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Performance of a prototype of the Microstrip Gas Chambers for the CMS experiment at LHC

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Abstract

A set of microstrip gas chamber (MSGC) prototypes, developed for the barrel Tracking Detector of the CMS experiment at LHC, has been tested in a beam. The chambers were 10 cm long, with Pestov or diamond coated glass substrate. The results on the performance of the chambers are reported. The spatial uniformity of the chambers is also illustrated.

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1 Experimental set-up

Five prototypes of the CMS [1] barrel tracker microstrip gas chambers (MSGC) were exposed to a 30 GeV/c pion beam at the CERN SPS X7 facility. The detectors were mounted on a two meter long optical bench together with four double-sided microstrip silicon detectors. The readout electronics was Premux [2], with shaper peaking time of 40 ns, followed by Sirocco ADCs. All the channels were read out and the HV was on during the whole period. One MSGC was installed on a movable table, to allow for uniformity studies over the whole detector surface. About 2,000,000 events were recorded and analyzed.

The operational principles of the MSGC are described in detail in Refs [3]. The chambers were built on 300 μm thick DESAG D263 glass substrates, with Pestov or diamond undercoating [4, 5] of surface resistivity $10^{15} - 10^{16} \Omega/\text{cm}^2$. The gold strips are 1 μm thick, 10 cm long, and have a width of 7 μm and 90 μm for anode and cathode respectively. The strip pitch is 200 μm . Each MSGC has 512 anode strips, over the surface of 10x10 cm^2 , with a drift gap of 3 mm. The chambers were filled with different mixtures of Ne and DME gas.

2 Results

The strip noise, defined as the RMS of its pedestal, is 5 ADC counts. In a cluster, the signal to noise ratio of each strip must be larger than 3 and for at least one strip it must be larger than 6. At the standard voltage conditions, $V_{cathode} = 530 \text{ V}$, $V_{drift} = 3000 \text{ V}$, with a gas mixture 25% Ne - 75% DME, we measure a hit efficiency of $98.5 \pm 0.2 \%$, with an occupancy of 1.20 ± 0.01 hits per detector, where the errors are statistical. The average cluster size is 1.95 ± 0.01 strips. The amplitude of the cluster charge is well described by a Landau function (Figure 2). The most probable value of the signal to noise ratio is $S_{peak}/N = 30.9 \pm 0.2$, where N is the noise of one strip, averaged on all the strips in the cluster.

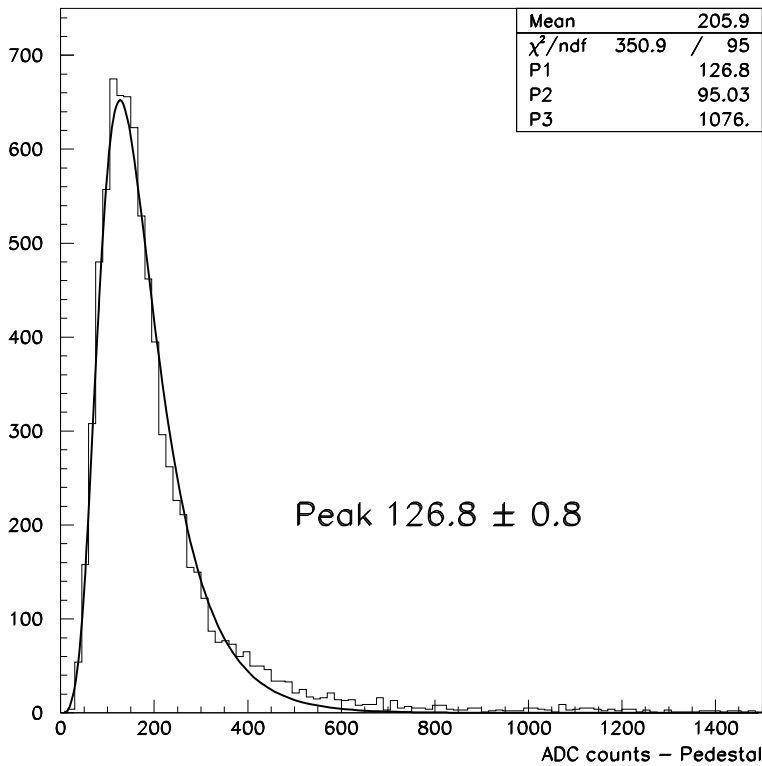


Figure 1: Cluster charge at $V_{cathode} = 530 \text{ V}$, $V_{drift} = 3000 \text{ V}$, 25% Ne - 75% DME gas mixture.

The hit residuals are measured with respect to a track found excluding the chamber under study from the fit. The results show a standard deviation in a range of 35-45 μm for the different chambers tested. If the contribution of the track error is unfolded from the residuals, the intrinsic hit resolution is measured to be 30-40 μm . The best resolution obtained is $30.5 \pm 0.4 \mu\text{m}$.

2.1 Spatial Uniformity

To prove good mastering of the mechanics and the assembling procedure of the final modules for the CMS detector, we have studied the resolution and the gain uniformity near the chamber edges. A uniformity scan has been performed across and along the strips of the detector mounted on a movable frame. The resolution is uniform up to 2 mm from the chamber edge, corresponding to the 10 readout strips (Figure 2.1). Good uniformity has been measured all over the chamber surface.

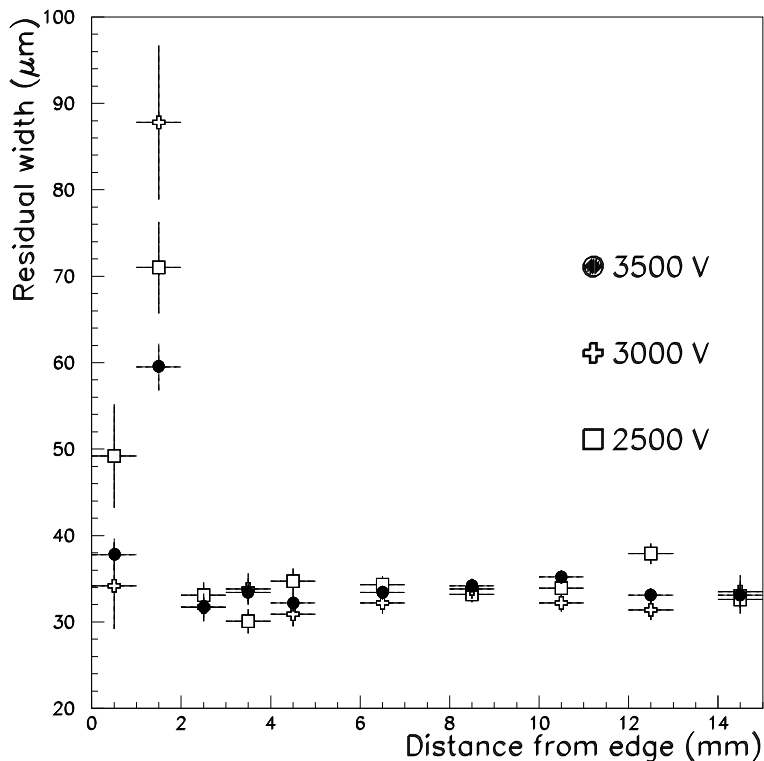


Figure 2: Standard deviation of the residual distribution as a function of the distance from the chamber edge, at $V_{cathode} = 540$ V, 25% Ne-75% DME gas mixture, for different conditions of the drift voltage.

3 Conclusions

The results reported illustrate the basic performance of undercoated MSGCs in a test beam. A signal-to-noise ratio of 30.9 ± 0.2 , corresponding to an efficiency of 98.5 ± 0.2 % has been achieved. The hit resolution is measured to be 30.5 ± 0.4 μm . The response has proven to be uniform all over the detector, with only small deviations (less than a factor 3) at a distance less than 2 mm from the edge. The results indicate that the coated MSGCs are suitable for the LHC specifications in their efficiency, spatial resolution and uniformity of response.

Acknowledgement

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