Study of Di-electron + Photon Production at CDF
Heather Gerberich, Duke University for the CDF Collaboration

Motivation
- This is a signature-based search for an eγ final state with a resonance in the eγ channel
- eγ signature has low background
- We search for the production of excited or exotic electrons (e*) in the following reaction:
  \[ p + \bar{p} \rightarrow e^* + e \rightarrow e\gamma + e \]

Excited Electron Model
- The production of excited states of quarks and leptons is expected in many compositeness models
- We use a model for excited fermions that is described by their coupling to quarks and leptons through contact interactions (U. Baur, M. Spira, and P. M. Zerwas, Phys Rev D 42, 3)
- Cross section depends on two parameters: e* mass and compositeness scale (Λ)
  \[ \rightarrow \text{Currently no mass limits published for this particular excited electron model} \]

Dataset and Signal Selection
- 125 pb\(^{-1}\) of data taken with the high ET electron trigger from March 2002 through May 2003
- One central (|η| < 1) electron
- Second electron and photon can be central or plug (1.2 < |η| < 2.8)
- Electron and photon ET > 25 GeV

Excited Electron Mass Limit
- A Bayesian approach is used to obtain the upper limit on the experimental cross-section at the 95% confidence level

In the central region, electrons must have a COT track. Photons should have no track in the vicinity.

Background Estimates
- The eγ signal from ee* events can be mimicked by several standard model and detector sources:
  - Zγ (D Y)
  - Z jet
  - WZ
  - Electron misidentified as photon
  - Multi-jet
  - Jets fake two electrons and one photon
  - Di-photon + jet
  - Jet fakes electron
  - W jets
  - Jets fake electron and photon

The following plot shows the cumulative backgrounds as a function of eγ invariant mass

The above plot shows the total background prediction as a function of e* mass, demonstrating the expected backgrounds are small.

Total Signal Acceptance
- Shown is the total signal acceptance for the central detector, plug detector and the two regions combined
- The fiducial acceptance is large due to plug inclusion
- Systematic error of 6% on acceptance with dominant contributions from:
  - Photon efficiency
  - Energy scale and resolution

We find 1 ee candidate event with one central electron (e) and two plug EM objects (p₁ and p₂).

<table>
<thead>
<tr>
<th>( M_{p_1} ) (GeV)</th>
<th>( M_{p_2} ) (GeV)</th>
<th>( E_e (\text{GeV}) )</th>
<th>( \eta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>170</td>
<td>59</td>
<td>36.9</td>
<td>0.62</td>
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<tr>
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<td>65.9</td>
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<tr>
<td></td>
<td>297</td>
<td>43.7</td>
<td>2.20</td>
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</tbody>
</table>

Simulated e* Signal
- PYTHIA with a GEANT based CDF detector simulation is used to study e* production
- An e* signal would manifest itself as a narrow resonance peak in the eγ invariant mass
- The mass width is dominated by detector resolution

Summary
- We set the first mass limits on excited electron models from the Tevatron and the first limit using an effective four-fermion Lagrangian with compositeness scale Λ
- Inclusion of the plug detector improves search sensitivity by a factor of two over searching only the central region
- For \( M_{e*} = \Lambda \), \( M_{e*} < 863 \text{ GeV} \) is excluded
- Established exclusion regions in the \( M_{e*} \) -- \( \Lambda \) plane
- Signal based search results can be applied to models yielding eγ signature, including other excited and exotic electron models

Exclusion Region
- Excited electron contact interaction model is valid for \( M_{e*}/\Lambda < 1 \)
- Below is the exclusion region in the \( M_{e*}/\Lambda \) versus \( M_{p_1} \) plane

Because the excited electron theory depends on both e* mass and the compositeness scale, A, the two-dimensional A-Me* exclusion region is plotted above