Correlations of flavour and collider physics

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Overview

- Squark mixing
- Low energy constraints
- Strategy
- Squark decays
- Implications for LHC and LC
- Summary and Outlook

Squark Mixing

$$M_{\tilde{q}}^2 = \begin{pmatrix} M_{LL}^2 & M_{LR}^2 \\ M_{LR}^{2\dagger} & M_{RR}^2 \end{pmatrix}$$

d-squarks

$$\begin{aligned}
M_{LL,ij}^2 &= M_{Q,ij}^2 + \frac{v_d^2 Y_{ik}^d Y_{jk}^{d*}}{2} + \delta_{ij} D_{d,L} \\
M_{LR,ij}^2 &= \frac{v_d A_{ij}^d - \mu^* v_u Y_{ij}^d}{\sqrt{2}} \\
M_{RR,ij}^2 &= M_{D,ij}^2 + \frac{v_d^2 Y_{ki}^{d*} Y_{kj}^d}{2} + \delta_{ij} D_{d,R}
\end{aligned}$$

u-squarks

$$\begin{aligned}
M_{LL,ij}^2 &= M_{Q,ij}^2 + \frac{v_u^2 Y_{ik}^u Y_{jk}^{u*}}{2} + \delta_{ij} D_{u,L} \\
M_{LR,ij}^2 &= \frac{v_u A_{ij}^u - \mu^* v_d Y_{ij}^u}{\sqrt{2}} \\
M_{RR,ij}^2 &= M_{U,ij}^2 + \frac{v_u^2 Y_{ki}^{u*} Y_{kj}^u}{2} + \delta_{ij} D_{u,R}
\end{aligned}$$

M_Q^2, M_D^2, M_U^2 hermitian 3×3 matrices

Y^u, Y^d, A^u, A^d general 3×3 complex matrices

Low Energy Constraints

- K-physics: ϵ'/ϵ, K^0-$\bar{K}^0$ mixing, ...
  $\Rightarrow$ neglect $1-2$ and $1-3$ mixing

- B-physics: $b \to s\gamma$, ...
  most important beyond SM contributions:
  H^+, $\tilde{\chi}_i^+$, $\tilde{g}$
  requires left-right transition
  $\Rightarrow$ mainly restricts A^d_{ij}, A^u_{ij}

In practice:

- For simplicity: real parameters only

- take QCD corrections for $b \to s\gamma$ as given in F. Borzumati et al., Phys. Rev. D62, 075005 (2000)

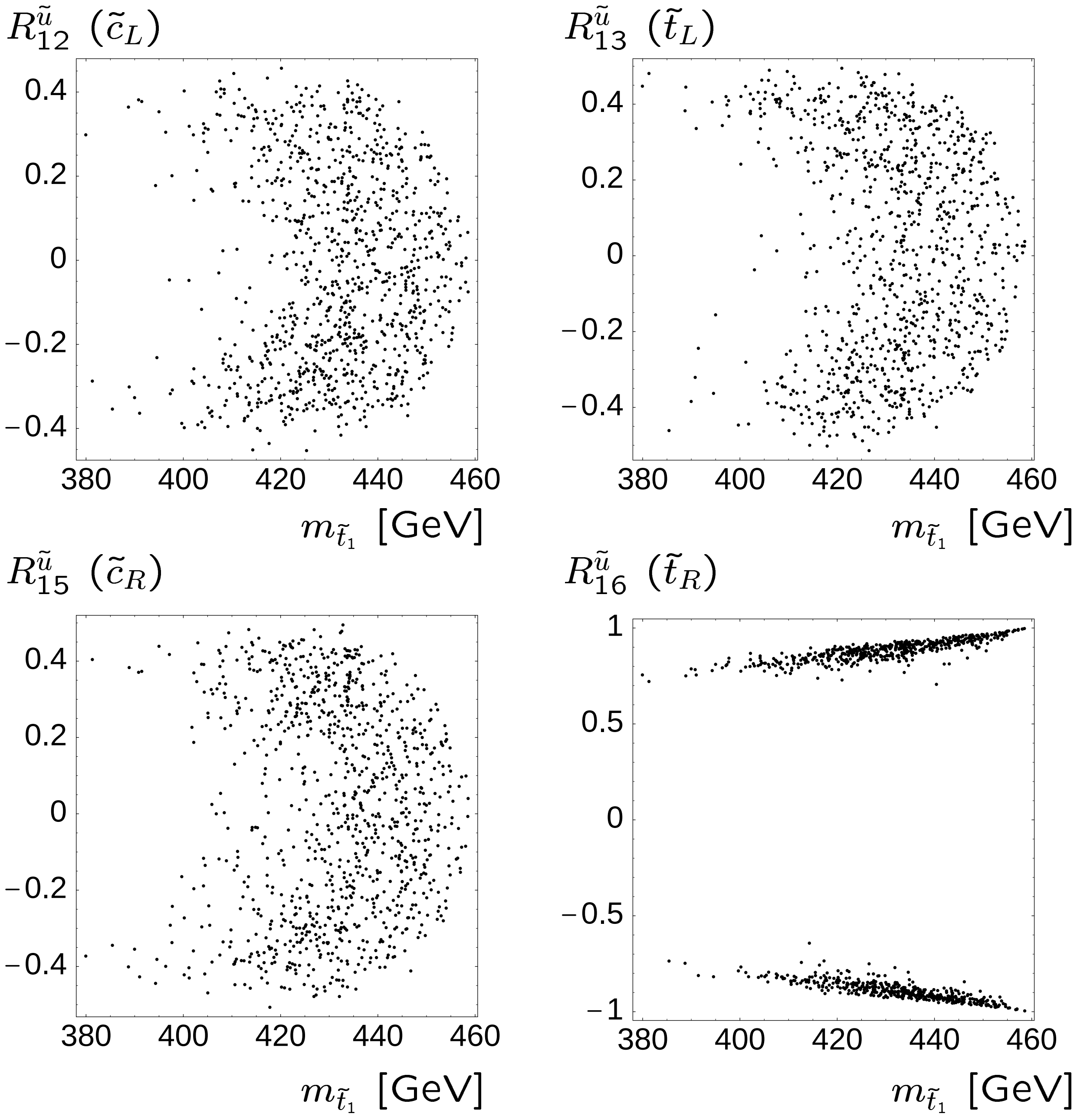
Strategy

Take SPS1a as starting point:
$M_0 = 100$ GeV, $M_{1/2} = 250$ GeV
$A_0 = -100$ GeV, $\tan\beta = 10$, $\mu > 0$
$\Rightarrow$
$M_2 = 192$ GeV, $\mu = 351$ GeV
$m_{H^+} = 403$ GeV $m_{\tilde{g}} = 594$ GeV, $m_{\tilde{t}_1} = 400$ GeV
$m_{\tilde{t}_2} = 590$ GeV, $m_{\tilde{q}_R} \simeq 550$ GeV, $m_{\tilde{q}_L} \simeq 570$ GeV

vary:
$|M^2_{Q,23}|, |M^2_{D,23}|, |M^2_{U,23}| |A^u_{ij}|, |A^d_{ij}| < 10^5$ GeV^2
$(i, j = 2, 3)$ in super CKM-basis
accept points with $2 \leq 10^4$ BR$(b \to s\gamma) \leq 4.5$

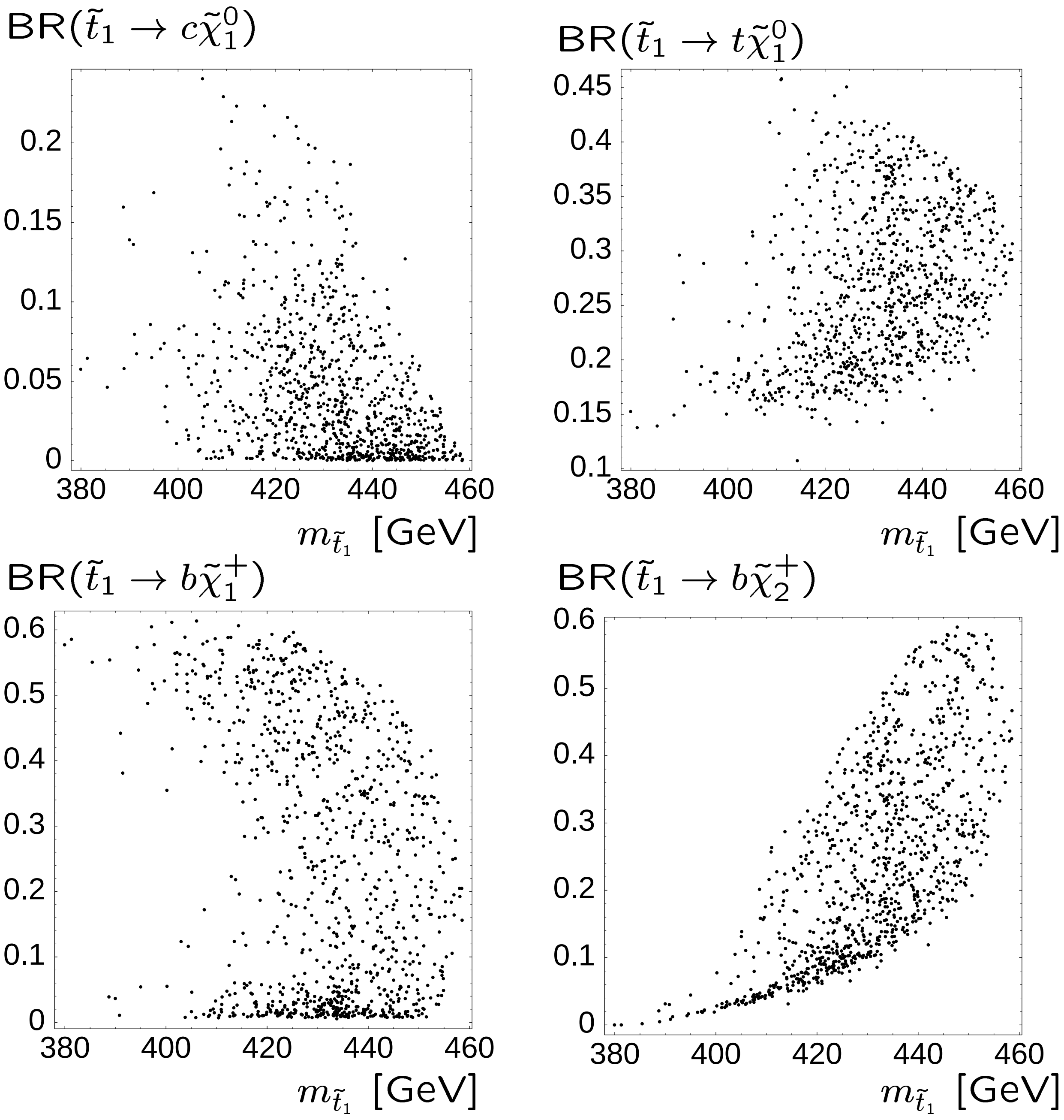
Content of $\tilde{t}_1$

lightest u-type squark



preliminary results

Branching of $\tilde{t}_1$



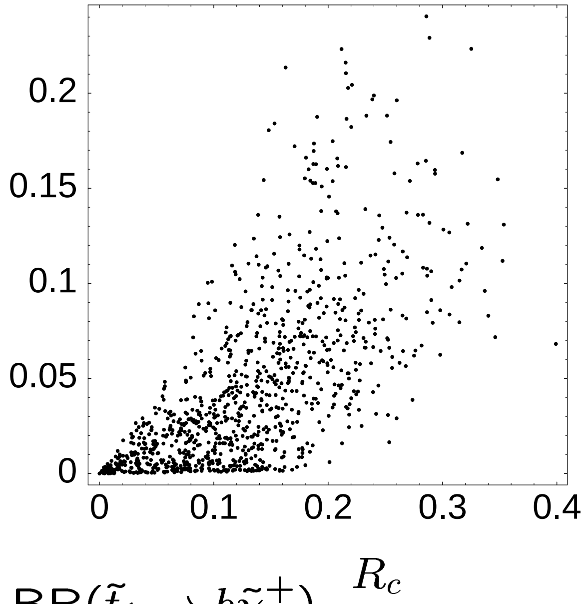
preliminary results

Branching of $\tilde{t}_1$

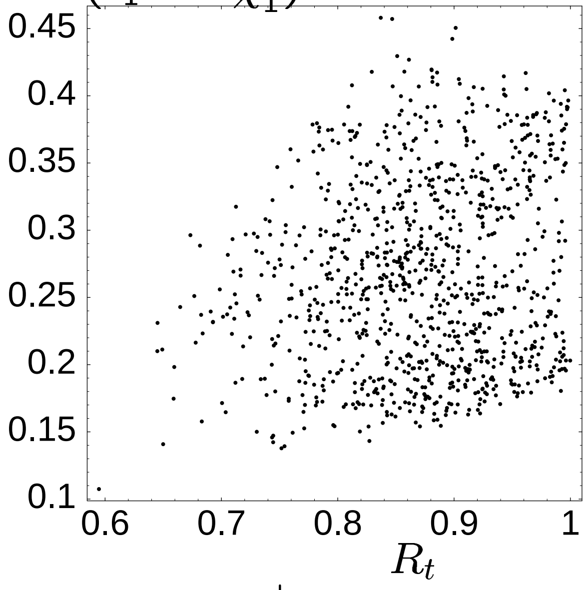
define: $R_c = (R^{\tilde{u}}_{12})^2 + (R^{\tilde{u}}_{15})^2$

$R_t = (R^{\tilde{u}}_{13})^2 + (R^{\tilde{u}}_{16})^2$

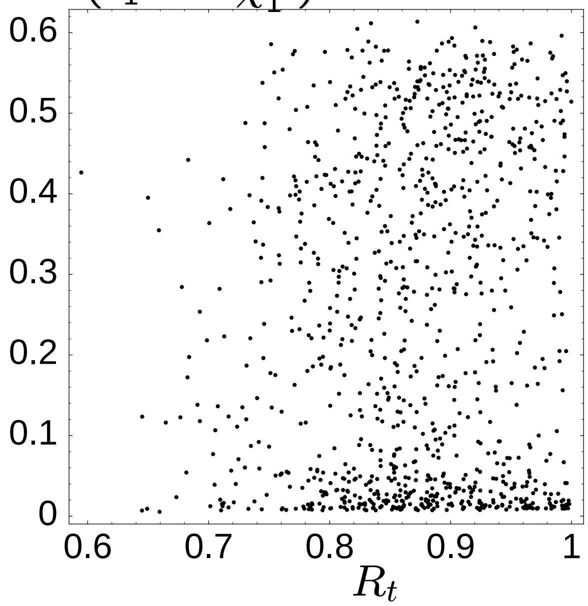
BR($\tilde{t}_1 \to c\tilde{\chi}^0_1$)



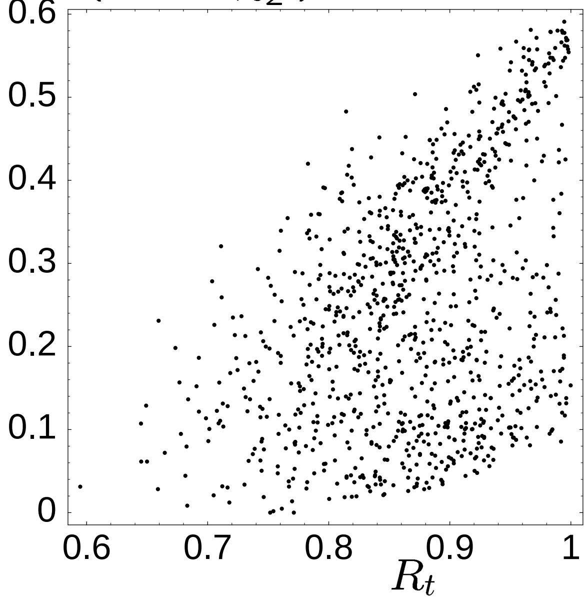
BR($\tilde{t}_1 \to t\tilde{\chi}^0_1$)



BR($\tilde{t}_1 \to b\tilde{\chi}^+_1$)



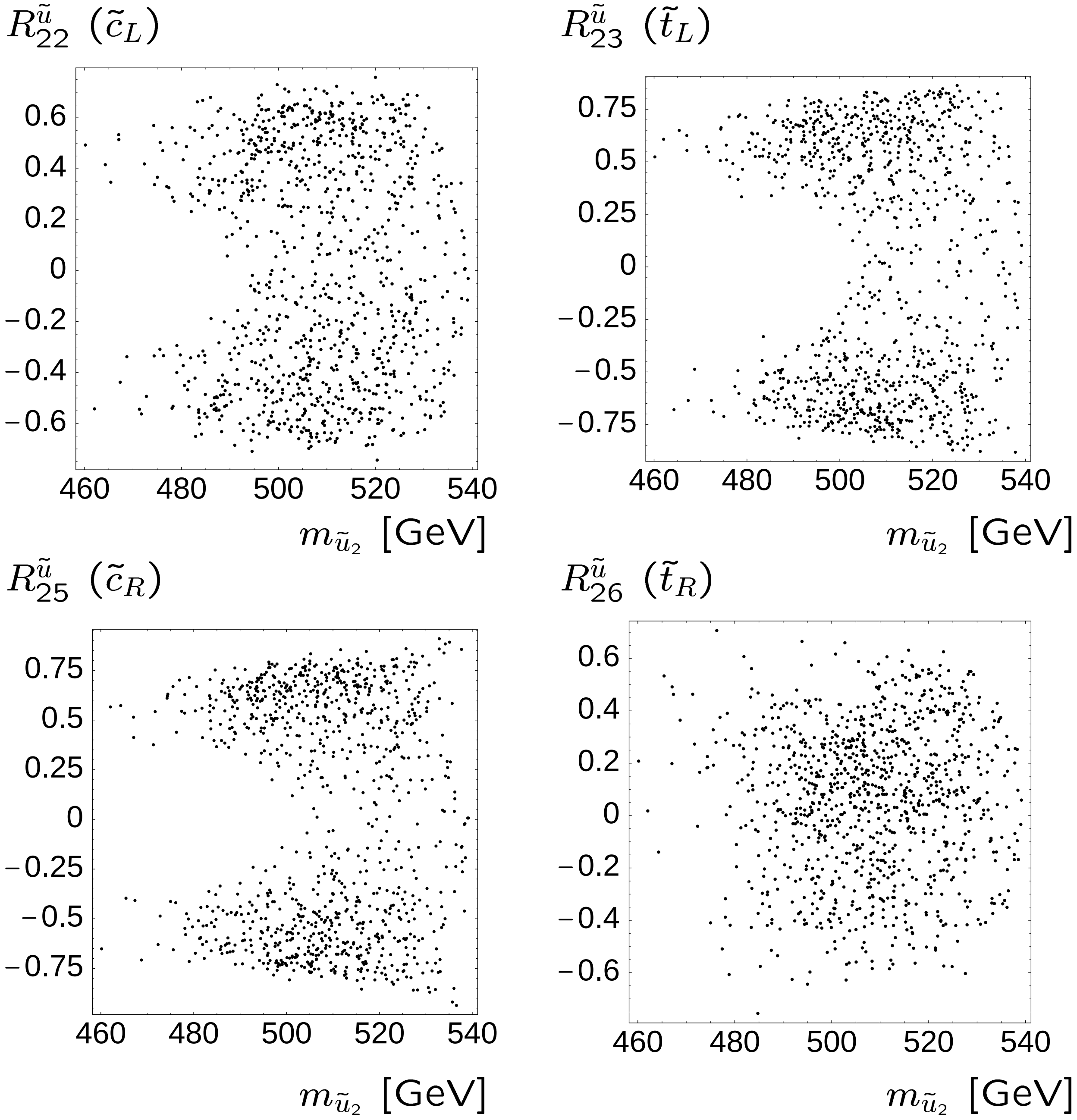
BR($\tilde{t}_1 \to b\tilde{\chi}^+_2$)



preliminary results

Content of $\tilde{u}_2$

strong mixture between $\tilde{t}_2$ and $\tilde{c}_1$

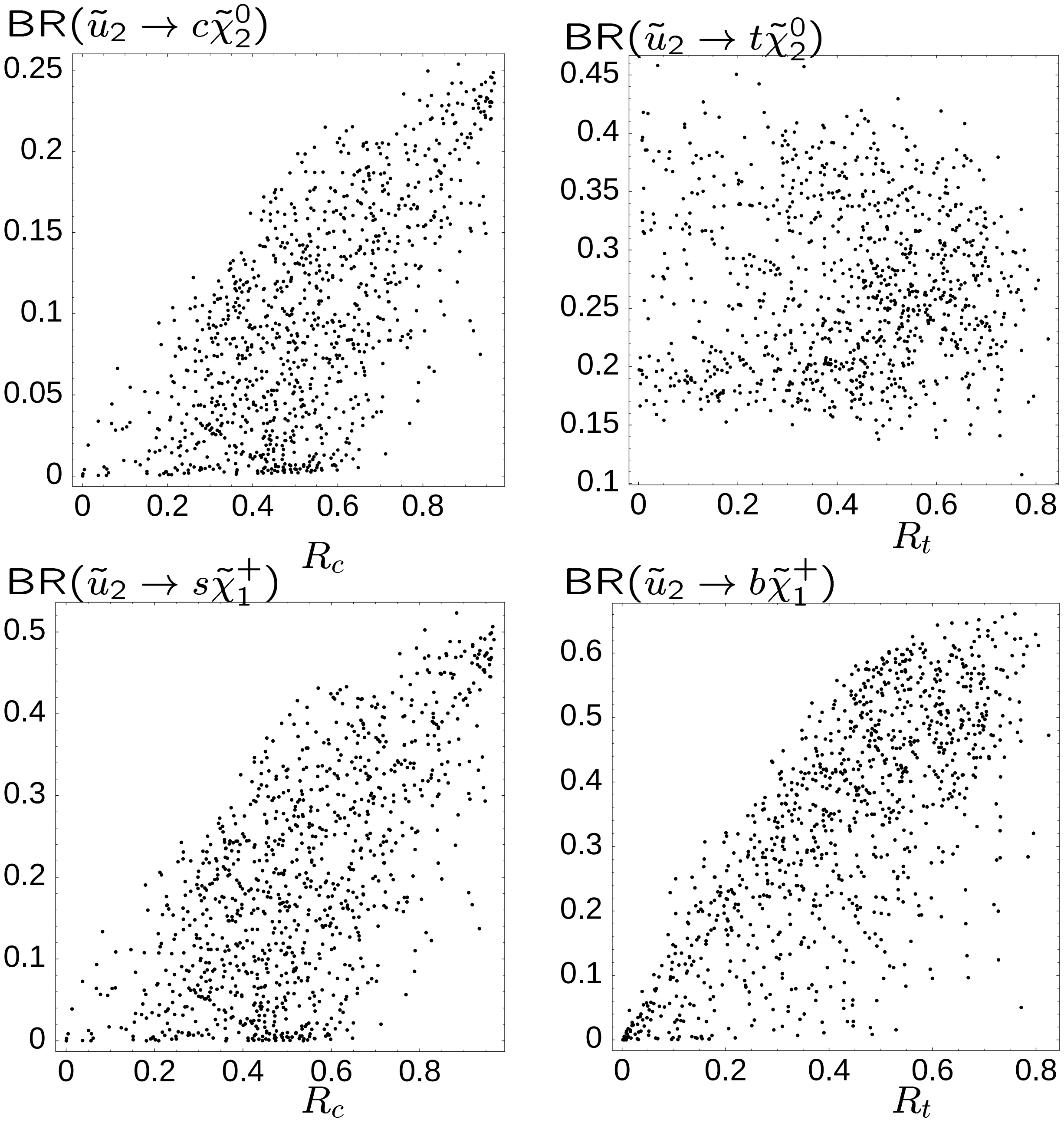


preliminary results

Branching of $\tilde{u}_2$

define: $R_c = (R^{\tilde{u}}_{22})^2 + (R^{\tilde{u}}_{25})^2$

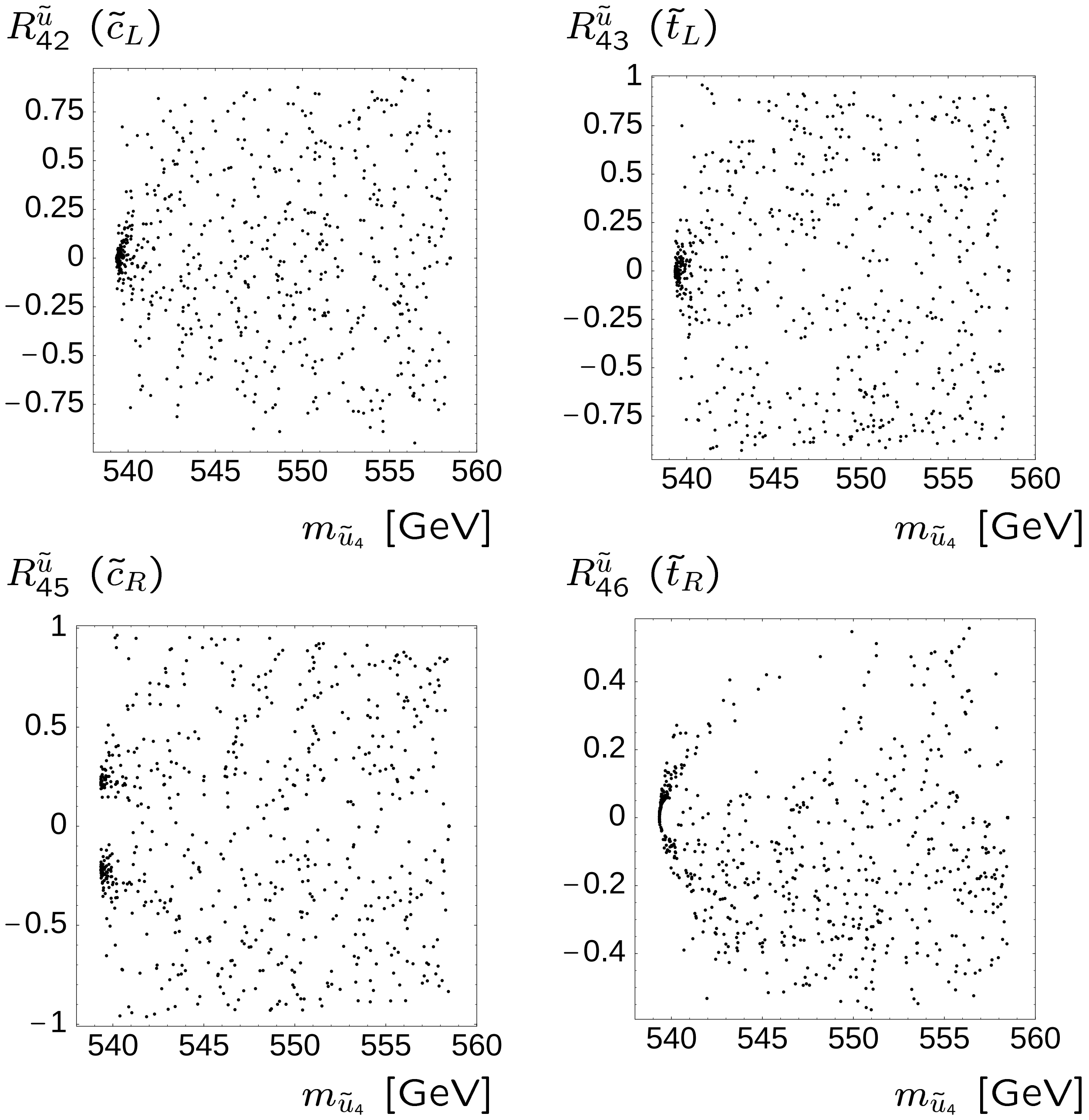
$R_t = (R^{\tilde{u}}_{23})^2 + (R^{\tilde{u}}_{26})^2$



preliminary results

Content of $\tilde{u}_4$

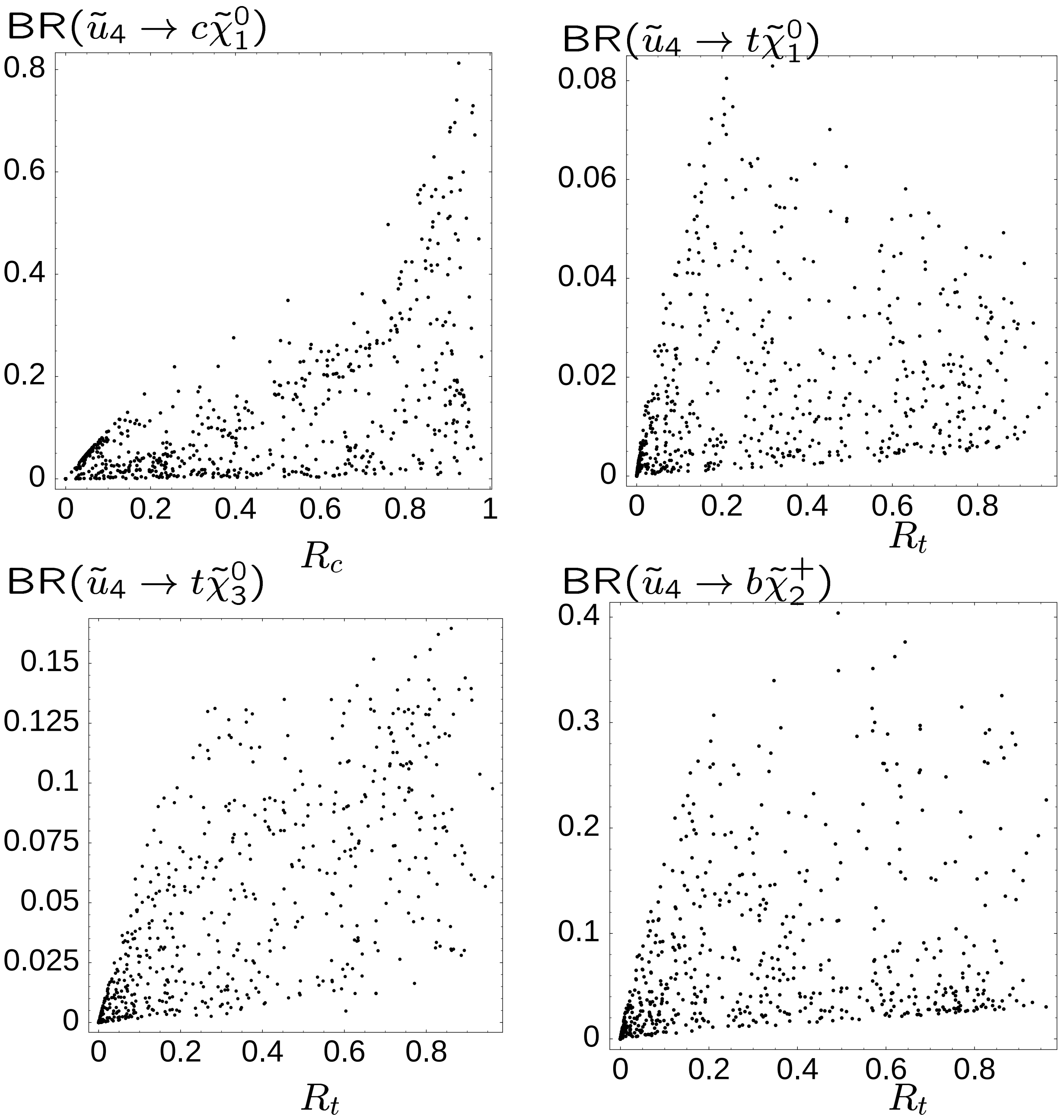
strong mixture between $\tilde{t}_2$ and $\tilde{c}_1$



preliminary results

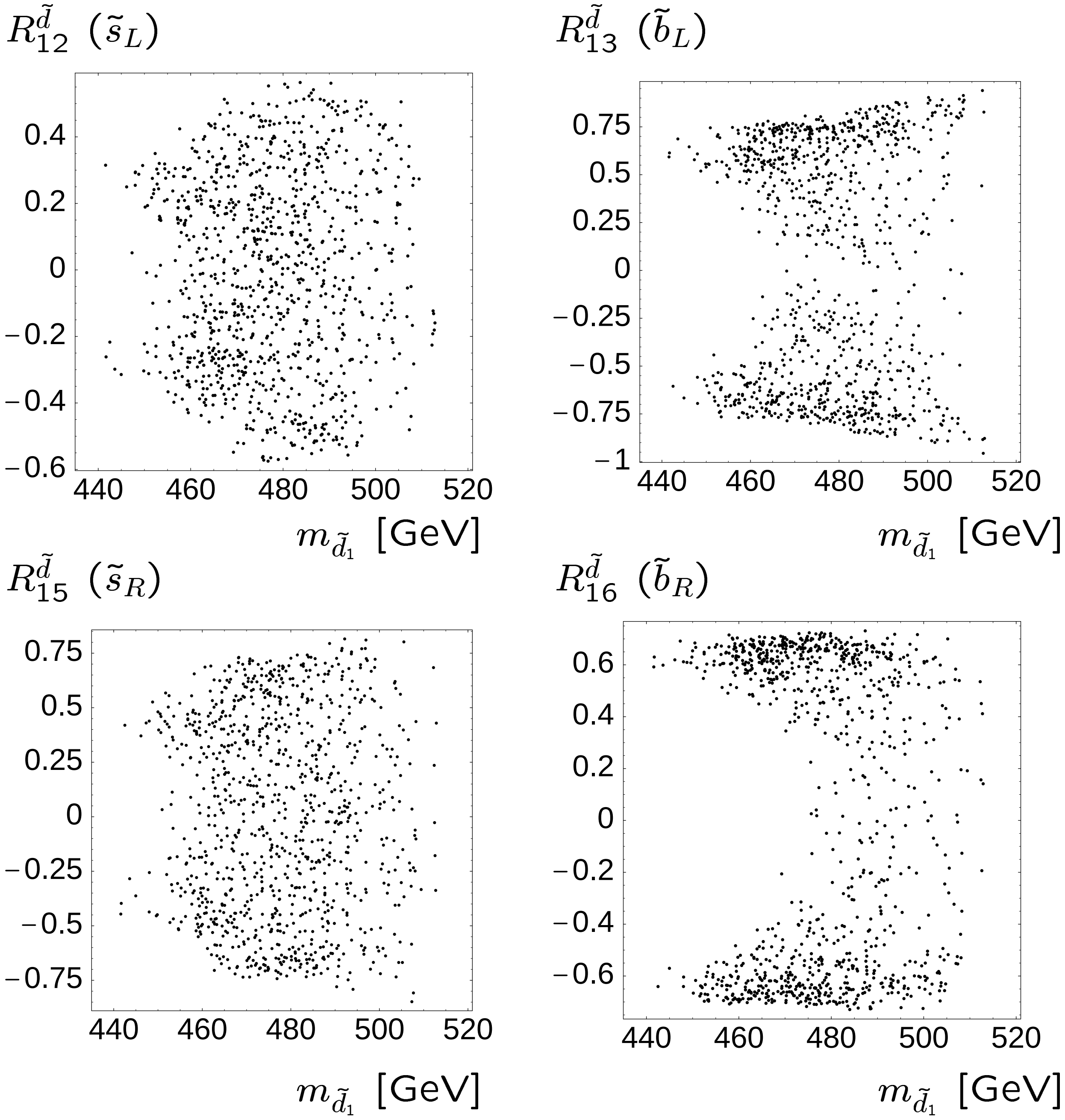
Branching of $\tilde{u}_4$

define: $$R_c = (R^{\tilde{u}}_{42})^2 + (R^{\tilde{u}}_{45})^2$$
$$R_t = (R^{\tilde{u}}_{43})^2 + (R^{\tilde{u}}_{46})^2$$



preliminary results

Content of $\tilde{d}_1$

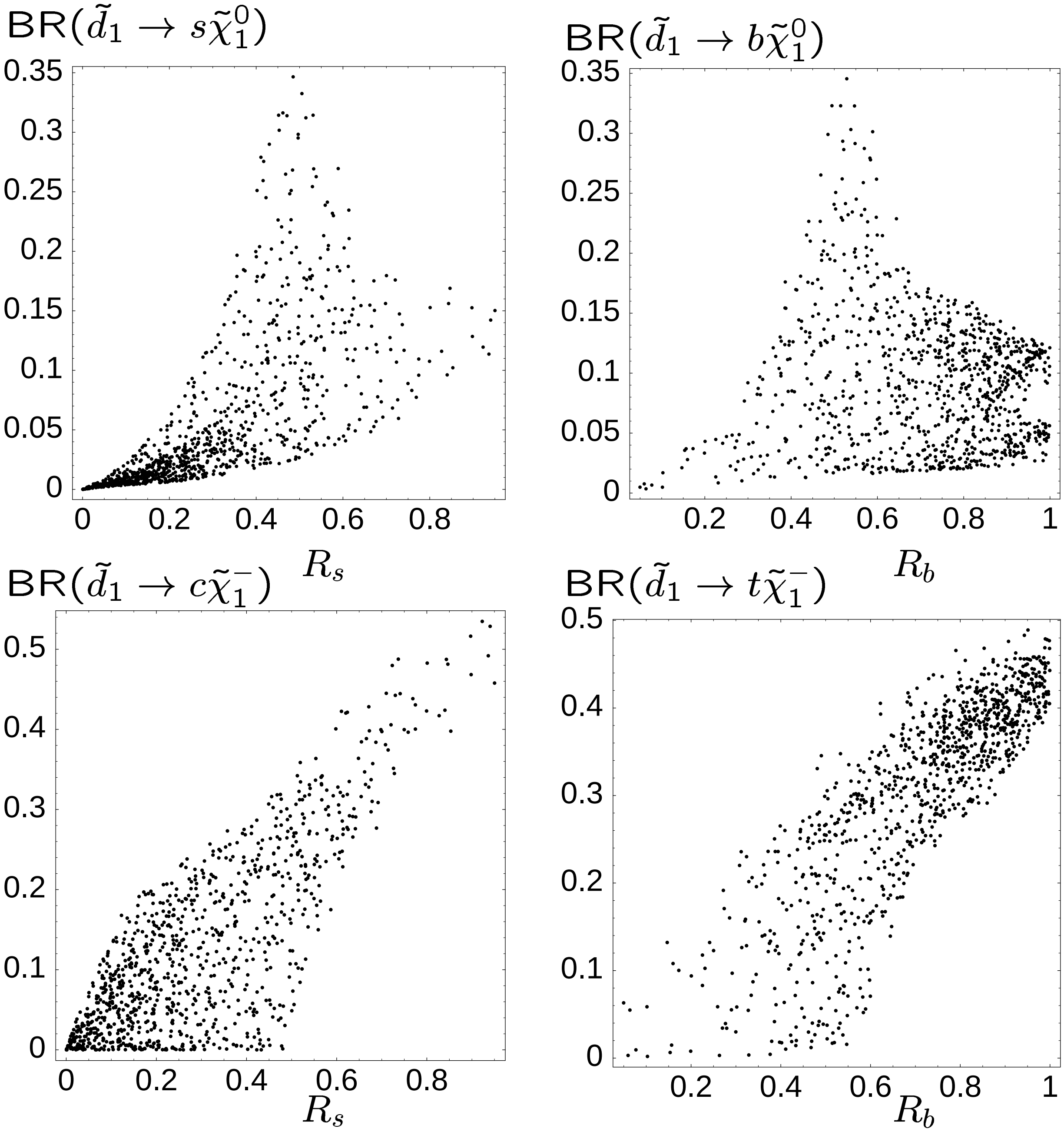


preliminary results

Branching of $\tilde{d}_1$

define: $R_s = (R^{\tilde{d}}_{12})^2 + (R^{\tilde{d}}_{15})^2$

$$R_b = (R^{\tilde{d}}_{13})^2 + (R^{\tilde{d}}_{16})^2$$



preliminary results

Some implications for LHC, LC

LHC:

- Potentially four particles decaying into $s\tilde{\chi}_i^+$, $b\tilde{\chi}_i^+$ $c\tilde{\chi}_j^0$, $t\tilde{\chi}_j^0$ with branching ratios larger than 5%.
- Similarly for d-type squarks: $c\tilde{\chi}_i^-$, $t\tilde{\chi}_i^-$ $s\tilde{\chi}_j^0$, $b\tilde{\chi}_j^0$ with branching ratios larger than 5%.
- The edge variables (e.g. those including momentum of b) might have more complicated structures

LC:

- Can measure precisely the branching ratios of $\tilde{t}_1$, $(\tilde{s}_1/\tilde{b}_1)$, might serve as feedback for LHC.
- There are points in parameter space with $\sigma(e^+e^- \to \tilde{t}_1\tilde{c}_1) \geq$ 0.1 fb for $\sqrt{s} = 1$ TeV,
- $\sigma(e^+e^- \to \tilde{t}_1\tilde{c}_1)$ potentially larger than $\sigma(e^+e^- \to \tilde{t}_1\tilde{t}_2)$ because RR-mixing larger than LR mixing.

Summary and Outlook

- $b \to s\gamma$ allows for large mixings between second and third generation squarks, constrains mainly LR mixing
- $\tilde{t}_i$, $\tilde{c}_i$ can have large flavour violating decay modes
- makes life at LHC potentially more interesting and more difficult
- $\sigma(e^+e^- \to \tilde{t}_1\tilde{c}_1) \geq 0.1$ fb for $\sqrt{s} = 1$ TeV for quite some fraction of parameter space
- d-type squarks also have large flavour violating decay modes

To Do

- studies of $\tilde{c}_2$, $\tilde{d}_j$ $(j > 1)$
- studies of $\tilde{g}$ decay modes
- study of other SPS points
- inclusion of 1st generation