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**Abstract**

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# Resistive Plate Chambers performance with Cosmic Rays in the CMS experiment

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**Abstract**

The Resistive Plate Chambers are used in the CMS experiment as a dedicated muon trigger both in barrel and endcap system. About 4000 square meter of double gap RPCs have been produced and have been installed in the experiment since more than one year and half. The full barrel system and a fraction of the endcaps have been monitored to study dark current behaviour and system stability, and have been extensively commissioned with Cosmic Rays collected by the full CMS experiment.

*Key words:*
RPC, CMS, CRaFT

## 1. Introduction

In October 2008 the CMS experiment[1] performed a dedicated period of data taking for about one month called CRaFT (Cosmic Run At Four Tesla). During this run all sub-detectors have been operated as a whole system in order to learn as much as possible about operations and performance before the LHC start-up. RPC[2] system participated to the data taking with the full barrel and half endcaps in operation. The focus of this report is the analysis of the performance of the RPC detector during CRaFT and represent an extension to the full system of the analysis already performed on part of the apparatus during summer 2006[3].

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## 2. Detector layout and system stability

Resistive Plate Chambers (RPC) are used in both Barrel end Endcaps as dedicate trigger detectors. They complement the muon tracking devices defined by Drift Tubes (DT) in the barrel and Cathode Strip Chambers (CSC) in the endcaps.

A total of 480 chambers in the Barrel (about 2400 $m^2$ of double gaps working in avalanche mode) and 432 in the EndCaps (about 1500 $m^2$ of double gaps) are installed inside the iron slabs used to close the magnetic flux of the solenoid.

The system volume is 18 $m^3$ flushed at a rate of 5 $m^3$/h and operated in closed loop with a fresh mixture addition of 10 % per cycle. This is the first time that a so large number of RPCs has been performed with a closed loop system, so special care is dedicated to the study of the detector stability.

To monitor the system stability the Dark Current behaviour is taken under control. During the Data taking period every RPC chamber (about 5 $m^2$ of double gap) have been worked with a dark current below 9 $\mu A$. The trend versus time of the dark current averaged over all the barrel chambers is reported in Fig.1 showing that the system works with an average dark current well below 1.5 $\mu$A.

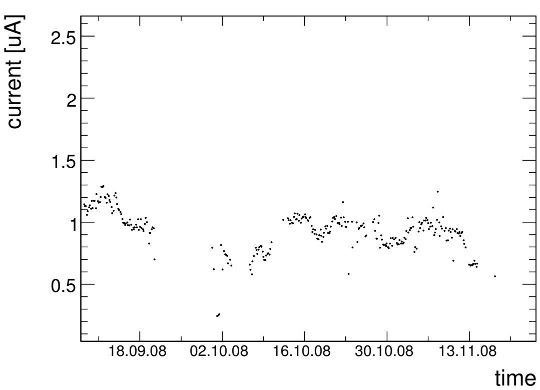


Figure 1: RPC Dark Current averaged over all the barrel chambers as a function of the time during the CRaFT period

## 3. RPC detector performance

The CRaFT data have been fundamental to study the synchronization of the RPC system. Signals coming from different regions of the detector arrive to the readout electronics at different times due to time of flight, time of propagation along the strip and different cable lengths. In order to get the maximum efficiency all the signals should be collected in the same bunch crossing interval. Additional difficulties arise because of the asynchronous arrival time of the Cosmic Rays respect to the bunch crossing reference. Data collected have been used to synchronize in the best way all the chamber signals and the trigger response of the RPC system with respect to the other triggers.

After the synchronization the performance othe detector have been studied making use of the interplay between DT/CSC muon system and RPCs. Barrel RPCs can be studied by making use of the local reconstruction of the DT hits at chamber level.

The extrapolation of DT segment on the RPC plane gives the possibility to study the RPC performance at local level. For every extrapolation on the RPC surface, RPC fired strips are checked in a small region around the impact point (± 2 strips).

Although with a rough precision the RPCs are a position detector. Contiguous fired strips on the same RPC plane are merged together to define a cluster. The cluster size is the number of fired strips of the cluster generated by a crossing particle. This number is a function of the strip pitch that range between 2.3 cm and 4.1 cm according to the layer position and of the incident angle. The mean value of the cluster size integrated overall the barrel system is 1.5 and about 90 % of the clusters have less than 3 strips fired.

The centre of the cluster is a good estimator of the particle crossing position. The residual distribution of the difference between the extrapolated point and the centre of the cluster is still a function of the strip pitch and of the cluster size. The residual distribution integrated overall the barrel system shows a sigma of about 1.12 cm.

RPC detection efficiency has been studied during the CRaFT period taking data at different applied High Voltage and estimating the maximum efficiency for every double gap RPC of the system. The RPC is considered efficient if at least a fired strip has been found at a distance of (± 2 strips) respect to the impact point extrapolated from the DT segment. The results obtained in terms of efficiency are still preliminary due to the random arrival time of the cosmic rays that could arrive off time on some RPC layer, and to the still-not-optimized signal threshold and working voltage. The data have been used anyway to study the tools for efficiency measurement and to get first indications about the performance. Hardware problems like dead gaps, noisy or dead strips and swapped cables have been identified and fixed during the shut down activities. Preliminary results show an efficiency distribution around 93 %.

## 4. Conclusions

For the first time during the end of 2008 the CMS experiment has been operated as whole system. The complete barrel RPC system has been studied and preliminary results show good performance in terms of dark current, position measurements and stability of the operations. All the tools for system synchronization and efficiency measurement have been developed and preliminary results show an average maximum efficiency greater than 91 % for the barrel RPCs.

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