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Noise and Performance Study of Sealed MRPC Detectors with Different Spacers Based on Simulation and Cosmic Ray Test

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MRPC detectors, known for their excellent time resolution, are widely used in Time of Flight (TOF) systems for high-energy physics experiments. The CBM experiment requires detectors that can handle an intensity greater than 20 kHz/cm². MRPCs with low-resistance glass and pad spacers meet these requirements. Tsinghua University undertook the development and production of the CBM-TOF MRPC2. This paper primarily investigates three main aspects.

Firstly, this paper presents a theoretical study on the noise performance of sealed MRPCs based on simulations, discussing the noise performance of pad spacer sealed and fishline spacer sealed MRPCs.

Secondly, cosmic ray tests with the self-trigger method were conducted on pad spacer and fishline spacer MRPCs. High voltage scans were performed to test the dark currents and noise signal frequency as a function of voltage. The noise count rate of both types of MRPC follows an exponential increase with operating voltage. For pad-sealed MRPCs, under the same high voltage, the noise rate per unit area is approximately one percent of the fishline-sealed MRPCs. Additionally, the study obtains hit position maps of the self-trigger cosmic ray tests, Which noise signals occupy the majority. The position maps clearly show higher noise rates at the spacer locations, and a statistical analysis of the noise rate differences between the spacer locations and other parts of the detector is also conducted. This research systematically studies the noise principles and performance of pad spacer and fishline spacer sealed MRPC detectors.

Finally, an external-trigger cosmic test scans the efficiency and time resolution performances of both MRPC2 types, Both sealed MRPC2 with different spacers reached a time resolution of better than 90 ps and an efficiency of better than 95% at a high voltage of 5700V. Additionally, a coincidence self-trigger cosmic test is also held, providing a faster testing method for the performance of MRPC2 in mass production.

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