B-Mixing & Lifetime Difference at CDF & DØ

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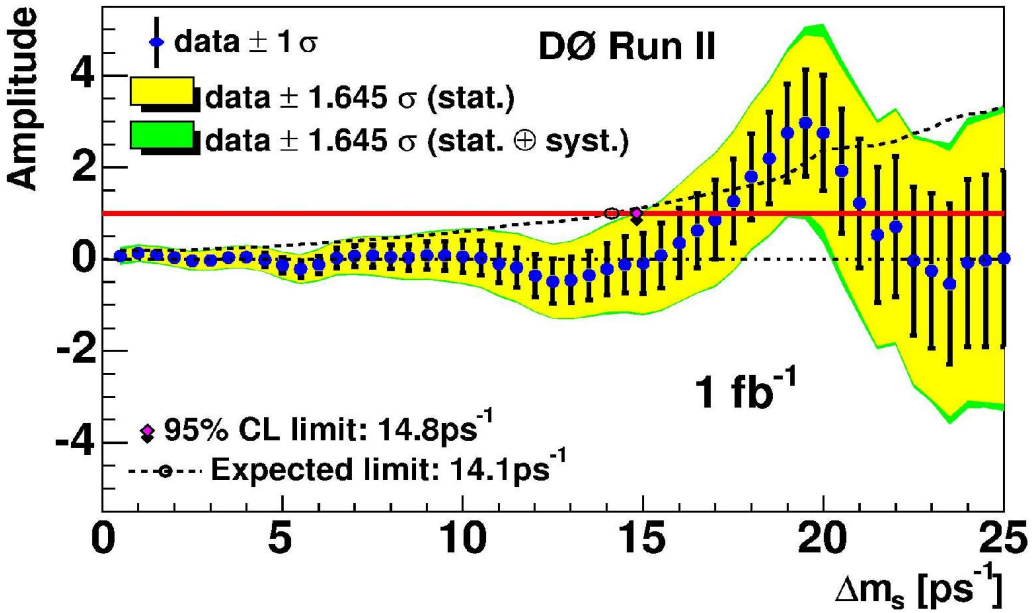
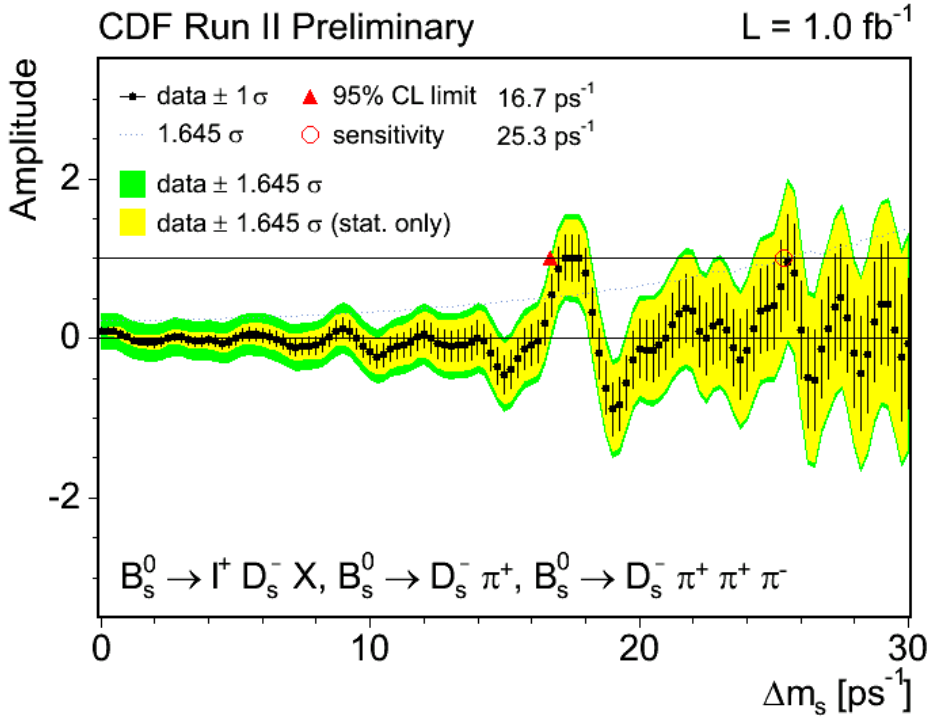
(for the CDF & DØ collaborations)





Outline

1) The EW Symmetry – Flavor Connection
   - and the b-quark's role

2) B_s Mixing at the Tevatron
   - with a few words about B_d

see also: plenay talk by M. Jones

3) $\Delta\Gamma_s$ Measurements

4) Where We Stand – Where We're Going

EW Symmetry & Flavor

In the SM: EW Sym Breaking, Mass & Flavor are Entwined

$$L_Y = -\sum_{i,j=\text{family}} [\hat{y}^e_{ij} \bar{L}^i_L \phi E^j_R + \hat{y}^d_{ij} \bar{Q}^i_L \phi D^j_R + \hat{y}^u_{ij} \bar{Q}^i_L \phi U^j_R + h.c.]$$

SM Symmetries & Yukawa Couplings ⇒ Obs Flavor Struct.

$$L_Y = -\sum_{i,j} [y^d_j \bar{Q}^i_L \tilde{\phi} V_{ij} D^j_R + h.c.] - \sum_i [y^u_i \bar{Q}^i_L \tilde{\phi} U^i_R + h.c.] - \sum_i [y^e_i \bar{L}^i_L \tilde{\phi} E^i_R + h.c.]$$

CKM Matrix:

$$\text{weak} \begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} \text{mass}$$

- unitary
- 3 angles
- 1 complex phase (CPV)

1 Higgs Doublet in SM ⇒ Flavor Sector Strongly Constr.

- FCNCs Suppressed
- Unitary V_{CKM}
- 1 param for all CPV
- No CPV in flav diag proc's (edm)
- nearly all flavor observables are related (in the SM)

The b-Quark's Place

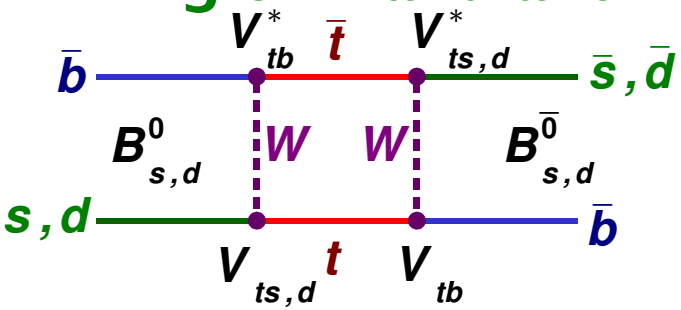
New Physics is MUCH less constraining than the SM

- *e.g.* 43 CP violating variables in MSSM

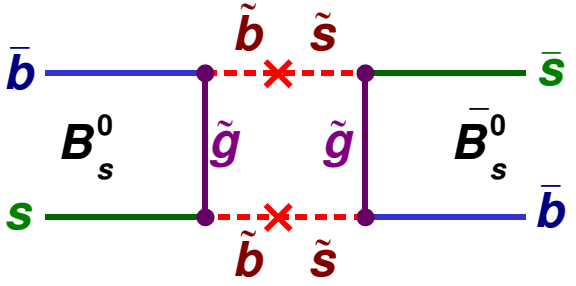
Agreement b/w Observations and SM

- flavor already a strong input to model builders
- NP effects only visible in loop-mediated processes

Mixing of B and anti-B Mesons



SM Box Diagram



SUSY Example

(+ charginos, neutralinos, etc @ tanβ >>1)

What We Measure

Weak ≠ Mass Eigenstates ⇒ Shrödinger Eqn Matrix

$$i\frac{d}{dt}\begin{pmatrix}|B^0(t)\rangle\\ |\bar{B}^0(t)\rangle\end{pmatrix}=\left(M-i\frac{\Gamma}{2}\right)\begin{pmatrix}|B^0(t)\rangle\\ |\bar{B}^0(t)\rangle\end{pmatrix}$$

M, Γ = Hermitian, 2x2 matrices

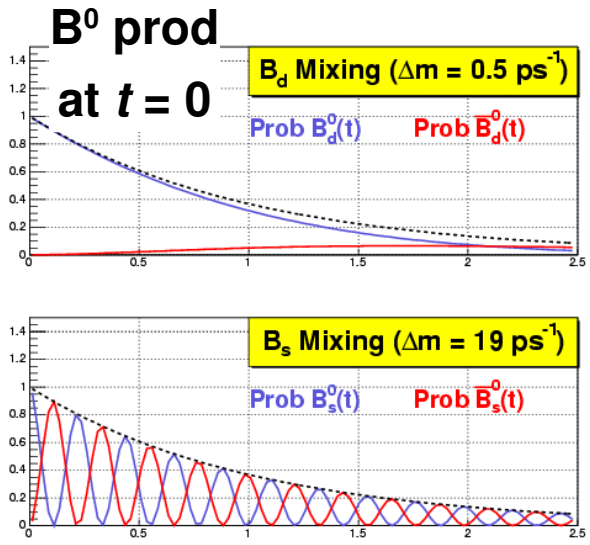
$$|B_H\rangle = p|B^0\rangle + q|\bar{B}^0\rangle \quad |B_L\rangle = p|B^0\rangle - q|\bar{B}^0\rangle \quad ; \quad |B_H\rangle \sim |B^{CP-odd}\rangle \quad |B_L\rangle \sim |B^{CP-even}\rangle$$

Observables

$\Delta m = M_H - M_L \sim 2|M_{12}|$ sens. to NP

$\Delta\Gamma_{CP} \sim \Gamma_L - \Gamma_H \sim 2|\Gamma_{12}|$ not sens. to NP

$\Delta\Gamma = \Gamma_L - \Gamma_H \;\; \Delta\Gamma_{CP}\cos\phi$ very sens. to NP



In the SM

$$\left(\frac{\Delta\Gamma}{\Gamma}\right)_s = 0.12 \pm 0.05 \qquad \phi_s \sim 0.03^o$$

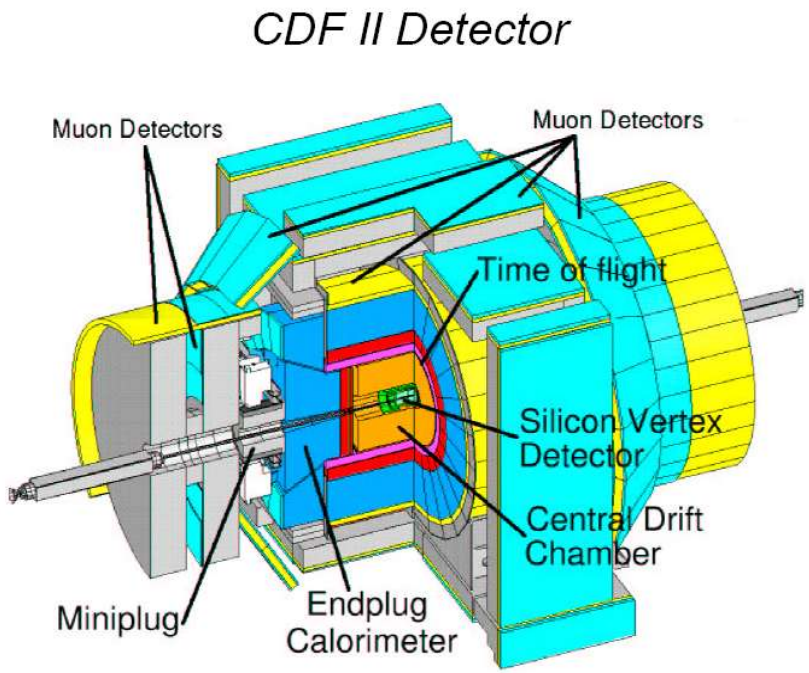
A.Lenz hep-ph/0412007

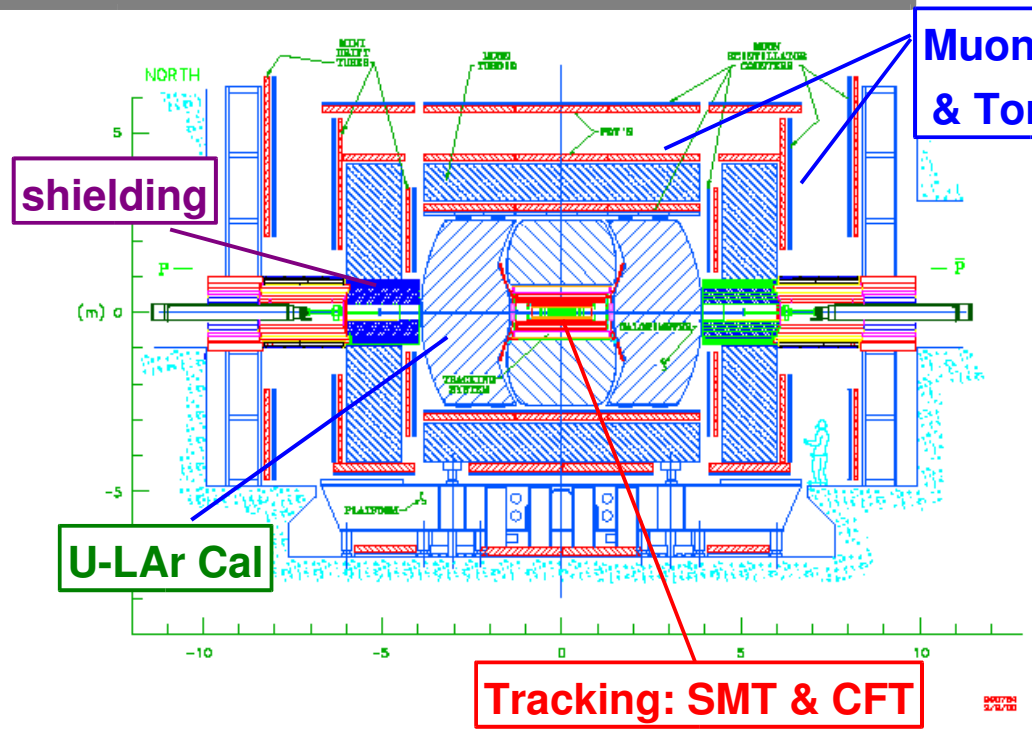
$$\frac{\Delta m_d}{\Delta m_s} = \frac{M_{Bd}}{M_{Bs}} \frac{f_{Bd}^2 B_{Bd}}{f_{Bs}^2 B_{Bs}} \left|\frac{V_{td}}{V_{ts}}\right|^2$$

$$\left(1.210^{+0.047}_{-0.035}\right)^2$$

M.Okamoto hep-lat/0510113

CDF and DØ





Component	CDF	D0
Triggers	2-Trk @ L1 SVT @ L2	1 & 2 Muon
Tracking	$\sigma(p)/p \sim 0.1\%$ $\langle\sigma(ct)\rangle \sim 26\,\mu m$	$\sigma(p)/p \sim 0.2\%$ $\langle\sigma(ct)\rangle \sim 33\,\mu m$
Lepton ID	$\mu: \lvert\eta\rvert < 1$	$\mu: \lvert\eta\rvert < 2$
π/K sep	dE/dx & TOF	---

Both Exp's Integrated Lumi:

- ~1.3 fb^{-1} collected
- up to 1 fb^{-1} analyzed

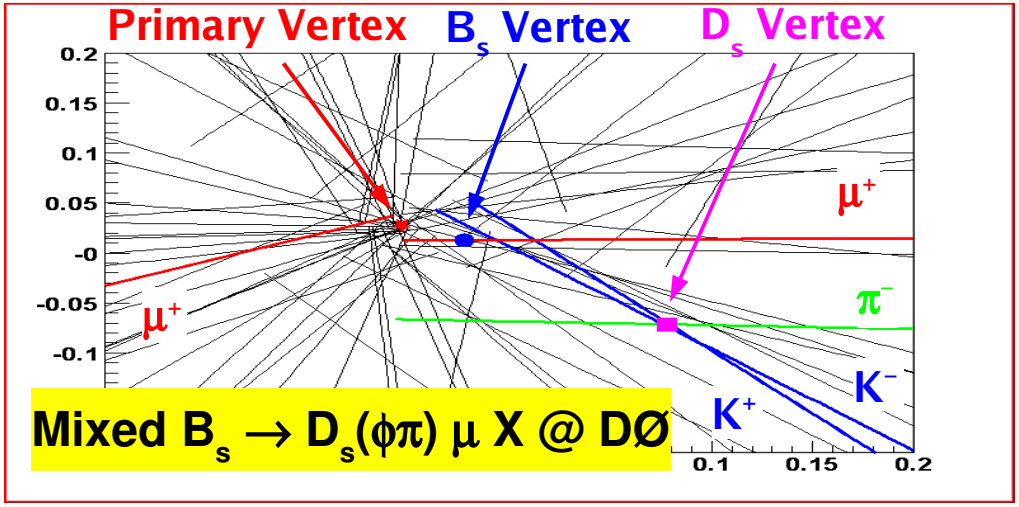
Anatomy of a Mixing Analysis

1) Identify B_s Candidates
   - trigger on them
   - reconstruct them
   - understand backgrounds

2) Tag as "Mixed" or "Unmixed"
   - flavor at production
   - flavor at decay

3) Determine Decay Time
   - decay length
   - $ct = L / \gamma\beta$

4) Fit for Δm (or limit)



$$\langle \text{Significance} \rangle = \frac{S}{\sqrt{S+B}} \sqrt{\frac{\epsilon D^2}{2}} \exp\left[\frac{-(\Delta m \sigma_t)^2}{2}\right]$$

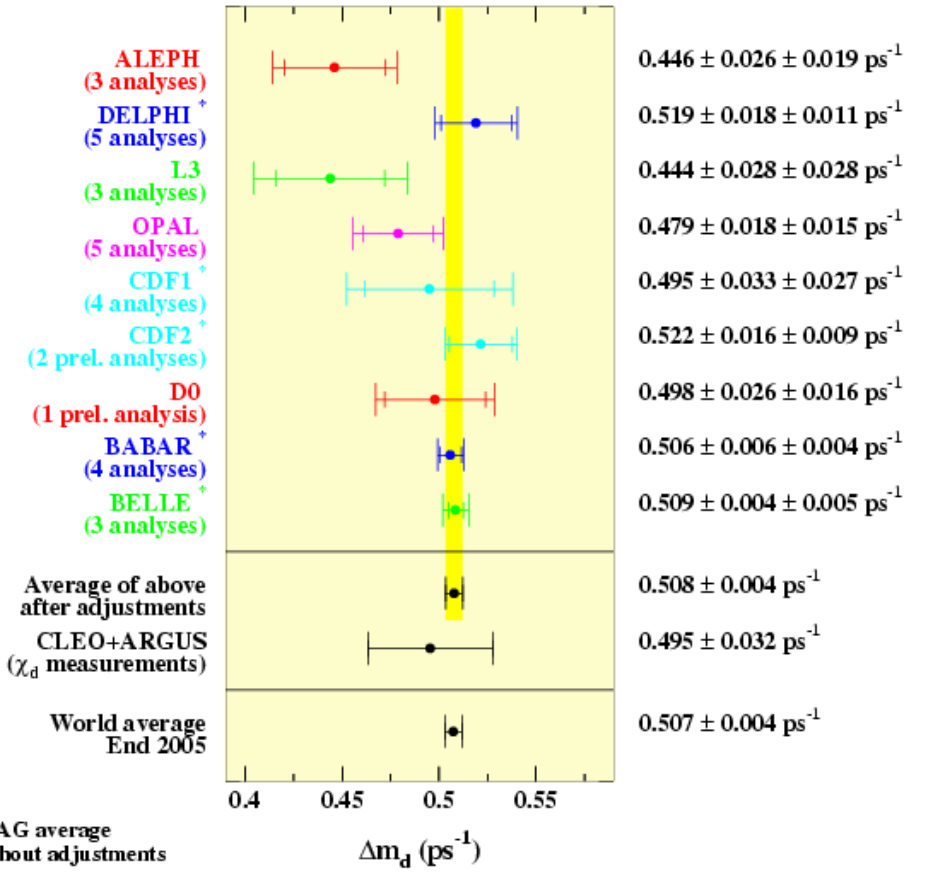
Signal / Bgrd in unTagged Sample

Tagging Power

Proper Time Resolution

Previous Results

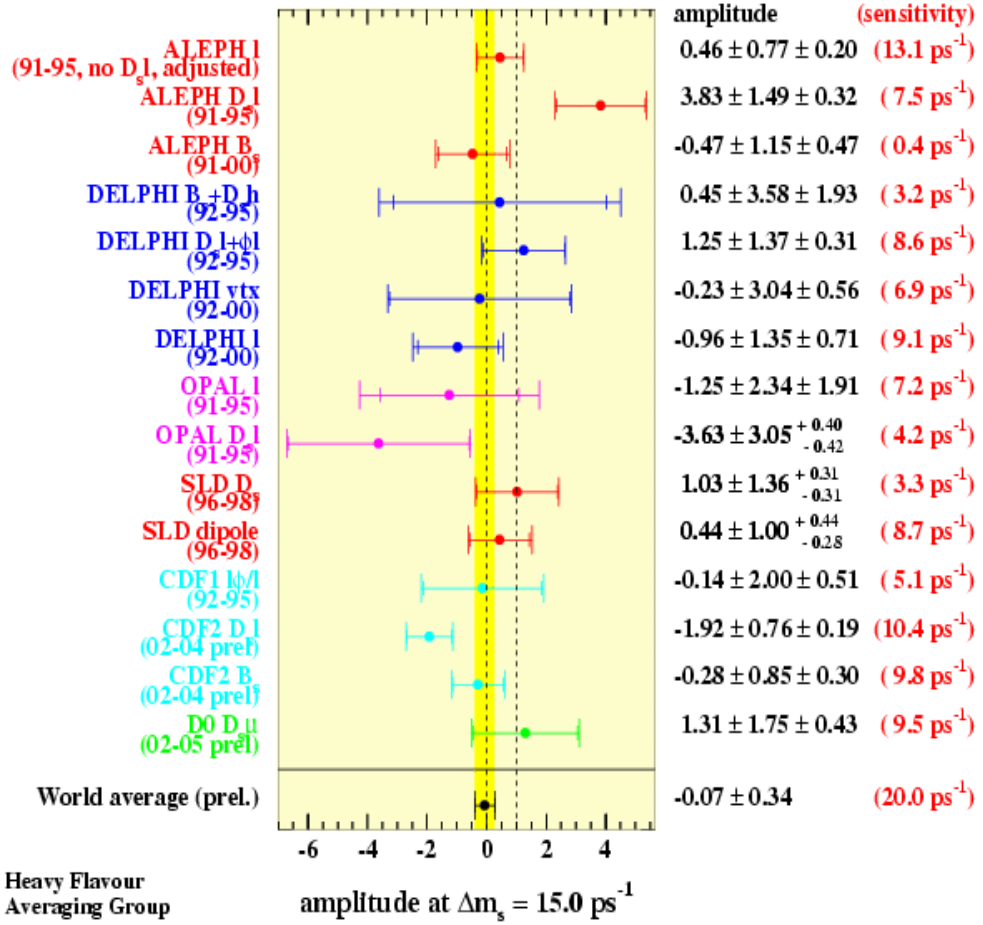
$\Delta m_d = 0.507 \pm 0.004$ ps^{-1}



* HFAG average without adjustments

>30 separate measurements !

$\Delta m_s > 16.6$ ps^{-1} (95% CL)

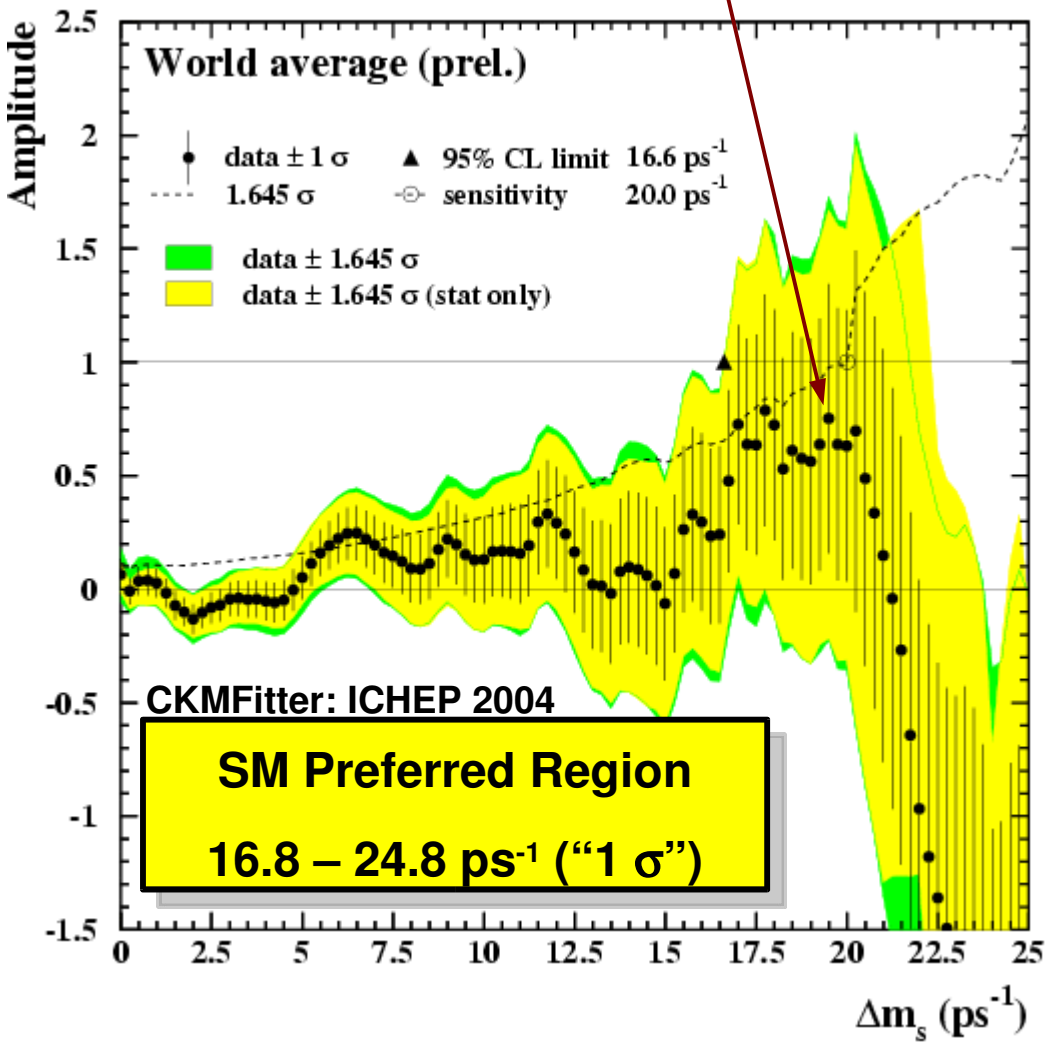


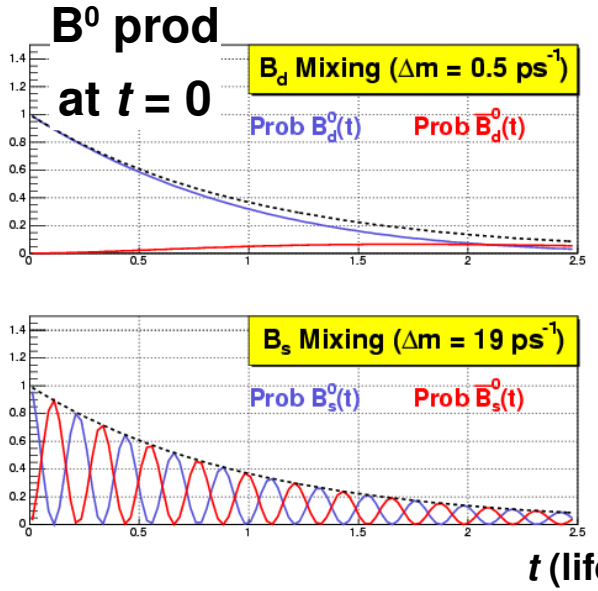
Heavy Flavour Averaging Group
End 2005 update

Some Hints ?

$$p^{unm/mix}(t) \propto e^{-t/\tau}\left[1 \pm A_{\Delta m*} D\cos(\Delta m^* t)\right]$$

HFAG: end 2005





Results presented as "Probability" that data is consist w/ oscillations at various values of Δm_s

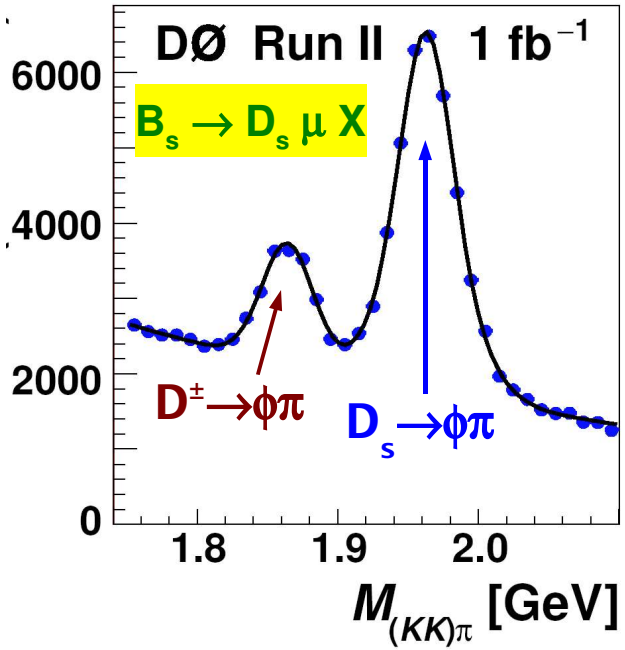
Observation

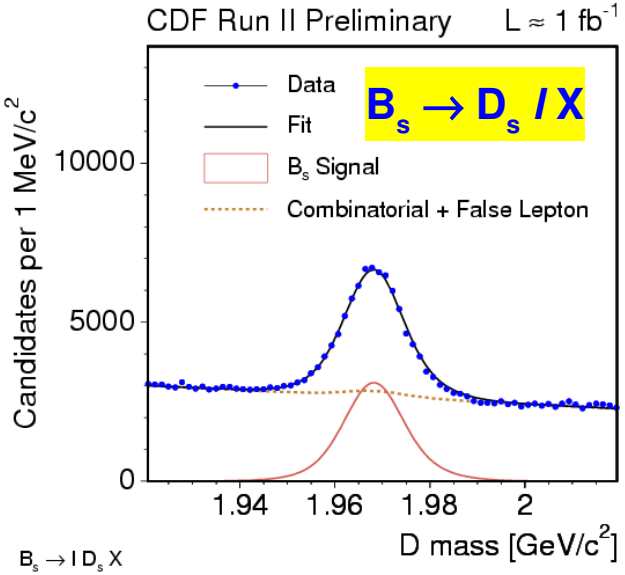
Stat signif Amp(Δm_s^{true}) = 1

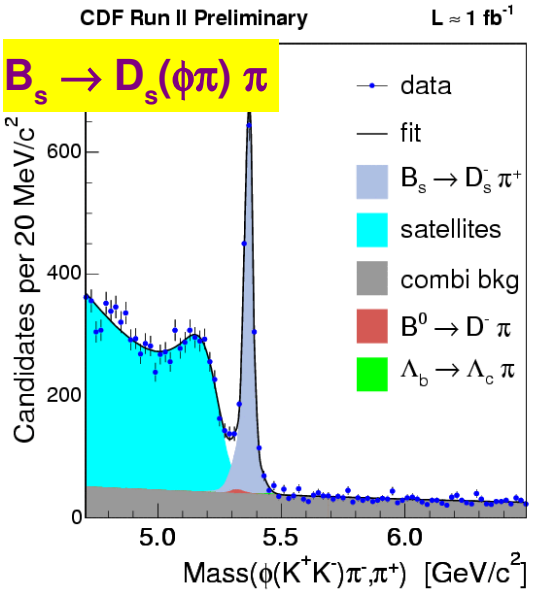
95% C.L. Limit

Amp + 1.645 = 1

(untagged) Event Samples







Channel	(Ds Mode)	CDF	total	D0
$B_s \to D_s$ / X	$(\phi\pi)$	32 K		21 K
	(K^*K)	11 K		
	(3π)	10 K	53 K	
$B_s \to D_s\,\pi$	$(\phi\pi)$	1600		
	(K^*K)	800		
	(3π)	600		
$B_s \to D_s\,3\pi$	$(\phi\pi)$	500		
	(K^*K)	200	3700	

Semi-Leptonic Modes
- high statistics
- missing particles

Hadronic Modes
- lower statistics
- fully meas $P_T(B)$

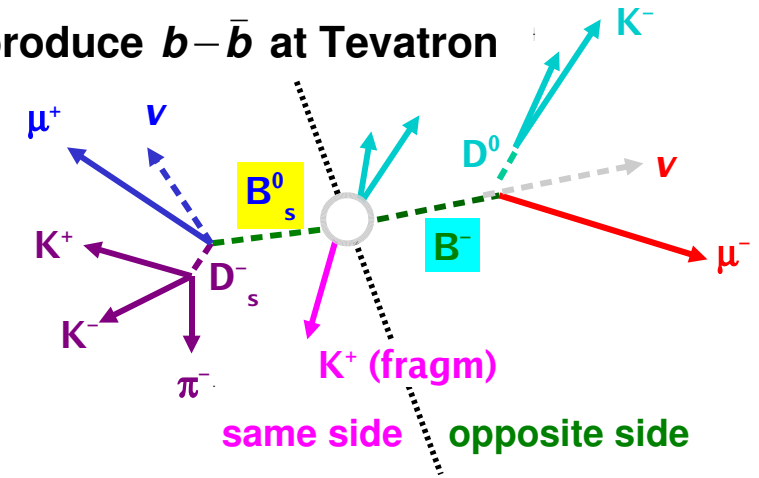
Tagging

1) **Tag Flavor at Production**
   a) **Opposite Side**
      * μ/e (jet) charge
      * jet/vertex/event charge
   b) **Same Side (fragm tracks)**
      * $K^+ \leftrightarrow B_s$ (use CDF TOF)

2) **Tag Flavor at Decay**
   * $l^+, \pi^+ \leftrightarrow b$-quark

3) **Calibrate using:**
   a) B_d Mixing — Opp Side
   b) + MC Tuning — Same Side

pair produce $b-\bar{b}$ at Tevatron



4) **Figure of Merit: εD^2**
   a) **Efficiency:** N(tag)/N(cand)
   b) **Purity:** N(correct)/N(tag)
      * **Dilution** D = 2xPurity − 1

	CDF: Hadr.	Lept (1 fb-1)	D0: Lept (1 fb-1)
εD^2: Opp [%]	1.47 ± 0.10	1.54 ± 0.04 ± 0.05	$2.48 \pm 0.21^{+0.08}_{-0.06}$
εD^2: Same	3.42 ± 0.98	4.00 ± 1.02	
Δm_d [ps^{-1}]	0.536 ± 0.028 ± 0.006	0.509 ± 0.010 ± 0.016	0.506 ± 0.020 ± 0.016
Δm_d (W.A.)	0.507 ± 0.005 (HFAG – PDG 2006)		

Proper Time Reconstruction

1) **Estimate Decay Length (L_{xy})**
   a) primary vertex (evt-by-evt)
   b) B_s vertex

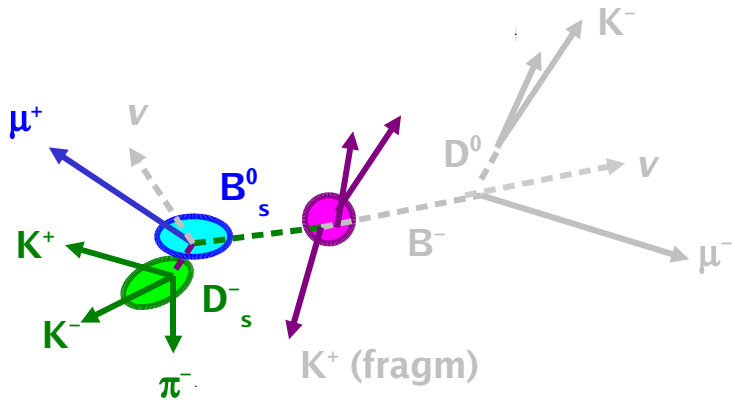
2) **Estimate B-Momentum**
   a) Hadronic: $P_T^{meas} = P_T(B)$
   b) Semi-Lep: $P_t^{meas} = K\, P_T(B)$
      * $K = P_T(D_s l) / P_T(B)$

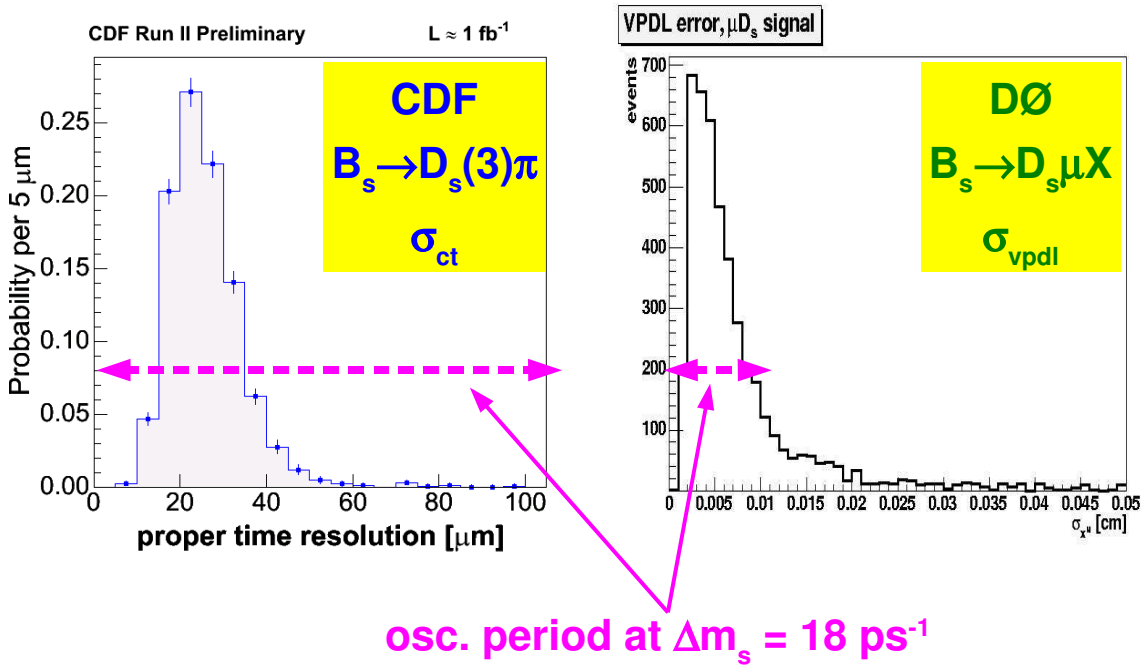
3) **Proper Time:**

$$ct = \left(M_{Bs} \frac{L_{xy}}{P_T^{meas}} \right) (K)$$

VPDL

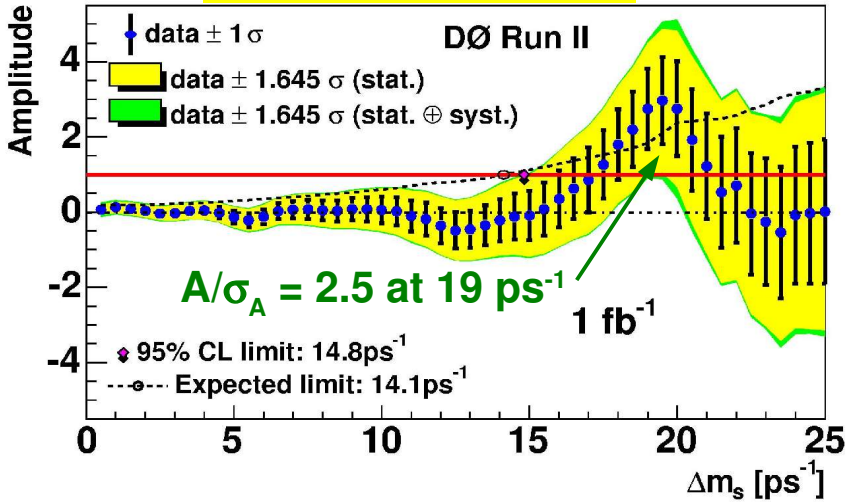
4) **Calibration**
   a) Lifetime Measurements
   b) Control Samples



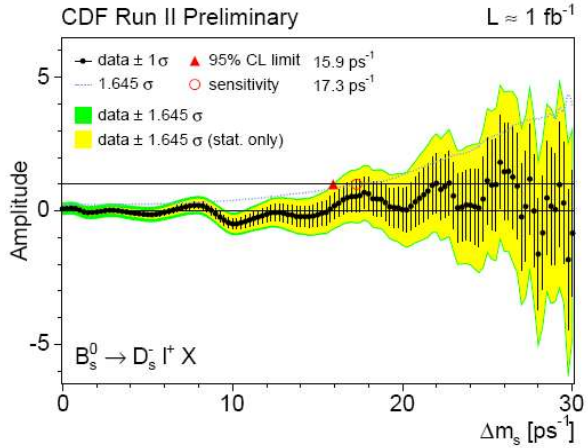


Amplitude Fits

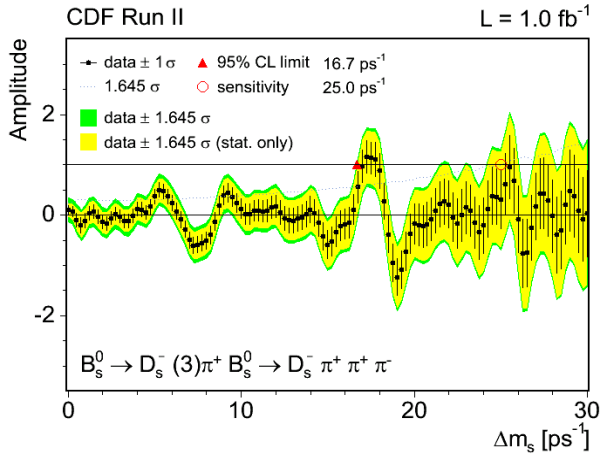
DØ Semi-Leptonic



CDF Semi-Leptonic



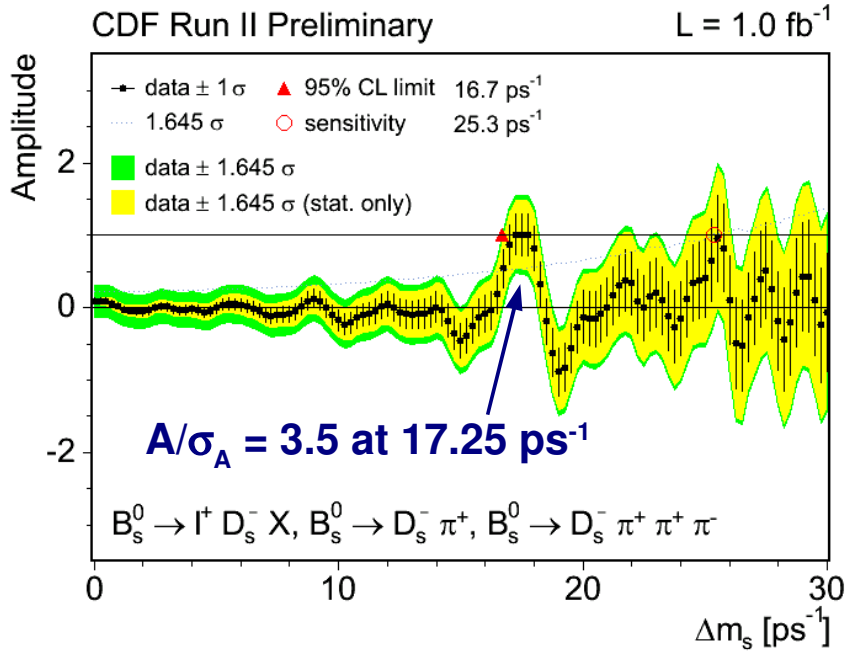
CDF Hadronic



Evt-by-Evt Likelihood Fits

- event Dilution & σ_{ct}
- event var PDFs
- Resolution & K-Fact. conv
- "Physics" PDFs for sig & bgrd src's

CDF Combined

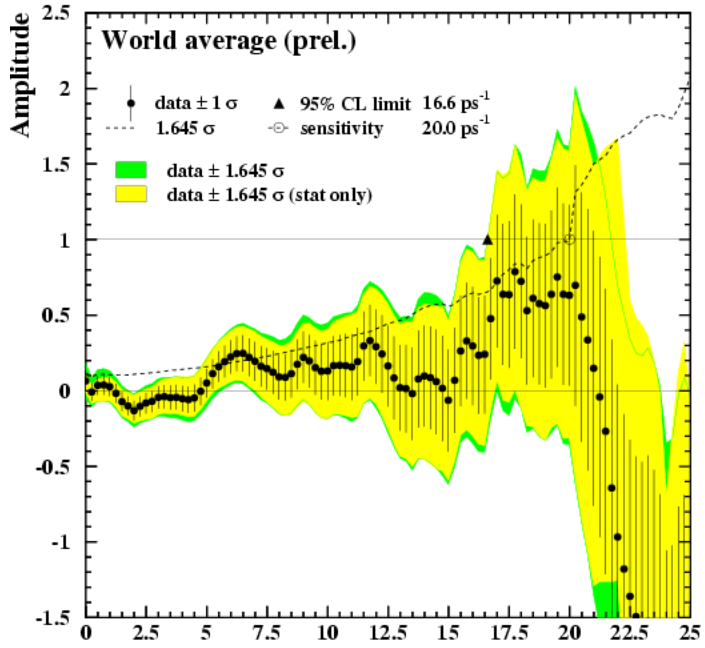


Results

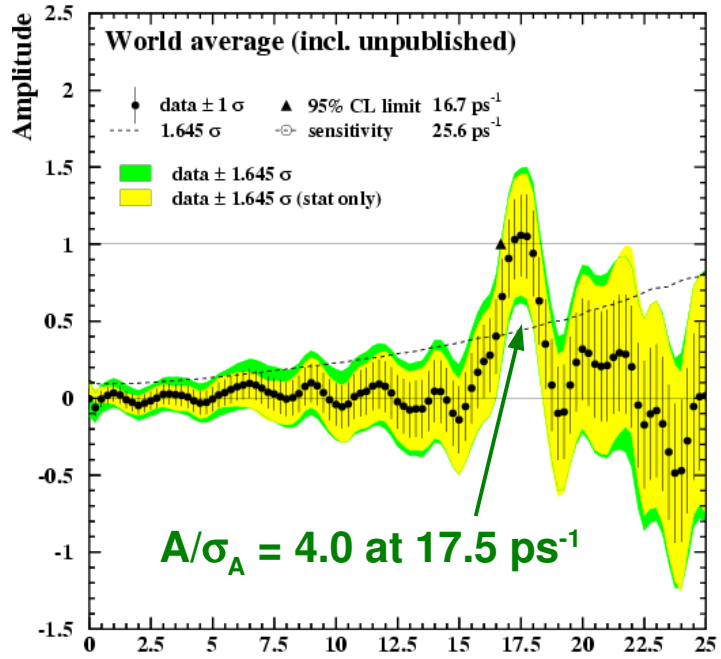
- DØ $17 < \Delta m_s < 21\ ps^{-1}$ (90% CL)
- CDF $\Delta m_s = 17.33^{+0.42}_{-0.21} \pm 0.07\ ps^{-1}$

Impact of New Results

Check	CDF	D0	Method
Prob that meas is due to a fluctuation	~0.5%	~5%	randomize tags in data ($\Delta m=\infty$)
Prob of seeing obs signif or greater	~40%	~15%	toy MC



HFAG: Summer 2005



HFAG: incl. new CDF & DØ

CDF: $\left|\frac{V_{td}}{V_{ts}}\right| = 0.208^{+0.008}_{-0.007}$

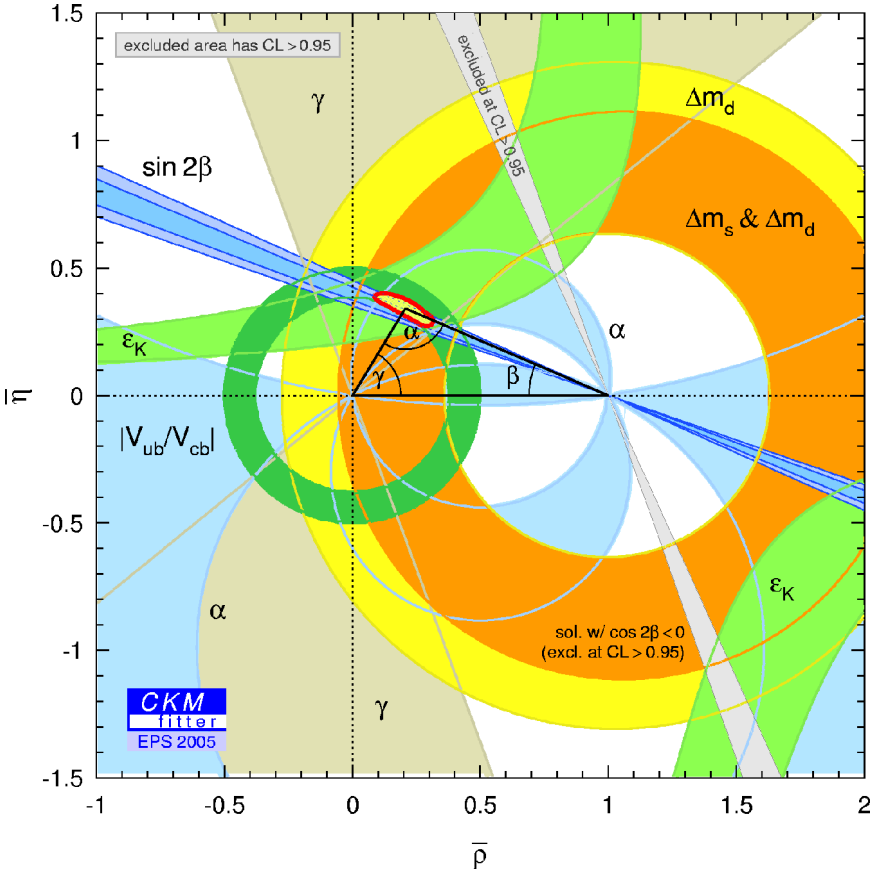
c.f. Belle $b \to d\gamma$: $0.199^{+0.026+0.018}_{-0.025-0.015}$ (hep-ex/0506079)

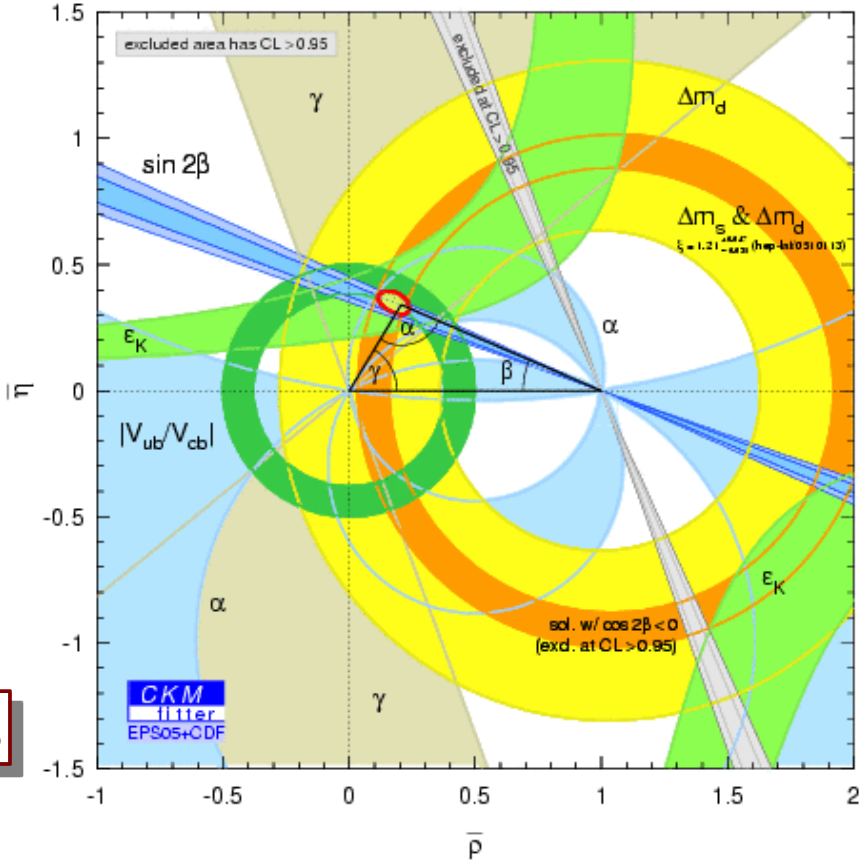
Impact on Unitarity Triangle

CKM Fitter: EPS 2005

CKM Fitter: incl. new CDF (& lattice calc)

see also new Utfit results: http://utfit.roma1.infn.it/





~ ±7%

$$\left|\frac{V_{td}}{V_{ts}}\right|^2 = \frac{M_{Bs}}{M_{Bd}} \frac{f_{Bs}^2 B_{Bs}}{f_{Bd}^2 B_{Bd}} \frac{\Delta m_d}{\Delta m_s}$$

Δm_d → < ±1%

Δm_s → ±2.5%

Strategies for $\Delta\Gamma$

Fit to Resolve CP Comp's

- Use $B_s \to J/\psi(\mu^+\mu^-)\ \phi(K^+K^-)$
  - comb. of CP-even & -odd
  - decay distrib $\Rightarrow$ 3 angles
- Likelihood Fit
  - M_{bs}, *ct*, 3 angles

    $\Rightarrow \Delta\Gamma$, $<\tau>$, CP-odd frac, ...
- Main Issue: accept vs angles
  - use different MC models
  - tuned to data kinematics

CP-specific States

- BR($B_s \to D_s^{(*)}\ D_s^{(*)}$)
  - mainly CP-even (~$|B_L>$)
  - signal from fits to mass distrib

$$2BR_{BL} = \frac{\Delta\Gamma}{\Gamma}\left[\frac{1}{1+\Delta\Gamma/2\Gamma}\right]$$

- Lifetime($B_s \to K^+\ K^-$)
  - CP-even state
  - Multi-Var fit to $B \to h^+\ h^-$
    - includes dE/dx

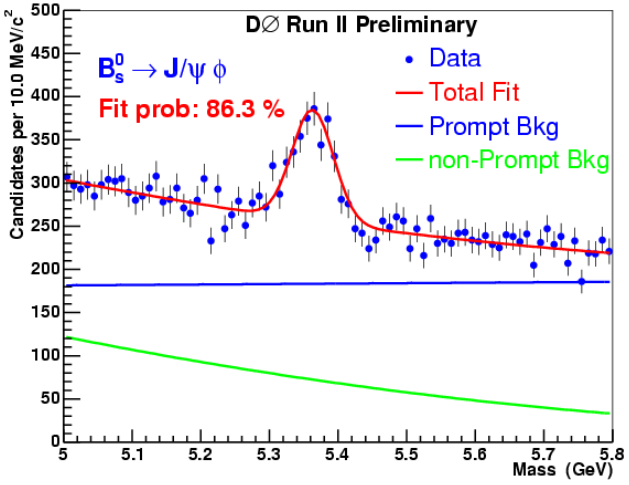
$$\tau_{BL} = \frac{1}{\Gamma}\left[\frac{1}{1+(\Delta\Gamma/2\Gamma)}\right]$$

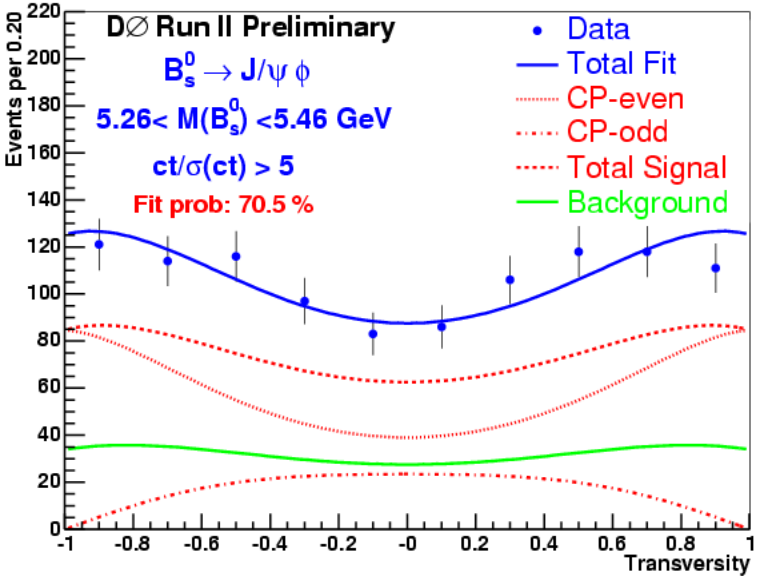
Flavor Spec. States (½ even - ½ odd)

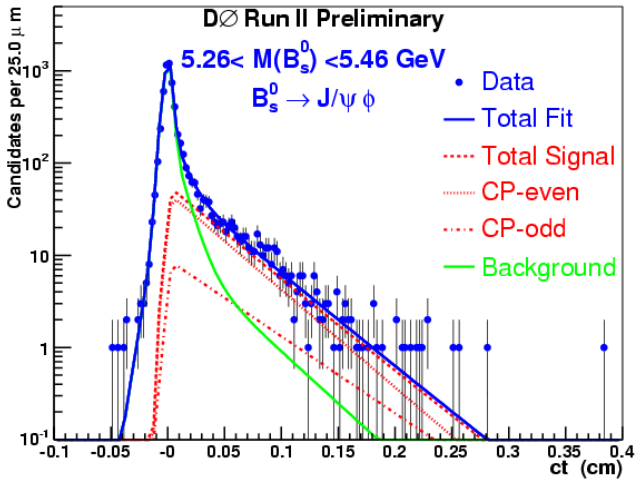
- Lifetime meas sensitive to $\Delta\Gamma^2$

$$\tau_{fs} = \frac{1}{\Gamma}\left[\frac{1+(\Delta\Gamma/2\Gamma)^2}{1-(\Delta\Gamma/2\Gamma)^2}\right]$$

$B_s \rightarrow J/\psi\,\phi$ Results

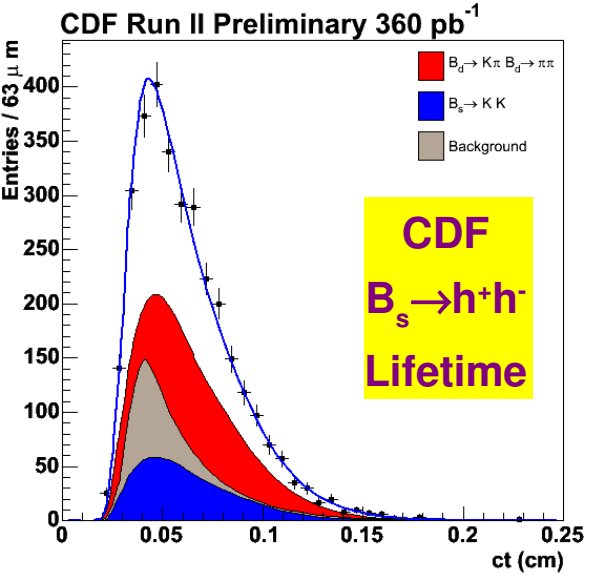




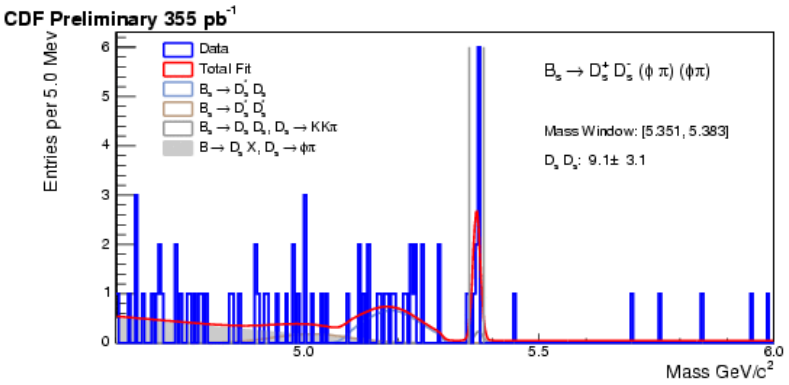


Observable		CDF 2004 (355 pb-1)	D0 2006 (1 fb-1)	ϕ free ($\delta_2 \equiv 0$)
Candidates	N_{Bs}	203 ± 15	978 ± 45	
Lifetime Diff	$\Delta\Gamma$ (ps^{-1})	$0.47^{+0.19}_{-0.24} \pm 0.01$	$0.15 \pm 0.10^{+0.03}_{-0.04}$	0.17 ± 0.09
Ave Lifetime	$\langle\tau\rangle$ (ps^{-1})	$1.40^{+0.15}_{-0.13}$	$1.53 \pm 0.08^{+0.01}_{-0.04}$	1.53 ± 0.08
CP-Odd Frac	$R_\perp$	0.13 ± 0.08	$0.19 \pm 0.05 \pm 0.01$	0.19 ± 0.05
CP-Even	$\lvert A_0(0)\rvert^2$ - $\lvert A_\parallel(0)\rvert^2$	0.355 ± 0.067	$0.35 \pm 0.07 \pm 0.01$	0.34 ± 0.07
Strong Phases	$\delta_1 - \delta_2$	1.94 ± 0.36	2.5 ± 0.4	2.6 ± 0.4
CPV Phase	ϕ	$\equiv 0$	$\equiv 0$	-0.9 ± 0.7

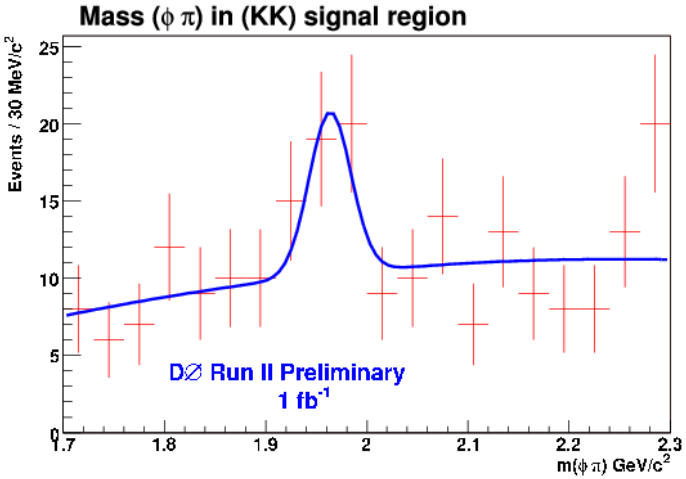
New CP Specific Results



CDF: $B_s \to D_s^+(\phi\pi)\, D_s^-(\phi\pi)$ Mass



DØ: $B_s \to D_s^{(*)}(\phi\pi)\, D_s^{(*)}(\mu\phi X)$

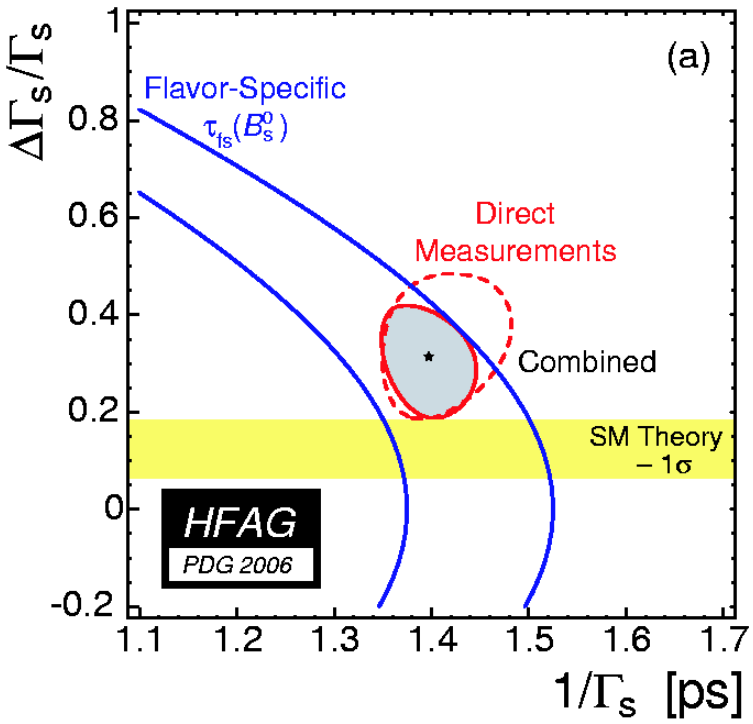


M($\phi\pi$) for events w/ 2nd ϕ + μ

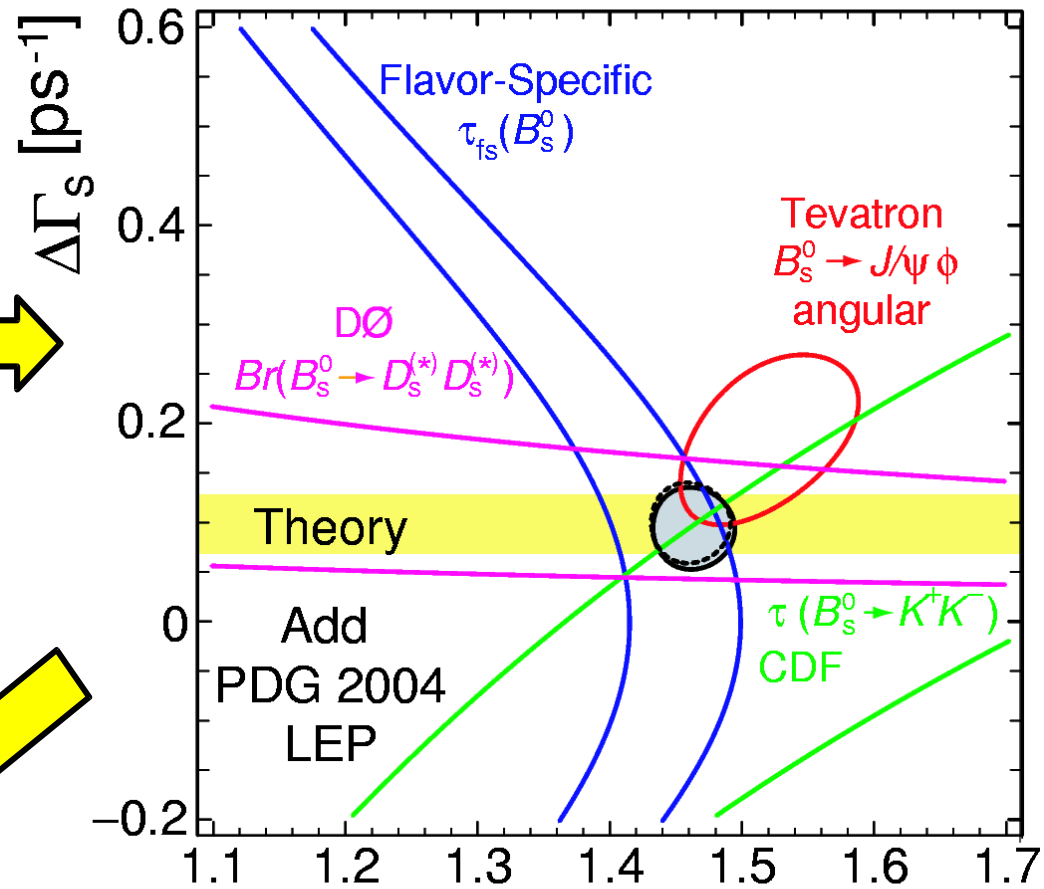
Exp	Mode	Lumi	N(signal)	BR / τ	$\Delta\Gamma/\Gamma$
CDF	$\tau(B_s \to K^+K^-)$ [ps]	360 pb-1	718 ± 55	1.53 ± 0.18 ± 0.02	–0.08 ± 0.23 ± 0.03
CDF[1]	BR($B_s \to D_s^+ D_s^-$)	355 pb-1	23.5 ± 5.5	0.013 ± 0.006	difficult b/c non-inclus.
D0	BR($B_s \to D_s^{(*)} D_s^{(*)}$)	1 fb-1	17.6 ± 7.9	$0.071 \pm 0.035^{+0.029}_{-0.025}$	$0.142 \pm 0.064^{+0.058}_{-0.050}$
ALEPH 2000				$0.12 \pm 0.05^{+0.10}_{-0.05}$	$0.26^{+0.30}_{-0.15}$

[1] uses CDF meas $\dfrac{BR(B_s \to D_s^+ D_s^-)}{BR(B^0 \to D_s^+ D^-)} = 1.67 \pm 0.41(stat) \pm 0.12(syst) \pm 0.24(f_s/f_d) \pm 0.39(BR_{\phi\pi})$ and $BR(B^0 \to D_s^+ D^-) = 0.0080 \pm 0.0030$ (PDG 2006)

Progress on $\Delta\Gamma$



1-sigma contours ($\Delta(\log L) = 0.5$)



Unofficial World Average

$$\Delta\Gamma_s = 0.097^{+0.041}_{-0.042}\ \text{ps}^{-1}$$

$$\bar{\tau} = \frac{1}{\Gamma_s} = 1.461 \pm 0.003\ \text{ps}$$

Theory: $\Delta\Gamma_s = 0.10 \pm 0.03 \left(\frac{f_{Bs}}{(260\,MeV)^2} \right)$

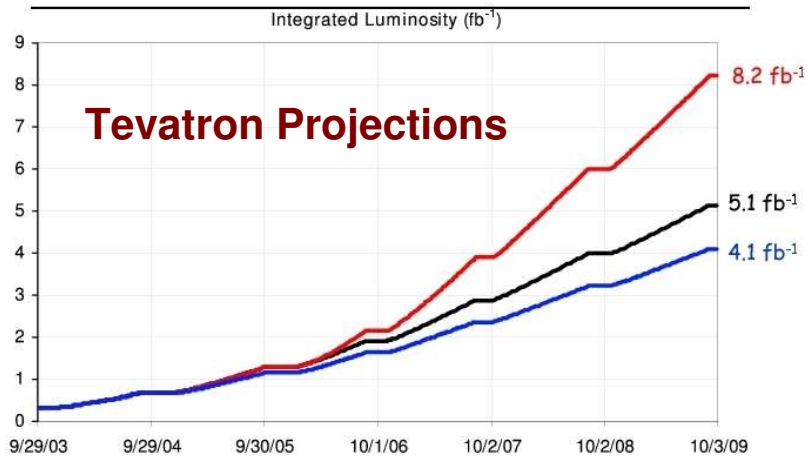
update (Nierste) of PLB 459, 631 (1999)

What's Next ?

Both Δm_s and $\Delta\Gamma_s$ are Statistics Limited

- res. improve. also benefit Δm_s

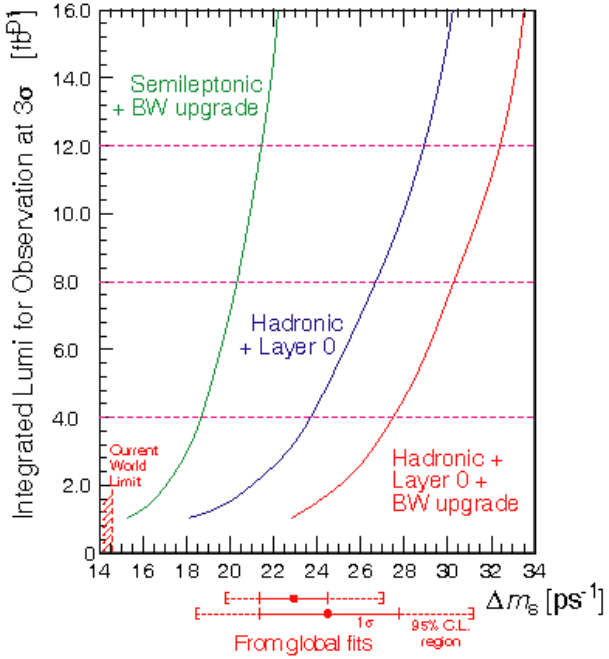
Tevatron: 1 fb^{-1} → 4 – 8 fb^{-1} by 2009



DØ Plans

- Layer-0 Silicon installed
  - σ_{ct} improves by 25%
- Trigger bandwidth upgrade
  - > factor 2 increase in B-events
- Add Hadronic & other Semi-Lept Modes
- Same Side Tagging

ex. of possible DØ improvements



CDF Plans

- Trigger upgrades ⇒ improve B_s accept
- Partially reconstructed decays
- Neural Net selections

Conclusions

Signature Consistent with B_s Oscillation Found !

Exp	Δm_s (ps^{-1})	Signif (σ)	Prob of Fluct
CDF	$17.33^{+0.42}_{-0.41} \pm 0.07$	3.5	~0.5%
D0	17 – 21 (90% C.L.)	2.5	~5%

World Ave. $\Delta\Gamma_s$ now 2.4σ from Zero

- starting to be sensitive to CPV phase ϕ

Both Δm_s and $\Delta\Gamma_s$ consistent with SM

- $\Rightarrow$ Constraints on New Physics (esp. with $B_s \rightarrow \mu^+ \mu^-$)
  - see talk by R. Jesik

Excellent Prospects for Improvements at CDF and DØ !

Backup Slides

CKM Matrix

Quark Weak ≠ Mass Eigenstates

⇒ CKM Mixing Matrix

- 3 angles
- 1 complex phase ⇒ CP-violation
- Obs. CPV requires $m(q_i) \neq m(q_j)$

$$\text{Weak}\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix} \text{Mass}$$

CKM Matrix: *V*

Wolfenstein Parameterization

$$A = 0.825^{+0.011}_{-0.019}$$

$$\lambda = 0.2262^{+0.0010}_{-0.0010}$$

$$\bar{\rho} = 0.207^{0.036}_{-0.043}$$

$$\bar{\eta} = 0.340^{+0.023}_{-0.023}$$

CKMFitter Group: summer 2005

$$\begin{pmatrix} 1-\frac{1}{2}\lambda^2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\frac{1}{2}\lambda^2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

very different hierarchy than Lepton Mixing Matrix

Strength of CPV

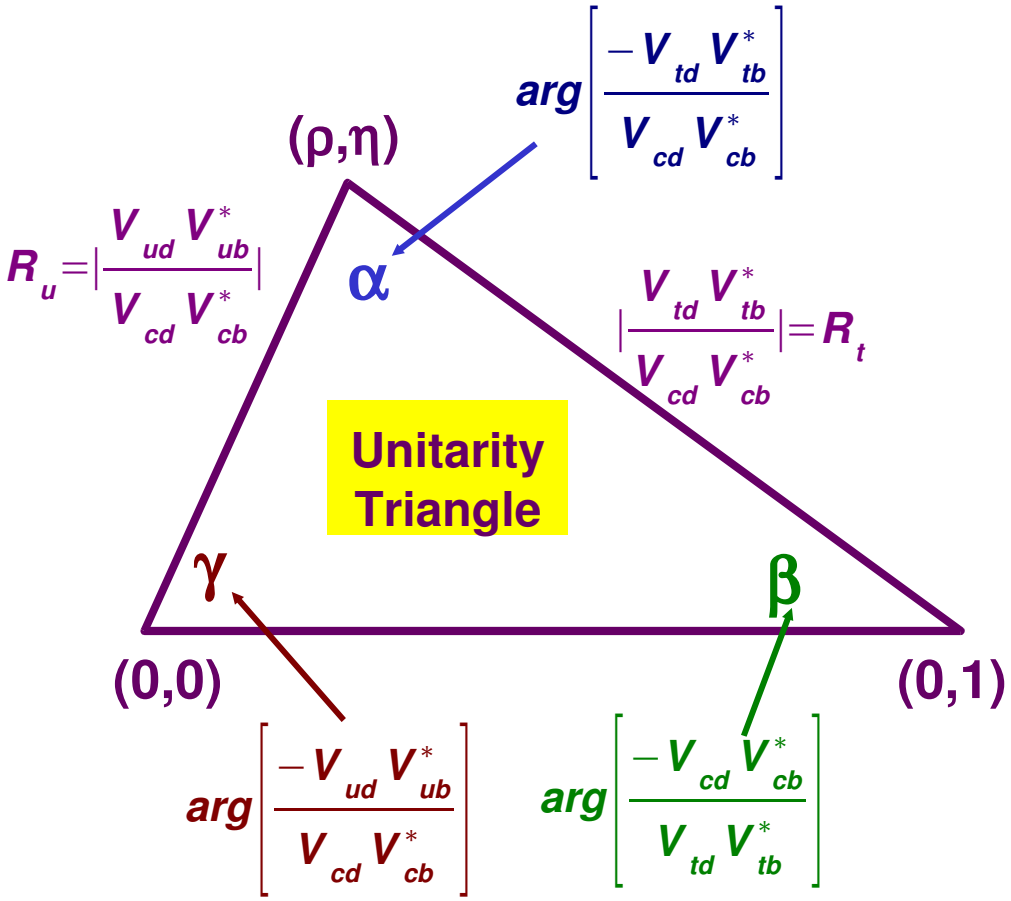
- $J = A^2\lambda^6\,\eta \sim (7\times10^{-5})\,\eta$

The Beautiful Triangle

Unitarity of $V_{CKM} \Rightarrow$ 6 triangles

- one has all sides ~ equal

$$V_{ub}V_{ud}^{*}+V_{cb}V_{cd}^{*}+V_{tb}V_{td}^{*}=0$$



Angles

- α — CPV in $B^0 \to \pi\pi,\rho\rho,\rho\pi$
- β — CPV in $B^0 \to J/\psi\ K^0,\eta,\eta'$
  CPV in $B^0 \to \phi,\eta,\eta'\ K^0$
- γ — CPV in $B^{\pm} \to D^0\ K^{\pm}$
  CPV in $B^0 \to D^{(*)+}\pi^-$

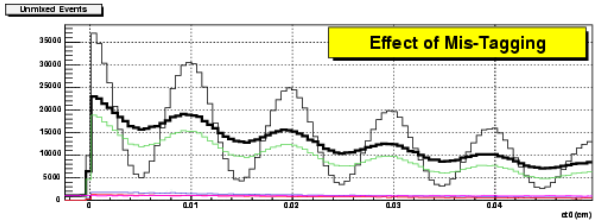
Sides

- R_u — B.R.($B \to X_{c,u}\ l\nu$)
- R_t — B_d Mixing
  $b \to u\ \gamma$

Other

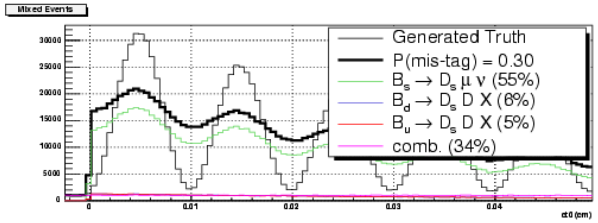
- ρ,η — CPV in K^0 system
  $K^+ \to \pi^+\ \nu\ \nu$
- η — $K^0 \to \pi^0\ \nu\ \nu$
- N.P. $B_{d,s} \to \mu^+\mu^-$, $\mu^+\mu^-\ X_{d,s}$

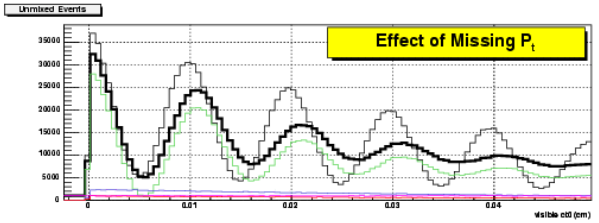
Resolution Effects



Mis-Tagging

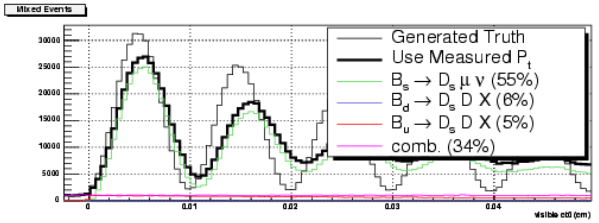
- reduces ampl

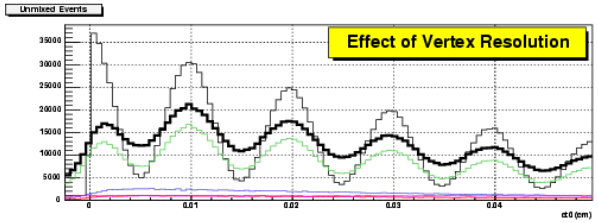




Missing Particles

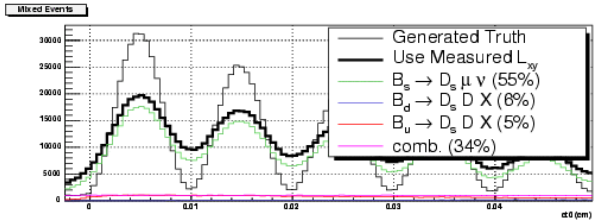
- affects large *ct*



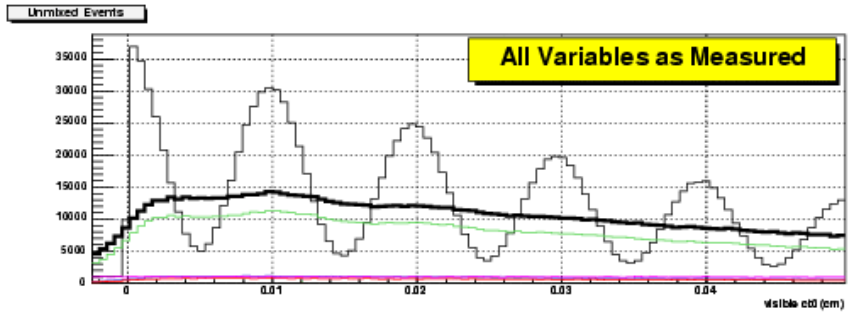


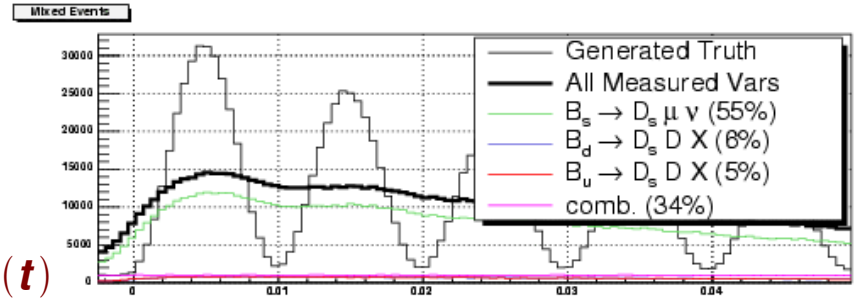
Vertex Res

- affects small *ct*

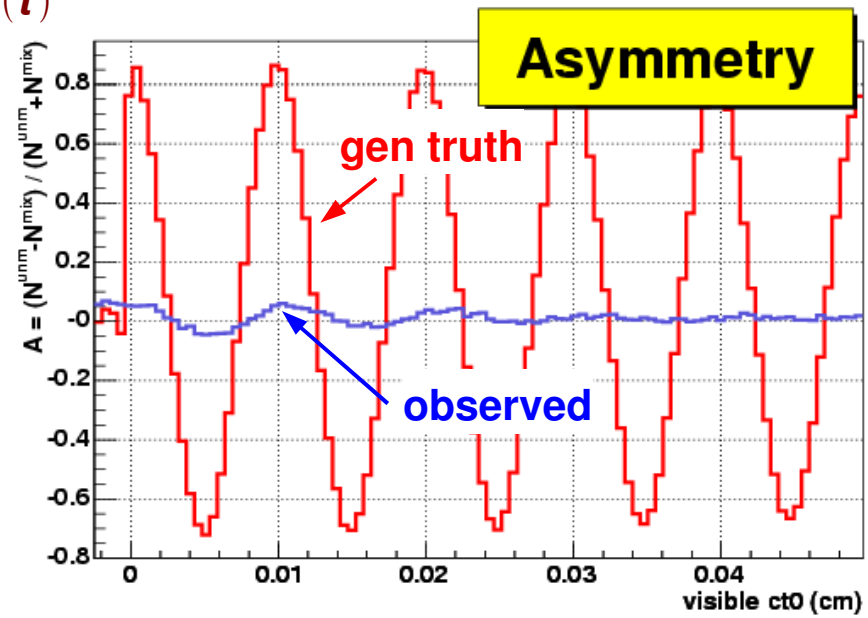


$$A(t) = \frac{N^{unm}(t) - N^{mix}(t)}{N^{unm}(t) + N^{mix}(t)}$$

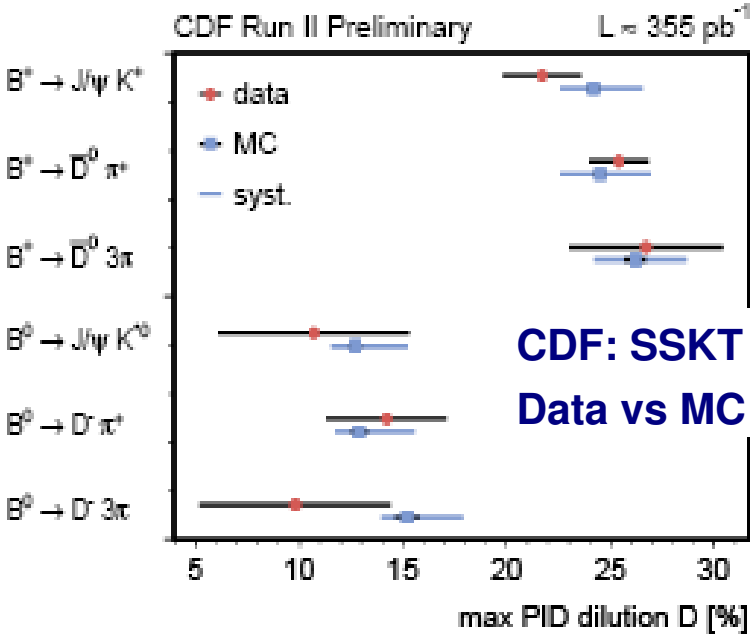




visible *ct*



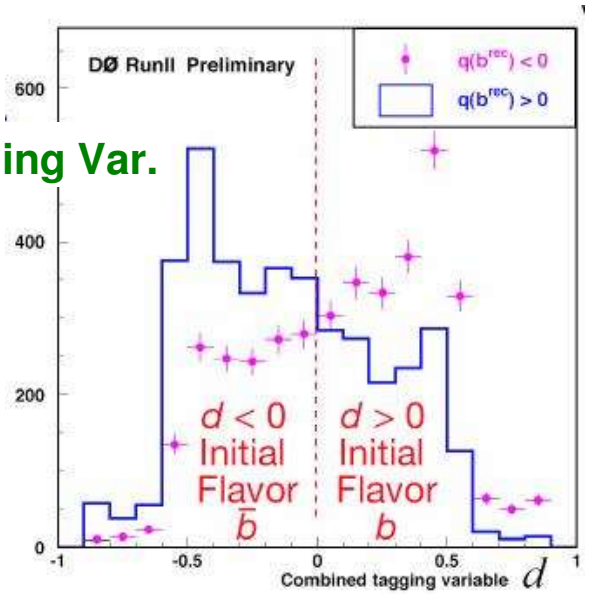
Tagging Performance

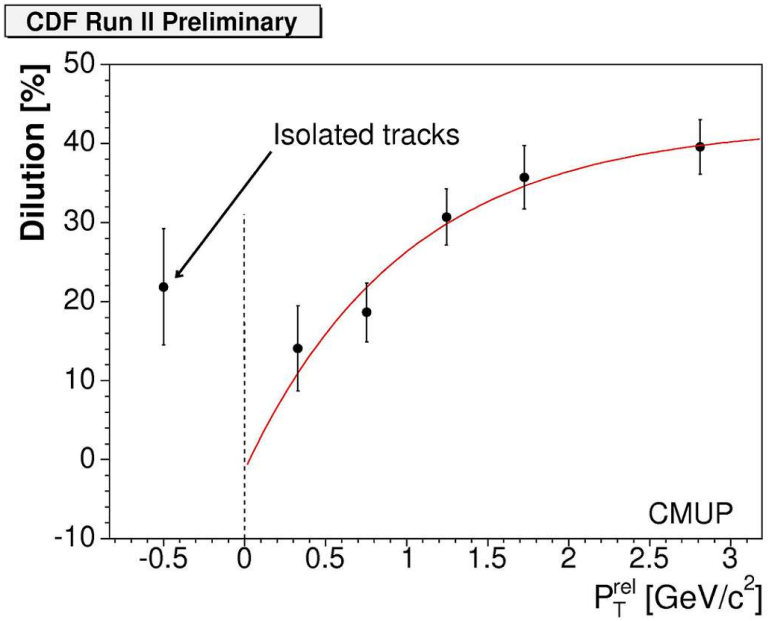


CDF: SSKT Calib

Data vs MC

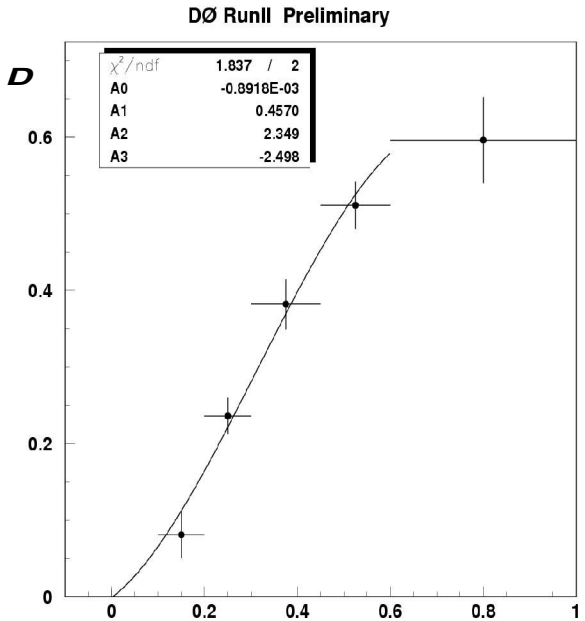
DØ: Tagging Var.





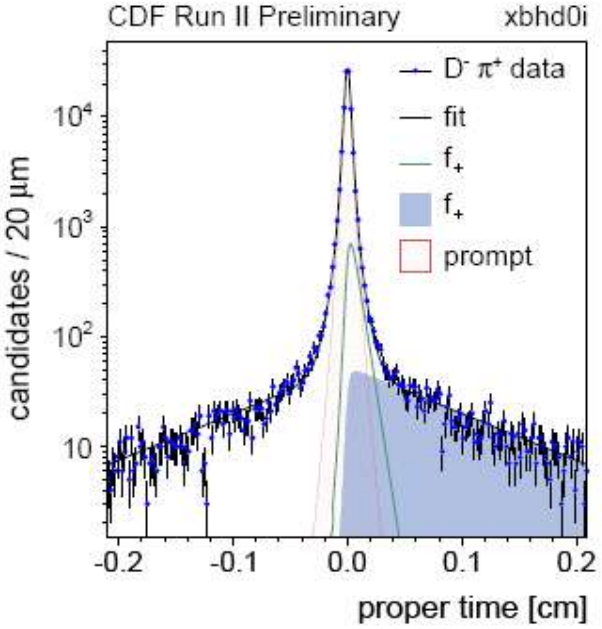
Event-by-Event

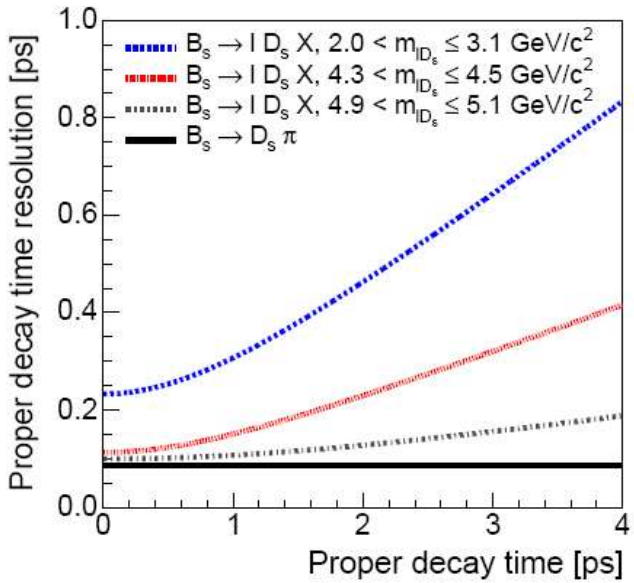
Dilution Estimate



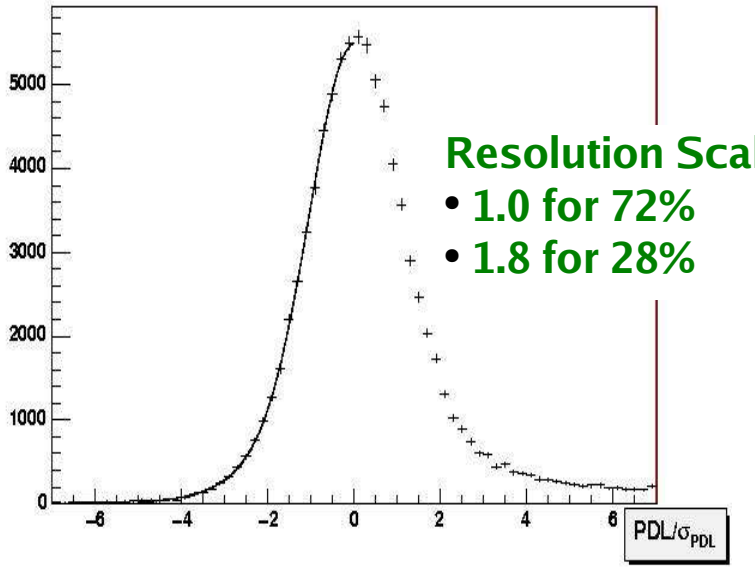
Resolution

CDF: D_s + prompt track



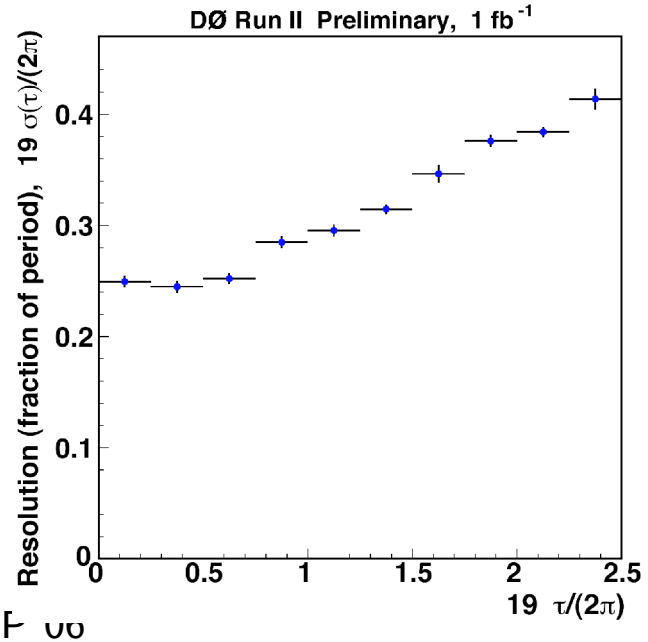


DØ: Impact Parameter in $J/\psi \rightarrow \mu^+\mu^-$

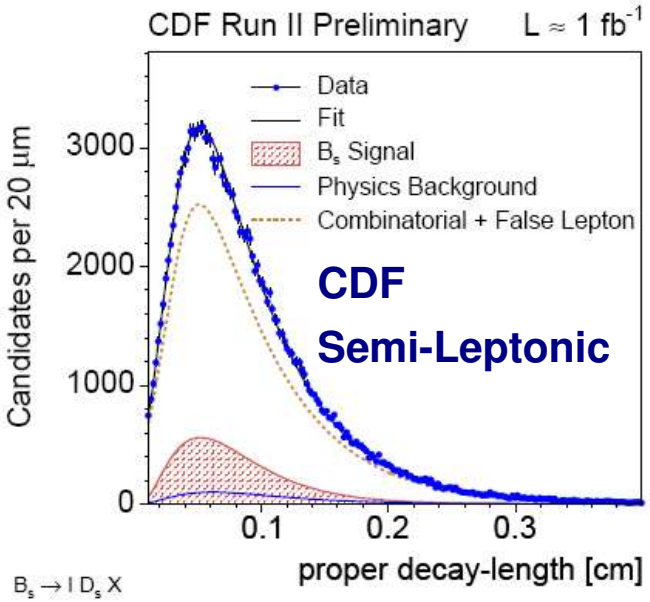


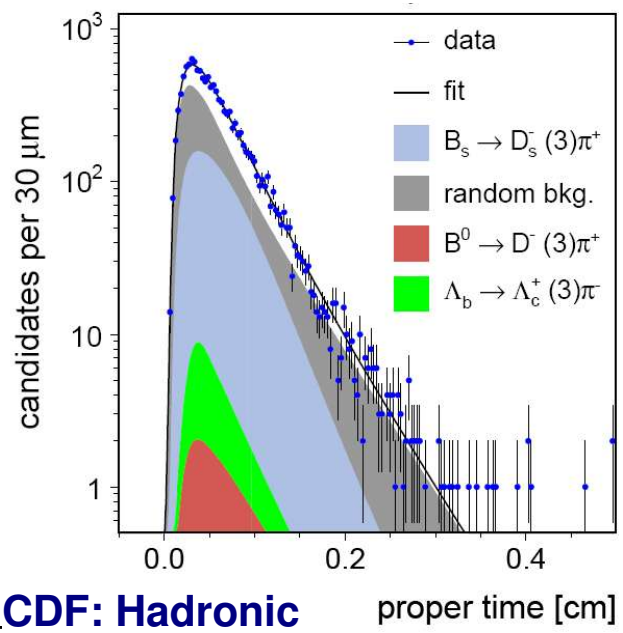
Resolution Scale Factor

- 1.0 for 72%
- 1.8 for 28%



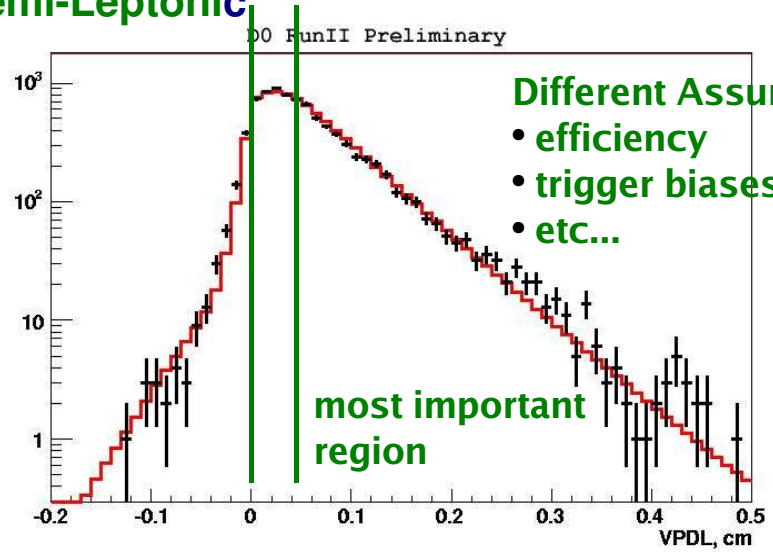
Lifetimes





CDF: Hadronic

DØ: Semi-Leptonic



Mode	CDF	D0	W.A.
$B_s \to l D_s X$	1.480 ± 0.030	1.37 ± 0.03	1.454 ± 0.040
$B_s \to D_s \pi(\pi\pi)$	1.538 ± 0.040		1.454 ± 0.040
$B_d \to D^- \pi^+$	1.508 ± 0.017		1.527 ± 0.008
$B^- \to D^0 \pi^-$	1.638 ± 0.017		1.643 ± 0.010

Likelihood (DØ example)

Use Likelihood Method: Minimize –ln *L*: $L = \prod_{i=evts} \left[F_{sig} f_{i,sig}(\vec{x}_i;\vec{p}) + (1 - F_{sig}) f_{i,bgd}(\vec{x}_i;\vec{p}) \right]$

Prob Density Func's (src = a): $f_i = P_a^{tag}(X^M|\sigma_X, D, M_{\phi\pi};\vec{p}) P_a(\sigma_X) P_a(D) P_a(M_{\phi\pi}) P_a(y)$

"physics" functions — derived from data

Event Observables: $\vec{x} = X^M, \sigma_X, tag, D, M_{\phi\pi}, y\,(signal/bgrd\ discrim)$

Parameters: $\vec{p} = \Delta m_s, \tau_s, \Delta m_d, \tau_d, eff.\,param's, res.\,param's, \ldots$

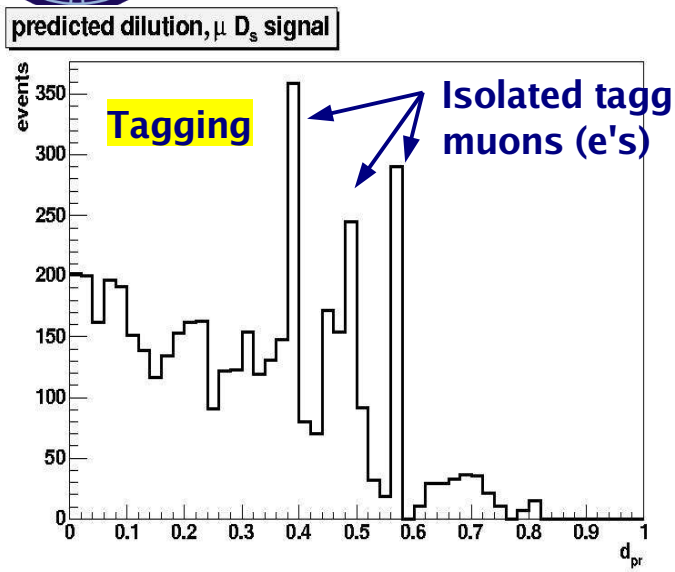
$$P_{sig}^{tag}(X^M|\sigma_X, D, M_{\phi\pi};\vec{p}) = \frac{\epsilon(X^M)}{N_\epsilon} \int_0^\infty dX\, R(X - X^M; s\sigma_X)\ p^{tag}(X)$$

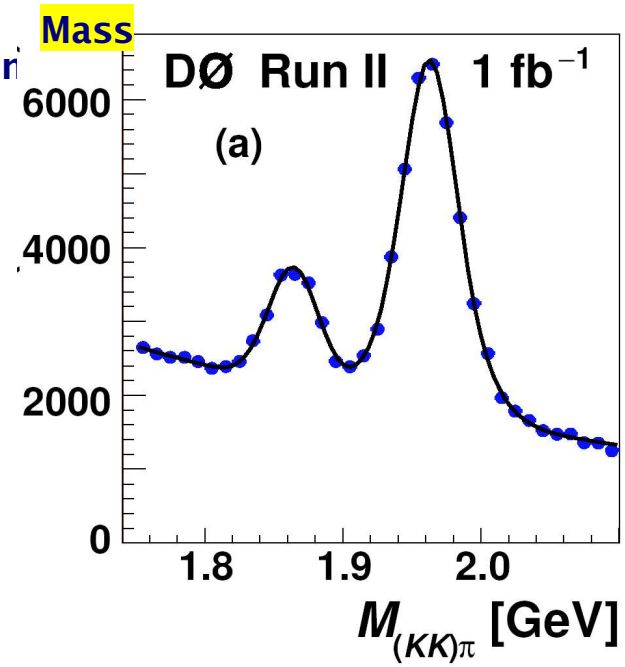
efficiency — resolution function convolution — oscillation function

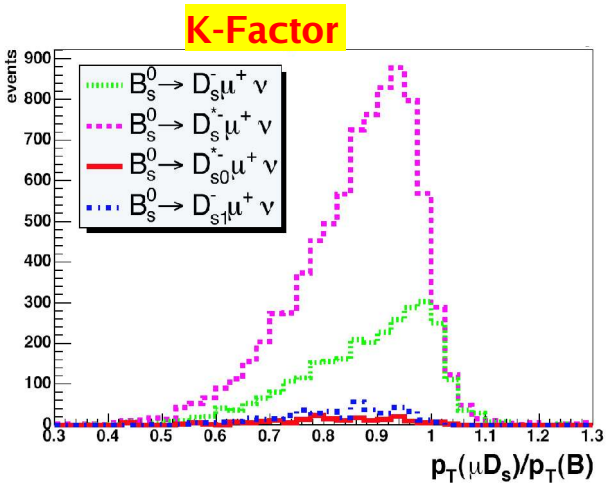
$$p^{unm/mix}(X) = \int dK\, P_{sig}(K)\ \frac{K(M_{\phi\pi})}{c\tau_s} \exp\left(\frac{-KX}{c\tau_s}\right)\ \frac{1}{2}\left[1 \pm D\cos\left(\frac{\Delta m_s \cdot KX}{c}\right) A\right]$$

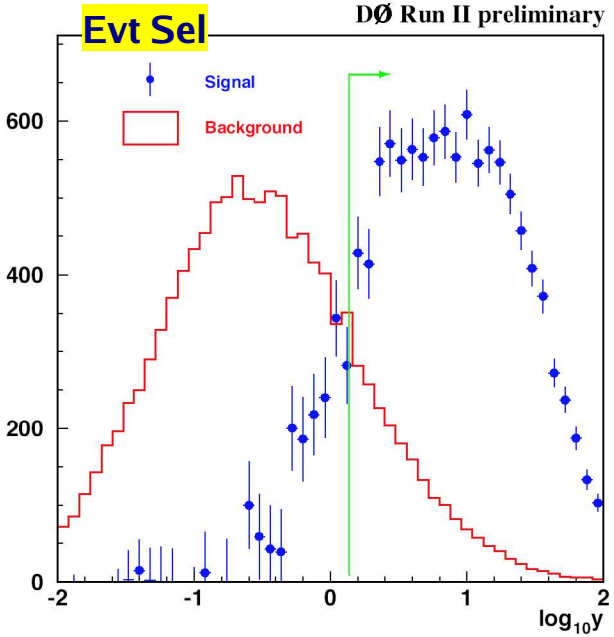
K-Factor convolution — K-Factor vs M from MC

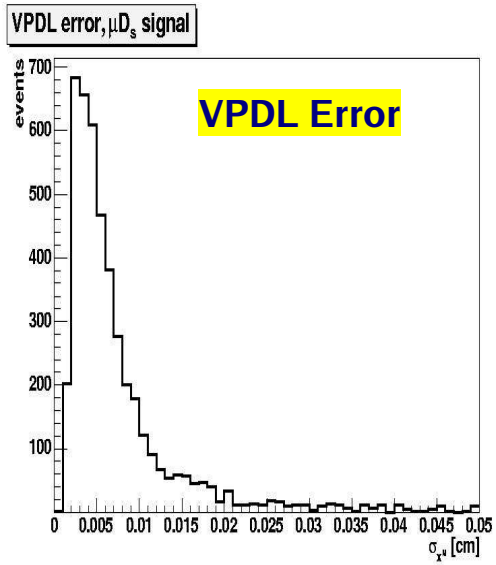
Signal PDFs (DØ)

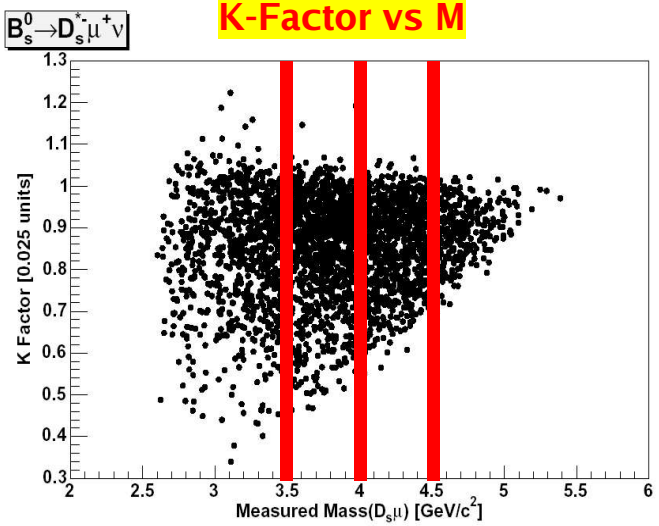






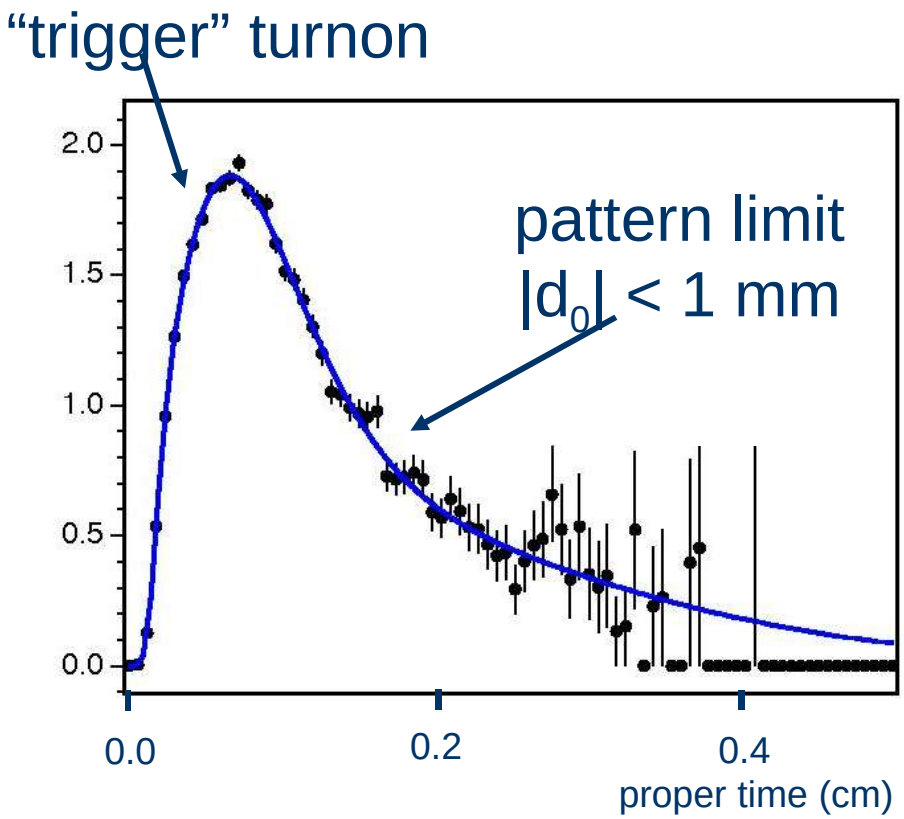




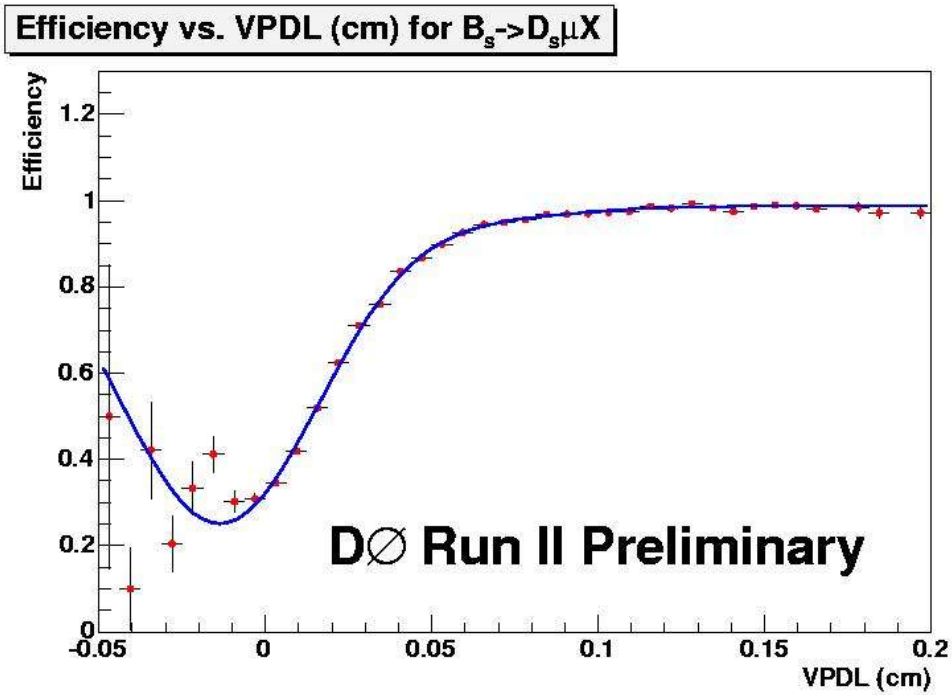


Efficiency vs Proper Time

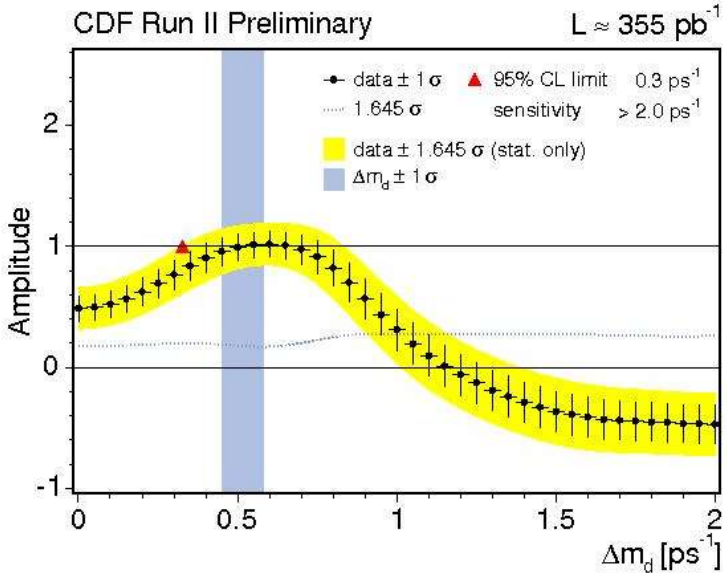
CDF Hadronic Efficiency



DØ Semi-Leptonic Efficiency

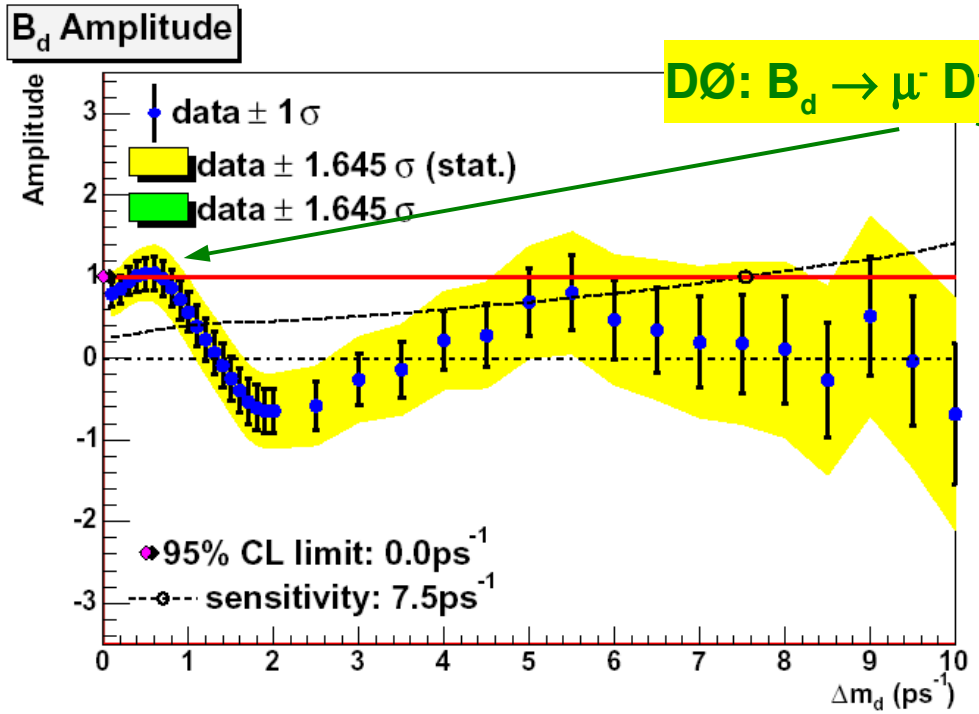


Cross-Check w/ B_d Mixing

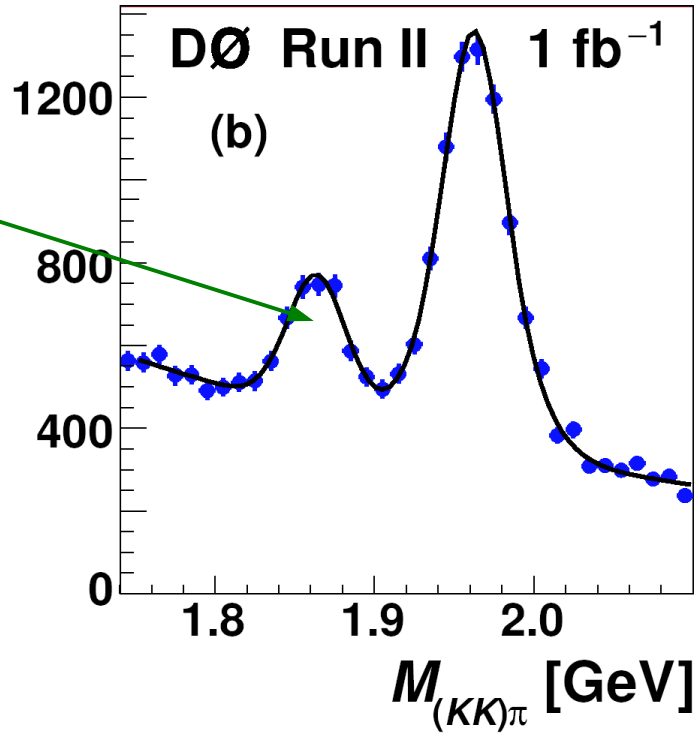


CDF B_d Amplitude Fit

- **Hadronic Modes**

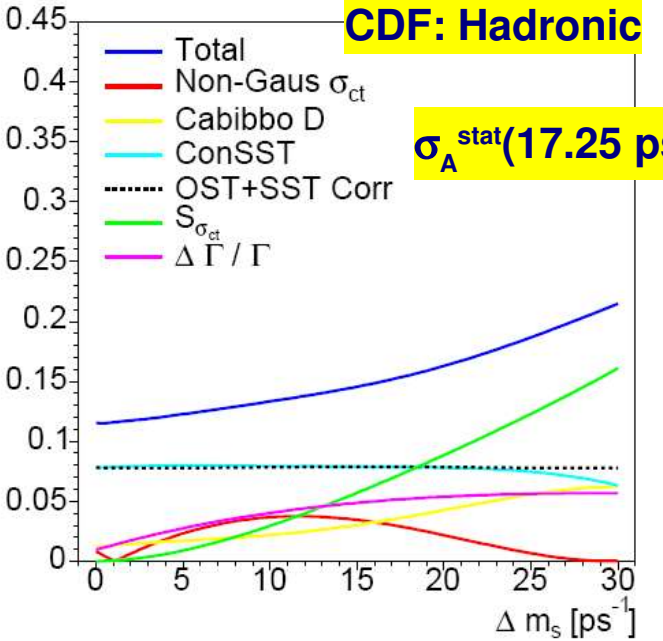


DØ: $B_d \rightarrow \mu^- D^+(\phi\pi)$ X



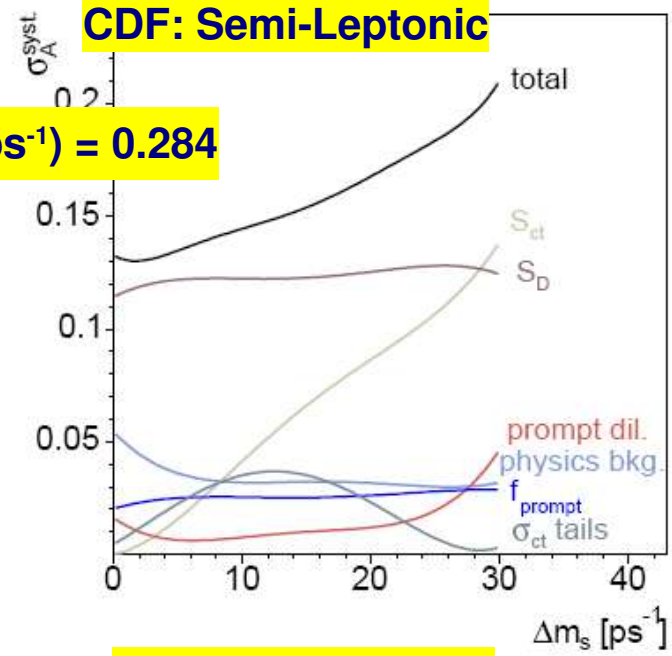
Mixing Systematics (σ_A^{syst})

CDF: Hadronic



$\sigma_A^{stat}(17.25\ ps^{-1}) = 0.284$

CDF: Semi-Leptonic

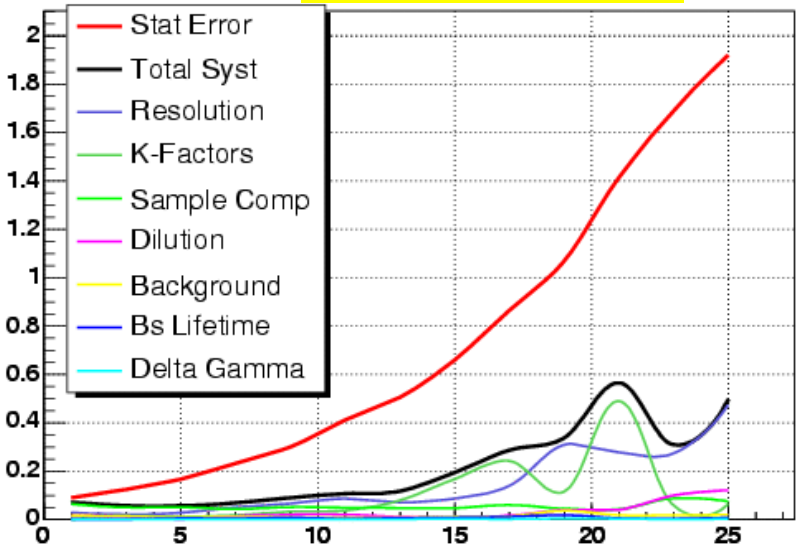


CDF: Syst's on Δm_s Meas

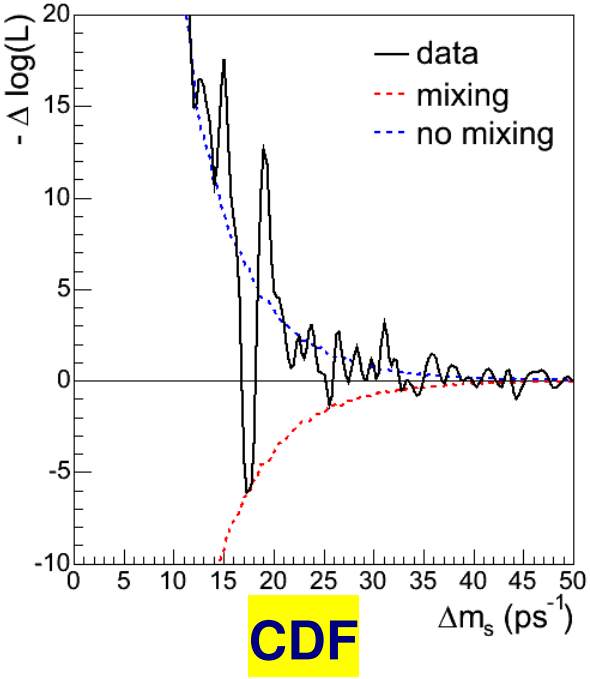
Source	Syst (ps^{-1})
SVX Align	0.04
Track Fit Bias	0.05
PV Bias (tagging)	0.02
Other	< 0.01
Total	0.07

σ(A) vs Δ m_s

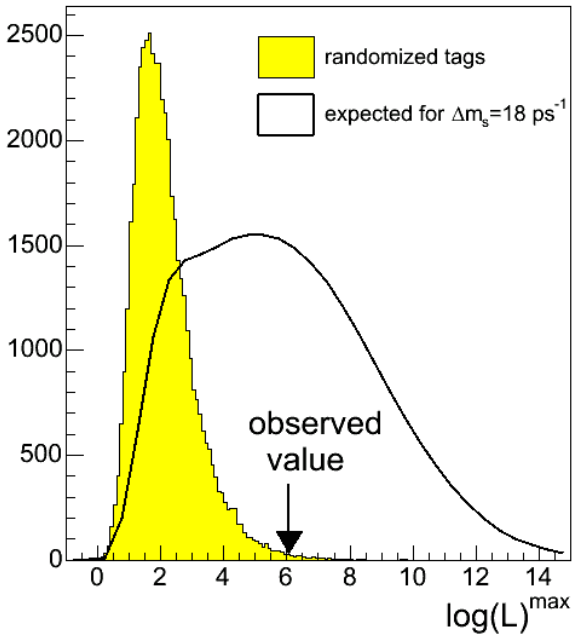
DØ: Semi-Leptonic

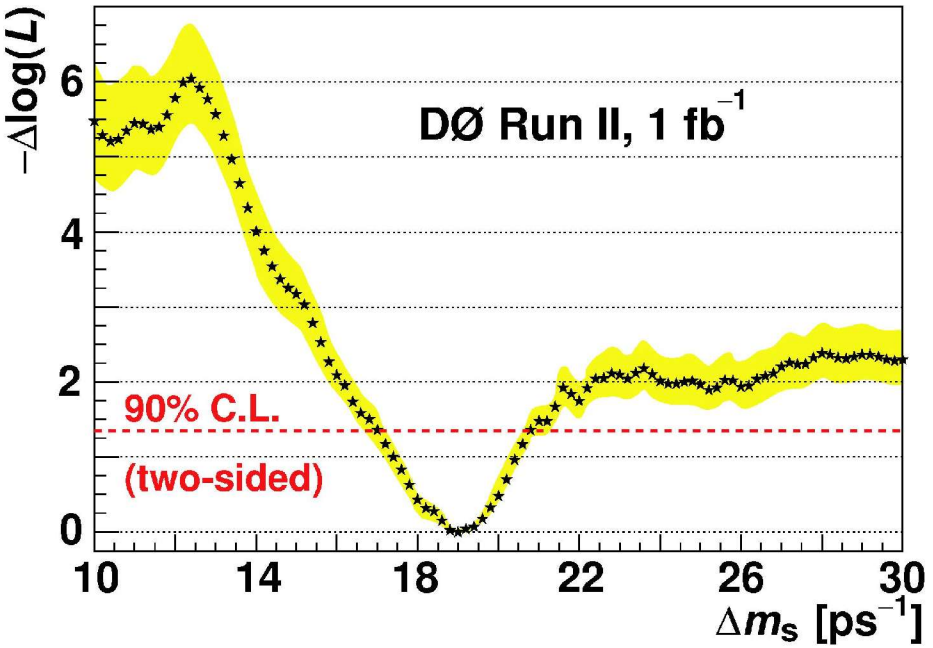


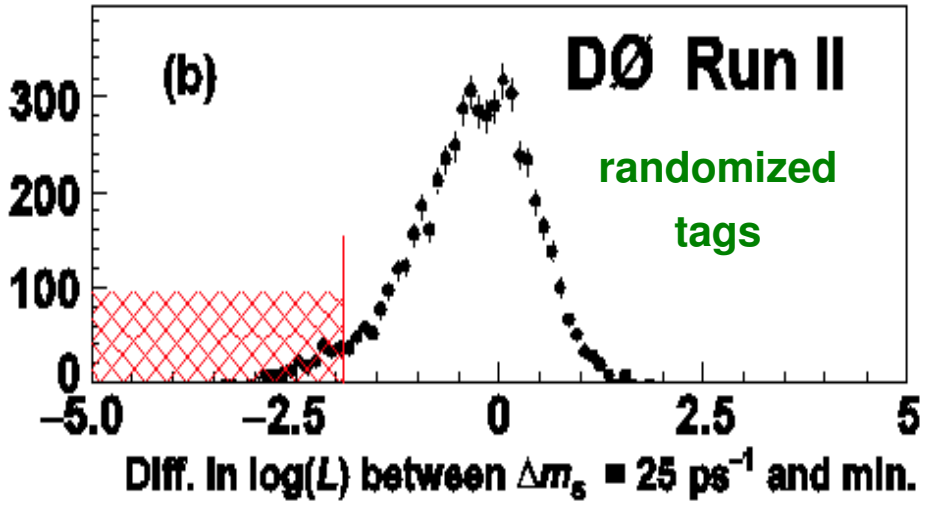
Mixing Likelihoods and Signif



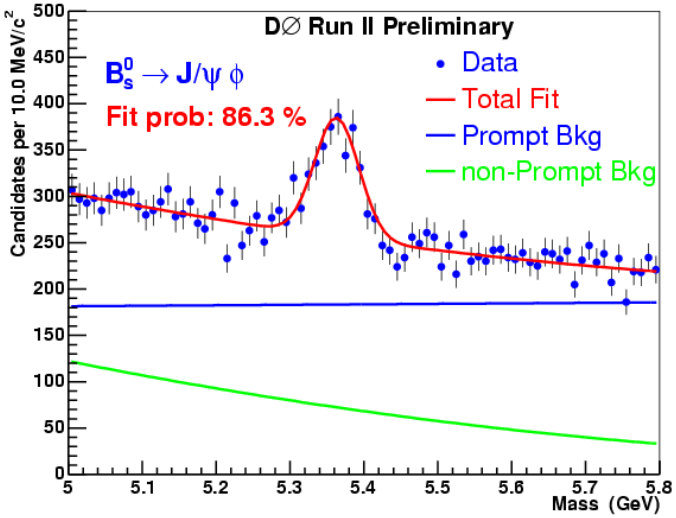
CDF

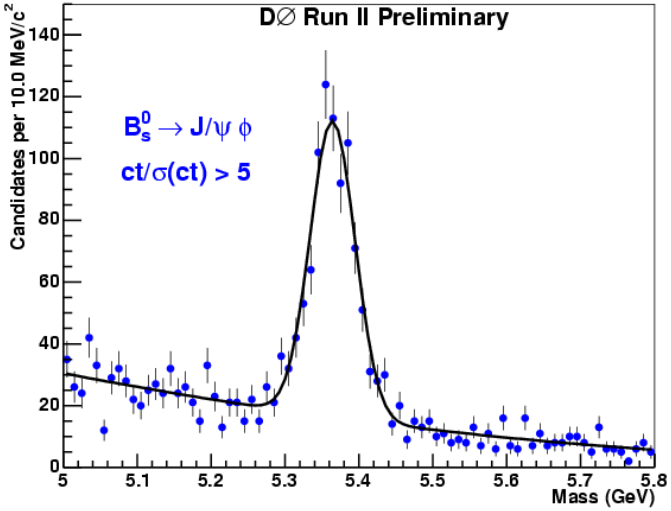


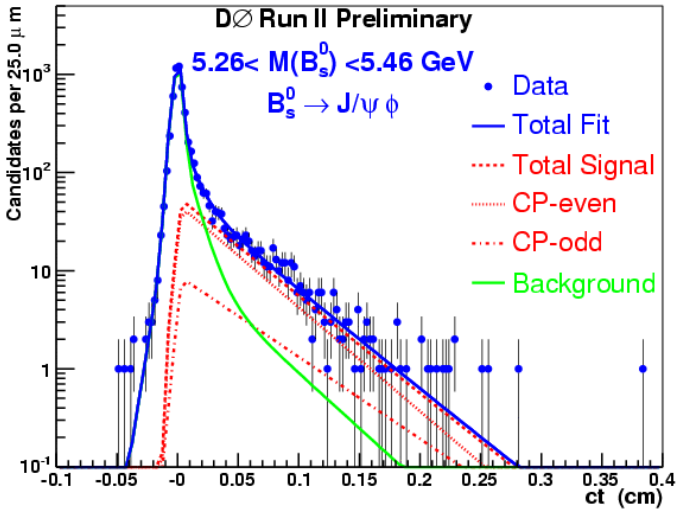


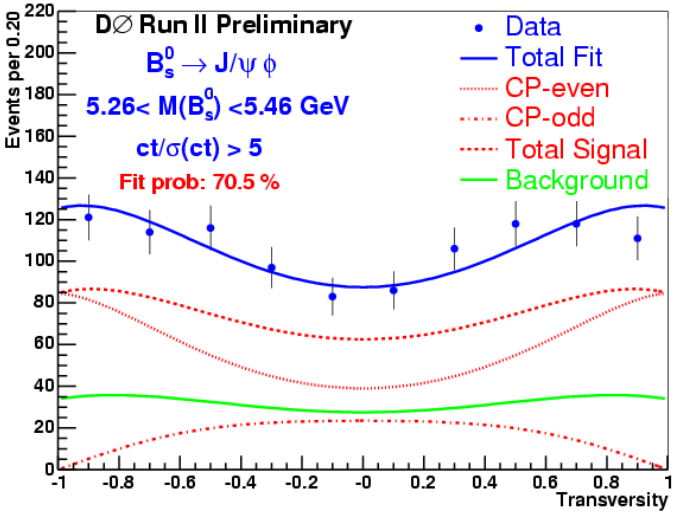


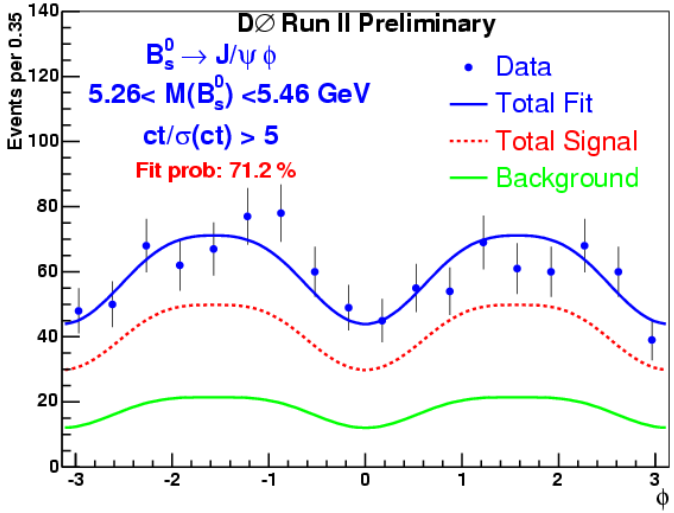
$B_s \rightarrow J/\psi\,\phi$ Fit Var Distributions

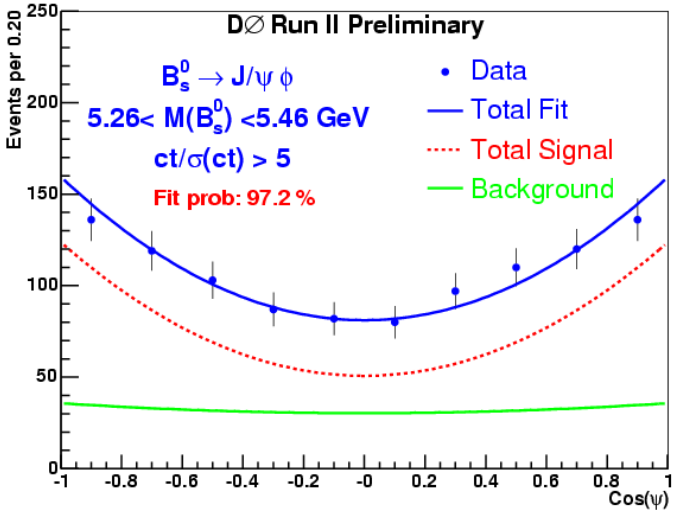












$B_s \rightarrow J/\psi\,\phi$ Systematics

Source	$c\tau(B_s^0)$ μm	$\Delta\Gamma$ ps^{-1}	$R_\perp$	$\lvert A_0(0)\rvert^2 - \lvert A_\parallel(0)\rvert^2$	$\delta_\perp$
Acceptance vs. θ,φ, ψ	± 0.5	± 0.001	± 0.003	± 0.01	± 0.02
Procedure test	± 2.0	± 0.025	± 0.01	–	–
Event processing	-8.0	0.00	-0.01	–	–
Detector alignment	± 2.0	–	–	–	–
ct definition	1.3	0.001	-0.001	-0.002	-0.009
"Outlier"	-7.5	-0.03	0.01	0.0	0.0
Total	$-11.3, +3.2$	$-0.04, +0.03$	± 0.01	± 0.01	± 0.02

$B_s \rightarrow K^+ K^-$ Fit Variables