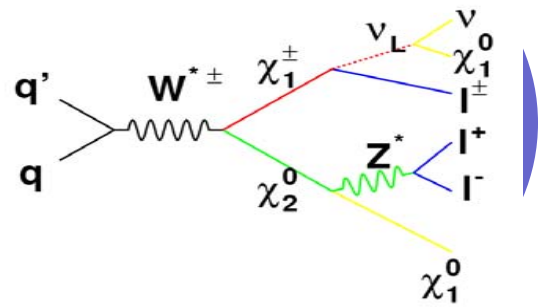
Search for chargino and neutralino associated production at the Tevatron



D. Bortoletto

Purdue University

Representing CDF and D0

ABS 234 and 741

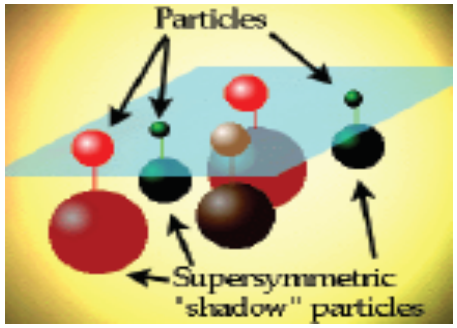
HEP2005 Europhysics Conference in Lisboa, Portugal

July 21 to July 27, 2005

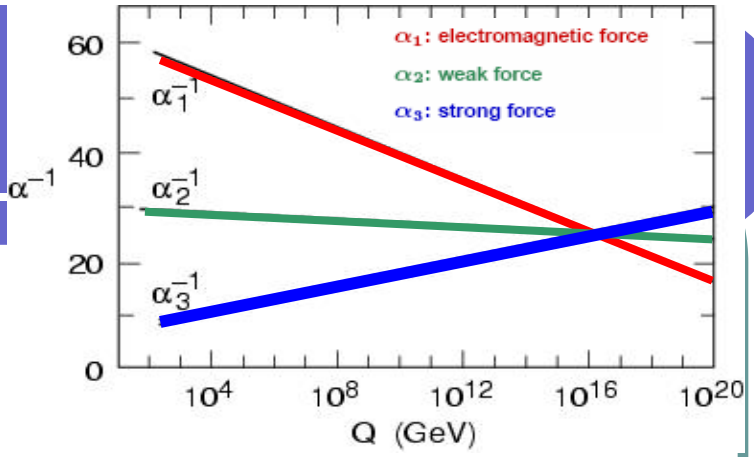
SUSY

- **Extension of the SM**
  - **Solves "fine-tuning" (if M_{SUSY}<1 TeV)**
  - **Unifies gauge couplings**
  - **Includes quantum gravity**
- **SM and SUSY states carry opposite $R_{parity}=(-1)^{3(B-L)2S}$**

SM Bosons R_p=+1	$W^{\pm}, H^{\pm}$ $\gamma, Z^0, h^0, H^0, A^0$
SUSY fermions R_p=-1	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^{\pm}$ $\tilde{\chi}_1^0, \tilde{\chi}_2^0, \tilde{\chi}_3^0, \tilde{\chi}_4^0$



- **If R-parity is conserved**
  - **Lightest SUSY Particle (LSP) is a dark matter candidate**
- **SUSY is broken (M_{SUSY}>M_{SM})**
- **Simplest extension (MSSM) has 124 free parameters**



CMSSM

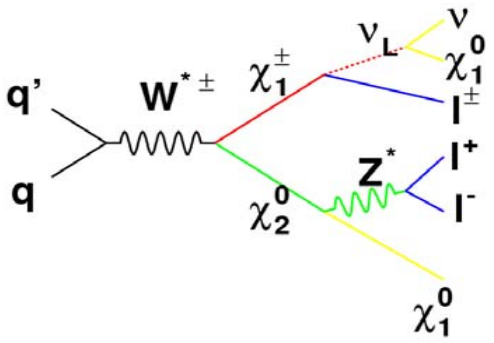
m_0: sfermion mass
$m_{1/2}$: gaugino mass
Sgn(μ) : higgs(ino) mass term
tanβ : ratio Higgs fields vev
A_t: trilinear coupling stop
M_A: pseudoscalar Higg mass

MSUGRA

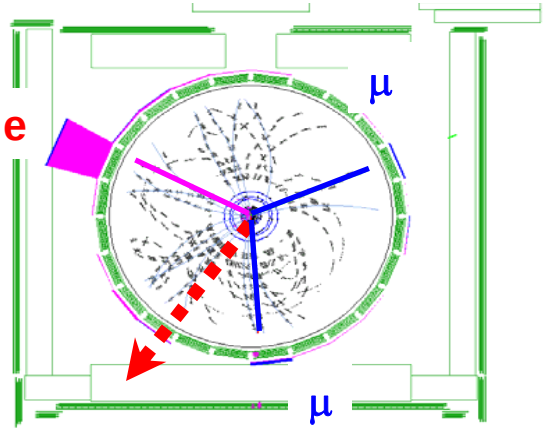
m_0: sfermion mass
$m_{1/2}$: gaugino mass
Sgn(μ) : higgs(ino) mass term
tanβ : ratio Higgs fields vev
A_0 : trilinear coupling (Higgs-$sfermion_L$-$sfermion_R$)

Chargino and neutralino

- **Chargino and neutralino associated production and decay into leptons is the SUSY golden channel**



Simulated SUSY event

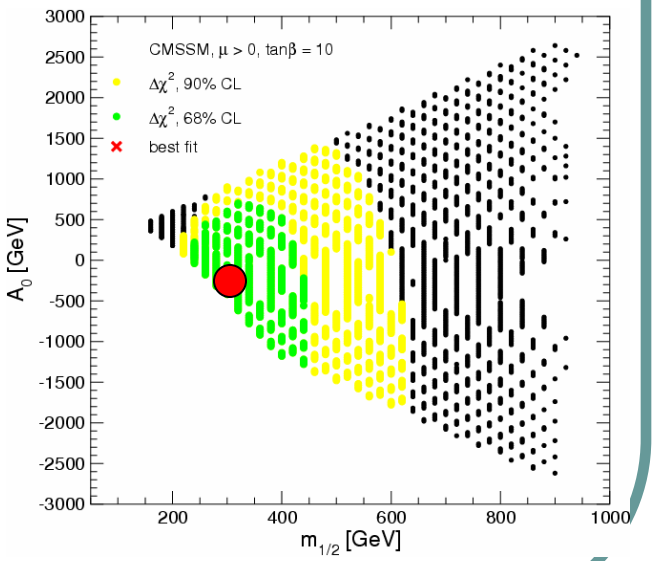


Energy Imbalance

Constrain CMSSM using M_W, $\sin^2\theta_{eff}$, BR($b \to s\gamma$), $(g-2)_\mu$ and WMAP

Best fit for tanβ=10 prefers $m_{1/2}$~300 GeV

Prospects to observe SUSY at the Tevatron



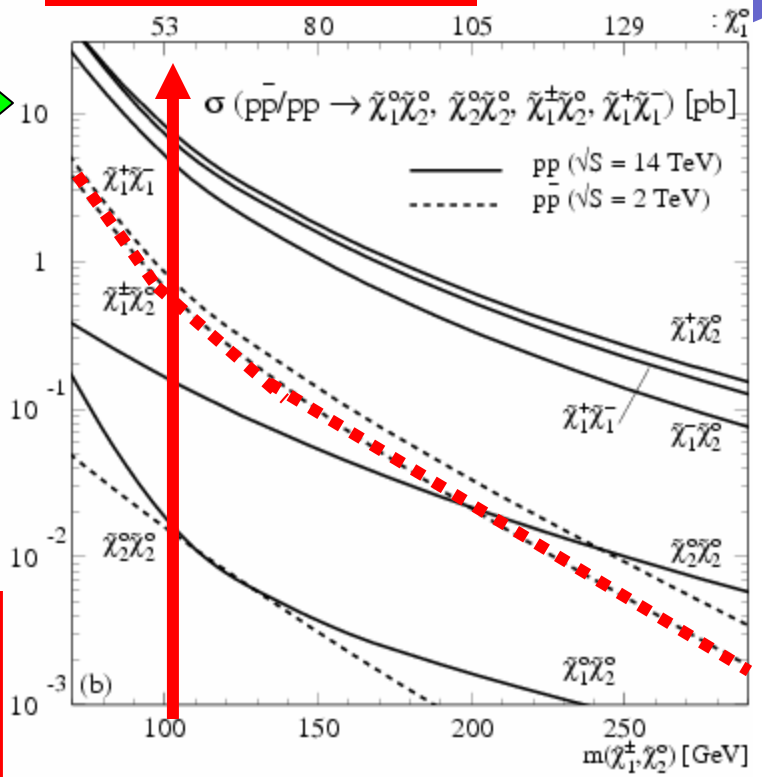
Ellis, Heinemeyer, Olive and Weiglein

- **Very clean final state with 3 charged leptons and MET**

Cross sections

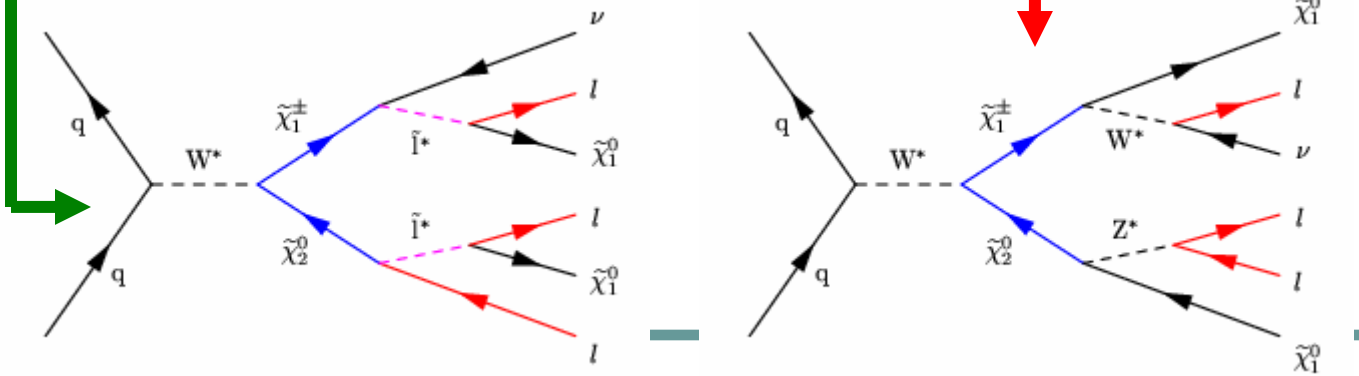
- **Tevatron Cross section ~ 0.1-1 pb above LEP limit**
- **σ×BR(3ℓ) depends on SUSY scenario:**
  - **Small slepton masses: additional decays into leptons**
  - ***3ℓ max scenario* for** $m_{\tilde{\ell}} \geq m_{\tilde{\chi}_2^0}$
  - **Large slepton masses: enhanced gaugino →gauge boson (*large m_0 scenario*, ~3% of WZ → 3ℓ)**
- **If scalar mass unification is relaxed σ is large if squark masses are large (*heavy-squarks scenario*)**

LEP chargino limit > 103.5 GeV



NLO cross section

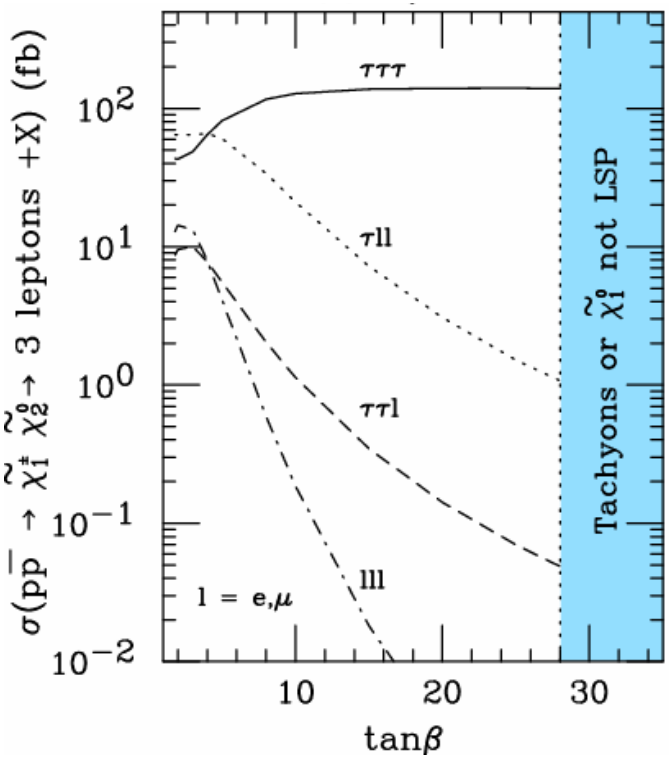
Beenakker, Klasen, Kramer, Plehm, Spira, Zerwas



Decays

- **Final state depends also on tan β**
  - **Large tan β ⇒stau becomes the lightest slepton⇒ enhanced decays into τ**

E_{CMS}= 2 TeV, $M_{1/2}$=200 GeV, m_0=100 GeV, μ>0



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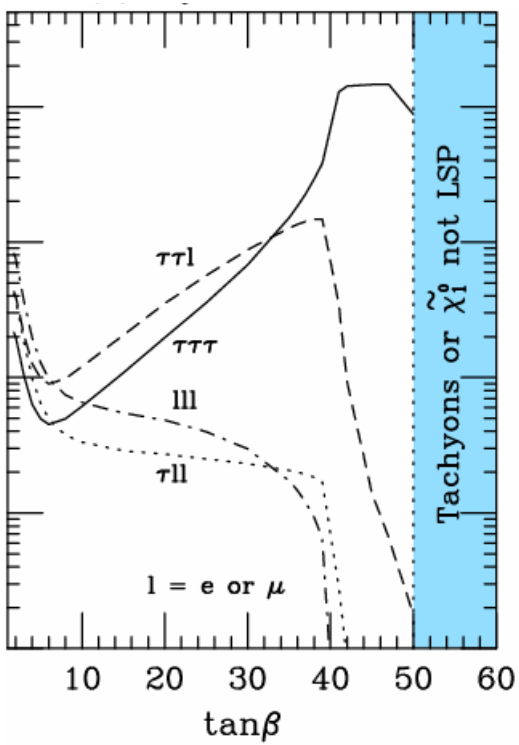
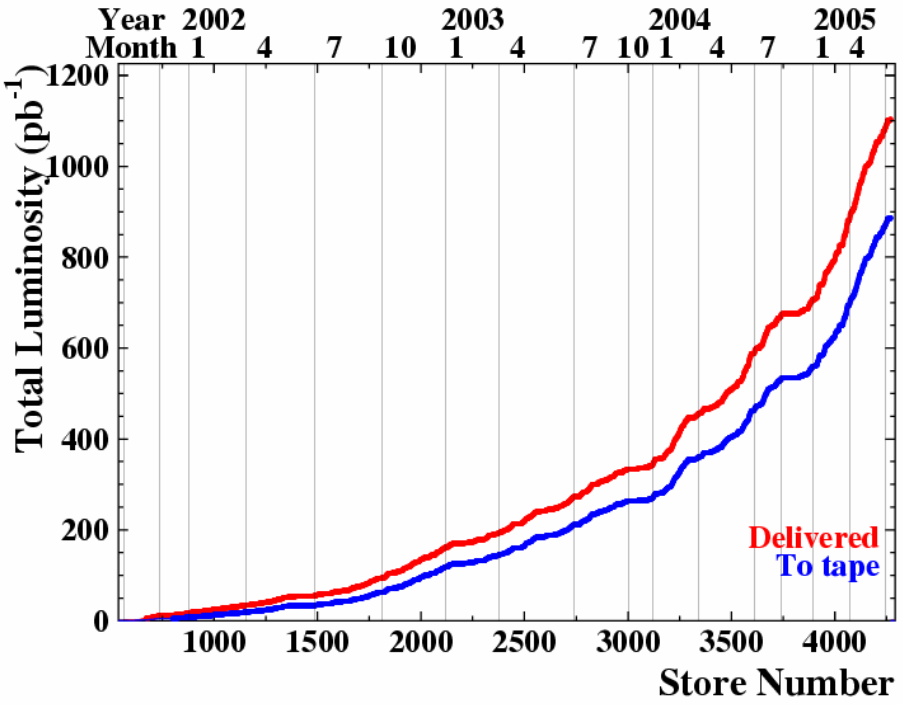


Report SUGRA working group FERMILA-PUB-00-349

The Tevatron at Fermilab



Data taking up to 2009 should achieve 4.4-8.5 fb^{-1}

Run II: about 1 fb^{-1} delivered to the experiments

Analysis based on about 300 pb^{-1}

Analysis Status

D0 6 analysis

ee, μμ, or eμ ($P_T \cong 10$ GeV) + ℓ
ℓ= isolated track P_T>5 GeV

eτ or μτ + ℓ or τ
τ= identified with NN
ℓ= isolated track P_T>5 GeV

μμ same sign ($P_T \cong 10$ GeV)

COMBINED RESULTS AVAILABLE

- I will show selected results:
  - Leptons + taus from D0
  - High pT ee and μμ + lepton from CDF

CDF 6 analysis

High p_T μμ + lepton
(P_T > 20, 8, 5 GeV)

High E_T ee + lepton
(P_T > 20, 8, 5 GeV)

Low E_T ee+ track
(P_T >10,5,4 GeV)
(sensitive to τ 1p decays)

Low p_T μμ+ lepton

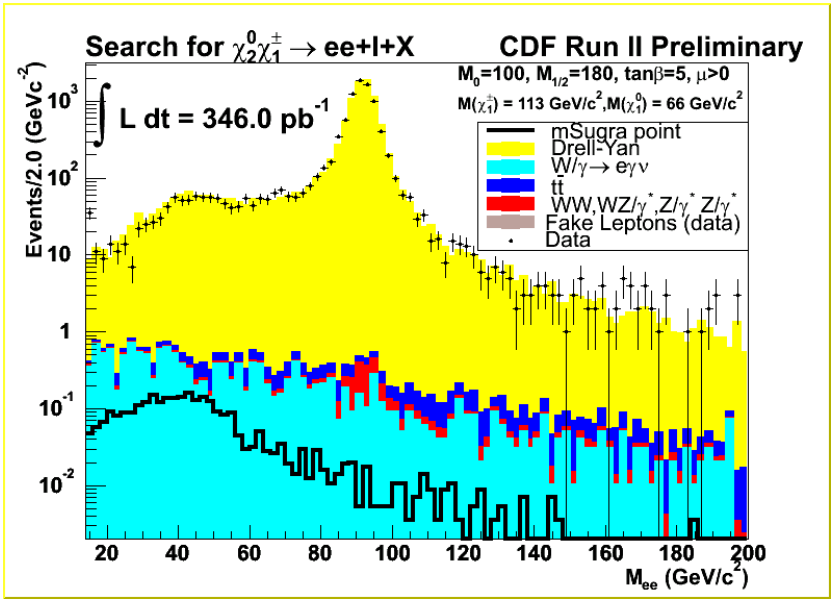
High p_T eμ + lepton

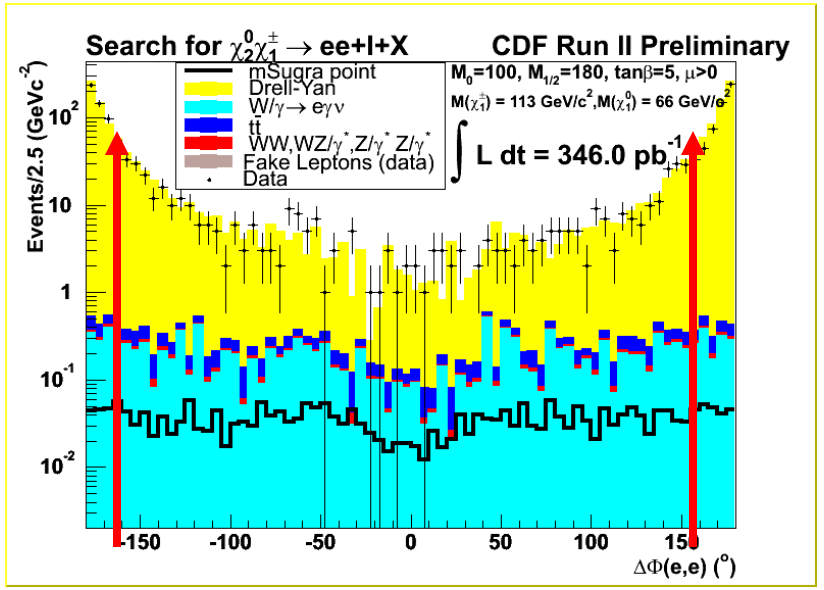
Low p_T eμ + track

In progress

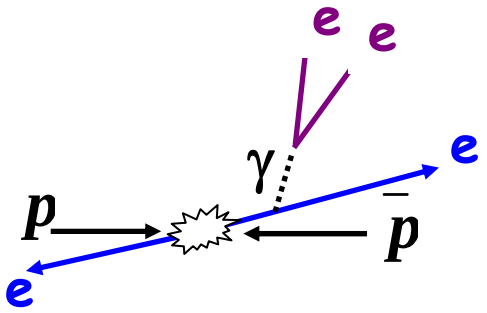
CDF eeℓ and $\mu\mu\ell$ analyses

- ***SM background*** **Z/ γ*, W+ γ, diboson, Z/ γ*, $\rightarrow \tau\tau$, $t\bar{t}$**
  overwhelms New Physics

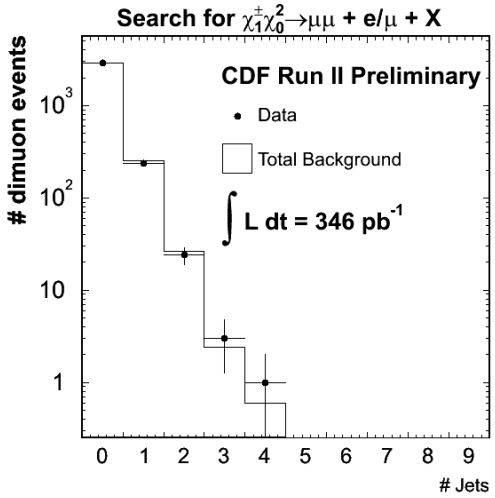




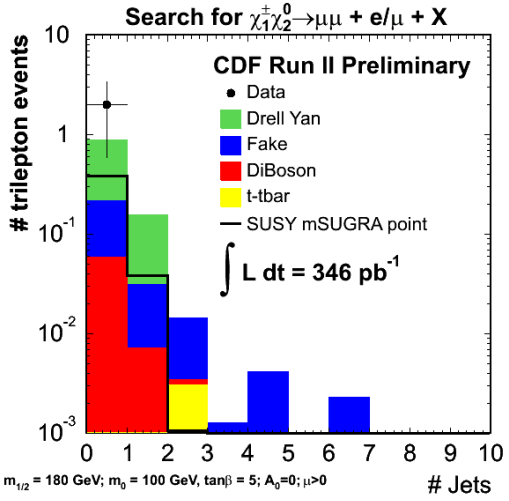
- **VETO J/Ψ, Υ and Z:**
  - **15 < M($\ell\ell$) < 76 GeV, M($\ell\ell$) > 106 GeV**
- **Angular cut |$\Delta\varphi$(ee)|<160°**
- **Require MET > 15 GeV**



CDF eeℓ and $\mu\mu\ell$ analyses



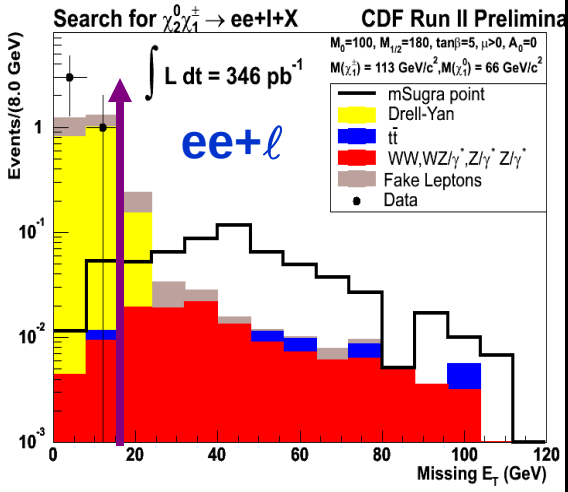
- Reduce tt : $N_{jet}<2$, $E_{T,jet} > 20$GeV
- Require 3rd lepton
- 12 control regions are used check SM background and fake predictions
- Example of agreement before requiring the third lepton

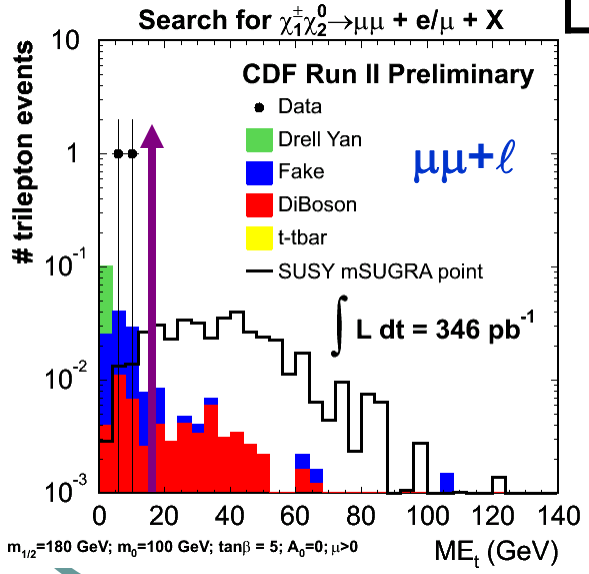


Control Region $\mu\mu$+ℓ analysis	Background	Observed data
Z veto, low MET, n. Jets < 2	522±14±78	538
Z mass, high MET, n. Jets > 1	1.8±0.8±0.7	2
Z mass window	3178±35±540	3168

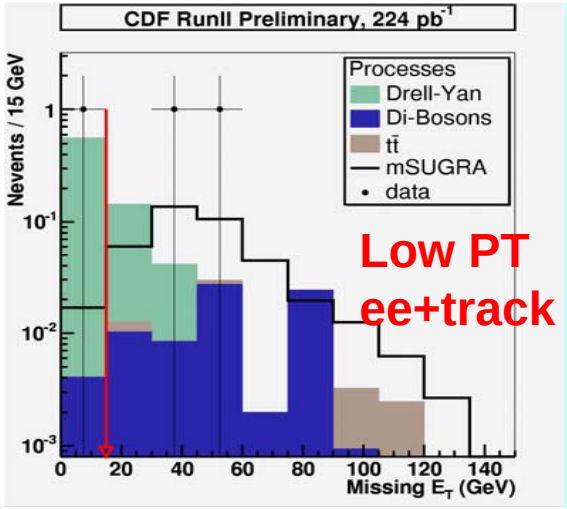
- Systematic errors:
  - **BCKG:**
    - **Jet energy scale 22%**
    - **Fake rate 5%**
  - **Signal**
    - **Muon P_T resolution 7%**
    - **Lepton ID 5%**
  - **Theor. cross section 7%**
  - **Luminosity 6%**

CDF Summary Results





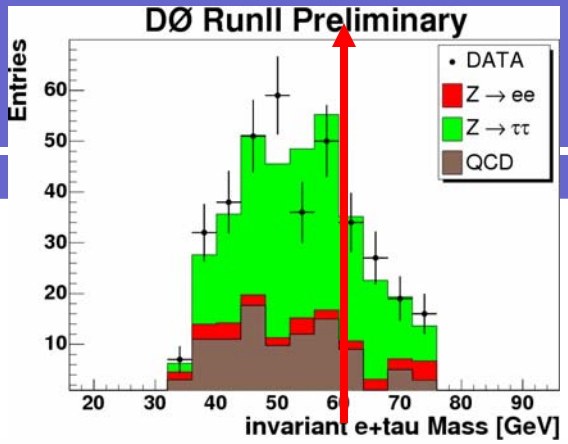
Analysis	Background	SUSY M_0=100 GeV , $M_{1/2}$=180GeV, tanβ>5, μ>0	Obs. data
μμ+ℓ	0.09±0.03	0.37±0.05	0
ee+ℓ	0.17±0.05	0.49±0.05	0
Low PT ee+track	0.36±0.27	0.46±0.07	2

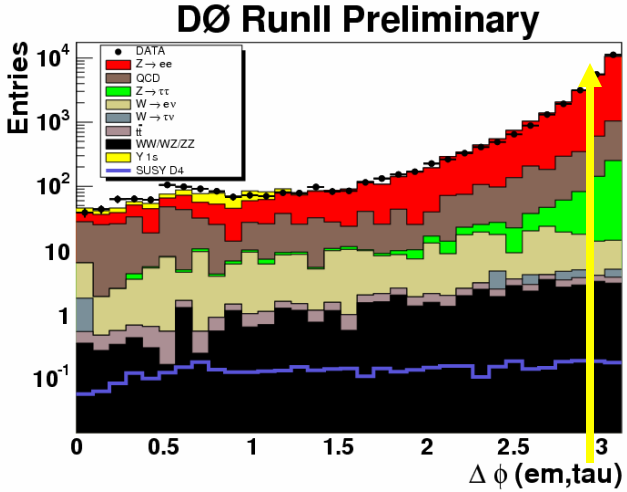


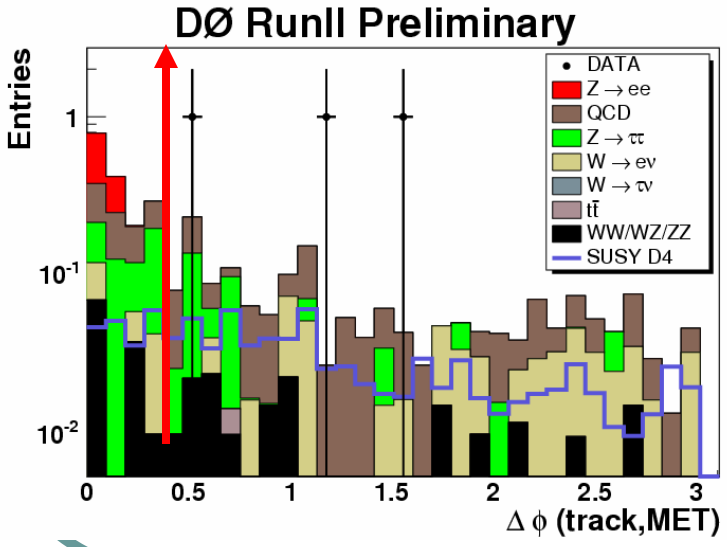
- CDF plans to:
  - Increase acceptance (forward region)
  - Finish other analyses and combine the results

D0 $e\tau^{had}$+lepton

- τ ID: narrow calorimeter cluster matched up to 3 tracks (NN) **tested on $Z/\gamma^* \rightarrow \tau\tau$**
- $P_T(e) > 8$ GeV, $P_T(\tau) > 8$ GeV
- Z Veto: $10 < M(e,\tau) < 60$ GeV, $\Delta\phi(e, \tau) < 2.9$
- Significant MET
  - MET>25 GeV, scaled MET>$8\sqrt{}$GeV
  - Min(MT(e,MET), MT(τ,MET) >10 GeV
- **tt veto:** $H_T < 60$ GeV where $H_T = \Sigma P_{T,jets}$



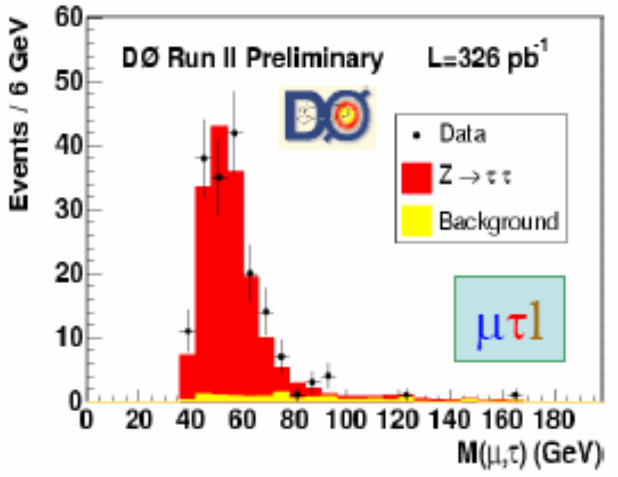


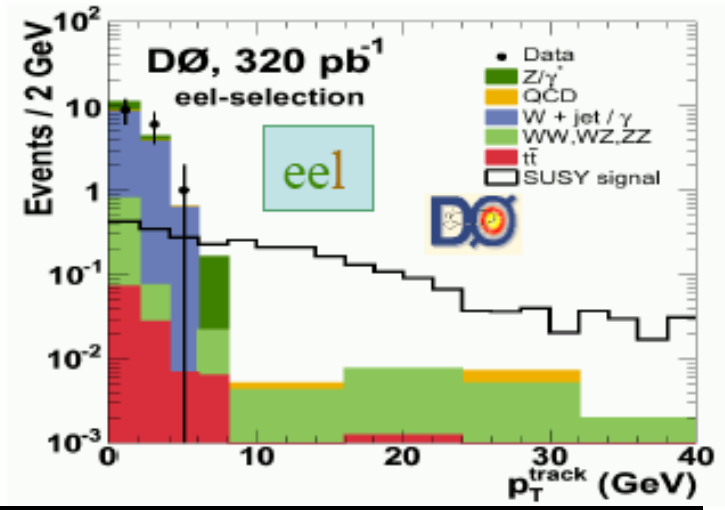


- Third ℓ_3 : tau or isolated track (P_T>5GeV)
  - DiBoson veto: $\Delta\phi$(MET, ℓ_3) >0.3
  - $P_{track} \times$ MET>350 GeV
- Systematic errors
  - Bckg 17.3% (jet calibration 15.4%)
  - Signal 7.4% (track eff. 2.8% trigger 1.8%)

Summary D0 analysis

analysis	data	background
eeℓ	0	0.21±0.11±0.05
eμℓ	0	0.31±0.13±0.03
μμℓ	2	1.75±0.37±0.44
LS μμ	1	0.64±0.36±0.13
eτℓ	0	0.58±0.11±0.09
μτℓ	1	0.36±0.12±0.06
SUM	4	3.85±0.57±0.49





7 SUSY points studied: tan β=3, A_0=0

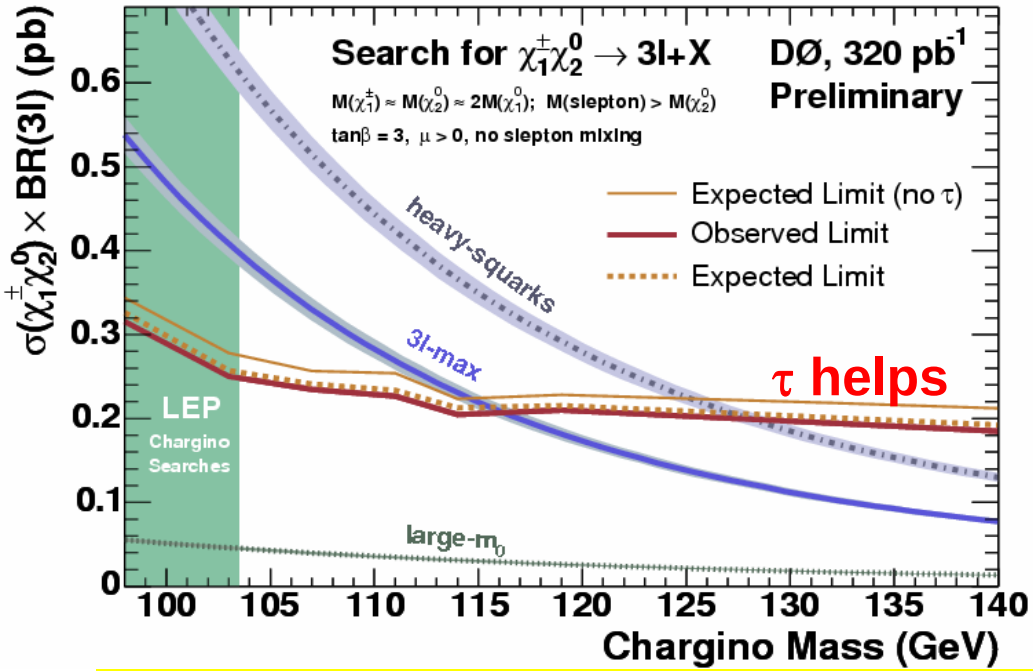
SUSY point	M($\tilde{\chi}^{\pm}$) GeV	M($\tilde{\chi}_2^0$) GeV	M($\tilde{\ell}_R$) GeV	σ×BR	Expected events
1	98	102	99	0.536	9.5±0.3±0.4
5	114	114	115	0.231	6.0±0.1±0.3

Combined D0 limit

- Combine analysis, using LEP CLs method:
  - Assign signal to maximize the combined sensitivity
- m-SUGRA scenario

$$m(\tilde{\chi}^{\pm}) \approx m(\tilde{\chi}_2^0) \approx 2m(\tilde{\chi}_1^0)$$

- For degenerate slepton masses limit is function of the chargino and slepton masses



Hep-ex/050432: limits for ee, μ μ or eμ + ℓ and same sign μμ

Slightly better than preliminary analysis

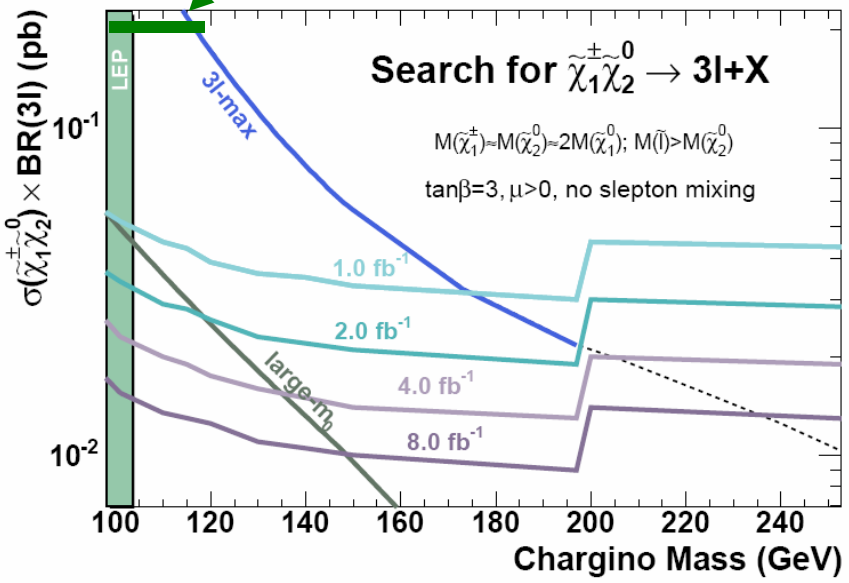
- In the 3ℓ-max scenario $m(\tilde{\chi}_1^{\pm}) > 116 GeV \ \ at \ \ 95\% CL$
- In the heavy squark limit $m(\tilde{\chi}_1^{\pm}) > 128 GeV \ \ at \ \ 95\% CL$

Conclusions

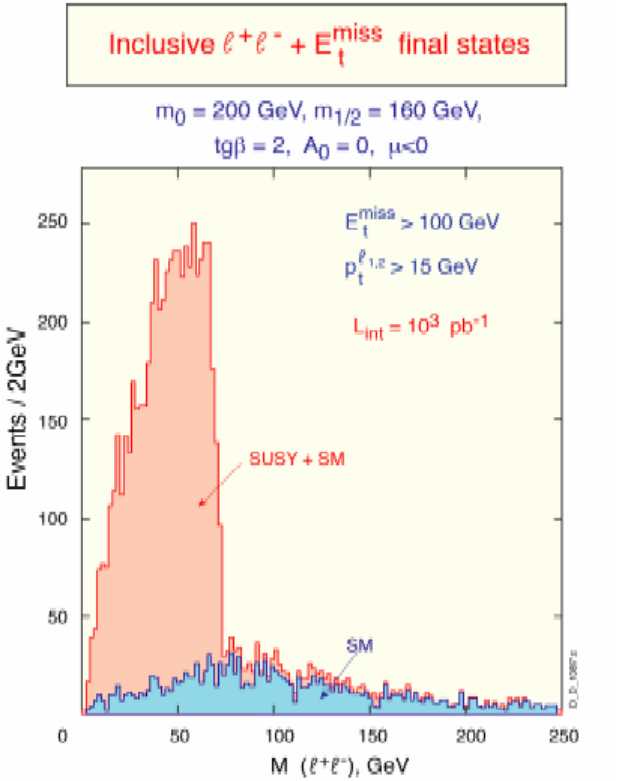
- Tevatron is starting to probe above LEP excluded region.
- Opportunities for discovery as more data is collected

Current sensitivity

Expect 20×current data/experiment



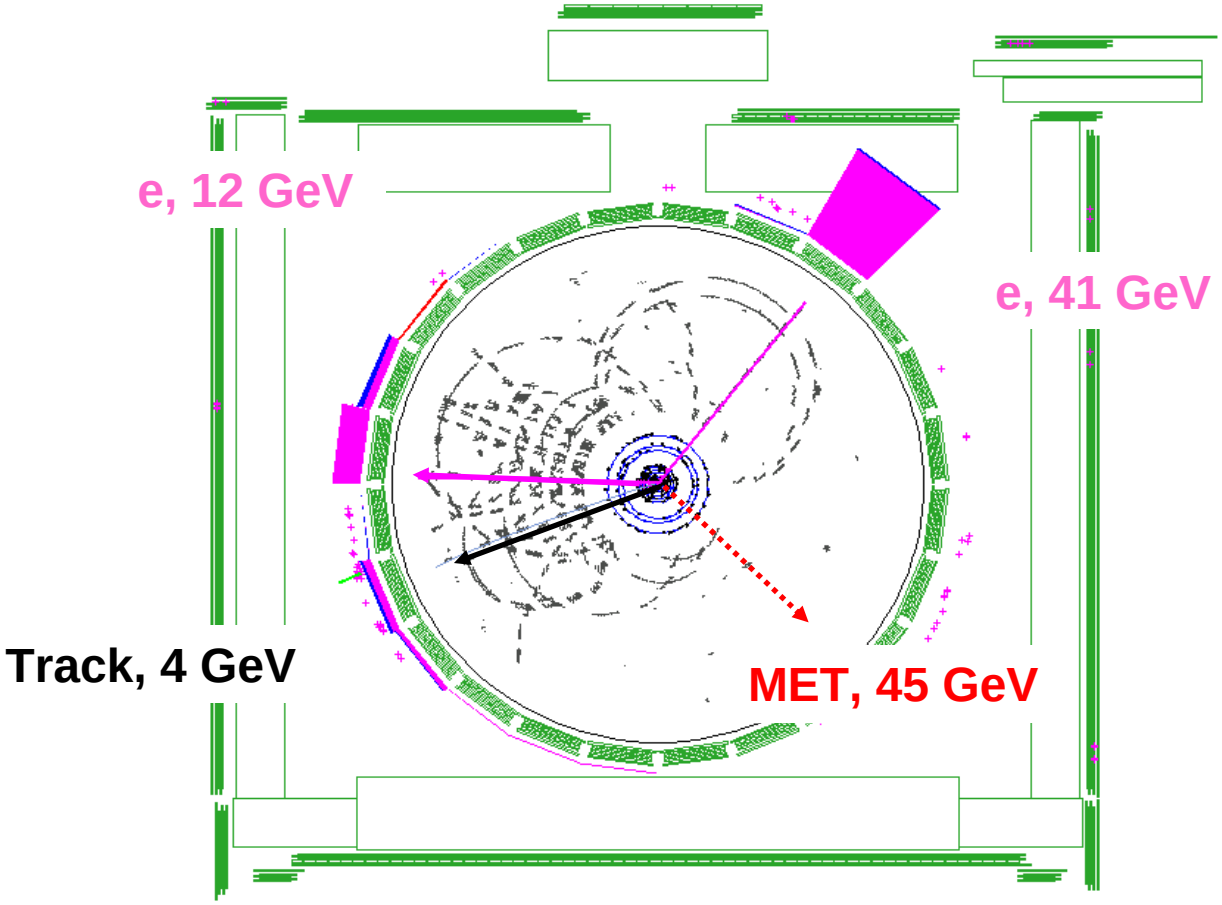
- LHC expected to provide final answer



http://www-cdf.fnal.gov/physics/exotic/exotic.html

http://www-d0.fnal.gov/Run2Physics/WWW/results/np.html

Candidate event



Mass OS1	41.6 GeV
Mass OS2	27.0 GeV