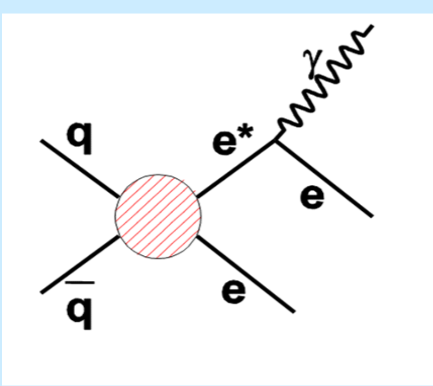
Study of Di-electron + Photon Production at CDF

Heather Gerberich, Duke University
for the CDF Collaboration

Motivation

- This is a signature-based search for an $ee\gamma$ final state with a resonance in the $e\gamma$ channel
- $ee\gamma$ signature has low background
- We search for the production of **excited** or **exotic** electrons (e*) in the following reaction:

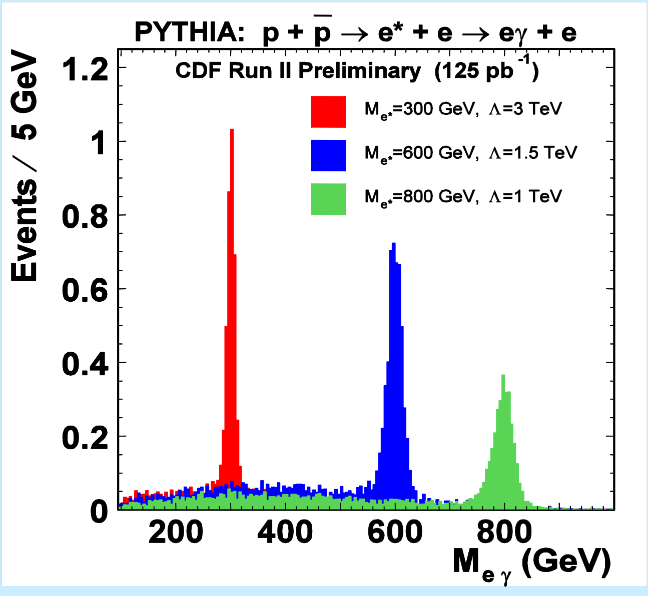
$$p + \overline{p} \rightarrow e^* + e \rightarrow e\gamma + e$$



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)
- **→ Currently no mass limits published for this particular excited electron model**

Simulated e* Signal



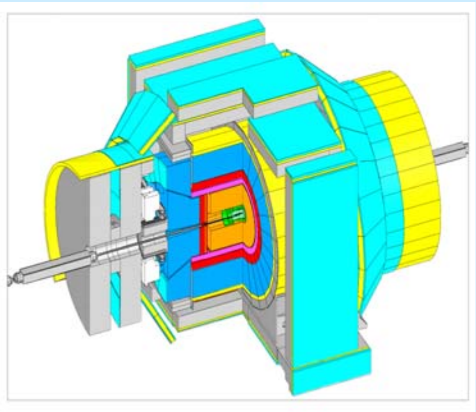
- PYTHIA with a GEANT based CDF detector simulation is used to study e* production
- An e* signal would manifest itself as a narrow resonance peak in the $e\gamma$ invariant mass
- The mass width is dominated by detector resolution

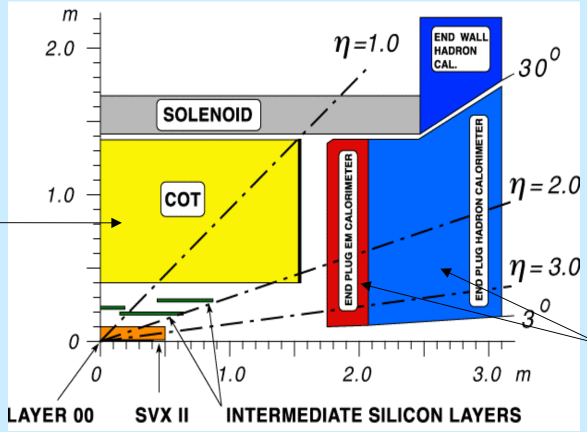
Dataset and Signal Selection

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

- Central Outer Tracker
- **Electromagnetic Calorimeter**
- **Hadronic Calorimeter**

are used to identify central electrons and photons



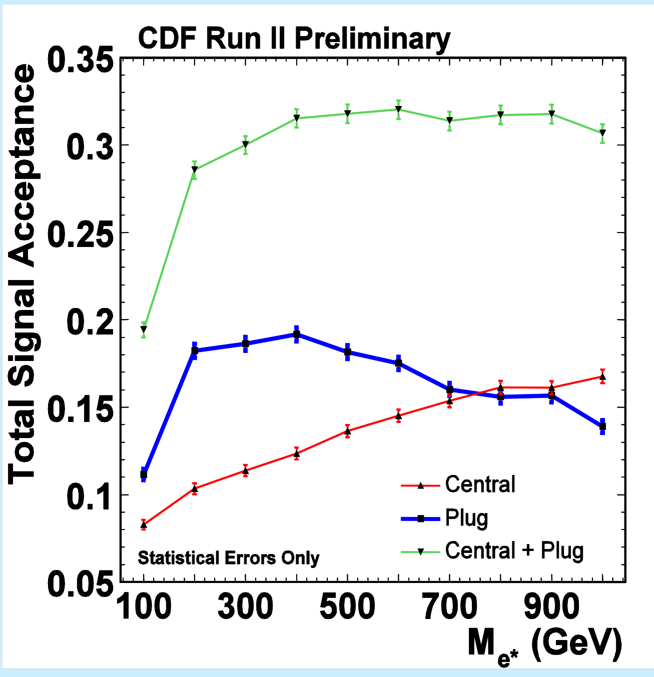


In the central region, **electrons** must have a **COT track**. **Photons** should have **no track** in the vicinity

Electrons and photons in the plug region are identified by their calorimeter shower properties

Total Signal Acceptance

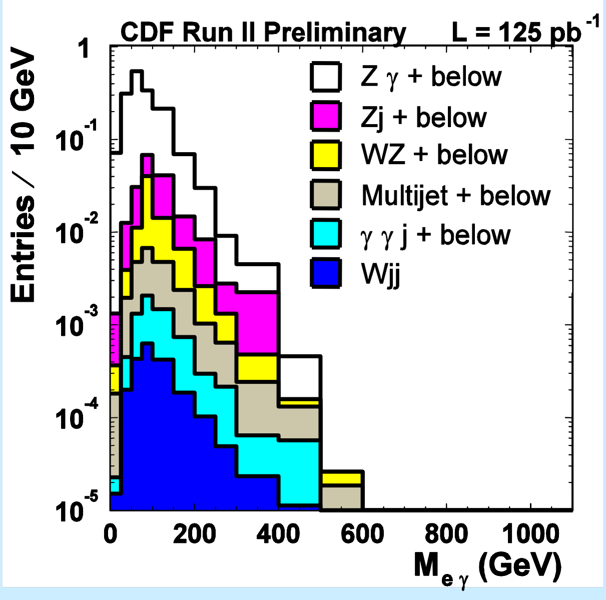
- Shown is the **total signal acceptance** for the **central** detector, **plug** detector and the two regions **combined**
- The fiducial acceptance is large due to **plug** inclusion
- Systematic error of 6% on acceptance with dominant contributions from:
  - Photon efficiency
  - Energy scale and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

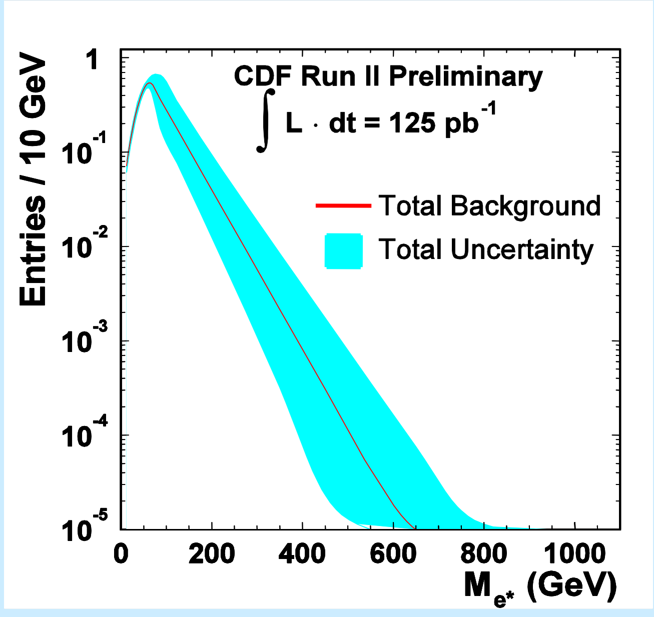


Background Estimates

- The $ee\gamma$ signal from ee* events can be mimicked by several standard model and detector sources:
- $Z\gamma$ (D.Y.)
- Z+jet
  - Jet fakes photon
- 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 $e\gamma$ invariant mass





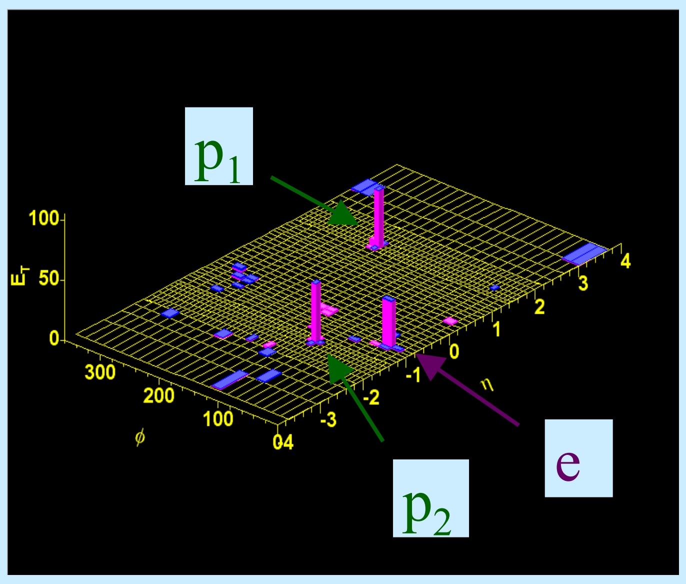
- The above plot shows the total background prediction as a function of e* mass, demonstrating the expected backgrounds are small

eeγ Candidate Event

- We find 1 $ee\gamma$ candidate event with one **central electron** (e) and two **plug EM objects** (p_1 and p_2).

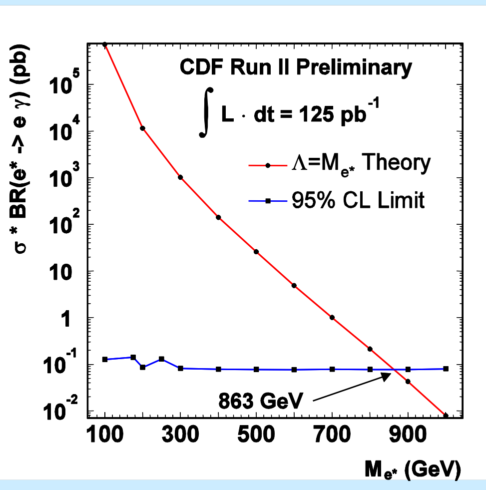
- $M_{e\,p_1}$ = 170 GeV
- $M_{e\,p_2}$ = 59 GeV
- $M_{p_1\,p_2}$ = 237 GeV
- $M_{e\,p_1\,p_2}$ = 297 GeV

	E_T (GeV)	ϕ	η
e	36.9	0.62	-1.01
p_1	65.9	4.04	1.28
p_2	43.7	2.20	-1.64

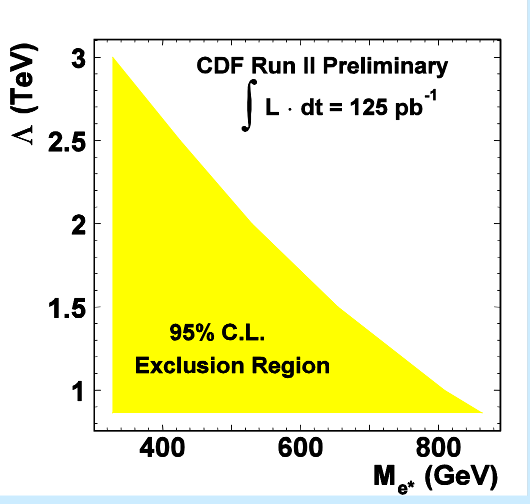


Excited Electron Mass Limit

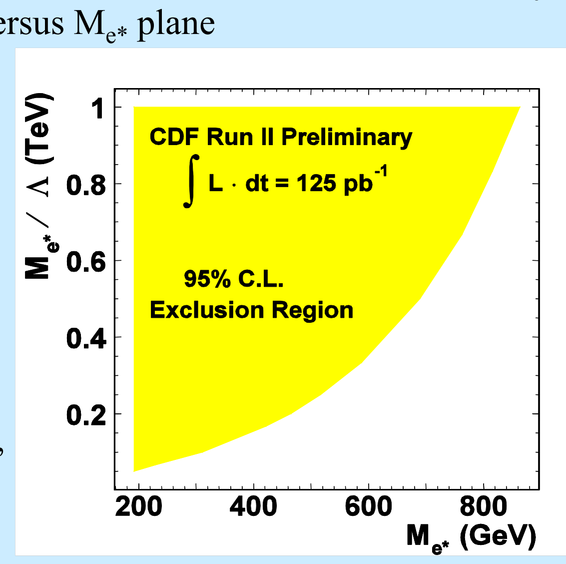
- A Bayesian approach is used to obtain the upper limit on the experimental cross-section at the 95% confidence level
- The **red** curve shows the theoretical cross-section for $M_{e^*}=\Lambda$
- The **blue** curve shows experimental cross-section limit
- The intersection at M_{e^*} = **863 GeV** gives the lower mass limit for $M_{e^*}=\Lambda$



Exclusion Region



- Excited electron contact interaction model is valid for $M_{e^*}/\Lambda < 1$
- Below is the exclusion region in the M_{e^*}/Λ versus M_{e^*} plane



- Because the excited electron theory depends on both e* mass and the compositeness scale, Λ, the two dimensional Λ-M_{e^*} exclusion region is plotted above

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 GeV** is excluded
- Established exclusion regions in the M_{e^*} — Λ plane
- Signal based search results can be applied to models yielding $ee\gamma$ signature, including other excited and exotic electron models

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Heather Kay Gerberich, Duke University for the CDF Collaboration (hkg@phy.duke.edu)