Comments by Nikhef and VU University on LHCb-PAPER-2012-002:

Measurement of the branching fractions of charmless charged hadrons two-body decays of bottom hadrons

Dear authors of this paper,

We discussed the draft with Nikhef and VU University group members on Friday 11th of May. First of all we want to say that we are very happy with these nice results and the well written paper.

General comments:

We justify our measurements by theoretical interest in the BF. We have pointed out in arxiv:1204.1735 that in order to compare with theoretical expectations Bs BFs need to be either converted to BFs at t=0 by using the effective lifetime, or by giving the lifetime acceptance, so that the fraction of heavy and light states in our sample can be inferred.

The selection criteria in Table 1 do not seem to be optimal for these measurements (for instance, $t_{\pi\pi} > 2$ ps; what background lives that long?). Also the selections A, B and C are not justified. A follow-up of the analysis with more data should reconsider the selection criteria. We propose then to optimize the cuts and not to split into three different samples, but encourage to use the measured helicity angle to discriminate against the background.

The BF results must be highly correlated. It is strange that no reference is given where other users like the HFAG can access such information.

Although the PID calibration is described in detail, its application in the selection of the decay channels is not explained.

Only systematic uncertainties for the event yield ratios are given. Are the systematic uncertainties of the "overall" reconstruction efficiency ratios negligible?

We propose to add the charges of the $K^+\pi^-$ final state in B_0 decays and that of the π^+K^- final state in B_s^0 decays. The inclusion of charge conjugate modes is implied, as written in line 17.

If we want to add the interesting, but unnecessary, specification "annihilation decay" to $B_0 \rightarrow \pi^+\pi^-$, we should explain why this is called annihilation.

Below follow our comments per line.

- Title
  Dilepton decays are not excluded by this title.
  Triple use of 'of' can be avoided.
  "Measurement of the bottom hadron branching fractions for decay into two oppositely charged hadrons without charm."

- Abstract
  The list of measured values is too long and the duplication of branching fractions gives the impression that we cannot agree on a choice that must be made.
  One option is to keep the first 6 measured values, remove the derived 5 values and keep the text with minor modifications.
  "From a data sample collected by LHCb in 2011 corresponding to 0.37 fb^{-1} we measure the following branching fraction relations: ...
  with their statistical and systematic uncertainties. By using the most recent value

of the branching fraction $\mathcal{B}(B^0 \rightarrow K^+\pi^-)$ and the LHCb measurement of f_s/f_s we derive branching fractions of which $\mathcal{B}(B_s^0 \rightarrow K^+K^-)$, $\mathcal{B}(B_s^0 \rightarrow \pi^+K^-)$, and $\mathcal{B}(B^0 \rightarrow K^+\pi^-)$ are the most precise ones today. The decay $B_0 \rightarrow \pi^+\pi^-$ is observed for the first time with a significance above 5σ".

- Line 5.
  A measurement cannot be "theoretically clean".
  Remove the superfluous text "In contrast to the case of other theoretically clean measurements ... in the b quark sector".

- Line 9.
  Avoid the word "pollution" as penguins can be considered valuable.
  Replace "Such penguin pollution poses" by "These higher-order contributions pose".
  Replace "clean determination" by "accurate determination".

- Line 13.
  Make the text consistent with the abstract.

- Line 17.
  Add "decay" to "charge conjugate decay modes".

- Lines 17a, 62, 67, 81, 84, 87, 108, 114 and 146.
  The notation in Eq. (1) with H_b', h''^-, and h'''^+ is not very elegant.
  Replace Eq. (1) by an example equation for the second branching fraction relation in the abstract with B^0 and B_s^0 for H_b and H_b', π and K for h and h', and f_s/f_d for $f_{H_b'}/f_{H_b}$, respectively.
  The reader will be able to substitute the proper hadrons and quarks for the other decay modes.
  "The branching fraction ratio for two specific decays can be expressed as ... , where $f_{s(d)}$ is the probability for a b quark to hadronize into a $B_{(s)}^0$ hadron".

- Lines 37-49.
  This text might be rewritten with proper care for the HLT1 and HLT2 parts of the trigger and for a logical order of introducing the ingredients of the trigger criteria. Impact parameter χ^2 and d_{IP} seem to be two of a kind. The track for which χ^2/ndf< 2 is required is not specified. This is later called χ^2 per degree of freedom with dof instead of ndf. How are these quantities combined? BDT? NN? Cuts?

- Line 51.
  Add "trigger" to "the same trigger criteria" to emphasize that this is happening at the software trigger level.

- Line 59.
  Explain here why the three different selections are made, as these seem to complicate the analysis considerable. Is it because of statistics of the signal, the level of the background, or historical reasons?

- Table 1.
  The Track χ^2/dof< 3 requirement seems to contradict the trigger requirement. We should mention somewhere that in the offline reconstruction a more involved Kalman fit is used (with a different χ^2?) .

- Line 73.
  Replace "a sample" by "two control samples".

The following sentence is confusing with "not used to select either sample".
Replace it by "The two samples are already very pure by means of kinematic criteria alone. Therefore, the particle identification (PID) information from the RICH detector can be studied from these samples."

- Line 79.
  "Momentum dependent information" and "reweighting" may be not well formulated. Is PID information also sensitive to η? If so, why is the weighting only done for the momentum distributions?

- Line 100.
  How are the PID criteria applied?
  If the assignment is not a partitioning (i.e. events can appear in more than one spectrum) then we need to consider double counting of statistics. If it is a partitioning, the PID requirement is probably not the same for all events. In that case, how is the PID efficiency determined in detail?
  If so, do mention that in spite of the probabilistic nature of the PID information, at most one particle type is assigned to a track, independent of the applied cuts on the event.

- Line 118, 120.
  Replace "simultaneous fits" by "a simultaneous fit".

- Line 141a, Figure 4.
  The figure would benefit if the relevant decay is explicitly written below LHCb. Similar as in Fig. 2 of: https://cdsweb.cern.ch/record/1446187/files/LHCb-PAPER-2012-011.pdf

- Line 141a, Figure 4f and 5d.
  We use a single Gaussian and test a double Gaussian for systematics. Are we sure (e.g. from MC) that we do not need a more complicated description of the tail? How large would our $B_s \to \pi\pi$ signal be with a double DB with tails fixed from MC?

- Line 141a, Table 6.
  Why are the total systematic errors of Table 7 not shown for comparison in Table 6? This is very relevant to the importance of the statistical uncertainty.

- Line 141a, Table 7.
  With our compliments for all the figures and the other tables, this table seems to have slipped through the readability check. Also the order of the ratios is different from that in Table 6. In Table 6 different catagories can be defined for the six ratios, which can then be used in Table 7 to shorten the head of the table. 'Negligible' can also be replaced by a shorter notation.

- Lines 155-165.
  The systematic uncertainty is chosen to be the difference between the simple and the better fit. Why is the result of the simple fit quoted as the baseline result instead of that of the better fit?

- Line 166.
  Add "of the ratio of event yields" after "all systematic uncertainties".

- Lines 168-169.
  Add "by" to "by using".

Remove the dot from "Tabs.".
Make the text consistent with the abstract: "the following branching fraction relations".

- Line 172.
  Add "b quark" to "the b quark hadronization probabilities".

- Line 173.
  Remove "absolute" from "absolute branching fractions".

- Line 173a.
  Can we split of the significant contribution of f_s/f_d from the systematic uncertainties?

- Line 174.
  Replace "status" by "averages".

- Line 185.
  Replace "the ratios of the yields" by "the B to S+B yield ratio" to avoid confusion with the ratio of event yields in Table 6 and 7.
  It is a rather abrupt end to the paper here with a discussion on a small correction to the last digit of the statistical significance of the $B_0 \rightarrow \pi^+\pi^-$ decay. Other more important items should also be discussed here: The correlations between the measured branching fractions, the proper time domain for which these branching fractions are extracted, and how the systematic uncertainties can be reduced in the future with a measurement of higher statistical accuracy.

- Lines 229-231.
  Add "v3 (2011)" to arXiv:1010.1589v3 (2011)".

Tjeerd Ketel for the Nikhef and VU group, 11 May 2012.