## 0.1 Combinatorial Background

The real challenge in the search for $B_s \to \mu^+\mu^-$ is how to deal with the enormous level of background. In this aspect, it is fundamental to have a very good invariant mass resolution to be able to reduce the search window and reduce the level of combinatorial background and misidentified two body decays.

The three LHC experiments (ATLAS, CMS and LHCb) have concluded that the dominant background in this channel is combinatorial, that is, most of the background event contains real muons (from b-decays) that are combined to fake the signal.Other very rare decays may not be negligible, depending very much on the size of the search window, hence on the invariant mass resolution of each experiment, see next section.

ATLAS and CMS have generated simulated samples were cuts are introduced at generator level: for each minimum bias event generated, it is required to have two muons with, $|\eta| < 2.5(2.4)$, Pt$> 6(3)$ GeV, and the distance between the two muons in the $\eta - \phi$ plane, $\Delta R$, should be less than 0.9(1.2), for ATLAS(CMS) respectively. CMS also requires the Pt of the Bs candidate to be larger than 5 GeV, and the invariant mass be within 5 and 6 Gev. The number of background events generated with these cuts corresponds to ??( 0.8) pb$^{-1}$ for ATLAS(CMS) respectively. Both experiments evaluate the background using these samples, and extrapolate the results to a given integrated luminosity, for instance, at 10 fb$^{-1}$ ATLAS expects 20$\pm$?? events[1], and CMS $14\pm^{22}_{14}$ events[2].

LHCb is a dedicated b-physics experiment, hence most of the computing resources are devoted to generate and fully reconstruct a large sample of inclusive $b\bar{b}$ events, used by the experiment to evaluate generic backgrounds. The only requirement is that both $b$-quarks have $|\theta| < 400$ mrad to match, on the safe side, the LHCb acceptance of 300 mrad. Nevertheless, a sample of 34 million events corresponds to just 0.16 pb$^{-1}$. The study of this sample, however, shows that in the sensitive region of phase space, the relevant background contains two real muons from $b$-decays. Hence, a specific sample of 8 million events was generated, that corresponds to 3 pb$^{-1}$,were both $b$-quarks are required to contain a muon within its decay products, but no other requirement. LHCb uses this sample to evaluate the background and extrapolate the result to a given integrated luminosity, for instance, at 2 fb$^{-1}$ in the sensitive region (G>0.7)[3], they don't select any background event, hence an upper limit of 125 events is estimated at 90% C.L.

As can be seen from the previous discussion, it is clear that the estimation of the combinatorial background is very much limited by the MonteCarlo statistics available. Hence, it is important not to neglect the uncertainties in these estimations. Notice, however, that when LHC starts running the evaluation of this background from the sidebands will not suffer at all from statistics.

# References


[1] ATLAS note

[2] CMS note

[3] LHCb note