

B Lifetime and Oscillation Results from CDF and D0



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(for the D0 and CDF Collaborations)

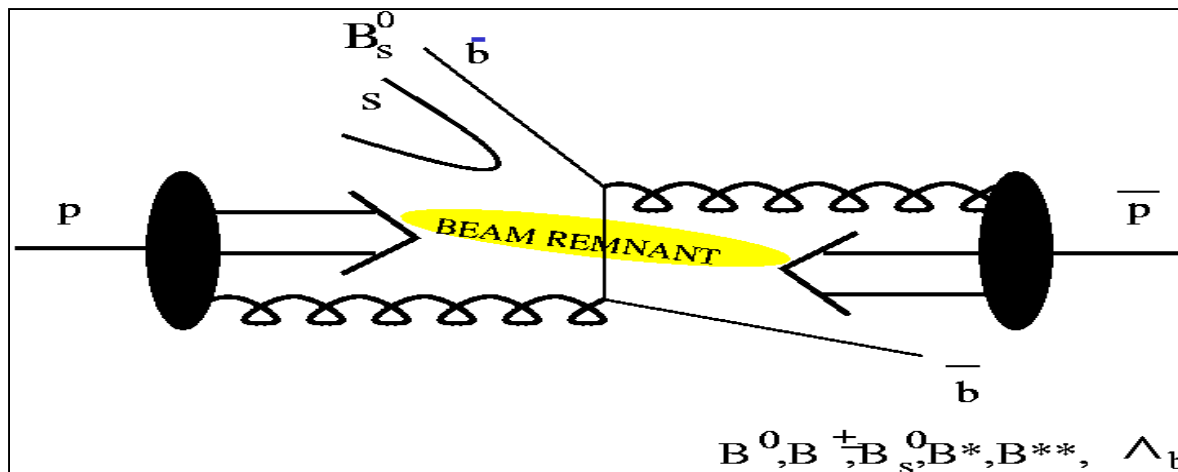
HCP 2004

East Lansing, June 16, 2004

Outline

- Tevatron Run II – B triggers and data
 - on tape: **> 370 pb⁻¹** per experiment
 - results presented here: **180 – 270 pb⁻¹**
- B Meson Lifetimes from Exclusive Decays (CDF)
 - $B^+ \rightarrow J/\psi + K^+$
 - $B^0_d \rightarrow J/\psi + K^*$
 - $B^0_s \rightarrow J/\psi + \phi$
- Polarization Amplitudes for $B \rightarrow J/\psi + V$ channels (CDF)
- $\tau(B^+)/\tau(B^0_d)$ Ratio from Semileptonic Decays (D0)
- B^0_d oscillations using:
 - semileptonic decays, **Opposite Side μ tag (D0)**
 - hadronic exclusive decays, **Same Side π tag (CDF)**

B Physics at the Tevatron



pros

- Large $b\bar{b}$ cross section:
 - ~ 150 μbarn total
 - ~ 3-5 μbarn “reconstructible”
- At $4 \times 10^{31} \text{cm}^{-2}\text{s}^{-1} \rightarrow \sim 150 \text{ Hz}$ of “reconstructible” B’s
- All B species produced
world best source of B_s and Λ_b
- Production incoherent
 reconstruction of both Bs
 not needed

cons

- Large background
 - $b\bar{b}$ cross section $\sim 10^{-3}$ total inelastic
 - special triggers (leptons, displaced tracks)
- combinatorics in reconstruction
- Typical kinematic cuts:
 - $p_T(\mu) > 1.5 \text{ GeV}/c$ for μ ’s from J/ψ
 - $p_T(B) > 5 \text{ (6) GeV}/c$

Triggers for B Lifetime/Mixing Studies



Di-muon

$p_T(\mu) > 3 \text{ GeV}/c$, $|\eta(\mu)| < 2.2$
unprescaled, $\sim 4\text{Hz}$ @ 40 E30 $\text{cm}^{-2}\text{s}^{-1}$

$p_T(\mu) > 1.5 \text{ GeV}/c$, $|\eta(\mu)| < 2.2$
Luminosity dependent prescale

Single μ ,

$p_T(\mu) > 3 - 5 \text{ GeV}/c$, $|\eta(\mu)| < 2.2$
Luminosity dependent prescale
unprescaled $\rightarrow \sim 50\text{Hz}$ @ 40 E30 $\text{cm}^{-2}\text{s}^{-1}$

Displaced tracks (L2)
being commissioned

Single- μ & Di-muon (J/ψ)

$p_T(\mu) > 1.5 \text{ GeV}/c$, $|\eta(\mu)| < 0.6$
 $p_T(\mu) > 2.0 \text{ GeV}/c$, $0.6 < |\eta(\mu)| < 1.0$

Hadronic track triggers:

Level 1 : Fast track trigger finds tracks
with $p_T > 1.5 \text{ GeV}/c$

Level 2 : Links tracks into silicon
Finds tracks with impact
parameter $> 120 \mu\text{m}$



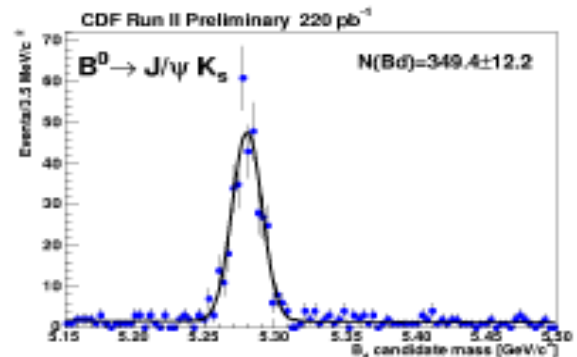
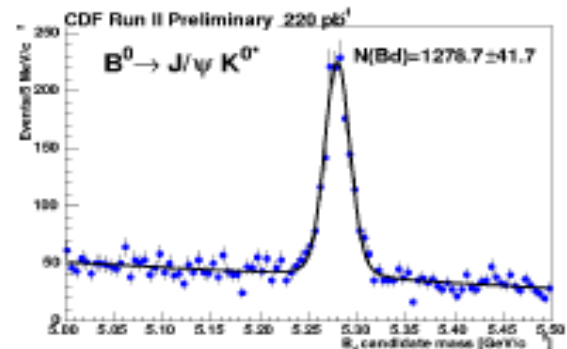
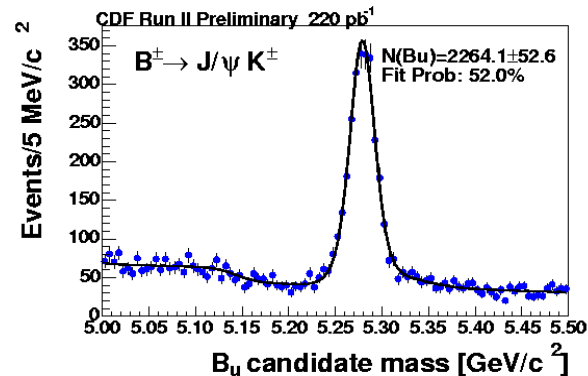
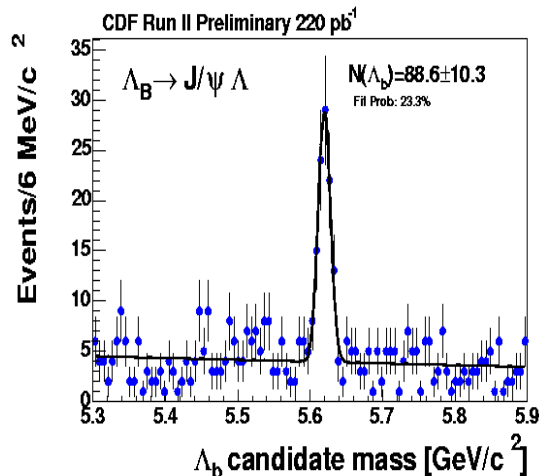
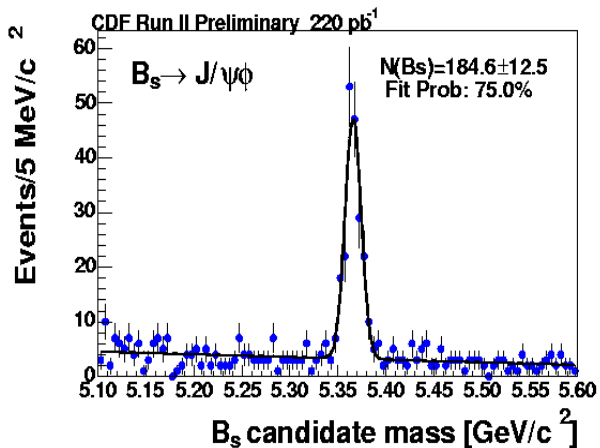
lepton + displaced track

$p_T(e/\mu) > 4 \text{ GeV}/c$ $p_T(\text{trk}) > 2 \text{ GeV}/c$
 $120 \mu\text{m} < d_0(\text{trk}) < 1 \text{ mm}$

two displaced tracks

$p_T(\text{trk}) > 2 \text{ GeV}/c$, $\sum p_T > 5.5 \text{ GeV}$
 $120 \mu\text{m} < d_0(\text{trk}) < 1 \text{ mm}$

Exclusive B decays (CDF)



Mass measurements from exclusive $B \rightarrow J/\psi X$ channels:

	mass, MeV/c ² CDF -preliminary	mass, MeV/c ² PDG
B^+	$5279.10 \pm 0.41 \pm 0.34$	5279.0 ± 0.5
B^0	$5279.57 \pm 0.53 \pm 0.30$	5279.4 ± 0.5
B_s	$5366.01 \pm 0.73 \pm 0.30$	5369.6 ± 2.4
Λ_b	$5619.7 \pm 1.2 \pm 1.2$	5624 ± 9

$m(B_s)$ & $m(\Lambda_b)$ – the world best measurement

Exclusive B Decays (D0)

- D0 finds in $\sim 250 \text{ pb}^{-1}$:

$B^+ \rightarrow J/\psi K^+$ (N ~ 4300)

$B^0 \rightarrow J/\psi K^*$ (N ~ 1900)

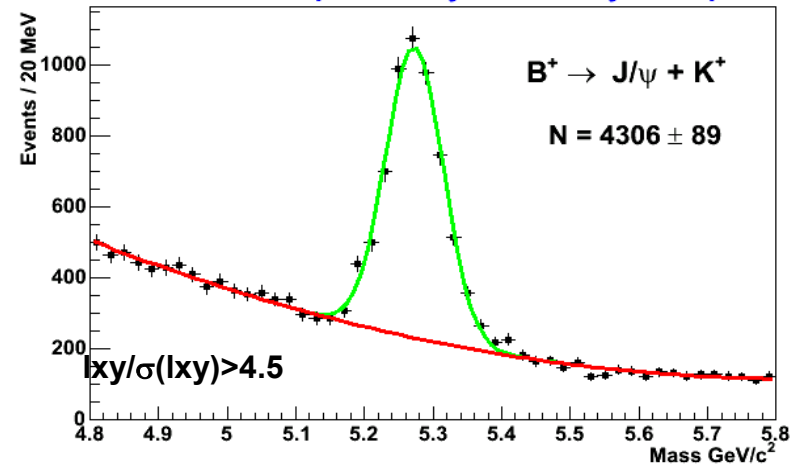
$B^0 \rightarrow J/\psi K_s$ (N ~ 375)

$B^0 \rightarrow J/\psi \phi$ (N ~ 400)

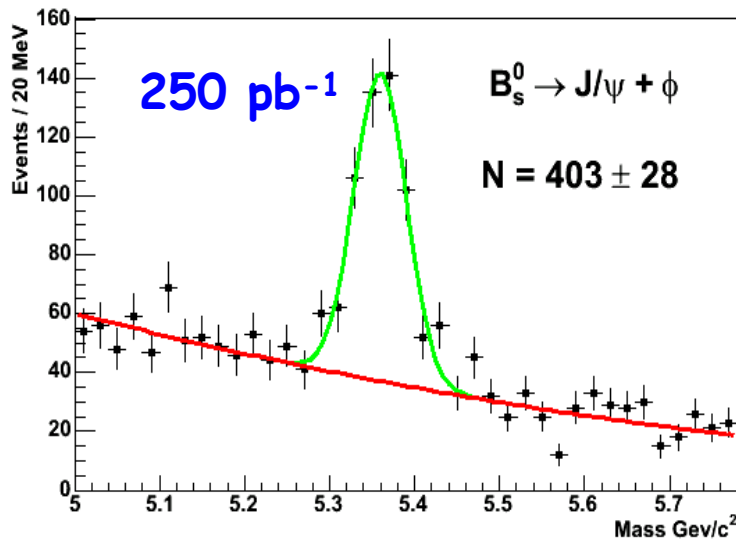
$\Lambda_b \rightarrow J/\psi \Lambda$ (N ~ 52)

S/B improves with stronger lifetime cuts

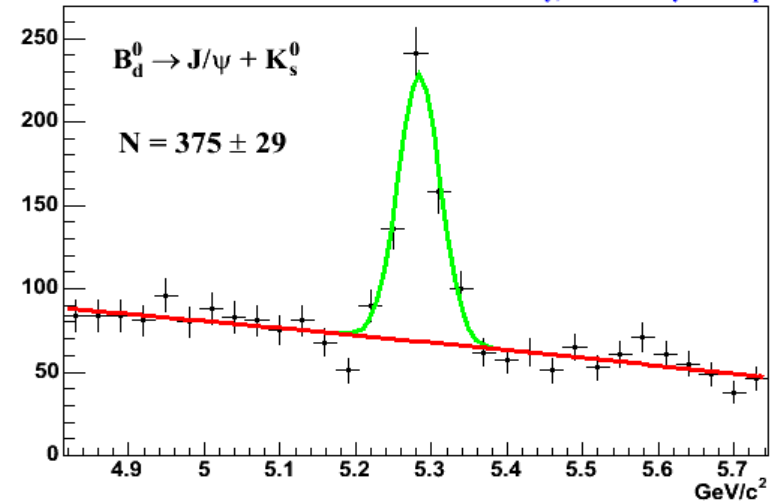
D0 RunII preliminary. Luminosity $\sim 225 \text{ pb}^{-1}$



D0 RunII preliminary.

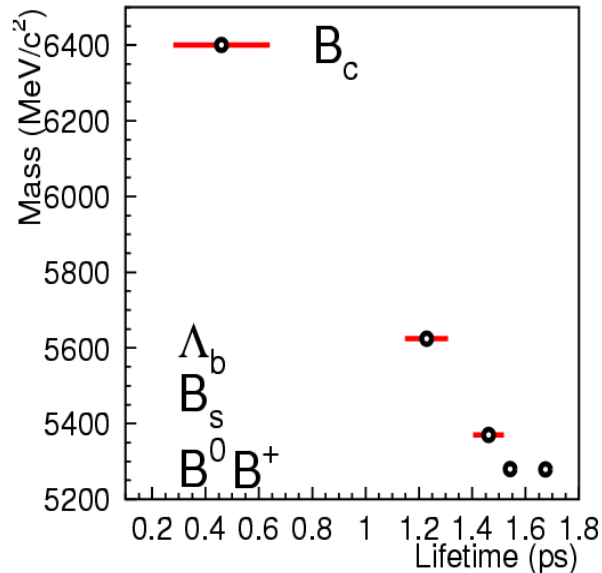


D0 Run II Preliminary, Luminosity = 225 pb^{-1}



B Hadron Lifetimes

B Hadron Lifetimes: Expectations and Existing Data



- In the **naive quark spectator** model, the decay is a $1 \rightarrow 3$ process common to all b hadrons.
- (NLO) QCD \rightarrow **Heavy Quark Expansion** predicts deviations in rough agreement with data
- Experimental and theoretical uncertainties are comparable
- Lifetime differences probe the **HQE** at the 3rd order in $\Lambda_{\text{QCD}} / m_b$
- **Goal \rightarrow measure the ratios accurately**

B Meson Lifetimes from Exclusive $B \rightarrow J/\psi X$ Decays; $X = K^+, K^*, \phi$ (CDF)

Fit Method: Simultaneous fit of:

← $M(B)$ → signal fraction, def sidebands

$c\tau(B)$ → lifetime

Signal Contribution:

$$F_{sig} = \frac{1}{c\tau} \exp\left(\frac{-t}{c\tau}\right) \otimes G(t, s\sigma_i)$$

Background Parameterization:

$$F_{bkg} = \left(\begin{array}{l} (1 - f_- - f_+ - f_{++})\delta(t) \\ + \frac{f_-}{c\tau_-} \exp\left(\frac{t}{c\tau_-}\right) + f_+ \frac{f_+}{c\tau_+} \exp\left(\frac{-t}{c\tau_+}\right) \\ + \frac{f_{++}}{c\tau_{++}} \exp\left(\frac{-t}{c\tau_{++}}\right) \end{array} \right) \otimes G(t, s\sigma_i)$$

B Lifetimes; analysis details - CDF

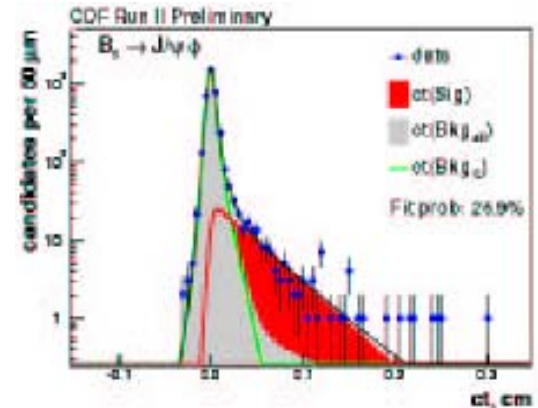
- $L \sim 240 \text{ pb}^{-1}$
- B candidate selection:

Decay	$p_T(\text{B})$	$p_T(\text{K}/\phi)$	$\text{Prob}(\chi^2)$	K/ ϕ window	B mass window
$\text{B}^+ \rightarrow \text{J}/\psi \text{ K}^+$	5.5 GeV/c	1.6 GeV/c	10^{-3}	-----	5170-5390 MeV/c ²
$\text{B}^0 \rightarrow \text{J}/\psi \text{ K}^{*0}$	6.0 GeV/c	2.6 GeV/c	10^{-4}	$M_{\text{PDG}} \pm 50 \text{ MeV}/c^2$	5170-5390 MeV/c ²
$\text{B}_s \rightarrow \text{J}/\psi \phi$	5.0 GeV/c	1.5 GeV/c	10^{-5}	$M_{\text{PDG}} \pm 6.5 \text{ MeV}/c^2$	5220-5520 MeV/c ²

- Substantial improvements in the analysis since 2003: **optimized kinematic cuts to minimize $\text{stat} \oplus \text{syst.}$, B reflections excluded or carefully parametrized, final SVX alignment**
- **12 parameter fit**, individual mass & proper decay length uncertainties, unbinned likelihood fit
- Systematic uncertainties at $\sim \mathcal{O}(1\mu\text{m})$ level

D0 is using the same method, no new results since Summer 2003; new analyses of B_d , B_s , Λ_b lifetimes \rightarrow being reviewed by EB

Exclusive B Lifetimes; CDF results



B meson	N(B)	τ (B), ps	PDG'03, ps	Single best measur., ps
B^+	~3390	$1.662 \pm 0.033 \pm 0.008$	1.671 ± 0.018	$1.695 \pm 0.026 \pm 0.015$
B^0	~1160	$1.539 \pm 0.051 \pm 0.008$	1.537 ± 0.015	$1.529 \pm 0.012 \pm 0.029$
B_s	~260	$1.369 \pm 0.100^{+0.008}_{-0.010}$	1.461 ± 0.057	$1.36 \pm 0.09^{+0.06}_{-0.05}$

Lifetime Ratios (most systematic uncertainties 100 % correlated)

$$\tau(B^+) / \tau(B^0) = 1.080 \pm 0.042 \text{ (tot.)}$$

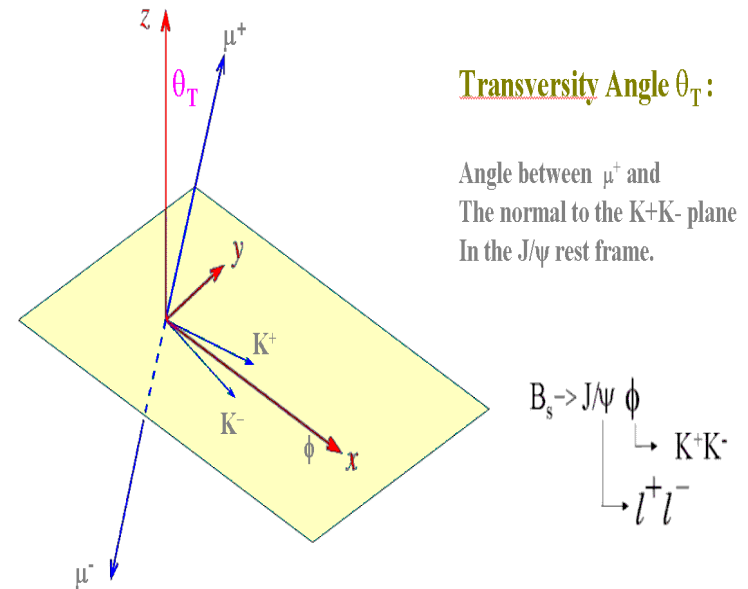
$$\tau(B_s) / \tau(B^0) = 0.890 \pm 0.072 \text{ (tot.)}$$

B \rightarrow V V Polarization Amplitudes

- One of the Run II goals \rightarrow measure the lifetime difference $\Delta\Gamma_s$ between the CP eigenstates $B_{s,H}$ (CP=-1) and $B_{s,L}$ (CP=+1)
- Angular analysis based on transversity variables, combined with a lifetime measurement allows one to separate the CP odd and CP even final state
- Time-integrated polarization amplitude analysis \rightarrow a step towards a $\Delta\Gamma_s$ measurement and a test of factorization (\rightarrow weak decay matrix element a product of two independent hadronic currents)
- **CDF** analysis uses: dimuon trigger data sets, $L \sim 180 \text{ pb}^{-1}$
 $B_d \rightarrow J/\psi K^{*0}$ (N \sim 1000) $B_s \rightarrow J/\psi \phi$ (N \sim 180)

B → V V Polarization Amplitudes

- **Three** linear polarization states:
 - **J/ψ and φ (K*) polarization vectors:**
 - longitudinal (0) to the **B** direction ;
 - transverse and parallel (||), and
 - transverse to **B** and (⊥) to each other
- Angular distribution **B → V V** function of decay angles (cos Θ_T, cos Θ_K, Φ_T) and transversity amplitudes A₀, A_{||}, A_⊥
- Constraints: |A₀|² + |A_{||}|² + |A_⊥|² = 1, overall phase symmetry → A₀ chosen positive real number
- **four** degrees of freedom
 - A₀ = cos(Θ₁)
 - A_{||} = sin(Θ₁) cos(Θ₂) exp(-iφ₁)
 - A_⊥ = sin(Θ₁) sin(Θ₂) exp(-iφ₂)



Transversity plane in the **J/ψ** rest frame

B meson defines positive **x-axis**

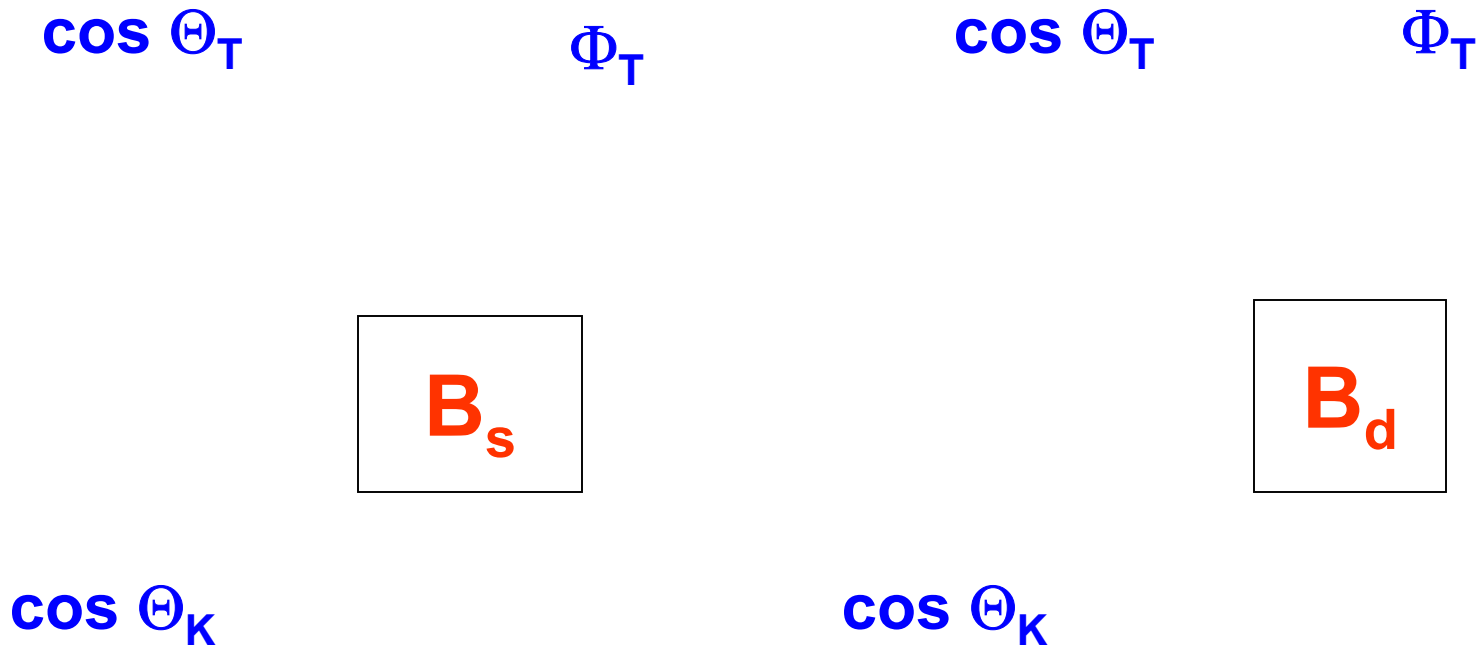
Kπ (KK) plane defines **(x,y)** plane

K (K⁺) +ve **y** momentum

Θ_T, Φ_T polar & azimuthal angles of **μ⁺**

Θ_K helicity angle of **K* (φ)**

Projection plots of the fitting results to the sideband subtracted angular distributions



Preliminary Results - CDF

- **For B^0_d** $A_0 = 0.792 \pm 0.024 \pm 0.016$
 $A_{\parallel} = (0.436 \pm 0.057 \pm 0.045) e^{(3.07 \pm 0.40 \pm 0.07) i}$
 $A_{\perp} = (0.428 \pm 0.059 \pm 0.063) e^{(0.11 \pm 0.23 \pm 0.06) i}$
- **For B^0_s** $A_0 = 0.767 \pm 0.045 \pm 0.017$
 $A_{\parallel} = (0.424 \pm 0.118 \pm 0.013) e^{(2.11 \pm 0.55 \pm 0.29) i}$
 $|A_{\perp}| = 0.482 \pm 0.104 \pm 0.014 \leftarrow$ phase of A_{\perp} lost, B_s & \overline{B}_s not distinguishable by their final state particles
- B^0_d Comparison \rightarrow Babar, Belle, CLEO, CDF Run I

B^0_d	$ A_0 ^2$	$ A_{\perp} ^2$	$arg(A_{\parallel})$	$arg(A_{\perp})$
CDF Run I	$0.59 \pm 0.06 \pm 0.01$	$0.13 \pm 0.10 \pm 0.06$	$2.2 \pm 0.5 \pm 0.1$	$-0.6 \pm 0.5 \pm 0.01$
CLEO (1997)	$0.52 \pm 0.07 \pm 0.04$	$0.16 \pm 0.08 \pm 0.04$	$3.00 \pm 0.37 \pm 0.04$	$-0.11 \pm 0.46 \pm 0.03$
BABAR (2001)	$0.60 \pm 0.03 \pm 0.02$	$0.16 \pm 0.03 \pm 0.03$	$2.50 \pm 0.20 \pm 0.08$	$-0.17 \pm 0.16 \pm 0.07$
BELLE (2002)	$0.62 \pm 0.02 \pm 0.03$	$0.19 \pm 0.02 \pm 0.03$	$2.83 \pm 0.19 \pm 0.08$	$-0.09 \pm 0.13 \pm 0.06$
This measurement.	$0.63 \pm 0.04 \pm 0.03$	$0.18 \pm 0.05 \pm 0.05$	$3.07 \pm 0.40 \pm 0.07$	$0.11 \pm 0.23 \pm 0.06$

Argand Diagrams

- dominant longitudinal polarization $\Gamma_L/\Gamma = |A_0|^2$
- non-zero parity-odd fraction $\Gamma_\perp/\Gamma = |A_\perp|^2$, (P-wave, CP= -1 for B_s)
- $\arg(A_{||}) \approx \pi$ for B_d , $\neq 0$ or π for B_s (factorization ?)

B_s CP = +1 & CP = -1 Lifetimes

- $B_s^0 \rightarrow J/\psi \phi$ unknown mixture of CP = +1 & CP = -1 states

$$\Gamma_s = (\Gamma_L + \Gamma_H) / 2; \quad \Delta\Gamma_s = \Gamma_H - \Gamma_L$$

CP=+1 CP=-1

theory predicts $\Delta\Gamma_s / \Gamma_s = -0.13 \pm 0.06$

current limit $|\Delta\Gamma_s / \Gamma_s| < 0.31 \leftarrow$ LEP B_s BRs

In the case of untagged decay, the CP – specific terms evolve like:

CP - even: $(|A_0|^2 + |A_{||}|^2) \exp(-\Gamma_L t)$

CP - odd: $|A_{\perp}|^2 \exp(-\Gamma_H t)$

- Flavor specific final states (e.g. $B_s^0 \rightarrow l\nu D_s$) measure:

$$\Gamma_{fs} = \Gamma_s - (\Delta\Gamma_s)^2 / 2\Gamma_s + \mathcal{O}((\Delta\Gamma_s)^3 / \Gamma_s^2)$$

see: B-physics at the Tevatron Run II, p.361

$\Delta\Gamma_s$ from 3-D fits (mass, ct, transversity θ_T)

The CP-even and CP-odd components have distinctly different decay distributions in *transversity* variable θ_T :

$$d\Gamma(t)/d\cos\theta_T \propto (|A_0(t)|^2 + |A_{\parallel}(t)|^2) (1 + \cos^2\theta_T) + |A_{\perp}(t)|^2 2\sin^2\theta_T$$

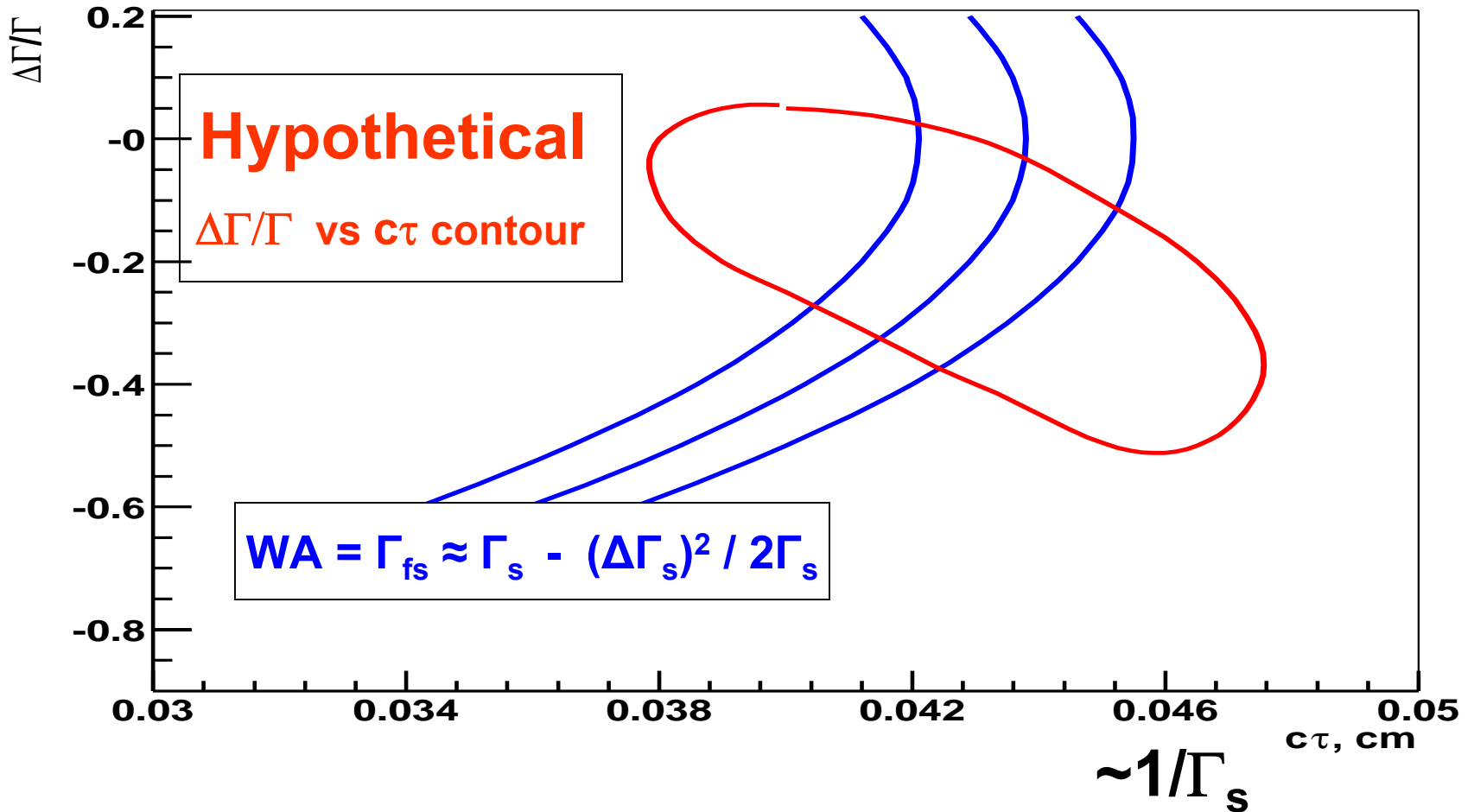
MC distributions for CP = +1 & CP = -1 for accepted events (an example)

CP=+1

CP= -1

An illustration: combining $B_s \rightarrow J/\psi \phi$ with World Average $c\tau_s$ for flavor-specific decays

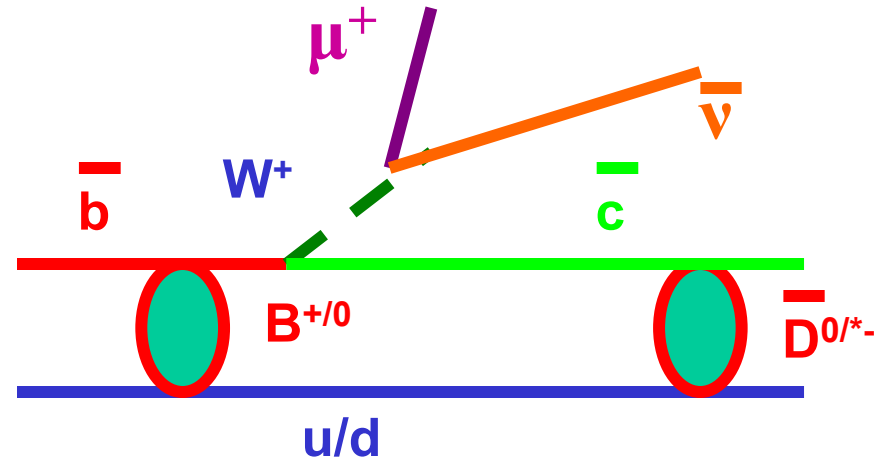
$\rightarrow \Delta\Gamma_s / \Gamma_s$ vs $c\tau_s$



CDF & D0 results on $\Delta\Gamma_s/\Gamma_s$ expected soon

$\tau(B^+)/\tau(B^0_d)$ from Semileptonic Decays

spectator model:



B^+ and B^0_d lifetimes - same ← naïve spectator model

$$\text{(NLO) QCD} \rightarrow \tau(B^+)/\tau(B^0_d) - 1 = 0.0325 \left(\frac{|V_{cb}|}{0.04} \right)^2 \left(\frac{m_b}{4.8 \text{ GeV}} \right)^2 \left(\frac{f_B}{200 \text{ MeV}} \right)^2 \times$$

x [Hadronic matrix elements from lattice QCD with coeff.]

$$\tau(B^+)/\tau(B^0_d) = 1.047 \pm 0.016(\text{NLO+had}) \pm 0.017(m_b V_{cb}, f_B) \pm 0.007(1/m_b)$$

(e.g. *M.Beneke, G.Buchalla, C.Greub, A.Lenz and U.Nierste, hep-ph/0202106*)

$\tau(B^+)/\tau(B^0)$ from Semileptonic Decays

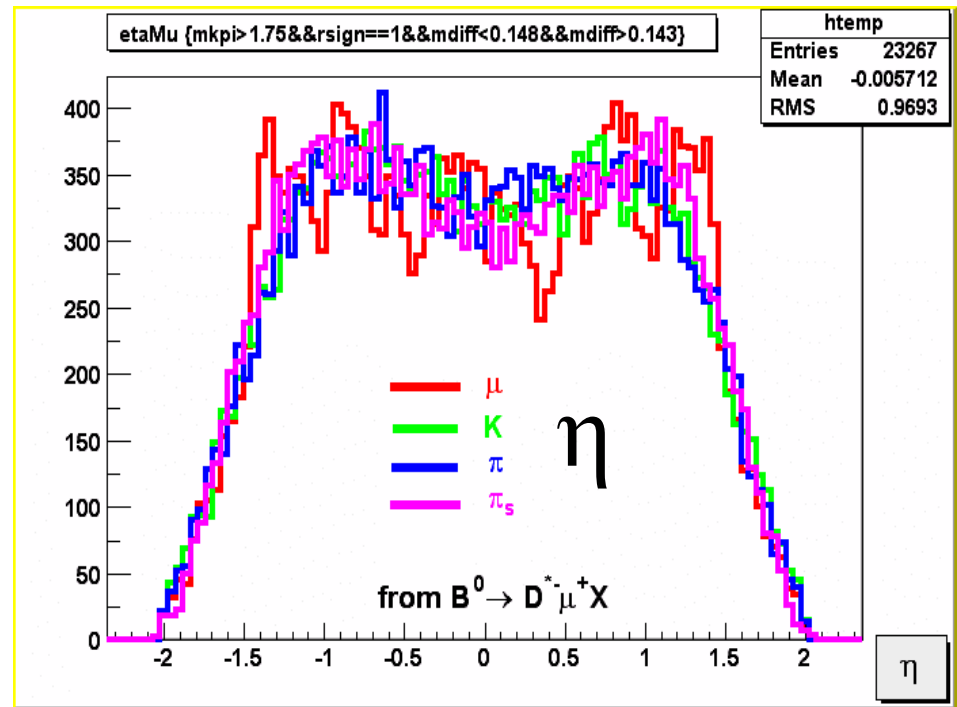
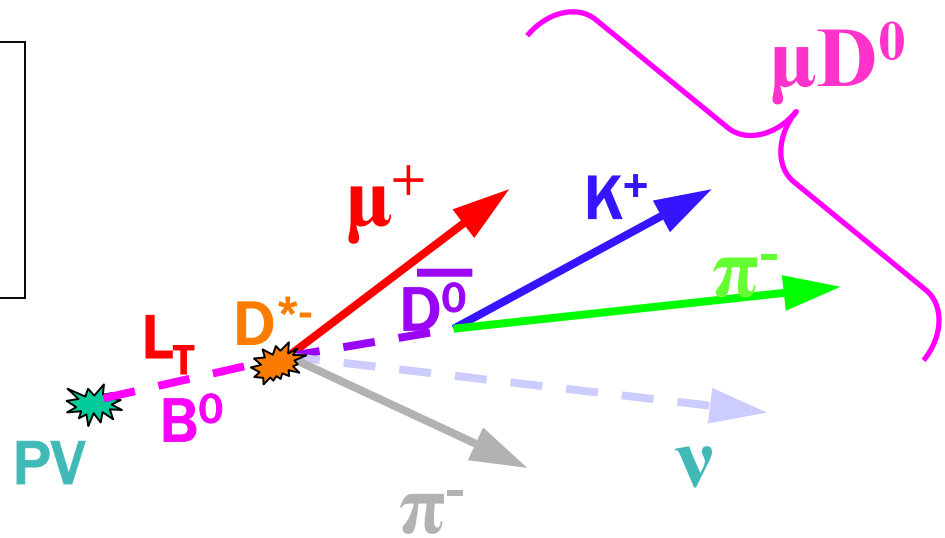


Novel Analysis Technique (D0)

- **Measure directly lifetime ratio instead of individual lifetimes**
- **Split $D^0 \rightarrow K\pi$ sample: presence / absence of $D^* \leftarrow (D^0 + \text{slow } \pi)$**
- **Make use of :**
 - $D^* \leftarrow$ mainly from B^0
 - $D^0 \leftarrow$ mainly from B^+
- Group events into several bins of Visible Proper Decay Length
- Measure $r = N(\mu D^*)/N(\mu D^0)$
- In **both** cases fit D^0 signal to extract **N**
- use **slow pion** only to distinguish B^0 from B^+
(not in vertexing , K - factors etc \rightarrow to avoid lifetime bias)
- **Account for feed-down from D^{**} using PDG branching ratios and Monte Carlo**

$\mu, D^0 \rightarrow K^-\pi^+$ &
slow π selection

- **muon** with $|\eta| < 2$ & $P_T > 2$ GeV
- **K, π** \rightarrow two tracks of opposite charge with $P_T > 0.7$ GeV, $|\eta| < 2$ in the **same jet** as the **muon**
- Slow pion $P_T > 0.18$ GeV
- Lifetime and topological cuts
- η acceptance from CFT
- statistics decreases by 2.3 if $|\eta| < 1$ cut applied to all particles

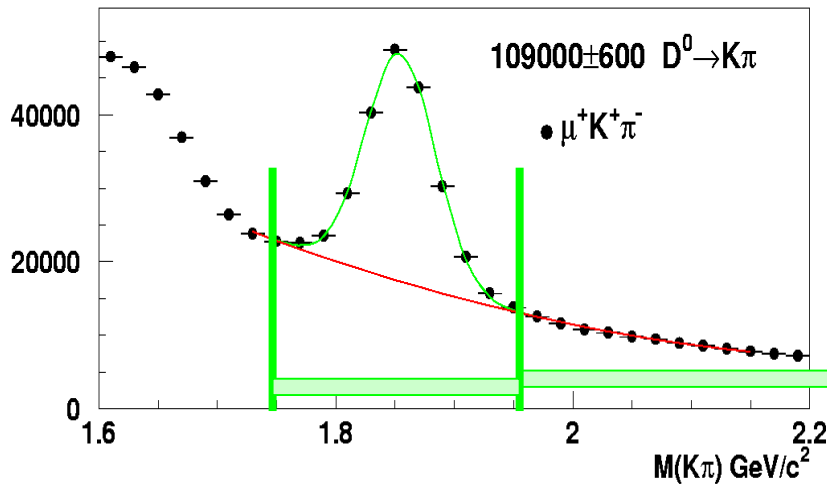


Semileptonic B_d data sample (D0)

109k inclusive $B \rightarrow \mu \nu D^0$ candidates

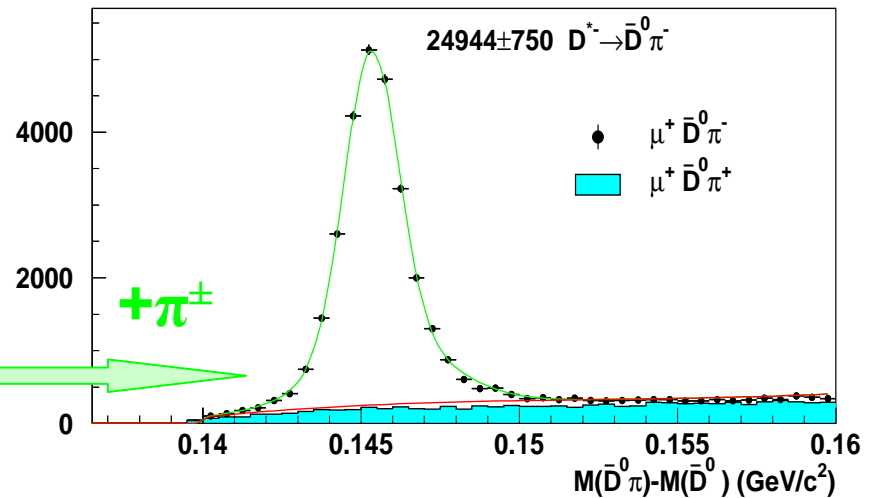
25k $B \rightarrow \mu \nu D^*$ candidates

DØ RunII Preliminary, Luminosity=250 pb⁻¹



Dominated by B^+ decays

DØ RunII Preliminary, Luminosity = 250 pb⁻¹

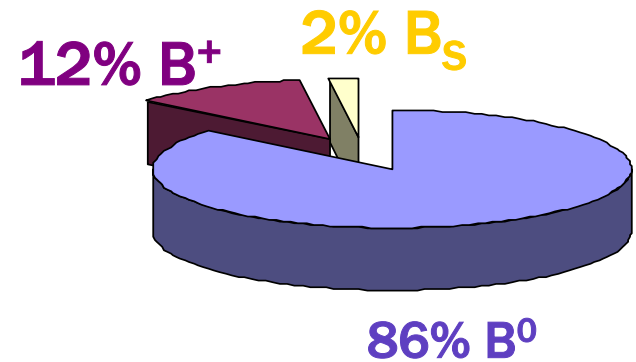


Dominated by B^0 decays

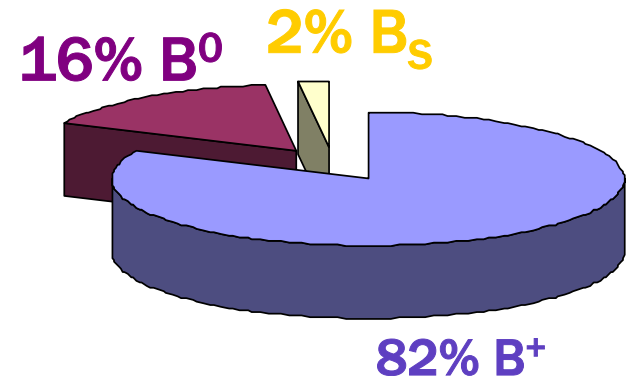
Sample Composition

From known branching ratios and reconstruction efficiencies for a given channel →

- D^* sample composed of



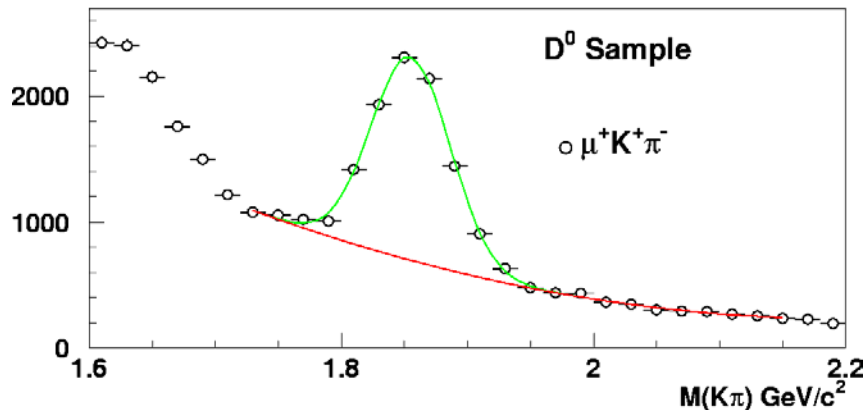
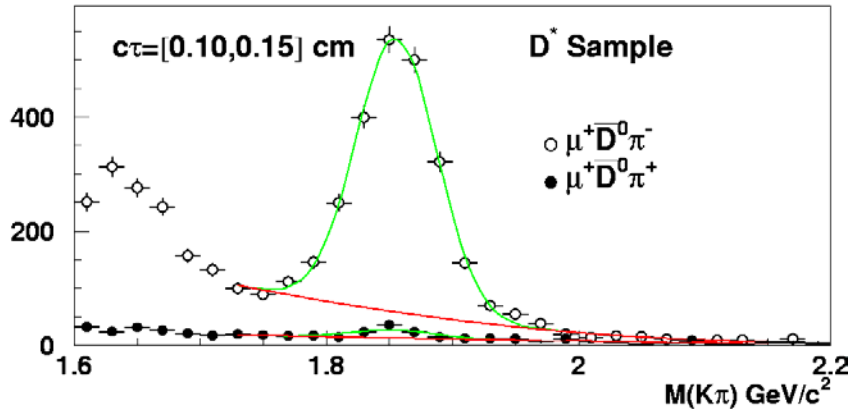
- D^0 sample composed of



$\tau(B^+)/\tau(B^0)$: fitting strategy

one example : VPDL bin [0.10 - 0.15 cm]

DØ RunII Preliminary, Luminosity=250 pb⁻¹



Fit : Gaussian + 2nd order polynomial

• In each VPDL bin

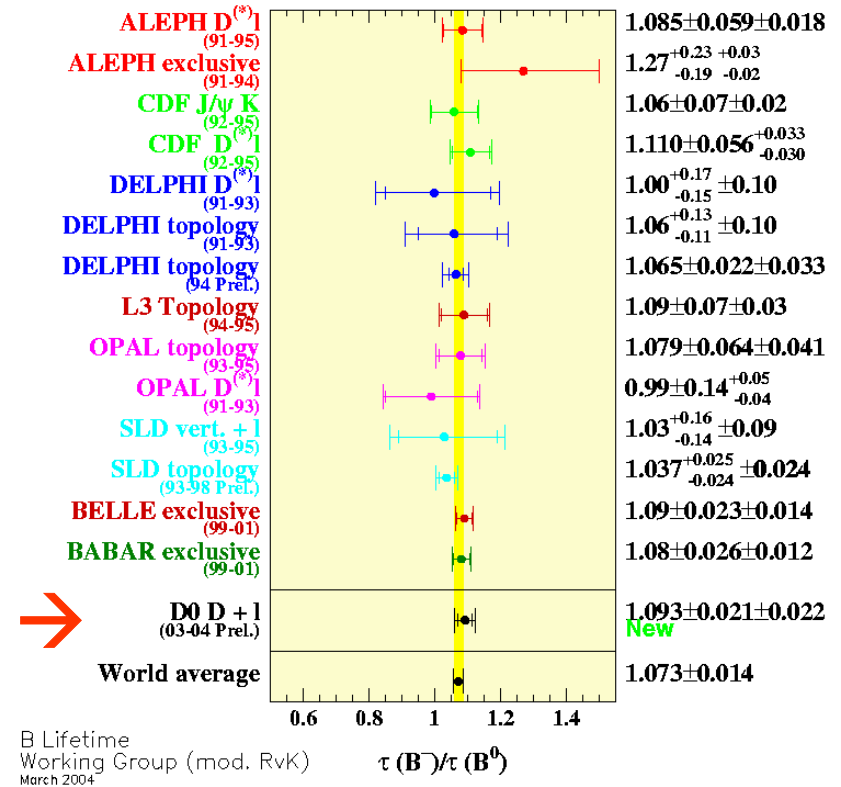
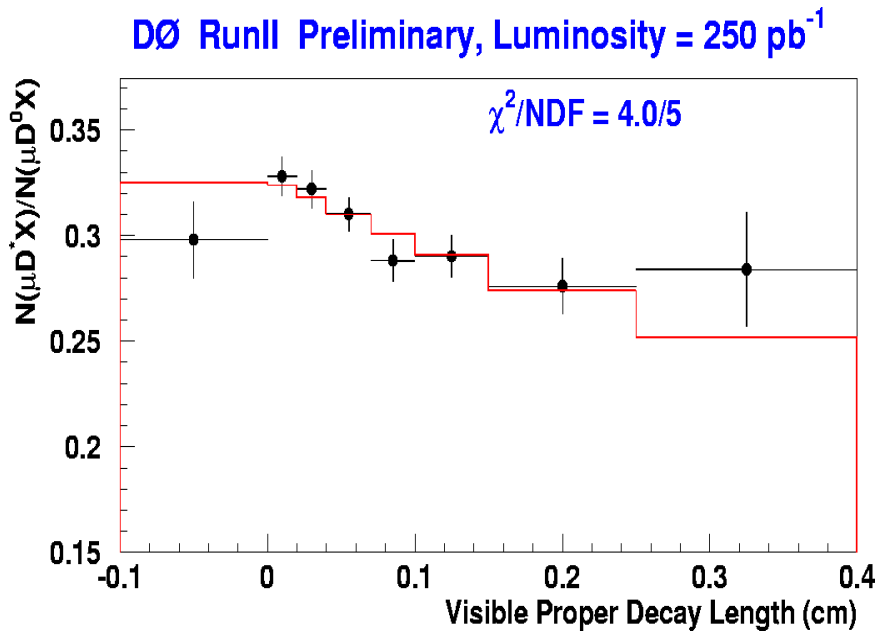
$$r_i = \frac{N_i(\mu^+ D^{*-})}{N_i(\mu^+ \bar{D}^0)} = \frac{N_i^{*R} - C \cdot N_i^{*W}}{N_i^0 + (1 + C) \cdot N_i^{*W}}$$

- Fit D⁰ mass peak in both cases **same way**
 - Decreases systematics
- N (D^{*}) is corrected for combinatorial bkg in the D^{*} mass window
 - Estimated from wrong sign Kππ combinations → small correction
- N (D⁰) is corrected for D⁰'s lost due to D^{*} mass window cut
- Determine expected values of **r^e_i (k)** from sample composition, channel dependent K-factors, efficiencies and resolutions

k – lifetime ratio, fit parameter

$\tau(B^+)/\tau(B^0)$: Preliminary Result (D0)

binned χ^2 fit of event ratios



$$\tau(B^+)/\tau(B^0) = 1.093 \pm 0.021 \text{ (stat)} \pm 0.022 \text{ (syst)}$$

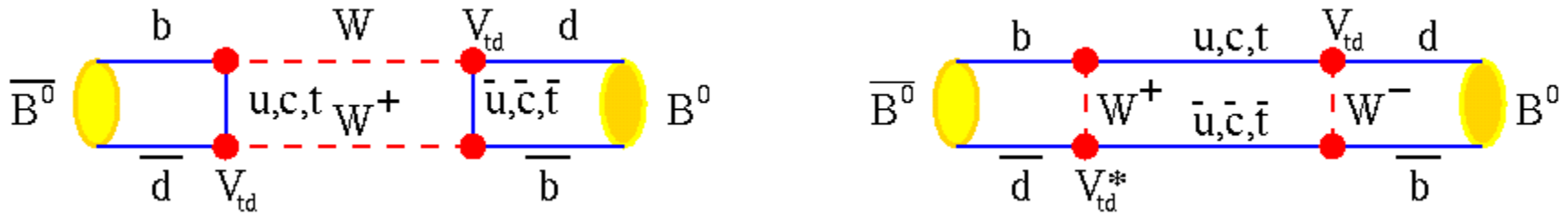
one of the most precise measurements

B^0_d Meson Oscillations

Use → Semileptonic B^0_d decays (D0, CDF - in progress)

Use → Fully reconstructed B^0_d decays (CDF, D0 – in progress)

B^0/\bar{B}^0 mixing



- In SM B_d mixing is explained by box diagrams
 - Constrains V_{td} CKM matrix element
 - Mixing frequency Δm_d has been measured with high precision at B factories ($0.502 \pm 0.007 \text{ ps}^{-1}$)
- Δm_d measurement provides:
 - Benchmark the initial state flavor tagging for later use in B_s and Δm_s measurements
 - at hadron colliders can also constrain more exotic models of b production e.g. light gluino & sbottom production

(Berger *et al.*, Phys.Rev.Lett.86,4231(2001))

Procedure for a B^0_d mixing measurement

- **Reconstruct the final state, identify B flavor at decay**
 - Data sample: μ triggers $\rightarrow B_d \rightarrow \mu^+ D^{*-} X$ ($D^{*-} \rightarrow \bar{D}^0 \pi^-, \bar{D}^0 \rightarrow K^+ \pi^-$)
 - Find μ^+, D^0, π^- consistent with B decay
 - Determine $N(D^{*-})$ from mass difference $M(D^0 \pi^-) - M(D^0)$ distributions
- **Identify B flavor at production**
 - several B-flavor tagging algorithms
 - tagging efficiency: $\varepsilon = (N^{\text{corr}} + N^{\text{wr}}) / (N^{\text{corr}} + N^{\text{wr}} + N^{\text{notag}})$
 - tagging dilution: $D = (N^{\text{corr}} - N^{\text{wr}}) / (N^{\text{corr}} + N^{\text{wr}})$
 - figure of merit: εD^2
- **Measure Visible Proper Decay Length**
- **Calculate observed asymmetry in bins of VPDL**
- **Use PDG BRs & MC to calculate expected asymmetry(t)**
- Δm_d & **purity** = $(1+D)/2$ **free parameters of the fit**

Flavor Tagging algorithms

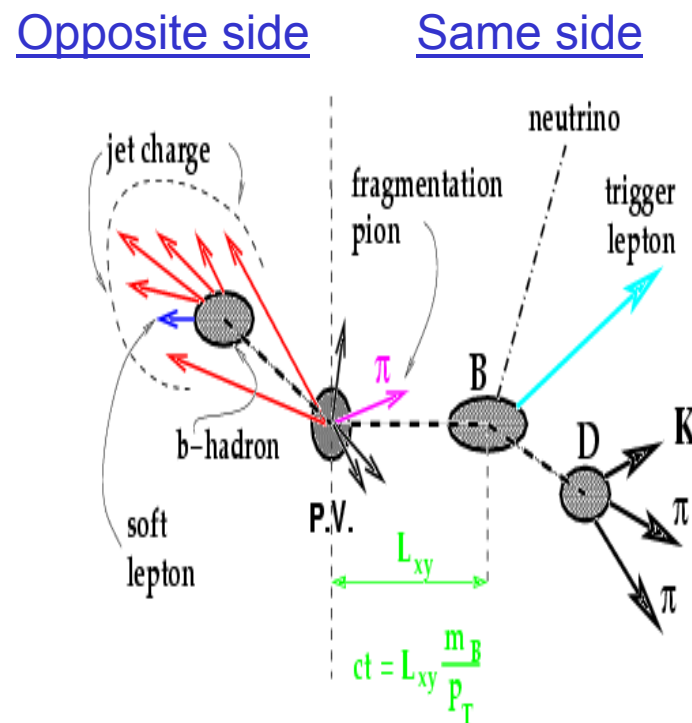
from Gomez-Ceballos

OST (Opposite Side Tagging):

- **JETQ**: sign of the weighted average charge of opposite B-Jet
- **SLT**: identify the **soft lepton** from semileptonic decay of opposite B
- **Opposite Side K**: due to $b \rightarrow c \rightarrow s$ it is more likely that a **B** meson will contain in final state a K^+ than a K^- (CDF)

SST (Same Side Tagging):

- **SS pion T**: B^0 is likely to be accompanied by a π^+ from fragmentation
- **SS Kaon T**: B_s is likely to be accompanied by a K^+ from fragmentation (CDF)

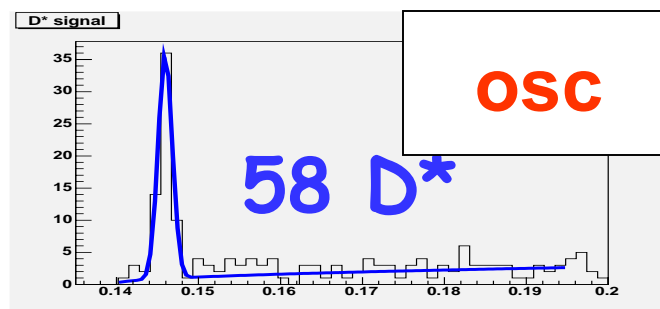
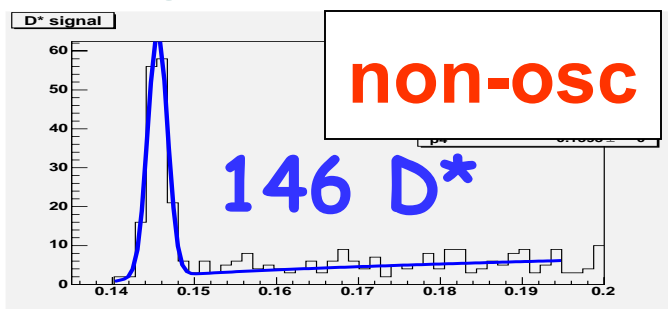


B^0_d oscillation from semileptonic decays

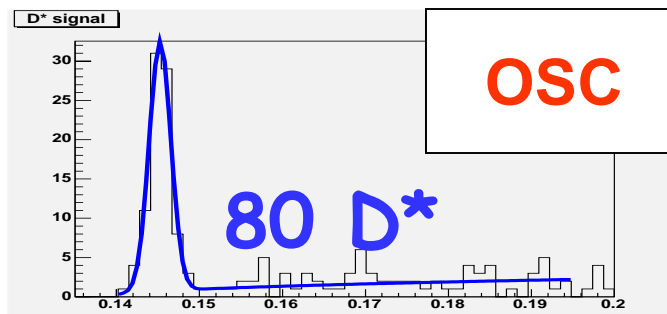
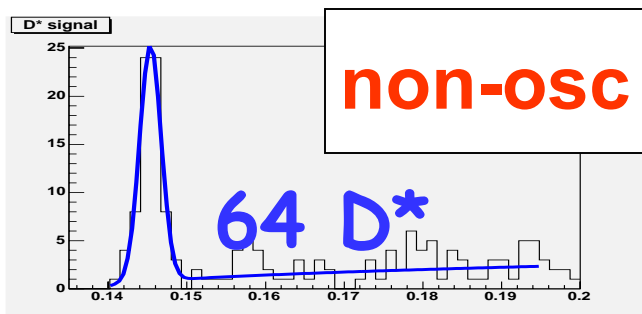
Opposite Side Muon Tagging (D0)

D0 uses 25k $B \rightarrow \mu D^* X$, $D^* \rightarrow D^0 \pi$ candidates to measure Δm_d :

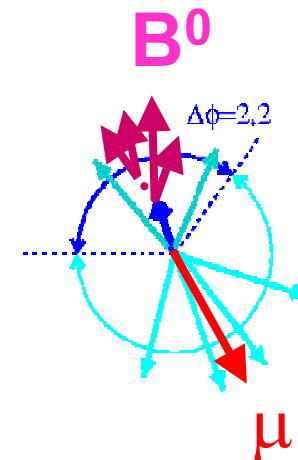
- e.g. First bin VPDL = [0.0 - 0.025 cm]



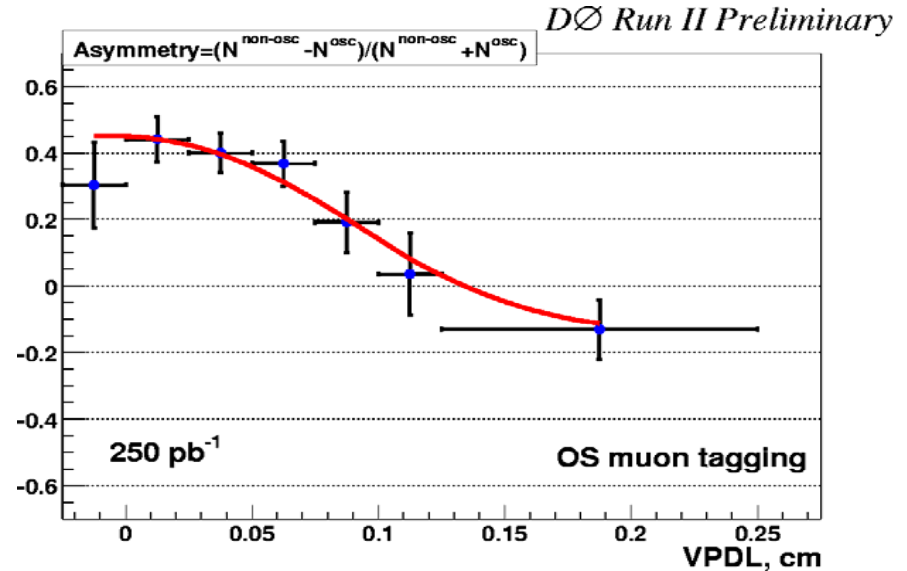
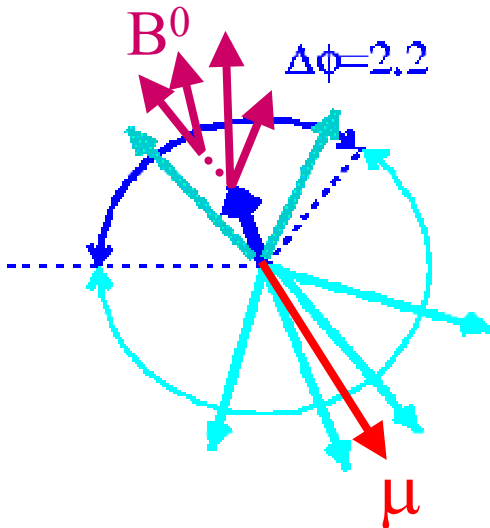
- e.g. Last bin VPDL = [0.125 - 0.250 cm]



Final state: Not oscillated: $Q_{\mu OS} \times Q_{\mu SS} < 0$
 Oscillated: $Q_{\mu OS} \times Q_{\mu SS} > 0$



B^0/\bar{B}^0 Mixing Results: OS muon tagging



Tagging procedure

- opposite side muon
- muon $p_T > 2.5 \text{ GeV}/c$
- $\cos \Delta\phi(\mu, B) < 0.5$

Fit procedure

- Binned χ^2 fit

Preliminary results:

$$\Delta m_d = 0.506 \pm 0.055(\text{stat}) \pm 0.049(\text{syst}) \text{ ps}^{-1}$$

Tagging efficiency: $4.8 \pm 0.2 \%$

Tagging purity: $73.0 \pm 2.1 \%$

- One of the best measurements at a hadron collider
- Good prospects for improving accuracy
 - work in progress to decrease systematic uncertainty (mass fit)
 - use other tagging methods
 - add more D^0 decay channels

B^0 Oscillations Using Same-Side Tagging (CDF)

- $L \sim 270 \text{ pb}^{-1}$
- Use fully reconstructed ($N \sim 5900$) :
 $B^0 \rightarrow J/\psi K^{*0}$ ($J/\psi \rightarrow \mu^+ \mu^-$, $K^{*0} \rightarrow K^+ \pi^-$)
 $B^0 \rightarrow D^- \pi^+$ ($D^- \rightarrow K^+ \pi^- \pi^-$) \leftarrow track trigg
- Use B^+ control samples ($N \sim 7800$) :
 $B^+ \rightarrow J/\psi K^+$ ($J/\psi \rightarrow \mu^+ \mu^-$)
 $B^+ \rightarrow \bar{D}^0 \pi^+$ ($\bar{D}^0 \rightarrow K^+ \pi^-$)
- Use same side tagging (SST) based on expected flavor-charge correlation between the B meson and charged tracks in its vicinity
- Tagging parameters

	$\epsilon(\%)$	$D(\%)$	$\epsilon D^2(\%)$
B^+	62.7 ± 0.7	21.2 ± 2.0	2.8 ± 0.5 (stat)
B^0	63.0 ± 0.6	12.4 ± 3.3	1.0 ± 0.5 (stat)

Results (CDF)

- Combined fit of $J/\psi K^{*0}$ & $D^-\pi^+$ channels:

$$\Delta m_d = 0.55 \pm 0.10(\text{stat.}) \pm 0.01(\text{syst.}) \text{ ps}^{-1}$$

- Systematic errors for $\Delta m_d \leftarrow$ (mass fitting: 0.008 ps^{-1} ; ct resolution: 0.009 ps^{-1})
- CDF Run I $\rightarrow \Delta m_d$ (all methods) = $0.495 \pm 0.026 \pm 0.025 \text{ ps}^{-1}$

Summary - lifetimes

- New **B meson** lifetime measurements from **exclusive B \rightarrow J/ ψ X** channels by **CDF**
- Measurement of **B⁺/B_d⁰** lifetime ratio from semileptonic B decays - a novel analysis technique (**D0**)

	CDF	D0	World average
B ⁺	1.662 ± 0.033 ± 0.008 ps	1.65 ± 0.08 ± 0.12 ps (2003)	1.671 ± 0.018 ps
B _d ⁰	1.539 ± 0.051 ± 0.008 ps	1.51 ± 0.18 ± 0.20 ps (2003), → ICHEP	1.537 ± 0.015 ps
B _s ⁰	1.369 ± 0.100 ± 0.008 - 0.01 ps	1.19 ± 0.18 ± 0.14 ps (2003), → ICHEP	1.461 ± 0.057 ps
Λ _b	1.25 ± 0.26 ± 0.10 ps (2003)	→ ICHEP 04	1.233 ± 0.077 ps
τ(B _Λ)/τ(B _d ⁰)	0.91 ± 0.20 (tot) (2003)	→ ICHEP 04	0.798 ± 0.052
τ(B ⁺)/τ(B ⁰)	1.08 ± 0.042 (tot.)	1.093 ± 0.021 ± 0.022	1.085 ± 0.017
τ(B _s)/τ(B ⁰)	0.890 ± 0.072 (tot.)	→ ICHEP 04	0.951 ± 0.038

- Results competitive with B-factories, expect 1% ratio precision (2 fb⁻¹)
- Measurement of polarization amplitudes of **B_d⁰ → J/ ψ K*** & **B_s⁰ → J/ ψ φ**
- Measurement of **ΔΓ_s/Γ_s** → **in progress**, expect 5% precision (2 fb⁻¹)

Summary – B^0_d Oscillations

- **New measurements of B^0_d Oscillations using:**
 - **semileptonic decays; Opposite-Side μ tagging (D0)**
 - $\Delta m_d = 0.506 \pm 0.055(\text{stat}) \pm 0.049(\text{syst}) \text{ ps}^{-1}$
 - **$B^0 \rightarrow J/\psi K^{*0}, D^-\pi^+$ decays, Same-Side π tagging (CDF)**
 - $\Delta m_d = 0.55 \pm 0.10(\text{stat}) \pm 0.01(\text{syst}) \text{ ps}^{-1}$
- **World average: $\Delta m_d = 0.502 \pm 0.007 \text{ ps}^{-1}$**
- **Work in progress** in both experiments:
semileptonic/exclusive channels, other tagging methods,
more D^0 decay channels etc