SUSY searches at TeVatron

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On behalf of the CDF and D0 Collaborations

Outline

Focusing on latest SUSY results (up to 4 fb^{-1})

- Supersymmetry in 30''
- Squarks and Gluinos in MET + jets (mSUGRA)
- Third Generation Squarks (MSSM)
  - Direct Sbottom Pair Production
  - Direct Stop Pair Production
- Chargino/Neutralino in Trilepton Final State (mSUGRA)
- GMSB Diphoton
- Hidden Valley Dark Photon
- R_P Violation (RPV) Tau Sneutrino

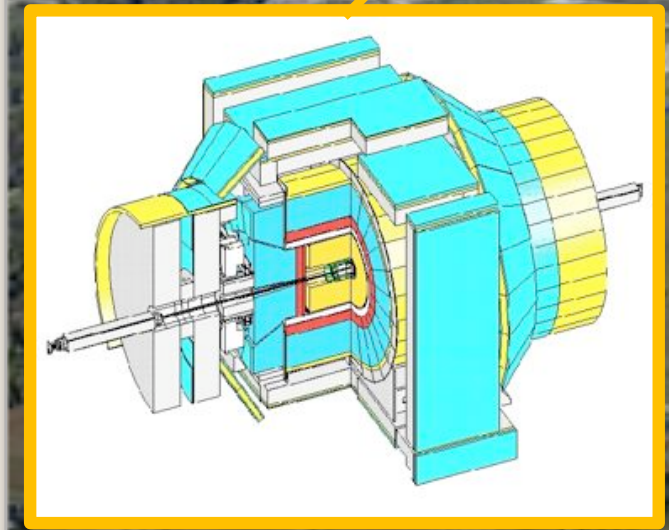
The D0 and CDF Experiments

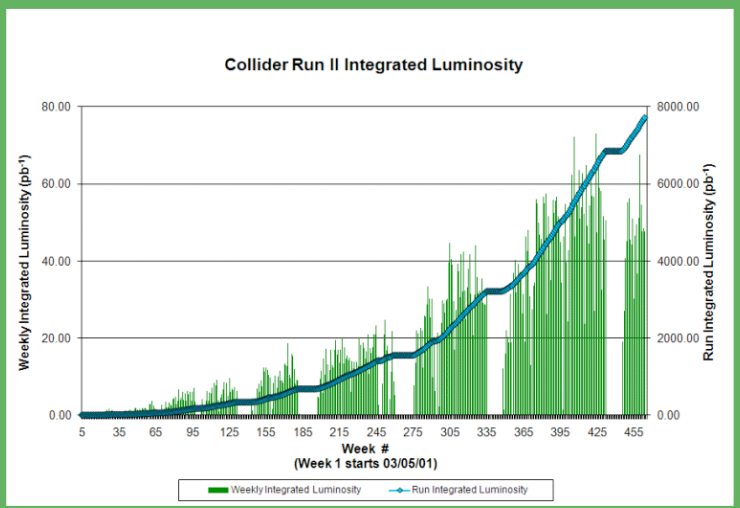
- 8 fb^{-1} delivered since Jan 2001.
- Plan to run through 2011.
- Latest SUSY searches results with up to 4 fb^{-1}.
- More results to come with full dataset.

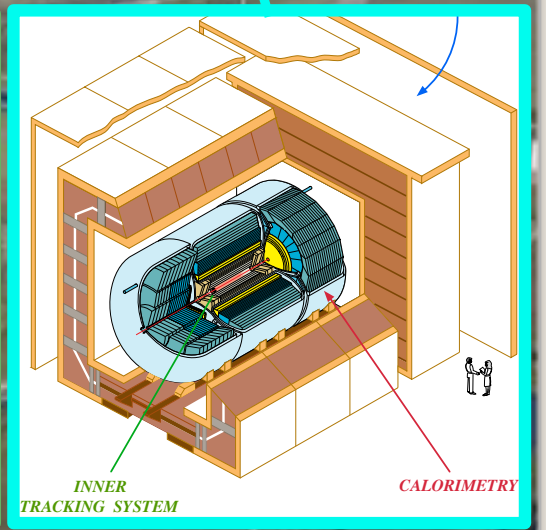
CDF

Dzero

Tevatron



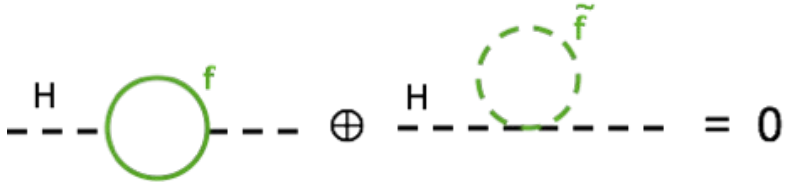




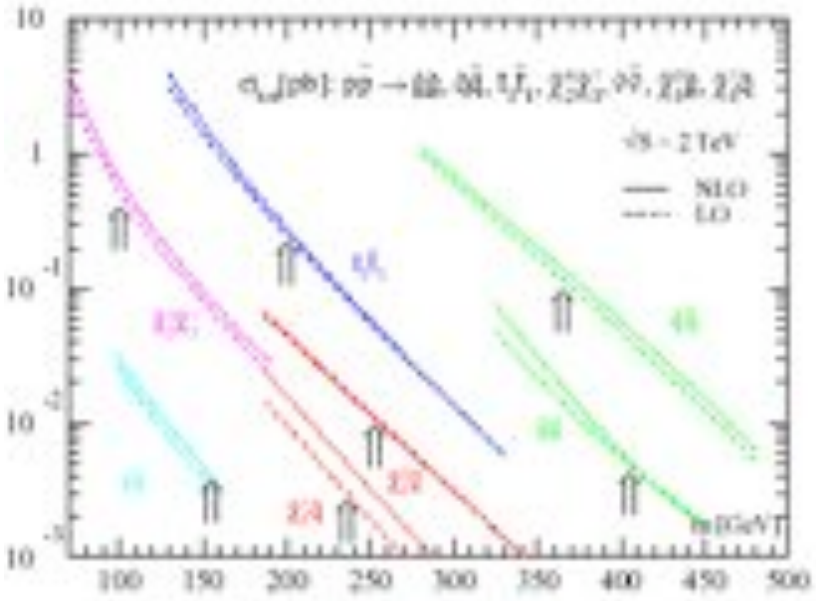
Supersymmetry in 30”

$$Q|\text{boson}\rangle = |\text{fermion}\rangle$$
$$Q|\text{fermion}\rangle = |\text{boson}\rangle$$

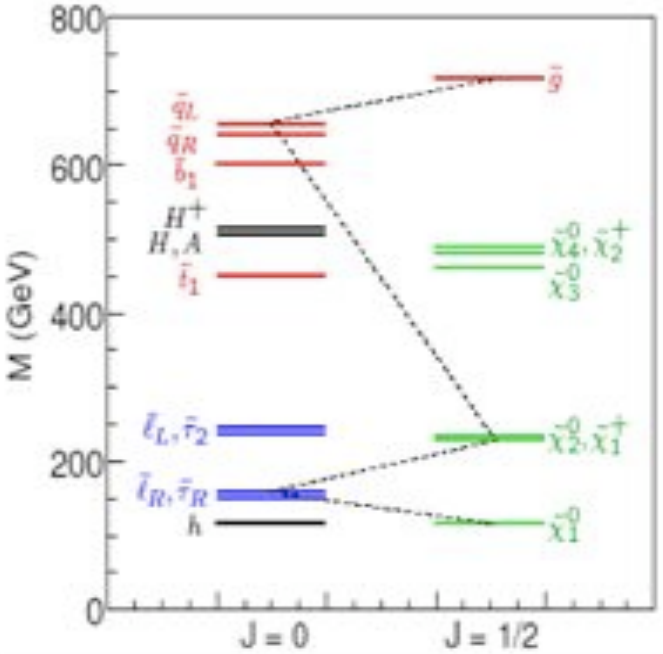
- Elegant solution to the hierarchy problem: exact cancellation between fermion and boson loops for higgs.



- Pay the price: 2-times more particles.



Typical mSUGRA mass spectrum

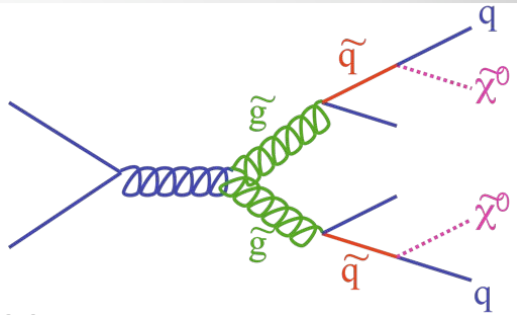


- SUSY must be broken: model dependent phenomenology:
  - Can provide Dark Matter candidate
  - Also good framework for unification of forces
- Searches at Tevatron assuming different SUSY-breaking scenarios:
  - MSSM, mSUGRA, GMSB, RPV …
  - Typical signature with jets and/or leptons in association with MET due to undetected lightest supersymmetric particles (LSP).

Squarks and Gluinos

~ 2 fb^{-1}

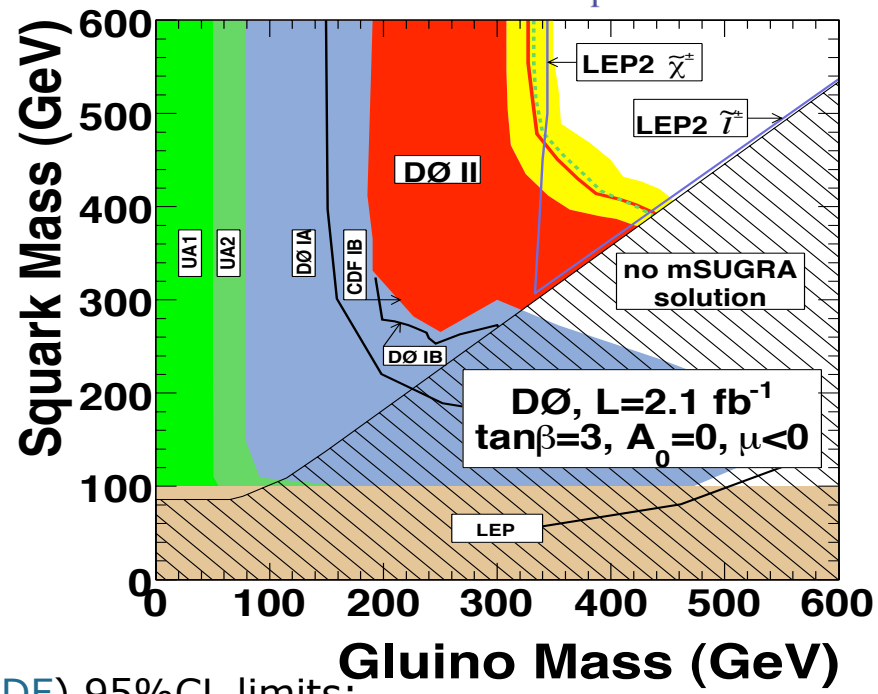
- mSUGRA scenario with R_P conserved and low tanβ: $\tilde{q}/\tilde{g}$ produced in pair.
- Degenerate squark masses (stop production not considered).
- Dominant bkg: QCD, $W\rightarrow\nu\ell$, $Z\rightarrow\nu\nu$, $t\bar{t}$.
- SM QCD bkg from DATA (D0) or MC (CDF).
- SM non-QCD bkg from MC simulation.

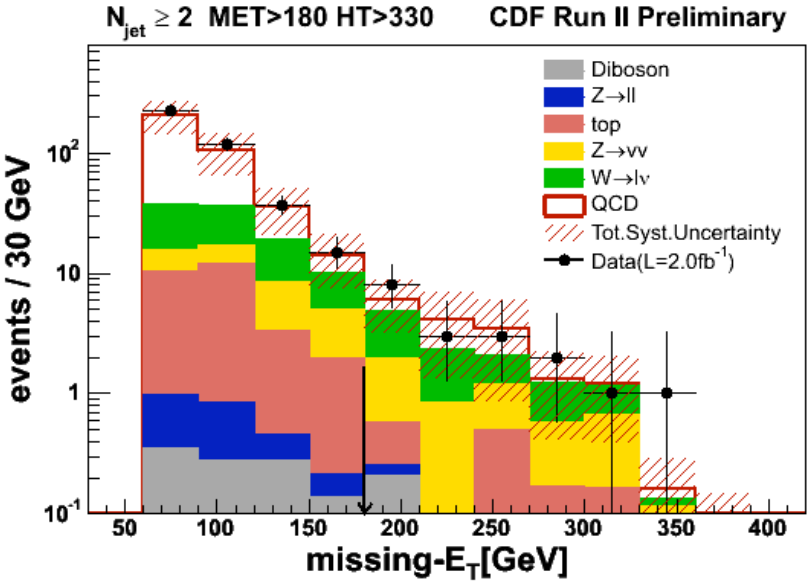


Signature: Jets of hadrons and MET from $\tilde{\chi}^0$ (LSP)

CDF: L=2.0 fb^{-1}
•3 anayses requiring ≥2,3,or 4 jets + MET and higher energies with increasing M($\tilde{g}$).

D0: L=2.1 fb^{-1}
•Combination of 7 signal regions with exclusive jet-multiplicity and kinematic requirements.





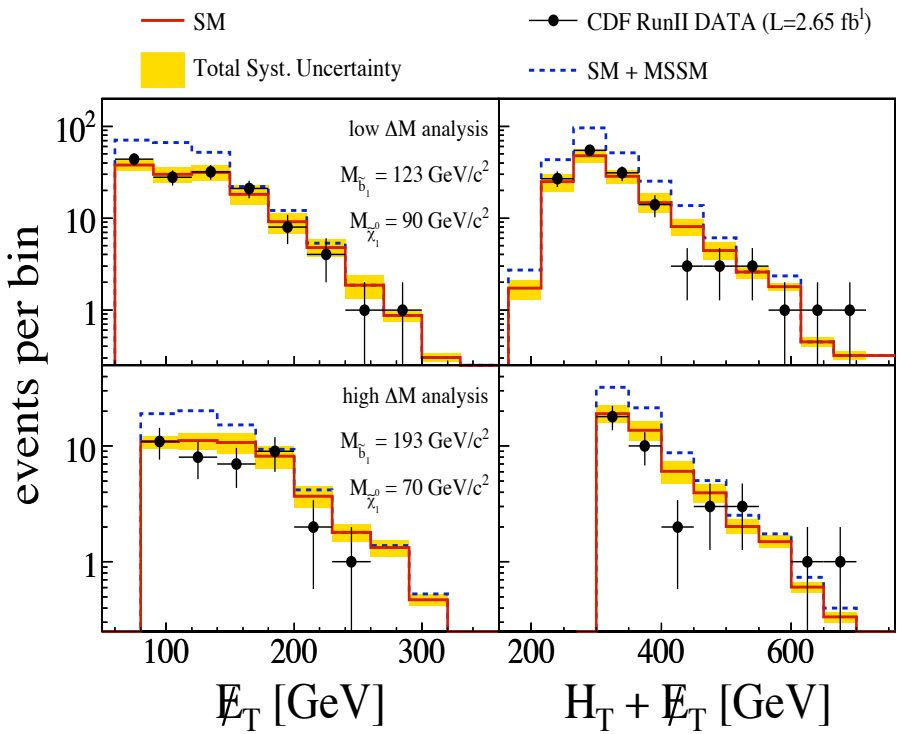
D0 (CDF) 95%CL limits:

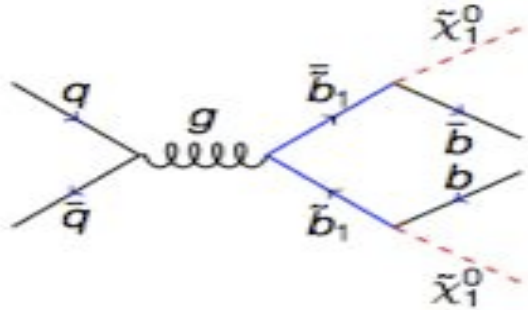
- ➠ M($\tilde{g}$,$\tilde{q}$)>390 (390) GeV/c^2 when M($\tilde{g}$)~M($\tilde{q}$)
- ➠ M($\tilde{g}$)>308 (280) GeV/c^2 for any M($\tilde{q}$)
- ➠ M($\tilde{q}$)>379 (340) GeV/c^2 for any M($\tilde{g}$)

Sbottom Pair Production

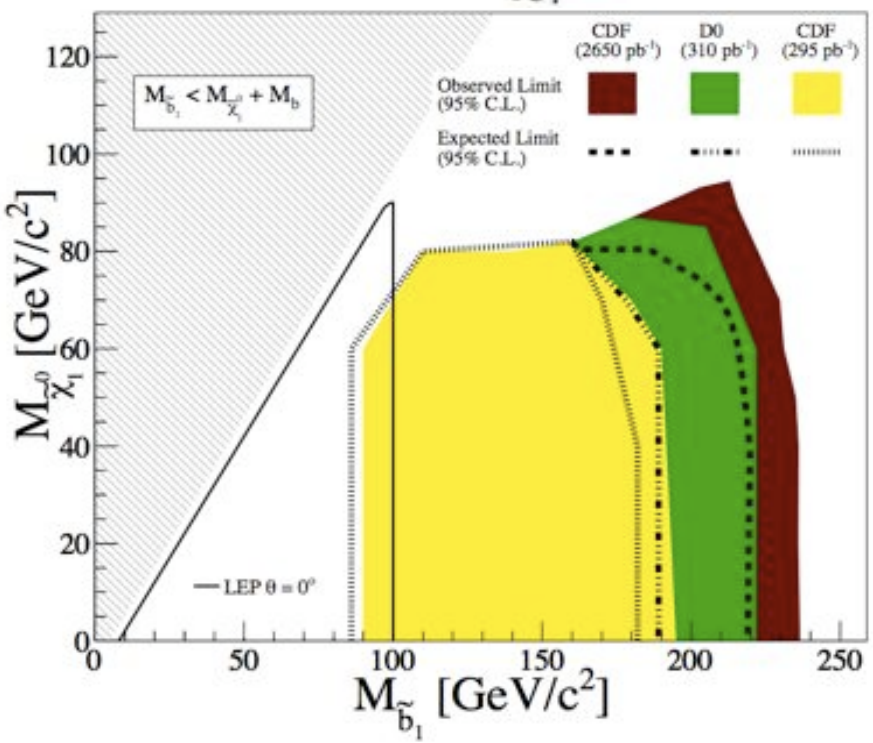
2.65 fb^{-1}

- MSSM scenario with pair production of light b_1.
- $BR(b_1 \rightarrow \tilde{\chi}_1^0 \tilde{b}) = 100\%$.
- state with 2 jets + MET.
- At least 1 jet is b-tagged.
- Two signal regions with increasing energy thresholds sensitive different $DM=M(\tilde{b})-M(\tilde{\chi})$ scenarios:
  - Low DM (≤ 90 GeV)
  - High DM (≥ 90 GeV)





Signature:
2 b-jets and MET
($\tilde{\chi}_1^0$=LSP)



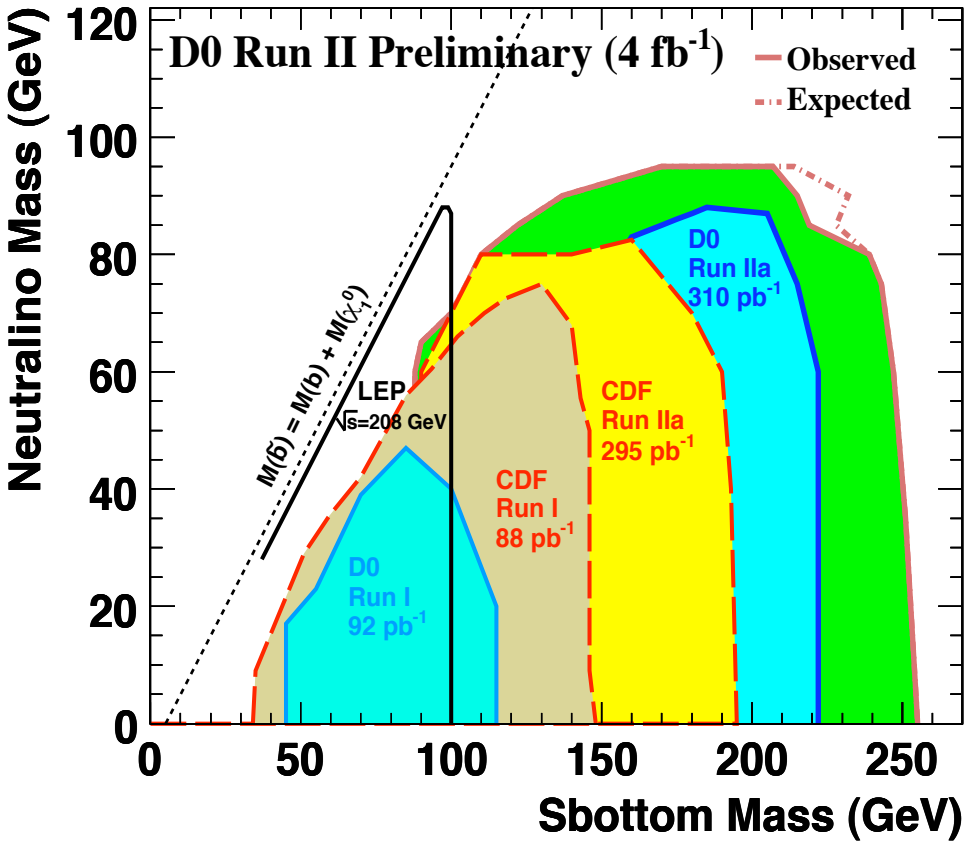
CDF 95%CL limits:

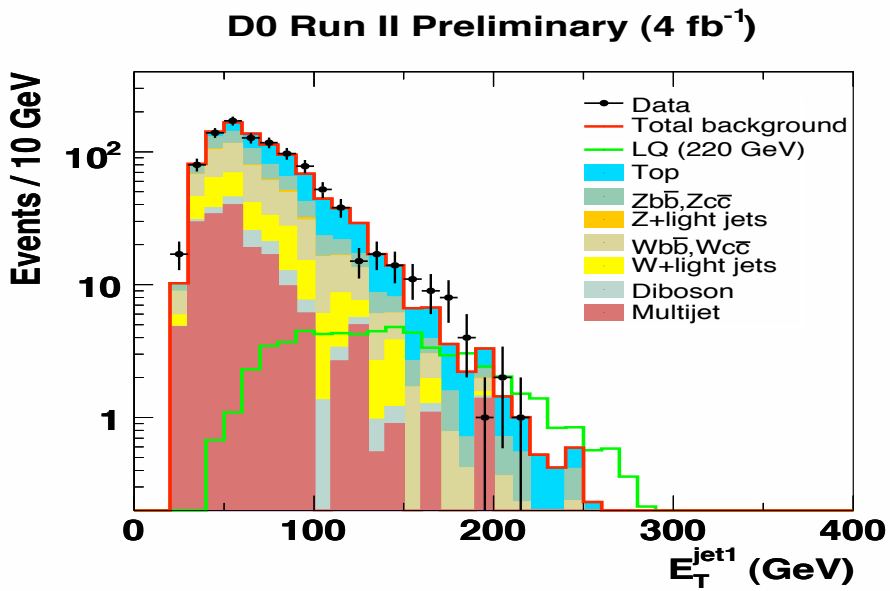
➡ $M(\tilde{b}_1)>230$ GeV/c^2 when $M(\tilde{\chi})<70$ GeV/c^2

Sbottom Pair Production

4.0 fb^{-1}

- Similar MSSM scenario with respect to CDF.
- Final state with 2 or 3 jets + MET.
- NN b-tagging on the 2 leading jets.
- Bkg dominated by QCD and mistag events (estimated with DATA-driven techniques). Other bkg from MC simulation.
- Good agreement between observed DATA and expected SM.





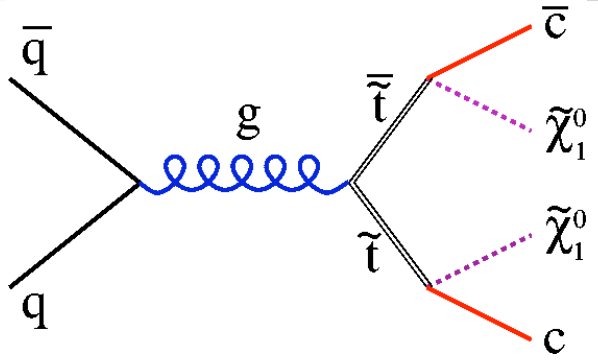
D0 95%CL limits:

➡ $M(\tilde{b})>250$ GeV/c^2 when $M(\tilde{\chi})<70$ GeV/c^2

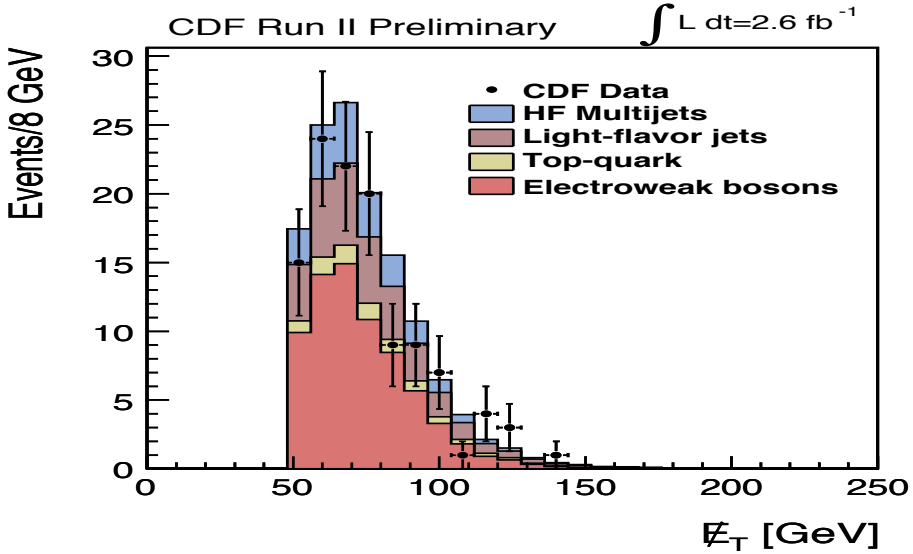
Stop Pair Production

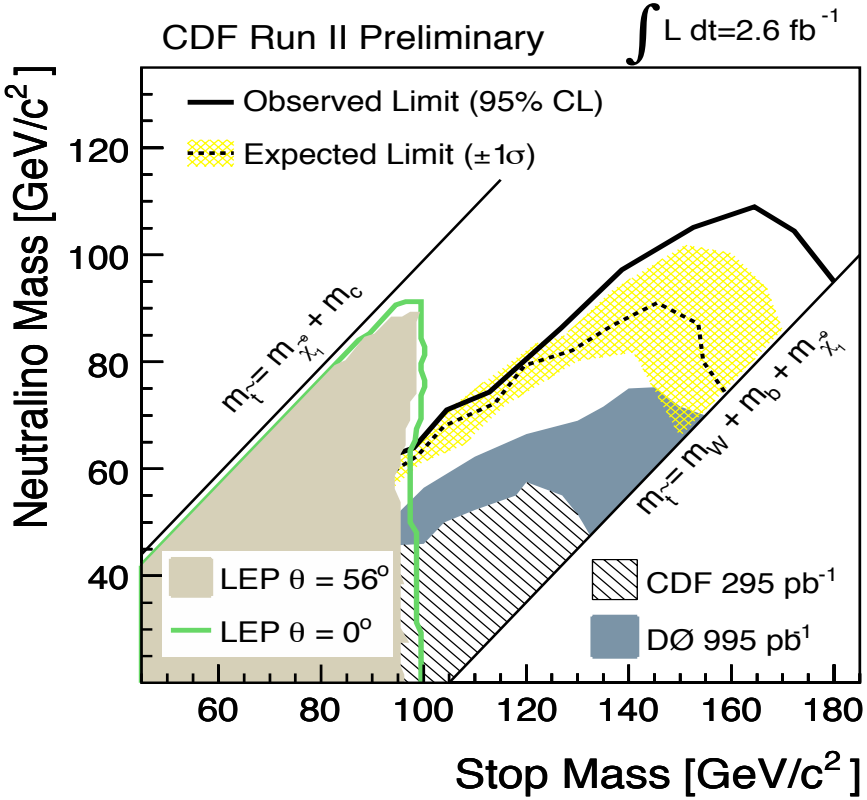
2.6 fb^{-1}

- MSSM scenario with conserved R_P with $BR(\tilde{t}_1 \rightarrow c\tilde{\chi}_1^0) = 100\%$.
- Final state with ≥ 2jets+MET. At least one of the two leading jets is heavy flavour tagged.
- NN-based flavour separator algorithm to enhance the c-tagging efficiency.
- QCD and mistags from DATA, other bkg from MC simulation.
- Sensitivity optimized with NN-based selection.



Signature:
2 c-jets and MET
($\tilde{\chi}_1^0$=LSP)





95% CL limit:

➠ $M(\tilde{t})>180$ GeV/c^2 (with $M_{\tilde{\chi}}\sim90$ GeV/c^2)

Stop Pair Production

3.1 fb^{-1}

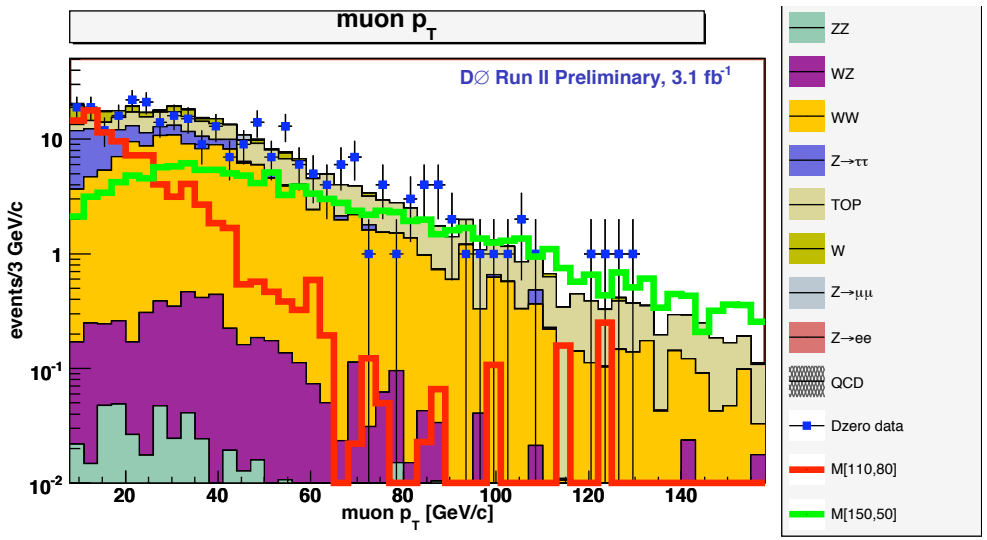
- Final state with one electron and one muon (opposite charge) and MET.
  - PT(e)>15GeV, Pt(m)>8GeV
- No minimum number of jets required.
- QCD from DATA, other bkg from MC simulation.
- Selection optimized for large and small $\Delta M = M\tilde{t}_1 - M\tilde{\nu}$.
- Good agreement between DATA and SM.

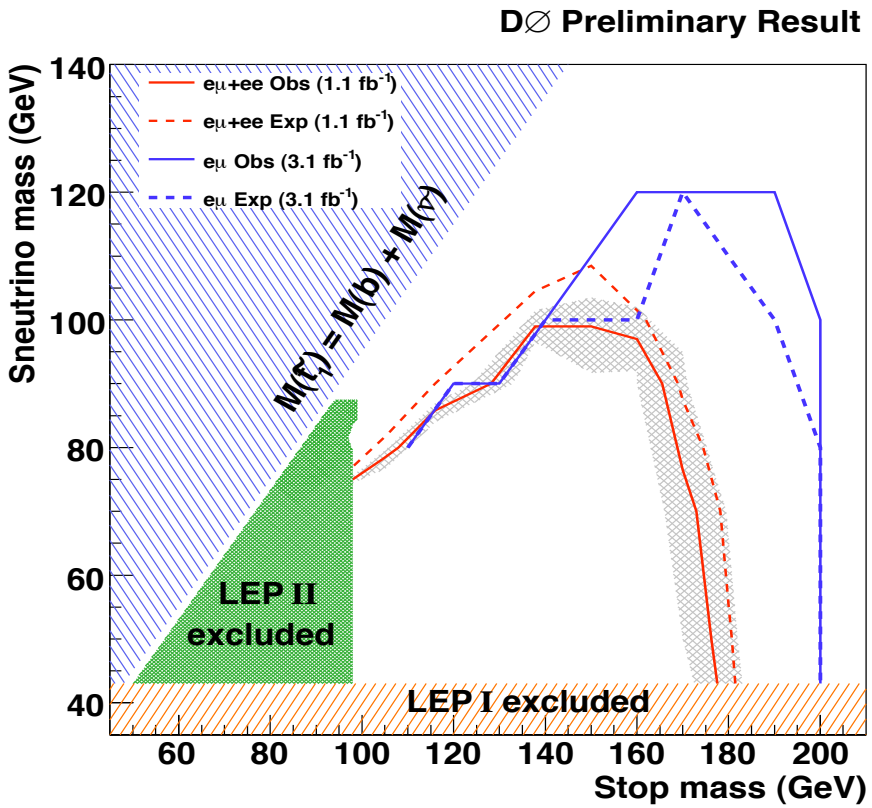
MSSM scenario with conserved R_P:

➡ $\tilde{t}_1$ is pair produced

➡ $BR(\tilde{t}_1 \to b\tilde{\nu}\ell^{\pm}) = 100\ \%$

➡ Sneutrino ν is LSP.





95% CL exclusion limit:

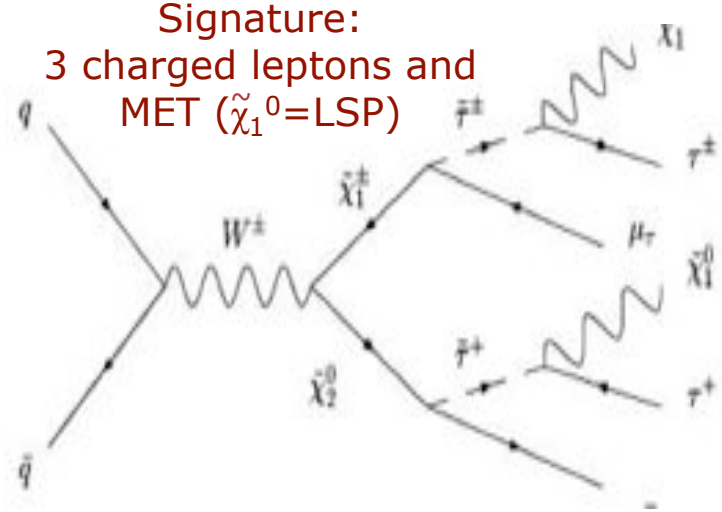
➡ $M(\tilde{t}_1) > 200\ GeV/c^2$ ($M\tilde{\nu} < 100\ GeV/c^2$)

Chargino/Neutralino

3.2 fb^{-1}

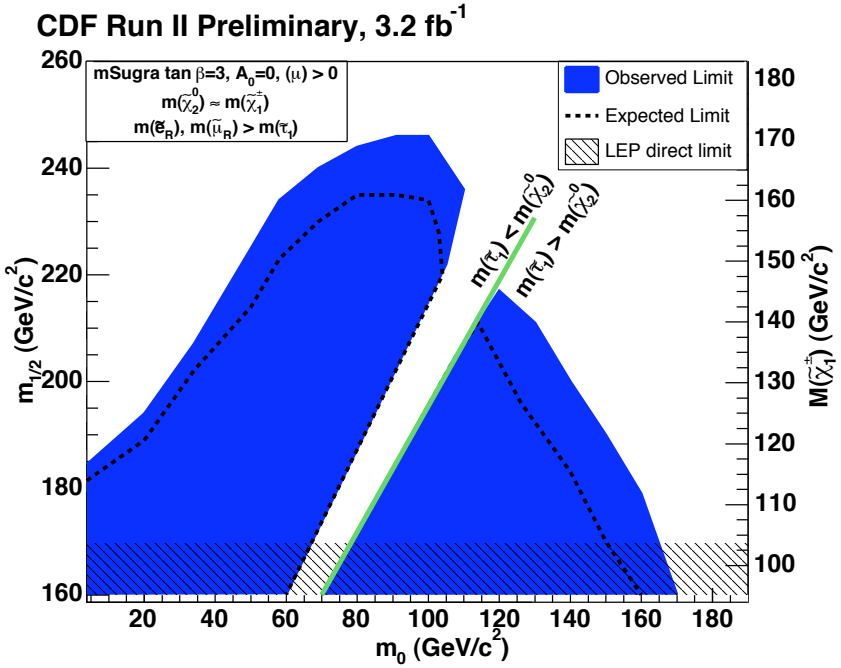
- Selection based on identification of $e^{\pm}/m^{\pm}$, and isolated tracks.
- 5 exclusive signal regions with a combination of tight leptons (t), loose leptons (l), or charged tracks (T).
- SM bkg yields from MC simulation.
- Good agreement between DATA and SM.
- Results interpreted in mSUGRA scenario.

Signature:
3 charged leptons and
MET ($\tilde{\chi}_1^0$=LSP)



CDF II Preliminary, 3.2 fb^{-1}			
Channel	Total Background ± (stat) ± (sys)	Signal Point ± (stat) ± (sys)	Observed
ttt	0.83 ± 0.14 ± 0.11	3.64 ± 0.22 ± 0.49	1
ttC	0.39 ± 0.07 ± 0.04	2.62 ± 0.18 ± 0.35	0
tll	0.25 ± 0.08 ± 0.03	1.12 ± 0.12 ± 0.15	0
ttT	5.85 ± 0.57 ± 1.11	7.15 ± 0.31± 0.91	4
tlT	3.53 ± 0.52 ± 0.5	4.06 ± 0.23 ± 0.53	2

mSugra Signal point: $M_0 = 60, M_{1/2} = 190, \tan\beta = 3, A_0 = 0$



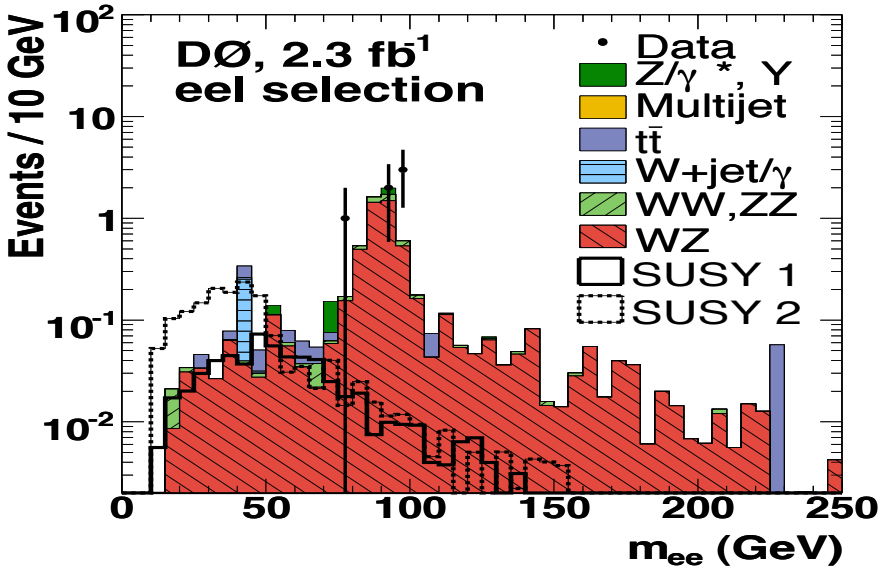
95% CL exclusion limit:

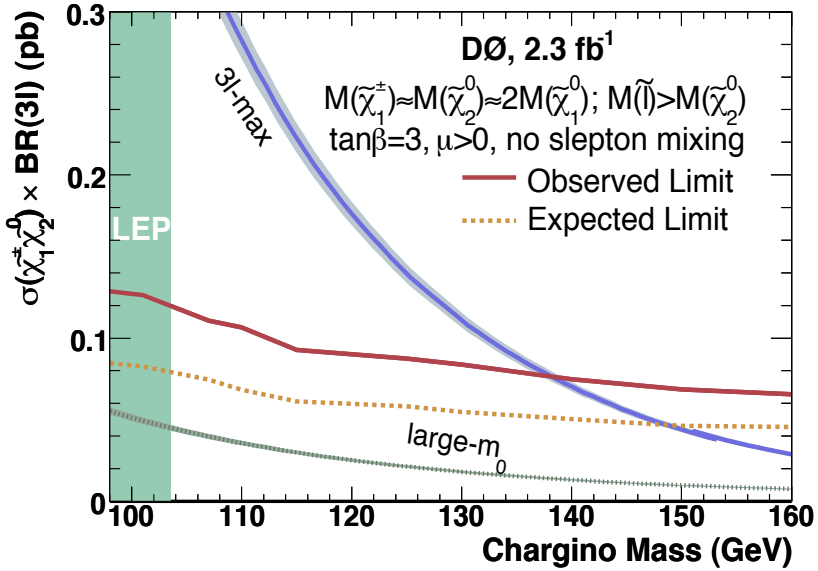
➡ $M(\tilde{\chi}^{\pm}) > 164$ GeV/c^2
(mSUGRA with m_0=60, tanβ=3, A_0=0, μ>0)

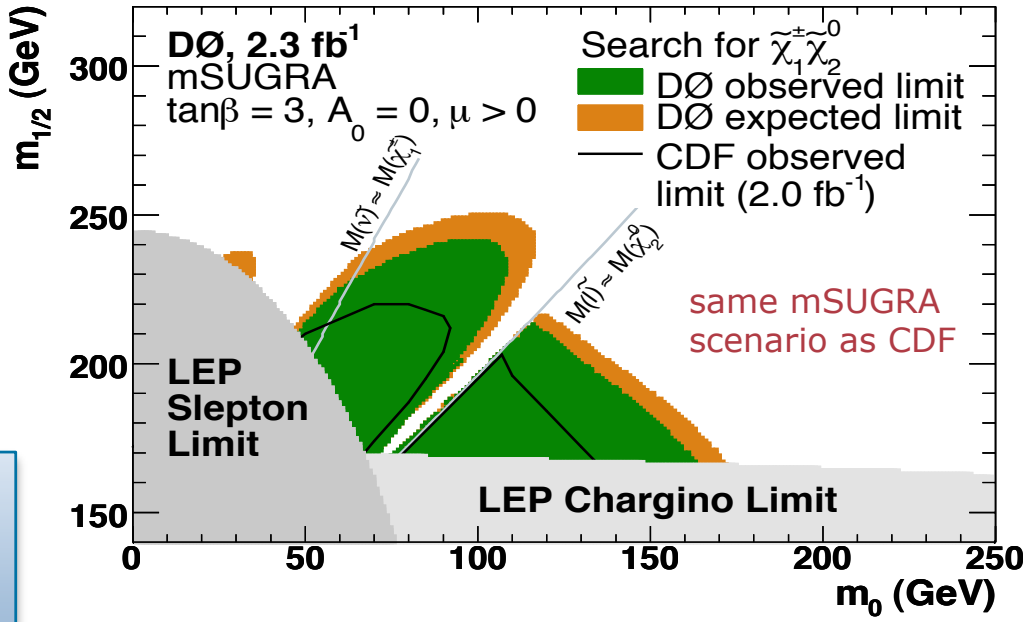
Chargino/Neutralino

2.3 fb^{-1}

- Selection based on e/μ/τ ID:
  - $e^{\pm}$ ID: jet shower shape and track isolation
  - $\mu^{\pm}$ ID matching tracks and muon chambers.
  - NN algorithm to separate $\tau^{\pm}$ and jets.
- 5 analyses with exclusive lepton content: $ee\ell$, $\mu\mu\ell$, $e\mu\ell$, $\mu\tau\ell$, $\mu\tau\tau$.
- QCD bkg from data, non-QCD form MC.
- Good agreement between DATA and SM.





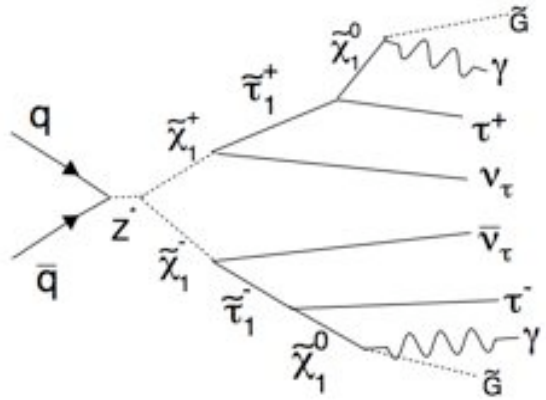


95% CL limit :
➡ $M(\tilde{\chi}^{\pm}) > 138$ GeV/c^2
➡ more general scenario with
$M(\tilde{\chi}_1^{\pm})=M(\tilde{\chi}_2^0)=M(\tilde{\chi}_1^0)$; $M(\ell)=M(\tilde{\chi}_2^0)$

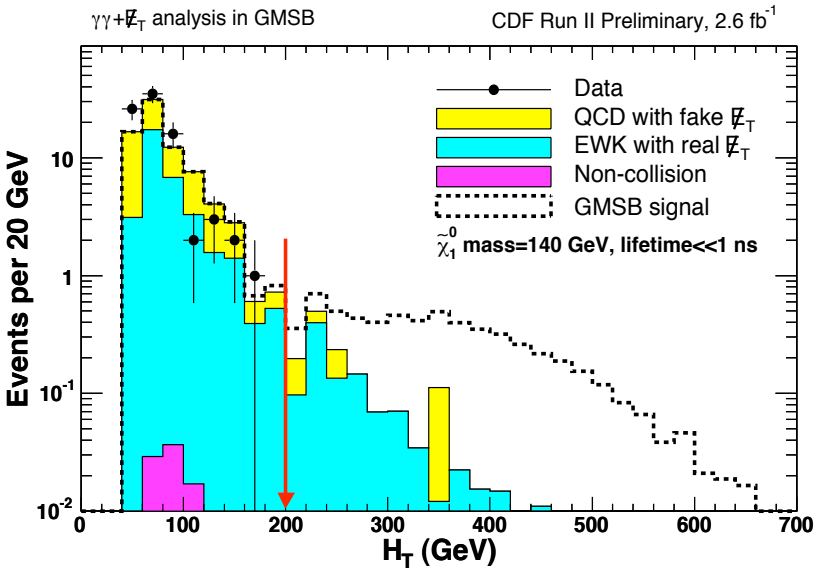
GMSB Diphoton

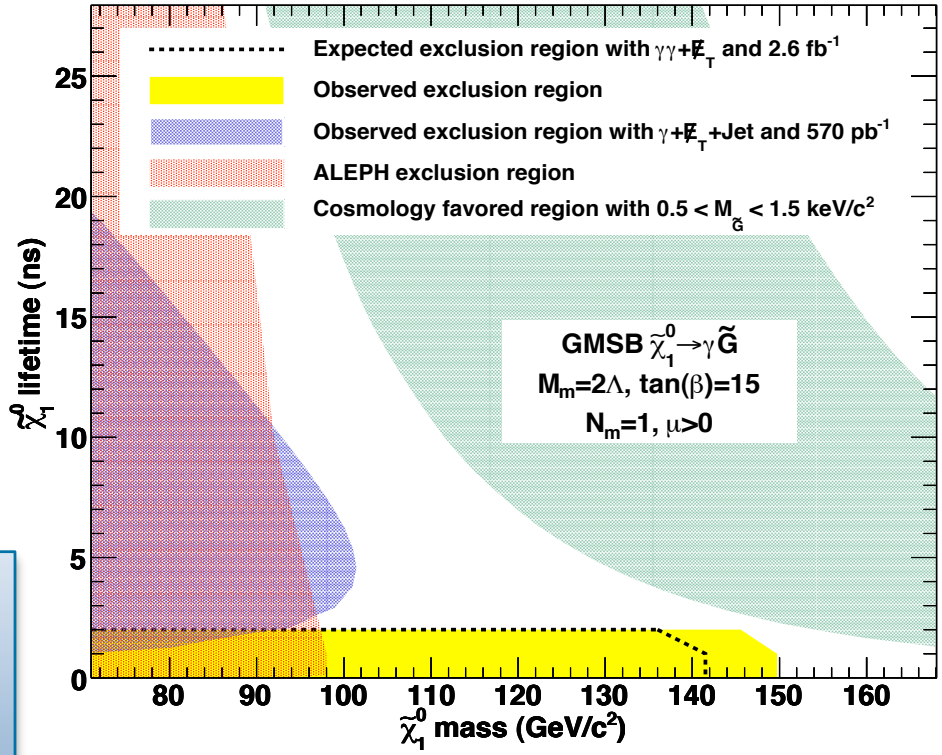
2.6 fb^{-1}

- GMSB scenario with $\tilde{\chi}^0$ next-to-LSP.
- $\tilde{\chi}^0 \to \tilde{G}\gamma$, where $\tilde{G}$ is LSP.
- Quasi model-indipendent approach: signature-based selection with 2 isolated photons ($E_T(\gamma)>13$ GeV) and MET.
- Very little SM bkg expected (1.23±0.38) and no observed events in the signal region.



Signature:
$\gamma\gamma$ and MET
(G=LSP)





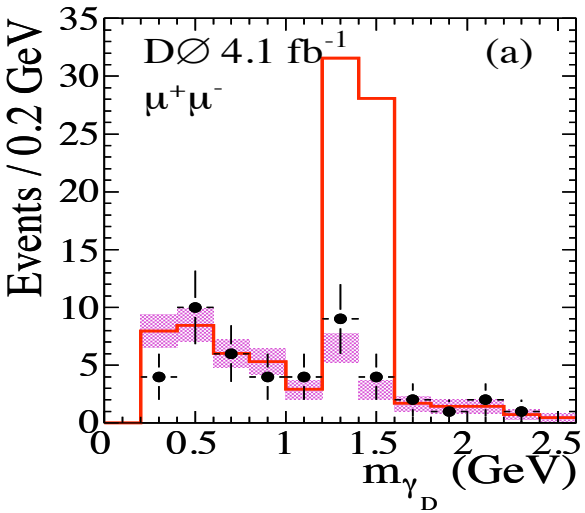
95% CL exclusion limit:

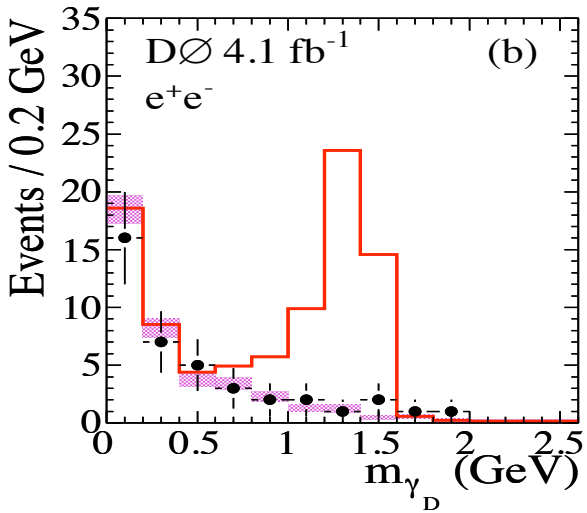
➡ $M(\tilde{\chi}^0) > 149$ GeV/c^2 $\tilde{\chi}^0$ lifetime of 0 and 1 ns.

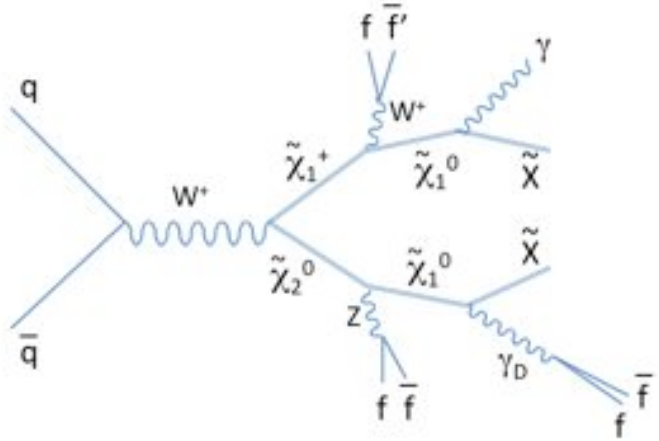
➡ > 2ns lifetimes covered by single delayed photon analyses.

Hidden Valley Dark Photon

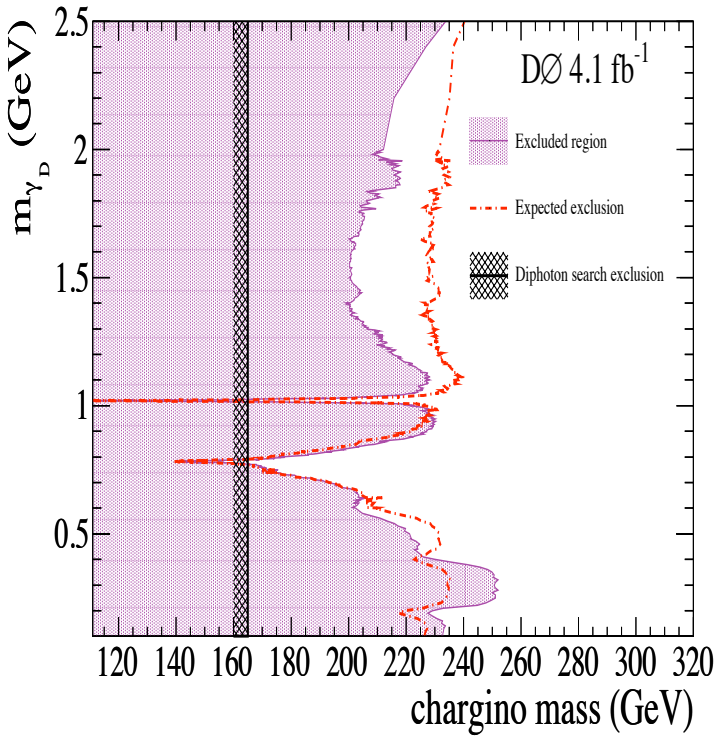
4.1 fb^{-1}







- SUSY hidden valley model assumed with production of dark photons (γ_D).
- At Tevatron produced through neutralino decays.
- Only γ_D->ee or $\mu\mu$ considered: final state with one photon + two leptons (spatially closed) + MET.
- Signal as narrow peak in dilepton invariant mass.
- SM bkg form QCD, W->e/μ ν, W->$\tau\nu$->3hν.
- No evidence of dark photon peak.

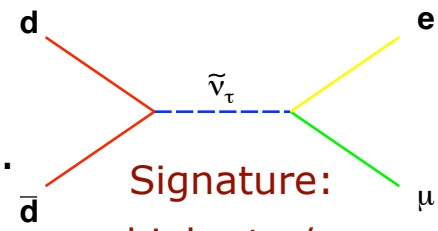


95% CL exclusion limit:

➠ $M(\tilde{\chi}^{\pm}) > 230$ GeV/c^2 for $M(\gamma)_D < 0.5$ GeV/c^2

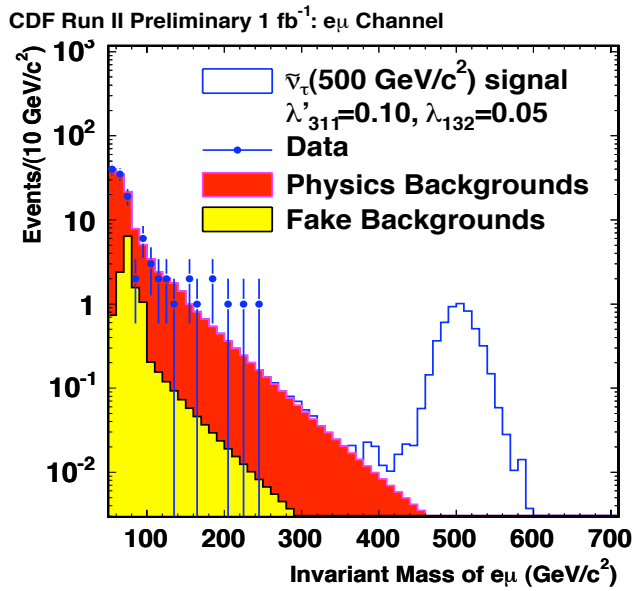
RPV Tau Sneutrino

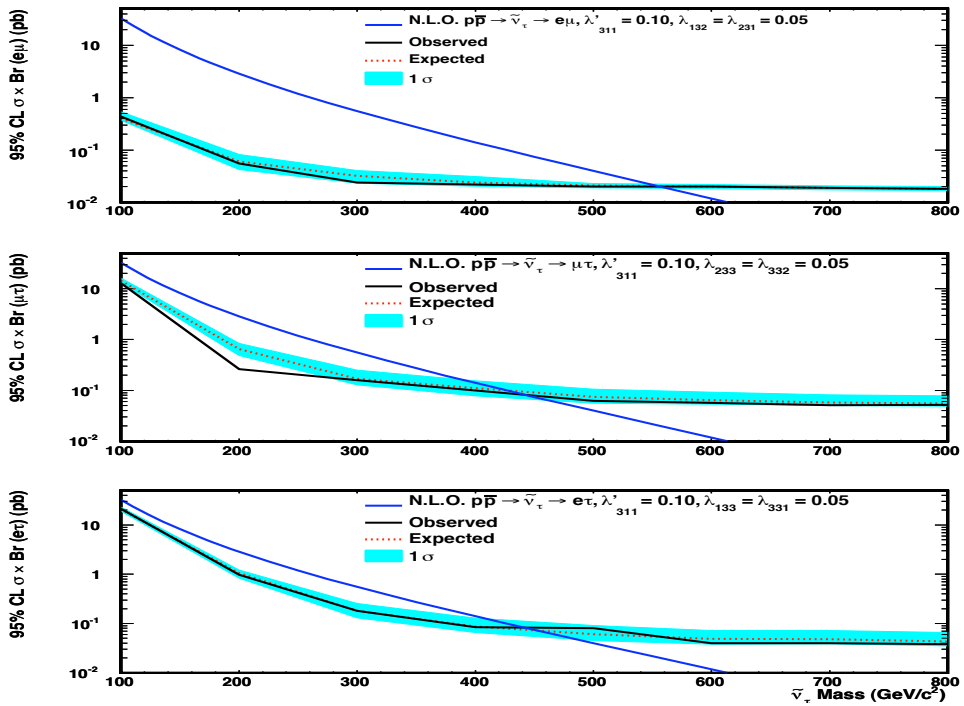
- R_P violating (RPV) scenario.
- $\tilde{\nu}_T$ is the LSP and decays to eμ (lepton flavour violating channel).
- D0 final state with eμ.
- CDF final states with eμ, eτ, mt.
- 95% CL limit on $\tilde{\nu}_T$ production and mass for different RPV models.

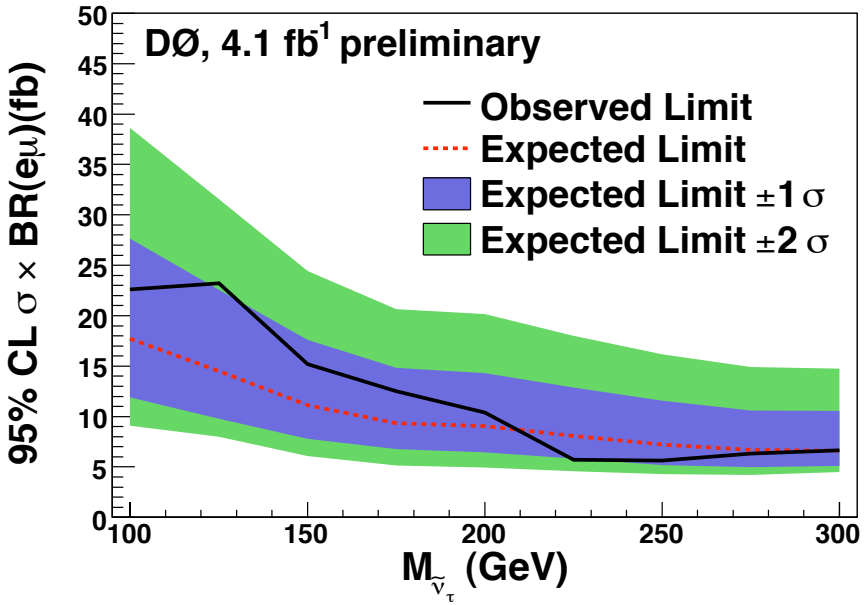


Signature:

high pt μ/e pair.







Summary

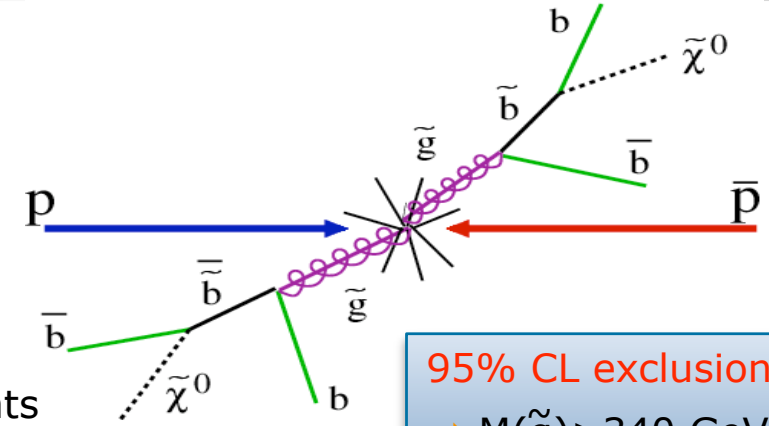
- Presented latest results of SUSY searches at Tevatron with up to 4 fb^{-1} of data.
- Best exclusion limits s-particle masses in different scenarios:
  - excluded gluino/squark masses up to 390 GeV/c^2
  - excluded light sbottom masses up to 250 GeV/c^2
  - excluded light stop masses up to 200 GeV/c^2
  - excluded chargino/neutralino masses up to 150 GeV/c^2
- More results expected with full dataset.

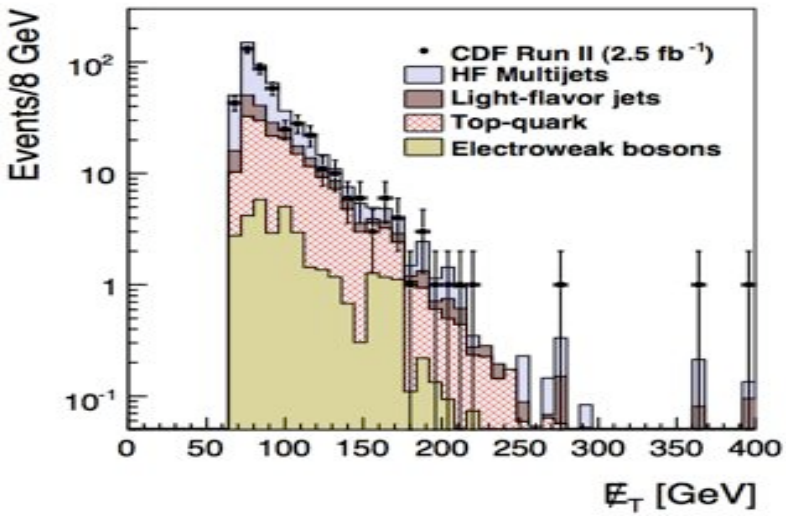
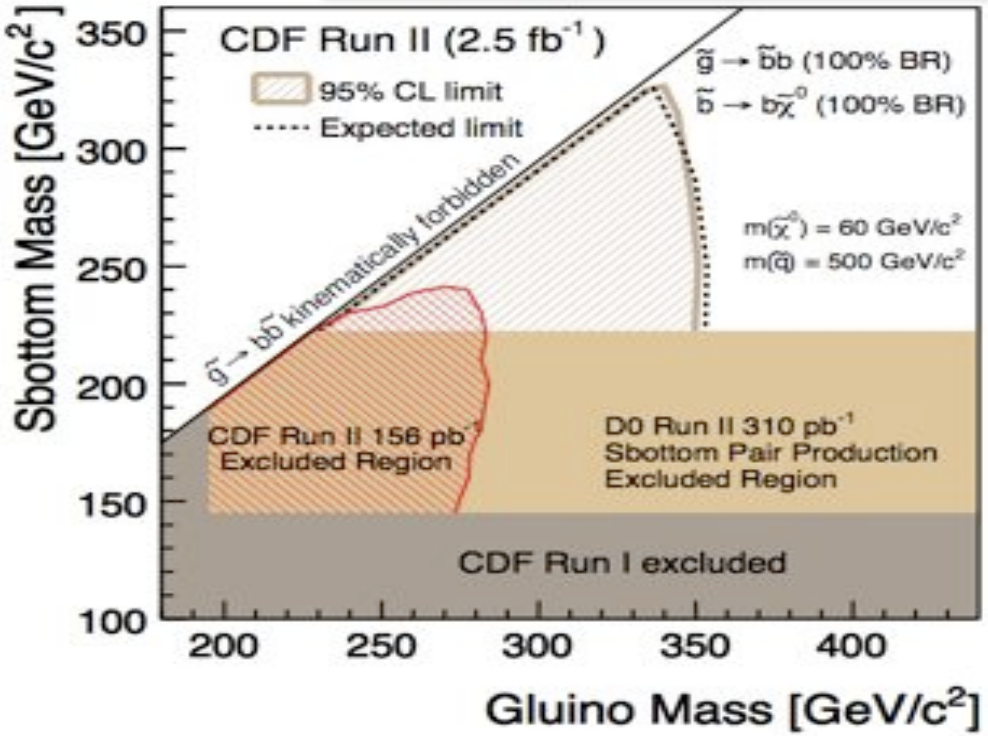
backup slides

Gluino-mediated Sbottom

2.5 fb^{-1}

- MSSM scenario with conserved R_P.
- $BR(\tilde{g}\rightarrow b\tilde{b}_1) = BR(\tilde{b}_1\rightarrow\tilde{\chi}_1^0 b) = 100\%$.
- 2 exclusive final states considered:
  - ≥2 jets + MET, only 1 b-jet
  - ≥2 jets + MET, at least 2 b-jets
- Bkg dominated by QCD and mistag events estimated with DATA-driven techniques. Other bkg from MC simulation.
- Sensitivity optimized with NN-based selection for large and small $DM=M\tilde{g}-M\tilde{b}_1$
- Good agreement DATA - SM



Signature:
4 b-jets and MET
(χ_1^0=LSP)

95% CL exclusion limit:
➡ $M(\tilde{g})>340$ GeV/c^2 (any $M\tilde{b}$)