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Real-time Timepix3 data clustering, visualization and classification with a new Clusterer framework.

With the next-generation Timepix3 hybrid pixel detector, new possibilities and challenges have arisen. The Timepix3 segments active sensor area of 2cm² into a square matrix of 256 x 256 pixels. In each pixel, the ToA (Time of Arrival, with a precision of 1.56 ns) and ToT (Time over Threshold, energy) are measured simultaneously in data-driven, self-triggered, read-out scheme.

This contribution presents a framework for data acquisition, real-time clustering, visualization, classification and data saving. All of these tasks can be performed online directly from multiple readouts via UDP protocol. Clusters are reconstructed on a pixel-by-pixel decision from the stream of not-necessarily chronologically sorted pixel data. To achieve quick spatial pixel-to-cluster matching, non-trivial data structures were utilized (e.g. Quadtree). Furthermore, parallelism (i.e. multithreaded architecture) is used to further improve the performance of the framework. Such real-time clustering offers the advantages of an online filtering and classification of events. Versatility of the software is ensured by supporting all major operating systems (macOS, Windows and Linux) with both graphical and command-line interface.

Using plug-in architecture, most efficient cluster features were selected and multiple approaches to artificial intelligence classification, such as neural networks and semi-labeled data learning, were applied to data measured in test beam campaigns. The performance of the real-time clustering and the applied classification methods are demonstrated using data from the Timepix3 network installed in the ATLAS and MoEDAL experiments at CERN.

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Track Classification: 2: Real-time pattern recognition, fast tracking and performance evaluation