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Search for $B_s^0 \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$ decays in CMS

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Summary. — A search for the rare decays $B_s^0 \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$ performed in pp collisions at $\sqrt{s} = 7\,\text{TeV}$ is presented. The data sample, collected by the CMS experiment at the LHC, corresponds to an integrated luminosity of about $5\,\text{fb}^{-1}$, corresponding to all 2011 data taking.

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In the standard model (SM) of particle physics, flavor-changing neutral-current decays are highly suppressed. The SM predictions [1], $(3.2 \pm 0.2) \times 10^{-9}$ for $B_s^0 \to \mu^+\mu^-$ and $(1.0 \pm 0.1) \times 10^{-10}$ for $B^0 \to \mu^+\mu^-$, are significantly enhanced in several extensions of the SM [2], although in some cases the decay rates are lowered [3]. A blind search, in which the signal region is not observed until all selection criteria are established, is presented here for the rare decays $B_s^0 \to \mu^+\mu^-$ and $B^0 \to \mu^+\mu^-$, using $5\,\text{fb}^{-1}$ of integrated luminosity collected by the CMS experiment [4].

1. – Analysis

An event-counting experiment is performed in the dimuon mass region $[4.9, 5.9]\,\text{GeV}$. Monte Carlo (MC) simulations are used to estimate backgrounds due to rare B decays while combinatorial backgrounds are evaluated from the side-band data. The mass resolution and the background level depend on the pseudorapidity η of the reconstructed tracks. Thus, data are analyzed separately in two channels, "barrel" (if both muons have $|\eta| < 1.4$) and "endcap" (elsewhere), and then combined for the final result. Events from $B^+ \to J/\psi K^+$ decays (where $J/\psi \to \mu^+\mu^-$) are used as a "normalization" channel, to remove uncertainties related to the $b\bar{b}$ production cross section and the integrated luminosity. To validate the B_s^0 distributions, a "control" sample of reconstructed $B_s^0 \to J/\psi\phi$ decays (where $J/\psi \to \mu^+\mu^-$ and $\phi \to K^+K^-$) is used. The reconstruction of $B_s^0 \to \mu^+\mu^-$ candidates starts by looking at two oppositely-charged muons that originate from a common vertex. The most discriminating variables are i) the 3D impact parameter significance of the B candidate; ii) the pointing angle; iii) the isolation, for which

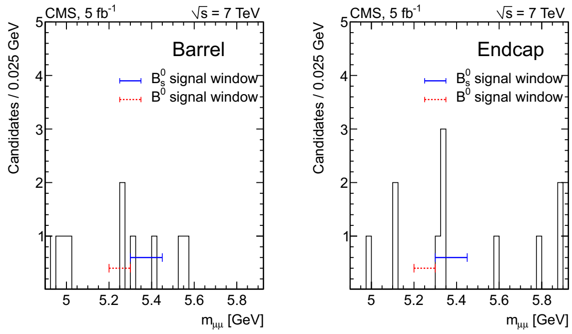

Fig. 1. – Dimuon invariant mass distributions in the barrel (left) and endcap (right) channels.

three variables are used, one based on the primary vertex ($I = p_T(B)/(p_T(B)+\sum_{trk} p_T)$) and two based on the secondary vertex: the number of tracks close to the B-candidate vertex and the minimum distance of closest approach of the closest track.

2. – Results

The variables described above are optimized with a random-grid search to obtain the best expected upper limit, using MC events for the signal and data side-band events for the background.

The branching fractions are measured using the following equation:

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = \frac{N_\mathrm{s}}{N_\mathrm{obs}^{B^+}} \frac{f_\mathrm{u}}{f_\mathrm{s}} \frac{\epsilon_\mathrm{tot}^{B^+}}{\epsilon_\mathrm{tot}} \mathcal{B}(B^+), \tag{1}$$

where ϵ_tot is the total signal efficiency, $N_\mathrm{obs}^{B^+}$ is the number of reconstructed $B^+ \to J/\psi K^+$ decays, $\epsilon_\mathrm{tot}^{B^+}$ is the total efficiency of B^+ reconstruction, $\mathcal{B}(B^+)$ is the branching fraction for $B^+ \to J/\psi K^+ \to \mu^+\mu^- K^+$, $f_\mathrm{u}/f_\mathrm{s}$ is the fragmentation function ratio and N_s is the background-subtracted number of observed signal candidates in the $B_s^0 \to \mu^+\mu^-$ window $[5.30, 5.45]$ GeV. An analogous equation is used for $B^0 \to \mu^+\mu^-$, with signal window $[5.20, 5.30]$ GeV. Figure 1 shows the measured dimuon invariant mass distribution. Upper limits on the $B^0 \to \mu^+\mu^-$ and $B_s^0 \to \mu^+\mu^-$ branching fractions are determined using the CLs method, taking into account statistical and systematical uncertainties. The combined upper limits for the barrel and endcap channels are

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) < 7.7 \times 10^{-9} \text{ (95\% CL)},$$
$$\mathcal{B}(B^0 \to \mu^+\mu^-) < 1.8 \times 10^{-9} \text{ (95\% CL)}.$$

The SM median expected upper limits at 95% CL are 8.4×10^{-9} for $B_s^0 \to \mu^+\mu^-$ and 1.6×10^{-9} for $B^0 \to \mu^+\mu^-$. The observed number of events is consistent with the SM predictions.

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