# CDF Searches for New and Exotic Physics

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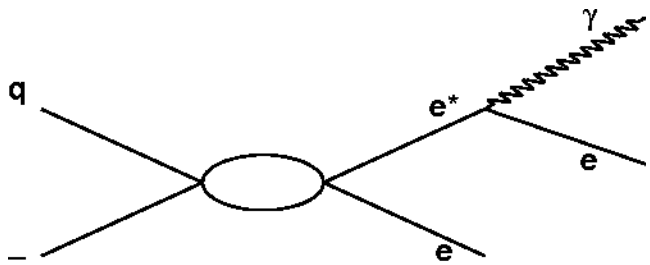
# New Results from CDF

| | pb-1 |
|---|---|
| o Supersymmetry | |
| – Gluino → sbottom bottom | 156 |
| – GMSB diphotons | 202 |
| o High mass diphotons | |
| – Randall-Sundrum Gravitons in $\gamma\gamma$ | 345 |
| o Leptoquarks | |
| – LQ decays to evjj, eejj, $\mu\mu$jj | 203 |
| o Compositeness | |
| – $e^* \rightarrow e\gamma$ | 200 |
| o High mass Drell Yan | |
| – $Z' \rightarrow \tau\tau$ | 195 |
| o Technicolor | |
| – Techni-$\rho$, techni-$\pi$ | 162 |
| o Even cooler stuff | |
| – Dirac Monopoles | 25 |

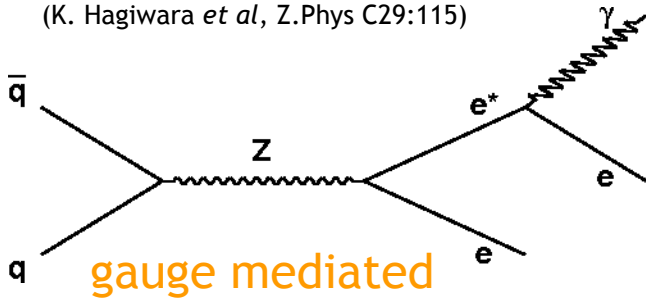
# Excited electrons: e*

- Search for an excited or exotic electron in $p\bar{p} \rightarrow e^* + e \rightarrow e\gamma + e$
  - Select events with $ee\gamma$ final state
  - Look for resonances in an $e\gamma$ pair
  - Backgrounds small; mainly $Z\gamma$ but also Zj, WZ, multijet, $\gamma\gamma j$, Wjj
- Expected in Compositeness models
  - Cross section parameterized by e* mass and compositeness scale ($\Lambda$)



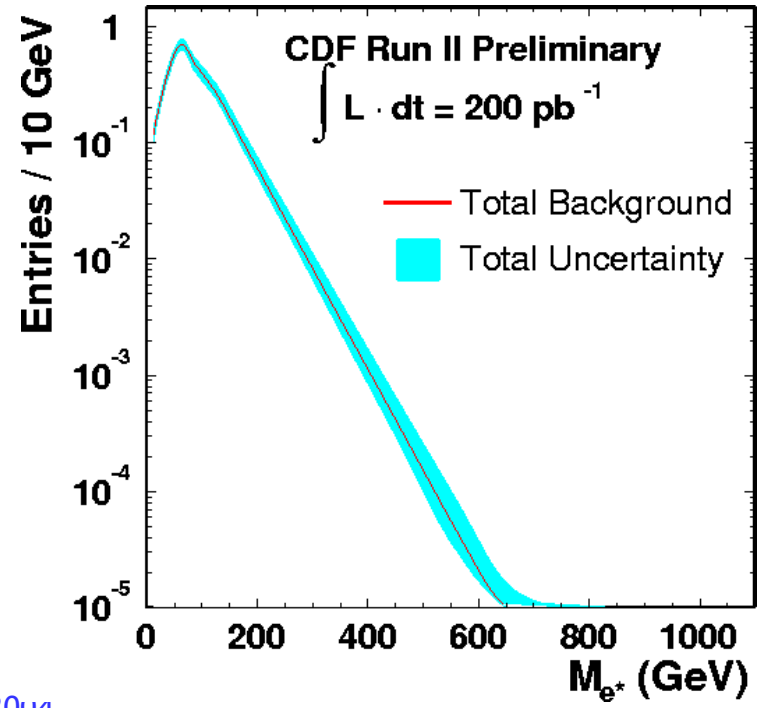

contact interaction

(K. Hagiwara *et al*, Z.Phys C29:115)




gauge mediated

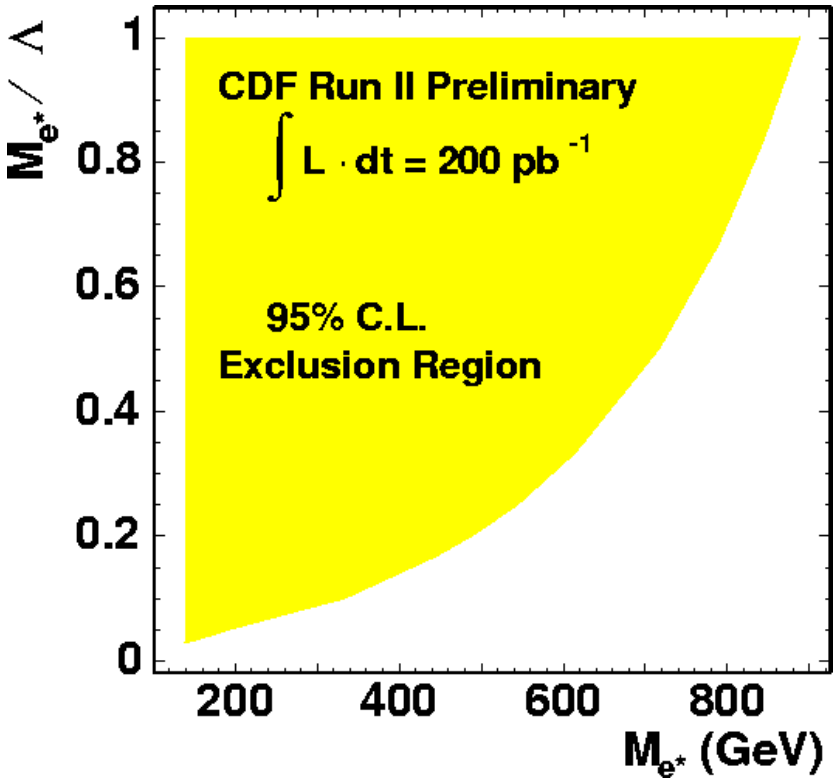
(U. Baur, Phys Rev D42, 3)

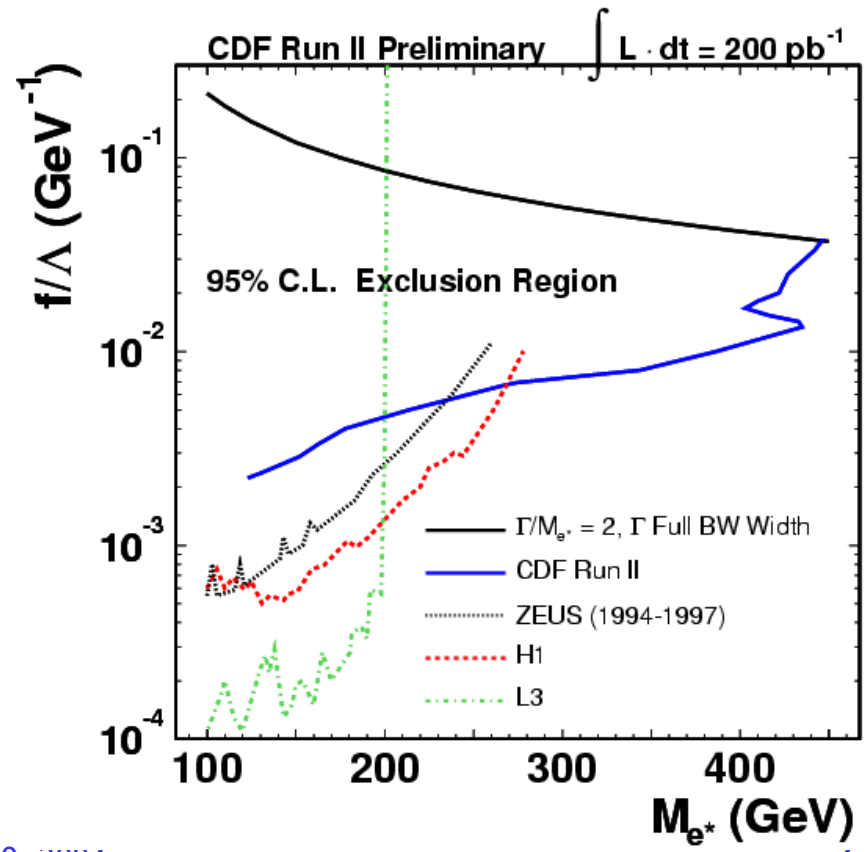


# Excited electrons: e*

Coming soon: μ*

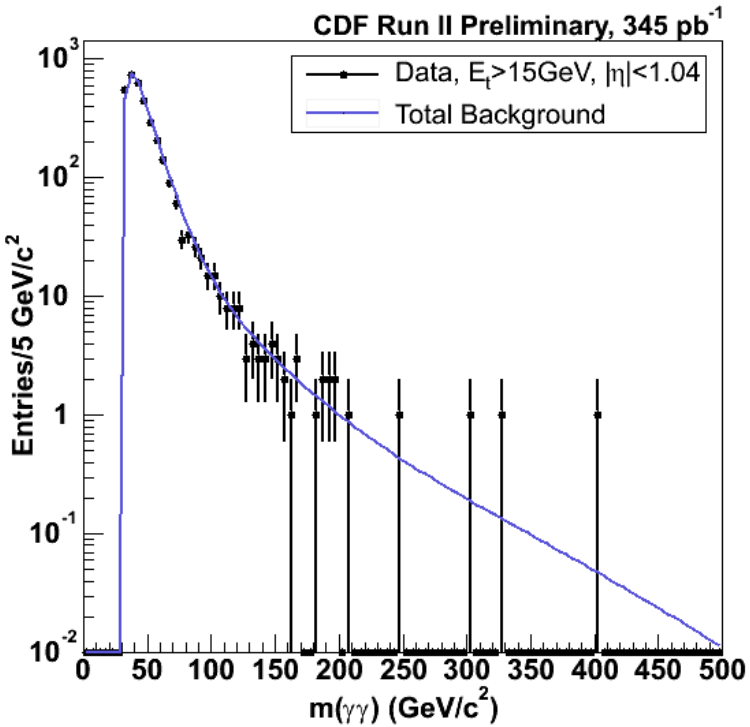
- In 200 $pb^{-1}$, expect ~3 events, see 3 events
  - Limits for contact interaction $M_{e^*}/\Lambda$ vs. $M_{e^*}$ shown at left
  - Gauge mediated result plotted as a function of $f/\Lambda$ vs. $M_{e^*}$ at right
- For $M_{e^*} = \Lambda$, $M_{e^*}$ >889 GeV/$c^2$ (contact) or >208 GeV/$c^2$ (gauge)

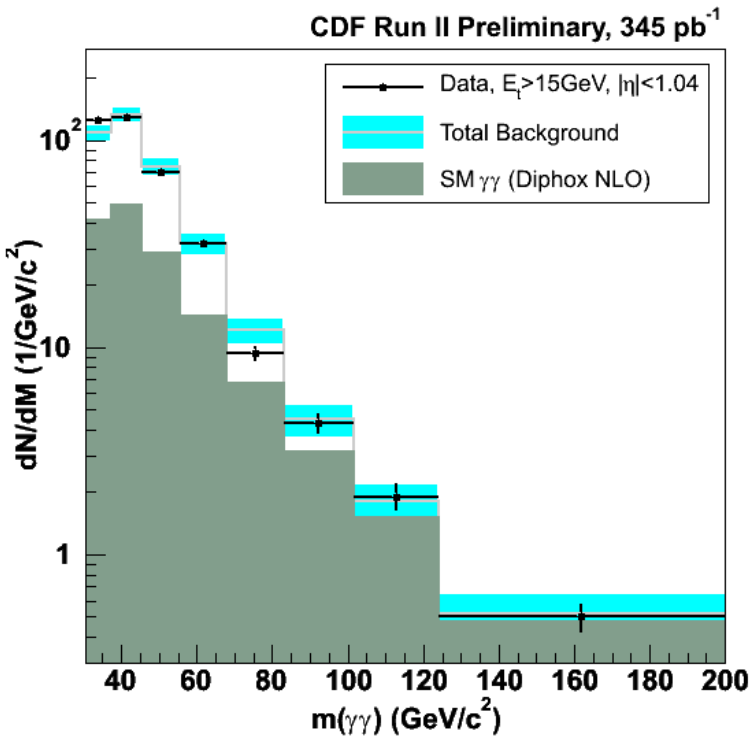


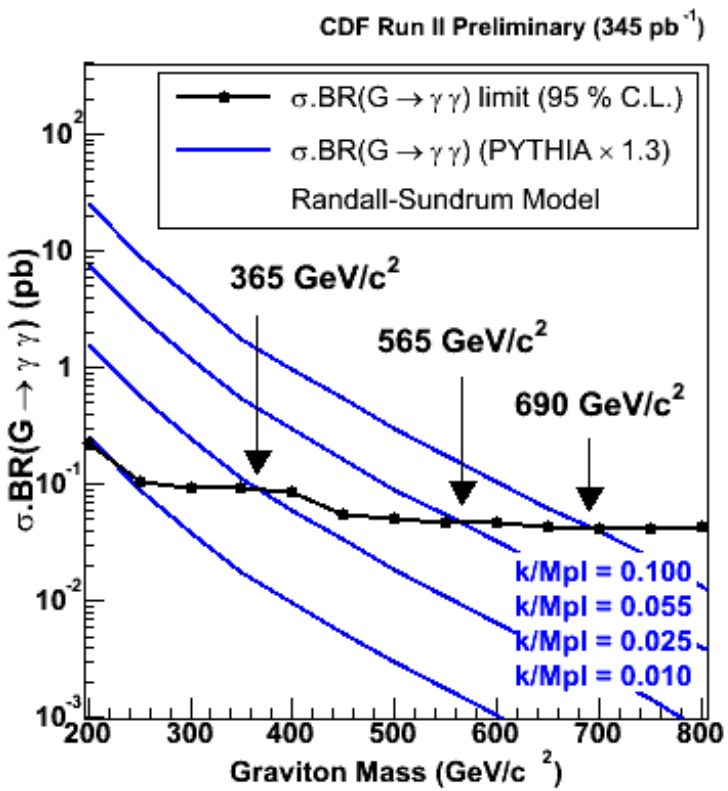
# High Mass Di-photons

- Search for high mass γγ events in 345 $pb^{-1}$ (data up to June)
- Backgrounds from
  - Standard model diphoton
  - Misidentifications: γj or jj where jet gives a hard $\pi^0$
- Highest mass event: $m(\gamma\gamma) = 405\ GeV/c^2$



# Di-photon and Large Extra Dimensions

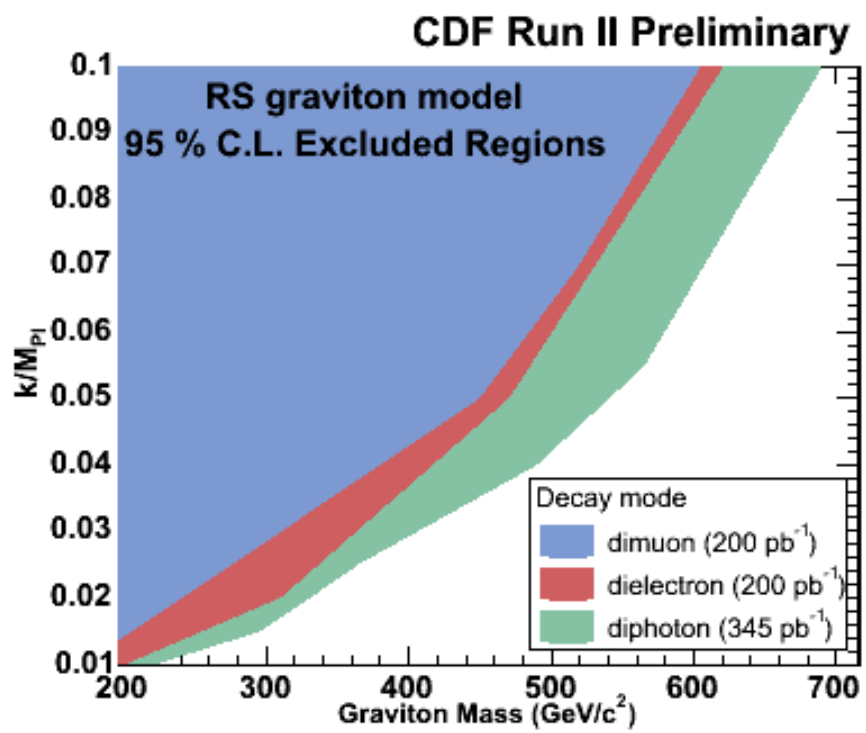



- Limit σBR(G→γγ) to < 0.05 pb

Coming soon: updates to ee, μμ, combined plots

- Combined limits of ee, μμ, γγ
- Acceptance higher at high mass…

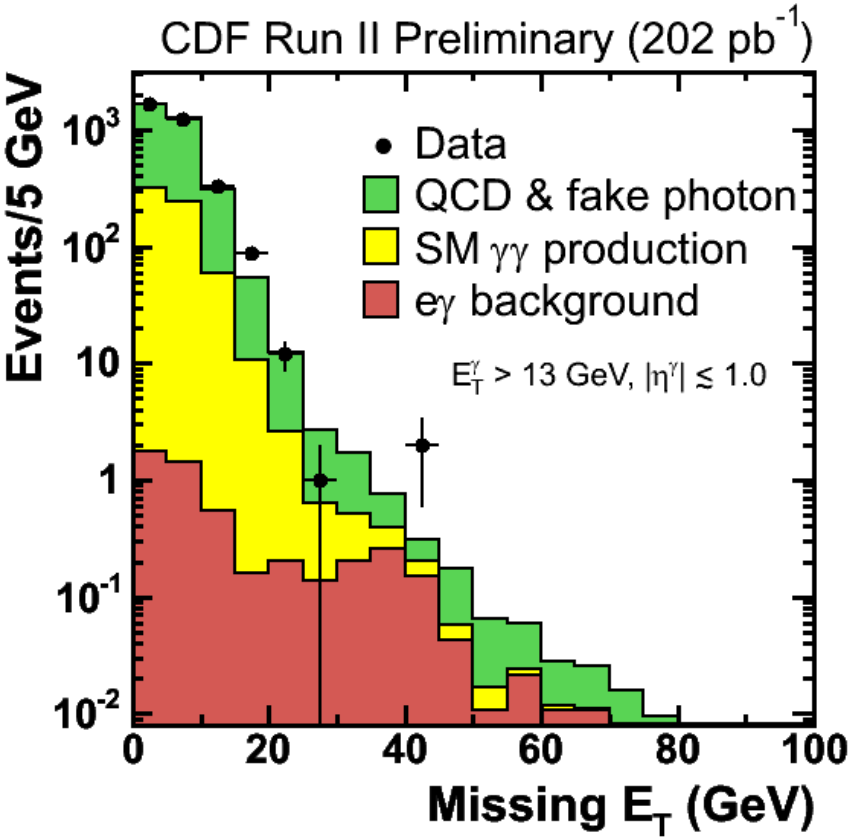
BR(G→γγ) = 2×BR(G→ee)




(L.Randall and R.Sundrum, Phys Rev Lett 83. 3370)

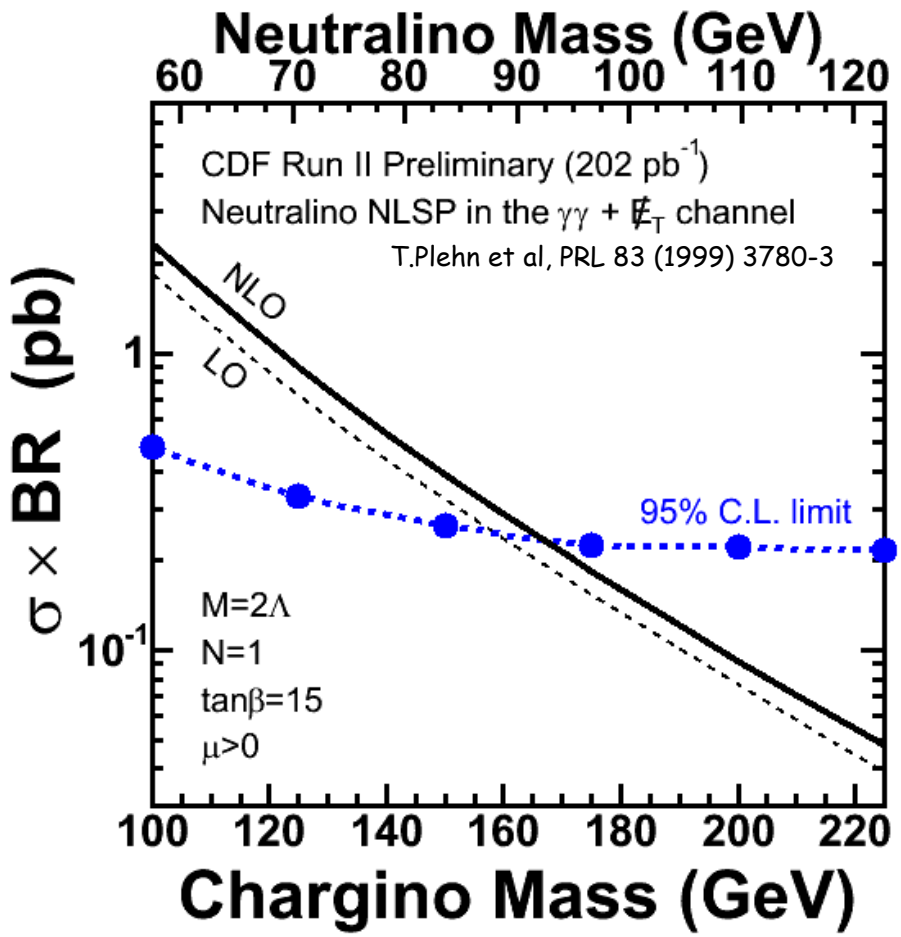
# Di-photons and Missing Energy

- Search for events with γγ + Missing Energy (MET)
  - Gauge Mediated SUSY: $N_1 \rightarrow \gamma\tilde{G}$, so $p\bar{p} \rightarrow X$ + neutralinos → γγ+MET
- Event selection
  - Two central photons, $E_T > 13$ GeV
  - Understanding MET is important
  - Best sensitivity expected at MET > 45 GeV
- Backgrounds include
  - QCD + 'fake' MET
  - e faking γ
  - Cosmic rays, beam halo



# Di-photons and GMSB

- Expect ~0.6 events and see 0 events in 202 $pb^{-1}$

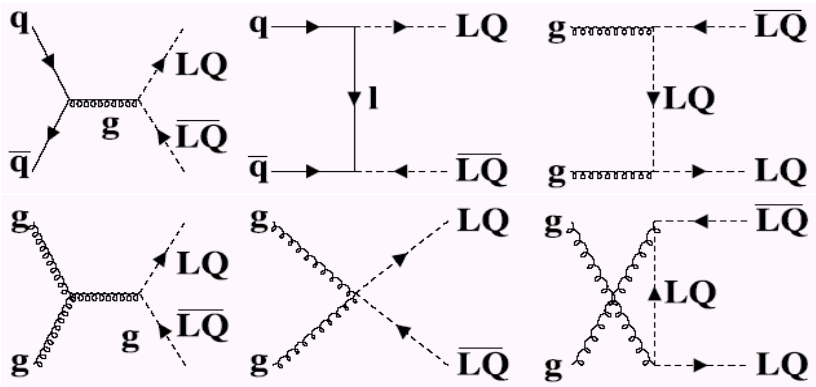



$M(C_1) > 168$ GeV/$c^2$ 95% CL
$M(N_1) > 93$ GeV/$c^2$ 95% CL

Coming soon: searches in more exclusive channels

# Leptoquarks

- Leptoquarks appear in many SM extensions including
  - SU(5), SU(4) Pati-Salam models, Technicolor, Compositeness
  - LQ carry both lepton and baryon number
- Finding leptoquarks at the TeVatron
  - Pair-produced at the TeVatron predominantly via gg fusion
  - Produce isolated high-$p_T$ leptons and 2jets
  - TeVatron signatures include $\ell\ell jj$, $\ell\nu jj$, and $\nu\nu jj$
  - Make use of kinematics of LQ events; large $\Sigma jet E_T$ and $\Sigma \ell E_T$



# Leptoquarks – 1st Generation

- Analysis cuts for eejj

  $2E_T(e) > 25$ Z removal

  $E_T(j1) > 30$ $E_T(j2) > 15$

  $\Sigma jetE_T > 85$ $\Sigma jetE_T > 85$
- Backgrounds; fakes, W/Z+2jets, top
- Expect 6.24±~3, see 4 events

- Analysis cuts for evjj

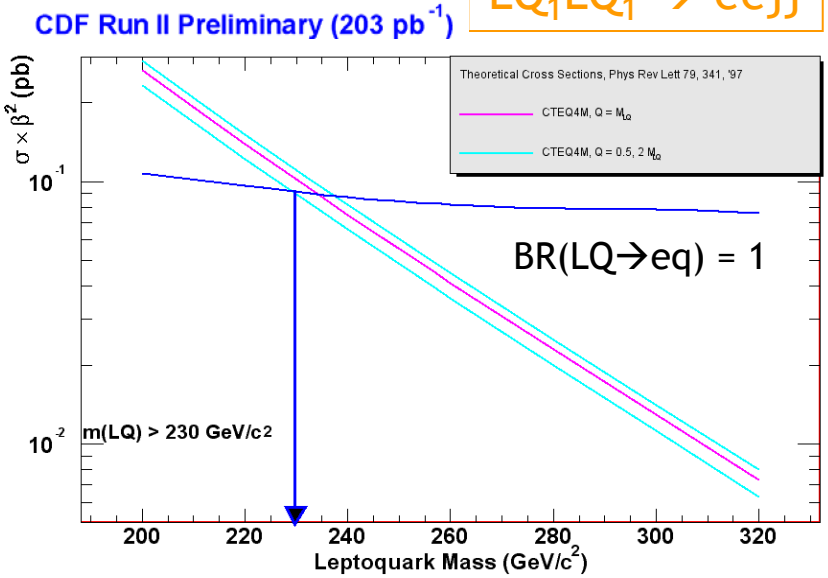
  $E_T(e) > 25$ veto second e

  MET > 60 $m_T(e,MET) > 120$

  Jet $E_T > 30$ $\Sigma jetE_T > 80$

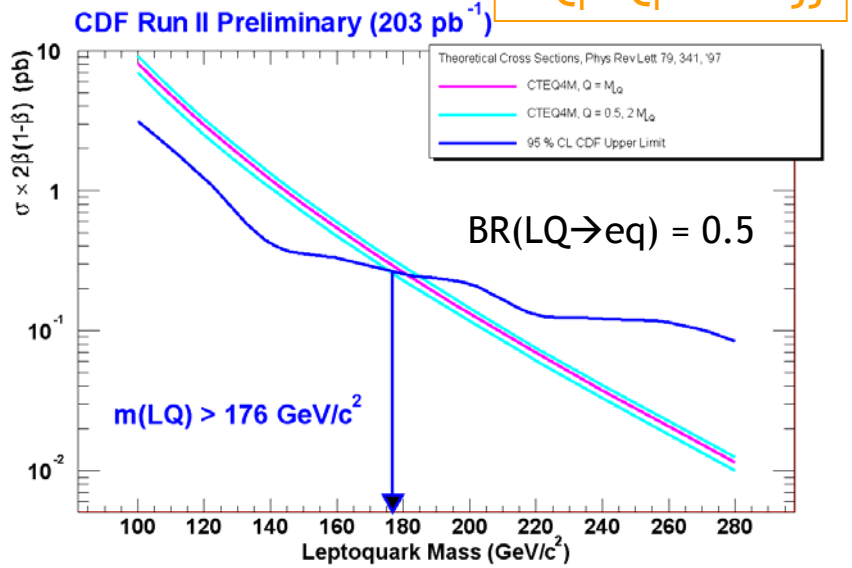
  Select $\min[m(e,jet) - m_T(MET,jet)]$
- Backgrounds; W+2jets, top
- At 180 GeV, expect 4.9±4, see 4

$LQ_1LQ_1 \rightarrow eejj$




m(LQ) > 230 GeV/c2 95% CL

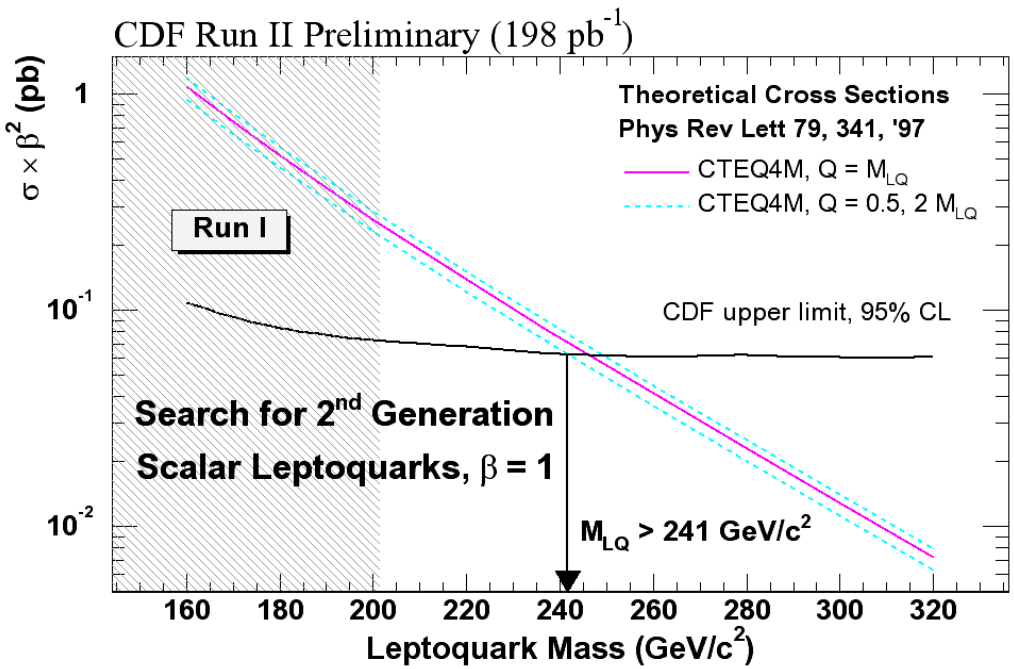
$LQ_1LQ_1 \rightarrow evjj$

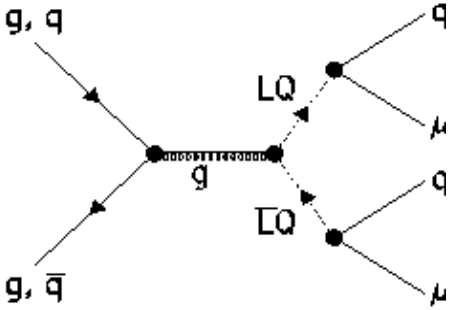



m(LQ) > 176 GeV/c2 95% CL

# Leptoquarks – 2nd Generation

- Signature investigated is μμ + 2 jets
  - Make use of tight dimuon data and muon+track
  - Backgrounds include QCD (fakes), top, and Z+2jets
- Expect 3.15 ± 1.15 events in 198 $pb^{-1}$, see 2 events
  - Limits set assuming β = BR(LQ→μq) = 1



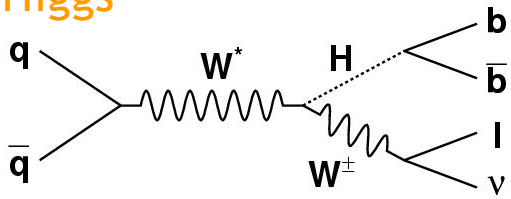

$M(LQ_2) > 241 GeV/c^2$
95% CL

Coming soon: finish 2nd generation, begin 3rd

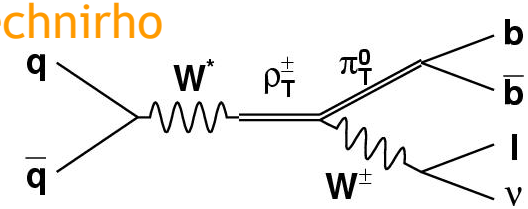
# Technicolor

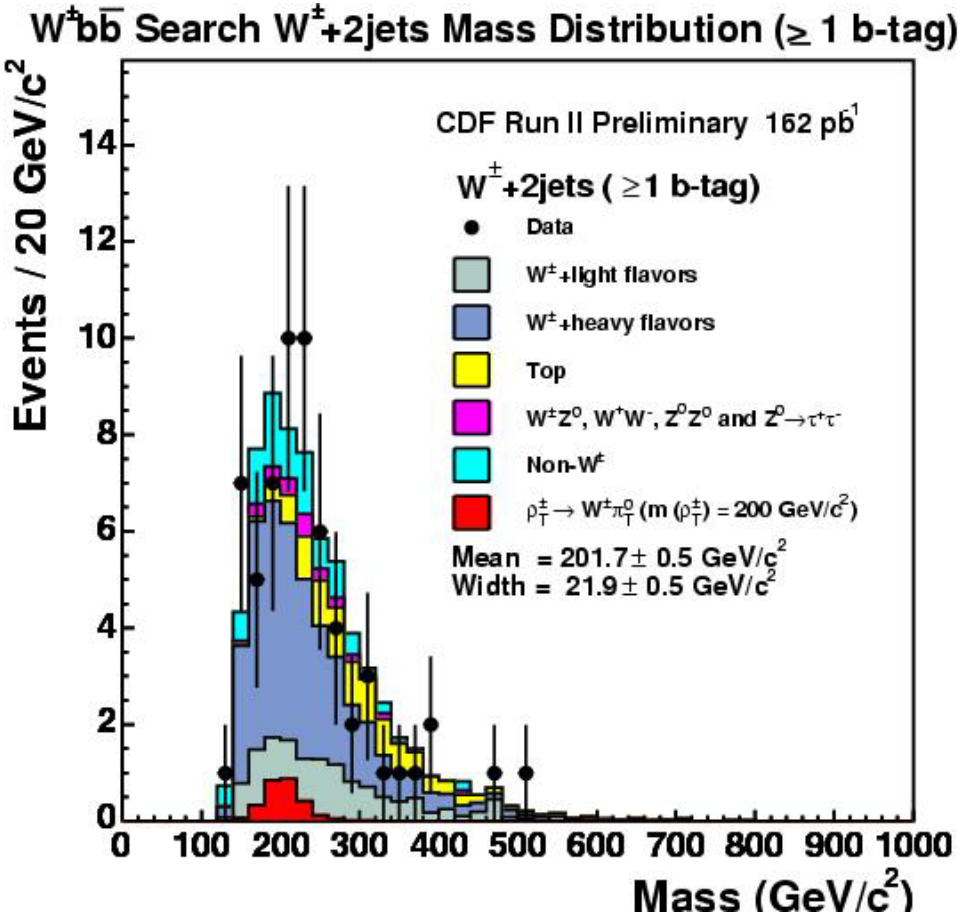
- Can search for Technicolor in many signatures
  - New search explores same signature as SM Higgs (lvbb)
  - Looks for techni-pi coupling to bb

SM Higgs



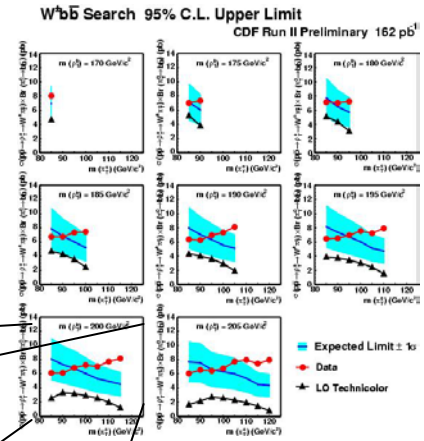

Technirho

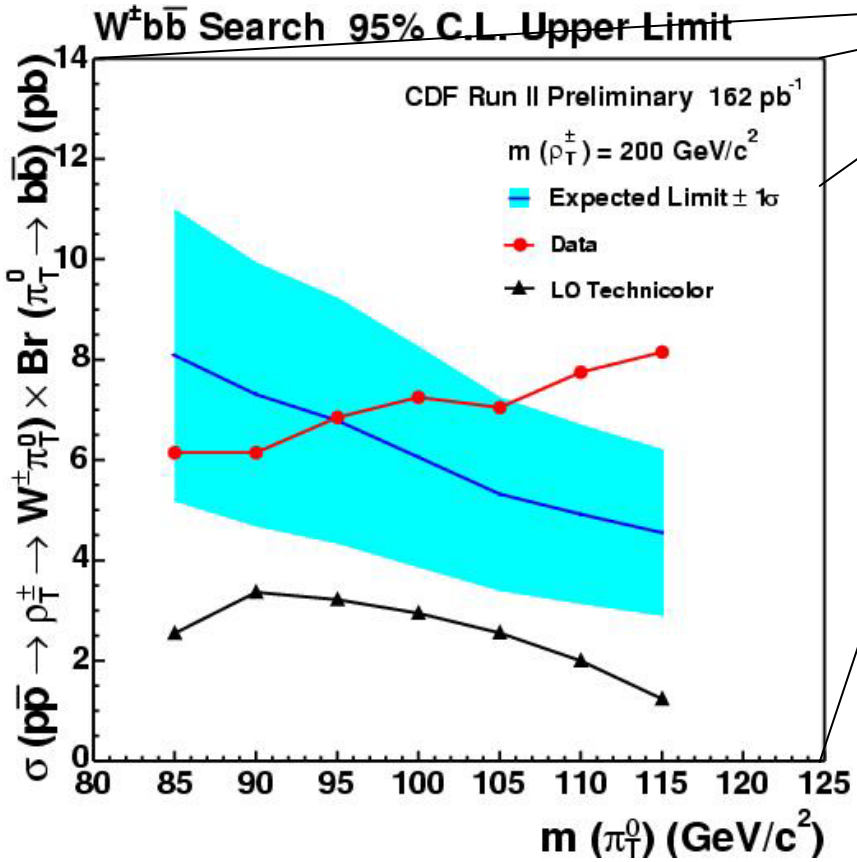


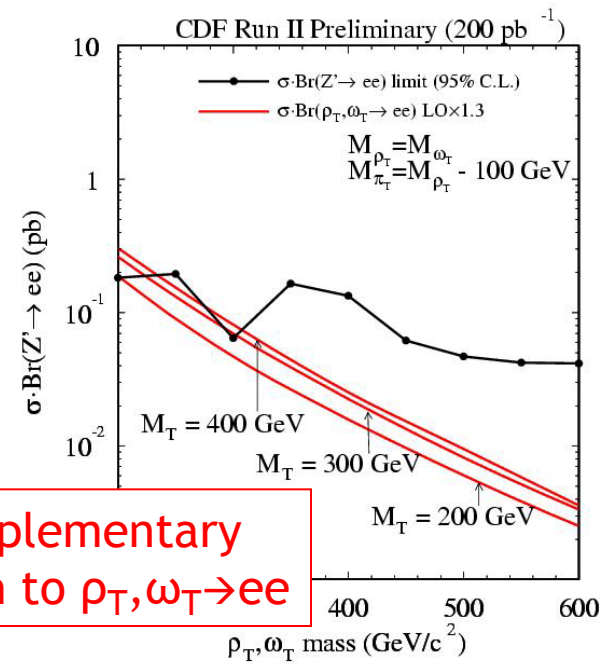



# Technicolor

- Results depend on $m(\rho_T)$ and $m(\pi_T)$
- Close to production $\sigma \times BR$



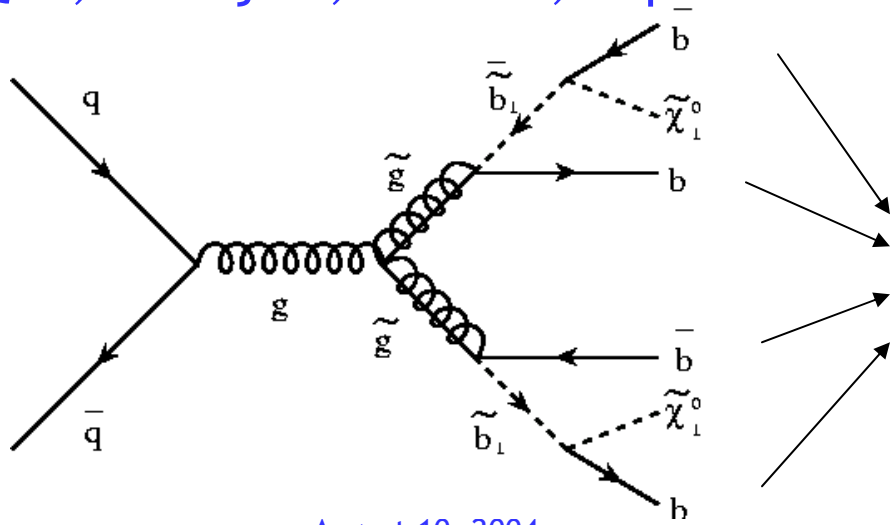




Complementary search to $\rho_T, \omega_T \rightarrow ee$

# Gluino → sbottom bottom

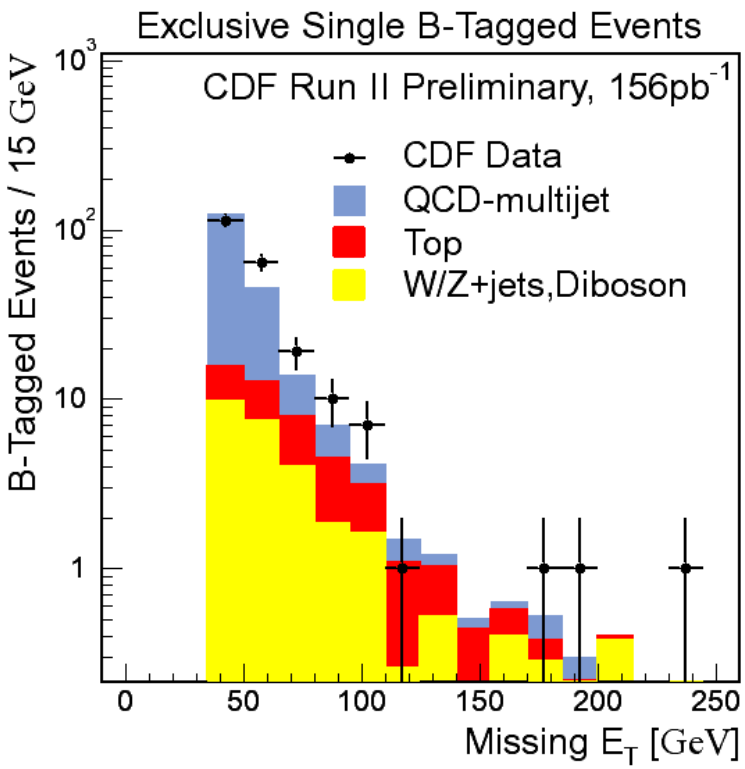
- Large production σ at the TeVatron, sbottom may be light
  - Assume BR($\tilde{b}_1 \rightarrow b\tilde{X}_1^0$) = 100%, R-parity conserved
  - Assume $m(\tilde{g}) > m(\tilde{b}_1) > m(\tilde{X}_1^0)$, $m(t) + m(\tilde{X}_1^+) > m(\tilde{b}_1)$
- Exploit b tagging and kinematics of events
  - 3 jets > 15 GeV, $|\eta| < 2$
  - MET > 35 GeV
  - $\Delta\varphi$(MET,jets) > 40°
  - b-jet secondary vertex tag
- Backgrounds: QCD, W/Z+jets, Diboson, Top

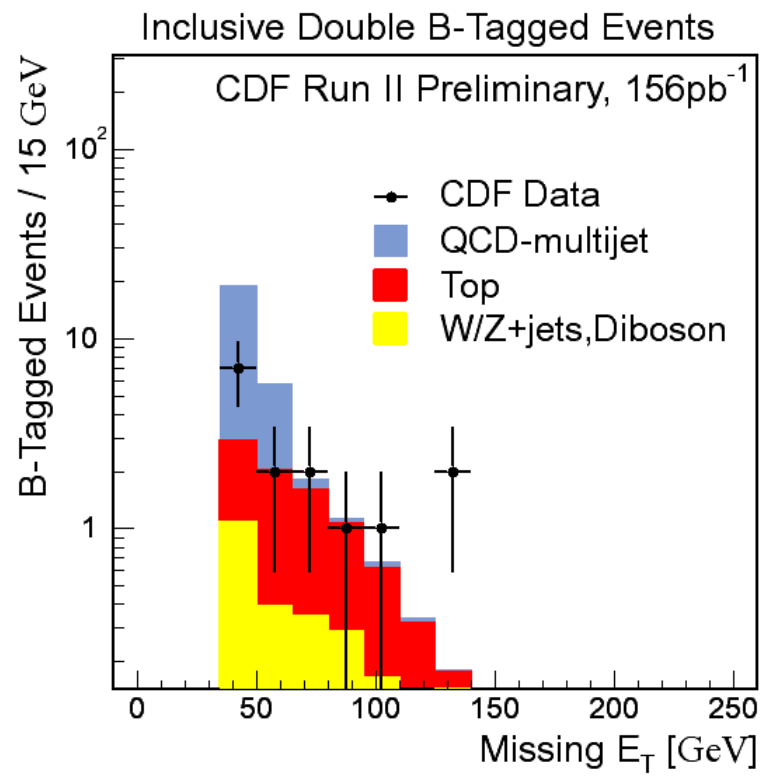



4 b-jets + MET

# Gluino → sbottom bottom

- Single and double b-tagged events in 156 $pb^{-1}$ of data




Expect 16.4 ± 3.7
Observe 21

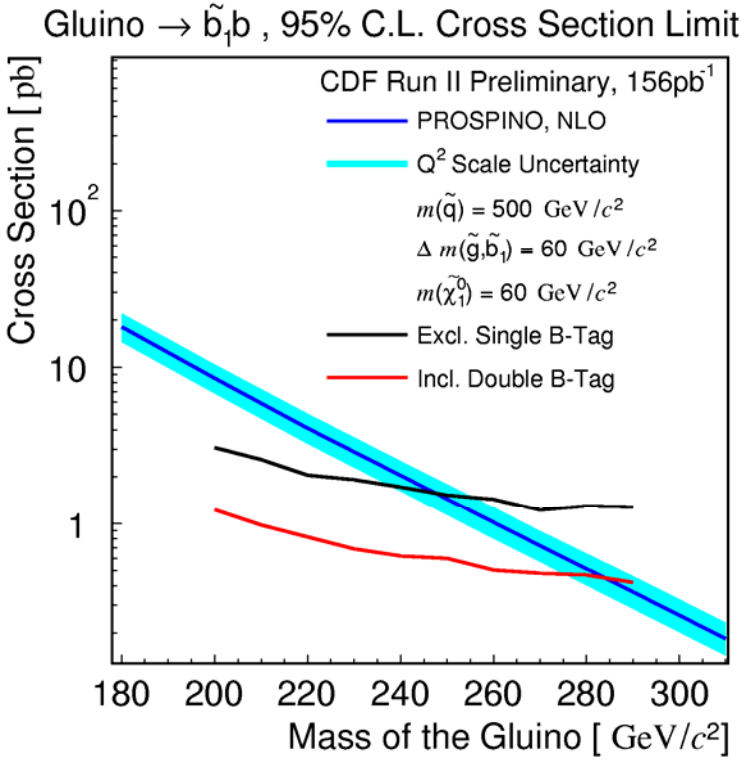
Expect 2.6 ± 0.7
Observe 4

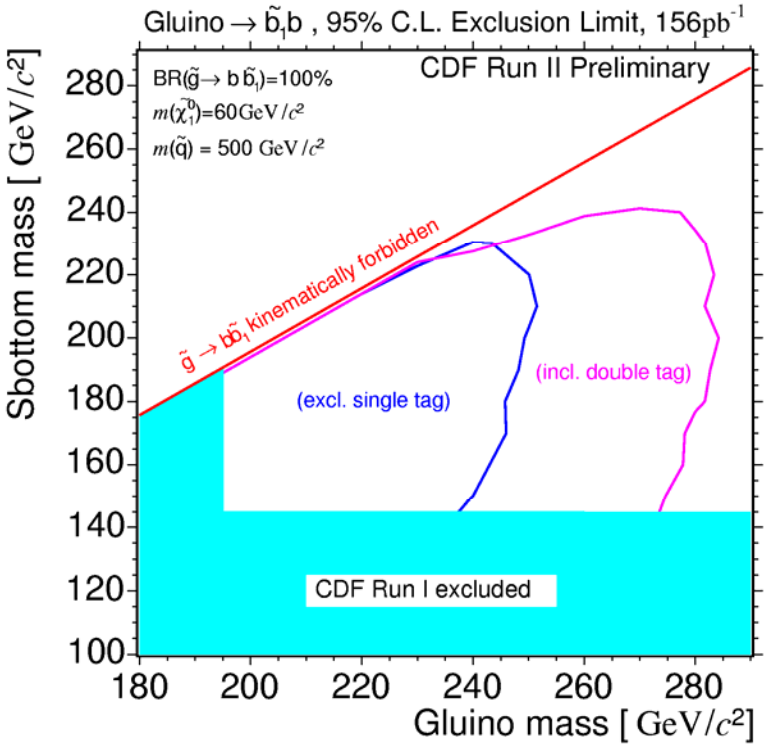
Perform counting experiment…

# Gluino → sbottom bottom

- For ΔM(gluino, sbottom) = 60 GeV/$c^2$…
  - Exclude 20.6 single tag events at 95% CL
  - Exclude 8.7 double tag events at 95% CL

Many SUSY analyses in progress!

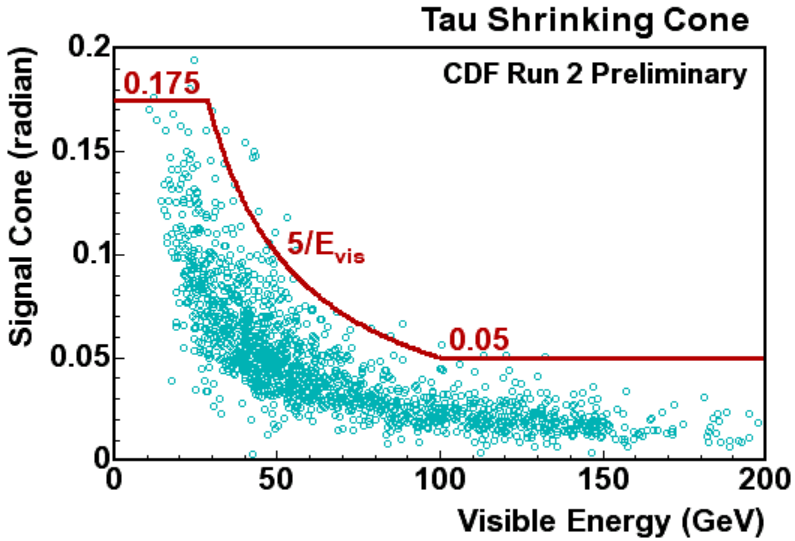


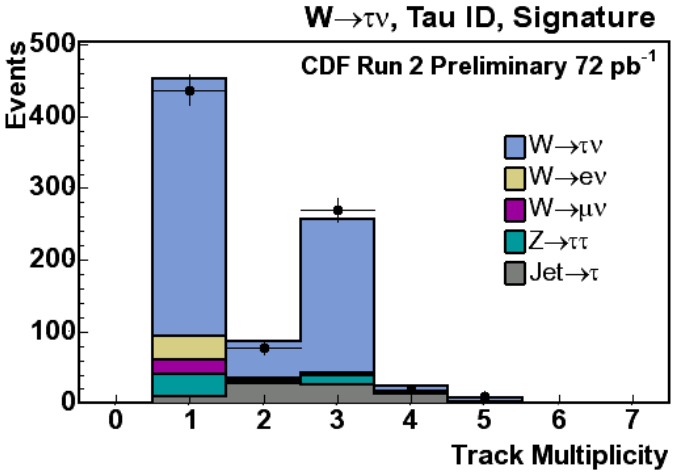



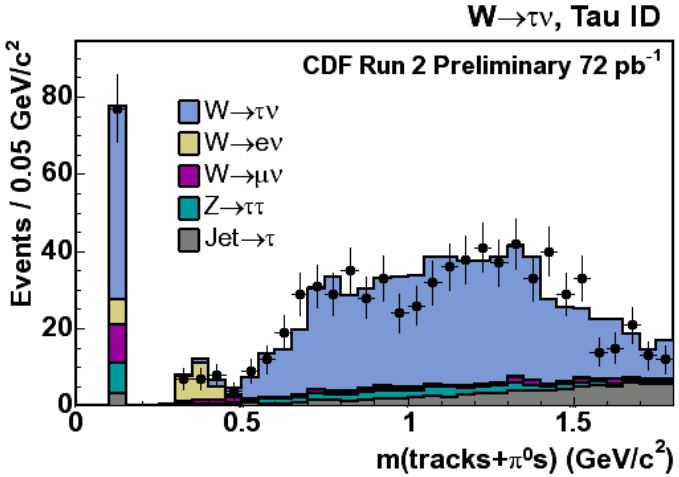

Large exclusion region added in sbottom-gluino plane

# High-mass Drell Yan: Z′ → ττ

- Tau channels important for searches
  - For high tanß SUSY
  - other physics w/ enhanced couplings to 3rd generation
- Tau finding algorithm much improved and tuned
  - Shrinking cone implemented
  - $\pi^0$ reconstruction much improved



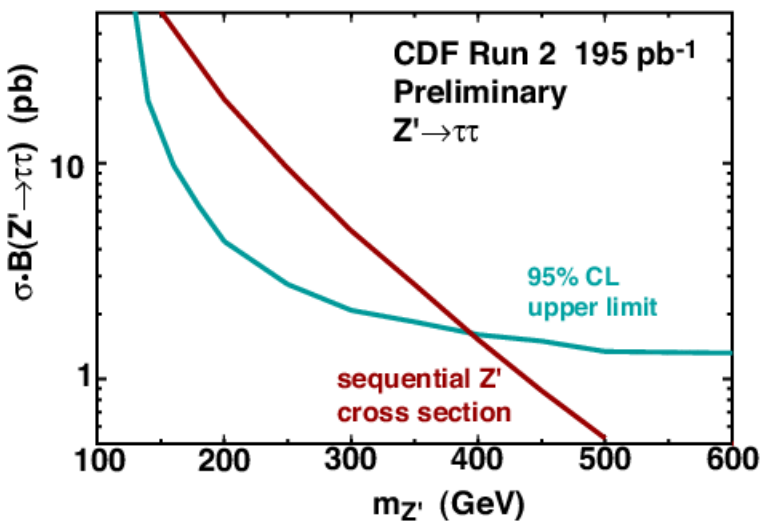



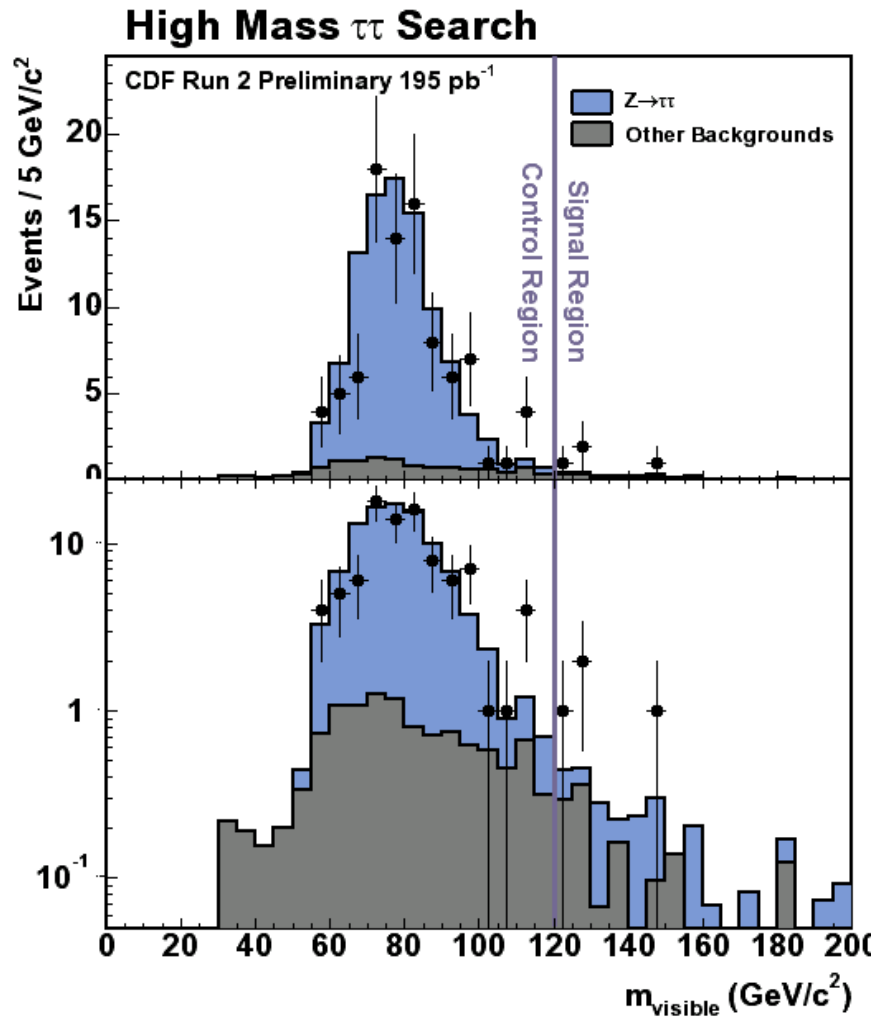




Checks with W→τν look good!

# High-mass Drell Yan: Z´ → ττ

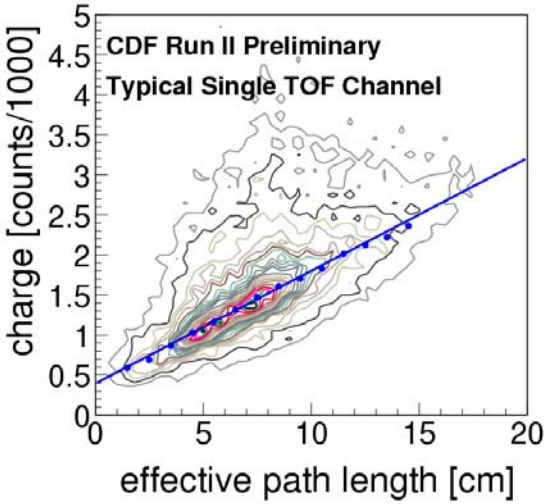
- Look in high mass region for new physics
  - M(MET,τ,τ) > 120 GeV
  - MET > 15 GeV
  - $|\Delta\varphi(\text{MET}, \tau_l)| > 30°$
  - 'counting experiment'
- Expect 2.83±0.39 events, see 4
  - Exclude Z´<394 GeV/$c^2$ 95% CL (Z´ with SM couplings)

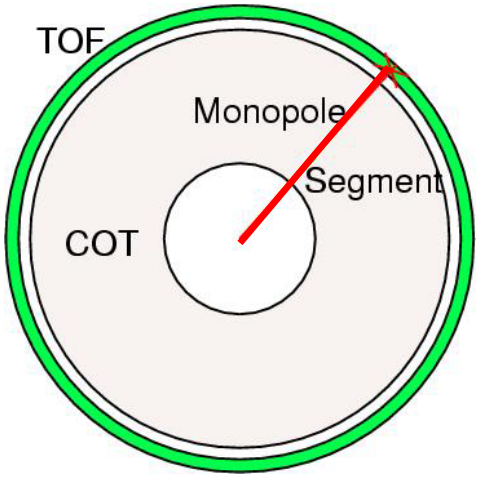


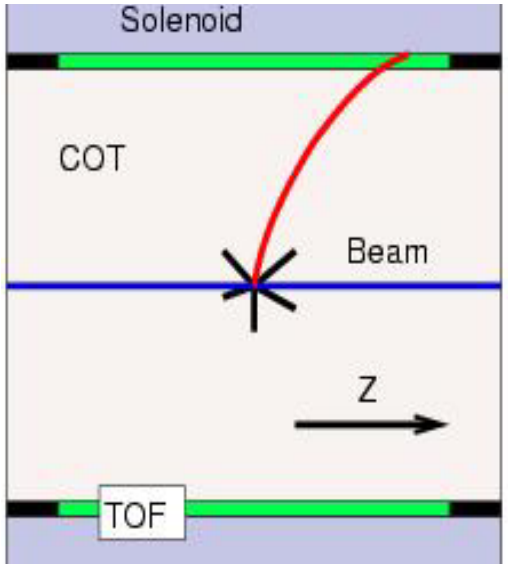



# Dirac Monopoles

- Truly "Exotic" signature
  - Large pulses in Time of Flight (TOF)…
    ~500 MIPs!
  - Large ionization in drift chamber (COT)
  - No curvature in r-phi
  - Curvature in r-z (not cut on in this analysis)
- Developed a dedicated Monopole trigger
  - TOF-based
  - Trigger threshold >30 MIPs
  - Extensive study of de/dx,
    TOF response
- Custom track fitting



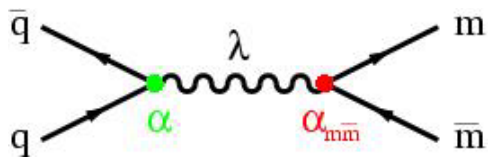



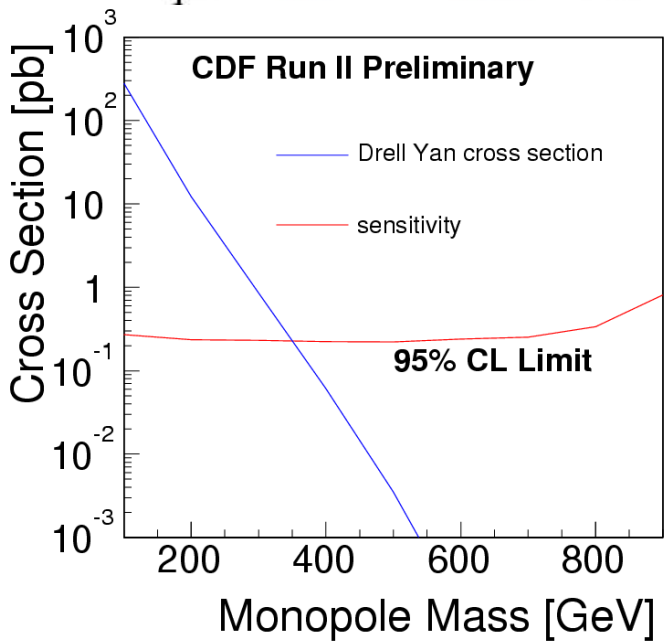



# Monopole Search Results

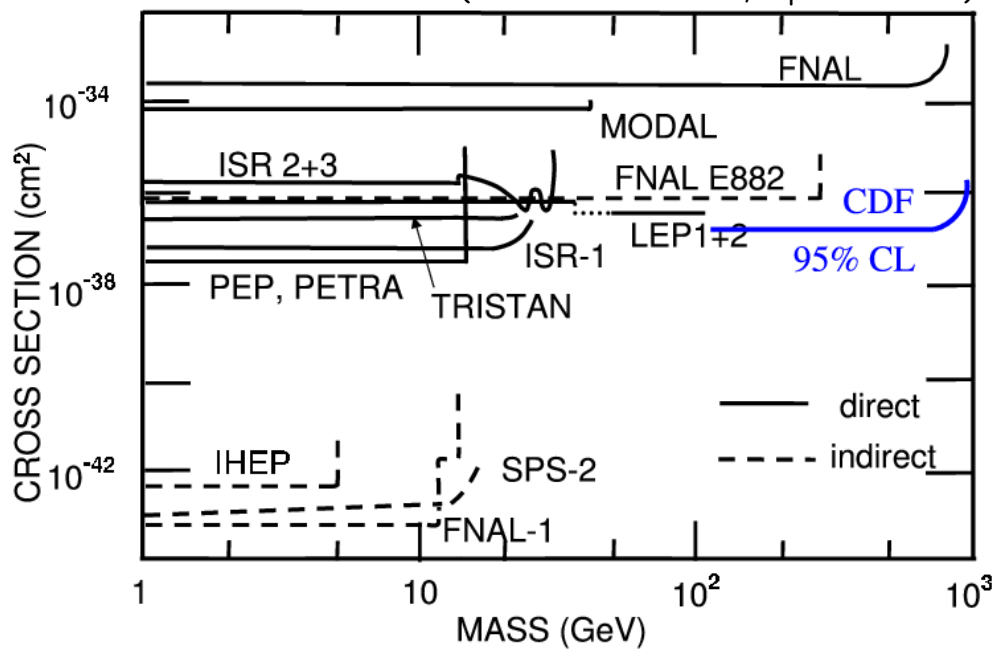
- Drell-Yan like cross section

0 monopole candidate events found




(Giacomelli and Patrizii, hep-ex/0302011)




Other cool stuff in progress…
CHAMPS; quasi-stable stop, stau

# Conclusions

The TeVatron is running smoothly, lets make the most of it!

- Supersymmetry
  - Gluino → sbottom bottom
  - GMSB diphotons
- High mass diphotons
  - Randall-Sundrum Gravitons in $\gamma\gamma$
- Leptoquarks
  - LQ decays to evjj, eejj, $\mu\mu$jj
- Compositeness
  - $e^* \rightarrow e\gamma$
- High mass Drell Yan
  - $Z' \rightarrow \tau\tau$
- Technicolor
  - Techni-$\rho$, techni-$\pi$
- Even cooler stuff
  - Dirac Monopoles

Many more analyses in progress…
Stay Tuned!