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Enhancing Electron Identification Using RCNet: A Deep CNN Approach for RICH Ring Reconstruction

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The Ring Imaging Cherenkov (RICH) detector is integral to the CBM experiment's electron identification process, aiming to distinguish electrons and suppress pions in the study of dielectronic decay channels of vector mesons. This study is crucial for exploring the phase diagram of strongly interacting matter under conditions of high net baryon densities and moderate temperatures, as encountered at FAIR energies. A critical challenge for the RICH detector is the efficient identification of ring-like structures from the numerous hits on its photodetector plane. To address this, we introduce a novel ring recognition algorithm leveraging convolutional neural networks (CNNs).

Our approach involves the deployment of a segmentation-like model named Ring Center Net (RCNet). This model is adept at identifying the centers of Cherenkov rings. Subsequently, we apply a modified, parameter-reduced standard chi-square circle fitting method to accurately determine the complete ring parameters. RCNet has been rigorously tested on a custom dataset designed to emulate the hit patterns expected on the RICH detector's photodetector plane, with a ring density surpassing that anticipated in CBM experiments. Notably, our method operates independently of prior track information, enhancing its suitability for real-time triggering applications.

One of the standout features of RCNet is its convolutional structure, offering exceptional adaptability to various input sizes. This flexibility is achieved through strategic padding, allowing the model to process input from photodetector planes with diverse geometries. Consequently, RCNet can fully utilize the data from hits on the RICH detector's photodetector plane. Moreover, the model's pixel classification approach in the center finding algorithm minimizes restrictions on the number of rings that can be processed in a single input. Empirical tests demonstrate that RCNet achieves an impressive 94% efficiency in detecting rings with over 14 hits within a 128x128 image containing up to 30 rings.

The report details the development and testing of RCNet, emphasizing its potential to significantly enhance electron identification in high-energy and heavy-ion physics experiments.

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