Search for R-parity Violation at DØ

on behalf of the DØ collaboration

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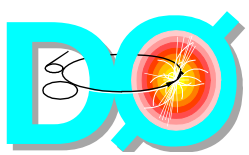


Search for R-parity Violation at DØ

- introduction

  → the TeVatron and the DØ experiment

  → R-parity violation

- pair production + $\not{R}_p$ LSP decay

  → dilepton signal via λ' ✔

  → trilepton signal via λ

- top decays via λ' or λ'' ✔

- sparticle resonant production

  → resonant slepton production ✔

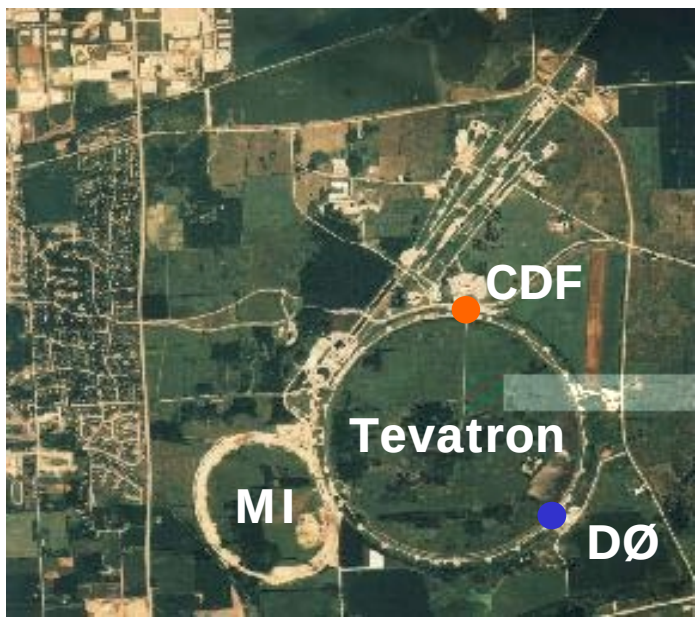
  → resonant stop production ✔

✔ : new results included

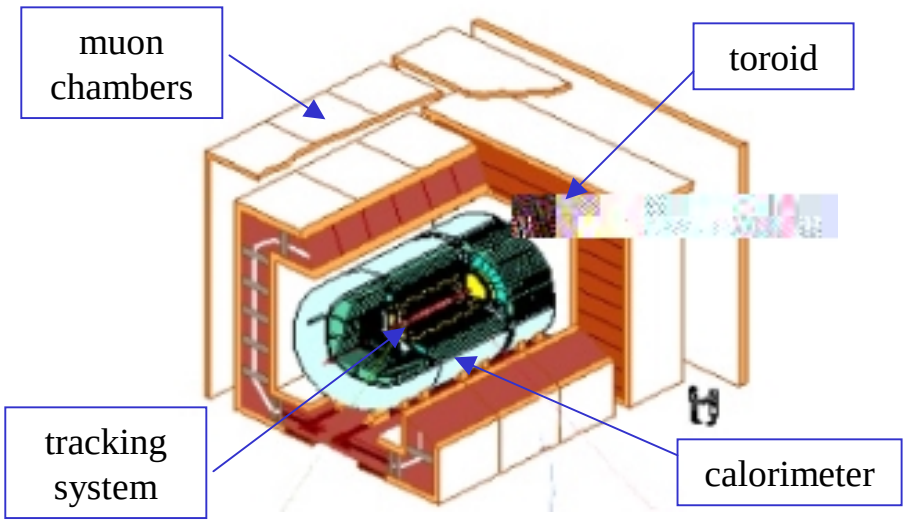
The TeVatron

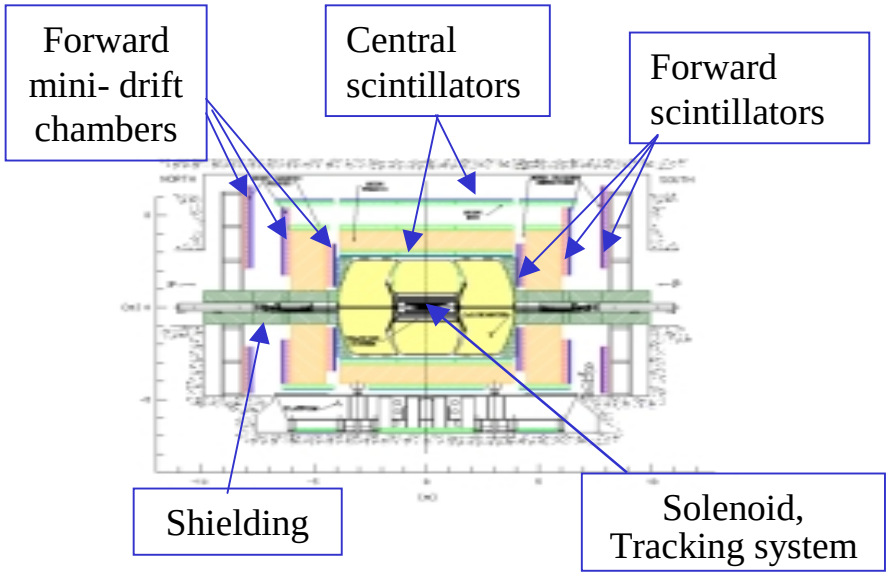
Run	duration	center of mass energy	integrated luminosity
RunI	1992-1996	1.8 TeV	~ 0.13 fb^{-1}
RunIIa	2001-2003	2.TeV	2 fb^{-1}
RunIIb	2004-2007	2.TeV	15 fb^{-1}

- RunII: 2 new accelerators: (3.3 km ring)
  - → Main injector (injector to the TeVatron, $\bar{p}$ production)
  - → recycler ($\bar{p}$ recycling ring)



The DØ Detector





- DØ in Run I:

→ central detector (drift chambers, transition radiation detector)

→ no central magnetic field

- DØ upgrade for Run II:

→ compact and hermetic Ar-U calorimeter

→ new tracking system (Si tracker, fiber tracker)

→ central solenoid

→ preshower

→ new forward muon system

→ muon system with iron toroid

R-parity

- discrete quantum number:

  $R = (-1)^{3B+L+2S}$, B: baryon nb, L: lepton nb, S spin

  $\rightarrow$ R = +1 for SM particle

  $\rightarrow$ R = -1 for SUSY particle

- R parity violation terms compatible with all superpotential symmetries:

$$W_{\not R p} = \underbrace{\lambda_{ijk} L_i L_j E^c_k + \lambda'_{ijk} L_i Q_j D^c_k}_{\not L} + \underbrace{\lambda''_{ijk} U^c_i D^c_j D^c_k}_{\not B}$$

  $\rightarrow$ 45 new Yukawa couplings

  can not be excluded theoretically

R-parity Violation

- experimental consequences of $\not{R}_p$:
  - $\rightarrow$ B and/or L violation
  - $\rightarrow$ LSP can decay with or without displaced vertices
  - $\rightarrow$ sparticles can be produced resonantly
- usual search hypothesis:
  - $\rightarrow$ mSUGRA with $\tilde{\chi}^0_1$ as LSP and $\not{R}_p$
  - $\rightarrow$ similarly to Yukawa couplings hierarchy, only one $\not{R}_p$ coupling dominates
  - $\rightarrow$ if $\not{R}_p$ coupling large enough, resonant production
  - $\rightarrow$ otherwise pair production + $\not{R}_p$ does not affect branching ratios except for LSP decay

Limits on R-parity Violation Couplings

Ledroit, Sajot, GDR-S-008 (98)
Allanach et al., PRD 60 (99) 75014

- indirect limits via low energy processes (assuming a single dominant $\not{R}_p$):
  - → neutrinoless double-beta decay
  - → charged-current universality constraints
  - → e-μ-τ universality
  - → ν_μ-e scattering
  - → A_{FB}
  - → atomic parity violation

2 σ limits
for $\tilde{m}$ = 100GeV
often linear in masses

ijk	λ_{ijk}	ijk	λ'_{ijk}	ijk	λ'_{ijk}	ijk	λ'_{ijk}	ijk	λ''_{ijk}
121	0.05	111	$5.2\ 10^{-4}$	211	0.06	311	0.12	112	10^{-6}
122	0.05	112	0.02	212	0.06	312	0.12	113	10^{-5}
123	0.05	113	0.02	213	0.06	313	0.12	123	1.25^{*}
131	0.062	121	0.04	221	0.18	321	0.52	212	1.25^{*}
132	0.062	122	0.04	222	0.18	322	0.52	213	1.25^{*}
133	0.006	123	0.04	223	0.18	323	0.52	223	1.25^{*}
231	0.07	131	0.02	231	0.18	331	0.45	312	0.50
232	0.07	132	0.28	232	0.45	332	0.45	313	0.50
233	0.07	133	$1.4\ 10^{-3}$	233	0.15	333	0.45	323	0.50

Pair Production: Dielectron Channel

DØ, PRL 83 (99) 4476

- All pair production processes considered
- dominant coupling: one of the six λ'_{1jk} (j=1,2; k=1,2,3)

$\rightarrow$ LSP decay to 1 electron and 2 jets (close to its production)

- channel: $\geq$ 2 electrons + $\geq$ 4 jets

  Offline cuts: $E_t^{el} \geq 15, 10$ GeV, $E_t^{jets} \geq 15$ GeV, Mee $\not\in$ 76-106 GeV

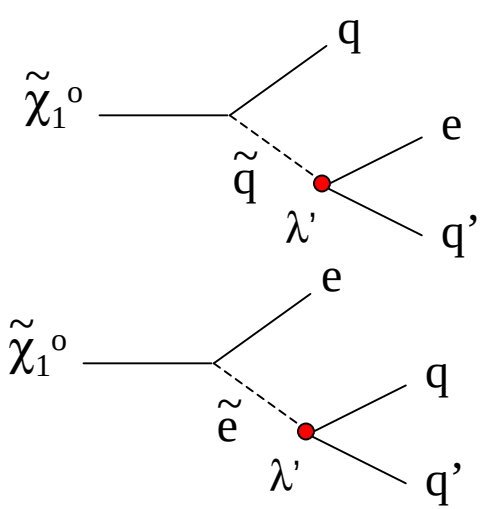
- background: Drell Yan, $t\bar{t}$, $Z \rightarrow \tau\tau \rightarrow ee+...$, misidentification of jets as electrons

Run I Results:

$L_{int} = 99 \pm 4.4$ pb^{-1}

Events observed: 2

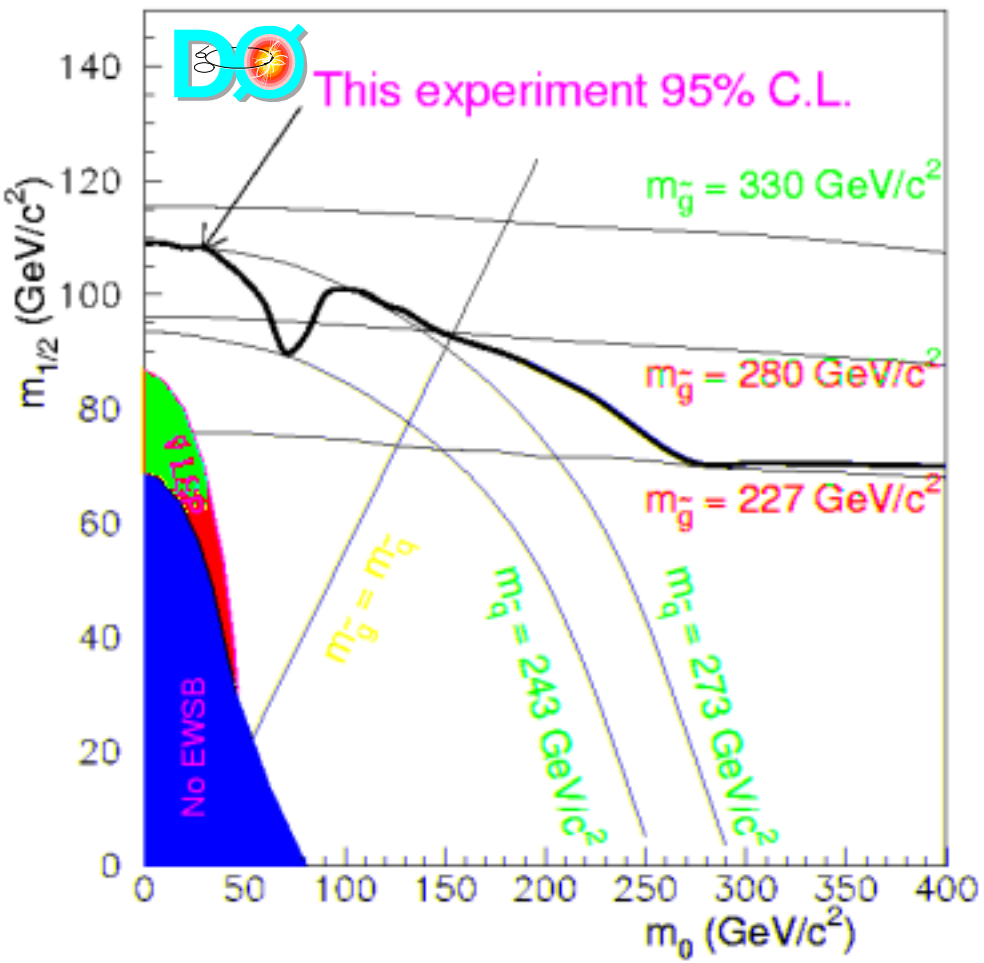
Expected Bkg: $1.8 \pm 0.2 \pm 0.3$



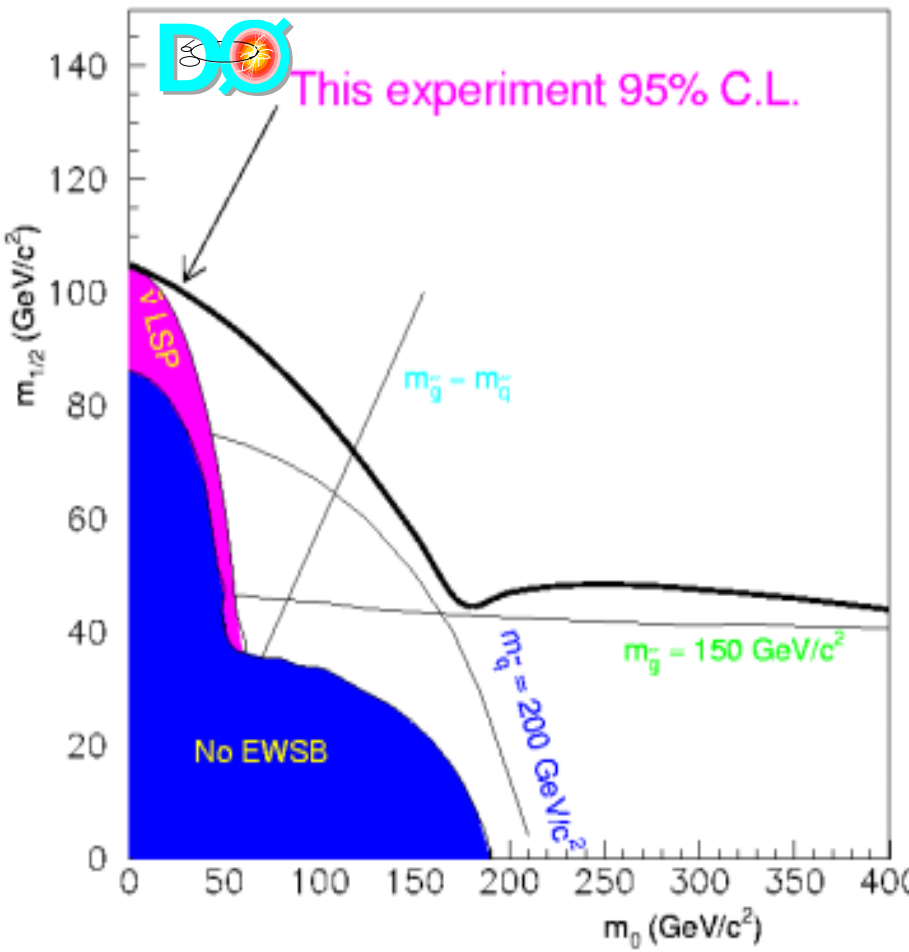
λ'_{1jk}: Dielectron Channel in Run I

Validity: $\lambda'_{1jk} \gtrsim 10^{-3}$

$A_0=0$, $\mu<0$, $\tan\beta = 2$

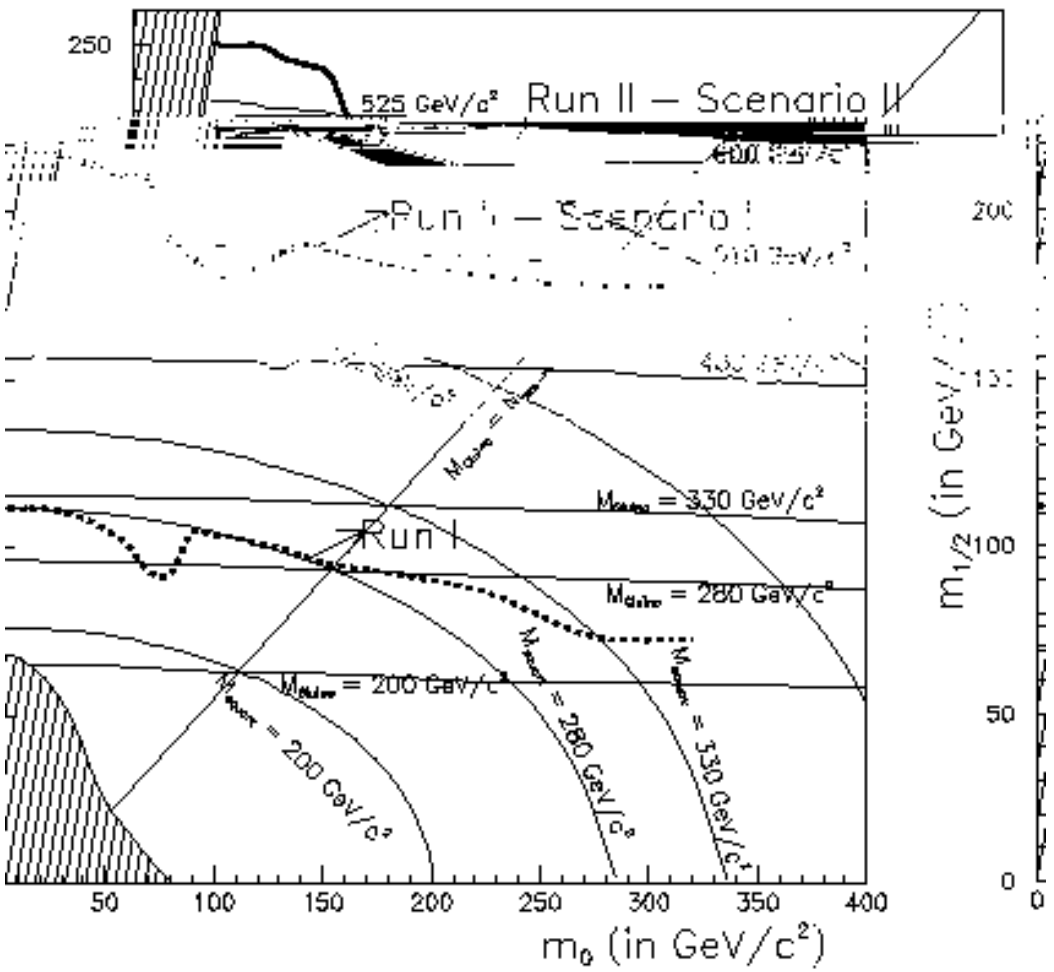


$A_0=0$, $\mu<0$, $\tan\beta = 6$



Dielectron Channel in Run II

$A_0=0$, $\mu<0$, $\tan\beta = 2$



L_{int}= 2 fb^{-1}, $\sqrt{s}$=2 TeV

Scenario I: extrapolation from RunI

Scenario II: electrons misidentification reduced by a factor 2 due to central magnetic field

$M\tilde{g} \rightarrow 500$ GeV

$M\tilde{q} \rightarrow 400$ GeV

Pair Production: Dimuon Channel

DØ, preliminary

- All pair production processes considered
- dominant coupling:

  → same analysis as previously with a dominant λ'_{2jk}
- channel: ≥ 2 muons + ≥ 4 jets

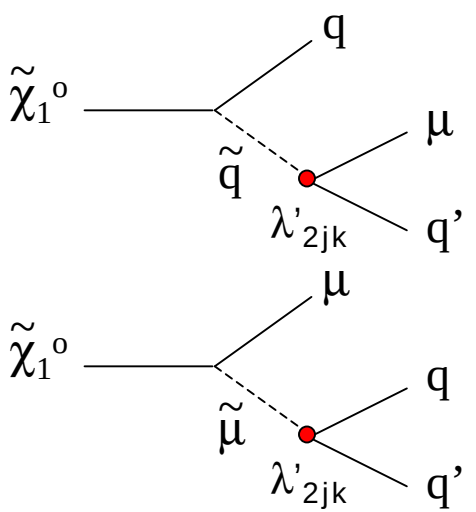
  Offline cuts: $p_t^{\mu} \geq 15, 10$ GeV, $E_t^{jets} \geq 15$ GeV, $H_t > 150$ GeV, $M_{\mu\mu} > 5$ GeV, Acoplanarity > 0.03
- background: Drell Yan, $t\bar{t}$, $Z \to \mu\mu$+jets, $Z \to \tau\tau \to \mu\mu$, $WW \to \mu\mu$

Run I Results:

$L_{int} = 77.5 \pm 4$ pb^{-1}

Events observed: 0

Expected Bkg: $0.18 \pm 0.031 \pm 0.02$

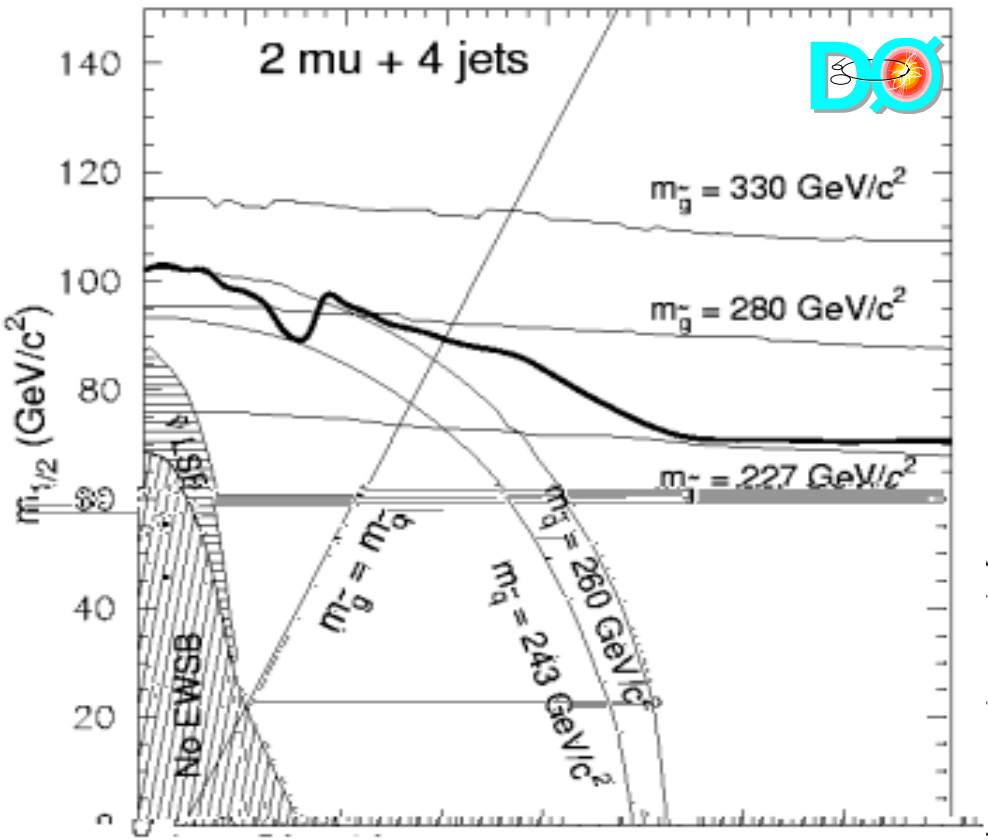


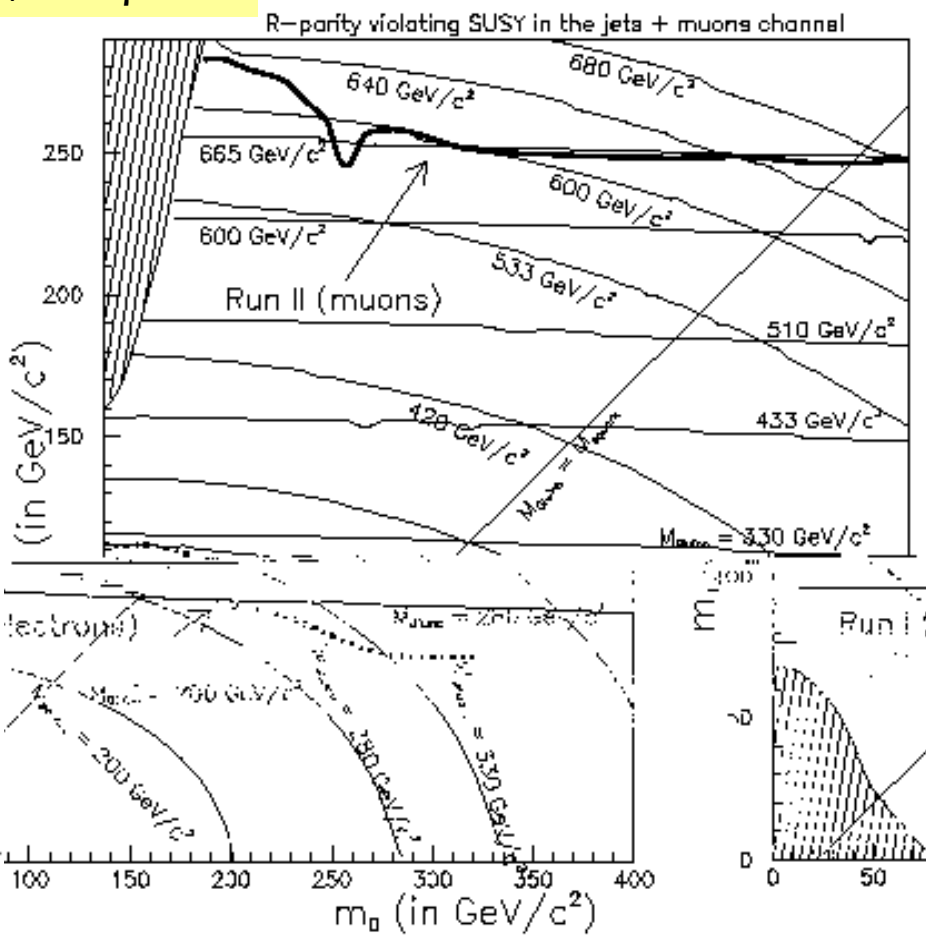
λ'_{2jk}: Dimuon Channel

Run I

Run II, 2 fb^{-1}

$A_0=0$, $\mu< 0$, $\tan\beta = 2$





Pair Production: Multilepton Channel

DØ, PRD 62 (00) 071701

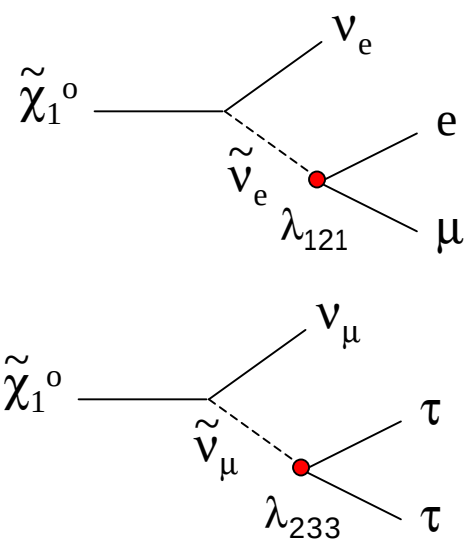
- dominant coupling: λ_{121} ,λ_{122} or λ_{233}

$\rightarrow$ LSP decay to 2 charged leptons and a neutrino

- channel: reinterpretation of search for $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^{0}$ production

  4 different final states: $\geq$ eee, $\geq$ eeμ, $\geq$ e$\mu\mu$, $\geq \mu\mu\mu$ + $\not\!\!E_t$

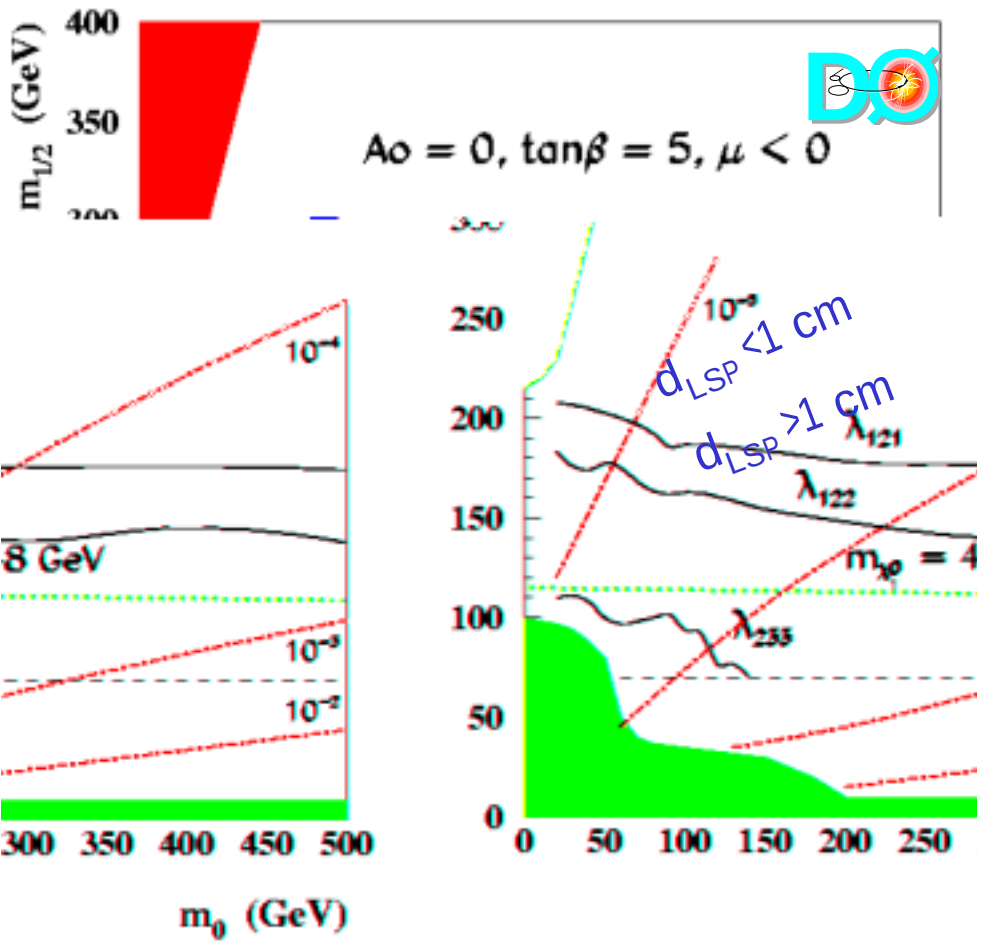
- background: Drell Yan, $t\bar{t}$, $Z\rightarrow\tau\tau\rightarrow$ee+..., misidentification of jets as electrons

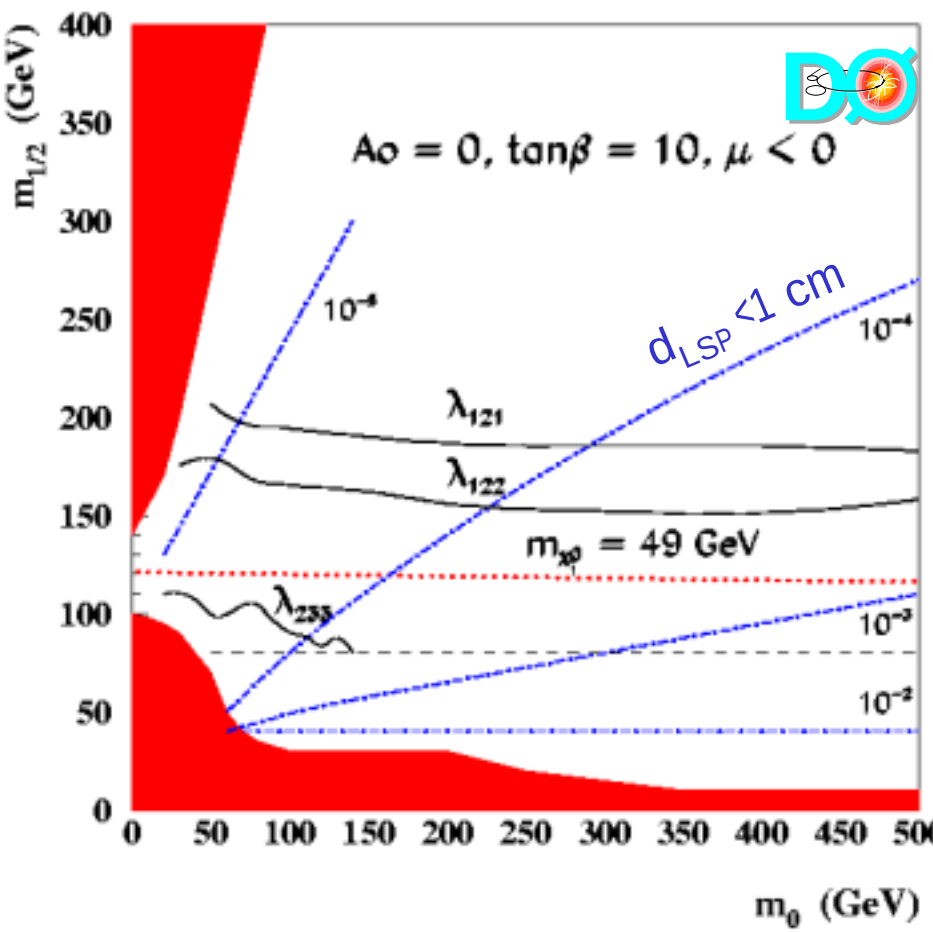


Run I Results:

	eee	eeμ	e$\mu\mu$	$\mu\mu\mu$
L_{int}	97.8 $\pm$5.2	97.8 $\pm$5.2	93.1 $\pm$4.9	78.3 $\pm$4.1
Obs evts	0	0	0	0
Bkg	0.34 $\pm$0.07	0.61 $\pm$0.36	0.11 $\pm$0.04	0.20 $\pm$0.04

λ_{ijk}: Multilepton Channel in Run I





Top Decay via $\not{R}_p$

- dominant coupling: λ''_{331}

  $p\bar{p} \rightarrow t\bar{t}$ with one $t \rightarrow bd\tilde{\chi}^0_1$ ($\tilde{\chi}^0_1$ decays outside the

Top Decay via $R\!\!\!/_p$

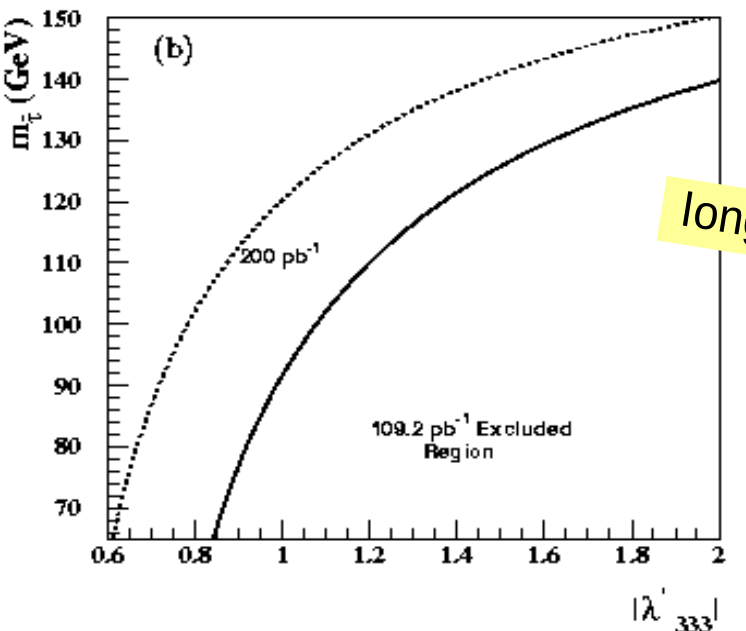
Han et al., PLB 476 (00) 79

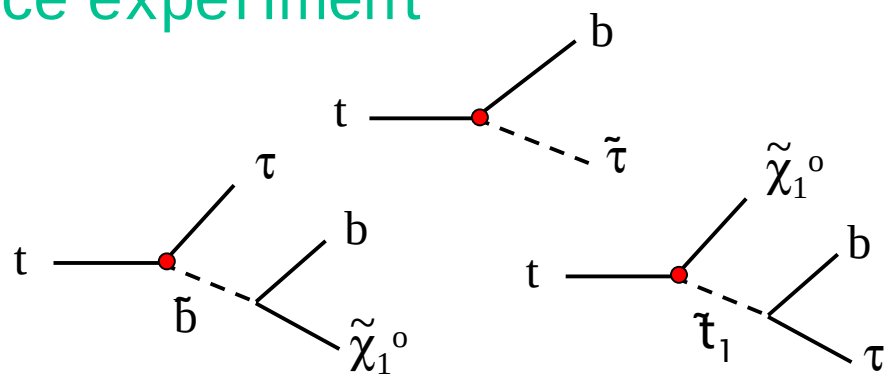
- dominant coupling: λ'_{333}

  $p\bar{p} \rightarrow t\bar{t}$ with one $t \rightarrow \tau b \tilde{\chi}^0_1$ ($\tilde{\chi}^0_1$ decays in or outside the detector)

- channel: same signal as $H^+ \rightarrow \tau b \nu$: detection optimized for SM $t\bar{t}$ analysis $\Rightarrow$ disappearance experiment

- background: $t\bar{t}$, W+jets





long lived LSP

Run I: for $M_{\tilde{\tau}}$ = 70 GeV,

$\lambda'_{333} < 0.94$ at 95 % CL

Indirect 2 σ limit for $\tilde{m}$ = 100 GeV: $\lambda'_{333} = 0.45$

Run II: (2 fb^{-1}): $\lambda'_{333} < 0.38$

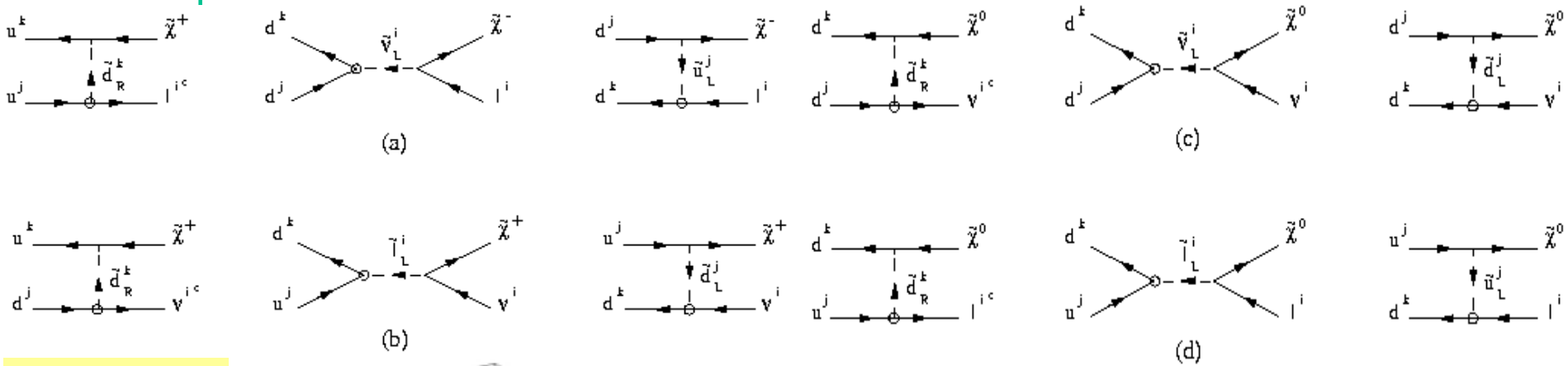
Resonant Production

- at hadronic colliders, resonant production via λ' or λ''
  - $\rightarrow$ via λ': resonant slepton production ($\tilde{\mu}$,$\tilde{\nu}$)
  - $\rightarrow$ via λ'': resonant squark production ($\tilde{t}$)
- generally assumed that those sparticles decay via R_p conserved couplings
- cascade to LSP which decays into the detector or outside the detector depending on the dominant coupling considered

Resonant Slepton Production

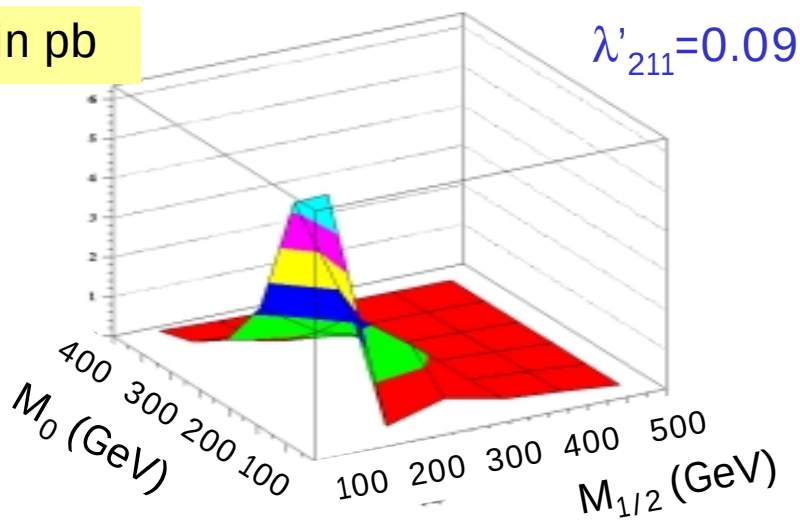
Déliot et al., EPJ C 19 (01) 155

- dominant coupling: λ'
  - → chargino or neutralino singly produced
  - → 4 possible channels:

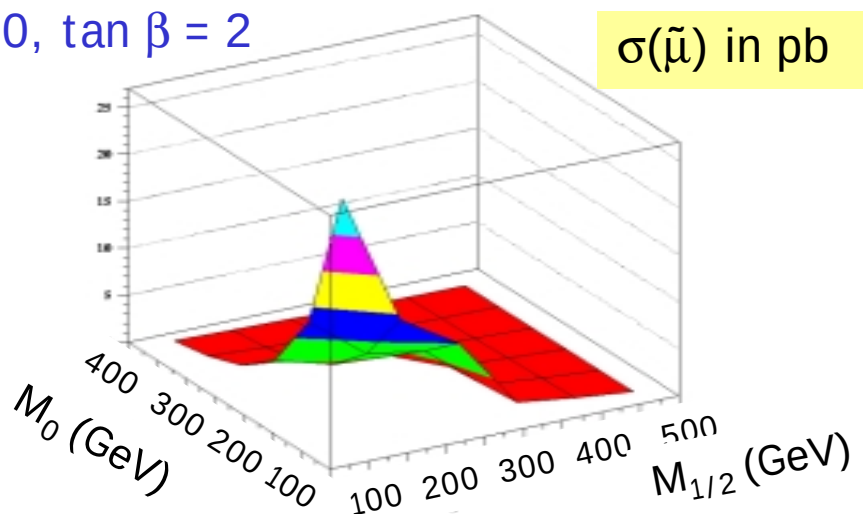


$\sigma(\tilde{\nu})$ in pb

λ'_{211}=0.09, μ< 0, tan β = 2



$\sigma(\tilde{\mu})$ in pb



Resonant Production: Dimuon Channel

DØ, preliminary

- dominant coupling: λ'_{211}

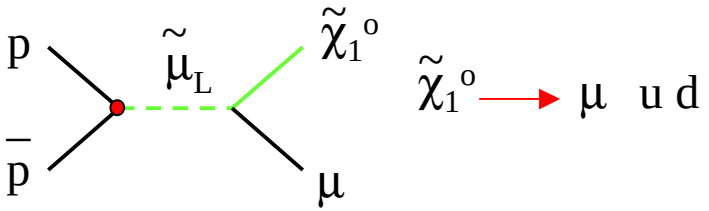
  $\rightarrow$ resonant $\tilde{\mu}$ or $\tilde{\nu}_\mu$ production

- channel: $\geq$ 2 muons + $\geq$ 2 jets

  Offline cuts: $p_t^{\mu} \geq 20$ GeV, $E_t^{jets} \geq 20$ GeV,

  $H_t > 50$ GeV, $\Delta R_{\mu j} > 0.5$

- background: $t\bar{t}$, Z+2jets, WW+jets

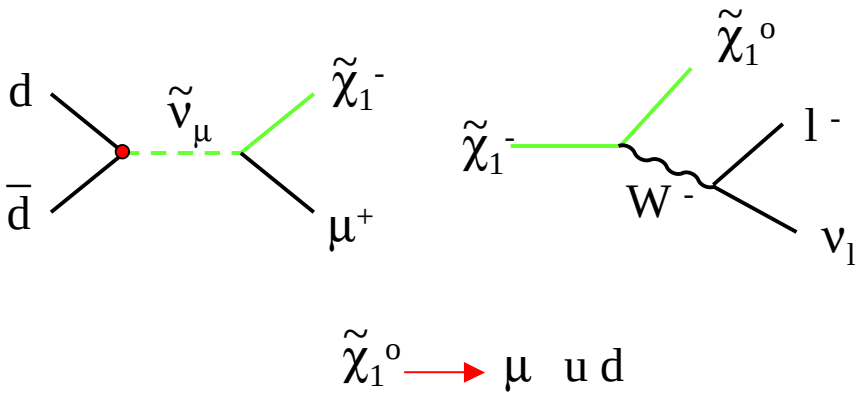


Run I Results:

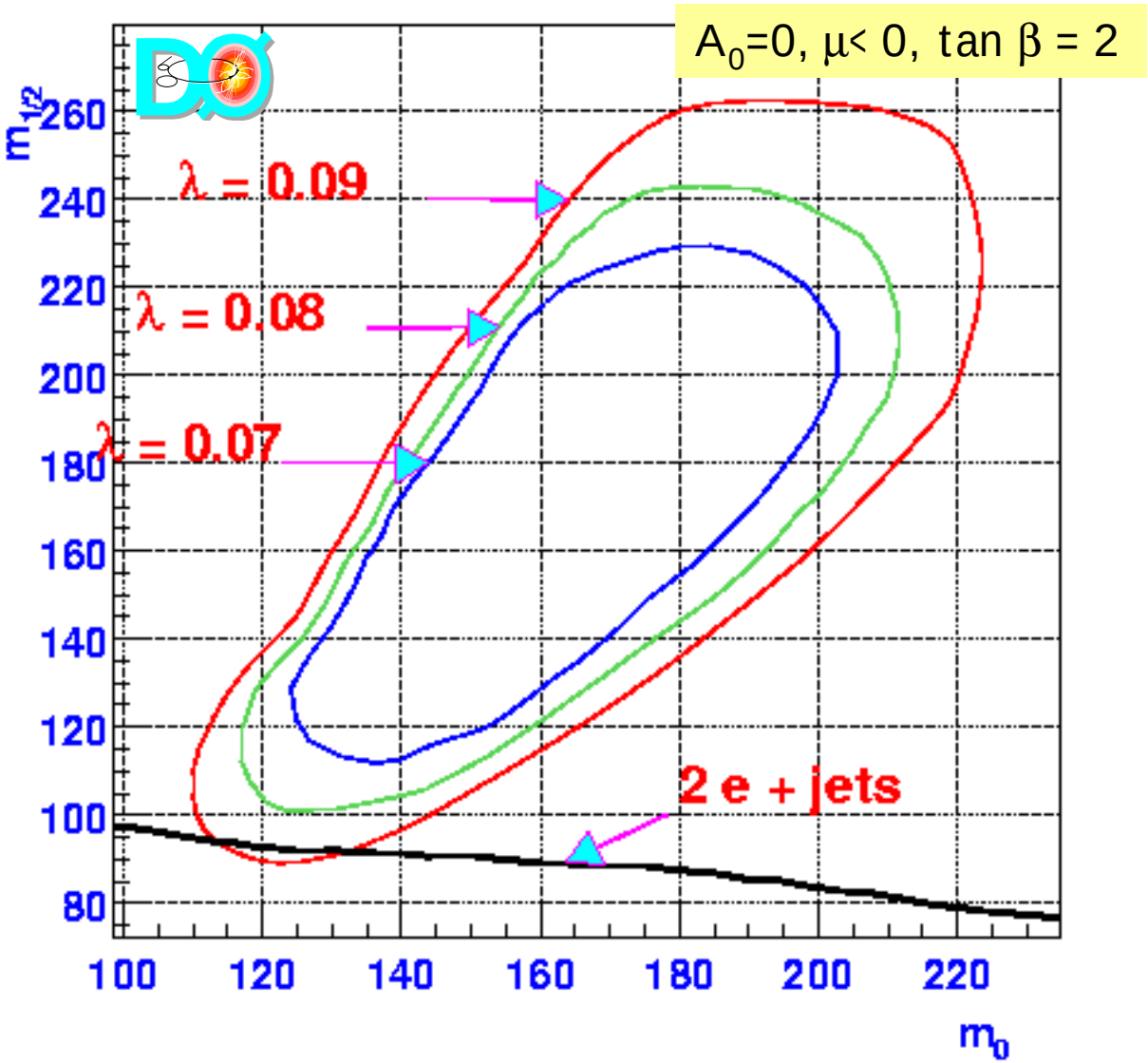
$L_{int} = 94 \pm 5\ pb^{-1}$

Events observed: 5

Expected Bkg: 5.34 ± 0.07



Resonant λ'_{211} : Dimuon Channel in Run I



$\sqrt{s}$=1.8 TeV

Exclusion contours at 95% CL down to λ'_{211} =0.07

and $m_0 \rightarrow$ 200 GeV
$m_{1/2} \rightarrow$ 220 GeV

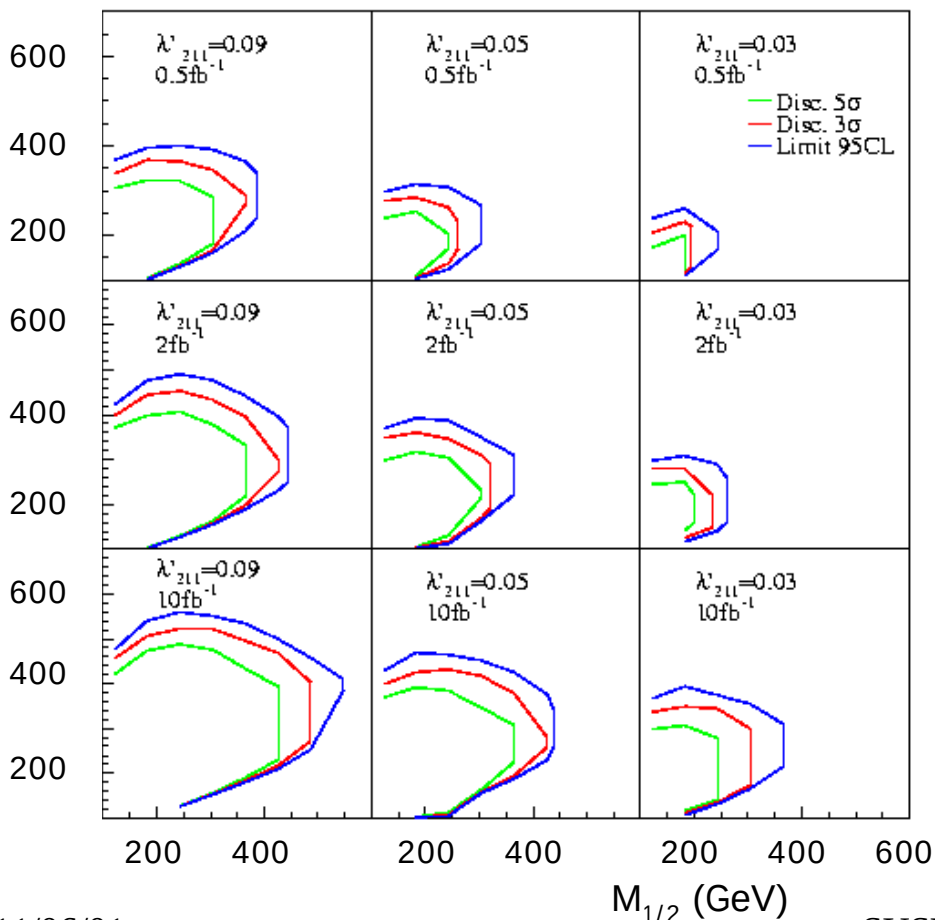
Indirect 2 σ limit for $\tilde{m}$ = 100 GeV:
λ'_{211} =0.06

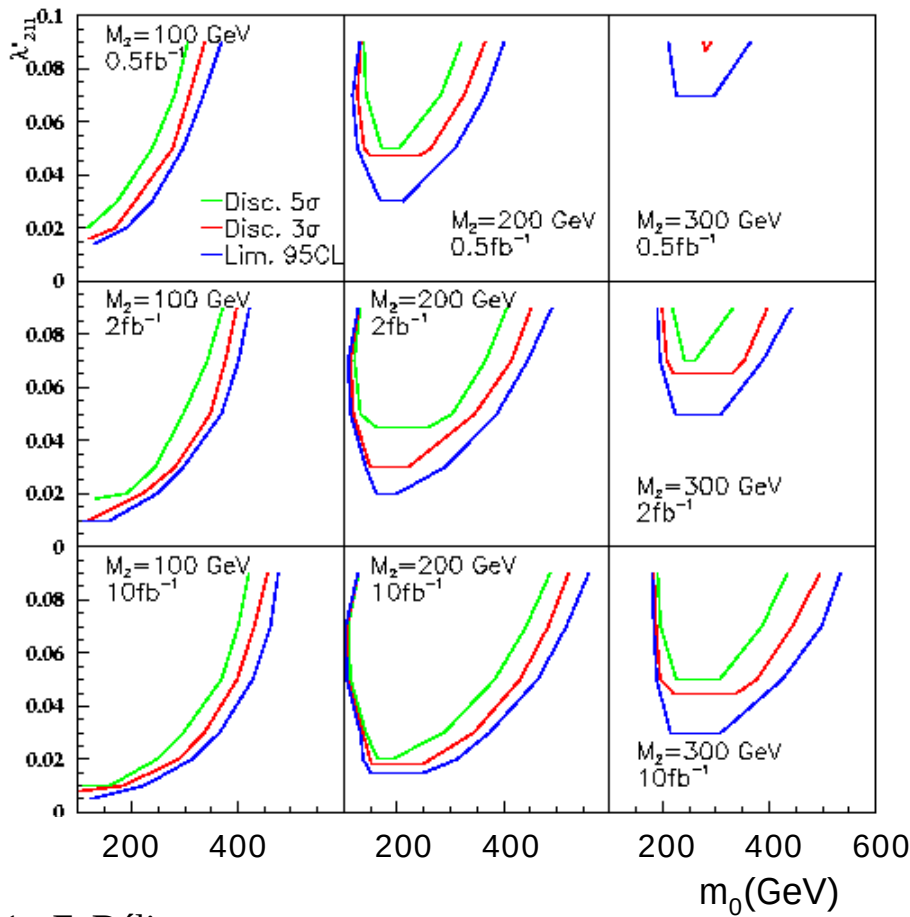
Resonant λ'_{211} in RunII: Trilepton Channel

Déliot et al., EPJ C 19 (01) 155

search for trilepton channel via resonant sneutrino production

$\sqrt{s}$=2 TeV, A_0=0, μ< 0, tan β = 1.5



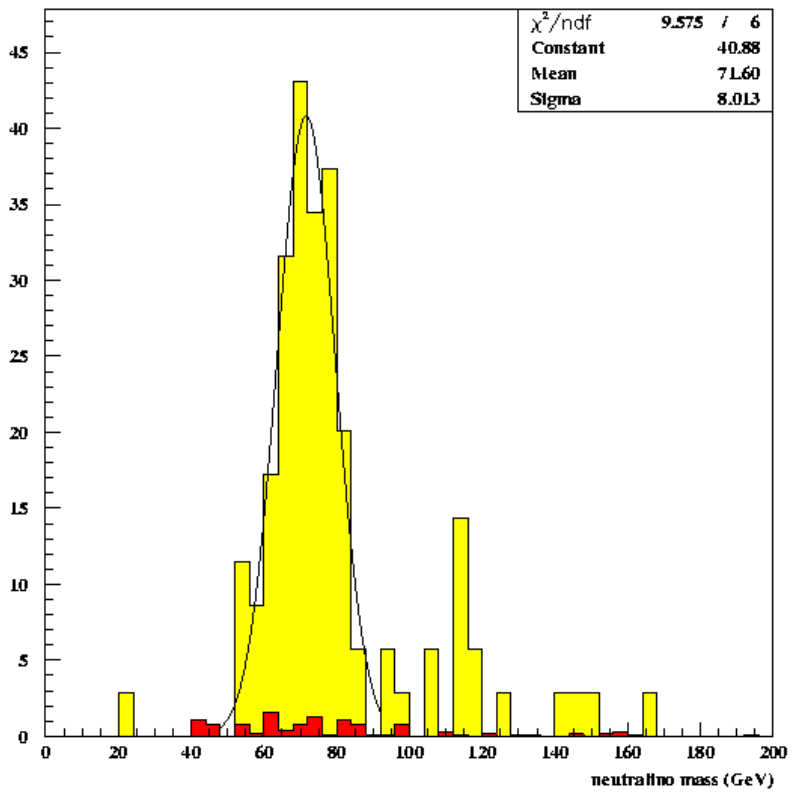


Run II Trilepton Channel: Mass Reconstruction

- allow mass reconstructions:
  - → simulation: $M\tilde{\chi}^0_1$=77.7 GeV, $M\tilde{\chi}^+_1$=158.3 GeV, $M\tilde{\nu}$=236 GeV
  - → 2 jets and softer muon: $M\tilde{\chi}^0_1$=71 GeV (±9)

$L_{int} = 10 fb^{-1}$

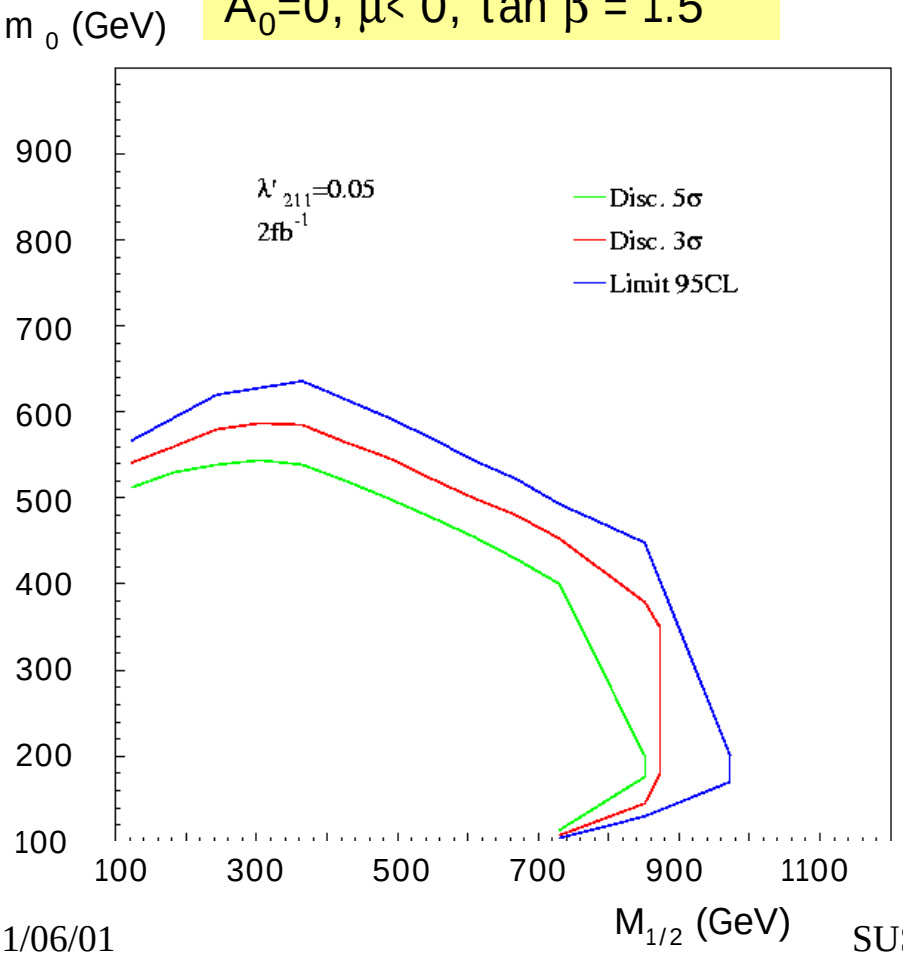
$\lambda'_{211} = 0.09$



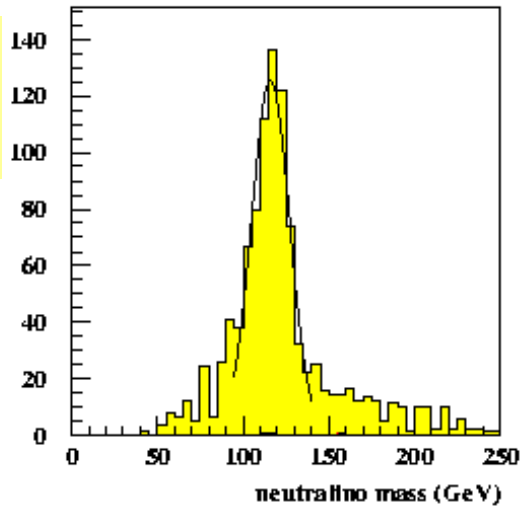
Resonant λ'_{211} in Run II: Dimuon Channel

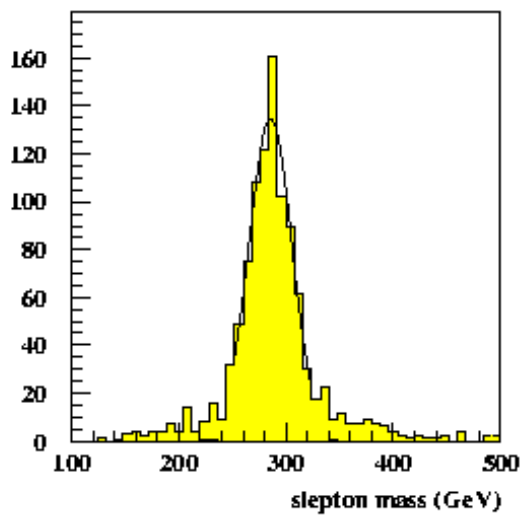
search for dimuon channel via resonant smuon production

$L_{int} = 2fb^{-1}$, $\lambda'_{211}=0.05$
$A_0=0$, $\mu< 0$, $\tan\beta = 1.5$



$L_{int} = 10fb^{-1}$
$\lambda'_{211}=0.05$





Resonant Squark Production

Berger et al., PRD 63 (01) 115001

- dominant coupling: λ''_{3jk}

  $\rightarrow$ resonant stop production, decay to: b $\tilde{\chi}^+_1$ and $\tilde{\chi}^0_1$ decays outside the detector

- channel: 1 b-tagged jet, 1 e or 1 μ + $\not{E}_t$

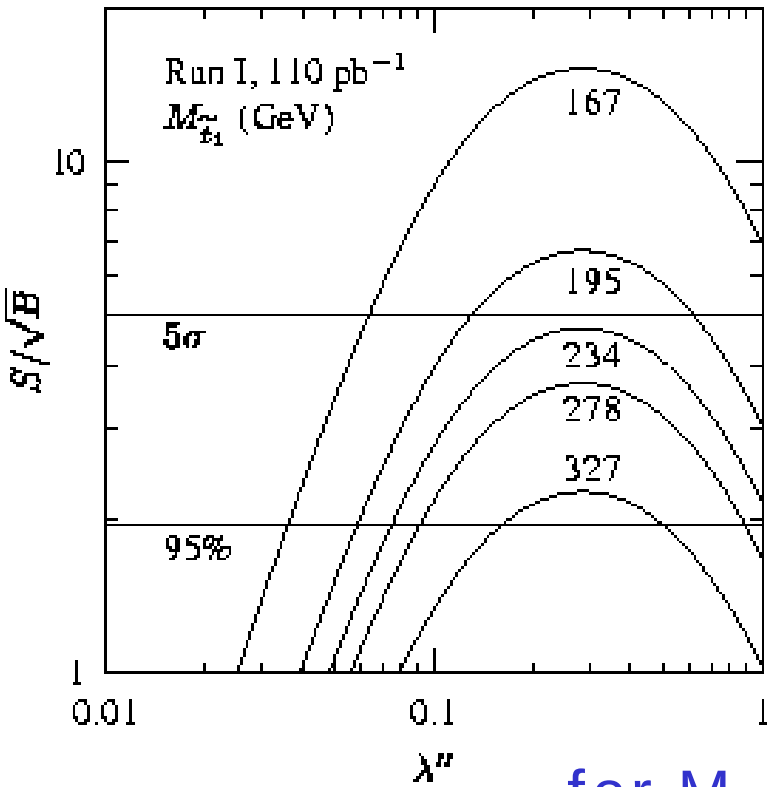
  Detector simulation: SHW (approximation of CDF/DØ)

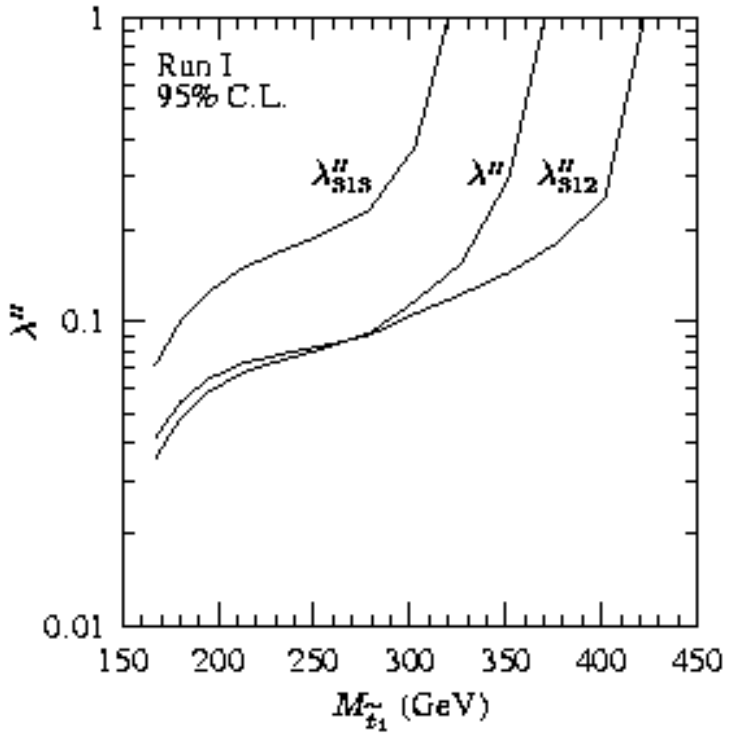
  Cuts: $E_t^b \geq 40$ GeV, $E_t^{lept} \geq 20$ GeV, veto: $E_t^{lept} \geq 45$ GeV, $E_t^{jets} \geq 30$ GeV

- background: Wc, Wj with c or j that mimics a b, $Wb\bar{b}$, $Wc\bar{c}$, single top via Wg

Resonant λ''_{3jk} in Run I

$\sqrt{s}$=1.8 TeV, L_{int} = 110pb^{-1}





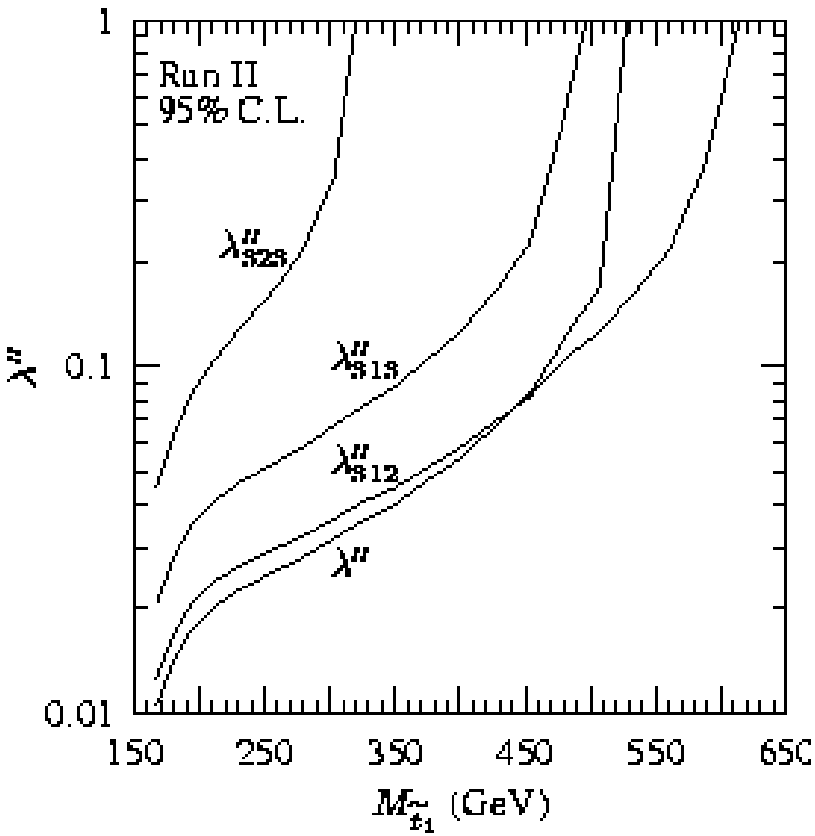
for $M_{\tilde{t}}$ = 255 GeV,

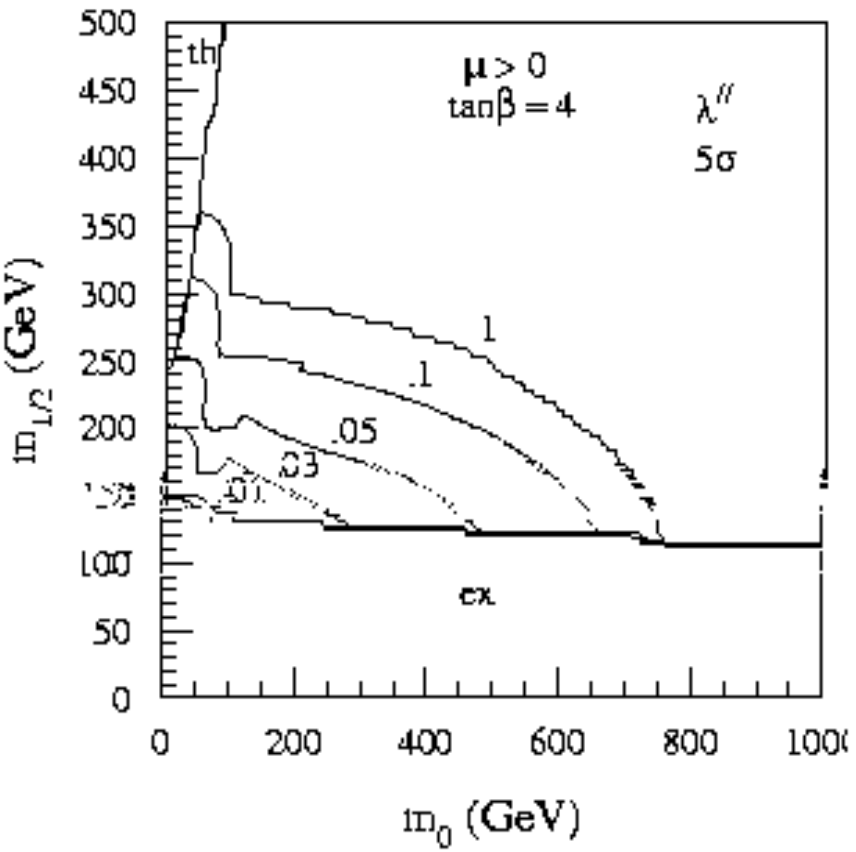
$\lambda''_{312} < 0.08$ at 95 % CL

Indirect 2 σ limit for $\tilde{m}$ = 100 GeV: λ''_{312} =0.50

Resonant λ''_{3jk} in Run I I

$\sqrt{s}$=2 TeV, L_{int} = 2 fb^{-1}





Conclusion

- DØ searches for R-parity violation in Run I:

  $\rightarrow$ large number of $\not{R}_p$ couplings explored

  $\Rightarrow$ No sign of $\not{R}_p$ SUSY found

- DØ Run II will provide a wide range of improved coupling limits and a great discovery potential:

  $\rightarrow \geq 20 \times$ more luminosity (2003)

  $\rightarrow$ 10% more energy

  $\rightarrow$ improved detectors

  $\Rightarrow$ large increase on $\not{R}_p$ coupling and mass sensitivity