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THE RPC SYSTEM OF E771, COSMIC RAYS TEST RESULTS

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ABSTRACT

The fixed target experiment E771 at FNAL is aimed at the study of beauty hadroproduction and decay. Essential component of the spectrometer is the muon detector which is made of Resistive Plate counters (RPC). Results on efficiency and time resolution of the RPC are reported for a set of data collected during the set up phase of the experiment.

1. INTRODUCTION

Experiment E771 at FNAL is aimed at the study of beauty hadroproduction and decay[1].

Using the Tevatron primary proton beam impinging on a 2cm Si target at a rate of 10^7 interactions/sec, one can get up to 8 BB/sec or, equivalently, of the order of 150 million beauty mesons per year[2].

We have chosen[3] to trigger on dimuons produced according to the decay chain $B \rightarrow J/\Psi \rightarrow \mu\mu$. The observation of a J/Ψ from a secondary vertex, in fact, unambiguously insures that the event contains a BB pair, rejecting almost all potential backgrounds.

A fast and efficient way of selecting high mass dimuons is to require two muons in the RPC muon detector and to require that at least one of them has a large p_t. Such a trigger contains a single muon trigger as a natural component and, therefore, allows us to trigger also on the semimuonic decays of the B's with the possibility of enriching the sample and having a way to "tag" the other B decay.

Essential component of the spectrometer (see Fig. 1), because it enters in the definition of all levels of the trigger, is the muon detector which is made of a novel[4] type of devices: the Resistive Plate Counters (RPC).

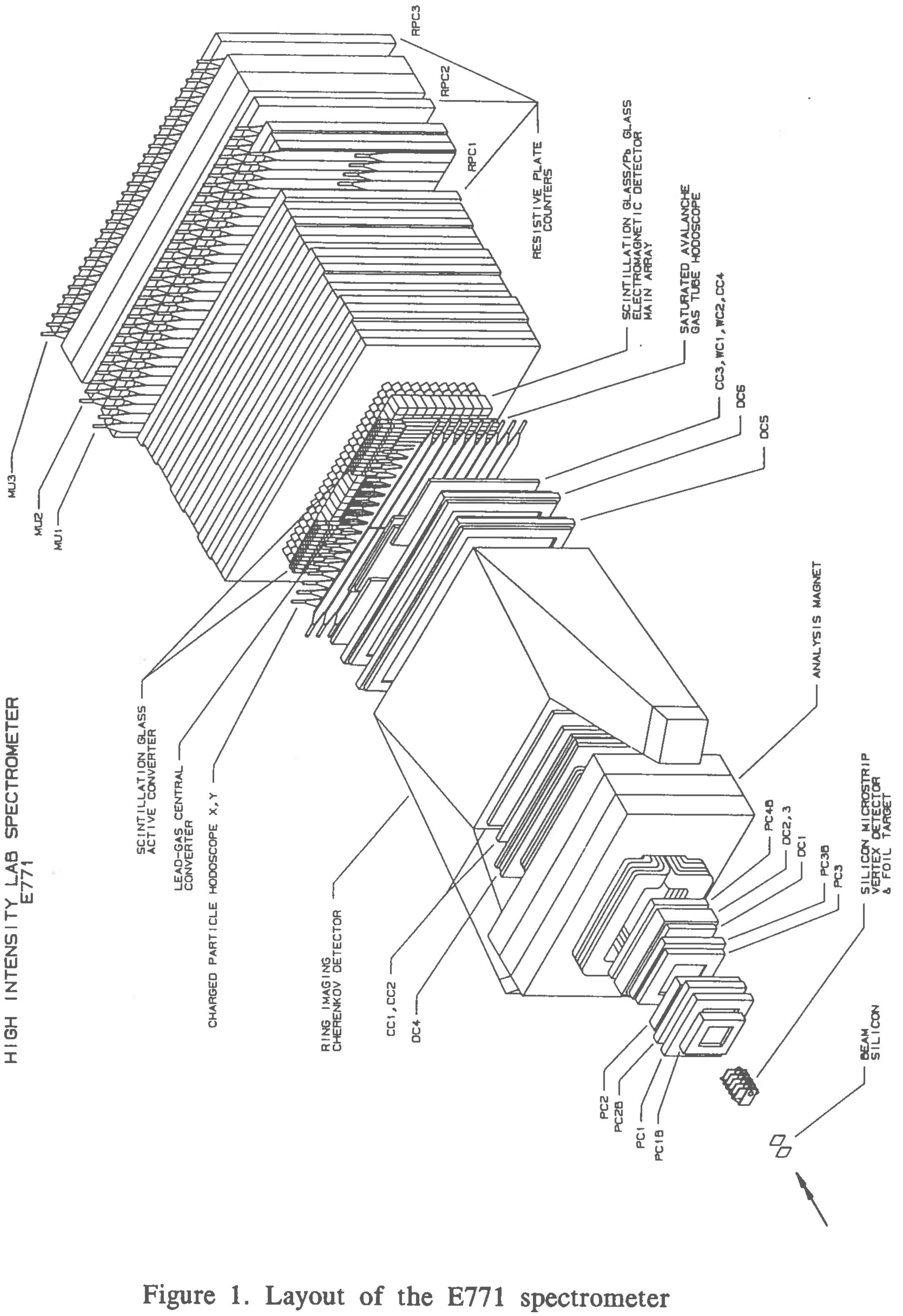

Figure 1. Layout of the E771 spectrometer

2. RESISTIVE PLATE COUNTERS

The RPC 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) wich 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 m^2/week in standard modules of 1×2 m^2 at a price of roughly 200 \$/m^2. 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 2 shows a sketch of the RPC stratigraphy.

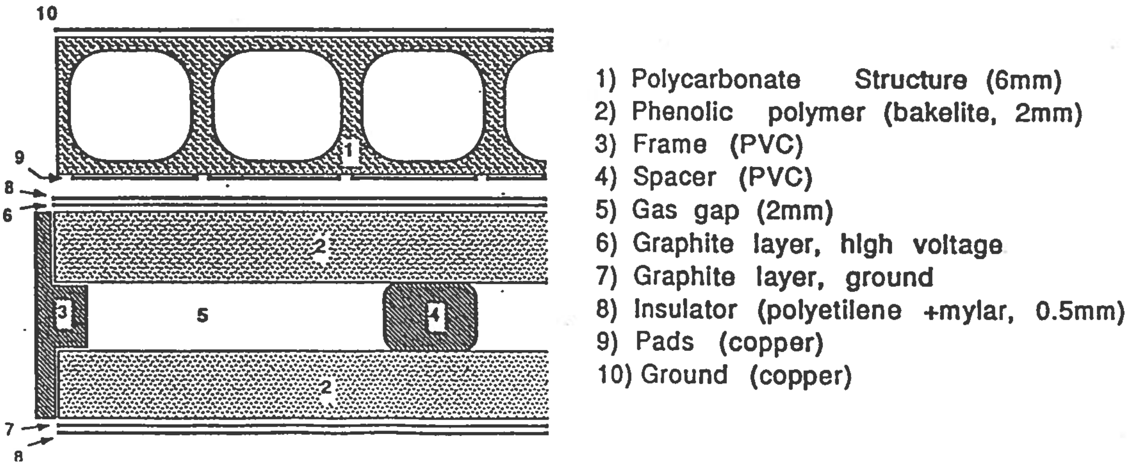

Figure 2. Sketch of RPC stratigraphy

3. THE MUON DETECTOR

The muon detector consists of three planes of RPC modules embedded in the hadron absorber at the downstream end of the E771 Spectrometer (see Fig. 1). Ten RPC modules (standard size: 2×1 m^2) are assembled together as in Fig. 3 to form a detector plane. Slight overlap of the modules is necessary to account for the dead area around the perimeter of the detector.

The presence of the beam dump in the first two absorber gaps has forced the construction of non standard, L-shaped modules to cover the entire surface.

The inset in Fig. 3 shows the pad configuration for the signal pick up.

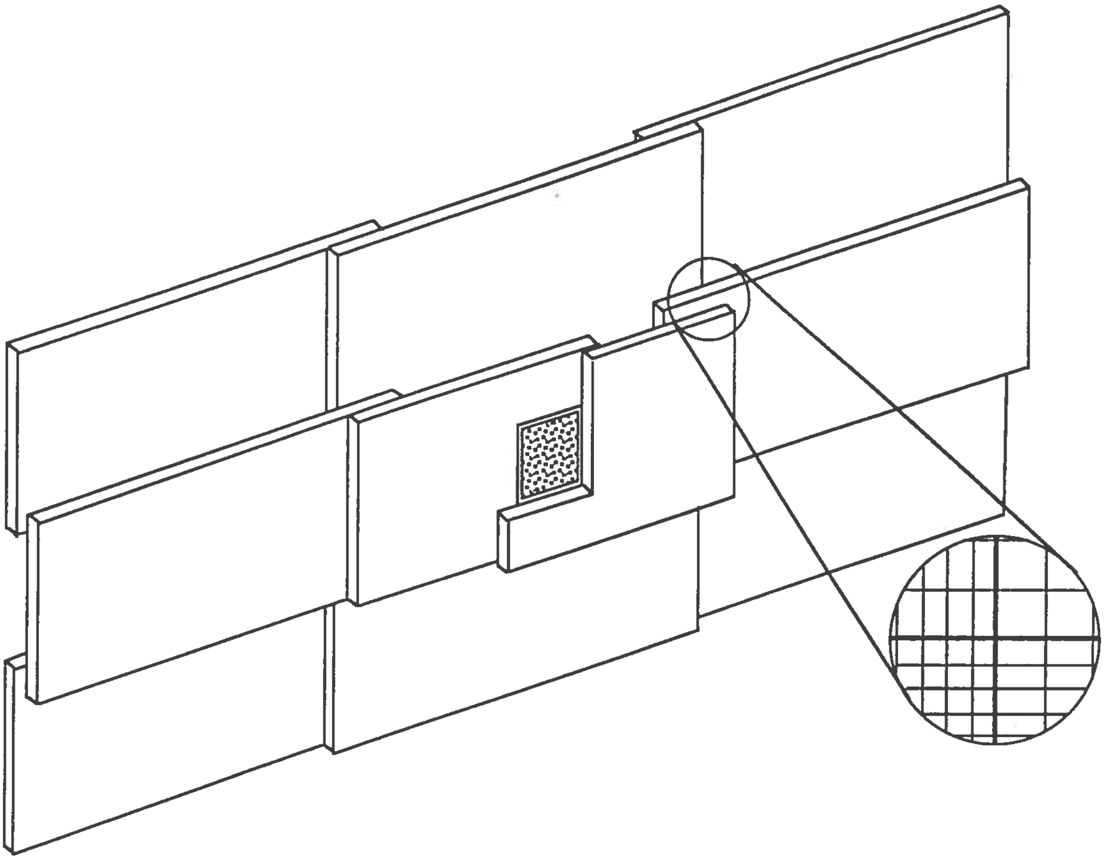

Fig. 3. Muon detector plane and pad configuration

4. COSMIC RAY TEST RESULTS

Figure 4 shows the efficiency plateau for a 12×12 cm^2 pad RPC measured with a scintillator telescope and cosmic rays. Full efficiency is not reached because of misalingnment 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).

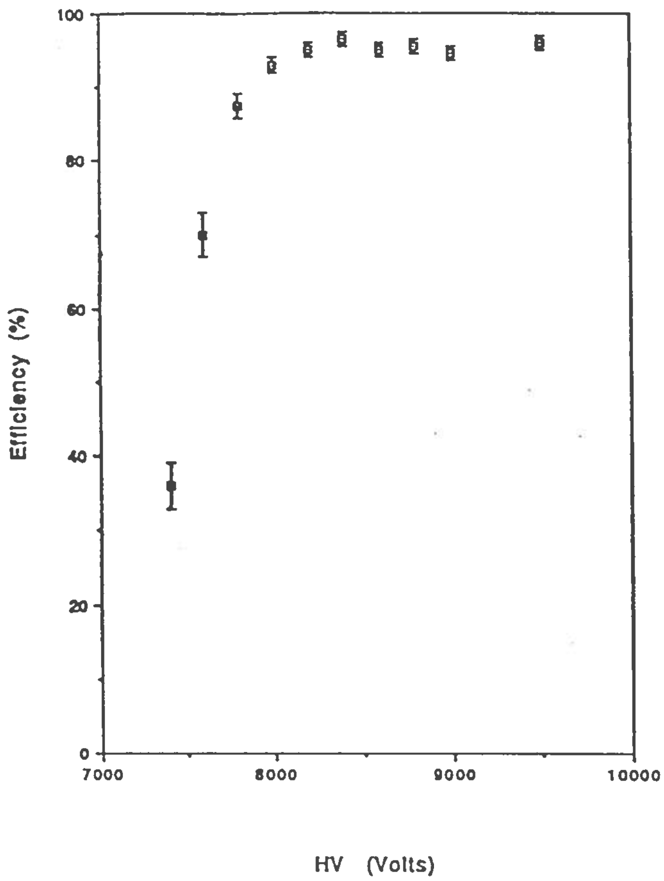

Figure 4. Efficiency plateau. Threshold=90mV.

Figures 5 and 6 represent, respectively, the distribution of the charge collected on a 12×12 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 7.

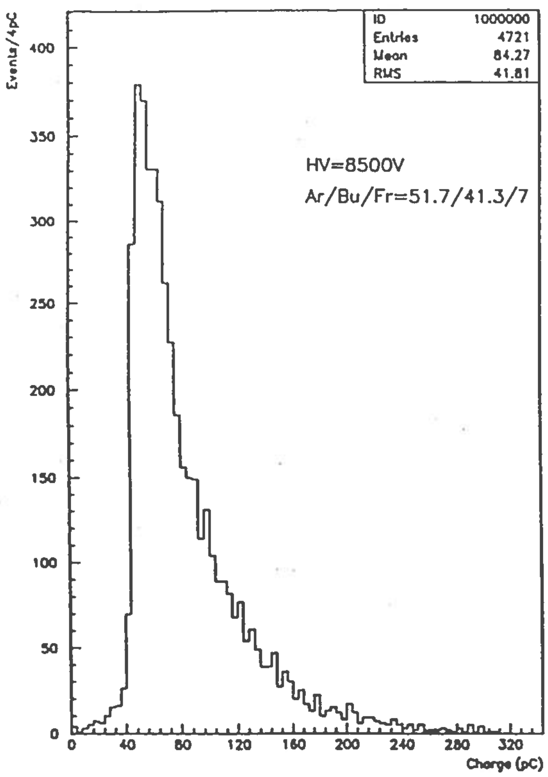

Figure 5. Charge distribution $12 \times 12\ cm^2$ pad

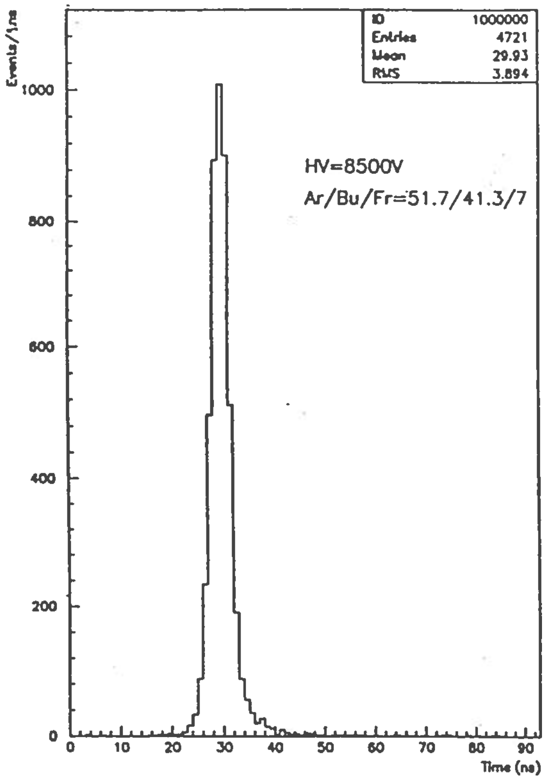

Figure 6. Time distribution $12 \times 12\ cm^2$ pad

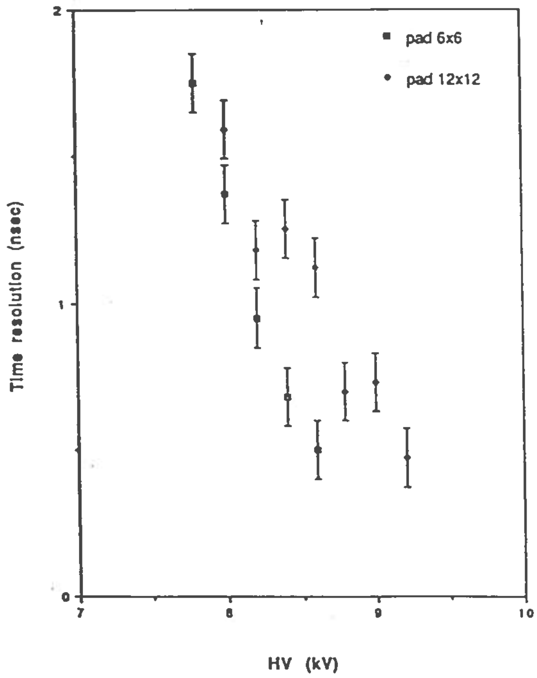

Figure 7. Time resolution vs. high voltage

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 studies as far as efficiency and resolution are concerned[5]. Detailed results will be reported in a forthcoming paper.

6. BEAM TEST RESULTS

The RPC are used as the active element in the muon detector of the experiment E771 at Fermilab. 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[6] for a test beam at CERN. Figure 8 summarizes such results. In the hottest region, aound the proton beam, and in the first of the three planes of RPC, even at the higest 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.

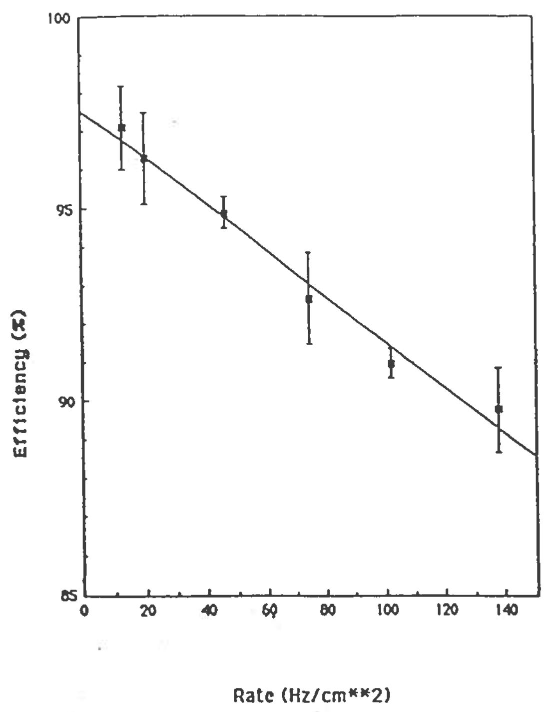

Figure 8. Degradation of efficiency with rate

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