INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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SMR.762 - 32

SUMMER SCHOOL IN HIGH ENERGY PHYSICS AND COSMOLOGY

13 June - 29 July 1994

HIGHLIGHTS FROM THE FERMILAB PROTON-ANTIPROTON COLLIDER AND PERSPECTIVES

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HIGHLIGHTS FROM THE FERMILAB PROTON-ANTIPROTON COLLIDER AND PERSPECTIVES

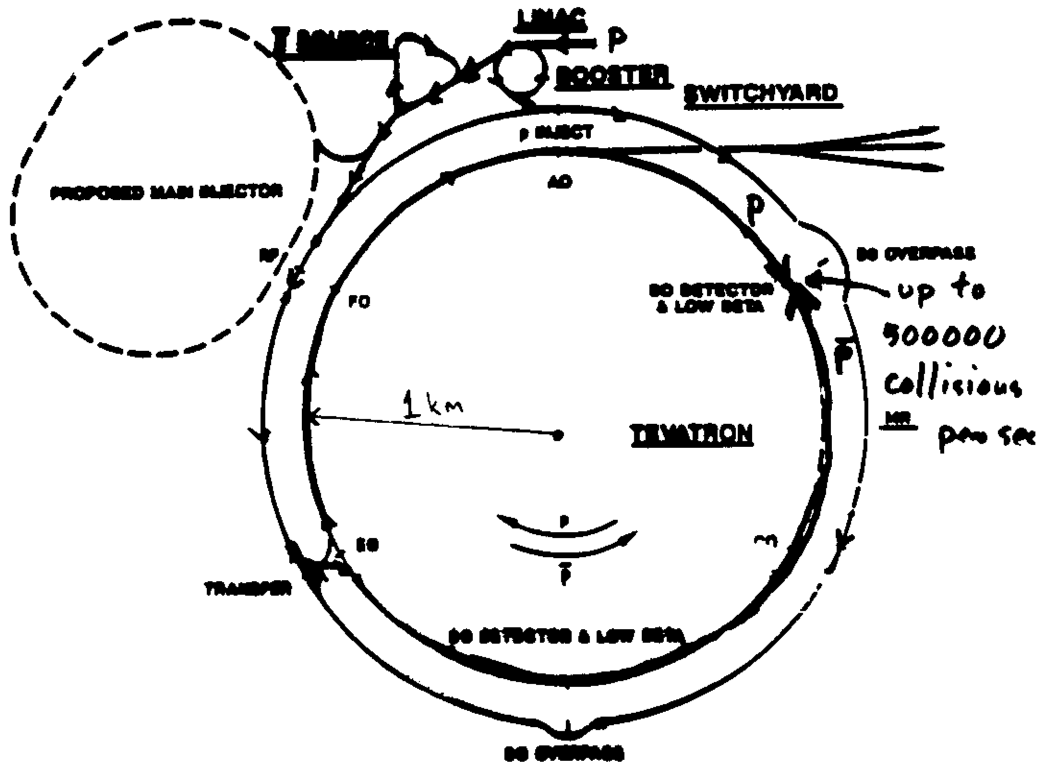
Thomas Müller, UCLA

- Tevatron, CDF and D0
- Electroweak results
- Bottom quark production and decay
- The Top quark
- Outlook

An apology:

- This talk will cover only a part of all the good Physics
- Most results are from CDF

Fermilab accelerator complex

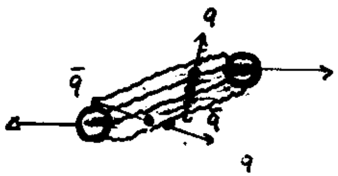


			$\beta = v/c$
Accelerators:	750 keV	Cockroft-Walton	.04
	200 MeV	linac	.57
	8 GeV	booster	.995
	150 GeV	main ring	.99998
	900 GeV	superconducting Tevatron ring	.9999995

HADRON-COLLIDER ARE *QUARK FACTORIES*

- **MOST PROTON-ANTIPROTON COLLISIONS ARE "SOFT"**

After collision fragments of p, $\bar{p}$ carry color

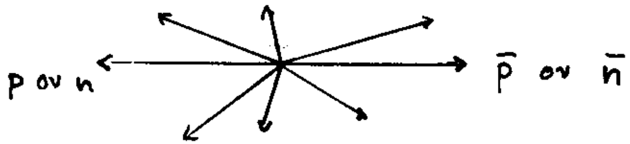


q : typically u, d, s

Gluon field

Spontaneous formation of quark antiquark pairs

Formation of mesons, baryons; $\langle p_T \rangle \sim 0.5$ GeV/c



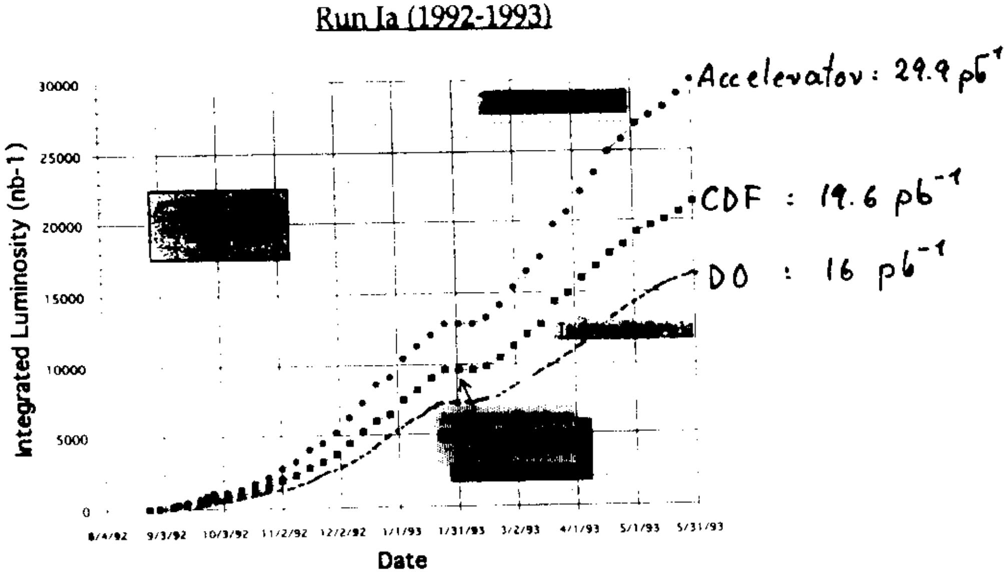
Typical inelastic $p\bar{p}$ cross section 50 mb

$\Rightarrow$ @ $\mathcal{L} = 10^{31}/cm^2s$ $\dot{n} = 500$ KHz !

RUN 1a of the Tevatron Collider

March 1992 - June 1993

Highest luminosity $8\ 10^{30}/cm^2s$



With 19.6 pb^{-1} : 10^{12} inelastic collisions in CDF

10^{7} recorded on tape

19.6 pb^{-1} correspond to

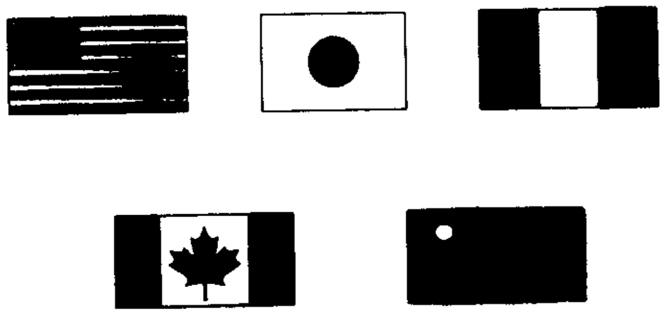
$6 \cdot 10^{8}$	$b\bar{b}$ events	$\sigma \sim 30\ \mu b$
20000	$W^+ \to e^+\nu$	$\sigma \sim 1$ mb
100	$t\bar{t}$ events	$\sigma \sim 5$ pb

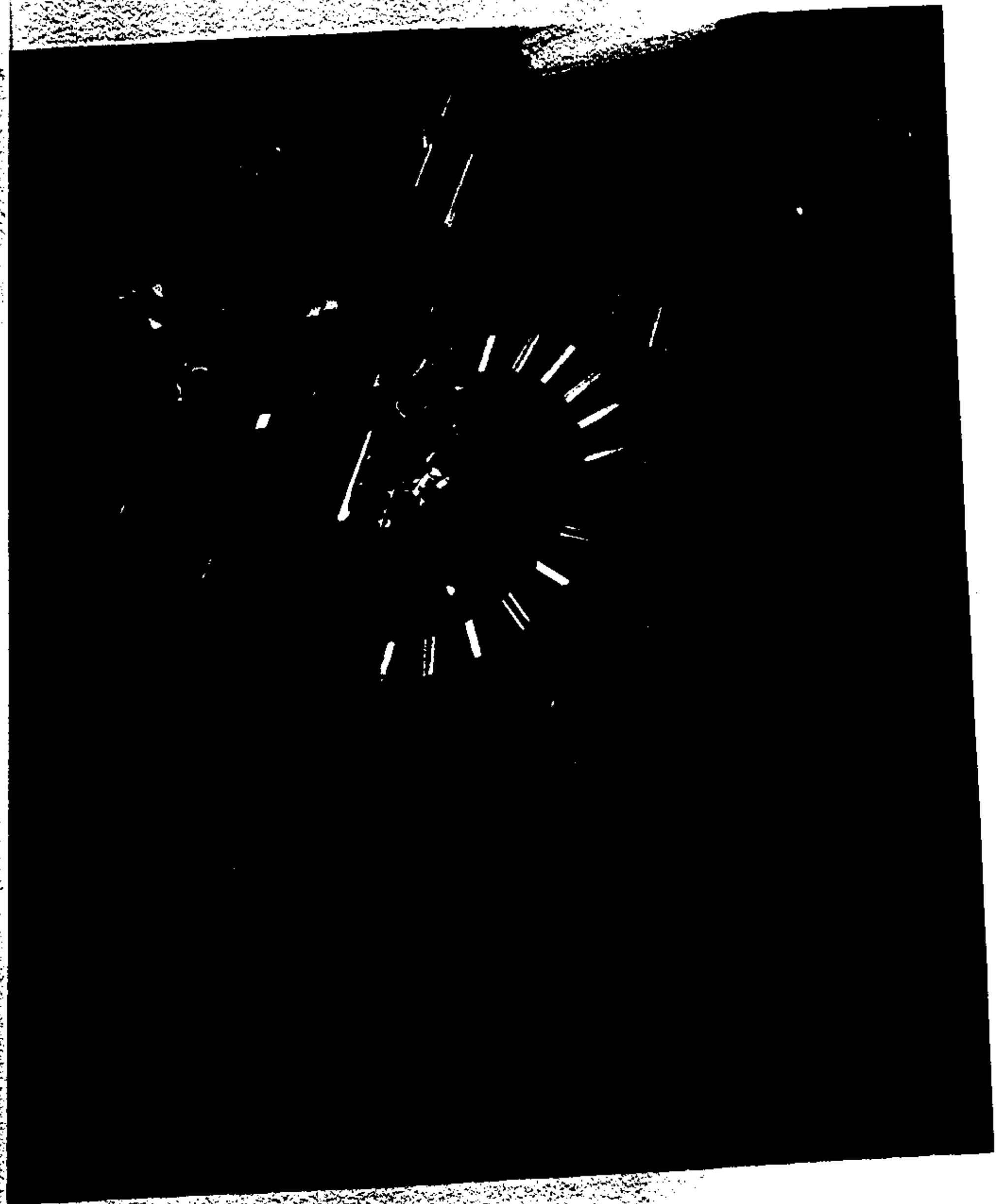
The CDF Collaboration

Anway-Wiese
Hausen
Joyce
Keyvan
Sammel *
Lindgren
Müller
Neuberger
Undergraduate
...erstipendiat

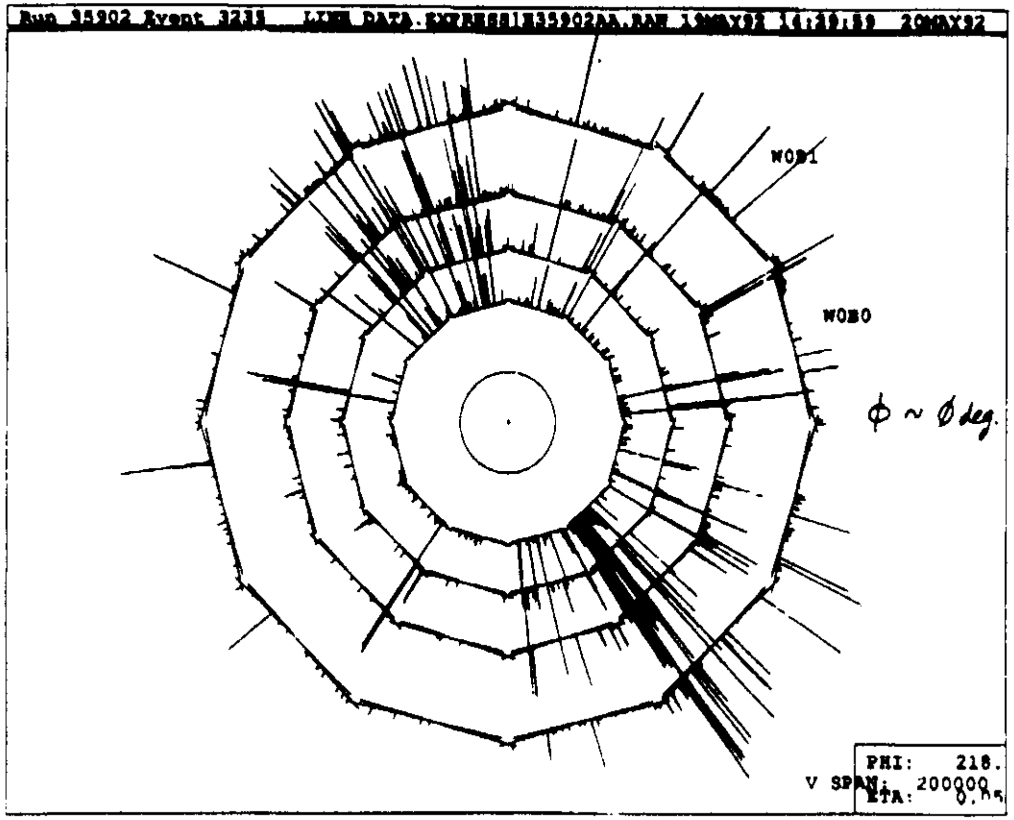
- Academica Sinica/Taiwan, Argonne, Bologna, Brandeis, UCLA, Chicago, Duke, FNAL, Frascati, Harvard, Illinois, IPP/Canada, Johns Hopkins, KEK, LBL, MIT, Michigan State, Michigan, New Mexico, Osaka City, Padova, Penn, Pisa, Pittsburgh, Purdue, Rochester, Rockefeller, Rutgers, SSCL, Texas A&M, Tsukuba, Tufts, Wisconsin, Yale

416 people, 34 institutions, 5 countries , ~140 Graduate students





Two Jet Event seen in SVX



note: black = west barrel ($\eta < 0$)
blue = east barrel ($\eta > 0$)

Resolution: 40 μm for $P_T = 1$ GeV/c
15 μm for $P_T = 10$ GeV/c

The D0 Collaboration

40 Institutions

424 Collaborators

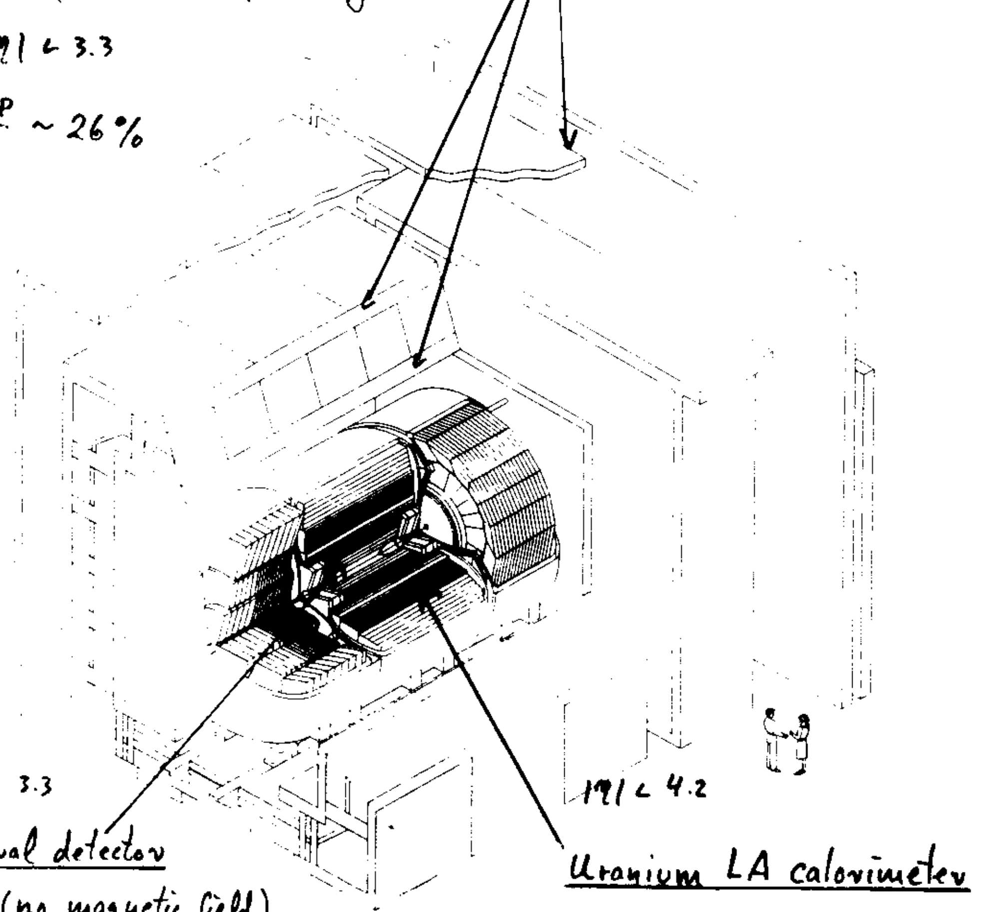
Universidad de los Andes, Bogota, Columbia
University of Arizona
Brookhaven National Laboratory
Brown University
University of California, Davis
University of California, Irvine
University of California, Riverside
Centro Brasiliero de Pesquisas Fisicas, Rio de Janeiro, Brazil
CINEVESTAV, Mexico City, Mexico
Columbia University
Delhi University, Delhi, India
Fermilab,
Florida State University
University of Hawaii
University of Illinois, Chicago
Indiana University
Iowa State University
Korea University, Seoul, Korea
Lawrence Berkeley Laboratory
University of Maryland
University of Michigan
Michigan State University
Moscow State University, Russia
University of Nebraska
New York University
Northeastern University
Northern Illinois University
Northwestern University
University of Notre Dame
Panjab University, Chandigarh, India
Institute for High Energy Physics, Protvino, Russia
Purdue University
Rice University
University of Rochester
CEN Saclay, France
State University of New York, Stony Brook
SSC Laboratory
Tata Institute for Fundamental Research, Bombay, India
University of Texas, Arlington
Texas A&M University

Muon chambers with 2 T toroids

13 - 18 λ absorption of material

$|\eta| < 3.3$

$\frac{\delta p}{p} \sim 26\%$



$|\eta| < 3.3$

Central detector

(no magnetic field)

Vertex chamber

$\sigma_{r\phi} = 60\,\mu m$

Tracking chamber

$\sigma_{r\phi} = 120\,\mu m$

TRD ; dE/dx

DØ Detector

1992

$|\eta| < 4.2$

Uranium LA calorimeter

$33\ X_0$ EM; 4 segments

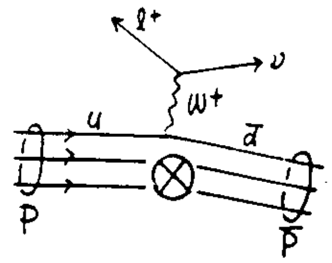
$\frac{\delta E}{E} = \frac{15\%}{\sqrt{E}} + 0.3\%$

$6\ \lambda$ Had; 5 segments

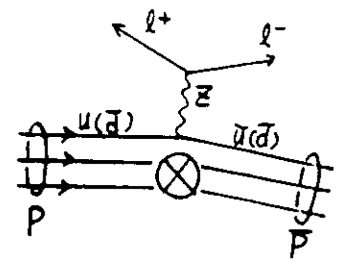
$\frac{\delta E}{E} = \frac{50\%}{\sqrt{E}} + 4\%$

PHYSICS WITH W, Z BOSONS

$\bar{P}P \to W^+X \to l^+\nu X$



$\bar{P}P \to Z^0X \to l^+l^-X$



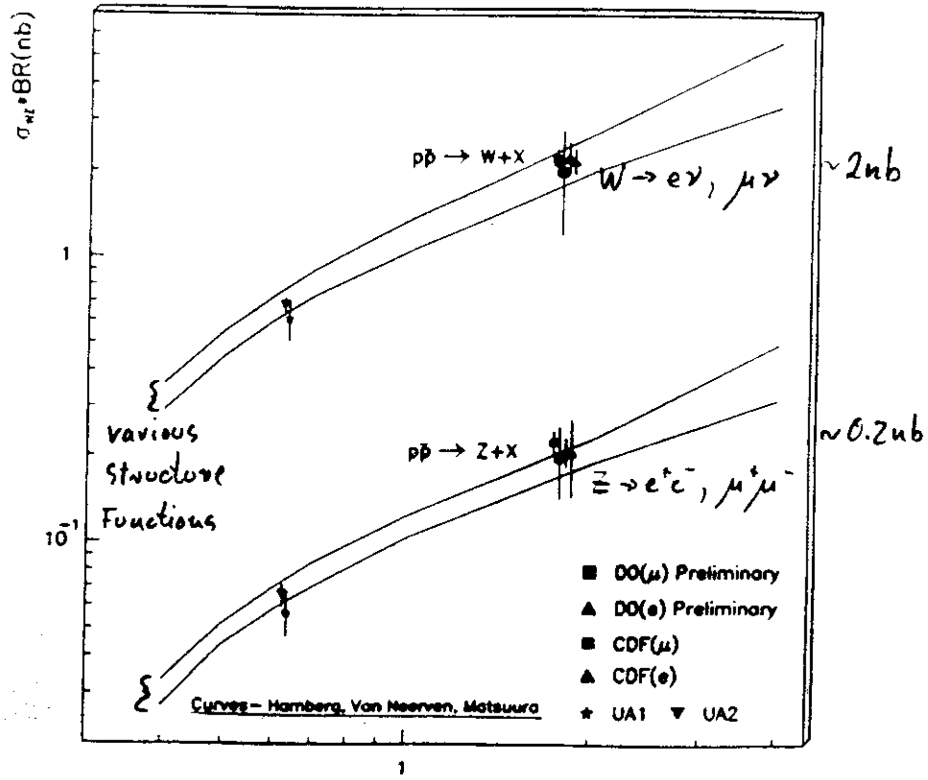
<u>W tagging</u> :

High P_T e or μ (20 GeV/c)
High $\not{E}_t$ (20 GeV)

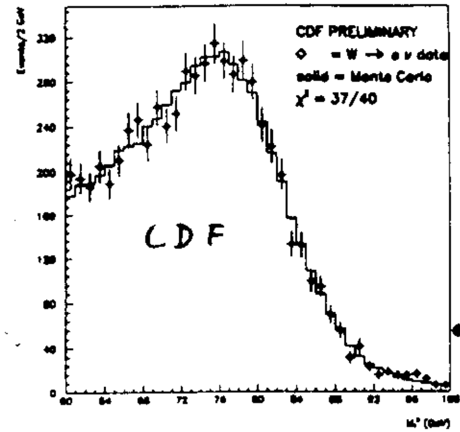
<u>Z tagging</u> :

Two high P_T (20 GeV/c)
e^+e^- or $\mu^+\mu^-$

<u>W and Z production cross sections</u>



MEASUREMENT OF M_W, Γ_W



~ 17000 $W \to e\nu, \mu\nu$

~ 1700 $Z \to ee, \mu\mu$

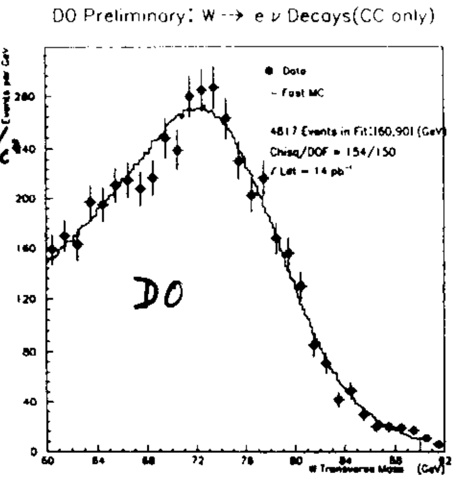
- $M_W = 80.38 \pm 0.23$ GeV/c^2

  (uses J/ψ to calibrate momentum scale, electron tracks to calibr. energy scale)

- $\Gamma_W = 2.06 \pm 0.09$ GeV (*)

$\Gamma_W^{SM} = 2.07 \pm 0.02$ GeV {Rosner et al.}

$\longrightarrow M_t > 62$ GeV/c^2 (95% CL)



- $M_W = 79.86 \pm 0.16 \pm 0.20 \pm \underline{0.31}$ GeV/c^2

  (uses $Z \to ee$ events to calibrate energyscale)

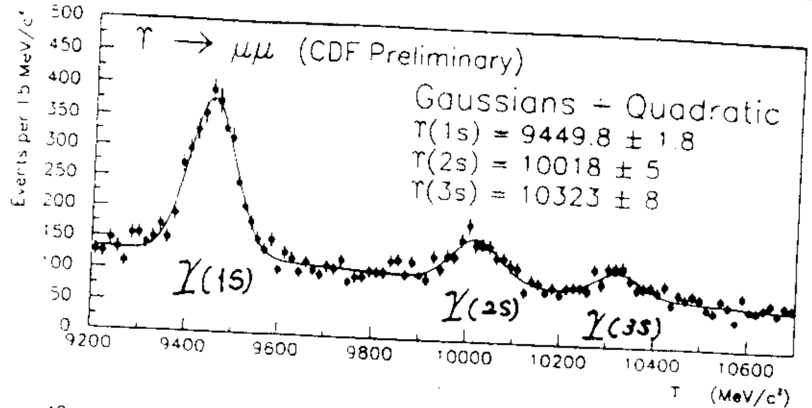
- $\Gamma_W = 2.05 \pm 0.16$ GeV (*)

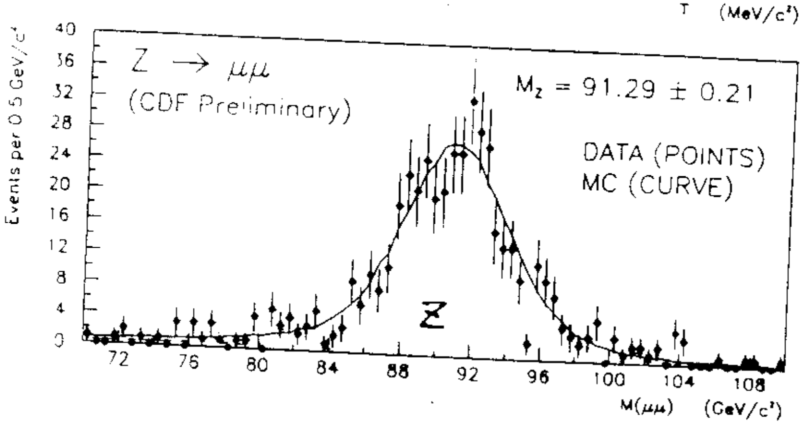
*) Γ_W was determined indirectly from

$$R = \frac{\sigma_W \cdot Br(W \to e\nu)}{\ldots} = \frac{\sigma_W \cdot \Gamma(W \to e\nu) \cdot \Gamma(Z)}{\ldots}$$

Cross Checks

Reconstructed masses of $\Upsilon \to \mu^+\mu^-$ and $Z \to \mu^+\mu^-$



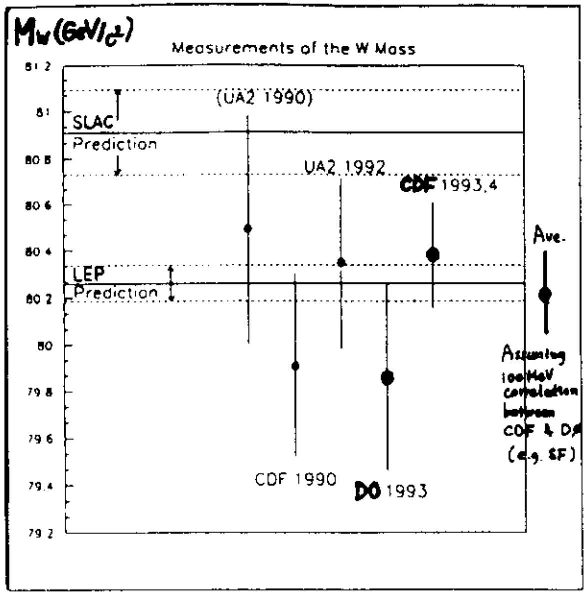


Apply the scale factor at J/ψ to Υ and Z

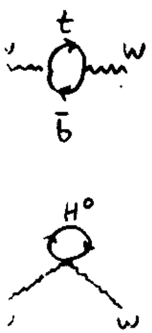
× 1.00076

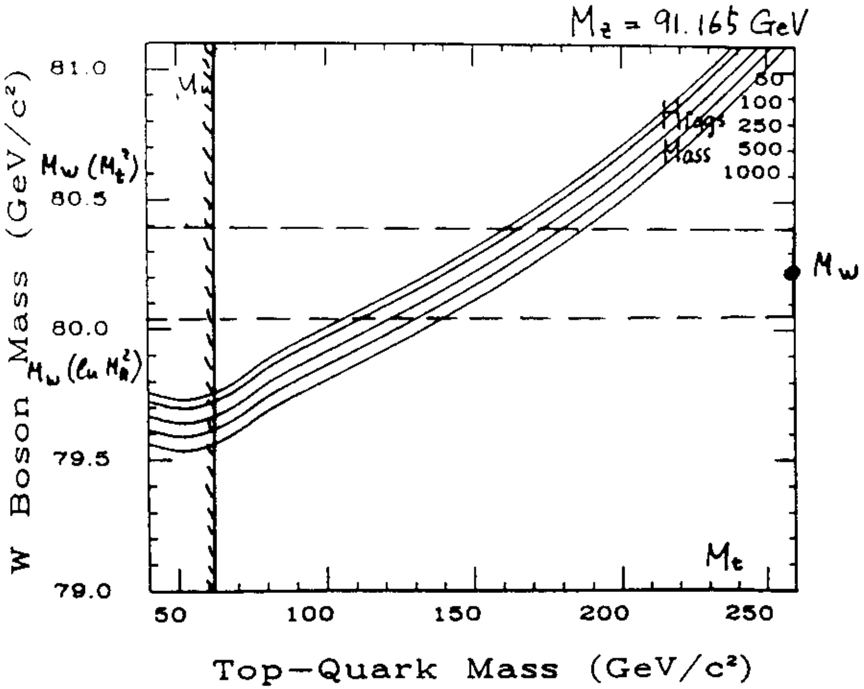
Sample	CDF	PDG	SCALED	Unit
J/ψ	3094.28±2.2	3096.93±0.09		MeV/c^2
Υ (1s)	9449.8 ±1.8	9460.3 ±0.2	9457.0±1.8±7	MeV/c^2
Υ (2s)	10018 ±5	10023.3±0.3	10026 ±5 ±7	MeV/c^2
Υ (3s)	10323 ±8	10355.5 ±0.5	10331 ±8 ±7	MeV/c^2
Z^o	91.22±0.21	91.173±0.020	91.29±0.21±0.065	GeV/c^2

MASS OF W BOSON 1994



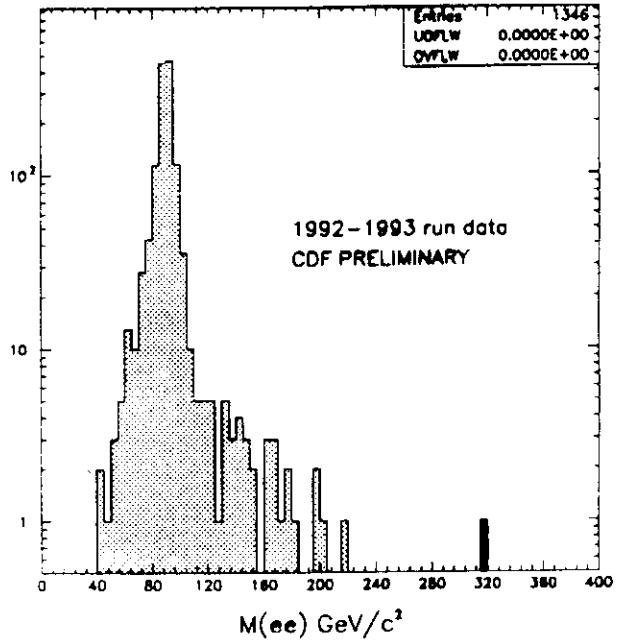
$\langle M_W \rangle = 80.21 \pm 0.18$ GeV/c^2





World-wide EWK Fit : $M_t = 174 \pm 17$ GeV/c^2

SEARCH FOR $Z' \to \ell^+\ell^-$



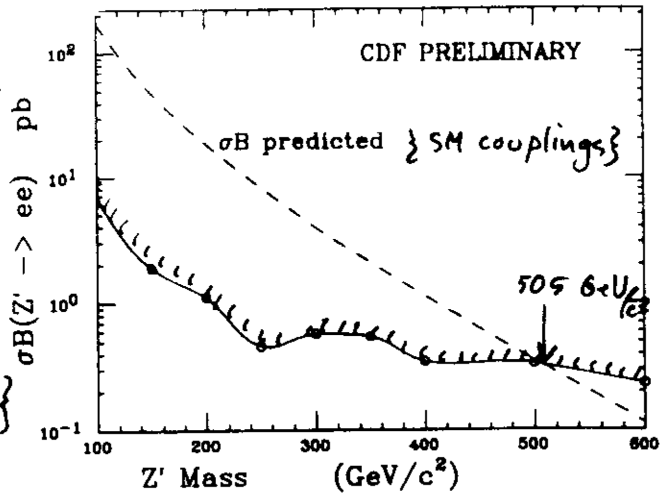
CDF:

$M_{Z'} > 505$ GeV/c^2

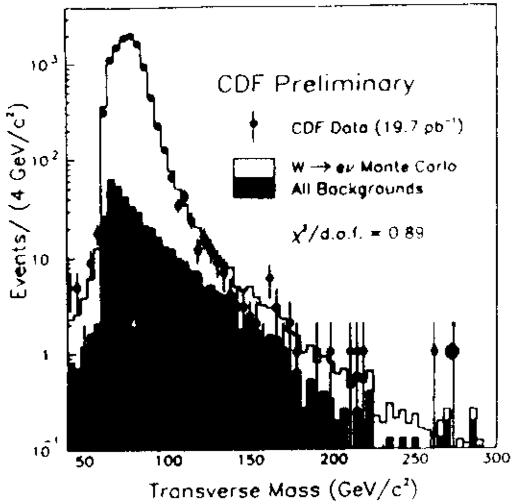
D0:

$M_{Z'} > 440$ GeV/c^2

{95% CL}



SEARCH FOR $W' \to \ell\nu$



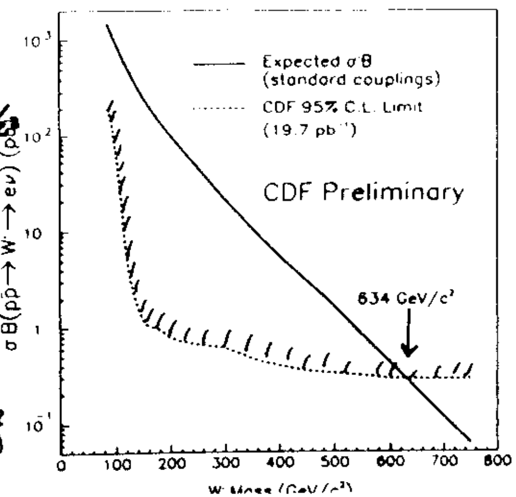
CDF :

$M_{W'} > 634\ GeV/c^2$

DO :

$M_{W'} > 600\ GeV/c^2$

$\{95\%\ CL\}$

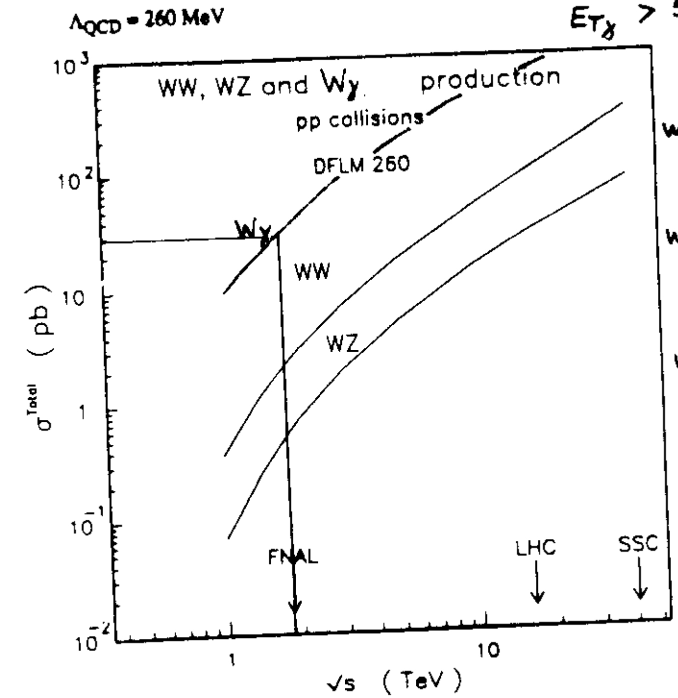


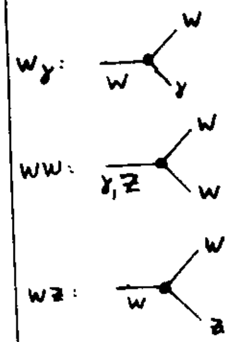
CROSS SECTION FOR BOSON PAIR PRODUCTION, $\sqrt{s}$ = 1800 GeV

$|\eta_\gamma| < 1$

$\Delta R_{\ell\gamma} > 0.7$

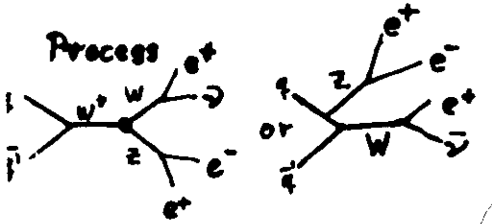
$E_{T_\gamma} > 5$ GeV





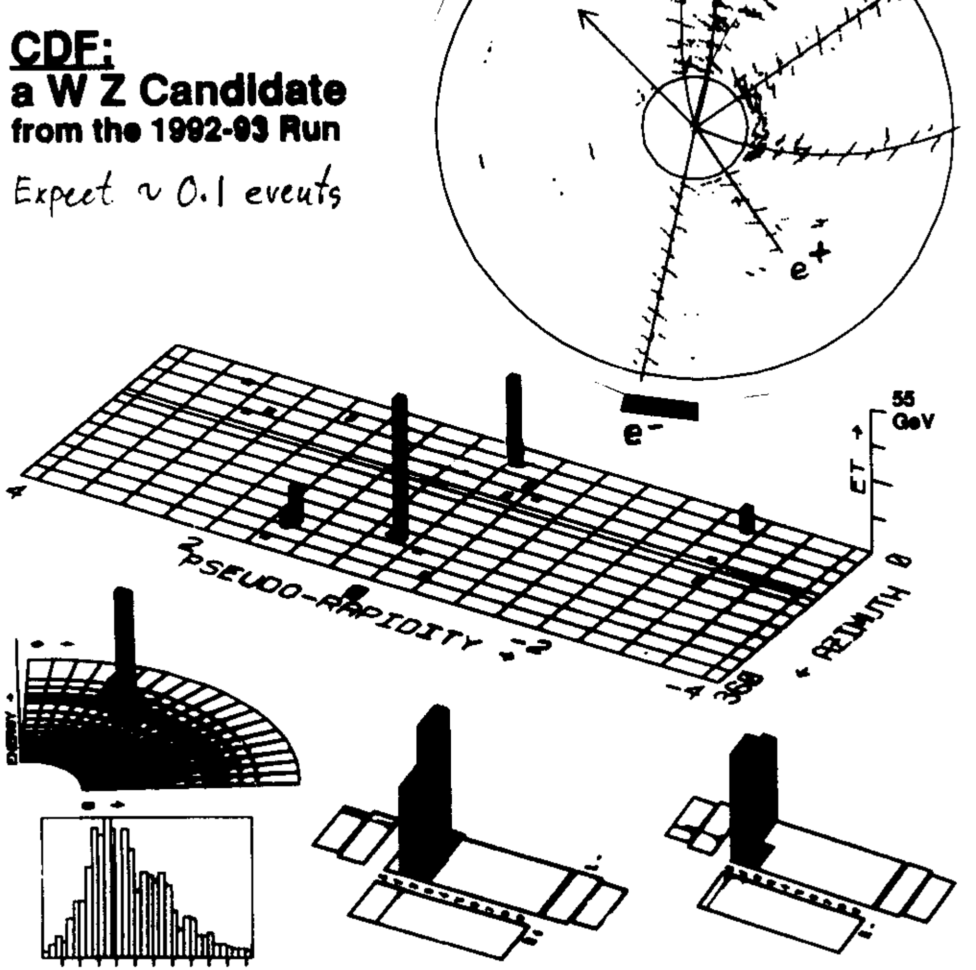
Total W^+W^-, Z^0Z^0 and $W^\pm Z^0$ pair production as a function of $\sqrt{s}$

→ **Wγ – EVENTS ARE THE MOST FREQUENT** (but ~100 * less abundant than W)

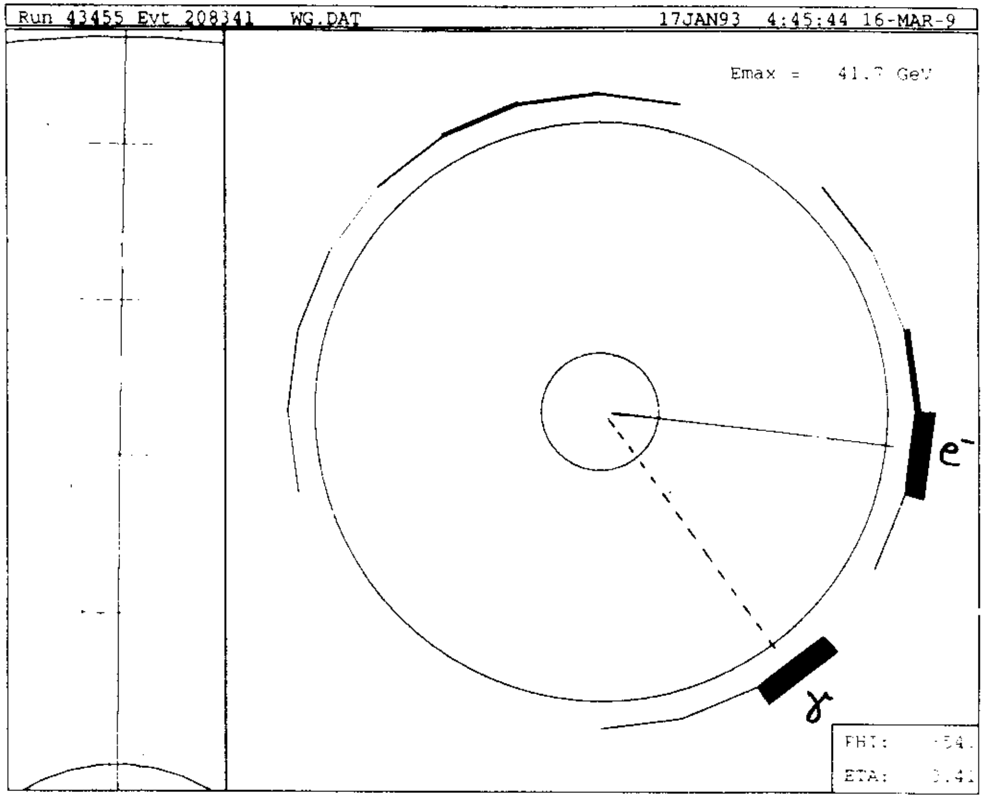


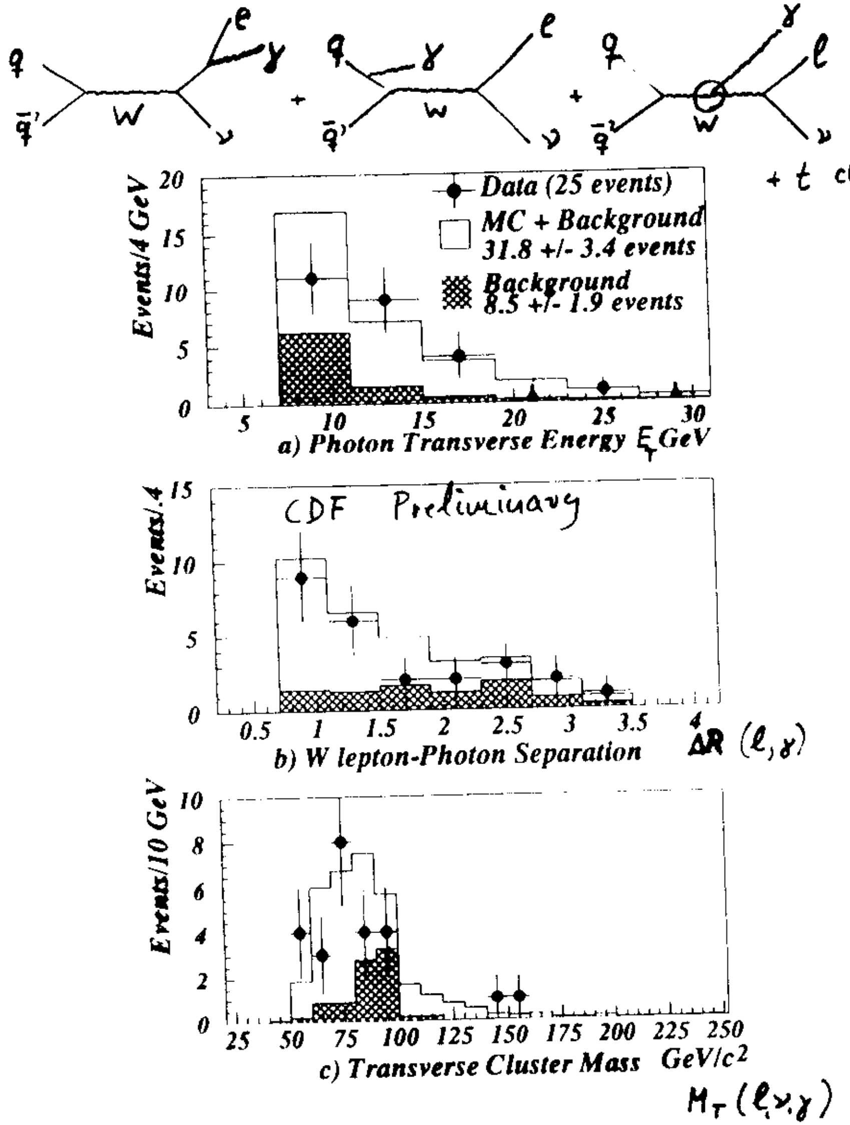
CDF:
a W Z Candidate
from the 1992-93 Run

Expect ~ 0.1 events



Candidate $W^-(e^- \bar{\nu}) + \gamma$ Event





+ t channel

Figure 1: a)E_T distribution of central photon candidates in $W\gamma$ events. b)The angular separation, $\Delta R_{\ell\gamma}$, between the photon candidate and the charged lepton from the W decay. c)The cluster transverse mass M_{CT}^{W} of the W decay leptons and the photon. The prediction for the SM signal has been added to the background prediction.

Anomalous $WW\gamma$ couplings : expect enhancement at high $E_{T\gamma}$, $M_T(\ell\nu\gamma)$

Limit contours on anomalous $WW\gamma$ couplings, W EM moments

CDF:

$-2.3 < \Delta\kappa < 2.3$

$(\lambda = 0)$

$-0.7 < \Delta\kappa < 0.7$

$(\Delta\kappa = 0)$

CDF:

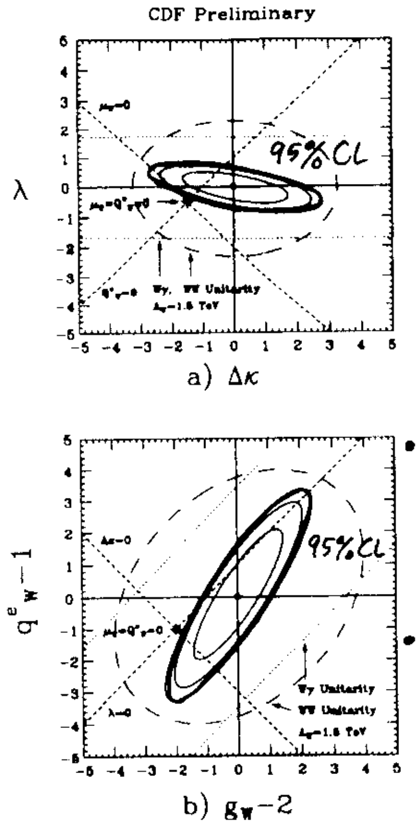
$0.8 < g_W < 3.2$

$(g_W = 1)$

$-0.6 < g_W < 2.7$

$(g_W = 2)$

DØ : similar results



Standard Model:

$\kappa = 1$, $\lambda = 0$

$\tilde{\kappa} = 0$, $\tilde{\lambda} = 0$

• Magnetic Dipole Moment

$$\mu_W = \frac{e}{2M_W}\{\underbrace{1+\kappa+\lambda}_{g_W}\}$$

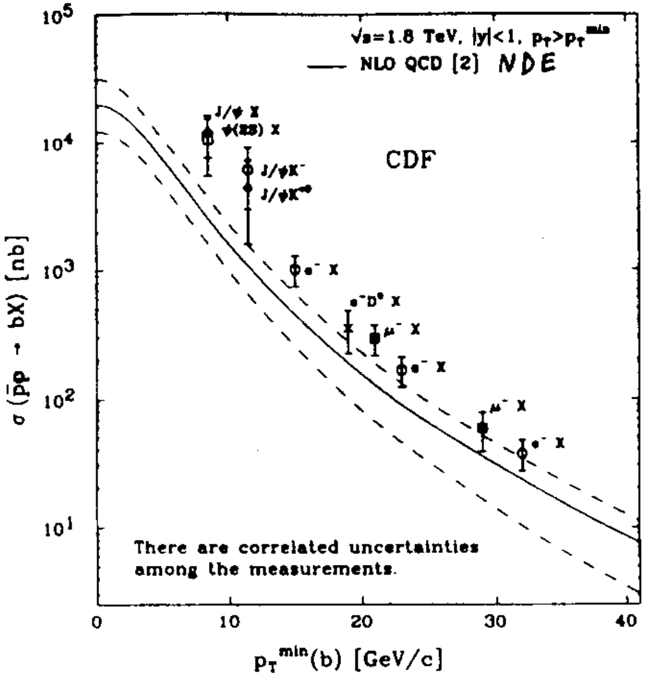
• Electric Quadrupole Mom.

$$Q_W = -\frac{e}{M_W^2}\{\underbrace{\kappa-\lambda}_{q_W}\}$$

Note: $\mu_W \sim 6 \cdot 10^{-6} \mu_e$

Figure 7: Direct limits on CP-conserving $WW\gamma$ anomalous couplings (a) and on the static CP-conserving EM multipole moments of the W boson (b) for the combined $e + \mu$ $W + \gamma$ data sample. In each figure, the star indicates the point where these EM moments vanish. The solid ellipses show the 68%, 90% and 95% CL limit contours. The W^+W^- and $W\gamma$ unitarity limits for a form factor scale $\Lambda_W = 1.5$ TeV are indicated by dashed and dotted curves, respectively.

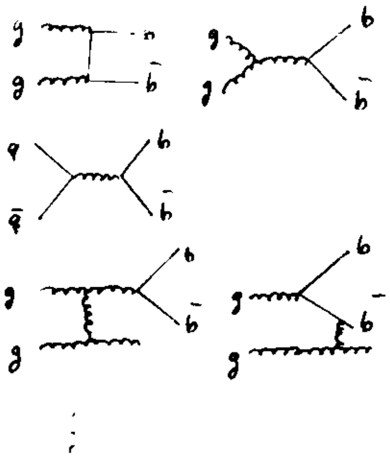
PHYSICS WITH BOTTOM QUARKS

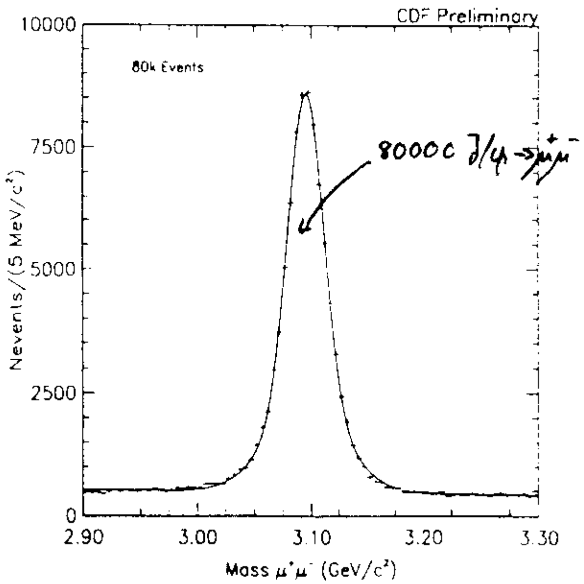


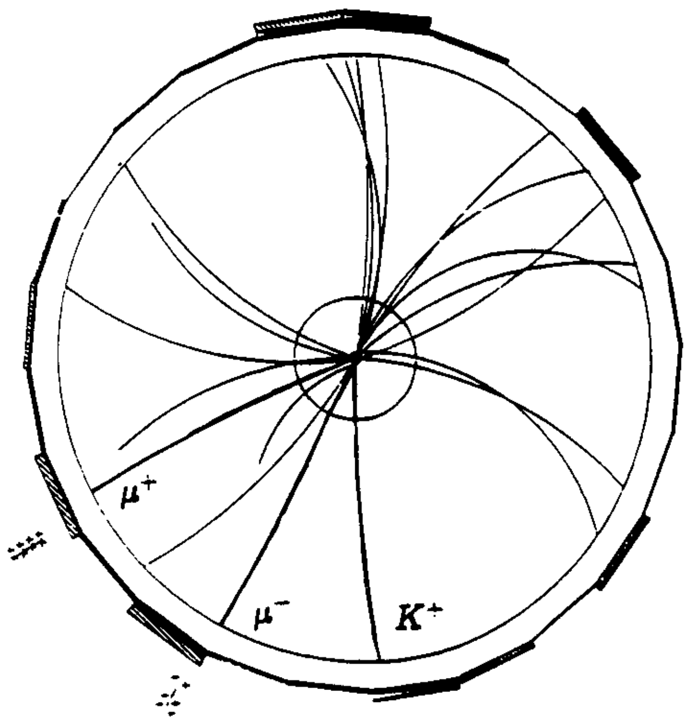
Observation of
$B \to \psi X,\ \psi' X$
$\psi K,\ \psi K^{0*}$
$eX,\ eD^0X$
μX

Candidate for $p\bar{p} \to B^+ X$
$\hookrightarrow K^+ \psi$
$\hookrightarrow \mu^+\mu^-$

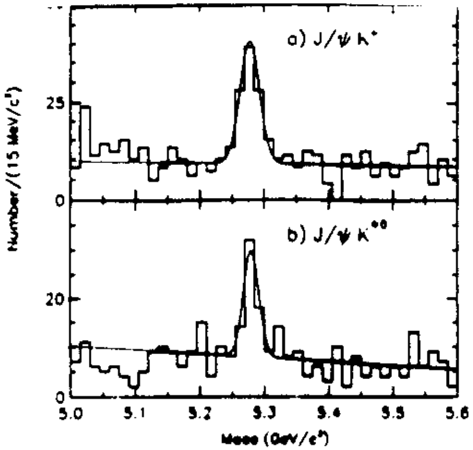
b quark production:







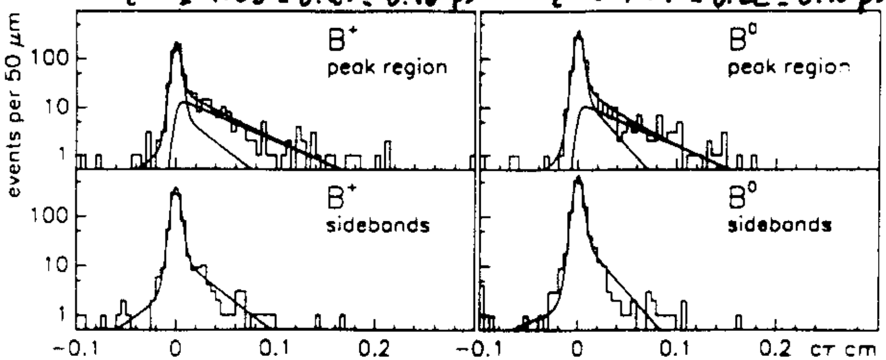
$m(\mu^+, \mu^-, K^+) = m(B^+)$



$B^+ \rightarrow \psi K^+$

$B^0 \rightarrow \psi K^{*0}$

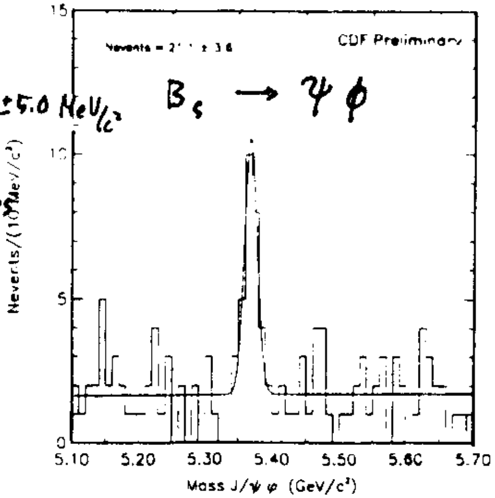
$\tau^{\pm} = 1.63 \pm 0.21 \pm 0.16$ ps $\qquad \tau^0 = 1.54 \pm 0.22 \pm 0.10$ ps



$m(B_s^0) = 5383.3 \pm 4.5 \pm 5.0$ MeV/c^2

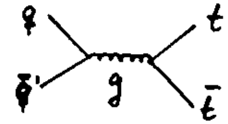
$\tau(B_s^0) = 1.54^{+.42}_{-.34} \pm .12$ ps

$B_s \rightarrow \psi \phi$



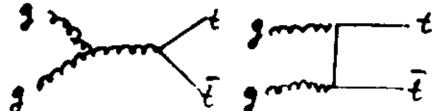
Production of Top Quarks

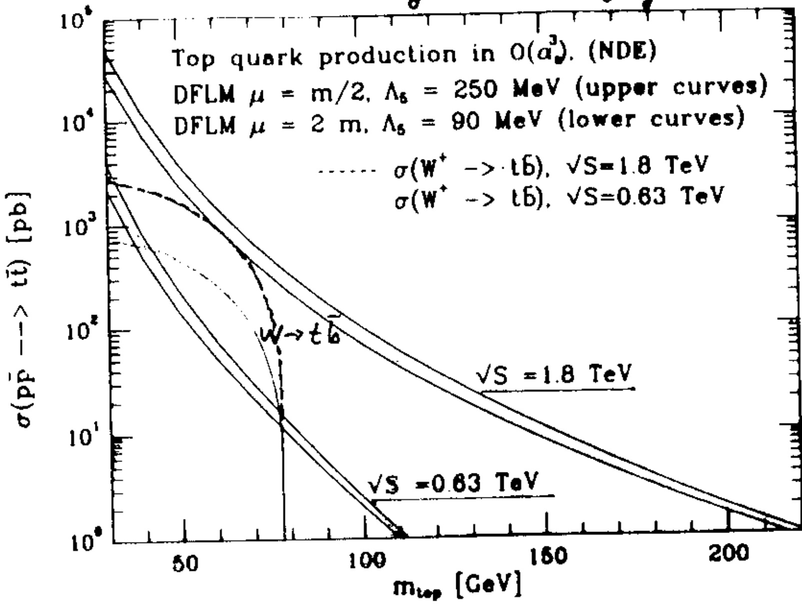
Dominant process:



(> 70% for $M_t > 120$ GeV/c^2)

Also:





$M_t = 150$ GeV

$\frac{1 \text{ event}}{5 \cdot 10^9\ p\bar{p}}$

Fig. 4.4: The inclusive t-quark production cross-section as a function of the t-quark mass (for the CERN $p\bar{p}$ Collider and the Tevatron).

Knowledge before 1992: $M_t > 91$ GeV/c^2 (95% CL)

[CDF]

TOP SEARCH WITH CDF

A) SEARCH FOR TOP QUARKS IN EVENTS WITH 2 CHARGED LEPTONS, MISSING ET AND JETS

Search for $p\bar{p} \to t\bar{t}\ X$;

$$t \to W^+ b$$
$$\bar{t} \to W^- \bar{b}$$

$\to$ $BR(W \to e\nu) = 1/9$

$\to$ $BR(W \to \mu\nu) = 1/9$

$BR(W \to q\bar{q}') = 2/3$

$$t\bar{t} \to e^+e^-\nu_e\bar{\nu}_e\, b\bar{b} \qquad (1/81)$$
$$\to \mu^+\mu^-\nu_\mu\bar{\nu}_\mu\, b\bar{b} \qquad (1/81)$$
$$\to e^\pm\mu^\mp\nu_e\nu_\mu\, b\bar{b} \qquad (2/81)$$

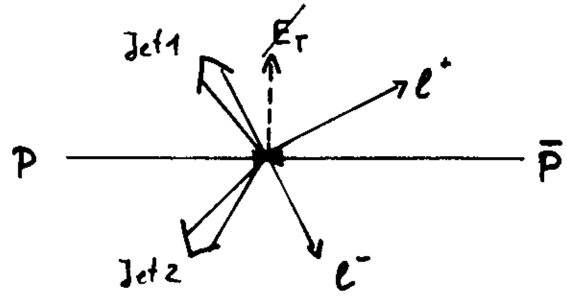
- We expect (~ 0.5 - 0.9 % acceptance) :

m_t = 120 GeV/c^2 : 3.7 events

140 GeV/c^2 : 2.2 events

160 GeV/c^2 : 1.3 events

- Topology of events :



Because of high m_{top} isotropic distribution

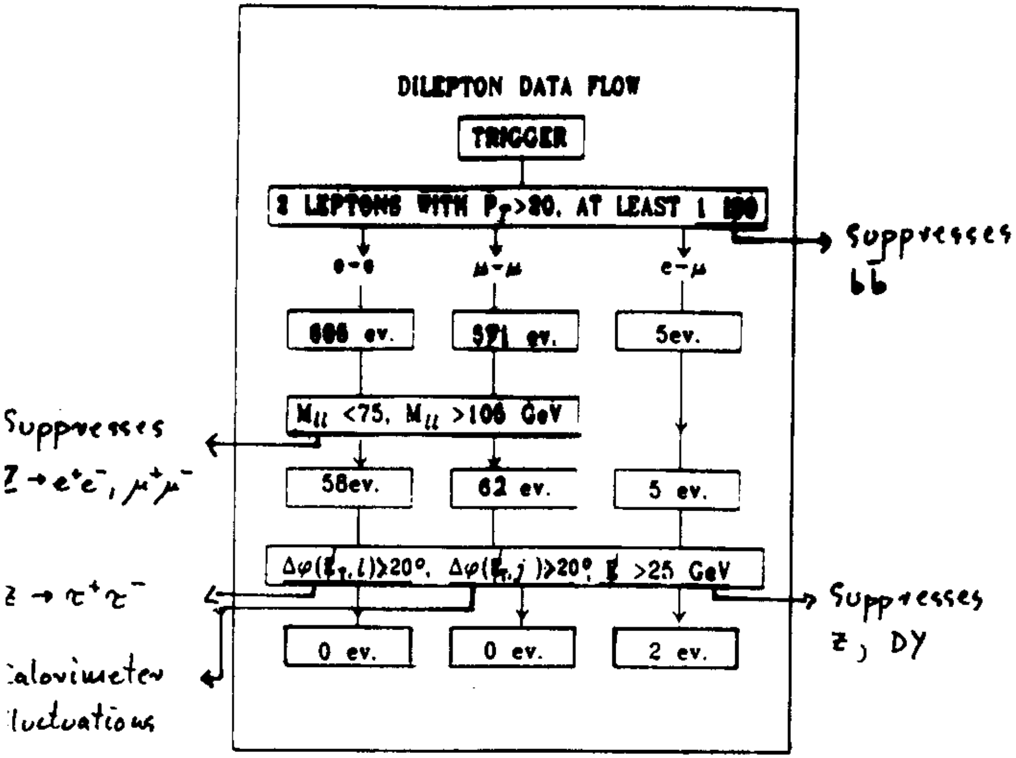
- Important background:

$p\bar{p} \to W^+W^-X$, $p\bar{p} \to Z^0 X$, $Z^0 \to \tau^+\tau^-$ } Only few events have two jets

$p\bar{p} \to b\bar{b}\ X$ } Leptons are not isolated

$p\bar{p} \to \ell^+\ell^- X$ (Drell Yan) } $\not{E}_T$ is small

$p\bar{p} \to Z^0 X$, $Z^0 \to \ell^+\ell^-$ } Cut on $m(\ell^+\ell^-)$

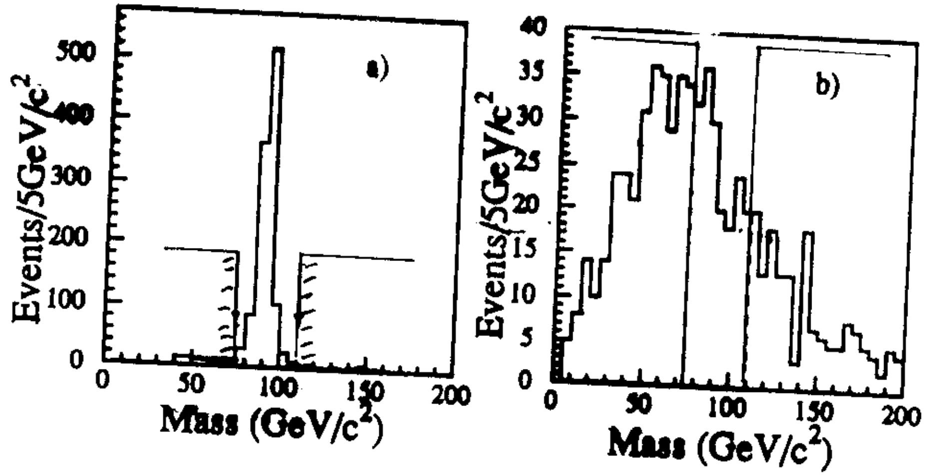


		Without $\not{E}_T$ and two-jet cuts	Without two-jet cut	All cuts
$e\mu$	WW	1.1	0.74	0.10±0.04
	$Z \to \tau\tau$	3.7	0.22	0.07±0.02
	$b\bar{b}$	1.3	0.10	0.04±0.03
	Fake	1.2	0.19	0.03±0.03
	Total background	7.2	1.25	[redacted]
	CDF data	5	2	[illegible]
$ee, \mu\mu$	WW	0.6	0.43	0.06±0.02
	$Z \to \tau\tau$	3.0	0.20	0.06±0.02
	$b\bar{b}$	1.6	0.12	0.05±0.03
	Fake	1.7	0.25	0.04±0.03
	Drell-Yan	113	0.28	0.10±0.10
	Total background	120	1.28	$\boxed{0.31±0.11}$
	CDF data	120	0	$\boxed{0}$

Dilepton Event Selection

- Mass cut for ee, μμ to remove Z's

75 GeV/c2 < Mll < 105 GeV/c2



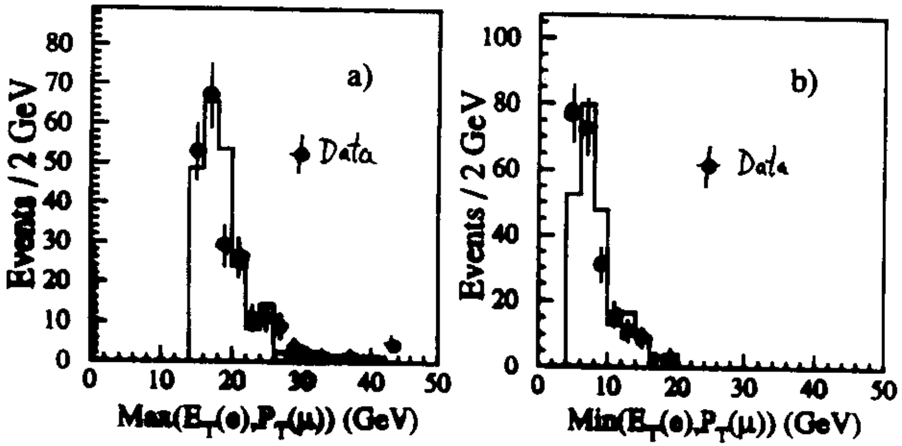
ee, μμ data

top MC, Mtop = 160 GeV/c2

Dilepton Backgrounds

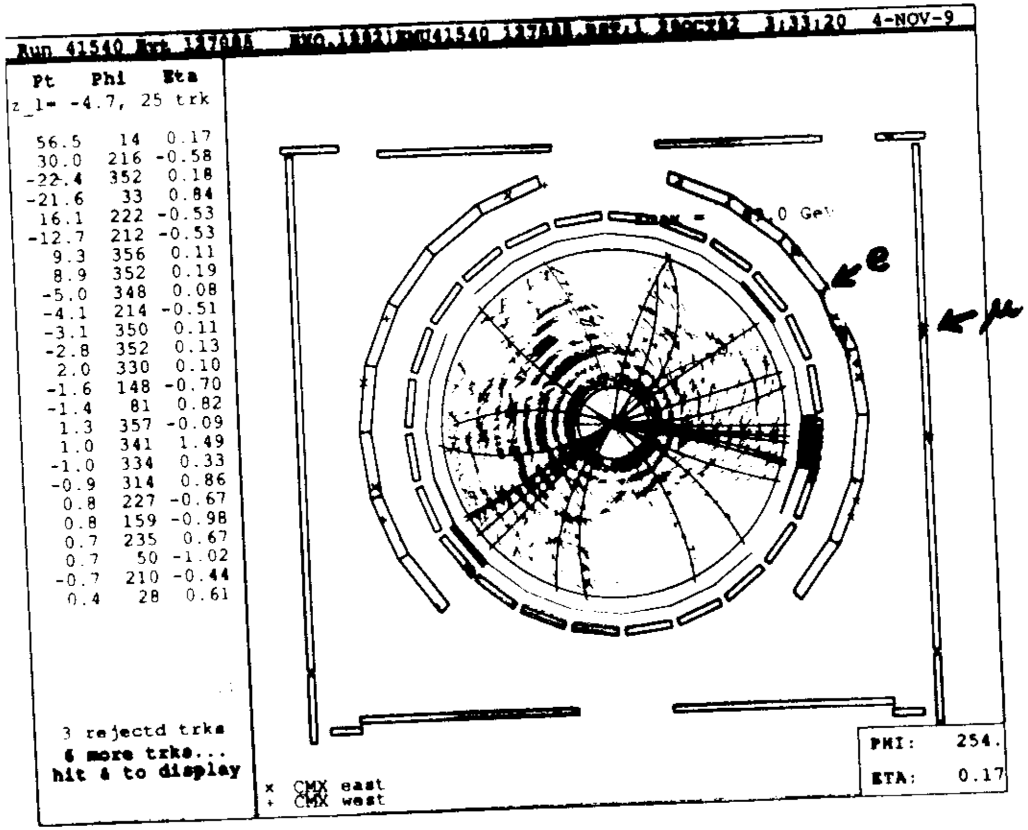
- $b\bar{b}$ background

ISAJET for production and CLEO MC for b decays. Normalize to the data with lower momentum cuts where heavy flavor is dominant. Scale MC to higher momentum

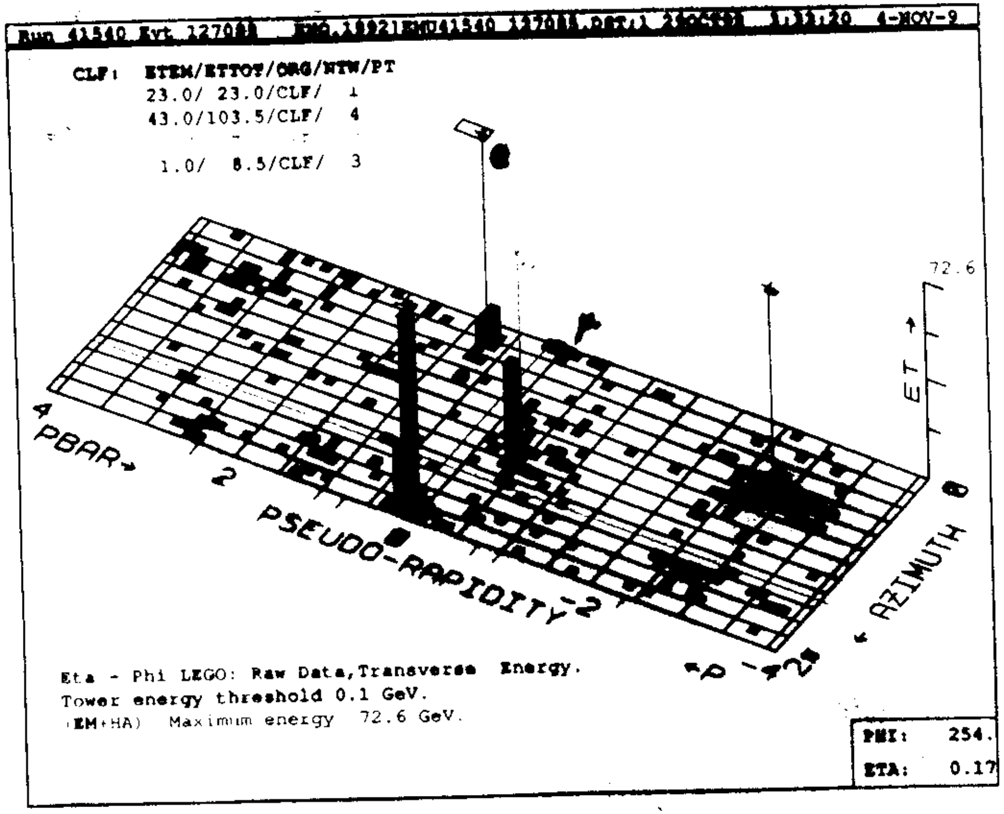


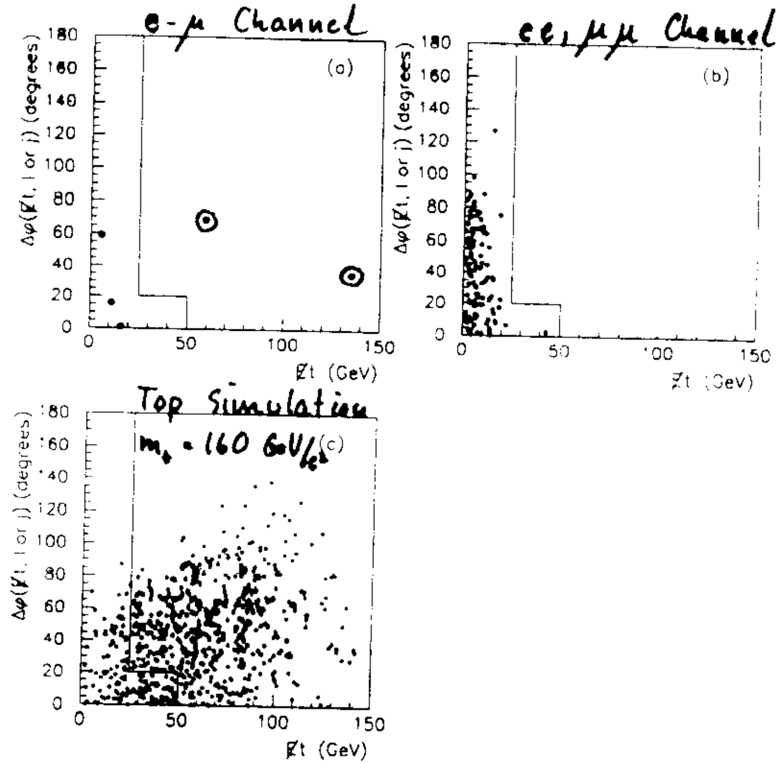
0.10 ± 0.06 events

CDF Top Quark candidate



CDF TOP EVENT CANDIDATES IN THE DILEPTON CHANNEL





2 Signal events

0.55 Background events expected

B) SEARCH FOR TOP QUARKS IN W + JET EVENTS

$t\bar{t} \to \ell^{\pm} \nu_\ell \; q \bar{q}' \; b \bar{b} \quad (8/27)$

- We expect (≥ 3 Jets, $E_T > 15$ GeV, $|\eta| < 2$):

m_t = 120 GeV/c^2 : 43 events
140 GeV/c^2 : 24 events
160 GeV/c^2 : 13 events
180 GeV/c^2 : 7 events

- Dominant background:

$p\bar{p} \to W + n$ Jets $+ X$: 50 $W + \geq 3$ jet events

We have in our data 52 !

$\Longrightarrow$ Need additional signature: identification of b !

1. Presence of secondary vertex from B-decay ($\tau_B \sim 1.5$ ps)
2. Presence of lepton from semi-leptonic B-decay ($b \to \ell \nu c$)

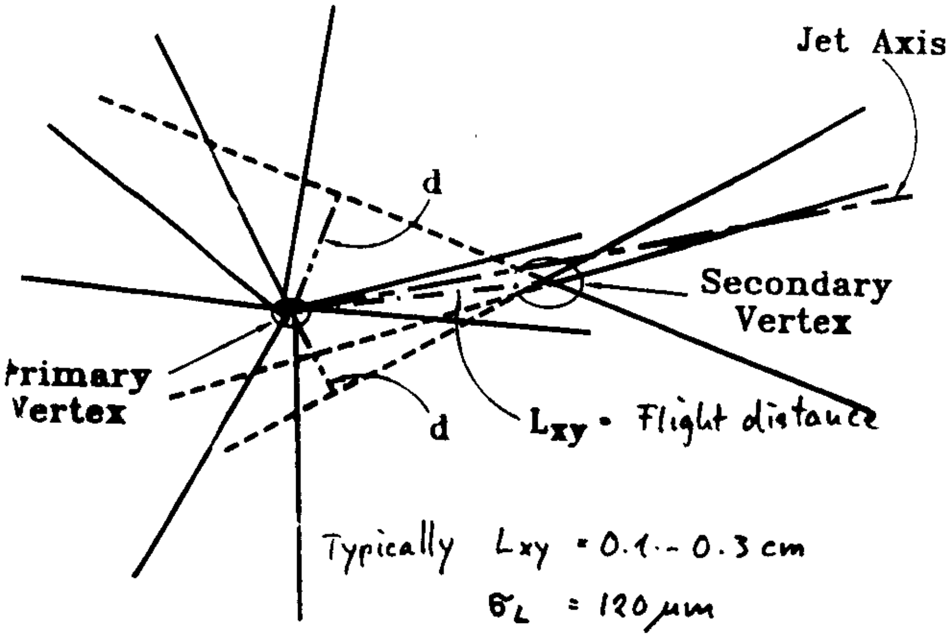
(1) **W + jets SVX algorithm**

- **≥ 2 good SVX tracks**

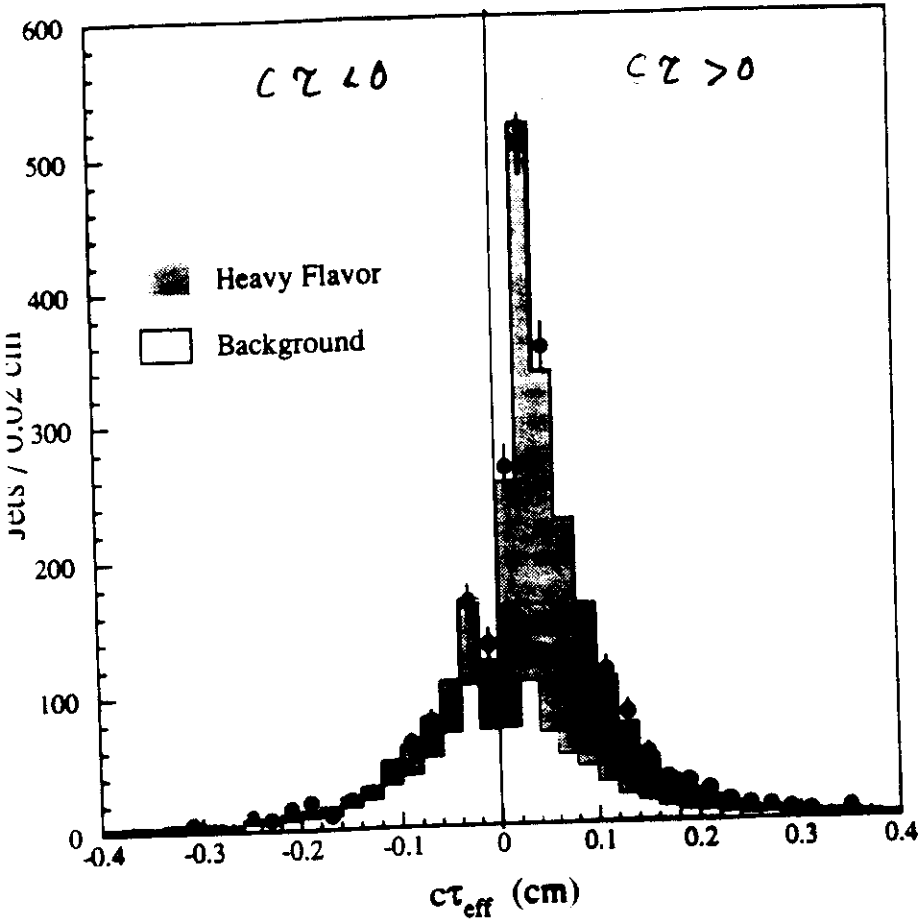
$P_t > 2.0$ GeV/c
χ^2 with CTC track < 6.0 per SVX hit
$|d| \geq 3.0 \; \sigma_d$ ← Tracks don't come from primary vertex
≥ 2 good SVX hits per track

- **Lxy** $\geq 3.0 \; \sigma$ ← Secondary vertex incompatible with primary v.

(Results checked with 2 other algorithms: one based on parametrized probability of significant impact parameter, the other on correlation in d - ϕ space)



Typically $L_{xy} = 0.1 - 0.3$ cm
$\sigma_L = 120\,\mu m$



Estimate of false tags at cτ > 0 from
events with cτ < 0

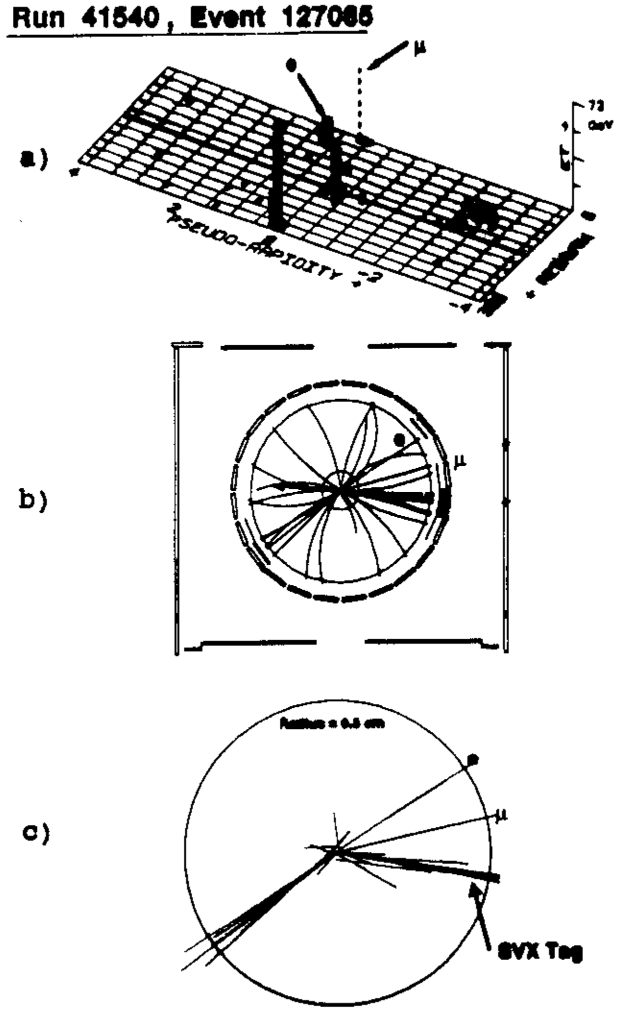


Figure 10: Event Display for one of the $e\mu$ events; (a) displays the observed calorimeter E_T in the $\eta - \phi$ plane, (b) shows the found CTC and charged tracks in the $r - \phi$ plane, and (c) shows a similar display for the found SVX tracks. The highlighted tracks in (c) are the tracks which form the displaced vertex.

SVX Backgrounds Summary

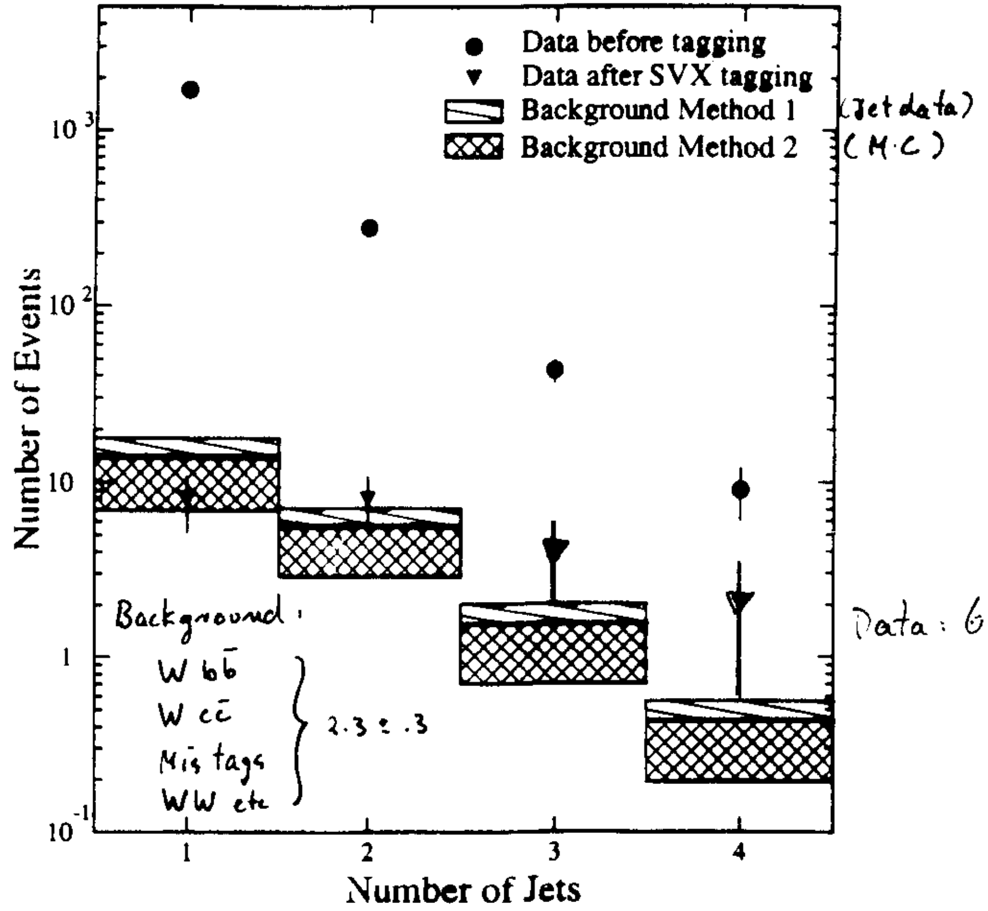
Source	Background in W + ≥ 3 jets
Wbb, Wcc + mistags	
Method 1	1.99 ± 0.26
Method 2	1.13 ± 0.53
Wc	0.14 ± 0.07
Z -> ττ, WW, WZ	0.08 ± 0.04
non-W	0.09 ± 0.09
Total	
$\boxed{\text{Method 1 (BG used)}}$	$\boxed{2.30 \pm 0.29}$
Method 2 (check)	1.44 ± 0.54
Events before tagging	52
$\boxed{\text{Tagged events}}$	$\boxed{6}$

For cross checks 2 background estimates:

1: Assumes $b\bar{b}$, $c\bar{c}$ content of jet-jet events is the same as in W + jet events (pessimistic)

2: $Wb\bar{b}$, $Wc\bar{c}$ simulation added to false rate

SEARCH FOR TOP QUARKS IN W+n jet EVENTS WITH SVX TAGS



Expect for

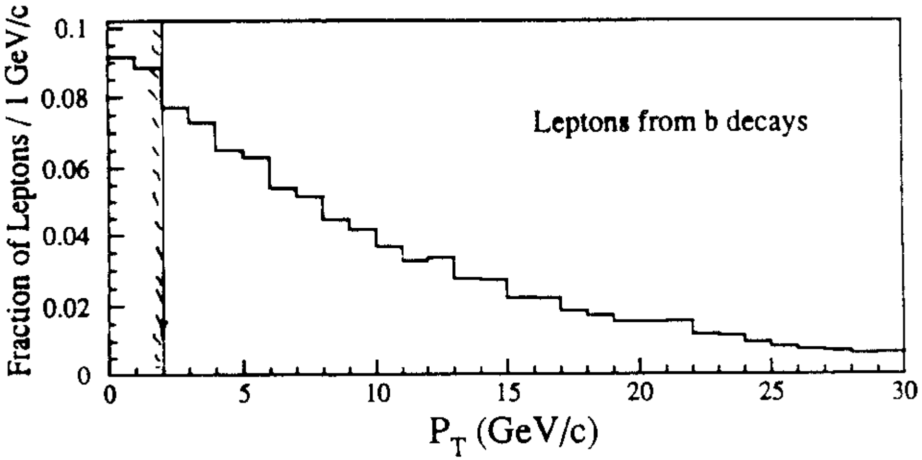
m_{top} = 120 GeV/c² 7.7 ± 2.5
140 GeV/c² 4.8 ± 1.7
160 GeV/c² 2.7 ± 0.9

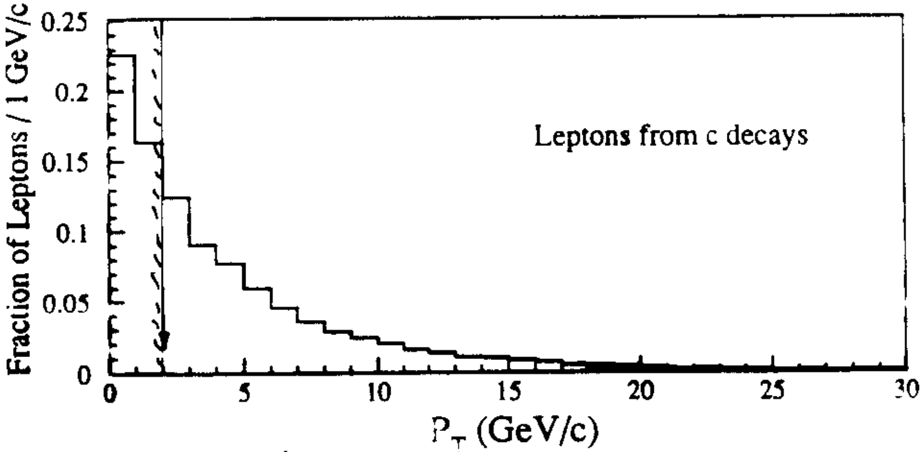
} Events with ≥ 3 jets;

(2) SLT tagging algorithm

- Search for semileptonic decays in jets
  $b \to e, \mu + X$, or $b \to c \to e, \mu + X$

  $P_t(e, \mu) > 2$ GeV/c





Background dominantly
Fake tags, $Wb\bar{b}$, $Wc\bar{c}$; 3.1 ± 0.3 events

SLT Backgrounds

- For main backgrounds :
  W + heavy flavor
  W + fake tags

Use same technique as SVX Method 1 (overestimate)

Apply parametrized tag rate per track to all tracks in the 52 event W + ≥ 3 jet sample

Find 2.70 ± 0.27 events of estimated background

The equivalent of SVX Method 2 would give 2.3 ± 1.2 events

- Other (smaller) backgrounds

Drell-Yan is reduced by rejecting isolated, opposite-sign lepton pairs. The remaining Drell-Yan background is estimated using the inefficiency of the isolation criteria.

Remaining backgrounds are estimated using same techniques as described for the SVX analysis

$Z \to \tau\tau$
WW, WZ
W + charm
non- W

CDF TOP CANDIDATES IN W+JET CHANNEL WITH SVX OR SLT TAGS

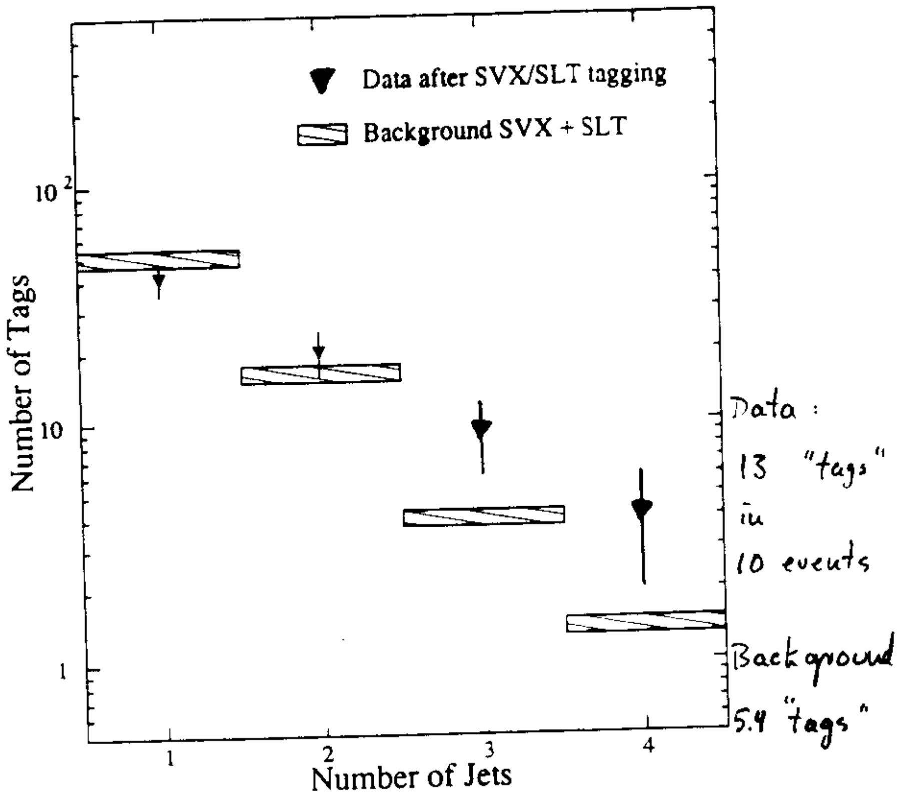


Figure 43: The sum of SVX and SLT tags observed in the W+jets data (solid triangles). Events tagged by both algorithms are counted twice. The shaded area is the sum of the method 1 background estimates for SVX and SLT, with its error.

Checks with Z + multijet sample

	Z + 1 Jet	Z + 2 Jet	Z + $\geq$ 3 Jets
Observed Z Candidates	176	21	$\boxed{5}$
SVX Tags	0	0	2
SVX background prediction	1.4±0.2	0.32±0.05	0.31±0.05
SLT Tags	6	0	0
SLT background prediction	2.9±0.3	0.52 ±0.05	0.33 ±0.03
SVX + SLT Tags	6	0	2
SVX + SLT background prediction	4.3 ± 0.4	0.84 ± 0.07	$\boxed{0.64 \pm 0.06}$

- **Though statistically limited, the excess of Z + ≥ 3 jet tags could indicate a non-top source of vector boson + heavy flavor not included in our background estimation. Higher statistics checks in W + 1,2 jets agree with expectation.**

Summary of counting experiments

- **Dileptons**

  Observe 2 events

  Predict 0.56 + 0.25 - .13 events of background

  One event has b tag

  P (Fluctuation) = 12 %

- **SVX tags**

  Observe 6 events

  Predict 2.3 ± 0. 3 events of background

  P (Fluctuation) = 3.2 %

- **SLT tags**

  Observe 7 events

  Predict 3.1 ± 0. 3 events of background

  P (Fluctuation) = 3.8 %

- **Three events tagged by both SVX and SLT**

⇒ Total number of "counts" : 15 observed in 12 events
6 expected from backgr.

P (Fluctuation) = 2.6×10^{-3} (2.8 σ)

Mass Determination of the Top Quark

kinematic fit (20 equations, 18 unknown)
to 7 W + 4 Jet events with tag

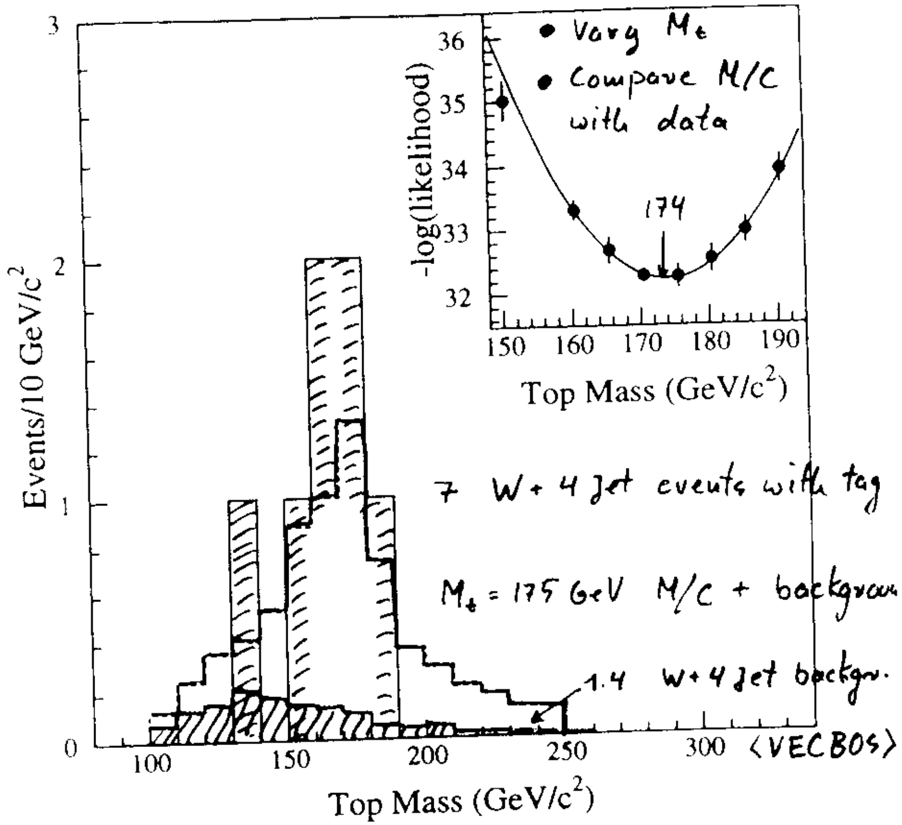


Figure 2: Top mass distribution for the data (solid histogram), the W+jets background (dots), and the sum of background + Monte Carlo $t\bar{t}$ for M_{top} = 175 GeV/c^2 (dashed). The background distribution has been normalized to the 1.4 background events expected in the mass-fit sample. The inset shows the likelihood fit used to determine the top mass.

D0 TOP CANDIDATES

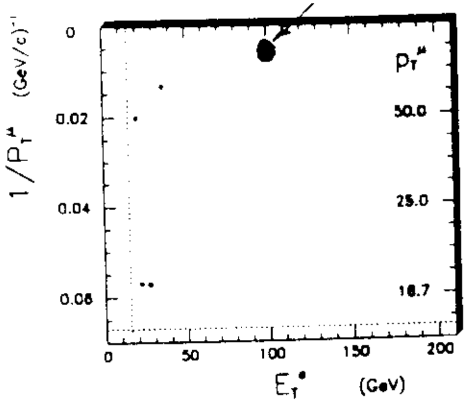
TABLES

TABLE I. Efficiency × branching fraction ($\epsilon \times B$), expected number of events ($\langle N \rangle$) for signal and background sources for the observed integrated luminosity ($\int \mathcal{L} dt$), and number of events observed in the data.

m_t [GeV/c^2]		$e\mu$	ee	$\mu\mu$	e + jets	μ + jets	e + jets(+μ)	ALL
140	$\epsilon \times B$(%)	.45 ± .10	.22 ± .03	.13 ± .02	1.3 ± 0.3	0.5 ± 0.2	0.9 ± 0.2	
	$\langle N \rangle$	1.2 ± 0.3	.56 ± .10	.24 ± .04	3.3 ± 0.9	0.9 ± 0.4	2.3 ± 0.6	8.5 ± 1.4
160	$\epsilon \times B$(%)	.47 ± .11	.23 ± .03	.13 ± .02	1.7 ± 0.4	0.7 ± 0.3	1.3 ± 0.2	
	$\langle N \rangle$	0.6 ± 0.1	.29 ± .05	.12 ± .02	2.1 ± 0.5	0.7 ± 0.3	1.6 ± 0.3	5.4 ± 0.9
180	$\epsilon \times B$(%)	.46 ± .11	.24 ± .03	.13 ± .02	1.9 ± 0.4	0.8 ± 0.3	1.5 ± 0.2	
	$\langle N \rangle$	0.3 ± 0.1	.15 ± .03	.06 ± .01	1.2 ± 0.2	0.4 ± 0.2	1.0 ± 0.2	3.1 ± 0.5
Background		.37 ± .09	.25 ± .08	.36 ± .06	1.1 ± 0.5	0.5 ± 0.3	2.1 ± 0.8	$\boxed{4.7 \pm 1.0}$
$\int \mathcal{L} dt$ [pb^{-1}]		15.2 ± 1.8	15.2 ± 1.8	11.0 ± 1.3	15.2 ± 1.8	11.0 ± 1.3	15.2 ± 1.8	
Data		1	0	0	1	2	3	$\boxed{7}$

D0 Top Quark Candidate

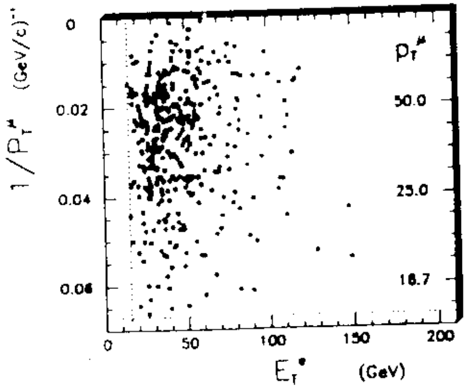
$t\bar{t} \to e\mu$ Jets $\not{E}_T$



E_T^e vs $1/P_T^\mu$

Collider Data

$\int Ldt = 15.2\ pb^{-1}$

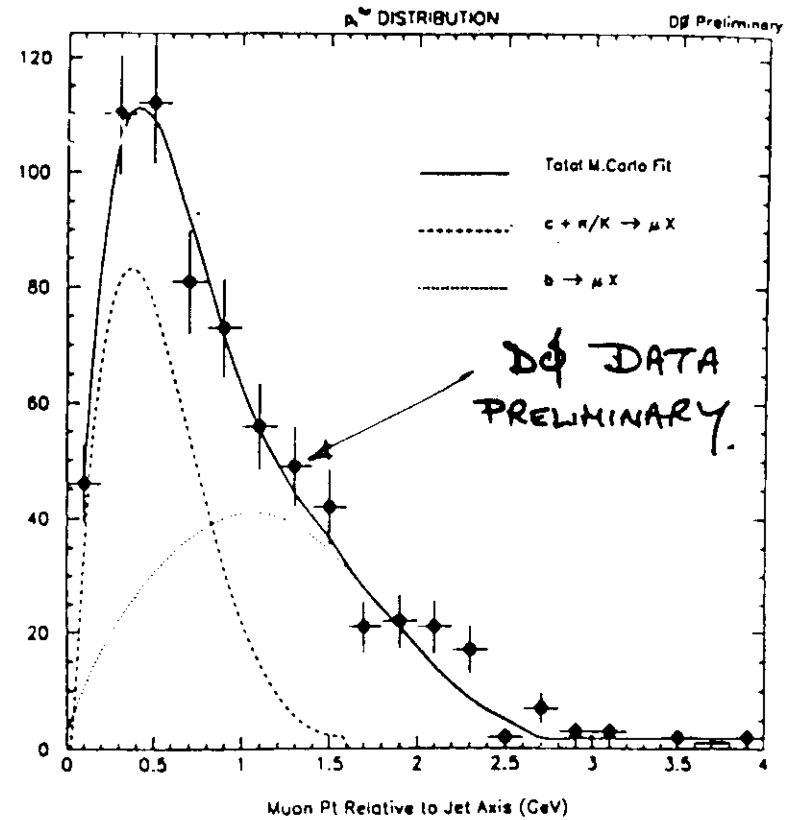


E_T^e vs $1/P_T^\mu$

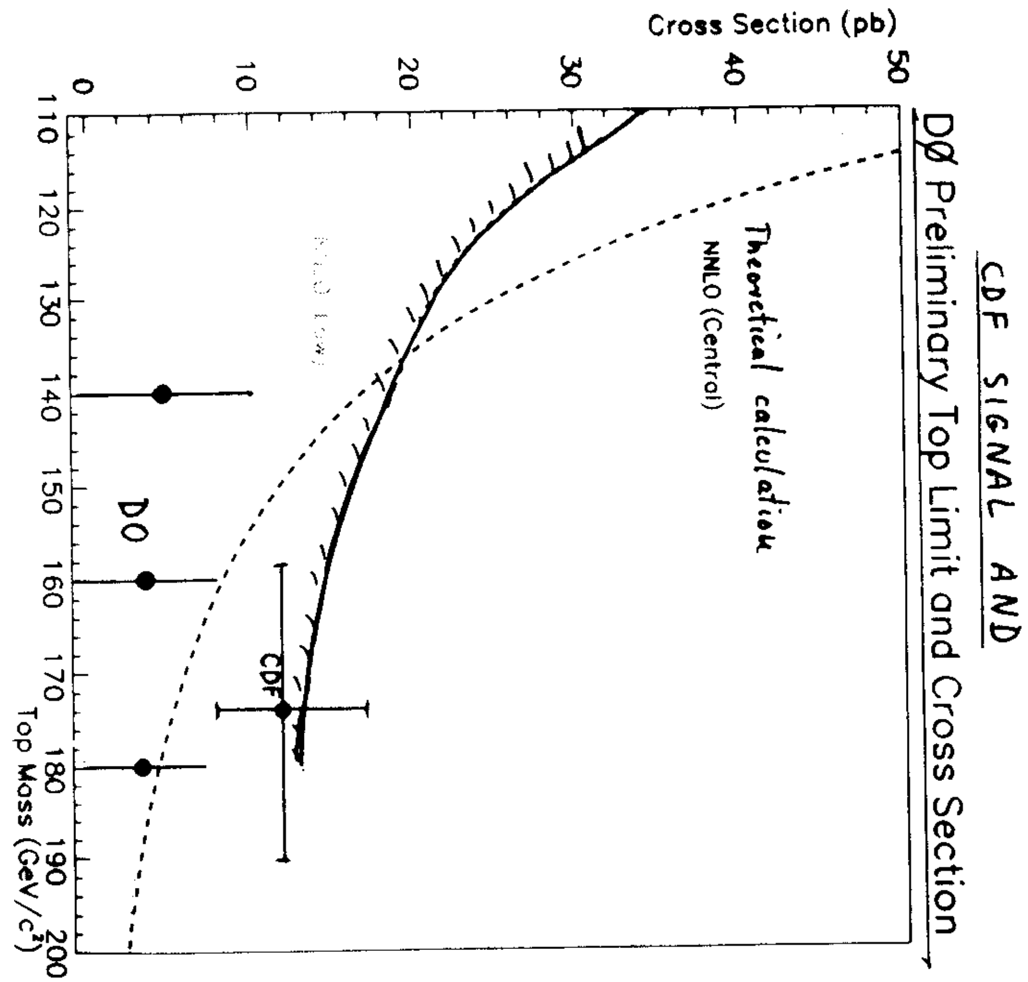
$tt \to e\mu$ ($m_t = 140$)

monte carlo

$\int Ldt = 2416\ pb^{-1}$



DISTRIBUTION
DØ Preliminary
Total M.Carlo Fit
c + π/K → μ X
b → μ X
DØ DATA
PRELIMINARY
Muon Pt Relative to Jet Axis (GeV)



CDF SIGNAL AND
DØ Preliminary Top Limit and Cross Section
Cross Section (pb)
Theoretical calculation
NNLO (Central)
DO
CDF
Top Mass (GeV/c²)

SUMMARY, OUTLOOK

The Tevatron Collider opens a vast field of Physics:

- First evidence for Top ($M_t = 174 \pm 17$ GeV/c
- Heavy Flavour Physics (Rare B decay mod. B_s, Λ_B, B_c, masse lifetimes, oscillation
- Precision EWK Physics ($M_W = 80.21 \pm 0.18$ GeV, $\Gamma_W = 2.06 \pm 0.08$ GeV/c
  Gauge Boson selfcoupling $\Delta\kappa < 2$, $\lambda < 0.7$..)
- QCD (Jet physics)
- Searches at the Energy Frontier (SUSY, leptoquarks, excited quarks, W', Z', compositnes, ..)

Prospects:

1994-95: Collider Run 1b $\mathcal{L}_{max} \sim 10^{31}/cm^2s$ $\sim 75\ pb^{-1}$

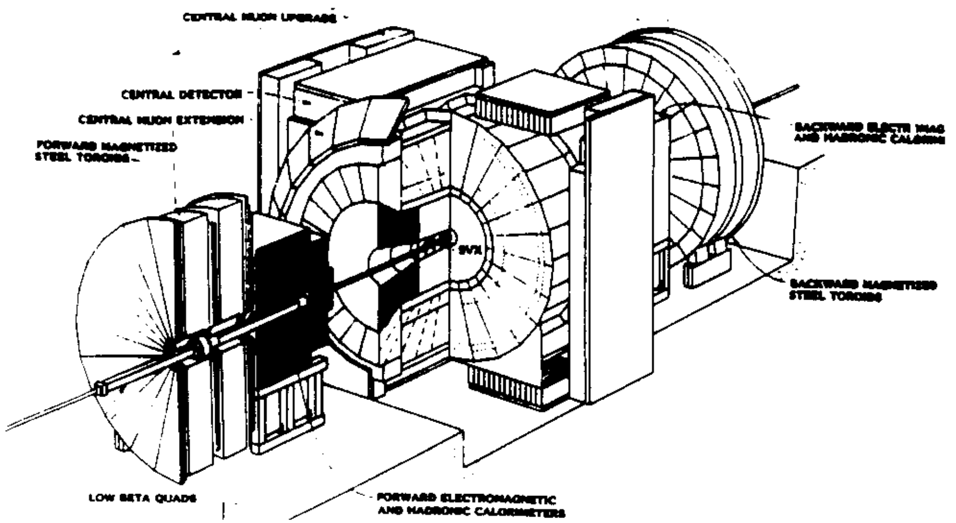
1998-2001: Run II with Main Injector, $\sqrt{s} = 2$ TeV
Upgraded CDF, D0 $\mathcal{L}_{max} \sim 5\ 10^{31}/cm^2s$ $\sim 500\ pb^{-1}$/Year

Afterwards: "Tevatron-Prime" $\mathcal{L}_{max} > 10^{32}/cm^2s$ $> 10\ fb^{-1}$

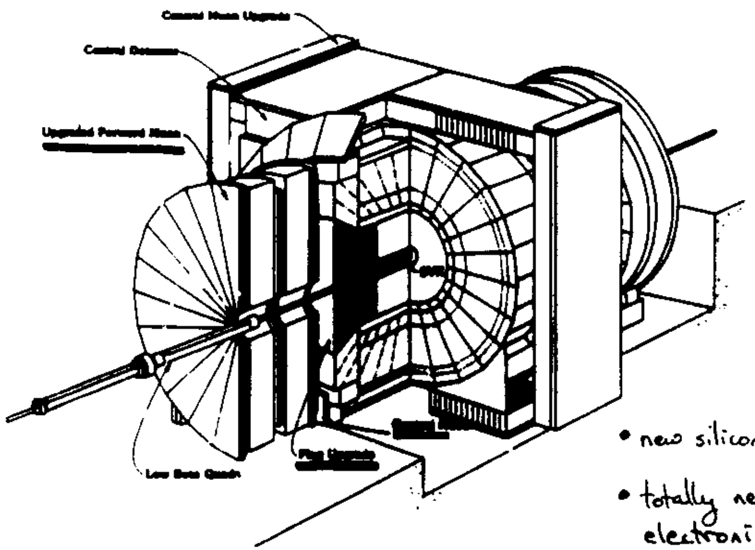
- Top physics
- SUSY
- CP (b system)

$\Bigg\}$ One upgraded detector, one new B-detector

CDF 1993



CDF 1998



- new silicon vertex detector
- totally new readout electronics

D0 Upgrades

- Central 2 T magnetic field
- New Central Tracking System:
  - silicon microstrip barrel $|\eta| < 1$
  - disks $|\eta| < 3$
  - scintillating fiber outer tracker
- Preshower Detector
- Cosmic ray shield

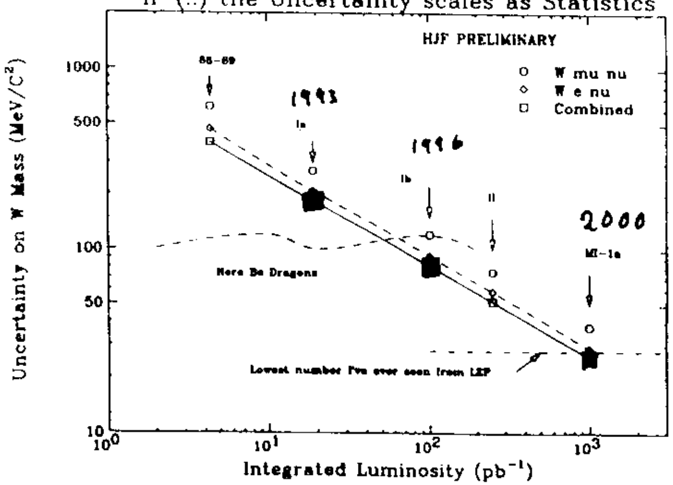
Uncertainties on the W mass Measurement

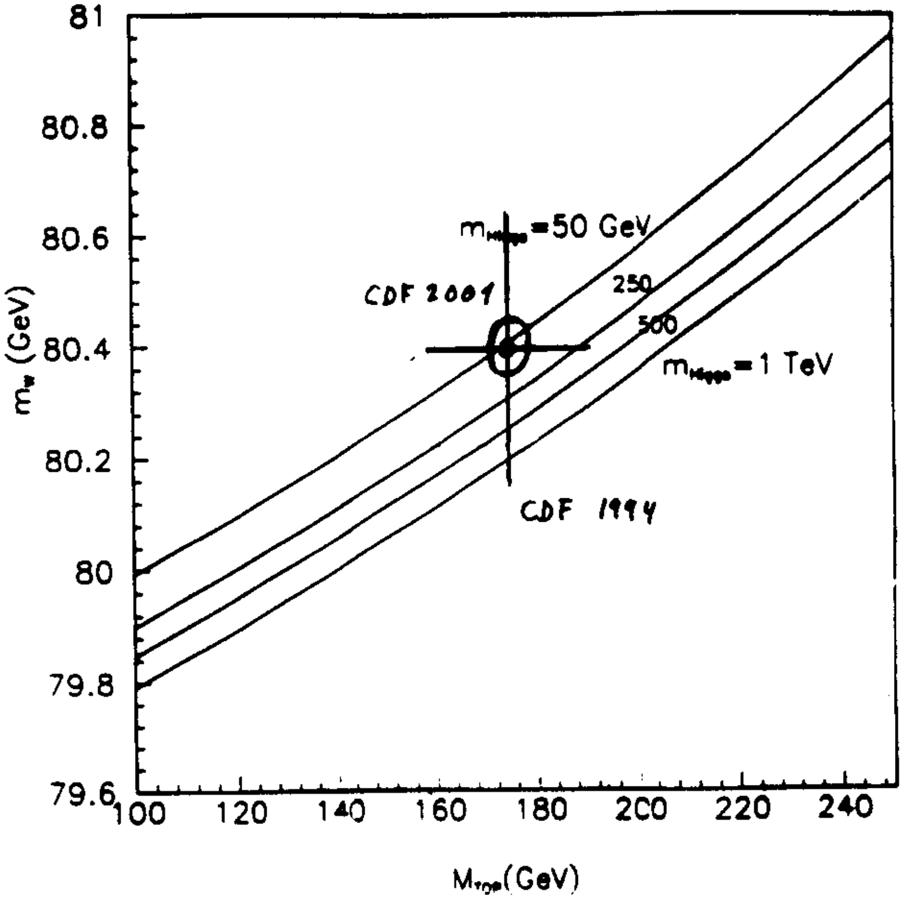
CDF Preliminary

	e	μ	Common	e	μ
Statistical	150	200		150	200
Momentum Scale	130	60	60	120	
Systematics	210	220			
Momentum Resolution	140	120		140	120
P_T^W	40	70		40	70
Z P_T Resolution	80	80	80		
Z P_T Statistics	20	20	20		
Parallel Balance	70	90		70	90
Backgrounds	50	50		50	50
Fitting	20	20		20	20
Structure Functions	100	100	100		
Total	290	300	140	260	270

1. ΔM_W due to backgrounds. +80 MeV (e), +232 MeV (μ)
2. Radiative correction. +80 MeV (e), +154 MeV (μ)

IF (!!) the Uncertainty scales as Statistics





Expectation: with Main Injector, upgraded CDF / D0:

$\delta M_W = 50\ MeV/c^2$

$\delta M_t = 5\ GeV/c^2$