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BEAM TESTS WITH MICROSTRIP GAS COUNTERS

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Abstract

We have measured the efficiency, timing and pulse heights in several types of microstrip Gas Chambers with plastic substrates passivated with a thin Nickel layer. We used as active gas mixtures Argon/Isobutane and CF_4/Isobutane. We placed the detectors in a secondary beam at TRIUMF tuned to a momentum of 100 MeV/c of pions, muons and electrons. Preliminary results indicate good efficiency for minimum ionizing particles in Argon/Isobutane mixtures but lesser efficiency in CF_4 based gases indicating the importance of high quality preamplifiers to in- crease the signal to noise ratio.

I. Introduction

Since their inception [1] Microstrip gas chambers (MSGC) have shown excellent potential as tracking detectors in high flux experiments [2,3]. Many different substrates, gases and geometries have been tested [4]. The detectors have also been used at least in one experiment [5].

Recently we have tested prints with plastic substrates where the required resistivity to remove charges was obtained by means of a passivating coating of Ni and NiO (see Refs. [6,7]). In this paper we would like to report on beam measurements with such substrates. Similar tests will also be reported by Dixit *et al.* at this workshop.

The main advantage of plastic substrates is the low Z and low density of the material in the beam [8-12], thereby reducing significantly the multiple scattering of the detected particles. Plastics have the added benefit of allowing for curved surfaces. The difficulty encountered originally of modifying the substrate resistivities was solved by the Ni passivation process mentioned above.

Several parameters are important if these detectors are to be used in large experiments in the future. One of them is the efficiency [5,13-16] and the measurements described in the next section focus on this parameter. Another important variable is the timing capability of MSGC's as there will be a requirement for pulse bucket identification in large experiments. Previous experiments [5,6] have shown that for drift distances of about 3 mm one could expect 15 to 40 ns FWHM although much better values were obtained at low pressure and secondary emission devices [17,18] but at the cost of lower efficiency.

II. Experimental Set-up

The M13 beam at TRIUMF is a secondary channel that collects pions, muons and electrons from a 1 cm graphite target and momentum selects them with two dipoles and seven quadrupole magnets. Its total length from production to focal point is 11 meters. We operated the channel at 100 MeV/c momentum with a large aperture and positive polarity. The total rate at this momentum was 10^5 particles/sec of which approximately 70% were pions, 30% positrons with a very small number of muons.

Four MSGC's were mounted on a table (Fig. 1) in the beam, and three scintillators in front and behind were inserted and used to define the particles traversing the detectors. The coincidence signals of these scintillators were also used as trigger signals and defined the timing of the events.

The argon/isobutane (90:10) gas mixture supplied to the chambers had a flow of 100 cc/min and was subsequently vented. The purity of the argon was 99.9% and the isobutane 99.5%. The oxygen level was monitored to be less than 15 ppm. The CF_4/isobutane (80:20) mixture was recirculated at a flow of 100 cc/min and 7% was vented. During recycling the mixture was filtered with an R3-11 activated copper (BASF) and with a 3 angstrom molecular sieve. The purity of the CF_4 was 99.95%. The mixture was controlled by a mass flow controller.

Three different types of prints were used: a pyrex glass substrate with aluminum traces and 390 microns pitch, a Upilex [19] substrate with gold traces and 400 microns

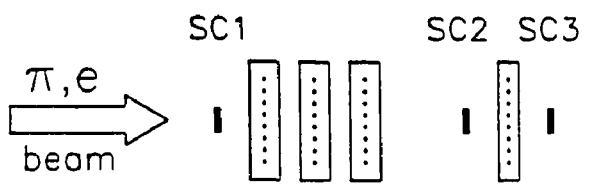

Fig. 1. The experimental geometry. The boxes represent MSGC's and the SCi's are scintillators.

pitch and an Upilex substrate with 500 microns pitch. The first one was manufactured at the Simon Fraser University Microelectronics Department and the two last ones at PPM (Montreal). The last one, with an area of 5 × 8 cm^2 will be used in Expt. 885 at Brookhaven. All three types of prints were passivated with a coating of Ni and NiO (see Ref. [6,7]). The drift gap was 3 mm and the drift voltage was 1500 V.

Two types of preamplifiers have been used. One with 40 ns and another with 100 ns shaping time. The second one, with a 40 times higher gain, performed better. Signals from these preamps were shaped and sent to LeCroy 2249A Camac ADC's gated with the coincidence of the scintillators in the beam; the data were recorded on video cassettes event by event. A TDC in the Camac crate was used as well. The start signal was provided by the scintillator coincidence and a stop signal provided by the RF signal of the Cyclotron. This signal is synchronous with the primary proton beam, thereby allowing a time measurement of the secondary particles. This in turn was used to separate the positrons from the pions in the beam. The positrons were minimum ionizing and the pions were not.

The data were recorded on video tapes and analyzed online by means of a microvax computer. For off-line analysis we replayed the tapes and used a VAX computer. The data analysis presented here is preliminary and further work is presently ongoing.

III. Results

The pulse amplitude spectra as digitized by the ADC's is shown in Fig. 2 in which one can see the pion and positrons peaks. In order to separate and analyze them independently we used the time of flight as described above. In Fig. 3 we show the timing peaks of positrons and pions.

The efficiency measurements were performed by taking the ratio of events in a set of anodes to the number of trigger signals as defined by two small scintillators (5 mm × 5 mm) each placed in front and behind the MSGC and shown in Fig. 1. The results obtained as a function of the anode-cathode voltage are shown in Fig. 4. We obtained 98% efficiency for pions and 93% for positrons. In some instances (where we used the faster preamplifier or for anode traces of poor quality) we couldn't obtain 100% efficiency as shown in Fig. 5.

All the measurements quoted above were performed with Argon/Isobutane (90:10) gas, but we also used CF_4/Isobutane for which the primary charges collected were less (about 30%). In this case we obtained only 50% efficiency as the signals were comparable to the preamplifier noise. We expect that this could be improved with better quality preamplifiers.

The anode signals were also fed to constant fraction discriminators and these timing signals recorded in LeCroy 2228 TDC's. In this fashion we determined the relative

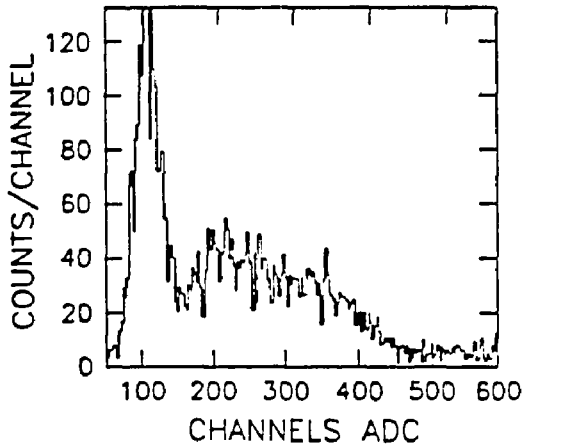

Fig. 2. An amplitude spectrum of a single anode of the MSGC as recorded by an ADC.

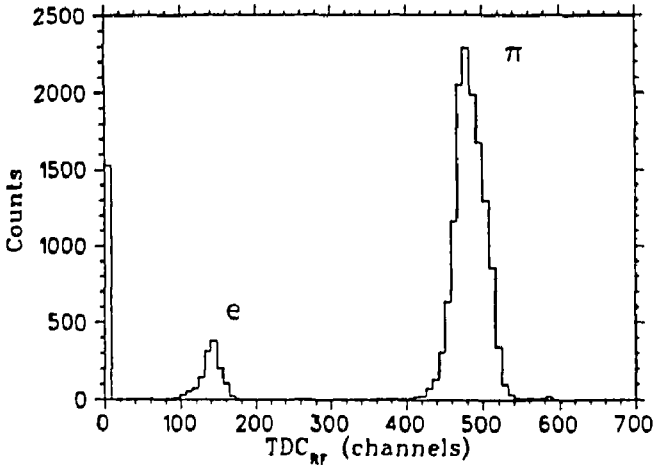

Fig. 3. A TDC spectrum of events showing the arrival time difference between pions and positrons.

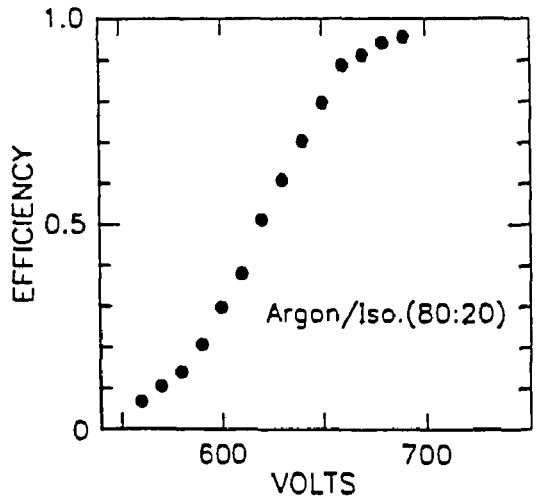

Fig. 4. The efficiency for positrons versus the anode-cathode voltage difference in the smaller Upilex prints.

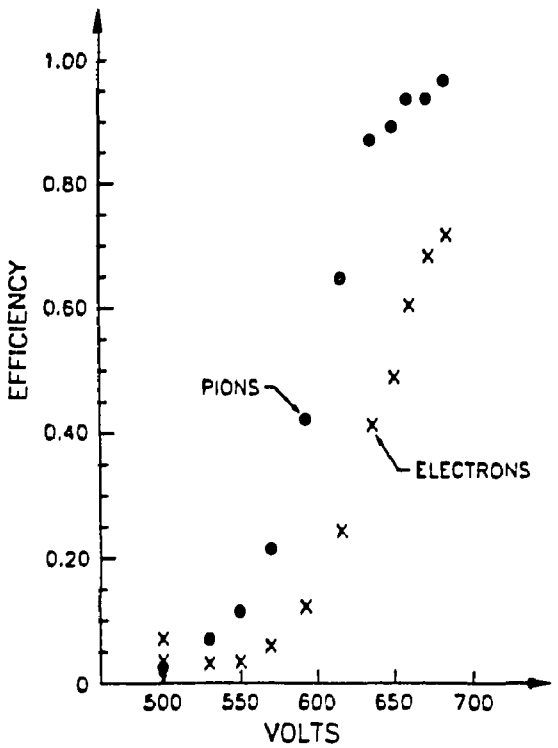

Fig. 5. The efficiency for pions and positrons.

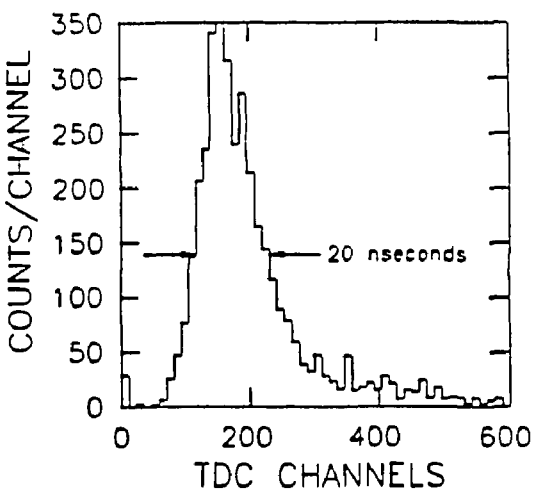

Fig. 6. The time spectrum for the MSGC signals respect to the scintillators.

timing of the MSGC's with respect to the trigger scintillators. In Fig. 6 we show one such spectrum with a 20 ns FWHM resolution. The distribution is not gaussian because of the drift of primary charges to the print.

IV. Conclusions

The efficiency obtained for minimum ionizing particles (positrons) was ≈100% for Argon based gas mixtures but not for CF_4 mixtures. This was achieved with a drift gap of 3 mm. For larger gaps one could use other gases without a loss in efficiency.

In order to achieve close to 100% efficiency it is important to use appropriate preamplifiers. Shaping times of about 50 to 100 ns are required. The noise introduced should be less than 10^3 electrons rms. All of the above is needed because of the restricted gain that can be obtained with MSGC's.

In prints of very high resistivity (larger than 10^{14} ohms/square) we noticed instabilities due to charge-up effects related to the beam. These were charges generated by the beam through secondary electron emission. This effect should put an upper limit on the substrate resistivity.

The timing obtained was not very good; a better alternative would be a CF_4 gas mixture as it is a faster gas [20] but would require better preamplifiers.

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