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A^b_{sl} and the Anomalous like-sign Dimuon asymmetry at D0.

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Recent results on measurements of CP violation parameters in B-meson mixing as performed D0 collaborations are presented. These results include the measurement of a^s_{sl} in a lifetime analysis of the decays $B_s \to D_s^- \mu^+ X$ and the measurement of the like sign dimuon asymmetry, $A^b_{\rm sl} = -0.00957 \pm 0.00251\ (\text{stat}) \pm 0.00146\ (\text{syst})$. This result differs by 3.2 standard deviations from the standard model prediction $A^b_{\rm sl}(SM) = (-2.3^{+0.5}_{-0.6}) \times 10^{-4}$ and provides first evidence of anomalous CP-violation in the mixing of neutral B mesons.

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1. CP Violation in B-Meson Mixing

At Fermilab's Tevatron most of the b-quarks are produced in $b\bar{b}$ pairs which then hadronise into B-mesons. A small fraction of these mesons decay semi-leptonically to muons ($\mu^{\pm}+X$). In the case of neutral B-mesons the mesons oscillation can lead to the muon having the "wrong" sign. The CP-asymmetry of the "wrong"-charge can then be defined as:

$$a^b_{sl} = \frac{\Gamma(\overline{B} \to \mu^+ X) - \Gamma(B \to \mu^- X)}{\Gamma(\overline{B} \to \mu^+ X) + \Gamma(B \to \mu^- X)}. \tag{1.1}$$

This asymmetry can be investigated in several ways. In this paper the measurement of $a^s_{\rm sl}$ in time dependent, tagged, exclusive B_s decays and the measurement of the same-sign dimuon asymmetry are ppresented.

1.1 $a^s_{\rm sl}$: $B_s \to D_s^- \mu^+ X$ Lifetime Analysis

a^s_{sl} can be measured via a tagged lifetime analysis of the decays $B_s \to D_s^- \mu^+ X$. D0 [1] analyses the two decay channels where $D_s^- \to \phi\pi^-$; $\phi \to K^+K^-$, and $D_s^- \to K^{0*}K^-$; $K^{0*} \to K^+\pi^-$ (see Fig.1) using 5.0 pb^{-1} of data. Here

$$a^s_{sl} = \frac{\Gamma_{\overline{B}_s(t)} - \Gamma_{B_s(t)}}{\Gamma_{\overline{B}_s(t)} + \Gamma_{B_s(t)}} = \frac{\Delta\Gamma_s}{\Delta m_s}\tan\phi_s. \tag{1.2}$$

The asymmetry values are extracted via an unbinned likelihood fit of the visible proper decay length taking into account of tagging probabilities, decay length resolution and the contributions from backgrounds such as B_d and B^+ decays. The likelihood function used is

$$\Gamma_{B_s(t)\to\bar{f}} = N_f|\bar{A}_{\bar{f}}|^2\left(1 - a^s_{fs}\right)\exp\left(-\Gamma_s t\right)\left[\frac{\cosh(\Delta\Gamma_s t/2) - \cos(\Delta m_s t)}{2}.\right] \tag{1.3}$$

The number of signal events for oscillated B_s decays are extracted for the various different magnet polarities and used to determine a^s_{fs}:

$$a^s_{fs} = \left[-1.7 \pm 9.1(\text{stat}) \begin{matrix}+1.2\\-2.3\end{matrix}(\text{syst.})\right] \times 10^{-3}. \tag{1.4}$$

1.2 Same Sign Dimuon Asymmetry

The measurement by D0 of the same sign dimuon asymmetry is given in great detail in [2].

CP violation in the mixing of neutral B mesons can be searched for by measuring the asymmetry in same sign dimuon events:

$$A^b_{\rm sl} = \frac{N_b^{++} - N_b^{--}}{N_b^{++} + N_b^{--}}. \tag{1.5}$$

The Tevatron is an ideal place to measure this asymmetry as the B-mesons are produced from a CP-invariant initial state ($p\bar{p}$) and have a substantial contribution from B_s mesons. By making use the previously measured production and mixing properties of neutral B-mesons we have:

$$A^b_{\rm sl} = (0.506 \pm 0.043)a^d_{\rm sl} + (0.494 \pm 0.043)a^s_{\rm sl}, \tag{1.6}$$

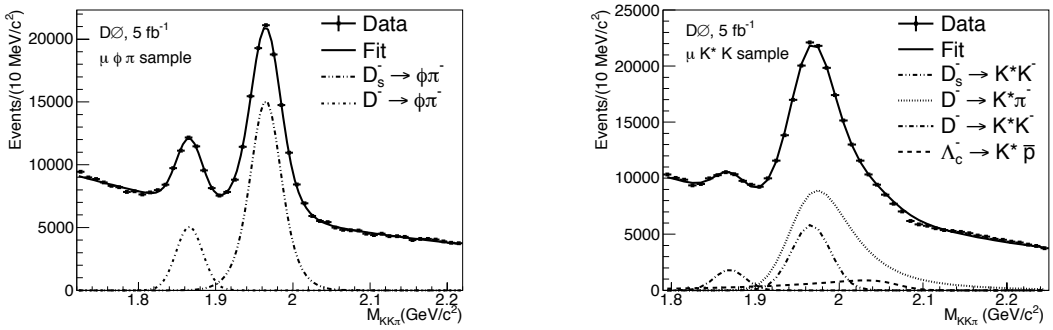

Figure 1: Reconstruction of B_s decays in D0. Left: $K^+K^-\pi^-$ invariant mass distribution for the $\mu^+\phi\pi^-$ sample with the solid line representing the mass fit result. Right: $K^+K^-\pi^-$ invariant mass distribution for the $\mu^+K^{*0}K^-$ sample with the solid line representing the mass fit result.

where $a^d_{\rm sl}$ and $a^s_{\rm sl}$ are the flavour-specific asymmetries for B_d and B_s mesons respectively. This asymmetry can be expressed as

$$a^q_{\rm sl} = \frac{\Delta\Gamma_q}{\Delta M_q}\tan\phi_q. \tag{1.7}$$

In the SM, $A^b_{\rm sl}$ is predicted to be very small

$$A^b_{\rm sl}({\rm SM}) = (-2.3^{+0.5}_{-0.6})\times 10^{-4}. \tag{1.8}$$

D0 has measured this asymmetry using a sample of 1.5 billion inclusive muon events and a sample of 3.7 million same sign dimuon events obtained from a sample of 6.1 fb^{-1}. The analysis measures and corrects the data for physics background and the dilution of the signal by processes that produce sam sign dimuons that do not originate from the oscillations of B-mesons.

The like-sign dimuon charge asymmetry $A^b_{\rm sl}$ of semileptonic b-hadron decaysis extracted from the data and is found to be

$$A^b_{\rm sl} = -0.00957 \pm 0.00251\ ({\rm stat}) \pm 0.00146\ ({\rm syst}). \tag{1.9}$$

This value differs by 3.2 standard deviations from the standard model prediction of $A^b_{\rm sl}$

Figure 2 presents this measurement in the $a^d_{\rm sl}$–$a^s_{\rm sl}$ plane, together with the existing direct measurements of $a^d_{\rm sl}$ from the B-Factories [4] and of our independent measurement of $a^s_{\rm sl}$ in $B^0_s \to D_s\mu X$ decays [1]. Using the current experimental value of $a^d_{\rm sl} = -0.0047 \pm 0.0046$ [4], we obtain

$$a^s_{\rm sl} = -0.0146 \pm 0.0075, \tag{1.10}$$

which agrees with our direct measurement of $a^s_{\rm sl} = -0.0017 \pm 0.0091$ [1].

2. Conclusion

Using minimal input from simulation D0 has measured $a^s_{\rm sl}$ and the asymmetry in like sign dimuon events. The like sign dimuon asymmetry is inconsistent with the SM prediction at the 99.8% level.

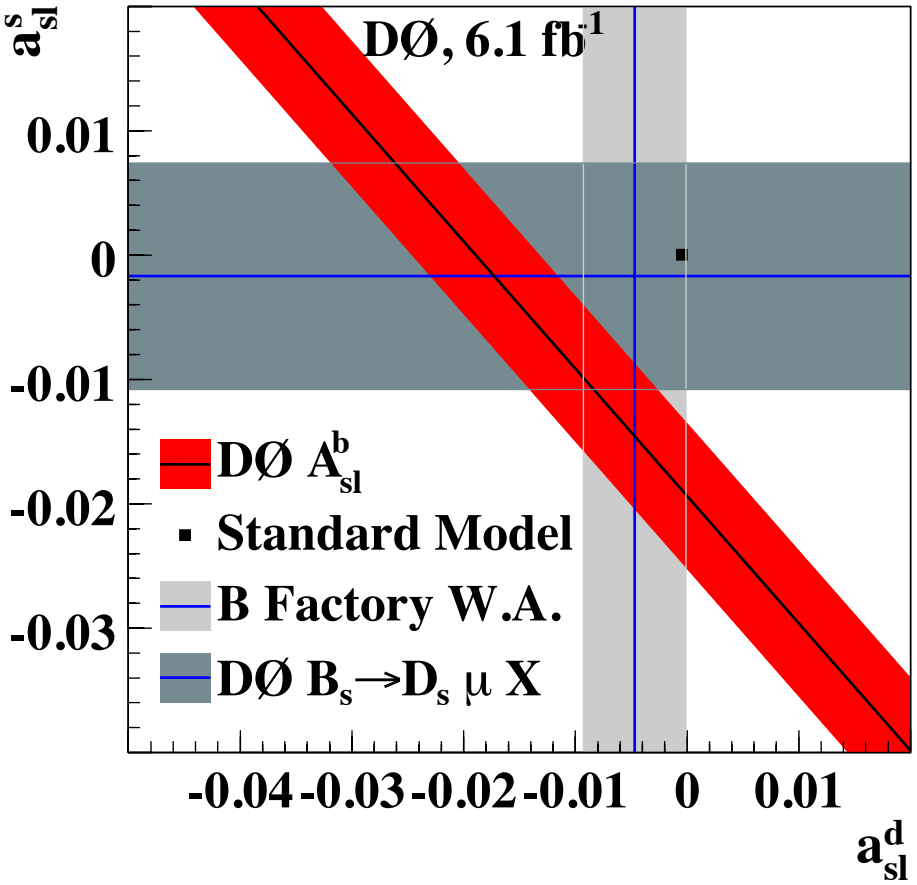

Figure 2: Comparison of $A^b_{\rm sl}$ in data with the standard model prediction for $a^d_{\rm sl}$ and $a^s_{\rm sl}$. Also shown are the existing measurements of $a^d_{\rm sl}$ [4] and $a^s_{\rm sl}$ [1]. The error bands represent the ± 1 standard deviation uncertainties on each individual measurement.

References

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