The R&D Program for RPC *CAPIRE*

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The results obtained by the R&D program CAPIRE, an effort study the operational characteristics of Resistive Plate Chambers are described. Such devices could be utilized as active detectors both for the hadronic calorimeter and the muon identifier of a general purpose experimental apparatus.

1. RPC IN HADRONIC CALORIMETRY AND MUON IDENTIFICATION

In a general purpose detector, hadronic calorimetry and muon identification both require a device capable to detect efficiently minimum ionizing particles, over large areas ($\approx 10,000\text{m}^2$).[1] An obvious candidate for this purpose is the Resistive (parallel) Plate Chamber (RPC), with its robustness, ease of construction and low cost. Other features, like the good timing capabilities and large pulse height (if used in streamer mode) make it a very appropriate choice to be used in the outside part of any general purpose (Linear Collider) Detector. Requirements that Physics would impose are relatively light and could be reasonably fulfilled by detectors that can be built today. The extremely high granularity required by the particle flow method, advocated in many designs, [1] could be achieved in a natural way, should one use resistive glass as electrode material and the silk printing technique to draw on the electrodes themselves (pads and/or strips). The expected hit density, at least in the barrel region, is quite low and the needed local rate capability is essentially set by the used granularity ($\approx 1/\ \text{cm}^2$) for the hadronic calorimeter; for the muon detector it is even lower and would not pose any problem whatsoever. The operational details for RPC, including long term reliability have been studied extensively by the "CAPIRE" collaboration: here I will report the results obtained with small ($\approx 25 \times 25\text{cm}^2$) chambers exposed to the Beam Test Facility (BTF) [2] in Frascati. A direct measurement of the recovery time, and thus of the local rate capability, can be obtained from the data, given the peculiarity of the beams used.

2. EXPERIMENTAL SETUP

The setup used for the measurement described consisted of seven glass RPCs 25×25 cm^2; the active area was 20×20 cm^2. Four chamber had 3 mm thick electrodes with $\rho = 1 \times 10^{13}\Omega \times$ cm; the other three had 2 mm thick electrodes with $\rho = 4 \times 10^{12}\Omega \times$ cm. Each chamber was equipped with two layers of strips (horizontal and vertical), so that the beam impact point could be determined at each detector. The strip size was $\approx$ 8mm, hence, the overall spatial resolution was 2.5 mm. Both single threshold strip response and total pulse height over the individual chambers'

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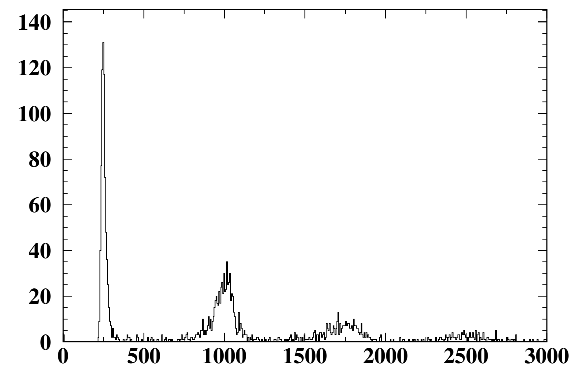

Figure 1: Calorimeter response in ADC channels: clear peaks at 0,1,2 and 3 particles can be seen.

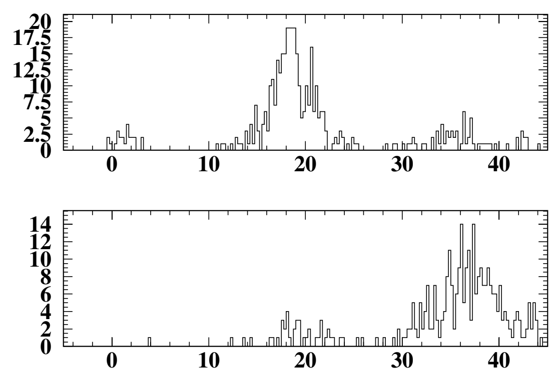

Figure 2: Amplitude response of Ch #5 (2 mm. thick electrodes) to one (upper) and two (lower) particles. The horizontal scale is in pCoul. The gas mix used is: Ar. 14.4% Fr. (134a) 80.8% Isob. 4.5% SF_6 0.5%. The operational regime is a *low charge limited streamer*

active area were recorded on a minimum bias trigger (the RF driver of the BTF linac). The DAQ also recorded the pulse height of a beam defining counter and of a crystal (CsI) calorimeter whose signal was used to count the total number of electrons impinging on the setup. In Fig. 1 a typical plot of the crystal calorimeter's total reconstructed energy can be seen with its discriminating power on electron/bucket counting.

By varying the BTF Linac repetition frequency and by selecting events in which one or more particles were impinging on the detectors, one could measure the efficiency to detect minimum ionizing particles in a very wide range of local crowding; furthermore, as the beam spot can be tuned in size between 0.2 and 2.0 cm. the spatial response of the detectors can be also studied in detail.

3. MEASUREMENTS

Measurements were carried out in different operating conditions spanning different operating voltages and different gas mixtures: both limited streamer and avalanche regimes were explored. As an example, Fig. 2 shows the response of the one of RPC with 2 mm. thick electrodes selecting either one or two particles impinging on the chamber.

A typical plateau curve for the same gas can be seen in Fig. 3

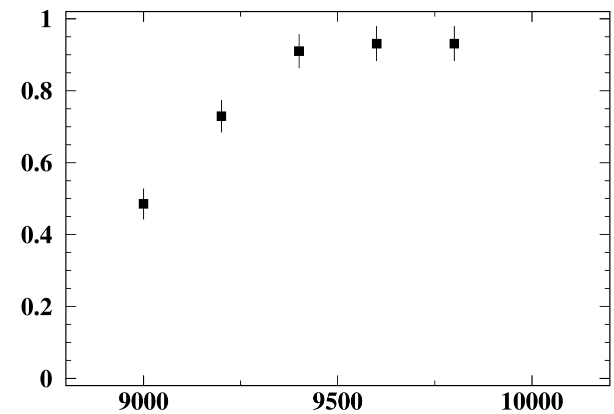

Figure 3: **Streamer** plateau curve for Chamber 4 (2 mm. thick electrodes) The gas mix used is: Ar. 14.4% Fr. (134a) 80.8% Isob. 4.5% SF_6 0.5%. It is worth noticing that the overall efficiency of the counter is very close to one: when the curve flattens out, $\approx$ 6% of the trigger result in an avalanche pulses (roughly 20 times smaller than the streamers' in charge).

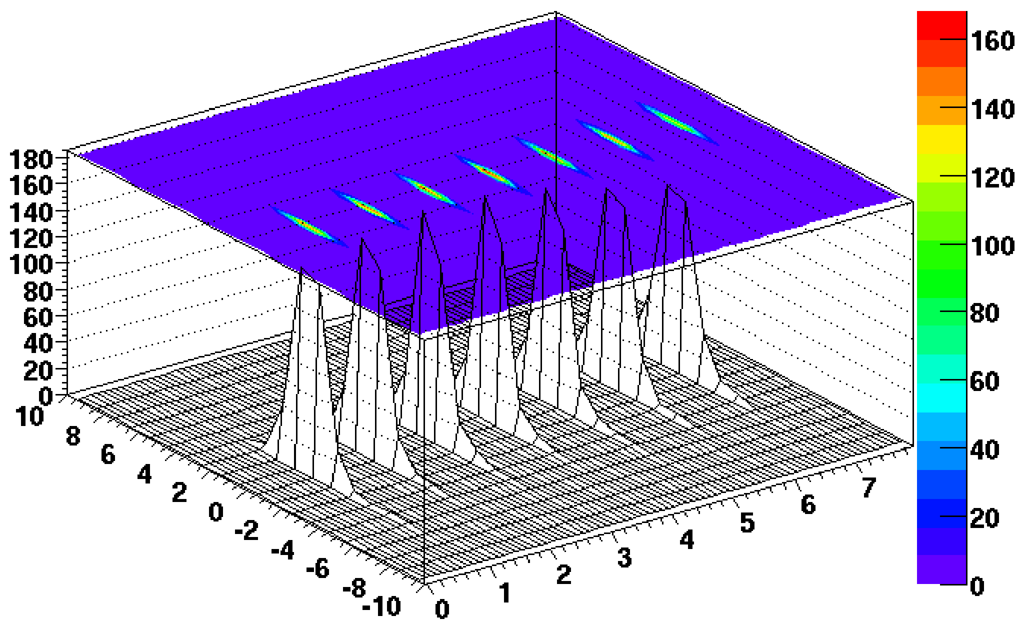

Figure 4: The radial distribution of hits in the seven RPC under test: the average electron multiplicity was 0.5 and the magnetic focusing of the beam was off, so that the expected beam spot extension was abut 2.0 cm.

As mentioned before different gas mixtures were tested: both low charge streamer and avalanche mode were used in order to find differences between the two. The local rate capability was measured changing the Linac repetition rate and the beam dimensions. All the results reported here, refer to events in which a single minimum ionizing electron was impinging on the RPCs under test. The analysis for events in which multiple particles cross the chambers is in progress. In Fig. 4 the radial distribution of the beam is shown, as seen by the chambers under test.

A typical behavior of the efficiency vs the local particle flux, with a low charge streamer mix can be seen in Fig.

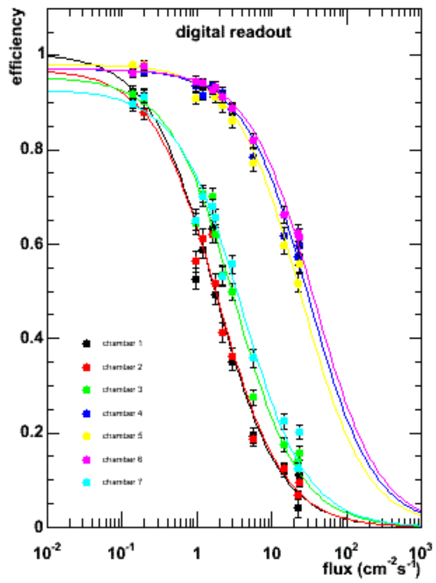

Figure 5: Efficiency vs local rate for the seven chambers under test: the difference between the 3 mm. (1,2,3 and 7) thick electrodes and the 2 mm. (4, 5 and 6) thick electrodes is clear. Data are based on events with one single particle hitting the chambers. The mix is the one mentioned in Fig. 2

5. The first order calculation based on the glass recovery time, which in turn, depends on the resistivity and the dielectric constant is also shown. The difference between the detectors with 3 mm and 2 mm thick electrodes is evident.

4. CONCLUSIONS AND OUTLOOK

RPCs are good candidates to be the active device of choice, both for hadronic calorimetry and muon identification in a general purpose detector for the Linear Collider. R&D on the operational details and the long term reliability of the detectors are going on at different Laboratories: as of now, results indicate that glass RPCs would perform well in the two detector areas mentioned above. However R&D programs will continue especially to check the long term reliability of these detectors. Physics Programs, like the International Linear Collider, will require operating periods of the order of tens of years and, the idea of replacing the calorimeter active detectors doesn't look appealing at all.

References

[1] G. Alexander *et al.* " TESLA technical design report, Part IV , A detector for TESLA",T, Behnke ,S. Bertolucci, R.D. Heuer, R. Settles editors, Desy-01-11

[2] G. Mazzitelli *et al.* " Commissioning the DAFNE beam test Facility" NIAM A **515** 2003.