

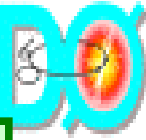
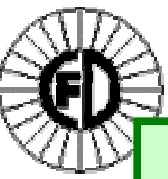
Search for SUSY at the Tevatron

Vishnu V. Zutshi

Northern Illinois University

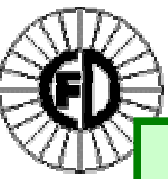
for the

CDF and DØ Collaborations

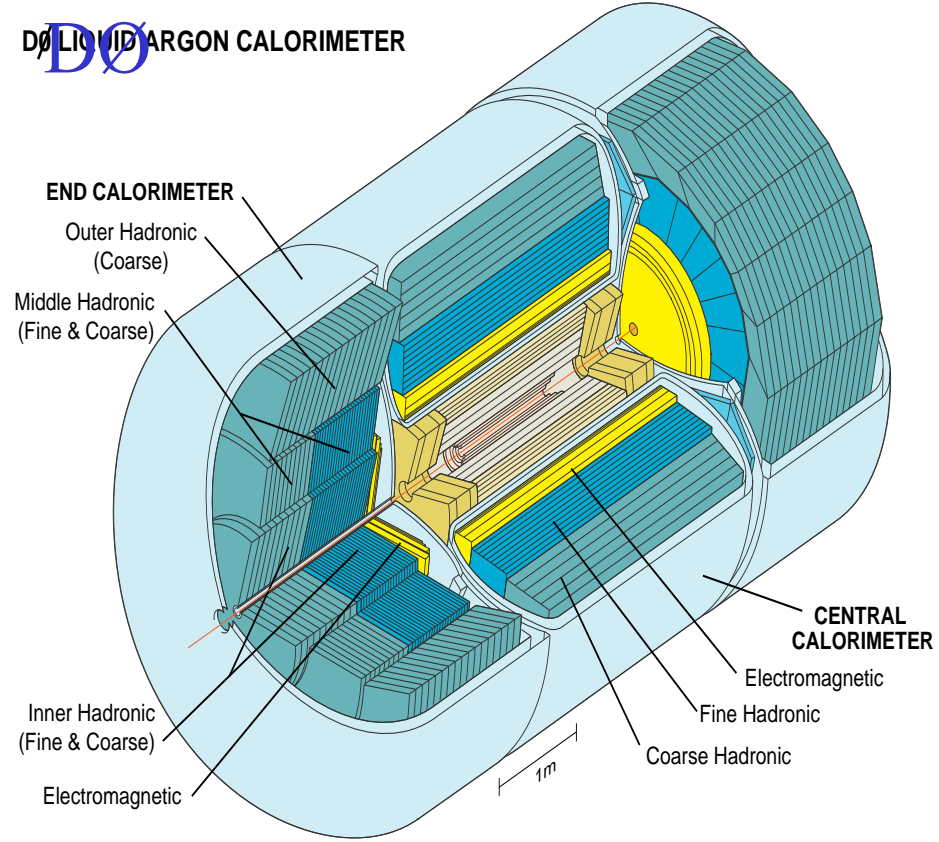
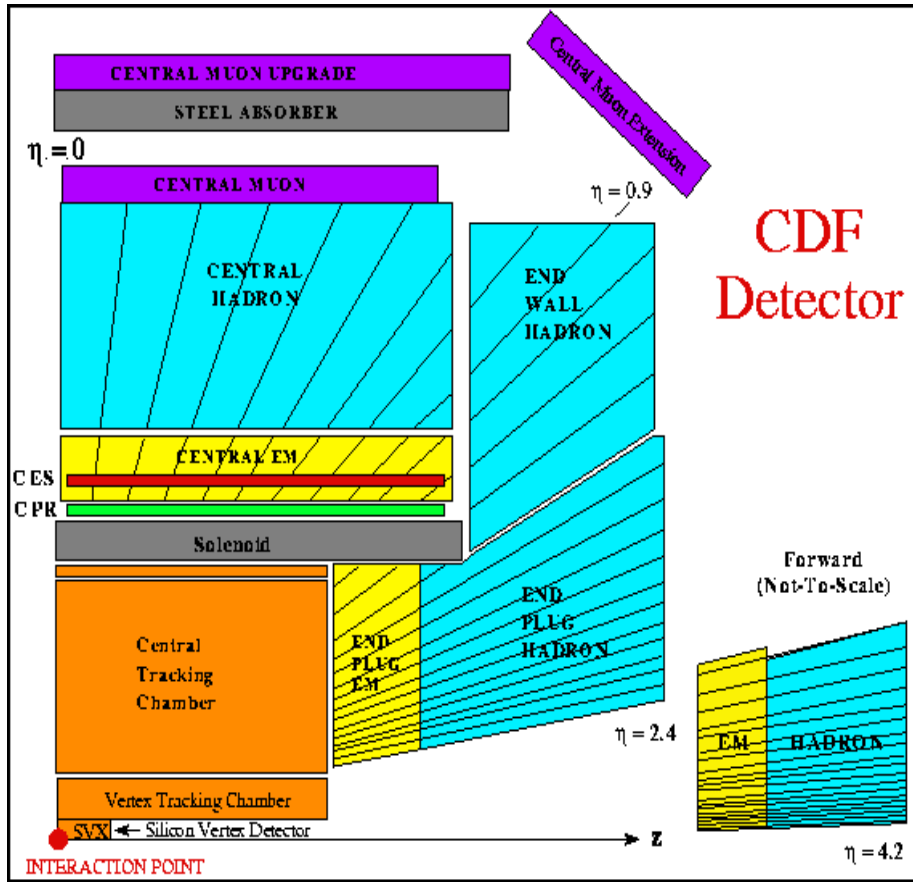


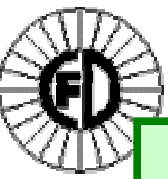
Outline

- MSSM
Stop search (CDF)
- mSUGRA
Single electron channel search ($D\emptyset$)
- RPV
Decays of stop pair (CDF)
di-muon channel, pair & resonant prod. ($D\emptyset$)
- GMSB
Light gravitino search (CDF)
di-photon channel search ($D\emptyset$)

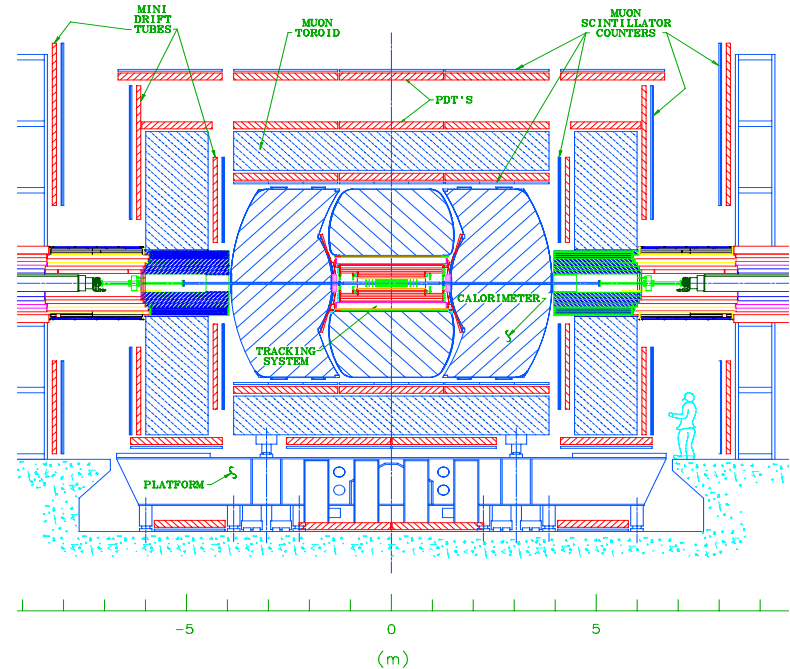
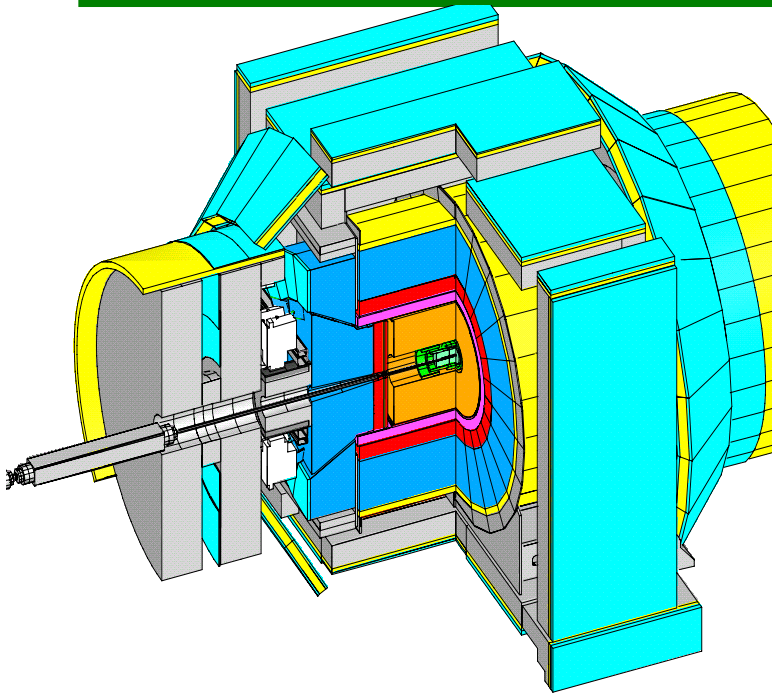


Run1 CDF and DØ Detectors



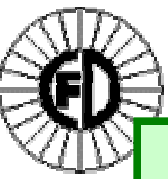


Run 2 CDF and DØ Detectors

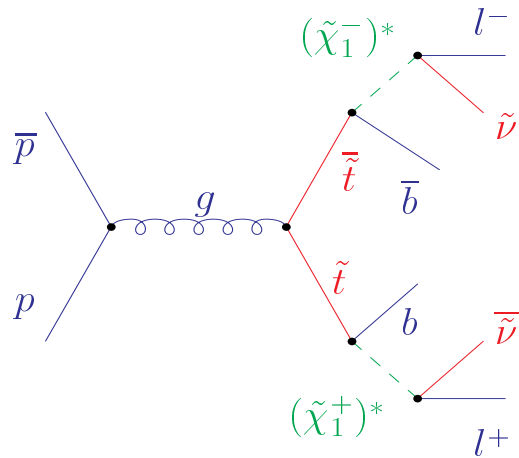


silicon detector, c.o.t., tile plug
and forward calorimeters.....

sci-fi central tracker, silicon detector
2T magnet, preshower detectors.....



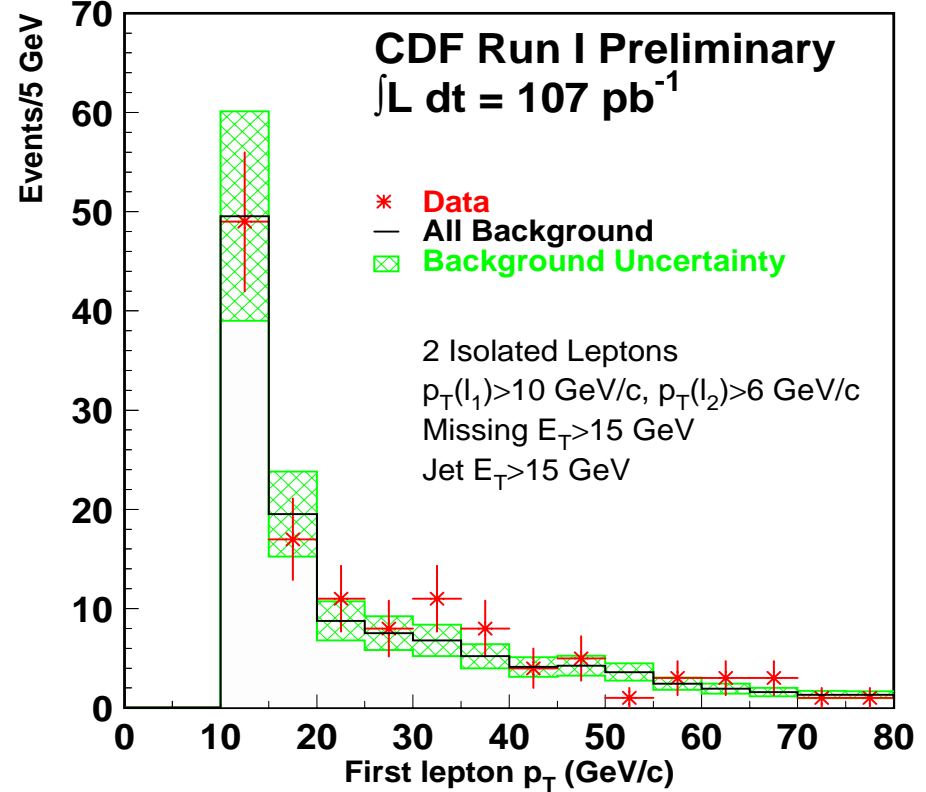
Stop Search

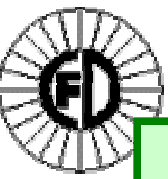


Final state: 2 leptons+jets+ME_T

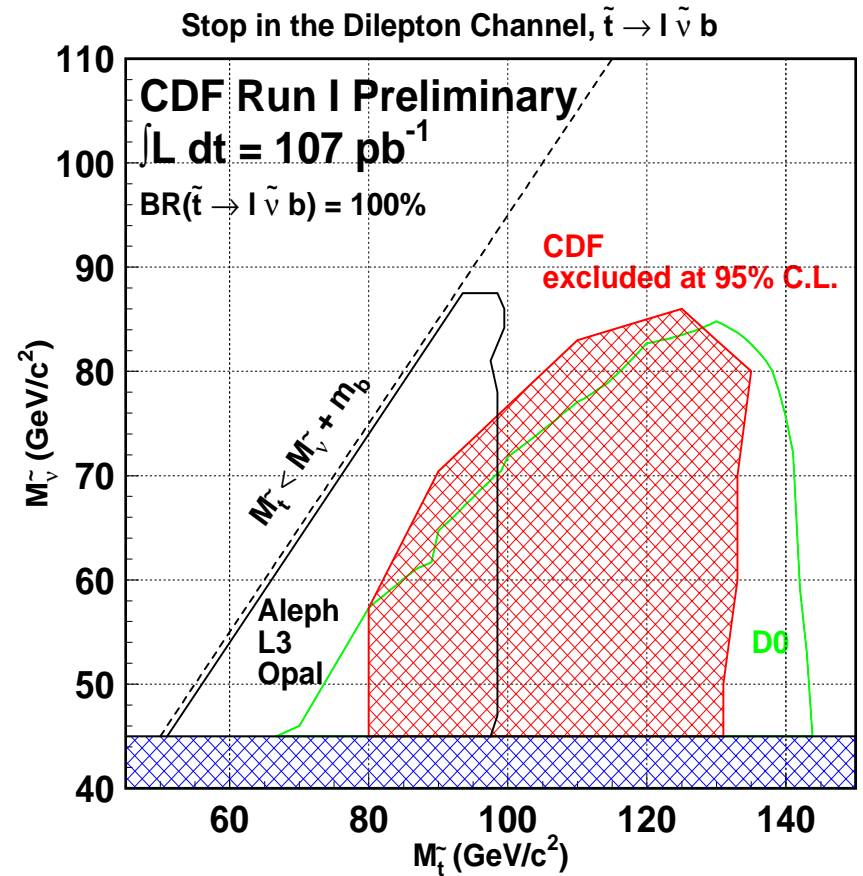
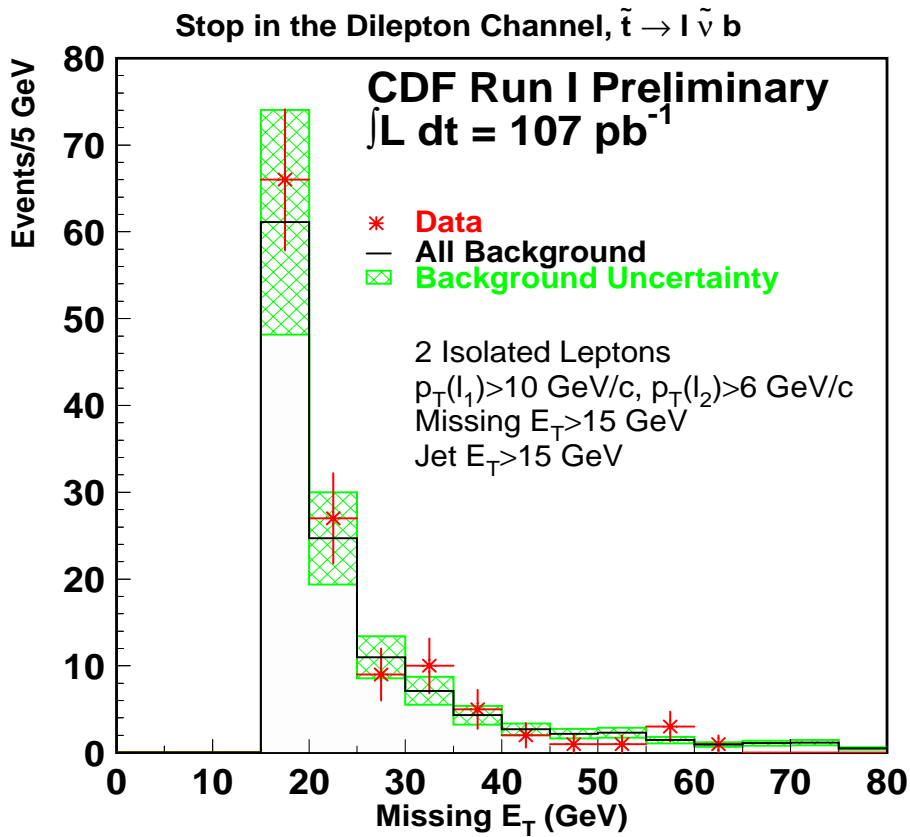
Drell-Yan, heavy quark pair prod.,
QCD fakes, diboson production

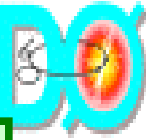
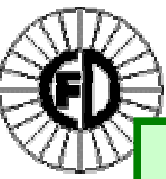
Stop in the Dilepton Channel, $\bar{t} \rightarrow l \bar{\nu} b$





Stop Search (II)





(m)SUGRA models

- SUSY breaking is communicated to the physical sector by gravitational interactions
- GUT scale parameters + RGE's \rightarrow low-scale phenomenology

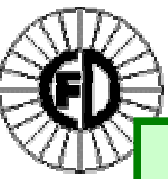
M_0 = common scalar mass

$M_{1/2}$ = common gaugino mass

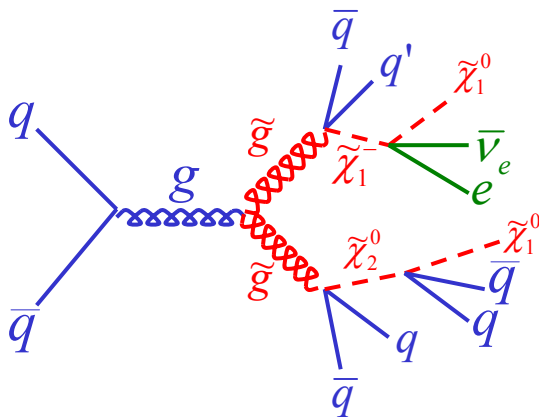
A_0 = common trilinear coupling value

$\tan\beta$ = ratio of the V.E.V. of the two Higgs doublets

sign of μ = Higgsino mass parameter



Single Electron Channel

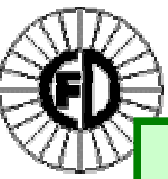


Bckg: W +jets, qcd multijet, $t\bar{t}$
 Cuts: $E_t^e > 20$ GeV, $E_t^j > 14$ GeV
 (≥ 4), no isolated muons,
 $ME_T > 25$ GeV
 $L = 92.7$ pb $^{-1}$

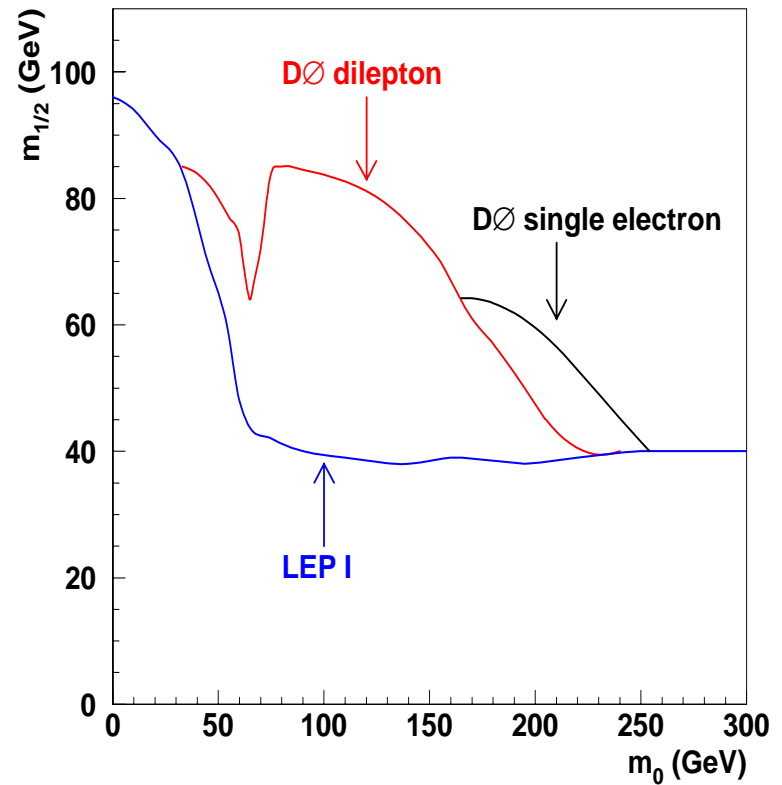
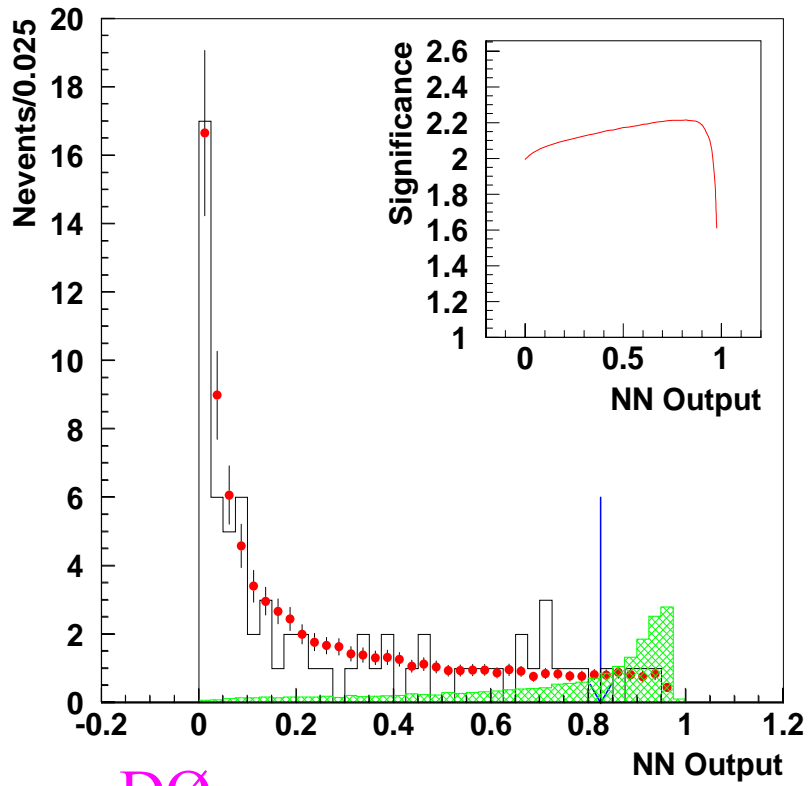
Sensitive to moderate m_0
 Complements dilepton and
 Jets+ ME_T channels

Observed events = 72
 Expected background = 80 ± 10

DØ



Single Electron Channel





R-parity and its violation

- Discrete quantum number

$R = (-1)^{3B+2S+L}$; is 1 for SM particle, -1 for sparticles

- R-parity violation can be introduced by

$$W_{\Delta L=1} = (1/2)\lambda^{ijk}L_iL_j\bar{e}_k + \lambda'{}^{ijk}L_iQ_j\bar{d}_k + \mu'{}^iL_iH_u$$

$$W_{\Delta B=1} = (1/2)\lambda''{}^{ijk}\bar{u}_i\bar{d}_j\bar{d}_k$$

Decay of the LSP

Signatures maybe very different

Single sparticle production possible

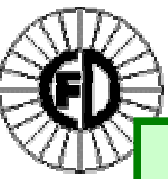
Whither dark matter candidate

mSUGRA with RPV

One RPV coupling dominates

If coupling large enough, resonant prod.

Otherwise pair production



Decays of Stop Pair

Assuming RPV only in 3rd gen.

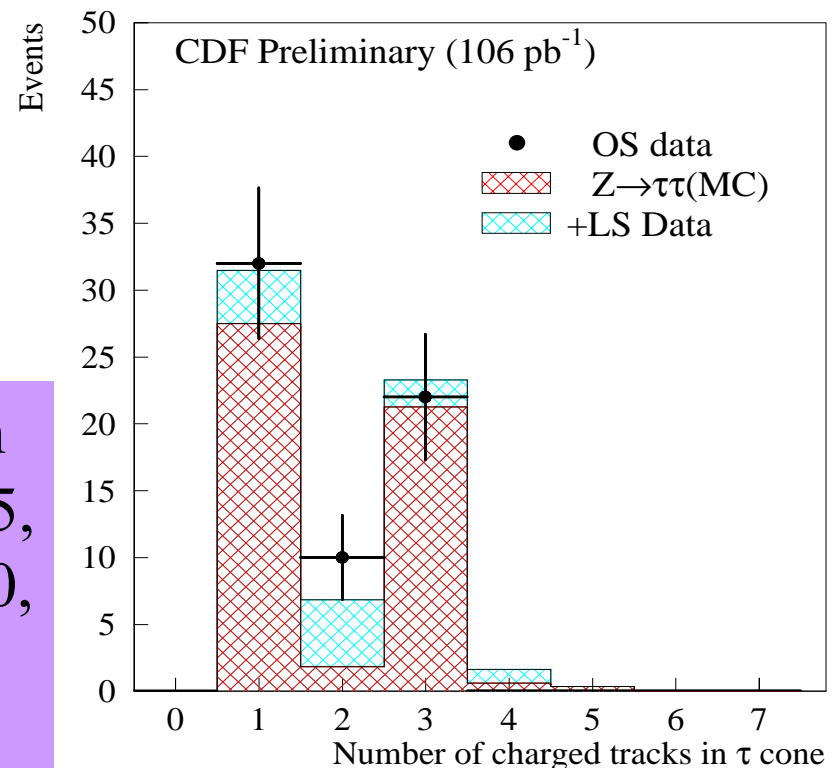
$$tt+X = \tau_l + b + \tau_h + b + X$$

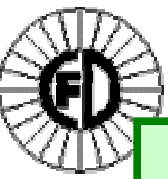
Final state: lepton + hadronic τ
+ 2 jets

Bckg: W/Z + jets, multijet, diboson

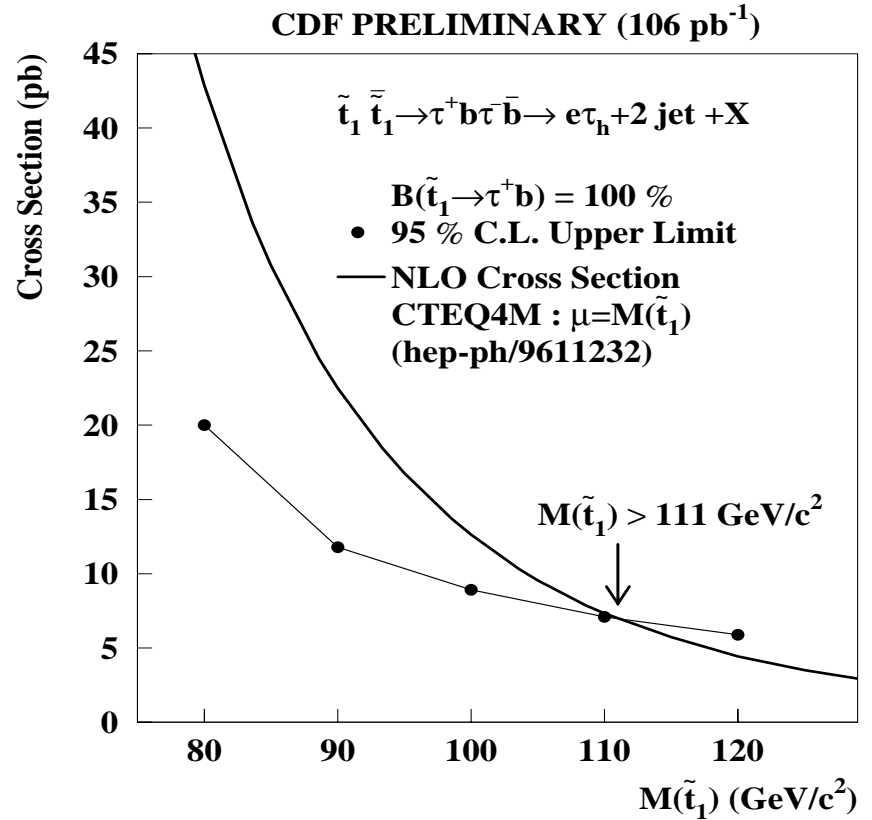
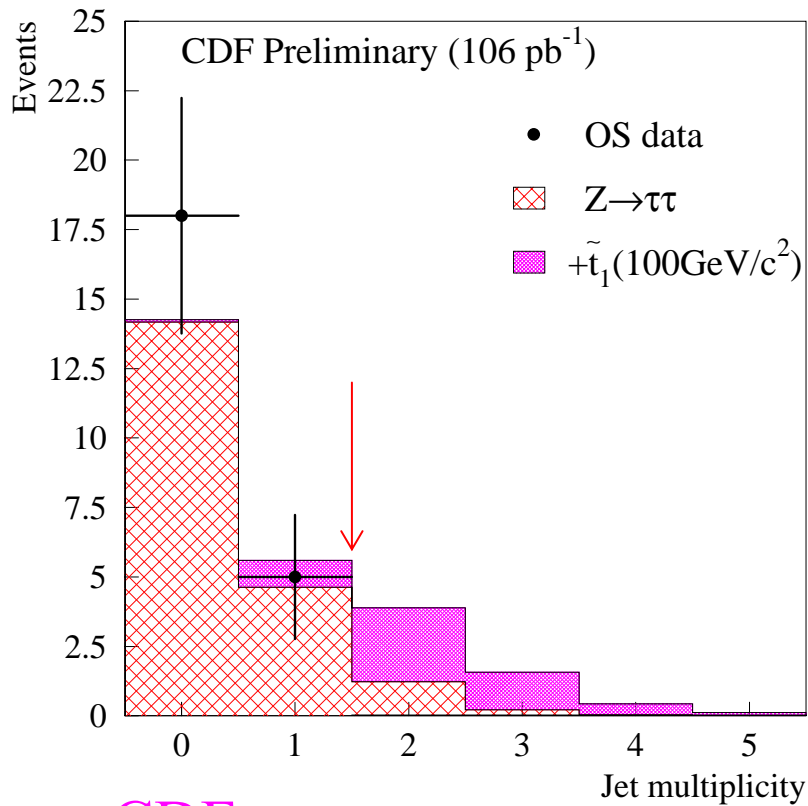
Cuts: $p_T^{\text{lepton}} > 10 \text{ GeV}$, $\tau_h \text{ cluster} > 15$,
 $M_T^{\text{(lepton, Met)}} < 35 \text{ GeV}/c^2$, $H_T > 70$,
 $\geq 2 \text{ jets } (E_T > 15 \text{ GeV})$

$L = 106 \text{ pb}^{-1}$



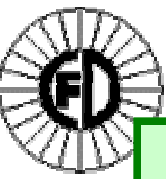


Decays of Stop Pair



CDF

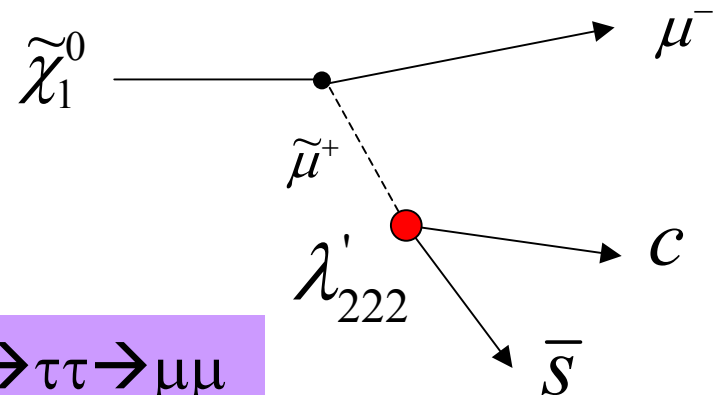
Run IIa proj. $\sim m_t$



Pair Production: di-muon channel

Final state: $2\mu + 4\text{jets}$

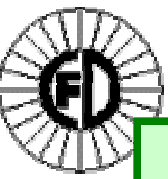
- Bckg: Drell-Yan, $t\bar{t}$, $Z \rightarrow \mu\mu + \text{jets}$, $Z \rightarrow \tau\tau \rightarrow \mu\mu$
- Cuts: $p_t^\mu > 15(10) \text{ GeV}$, $p_t^{\text{jets}} > 15 \text{ GeV}$,
- $S_t > 150 \text{ GeV}$, $M_{\mu\mu} > 5 \text{ GeV}$, $A_{\text{coplanarity}} > 0.03$
- Run1 $L = 77.5 \pm 4 \text{ pb}^{-1}$



DØ

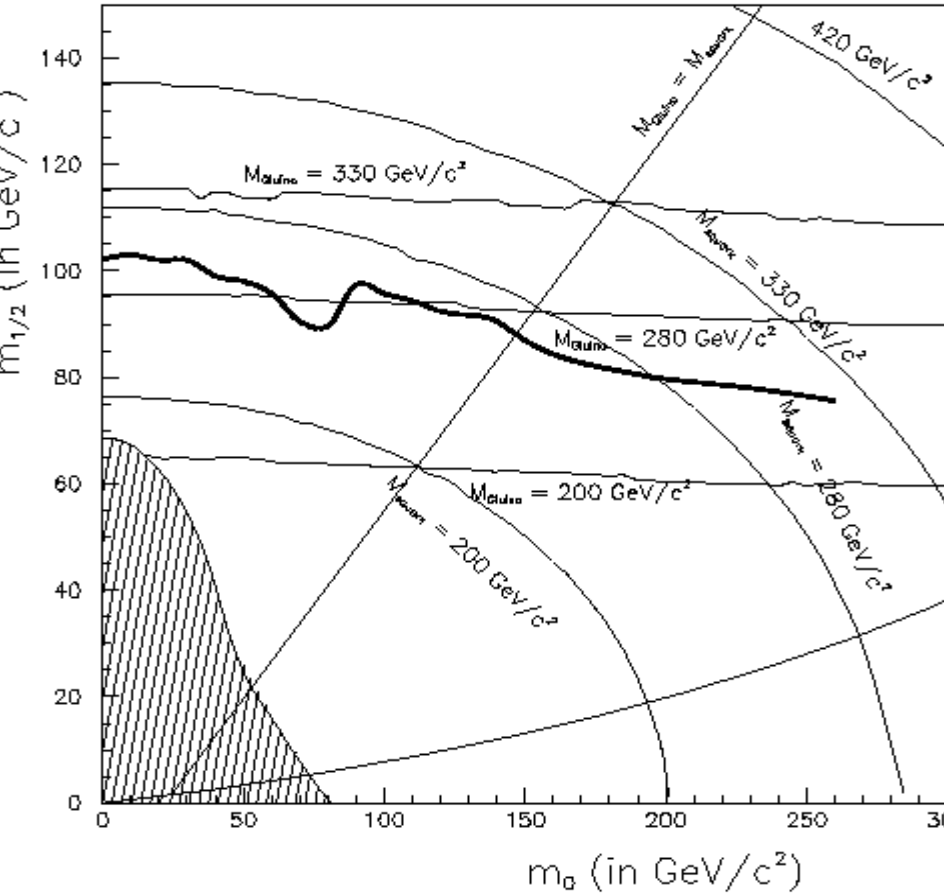
Events observed = 0

Expected bckg. = $0.18 \pm 0.03 \pm 0.02$

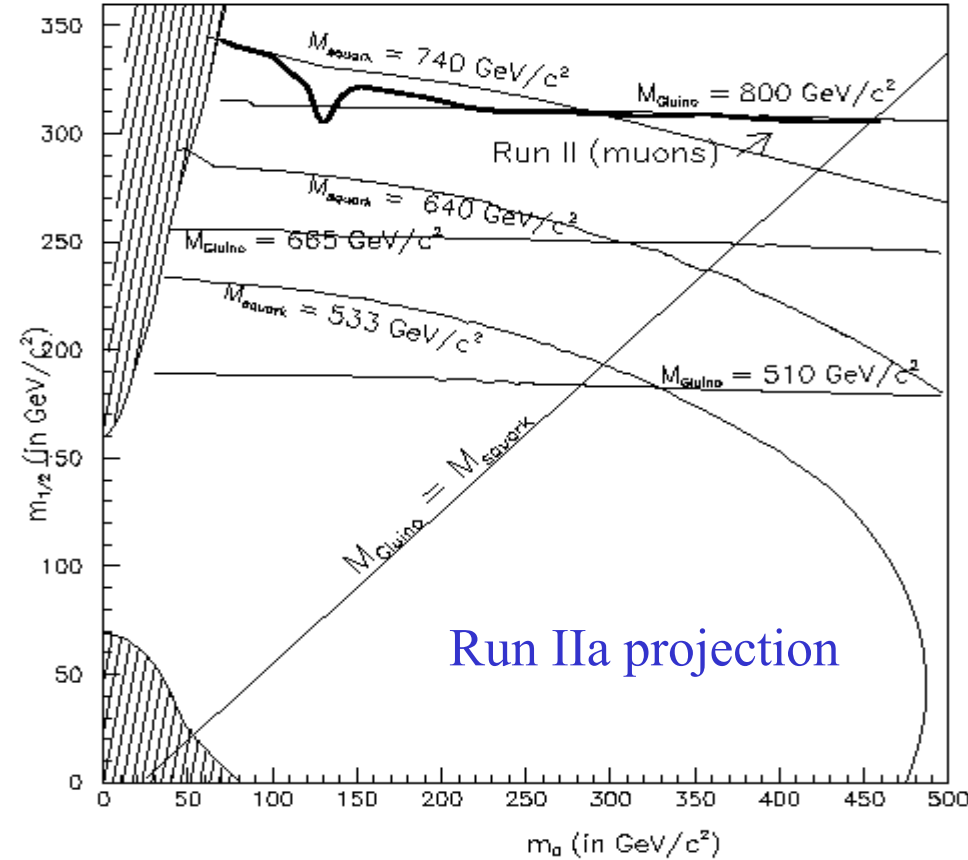


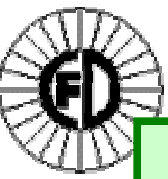
Pair Production: di-muon channel

R parity violating SUSY in the channel -- 2 muons+4 jets



R-parity violating SUSY in the jets + muons channel

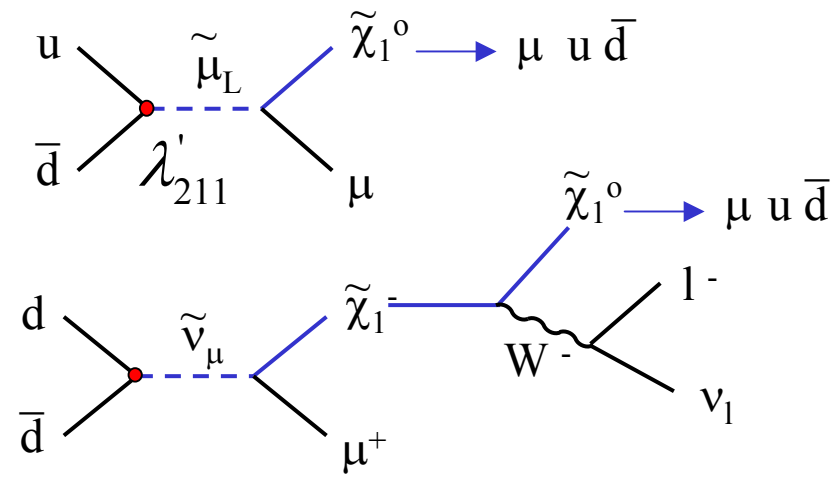




Resonant Production: di-muon channel

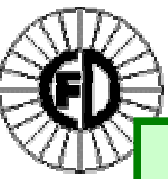
Resonant prod. and decay
of LSP via RPV
Final state: $2\mu + 2\text{jets}$

Bckg: $t\bar{t}$, $Z+2\text{jets}$, $WW+\text{jets}$
Cuts: $p_T^\mu > 20 \text{ GeV}$, $p_T^{\text{jets}} > 20 \text{ GeV}$,
 $S_T > 50 \text{ GeV}$, $\Delta R(\mu\text{-jet}) > 0.5$
 $L = 94 \pm 5 \text{ pb}^{-1}$

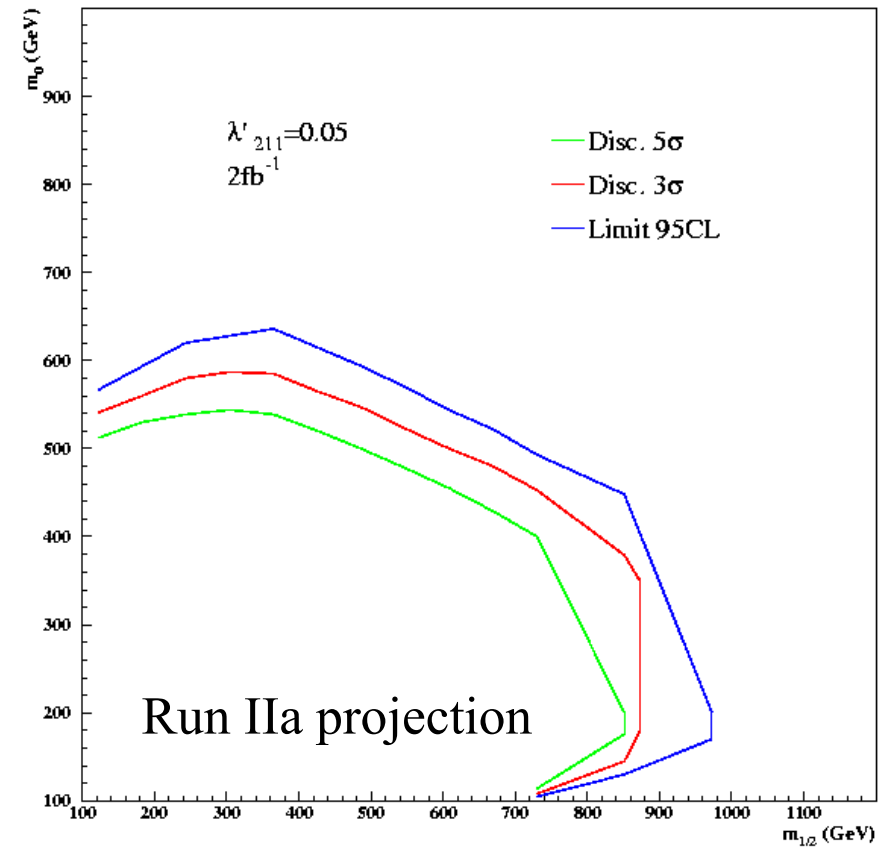
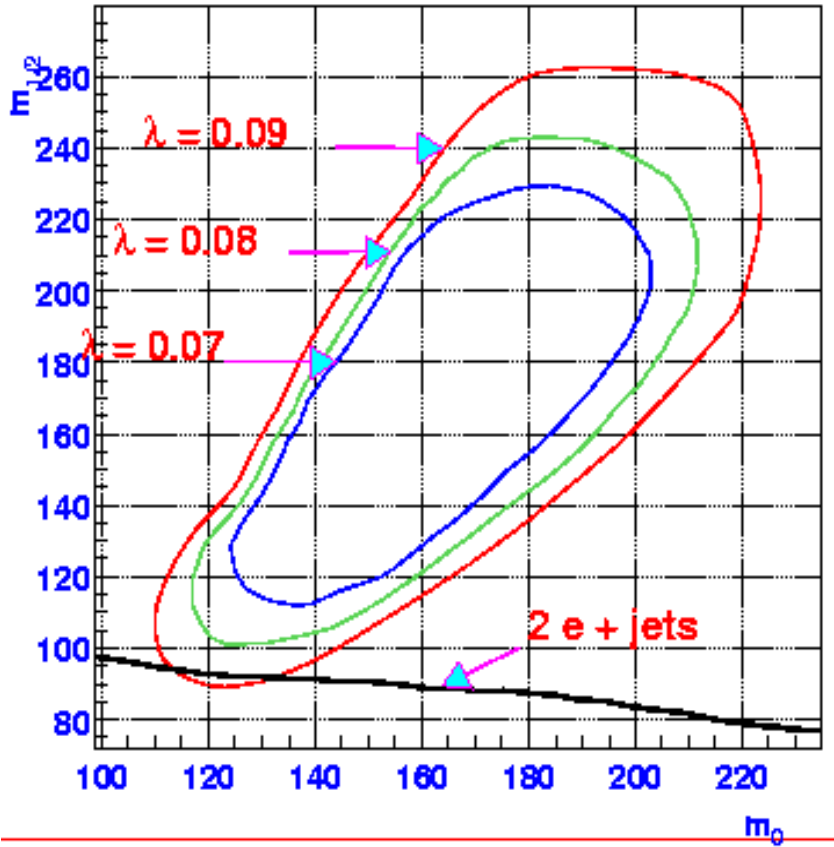


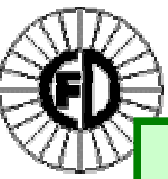
Observed events = 5
Expected bckg = 5.34 ± 0.07





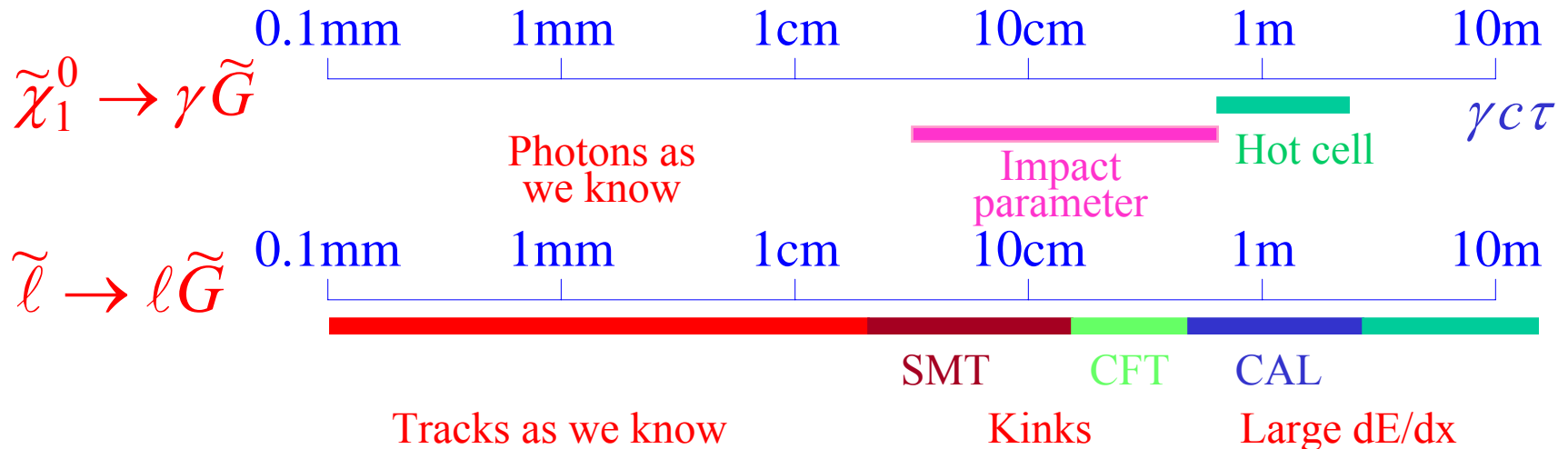
Resonant Production: di-muon channel

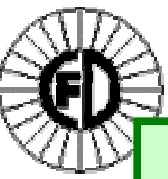




GMSB models

- ‘Messenger’ sector couples to source of SUSY-breaking and physical sector of MSSM (through gauge interactions)
- The identity of the NLSP and its lifetime determine the phenomenology





Light Gravitino Search

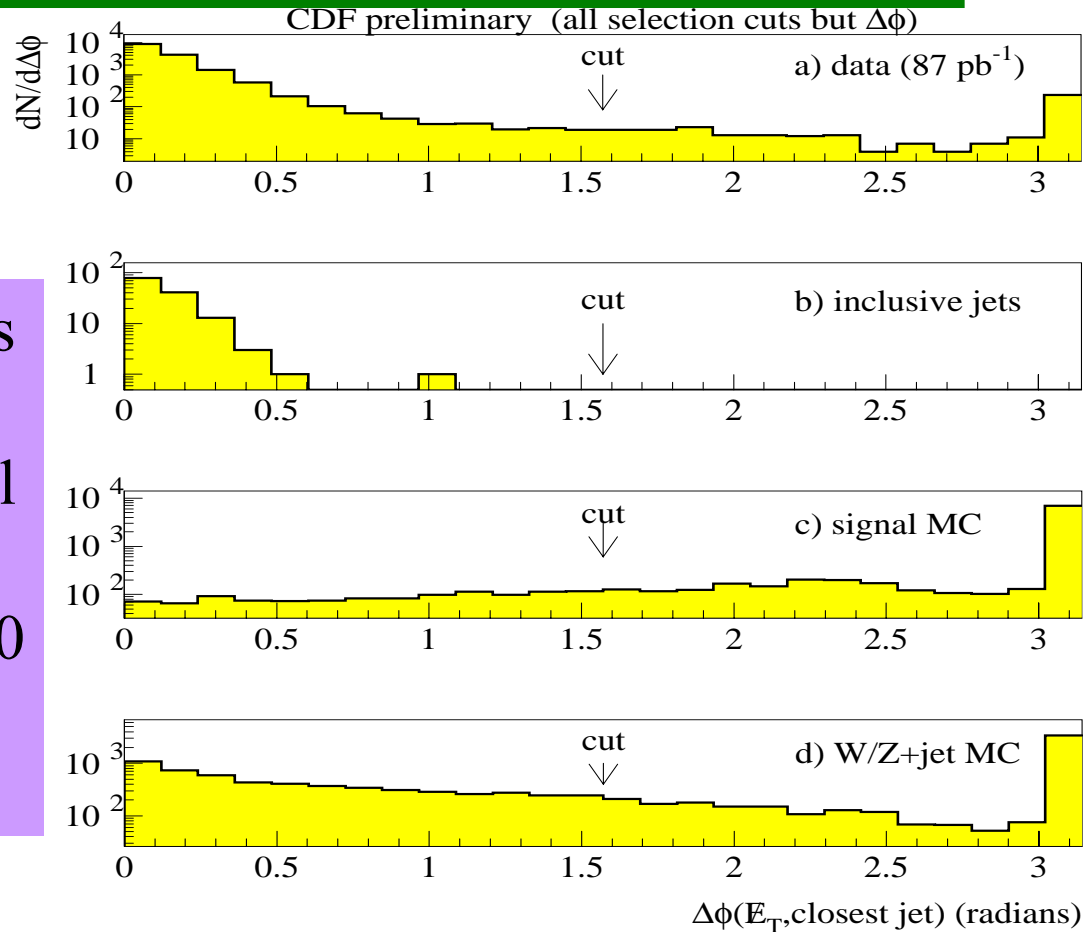
$$p\bar{p} \rightarrow \tilde{G}\tilde{G}X$$

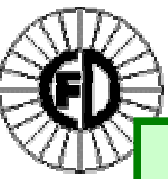
Final state: $ME_T + \text{jet}$

Bckg: mismeasured multi-jets
W/Z + jets, tt, diboson

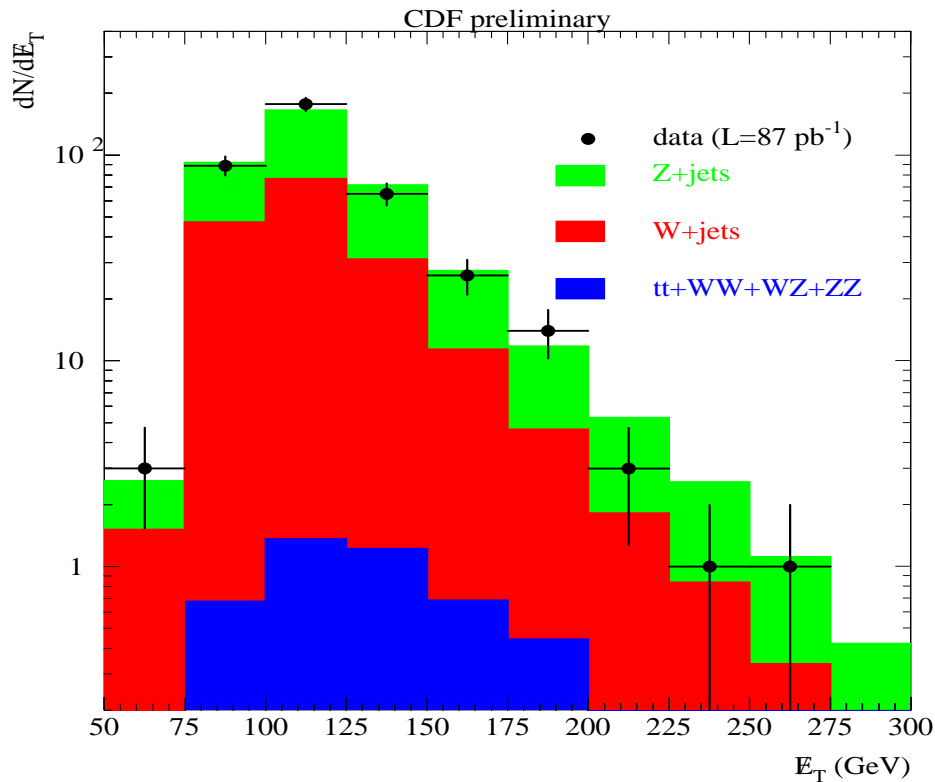
Cuts: $ME_T > 50$ GeV, removal
of events w/ isolated tracks,
 $\Delta\phi(ME_T, \text{jet}) > 90^\circ$, $E_t^{\text{lead-jet}} > 80$
GeV, $0.1 < EMF^{\text{lead-jet}} < 0.95$
 $L = 87 \text{ pb}^{-1}$

CDF





Light Gravitino Search (II)

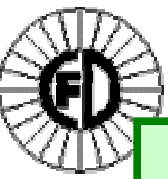


For $ME_T > 175 \text{ GeV}$:
 Events observed = 19
 Expected bckg = 21.6

$\sigma(P_T^{\tilde{G}\tilde{G}} > 100 \text{ GeV}) < 3.1 \text{ pb}$
 $\sqrt{F} > 217 \text{ GeV}$
 $m_{\tilde{G}} > 1.1 \times 10^{-5} \text{ eV}/c^2$

Run IIa proj. $\sim 270 \text{ GeV}$

CDF



Di-photon Channel

$$p\bar{p} \rightarrow \tilde{\chi}_i^\pm \tilde{\chi}_i^0 \rightarrow X(\gamma\tilde{G})(\gamma\tilde{G})$$

Final state: 2 photons + ME_T

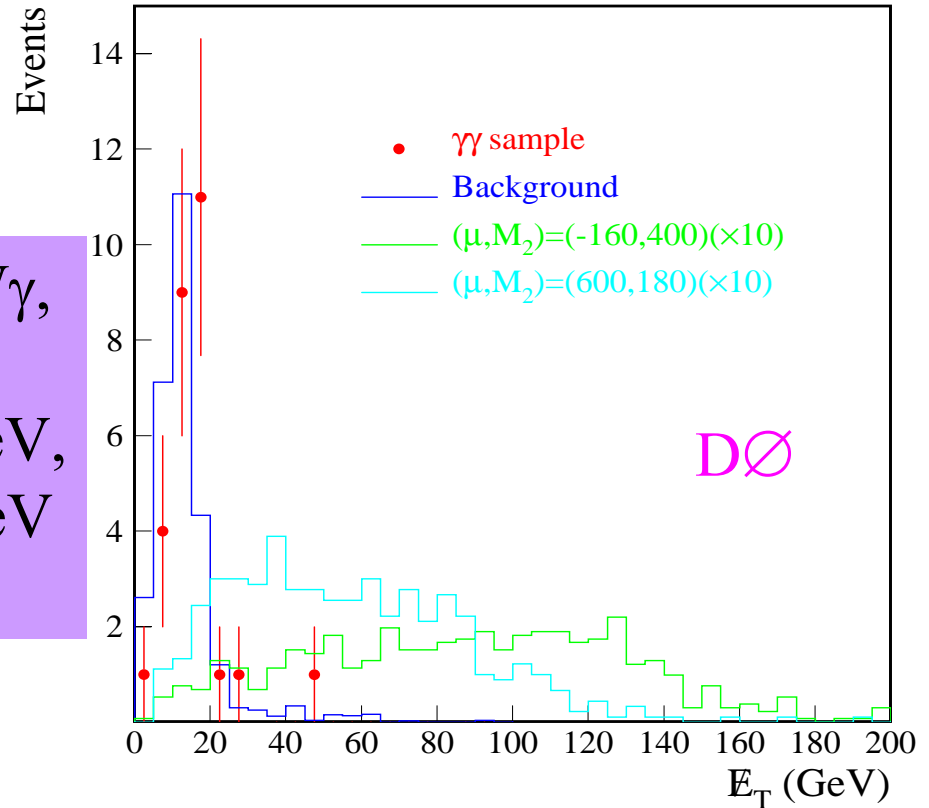
Bckg: multijet, direct photons, $W\gamma$,
 W +jets, $Z \rightarrow ee$

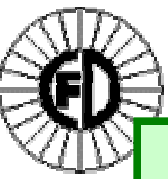
Cuts: $E_T^{\gamma 1} > 20$ GeV, $E_T^{\gamma 2} > 12$ GeV,
 recon. Vertex, $ME_T > 25$ GeV

$L = 106.3 \pm 5.6$ pb⁻¹

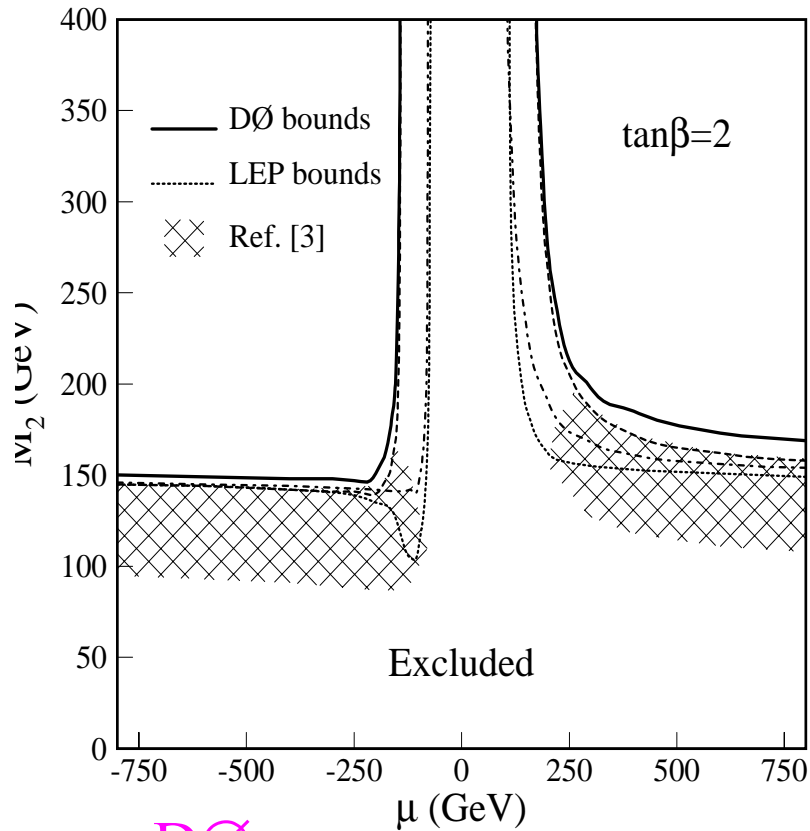
Events observed = 2

Expected bckg = 2.3 ± 0.9

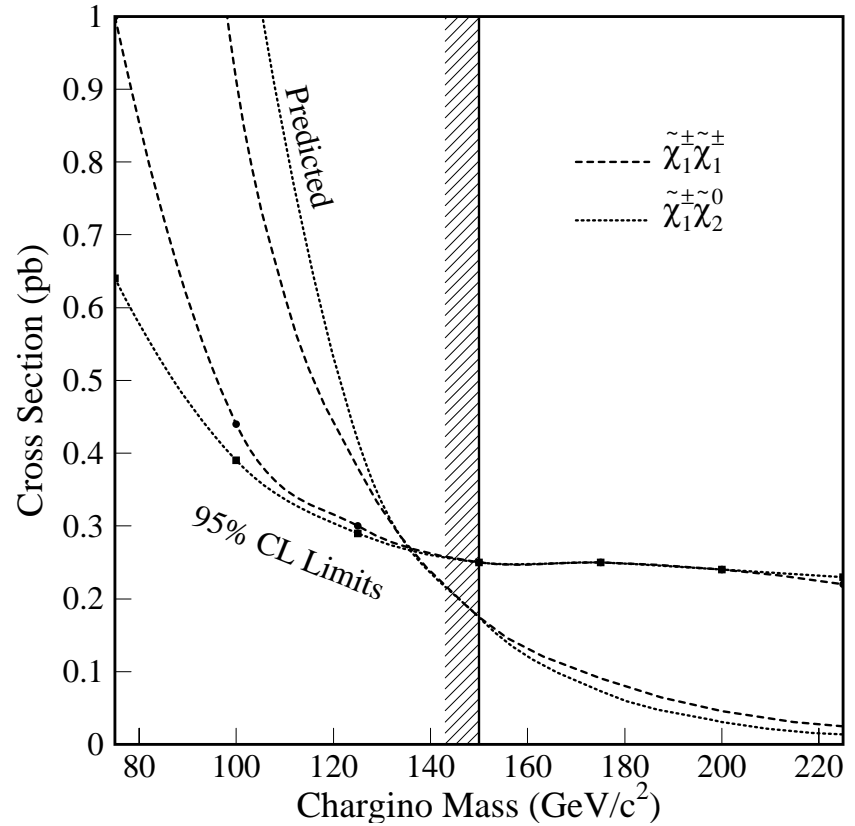




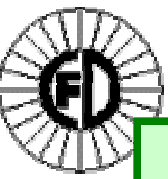
Di-photon Channel (II)



DØ

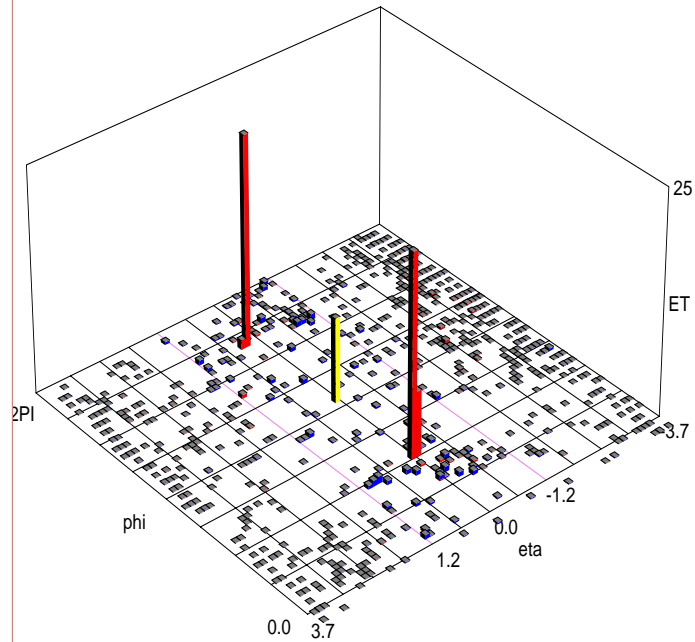
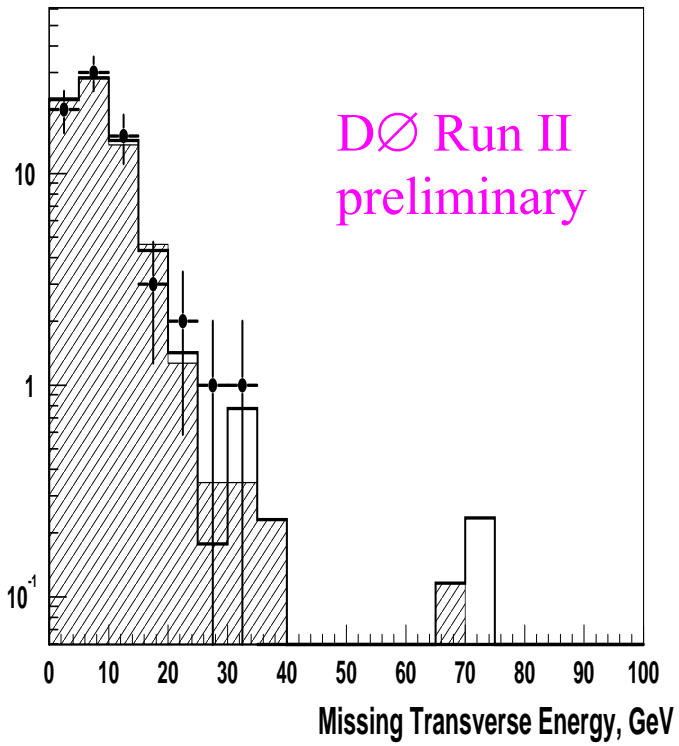


Run IIa proj. ~ 300 GeV

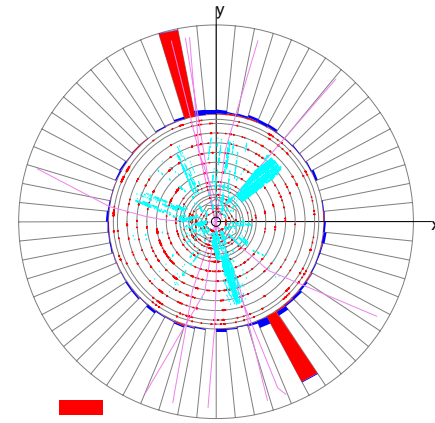


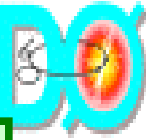
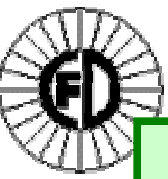
Di-photon Channel (III)

Run 151894 Event 24696678 Wed May 15 11:06:57 2002



Run II





Summary

- Comprehensive searches for SUSY have been carried out at the Tevatron exploiting the Run 1 data to the fullest.
- A new era is beginning