

Tevatron Chargino-Neutralino Searches

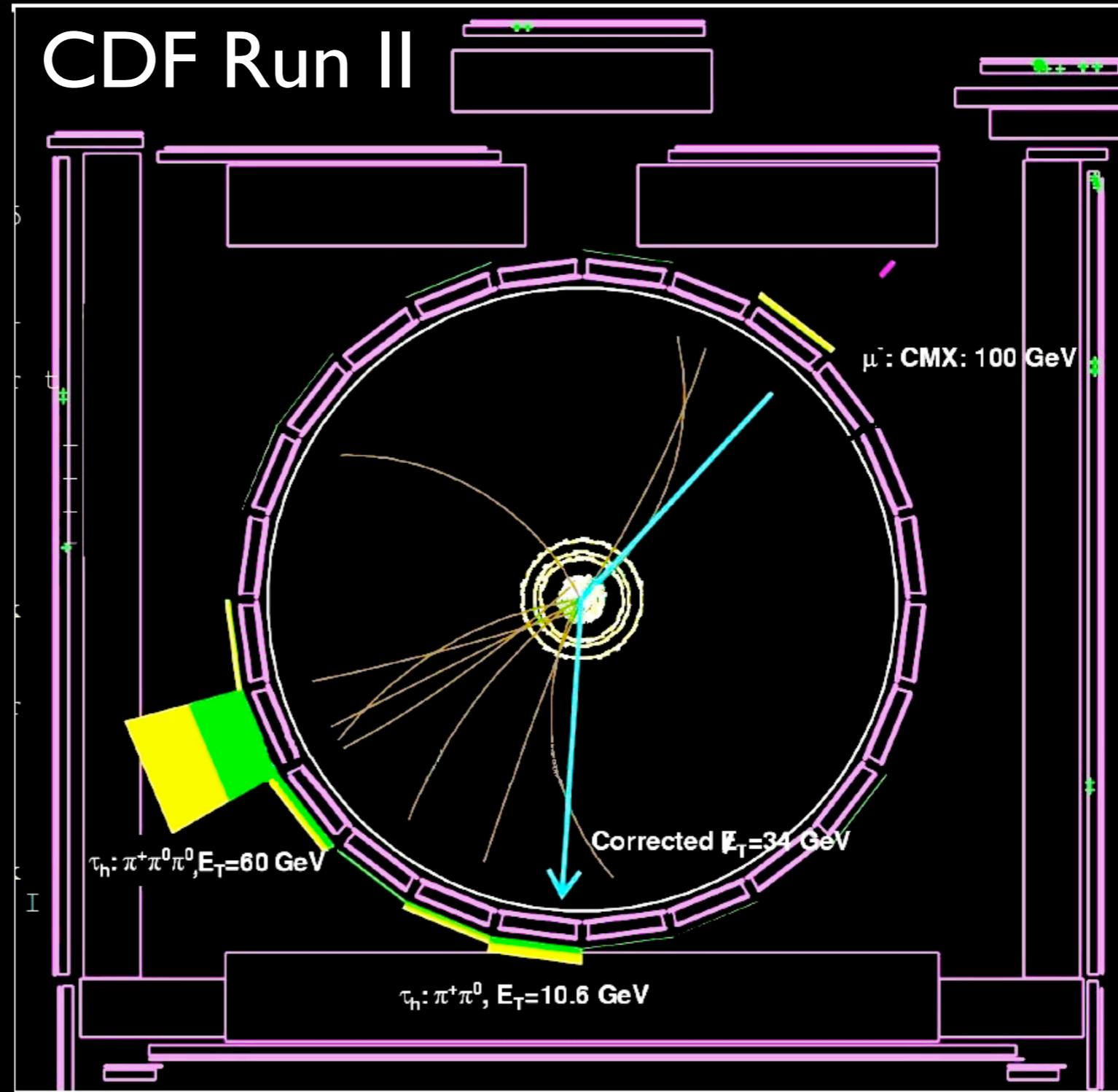
Maxwell Chertok, UC Davis
on behalf of the CDF and D0 collaborations

DIS 08

London, 7-11 April 2008

H⁺⁺ search interesting event

- $\mu^- \tau^+ \tau^+$
- All tracks shown!
- Such events piling up at the Tevatron



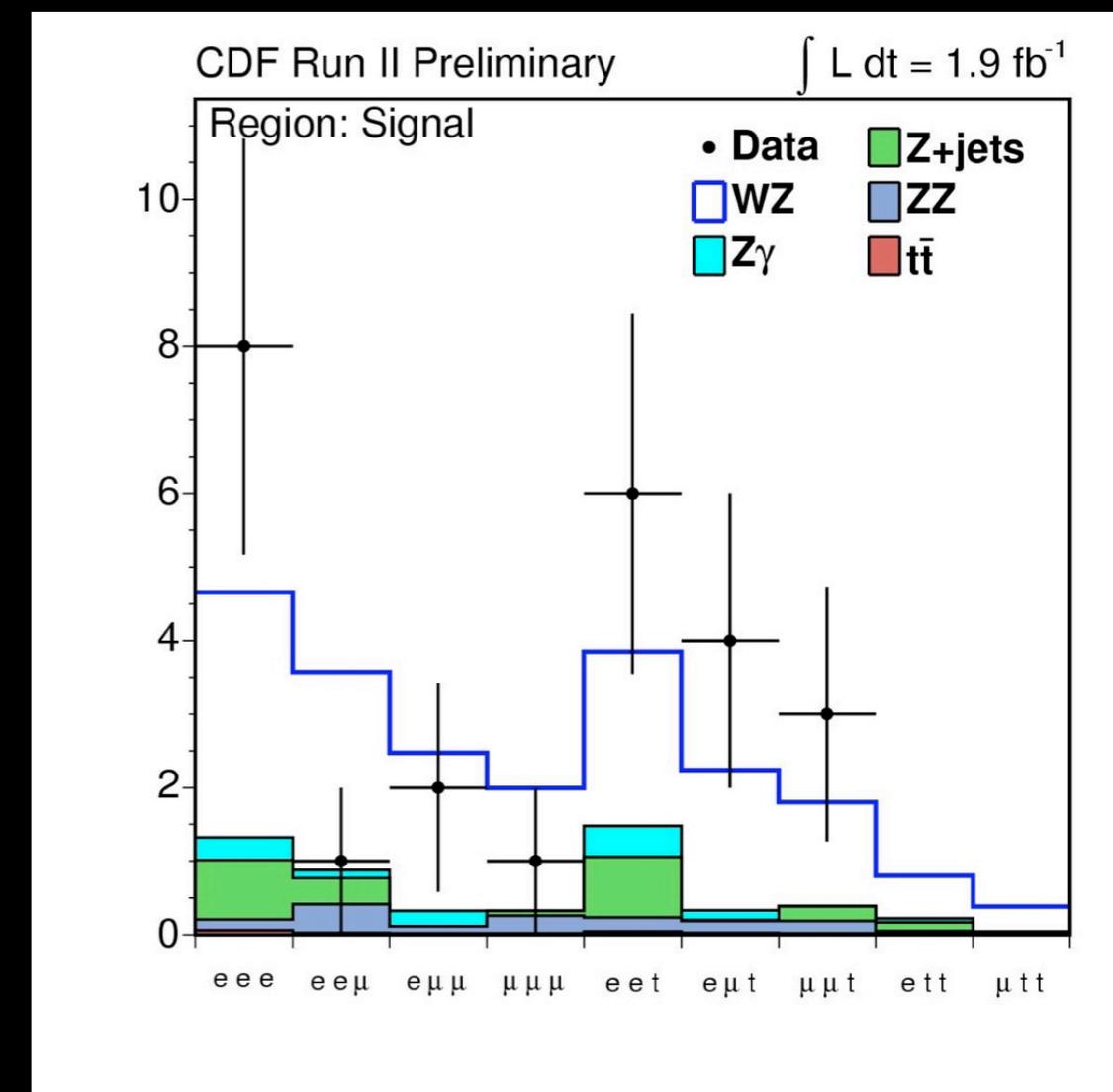
CDF WZ results

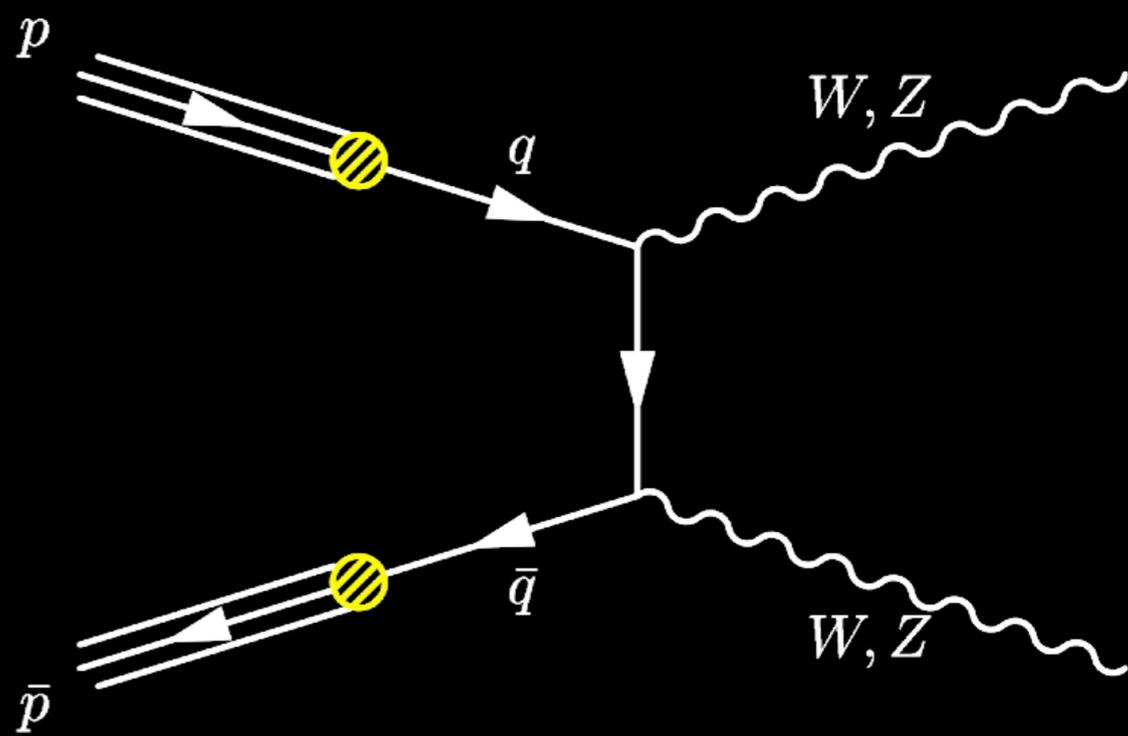
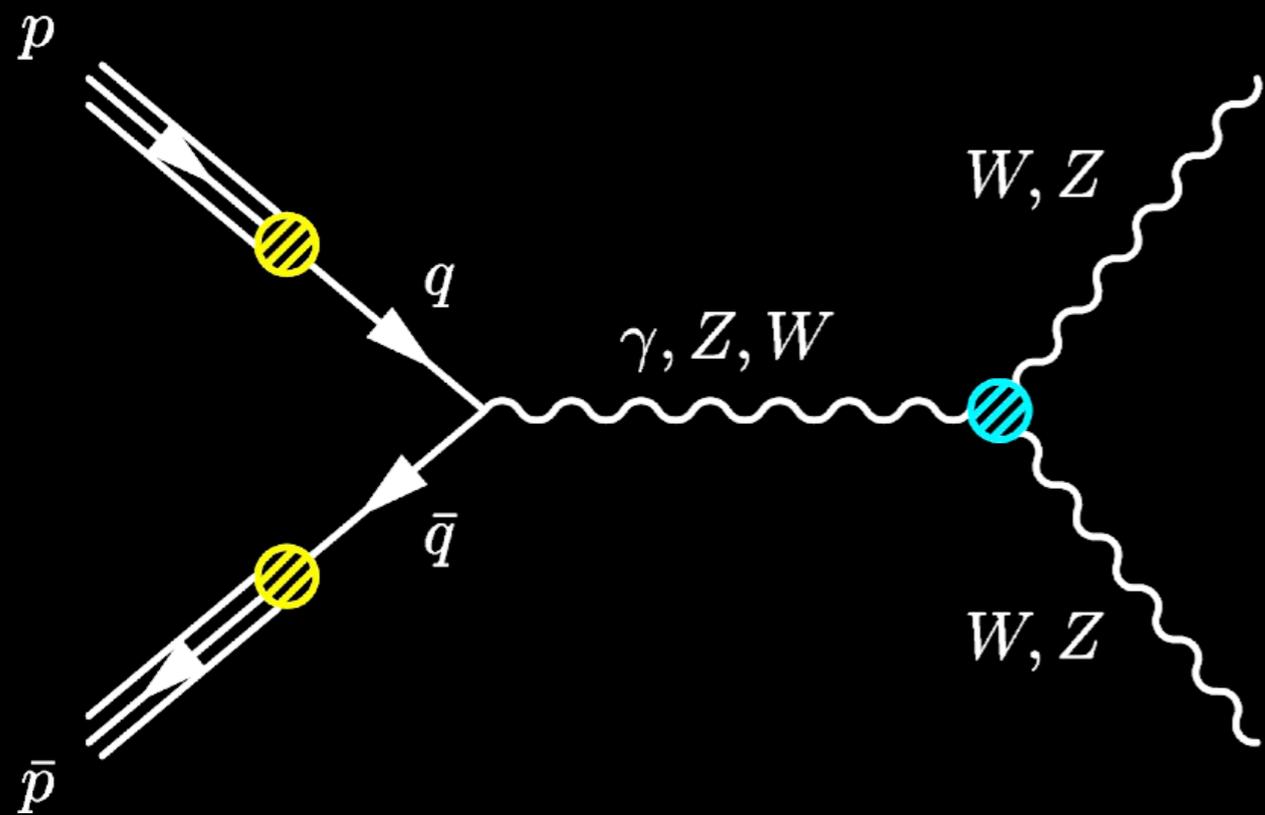
Source	Expected \pm Stat \pm Syst \pm Lumi
Z +jets	$2.45 \pm 0.48 \pm 0.48 \pm 0.00$
ZZ	$1.53 \pm 0.01 \pm 0.16 \pm 0.09$
$Z\gamma$	$1.03 \pm 0.06 \pm 0.35 \pm 0.06$
$t\bar{t}$	$0.17 \pm 0.01 \pm 0.03 \pm 0.01$
WZ	$16.45 \pm 0.03 \pm 1.74 \pm 0.99$
Total	$21.63 \pm 0.48 \pm 2.25 \pm 1.15$
Observed	25

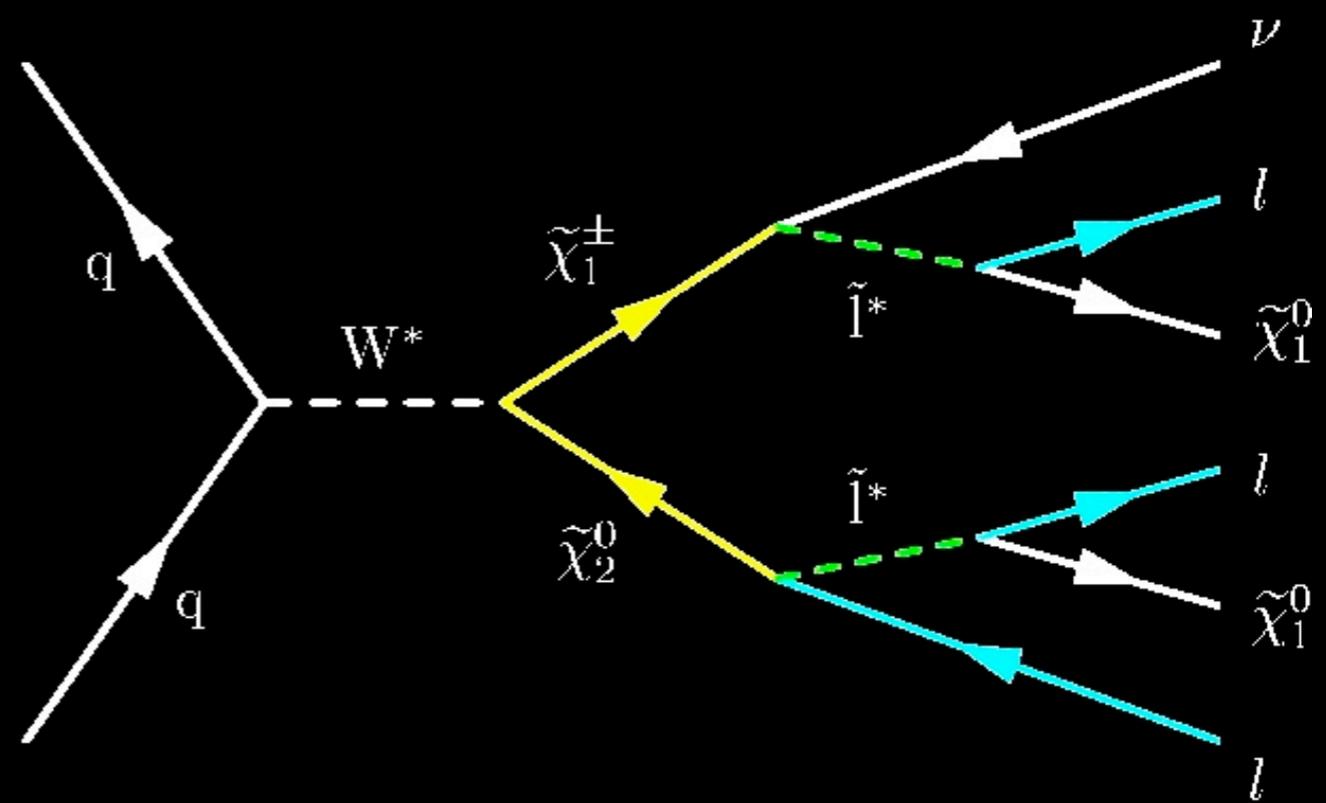
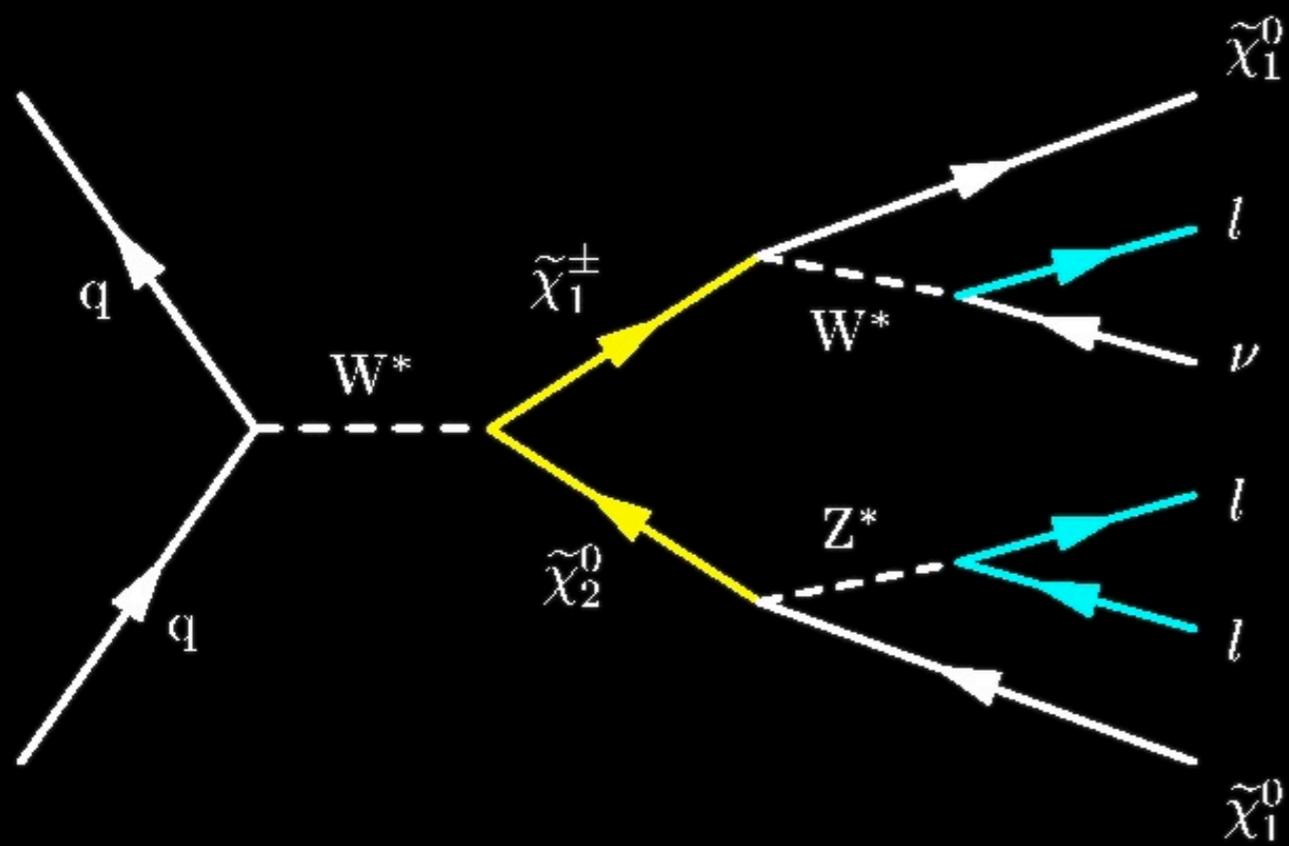
$$4.3^{+1.3}_{-1.0}(\text{stat.}) \pm 0.4(\text{syst.} + \text{lumi.})\text{pb}$$

$$4.3^{+1.3}_{-1.0}(\text{stat.}) \pm 0.2(\text{syst.}) \pm 0.3(\text{lumi.})\text{pb}$$

► Theory: $\sigma(\text{NLO}) = 3.7 \pm 0.3 \text{ pb}$



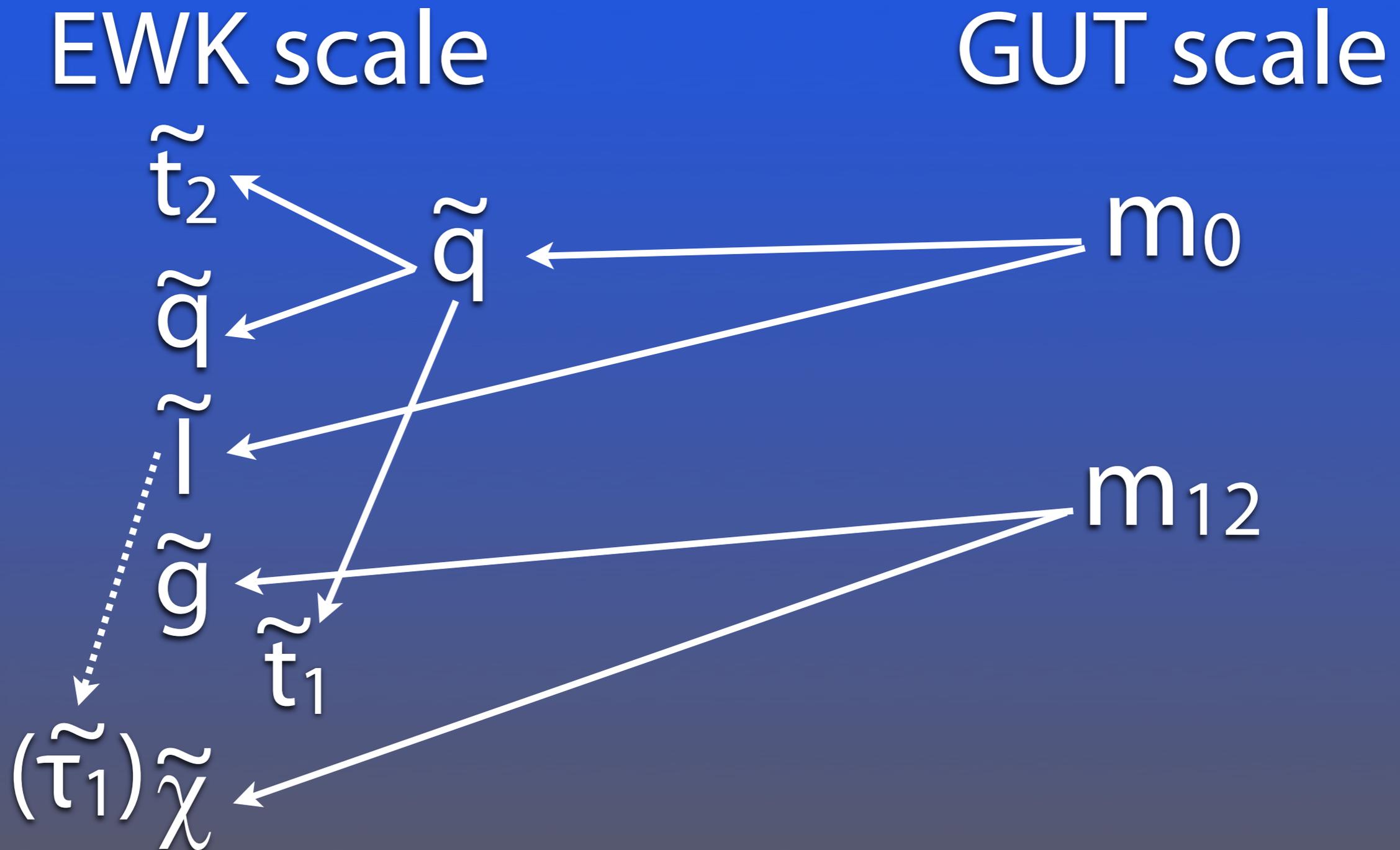




Outline

- **Why trileptons?**
- **D0 searches**
- **CDF searches**
- **Conclusions**

Supergravity masses



Trileptons & SUSY

- **Leptonic signatures: clean**
 - ▶ strong hadronic int. background rejection
 - ★ trileptons or LS dileptons – powerful signature
 - ▶ **N_2 (2nd neutralino) and C_1 (1st chargino) light**
 - ★ appreciable cross sections
 - ▶ look for direct N_2 - C_1 production:
 - ★ no additional jets (except for ISR, etc)
 - ★ rather insensitive to gluino masses, universality arguments, etc.
 - ★ SUSY predicts (R_PC) stable LSPs: thus signature includes MET

Trileptons in SM

● **WZ, ZZ**

- ▶ true trileptons + MET
- ▶ cross sections small

● **t-tbar**

- ▶ both W's decay leptonically
- ▶ one b decays semileptonically

● **Z+gamma, W+gamma, Z+jets, W+jets**

Results from D0

- **Analysis probes electron-electron-lepton signature**

- ▶ Data corresponds to 590/pb of integrated luminosity
- ▶ "lepton" = isolated track

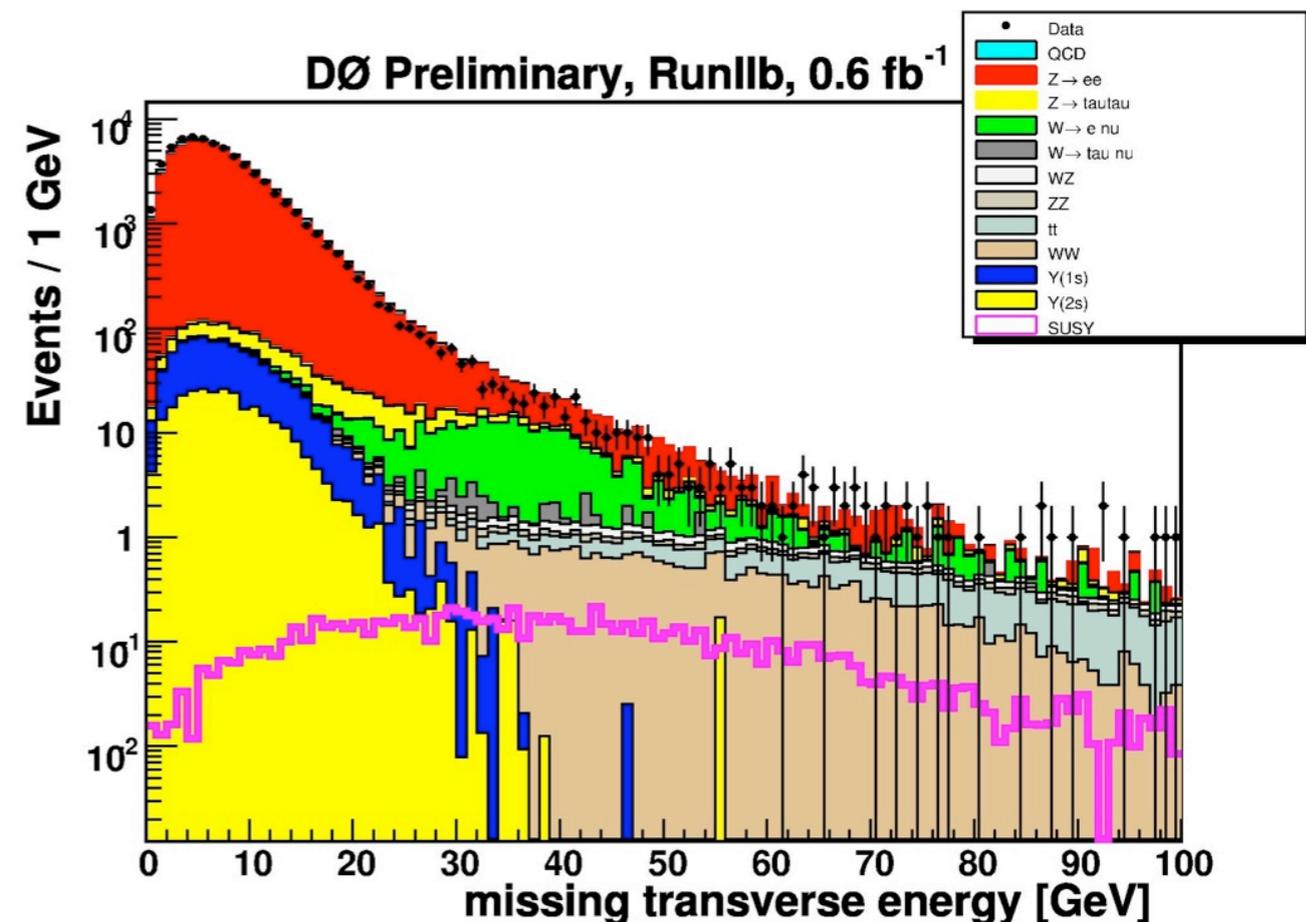
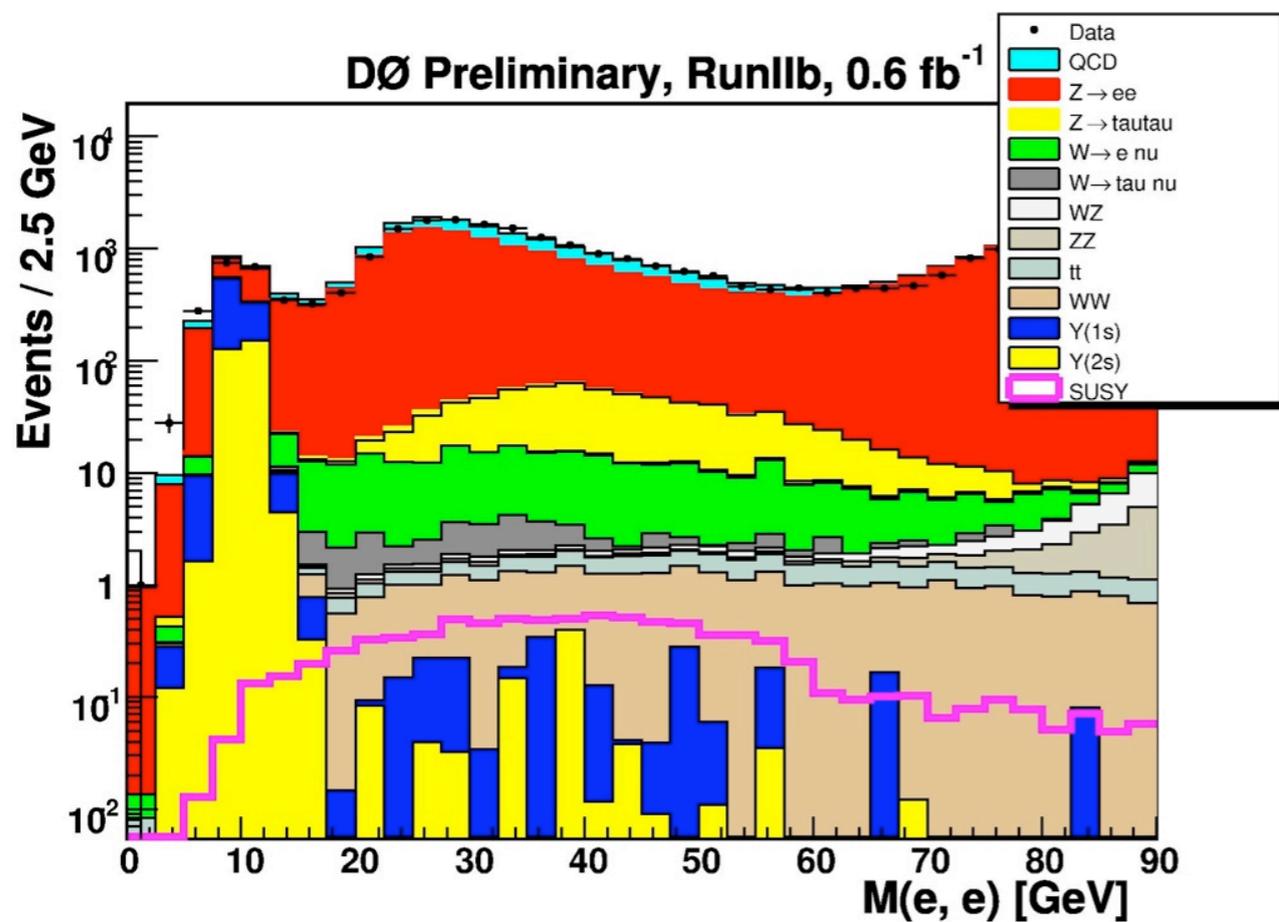
- **Combination of this with 4 other channels**

- ▶ electron-electron-lepton, Like-sign muons, muon-muon-lepton, electron-muon-lepton
- ★ 1/fb of integrated luminosity

D0: Event Selection

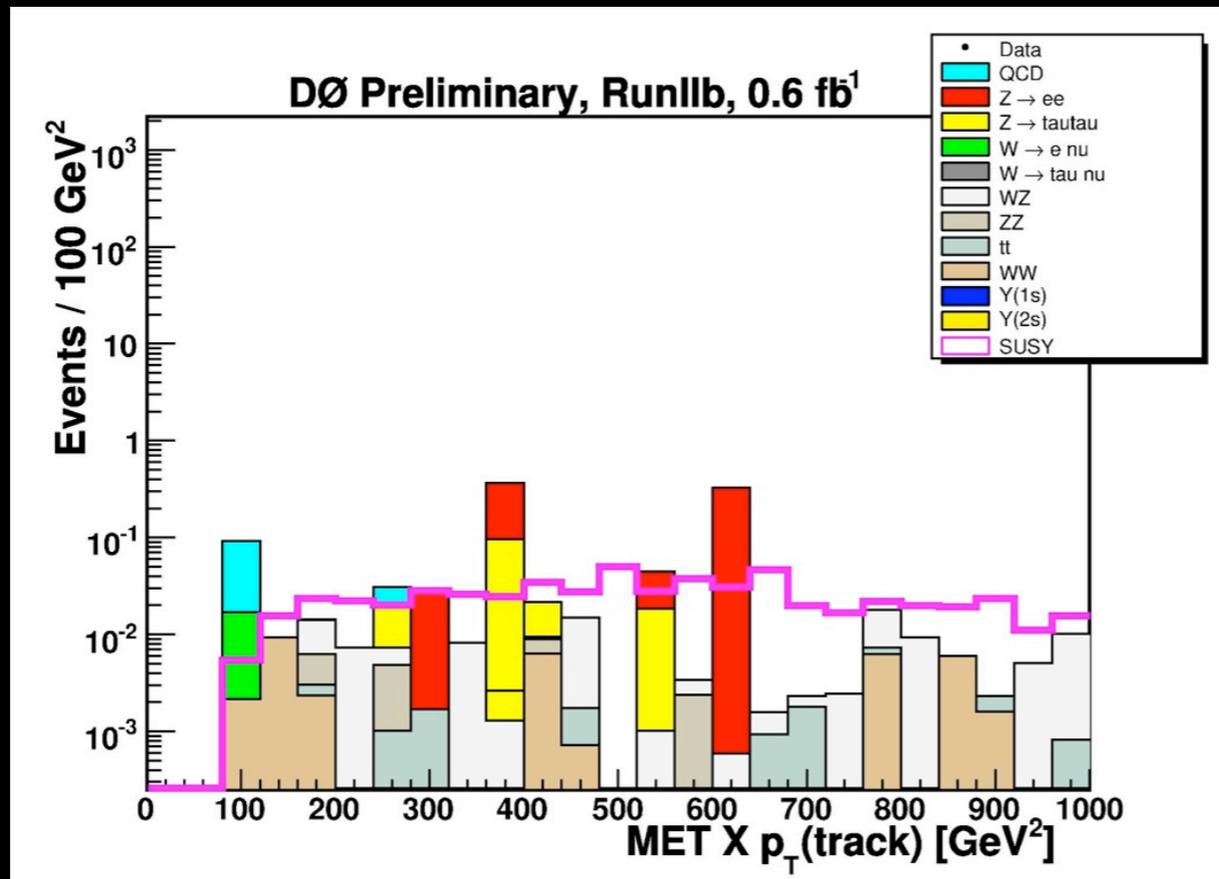
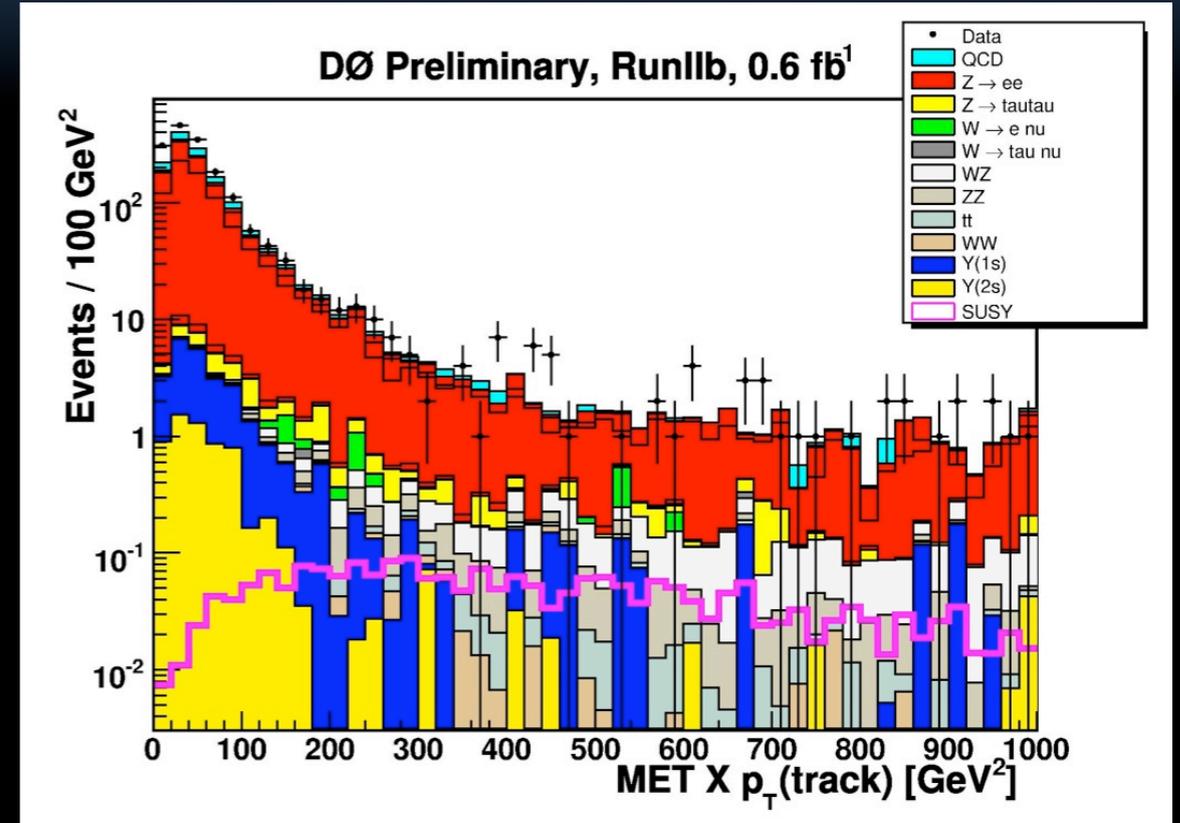
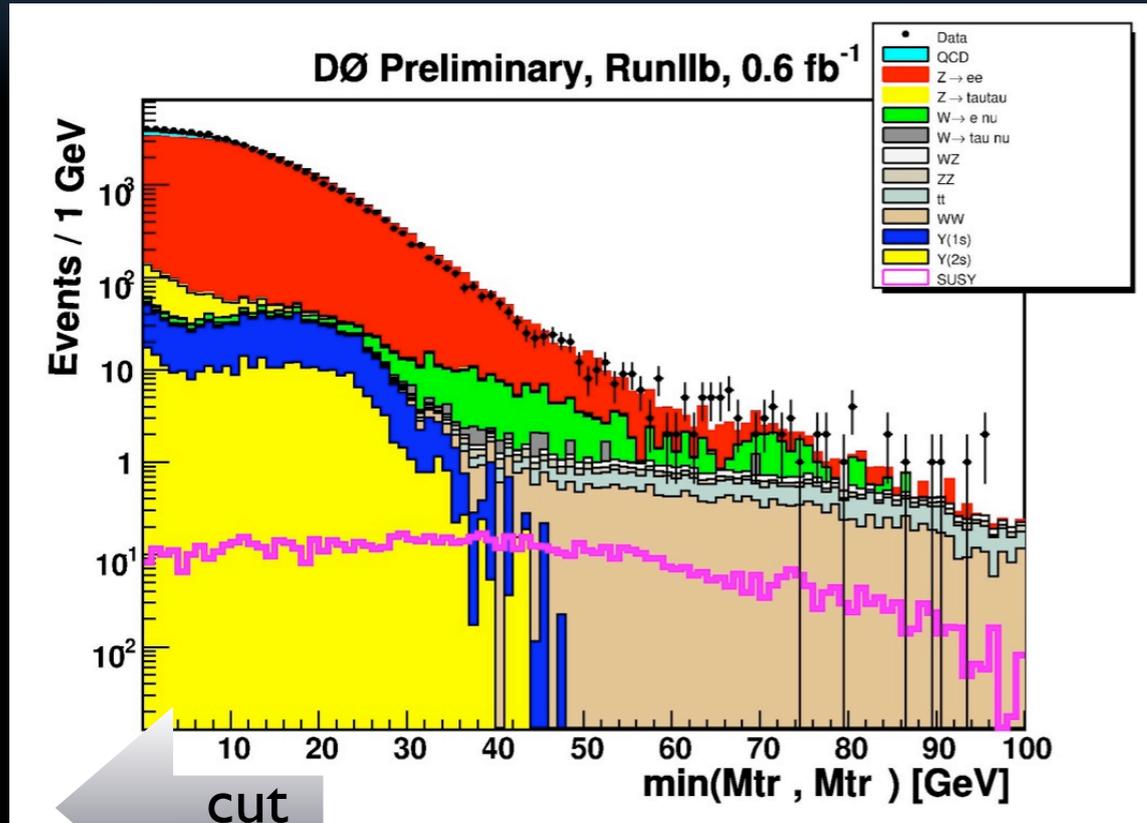
Preselection	$P_T(e) > 12, 8 \text{ GeV}$; High electron likelihood
Anti Z-> ee	$18 \text{ GeV} < M(ee) < 60 \text{ GeV}$; $\Delta\Phi < 2.9 \text{ rad}$
Anti t-tbar	$H_T < 80 \text{ GeV}$
Isolated track	$P_T > 4 \text{ GeV}$; isolation: $\Sigma P_T < 1 \text{ GeV}$; $E_{iso} < 3 \text{ GeV}$; $E_{iso} < 0.6\sqrt{P_T}$
MET	$MET > 22 \text{ GeV}$; $M_T(e, MET) > 20 \text{ GeV}$; $\text{Sig}(MET) > 8$
Anti W for track	$P_T(l_3) > 7 \text{ GeV}$ if $M_T > 65 \text{ GeV}$ (W-like)
Anti Z	$M(e, l_3) < 60 \text{ GeV}$ or $M(e, l_3) > 120 \text{ GeV}$ if track outside CALO
Tr X MET	$MET \times P_T(l_3) > 220 \text{ GeV}^2$

DØ: e-e-I Preselection



name [LHA]	m0	m12	M(LSP)	M(C1)	M(N2)	m(slep _R)	σXBR [fb]
131.232	98	192	69	125	127	129	123

DØ: M_T , MET



Expect remaining Z, QCD to have low $P_T(l_3)$ and MET

After MET cuts

D0: e-e-l results

● **0 observed, 1.0 ± 0.3 (stat) SM expected**

▶ Drell-Yan: 0.6, WZ: 0.2

▶ Number of signal events expected at various stages:

cut	LHA.131.232
Preselection	9.0
Anti-Z	5.3
Isolated track	2.9
MET	1.9
Tr X MET	1.4
3 lepton efficiency	2.6%

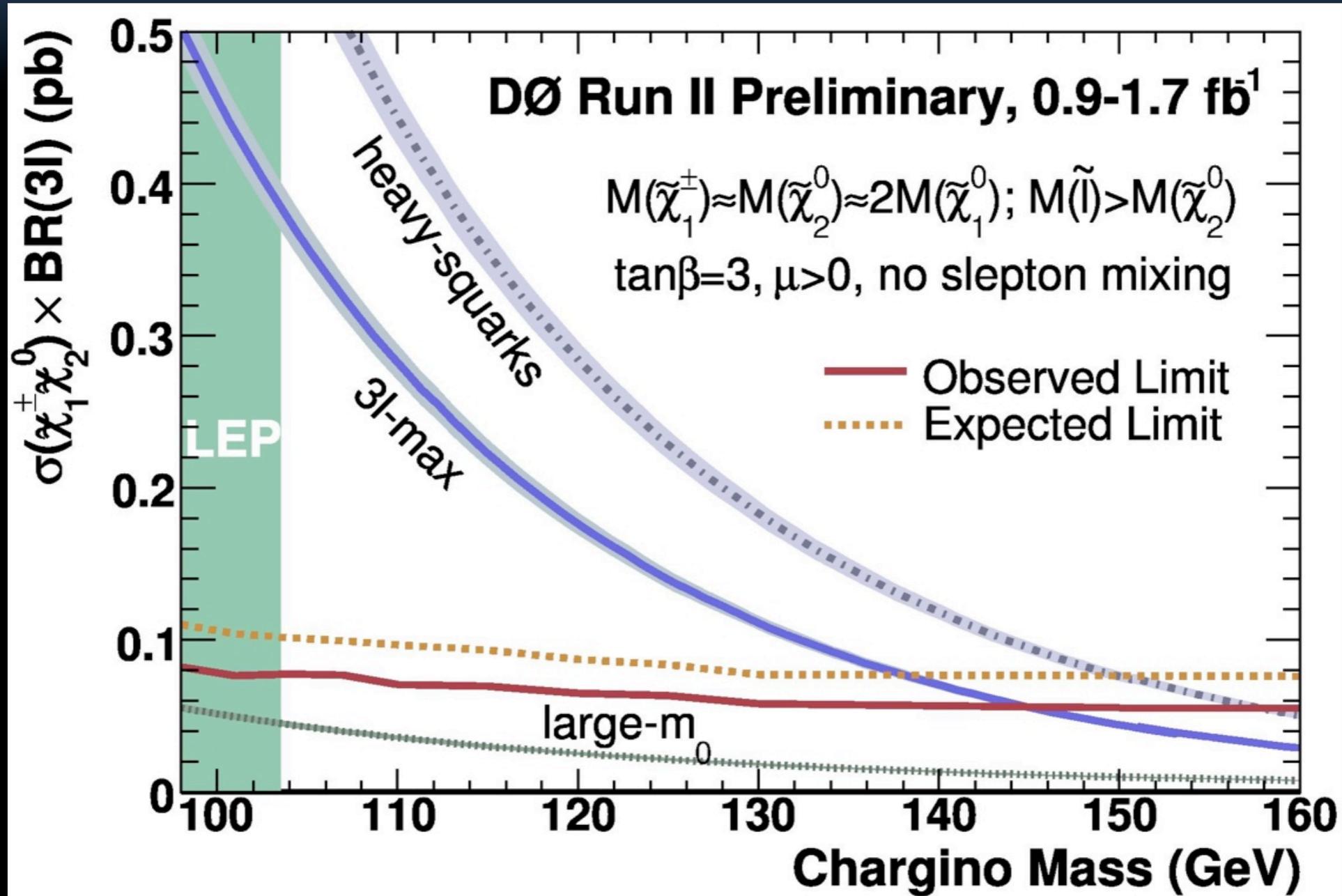
D0: Previous results

- for combination with latest analysis:

Channel Signal Background Obs.

ee + T	1.7-4.7	0.8 ± 0.7	0
$\mu\mu$ + T	0.5-2.5	$0.3 \pm^{1.3}_{0.3}$	2
eμ + T	2.0-2.6	0.9 ± 0.4	0
$\mu^\pm\mu^\pm$	0.6-3.8	1.1 ± 0.4	1

DØ: Combined results



3l-max: leptonic decays enhanced for $M(\text{slep}) \gtrsim M(N_2)$
 Production of $N_2 C_1$ has negative interference with t-channel squark exchange. Cross section maximal for **heavy squarks**

Exclude: $\sigma \times \text{BR} > 80 \text{ fb}, M(C_1) < 145 \text{ GeV}$

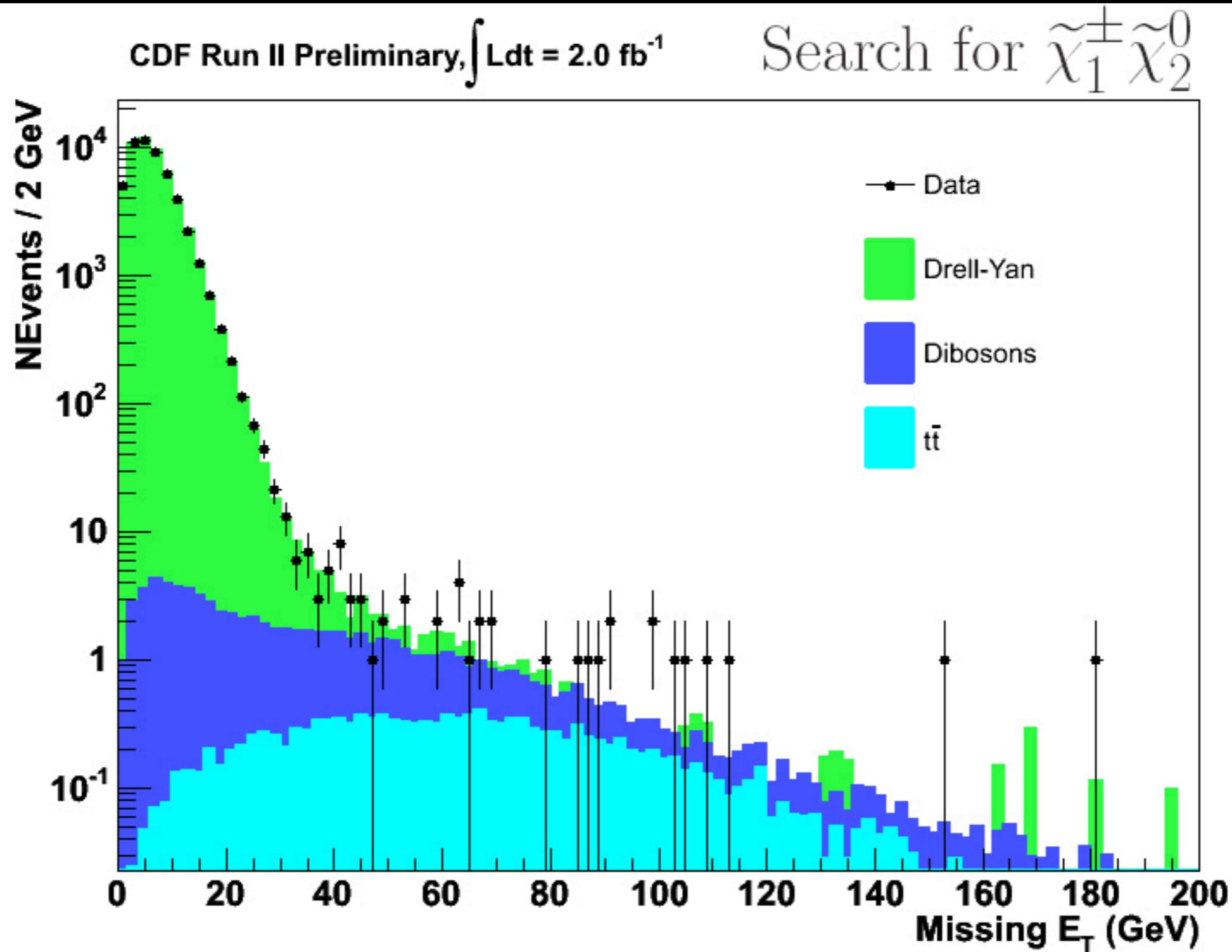
Results from CDF

- single analysis: 2/fb and 5 exclusive channels

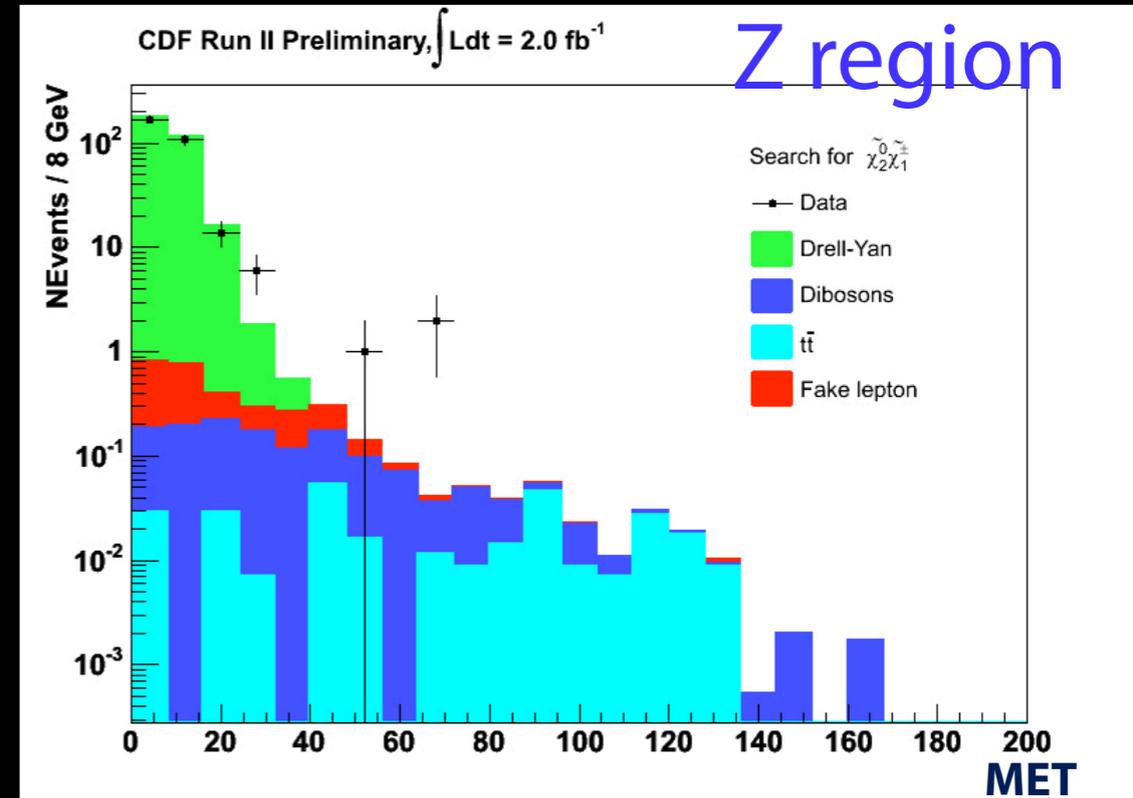
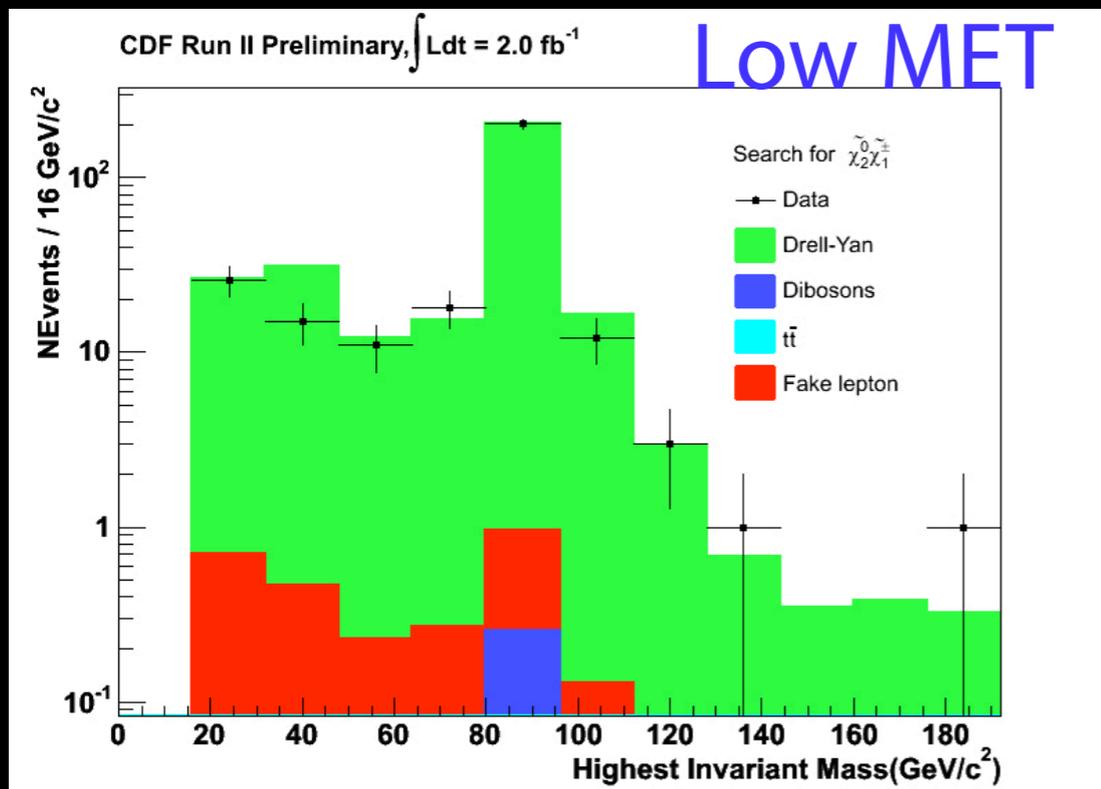
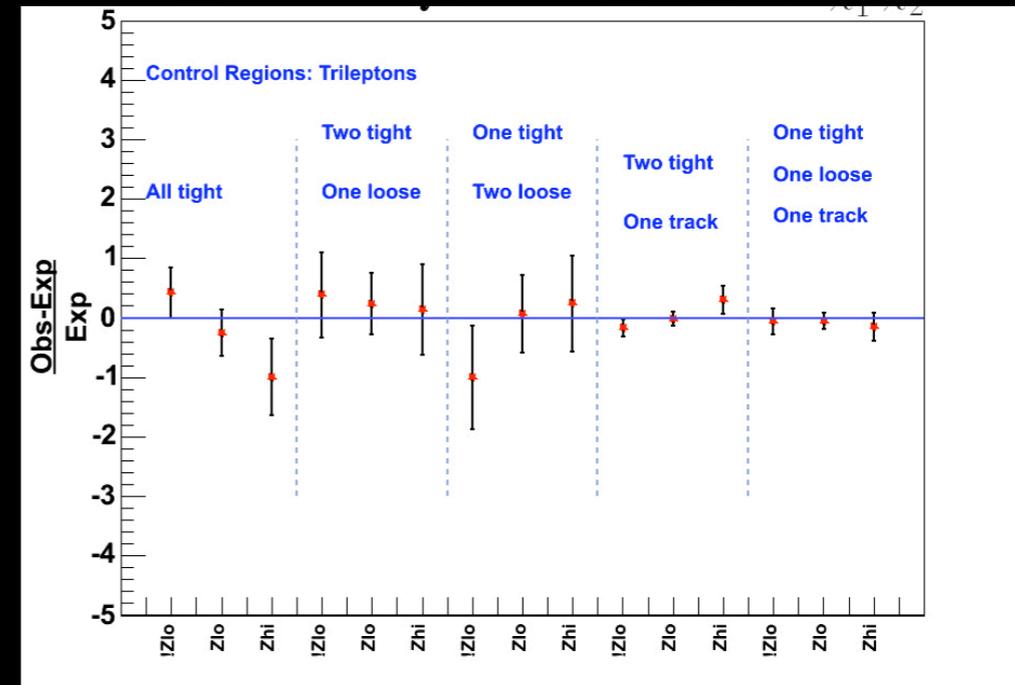
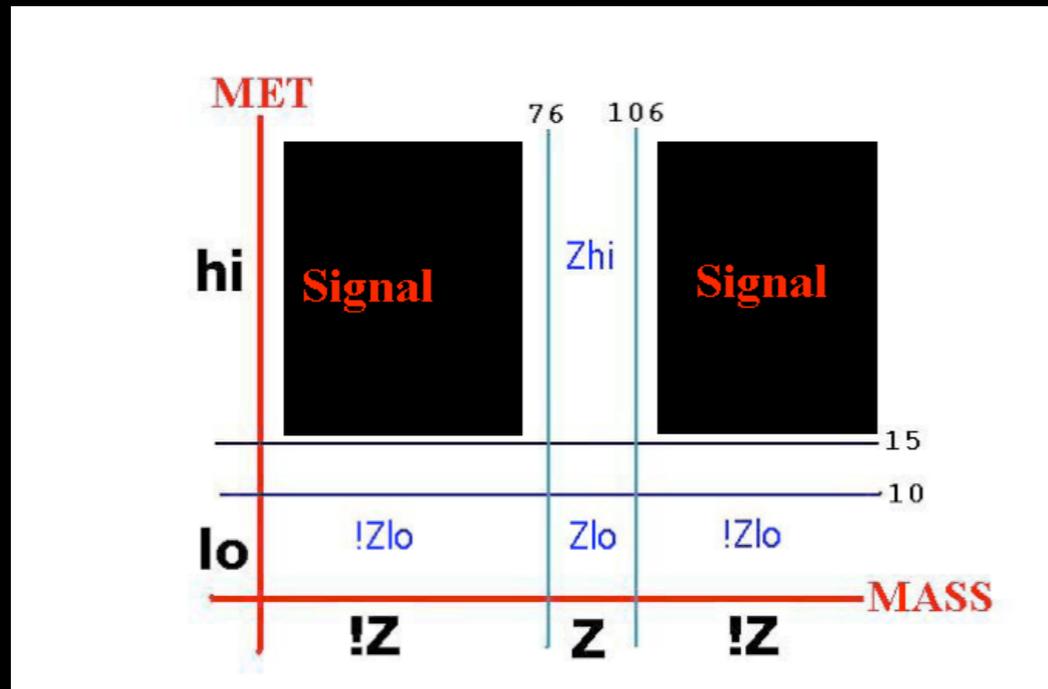
	channels	selection	(E _T or P _T) ₁₂₃ [GeV]
trilepton	3 tight	3 tight <i>l</i> or 2 tight <i>l</i> + 1 loose e	15,5,5
	2 tight + 1 loose	2 tight <i>l</i> + 1 loose muon	15,5,10
	1 tight + 2 loose	1 tight lepton + 2 loose <i>l</i>	20,8,5 *
dilep+track	2 tight + 1 track	2 tight <i>l</i> + 1 iso track	15,5,5
	1 tight + 1 loose +1 track	1 tight <i>l</i> + 1 loose <i>l</i> + 1 iso track	20,8*,5

* 10 GeV if loose muon

CDF: MET in Z peak



CDF: 3 lepton ctrl regions



CDF: Event Level

- **Lepton charge sum magnitude unity**

- ▶ 2 OS pairs. Require $M(l^+l^-)_{\max} > 20 \text{ GeV}$, $M(l^+l^-)_{\min} > 13 \text{ GeV}$
- ▶ Back-to-back and Z vetoes for OS pairs

- **MET > 20 GeV**

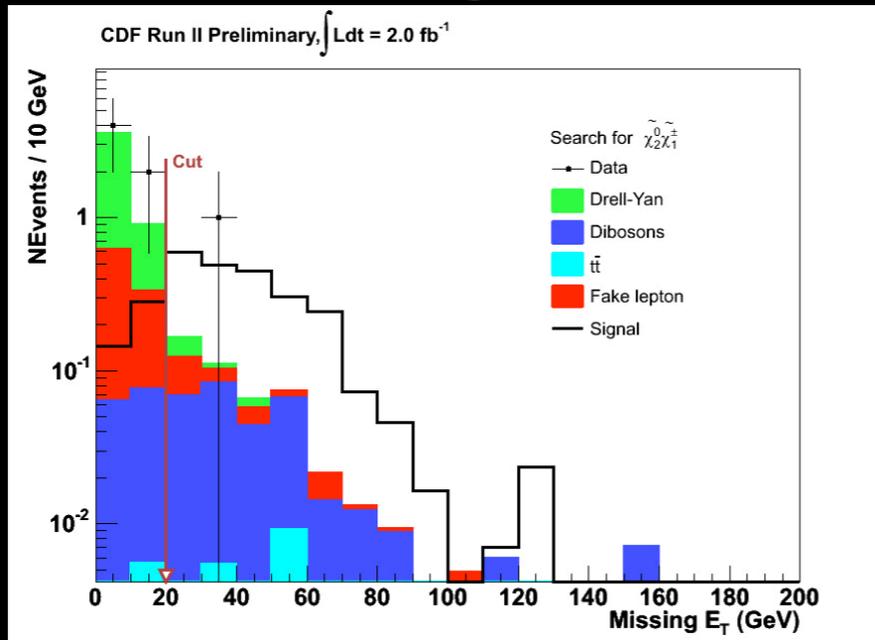
- ▶ Although LSP induced MET partially cancels, still provides BG rejection

- **$N_i \leq 1$, $E_T(j) < 80 \text{ GeV}$**

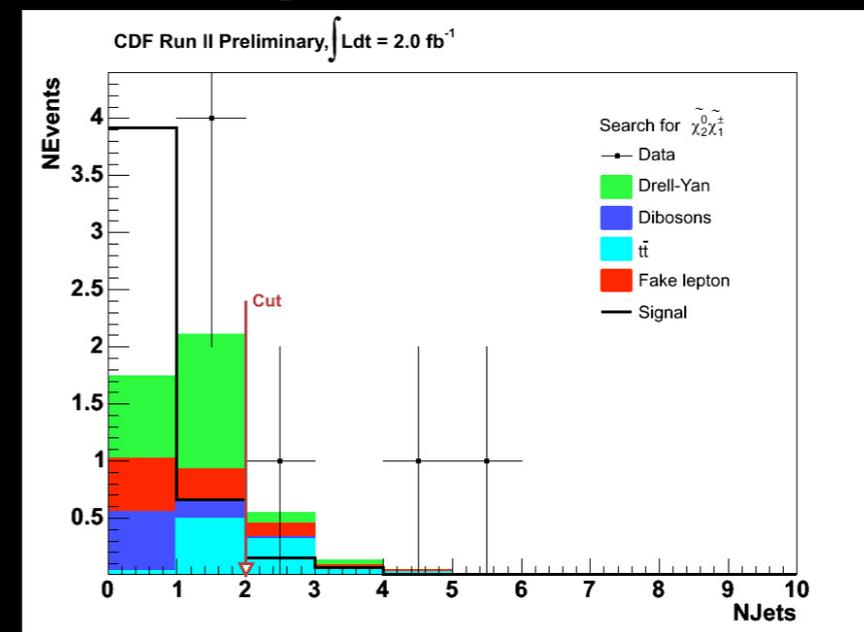
- ▶ Rejects t-tbar

CDF: Results

3 tight

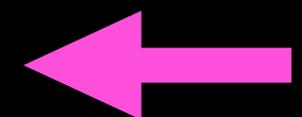
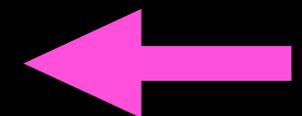


2 tight + 1 track

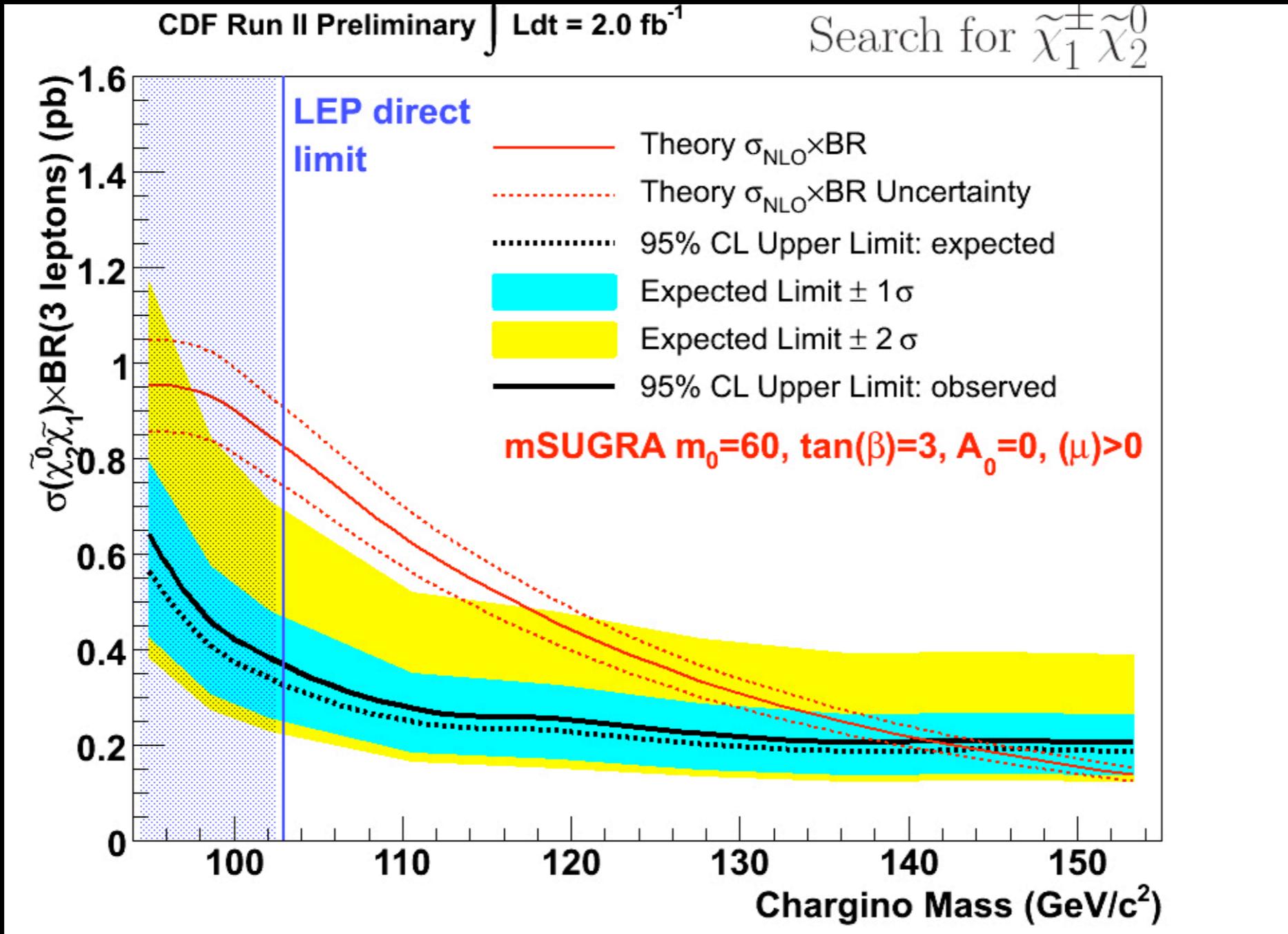


Signal: $m_0 = 60$, $m_{1/2} = 190$, $\tan(\beta) = 3$, $A_0 = 0$, $\mu > 0$

Channel	Signal	Background	Observed
3tight	$2.25 \pm 0.13(\text{stat}) \pm 0.29(\text{syst})$	$0.49 \pm 0.04(\text{stat}) \pm 0.08(\text{syst})$	1
2tight,1loose	$1.61 \pm 0.11(\text{stat}) \pm 0.21(\text{syst})$	$0.25 \pm 0.03(\text{stat}) \pm 0.03(\text{syst})$	0
1tight,2loose	$0.68 \pm 0.07(\text{stat}) \pm 0.09(\text{syst})$	$0.14 \pm 0.02(\text{stat}) \pm 0.02(\text{syst})$	0
Total Trilepton	$4.5 \pm 0.2(\text{stat}) \pm 0.6(\text{syst})$	$0.88 \pm 0.05(\text{stat}) \pm 0.13(\text{syst})$	1
2tight,1Track	$4.44 \pm 0.19(\text{stat}) \pm 0.58(\text{syst})$	$3.22 \pm 0.48(\text{stat}) \pm 0.53(\text{syst})$	4
1tight,1loose,1Track	$2.42 \pm 0.14(\text{stat}) \pm 0.32(\text{syst})$	$2.28 \pm 0.47(\text{stat}) \pm 0.42(\text{syst})$	2
Total Dilepton+Track	$6.9 \pm 0.2(\text{stat}) \pm 0.9(\text{syst})$	$5.5 \pm 0.7(\text{stat}) \pm 0.9(\text{syst})$	6



CDF: Limits



Maximum exclusion: $\sigma \times \text{BR} > 200 \text{ fb}, M(C1) < 140 \text{ GeV}$

Conclusions

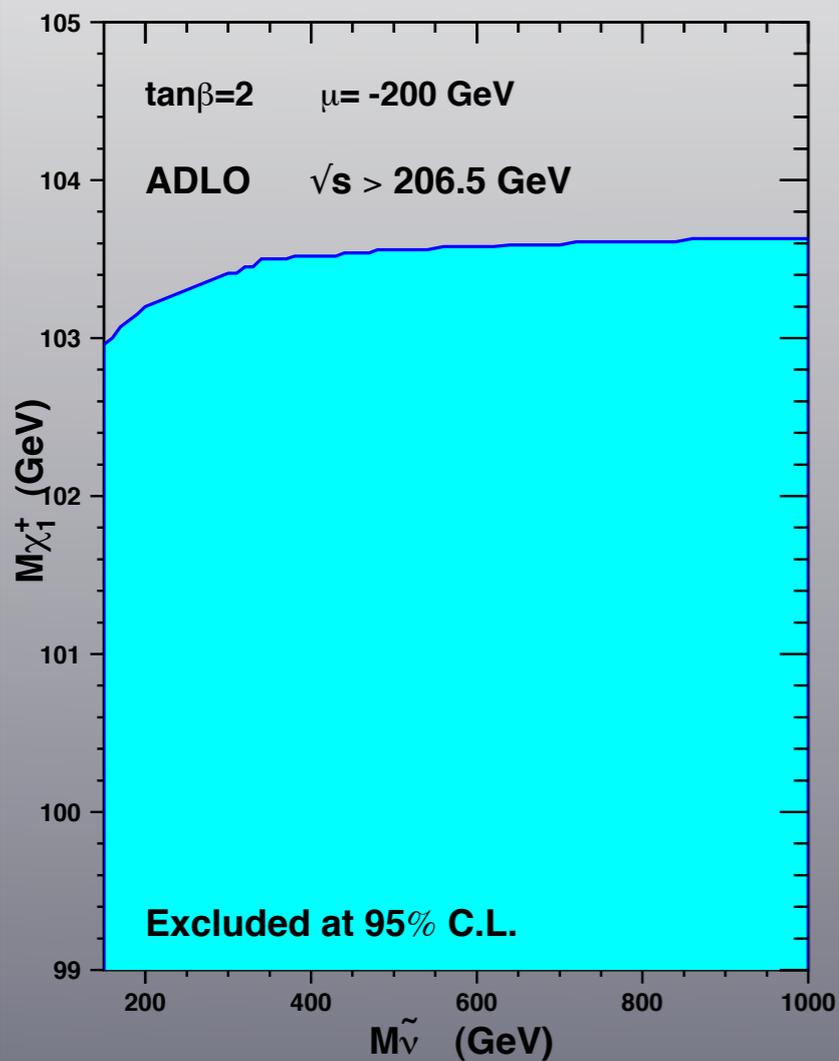
- **Reach of leptonic signatures proven with well understood detectors and data sets**
 - ▶ Clear need to combine various channels
- **CDF and D0 have performed several N2C1 searches with trileptons in Run II**
 - ▶ Focus still on electrons and muons with additional “very loose” third object
 - ▶ tan beta & mixing: stau becomes light. \Rightarrow Add hadronic taus explicitly

Backup Slides

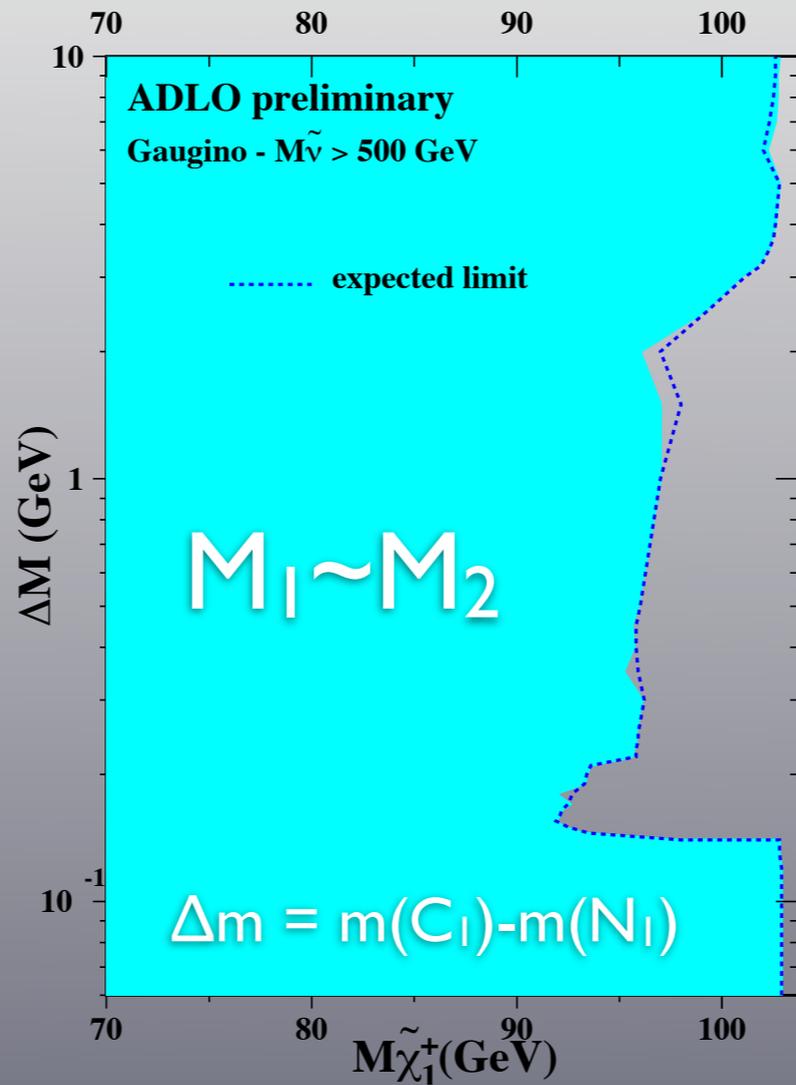
LEP II Final results

- LEP looked for chargino pairs to $\sqrt{s} = 208 \text{ GeV}$
 - consider all possible decays of chargino

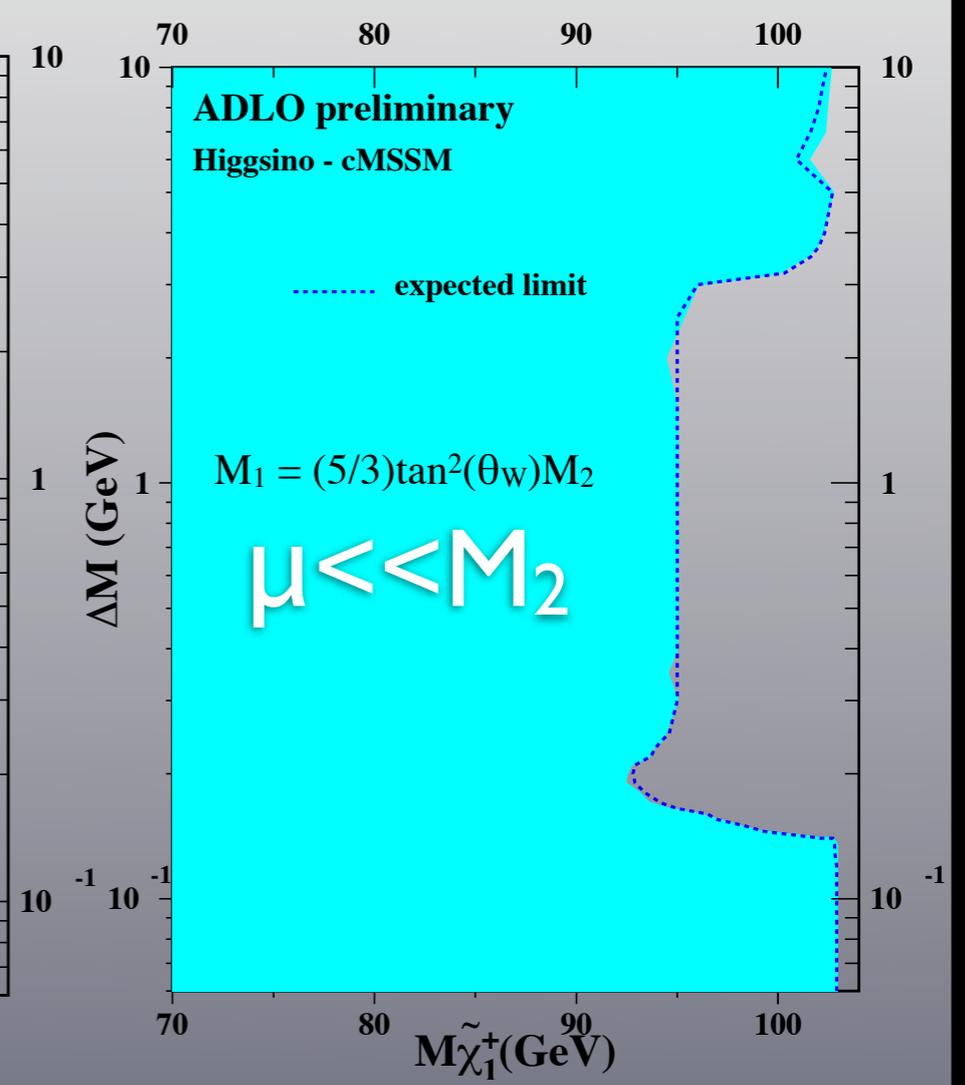
large m_0



small Δm



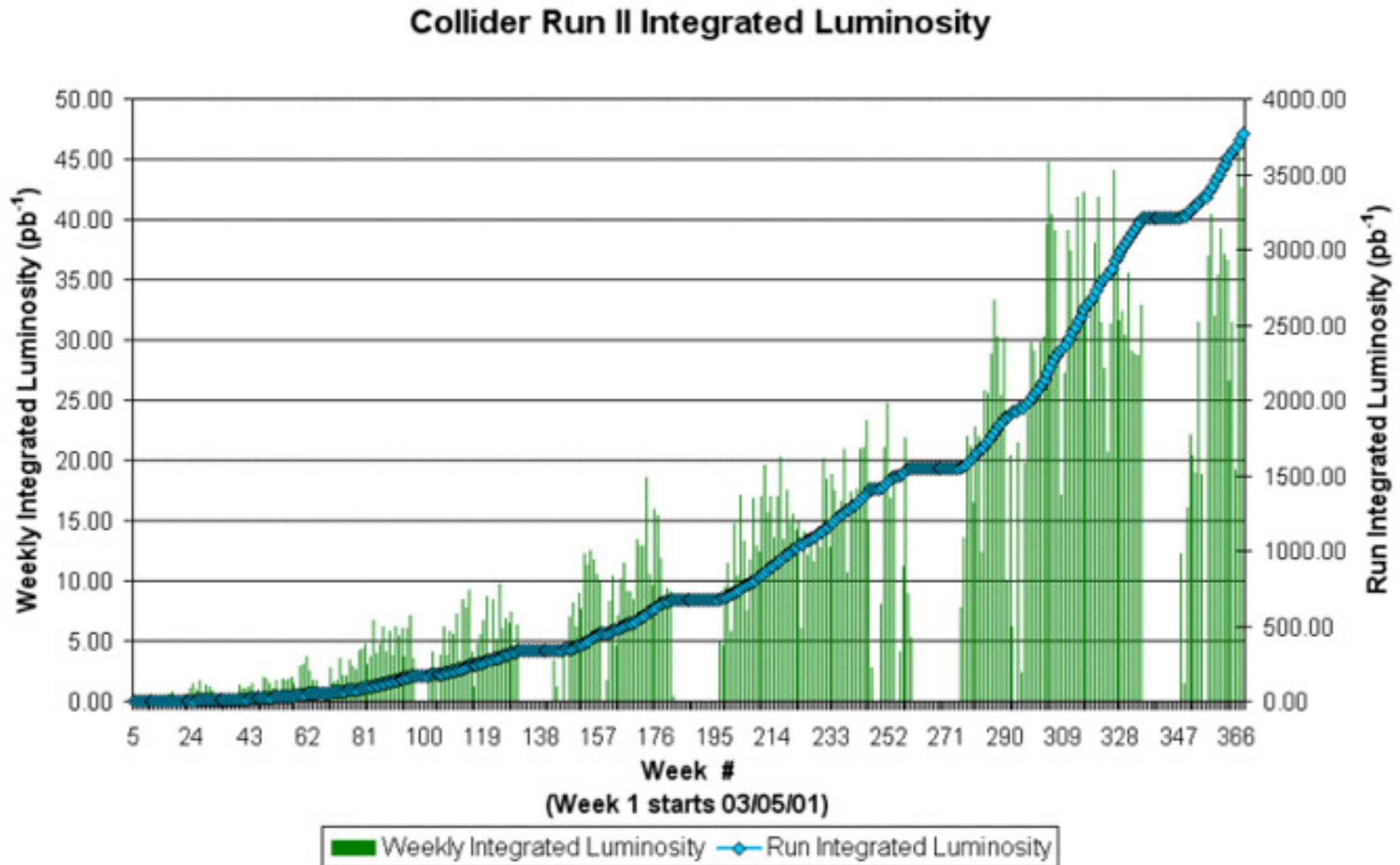
small Δm



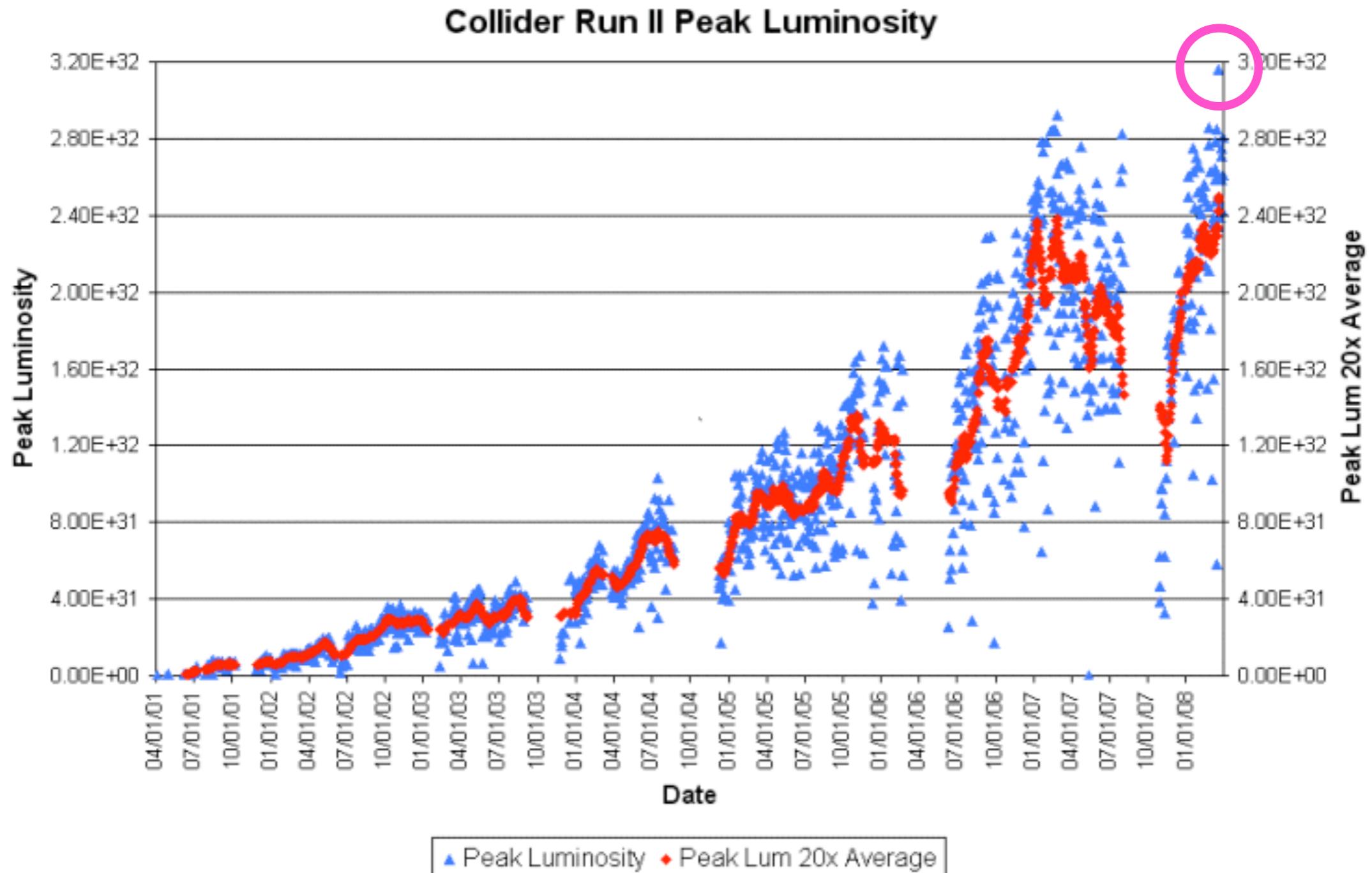
$\therefore m(C_1) > 103 \text{ GeV}$

$\therefore m(C_1) > 92 \text{ GeV}$

Tevatron performance



Peak record!



Oddone comment

● FNAL Today, April 1, 2008:

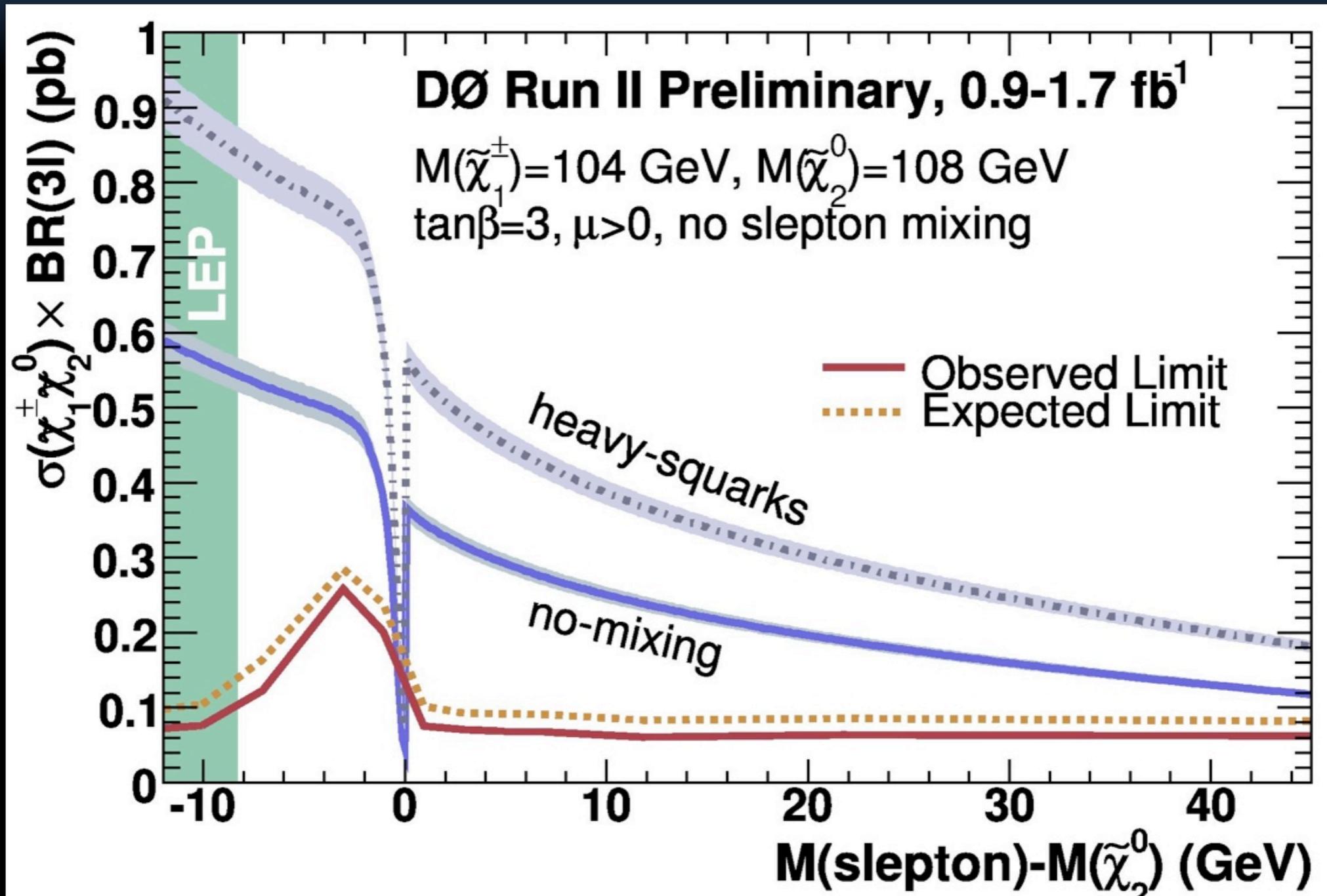
- ★ I have decided that the best course of action is not have a shutdown of the accelerator complex during FY08. Instead, in the Spring of 2009 we would have a shutdown of about 10 weeks. There is an increased risk of developing problems during such an extended run lasting until a year from now, but the risk is acceptable. The advantage of this new schedule is that we would have only this single shutdown through FY2010, thus maximizing the integrated luminosity over the balance of the Tevatron program.

DO: e-e-l

name [LHA]	m0	m12	M(LSP)	M(C1)	M(N2)	m(slep _R)	σ_{XBR} [fb]
244.324	121	221	82	150	152	153	37
131.232	98	192	69	125	127	129	123
87.194	88	182	63	115	118	119	198

- **This choice of mSUGRA points gives chargino masses in the target range**

DØ: $\Delta M(\text{slepton}, N2)$

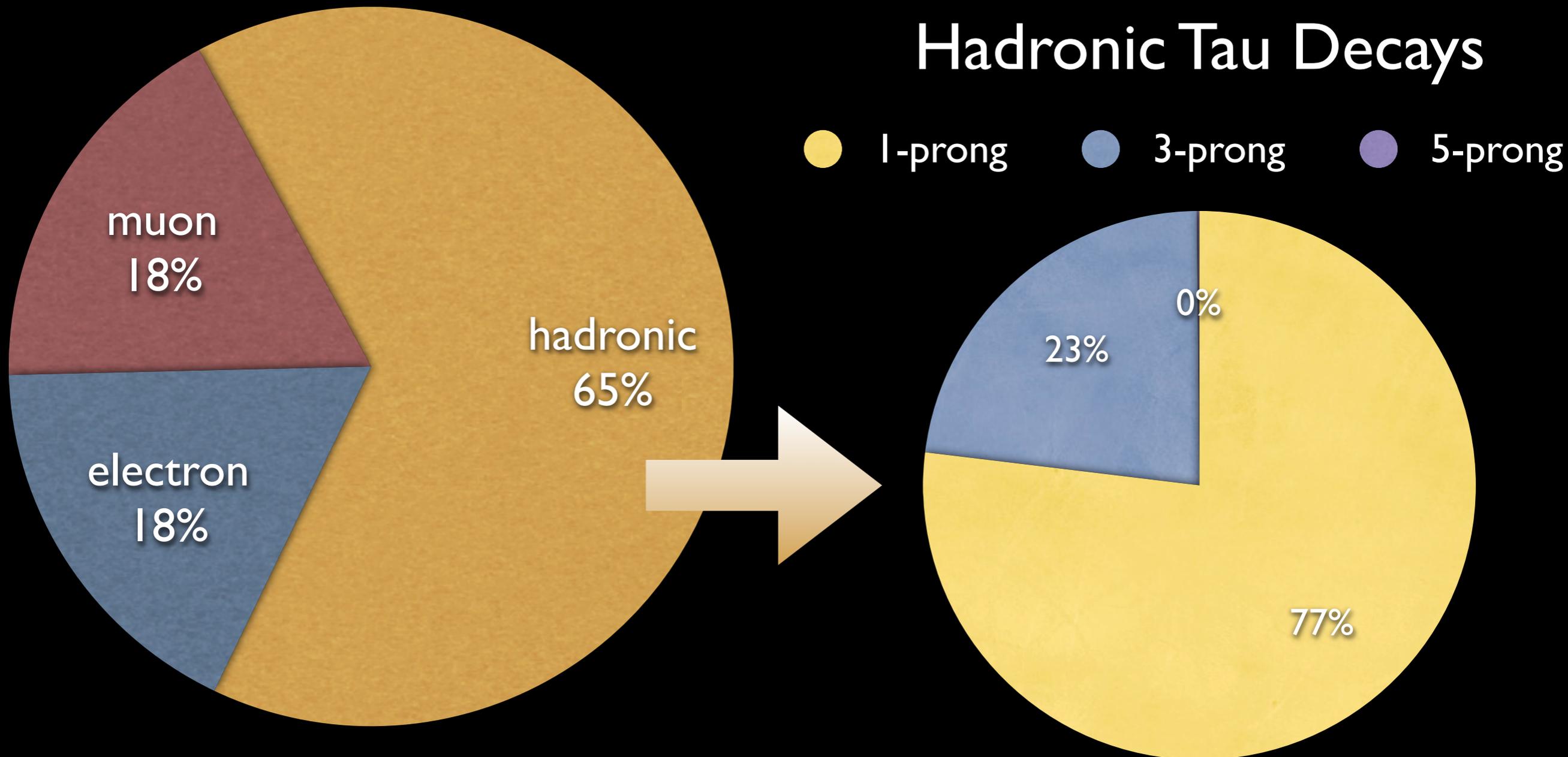


For light sleptons, two body decays. However, resulting lepton is soft. Only LS muon selection efficient here.

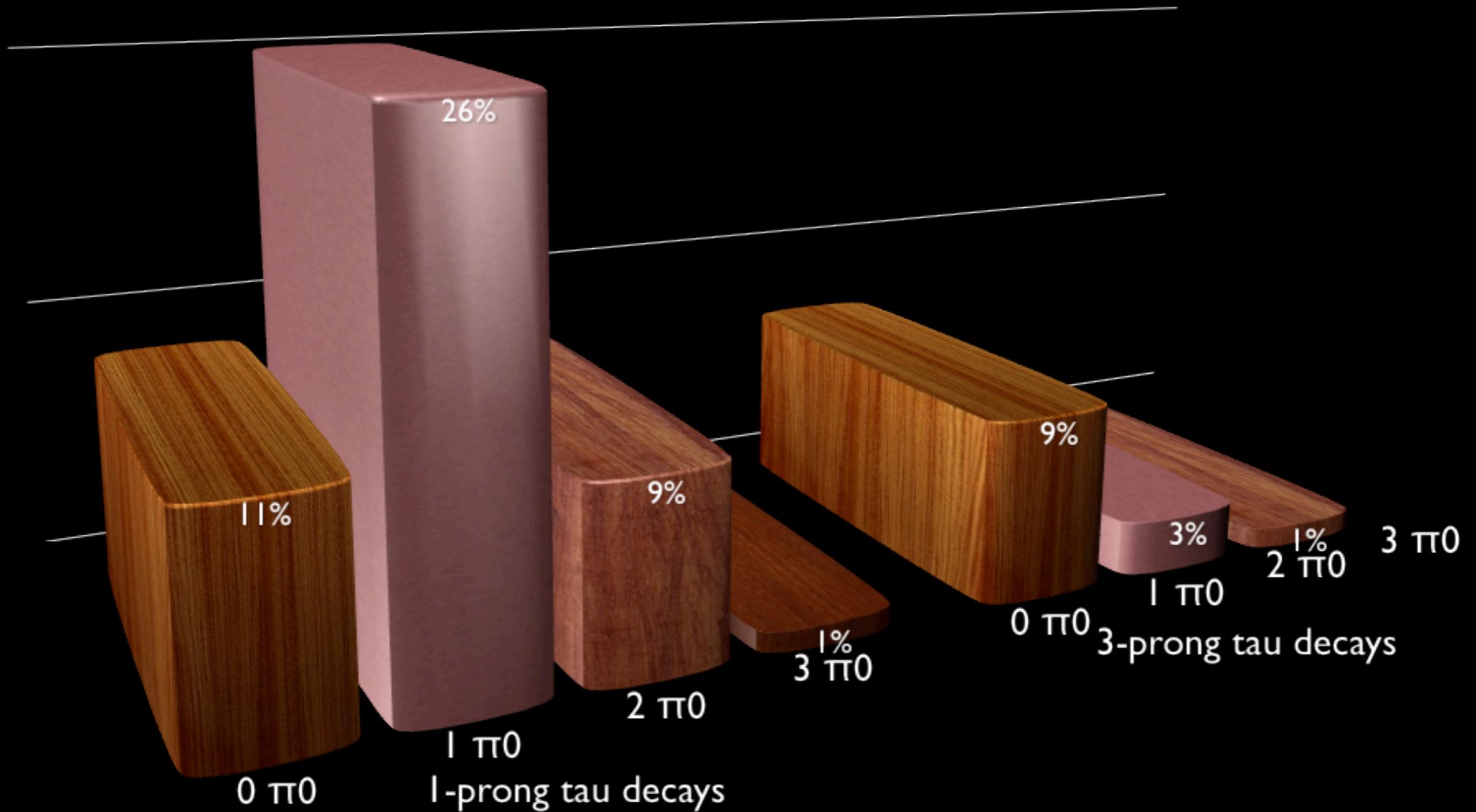
The Tau Lepton

● The tau is identical to the electron!

★ (except that it's 3400 X heavier) ∴ "Interesting" decays



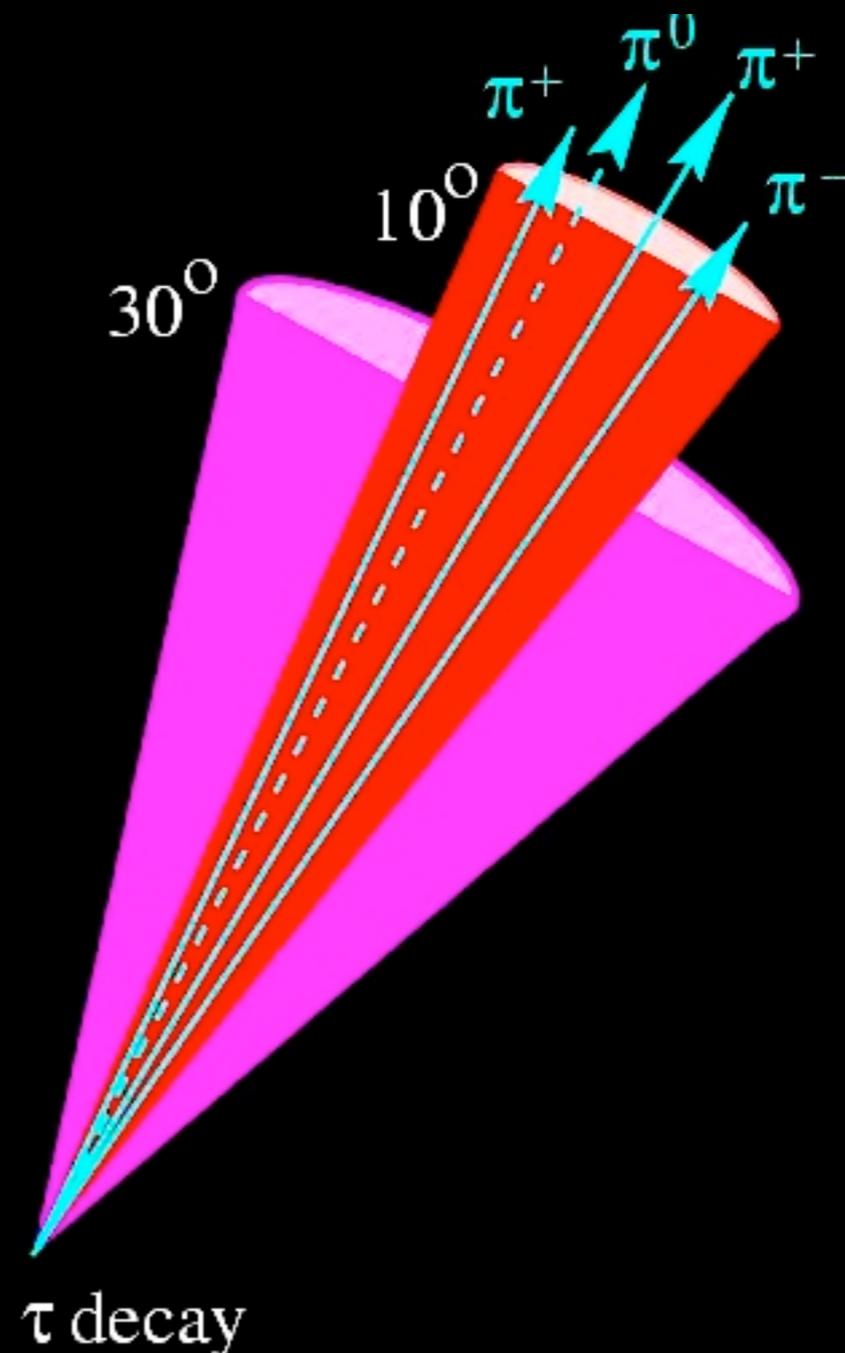
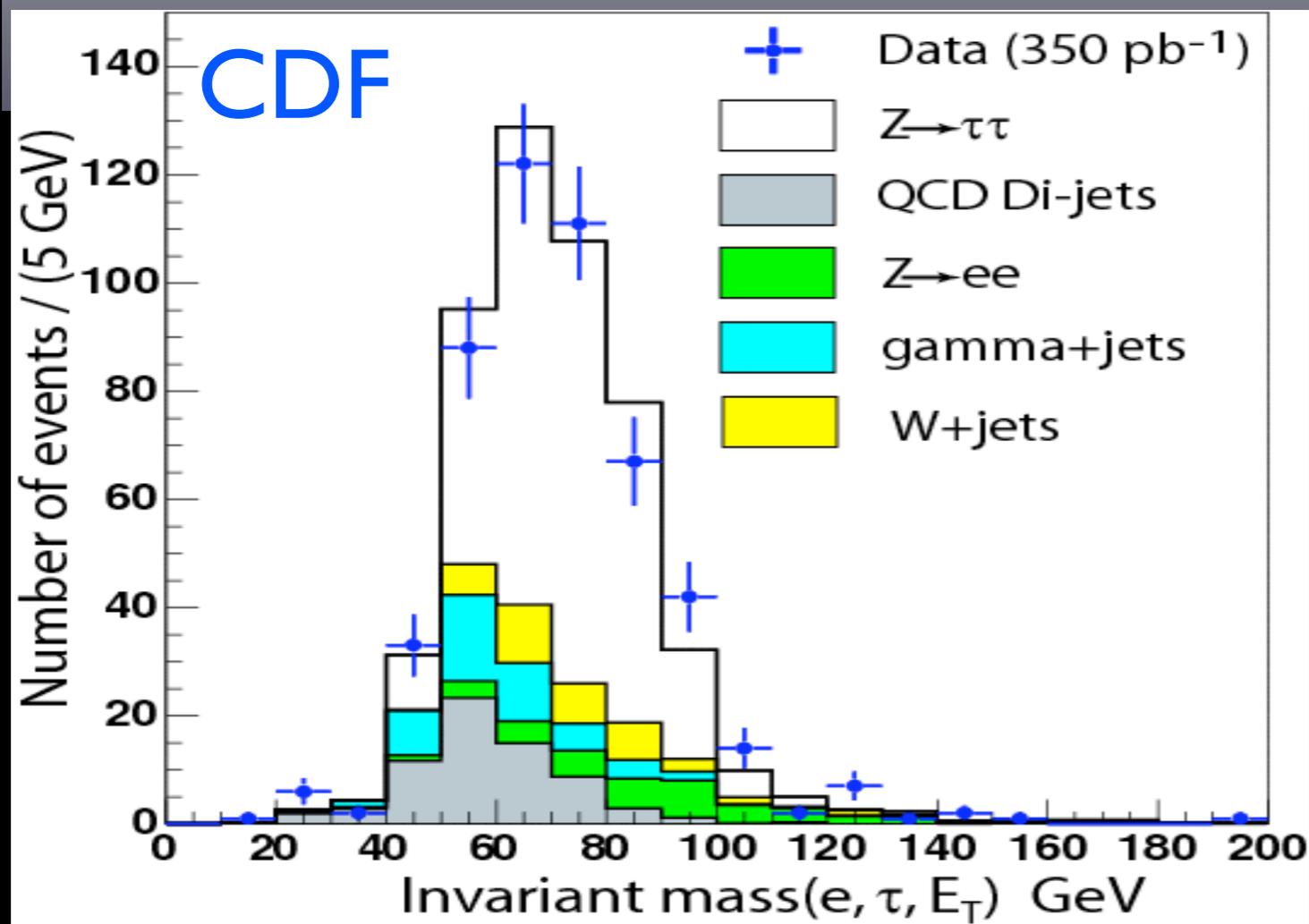
Neutral pion multiplicity



Lepton+Track Triggers

◇ Original Motivation: $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$ search

- Golden signature (3ℓ)
- In Run I, “threw away” tau channels
- Moreover, high $\tan\beta \rightarrow M(\tilde{\tau})$ light
- Stau decays: $\tilde{\tau} \rightarrow \tau \tilde{\chi}_1^0$
- p_T too low for inclusive lepton triggers



Prospects