In-flight-decay of $\tilde{\tau}$ in the LHC tracker

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Background

$\tilde{\tau} = \text{Long Lived??}$
- $\tilde{\tau}$ LSP + tiny $R$-parity viol.
- $\tilde{G}$ LSP + $\tilde{\tau}$ NLSP
- Axion LSP + $\tilde{\tau}$ NLSP etc...

How to detect???
- Decay @ center $\rightarrow$ usual analysis
- Decay outside $\rightarrow$ “heavy muon” “stopping”
- Decay inside $\rightarrow$ ???????

Kink Tracks in ATLAS detector

Kink tracks

$\eta = 0.63$

TRT

3rd layer

2nd layer

1st layer

Pixel detector & SCT

Kink detection

= stau track id. @ pixel/SCT
+ daughter track id. @ TRT 3rd

What is the daughter?

$\tilde{G}$-LSP model : $\tilde{\tau} \rightarrow \tau + \tilde{G}$
RpV ($L_i L_j \tilde{E}_k$) : $\tilde{\tau} \rightarrow (e, \mu, \tau) + \nu$
(depending on $i, j, k$)

Daughter identification $\rightarrow$ Model discrimination!

Results

8 TeV, 5 fb$^{-1}$

14 TeV, 10 fb$^{-1}$

Conclusion

We can see kinks for $cT \sim 1 \text{ cm–100 m.}$

\begin{align*}
\text{For } \tilde{G} \text{ model :} & \quad m_{3/2} \sim 0.1–10 \text{ keV} \\
\text{For RpV model :} & \quad \lambda \sim 10^{-9}–10^{-7}
\end{align*}

Model discrimination is possible by identifying daughter species ($e$, $\mu$, $\tau$).

Monte Carlo System

- SUSY-HIT
  - SUSY spectrum generator
- Pythia6
  - Event generator
- Tauola
  - C++ interface
- Pythia6
  - Decay of $\tau$ decay products
- PGS4
  - Detector simulation (jet/MET)
- $\tilde{\tau}$ decay $\rightarrow e, \mu$

Topics to discuss with you

- We can see kinks for $cT \sim 1 \text{ cm–100 m.}$

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Supporting Materials

Mass spectrum for $M_{1/2} = 400$ GeV. (BC1 benchmark point)

Cut flow for $cτ = 400$ mm, $M_{1/2} = 400$ GeV. (BC1 benchmark point)

I, II, III for a $e/μ$ daughter, and I, II', III' for a $τ$ daughter.

Trigger efficiency (> 90%) is not included.
Daughter reco eff is included.

<table>
<thead>
<tr>
<th></th>
<th>7 TeV, 2 fb$^{-1}$</th>
<th>8 TeV, 5 fb$^{-1}$</th>
<th>14 TeV, 10 fb$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>I total SUSY event</td>
<td>673 events</td>
<td>2832 events</td>
<td>42463 events</td>
</tr>
<tr>
<td>triggered event</td>
<td>426 events</td>
<td>1938 events</td>
<td>36240 events</td>
</tr>
<tr>
<td>II $τ$ track</td>
<td>852 events</td>
<td>3876 events</td>
<td>72480 events</td>
</tr>
<tr>
<td>$</td>
<td>τ</td>
<td>&lt; 0.63$</td>
<td>409 events</td>
</tr>
<tr>
<td>$P_{T}(τ) &gt; 100$ GeV</td>
<td>378 events</td>
<td>1641 events</td>
<td>26642 events</td>
</tr>
<tr>
<td>$τ$ decay in TRT 1st/2nd</td>
<td>67 events</td>
<td>230 events</td>
<td>3642 events</td>
</tr>
<tr>
<td>kink $0.1 &lt; Δφ &lt; π/2$</td>
<td>46 events</td>
<td>179 events</td>
<td>2601 events</td>
</tr>
<tr>
<td>daughter reconstructed</td>
<td>28 events</td>
<td>101 events</td>
<td>1586 events</td>
</tr>
<tr>
<td>III event with 1 or 2 kink</td>
<td>24 events</td>
<td>100 events</td>
<td>1563 events</td>
</tr>
<tr>
<td>event with 2 kinks</td>
<td>4 events</td>
<td>1 event</td>
<td>23 events</td>
</tr>
</tbody>
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for the case where the stau emits $τ$:

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</tr>
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<tbody>
<tr>
<td>II' separation $0.1 &lt; Δφ &lt; π/2$</td>
<td>52 events</td>
<td>189 events</td>
<td>2805 events</td>
</tr>
<tr>
<td>daughter reconstructed</td>
<td>26 events</td>
<td>95 events</td>
<td>1391 events</td>
</tr>
<tr>
<td>III' event with 1 or 2 kink</td>
<td>24 events</td>
<td>92 events</td>
<td>1374 events</td>
</tr>
<tr>
<td>event with 2 kinks</td>
<td>2 events</td>
<td>3 events</td>
<td>17 events</td>
</tr>
</tbody>
</table>

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(Also you can find me on Twitter / Facebook.)

Reference: Shoji Asai, Yuya Azuma, Motoi Endo, Koichi Hamaguchi and S.I.,
Stau Kinks at the LHC, submitted. [arxiv: 1103.1881]