Report on JHEP_213P_1119

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Referee report

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Summary

I consider that this preprint satisfies the criteria for being published in JHEP.
I have listed few comments that need, eventually, to be considered by the authors before publication.

1 Summary of the draft content

In this draft, a measurement of the Cabibbo suppressed semileptonic decay $B^+ \to p\overline{p}\mu^+\nu_\mu$ branching fraction is obtained, for the first time, relative to the already measured $B^+ \to J/\Psi K^+$ channel.

2 Few comments on the analysis

2.1 Introduction

I do not really agree with what you say in paragraphs 3 and 4.

You seem to justify the interest of your analysis by the fact that it can help understanding the dynamics of B-meson decays into final states that contain a baryon-antibaryon pair. Especially because in hadronic decays the baryons can interact with the additional hadron(s) whereas this is not occuring in semileptonic decays. In practice, the complexity of hadronic decays comes also from the fact that baryons can be produced by several mechanisms (external or internal W, exchange, penguins, ...) and therefore it is not only the problem of interaction with the additional hadron.

Semileptonic decays can help to study the dynamics by measuring the form factors that enter in the $B \to p\overline{p}$ transition which are not known at present. This may clarify only a class of baryon production mechanisms; those that can be related, for example, to semileptonic decays by factorization (external W).

You say also "It is surprising that the branching fractions of decays of B mesons to final states comprising only two baryons are suppressed compared to those of two baryons and one or more extra final state particles." I consider that it is the reverse that would be surprising! The natural multiplicity of a B-meson decay is much higher than 2 charged particles (it is about 5.5).

You comment also about the fact that the $p\overline{p}$ mass shows an accumulation at low values. For decays that are governed by diagrams that are similar to the semileptonic one, this is in fact what you expect. If you consider the usual $B \to DXl\nu_l$ of $B \to hXl\nu_l$ semileptonic decays, the hadronic mass distribution, $m(DX)$ or $m(hX)$, is peaked at low values. This is a consequence of the semileptonic decay dynamics.

2.2 selection

I would like to have a bit more details on the background sources and on the way you suppress it.

2.2.1 background sources

The signal is $B^+ \to p\overline{p}\mu^+\nu_\mu$ but you don't know, experimentally, if you are measuring a B^+ or a B^-, unless you are using some tagging (?). Therefore, for the background you have also to envisage decays that can give the two charged states.

In the text you mention $B^+ \to p\overline{p}DX$. This is a priori a Cabibbo suppressed decay and the D has to decay emitting a μ^+. But you have also $B^+ \to p\overline{p}\overline{D}X$ which is Cabibbo allowed and in which the $\overline{D}$ emits a μ^-. Maybe it is this channel you have in mind as background?

There is one possible background component which is not mentioned: $\Lambda_b \to \Lambda_c\mu^- X$ where a proton is emitted by the Λ_c and an antiproton comes from fragmentation, acompanying the Λ_b? Maybe this component can be neglected because the $\overline{p}$ is too soft to satisfy the cut at 18 GeV or because it has a too large offset relative to the Λ_b decay vertex?

You have considered backgrounds coming from excited baryons: $B^+ \to N^{(*)}\overline{N}^{(*)}\mu^+\nu_\mu$ and considered that their corresponding branching fractions are "similar to the signal". What is the importance of this remaining source of background in Fig.3. How such events have been generated (phase space or using a model similar to the signal with m(NN) peaked at low values). I would like to be sure that this background component cannot produce a peaking background versus m_{corr} and that the fact you do not observe a peak, from this source, is not due to the simulation model used to generate it (ten lines before section 4 you indicate that you are using phase space to simulate backgrounds that have not been measured)? If $m(p\overline{N}^*)$ is peaked at low values and if $\overline{N}^* \to \overline{p}\pi^0$, it may be possible that the corresponding $m_{corr.}$ distribution has a peak?

2.2.2 cuts on BDT

You are using two BDT selectors. The first one considers the isolation of the B vertex. When you say that it rejects 80% of the major background is this obtained including decays that have only neutrals tracks in addition to the triplet $p\overline{p}\mu$?

I have not understood the interest of using the second BDT because it removes only 18% of the decays $B^+ \to p\overline{p}DX$ and its effect may depend on the way the signal has been simulated?

In the top of page 5 you mention a selection using the uncertainty on $m_{corr.}$. Can you indicate the typical resolution on this quantity and what selection is used so that one can compare it with the peak width in Fig. 4?

2.3 Section 4, end of page 5

I have not understood how you have measured the rate for proton misID. I guess that you need for that to have sources of real pions and kaons and measures the fractions that are identified as protons? I have not understood what is the "separate independent data sample" and how it is used?

2.4 Section 6, end of page 8

I have not understood why you need to add uncertainties on B^+ production cross-section and integrated luminosities when combining Run 1 and 2016 because you are measuring the ratio between two branching fractions? Contributions from these uncertainties are expected to cancel in the ratio?

3 Some possible typos

In page 2, 7 lines before the end: "b hadron" can be changed into "b-hadron".

Section 3, fourth paragraph: $B \to p\overline{p}\overline{D}X$ and transform the D notations into $\overline{D}$ in the text, just after.