Measurement of the B_c^+ meson lifetime using $B_c^+ \to J/\psi \mu^+ \nu_\mu X$ decays

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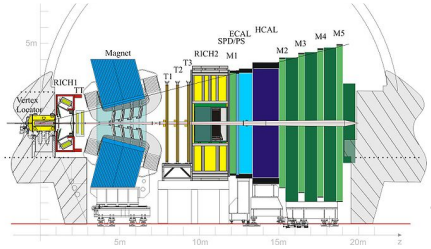
Introduction

The B_c^+ meson, formed of a $\bar{b}$ and a c quark, is an excellent laboratory to study QCD and weak interaction.
It can be described with non-relativistic QCD expansion as quarkonia, but it is an open-flavour state formed of two heavy quarks. The only one in the Standard Model.
The lifetime of the B_c^+ meson is measured using semileptonic decays including a J/ψ meson in the final state.
The data, corresponding to an integrated luminosity of 2 fb^{-1}, are collected by the LHCb detector in pp collisions at a center-of-mass energy of 8 TeV.

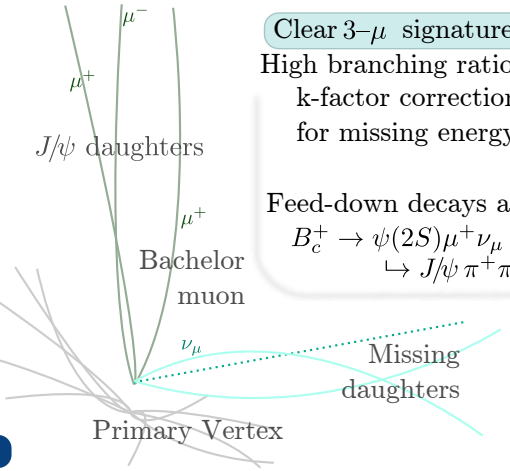
The LHCb detector

Single-arm forward spectrometer.
Rapidity range $2 < \eta < 5$
Proper-time resolution 30 − 50 fs
Charged tracks $\Delta p/p < 0.35 - 0.55\%$
Very efficieny muon identification



Signal model

Lifetime-unbiased selection.



Clear 3–μ signature.
High branching ratio.
k-factor correction for missing energy

Feed-down decays as
$B_c^+ \to \psi(2S)\mu^+\nu_\mu$
$\hookrightarrow J/\psi\,\pi^+\pi^-$

Background model

Muon misidentification.
Large detached background from $H_b \to J/\psi X$
Data-driven model constraining both shape and normalization in the final fit.

False J/ψ candidate.
Modelled in the final fit using J/ψ sidebands

Combinatorial background
A true muon and a true J/ψ.
Detached component is model from simulation, and checked on data having $M(3\mu) > M(B_c^+)$.
Prompt component is free in the fit.

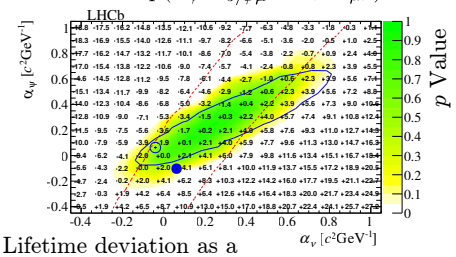
Wrong Primary Vertex association.
Using PVs from previous selected event

Systematic uncertainties

Dominant effect of background model.
In particular prompt peak (± 6.4 fs), combinatorial (± 7.4 fs), and false J/ψ (± 2.4 fs).

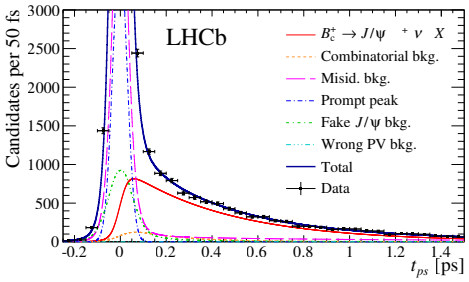
Uncertainty due to the theoretical model (± 5 fs) is constrained studying the simulation-data consistency for models deformed through the weight function

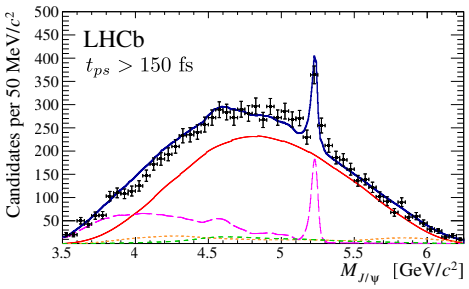
$$\exp(\alpha_\psi M_{J/\psi\mu} + \alpha_\nu M_{\mu\nu})$$



Lifetime deviation as a function of the deformation parameters.

Two dimensional fit





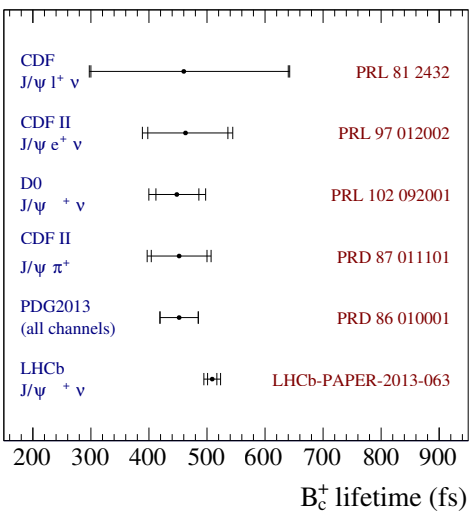
Maximum likelihood unbinned fit on 29756 selected events.
Signal candidates: 8995 ± 103 Background candidates: 20760 ± 130

Conclusion

The measured B_c^+ lifetime is

$$\tau(B_c^+) = 509 \pm 8 \pm 12 \text{ fs}$$

where the first uncertainty is statistical and the second is systematic.
This is the most precise measurement of the B_c^+ lifetime to date.
It is consistent with the current world average and has less than half the uncertainty.



Learn more!

Paper: LHCb-PAPER-2013-063
Preprint: arXiv:1401.6932
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