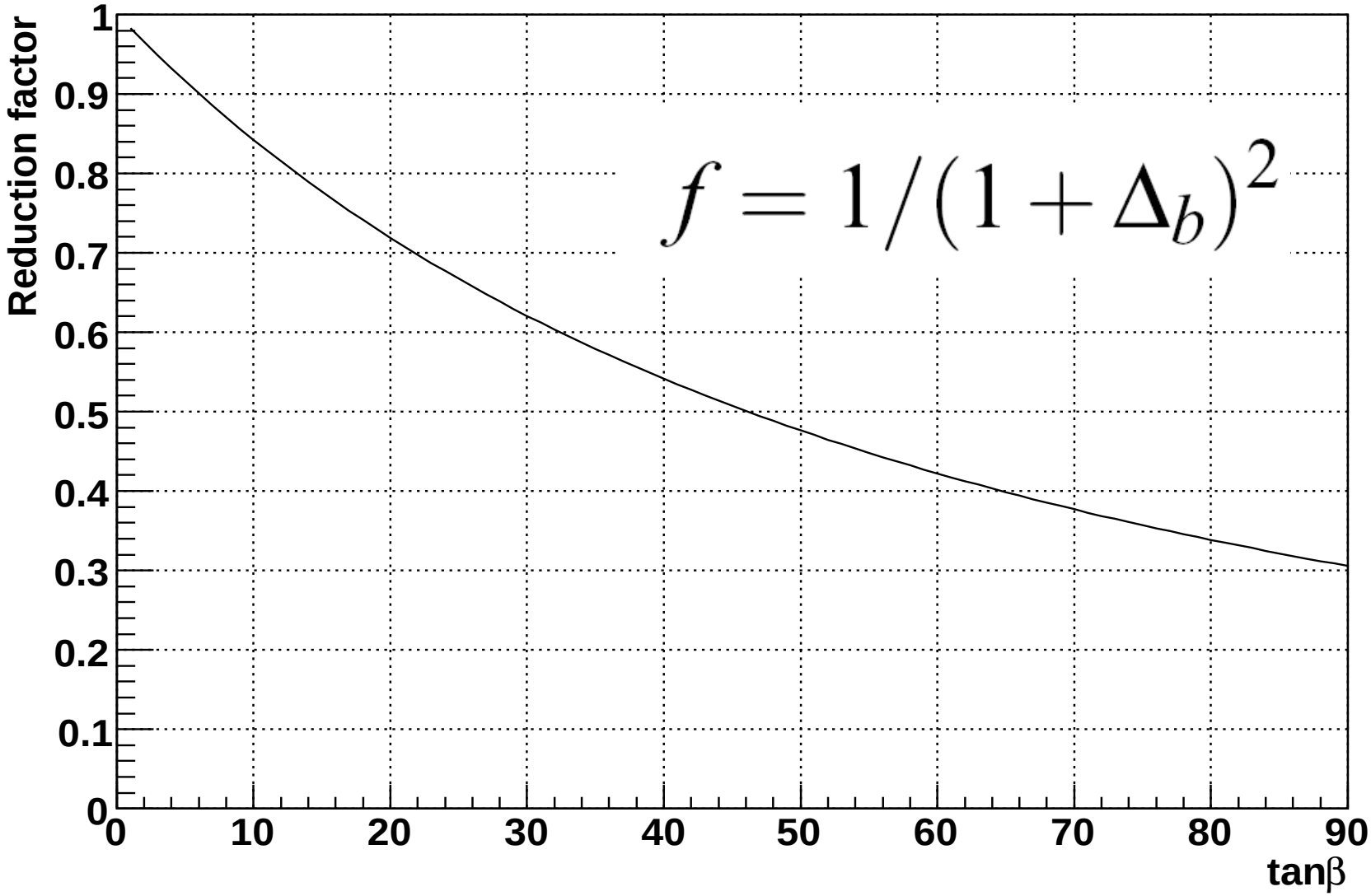
Low-mass Cross-section A



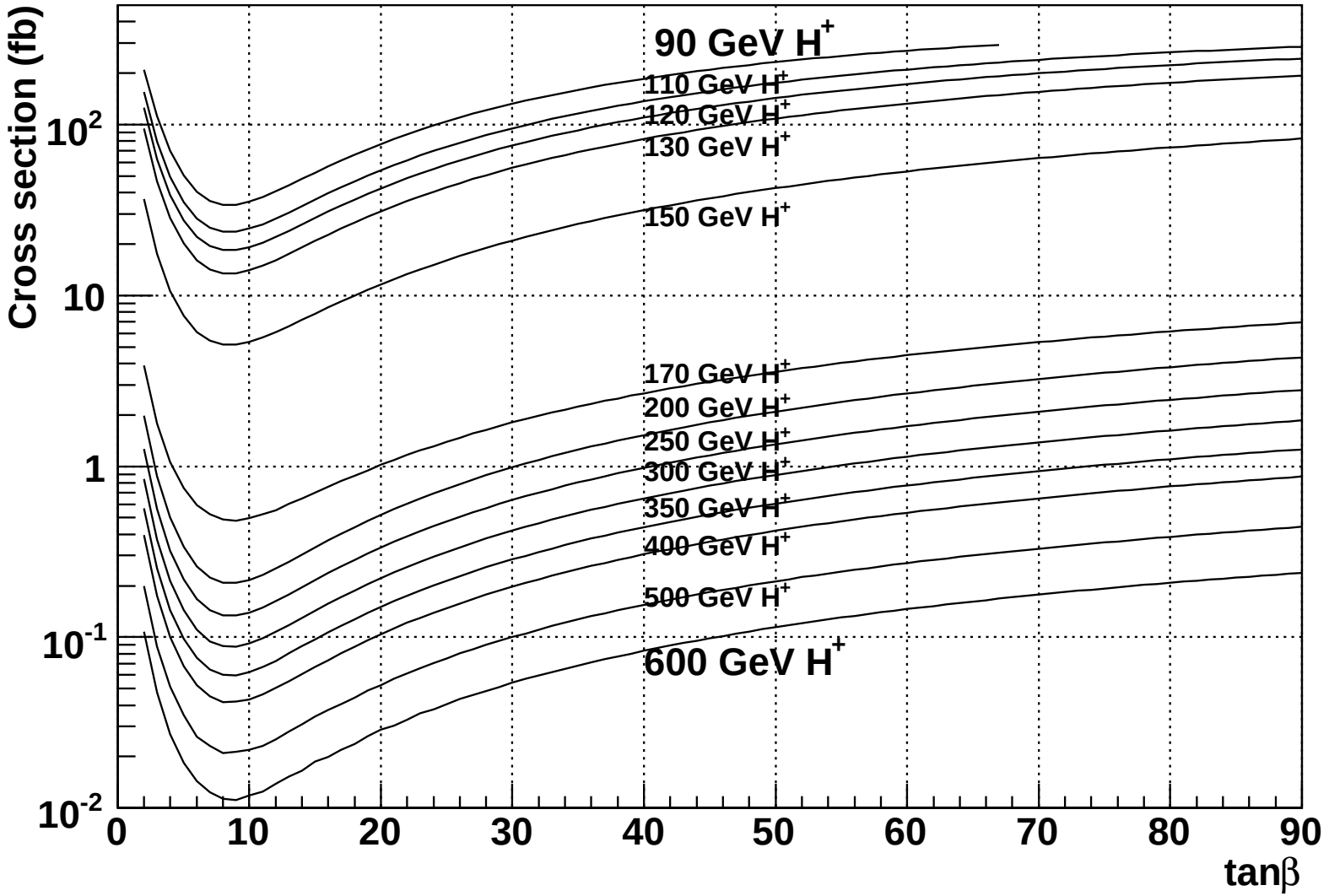
High-mass Cross-section Independent of Scenarios A and B



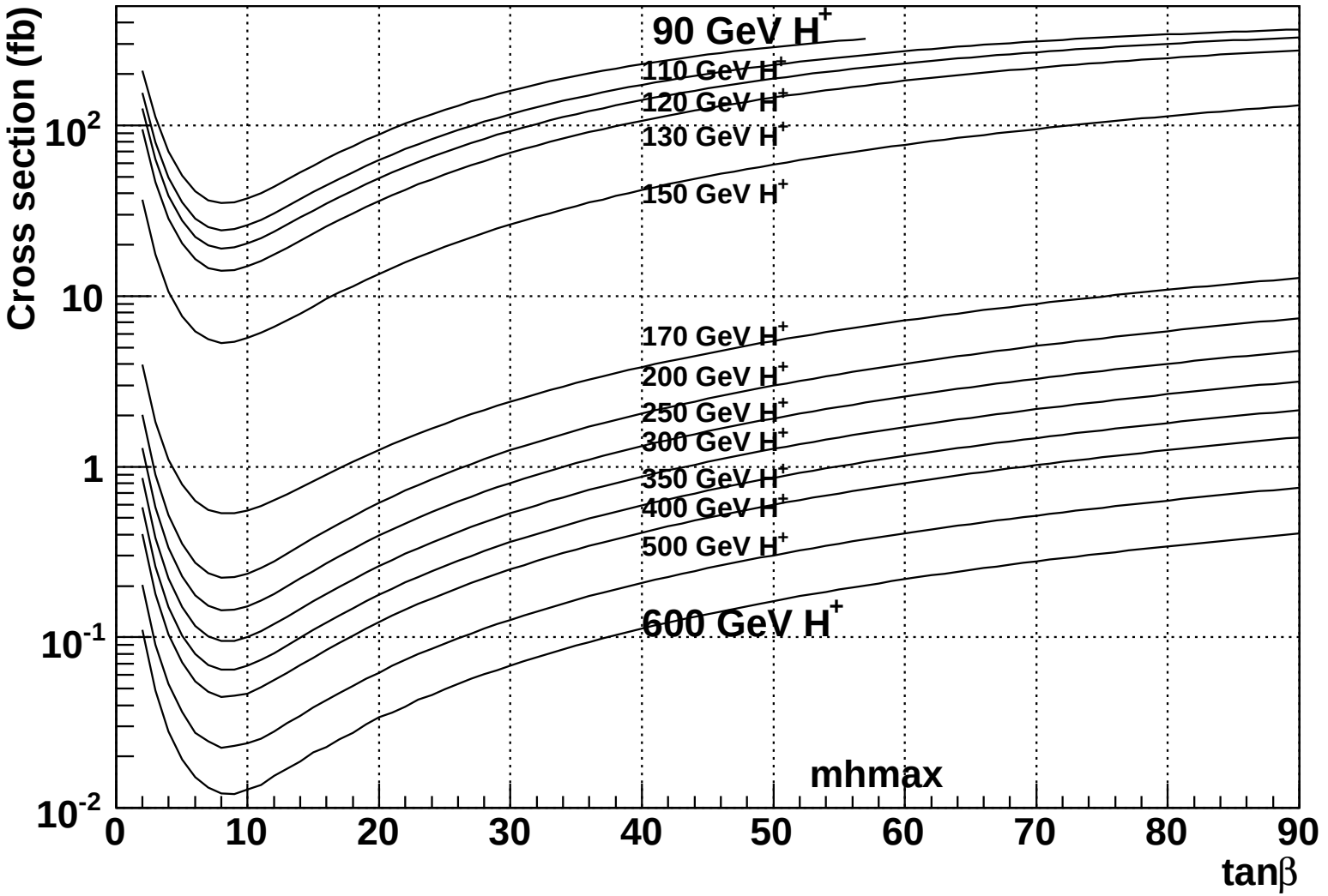
Factor for Cross-section (Scenario A)



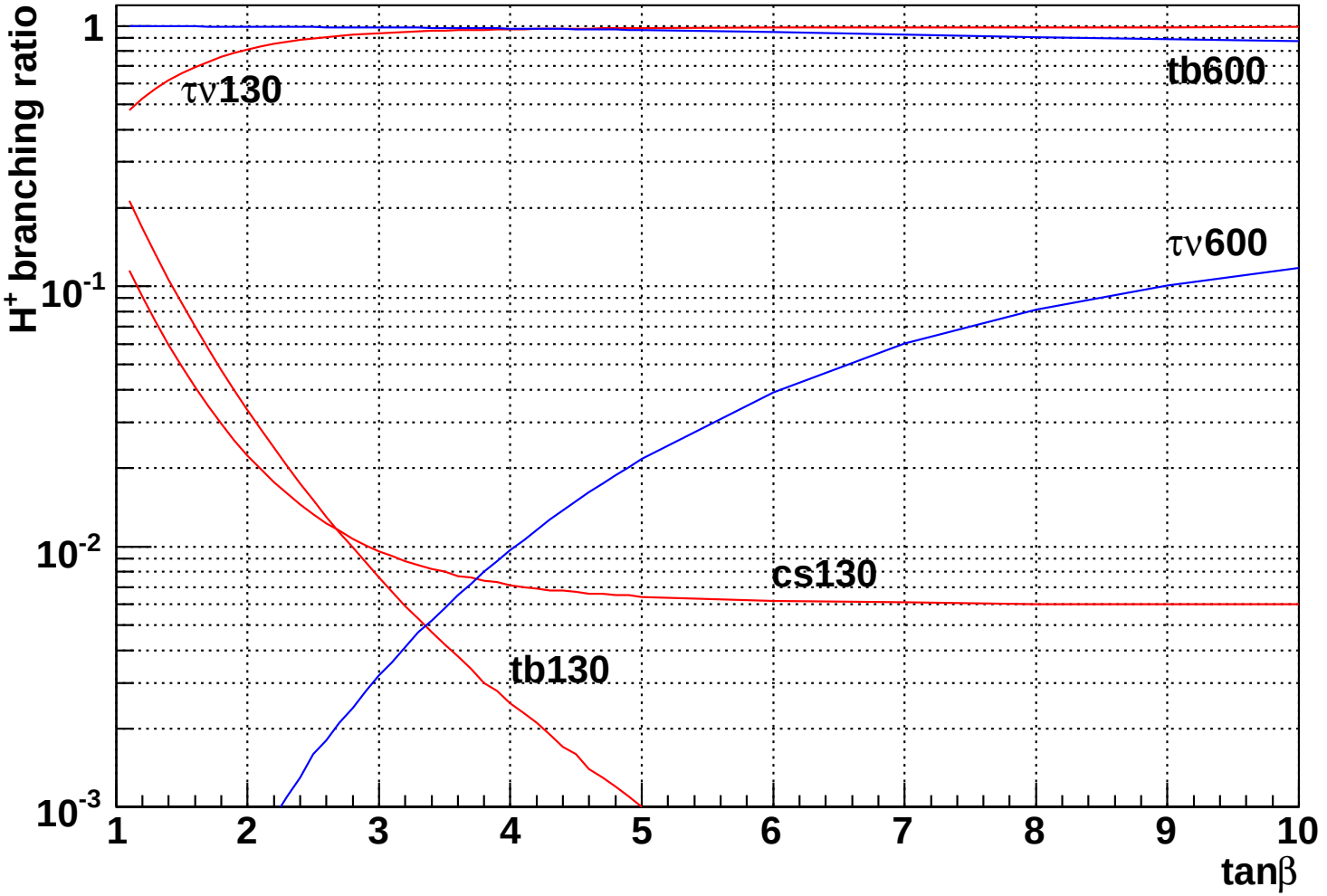
High-mass Cross-section A



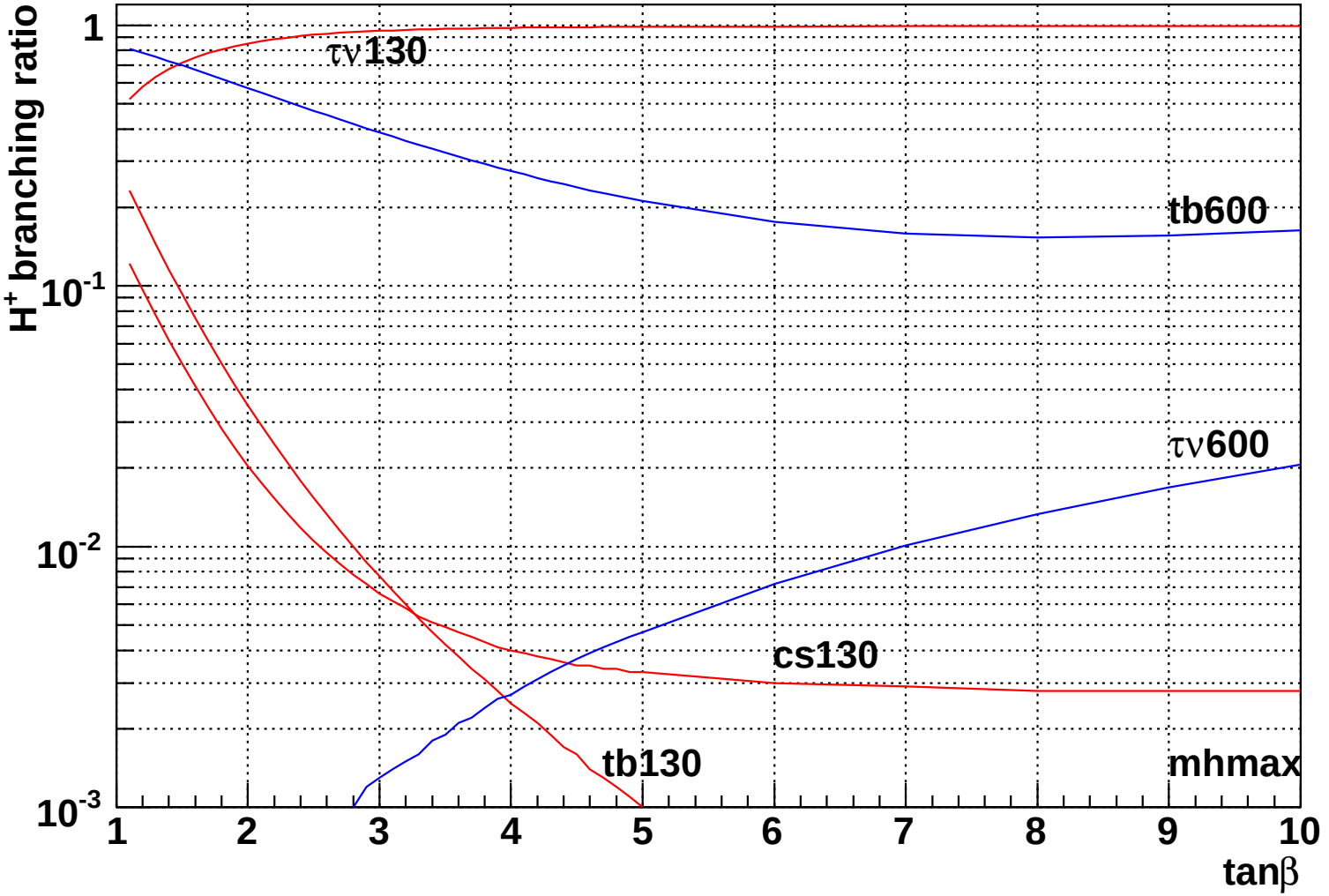
High-mass Cross-section B



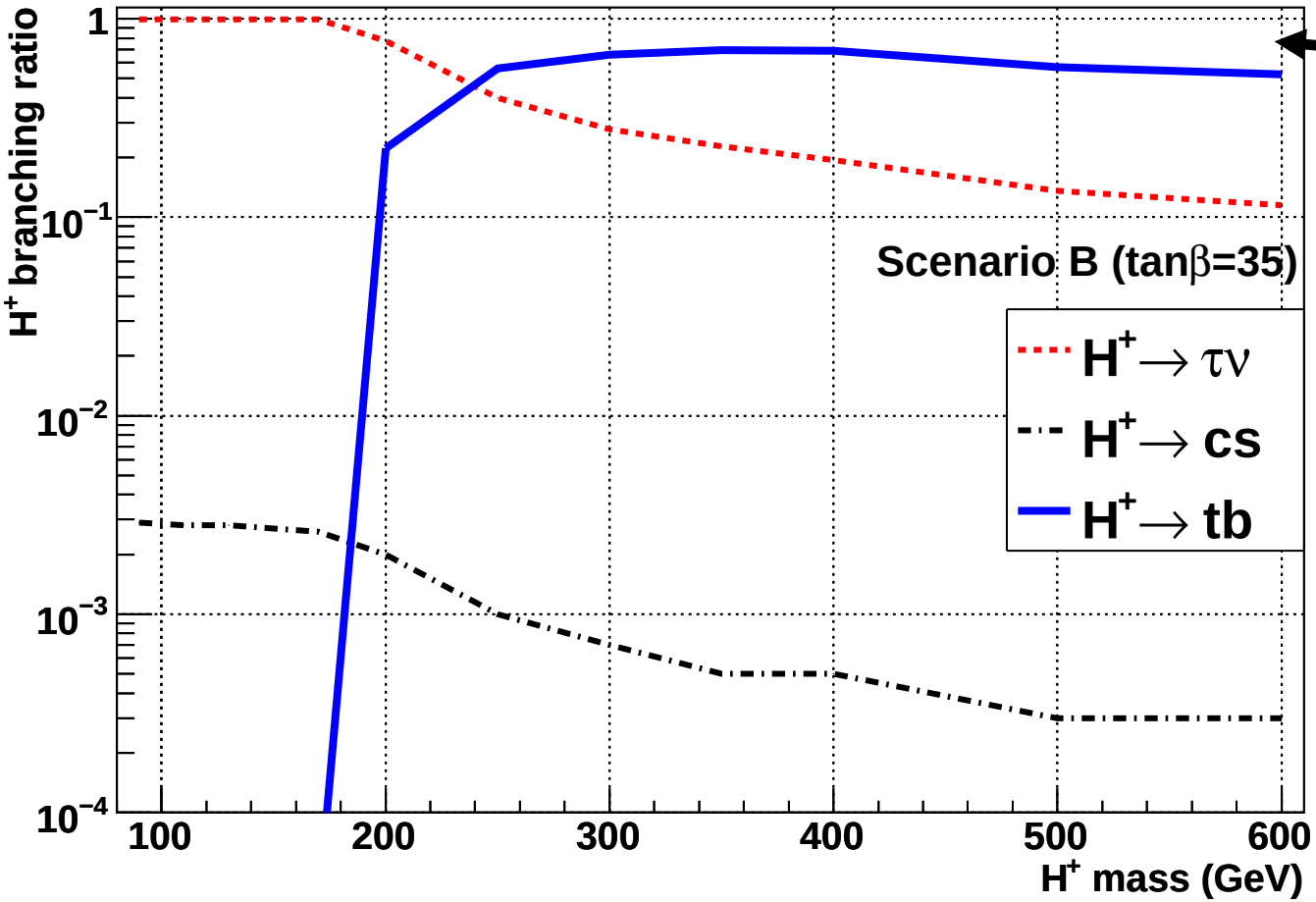
BR($H^+ \to \ldots$) Scenario A



BR($H^+ \to \ldots$) Scenario B



BR($H^+ \rightarrow \ldots$)



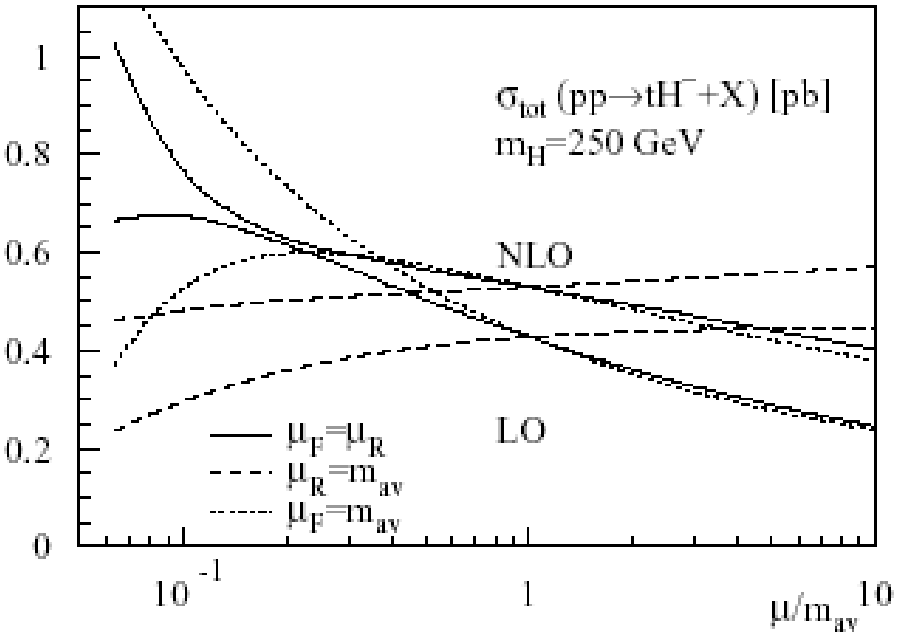
Note: for intermediate tanβ and large H^+ mass BR($H^+ \rightarrow hW^+$) could be dominant.

Systematic Uncertainties
related to NLO gb→tH$^+$ cross-section

[Berger, Han, Jiang, Plehn PRev D67 (2003) 014018]:

1. one-loop contributions largely improve the theoretical uncertainty of the leading order (LO) cross-section.
2. NLO: determine cross-section uncertainty from dependence on the renormalization and the factorization scale: 20%

$$\mu_F \sim C\, m_{\rm av} = C\, \frac{m_t + m_H}{2}$$



MSSM Systematic Uncertainties related to NLO $gb \rightarrow tH^+$ cross-section

[Berger, Han, Jiang, Plehn PRev D67 (2003) 014018]:

Uncertainties from supersymmetric corrections are in addition: the on-shell renormalization of the bottom quark mass alters the relation between the bottom mass and the bottom Yukawa coupling. These Δ_b corrections are the leading supersymmetric one-loop corrections with respect to powers of tanβ. Their effect on the total cross-section in a simple mSUGRA model is estimated to stay below±5% for tanβ=30 and below ±20% for tanβ=50. In the MSSM the cross-section can be reduced by a factor 2.

BR Systematic Uncertainties

FeynHiggs v2.6.2:

BR($H^+ \to \tau\nu$,cs,tb) and BR($t \to H^+ b$):

a) non-calculated loop corrections to tbH^+ vertex

b) running masses of c and s quarks

Estimates:

$\Delta BR(H^+ \to \tau\nu) < 5\%$

$\Delta BR(H^+ \to cs,tb) < 10\%$

$\Delta BR(t \to H^+ b) < 10\%$

Conclusions

- For LHC startup H^+ cross-section and branching ratios determined for specific ATLAS scenarios (→talk by M.Flechl).
- Two MSSM benchmark scenarios (→talk by S.Heinemeyer).
- Investigated mass points 90, 110, 120, 130, 150, 170, 200, 250, 400 and 600 GeV.
- BR($t \to H^+ b$) similar for scenarios A and B.
- Cross-sections differ slightly in the low-mass region between scenarios A and B. For high-mass region: same values in NLO $gb \to tH^+$ calc. (Higher order corr.→talk by N.Kidonakis).
- MSSM dependences on cross-sections included.
- BR($H^+ \to \ldots$) differences for large H^+ masses.
- html tables and root tuples for wider use available.
- Systematic uncertainties for H^+ sensitivity interpretations.
- THANKS: J.Alwall, S.Heinemeyer, T.Plehn, M.Spira, O.Stål, ATLAS csc H^+ group, ATLAS UK Higgs group and Elementary Particle Physics group at Uppsala University.