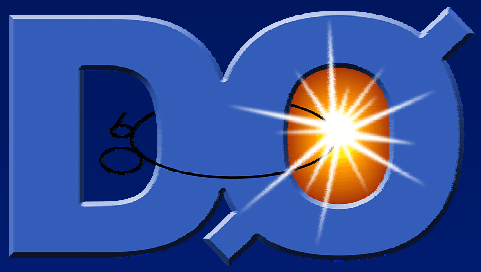


Searches for R-parity Violating Supersymmetry with the DØ Detector

Todd Adams

Florida State University

October 31, 2006

Outline

- R-parity violating supersymmetry
- Gaugino searches in trileptons
- Resonant slepton production
- Neutral, long-lived particles
- Summary

R-Parity Violating Supersymmetry

$$\text{R-parity}: R_P = (-1)^{3B+L+2S}$$

B = baryon number
L = lepton number
S = spin

R_P = +1 for normal particles
-1 for supersymmetric particles

$$W = W_{MSSM} + W_{RPV}$$

R-parity violating extension of MSSM

$$W_{RPV} = \frac{1}{2}\lambda_{ijk} L_i L_j \overline{E}_k + \lambda'_{ijk} L_i Q_j \overline{D}_k + \lambda''_{ijk} \overline{U}_i \overline{D}_j \overline{D}_k$$

I,j,k = 1,2,3 generation indicies

ΔL=1: Lepton number violation
Gauge symmetry: $\lambda_{ijk} = -\lambda_{ijk}$
→9 λ couplings

L: lepton doublet superfield
E: lepton singlet superfield
Q: quark doublet superfield
D: down-like quark singlet
λλ′λ″ : Yukawa couplings

Generally assume only one non-zero coupling at a time

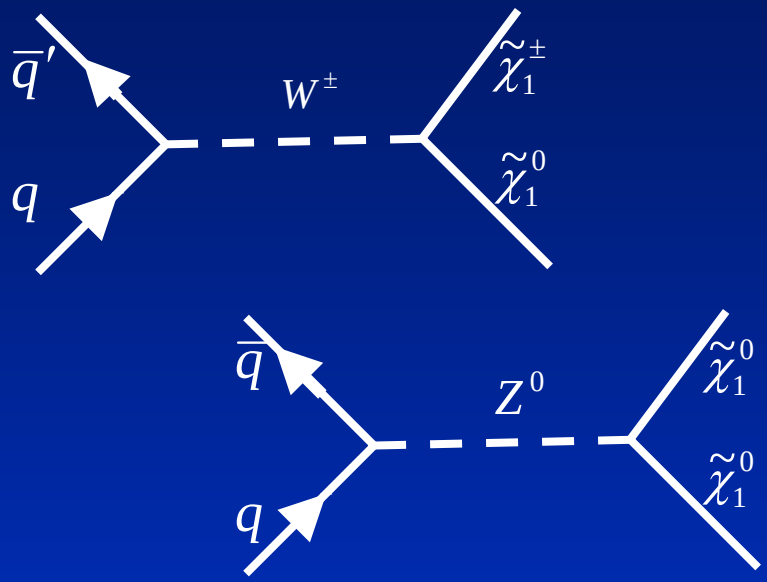
ΔL=1: Lepton number violation
27 λ′ couplings

Outline

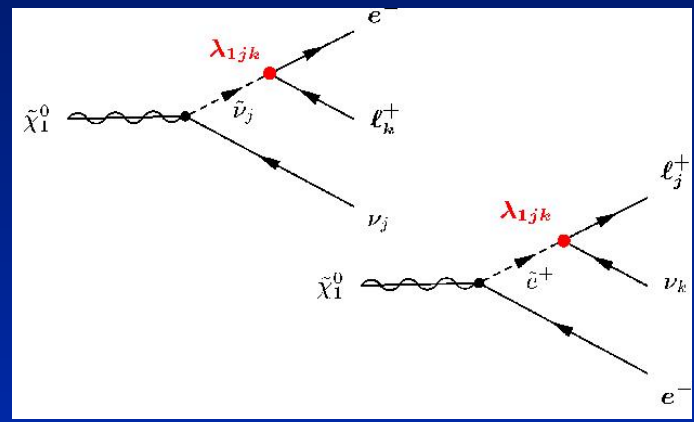
- R-parity violating supersymmetry
- Gaugino searches in trileptons (LLE)
- Resonant slepton production
- Neutral, long-lived particles
- Summary

Search for LLE Couplings

Pair Production



RPV Decays



χ_1^0 is assumed to be LSP

λ>0.01 (prompt decay)

mSUGRA:

m_0 = 1 TeV, $m_{1/2}$ = 280 GeV

tanβ=5, μ>0, A_0=0

Signal: 4 leptons + 2 neutrinos

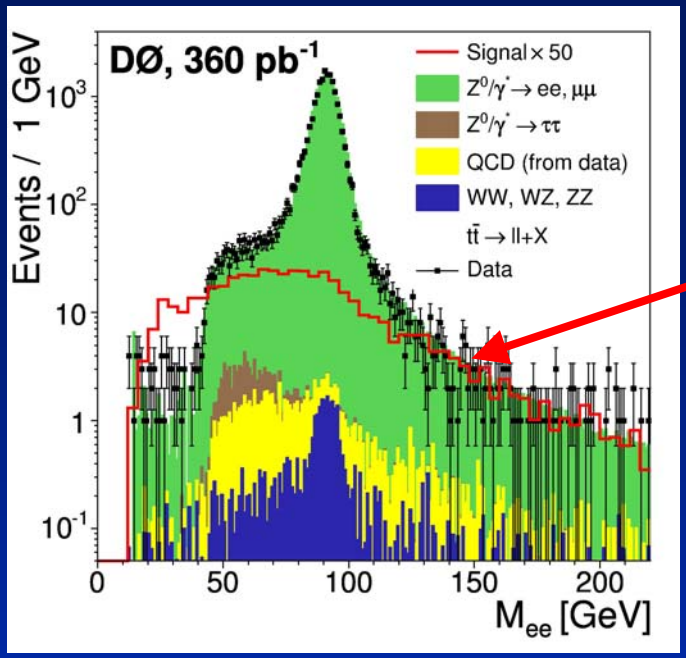
Analysis: 3 leptons

+ missing E_T (MET)

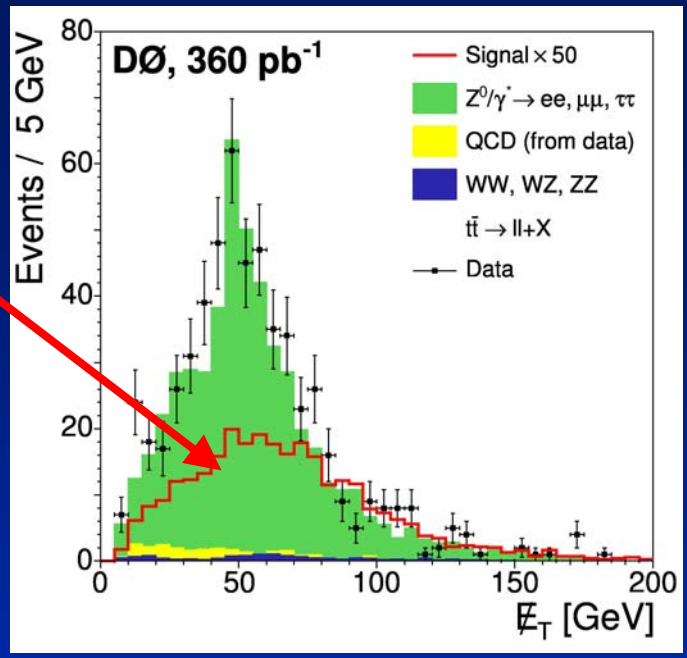
Three Combined Analyses

λ_{121}	λ_{122}	λ_{133}
***eee* or *ee*μ**	**$\mu\mu\mu$ or $\mu\mu e$**	***ee*τ**
electron p_T > 20 GeV	muon p_T > 12 GeV	electron p_T > 10 GeV
electron p_T > 20 GeV	muon p_T > 8 GeV	electron p_T > 10 GeV
electron or muon p_T > 10 GeV	electron or muon p_T>5 GeV p_T>4 GeV	tau neural network p_T > 10 GeV
missing E_T > 15 GeV	missing E_T > 10 GeV	
	Σp_T(lepton) > 50 GeV	18 < M_{ee} < 80 GeV
	2D cut ($M_{\mu\mu}$, MET)	MET/$\sqrt{S_T}$ > 1.5 $GeV^{1/2}$

ee Sample

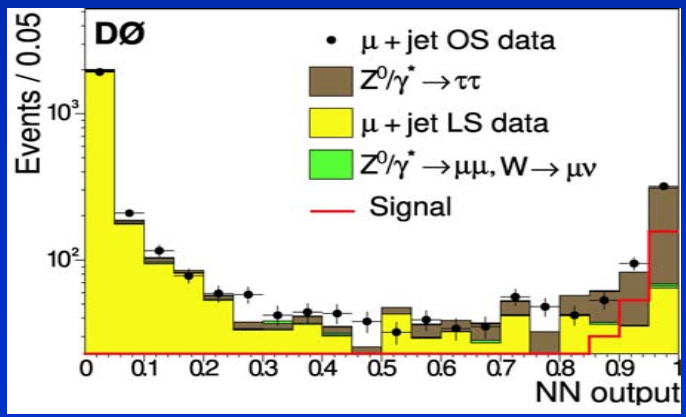


μμ Sample w/ Z veto



Signal x50

τ neural network

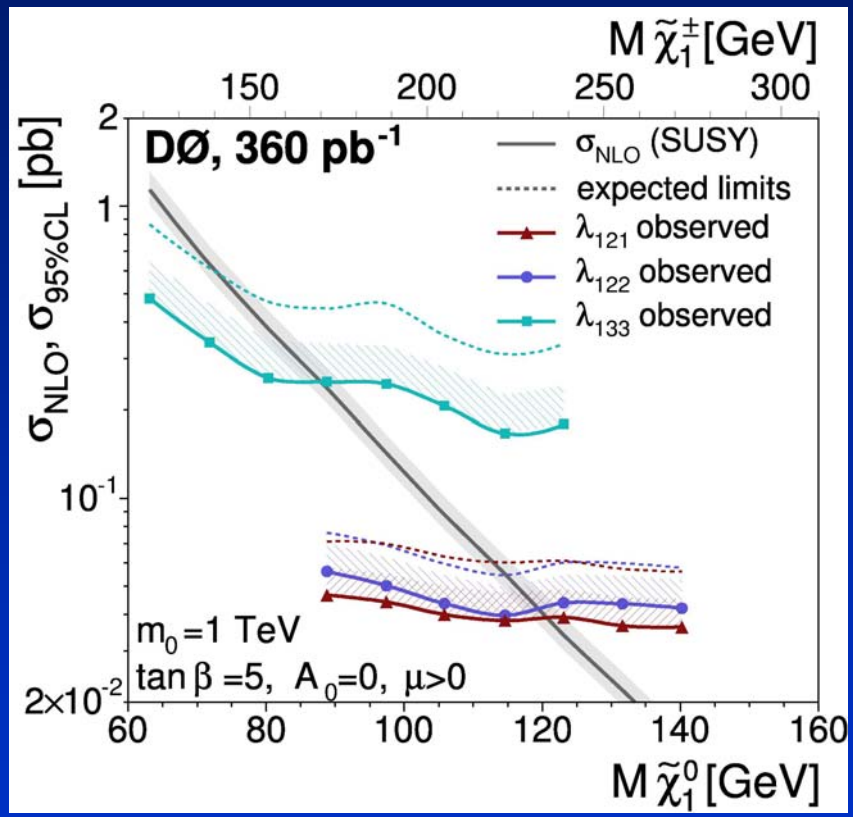


	SM Background	Data
eee* or *eeμ (λ_{121})	$0.9\ ^{+0.4}_{-0.1} \pm 0.1$	0
μμμ* or *μμe (λ_{122})	$0.4 \pm 0.1 \pm 0.1$	0
eeτ (λ_{133})	$1.3 \pm 1.7 \pm 0.5$	0

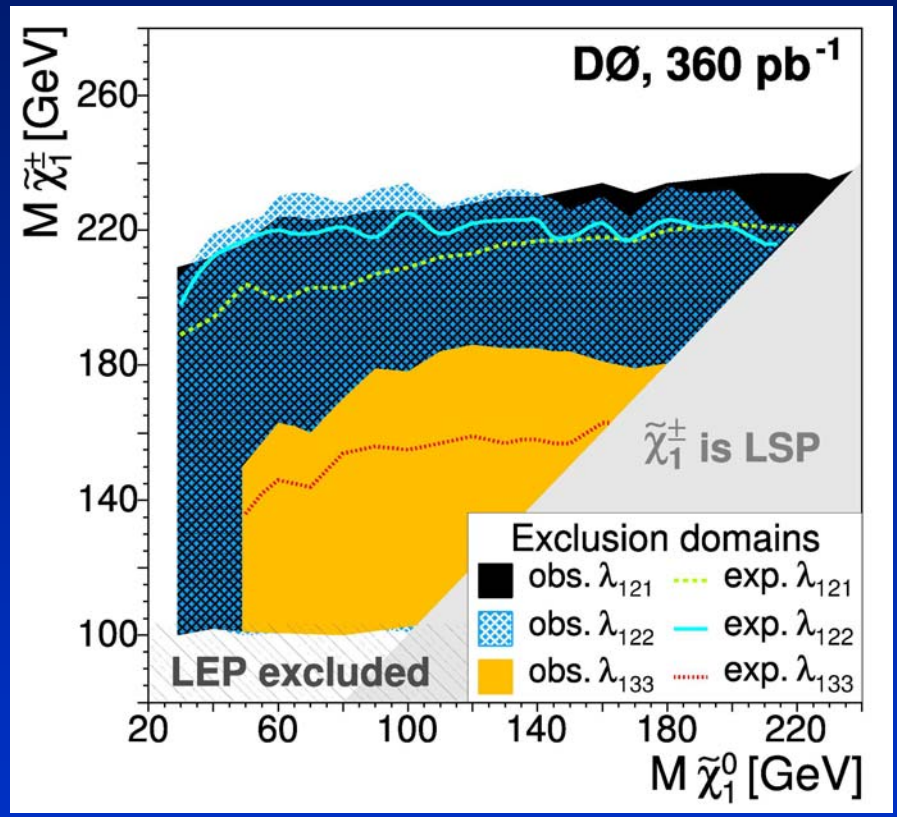
SUSY Limits

Phys. Lett. B638 (2006) 441

mSUGRA



unconstrained MSSM
(no relation between M_1 and M_2)



Mass limits:

$M(\chi_1^0) > 119$ GeV

$M(\chi_1^\pm) > 234$ GeV

χ_1^0 - $\chi_1^\pm$ plane

Outline

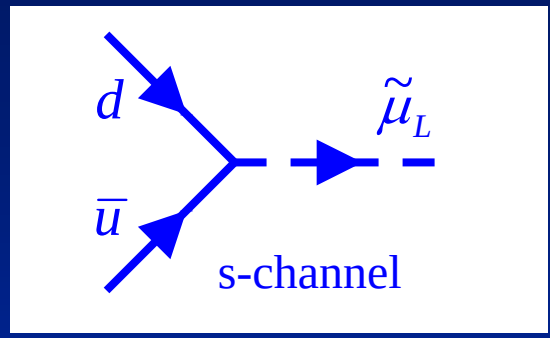
- R-parity violating supersymmetry
- Gaugino searches in trileptons (LLE)
- Resonant slepton production
- Neutral, long-lived particles
- Summary

Search for Resonant Slepton Production

RPV Production:

λ'_{211}

RPV Decay: $\chi_1^0 \rightarrow \mu qq$

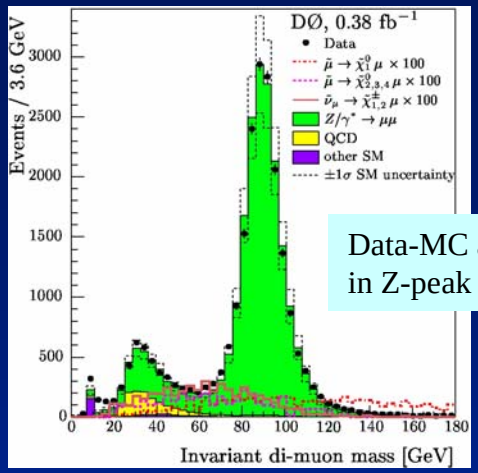


$$\tilde{\mu} \rightarrow \tilde{\chi}_1^0 \mu \qquad \tilde{\mu} \rightarrow \tilde{\chi}_{2,3,4}^0 \mu \rightarrow \tilde{\chi}_1^0 Z \qquad \tilde{\nu}_\mu \rightarrow \tilde{\chi}_1^\pm \mu \rightarrow \tilde{\chi}_1^0 W^\pm$$

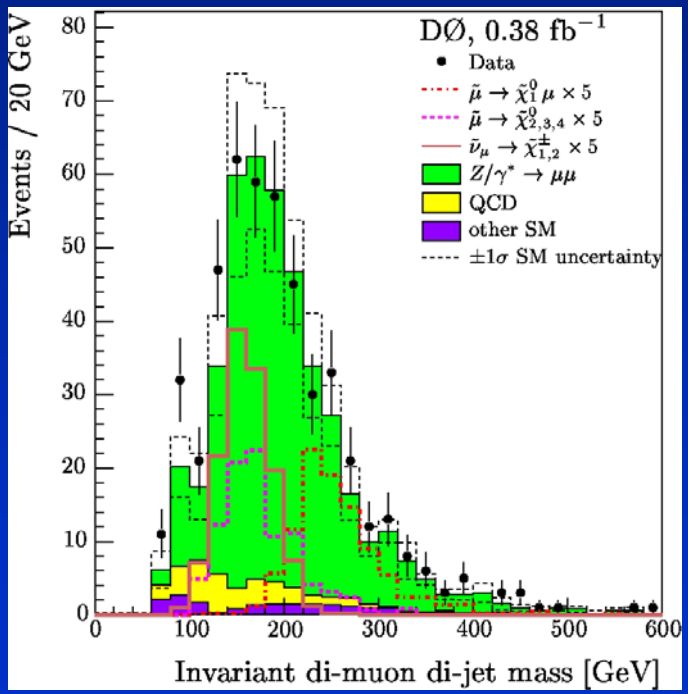
Final state: 2 muons and 2 jets

- 3 channels analyzed separately
- Cross-section limits for each channel
- Combined within mSUGRA

can reconstruct χ_1^0 mass



Data-MC agreement in Z-peak



- Selection criteria tuned for each slepton/neutralino mass
- Example:
  - m($\tilde{l}$) = 260 GeV
  - m($\tilde{\chi}$) = 100 GeV

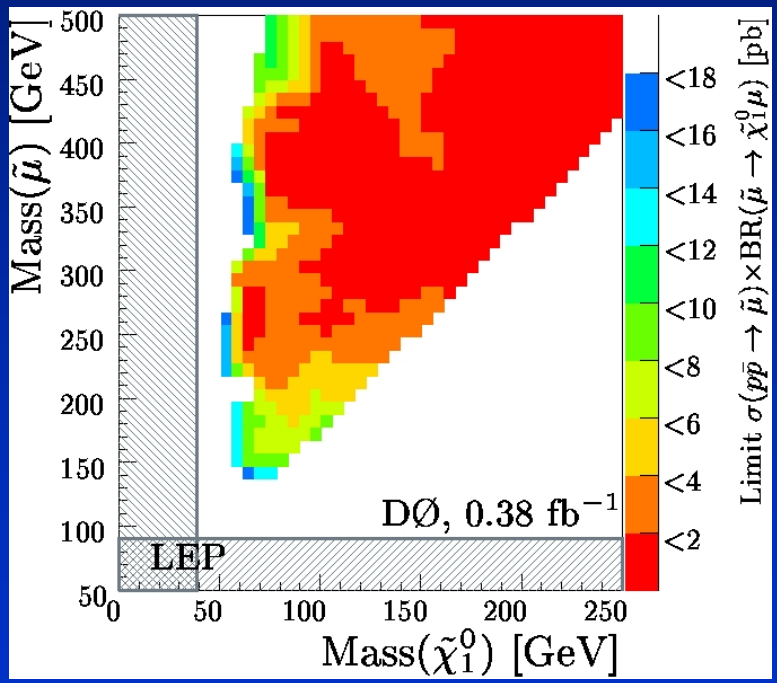
	SM Background	Data
$\tilde{\mu} \to \tilde{\chi}_1^0 \mu$	11.9 ± 2.1 ± 1.6	14
$\tilde{\mu} \to \tilde{\chi}_{2,3,4}^0 \mu$	25.4 ± 3.2 ± 5.4	28
$\tilde{\nu}_\mu \to \tilde{\chi}_{1,2}^\pm \mu$	6.5 ± 1.6 ± 1.6	8

Limits

Phys. Rev. Lett. 97 111801 (2006)

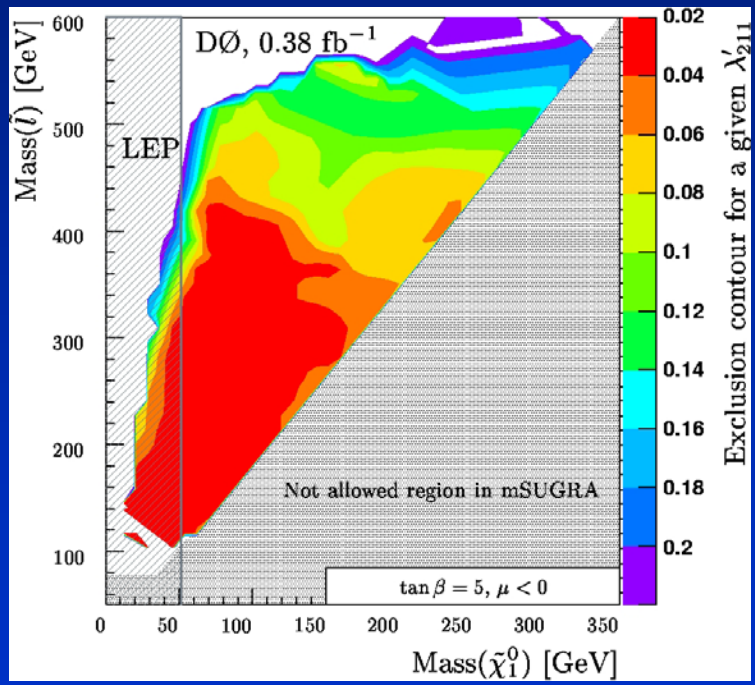
Limits on σ×BR

$\tilde{\mu} \to \tilde{\chi}_1^0 \mu$



Limits on λ'$_{211}$

combined within mSUGRA

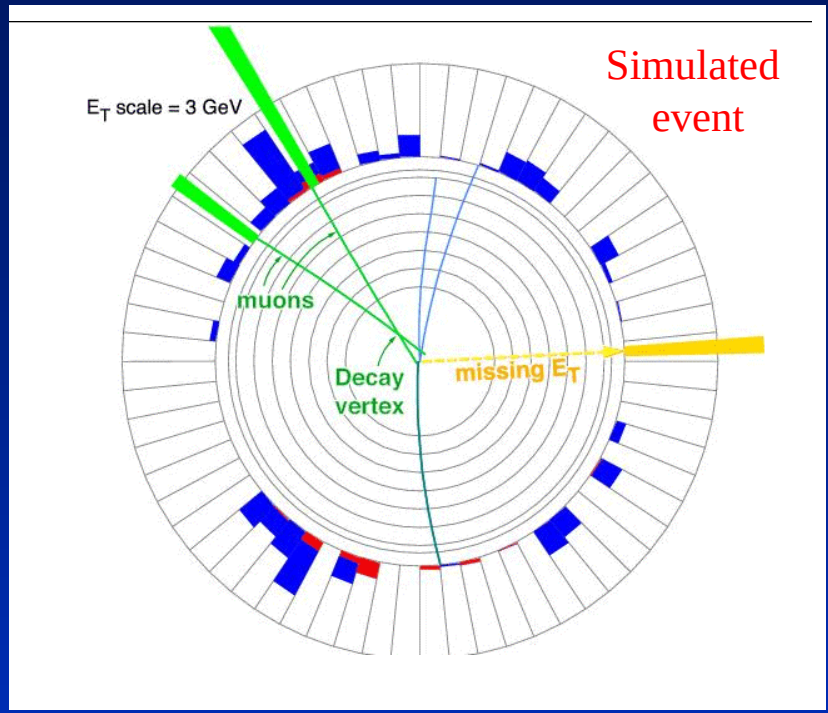


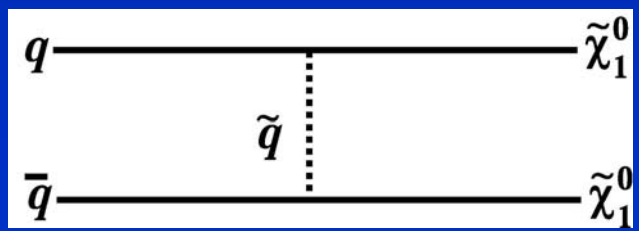
Outline

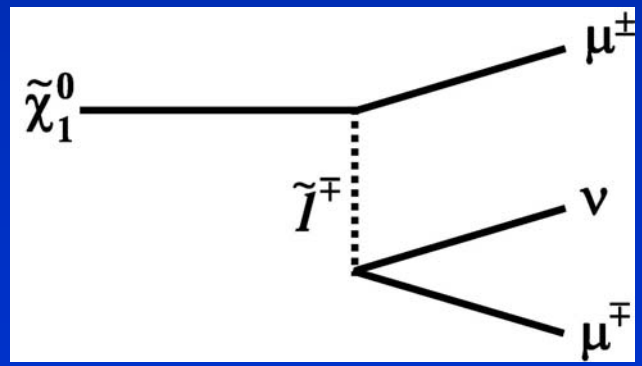
- R-parity violating supersymmetry
- Gaugino searches in trileptons (LLE)
- Resonant slepton production
- Neutral, long-lived particles
- Summary

Search for Neutral, Long-lived Particles

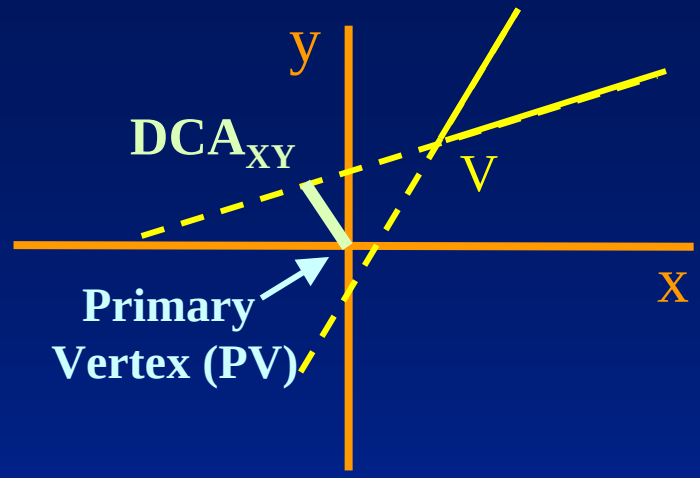
- Search for pair production of two neutral particles
- Look for decay well away from production point
  - two isolated muons p_T>10 GeV
- Sample signal
  - χ_1^0 pair production
  - lifetime depends on λ_{122} and slepton mass







Long Decay Lengths

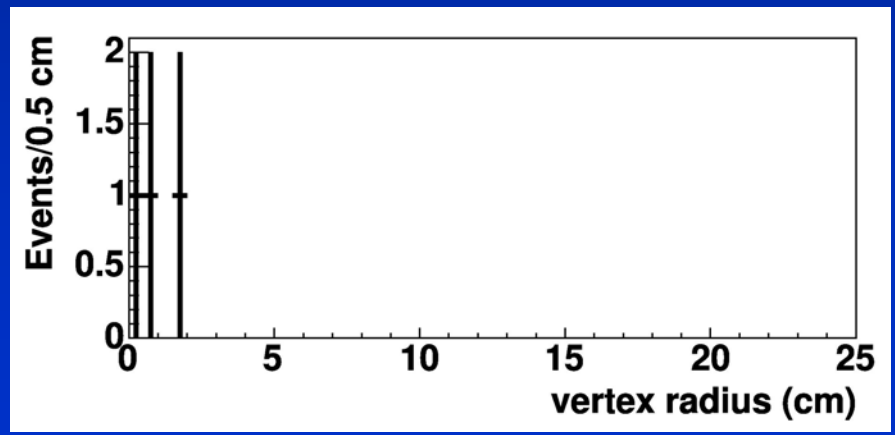


DCA – distance of closest approach
require: $DCA_{X,Y}>0.01$ and $DCA_Z>0.1$ cm

$$radius = \sqrt{(X - X_{PV})^2 + (Y - Y_{PV})^2}$$

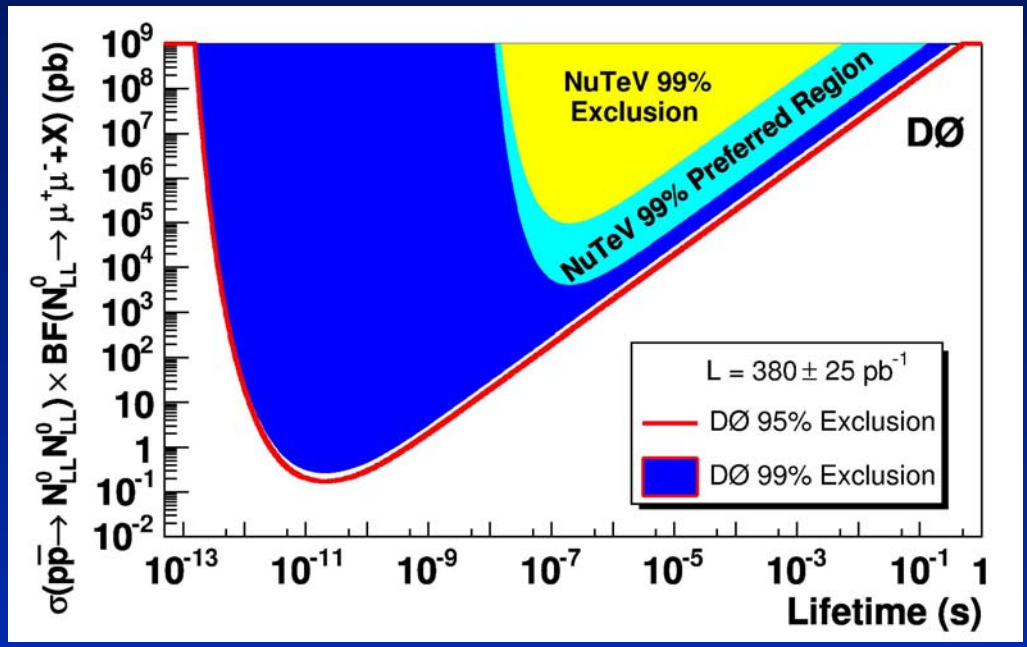
require: 5 < radius < 20 cm

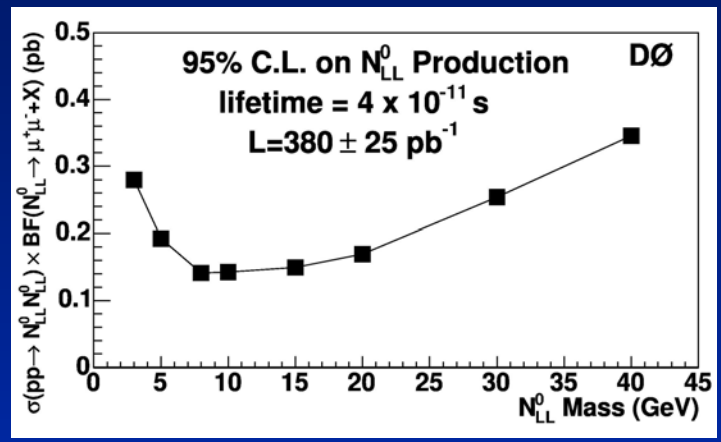
use $K_S \rightarrow \pi\pi$ for efficiency studies
expected background:
0.8 ± 1.1 ± 1.1 events
observed 0 events



Limits on NLLP Production

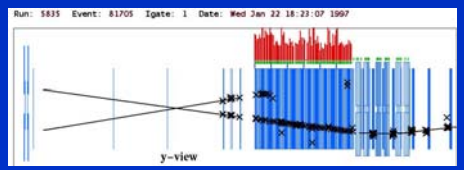
Phys. Rev. Lett. 97 161802 (2006)





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

- DØ has completed several searches for RPV SUSY
  - LLE: trileptons
  - LLQ: resonant sleptons
  - NLLP: long-lived particles
- No excess is observed in the data
- Significantly improved limits are set
- More data is available and on the way
  - Run II still has a lot of discovery potential
    - 4x statistics already available, 16x possible