Aspects of (non-minimal) SUSY phenomenology

Philip Diessner

DESY Hamburg, Theory Group

FH Fellow Meeting, 29.11.2016

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Diplom and PhD at TU Dresden
until Oct.
Floated down the Elbe to DESY

Introduction

Supersymmetry

- Solution to Hierarchy problem
- Provides dark matter candidate
- Studied for decades as extension of the SM
- Usually in the minimal direction: MSSM, NMSSM

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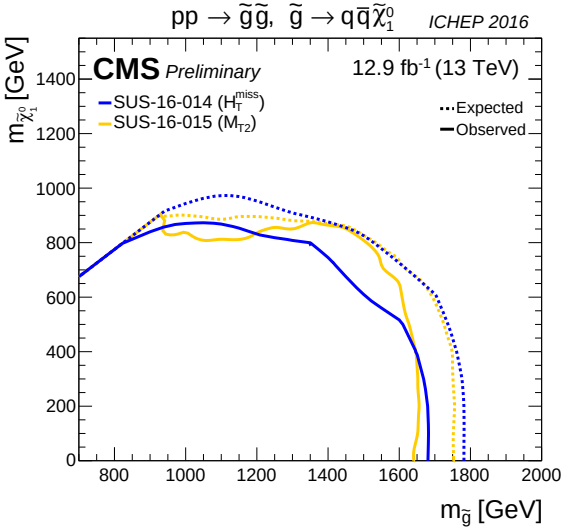
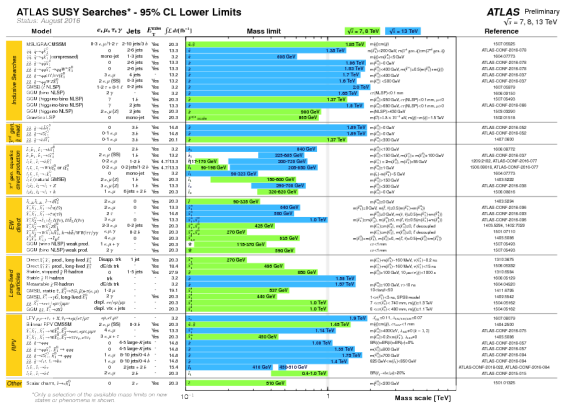
But which one?





Going non-minimal

- So far no clear signal of SUSY (or any BSM) at the LHC
- Might be something unconventional, need to explore different avenues
- Community has many years of experience studying BSM physics
- In the last years, big efforts to generalize codes and availability (check e.g. `hepforge.org`)
- Straight-forward application?

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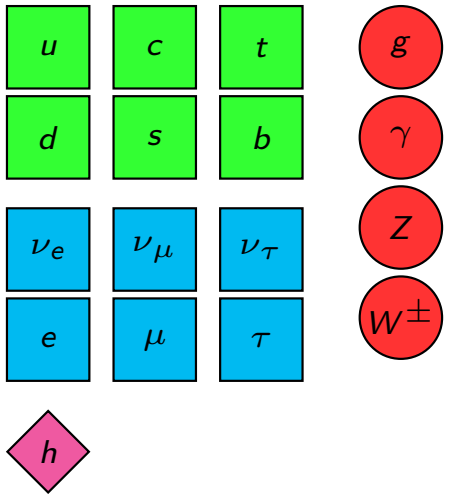
$\Rightarrow$ Take unconventional (low-energy) model and test it thoroughly against different experimental constraints.
In the following: **R-symmetric SUSY**

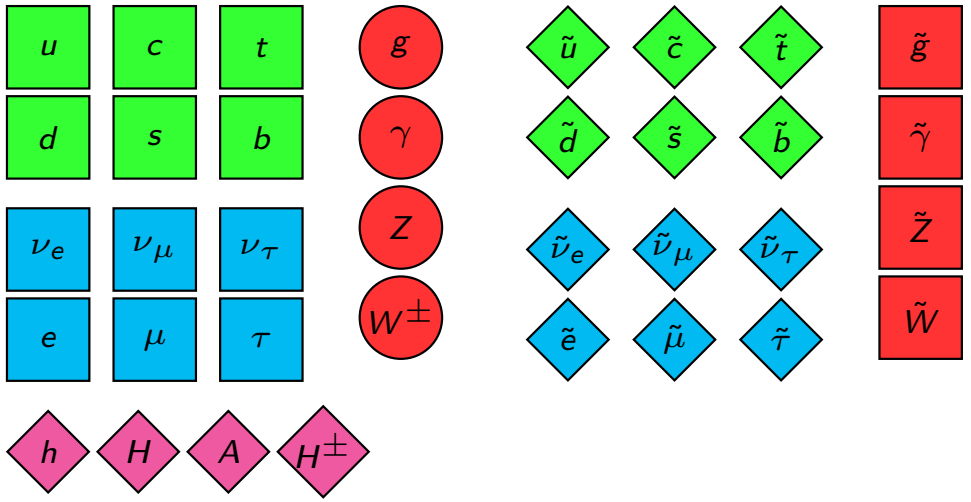
Standard Model

- Describes strong and electroweak interactions
- Higgs as first elemental scalar
- Misses dark matter, gravity



Minimal Supersymmetric Standard Model

- "Haag-Łopuszański-Sohnius-Theorem" allows extension of space-time symmetry
- Connection between fermions and bosons

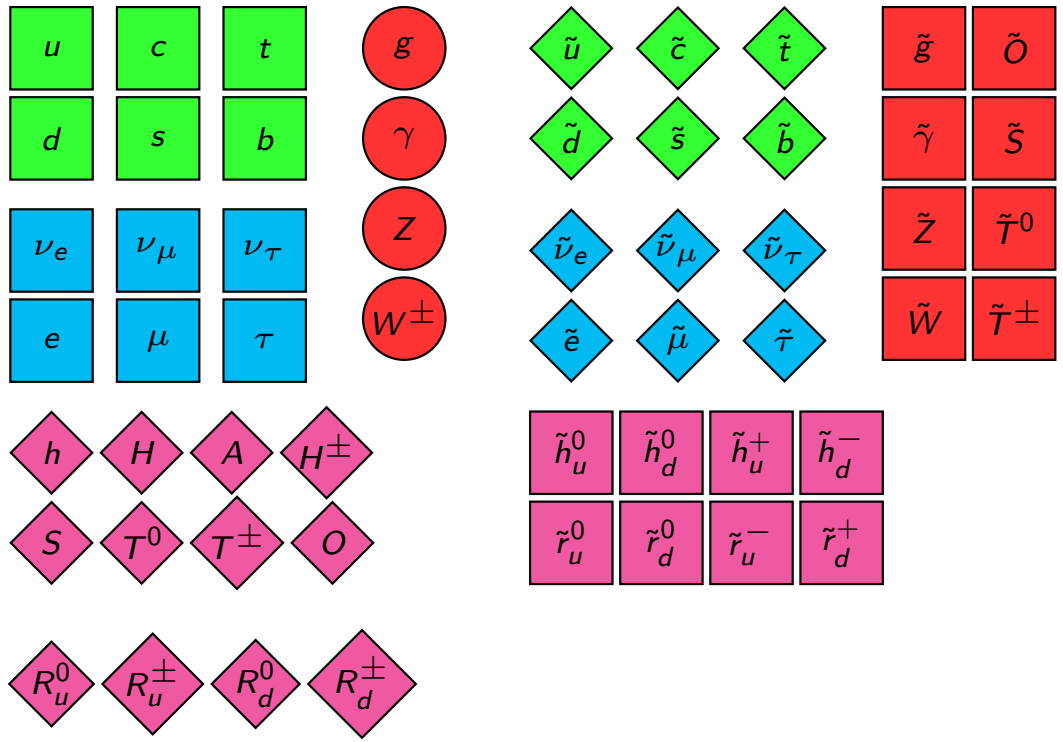


MSSM

Minimal R-Symmetric Supersymmetric Standard Model

R-Symmetry

- Additional symmetry included in SUSY algebra
- For $(N = 1)$ SUSY is a global $U(1)$ symmetry
- Only symmetry to distinguish SM field and superpartner

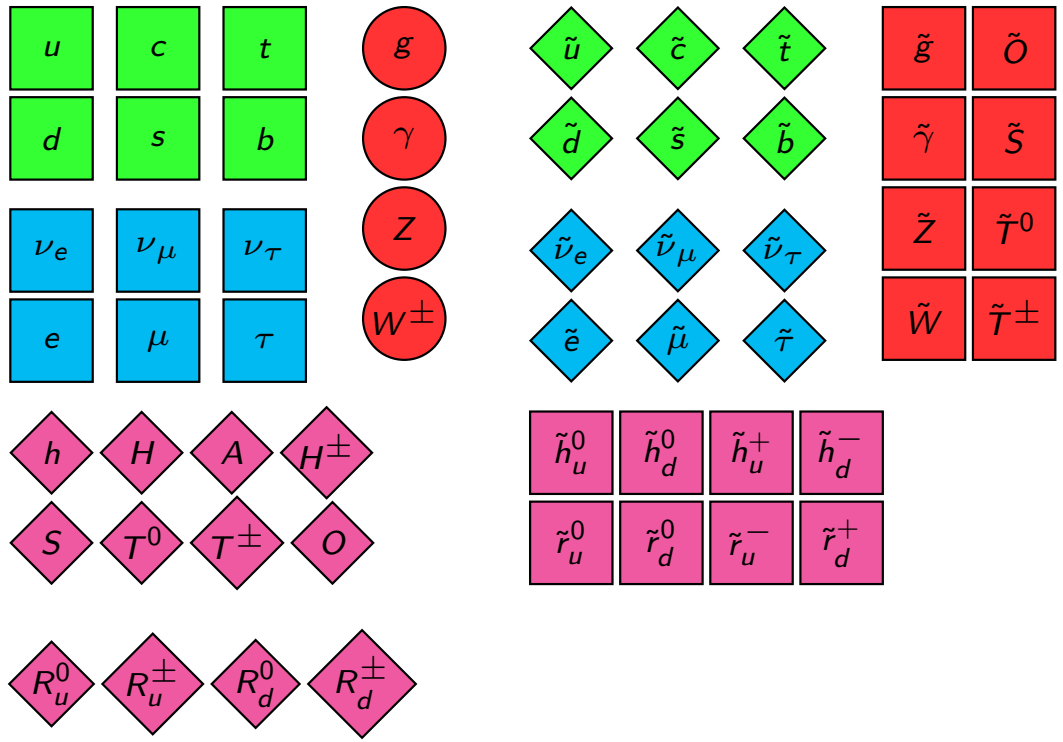


MRSSM

Minimal R-Symmetric Supersymmetric Standard Model

Consequences

- No Majorana masses for gauginos and higgsinos
- $\rightarrow$ Dirac neutralinos
- Extended Higgs sector
- No A-terms



MRSSM

Phenomenological study

Predictions

- Heavy Dirac gluinos more natural than in MSSM
- Cross section for Squark production is reduced
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Observables

- Higgs boson mass (and signal strength)
- EW precision observables, here W boson mass
- Dark matter observables
- Recasting direct LHC searches

Relevant model parameters

- Dirac mass M_W^D
- Yukawa coupling Λ_u
- Higgsino mass μ_u
- Squark masses $m_{\tilde{q}}$

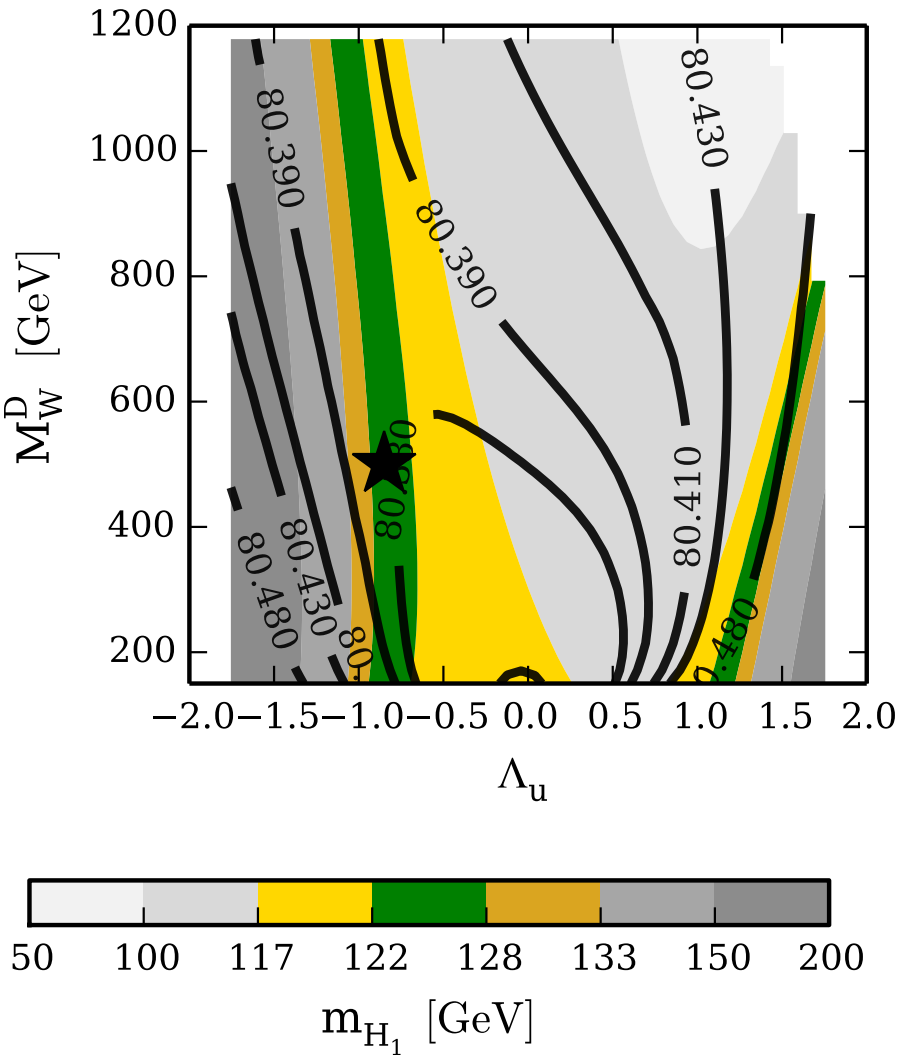
Higgs and W mass

Higgs boson

- $m_H = 125$ GeV
- Prediction in SUSY model
- 3 GeV theory uncertainty
- Full one-loop effects, two-loop eff. potential

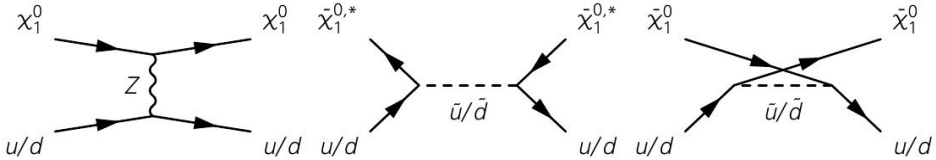
W boson

- $m_W^{\text{exp}} = 80.385 \pm 0.015$ GeV
- Full one-loop, leading SM two-loop effects



Dark matter

SUSY models usually predict WIMP candidates.
Direct detection experiments become quite constraining for WIMPs.



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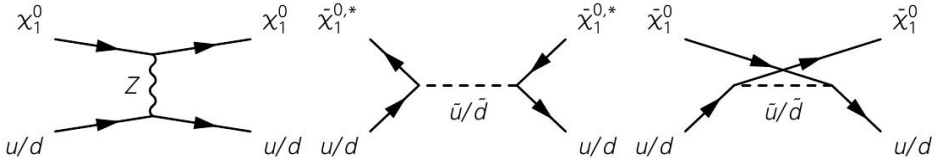

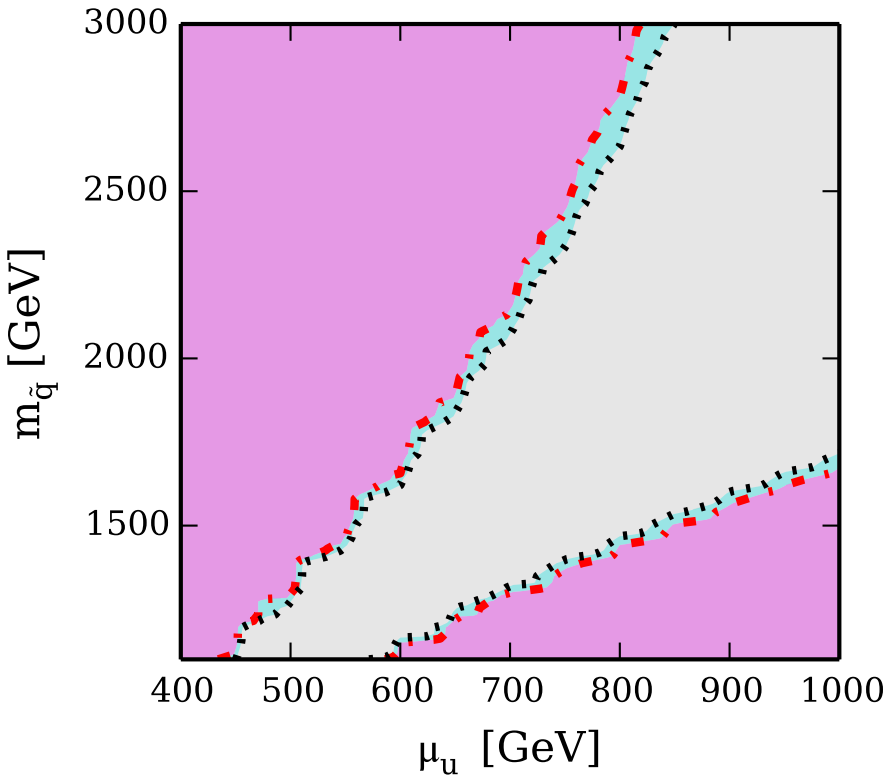

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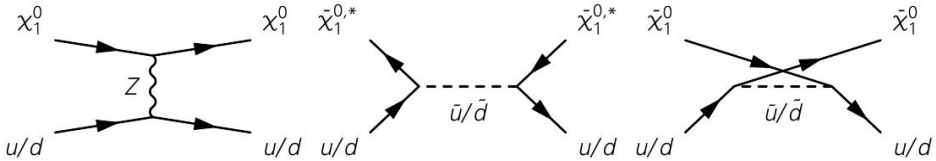

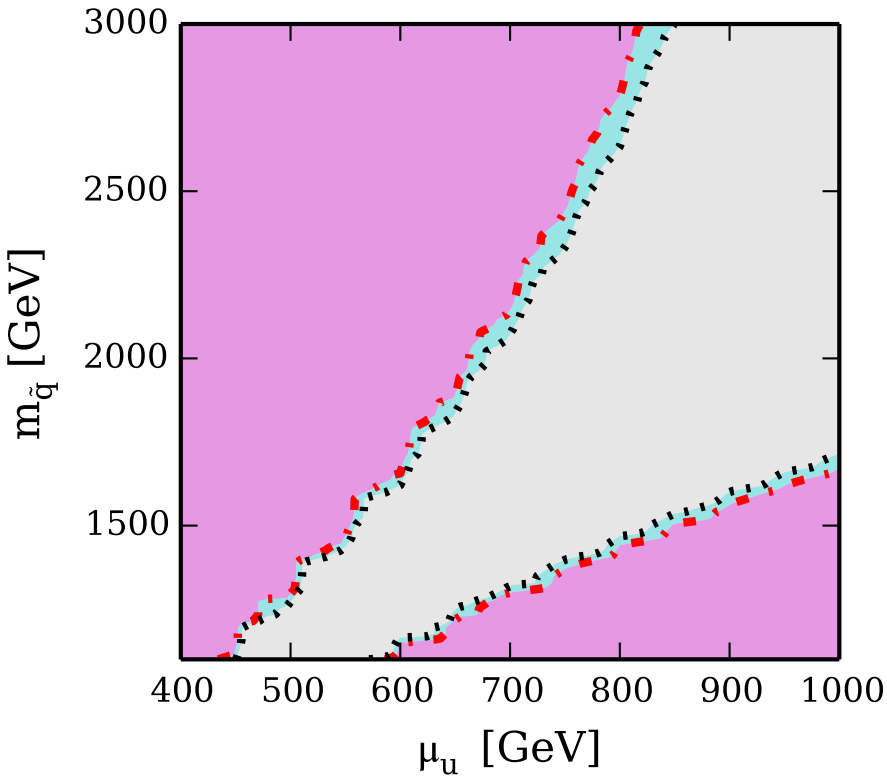

Also have to ensure the correct DM relic density.

LHC searches for electroweak SUSY states

Recasting

- Model does not fit assumptions e.g. simplified model
- Take signal regions, number of background and data events from experiment
- Simulate signal events ourselves
- Including (MC) detector simulation and statistics

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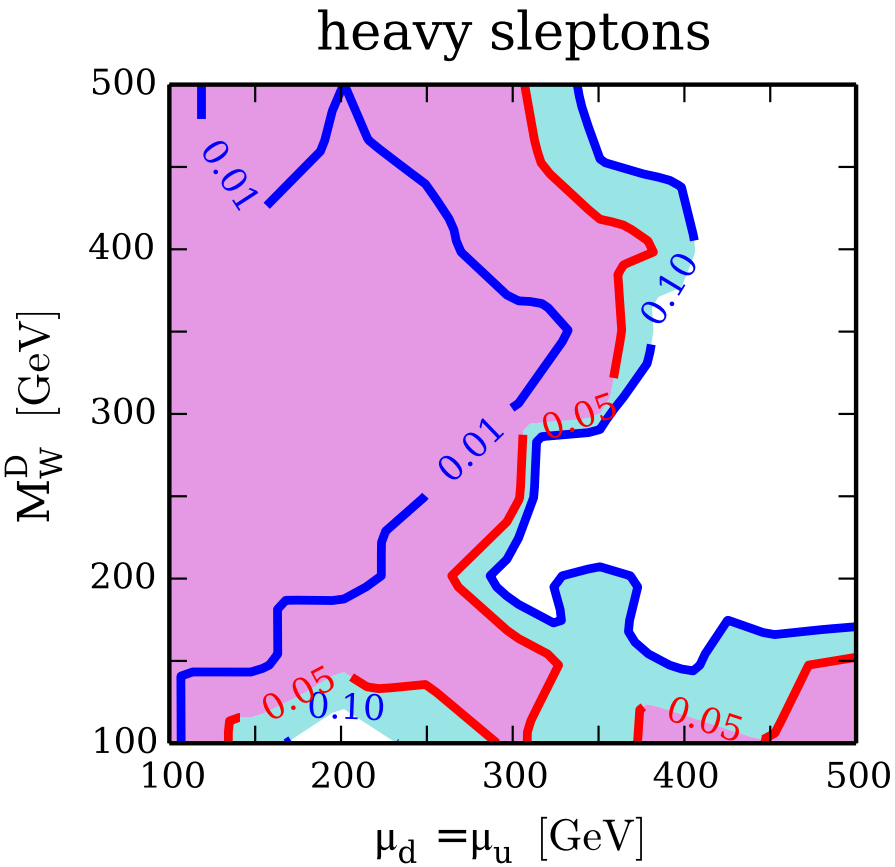

Conclusions

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- At the moment: SUSY QCD@NLO with Dirac gluino
- After that I am looking for new things

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Based on
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Adv.High Energy Phys. 2015 760729 [arXiv:1504.05386]
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done in collaboration with J. Kalinowski, W. Kotlarski, D. Stöckinger