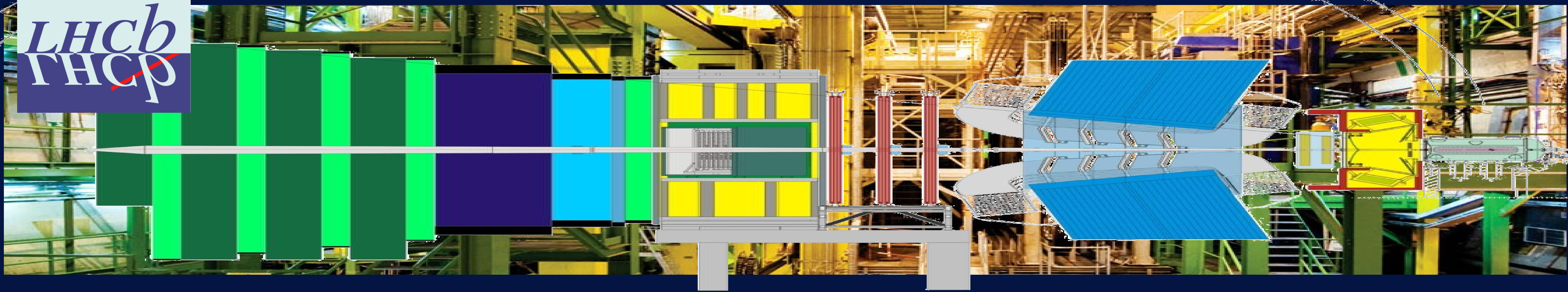

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Search for the rare decays $B^0_{(s)} \to \mu^+\mu^-$ with the LHCb Experiment

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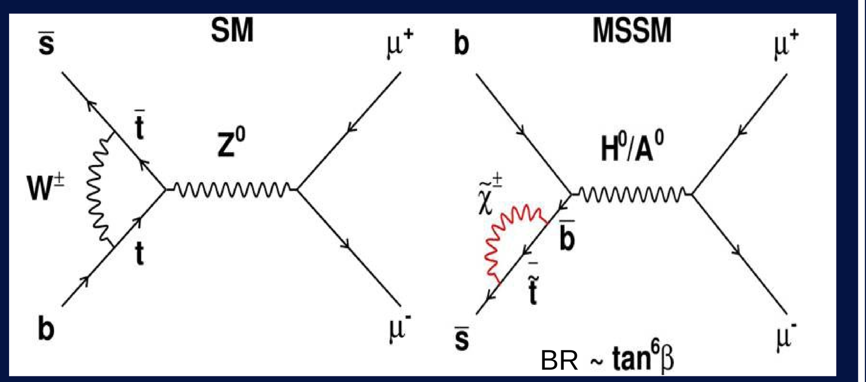
1. Introduction

With 37 pb^{-1} of integrated luminosity the LHCb Collaboration has obtained a world competitive measurement of the upper limits on the $B^0_{(s)} \to \mu^+\mu^-$ decays [1].

Within the Standard model (SM) these processes are very rare (FCNC and helicity suppressed).

$B^0_s \to \mu^+\mu^-$ Feynman diagrams



As described in [2] the SM predictions are:

$\mathcal{B}(B^0_s \to \mu^+\mu^-) = (0.32 \pm 0.02) \times 10^{-8}$

$\mathcal{B}(B^0 \to \mu^+\mu^-) = (0.010 \pm 0.001) \times 10^{-8}$

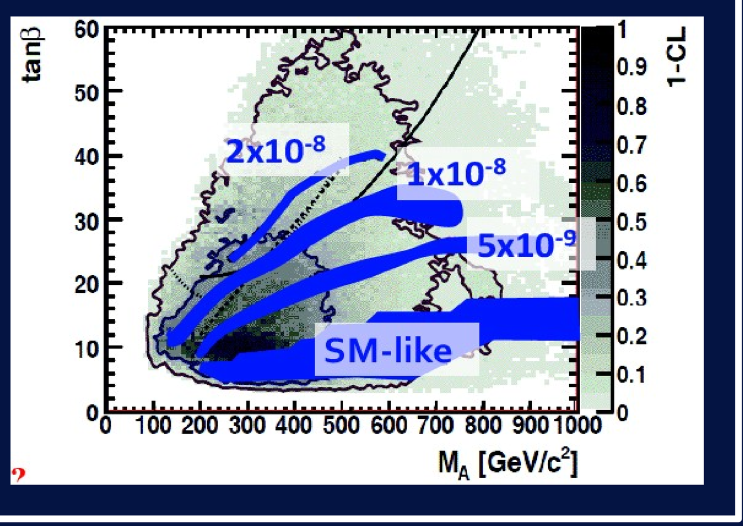
Most restrictive experimental preliminary limits published by D0 [3] and CDF [4] are:

$\mathcal{B}(B^0_s \to \mu^+\mu^-) < 3.6 \times 10^{-8}$ at 90% C.L.

$\mathcal{B}(B^0 \to \mu^+\mu^-) < 0.76 \times 10^{-8}$ at 90% C.L.

In New Physics (NP) scenarios with large tan β the BR of these decays can be high.

Regions of the tan β vs m_A plane compatible with different $BR(B^0_s \to \mu^+\mu^-)$ in MSSM with large tan β [5].



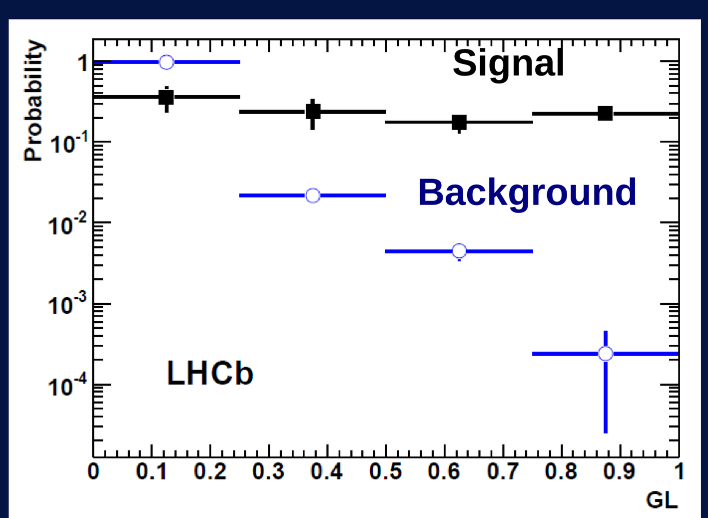
2. B → μμ at LHCb

LHCb performance

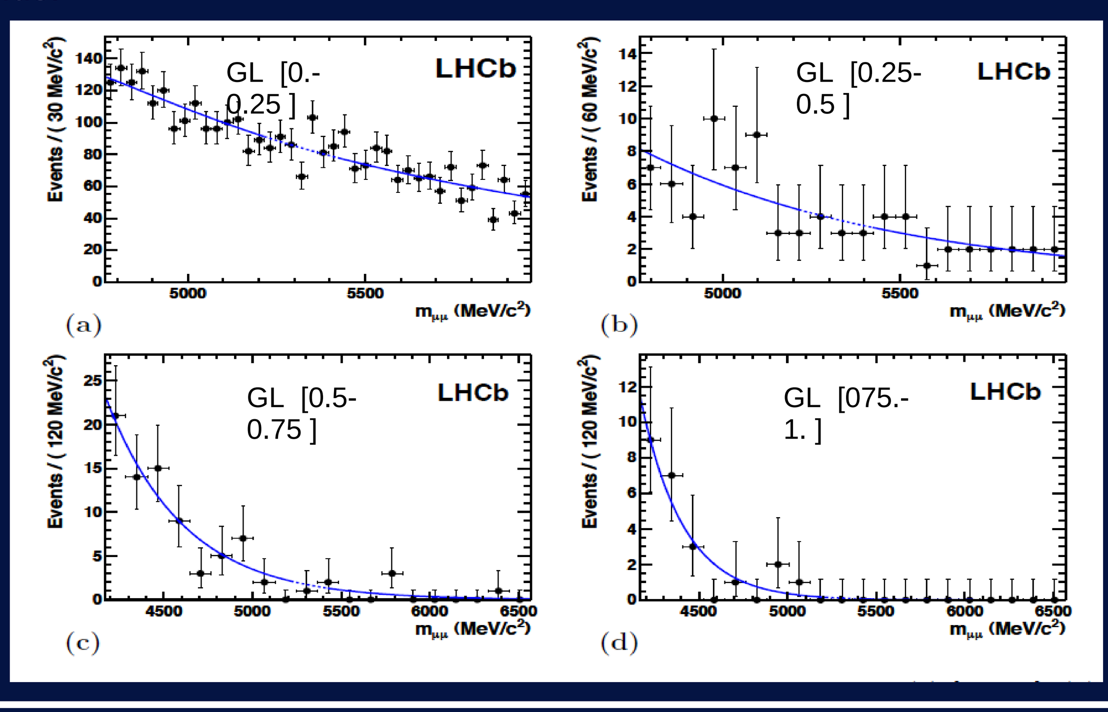
- Large cross section: $\sigma(pp \to b\bar{b}X) \sim 300$ μb at 7 TeV [6].
- Large acceptance for bb pairs produced mostly forward/backward: LHCb covers 1.9<η<4.9.
- Efficient trigger on low p_T muons.
- Large boost: the B meson decay vertex is displaced in average ~ 1 cm from the PV .
- Good mass resolution: $\sigma(B^0_{(s)} \to \mu^+\mu^-) = 26.7$ MeV/c^2.
- Good impact parameter resolution: σ(IP) ~25 μm (p_T = 2 GeV/c).
- MuonID performance: ε(μ→μ) ~ 97 % (p>10 GeV/c), ε(h→μ) < 1% (p>10 GeV/c).

3. Analysis strategy

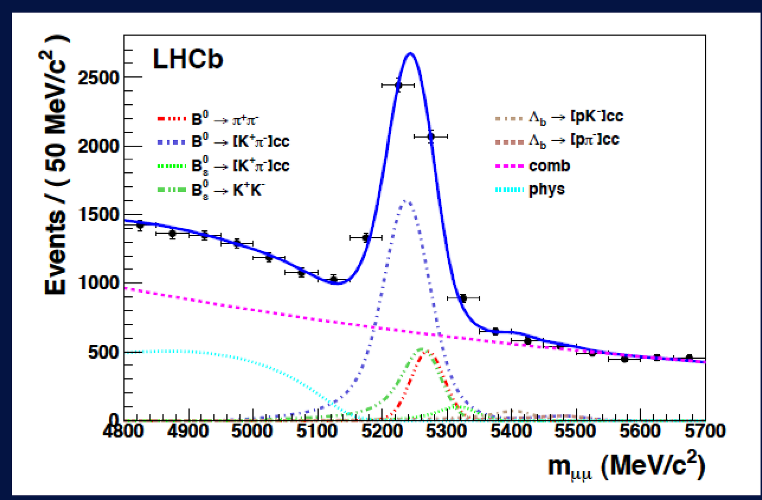
- Soft selection that reduces the size of the data sample and rejects most of the background.
- After the selection, a further discrimination between signal and background is achieved by combining some variables related with the geometry and the kinematics of the event (the lifetime of the B candidate, the lowest impact parameter significance of the muons with respect to any reconstructed PV, the impact parameter of the B candidate, the distance of closest approach of the two muon candidates, the isolation of each muon candidate and the transverse momentum of the B candidate) into a single variable, the geometry likelihood (GL), which is flat for signal and peaked at zero for background.



- Each event is given a probability to be signal or background in a two-dimensional space defined by the invariant mass and the GL. This 2D space is binned in equally sized bins (4 in the GL and 6 in the invariant mass).
- The expected number of background events in each bin is obtained by interpolating from the mass sidebands.



- The GL shape for signal is calibrated on data using a B → hh inclusive sample and for background it is obtained using the sidebands of the μμ invariant mass distribution. The invariant mass lineshape for signal is calibrated using inclusive B → hh sample and dimuon resonances for the resolution.



- The expected number of signal events in each bin is obtained by normalizing to a channel with known BR. In this way the knowledge of the absolute luminosity and the $b\bar{b}$ cross section are not needed:

$$BR = BR_{cal} \times \frac{\epsilon^{REC}_{cal}\,\epsilon^{SEL|REC}_{cal}\,\epsilon^{TRIG|SEL}_{cal}}{\epsilon^{REC}_{sig}\,\epsilon^{SEL|REC}_{sig}\,\epsilon^{TRIG|SEL}_{sig}} \times \frac{f_{cal}}{f_{B^0_q}} \times \frac{N_{B^0_s\to\mu^+\mu^-}}{N_{cal}} = \alpha \times N_{B^0_s\to\mu^+\mu^-}$$

Normalization factor

ϵ^{REC} reconstruction efficiency, includes acceptance and particle identification;
$\epsilon^{SEL|REC}$ selection efficiency on reconstructed events;
$\epsilon^{TRIG|SEL}$ trigger efficiency on reconstructed events

f_x denotes the probability that a b-quark fragments into a B_x hadron

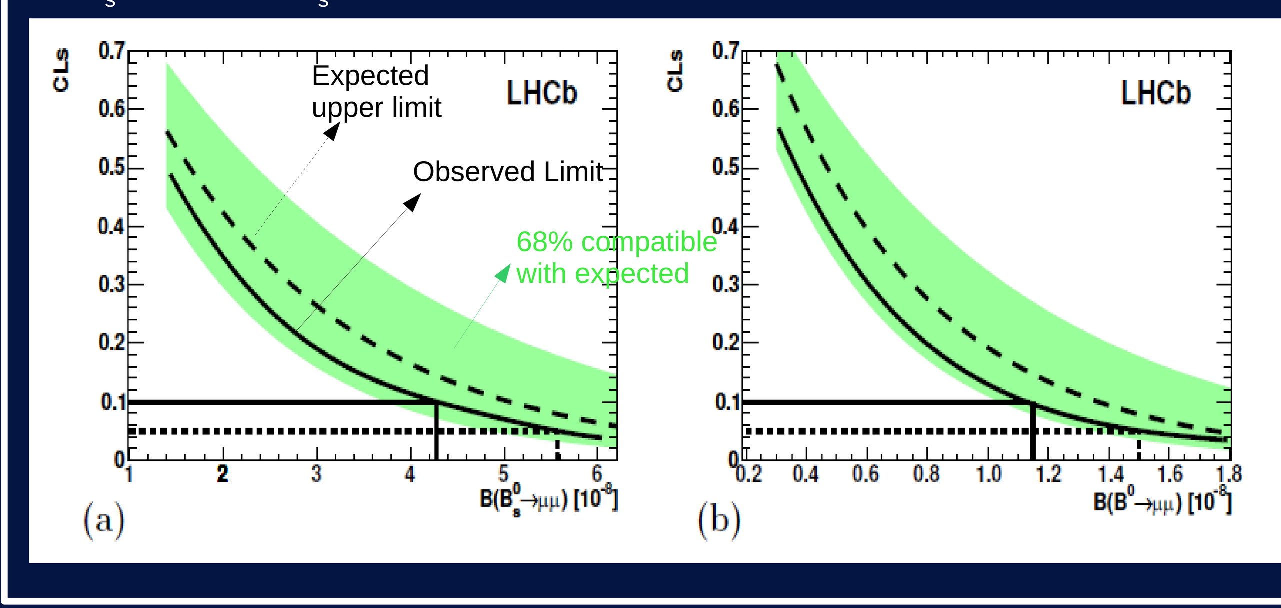
Two of the channels used have similar trigger efficiency and muon identification efficiency to the signal but a different number of particles in the final state. The third one has the same topology but is selected with different trigger. (BR values on table below).

	$\mathcal{B}$ $(\times 10^{-5})$	$\frac{\epsilon^{REC}_{norm}\epsilon^{SEL\|REC}_{norm}}{\epsilon^{REC}_{sig}\epsilon^{SEL\|REC}_{sig}}$	$\frac{\epsilon^{TRIG\|SEL}_{norm}}{\epsilon^{TRIG\|SEL}_{sig}}$	N_{norm}	$\alpha_{B^0_s\to\mu^+\mu^-}$ $(\times 10^{-9})$	$\alpha_{B^0\to\mu^+\mu^-}$ $(\times 10^{-9})$
$B^+ \to J/\psi K^+$	5.98 ± 0.22	0.49 ± 0.02	0.96 ± 0.05	12366 ± 403	8.4 ± 1.3	2.27 ± 0.18
$B^0_s \to J/\psi\phi$	3.4 ± 0.9	0.25 ± 0.02	0.96 ± 0.05	760 ± 71	10.5 ± 2.9	2.83 ± 0.86
$B^0 \to K^+\pi^-$	1.94 ± 0.06	0.82 ± 0.06	0.072 ± 0.010	578 ± 74	7.3 ± 1.8	1.99 ± 0.40

- For each 2D bin evaluate CL_S and CL_B [7] and calculate the expected exclusion limit.

4. Results

CL_s vs BR for $B_s \to \mu\mu$ (a) and for $B^0 \to \mu\mu$ (b):



Observed upper limits at 95 % C.L.:

$\mathcal{B}(B^0_s \to \mu^+\mu^-) < 5.6 \times 10^{-8}$

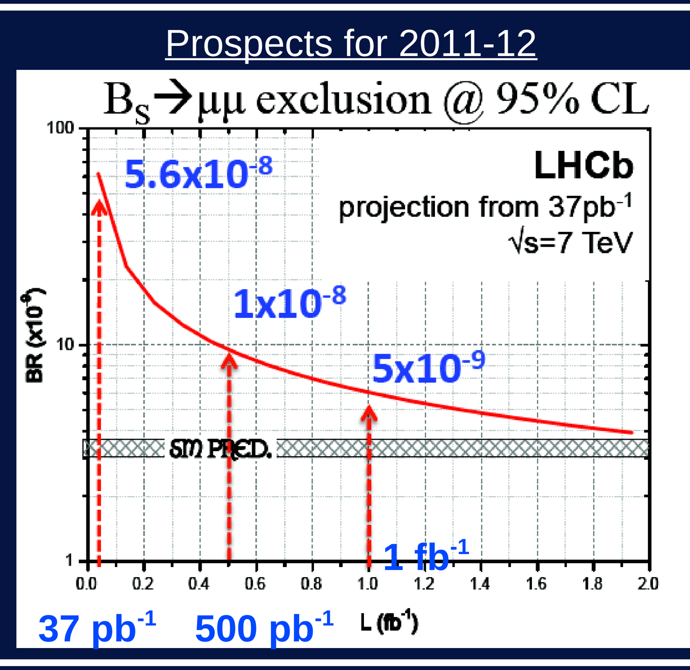
$\mathcal{B}(B^0 \to \mu^+\mu^-) < 1.5 \times 10^{-8}$

5. Conclusions

With only ~ 37 pb^{-1} LHCb has searched for the rare dimuon decays of the B^0_s and B^0 and has set limits close to the best existing ones. The observed yields are compatible with the background expectations.

The data expected during 2011 will allow LHCb to explore the region of branching ratios below 10^{-8}.

Prospects for 2011-12



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