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Quality control of MRPC mass production for STAR TOF

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ABSTRACT

Multi-gap Resistive Plate Chambers (MRPCs) were selected to construct the barrel Time of Flight (TOF) detector for the STAR experiments. Its mass production started in 2006. The production procedure and related quality control (QC) are described. A summary of the MRPC production status (2006–2008) and the test results with cosmic rays is given. With strict QC throughout the production process, over 95% of the constructed MRPC modules meet the criteria required by STAR experiments.

1. Introduction

The STAR Collaboration is building a barrel Time of Flight (TOF) detector based on the Multi-gap Resistive Plate Chamber (MRPC) technology, recently developed by ALICE TOF group at CERN for the LHC [1]. It is a good choice for particle identification (PID) in high multiplicity final states in Heavy Ion Collision. This detector will significantly extend the reach of the STAR scientific program, and greatly enhance the identification capability of charged hadrons to more than 95% of all those produced within the MRPC-TOF acceptance ($|\eta|<1$) [2]. The increase in particle identification efficiency over a large solid angle will enhance the PID physics abilities, which is important to search for Quark Gluon Plasma. The extended momentum range for particle identified spectra provided by the MRPC barrel TOF detector [8,9] is crucial to understand the information contained in the large scale correlations and fluctuations observed in Au + Au collisions at RHIC.

The barrel TOF consists of about 3800 MRPC modules. Both Tsinghua University and the University of Science and Technology of China (USTC) have been preparing MRPC mass production facilities since 2005. Tsinghua University is responsible for 70% of the total production, and the USTC for the other 30%. The MRPC mass production was started after the US and China joint expert group review in April 2006. The same materials, tools, MRPC production procedures, the criteria for QC, and the cosmic test system are used at both sites.

2. MRPC TOF system

The MRPC is a new detector capable of better than 100 ps time resolution and high detection efficiency (>95%) for minimum ionizing particles. It takes 120 trays to cover the cylindrical outer radius of the Time Project Chamber (TPC) at STAR, which are arranged as two adjoining cylindrical shells of 60 trays each. Each cylindrical shell subtends approximately 1 unit of pseudo-rapidity. The whole TOF system has an area of $64\,m^2$ and will replace the present STAR Central Trigger Barrel (CTB). Each MRPC module has six pairs of copper readout pads, each having an active area of $3.15\,cm \times 6.3\,cm$. The envisioned detector would comprise of approximately 23,000 channels.

Shown in Fig. 1 are two side views of an MRPC module appropriate for STAR. Please note that they are not shown at the same scale. An MRPC is basically a stack of resistive plates with a series of uniform gas gaps. Electrodes are applied to the outer surface of the two outmost plates. A strong electric field is generated in each sub-gap by applying a high voltage (HV) across the external electrodes. All the internal plates are electrically floating. A charged particle going through the chamber generates avalanches in the gas gaps. Because the glass plates are highly resistive, they are transparent to fast charge induction from avalanches in the gaps. Typical resistivity for the glass plates is in the order of $10^{12-13}\,\Omega\,cm$. The induced signal on the pads is the

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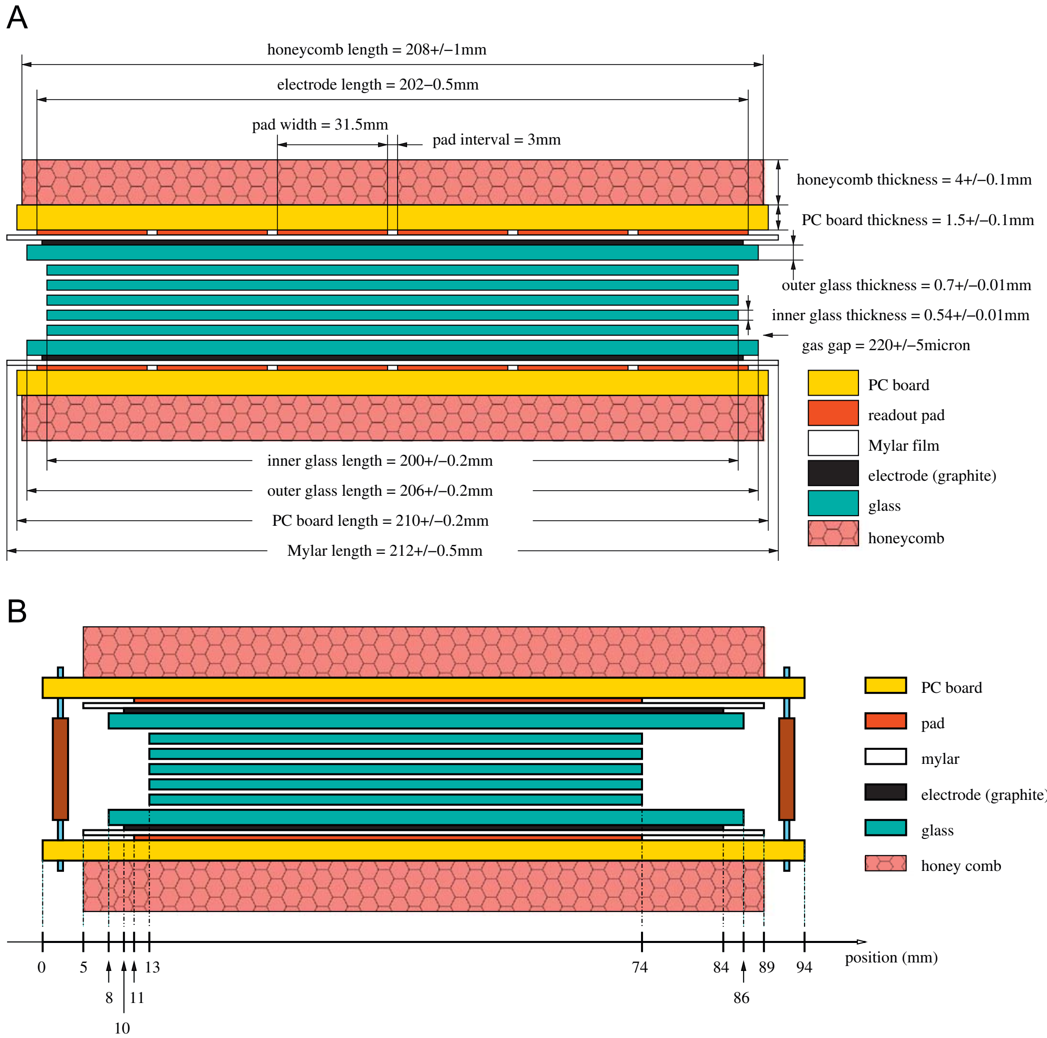

Fig. 1. The module structure of 6-gap MRPC design for STAR TOF.

sum of possible avalanches from all gas gaps. The electrodes are made of resistive graphite tape and also transparent to induced signal charge. In our case, the inner glass plates are 0.54 mm thick and are kept parallel by using 0.22 mm diameter nylon fishing lines as spacer. The outer glass plates are 0.7 mm thick, and the carbon tape is on the outer glass sheet. The signals are read out by an array of copper pickup pads. The pickup pad layer is insulated from the outer electrode by a 0.35 mm thick Mylar layer. A view of these pads for the present MRPCs is shown in Fig. 2.

3. QC of MRPC mass production

3.1. MRPC mass production preparation and schedule

In the first stage of the project (since 2002), efforts were made regarding the R&D of mass production of MRPC modules, including the production techniques and quality control [3–8,10]. Significant progress was made including:

- installation of clean room for MRPC assembly,
- training of qualified workers and technicians,
- preparation of the manual for module construction,
- establishment of quality control steps, and
- MRPC test equipment setup.

After all the standards in MRPC production and quality test had been established, the mass production formally started in June 2006. According to the execution plan of STAR TOF, the production of MRPC modules should be completed before August 15, 2008. The schedule for the USTC site is shown in Fig. 3.

3.2. MRPC mass production site at the USTC

A clean room of 200 m^2 for MRPC mass production was built. The room temperature and relative humidity are kept stable at $22 \pm 2\,^{\circ}C$ and $<40\%$, respectively. The cleanness level is better than class 100k, while for the four assembly desks it is at class 100. It was found the environment condition has a significant influence on the quality of the produced MRPC without the clean room. The humidity is often above 80% from June to August in Hefei. It is very hard to completely clear all vapor on the glass surface in a moist environment. The residual vapor can be sealed inside the electrode and cause high voltage test failure. So it is