Spark protection solution for Front End Electronics board in ALICE Photon Multiplicity Detector

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Photon Multiplicity Detector (PMD) [1] in the ALICE experiment at CERN comprises of large arrays of hexagonal gas cells. The honeycomb structure forms the cathode with a wire at the centre of each honeycomb acting as the anode. The detector operates at a maximum negative voltage of 1400V. The readout being wire read out, the anode wire is directly coupled to the inputs of the front end chip MANAS [2] on the on the FEE boards as shown in fig.1.

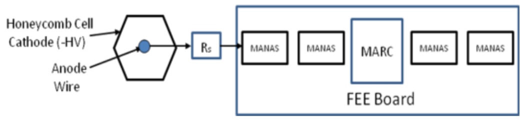

Fig.1 Honeycomb Detector cell FEE connection

As the gaseous detectors are prone to sparks, these sparks get injected to the FEE boards. MANAS chip has a built in ESD protection shown in fig.2. This protection was tested with the configuration shown in fig.3 where DUT is a MANAS channel. Inspite of ESD protection FEE boards were going bad with HV sparks.

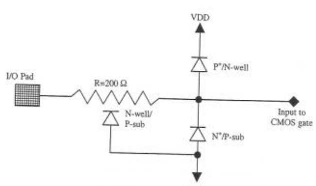

Fig.2 Inbuilt ESD protection in MANAS [1]

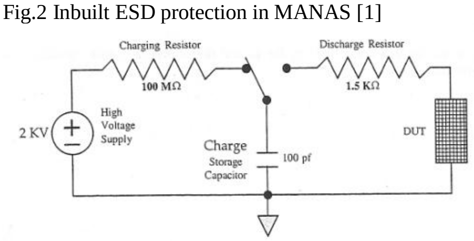

Fig.3 Testing done with MANAS [1]

Here the charge storage capacitor used for the testing was 100pf and the series resistance was 1.5KΩ. In the real scenario, the detector capacitance is 1.1nF when the entire electronics is mounted on one detector module and the series resistance is only 200Ω, which is internal to the MANAS chip. The general HV layout of the PMD is shown in fig.4.

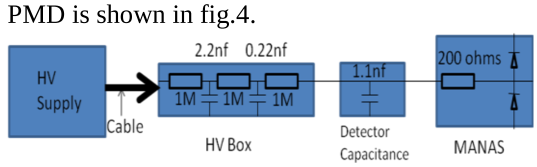

Fig.4. General HV layout

Based on detector HV scheme we simulated the peak currents in ESD diode of MANAS channel with time, considering detector spark with 1400V. The behavior of current which is going through the ESD protection diodes of MANAS channel after spark is shown in fig.5.

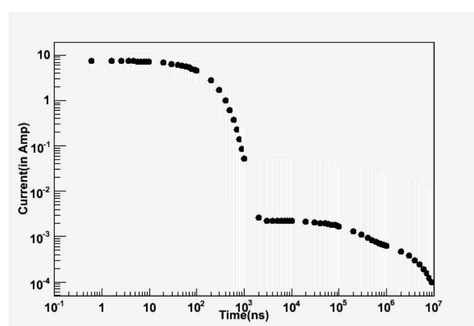

Fig.5. Simulation of energy injection in MANAS with spark where peak current goes upto 8A

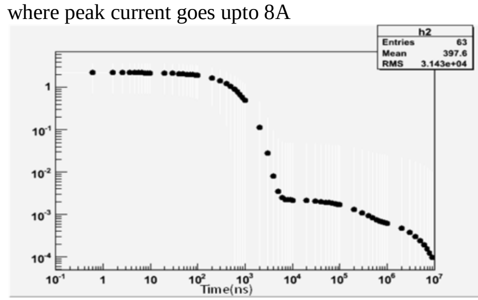

Fig.6 Simulated energy deposition in MANAS after introducing series resistance reducing peak current to 2A

A series resistance Rs was introduced as shown in fig.1 to reduce the peak energy deposition in ESD diode of MANAS channel due to spark. After several iterations an addition of 470Ω was showing good results with the simulated detector capacitance of 1.1nf without compromising much on noise. The simulation results are shown in fig.6. To support this, we did lab tests and injected sparks in the MANAS channels with simulated detector capacitance. The lab test setup is shown in fig.7.

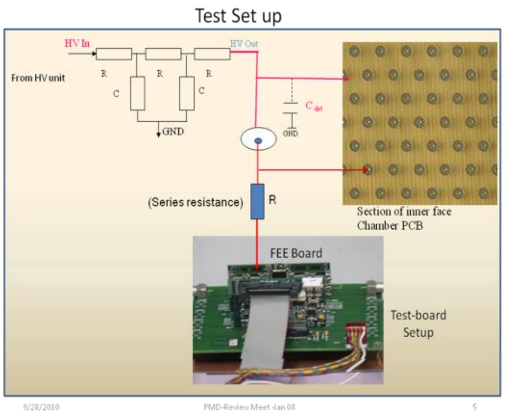

Fig.7 Lab test setup for spark injection

The series resistance was mounted on the flexible kapton cable which routes detector signals to FEE. Since the kapton were already fabricated, so there was severe space constraint. Therefore, unlike conventional manner, resistances were soldered vertically between connector and flexible cable pads. This is shown in fig.8 where we can see kapton cable with and without series resistance. The size of series resistance was chosen to be SMD 0805 size since SMD 0603 sizes, spark jump-over were observed.

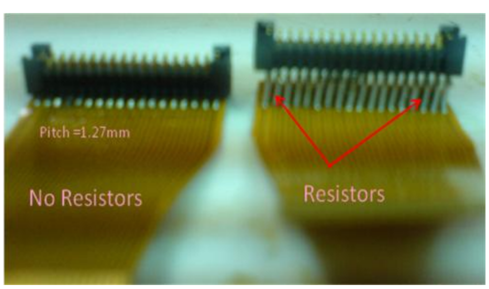

Fig.8 Kapton with and without series resistance

The general noise performance study with addition of series resistance was done. It was seen that with the series resistance there is a marginal change in noise till 1KΩ as shown in fig.9.

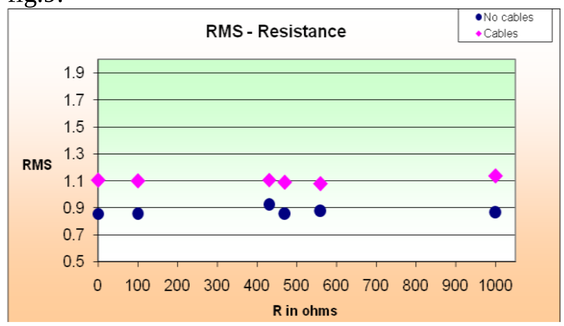

Fig.9 Noise study with the variation of series resistance

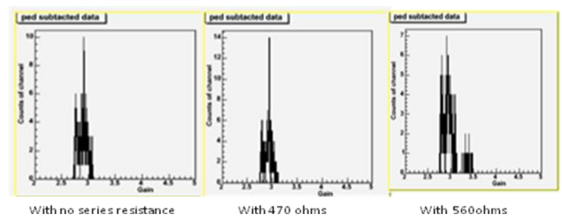

Fig.10 Gain spread with no series resistance, 470Ω and 560Ω

We have studied the gain spread with and without series resistance and it was found that till 470Ω there was negligible gain spread seen but with 560Ω some channels showed shift in gain as seen in fig.10. So with this study, 470Ω was found to be optimum value and all the 8000 Kapton cables have been assembled with this value.

The detector with full electronics with series resistance is installed in July 2009 and successfully running for last one year and it is observed that FEE boards are not going bad. Details of the study, the results and the experience of running will be presented.

References

[1] Photon Multiplicity Detector Technical Design Report CERN/LHCC 99-32

[2] The Electronics of ALICE Dimuon Tracking Chambers