

Performances of the Resistive Plate Chambers at YBJ

Sheng Xiangdong^a, Cardarelli Roberto^b, He Huihai^a, Liguori Giuseppe^c, Lu Zhaoxin^d,
Panareo Marco^e, Qu Xiaobo^f, Wang Yungang^a and Wu Chaoyong^a

(a) Key Laboratory of Particle Astrophysics, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China

(b) INFN and Dipartimento di Fisica dell'Università di Roma "Tor Vergata", 00133 Rome, Italy

(c) INFN and Dip.to di Fisica Nucleare e Teorica dell'Università, Pavia, Italy

(d) South West Jiaotong University, 610031 Chengdu, China

(e) INFN and Dipartimento di Fisica dell'Università di Lecce, 73100 Lecce, Italy

(f) Shandong University, 250100 Jinan, China

Presenter: Wu Chaoyong (wucy@ihep.ac.cn), chn-wu-C-abs1-og27-oral

The performances of the resistive plate chamber (RPC) used in ARGO-YBJ experiment, including the current of the RPC at different temperatures, detection efficiency, time resolution, strip multiplicity and PAD multiplicity were studied in April 2005 at YBJ (4300 a.s.l.). The results are presented and the ratio of multi-hit of one RPC in single hit events is derived.

1. Introduction

ARGO-YBJ (Astrophysics Research at Ground-based Observatory at Yangbajing) experiment (90°31'50"E, 30°6'38"N, 4300m a.s.l., 606g/cm²) is designed mainly to study gamma ray astronomy and gamma ray burst covering an energy region of 100GeV--200TeV, by means of detecting small size EAS (Extensive Air Shower) using a full coverage RPC array (see Fig.1).

The whole array is divided into the central area and the guarding ring with the central area consisting of 10×13 CLUSTERS. The guarding ring which consists of 24 CLUSTERS is used mainly to discriminate inner events from out ones. Each CLUSTER is a combination of 12 RPCs (1.25m×2.85m) which is made up of 2×5 detector units (called PAD, 56cm×62.5cm). Eight unilateral read-out strips (6.7cm×62cm) on each PAD provide particle number information (referred as strip multiplicity). Totally the whole array consists of 154 CLUSTERS, i.e. 18480PADs.

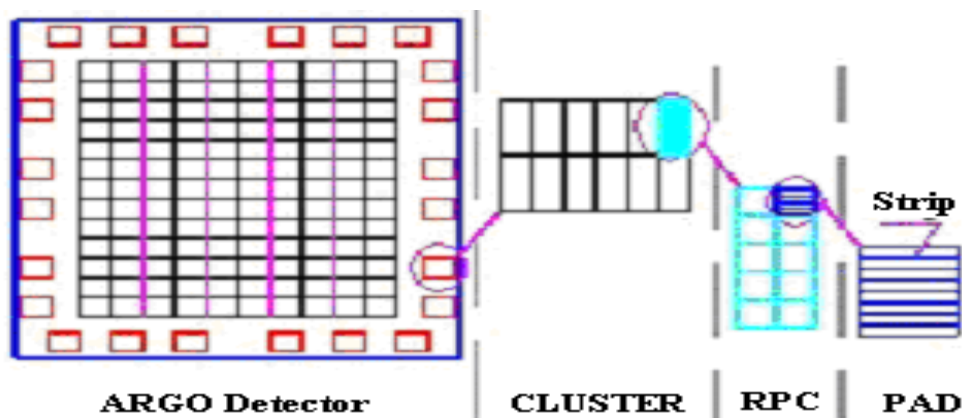


Figure 1: ARGO-YBJ carpet detectors

The RPCs work under the streamer mode, while each PAD provides a fast-or signal (called one hit) when at least one of its 8 strips is fired. The trigger signal (called common stop) is generated when the hit

multiplicity gets over the preset threshold. When a common stop occurs, information of time and position of all the hits in the carpet will be stored in the hard disk as an event. The information can be used to reconstruct the incident direction, energy and core position of the primary particles.

ARGO-YBJ experiment requires RPC detector with high detection efficiency, good time resolution ($\sim 1\text{ns}$) and low strip multiplicity (~ 1.2). Here we report the results of a field test to the RPC which was done in April 2005 at YBJ.

2. Experiment setup

The gas mixture in this experiment is argon:isobutane:Freon=15:10:75, same as the mixture in the whole carpet. The test system (Fig. 2) is constructed with 5 overlapped RPCs. Among these RPCs, RPC0, RPC2 and RPC4 are used as standard detectors while the RPC1 and RPC3 are the test RPCs. The test RPCs are staggered with the standard RPCs along the horizontal direction to eliminate the geometric inefficiency. The standard detectors work under the High Voltage (H.V.) of 7200V and H.V. of the test RPCs increase from 5500V to 7800V with the step of 100V during which the current and the temperature are measured.

Strip signals coming from the same PAD are operated with OR and generate a fast-or signal. The fast-or is sent to TDC to record the time information. At the same time, the fast-or is also sent to the trigger unit to calculate the hit multiplicity. When the hit multiplicity of the five RPCs is larger than 3 (preset threshold, means that at least one particle crosses through the RPCs), the TDC time and the strip pattern (information of the fired strip) would be stored in the disk as an event. In the offline analysis, events with RPC0, RPC2 and RPC4 being all fired once are further selected.

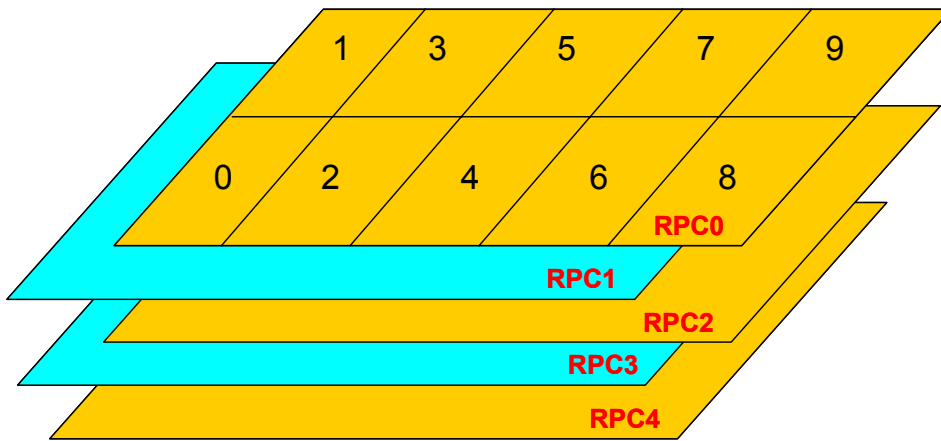


Figure 2: experiment setup, number 0 to 9 are the PAD in one RPC

3. Results

The currents of single RPC at different temperature are presented below. Although the temperature variation is not too big because this experiment was done in the ARGO laboratory at YBJ where there is a good heat preservation. The efficiency of the test RPCs and H.V. current are shown in fig. 3. When the H.V. meets 7200V (ARGO working point now), the efficiency is higher than 95%. And the efficiency will be close to 97% when the H.V. goes up to 7800V. Those events in which each RPC has only one hit were selected. Assuming a Gaussian behavior in the curve of the distribution of time of flight (T.O.F.) between RPC1 and RPC3 and the two RPCs have the same time resolution. The time resolution of one RPC can be estimated as: $\sigma = \text{FWHM}/(2.36 \times \sqrt{2})$. When the H.V. meet 7800V, the time resolution decreases to 1 ns. The time resolution and strip multiplicity of the RPCs are shown in Fig.4 .

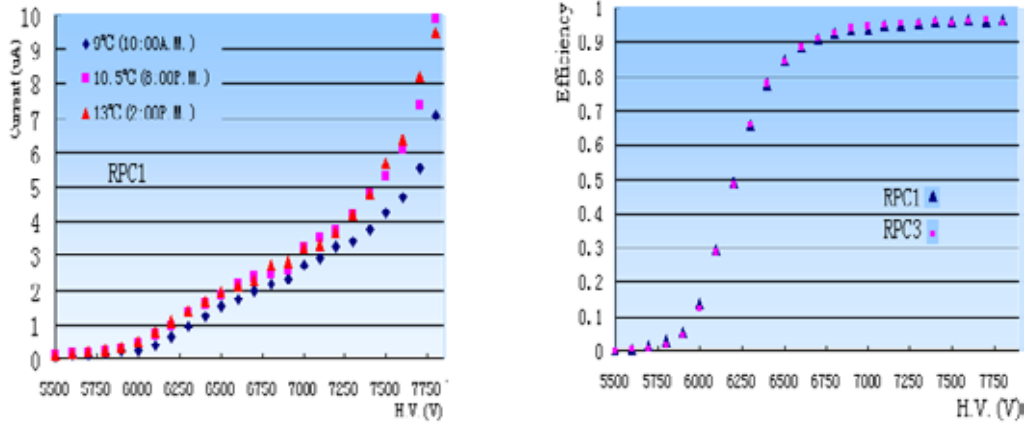


Figure 3: Current of the RPC at different temperature and RPC efficiency

Selecting the single hit event by the standard RPCs, the details of the strip multiplicity under 7200V on one PAD (PAD 4 of RPC1) is presented in table 1 with the mean value of ~1.06ns.

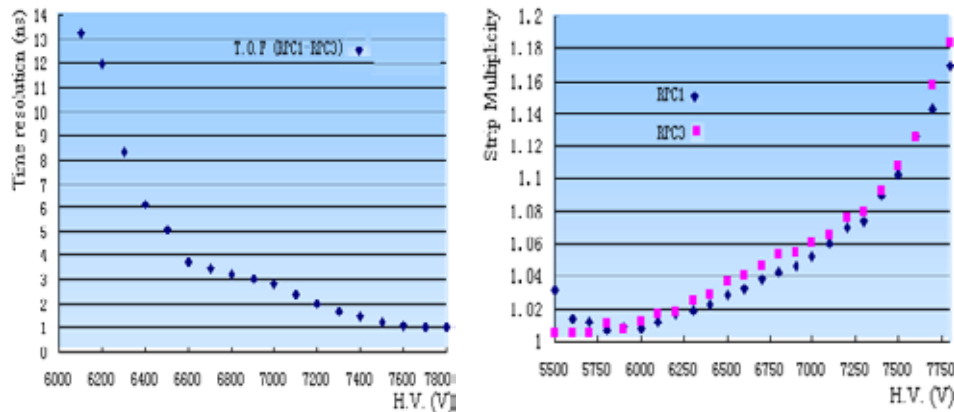


Figure 4: the time resolution and strip multiplicity of the RPCs

When a particle hits the border area of one PAD, with more than one strips fired, which may belong to its neighborhood PADs, thus more than one PADs could be fired with multi-hit generated (referred as edge

Table 1: Strip multiplicity in one PAD in single hit events

strip multiplicity	1	2	3	4	≥ 5
Percentage (%)	93.89±0.01	5.76±0.01	0.31±0.01	0.03±0.01	< 0.01

effect below). The edge effect is studied in detail using a simple experiment setup that each PAD of the standard RPCs is placed at the center of PAD4-7 (as the test PADs) of RPC1 (see Fig.5). Events with only one hit in each PAD4 of the standard RPCs are selected. Table 2 shows the ratio of hit multiplicity 0-4 in RPC1.

Table 2: multi-hit in single hit events

n	0	1	2	3	4
P(%)	4.16±0.08	92.0±0.5	3.69±0.07	0.11±0.01	0.011±0.004

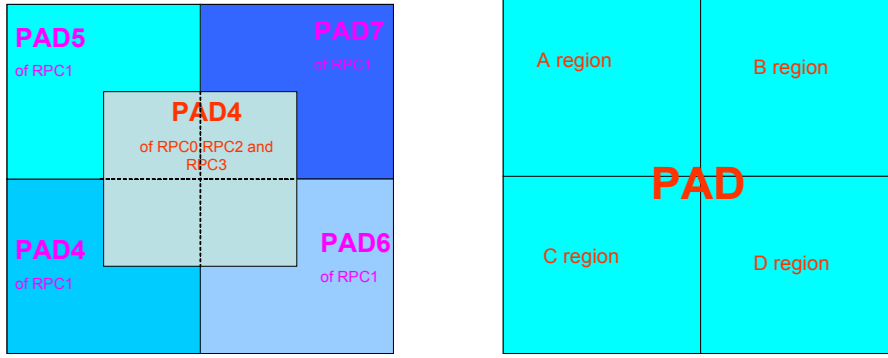


Figure 5: new setup of the experiment and the regions in one PAD

Each PAD in RPC1 is divided into 4 regions according to how many neighborhood PADs it has (see Fig.5) with region A: no neighbor, B: one neighbor along the strip direction, C: one neighbor perpendicular to the strip direction, D: 3 neighbors. In one RPC, there are 4A, 4B, 16C and 16D regions. When 1 particle hits region A, only one hit can be generated with the possibility equal to the efficiency. For region D, the possibilities for different multiplicities are just listed in Table 2.

To calculate the possibility of that one particle hitting region B generating 2 hits, events are vetoed if PAD4 or PAD7 of RPC1 is fired (for region C, similar consideration). The result is shown in table 3. With the

Table 3: possibility of 2 hits generated in different regions in single hit events

region	C	B
Percentage (%)	1.23±0.05	1.68±0.05

above results, the possibility for one particle hitting a RPC and generating different number of hits can be derived (see table 4).

Table 4: possibility of multi-hit of one RPC in single hit events

Number of PADs fired	1	2	3	4
Percentage (%)	92.03	2.136	0.044	0.0044

4. Discussion

The current of RPC at different temperatures shows that the RPC works with low current. It is a safe current level for long time running. The efficiency increases to 97%, while the time resolution reaches 1ns under 7800V. It approaches the requirement of ARGO experiment. But the working point now is 7200V, because the beginning of the efficiency plateau is 6800V and it's a little danger to set the working point to 7800V which is close to the end of the plateau. A previous experiment has been done by other collaborators in ARGO experiment before. A little SF6 (0.3%) was added in the gas mixture and the efficiency curve was shifted to right. The beginning of the efficiency plateau was shifted to 7200V and the efficiency and time resolution were still good under the H.V. of 7800V. The strip multiplicity is 1.06 at 7200V and less than 1.2 at 7800V. it reaches the requirement of ARGO experiment. The multi-hit ratio in one RPC has been derived. And it's a meaningful value for future research.

References

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