Searches for Physics Beyond the Standard Model at CDF Run II

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Outline

• Exotics domain and strategy
• Present CDF analyses
• Overview of other CDF Results
• Coming attractions
BSM: Subjects & Status

- Higgs: SM and SUSY (...and...)
- SUSY: SUGRA, RPV, GMSB, AMSB ....
- Leptoquarks
- Technicolor (little Higgs, etc...)
- Extra dimensions
- Heavy gauge bosons (Z’, W’)
- Excited fermions
Beyond the SM: Strategy
• Signature-based searches
• then, apply to every model you can find!

Run II enhancements: more data, higher $\sqrt{s}$, better detector and DAQ
Leptoquarks @Tevatron

LQ : color-triplet bosons w/ both lepton and baryon quantum #s, predicted in various BSM theories: Grand Unification, Technicolor, SUSY

Strong pair-production, cross section independent of Yukawa coupling to l and q, assume generations don’t mix

Feynman diagrams for pair production of leptoquarks at hadron colliders.
Search for LQ1 in Jets+MET

Assume $\text{Br}(LQ1 \rightarrow q\nu) = 1.0$

Signature: MET+2 high $E_T$ jets

Signal region: MET > 60, 80 < $\Delta \phi(jj)$ < 165, #lept = 0

Main backgrounds: $W$+jets, $Z$+jets
LQ1 in Jets+MET (2)

Signal region: $118 \pm 14$ expected (bg), 124 observed

Compare with NLO prediction & set limits
Search for LQ2 in $\text{di-}\mu$

- $\text{Br}(\text{LQ2} \rightarrow \mu q) = 1$
- Signature: dimuons + dijets
- BG: $t\bar{t}$, $Z+2$jets

Kinematical cuts:

\[ E_T(j_1) + E_T(j_2) > 85 \text{ GeV} \quad \text{AND} \quad P_T(m_1) + P_T(m_2) > 85 \text{ GeV} \]

\[ \sqrt{(E_T(j_1) + E_T(j_2))^2 + (P_T(m_1) + P_T(m_2))^2} > 200 \text{ GeV} \]
Search for LQ2 in di-\(\mu\) (2)

Predicted number of CMUP/CMUP, CMUP/CMX, CMX/CMX events in 126pb\(^{-1}\)

<table>
<thead>
<tr>
<th>M(LQ)</th>
<th>(Q^2=M(LQ)^2/4)</th>
<th>(Q^2=4M(LQ)^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td>13.11</td>
<td>10.44</td>
</tr>
<tr>
<td>180</td>
<td>7.54</td>
<td>6.05</td>
</tr>
<tr>
<td>200</td>
<td>4.48</td>
<td>3.62</td>
</tr>
<tr>
<td>220</td>
<td>2.56</td>
<td>2.06</td>
</tr>
<tr>
<td>240</td>
<td>1.45</td>
<td>1.17</td>
</tr>
<tr>
<td>260</td>
<td>0.84</td>
<td>0.67</td>
</tr>
<tr>
<td>280</td>
<td>0.46</td>
<td>0.36</td>
</tr>
<tr>
<td>300</td>
<td>0.26</td>
<td>0.21</td>
</tr>
<tr>
<td>320</td>
<td>0.15</td>
<td>0.12</td>
</tr>
</tbody>
</table>

BG: \(tt\), with both \(W\rightarrow\mu_1\nu\): 0.09 events
DY+2jets: 0.34 events

Data

<table>
<thead>
<tr>
<th>Type of Cut</th>
<th>Tot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muon ID (2 tight)</td>
<td>1668</td>
</tr>
<tr>
<td>(Pt_{\mu1} &amp; Pt_{\mu2}&gt;25) GeV</td>
<td>1561</td>
</tr>
<tr>
<td>(Et\ j1,j2 &gt; 15,30) GeV</td>
<td>15</td>
</tr>
<tr>
<td>(M_{\mu\mu}) cut</td>
<td>4</td>
</tr>
<tr>
<td>Sum(\mu),Sum(j) &gt; 85 GeV</td>
<td>1</td>
</tr>
<tr>
<td>(\sqrt{Sum_{\mu}^2+Sum_j^2}) &gt; 200 GeV</td>
<td>0</td>
</tr>
</tbody>
</table>
LQ2 in di-μ Results

Run I limit: 202 GeV/c²

Next: include MI tracks to increase acceptance
Search for H++

- Predicted in left-right symmetric models
- SUSY LR models predict $100\text{Gev} < M(H^{++}) < 1\text{TeV}$
- Search: $240 \text{ pb}^{-1}$
- Strategy: LS dileptons, mass window of $\pm 10\% * M(H^{++})$
Search for H++ (2)

Low mass region: predict 3.4 evts, obs. 1 ee event
High mass (search) region: 0 obs.
Results for H++

No same-sign events observed in the signal region

Set cross section limits on doubly-charged Higgs pair:

- \(135 \text{ GeV} \) \((ee)\), \(135 \text{ GeV} \) \((\mu\mu)\), and \(115 \text{ GeV} \) \((e\mu)\) for \(H^{++}_{L}\)
- \(110 \text{ GeV} \) \((\mu\mu)\) and \(90 \text{ GeV} \) \((e\mu)\) for \(H^{++}_{R}\)
Search for excited electrons (e* → eγ)

- Examine 200pb⁻¹ data for resonance in eγ channel
- Effective 4-f Lagrangian, GM e* models (Baur, Phys Rev D42,3)
- σ depends on M(e*) and comp. scale Λ
Candidate eee event

Both p-objects have good tracks!
Inv. Masses: this is ZZ!

$\text{MET} = 13 \text{ GeV}$

$\textstyle\begin{array}{ll}
\text{Et}(e_1) = 44 \text{ GeV} & \\
\text{Et}(e_2) = 42 \text{ GeV} & \\
\text{Et}(p_1) = 46 \text{ GeV} & \\
\text{Et}(p_2) = 26 \text{ GeV} & \\
\end{array}$
**Results**

- Three events observed in 200 pb$^{-1}$, total expected: 3 events! Set limits on Cl, GM
eeγ Results (2)

Contact Int. Limits

Gauge Mediated

CDF Run II Preliminary

\[ \int L \cdot dt = 200 \text{ pb}^{-1} \]

95% C.L. Exclusion Region

CDF μ* Results are forthcoming
Other Recent CDF Results

- Z’ (See D. Water’s talk)
- X→di–jets
- scalar-b
- gamma + Missing Et, gamma-gamma
- gamma + heavy flavor
- Bs→μμ
- CHAMPs
Coming soon from a Collider Detector near you!

- Enhanced LQ2 search with full data set, other LQ decay modes
- Magnetic Monopoles
- $Z \rightarrow \tau \tau$ cross section, $Z' \rightarrow \tau \tau$ search
- SUSY with Tau Leptons!

\[
\begin{align*}
\text{Neutralino Decays} & \\
\chi_2 \rightarrow \chi_1 \tau^+ \tau^- & \text{ (blue line)} \\
\chi_2 \rightarrow \chi_1 \mu^+ \mu^- & \text{ (red line)}
\end{align*}
\]

\[
\begin{align*}
\text{Chargino Decays} & \\
\tilde{\chi}_1 \rightarrow \chi_1 \tau^+ \nu & \text{ (blue line)} \\
\tilde{\chi}_1 \rightarrow \chi_1 \mu^+ \nu & \text{ (red line)}
\end{align*}
\]

\[\tan \beta \]

mSUGRA points: $m_0 = 150$, $m_{1/2} = 150$, $A_0 = 0$, $\text{sign(}\mu\text{)} = +1$