Performance of the RPCs for the ARGO detector operated at the YangBaJing laboratory (4300 m a.s.l.)

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Abstract

Bakelite RPCs, assembled according to the ARGO design, have been operated in the high altitude Laboratory of YBJ using dedicated electronics to pick-up the streamer signal. Here we report on the results concerning absorbed
current, single counting rate, efficiency and time resolution. Environmental data concerning the operating temperature inside the ARGO experimental hall are also reported.

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1. Introduction

The Argo [1] experiment is presently in a mounting and debugging phase at the YangBaJing High Altitude Cosmic Ray Laboratory (4300 m a.s.l., 606 g/cm²), 90 km North to Lhasa (Tibet, China).

The aim of the ARGO-YBJ experiment is the study of fundamental issues in cosmic ray and astroparticle physics including γ-ray astronomy, GRBs physics at a few hundred GeV threshold energy and the measurement of the antip/p at TeV energies. The apparatus consists of a full coverage detector of dimension $71 \times 74$ m² realized with a single layer of Resistive Plate Counters (RPCs). A guard ring partially (about 50%) instrumented with RPCs, surrounds the central detector, up to $100 \times 100$ m²; it improves the apparatus performance by enlarging the fiducial area for the detection of showers with the core outside the full coverage carpet. A lead converter 0.5 cm thick will cover uniformly the RPC plane in order to increase the number of charged particles by conversion of shower photons and to reduce the time spread of the shower particles.

Test on site have already been performed both on single RPC performance [2] and on a small RPC carpet [3]. At the end of ‘2000 it has started the mounting of the experiment. On the first 40 chambers that have been mounted we have performed very careful tests whose results are reported here. Moreover we have monitored the temperature inside the building in order to understand the uniformity and stability of the operating temperature.

First, we report about the environmental data results, then about the performance of the chambers.

2. The ARGO experimental hall

The ARGO RPCs are operated in streamer mode with the same gas mixture that we used in

Fig. 1. Daily temperature variation at YBJ outside and inside the ARGO experimental hall in January 2001 as monitored by sensors Nos. 13, 9 and 5 (see also Fig. 3 for explanation).
In order to ensure sufficient vaporization of the iso-Butane, the chambers have to be operated at a temperature >5°C. Moreover, to get reliable measurements of the Extended Air Shower (EAS) features, it is fundamental to control the operating temperature of the RPCs which will be distributed over an area of 10,000 m². A good uniformity of the temperature inside the building has been obtained by adopting a light structure in which two steel plates sandwich a polyurethane panel. The steel pillars were precisely arranged to ensure ~93% effective RPC coverage; the roof material was strictly controlled to be <2 g/cm² on average to reduce the interaction probability of the EAS particles with the roof material. To monitor the indoor temperature 25 sensors were distributed on a lattice structure, 30 cm above the floor. This monitoring showed that, even in the coldest day of January, the natural temperature in the ARGO experimental hall remains above 0°C (Fig. 1) while the day/night temperature variation is kept stable within a few degrees (Fig. 2). The temperature gradient with respect to the distance from the centre of the experimental hall is of the same order and even less as shown in Fig. 3.

3. Performance of the installed RPCs

We have tested the first 40 RPCs that have been shipped to YBJ and installed in November
2000. These are the new generation RPCs, in the final version for ARGO. They are equipped with a new electronics [4]. The RPC size is 125 × 280 cm², the signals are picked up by 80 copper strips 62 cm long and 6.7 cm wide. The RPCs were operated with the same mixture that we used in the ARGO-test experiment, namely Ar/i-But/TFE = 15/10/75.

Here we report on the results concerning absorbed current, single counting rate, efficiency and time resolution. For the efficiency and time resolution measurements, we have used a small telescope consisting of three RPCs of area 50 × 50 cm² [2].

The typical behaviour of current vs. applied voltage is shown in Fig. 4, we can see that between 7200 and 7300 V—where the efficiency reaches the plateau—the current is less than 2 μA. The corresponding value for an old generation RPC, as measured in the same conditions [2], is about 6 μA, thus there is a reduction of a factor 2–3 in the absorbed current between new and old generation RPCs all over the working voltage range.

The counting rate shown in Fig. 5 refers to the counts in 15 s over one RPC whose signals are discriminated with a threshold of about 50 mV and shaped to 100 ns. We also tried different time shaping, namely 200 and 500 ns, but no substantial differences were observed in the counting rate. The scaler boards are custom-made, each channel refers to one strip, the integration time can be fixed by program. In Fig. 5 are also reported some reference rate lines, corresponding to 400, 500 and 600 Hz/pad (one pad corresponds to 8 strips). Although the slope is higher than that reported in Ref. [2] for old generation RPCs, the rate that we measure in the 7.2–7.6 kV range is between 400 and 600 Hz/pad.

Fig. 6(a) shows the mean efficiency of our RPC sample; the plateau starts around 7.4 kV with a 96% value. In Fig. 6(b) the efficiency distributions at fixed operating voltage, namely 7.5, 7.7 and 7.9 kV are shown: the efficiency distribution gets narrower and peaks at the geometrical limit (98.5%) when increasing the operating voltage.

In order to estimate the time resolution we have measured the time difference between two strips of two different and overlayed RPCs. When the external telescope provided the trigger, an additional coincidence between the telescope trigger
and these two strips was required. The selected tracks were almost vertical and the impinging point almost at one end of the strip. Fig. 7 reports the time difference distribution at 7.3 kV. Assuming that the two RPCs have equal time resolution and the time response is gaussian distributed, we obtain the RPC time resolution shown in Fig. 8 as a function of the applied voltage. Accordingly the time resolution is better than 1 ns.

The percentage of dead strips has been measured and results less than 0.5%.

4. Conclusions

In conclusion we can say that the new generation ARGO RPCs operated at YBJ with an applied voltage of 7.5 kV, absorb very low current—less than 3 μA—, have a single counting rate below 500 Hz/pad, provide an efficiency greater than 96% and a time resolution better than 1 ns. The temperature distribution inside the ARGO experimental hall does not imply any problem concerning the operation of the detector.
Fig. 7. Time difference distribution between two strips of two different RPCs put one on each other. The operating voltage is 7.3 kV.

Fig. 8. Time resolution.

References