Aging studies for the CMS Improved Resistive Plate Chambers

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1. Introduction

The Compact Muon Solenoid detector Resistive Plate Chamber (CMS-RPC) system [1] was designed to provide muon identification and reconstruction. They work in double-gap mode, where each gap is 2 mm width. The gas mixture used is composed of $C_2H_2F_4$ (95.2%), iC_4H_{10} (4.5%) and SF_6 (0.3%) with a relative humidity of 40-50%. With the High-Luminosity LHC (HL-LHC) the luminosity will increase five times. This new condition can affect the detector properties, introducing non-recoverable aging effects. To cope with these changes the CMS detector is under upgrade. The existing system is being submitted to a longevity study with the radiation levels that will be found in HL-LHC [2]. Besides that, an improved version of the RPC known as improved RPC (iRPC) will be installed in the high pseudorapidity region on the 3rd and 4th endcap disk. Therefore, it is important to study the possible aging effects in the iRPC chambers

2. Aging in gaseous detectors

The aging effects in the RPCs can be understood as the degradation of their performance due to long exposure to radiation. Such degradation is caused by the production of polymers by chemical reactions. Usually, the aging effects are manifested in the degradation of the efficiency, in the increase of the dark current, and in the increase of the noise pulses in the detector [3].

3. Experimental setup

The system is set up at the Gamma Irradiation Facility (GIF++). This facility combines a 14 TBq ^{137}Cs source with a high energy muon beam. The system is located at GIF++ bunker and is composed of two trolleys, trolley 1 (T1) and trolley 3 (T3). The tracking system is installed in T1 and the prototype is installed in T3. The prototype is a 1.4 mm double gap chamber equipped with a custom electronics.

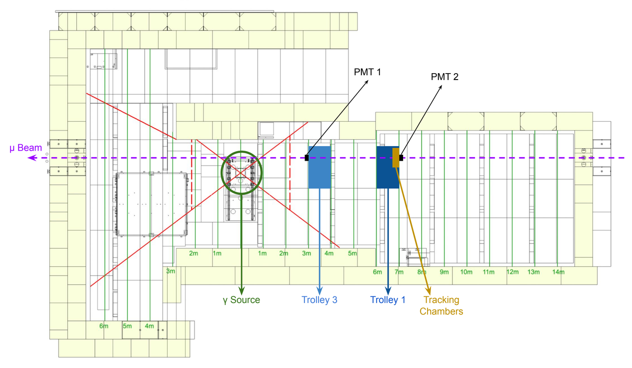
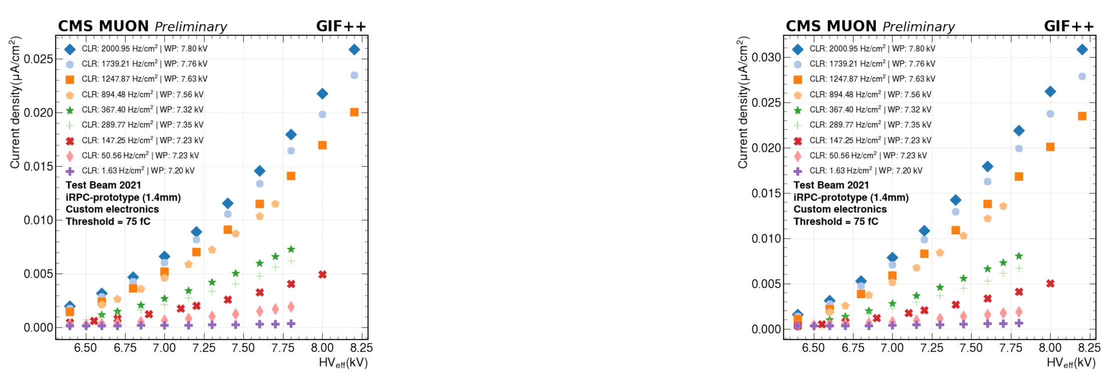


Figure 1: *Experimental layout. The detector is installed 3 m away from the source.*

4. Results

Figure (2) shows the current density measured in both gaps. CLR represents the cluster rate at the working point (WP). The error bars are small and are behind the data points.



(a) Current density in top gap. (b) Current density in bottom gap.

Figure 2: *Current density measured in both gaps in function of the effective voltage.*

Figure (3) shows the efficiency versus HV_{eff}. The efficiency is obtained after subtracting the gamma background and using the tracking system. The detector's WP moves to higher values as the rate increases. The error bars are small and are behind the data points.

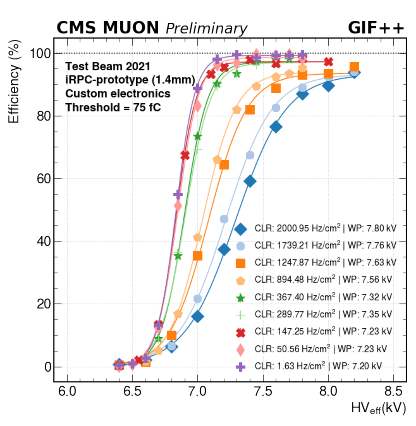
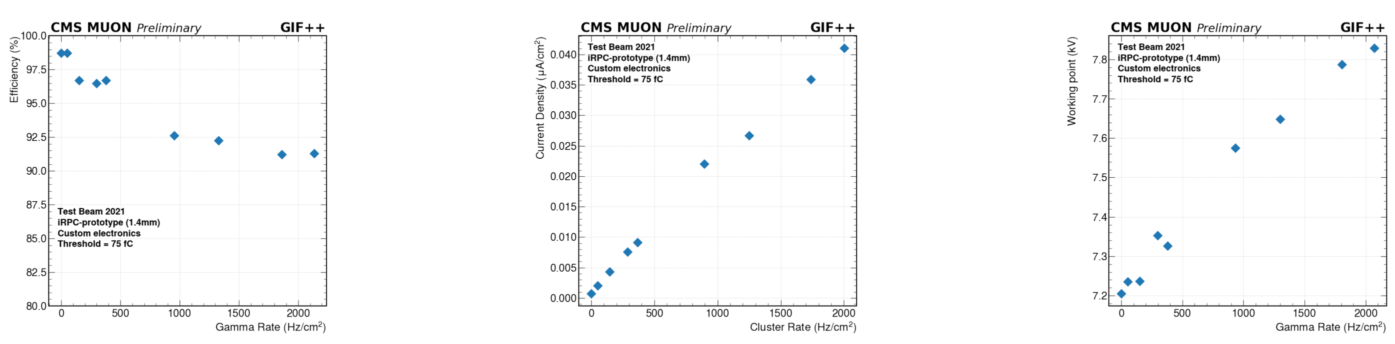


Figure 3: *Efficiency versus HV_{eff}.*

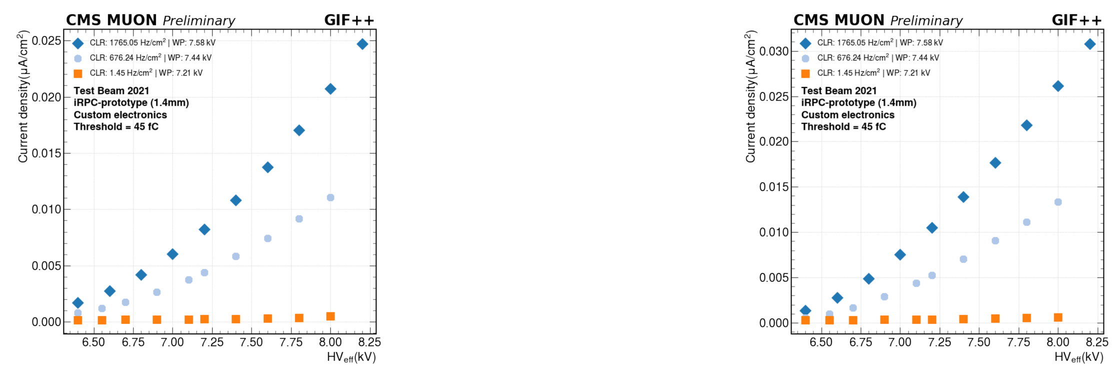
Figure (4) shows the detector parameters at the WP.



(a) (b) (c)

Figure 4: *Important detector parameters measured at the WP.*

Figure (5) shows the current measured in both gaps with lower threshold. Compared to the 75 fC threshold results, currents are similar while the rates at the WP are lower.



(a) Current density in top gap. (b) Current density in bottom gap.

Figure 5: *Current density measured in both gaps in function of the effective voltage. Now the electronic threshold is set at 45 fC.*

Figure (6) shows efficiency comparison between the two thresholds configurations. It is worth mentioning that the tracking system was not used in both plots. In the configuration with source off the WP is similar for both cases while in the highest rate it is lower with 45 fC.

(a) Source off comparison (b) Rate comparison

Figure 6: *Efficiency curve comparison between the two threshold configurations.*

Figure (7) shows the ohmic current versus integrated charge. Each point is taken weekly without gamma background at 5 kV. After the highest value of current at this point was obtained the chamber was turned off between the weekly measurements reducing the currents in both gaps. The currents in bottom gap are increasing until the last point. The cause of this increase is under study.

(a) Ohmic current in top gap. (b) Ohmic current in bottom gap.

Figure 7: *Ohmic current versus integrated charge.*

Figure (8) shows the physics current versus integrated charge. Each point is taken with the source off at 7.2 kV. It is desirable currents lower than 0.5 μA, which is seen in top gap in all data points. However, the same is not observed in bottom gap.

(a) Physics current in top gap. (b) Physics current in bottom gap.

Figure 8: *Physics current versus integrated charge.*

5. Conclusions

In this work we presented the beam tests for an iRPC prototype and the monitoring of its ohmic and physics currents in function of the accumulated charge. The performance results during the beam tests are satisfactory. Using a custom electronics with threshold 75 fc the drop in the efficiency between source off and the rate of 2.2 kHz/cm^2 is around 5.5%, while the increase in the WP is around 600 V. Moreover, using threshold 45 fc the drop in the WP is reduced to 380 V.With the accumulated charge of 50 mC/cm^2 the level of currents in top gap is acceptable. However, the ohmic current in bottom gap is increasing and the cause of this increase is under study.

6. Acknowledgments

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References

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