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Study on Cosmic Test and QC method of high-rate MRPC for CBM-TOF

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Abstract: In the near future, the CBM (Compressed Baryonic Matter) experiment constructed at FAIR (Facility for Anti-proton and Ion Research) at GSI, Darmstadt, Germany, will provide unique research opportunities to explore the phase diagram of nuclear matter. As one of the core detectors in the CBM experiment, the Time-of-Flight (TOF) system applies MRPC (Multi-gap Resistive Plate Chamber) for a precise particle identification for all the incident charged hadrons. In order to acquire data for rare probes such as charmed hadrons, multiple strange baryons, di-electrons and di-muons, the CBM-TOF will be operated at ion beam intensity up to 10ˆ9 /s. This means the particle fluxes on the TOF wall can reach an unprecedentedly high rate, up to 30 kHz/cm2. Almost half of the MRPC counters are from inner region of the TOF wall, and they will be assembled with low-resistive glass which enables it to work under such high rate. This is the first time of the large scale application of these low-resistive glass MRPCs into the nuclear and high-energy physics experiments. It is especially important to study on the production and test procedure to keep the good performance of all these counters. The design of this MRPC is a double stack counter with 2x4 gas gaps, each 250 μm wide. There are 32 double-ended readout strips on the counter, and each strip is 270 mm long, 7 mm wide with the 3 mm interval. A real-size prototype has already been produced and tested with 30 AGeV Pb beam in SPS Nov 2015 beam test. The observed 98% efficiency and 60 ps time resolution prove that the type of counter fully meet the requirement of CBM-TOF. 750 counters are expected to be ready in one and a half years. For this mass production, we have developed a set of specified manufacturing procedures and quality control method to guarantee the performance of all the counters. A newly developed method to check the uniformity of the gas gap with help of the projection imaging technique has been first applied. In the HV carried out after the assembling, counters are considered qualified with dark current below 50 nA and noise rate below 2 Hz/cm2. A cosmic-ray test system based on TRB board, FPGA TDC and PADI10 front-end electronics are established in our lab. It can provide 256 channels and support 3 MRPCs to be tested with cosmic-ray at the same time. Until now, 40 MRPCs have been produced for the eTOF project in the BESII detector upgrade at STAR. Calibrated and analyzed by the CBM-Root, all the produced counters show a stable performance of 60 ps time resolution and 98% efficiency. An X-ray test also shows the counter's rate ability. All these information from the production and test process are consistent with our expectation. Written into the barcode on the counter and a data recording website, these information are available to anyone who needs. The study on the mass production of the low-resistive plate chamber will provide experience for MRPC widely applied in the high rate experiment in the future. In this paper, the counter design, manufacturing procedures, quality control methods and test results for this MRPC counter are described in a detailed way.
Keyword: MRPC; CBM-TOF; Time-of-Flight; Mass Production; Quality Control; Cosmic Test; High Rate.

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