Dependence on Temperature and Voltage of MRPC Noise and Dark Current *

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Abstract With different gas mixtures and high voltage, the temperature dependence of the noise and dark current for a 6-gap Multi-gap Resistive Plate Chamber (MRPC) is measured, and they are found to increase exponentially with the increase of temperature.

Key words MRPC, temperature, noise, dark current, working voltage

1 Introduction

The Multi-gap Resistive Plate Chamber (MRPC) is a new kind of gas detector first developed by LHC-ALICE group at CERN in the late 90's[1]. The MRPC has good timing characteristics and fits for detection of high multiplicity events. Its cost is relatively cheap. Thus it has become a favorable candidate of the time of flight detector (TOF) in high energy physics experiments and heavy ion collision experiments. A two-meter long prototype TOF composed of 28 MRPC models was installed in the STAR detector of RHIC at BNL and took part in physics run. Some important physics results are gathered. The environmental temperature rise caused by front-end electronics power consumption may affect the performance of the MRPC. In order to understand this effect, we measured the noise and dark current of a MRPC at different temperatures.

2 The structure of MRPC

The structure of MRPC is shown in Fig.1.[2—4]. It is made of a few of resistive plates (bulk resistance ~ $10^{12}\Omega\cdot$cm). The gap between the plates is about 0.22mm that is put in a gas mixture mainly composed of Freon 134A. We used 0.5mm float glass as the high resistive plate. The active area of the MRPC is 20cm × 6cm. There are six 6.3cm × 3.3cm readout strips in every MRPC.

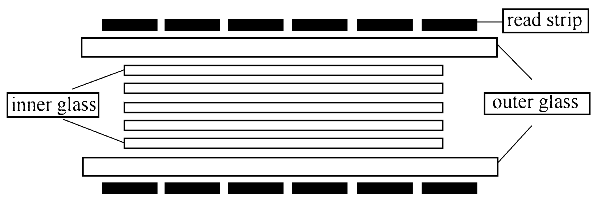

Fig.1. The sketch map of the structure of MRPC.

The beam test results[5,6] of the MRPC operated in three gas mixtures are shown in Fig.2. Fig.2(a) shows that the detection efficiencies plateau with HV can all go up by over 95% in different gas configurations, and indicates that the MRPC enters its HV plateau from 14500V for $C_2H_2F_4$ + i-C_4H_{10} + SF_6(curve A), from 14000V for $C_2H_2F_4$ + i-C_4H_{10} (curve B) and from 14250V for pure $C_2H_2F_4$(curve C). Fig.2(b) shows that the time resolution of the MRPC is 76 ps for pure $C_2H_4F_2$, while it is close to 60 ps for the other two gas configurations.

Received 27 March 2004
* Supported by National Natural Science Foundation of China(10155002)
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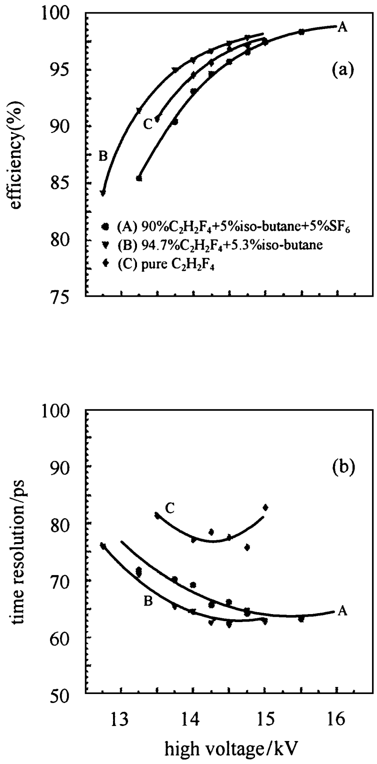

Fig.2. (a) The detection efficiency of 6-gap MRPC; (b) The time resolution of 6-gap MRPC.

3 Test condition and data analysis

To change the working temperature of the MRPC, a belt resistor is used to wrap the sealed aluminum box that holds the MRPC. When a certain voltage is applied to the resistor, the box will be heated up and transfer the heat to the MRPC and gas inside the box. A temperature sensitive resistor is put in the box. By measuring its resistance, the environment and working temperature of the MRPC can be monitored as the following formula,

$$T = \frac{R - 100}{0.385}(℃)$$

where R is the resistance measured and T is the temperature of the environment where the MRPC works. The dark current of the MRPC after applying HV is read out directly from CAEN N471A that offers the HV. Its sensitivity is 1nA. The output signals from the MRPC readout strips go through the front-end electronics (differential amplifier) and then are sent to a scaler (FH1011A) to count the noise. The test pattern is shown in Fig.3.

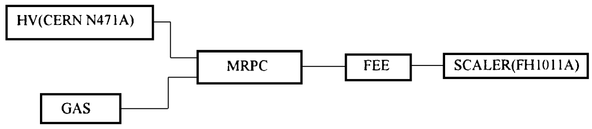

Fig.3. The test pattern.

4 Test results

Different working HV settled for the three gas configurations from their efficiency plateau, we measured their noise and dark current at different temperatures as shown in Fig.4 and Fig.5.

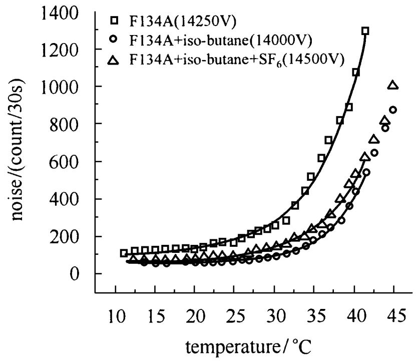

Fig.4. The noise changed with temperature at fixed voltage.

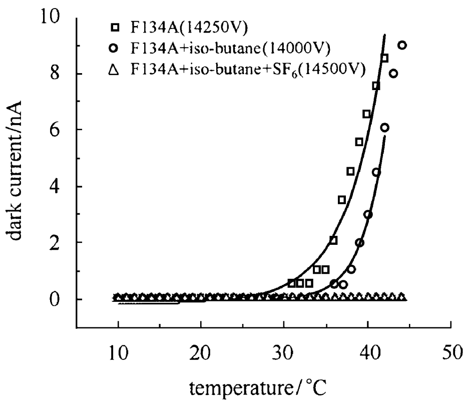

Fig.5. The dark current changed with temperature at fixed voltage.

Fig.4 shows the noise development with temperature. Similar exponential behavior is found as before. When the temperature is low, the noise increases slowly. When the temperature is high, the noise goes up sharply. This is especially apparent for the case of pure F134A whose critical temperature is at about 30℃. For F134A + i-C_4H_{10}, this temperature is at about 32℃ while for the three gas mixture case, it is about 34℃. Thus different gas configurations will require different working HV and the corresponding maximum working temperature permitted is also different. The dark current measured shows the similar trend as plotted in Fig.5. Except for F134A + i-C_4H_{10} + SF_6, the other two gas mixtures have similar exponential behavior.

We also measured the noise and dark current development at different HV after setting a certain temperature for each gas configuration. The results of noise are shown in Fig.6 and Fig.7.

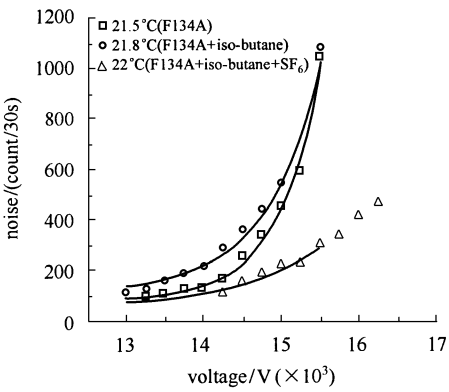

Fig.6. The noise changed with voltage at about 22℃.

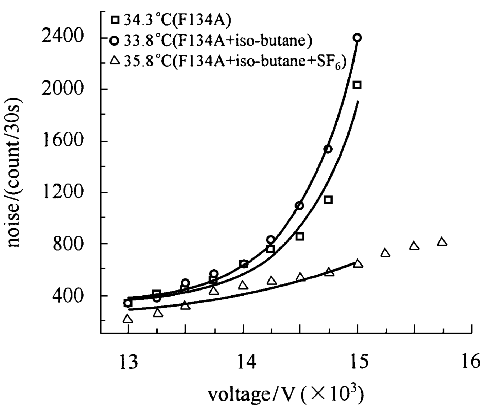

Fig.7. The noise changed with voltage at about 34℃.

In Fig.6, the temperature is set at about 22℃ for different gas mixtures. It can be seen that the existence of SF_6 restrains the increase of noise with HV sharply. Fig.7 is the case for temperature around 34℃. An exponential behavior is obvious. Similar trend is found in dark current measurement as Fig.8 and Fig.9 show.

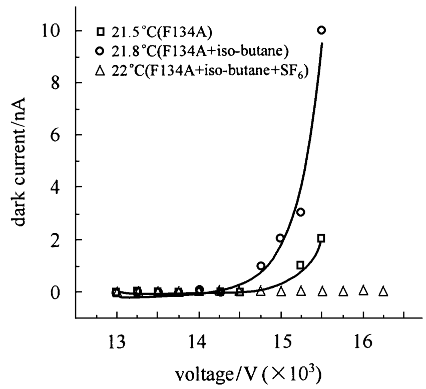

Fig.8. The dark current changed with voltage At about 22℃.

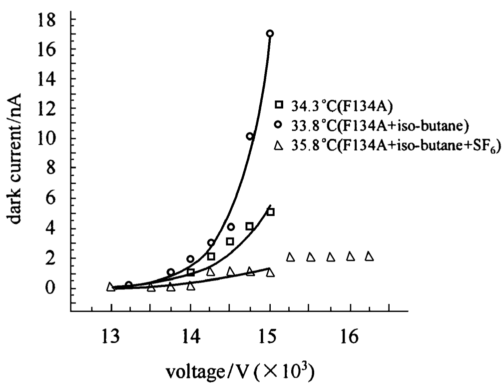

Fig.9. The dark current changed with voltage au about 34℃.

5 Conclusion

Two groups of noise and dark current measurements are done for the MRPC with three different gas configurations. (a) with a definite HV selected for a certain working gas, we measured their development with the environment temperature; and (b) with the temperature settled, we measured its development with changing HV. The results show that the working temperature has strong effect upon the working characteristics of the MRPC. The noise and dark current increase exponentially with the temperature. More researches need to be done to figure out the temperature effect upon the detection efficiency and the time resolution of the MRPC as well as to find out the physical mechanism of the temperature effect.

References

1 Zeballos E et al. Nucl. Instrum. Methods, 1996, **A374**(1): 132—135
2 LI Cheng et al. HEP & NP, 2001, **25**(9): 933—936(in Chinese)
(李澄等.高能物理与核物理,2001, **25**(9): 933—936)
3 CHEN Hong-Fang et al. HEP & NP, 2002, **26**(3): 201(in Chinese)
(陈宏芳等.高能物理与核物理,2002, **26**(3): 201)
4 LI Cheng et al. HEP & NP, 2002, **26**(5): 455(in Chinese)
(李澄等.高能物理与核物理,2002, **26**(5): 455)
5 SHAO M, RUAN L J et al. Nucl. Instrum. Methods, 2002, **A 492**: 344—350
6 Geurts F, Ming S, Bonner B et al. Proceeding of RPC 2003

MRPC 噪声和暗电流对温度和工作高压的依赖*

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摘要 不同混合气体不同高压,6个气隙的阻性板室工作在不同的环境温度下,测试其噪声和漏电流.噪声和漏电流随温度升高指数上升.

关键词 多间隙阻性板室 温度 噪声 漏电流 工作高压

2004-03-27 收稿
* 国家自然科学基金(10155002)资助
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