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Automatised data quality monitoring of the LHCb Vertex Locator

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The LHCb Vertex Locator (VELO) is a silicon strip semiconductor detector operating at just 8mm distance to the LHC beams. Its 172,000 strips are read at a frequency of 1 MHz and processed by off-detector FPGAs followed by a PC cluster that reduces the event rate to about 10 kHz. During the second run of the LHC, which lasts from 2015 until 2018, the detector performance will undergo continued change due to radiation damage effects. This necessitates a detailed monitoring of the data quality to avoid adverse effects on the physics analysis performance.

The VELO monitoring infrastructure has been re-designed compared to the first run of the LHC when it was based on manual checks. The new system is based around an automatic analysis framework, which monitors the performance of new data as well as long-term trends and flags issues whenever they arise.

An unbiased subset of the detector data are processed about once per hour by monitoring algorithms. The new analysis framework then analyses the plots that are produced by these algorithms. One of its tasks is to perform custom comparisons between the newly processed data and that from reference runs. A single figure of merit for the current VELO data quality is computed from a tree-like structure, where the value of each node is computed using the values of its child branches. The comparisons and the combination of their output is configurable through steering files and is applied dynamically. Configurable thresholds determine when the data quality is considered insufficient and an alarm is raised. The most-likely scenario in which this analysis would identify an issue is the parameters of the readout electronics no longer being optimal and requiring retuning.

The data of the plots are reduced further, e.g. by evaluating averages, and these quantities are input to long-term trending. This is used to detect slow variation of quantities, which are not detectable by the comparison of two nearby runs. Such gradual change is what is expected due to radiation damage effects. It is essential to detect these changes early such that measures can be taken, e.g. adjustments of the operating voltage, to prevent any impact on the quality of high-level quantities and thus on physics analyses.

The plots as well as the analysis results and trends are made available through graphical user interfaces (GUIs). One is available to run locally on the LHCb computing cluster, the other provides a web interface for remote data quality assessment. The latter operates a server-side queuing system for worker nodes that retrieve the data and pass it on the client for displaying. Both GUIs are dynamically configured by a single configuration that determines the choice and arrangement of plots and trends and ensures a common look-and-feel. The infrastructure underpinning the web GUI is used as well for other monitoring applications of the LHCb experiment.

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