



Searches for New Phenomena with Lepton Final States at the Tevatron

**including charginos, neutralinos, excited leptons
and unexpected signatures**

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The path to new understanding is through discovery

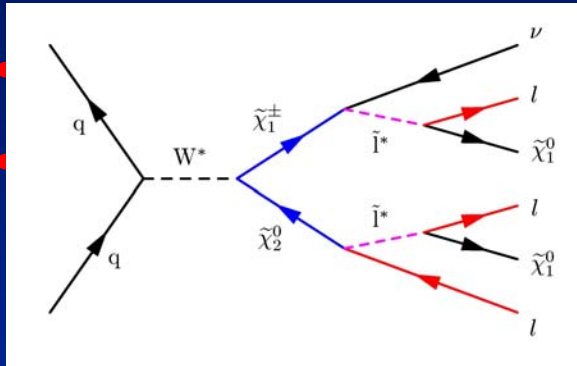
Historically, lepton final states have led to numerous discoveries

Many possibilities = many searches

Outline

- SUSY Trileptons
 - combined final states
- W'
- Z'
- Excited electrons
- RS Gravitons
- NLLP
- Summary

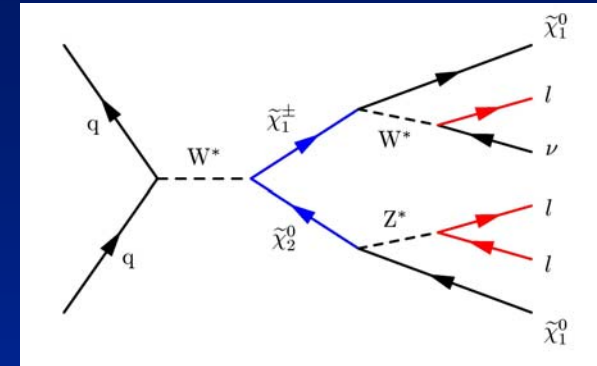
Charginos and Neutralinos in Trileptons



R-parity conserved

$$p\bar{p} \rightarrow \tilde{\chi}_1^\pm \tilde{\chi}_2^0$$

$$\tilde{\chi}_1^\pm \rightarrow l \nu \tilde{\chi}_1^0 \quad \tilde{\chi}_2^0 \rightarrow l \bar{l} \tilde{\chi}_1^0$$



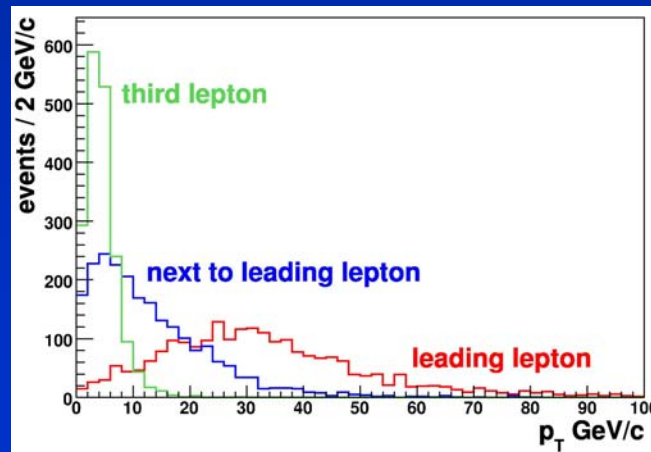
Trileptons:

Advantages

- small backgrounds

Disadvantages

- 3rd lepton is low p_T
- small cross-section \times branching ratio



Techniques

- all 3 leptons
- 2 leptons + track
- same-sign leptons



14 Combined Results

3lep	ee+l CEM	ee+l plug	eμ+l	μμ+l high p _T	μe+l CEM	μe+l plug	ee + track	μμ+l low p _T
Lumi (pb ⁻¹)	1034	954	1034	745	745	680	1013	976
Bkgd	0.44 ± 0.08	0.34 ± 0.10	0.28 ± 0.09	0.64 ± 0.18	0.42 ± 0.08	0.36 ± 0.07	0.97 ± 0.28	0.42 ± 0.12
Data	0	0	0	1	0	0	3	1

LS lep	ee LS	ee _{si} LS	e _{si} e _{si} LS	e _{si} μ LS	eμ LS	μμ LS
Lumi (pb ⁻¹)	993	993	993	971	971	1087
Bkgd	0.10 ± 0.10	0.50 ± 0.30	1.30 ± 0.30	1.70 ± 0.20	2.30 ± 0.50	0.90 ± 0.10
Data	1	2	1	4	4	1



SUSY Interpretation

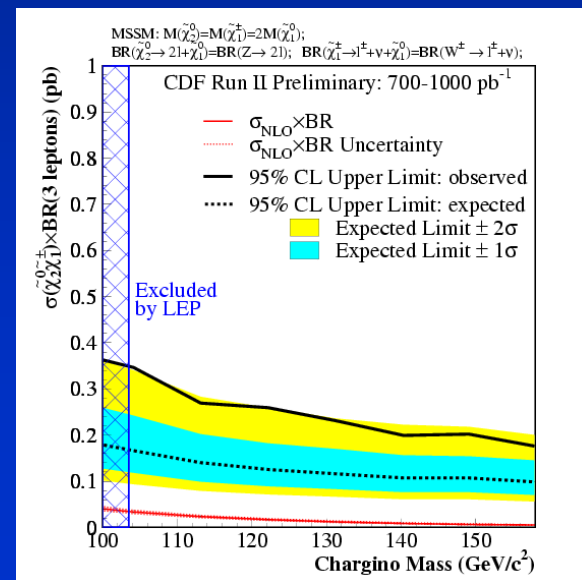
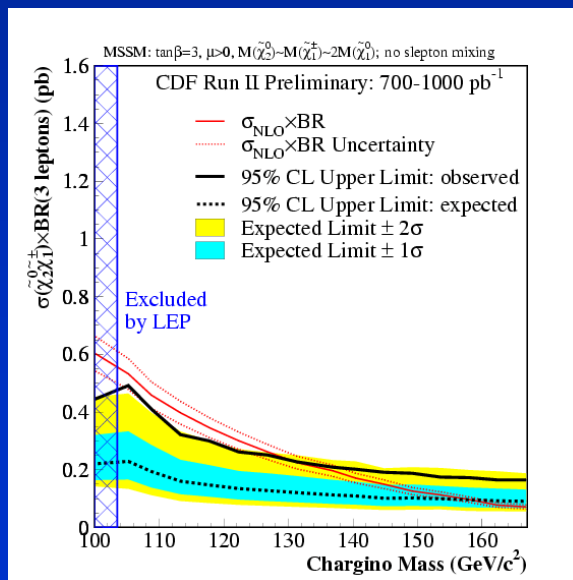
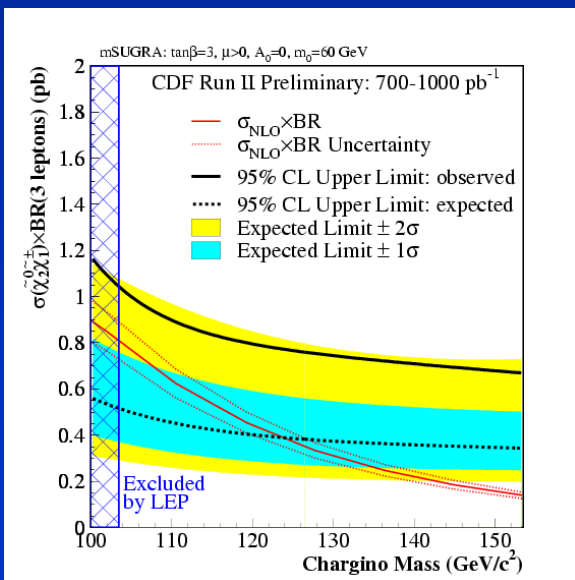
mSUGRA (inspired)

$\tan\beta=3, A_0=0, \mu>0, m_0=60$

A. mSUGRA
no limit yet

B. MSSM
same as mSUGRA
without slepton mixing
 $M(\chi_1^\pm) > 130 \text{ GeV}$

C. MSSM
set lepton BR to
same as W/Z
no limit yet





4 Combined Results

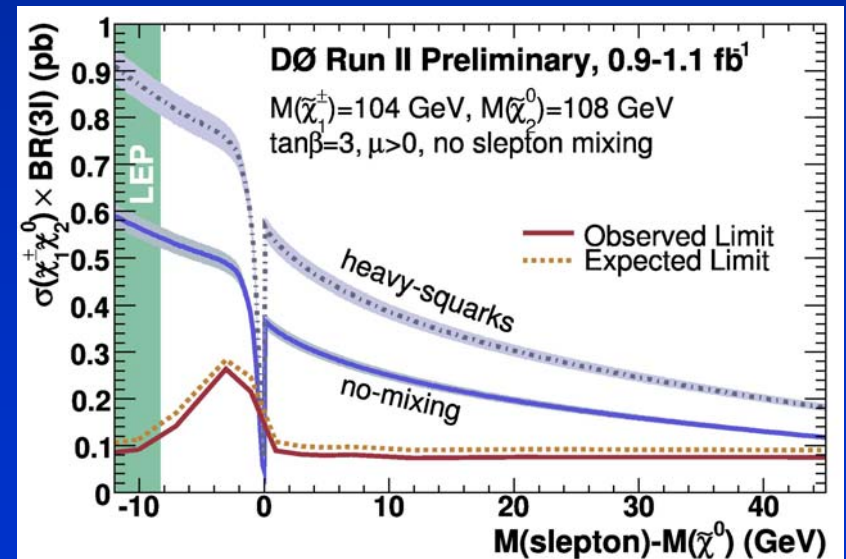
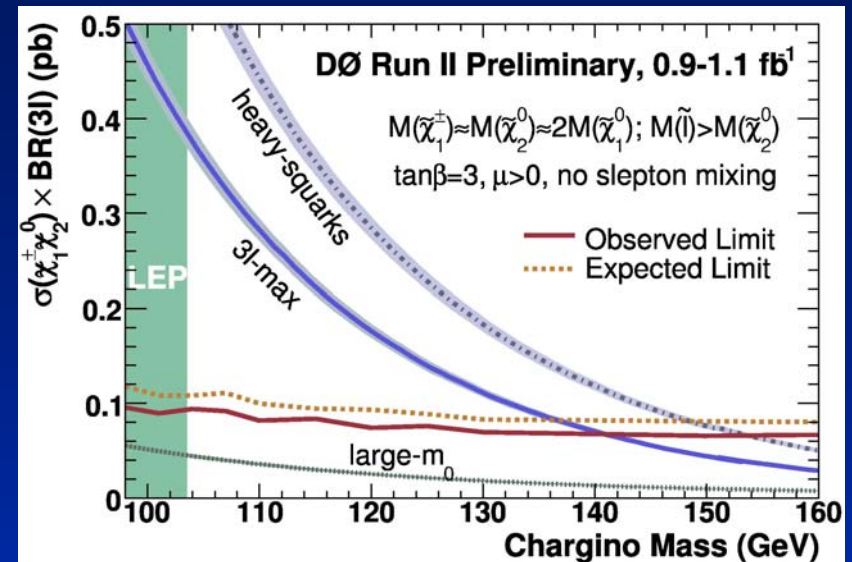
- **New channels**
 - $\mu\mu l$ and $e\mu l$

	Lumi (pb⁻¹)	Bkgd	Data
<i>eel</i>	1000	0.76 ± 0.67	0
<i>$\mu\mu l$</i>	1100	0.32 ± 1.34	2
<i>$\mu e l$</i>	1100	0.94 ± 0.40	0
LS $\mu\mu$	1000	1.1 ± 0.4	1



SUSY Limits from Trileptons

- Use 3 SUSY models
 - mSUGRA inspired
 - $m(\chi_1^\pm) \approx m(\chi_2^0) \approx 2m(\chi_1^0)$
 - no slepton mixing
 - large m_0
 - **W/Z decays dominate**
 - **no sensitivity**
 - 3l-max
 - **m(slepton) slightly larger than $m(\chi_2^0)$**
 - **$M(\chi_1^\pm) > 141$ GeV**
 - heavy squarks
 - **relax scalar mass unification**





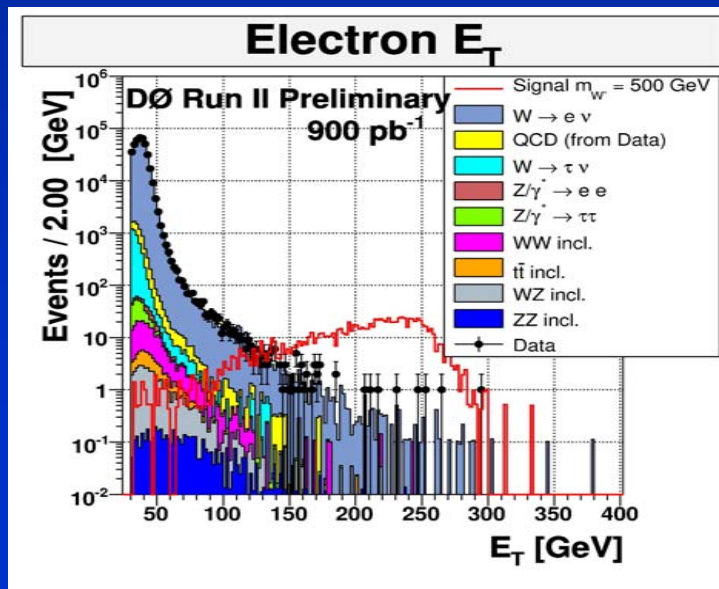
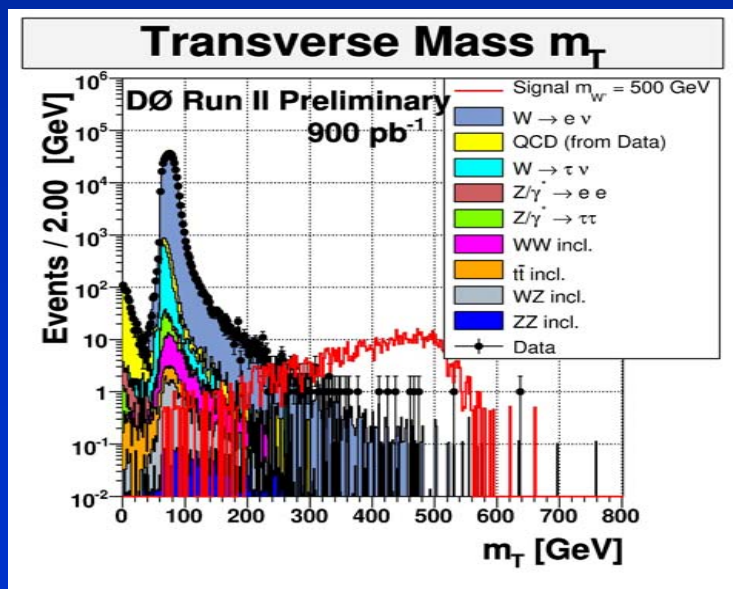
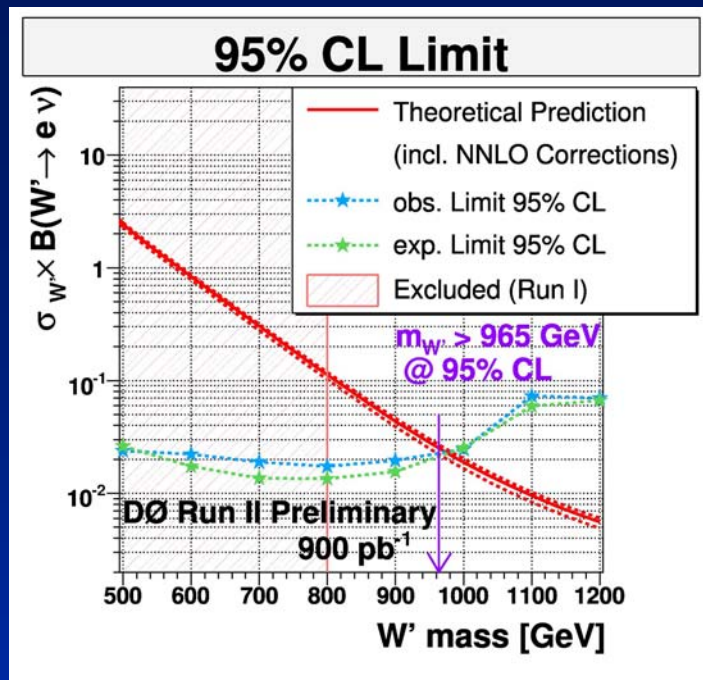
W' Search

- Search for additional charged gauge boson
- Events w/ electron ($E_T > 30$ GeV, $MET > 30$ GeV, $M_T > 150$ GeV)

Data = 630 events

Bkgd = $623 \pm 18^{+83}_{-75}$ events

$M_{W'} > 965$ GeV @ 95% CL

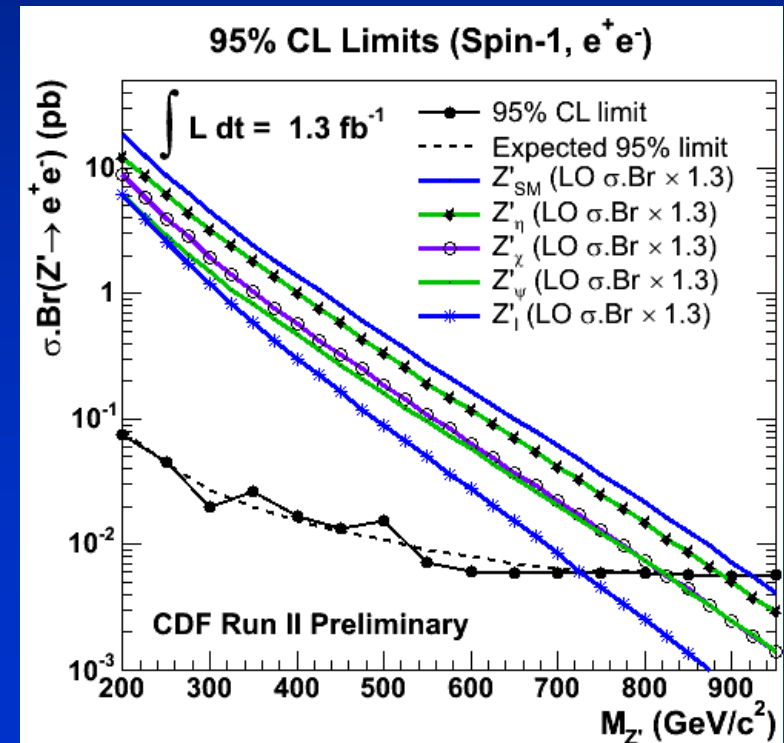
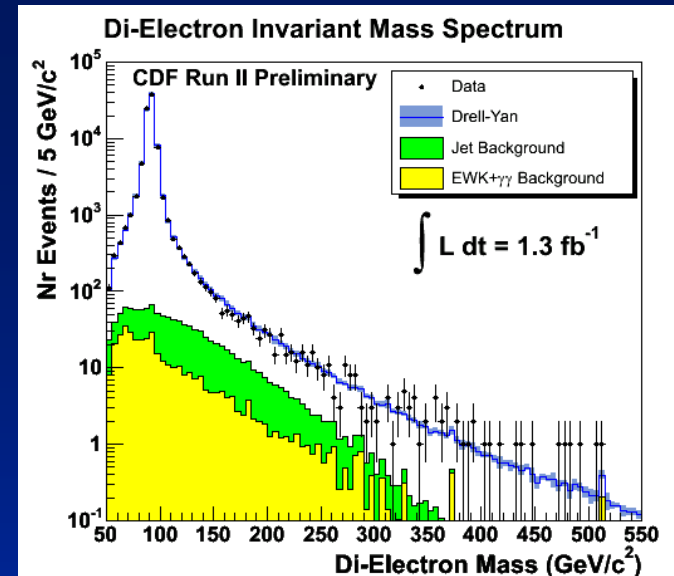




DiElectron High Mass Search

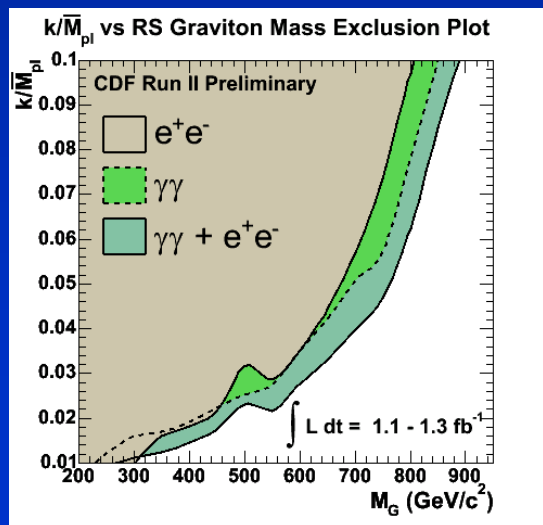
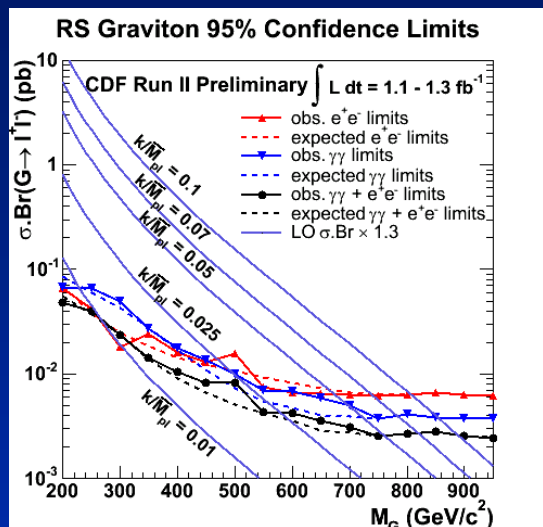
- Select events with two electrons ($E_T > 25$ GeV)
- Search for narrow high mass resonances
 - $150 < M(ee) < 950$ GeV
 - Model independent
 - No excess found
- Z' (spin 1) additional neutral gauge boson

$Z'_{SM} > 923$ GeV	$Z'_I > 729$ GeV
$Z'_\psi > 822$ GeV	$Z'_\chi > 822$ GeV
$Z'_\eta > 891$ GeV	





RS Gravitons



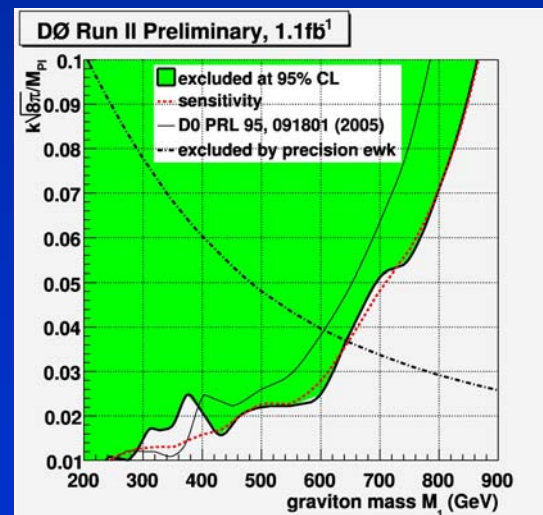
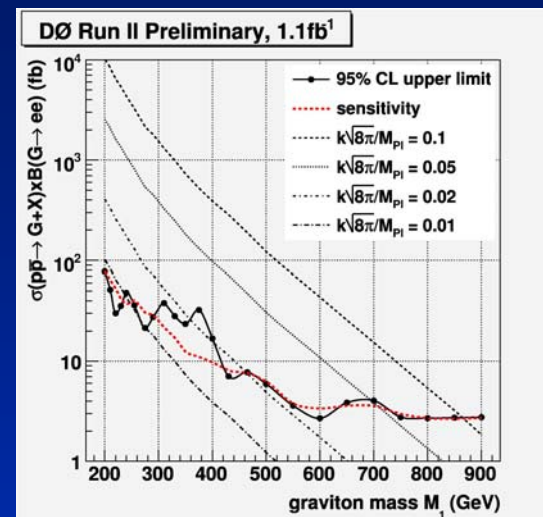
- Use extra dimensions to address hierarchy problem
- Resonant production of gravitons at Tevatron
- Combine dielectron w/ diphoton search
 - Diphoton is twice as sensitive (spin 2)

CDF

- $M_G > 889 \text{ GeV}$ for $k/\bar{M}_{pl} = 0.1$

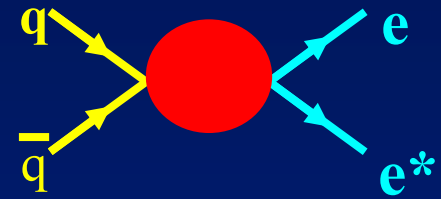
D0

- $M_G > 865 \text{ GeV}$ for $k/\bar{M}_{pl} = 0.1$

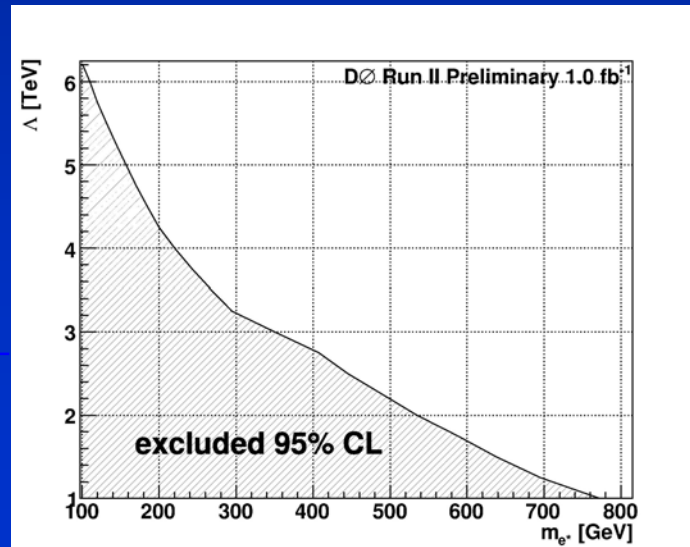
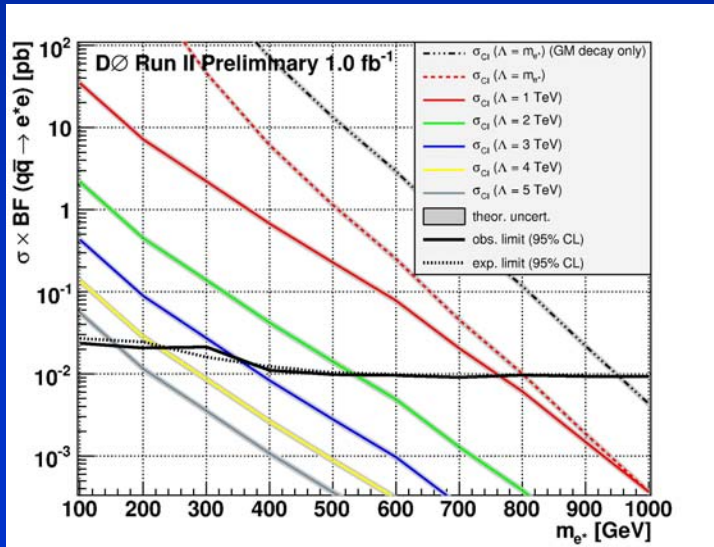
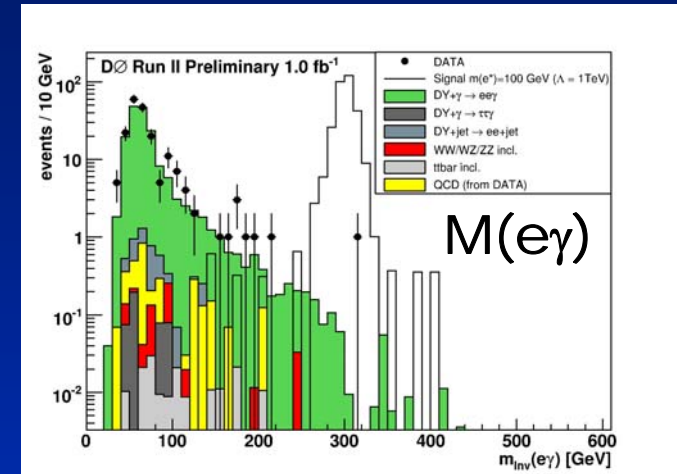




Excited Electrons



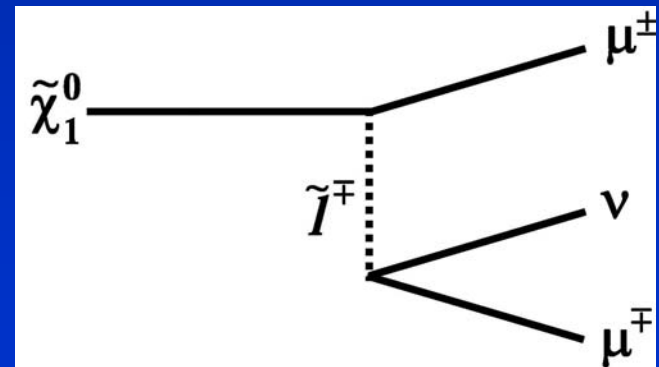
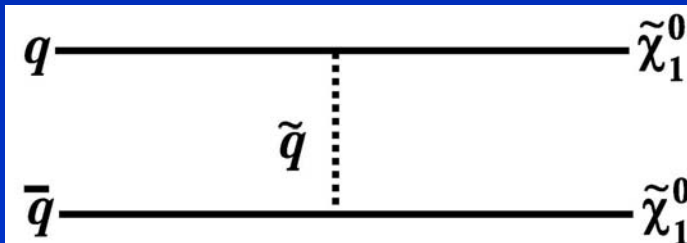
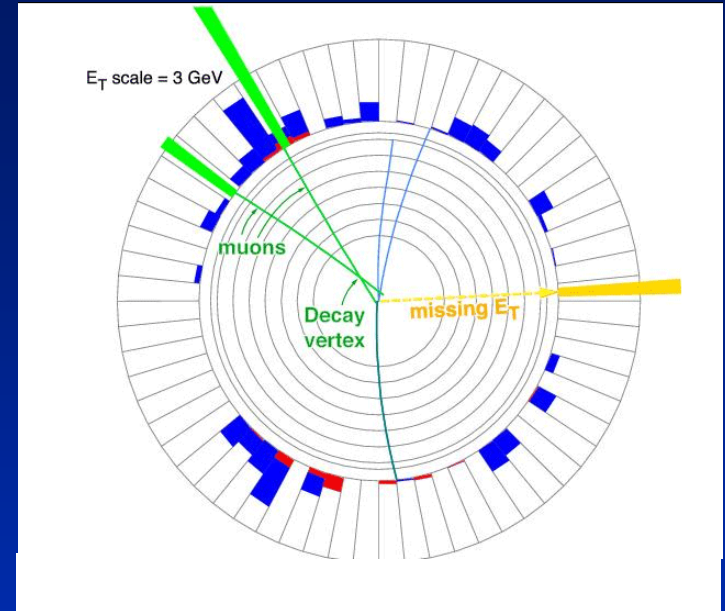
- Some models predict quarks and leptons are made of smaller pieces
 - allows excited states (e^* , μ^* , q^* , etc)
- Search in $ee\gamma$
 - possible decay mode $e^* \rightarrow e\gamma$
 - $p_T(e_1/e_2/\gamma) > 25/15/15$ GeV
 - observed 259 events
 - expectation = $232 \pm 3 \pm 29$ events
- $m_{e^*} > 756$ GeV





Search for Neutral, Long-lived Particles

- Search for pair production of two neutral particles
- Look for decay well away from production point
 - two isolated muons $p_T > 10$ GeV
- Sample signal
 - RPV SUSY
 - χ_1^0 pair production



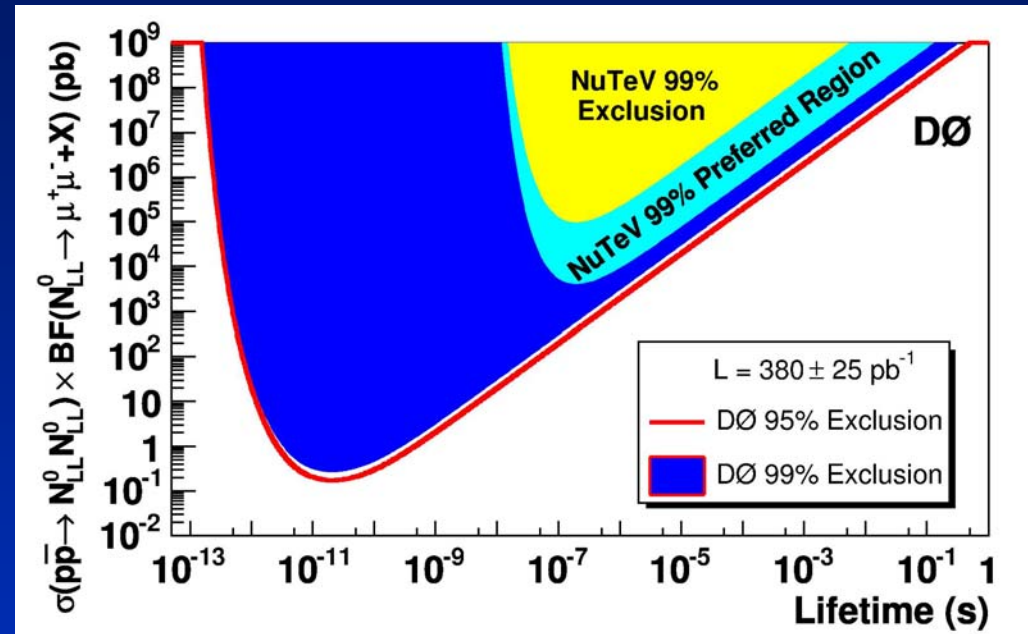
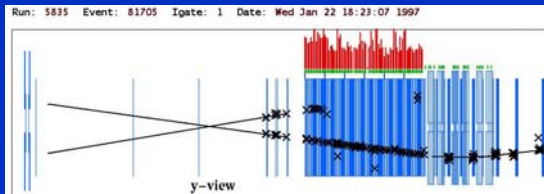
Limits on NLLP Production

Phys. Rev. Lett. 97
161802 (2006)

0 events observed
 $0.75 \pm 1.1 \pm 1.1$ expected

NuTeV

- neutrino experiment at Fermilab
- observed 3 dimuon events in decay region



DØ sets limits on pair production cross-section vs. lifetime

Excludes some interpretations of NuTeV result



Summary



- The Tevatron has an exciting program of searches for new phenomena using leptons
- I've shown some of the more recent ones
 - Trileptons, W' , Z' , RS gravitons, NLLP
- Many more not covered
 - RPV SUSY, technicolor, leptoquarks, charged massive stable particles and more
- Significant discovery potential remains
- Also, excellent preparation for initial LHC searches
- Now for some jets and photons...