$B^0_{(s)} \to \mu^+\mu^-$ searches at LHCb

COSME ADROVER PACHECO on behalf of the LHCb collaboration
Centre de Physique des Particules de Marseille (CPPM)
Aix-Marseille Université, France

1 Introduction

The rare decays $B^0_s \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$ are benchmark channels to constrain models beyond the Standard Model (SM) with a larger Higgs sector. In the SM these processes are highly suppressed as they occur through loop processes. Together with an associated helicity suppression renders the branching fraction of these decays to be [2]: $\mathcal{B}(B^0_{(s)} \to \mu^+\mu^-) = 3.2 \pm 0.2 \times 10^{-9}$ and $\mathcal{B}(B^0 \to \mu^+\mu^-) = 0.10 \pm 0.01 \times 10^{-10}$.

Any deviation from these well predicted branching fractions can lead to indications of physics beyond the SM. For instance, they can be significantly enhanced within Minimal Supersymmetric extensions of the SM (MSSM) due to contributions from new processes or new heavy particles. In these scenarios, $\mathcal{B}(B^0_s \to \mu^+\mu^-)$ is proportional to $\tan^6\beta$ [3], where $\tan\beta$ is the ratio of the vacuum expectation values of the two Higgs fields.

2 Branching fraction measurements of $B^0_{(s)} \to \mu^+\mu^-$ at the LHCb

The LHCb experiment [1] has collected $1.0\,\mathrm{fb}^{-1}$ of data during the 2011 at a center-of-mass energy of $\sqrt{s} = 7\,\mathrm{TeV}$.

The $B^0_{(s)} \to \mu^+\mu^-$ analysis starts with a loose and efficient selection of the $B^0_{(s)} \to \mu^+\mu^-$ candidates and control channels ($B^0_{(s)} \to h^+h'^-$ decays, where h can be either a pion or a kaon, $B^+ \to J/\psi(\to \mu^+\mu^-)K^+$ and $B^0_s \to J/\psi(\to \mu^+\mu^-)\phi(\to K^+K^-)$ decays). The main goal of this selection process is to reduce the background to manageable levels, while keeping the same efficiency in all aforementioned channels.

After the selection, $B^0_s \to \mu^+\mu^-$ candidates are classified according to their invariant mass and the output of a multivariate classifier (figure 1 on the left) combining geometrical and kinematic information. This classification is performed in a binned 2D parameter space. The signal expectation in each bin is calculated using data events such as $B^0_{(s)} \to h^+h'^-$ and $B^+ \to J/\psi(\to \mu^+\mu^-)K^+$ decays. The number of background is obtained after an interpolation from the invariant mass sidebands.

The distribution of observed events (figure 1 on the right) is finally compared with the signal plus background and background only hypothesis using the CL_S method [4].

The upper limits [5] on the branching fractions are:

$$\mathcal{B}(B^0_{(s)} \to \mu^+\mu^-) < 4.5 \times 10^{-9}, \tag{1}$$

$$\mathcal{B}(B^0 \to \mu^+\mu^-) < 1.0 \times 10^{-10}. \tag{2}$$

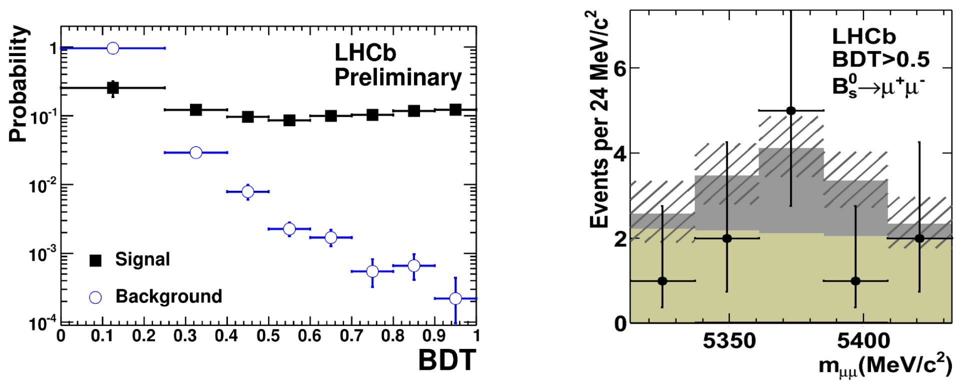

Figure 1: On the left, the output of the multivariate classifier for signal $B^0_{(s)} \to \mu^+\mu^-$ events (black dots) and background (empty blue dots). On the right, distribution of the selected di-muon events in the $B^0_s \to \mu^+\mu^-$ mass window with BDT (classifier) requirement above 0.5, combinatorial background (light gray) and SM $B^0_s \to \mu^+\mu^-$ (gray).

The aforementioned limits are the most restrictive limits on these branching fractions obtained to date.

References

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