DØnote 5189-Conf

Combination of DØ results on CP violation phase in B_s system

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We combine all DØ results on the CP-violating phase ϕ_s in B_s system. The first direct measurement of the mixing phase obtained from the untagged decay B_s^0 decays is combined with the independent information on the charge asymmetry in semileptonic B_0 decays. We obtain $\phi_s = -0.56^{+0.44}_{-0.41}$.

Preliminary Results for Summer 2006 Conferences

This note presents a combination of all DØ results [1–3] on the CP-violating phase ϕ_s in B_s system. The direct measurement of ϕ_s (called δ *phi* in D0 Note 5144) from the study of the decay process $B_s^0 \to J/\psi\phi$ is reported in D0 Note 5144, where result with the additional constraint from the charge asymetry in semileptonic B_s^0 decays are also shown. Here we provide a summary of the information used as input to this constraint: the combined DØ measurement of the charge asymmetry in semileptonic B meson decays, the available data from B factories [4–6] on B_d decays, and the new measurement of the oscillation parameter ΔM_s by CDF [7].

The phase ϕ_s, together with the width difference $\Delta\Gamma_s = \Gamma_L - \Gamma_H$ and the mass difference $\Delta M_s = M_H - M_L$ describe the oscillation in the B_s system [8]. The phase ϕ_s is predicted to be very small in the Standard Model [9], while a contribution of new physics can alter it significantly. Nonzero value of ϕ_s would produce the CP-violating asymmetry of flavor-specific (e.g. semileptonic) B_s^0 decays [9]:

$$A_{SL} = \frac{N(\bar{B} \to l^+X) - N(B \to l^-X)}{N(\bar{B} \to l^+X) + N(B \to l^-X)} = \frac{\Delta\Gamma}{\Delta M}\tan\phi. \tag{1}$$

The DØ experiment performed two independent measurements of A_{SL}, using the same sign dimuon pairs [2], and using the time-integrated semileptonic decays $B_s^0 \to \mu\nu D_s$ with $D_s \to \phi\pi$ [3].

In general, the same sign dimuon asymmetry at Tevatron can be expressed as [10]:

$$\begin{aligned} A_{SL} &= \frac{N(b\bar{b} \to l^+l^+X) - N(b\bar{b} \to l^-l^-X)}{N(b\bar{b} \to l^+l^+X) + N(b\bar{b} \to l^-l^-X)} = \frac{f_d Z_d A_{SL}^d + f_s Z_s A_{SL}^s}{f_d Z_d + f_s Z_s} \\ Z_q &= \frac{1}{1-y_q^2} - \frac{1}{1+x_q^2} \\ x_q &= \Delta M_q/\Gamma_q; \quad y_q = \Delta\Gamma_q/2/\Gamma_q \end{aligned} \tag{2}$$

Here $f_d = 0.397 \pm 0.01$, $f_s = 0.107 \pm 0.011$ are the fractions of B_d and B_s produced in the hadronization of b quark.

The measured asymmetry A_{SL} in Ref. [2] was transformed into A_{SL}^d assuming $A_{SL}^s = 0$:

$$A_{SL}(\text{D}\emptyset) = A_{SL}\frac{f_d Z_d + f_s Z_s}{f_d Z_d} = -0.0044 \pm 0.0040(stat) \pm 0.0028(syst). \tag{3}$$

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Expressing this result through A_{SL}^d and A_{SL}^s we get:

$$A_{SL}(\text{D}\emptyset) = A_{SL}^d + \frac{f_s Z_s}{f_d Z_d} A_{SL}^s. \tag{4}$$

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The asymmetry A_{SL}^d has been measured at b factories [4–6], where only B_d and $B^\pm$ mesons are produced. Their unofficial combination is [10]:

$$A_{SL}^d = +0.0011 \pm 0.0055. \tag{5}$$

Combining (4) and (5) together, we get:

$$A_{SL}^s = -0.0076 \pm 0.0102. \tag{6}$$

The direct measurement of A_{SL}^s using the semileptonic B_s^0 decays [3] gives:

$$A_{SL}^s = +0.0245 \pm 0.0193. \tag{7}$$

The measurements (4) and (7) are independent with different systematic contributions. Their combination gives the world first result on the charge asymmetry in semileptonic B_s^0 decays:

$$A_{SL}^s = -0.0007 \pm 0.0090. \tag{8}$$

The study of $B_s^0 \to J/\psi\phi$ decays [1] provides the following measurement of the CP phase:

$$\begin{aligned} \Delta\Gamma_s &= 0.17 \pm 0.09 \pm 0.03 \text{ ps}^{-1} \\ \phi_s &= -0.79 \pm 0.56 \pm 0.01. \end{aligned} \tag{9}$$

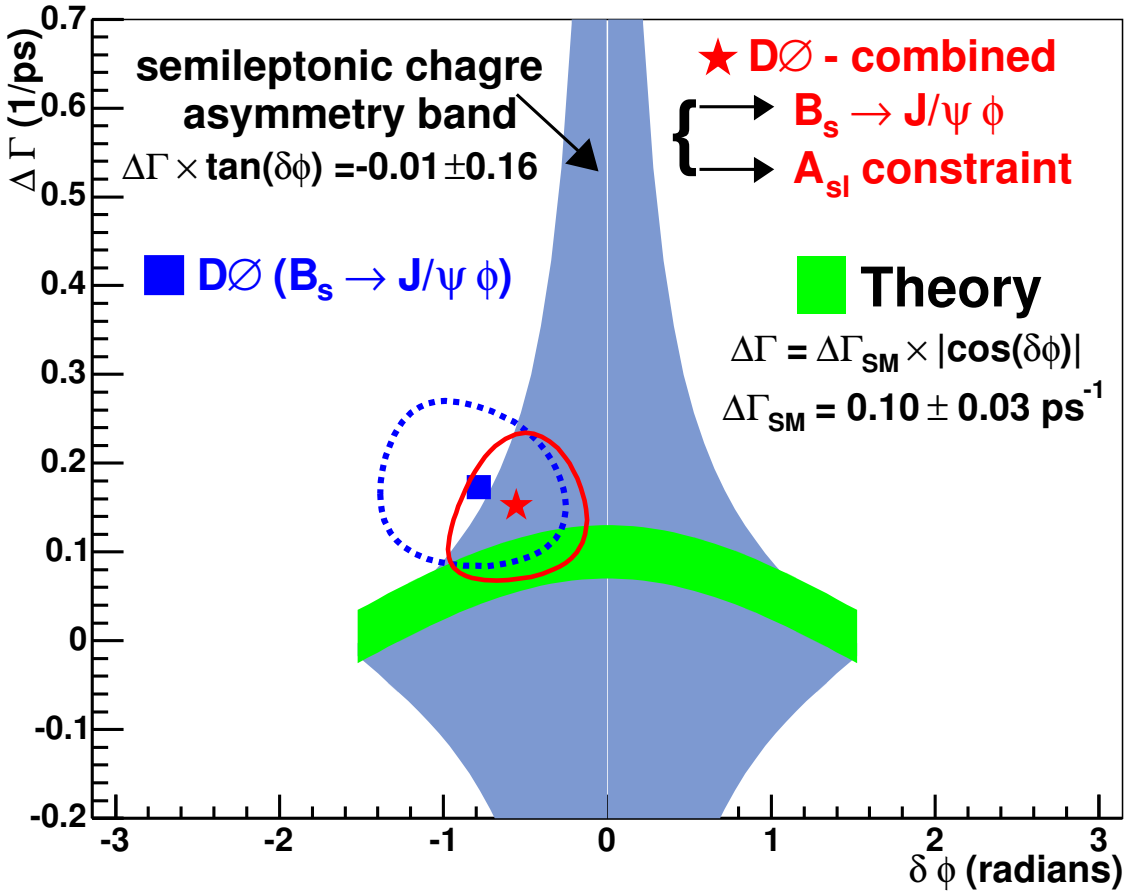

FIG. 1: The one-sigma contour (full line) for a combination of all DØ results on CP violation phase in B_s^0 system in the $\Delta Gamma_s$ versus ϕ_s plane. The allowed regions from $B_s^0 \to J/\psi\phi$ (dotted line) and from the charged asymmetry analyzes (filled area) are shown.

Combining (8) and (9) using the relation (1) $A_{SL} = \Delta\Gamma/\Delta M \cdot \tan(\phi)$ and the new result $\Delta M_s = 17.3 \pm 0.3$ from CDF [7], we get an improved estimate of the ϕ_s and $\Delta\Gamma$:

$$\begin{aligned} \Delta\Gamma_s &= 0.15^{+0.09}_{-0.08}\ \mathrm{ps}^{-1}, \\ \phi_s &= -0.56^{+0.44}_{-0.41}. \end{aligned} \tag{10}$$

Figure 1 shows the combination of all DØ measurements. The obtained result is consistent with the SM value $\phi_s = 0.005$.

[1] DØ Collaboration, conference note 5144.
[2] DØ Collaboration, Conference note 5042.
[3] DØ Collaboration, Conference note 5143.
[4] Babar Collaboration, hep-ex/0603053.
[5] Belle Collaboration, hep-ex/0505017.
[6] D. Jaffe *et al.* (CLEO Collaboration), Phys. Rev. Lett. **86**, 5000 (2001).
[7] CDF Collaboration, hep-ex/0606027.
[8] I. Dunietz, R. Fleischer, U. Nierste, hep-ph/0012219.
[9] M. Beneke, G. Buchalla, A. Lenz and U. Nierste, Phys. Lett. B **576** (2003) 173 [arXiv:hep-ph/0307344].
[10] Y. Grossman, Y. Nir, G. Raz, hep-ph/0605028.