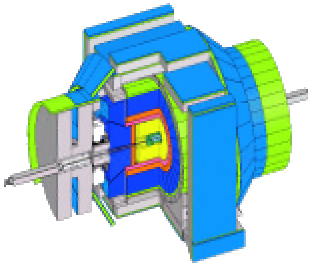
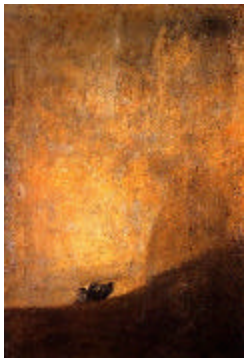
NEW CDF RESULTS



Mario Martinez
(FNAL)

On behalf of the CDF Collaboration



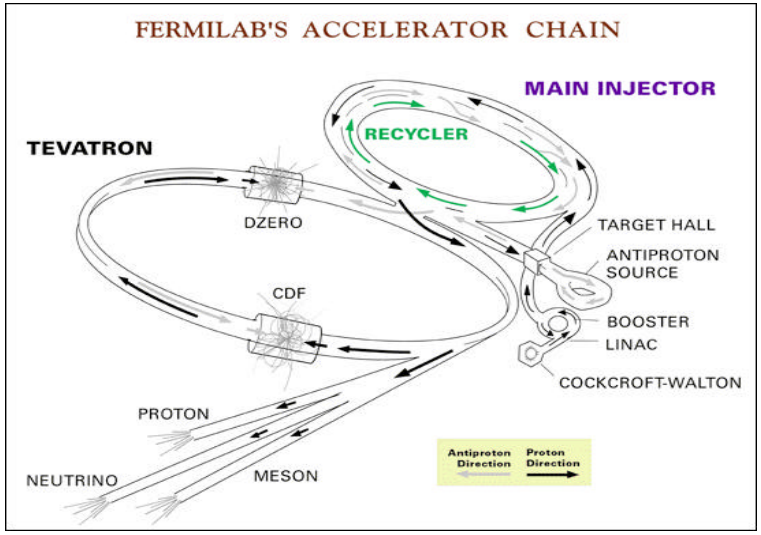
PLANCK'03, 6th European Meeting
From The Planck Scale To The Electroweak Scale
CSIC, Madrid, 26th-31st May 2003

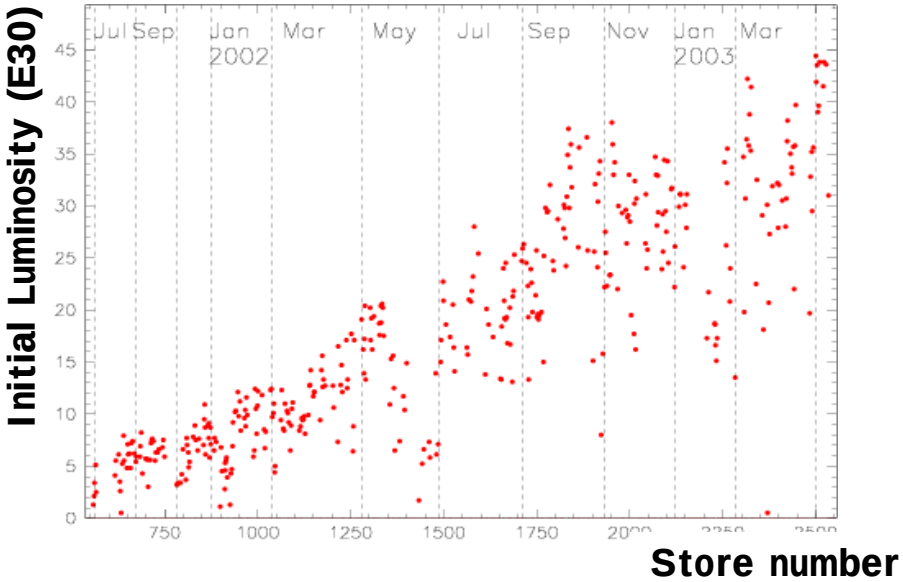
Tevatron Run II

- Main injector (150 GeV proton storage ring) replaces main ring
- New pbar recycler (still under commissioning)
- Increased $\sqrt{s}$ (1.8 $\Rightarrow$ 1.96 TeV)
- More bunches (6 $\Rightarrow$36, 396 ns crossing time)
- Tevatron Record Inst. Lumi:

  ~4.5 E31 cm-2 s-1 (to date)

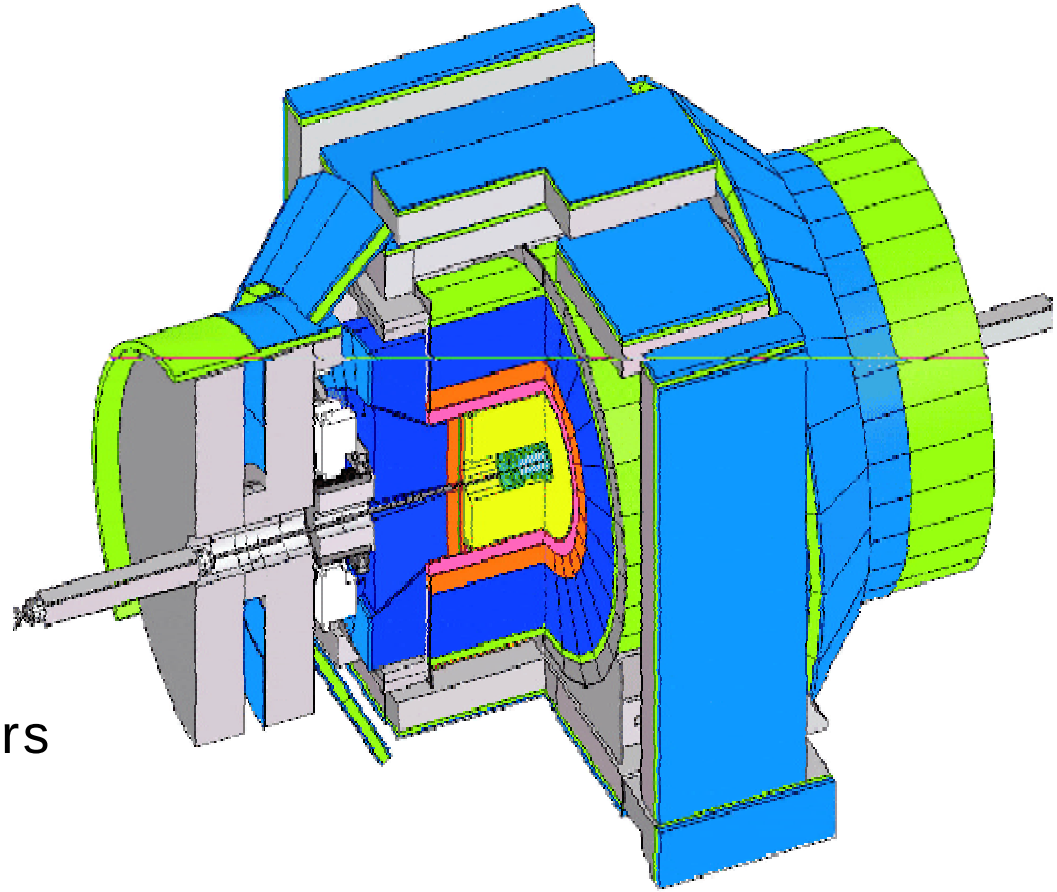
  (Run 2 goal: 2 E32 cm-2 s-1)





CDF II Upgraded Detector

- Upgraded Muon Detectors
- New TOF Detector
- New Plug Calorimeters
- New Drift Chamber
- New Silicon Tracking
- New Mini-Plugs Calorimeters
- New DAQ System

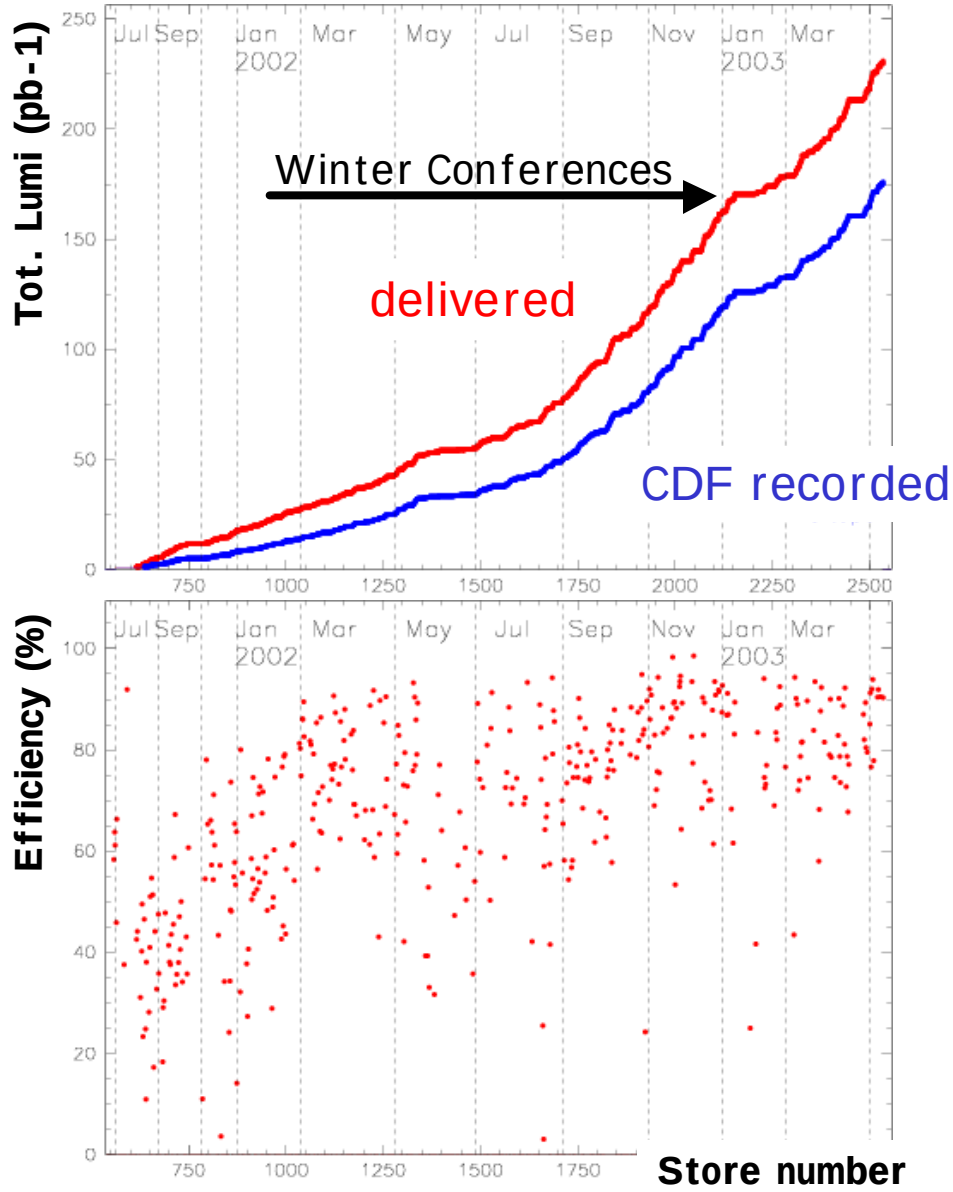


CDF detector working beautifully

CDF II Data Samples

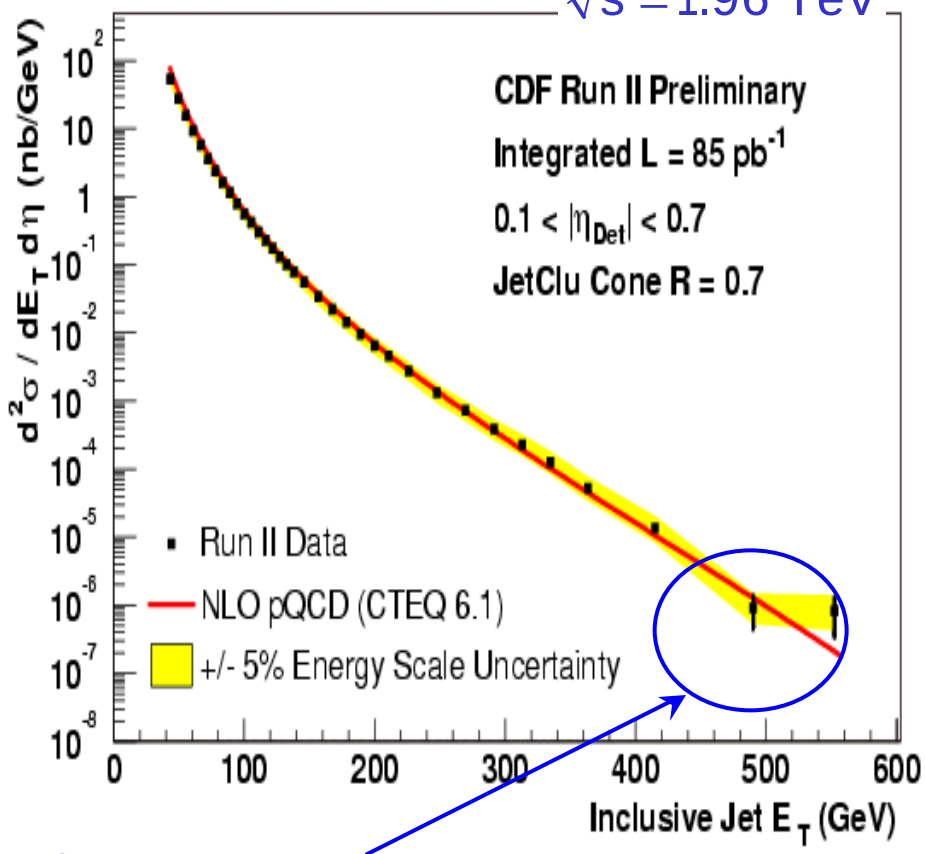
- CDF is taking Physics Data since February '02
- More than 170 pb-1 now collected on tape
- ~8 pb-1/week
- > 90% CDF data-taking efficiency

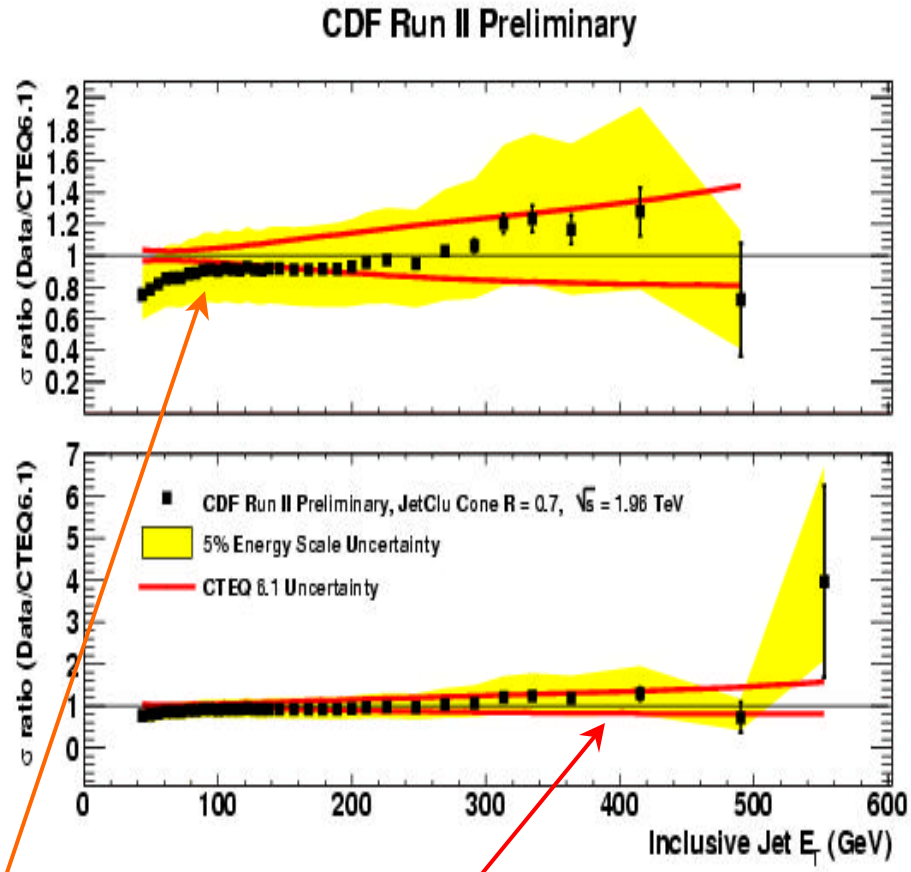
Winter Phys. Results used samples between 50 – 91 pb-1



Inclusive Jet Production

$\sqrt{s} = 1.96$ TeV





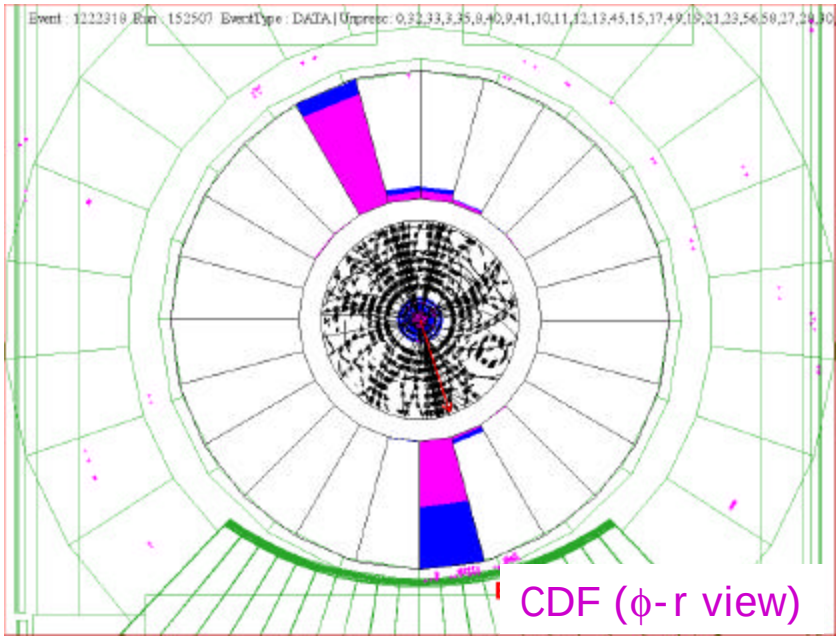
E_T^{jet} range increased up to ~600 GeV

Systematic errors dominated by 5% e-scale uncertainty…to be reduced

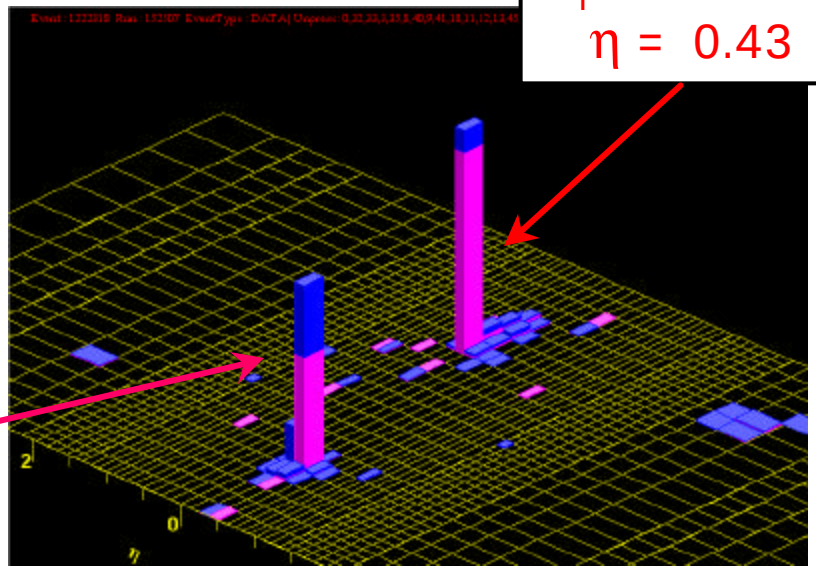
Theoretical error dominated by PDF's (gluon at high-x)

…agreement within uncertainties…

Highest Mass Dijet Event



Dijet Mass = 1364 GeV

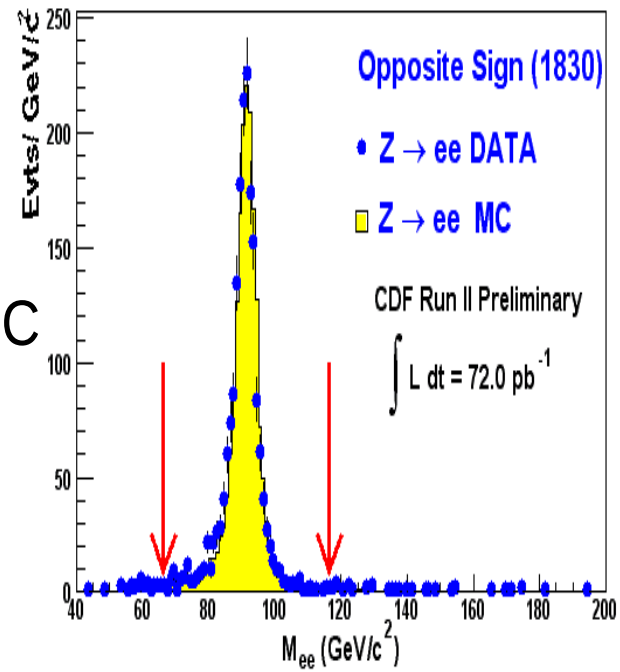


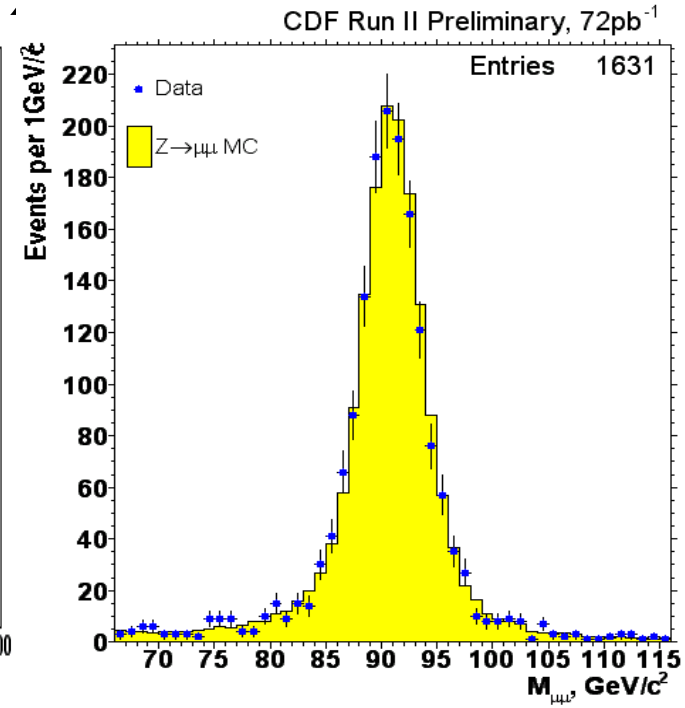
E_T = 666 GeV
η = 0.43

E_T = 633 GeV
η = -0.19

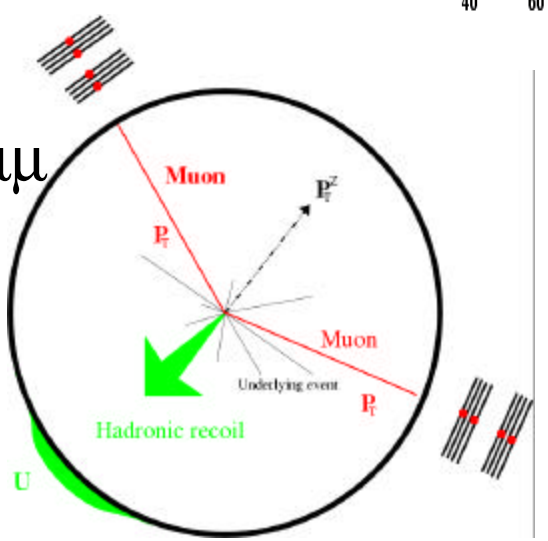
$\sigma \cdot B(Z^0 \rightarrow l^+l^-)$

- Isolated leptons
- Very Clean
- Used for CAL/EMC calibrations & ID
- 72 pb^{-1}





Z→μμ

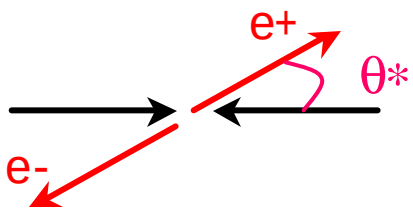


	Sample	Back.	σ•B(Z-->ll) (pb)
e	1830	0.6%	**267**$\pm 6_{stat} \pm 15_{sys} \pm 16_{lum}$
μ	1631	0.9%	**246**$\pm 6_{stat} \pm 12_{sys} \pm 15_{lum}$

NNLO @ $\sqrt{s}$=1.96 TeV: 252 ± 9 pb

A_{FB} asymmetry ($Z^0 \rightarrow e^+e^-$)

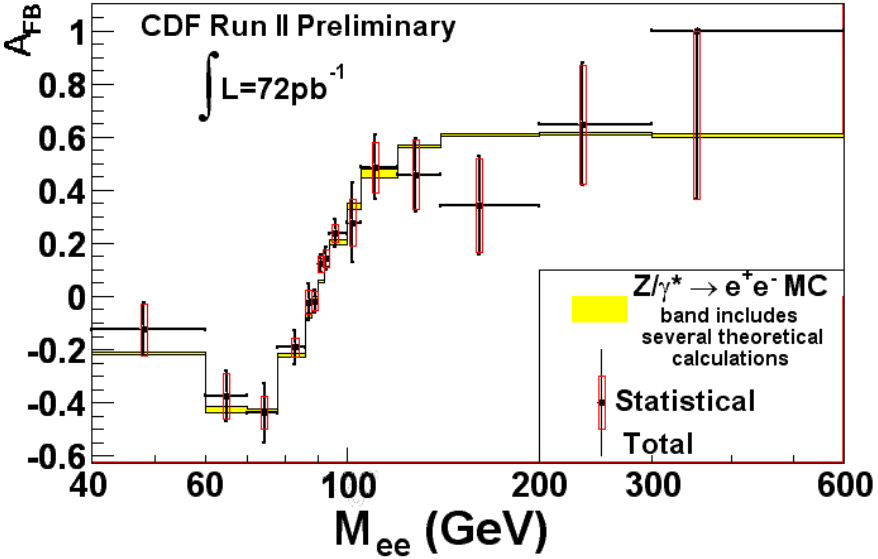
- Forward-Backward Asymmetry

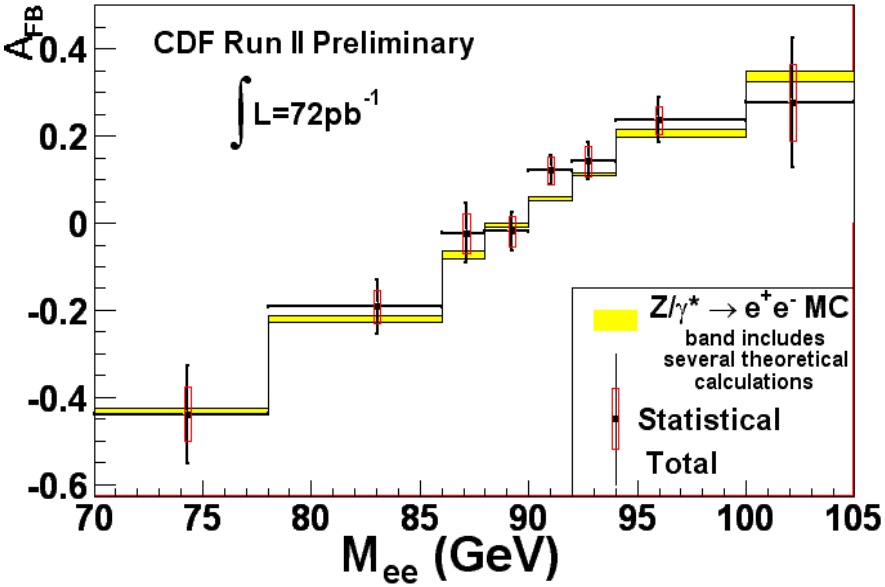


$$A_{FB} = \frac{d\sigma(\cos\theta > 0) - d\sigma(\cos\theta < 0)}{d\sigma(\cos\theta > 0) + d\sigma(\cos\theta < 0)}$$

- Direct probe of γ,Z couplings (sensitive to new physics)
- High mass unique to Tevatron
- Results consistent with SM

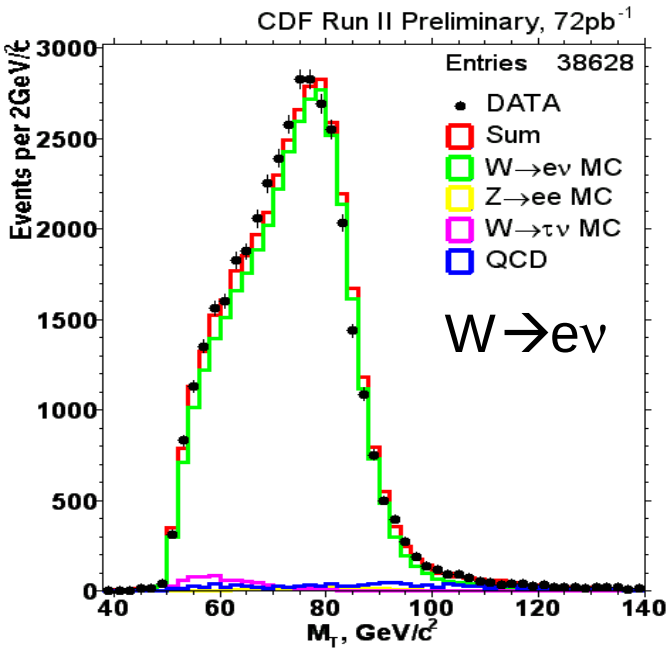
...waiting for more data...

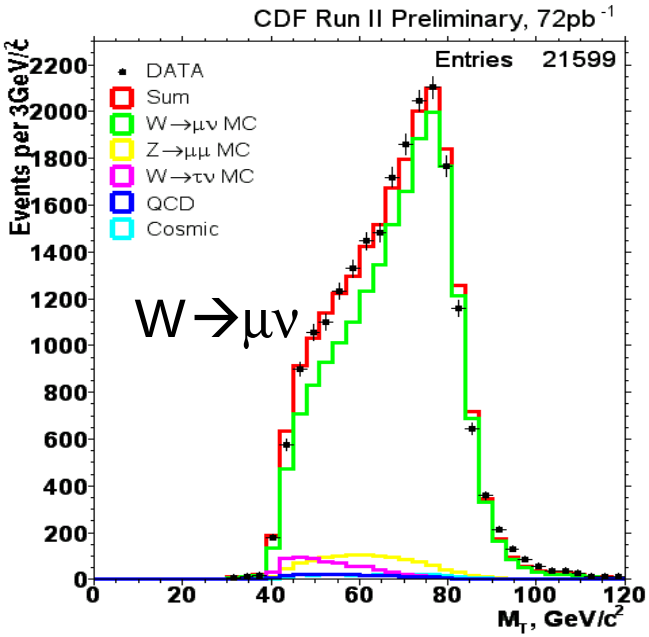




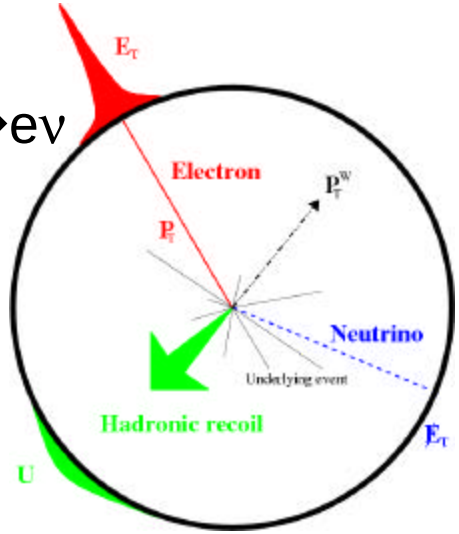
$\sigma \cdot B(W \rightarrow l\nu)$

- Signature
  - Isolated lepton
  - Missing E_T
- High σ & S/B
- 72 pb^{-1}





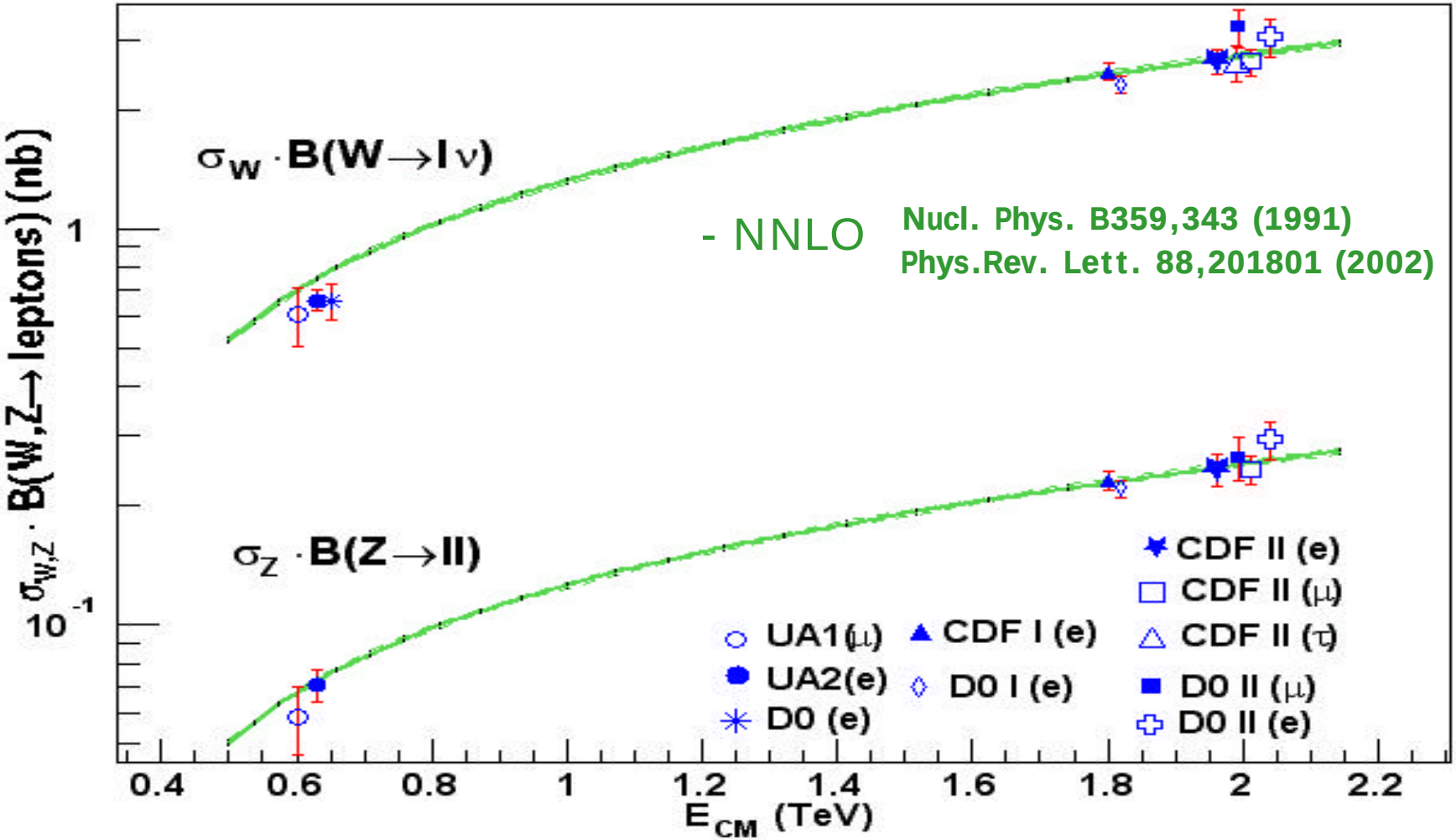
W→eν



	Sample	Back.	$\sigma \bullet B(W \rightarrow l\nu_l)$ (nb)
e	38625	6%	$2.64 \pm 0.01_{stat} \pm 0.09_{sys} \pm 0.16_{lum}$
m	21599	11%	$2.64 \pm 0.02_{stat} \pm 0.12_{sys} \pm 0.16_{lum}$
t	2346	26%	$2.62 \pm 0.07_{stat} \pm 0.21_{sys} \pm 0.16_{lum}$

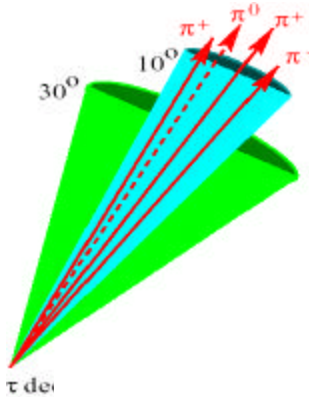
NNLO @ $\sqrt{s}$=1.96 TeV: 2.69 ± 0.10 nb

W/Z Production Cross Sections



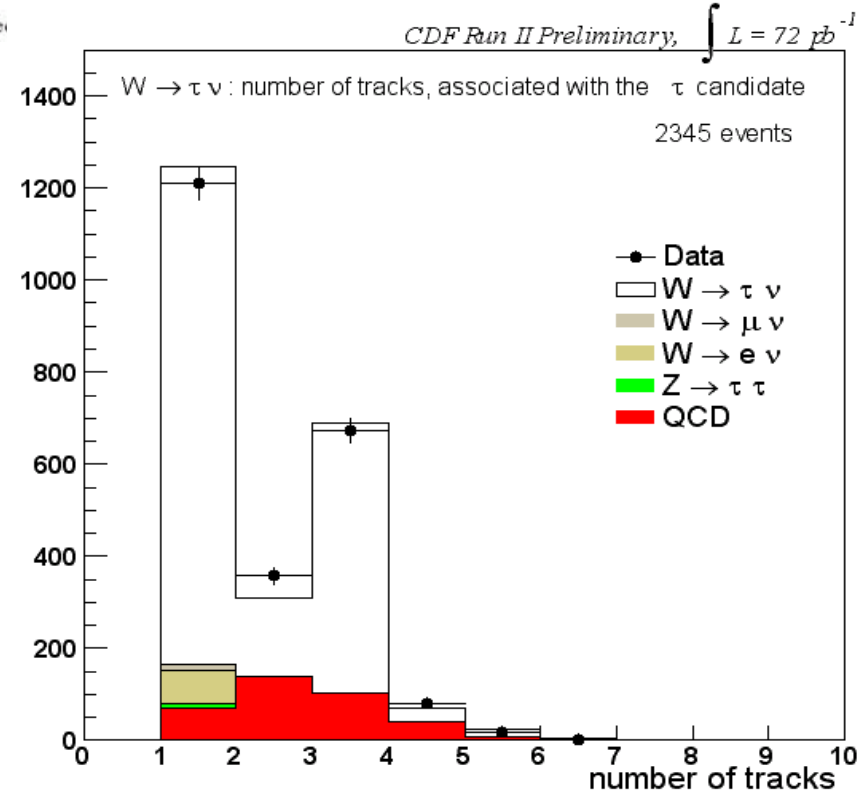
...good agreement with NNLO predictions ....

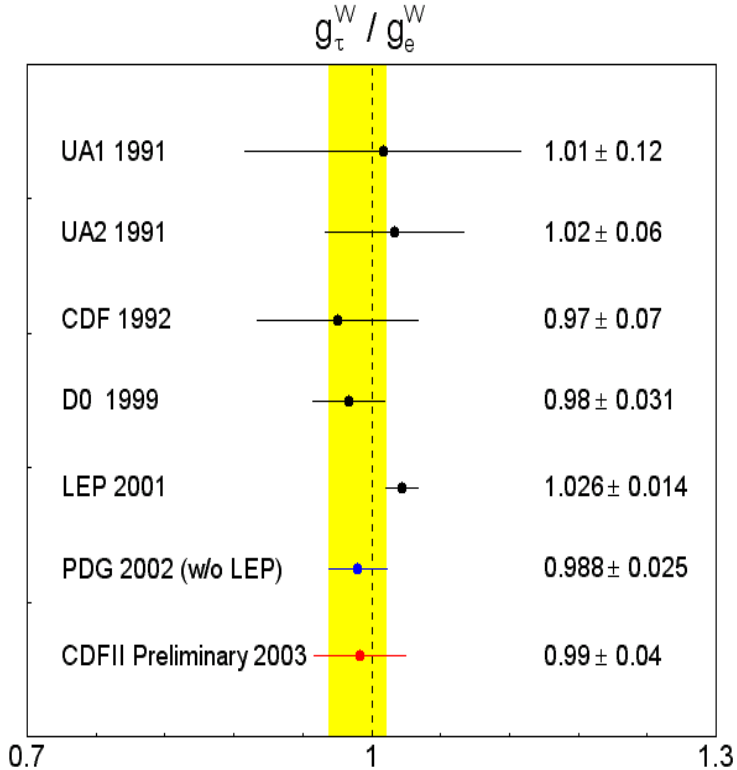
W→τν and Lepton Universality



- Clean W→τν decays
- Baseline for τ's analyses

2345 candidates (72pb-1)
Backg. ~26% (mainly QCD)



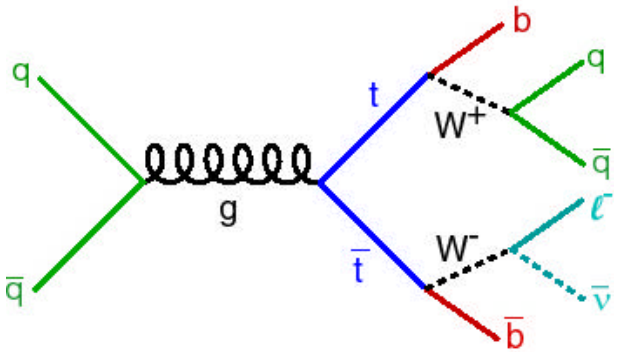


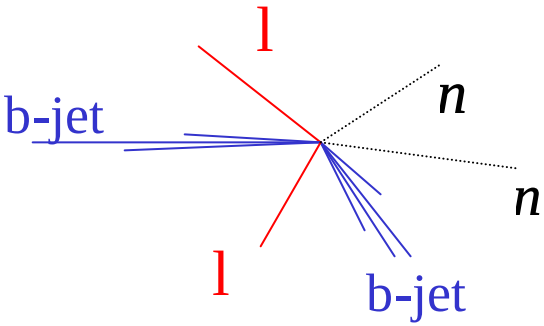
$$\frac{\sigma \cdot BR(W \to \tau\nu)}{\sigma \cdot BR(W \to e\nu)} = 0.99 \pm 0.04_{stat} \pm 0.07_{sys}$$

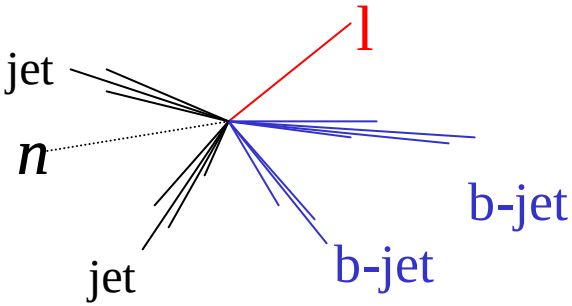
$$\frac{g_\tau}{g_e} = 0.99 \pm 0.02_{stat} \pm 0.04_{sys}$$

Top Quark Physics

- Top decays as a free quark
  - $\tau_{top} \sim 4\times10^{-25}$s
  - BR(t->Wb) ~100%
- Measured decay signals (to date)
  - Dilepton
    - 2 high-p_T leptons, 2 b jets
    - Missing E_T
    - BR (e,μ : ~5%)
    - Backg-> W+jets, fakes
  - Lepton + Jets
    - 1 high-p_T lepton, 4 jets (2 b's),
    - Missing E_T
    - BR (e,μ: ~30%)
    - Backg-> WW, ZW, $Z \to \tau\tau$, fakes

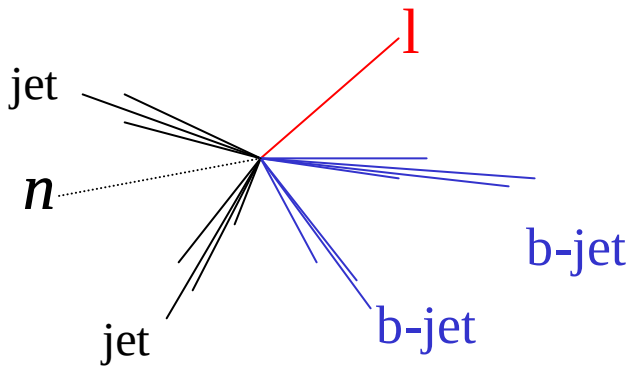


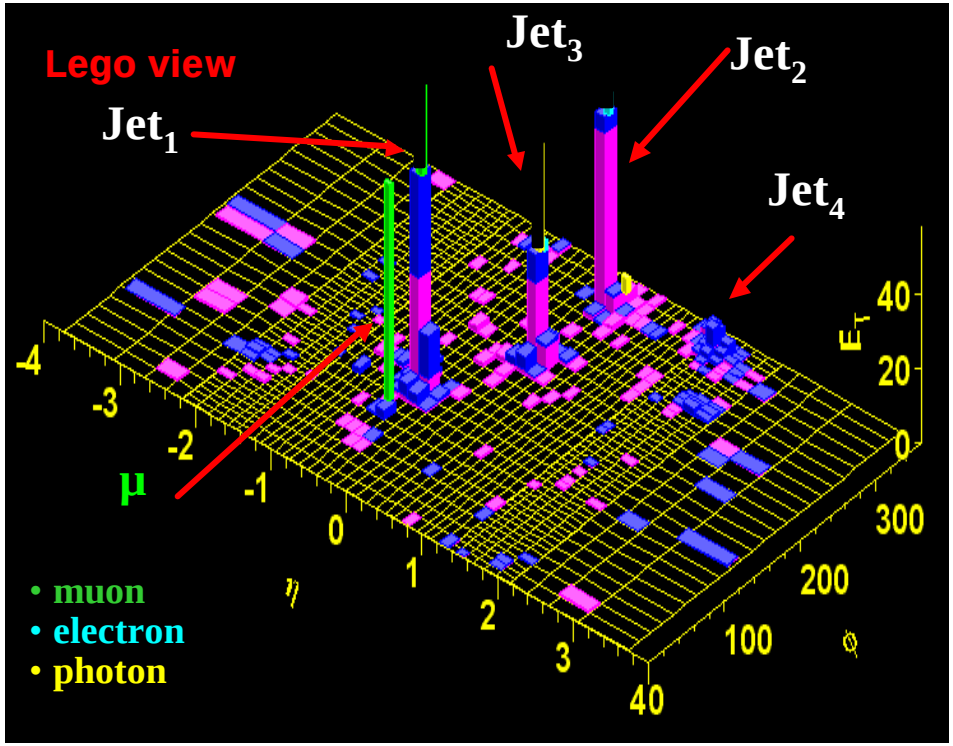


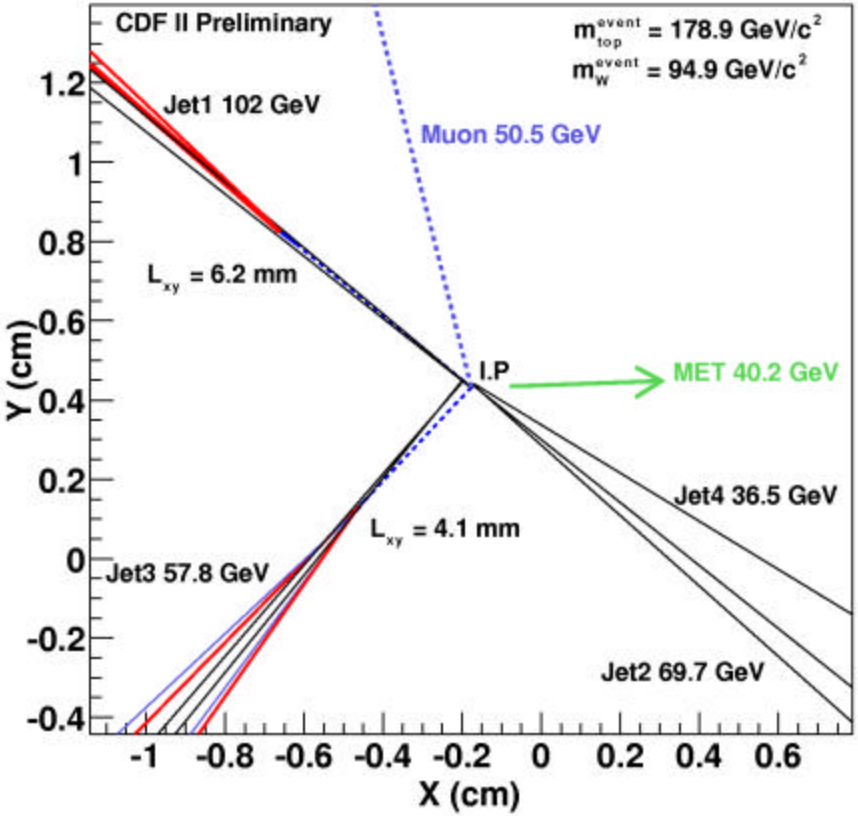


$$\sigma_{t\bar{t}}(\sqrt{s} = 1.96\,\text{TeV}) \approx 1.30 \times \sigma_{t\bar{t}}(\sqrt{s} = 1.8\,\text{TeV})$$

Lepton + Jets Candidate







$p_T(\mu)$ = 54.4 GeV

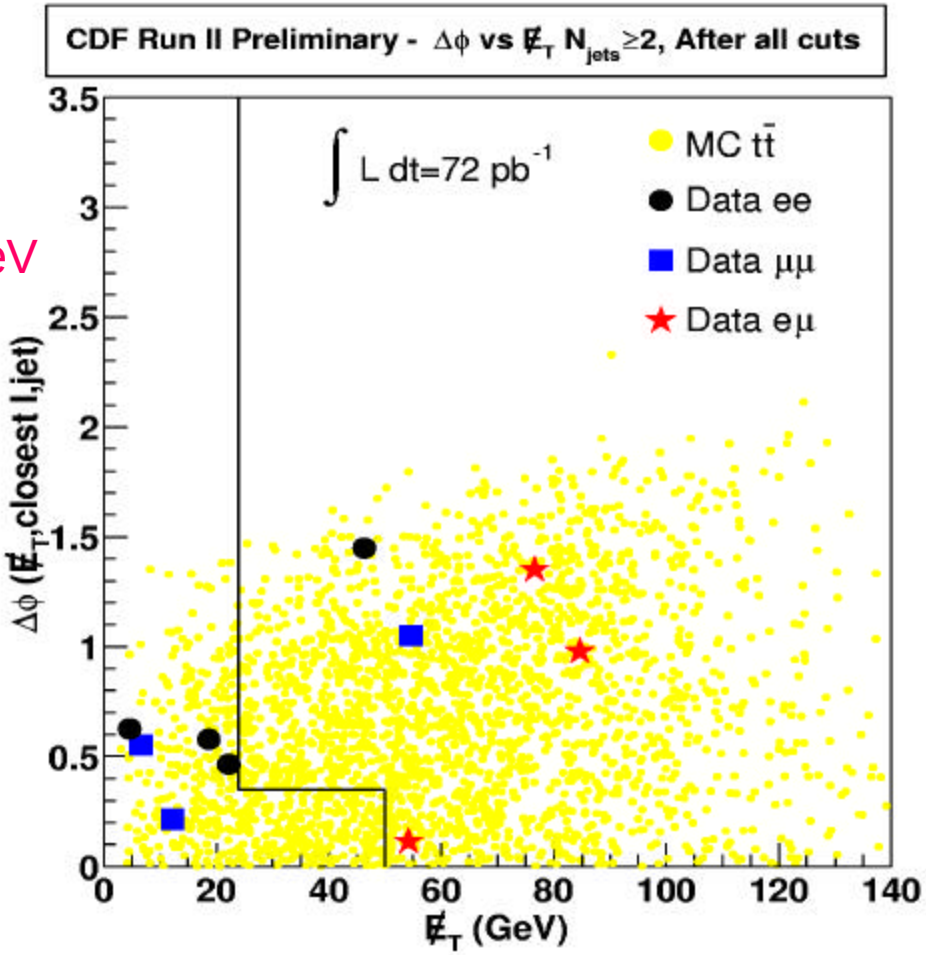
E_T^j = 96.7, 65,8, 54.8, 33.8 GeV

Missing E_T= 40.8 GeV

Top Cross Section

(Dilepton Channel)

- Signature
  - Two high p_T Isolated leptons
  - Veto Z, cosmic, conversion
  - $\Delta\Phi(E_T, l/j) > 20^o$, or Missing $E_T > 50$ GeV
  - Missing $E_T > 25$ GeV
  - Two jets with $E_T > 10$ GeV
  - Total $E_T > 200$ GeV
- Expect S/B ~ 9, S~2.5
- Find 5 candidate events in 72 pb^{-1}
- Expect 0.3 ± 0.12 backg. events

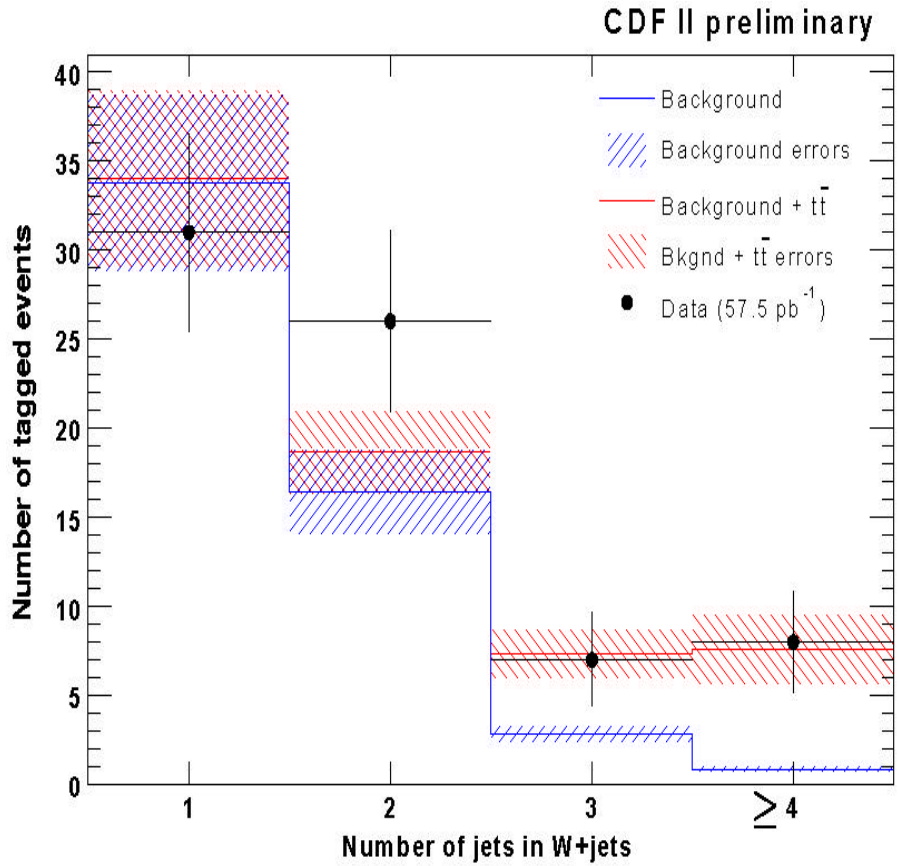


$\sigma_{tt} = 13.2 \pm 5.0_{stat} \pm 1.5_{sys}$ pb

Top Cross Section

(Lepton + Jet(s) Channel)

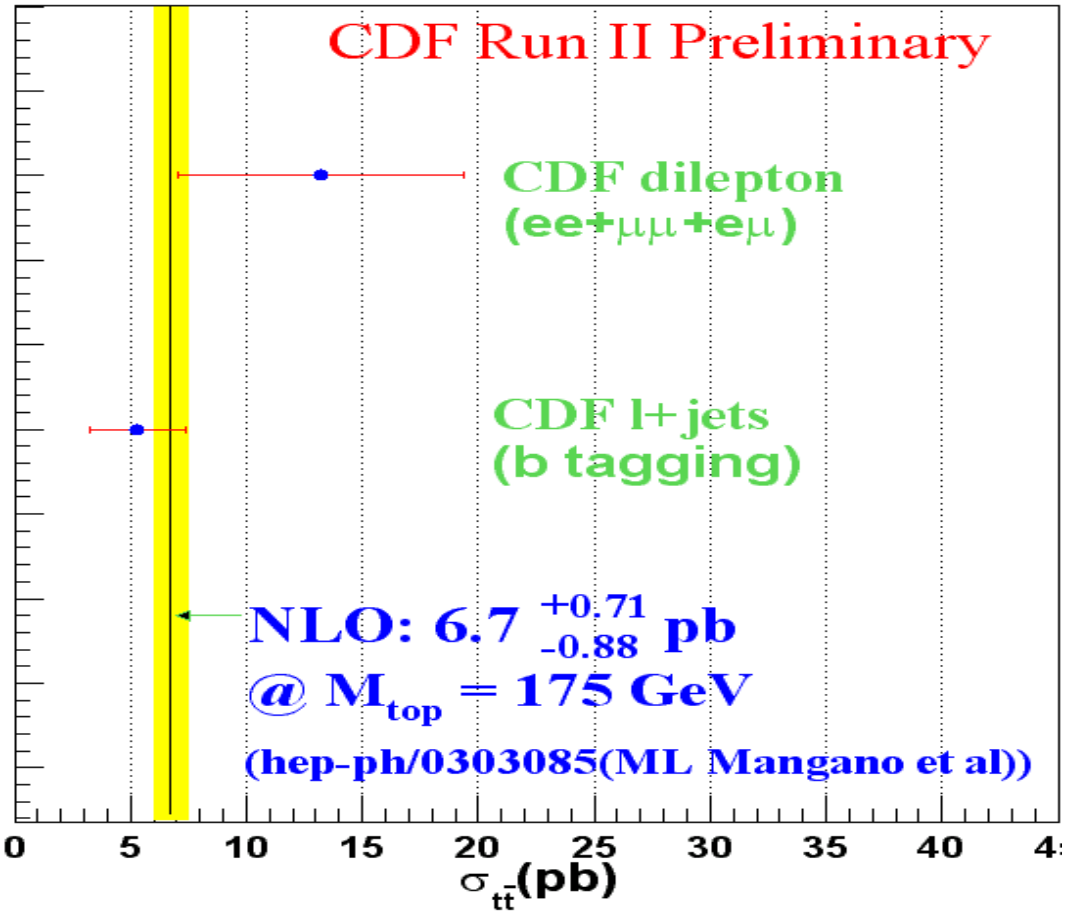
- Signature
  - One high p_T Isolated lepton
  - Veto Z, cosmic, conversion
  - Missing E_T > 20 GeV
  - 3 or more jets with E_T>15 GeV
  - 1 jet with secondary vertex tag
- B tag improves S/B 1/6 → 3/1
- 15 candidate events in 57.5 pb^{-1}
- Expect 3.8 ± 0.5 backg. events



σ_{tt}=5.3 ±1.9$_{stat}$ ±0.8$_{sys}$pb

control region ⟷ signal region

Top Production Cross Section



…updated results to come during summer…

Top Mass
(Lepton + Jets Channel)

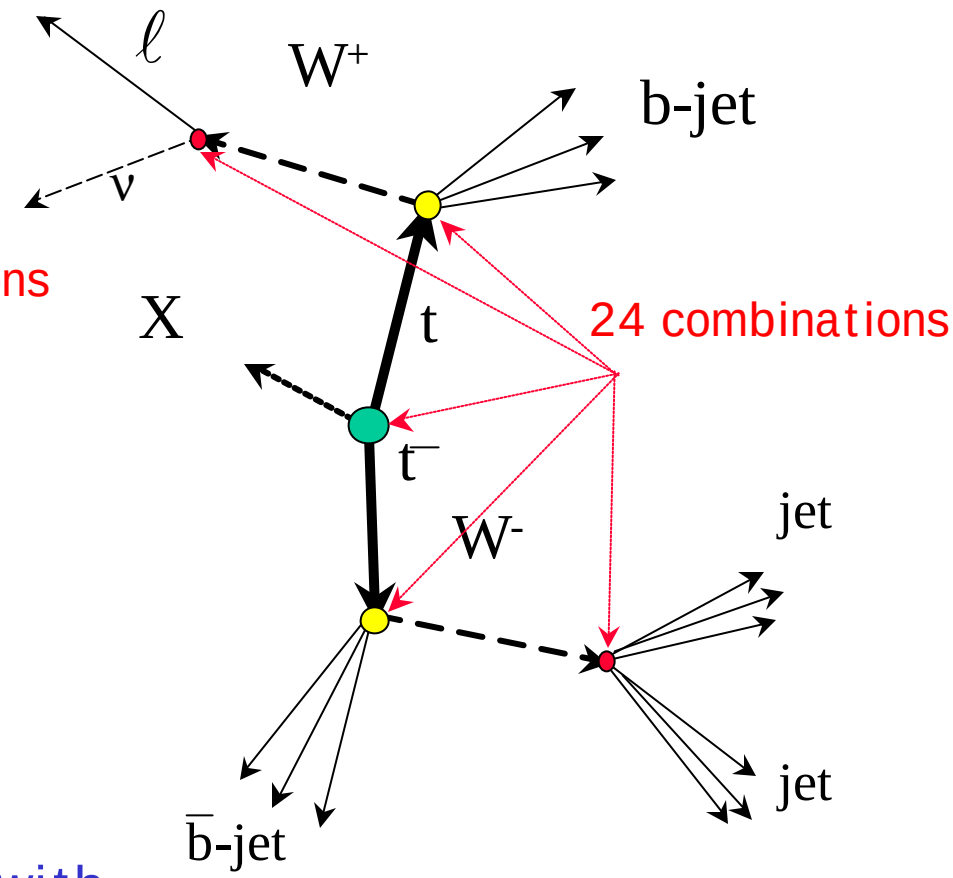
- Lepton + 4 jets (no b-tags required)
- 24 possible combinations
  - 12 for parton-jet match
  - Every combination has 2 solutions for neutrino's z-component
- Impose

$$M_{top} = M_{\overline{top}}$$

$$M(j,j) = M(l,\upsilon) = M_W$$

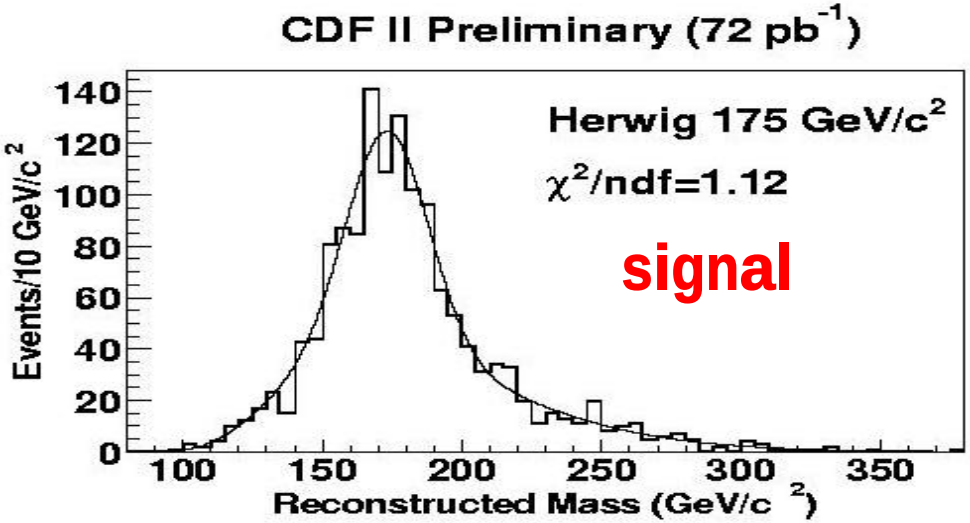
$$\text{PDG}: M_W, \Gamma_W, \Gamma_{top}$$

- 2-C fit applied and combination with smallest χ^2 value is chosen

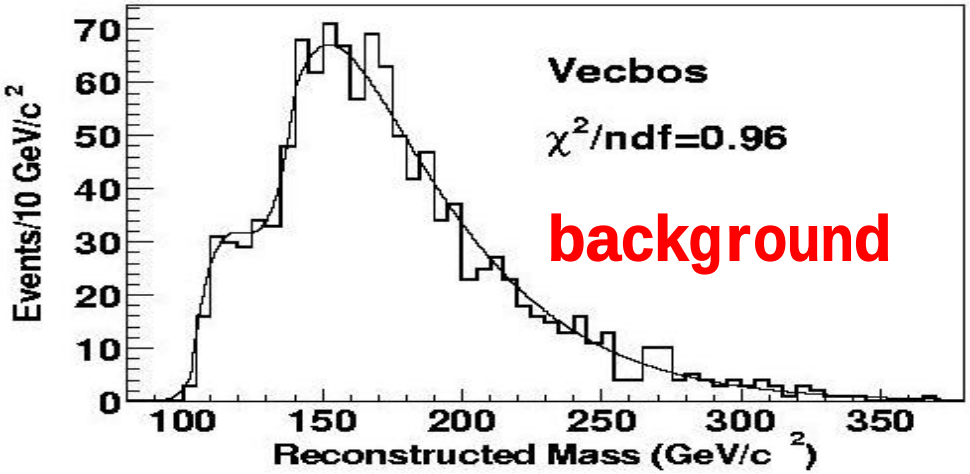


Top Mass Templates

- Reconstructed top masses from data are compared to parameterized templates of top and background Monte Carlo events

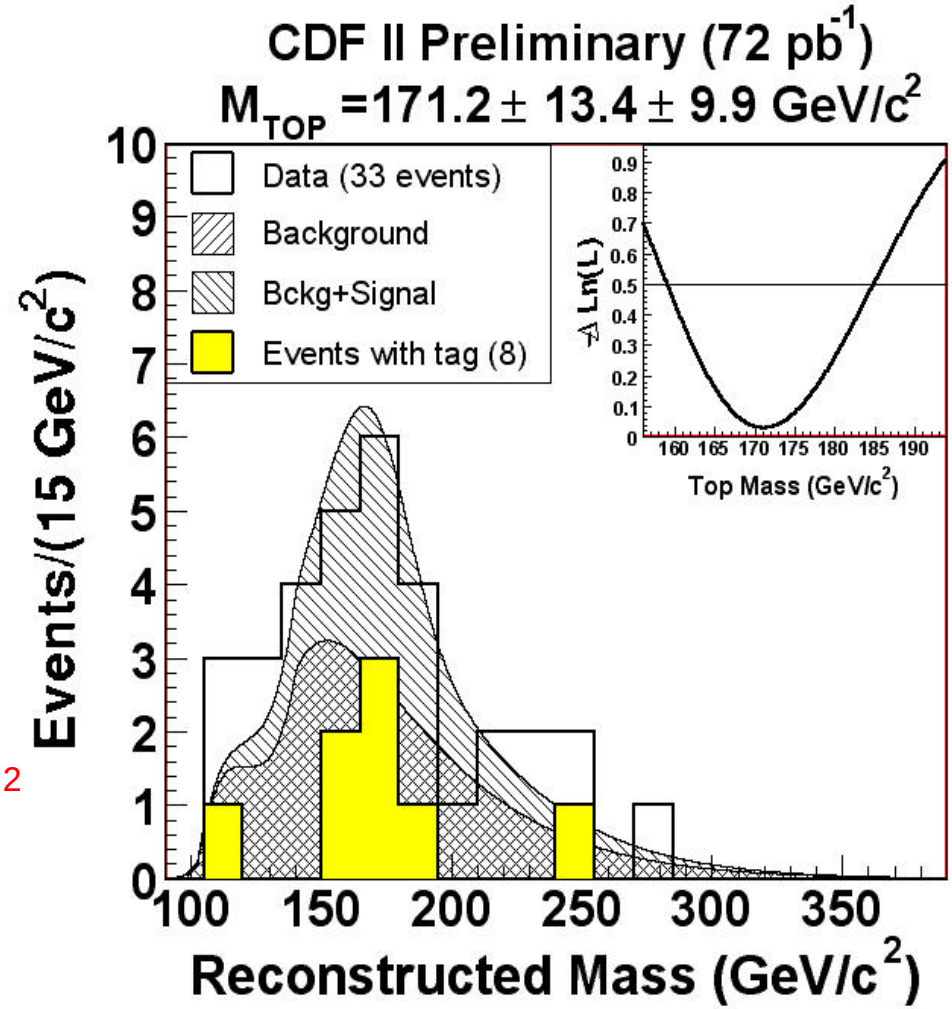


- A likelihood method is used to extract the the final top mass value



Top Mass

- Use a continuous likelihood method to extract top mass and statistical uncertainty
- M_{top} is the minimum of the log-likelihood distribution
- σ_{top} corresponds to a change of 0.5 units in the log-likelihood

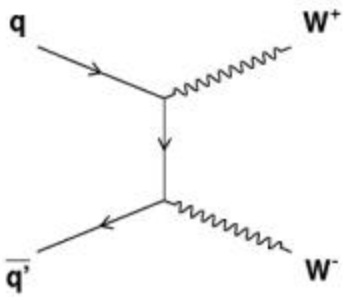


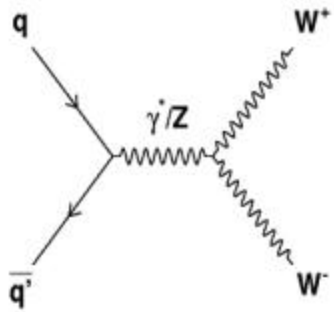
$M_{top} = 171.2 \pm 13.4_{stat} \pm 9.9_{sys}$ GeV/c^2

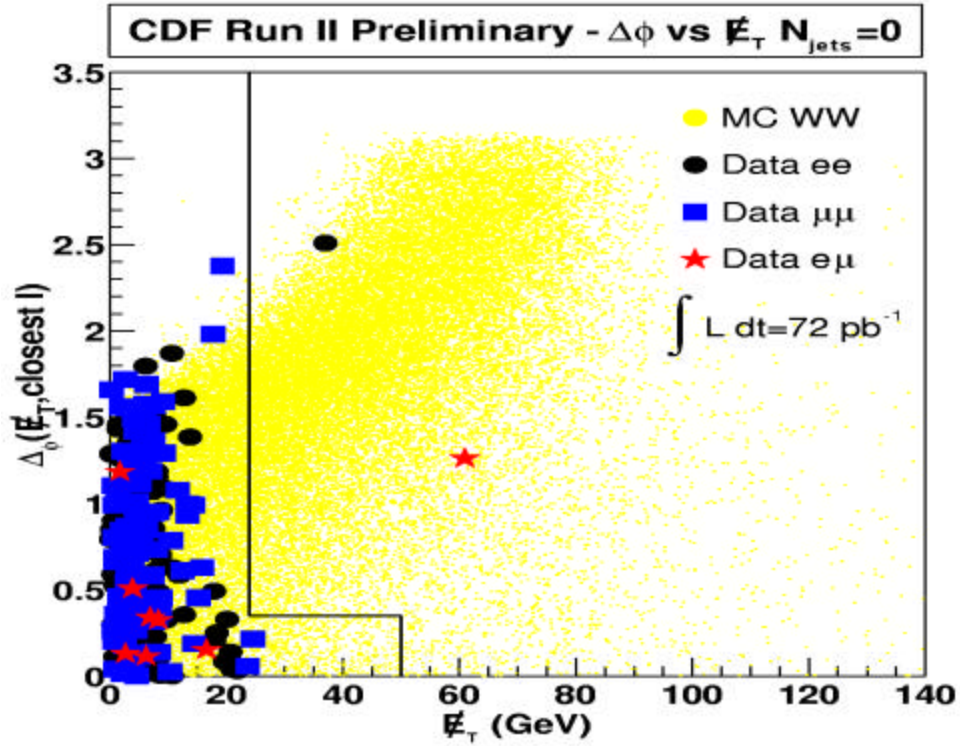
CDF Run 1 combined:
$M_{top} = 176.1 \pm 6.5$ GeV/c^2

..syst. uncertainty dominated by jet e-scale...

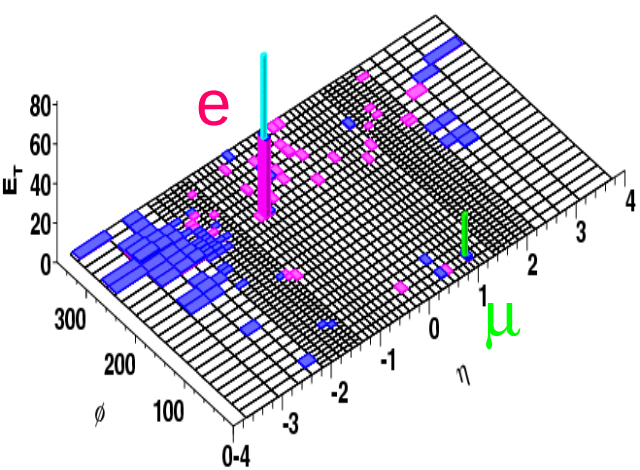
WW→llνν Production







- Signature
  - Dileptons & Missing E_T
  - $\Delta\phi$(Missing E_T , l/j)
- 72 pb^{-1}



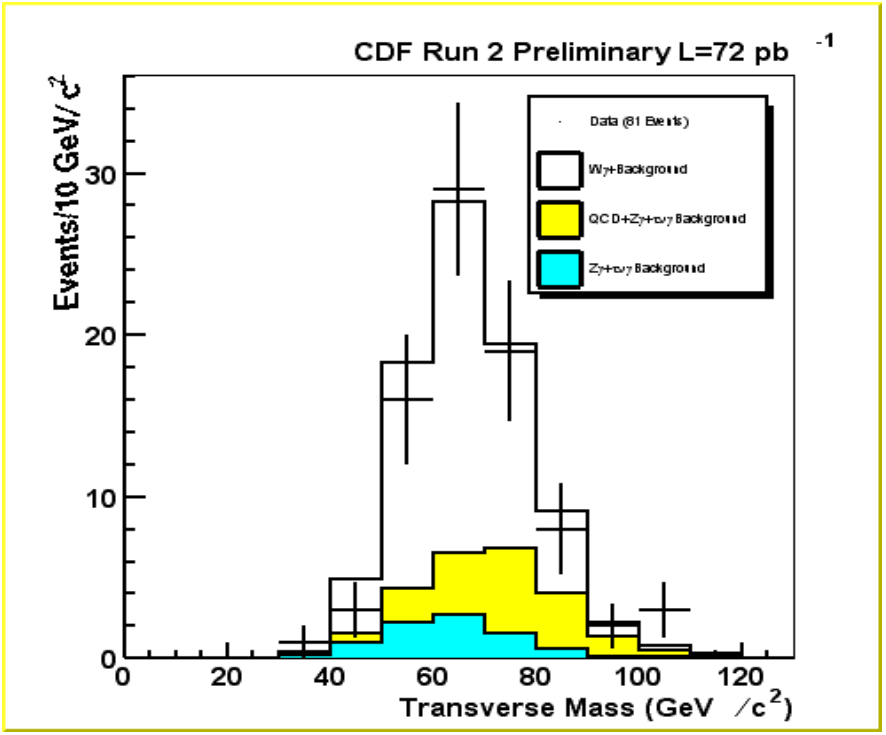
	ee	μμ	eμ	ll
Backgr.	0.29±0.13	0.47±0.19	0.77±0.60	1.53±0.64
WW→llnn	0.55±0.13	0.66±0.15	1.58±0.36	2.79±0.62
Data	1	0	1	2

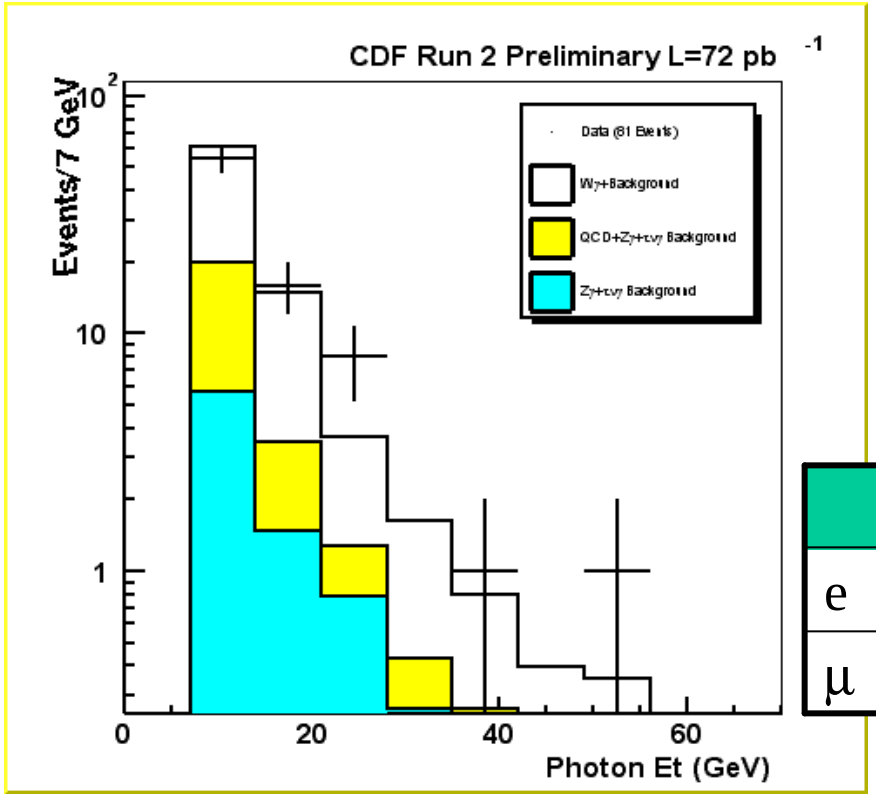
Consistent with SM ….waiting for more data…

Wγ Production

Signature

- One high p_T lepton
- One photon ($\Delta R(\gamma\text{-}l)>0.7$)
- Missing E_T





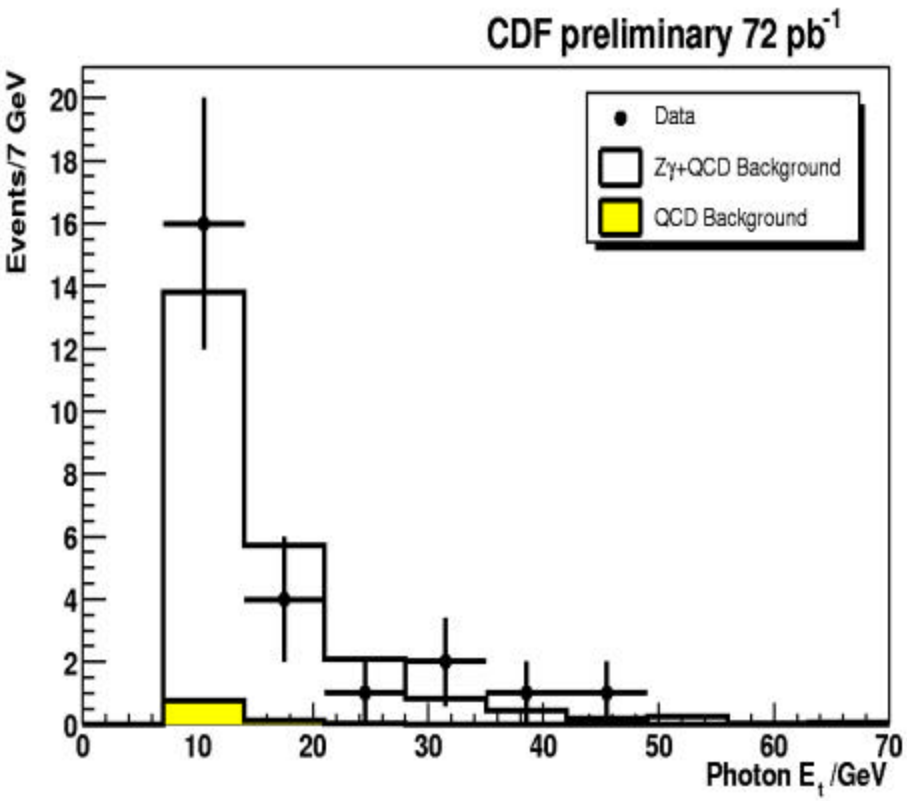
	Sample	Back.	σ•B(Wγ-->lνγ) (pb)
e	43	33%	**17.2**$\pm3.8_{stat}\pm2.8_{sys}\pm1.0_{lum}$
μ	38	29%	**19.8**$\pm4.5_{stat}\pm2.4_{sys}\pm1.2_{lum}$

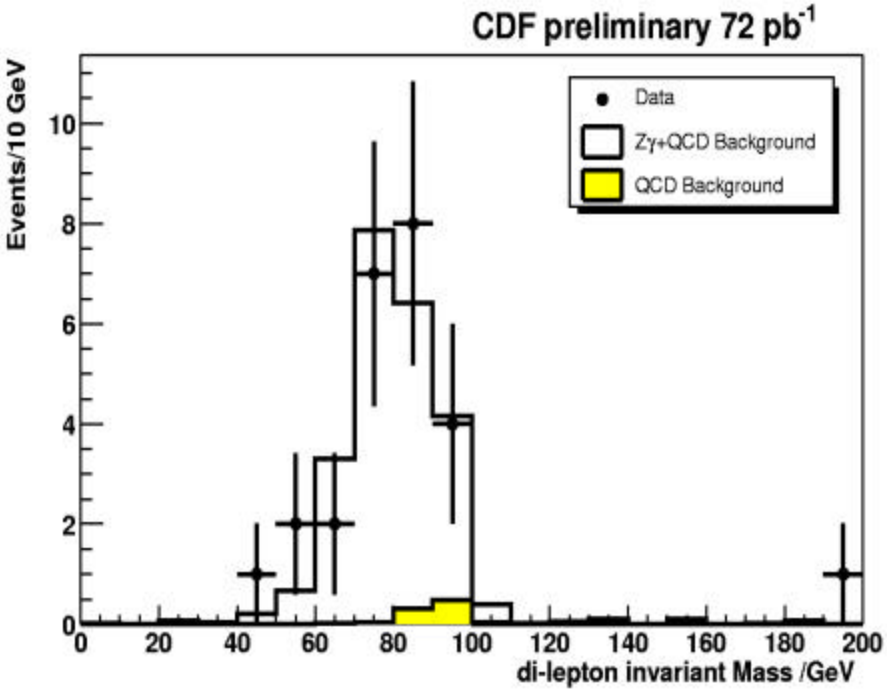
SM: σ•B(Wγ-->lνγ) = 18.7 ±1.3 pb

Zγ Production

Signature

- Two high p_T leptons
- One photon ($\Delta R(\gamma\text{-}l)>0.7$)



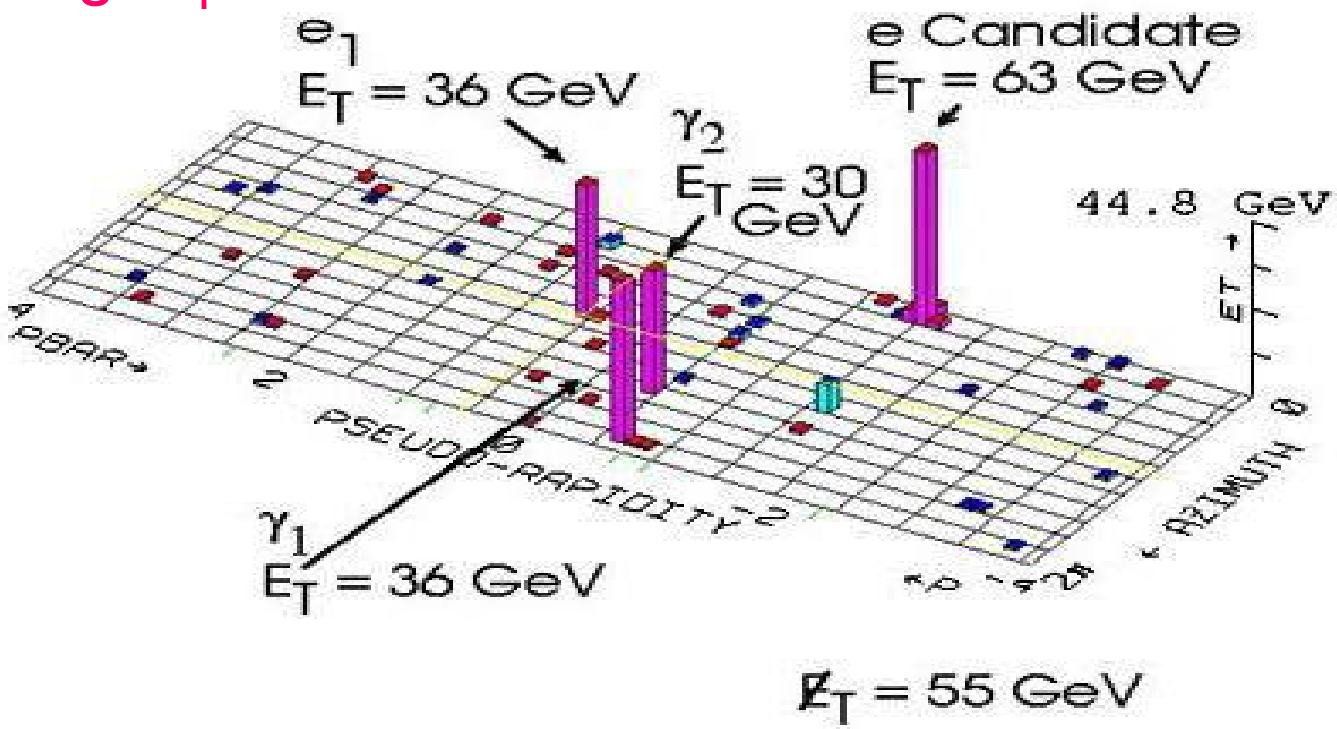


	Sample	Back.	σ•B(Zγ-->llγ) (pb)
e	11	4.6%	**5.5**±1.7$_{stat}$±0.6$_{sys}$±0.3$_{lum}$
m	14	4.0%	**6.0**±1.6$_{stat}$±0.7$_{sys}$±0.4$_{lum}$

SM: σ•B(Zγ-->llγ) = 5.4 ± 0.4 pb

Following up Run I anomalies

$\gamma\gamma$ ee + Missing E_T



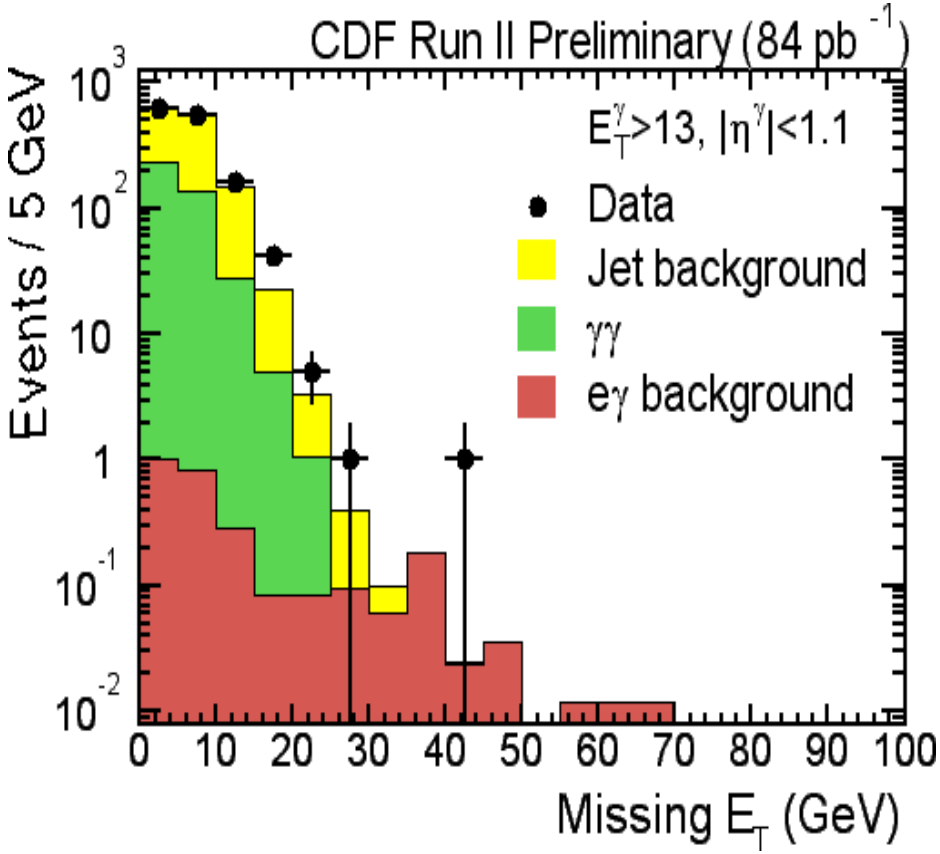
It was proposed as possible SUSY candidate
..e.g., radiative decay of neutralinos…
(GMSB scenario where gravitino is the LSP)

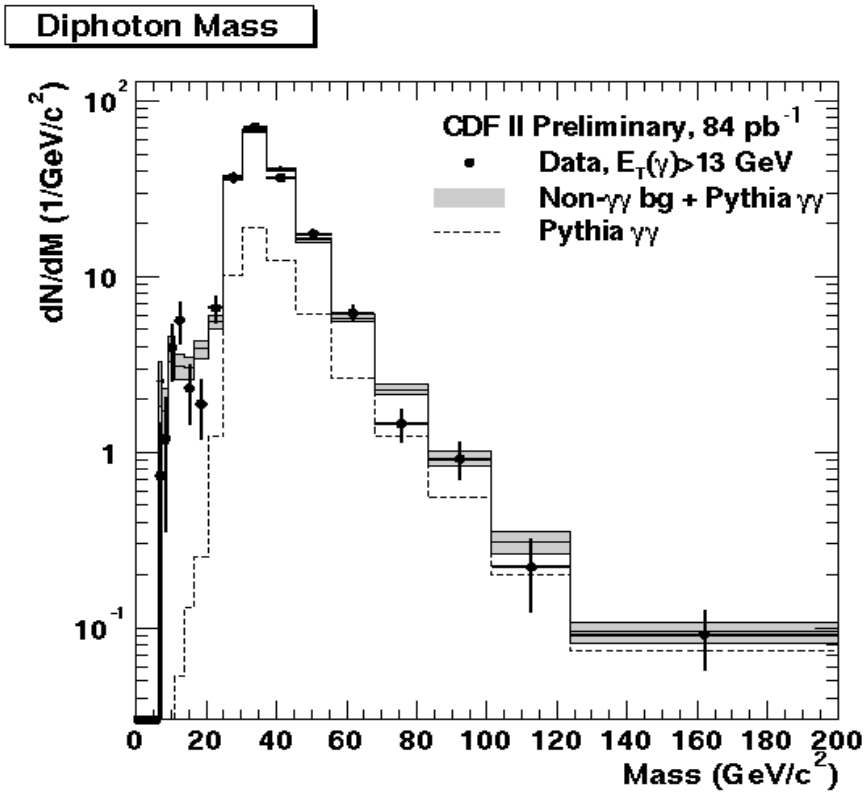
Run II Diphoton Search

Two central photons E_T>13 GeV

Cosmic and beam halo rejection

Good agreement with SM

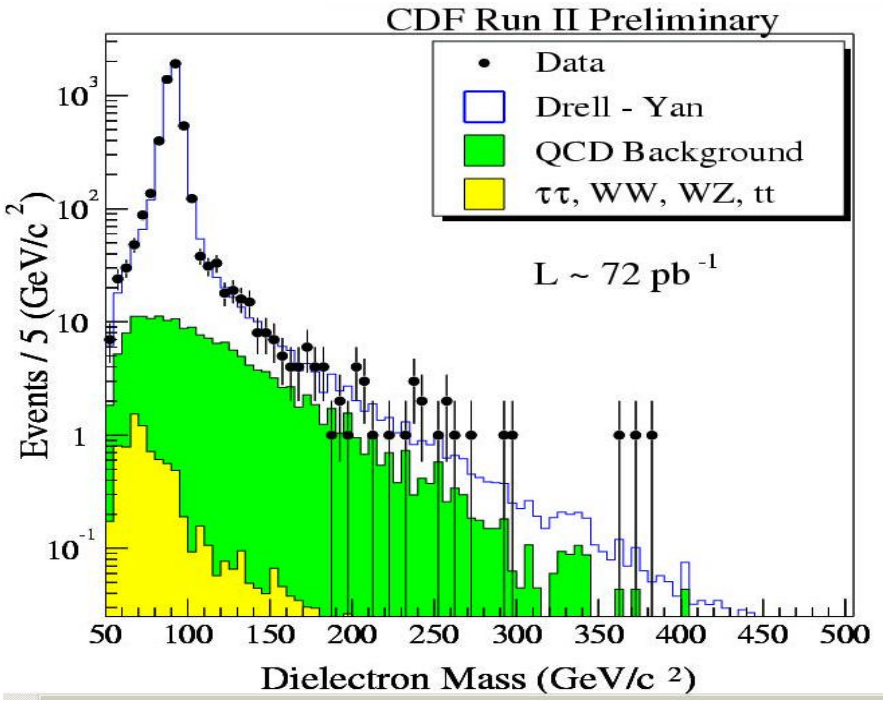




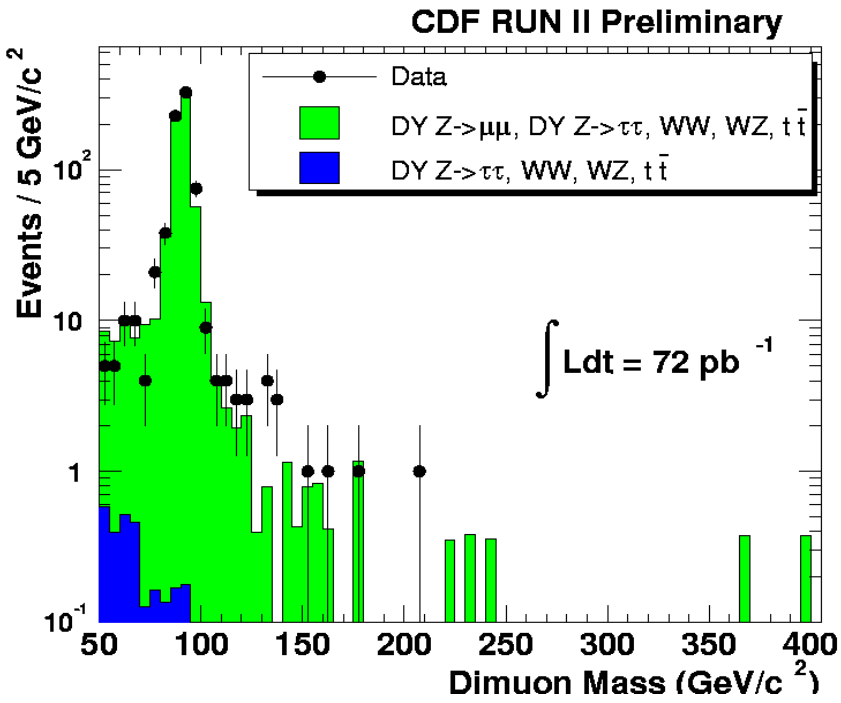
…no Diphoton + Lepton(s) Events Observed…

Drell-Yan Spectra

- Two high pt isolated electrons
- No significant Missing Et



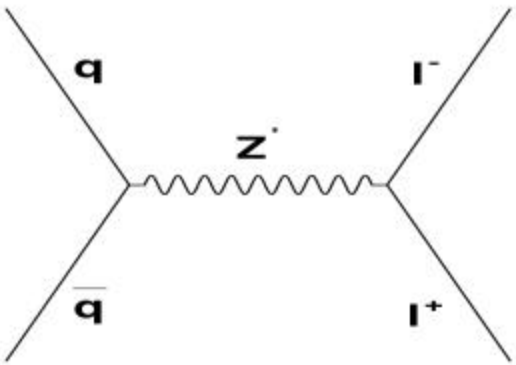
- Two high pt isolated muons
- veto against cosmic rays



No excess observed

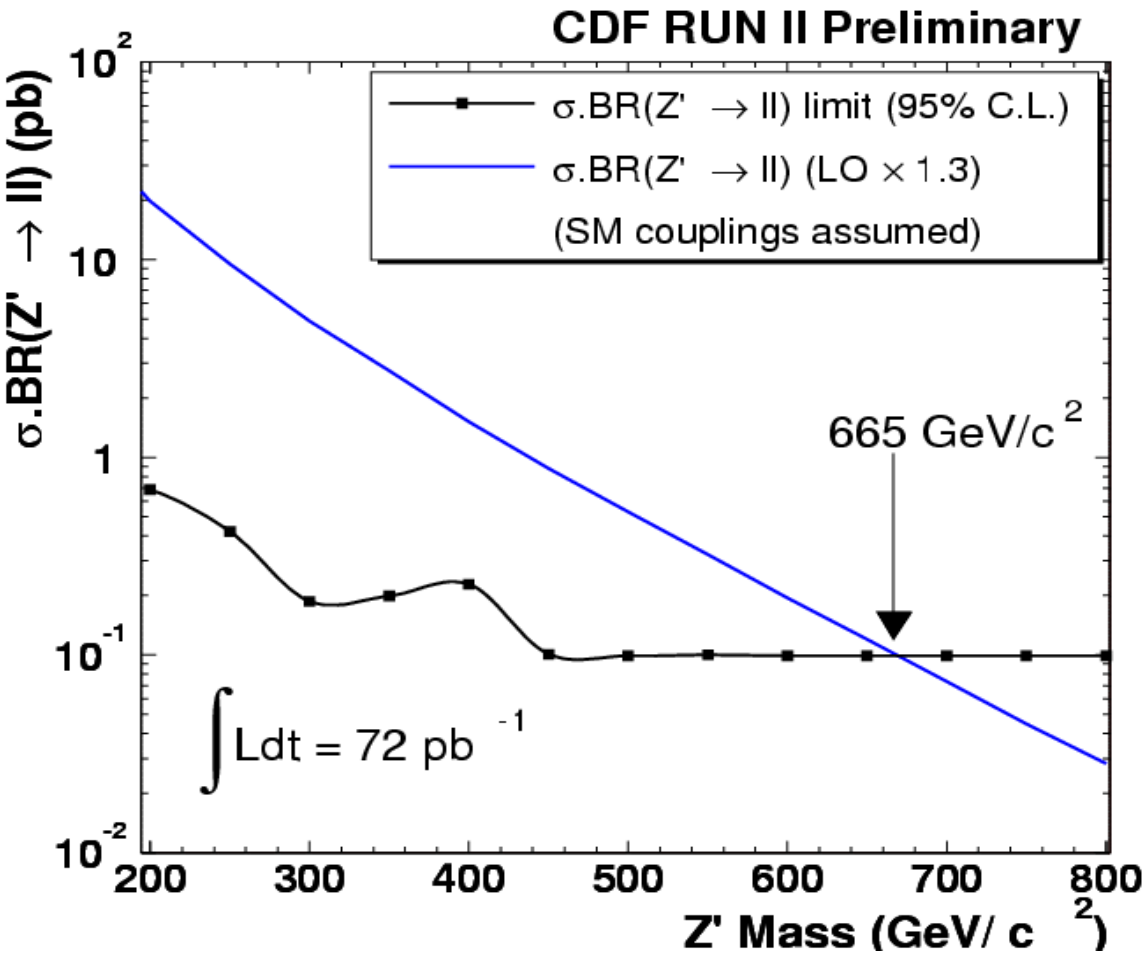
Mass > 150 GeV	ee	μμ
Events Data	63	4
SM Expected	62.8	5.16

Z' Limits



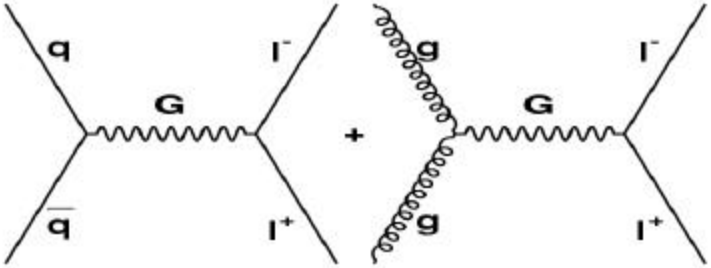
New Limits @ 95% C.L.
(SM-like coupling)

	M(Z') 95%CL Limit (GeV)
electrons	> 650
muons	> 455
combined	> 665



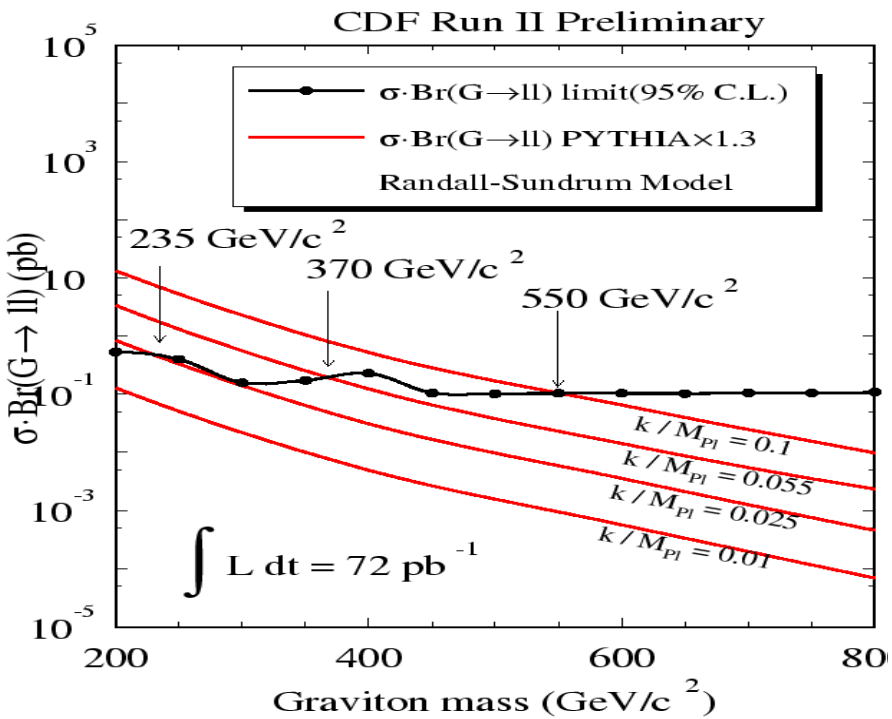
σBr(Z'-> ll) < 0.1 pb for M(Z') >500 GeV

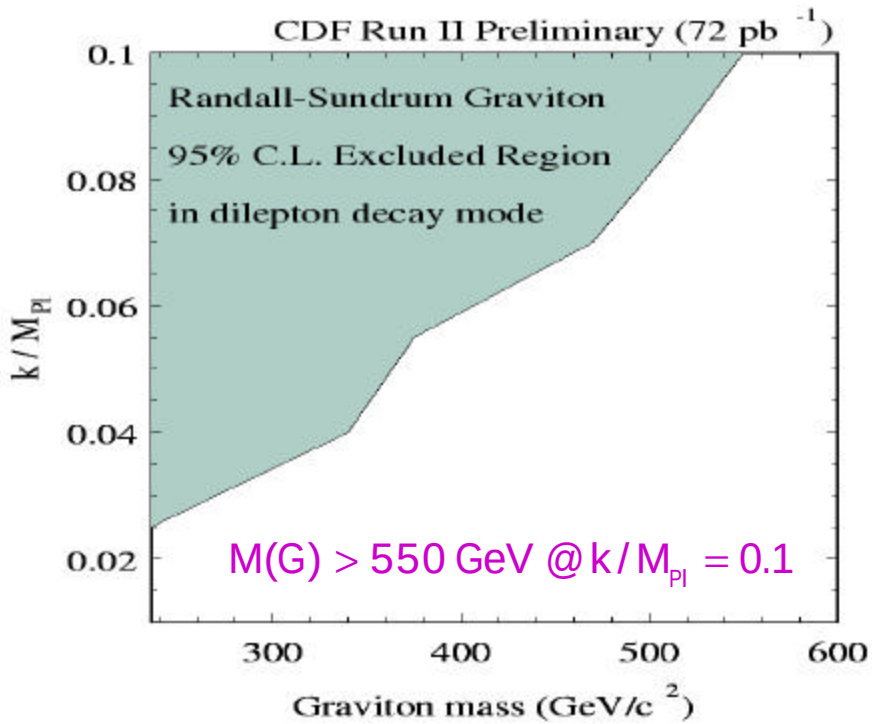
Randall-Sundrum Graviton Limits



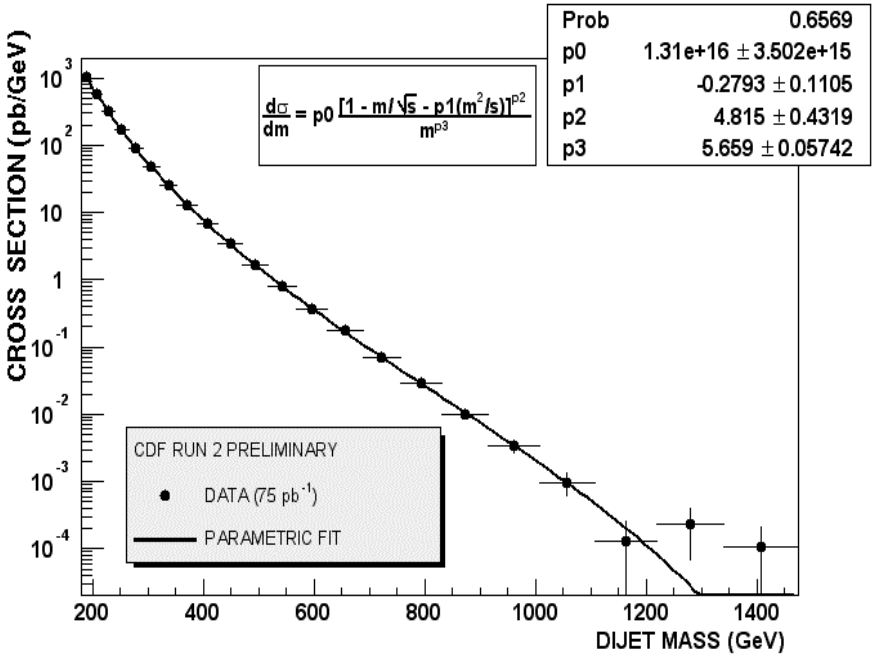
Excited graviton (spin-2 KK resonance)

- Two free parameters : M(Graviton), k/M(Planck)
- k/M(Planck) determines the coupling and resonance width



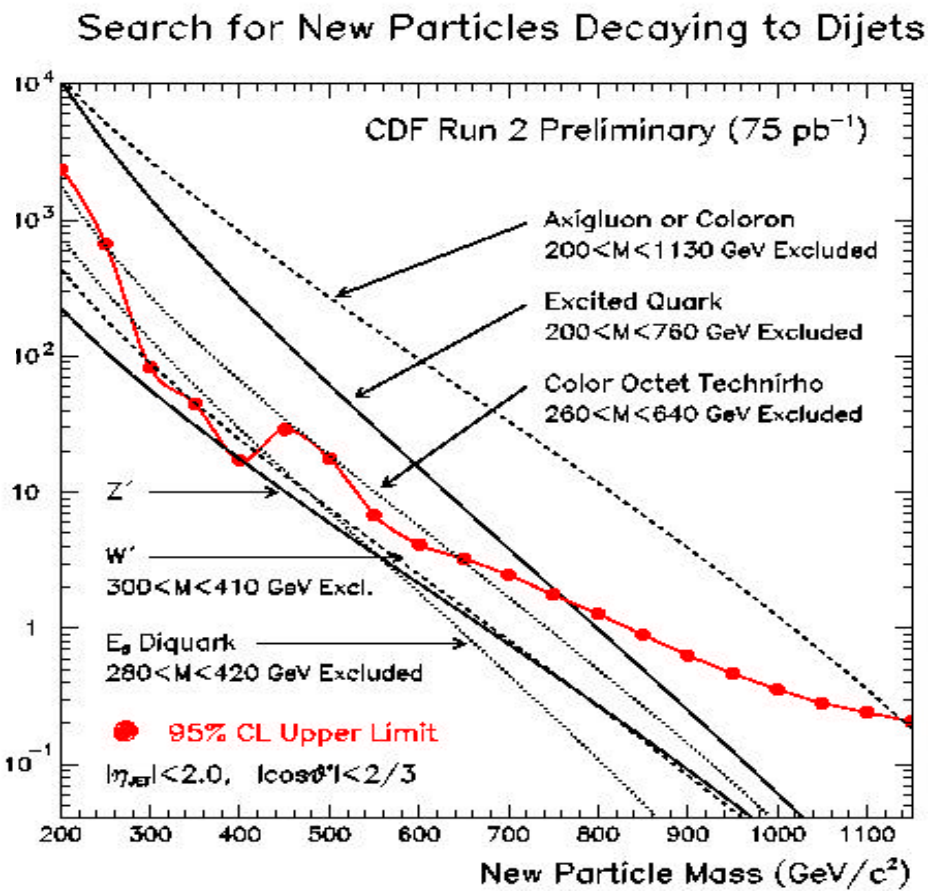


Search for Resonance in Dijets

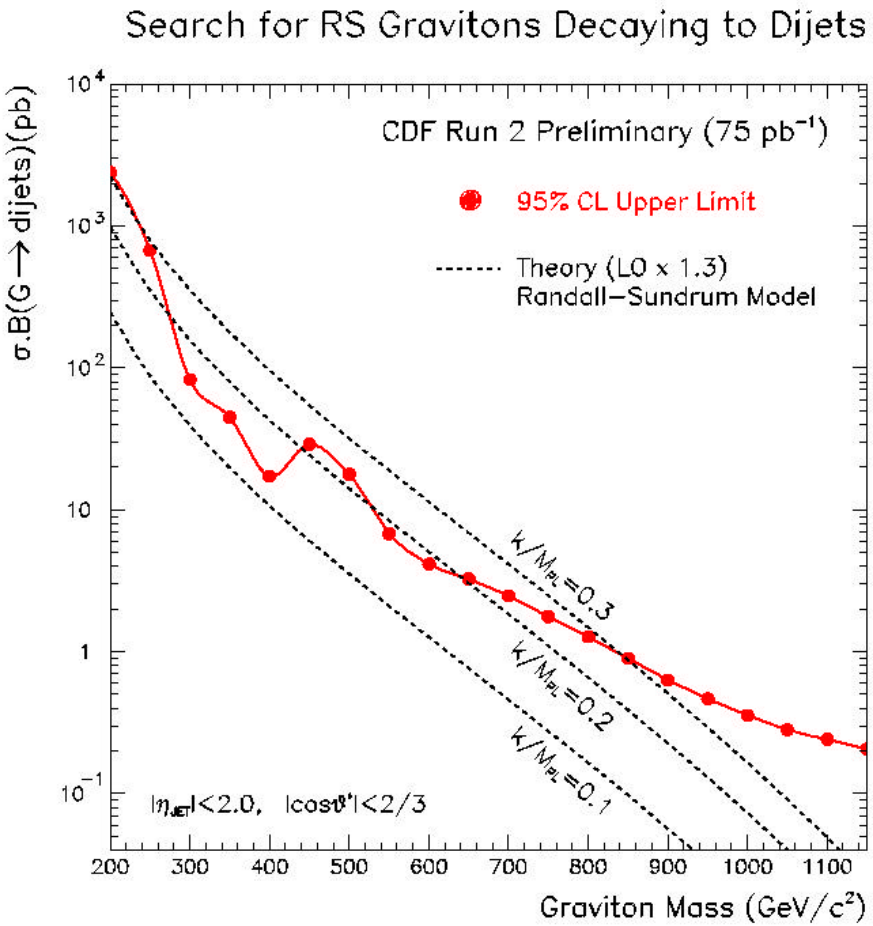


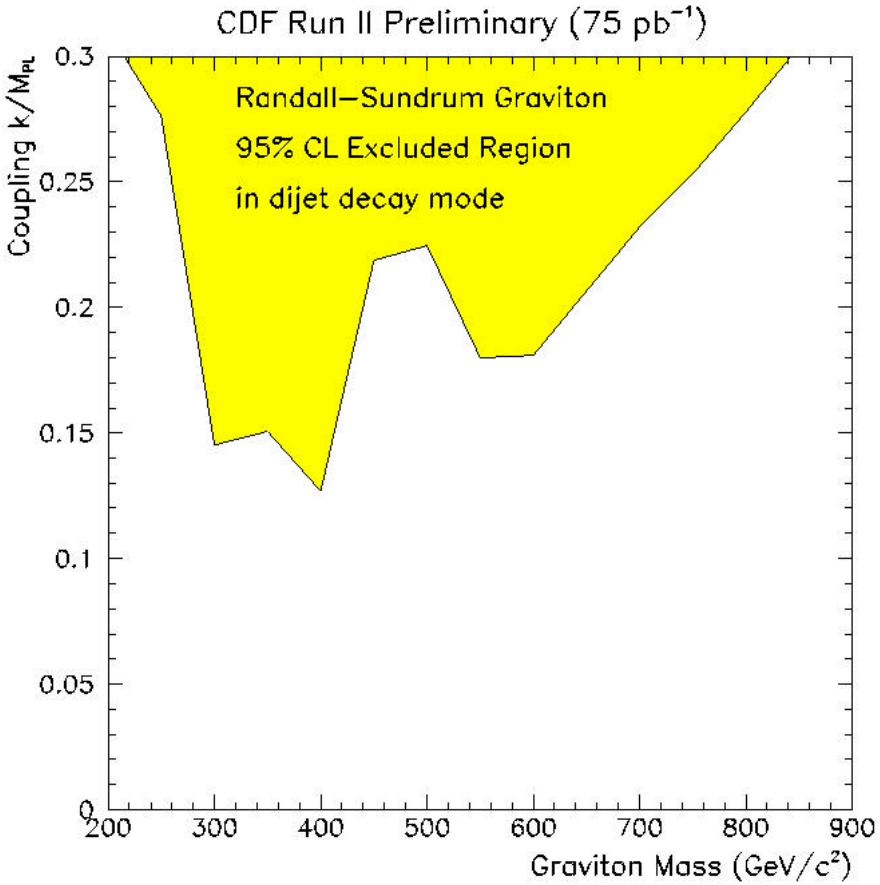
Consistent with SM shape
...used to set limits on new physics..

New Particle	Limit (GeV)
Axigluons/Colorons	200< M <1130
Excited quarks	200< M <760
Color octet techni-ρ's	260< M < 640
E6 diquarks	280 < M < 420
Z'/W'	300 < M < 410



Randall-Sundrum Limits from Dijets



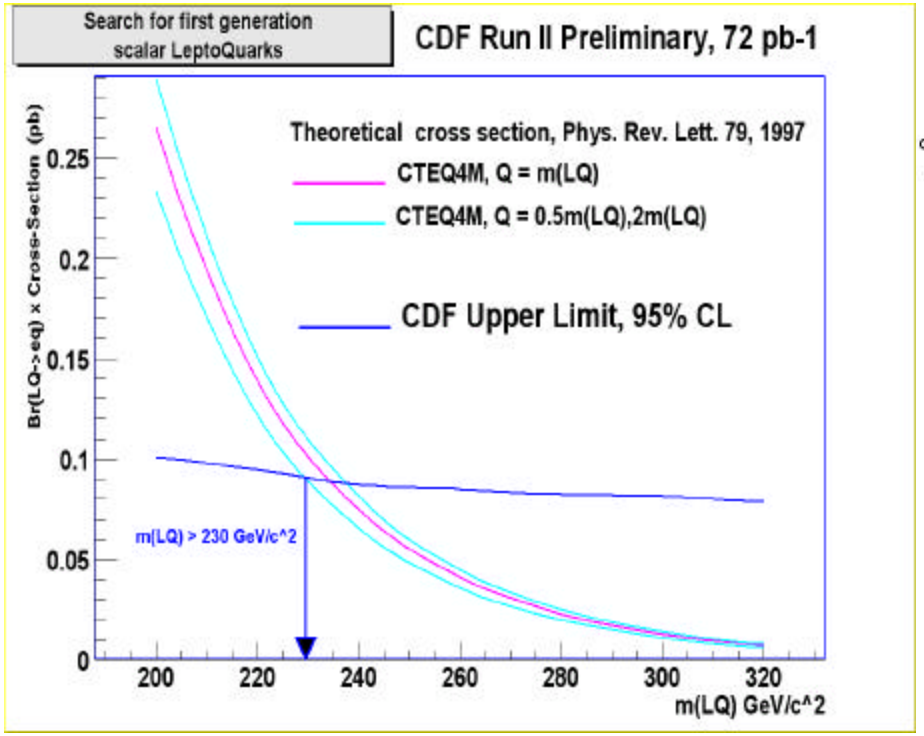


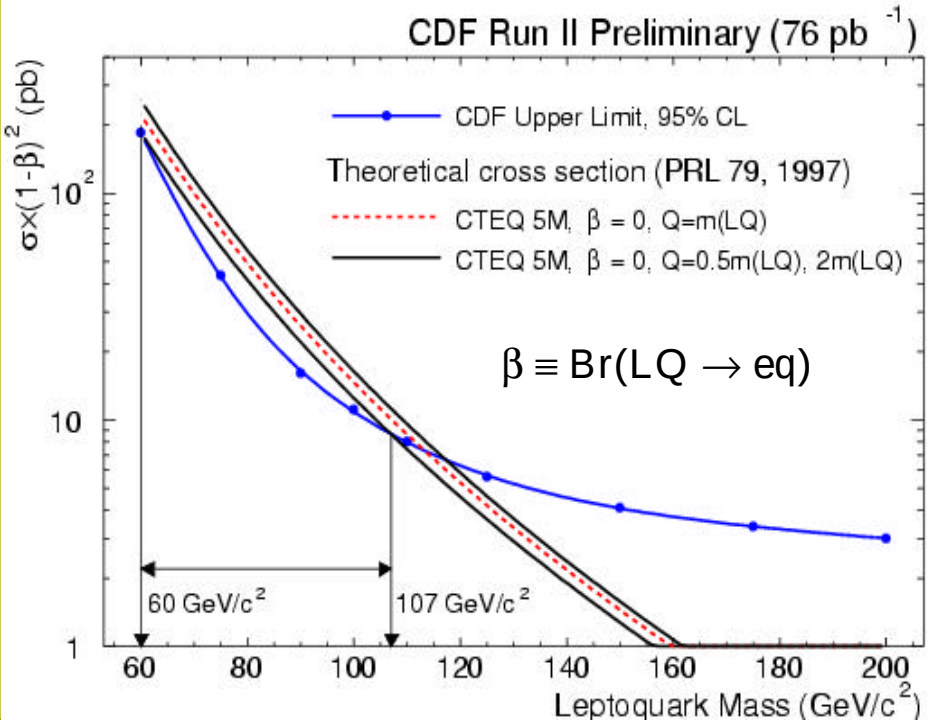
Dijet channel excludes region: $k / M_{Planck} \sim 0.3, 200 < M_{dijets} < 800$

First Generation Scalar LeptoQuarks

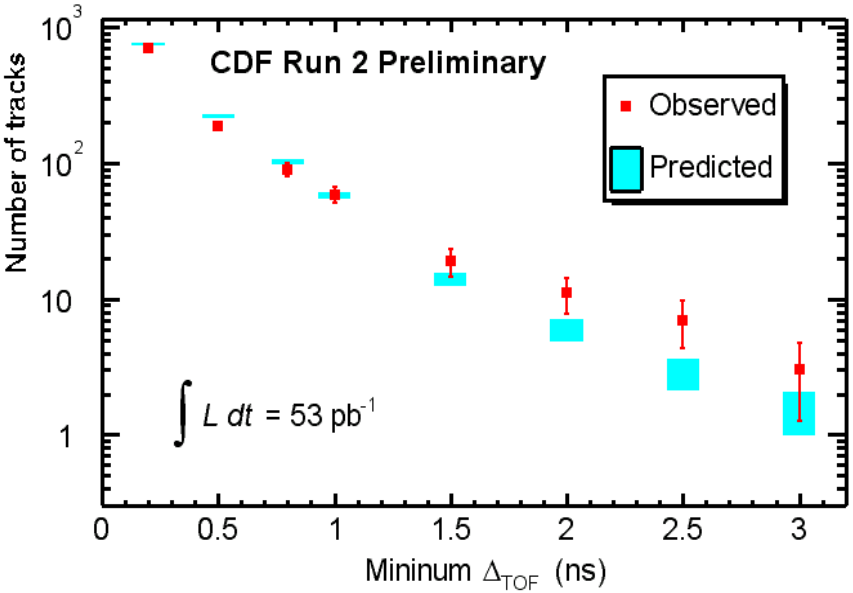
- LQLQ → e^+e^-qq
  - 2 high E_T electrons, 2 jets
- 0 events observed
  - Background: 3.4±3 events
  - Limit: M(LQ)>230GeV/c^2

- LQLQ →$\nu\nu qq$
  - 2 high E_T jets, large E_T
- 42 events observed
  - Background: 43±11 events
  - Exclusion:60<M(LQ)<107GeV





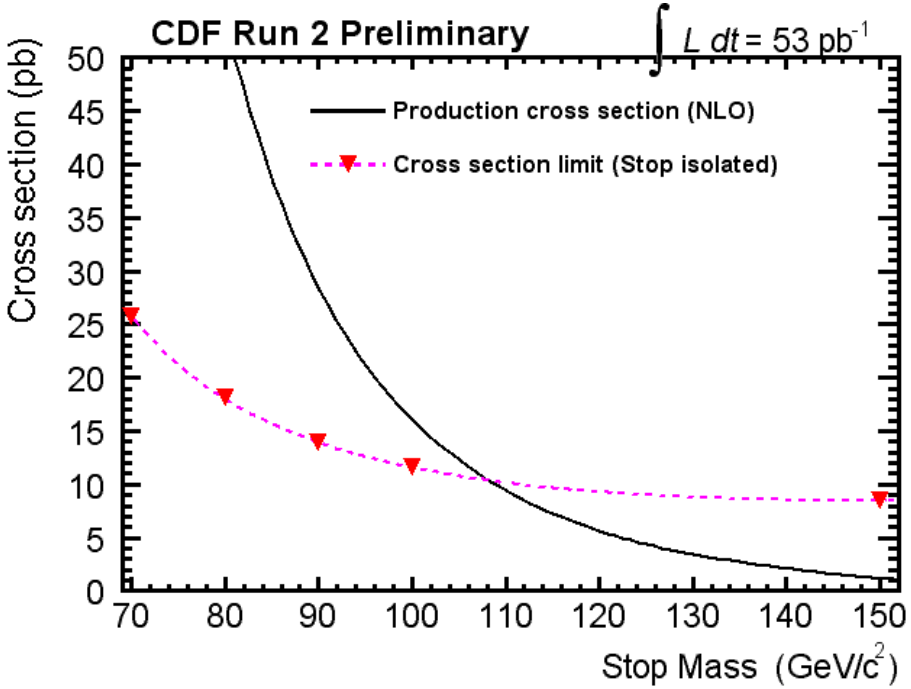
Charged Massive Particles



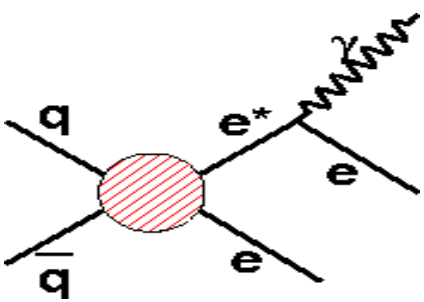
- Long-lived charged particle
- Massive → Slow moving
- Use time from TOF data
- Define ΔTOF as difference w.r.t. a particle moving with speed = c

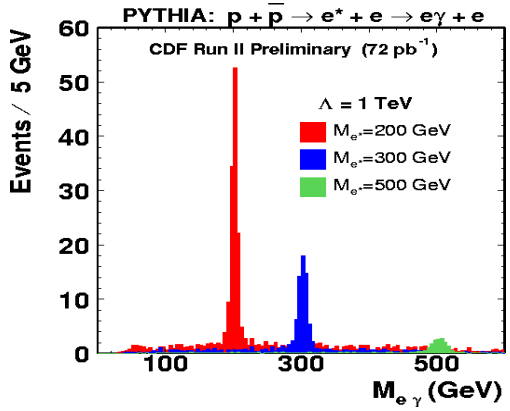
Signal Region : ΔTOF > 2.5 ns

- 7 events observed (Background: 2.9±3.2 events)
- Candidate: stop
  - NLSP in GMSB
- Limit: M(stop) > 108 GeV



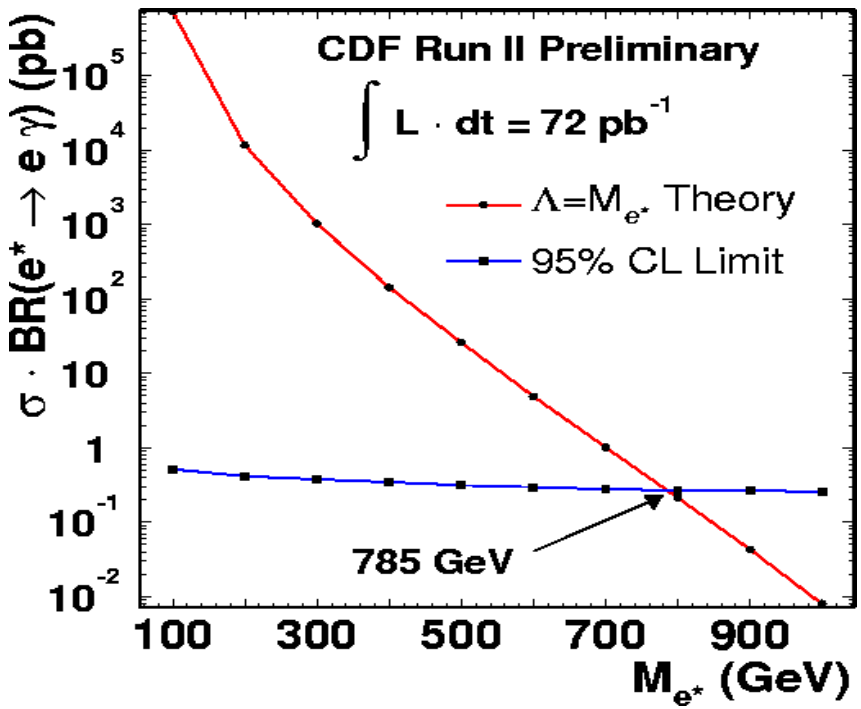
Limits on Excited Fermions

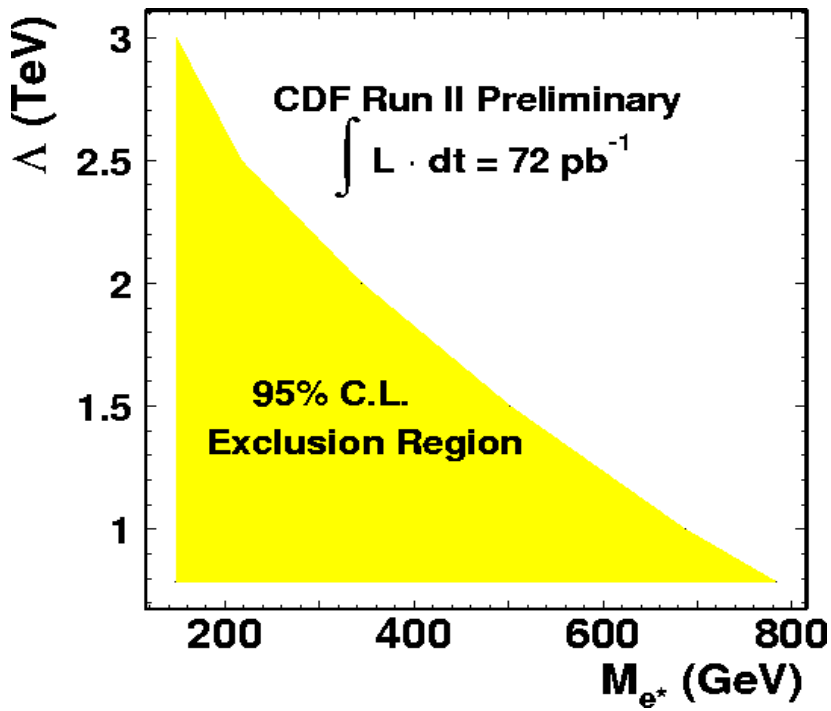




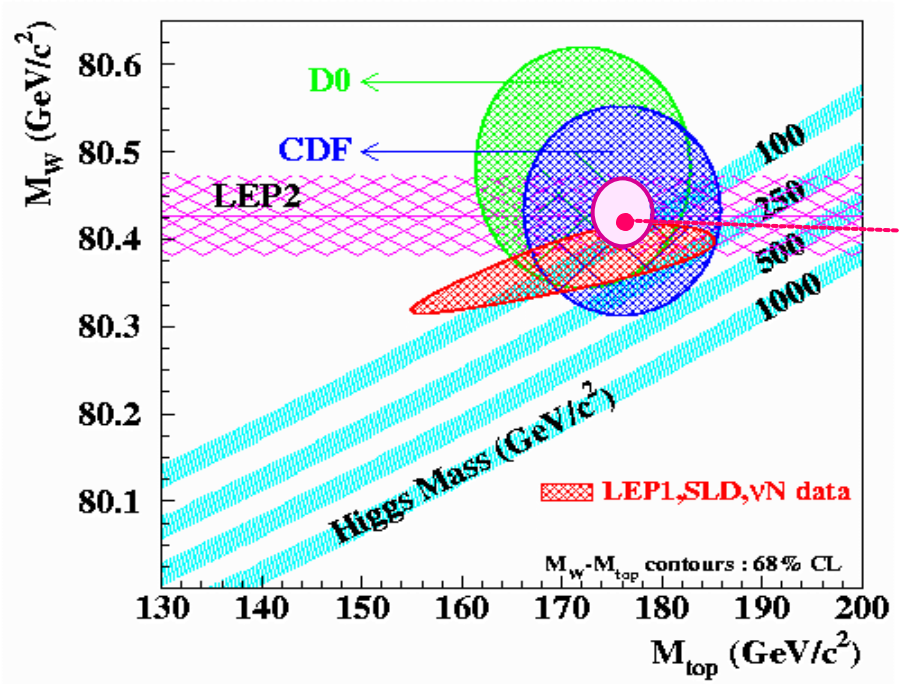
- Compositeness models
- Clear Signature in $M_{e\gamma}$
- Two parameters:

  Λ (comp. scale), $M_{e\gamma}$



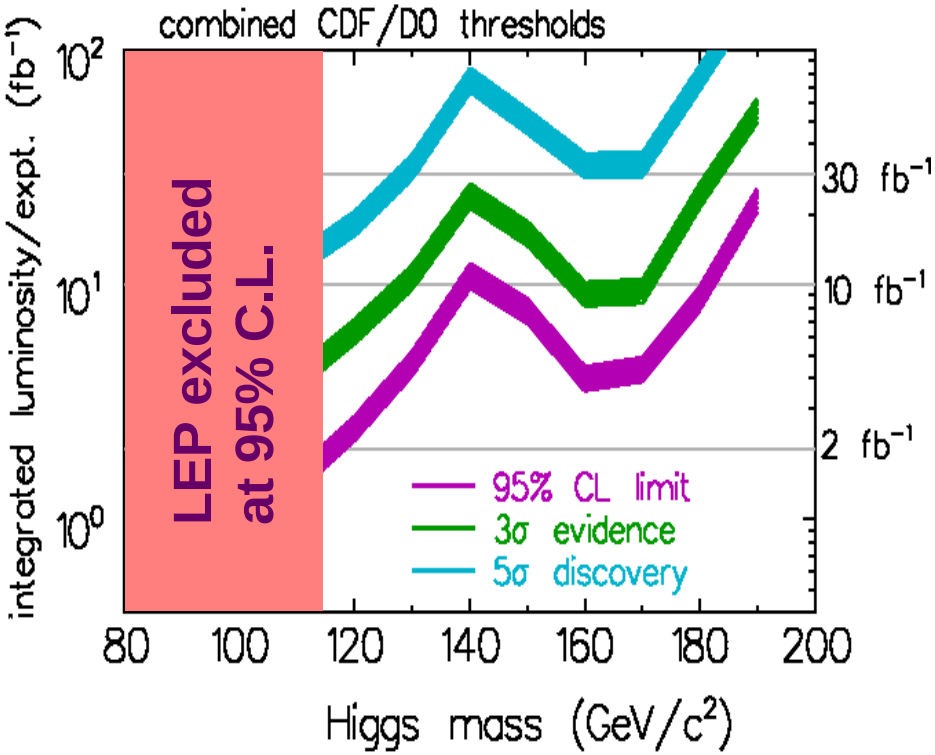


SM Higgs Prospects



Run IIa prospects (2 fb-1)

$\delta M_W \sim 40$ MeV
$\delta M_t \sim 3$ GeV



- Higgs direct search will need time & lots of luminosity
- Ongoing revisited estimations with Run II detector simulation (Report expected by June'03)

Summary

- Tevatron performance gradually improving…
- CDF detector working beautifully and taking data with great efficiency.
- Many results already presented in all fronts!

…very exciting years to come!….lots of physics!…