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Performance of glass RPC with industrial silk-screen-printed electrodes

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Abstract

In this paper we describe the performance of several Glass RPCs, where the water-based graphite coating is replaced by a synthetic coating applied using the screen printing technique. As expected, the performance of the detectors is good and reproducible due to the accurate control of the coating resistivity value. The resistance of the coating to the action of mechanical and chemical agents permits an easy electrode cleaning and mounting with respect to the RPC coated with the graphite varnish. This coating, together with the use of float glass as electrode material, allows an industrial production, where the detector characteristics can be tailored as a function of the experiment requirements.

Keywords: RPC; Neutrino

1. Introduction

Resistive Plate Counters (RPC) are used intensively in large-area experiments for their capability to provide precise time measurements (1 ns is easily achievable) on a large area at a relatively low cost. Moreover, the detector can be equipped with various versatile pick-up elements making the experiment assembling fast and easy. These characteristics were particularly appreciated when designing the MONOLITH (Massive Observatory for Neutrino Oscillation or LImit on Their existence) experiment [1], a massive magnetized apparatus consisting of 120 iron planes, 8 cm thick, 30 m long and 15 m wide. The iron planes were interleaved with sensitive planes for a total area of more than 50,000 m^2. Glass electrode RPCs were developed for this experiment assembling commercially available materials. As a result a detector having the required performances (1 ns time resolution with 3 cm copper strips) has been obtained at a low cost [2]. The particular detector

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layout was designed for an easy assembling without the use of gluing procedure thanks to the use of noryl envelopes and spacers ensuring a uniform gap of 2 mm with a precision better than 0.5% even on larger area [3].

In this paper we report on a detector development using commercial glass, $10^{12}\,\Omega\,\mathrm{cm}$ resistivity, coated with industrial silk-screen-printed technique ensuring to the electrodes an absolutely uniform surface resistivity, a good resistance to mechanical actions and a good response to chemical agents. In addition, the industrial procedure applied allows the realization of a large amount of detectors with easy, fast and cheap process.

2. Detector design

The float glass layers are industrially silk-screen printed [4] in order to have a surface resistivity of $400\,\mathrm{k}\Omega/\square$. From these layers electrodes 243 mm wide, 1.85 mm thick and 110 cm long are obtained. Fig 1 shows the detector layout: the two glass electrodes are inserted inside a noryl envelope ensuring the gas containment. Electrodes are spaced by means of injection-molded spacers, 2 mm thick and 150 mm long, ensuring the uniformity of electrodes spacing on the wide area and optimizing the gas flow. The detector is closed by two injection-molded end caps. The HV supply to each electrode is ensured by a properly shaped harmonic metal contact located in one of the two end caps (Fig. 1). The float glass properties have been accurately studied [5]. A stable volume resistivity of $\sim 3\times10^{12}\,\Omega\,\mathrm{cm}$ has been measured at 22°C. The resistivity varies linearly from $10^{13}\,\Omega\,\mathrm{cm}$ at 8°C down to $10^{12}\,\Omega\,\mathrm{cm}$ at 28°C, depending only on temperature. The characteristic hopping electronics conductivity of glass avoids resistivity variations also at a high charge current.

The detector production and assembling results are very fast and easy to perform: the float glass electrode does not need the surface treatment with linseed oil, the graphite coating is replaced by the industrially produced silk-screening coating, the spacers are applied without gluing and the HV contacts are realized without soldering. Finally, the use of an envelope for the gas containment reduces the occurrence of the leakage. These characteristics, compared to one of the bakelite RPCs [6,7], make this detector more suitable for large production due to the reduction in necessary manpower and costs.

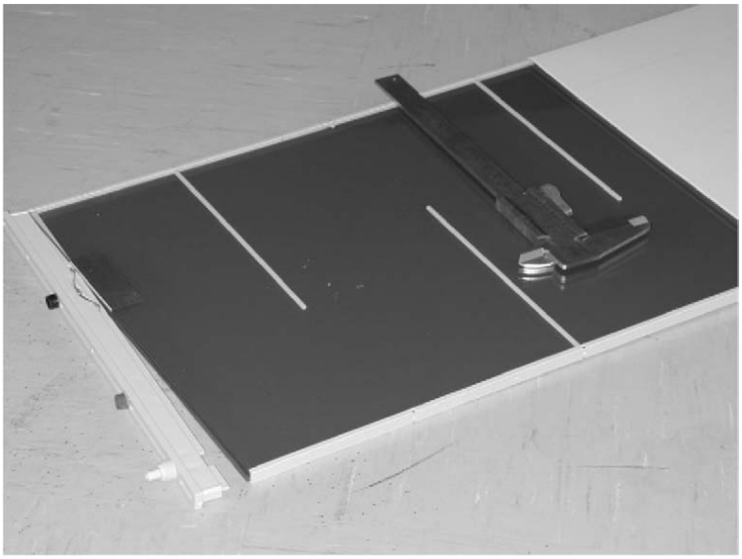

Fig. 1. Sketch of a glass RPC.

3. Test measurements

The experimental test setup is shown in Fig. 2: two glass RPCs were superimposed on a plastic scintillator of the same area. Two fast plastic scintillators, $5 \times 16\,cm^2$, are used to limit the measuring area by means of a coincidence between them and the large-area scintillator. Flat cables have been used [8] with readout cards on both cable ends as RPC pickup. The setup has been build in the Laboratorio Nazionale del Gran Sasso Laboratory, Assergi, L'Aquila. Tests were mainly devoted to measure the detector noise, efficiency and time resolution obtainable with the new layout with silk-screen-printed electrodes. RPCs were operated with argon/isobutane/R134A gas mixture in the ratio 46%/8%/46%.

Fig. 3a shows the plateau evolution of the upper RPC obtained in single counting rate in the first 3 days of detector operation. A large plateau is clearly visible, as well as the immediate good performance of detector also at its first use. The plateau level corresponds to the cosmic ray flux and environmental radioactivity. The comparison between the two RPCs reported in Fig. 3b enhances the reproducibility of detector performances. Note that these results have been obtained without any detector conditioning procedure.

The time evolution of detector efficiency is shown in Fig. 4a: raw data show a detector efficiency higher than 90% (taking into account a geometrical inefficiency of 2.1%). A similar value has been measured for the second detector, as shown in Fig. 4b. The current absorption at the plateau level is about $1\,\mu A/m^2$, that means that no dark current is present. No conditioning procedure is required at the beginning.

The time resolution has been measured comparing the coincidence signal between the two fast scintillators on the top of the setup used as common start to a fast Lecroy TDC with the detector signal used as TDC stop. The time resolution as a function of HV, measured as the sigma of the time delay distribution between signals of the two RPC triggered by scintillators, is shown in Fig. 5.

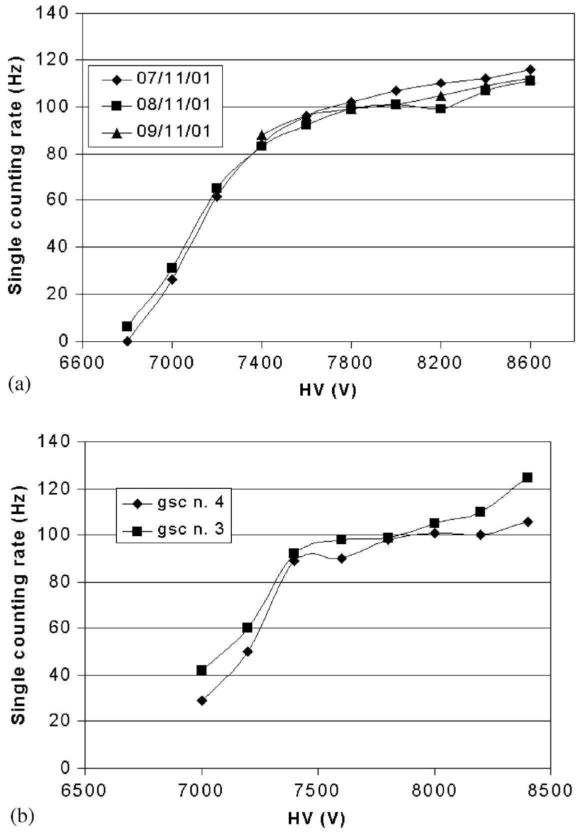

Fig. 3. (a) Plateau evolution of a new GSC detector. (b) Plateau comparison between two new GSCs.

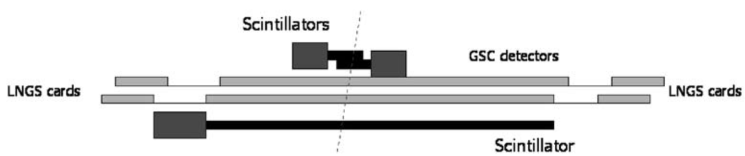

Fig. 2. Test setup.

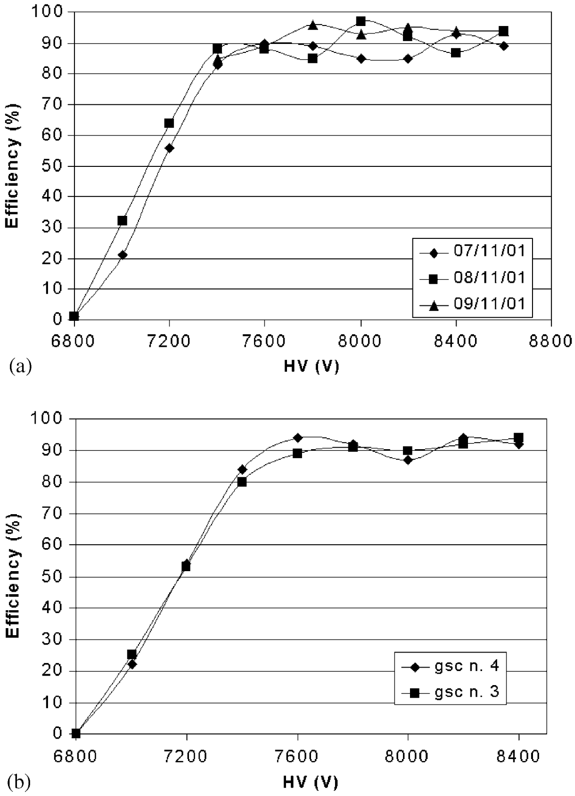

Fig. 4. (a) Efficiency evolution for a new GSC detector. (b) Efficiency comparison between two new GSCs.

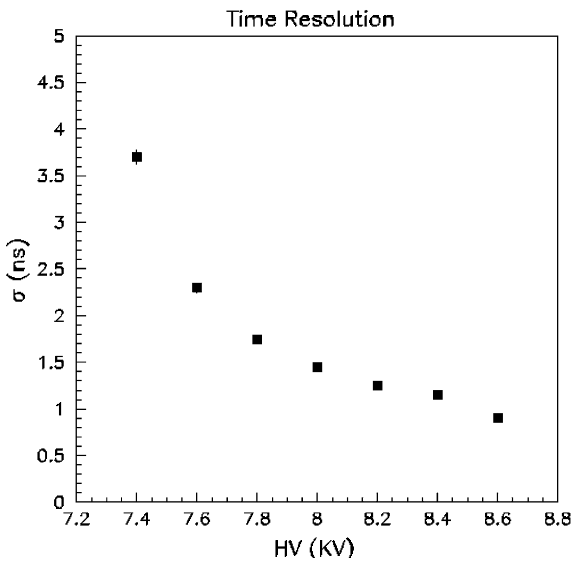

Fig. 5. GSC time resolution as a function of HV.

4. Conclusion

The first measurements on glass RPC detectors with industrial silk-screen-printed electrodes reported here demonstrate both the good answer of coating and the reproducibility of detector performance. The new detectors show stable behavior, large plateau, high efficiency and good time resolution. The described detector performances result remained unchanged after 2 months of continuous operation. The glass RPC described is suitable for a mass production due to the use of commercially available materials and the simple assembling. A $1000\,m^2$/day silk-screening electrodes production capability is now allowed.

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