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Machine Learning approach to CMS RPC HV scan data analysis

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The HV scan is a crucial sequence of calibration runs typically conducted at the onset of each data-taking year with the initial collisions of the CERN Large Hadron Collider (LHC) at nominal luminosity. This procedure ensures the proper functioning of the Resistive Plate Chamber (RPC) detectors at the Compact Muon Solenoid (CMS) experiment at CERN by establishing correct working points. In the past, aspects of the HV scan analysis were performed manually, leading to time-consuming procedures. This study endeavors to revolutionize the analysis of RPC HV scan data by integrating machine learning (ML) algorithms. The primary objective is to automate and expedite manual steps in the analysis process, thereby enhancing the efficiency and speed of task deliverables. Through the application of ML techniques, this research seeks to optimize RPC detector performance analysis, facilitating quicker decision-making processes and ensuring timely adjustments to detector settings for optimal data collection during LHC operations. The HV scan measures efficiency and cluster size as functions of operating voltage for each RPC double gap, within the effective voltage range of [8600, 9800]V. Our methodology prioritizes parametrizing efficiency curves to enable the evaluation of RPC double gap efficiency at arbitrary voltage values. To achieve this, we employ an artificial neural network (ANN) capable of discarding outliers and approximating efficiency behavior, even in cases when data is missing within the efficiency plateau. We developed a dedicated autoencoder ANN that operates in Fourier space to approximate efficiency vs. HV curves per double gap. This autoencoder takes measured efficiency at various supply voltage values and estimates detector efficiency within the voltage interval of 8.0 to 10.5 kV. Subsequently, the refined curve undergoes sigmoidal function fitting, and resulting parameters are utilized in the working point definition procedure. Once the working HV point per double gap is established, a specialized optimization procedure is employed to evaluate working points per HV channel. Multiple double gaps share a single HV supply line, and voltage adjustments are made to fulfill efficiency and cluster size requirements, providing the necessary output for analysis. Thanks to novel technologies and the applied methodology, the time required to analyze the calibration data of the CMS RPC HV scan can be reduced from over 3 months to less than a week.

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