SUSY Searches at the TeVatron

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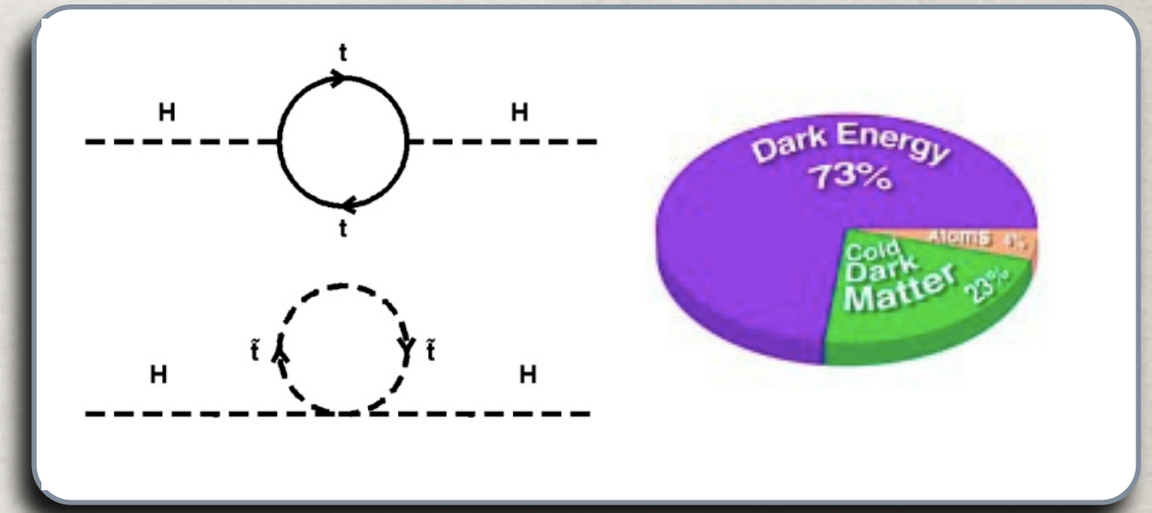
Valencia Spain, on behalf of the CDF and DØ Collaborations

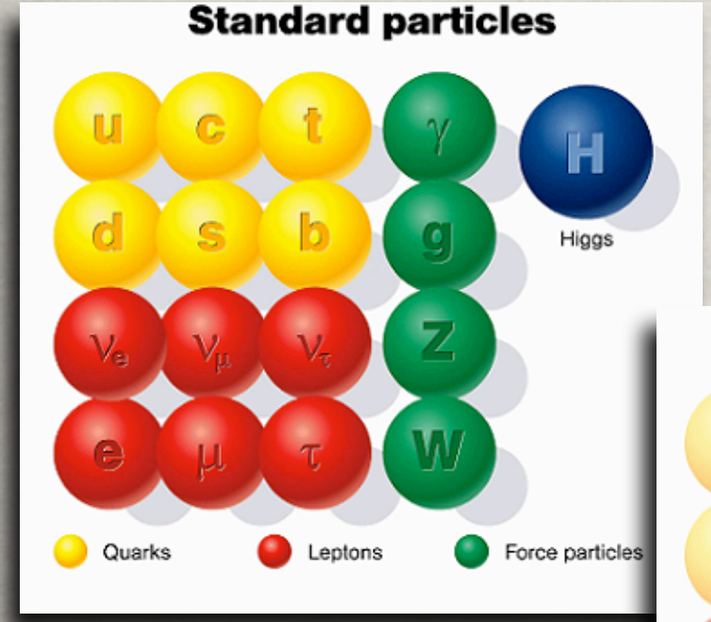
Outline

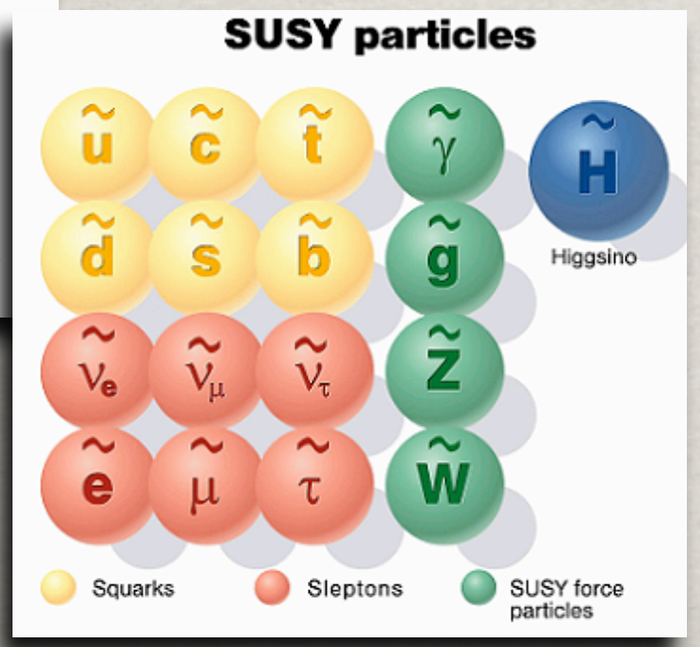
- Introduction
  - SUSY
  - Tevatron (CDF/DØ)
- mSUGRA
  - Chargino/Neutralino in Trilepton Final State
  - Squarks and Gluinos in MET + jets
- MSSM
  - Sbottom Pair Production
  - Stop Pair Production
- GMSB Di-photon
- Hidden Valley Dark Photon
- R_P Violation (RPV) Tau Sneutrino
- Summary

Introduction: SUSY

- Standard Model (SM) is good, but seems incomplete.
  - Requires fine tuning, doesn't account for the dark energy/matter



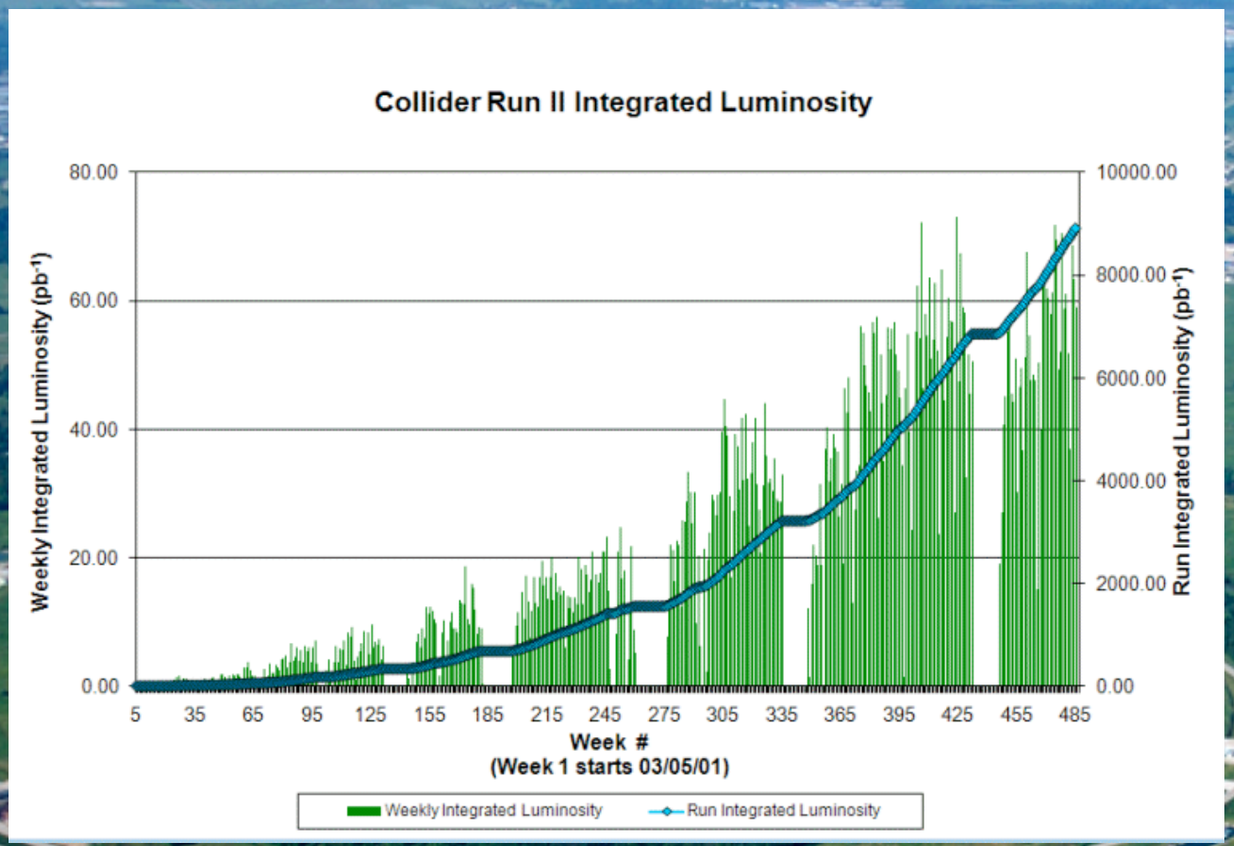




- Supersymmetry (SUSY)
  - Symmetry relating fermions and bosons
  - Lessens the hierarchy problem
  - Provides an excellent dark matter candidate

Tevatron At FNAL

Tevatron At FNAL

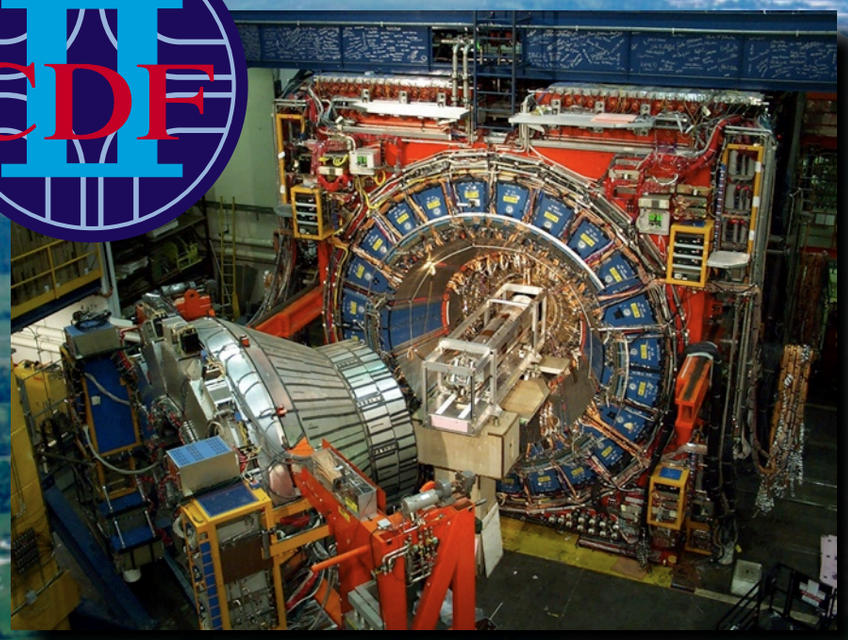


Tevatron is performing excellently

- Proton-AntiProton Collisions at $\sqrt{s}$ = 1.96 TeV
- Integrated Luminosity of ~9 fb^{-1}
- Expect ~12 fb^{-1} by 2011

Special thanks to the Accel. Division

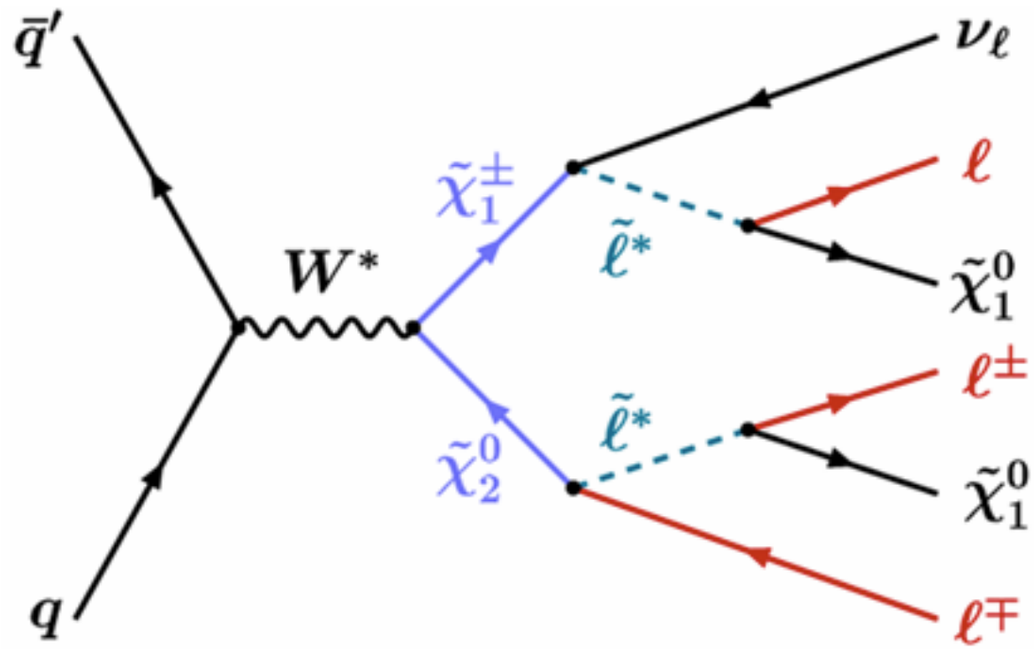
Tevatron At FNAL



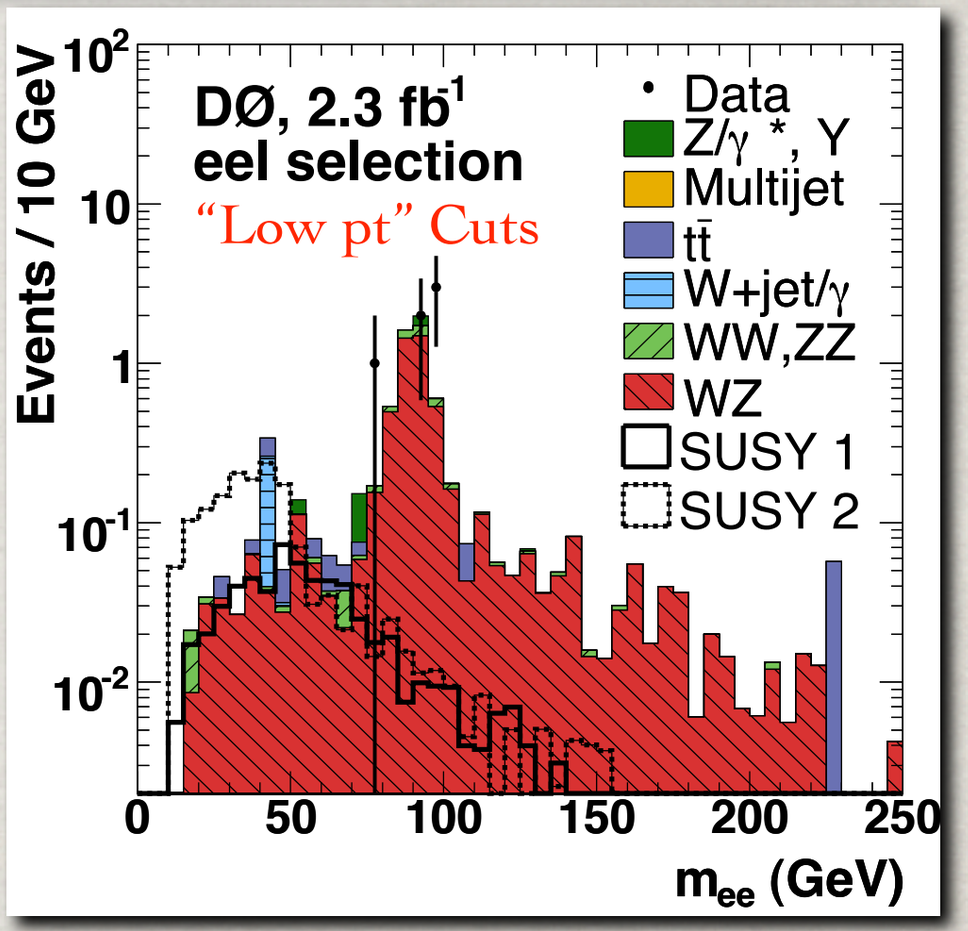
- General Purpose Detectors
  - Central Tracker
  - Calorimetry (EM & Had)
  - Muon System

Chargino/Neutralino

Three isolated leptons+MET



Small SM Bkgd, 3rd Lep. Low pt



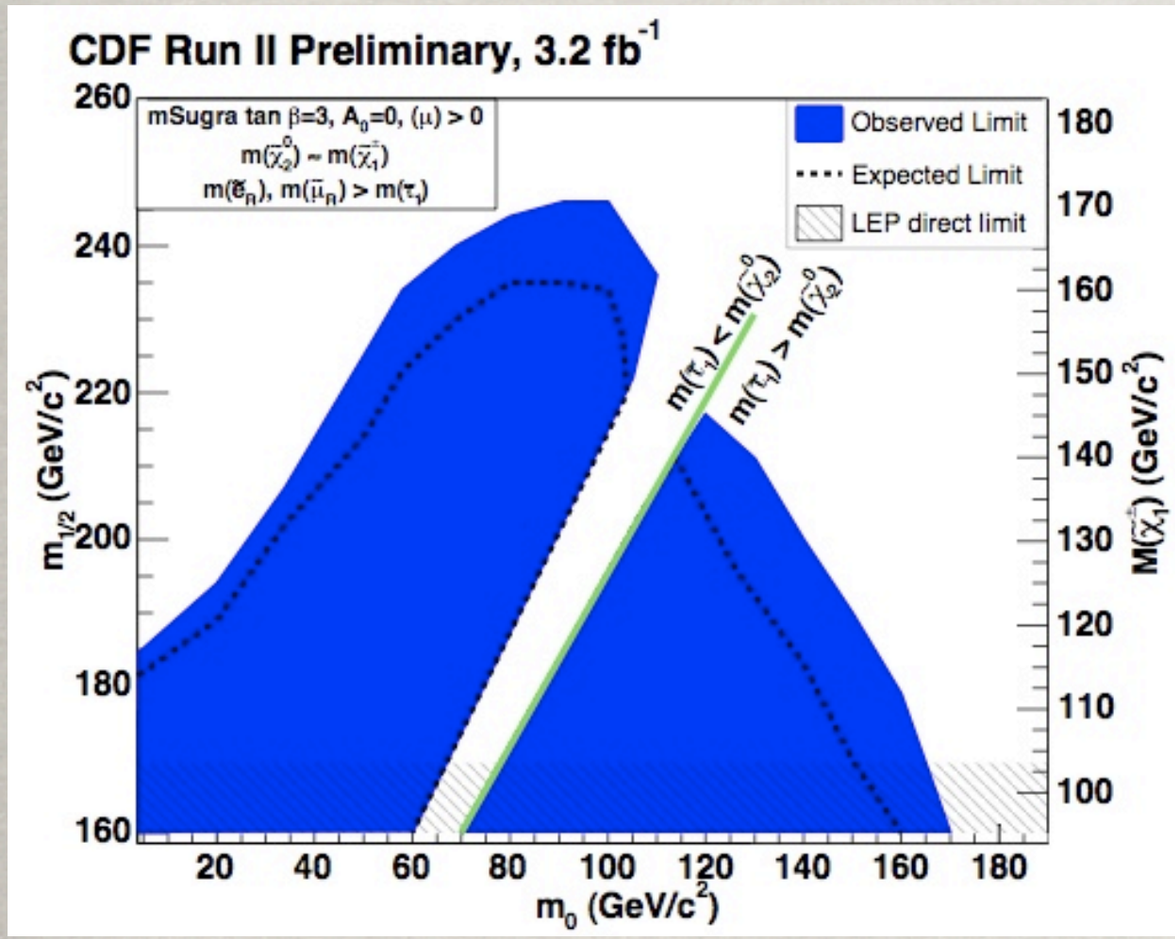
Optimize signal/background in mSUGRA

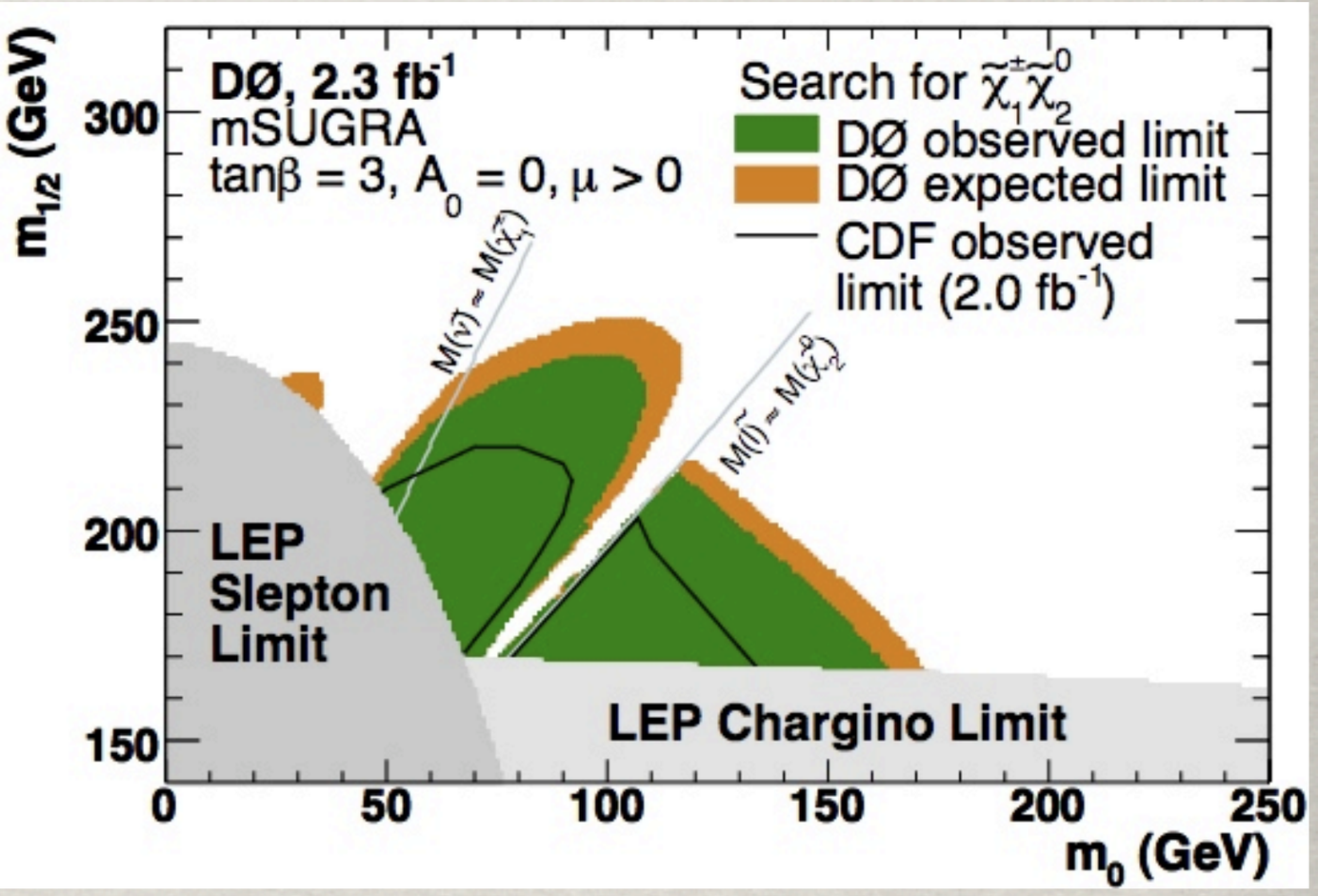
- Assign by quality (tight(t)/loose(l)/track(T))
  - Optimized for purity (ie ttt,ttl...)
  - 5 exclusive channels
- Identified leptons e/μ (no τ)
- Assign by lepton type (e/μ), plus track (T)
  - Also μτ+T and μττ(had. decay)
  - 5 exclusive channels
- Optimized cuts for "low-pt" and "high-pt"

Channel	SM Expectation	Data
trileptons	1.5±0.2	1
dileptons+track	9.4±1.4	6

Channel	SM Expectation	Data
Low p_T	5.4±0.6	9
High p_T	3.3±0.4	4

Trilepton Summary





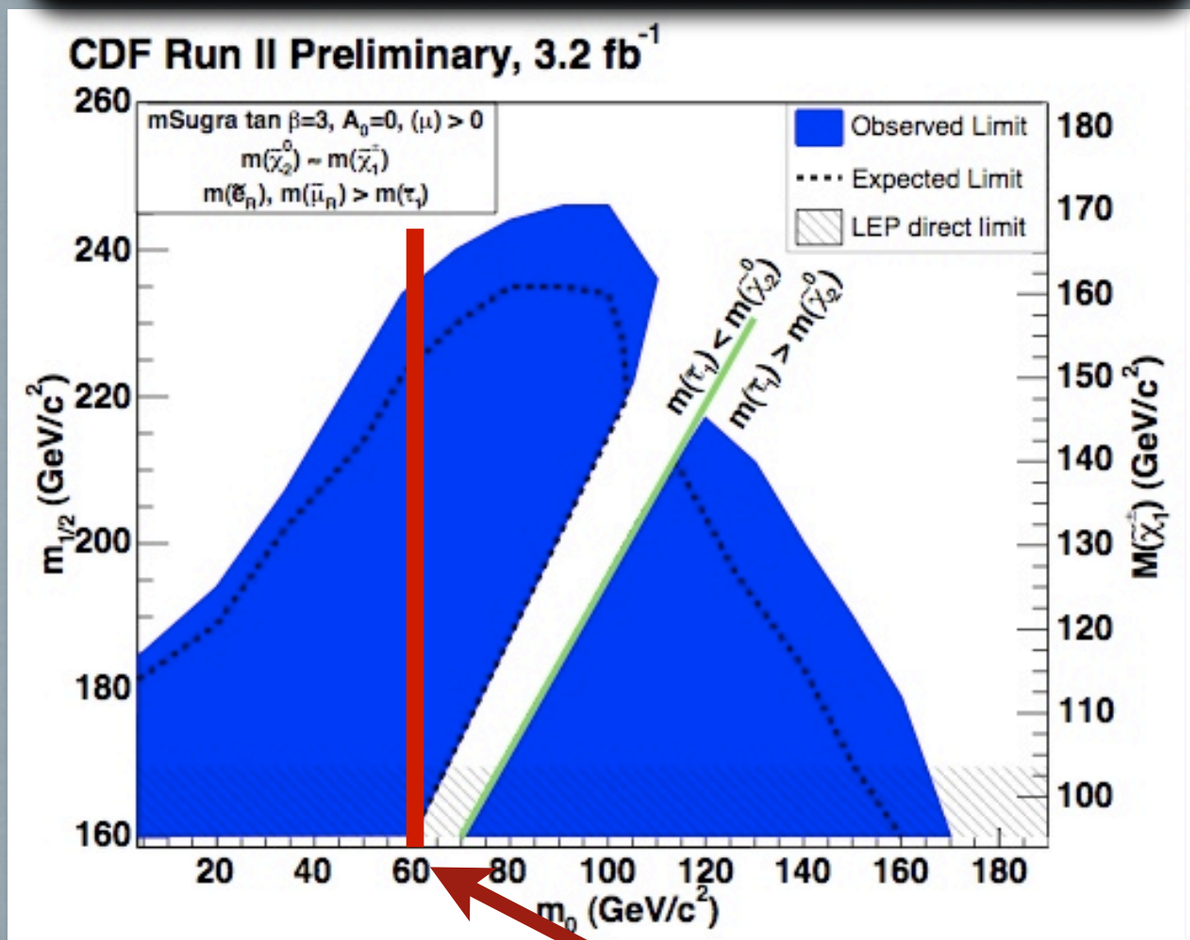
mSUGRA

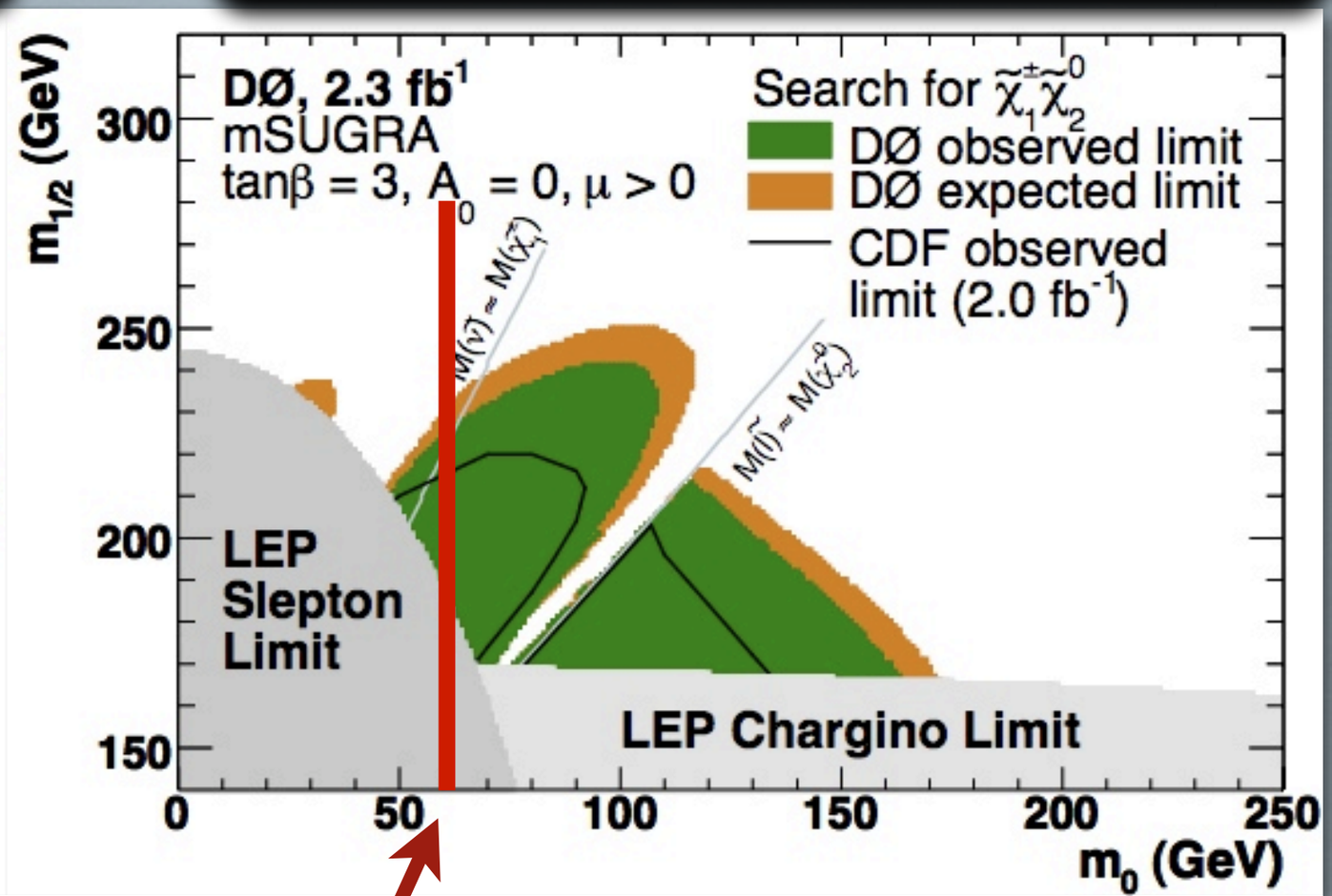
- Benchmark Scenario: $\tan(\beta)=3$, $A_0=0$, $\mu>0$
- Above is the excluded region in $m_{1/2}$-m_0 space.
- Limits depend on neutralino-slepton mass difference.

Tevatron Summary

Constrain $m_{chargino}$ > 164 GeV
CDF(2.6 fb-1) [PRL 101 (2008) 251801]

Constrain $m_{chargino}$ > 155 GeV
DØ(2.3 fb-1) [PLB 680 (2009) 34]

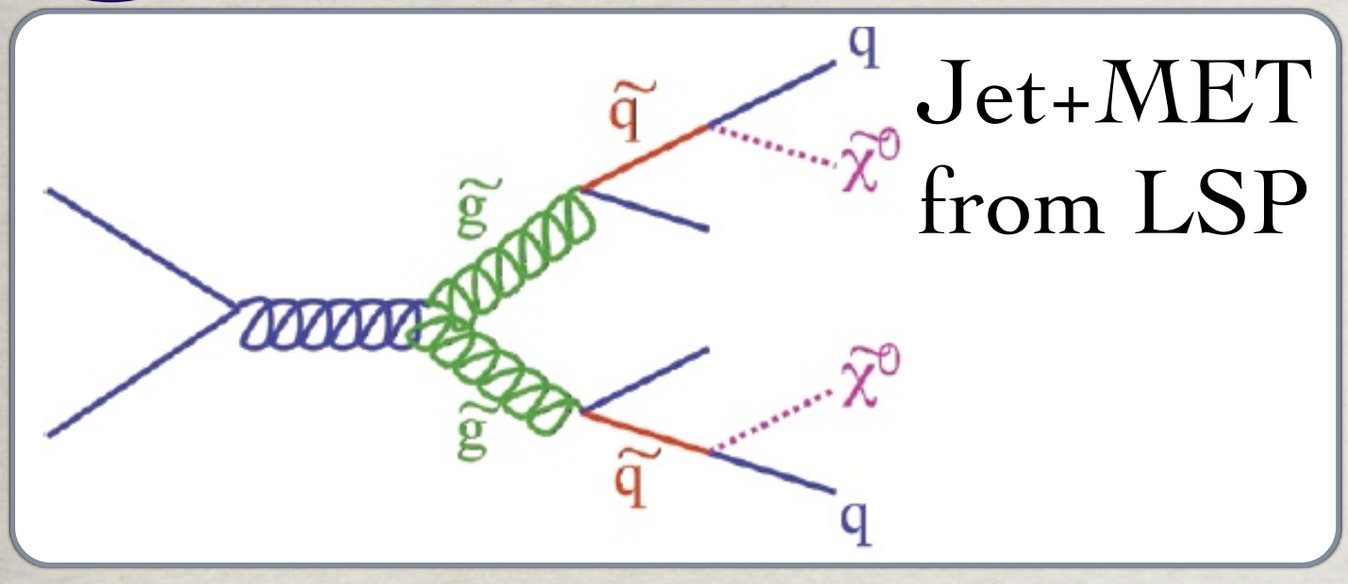




- Benchmar… …μ>0
- Above is t… …space.
- Limits dep… …lass difference.

Limits at the mSUGRA test point:
m_0=60, tanβ=3, A_0=0, μ>0

Squarks and Gluinos



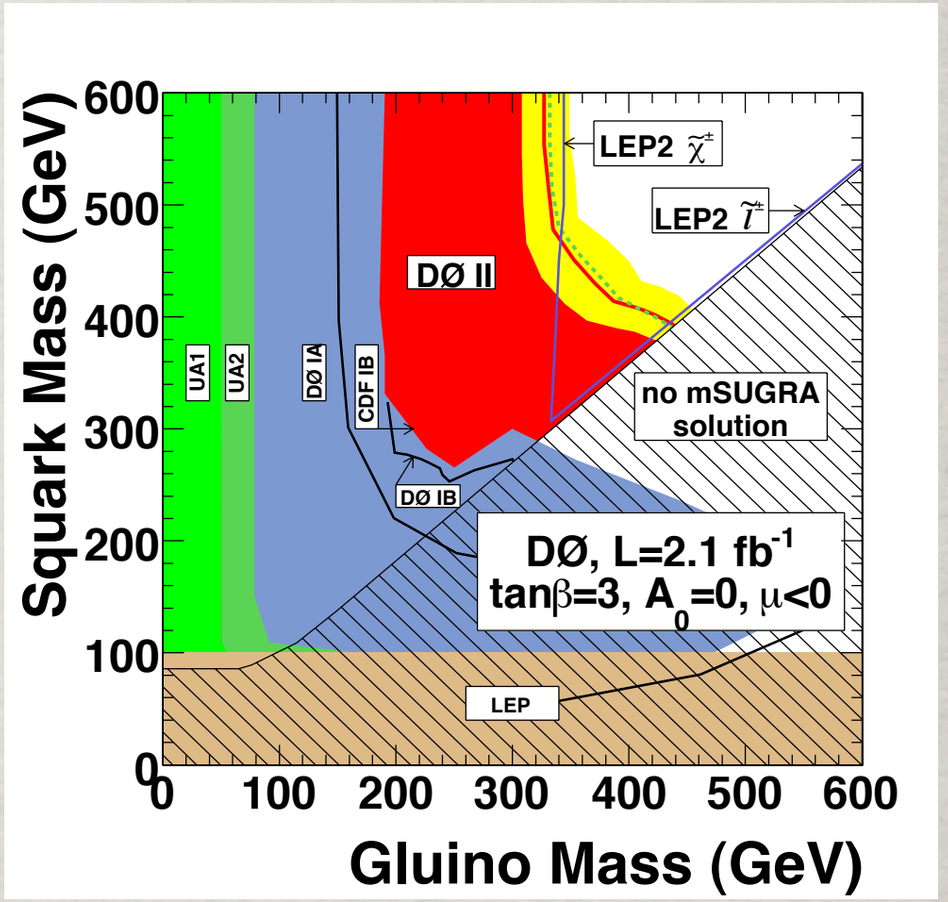
Jet+MET from LSP

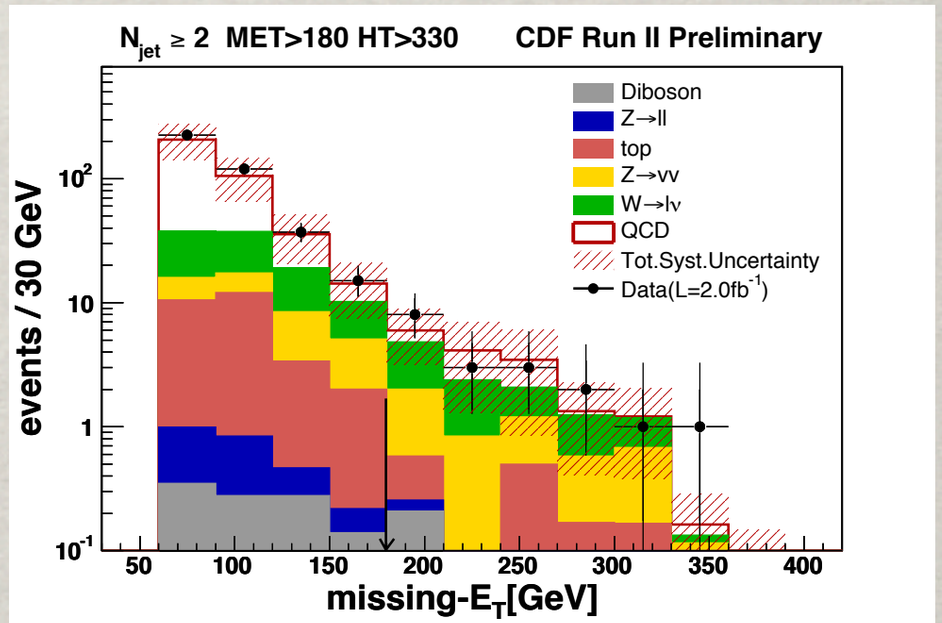
- mSUGRA scenario with R_P conserved, and degenerate squark masses (stop production not considered).
- Searches performed separately in 2jet, 3jet and 4jet final states.

95% C.L.	D0	CDF
$m(\tilde{g})$~$m(\tilde{q})$	$m(\tilde{q}/\tilde{g})$ > 390 GeV	$m(\tilde{q}/\tilde{g})$ > 390 GeV
Any $m(\tilde{g})$	$m(\tilde{q})$ > 308 GeV	$m(\tilde{q})$ > 280 GeV
Any $m(\tilde{q})$	$m(\tilde{g})$ > 379 GeV	$m(\tilde{g})$ > 340 GeV

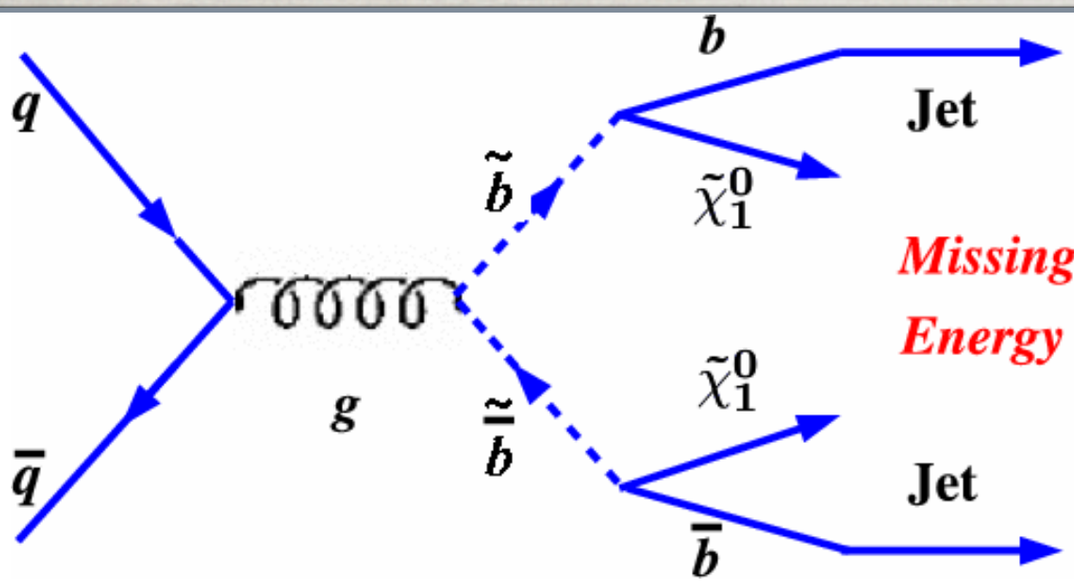
DØ(2.1 fb-1) [PLB 660 (2008) 449]

CDF (2.0 fb-1) [PRL 102 (2009) 121801]





Sbottom Pair Production



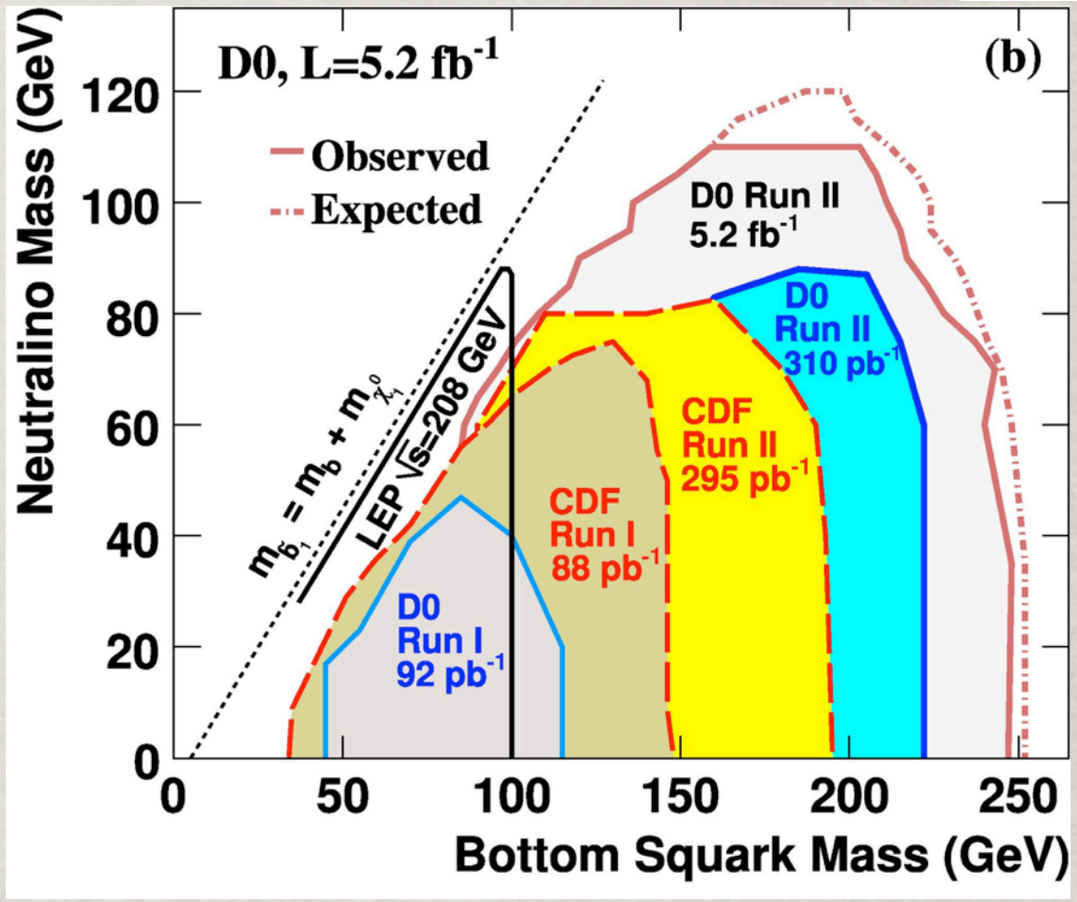
$B.R.(\tilde{b} \to b\ \tilde{\chi}_1^0) = 100\%$: $\tilde{\chi}_1^0 = LSP$

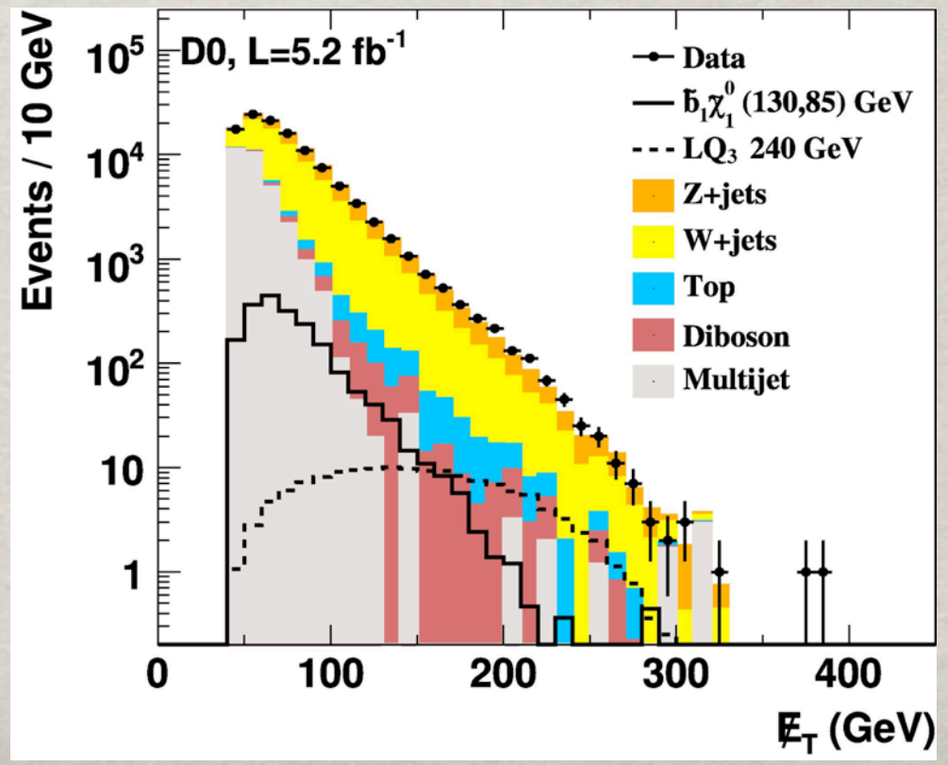
- MSSM Model: Final state with 2 or 3 jets + MET.
- NN b-tagging on the 2 leading jets.
- Background dominated by QCD and mistag events
- Good agreement between observed DATA and expected SM.

With 5.2 fb^{-1} constrain (massless LSP)

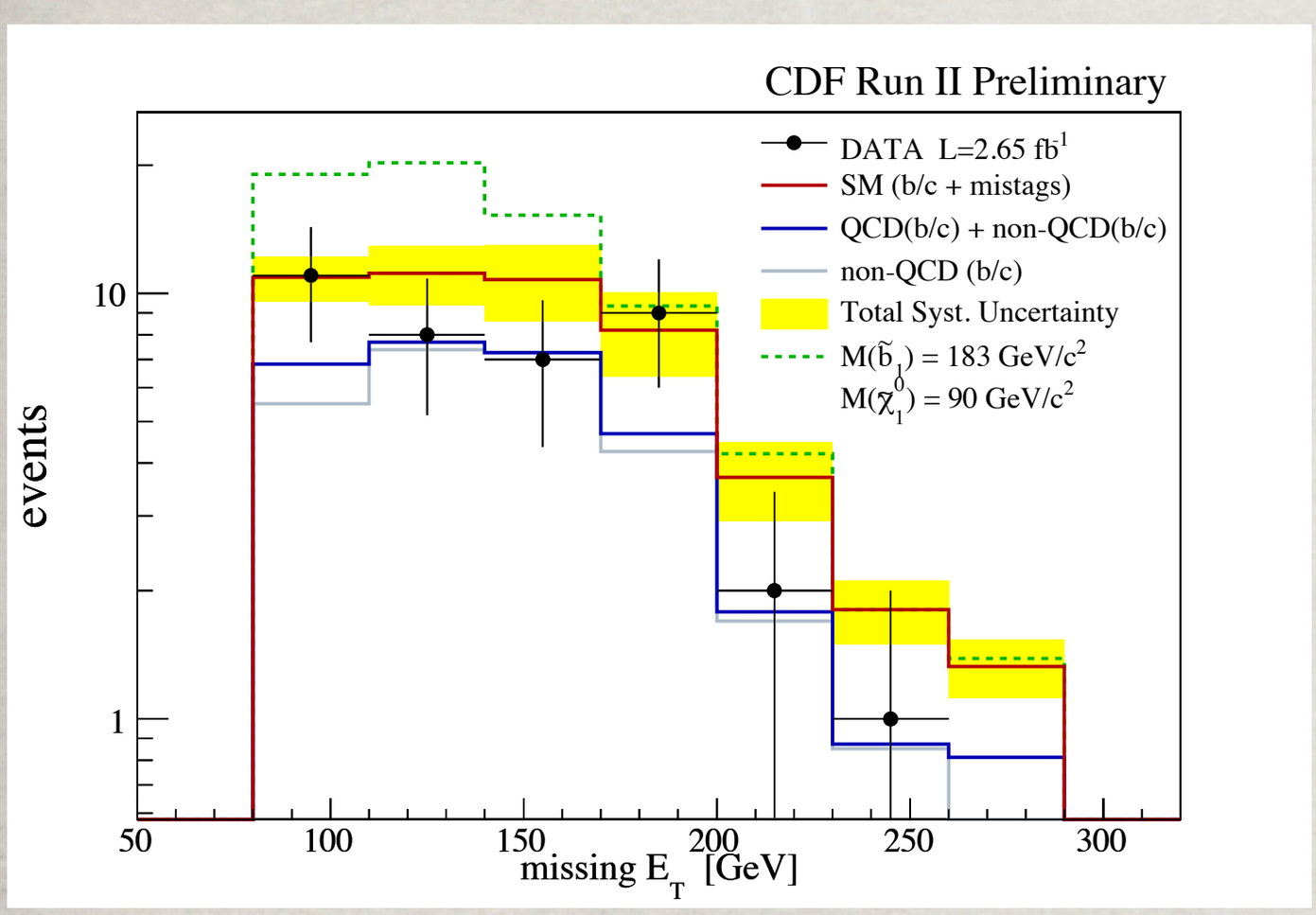
$m_{sbottom} > 247$ GeV

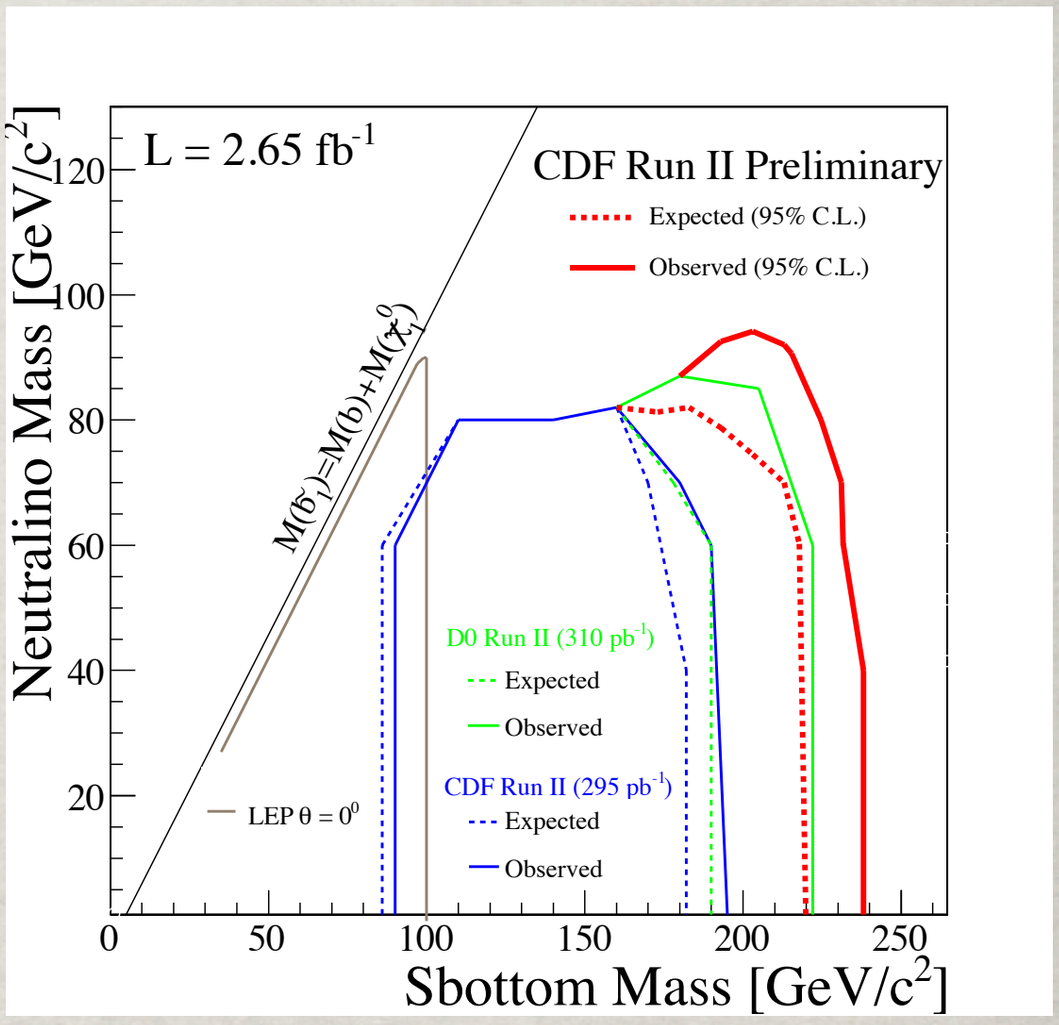
DØ(5.2 fb-1) [arXiv: 1005:2222]





Sbottom Pair Production





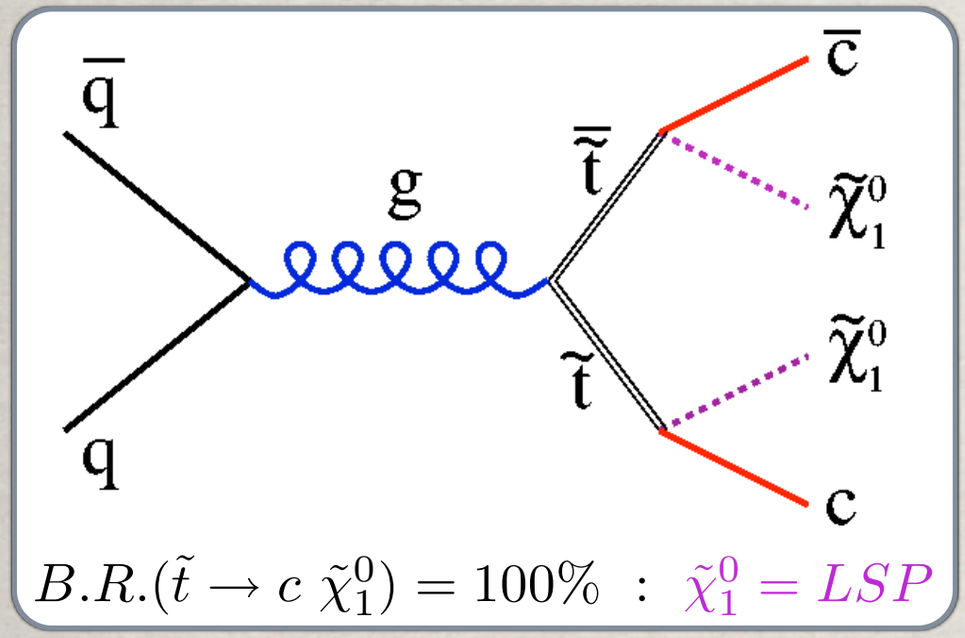
- 2 jets + MET.
- At least 1 jet is b-tagged.
- Two signal regions:
  $\Delta m = m(\tilde{b}) - m(\tilde{\chi}^0_1)$ scenarios:
  - Low Δm (≤ 90 GeV)
  - High Δm (> 90 GeV)

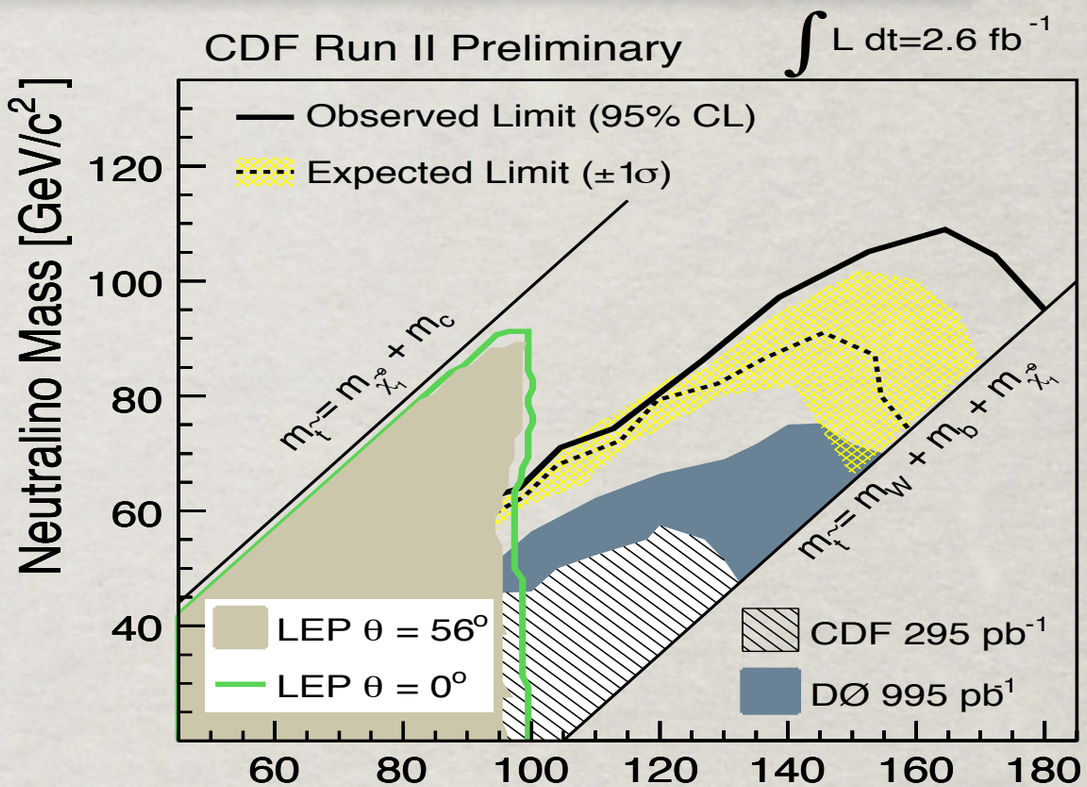
With 2.65 fb^{-1} constrain ($m_{LSP} < 80$ GeV):

$m_{sbottom} > 230$ GeV

CDF (2.65 fb-1) [arXiv: 1005.3600]

Stop Pair Production



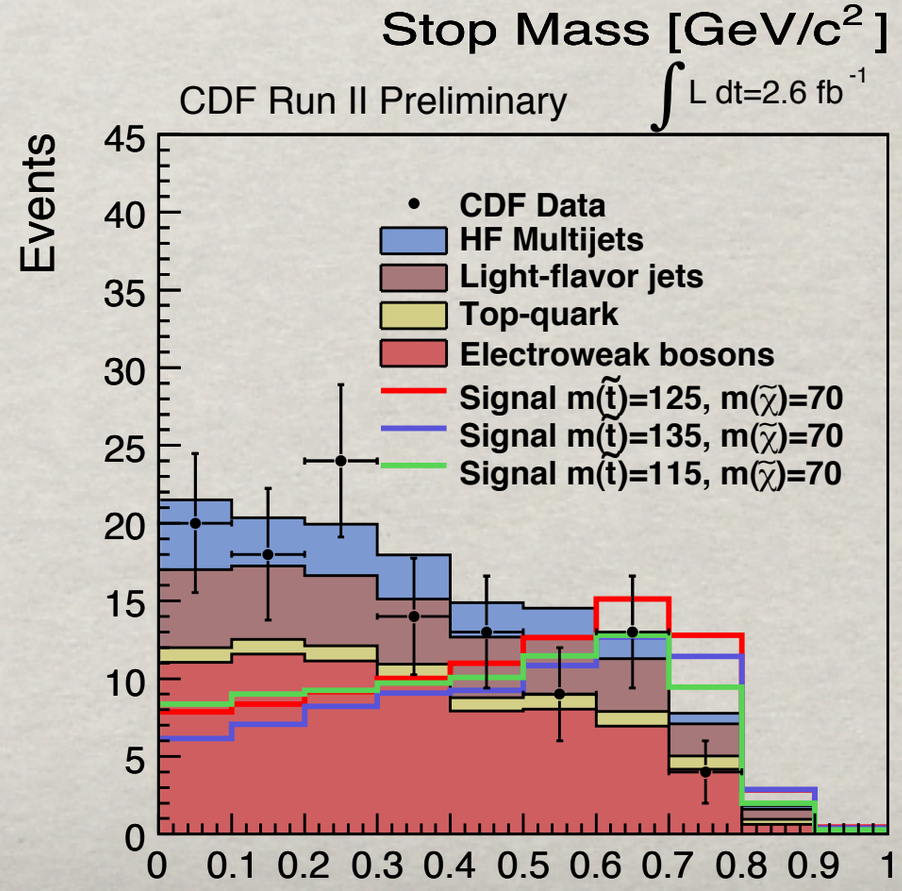


- MSSM scenario with R_P conserved
- Final state with 2jets+MET. At least one heavy flavor tag.
- NN-based flavor separator algorithm to enhance c-tagging efficiency.
- QCD and mistags from DATA
- Sensitivity optimized with NN-based selection.

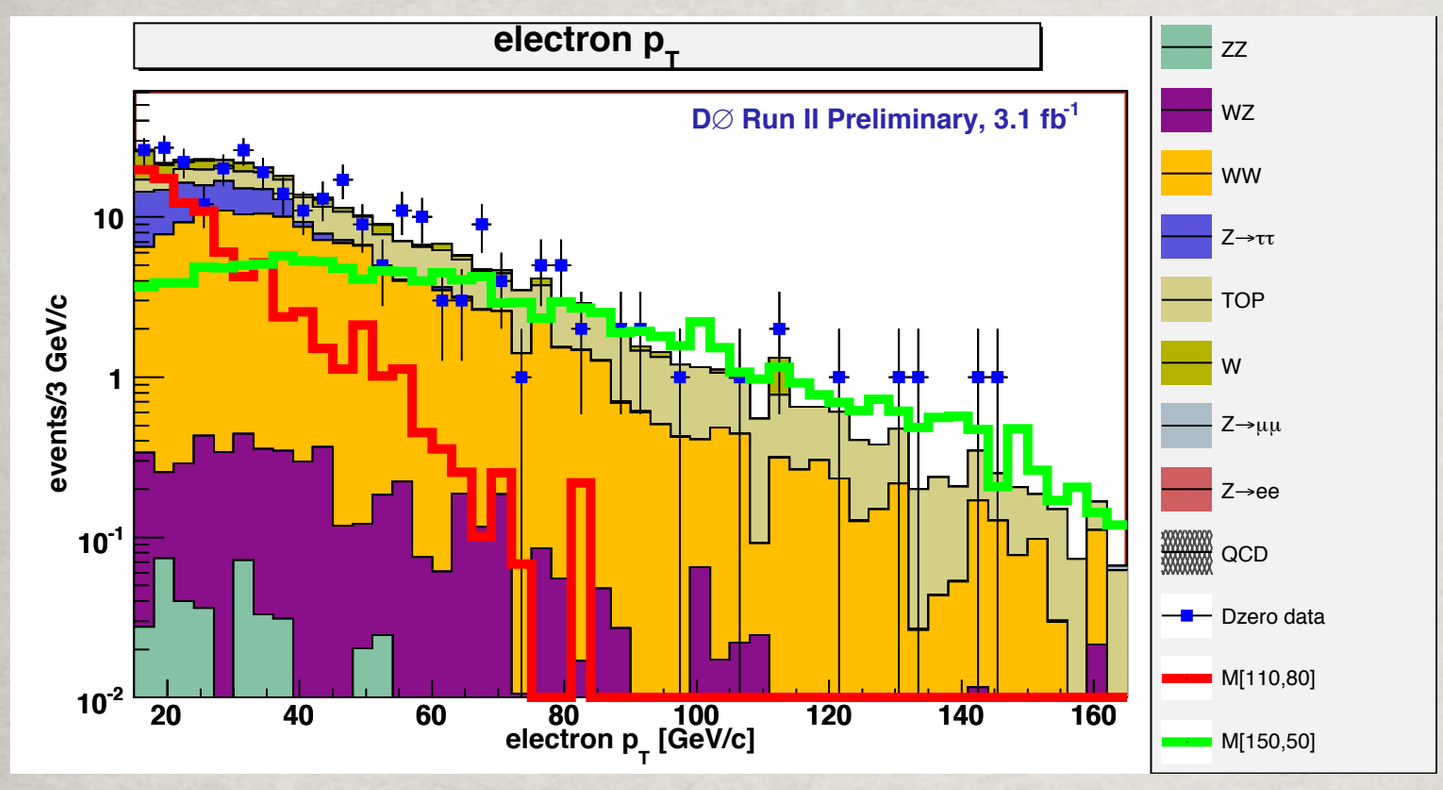
With 2.6 fb^{-1} constrain (m_{LSP} = 80 GeV):

$m_{stop} > 180$ GeV

DØ(1 fb-1) [PLB 665 (2008) 1]



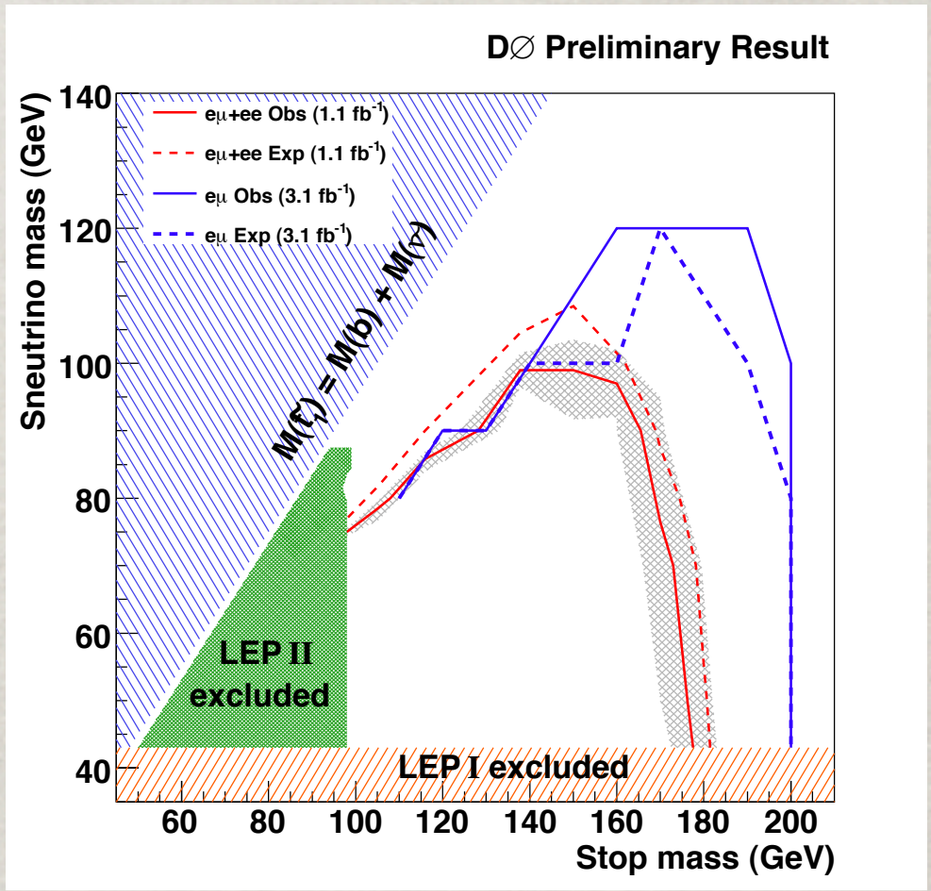
Stop Pair Production



$$\text{MSSM: } R_P \text{ Conserved}$$

$$B.R.(\tilde{t} \rightarrow b\ \tilde{\nu} l^{\pm}) = 100\%$$

$$\tilde{\nu} = LSP$$

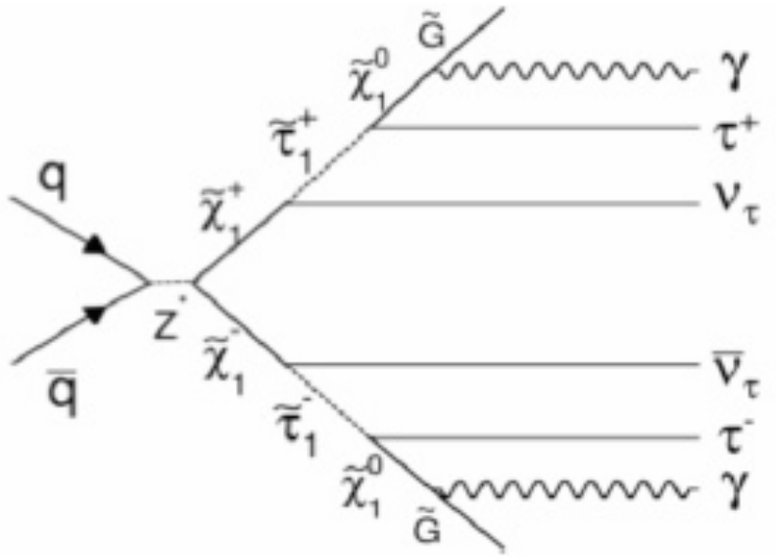


- Final state with one electron and one muon (opposite charge) and MET.
- No minimum number of jets required.
- QCD background from DATA
- Selection optimized for large and small $\Delta m = m_{\tilde{t}} - m_{\tilde{\nu}}$

With 3.1 fb^{-1} constrain ($m_{LSP} < 80$ GeV):

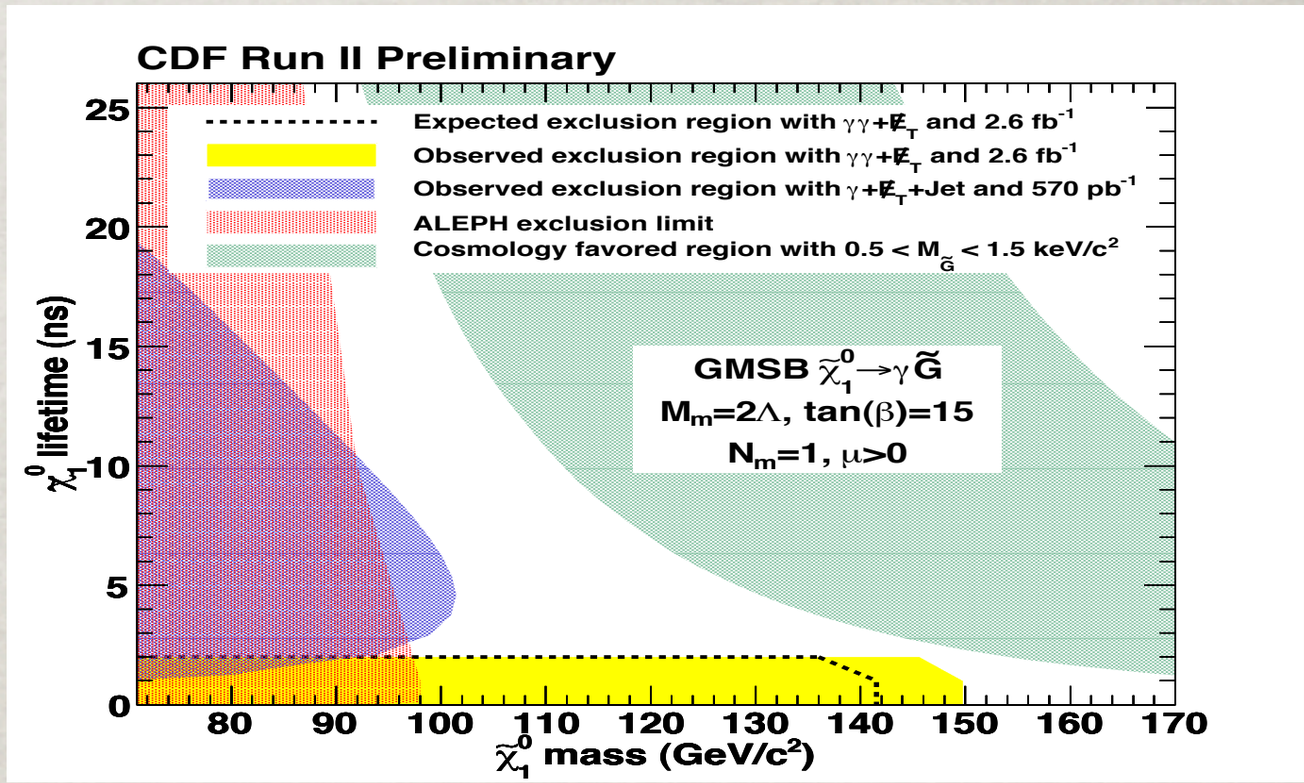
$m_{stop} > 200$ GeV

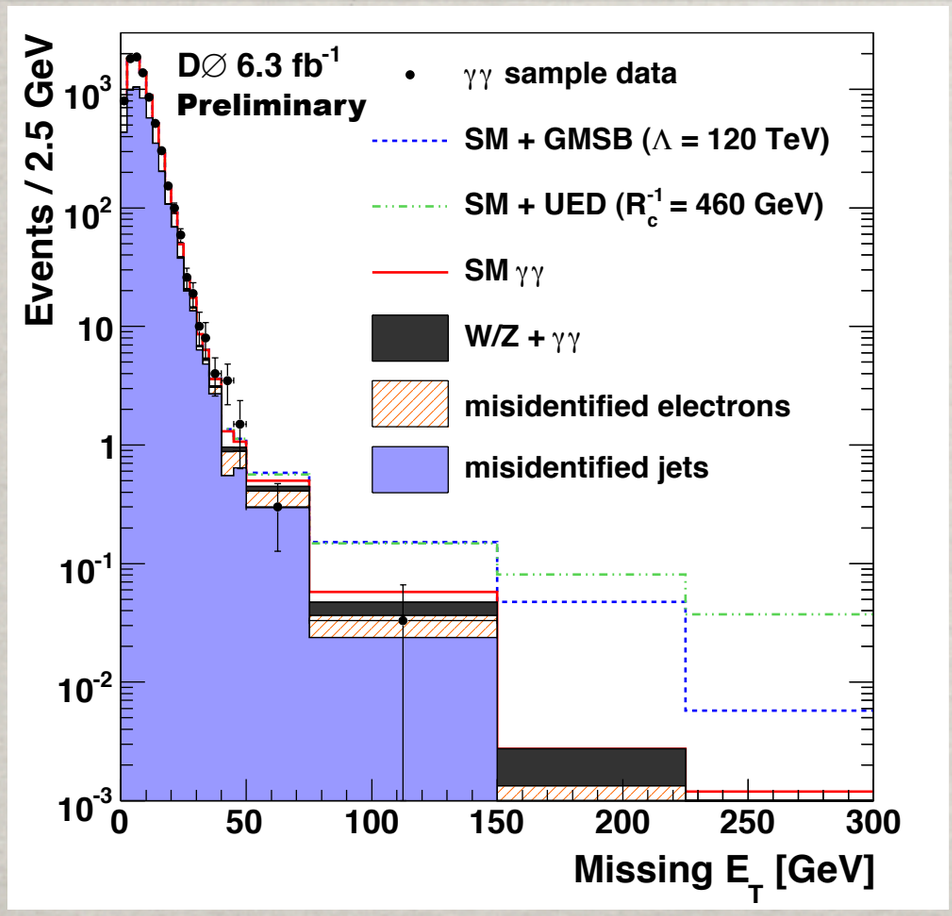
GMSB Diphoton



di-photon + MET

- GMSB, Gravitino ($\tilde{G}$) is LSP
- Gaugino pair production, with cascade decays to NLSP (neutralino) which then decays to $\tilde{G}+\gamma$





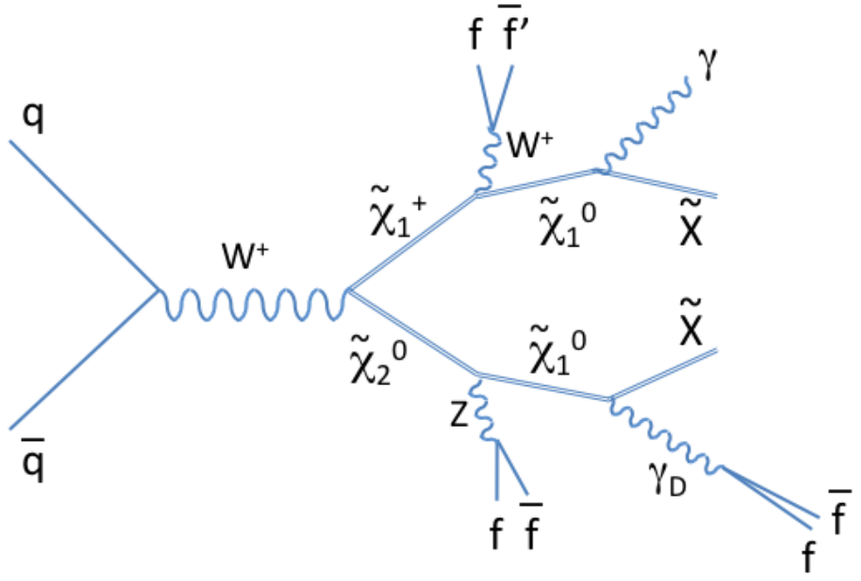
CDF (2.6 fb^{-1}) constrain $m_{neutralino} > 149$ GeV

CDF (2.6 fb-1) [PRL 104 (2010) 011801]

DØ (6.3 fb^{-1}) constrain $m_{neutralino} > 175$ GeV

DØ(1.1 fb-1) [PLB 659 (2008) 856]

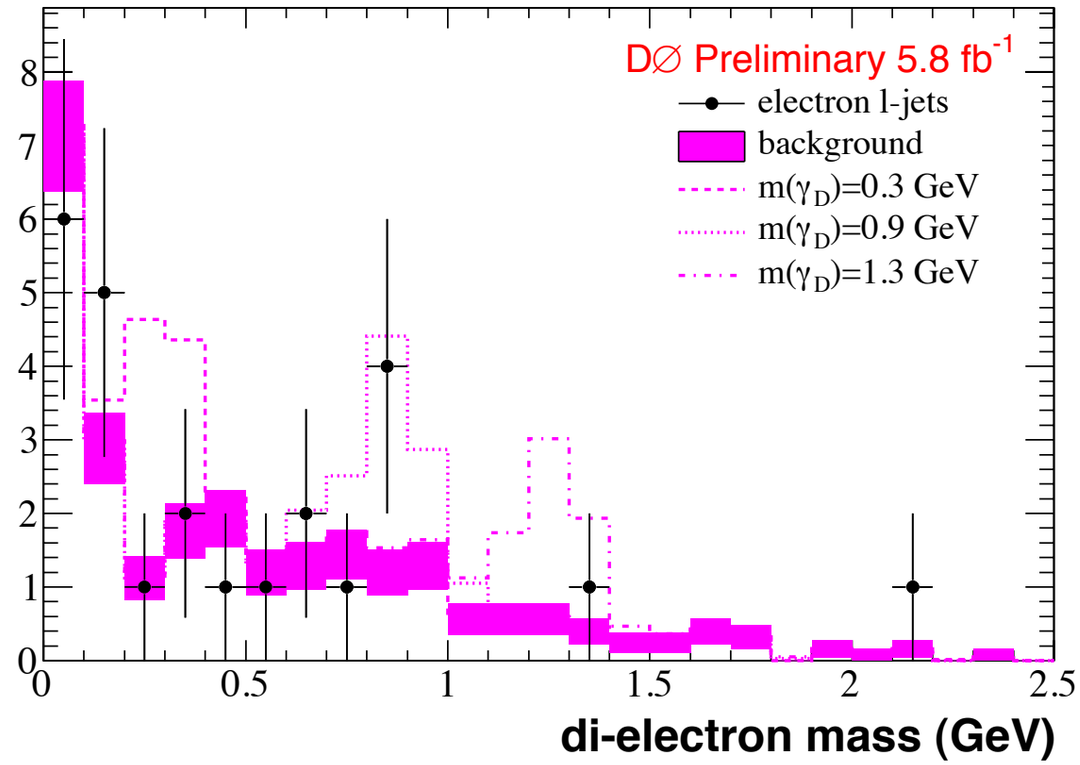
Hidden Valley Dark Photon

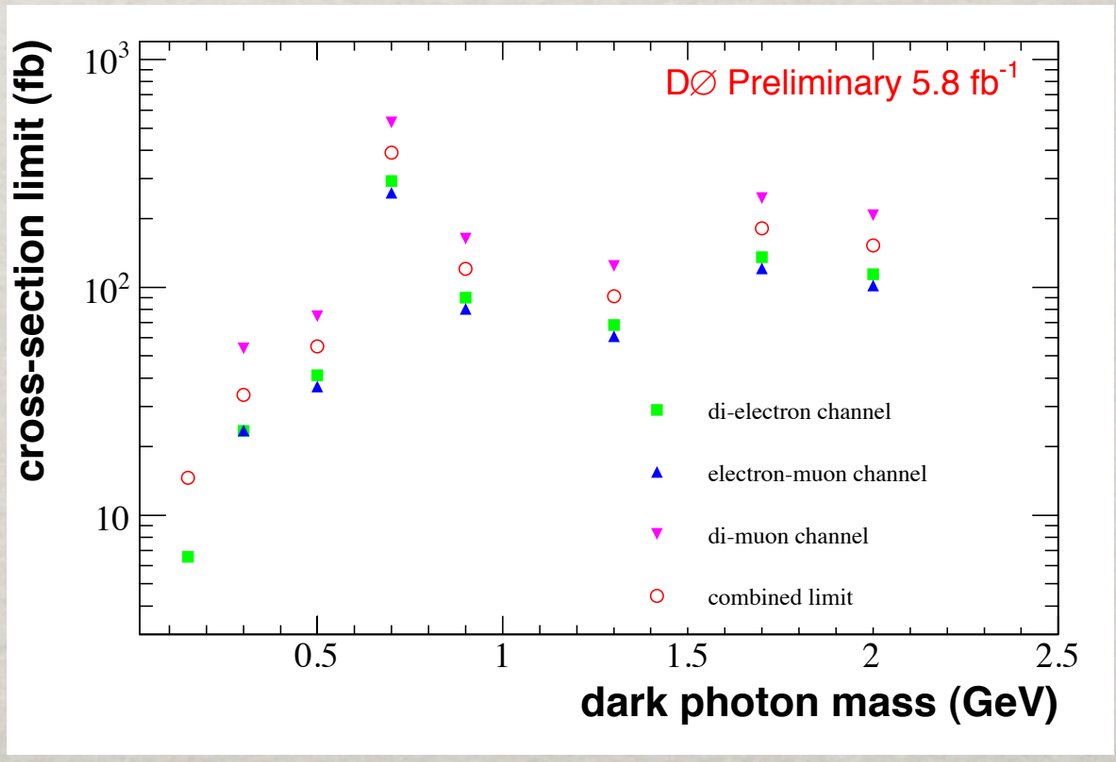


γ + MET + ee/μμ/eμ

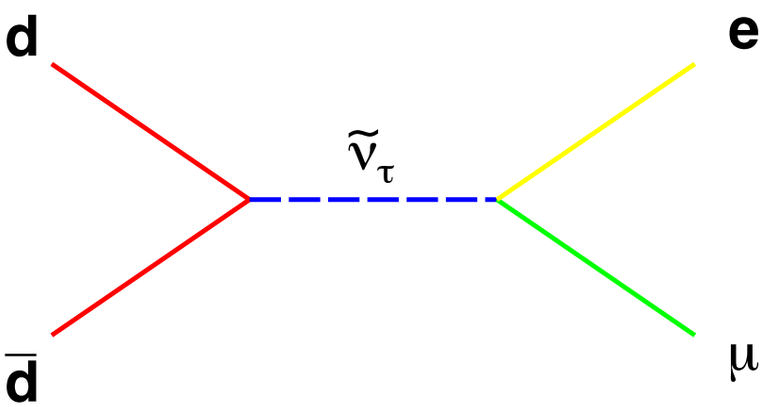
- SUSY hidden valley model assumed with production of dark photons (γ_D).
- Gaugino pair production with cascade decays to LSP
- LSP decays to hidden sector
- Signal as narrow peak in dilepton invariant mass.
- No excess seen

DØ(4.1 fb-1) [PRL 103 (2009) 081802]



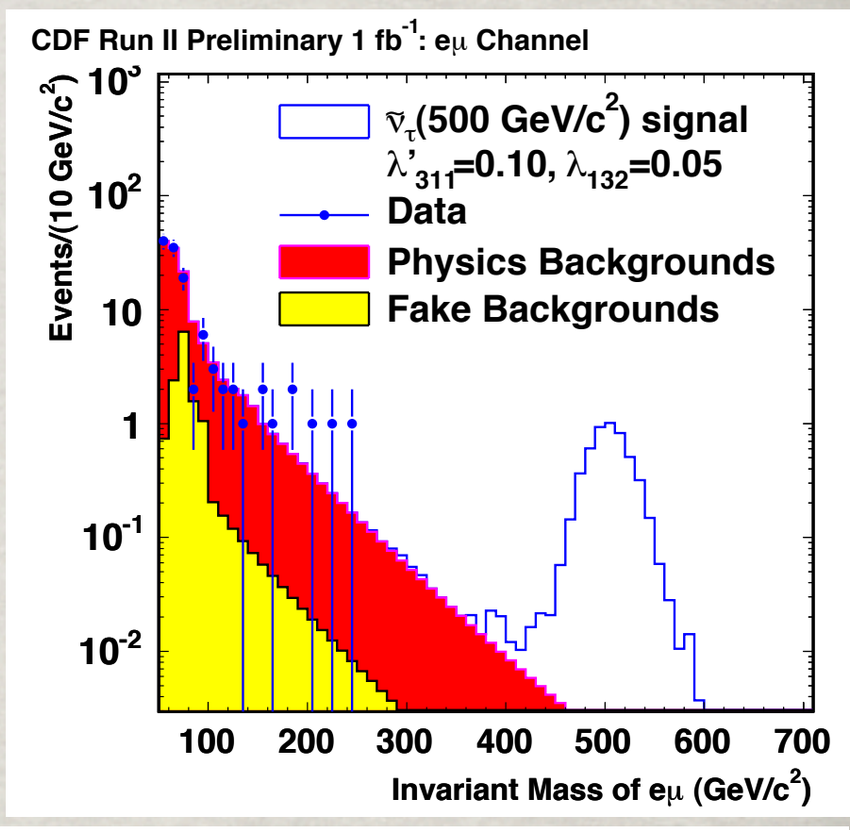


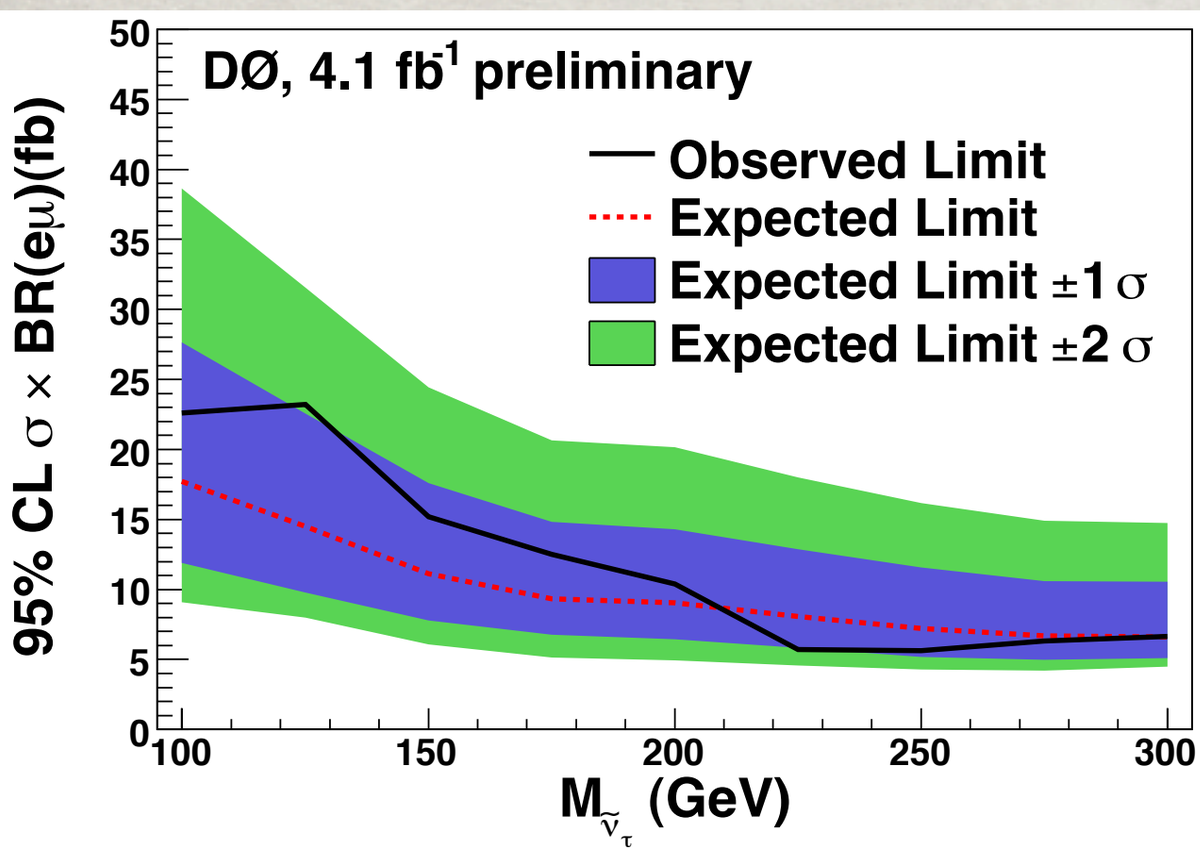
RP Violation (RPV) Tau Sneutrino

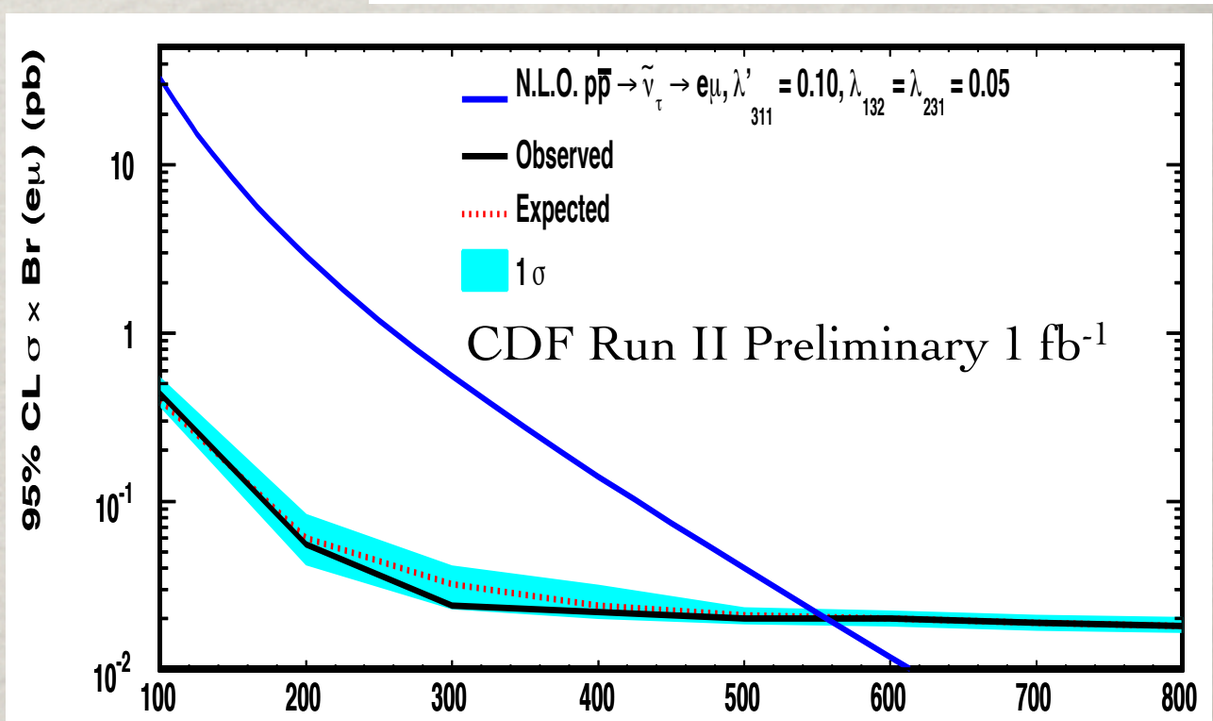


Lepton flavor violation

- R_P violation
- $\tilde{\nu}_\tau$ is the LSP decaying to leptons
- DØ: eμ
- CDF: eμ, eτ, μτ







Summary: SUSY at the Tevatron

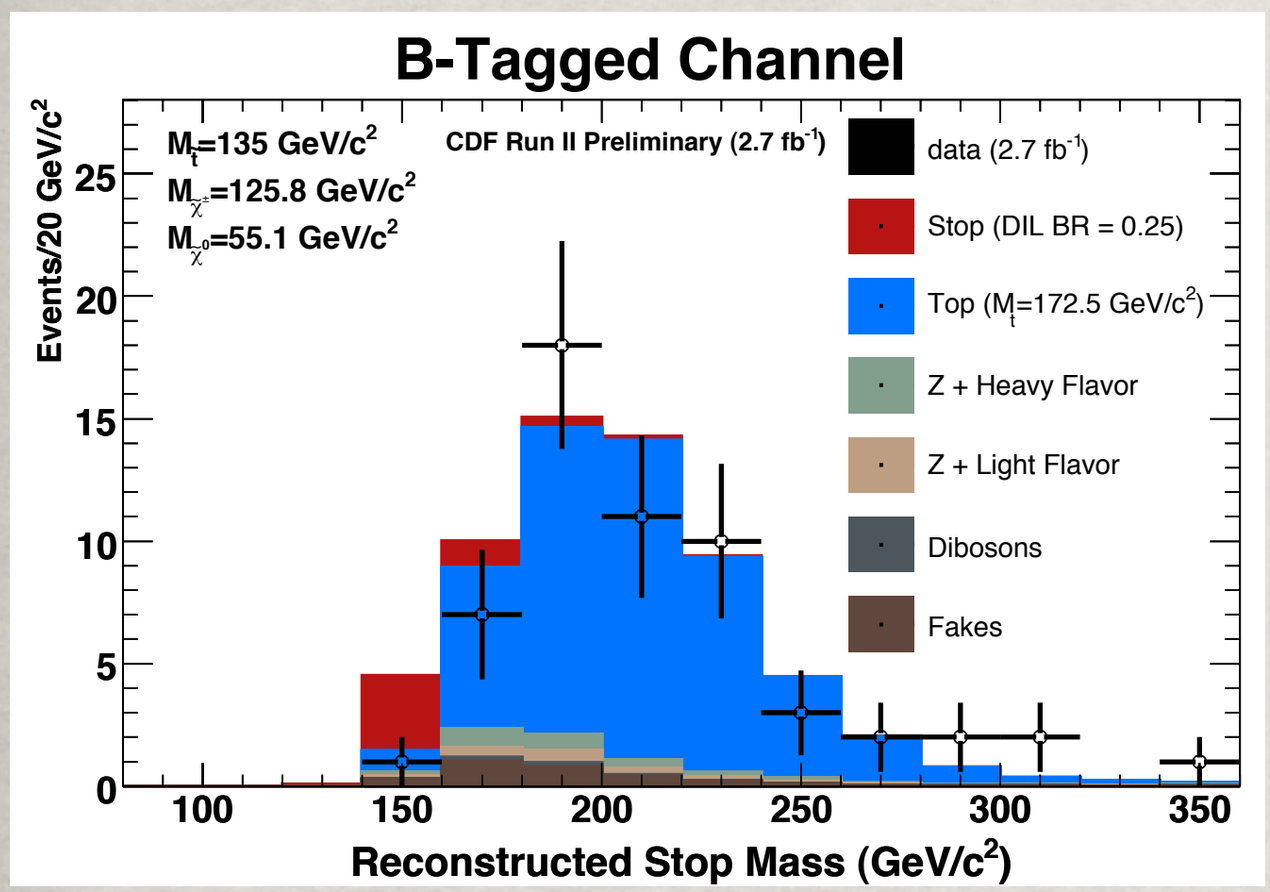
- Wide variety of analysis exploring many models/particles.
  - Currently no evidence, but we have excluded portions of phase space.
    - excluded gluino/squark masses up to 390 GeV
    - excluded light sbottom masses up to 250 GeV
    - excluded light stop masses up to 200 GeV
    - excluded chargino/neutralino masses up to 160 GeV
- Analysis with up to 6.3 fb^{-1} of data.
- TeVatron to run though 2011 (and beyond?), with expected 12 fb^{-1}

The Tevatron is collecting high quality data at an unprecedented rate. Expect more results soon.

http://www-cdf.fnal.gov/physics/exotic/exotic.html
http://www-d0.fnal.gov/Run2Physics/WWW/results/np.htm

Back-up Slides

Stop Pair Production



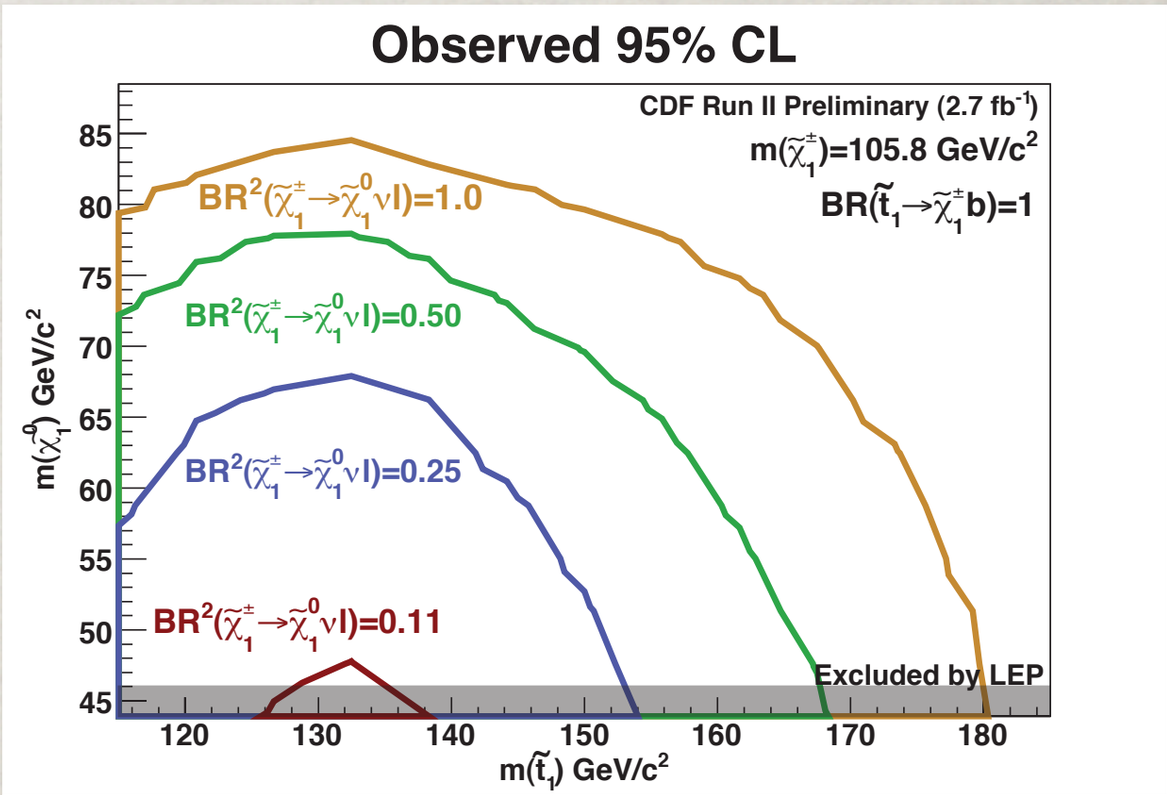
- 2 opposite signed leptons, 2 Jets, and MET
- B-tagged and Non-B-tagged Channels
  - Optimized separately

MSSM: R_P Conserved

$$B.R.(\tilde{t} \rightarrow b\tilde{\chi}_1^{\pm}) = 100\%$$

$$\tilde{\chi}_1^0 = LSP$$

$$\tilde{t} \rightarrow b\tilde{\chi}_1^{\pm} \rightarrow b\tilde{\chi}_1^0 \nu l^{\pm}$$



With 2.7 fb^{-1} exclude (m_{LSP} < 70 GeV):

m_{stop} < ~170 GeV

CDF (2.7 fb-1) [PRL 104 (2010) 251801]