The MSSM beyond minimal flavour violation: Phenomenology and signatures at LHC

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Bozzi, Fuks, Herrmann, Klasen, Nucl. Phys. B787: 1-54 (2007), arXiv:0704.1826

Fuks, Herrmann, Klasen, Nucl. Phys. B810: 266-299 (2008), arXiv:0808.1104

Bruhnke, Herrmann, Porod, JHEP 09:006, 1-35 (2010), arXiv:1007.2100

Bartl, Eberl, Herrmann, Hidaka, Majerotto, Porod, *accepted by Phys. Lett. B*, arXiv:1007.5483

Bartl, Eberl, Ginina, Herrmann, Hidaka, Majerotto, Porod, *to be published*

Herrmann, Klasen, Le Boulc'h, *to be published*

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Outline

Flavour in the MSSM

Experimental constraints

Squark production and decay

Gluino production and decay

Dark matter annihilation

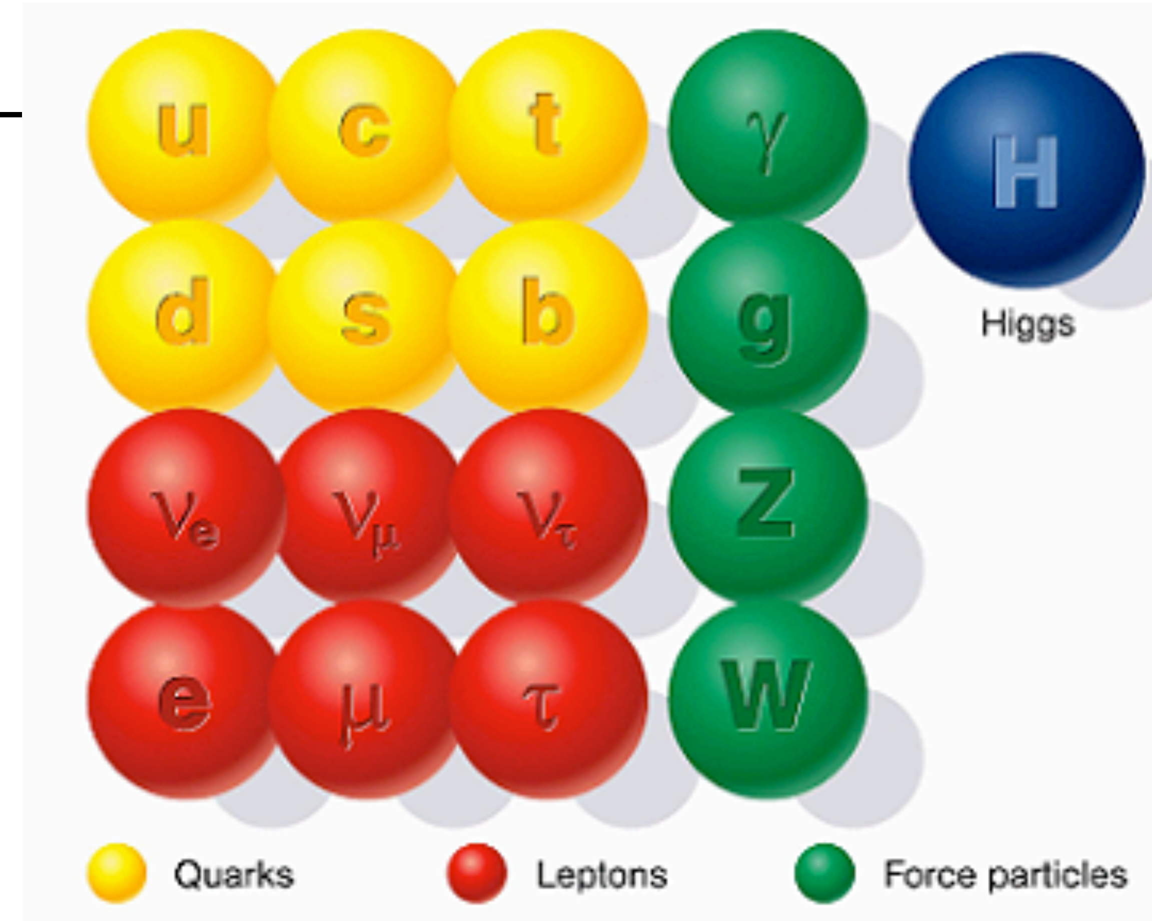
Conclusion

Flavour violation in the MSSM

Flavour in the Standard Model...

Only source of flavour violation are Yukawa matrices

$$u_L^{(i)} = V_u \, u_L^{(m)}$$
$$u_R^{(i)} = U_u \, u_R^{(m)}$$
$$d_L^{(i)} = V_d \, d_L^{(m)}$$
$$d_R^{(i)} = U_d \, d_R^{(m)}$$



Quark flavour violating (i.e. charged current) interactions...

$$\Gamma_{W^+ d_i \bar{u}_j} \propto \frac{g_2}{\sqrt{2}} \gamma^\mu \frac{1-\gamma_5}{2} (V_{\rm CKM})_{ij}$$

... proportional to Cabbibo-Kobayashi-Maskawa (CKM) matrix

$$V_{\rm CKM} = V_u^\dagger V_d \sim \begin{pmatrix} 1 & \lambda & \lambda^3 \\ \lambda & 1 & \lambda^2 \\ \lambda^3 & \lambda^2 & 1 \end{pmatrix} \qquad \lambda \sim 0.2$$

... and beyond

Example: Minimal Supersymmetric Standard Model (MSSM)

Minimal flavour-violation

- same flavour structure as in SM, i.e. no new sources of flavour violation
- in super-CKM basis squarks undergo same rotations as quarks
- all flavour-violating elements related to CKM-matrix
- Example: $\tilde{\chi}_i^{\pm} \tilde{q}_j q_k$ interaction proportional to $V_{q_j q'_k}$

Non-minimal flavour-violation

- new sources of flavour violation can appear within SUSY-GUTs
- corresponding flavour-violating terms related to SUSY breaking (e.g. gravity mediation, messenger-matter mixing, ...)
- not related to CKM-matrix
- conveniently considered as free parameters at the weak scale

see e.g. Gabbini, Masiero (1989); Gabbiani, Gabrieli, Masiero, Silvestrini (1996); Ciuchino, Degrassi, Gambino, Giudice (1998)
for a review on flavour violation in the MSSM see e.g. Lari, Pape, Porod *et al.* (2008)

Experimental distinction between MFV and NMFV possible...?

The Minimal Supersymmetric Standard Model (MSSM)

Supersymmetry relates bosons and fermions:

$$\mathcal{Q}\,|b\rangle = |f\rangle \qquad \mathcal{Q}\,|f\rangle = |b\rangle$$

SM Particles		Spin		Spin		Superpartners
Quarks	$(u_L \;\; d_L)$	$1/2$	Q	0	$(\tilde{u}_L \;\; \tilde{d}_L)$	Squarks
	$u_R^\dagger$	$1/2$	$\bar{u}$	0	$\tilde{u}_R^*$	
	$d_R^\dagger$	$1/2$	$\bar{d}$	0	$\tilde{d}_R^*$	
Leptons	$(\nu \;\; e_L)$	$1/2$	L	0	$(\tilde{\nu} \;\; \tilde{e}_L)$	Sleptons
	$e_R^\dagger$	$1/2$	$\bar{e}$	0	$\tilde{e}_R^*$	
Higgs	$(H_u^+ \;\; H_u^0)$	0	H_u	$1/2$	$\tilde{\chi}^0_{1,2,3,4}$	Neutralinos
	$(H_d^0 \;\; H_d^-)$	0	H_d			
W bosons	$W^0, W^\pm$	1		$1/2$	$\tilde{\chi}^\pm_{1,2}$	Charginos
B boson	B^0	1				
Gluon	g	1		$1/2$	$\tilde{g}$	Gluino
Graviton	G	2		$3/2$	$\tilde{G}$	Gravitino

Supersymmetric models cure the hierarchy problem of the Standard Model, can lead to gauge coupling unification, include candidates for cold dark matter, ...

The squark sector of the MSSM

Squark mass matrices at the electroweak scale can include off-diagonal (i.e. flavour-violating) terms

$$\mathcal{M}^2_{\tilde{u}} = \begin{pmatrix} \mathcal{M}^2_{uLL} & \left(\mathcal{M}^2_{uRL}\right)^\dagger \\ \mathcal{M}^2_{uRL} & \mathcal{M}^2_{uRR} \end{pmatrix}$$

$$\begin{aligned}
\mathcal{M}^2_{LL,\alpha\beta} &= M^2_{Q,\alpha\beta} + \frac{1}{2}\left[m^2_{u,\alpha} + \left(\frac{1}{2} - \frac{2}{3}s^2_W\right) m^2_Z c_{2\beta}\right]\delta_{\alpha\beta} \\
\mathcal{M}^2_{RR,\alpha\beta} &= M^2_{U,\alpha\beta} + \frac{1}{2}\left[m^2_{u,\alpha} + \frac{2}{3}s^2_W m^2_Z c_{2\beta}\right]\delta_{\alpha\beta} \\
\mathcal{M}^2_{RL,\alpha\beta} &= \frac{v_2}{\sqrt{2}} A_{U,\alpha\beta} - m_{u,\alpha}\frac{\mu^*}{\tan\beta}\delta_{\alpha\beta}
\end{aligned}$$

Dimensionless (and scenario-independent) parametrization of flavour violating entries

$$\begin{aligned}
\delta^{uLL}_{\alpha\beta} &= M^2_{Q,\alpha\beta} \Big/ \sqrt{M^2_{Q,\alpha\alpha} M^2_{Q,\beta\beta}} \\
\delta^{uRR}_{\alpha\beta} &= M^2_{U,\alpha\beta} \Big/ \sqrt{M^2_{U,\alpha\alpha} M^2_{U,\beta\beta}} \\
\delta^{uRL}_{\alpha\beta} &= \frac{v_2}{\sqrt{2}} A_{U,\alpha\beta} \Big/ \sqrt{M^2_{U,\alpha\alpha} M^2_{Q,\beta\beta}}
\end{aligned}$$

Diagonalization through 6x6 rotation matrix leads to mass eigenstates

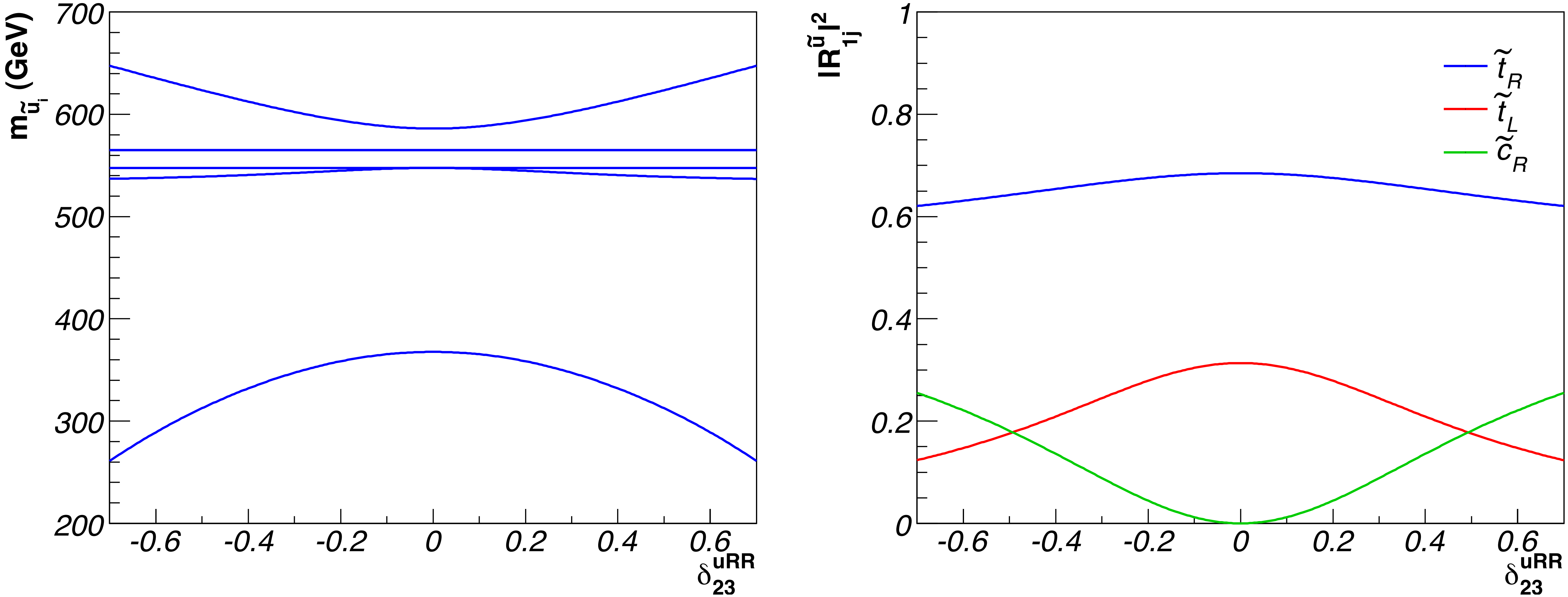
$$\mathcal{R}_{\tilde{u}} \mathcal{M}^2_{\tilde{u}} \mathcal{R}^\dagger_{\tilde{u}} = \mathrm{diag}\left(m^2_{\tilde{u}_1}, m^2_{\tilde{u}_2}, m^2_{\tilde{u}_3}, m^2_{\tilde{u}_4}, m^2_{\tilde{u}_5}, m^2_{\tilde{u}_6}\right)$$

Squark masses and flavour contents

Reference scenario: SPS1a' [Aguilar-Saavedra *et al.* 2006] (mSUGRA / CMSSM)

$$m_0 = 70\ \text{GeV}, m_{1/2} = 250\ \text{GeV}, A_0 = -300\ \text{GeV}, \tan\beta = 10, \mu > 0$$

Introduce non-diagonal elements in squark mass matrix at the electro-weak scale (Q=1 TeV)



Increased mass splitting and altered flavour decomposition w.r.t. minimal flavour violation

Experimental constraints

Experimental constraints

Mass limits from collider searches [PDG 2008-2010]

Consider only additional flavour-mixing between second and third generation squarks due to strong constraints on mixing involving the first generation from precision measurements related to B- and K-mesons [Hagelin *et al.* 1994; Gabbiani *et al.* 1996; Ciuchini *et al.* 2007]

Electroweak precision and low-energy measurements [PDG 2008-2010; HFAG 2008-2010]

$$\begin{aligned} \mathrm{BR}(b \to s\gamma) &= (3.57 \pm 0.65) \cdot 10^{-4} \\ \Delta M_{B_s} &= (17.77 \pm 3.31)\ \mathrm{ps}^{-1} \\ \mathrm{BR}(b \to s\mu^+\mu^-) &= (1.60 \pm 1.00) \cdot 10^{-6} \\ \mathrm{BR}(B_s \to \mu^+\mu^-) &< 4.3 \cdot 10^{-8} \end{aligned}$$

Highly sensitive to QFV elements

$$\Delta a_\mu = a_\mu^{\mathrm{SM}} - a_\mu^{\mathrm{exp}} = (29.0 \pm 8.6) \cdot 10^{-10}$$

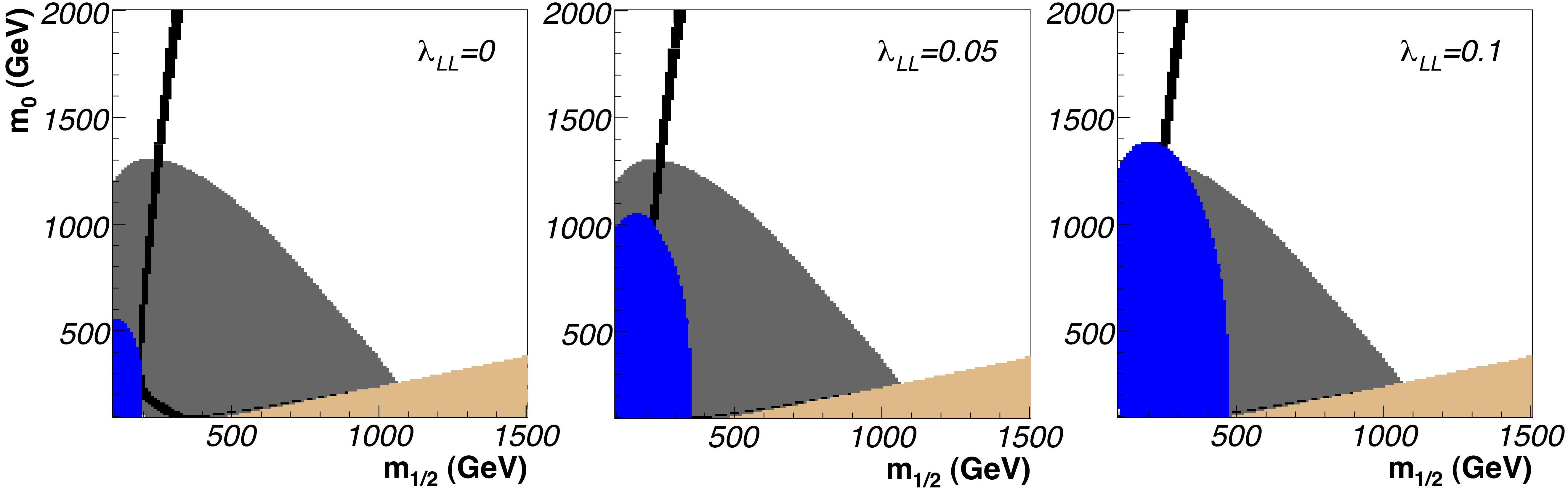
Rather insensitive to QFV elements

Cosmological constraints due to cold dark matter [WMAP 2010]

$$0.1018 < \Omega_{\mathrm{CDM}} h^2 < 0.1228$$

Constraints on the mSUGRA parameter space

Bozzi, Fuks, Herrmann, Klasen (2007)



b→sγ excluded — WMAP favoured
a_μ favoured — charged LSP

$$\tan\beta = 10,\ \ A_0 = 0,\ \ \mu > 0$$

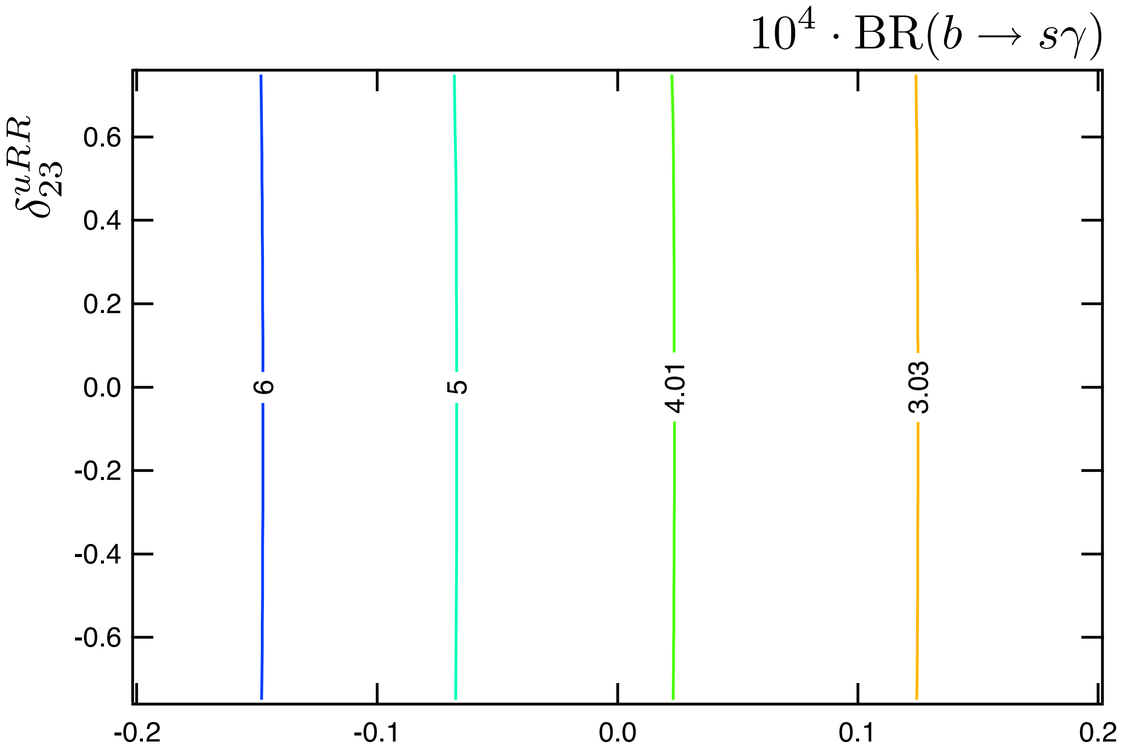
BR(b→sγ) very sensitive to flavour-violating elements (especially in the left-left sector)

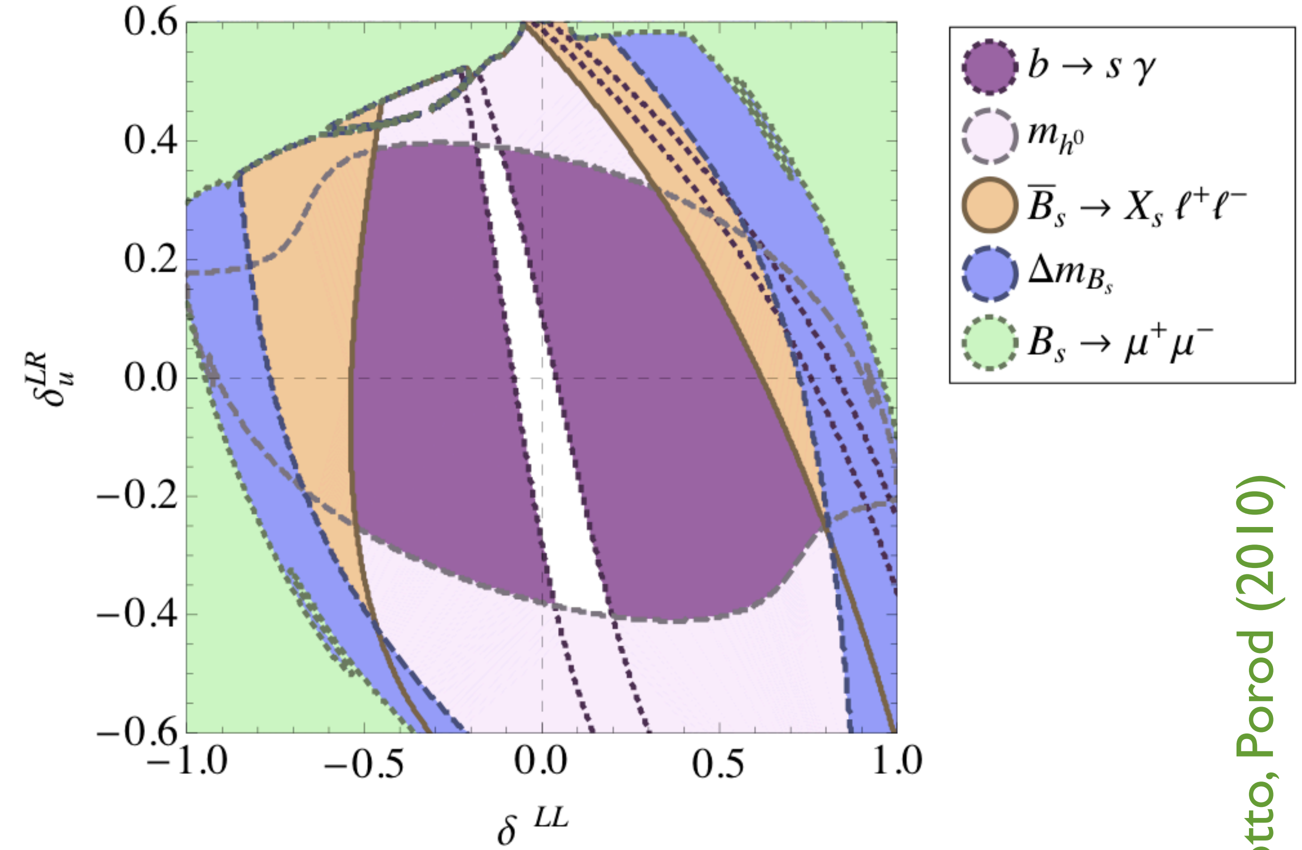
Dark matter relic density and anomalous magnetic moment practically insensitive

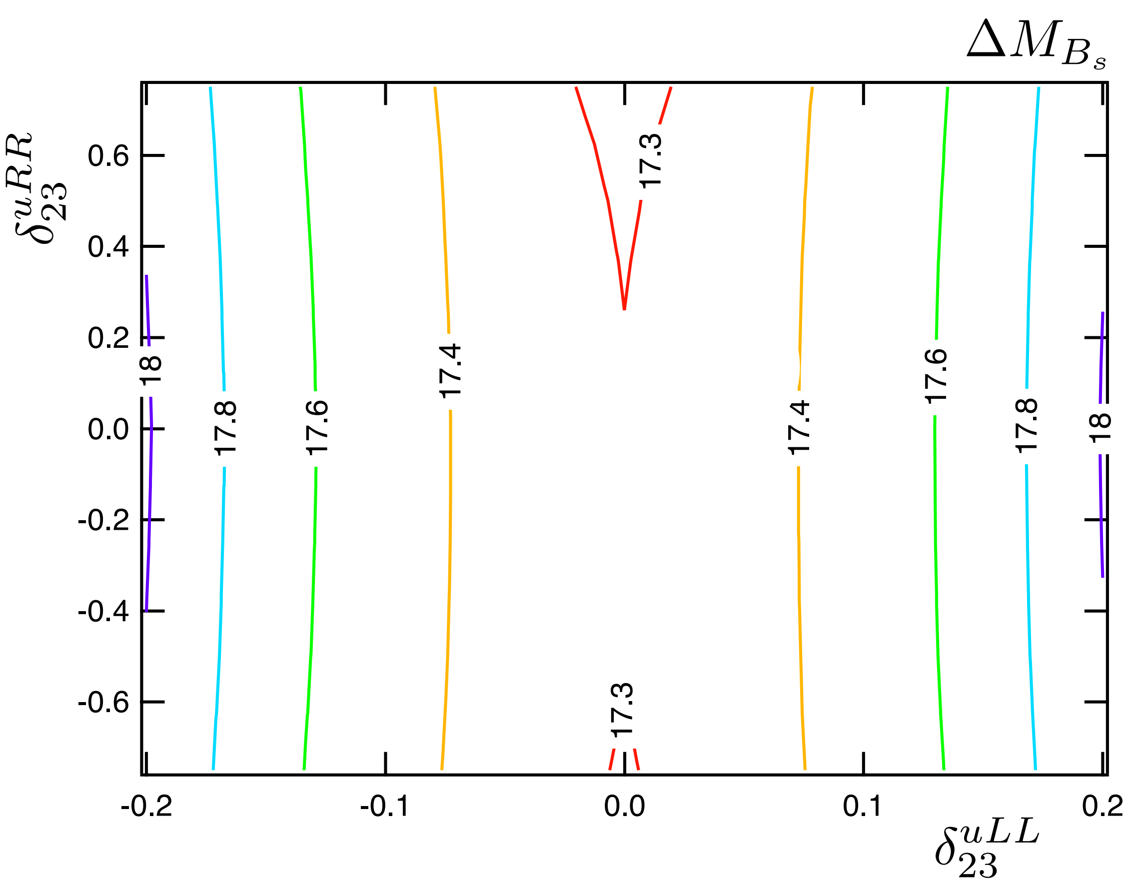
Constraints from further B-meson observables or lightest Higgs mass less stringent in most cases

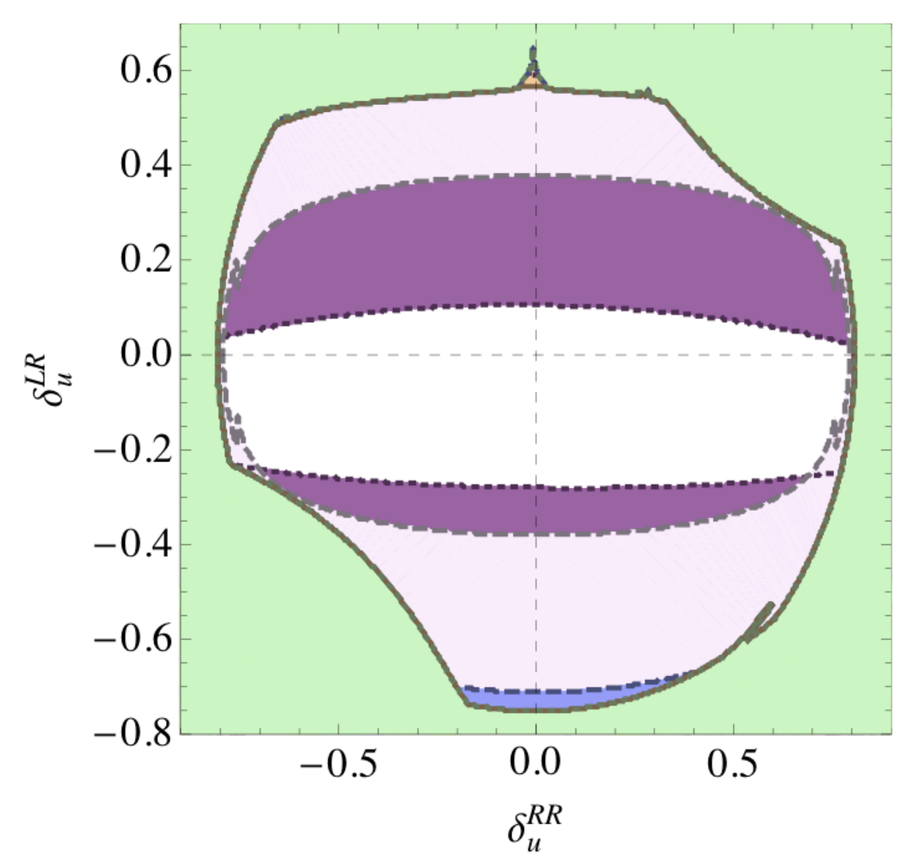
(see next slide...)

Constraints on quark flavour violation









Bruhnke, Herrmann, Porod (2010)

Bartl, Eberl, Herrmann, Hidaka, Majerotto, Porod (2010)

Computational tools

Supersymmetric mass spectrum

- **SPheno 3.0** [Porod (2003-2011)]
  Renormalization group equations, supersymmetric mass spectrum, precision observables, and branching ratios in MSSM with NMFV
- **FeynHiggs** [Hahn, Heinemeyer *et al.* (2002-2011)]
  Mass spectrum and precision observables in MSSM with NMFV

Production cross-sections

- **XSUSY** [Fuks, Herrmann (2008-2011)]
  Squark and gluino hadroproduction and decays in MSSM with NMFV
- **Whizard / O'Mega** [Kilian, Reuter, Ohl (2001-2011)]
  Monte-Carlo event generator, MSSM with NMFV implemented [Herrmann]

Relic density calculation

- **DarkSUSY** [Gondolo, Edsjö, Ullio *et al.* (2004-2011)]
  includes 6x6 rotation matrices for squarks and sleptons
- **micrOMEGAs / CalcHEP** [Bélanger, Boudjema, Pukhov *et al.* (2001-2011)]
  Model files for MSSM with NMFV generated
  with the help of Mathematica package SARAH [Herrmann, Staub (2010)]

Signatures related to squark production and decay

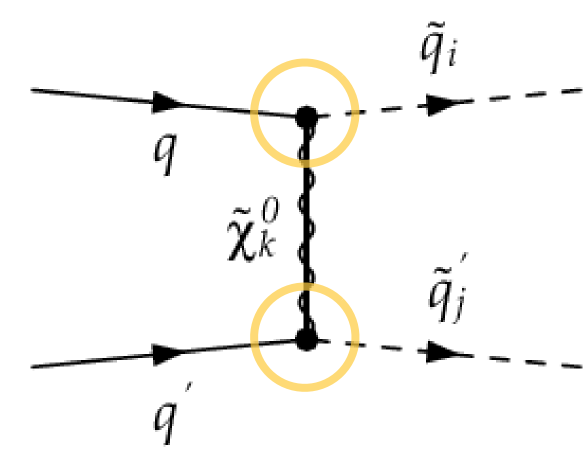
Particle production at hadron colliders

QCD factorization theorem: Convolution of partonic cross section with parton density functions

$$\sigma = \int_{t_-}^{t_+} \mathrm{d}t \int_{4m^2/s}^{1} \mathrm{d}\tau \int_{-1/2\ln\tau}^{1/2\ln\tau} \mathrm{d}y \; f_{a/A}(x_a, M_a^2) \; f_{b/B}(x_b, M_b^2) \; \frac{\mathrm{d}\hat\sigma}{\mathrm{d}t}$$

Example: Squark pair production through t-channel neutralino exchange

$$\frac{\mathrm{d}\hat\sigma_{h_a h_b}}{\mathrm{d}t} = (1-h_a)(1-h_a)\sum_{k,l=1}^{4}\frac{[\mathcal{NT}]_{11}^{kl}}{t_{\tilde\chi_k^0} t_{\tilde\chi_l^0}} + (1+h_a)(1+h_a)\sum_{k,l=1}^{4}\frac{[\mathcal{NT}]_{22}^{kl}}{t_{\tilde\chi_k^0} t_{\tilde\chi_l^0}}$$
$$+(1-h_a)(1+h_a)\sum_{k,l=1}^{4}\frac{[\mathcal{NT}]_{12}^{kl}}{t_{\tilde\chi_k^0} t_{\tilde\chi_l^0}} + (1+h_a)(1-h_a)\sum_{k,l=1}^{4}\frac{[\mathcal{NT}]_{21}^{kl}}{t_{\tilde\chi_k^0} t_{\tilde\chi_l^0}}$$



Form factors include coupling constants and Dirac traces

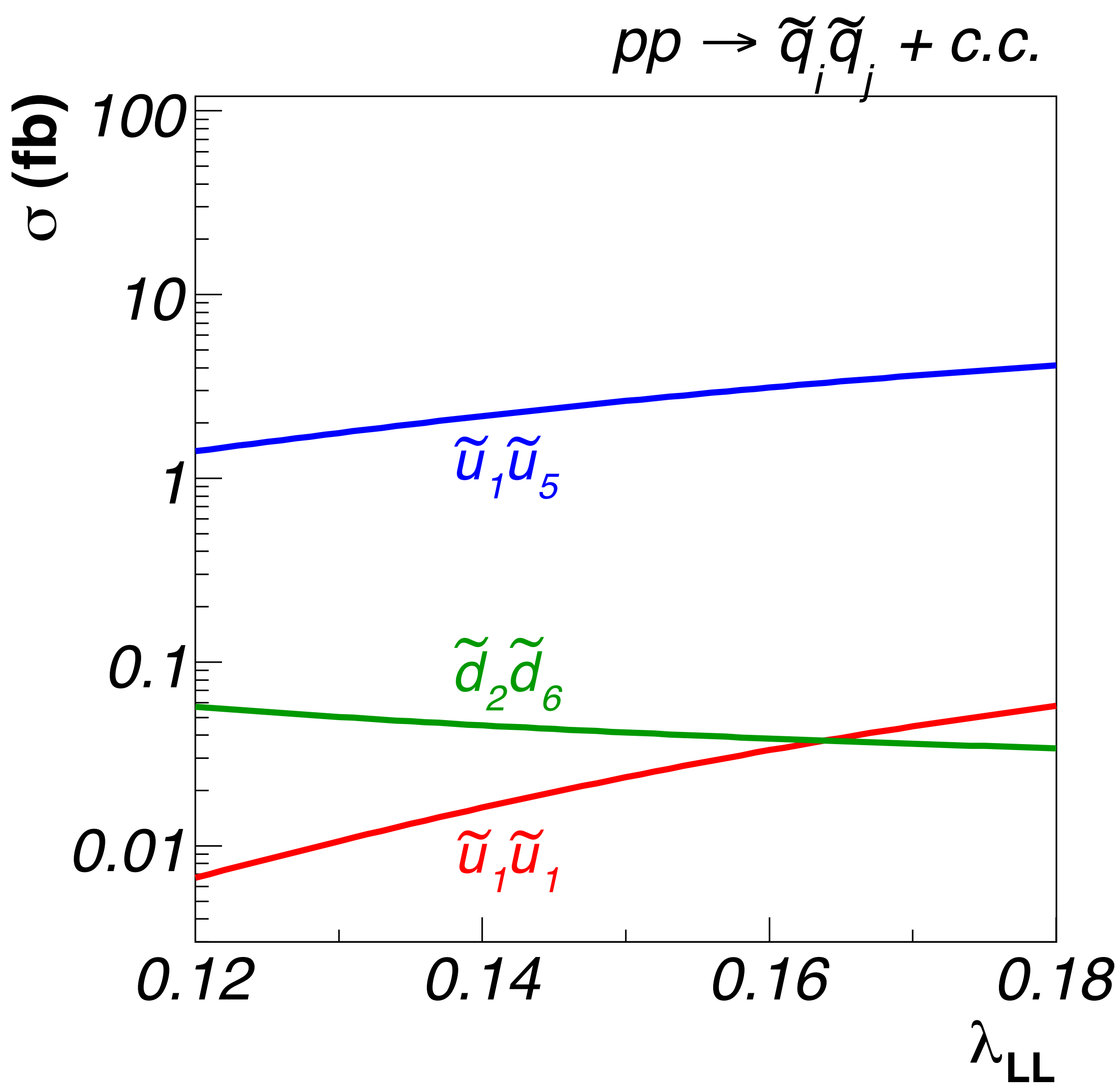
$$[\mathcal{NT}]_{mn}^{kl} = \frac{\pi\,\alpha^2}{\sin^4\theta_W\,\cos^4\theta_W\,s^2}\,\mathcal{C}^{n*}_{\tilde q_j q' \tilde\chi_k^0}\,\mathcal{C}^{m*}_{\tilde q_i q \tilde\chi_k^0}\,\mathcal{C}^{n}_{\tilde q_j q' \tilde\chi_l^0}\,\mathcal{C}^{m}_{\tilde q_i q \tilde\chi_l^0}\left[\left(u\,t - m^2_{\tilde q_i}\,m^2_{\tilde q_j}\right)(1-\delta_{mn}) + m_{\tilde\chi_k^0}\,m_{\tilde\chi_l^0}\,s\,\delta_{mn}\right]$$

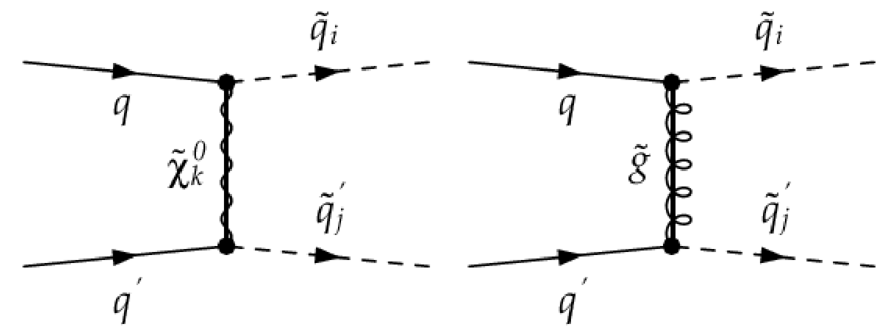
$$\{\mathcal{C}^1_{\tilde q_j q' \tilde\chi_k^0}, \mathcal{C}^2_{\tilde q_j q' \tilde\chi_k^0}\} = \{L_{\tilde q_j q' \tilde\chi_k^0}, R_{\tilde q_j q' \tilde\chi_k^0}\} \sim \{(\mathcal{R}_{\tilde q})_{jg}, (\mathcal{R}_{\tilde q})_{j(g+3)}\}$$

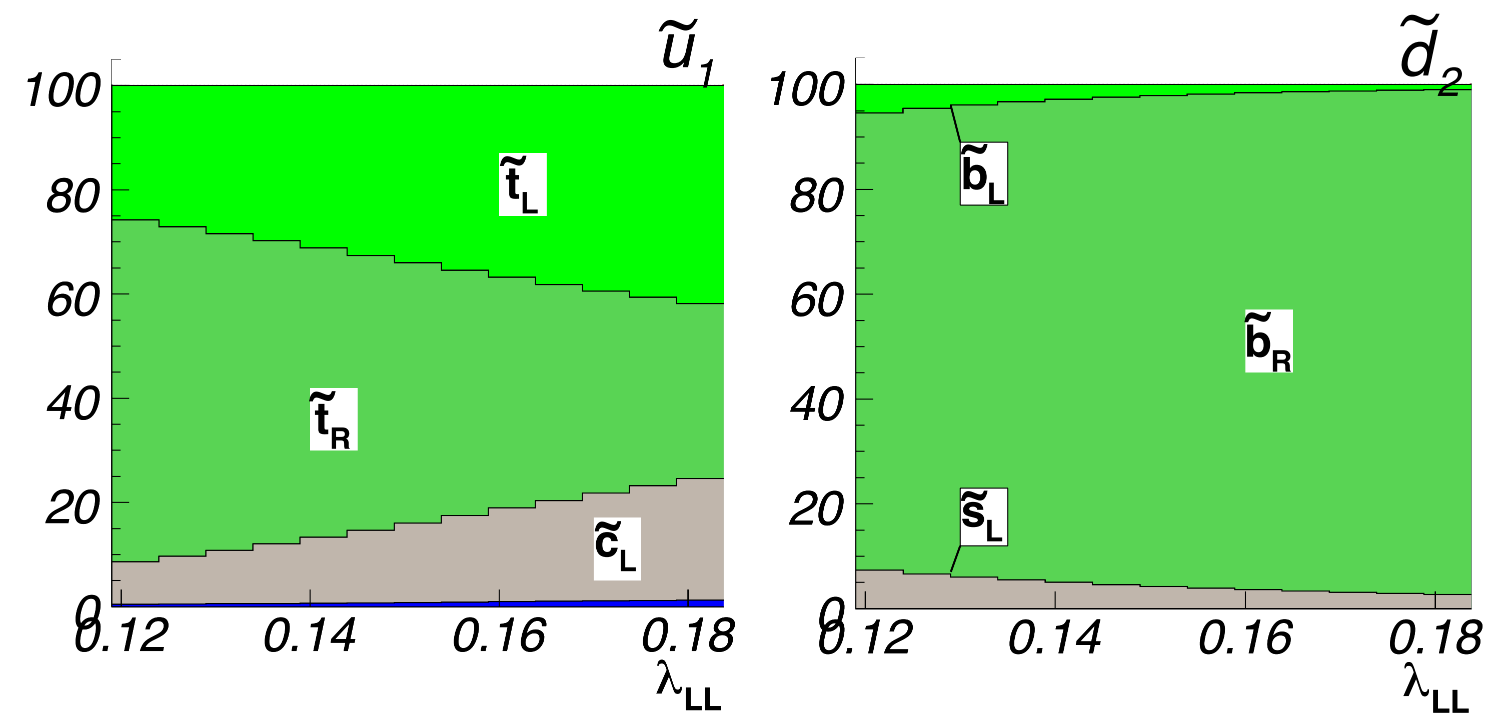
Agreement with previous results in flavour-conserving limit [Bozzi, Fuks, Klasen (2005)]

Squark pair production at LHC

Bozzi, Fuks, Herrmann, Klasen (2007); Fuks, Herrmann, Klasen (2009)







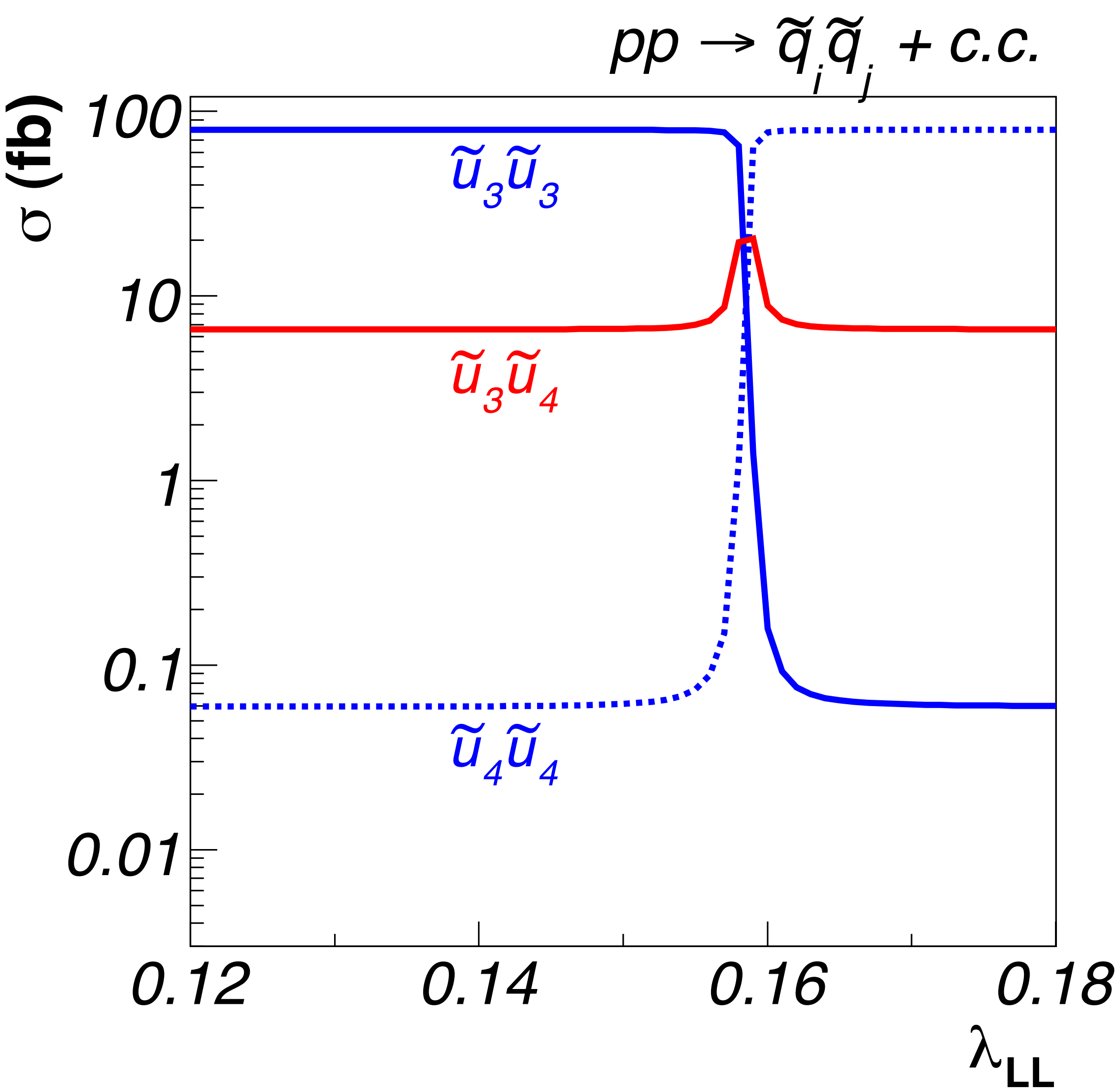
Cross sections sensitive to flavour violation through to $q\tilde{q}\tilde{g}$- and $q\tilde{q}\tilde{\chi}$-vertices

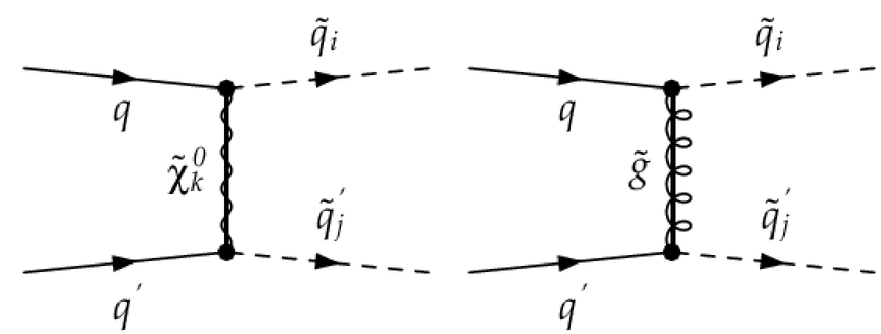
$\tilde{u}_1\tilde{u}_5$ and $\tilde{u}_1\tilde{u}_1$ production cross sections increase with light flavour content in $\tilde{u}_1$

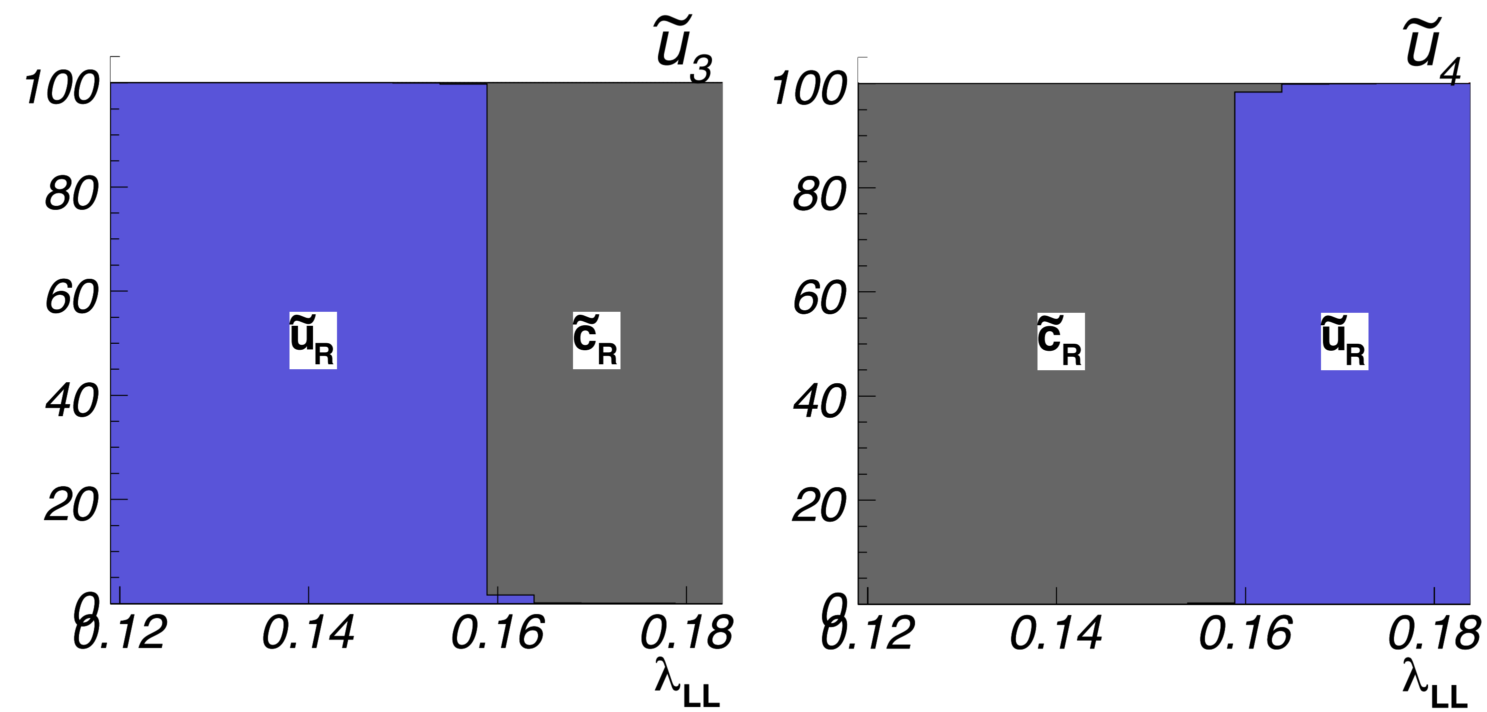
$\tilde{d}_2\tilde{d}_6$ production cross section decreases with light flavour content in $\tilde{d}_2$

Squark pair production at LHC

Bozzi, Fuks, Herrmann, Klasen (2007); Fuks, Herrmann, Klasen (2009)







Flavour exchanges between $\tilde{u}_3$ and $\tilde{u}_4$ related to "avoided crossings" of mass eigenvalues

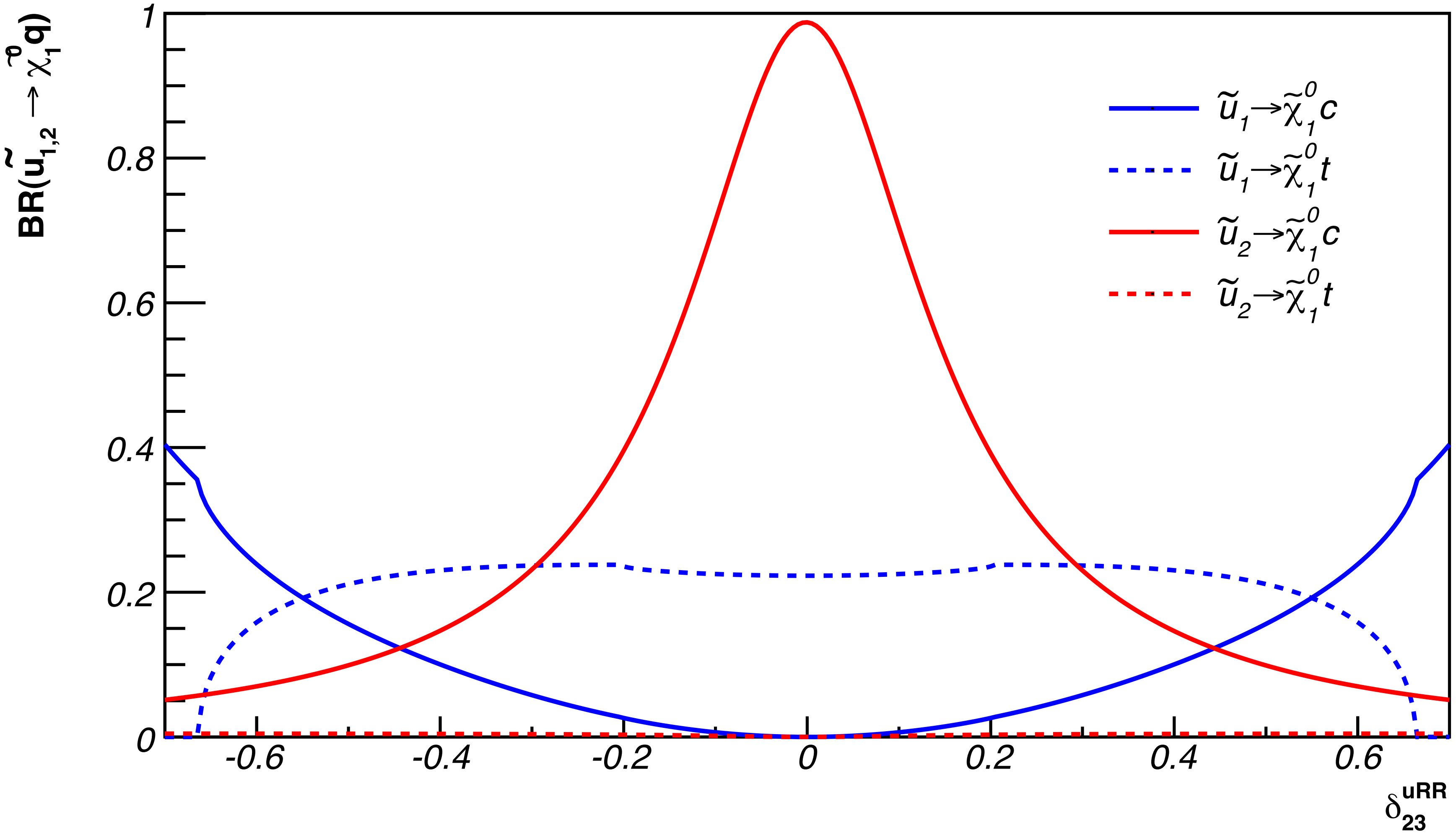
→ flavour exchanges lead to sharp transitions in particular production channels

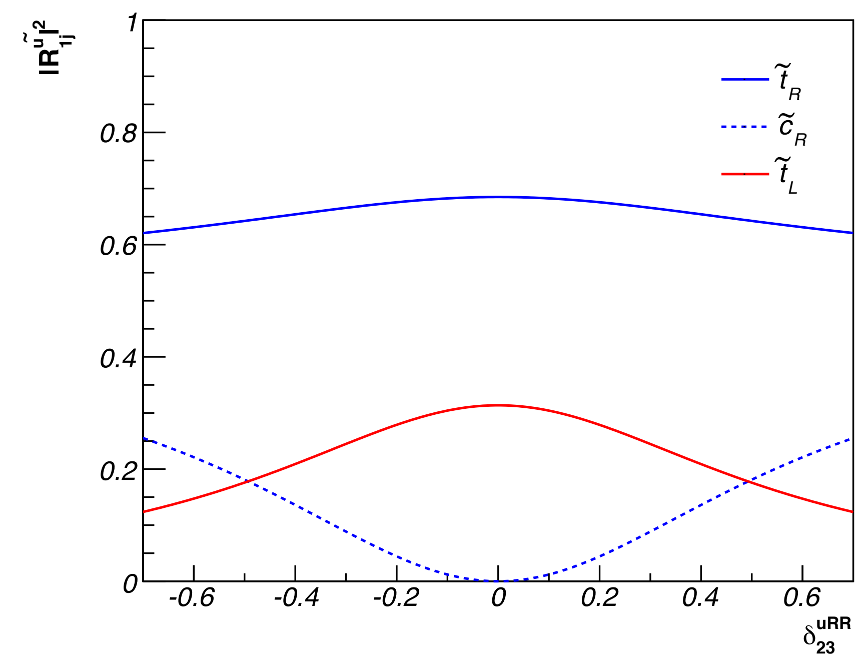
Resonance-like behaviour of $\tilde{u}_3\tilde{u}_4$ production cross section due to smooth flavour exchange

→ both squark mass eigenstates receive significant up-quark contributions

Fermionic squark decays

Bartl, Eberl, Herrmann, Hidaka, Majerotto, Porod (2010)





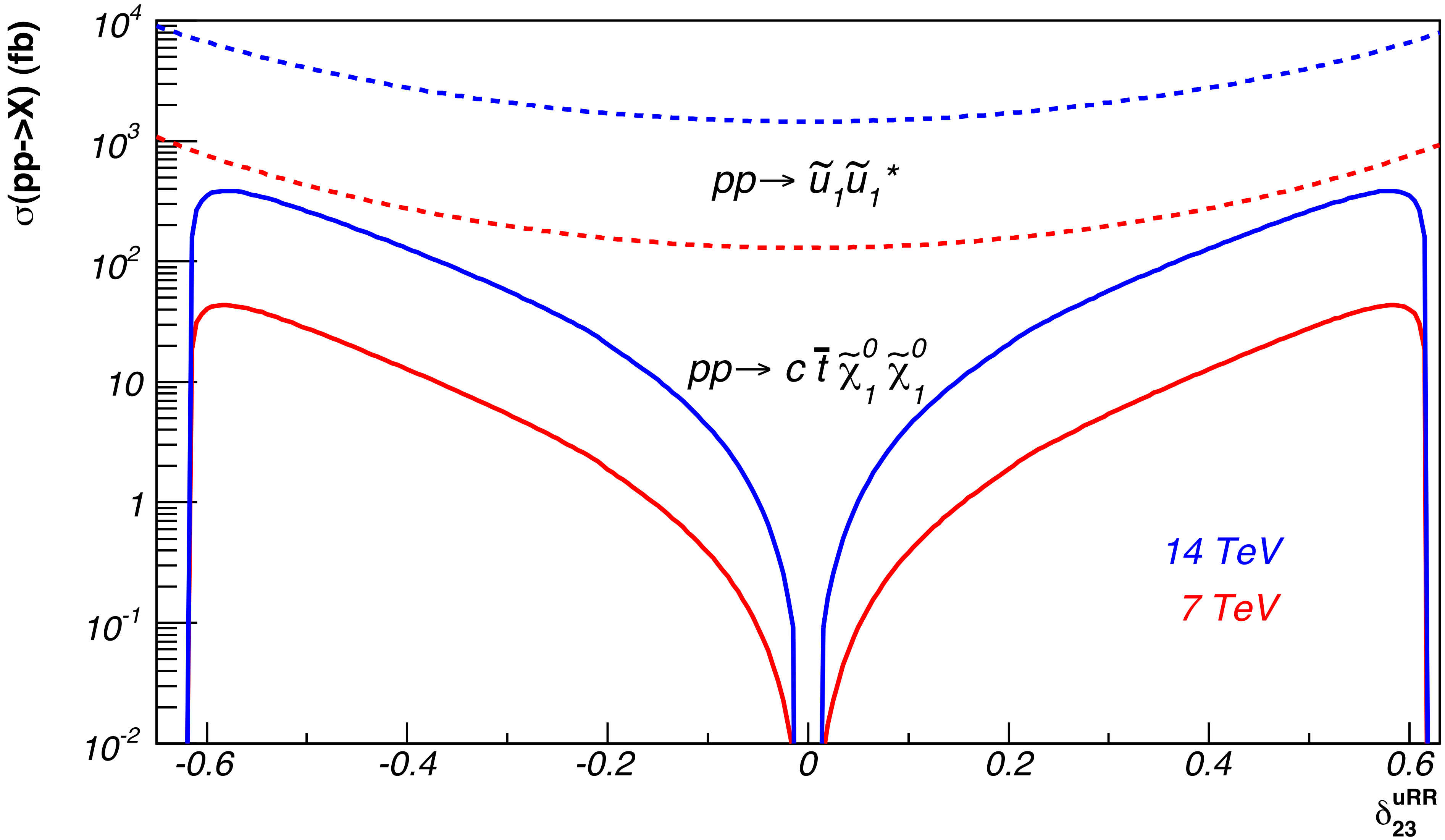
Branching ratios of squarks into different generations can become simultaneously sizeable

Potentially large branching ratios may lead to interesting production signatures at colliders

$$p\,p \;\rightarrow\; \tilde{u}_{1,2}\,\tilde{u}^*_{1,2} \;\rightarrow\; c\,\bar{t}\;\tilde{\chi}^0_1\,\tilde{\chi}^0_1$$
$$p\,p \;\rightarrow\; \tilde{u}_{1,2}\,\tilde{u}_{1,2} \;\rightarrow\; t\,t\;\tilde{\chi}^0_1\,\tilde{\chi}^0_1$$

Production cross-sections and LHC signatures

Bartl, Eberl, Herrmann, Hidaka, Majerotto, Porod (2010)



Expect up to 10^4 events for "jet + top + E_T^{miss}" production at E_{cm}=14 TeV and L_{int}=100 fb^{-1}

Event rate for top-top production found to be rather small ($\sigma \leq 0.1$ fb at E_{cm}=14 TeV)

Loop corrections for dominant (flavour-conserving) channels increase cross-section by about 30%

[Beenakker, Höpker, Spira, Zerwas 1997]

Discrimation and Background

Bartl, Eberl, Herrmann, Hidaka, Majerotto, Porod (2010)

$$p\,p \to \tilde{u}_{1,2}\,\tilde{u}^*_{1,2} \to c\,\bar{t}\;(t\,\bar{c})\;\tilde{\chi}^0_1\,\tilde{\chi}^0_1$$??? $$p\,p \to \tilde{u}_{1,2}\,\tilde{u}^*_{1,2} \to t\,\bar{t}\;\tilde{\chi}^0_1\,\tilde{\chi}^0_1$$

Identification of top-quarks crucial: $t \to bW^+ \to b\;q\bar{q}$

Efficient charm-tagging useful, otherwise search for $p\,p \to \tilde{u}_{1,2}\,\tilde{u}^*_{1,2} \to q\,\bar{t}\;(t\,\bar{q})\;\tilde{\chi}^0_1\,\tilde{\chi}^0_1$

$$p\,p \to \tilde{u}_{1,2}\,\tilde{u}^*_{1,2} \to t\,t\;\tilde{\chi}^0_1\,\tilde{\chi}^0_1$$??? $$p\,p \to \tilde{u}_{1,2}\,\tilde{u}^*_{1,2} \to t\,\bar{t}\;\tilde{\chi}^0_1\,\tilde{\chi}^0_1$$

Discrimination between top and anti-top necessary:

$$t \to bW^+ \to b\;l^+\nu$$
$$\bar{t} \to \bar{b}W^- \to \bar{b}\;l^-\nu$$

$$p\,p \to \tilde{u}_{1,2}\,\tilde{u}^*_{1,2} \to c\,\bar{t}\;(t\,\bar{c})\;\tilde{\chi}^0_1\,\tilde{\chi}^0_1$$??? $$p\,p \to \tilde{g}\,\tilde{\chi}^0_1 \to c\,\bar{t}\;(t\,\bar{c})\;\tilde{\chi}^0_1\,\tilde{\chi}^0_1$$

Gluino production channel found to be numerically small

Most important background is $pp \to t\bar{t} + E_T^{\rm miss}$ with missed / misidentified lepton from top decay

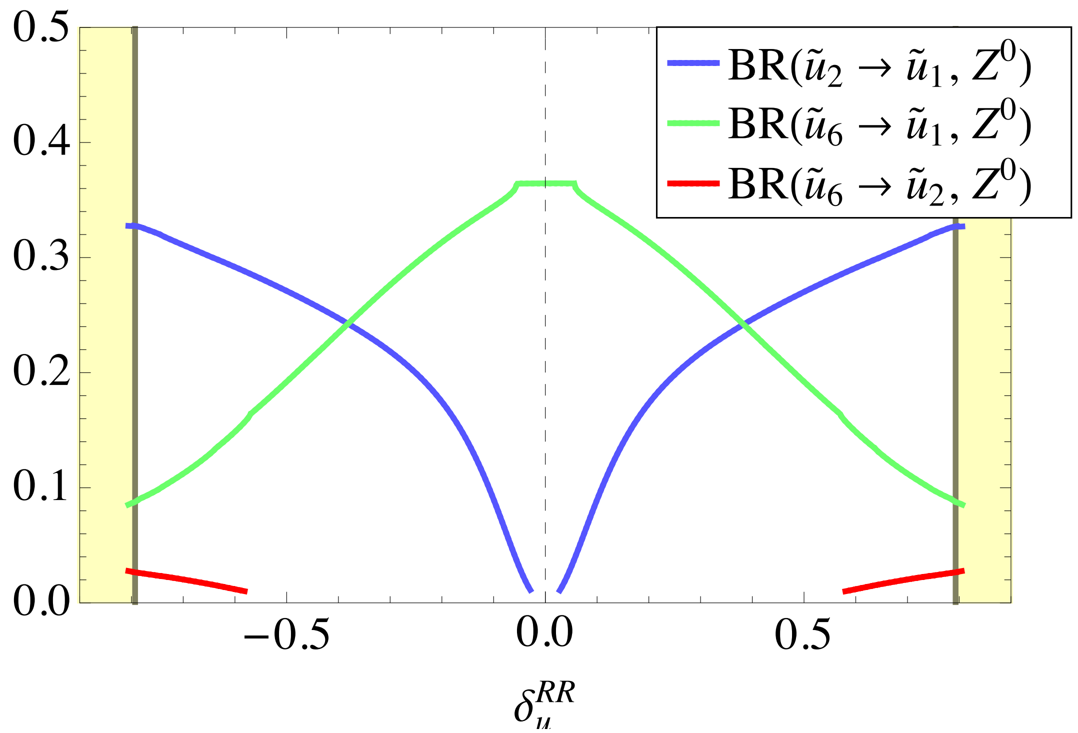
Cross-section for single-top production numerically small (due to weak interaction)

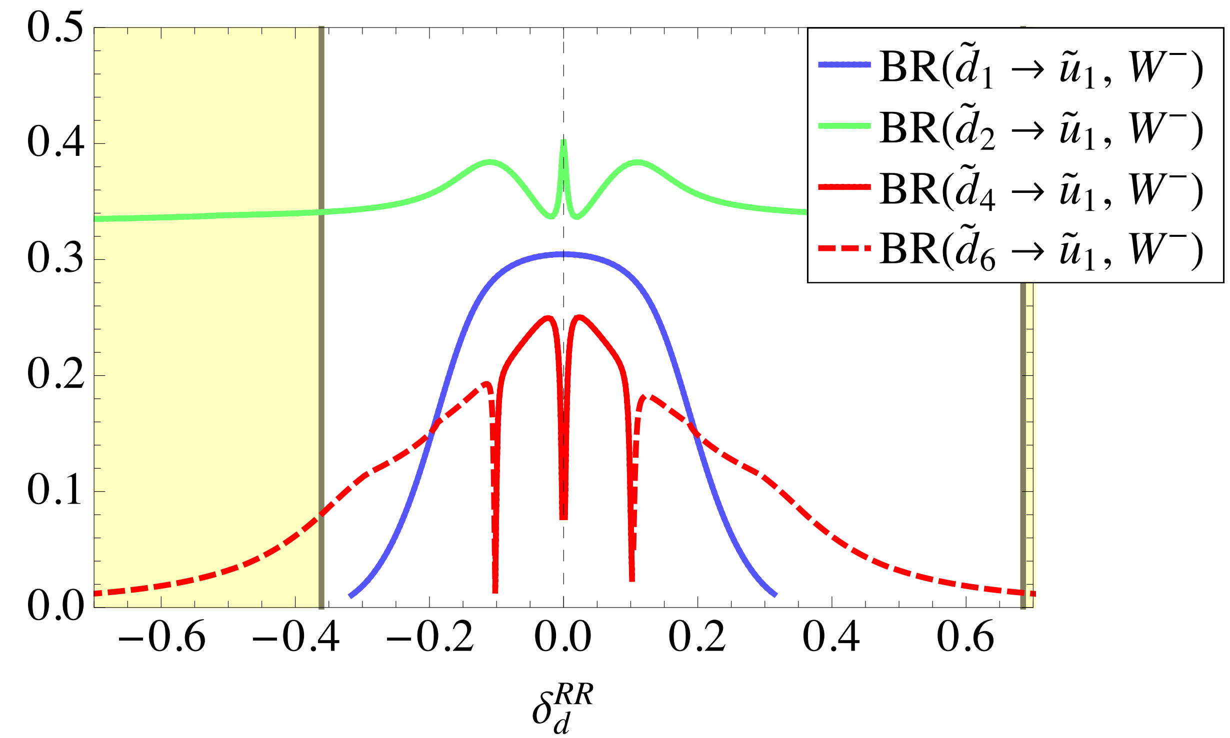
Bosonic squark decays

Bruhnke, Herrmann, Porod (2010)

Within MFV, only one (two) squark(s) can decay into a given squark plus a neutral (charged) boson

Considering NMFV, additional decay channels with the same final state can be opened due to the modified phase space and squark flavour contents





Characteristical signatures found in wide ranges of NMFV-MSSM parameter space

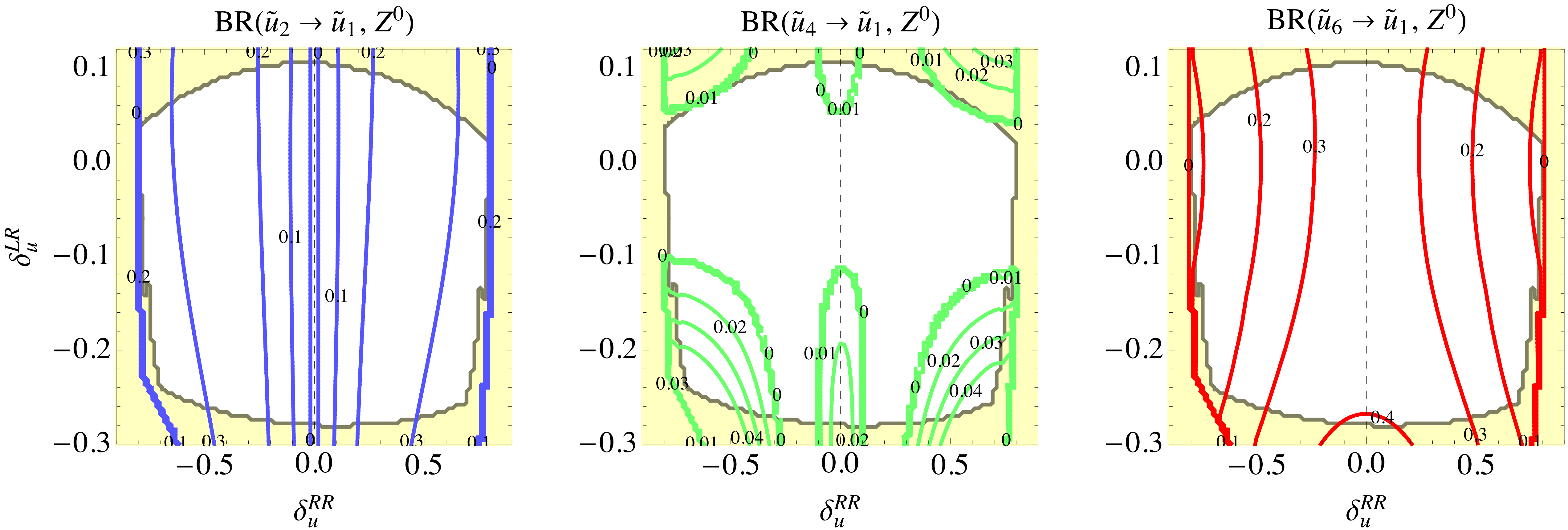
$\tilde{q}_i \to \tilde{q}_j Z^0/H^0$ for given i and (at least) two different values of j (or vice-versa)

$\tilde{q}_i \to \tilde{q}'_j W^\pm(H^\pm)$ for given i and (at least) three different values of j (or vice-versa)

If squarks are observed at LHC, bosonic modes can provide complementary information w.r.t. fermionic decays (which will be helpful for reconstruction of couplings and mass parameters)

Variation of two QFV parameters

Bruhnke, Herrmann, Porod (2010)



Each of the seven QFV-parameters has specific impact on squark generation mixing

Simultaneous variation superimposes the corresponding effects and amplifies signal patterns

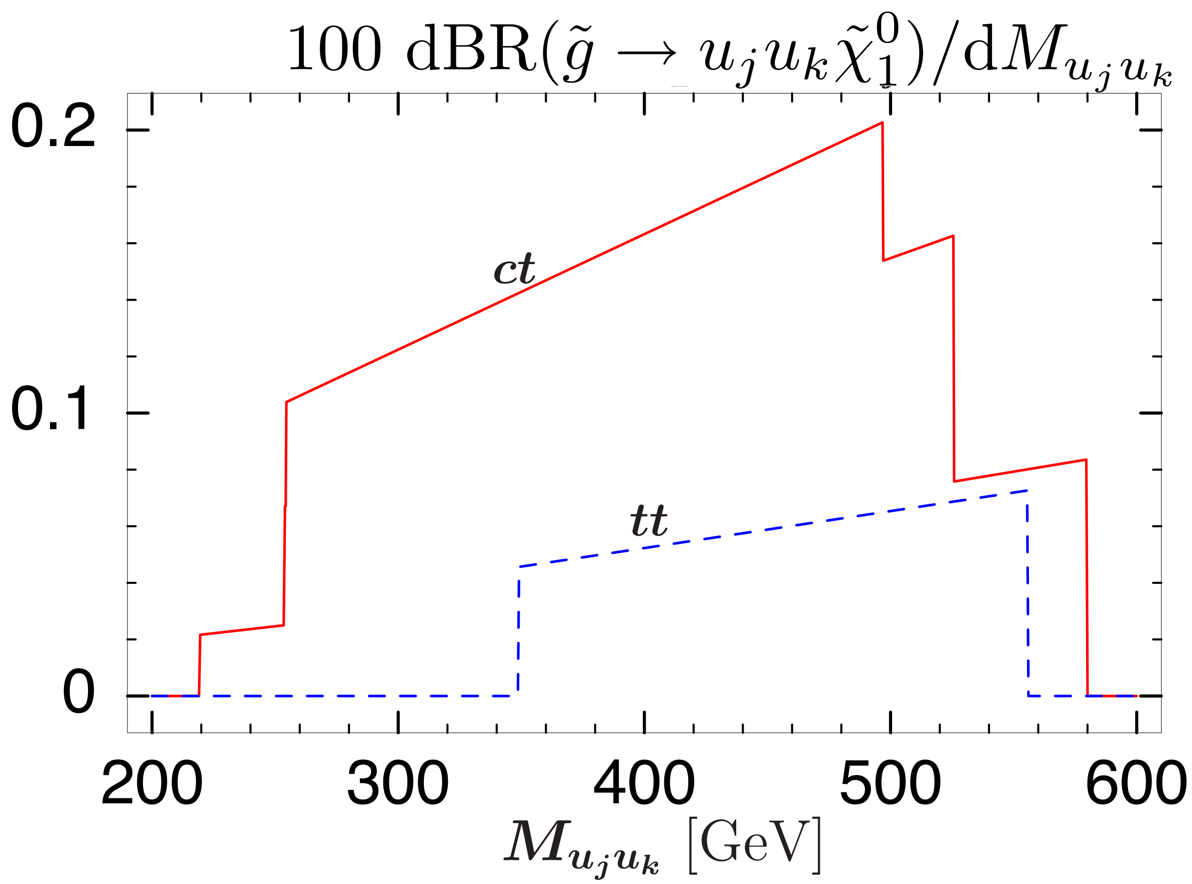
Studies of other scenarios (e.g. SPS1b, ...) show qualitatively similar signatures

However, differences in the mass spectrum lead to quantitatively different results

Signatures related to gluino production and decay

Gluino two-body decays (including subsequent squark decays)

Hurth, Porod (2009); Bartl, Hidaka, Hohenwarter-Sodek, Kernreiter, Majerotto, Porod (2009)



$$m_{\tilde{g}} = 800\ \mathrm{GeV}, \quad \delta_{23}^{uRR} = 0.144$$
$$m_{\tilde{u}_1} = 558\ \mathrm{GeV}, \quad m_{\tilde{u}_2} = 642\ \mathrm{GeV}$$

$$\mathrm{BR}(\tilde{g} \to q\tilde{q}' \to c\bar{t}\tilde{\chi}_1^0) = 46\%$$
$$\mathrm{BR}(\tilde{g} \to q\tilde{q}' \to c\bar{c}\tilde{\chi}_1^0) = 38\%$$
$$\mathrm{BR}(\tilde{g} \to q\tilde{q}' \to t\bar{t}\tilde{\chi}_1^0) = 12\%$$

Invariant mass distribution of produced quark pairs from gluino (and subsequent squark) decay

No additional edge structure for top-top final state (only ũ₁ can mediate this channel)

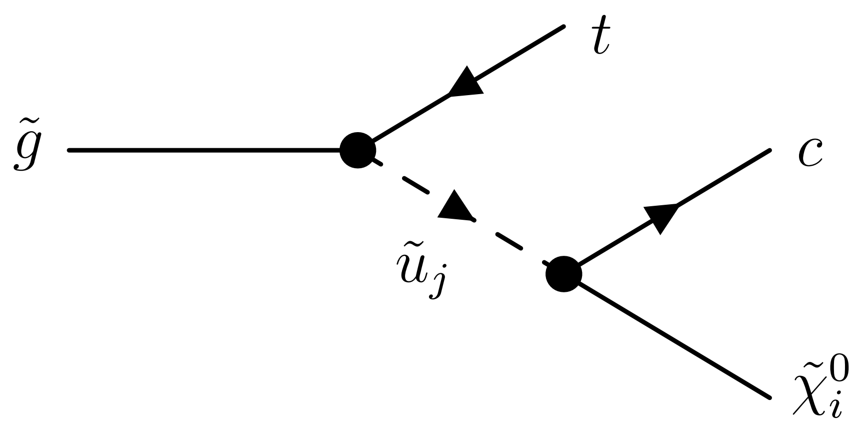
Additional (well seperated) edge structure for top-charm corresponding to kinematical endpoints

$$\tilde{g} \to t\tilde{u}_1^* \to c\bar{t}\tilde{\chi}_1^0 \qquad M_{tc} = [253, 526]\ \mathrm{GeV}$$
$$\tilde{g} \to c\tilde{u}_1^* \to c\bar{t}\tilde{\chi}_1^0 \qquad M_{tc} = [254, 580]\ \mathrm{GeV}$$
$$\tilde{g} \to c\tilde{u}_2^* \to c\bar{t}\tilde{\chi}_1^0 \qquad M_{tc} = [219, 497]\ \mathrm{GeV}$$

Gluino three-body decays

Bartl, Ginina, Eberl, Herrmann, Hidaka, Majerotto, Porod *(to be published)*

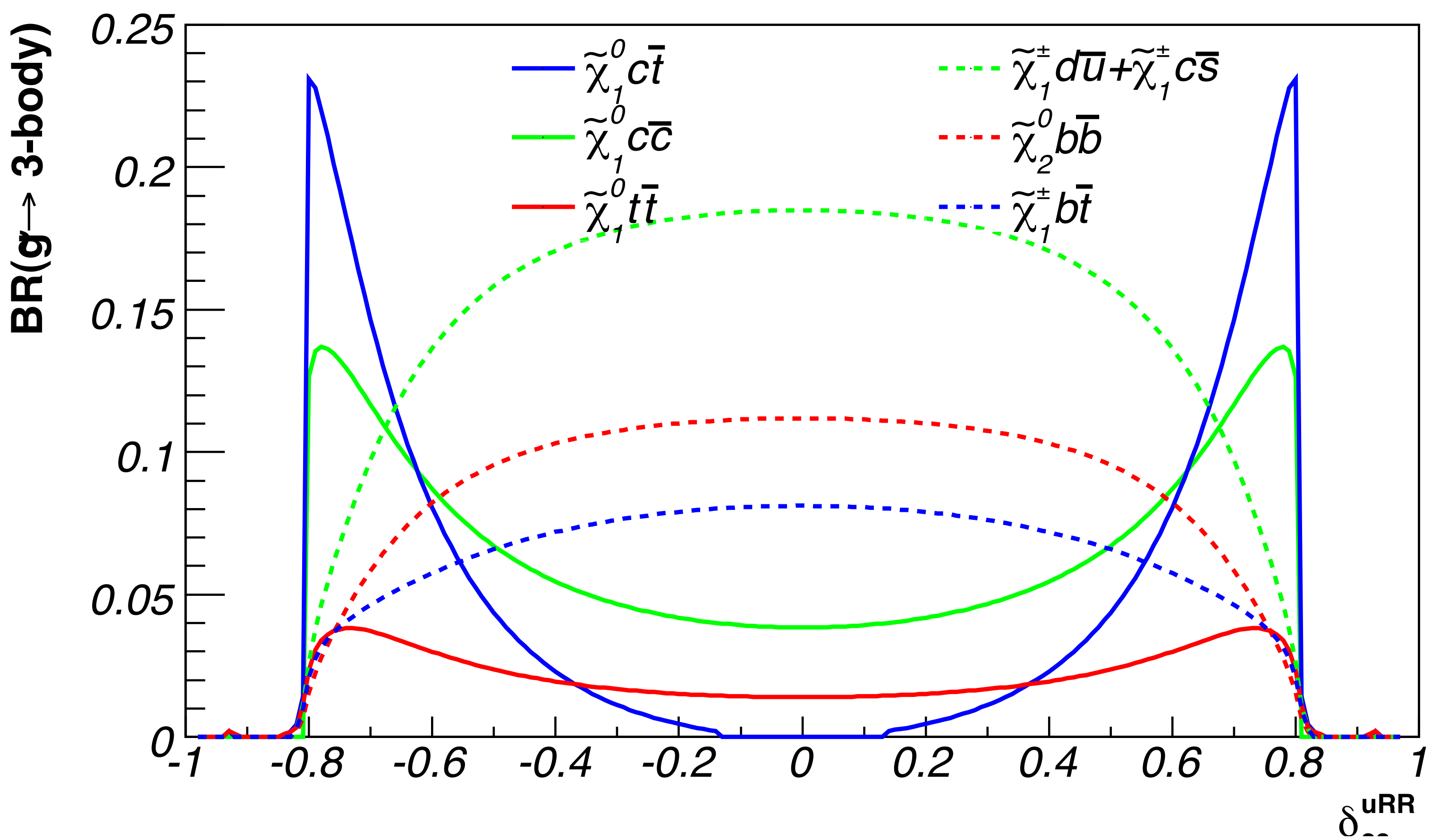
If the gluino is lighter than all squarks, three-body decays may lead to flavour-violating signatures



$$\tilde{u}_1 \sim \sin\theta\ \tilde{c}_R + \cos\theta\ \tilde{t}_R$$
$$\tilde{u}_2 \sim \cos\theta\ \tilde{c}_R - \sin\theta\ \tilde{t}_R$$

$$\Gamma_{\tilde{g}\to c\bar{t}\tilde{\chi}_1^0} \sim \underbrace{(\cos\theta\sin\theta)}_{\tilde{u}_1} + \underbrace{(-\cos\theta\sin\theta)}_{\tilde{u}_2} \sim 0$$

However, strong destructive interference between ũ₁ and ũ₂ contributions if masses are similar

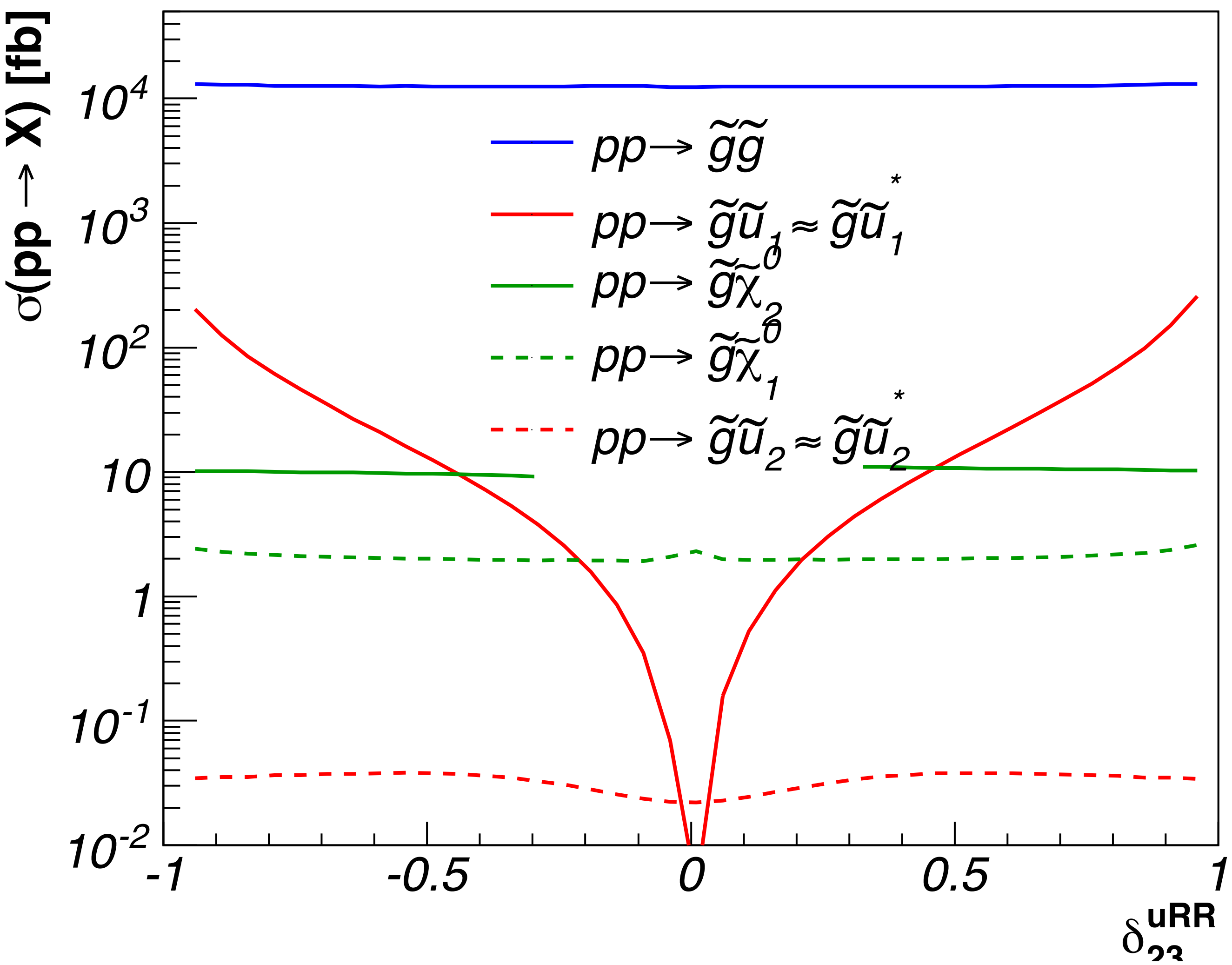


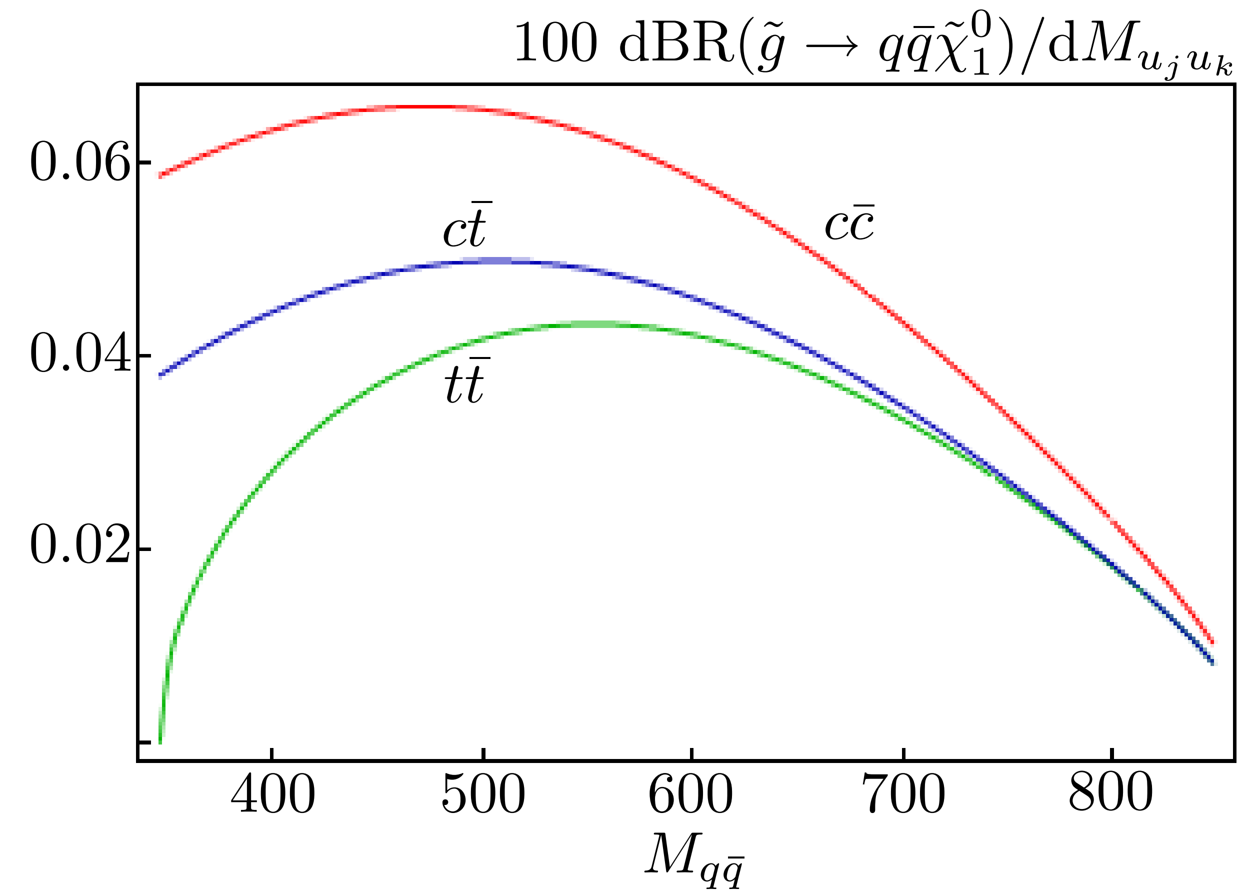
Sizeable flavour violation effects for rather large off-diagonal entries (where $m_{\tilde{g}} \lesssim m_{\tilde{u}_1}$)

For $m_{\tilde{u}_1} < m_{\tilde{g}}$, two-body decays become dominant ($\delta_{23}^{uRR} \gtrsim 0.8$)

Gluino three-body decays at LHC *(preliminary results)*

Bartl, Ginina, Eberl, Herrmann, Hidaka, Majerotto, Porod *(to be published)*





Dominating gluino pair production from gluon fusion insensitive to flavour violating couplings

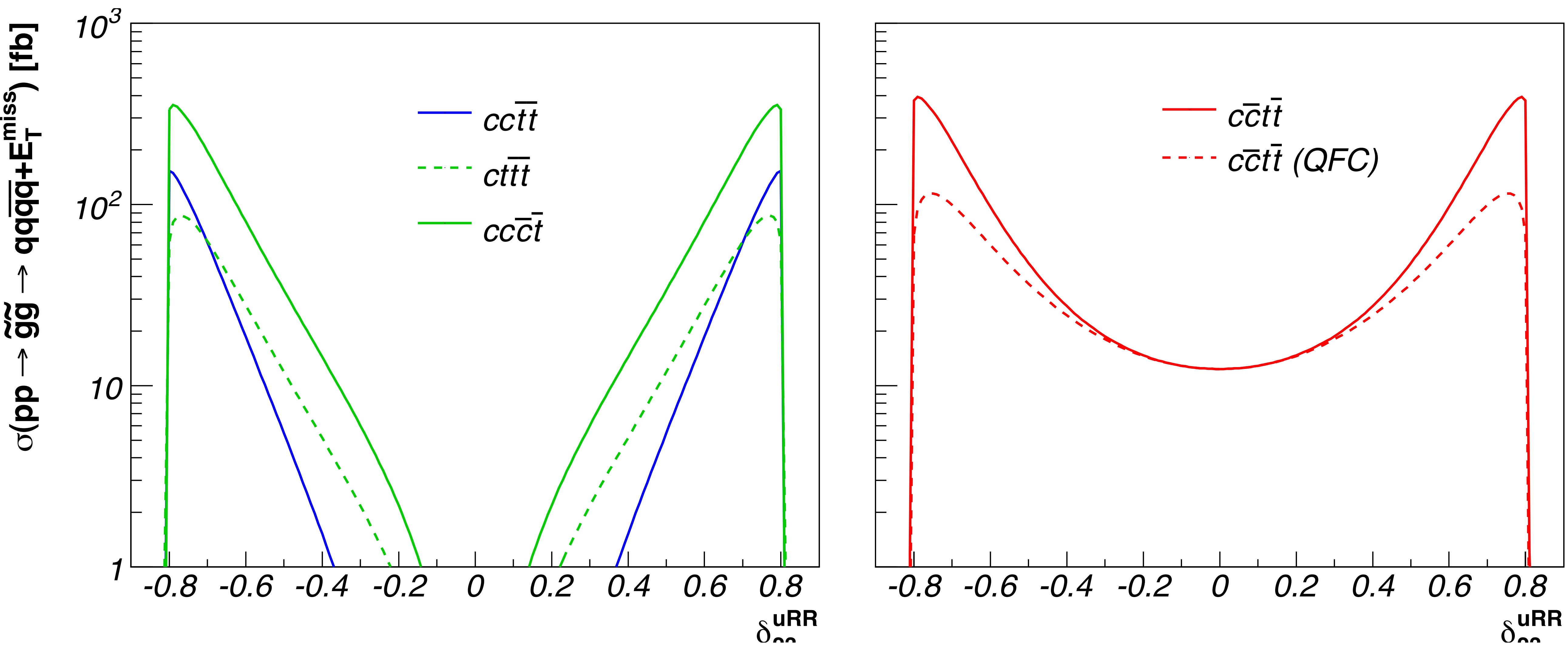
Gluino-gaugino production practically insensitive (squarks only in internal propagators)

Gluino-squark production enhanced with QFV elements due to squark flavour decomposition

Smooth invariant mass distribution (no edge structure) due to off-shell squark in the propagator

Gluino three-body decays at LHC *(preliminary results)*

Bartl, Ginina, Eberl, Herrmann, Hidaka, Majerotto, Porod *(to be published)*



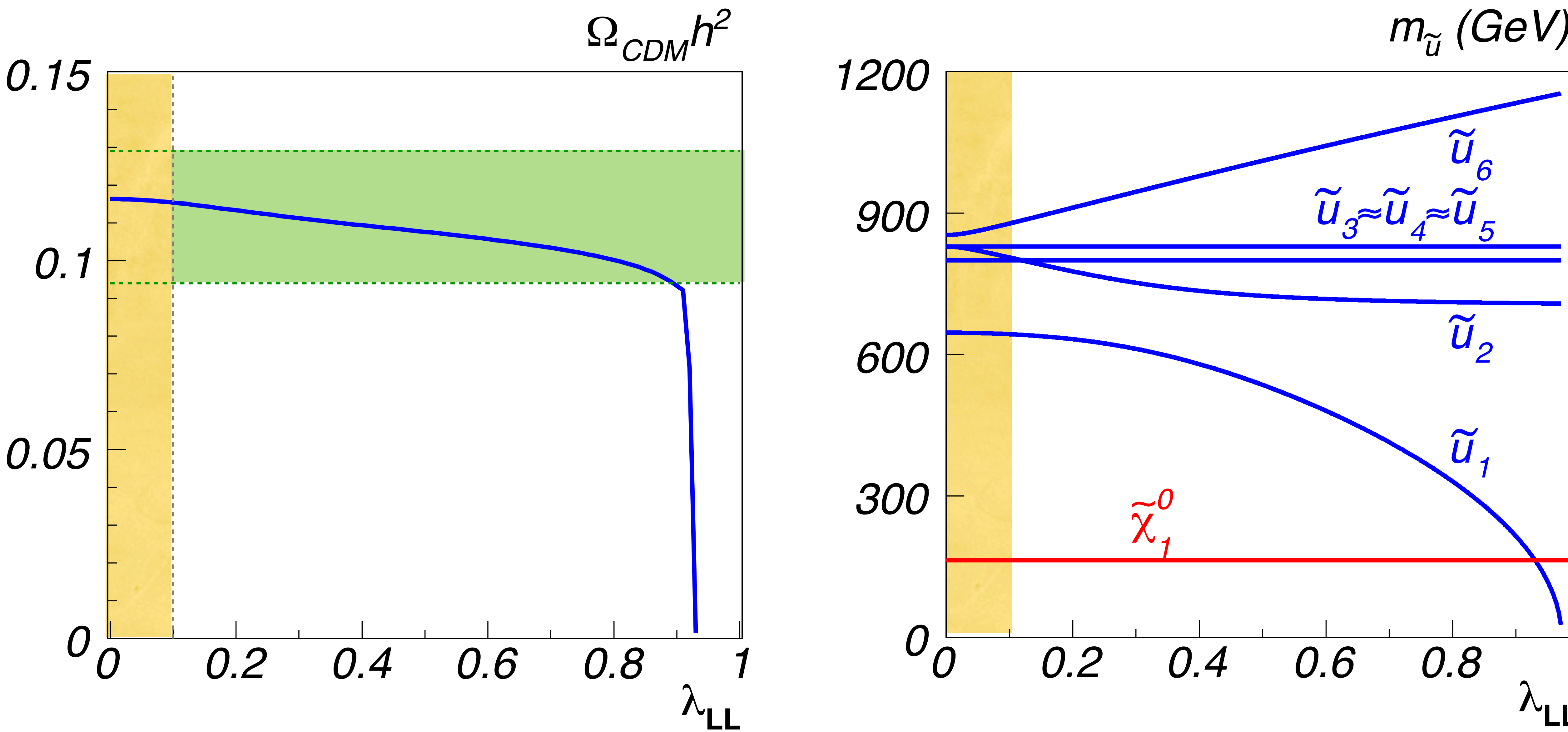
Expect up to 10^3 to 10^4 events for each signal at E_{cm}=14 TeV and L_{int}=100 fb^{-1} with contributions from flavour conserving processes (enhanced through altered squark mass)

Again, top / anti-top identification necessary and efficient charm tagging useful

Dark matter annihilation

Neutralino pair annihilation

Bozzi, Fuks, Herrmann, Klasen (2007)



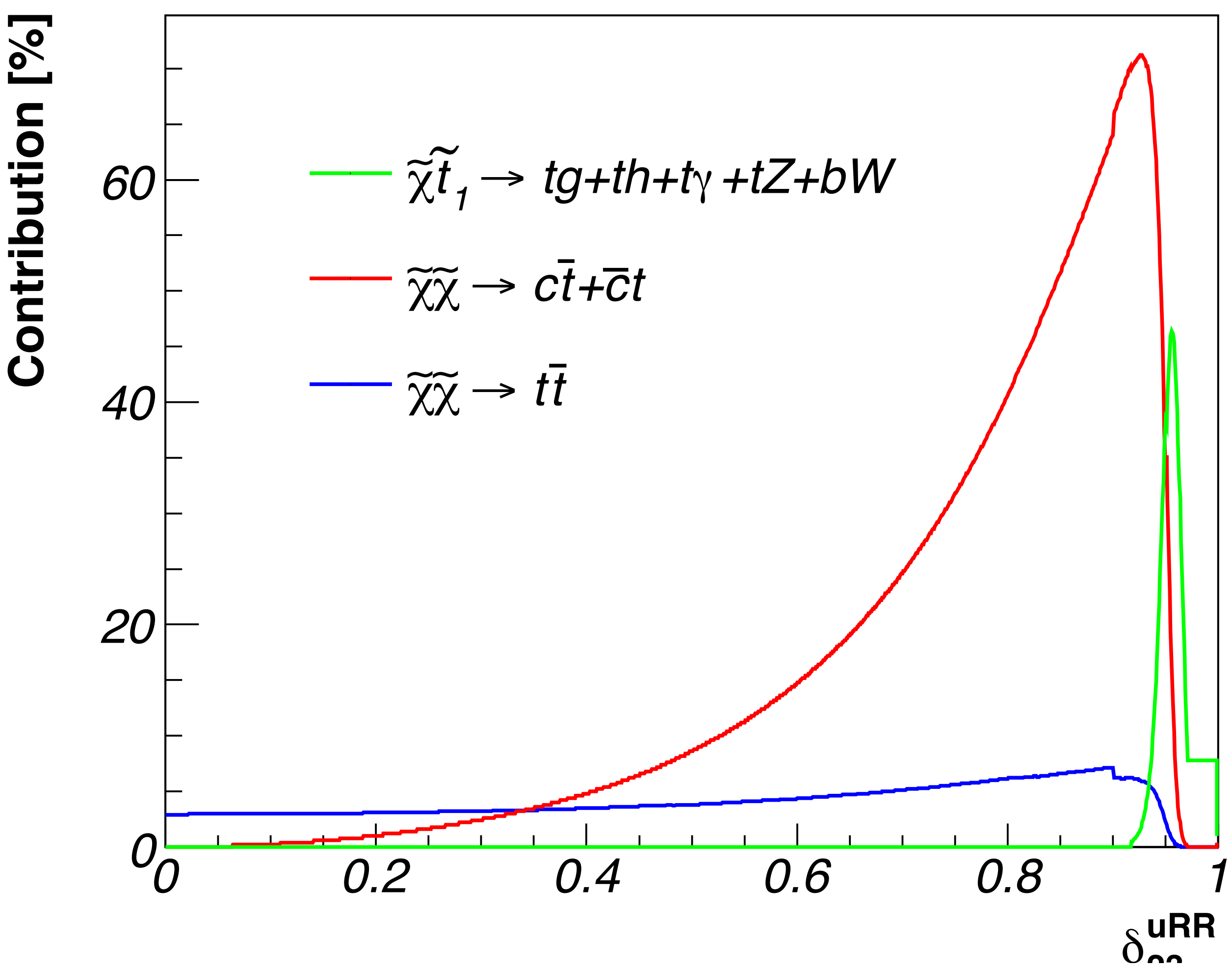
Relic density almost constant for small flavour violating entries

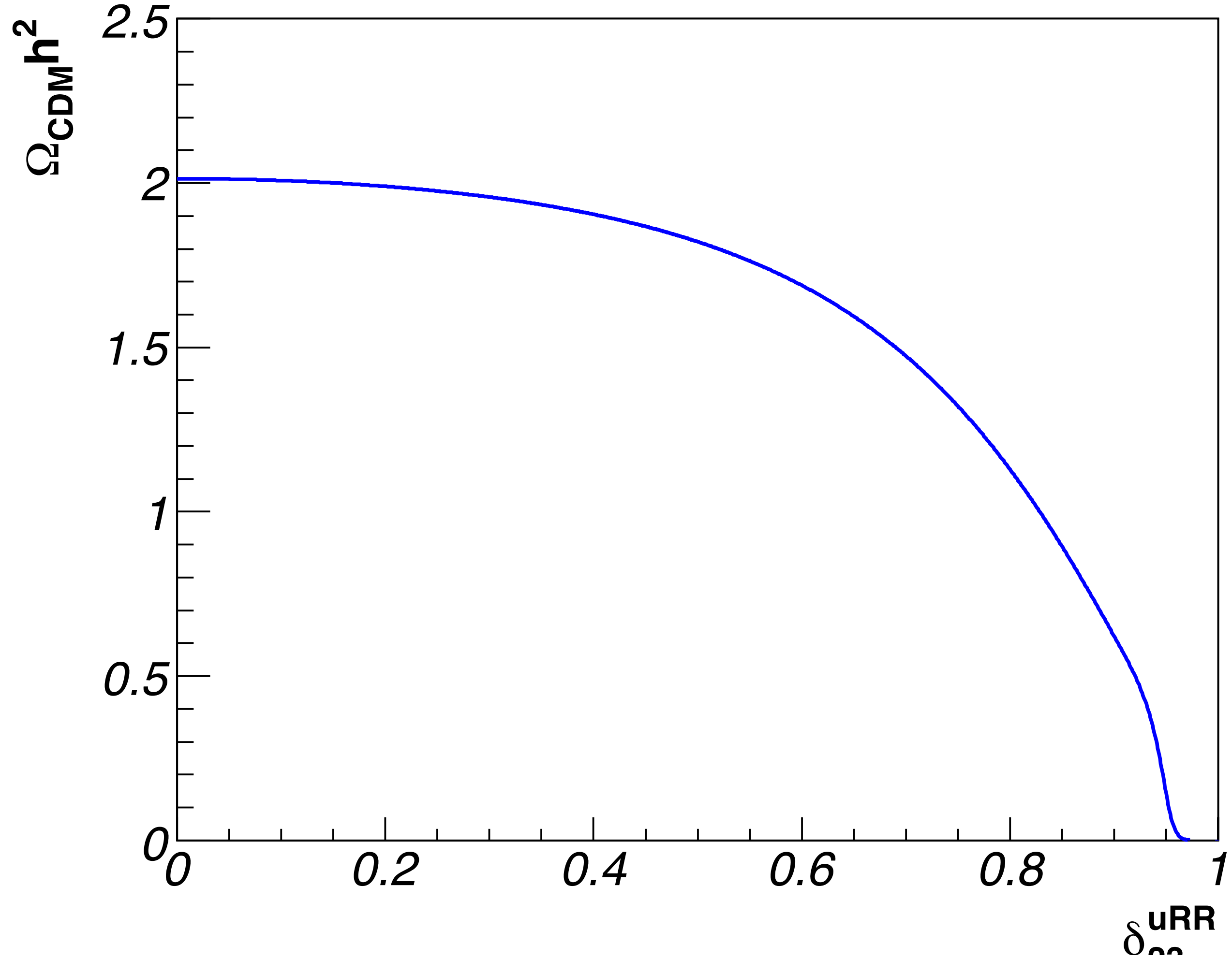
→ Squarks only appear in propagators (as also in the case of gaugino production)

Rapid fall-off when lightest squark and neutralino get close in mass due to coannihilations

Neutralino pair annihilation

Herrmann, Klasen, Le Boulc'h *(to be published)*





Flavour violating couplings can open new (co-)annihilation channels

In consequence, the relic density decreases with increasing flavour mixing

Co-annihilation mainly influenced by decreasing mass difference between squark and neutralino

Effects of rotation matrix in couplings less important in this context

Conclusion

Conclusion and Outlook

Flavour-violating terms can *a priori* be present in soft-breaking terms at the weak scale

Possibly not related to CKM-matrix but to SUSY breaking (non-minimal flavour violation)

Important impact on phenomenology (e.g. masses, flavour contents, ...)

Effect on dark matter relic density (e.g. new annihilation channels)

Observation of characteristic signatures at colliders might rule out hypothesis of MFV

New decay channels of squarks are possible in NMFV

Fermionic decays may lead to sizeable event rates at the LHC

$$p\,p \;\rightarrow\; \tilde{u}_{1,2}\,\tilde{u}^*_{1,2} \;\rightarrow\; c\,\bar{t}\;\tilde{\chi}^0_1\,\tilde{\chi}^0_1 \qquad\qquad p\,p \rightarrow \tilde{g}\,\tilde{g} \rightarrow c\,c\,\bar{t}\,\bar{t}\;\tilde{\chi}^0_1\,\tilde{\chi}^0_1$$

Bosonic decays may give additional information (once squarks are observed)

$$\tilde{q}_i \rightarrow \tilde{q}_j\,Z^0/H^0 \qquad\qquad \tilde{q}_i \rightarrow \tilde{q}'_j\,W^{\pm}/H^{\pm}$$

→ **This clearly calls for detailed Monte-Carlo studies**

Explore feasibility in current collider experiments

Determine regions of parameter space where signals would be observable

[Herrmann, Porod *(in preparation)*]