

Probing flavor-violating decays of squarks at the LHC

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Post-Higgs discovery era

ATLAS SUSY Searches* - 95% CL Lower Limits
May 2017

ATLAS Preliminary
 $\sqrt{s} = 7, 8, 13 \text{ TeV}$

Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt [\text{fb}^{-1}]$	Mass limit	$\sqrt{s} = 7, 8 \text{ TeV}$	$\sqrt{s} = 13 \text{ TeV}$	Reference
Inclusive Searches	MSUGRA/CMSSM	0-3 $e, \mu/1-2 \tau$	2-10 jets/3 b	Yes	20.3	\tilde{g}, \tilde{g}	1.85 TeV	$m(\tilde{g})=m(\tilde{g})$
	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{X}_1^0$	0	2-6 jets	Yes	36.1	\tilde{q}	1.57 TeV	$m(\tilde{X}_1^0) < 200 \text{ GeV}, m(1^{\text{st}} \text{ gen. } \tilde{q})=m(2^{\text{nd}} \text{ gen. } \tilde{q})$
	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q\tilde{X}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	3.2	\tilde{q}	608 GeV	$m(\tilde{g})=m(\tilde{X}_1^0) < 5 \text{ GeV}$
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{X}_1^0$	0	2-6 jets	Yes	36.1	\tilde{g}	2.02 TeV	$m(\tilde{X}_1^0) < 200 \text{ GeV}$
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{X}_1^0 \rightarrow q\tilde{q}W^\pm\tilde{X}_1^0$	0	2-6 jets	Yes	36.1	\tilde{g}	2.01 TeV	$m(\tilde{X}_1^0) < 200 \text{ GeV}, m(\tilde{X}_1^\pm) = 0.5(m(\tilde{X}_1^0) + m(\tilde{g}))$
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}(\ell\ell/\nu\nu)\tilde{X}_1^0$	3 e, μ	4 jets	-	36.1	\tilde{g}	1.825 TeV	$m(\tilde{X}_1^0) < 400 \text{ GeV}$
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}WZ\tilde{X}_1^0$	0	7-11 jets	Yes	36.1	\tilde{g}	1.8 TeV	$m(\tilde{X}_1^0) < 400 \text{ GeV}$
	GMSB ($\tilde{\ell}$ NLSP)	1-2 $\tau + 0-1 \ell$	0-2 jets	Yes	3.2	\tilde{g}	2.0 TeV	$c\tau(\text{NLSP}) < 0.1 \text{ mm}$
	GGM (bino NLSP)	2 γ	-	Yes	3.2	\tilde{g}	1.65 TeV	$m(\tilde{X}_1^0) < 950 \text{ GeV}, c\tau(\text{NLSP}) < 0.1 \text{ mm}, \mu < 0$
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	\tilde{g}	1.37 TeV	$m(\tilde{X}_1^0) > 680 \text{ GeV}, c\tau(\text{NLSP}) < 0.1 \text{ mm}, \mu > 0$
GGM (higgsino-bino NLSP)	γ	2 jets	Yes	13.3	\tilde{g}	1.8 TeV	$m(\text{NLSP}) > 430 \text{ GeV}$	
GGM (higgsino NLSP)	2 e, μ (Z)	2 jets	Yes	20.3	\tilde{g}	900 GeV	$m(\text{NLSP}) > 430 \text{ GeV}$	
Gravitino LSP	0	mono-jet	Yes	20.3	$F^{3/2}$ scale	865 GeV	$m(\tilde{G}) > 1.8 \times 10^{-4} \text{ eV}, m(\tilde{g})=m(\tilde{g})=1.5 \text{ TeV}$	
3 rd gen. \tilde{g} med.	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow b\tilde{b}\tilde{X}_1^0$	0	3 b	Yes	36.1	\tilde{g}	950 GeV	$m(\tilde{X}_1^0) < 100 \text{ GeV}$
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t\tilde{t}\tilde{X}_1^0$	0-1 e, μ	3 b	Yes	36.1	\tilde{g}	950 GeV	$m(\tilde{X}_1^0) < 100 \text{ GeV}$
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow b\tilde{b}\tilde{X}_1^0$	0-1 e, μ	3 b	Yes	20.1	\tilde{g}	950 GeV	$m(\tilde{X}_1^0) < 100 \text{ GeV}$
3 rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow b\tilde{X}_1^0$	0	2 b	Yes	36.1	\tilde{b}_1	950 GeV	$m(\tilde{X}_1^0) < 100 \text{ GeV}$
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1 \rightarrow t\tilde{X}_1^0$	2 e, μ (SS)	1 b	Yes	36.1	\tilde{b}_1	275-700 GeV	$m(\tilde{X}_1^0) = m(\tilde{X}_1^0) + 100 \text{ GeV}$
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{X}_1^0$	0-2 e, μ	1-2 b	Yes	4.7/13.3	\tilde{t}_1	117-170 GeV	$m(\tilde{X}_1^0) = m(\tilde{X}_1^0) + 55 \text{ GeV}$
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow Wb\tilde{X}_1^0$ or $\tilde{t}_1\tilde{t}_1$	0-2 e, μ	0-2 jets/1-2 b	Yes	20.3/36.1	\tilde{t}_1	90-198 GeV	$m(\tilde{X}_1^0) = 1 \text{ GeV}$
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow c\tilde{X}_1^0$	0	mono-jet	Yes	3.2	\tilde{t}_1	90-323 GeV	$m(\tilde{X}_1^0) = 1 \text{ GeV}$
	$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e, μ (Z)	1 b	Yes	20.3	\tilde{t}_1	150-600 GeV	$m(\tilde{X}_1^0) = 5 \text{ GeV}$
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2 \rightarrow t_1 + Z$	3 e, μ (Z)	1 b	Yes	36.1	\tilde{t}_2	290-790 GeV	$m(\tilde{X}_1^0) > 150 \text{ GeV}$
$\tilde{t}_2\tilde{t}_2, \tilde{t}_2 \rightarrow t_1 + h$	1-2 e, μ	4 b	Yes	36.1	\tilde{t}_2	320-880 GeV	$m(\tilde{X}_1^0) = 0 \text{ GeV}$	
EW direct	$\tilde{\ell}_L\tilde{\ell}_L, \tilde{\ell} \rightarrow \ell\tilde{X}_1^0$	2 e, μ	0	Yes	36.1	$\tilde{\ell}$	90-440 GeV	
	$\tilde{\chi}_1^+\tilde{\chi}_1^+, \tilde{\chi}_1^+ \rightarrow \tilde{\nu}(\ell\nu)$	2 e, μ	0	Yes	36.1	$\tilde{\chi}_1^+$	710 GeV	
	$\tilde{\chi}_1^+\tilde{\chi}_1^+, \tilde{\chi}_1^+ \rightarrow \tilde{\nu}(\nu\tilde{\nu}), \tilde{\chi}_2^0 \rightarrow \tilde{\nu}(\nu\tilde{\nu})$	2 τ	0	Yes	36.1	$\tilde{\chi}_1^+$	760 GeV	
	$\tilde{\chi}_1^+\tilde{\chi}_1^+, \tilde{\chi}_1^+ \rightarrow \tilde{\nu}(\ell\nu), \tilde{\nu} \rightarrow \tilde{\nu}(\ell\nu)$	3 e, μ	0	Yes	36.1	$\tilde{\chi}_1^+$	1.8 TeV	
	$\tilde{\chi}_1^+\tilde{\chi}_1^+ \rightarrow W\tilde{X}_1^0Z\tilde{X}_1^0$	2-3 e, μ	0-2 jets	Yes	36.1	$\tilde{\chi}_1^+$	580 GeV	
	$\tilde{\chi}_1^+\tilde{\chi}_1^+ \rightarrow W\tilde{X}_1^0h\tilde{X}_1^0, h \rightarrow b\tilde{b}/WW/\tau\tau/\gamma\gamma$	e, μ, γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^+$	270 GeV	
	$\tilde{\chi}_2^0\tilde{\chi}_2^0, \tilde{\chi}_2^0 \rightarrow \tilde{\ell}R\ell$	4 e, μ	0	Yes	20.3	$\tilde{\chi}_2^0$	635 GeV	
	GGM (wino NLSP) weak prod., $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$	1 $e, \mu + \gamma$	-	Yes	20.3	\tilde{W}	115-370 GeV	
GGM (bino NLSP) weak prod., $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$	2 γ	-	Yes	20.3	\tilde{W}	590 GeV		
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^+$ prod., long-lived $\tilde{\chi}_1^+$	Disapp. trk	1 jet	Yes	36.1	$\tilde{\chi}_1^+$	430 GeV	
	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^+$ prod., long-lived $\tilde{\chi}_1^+$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}_1^+$	495 GeV	
	Stable, stopped \tilde{g} R-hadron	0	1-5 jets	Yes	27.9	\tilde{g}	850 GeV	
	Stable \tilde{g} R-hadron	trk	-	-	3.2	\tilde{g}	-	
	Metastable \tilde{g} R-hadron	dE/dx trk	-	-	3.2	\tilde{g}	-	
	GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0 \rightarrow \tilde{\tau}(\tilde{e}, \tilde{\mu}) + \tau(e, \mu)$	1-2 μ	-	-	19.1	$\tilde{\chi}_1^0$	537 GeV	
	GMSB, $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	20.3	$\tilde{\chi}_1^0$	440 GeV	
$\tilde{g}\tilde{g}, \tilde{X}_1^0 \rightarrow e\tilde{\nu}/\mu\tilde{\nu}/\mu\tilde{\nu}$	displ. $e\tilde{\nu}/\mu\tilde{\nu}$	-	-	20.3	\tilde{X}_1^0	1.0 TeV		
GGM $\tilde{g}\tilde{g}, \tilde{X}_1^0 \rightarrow Z\tilde{G}$	displ. vtx + jets	-	-	20.3	\tilde{X}_1^0	1.0 TeV		
RPV	LFV $pp \rightarrow \tilde{\nu}_e + X, \tilde{\nu}_e \rightarrow e\mu/\tau\mu/\mu\tau$	$e\mu, \tau\mu, \mu\tau$	-	-	3.2	$\tilde{\nu}_e$	1.9 TeV	$\lambda_{111} = 0.11, \lambda_{132}/133/233 = 0.07$
	Billinear RPV CMSSM	2 e, μ (SS)	0-3 b	Yes	20.3	\tilde{g}, \tilde{g}	1.45 TeV	$m(\tilde{g})=m(\tilde{g}), c\tau_{RPV} < 1 \text{ mm}$
	$\tilde{\chi}_1^+\tilde{\chi}_1^+, \tilde{\chi}_1^+ \rightarrow W\tilde{X}_1^0, \tilde{\chi}_1^+ \rightarrow e\tilde{\nu}, \mu\tilde{\nu}, \mu\tilde{\nu}$	4 e, μ	-	Yes	13.3	$\tilde{\chi}_1^+$	1.1 TeV	
	$\tilde{\chi}_1^+\tilde{\chi}_1^+, \tilde{\chi}_1^+ \rightarrow W\tilde{X}_1^0, \tilde{\chi}_1^+ \rightarrow \tau\tilde{\nu}_e, e\tilde{\nu}_\tau$	3 $e, \mu + \tau$	-	Yes	20.3	$\tilde{\chi}_1^+$	450 GeV	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}q$	0	4-5 large-R jets	-	14.8	\tilde{g}	1.08 TeV	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{X}_1^0, \tilde{X}_1^0 \rightarrow q\tilde{q}q$	0	4-5 large-R jets	-	14.8	\tilde{g}	-	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t\tilde{t}\tilde{X}_1^0, \tilde{X}_1^0 \rightarrow q\tilde{q}q$	1 e, μ	8-10 jets/0-4 b	-	36.1	\tilde{g}	-	
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{s}$	1 e, μ	8-10 jets/0-4 b	-	36.1	\tilde{g}	-	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{s}$	0	2 jets + 2 b	-	15.4	\tilde{t}_1	410 GeV	
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1 \rightarrow b\tilde{\ell}$	2 e, μ	2 b	-	36.1	\tilde{t}_1	450-510 GeV	
Other	Scalar charm, $\tilde{c} \rightarrow c\tilde{X}_1^0$	0	2 c	Yes	20.3	\tilde{c}	510 GeV	

1 TeV

Several BSM models probed, strong limits, many assumptions; (Similar at CMS)

How robust they are?

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

Agenda

Flavor mixing:

Generation mixing (squark) in MSSM w/o adding new fields/complexity

- **Direct search:** Production and Decay changes significantly, limits reduces! 😄
- **Additional sources** of FV, large contributions to various FCNC process, constraints from low energy physics data. 😞

In tension!

But, certain mixing (RR-type) bounds are weak too!

Goal:

1. Can we constrain these RR-type couplings with updated LHC data?
2. Sensitivity of 300 fb or, say HL-LHC ?

Outline

- Flavor violation: SM and Beyond
- A Bottom-up approach (i.e., Simplified Model)
- Phenomenology, LHC sensitivity (high lumi)

Flavor in SM

Yukawa interaction: only source of FV in the SM

$$\mathcal{L}_Y = \sum_{i,j=1}^3 (y_{ij}^e \bar{L}_{Li} \Phi e_{Rj} + y_{ij}^u \bar{Q}_{Li} \tilde{\Phi} u_{Rj} + y_{ij}^d \bar{Q}_{Li} \Phi d_{Rj}) + \text{h.c}$$

$$Q_i = \begin{pmatrix} u_i \\ d_i \end{pmatrix}_L \sim (3, 2, 1/3) \quad U_i = u_{Ri} \sim (3, 1, 4/3)$$

$$L_i = \begin{pmatrix} \nu_{e_i} \\ e_i^- \end{pmatrix}_L \sim (1, 2, -1) \quad D_i = d_{Ri} \sim (3, 1, -2/3) \quad E_i = e_{Ri} \sim (1, 1, -2)$$

$G_{\text{SM}} = \text{SU}(3)_C \times \text{SU}(2)_L \times \text{U}(1)_Y$

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

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

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

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

Highly suppressed
Off-diagonal
terms

Flavor in MSSM

- Same flavor structure as in SM
- Super-CKM basis: squarks undergo same rotation as quarks
- All FV effects are proportional to CKM elements

Minimal Flavor Violation

$$\mathcal{M}_{\tilde{u}}^2 = \begin{pmatrix} \mathcal{M}_{uLL}^2 & (\mathcal{M}_{uRL}^2)^\dagger \\ \mathcal{M}_{uRL}^2 & \mathcal{M}_{uRR}^2 \end{pmatrix}_{6 \times 6}$$

Basis:

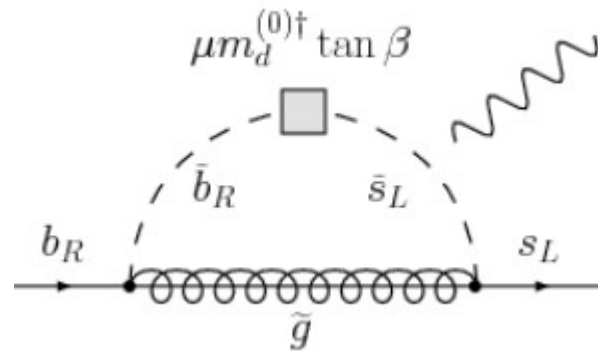
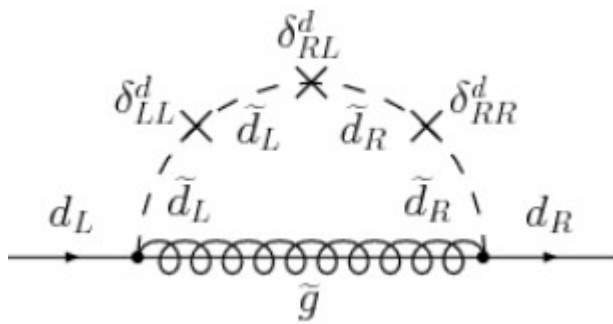
$$\left\{ \begin{array}{l} (\tilde{u}_L, \tilde{c}_L, \tilde{t}_L, \tilde{u}_R, \tilde{c}_R, \tilde{t}_R) \\ (\tilde{d}_L, \tilde{s}_L, \tilde{b}_L, \tilde{d}_R, \tilde{s}_R, \tilde{b}_R) \end{array} \right.$$

- New sources of FV appears
- Mostly from Soft-SUSY breaking terms (e.g.: gravity mediation, gauge mediation with messenger mixing, ...) [Porod et. al.,
- No direct relation with CKM
- Generation mixing at EW scale
- Independent parameters

Non-Minimal Flavor violation

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

Consequences of Generation mixing



- **Potential effects to low energy processes; K, B, D-physics, Meson mixing, ...**

Precise measurements; strong constraints

- **Higgs data also puts limits on LR-type mixing**

- **Production and Decay of SUSY particles**, change significantly

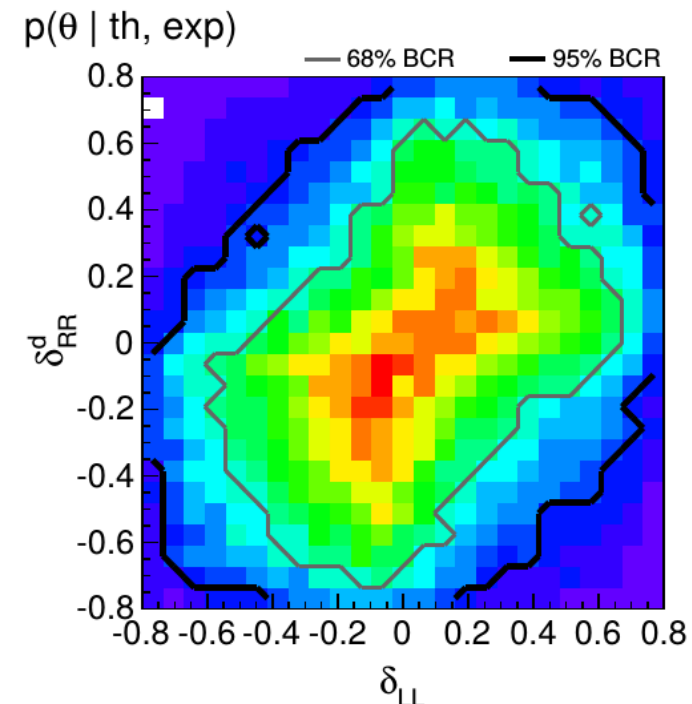
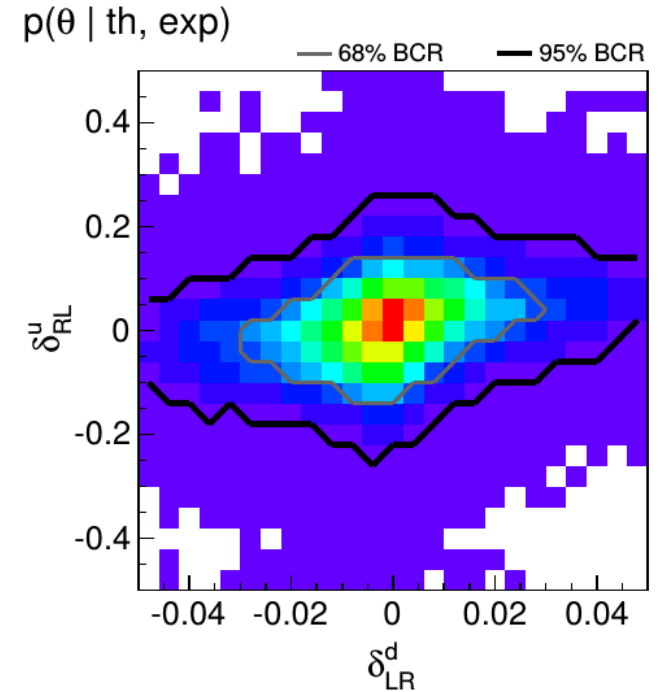
Relatively weaker bounds at LHC

- The **RR-sector (up-type)** with the mixing

Focus:

Impact of Stop search and also scharm search on

BR(c-t) mixing parameter



Simplified Model

Model: SM + right-handed stop + right-handed scharm + Gluino + Neutralino (bino)

- Squarks are admixtures of different flavors
- Simplified model: right stop-scharm mixing

$$\begin{pmatrix} \tilde{u}_1 \\ \tilde{u}_2 \end{pmatrix} = \begin{pmatrix} \cos \theta_{tc} & \sin \theta_{tc} \\ -\sin \theta_{tc} & \cos \theta_{tc} \end{pmatrix} \begin{pmatrix} \tilde{c}_R \\ \tilde{t}_R \end{pmatrix}$$

Production
&
Decay

- 3D parameter space (2 masses, one mixing angle)
 $m_{\tilde{u}_1}, m_{\tilde{u}_2}, \theta_{tc}$

- Possible flavor-violating decays: $\tilde{u}_i \rightarrow t + \cancel{E}_T$ or $c + \cancel{E}_T$

- Signatures

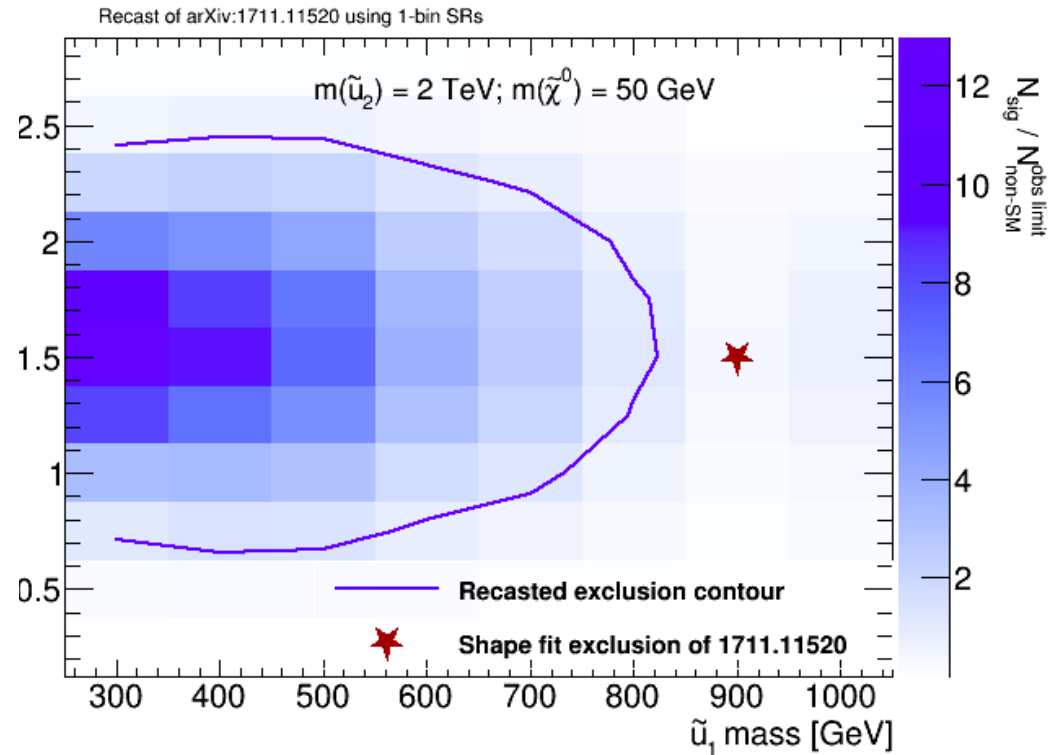
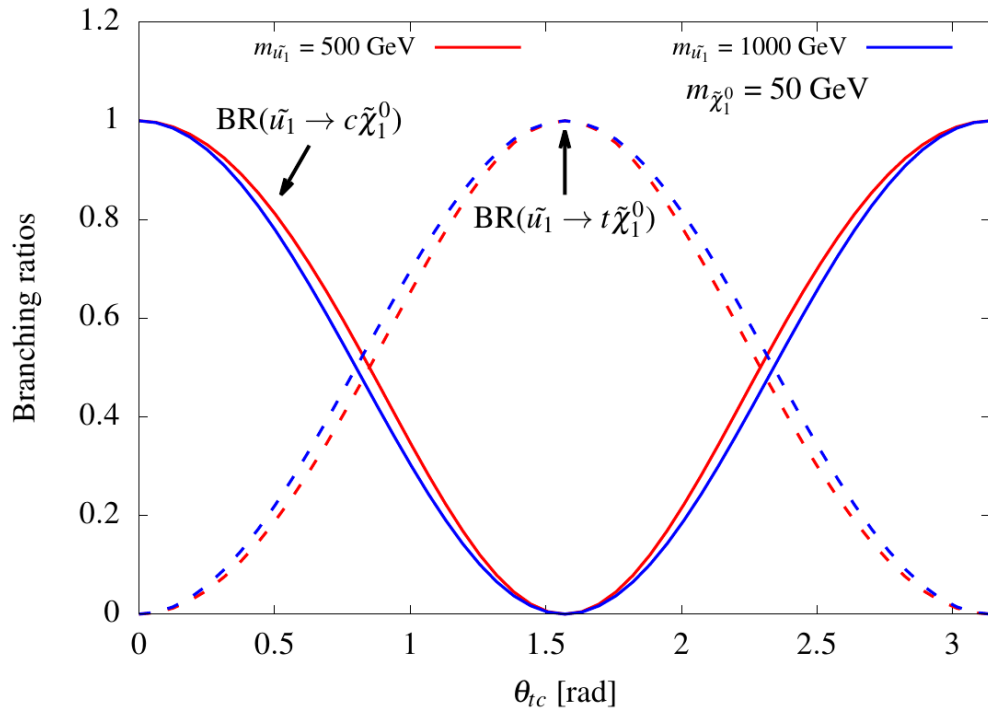
$$\begin{aligned} t\bar{t} + E_T^{miss} &> 1407.0583 \\ c\bar{c} + E_T^{miss} &> 1501.01325 \\ c + t + E_T^{miss} &> \text{Monotops?} \end{aligned}$$

(replaced with new 13 TeV)
(8 TeV available)

Objectives:

- Coverage of current searches ?
- Potential of a dedicated top-charm analysis

Recast of LHC 13 TeV data

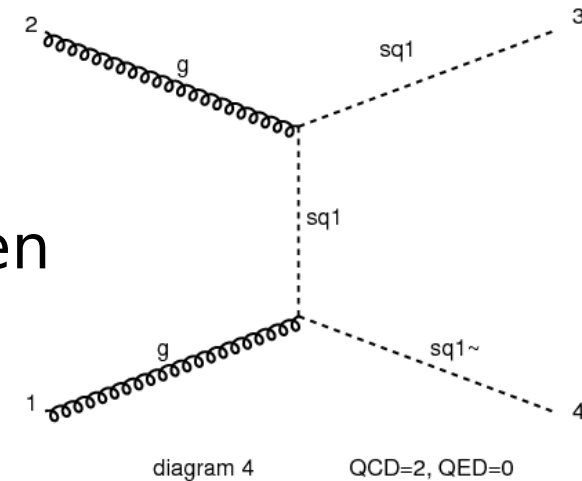
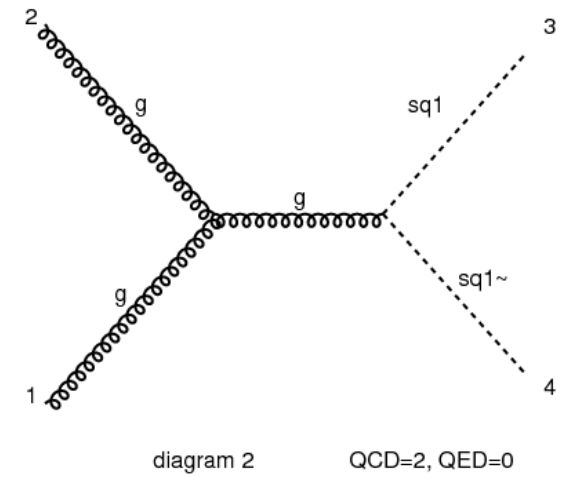
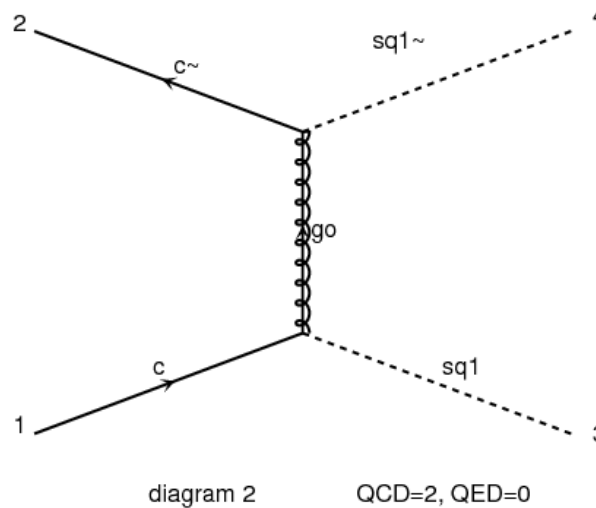
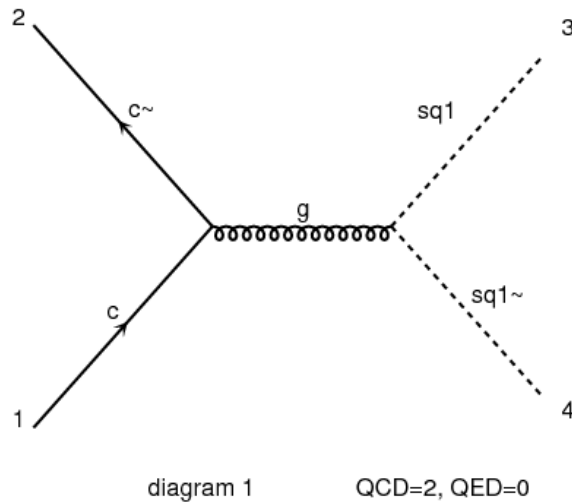


- **Scharm search**: ~ 500 GeV @ 8 TeV
- **Stop search**: **1-lepton, jets + MET search at 13 TeV**
- Translate to 3-parameter plane: $m(u_1)$, $m(u_2)$ and $\theta(tc)$.
- **Recast**: compare signal yields with Model independent limits on non-SM contributions from the observed data.

Define: $R = N_{\text{sig}} / N_{\text{non-SM(obs)}} ; R > 1 \Rightarrow$

Excluded!!

Monte-Carlo set-up



- **Signal:** LO using MG5, passed to PY8 and then Delphes; normalized using NLO+NLL xsec
- **Bkg:** ttbar, signal top @NLO, ttbarZ, ttbarW, W+jets, Z+jets @LO; PY8 + Delphes; normalized with NNLO/NLO xsecs
- **Squark pair-production:** $m(u1) = [600, 1400]$ GeV, $m(\chi) = 50$ GeV, mixing angle fixed at $\theta(tc) = \pi/4$.
- **Jets:** Fastjet with $R=0.4$, anti-kT, ATLAS card.

Event selection

Aim : top + charm + MET topology

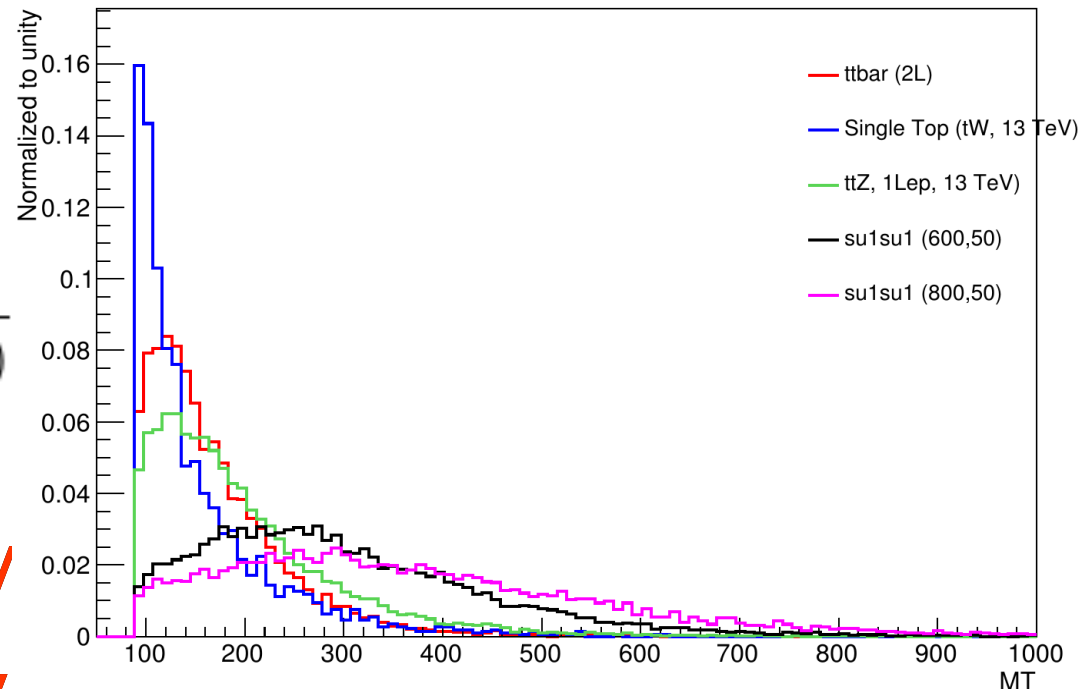
- Exactly **one lepton** with $p_T > 25$ GeV, $|\eta| < 2.5$.
- Exactly **one b-tagged jet** with $p_T > 30$ GeV; Veto additional b-jets ($\varepsilon_b = 77\%$).
- At least **one light jet** with $p_T > 100$ GeV (jet failing b-tagging criteria).
- **$m_T(\text{lep}, \text{MET}) > 90$**
& **$\text{MET} > 80$ GeV.**

$$m_T^{\text{lep}} \equiv \sqrt{2 |\vec{p}_T^\ell| |\vec{p}_T^{\text{miss}}| (1 - \cos \Delta\phi_{\vec{p}_T^\ell \vec{p}_T^{\text{miss}}})}$$

- Further,

$$m_T(\text{lep}, \text{MET}) > 160 \text{ GeV}$$

$$m(\text{lep}, \text{b-jet}) < 160 \text{ GeV}$$



Event selection - II

- $|\Delta\phi_{\min}| > 0.6$, between MET and jets.

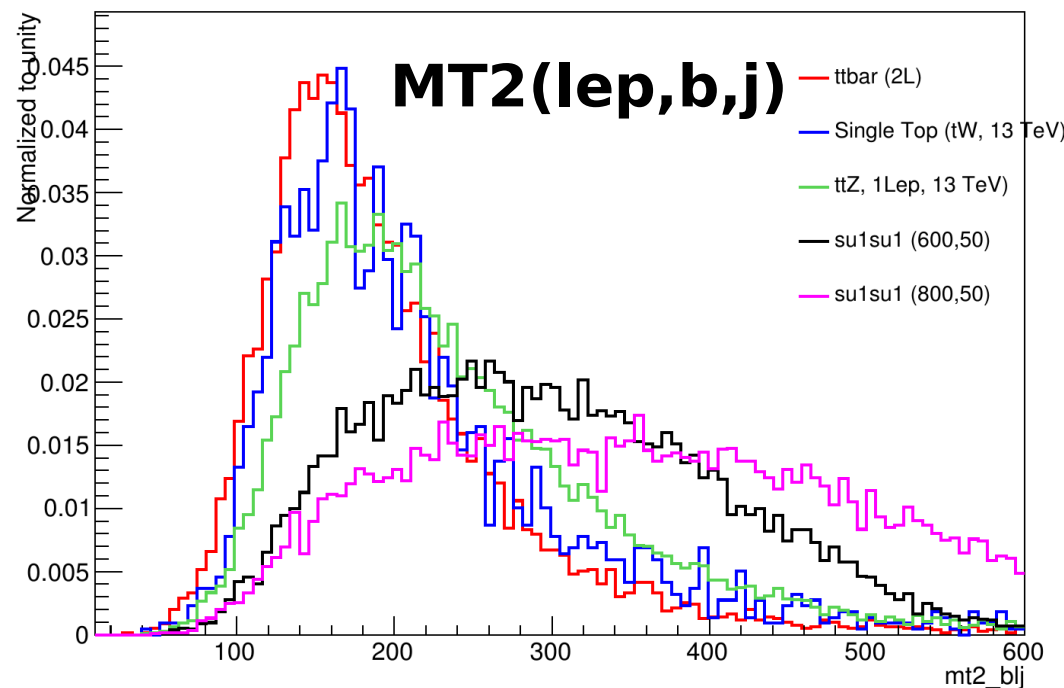
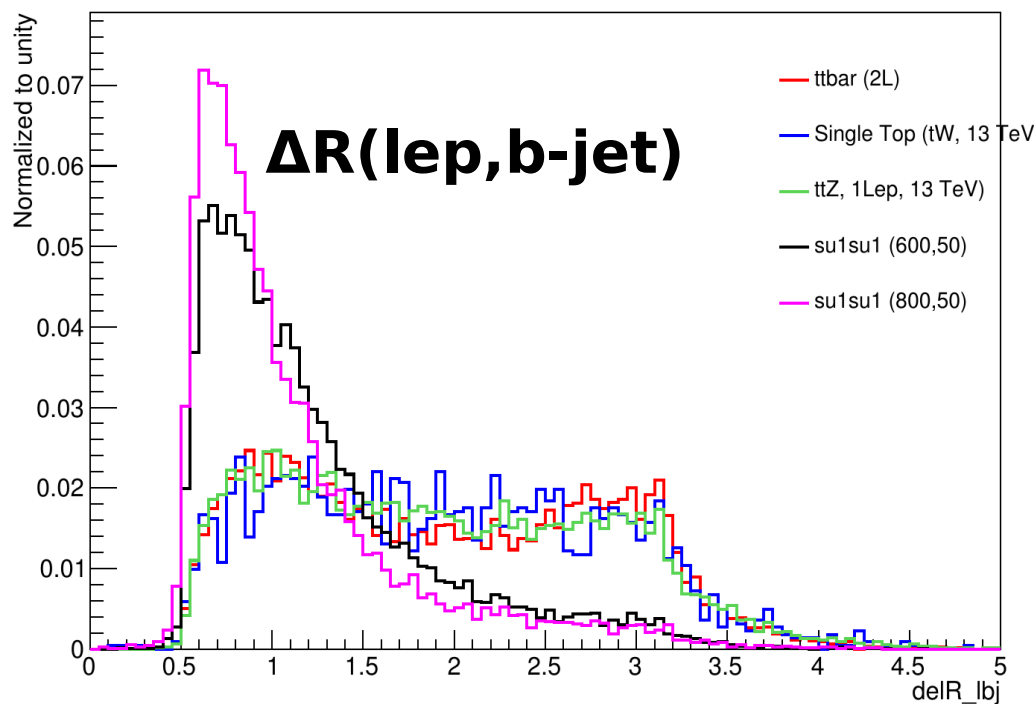
- $\Delta R(\text{lep}, \text{b-jet}) < 1$.

$$M_{T2}(\vec{p}_T^{\ell 1}, \vec{p}_T^{\ell 2}, \vec{p}_T) = \min_{\vec{p}_T = \vec{p}_T^1 + \vec{p}_T^2} \left[\max\{M_T(\vec{p}_T^{\ell 1}, \vec{p}_T^1), M_T(\vec{p}_T^{\ell 2}, \vec{p}_T^2)\} \right],$$

- **Asym MT2**: aMT2 > 200 GeV (reduce di-lep ttbar)

(V1 = lepton, b-jet; V2 = leading non-btagged jet or c-jet or light-jet; MET system = (0,80 GeV))

- Vary **MT2(lep,b-jet,light-jet)** for optimization: **Squark mass dependent end-point**



Note: No charm tagging used, use of b-veto helps better for estimating exclusion limits.

Reach @ 14 TeV

$m_{\tilde{u}_1}$ (GeV)	$m_{\tilde{\chi}_1^0}$ (GeV)	$m_{T_{2blj}}$ cut (GeV)	N_s	N_b	$\sigma^{\text{excl}} / \sigma^{\text{SUSY}}$	
600	50	400	124.9	63.0	0.23	
700	50	450	55.6	31.5	0.30	5 σ
800	50	500	25.8	15.3	0.41	
900	50	500	17.0	15.3	0.63	
1000	50	550	8.3	7.6	0.89	2 σ
1100	50	600	4.0	4.4	1.41	

Likelihood Analysis; 95% CL Upper Limit on the Ratio of Signal yields to the same for the Simplified model

- ✓ **Mass ~ 1 TeV can be probed at LHC-14 at 300 ifb, ~1.3 TeV at 3000 ifb.**
- ✓ **Increased sensitivity with significant mixing in the stop-scharm sector**
- ✓ **How to know the “mixed stop” is originating from t-c mixing or t-u mixing?**
- ✓ **Charm tagging is important; Amount of c-jets in signal events can be estimated by changing the b-tagging working point!** [Higgs coupling: Perez et. al. 2015].