# Charged Higgs Boson Cross Sections: Status Report from the Experiments

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Freiburg,
April 12, 2010

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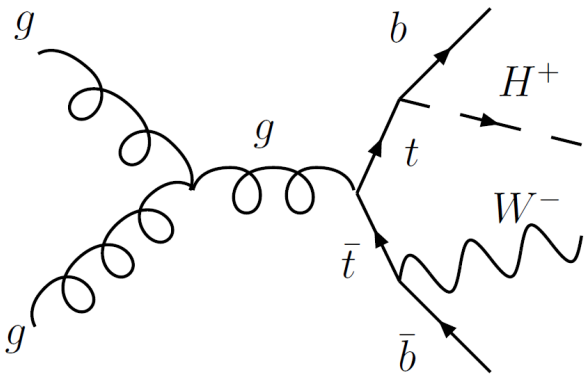
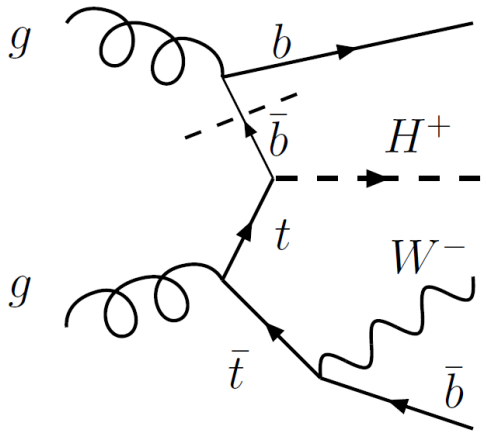
- Summarizing the recent ATLAS efforts
- H+ Cross Sections, Branching Ratios
- Uncertainties
- Dependence on √s

# H+ Overview

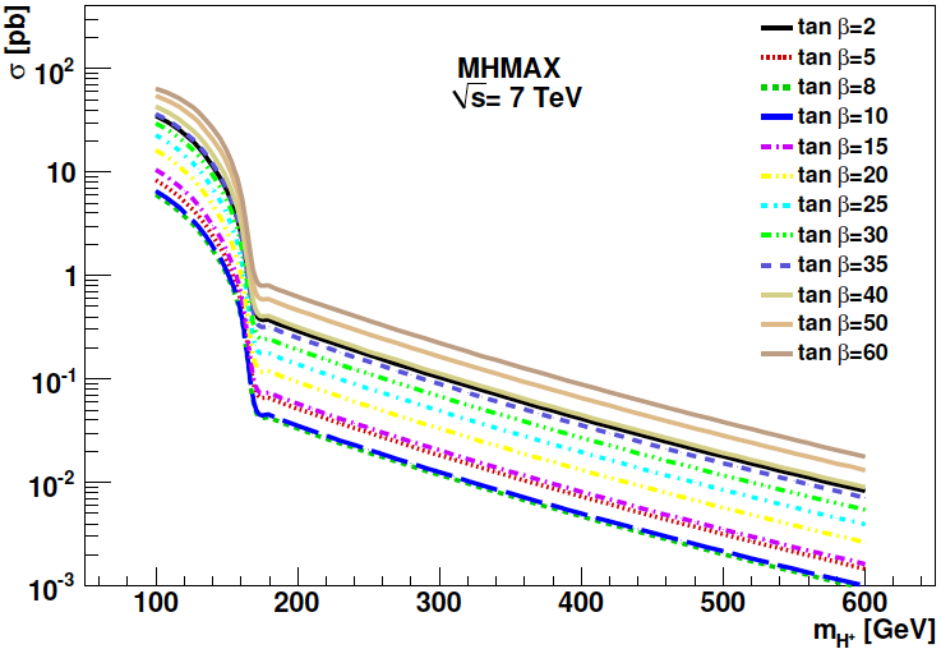
- **Three ingredients for H+ cross sections:**
  - **σ(ttbar)**
    ATLAS: Moch et al.
  - **σ(gb→tH+)**
    Semi-public code (Tilman Plehn)
    NLO QCD+SUSY; 5FS
  - **BR(t→bH+), BR(H+→...)**
    FeynHiggs 2.6.5
  - All done for 7, 10, and 14 TeV



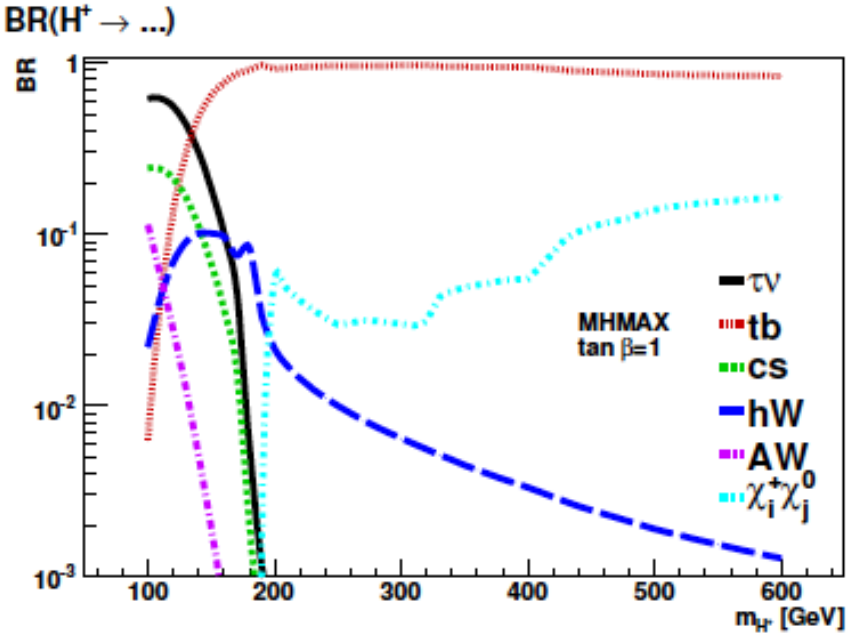
# Cross Section, mh-max

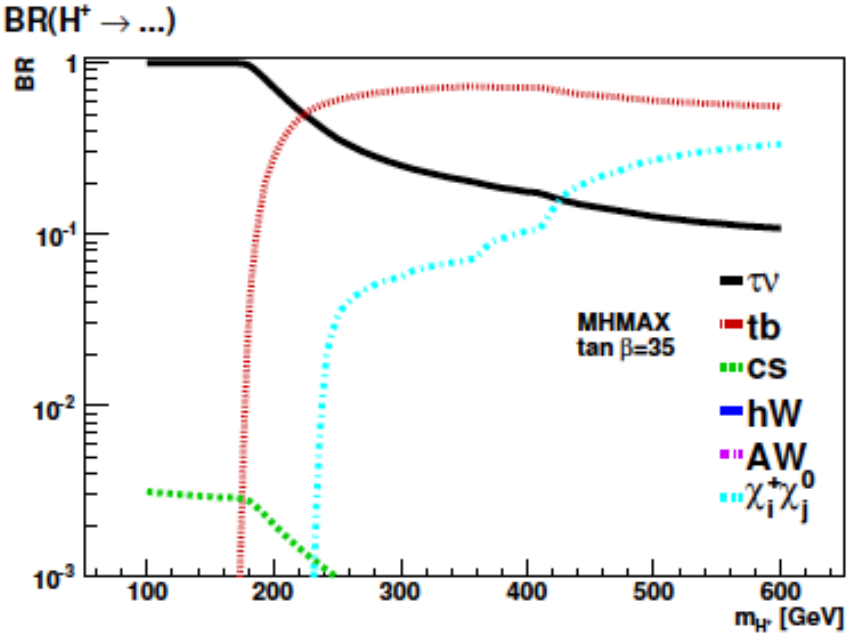
- (pp→tt→bH+bW)
  - for $m_{H+}$ << mtop
    =2* (tt)*BR(t→bH+)*(1-BR(t→bH+))
- (gb→tH+) [w/o intermediate
  - for $m_{H+}$ >> mtop
- (incoherent) sum of both
  for $m_{H+} \approx$ mtop
- Ingredients:
  - (tt): Moch et al. (401.6 pb)
  - BR(t→bH+): FeynHiggs 2.6.5
  - (gb→tH+): Code from Tilman Plehn, CTEQ6.6M



# Branching Ratio, mh-max

- **BR(H+→...): FeynHiggs 2.6.5**
- tan β: 1...70
- $m_{H+}$: 100...600 GeV



# Scenarios A & B

- **Scenarios for H+ to SUSY**

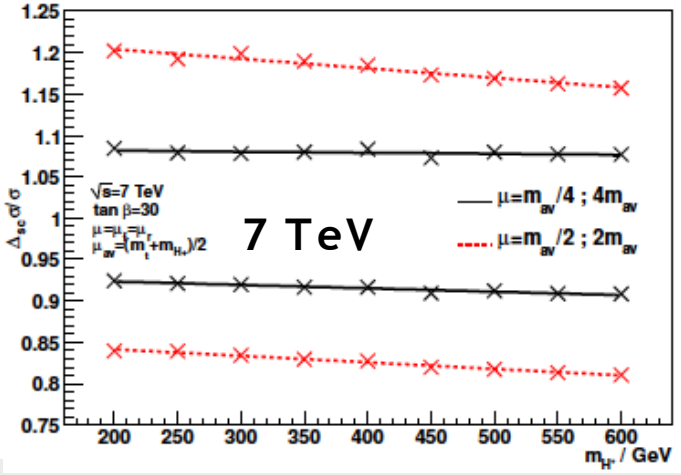
Designed for $H^+ \rightarrow {}^{+}_{i}\,{}^{0}_{j} \rightarrow$ 3 leptons + X study

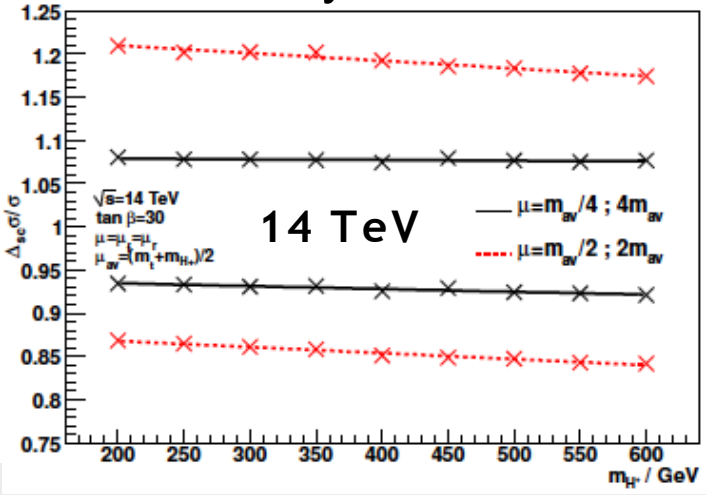
M_A=390 GeV M_SUSY=1000 GeV
A_t=A_b=2000 GeV M_3=800 GeV
M_stau (L,R)=250 GeV M_slepton
(L,R)=150 GeV
A_tau=A_l=0
**Scenario A**: mu=135 GeV, M_2=210 GeV; tan β=7 /15
**Scenario B**: mu=200 GeV, M_2=310 GeV; tan β=7 /15

| Scenario | Cross Section [pb] at $\sqrt{s}$ = 7 TeV | 10 TeV | 14 TeV | BR($H^+ \rightarrow \chi^+\chi^0$) |
|---|---|---|---|---|
| A1 | 0.0039 | 0.017 | 0.049 | 0.73 |
| A2 | 0.0074 | 0.028 | 0.082 | 0.56 |
| B1 | 0.0038 | 0.017 | 0.048 | 0.35 |
| B2 | 0.0072 | 0.027 | 0.079 | 0.19 |

# Scale Uncertainties

- **σ: Scale Uncertainties ($\mu_F$, $\mu_R$)**
  - low mass: from ttbar cross section: 3% [Moch09]
  - high mass: < 20% at 14 TeV [Plehn03]. Have reinvestigated for other √s:
    - Uncertainties are almost identical: about +20% / -15%, small dependence on mH+ [when varying $m_{av}/4 < \mu < 4\, m_{av}$]
  - [Berger05]: when varying over a very large range ($m_{av}/10 < \mu < 10\, m_{av}$), $\mu_F$, $\mu_R$ should be varied independently and uncertainties can be huge. Still, they advocate a 20% total scale uncertainty.



# Other Systematic Uncertainties

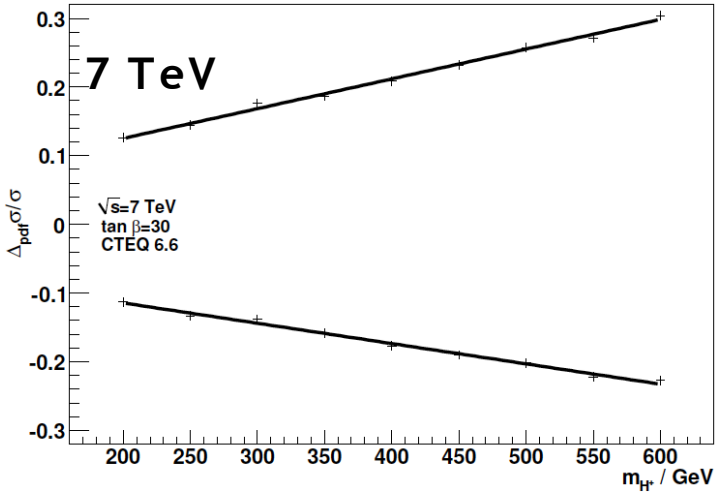
- σ: SUSY loop corrections
  - Leading corrections taken into account (Δb), rest negligible [Plehn03]

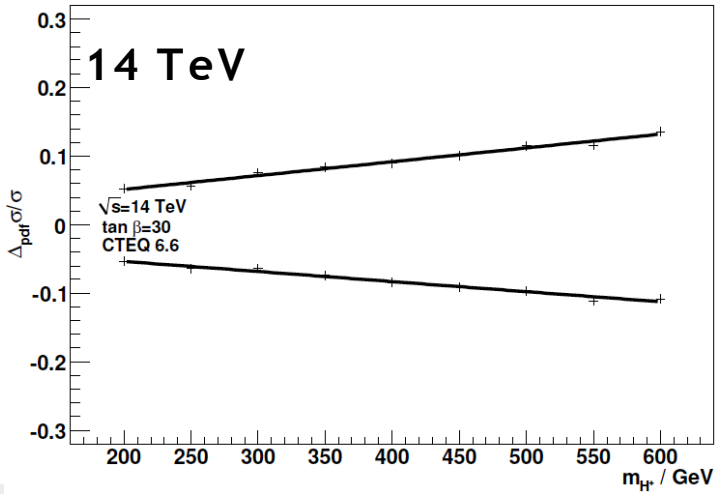
- BR: Loop corrections to tbH+ vertex, running of c and s masses: [communication with Sven Heinemeyer]

  - ΔBR(t→bH+) / BR < 10%
  - ΔBR(H+→τν) / BR < 5%
  - ΔBR(H+→tb, cs)/ BR < 10%

# PDF Uncertainties

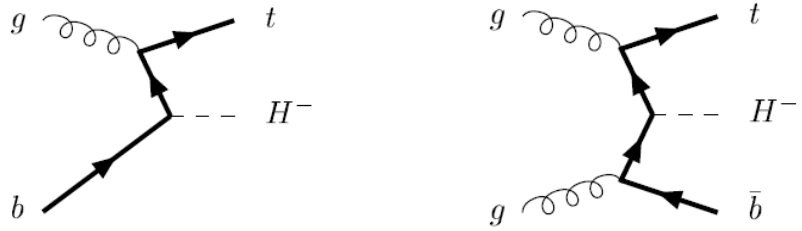
- CTEQ 6.6M, 44 error PDFs
- Results – PDF Uncertainties:
  - 7 TeV: 11-30%
  - 10 TeV: 7-20%
  - 14 TeV: 5-14%
  - Do not depend on tan β; increase with mH+; decrease with √s



# 4FS vs 5FS

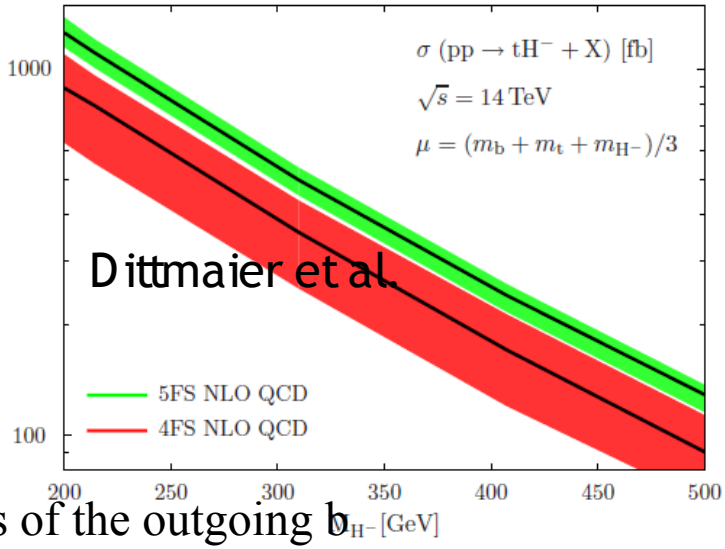
- 5FS (Plehn03) vs 4FS (Dittmaier/Krämer/Spira/Walser09)




Resummation of
log(mhp^2/mb^2) =>introduces b PDFs

works only for low-pT b;
b massless and on-shell

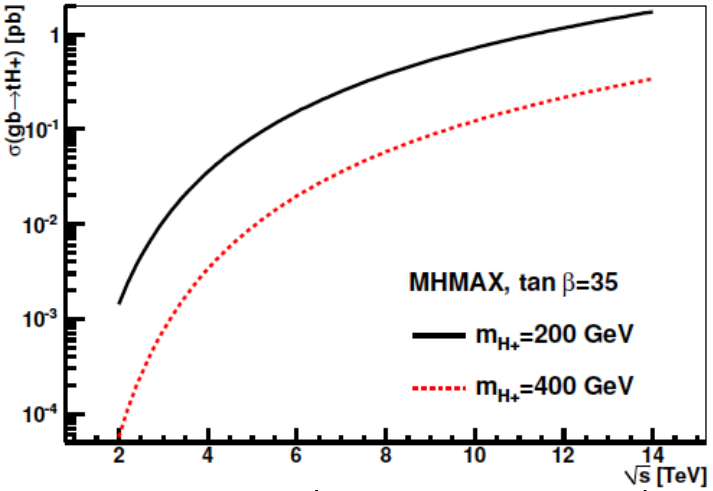
b massive, can be off-shell
can reproduce distributions of the outgoing b

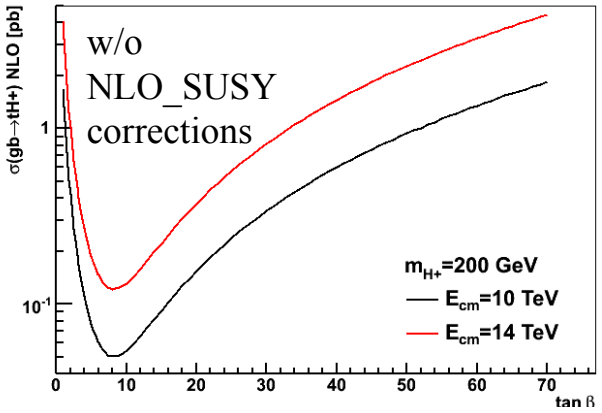



- 4FS ≈ 0.7*5FS; Barely within each others scale uncertainties;
- Possible explanations:
  - PDF uncertainties not included in the comparison;
  - scale choice not optimal for 5FS [Plehn03] →shifts green band 5-10%
  - b PDF uncertainties underestimated

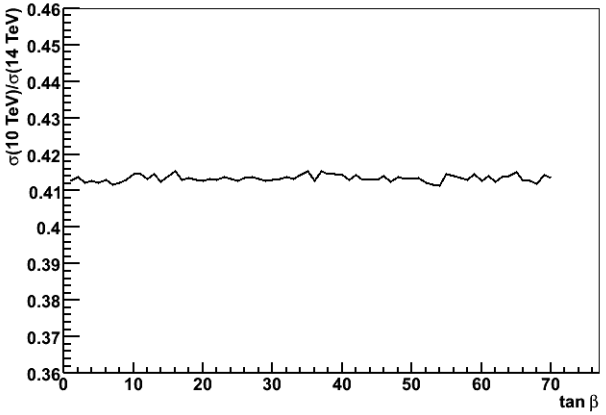
# gb→tH+ as f(√s)

- Tilman's code – σ(√s): 10 vs 14 TeV, f(tan β)



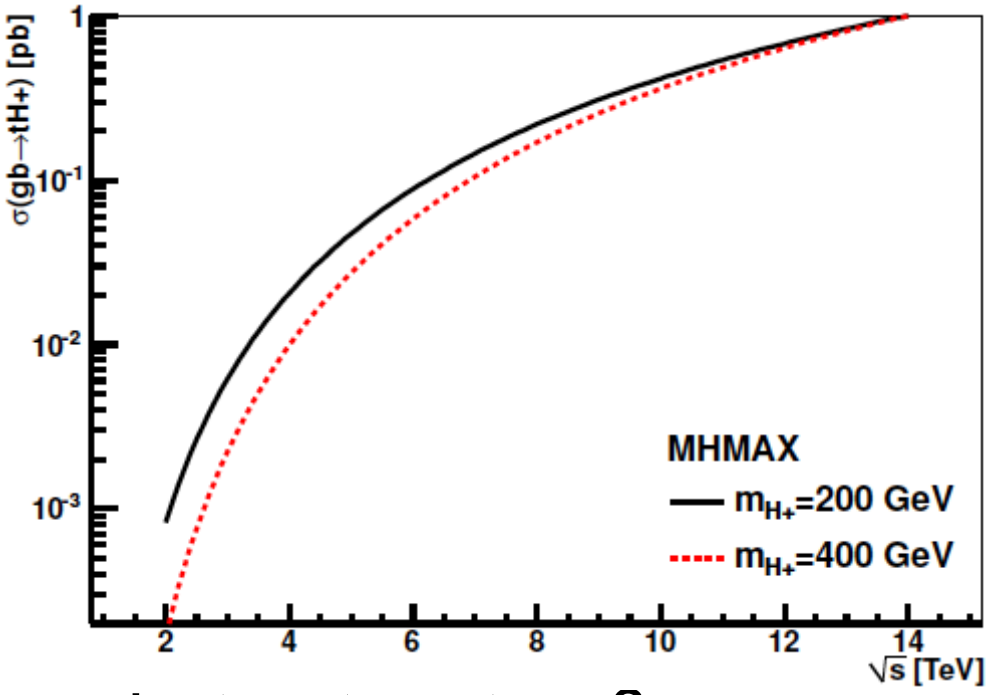

- The ratio √s(10 TeV)/√s(14 TeV) is constant wrt tan β.
- All results for 10 TeV can easily be scaled to any other √s
  → scale factor is only f($m_{H+}$).




- Δb corrections can be applied afterwards (very fast)

# gb→tH+ : Scaling with √s

- Scale factors for different √s
  (wrt the 14 TeV-cross section)




- Depend on $m_{H+}$, but not on tan β
  (as expected)

# Summary

- ATLAS Status:
  - All important numbers calculated, framework set up
  - So far using 5FS calculations
  - Now need to agree on common input and re-run

- To do for H+:
  - Closer look at 4FS vs 5FS (see Sami's talk)
  - Reinvestigate PDF uncertainties (compare sets)