PROCEEDINGS OF SCIENCE

CP-conserving and CP-violating properties in semileptonic B_s decays with the DØ experiment

Lars SONNENSCHEIN[*]
RWTH Aachen IIIA
E-mail: `lars.sonnenschein@cern.ch`

A search for CP violation has been performed in a sample of semileptonic B_s decays corresponding to approximately 5 fb^{-1} of data collected by the DØ detector in Run II at the Fermilab Tevatron collider. A time-dependent fit to the distributions of B_s candidates yields the flavour-specific asymmetry $a^s_{fs} = [-1.7 \pm 9.1(\text{stat})^{+1.2}_{-2.3}(\text{syst})] \times 10^{-3}$, corresponding to the most precise measurement to date for this CP violation parameter. Furthermore a search for the semi-inclusive process B_s to $D_s^{(*)} D_s^{(*)}$ has been performed on a data sample of 2.8 fb^{-1}. 26.6 ± 8.4 signal events are observed with a significance of 3.2 standard deviations above background, leading to a branching ratio of $0.035 \pm 0.010(\text{stat}) \pm 0.011(\text{syst})$. Under certain theoretical assumptions, these double-charm final states saturate CP-even eigenstates in the B_s decays, resulting in a width difference of $\Delta\Gamma_s^{CP}/\Gamma_s = 0.072 \pm 0.021(\text{stat}) \pm 0.022(\text{syst})$.

European Physical Society Europhysics Conference on High Energy Physics
July 16-22, 2009
Krakow, Poland

[*]Speaker.

PoS(EPS-HEP 2009)174

1. Introduction

The search of large CP violation in the $B_s^0 - \bar{B}_s^0$ system is of special interest since its observation provides direct indication of new physics. A non-zero CP violation weak phase ϕ_s arises due to a difference between the $B_s^0 - \bar{B}_s^0$ mixing amplitude and the amplitudes of the subsequent B_s^0 and $\bar{B}_s^0$ decays. The decay width differences $\Delta\Gamma_s = \Gamma_L - \Gamma_H$ of the light and heavy eigenstates and $\Gamma_s^{CP} = \Gamma_s^{\text{even}} - \Gamma_s^{\text{odd}}$ of the CP eigenstates can be related to the possible presence of new physics by the equality $\Delta\Gamma_s = \Delta\Gamma_s^{CP} \cos\phi_s$. On the other hand the flavor specific asymmetry a_{fs}^s can be related to the CP violation phase by $a_{fs}^s = \frac{\Delta\Gamma_s}{\Delta m_s} \tan\phi_s$. The two B_s^0 decay analyses presented here are dedicated to set constraints on CP violation.

2. Search for CP violation in semileptonic B_s^0 decays

The two $B_s^0 \to \mu^+ D_s^- X$ final states $D_s^- \to \phi\pi^-$ (with $\phi \to K^+K^-$) and $D_s^- \to K^{0*}K-$ (with $K^{0*} \to K^{=}\pi^-$) are considered in this analysis [1] which makes use of an integrated luminosity of 5 fb^{-1}. Initial state flavour is determined from the opposite side and the final state flavour from the muon charge of the semileptonic B_s^0 meson decay. A likelihood ratio method is applied to increase the significance of the signal candidate sample. The flavour specific asymmetries a_{fs}^s (signal), a_{fs}^d and a_{fs}^{bkg} (background) are determined from an unbinned likelihood fit in which enter variables such as the visible proper decay length, its error, the invariant $K^+K^-\pi$ mass and flavour tagging parameters. To obtain unbiased measurements of the flavour specific asymmetries the probability density functions entering into the likelihood take properly into account all possible detector asymmetries, such as the north south asymmetry of the detector and the range out asymmetry which describes the difference in acceptance for oppositely charged track magnet polarities. The flavour specific asymmetries are fitted separately for the $\mu^+\phi\pi^-$ and $\mu^+K^{0*}K^-$ samples. Their combination yields $a_{fs}^s = \left(-1.7 \pm 9.1(\text{stat})^{+1.2}_{-2.3}(\text{syst})\right) \times 10^{-3}$, which is consistent with the world average values [3] of $\Delta\Gamma_s$, Δm_s and ϕ_s.

3. Evidence for the Decay $B_s^0 \to D_s^{(*)} D_s^{(*)}$ and a Measurement of $\Delta\Gamma_s^{CP}/\Gamma_s$

The $B_s^0 \to D_s^{(*)} D_s^{(*)}$ decays $D_S \to \phi\pi$ and $D_S \to \phi\mu\nu$ (both with $\phi \to K^+K^-$) are considered in this analysis [2] which makes use of an integrated luminosity of 2.8 fb^{-1}. γ's and π^0's from D_s^* decays are not identified. The branching fraction is extracted by normalising the decay $B_s^0 \to D_s^{(*)} D_s^{(*)}$ to the decay $B_s^0 \to D_s^{(*)}\mu\nu$. A two dimensional maximum likelihood fit is applied to the invariant $\phi\pi$ mass distribution of the hadronic D_s candidate versus the invariant KK mass of the semileptonic D_s candidate. The two dimensional distribution consists of the following components: correlated D_sD_s signal; uncorrelated $D_s \to \phi\pi$ signal with D_s background, uncorrelated D_s background with $D_s \to \phi\mu\nu$, $\phi \to K^+K^-$ signal and correlated D_sD_s background. The signal template is extracted from a $B_s^0 \to D_s^{(*)}\mu\nu$ data sample. By extracting the background components the signal yield is estimated to 26.6 ± 8.4 events, corresponding to a significance of 3.2σ.

The branching ratio B_s^0 into two $D_s^{(*)}$ mesons is measured to $\mathscr{B}(B_s^0 \to D_s^{(*)} D_s^{(*)}) = 0.035 \pm 0.010(\text{stat}) \pm 0.008(\text{exp syst}) \pm 0.007(\text{ext})$, where external errors are due to the external input branching ratios taken from the PDG [3], leaving space for further improvements. Considering the heavy

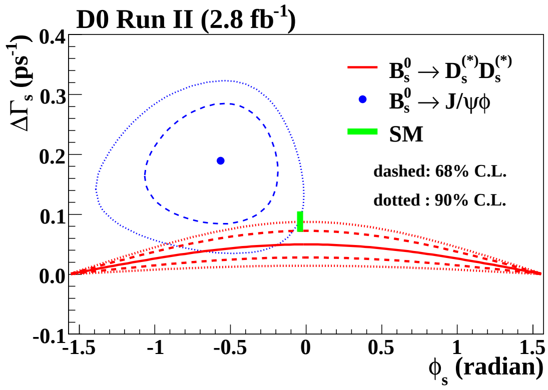

Figure 1: Constraints in the $\Delta\Gamma_s - \phi_s$ plane. The solid line represents this measurement under the theoretical assumptions given in the text. The dashed and dotted lines correspond to the 68% and 90% C.L. intervals respectively. Contours from the $B_s^0 \to J/\psi\phi$ decay are the equivalent C.L. regions when measuring simultaneously $\Delta\Gamma_s$ and ϕ_s. No theoretical uncertainties are reflected in the plot.

quark hypothesis [5] ($\sim 5\%$ theoretical uncertainty) along with the Shifman-Voloshin limit [4] ($3-5\%$ theoretical uncertainty) the inclusive final state saturates CP-even eigenstates in the $B_s^0 - \bar{B}_s^0$ system. This scenario is presented in Fig. 1, assuming the relation $\Delta\Gamma_s = \Delta\Gamma_s^{CP}\cos\phi_s$. Furthermore the mass eigenstates coincide with the CP eigenstates in the Standard Model. In this approximation the relative CP decay width difference can be determined to $\frac{\Delta\Gamma_s^{CP}}{\Gamma_s} \simeq \frac{2\mathscr{B}(B_s^0\to D_s^{(*)}D_s^{(*)})}{1-\mathscr{B}(B_s^0\to D_s^{(*)}D_s^{(*)})} = 0.072 \pm 0.021(\text{stat}) \pm 0.022(\text{syst})$. This result is consistent with the Standard Model prediction and the world average value [3]. If the CP structure of the final state can be disentangled and the theoretical errors can be controlled this measurement can provide a powerful constraint on B_s^0 mixing and CP violation.

4. Acknowledgments

Many thanks to the staff at Fermilab and collaborating institutions. This work has been supported by the DOE and NSF (USA); CEA and CNRS/IN2P3 (France); FASI, Rosatom and RFBR (Russia); CNPq, FAPERJ, FAPESP and FUNDUNESP (Brazil); DAE and DST (India); Colciencias (Columbia); CONACyT (Mexico); KRF and KOSEF (Korea); CONICET and UBACyT (Argentina); FOM (The Netherlands); STFC (United Kingdom); MSMT and GACR (Czech Republic); CRC Program, CDF, NSERC and WestGrid Project (Canada); BMBF, DFG and the Alexander von Humboldt Foundation (Germany); SFI (Ireland); The Swedish Research Council (Sweden); and CAS and CNSF (China).

References

[1] V. M. Abazov (DØ Collaboration), Fermilab-Pub-09-140-E, submitted to Phys. Rev. Lett. (2009).

[2] V. M. Abazov (DØ Collaboration), Phys. Rev. Lett. **102**, 091801 (2009).

[3] C. Amsler *et al.*, Phys. Lett. B **667**, 1 (2008).

[4] M. A. Shifman, M. B. Voloshin, Yad. Fiz. **47**, 801 (1988) [Sov. J. Nucl. Phys. **47**, 511 (1988)].

[5] R. Aleksan *et al.*, Phys. Lett. B **316**, 567 (1993).