D0 SUSY Searches At The TEVATRON Run II

OUTLINE

I. Introduction

II. Gravity Mediated SUSY X

A. RPC Analyses:

- Chargino+Neutralino → trileptons+mET
- Stop Pairs → dileptons+2b+mET
- Stop Pairs → 2c+mET
- Top/Stop Pairs → lepton+jets+mET
- Squark/Gluino Pairs → jets+mET
- Squark/Gluino Pairs → tau(s)+jets+mET

B. RPV Analysis:

- Sneutrino+X → e+mu+X'

III. Gauge Mediated SUSY X

- Chargino/Neutralino Pairs → 2γ+mET
- LL Neutralino Pair → 2e(2γ)+X

IV. Conclusions & Prospects

- Int. $\mathcal{L} > 1$ fb^{-1} of data
- All limits @ 95% CL

I. Introduction

Instrumental Context: p+pbar collisions @ 1.96 TeV

Run IIa (2001-06):

- **delivered / stored / analysed**
  1.6 / 1.4 / 1.1 fb^{-1}
- **Peak Inst. $\mathcal{L}$: [$3x10^{31}$,$2x10^{32}$] $cm^{-2}s^{-1}$**

Upgrades (2006):

- **TEVATRON**
- **D0 Detector:**
  - **Silicon Tracker: « Layer 0 »**
  - **Trigger: L1 Calo**

Run IIb (2006-09/10):

- **delivered / stored / analysed (incl)**
  4.6 / 4.0 / 2.7 fb^{-1}
- **Peak Inst. $\mathcal{L}$: $3x10^{32}$ $cm^{-2}s^{-1}$**
- **Current DAQ ε: ~90%**

II. Gravity Mediated SUSY X

- SUSY X in the hidden sector
- Transmitted to the visible sector by gravity
- LSP:
  - lightest neutralino $\tilde{\chi}_1^0$ (or $\tilde{\nu}$)

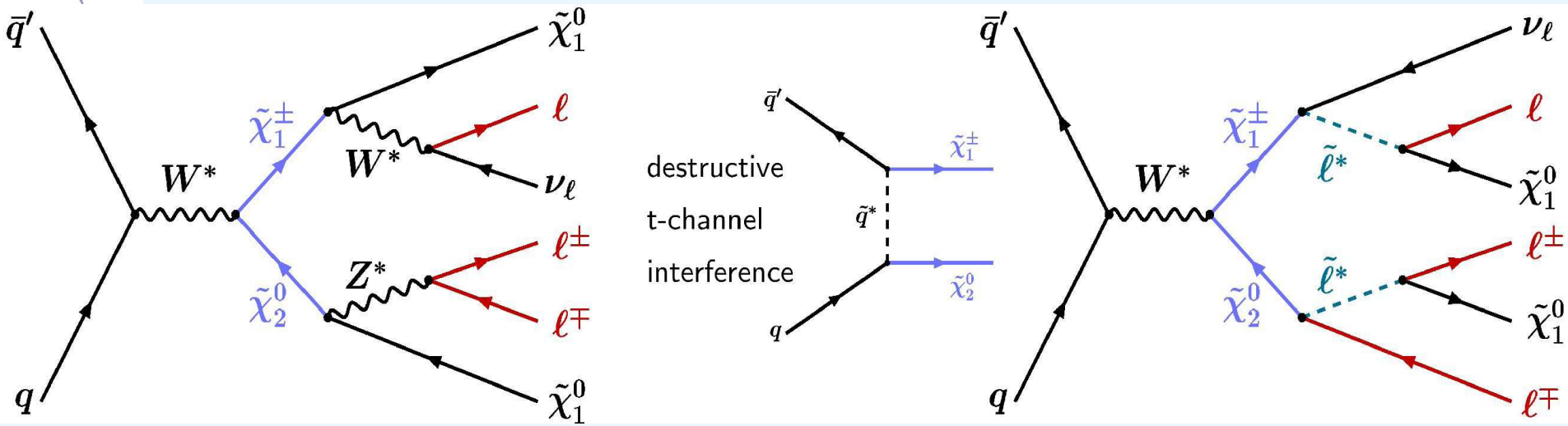
- R-parity: $R_P = (-1)^{L+2S+3B}$
  - RPC => generic mE_T signature (CDM)
  - RPV => not so

RPC Searches

1. Chargino/Neutralino Pairs
2. Top Squarks
3. Squarks/Gluinos Pairs

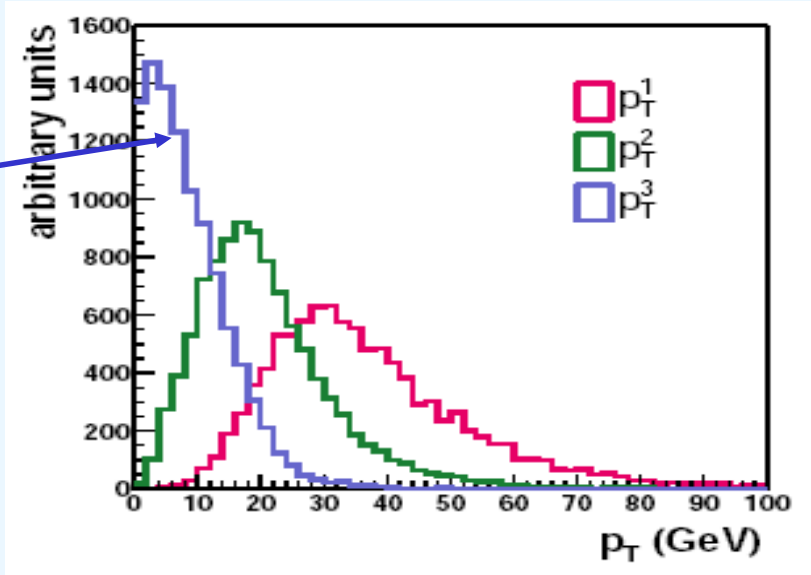
1. $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \rightarrow 3\ell^{\pm} + \not{E}_T$

Production & Decay



3l+mET:

- Low SM bkgd
- BUT: small σ & soft leptons



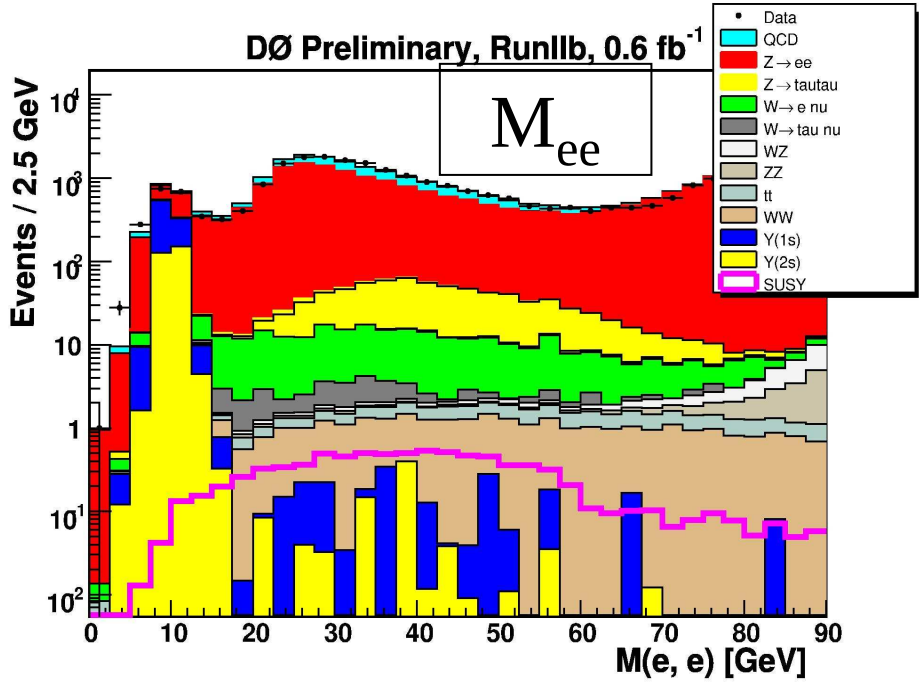
This Analysis Update:

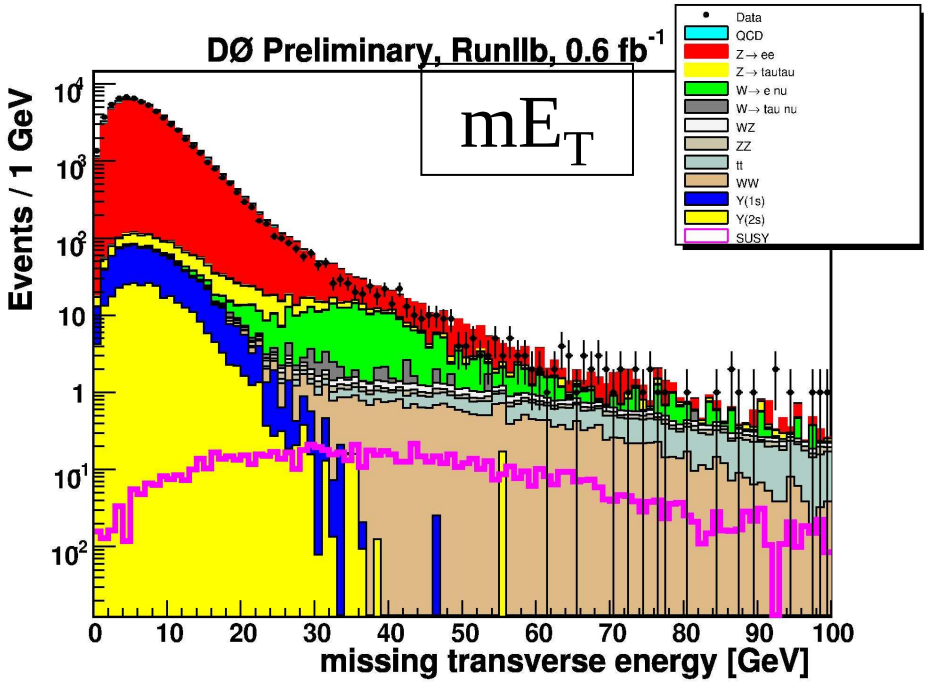
- Search Topology: e^+e^-+track
- Data samples: 0.59 fb^{-1} from Run IIb

1. $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \rightarrow 3\ell^{\pm} + \not{E}_T$

Events Selection

- Trigger: single e, di-e, e+track
- Offline:
  - 2 isolated electrons w/ track match
  - 1 isolated track
  - mE_T
  - Vetos: Z, jets,…



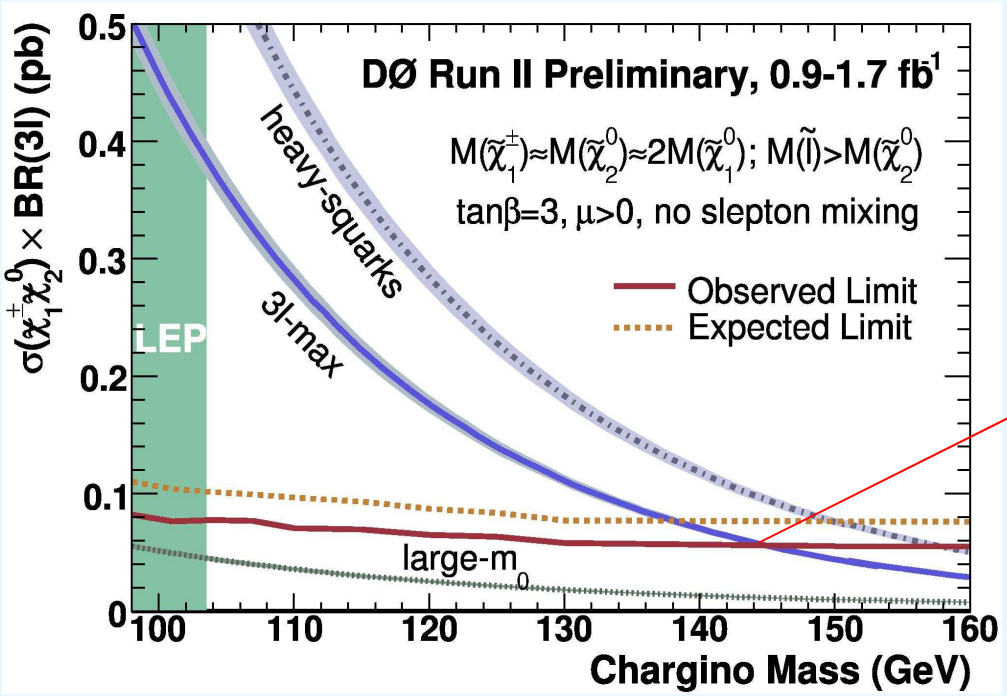


1. $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0 \rightarrow 3\ell^{\pm} + \not{E}_T$

Cut	Data	Sum BG	$Z/\gamma^* \rightarrow ee$	$W \rightarrow e\nu$	$Z/\gamma^* \rightarrow \tau\tau$	WW/WZ	WZ	QCD multijet	$t\bar{t} \rightarrow ee$
(1) Presel	64877	65393 ± 104	59350	274	558	71	38	4157	22
(2) Anti-Z	5577	6566 ± 36	5714	61	115	14	2.4	1222	5.9
(3) Isolated Track	182	208 ± 7	173	0.01	4.7	0.26	0.60	29	0.08
(4) $\not{E}_T$ related	1	1.5 ± 0.4	0.78	0.01	0.14	0.11	0.33	0.08	0.06
(5) Tr$\times\not{E}_T$	0	1.0 ± 0.3	0.59	0.0	0.14	0.06	0.21	0.01	0.03

- Result: **0 (obs) for 1.0+/-0.3 (exp)** $\int \mathcal{L}dt = 0.59\ fb^{-1}$

combination w/ previous 1 fb^{-1} Run IIa analyses $\int \mathcal{L}dt = 0.9 - 1.7\ fb^{-1}$

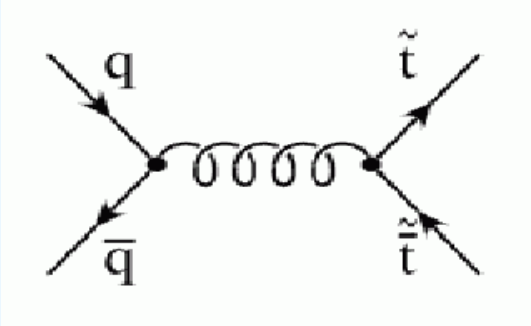


$m_{\tilde{\chi}_1^{\pm}} > 145$ GeV

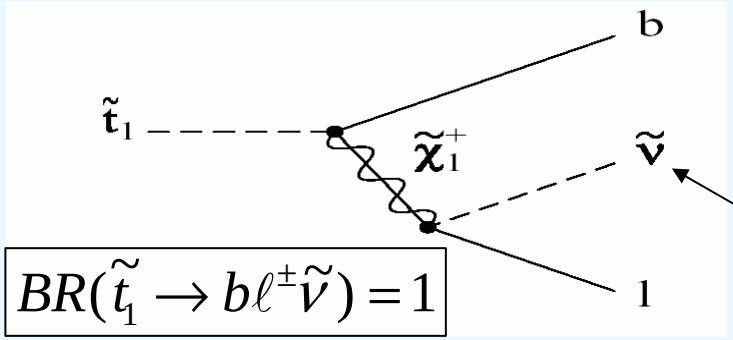
2. $\tilde{t}\bar{\tilde{t}} \rightarrow e^{\pm} + \mu^{\mp} + b\bar{b} + \not{E}_T$

$\int \mathcal{L}dt = 1\, fb^{-1}$

Production



Decay

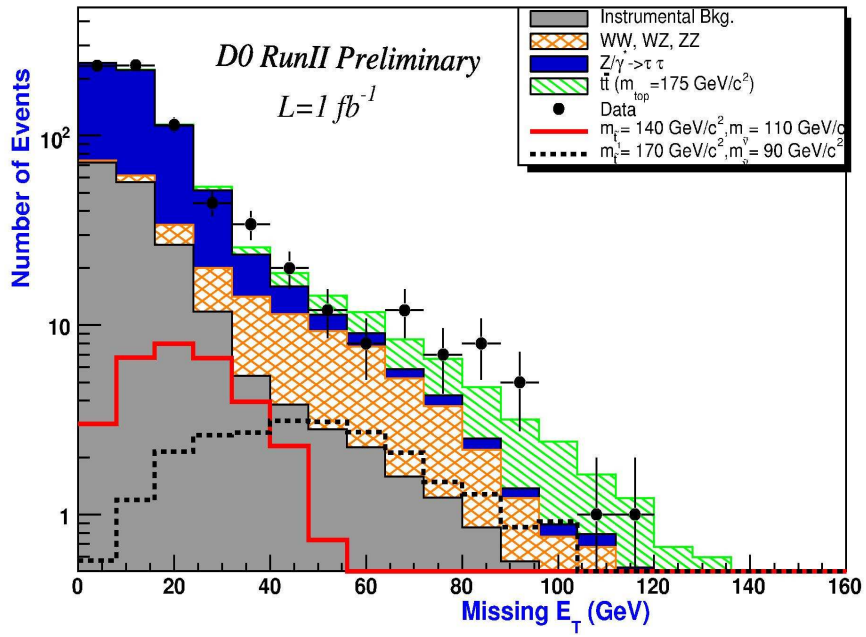


LSP

$BR(\tilde{t}_1 \rightarrow b\ell^{\pm}\tilde{\nu}) = 1$

Events Selection

- Trigger: low p_T e-μ
- Offline:
  - $p_T(\mu) >$ 8 GeV, isolated
  - $p_T(e) >$ 15 GeV, isolated
  - $m\not{E}_T >$ 30 GeV
- BKGD:
  - $\gamma^*/Z \rightarrow \tau\tau$, WW, ttbar
  - instrumental (from data)



Search Topology: $e^{\pm} + \mu^{\mp} + b\bar{b} + \not{E}_T$

2. $\tilde{t}\bar{\tilde{t}} \rightarrow e^{\pm} + \mu^{\mp} + b\bar{b} + \not{E}_T$

$\int \mathcal{L} dt = 1\, fb^{-1}$

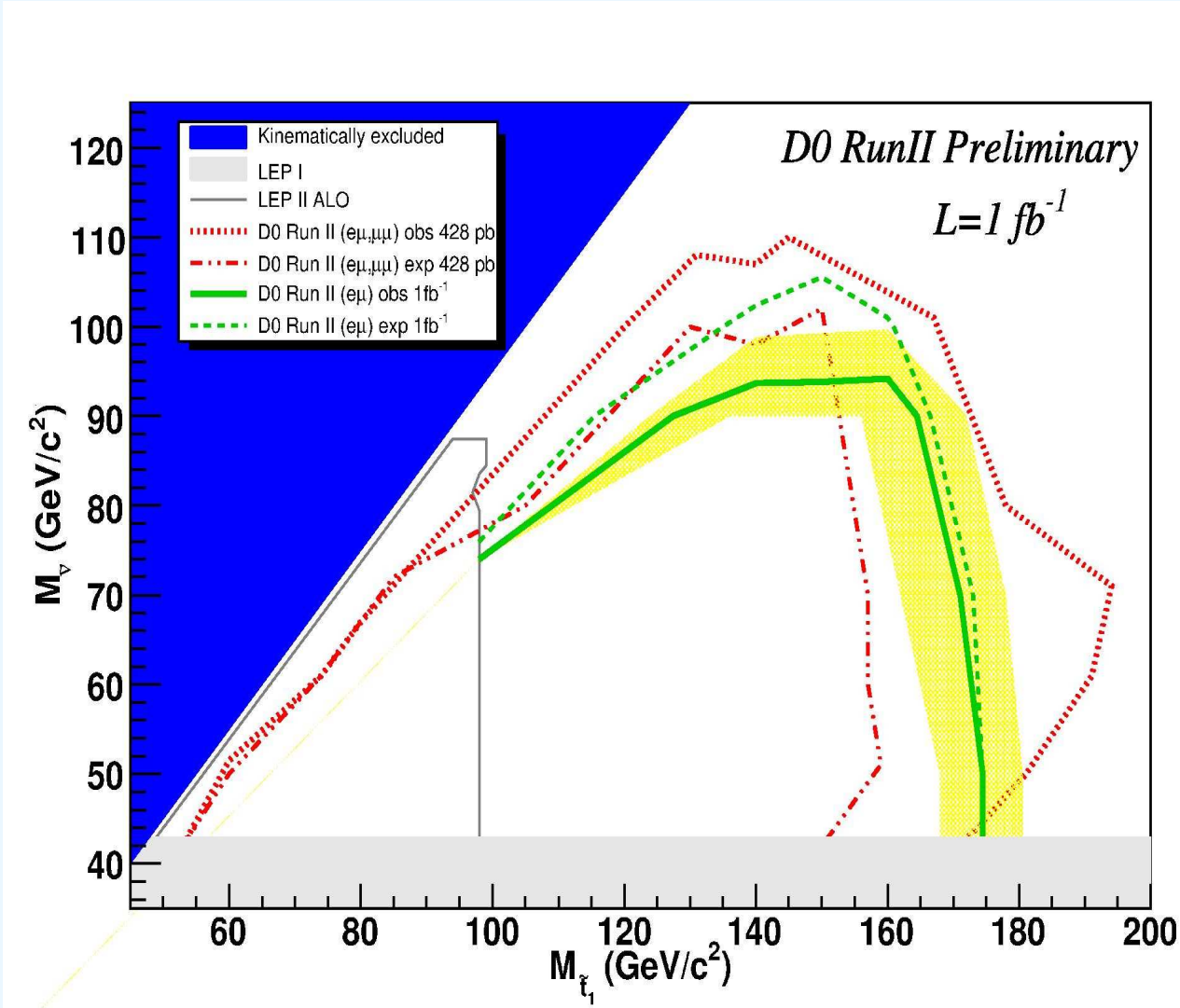
H_T & S_T>120 GeV:

Obs: 6

Exp: 7+/-1

S(170,90) =1.1+/-0.1

$m_{\tilde{t}_1}$ $m_{\tilde{\nu}}$



3. $\tilde{t}\bar{\tilde{t}} \rightarrow c\bar{c} + \not{E}_T$

$\int \mathcal{L} dt = 1\, fb^{-1}$

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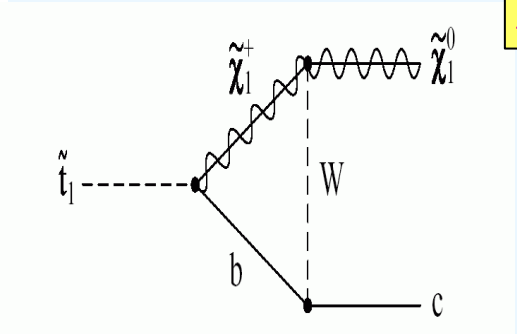
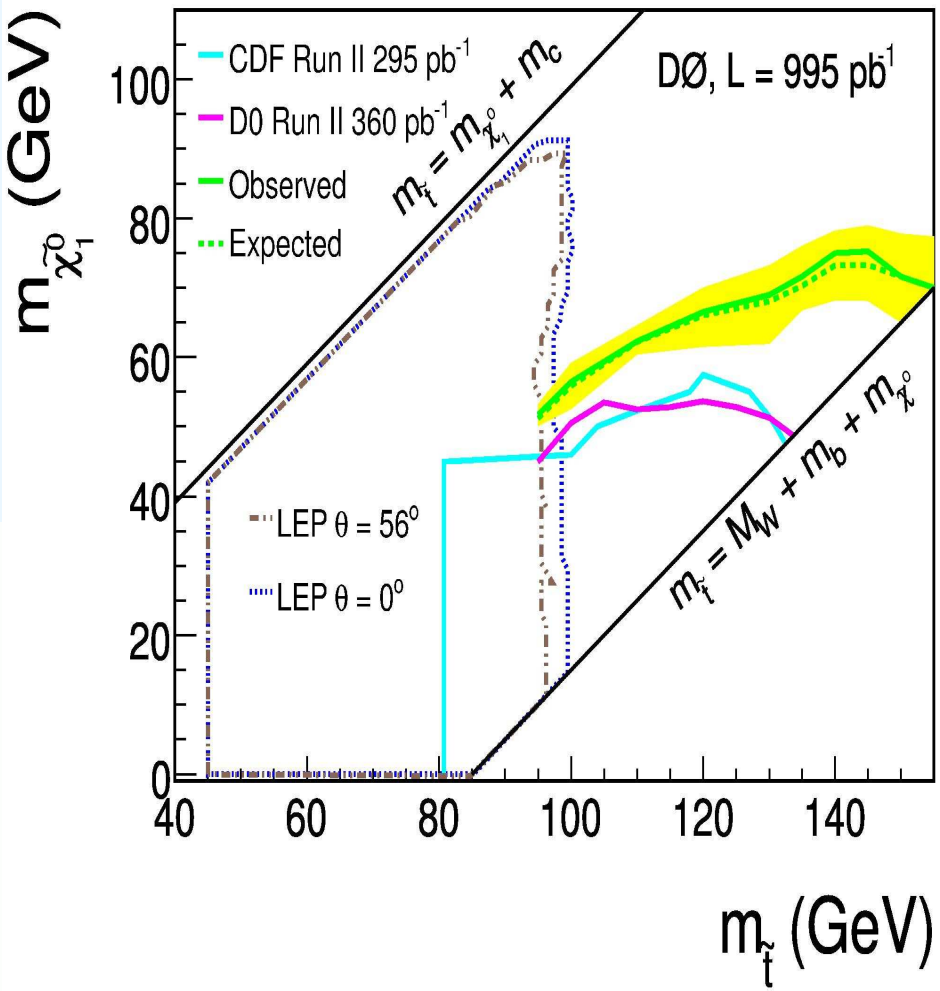


- Search topology: acoplanar dijet
- Main bkgd: V+QQ
- Events selection:
  - Trigger: jets+mE_T
  - Offline: mE_T , $\Delta\phi$, H_T,1 c-tagged jet
  - c-tagging: $\varepsilon_{Data}^{Esti}(c) = \varepsilon_{Data}^{Meas}(b) \times \frac{\varepsilon_{MC}(c)}{\varepsilon_{MC}(b)}$

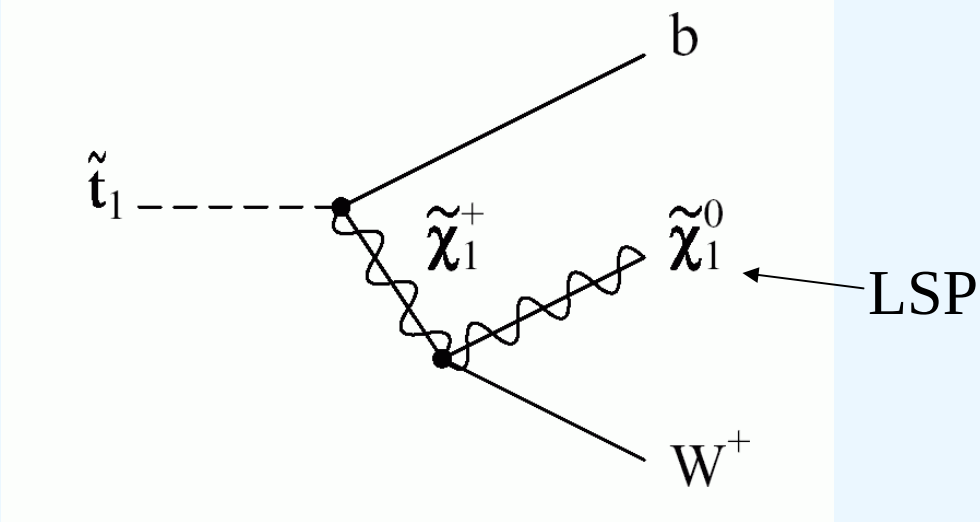
MET > 70 GeV in all cases

$m_{\tilde{t}}$	H_T	S	Observed	Predicted
95 – 130	> 100	< 260	83	$85.3 \pm 1.8^{+12.8}_{-13.0}$
135 – 145	> 140	< 300	57	$59.0 \pm 1.6^{+8.5}_{-8.8}$
150 – 160	> 140	< 320	66	$66.6 \pm 1.1^{+9.6}_{-10.0}$

Limit

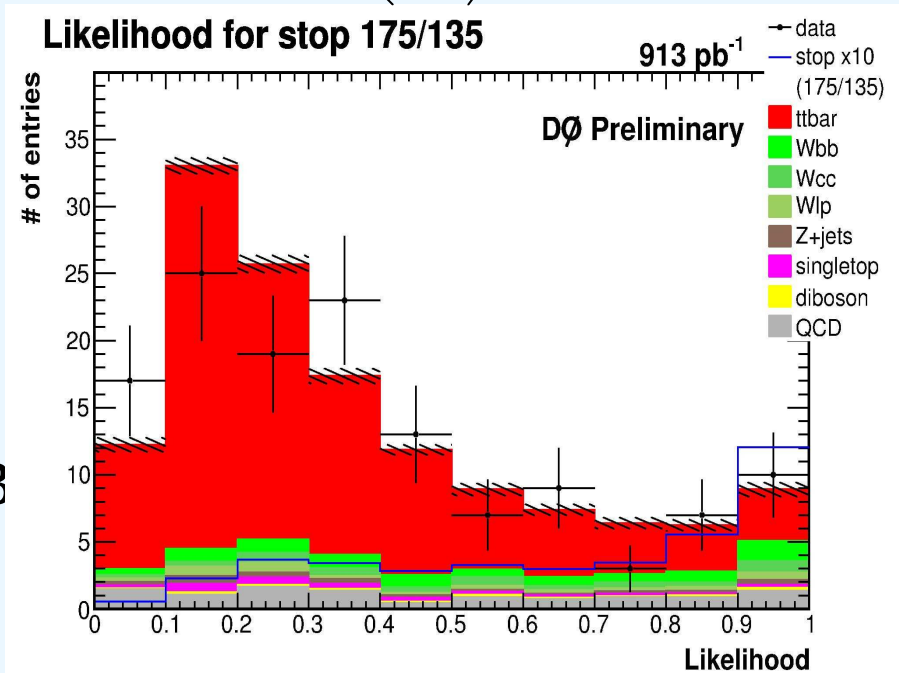


4. $\tilde{t}\bar{\tilde{t}}$ in $t\bar{t} \rightarrow \ell^{\pm} + jets + \not{E}_T$



0.91 fb^{-1} in e+jets channel
0.87 fb^{-1} in μ+jets channel

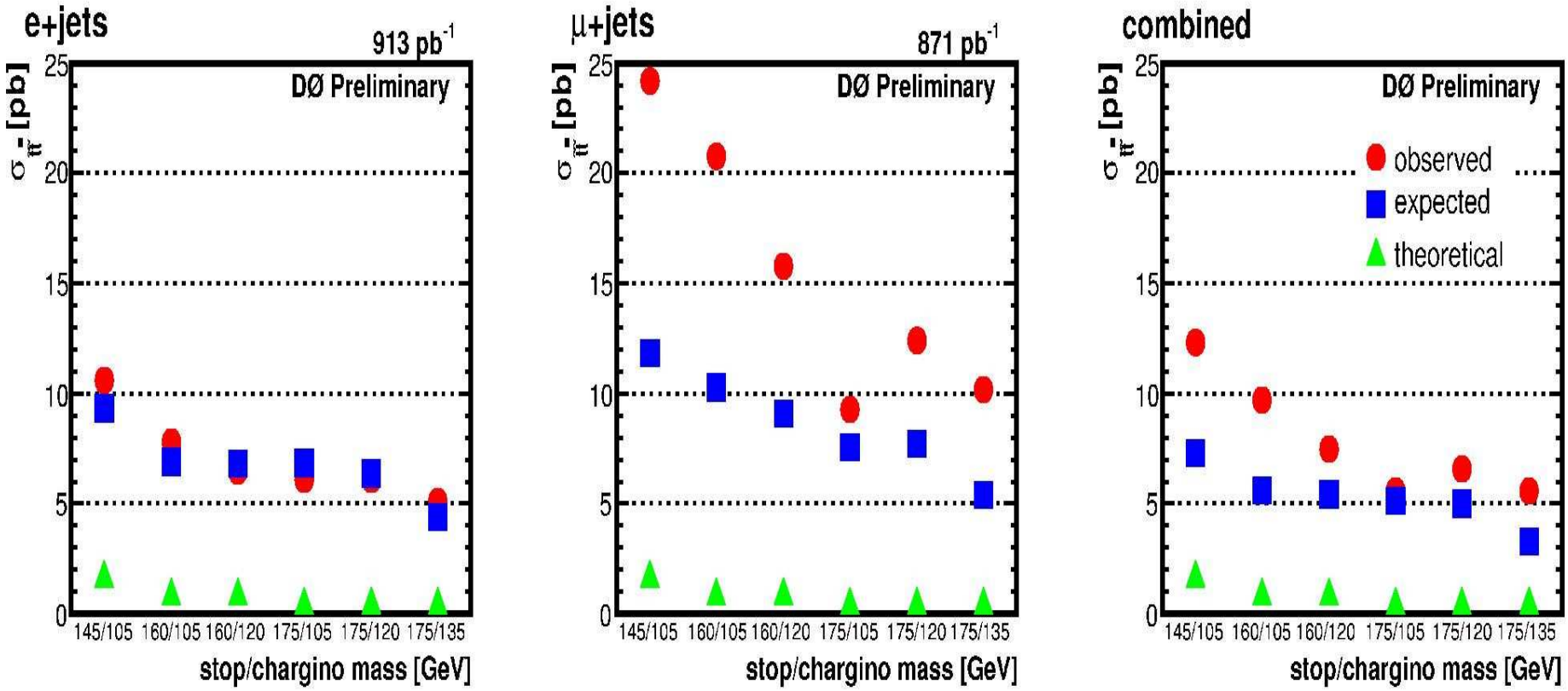
$m_{\tilde{t}_1}$ $m_{\tilde{\chi}_1^{\pm}}$



- Main bkgd: ttbar, W+jets
- Events selection:
  - typical ttbar analysis selection w/
  - 1 b-tagged jet
- Use LL discriminant between S and B to set bayesian limit

4. $\tilde{t}\bar{\tilde{t}}$ in $t\bar{t} \rightarrow \ell^{\pm} + jets + \not{E}_T$

Limits



Can't exclude stop yet:

σ_{limit} ~7-12 larger than MSSM prediction

5. $\tilde{q}\tilde{q} + \tilde{q}\tilde{g} + \tilde{g}\tilde{g} \rightarrow jets + \not{E}_T$

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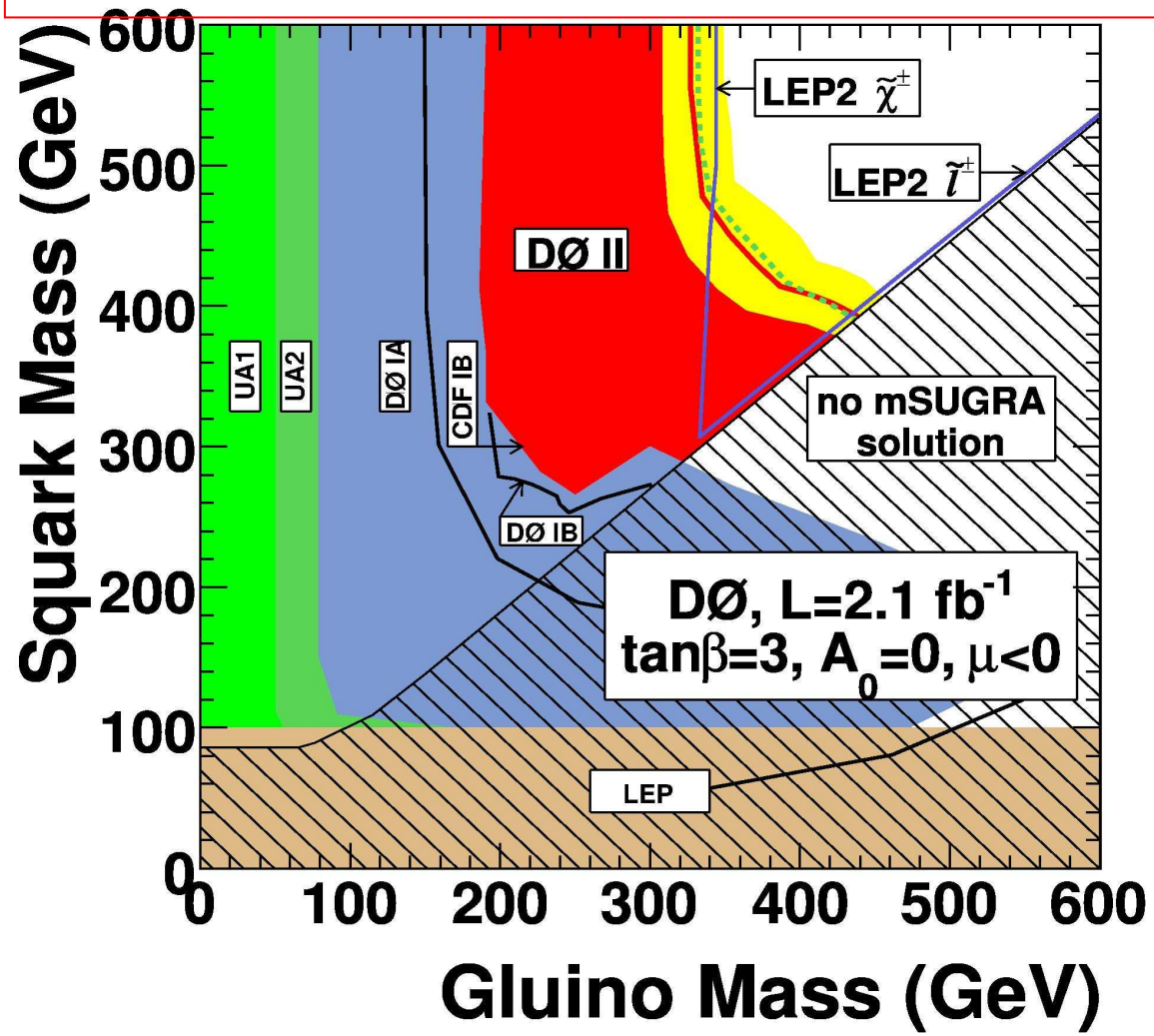
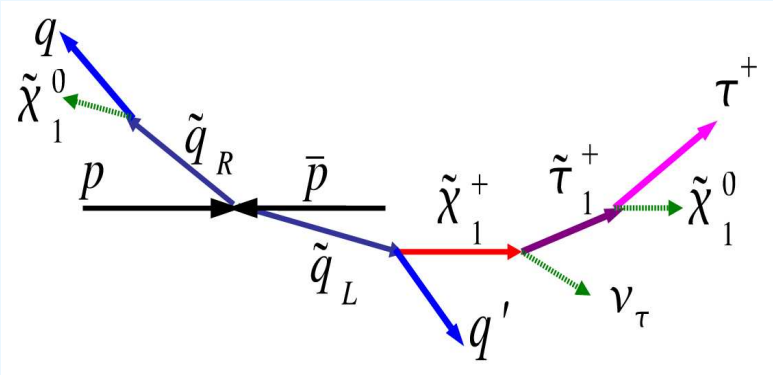
- Multijet+mE_T generic search
  - 2j+mE_T : $\tilde{q}\tilde{q}$
  - 3j+mE_T : $\tilde{q}\tilde{g}$
  - 4j+mE_T : $\tilde{g}\tilde{g}$
  - mSUGRA
- Veto on isolated leptons
- Look for excess in mE_T & H_T
- Limits:
  - m(~q) > 392 GeV
  - m(~g) > 327 GeV
  - m(~g) > 408 GeV (for equal mass)

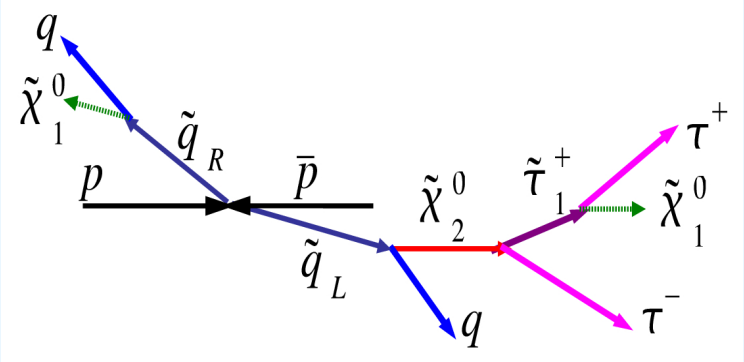
2.1 fb^{-1} combined Run IIa+IIb

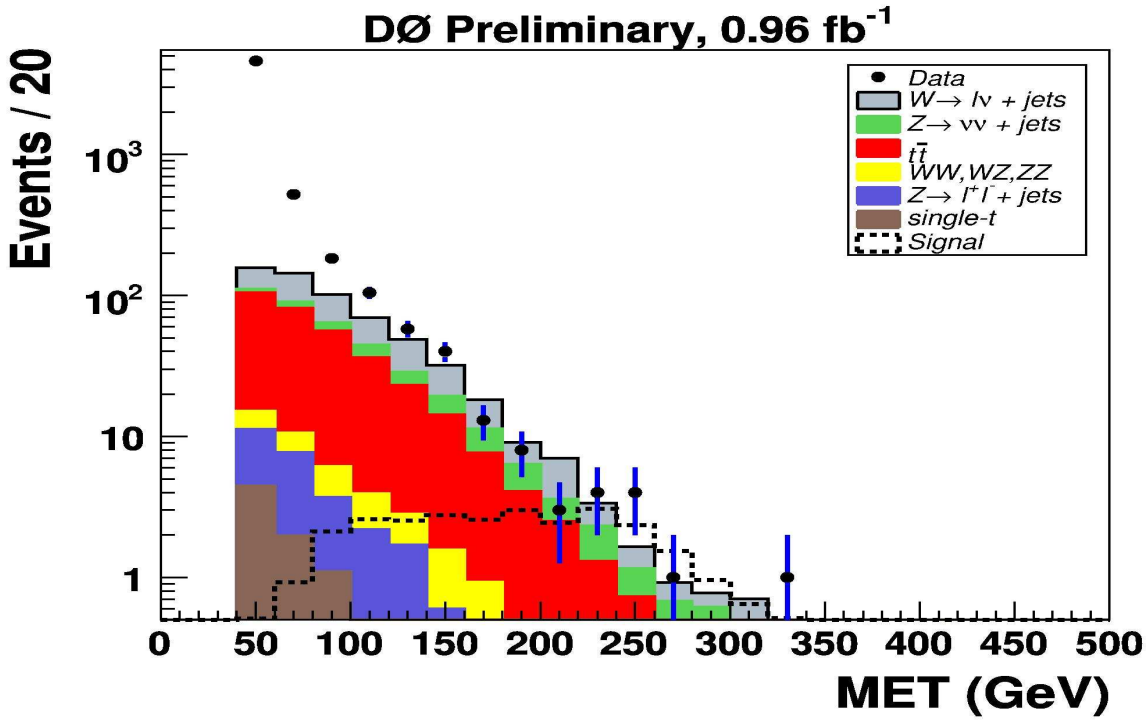


6. $\tilde{q}\tilde{q} + \tilde{q}\tilde{g} + \tilde{g}\tilde{g} \rightarrow tau(s) + jets + \not{E}_T$

1 fb^{-1} Run IIa







NLSP: $\tilde{\tau}_1^{\pm}$

Event selection:

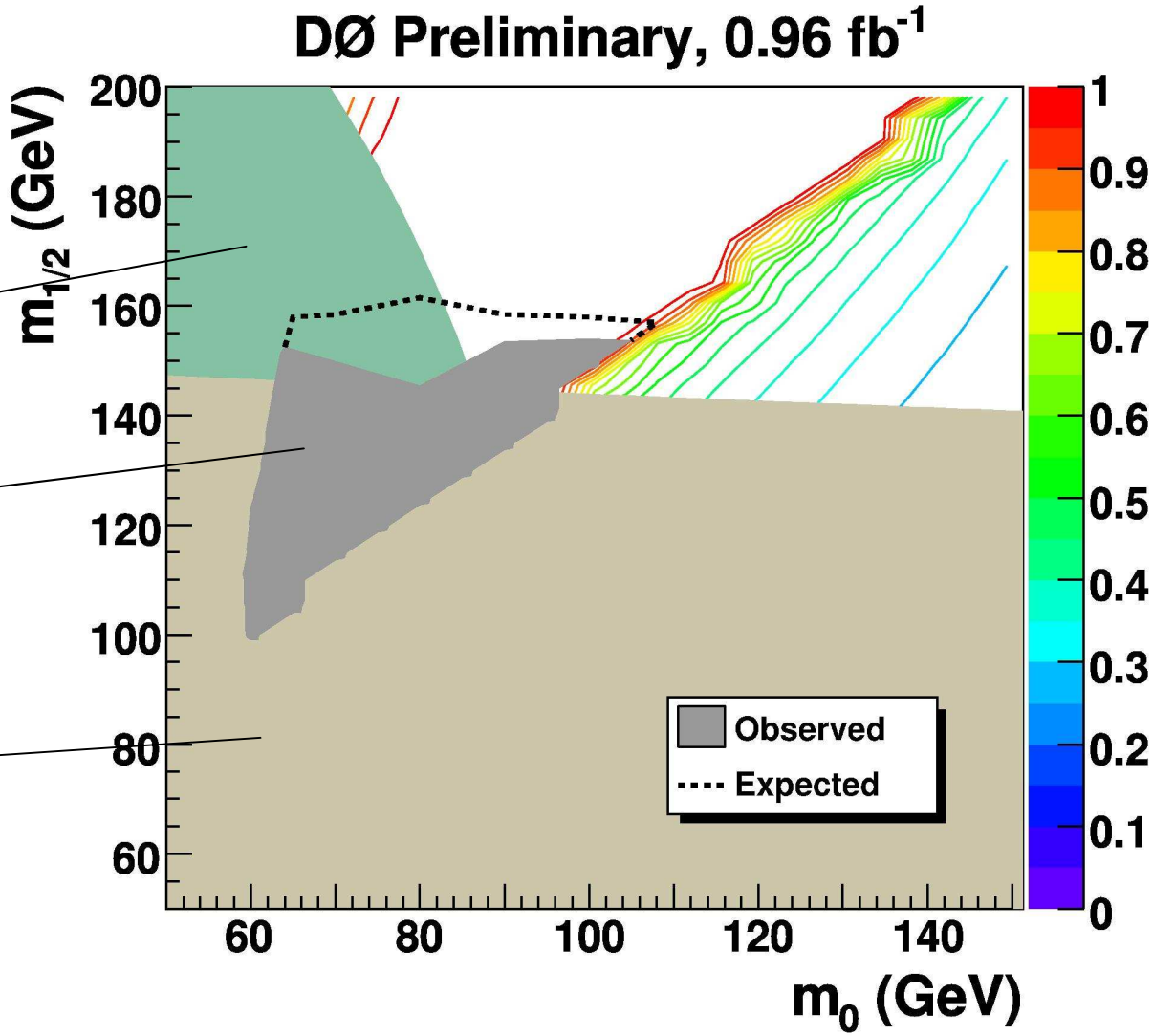
- 2 acoplanar jets
- mE_T > 75 GeV, isolated
- τ–ID:
  - p_T > 15 GeV
  - ΔR(τ,jets)>0.5
  - NN-ID

6. $\tilde{q}\tilde{q} + \tilde{q}\tilde{g} + \tilde{g}\tilde{g} \rightarrow tau(s) + jets + \not{E}_T$

Excluded by LEP Sleptons searches

This analysis

Excluded by LEP chargino searches



II. Gravity Mediated SUSY X

RPV Search

1. Scalar Neutrino Resonant Production

7. $\tilde{\nu} + X \rightarrow e^{\pm} + \mu^{\mp} + X'$

$\int \mathcal{L} dt = 1\, fb^{-1}$

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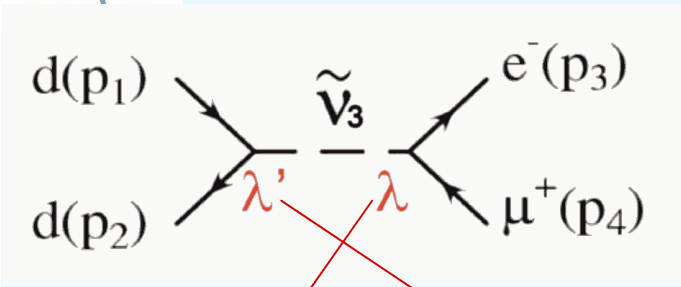


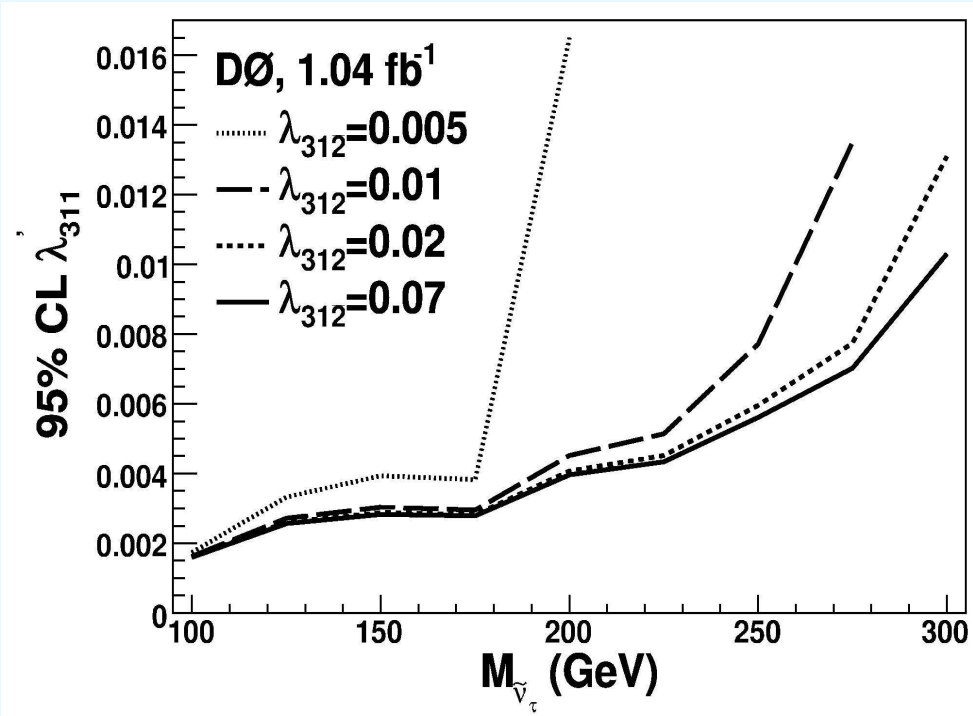
$$W_{\not{R}_p} = \frac{1}{2}\varepsilon_{ab}\lambda_{ijk}\hat{L}_i^a\hat{L}_j^b\hat{E}_k + \varepsilon_{ab}\lambda_{ijk}'\hat{L}_i^a\hat{Q}_j^b\hat{D}_k + \frac{1}{2}\varepsilon_{\alpha\beta\gamma}\lambda''_{ijk}\hat{U}_i^\alpha\hat{D}_j^\beta\hat{D}_k^\gamma + \varepsilon_{ab}\delta_i\hat{L}_i^a\hat{H}_2^b$$

Limit:

- $m_{\tilde{\nu}_\tau} = 100$ GeV
- $\lambda_{312} = 0.01$

$\lambda'_{311} > 0.0016$

- LSP: $\tilde{\nu}_\tau$
- Non-zero couplings:
  - λ'_{311}
  - $\lambda_{312} = \lambda_{321}$
- Events selection:
  - 1 isolated e
  - 1 isolated μ



III. Gauge Mediated SUSY X

- SUSY X in the hidden sector
- Transmitted to the visible sector by gauge interactions of some messenger fields
- LSP:
  - gravitino $\tilde{G}$
- NLSP:
  - lightest neutralino $\tilde{\chi}_1^0$ (or slepton $\tilde{\ell}$)

RPC Searches

1. Charginos/Neutralinos Pairs
2. Long Lived Neutralino Pairs

8. $\tilde{\chi} + \tilde{\chi} \rightarrow 2\gamma + \not{E}_T$

$\int \mathcal{L} dt = 1.1\, fb^{-1}$

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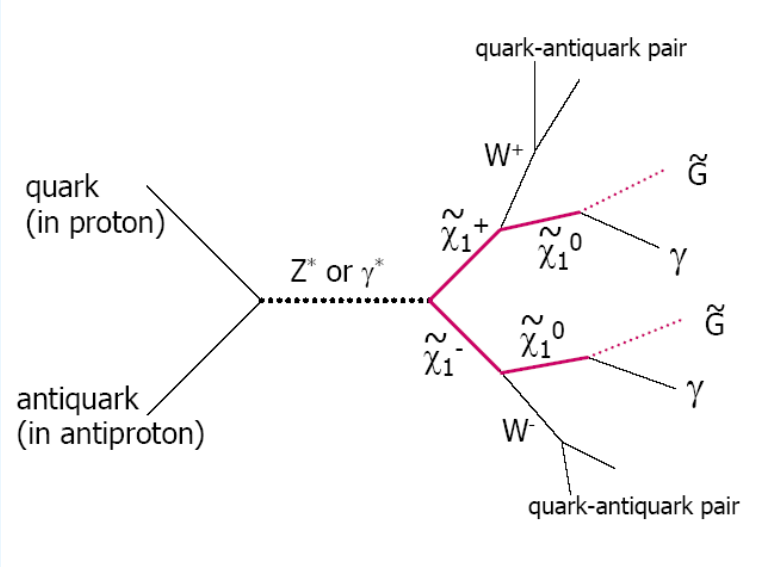
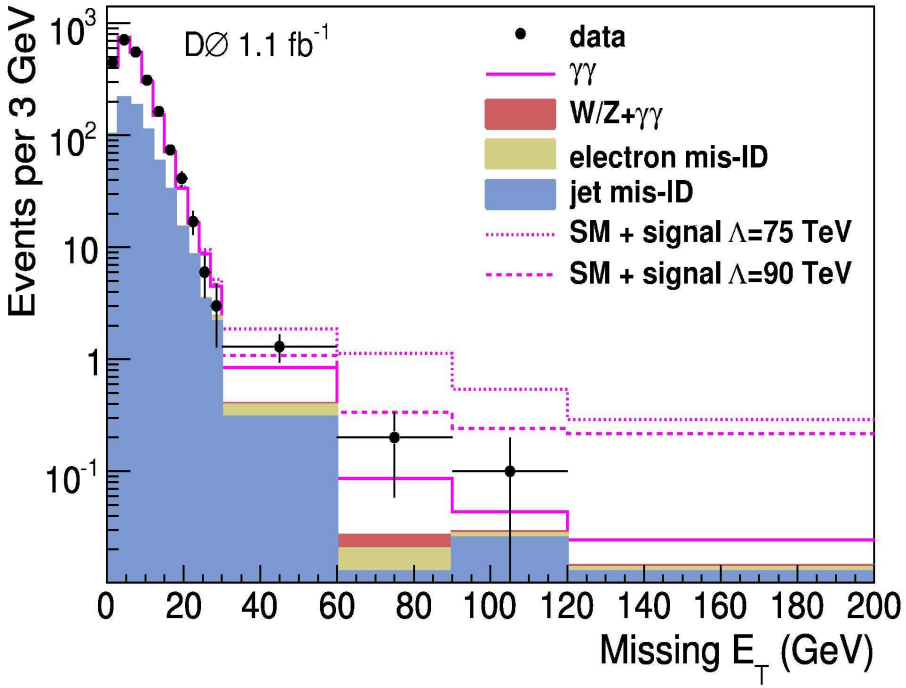
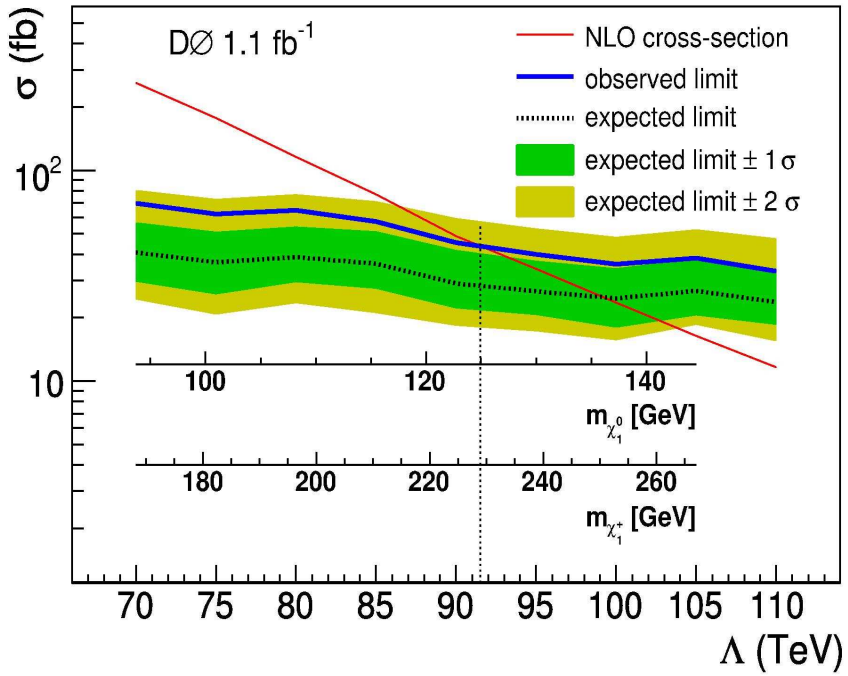


Limits

Best limit to date:

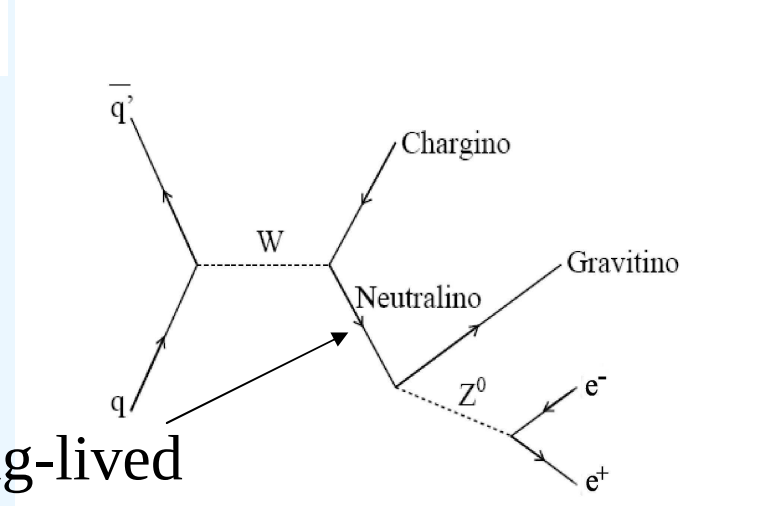
- $\Lambda > 91.5$ TeV
- $m(\chi_1^0) > 125$ GeV
- $m(\chi_1^+) > 229$ GeV





9. $LL\ \tilde{\chi}\tilde{\chi} \rightarrow 2e^{\pm}(2\gamma) + \not{E}_T$

$\int \mathcal{L}dt = 1.1\ fb^{-1}$



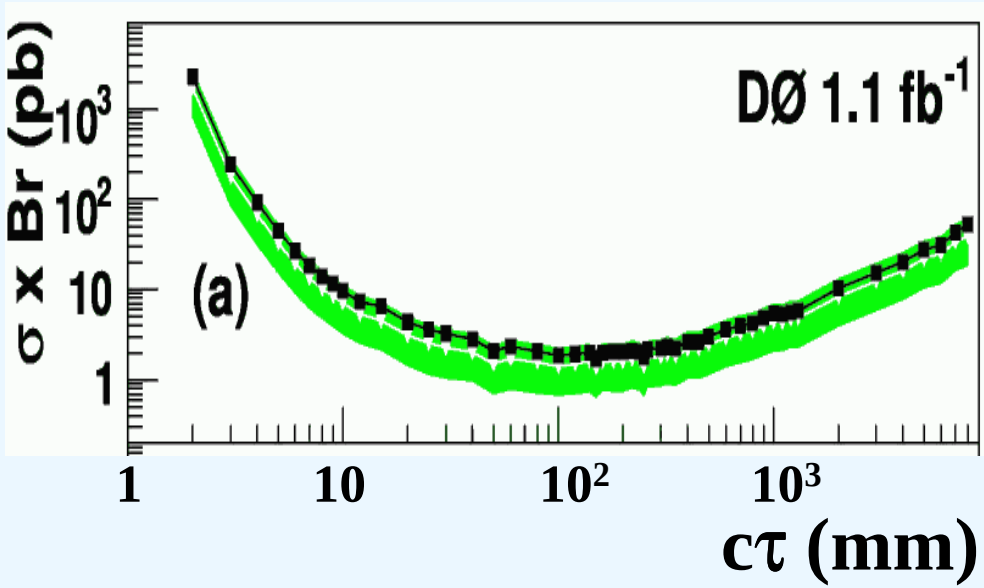
Long-lived

Limit:

- $c\tau$=100 mm
- mE_T > 30 GeV
- M_{ee} > 20 GeV

σ x BR < 1.9 pb

- **Events selection:**
  - **Trigger: single EM**
  - **Offline:**
    - **2 good & isolated EM clusters**
    - **$|\eta|$<1.1 & p_T >20 GeV**
    - **each matched to CPS cluster**
    - **PV from γ-pointing**
    - **reconstruct PV radius**



Accepted PRL
hep-ex arXiv:0806.3527

IV. Conclusions & Prospects

- Various D0 SUSY searches presented w/ int. L up to 2.1/fb
- Some not covered in this talk but more signature inspired:
  - Stopped gluinos
  - CMSP
- So far, no signs of SUSY production
- Improved limits

Quantitative Improvements	Qualitative Improvements
• Analyze more Run IIb data (run in 2010?)	• Improve/maintain algorithms at high $\mathcal{L}$
• Combine differents analyses within D0	• Reduce systematics
• Combinations w/ CDF results	• Improve events selection

- NB: Very difficult to get model-independent constraints for some analyses

Further details at http://www-d0.fnal.gov/Run2Physics/WWW/results/np.htm