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Real-time alignment procedure at the LHCb experiment for Run3

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The LHCb detector at the LHC is a general purpose detector in the forward region with a focus on studying decays of c - and b -hadrons. For Run 3 of the LHC (data taking from 2022), LHCb will take data at an instantaneous luminosity of $2 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$, five times higher than in Run 2 (2015-2018). To cope with the harsher data taking conditions, LHCb will deploy a purely software based trigger with a 30 MHz input rate.

The software trigger at LHCb is composed of two stages: in the first stage the selection is based on a fast and simplified event reconstruction, while in the second stage a full event reconstruction is used. This gives room to perform a real-time alignment and calibration after the first trigger stage, which provides an offline-quality detector alignment in the second stage of the trigger. The detector alignment is an essential ingredient to have the best detector performance in the full event reconstruction. The alignment of the whole tracking system of LHCb is evaluated in real-time by an automatic iterative procedure. This is particularly important for the vertex detector, which is retracted for LHC beam injection and centered around the primary vertex position with stable beam conditions in each fill. Hence it is sensitive to position changes on fill-by-fill basis.

The real-time alignment procedure is fully automatic procedure in the online framework that uses a multi-core farm. It is executed as soon as the required data sample is collected. The alignment tasks are split in two parts to allow the parallelization of the event reconstruction via a multi-threads process, while the evaluation of the alignment parameters is performed on a single thread after collecting all the needed information from all the reconstruction processes in the first part. The execution of the alignment tasks is under the control of the LHCb Experiment Control System, and it is implemented as a finite state machine. The procedure is run at the beginning of each LHC fill and for the alignment of the full tracking system (about 300 elements and about 1000 dofs) takes few minutes. The parameters are updated immediately in the software trigger. This in turn allows to achieve the optimal performance in the trigger output data that can be used for physics analysis without a further offline event reconstruction.

The framework and the procedure for a real-time alignment of the LHCb detector developed for Run 3 data taking are discussed from both the technical and operational point of view. Specific challenges of this procedure and its performance are presented.

Significance

The real-time alignment and calibration was pioneer in Run2 at LHCb. In Run 3, LHCb runs with a full software trigger, this increases further the importance of this real-time alignment to be used in the trigger without affecting the physics performance.

A new implementation of the real-time alignment was needed to be adapted and optimised to the new computing framework and to the new detectors.

The data taking just started and we plan to present the implementation and the performance of the real-time alignment within novel fully software LHCb trigger in Run 3 for the first time at ACAT.

References

Experiment context, if any

LHCb collaboration

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