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The tracking system at LHCb in run-2: hardware alignment systems, online calibration, radiation tolerance and 4D tracking with timing

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Content

The LHCb experiment is designed to study B and D decays at the LHC, and as such is constructed as a forward spectrometer. The large particle density in the forward region poses extreme challenges to the subdetectors, in terms of hit occupancies and radiation tolerance. Two methods and their results will be presented that show no radiation damage of the gaseous straw tube detector after having received a dose of about 0.2 C/cm2 in the hottest area.
The precision measurements at LHCb require accurate alignment of their elements. In run-2 of the LHC the full potential of the state-of-the-art alignment system "RASNIK" is being exploited. Relative movements down to 1 um are being monitored and will be shown for the first time at this conference. High accuracy of the RASNIK data allow to track deformations connected with changing magnetic field configurations, operational interventions and environmental conditions. The RASNIK system also provides crucial input to the software alignment by constraining the so-called "weak-modes", like movements in the longitudinal direction z.
The Outer Tracker subdetector is a gaseous straw tube tracker that measures the drift time with a resolution of 2.4 ns. This accuracy implies an improvement of 20% with respect to the run-1 performance, thanks to a new strategy used for the drift time calibration including real-time calibration during data taking deployed in run-2.
Interestingly, recent studies show that this superb timing resolution can be combined to measure the time-of-flight of single particles with an accuracy of 0.55 ns. We will show that low momentum protons can be cleanly distinguished from pions. In addition, these pilot studies show the potential of distinguishing primary vertices which occur at different times, which will be crucial for LHCb when operating in the high-luminosity regime as is being proposed after the phase-II upgrade. The possibility is being investigated to use the vertex timing for the measurement of the longitudinal distribution of the unintentional beam population in the nominally empty slots, which requires a timing precision better than about 2.5 ns.

Summary

State-of-the art hardware alignment systems are being deployed in run-2 of the LHC, to a precision of 1 um lateral displacement. In addition, very accurate drift time measurements have been achieved with the LHCb straw tube detector, leading to time-of-flight measurements of protons with a precision of about 500 ps. This has been made possible thanks to the recent implementation of real time calibration during data taking. The application of timing information show the use of 4D tracking for future upgrades of LHCb.

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