STATE RESEARCH CENTER OF RUSSIA
INSTITUTE FOR HIGH ENERGY PHYSICS

IHEP 2006-24

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TEST OF RPC OPERATED IN AVALANCHE MODE AT A 5 TESLA MAGNETIC FIELD

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Protvino 2006

UDK 537.613 M–24

Abstract

Ammosov V. et al. Test of RPC Operated in Avalanche Mode at 5 Tesla Magnetic Field: IHEP Preprint 2006-24. – Protvino, 2006. – p. 6, figs. 6, refs.: 4.

A multi-pad glass RPC with digital readout was placed inside a superconducting solenoid to investigate possible effects of strong magnetic fields on this detector. The RPC operated in avalanche mode was tested with cosmic muons. No influence was observed for field strengths of 5 T.

Аннотация

Аммосов В. и др. Испытание РПК, работающей в лавинном режиме в магнитном поле силою в 5 тесла: Препринт ИФВЭ 2006-24. – Протвино, 2006. – 6 с., 6 рис., библиогр.: 4.

Многопадовая стеклянная РПК с цифровым съемом информации была помещена в сверхпроводящий соленоид, чтобы определить, влияет ли сильное магнитное поле на этот детектор. РПК работала в лавинной моде, испытание проводилось на космических частицах. Никакого влияния магнитного поля силою в 5 тесла не было обнаружено.

Introduction

Resistive plate chambers (RPCs) are considered as a possible active medium in high granularity digital hadron calorimetry (DHCAL) developed now for a future international linear e^+e^- collider, the ILC [1]. The optimization of RPC parameters for a DHCAL using Monte-Carlo simulations is described in [2]. It was found that glass RPCs with 1×1 cm^2 readout pads and working in avalanche mode are a good choice for the DHCAL active detector. In the same paper our results obtained from tests of small prototypes with hadron beams can be found.

Given the large area to be covered in a full detector with such high granularity, the huge number of channels presents a particular challenge. The demand for early digitization and zero suppression as well as short signal paths require the front end electronics to be placed close to the pads.

RPCs were used successfully in detectors with magnetic fields, but with smaller field strength. Here, we check that our multichannel prototype with 1×1 cm^2 electrodes behaves well in a field of 5 Tesla, as typically envisaged for a detector at the ILC. This paper describes a cosmic ray test made with a superconducting magnet providing a 5 T solenoidal field. The test was done at DESY in framework of the detector research and development for the ILC. The main goals of this work were:

- to test a read-out concept in which 64 channels are integrated in one read-out line;
- to check whether strong magnetic fields affect the RPC operation in avalanche mode.

Experimental setup

Three glass RPCs with 1.2 mm gas gap each were used in the test: two of them as trigger detectors and the third one as tested RPC. All RPCs were filled with a non-flammable gas mixture consisting of $C_2H_2F_4$/isobutane/SF_6 (93/5/2) and were operated in avalanche mode. More details on the design of our glass RPCs can be found in [2], [3]. Each trigger RPC had a single read-out pad of 4×4 cm^2 size. Amplifiers attached to the trigger RPCs provided an amplitude gain of a factor 12.

The tested RPC had on the anode side 8x8 pads with 1×1 cm^2 size each. This RPC was equipped with eight 8-channel charge sensitive amplifier-discriminators OKA-1 (already used at IHEP, gain=12 mV/fC, ENC=1150 e + 32 e/pF, cross-talk between channels $\sim 0.5\%$) and one programmable logical device Altera ACEX EP1K50 (see WEB pages [4]) used as FPGA. On the cathode side, the tested RPC had a single 10×11 cm^2 pad. The signal from this pad was amplified using an amplifier with gain 10 and served to adjust the threshold in the multi-channel front-end electronics of the anode side.

Fig. 1 shows a sketch of our experimental setup. The tested RPC was inserted into a ~ 6 cm gap between the two trigger chambers. The signals from the trigger RPCs were transmitted via 20 m coaxial cables to the counting room. A coincidence of two trigger RPC signals was required to trigger the ACEX. If at least one signal from the anode pads was above threshold, all 64 ACEX bits were stored in memory together with a trigger counter. An RS232 interface was used to read the ACEX memory. The ACEX was read out in two possible modes: either individual events upon each trigger signal arrival, or blocks of events accumulated in the ACEX memory for several hundred triggers. In both cases the digital information from the 8×8 pads was available on event-by-event basis.

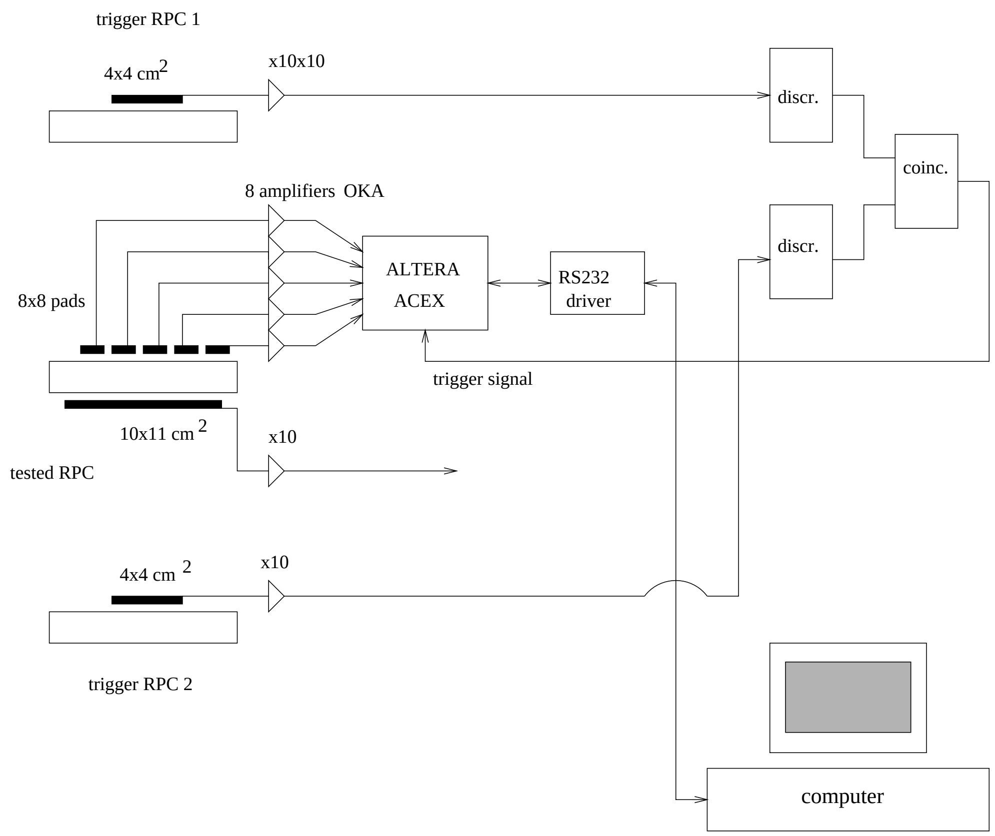


Figure 1. Experimental Setup.

Results

A typical distribution of the occupancy of the 8×8 matrix observed after ~ 1000 triggers is shown in fig. 2. In the plane of the read-out electrodes the sensitive trigger area covers 4×4 central pads in the tested RPC. The eight cells from each column in this figure correspond to the eight channels of one amplifier unit.

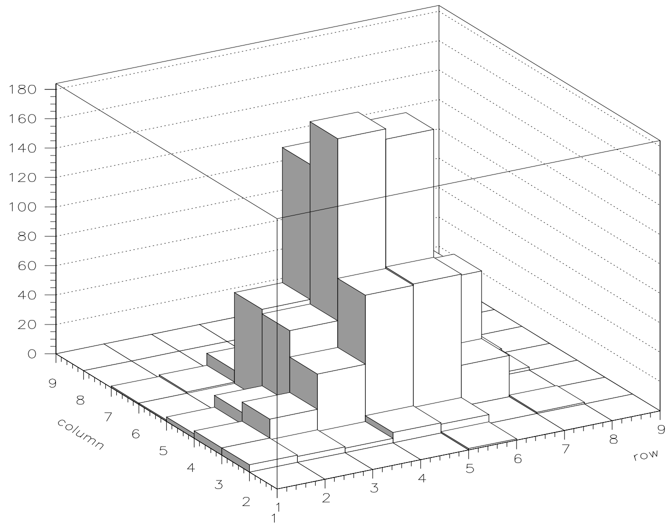


Figure 2. Population of 8×8 matrix after ~ 1000 cosmic triggers. HV=7.3 kV.

Fig. 3, displays a typical distribution of the number of fired pads per event. In general, multi-pad events arise due to the fact that the induced signal spreads over adjacent pads. We note that the multiplicity of fired channels per event appeared here to be somewhat higher than observed in our early tests [2].

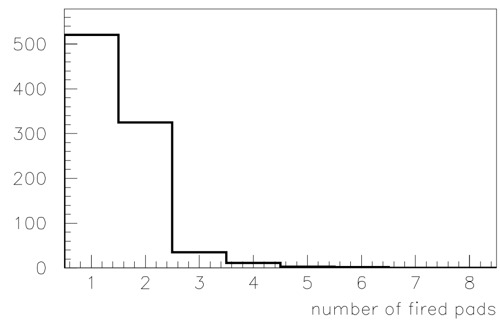
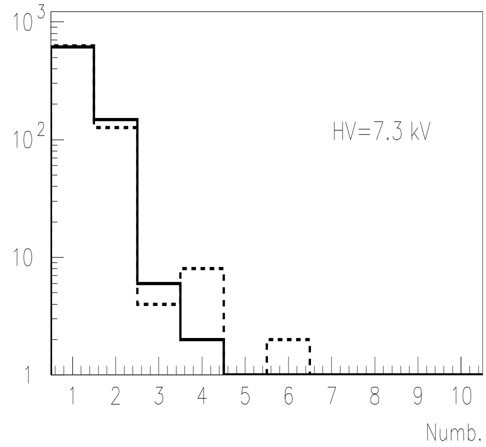


Figure 3. Typical distribution on the fired pad multiplicity.

To investigate the impact of electronic cross-talk on the pad multiplicity, we compared the number of fired columns with the number of fired rows. Fig. 4 shows distributions of fired column (solid) and fired row multiplicities (dashed), measured at two different voltages applied to the test RPC: at $HV = 7.3\ kV$ and at $HV = 7.6\ kV$.



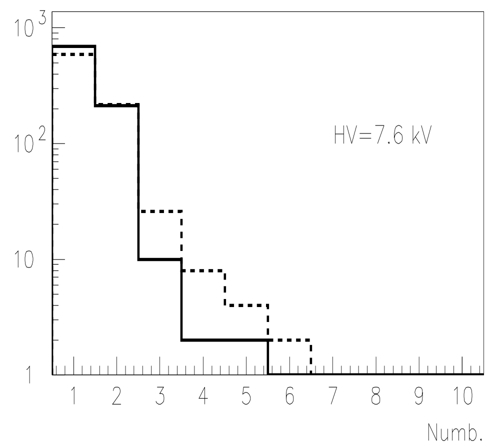


Figure 4. Multiplicity of the fired columns (solid) and rows (dashed) at HV=7.3 kV and HV=7.6 kV.

The multiplicity distribution for rows is found to be somewhat wider than that for columns. This indicates that multi-pad events are not entirely due to a sharing of induced signal between adjacent pads, but that electronic cross-talk between the channels of one amplifier (in one column) adds a minor contribution to the row multiplicity. However, we conclude that the observed multiplicity distributions primarily reflect the properties of the signal generation in the chambers.

To study the influence of a strong magnetic field, the measurements were carried out in 3 different configurations:

- a) the magnet was off;
- b) the magnet was operated at 5 T, the angle between the magnetic and the electric field lines was 90^0;
- c) the magnet was operated at 5 T, the angle between the fields was $\sim 45^0$.

The average trigger rate (for cases "a" and "b") was $0.1\ Hz$. Fig. 5 shows the mean multiplicity of fired pad as a function of the applied voltage, HV. The three sets of points correspond to the three different conditions. Each point in the figure is based on 300 triggers. Within the shown statistical errors no differences between data taken with and without magnetic field are observed.

The measured efficiency as a function of HV is also presented for the three conditions in Fig. 6. The figure demonstrates good agreement between the three sets of points.

Conclusions

In the framework of the study towards a possible use of RPCs as an active detector in the digital hadron calorimeter for an ILC detector we tested a 64 channel chamber inside a 5 T magnetic field in different orientations. Within statistical errors of order 1% no differences in the RPC behaviour – efficiency pad multiplicity – were observed between cases where the 5 T magnet was on and where it was off. The electronics developed to read the multi-pad system worked with high efficiency. Further effort on the design of integrated front-end electronics for larger numbers of channels is needed.

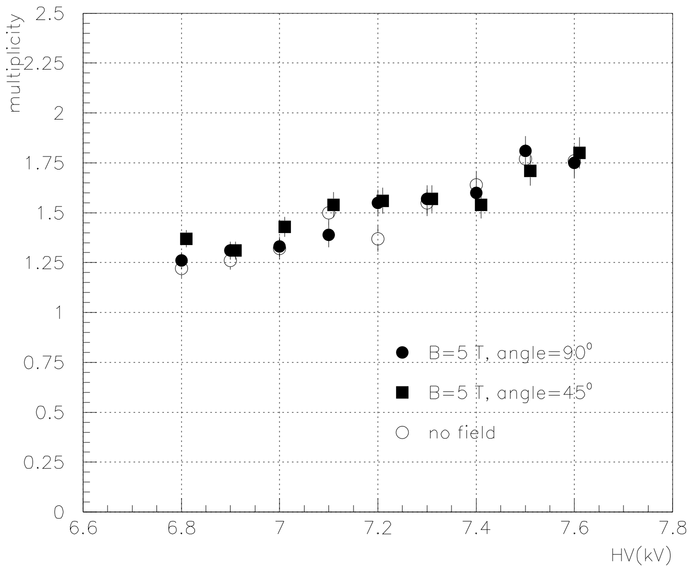


Figure 5. Multiplicity of the fired pads as a function of HV.

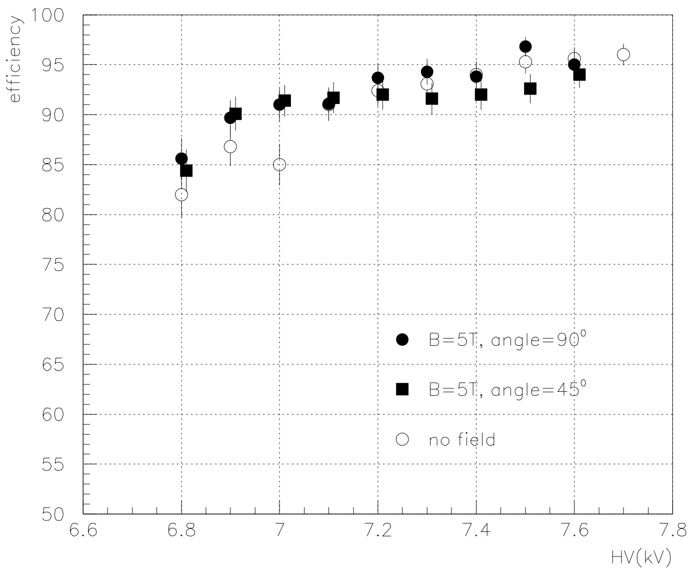


Figure 6. Efficiency as a function of HV.

Acknowledgements

We wish to thank A. Golovin for his efforts in manufacturing the RPC prototypes. Furthermore we thank deeply the members of the FLC group from DESY who helped us during our measurements.

This work was partially supported by the ILC DESY fund and by the RFBR grant No. 05-02-17037a.

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Received November 15, 2006.

Препринт отпечатан с оригинала-макета, подготовленного авторами.

В. Аммосов и др.
Испытание РПК, работающей в лавинном режиме в магнитном поле силою в 5 тесла.

Оригинал-макет подготовлен с помощью системы **LaTeX.**

Подписано к печати 15.11.2006. Формат $60 \times 84/8$.
Офсетная печать. Печ.л. 1. Уч.-изд.л. 0,8. Тираж 80. Заказ 108.
Индекс 3649.

ГНЦ РФ Институт физики высоких энергий
142281, Протвино Московской обл.

Индекс 3649

П Р Е П Р И Н Т 2006–24, И Ф В Э, 2006