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Towards first observation of the $B_s^0 \to D_s^{*\mp}\ K^{*\pm}$ decay and calibration of the Upstream Tracker detector.

Summary

The research covered in this dissertation addresses two areas: the analysis of the decay of beauty meson, B_s^0, and the development of a platform for the monitoring and calibration of one of the tracking detectors. This work was carried out in cooperation with the LHCb collaboration.

The first part of the study concerns the selection of a rare and so far unobserved decay of the meson B_s^0 to two vector mesons $D_s^{*\mp}$ and $K^{*\pm}$ in data collected by the LHCb spectrometer in 2015-2018 (Run 2). This decay belongs to the $B \to DK$ decay family, where the interference between the amplitudes of the $b \to c$ and $b \to u$ quark transitions, which occur in these decays, allows precise measurements of one of the parameters of the Cabibbo-Kobayashi-Maskawa (CKM) matrix - the CKM angle γ. The low branching ratio (of the order of 10^{-4} or smaller) limits the number of expected $B \to DK$ decay events recorded at the LHCb. The introduction of new processes, such as the discussed $B_s^0 \to D_s^{*\mp}K^{*\pm}$, is therefore beneficial and will improve the precision of the measurement.

The complicated decay topology of $B_s^0 \to D_s^{*\mp}K^{*\pm}$ and the large (7) number of final states, including neutral particles, results in a very small expected number of observed decay events, which are hidden in the huge number of physical and combinatorial background events. The research task was to develop selection criteria for $B_s^0 \to D_s^{*\mp}K^{*\pm}$ candidates, including methods of computational intelligence, such as BDT (Boosted Decision Trees), which improve the separation of the decay events from the background and then verify their effectiveness. Decay dynamics, results in a number of resonance and intermediate states that should be observed and analysed. This study is followed by a discussion on candidates for the control channel, with respect to which the branching fraction of unobserved decay is measured.

The second part of the research work concerns the development of the software for the Upstream Tracker (UT) detector, which will be a part of the particle's tracks reconstruction system in the upgraded LHCb detector (from 2022). The active part of the detector consists of silicon sensors. Its purpose is to reconstruct the tracks of charged particles before the LHCb dipole magnet and enables secondary vertices reconstruction of long-lived particles like K_s^0 and Λ^0. This information is also crucial for the LHCb trigger system, which is expected to reconstruct particle's tracks in real-time (online) with an efficiency close to that of the offline type reconstruction (already performed on events stored on disks, this system was used during Run 1 and 2 in 2010 - 2018). The research task was to develop an autonomous platform, Vetra, to control the quality of the data recorded by the detector and its calibrations. This platform uses a dedicated RAW data stream to monitor the detector's status and, in future, make autonomous decisions regarding its operation. An additional component of the system, the Titania application was developed to provide monitoring for the UT detector based on the performance of the UT detector's sensors, determined by Vetra.

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