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A Prototype of the High Time Resolution MRPC*

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Abstract A prototype of single cell Multi-gap Resistive Plate Chamber (MRPC) has been made together with the setup of the test system. The property of the chamber has been tested with both the cosmic ray test system and the test beam facility T10 of CERN in Geneva. The time resolution measured is around 70ps. The detection efficiency for minimum ionizing particle is above 95%.

Key words MRPC, time resolution, detection efficiency

1 Introduction

In high energy and nuclear physics experiments, it is critical for physics analysis to clearly identify final state particles. And there are always different sub-detectors to do the particle identification. For example, the STAR experiment of RHIC (Relativistic Heavy Ion Collider) at Brookhaven is going to search for the theoretically predicted quark gluon plasma (QGP). One of the characteristics of the existence of QGP is that there is a production enhancement of strange particles[1]. And these strange particles will finally decay into Ks. Thus to identify K from π and p is of much importance to the experiment result. The time of flight (TOF) detector is designed for this goal and has to efficiently separate K and π with momentum up to 1.8GeV/c. The multi-gap resistive plate chamber (MRPC)[2] is one of the candidates of TOF[3]. A prototype of a single cell MRPC is made and its property is tested. The time resolution measured is around 70 ps. The detecting efficiency for minimum ionization particle is above 95%

2 Chamber Structure and Experimental Setup

Fig.1 is the side view of the single cell MRPC that has been made and tested. The five 0.22mm gaps inside the chamber are divided by 4 layers of 0.63mm glass (denoted as B in Fig.1) and 2 layers of 1.83 mm glass (A in Fig.1). Each of the glass layer covers an area of $5\times5\text{cm}^2$. The thick glass layers are put at the top and bottom. On the outer surfaces of the 2 thick glass layers are copper tapes (dark line in Fig.1) and each covers an area of $3\times3\ \text{cm}^2$. The top copper tape acts as the cathode connecting to the negative high voltage (HV) while the bottom one is the anode to output the signal collected. Outside the copper tape is plastic supporting structure (C in Fig.1). When the chamber works, there is a flow of gas mixture composed of 90% freon, 5% iso-C_4H_{10} and 5% SF_6 through the gaps from one side to the opposite side. The gas is at one atmosphere pressure

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and room temperature.

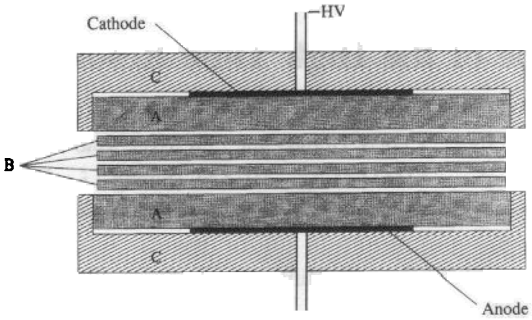

Fig.1 Cross section of the single cell MRPC.

The test system of the single cell MRPC includes a cosmic ray telescope system composed of two photomultiplier tubes (PMT XP2020) and the accompanying plastic scintillation crystals. One PMT is above the MRPC and the other below. Signals from PMTs go to two discriminators (CFD583) respectively and then to logic gate (L322C). And finally the coincident signal from L322C goes to CAMAC TDC (KEK OCTAL). The coincident signal offers the trigger and start signals to the MRPC to guarantee that a particle enters the cell. A HV power supply offers − 11000—− 14000 V to the cathode of MRPC. Signals from the MRPC go into pre-amplifier (MX3760) and discriminator (LeCroy 623Z). Then the logic output from the discriminator goes to TDC (KEK OCTAL) and the analogue output goes to ADC (LeCroy 2249A) that sit in a CAMAC crate. Finally a LabVIEW based DAQ system receives the data from the crate controller to save and display them. In Fig.2, channel 1 is an output avalanche signal captured while channel 2 corresponds to the trigger signal from the telescope system.

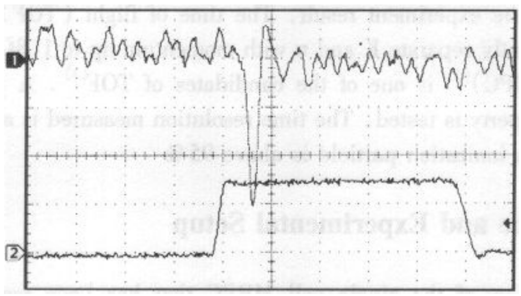

Fig.2 An avalanche current pulse directly observed on a 50Ω resistor.
The HV is at − 11000V. Channel 2 is the trigger signal from telescope system. The scale for channel 1 is 10mV/div and channel 2 is 500mV/div. The time scale is 10ns/div.

The MRPC is also tested in the test beam facility T10 at CERN in Geneva. The start signal is offered by 4 PMTs and other conditions are the same as in the cosmic ray test system at USTC. As the start signal is the average of the 4 PMTs and the test beam particle has a precise incoming direction and position, the time resolution measured is better than that from the cosmic test system. The result following is from the measurement of test beam.

3 Results

Fig.3 shows the relation between signal amplitude and its time measured with reference to the start time. As the rising edge gives the stop signal, a high amplitude always gives an earlier stop signal, thus the time value in the figure is small. To acquire a correct time resolution, this effect needs to be corrected. A polynomial formula is used to do the correction. The final time resolution distribution is shown in Fig.4. The fitting result gives a σ of 1.39 TDC channels and each channel corresponds to 50ps as shown in the figure. The time resolution calculated is around 70 ps. Fig.5 shows the detection efficiency for minimum ionizing particle of the chamber at different voltages. It is above 95% between the range of 12000 and 13500 V.

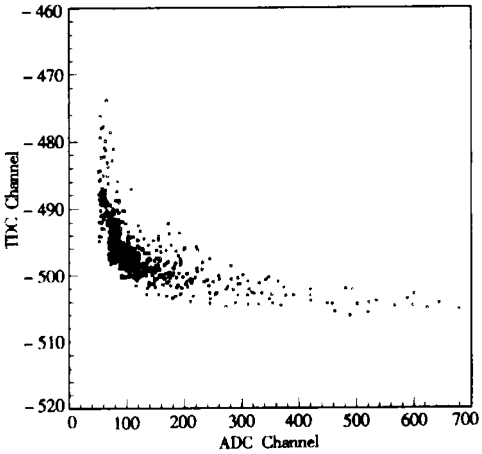

Fig.3　Time-Amplitude distribution of the MRPC.

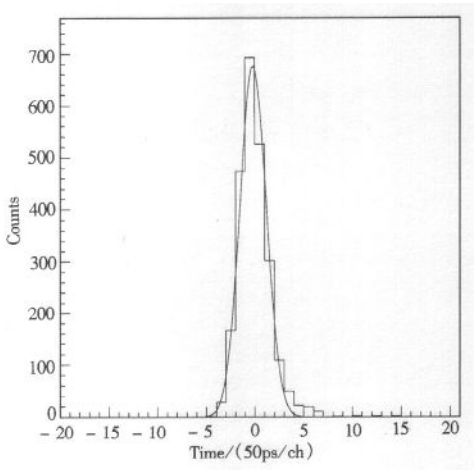

Fig.4　Time distribution after T-A correction of the MRPC.

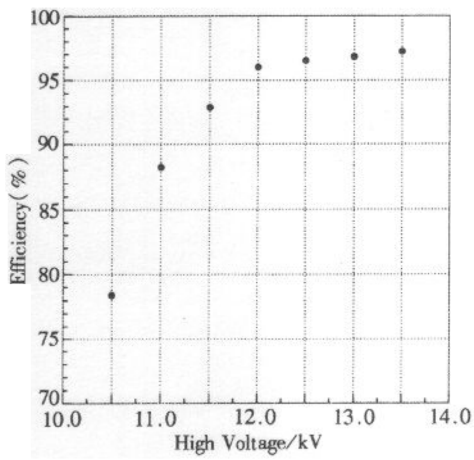

Fig.5　Detection efficiency of the MRPC at different voltages.

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一个高时间分辨的多间隙电阻板室原型*

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摘要　研制了一种多气隙电阻板室原型并建立了相关的测试系统. 利用宇宙线测试系统和欧洲核子中心的试验束装置T10对其性能进行了测试,给出了初步结果. 时间分辨达到70ps,对最小电离粒子的探测效率大于95%.

关键词　多间隙电阻板室　时间分辨　探测效率

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