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A High Compression Ratio Channel Multiplexing Method for Micro-pattern Gaseous Detectors

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Micro-pattern gaseous detectors (MPGDs) find wide-range applications in particle physics experiments, industry, and medical imaging, owing to their large area, fine spatial resolution, and relatively low material content within the sensitive region. However, the requirement of a large number of readout channels poses a challenge, limiting the application of MPGD to achieve higher accuracy and larger area. This requirement also presents significant challenges regarding system integration, power consumption, cooling, and cost. Previous studies have shown that, under sparse effective hits, a channel multiplexing method based on position encoding can address this issue. Nonetheless, improving the compression ratio and addressing the high event rate problem remain key challenges requiring further investigation.

In this research, we have developed two types of high compression ratio multiplexing methods and their mathematical models. It is shown that a maximum of $n(n-2)/2+2$ detector channels can be read out with n electronics channels if n is even. Using these methods, several multiplexing boards were designed and implemented. Considering the real condition of the detectors, we achieved an encoding board with 64 readout electronics reading out 1024 detector channels, marking the highest compression ratio in current research. Additionally, we developed waveform digitization front-end electronics to address the high event rate problem. Different events can be distinguished and properly decoded by introducing the signal arriving time. Moreover, these encoding circuits were utilized and verified in our cosmic-ray muon imaging facilities, demonstrating their advantage of reducing the required number of front-end electronic cards.

Minioral

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