B_s Physics at CDF & DØ

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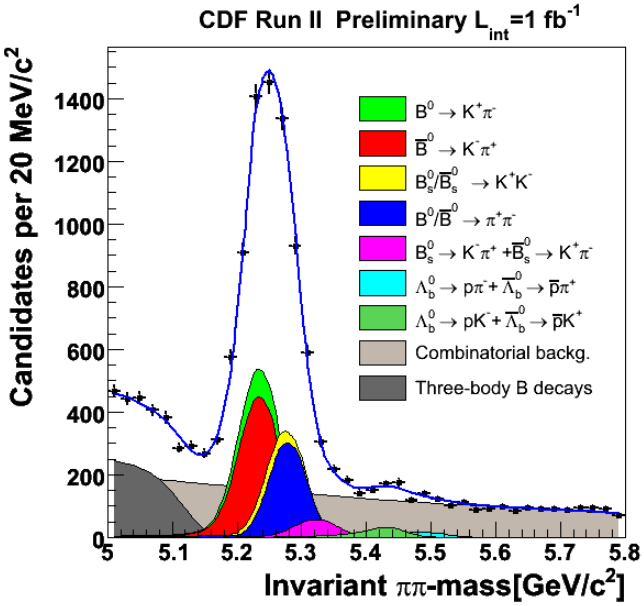
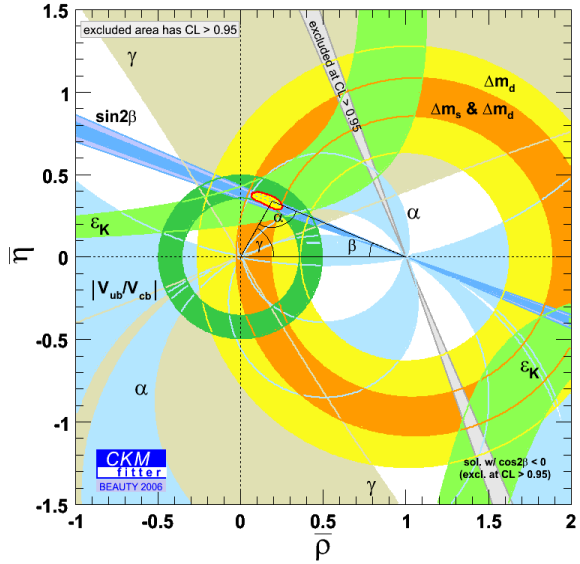
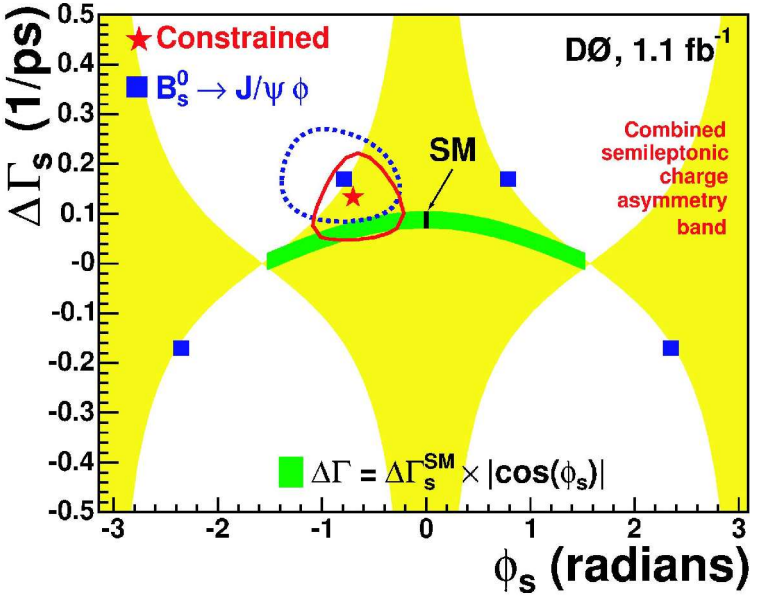
(for the CDF & DØ collaborations)

XXI Rencontres de Physique de la Vallée d'Aoste: 6-10 March, 2007







What You're In For

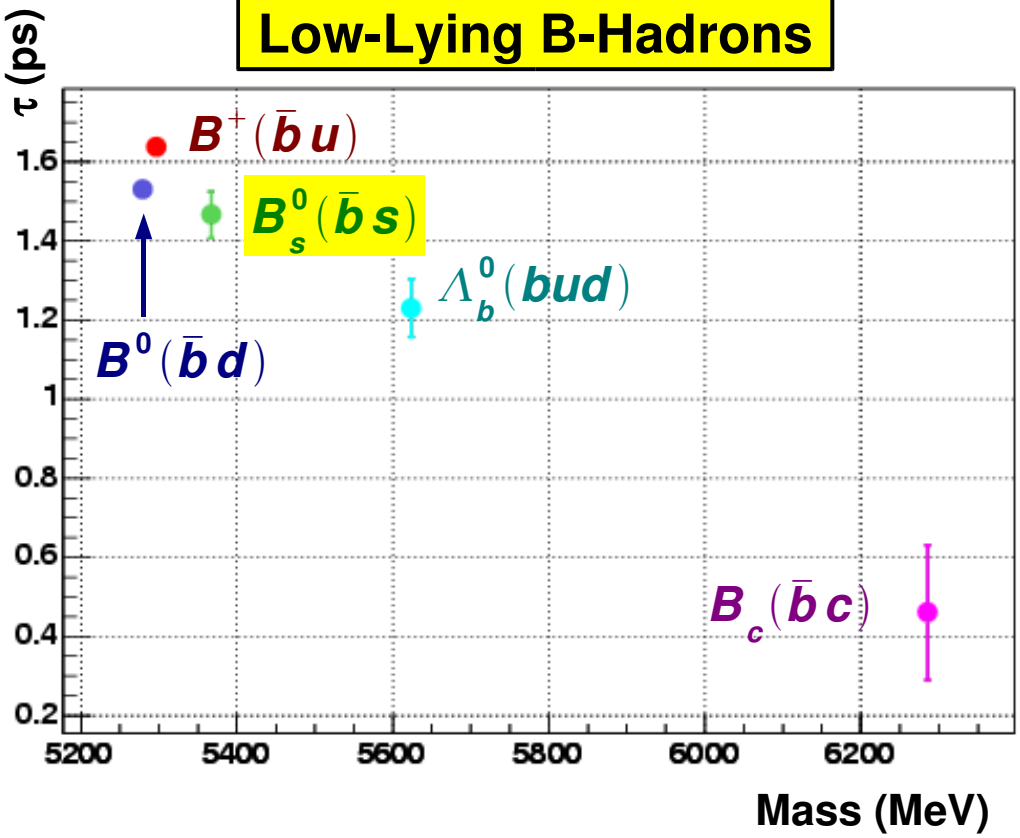
1) 36 B_s-specific results from the Tevatron since 2005 !
   - cannot possibly cover them all in detail
   - and (even worse) will ignore all other B-hadrons
   - also will not cover recent CLEO and Belle Y(5S) results

2) Concentrate on the Breadth of B_s Physics
   - B_s properties and QCD Model Building
   - Direct Searches for Beyond SM effects
   - Indirect Searches: EW Symmetry breaking, CP Violation...

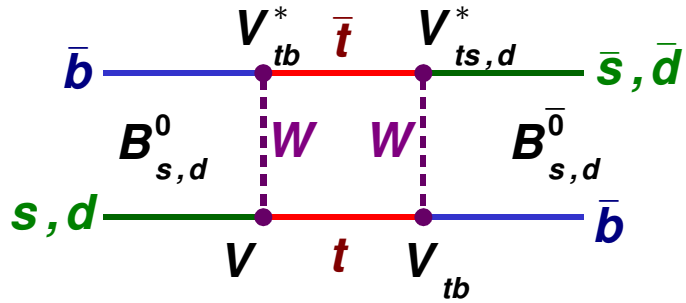
3) Outline: Progress on B_s Physics since the start of Run II
   - Why the B_s ?
   - Experimental Ingredients
   - Results
   - Future Prospects

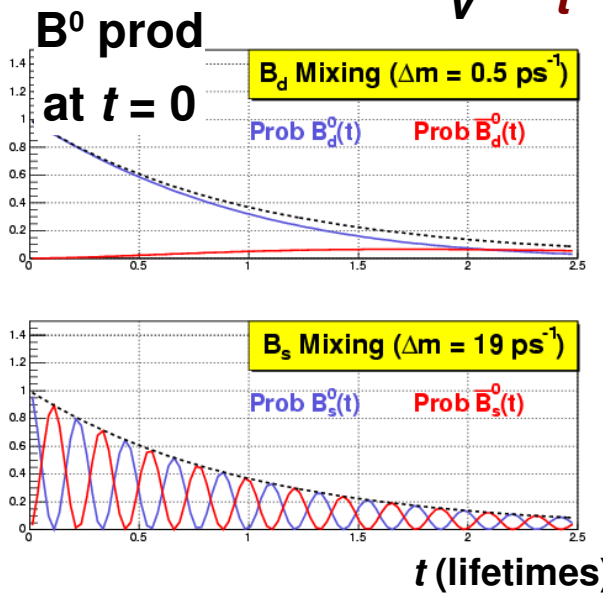
The B-Hadron Family

Low-Lying B-Hadrons



Neutral B-Hadrons Mix





Meson	Δm/m	ΔΓ/Γ
B_d	6.4×10^{-14}	< 0.01
B_s	2.2×10^{-12}	~0.12
K^0	7.0×10^{-15}	~1

The Useful B_s

QCD Modelling: compare & contrast with B_d

- SU(3) Flavor Symmetry, Heavy Quark Effective Theory
- Lattice ...

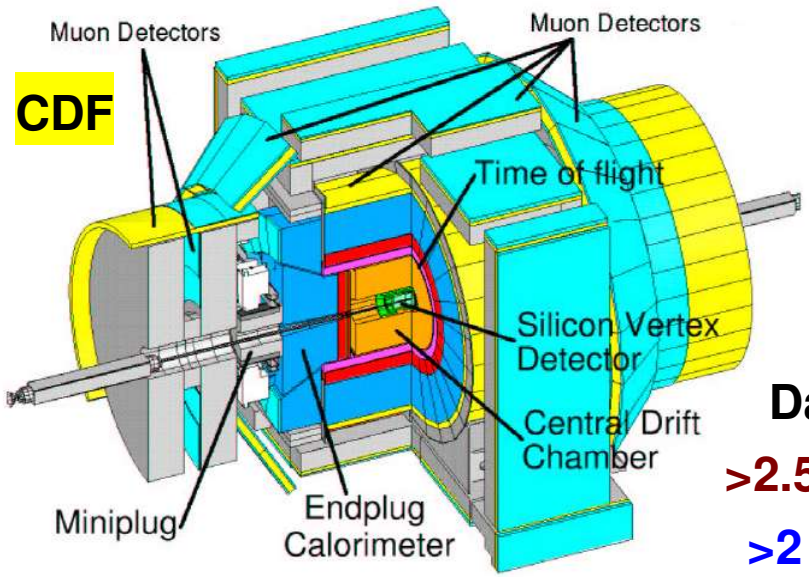
Direct Searches for Beyond the SM Effects

- Rare (Leptonic) Decays: many models predict large effects in B_s

Electro-Weak Symmetry Breaking

- In SM: EW Sym. Breaking ⇔ Flavor Struct. (CKM matrix, CPV)
- 1 SM Higgs Doublet ⇒ Strong Flavor Constraints
  - FCNCs suppressed — Unitary V_{ckm}
  - 1 param for all CPV — No CPV in flavor diag. processes
- Other Models much Less Constrained
  - *e.g.* 43 (!) CPV parameters in MSSM
  - different relationships b/w observables from different families

B_s at CDF and DØ

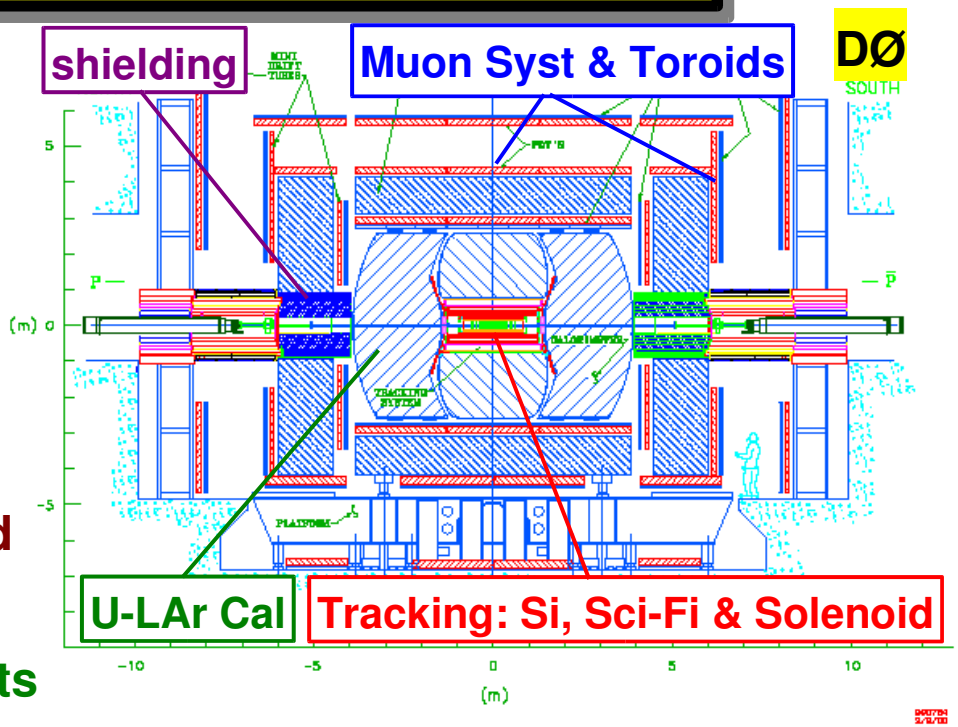


Data Samples

>2.5 fb^{-1} delivered

>2 fb^{-1} recorded

up to 1.3 fb^{-1} results



Production	LEP	B-Factories	Tevatron	LHCb
	E_{CM}=91 GeV	Υ(5S)	(in accept)	(in accept)
Approx B_s Rate	0.04 Hz	1 Hz	600 Hz	5000 Hz

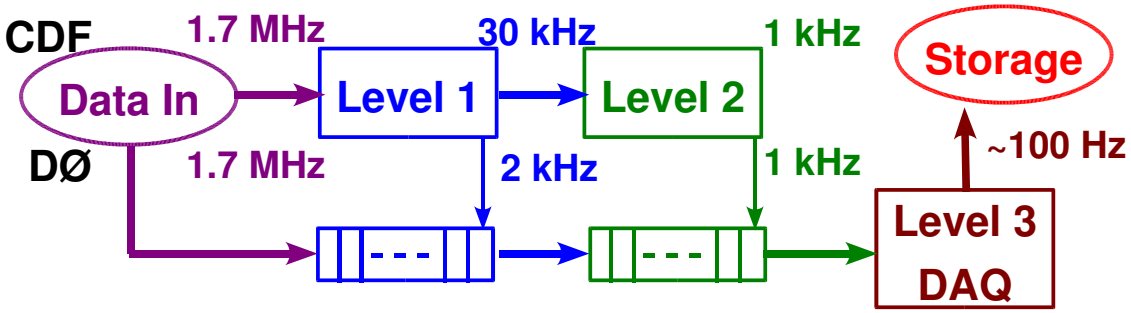
Important at the Tevatron

- **Triggering**
- **Muons**
- **Tracking/Vertexing**
- ***(π / K Separation)***

Decay Mode	B.R.
$B_s \to D^-_s X$	94%
$B_s \to D^-_s l^+ \nu X$	7.9%
$B_s \to J/\psi(\mu^+\mu^-)\ \phi(K^+K^-)$	2.7×10^{-5}
$D^+_s \to \phi(K^+K^-)\ \pi^+$	2.2%
$D^+_s \to K^{*0}(K^-\pi^+)\ K^+$	2.5%
$D^+_s \to \pi^+\ \pi^-\ \pi^+$	1.2%

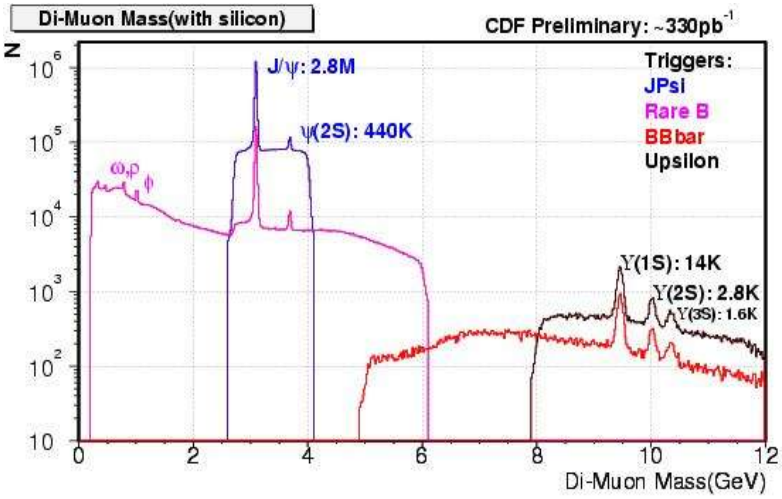
Triggering & Muons

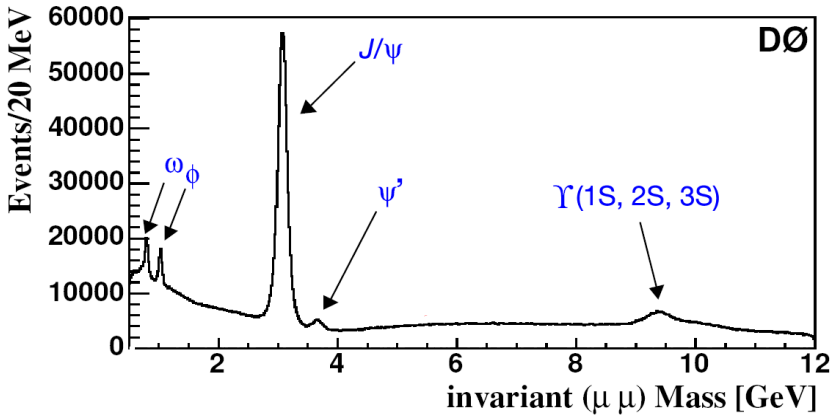
3 Level Trigger Systems



Muons	Coverage	Shielding
DØ	$\|\eta\| < 2.0$	12-18 λ_I
CDF	$\|\eta\| < 1.0$	>5 λ_I

Trigger	CDF	DØ
2-Track	P_T(trk)>2.0 GeV $0.12<d_0<1$ mm ΣP_T>5.5 GeV	—
l + Displ Trk	P_t^l>4, P_t^{trk}>2 GeV $0.12<d_0<1$ mm	—
1-Muon	—	P_T>3,4,5 GeV or P_T>5 GeV & $d_0/\sigma(d_0)$>3 (luminosity dependent)
2-Muon	P_T(μ's)>1.5 GeV	P_T(μ's)>2.0 GeV



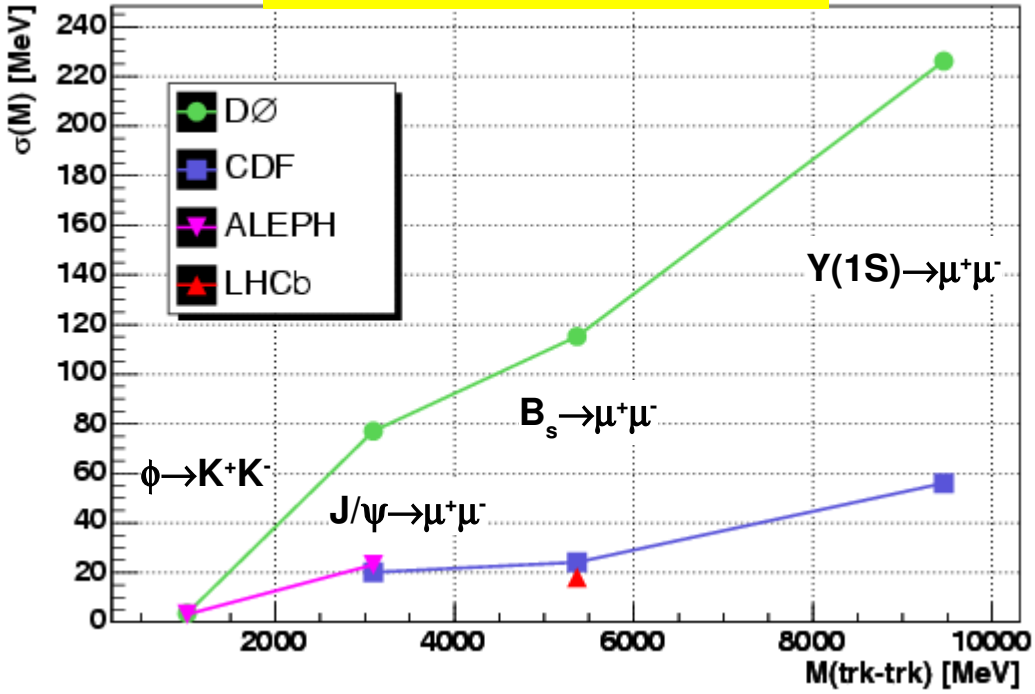


Tracking & Vertexing

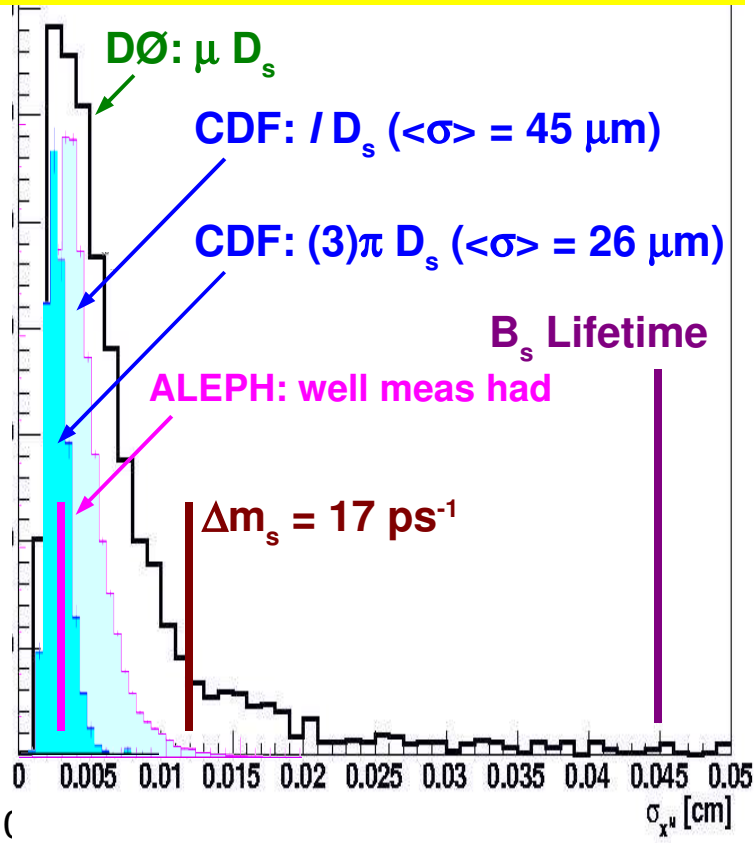
Exp	B	Radii [cm]	$\|\eta\|$ Range	<Space Pts>
CDF	1.4 T	1.5 – 137	< 2.0	>100
D0	2.0 T	2.8 – 52	< 3.0	20

1.7 w/ Layer 0 ⟶ 25% gain in proper time resolution

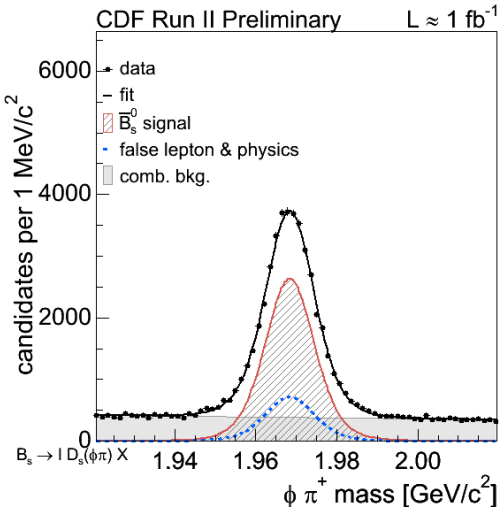
2-Track Mass Resolution

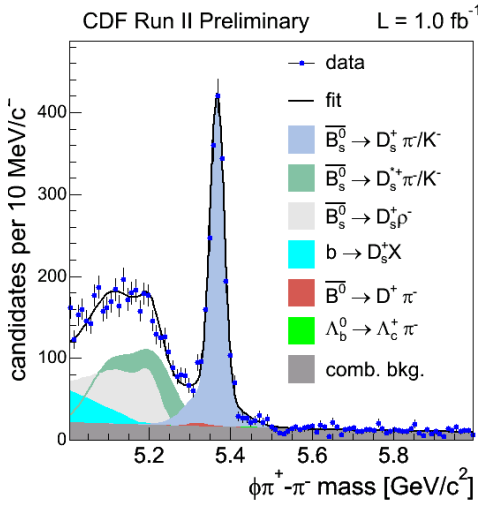


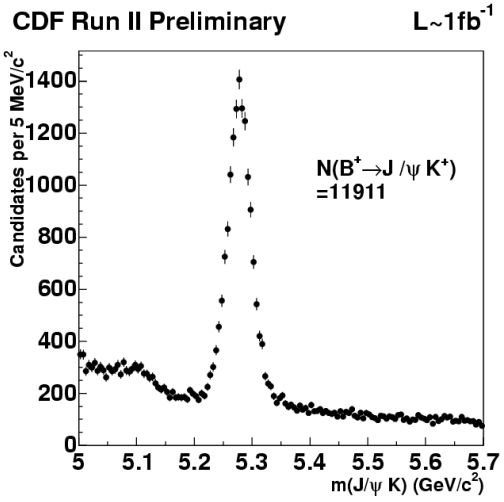
(pseudo) Proper Time Resolution

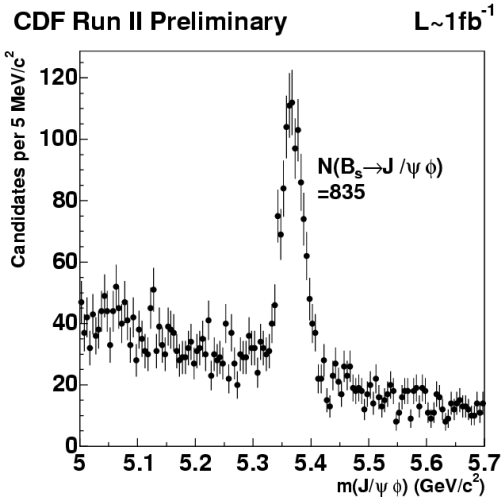


Re-Usable Components









l^+ $D_s^-(\phi\pi, K^{*0}K^-, 3\pi^\pm)$

- **mixing**
- **BRs, CPV**

π^+ $D_s^-(\phi\pi, K^{*0}K^-, 3\pi^\pm)$

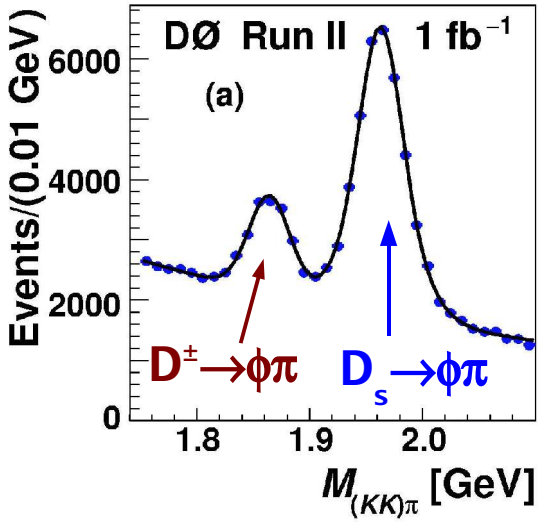
- **mixing**
- **BRs**

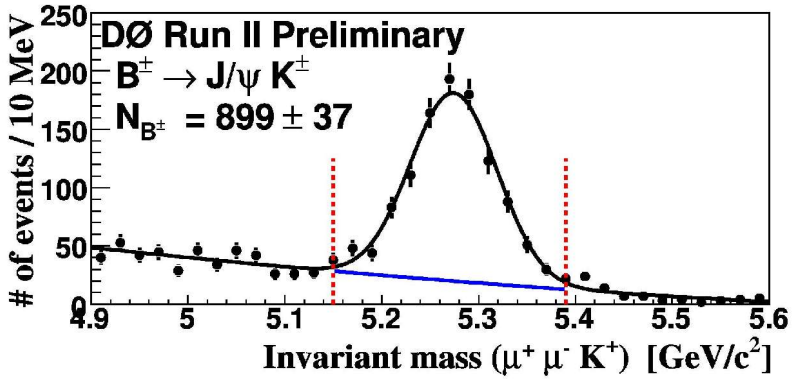
$B^+ \rightarrow J/\psi(\mu^+\mu^-) K^+$

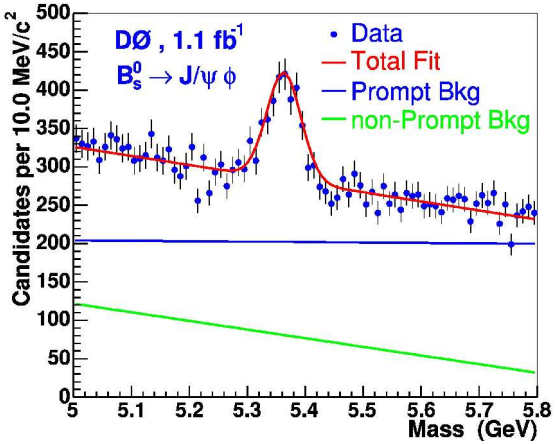
- **norm for rare decays**

$J/\psi(\mu^+\mu^-)\ \phi(K^+K^-)$

- **CPV & $\Delta\Gamma$**
- **norm for rare decays**





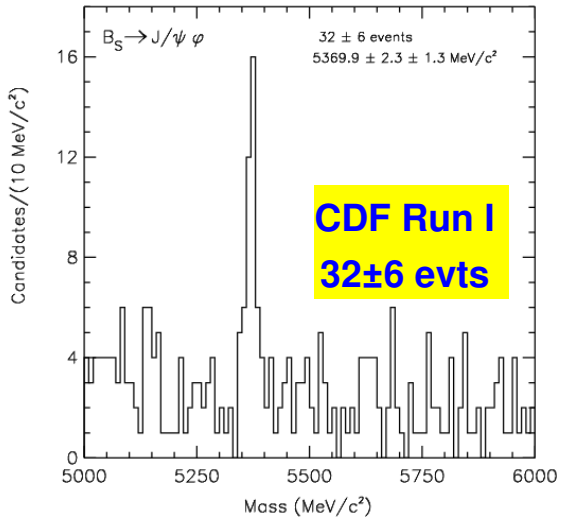


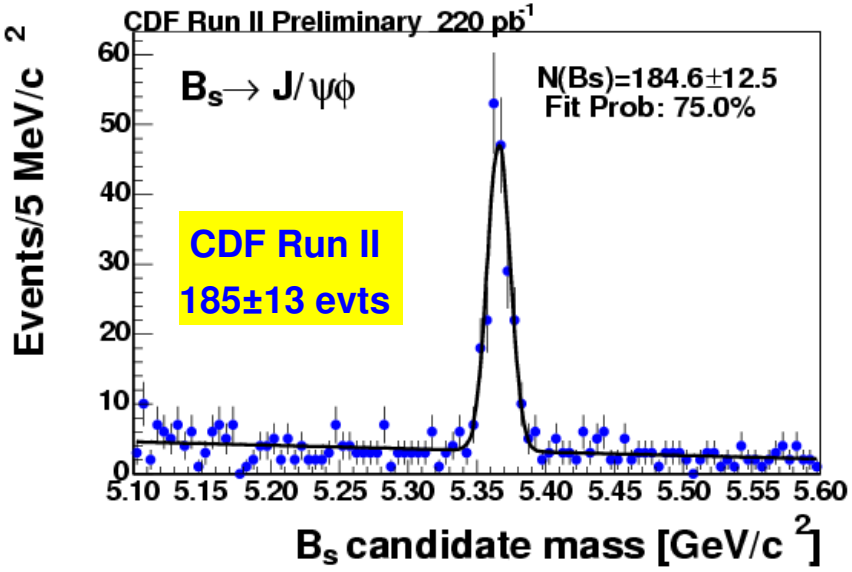
B_s Properties

Property	2002 PDG	New Result	
Prod. Frac. [%]	10.6 ± 1.3	10.4 ± 1.3	WA (HFAG)
		10.3 ± 0.9	LEP (HFAG)
		12.7 ± 3.8	CDF prelim [1]

from $B_s \to l^- D_s^+(\phi\pi)X$ in $360\,pb^{-1}$: $f_s/(f_u+f_d) = 0.160 \pm 0.005\,(\text{stat})^{+0.011}_{-0.010}\,(\text{syst})^{+0.057}_{-0.034}\,(\text{BR})$

Mass [MeV]	5369.6 ± 2.4	5366.01 ± 0.73 ± 0.33	CDF [2]

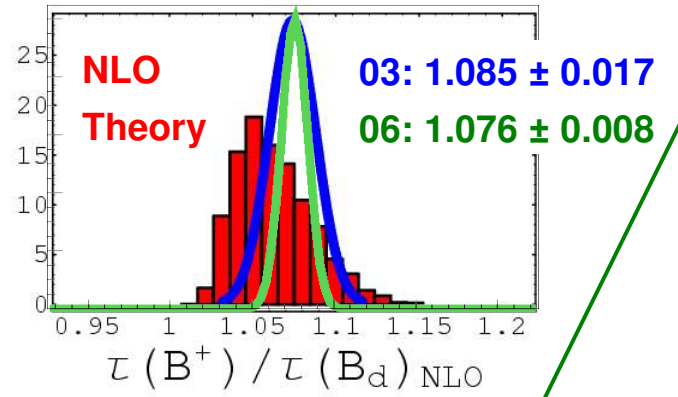


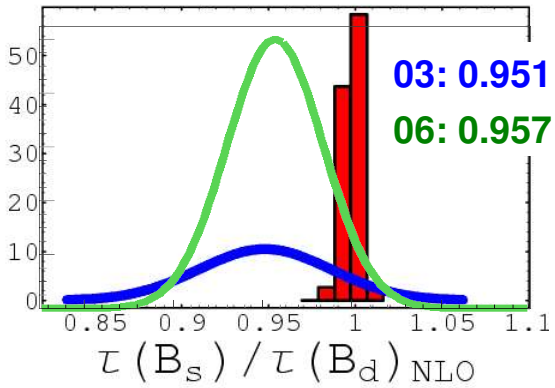


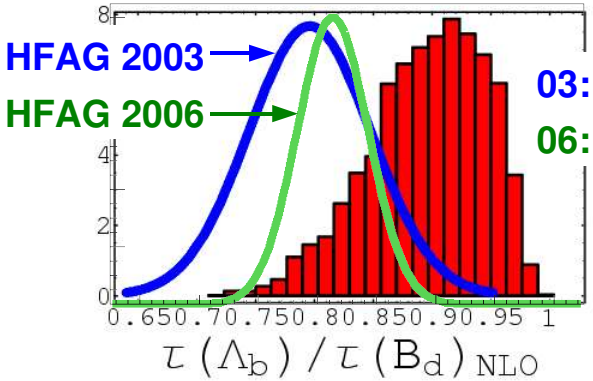
Ave. Lifetime [ps]	1.461 ± 0.057 ps	1.461 ± 0.040 ps	WA (HFAG)

B Lifetimes

C.Tarantino, hep-ex/0310241

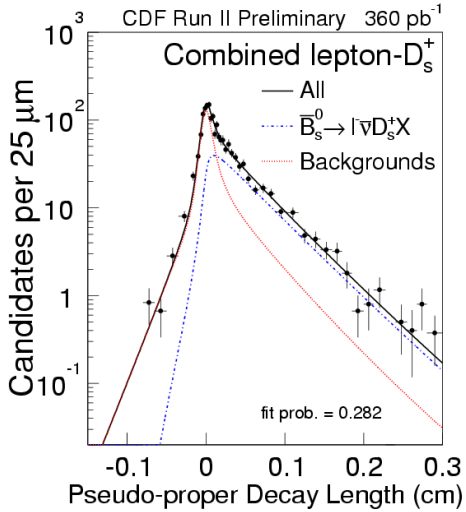




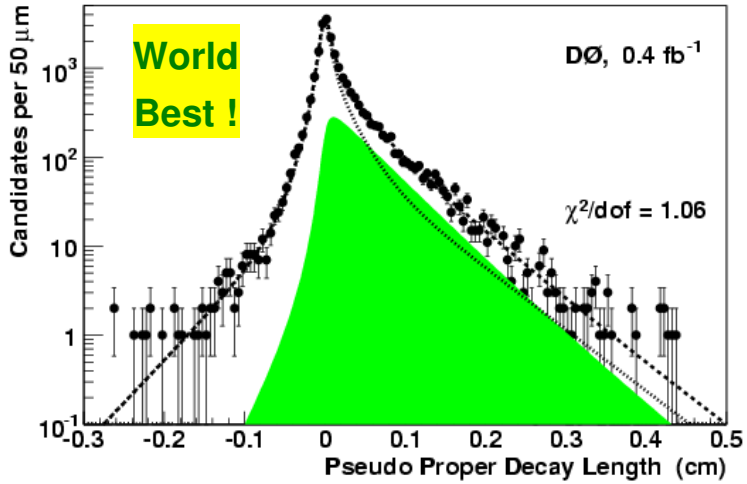


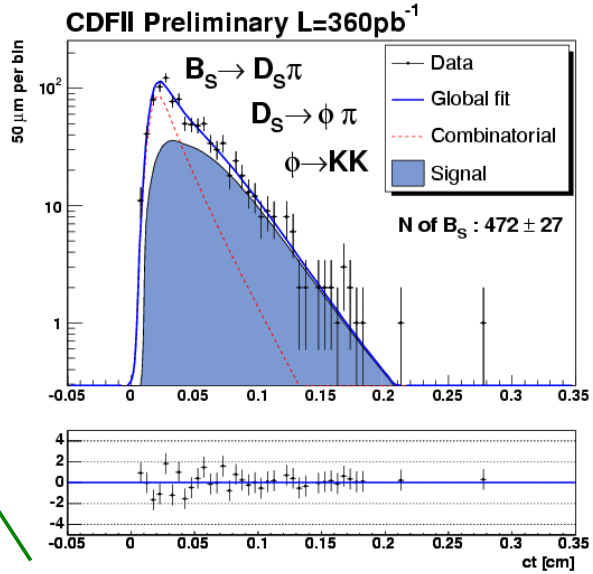
see also C.Tarantino, hep-ex/0702235

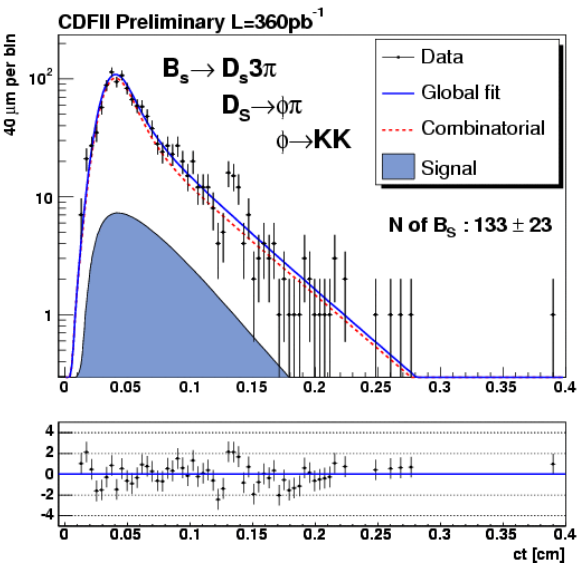
$\tau(B_s) = 1.381 \pm 0.055^{+0.052}_{-0.046}$ ps [4]



$\tau(B_s) = 1.398 \pm 0.044^{+0.028}_{-0.025}$ ps [3]





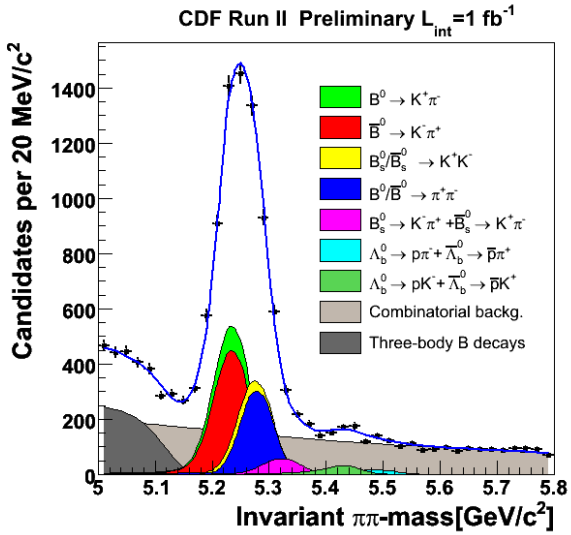


$\tau(B_s) = 1.60 \pm 0.10 \pm 0.02$ ps [5]

Rare Hadronic B.R.s

1) CDF: B_s / $B^0 \rightarrow h^+ h'^-$ [6]

- test of SU(3)
- CP Asymmetries (γ)



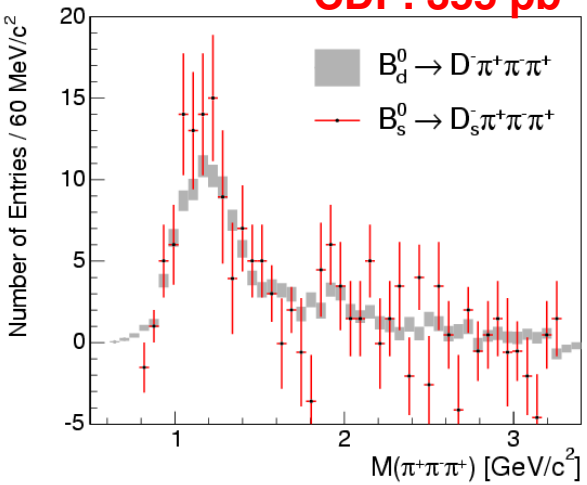
Fit for composition

- $M(h^+h^-)$
- dE/dx
- $P(h^+)$, $P(h^-)$

2) CDF: $B_s \rightarrow D_s^- \pi^+$ & $D_s^- 3\pi^\pm$ [7]

- test of SU(3)

CDF: 355 pb^{-1}



Decay Modes

- $D_s^-(\phi\pi^-)\ \pi^+$
- $D_s^-(\phi\pi^-, K^{*0}K^-, \pi^-\pi^-\pi^+)\ \pi^+\ \pi^+\ \pi^-$

3) CDF: $B_s \rightarrow \psi(2S)\ \phi$ [8]

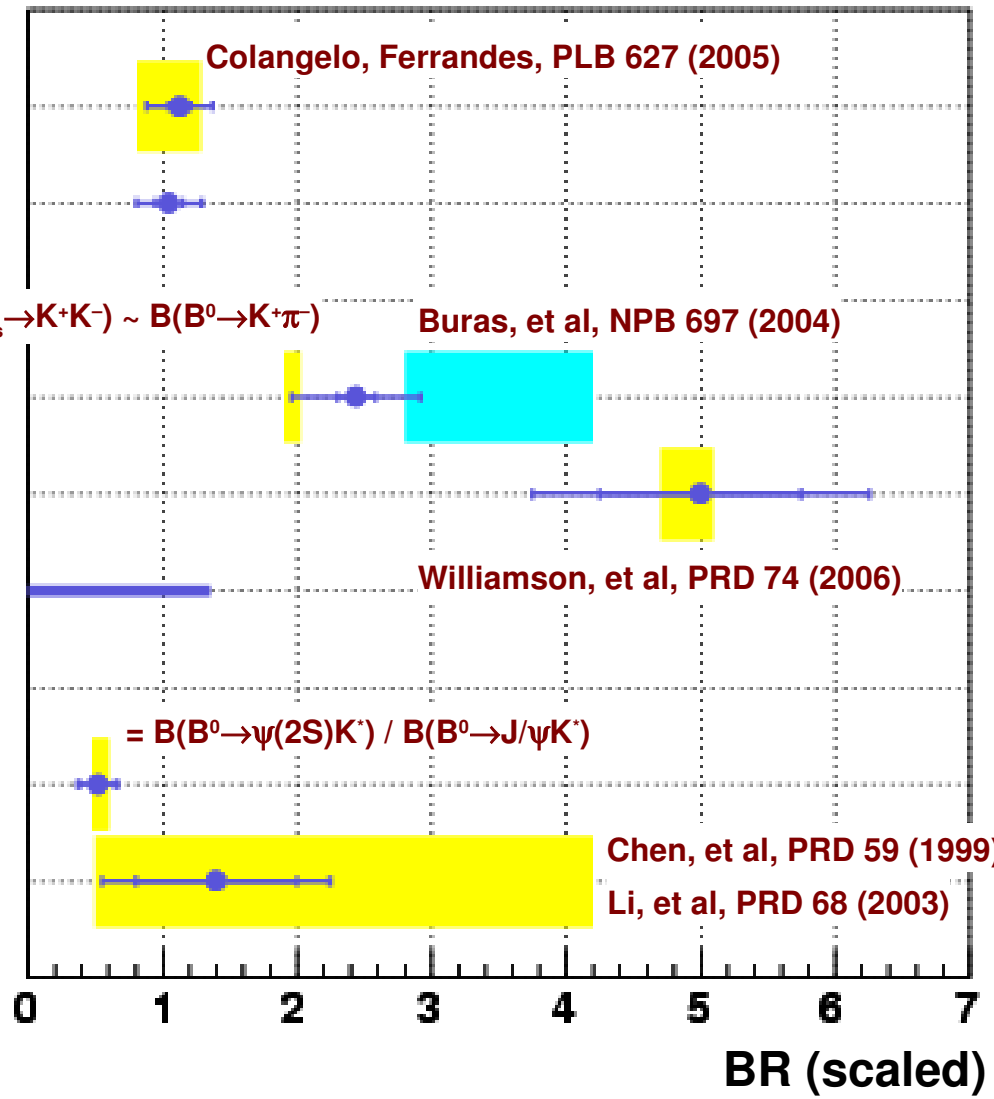
- comp to $B^{+,0} \rightarrow \psi(2S)\ K^{+,*0}$
- CP-even vs -odd (c.f. $B_s \rightarrow J/\psi\ \phi$)

4) CDF: $B_s \rightarrow \phi\ \phi$ [9]

- CP-even vs -odd (c.f. $B_s \rightarrow J/\psi\ \phi$)

Hadronic BR Results

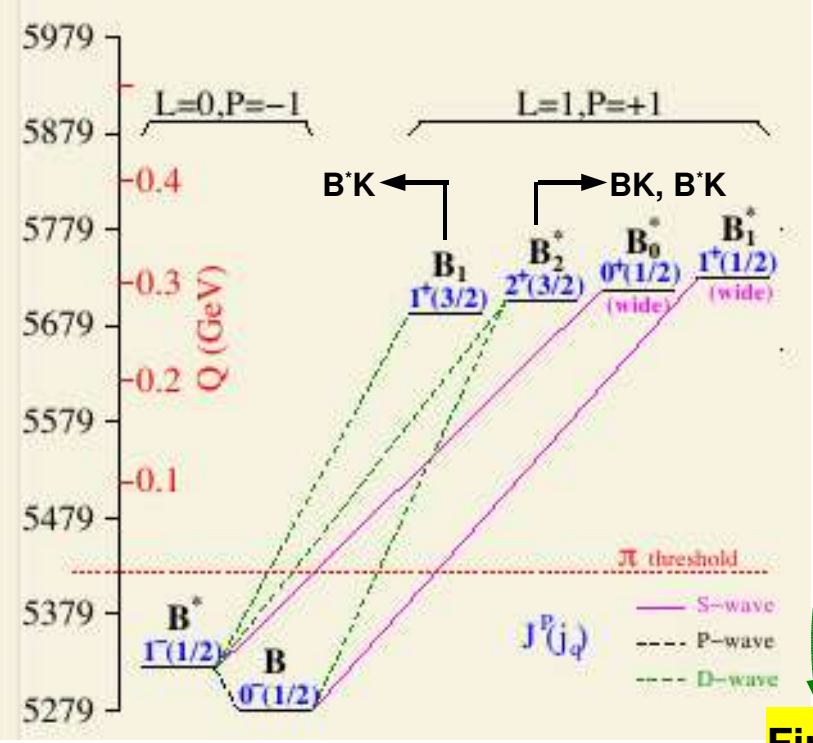
CDF Branching Ratio Results



preliminary

	N(signal)	Result	Signif
$\frac{B_s \to D_s^- \pi^+}{B^0 \to D^- \pi^+}$	494±28	1.13 ± 0.08 ± 0.23	
$\frac{B_s \to D_s^- \pi^+ \pi^+ \pi^-}{B^0 \to D^- \pi^+ \pi^+ \pi^-}$	309±26	1.05 ± 0.10 ± 0.22	
$B_s \to K^+ K^-$ $(\times 10^5)$	1307±64	2.44 ± 0.14 ± 0.46	
$B_s \to K^- \pi^+$ $(\times 10^6)$	230±38	5.00 ± 0.75 ± 1.00	
$B_s \to \pi^+ \pi^-$ $(\times 10^6)$	26±21	< 1.36 @ 90% CL	
$\frac{B_s \to \psi(2S)\phi}{B_s \to J/\psi\phi}$	32.5±6.5	0.52 ± 0.13 ± 0.07	6.4σ
$B_s \to \phi\phi$ $(\times 10^5)$	7.3±2.9	1.4 ± 0.6 ± 0.6	4.7σ

Excited B_s and D_s States



see talk by Thomas Kuhr

Meas [MeV]	CDF [10]	DØ [11]
$M(B_1)$	$5734 \pm 3 \pm 2$	$5720.8 \pm 2.5 \pm 5.3$
$M(B_2^*)$	$5738 \pm 5 \pm 1$	$5746.8 \pm 3.9 \pm 5.4$
$\Delta M(B^*_2 - B_1)$	$4 \pm 6 \pm 2$	$25.2 \pm 3.0 \pm 1.1$
Γ	16 ± 6(fixed)	$6.6 \pm 5.3 \pm 4.2$
$M(B_{s1})$	$5829.4 \pm 0.2 \pm 0.6$	—
$M(B_{s2}^*)$	$5839.4 \pm 0.4 \pm 0.5$	$5839.1 \pm 1.4 \pm 1.5$
$\Delta M(B^*_{s2} - B_{s1})$	$10.20 \pm 0.44 \pm 0.35$	—

First Observation !

too low to allow $B_{s1} \to B^{*+} K^-$

$B_s \to D^-_{s1}(2536)\ \mu^+\ \nu\ X$

$\to D^{*-}\ K^0_S \to \pi^+\ \pi^-$

$\to D^0\ \pi^-$

$\to K^+\ \pi^-$

DØ: 1 fb^{-1} [12]

Mass D_{s1} = $2535.7 \pm 0.6 \pm 0.5$ MeV

(2535.34 ± 0.31 MeV – PDG 2006)

$BR(B_s \to D_{s1} \mu \nu X) = (0.86 \pm 0.16_{stat} \pm 0.13_{syst} \pm 0.09_{prod})\%$

Theory: (0.195 – 0.53)%

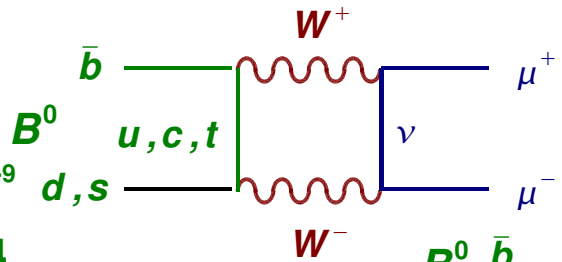
Scora,Isgur PRD 52 (1995); Mayorga,Moreno-Briceno,Munoz JPG 29 (2003)

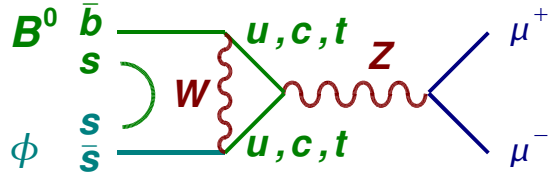
Ebert,Faustov,Galkin PLB 434 (1998)

Leptonic B_s Decays & FCNCs

$B^0 \to \mu^+ \mu^-$ Predictions

- $BR(B_s) = (3.4 \pm 0.5) \times 10^{-9}$
- $BR(B_d) \downarrow |V_{td} / V_{ts}|^2 \sim 0.04$

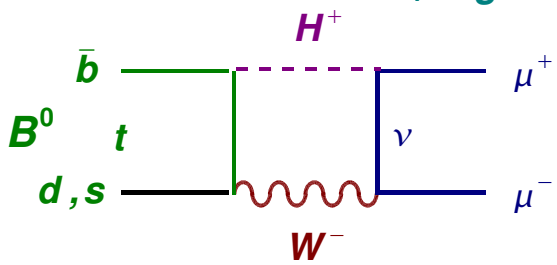


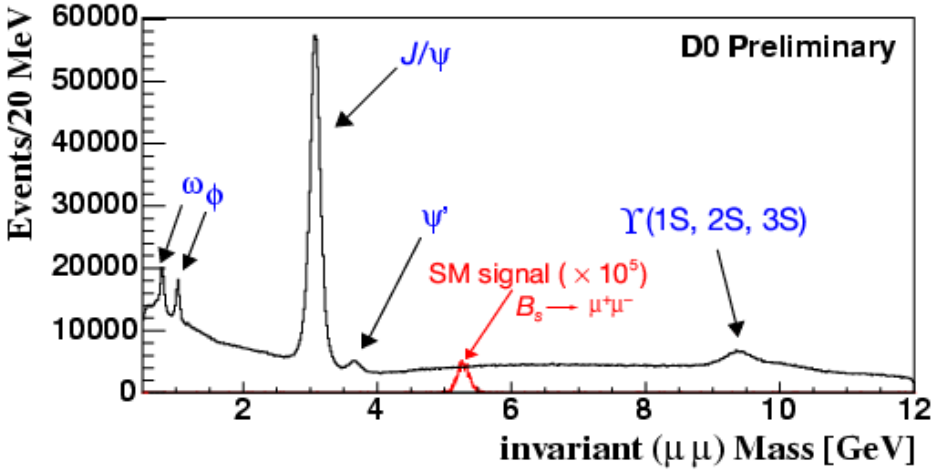


$B_s \to \mu^+ \mu^- \phi$ Predictions

- analog to $B_d \to \mu^+ \mu^- K^{*/+}$ $(b \to s \mu^+ \mu^-)$
- $BR \sim 1.6 \times 10^{-6}$

- $BR \propto \tan^6 \beta$ in MSSM
  $\propto \tan^4 \beta$ in 2HDM



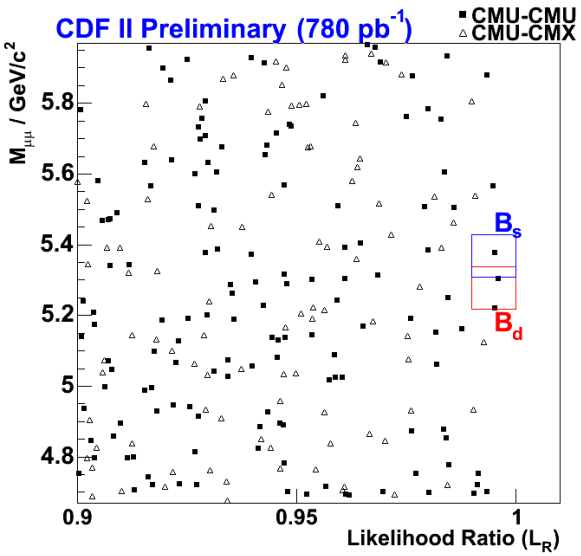


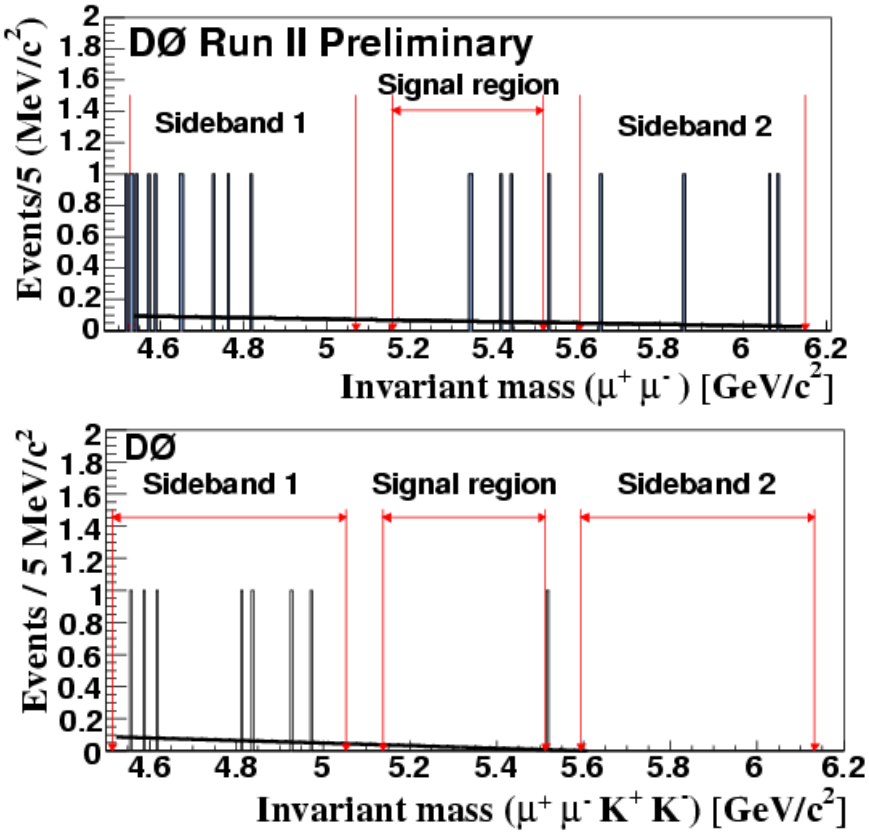
Meeting the Exp Challenges

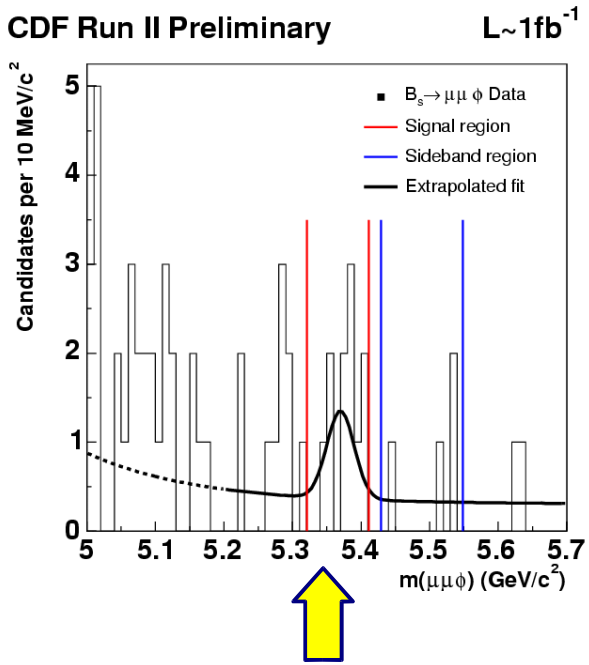
- Cut around J/ψ and ψ'
- Discrim against other di-μ sources
  - Isolation
  - Decay Length Significance
  - Angle b/w decay length and momentum vectors
- Normalize to known decays
  - $B^+ \to J/\psi\, K^+$; $B_s \to J/\psi\, \phi$

Preliminary FCNC Results

$B \to \mu^+ \mu^-$ Results



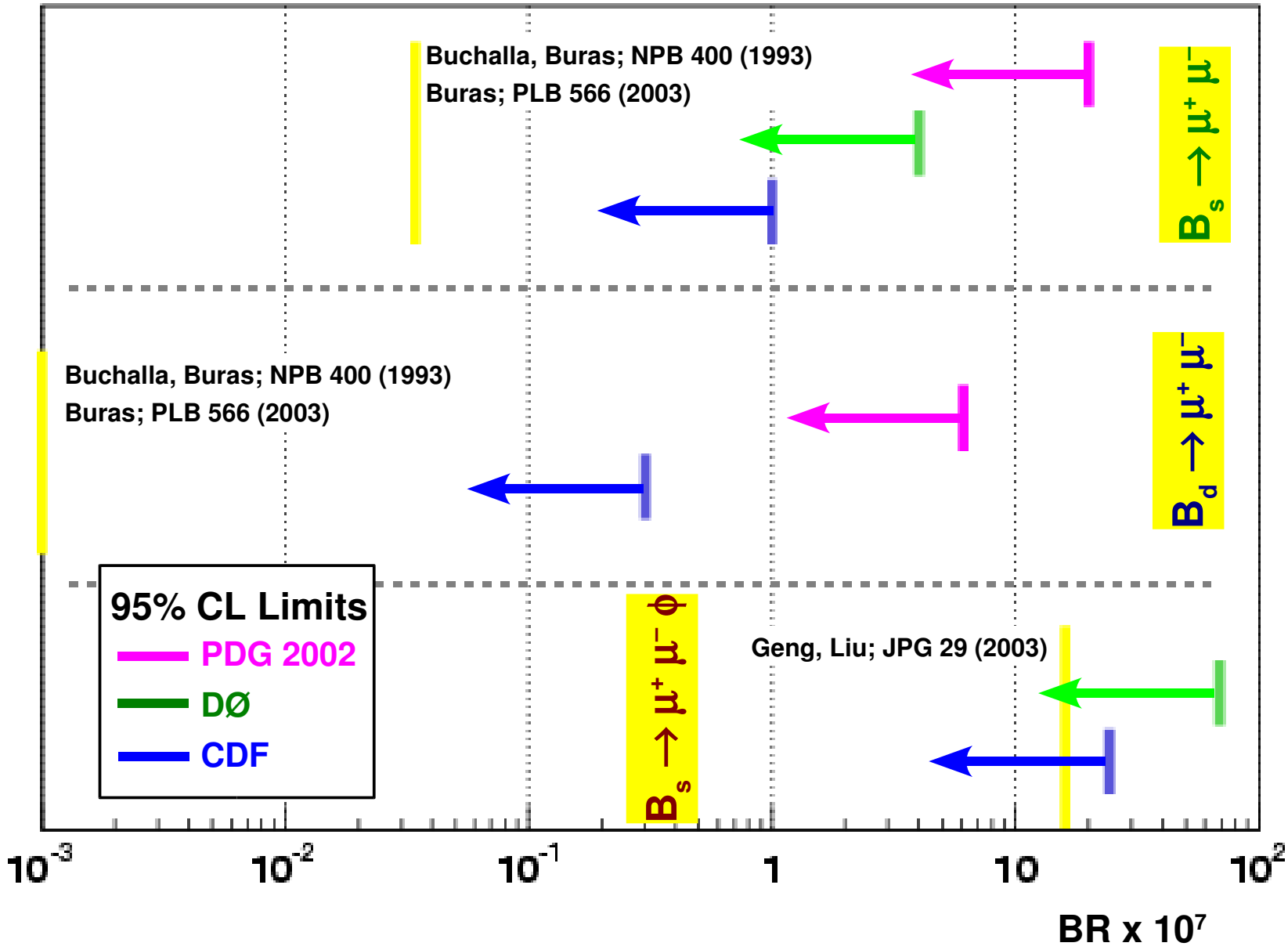




$B_s \to \mu^+ \mu^- \phi$ Results

Exp		Mode	Lumi [pb^{-1}]	Final Evts	Bgrd Pred	BR Limit (95% CL)	Comments
DØ	[13]	$B_s \to \mu^+ \mu^-$	300	4	4.3 ± 1.2	< 4.0 x 10^{-7}	2.3x10^{-7} exp for 700 pb^{-1}
	[15]	$B_s \to \mu^+ \mu^- \phi$	450	0	1.6 ± 0.4	< 68.8 x 10^{-7}	
CDF	[16]	$B_s \to \mu^+ \mu^-$	780	1	1.27 ± 0.37	< 1.0 x 10^{-7}	
	[16]	$B_d \to \mu^+ \mu^-$	780	2	2.45 ± 0.40	< 0.3 x 10^{-7}	
	[17]	$B_s \to \mu^+ \mu^- \phi$	924	11	3.5 ± 1.5	< 24.3 x 10^{-7}	2.4 σ signal

FCNC Limits


Buchalla, Buras; NPB 400 (1993)
Buras; PLB 566 (2003)
$B_s \to \mu^+\mu^-$
Buchalla, Buras; NPB 400 (1993)
Buras; PLB 566 (2003)
$B_d \to \mu^+\mu^-$
95% CL Limits
PDG 2002
DØ
CDF
$B_s \to \mu^+\mu^-\phi$
Geng, Liu; JPG 29 (2003)
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
BR x 10^7

Mixing and CP Violation

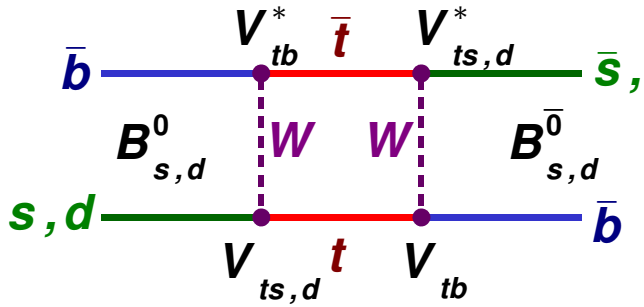
EW Symmetry Breaking ⇒ Weak ≠ Mass ≠ CP Eigenstates

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

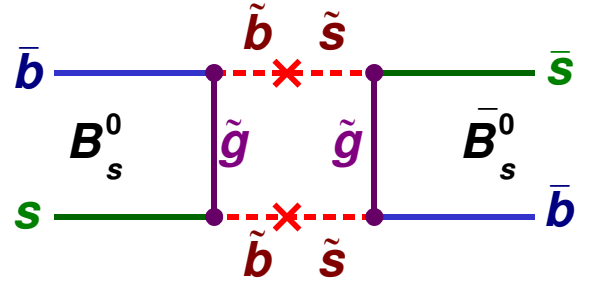
$$|B_H\rangle=p|B^0\rangle+q|\bar{B}^0\rangle \quad |B_L\rangle=p|B^0\rangle-q|\bar{B}^0\rangle$$

$$|B_{odd}\rangle=|B^0\rangle+|\bar{B}^0\rangle \quad |B_{even}\rangle=|B^0\rangle-|\bar{B}^0\rangle$$

SM Diagram



SUSY



Observables

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

$\Delta\Gamma_{CP} = \Gamma_{even} - \Gamma_{odd} \sim 2|\Gamma_{12}|$ not sens. to NP

$\Delta\Gamma_s = \Gamma_L - \Gamma_H = \Delta\Gamma_{CP}\cos\phi_s$ very sens. to NP

(ϕ_s = -0.5 – -0.8 in 4-gen models)

Hou,Nagashima,Soddu; hep-ph/0610385

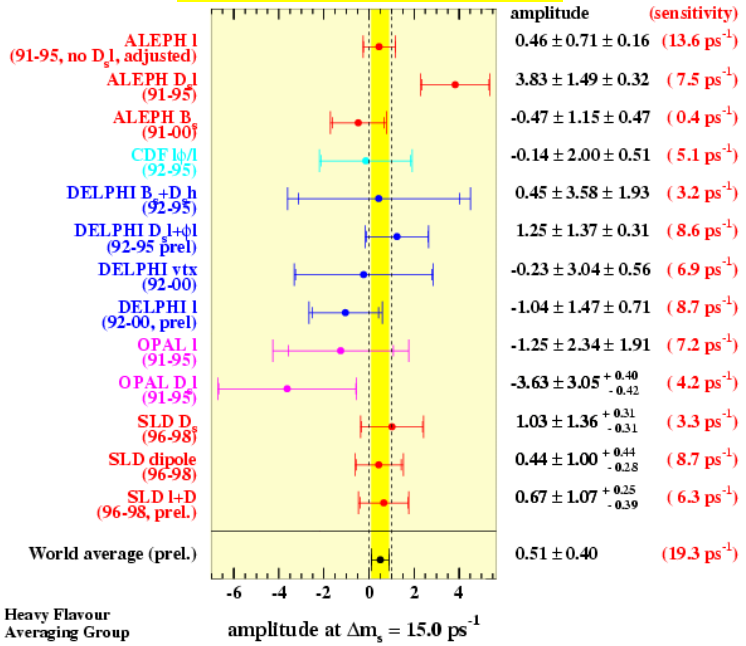
(+ charginos, neutralinos, etc @ tanβ >>1)

In the SM

$$\frac{\Delta\Gamma_s}{\Delta m_s}=O\left(\frac{m_b^2}{m_t^2}\right)\ \text{(QCD)} \qquad \phi_s\sim 0 \qquad \frac{\Delta m_d}{\Delta m_s}=\frac{M_{Bd}}{M_{Bs}}\frac{f_{Bd}^2 B_{Bd}}{f_{Bs}^2 B_{Bs}}\left|\frac{V_{td}}{V_{ts}}\right|^2$$

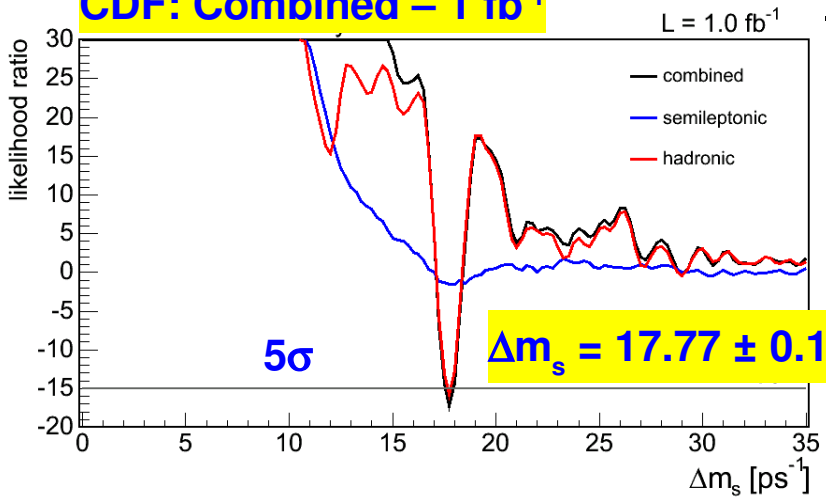
B_s Mixing

HFAG: Winter 2003



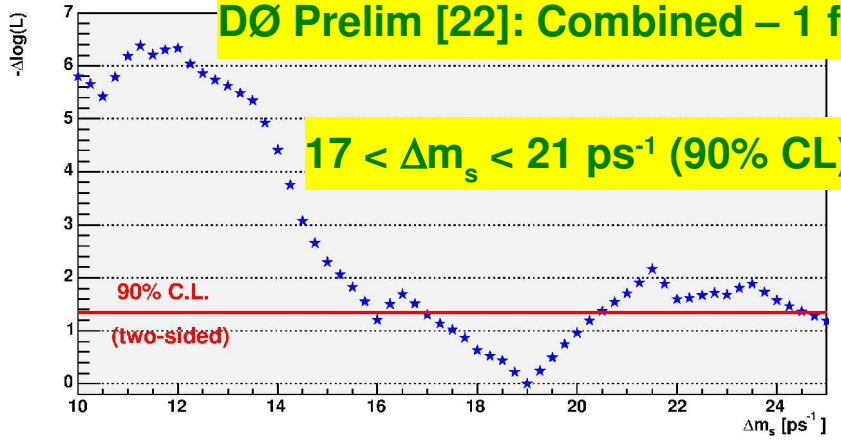
Exp	Mode		Sample	<εD^2> (OST)	(SST)	Sens [ps^{-1}]
ALEPH	Hadronic		28.5	27%		13.6
DØ	μ D_s(φπ)	[18]	26,710	2.48%		14.1
	μ D_s(K^*K)	[19]	12,650			11.7
	e D_s(φπ)	[20]	1,010			8.2
	μ D_s($K^0_s K$)	[21]	2,600			1.9
CDF	l D_s (all)	[23]	61,500	1.8%	4.8%	19.3
	D_s(φπ) π		2,000	1.8%	3.7%	30.7
	part. rec.		3,100			
	D_s(K^*K) π		1,400			
	D_s(3π) π		700			
	D_s(φπ) 3π		700			
	D_s(K^*K) 3π		600			
	D_s(3π) 3π		200			

CDF: Combined – 1 fb^{-1}



$\Delta m_s = 17.77 \pm 0.10 \pm 0.07$ ps^{-1}

DØ Prelim [22]: Combined – 1 fb^{-1}



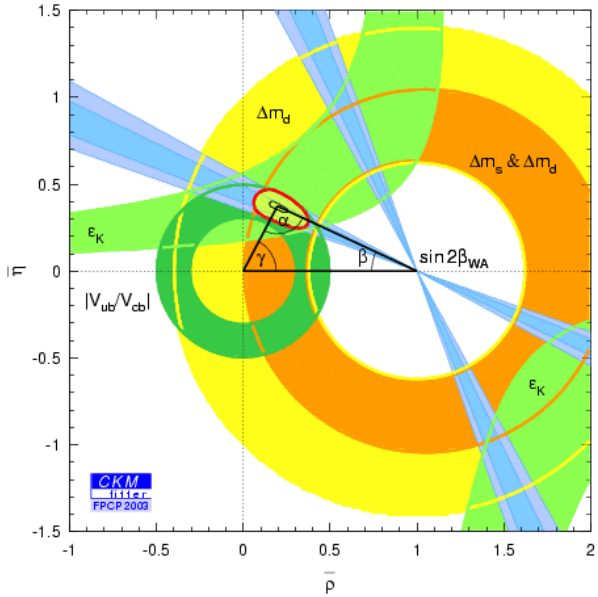
$17 < \Delta m_s < 21$ ps^{-1} (90% CL)

Impact on Unitarity Triangle

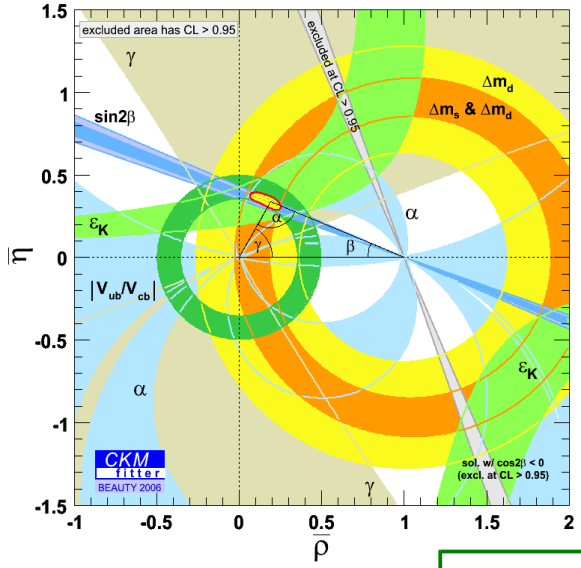
see also Utfit: http://utfit.roma1.infn.it/

http://ckmfitter.in2p3.fr/

CKM Fitter: FPCP 2003



CKM Fitter: Beauty 2006



$$\left|\frac{V_{td}}{V_{ts}}\right| = 0.2060 \pm 0.0007\,(\text{exp})^{+0.0081}_{-0.0060}\,(\text{theor}) = \sqrt{\frac{M_{Bs}}{M_{Bd}}\,\frac{f^2_{Bs}B_{Bs}}{f^2_{Bd}B_{Bd}}\,\frac{\Delta m_d}{\Delta m_s}}$$

±0.5% (Δm_d) ±0.3% (Δm_s) ±3.4% (f²_Bs B_Bs / f²_Bd B_Bd)

CDF Measurement

BaBar and Belle Ave: $0.200 \pm 0.016\,(\text{exp})^{+0.016}_{-0.015}\,(\text{theo})$ $\left|\frac{B\to\rho\gamma}{B\to K^*\gamma}\right|$ see talk by S.Nishida

M.Okamoto hep-lat/0510113

New CDF $B_s \to K^- \pi^+$ [6] Sensitive to $\gamma \Rightarrow 2.5\sigma$ significant meas of direct CPV in B_s

- $A_{CP}(B_s \to K^- \pi^+) = 0.39 \pm 0.15 \pm 0.08$ **[SM pred ~ 0.37 – Lipkin, PLB 621 (2005)]**

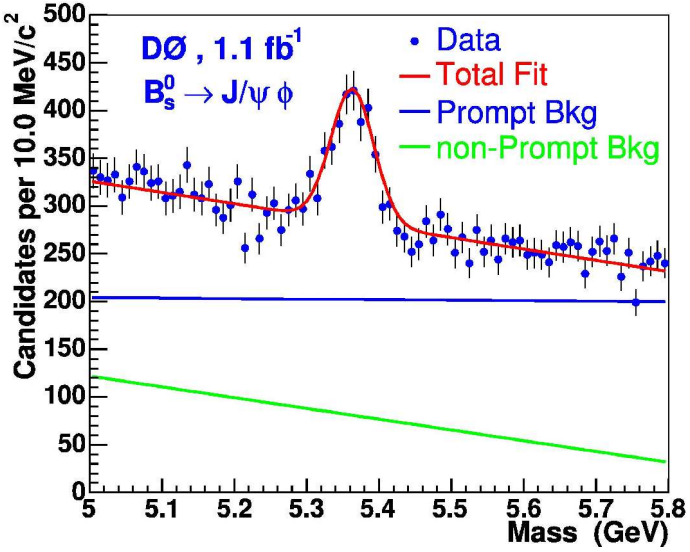
$B_s \to J/\psi\,\phi$ Results

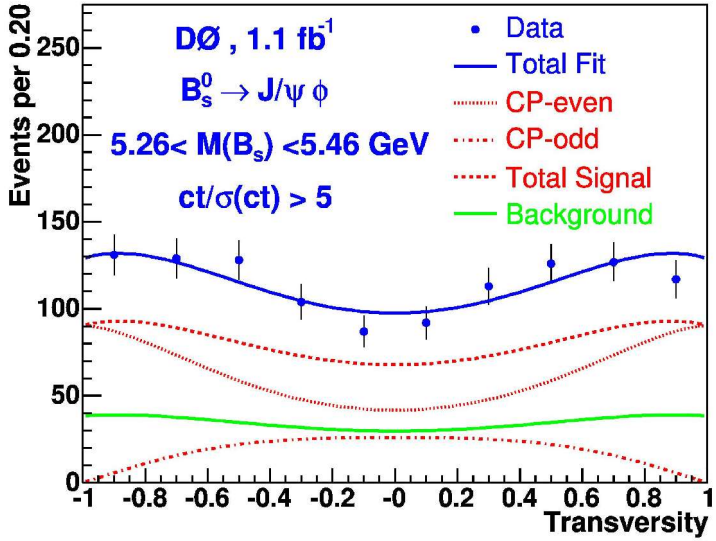
$B_s \to J/\psi\,\phi$ contains both:

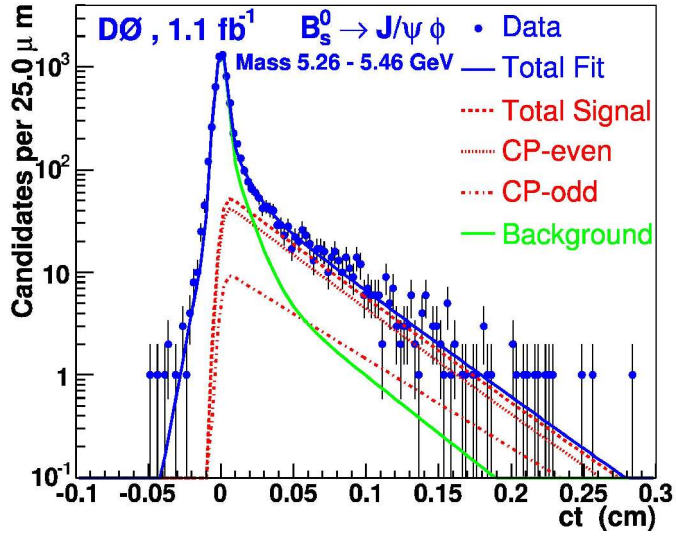
- CP-even & CP-odd comp's
- disentangle using ang. distrib's

Fits to CDF & DØ Untagged Data

- M(J/ψφ)
- Proper Time
- 3 Decay Angles







Observable	CDF [24] (355 pb-1)	D0 [25] (1.1 fb-1)	ϕ_s free
$N(B_s)$	203 ± 15	1039 ± 45	
$\Delta\Gamma_s$ (ps^{-1})	$0.47^{+0.19}_{-0.24} \pm 0.01$	$0.12^{+0.08}_{-0.10} \pm 0.02$	0.17 ± 0.09
$\langle\tau\rangle$ (ps^{-1})	$1.40^{+0.15}_{-0.13} \pm 0.02$	$1.52 \pm 0.08^{+0.01}_{-0.03}$	1.49 ± 0.08
ϕ_s	$\equiv 0$	$\equiv 0$	$-0.79 \pm 0.56^{+0.14}_{-0.01}$

Also Fit for:

- CP-even & -odd ampl's
- strong phases

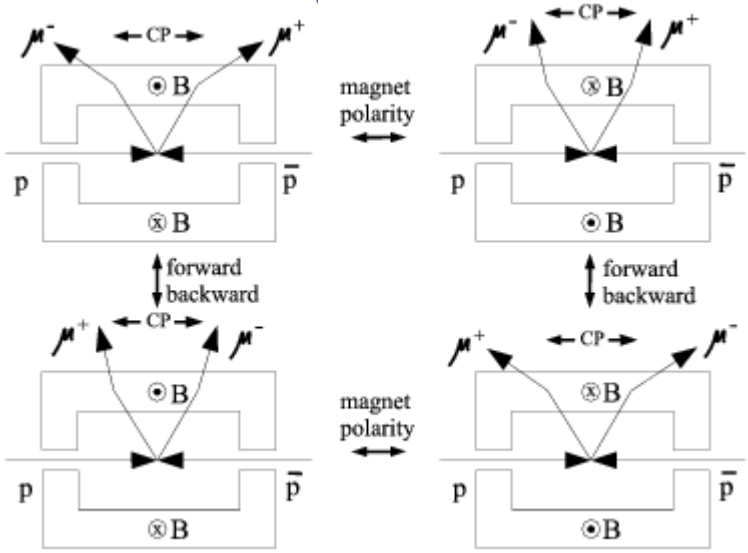
Muon Charge Asymmetries

Asymmetries in (untagged) Flavor Specific Decays
⇒ Sensitivity to CP Violation in B Mixing

DØ [26]: $p\bar{p} \to b\bar{b} \to \mu^{\pm}\mu^{\pm}$

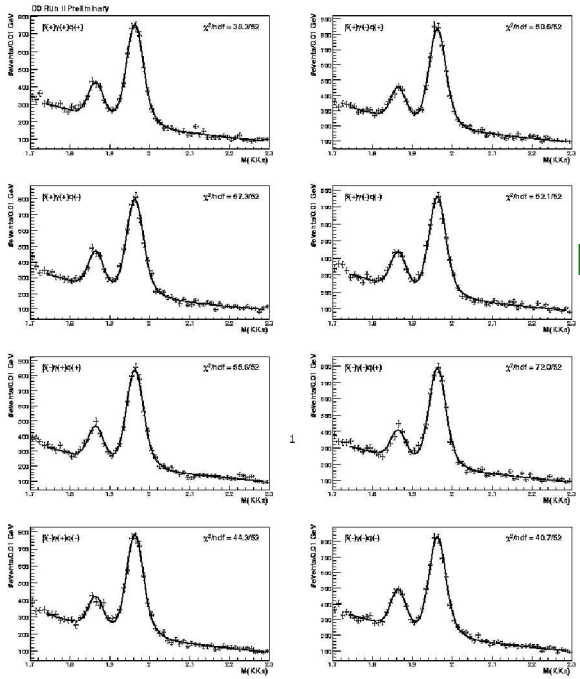
$$A_{SL}^{\mu\mu} = \frac{N(b\bar{b}\to\mu^+\mu^+) - N(b\bar{b}\to\mu^-\mu^-)}{N(b\bar{b}\to\mu^+\mu^+) + N(b\bar{b}\to\mu^-\mu^-)} = A_{SL}^{d} + \frac{f_s Z_s}{f_d Z_d} A_{SL}^{s}$$

$$\left(Z_q = \frac{1}{1-(\Delta\Gamma_q/2\Gamma_q)^2} - \frac{1}{1+(\Delta m_q/\Gamma_q)^2} \right)$$



DØ [27]: $B_s \to \mu^{\pm} D_s X$

$$A_{SL}^{s} = \frac{N(B_s\to\mu^+ D_s^-) - N(B_s\to\mu^- D_s^+)}{N(B_s\to\mu^+ D_s^-) + N(B_s\to\mu^- D_s^+)} \sim \frac{1}{2}\frac{\Delta\Gamma_s}{\Delta m_s}\tan\phi_s$$



D_s Mass for Different
η-hemisphere
Solenoid Polarity
Toroid Polarity

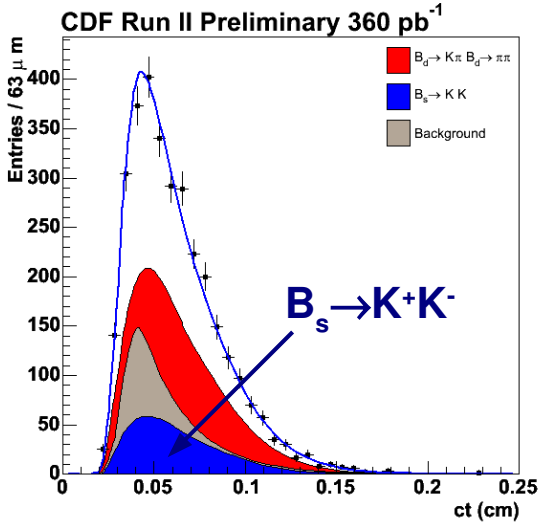
Change Toroid & Solenoid Polarities ⇒ reduce sensitivity to detector-related bgrds

$A_{SL}^{\mu\mu} = (-0.92 \pm 0.44 \pm 0.32)\%$

$A_{SL}^{s} = (1.23 \pm 0.97 \pm 0.17)\%$

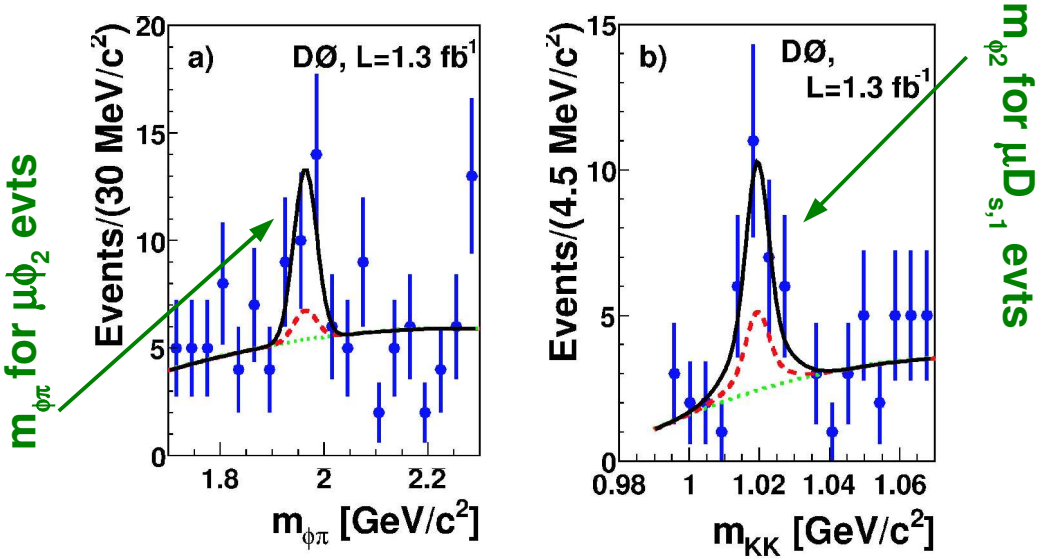
CP Specific Results

$B_s \to K^+K^-$ = CP-even



$$\tau_{CP-even} \sim \frac{1}{\Gamma_s}\left[\frac{1}{1+(\Delta\Gamma_{CP}/2\Gamma_s)}\right]$$

$B_s \to D_s^{(*)} D_s^{(*)}$ ~ CP-even



$$2BR_{CP-even} \sim \frac{\Delta\Gamma_{CP}}{\Gamma_s}\left[\frac{1}{1+\Delta\Gamma_{CP}/2\Gamma_s}\right]$$

Exp	Mode	Lumi	N(signal)	$\Delta\Gamma_{CP}/\Gamma_s$
CDF [30]	$B_s \to K^+K^-$	360 pb-1	718 ± 55	–0.08 ± 0.23 ± 0.03
CDF [29]	$B_s \to D_s^+(\phi\pi)\, D_s^-(\phi\pi)$	355 pb-1	23.5 ± 5.5	diff b/c non-inclus.
D0 [28]	$B_s \to D_s^{(*)}(\phi\pi)\, D_s^{(*)}(\mu\phi X)$	1.3 fb-1	11.4 ± 6.5	$0.079^{+0.038+0.031}_{-0.035-0.030}$
ALEPH 2000				$0.26^{+0.30}_{-0.15}$

$\tau(B_s \to K^+K^-)$ = 1.53 ± 0.18 ± 0.02 ps

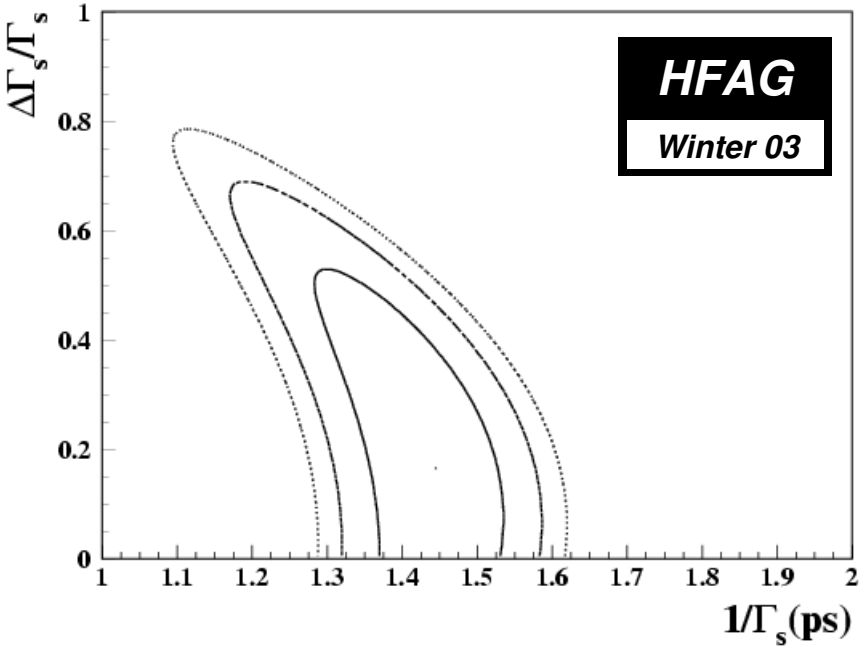
$BR(B_s \to D_s^+ D_s^-)$ = (1.3 ± 0.6)%[1]

$BR(B_s \to D_s^{(*)} D_s^{(*)})$ = (3.9 ± 1.8 ± 1.6)%

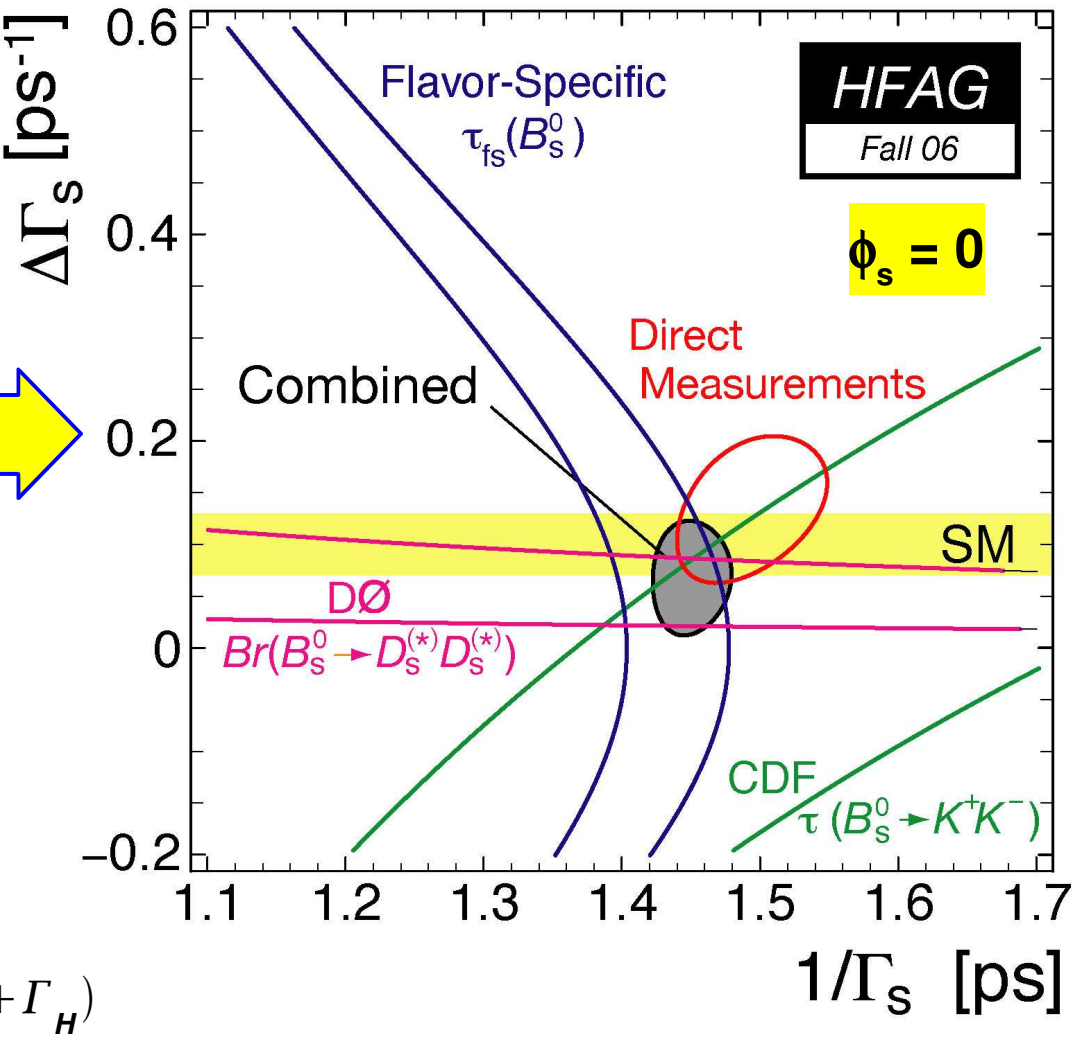
$BR(B_s \to D_s^{(*)} D_s^{(*)})$ = (7.7 ± 4.7)%

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

Improvements in $\Delta\Gamma_s$

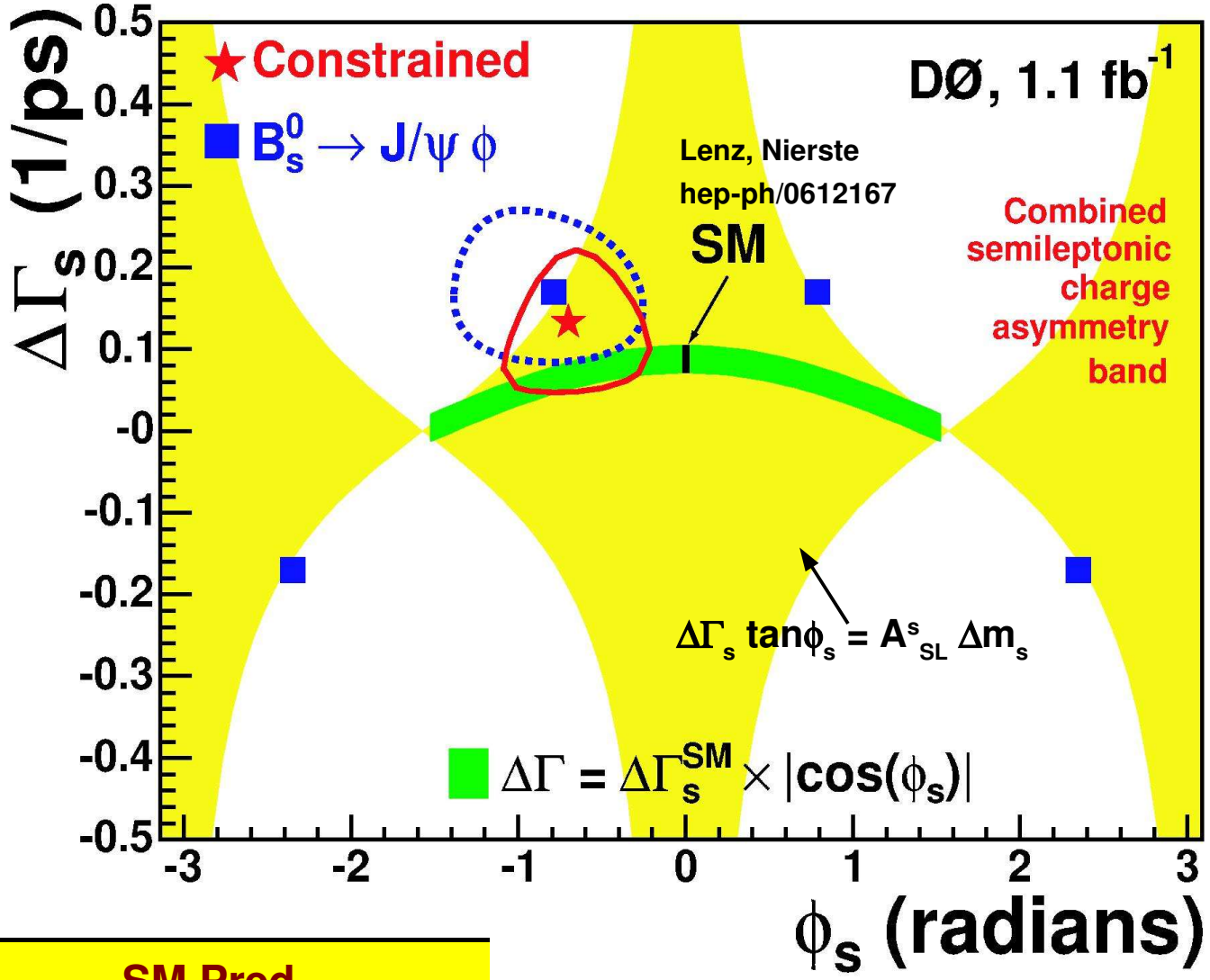


1-sigma contours ($\Delta(\log L) = 0.5$)



$$\tau_{fs} = \frac{1}{\Gamma_s}\left[\frac{1+(\Delta\Gamma_s/2\Gamma_s)^2}{1-(\Delta\Gamma_s/2\Gamma_s)^2}\right] \qquad \Gamma_s = \frac{1}{\bar{\tau}_s} = \frac{1}{2}(\Gamma_L + \Gamma_H)$$

Combination of DØ Results



"Constrained" Includes:

- $B_s \to J/\psi\,\phi$
- $B_s \to \mu\,X$ Asymmetry
- Dimuon Asymmetry
- World Average: τ_{fs}

	DØ Comb [31]	SM Pred
$\Delta\Gamma_s$	0.13 ± 0.09 ps^{-1}	0.088 ± 0.017 ps^{-1}
ϕ_s	$-0.70^{+0.47}_{-0.39}$	$(4.2 \pm 1.4) \times 10^{-3}$

Lenz,Nierste hep-ph/0612167

The Future

Detectors and Data Collection

- up to 8 fb^{-1} (per exp) with Run IIb (note: increasingly restrictive triggers)
- DØ Layer-0 Silicon: 25% improvement in proper time res.

B_s Properties: Lifetime, BRs, Spectroscopy...

- increasing sensitivity to rare modes

FCNC Decays

- should observe $\mu^+ \mu^- \phi$ if close to SM prediction
- get within a factor of ~10 of $\mu^+ \mu^-$ prediction

B_s Oscillations and the Unitarity Triangle

- $|V_{td} / V_{ts}|$ now dominated by theory error
- sensitivity to γ from $B_s \rightarrow K^+ \pi^-$

$\Delta\Gamma$ and CP Violation

- fits to tagged $B_s \rightarrow J/\psi \phi \Rightarrow$ sensitivity to Δm_s

Roundup of Progress with B_s

Remarkable Progress in B_s Physics since Start of Run II !

B_s Properties: Lifetime, BRs, Spectroscopy...

- several modes observed for the first time
- valuable tests of QCD Modelling: SU(3), etc.

FCNC Decays

- $B_s \to \mu^+ \mu^- \phi$ limits approaching SM predictions
- $B_s \to \mu^+ \mu^-$ limits only a factor of 30 from SM

B_s Oscillations and the Unitarity Triangle

- Δm_s now measured: $|V_{td} / V_{ts}|$ error dominated by theory
- CP asymmetry measurement in $B_s \to K^- \pi^+$

$\Delta\Gamma$ and CP Violation

- sensitivity to CPV phase ϕ_s

Bibliography of Results

[1]	CDF	"*Measurement of* B *Hadron Relative Fragmentation Fractions*", Feb. 2006	PRELIMINARY (360 pb^{-1})
[2]	CDF	"*Measurement of* b *hadron masses in exclusive J/ψ decays with the CDF detector*", PRL 96, 202001 (2006), hep-ex/0508022	(220 pb^{-1})
[3]	D0	"*Measurement of the* B^0_s *Lifetime Using Semileptonic Decays*", PRL 97, 241801 (2006), hep-ex/0604046	(400 pb^{-1})
[4]	CDF	"*Measurement of the* B^0_s *Meson Lifetime Using Semileptonic Decays with Single Lepton Datasets in CDF Run II*", Aug. 2005	PRELIMINARY (360 pb^{-1})
[5]	CDF	"*B mesons lifetime determination in fully hadronic decays*", Mar. 2005	PRELIMINARY (360 pb^{-1})
[6]	CDF	"*Measurement of branching fractions and direct CP asymmetries of* $B_s \to h^+h'^-$ *decays in 1* fb^{-1}", Nov.2006	PRELIMINARY (1 fb^{-1})
[7]	CDF	"*Measurement of the Ratios of Branching Fractions* $B(B_s \to D_s 3\pi^\pm)/B(B^0 \to D^- 3\pi^\pm)$ *and* $B(B_s \to D_s\pi^+)/B(B^0 \to D^-\pi^+)$", hep-ex/0610045	(355 pb^{-1})
[8]	CDF	"*Observation of* $B_s \to \psi(2S)\phi$ *and Measurement of the Ratio of Branching Fractions...*", PRL 96, 231801 (2006), hep-ex/0602005	(360 pb^{-1})
[9]	CDF	"*First Evidence for* $B_s \to \phi\phi$ *Decay and Measurements of Branching Ratio and* A_{CP} *for* $B^+ \to \phi K^+$", PRL 95, 031801 (2005), hep-ex/0502044	(180 pb^{-1})
[10]	CDF	"*Observation of orbitally excited (L=1)* B_s *mesons*", Sep.2006	PRELIMINARY (1 fb^{-1})
[11]	D0	"*First Direct Observation of* B^*_{s2} *meson*", Feb.2006	PRELIMINARY (1 fb^{-1})
[12]	D0	"*First Measurement of the* B_s *Semileptonic Branching Ratio to an Orbitally Excited* D_s^{**} *State*", Mar.2006	PRELIMINARY (1 fb^{-1})
[13]	D0	"*Update of the Upper Limit on the Rare Decay* $B_s \to \mu^+\mu^-$ *with the D0 Detector*", Mar.2005	PRELIMINARY (300 pb^{-1})
[14]	D0	"*A new expected upper limit for the rare decay* $B_s \to \mu^+\mu^-$ *with the D0 Detector*", Mar.2006	PRELIMINARY (700 pb^{-1})
[15]	D0	"Search for the Rare Decay $B_s \to \mu^+\mu^-\phi$ *with the D0 Detector*", PRD 74, 031107 (2006), hep-ex/0604015	(450 pb^{-1})
[16]	CDF	*"Search for* $B_s \to \mu^+\mu^-$ *and* $B_d \to \mu^+\mu^-$ *Decays in ppbar Collisions with CDF II"*	PRELIMINARY (780 pb^{-1})
[17]	CDF	*"Search for Rare Decays* $B_s \to \mu^+\mu^- K^+$, $B_s \to \mu^+\mu^- K^{*0}$ *and* $B_s \to \mu^+\mu^-\phi$*"*	PRELIMINARY (924 pb^{-1})

Bibliography (2)

[18] D0 *"Direct Limits on the B_s Oscillation Frequency"*, PRL 97, 021802 (2006) (1 fb^{-1})

[19] D0 *"B_s Mixing studies with $B_s \to D_s \mu X$ ($D_s \to K^* K$) Decay using Unbinned Fit"*, Jul.2006 **PRELIMINARY** (1 fb^{-1})

[20] D0 *"B_s Mixing in $B_s \to D_s e X$ ($D_s \to \phi\pi$) decay mode"*, Jul.2006 **PRELIMINARY** (1 fb^{-1})

[21] D0 *"A Search for B_s Oscillations Using $B_s \to D_s \mu X$ ($D_s \to K^0_S K$) Decays"*, Oct.2006 **PRELIMINARY** (1 fb^{-1})

[22] D0 *"Combination of B_s – B_s-bar Oscillation Results from D0"*, Jul.2006 **PRELIMINARY** (1 fb^{-1})

[23] CDF *"Observation of B_s – B_s-bar Oscillations"*, PRL 97 242003 (2006), hep-ex/0609040 (1 fb^{-1})

[24] CDF *"Measurement of the Lifetime Difference Between B_s Mass Eigenstates"*, PRL 94, 101803 (2005), hep-ex/0412057 (355 pb^{-1})

[25] D0 *"Lifetime Difference and CP-Violating Phase in the B_s System"*, accept by PRL, hep-ex/0701012 (1.1 fb^{-1})

[26] D0 *"Measurement of the Charge Asymmetry in Seileptonic B_s Decays"*, hep-ex/0701007 (1.3 fb^{-1})

[27] D0 *"Measurement of the CP-violation parameter in B^0 mising and decay with p-pbar $\to \mu\mu$ X data"*, PRD 74, 092001 (2006) (1 fb^{-1})

[28] D0 *"Measurement of Branching Ratio Br($B_s \to D_s^{(*)} D_s^{(*)}$) with the D0 Experiment"*, hep-ex/0702049 (1.3 fb^{-1})

[29] CDF *"Observation of exclusive $B_s \to D_s D_s$, $D_s \to \phi\pi$ (3π,K^*K), $D^+ \to K\pi\pi$ with 355 pb^{-1} in Run II"*, Mar.2006 **PRELIMINARY** (355 pb^{-1})

[30] CDF *"Measurement of the $B_s \to K^+K^-$ lifetime and extraction of $\Delta\Gamma_{CP}/\Gamma_{CP}$"*, Feb.2006 **PRELIMINARY** (360 pb^{-1})

[31] D0 *"Combined D0 Measurements Constraining the CP-Violating Phase and Width Difference in the B_s System"*, hep-ex/0702030 (1.1 fb^{-1})