

# Charged Higgs bosons

LHCHXSG,  
Jan 23th, 2015

Martin Flechl

S. Dittmaier, R. Klees, S. Heinemeyer, M. Krämer,  
S. Lehti, S. Sekula, M. Spira, M. Ubiali (direct contributions)  
+ many more (indirect contributions)



- Available results
- Experimental status / needs
- Plans



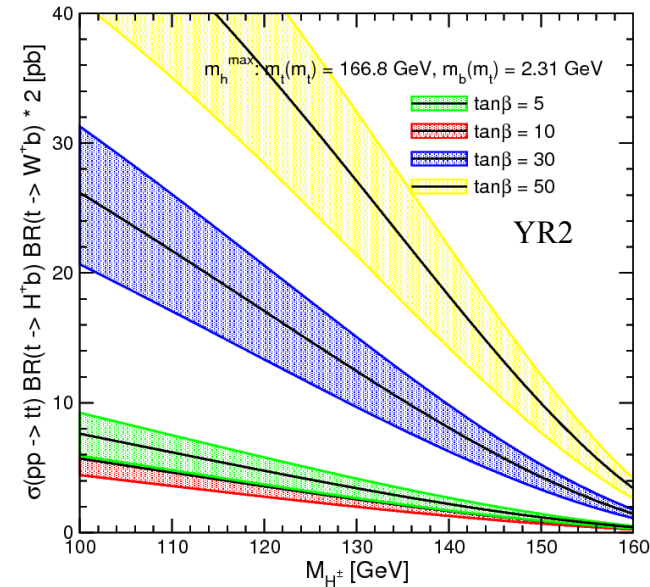
# Available results

# Light H+: Cross sections

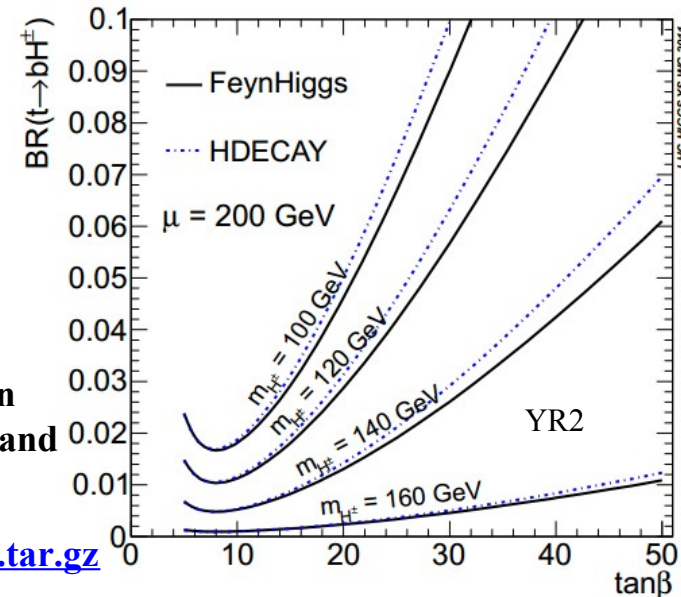
## Available:

- BR(t→bH+) [1] as function of mH+ and tan β
  - to be combined with σ(ttbar)
  
- Theoretical uncertainties
  - on top of those associated to ttbar production
  
- For any center-of-mass energy (BR !), as long as σ(ttbar) is known

Light H+ cross section vs mH+ for various values of tan beta, including uncertainties



Comparison FeynHiggs and HDecay



[1] <https://twiki.cern.ch/twiki/pub/LHCPhysics/MSSMCharged/mhmax-tb.tar.gz>

# Heavy H<sup>+</sup>: Cross sections

- Cross section  $gg/gb \rightarrow tH^+ + X$  [2]
  - for 4FS, 5FS and Santander-matched
  - Grid:  $\tan \beta = 1-60$ ,  $m_{H^+} = 200-600$  GeV
- Extensive evaluation of theoretical uncertainties
- $\sqrt{s}$ : 8 and 14 TeV
- Numbers given for general 2HDM, type II
- Recipes provided to translate numbers for
  - any MSSM benchmark scenario
  - 2HDM of type I, III, IV

[arXiv:1409.5615](https://arxiv.org/abs/1409.5615)

Improved cross-section predictions for heavy charged Higgs boson production at the LHC

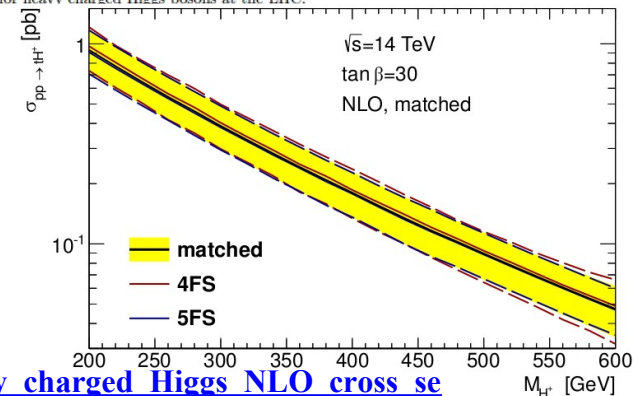
Martin Flechl<sup>1,2</sup>, Richard Klees<sup>3</sup>, Michael Krämer<sup>3,4</sup>, Michael Spira<sup>5</sup>, and Maria Ubiali<sup>6,7</sup>

\* with a lot of input from Dittmaier/Maltoni/Plehn/Ridolfi/...

- <sup>1</sup> *Physikalisches Institut, Freiburg University, Hermann-Herder Str. 3a, D-79104 Freiburg, Germany*
- <sup>2</sup> *Institute of High Energy Physics, Austrian Academy of Sciences, Nikolsdorfergasse 18, A-1050 Vienna, Austria*
- <sup>3</sup> *Institute for Theoretical Particle Physics and Cosmology, RWTH Aachen University, D-52056 Aachen, Germany*
- <sup>4</sup> *SLAC National Accelerator Laboratory, Stanford University, Stanford, CA 94025, USA*
- <sup>5</sup> *Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland*
- <sup>6</sup> *Cavendish Laboratory, University of Cambridge, J.J. Thomson Avenue, CB3 0HE, Cambridge, UK*
- <sup>7</sup> *Department of Applied Mathematics and Theoretical Physics, University of Cambridge, Wilberforce Road, CB3 0WA, Cambridge, UK*

Abstract:

In most extensions of the Standard Model, heavy charged Higgs bosons at the LHC are dominantly produced in association with heavy quarks. An up-to-date determination of the next-to-leading order total cross section in a type-II two-Higgs-doublet model is presented, including a thorough estimate of the theoretical uncertainties due to missing higher-order corrections, parton distribution functions and physical input parameters. Predictions in the four- and five-flavour schemes are compared and reconciled through a recently proposed scale-setting prescription. A four- and five-flavour scheme matched prediction is provided for the interpretation of current and future experimental searches for heavy charged Higgs bosons at the LHC.



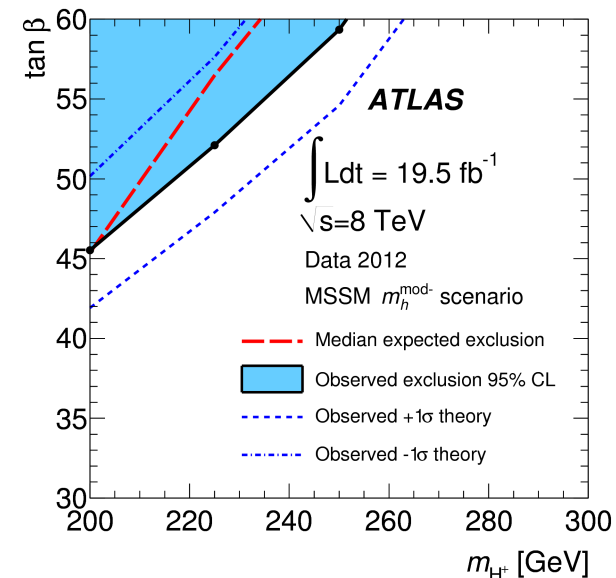
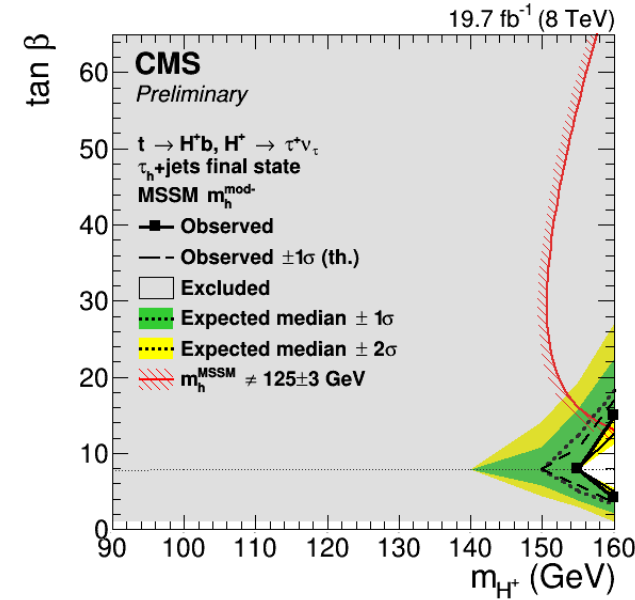
arXiv:1409.5615v1 [hep-ph] 19 Sep 2014



# Experimental status / needs

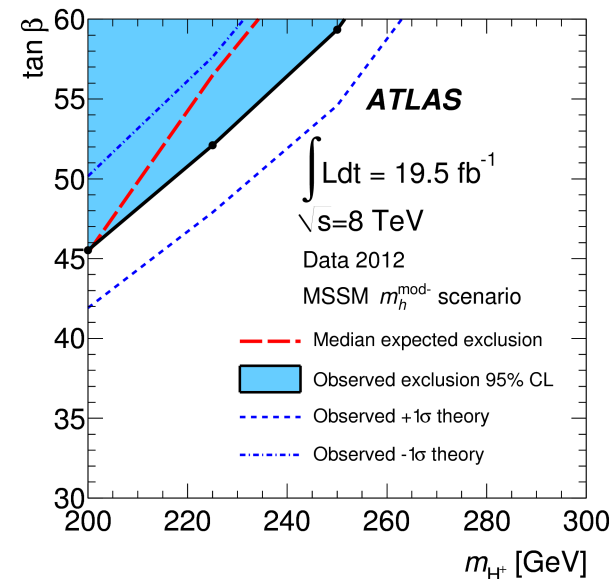
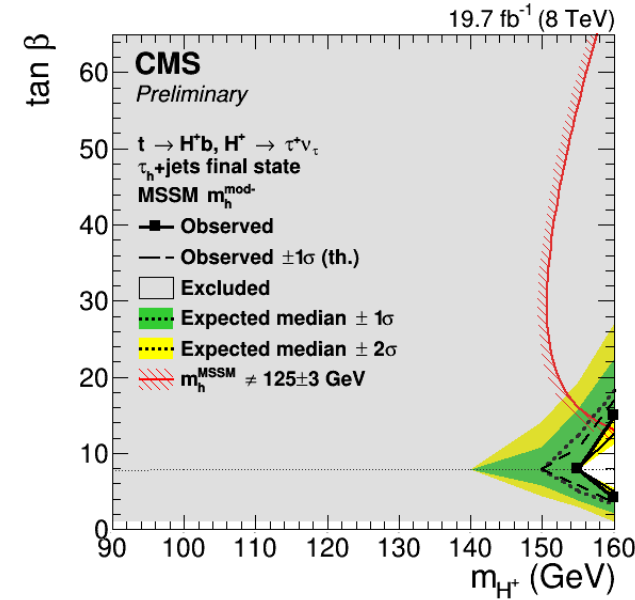
# Status of MSSM H+ after Run 1

- Light H+:
  - essentially excluded ( $m_{H^+} < 150$  GeV).  
[MSSM, for a wide range of scenarios]
  
- Heavy H+
  - Just starting to exclude regions of the MSSM
  
- Intermediate region (160 GeV-200 GeV):
  - No exclusion, as no recommendations exist!



# Run 1: Consequences for run 2

- Light H<sup>±</sup>:
  - No further work required (?)
  
- Heavy H<sup>±</sup>
  - Need to provide cross sections and extend the grid.
  
- Intermediate region
  - Should probably become the main focus now:
    - no recipe exist, but
    - experimental sensitivity is high

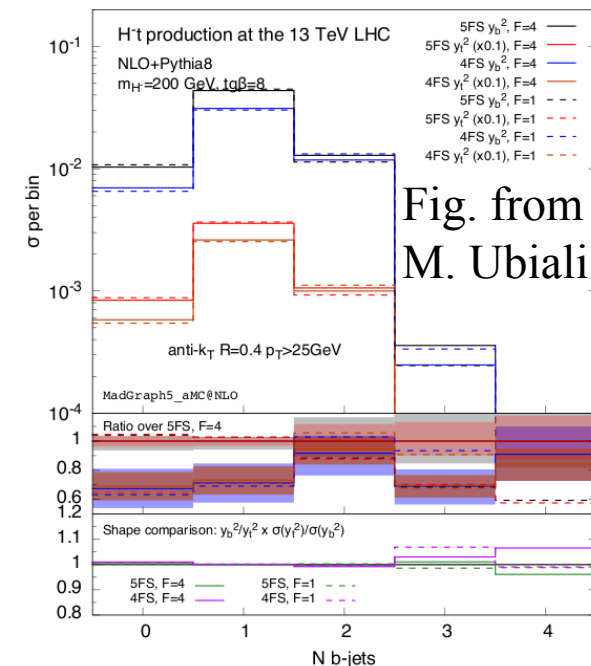




# Plans

- Provide 4FS/5FS/Santander-matched cross sections for **13 TeV**
  
- Extend grid (currently,  $m_{H^+}=200-600$  GeV,  $\tan \beta=1-60$ )
  - to 1 TeV in  $m_{H^+}$
  - to lower  $m_{H^+}$  values (for „intermediate region“)
    - for non-resonant production; but also for production via  $t\bar{t}$
  - to lower  $\tan \beta$  values (if requested, e.g. for  $H^+ \rightarrow t\bar{b}$  or  $H^+ \rightarrow c\bar{s}$ )

- Recipe to deal with „intermediate region“ around  $m_{top}$  threshold
  - see meeting of Nov 11, 2014, and minutes thereof <https://indico.cern.ch/event/352630/>
  - no conclusions reached yet, need further expert input
  
- Consistency of MSSM charged and neutral cross sections
  - parameter values used
  - grid points ( $m_{H^+}$  vs  $m_A$ )
  - use case: combination of MSSM searches
  
- Recommendations for event generation
  - following comparisons of 4FS and 5FS NLO+PS



- Rich set of results provided and used for Run-1 results
  - low-mass  $H^+$  essentially excluded (MSSM)
  
- Run 2 – needs and plans:
  - Intermediate region around  $m_{top}$  [also still relevant for Run 1!]
  - Extended high-mass  $H^+$  grid at 13 TeV / 14 TeV
  - Comparison of NLO+PS, 4FS / 5FS
  
- For any other needs: contact us!