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Novel real-time calibration & alignment and tracking performance for LHCb Run II

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The LHCb detector consists of subsystems designed to perform high efficiency tracking (>95%) with an excellent momentum resolution (0.5% for p<20 GeV). Two Ring Imaging Cherenkov detectors provide precise particle identification.
In Run II of the LHC, a new scheme for the LHCb software trigger allows splitting the triggering of the event in two stages, giving room to perform the alignment and calibration in real time. In the novel detector alignment and calibration strategy for Run II, data collected at the start of the fill are processed in a few minutes and used to update the alignment, while the calibration constants are evaluated for each run. This allows identical constants to be used in the online and offline reconstruction. The larger timing budget, available in the trigger, results in the convergence of the online and offline track reconstruction. The same performance of the track reconstruction and PID are achieved online and offline. This offers the opportunity to optimise the event selection in the trigger with stronger constraints and including the hadronic PID. It additionally increases selection efficiencies and purity and reduces systematic uncertainties. The novel real-time alignment and calibration strategy at LHCb is discussed from both the operational and physics performance points of view. The development and improvements in the track reconstruction are highlighted. The overall performances of the LHCb detector on the first data of Run II are presented.

additional information

The LHCb detector consists of subsystems designed to perform track reconstruction and particle identification. The tracking subdetectors are a Vertex Locator around the interaction point, a tracking station with four layers of silicon strip detectors in front of the magnet, and three tracking stations, using either straw-tubes or silicon strip detectors, behind the magnet. This system allows to reconstruct charged particles with a high efficiency (typically > 95% for particles with momentum > 5 GeV) and an excellent momentum resolution (0.5% for particles with momentum < 20 GeV). Two Ring Imaging Cherenkov detectors provide separation between kaons and pions and - in addition to the calorimeters and the muon system - identify particles with a high precision.
In Run II of the LHC, a new scheme for the software trigger in LHCb was implemented. It allows splitting the triggering of the event in two stages, giving room to perform the alignment and calibration online after the first stage of the software trigger and using it directly as an input for the second stage of the software trigger. In addition, a larger timing budget is available for both stages of the software trigger, resulting in a more sophisticated track reconstruction which is identical to the one performed offline.
In the novel real-time detector alignment and calibration strategy, data collected at the start of the fill will be processed in a few minutes and used to update the alignment, while the calibration constants will be evaluated for each run. This procedure will improve the quality of the online alignment. This is particularly important for the Vertex Locator, which is retracted and reinserted for stable beam collisions in each fill to be centred on the primary vertex position in the transverse plane. Therefore,
its position changes on a fill-by-fill basis. Critically, this new real-time alignment and calibration procedure allows identical constants to be used in the online and offline reconstruction, thus improving the correlation between triggered and offline selected events.

This offers the opportunity to optimise the event selection in the trigger by applying stronger constraints. The online calibration facilitates the use of hadronic particle identification using the RICH detectors at the trigger level. The required computing time constraints are met thanks to a new dedicated framework using the multi-core farm infrastructure for the trigger.
The motivation for a real-time alignment and calibration of the LHCb detector is discussed from both the operational and physics performance points of view. Specific challenges of this novel configuration are discussed, as well as the working procedures of the framework and its performance, showing first results of Run II of LHCb.
The convergence of the online and offline track reconstruction results in better overall selection efficiencies and reduced systematic uncertainties due to a perfect overlap. We will highlight the developments and improvements in the track reconstruction which were necessary for this unification and give first results from the operation of LHCb in this mode in Run II.

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