Introduction

The time evolution for $B^0$ and $\bar{B}^0$ mesons can be written as

$$|B_{sL}^0(t)| = g_s (t) |B_{sL}^0(0)| + \frac{1}{2} g_d (t) |B_{dL}^0(0)|$$

$$|B_{dL}^0(t)| = g_d (t) |B_{dL}^0(0)| + \frac{1}{2} g_s (t) |B_{sL}^0(0)|$$

where $g_s(t) = \frac{1}{2} (e^{-iw_{00}} + e^{-iw_{dd}})$ and $g_d(t) = \frac{1}{2} (e^{-iw_{00}} + e^{-iw_{dd}})$. $L$ and $H$ denote the light and heavy mass eigenstates, $\Delta m = m_H - m_L$, and $\Delta \Gamma = \Gamma_H - \Gamma_L$ are related to CKM matrix elements.

Inclusive Branching Fraction in $B^0 \rightarrow D^{(*)} D_s^{(*)}$

- $B^0 \rightarrow D^{(*)+} D_s^{(*)-}$ branching fraction contributes to the determination of $\Delta \Gamma_s / \Gamma_s$ [1]
- It is one of the dominant contributions to the total inclusive $\rightarrow c\bar{c}s$ branching fraction

What we measure is the branching fraction of $B^0 \rightarrow D_s^{-} D^{+}$ relative to $B^0 \rightarrow D_s^{+} D^{-}$

$$B(B^0 \rightarrow D_s^{-} D^{+}) = \frac{a^0_{B_{D_s^{-} D^{+}}} B(D_s^{-} \rightarrow K^{-} \pi^{+}) / N_{d}}{N_{h}}$$

$n_{d}$ and $n_{h}$ are the number of signal events in the $D_s^{-} D^{+}$ and $D_s^{+} D^{-}$ samples, respectively.

Data sample and Event selection

- The data set analysed corresponds to an integrated luminosity of $1 fb^{-1}$
- $D^0$ decays to $D_s^{(*)} (93.5\%)$ and $D_s^{(*)} \rightarrow D_s^{(*)} (8.5\%)$
- Neither of the neutral particles is reconstructed in the decay chain

Mass Fit

- $B^0$ and $\bar{B}^0$ yields are extracted by a three-dimensional fit on $(m_{D_s}, m_{D_s^{(*)}}, m_{D_s^{(*)}})$
- Fixed shape parameters are taken from MC samples

Results [3]

- The uncertainties are statistical, systematic and due to the normalisation channel
- The LHCb result is the most precise determination to date

Future Analysis: $B^0 \rightarrow D^+ D^0$

- $B^0 \rightarrow D^+ D^0$ has the same underlying physics as $B^0 \rightarrow D D$
- The $D^+$ is a vector particle and a full angular analysis will be required, the $3b^{-1}$ taken in Run I would not be sufficient
- The channel $B^0 \rightarrow D_s \pi^+ (K \pi \pi) D_s (K \pi \pi)$ can be used to measure CP violation

This analysis has started

CP Violation Measurement in $B^0 \rightarrow D^+ D^-$

- Tree and penguin diagrams contribute to the decay amplitude [7]
- CP violation occurs in interference between decay and decay after mixing
- $\sin(2\phi_4)$ can be determined
- What we measure is the CP asymmetry
- $A_{CP}(t) = -C_{D_s^+ D^-} \cos(\Delta m t) + S_{D_s^+ D^-} \sin(\Delta m t)$

Data sample and Event selection

- The data sample analysed corresponds to an integrated luminosity of $30 fb^{-1}$
- $D_s^{(*)}$ mesons are reconstructed through the decay $D_{s} \rightarrow K^{*0} K K\pi$ (the second mode is included by BaBar [4] and Belle [5])
- Mass fit is performed to disentangle signal from background

Flavour Tagging

- Flavour tagging is performed by using the flavour specific decay $B^0 \rightarrow D^+ D^-$
- $D_s$ mesons are reconstructed through the decay $D_s \rightarrow K^{+} (K \pi \pi)$
- OS tagger combination and a $SSp+ SS\pi$ combination (see D. Fazzini’s poster for details) are used to extract calibration parameters
- A fit of the $B^0/\bar{B}^0$ asymmetry is performed simultaneously for events tagged as $B^0$ and $\bar{B}^0$
- The Tagging Power obtained is $t_{eff} = (7.5 \pm 0.3) \%$

Data Fits and Conclusion

- A decay time fit is performed in order to extract $CP$ parameters
- A per-event resolution is used, taken from simulation
- The acceptance is described using cubic splines
- The blinded analysis is ongoing
- LHCb sensitivity is expected to rival that of BaBar and Belle

References

1. C.-K. Chua, W.-S. Hon, and C.-R. Shen, *Long-distance contribution to $\Delta \Gamma_s/\Gamma_s$ of the $B^0 \rightarrow B_s^0$ decay* (2009) 1209.1444
2. LHCb collaboration, *Measurement of $B^0 \rightarrow D^{(*)+} D_s^{(*)-}$ branching fractions*, arXiv:1107.4325