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Results on the radiation hardness of Small Gap Chambers

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The capability of Small Gap Chambers to withstand a high flux of hadrons was studied at the Paul Scherrer Institut. We report the observed radiation hardness according to the level of signal required from the chambers.

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1 Design considerations

Fig. 1. Small Gap Chamber design.

The variants of Micro-Strip Gas Chambers with a small anode-cathode distance were proposed to avoid a substantial charging of the substrates when exposed to a high particle flux [1,2]. In the case of the SGCs, the electrodes are $12\ \mu\text{m}$ apart and the gap is passivated with an insulating layer overlapping both edges by $1\ \mu\text{m}$ (fig. 1). The behaviour of these chambers under MIP or X-ray irradiation has been well established and they can reach a gain in excess of 6000 without significant drop when increasing the flux up to $100\ \text{kHz}/\text{mm}^2$ [2,3].

When it was observed that Highly Ionizing Particles can damage the MSGC strips [4], the passivation of their edges, an intrinsic feature of the SGCs, was suggested as a possible improvement of the chambers [5]. Indeed, a first test of SGCs exposed to a $6\ \text{kHz}/\text{mm}^2$ beam of 350 MeV pions at the Paul Scherrer Institut provided promising results [6]. Such a beam has been shown by simulation to provide a close environment to the one of MSGCs operated in the CMS experiment at LHC [7]. For instance, the expected rate of HIPs with an energy loss of more than 1 MeV is of the order of $1\ \text{Hz}/\text{cm}^2$. In this paper, we summarize the results of one month of experimentation performed at the PSI with 12 SGCs.

2 Experimental set-up

A view of the experimental bench at the beam area is shown in fig 2. The chamber substrates were made of $300\ \mu\text{m}$ thick glasses (Desag D263) with

Fig. 2. View of the experimental bench at the PSI beam area.

128 gold strips, 5 cm long and $1\ \mu\text{m}$ thick. The passivation was realized with Benzo-Cyclo-Butene. The drift gaps were 3mm and, during the test, the chambers were flushed with a mixture of 60 % DME and 40 % Neon. The signal read-out was performed at the anodes with PREMUX chips consisting of 128 multiplexed CR-RC amplifiers of 50 ns time constant [8].

Scintillating counters were used to monitor the beam intensity and trigger the acquisition of the PREMUX signal. The registered data included a 2 ms sampling of the cathode current drawn by each couple of chambers and also of the drift current for some of them.

Fig. 3. Cluster and seed strip signals and signal to noise ratio at low intensity.

3 Experimental data

Fig. 4. Gain stability at HI from the current measurements.

During the data taking, periodical runs at low intensity (100 Hz/mm^2) were recorded to measure the signal without the pile-up of uncorrelated tracks which are present at high intensity (fig. 3). In this latter case, the gain stability was continuously monitored with the current measurements (fig. 4). At a cathode voltage of -400V and a drift voltage of -3500V , the gain was 1450 ± 300 , estimated with a calibration of the PREMUX, and 1300 ± 400 from the current measurements with a larger uncertainty due to the estimation of the integrated flux.

Cathode sparks were identified in the current sampling as spikes with a given shape and charge. An example is shown in figure 5 together with the charge distribution. For the chosen grouping of 8 cathodes, the mean charge at 400V is 17.5 nC leading to a discharge capacitance of 44 pF . It is compatible within 50% with the strip capacitance estimated at the input of the amplifiers from the measured equivalent noise of $750e^-$.

During the test, any drop of efficiency appearing in a beam profile was considered as a damage to a strip. A strict correlation with a decrease in the noise profile was observed, as expected for cuts (fig. 6).

Fig. 5. Example of a spark (a) and charge distribution (b).

Fig. 6. Example of noise and beam profiles showing one cut after 25 days of irradiation at high intensity.

4 Radiation hardness

As demonstrated in reference [2], defining the signal to noise ratio (S/N) as the one for the seed strip of a cluster, the efficiency plateau with a 3 rms threshold

Fig. 7. Spark rates as a function of cathode voltage and corresponding gain for couple of chambers.

is reached at a value of 10 for perpendicular tracks. To provide some margin from the beginning, the 12 chambers were operated for the seven first days at high intensity at a signal to noise ratio of 15 and no damage to the strips were observed.

Then, a scan with the cathode voltage brought the chambers to larger gains and observable levels of sparking. With a $\pm 5V$ dispersion, the same spark rates were measured for the different substrates with a mean growth by a factor 7 per 10V applied to the cathodes (fig. 7). During this scan, strip cuts were observed with a mean number following the number of sparks as shown in figure 8. The data are compatible with a hardening phase of 1 to 2 cuts per substrate, followed either by a saturation or by a linear increase of the number of cuts with a maximum slope of 1 per 4000 sparks at a 95 % confidence level. Using this simple parametrisation and the measured spark rate, it is possible to extrapolate how many days a chamber can withstand the high intensity beam, as a function of the gain and for a given amount of cuts. This extrapolation is shown in figure 9.

Fig. 8. Mean number of cuts per substrate as a function of the number of sparks.

Fig. 9. Number of days a substrate can withstand high intensity with a 2%, 5% or 10% fraction of cuts as a function of the gain and corresponding S/N.

5 Conclusions

The behaviour of 12 small size SGCs has been thoroughly tested at the PSI in a 6 kHz/mm² beam of 350 MeV pions. At the beginning of the efficiency plateau (3 rms noise cut) the spark rate was too small to be measured in a limited time. However, increasing the cathode voltage it was found to grow by a factor 7 per each step of 10V. A correlation was established between the number of sparks and the number of cuts, showing some hardening of the substrates, at the level of one or two cuts, until an asymptotic behaviour is reached. We conclude that the SGCs in their present size and design should withstand the HIP environment in the PSI beam for 500 days at a gain of 2000 and with a rate of cuts of less than 5% of the number of strips. Given the noise of the present electronics, this gain is 2.5 times the one at the beginning

of the efficiency plateau.

References

- [1] F. Angelini et al., Nucl. Instr. and Meth. A315 (1992) 21
- [2] J.F. Clergeau et al, Nucl. Instr. and Meth. A392 (1997)140
- [3] V. Chorowicz et al., Nucl. Instr. and Meth. A401 (1997) 238
- [4] B. Schmidt, Nucl. Instr. and Meth. A419 (1998) 230
- [5] E. Albert et al., Nucl. Instr. and Meth. A409 (1998) 70
- [6] V. Chorowicz et al., Nucl. Instr. and Meth. A419 (1998) 464
- [7] M. Hutinen CMS Note 1997/073
- [8] N. Bacchetta et al. CMS Note 1995/164