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

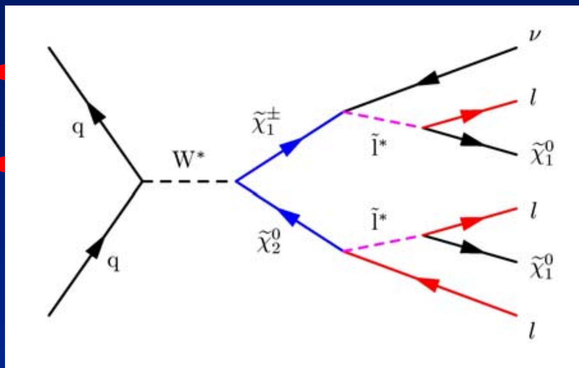
Historically, lepton final states have led to numerous discoveries

Many possibilities = many searches

Outline

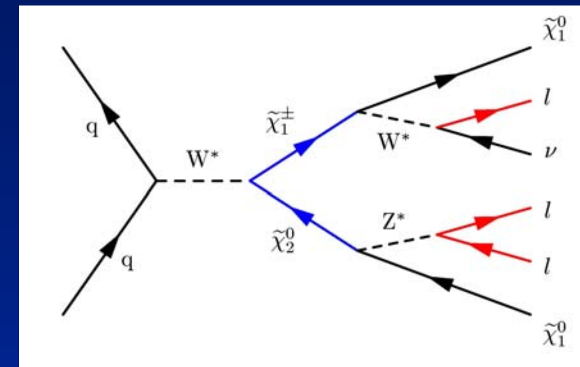
- SUSY Trileptons
  - combined final states
- W'
- Z'
- Excited electrons
- RS Gravitons
- NLLP
- Summary

Charginos and Neutralinos in Trileptons



R-parity conserved

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



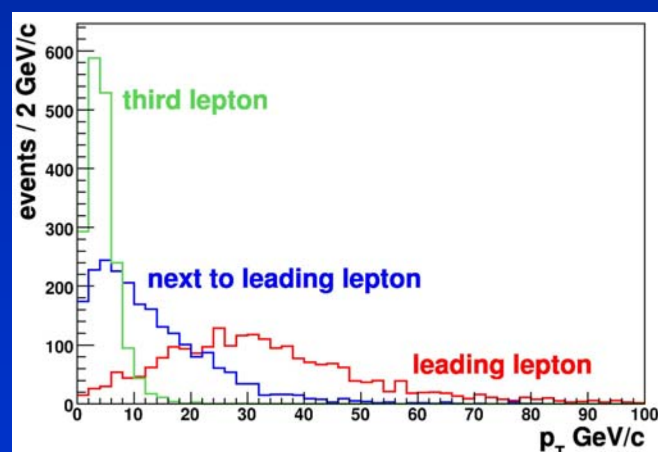
Trileptons: $\tilde{\chi}_1^\pm \rightarrow l\nu\tilde{\chi}_1^0$ $\quad \tilde{\chi}_2^0 \rightarrow l\bar{l}\tilde{\chi}_1^0$

Advantages

- small backgrounds

Disadvantages

- 3rd lepton is low p_T
- small cross-section x 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 ± 020	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

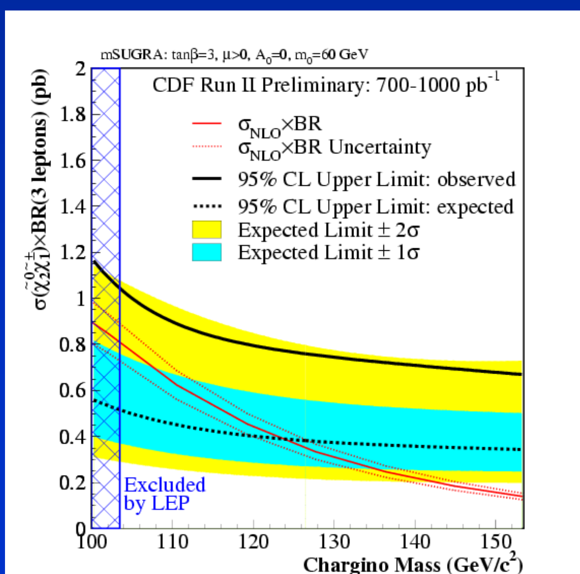
$M(\chi_1^{\pm}) > 130$ GeV

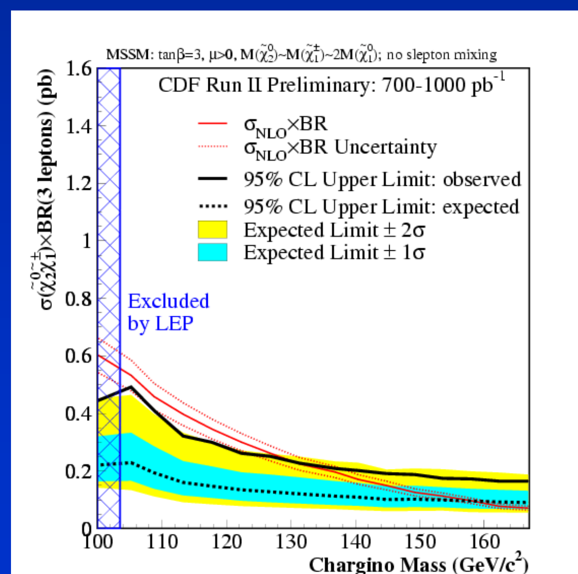
C. MSSM

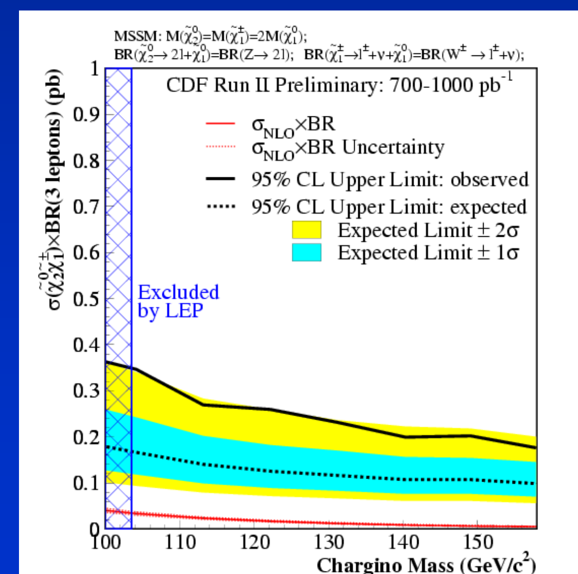
set lepton BR to

same as W/Z

no limit yet







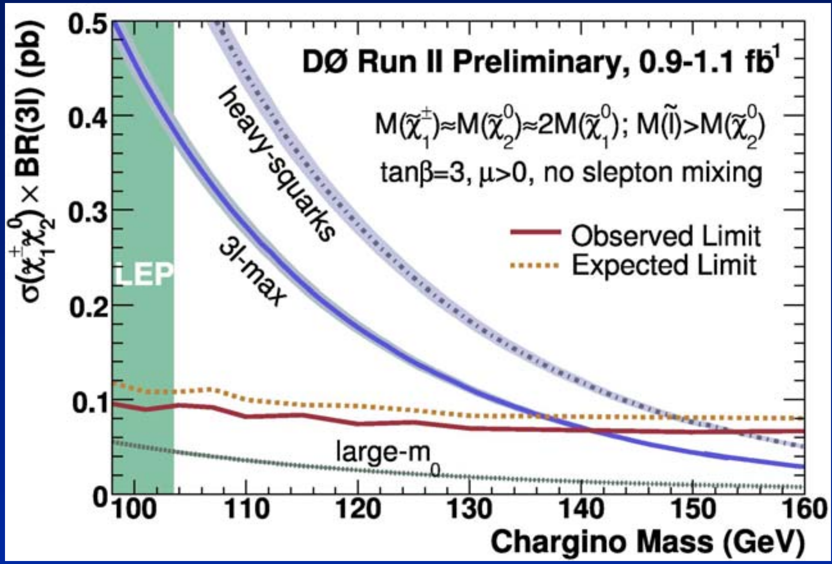
4 Combined Results

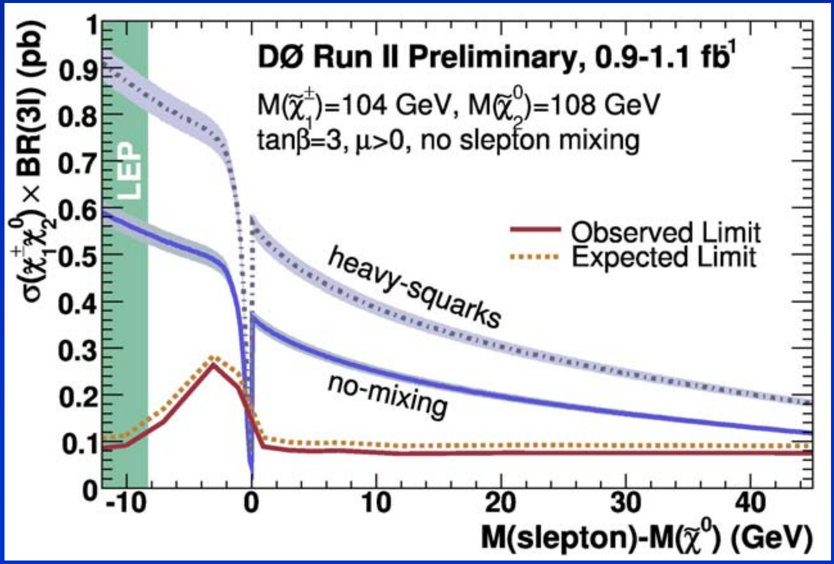
- **New channels**
  - $\mu\mu l$ and $e\mu l$

	Lumi (pb^{-1})	Bkgd	Data
eel	1000	0.76 ± 0.67	0
$\mu\mu l$	1100	0.32 ± 1.34	2
μel	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
  - 3*l*-max
    - m(slepton) slightly larger than $m(\chi_2^0)$
    - $M(\chi_1^{\pm}) > 141$ GeV
  - heavy squarks
    - relax scalar mass unification





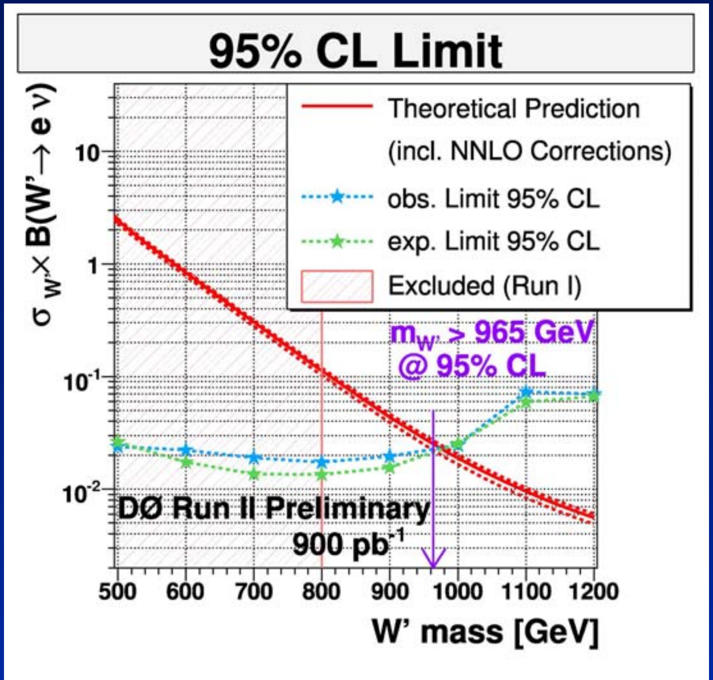
W' Search

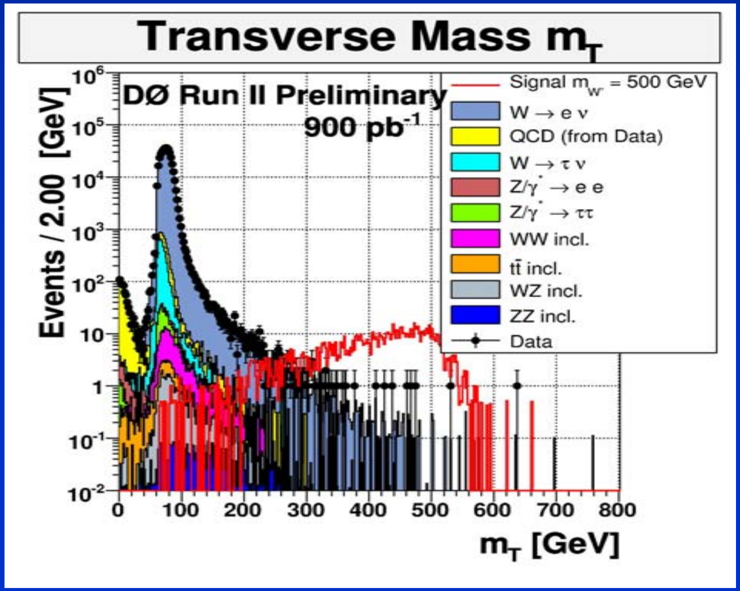
- Search for additional charged gauge boson
- Events w/ electron (E_T>30 GeV, MET>30 GeV, M_T>150 GeV)

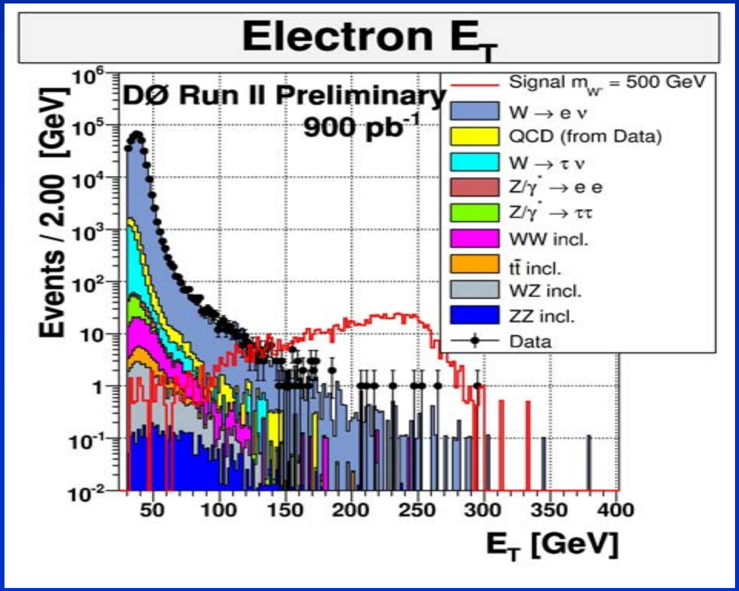
Data = 630 events

Bkgd = 623 ± 18 $^{+83}_{-75}$ events

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



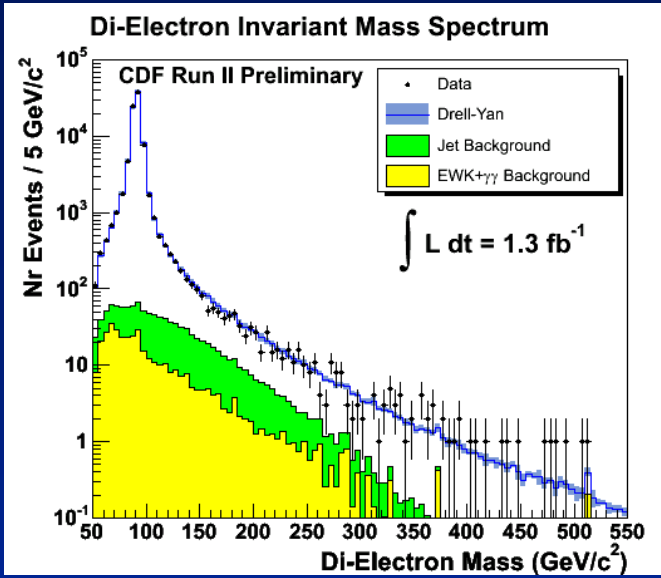


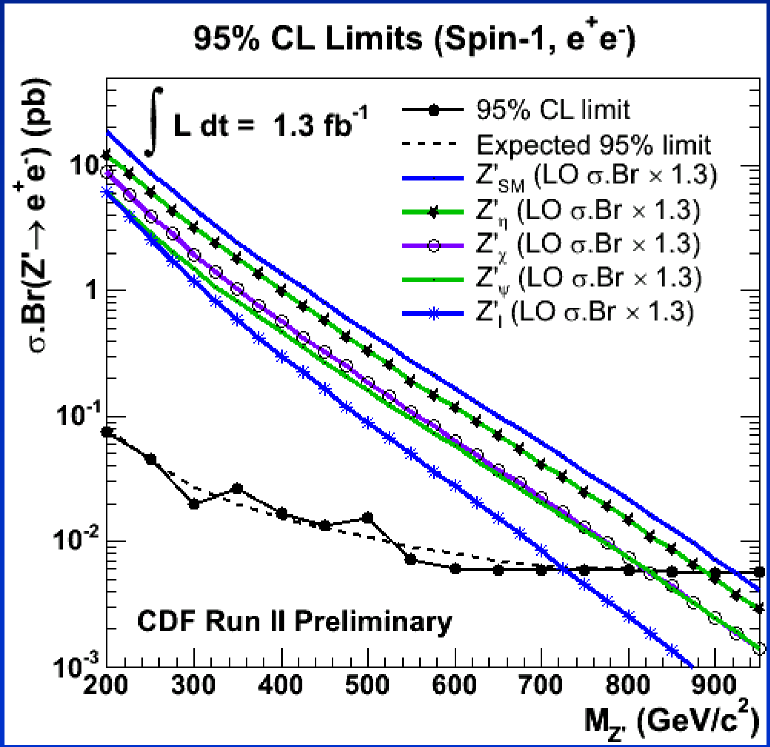


DiElectron High Mass Search

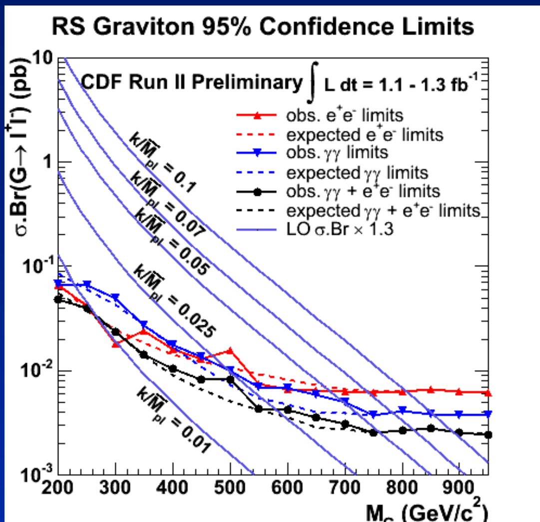
- Select events with two electrons (E_T>25 GeV)
- Search for narrow high mass resonances
  - 150<M(ee)<950 GeV
  - Model independent
  - No excess found
- Z' (spin 1) additional neutral gauge boson

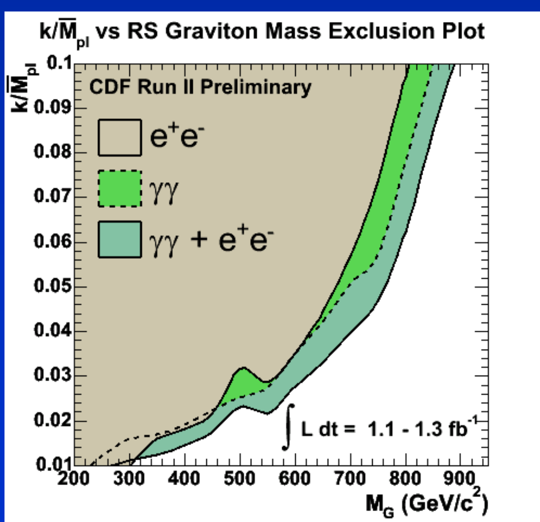
Z'_{SM}>923 GeV Z'_{I}>729 GeV
Z'_{ψ}>822 GeV Z'_{χ}>822 GeV
Z'_{η}>891 GeV



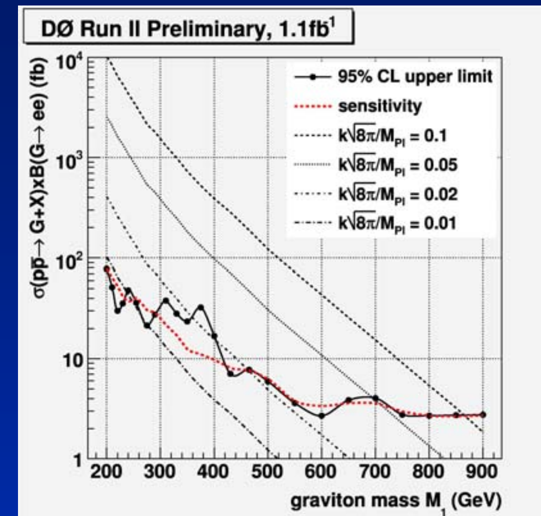


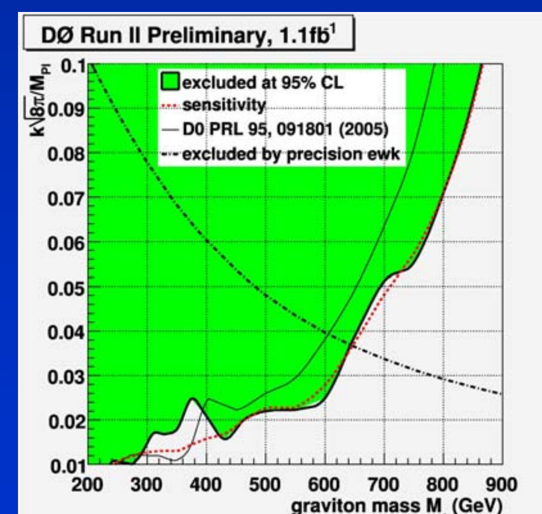
RS Gravitons



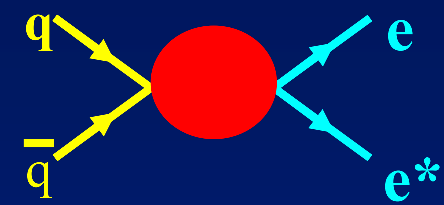


- Use extra dimensions to address hierarchy problem
- Resonant production of gravitons at Tevatron
- Combine dielectron w/ diphoton search
  - Diphoton is twice as sensitive (spin 2)
- CDF
  - M_G>889 GeV for $k/\overline{M}_{pl} = 0.1$
- D0
  - M_G>865 GeV for $k/\overline{M}_{pl} = 0.1$

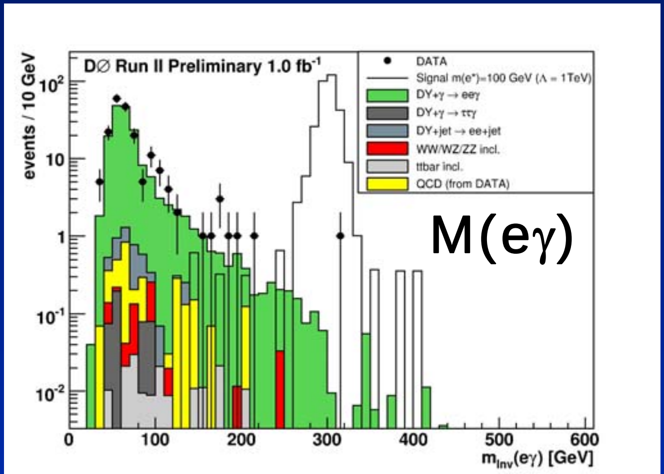


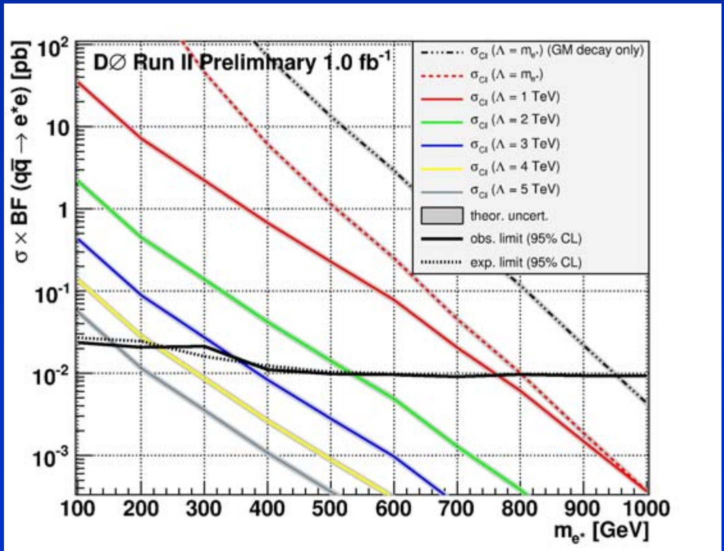


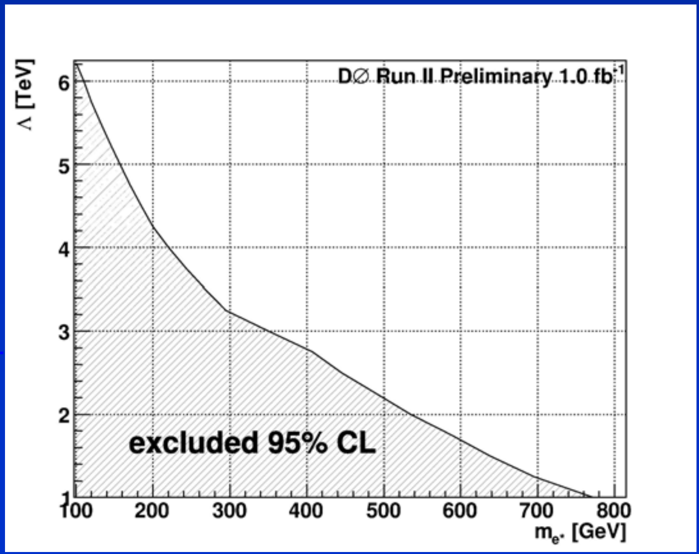
Excited Electrons



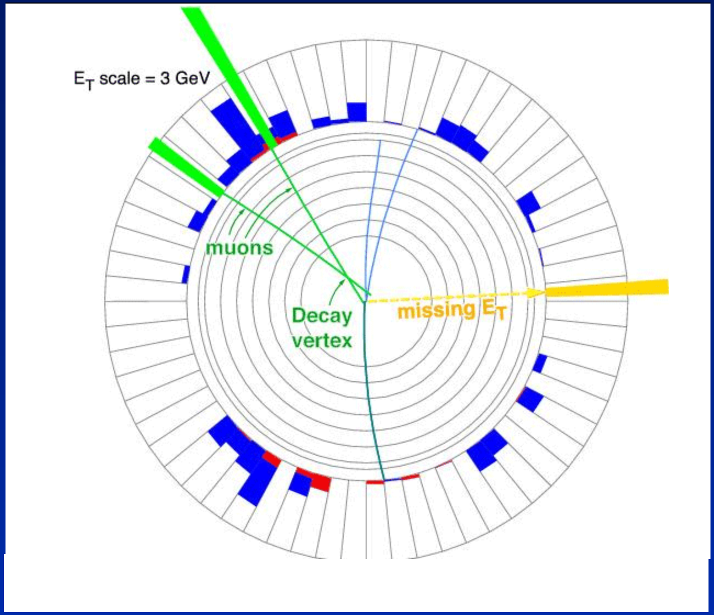
- Some models predict quarks and leptons are made of smaller pieces
  - allows excited states (*e**, *μ**, *q**, *etc)*
- Search in eeγ
  - possible decay mode e*→eγ
  - $p_T(e_1/e_2/\gamma) > 25/15/15$ GeV
  - observed 259 events
  - expectation = 232 ± 3 ± 29 events
- $m_{e*} > 756$ GeV



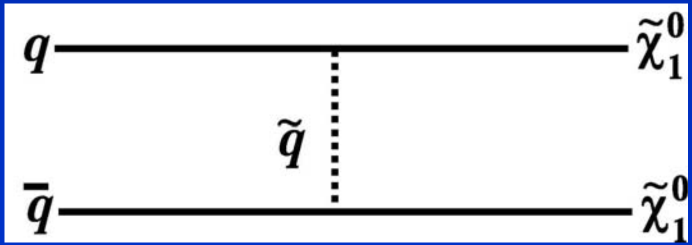


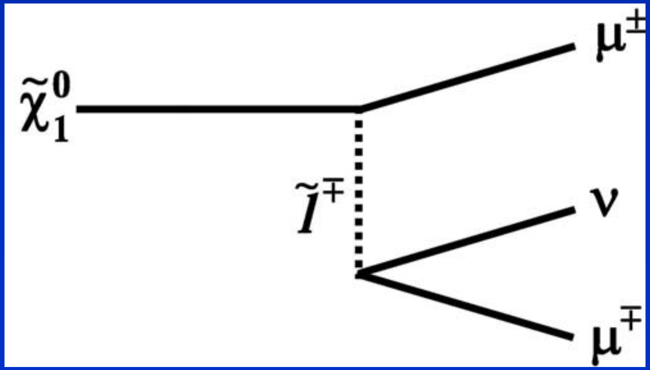


Search for Neutral, Long-lived Particles



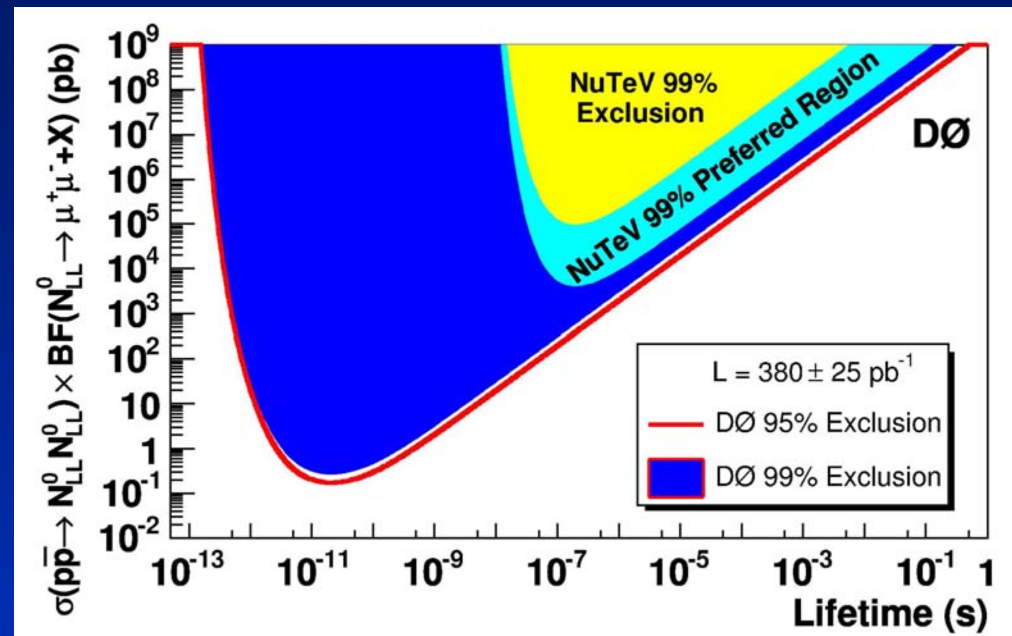
- Search for pair production of two neutral particles
- Look for decay well away from production point
  - two isolated muons p_T>10 GeV
- Sample signal
  - RPV SUSY
  - χ_1^0 pair production





Limits on NLLP Production

Phys. Rev. Lett. 97 161802 (2006)

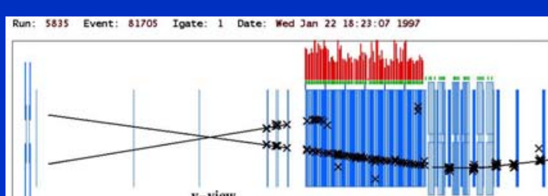


0 events observed

0.75 ± 1.1 ± 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…