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Recent results and developments on double-gap RPCs for CMS

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Abstract

A 3 mm wide-gap Resistive Plate Chamber, as proposed for CMS, has been tested in the H2 Cern beam line. Results on efficiency, rate capability, time resolution and cluster size are reported.

1. Introduction

Double-gap RPCs operated in avalanche mode have been proposed as first-level muon trigger detector for the CMS [1] experiment at LHC. The goal of the first-level muon trigger system is to identify isolated high P_T muons and determine the bunch crossing from which muons are originated, with accuracy better than 25 ns and with an output trigger rate of $\approx$ 3–6 kHz.

The effects of a new treatment of the electrode surface and different gas gap width have been studied by measuring the basic working parameters of three double-gap $50 \times 50\,cm^2$ RPCs, operated with 90% $C_2H_2F_4$, 10% i–C_4H_{10} gas mixture: two of them, with gas gap widths of 2 and 3 mm, were treated with oil; the third one, with 2 mm gas gap, was built out of new electrodes with improved surface flatness, obtained at the production stage [2]. The test was performed on the H2 Cern beam line of SPS during the summer 1996 with different particle rates: 250 Hz/cm^2 (300 GeV/c muons), 1 kHz/cm^2 and 2.7 kHz/cm^2 (100 GeV/c pions). Results on 2 mm gap chambers (with and without oil) have been extensively reported in Ref. [3]. Here the performances of the 3 mm wide gap chamber are presented.

2. Beam test results

The RPCs were equipped with front-end preamplifiers, having a 10 MHz bandwidth and a charge sensitivity of about 1.5 mV/fC. The amplified signals were discriminated at 30 mV. The charge was measured by ADCs with 0.25 pC channel sensitivity; efficiency, time and cluster size were measured by means of TDCs with a time sensitivity of 100 ps.

The streamer probability was also evaluated as the fraction of events with a charge greater than 60 pC. All three chambers exhibit an operation plateau of $\approx$ 300 V with an efficiency $> 95\%$ and streamer probability $< 10\%$.

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In particular, the efficiency versus the high voltage for the 3 mm wide gap chamber is shown in Fig. 1 for different beam fluxes. The streamer probability at the lowest flux value is also plotted. The efficiencies given in Fig. 1 are, however, average values over the SPS spill period of about 2.5 s. It is also interesting to plot the efficiency at different times elapsed from the start of the spill. This is shown in Fig. 2, again for different beam fluxes. It can be seen that, up to a flux of incoming particles of 1 kHz/cm^2, there is no depletion of efficiency during the spill.

In Fig. 3 the 3 mm chamber efficiency versus the beam flux values at the knee of the high voltage plateau is plotted. For comparison, the corresponding values of the two other (2 mm wide gap) chambers under test are also shown. As expected, the 3 mm wide gap chamber exhibits a better rate capability.

The cluster size was estimated by considering the number of adjacent fired strips with signal arrival times within 10 ns with respect to the fast one. The results are shown in Fig. 4. In the regions of higher streamer probabilities a decrease of the cluster size with the rate was observed. This effect might be due to the local reduction of effective high voltage across the gap.

The bunch crossing identification requires that the event arrival times should stay in a 15 ns wide window. The time resolution was calculated as the rms of the time distribution, to take into account the non-Gaussian tails which can be important. In Fig. 5 the time resolution is shown. The spoiling of time performances observed at higher beam flux values is still compatible with the CMS requirements.

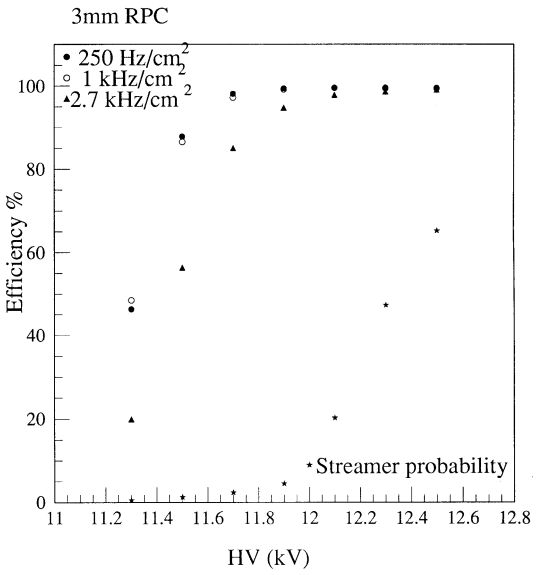

Fig. 1. Efficiency for 3 mm gap RPC.

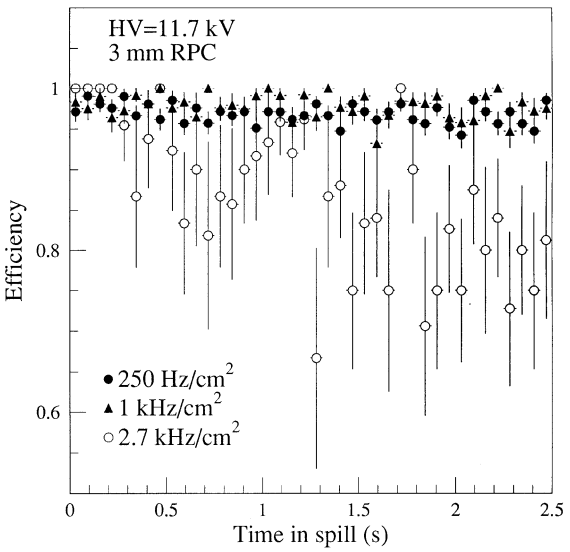

Fig. 2. Efficiency during the spill.

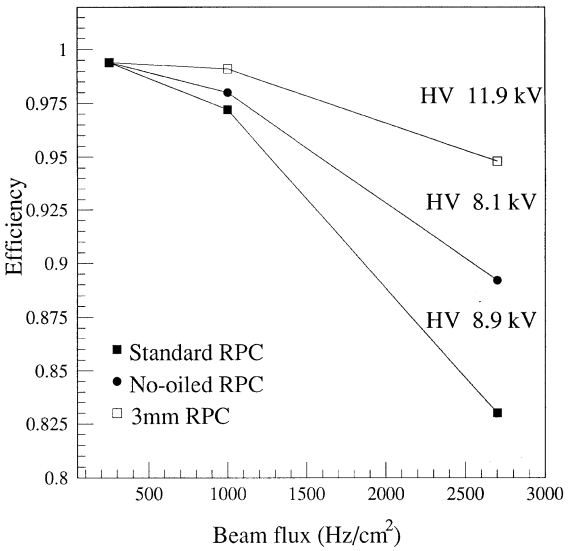

Fig. 3. Rate capabilities for all three chambers.

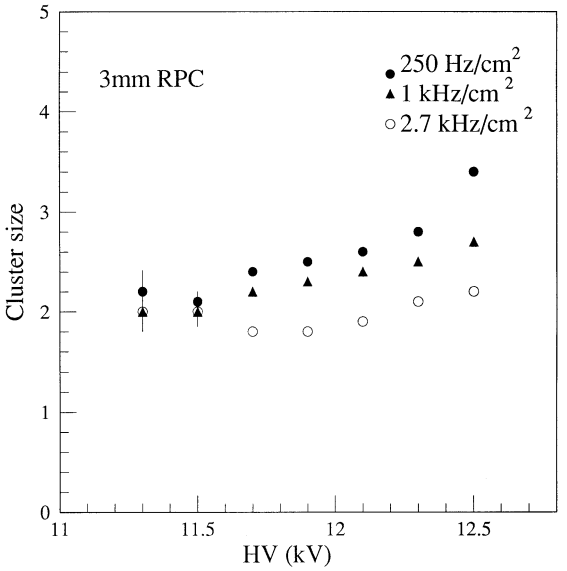

Fig. 4. Cluster size.

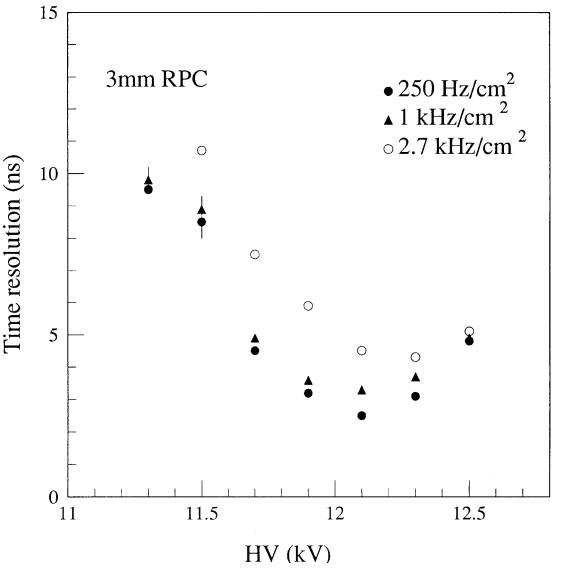

Fig. 5. Time resolution.

3. Conclusions

The performances of a 3 mm wide gap RPC for CMS have been studied. The chamber can be operated with very high efficiency and with low streamer probability up to beam flux value of about 2.7 kHz/cm^2.

The time resolution is slightly worse with respect to a 2 mm wide gap RPC, but still compatible with the CMS requirements.

References

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