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The Compact Muon Solenoid Experiment

Conference Report

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CMS Resistive Plate Chambers performance at $\sqrt{s}$ =13 TeV

Andres Leonardo Cabrera Mora on behalf of the CMS Collaboration

Abstract

During 2015, the Large Hadron Collider (LHC) at CERN has reached the record-breaking center-of-mass energy of 13 TeV for proton-proton collisions. The LHC restarted operations successfully after a two-year technical stop, known as Long Shutdown 1 (LS1), needed for servicing and consolidating the CERN accelerator complex. The Compact Muon Solenoid detector, a general-purpose detector at LHC, benefited from LS1 by performing crucial tasks necessary to operate the detector at higher energies. In particular, the Resistive Plate Chamber (RPC) system, one of the three muon detector technologies in CMS, was serviced, re-commissioned, and upgraded with 144 new chambers to enhance muon trigger efficiency. The CMS RPC system confers robustness and redundancy to the muon trigger. A total of 1056 double-gap chambers cover the pseudo-rapidity region $|\eta| \leq$1.6. The CMS RPC collaboration has exploited early data samples at 13 TeV for detector performance studies. These data allowed for a first characterization of the newly installed chambers. The results obtained are presented here.

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I. Introduction

The Compact Muon Solenoid (CMS) [1] is one of the two general purpose experiments from the LHC [2]. One of the most important tasks of the experiment is to detect muons. Their presence in the final state of a proton-proton collision is usually a sign of interesting physics. For example, one of the cleanest signatures of the Higgs Boson is its decay with four muons in the final state, also, it is expected that muons will be produced in the decay of a number of potential new particles [3]. The muon system of the CMS experiment has three different type of gaseous detectors. For an accurate measurement of the muon trajectory, in the central region of the barrel ($|\eta|$ <1.2), Drift Tubes (DT) are used. Cathode Strip Chambers (CSC), are used in the endcap region (0.9< $|\eta|$ <2.4) for the same purpose. In both, the barrel and the endcap region ($|\eta|$ <1.6 for L1 trigger and $|\eta|$ <1.8 for reconstruction), Resistive Plate Chambers (RPC) are installed as it is shown in figure 1. RPCs provide a fast signal when there is a muon passing through them, this signal is used to activate the DTs, CSCs and the overall data acquisition system of the CMS experiment [4].

II. Resistive Plate Chambers Configuration

The RPCs are gaseous detectors [6] with good time resolution (1 ns, 50 ps for multiple-gap RPCs) and spatial resolution ($\leq$10 mm) [7] that can identify the passage of charged particles. An RPC is made of two parallel plates with a phenolic high pressure laminate (HPL, bakelite). Resistive plates of resistivity ranging from 10^{10} to 10^{11} Ωcm are separated by a 2 millimeter gas gap as can be seen in figure 2. The outer layers of the plates are covered with graphite paint to form the electrodes of the chamber. One electrode acts as the ground, and the other has a specific electric potential for the measurement of the ionization produced in the chamber [8]. Copper strips that are separated by a layer of insulating material (mylar or PET film) receive the output signal (see figure 2).

The CMS experiment uses double gap RPC chambers (see figures 2 and 3). They are operated in avalanche mode with a gas mixture of three components (with 35%-40% of Humidity):

- 95.2% $C_2H_2F_4$ (Tetrafluoroethane, R-134a)
- 4.5% iC_4H_{10} (Isobutane)
- 0.3% SF_6

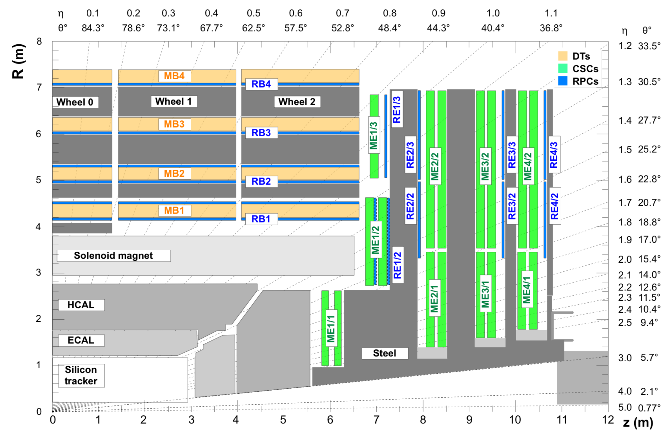

Fig. 1. Cross section of a quadrant of the CMS detector [5]

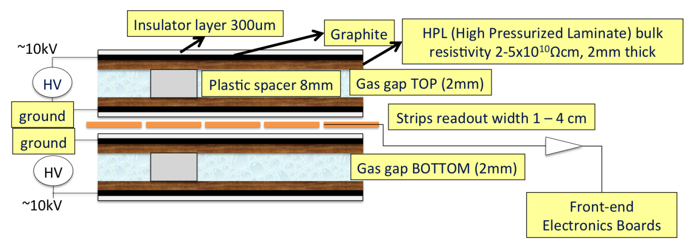

Fig. 2. Cross-section of a Resistive Plate Chamber.

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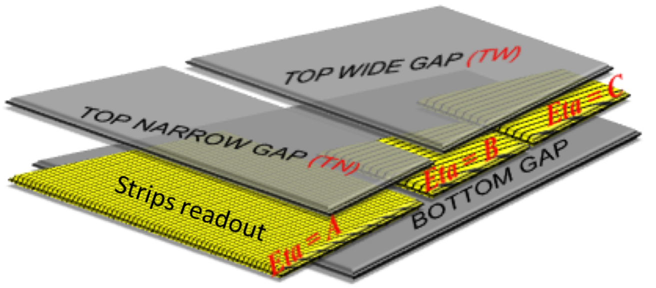

Fig. 3. Representation of an RPC Dougle gap chamber in the CMS Experiment.

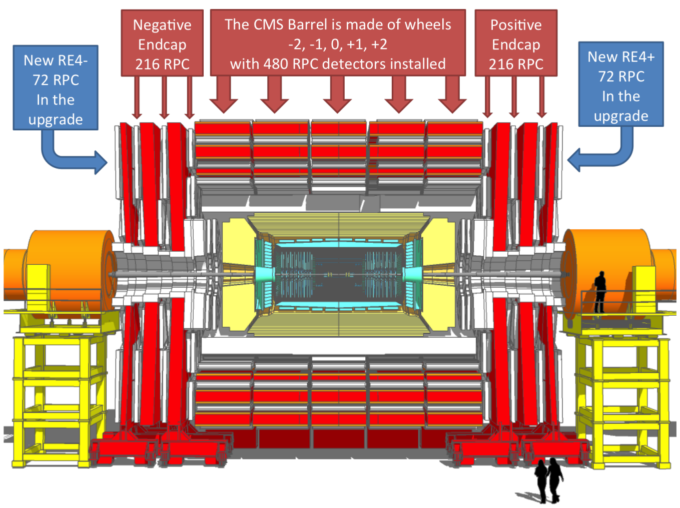

Fig. 4. RPC Chamber Distribution in the CMS Experiment.

III. RPC Chamber Distribution in the CMS Experiment

The barrel region of the CMS experiment is equipped with 480 RPC chambers. Each endcap region (positive and negative) is equipped with 216 chambers.

During the long shutdown of the LHC in 2013 and 2014, additional 144 RPC chambers were installed in the endcap region, corresponding to the RE4/2 and RE4/3 stations in figure 1. There are in total 1056 RPC chambers for the entire CMS experiment as can be seen in figure 4. Given the increased redundancy with these upgrades, higher efficiency is achieved in the Level 1 muon trigger. The extra RPC stations allow the possibility to tighten the trigger quality requirements, producing a reduction on the rate, while keeping a reasonably low threshold with a high instantaneous luminosity [3].

IV. RPC Performance

The RPCs are efficiently taking high-quality data. The efficiency is determined by taking the ratio of number of detected to the number of expected muon hits. This latest number is obtained from the extrapolation of muons reconstructed only in the muon system of the CMS experiment, without the RPC system. Segments (DT in the Barrel and CSC in the Endcap) that belong to this muon track, are selected and extrapolated to the plane of a given RPC. The detector unit is considered

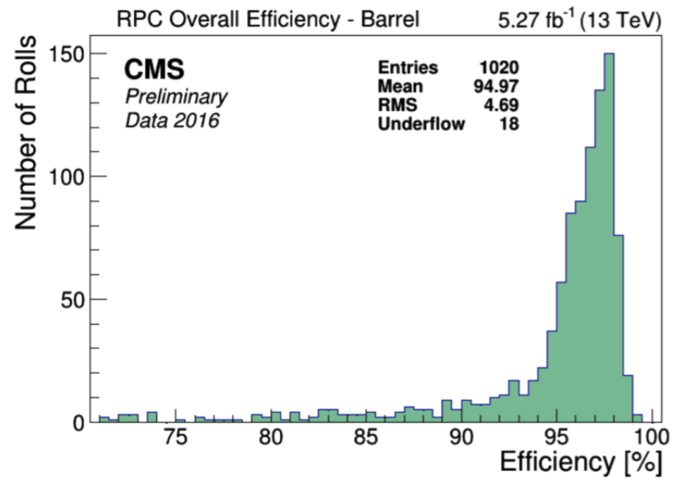

Fig. 5. Efficiency (%) of each RPC in the CMS Barrel to provide reconstructed hits [9].

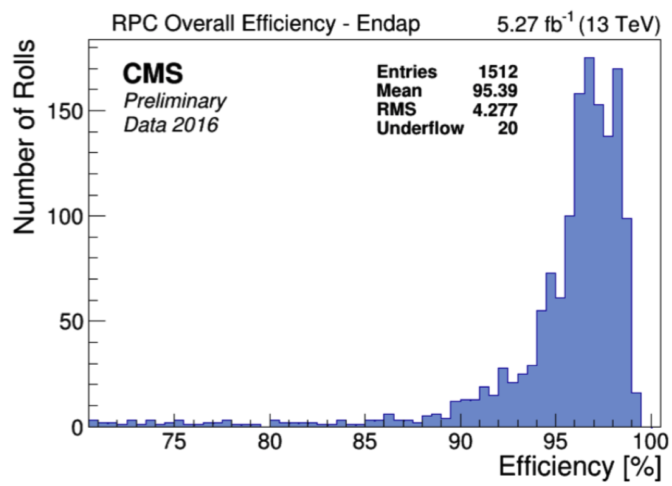

Fig. 6. Efficiency (%) of each RPC in the CMS Endcap to provide reconstructed hits [9].

efficient if an RPC reconstructed hit is found within $\pm$ 2 strips from the position extrapolated from the DT/CSC segment [9]. Figures 5 and 6 show the efficiencies of the RPC chambers for both Barrel and Endcap, respectively.

Acknowledgment

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