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Analysis of Stability of a gaseous Muon Detector in CMS

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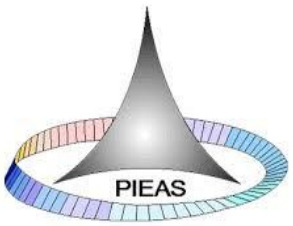

Analysis of the stability of a gaseous Muon detector in CMS

Objective

The objective of this project is to analyze the stability of the Resistive Plate Chamber (RPCs) gaseous muon detectors based on the current drawn by the detector and eventually spots aging effects after 10 years from the construction of the chambers.

Introduction

Resistive Plate Chambers

RPCs are fast gaseous detectors that are used in Muon trigger system along with the Drift Tubes (DTs) and Cathode Strip Chambers (CSCs).

Construction

RPCs consist of two parallel plates, a positively charged anode and a negatively charged cathode; both made of a very high resistivity plastic material (Bakelite) and separated by a gas volume.

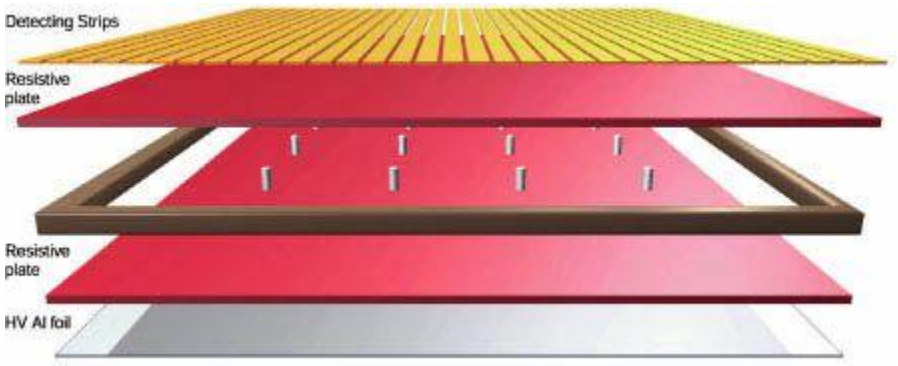

Figure 1: Basic Construction of an RPC detector

Working

The working principle of a RPC is described as follows: When a Muon passes through the chamber, it knocks out the electrons of gas atoms. These electrons then hit other atoms causing an avalanche of electrons. The electrodes are transparent to the signal (the electrons), which are instead picked up by external metallic strips after a small but precise time delay. The pattern of hit strips gives a quick measure of the Muon momentum, which is then used by the trigger system for making some decisions like whether the data is worth keeping or not. RPCs combine a good spatial resolution with a time resolution of just one nanosecond. The high voltage of the very small area involved in the avalanche drops of about 1-2 KV. The high voltage drop is then recovered by the high voltage power supply and this effect is spotted as an increase of the HV power supply current. During the beam collision at LHC the

average rate of particle is about 5-10 Hz/cm^2 (linearly correlated with beam luminosity) and the average current drown by an RPC detector (about 2 m^2) is in the range from 2 to 20 μA (depends on the region of the muon system).

Stability Analysis

One of the possible way to study the stability of the gas detector is to monitor the current and see how stable is this parameter taking into account all the possible source of variation (particle rate, gas flow, temperature, pressure, humidity….). Any increase in time of the "normalized" current can spot an aging effect of the chamber or some malfunctioning of the system.

During the RUN-I of Large Hadron Collider (LHC), the information about the currents of each of the High voltage channels has been saved in the Database. This information about current is used for the analysis. The Compact Muon Solenoid (CMS) detector consists of different RPC chambers. It should be noted that analysis cannot be based only on current information. There are two possible reasons for increase of current in the detector which are either the current is rising because of problem in detector or because of increasing the luminosity. Luminosity and current are about directly proportional to each other. Hence decision should be made not only with current but based on correlation of current and luminosity and this is what I have done for my analysis.

Each RPC chamber can be identified by specifying the parameters like region, ring, station, layer, sector and subsector. Each RPC chamber and supply type used by it is given a unique number called PVSSID. The information in the database contains the information about the PVSSID and corresponding current drawn by channel at different times. Hence we can identify a particular chamber and the supply type by a PVSSID and find the corresponding current from the database. This current can be plotted and observed to check either it is in safety limit or not. If it is in safe limits that means detector is working fine and if it is not that means there is problem in the detector.

I used the "ROOT" software for analysis.

Observations and Discussion

Following are some the graphs and distributions to analyze the working of chambers:

The run number denotes the different times of year and their values increase as we proceed further in the year. In the first two plots (Fig.2, 3) is shown the currents versus the run numbers (history plot) in a range of about one year. The current of all the RPC chambers has shown a clear positive trend corresponding to an average increase of about a factor 2-3 (in some region is higher). As discussed before this increase can be generated by many factors and for this reasons I first analyzed the behavior of the LHC luminosity in the same period (Fig.5). The luminosity showed a trend similar to the current with an increase of a factor 3 in the full period.

In Fig.4 is shown the correlation between the average current and the luminosity in the full period. A clear linear increase of the current as function of the luminosity and then number of particles is shown. The linear trend explains very well the current increase observed in the full system.

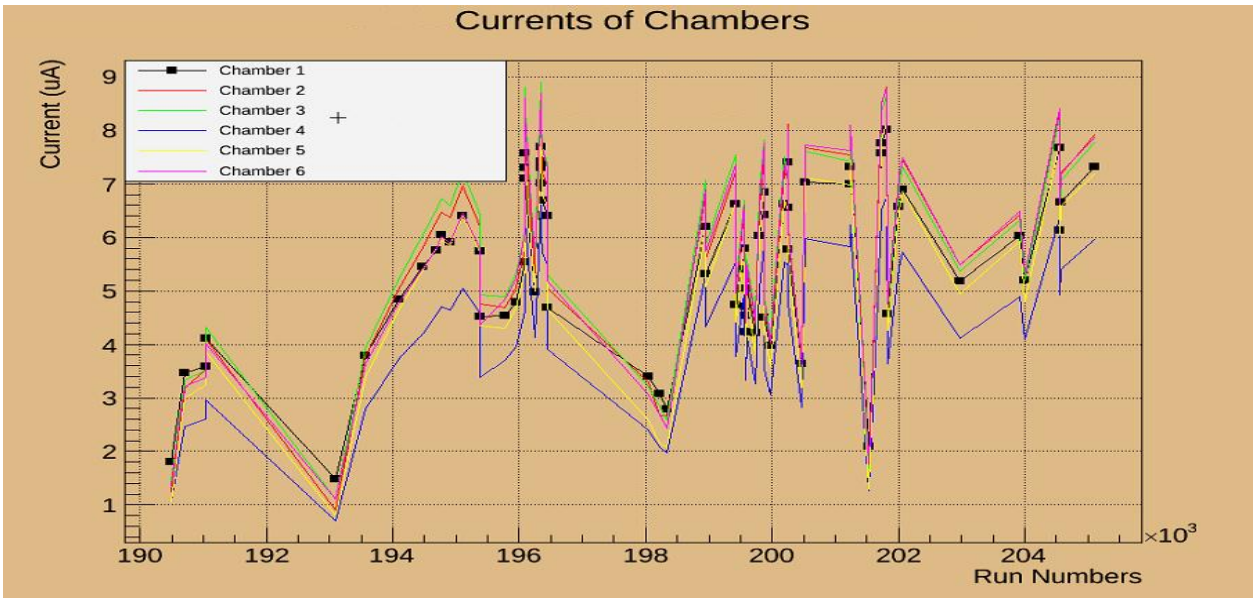

Figure 2: Current versus run number in one year of data taking for six chambers of the endcap region (chamber RE+3, Ring 2 Chambers 1-6).

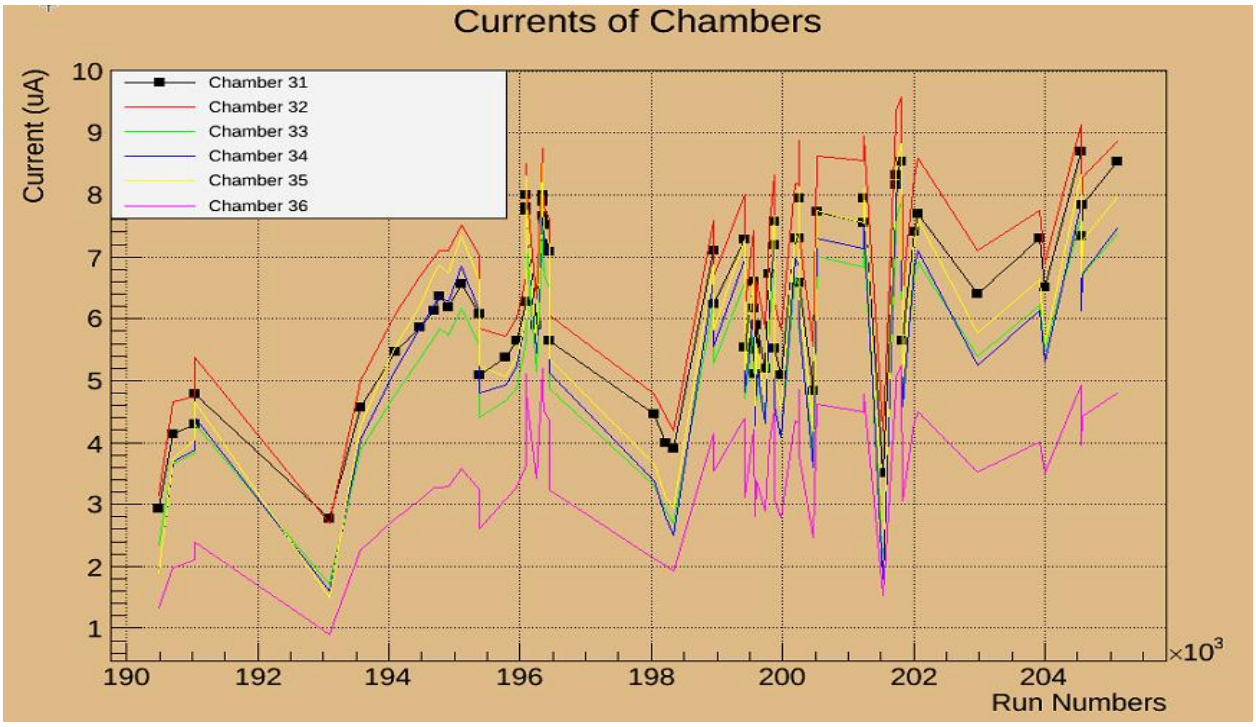

Figure 3: Current versus run number in one year of data taking for six chambers of the endcap region (RE+3, Ring 2 Chambers 31-36)

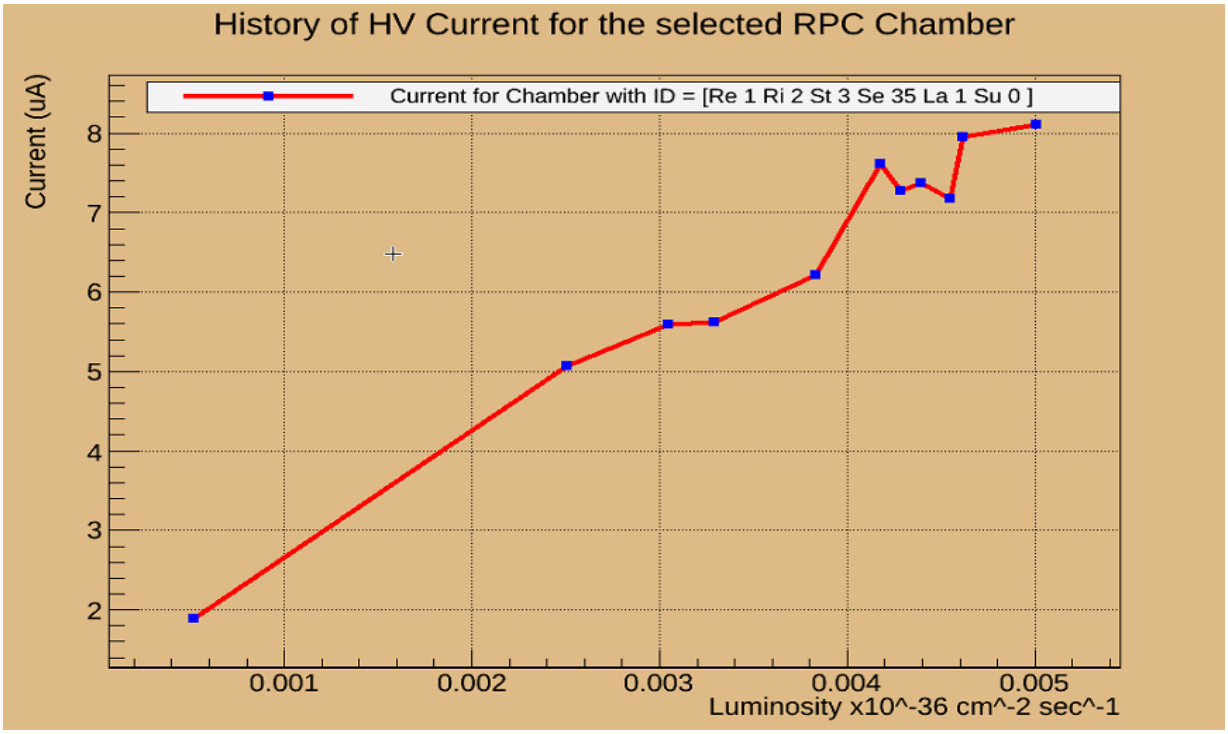

Figure 4: Average current versus luminosity

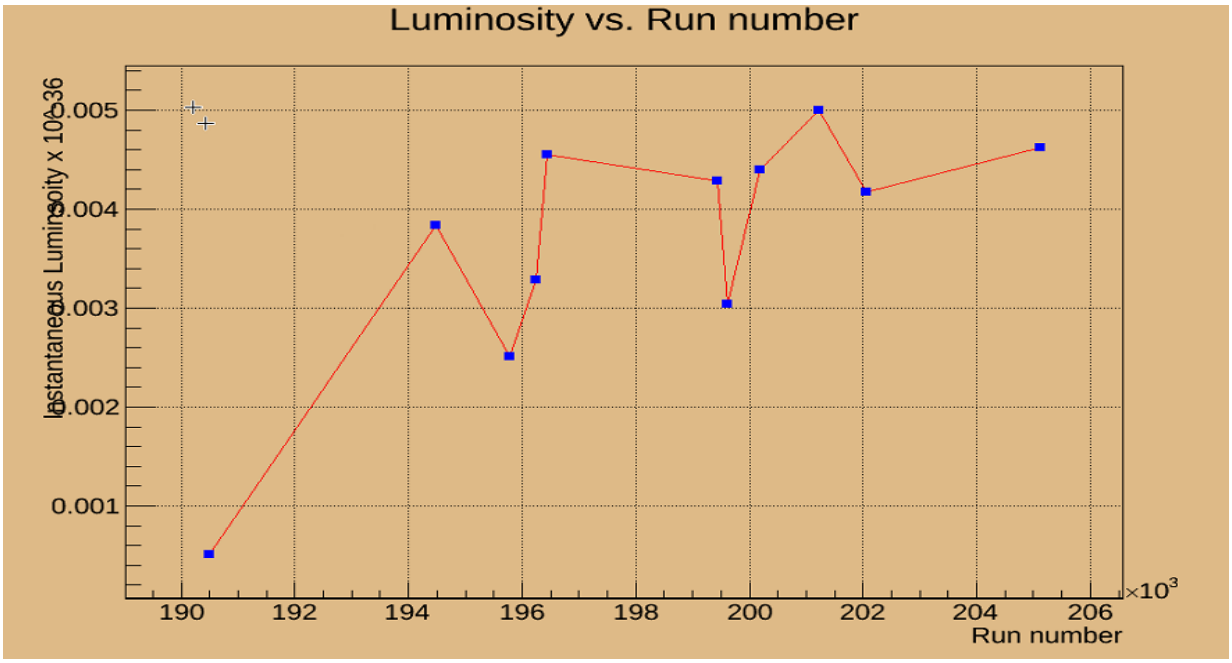

Figure 5: Luminosity versus run number in 1 year of data taking

Conclusion:

The correlation between the current drown by the RPC detectors and the LHC luminosity is clearly shown in figure 4. This correlation was well know since the beginning for all the muon gas detectors and has been now studied in details. The linear trend shows that there is no saturation (constant current versus luminosity) up to the maximum luminosity reached in the 2013 and explains us that the current increased observed in all the detectors is only due to the luminosity. Some second order effects could be present and will be investigated in details looking at all the possible parameters that can be correlated to the currents.

References

- http://cms.web.cern.ch/news/resistive-plate-chambers
- https://twiki.cern.ch/twiki/bin/viewauth/CMS/RPC2014SummerStudents