DECAYS OF BEAUTY HADRONS MEASURED IN CMS AND ATLAS

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The ATLAS and CMS data collected in pp collisions during 2010 and 2011 allowed a good quality of B-physics measurements, reproducing essential b-hadron properties, such as masses and lifetimes, and demonstrating a good performance of the two detectors within an increasing instantaneous luminosity of the LHC machine. These features enabled in particular a measurement of rare B decays with a precision that contributes to the LHC potential along with the LHCb experiment dedicated to B-physics. The CMS and ATLAS results on searches for $B_s^0 \to \mu^+\mu^-$and $B^0 \to \mu^+\mu^-$decays with 2011 data are reported here.

1 Introduction

The ATLAS[?] and CMS[?] experiments have rich and competitive heavy flavor programs including measurements of b-quark production, studies of b-hadron decays, as well as measurements of quarkonium and exotic states production. Both are ready to perform indirect searches for new physics, such as the rare decays of $B_s^0 \to \mu^+\mu^-$, $B^0 \to \mu^+\mu^-$, and measurements of CP-violating phase in the B_s^0 decay, that provide important constraints to the Standard Model (SM) and are complementary to direct searches for new physics. In 2010, the CMS and ATLAS have collected 40 pb^{-1} of data with a peak instantaneous luminosity of 2×10^{32} $cm^{-2}s^{-1}$. In 2011 the data taking was characterized by an increase of the LHC instantaneous luminosity reaching values of 3.5×10^{33} $cm^{-2}s^{-1}$ and the total integrated recorded luminosity was about 5 fb^{-1}.

The ATLAS and CMS B-physics trigger strategies are based on muon signatures. Due to bandwidth limitations the trigger menus in 2011 were mainly based on di-muon signatures at the first level trigger, combined at the higher trigger levels with a precise tracking and a vertex reconstruction capabilities.

A good track reconstruction performance with increasing instantaneous luminosity is important. For b-hadrons, decays trajectories of secondary particles are displaced from the primary vertex and the reconstruction of their shortest distances from the primary vertex (impact parameters) is of key importance. CMS measured the resolution of the track transverse impact parameter as a function of the track p_{T}[?]. This resolution, shown in Figure **??** was measured from data and compared with predictions from simulations. A precise test of these capabilities was made in ATLAS by reconstructing transverse impact parameters of tracks originating (mostly) from primary vertex for three different values of average number of interactions per beam crossing during 2011 data taking, Figure **??**, right. It was demonstrated that the resolution with increasing luminosity is preserved. The tails are potentially sensitive to the rate of secondaries and fakes and the results show no significant increase in the fake rate.

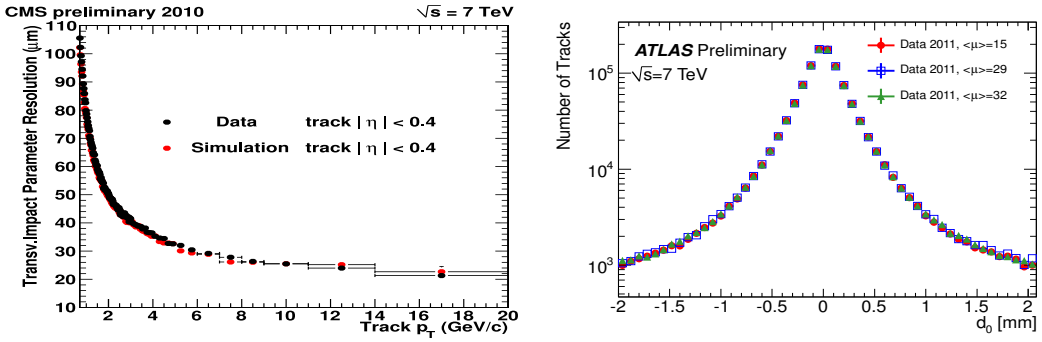

Figure 1: Left: CMS measured resolution of the track transverse impact parameter as a function of the track $p_{\rm T}$ [?] . Only central tracks with $|\eta| < 0.4$ are considered. Black and red symbols correspond to results from data and simulation, respectively. Right: ATLAS transverse impact parameter of reconstructed track with respect to primary vertex for three different values of average number of interactions per beam crossing during 2011 data taking [?] .

2 b-hadron masses and lifetimes in decays with $J/\psi \to \mu^+\mu^-$ in final state.

Using 2010 and 2011 data most of b-hadron species have been extracted in ATLAS and CMS using exclusive decays with $J/\psi \to \mu^+\mu^-$ in final state, and masses and most of lifetimes were measured. These measurements showed a consistency with PDG values and thus provided a precise test of $p_{\rm T}$-scale calibration in low $p_{\rm T}$ region, a precise test of detector alignment and a validation of vertexing algorithms.

High precision lifetime measurements performed by ATLAS and CMS using 2010 data were an important milestone on the way towards high precision time-dependent CP violation measurements. An overview of lifetime measurements using decay channels with $J/\psi \to \mu^+\mu^-$ in final state is given in Table **??** showing good agreement with PDG values. Figure **??** is showing fits to proper-decay times; the ATLAS measurement of average B-meson in inclusive decay $B \to J/\psi$ (left) [?] and CMS measurement of B^0 lifetime in $B^0 \to J/\psi K^0$ decay (right) [?]. An

		measured lifetime	PDG
$B^0 \to J/\psi K^0$	CMS [?]	$c\tau = 479 \pm 22$ μm	457 ± 3 μm
$B^0 \to J/\psi K^{*0}$	ATLAS [?]	$\tau = 1.51 \pm 0.04$ (stat) ± 0.04 (syst)	1.525 ± 0.009 ps
$B_s^0 \to J/\psi\phi$	CMS [?]	$c\tau = 478 \pm 26$ μm	491.0 ± 8.7 μm
$B_s^0 \to J/\psi\phi$	ATLAS [?]	τ =1.41 $\pm$ 0.08 (stat) $\pm$ 0.05 (syst) ps	1.472 ± 0.026 ps
$B \to J/\psi$	ATLAS [?]	τ =1.489 $\pm$ 0.016 (stat) $\pm$ 0.043 (syst) ps	1.544 ± 0.014 ps

Table 1: b-hadron lifetimes measured in CMS and ATLAS using 40 pb^{-1} of 2010 data.

example of two mass signals using 2011 data is given in Figure **??**. First is a Λ_b^0 signal in decay channel $\Lambda_b^0 \to \Lambda^0 J/\psi$ measured in CMS using 1.8 fb^{-1} of 2011 data [?], the extraction of this signal was used for a production cross section measurement. Second example is the ATLAS measurement of B_c meson mass, through its decay into $B_c^{\pm} \to J/\psi\pi^+(\pi^-)$, using 4.3 fb^{-1} of data in 2011 [?]. The B_c mass distribution is fitted with an unbinned maximum likelihood fit. The fitted mass of 6.282$\pm$0.007 (stat.) GeV is consistent with the PDG value m(B_c)= 6.277$\pm$0.006 GeV.

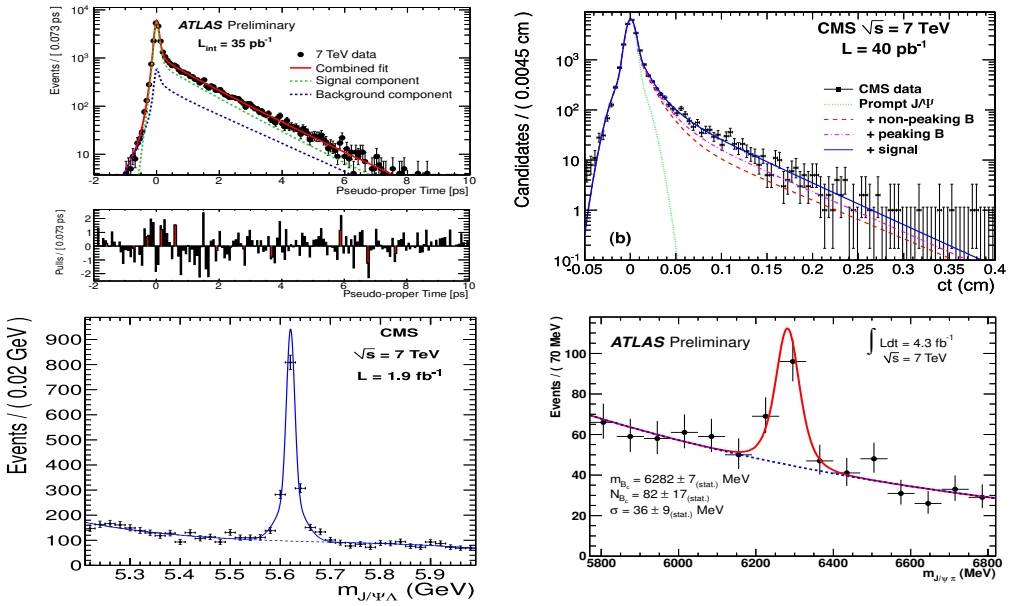

Figure 2: Left, top: ATLAS measurement of average b-hadron lifetime in inclusive decay $B \to J/\psi$ X [?] . The signal component (green hashed line), background components (blue dotted line) and the sum of signal and backgrounds (red solid line). Right, top: CMS measurement of B^0 lifetime [?] , the sum of all contributions (blue solid line); the prompt J/ψ (green dotted); the sum of the prompt and non-prompt J/ψ (red dashed), and the sum of all backgrounds (purple dot-dashed). Left, down CMS Λ_b^0 mass [?]. Right, down: ATLAS $B_c^{\pm} \to J/\psi\pi^+(\pi^-)$ mass [?]. Red (full) line shows a fit projection to signal and background, blue (hash) line to background.

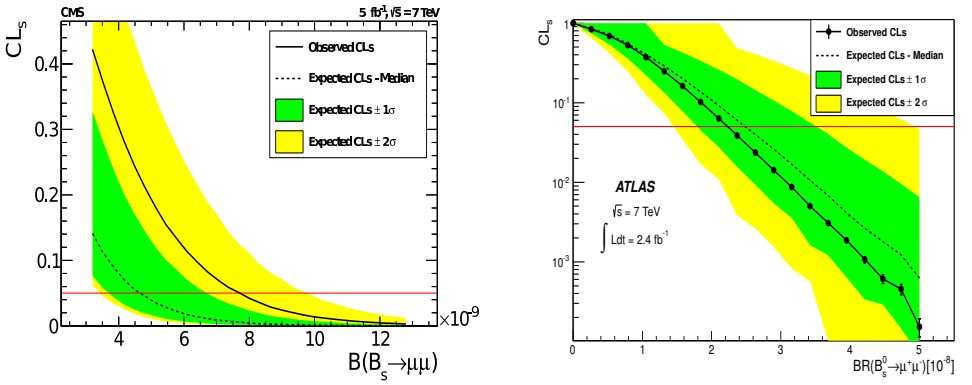

Figure 3: The expected and observed CLs functions of BR($B_s^0 \to \mu^+\mu^-$) for CMS [?] (left) and ATLAS [?] (right). Details given in the text.

3 Searches for rare B-meson decays

The rare decays $B_s^0 \to \mu^+\mu^-$and $B^0 \to \mu^+\mu^-$offer a profound probe into the effects of physics beyond the Standard Model (SM). The decays are flavour-changing neutral-current processes which are forbidden in the SM at tree level, occurring only via higher order diagrams. In the SM, these di-muonic B-decays have been calculated with high precision and with minimal non-perturbative uncertainties. These decays are also helicity suppressed, resulting in expected branching ratios (BR) of $(3.2 \pm 0.2) \times 10^{-9}$ and $(1.0 \pm 0.1) \times 10^{-10}$, respectively [?].

The results of CMS and ATLAS are using 4.9 fb^{-1} and 2.4 fb^{-1} of 2011 data respectively. The obtained CMS upper limits on BR at 95% C.L. are 7.7×10^{-9} and 1.8×10^{-9} for the $B_s^0 \to \mu^+\mu^-$and $B^0 \to \mu^+\mu^-$decays, respectively [?]. ATLAS determined the upper limit on the BR($B_s^0 \to \mu^+\mu^-$) 2.2×10^{-8} at 95% C.L. [?]. The expected and obtained CLs functions of branching ratios for $B_s^0 \to \mu^+\mu^-$decay are given for CMS and ATLAS in Figures **??**.

In both cases, the 95% CL limit is indicated by the red line and the solid black curves are the observed CLs. The yellow and green bands are the $\pm$ 1 σ and $\pm$ 2 σ fluctuations on the expected CLs (dashed black line) based on pseudo experiments with setting the counts in the search window to the interpolated background including the resonant one - before unblinding the region.

4 Conclusions

The CMS and ATLAS experiments have a rich program in the field of b-hadron decays. Precise measurements of lifetimes and masses of b-hadrons demonstrated that these experiments are well equipped for coming CP violation measurements. Searches for the rare decays $B_s^0 \to \mu^+\mu^-$and $B^0 \to \mu^+\mu^-$have been conducted, setting stringent constraints on extensions to the Standard Model.

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