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Letter to the Editor

Technique for the characterization of discharges in micro-strip gas chambers

R. Bellazzini[a,b,*], A. Brez[a], L. Latronico[a], N. Lumb[a], G. Spandre[a], M. Bozzo[c], A. Cattai[c], A. Tsirou[c]

[a] INFN, Sezione di Pisa, Via Livornese, 1291, 56010 S. Piero a Grado, Pisa, Italy
[b] University of Pisa, Pisa, Italy
[c] CERN, Geneva, Switzerland

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Abstract

A method is described for the characterization and counting of discharges in MSGCs. It is shown that the technique is sensitive enough to detect the micro-discharges which occur prior to full sparking, with a detection efficiency of 0.8. Some example results are presented, showing the variation of micro-discharge rate with gain.

1. Introduction

The Micro-Strip Gas Chamber (MSGC) [1] is a gas-filled proportional counter capable of high counting rates, with high granularity and excellent spatial resolution. These favourable properties have led to the inclusion of MSGCs in the central tracker of the CMS experiment at LHC [2]. The tracker will incorporate over 10^7 MSGC channels; the need to keep sparking rates to an absolute minimum is clear, particularly for the detection of heavily ionizing particles. We describe a method for characterizing electrical discharges in MSGCs, and for determining the rate of these discharges as a function of gain in the regime preceding full sparking. Some example results displaying the features of the technique are presented.

2. RC model of an MSGC

The RC equivalent circuit for an MSGC containing four groups of 16 anode strips is shown in Fig. 1. For the MSGCs used in this work, the capacitance of a group was 16 pF, and each cathode group was connected in series with a 100 kΩ resistor. The anodes were connected to ground and all the cathode groups were connected to the HV supply via a 1 MΩ protection resistor.

A micro-discharge or spark between an anode and cathode may be modelled by an internal discharge of the group capacitor, resulting in a drop in voltage across that circuit element. The charge to restore the voltage on the capacitor is drawn ultimately from the HV supply, but this is a relatively slow process as the current must flow through the 1 MΩ resistor. Much faster is the rearrangement of charge which takes place between the four capacitors. Here the current is only limited by 100 kΩ resistances, and the corresponding time constant is 1.6 μs, compared with 64 μs for the HV supply.

3. Measurement technique

The anodes of the monitored groups are short circuited and connected in series with a pico-ammeter (Keithley 487), which fills a buffer with 512 readings and determines the maximum and minimum values. The pico-ammeter is monitored using the Labview data acquisition system (Version 3.1) that reads the maximum current value of the buffer. If the reading is over the threshold, the program counts one micro-discharge and begins a further 512 acquisitions; if not it starts another acquisition series without incrementing the counter. The sequence is repeated until the required number of readings have been made. Reading only the maximum current value of the buffer reduces dead time and the time to

*Correspondence address: INFN, Sezione di Pisa, Via Livornese, 1291, 56010 S. Piero a Grado, Pisa, Italy. Tel.: +39 50 880 111, fax: +39 50 880317

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process a single buffer is 12.9 s; this processing rate is sufficient to cope with the maximum rate of discharges expected in the future tests. The integration time of our pico-ammeter is 20 ms, and the charge of the recharging pulse (with time constant 64 μs) is spread over this window, resulting in a very low mean current. Typically we see values of 50 nA, corresponding to a charge of 1 nC from the HV supply. Comparison of this value with the 10 nC charge stored on a group at an operating voltage of 600 V, shows that the initial drop in voltage is about 10%. We therefore do not see the complete discharge of the group capacitance associated with sparking, but rather partial discharges, precursors to sparks, which are quenched by the voltage drop. Fig. 2 shows a typical micro-discharge event as displayed on the instrument panel on the computer.

The micro-discharge detection efficiency was measured by sending standard NIM pulses from a timing unit to the pico-ammeter through a 13 kΩ resistor, out of phase with the pico-ammeter buffer acquisitions. The interval between pulses was set at 16 s, in order to ensure that not more than one pulse was sent per buffer acquisition. The pulse length was chosen such that the charge injected was comparable with that expected from a micro-discharge. A total of 483 pulses were sent to the pico-ammeter, of which Labview registered 389 above threshold; the efficiency was therefore 0.80 ± 0.02. In general, the detection efficiency for random events is less than this as the probability of obtaining more than one pulse above threshold in a single buffer is then always non-zero. However, for the maximum discharge rate of interest (less than one/h, say, compared with the buffer processing time of 12.9 s)

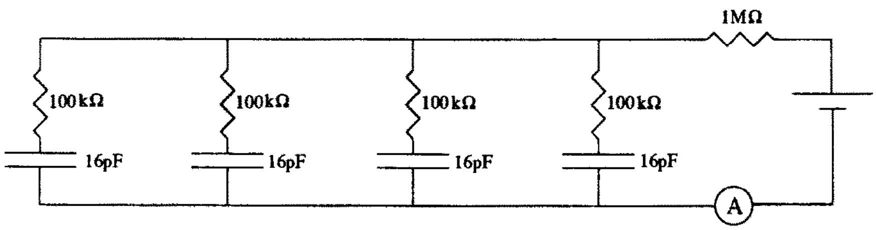

Fig. 1. Electrical model of MSGCs used in the tests.

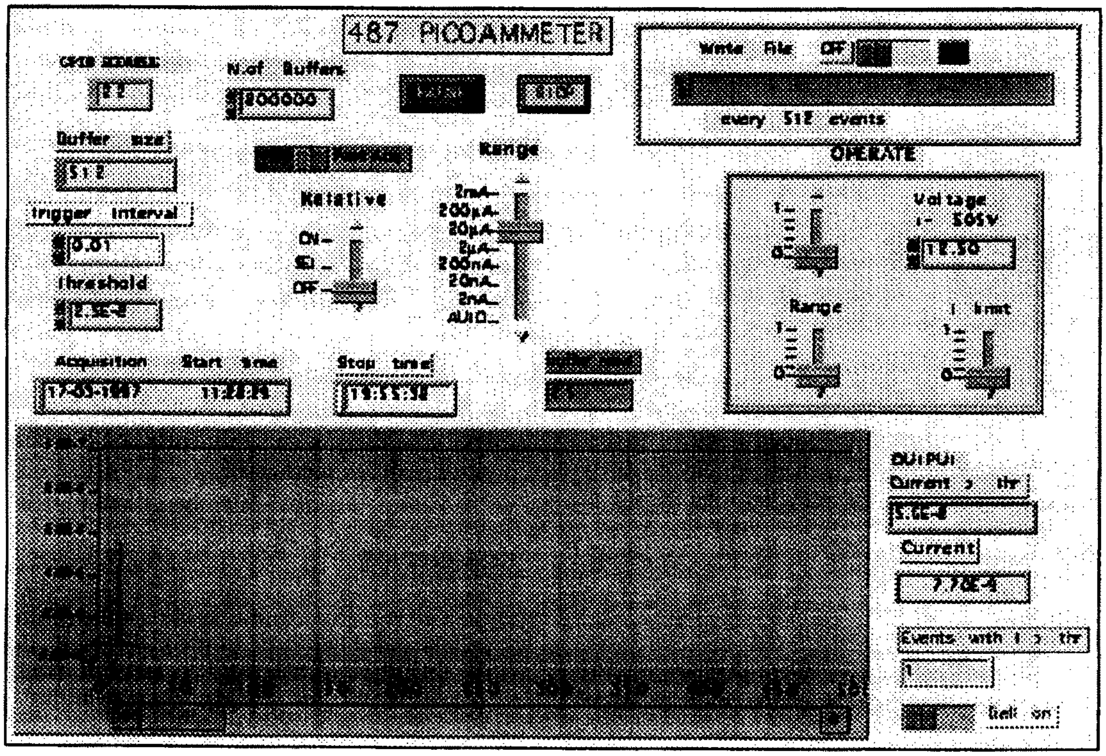

Fig. 2. Labview display showing typical micro-discharge event.

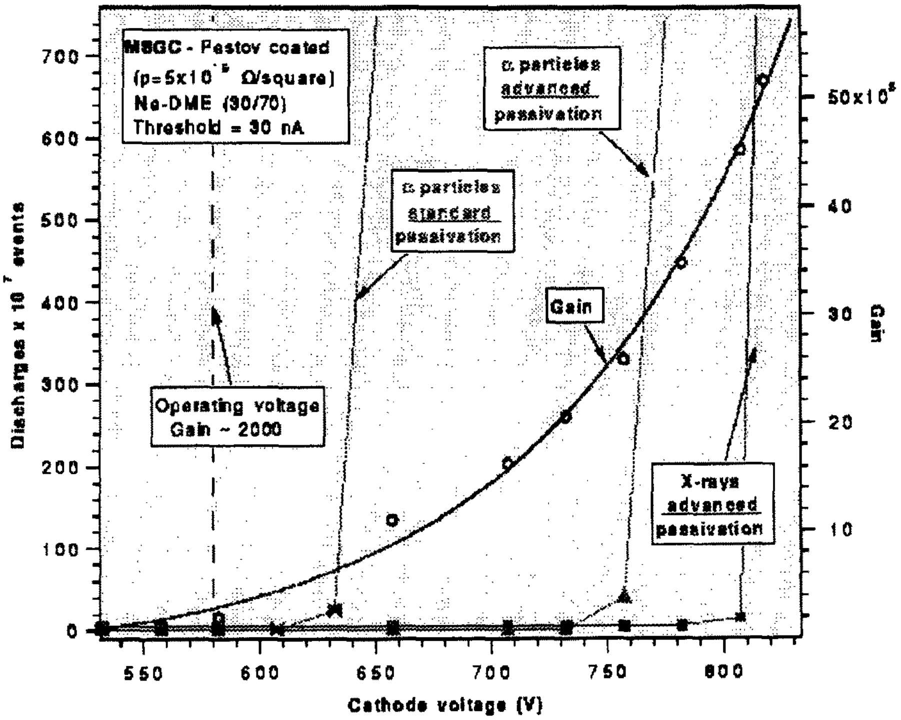

Fig. 3. Example results showing sparking rate as a function of cathode voltage, for two types of passivation.

the correction is very small and the efficiency recorded above using a periodic trigger may be assumed.

4. Example results

Some example results obtained using the pico-ammeter to count real micro-discharges are displayed in Fig. 3. Two chambers, one with 'standard' passivation across the ends of the strips and one with 'advanced' passivation along the cathode edges [3] were tested with two different types of radiation–X-rays and α-particles. The gain curve for the advanced passivated chamber is also displayed in Fig. 3 (solid line). The preliminary results from the discharge counting studies (dotted lines) show that the voltage range over which a chamber may be safely operated is extended by more than 100 V by the use of advanced passivation.

5. Conclusions

We have shown that there is a micro-discharge regime prior to sparking, in which the charge on a group of strips is only partially released. The small currents resulting from these events cannot be detected by the standard HV current monitor and can only be observed using a pico-ammeter. We have developed a method for counting micro-discharges with a detection efficiency of 0.8. This enables us to characterize the sparking resistance of our chambers before entering the heavy sparking regime, in which the detector is irreversibly damaged. Other methods, e.g. counting the number of trips in the HV supply, bring the chamber into this region, thus risking damage to the chamber. Furthermore, the technique described introduces negligible additional capacitance, keeping the discharge energy at a minimum. This is important as a damaged chamber is more susceptible to sparking and any extra capacitance could enhance this positive feedback mechanism.

References

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