Phenomenology of the Righted Strange-Bottom Squark

LCWS 2004

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Outline

- Motivation from the Belle $B \rightarrow \phi K_S$ discrepancy
- Near-maximal mixing in the 2 – 3 sector RH squarks
- Production of strange-beauty squark at hadronic Colliders
- Decay and detection at the Tevatron
- Prospect for the $e^+e^-$ linear colliders
Motivations: $S_{\phi K_S}$ Sign Anomaly

- World average: $\sin(2\beta) = 0.734 \pm 0.055$, using $B \rightarrow J/\psi K_S$
- 2003 using $B \rightarrow \phi K_S$,

\[
\text{Belle : } \sin(2\beta) = -0.96 \pm 0.50 \pm 0.09 \quad \text{and} \quad -0.11
\]

\[
\text{BaBar : } \sin(2\beta) = 0.45 \pm 0.43 \pm 0.07
\]

both data are in $2.1\sigma$ disagreement

Average: $S_{\phi K_S} = -0.15 \pm 0.33$ still $2.7\sigma$ from world average

- Call for new physics in $b \rightarrow s$ CPV effect
  - Large $b - s$ mixing
  - New CPV phase
  - Right-handed interaction
Abelian flavor symmetry $\oplus$ SUSY

- Abelian flavor symmetry gives strong RH $s - b$ mixing (Nir-Seiberg PLB'93, Leurer-Nir-Seiberg NPB'94)

\[
\hat{M}_u = \frac{M_u}{m_t} \sim \begin{pmatrix}
\lambda^7 & \lambda^5 & \lambda^3 \\
\lambda^6 & \lambda^4 & \lambda^2 \\
\lambda^4 & \lambda^2 & 1
\end{pmatrix}, \quad \hat{M}_d = \frac{M_d}{m_b} \sim \begin{pmatrix}
\lambda^4 & \lambda^3 & \lambda^3 \\
\lambda^3 & \lambda^2 & \lambda^2 \\
\lambda & 1 & 1
\end{pmatrix}
\]

Ansatz: $M_{ij} M_{ji} \approx M_{ii} M_{jj}$

Focus on $s - b$ sector only.
Bring in the 2 − 3 squark sector

Assume a heavy soft SUSY scale $\tilde{m} \sim \text{TeV}$

AFS not far above the SUSY scale.

- $(\tilde{M}_d^2)_{LL}$ is constrained by CKM
- $(\tilde{M}_d^2)_{LR} \sim m_q$ suppressed by small $m_q$
- Only the $(\tilde{M}_d^2)_{RR}$ has the freedom to allow maximal $2 - 3$ sector mixing:

\[
(\tilde{M}_d^2)_{RR} \sim \tilde{m} \begin{bmatrix}
1 & 0 & 0 \\
0 & 1 & 1 \\
0 & 1 & 1
\end{bmatrix}
\]
Near-Maximal 2-3 Squark Mixing

The mass matrix is given by

$$\mathcal{L} = - (\tilde{s}_R^* \tilde{b}_R^*) \begin{pmatrix} \tilde{m}_{22}^2 & \tilde{m}_{23}^2 e^{-i\sigma} \\ \tilde{m}_{23}^2 e^{i\sigma} & \tilde{m}_{33}^2 \end{pmatrix} \begin{pmatrix} \tilde{s}_R \\ \tilde{b}_R \end{pmatrix}.$$ 

Diagonalized by a rotation

$$\begin{pmatrix} \tilde{s}_R \\ \tilde{b}_R \end{pmatrix} = R \begin{pmatrix} \tilde{s}_b_1 \\ \tilde{s}_b_2 \end{pmatrix} = \begin{pmatrix} \cos \theta_m & \sin \theta_m \\ -\sin \theta_m e^{i\sigma} & \cos \theta_m e^{i\sigma} \end{pmatrix} \begin{pmatrix} \tilde{s}_b_1 \\ \tilde{s}_b_2 \end{pmatrix},$$

Then

$$\mathcal{L} = - (\tilde{s}_b_1 \tilde{s}_b_2) \begin{pmatrix} \tilde{m}_1^2 & 0 \\ 0 & \tilde{m}_2^2 \end{pmatrix} \begin{pmatrix} \tilde{s}_b_1 \\ \tilde{s}_b_2 \end{pmatrix}.$$ 

$\tilde{m}_1$ can be small due to a strong cancellation.
The scenario

- Soft SUSY scale $\sim$ TeV
- A RH strange-beauty squark as light as 200 GeV
- Also need a relatively light gluino $\sim$ 500 GeV, that goes together in the gluino-squark loop.

\[
m_{\tilde{s}b_1} \sim 200 \text{ GeV}, \quad m_{\tilde{g}} \sim 500 \text{ GeV}
\]

- Can account for $S_{\phi K_S}$, but not affect the others.
- This $\tilde{s}b_1$ can be produced directly at the Tevatron, LHC, and LC.
\( S_{\phi K_S}, S_{\eta' K_S}, S_{K_S\pi^0}, S_{K_S\pi^0\gamma} \)

(Chua-Hou-Nagashima PRL'04)
Interactions

Gluino-squark-quark:

\[
\mathcal{L} = -\sqrt{2} g_s T_{k,j}^a \left[ -\tilde{g}_a P_R s_j \tilde{s}^* b_{1k} \cos \theta_m + \tilde{g}_a P_R b_j \tilde{s} b_{1k}^* \sin \theta_m e^{-i\sigma} \right. \\
\left. -\tilde{g}_a P_R s_j \tilde{s} b_{2k}^* \sin \theta_m - \tilde{g}_a P_R b_j \tilde{s} b_{2k}^* \cos \theta_m e^{-i\sigma} + \text{h.c.} \right].
\]

Squark-squark-gluon:

\[
\mathcal{L} = -i g_s A_{\mu}^a T_{i,j}^a \left( \tilde{s} b_{1i}^* \partial_\mu \tilde{b}_{1j} + \tilde{s} b_{2i}^* \partial_\mu \tilde{b}_{2j} \right) \\
+ g_s^2 (T^a T^b)_{ij} A_{\mu}^a A_\mu^b \left( \tilde{s} b_{1i} \tilde{b}_{1j} + \tilde{s} b_{2i} \tilde{b}_{2j} \right)
\]
Squark, gluino, gluon interactions
Hadronic Production

Possible Channels:

1) $q\bar{q}$ and $gg$ fusion

$$q\bar{q}, \; gg \rightarrow \tilde{s}_b \tilde{s}_b^*$$

If $s\bar{s}$ or $b\bar{b}$ in the initial state, there is an additional contribution from the $t$-channel gluino exchange diagram.

$$b\bar{s} \rightarrow \tilde{s}_b \tilde{s}_b^*$$ via $t$-channel gluino exchange only.

2) $ss, bb, s\bar{s}, b\bar{b}, sb, s\bar{b}$ initial state scattering via $t$- and $u$-channel gluino exchange diagrams

$$ss, \; sb, \; bb \rightarrow \tilde{s}_b \tilde{s}_b, \; s\bar{s}, \; s\bar{b}, \; b\bar{b} \rightarrow \tilde{s}_b^* \tilde{s}_b^*,$$
3) Feed down from gluino pair production

\[ q\bar{q}, gg \rightarrow g\bar{g}; \quad \tilde{g} \rightarrow s\tilde{s}b_1, b\tilde{s}b_1, \tilde{s}\tilde{s}b_1, \tilde{b}\tilde{s}b_1. \]

For \( s\bar{s}, b\bar{b} \) in the initial states there are additional \( t \)- and \( u \)-channel diagrams.

\( s\bar{b}, \bar{s}b \rightarrow g\bar{g} \) through the \( t \)- and \( u \)-channel diagrams.

4) Associated production of \( \tilde{s}b_1 \) with gluino

\[ sg, bg \rightarrow \tilde{s}b_1\tilde{g} \]
Squark pair production channels
Cross Section Formulas

Introduce some short-hand notation.

\[ \hat{t}_g = \hat{t} - m_g^2, \quad \hat{u}_g = \hat{u} - m_g^2, \]

\[ \hat{t}_{sb} = \hat{t} - m_{\tilde{s}b}^2_{s\tilde{b}_1}, \quad \hat{u}_{sb} = \hat{u} - m_{\tilde{s}b}^2_{s\tilde{b}_1}, \quad \beta_{sb} = \sqrt{1 - \frac{4m_{\tilde{s}b}^2}{\hat{s}}}, \]

\[ \beta_{g} = \sqrt{1 - \frac{4m_g^2}{\hat{s}}}, \quad \beta_{sbg} = \sqrt{\left(1 - \frac{m_g^2}{\hat{s}} - \frac{m_{\tilde{s}b}^2_{s\tilde{b}_1}}{\hat{s}}\right)^2 - 4\frac{m_g^2}{\hat{s}} \frac{m_{\tilde{s}b}^2_{s\tilde{b}_1}}{\hat{s}}} \]

Direct production of \( \tilde{s}_b \tilde{s}_b^* \):

\[ \frac{d\sigma}{d\cos\theta^*}(q\bar{q} \to \tilde{s}_b \tilde{s}_b^*) = \frac{2\pi \alpha_s^2}{9\hat{s}} \beta_{sb} \left[ \frac{1}{4} (1 - \beta_{sb}^2 \cos^2 \theta^*) - \frac{m_{\tilde{s}b}^2}{\hat{s}} \right], \]

\[ \frac{d\sigma}{d\cos\theta^*}(gg \to \tilde{s}_b \tilde{s}_b^*) = \frac{\pi \alpha_s^2}{256\hat{s}} \beta_{sb} \left( \frac{64}{3} - \frac{48\hat{u}_{sb} \hat{t}_{sb}}{\hat{s}^2} \right) \left( 1 - \frac{2\hat{s} m_{\tilde{s}b}^2_{s\tilde{b}_1}}{\hat{u}_{sb} \hat{t}_{sb}} + \frac{2\hat{s}^2 m_{s\tilde{b}_1}^4}{\hat{u}_{sb}^2 \hat{t}_{sb}^2} \right) \]
\[
\frac{d\sigma}{d\cos \theta^*}(s \bar{s} \to \tilde{s}_b \tilde{s}_b^*) = \frac{2\pi\alpha_s^2/\beta_{sb}}{9\hat{s}} \left( \frac{1}{4} \left( 1 - \beta_{sb}^2 \cos^2 \theta^* \right) - \frac{m_{s_b}^2}{\hat{s}} \right) \\
\times \left[ 1 - \frac{1}{3} \frac{\hat{s}}{\hat{t}_{\tilde{g}}} \cos^2 \theta_m + \frac{1}{2} \frac{\hat{s}^2}{\hat{t}_{\tilde{g}}^2} \cos^4 \theta_m \right]
\]

For \( b\bar{b} \to \tilde{s}_b \tilde{s}_b^* \), replace \( \cos^2 \theta_m \leftrightarrow \sin^2 \theta_m \).

\[
\frac{d\sigma}{d\cos \theta^*}(s \bar{b} \to \tilde{s}_b \bar{b}_b^*) = \frac{\pi\alpha_s^2/\beta_{sb}}{9} \frac{\hat{s}}{\hat{t}_{\tilde{g}}} \cos^2 \theta_m \sin^2 \theta_m \left( \frac{1}{4} \left( 1 - \beta_{sb}^2 \cos^2 \theta^* \right) - \frac{m_{s_b}^2}{\hat{s}} \right)
\]
Formulas

Direct production of $\tilde{s}b_1\tilde{s}b_1$:
Proceed via $t$ and $u$ gluino diagrams

$$\frac{d\sigma}{d \cos \theta^*}(ss \rightarrow \tilde{s}b_1 \tilde{s}b_1) = \frac{\pi \alpha_s^2 \beta_{sb}}{18} \cos^4 \theta_m m_g^2 \left[ \frac{1}{\hat{t}_g^2} + \frac{1}{\hat{u}_g^2} - \frac{2}{3} \frac{1}{\hat{t}_g} \frac{1}{\hat{u}_g} \right],$$

For $bb \rightarrow \tilde{s}b_1 \tilde{s}b_1$ replace $\cos^4 \theta_m \leftrightarrow \sin^4 \theta_m$.

For $sb \rightarrow \tilde{s}b_1 \tilde{s}b_1$ replace $\cos^4 \theta_m \leftrightarrow \cos^2 \theta_m \sin^2 \theta_m$. 
Formulas

Feed down from gluino-pair production

\[
\frac{d\sigma}{d \cos \theta^*} (q\bar{q} \rightarrow \tilde{g}\tilde{g}) = \frac{2\pi \alpha_s^2}{3 \hat{s}} \beta_g \frac{\hat{t}_g^2 + \hat{u}_g^2 + 2m_{\tilde{g}}^2 \hat{s}}{\hat{s}^2},
\]

\[
\frac{d\sigma}{d \cos \theta^*} (gg \rightarrow \tilde{g}\tilde{g}) = \frac{9\pi \alpha_s^2}{16 \hat{s}} \beta_g \left(1 - \frac{\hat{t}_g \hat{u}_g}{\hat{s}^2}\right) \left(\frac{\hat{s}^2}{\hat{t}_g \hat{u}_g} - 2 + \frac{4m_{\tilde{g}}^2 \hat{s}}{\hat{t}_g \hat{u}_g} - \frac{4\hat{s}^2 m_{\tilde{g}}^4}{\hat{t}_g^2 \hat{u}_g^2}\right)
\]

\[
\frac{d\sigma}{d \cos \theta^*} (s\bar{s} \rightarrow \tilde{g}\tilde{g}) = \frac{2\pi \alpha_s^2}{3 \hat{s}} \beta_g \left\{ \frac{\hat{t}_g^2 + \hat{u}_g^2 + 2m_{\tilde{g}}^2 \hat{s}}{\hat{s}^2} + \frac{2}{9} \cos^4 \theta_m \left(\frac{\hat{t}_g^2}{\hat{t}_{sb}} + \frac{\hat{u}_g^2}{\hat{u}_{sb}}\right) \right\} + \frac{1}{2} \cos^2 \theta_m \frac{1}{\hat{s}} \left(\frac{\hat{s} m_{\tilde{g}}^2}{\hat{t}_{sb}} + \frac{\hat{t}_{sb}}{\hat{m}_{\tilde{g}}^2} \right) + \frac{1}{18} \cos^4 \theta_m \frac{\hat{s} m_{\tilde{g}}^2}{\hat{m}_{\tilde{g}}^2 \hat{t}_{sb}}
\]

\[
\frac{d\sigma}{d \cos \theta^*} (s\bar{b} \rightarrow \tilde{g}\tilde{g}) = \frac{\pi \alpha_s^2}{27 \hat{s}} \beta_g \cos^2 \theta_m \sin^2 \theta_m \left\{ 4 \left(\frac{\hat{t}_g^2}{\hat{t}_{sb}} + \frac{\hat{u}_g^2}{\hat{u}_{sb}}\right) + \frac{\hat{s} m_{\tilde{g}}^2}{\hat{m}_{\tilde{g}}^2 \hat{t}_{sb}} \right\}
\]
Formulas

Associated production of $\tilde{s}b_1\tilde{g}$

$$\frac{d\sigma}{d\cos\theta^*}(sg \to \tilde{s}b_1\tilde{g}) = \frac{\pi \alpha_s^2}{192\hat{s}} \beta_{sbg} \cos^2 \theta_m \left[ 24 \left( 1 - \frac{2\hat{s}\hat{u}_{sb}}{\hat{t}_{\tilde{g}}^2} \right) - \frac{8}{3} \right]$$

$$\times \left[ -\frac{\hat{t}_{\tilde{g}}}{\hat{s}} + \frac{2(m_{\tilde{g}}^2 - m_{sb1}^2)\hat{t}_{\tilde{g}}}{\hat{s}\hat{u}_{sb}} \left( 1 + \frac{m_{sb1}^2}{\hat{u}_{sb}} + \frac{m_{\tilde{g}}^2}{\hat{t}_{\tilde{g}}} \right) \right]$$

For the $bg$ initial state, the above formula is modified by changing $\cos^2 \theta_m \leftrightarrow \sin^2 \theta_m$. 
Squark pair cross section at the Tevatron

Cross Section (pb)

$E_{CM} = 1.96$ TeV
Tevatron
$m_{\tilde{g}} = 500$ GeV

$10^{-4}$
$10^{-3}$
$10^{-2}$
$10^{-1}$
$10^{0}$
$10^{1}$

$m_{\tilde{b}_1}$ (GeV)

$\tilde{b}_1 \tilde{b}_1 + \tilde{b}_1^* \tilde{b}_1^*$

$\tilde{b}_1 g$

$\tilde{b}_1 \tilde{b}_1$ production

qq

gg

sum
Gluino pair cross section at the Tevatron

\[ E_{\text{CM}} = 1.96 \text{ TeV} \]

\[ m_{\tilde{s}b_1} = 200 \text{ GeV} \]

Cross Section (pb) vs. \( m_{\tilde{g}} \) (GeV)
Squark pair cross section at the LHC

\[ \text{Cross Section (pb)} \]

\[ \text{m}_{\tilde{s}b_1} \text{ (GeV)} \]

- \[ \tilde{g} \tilde{g} \]
- \[ q\bar{q} \text{ sum} \]
- \[ \tilde{b}_1 \tilde{b}_1 + \tilde{b}_1 \tilde{b}_1 \]
- \[ \tilde{b}_1 \tilde{b}_1 \text{ production} \]

- \[ E_{CM}=14 \text{ TeV} \]
- \[ \text{LHC} \]
- \[ m_{\tilde{g}} = 500 \text{ GeV} \]
Gluino pair cross section at the LHC

\[ E_{CM}=14 \text{ TeV} \]

LHC

\[ m_{\tilde{b}_1}=200 \text{ GeV} \]

- \( g \tilde{g} \) production
- \( \tilde{q} \tilde{q} \) production
- \( g\tilde{g} \) production
- \( \tilde{s}_1 \tilde{g} \) production

Cross Section (pb)

\[ m_{\tilde{g}} \text{ (GeV)} \]

200 400 600 800 1000 1200 1400 1600 1800 2000
Production at $e^+e^-$ Colliders

\[
\frac{d\sigma}{d\cos\theta}(e^- e^+ \rightarrow \tilde{s}b_1 \tilde{s}b_1^*) = \frac{\pi\alpha^2 s}{24} \beta^3 \sin^2 \theta \left\{ \left| \frac{1}{s} + \frac{g_L^e}{\cos^2 \theta_W} \frac{1}{s - m_Z^2} \right|^2 \right. \\
+ \left. \left| \frac{1}{s} + \frac{g_R^e}{\cos^2 \theta_W} \frac{1}{s - m_Z^2} \right|^2 \right\}
\]
Squark pair cross section at the LC

Cross Section (pb)

$m_{\tilde{b}_1}$ (GeV)

$E_{CM} = 0.5$ TeV

$E_{CM} = 1$ TeV

$E_{CM} = 1.5$ TeV

$\tilde{b}_1 \tilde{b}_1$ production
Decay scenarios of the strange-beauty squark pair

1. \( \tilde{s}b_1 \) is the LSP and \( R \)-parity is conserved,

2. \( \tilde{s}b_1 \) is the LSP but \( R \)-parity is violated. It decays into 2 jets or 1 lepton plus 1 jet,

3. \( \tilde{s}b_1 \) is the NLSP, decay into neutralino (in SUGRA) or gravitino (gauge-mediated) and \( b/s \) quark.
Stable strange-beauty squark

- Stable $\tilde{s}b_1$ hadronize into neutral or charged particles.
- Neutral stable particle escapes detection easily
- Charged stable particle ionizes in central tracking and in muon chamber, so behaves like a "heavy muon".
- Selection cuts:

$$p_T(\tilde{s}b_1) > 20 \text{ GeV}, \quad |y(\tilde{s}b_1)| < 2.0, \quad 0.25 < \beta \gamma < 0.85.$$
$\beta \gamma \equiv p/ m_{\tilde{s}b_1}$ spectrum

\[ \frac{1}{\sigma} \frac{d\sigma}{d(\beta \gamma)} \]

- $m_{\tilde{s}b_1} = 400 \text{ GeV}$
- $m_{\tilde{s}b_1} = 300 \text{ GeV}$
- $m_{\tilde{s}b_1} = 200 \text{ GeV}$
<table>
<thead>
<tr>
<th>$m_{\tilde{s}b_1}$ (GeV)</th>
<th>$\sigma_{1\text{MCP}}$ (fb)</th>
<th>$\sigma_{2\text{MCP}}$ (fb)</th>
<th>$\sigma_{\geq 1\text{MCP}}$ (fb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>41 (0.46)</td>
<td>9.3 (0.02)</td>
<td>50 (0.48)</td>
</tr>
<tr>
<td>250</td>
<td>10.9 (0.96)</td>
<td>2.8 (0.14)</td>
<td>14 (1.1)</td>
</tr>
<tr>
<td>300</td>
<td>3.1 (1.2)</td>
<td>0.91 (0.3)</td>
<td>4.0 (1.5)</td>
</tr>
<tr>
<td>350</td>
<td>0.87 (1.3)</td>
<td>0.29 (0.43)</td>
<td>1.2 (1.8)</td>
</tr>
<tr>
<td>400</td>
<td>0.23 (1.4)</td>
<td>0.088 (0.48)</td>
<td>0.32 (1.8)</td>
</tr>
<tr>
<td>450</td>
<td>0.058 (1.4)</td>
<td>0.024 (0.51)</td>
<td>0.082 (1.9)</td>
</tr>
</tbody>
</table>

() feed down from gluino pair production
\( R \)-parity violating decay of \( \tilde{b}_1 \)

- \( \lambda'' U^c D^c D^c \) only gives multijet decay.
- Choose the \( \lambda' LQ D^c \) coupling, such that
  \[ \tilde{b}_1 \rightarrow e^- u \text{ or } \mu^- c \]
  with \( \lambda'_{ii3} \) and \( \lambda'_{ii2} \) couplings, \( i = 1, 2 \).
- \( \tilde{b}_1 \) then behaves like a scalar leptoquark.
- Current best limit on the first generation LQ:
  \[ M_{LQ} \gtrsim 260 \text{ GeV} \text{ prelim. from combined CDF, DØ Runs I, II} \]

- Our estimate for a 2 fb\(^{-1} \) RunII will give a sensitivity up to 300 GeV, and for 20 fb\(^{-1} \) can be up to 350 GeV.
\( \tilde{b}_1 \) \text{ NLSP}

- \( \tilde{b}_1 \) will decay promptly into a \( b/s \) quark plus a neutralino in SUGRA.

- \( \tilde{b}_1 \) will decay into a \( b/s \) quark plus a gravitino (or via an intermediate neutralino into gravitino and photon) in gauge-mediated models.

\[
\frac{1}{\sqrt{F_{\text{SUSY}}}} \lesssim 10^7 \text{GeV}
\]

otherwise behaves like a stable particle within the detector.

- For \( \tilde{b}_1 \) pair production, or feed down from gluino production, multi \( b/s \) jets plus \( E_T \) in the final state.
Event rates for $\tilde{s}b_1$ NLSP

• Note that

\[ \tilde{s}b_1 \rightarrow b \tilde{\chi}_1^0 \] scales with $\sin^2 \theta_m$

• Selection cuts

\[ p_{Tj} > 15 \text{ GeV} \, , \quad |\eta_j| < 2.0 \, , \quad p_T > 40 \text{ GeV} , \]
\[ \epsilon_{btag} = 0.6 \, , \quad \epsilon_{mis} = 0.05 . \]

• Most events pass the jet cuts if

\[ m_{\tilde{s}b_1} - m_{\tilde{\chi}_1^0} > 50 \text{ GeV} \]

• If we choose $B(\tilde{s}b_1 \rightarrow b\tilde{\chi}_1^0) = 1 (0.5)$, the ratio of $0 : 1 : 2$ B-tagged events

\[ 16 : 48 : 36 \quad (49 : 42 : 9) \]
## Event rates (fb) for $\tilde{s}b_1$ at Tevatron

<table>
<thead>
<tr>
<th>$m_{\tilde{s}b_1}$ (GeV)</th>
<th>0 $b$-tag</th>
<th>1 $b$-tag</th>
<th>2 $b$-tag</th>
<th>0 $b$-tag</th>
<th>1 $b$-tag</th>
<th>2 $b$-tag</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\sin^2 \theta_m = 1$</td>
<td></td>
<td></td>
<td>$\sin^2 \theta_m = 0.75$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>115(0.11)</td>
<td>288(0.54)</td>
<td>175(2.2)</td>
<td>190(0.29)</td>
<td>284(0.89)</td>
<td>104(1.6)</td>
</tr>
<tr>
<td>200</td>
<td>26(0.091)</td>
<td>70(0.49)</td>
<td>47(2.2)</td>
<td>44(0.27)</td>
<td>70(0.85)</td>
<td>28(1.7)</td>
</tr>
<tr>
<td>250</td>
<td>6.1(0.090)</td>
<td>17(0.49)</td>
<td>11(2.2)</td>
<td>11(0.27)</td>
<td>17(0.85)</td>
<td>6.8(1.7)</td>
</tr>
<tr>
<td>300</td>
<td>1.5(0.090)</td>
<td>4.2(0.49)</td>
<td>2.9(2.2)</td>
<td>2.6(0.27)</td>
<td>4.2(0.85)</td>
<td>1.7(1.7)</td>
</tr>
<tr>
<td>350</td>
<td>0.38(0.090)</td>
<td>1.1(0.49)</td>
<td>0.72(2.2)</td>
<td>0.66(0.27)</td>
<td>1.1(0.86)</td>
<td>0.43(1.7)</td>
</tr>
<tr>
<td></td>
<td>$\sin^2 \theta_m = 0.5$</td>
<td></td>
<td></td>
<td>$\sin^2 \theta_m = 0.25$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150</td>
<td>283(0.66)</td>
<td>243(1.2)</td>
<td>51(1.0)</td>
<td>395(1.3)</td>
<td>165(1.1)</td>
<td>17(0.40)</td>
</tr>
<tr>
<td>200</td>
<td>68(0.63)</td>
<td>61(1.1)</td>
<td>14(1.0)</td>
<td>96(1.3)</td>
<td>42(1.1)</td>
<td>4.6(0.42)</td>
</tr>
<tr>
<td>250</td>
<td>16(0.62)</td>
<td>15(1.1)</td>
<td>3.3(1.0)</td>
<td>23(1.3)</td>
<td>10(1.1)</td>
<td>1.1(0.42)</td>
</tr>
<tr>
<td>300</td>
<td>4.0(0.63)</td>
<td>3.7(1.1)</td>
<td>0.84(1.0)</td>
<td>5.8(1.3)</td>
<td>2.5(1.1)</td>
<td>0.28(0.42)</td>
</tr>
<tr>
<td>350</td>
<td>1.0(0.63)</td>
<td>0.93(1.1)</td>
<td>0.21(1.0)</td>
<td>1.4(1.3)</td>
<td>0.64(1.1)</td>
<td>0.071(0.43)</td>
</tr>
</tbody>
</table>

() feed down from gluino pair production
Summary

- The Belle $B \to \phi K_S$ anomaly calls for strong right-handed strange-beauty mixing.
- A near-maximal mixing in the 2 – 3 squark sector gives a relatively light right-handed strange-beauty squark.
- It is feasible to search for $\tilde{s}b_1$ at Tevatron Run II.
- We studied 3 decay scenarios:
  1. stable $\tilde{s}b_1$
  2. RPV decay of $\tilde{s}b_1$, like leptoquark
  3. $\tilde{s}b_1 \to b/s\chi^0_1$
- In general, the sensitivity is up to 300 GeV at Run II with 2 fb$^{-1}$.
- At 0.5 TeV LC with 100 fb$^{-1}$ can cover slightly above 200 GeV. At 1 TeV LC with 100 fb$^{-1}$ can easily cover up to 400 GeV.