

ISTITUTO NAZIONALE DI FISICA NUCLEARE

Sezione di Lecce

INFN/AE-90/19
3 Dicembre 1990

F. Grancagnolo:

THE RPC AS A MUON DETECTOR: THE E771 EXPERIENCE

Presented at the
*Symposium on Detector Research and Development for the
Superconducting Super Collider*
Fort Worth, Texas, October 15-18, 1990

THE RPC AS A MUON DETECTOR: THE E771 EXPERIENCE

Francesco Grancagnolo

Istituto Nazionale di Fisica Nucleare, Sezione di Lecce - Italy

ABSTRACT

The parameters of the Resistive Plate Counters (RPC) have been studied at FINAL during the setup phase of the experiment E771. Results on efficiency and time resolution are reported as a function of the incident rate of particle.

INTRODUCTION

The RPC [1] is a dc operated gas device working in limited streamer mode. The high field necessary for its operation (40 KV/cm) is generated by a thin layer of graphite (surface resistivity 10^5 Ohm/square) which coats the outside surfaces of two parallel plates made out of a phenolic polymer (2 mm thick bakelite) of high volume resistivity (10^{10} - 10^{12} Ohm \times cm).

When an ionizing particle crosses the thin (2 mm) gas gap between the two bakelite plates, the streamer, initiated by the liberated electrons, is quenched by the prompt switching off of the local field around the discharge point due to the high resistivity of the electrodes and by the action of the gas. The duration of the discharge is of the order of 20 nsec whereas the relaxation time of the bakelite electrodes is of the order of the product of the volume resistivity times the dielectric constant, i.e., 10 msec, thus ensuring, during the discharge, that the electrodes behave like insulators and the discharge is confined to a restricted area of the order of 10 mm^2 for a time of the order of 10 msec.

The high resistivity of the electrodes allows also to read out the generated pulse on external pick up electrodes. The spatial resolution of the device is dominated by the strip or pad size when read out in a digital mode.

The most interesting peculiarity of the RPC is due to the reduced size of the gas gap (2 mm) which allows for a very intense and uniform electric field. Under these conditions, the formation of the streamer occurs in a very short time and with minimal fluctuations. The time resolution one gets is of the order of 1 nsec or less and the time delay from the passage of a particle to the signal formation is of the order of 10 nsec making the RPC a suitable device for triggering purposes.

A further advantage of the RPC with respect to other devices is its economicity. The RPC are currently produced at a rate of about 30 m²/week in standard modules of 1×2 m² at a price of roughly 200 \$/m². Also, the cost of the front end electronics is greatly reduced because of the robustness of the read out signals, which are typically of the order of 100 pCoul per pulse, the duration of which is around 15-20 nsec.

The typical gas mixture used is 55% argon, 41% normal butane (for the absorption of the ultraviolet photons), 4% freon 13B1 (for the capture of peripheral electrons around the streamer in order to reduce the transversal size of the avalanche).

Figure 1 shows a sketch of the RPC stratigraphy.

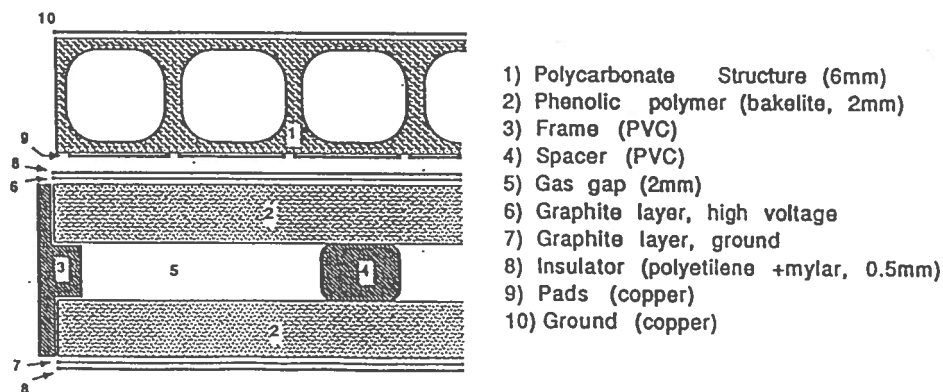


Figure 1. Sketch of RPC stratigraphy

COSMIC RAY TEST RESULTS

Figure 2 shows the efficiency plateau for a 12×12 cm² pad RPC measured with a scintillator telescope and cosmic rays. Full efficiency is not reached because of misalignment and of the dead area around the spacers.

To be noticed are the steep gain in efficiency, despite the relatively high threshold, and the stability of operation (length of the plateau well over 1500 V).

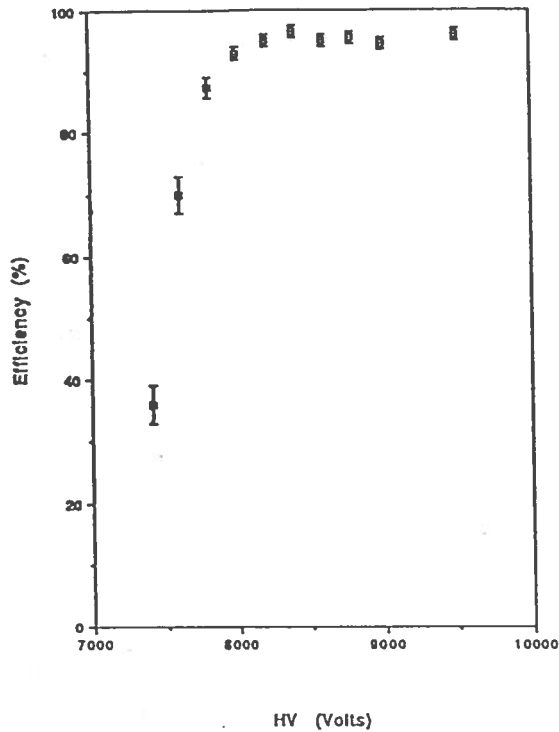


Figure 2. Efficiency plateau
Threshold = 90mV.

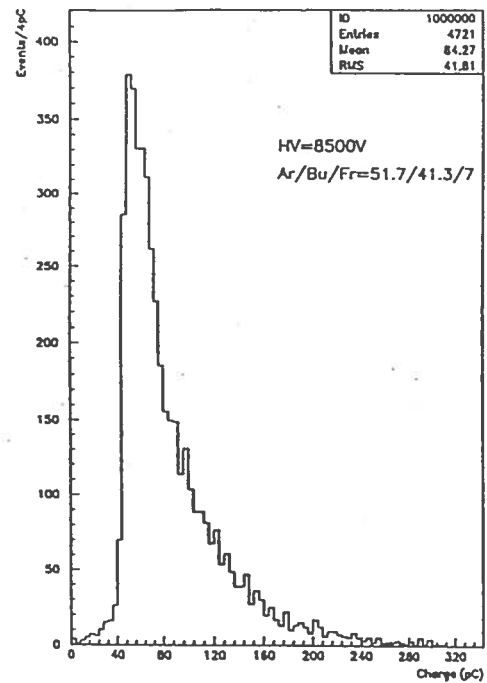


Figure 3. Charge distribution
 $12 \times 12 \text{ cm}^2$ pad.

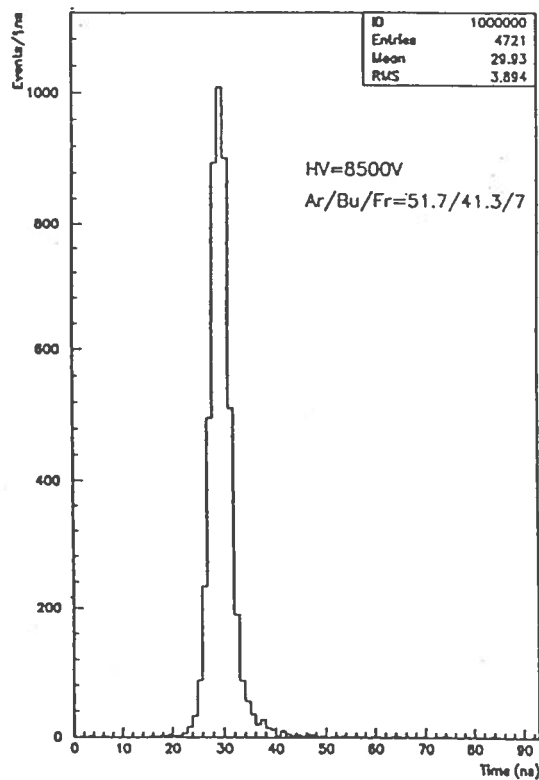


Figure 4. Time distribution. $12 \times 12 \text{ cm}^2$ pad

Figures 3 and 4 represent, respectively, the distribution of the charge collected on a $12 \times 12 \text{ cm}^2$ pad and the corresponding time distribution. The very little noise at low values of charge is associated with the long tail in the time distribution and can therefore be easily removed. The width of the charge distribution is typical of a streamer process (FWHM of about 40%). The time distribution is convoluted with the jitter of the scintillator telescope. By unfolding such a contribution one gets time resolutions whose behaviour with the high voltage is shown in Figure 5.

The behaviour of the RPC versus the gas composition, in particular versus the ratio of butane over argon and with different amount of freon, has been carefully studied as far as efficiency and resolution are concerned [2]. Detailed results will be reported in a forthcoming paper.

BEAM TEST RESULTS

The RPC are used as the active element in the muon detector of the experiment E771 at Fermilab [3]. During the setup phase of the experiment, last summer, the entire system of RPC (29 for a total of about 54 m^2) has been exposed to a proton beam of variable intensity. Results on efficiency and time resolution versus rate had already been reported [4] for a test beam at CERN. Figure 6 summarizes such results. In the hottest region, around the proton beam, and in the first of the three planes of RPC, even at the highest interaction rate (10^7 interaction/sec) at which the experiment E771 will be exposed, the rate of particles per unit area will not be larger than 50 Hz/cm^2 . At this rate and with the CERN setup (30 m long 50 Ohm cable before the discrimination of the signal at a threshold of 100 mV), the degradation of the efficiency is of the order of 2%.

Analogous results have been obtained at FNAL. Some recovery of the efficiency at high rate can be attempted by lowering the discriminator threshold and by acting simultaneously on the gas mixture and on the high voltage.

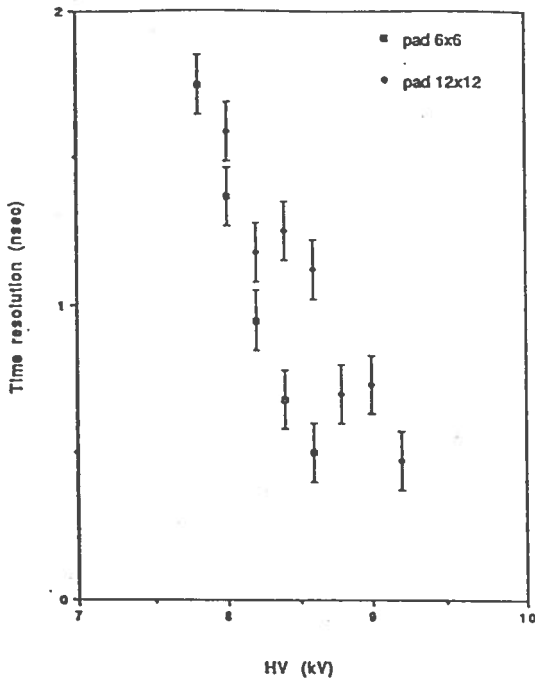


Figure 5. Time resolution vs. high voltage

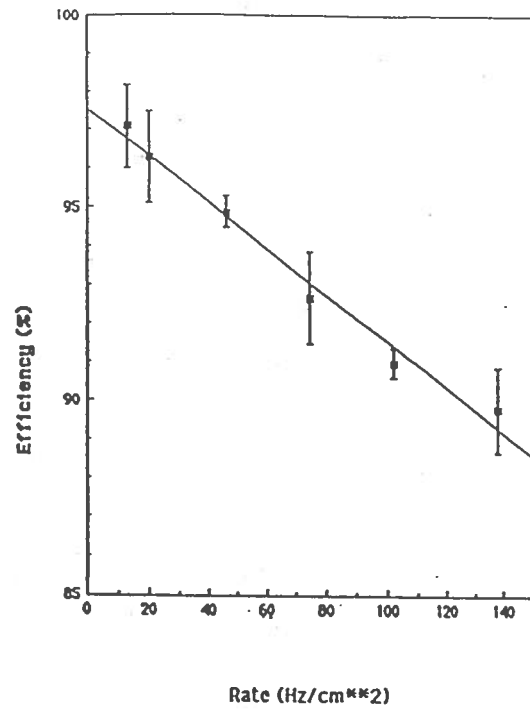


Figure 6. Degradation of efficiency with rate

REFERENCES

- [1] R. Santonico and R. Cardarelli, NIM 187 (1981) 377 R. Cardarelli et al., NIM A263 (1988) 20.
- [2] F. Grancagnolo, "The RPC System of the Experiment E771, Cosmic Ray Test Results." Presented at the 4th Topical Seminar on Experimental Apparatus for High Energy Particle Physics and Astrophysics, San Miniato, Tuscany, Italy, 28 May-1 June, 1990.
E. Gorini, "The RPC Muon System of E771," presented at the 2nd International Conference on Advanced Technology and Particle Physics, Como, Italy, 11-15 June 1990.
- [3] B. Cox et al., "Experiment E771: An Experiment to Study Beauty Production and Other Heavy Quark Physics Associated with Dimuon Production in 800 (925) GeV/c pp Interactions," Fermilab, P771, May 1986.
F. Grancagnolo, "Studies of B-Physics with FNAL E771", in Proceedings of the XXV Rencontre de Moriond, "High Energy Hadronic Interactions", Les Arcs, Savoie, France, March 11-17, 1990 and INFN-AE/90-07, 10 luglio 1990.
- [4] M. Bertino et al., NIM A283 (1989) 654.