

A Glass Resistive Plate Chamber for Large Production

C. Gustavino, M. D'Incecco and E. Tatananni

To be submitted to Nucl. Instr. and Meth.

INFN – Laboratori Nazionali del Gran Sasso

*Published by SIS-Pubblicazioni
Laboratori Nazionali di Frascati*

A Glass Resistive Plate Chamber for Large Production

C. Gustavino, M. D’Incecco and E. Tatananni

Laboratori Nazionali del Gran Sasso, Assergi – Italy

Abstract

A new type of glass electrode RPC is described. The design is conceived to allow a large and fast production, good performance and an easy detector operation. These characteristics make the detector suitable for very large arrays, such as future neutrino experiments.

1 Introduction

The indication for the existence of neutrino oscillation has appeared in the atmospheric neutrino data of Kamiokande [1] and IMB [2]. More recently Superkamiokande [3], MACRO [4], and SOUDAN2 [5] data reinforced the oscillation hypothesis. Many experiments have been proposed to study the neutrino oscillation around $\Delta m^2 = 10^{-3} \text{ eV}^2$ with large mixing angle. A possible method is based on the development of long-baseline accelerator neutrino beam programs [6, 7, 8]. On the other hand, measurements of atmospheric neutrinos can also provide convincing evidence of oscillations, as a results of detectable effects on the energy, zenith angle and L/E distributions of the events. In particular, there has been proposed the installation of a high density detector for atmospheric neutrinos at the Laboratori Nazionali del Gran Sasso (LNGS) [9]. Briefly, the proposed detector consists of 120 horizontal iron planes 8 cm thick, 30 m long and 15 m wide. The iron slabs are interleaved by sensitive planes for a total active area of about 50,000 m². Resistive Plate Chamber (RPC) [10, 11] can be used as the basic device for this experiment because of the good spatial localization of the crossing particle and a time resolution of the order of 1 ns. In fact, the proposed detector must be able to recognize the particle direction by means of the time-of-flight technique, and it must have a good tracking capability for the L/E measurement. Beside the good tracking and timing performance mentioned above, the device used in such large experiments must be cheap and easy to construct. Moreover, uniform working conditions in all the detectors are very important to allow an easy calibration and monitoring of the apparatus.

A glass electrode RPC conceived for large apparata is described below. The simple assembling allows a fast and low cost production. Its design permits an easy operation and good performance. Finally, the safety restrictions of an underground laboratory have been taken into account.

2 Detector design

The Glass RPC (fig.1,2), consists of a pair of float glass electrodes 245 mm wide, 1.85 mm thick. The detector lenght can be chosen as a function of experimental requirements. The volume resistivity at room temperature of the commercial float glass is about $\rho = 10^{12} \text{ }\Omega\text{cm}$, suitable for operation in streamer mode in low particle rate environments. The 2 mm distance between the electrodes is ensured by several NORYL injection molded spacers. Each spacer has two sticks 2 mm thick and 2 mm wide. The sticks are 150 mm and 4 mm long, respectively. The profile of these sticks is knurled to prevent possible discharge between the glass (see the magnification in fig.1). The 100 mm distance between the sticks is ensured by a 200 mm profile. Each spacer is clamped at the edge of the electrodes in correspondence of the two sticks (see the magnification in fig.1). As shown in fig.1, the shape of the spacers optimize the gas flow. In fact, they provide a channel for the gas to flow from the input, located in one end cap, back and forth across the total area of the detector and then out of the other end cap. A 140 μm thick carbon-polyethylene adhesive foil is applied to the external surfaces of the glass to provide the

high voltage supply (in fig.2 the foil applied on the upper electrode has been partially removed to show the spacers inserted between the glass plates). The surface resistivity of the foil is about $10 \text{ M}\Omega/\text{square}$, providing a full transparency for the fast streamer signals generated between the plates. These signals can be picked up by using external read-out electrodes (not shown in fig.1,2) [12]. The glass plates and the spacers are inserted in an extruded NORYL envelope with 1.5 mm thick walls. The external cross section of the envelope is $250 \times 9 \text{ mm}^2$. The detector is closed by 2 injection molded NORYL end caps, in which are located the gas connectors. The H.V. supply to each electrode is ensured by a properly shaped harmonic metal strip located in one of the two end caps. The electrical contact between the metal strip and the carbon-polyethylene foil is performed by means of an adhesive copper tape.

With respect to the bakelite RPC [10], this detector is more suitable for large production, because of the reduction in necessary manpower. In fact, the float glass electrode does not need the surface treatment with linseed oil [13]; the graphite coating is replaced by an adhesive foil; the spacers are applied without gluing; the H.V. contacts are realized without soldering. The use of an envelope for the gas containment instead of a glued frame between the electrodes prevent the occurrence of leakage.

In the RPC detectors a good gap tolerance is crucial to obtain a time resolution of about 1 ns. Fig.3 shows the time walk in the Glass RPC as a function of the electric field. We note that the signals from the glass The signals from the Glass RPC are generated faster as the electric field increases, with a slope $\Delta t(\text{ns})/\Delta E(\text{V}/\text{mm}) \simeq 10^{-2}$. Therefore, a time resolution of the order of 1 ns is possible only if the electric field is uniform at the percent level. Consequently, a gap tolerance less than few tens of microns is necessary. The gap uniformity is very important especially in very large arrays and it has been taken into account in the Glass RPC described here. The sticks of the injection molded spacers have a tolerance of $\pm 5 \mu\text{m}$. Moreover their insertion without gluing prevents a possible increase of the distance between the electrodes. The gap tolerance depends also on the glass sagitta due to the gravity and due to the electric field between the electrodes. The sagitta S due to the gravity of a horizontal sheet scales as the square of the sheet thickness b and as the fourth power of its length l :

$$S = kl^4/b^2$$

For the float glass we have measured $k = 50 \cdot 10^{-12} \text{ mm}^{-1}$. In the detector, the maximal distance between the sticks of the spacers is 100 mm, therefore the glass sagitta due to the gravity in the detector is less than $1.5 \mu\text{m}$. The sagitta due to the electrostatic attraction between the electrode (assuming an electric field of 4 kV/mm) is less $5 \mu\text{m}$ for each electrode. Differently from standard RPC, the gas containment in this detector is ensured by the envelope and not by the electrodes themselves, thus no change of the distance between the electrodes can occur due to the pressure of the flowing gas, that is typically several mbar higher than the atmospheric one. Furthermore, the envelope strongly reduce the detector damaging due to possible gas flowing failure. Taking into account all the factors mentioned above, the gap tolerance is less than the 0.5%.

The end caps, the spacers and the envelope are realized in NORYL ENV130 because

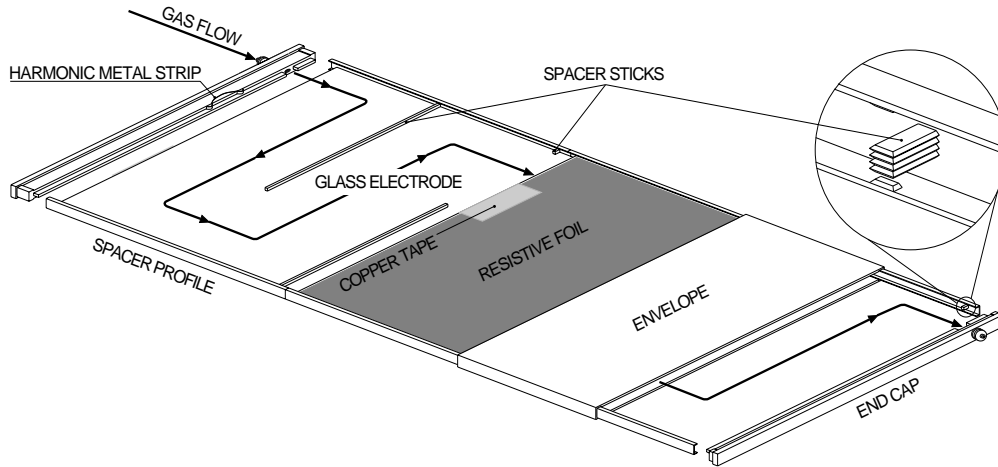


Figure 1: Sketch of a Glass RPC.

of its excellent properties from the safety point of view [14] and because of its dielectric properties (the dielectric strength is about 20 kV/mm, the volume resistivity is about $10^{17} \Omega\text{cm}$ and the surface resistivity is greater than $10^{15} \Omega/\text{square}$).

We have built 100 of the described Glass RPC, 110 cm long, for a total surface area of about 27.5 m^2 . 84 Glass RPC have been tested at the CERN PS-T7 particle beam in a prototype of the neutrino experiment described in [9]. Taking into account the safety rules of the LNGS laboratory, an ecological and non-flammable gas mixture (argon+Isobutane+R134A=48%+4%+48%) has been used in the beam test. The results of the measurements on the beam are reported in [15]; As foreseen, all the detectors show the same performance, i.e. a r.m.s. time resolution of about 1 ns and a counting level of about $500 \text{ Hz}/\text{m}^2$. Finally, the plane efficiency is about 96%, essentially due to the geometrical dead zone.

3 Conclusions

The Glass RPC described is suitable for a mass production because the use of commercially available materials and the simple assembling. Our pilot production allows a cost estimate for a large production of about $10 \text{ \$/m}^2$, while the production rate should be at least $100 \text{ m}^2/\text{person-day}$. The modularity of the detector and its easy operation match the requirements for a feasible large neutrino experiment.

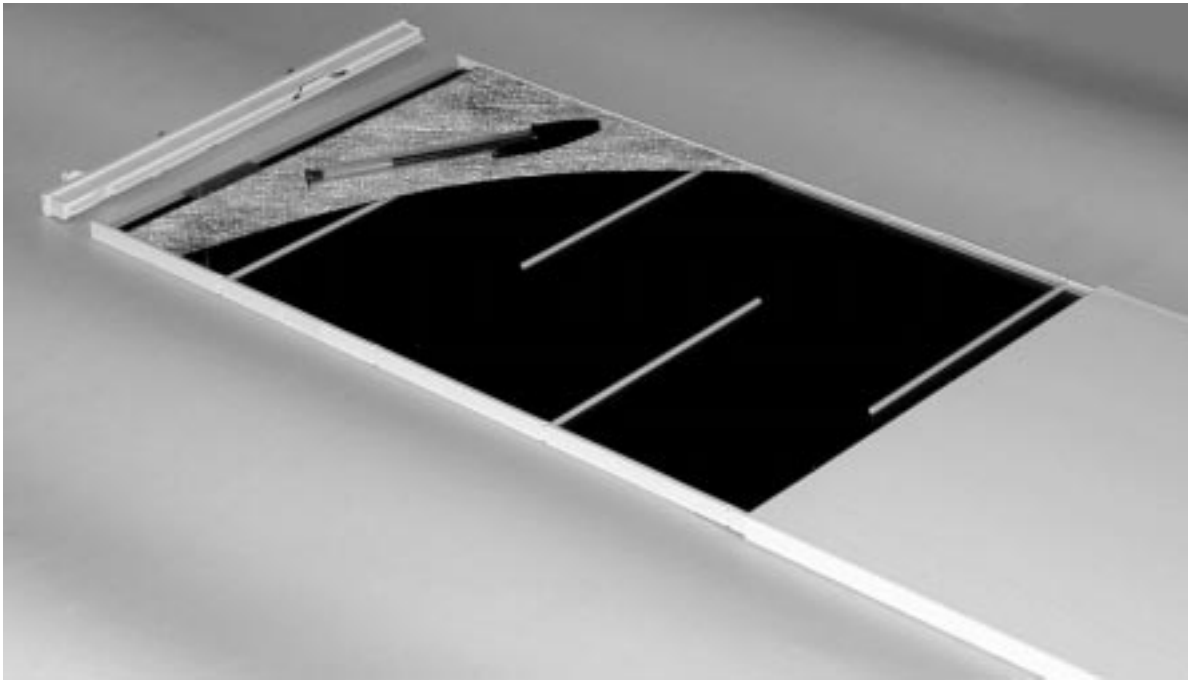


Figure 2: Picture of a Glass RPC.

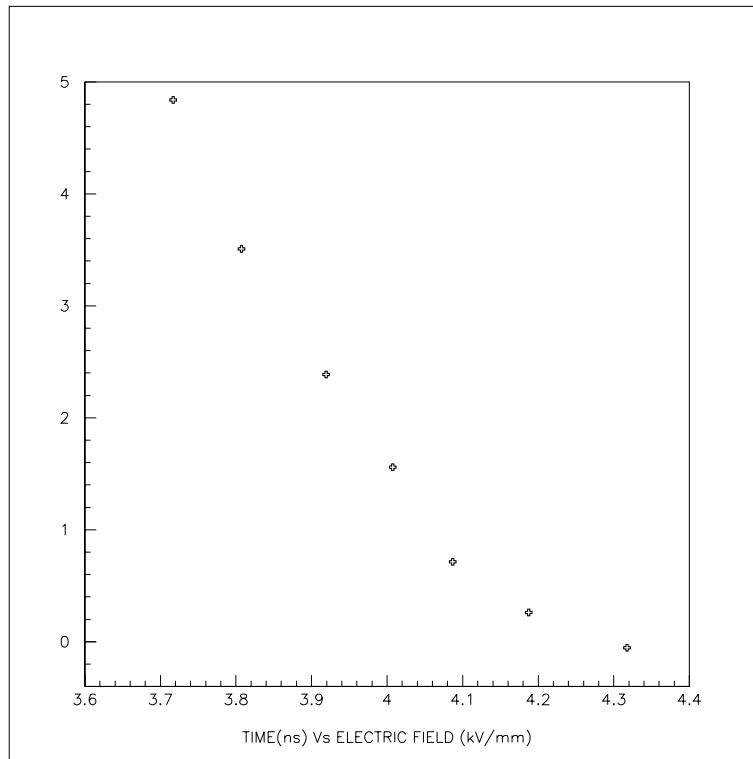


Figure 3: Time walk in the Glass RPC as a function of the electric field.

References

- [1] K.S Hirata et al, Phys Lett. B 205,416(1988). K.S Hirata et al, Phys Lett. B 280,146(1992). Y.Fukuda et al, Phys Lett. B 335,237(1994).
- [2] R.Becker-Szendy et al, Phys. Rev.D 46,3720(1992). R.Becker-Szendy et al, Phys. Rev. Lett. 69, 1010 (1992).
- [3] Y.Fukuda et al, Phys Lett. 81,1562-1567(1998).
- [4] M.Ambrosio et al.,INFN/AE-98/13,1998.
- [5] H.Gallagher et al,Proceedings of XIX Int.Conf on High Energy Physics, Vancouver, July 23-29,1998.
- [6] CERN 98-02 and CERN-SPSC 98-35 documents.
- [7] Proposal for a Long Baseline Neutrino Oscillation Experiment Using KEK-PS and Super-Kamiokande, KEK report E362, 1995.
- [8] J.Hylen et al, Conceptual Design for the Technical Components of the Neutrino Beam for the Main Injector (NuMi), FERMILAB-TM-2018, 1997.
- [9] M.Ambrosio et al, Measurement of Atmospheric Neutrino Oscillation with a High-Density Detector, CERN/SPSC/99-24 & M636, 1999.
- [10] R.Santonico and R.Cardarelli, Nucl. Instr. And Meth. 187 (1981) 377. R.Santonico and R.Cardarelli, Nucl. Instr. and Meth. A345 (1994) 20.
- [11] G.Bencivenni et al, Nucl. Instr. And Meth. A236 (1988) 456-460. N.Morgan, Proc. of RPC95, Pavia, 15 may 1996, 101, Ed. S.P.Ratti, M.Merlo.
- [12] G.Battistoni et al, Nucl. Instr. And Meth. 202 (1983) 459-464.
- [13] P.Vitulo et al., Proc. of RPC97, Napoli, 15 may 1998, 233, Ed. S.P.Ratti, R.de Asmundis.
- [14] G.E. Plastics S.p.A., Viale Brianza 181,I 20092 Cinisello Balsamo, Milano, Italy.
- [15] C.Gustavino et al., Proc. of RPC99, BARI, 28-29 october 1999, to be submitted to Nucl. Instr. and Meth.