Asymmetries in the decay of beauty

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Summary

This thesis "Asymmetries in the decay of beauty" describes two main subjects for the LHCb experiment at the LHC accelerator. The first topic is a track pattern recognition algorithm for the tracking stations of the LHCb spectrometer. The second topic is an unbinned counting analysis of the muonic forward-backward asymmetry in the flavour changing neutral decay $B^0 \rightarrow K^*\mu^+\mu^-$. During the research use has been made of Monte Carlo events because the experiment and the accelerator were not yet operational.

The pattern recognition algorithm for the tracking stations that is described delivers tracks from an input of hits from the tracker stations (T stations) of LHCb. The algorithm is based on a global track finding approach, where hits in outer layers are interpolated to find more hits that belong together. The algorithm makes use of the residual magnetic field in the T stations to calculate a momentum estimate from the curvature. The quality of the tracks is calculated with a likelihood routine based on track prediction and actual hit position. The quality of the tracks, and hence the performance of the algorithm is tested against known Monte Carlo information. The ratio of correctly found MC particles to total MC particles available (*efficiency*) was found to be 85% while the ratio of wrongly reconstructed tracks to the total number of reconstructed tracks (*ghostrate*) was found to be 15% for a particular optimal tuning. Furthermore the momentum dependence of the efficiency and ghostrate were investigated as were the track parameters. With the tracks also a momentum resolution dependence on the reconstructed momentum was investigated. From the corrected distributions a multiple scattering term for the resolution can be extracted of $1.8\ 10^{-2}$. Also a co-ordinate resolution term is extracted of $6.8\ 10^{-4}$ GeV^{-1}.

The analysis of the flavour changeing neutral decays $B^0 \rightarrow K^*\mu^+\mu^-$ is treated in the second part. In this decay the muons have an angular distribution which is sensitive to effects of possible new physics. The positively charged muon in this decay has a polar angle that is either in a direction forward or backward with respect to the K^* direction in the rest frame of the B^0. The amount of forward or backward going muons depends on the dimuon mass, and as such an asymmetry of the amount of forward and backward traveling muons as a function of the dimuon invariant mass can be made. The invariant mass at which this asymmetry vanishes, is sensitive to new couplings.

Potential systematic effects are investigated for an event selection for $B^0 \rightarrow K^*\mu^+\mu^-$ for signal events. The effects on the forward-backward asymmetry and its zero-crossing are minimal for the given selection procedures. The combined restrictions on the muons have the largest influence on the shapes of the distributions of the invariant dimuon

mass s and the muon polar angle θ_l.

The selection effects for background events show that there is no preference for events with either forward or backward going muons. This will not cause any artificial effect in the zero-crossing of the forward-backward asymmetry.

The distributions of the invariant dimuon mass, s for the dimuon inclusive background shows a similar shape in the sideband regions and the peak region of the B^0 mass distribution. The shape of the distribution in the B^0 mass sidebands can therefore be used to estimate the shape and number of the background events in the peak region. The same holds for the distribution of the polar angle θ_l. This is exploited when the background fraction in the peak region is determined by interpolation.

An unbinned method for determining the asymmetry uses an unbinned polynomial fit of the invariant mass distributions of the forward and backward events separately. Subsequently the two fitted polynomials are subtracted and normalised to obtain an asymmetry. The zero crossing of the polynomial is obtained by using a Monte Carlo solution in which the error on the fit is propagated to the zero crossing by realising many curves with parameters that are smeared according to the decorrelated parameter errors.

The expectation value of the asymmetry for the SM is estimated with a Monte Carlo sample corresponding to an integrated luminosity of 2 fb^{-1}. In addition the expectation value for the zero crossing is estimated. The error on the zero crossing point after one nominal year of LHCb running is determined to be 0.44 GeV^2.

The effects of several background contributions are determined. Two artificially created types of background are added: First a background sample flat in the polar angle of the muon, θ_l and non-flat in invariant dimuon mass squared s do not alter the zero-crossing point, however the shape of the A_{FB} is changed. Second a background sample asymmetric in the angle θ_l and flat in the dimuon mass squared is added, and both the shape and the position of the zero-crossing point are changed.

Background events from a dimuon inclusive sample is added to a signal sample. From the sidebands of the B^0-meson mass distribution the shape and size of the s distribution of the background is estimated. The background contribution is subsequently fixed while fitting the signal plus background in the B^0-mass peak region. As a result the signal contribution of the s distribution is recovered and a correction of the background is made. The correction to the background results in an asymmetry which is within 1 standard deviation of the original signal.

The potential of the unbinned method to distinguish asymmetries from the SM and two new physics models with a reversed sign Wilson coefficient C_7 is examined. With the unbinned method it is possible to distinguish two new physics models from the standard model in the low invariant dimuon mass regions.