MEASUREMENT OF THE ANGLE $\phi_1(\beta)$ AND $B\bar{B}$ MIXING
(RECENT RESULTS FROM BaBar AND Belle)

Kazuo Abe
KEK, Tsukuba, Japan 305-0801

ABSTRACT
Recent results from BaBar and Belle experiments on $B\bar{B}$ mixing and $\sin 2\phi_1$ are presented. Accuracy of $\Delta m_d$ measurements has reached 1.2%. Higher order effects within the Standard Model or possible new physics effect that might appear in the $B\bar{B}$ mixing through non-zero $\Delta \Gamma / \Gamma$, $CP$ violation, or $CPT$ violation have been explored. The BaBar and Belle results on $\sin 2\phi_1$ from the $b \to c\bar{c}s$ modes are in good agreement with each other and a combined result with an accuracy of 8% is in good agreement with a global CKM fit. A simple average of the $\sin 2\phi_1$ values that were measured in the penguin-loop dominated decay modes, $\phi K_S$, $\eta' K_S$, and $K^+ K^- K_S$, shows about 2.5$\sigma$ deviation from the Standard Model.
A scheme of producing $\Upsilon(4S)$ in an asymmetric-energy $e^+e^-$ collision, that is used at PEP-II and KEKB, enables separation of the decay vertices of the two $B$ mesons. PEP-II operates at 9 GeV $e^- \times 3.1$ GeV $e^+$ corresponding to $\Delta z \simeq 260 \mu m$, while KEKB operates at 8 GeV $e^- \times 3.5$ GeV $e^+$ corresponding to $\Delta z \simeq 200 \mu m$. Since the size of interaction region in the $z$ direction is much larger than these $\Delta z$ ($\sim 7 \text{mm}$ at KEKB), the reference of the proper time must be the decay point of the other $B$ (See Fig. 1). Conservation of charge-conjugation in the $\Upsilon(4S) \rightarrow B^0\bar{B}^0$ decay forces

$$e^-e^+ \rightarrow \Upsilon(4S) \rightarrow B\bar{B}$$

the time structure of $B\bar{B}$ system to stay as $\psi(t) = |B^0> + |\bar{B}^0> - |\bar{B}^0> > |B^0>$ at any $t$ until one $B$ meson decays. This feature is used to determine the flavor of the reconstructed $B$ at $\Delta t = 0$.

\section{B\bar{B} Mixing}

Mass and flavor eigenstates of the neutral $B$ meson states are expressed by

$$| B_1 > = p \ | B^0 > + q \ | \bar{B}^0 > , \quad | B_2 > = p \ | B^0 > - q \ | \bar{B}^0 > .$$

Well defined time dependence of $(B_1, B_2)$ and flavor-specific decays of $(B^0, \bar{B}^0)$ lead to the $B^0\bar{B}^0$ oscillation. Probabilities of observing the two $B$ mesons as having the opposite-flavor (OF) or having the same-flavor (SF) at $\Delta t$ are expressed by

$$P_{\text{OF}} \propto e^{-|\Delta t/\tau_{B^0}|} [1 + \cos(\Delta m_{d} \Delta t)] , \quad P_{\text{SF}} \propto e^{-|\Delta t/\tau_{B^0}|} [1 - \cos(\Delta m_{d} \Delta t)] .$$

The mixing parameters can be obtained either by reconstructing one $B$ in flavor-specific modes such as $D^{(*)}\pi$, $D^{(*)}\rho$, $D^{(*)}\ell\nu$, and flavor-tagging the other $B$ using information of remaining tracks in the event, or by using dilepton events. For the sin $2\phi_1$ measurement, we reconstruct one $B$ as $CP$ eigenstates such as $J/\psi K_S$. The OF-SF asymmetries that were measured by Belle \cite{1} and BaBar \cite{2} are shown in

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure1.png}
\caption{Schematical drawing of $e^+e^- \rightarrow \Upsilon(4S) \rightarrow B\bar{B}$ process at PEP-II and KEKB.}
\end{figure}
Fig. 2: Belle $\Delta m_d$ measurements based on 32 million $B\bar{B}$. From left to right, dileptons, semileptonic decays, hadronic decays, and partially reconstructed $D^*\pi$ decays.

Fig. 3: BaBar $\Delta m_d$ measurements. From left to right, dileptons (23M $B\bar{B}$), semileptonic decays (23M $B\bar{B}$), hadronic decays (32M $B\bar{B}$).

3 $B\bar{B}$ mixing in Standard Model

In the Standard Model, box-diagram is responsible for $B\bar{B}$ mixing, and expressed as $\Delta m_d = m_H - m_L = 2|M_{12}|$ where

$$M_{12} = -\frac{G_F^2 m_W^2 \eta_B m_B B f_B^2}{12\pi^2} S_0(m_t^2/m_W^2)(V_{td}^* V_{tb})^2.$$  \hspace{1cm} (3)

Here $B_1$ and $B_2$ are redefined as $B_H$ and $B_L$. Extraction of $|V_{td}|$ from $\Delta m_d$ is dominated by a large uncertainty in $f_B \sqrt{B_{B_d}} = 230 \pm 40$ MeV. Improved lattice QCD calculations and $\Delta m_s$ measurements are awaited.

The mixing also has an absorptive part $\Delta \Gamma = \Gamma_L - \Gamma_H = 2|\Gamma_{12}|$, which is tiny in the Standard Model.

$$\left|\frac{\Gamma_{12}}{M_{12}}\right| \sim \frac{\Delta \Gamma}{\Gamma} \sim \frac{3\pi}{2} \frac{m_b^2}{m_W^2} S_0(m_t^2/m_W^2) \frac{1}{S_0(m_t^2/m_W^2)} \sim 5 \times 10^{-3}(\pm 30\%).$$  \hspace{1cm} (4)
Figure 4: Present status of $\Delta m_d$ measurements.

Any deviation will be difficult to explain in the Standard Model, which of course makes this measurement very interesting. For non-zero $\Delta \Gamma$, the time-dependent decay rates for the flavor-specific state ($B \to f(\bar{f})$) must be modified as

$$[1 \pm \cos(\Delta m_d \Delta t)] \to \left[ \cosh \frac{\Delta \Gamma \Delta t}{2} \pm \cos(\Delta m \Delta t) \right]$$

while for $CP$ eigenstate ($B^0 \to f_{CP}$, $CP$-even ($CP$-odd)), it must be modified as

$$[1 \pm \sin 2\phi_1 \sin(\Delta m_d \Delta t)] \to \left[ \cosh \frac{\Delta \Gamma_d \Delta t}{2} \mp \cos 2\phi_1 \sinh \frac{\Delta \Gamma_d \Delta t}{2} \pm \sin 2\phi_1 \sin(\Delta m \Delta t) \right].$$

$CP$ violation in the $B\bar{B}$ mixing leads to $|q/p| \neq 1$ and it is related to $\Gamma_{12}$ and $M_{12}$ as

$$1 - |\frac{q}{p}|^2 \simeq Im \left( \frac{\Gamma_{12}}{M_{12}} \right).$$

In the Standard Model, $|q/p|$ is less than $10^{-3}$ because $|\Gamma_{12}/M_{12}| \sim 5 \times 10^{-3}$ and $\phi_{M_{12}} - \phi_{\Gamma_{12}} = \pi + O(m_c^2/m_b^2)$. Probabilities of observing the SF events are given for $++$ and $-$ combinations separately by $P_{++}^{SF} = |p/q|^2 \cdot P_{++}^{SF}$ and $P_{--}^{SF} = |q/p|^2 \cdot P_{--}^{SF}$. Thus a charge asymmetry in the SF events appears if $CP$ is violated.
CPT violation leads to $p \neq p'$ and/or $q \neq q'$ where the $B$ meson states are described by $|B_H \rangle = p |B^0 > + q |\overline{B}^0 >, \quad|B_L \rangle = p' |B^0 > - q' |\overline{B}^0 >$. We introduce variables $\theta$ and $\phi$ where $q/p = \tan(\frac{\theta}{2})e^{i\phi}$, and $q'/p' = \cot(\frac{\theta}{2})e^{i\phi}$. The time dependence of the OF decay is modified as

$$1 + \cos(\Delta m_d \Delta t) \to [1 + |\cos \theta|^2 + (1 - |\cos \theta|^2) \cos(\Delta m_d \Delta t) - 2i m(\cos \theta) \sin(\Delta m_d \Delta t)].$$

(8)

A time-dependent asymmetry in the OF events can appear if CPT is violated [4].

4 Results of $\Delta \Gamma/\Gamma$, $|q/p|$, $\cos \theta$

BaBar has performed a global fit to the fully reconstructed hadronic events from the $88M B\overline{B}$ sample and extracted $\Delta \Gamma/\Gamma$, $|q/p|$, $Re(\cos \theta)$, and $Im(\cos \theta)$ [5]. BaBar also obtained $|q/p|$ from the dilepton events in the $23M B\overline{B}$ sample [6]. Belle determined $Im(\cos \theta)$ and $Re(\cos \theta)$ using the dilepton events in the $32M B\overline{B}$ sample [1]. Results are summarized in Table 1.

Table 1: Results of $\Delta \Gamma/\Gamma$, $|q/p|$, $\cos \theta$. The parameter $z$ is equivalent to $\cos \theta$. $sgn(Re\lambda_{CP}) = +1$ in SM. $Re\lambda_{CP}/|\lambda_{CP}| \approx 0.672 \pm 0.068$.

| data         | variables           | result                  |
|--------------|---------------------|-------------------------|
| BaBar hadronic | $sgn(Re\lambda_{CP})\Delta \Gamma/\Gamma$ | $-0.008 \pm 0.037 \pm 0.018$ |
|              | $|q/p|$             | 1.029 \pm 0.013 \pm 0.011 |
|              | $Re\lambda_{CP}/|\lambda_{CP}| Re z$ | 0.014 \pm 0.035 \pm 0.034 |
|              | $Im z$              | 0.038 \pm 0.029 \pm 0.025 |
|              | $|q/p|$             | 0.998 \pm 0.005 \pm 0.007 |
| BaBar dileptons | $Im(\cos \theta)$  | 0.00 \pm 0.12 \pm 0.01  |
| Belle dileptons | $Re(\cos \theta)$  | 0.00 \pm 0.12 \pm 0.01  |

5 $\sin 2\phi_1$ from $J/\psi K_S$ and other $b \to c\bar{c}s$ decays

Asymmetry of time-dependent decay rates between $(B^0 \to f)$ and $(\overline{B}^0 \to \overline{f})$ for the final state $f = \overline{f} = f_{CP}$ is expressed by

$$a_f(t) = \frac{\Gamma(\overline{B}^0(t) \to \overline{f}) - \Gamma(B^0(t) \to f)}{\Gamma(\overline{B}^0(t) \to \overline{f}) + \Gamma(B^0(t) \to f)} = \frac{2Im\lambda_f}{|\lambda_f|^2 + 1} \sin(\Delta m t) + \frac{|\lambda_f|^2 - 1}{|\lambda_f|^2 + 1} \cos(\Delta m t).$$

(9)

Information of $CP$ violation is in a quantity $\lambda_f$. Namely $Im\lambda_f \neq 0$ results in mixing-assisted $CP$ violation, and $|\lambda_f| \neq 1$ results in direct $CP$ violation. The $\lambda_f$ is defined
as $\lambda_f = (q/p) \times <f|H|\bar{B}^0> / <f|H|B^0>$ where the $B\bar{B}$ mixing contribution is given by $q/p = (V_{tb}^*V_{td})/(V_{tb}V_{td}^*)$ which is equal to $e^{-2i\phi_1}$ in the Standard Model.

For the $J/\psi K_S$ final state (Fig. 5 followed by $K^0 \to K_S$), $\lambda$ is given by

$$\lambda(J/\psi K_S) = \frac{V_{tb}^*V_{td}}{V_{tb}V_{td}^*} \cdot \eta_{J/\psi K_S} \cdot \left( \frac{V_{cb}V_{cs}^*}{V_{cb}^*V_{cs}} \right) \cdot \left( \frac{V_{cd}V_{cs}^*}{V_{cd}^*V_{cs}} \right). \quad (10)$$

Here $\eta_f$ is $CP$ eigenvalue of the $f$ state. We obtain $\text{Im}\lambda(J/\psi K_S) = \sin 2\phi_1$ and $\text{Im}\lambda(J/\psi K_L) = -\sin 2\phi_1$.

![Diagram for $B^0 \to J/\psi K_S$.](image)

Methods for the event selections are given in detail in references [7] and [8]. The results presented here are based on the data set of $88M B\bar{B}$ for BaBar and $85M B\bar{B}$ for Belle. Both group used $J/\psi K_S$, $\psi' K_S$, $\chi_{c1} K_S$, $\eta_c K_S$, $J/\psi K^*$, and $J/\psi K_L$ final states. Except for the $J/\psi K_L$ final state, the candidate events peak in the mass distributions for reconstructed $B$ mesons. For the $J/\psi K_L$ events, two-body decay of $B$ must be assumed since the $K_L$ energy cannot be detected. BaBar uses the energy-difference, $\Delta E$, between reconstructed $B$ and beam energy, whereas Belle uses the center-of-mass momentum of reconstructed $B$, $p_{B}^*$. They are shown in Fig. 6.

Extraction of $\sin 2\phi_1$ from the $\Delta t$ distributions are done by maximize a likelihood $L = 1 \times \prod_i P_i$ (i.e., each candidate event). The probability of each candidate event is described by

$$P_i = \frac{\int [f_{\text{sig}} P_{\text{sig}}(\Delta t') R_{\text{sig}}(\Delta t - \Delta t') + (1 - f_{\text{sig}}) P_{\text{bkg}}(\Delta t') R_{\text{bkg}}(\Delta t - \Delta t')] d\Delta t'}{(f_{\text{sig}} P_{\text{sig}}(\Delta t') R_{\text{sig}}(\Delta t) + (1 - f_{\text{sig}}) P_{\text{bkg}}(\Delta t') R_{\text{bkg}}(\Delta t))} \quad (11)$$

where $f_{\text{sig}}$ is signal fraction of candidate event, $P_{\text{sig}}$ and $P_{\text{bkg}}$ are the probability density functions, and $R_{\text{sig}}$ and $R_{\text{bkg}}$ are the $\Delta t$ resolutions. The $\Delta t$ distributions and asymmetries are shown in Fig. 7 together with their fit results.

The BaBar results are $\sin 2\phi_1 = 0.741 \pm 0.067 \pm 0.034$ and $|\lambda| = 0.948 \pm 0.051 \pm 0.030$, while the Belle results are $\sin 2\phi_1 = 0.719 \pm 0.074 \pm 0.035$ and $|\lambda| = 0.950 \pm 0.049 \pm 0.025$. A combined result is $\sin 2\phi_1 = 0.734 \pm 0.055$. Fig. 8 shows an allowed region of ($\rho-\eta$) plane from the sin $2\phi_1$ measurement and from a global CKM fit without using sin $2\phi_1$. Agreement is excellent.
Figure 6: (Left) Beam-energy substituted mass distribution for the $\eta_{CP} = -1$ final states and $\Delta E$ distribution for the $J/\psi K_L$ final state for BaBar. (Right) Beam-energy substituted mass distribution for the $\eta_{CP} = -1$ final states and $p_B^*$ distribution for the $J/\psi K_L$ final state for Belle.

Figure 7: BaBar $\Delta t$ distributions and asymmetries for CP-odd final states (far-left) and $J/\psi K_L$ state (2nd-left). Belle $\Delta t$ distributions for a sum of $B^0$-tagged $J/\psi K_L$ and $\bar{B}^0$-tagged CP-odd states (labeled as $q\xi_f = +1$) and for a sum of $\bar{B}^0$-tagged $J/\psi K_L$ and $B^0$-tagged CP-odd states (labeled as $q\xi_f = -1$) (2nd-right). Far-right are Belle asymmetries for $q\xi_f = +1$ and $q\xi_f = -1$ samples combined (a), each separately (b) and (c), and for non-CP sample (d).
\[ \sin 2\phi_1 \text{ from loop diagram decays} \]

\subsection{\phi K_S}

The \( B^0 \to \phi K_S \) decay has only \( b \to ss\bar{s} \) penguin contribution in the Standard Model (Fig. 9). Leading term has a CKM factor of \( V_{cb}V_{cs}^* (P_c - P_t) = A\lambda^2 (P_c - P_t) \), where

\begin{align*}
P_q \text{ are the penguin amplitudes. This is same as the CKM factor for } B^0 \to J/\psi K_S. \\
\text{Next-to-leading term } V_{ub}V_{us}^* (P_u - P_t) = A\lambda^4 (\rho - i\eta)(P_u - P_t) \text{ has a different phase, but is suppressed by } \lambda^2 \simeq 5\%. \text{ Since } \eta_{\phi K_S} = -1, \sin 2\phi_1 \text{ measured in this mode should be the same as that for the } J/\psi K_S \text{ in the Standard Model. In order to allow room for new physics, we parameterize the asymmetry distribution by}
\end{align*}

\[ a_f(\Delta t) = S_f \sin(\Delta m_d \Delta t) + A_f \cos(\Delta m_d \Delta t) \quad (12) \]

where

\[ S_f = \frac{2Im\lambda_f}{|\lambda_f|^2 + 1} (\simeq -\eta_f \sin 2\phi_1 \text{ in SM}), \quad A_f = -C_f = \frac{|\lambda_f|^2 - 1}{|\lambda_f|^2 + 1} (\simeq 0 \text{ in SM}). \quad (13) \]
Any deviation would be an indication of new physics in penguin loop.

The BaBar results based on 84M $B\bar{B}$ [9] are $S_{\phi K_S} = -0.18 \pm 0.51 \pm 0.07$ and $A_{\phi K_S} = +0.80 \pm 0.38 \pm 0.12$, whereas the Belle results based on 85M $B\bar{B}$ [10] are $S_{\phi K_S} = -0.73 \pm 0.64 \pm 0.22$ and $A_{\phi K_S} = -0.56 \pm 0.41 \pm 0.16$.

6.2 $\eta'/K_S$

This mode is contributed by $b \to ss\bar{s}$ penguin, $b \to sdd\bar{d}$ penguin, and $b \to u$ tree diagrams (Fig. 10). In the Standard Model, presence of additional $b \to sdd\bar{d}$ penguin

![Diagram](image)

Figure 10: Standard Model contributions to $B^0 \to \eta'/K_S$.

does not cause any change from the $\phi K_S$ case, and only difference is the additional $b \to u$ tree diagram which is only 5% effect. Since $\eta_{\eta'K_S} = -1$, we expect to have $S_f \simeq \sin 2\phi_1$.

The BaBar results based on 88.9M $B\bar{B}$ [11] are $S_{\eta'K_S} = +0.02 \pm 0.34 \pm 0.03b$ and $A_{\eta'K_S} = -0.10 \pm 0.23 \pm 0.03$, whereas the Belle results based on 85M $B\bar{B}$ [10] are $S_{\eta'K_S} = +0.71 \pm 0.37_{+0.05}^{+0.06}$ and $A_{\eta'K_S} = +0.26 \pm 0.22 \pm 0.03$.

6.3 $K^+K^-K_S$

This decay is contributed by $b \to s$ penguin and $b \to u$ tree diagrams (Fig. 11). The Belle analysis for this decay mode shows that the $b \to u$ tree contribution

![Diagram](image)

Figure 11: Standard Model contributions to $B^0 \to K^+K^-K_S$.

is negligible and furthermore $CP$ content of the final state is predominantly even ($\eta_{K^+K^-K_S} = +1$) [10]. Therefore we expect $S_f \simeq -\sin 2\phi_1$. The results based on 85M $B\bar{B}$ are $S_{K^+K^-K_S} = -0.49 \pm 0.43 \pm 0.11$ and $A_{K^+K^-K_S} = -0.40 \pm 0.33 \pm 0.10$.

Fig. 12 summarizes the $(-\eta_f S_f)$ measurements for the penguin loop decays. An average “$\sin 2\phi_1$” of those three penguin decays is $0.19 \pm 0.20$, about 2.5$\sigma$ off the
Standard Model. We are entering an exciting era for exploring new physics through 

\[ \sin \theta_1 \] measurements in different decay modes.

7 \ \sin \theta_1 \ \text{from other modes}

7.1 \ \jpsi\pi^0

In this mode, the tree and penguin contributions are of comparable size(Fig. 13). The CKM factors are \[ V_{cb}V_{cd}^* = -A\lambda^3 \] for the tree, and \[ V_{cb}V_{cd}^*(P_c - P_t) = -A\lambda^3(P_c - P_t) \] and \[ V_{ub}V_{ud}^*(P_u - P_t) = A\lambda^3(\rho - i\eta)(P_u - P_t) \] for the penguins, respectively. In an

\[ \begin{align*}
&b \rightarrow \bar{c} J/\psi d \\
&B^0 \\
&d \rightarrow \pi^0 \\
&b \rightarrow \bar{c} J/\psi d \\
&B^0 \\
&d \rightarrow \pi^0
\end{align*} \]

Figure 13: Standard Model contributions to \( B^0 \rightarrow J/\psi \pi^0 \).
extreme case of ignoring the penguin, we obtain $S_f \simeq -\sin 2\phi_1$ since $\eta_{J/\psi \pi^0} = +1$. If a deviation is seen, presence of penguin should be suspected first. The BaBar results based on $88M \bar{B}B$ [12] are $S_{J/\psi \pi^0} = +0.05 \pm 0.49 \pm 0.16$ and $A_{J/\psi \pi^0} = -0.38 \pm 0.41 \pm 0.09$, whereas the Belle results based on $85M \bar{B}B$ [13] are $S_{J/\psi \pi^0} = -0.93 \pm 0.49 \pm 0.08$ and $A_{J/\psi \pi^0} = -0.25 \pm 0.39 \pm 0.06$.

7.2 $D^{*+}D^{*-}$ and $D^{*+}D^-$

These modes have similar “penguin pollution” as $J/\psi \pi^0$ (Fig. 14). The CKM factors are $V_{cb}V_{cd}^* = -\lambda^3$ for the tree, and $V_{cb}V_{cd}^*(P_c - P_u) = -\lambda^3(P_c - P_u)$ and $V_{ub}V_{td}^*(P_t - P_u) = \lambda^3(1 - \rho + i\eta)(P_t - P_u)$ for the penguins, respectively. BaBar angular analysis [15] showed that $CP$ content of the $D^{*+}D^{*-}$ final state is predominantly even ($\eta_{D^{*+}D^{*-}} \simeq +1$). In an extreme case of ignoring the penguin, we obtain $S_f \simeq -\sin 2\phi_1$. The $D^{*+}D^-$ final state is not a CP eigenstate. In an extreme case of ignoring the penguin, we obtain $S_{\pm}^f = S_{\mp}^f \simeq -\sin 2\phi_1$. The BaBar results based on $88M \bar{B}B$ [12] are

$$S_{D^+D^-}^+ = -0.24 \pm 0.69 \pm 0.12, \quad S_{D^+D^-}^- = -0.82 \pm 0.75 \pm 0.14$$
$$A_{D^+D^-}^+ = +0.22 \pm 0.37 \pm 0.10, \quad A_{D^+D^-}^- = +0.47 \pm 0.40 \pm 0.12. \quad (14)$$

8 Summary

Precision of $\Delta m_d$ has reached 1.2%. Attempt for observing higher order effect and possible new physics effects in $\bar{B}B$ mixing are vigorously explored. The $\Delta m_d$ measurements are an important testing ground for the $\Delta t$ measurement and flavor-tagging. Precision of $\sin 2\phi_1$ has reached 8%. Statistical error still dominates. It is in good agreement with a global CKM fit (without $\sin 2\phi_1$). $|\lambda|$ is consistent with 1 in $b \rightarrow c \bar{c}s$ decays as expected in the Standard Model. New physics search by “$\sin 2\phi_1$” measurements in penguin loops is well under way. “$\sin 2\phi_1$” measurements for “penguin polluted” decays were also pushed to find useful information.
References

1. N. Hasting et al., Phys. Rev. D 67, 052004 (2003); K. Hara et al., Phys. Rev. Lett. 89, 251803 (2002); T. Tomura et al., Phys. Lett. B542 207 (2002); Y. Zheng et al., Phys. Rev D 67, 092004 (2003).

2. B. Aubert et al. Phys. Rev. Lett. 88, 221803 (2002); B. Aubert et al. Phys. Rev. Lett. 88, 221802 (2002); B. Aubert et al. hep-ex/0212017.

3. K. Hagiwara et al. (Particle Data Group), Phys. Rev. D 66, 010001 (2002).

4. See, for example, A. Mohapatra, M. Satpathy, K. Abe, and Y. Sakai, Phys. Rev. D 58, 036003 (1998).

5. hep-ex/0303043.

6. B. Aubert et al., Phys. Rev. Lett. 88, 231801 (2002).

7. B. Aubert et al. Phys. Rev. Lett. 89, 201802 (2002).

8. K. Abe et al. Phys. Rev. D 66, 071102 (2002).

9. Talk presented at Moriond Conference (March 2003).

10. K. Abe et al. Phys. Rev. D 67, 031102(R) (2003).

11. B. Aubert et al. hep-ex/0303046.

12. B. Aubert et al. hep-ex/0303018.

13. K. Abe et al. Belle-CONF-0201.

14. B. Aubert et al. hep-ex/0303004.

15. Talk presented at FPCP (June 2003).