

# Research Interests

Florian Staub

CERN Theory Group Retreat 2015

## About me

- ▶ Born at the edge of Bavaria
- ▶ Positions:
  - ▶ -2011: PhD & PD in Würzburg
  - ▶ 2011-2014: PD in Bonn
  - ▶ 2014- : Fellow at CERN



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  - ▶ 2014- : Fellow at CERN
- ▶ Author of HEP tools:
  - ▶ SARAH
  - ▶ SPheno
  - ▶ Vevacious
  - ▶ ...
- ▶ Theory Convener of LHCHXSWG NMSSM



## Main research topics

1. Two-loop Higgs mass calculations
2. Phenomenology of non-minimal SUSY models

## The Higgs mass to constrain new physics

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### Higgs mass prediction of public NMSSM codes

[FS et al., 1507.05093]

	TP1	TP2	TP3	TP4	TP5	TP6
FlexibleSUSY	123.55	122.83	126.58	127.62	125.08	126.46
NMSSMCalc	120.34	118.57	124.86	126.37	123.14	123.45
NMSSMTOOLS	123.52	121.83	127.28	127.30	126.95	126.63
SOFTSUSY	123.84	123.08	126.59	127.52	125.12	126.67
SPHENO	124.84	124.74	126.77	126.62	125.61	131.29



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Common approaches to get Higgs masses in other models:

- ▶ One-loop eff. pot. calculation in a given model
  - ▶ Take MSSM results & forget about peculiarities of new model
- **both can suffer from huge uncertainties (10 GeV and more)**

# The Higgs mass to constrain new physics

The Higgs mass has become a precision observable ... but

## Theoretical uncertainty

- ▶ Already in the **MSSM** the **theoretical uncertainty** in the Higgs mass calculation for a given set of SUSY masses is estimated to be  $O(3 \text{ GeV})$ 
  - ▶ Missing two-loop electroweak corrections
  - ▶ Missing three-loop corrections
- ▶ Even this is for some scenarios (e.g.  $\tan\beta$  small) (see later)
- ▶ For any **other SUSY** model the theoretical uncertainty is in general **worse**

Common approach to Higgs masses in other models:

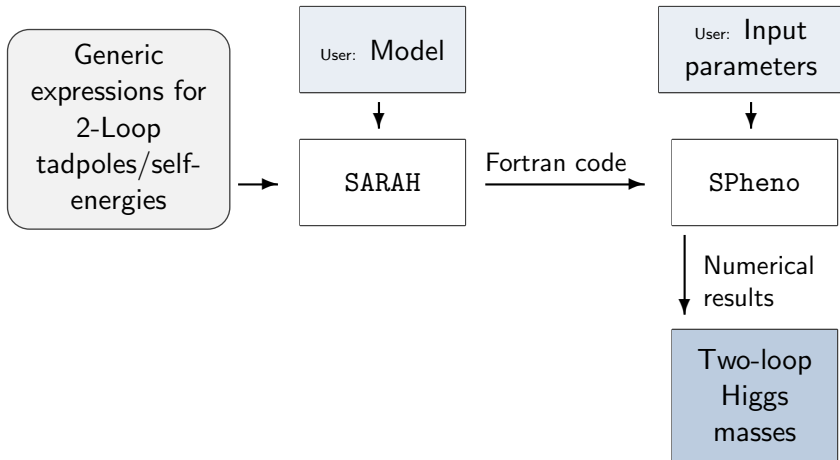
- ▶ One-loop calculation in a given model
- ▶ Compare results & forget about peculiarities of new model

→ but they **suffer from huge uncertainties (10 GeV and more)**

(At least) two-loop precision is necessary to be able to confront B(M)SM models with the measurements

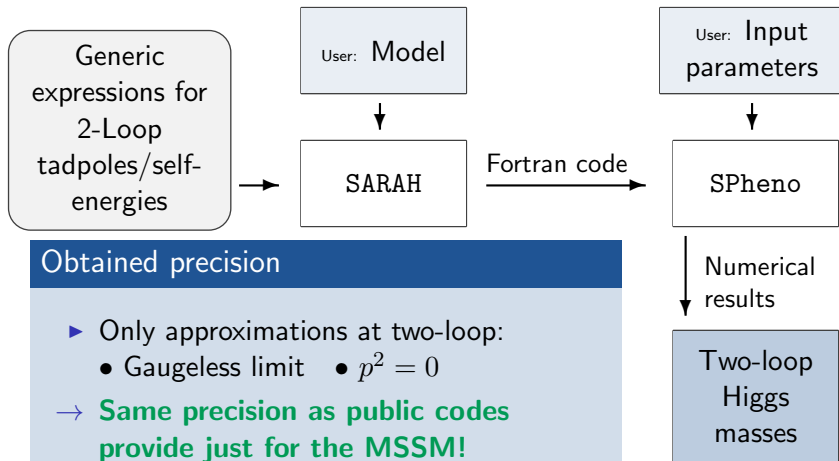
## Automatisation of two-loop Higgs mass calculations

[Goodsell,Nickel,FS,1411.0675],[Goodsell,Nickel,FS,1503.03098]



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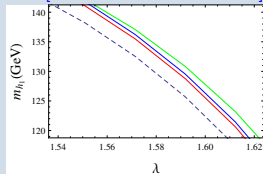
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# Some results

## NMSSM

[Goodsell, Nickel, FS, 1411.4665]



1-loop /  $\alpha_S(\alpha_b + \alpha_t)$  / full /

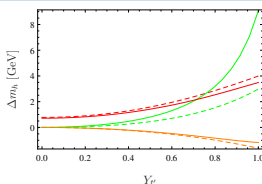
MSSM approx.

→ MSSM

approximations used  
in codes fail for large  
 $\lambda$  and/or light  
singlets!

## Vectorlike stops

[Nickel, FS, 1505.06077]



shift by momentum dependence,

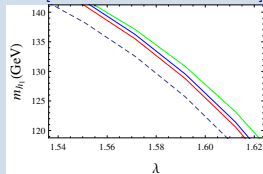
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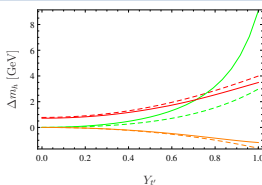
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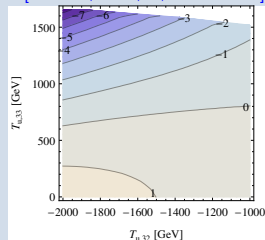


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 MSSM beyond  
MFV

[Goodsell,Nickel,FS,1511.XXXXX]



→ MSSM  
uncertainty quickly  
increases for large  
 $\tilde{t}-\tilde{c}$  mixing

## Future extensions

### Short (?) term

- ▶ support of **CP violation**:
  - under validation at the moment: **release soon!** 😊
- ▶ including **momentum dependence**:
  - linking TSIL possible, but **very slow** 😞

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### (Very) long term

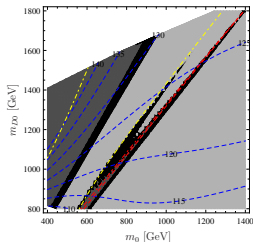
- ▶ Completing two-loop
- ▶ Dominant three-loop
- ▶ Resummation of large logs
- ▶ ...



# Some recent and current phenomenology studies

## $R$ -symmetric SUSY

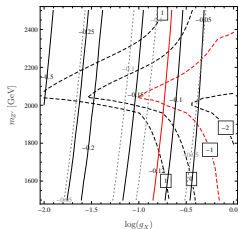
[Goodsell et al.,1507.01010 ]



black:  $\Omega h^2 \simeq 0.1$ ,  
 blue:  $m_h$ , red/yellow: resonances  
**DM** scenarios in  
 constrained models  
 with **Dirac gauginos**

## $b \rightarrow s$ anomalies

[Sierre,Vicente,FS,1503.06077]



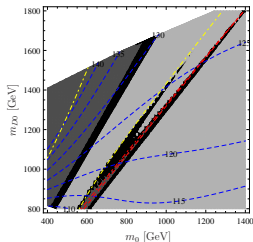
dashed:  $\Omega h^2$ , full:  $C_{10}^{NP}/C_{10}^{SM}$

**$U(1)$  extension** of  
 the SM to explain  
**flavour anomalies**  
 and **DM**.

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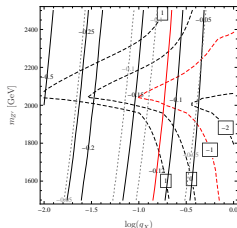
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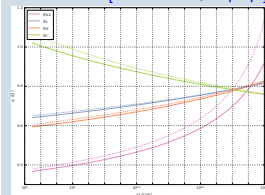
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## Left-right models

[Hirsch et al., in prep.]



1-loop (dashed), 2-loop (full)

Phenomenology of a  
 constrained SUSY  
 LR model with gauge  
 coupling unification.