LHC beam monitoring via real-time hit reconstruction in the LHCb VELO pixel detector

Wednesday 13 March 2024 16:15 (30 minutes)

The increasing computing power and bandwidth of programmable digital devices opens new possibilities in the field of real-time processing of HEP data. LHCb is exploiting this technology advancements in various ways to enhance its capability for complex data reconstruction in real time. Amongst them is the real-time reconstruction of hits in the VELO pixel detector, by means of cluster-finding "on-the-fly" embedded in the readout board firmware. This reconstruction, in addition to savings of DAQ bandwidth and HLT computing resources, also enables further useful applications in precision monitoring and diagnostics of LHC beam conditions. In fact, clusters of pixels, while being more reliable and robust indications of physical particle hits than raw pixel counts, are exempt from the complications associated to the reconstruction of tracks, that involve alignment issues and are sensitive to multi-layer efficiency products. In this talk, we describe the design and implementation of a flexible system embedded in the readout firmware of the VELO detector, allowing real-time counting of cluster density in many parts of the detector simultaneously, and separately for every bunch ID, for every single LHC collision, without any slowdown of data acquisition. Quantitative applications of this system to luminosity measurement and beam monitoring are demonstrated.

Significance

This is the first public presentation of a successful implementation of on-the-fly hit-statistics evaluation, transparently embedded in the readout in a complex detector at the full LHC average collision rate of 30 MHz. It also demonstrates its practical application to perform useful functions never before achieved at this high data rate.

References

This work is a spinoff of the following published work:
G. Bassi et al., "A FPGA-Based Architecture for Real-Time Cluster Finding
in the LHCb Silicon Pixel Detector", IEEE Trans. Nucl. Sci. 70 (2023) 1189,
arXiv:2302.03972

Experiment context, if any

LHCb (Real Time Analysis project)

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