

contribution from $B^0 \rightarrow J/\psi\pi\pi$ on the $B_s^0 \rightarrow J/\psi\pi\pi$ channel.
 May 24 2017

feedback from LHCP: the lifetime measurements presented by Nuno at LHCP were well received by the community. However, a comment was raised by LHCb regarding the $B_s^0 \rightarrow J/\psi\pi\pi$ channel which deserves our consideration. A contribution from $B^0 \rightarrow J/\psi\pi\pi$ is quite visible in the $J/\psi\pi\pi$ mass plot at around 5.27 GeV: it should be taken into account (or removed) in the final analysis. I hope that you can address this issue quickly.

Answer: Following the comment, we add a component in the pdf to take into account the $B^0 \rightarrow J/\psi\pi\pi$ contribution. The mass will be modeled by a gaussian function with the mean fixed from the pdg value and the width shared with the width used for B_s^0 gaussian signal, which is a free parameter of the fit. The fraction (the number of events, N_{B^0}) for this component is a free parameter of the fit too.

For ct , this component is modeled by an exponential decay convoluted with the resolution. The lifetime for this contribution is fixed to the B^0 lifetime taken from the PDG, being corrected by the factor $M_{B^0}/M_{B_s^0}$, since the ct variable was calculated using the B_s^0 mass. The invariant mass and ct distributions obtained from data are shown with the fit results superimposed Fig. 1. The average B_s^0 lifetime obtained from the fits is $ct = 502.5 \pm 10.2 \mu m$, which is in agreement with the previous one.

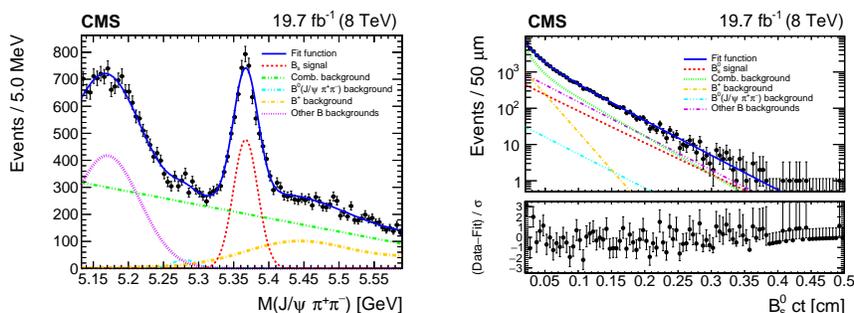


Figure 1: Invariant mass (left) and ct (right) distributions for B_s^0 candidates reconstructed from $B_s^0 \rightarrow J/\psi\pi\pi$ decays. The curves are projections of the maximum-likelihood fit to the data, with the contributions from signal (dashed), background (dotted), misidentified $B^+ \rightarrow J/\psi K^+$ background (dashed-dotted), $B^0 \rightarrow J/\psi\pi\pi$ contribution (dashed-dotted-dotted-dotted), partially reconstructed and (other) misidentified B backgrounds (dashed-dotted-dotted) and the sum of signal and background (solid) shown. The bottom panel of the right figure show the difference between the observed data and the fit divided by the data uncertainty.

Jonatan questions: 1) Can you try floating the width of the B^0 peak? In principle, it shouldn't be the same as that for the B_s signal.

Answer: Yes you are right, in principle they shouldn't be the same. In fact, the width of the B^0 is corrected by a factor of $M_{B^0}/M_{B_s^0}$.

2) How does the fit improve (or not) with the inclusion of the B^0 peak?

Answer: The reduced chi2 of the fits are basically the same, 1.058 for the nominal model and 1.063 when the B^0 component is included.

3) Sorry if I didn't notice before, but the signal peak looks like would be better fit with 2 gaussians sharing the mean value. Did you try?

Answer: In the past we tried that and the fit did not converge well (obtained unreasonable result). On the other hand, please take a look to Fig. 2, this is exactly the same (unbinned) fit shown using different binning. So we believe one Gaussian is good enough to model the signal peak.

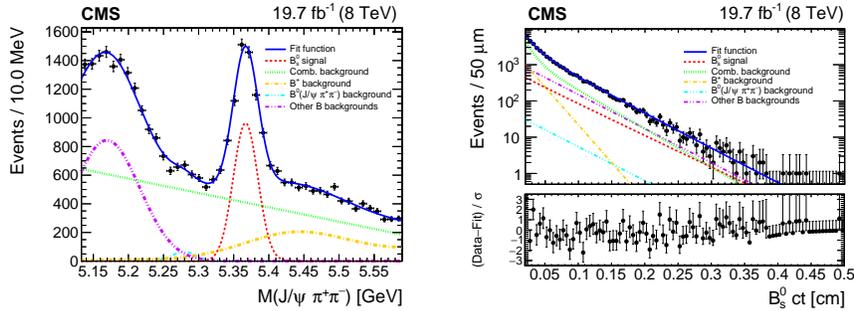


Figure 2: Invariant mass (left) and ct (right) distributions for B_s^0 candidates reconstructed from $B_s^0 \rightarrow J/\psi\pi\pi$ decays. The curves are projections of the maximum-likelihood fit to the data, with the contributions from signal (dashed), background (dotted), misidentified $B^+ \rightarrow J/\psi K^+$ background (dashed-dotted), $B^0 \rightarrow J/\psi\pi\pi$ (dashed-dotted-dotted-dotted) contribution, partially reconstructed and (other) misidentified B backgrounds (dashed-dotted-dotted) and the sum of signal and background (solid) shown. The bottom panel of the right figure show the difference between the observed data and the fit divided by the data uncertainty.

MARTINO questions: 1) It could be interesting to know what is the value of the B^0 fraction you get; is it in reasonable agreement with the ratio of the two BRs? Of course some assumption should be used for the efficiency ratio. In my opinion (of course if the conveners and the ARC agree) the default fit should be the one with the $B^0 \rightarrow J/\psi\pi\pi$ included.

Answer: Our fit give 4161 ± 107 signal events for B_s^0 and 277 ± 65 events for B^0 component. In the table 1 you can see the BRs taken from PDG. On the other

hand, maybe we can use this paper by LHCb¹ "PRL 109,152002 (2012)", where they study the same channel as us. We can see (infer) the events numbers for B_s^0 (B^0). Its numbers are in agreement with ours. Of course, remember it is different reconstruction, resolution, selection, cuts, etc.

Table 1: B^0 and B_s^0 BRs.

	B^0	B_s^0
$J/\psi\pi\pi$	$(4.03 \pm 0.18) \times 10^{-5}$	$(2.13 \pm 0.18) \times 10^{-4}$
$J/\psi f_0(\rightarrow \pi\pi)$	$< 1.1 \times 10^{-6}$	$(5.1 \pm 0.9) \times 10^{-5}$

2) In the first set of plots you posted, it seems as the B^0 peak in data (points) is narrower than the fit: what is the resulting width when you fit it? Is it narrower than the B_s^0 one?

Answer: The two gaussians (B^0 and B_s^0) are sharing the same width, but the the width of the B^0 is corrected by a factor of $M_{B^0}/M_{B_s^0}$. Then yes, B^0 width is narrower than the B_s one. On the other hand, if we let totally free the width of the B^0 we obtain a unreasonable result.

3) In the second set the of plots the statistics is doubled wrt the first set?.

Answer: As Jonatan talked us, "the binning is 10 MeV instead of 5 MeV ;) The statistics is the same".

¹[PRL 109,152002 \(2012\)](#)