

Minor corrections

Thesis: Rare hadronic decays of B mesons at LHCb

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This document lists the changes that have been made to the thesis as minor corrections. Changes are highlighted in red. Page numbers refer to the version of the thesis used in the Viva.

1 Front matter

- Added acknowledgements section
- Added a quote

2 Introduction

- Page 4: ... have **an** electromagnetic charge...
- Page 4: ... there exists **an** antimatter...
- Page 6: ... described **as** a non-Abelian...
- Page 13: ... production **of** Gravitons...

3 Theory

- Page 15: ... Ground state hadrons **containing a single b-quark** can only...
- Page 15: Added citation for Fermi coupling.
- Page 16: ...decay **was** measured ...
- Page 18: Added the definitions of λ , A , ρ , η in terms of V_{qq}
- Page 18: Double checked sizes of diagonal CKM elements
- Page 19: Added details about how K^0 and \bar{K}^0 mix into K_S^0 and K_L^0

- Page 19: Added details of the different types of CP violation and stated that direct CP violation is the only relevant method.
- Page 20: Added explanation to figure 2.1 caption describing what colour suppressed or favoured means.
- Page 21: ...expensive **and** requires the...
- Page 22: ...mass **of the** charged lepton...
- Page 22: Clarified introduction to pure annihilation decays
- Page 23: Added minus sign to limit order of magnitude 6.1×10^{-7}
- Page 23: .. this can **potentially** limit the sensitivity **to** the...
- Page 23: Added chapter reference when mentioning $B^+ \rightarrow D_s^+ \phi$
- Page 24: removed **dominantly**
- Page 27: ... SM values given **in Table 2.2** ...

4 The LHCb experiment

- Page 30: ... at the **shallowest and deepest** points...
- Page 30: Added LEP reference
- Page 34: Added LHCb detector reference
- Page 35: Added description of sub-detectors to figure 3.2 caption.
- Page 36: Added reference for bb production plot figure
- Page 39: Defined FPGA
- Page 42: Added to figure caption explaining which of the planes (X1, U, V, or X2) is shown in Figure 3.9
- Page 46: ...in the **maximum** value...
- Page 48: Defined calorimeter acronyms
- Page 51: ...to determine **if** the innermost...
- Page 53: ...trigger is composed **of** two parts...
- Page 54: A table of the hardware trigger thresholds in 2012 has been added for completeness.
- Page 54: ...pattern recognition **to** identify track candidates...
- Page 55: Added figure and reference showing corrected mass variable for B decays

5 Event selection

- Page 64: ...normalisation channel $B^+ \rightarrow D_s^+ \bar{D}^0$ with $\bar{D}^0 \rightarrow K^+ K^-$.
- Page 65: All signal and normalisation simulation samples are generated...
- Page 65: ...Samples are generated assuming...
- Page 65: ...requiring the \bar{D}^0 mesons to decay to the $K^+ K^-$ final state and the D_s^+ meson to one of $K^+ K^- \pi^+$, $K^+ \pi^- \pi^+$ or $\pi^+ \pi^- \pi^+$.
- Page 66: Removed: The event selection aims to reduce overall rate of collisions, whilst maximising the signal efficiency.
- Page 66: Added: However, all hardware triggers are implicitly used to select the signal candidates as it is possible for a unrelated interaction to have initiated the trigger. The reconstructed objects are then associated to the trigger decisions to determine if they were responsible.
- Page 66: Added: For a relatively simple trigger candidates, such as the combination of tracks considered in these hadronic decays, at least 70% of online VELO and IT/OT hits must be in the total set of offline tracking hits. For more complicated composite candidates, for example decays containing electrons with both tracks and calorimeter deposits, the combination of the individual trigger candidates is compared to the set of offline candidates.
- Page 67: ...if the deposit matched to a reconstructed...
- Page 68: ...hadronic hardware trigger (L0Hadron)...
- Page 69: ...hardware sub-systems (Muon, DiMuon, Electron, Photon or Hadron) is...
- Page 70: Corrected totals in Table 4.4.
- Page 72: ...products with respect to the proton beam axis...
- Page 74: ...track χ^2/N_{DOF} is required to be below 4.0 to remove poorly reconstructed tracks...
- Page 76: Added: These requirements have a combined efficiency of between 85-90%, depending on D_s^+ decay mode.
- Page 79: Added: As illustrated in Fig. 4.9, the blue and red regions in the D^0 sidebands are wider to the left of the peak than the right. This helps to prevent misidentified $B^+ \rightarrow D_s^+ (D^0 \rightarrow K^- \pi^+)$ decays from being included in the sideband sample, visible as an excess of points at high values of $m(K^+ K^-)$.
- Page 80: Added to table 4.6 caption: The selection requirements are chosen such that the contribution from charmless and single charm decays are below 2% of the normalisation yield. The large variation in residual yields therefore reflects the variation in the expected normalisation yields.

- Page 82: Added: These result from various signal or background processes in which incorrect tracks have been assigned to the the final state particles.
- Page 84: Clarified introduction to MVA methods.
- Page 88: Added: These variables improve the performance over the variables discussed in Section 4.3.2 by using input from all PID sub-detectors and exploiting any correlations.
- Page 90: ... to account for the difference in the kinematics and geometry of the validation and signal modes...
- Page 90: Add reference to pages where efficiencies are discussed.
- Page 90: Added: This figure of merit is chosen as it depends only on the signal efficiency rather than the absolute number of expected signal events. The parameter a defines the number of standard deviations corresponding to a one-sided Gaussian test, here chosen to be five to correspond to the significance required for an observation.
- Page 91: ...Requirements are placed on the impact...
- Page 93: Caption: The ϕ (left) and D_s^+ (right) invariant mass
- Page 93: ...normalisation channel decreases as the selection is applied, but only reduces to around half of the original size...
- Page 94: Caption: The D^0 (left) and D_s^+ (right) invariant mass
- Page 95: Caption: The K^+K^- (left) and D_s^+ (right) invariant mass

6 Mass fit to $B^+ \rightarrow D_s^+ K^+ K^-$ candidates

- Page 106: ...The parameters of interest in the two fits are...
- Page 106: Added: The error in the normalisation yield is found to be overestimated by the fit model. When propagated to the final branching fraction, this effect is reduced, therefore no attempt is made to correct it.
- Page 106: ...These figures show the distribution...
- Page 106: ...in the negative log likelihood minimisation...
- Page 108: ...Similarly the mass shifts vary between the two, but are consistent within the quoted uncertainties.
- Page 110: ...The relative charmless efficiency...
- Page 110: ...dependency on the position in phase-space...
- Page 111: ...dependence on the position in phase-space...

- Page 113: ... is found, however the possible resulting systematic uncertainty is quantified in Sec. 5.7.1.

7 Mass fit to $B^+ \rightarrow D_s^+ \phi$ candidates

- Page 126: ...pair from the ϕ meson, $m(K^+ K^-)$, and the cosine of the angle $\cos \theta_K$...
- Page 126: ...The total extended negative log likelihood (NLL) for...
- Page 127: Added reference for MINOS.
- Page 127: Added to fig 6.1 caption: The category labelled ' $D_s^+ \phi$ inner' refers to the invariant mass range $|m(K^+ K^-) - m(\phi)| < 10 \text{ MeV}/c^2$ and ' $D_s^+ \phi$ outer' to $10 < |m(K^+ K^-) - m(\phi)| < 40 \text{ MeV}/c^2$.
- Page 130: ... For each contribution, the fractions of each decay expected in the...
- Page 130: ...The maximum differences between the fully simulated and LAURA++ fractions are included...
- Page 130: ...half the difference between the $f_0^0(980)$ and $a_0^0(980)$ fractions...
- Page 134: ...These PDFs are updated to...
- Page 139: ...so the parameter would be expected...
- Page 140: Changed fit colour scheme to make signal more obvious.
- Page 151: ...The significance of the measured branching fraction, $BF(B^+ \rightarrow D_s^+ \phi) = (1.2_{-1.4}^{+1.6} \pm 0.8 \pm 0.1) \times 10^{-7}$, is not large enough to constitute evidence for the $B^+ \rightarrow D_s^+ \phi$ decay and the branching fraction is consistent with a value of zero...

8 Conclusions

- Added conclusions chapter.

9 Appendix A

- Page 161: swapped figures A.3 and A.4.

10 Appendix C

- Page 176: Added more detail to figure C.1 caption.

11 Appendix D

- Page 180: ...the **pull** is defined...
- Page 180: ...different D_s^+ decay modes are shown in **Fig. D.3**...

12 Appendix E

- Changed fit colour scheme.

13 References

- Page 189: Ref [1] ...JHEP 01 (2018) **131**...
- Page 191: Ref [23] ...**P. Dirac**, The quantum...
- Page 199: Ref [112] Add name to reference