Search for $B_s^0 \to \mu^+\mu^-$ and $B_d^0 \to \mu^+\mu^-$ at LHCb

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1 Introduction

Within the Standard Model (SM), the two flavour changing neutral current transitions, $B_s^0 \to \mu^+\mu^-$ and $B_d^0 \to \mu^+\mu^-$, occur only via loop diagrams and are helicity suppressed. These processes are therefore very rare with branching fractions ($\mathcal{B}$) predictions [1] of $\mathcal{B}(B_s^0 \to \mu^+\mu^-) = (0.32 \pm 0.2) \times 10^{-8}$ and $\mathcal{B}(B_d^0 \to \mu^+\mu^-) = (0.010 \pm 0.001) \times 10^{-8}$.

These precise predictions allow the SM to be tested against New Physics scenarios, for example the Minimal Supersymmetric SM [2], in which $\mathcal{B}$ are significantly enhanced.

The most restrictive experimental preliminary limits obtained by CDF [4] are: $\mathcal{B}(B_s^0 \to \mu^+\mu^-) < 4.3 \times 10^{-8}$ and $\mathcal{B}(B_d^0 \to \mu^+\mu^-) < 0.76 \times 10^{-8}$ at 95% confidence level (C.L.). The $37\,\mathrm{pb}^{-1}$ of data collected by the LHCb detector [3] already allow for upper limits to be set close to the world best ones.

2 The Analysis

The data used in the analysis are selected with cuts that remove most of the background, then each event is given a probability to be signal or background. This probability depends on two variables, the geometrical likelihood (GL, obtained from the geometry and kinematics of the event) and the di-muon invariant mass. The events are classified in the 4×6 bins of the plane made by these two variables. Finally the distribution of these events is compared to the expected ones for several $\mathcal{B}$ hypotheses and, using the modified frequentist approach [6], upper limits are extracted.

The expected background distribution is obtained by extrapolating in the signal mass region the mass side bands for each GL bin. For the signal, the relative heights of the GL bins are determined by fitting the yields of $B_s^0 \to hh$ event selected similarly to the signal but triggered independently of the tracks forming the $B_s^0 \to hh$ candidate. This line-shape is then scaled to a number of events (depending of the $\mathcal{B}_{sig}$ hypothesis) obtained by normalising to a control channel of known $\mathcal{B}$. In this way the knowledge of the absolute luminosity and the $b\bar{b}$ cross section are not needed. A more detailed description of the analysis can be found in [5].

3 Results

The observed and expected CLs distributions as a function of the $\mathcal{B}$ hypothesis are shown in Fig 1. The observed limits are:

$$\begin{aligned}\mathcal{B}(B_s^0 \to \mu^+\mu^-) &< 4.3\ (5.6) \times 10^{-8} \text{ at } 90\,\%\ (95\,\%) \text{ C.L.,}\\ \mathcal{B}(B_d^0 \to \mu^+\mu^-) &< 1.2\ (1.5) \times 10^{-8} \text{ at } 90\,\%\ (95\,\%) \text{ C.L}\end{aligned}$$

and show that with $37\,\mathrm{pb}^{-1}$, the LHCb sensitivity is similar to the best existing limits set by other experiments with larger data sets.

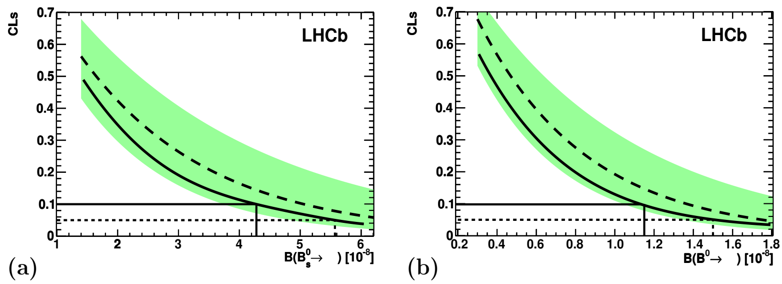

Figure 1: (a) Observed (solid curve) and expected (dashed curve) CLs values as a function of $\mathcal{B}(B_s^0 \to \mu^+\mu^-)$. The green shaded area contains the $\pm 1\sigma$ interval of possible results compatible with the expected value when only background is observed. The 90 % (95 %) C.L. observed value is identified by the solid (dashed) line. (b) The same for $\mathcal{B}(B_d^0 \to \mu^+\mu^-)$.

References

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