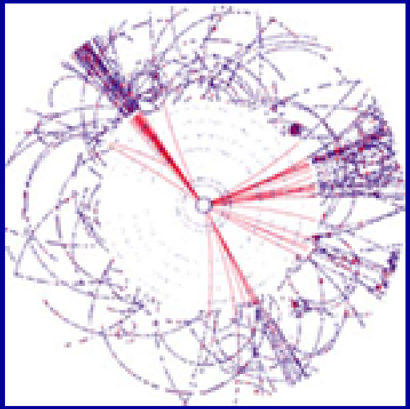
Flavour violating squark and gluino decays at LHC



K. Hidaka
Tokyo Gakugei University

In collaboration with
A. Bartl, H. Eberl, E. Ginina, B. Herrmann,
W. Majerotto and W. Porod

(A part of this work is published in Phys. Rev. D84 (2011) 115026;
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Contents

1. Introduction

- *If weak scale SUSY is realized in nature, gluinos and squarks will have high production rates for masses up to O(1) TeV at LHC.*

- *The main decay modes of gluinos and squarks are usually assumed to be quark-flavour conserving (QFC).*

- *However, squark generation mixings can induce quark-flavour violating (QFV) decays of gluinos and squarks.*

- *Here we study the effect of squark generation mixing on squark and gluino production and decays at LHC in the general MSSM with focus on mixing between 2nd and 3rd generation squarks.*

2. MSSM with QFV

- **The basic parameters of the MSSM with QFV:**

$\{\tan\beta, m_A, M_1, M_2, M_3, \mu, M^2_{Q,\alpha\beta}, M^2_{U,\alpha\beta}, M^2_{D,\alpha\beta}, T_{U\alpha\beta}, T_{D\alpha\beta}\}$

(at $Q = 1\,TeV$ scale (SPA convention)) $(\alpha, \beta = 1,2,3 = u, c, t$ or $d, s, b)$

$\tan\beta$: ratio of VEV of the two Higgs doublets $<H^0{}_2>/<H^0{}_1>$

m_A: CP odd Higgs boson mass (pole mass)

M_1, M_2, M_3: U(1), SU(2), SU(3) gaugino masses

μ: higgsino mass parameter

$M^2_{Q,\alpha\beta}$: left squark soft mass matrix

$M^2_{U\alpha\beta}$: right up-type squark soft mass matrix

$M^2_{D\alpha\beta}$: right down-type squark soft mass matrix

$T_{U\alpha\beta}$: trilinear coupling matrix of up-type squark and Higgs boson

$T_{D\alpha\beta}$: trilinear coupling matrix of down-type squark and Higgs boson

QFV parameters in our study are:

M^2_{Q23} : $\tilde{c}_L - \tilde{t}_L$ mixing term

M^2_{U23} : $\tilde{c}_R - \tilde{t}_R$ mixing term

T_{U23} : $\tilde{c}_L - \tilde{t}_R$ mixing term

T_{U32} : $\tilde{c}_R - \tilde{t}_L$ mixing term

(Note) We work in the super-CKM basis of squarks.

3. *Constraints on the MSSM*

Recent ATLAS and CMS SUSY searches at 7TeV with ~1-5 fb^{-1}

In a simplified model;

gluino mass > 800 GeV
squark mass > 850 GeV (for 1st & 2nd generation squarks)

In the context of the CMSSM (mSUGRA);

gluino mass > 840 GeV
squark mass > 1100 GeV (for 1st & 2nd generation squarks)

Respecting these limits, we assume a gluino mass of about 1 TeV in our analysis

(Note) *We also respect the constraint on (m_A, $\tan\beta$) from the recent MSSM Higgs boson search at LHC [arXiv:1202.4083].*

The following constraints are imposed in our analysis in order to respect experimental and theoretical constraints:

(a) Constraints from the B-physics experiments :

$2.87\times10^{-4} < B(b\to s\,\gamma) < 4.23\times10^{-4}$ (95% CL) (HFAG2010)

$0.60\times10^{-6} < B(b\to s\,\ell^+\ell^-) < 2.60\times10^{-6}$ (with $\ell = e$ or μ) (95% CL) (BELLE, BABAR)

$B(B_s\to\mu^+\mu^-) < 4.5\times10^{-9}$ (95% CL) (LHCb)

$B(B_u^+\to\tau^+\,\nu) = (1.68\pm0.31)\times10^{-4}$ (68% CL) (BELLE, BABAR)

$\Delta M_{B_s} = 17.77\pm0.12\ ps^{-1}$ (68% CL) (CDF) $\Delta M_{B_s} = 17.63\pm0.11\ ps^{-1}$ (68% CL) (LHCb)

(b) LEP limits on sparticle masses

(ex) $m_{\tilde{\chi}_1^\pm} > 103\ GeV$ *etc.*

(c) The experimental limit on SUSY contributions to the electroweak ρ parameter:

$\Delta\rho(SUSY) < 0.0012$

(d) Vacuum stability conditions on trilinear couplings

(see J.A. Casas and S. Dimopoulos, Phys. Lett. B 387 (1996) 107 [hep-ph/9606237].)

(ex) $|T_{U\,23}|^2 < h_t^2(M_{Q_L\,22}^2 + M_{U\,33}^2 + m_2^2)$ *etc.*

with $m_2^2 = (m_{H_2}^2 + m_Z^2\sin^2\theta_W)\cos^2\beta - \frac{1}{2}m_Z^2$

4. QFV gluino 3-body decays

4.1 QFV Benchmark Scenario

We take the following scenario as our prototype QFV scenario:

Table 2: Weak scale parameters at $Q = 1$ TeV for our prototype QFV scenario, except for m_{A^0} which is the pole mass (i.e. physical mass) of A^0. All of $T_{U\alpha\alpha}$ and $T_{D\alpha\alpha}$ are 0.

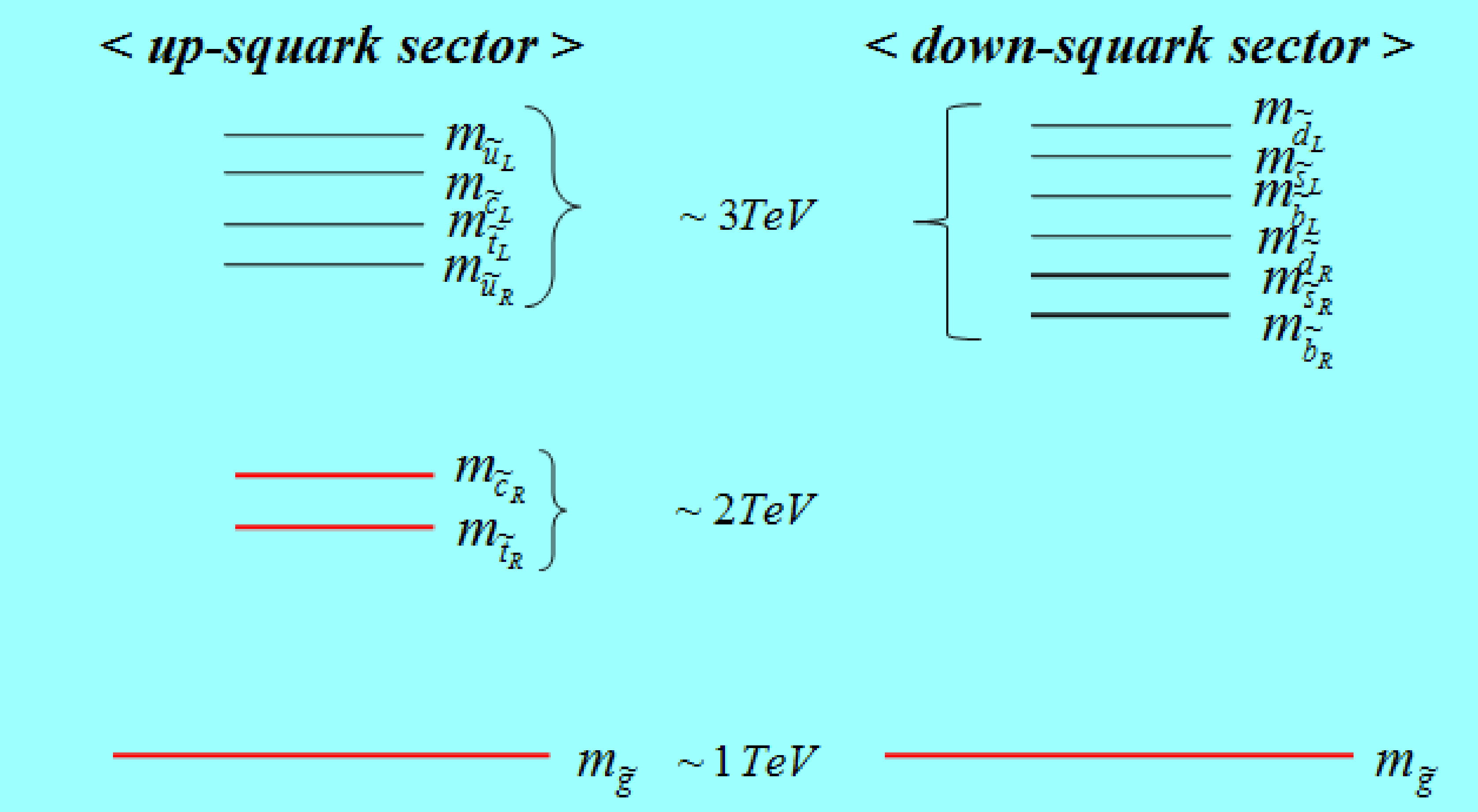
M_1	M_2	M_3	μ	$\tan\beta$	m_{A^0}
139 GeV	264 GeV	800 GeV	1000 GeV	10	800 GeV

	$\alpha = \beta = 1$	$\alpha = \beta = 2$	$\alpha = \beta = 3$
$M^2_{Q\alpha\beta}$	$(3150)^2$ GeV^2	$(3100)^2$ GeV^2	$(3050)^2$ GeV^2
$M^2_{U\alpha\beta}$	$(3000)^2$ GeV^2	$(2200)^2$ GeV^2	$(2150)^2$ GeV^2
$M^2_{D\alpha\beta}$	$(3000)^2$ GeV^2	$(2990)^2$ GeV^2	$(2980)^2$ GeV^2

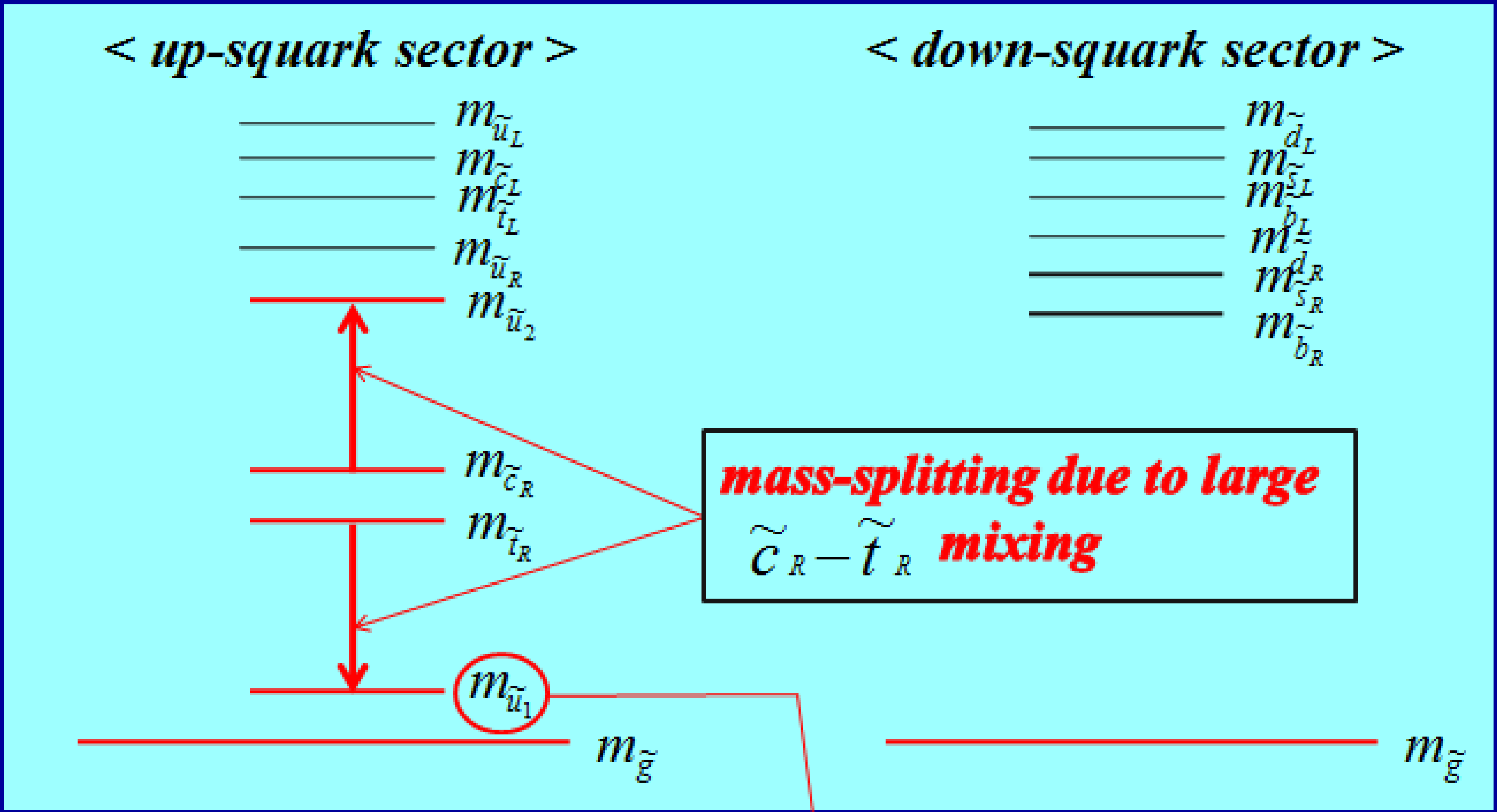
We add QFV parameters (i.e. squark-generation mixing parameters) to this scenario:

$M^2_{Q,\alpha\beta}$, $M^2_{U,\alpha\beta}$, $M^2_{D,\alpha\beta}$, $T_{U\alpha\beta}$, $T_{D\alpha\beta}$ $(\alpha\neq\beta)$

Prototype QFV scenario



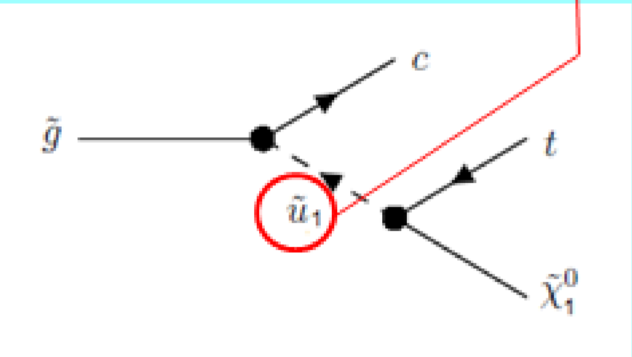
We add $\tilde{c}_R - \tilde{t}_R$ mixing to this scenario



In this large $\tilde{c}_R - \tilde{t}_R$ mixing scenario all squarks other than $\tilde{u}_1$ are very heavy. So, gluino decay is dominated by virtual $\tilde{u}_1$ exchange.

In this large $\tilde{c}_R - \tilde{t}_R$ mixing scenario;

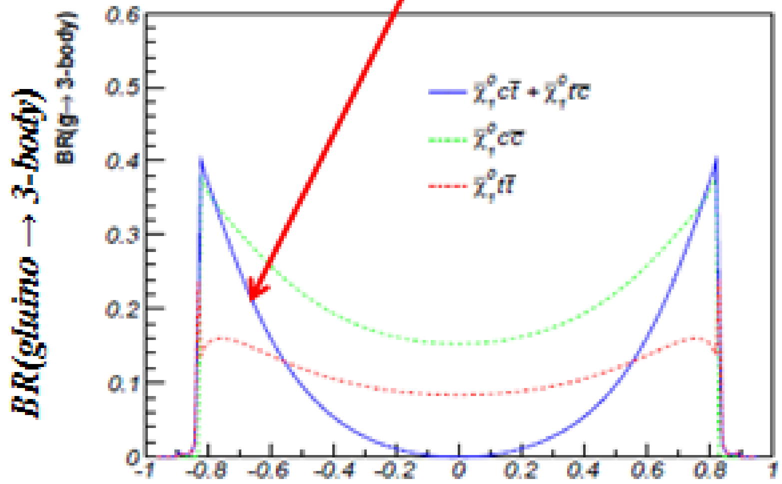
- ***Gluino decay is dominated by virtual $\tilde{u}_1$ exchange contribution.***
- ***$\tilde{u}_1$ is a strong mixture of $\tilde{c}_R$ and $\tilde{t}_R$.***



QFV branching ratio $B(\tilde{g} \to c\bar{t}\tilde{\chi}_1^0)$ could be very large!

4.2 Impact of squark generation mixing on gluino 3-body decays

QFV decay BR $B(\tilde{g} \to c\,\bar{t}\,\tilde{\chi}_1^0) + B(\tilde{g} \to t\,\bar{c}\,\tilde{\chi}_1^0)$



$\tilde{c}_R - \tilde{t}_R$ **mixing parameter** → δ_{23}^{uRR}

$$\delta_{\alpha\beta}^{uRR} \equiv M^2_{\tilde{U}\alpha\beta} / \sqrt{M^2_{\tilde{U}\alpha\alpha} M^2_{\tilde{U}\beta\beta}}$$

Figure 4: The branching ratios of the decays $\tilde{g} \to c\bar{t}\tilde{\chi}_1^0 + \bar{c}t\tilde{\chi}_1^0$, $\tilde{g} \to c\bar{c}\tilde{\chi}_1^0$ and $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$ as functions of δ_{23}^{uRR} for the other QFV parameters being zero and the other parameters are fixed as in Table 2.

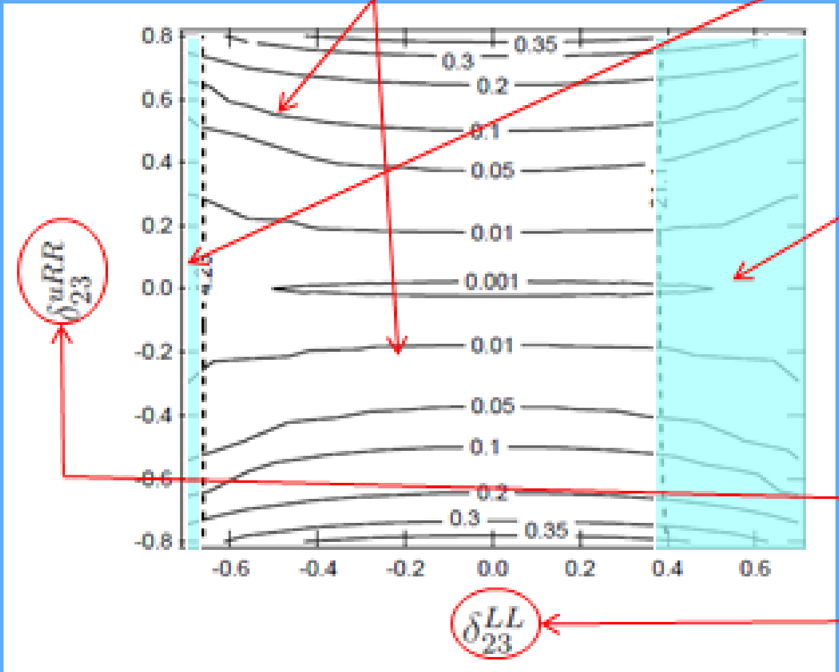
QFV gluino decay branching ratio $B(\tilde{g} \to ct\,\tilde{\chi}_1^0)$ **can be very large (up to ~40%) for large** $\tilde{c}_R - \tilde{t}_R$ **mixing parameter** δ_{23}^{uRR} **!**

Contour plots of QFV BR in our scenario

$B(\tilde{g} \to ct\tilde{\chi}_1^0)$ ***contours***

excluded by $B(b \to s\gamma)$ ***data***

excluded by ΔM_{Bs} ***data***



$$\delta_{\alpha\beta}^{uLL} \equiv M_{Q\alpha\beta}^2 / \sqrt{M_{Q\alpha\alpha}^2 M_{Q\beta\beta}^2}$$

$$\delta_{\alpha\beta}^{uRR} \equiv M_{U\alpha\beta}^2 / \sqrt{M_{U\alpha\alpha}^2 M_{U\beta\beta}^2}$$

$\tilde{c}_R - \tilde{t}_R$ ***mixing parameter***

$\tilde{c}_L - \tilde{t}_L$ ***mixing parameter***

The QFV decay branching ratio $B(\tilde{g} \to ct\tilde{\chi}_1^0)$ ***can be very large (up to ~40%) in a significant part of the*** $\delta_{23}^{uLL} - \delta_{23}^{uRR}$ ***plane allowed by all of the constraints.***

This can lead to large QFV effects at LHC!

4.3 Impact on gluino signals at LHC

Example of QFV gluino signal at LHC

Gluino pair production and the QFV gluino 3-body decay $\tilde{g} \to t\bar{c}\tilde{\chi}_1^0$ lead to

QFV gluino signature at LHC :

$$pp \to \tilde{g}\tilde{g}X \to (t\bar{c}\tilde{\chi}_1^0)(t\bar{c}\tilde{\chi}_1^0)X$$

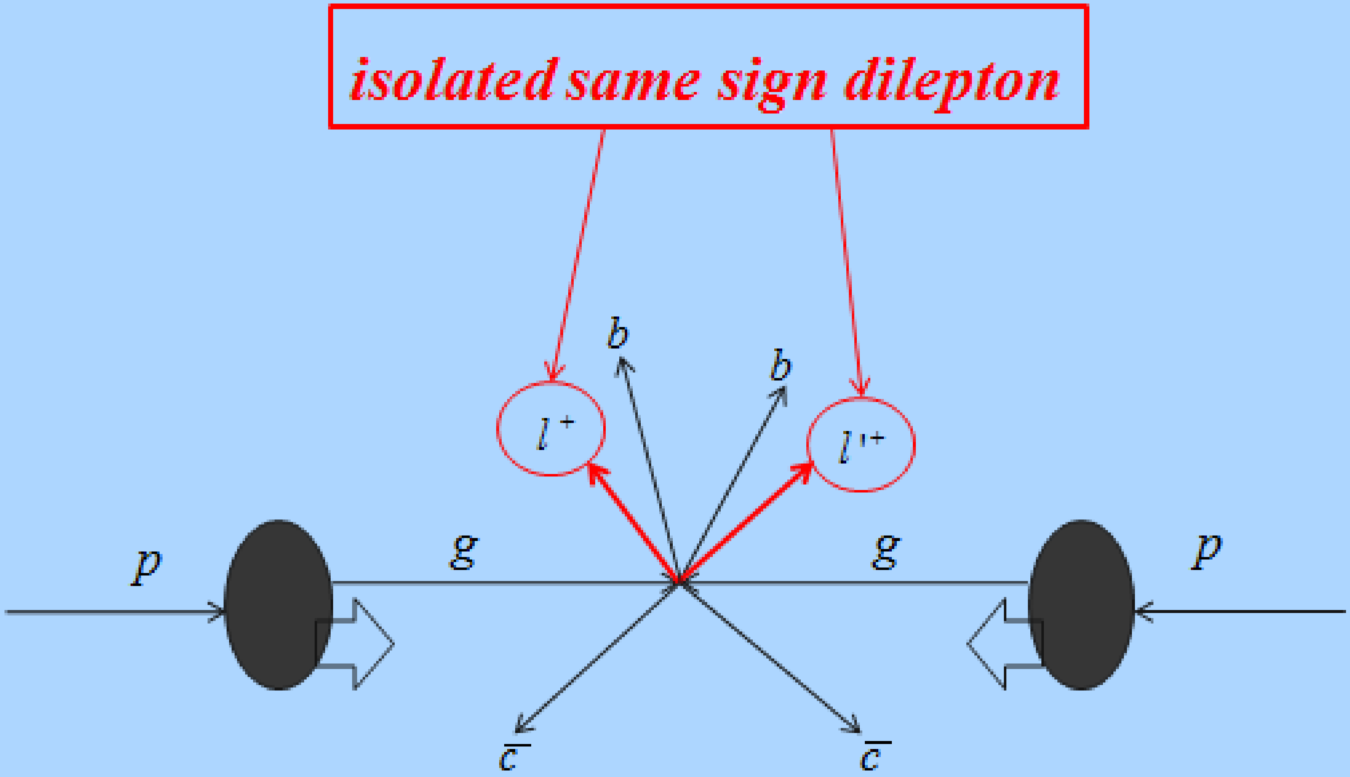
↓

'top-quark + top-quark + 2 jets + missing-E_T + beam-jets'

↓ $t \to bW^+ \to bl^+\nu$

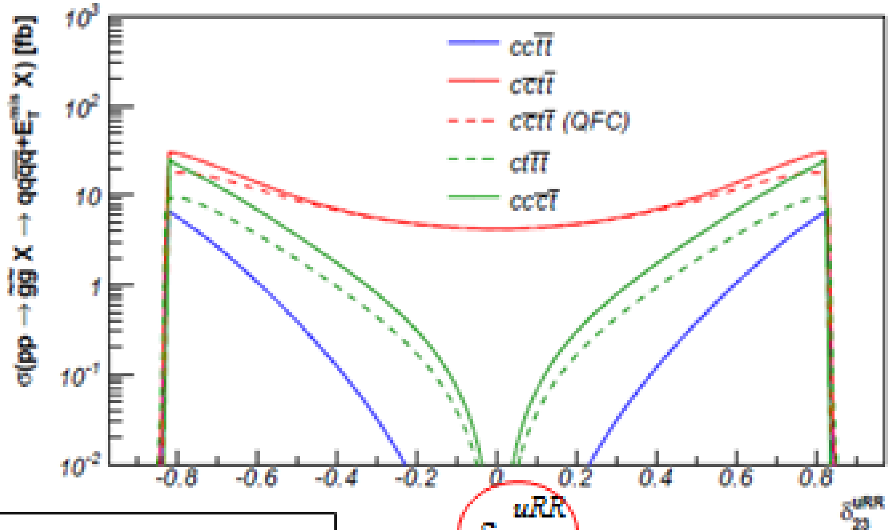
'isolated same sign dilepton + 4 jets + missing-E_T + beam-jets'

Example of QFV gluino signal at LHC



'isolated same sign dilepton + 4 jets + missing-E_T + beam-jets'

QFV gluino signal rates at LHC



$\tilde{c}_R - \tilde{t}_R$ *mixing parameter* → δ_{23}^{uRR}

Figure 9: Signal rates for $pp \to \tilde{g}\tilde{g}X$ at $\sqrt{s} = 14$ TeV where at least one of the gluinos decays as $\tilde{g} \to c\bar{t}(\bar{c}t)\tilde{\chi}_1^0$, as a function of δ_{23}^{uRR} with the other QFV parameters being zero and the other parameters fixed as in Table 2. Shown are the rates for the final states with $cc\bar{t}\bar{t}E_T^{mis}$ (full blue line), $c\bar{c}t\bar{t}E_T^{mis}$ (QFV + QFC) (full red line), $c\bar{c}t\bar{t}E_T^{mis}$ (QFC only) (dashed red line), $ct\bar{t}\bar{t}E_T^{mis}$ (dashed green line), $cc\bar{c}\bar{t}E_T^{mis}$ (full green line).

QFV signal rates such as $\sigma(pp \to \tilde{g}\tilde{g}\, X \to t\,t\,\bar{c}\,\bar{c}\,\tilde{\chi}_1^0\tilde{\chi}_1^0\, X \to t\,t\,\bar{c}\,\bar{c}\, E_T^{mis} X)$

can be significant for large $\tilde{c}_R - \tilde{t}_R$ ***mixing parameter*** δ_{23}^{uRR} ***at LHC!***

5. QFV squark bosonic decays

5.1 QFV Benchmark Scenario

We take the following scenario as our prototype QFV scenario:

decoupling Higgs scenario

These weak scale parameters are defined at $Q = 1$ TeV scale (SPA convention).

$(M_1, M_2, M_3) = (450, 855, 1000)$ GeV

$\mu = 2400$ GeV, $\tan\beta = 20$, $m_A(\text{pole}) = 1500$ GeV

(M^2_Q11, M^2_Q22, M^2_Q33) = (2400^2, 2360^2, 1450^2) GeV^2

(M^2_U11, M^2_U22, M^2_U33) = (2380^2, 780^2, 750^2) GeV^2

(M^2_D11, M^2_D22, M^2_D33) = (2380^2, 2340^2, 2300^2) GeV^2

All of $T_{U\alpha\alpha}$ and $T_{D\alpha\alpha}$ are zero, except $T_{U33} = -2160$ GeV.

large $\tilde{t}_L - \tilde{t}_R$ mixing scenario
(large top-trilinear-coupling scenario)

We add QFV parameters (i.e. squark-generation mixing parameters) to this scenario: $M^2_{Q,\alpha\beta}$, $M^2_{U,\alpha\beta}$, $M^2_{D,\alpha\beta}$, $T_{U\alpha\beta}$, $T_{D\alpha\beta}$ $(\alpha \neq \beta)$

Physical masses in the prototype QFV scenario

$$m_{h^0} = 125.5\ GeV$$

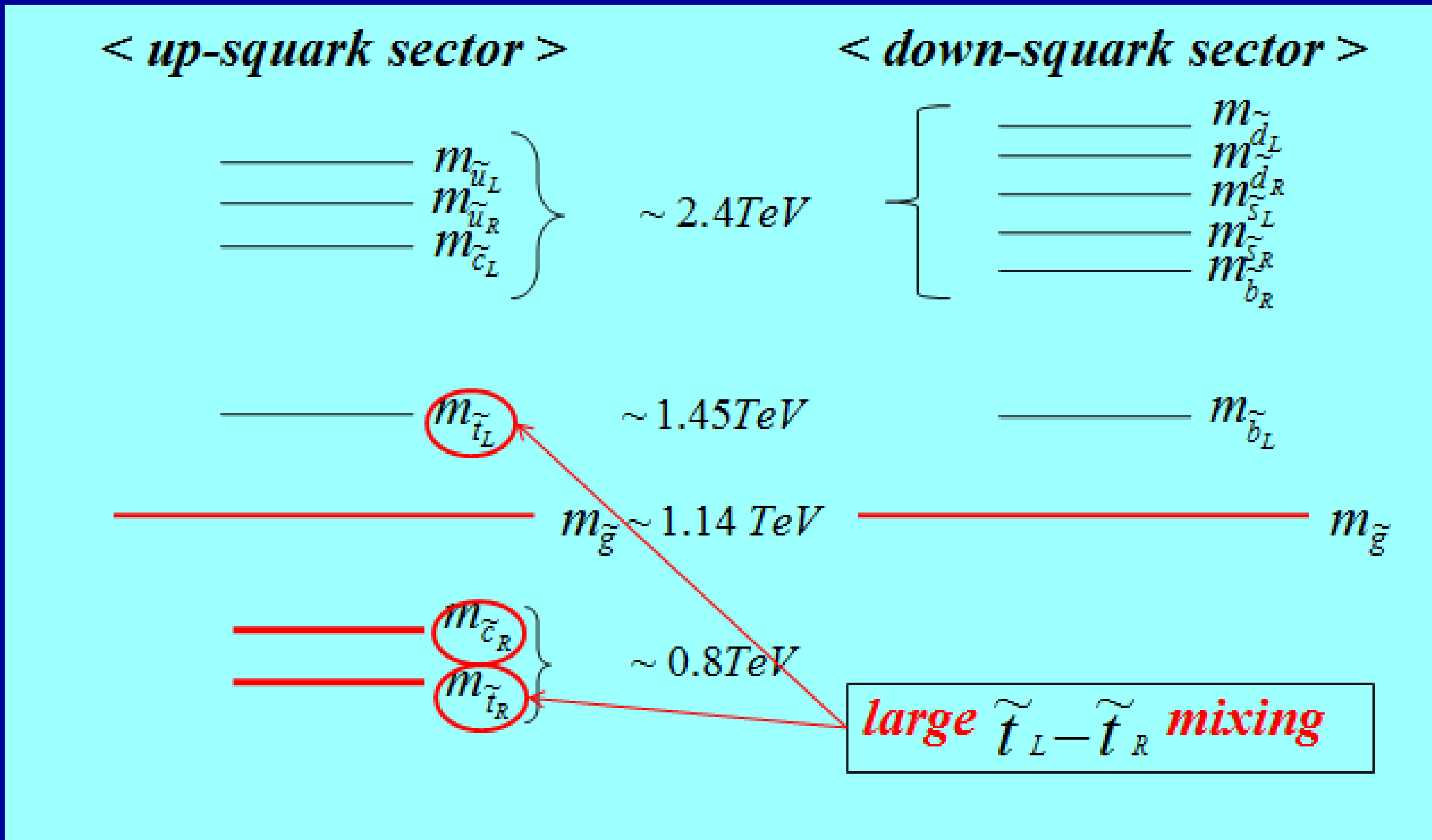
$$m_{H^0} \cong m_{H^+} \cong m_{A^0} = 1500\ GeV$$

$$m_{\tilde{g}}^{pole} = 1141 GeV$$

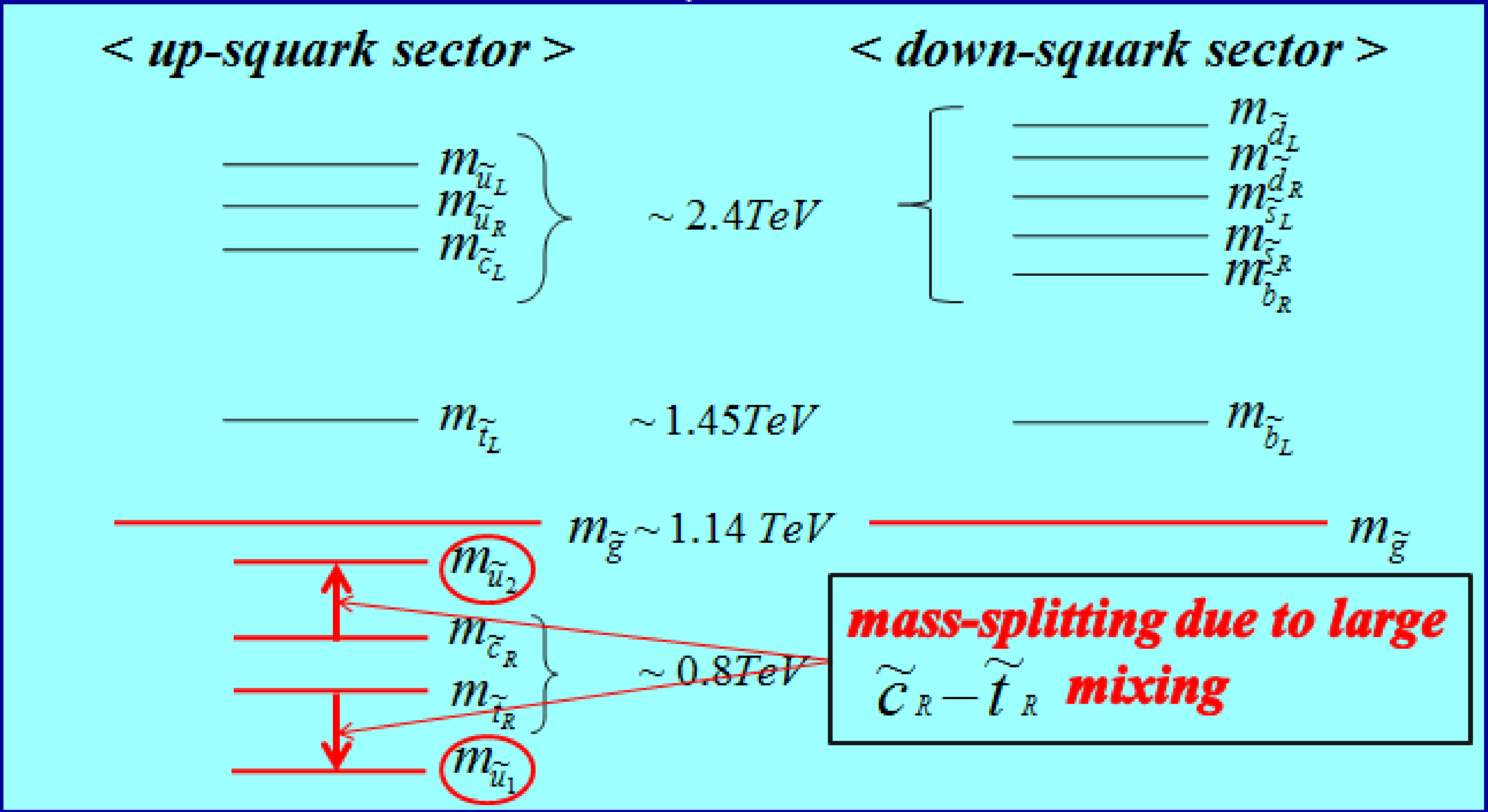
- *CP-even lighter Higgs boson h^0 is SM-like!*
- *its mass m_{h^0} = 125.5 GeV is in the LHC "possible Higgs signal" range ! : 122 < m_{h^0} < 128GeV.*

These masses are fairly insensitive to the QFV parameters.

Prototype QFV scenario



We add $\tilde{c}_R - \tilde{t}_R$ *mixing to this scenario*



large mass splitting between $m_{\tilde{u}_1}$ and $m_{\tilde{u}_2}$!

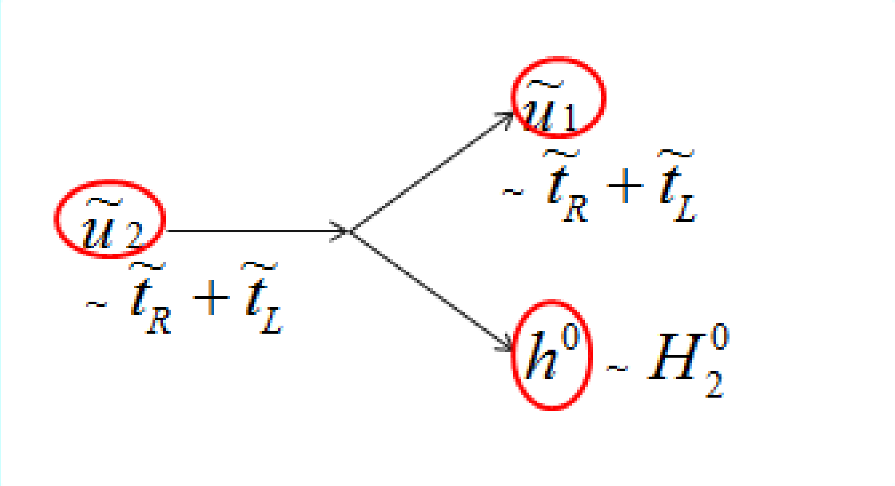
$B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ ***could be sizable!***

In this large $\tilde{t}_L - \tilde{t}_R$ & $\tilde{c}_R - \tilde{t}_R$ mixing scenario;

$\tilde{u}_1 \sim \tilde{t}_R + \tilde{c}_R + \tilde{t}_L$

$\tilde{u}_2 \sim \tilde{c}_R + \tilde{t}_R + \tilde{t}_L$

$h^0 \sim H_2^0$



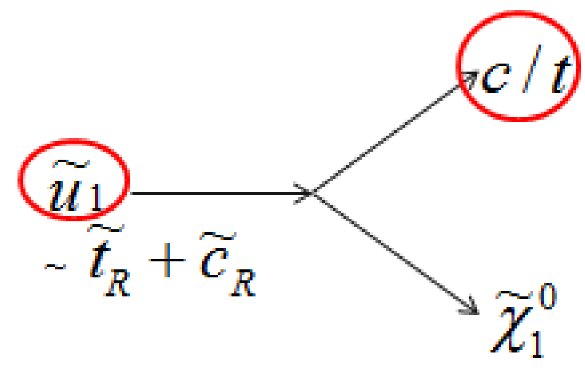
In our scenario "top trilinear coupling" ($\tilde{t}_L - \tilde{t}_R - H_2^0$ coupling) = T_{U33} is large!

$\tilde{u}_1 - \tilde{u}_2 - h^0$ ***coupling is large!***

QFV branching ratio $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ ***can be large!***

In this large $\tilde{t}_L - \tilde{t}_R$ & $\tilde{c}_R - \tilde{t}_R$ mixing scenario;

$\tilde{u}_1 \sim \tilde{t}_R + \tilde{c}_R + \tilde{t}_L$

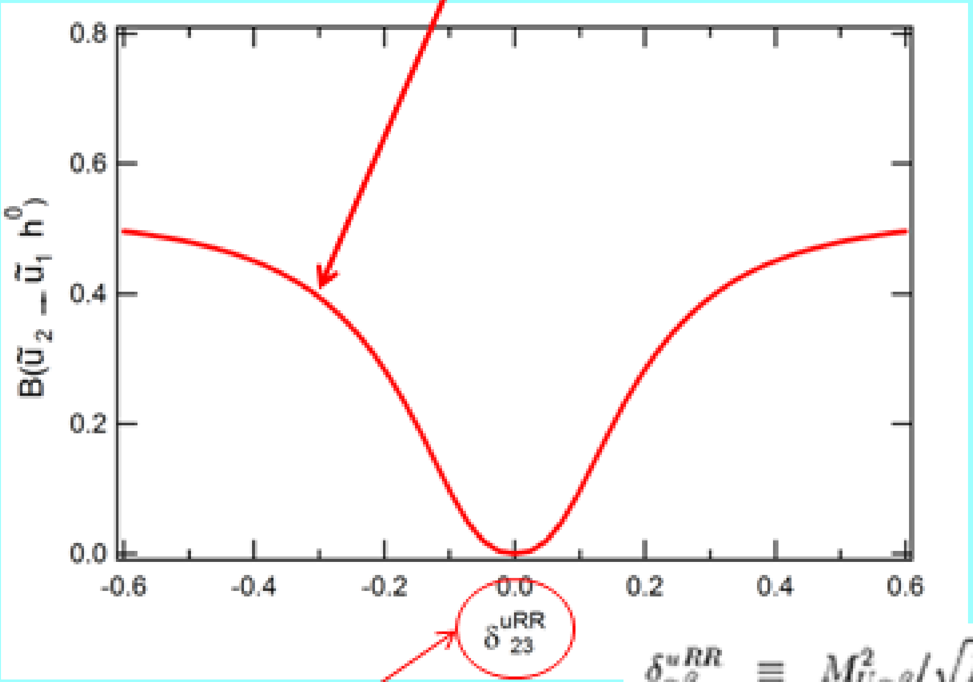


QFV BR $B(\tilde{u}_1 \to c / t \; \tilde{\chi}_1^0)$ ***can be large!***

QFV BR $B(\tilde{u}_2 \to \tilde{u}_1 h^0 \to c / t \; h^0 \; \tilde{\chi}_1^0)$ ***can be large!***

5.2 Impact of squark generation mixing on squark bosonic decays

QFV decay BR $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$

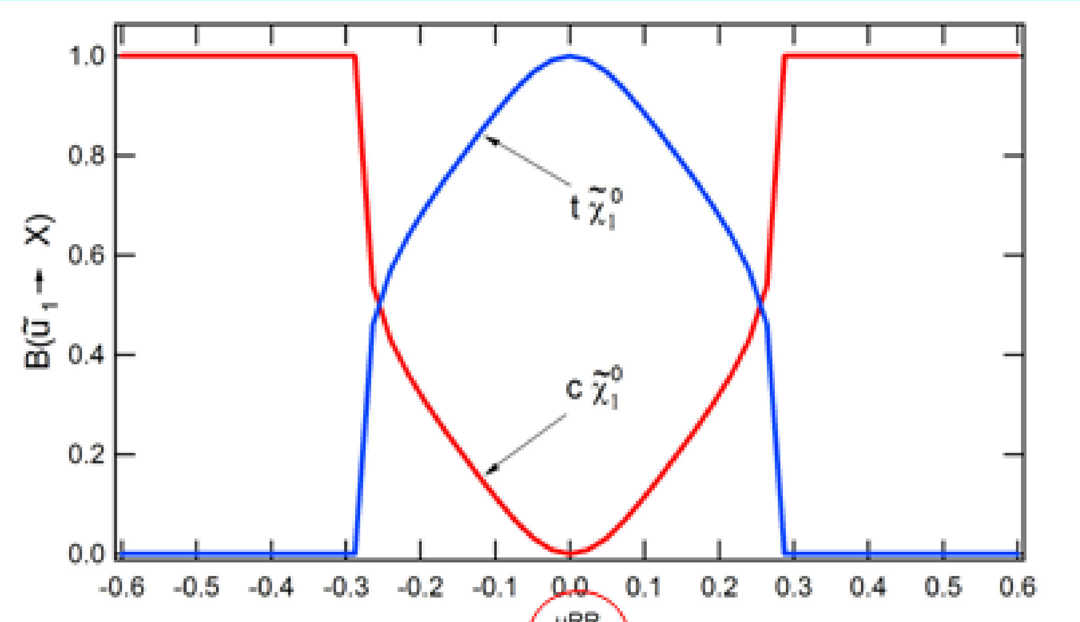


$\delta^{uRR}_{\alpha\beta} \equiv M^2_{U\alpha\beta}/\sqrt{M^2_{U\alpha\alpha} M^2_{U\beta\beta}}$

$\tilde{c}_R - \tilde{t}_R$ *mixing parameter*

QFV squark decay branching ratio $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ **can be very large (up to ~50%) for large** $\tilde{c}_R - \tilde{t}_R$ **mixing parameter** δ^{uRR}_{23}**!**

QFV decay BR $B(\tilde{u}_1 \to c/t\, \tilde{\chi}_1^0)$



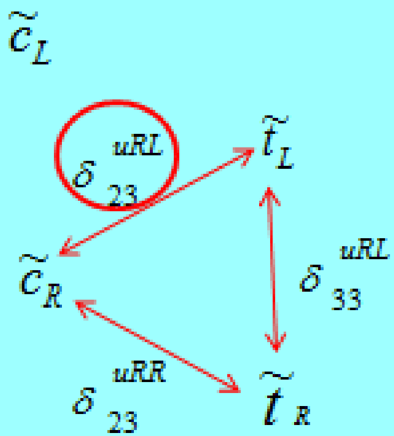
$\tilde{c}_R - \tilde{t}_R$ **mixing parameter**

$$\delta_{\alpha\beta}^{uRR} \equiv M^2_{U\alpha\beta} / \sqrt{M^2_{U\alpha\alpha} M^2_{U\beta\beta}}$$

QFV squark decay BR $B(\tilde{u}_1 \to c/t\, \tilde{\chi}_1^0)$ **can be very large simultaneously for sizable** $\tilde{c}_R - \tilde{t}_R$ **mixing parameter** δ_{23}^{uRR} **!**

We have obtained a similar result for δ^{uRL}_{23} dependence of QFV BR $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ and $B(\tilde{u}_1 \to c/t\ \tilde{\chi}^0_1)$!:

$B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ can be very large (up to ~50%) for large $\tilde{c}_R - \tilde{t}_L$ mixing parameter δ^{uRL}_{23} !



5.3 Impact on squark signals at LHC

Example of QFV squark signal at LHC

Gluino pair production and the QFV squark bosonic decay can lead to

QFV squark signature at LHC :

$$pp \to \tilde{g}\tilde{g}X \to (\tilde{u}_2\bar{c})(\tilde{u}_2\bar{c})X \to (\tilde{u}_1 h^0\bar{c})(\tilde{u}_1 h^0\bar{c})X$$

$$\to (t\tilde{\chi}_1^0 h^0\bar{c})(t\tilde{\chi}_1^0 h^0\bar{c})X \;(= tt\bar{c}\bar{c}h^0h^0\tilde{\chi}_1^0\tilde{\chi}_1^0 X)$$

↓

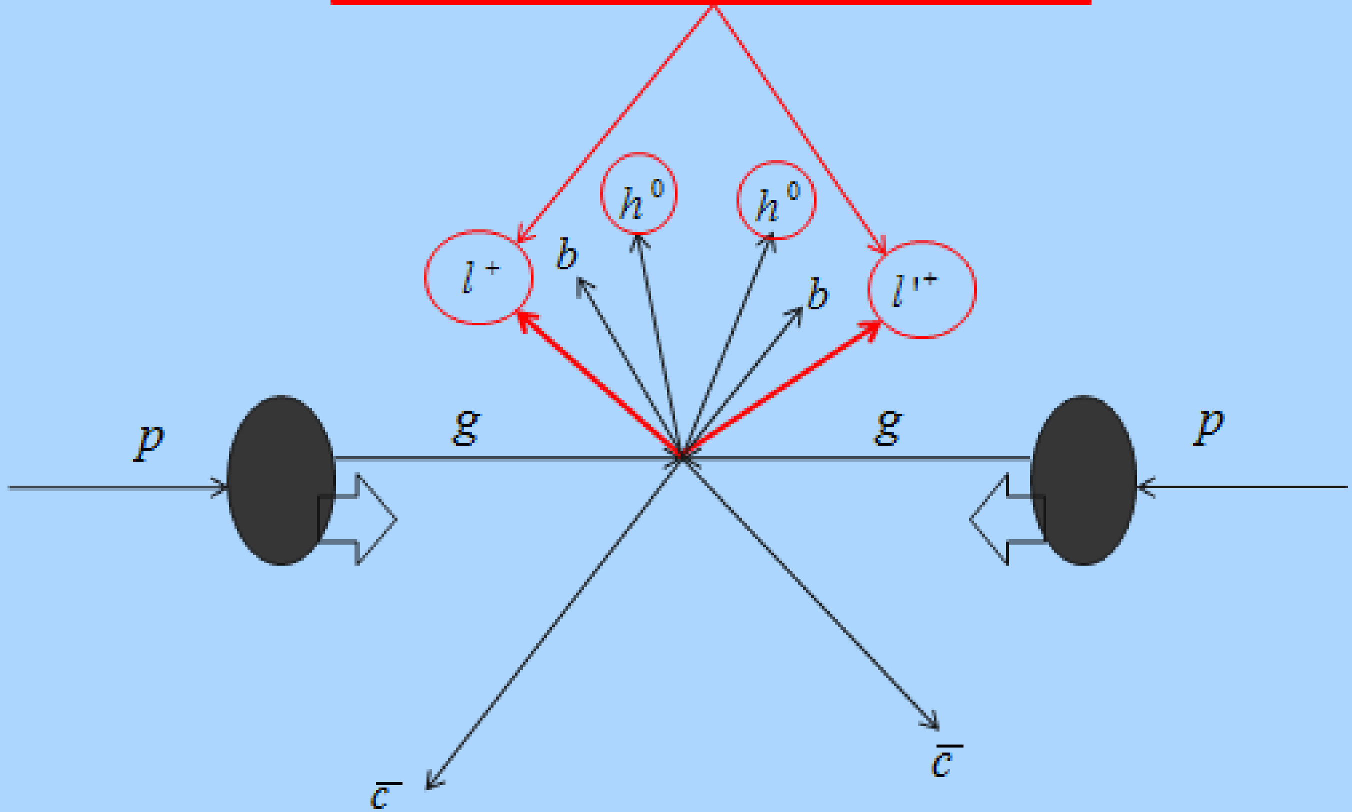
'2 top-quarks + 2 jets + 2 h^0 + missing-E_T + beam-jets'

↓ $t \to bW^+ \to bl^+\nu$

'isolated same sign dilepton + 4 jets + 2 h^0 + missing-E_T + beam-jets'

Example of QFV squark signal at LHC

isolated same sign dilepton



'isolated same sign dilepton + 4 jets + 2 h^0 + missing-E_T + beam-jets'

h^0 decay branching ratios

- $B(h^0 \to tau^- \, tau^+) = 9.1\%$
- $B(h^0 \to b$ b_bar$) = 57.3\%$
- $B(h^0 \to$ photon photon$) = 0.52\%$
- $B(h^0 \to W \, W^*) = 22.7\%$
- $B(h^0 \to Z \, Z^*) = 2.5\%$

h^0 is SM-like in our scenario!

QFV squark signal rates at LHC

In our scenario;

- gluino prod. cross section is significant:

$\sigma(pp \to \tilde{g}\tilde{g}X)$ *~ 80 fb at LHC(14 TeV)!*

\- $B(\tilde{g} \to \tilde{u}_2 c/t)$ *can be large (~ 25 %)!*

⇓

We can expect copious production of $\tilde{u}_2$ *from gluino prod. and decays at LHC(14 TeV)!*

⇓

QFV squark signal rates can be significant at LHC(14 TeV)!

6. Conclusion

Our analyses suggest the following:

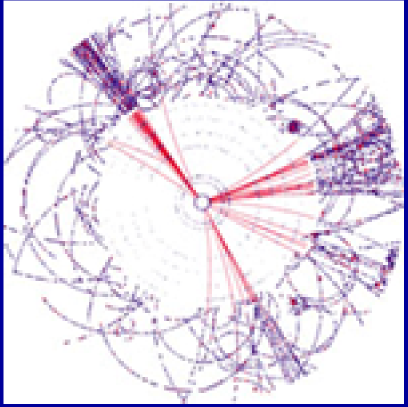
- ***One** should take into account the possibility of significant contributions from QFV decays in the squark and gluino search at LHC.*

- ***Moreover, one** should also include QFV squark parameters (i.e. squark–generation mixing parameters) in the determination of the basic SUSY parameters at LHC.*

- *We have studied production and decays of squarks and gluinos in the MSSM with **squark generation mixing**, especially* $\tilde{c}_{R/L} - \tilde{t}_{R/L}$ *mixing.*
- *We have shown that **QFV squark and gluino decay** branching ratios such as* $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$, $B(\tilde{u}_1 \to c/t\, \tilde{\chi}_1^0)$, $B(\tilde{g} \to ct \tilde{\chi}_1^0)$ *can be **very large (up to ~50%)** due to the* $\tilde{c}_{R/L} - \tilde{t}_{R/L}$ *mixing in a significant region of the QFV parameters despite the very strong constraints from B meson data.*
- *This can result in remarkable **QFV squark and gluino signal** events such as* '$pp \to t\, t\, \bar{c}\, \bar{c}\, h^0 h^0 + E_T^{mis}$ + beam-jets' *and* '$pp \to t\, t\, \bar{c}\, \bar{c} + E_T^{mis}$ + beam-jets' *with **a significant rate at LHC(14 TeV)**.*
- *These could have an important **impact** on the **search for squarks and gluinos** and the **MSSM parameter determination** at LHC.*

Backup Slides

Flavour violating squark and gluino decays at LHC



K. Hidaka
Tokyo Gakugei University

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(A part of this work is published in Phys. Rev. D84 (2011) 115026; arXiv:1107.2775 [hep-ph].)

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Contents

1. Introduction

(1) Motivation;

- *If weak scale SUSY is realized in nature, gluinos and squarks will have high production rates for masses up to O(1) TeV at LHC.*

- *The main decay modes of gluinos and squarks are usually assumed to be quark-flavour conserving (QFC).*

- *However, the squarks are not necessarily quark-flavour eigenstates.*

  The flavour mixing in the squark sector may be stronger than that in the quark sector.

  In this case quark-flavour violating (QFV) decays of gluinos and squarks could occur.

- *Here we study the effect of the mixing of charm-squark and top-squark on the squark and gluino decays at LHC.*

(2)Purpose of this work;

- *In this work we study the effect of squark generation mixing on squark and gluino production and decays at LHC in the general MSSM with focus on mixing between 2nd and 3rd generation squarks.*

- *Taking into account the constraints from B-physics experiments , we show that*
  various regions in parameter space exist where decays of squarks and/or gluinos into flavour violating final states can have large branching ratios of up to ~ 50%.
  Here we consider both fermionic and bosonic final states.

- *This could have an important impact on the search for squarks and gluinos and the MSSM parameter determination at LHC.*

2. MSSM with QFV

- The basic parameters of the MSSM with QFV:

$\{\tan\beta, m_A, M_1, M_2, M_3, \mu, M^2_{Q,\alpha\beta}, M^2_{U,\alpha\beta}, M^2_{D,\alpha\beta}, T_{U\alpha\beta}, T_{D\alpha\beta}\}$

(at $Q = 1$ TeV scale (SPA convention)) $(\alpha, \beta = 1,2,3 = u, c, t$ or $d, s, b)$

$\tan\beta$: ratio of VEV of the two Higgs doublets $\langle H^0{}_2\rangle / \langle H^0{}_1\rangle$

m_A: CP odd Higgs boson mass (pole mass)

M_1, M_2, M_3: U(1), SU(2), SU(3) gaugino masses

μ: higgsino mass parameter

$M^2_{Q,\alpha\beta}$: left squark soft mass matrix

$M^2_{U\alpha\beta}$: right up-type squark soft mass matrix

$M^2_{D\alpha\beta}$: right down-type squark soft mass matrix

$T_{U\alpha\beta}$: trilinear coupling matrix of up-type squark and Higgs boson

$T_{D\alpha\beta}$: trilinear coupling matrix of down-type squark and Higgs boson

- *We study* $\tilde{c} - \tilde{t}$ *mixing effect:*

QFV parameters in our study are:

M^2_{Q23} : $\tilde{c}_L - \tilde{t}_L$ *mixing term* ($\tilde{s}_L - \tilde{b}_L$ *mixing term*)

M^2_{U23} : $\tilde{c}_R - \tilde{t}_R$ *mixing term*

T_{U23} : $\tilde{c}_L - \tilde{t}_R$ *mixing term*

T_{U32} : $\tilde{c}_R - \tilde{t}_L$ *mixing term*

(Note) We work in the super-CKM basis of squarks:

$(\tilde{u}_L, \tilde{c}_L, \tilde{t}_L, \tilde{u}_R, \tilde{c}_R, \tilde{t}_R), (\tilde{d}_L, \tilde{s}_L, \tilde{b}_L, \tilde{d}_R, \tilde{s}_R, \tilde{b}_R)$.

3. *Constraints on the MSSM*

Recent ATLAS and CMS SUSY searches at 7TeV with ~1-5 fb^{-1}

In a simplified model;

gluino mass > 800 GeV
squark mass > 850 GeV (for 1st & 2nd generation squarks)

In the context of the CMSSM (mSUGRA);

gluino mass > 840 GeV
squark mass > 1100 GeV (for 1st & 2nd generation squarks)

Respecting these limits, we assume a gluino mass of about 1 TeV in our analysis

(Note) We also respect the constraint on (m_A, $\tan\beta$) from the recent MSSM Higgs boson search at LHC [arXiv:1202.4083].

3. *Constraints on the MSSM*

(continued)

The following constraints are imposed in our analysis in order to respect experimental and theoretical constraints:

(a) Constraints from the B-physics experiments :

$2.87\times10^{-4} < B(b\to s\,\gamma) < 4.23\times10^{-4}$ (95% CL) (HFAG2010)

$0.60\times10^{-6} < B(b\to s\,\ell^+\ell^-) < 2.60\times10^{-6}$ (with $\ell = e$ or μ) (95% CL) (BELLE, BABAR)

$B(B_s\to\mu^+\mu^-) < 4.5\times10^{-9}$ (95% CL) (LHCb)

$B(B_u^+\to\tau^+\,\nu) = (1.68\pm0.31)\times10^{-4}$ (68% CL) (BELLE, BABAR)

$\Delta M_{B_s} = 17.77\pm0.12\ \mathrm{ps}^{-1}$ (68% CL) (CDF) $\Delta M_{B_s} = 17.63\pm0.11\ \mathrm{ps}^{-1}$ (68% CL) (LHCb)

(b) LEP limits on sparticle masses

(ex) $m_{\tilde\chi_1^\pm} > 103\ GeV$ *etc.*

(c) The experimental limit on SUSY contributions to the electroweak ρ parameter:

$\Delta\rho(SUSY) < 0.0012$

(d) Vacuum stability conditions on trilinear couplings

(see J.A. Casas and S. Dimopoulos, Phys. Lett. B 387 (1996) 107 [hep-ph/9606237].)

(ex) $|T_{U\,23}|^2 < h_t^2\,(M^2_{Q_L\,22} + M^2_{U\,33} + m_2^2)$ *etc.*

with $m_2^2 = (m_{H^\pm}^2 + m_Z^2\sin^2\theta_W)\cos^2\beta - \frac{1}{2}m_Z^2$

(Note) We find that these constraints are very important:

$B(b \to s\gamma)$ *and* ΔM_{B_s} *data* => *strongly constrain the* ***QFV*** *squark* ***parameters***

$B(B_s \to \mu^+ \mu^-)$ *data* => *strongly constrain the* ***QFV*** *squark* ***parameters***

$B(B_u^+ \to \tau^+ \nu)$ *data* => *strongly constrain* $(m_{H^+}, \tan\beta)$

Vacuum stability conditions => *strongly constrain* ***QFV*** *trilinear couplings* $T_{U\alpha\beta}, T_{D\alpha\beta}$

(Note) We use the public code SPheno v3.1 in the calculation of the B-physics observables.

4. QFV gluino 3-body decays

4.1 QFV Benchmark Scenario

We take the following scenario as our prototype QFV scenario:

Table 2: Weak scale parameters at $Q = 1$ TeV for our prototype QFV scenario, except for m_{A^0} which is the pole mass (i.e. physical mass) of A^0. All of $T_{U\alpha\alpha}$ and $T_{D\alpha\alpha}$ are 0.

M_1	M_2	M_3	μ	$\tan\beta$	m_{A^0}
139 GeV	264 GeV	800 GeV	1000 GeV	10	800 GeV

	$\alpha = \beta = 1$	$\alpha = \beta = 2$	$\alpha = \beta = 3$
$M^2_{Q\alpha\beta}$	$(3150)^2$ GeV^2	$(3100)^2$ GeV^2	$(3050)^2$ GeV^2
$M^2_{U\alpha\beta}$	$(3000)^2$ GeV^2	$(2200)^2$ GeV^2	$(2150)^2$ GeV^2
$M^2_{D\alpha\beta}$	$(3000)^2$ GeV^2	$(2990)^2$ GeV^2	$(2980)^2$ GeV^2

We add QFV parameters (i.e. squark-generation mixing parameters) to this scenario:

$M^2_{Q,\alpha\beta}$, $M^2_{U,\alpha\beta}$, $M^2_{D,\alpha\beta}$, $T_{U\alpha\beta}$, $T_{D\alpha\beta}$ $(\alpha \neq \beta)$

Physical masses in the prototype QFV scenario

Table 3: Physical masses of the particles in the scenario of Table 2. m_{H^0} is the mass of the heavier CP-even neutral Higgs boson H^0.

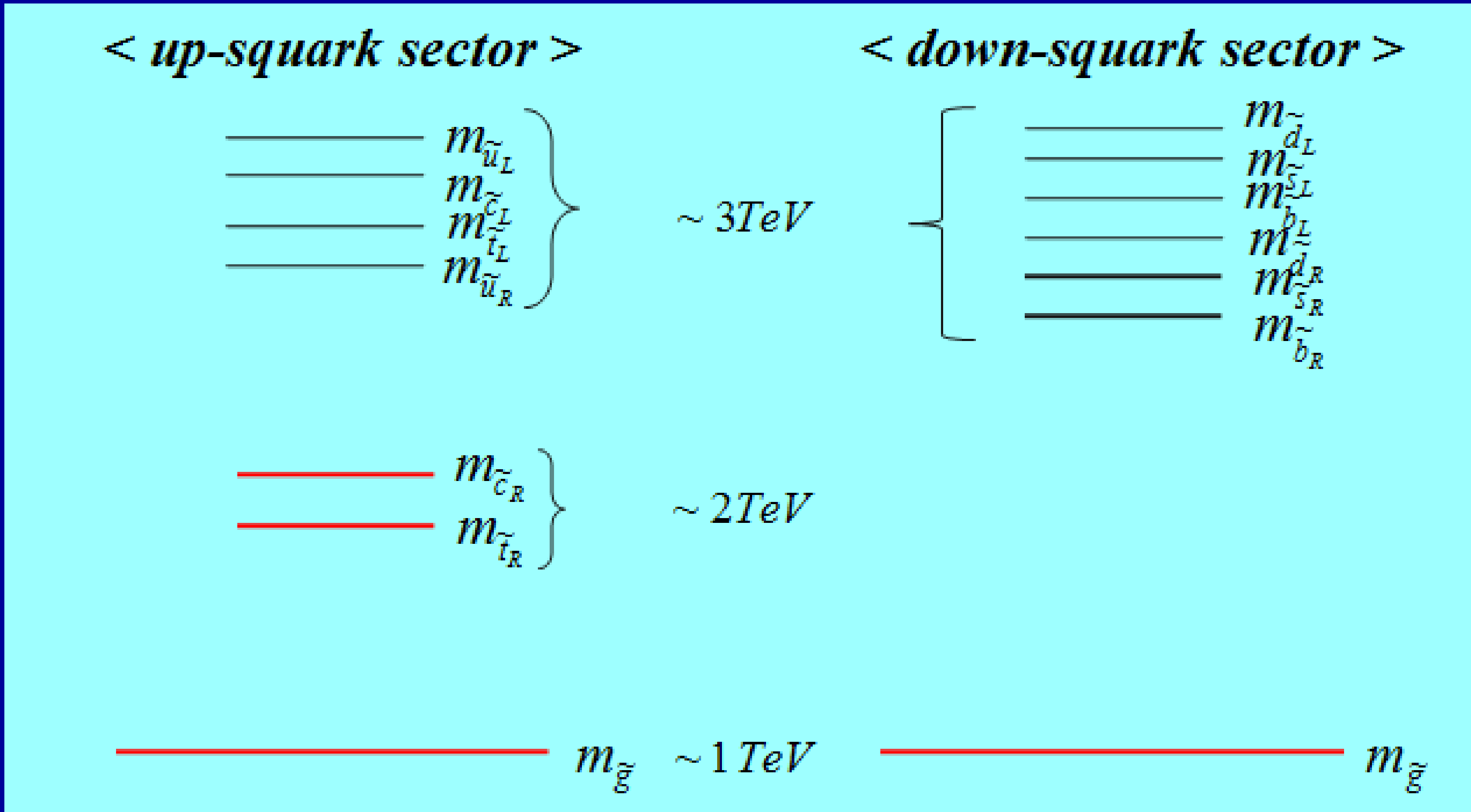
$m_{\tilde\chi^0_1}$	$m_{\tilde\chi^0_2}$	$m_{\tilde\chi^0_3}$	$m_{\tilde\chi^0_4}$	$m_{\tilde\chi^+_1}$	$m_{\tilde\chi^+_2}$
139 GeV	281.3 GeV	1017.9 GeV	1021.7 GeV	281.5 GeV	1022.7 GeV

$m_{\tilde g}$	m_{h^0}	m_{H^0}	m_{A^0}	m_{H^+}
975 GeV	121.1 GeV	800.3 GeV	800 GeV	804 GeV

These masses are fairly insensitive to the QFV parameters.

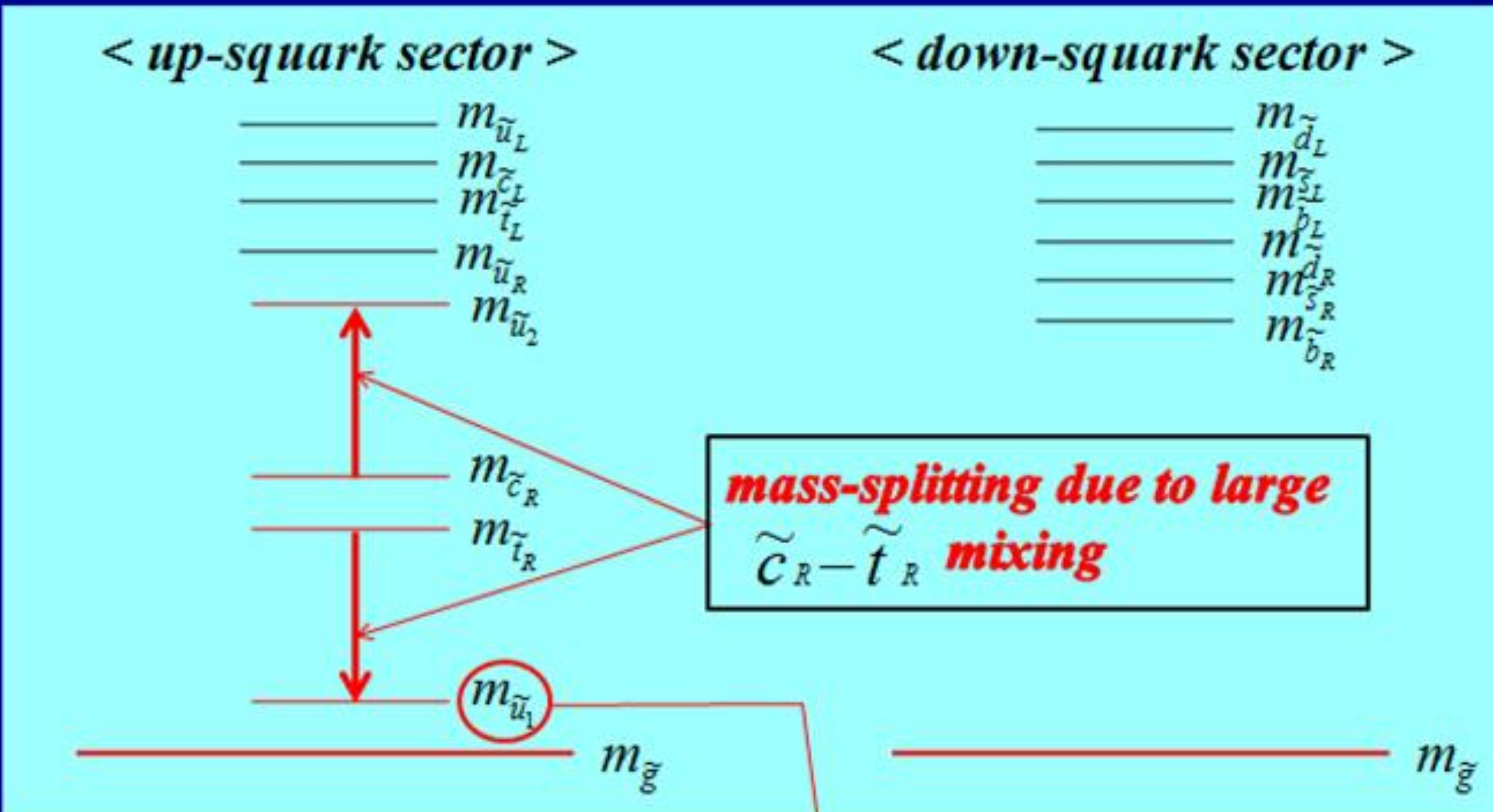
(Note) We can easily push up m_{h^0} to 125 GeV without changing our final conclusion, for example, by taking $\tan\beta = 20$ and $m_{A^0} = 1500$ GeV !

Prototype QFV scenario



We add $\tilde{c}_R - \tilde{t}_R$ *mixing to this scenario*

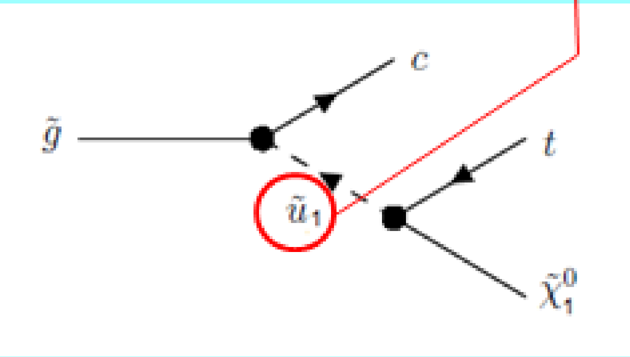
“Prototype QFV scenario” + “large $\tilde{c}_R - \tilde{t}_R$ mixing”



In this large $\tilde{c}_R - \tilde{t}_R$ mixing scenario all squarks other than $\tilde{u}_1$ are very heavy.
So, gluino decay is dominated by virtual $\tilde{u}_1$ exchange.

In this large $\tilde{c}_R - \tilde{t}_R$ mixing scenario;

- ***Gluino decay is dominated by virtual $\tilde{u}_1$ exchange contribution.***
- $\tilde{u}_1$ ***is a strong mixture of $\tilde{c}_R$ and $\tilde{t}_R$.***



QFV branching ratio $B(\tilde{g} \to c\,\bar{t}\,\tilde{\chi}_1^0)$ could be very large!

4.2 Impact of squark generation mixing on gluino 3-body decays

We study the effect of squark generation mixing on gluino production and decays at LHC for the case that the gluino is lighter than all squarks and dominantly decays into three particles:

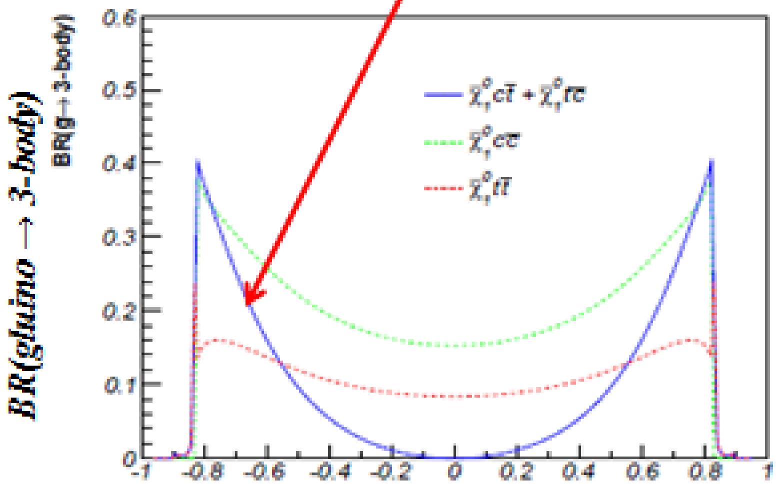
$$\tilde{g} \to q\,\bar{q}\,\tilde{\chi}_i^0 \qquad \tilde{g} \to q\,\bar{q}'\,\tilde{\chi}_j^\pm$$

In case of $\tilde{c} - \tilde{t}$ *mixing, gluino could decay as follows:*

$$\tilde{g} \to c\,\bar{t}\,\tilde{\chi}_1^0 \qquad \tilde{g} \to t\,\bar{c}\,\tilde{\chi}_1^0$$

• Gluino decay branching ratios in our scenario:

QFV decay BR $B(\tilde{g} \to c\bar{t}\tilde{\chi}_1^0) + B(\tilde{g} \to t\bar{c}\tilde{\chi}_1^0)$



$\tilde{c}_R - \tilde{t}_R$ mixing parameter → δ_{23}^{uRR}

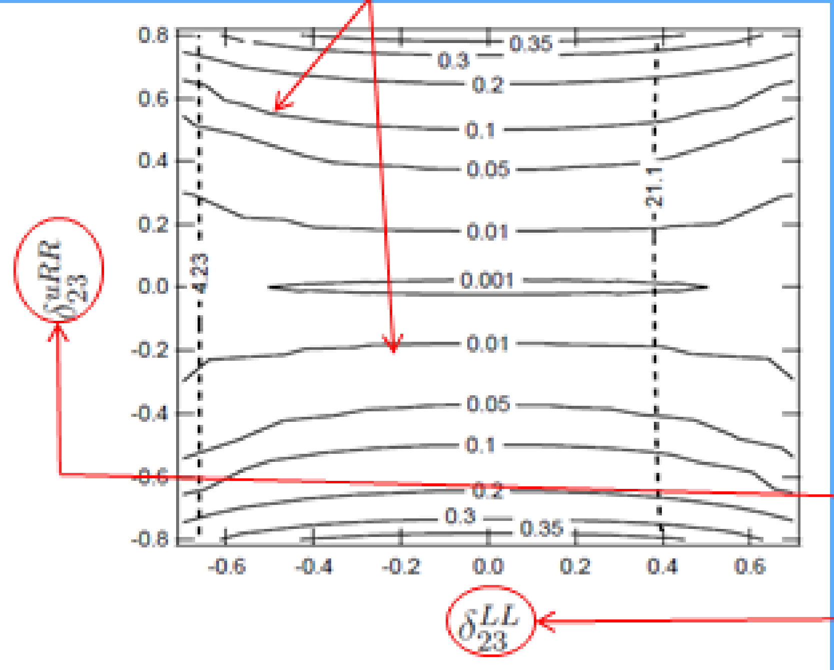
$$\delta_{\alpha\beta}^{uRR} \equiv M^2_{U\alpha\beta} / \sqrt{M^2_{U\alpha\alpha} M^2_{U\beta\beta}}$$

Figure 4: The branching ratios of the decays $\tilde{g} \to c\bar{t}\tilde{\chi}_1^0 + \bar{c}t\tilde{\chi}_1^0$, $\tilde{g} \to c\bar{c}\tilde{\chi}_1^0$ and $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$ as functions of δ_{23}^{uRR} for the other QFV parameters being zero and the other parameters are fixed as in Table 2.

QFV gluino decay branching ratio $B(\tilde{g} \to ct\tilde{\chi}_1^0)$ can be very large (up to ~40%) for large $\tilde{c}_R - \tilde{t}_R$ mixing parameter δ_{23}^{uRR} !

Contour plots of QFV BR in our scenario

$B(\tilde{g} \to ct\tilde{\chi}_1^0)$ ***contours***



$$\delta_{\alpha\beta}^{uLL} \equiv M_{Q\alpha\beta}^2 / \sqrt{M_{Q\alpha\alpha}^2 M_{Q\beta\beta}^2}$$

$$\delta_{\alpha\beta}^{uRR} \equiv M_{U\alpha\beta}^2 / \sqrt{M_{U\alpha\alpha}^2 M_{U\beta\beta}^2}$$

$\tilde{c}_R - \tilde{t}_R$ ***mixing parameter***

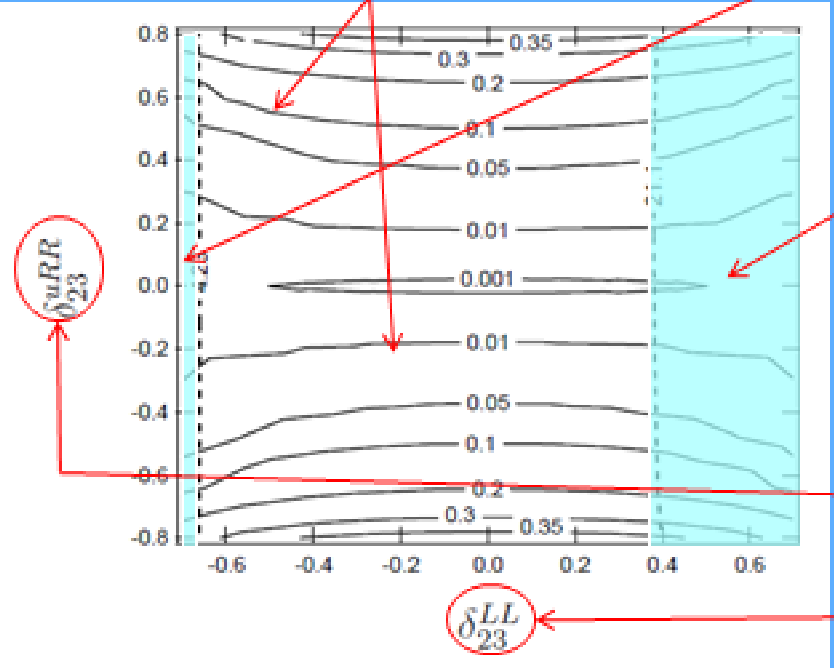
$\tilde{c}_L - \tilde{t}_L$ ***mixing parameter***

The QFV decay branching ratio $B(\tilde{g} \to ct\tilde{\chi}_1^0)$ ***can be very large in a significant part of the*** $\delta_{23}^{uLL} - \delta_{23}^{uRR}$ ***plane allowed by all of the constraints.***

This can lead to large QFV effects at LHC!

Contour plots of QFV BR in our scenario

$B(\tilde{g} \to ct\tilde{\chi}_1^0)$ **contours**



excluded by $B(b \to s\gamma)$ ***data***

excluded by ΔM_{Bs} ***data***

$$\delta_{\alpha\beta}^{uLL} \equiv M^2_{Q\alpha\beta}/\sqrt{M^2_{Q\alpha\alpha}M^2_{Q\beta\beta}}$$

$$\delta_{\alpha\beta}^{uRR} \equiv M^2_{U\alpha\beta}/\sqrt{M^2_{U\alpha\alpha}M^2_{U\beta\beta}}$$

$\tilde{c}_R - \tilde{t}_R$ ***mixing parameter***

$\tilde{c}_L - \tilde{t}_L$ ***mixing parameter***

The QFV decay branching ratio $B(\tilde{g} \to ct\tilde{\chi}_1^0)$ ***can be very large in a significant part of the*** $\delta_{23}^{uLL} - \delta_{23}^{uRR}$ ***plane allowed by all of the constraints.***

This can lead to large QFV effects at LHC!

We have obtained a similar result for the QFV 3-body decay branching ratio $B(\tilde{g} \to s\, b\, \tilde{\chi}_1^0) \equiv B(\tilde{g} \to s\, \bar{b}\, \tilde{\chi}_1^0) + B(\tilde{g} \to \bar{s}\, b\, \tilde{\chi}_1^0)$ **:**

It can be as large as ~35%!

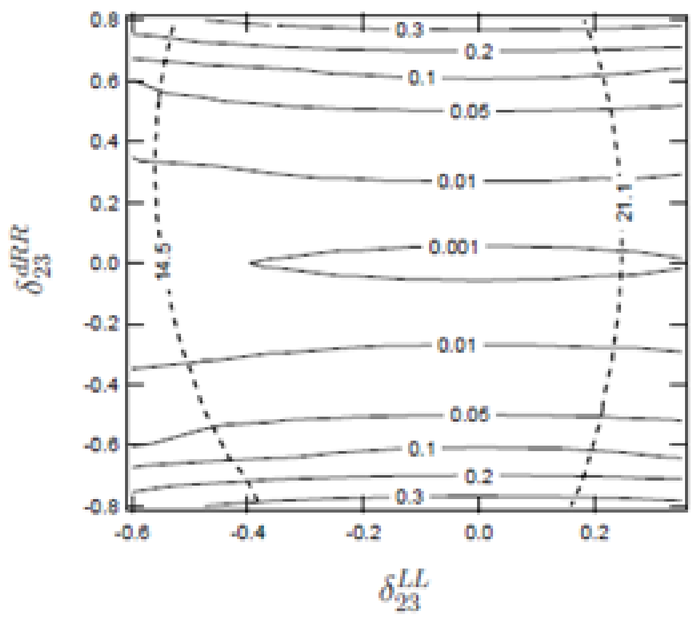


Figure 5: Contours of the QFV decay branching ratio B($\tilde{g} \to sb\tilde{\chi}_1^0$) in the δ_{23}^{LL} - δ_{23}^{uRR} plane, with the other QFV parameters being zero for the scenario of Table 2, but with the values of $M_{U\alpha\alpha}^2$ and $M_{D\alpha\alpha}^2$ interchanged (solid lines). Also shown are the contour lines for $\Delta M_{B_s} = 14.5\ \mathrm{ps}^{-1}$ and $\Delta M_{B_s} = 21.1\ \mathrm{ps}^{-1}$ (dashed lines). The region between the two dashed lines is allowed by all the constraints mentioned in Section 2, including the ΔM_{B_s} constraint.

Neutralino/chargino parameter dependence of QFV BR

$B(\tilde{g} \to ct\tilde{\chi}_1^0)$ **contours in $\mu - M_2$ plane**

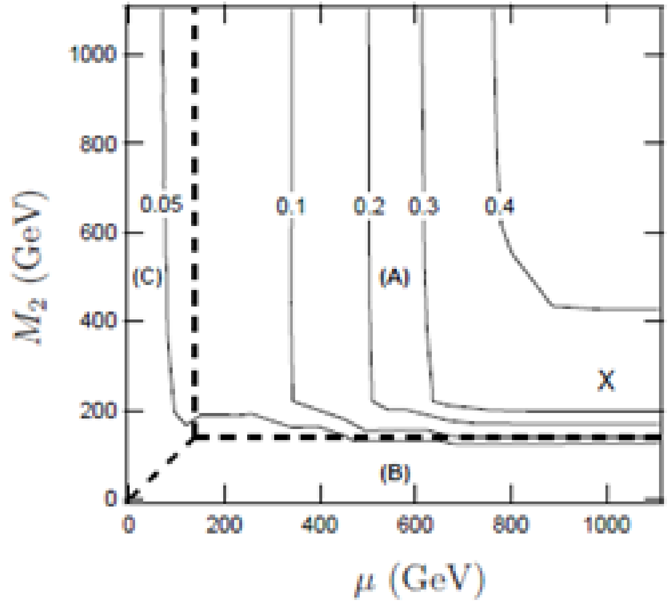


Figure 6: Contour plot for $B(\tilde{g} \to ct\tilde{\chi}_1^0)$ (solid lines) in the $\mu - M_2$ plane for $\delta_{23}^{uRR} = 0.8$, the other QFV parameters being zero, and the other parameters specified as in Table 2 with $M_1 = 139$ GeV. Region (A): bino-like LSP region; region (B): wino-like LSP region; region (C): higgsino-like LSP region. The point "X" corresponds to our reference scenario given in Table 2: $M_2 = 264$ GeV, $\mu = 1000$ GeV.

The branching ratios of the QFV 3-particle gluino decays depend quite strongly on the parameters of the neutralino/chargino sector!

4.3 Impact on gluino signatures at LHC

Large $\tilde{c}_R - \tilde{t}_R$ ***mixing***

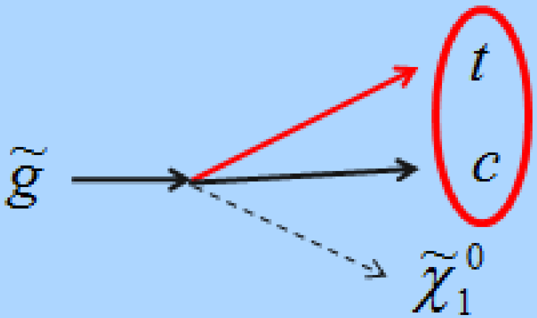
⬇

Large QFV BR $B(\tilde{g} \to t\bar{c}\,\tilde{\chi}_1^0)$

⬇

The signature of the QFV gluino decay $\tilde{g} \to t\bar{c}\,\tilde{\chi}_1^0$ ***at LHC:***

' top-quark + jet + missing-energy'



Example of QFV gluino signal at LHC

Gluino pair production and the QFV gluino 3-body decay $\tilde{g} \to t\bar{c}\tilde{\chi}_1^0$ *lead to*

QFV gluino signature at LHC :

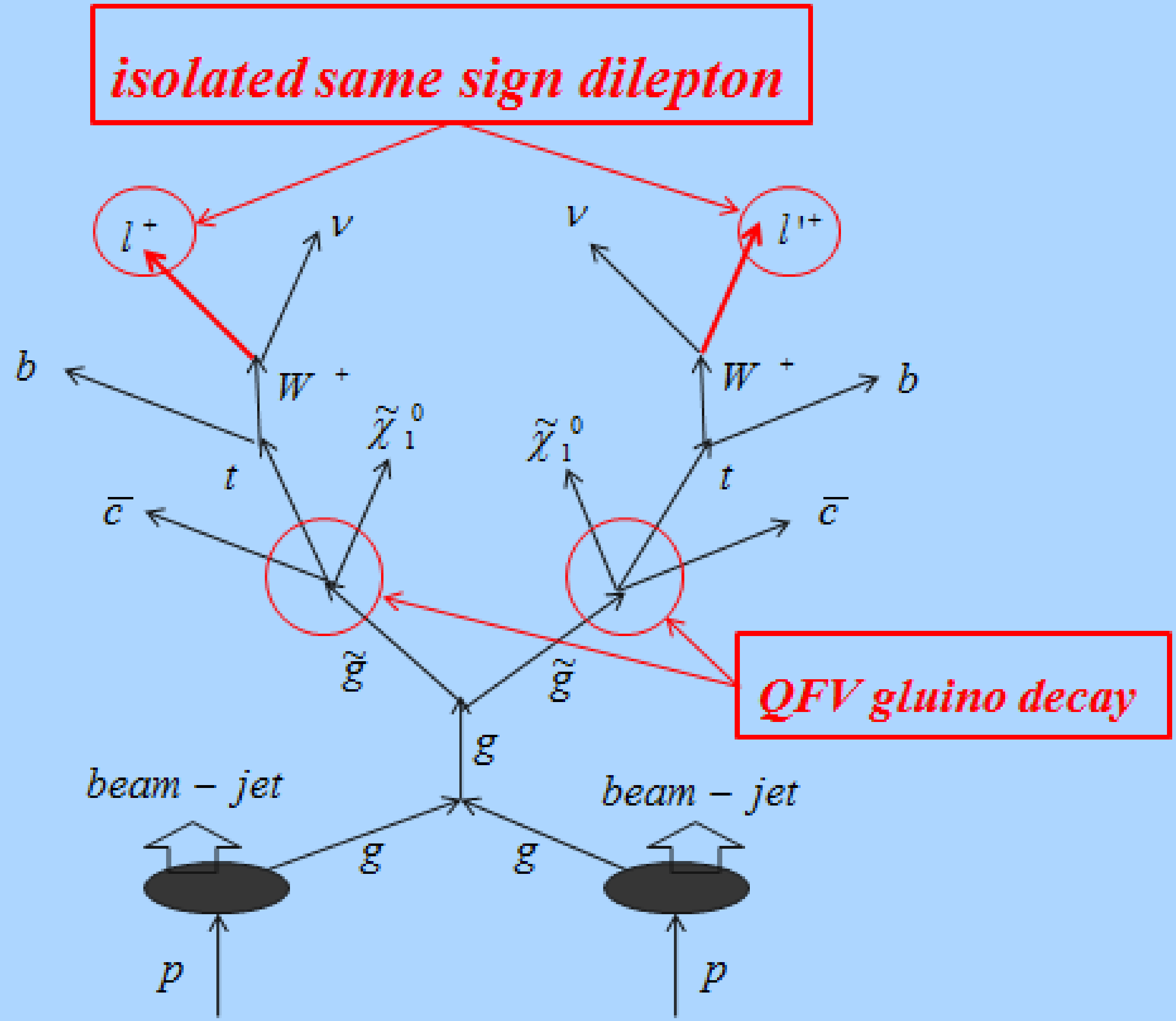
$$pp \to \tilde{g}\tilde{g}X \to (t\bar{c}\tilde{\chi}_1^0)(t\bar{c}\tilde{\chi}_1^0)X$$

'top-quark + top-quark + 2 jets + missing-E_T + beam-jets'

$$t \to bW^+ \to bl^+\nu$$

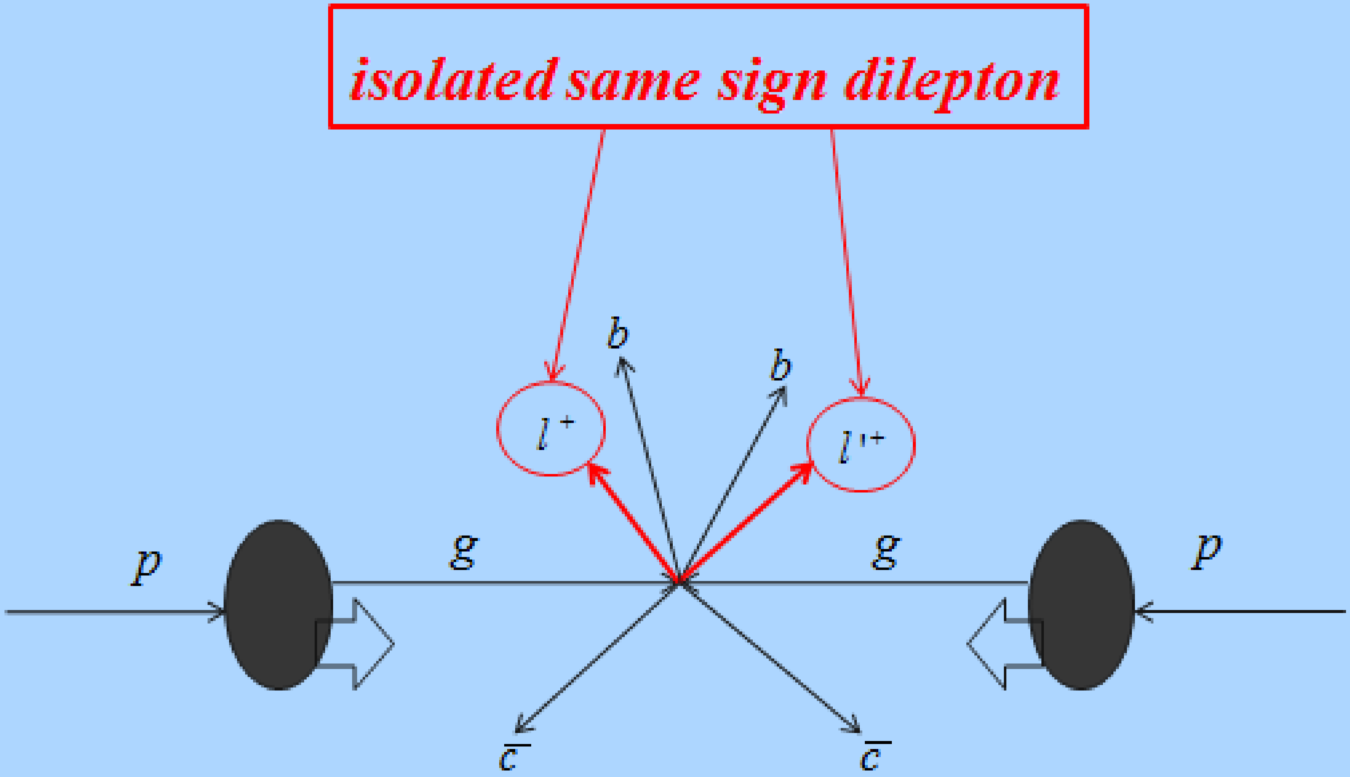
'isolated same sign dilepton + 4 jets + missing-E_T + beam-jets'

Example of QFV gluino signal at LHC



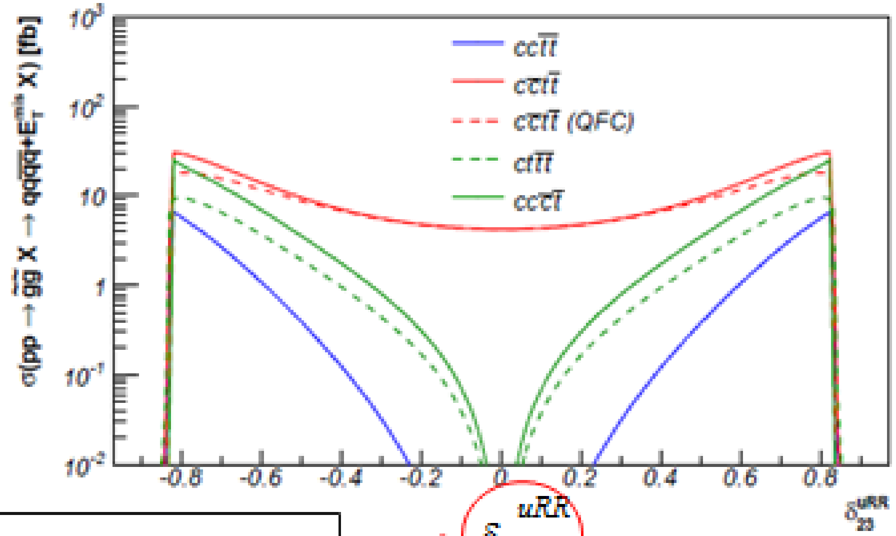
‘isolated same sign dilepton + 4 jets + missing-E_T + beam-jets‘

Example of QFV gluino signal at LHC



'isolated same sign dilepton + 4 jets + missing-E_T + beam-jets'

QFV gluino signal rates at LHC



$\tilde{c}_R - \tilde{t}_R$ *mixing parameter* → δ_{23}^{uRR}

Figure 9: Signal rates for $pp \to \tilde{g}\tilde{g}X$ at $\sqrt{s} = 14$ TeV where at least one of the gluinos decays as $\tilde{g} \to c\bar{t}(\bar{c}t)\tilde{\chi}_1^0$, as a function of δ_{23}^{uRR} with the other QFV parameters being zero and the other parameters fixed as in Table 2. Shown are the rates for the final states with $cc\bar{t}\bar{t}E_T^{mis}$ (full blue line), $c\bar{c}t\bar{t}E_T^{mis}$ (QFV + QFC) (full red line), $c\bar{c}t\bar{t}E_T^{mis}$ (QFC only) (dashed red line), $ct\bar{t}\bar{t}E_T^{mis}$ (dashed green line), $cc\bar{c}\bar{t}E_T^{mis}$ (full green line).

QFV signal rates such as $\sigma(pp \to \tilde{g}\tilde{g}\, X \to t\, t\, \bar{c}\, \bar{c}\, \tilde{\chi}_1^0 \tilde{\chi}_1^0\, X \to t\, t\, \bar{c}\, \bar{c}\, E_T^{mis} X)$ *can be significant for large* $\tilde{c}_R - \tilde{t}_R$ *mixing parameter* δ_{23}^{uRR} *at LHC!*

5. QFV squark bosonic decays

5.1 QFV Benchmark Scenario

*We take the following scenario as **our prototype QFV scenario**:*

decoupling Higgs scenario

These weak scale parameters are defined at Q = 1 TeV scale (SPA convention).

$(M_1, M_2, M_3) = (450, 855, 1000)$ GeV

$\mu = 2400$ GeV, $\tan\beta = 20$, $m_A(\text{pole}) = 1500$ GeV

(M^2_Q11, M^2_Q22, M^2_Q33) = (2400^2, 2360^2, 1450^2) GeV^2

(M^2_U11, M^2_U22, M^2_U33) = (2380^2, 780^2, 750^2) GeV^2

(M^2_D11, M^2_D22, M^2_D33) = (2380^2, 2340^2, 2300^2) GeV^2

All of $T_{U\alpha\alpha}$ and $T_{D\alpha\alpha}$ are zero, except $T_{U33} = -2160$ GeV.

large $\tilde{t}_L - \tilde{t}_R$ mixing scenario
(large top-trilinear-coupling scenario)

*We add **QFV parameters** (i.e. **squark-generation mixing parameters**) to this scenario:* $M^2_{Q,\alpha\beta}$, $M^2_{U,\alpha\beta}$, $M^2_{D,\alpha\beta}$, $T_{U\alpha\beta}$, $T_{D\alpha\beta}$ $(\alpha \neq \beta)$

Physical masses in the prototype QFV scenario

$m_{h^0} = 125.5\ GeV$

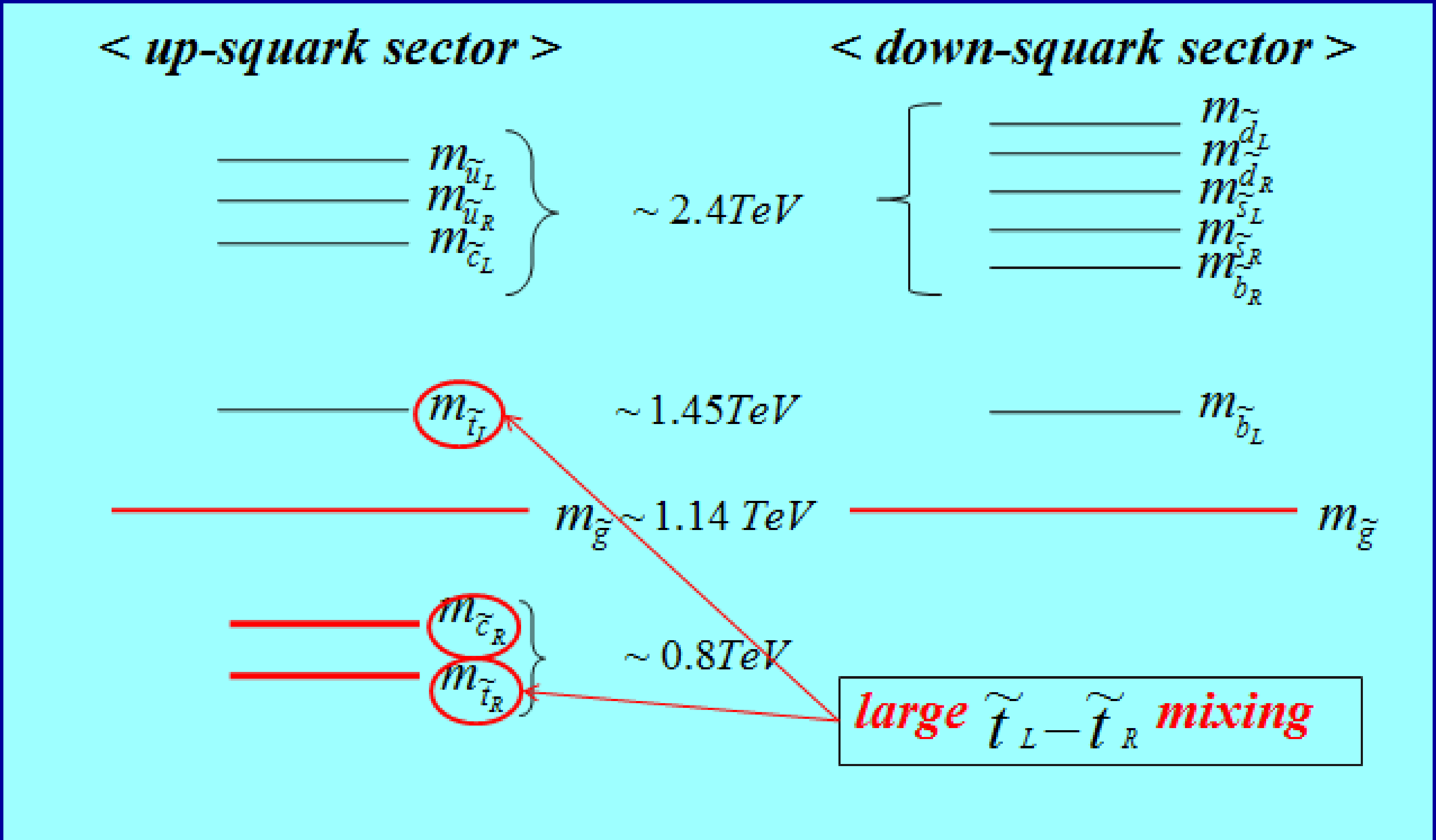
$m_{H^0} \cong m_{H^+} \cong m_{A^0} = 1500\ GeV$

$m_{\tilde{g}}^{pole} = 1141 GeV$

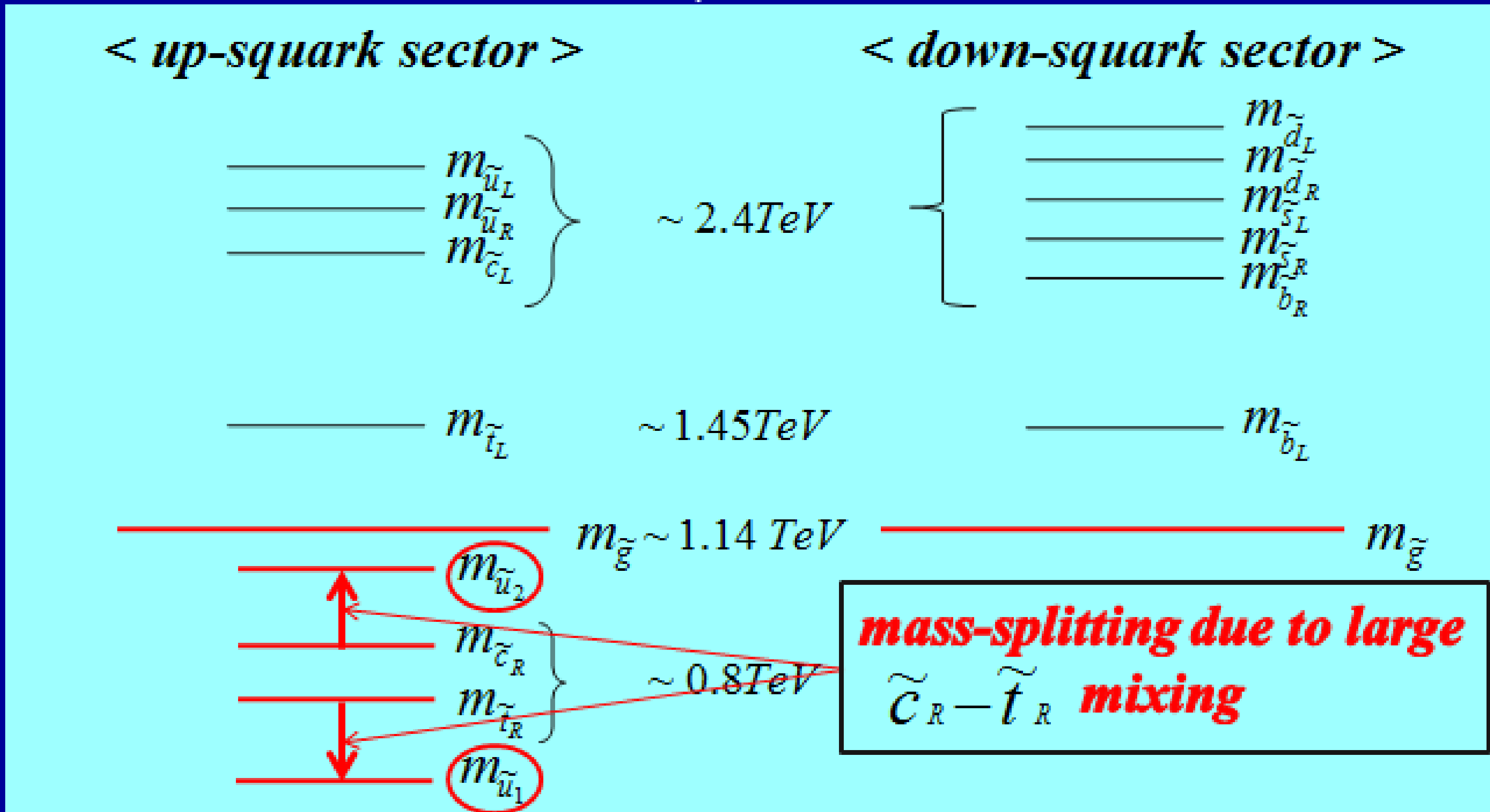
- CP-even lighter Higgs boson h^0 is SM-like!
- its mass $m_{h^0} = 125.5\ GeV$ is in the LHC "possible Higgs signal" range ! : $122 < m_{h^0} < 128 GeV$.

These masses are fairly insensitive to the QFV parameters.

Prototype QFV scenario



We add $\tilde{c}_{R/L} - \tilde{t}_{R/L}$ mixing to this scenario



large mass splitting between $m_{\tilde{u}_1}$ and $m_{\tilde{u}_2}$!

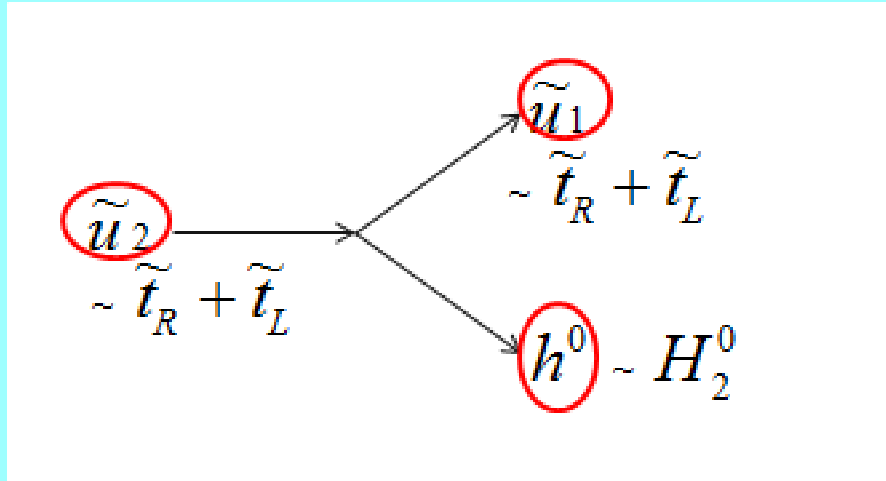
$B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ **could be sizable!**

In this large $\tilde{t}_L - \tilde{t}_R$ & $\tilde{c}_R - \tilde{t}_R$ *mixing scenario;*

$\tilde{u}_1 \sim \tilde{t}_R + \tilde{c}_R + \tilde{t}_L$

$\tilde{u}_2 \sim \tilde{c}_R + \tilde{t}_R + \tilde{t}_L$

$h^0 \sim H_2^0$



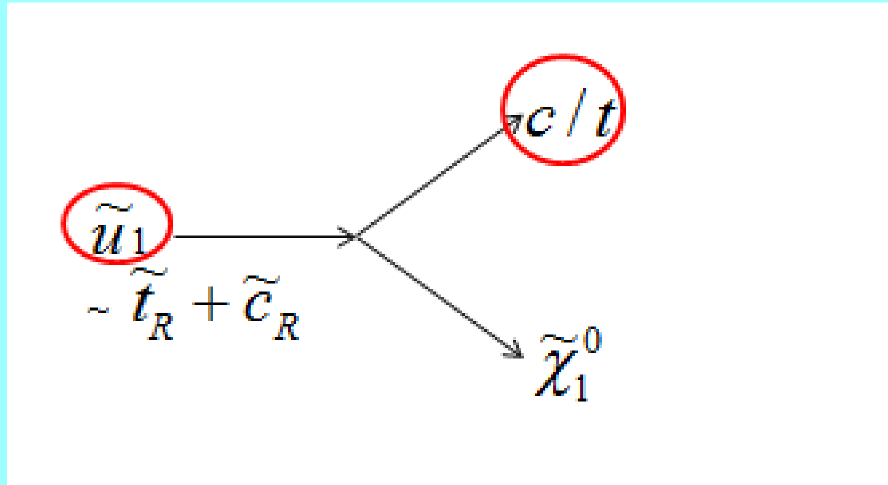
In our scenario "top trilinear coupling" ($\tilde{t}_L - \tilde{t}_R - H_2^0$ coupling) = T_{U33} is large!

$\tilde{u}_1 - \tilde{u}_2 - h^0$ *coupling is large!*

QFV branching ratio $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ *can be large!*

In this large $\tilde{t}_L - \tilde{t}_R$ ***&*** $\tilde{c}_R - \tilde{t}_R$ ***mixing scenario;***

$\tilde{u}_1 \sim \tilde{t}_R + \tilde{c}_R + \tilde{t}_L$



QFV BR $B(\tilde{u}_1 \rightarrow c/t\ \tilde{\chi}_1^0)$ ***can be large!***

QFV BR $B(\tilde{u}_2 \rightarrow \tilde{u}_1 h^0 \rightarrow c/t\ h^0\ \tilde{\chi}_1^0)$ ***can be large!***

5.2 Impact of squark generation mixing on squark bosonic decays

large $\tilde{t}_L - \tilde{t}_R$ & $\tilde{c}_R - \tilde{t}_R$ mixings

⇩

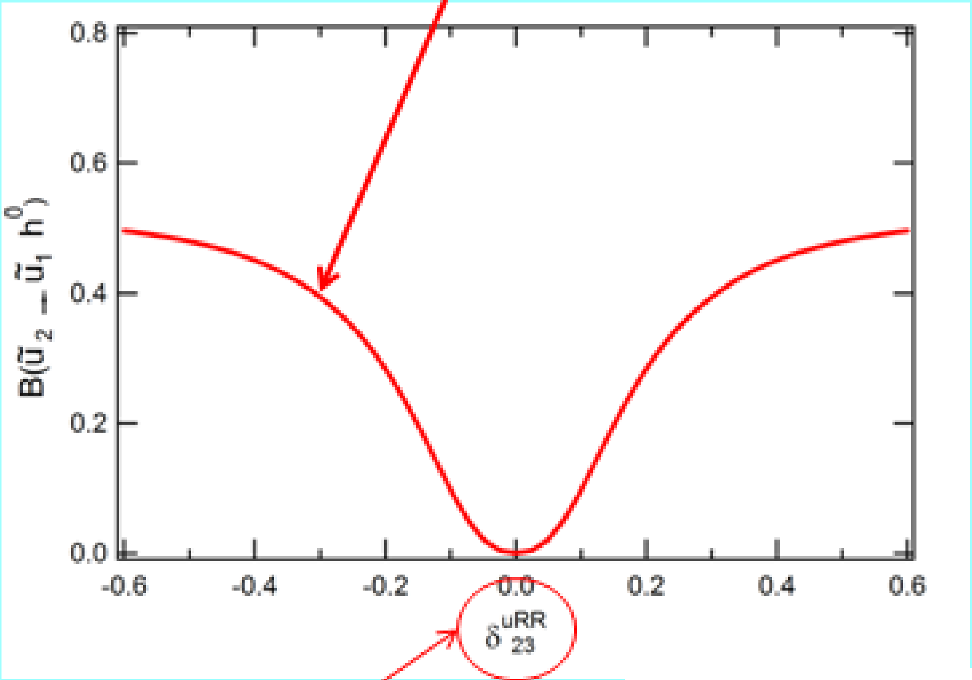
large QFV BR's $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ & $B(\tilde{u}_1 \to c/t\, \tilde{\chi}_1^0)$!

⇩

This can lead to large QFV effects at LHC!

- ***Squark decay branching ratios in our scenario:***

QFV decay BR $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$



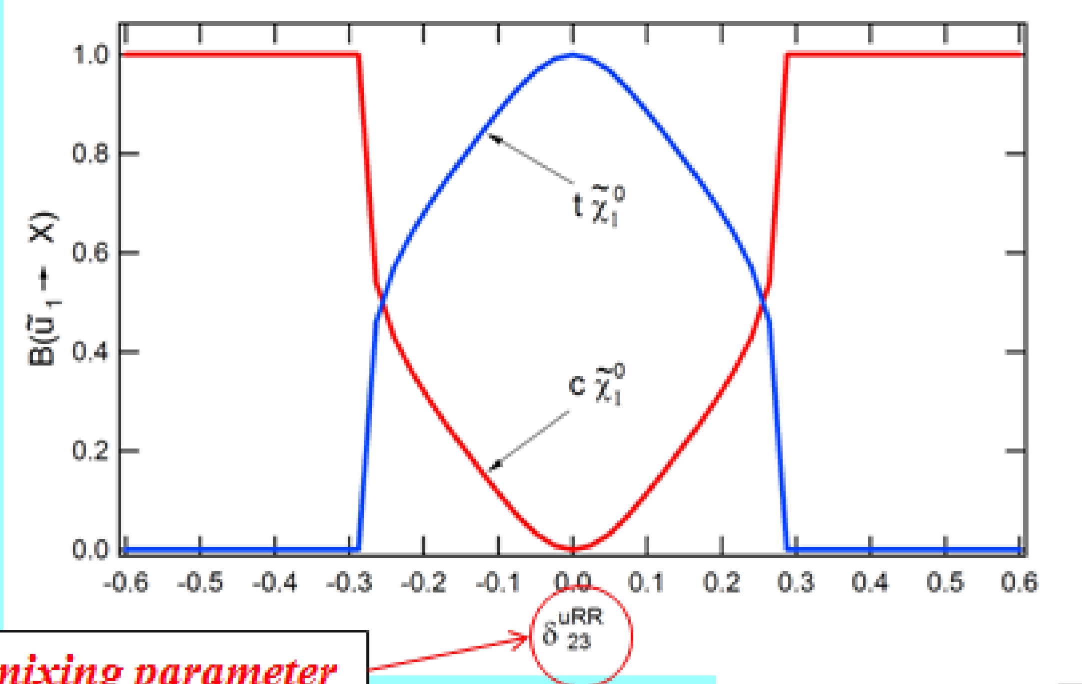
$\tilde{c}_R - \tilde{t}_R$ ***mixing parameter***

$\delta^{uRR}_{\alpha\beta} \equiv M^2_{U\alpha\beta} / \sqrt{M^2_{U\alpha\alpha} M^2_{U\beta\beta}}$

QFV squark decay branching ratio $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ ***can be very large (up to ~50%) for large*** $\tilde{c}_R - \tilde{t}_R$ ***mixing parameter*** δ^{uRR}_{23}***!***

- ## *Squark decay branching ratios in our scenario:*

QFV decay BR $B(\tilde{u}_1 \to c\,/\,t\ \tilde{\chi}_1^0)$



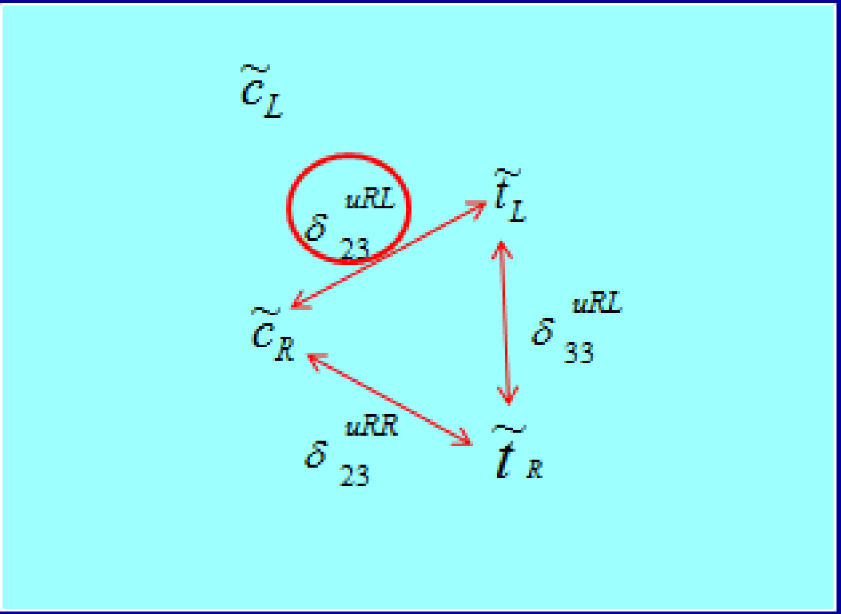
$\tilde{c}_R - \tilde{t}_R$ ***mixing parameter***

$$\delta_{\alpha\beta}^{uRR} \equiv M^2_{U\alpha\beta} / \sqrt{M^2_{U\alpha\alpha} M^2_{U\beta\beta}}$$

QFV squark decay BR $B(\tilde{u}_1 \to c\,/\,t\ \tilde{\chi}_1^0)$ ***can be very large simultaneously for sizable*** $\tilde{c}_R - \tilde{t}_R$ ***mixing parameter*** δ_{23}^{uRR} ***!***

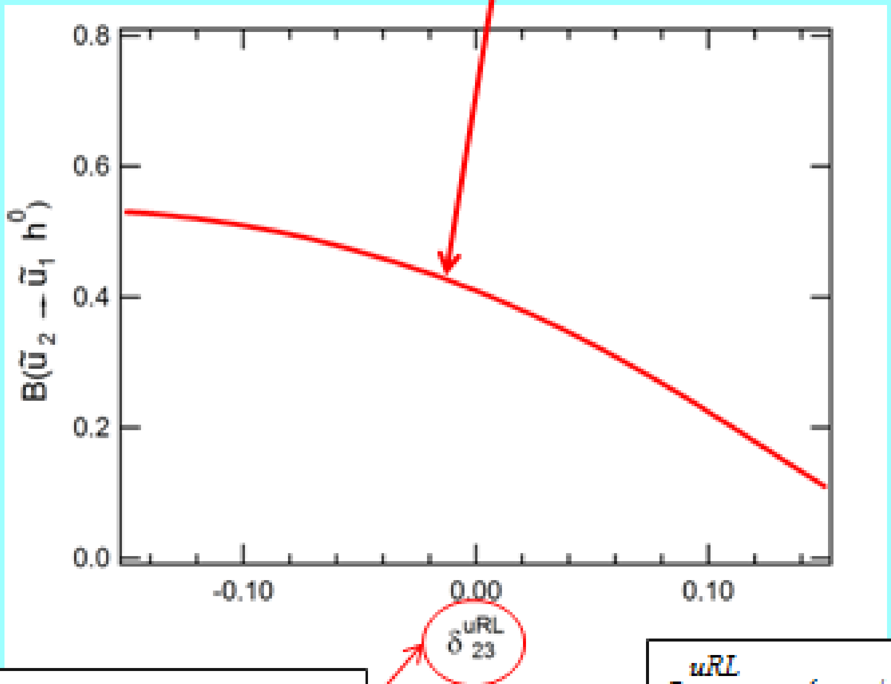
We have obtained a similar result for δ_{23}^{uRL} dependence of QFV BR $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ ***and*** $B(\tilde{u}_1 \to c/t\ \tilde{\chi}_1^0)$ ***!:***

$B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ ***can be very large (up to ~50%) for large*** $\tilde{c}_R - \tilde{t}_L$ ***mixing parameter*** δ_{23}^{uRL}***!***



- *Squark decay branching ratios in our scenario:*

QFV decay BR $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$



QFV parameters:
$M^2_{Q23} = (227\ GeV)^2$
$M^2_{U23} = (433\ GeV)^2$

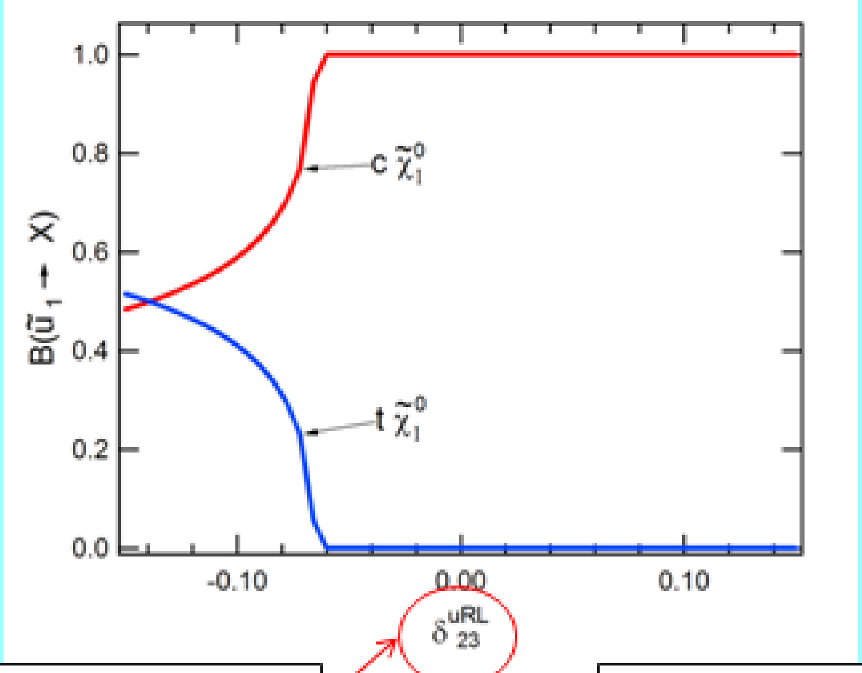
$\tilde{c}_R - \tilde{t}_L$ **mixing parameter**

$\delta_{23}^{uRL} \equiv (v_2/\sqrt{2}) T_{U32} / \sqrt{M^2_{U22} M^2_{Q33}}$

QFV squark decay BR $B(\tilde{u}_2 \to \tilde{u}_1 h^0)$ **can be very large (up to ~50%) for large** $\tilde{c}_R - \tilde{t}_L$ **mixing parameter** δ_{23}^{uRL} **!**

• Squark decay branching ratios in our scenario:

QFV decay BR $B(\tilde{u}_1 \to c/t\, \tilde{\chi}_1^0)$



QFV parameters:
$= (227\ GeV)^2$
$= (433\ GeV)^2$

$\tilde{c}_R - \tilde{t}_L$ *mixing parameter*

$$\delta_{23}^{uRL} \equiv (v_2/\sqrt{2})T_{U32} \Big/ \sqrt{M_{U22}^2 M_{Q33}^2}$$

QFV squark decay BR $B(\tilde{u}_1 \to c/t\, \tilde{\chi}_1^0)$ ***can be very large simultaneously for large*** $\tilde{c}_R - \tilde{t}_L$ ***mixing parameter*** δ_{23}^{uRL} **!**

5.3 Impact on squark signatures at LHC

Large $\tilde{t}_L - \tilde{t}_R$, $\tilde{c}_R - \tilde{t}_R$, $\tilde{c}_R - \tilde{t}_L$ mixings

⇓

Large QFV BR $B(\tilde{u}_2 \to \tilde{u}_1 h^0 \to c/t\ h^0\ \tilde{\chi}_1^0)$

⇓

QFV squark signals with significant rate at LHC !

Example of QFV squark signal at LHC

Gluino pair production and the QFV squark bosonic decay can lead to

QFV squark signal at LHC :

$$pp \to \tilde{g}\tilde{g}X \to (\tilde{u}_1\bar{c})(\tilde{u}_2\bar{c})X \to (\tilde{u}_1\bar{c})(\tilde{u}_1 h^0\bar{c})X$$

$$\to (c\tilde{\chi}_1^0\bar{c})(t\tilde{\chi}_1^0 h^0\bar{c})X \; (= tc\bar{c}\bar{c}h^0\tilde{\chi}_1^0\tilde{\chi}_1^0 X)$$

'top-quark + 3 jets + h^0 + missing-E_T + beam-jets'

Example of QFV squark signal at LHC

Gluino pair production and the QFV squark bosonic decay can lead to

QFV squark signal at LHC :

$$pp \to \tilde{g}\tilde{g}X \to (\bar{\tilde{u}}_1 t)(\tilde{u}_2 \bar{c})X \to (\bar{\tilde{u}}_1 t)(\tilde{u}_1 h^0 \bar{c})X$$

$$\to (\bar{c}\tilde{\chi}_1^0 t)(t\tilde{\chi}_1^0 h^0 \bar{c})X \; (= tt\bar{c}\bar{c}h^0\tilde{\chi}_1^0\tilde{\chi}_1^0 X)$$

'2 top-quarks + 2 jets + h^0 + missing-E_T + beam-jets'

$$t \to bW^+ \to bl^+\nu$$

'isolated same sign dilepton + 4 jets + h^0 + missing-E_T + beam-jets'

Example of QFV squark signal at LHC

Gluino pair production and the QFV squark bosonic decay can lead to

QFV squark signature at LHC :

$$pp \to \tilde{g}\tilde{g}X \to (\tilde{u}_2\bar{c})(\tilde{u}_2\bar{c})X \to (\tilde{u}_1 h^0\bar{c})(\tilde{u}_1 h^0\bar{c})X$$

$$\to (t\tilde{\chi}_1^0 h^0\bar{c})(t\tilde{\chi}_1^0 h^0\bar{c})X \; (= tt\bar{c}\bar{c}h^0h^0\tilde{\chi}_1^0\tilde{\chi}_1^0 X)$$

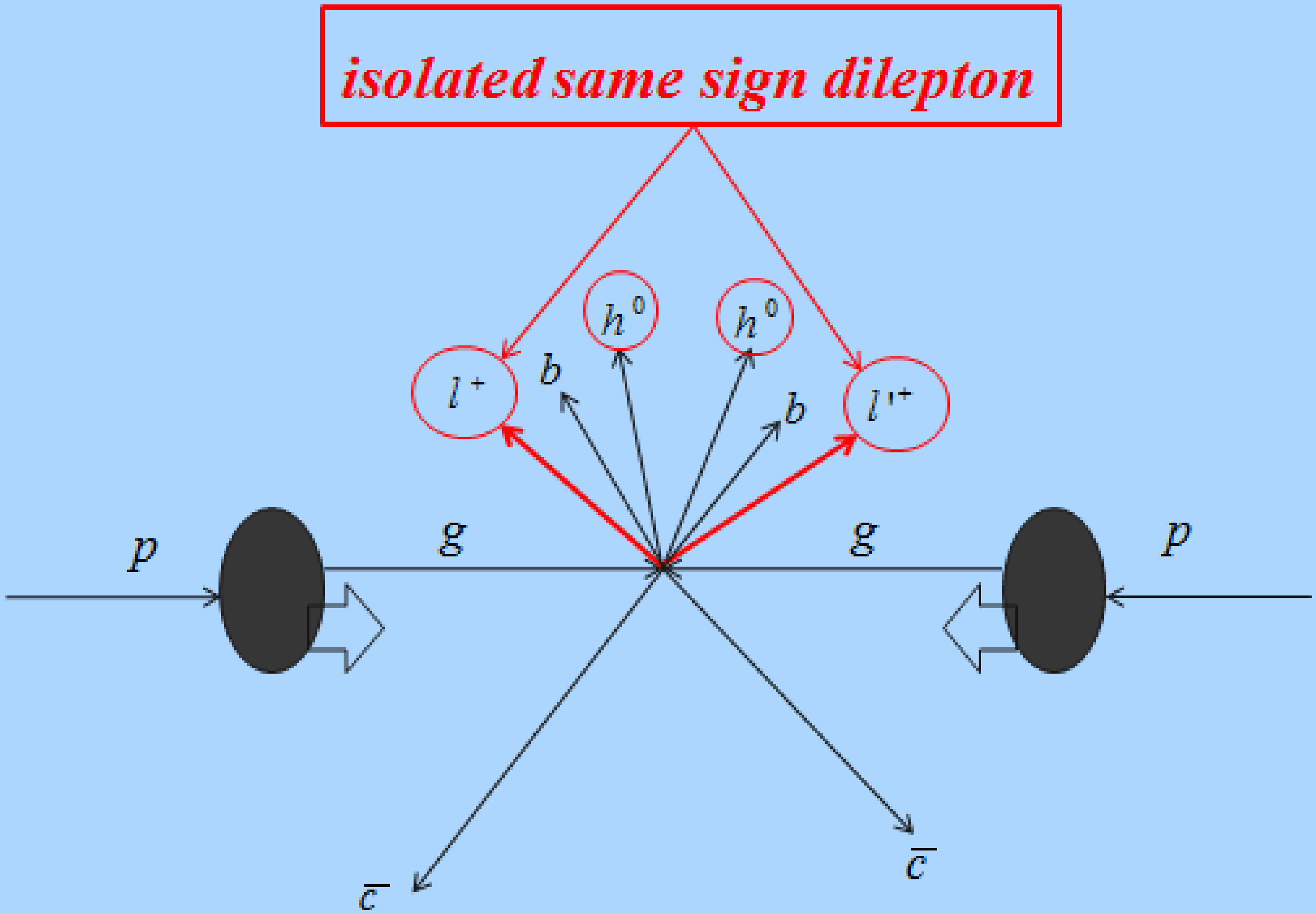
↓

'2 top-quarks + 2 jets + 2 h^0 + missing-E_T + beam-jets'

↓ $t \to bW^+ \to bl^+\nu$

'isolated same sign dilepton + 4 jets + 2 h^0 + missing-E_T + beam-jets'

Example of QFV squark signal at LHC



'isolated same sign dilepton + 4 jets + 2 h^0 + missing-E_T + beam-jets'

h^0 decay branching ratios

- $B(h^0 \rightarrow$ tau$^-$ tau$^+) = 9.1\%$
- $B(h^0 \rightarrow$ b b_bar$) = 57.3\%$
- $B(h^0 \rightarrow$ photon photon$) = 0.52\%$
- $B(h^0 \rightarrow W W^*) = 22.7\%$
- $B(h^0 \rightarrow Z Z^*) = 2.5\%$

h^0 is SM-like in our scenario!

QFV signal rates at LHC

In our scenario;

- *gluino prod. cross section is significant:*

  $\sigma(pp \to \tilde{g}\tilde{g}X)$ ~ 80 fb at LHC(14 TeV)!

- $B(\tilde{g} \to \tilde{u}_2\, c/t)$ can be large (~ 25 %)!

⇓

We can expect copious production of $\tilde{u}_2$ from gluino prod. and decays at LHC(14 TeV)!

⇓

QFV squark signal rates can be significant at LHC(14 TeV)!

6. Impact on squark & gluino search at LHC

Our analyses suggest the following:

- *One should take into account the possibility of significant contributions from QFV decays in the squark and gluino search at LHC.*
- *Moreover, one should also include QFV squark parameters (i.e. squark–generation mixing parameters) in the determination of the basic SUSY parameters at LHC.*

7. Conclusion

- *We have studied the effect of squark generation mixing on squark and gluino production and decays at LHC in the MSSM with focus on mixing between 2nd and 3rd generation squarks.*
- *Taking into account the constraints from B-physics experiments, we have shown that various regions in parameter space exist where decays of squarks and/or gluinos into flavour violating final states can have large branching ratios of up to ~ 50%. Here we have considered both fermionic and bosonic final states.*
- *Rates of the corresponding signals, e.g.* ' $pp \to t\,t\,\bar{c}\,\bar{c} + E_T^{mis}$ + beam-jets', *and* '$pp \to t\,t\,\bar{c}\,\bar{c}\,h^0 h^0 + E_T^{mis}$ + beam-jets' *can be significant at LHC(14 TeV).*
- *We conclude that the inclusion of flavour mixing effects can be important for the search of squarks and gluinos and the determination of the MSSM parameters at LHC.*