


SUSY Searches at the Tevatron

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For the CDF and D0 Collaborations

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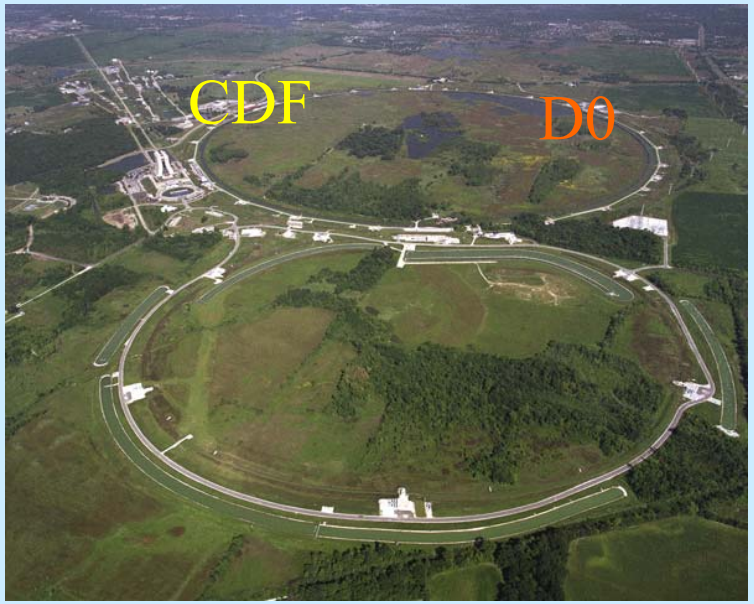
Outline

- The detectors
- SUSY at the Tevatron
- Some examples:
  - Missing E_T + jets
  - Di-photons
  - Leptons
- Summary



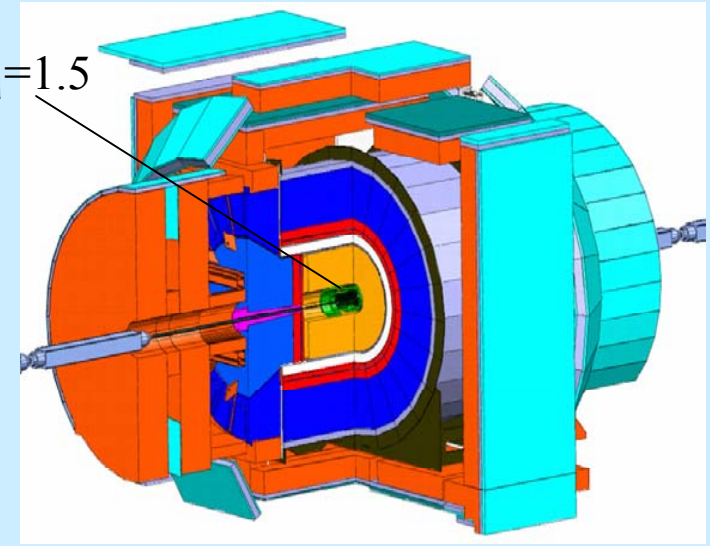
The Tevatron Run II Detectors

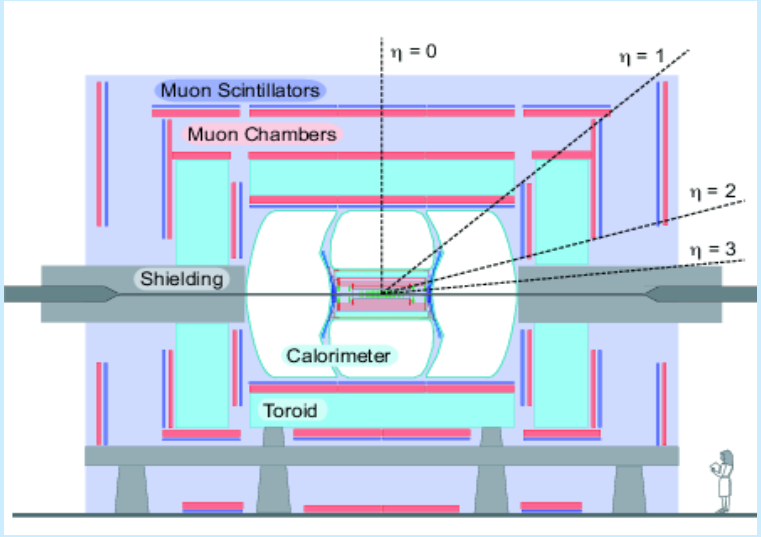
Both general purpose detectors:

- Excellent calorimeter and muon chamber coverage
- Precision tracking (Silicon)

Mature understanding of detectors

Analyses presented here uses up to 260 pb^{-1}

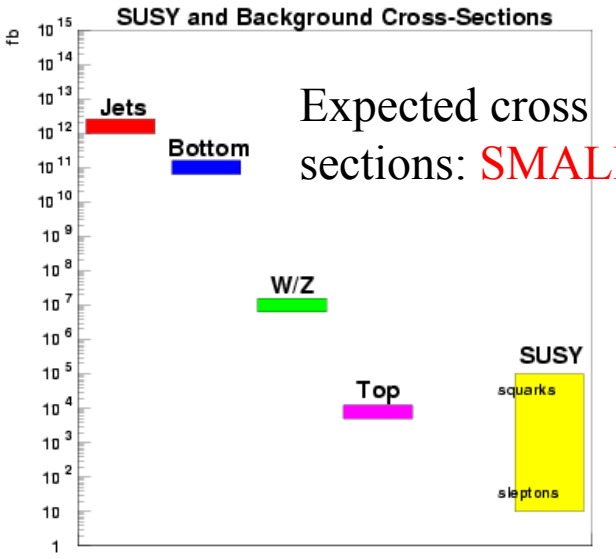




Supersymmetry at the Tevatron

Looking for supersymmetric partners of SM particles

Excesses in SM-like channels and SUSY-only signatures



Expected cross sections: SMALL!

Frameworks used:

-Minimal Supersymmetric extention of the SM (MSSM)

-minimal Supergravity (mSugra)

- Gauge mediated Supersymmetry Breaking (GMSB)

New quantum number: $R_P = (-1)^{B+L+2s}$ $\begin{cases} +1 & \text{SM} \\ -1 & \text{SUSY} \end{cases}$

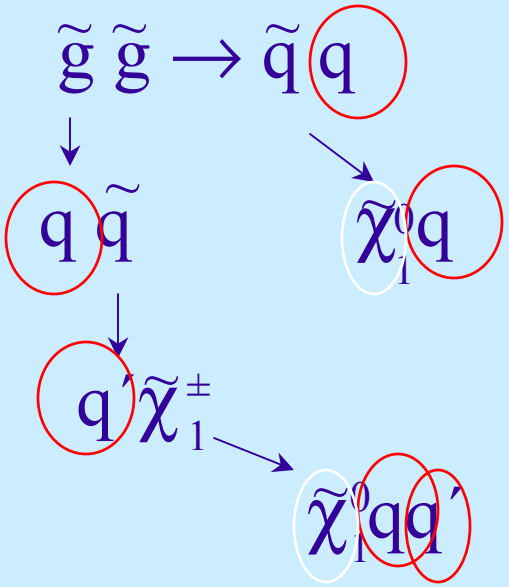
$\not\!\!E_T$ Signatures

$\not\!\!E_T$ classic signature in R_P conserving models

where lightest sparticle (LSP) is stable

LSP = ($\tilde{\chi}_1^0$, $\tilde{G}$) in minimal models

$\not\!\!E_T$ + jets from squarks and gluino cascade decays



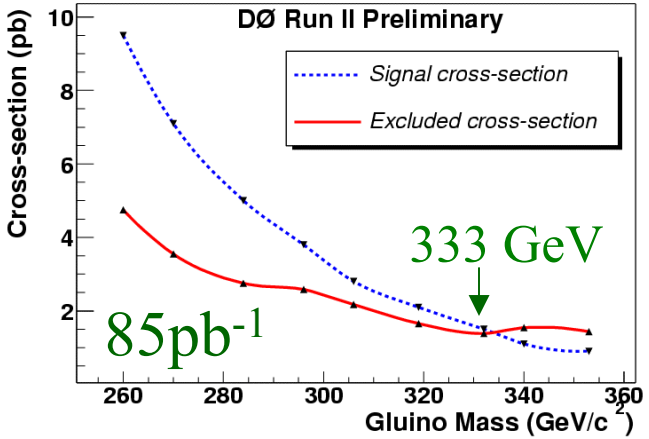
- Generic squarks and gluinos (D0)
- Sbottom quarks from gluinos (CDF)
- Also important for di-photons (both)

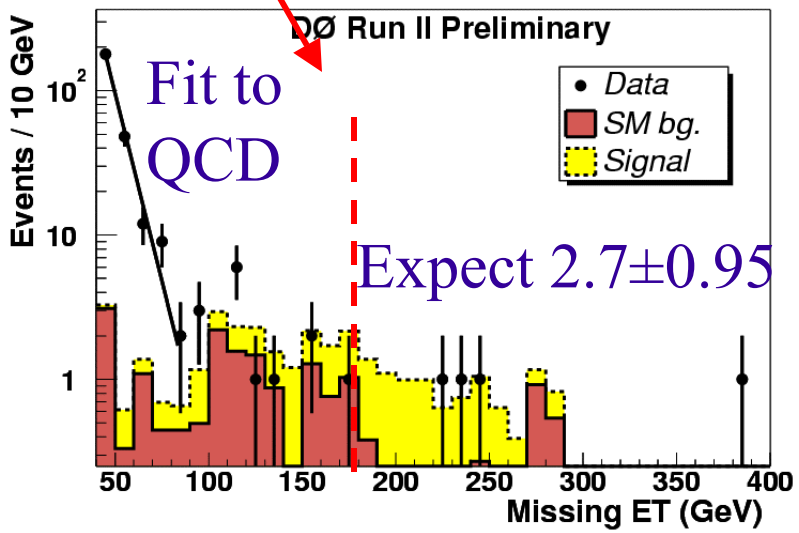
Squark-gluino Search

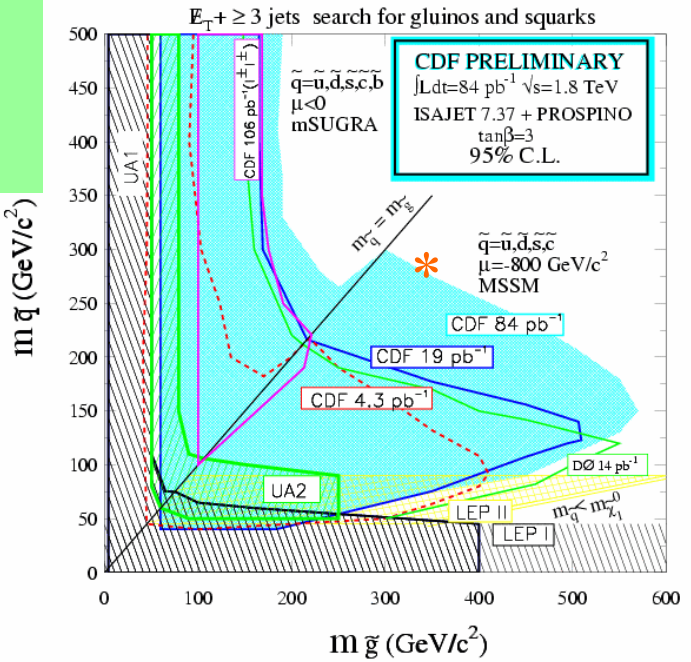
Assume $\tilde{q}$ mass < $\tilde{g}$ mass:
Cross section at the Tevatron: ~ a few pb

Signature: lots of $\not\!\!E_T$ and ≥ 2 jets
Background dominated by Z→νν + jets

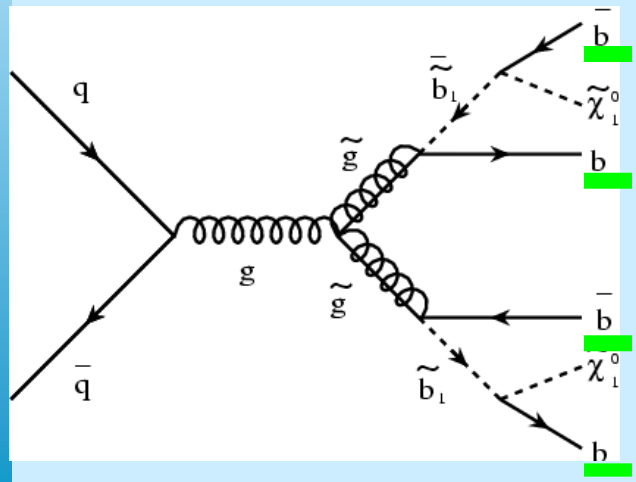
- $\not\!\!E_T$ > 175 GeV, Σ jet E_T > 275 GeV
- Lepton veto







Search for Gluino → Sbottom



- $\tilde{b}_1$ can be very light for large tanβ
- Expect large branching fraction of gluinos to sbottoms.

Assume BR($\tilde{b}_1 \rightarrow b\,\tilde{\chi}^0_1$) = 100 %

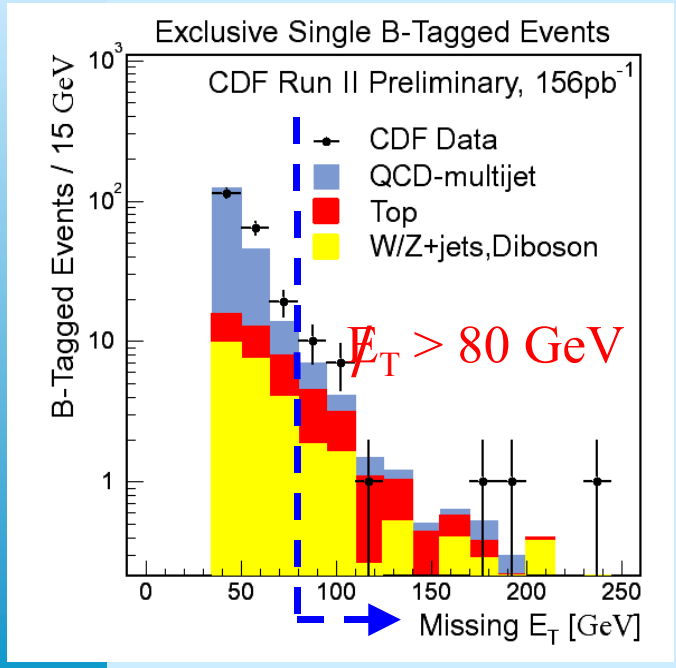
⇒ Distinctive signature:

4 b-jets and $\not\!\!E_T$

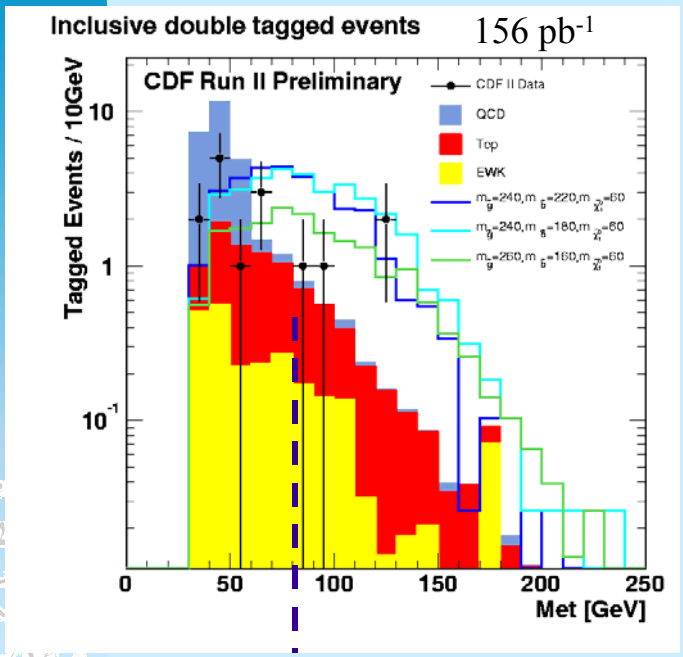
Efficiency of B-tagging depends on

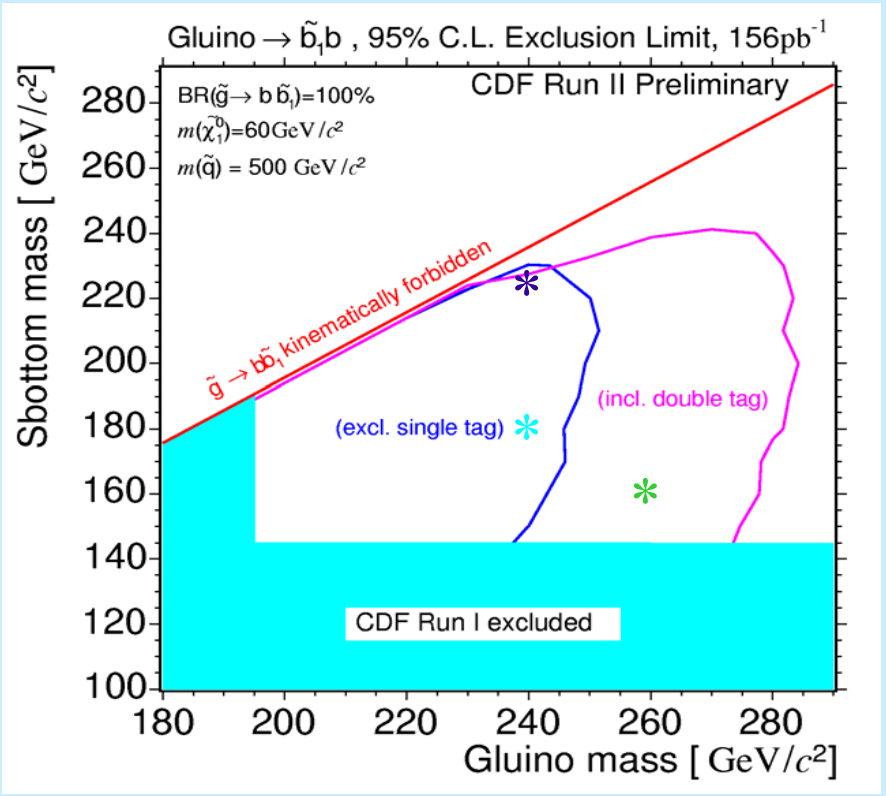
m(gluino) – m(sbottom)

Form 2 analyses: at least 3 jets + 1 or 2 tags

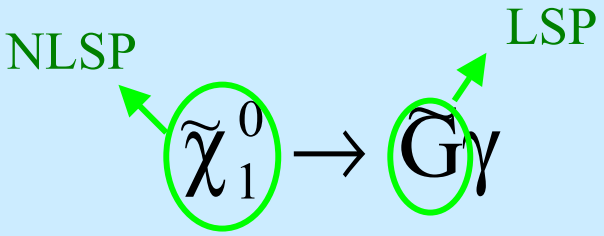


	Expected	Observed
Single tag	16.4 ± 3.7	21
Double tag	2.6 ± 0.7	4





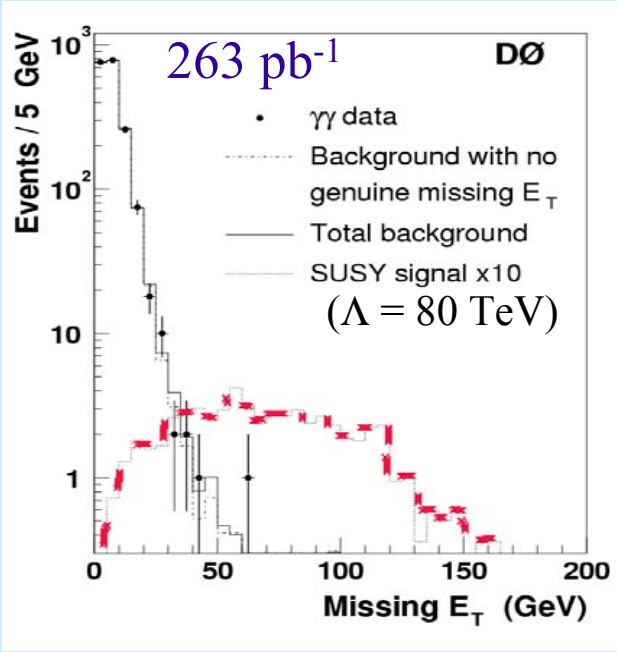
Diphotons

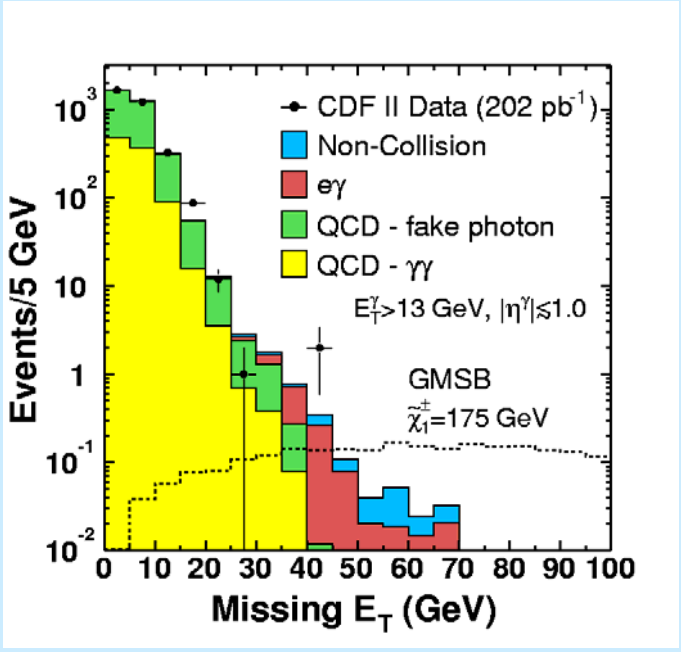


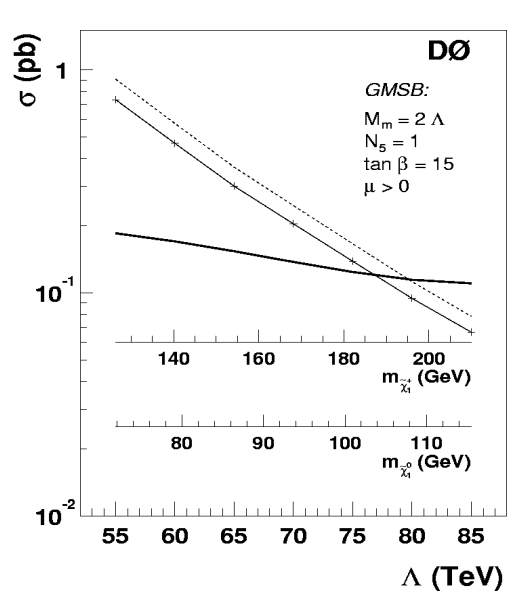
Typical GMSB signature from $\tilde{\chi}_1^0$ decay
Gaugino pair production → lightest neutralino

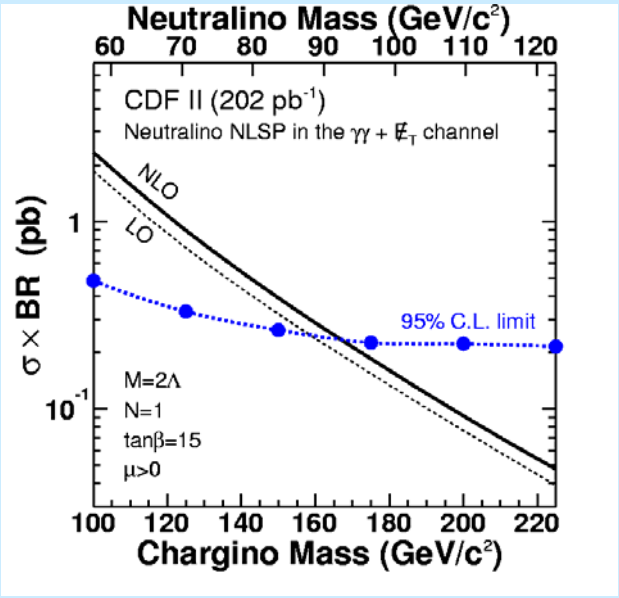
Signature: 2 energetic photons + $\not\!\!E_T$

Backgrounds estimated from data









D0: $E_T(\gamma) > 20$ GeV, $\not\!\!E_T > 40$ GeV
Expect: 3.6±0.6 events
See: 2

Current results:
CDF $m(\tilde{\chi}_1^\pm) > 167$ GeV
D0 $m(\tilde{\chi}_1^\pm) > 195$ GeV

CDF: $E_T(\gamma) > 13$ GeV, $\not\!\!E_T > 45$ GeV
Expect: 0.3±0.1 events
See: 0

Lepton Signatures

Also plentiful in SUSY both R_P and $\not{R}_P$

- cascade decays from charginos, neutralinos, sleptons

$$\tilde{\chi}_1^{\pm} \to \nu l \tilde{\chi}_1^0, \quad \tilde{\chi}_2^0 \to \tilde{l}\, l, \quad \tilde{l} \to l\, \tilde{\chi}_1^0$$

Most models predict low p_T, non-central leptons
High tanβ SUSY models predict τ-signatures

- Standard Trileptons (D0)
- RPV Stops (CDF)
- RPV Smuons (D0)
- $B_s \to \mu\mu$ (both)

Trileptons (Chargino-neutralino)

Clean signature but expected to be small

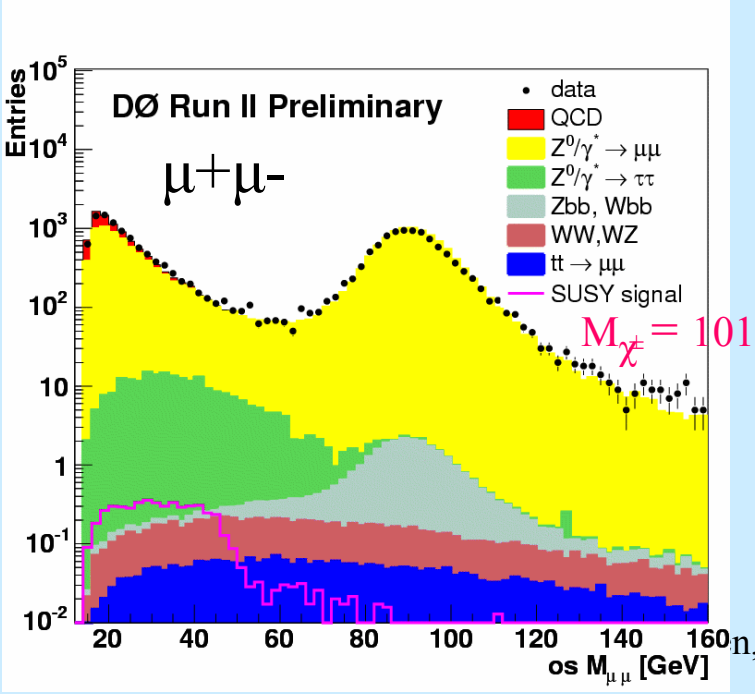
Track
$p_T \geq 3$ or 5 GeV

Strategy: 2 well defined leptons + track + $\not{E}_T$

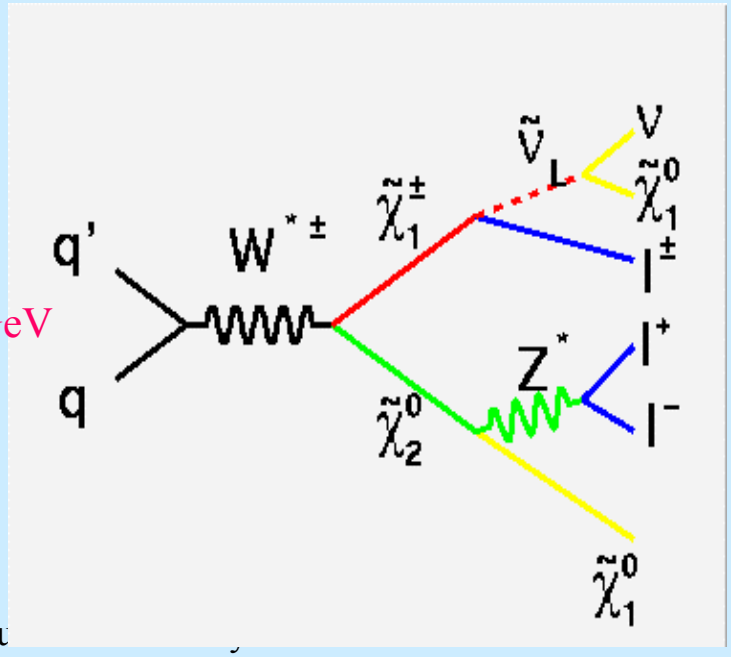
$\rightarrow$ Enhanced sensitivity to τ modes

4 analyses: e^+e^-l, $e^+\mu^-$/ μ^+e^-l, $\mu^+\mu^-l$, and $\mu^-\mu^-$

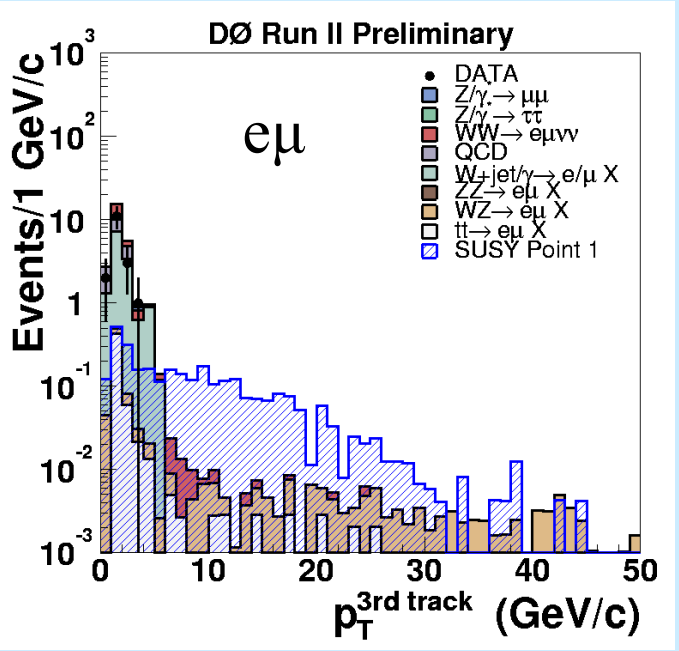
Main backgrounds: Dibosons: WZ^*/γ + conversions

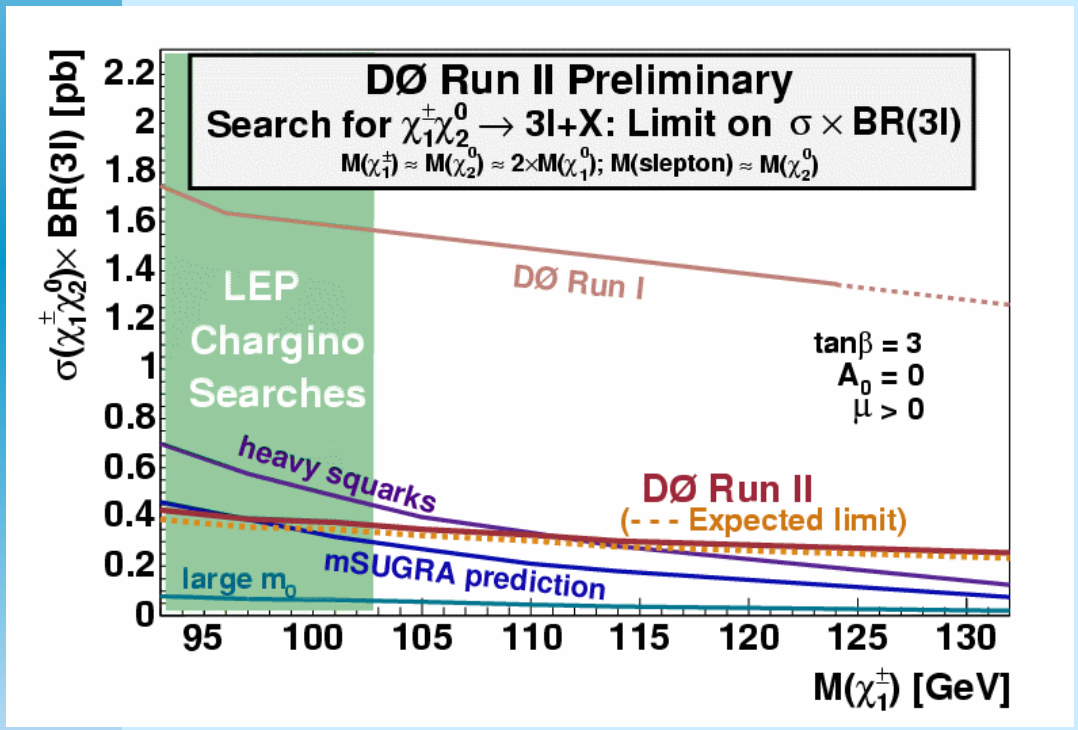


$M_{\tilde{\chi}^\pm} = 101$ GeV



	Expected	Observed
ee + track	0.68±0.40	1
μμ + track	1.83±0.40	1
eμ + track	0.29±0.33	0
SS μμ	0.13±0.06	1





Results with 150 – 250 pb^{-1}:

Limit:

$\sigma \cdot BR < 0.4$ pb @ 95% CL

In mSugra:

$m(\tilde{\chi}_1^\pm) > 97$ GeV

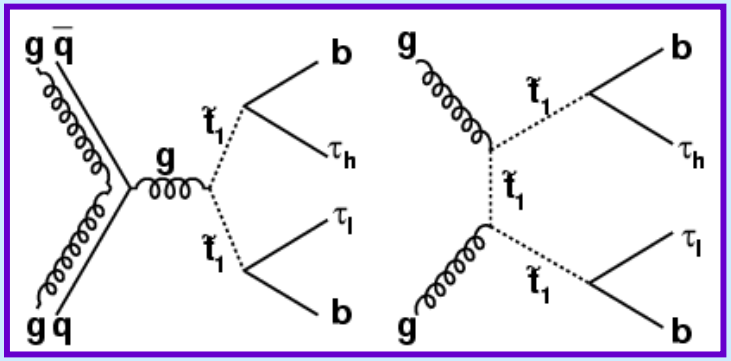
Results with more data out soon – will break new ground

RPV Stop Search

Stop often lightest squark accessible

If R_P violated is we can have

$$\tilde{t}_1 \rightarrow b\tau$$



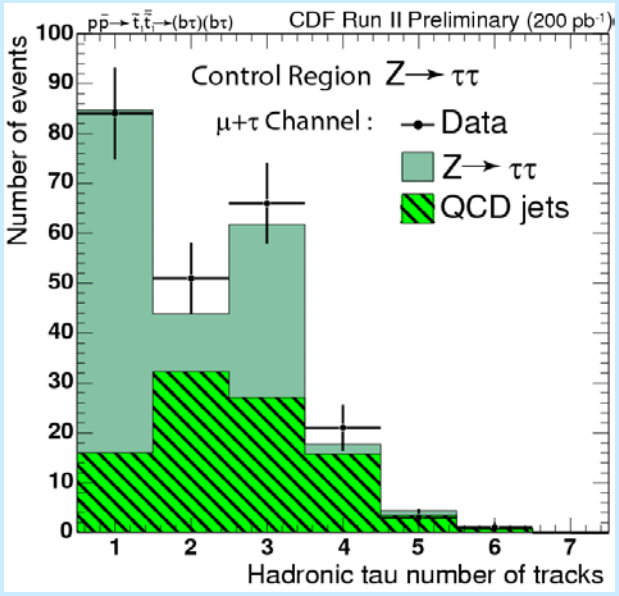
Signature investigated:

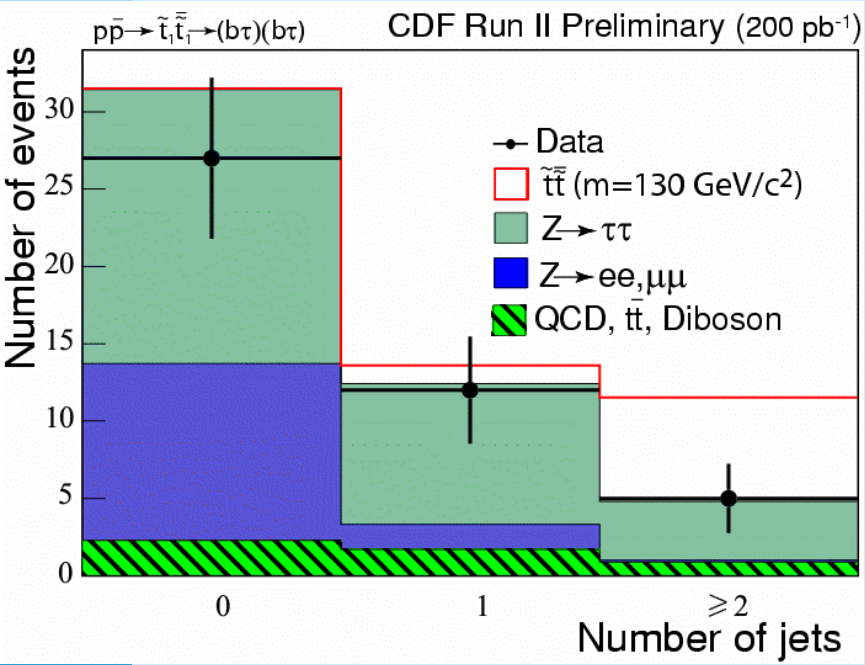
e or μ + hadronic τ + ≥ 2 jets

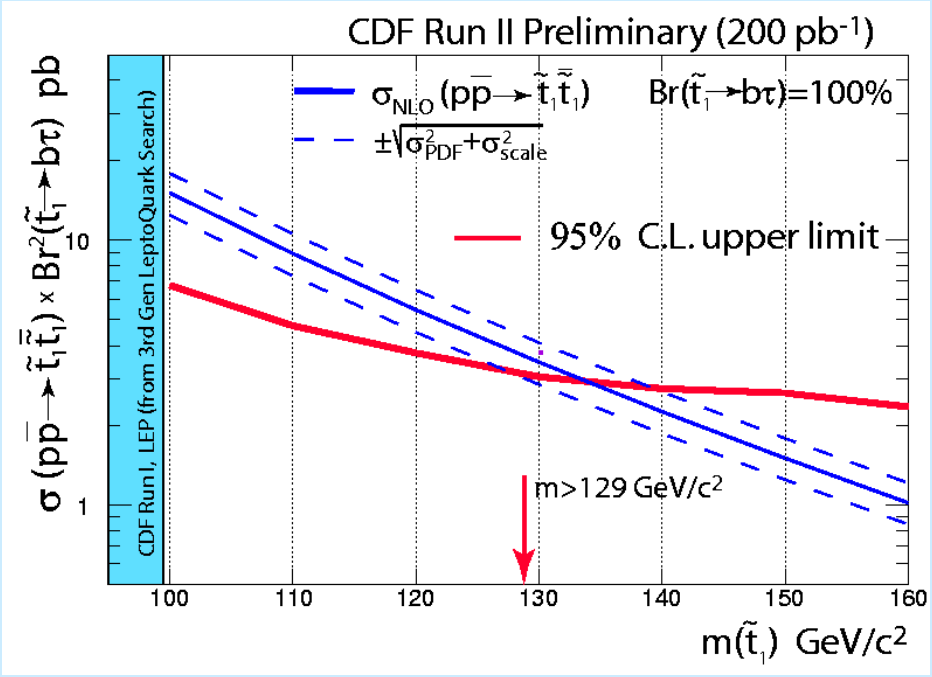
Most problematic background:

$$Z \rightarrow \tau\tau$$

Good agreement in control regions







Expect 4.8 ± 0.7 events
Observes 5

→ New limit on stop mass: $m(\tilde{t}_1)> 129$ GeV

Study also applicable for other new physics (LQ)

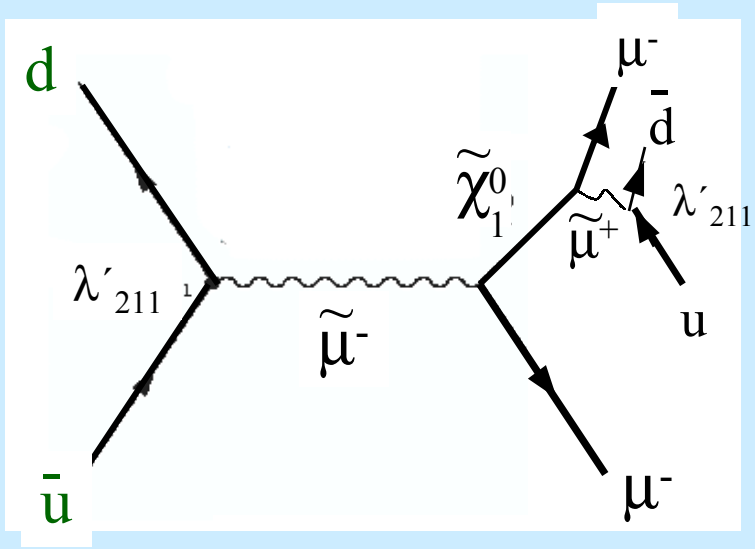
Resonant Smuon Production

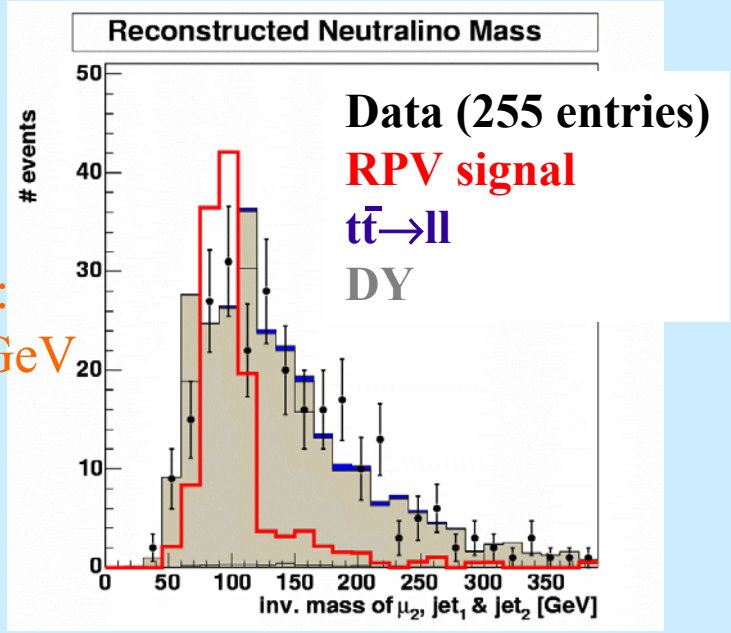
$\tilde{\mu}$ produced via $\not{R}_P$

$\tilde{\chi}_1^0$ decay

Result: 2 muons, 2 jets, and *no* $\not{E}_T$

i.e. possible to reconstruct mass chain





Mass: 102 GeV

Assume prompt $\tilde{\chi}_1^0$ decay

Soft leptons and jets:

- $p_T(\mu_2) \geq 10$ GeV
- p_T (leading jet) ≥ 25 GeV

Can reconstruct $\tilde{\chi}_1^0$ and $\tilde{\mu}$ masses

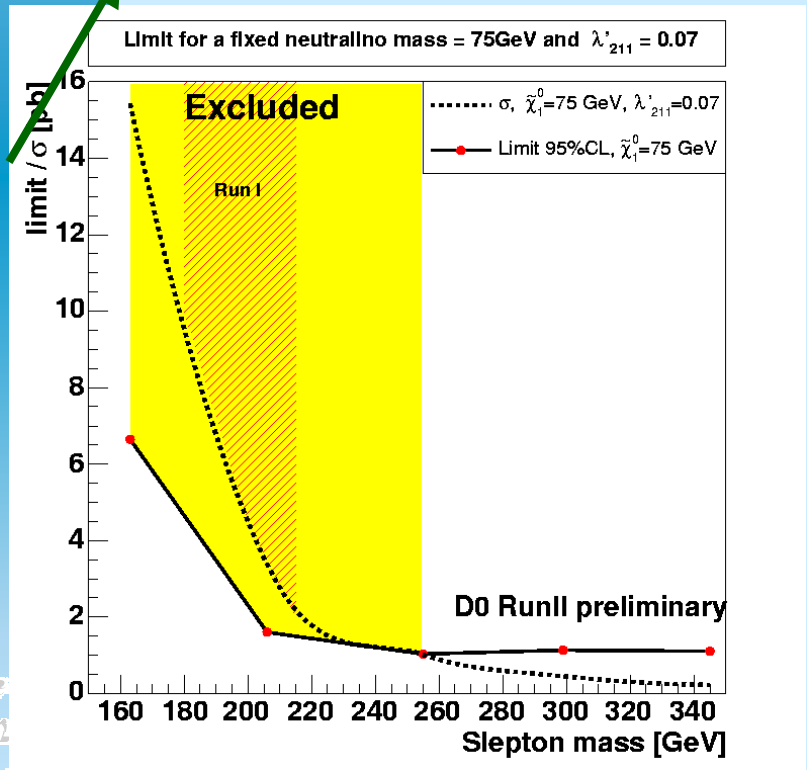
Use this to suppress backgrounds

In 154 pb^{-1} :

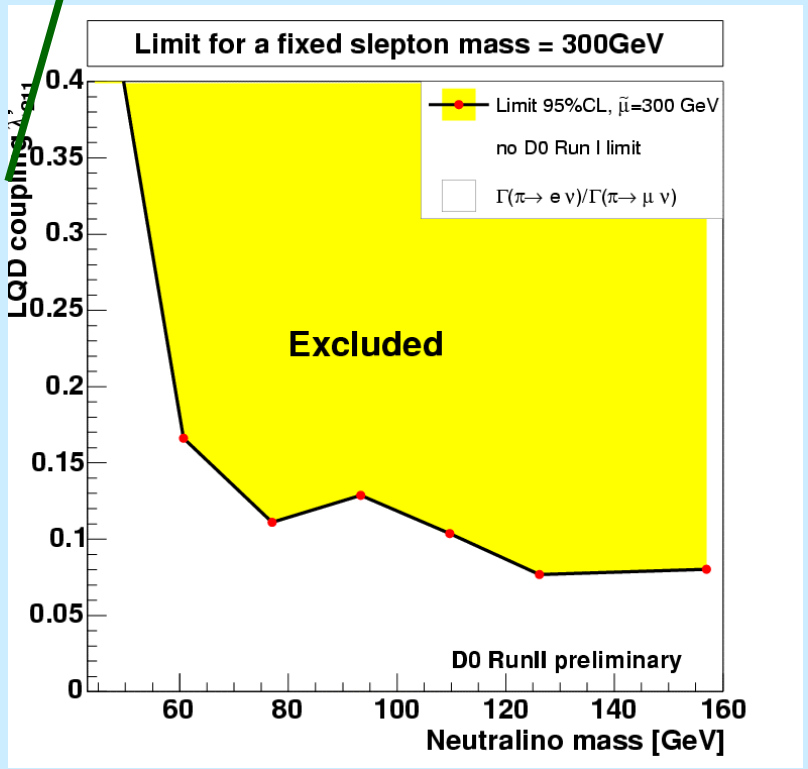
See 2 events

Expect 1.2 ± 0.3 from backgrounds

Limit on cross section



Limit on λ'_{211} coupling

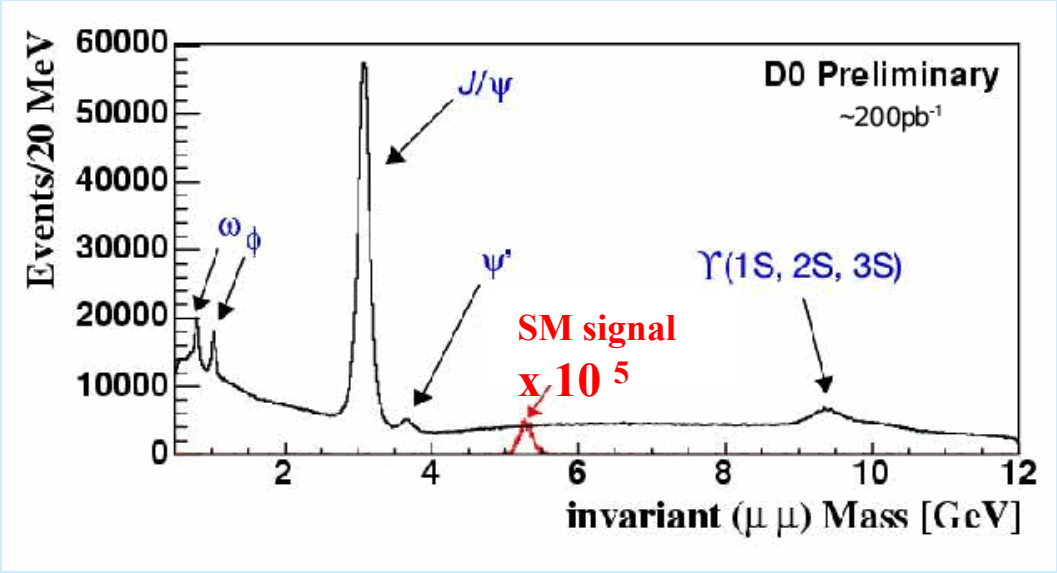


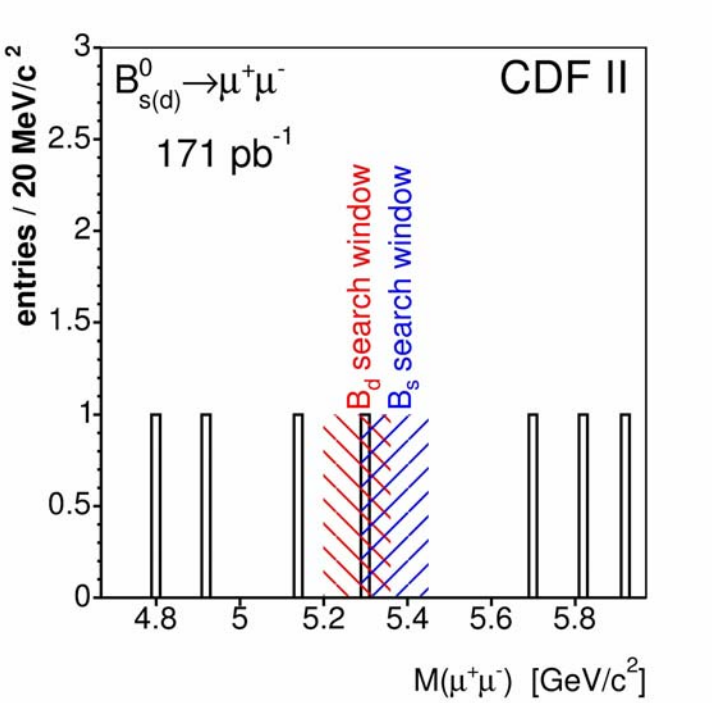
$B_s \rightarrow \mu\mu$

Complementary to other SUSY searches, indirect
BR could be enhanced from new physics:
loop decays (MSSM, mSugra) or direct ($\not{R}_P$)

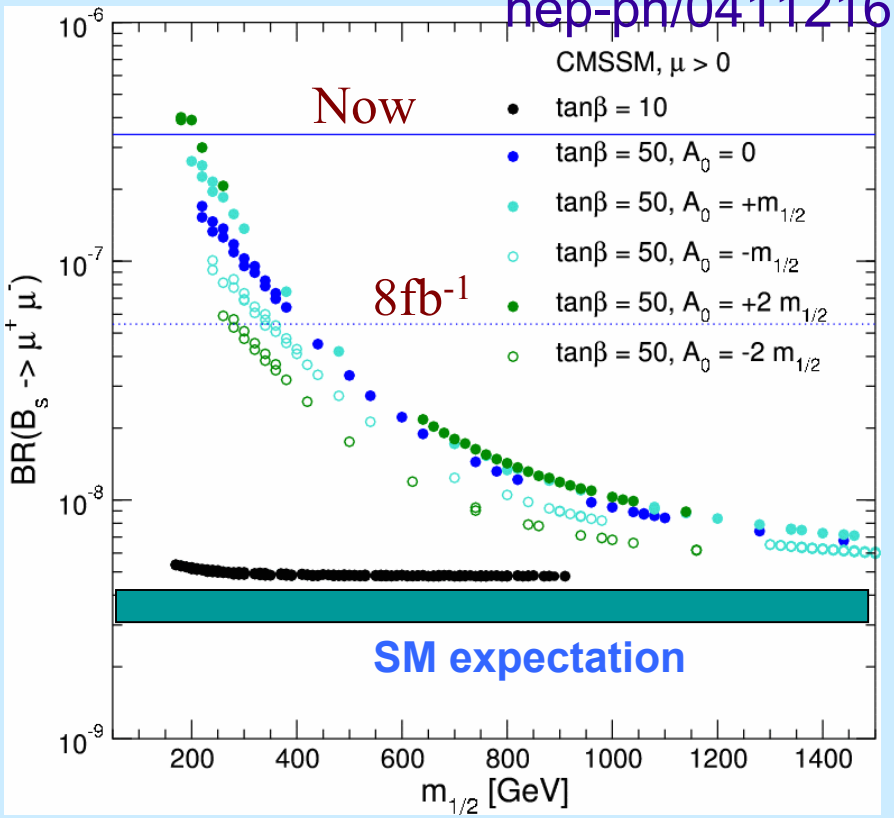
Still challenging, SM prediction is $3.4 \cdot 10^{-9}$ ...

Sidebands and same-sign data used to optimize cuts and check background estimates





hep-ph/0411216



CDF (171pb^{-1})

Expect: 1.05 ± 0.30

See : 1

D0(240pb^{-1})

Expect: 3.7 ± 1.1

See: 4

Combined: 90% CL

$BR(B_s \to \mu\mu) < 2.7 \cdot 10^{-7}$

$BR(B_d \to \mu\mu) < 1.5 \cdot 10^{-7}$ (CDF)

Summary

☹ No evidence for signal - yet

☺ We are looking in new areas in parameterspace!

- Tevatron Run II already has a rich SUSY program beyond the limits from previous collider experiments

- New results and updates are already in the pipeline to be shown in upcoming conferences!

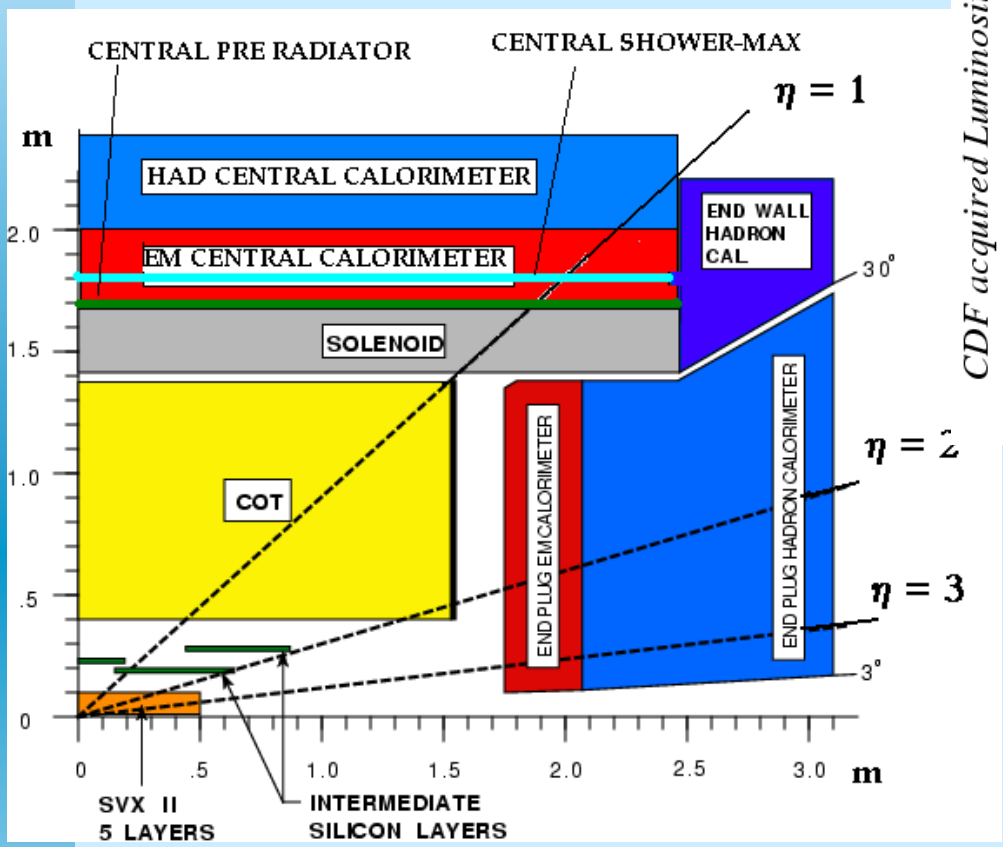
.. and this is just the beginning ...

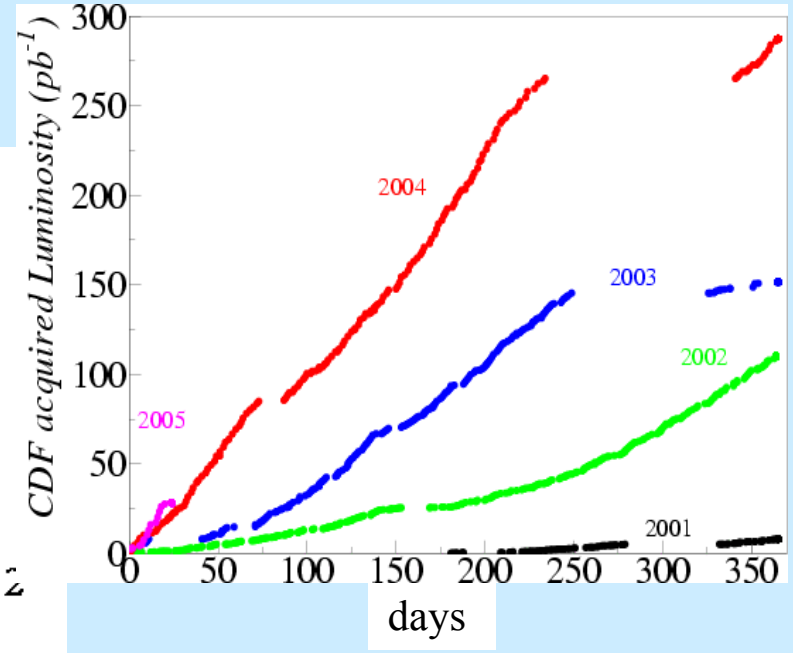
More data is on the way, almost 500 pb^{-1} for 2005

➡ Lots of room to make discoveries before LHC

Backup

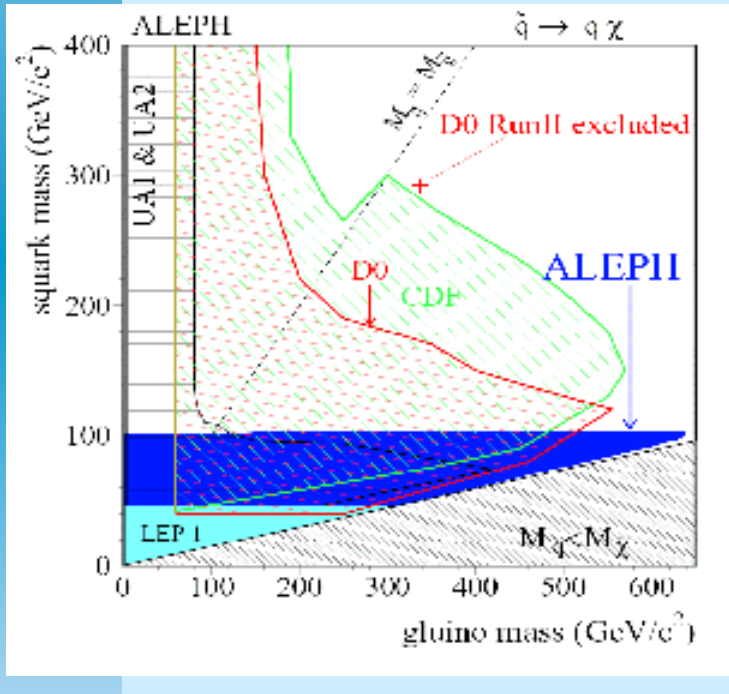
Detector backup

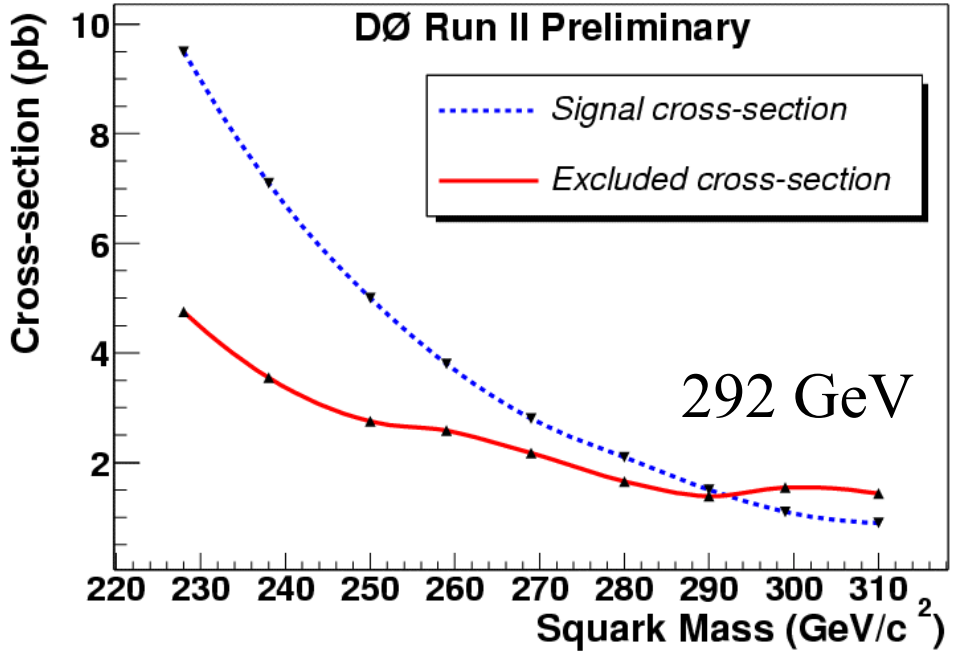




	Electrons	Muons
D0	$\|\eta\| < 3.0$	$\|\eta\| < 2.0$ (trigger: < 2.0)
CDF	$\|\eta\| < 3.0$	$\|\eta\| < 1.5$ (trigger: < 1.0)

Squark-gluino backup





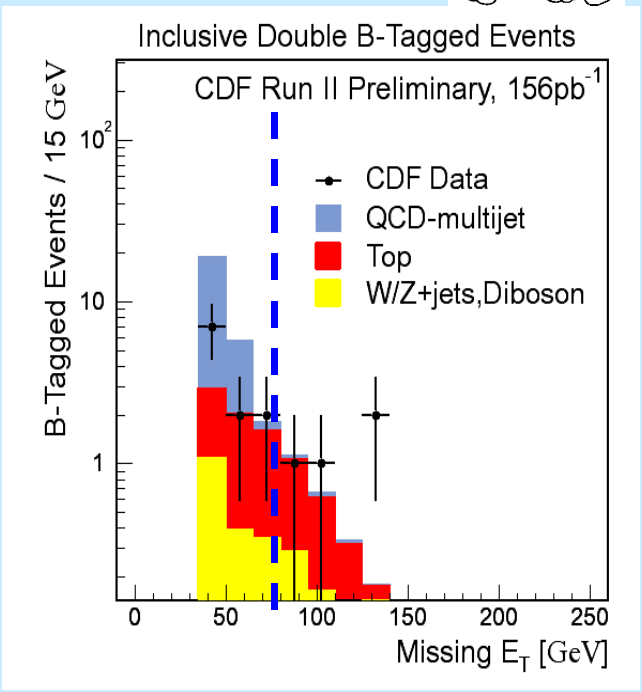
gluino-sbottom backup

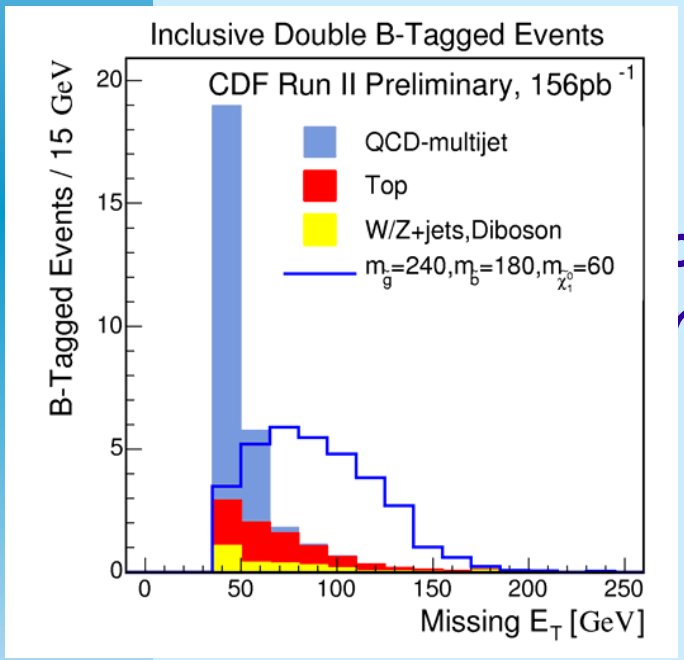
Analysis uses: $\not\!\!E_T \geq 80$ GeV

≥ 3 jets with ≥ 15 GeV

$\Delta\varphi(E_T,\text{jets})>40^o$

Veto leptons

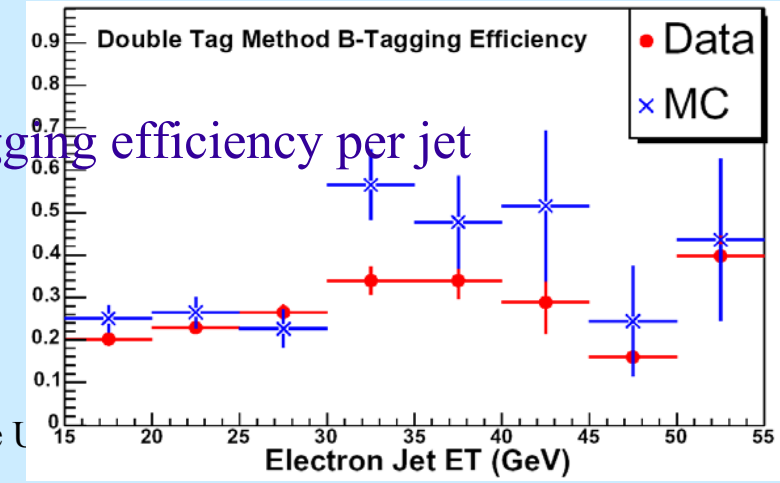




pect 28.6

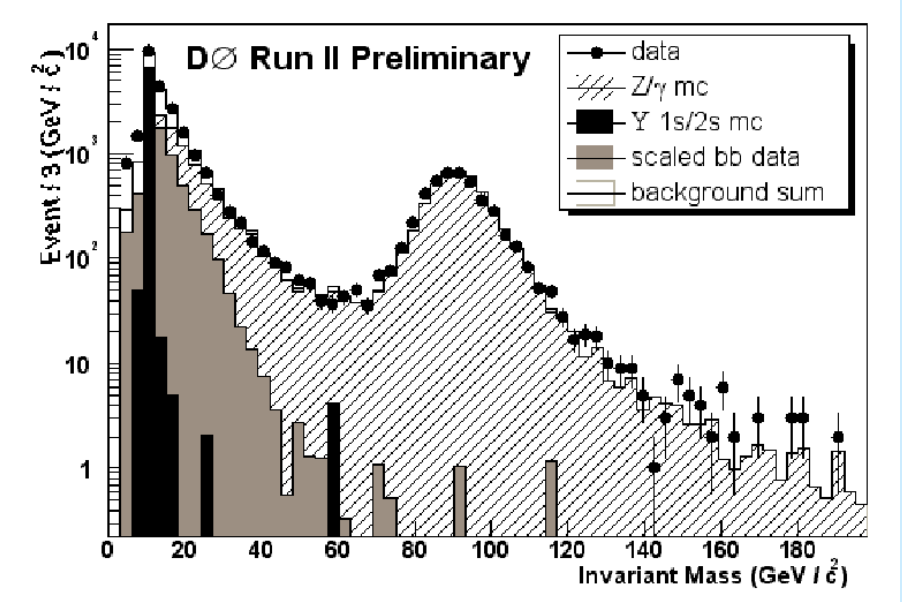
nal events

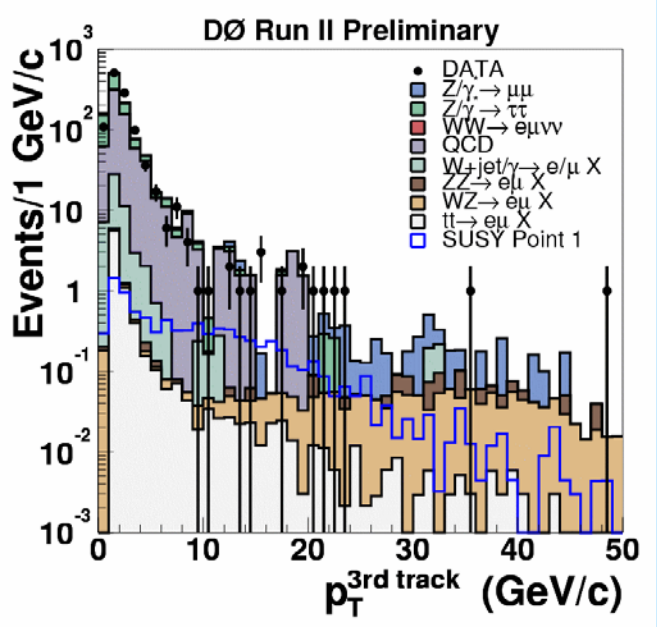
B-tagging efficiency per jet

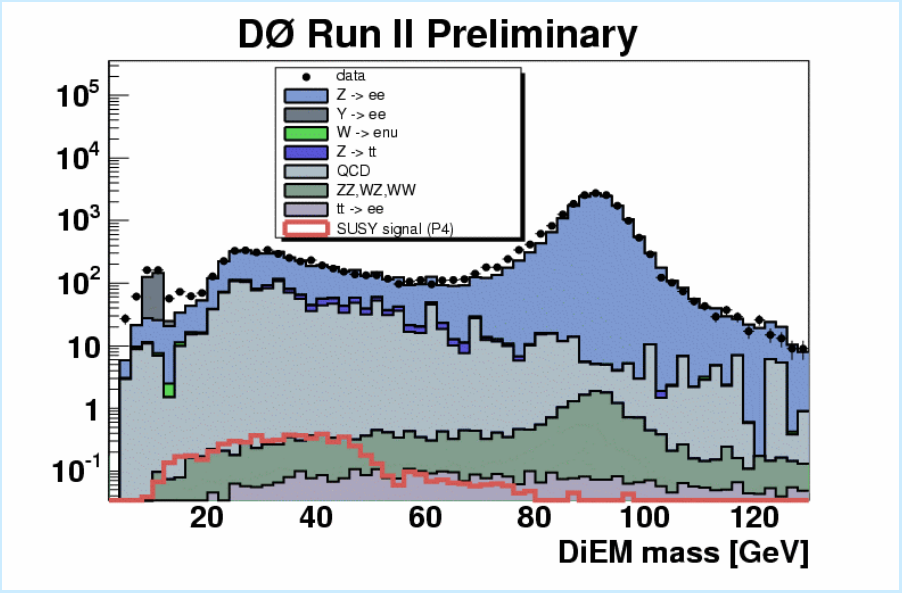


Backgrounds: QCD, tt, W/Z+jets, dibosons

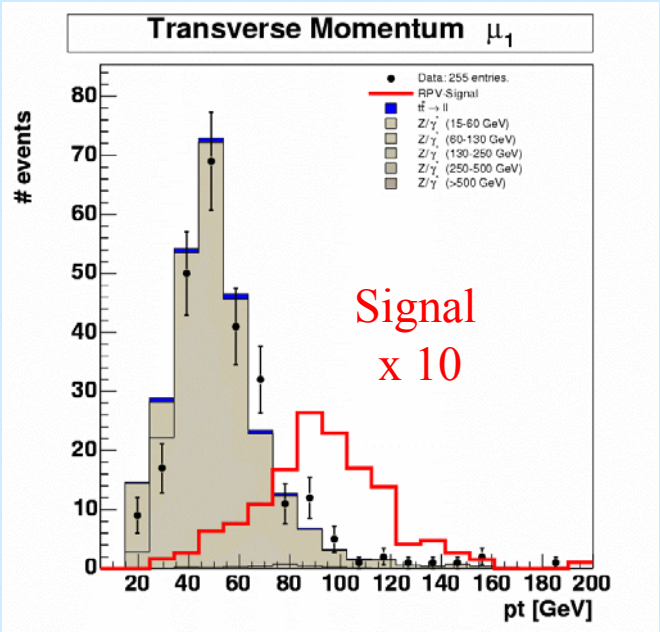
Trilepton Backup

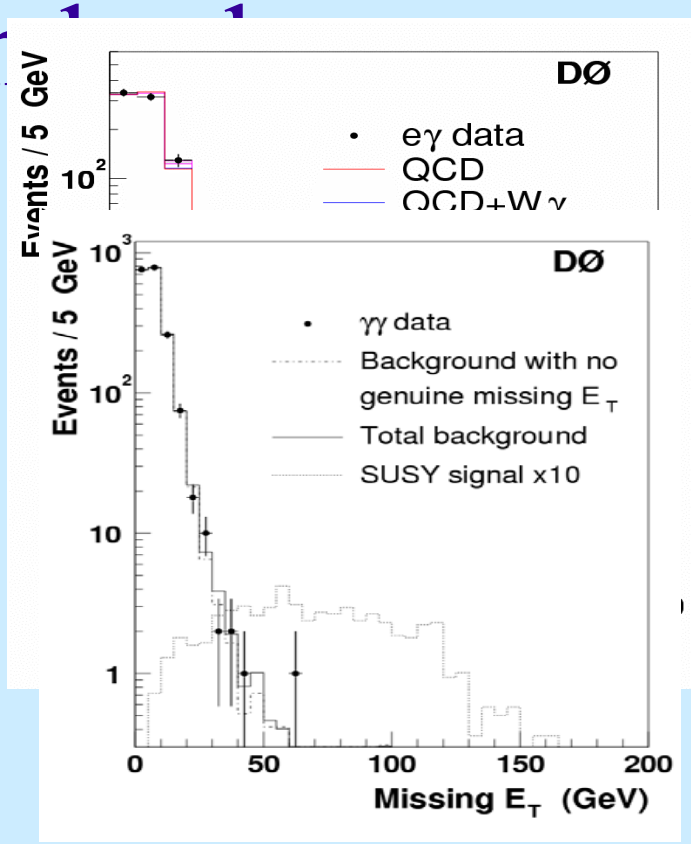




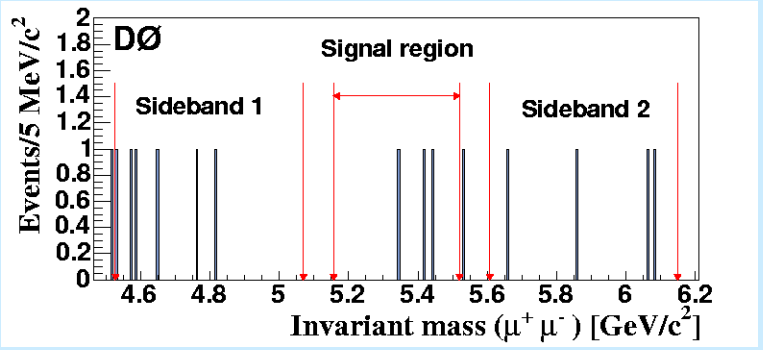


Diphoton + Smuon





Run II $B_s \rightarrow \mu\mu$



CDF: (171 pb^{-1})

$c\tau > 200\ \mu m$

$\Delta\varphi(B_s, \text{vertex}) < 0.1$ rad

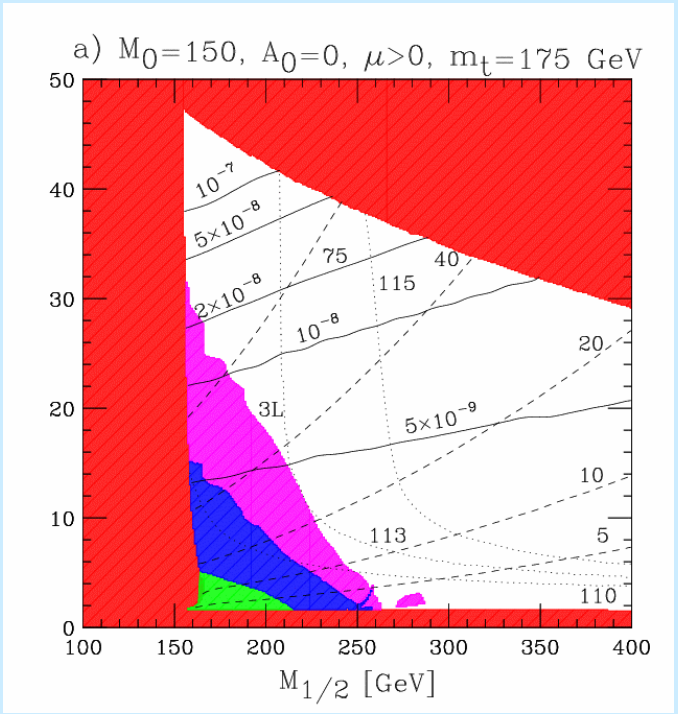
mass window: 3σ

D0: (240 pb^{-1})

$L_{xy}/\delta L_{xy} > 18.47$

$\Delta\varphi(B_s, \text{vertex}) < 0.2$ rad

mass window: 2σ



	B_s	
CDF	$< 5.8 \cdot 10^{-7}$	$1.5 \cdot 10^{-7}$ (90% CL)
D0 (240 pb^{-1})	$< 3.8 \cdot 10^{-7}$	
Combined:	$< 2.7 \cdot 10^{-7}$ @ 90% CL	

Stop to tau b backup