Cosmic Test Results of Multi-gap Resistive Plate Chamber *

HUANG Sheng-Li LI Cheng XU Zi-Zong WANG Xiao-Lian CHEN Hong-Fang WANG Zhao-Min
(Department of Modern physics, University of Science & Technology of China, Heifei 230027, China)

Abstract More than twenty MRPC modules made of Chinese material in our Lab are tested by using cosmic rays. The test bench of cosmic rays is described in detail. The time resolution of the cosmic rays telescope is around 70ps. The time resolution of MRPC in cosmic rays testing is around 90ps. The MRPC detection efficiency, the ADC spectrum and the induced signal influence between cells are presented too.

Key words cosmic test bench, reference time, T-A correction, cross talks

1 Introduction

MRPC(multi-gap resistive plate chamber) is a new kind of timing detector with good time resolution, high detection efficiency and low cost[1]. The RHIC-STAR detector plans to build its TOF (time of flight detector) by this new detector to upgrade particle identification capability[2]. More than twenty MRPC modules will be used to build one tray of this TOF. All tested modules have six gaps (220μm in width), 6 readout cells with an area of 60 $\times$ 30mm^2. Using big area cosmic test bench whose reference time resolution can reach around 70ps, this article reports the performance of MRPC modules in cosmic test.

2 Cosmic test bench

The cosmic rays test bench is built with three long plastic scintillators coupled with photo-multiplier tubes (PMT)[3]. Fig.1 shows the block diagram of the detector and the readout logic system.

If one cosmic muon goes through the scintillator 0 and scintillator 2, it will also go through scintillator 1 and one cell of the MRPC module. The signals from PMT0 and PMT4 are discriminated and adjusted before feeding into the coincident unit so that the timing of start signal from the coincident unit is determined by the leading edge of trigger counter signals (PMT0). Output of this coincident unit can be used as the TDC common start and the ADC gate signal.

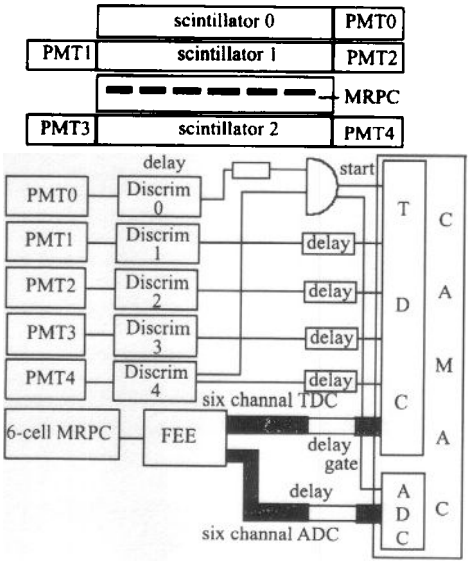

Fig.1. Block diagram of cosmic test system.

After discrimination and delay, the signals from the PMT1, 2, 3 are fed into a Phillips 16 - channel TDC (time resolution 25ps/count). The output signals of six cells of MRPC are amplified and discriminated by the front end electronics (FEE) to create time signals and analog signals which will be input into TDC and ADC modules of CAMAC.

As a cosmic muon passes through the system, the

Received 1 April 2002
* Supported by NSFC(10155002)

time intervals at which signals arrive at the TDC input from the PMT0, PMT1, PMT2, PMT3, PMT4 and one cell of tested MRPC are assumed as $T0$, $T1$, $T2$, $T3$, $T4$ and Tm, respectively. Then the TDC module will output five time signals of $T10$, $T20$, $T30$, $T40$, and $Tm0$:

$$T10 = T1 - T0,\quad T20 = T2 - T0,$$
$$T30 = T3 - T0,\quad T40 = T4 - T0,$$
$$Tm0 = Tm - T0.$$

After 24 hours data accumulation(~ 7000 events), 4 TDC spectra from PMTs and 6 TDC spectra from 6 cells of MRPC have been obtained.

In these 10 TDC spectra recorded on-line, the variance σ of each spectra has the $T0$ and $Ti(i = 1,2,3,4, m)$ fluctuation included. The TDC data are read out event by event and we can do the following calculation off-line:

$$Tmm(j) = Tm0(j) - [(T10(j) + T20(j)) + (T20(j) + T30(j))]/4 =$$
$$Tm(j) - [(T1(j) + T2(j)) + (T3(j) + T4(j))]/4$$

where the $Ti(j)$ is the TDC counts correspondent to a cosmic event which hit the cell j of MRPC. From the histogram of Tmm, we can get the σ_{Tmm} of the distribution of Tmm, which has been subtracted from the effect of $T0$'s jitter, and is contributed only from the fluctuations of Tm and $[(T1 + T2) + (T3 + T4)]/4$. The later is equal to $\sigma_{[(T1+T2)-(T3+T4)]/4}$ which can be drawn from the distribution of $[(T10 + T20) - (T30 + T40)]/4$ defined as reference time distribution. Fig.2 shows the distribution of reference time. The time resolution is $\sigma_{[(T1+T2)-(T3+T4)]/4} = 72.2$ps.

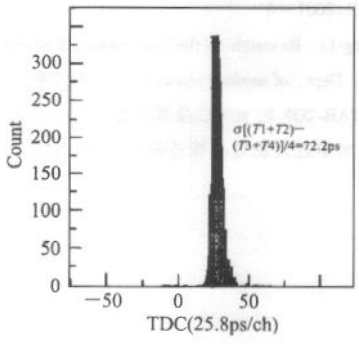

Fig.2. Reference time distribution $[(T10 + T20) - (T30 + T40)]/4$.

3 Cosmic test result of MRPC

The following data is from the 20 modules of MRPC with 6 gas gaps of 220μm, the working voltage is −14500V in the gas mixture of 5 % C_4H_{10}, 5 % SF_6, 90 % F134A($C_2H_2F_4$).

For eliminating the noise and cross talk signals among the cells, the data selection criteria are: 1) each cosmic event must have four PMT signals; 2) the hit cell must have TDC and ADC counts; 3) the cell ADC counts must be the biggest among the 6 cell signals. Using this data selecting criteria the typical ADC spectrum is shown in Fig.3 (a). Fig.3(b) shows the relation of TDC and ADC counts and is usually called the T-A correlation.

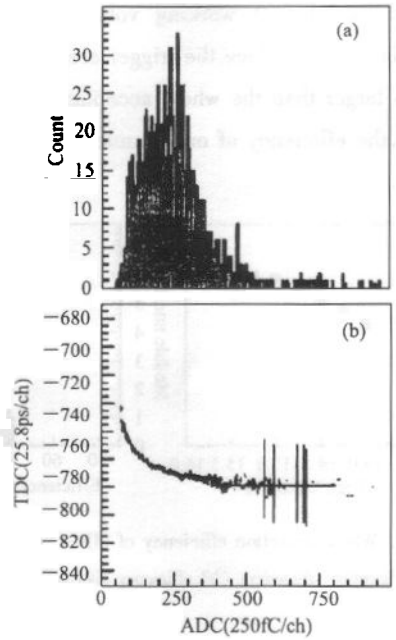

Fig.3. Cosmic test results of MRPC one cell.
(a) ADC spectrum; (b) T-A correlation.

The T-A correlation can be fit by using a six order multinomial (below 400 ADC ch) and a straight line (up 400 ADC ch). The T-A corrected Tmm data is shown in Fig.4 and the $\sigma_{Tmm} = 115.0$ps. After being subtracted the

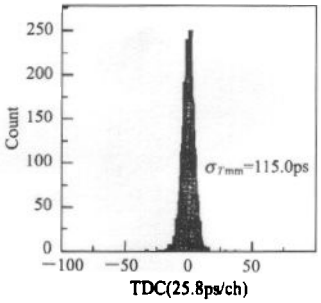

Fig.4. Time resolution Tmm of MRPC after corrected.

reference time jitter (72.2ps), the time resolution of one MRPC cell is about 89.5ps.

4 Efficiency for MIP

Since the cosmic test bench is not able to locate the cosmic track, the single cell's efficiency can not be determined, but the efficiency of the whole module can be tested.

HV-dependence of the whole detection efficiency of the tested module is shown in Fig.5 (a) which shows the detection efficiency has reached the efficiency plateau at -14500V. The distribution of the whole efficiency of these tested modules at working voltage -14500V is shown in Fig.5 (b). Since the trigger area of scintillation telescope is larger than the whole acceptance area of MR-module, the efficiency of our cosmic test bench is less than 90%.

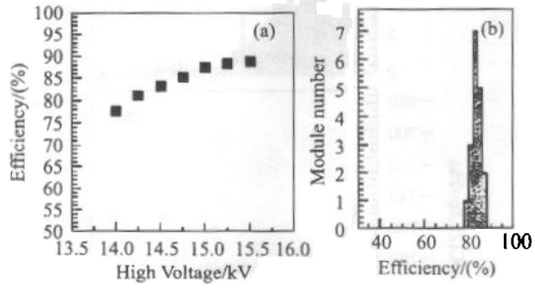

Fig.5. Whole detection efficiency of MRPC module.
(a) module detection efficiency; (b) efficiency distribution of modules

5 Cross talks between cells

Since the cosmic ray test bench can cover the whole 6-cell MRPC module, we can measure the MRPC module to get the information of the cross talks between cells. The big signal in one cell can induce signals in its neighbor cells which will disturb time resolution. Table 1 shows the cross talks on the cell 2 created from other cells. The first column is the ratio of the cross talk signals to real signals. The other columns show which cell these cross talks come from and their corresponding ratio. As the table shows, the cross talk is small and mainly comes from the neighbor cells. Under the effect of cross talks, the MRPC time resolution changes from 89.7ps to 97.3ps.

Table 1. Cross talks on cell 2.

Ratio of cross talk to real signal on cell 2	from cell 1	from cell 3	from cell 4	from cell 5	from cell 6
12.4%	35%	44%	11%	5%	5%

6 Conclusion

We presented the cosmic test results of about twenty MRPC modules made of Chinese glass. The results are gotten on the cosmic test bench whose time resolution of reference time is about 70ps. The MRPC modules can reach time resolution of 90ps, and the cross talk is about 12%.

References

1 Cerr on Zeballos E et al. Nucl. Inst. & Meth. In Physics research, 1996, **A374**: 132—135

2 Letter of Intent, RICE-TOF Group, Proposal for a single tray of MRPC TOF for STAR, 2001-6

3 HUANG Sheng-Li. Research on the Test System & STAR-TOF's MRPC. master thesis, Dept. of modern physics of USTC, 2001-11 (in Chinese) (黄胜利. STAR-TOF的MRPC及其测量系统时间性能的研究. 中国科学技术大学近代物理系硕士论文, 2001, 11)

多气隙电阻板室的宇宙线测量结果

黄胜利　李澄　许咨宗　汪晓莲　陈宏芳　汪兆民

(中国科学技术大学近代物理系　合肥　230027)

摘要　介绍了 20 多个多气隙电阻板室的宇宙线测量结果. 测量所用的宇宙线平台可以同时测量同一个电阻板室的多个 cell,其参考时间的时间分辨为 70ps. 在宇宙线的测量条件下,用国产材料制作的多气隙电阻板室的时间分辨可达到 90ps. 利用这套宇宙线测量系统,还对多气隙电阻板室的探测效率和 cell 间的相互串扰进行了研究.

关键词　宇宙线测量平台　参考时间　时间幅度修正　串扰

2002 - 04 - 01 收稿

* 国家自然科学基金(10155002)资助