Production of squarks at the LHC in R-symmetric SUSY.

In collaboration with W. Kotlarski, S. Liebschner, D. Stöckinger (JHEP 1710 (2017) 142 [arxiv:1707:04557])

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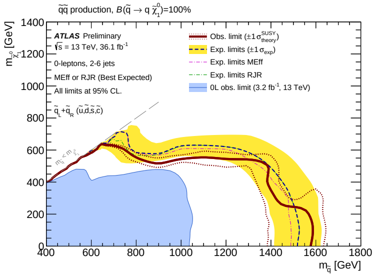
DESY

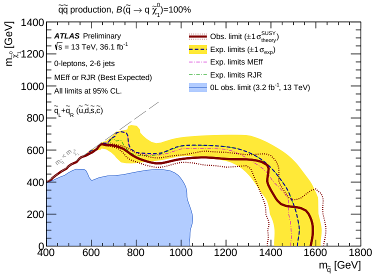
Going beyond the MSSM



Motivation

- LHC Run 2 on-going
- Look into non-minimal models for wide spectrum of alternative predictions

Going beyond the MSSM



Motivation

- LHC Run 2 on-going
- Look into non-minimal models for wide spectrum of alternative predictions
- Here: **R-Symmetry**
  - Includes solution to flavor problem of the MSSM
  - Extended Higgs sector, different predictions than (N)MSSM
  - Dirac gauginos (esp. gluino) might explain SUSY non-discovery

Outline

R-Symmetric SUSY

NLO Calculation

Results

R-symmetry

- Additional symmetry allowed by SUSY algebra described in "Haag-Łopuszański-Sohnius-Theorem"
- For $N = 1$ SUSY it is a global $U(1)_{\mathrm{R}}$ symmetry
  $\rightarrow$ charged Spinor coordinates:
  $Q_{\mathrm{R}}(\theta) = 1,\ Q_{\mathrm{R}}(\bar{\theta}) = -1; \quad (\theta \rightarrow e^{i\alpha}\theta, \bar{\theta} \rightarrow e^{-i\alpha}\bar{\theta})$
- Lagrangian has to be invariant
- SM fields have $Q_{\mathrm{R}} = 0$ (MRSSM Kribs et.al. [0712:2039])
- Assuming R-symmetry unbroken: Majorana gaugino mass terms forbidden

R-symmetric SUSY QCD

Following MRSSM conventions:

superfield		boson		fermion	
left-handed (s)quark	$\hat{Q}_L$	$\tilde{q}_L$	1	q_L	0
right-handed (s)quark	$\hat{Q}_R$	$\tilde{q}_R^\dagger$	1	$\bar{q}_R$	0
gluon vector superfield	$\hat{V}$	g	0	$\tilde{g}_L$	$+1$
adjoint chiral superfield	$\hat{O}$	O	0	$\tilde{g}_R$	-1

$$\begin{aligned}\mathcal{L}_{\text{soft}} = & -\frac{m^2_{\tilde{q}_L}}{2}|\tilde{q}_L|^2 - \frac{m^2_{\tilde{q}_R}}{2}|\tilde{q}_R|^2 \\ & - m_O^2\,|O^a|^2 - m_{\tilde{g}}\left(\overline{\tilde{g}_R}\tilde{g}_L - \sqrt{2}D^aO^a + \text{h.c.}\right)\ .\end{aligned}$$

Phenomenology

- Dirac gaugino masses are "super-soft"

  (Fox, et.al., [hep-ph/0206096])
- $\rightarrow$ Scenario with heavy gluino and rather light squarks natural
- Here: Concentrate on squark production in the MRSSM

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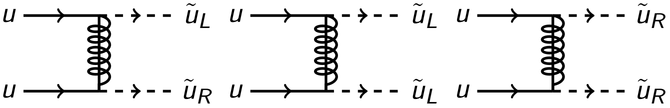

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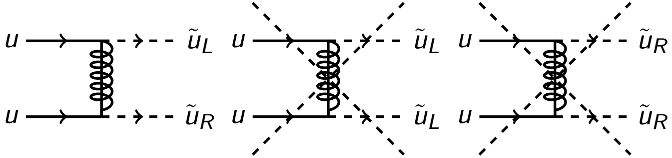

NLO calculation

- MSSM results known since many years used in form of (global) K-factors by experiments and pheno studies

$$K = \frac{\sigma_{NLO}}{\sigma_{LO}}$$

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MRSSM

- Well-known from MSSM that NLO effects sizable
- Additional scalar octet: sgluon
- Dirac nature of gluino

Implementation

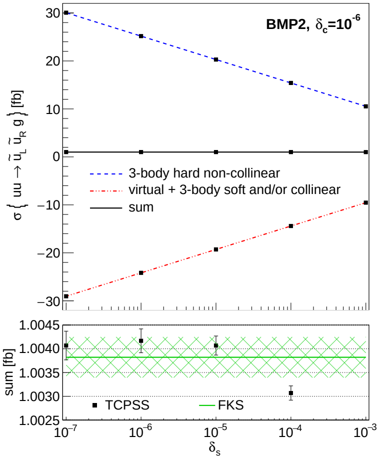
Combine popular programs and compare with own implementation of orthogonal methods

- GoSam and MadGraph_MC@NLO (+ own implementation of renormalisation)
- Independent calculation using classical PV functions and phase space slicing

Theoretical aspects

- Dimensional regularisation or reduction
- Cancellation of IR divergences
- On-shell renormalisability
- Treatment of on-shell resonances

Implementation



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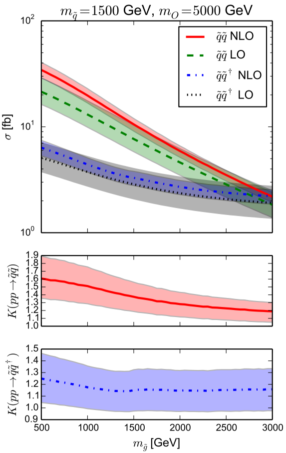
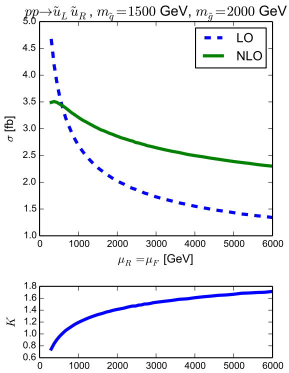
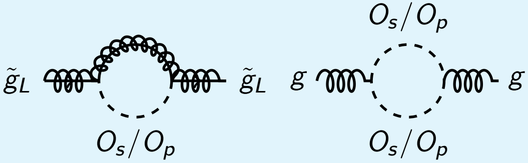




- Corrections behave similar as in MSSM
- Some prominent deviations exist

Sgluon effects

Superoblique corrections



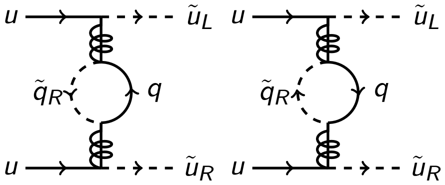
Integrating out the sgluon leads to physical difference:

$$\hat{g}_s - g_s = \frac{\alpha_s}{4\pi}\left(\log\frac{m_O^2}{m_{\tilde{g}}^2}\right)$$

$\hat{g}_s$ gluino coupling, g_s gluon coupling

Dirac gluino effects

MSSM:



- only one Dirac gluino chirality couples to matter
- Diagrams proportional to Majorana mass not present

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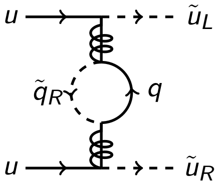

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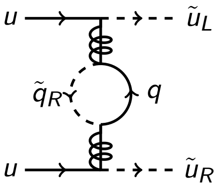

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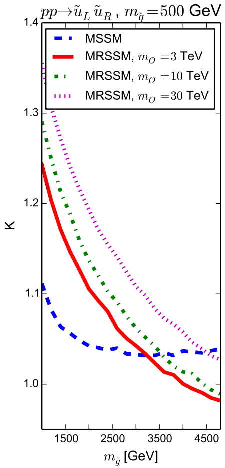
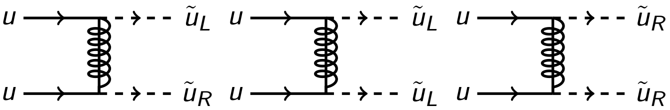


Comparison to the MSSM

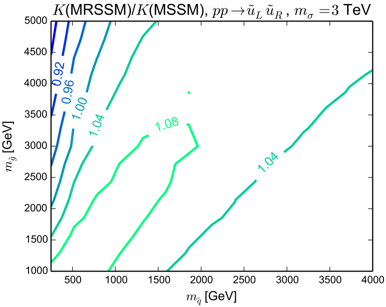
- Output from standard tools (Prospino, NLLfast) is $K(pp \to uu)$
- But $K(pp \to uu) \neq K(pp \to u_L u_R)$ in MSSM

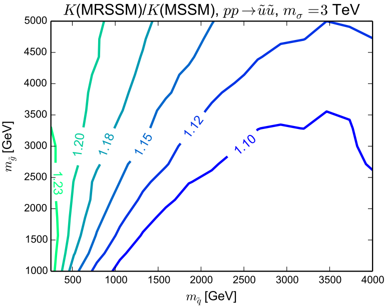


Compare $\frac{K(MRSSM)}{K(MSSM)}(pp \to \tilde{u}_L \tilde{u}_R)$ and $\frac{K(MRSSM)}{K(MSSM)}(pp \to \tilde{u}\tilde{u})$

Comparison to the MSSM

- Output from standard tools (Prospino, NLLfast) is $K(pp \to uu)$
- But $K(pp \to uu) \neq K(pp \to u_L u_R)$ in MSSM
- Leads to systematic error





Conclusions

- Shown NLO corrections to Non-minimal SUSY QCD
- Implementation will become available: `RSymSQCD`
- Be careful if using MSSM K-factors for other models
- Next steps:
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  - Add gluino final states

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Thanks for your attention!