New Physics Results from DØ

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for the DØ collaboration

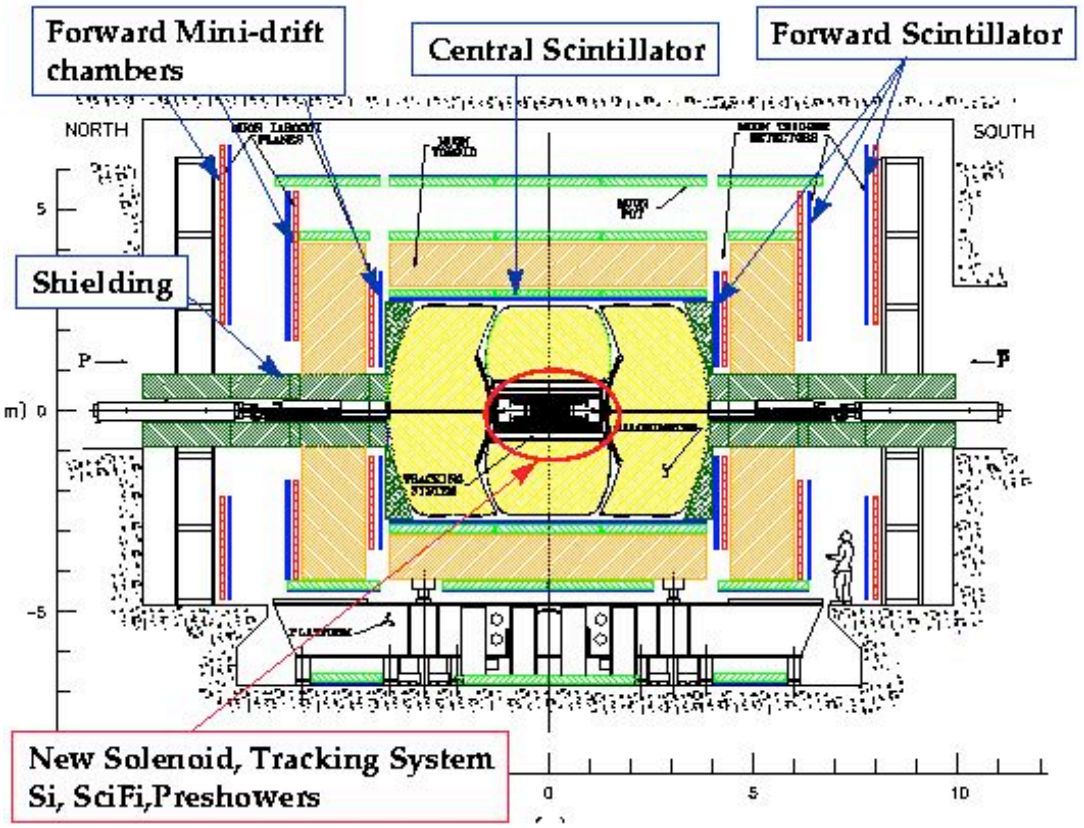
8/8/03
Fermilab Wine & Cheese Seminar

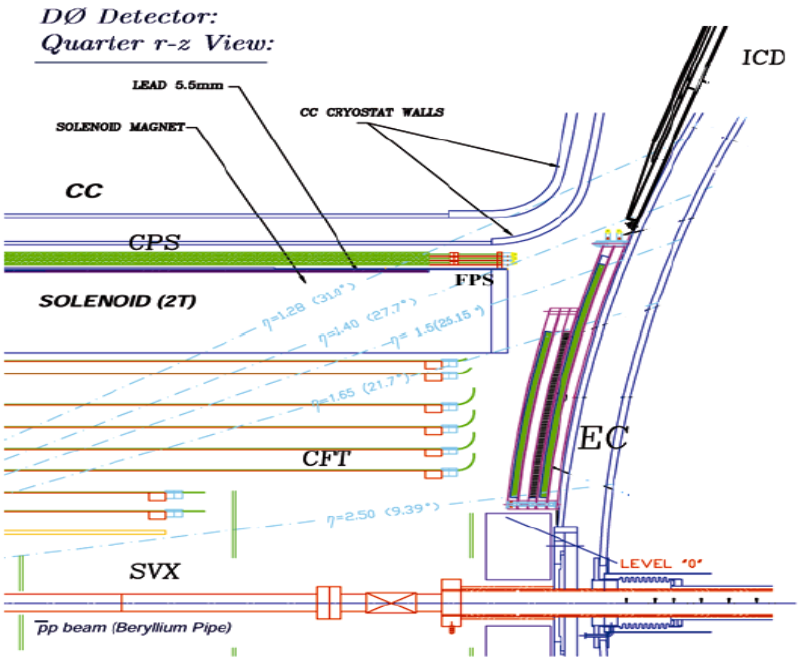
DØ at the Tevatron

multipurpose collider detector:

Tracking

- silicon vertex detector
- fiber tracker
- 2T magnetic field





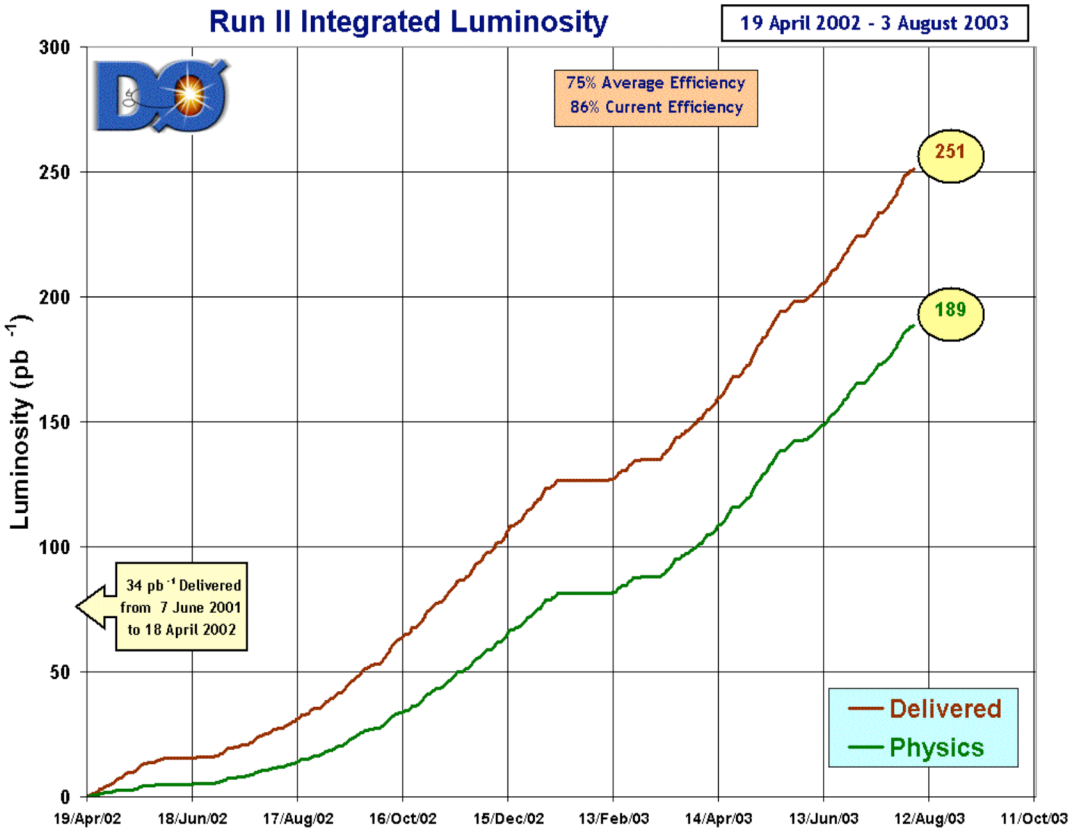
Calorimetry

- preshowers
- U/LAr calorimeters

Muon

- drift tubes and scintillator

Run II So Far



New c.o.m energy: 2 TeV

Tevatron delivered: $> 250\ pb^{-1}$

recorded with full detector:

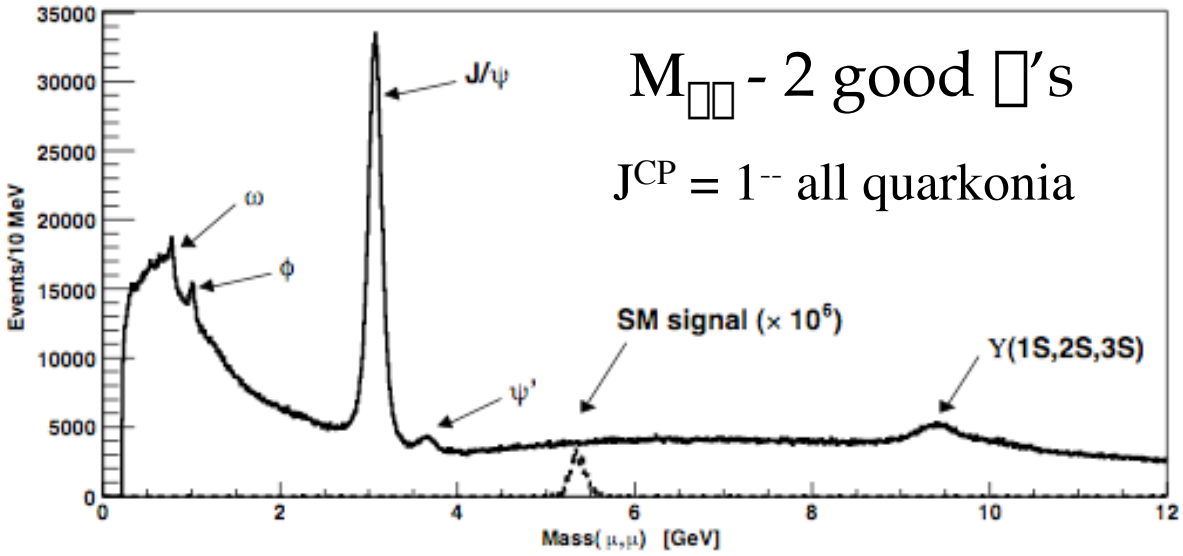
$> 190\ pb^{-1}$

$135\ pb^{-1}$ used in current analyses

- **exceeded Run I $\mathcal{L}$**
  - **large fraction analyzed**
  - **some analyses more sensitive than Run I**

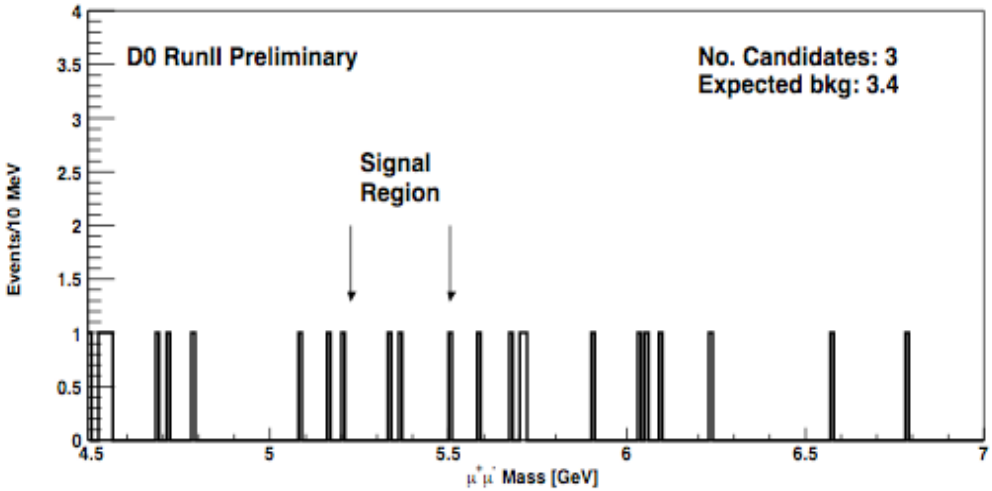
current operating efficiency: ~90%

b Physics

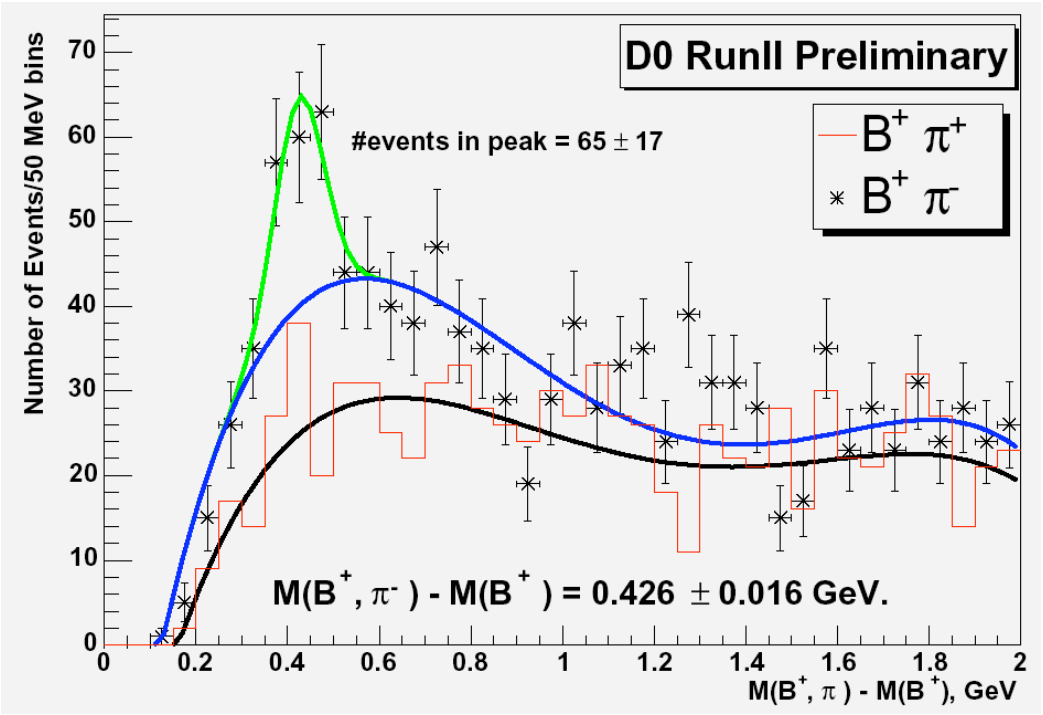


$BR(B_s \to \mu^+\mu^-)$

- only at Tevatron
- SM predicts 3.7×10^{-9}, but
- light Higgs models BR up to 10^{-6}
- can probe SUSY at high tan(□)



- data sample: 100 pb^{-1}
- in signal region after all cuts
  - –no peak
  - –3 candidates, 3.42 ± 0.79 evt BKG
- BR limit **1.6×10^{-6} @ 90% c.l.**
  - < 2.0 x 10-6 @ 90% c.l. (PDG)



Mass Reconstruction

$B_d^{**} \to B^+ \pi^-$

- fully reconstructible decays
- 114 pb^{-1}

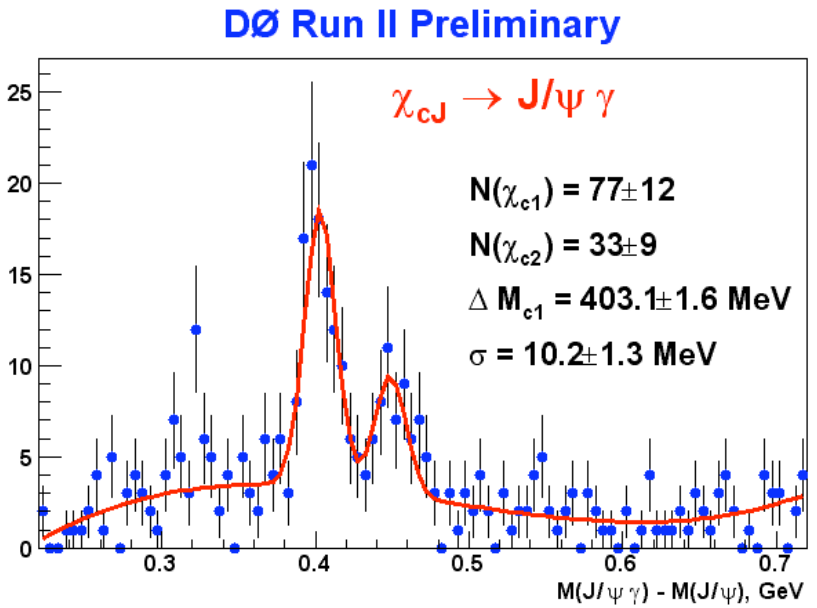
5.71 ± 0.016 GeV

PDG: 5.698 ± 0.008 GeV

- **1st observation at Tevatron**

$\chi_c \to J/\psi \gamma$

- **theo. production not understood**
- **can resolve two mass peaks**
  - χ_{c1} and χ_{c2}
  - **given spins, don't expect equal production**
- **$N\chi_{c1}$ = 77 ± 12 evts; $N\chi_{c2}$ = 33 ± 9 evts**

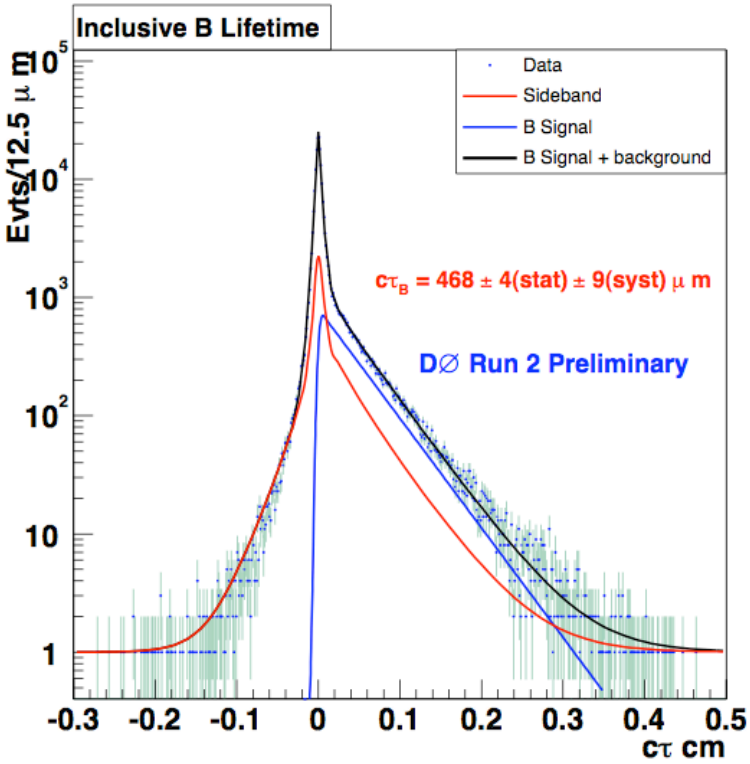


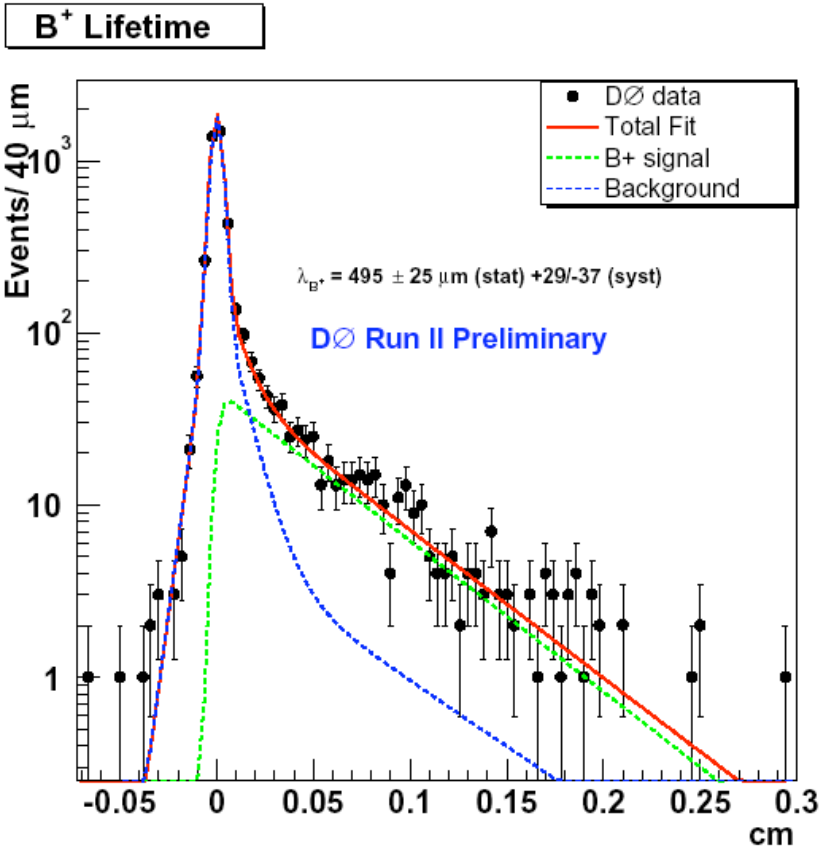
Lifetime Measurements

- Inclusive $B \to J/\psi + X$ lifetime
  - 300k J/ψ's 114 pb^{-1}

1.562 ± 0.013 (stat.) ± 0.045 (sys.) ps

  - 1.564 ± 0.014 (PDG)



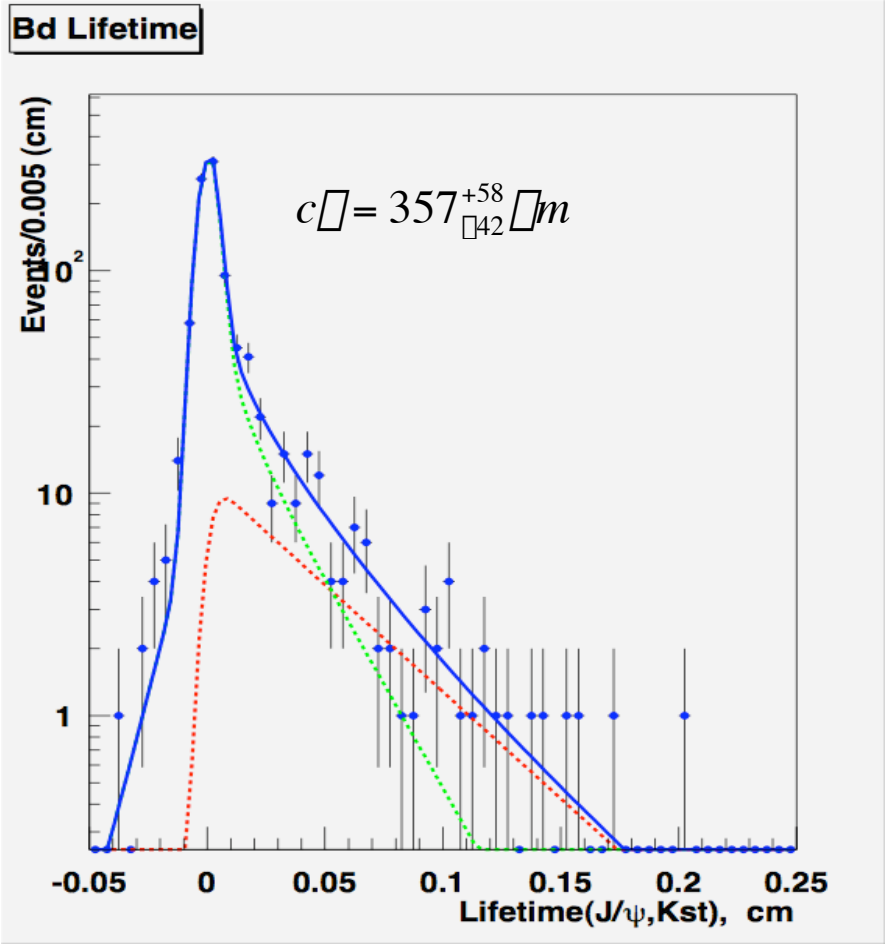


Charged B lifetime, $B^+ \to J/\psi + K^+$

mass: 5.272 ± 0.005 GeV

$$1.65 \pm 0.08(stat.)^{+0.10}_{-0.12}(sys.)\ \text{ps}$$

1.671 ± 0.018 ps (PDG)



- $B_d \to J/\psi K^*$ **lifetime**
  - **105 ± 19 B_d events**
  - **$\tau = 1.51^{+0.19}_{-0.17}$ ps**

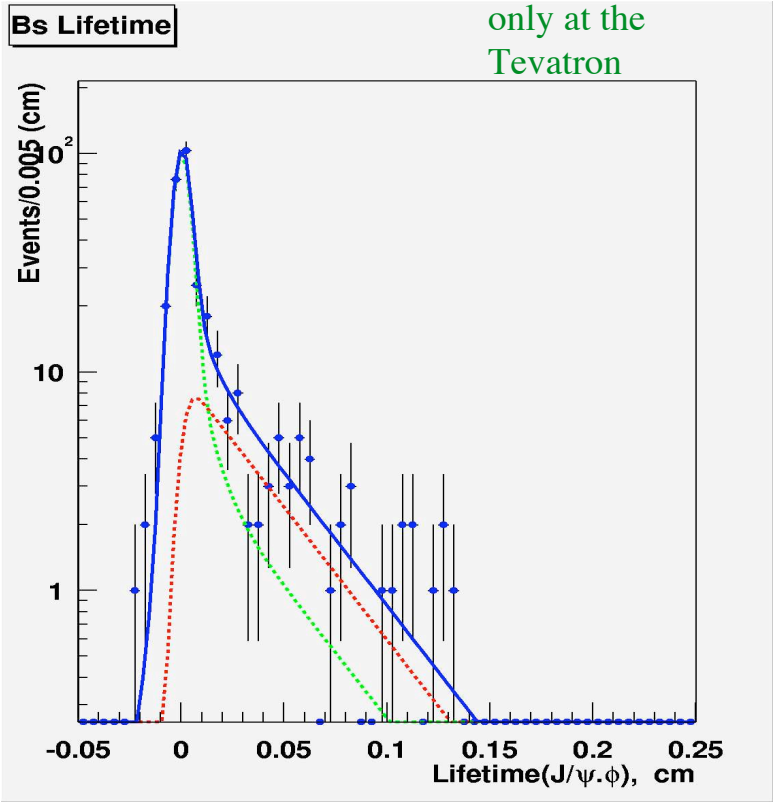
$B_s \to J/\psi \phi$ lifetime

114 pb^{-1}

69 ± 14 B_s events

$\tau = 1.19^{+0.19}_{-0.14}$ ps

only at the Tevatron

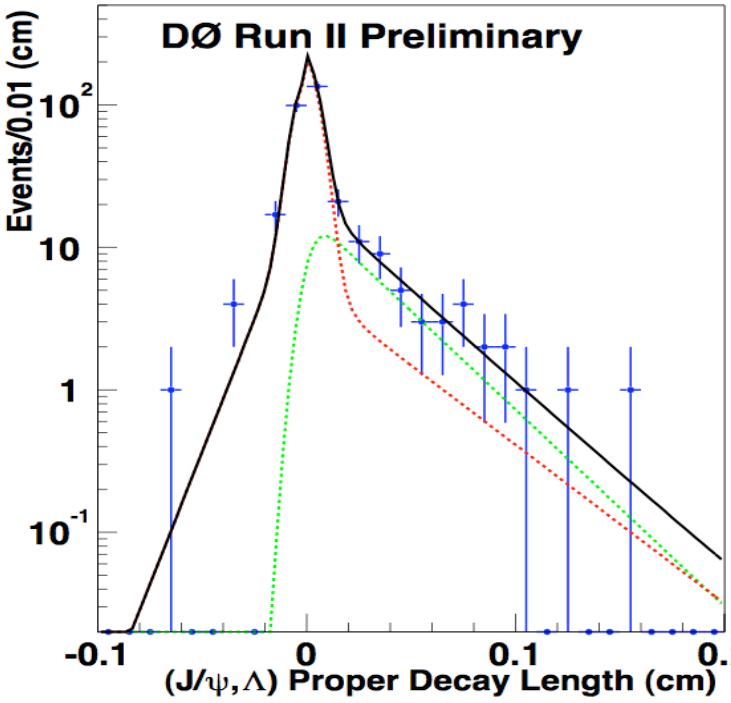


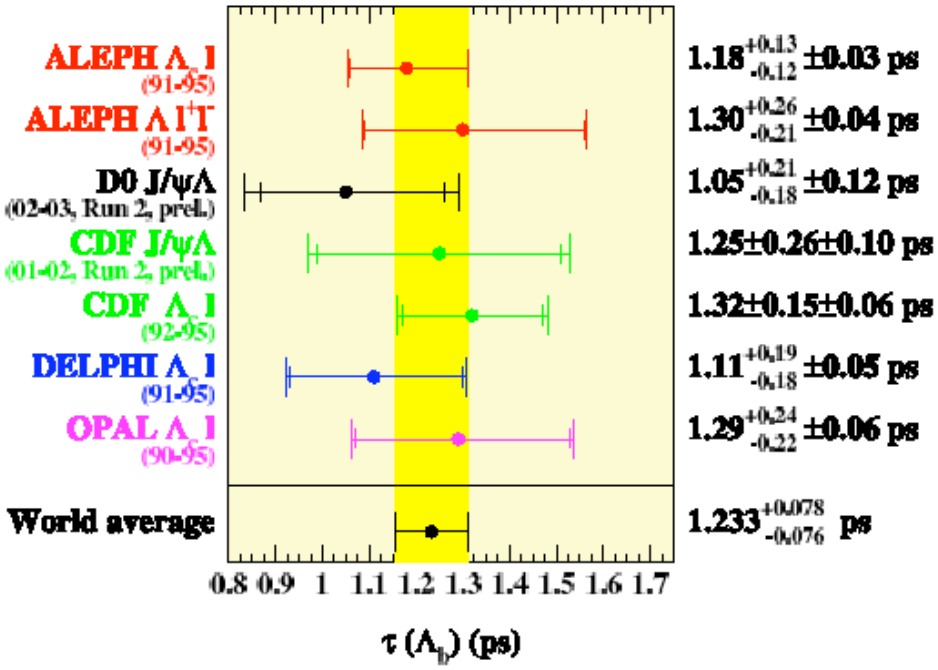
- Λ_b->J/ψ Λ 114 pb^{-1}

only at the Tevatron

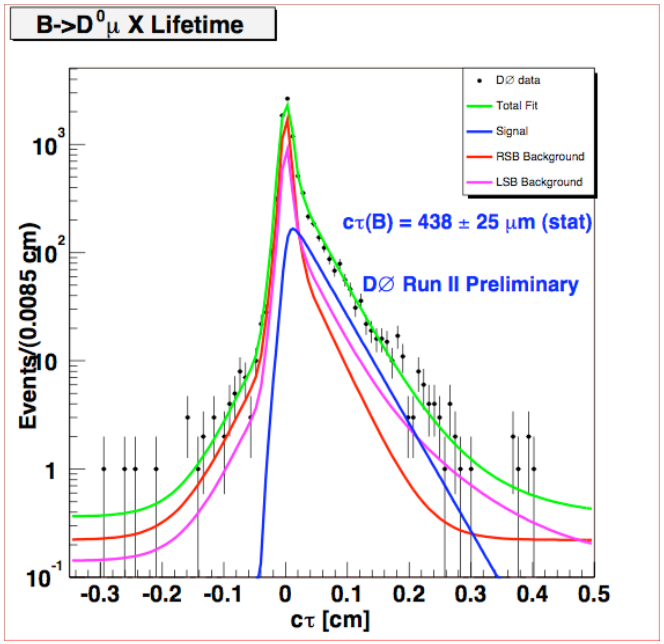
$$M_{\Lambda_b} = 5600 \pm 25 \text{MeV}$$

$$\tau = 1.05^{+0.21}_{-0.18}(stat.) \pm 0.12(sys.)\ \text{ps}$$



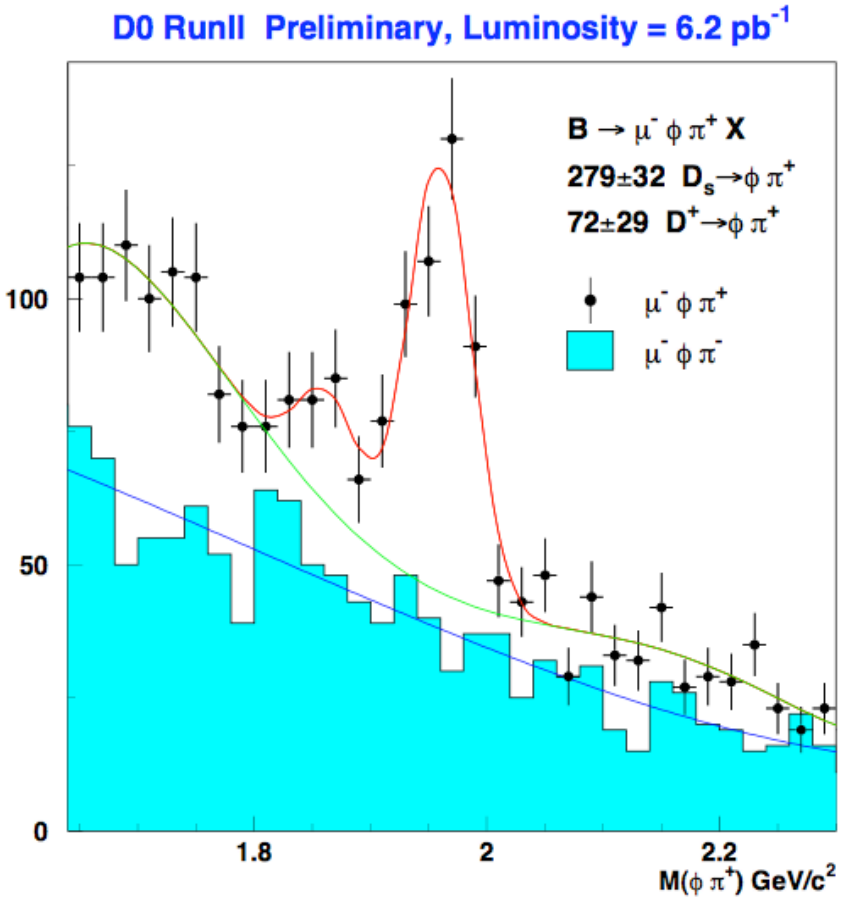


- B->D^{0}lΛ lifetime 12 pb^{-1}
  - develop techniques to efficiently select B semileptonic decays
    - aids B_s -> D_s lΛ measurement

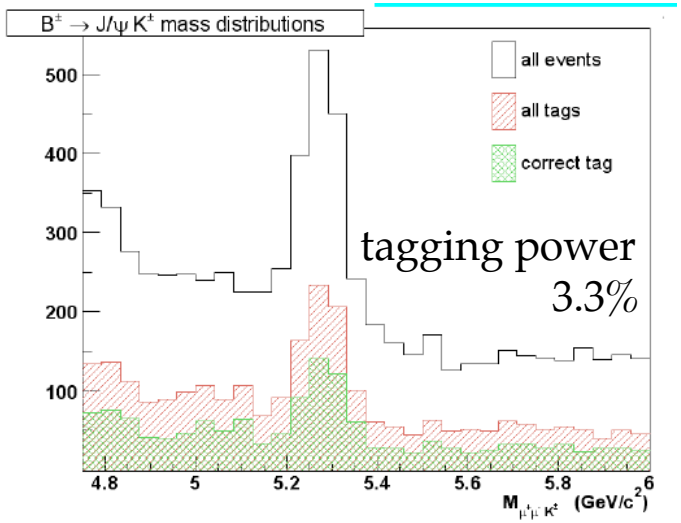


Towards a Measurement of B_s Mixing

- B_s->D_s l

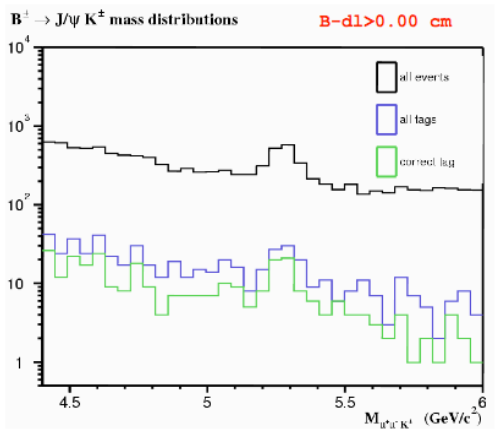


- Tagging results
  - opposite side jet charge tagging:

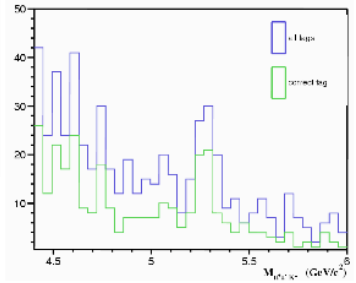


tagging power 3.3%

  - opposite side soft muon tagging:



tagging power 1.6%

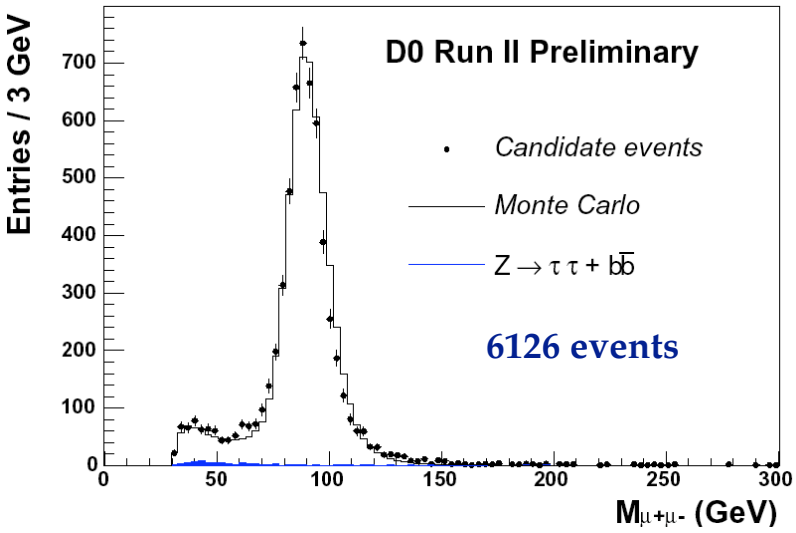


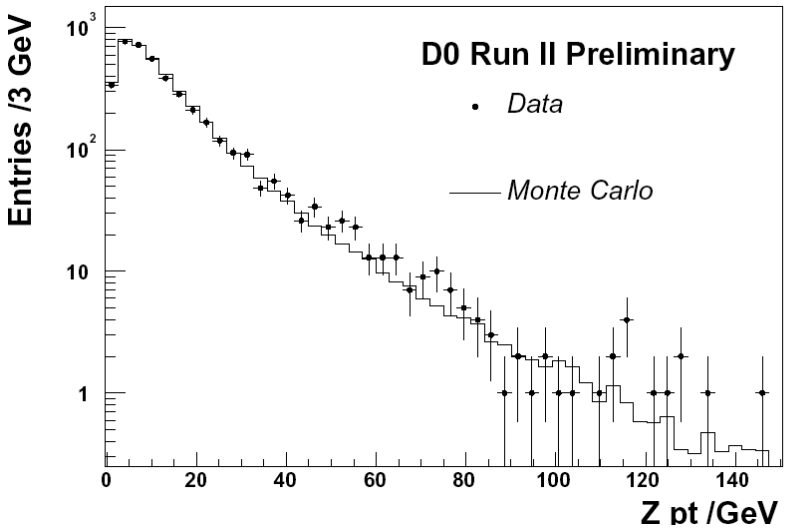
Soft Muon Tagging: Results for LP'03 – christos@fnal.gov

W and Z Cross Sections

- Z->□□ cross section

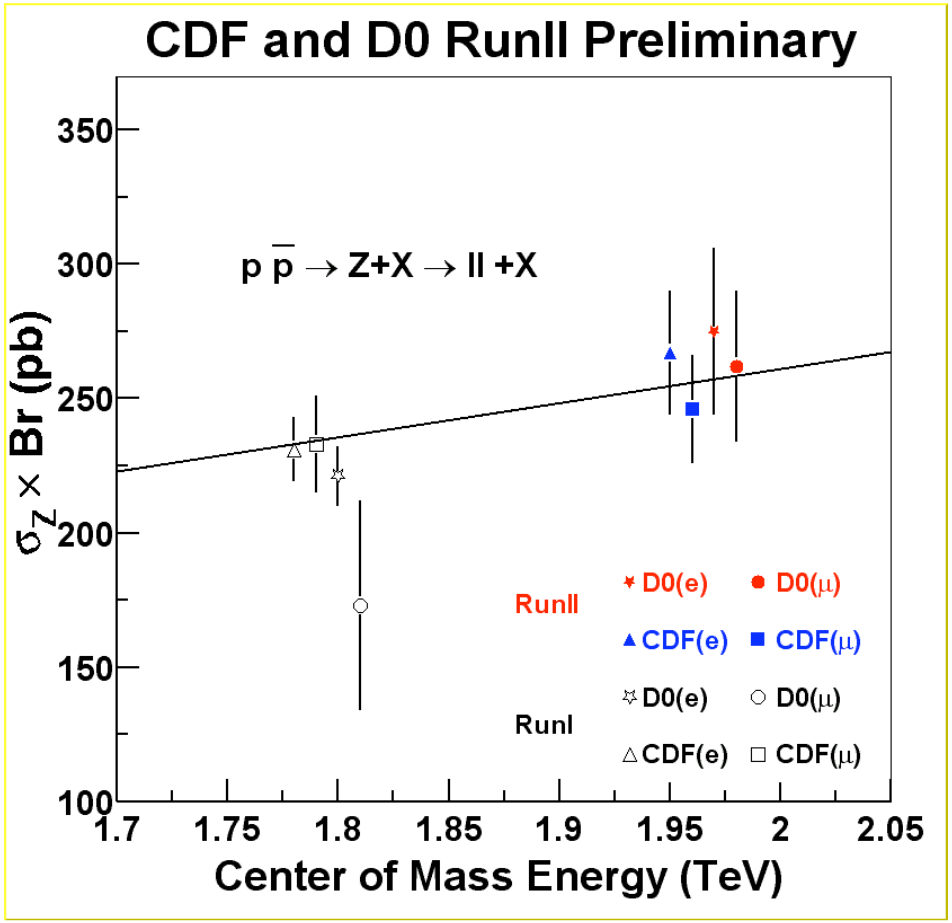
117 pb^{-1}





□□Br =

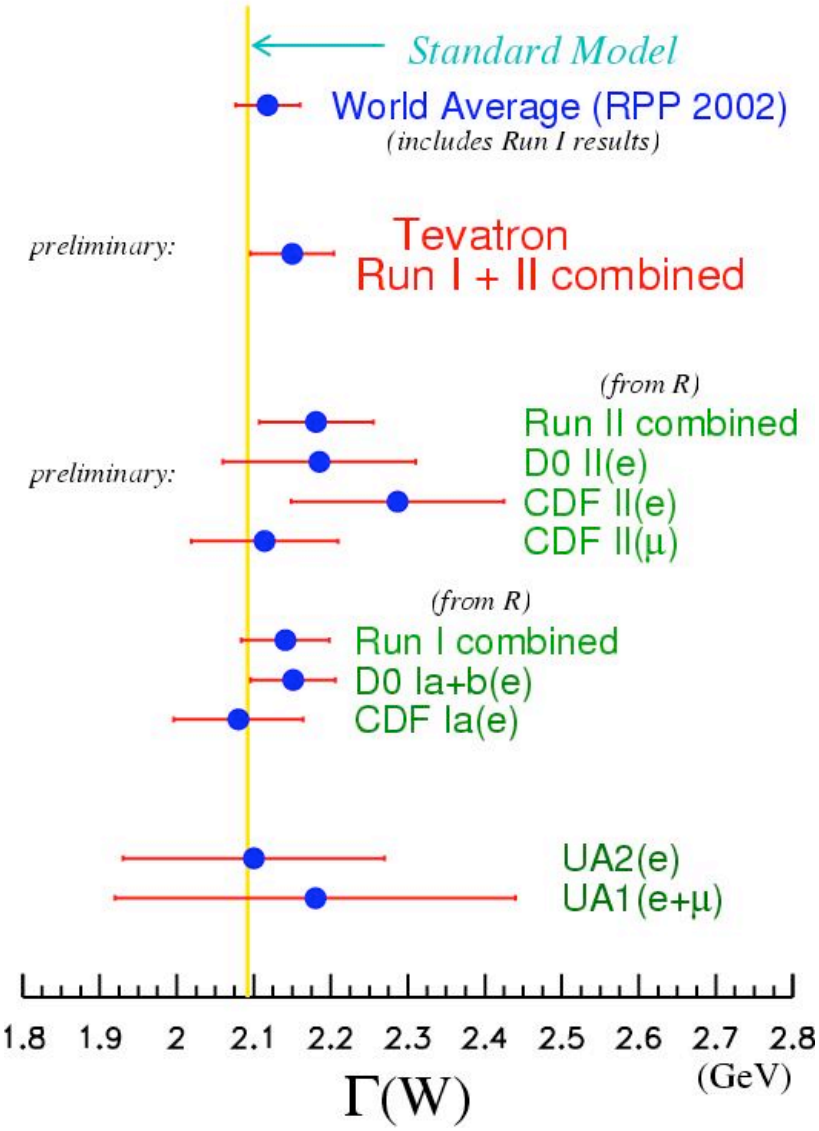
261.8 ± 5.0 (stat) ± 8.9 (sys) ± 26.2 (lum) pb



W/Z Cross Section Ratio

$$R = \frac{\sigma(p\bar{p} \to W \to l\nu)}{\sigma(p\bar{p} \to Z \to l^+l^-)}$$

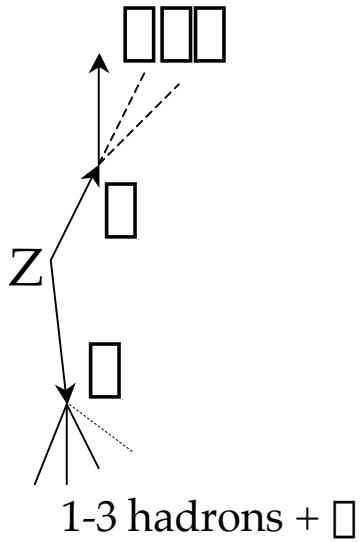
- luminosity uncertainty cancels
- based on DPF '03 electron cross sections
  - new acceptance study with CTEQ6
  - new systematic uncertainty evaluation
- **R = 10.34 ± 0.35 (stat) ± 0.48 (sys)**

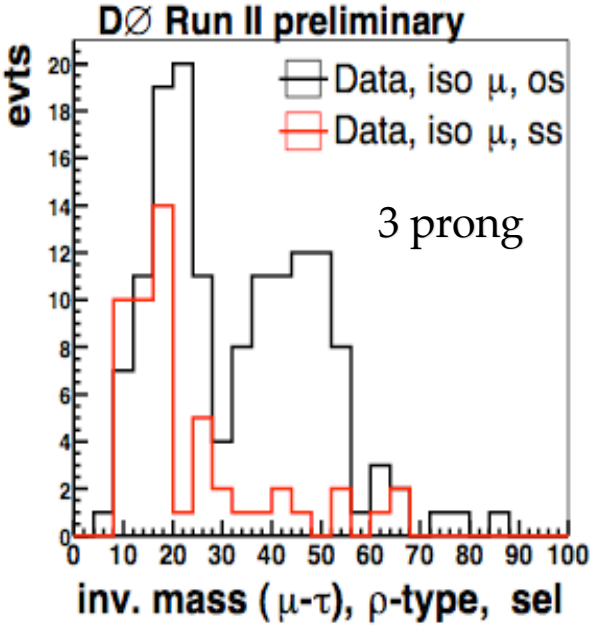


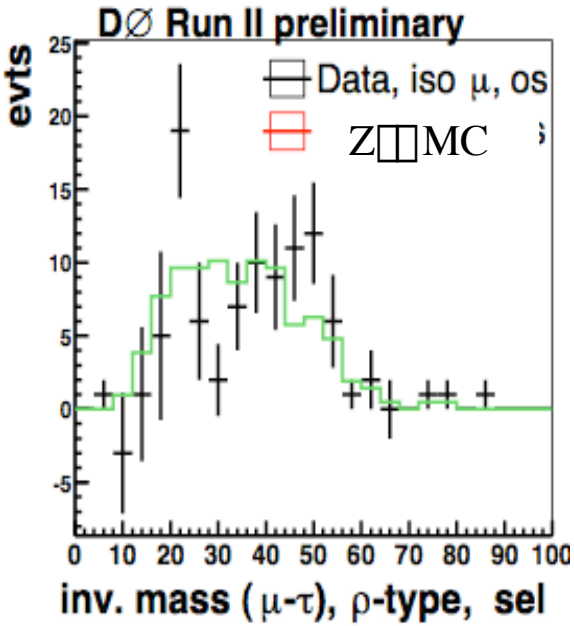
Z → □+□ Cross Section

- □s comprise an important final state of many processes
  - eg. Top, Higgs, searches for new phenomena
- consider decays giving final states with 1 □ + 1 hadronic □
  - excellent way to study hadronic tau reconstruction
- main backgrounds
  - heavy flavor, Z dimuon

68 pb^{-1}







cross sections:

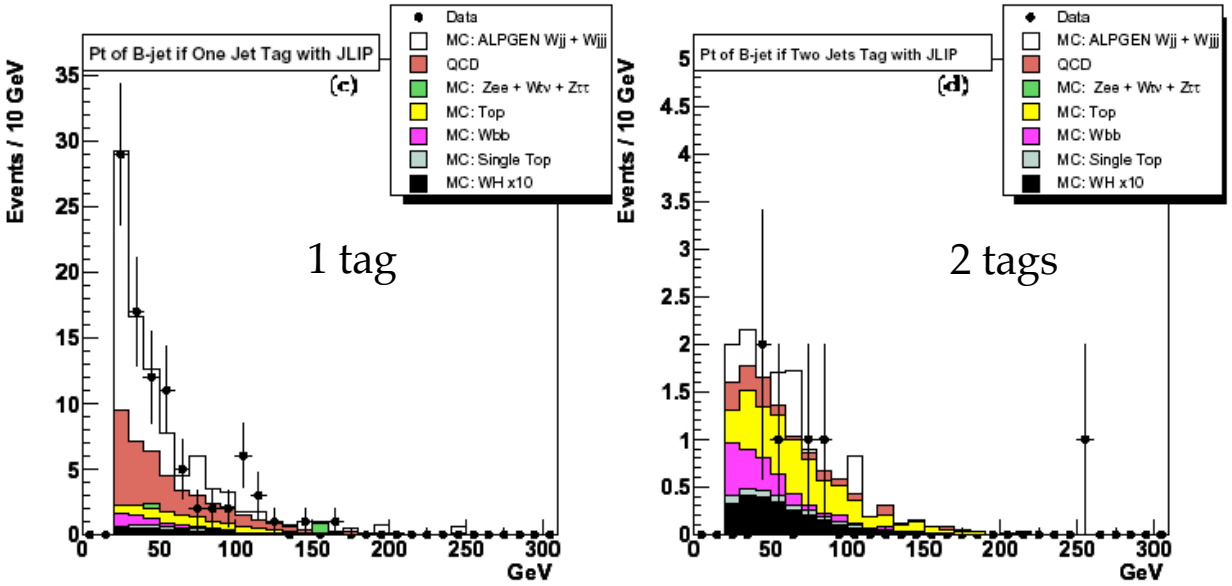
1-prong: **235 ± 127 pb**

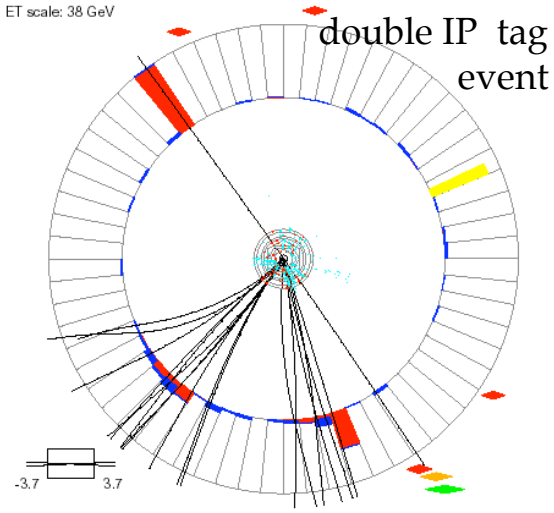
3-prong: **222 ± 71 pb**

- **□s observed in Run II!**

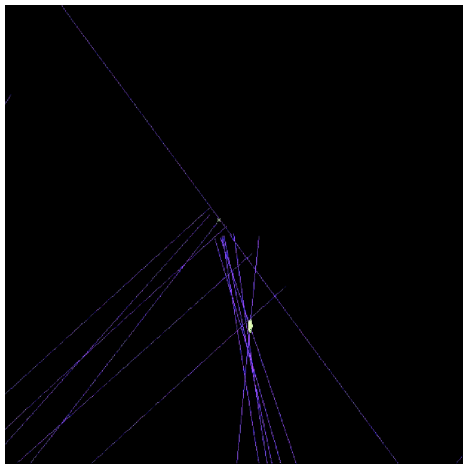
Searching for the Higgs

- **W(e□)+bb cross section** **117 pb^{-1}**
  - important background for single top and Higgs searches
  - benchmark for detector performance
  - 92 evts with 1 impact parameter tag





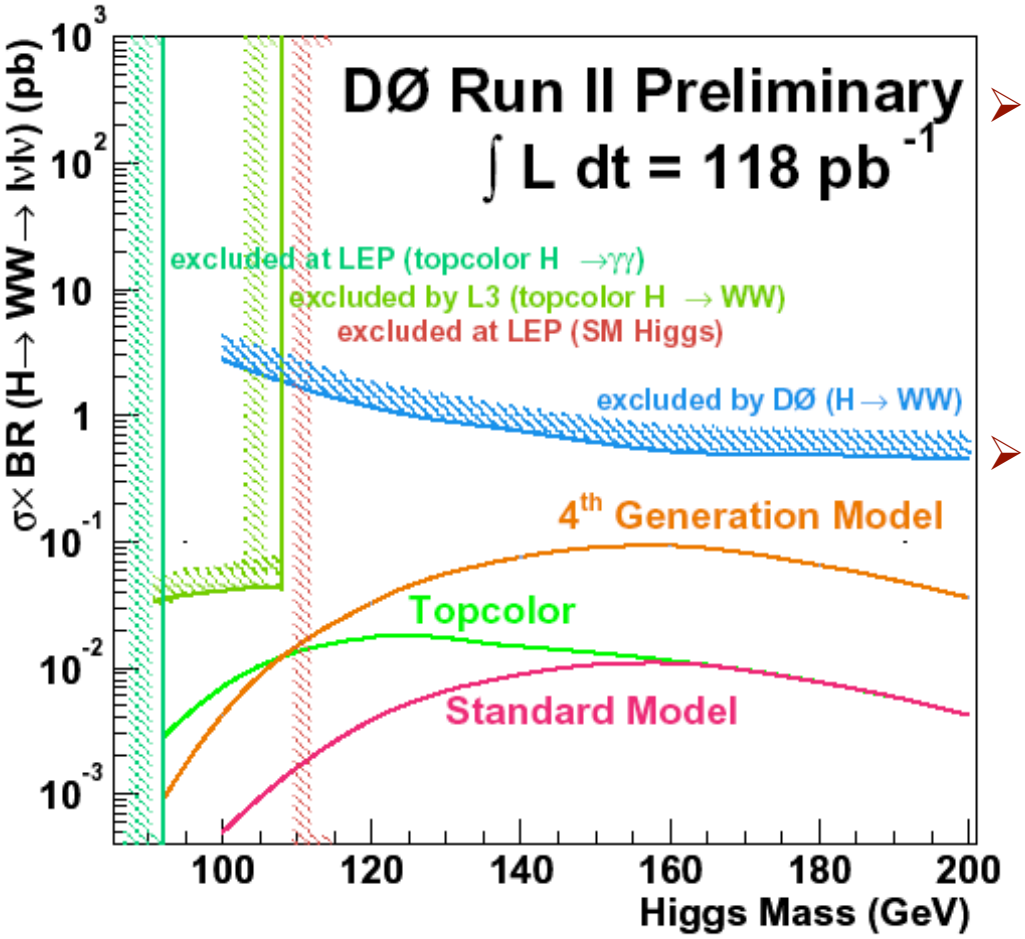
double IP tag event



  - search for double impact parameter tagged events
    - 3 evts observed, 5.5 ± 1.6 evts background

□(W+bb) < 33.4 pb @ 95% c.l.

$H \rightarrow WW$



- **ee(e□) final states** **118 (102) pb^{-1}**
  - **events observed**
    - ***ee*: 0 obs., 1.1 ± 0.8 background**
    - ***e□*: 1 obs., 0.9 ± 0.5 background**

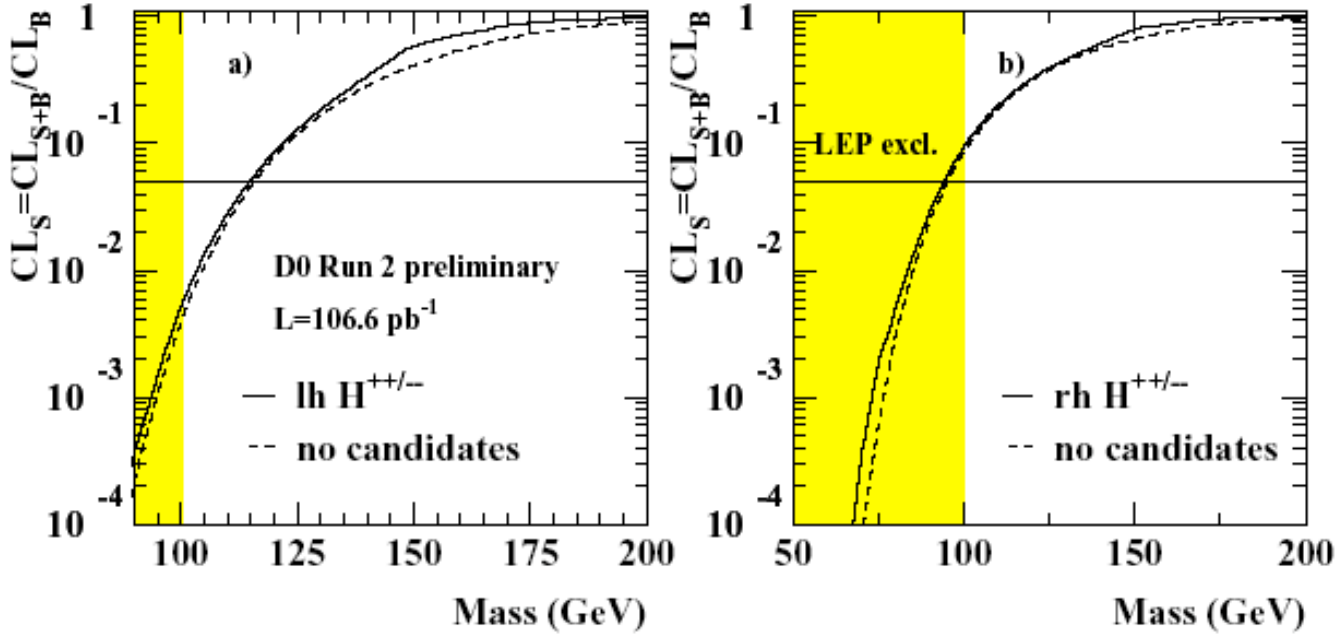
  □*BR < 0.45 pb to 2.8 pb

- **dimuon final state**
  - first time studied for H->WW
  - 114 pb-1
  - 1 event observed
  - 0.95 ± 0.12 (stat.) ± 0.14 (sys.)

  □*BR < 0.2 pb to 0.7 pb

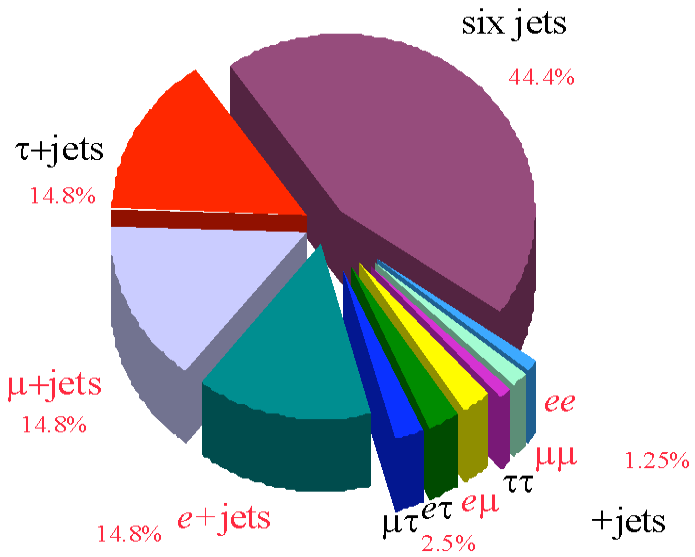
$p\bar{p} \rightarrow H^{++}H^{--} \rightarrow \ell^+\ell^+\ell^-\ell^-$

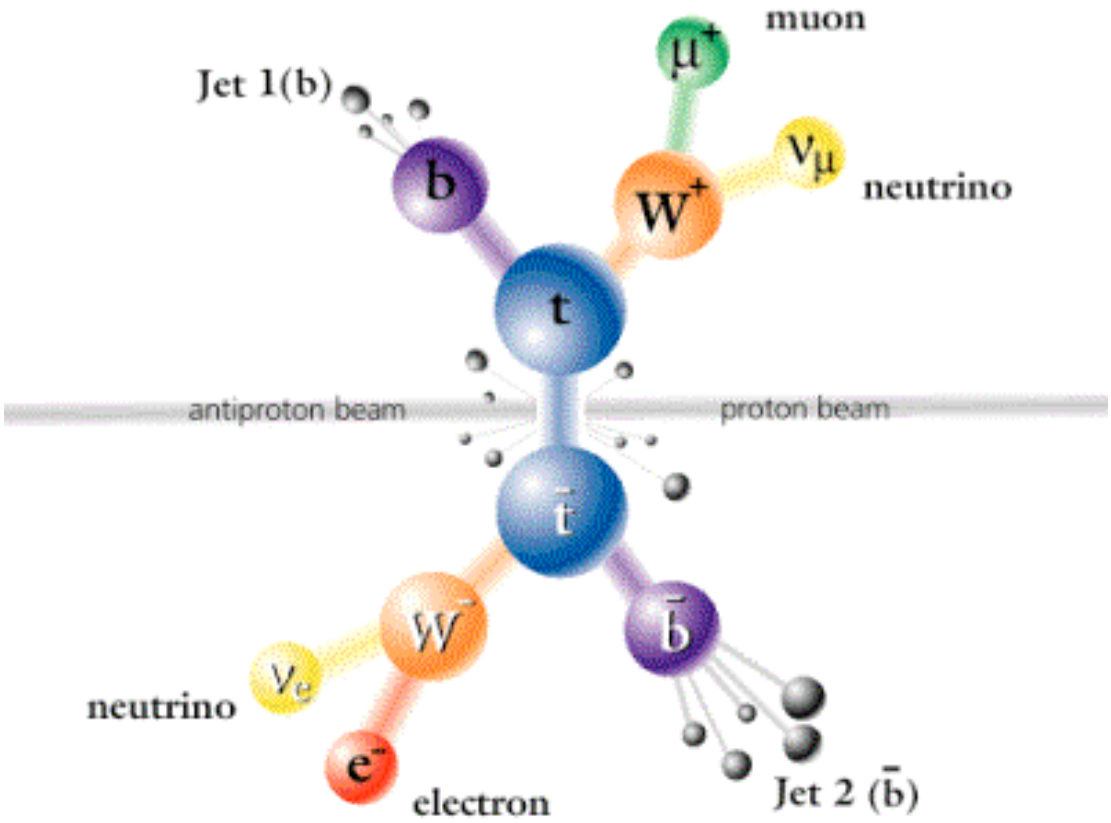
- **appear in left-right symmetric models**
  - **for M($H^{\pm\pm}$) < 160 GeV, dilepton decay modes dominant**
- **107 pb^{-1}**
- **M($H^{\pm\pm}$) > 95 GeV @ 95% c.l. (right-handed)**
- **M($H^{\pm\pm}$) > 115 GeV @ 95% c.l. (left-handed)**
  - **world's best limit**

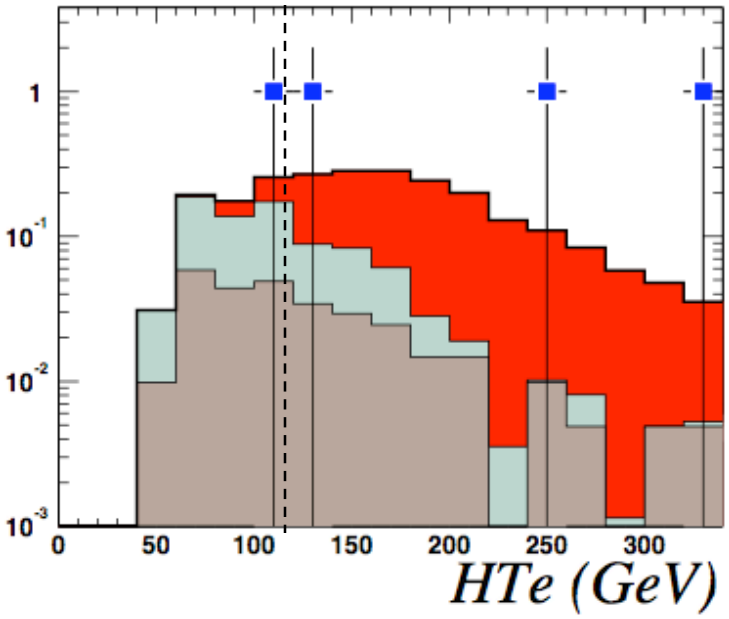


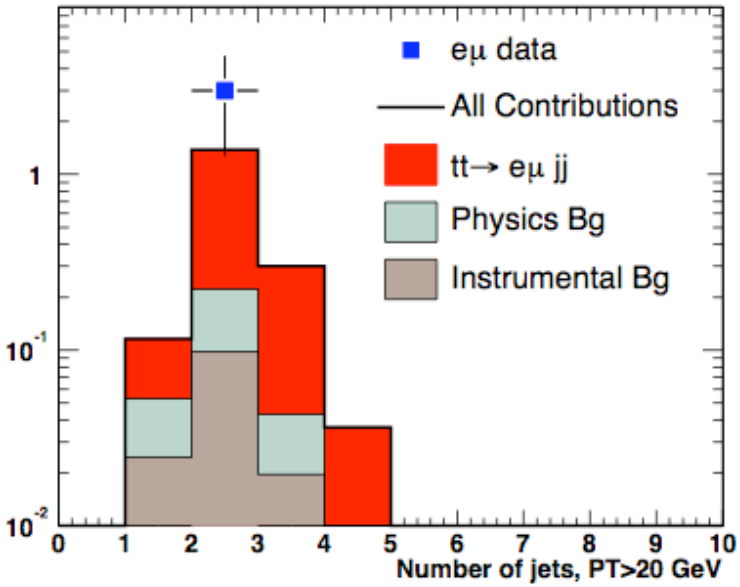
Top Physics

- **top-antitop production**
  - **mainly quark-antiquark annihilation**
- **W and b-quark decays specify final states**
  - **isolated high P_T leptons**
  - **soft leptons in jets**
  - **detached vertices in jets**









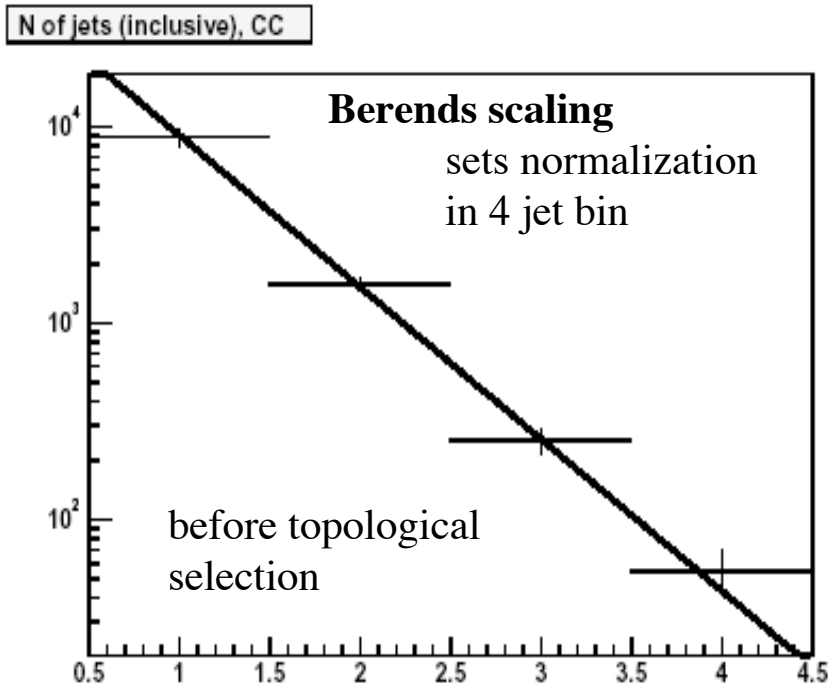
Dilepton Final States

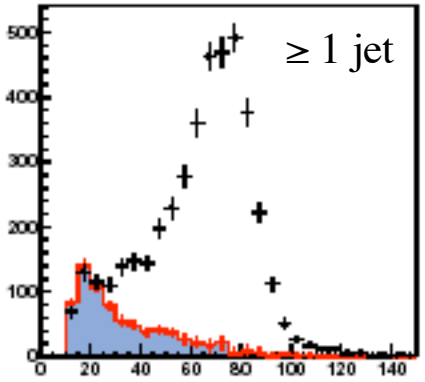
- look for evidence of high P_T leptons, jets and neutrinos
- *ee* 107 pb^{-1}
  - backgrounds 0.6 ± 0.5 evt
    - Z/□, WW, Z□□, W+jets, QCD fakes
  - 2 events observed
- □□ 90 pb^{-1}
  - backgrounds 0.7 ± 0.2 evt
    - Z/□, WW, Z□□, W+jets, bbbar
  - 0 events observed
- *e*□ 98 pb^{-1}
  - backgrounds 0.6 ± 0.2 evt
    - WW, Z□□, W+jets, bbbar
  - 3 events observed

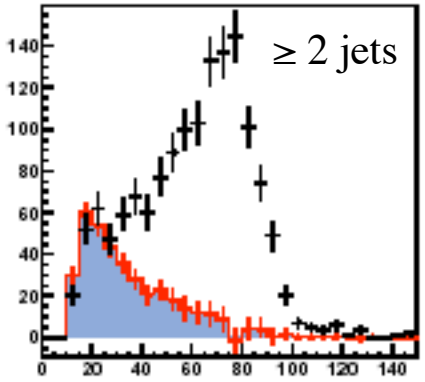
$$\sigma(p\bar{p} \rightarrow t\bar{t}) =$$
$$8.7^{+6.4}_{-4.7}(stat.)^{+2.7}_{-2.0}(sys.) \pm 0.9(lum.)\ pb$$

e+jets/topological

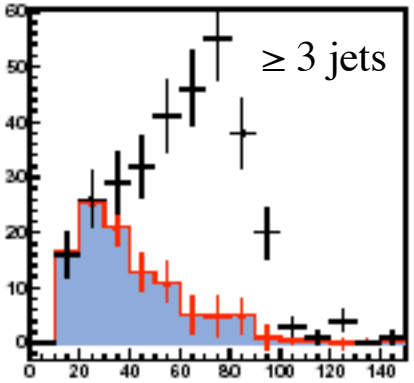
- use strategy of looking for events kinematically like top
  - veto on soft muons
- 92 pb^{-1}
- backgrounds
  - W+jets, multijet with fake '*e*'

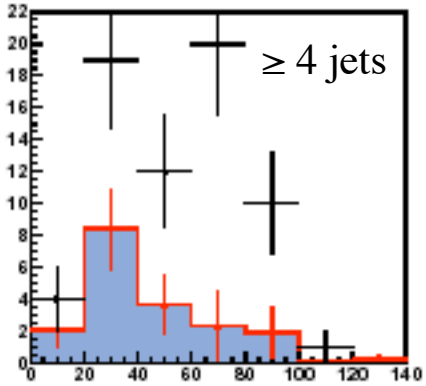






m_T





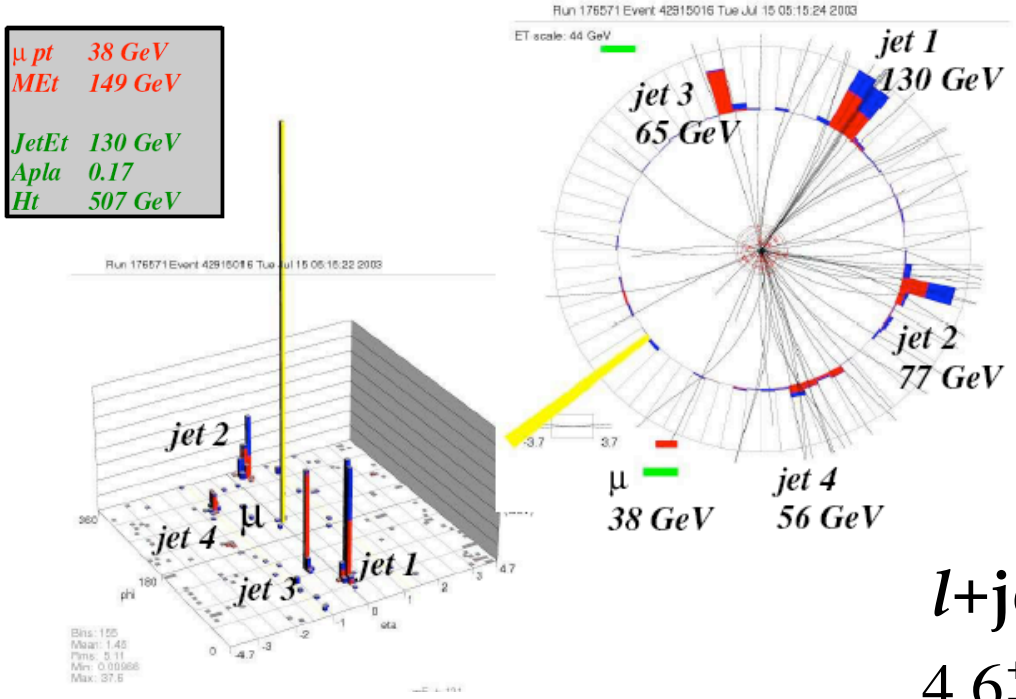
matrix method to separate W/QCD

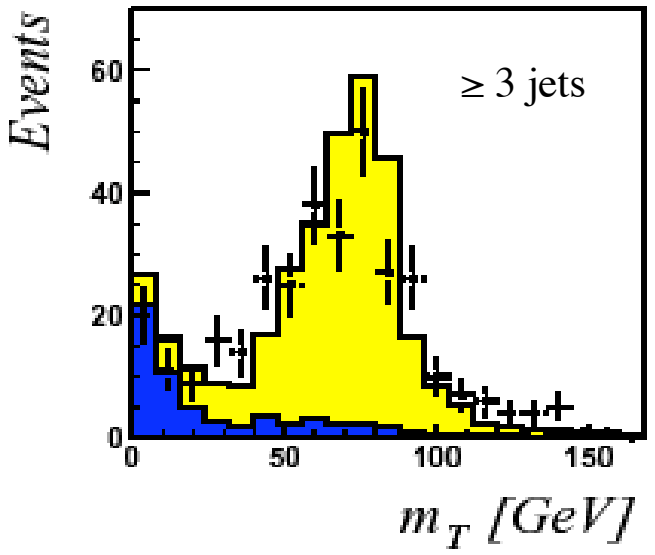
W m_T component evident in 4j bin

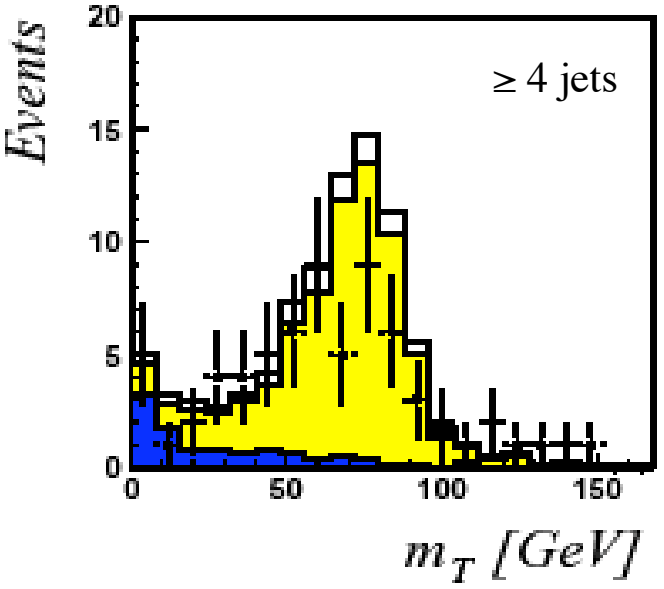
6.8 ± 1.6 evts background
12 events observed

□+jets/topological

- 94 pb^{-1}
- background
  - W+jets, QCD
  - 11.7 ± 1.9 evts background
  - 14 events observed







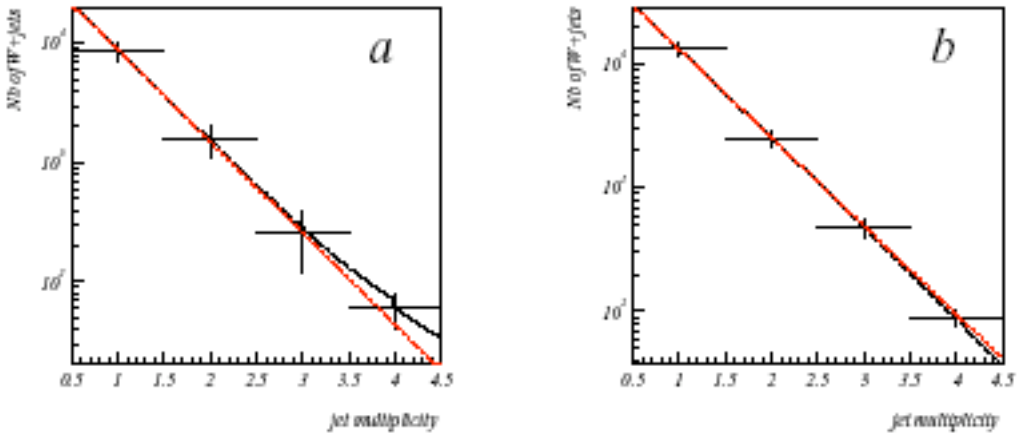
l+jets/topological:

$$4.6^{+3.1}_{-2.7}(stat.)^{+2.1}_{-2.0}(sys.) \pm 0.5(lum.)\ pb$$

Lepton+Jets Using *b*-Tagging

- **soft lepton tag**
  - relax topological selection
    - require soft, non-isolated muon within a jet
  - *e*+jets and □+jets channels

$$11.4^{+4.1}_{\square 3.5}(stat.)^{+2.0}_{\square 1.8}(sys.)\ \text{pb}$$

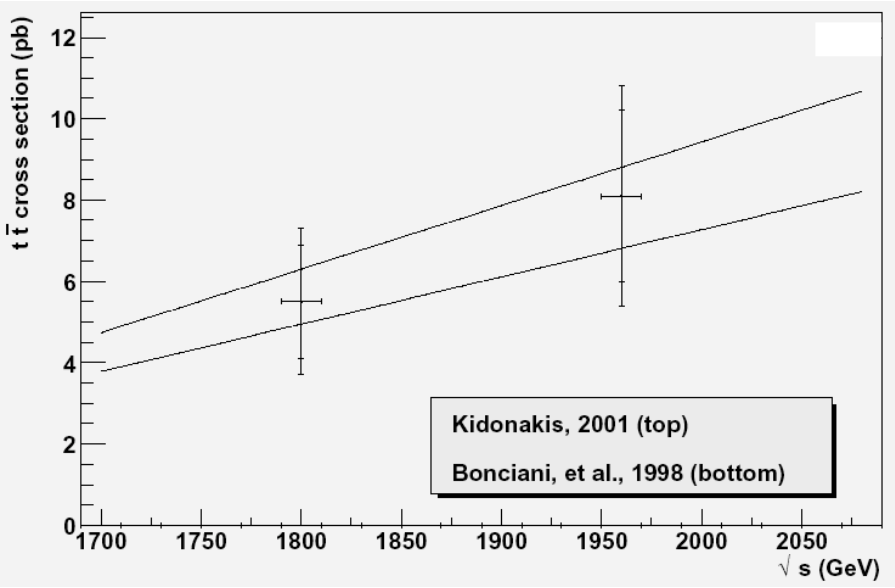


- **detached vertex tag consistent**
  - (see Flera Rizatdinova Wine and Cheese Seminar on 07/15/03)

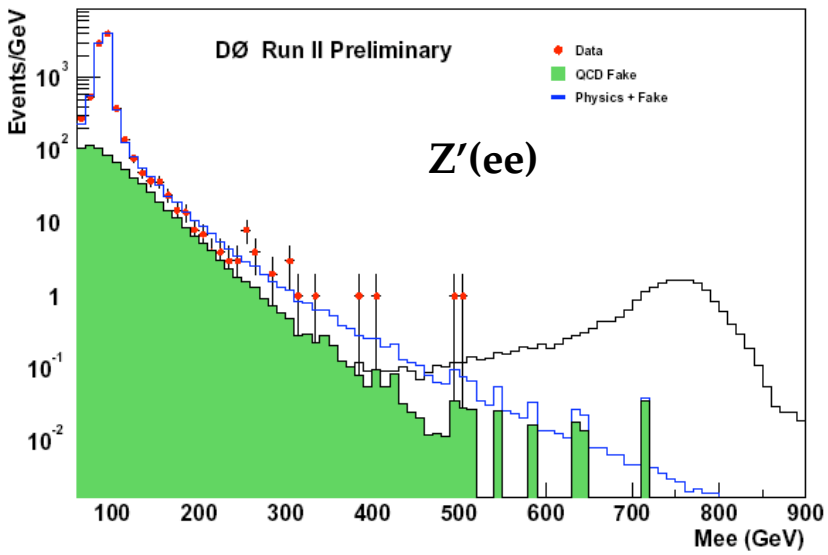
- **Combined Cross Section:**
  - dilepton
  - *l*+jets/topological
  - *l*+jets with soft muon tag

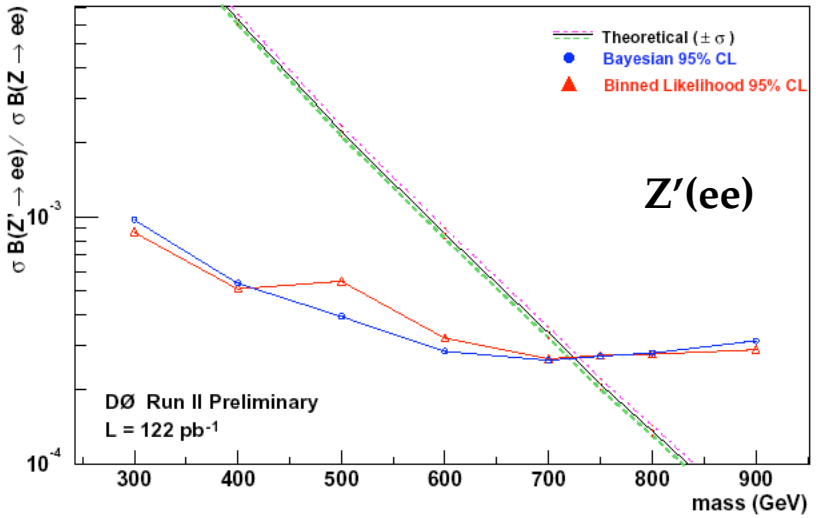
$$8.1^{+2.2}_{\square 2.0}(stat.)^{+1.6}_{\square 1.4}(sys.) \pm 0.8(lum.)\ \text{pb}$$

$$E_{cm} = 2\ \text{TeV}$$



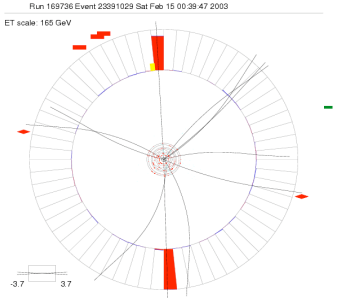
Searching for New Phenomena

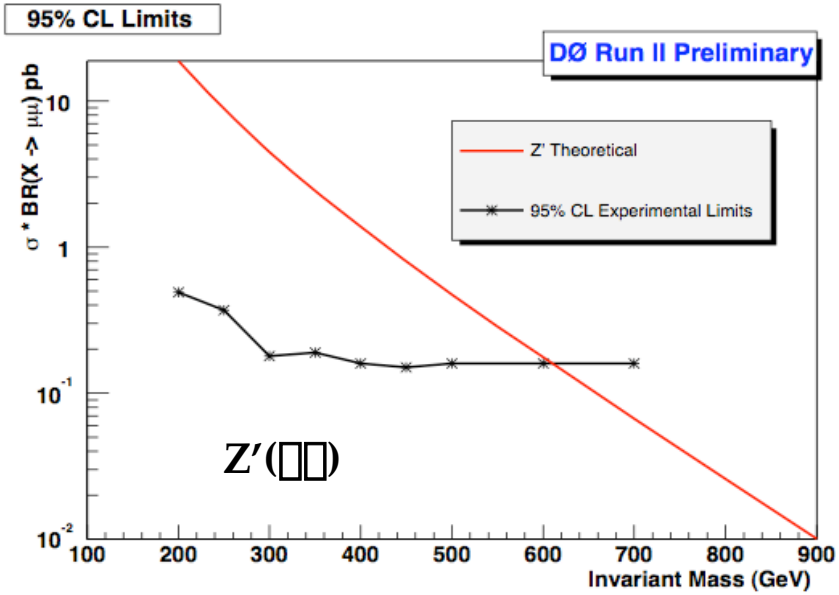




- Z′ searches
  - Z′->ee
    - 122 pb^{-1}
    - $M_{Z'}$ > 719 GeV @ 95% c.l.
    - more sensitive than Run I
  - Z′ -> □□
    - 100 pb^{-1}
    - $M_{Z'}$ > 620 GeV @ 95% c.l.

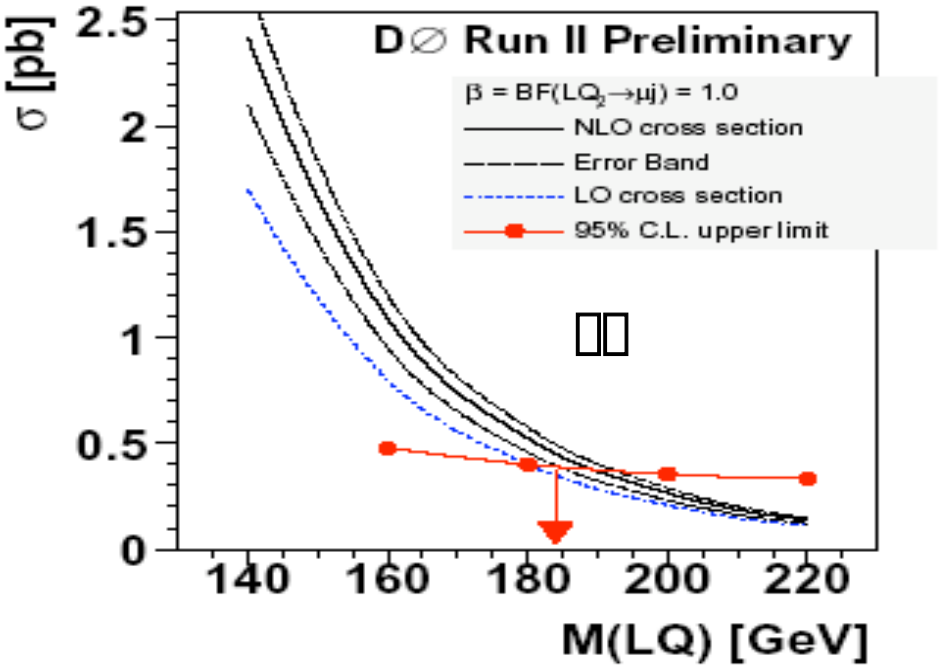
M_{ee} = 388 GeV

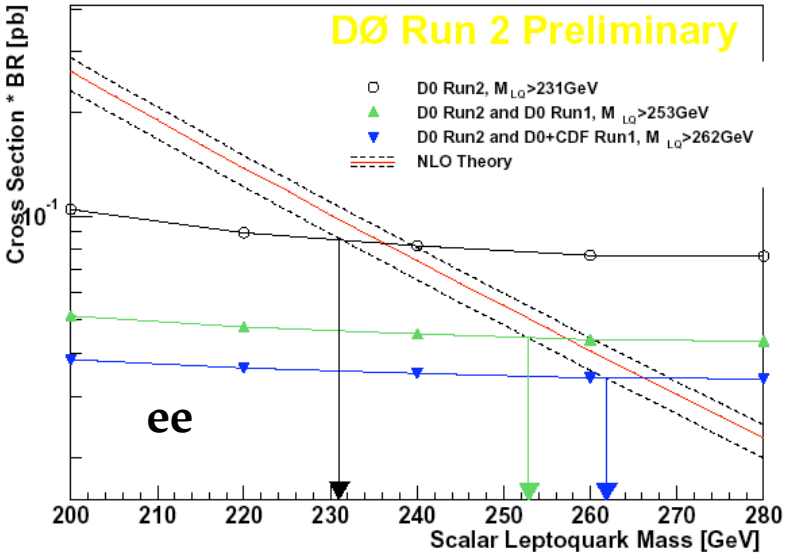




Leptoquark Searches

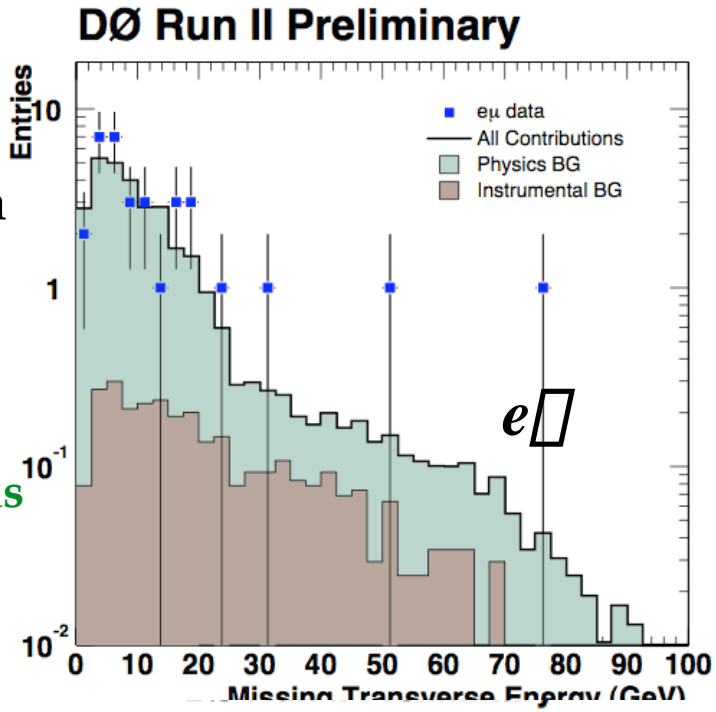
- $\ell^+q\ \ell^-q'$ 90 pb^{-1}
  - backgrounds DY, ttbar, WW
    - instrum. < 3% of high mass dimuon sample
  - $M_{LQ}(\beta=1) > 184$ GeV
- $e\ q\ \nu q'$ 121 pb^{-1}
  - backgrounds: W+2j, ν+2j, top
  - 3 events obs, 4.24 ± 1.0 expected
  - assume BR 0.5, $M_{LQ} > 159$ GeV
- $e^+q\ e^-q'$ 135 pb^{-1}
  - backgrounds DY, ttbar, QCD multijet with elec. fakes
  - cross section < 0.086 pb
    - $M_{LQ}(\beta=1) > 231$ GeV
      - with Run1, get 253 GeV
      - **most stringent limit to date**

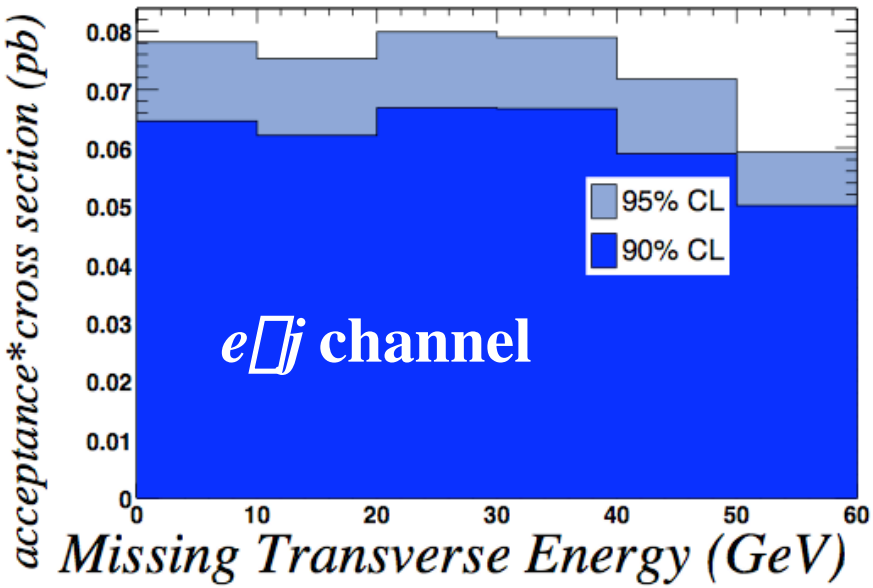


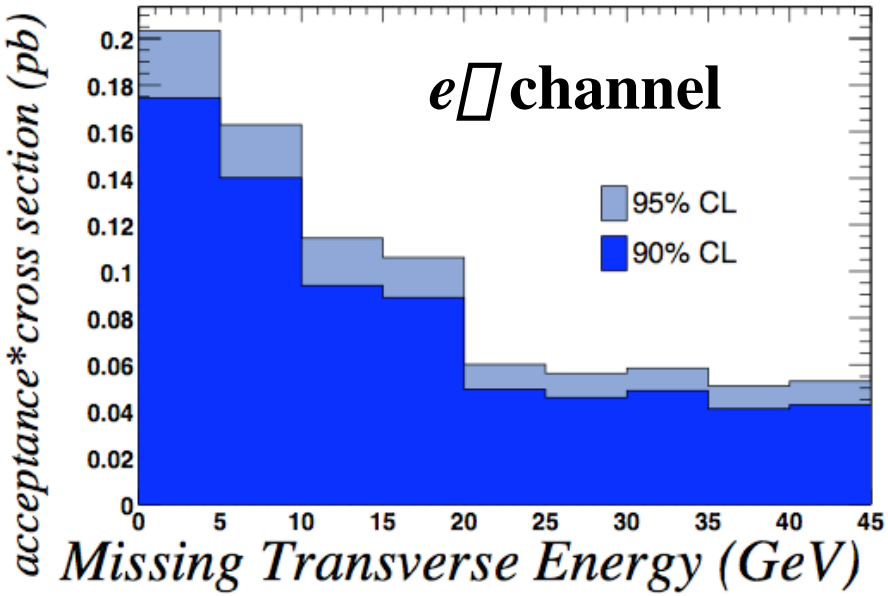


General $e\tau$ Search

- model independent limit on production of new physics (*a la* Sleuth)
- 98 pb^{-1}
- background
  - SM: $Z\tau\tau$, WW, ttbar, fake isolated leptons
  - $e\tau$: 1.8 ± 0.1 expected, 2 obs.
  - $e\tau j$: 0.1 evt expected, 0 obs.

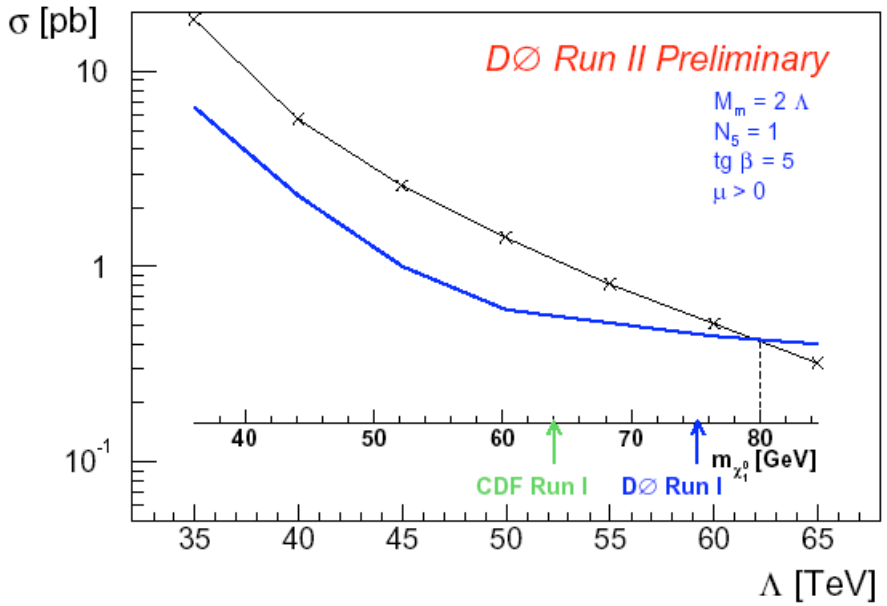


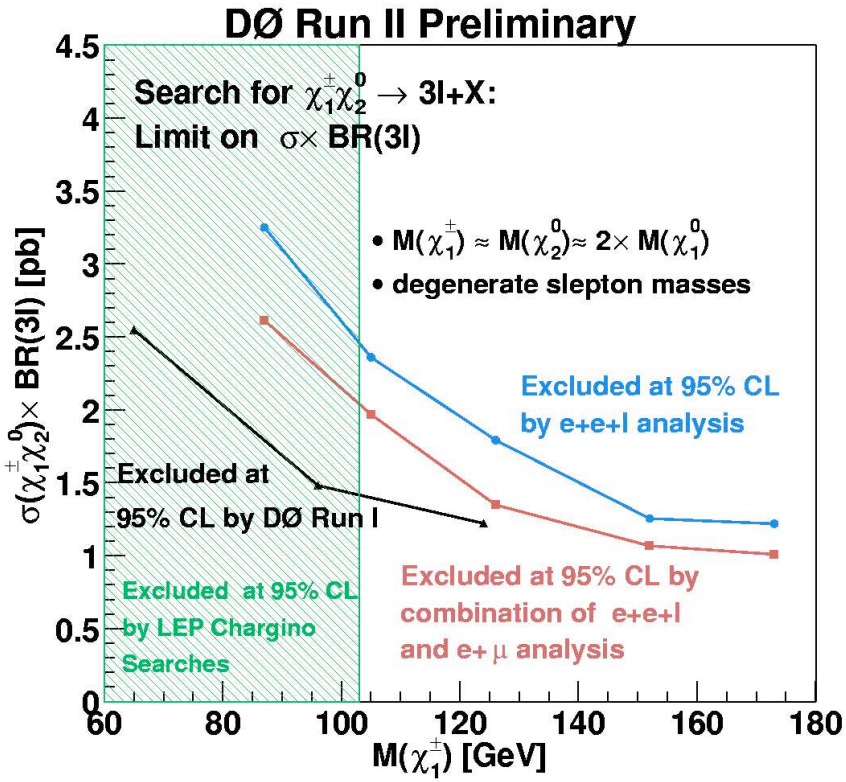




Search for Supersymmetry

- Dielectron chargino searches 120 pb^{-1}
  - σ < 1.95 pb @ 95% c.l.
- $\gamma\gamma$+met
  - gauge mediated SUSY breaking
  - backgrounds
    - DY, QCD
  - m(χ_0^1) > 80 GeV @ 95% c.l.
    - limits better than Run I
    - best Tevatron limit to date

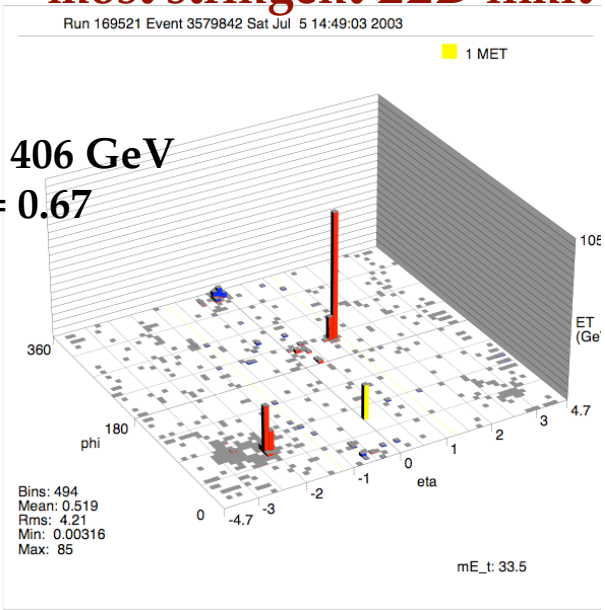




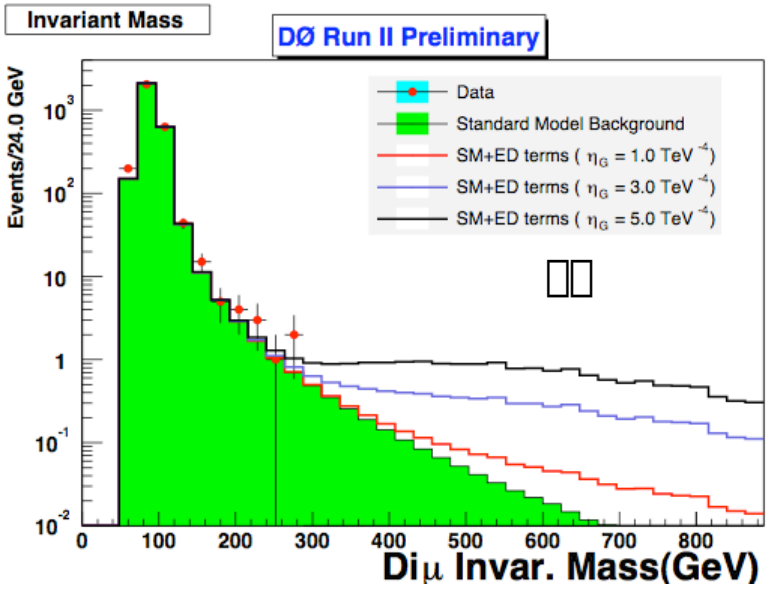
- R-parity Violating SUSY in trielectrons
  - –should be 4 charged leptons in final state
    - allow for loss of one electron
  - –118 pb^{-1}
  - –3 evts obs, 2.8 ± 1.4 expected BG
  - –$m_{1/2}$ > 150 GeV

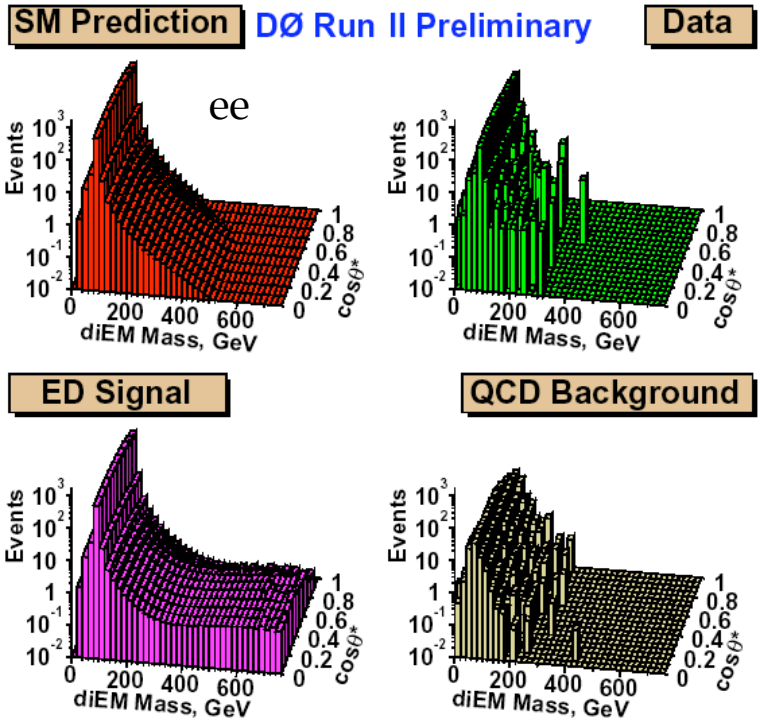
Large Extra Dimensions

- □□ 100 pb^{-1}
  - 2D fit in M_{ll} vs. cos(□*)
  - M_S(GRW) > 0.88 TeV @ 95% c.l.
- ee/□□ 128 pb^{-1}
  - backgrounds
    - SM: DY, □□ fake '*e*': QCD and direct □
  - M_S(GRW) > 1.28 TeV @ 95% c.l.
    - more stringent than Run1
    - combined with Run I: 1.37 TeV
    - most stringent LED limit to date



$M_{di\text{-}EM}$ = 406 GeV
cos(□*) = 0.67





Summary of New DØ Results

- **masses, or scale limits**
  - $M(B^{**}_d) = 5.71 \pm 0.016$ GeV
  - $m(\chi_0^1) > 80$ GeV
  - $m_{1/2} > 150$ GeV
  - M_S(GRW) > 1.28 TeV ($ee/\gamma\gamma$)
  - M_S(GRW) > 0.88 TeV ($\gamma\gamma$)
  - $M_{LQ}(\gamma\gamma) > 184$ GeV
  - $M_{LQ}(e\gamma) > 159$ GeV
  - $M_{LQ}(ee) > 231$ GeV
  - $M_{Z'}(ee) > 719$ GeV
  - $M_{Z'}(\gamma\gamma) > 620$ GeV
  - $M(H^{\pm\pm}) > 115$ GeV
- **BR and R**
  - $BR(B_s \to \gamma\gamma) < 1.6 \times 10^{-6}$
  - $R_{W/Z} = 10.34 \pm 0.35 \pm 0.48$
- **lifetimes**
  - τ(incl. B) = 1.562 ± 0.013 ± 0.045 ps
  - $\tau(B^+) = 1.65 \pm 0.083\ ^{+0.096}_{-0.1233}$ ps
  - $\tau(B_d) = 1.52\ ^{+0.19}_{-0.17}$ ps
  - $\tau(B_s) = 1.19\ ^{+0.19}_{-0.14}$ ps
  - $\tau_{\Lambda b} = 1.05\ ^{+0.21}_{-0.18} \pm 0.12$ ps
  - τ(B->D$l\nu$) = 1.46 ± 0.08 ps
- **cross sections, or limits**
  - $\sigma(t\bar{t}) = 8.1^{+2.2}_{-2.0}\ ^{+1.6}_{-1.4} \pm 0.8$ pb
  - $\sigma(Z\gamma\gamma) = 261.8 \pm 5.0 \pm 8.9 \pm 26.2$ pb
  - $\sigma(Z\gamma\gamma$, $\gamma\gamma$type) = 235 ± 137 pb
  - $\sigma(Z\gamma\gamma$, γ-type) = 222 ± 71 pb
  - $\sigma(W+b\bar{b}) < 33.4$ pb
  - σ*BR(H->WW->$ee/e\gamma$) < 0.45 to 2.8 pb
  - σ*BR(H->WW->$\gamma\gamma$) < 0.2 to 0.7pb

Conclusion

Many new results on b, electroweak, Higgs, top and New Phenomena presented

- Most already exceeding Run I reach

- Several measurements world's best

Coming months bringing Run II into frontier physics

- We've entered new territory in discovery potential for physics beyond the standard model