FLAVOUR CHANGING NEUTRAL CURRENT B DECAYS AT BABAR

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ABSTRACT

Recent BaBar results on rare B decays involving flavour-changing neutral currents are presented. New measurements of the CP asymmetries in $b \rightarrow s\gamma$ decays are reported as well as $b \rightarrow s l^+ l^-$ branching ratio measurements\(^1\).

1 Introduction

Since the first measurement of the exclusive $B \rightarrow K^*\gamma$ decay rate by CLEO [1], rare $B$ decays involving flavour changing neutral current have been a unique probe to search for new physics. In the Standard Model (SM), the lowest order diagram for the $b \rightarrow s\gamma$ decay is a loop (radiative penguin) diagram of top quark and $W$ boson. In principle, new particles such as charged Higgs or SUSY partners can form the same loop diagram and may modify the SM amplitude. A comparison between the measured rate and the SM prediction has provided a stringent constraint on such new particles. The inclusive decay is to date accurately calculated up to the next-to-leading order QCD corrections [2] and several measurements have already been performed. On the contrary, exclusive measurements, do not give a further constraint to new physics because of the large uncertainties in the form factors\(^1\).

\(^1\)Charge conjugate modes will be assumed throughout this text
Table 1: $A_{CP}$ measurements in $b \rightarrow s\gamma$. Errors are statistics and systematics respectively.

<table>
<thead>
<tr>
<th>Direct CP asymmetry $A_{CP}$</th>
<th>$B \rightarrow K^{*\gamma}$</th>
<th>$B \rightarrow X_s\gamma$</th>
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<tr>
<td>(-1.3 ± 3 ± 1)%</td>
<td>(2.5 ± 5.0 ± 1.5)%</td>
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computation. Other observables, such as the partial rate asymmetry ($A_{CP}$) between charge conjugate modes, could be more useful to constrain new physics. For example, the SM predicts very small asymmetry ($\approx 1\%$) [3], while there are several extensions of the SM predicting much larger $A_{CP}$. Electroweak processes, like $b \rightarrow s l^+ l^-$, are also useful probes for new physics searches. Expected rates are two order of magnitude smaller than for $b \rightarrow s\gamma$. At the lowest order, the decay is described by an electroweak ($Z$) penguin diagram and a $W$-box diagram in addition to the radiative penguin. If new particles with large weak bosons couplings exist, one can expect some additional contributions to $b \rightarrow s l^+ l^-$ that are not visible in $b \rightarrow s\gamma$.

2 Measurements of CP Asymmetries in $b \rightarrow s\gamma$

The exclusive $B \rightarrow K^{*\gamma}$ analysis is detailed in [4]. The $K^*$ is reconstructed in the four modes $K^{*0} \rightarrow K^+\pi^-, K_0^0\pi^0$ and $K^{*+} \rightarrow K^+\pi^0, K_0^0\pi^+$ and combined with a high energy isolated photon to form a B meson candidate. The background, mostly from continuum production, is suppressed by means of event topology variables. To reject events in which the photon comes from a $\pi^0(\eta)$ decay, a veto on $m_{\gamma\gamma}$ invariant mass is applied. The discriminating variables are the beam energy-substituted mass $m_{ES} = \sqrt{(E^*_{beam})^2 - (\vec{p}_B)^2}$ and the energy difference $\Delta E^* = E^*_B - E^*_{beam}$, where $\vec{p}_B$, $E^*_B$ and $E^*_{beam}$ denote the B-momentum, B-energy and beam energy in the center-of-mass (CM) frame, respectively. The signal yields are extracted from a likelihood fit to $m_{ES}$ and $\Delta E$. A “semi-inclusive” method, which measures a sum of exclusive $B \rightarrow X_s\gamma$ decays, is also used in BaBar [5]. The hadronic system $X_s$ is reconstructed in 12 final states including a $K_0^0$ or a $K^+$ and up to three pions (at most one $\pi^0$). The signal yields are extracted from a likelihood fit to $m_{ES}$. The results for the direct CP asymmetry, based on 81.9$fb^{-1}$, are reported in Table 1. These are consistent with zero and statistics limited.

3 Measurements of Branching Fractions in $b \rightarrow s l^+ l^-$

The exclusive $b \rightarrow s l^+ l^-$ measurement is described in [7]. Eight final states are reconstructed where a $K^+, K_0^0, K^{*0}$ or $K^{*+}$ recoils against a $\mu^+\mu^-$ or $e^+e^-$ pair,
Table 2: Branching Fractions (BF) Predictions and Measurements in $b \rightarrow s l^+l^-$ decays. Errors are statistics and systematics respectively.

<table>
<thead>
<tr>
<th></th>
<th>$B \rightarrow K l^+l^-$</th>
<th>$B \rightarrow K^* l^+l^-$</th>
<th>$B \rightarrow X_s l^+l^-$</th>
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<tbody>
<tr>
<td>BF Predictions ($\times 10^7$)</td>
<td>$3.5 \pm 1.2$</td>
<td>$11.9 \pm 3.9$</td>
<td>$42 \pm 7$</td>
</tr>
<tr>
<td>Measured BF ($\times 10^7$)</td>
<td>$6.5^{+1.4}_{-1.3}$ $\pm 0.4$</td>
<td>$8.8^{+3.3}_{-2.9}$ $\pm 1.0$</td>
<td>$56 \pm 15 \pm 12$</td>
</tr>
</tbody>
</table>

using an integrated luminosity of 113.1 fb$^{-1}$. Specific selection criteria are used to suppress individual backgrounds. Event shape variables are used to eliminate the continuum background. To reject events from $B \rightarrow J/\psi(\psi(2S))K^{(*)}$ decays with $J/\psi(\psi(2S)) \rightarrow l^+l^-$, a veto on $m_{ll}$ is applied. In each of the four $K^{(*)}l^+l^-$ final states, a signal is extracted from a fit to the $m_{ES}, \Delta E, (m_{k\pi})$ distributions. In the “semi-inclusive” approach [8], the reconstructed hadronic system $X_s$ consists of one $K_0^0$ or $K^+$ and up to two pions (at most one $\pi^0$). Background rejection is similar to the exclusive analysis. The signal yield is extracted from a likelihood fit to $m_{ES}$ and the analysis is performed with an integrated luminosity of 81.9 fb$^{-1}$. The measured branching ratios are reported in Table 2 together with the theoretical predictions [6]. These results are in agreement with the SM predictions within the current level of accuracy and have errors comparable to the theoretical prediction precision. With larger data samples at the $B$-factories, it will be possible to make precise tests of the theoretical predictions for the differential distributions in these decays.

References