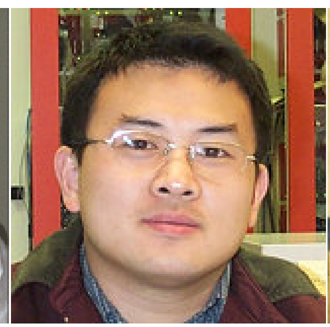
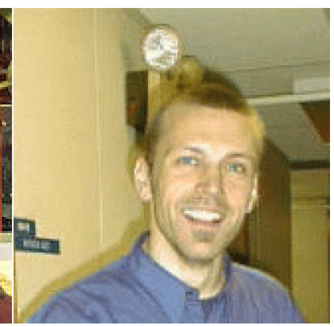
Measurement of $\Delta\Gamma_s$ at CDF II

Along with ΔM, $\Delta\Gamma$ and ϕ are the other two parameters describing mixing in a system of the neutral B mesons. $\Delta\Gamma \propto \Delta M$, hence large ΔM in the $B_s - \overline{B}_s$ system predicted by the Standard Model means large $\Delta\Gamma_s$. While larger ΔM is more difficult to determine experimentally, the larger $\Delta\Gamma$ is the easier it is to measure. This presentation reviews a measurement of $\Delta\Gamma_s$ accomplished by the CDF Collaboration using 260 pb^{-1} of data.



+Konstantin Anikeev

Users' Meeting • June 09, 2005

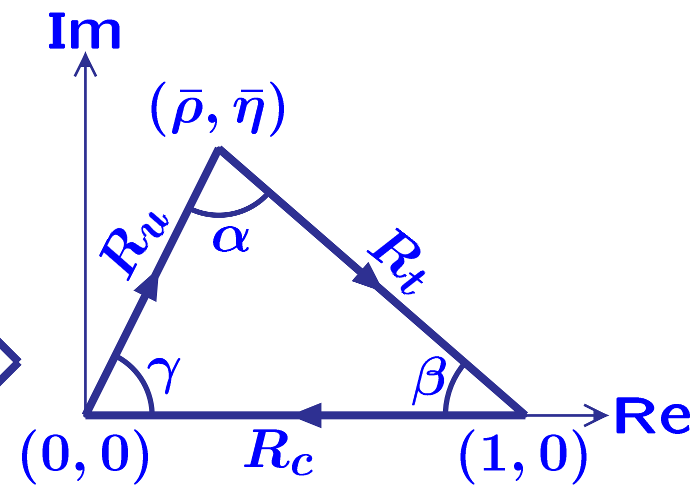
1. Motivation

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

$$V^\dagger = V^{-1}$$

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

$\Rightarrow$

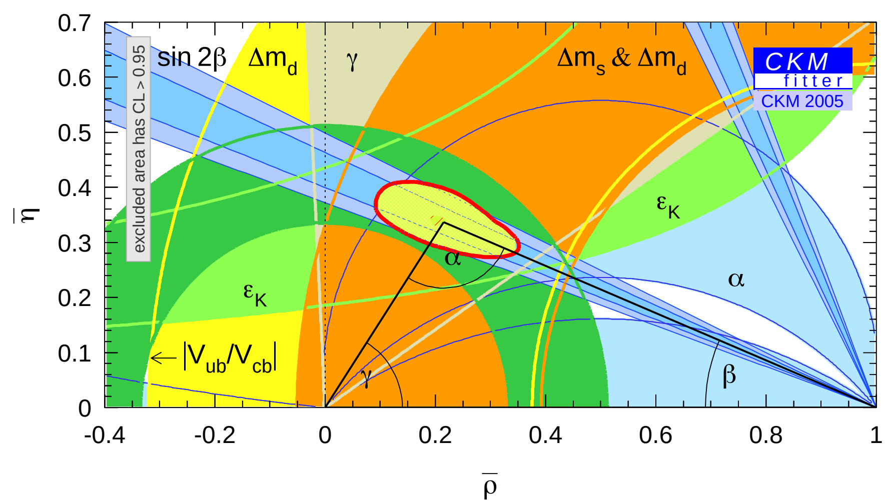


Over-constrain UT:

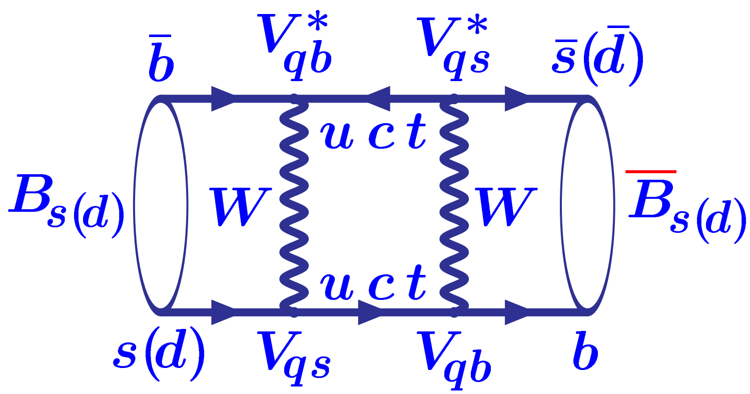
- measure $\alpha, \beta, \gamma, R_u \,\&\, R_t$
- in particular, extract

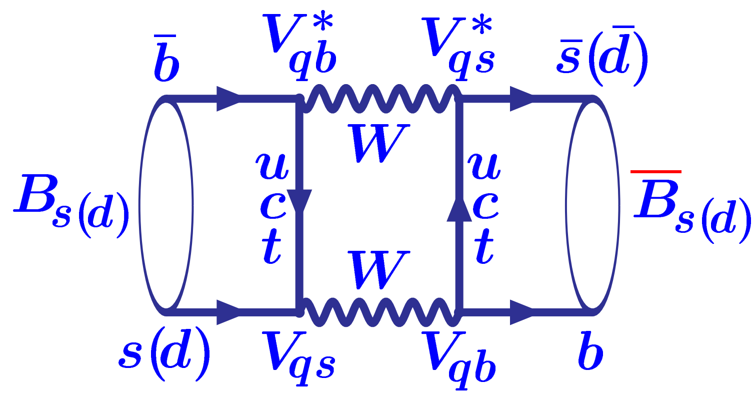
$$\boxed{R_t = \frac{1}{\lambda}\left|\frac{V_{td}}{V_{ts}}\right|}$$

by measuring ΔM in B_d and B_s mixing



B flavor oscillations 1





➜ **MIXING with eff.** $H = \begin{bmatrix} \mathrm{M} & \mathrm{M}_{12} \\ \mathrm{M}_{12}^* & \mathrm{M} \end{bmatrix} - \frac{i}{2} \begin{bmatrix} \Gamma & \Gamma_{12} \\ \Gamma_{12}^* & \Gamma \end{bmatrix}$

➜ **Diagonalize and get two eigenstates:**

$$|B^{L,H}\rangle = p|B^0\rangle \mp q|\overline{B}^0\rangle, \quad |p|^2 + |q|^2 = 1$$

$$\lambda_{L,H} = (\mathrm{M} - \tfrac{i}{2}\Gamma) \mp \tfrac{q}{p}(\mathrm{M}_{12} - \tfrac{\mathrm{i}}{2}\Gamma_{12}), \quad \frac{q}{p} = \sqrt{\frac{\mathrm{M}_{12}^* - \frac{\mathrm{i}}{2}\Gamma_{12}^*}{\mathrm{M}_{12} - \frac{\mathrm{i}}{2}\Gamma_{12}}} = \begin{cases} e^{2i\beta}, & B_d \\ 1 & , B_s \end{cases}$$

$(e^{2i\beta_s},\ \beta_s \approx 0.03)$

B flavor oscillations 2

$$\begin{matrix} M_{L,H} = & Re(\lambda_{L,H}) \\ \Gamma_{L,H} = & -2Im(\lambda_{L,H}) \end{matrix} \Rightarrow \begin{cases} \Delta M = M_H - M_L = 2|M_{12}| \\ \Delta\Gamma = \Gamma_L - \Gamma_H = 2|\Gamma_{12}|\cos\phi \end{cases}$$

$\phi = arg(-M_{12}/\Gamma_{12})$ - small

$$M_{12} = -\frac{\eta_{B_q}}{3\pi}\frac{m_W^2}{m_b^2} F\, S_0(m_t^2/m_W^2)(V_{tq}^* V_{tb})^2$$

$$\Gamma_{12} = \frac{\eta'_{B_q}}{2} F \left[(V_{tq}^* V_{tb})^2 + V_{tq}^* V_{tb} V_{cq}^* V_{cb} \mathcal{O}\left(\frac{m_c^2}{m_b^2}\right) + (V_{cq}^* V_{cb})^2 \mathcal{O}\left(\frac{m_c^4}{m_b^4}\right) \right]$$

where $F = \frac{G_F^2 m_b^2 M_{B_q} f_{B_q}^2 B_{B_q}}{4\pi}, \quad q = \{d, s\}$

A. Buras, W. Slominski, and H. Steger, Nucl. Phys. B245 369-398

$$\boxed{\frac{\Delta\Gamma_s}{\Delta M_s} = (3.7^{+0.8}_{-1.5}) \times 10^{-3}}$$

➜ ΔM, $\Delta\Gamma$ ➜ M_{12}, Γ_{12} ➜ V_{td}, V_{ts}

➜ Measure $\Delta M_{d,s}$ and $\Delta\Gamma_{d,s}$

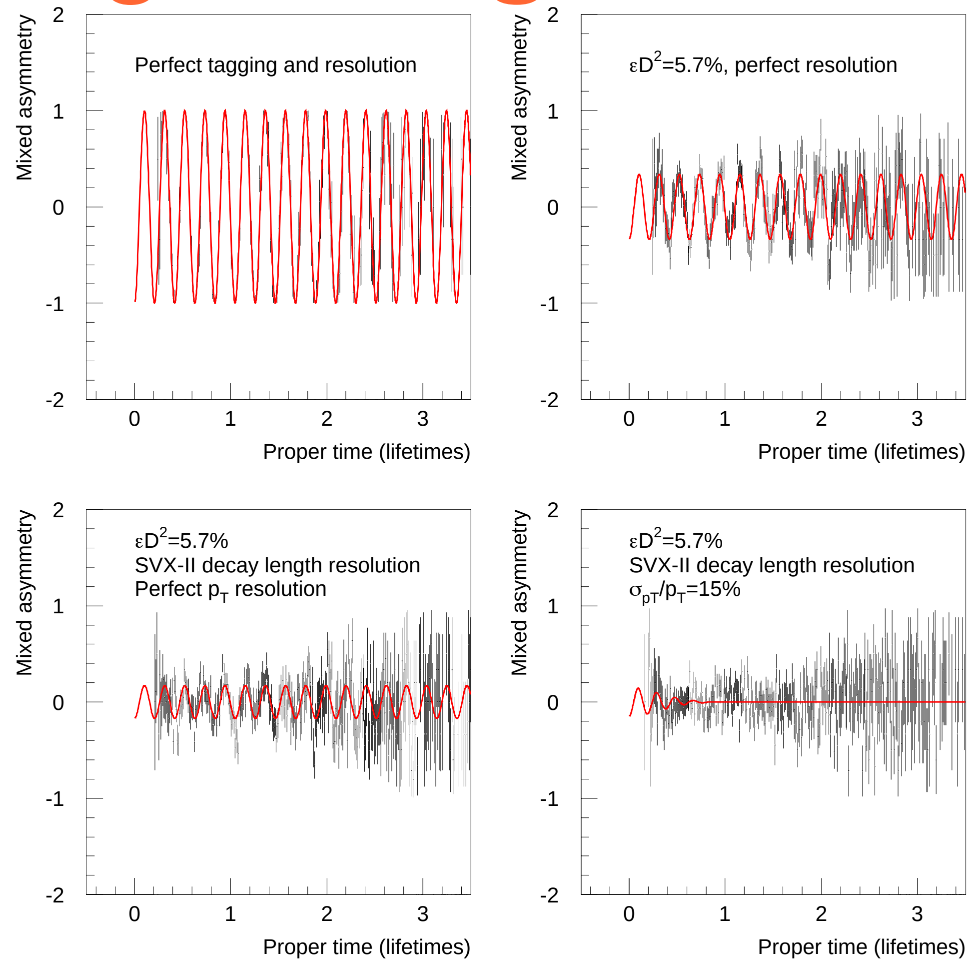
	ΔM	$\Delta\Gamma/\Gamma$
$B_d - \overline{B}_d$	$0.510 \pm 0.005\ \mathrm{ps}^{-1}$	-0.007 ± 0.038
$B_s - \overline{B}_s$	$> 14.4\ \mathrm{ps}^{-1}$ @ 95% C.L.	Today

Measuring large ΔM_s
...is hard

$$\frac{A}{\sigma_A} = \sqrt{\frac{\epsilon D^2 S}{2}\frac{S}{S+B}}\, e^{-\frac{\Delta M_s^2 \sigma_t^2}{2}}$$

One needs:

- **excellent t resolution,** $\sigma_t = \frac{M_{B_s}}{p_T}\sigma_{L_{xy}} \oplus t\frac{\sigma_{p_T}}{p_T}$
  - vertex resolution
  - p_T resolution
- **powerful tagging**
  - great efficiency, ϵ
  - large dilution, D
- **huge samples with good S/B**



With the state of the art technologies ΔM_s measurement may still be hostage to the (un)kindness of Nature

Measuring large $\Delta\Gamma_s$
...is easy!

$$\boxed{\frac{\Delta\Gamma_s}{\Gamma_s} = 0.12 \pm 0.06}$$

- $\sigma_t = \tau_{B_s}/10$ is all right
- no tagging required
  - effective signal size is much better than $S/100$

If you run a risk, it makes sense to have insurance – measure $\Delta\Gamma_s$

Straightforward approach facilitated by:

$$\frac{q}{p} = 1 \Rightarrow \begin{cases} |B_s^L\rangle = p|B_s\rangle - q|\overline{B}_s\rangle = \frac{1}{\sqrt{2}}\Big[|B_s\rangle - |\overline{B}_s\rangle\Big] & CP\text{–even} \\ |B_s^H\rangle = p|B_s\rangle + q|\overline{B}_s\rangle = \frac{1}{\sqrt{2}}\Big[|B_s\rangle + |\overline{B}_s\rangle\Big] & CP\text{–odd} \end{cases}$$

Phase convention: $CP|B_s\rangle = -|\overline{B}_s\rangle$

- statistically separate B_s^H from B_s^L using parity of the angular correlations in $B_s \to J/\psi\phi$ decay
- fit **distinct** lifetimes to B_s^H and B_s^L components
- **cross-check** the analysis by performing similar one on a $B_d \to J/\psi K^{*0}$ sample

Analysis of P→VV decays

$$B_d \to J/\psi K^{*0}$$
$$B_s \to J/\psi \phi$$
$J/\psi \to \mu\mu,\ \phi \to KK,\ K^{*0} \to K\pi$

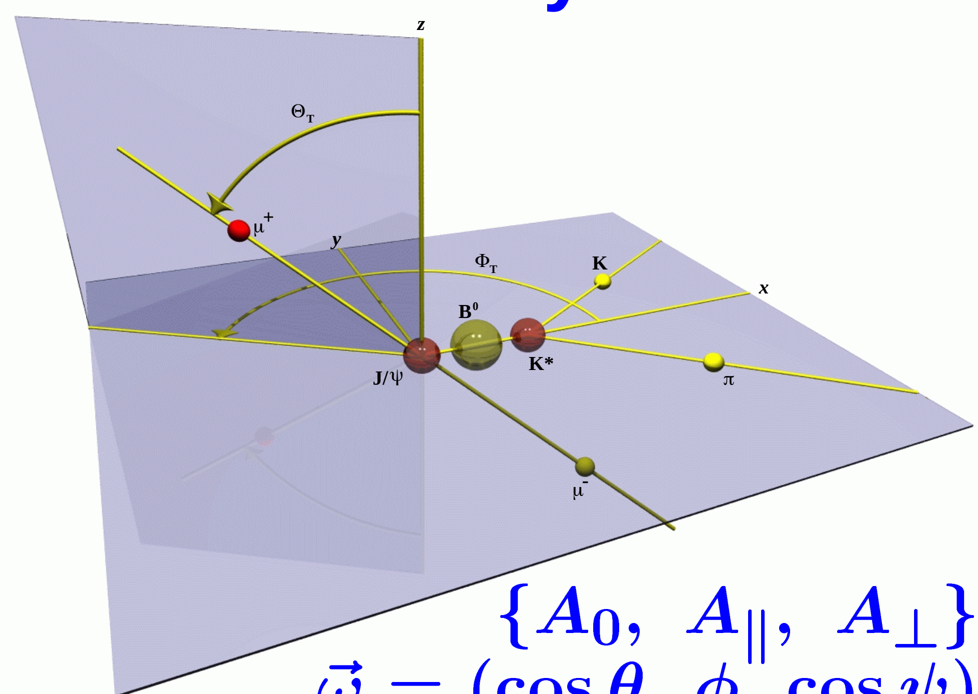
$$\begin{cases} Total & J = 0 \\ Spin & S = 0, 1, 2 \\ Orbital & L = 0, 1, 2 \end{cases}$$
$(S, P, D\ wave)$

Need three amplitudes to describe

$S, D\ wave = P-$even
$(CP-$even for $B_s)$
$P\ wave = P-$odd
$(CP-$odd for $B_s)$

Disentangle partial waves
$\Updownarrow$
isolate $|B_s^H\rangle$ from $|B_s^L\rangle$

Transversity basis



$$\{A_0,\ A_\parallel,\ A_\perp\}$$
$$\vec{\omega} = (\cos\theta,\ \phi,\ \cos\psi)$$

Angular analysis 1

time-dependent kind

$$\frac{d^4\mathcal{P}}{d\vec{\omega}\,dt} \propto |A_0|^2 \cdot g_1(t) \cdot f_1(\vec{\omega})$$
$$+|A_{\|}|^2 \cdot g_2(t) \cdot f_2(\vec{\omega})$$
$$+|A_{\perp}|^2 \cdot g_3(t) \cdot f_3(\vec{\omega})$$
$$\pm Im(A_{\|}^* A_{\perp}) \cdot g_4(t) \cdot f_4(\vec{\omega})$$
$$+Re(A_0^* A_{\|}) \cdot g_5(t) \cdot f_5(\vec{\omega})$$
$$\pm Im(A_0^* A_{\perp}) \cdot g_6(t) \cdot f_6(\vec{\omega})$$
$$\equiv \sum_{i=1}^{6} \mathcal{A}_i \cdot g_i(t) \cdot f_i(\vec{\omega})$$

$$\begin{aligned}
f_1(\vec{\omega}) &= 2\cos^2\psi(1-\sin^2\theta\cos^2\phi) \\
f_2(\vec{\omega}) &= \sin^2\psi(1-\sin^2\theta\sin^2\phi) \\
f_3(\vec{\omega}) &= \sin^2\psi\sin^2\theta \\
f_4(\vec{\omega}) &= -\sin^2\psi\sin 2\theta\sin\phi \\
f_5(\vec{\omega}) &= \frac{1}{\sqrt{2}}\sin 2\psi\sin^2\theta\sin 2\phi \\
f_6(\vec{\omega}) &= \frac{1}{\sqrt{2}}\sin 2\psi\sin 2\theta\cos\phi
\end{aligned}$$

$g_i(t)$ different for B_d and B_s and are rather non-trivial

A. Dighe et. al., Eur. Phys. J. C 6, 647-662

Angular analysis 2

time-dependent kind

$B_s \to J/\psi\phi$:

$$\frac{d^4\mathcal{P}}{d\vec{\omega}\,dt} \propto |A_0|^2 \cdot e^{-\Gamma_L t} \cdot f_1(\vec{\omega}) + |A_\parallel|^2 \cdot e^{-\Gamma_L t} \cdot f_2(\vec{\omega}) + |A_\perp|^2 \cdot e^{-\Gamma_H t} \cdot f_3(\vec{\omega}) + Re(A_0^* A_\parallel) \cdot e^{-\Gamma_L t} \cdot f_5(\vec{\omega})$$

- flavor blind decay
  - $\pm Im(\ldots)$ terms average out

$B_d \to J/\psi K^{*0}$:

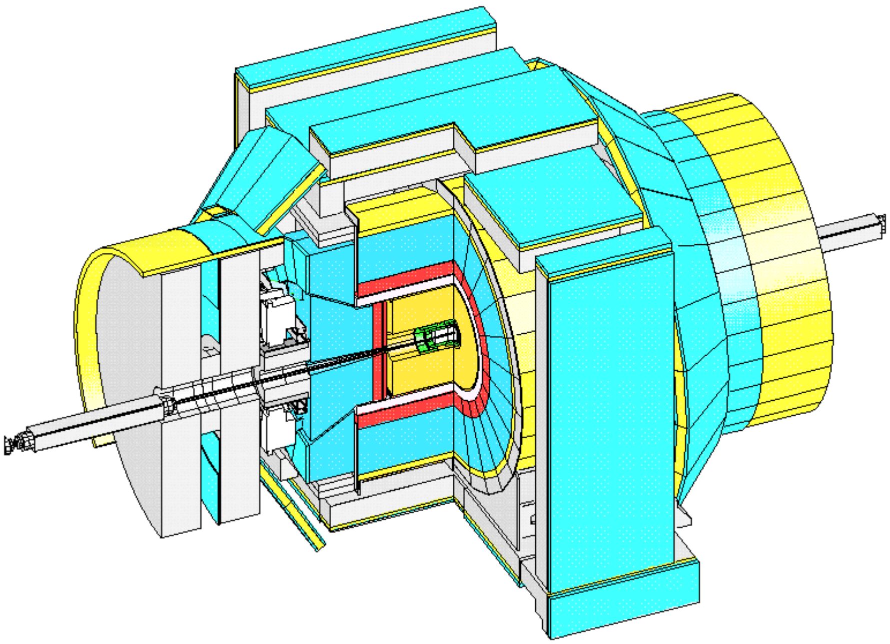
$$\frac{d^4\mathcal{P}}{d\vec{\omega}\,dt} \propto \left\{ |A_0|^2 \cdot f_1(\vec{\omega}) + |A_\parallel|^2 \cdot f_2(\vec{\omega}) + |A_\perp|^2 \cdot f_3(\vec{\omega}) \pm Im(A_\parallel^* A_\perp) \cdot f_4(\vec{\omega}) + Re(A_0^* A_\parallel) \cdot f_5(\vec{\omega}) \pm Im(A_0^* A_\perp) \cdot f_6(\vec{\omega}) \right\} \cdot e^{-\Gamma_d t}$$

- flavor specific decay
  - no linear sensitivity to $\Delta\Gamma$

Use these to extract A_0, $A_\parallel$, $A_\perp$, and $\Gamma_{(L,H)}$ from data

(set $arg(A_0) = 0$)

2. Measurement



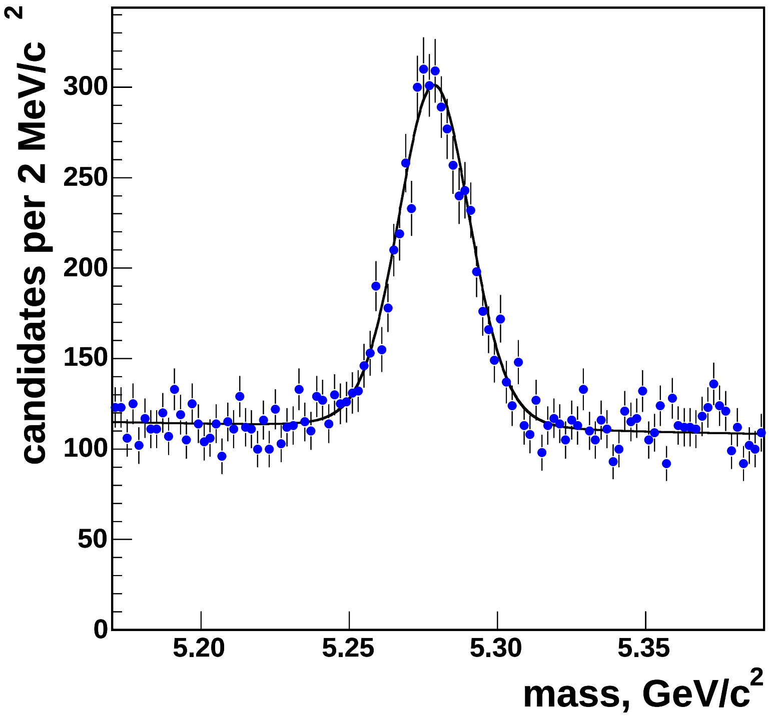
$J/\psi \to \mu^+\mu^-$ trigger
to collect samples of:

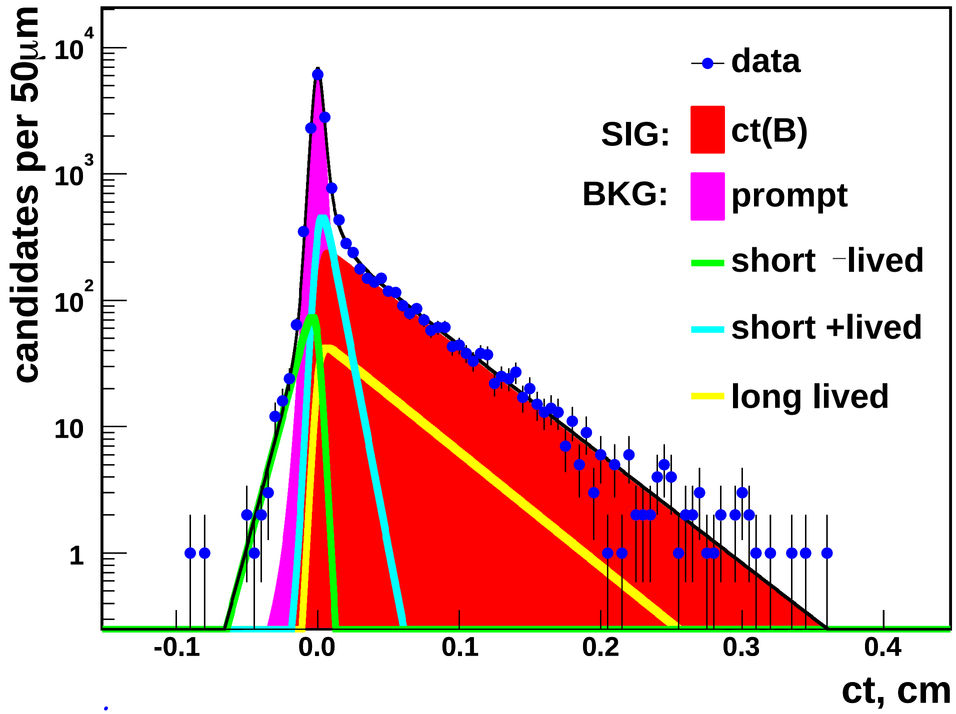
- $B_u \to J/\psi K^+$
- $B_d \to J/\psi K^{*0}$
- $B_s \to J/\psi \phi$

$260\,\mathrm{pb}^{-1}$ of data

- B candidate:
  $\{(m, \sigma_m), (ct, \sigma_{ct}), \vec{\omega}\}$
  - m – separate signal from background
  - ct – lifetime fit + addt-l S/B separation
  - $\vec{\omega}$ – angular analysis
- cross-checks in other B samples:
  - models
  - techniques

Modeling m and ct





$F_m^{sig}(m_i, \sigma_{m_i} | M, S_m)$,

$F_m^{bkg}(m_i | A)$

Gauss(m)+Pol$_1$(m)

$F_{ct}^{sig}(ct_i, \sigma_{ct_i} | c\tau_B, S_{ct})$,

$F_{ct}^{bkg}(ct_i, \sigma_{ct_i} | f_-, f_+, f_{++}, \lambda_-, \lambda_+, \lambda_{++}, S_{ct})$

$\delta \otimes$Gauss(ct)+$\sum_n$ Exp$_n \otimes$Gauss(ct)

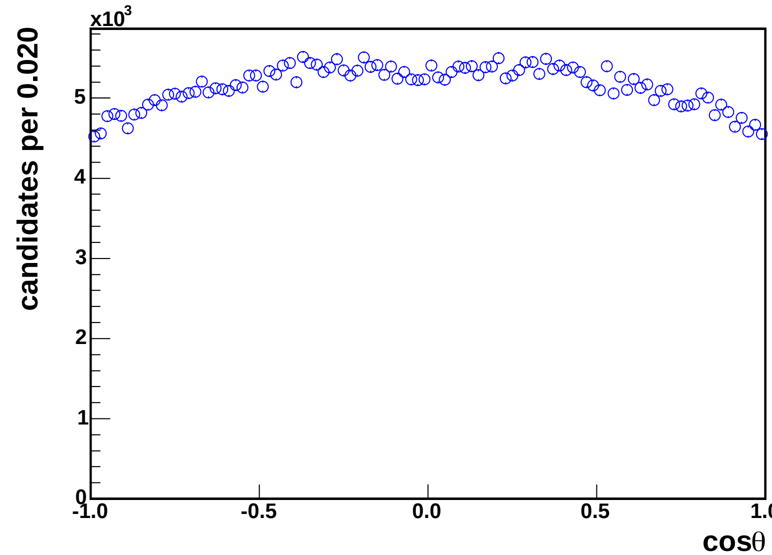
$$f(m_i, \sigma_{m_i}, ct_i, \sigma_{ct_i}, \vec{\omega}_i | \overrightarrow{\text{parameters}}) = f_s\, F_m^{sig}\, F_{ct}^{sig}\, F_{\vec{\omega}}^{sig} + (1 - f_s)\, F_m^{bkg}\, F_{ct}^{bkg}\, F_{\vec{\omega}}^{bkg}$$

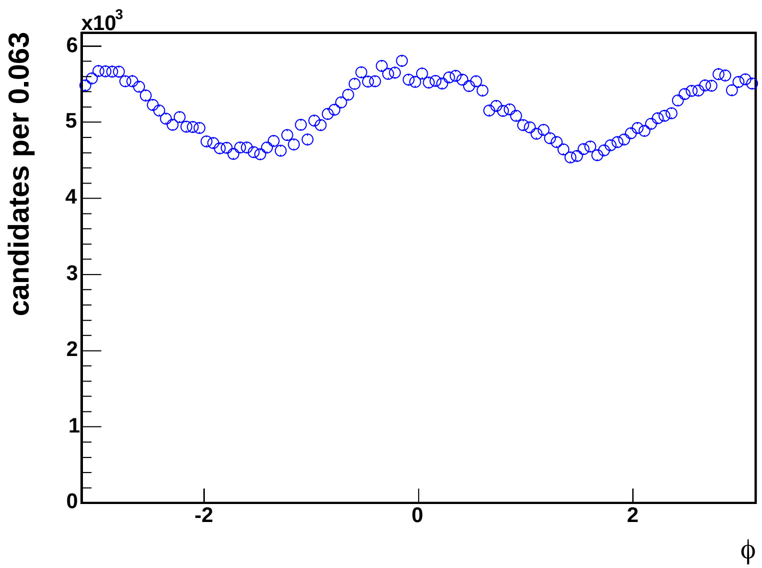
$$\mathcal{L} = -2\, log \prod_i f(m_i, \sigma_{m_i}, ct_i, \sigma_{ct_i}, \vec{\omega}_i | \overrightarrow{\text{parameters}})$$

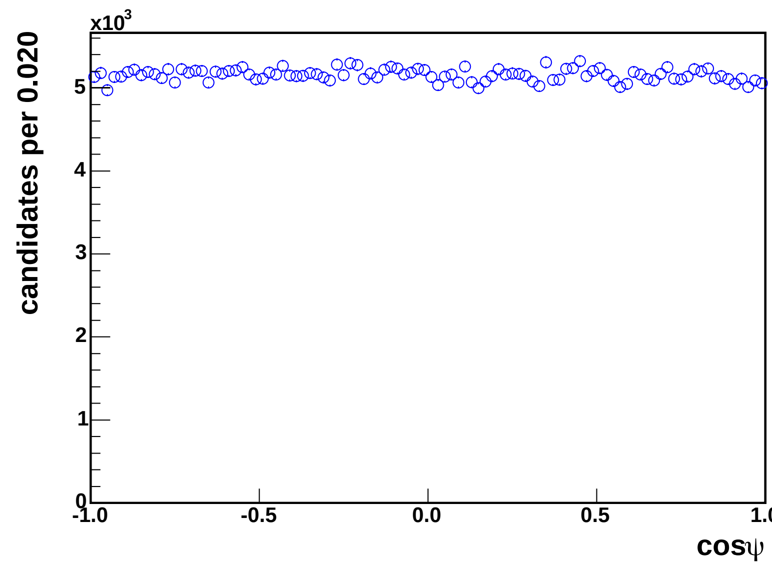
Modeling $\vec{\omega}$ – sculpting 1

	m	ct	$\vec{\omega}$
smearing	yes	yes	no
distortion	no	no	yes

Plots show angular distributions from $B_s \to J/\psi\phi$ **Monte Carlo sample generated according to phase-space (flat)**







Modeling $\vec{\omega}$ – sculpting 2

$$\Omega^{true}(\vec{\omega}\,|\{\mathcal{A}_i\}) = \sum_{i=1}^{6} \mathcal{A}_i f_i(\vec{\omega}) \longrightarrow$$

$$\Omega^{obs}(\vec{\omega},\, \vec{\kappa}\,|\{\mathcal{A}_i\}) = \sum_{i=1}^{6} \mathcal{A}_i f_i(\vec{\omega}) V(\vec{\kappa})\epsilon(\vec{\omega},\, \vec{\kappa})/\langle\epsilon\rangle,$$

$$\langle\epsilon\rangle = \iint_{\vec{\omega},\vec{\kappa}} d\vec{\omega}\, d\vec{\kappa}\, \Omega^{obs}(\vec{\omega}\, \vec{\kappa}|\{\mathcal{A}_i\}) = \sum_{i=1}^{6} \mathcal{A}_i \underbrace{\iint_{\vec{\omega},\vec{\kappa}} d\vec{\omega}\, d\vec{\kappa}\, f_i(\vec{\omega}) V(\vec{\kappa})\epsilon(\vec{\omega},\vec{\kappa})}_{\xi_i,\ \text{by MC}}$$

$$\equiv \sum_{i=1}^{6} \mathcal{A}_i \xi_i \quad \longleftarrow \quad \xi_i = \frac{1}{N^{rec}_{MC}} \sum_{j=1}^{N^{rec}_{MC}} f_i(\vec{\omega}_j)$$

backup slides show Data/MC comparison

$$\log\mathcal{L} = \log \prod_{j=1}^{N} \{\Omega^{obs}(\vec{\omega}_j, \vec{\kappa}_j\,|\{\mathcal{A}_i\})\} = \sum_{j=1}^{N} \log\left\{\sum_{i=1}^{6} \mathcal{A}_i f_i(\vec{\omega}_j)\right\}$$

$$- \sum_{j=1}^{N} \log\left\{\sum_{i=1}^{6} \mathcal{A}_i \xi_i\right\} + \sum_{j=1}^{N} \overset{\text{const}}{\cancel{\log\{V(\vec{\kappa})\epsilon(\vec{\omega}_j, \vec{\kappa}_j)\}}}$$

Modeling $\vec{\omega}$ – sculpting 3
does it work this way?

YES, IT DOES!

Indeed, no need to parametrize/integrate the acceptance

note:

$\xi_{1,2,3} \gg |\xi_5| > |\xi_{4,6}| \simeq 0$

i	$\xi_i^{B_s}$	$\xi_i^{B_d}$
1	3.81e-02	3.48e-02
2	4.06e-02	4.23e-02
3	4.07e-02	4.27e-02
5	-7.43e-05	-7.26e-04

Monte Carlo tests:

B_s prm.	input	fit result	diff., σ
$\|A_0\|^2$	0.5625	0.5627 ± 0.0019	0.0
$\|A_\parallel\|^2$	0.2025	0.2048 ± 0.0029	$+0.8$
$arg(A_\parallel)$	2.0	1.980 ± 0.014	-1.4
$c\tau_L$, μm	330.0	332.1 ± 1.4	$+1.5$
$\Delta\Gamma/\Gamma$, %	50.0	49.6 ± 0.9	-0.4
N_{sig}		132129	

B_d prm.	input	fit result	diff., σ
$\|A_0\|^2$	0.597	0.5912 ± 0.0020	-2.9
$\|A_\parallel\|^2$	0.243	0.2469 ± 0.0030	$+1.3$
$arg(A_\parallel)$	2.5	2.5356 ± 0.0170	$+2.1$
$arg(A_\perp)$	-0.17	-0.1743 ± 0.0128	-0.3
N_{sig}		132866	

3. Results

Avg. lifetime measurements

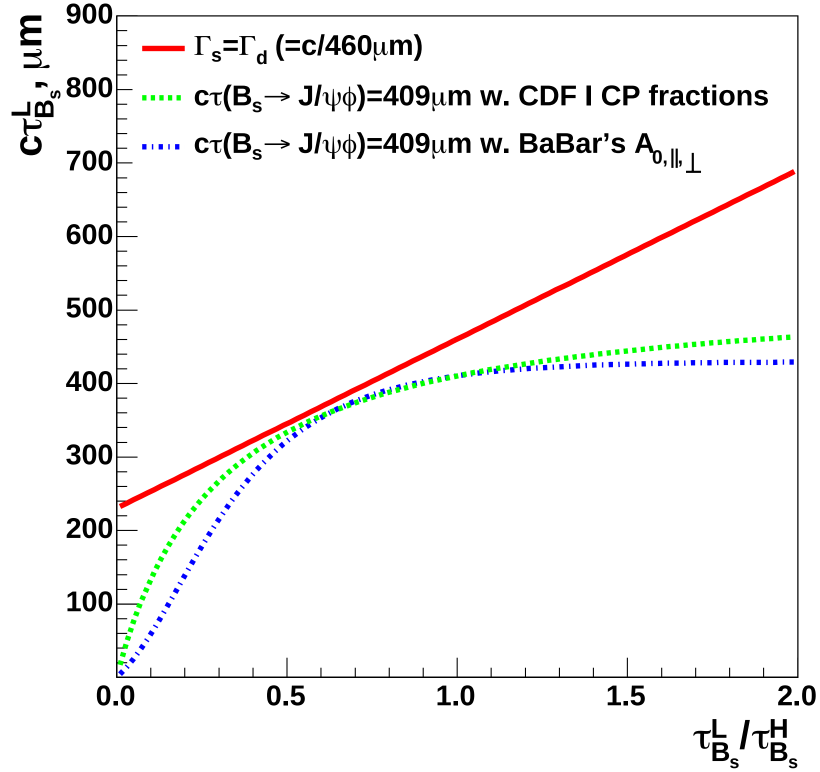
$\tau_{B_u} = (1.659 \ \pm 0.033 \ ^{+0.007}_{-0.008})$ ps

PDG'04: $\tau_{B_u} = (1.671 \pm 0.018)$ ps

$\tau_{B_d} = (1.549 \ \pm 0.051 \ ^{+0.007}_{-0.008})$ ps

PDG'04: $\tau_{B_d} = (1.536 \pm 0.014)$ ps

$\tau_{B_s} = (1.363 \ \pm 0.100 \ ^{+0.007}_{-0.010})$ ps



➜ τ_{B_u} and τ_{B_d} are in excellent agreement with PDG

➜ τ_{B_s} indicative of large $\Delta\Gamma_s$:

– $\frac{2c\tau_H\tau_L}{\tau_H+\tau_L} = 460\ \mu\text{m}\ (\Gamma_s = \Gamma_d)$

– $0.23c\tau_H + 0.77c\tau_L = 409\ \mu\text{m}$ (CDF I)

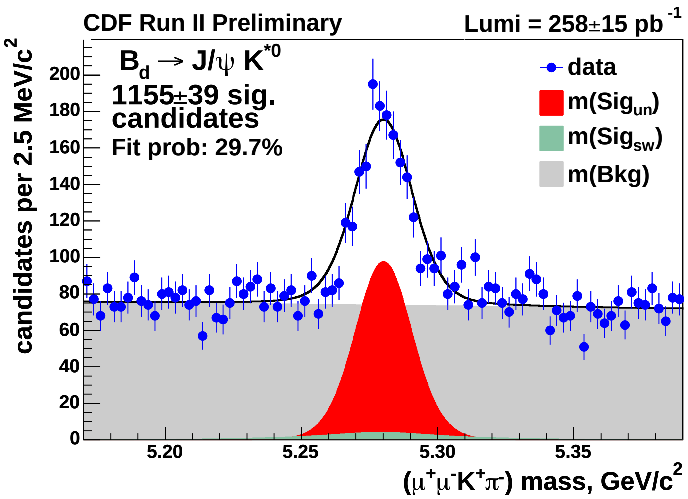
– $\frac{0.16\tau_H}{0.16\tau_H+0.84\tau_L}c\tau_H + \frac{0.84\tau_L}{0.16\tau_H+0.84\tau_L}c\tau_L = 409\ \mu\text{m}$ (SU(3))

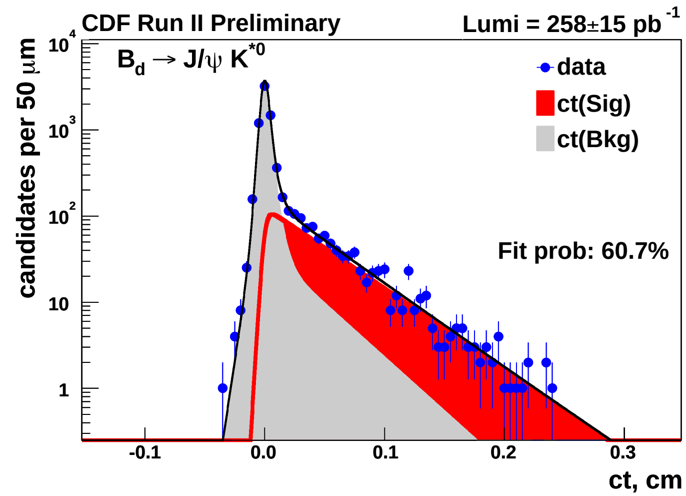
t-dep. angular analysis
fit results

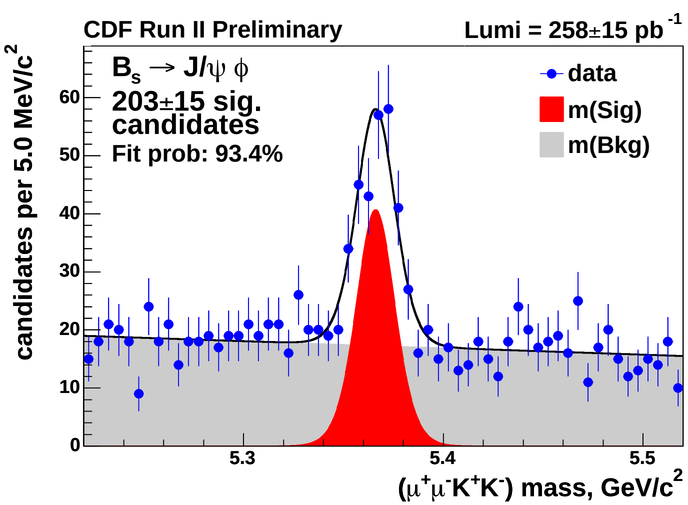
Parameter	Nominal fit	Constrained fit	Unit
M_{B_s}	5366.1 ± 0.8	5366.1 ± 0.8	MeV/c^2
$\lvert A_0\rvert^2$	0.615 ± 0.064	0.614 ± 0.064	
$\lvert A_\parallel\rvert^2$	0.260 ± 0.086	0.291 ± 0.080	
$\lvert A_\perp\rvert^2$	0.125 ± 0.066	0.095 ± 0.052	
$\lvert A_0\rvert$	0.784 ± 0.039	0.783 ± 0.038	
$\lvert A_\parallel\rvert$	0.510 ± 0.082	0.539 ± 0.070	
$\lvert A_\perp\rvert$	0.354 ± 0.098	0.308 ± 0.087	
$arg(A_\parallel)$	1.93 ± 0.36	1.90 ± 0.32	
$c\tau_L$	$316\ ^{+48}_{-40}$	$340\ ^{+40}_{-28}$	μm
$c\tau_H$	$622\ ^{+175}_{-138}$	$713\ ^{+167}_{-129}$	μm
$c\tau_s$	$419\ ^{+45}_{-38}$	460.8 ± 6.4	μm
$\Delta\Gamma_s/\Gamma_s$	$65\ ^{+25}_{-33}$	$71\ ^{+24}_{-28}$	%
$\Delta\Gamma_s$	$0.47\ ^{+0.19}_{-0.24}$	0.46 ± 0.18	ps^{-1}
N_{sig}	203 ± 15	201 ± 15	

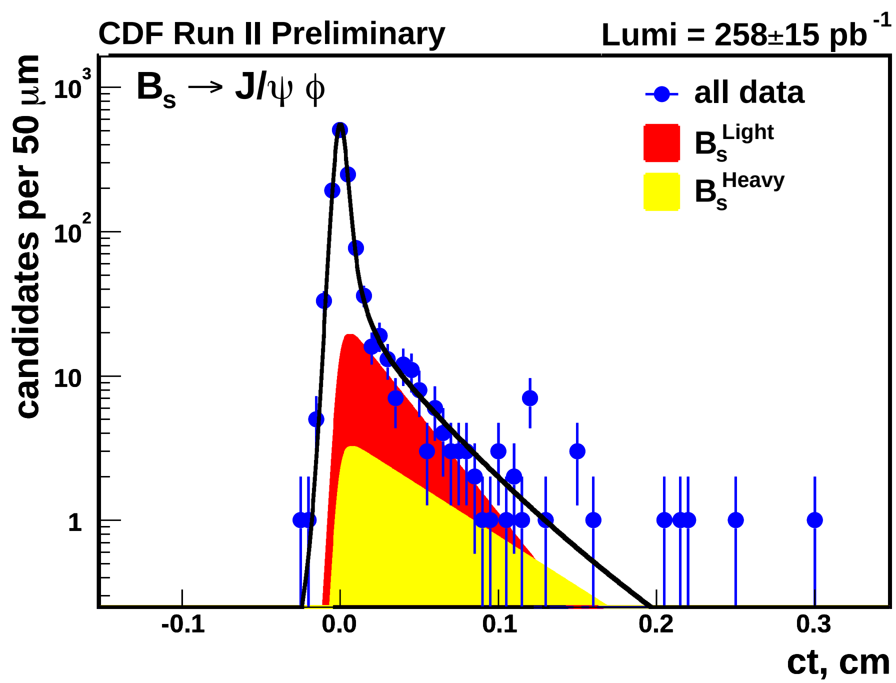
Use
$\Gamma_s/\Gamma_d = 1.00 \pm 0.01$,
i.e.
$\tau_s \equiv \frac{2\tau_H\tau_L}{\tau_H+\tau_L} = \tau_d$
within 1%

Fit projections 1

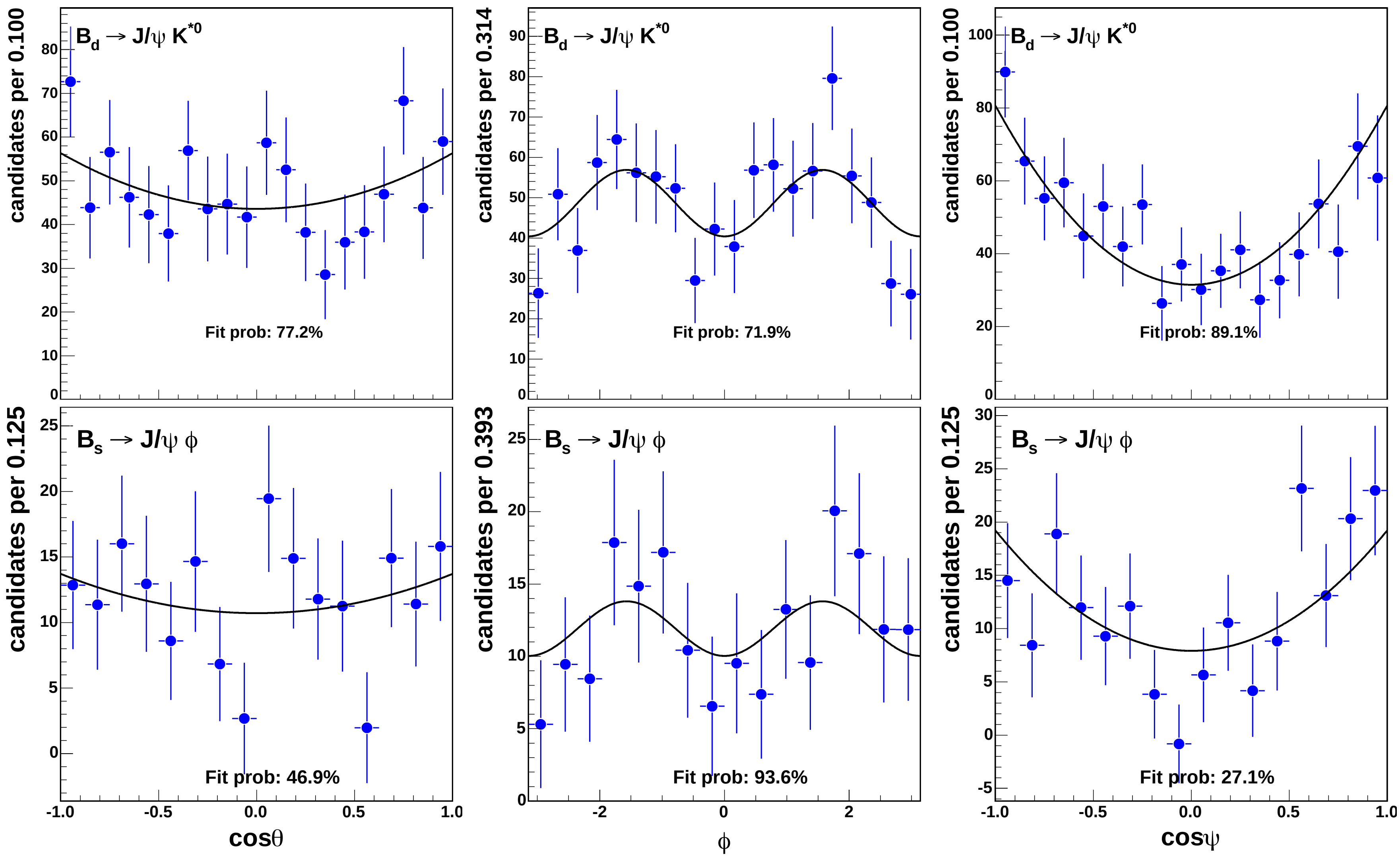








Fit projections 2



side-band subtracted, sculpting corrected signal. $ct > 0$ cut applied

Cross-checks

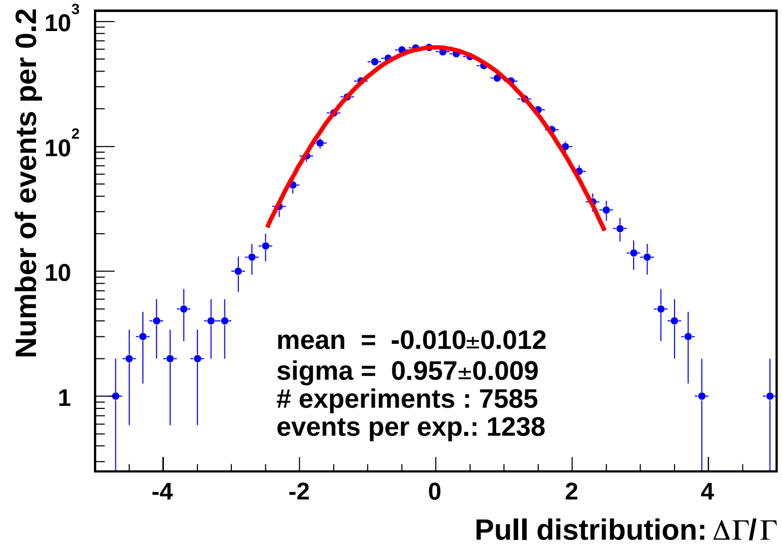
1. "$\Delta\Gamma/\Gamma$" from B_d

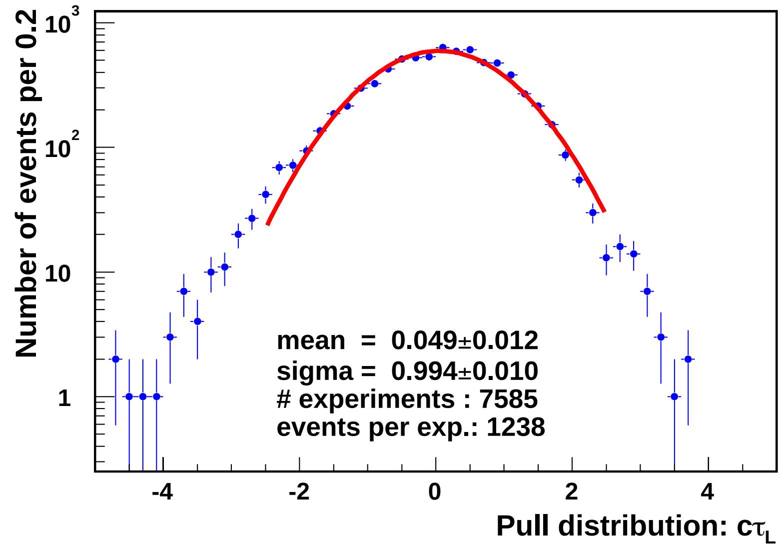
B_d sample	$\Delta\Gamma/\Gamma$, %	$c\tau_{(L)}$, μm
Full, one $c\tau$	——	461 ± 15
Full	14.5 ± 12.1	444 ± 21
Sub-sample 1	13.7 ± 27.9	422 ± 34
Sub-sample 2	25.1 ± 22.3	437 ± 39
Sub-sample 3	26.1 ± 23.0	437 ± 50
Sub-sample 4	-7.6 ± 27.6	475 ± 41

2. $f_{CP_{odd}}$ vs. ct cut

cut, μm	B_s: fitted $f_{CP_{odd}}$, %	B_s: pred. $f_{CP_{odd}}$, %	B_d: fitted $f_{P_{odd}}$, %
0	20.1 ± 9.0	$-20.1-$	21.6 ± 4.4
150	24.2 ± 10.3	24.1	23.0 ± 3.6
300	29.6 ± 12.7	28.6	23.0 ± 4.0
450	38.7 ± 11.6	33.6	23.6 ± 4.9

3. Pulls





Systematic uncertainty
summary

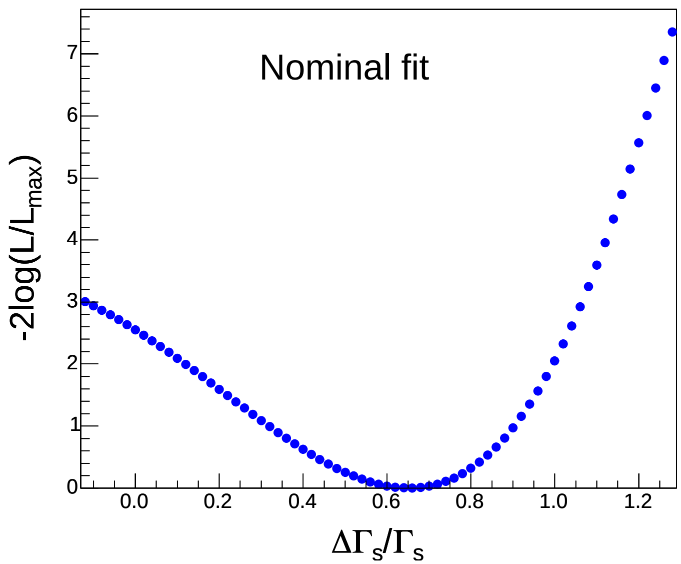
B_d	$c\tau$, μm	$\lvert A_0\rvert^2$	$\lvert A_\parallel\rvert^2$	$\lvert A_\perp\rvert^2$	$arg(A_\parallel)$	$arg(A_\perp)$
Bkg. angular model	±3.9	±0.013	±0.006	±0.007	±0.01	±0.01
Eff. and acc.	—	—	—	—	—	—
$K \leftrightarrow \pi$ swap	—	±0.006	±0.004	±0.002	±0.04	—
Non-resonant decays	—	±0.010	±0.001	±0.003	±0.07	±0.04
Lft. fit model	±1.7	—	—	—	—	—
SVX alignment	±1.0	—	—	—	—	—
Detector bias	-1.2	—	—	—	—	—
B_s cross feed	—	—	—	—	—	—
Total	${}^{+4.4}_{-4.6}$	±0.017	±0.007	±0.007	±0.08	±0.04

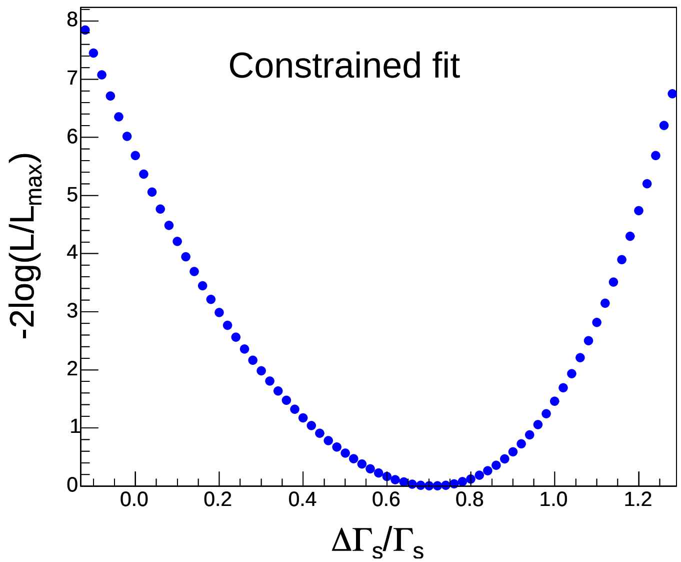
B_s	$c\tau_L$, μm	$\Delta\Gamma/\Gamma$	$\lvert A_0\rvert^2$	$\lvert A_\parallel\rvert^2$	$\lvert A_\perp\rvert^2$	$arg(A_\parallel)$
Bkg. angular model	±3.7	±0.007	±0.011	±0.013	±0.002	±0.03
Eff. and acc.	—	—	—	—	—	—
Unequal # B_s,$\bar{B}_s$	—	—	—	—	—	—
Lft. fit model	±1.7	—	—	—	—	—
SVX alignment	±1.0	—	—	—	—	—
Detector bias	-1.2	—	—	—	—	—
B_d cross feed	-5.0	±0.008	—	±0.003	±0.003	—
Total	${}^{+4.2}_{-6.7}$	±0.011	±0.011	±0.013	±0.004	±0.03

Final results

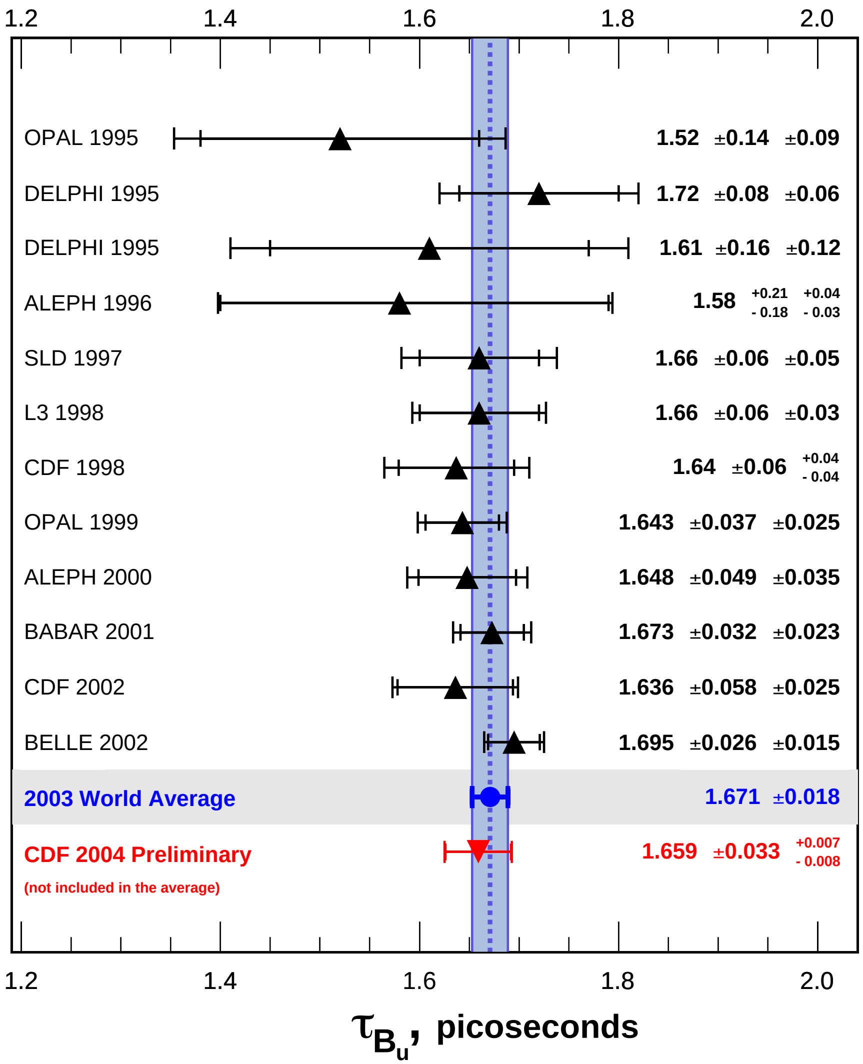
$$
\begin{aligned}
|A_0|^2 &= 0.615 \pm 0.064 \pm 0.011 \\
|A_\parallel|^2 &= 0.260 \pm 0.086 \pm 0.013 \\
|A_\perp|^2 &= 0.125 \pm 0.066 \pm 0.004 \\
arg(A_\parallel) &= 1.93 \pm 0.36 \pm 0.03 \\
\tau_L &= (1.05\ {}^{+0.16}_{-0.13} \pm 0.02)\ \text{ps} \\
\tau_H &= (2.07\ {}^{+0.58}_{-0.46} \pm 0.03)\ \text{ps} \\
\Delta\Gamma/\Gamma &= 0.65\ {}^{+0.25}_{-0.33} \pm 0.01 \\
\Delta\Gamma &= (0.47\ {}^{+0.19}_{-0.24} \pm 0.01)\ \text{ps}^{-1}
\end{aligned}
$$

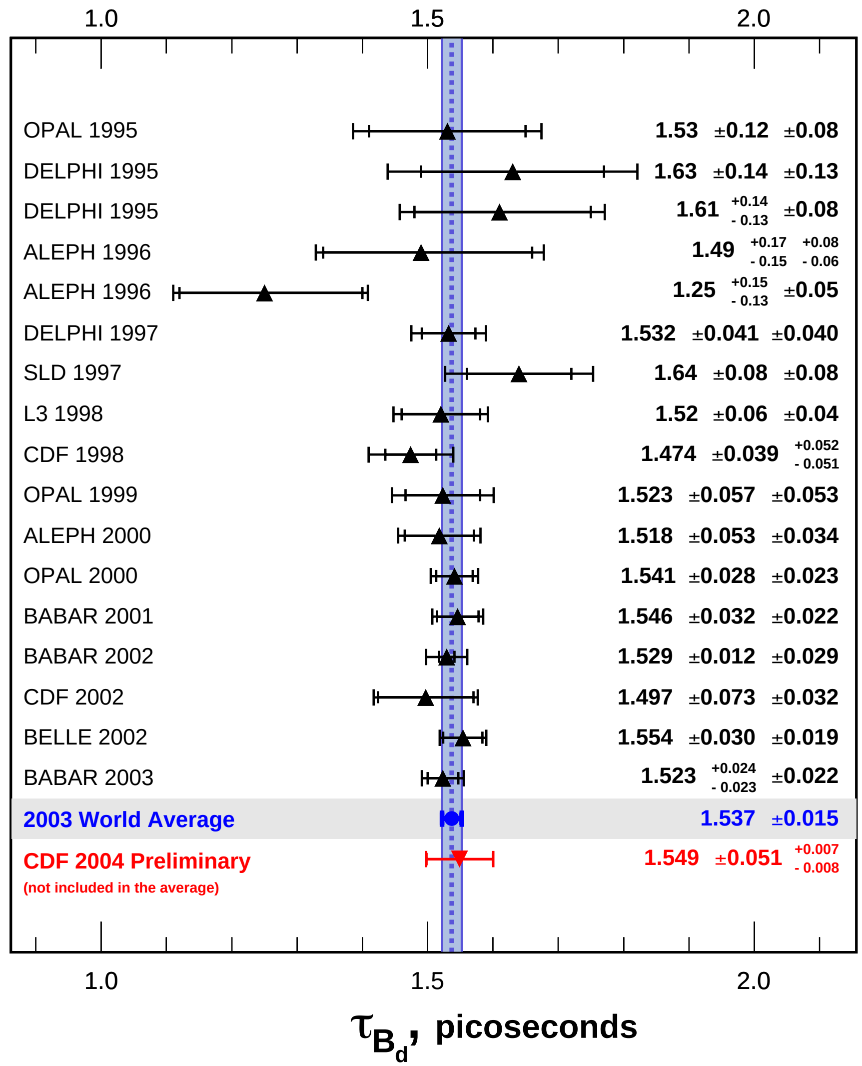
	Nominal fit		Constr. fit	
Input $\Delta\Gamma_s/\Gamma_s$	0.0	0.12	0.0	0.12
$\#(\Delta\Gamma_s/\Gamma_s > 0.65)$	20	94	—	—
$\#(\Delta\Gamma_s/\Gamma_s > 0.71)$	—	—	27	54
Betting odds, 1 in	335	75	300	149
Equiv. Gaussian significance, σ	2.75	2.21	2.72	2.48





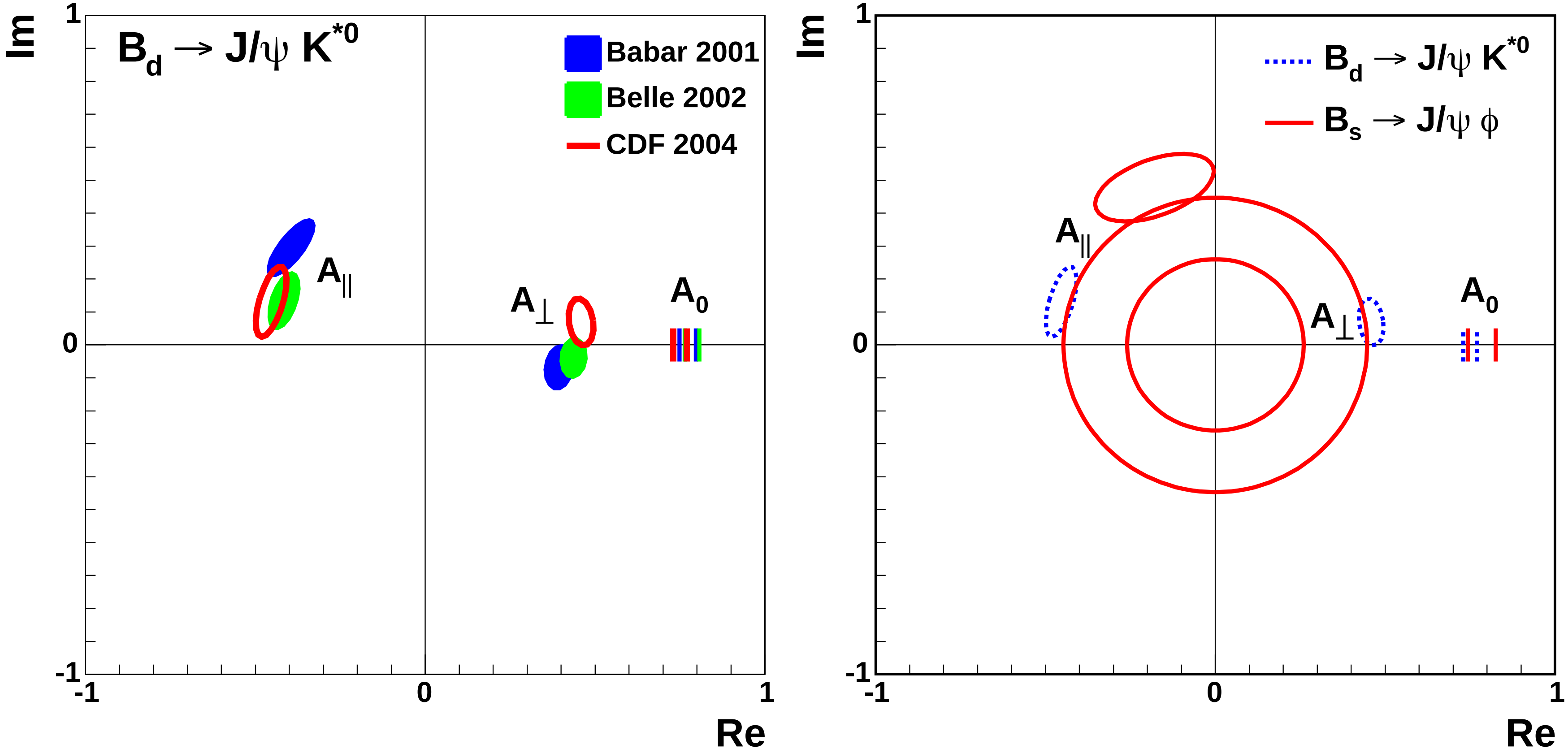
Comparison 1





CDF can do lifetimes (exceptionally) well

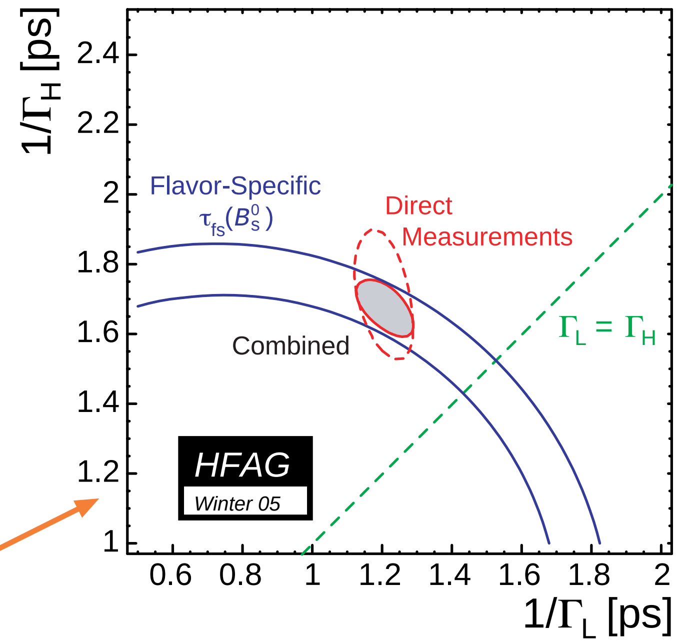
Comparison 2



CDF can do amplitudes very well too
and even see some SU(3) symmetry :o)

Summary

- **Measurement of $\Delta\Gamma_s/\Gamma_s$:**
  - PRL 94 101803 (2005)
  - a lot of excitement in the community and even some controversy
  - additional motivation for measurements of ΔM_s, τ_s^{fsp}, $Br(B_s \to D_s^{(*)+} D_s^{(*)-})$
  - more careful averaging of B_s lifetime measurements

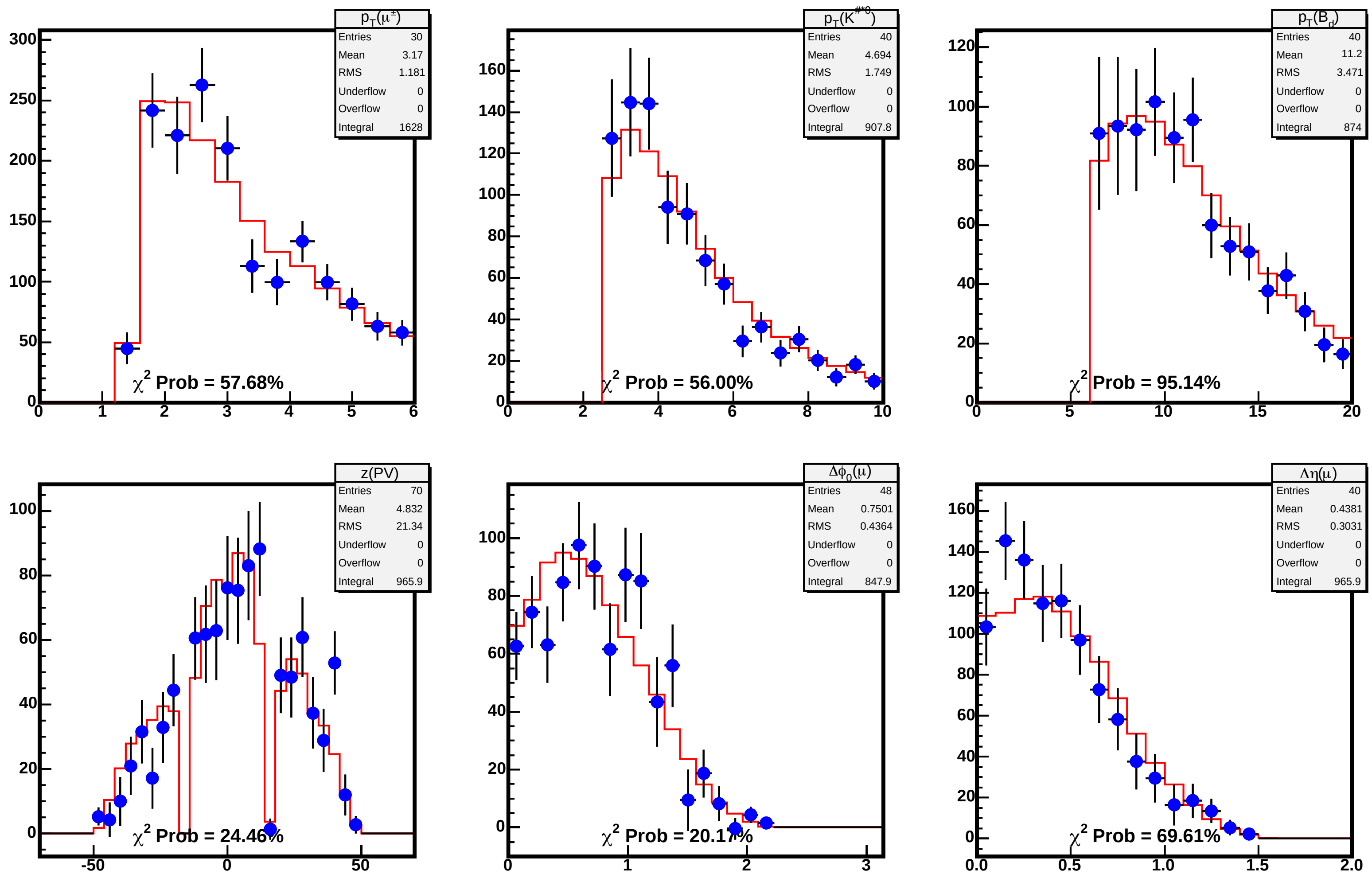


- **Don't stop here!**
  - improve technique
  - get better precision with more statistics
  - use alternative methods and combine results

BACKUP SLIDES

MC-Data agreement 1

know for B_u • check for B_d • assume for B_s



MC-Data agreement 2