

Run II Searches for Supersymmetry

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Structure

- SUSY searches at the Tevatron focus on mSUGRA/MSSM, GMSB and RPV
- Present every Run II result from first 200 pb⁻¹
 - ✦ Minor excesses or interesting events which I'll be keeping my eye on as the dataset doubles, quadruples or goes up an order of magnitude
 - ✦ New world's best limit
 - ✦ Hot off the presses result



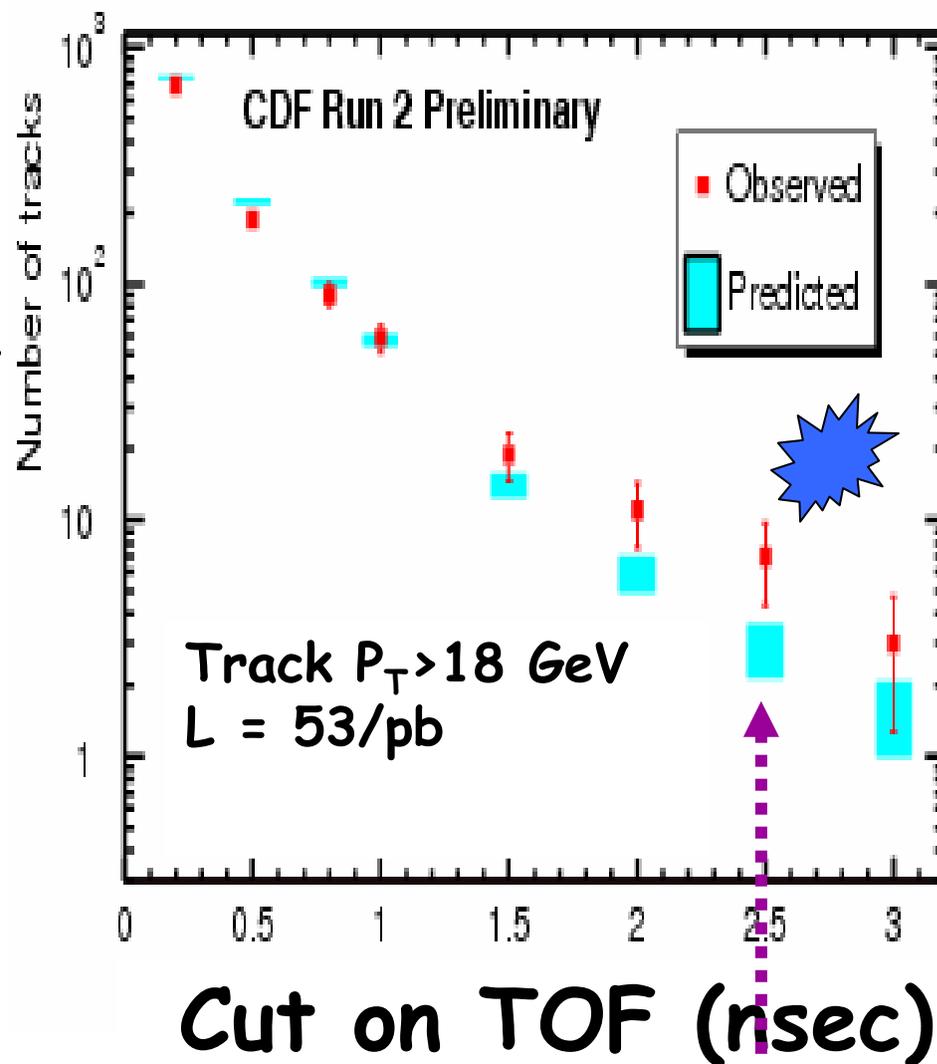
Overview of Results

- **CHAMP Searches**
- **Jets + Met Searches**
- **Multi-lepton Searches**
- **Diphoton+Met Searches**



CHARGED Massive Stable Particles

- Search for long-lived charged particles using Time-of-Flight system
- Particles behave like slow, but high P_T muons
- $2.9 \pm 0.3(\text{stat}) \pm 3.1(\text{sys})$ expected from instrumental mis-measurement
- Observe 7
 - Small excess...Lots more data already taken and being analyzed



Final Cut here



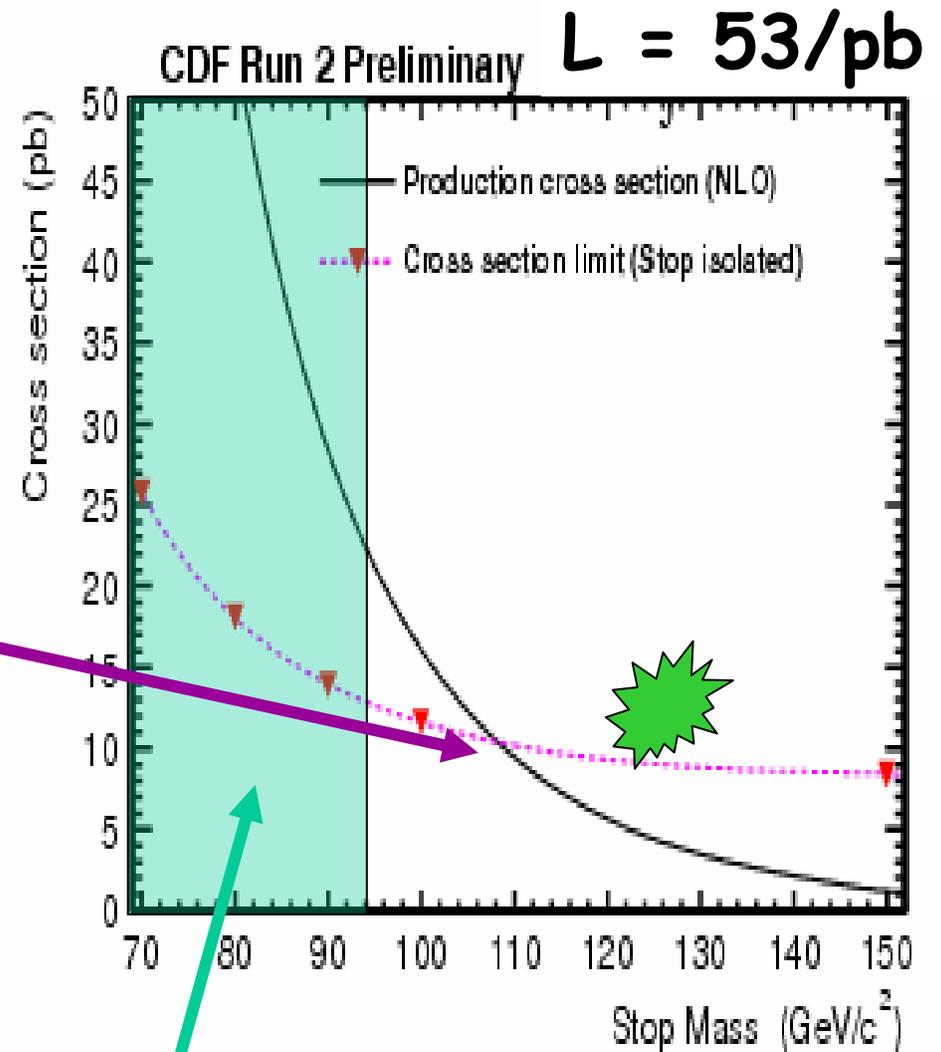
CHAMPS: Results and Limits

- Lots of theories predict CHAMPS

- Stop
- Staus
- Charginos
- Sleptons

- New limits on Stop at 107 GeV which is the new world limit

- Nice complement to the Run I decay based searches for stop

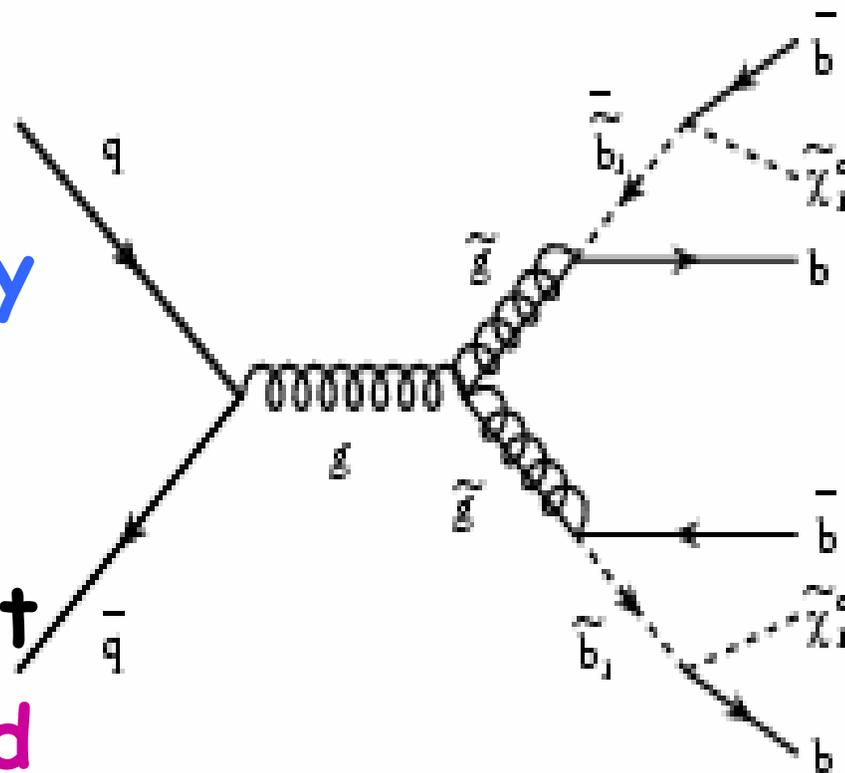


Excluded by Aleph



Search for New Physics in Jets+Met

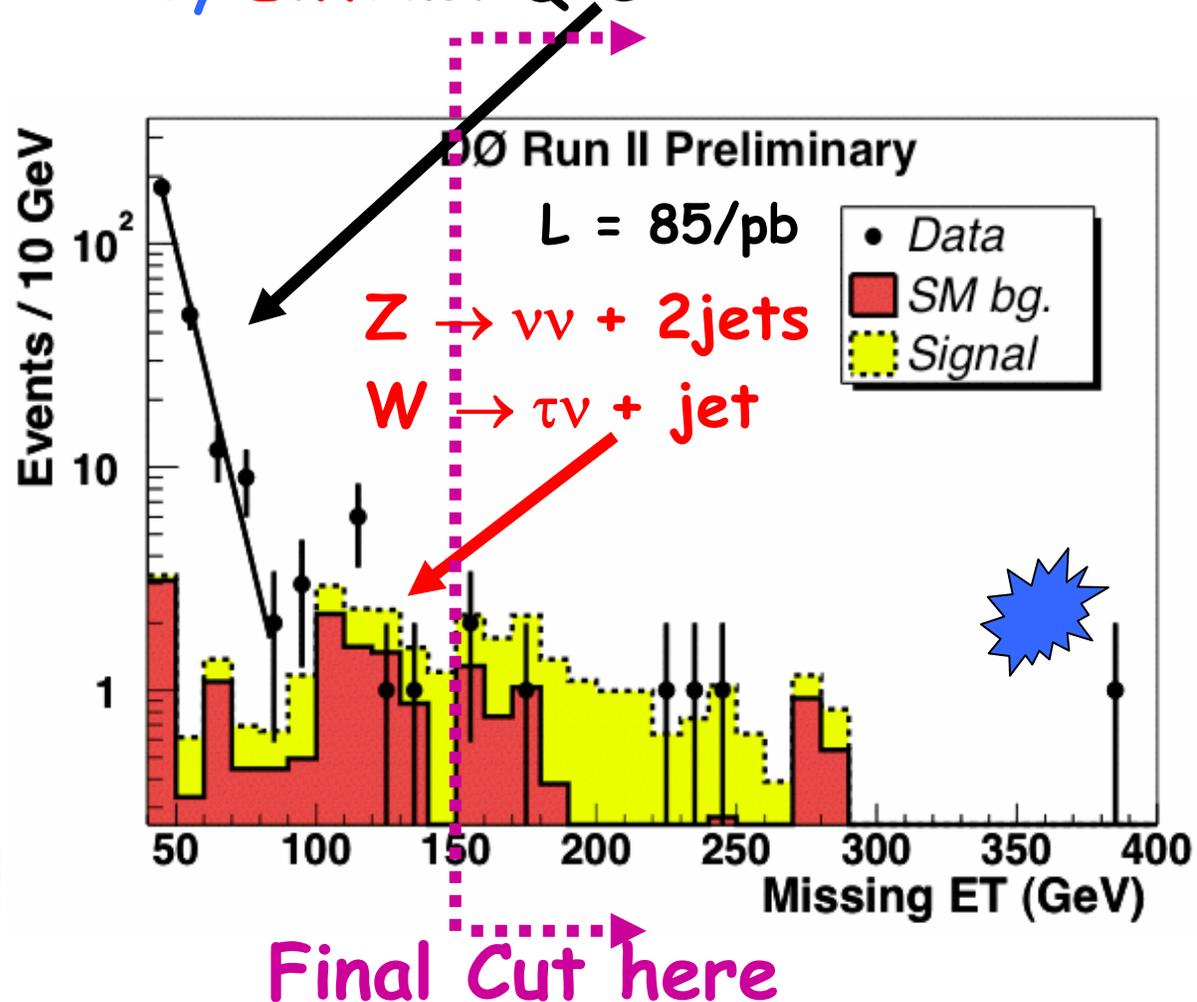
- Direct searches for Squarks and Gluinos in jets+met final state
- Two searches at the Tevatron with preliminary results
 - Light-quark jets+Met
 - Heavy flavor jets+Met
- Extend sensitivity beyond LEPs kinematic reach



Light-quark jets+Met

- Squarks and Gluinos produce acoplaner jets +Met
- Require:
 - At least two large jets
 - Total $H_T > 275$ GeV
 - Met > 175
- 2.67 ± 0.95 expected
- 4 events observed in the data

Background predictions dominated by EWK not QCD



The interesting event on the tail

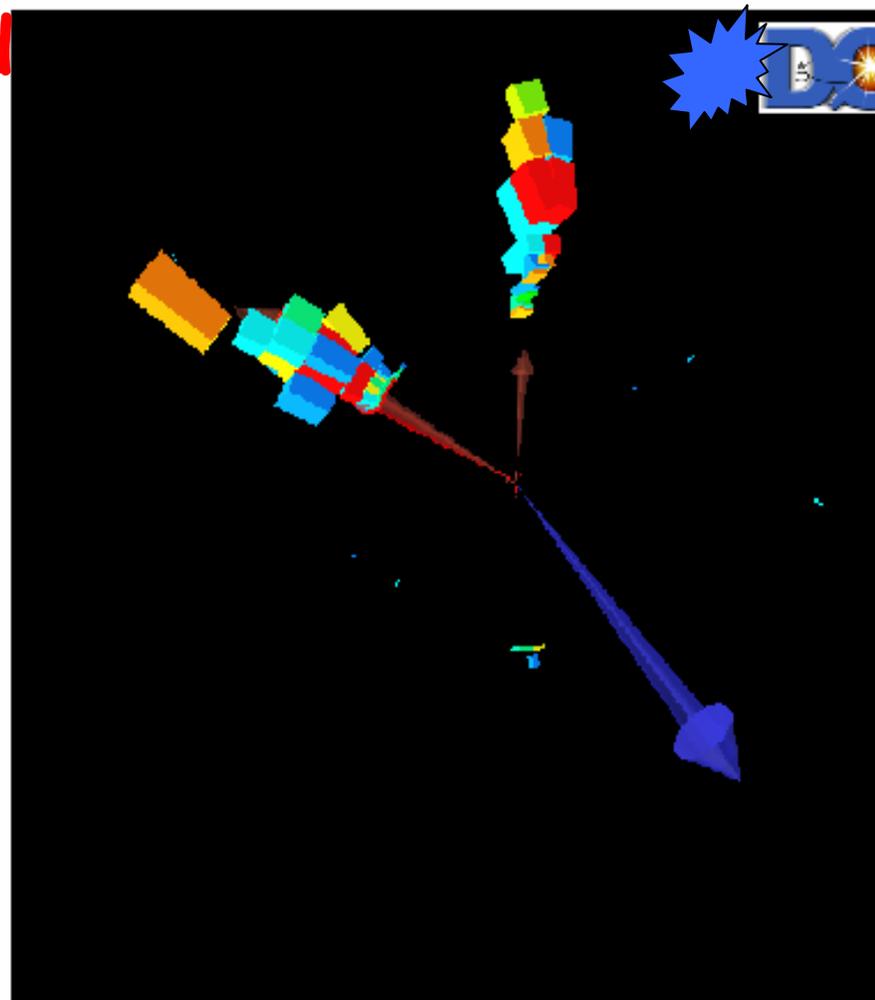
Kinematics:

- 2 big jets: $E_T=289$ GeV and 117 GeV
- 2 little jets: E_T -of 14 GeV and 11 GeV
- $Met=381$ GeV

Expect 1 event above 300 GeV;
 $\sim \frac{1}{4}$ above 350 GeV

Background dominated by
 $Z \rightarrow \nu\nu + \text{jets}$

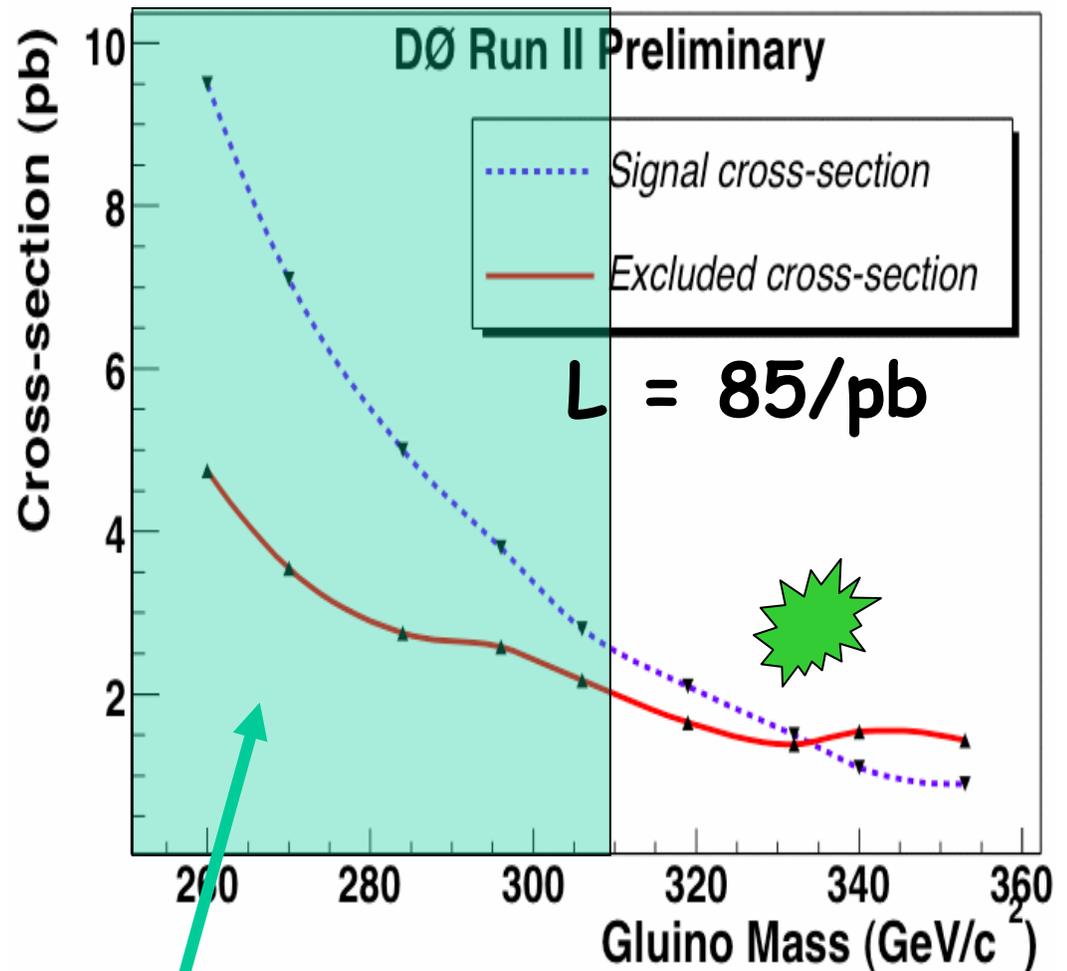
Doesn't particularly look like
signal or background



Limits on Squarks & Gluinos

- Set limits in mSUGRA scenario
- New limit at 333 GeV (for a squark mass of 292) extends previous world's best

mSUGRA model with $M_0 = 25 \text{ GeV}/c^2$, $A_0=0$, $\tan B = 3$, $\mu < 0$, varying $M_{\frac{1}{2}}$

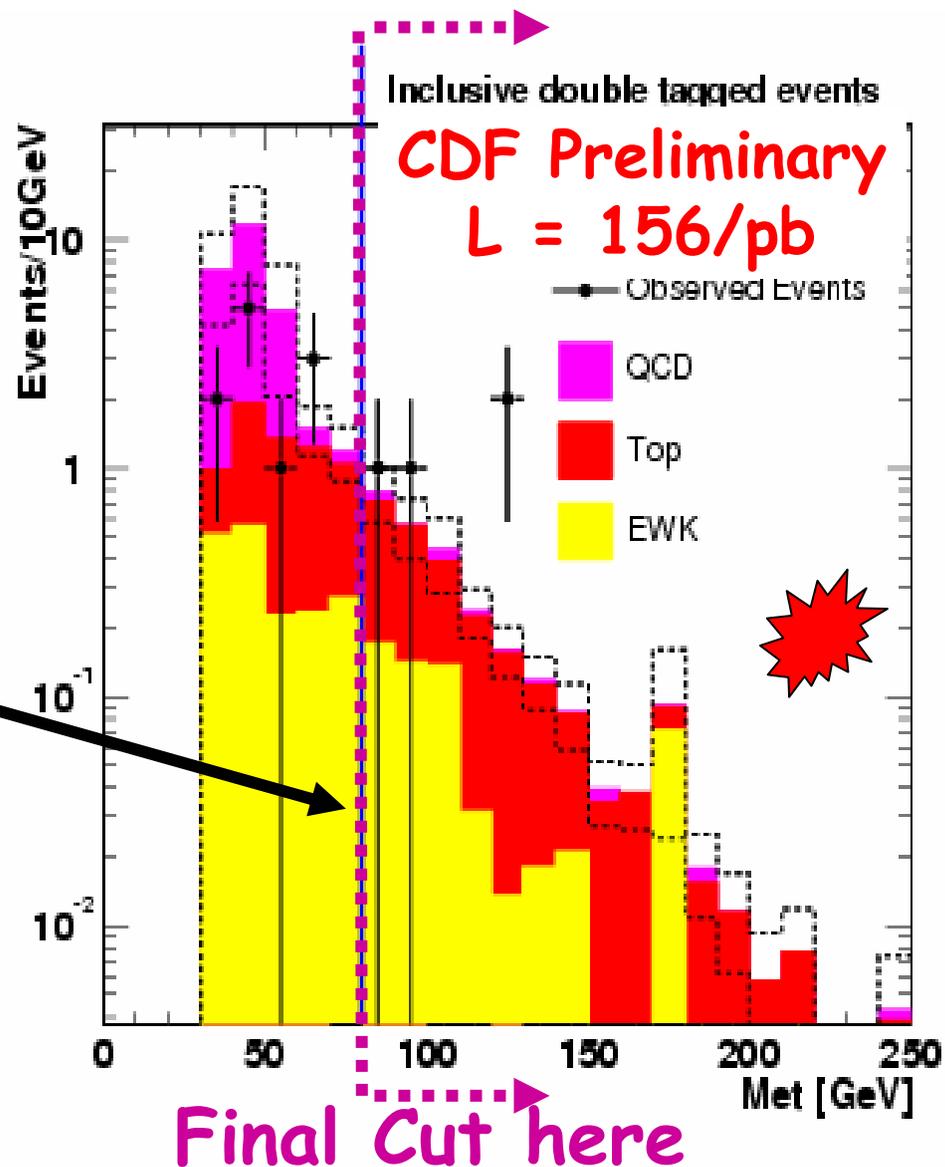


Excluded by CDF Run I



Search for Sbottom Squarks

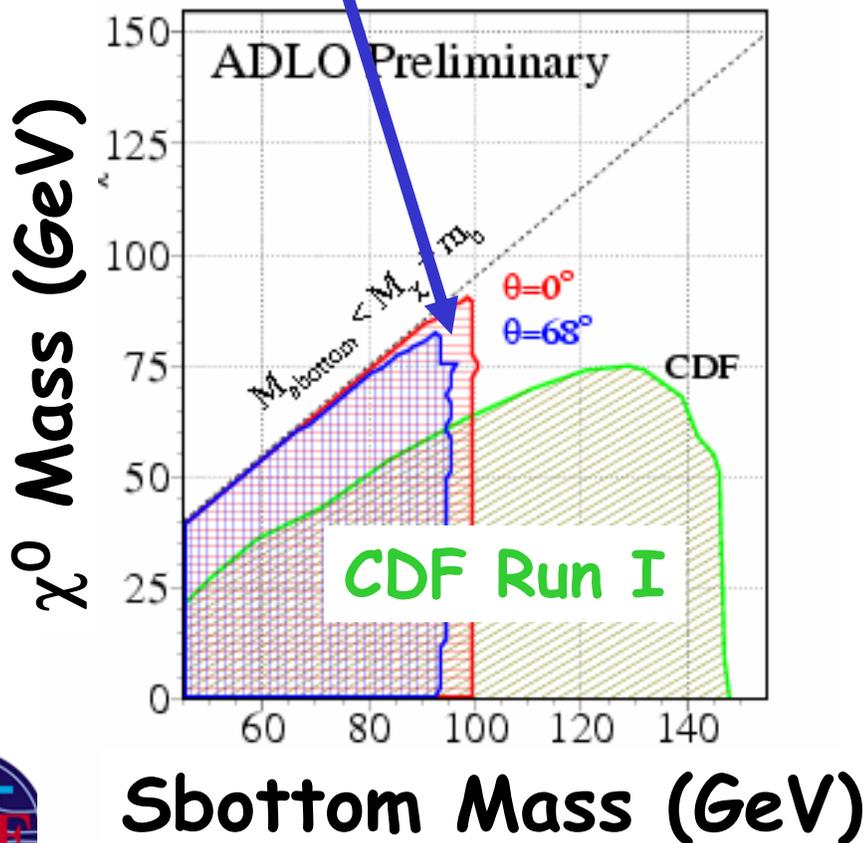
- Gluinos decay into Sbottom quarks and produce b -jets and Met
- Two separate analyses:
 1. Single-tag + Met :
Back = 16.6 ± 3.6
Observe 21
 2. Double-tag + Met :
Back = 3.4 ± 1.1
Observe 4
- Backgrounds dominated by Top quark pairs



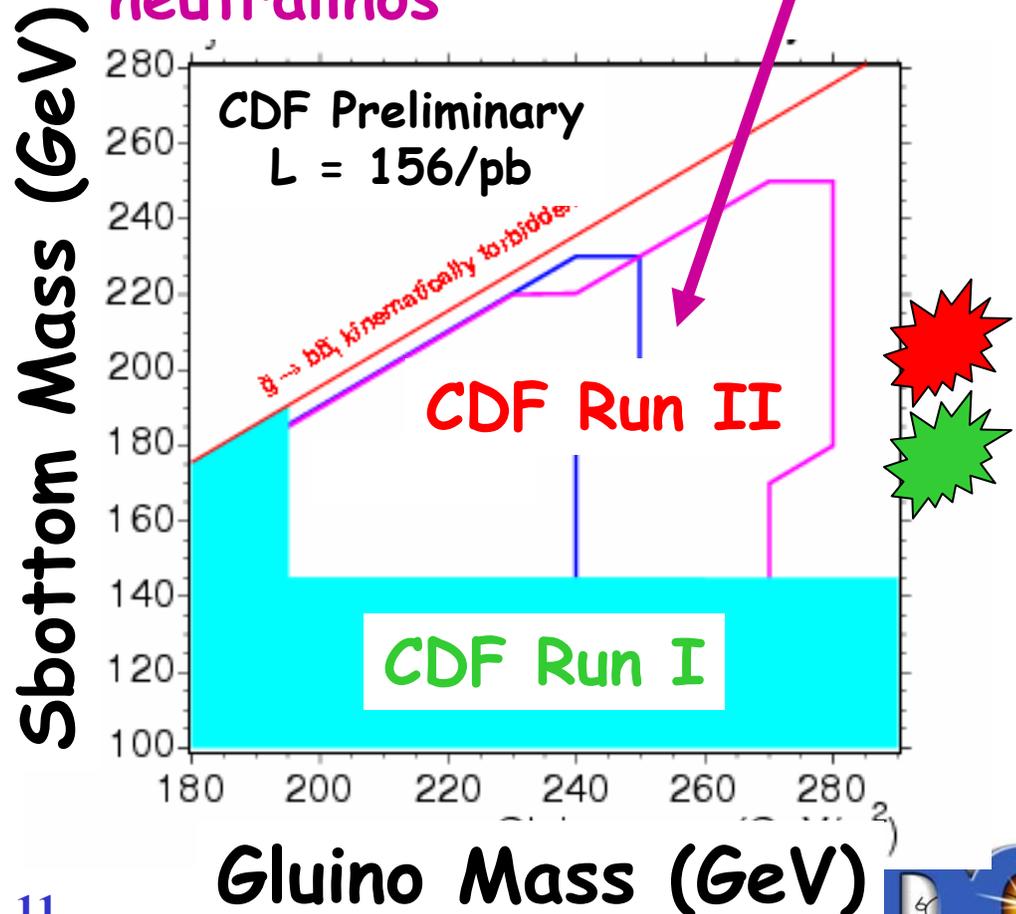
Limits on Sbottoms

New limits are not sensitive to when Sbottom mass is close to the LSP mass.

LEP sensitivity is still best there



Glino production allows significant extension of the best limits at high mass Sbottom and low mass neutralinos



Multi-lepton searches

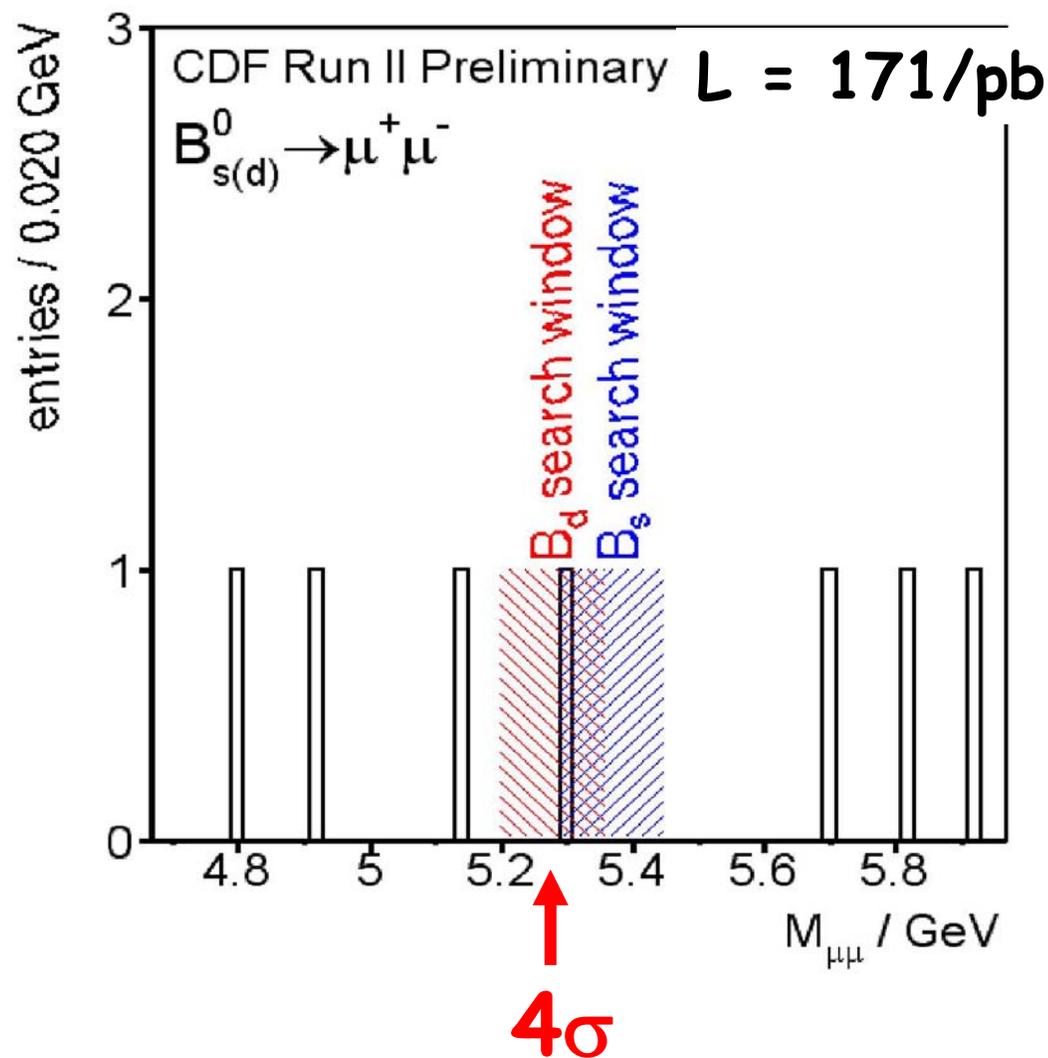
Multi-lepton final states have been a staple of SUSY searches for many years

- Low mass indirect searches in $B_s \rightarrow \mu\mu$
- High mass resonance searches for RPV Sneutrinos
- Chargino/Neutralino Pair-production and decay



$$B_s \rightarrow \mu\mu^*$$

- Indirect search for SUSY via loop diagrams which affect the branching ratio by one to three orders of magnitude.
- Search in 4σ mass window around known world average and optimize using topology cuts
- 1.1 ± 0.3 events expected
- 1 Event observed



*Accepted for publication in PRL

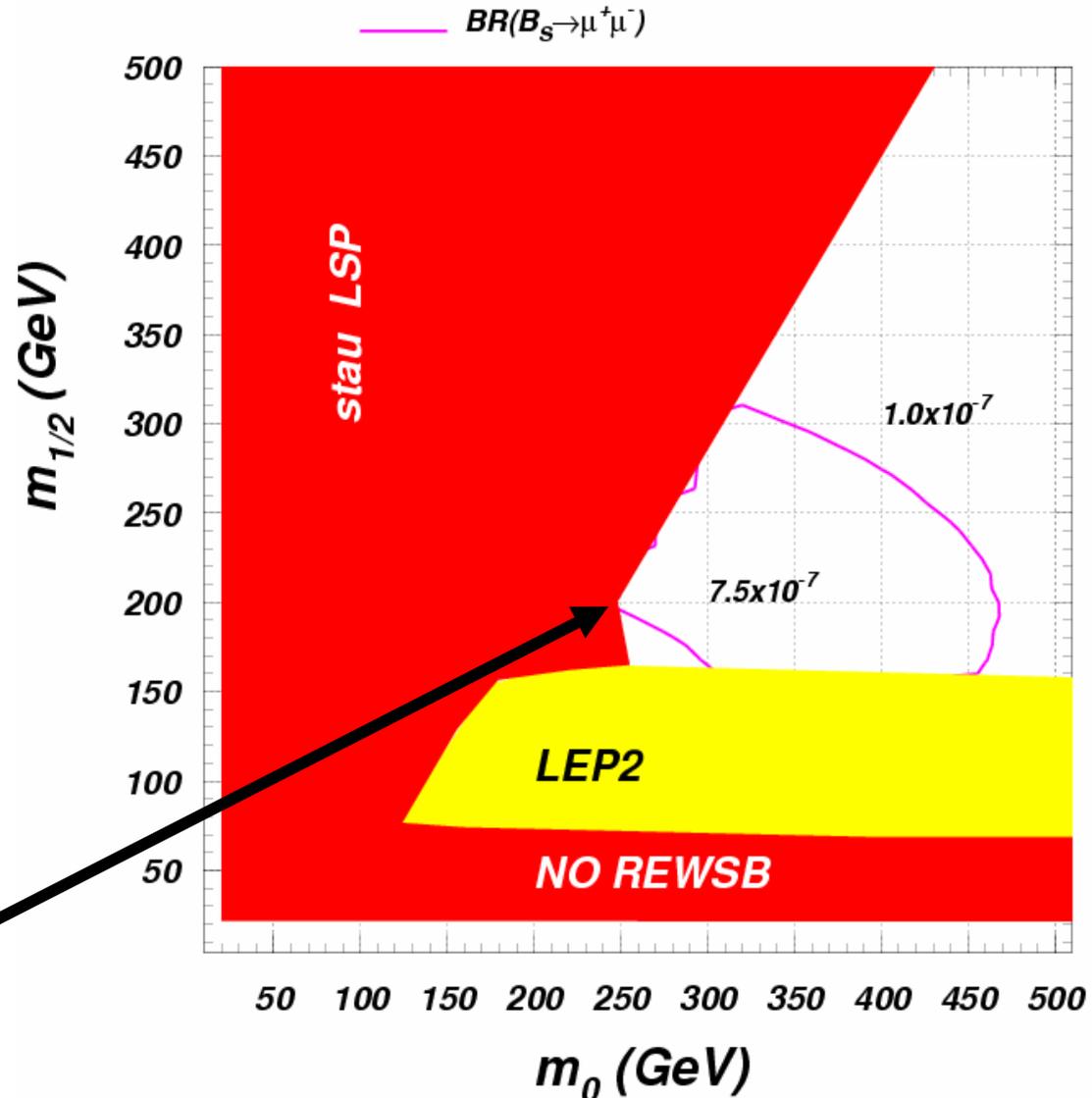
Mass Window



Limits and SUSY Interpretation

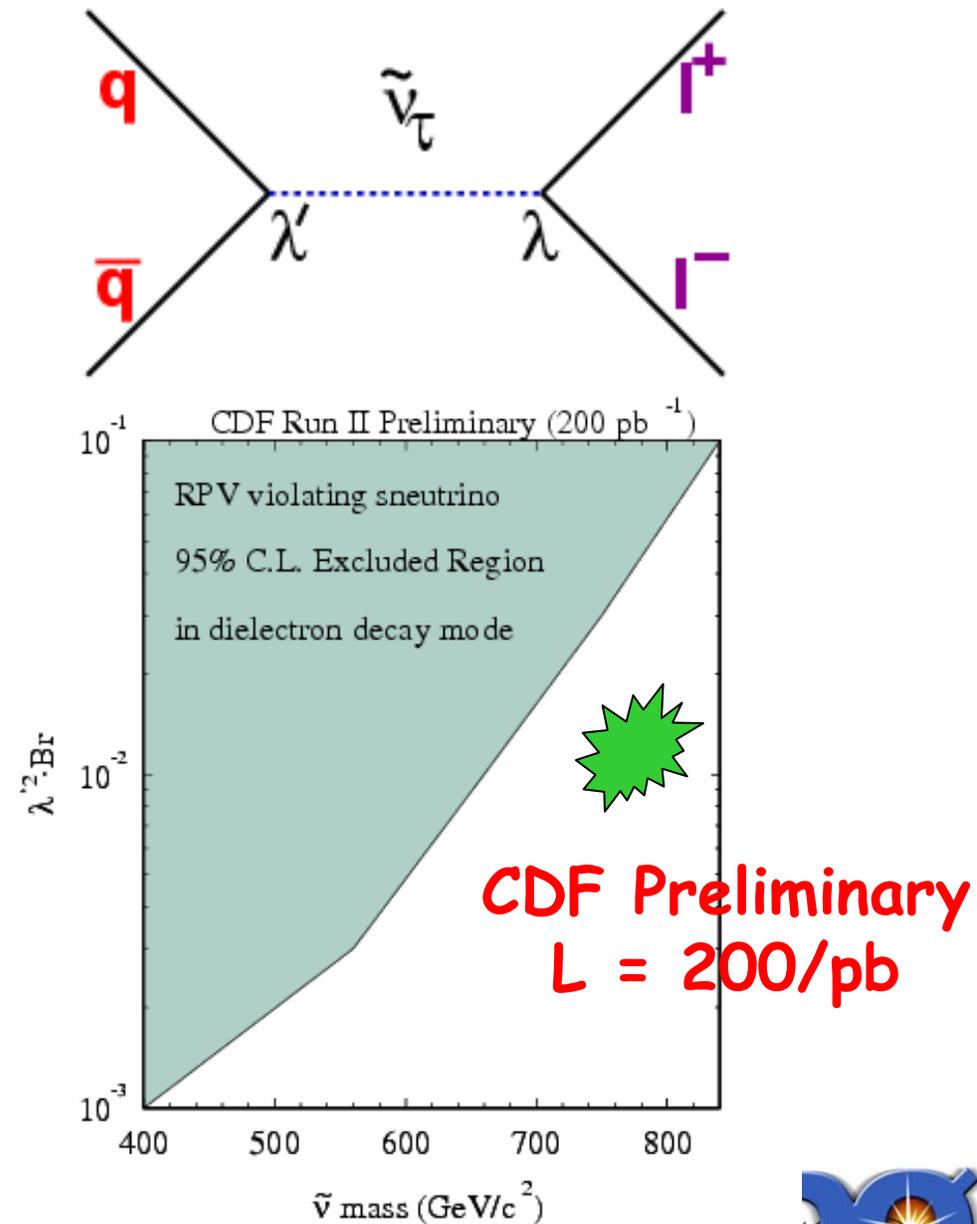
- $BR_{SM} = 3.5 \times 10^{-9}$
- Previous best limit at 2.0×10^{-6} (CDF Run 1)
- New Limit:  $Br(B_S \rightarrow \mu\mu) = 7.5 \times 10^{-7}$
→ World's best
- Many models to interpret this constraint
 - (Blow up of example from A. Balyaev)

$mSUGRA, \tan\beta=55, A_0=0, \mu>0, m_t=175\text{GeV}$



High Mass Resonance Searches

- People have been looking at ee and $\mu\mu$ for many years for Z' , E6, Higgs, Technicolor etc. (See talk by M. Gold for data)
- CDF now interprets its results in terms of RPV Sneutrino production and decay.
- First limits for large masses



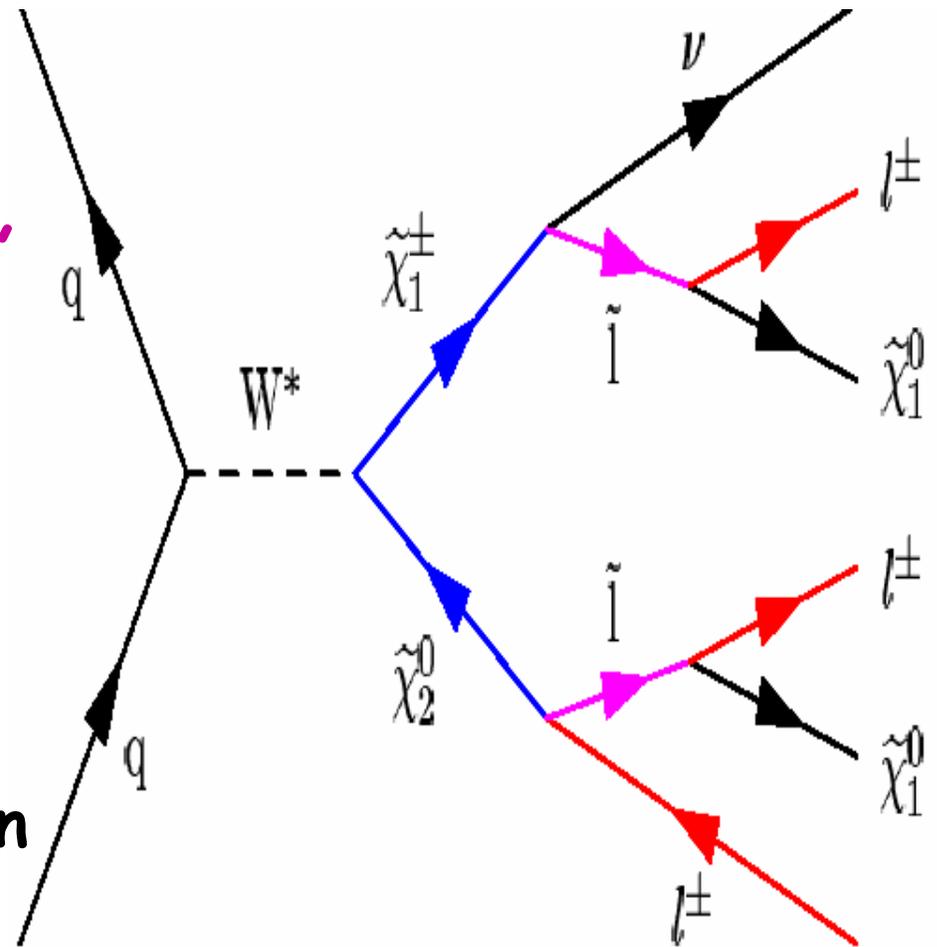
CDF Preliminary
 $L = 200/\text{pb}$



Chargino/Neutralino Pair Production

- **Chargino/Neutralino pair production can produce three leptons + Met**
- **Since the end of Run I, LEP has significantly improved the limits**
- **Three new results in this mode:**
 - Same sign muons
 - Two electrons + lepton
 - Electron + Muon + lepton

Gold plated signature of mSUGRA for low tanB

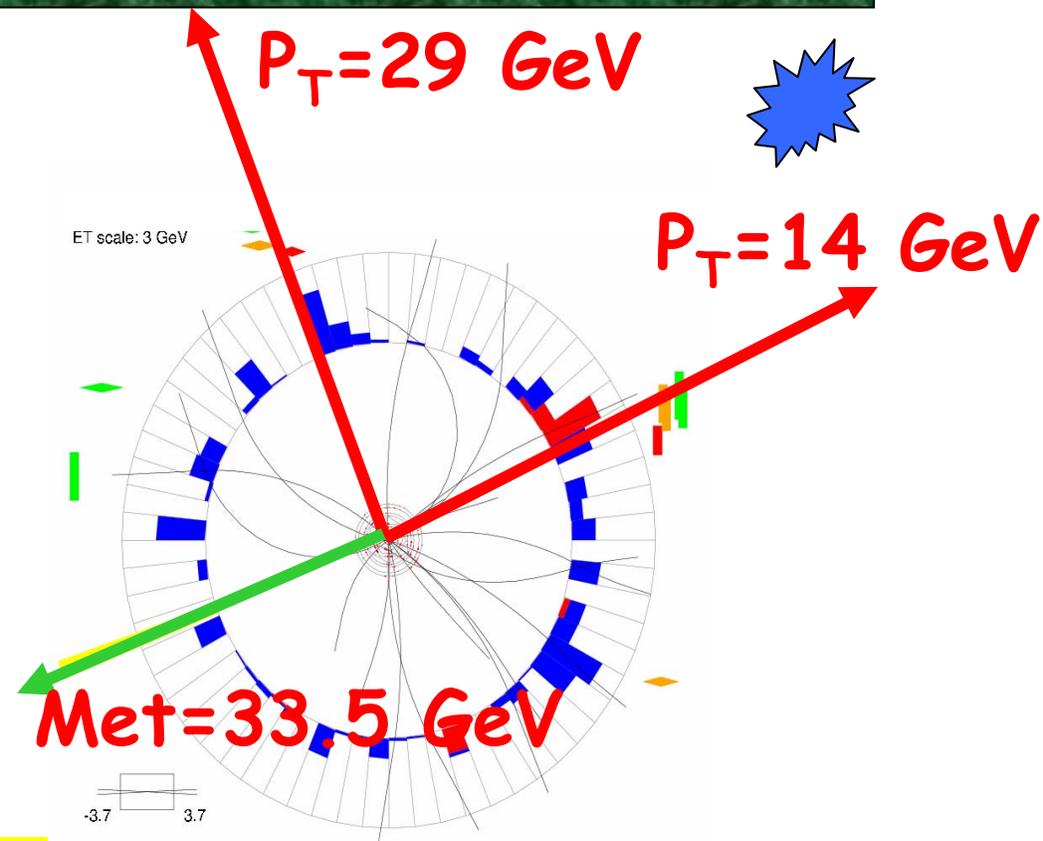


Like-Sign Muons

Increase acceptance by only requiring two out of three leptons

Reduce background by requiring them to be same-sign

- $P_{T1} > 11 \text{ GeV}$
- $P_{T2} > 5 \text{ GeV}$
- $M_{\text{et}} > 15 \text{ GeV}$
- $M_{\mu\mu} < 80 \text{ GeV}$



Predict 0.13 ± 0.06
Observe 1
interesting event

- Backgrounds dominated by WZ (0.07) and bb (0.04)
- No third lepton candidate
→ $b\bar{b}$?

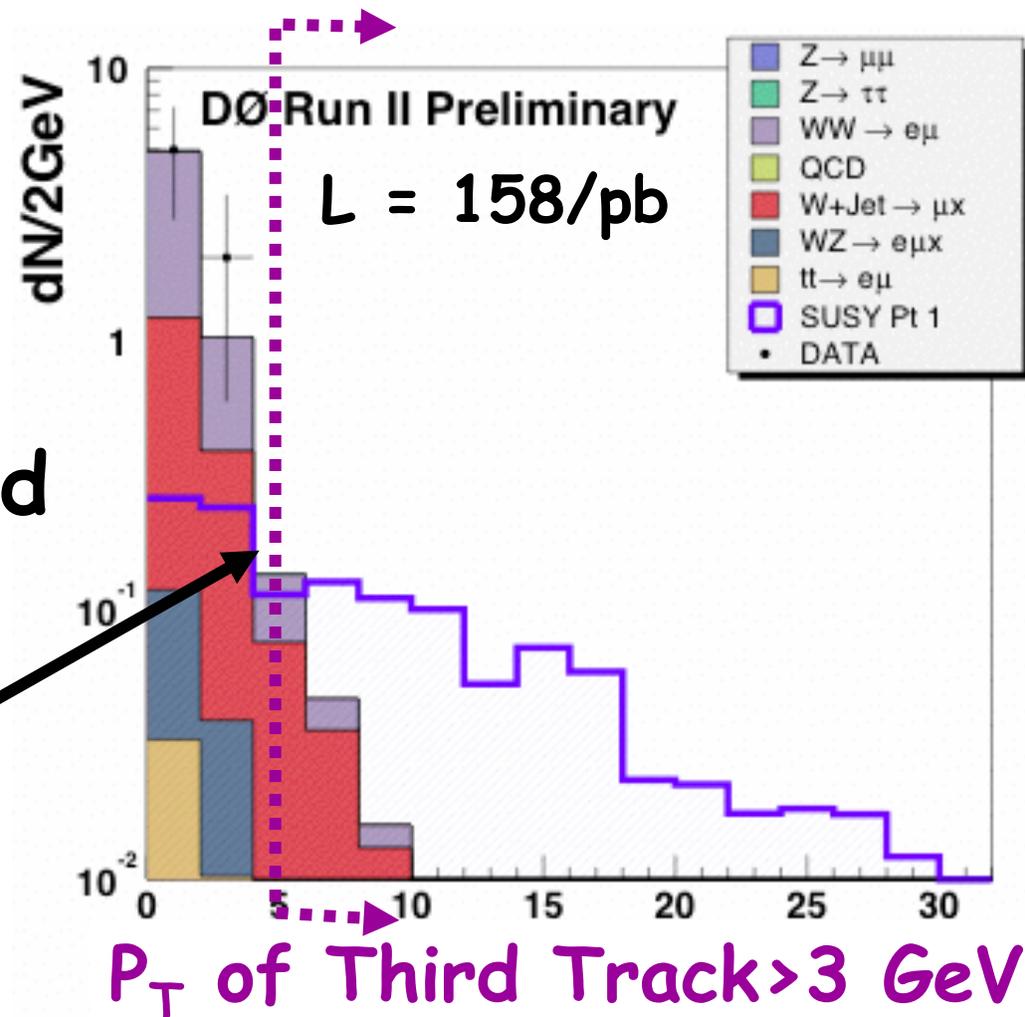
Electron+Muon+lepton

Require:

- Electron > 12 GeV
- Muon > 8 GeV
- Met > 15

Look for a third isolated track: e, μ or τ

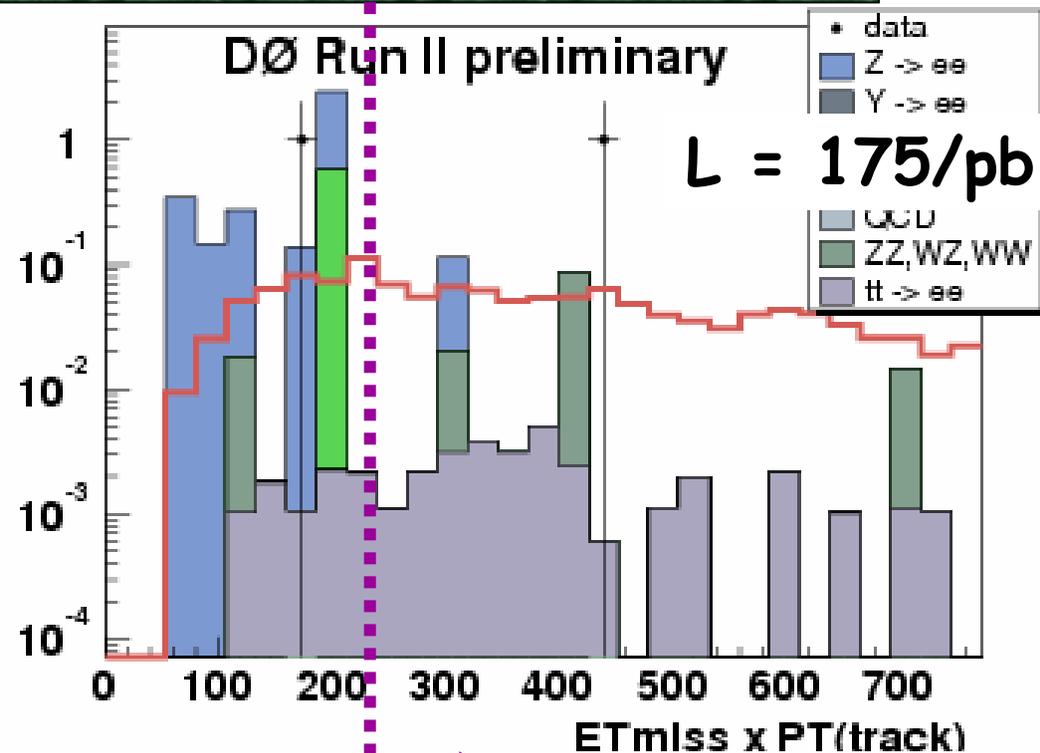
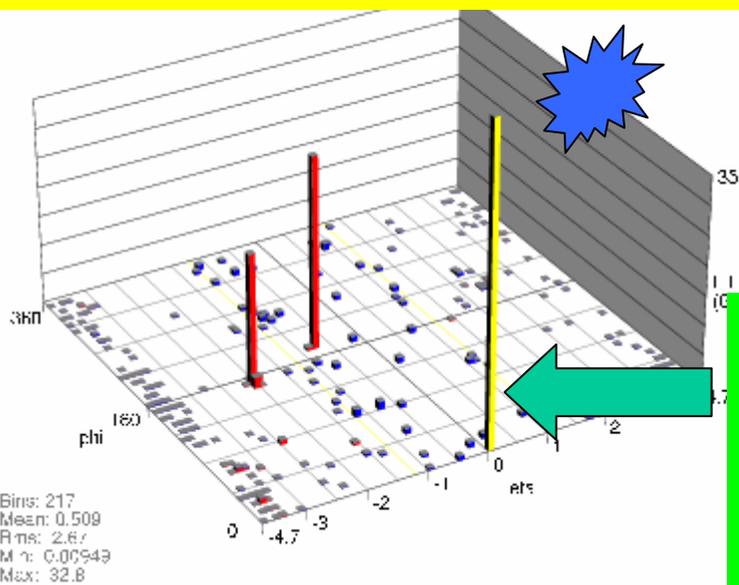
Predict 0.5 ± 0.2
0 observed



Two-electrons+lepton

Two high P_T isolated e 's, a 3rd lepton (high P_T isolated track) and Met

Predict $0.3^{+0.4}_{-0.3}$
Observe 1 event



Met x Pt(3rd Track) > 250 GeV²

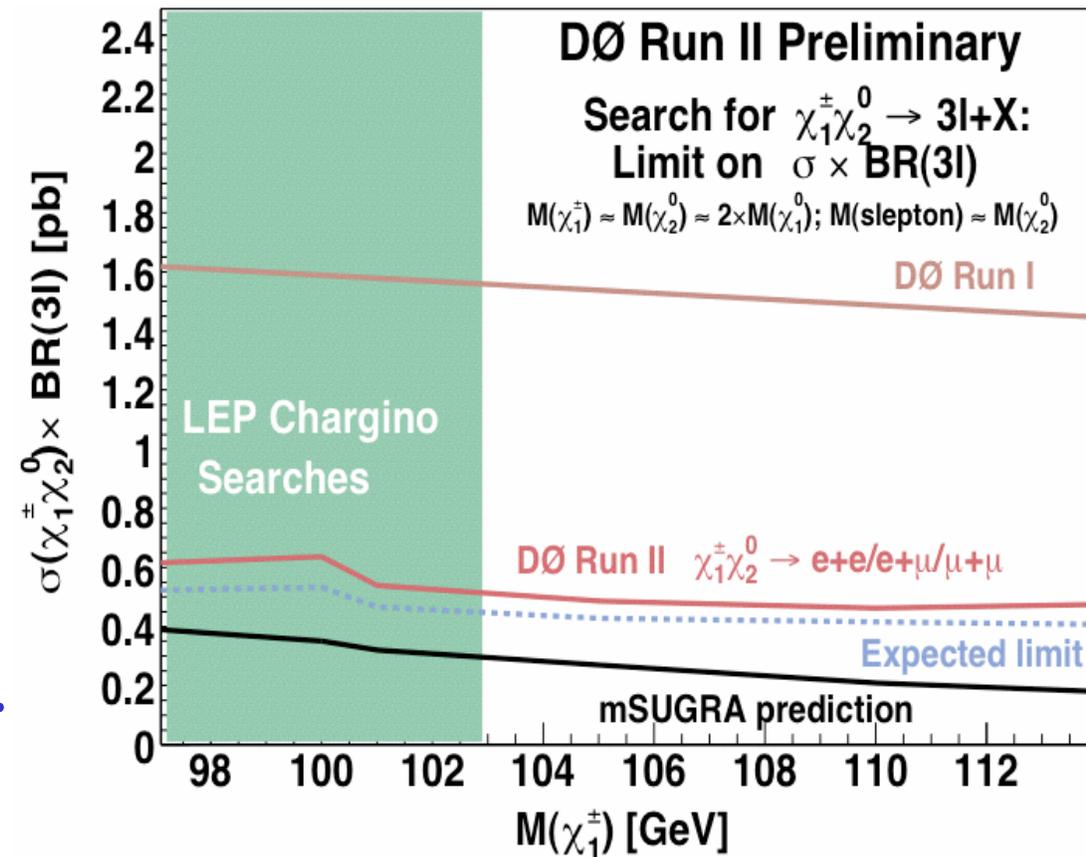
Electron $E_T = 33$ GeV and 26 GeV
Track $P_T = 8.6$ GeV
Met = 52.1 GeV

Background dominated by WW, but is likely $W\gamma$ where the photon converted



Combine results to set limits

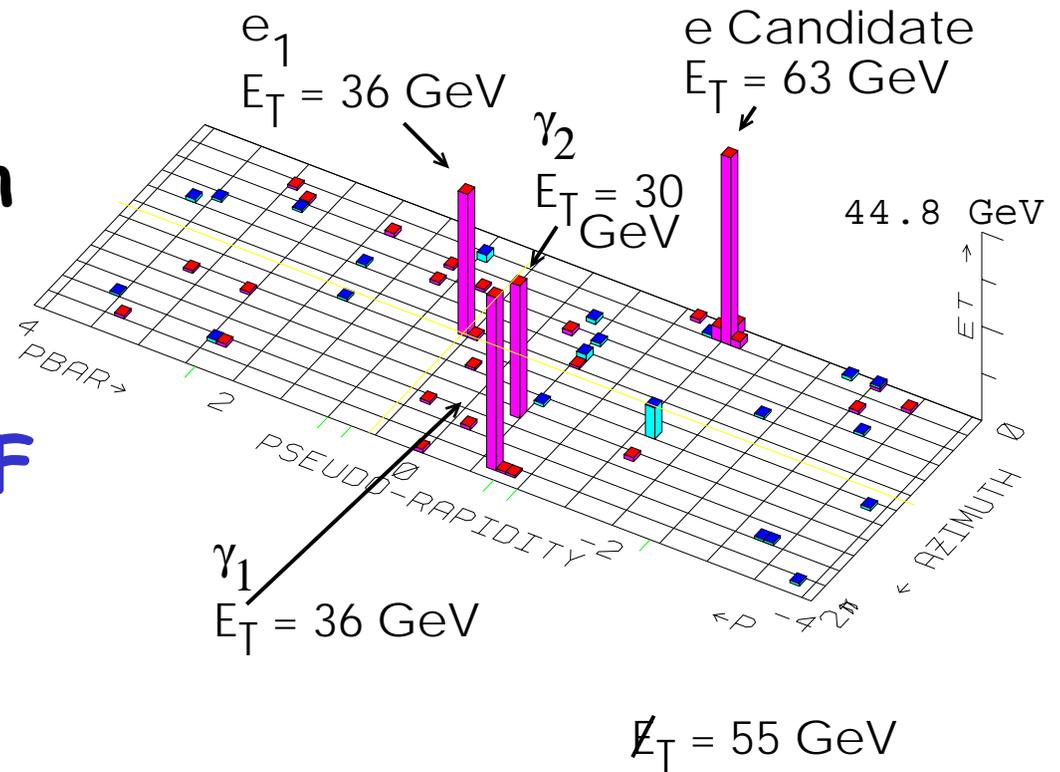
- All three searches are optimized for the region above the LEP limits
- Combined result produces the most stringent limits from the Tevatron to date
- Significant improvement over Run I results, but no extension of the exclusion region from LEP (yet)



GMSB Searches in Two Photons+Met

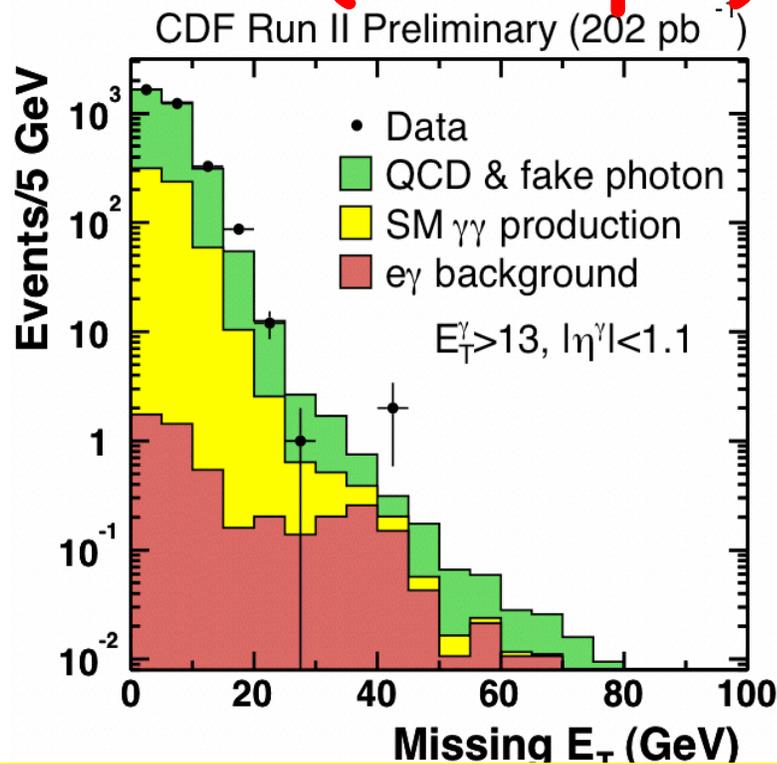
- In Run I CDF found an $ee\gamma\gamma$ +Met candidate event
- Extensive searches for similar events at LEP and the Tevatron produced no other interesting events
- New results from CDF and Dzero which optimized for GMBS $\chi^0 \rightarrow \gamma G$ scenario

CDF Run I $ee\gamma\gamma$ +Met Candidate Event



GMSB $\gamma\gamma$ +Met

CDF (202/pb)

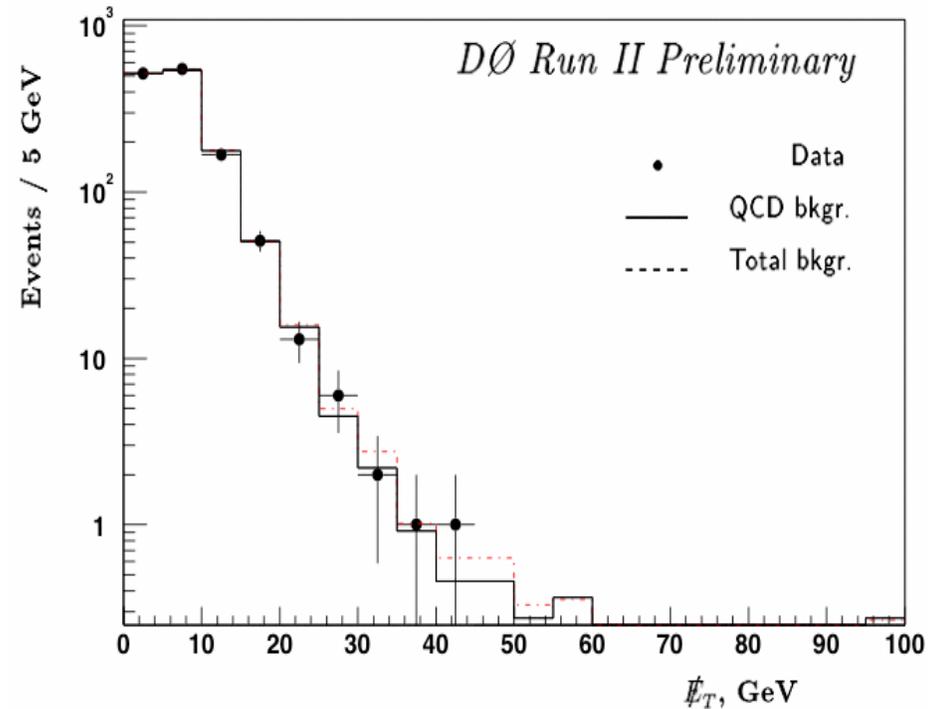


$E_T > 13$ GeV, $Met > 45$ GeV

Predict 0.6 ± 0.5

0 Observed

Dzero (185/pb)



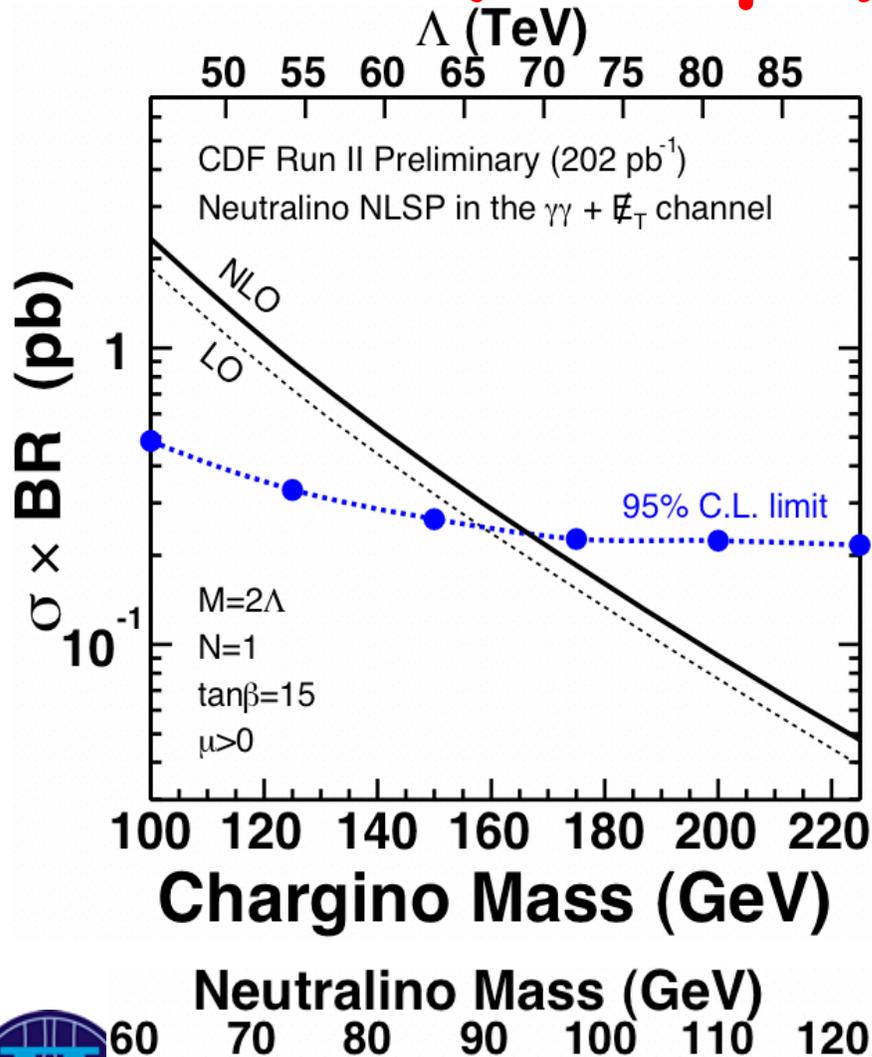
$E_T > 20$ GeV, $Met > 40$ GeV

Predict 2.5 ± 0.5

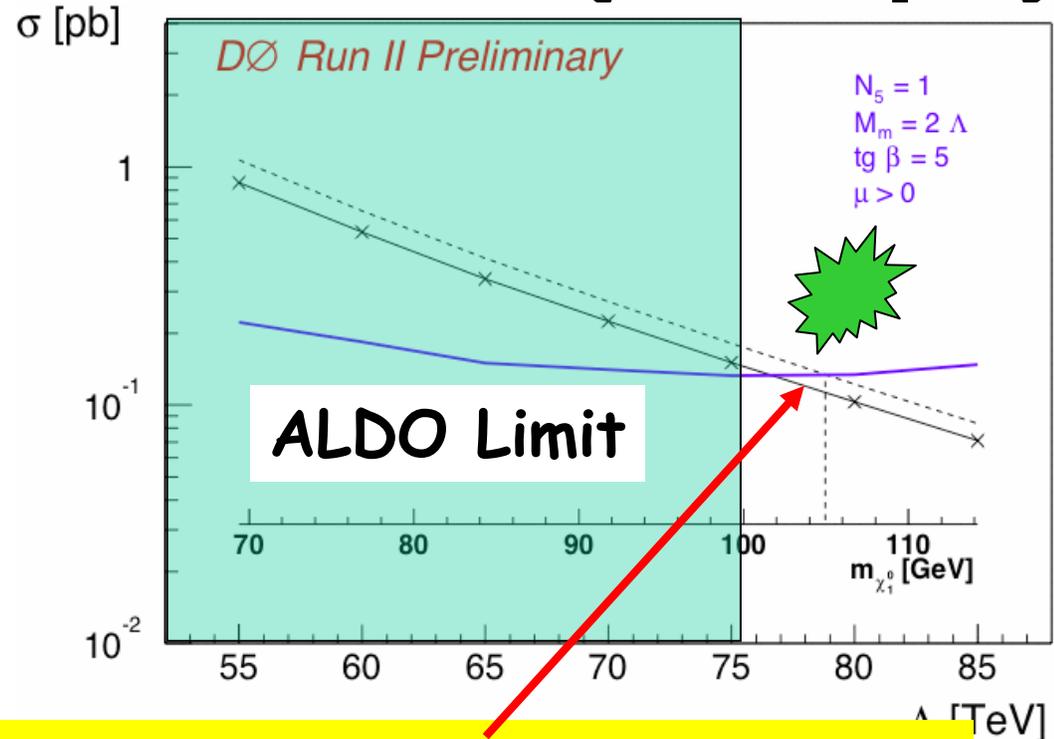
1 Observed

Limits on GMSB with $\tilde{\chi}^0 \rightarrow \gamma \tilde{G}$

CDF (202/pb)



Dzero (185/pb)



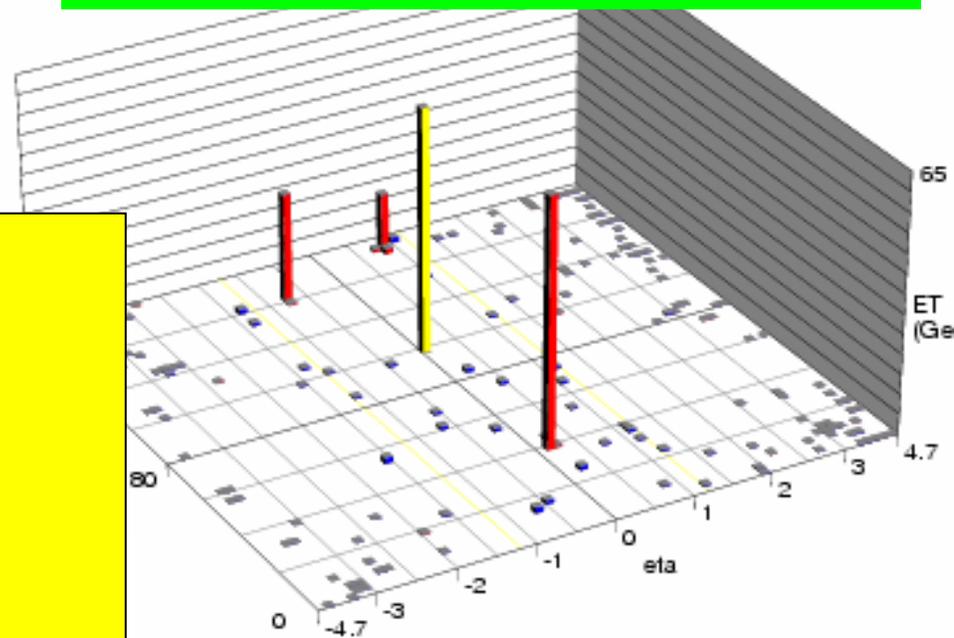
New world best limit!
 $\Lambda > 78.8$ TeV
 Chargino mass > 192 GeV
 Neutralino Mass > 105 GeV



Interesting Event

- Event is in data since the previous result, but is interesting nonetheless
- E_T of photons: 69 & 27 GeV
- E_T of electron 24 GeV
 - All well measured & Well separated
- Met=63 GeV

Dzero
e $\gamma\gamma$ Met
Candidate



W $\gamma\gamma$?

Cousin of CDF e $e\gamma\gamma$ Met?

If all "e $e\gamma\gamma$ Met" favored
SUSY parameter space is
nearly excluded, then what
is it?



Conclusions

- It's an exciting time to be at the Tevatron as it is the high energy frontier for the next N years.
- Preliminary results on the first 200 pb⁻¹ are starting to come rapid-fire with first publications already submitted & accepted 
- Many of these results are the world's most sensitive 
- Results on the next 200 pb⁻¹ are in the pipeline
- The detectors and the Tevatron continue to improve and provide new sensitivity
- Lots of interesting things to keep our eyes on in the coming year... 

