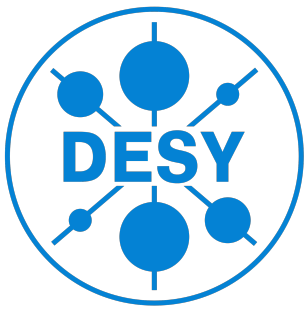
Testing BSM Higgs Sectors with HiggsBounds and HiggsSignals

Tim Stefaniak

Deutsches Elektronen-Synchrotron DESY, Hamburg

DESY FH Fellows Meeting 2018

February 27th, 2018



My personal trajectory so far...

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2004-2006: Bremen (Physics Vordiplom)

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2008: Uppsala (ERASMUS exchange)

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2009: Geneva (CERN Summer Student)

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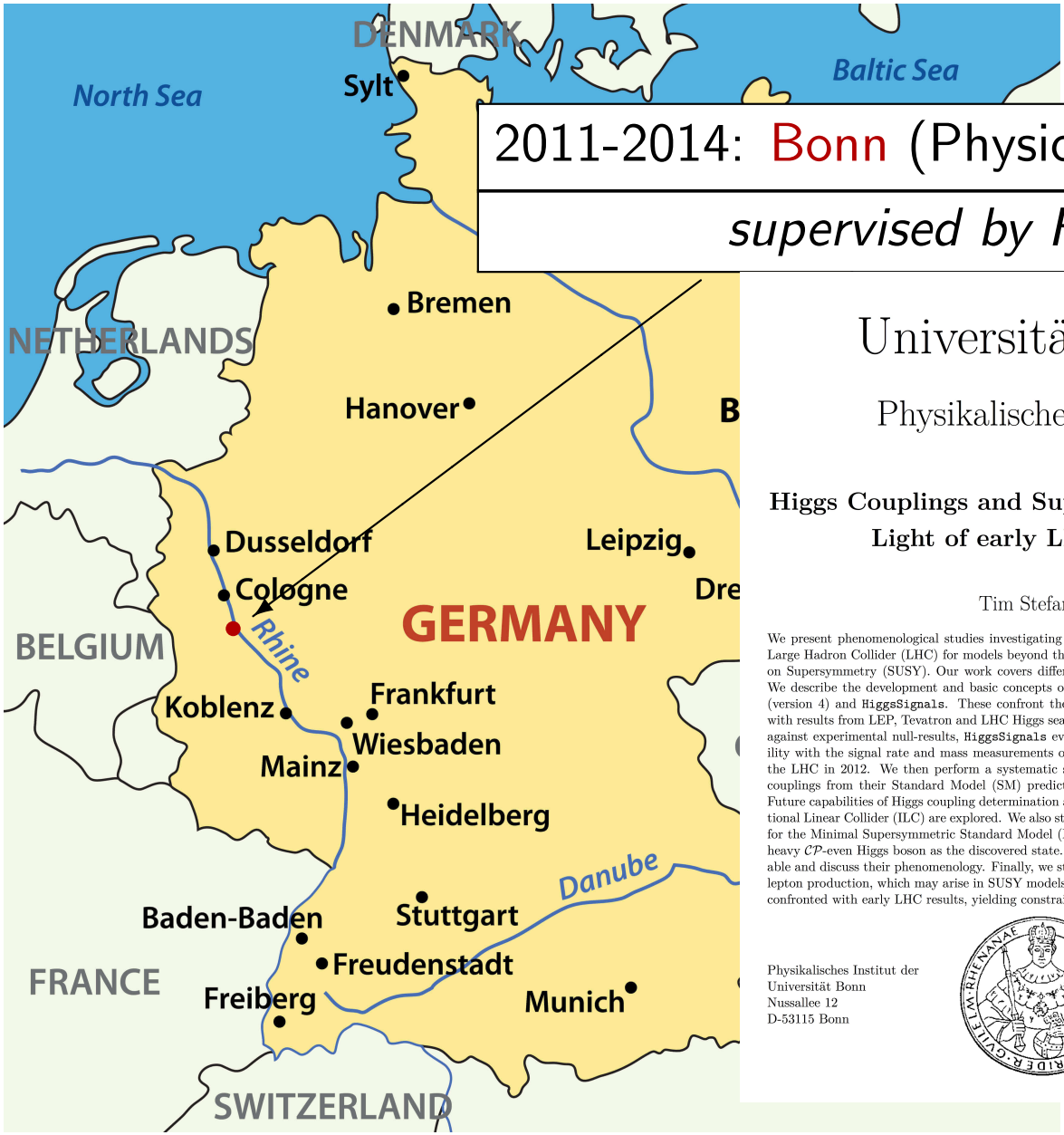

2011-2014: Bonn (Physics Doctorate)

supervised by Herbi Dreiner

Universität Bonn

Physikalisches Institut

Higgs Couplings and Supersymmetry in the Light of early LHC Results

Tim Stefaniak

We present phenomenological studies investigating the implications of early results from the Large Hadron Collider (LHC) for models beyond the Standard Model (BSM), mostly focusing on Supersymmetry (SUSY). Our work covers different aspects in this wide field of research. We describe the development and basic concepts of the public computer codes `HiggsBounds` (version 4) and `HiggsSignals`. These confront the Higgs sector predictions of BSM models with results from LEP, Tevatron and LHC Higgs searches. While `HiggsBounds` tests the model against experimental null-results, `HiggsSignals` evaluates the model's chi-squared compatibility with the signal rate and mass measurements of the Higgs boson, that was discovered by the LHC in 2012. We then perform a systematic study of potential deviations in the Higgs couplings from their Standard Model (SM) prediction. No significant deviations are found. Future capabilities of Higgs coupling determination at the later LHC stages and at the International Linear Collider (ILC) are explored. We also study the implications of the Higgs discovery for the Minimal Supersymmetric Standard Model (MSSM), considering either the light or the heavy $\mathcal{CP}$-even Higgs boson as the discovered state. We show that both interpretations are viable and discuss their phenomenology. Finally, we study the LHC signatures of resonant scalar lepton production, which may arise in SUSY models with R-parity violation (RPV). These are confronted with early LHC results, yielding constraints on the relevant RPV operators.

Physikalisches Institut der
Universität Bonn
Nussallee 12
D-53115 Bonn

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2014-2017: Santa Cruz (1st Postdoc)

w/ Howie Haber & Stefano Profumo

My personal trajectory so far...

since Oct. 2017: DESY (Theory group), Hamburg (2nd Postdoc)

My research

- Beyond the Standard Model (BSM) collider phenomenology
  - Extended Higgs sectors (2HDM, singlet extension,...), Supersymmetry (MSSM, NMSSM, R-parity violation,...);
  - LHC implications for BSM parameter space;
  - Development of public codes (`HiggsBounds` and `HiggsSignals`);
  - New BSM signatures and search strategies at the LHC;
  - Future colliders.
- Interplay between LHC, cosmology and dark matter
  - E.g., electroweak baryogenesis (EW phase transition, CP-violation).

HiggsBounds and HiggsSignals

Team: P. Bechtle, D. Dercks, S. Heinemeyer, T. Klingl, TS, G. Weiglein

http://higgsbounds.hepforge.org

HiggsBounds

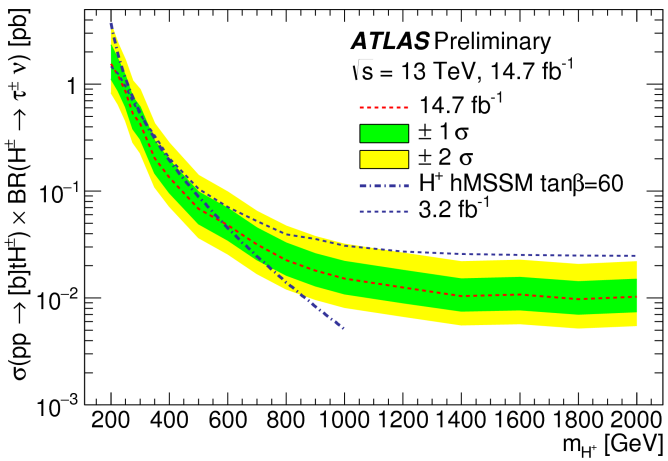
Confronts BSM Higgs sectors with exclusion limits from LEP, Tevatron and LHC Higgs searches

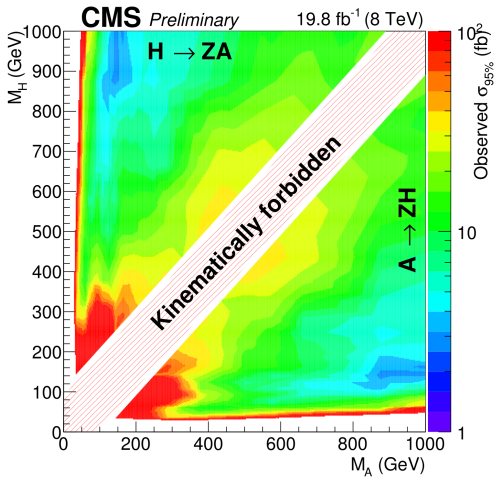
$\Rightarrow$ excluded/allowed at 95% C.L.

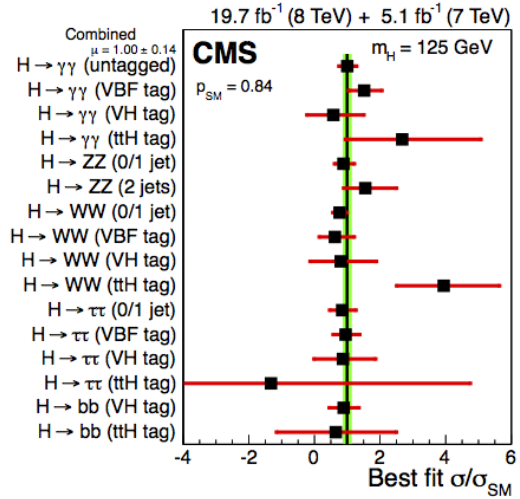
HiggsSignals

Confronts BSM Higgs sectors with LHC (& Tevatron) Higgs signal rate and mass measurements

$\Rightarrow \chi^2$ (sep. for rates and mass)







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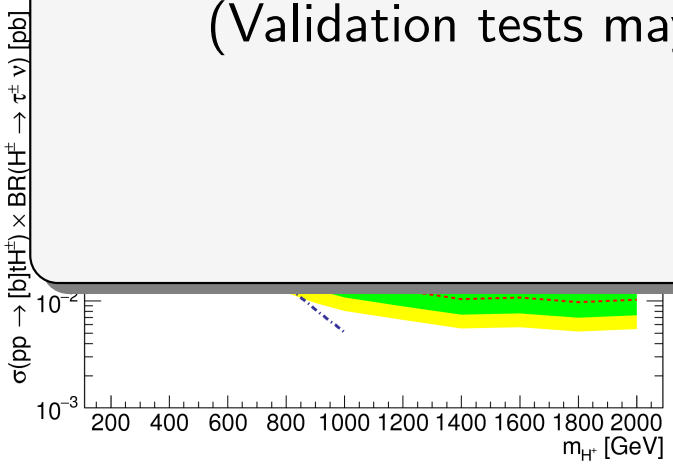
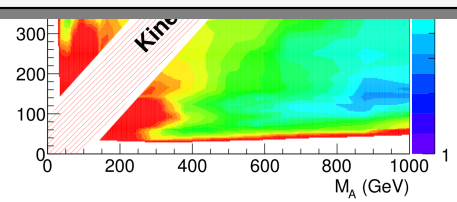
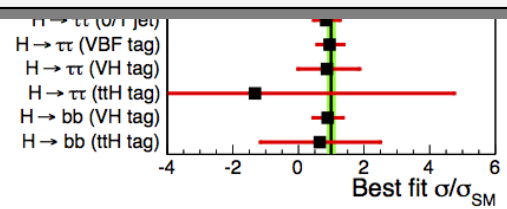
Useful in (at least) two ways:

1. for BSM theorists:
   Convenient way to test favorite BSM theory with LHC results;
2. for LHC experiments:
   Feedback on the presentation of experimental results.
   (Validation tests may reveal where important information is missing.)







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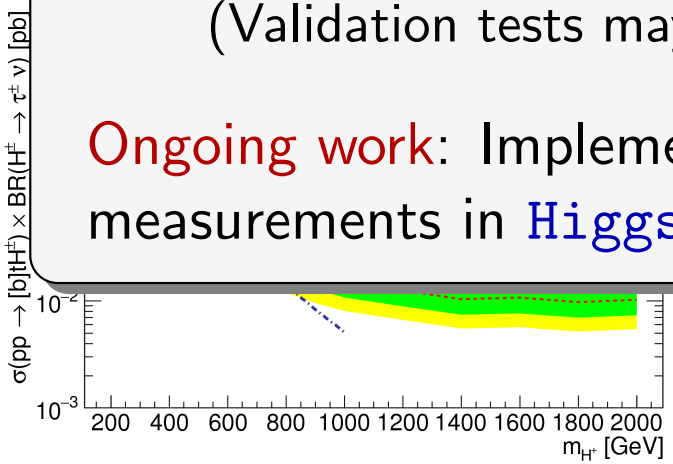
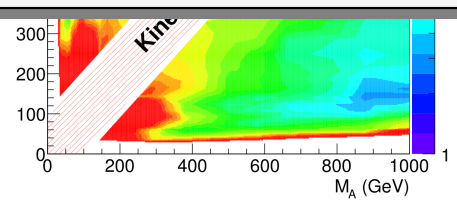
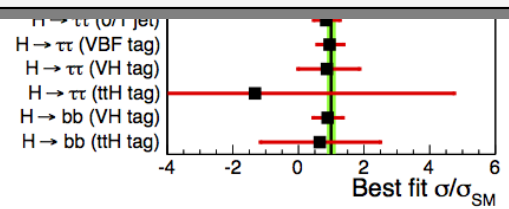
Ongoing work: Implementation of *Simplified Template Cross Section* measurements in HiggsSignals.



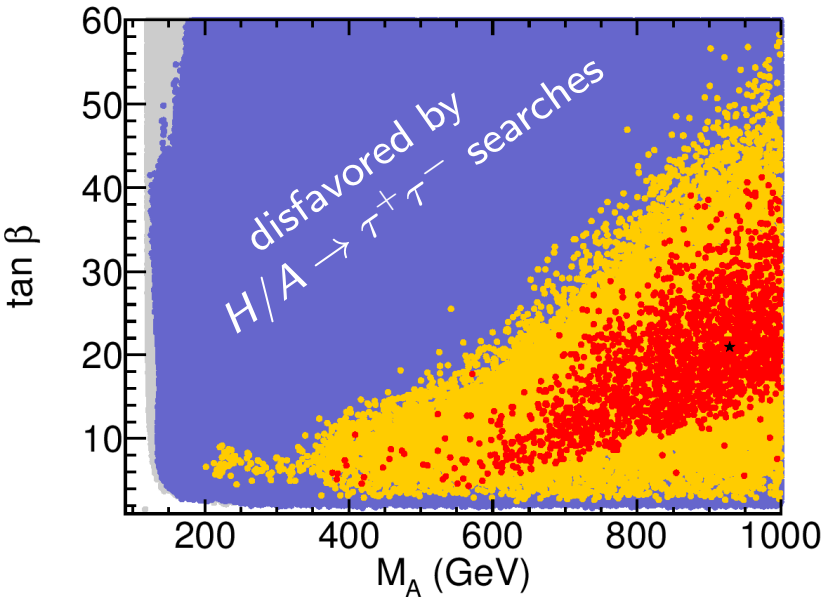




Some recent results and current work

(1) pMSSM fit to LHC Run-1 data

[P. Bechtle, H.E. Haber, S. Heinemeyer, O. Stål, TS, G. Weiglein, L. Zeune '17]



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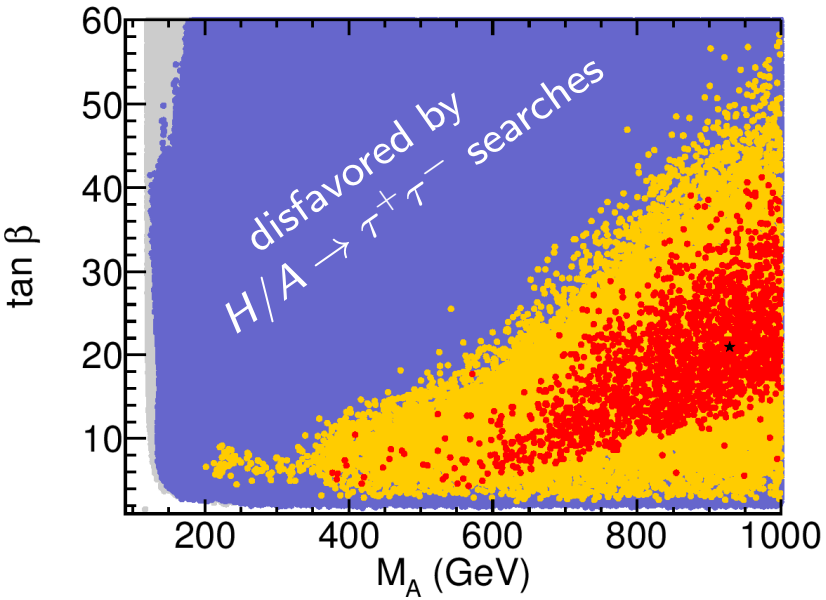

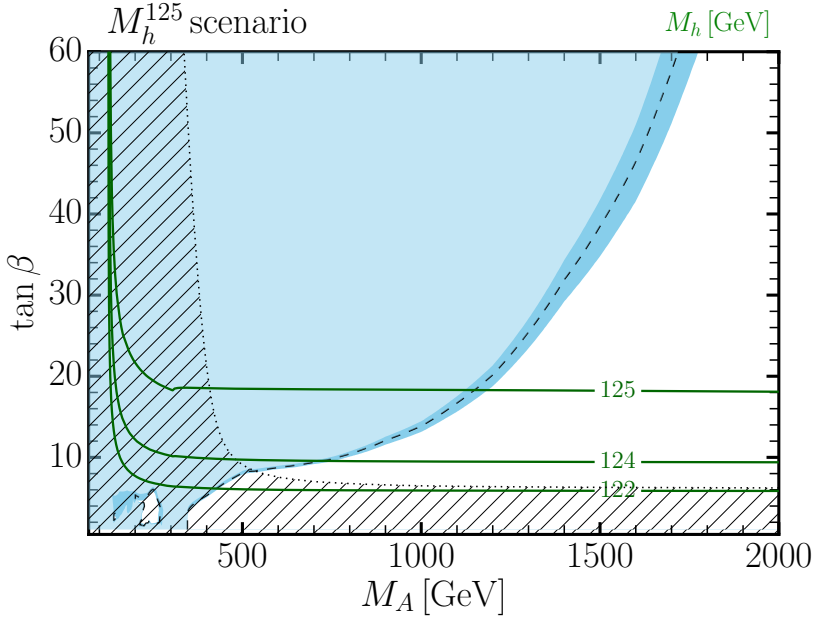

(2) New MSSM benchmark scenarios for LHC Higgs searches

[E. Fuchs, S. Heinemeyer, S. Liebler, S. Patel, TS, C.E.M. Wagner, G. Weiglein (to appear)]

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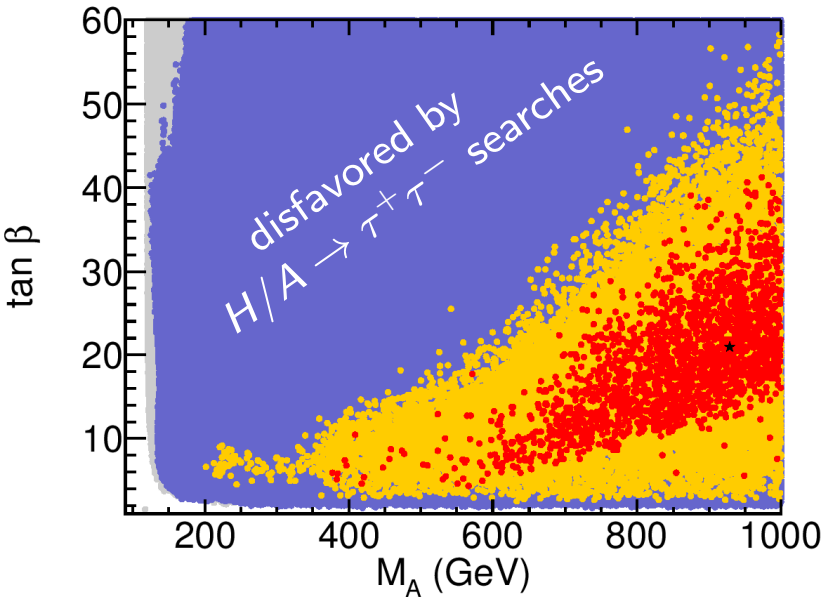

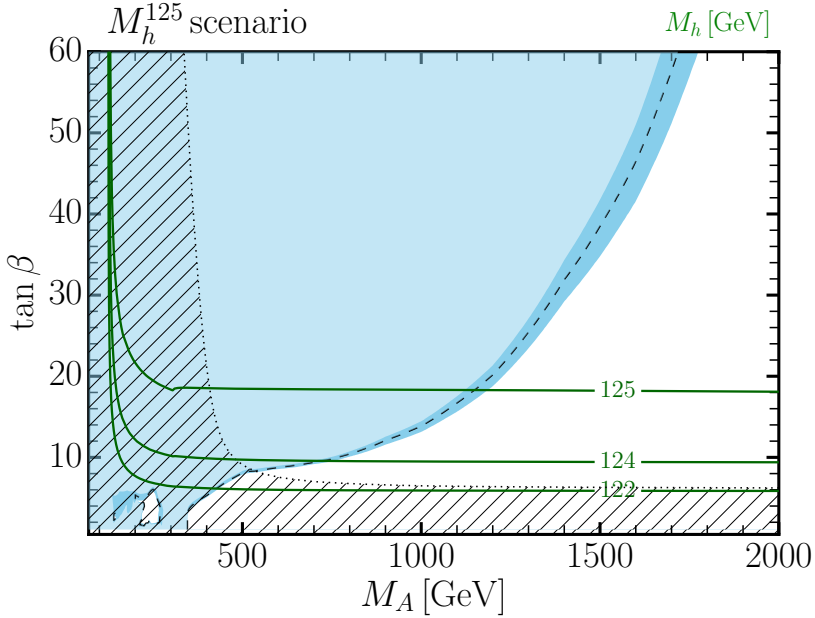

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(3) LHC discovery potential for charged Higgs ($H^\pm$) signature,

$$pp \to H^\pm t\, b$$
$$\hookrightarrow W^\pm h$$
$$\hookrightarrow \tau\tau, bb, WW, ZZ, \gamma\gamma$$

$M_{H^\pm} \in [145, 500]$ GeV,
$M_h \in [62.5, 110]$ GeV.

[H. AbouZeid, M. Hance, J. Nielsen, TS, J. Wittbrodt (in progress)]