Top to Bottom

New Results on Top and Bottom Quark Decays

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1. Top and Bottom Quark Decays in the SM
2. Summary of Run I Data Samples
3. Top Quark Branching Fractions
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5. Summary and Outlook for Run II

University of Rochester
HEP Seminar
September 1996

SM Top Quark Phenomenology

Top quarks decay via the weak force

- Predict $\sim$ 100% $t \to W^+ b$
- Lifetime depends on mass
- For heavy top ($M_{top} \gtrsim 100 - 120$ GeV/c^2), decays before it hadronises

Can be viewed as a "pure" charged current

$$\begin{aligned}\Gamma_{\text{top}} &= \frac{G_F M_t^3}{8\sqrt{2}\pi}\left(1-\frac{M_W^2}{M_t^2}\right)^2\left(1+2\frac{M_W^2}{M_t^2}\right) \\ &\sim 175\ \text{MeV}\left(\frac{M_t}{M_W}\right)^3 \sim 2\ \text{GeV}\end{aligned}$$

- Toponium doesn't have time to form
- T mesons $\sim$ degenerate (if there was time...)

Decay dominated by "longitudinal W^+"

- Means the W^+ prefers helicity 0
- Result of large top and W^+ mass

What Do Top Decays Tell Us?

SM predicts "pure" $V - A$ decay

- clear test of polarisation at decay vertex

$$\frac{W_{\text{long}}}{W_{\text{T}}} \sim \frac{1}{2}\left(\frac{M_t}{M_W}\right)^2 \sim 2.2$$

- V_{ts} CKM matrix elements
- Constraints on other SM parameters (eg. A_{LR})
- Effectively another consistency check of SM

Sensitive to some classes of "new physics"

- Higgs couples strongly to top
- Could decay into a SUSY H^+

$$t \to H^+ b, \quad H^+ \to \tau^+ \nu_\tau$$

- Top quark might be "special" in unexpected way
  - New physics that couples to $t\bar{t}$ system

$\boxed{\textbf{SM Bottom Quark Decays}}$

SM predicts similar charged-current decays

- Dominated by weak matrix element
- However, b is imbedded in "brown muck"
  - Strong interaction effects are important
  - higher-order diagrams also play a role

Have resorted to an effective Hamiltonian approach

- Use a basis convenient for a $Q\bar{q}$ system
  - $\Rightarrow$ Heavy Quark Effective Theory
- Assume that decay amplitude "factors" (BSW)
- Determine parameters empirically

Hadronic Bottom Decays

Start with

$$H = \frac{G_F}{\sqrt{2}} V_{cb} \left\{ \left[(\bar{d}u) + (\bar{s}c) \right] (\bar{c}b) \right\}$$

- Renormalise H to take into account QCD corrections

$$H_{\text{eff}} = \frac{G_F}{\sqrt{2}} V_{cb} \left\{ c_1(\mu) \left[(\bar{d}u) + (\bar{s}c) \right] (\bar{c}b) + c_2(\mu) \left[(\bar{c}u)(\bar{d}b) + (\bar{c}c)(\bar{c}b) \right] \right\}$$

- For $B \to J/\psi$ decays, employ BSW factorisation:

$$d\Gamma(B^+ \to J/\psi X) \propto a_2(m_b)^2 |V_{cb} V_{cs}^*|^2 \, |\langle J/\psi | (\bar{c}c) | 0 \rangle|^2 \, |\langle X | (\bar{s}b) | B \rangle|^2$$

- Have to put in b quark form factors by hand

Model is fundamental enough to warrant detailed study

- CLEO/ARGUS have looked at many decays systematically
- But studies have had limitations
  - low statistics
  - only have access to B° and B^+
    - cannot produce B_s° or b baryons

Hadron collider experiment overcomes some limitations

- Tevatron has produced $\sim 3 \times 10^9$ $b\bar{b}$ events
- CDF has measured a number of B branching fractions

Run I Results from CDF

CDF is general-purpose detector designed to study $\overline{p}p$ collisions

- approximately hermetic calorimeters in $|\eta| < 4.2$
- 84-layer drift chamber in 1.4 T solenoidal B field
- muon chambers outside calorimeter
- electron ID based on shower profiles & tracking

The CDF experiment ran from 1992-96

- Collected 20 pb^{-1} in 1992-93 (Run Ia)
- Collected 85 pb^{-1} in 1994-96 (Run Ib)
- Maximum L of $\sim 2.7 \times 10^{31}$ cm^{-2}s^{-1}

Top Quark Production

Top quark production is mediated by

$$q\bar{q}, gg \quad \rightarrow \quad t\bar{t}$$

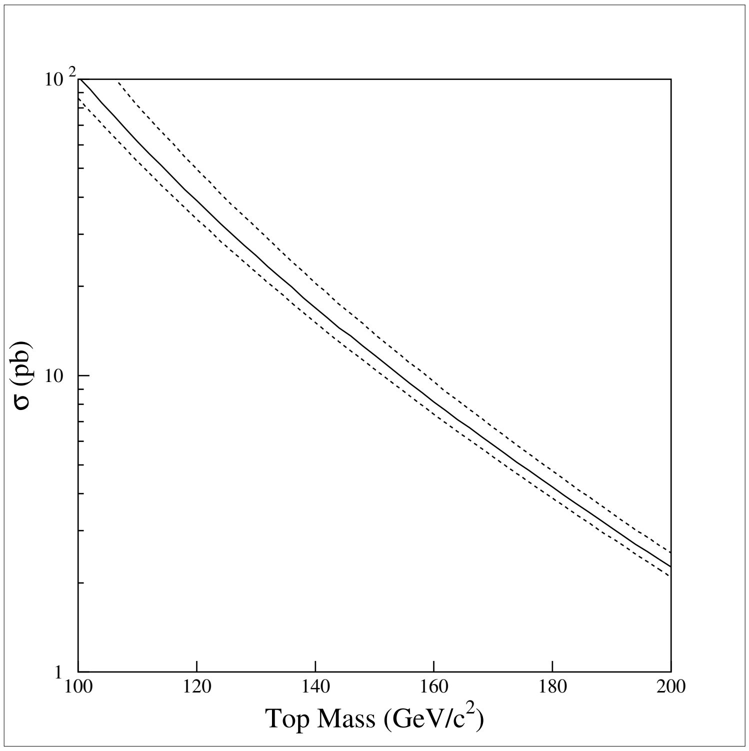
$$q\bar{q} \rightarrow t\bar{b}X \qquad \text{and} \qquad q\bar{q} \rightarrow W^{+} \rightarrow t\bar{b} \quad \text{both small}$$

Because top is heavy, need large x for initial partons

- Implies that cross section falls with mass
- $t\bar{t}$ system approximately at rest – $< P_T > \sim M_{top}/2$

Higher order corrections to $\sigma_{t\bar{t}}$ have been calculated

- Most recently by Laenen, Smith and Neerven, NP **B369**, (1992) 543.
- Biggest effects due to "soft gluon emission"



Top Decays and Detection Requirements

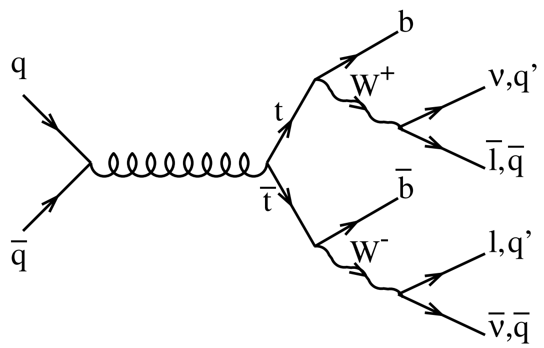
SM top quark decays via the weak force

$$t \rightarrow W^+ b$$

$\quad \hookrightarrow u\bar{d}$ or $c\bar{s}$ (2/3)

$\quad \hookrightarrow e^+\nu_e$ or $\mu^+\nu_\mu$ or $\tau^+\nu_\tau$ (1/3)

In proton-antiproton collisions,



This results in several distinct decay signatures

- Six jet final states (36/81)
- Lepton ($e^\pm$ or $\mu^\pm$) + Jet events (24/81)
- Dilepton events with 2 energetic $e^\pm$ and $\mu^\mp$ (4/81)
- Decay modes with τ's hard! ($\sim$ 12/81)

$\boxed{\textbf{Triggering Issues}}$

Use multi-level trigger to tag events in real-time

- Interaction rate of

  $\left(50 \times 10^{-27}\ \mathrm{cm}^2\right) \times \left(1.5 \times 10^{31}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}\right) = 7.5 \times 10^5\ \mathrm{Hz}$

  has to be reduced to of order 1-10 Hz

- Most challenging aspect of experiment
  - Depends critically on all subsystems
  - Need efficiency $> 75\%$ to be competitive

Triggering for "heavy" top is relatively easy

- Tag high P_T ($> 15 - 20$ GeV/c) lepton(s)
- Missing energy requirements ($\not{E}_T > 20 - 25$ GeV)
- Multijet topologies
- Trigger efficiencies $\geq 90 - 95\%$ in most cases

Top Signals

Have detected signals for $t\bar{t}$ production & decay

1. Lepton + jets channel
   - Require $e^{\pm}$ or $\mu^{\pm}$ with $P_T > 20$ GeV/c
   - Require $\not{E}_T > 20$ GeV to tag neutrino
   - Require ≥ 3 jets with $E_T > 15$ GeV
   - Require at least one jet with b tag
2. Dilepton channel
   - Require two $e^{\pm}$ or $\mu^{\pm}$ with $P_T > 20$ GeV/c
   - Require $\not{E}_T > 25$ GeV to tag neutrino
   - Require ≥ 2 jets with $E_T > 10$ GeV
3. Dileptons with τ's
   - Require τ candidate + additional lepton
   - Similar requirements to standard dileptons
4. Hadronic channel
   - Require 6 jets with $E_T > 20$ GeV
   - Require at least two jets with b tags
   - Make kinematic cuts to increase S/N

W+Jet Selection

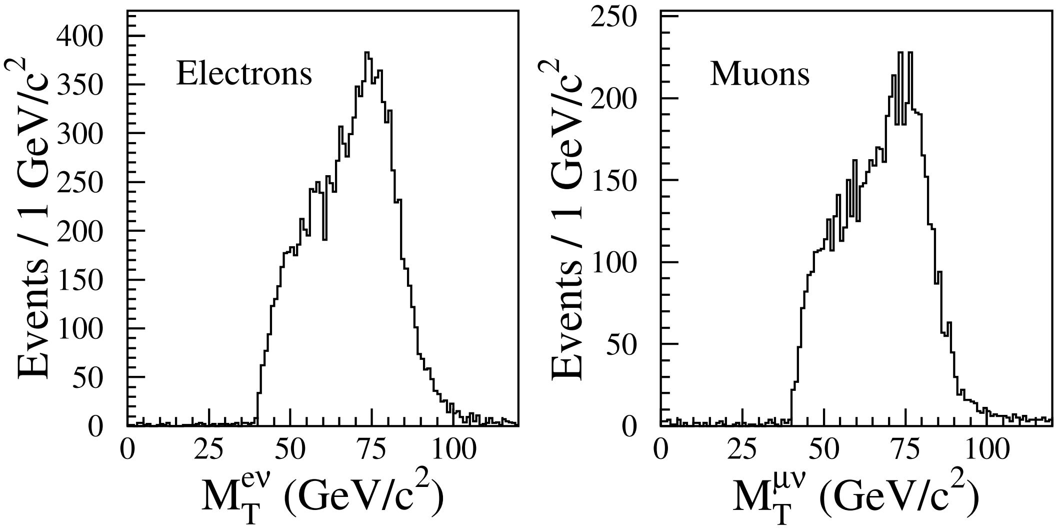
Selection of W candidates straightforward

- Require high P_T isolated lepton candidate
- Require significant $\not{E}_T$
- Require three or more high P_T jets

Have large W^+ samples

- CDF has 31,000 $e\nu_e$ and 21,000 $\mu\nu_\mu$ candidates

Run IA CDF data shows clear "W" signal:



W + Jet Sample

Require ≥ 3 or 4 jets (from other W and b quarks)

- ≥ 3 jets with $E_T > 15$ GeV and $|\eta| < 2.0$
- find 274 W+$\geq$ 3 jet events

Most background sources are small:

Background	Fraction of Events (%)
Fake leptons and $b\bar{b}$	9 ± 5
WW, WZ and ZZ	4 ± 2
$Z \rightarrow \tau\tau$, ee, $\mu\mu$	7 ± 2
Total	20 ± 6

QCD W+jets production is largest expected background

M_{top} (GeV/c^2)	Number of Events (CDF)
120	176 ± 28
140	105 ± 14
160	57 ± 10
180	16 ± 3.2
W+jets	238^{+76}_{-38}

b Quark Tagging in W+Jet Events

Have two different techniques for b-tagging

1. About 20% of b's decay via

$$b \rightarrow e^- \nu_e X \quad \text{and} \quad b \rightarrow \mu^- \nu_\mu X$$

   - Look for jets with "soft" leptons in them (SLT tags)

2. "Long" b lifetime – $c\tau \sim 450$ microns

   - Use Silicon Vertex Detector to identify jets with a secondary vertex

   - Expect 42% of $t\bar{t}$ events to have at least one SVX tag

Applied b tagging techniques to W+jet events

- The $W + 1$ and $W + 2$ jet samples are ultimate control
  - Don't expect significant top contribution
  - Theory predicts low b hadron content

Sample	SVX bkg	SVX tags	SLT bkg	SLT tags
W+1 jet	69 ± 15	70	272 ± 24	245
W+2 jet	29 ± 4	45	78 ± 7	82
W+$\geq$ 3 jet	9.3 ± 1.1	34	25.2 ± 3.0	40

Dilepton Top Sample

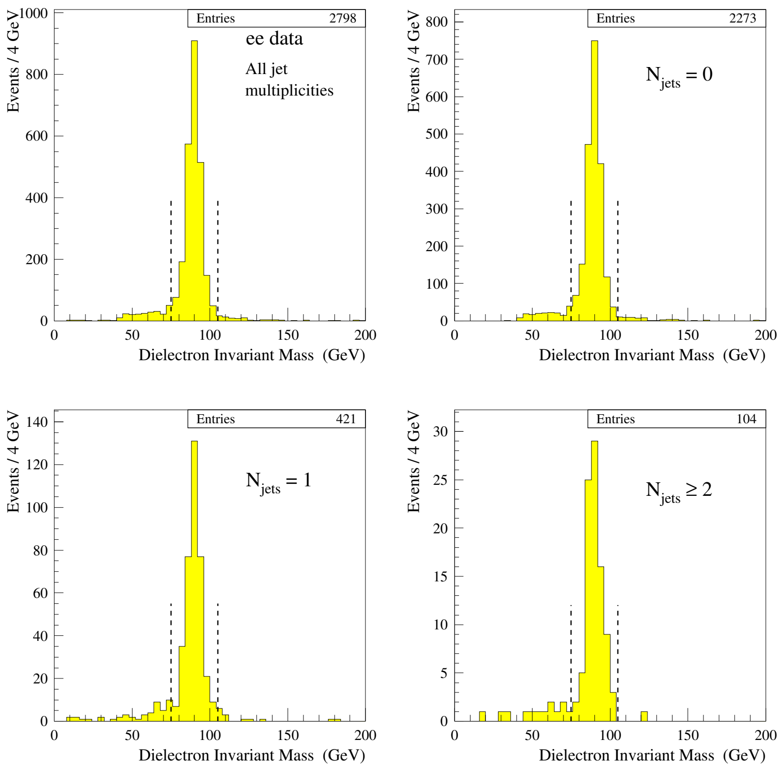
$t\bar{t}$ decaying into 2 leptons create unique signature

- Two charged leptons from $W^{\pm}$ decay
- Imbalance in total energy due to undetected neutrinos
- Two jets from bottom quarks

Select sample by requiring

- Two clean, high P_T lepton candidates
- Missing transverse energy $\not\!\!E_T > 25$ GeV
- Require two jets with $E_T > 10$ GeV and $|\eta| < 2.0$
- Reject specific backgrounds (e.g. Z°)

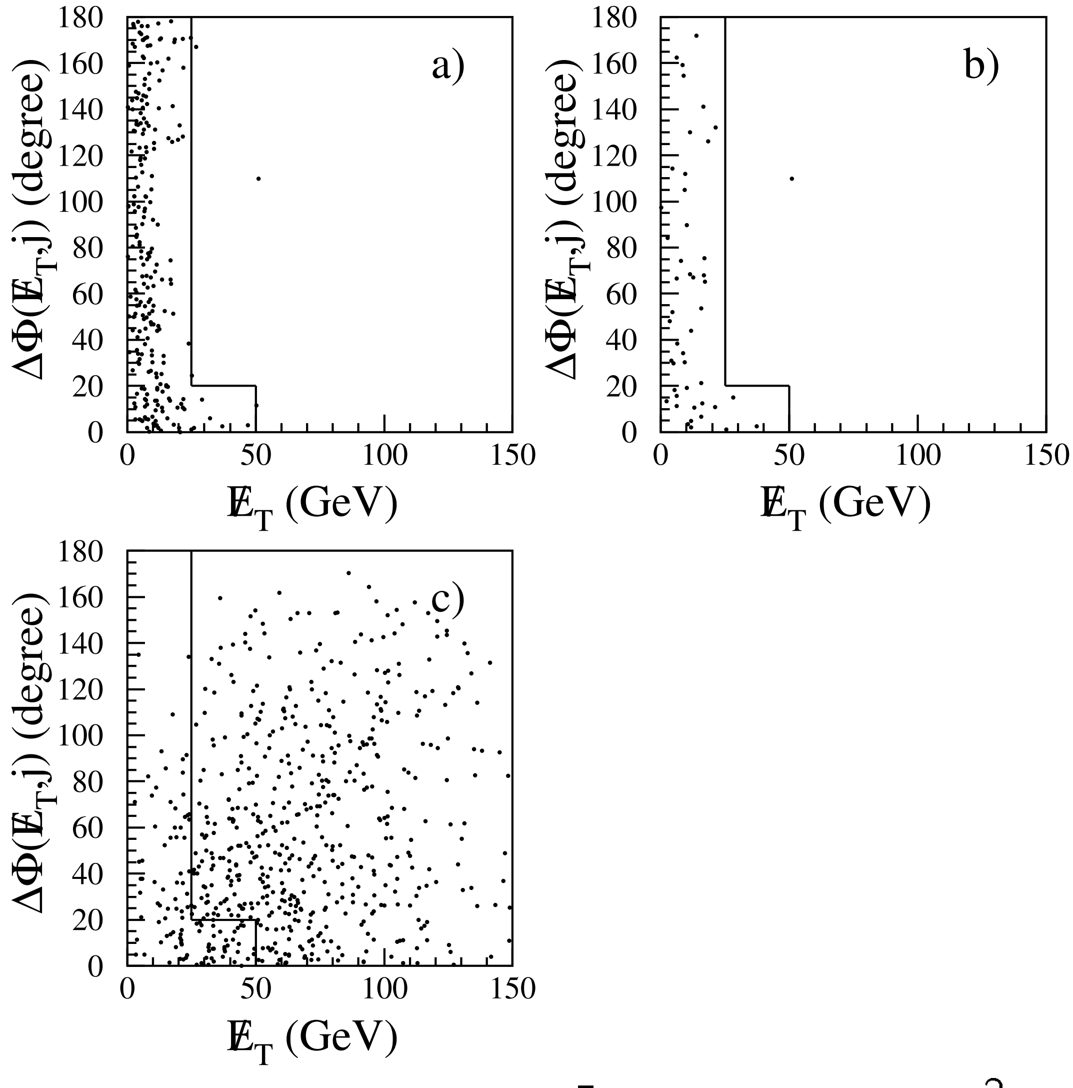
Run 1 ee data (109 pb^{-1}), CDF preliminary



Dilepton Channel

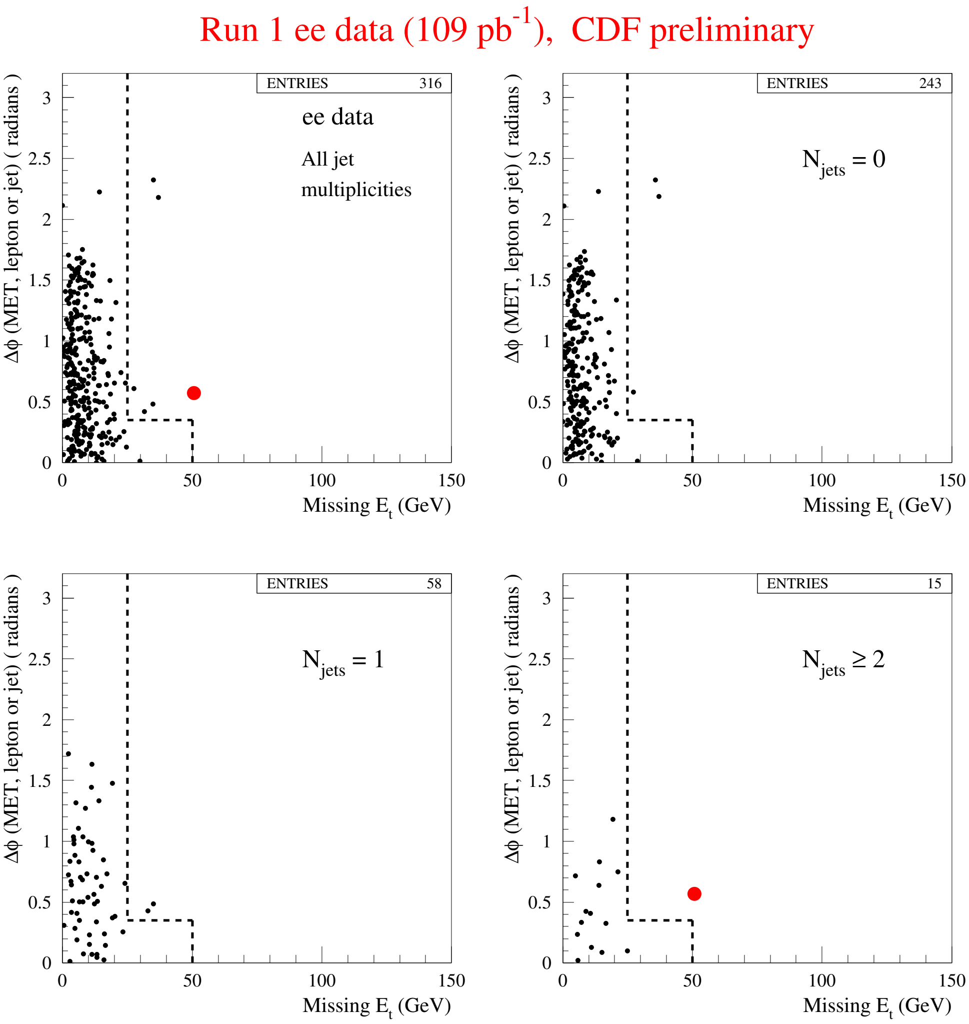
Significant dilepton background is Drell-Yan production

- $\not\!\!E_T$ signature created by mismeasured jet
- Harden $\not\!\!E_T$ cut to > 50 GeV if correlated with jet

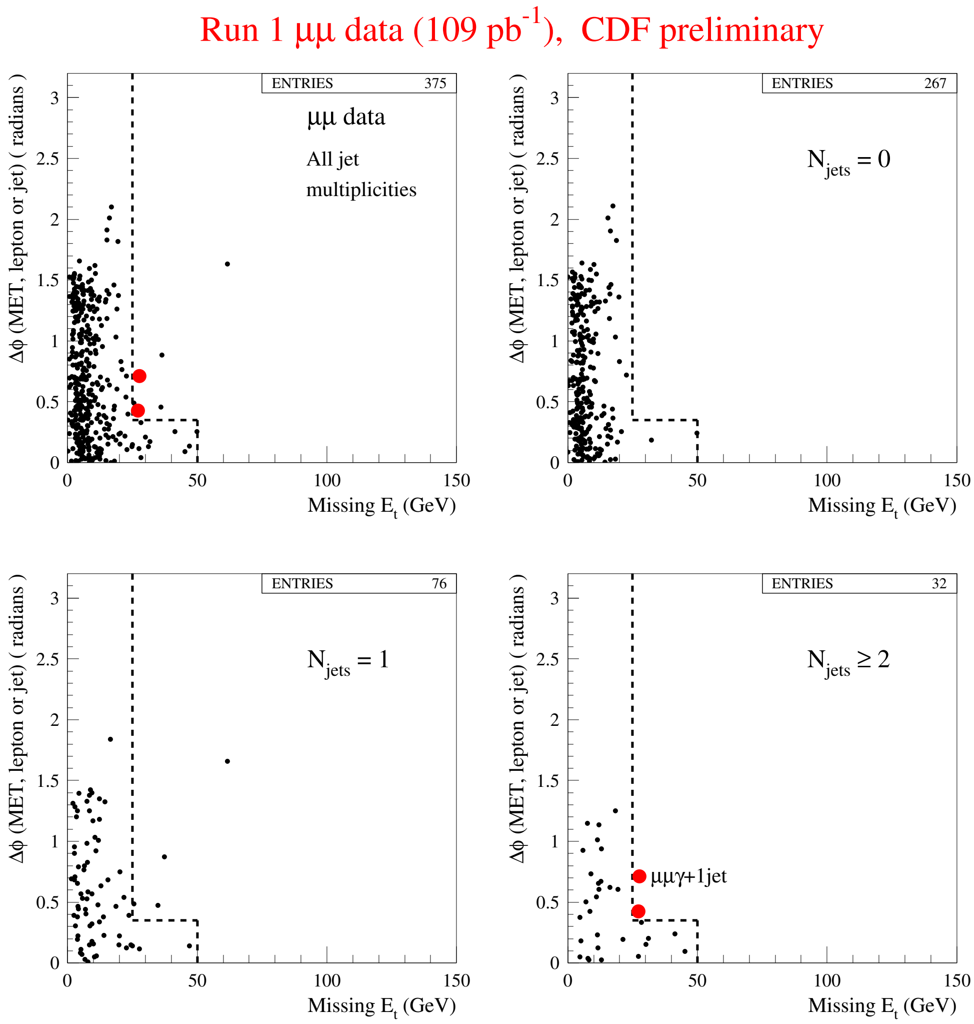


a) Z+1 jet, b) Z+ 2 jet, and c) $t\bar{t}$ ($M_{\mathrm{top}} = 160$ GeV/c^2)

Dielectron Data for Run 1A and 1B

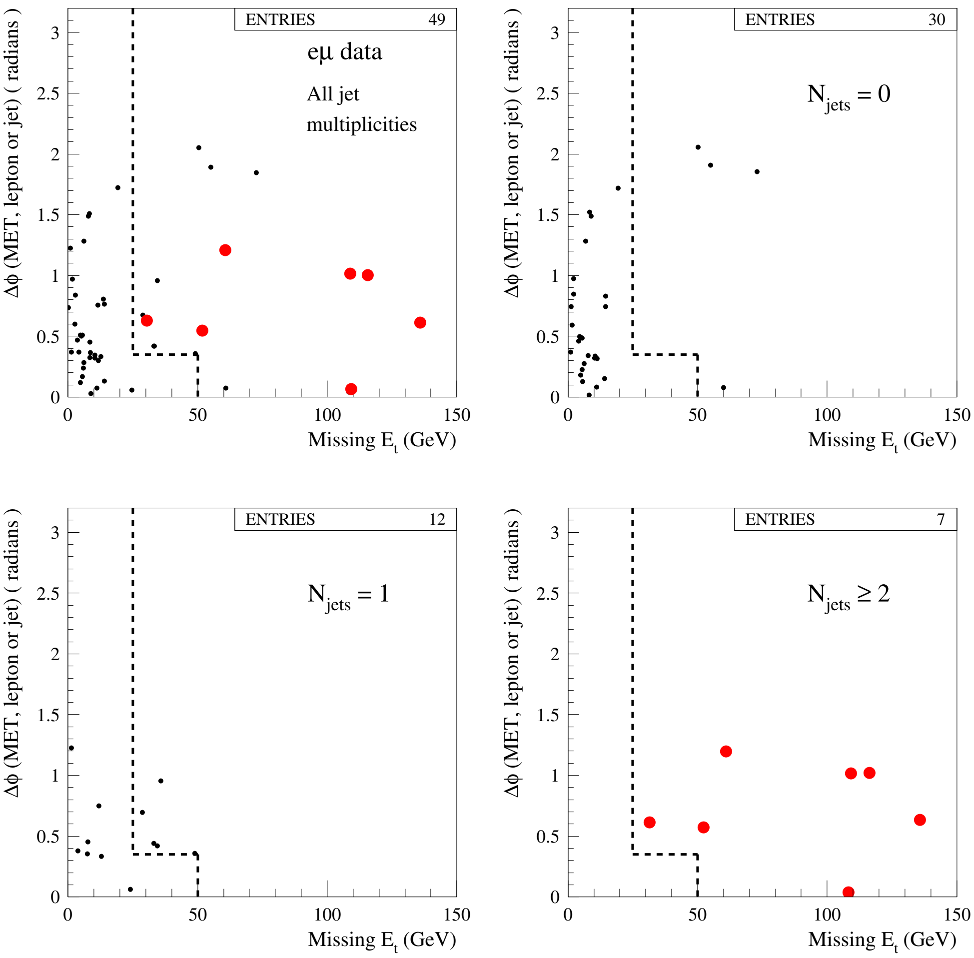


DiMuon Data for Run 1A and 1B



Electron-Muon Data for Run 1A and 1B

Run 1 eμ data (109 pb^{-1}), CDF preliminary



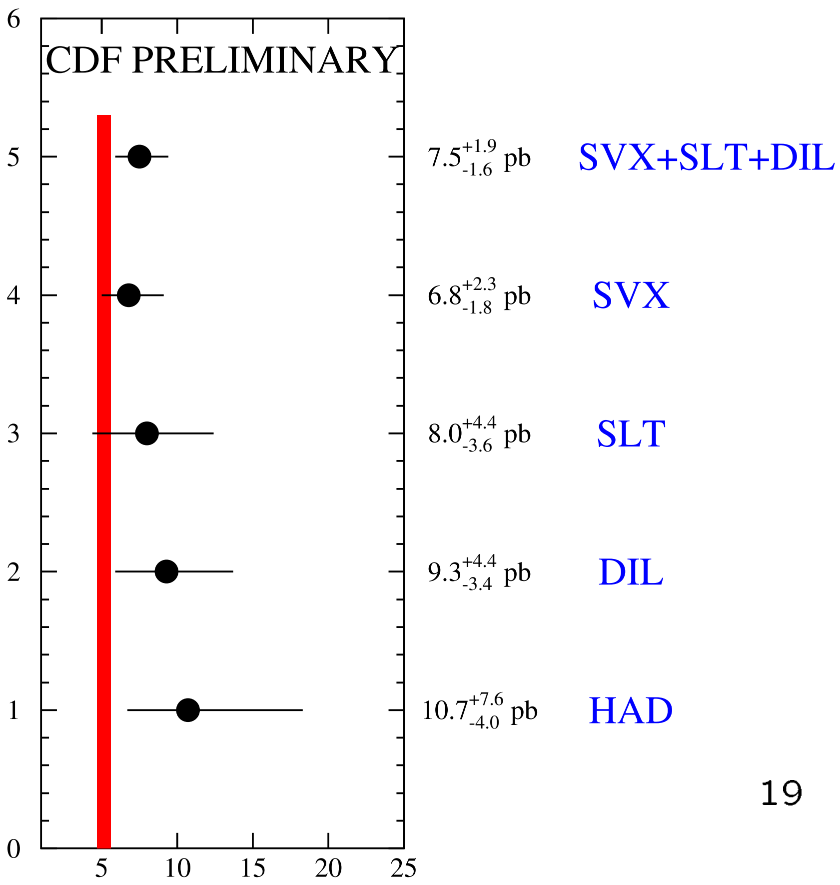
Summary of CDF Dilepton Search

Observe a total of 10 candidate events

- Observe 1 e^+e^- event, 2 $\mu^+\mu^-$ event and 7 $e\mu$ events
  - One $\mu^+\mu^-$ event suspicious (but we keep it)
  - Has $\mu^+\mu^-\gamma$ mass close to Z°
- Expect 2.1 ± 0.4 events from background

Acceptance $\times$ SM branching fraction $= 0.77 \pm 0.08\%$

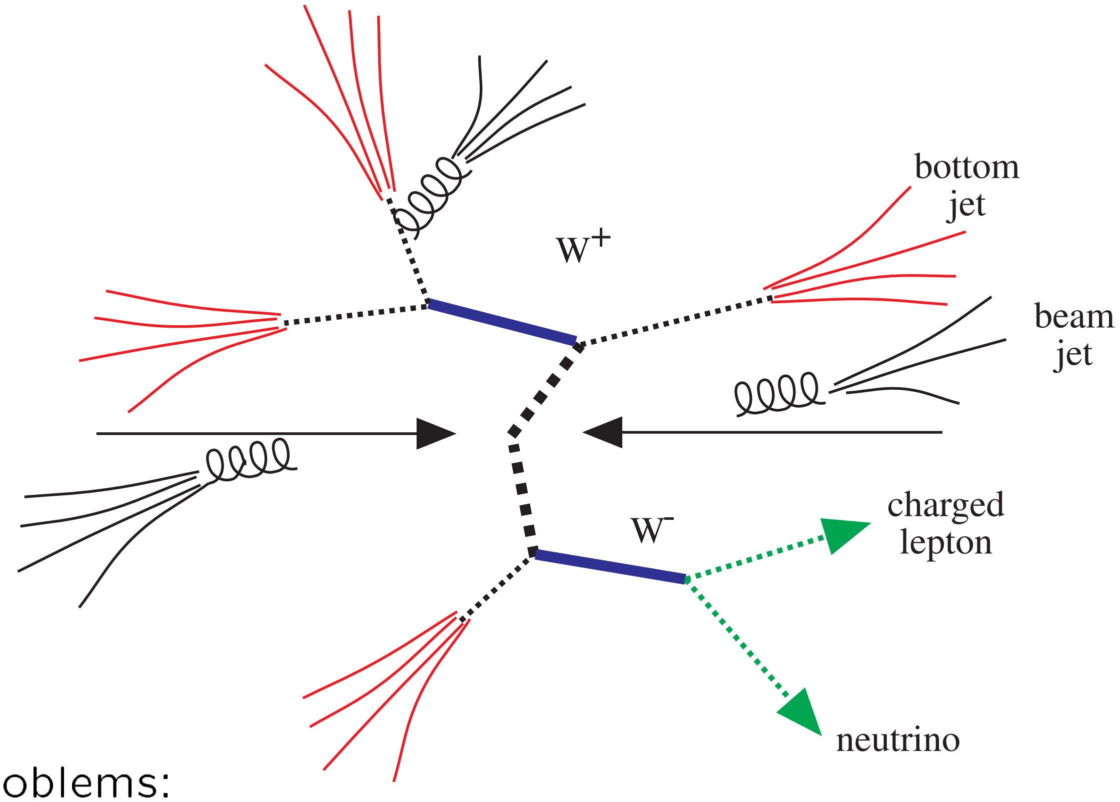
$$\sigma_{t\bar{t}} = 9.3^{+4.4}_{-3.4}\text{ pb}$$



Top Quark Mass from Lepton + Jets

In this mode, have measured almost all $t\,\bar{t}$ daughters

- Lepton 4-momentum solid and ν_l is missing only p_z
- $W \to q\bar{q}'$ observed as 2 jets
- bottom quarks observed as jets (perhaps tagged)



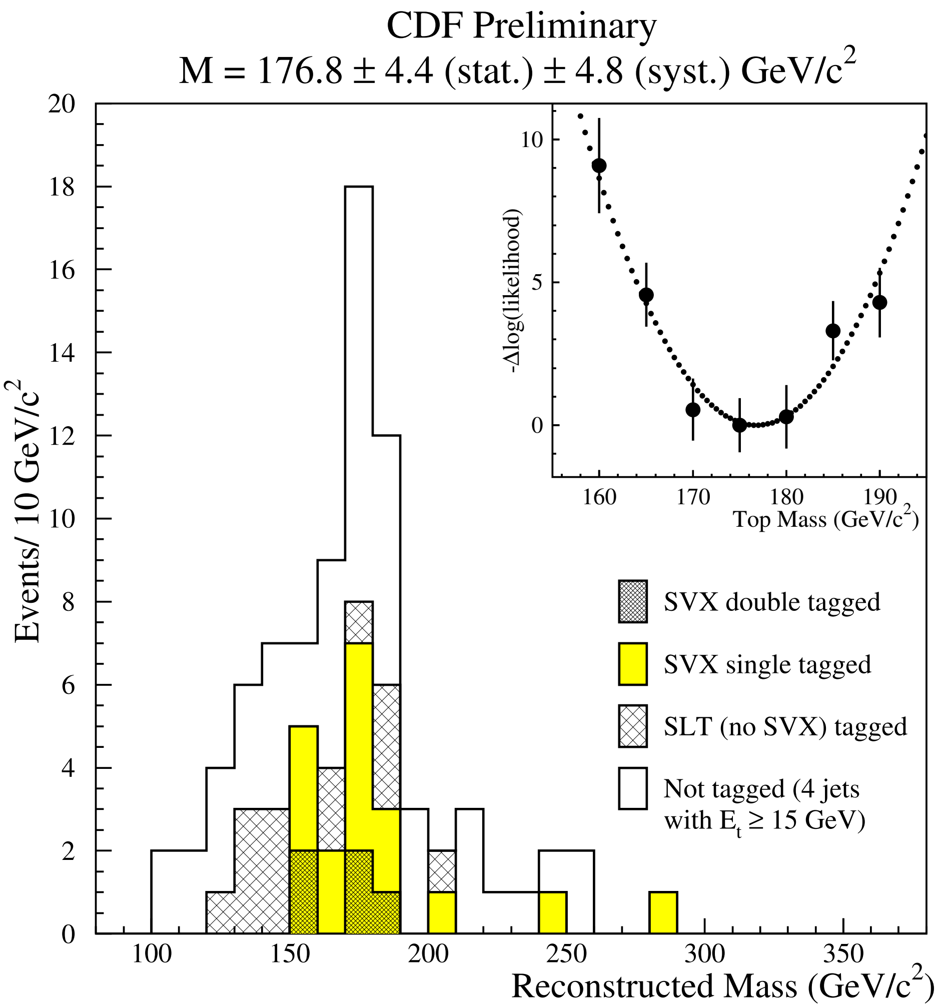
Problems:

- QCD radiation generates additional jets
- Combinatorics in identifying jets $\leftrightarrow$ partons
- Background events

Top Mass Results

Estimate mass based on 34 $W+\geq 4$ jet sample

- Use known fake tag rates and $Wb\bar{b}$
- Background shape in M_{top} comes from MC calculation
- Estimate background to be $6.4^{+2.1}_{-1.4}$ events
  - Primarily QCD W+jet



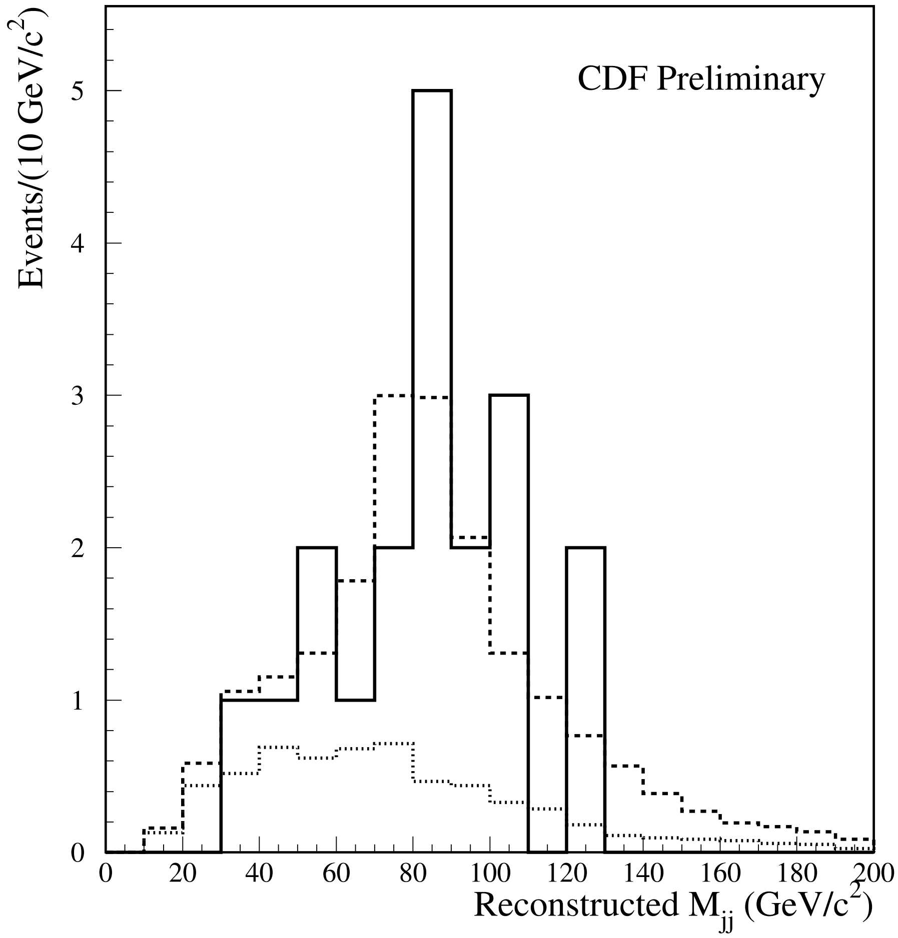
Evidence for $\mathbf{W \rightarrow q\bar{q}}$

Observation of $W \rightarrow q\bar{q}$ is important

- Strong evidence of signal in $W^+W^-b\bar{b}$ channel
- Can calibrate jet energy scale

Have to refit data relaxing W mass constraint

- Look for W signal plotting all mass combinations
  - Makes it tough since 6 combos/event
- Reduce backgrounds by requiring $H > 300$ GeV



Top Quark Branching Fractions

Indication of new physics would be if $\mathcal{B}(t \to W^{\pm}b) \neq 1$

- SM expects V_{tb} to be unity
  - Unitarity constraints
    - V_{ud} large from nuclear β and μ decay
    - V_{us} constrained by K_{e3} decays
    - V_{cd} comes from $\nu n \to cX$
    - V_{cs} constrained by D_{e3} decays
    - V_{cb} small because large τ_b
    - V_{ub} even smaller ($b \to u$)
  - Expect V_{ts} and V_{td} much smaller than V_{tb}
- $V_{tb} \lesssim 0.9985$ violates (or bends) SM

Experimentally, we determine

$$\mathcal{R} \equiv \frac{\mathcal{B}(t \to Wb)}{\mathcal{B}(t \to Wq)} = \frac{|V_{tb}|^2}{|V_{tb}|^2 + |V_{ts}|^2 + |V_{td}|^2}$$

Measure the rate of 0, 1 and 2 b-tagged events

- Need to be able to b tag
- Have to deal with large backgrounds in 0-tagged sample

$\boxed{\mathcal{B}\ \textbf{Technique}}$

Fraction of zero, single and double-tagged events is

$$\begin{aligned} f_0 &= (1-\mathcal{R}\epsilon)^2 \\ f_1 &= 2\mathcal{R}\epsilon(1-\mathcal{R}\epsilon) \\ f_2 &= (\mathcal{R}\epsilon)^2 \end{aligned}$$

- ϵ is tagging efficiency

Rate of single vs double tags gives

$$\mathcal{R} = \frac{2}{\epsilon(f_1/f_2+2)}$$

Rate of zero vs single tags gives

$$\mathcal{R} = \frac{1}{\epsilon(2f_0/f_1+1)}$$

Estimate $\mathcal{R}$ using maximum likelihood technique

- For a given number of observed events,
  - calculate probability of observing 0, 1 and 2 tags
  - maximize probability by varying $\mathcal{R}$
- Can use probability to constraint $\mathcal{R}$

Event Selection Details

Increase sensitivity by relaxing b tag requirement

- Reject large QCD background by cutting on
  1. Relative likelihood of $t\bar{t}$ vs W+jets
     - based on 2nd and 3rd leading jet E_T
     - Rejects 75% of W+jet background
     - Has efficiency of 75% for $t\bar{t}$
  2. Use sample with $|\cos\theta^*| < 0.7$ as check
     - Expected to be enriched in $t\bar{t}$
     - But fairly large systematic uncertainty
- Only using Run Ib data (~ 90 pb^{-1})

After applying likelihood cut,

- Have 68 events after relative likelihood cut
  - Expect non-$t\bar{t}$ background to be ~ 40 events
  - Have 24 events after additional $\cos\theta^*$ cut
- Have 10 and 5 single and double-tagged events

CDF BR Results

For dilepton events

- Have 5, 2 and 0 events with 0, 1 and 2 b-tags
- Backgrounds are very small ($\lesssim 2$ events)

Fit $\mathcal{B}(t \to W^+b)$ using observed event rates

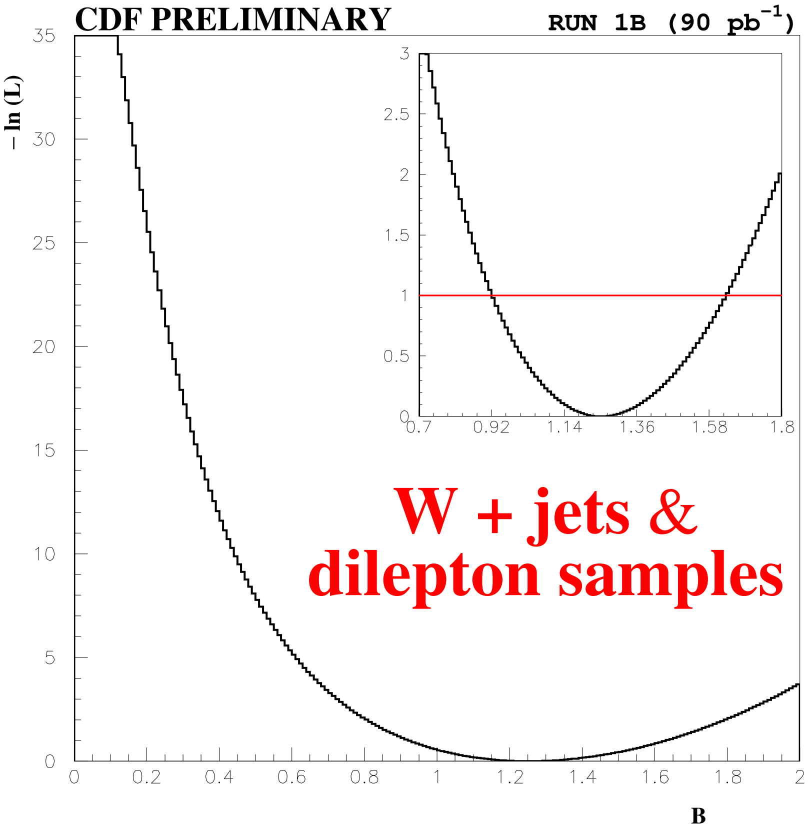
Class of Events	Observed	Fitted
Lepton + Jets – 0 tags	51.5	53
Lepton + Jets – 1 tags	10.4	10
Lepton + Jets – 2 tags	4.9	5
Dileptons – 0 tags	4.9	5
Dileptons – 1 tags	1.4	2
Dileptons – 2 tags	0.2	0

Fit results are:

$$\begin{aligned} \mathcal{R} &= 1.42^{+0.41}_{-0.39} \quad \text{(lepton + jets)} \\ \mathcal{R} &= 0.72^{+0.66}_{-0.44} \quad \text{(dileptons)} \\ \mathcal{R} &= 1.23^{+0.38}_{-0.33} \quad \text{(combined)} \end{aligned}$$

- Values > 1 allowed because of background fluctuations

Relating Back to V_{tb}



Find that $\mathcal{R} > 0.61$ at 95% C.L.

- Can relate that to V_{tb} using average values of
  - $0.004 \le |V_{td}| \le 0.015$ and $0.030 \le |V_{ts}| \le 0.048$

V_{tb}	$>$	0.78	(95%C.L.)	assuming CKM unitary
V_{tb}	$>$	0.38	(95%C.L.)	without CKM unitary

- Really saying that $|V_{tb}| \gg |V_{ts}|$ or $|V_{td}|$

Bottom Meson Decays at CDF

Hadron collider b experiment has serious S/N problem

- b cross section is of order ~ 30 μb
- light quark and gluon jet $\sigma \sim 5$ mb
- solution is to trigger on "unique" topologies
  - require semileptonic decays
  - require tag such as $J/\psi \to \mu^+\mu^-$ in final state
- All CDF studies have been based on these triggers

However, can extract clean samples efficiently

- Will focus on $B \to J/\psi X$ and $B \to \psi(2S)X$ decays
- Now have world's largest sample

Why are J/ψ and ψ(2S) States Interesting?

Expect decays to result from "internal" diagrams

- Theoretically expected to be very clean
- Strong test of factorisation
  - Technically considered type 2 decays
  - Only depend on a_2 in BSW model
- Test details of calculations

There has also been some controversy

- Polarisation in $B \to J/\psi K^*(890)$ decay larger than predicted
- Hard to reconcile this with branching fractions
- Few ways out
  - Measurements are wrong!
  - Factorisation only approximate
  - Form factors are just wrong

Measurement Technique

The observed cross section ($e.g. B^+ \to J/\psi K^+$) is

$$\sigma_{\text{obs}} = \sigma(p\bar{p} \to \bar{b}) f_u \mathcal{B}(B^+ \to J/\psi K^+) \epsilon^{K^+}$$

There are large uncertainties in $\sigma(p\bar{p} \to \bar{b})$

- Also significant systematic uncertainties in ϵ^{K^+}
- Strategy is to measure ratios of σ_{obs}

$$R^{K^\circ}_{K^+} = \frac{f_d}{f_u} \frac{\mathcal{B}(B^\circ \to J/\psi K^\circ)}{\mathcal{B}(B^+ \to J/\psi K^+)}$$

- We also get ratios of f_i for "free"
  - Have to use independent data or theory
  - However, tests "independent" fragmentation ansatzs

Selection of Exclusive $B \rightarrow J/\psi X$ Decays

Search for exclusive decays

$$
\begin{aligned}
B^{+} &\rightarrow J/\psi K^{+}, \\
B^{\circ} &\rightarrow J/\psi K^{\circ}, \\
B^{+} &\rightarrow J/\psi K^{*}(892)^{+}, \\
B^{\circ} &\rightarrow J/\psi K^{*}(892)^{0}, \\
B_s^{\circ} &\rightarrow J/\psi \phi(1020)
\end{aligned}
$$

Select decays by requiring

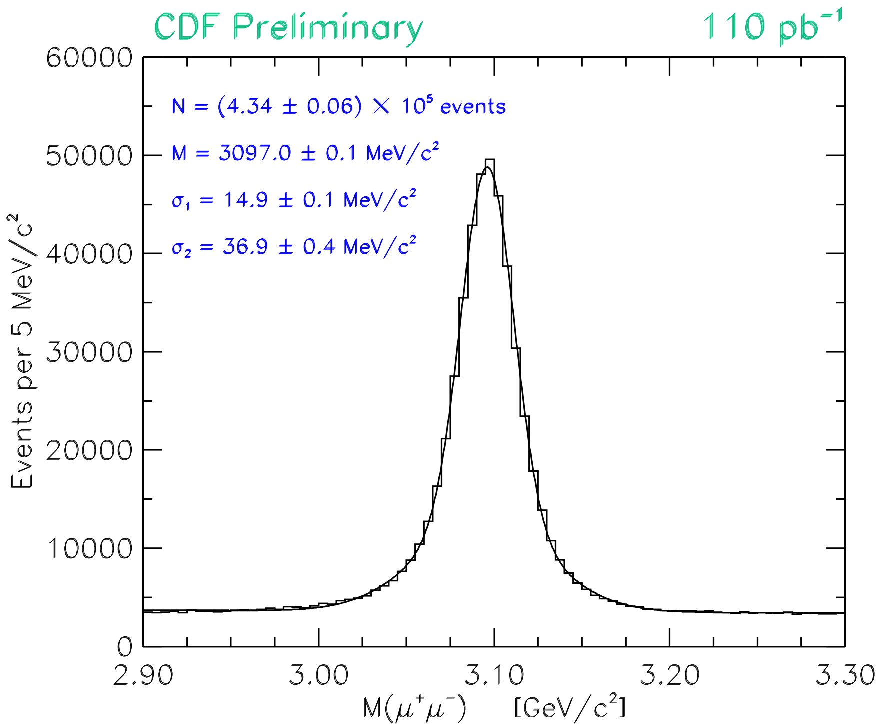
- Two muon candidates with $P_T \gtrsim 3$ GeV/c
- Require muons to come from common vertex
- Search combinatorially for daughter mesons
- Require B candidate $P_T > 6$ or 8 GeV/c
- Require meson daughter $P_T > 1.5$ or 2.0 GeV/c
- Require decay length of B candidate to be > 0

$\boxed{\textbf{J}/\psi \textbf{ Candidates}}$

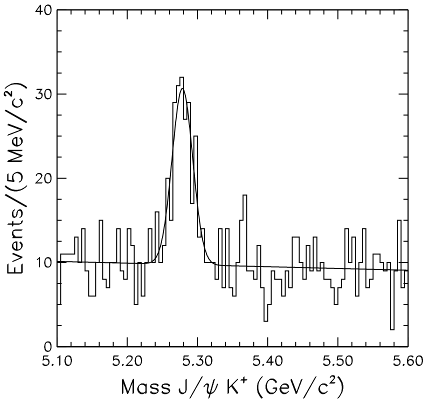
CDF dimuon trigger upgraded in Run I for J/ψ's

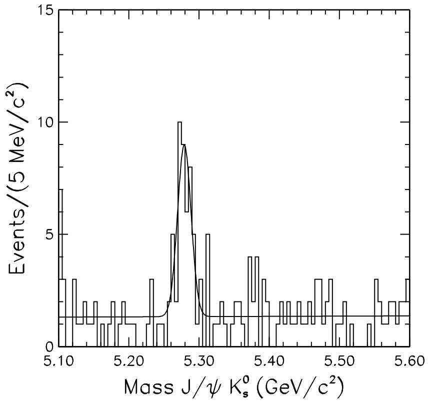
- Now extends over $|\eta| \lesssim 1.0$
- Added steel and chambers to reduce backgrounds

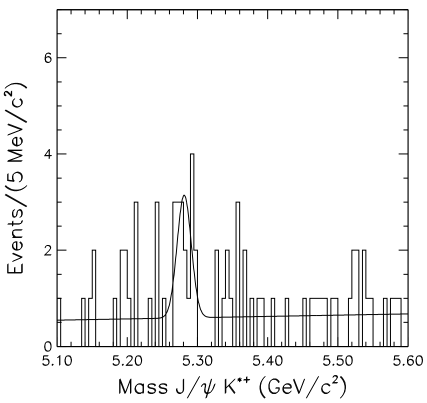
$\Rightarrow$ efficient trigger for J/ψ $P_T \gtrsim 6$ GeV/c

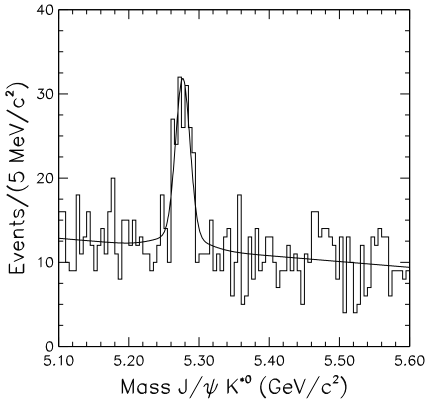


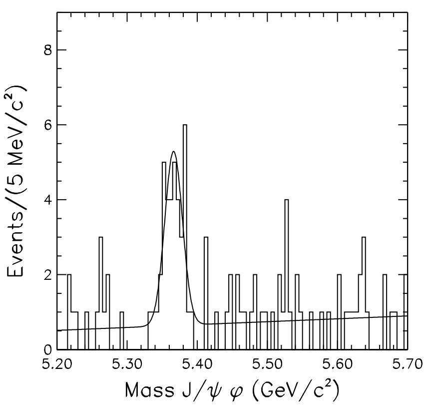
Run IA Results











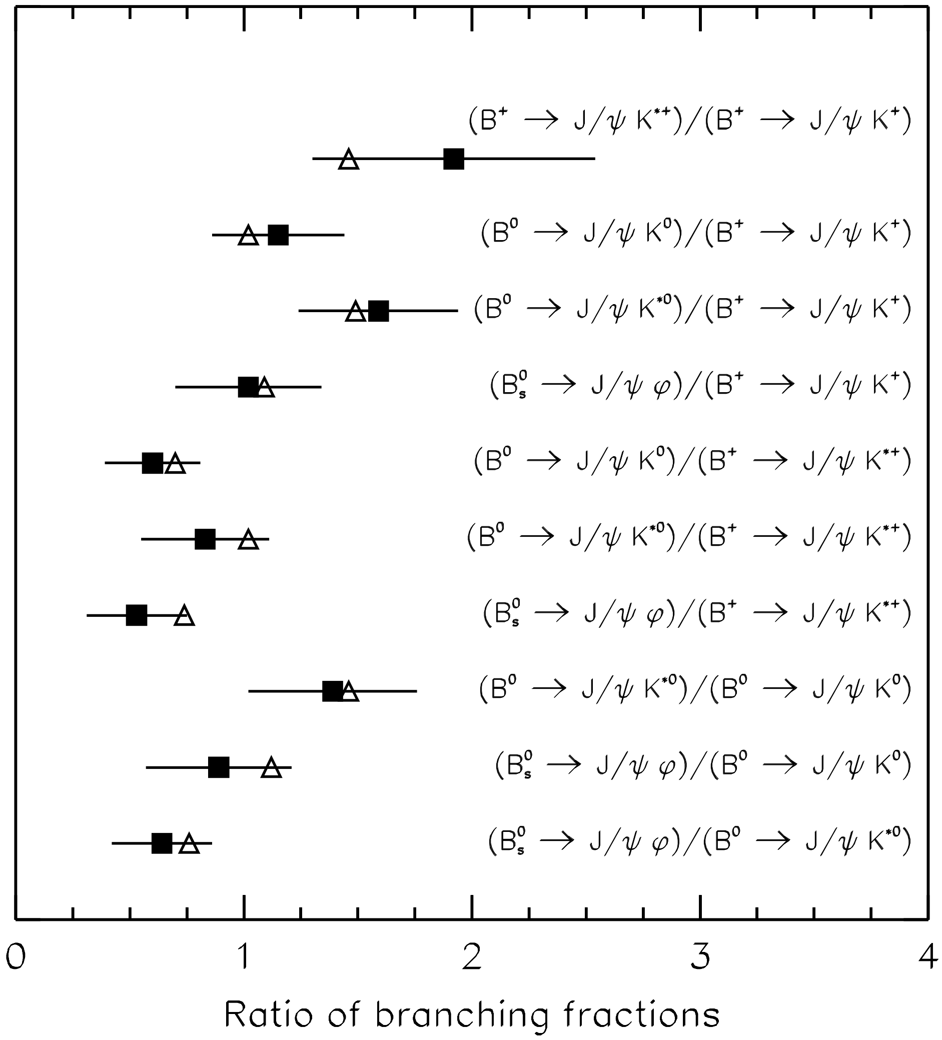
Ratios of Branching Fractions

$$
\begin{aligned}
R^{K^{\circ}}_{K^{+}} = \frac{f_d}{f_u}\,\frac{\mathcal{B}(B^{\circ} \to J/\psi K^{\circ})}{\mathcal{B}(B^{+} \to J/\psi K^{+})} &= 1.15 \pm 0.27 \pm 0.09, \\
R^{K^{*+}}_{K^{+}} = \frac{\mathcal{B}(B^{+} \to J/\psi K^{*+})}{\mathcal{B}(B^{+} \to J/\psi K^{+})} &= 1.92 \pm 0.60 \pm 0.17, \\
R^{K^{*\circ}}_{K^{+}} = \frac{f_d}{f_u}\,\frac{\mathcal{B}(B^{\circ} \to J/\psi K^{*\circ})}{\mathcal{B}(B^{+} \to J/\psi K^{+})} &= 1.59 \pm 0.33 \pm 0.12, \\
R^{K^{\phi}}_{K^{+}} = \frac{f_s}{f_u}\,\frac{\mathcal{B}(B^{\circ}_s \to J/\psi \phi)}{\mathcal{B}(B^{+} \to J/\psi K^{+})} &= 0.41 \pm 0.12 \pm 0.04, \\
R^{K^{*+}}_{K^{\circ}} = \frac{f_u}{f_d}\,\frac{\mathcal{B}(B^{+} \to J/\psi K^{*+})}{\mathcal{B}(B^{\circ} \to J/\psi K^{\circ})} &= 1.68 \pm 0.58 \pm 0.11, \\
R^{K^{*\circ}}_{K^{\circ}} = \frac{\mathcal{B}(B^{\circ} \to J/\psi K^{*\circ})}{\mathcal{B}(B^{\circ} \to J/\psi K^{\circ})} &= 1.39 \pm 0.36 \pm 0.10, nonumber \quad (1) \\
R^{K^{\phi}}_{K^{\circ}} = \frac{f_s}{f_d}\,\frac{\mathcal{B}(B^{\circ}_s \to J/\psi \phi)}{\mathcal{B}(B^{\circ} \to J/\psi K^{\circ})} &= 0.35 \pm 0.12 \pm 0.03, \\
R^{K^{*\circ}}_{K^{*+}} = \frac{f_d}{f_u}\,\frac{\mathcal{B}(B^{\circ} \to J/\psi K^{*\circ})}{\mathcal{B}(B^{+} \to J/\psi K^{*+})} &= 0.83 \pm 0.27 \pm 0.07, \\
R^{K^{\phi}}_{K^{*+}} = \frac{f_s}{f_u}\,\frac{\mathcal{B}(B^{\circ}_s \to J/\psi \phi)}{\mathcal{B}(B^{+} \to J/\psi K^{*+})} &= 0.21 \pm 0.08 \pm 0.02, \\
R^{K^{\phi}}_{K^{*\circ}} = \frac{f_s}{f_d}\,\frac{\mathcal{B}(B^{\circ}_s \to J/\psi \phi)}{\mathcal{B}(B^{\circ} \to J/\psi K^{*\circ})} &= 0.26 \pm 0.08 \pm 0.02, \quad (2)
\end{aligned}
$$

Comparison with HQET and BSW

Have compared results with several model predictions

- A. Deandrea, N. Di Bartolomeo, R. Gatto and G. Nardulli, Phys. Lett. B **318**, 549 (1993).
- Other calculations give similar results



Fragmentation Fractions

Can extract fragmentation fractions

- Use Deandra *et al.* model predictions
- Combine measurements from different channels

$$\frac{f_d}{f_u} = 0.99 \pm 0.19 \pm 0.08 \quad \text{and} \quad \frac{f_s}{(f_u, f_d)} = 0.34 \pm 0.10 \pm 0.03.$$

Can estimate absolute fragmentation fractions

- Assume that $f_u + f_d + f_s + f_{\Lambda_b} = 1$
- Assume that $f_{\Lambda_b} \sim 0.115$

$$f_u = \frac{1 - f_{\Lambda_b}}{1 + \frac{f_d}{f_u} + \frac{f_s}{f_u}}$$

- This gives us

$$\begin{aligned} f_u &= 0.39 \pm 0.04 \pm 0.04, \\ f_d &= 0.38 \pm 0.04 \pm 0.04 \text{ and} \\ f_s &= 0.13 \pm 0.03 \pm 0.01. \end{aligned}$$

In good agreement with PDG "LEP" values

- $f_u : f_d : f_s = 0.378 \pm 0.022 : 0.378 \pm 0.022 : 0.112 \pm 0.019$

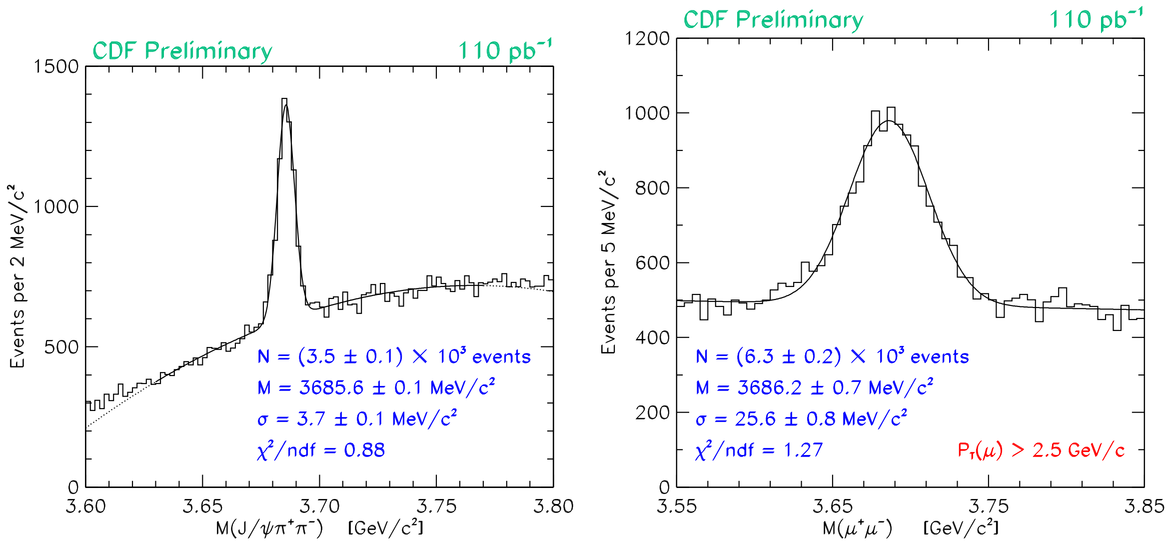
$\psi(2S)$ Branching Fractions

Currently working on measuring ratios

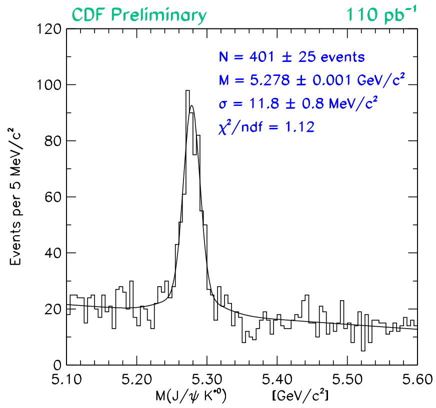
$$\frac{\mathcal{B}(B^+ \to \psi(2S)K^+)}{\mathcal{B}(B^+ \to J/\psi K^+)}$$
$$\frac{\mathcal{B}(B^0 \to \psi(2S)K^{*0})}{\mathcal{B}(B^0 \to J/\psi K^{*0})}$$

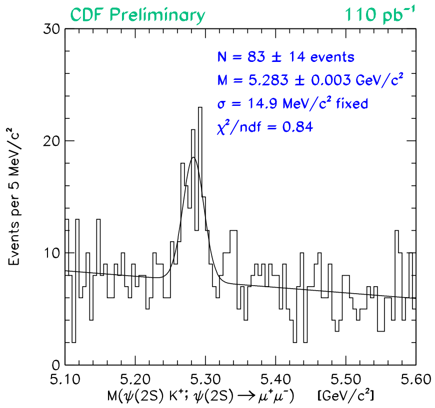
- Using full Run I data sample
- See clean inclusive $\psi(2S)$ signal

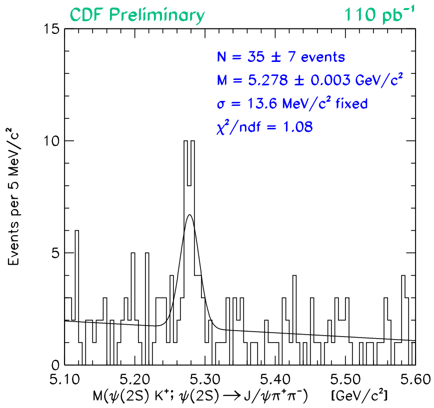
$$\psi(2S) \to J/\psi\pi^+\pi^- \text{ and } \psi(2S) \to \mu^+\mu^-$$

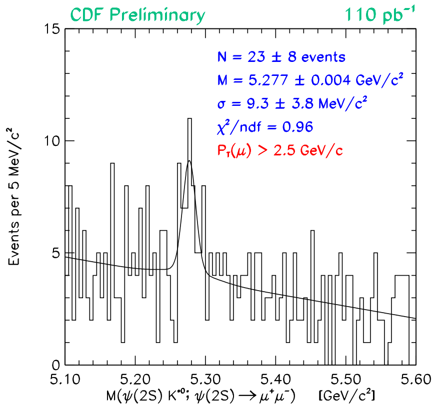


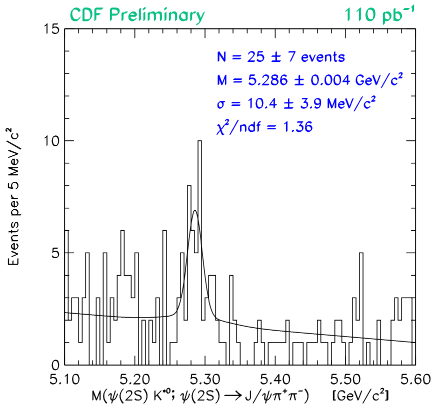
Run IB $B \to \psi(2S)X$ Signals











Preliminary Results

The ratios of branching fractions are

$$\frac{\mathcal{B}(B^+ \to \psi(2S)K^+)}{\mathcal{B}(B^+ \to J/\psi K^+)} = 0.666 \pm 0.093 \pm 0.101$$

$$\frac{\mathcal{B}(B^0 \to \psi(2S)K^{*0})}{\mathcal{B}(B^0 \to J/\psi K^{*0})} = 0.569 \pm 0.131 \pm 0.074$$

Can turn these into absolute branching fractions using

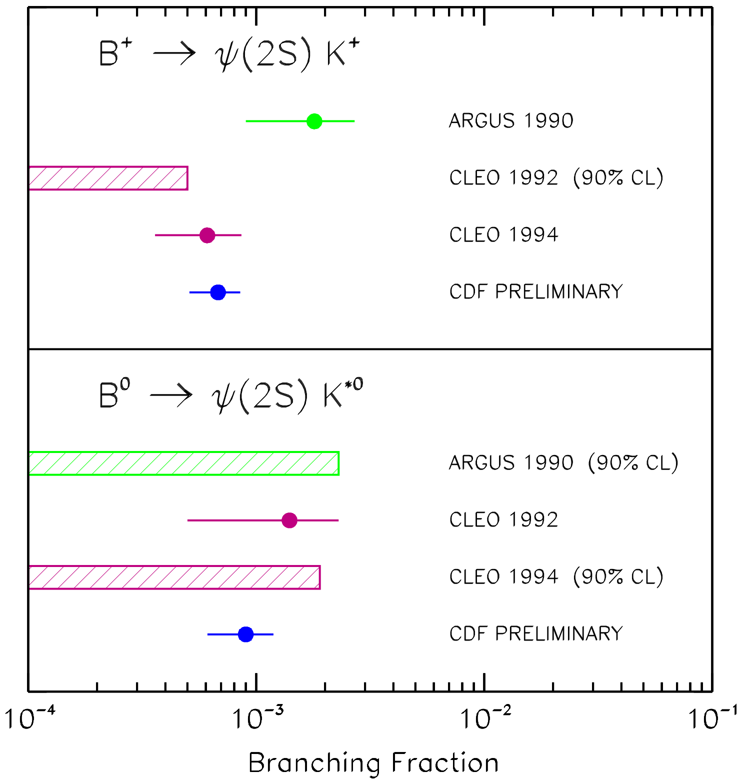
$$\begin{aligned}\mathcal{B}(B^+ \to J/\psi K^+) &= (1.02 \pm 0.14) \times 10^{-3} \\ \mathcal{B}(B^0 \to J/\psi K^{*0}) &= (1.58 \pm 0.28) \times 10^{-3}\end{aligned}$$

This gives us the branching fractions

$$\begin{aligned}\mathcal{B}(B^+ \to \psi(2S)K^+) &= (6.8 \pm 1.0 \pm 1.4) \times 10^{-4} \\ \mathcal{B}(B^0 \to \psi(2S)K^{*0}) &= (9.0 \pm 2.1 \pm 2.0) \times 10^{-4}\end{aligned}$$

Comparison with Other Measurements

These results can be compared with CLEO results



Now the world's best measurement

$\boxed{\textbf{Summary}}$

So far, top decays just like the SM predicts

- Constraints on $V_{tb} > 0.38$ at 95% C.L.
- Polarisation studies underway
- Nothing anomolous found

Bottom decay studies really only starting

- Expect to have the most precise $B \to J/\psi$ and $B \to \psi(2S)$ measurements in next year
- Polarisation studies of entire Run I sample underway
- Will allow tests of HQET and BSW factorisation

Run II expected to start in 1999

- Integrated luminosity of ~ 2 fb^{-1}
- Upgraded tracking, calorimetry and DAQ
- Will increase top and bottom samples by $\times 50$