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PERFORMANCE OF GAS GAIN MONITORING SYSTEM OF THE CMS RPC SYSTEM

Luigi Benussi for the CMS Collaboration

Abstract

The RPC muon system of experiment CMS at the LHC (CERN, Geneva Switzerland) is equipped with a Gas Gain Monitoring (GGM) system. The GGM is composed of twelve square single-gap RPC chambers in a cosmic ray hodoscope. Each chambers working point is continuously monitored to detect changes among fresh, before purifiers, after purifiers gas mixtures. The GGM has been in operation for the whole duration of 2011-2012 data taking period. Weekly efficiency scans were performed and gas problems were detected. A report of both performance and experience gained is given.

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Performance of the gas gain monitoring system of the CMS RPC muon detector

**L. Benussi[a,*], S. Bianco[a], L. Passamonti[a], D. Piccolo[a], D. Pierluigi[a], G. Raffone[a],
A. Russo[a], G. Saviano[a,+], Y. Ban[b], J. Cai[b], Q. Li[b], S. L[b]iu, S. Qian[b], D. Wang[b], Z. Xu[b],
F. Zhang[b], Y. Choi[c], D. Kim[c], S. Choi[d], B. Hong[d], J.W. Kang[d] , M. Kang[d], J.H. Kwon[d],
K.S. Lee,[d], S.K. Park[d], L. Pant[e], V.B.J. Singh[f], A.M.R. Kumar[f], S. Kumar[f],
S. Chand[f], A. Singh[f], V.K. Bhandari[f], A. Cimmino[g], A. Ocampo[g], F. Thyssen[g],
M. Tytgat[g], W. Van Donink[h], A. Ahmad[i], S. Muhamma[i], M. Shoaib[i], H. Hoorani[i],
I. Awan,[i] I. Ali[i], W. Ahmed[i], M.I. Asqhar[i], H. Shahzad[i], A. Sayed[l], A. Ibrahim[l], S. Ali[l],
R. Ali[l], A. Radi[l], T. Elkafrawi[l], A. Sharma[m], S. Colafranceschi[m], M. Abbrescia[n],
P. Verwilligen[n], S. Meola[o], N. Cavallo[o], A. Braghieri[p], P. Montagna[p], C. Riccardi[p],
P. Salvini[p], P. Vitulo[p], A. Dimitrov[q], R. Hadjiiska[q], L. Litov[q], B. Pavlov[q], P. Petkov[q],
A. Aleksandrov[r], V. Genchev[r], P. Iaydjiev[r], M. Rodozov[r], G. Sultanov[r], M. Vutova[r],
S. Stoykova[r], H.S. Ibargüen[s], M.I. Pedraza Morales[s], S. Carpinteyro Bernardino[s],
I. Bagaturia[t], Z. Tsamalaidze[t].**

[a] *Laboratori Nazionali di Frascati dell'INFN, Frascati, Italy*
[b] *Peking University, Peking, China*
[c] *SKK University, Seoul, S. Korea*
[d] *Korea University, Seoul, S. Korea*
[e] *BARC, Mumbai, India*
[f] *Chandigarh University, India*
[g] *Ghent Unversity, Ghent, Belgium*
[h] *VUB, Bruxelles, Belgium*
[i] *NCP, Islamabad, Pakistan*
[l] *ENHEP, Cairo, Egypt*
[m] *CERN, Geneve, Switzerland*
[n] *Università di Bari and INFN Bari, Bari, Italy*
[o] *Università di Napoli and INFN Napoli, Napoli, Italy*
[p] *Università di Pavia and INFN Pavia, Pavia, Italy*
[q] *University of Sofia, Sofia, Bulgaria*
[r] *INRNE, Sofia, Bulgaria*
[s] *Puebla University, Puebla, Mexico*
[t] *Tbilisi University and IHEPI, Tbilisi, Georgia*
[+] *also at Università degli Studi di Roma La Sapienza, Rome, Italy*
[*] *E-mail:* `luigi.benussi@lnf.infn.it`

ABSTRACT: The RPC muon detector of the CMS experiment at the LHC (CERN, Geneva, Switzerland) is equipped with a Gas Gain Monitoring (GGM) system. A report on the stability of the system during the 2011-2012 data taking run is given, as well as the observation of an effect which suggests a novel method for the monitoring of gas mixture composition.

KEYWORDS: CMS; RPC; muon detector; gas detector.

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[*] Corresponding author.

Contents

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1. Introduction

The Resistive Plate Counter (RPC) muon detector of the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider (LHC) at CERN is equipped with a Gas Gain Monitoring (GGM) system. Detailed descriptions of the GGM can be found in [1, 2, 3, 4]. The system has been in operation for the whole duration of the 2011-2012 CMS data taking period. A report of both its performance and the experience gained with it is given. A novel algorithm to spot gas mixture changes which exploits the time propagation of the mixture in the recirculation system is proposed.

2. Experimental setup

The GGM system is composed of 12 square single-gap RPC detectors arranged as a cosmic ray hodoscope (Fig.1). The GGM is located on the surface, in the SGX5 gas room of the CMS experimental area.

The system is designed to provide a fast and accurate determination of any shift in the working point of its chambers due to gas mixture changes. It compares three different gas mixtures from the CMS experiment: a newly supplied fresh gas mixture, and the gas mixture before and after the filters of the closed-loop recirculation system.

The 12 single bakelite gaps have a double pad readout (4 trigger gaps, 8 signal gaps) which allows removal of coherent noise (*i.e.,*the environmental baseline noise showing on both pads) by summing algebrically signals from both pads. The average event rate is 5 Hz, corresponding to about 30 minutes for 10000 events. Anode charge distributions are collected for blocks of 30 minutes, and changes of the charge averages over time provide indications of changes in the working point of the GGM chambers. An automatic compensation of environmental effects on the chamber responses is achieved by means of two-gap ratios of anode charge distributions (Fig.2).

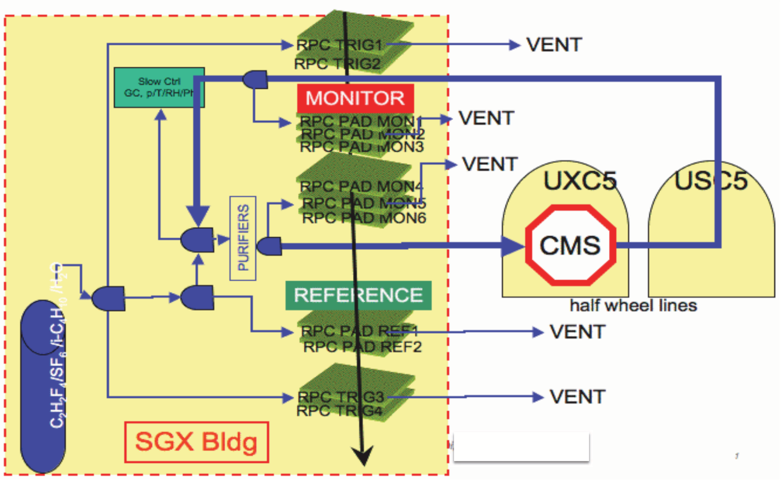

Figure 1. Schematic layout of the GGM and closed-loop gas recirculation system of the CMS RPC detector.

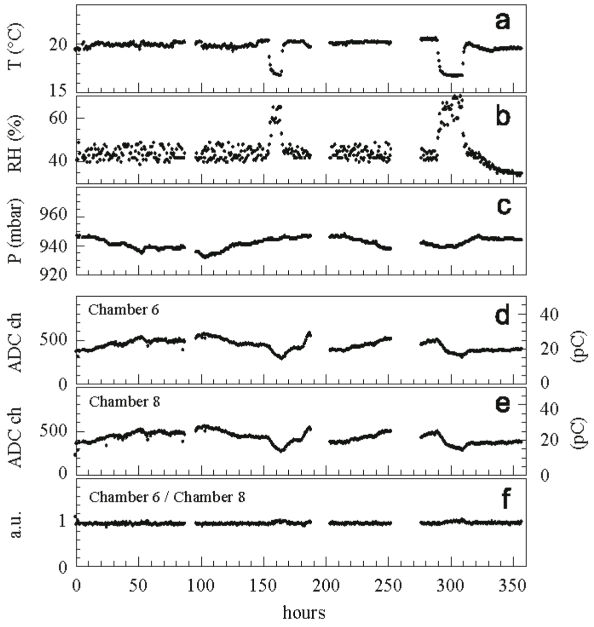

Figure 2. The principle of automatic compensation of environmental effects by charge ratios: environmental variables such as temperature (a), relative humidity (b), atmospheric pressure (c), gaps anodic charges (d,e) and their ratio (f).

2.1 High-voltage scans

The GGM system was designed to detect changes in the working point of the chambers via differences between a fresh gas mixture, and the mixtures before and after the purifiers of the gas recirculation system, using by also the charge ratio algorithm. Next to that, weekly RPC high voltage (HV) scans were performed which additionally provided a direct measurement of the GGM working point, allowing to spot changes in the gas mixture composition.

Fig. 3 shows typical HV scans of two GGM single-gap chambers, as a function of effective HV supply

$$HV_{eff} = HV \frac{p_0}{p} \frac{T}{T_0}. \tag{2.1}$$

The HV_{eff} value corresponding to the effective voltage where the chamber efficiency ε is at 50% of its maximum

$$HV50 \equiv HV_{eff}(\varepsilon = \varepsilon_{max}/2) \tag{2.2}$$

is a parameter sensitive to any change of the working point.

The HV50 parameter is shown for a few GGM chambers in Fig. 4 as a function of time for the 2011-2012 data taking period.

Each HV50 value is sensitive to common environmental effects that are not corrected for by the HV feedback. A normalization method taking the ratio of the HV50 values for the gas mixtures in the closed-loop system and the fresh gas mixture, provides a stable response over a period of several months (Fig.5).

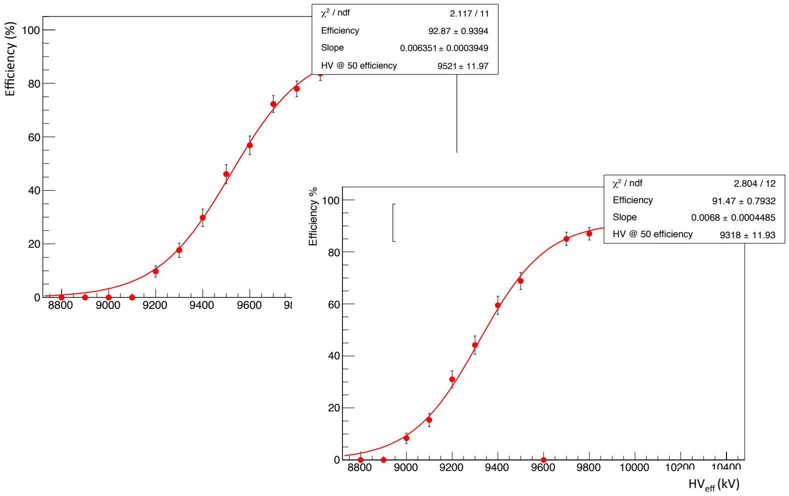

Figure 3. Typical HV scans for two GGM single-gap chambers.

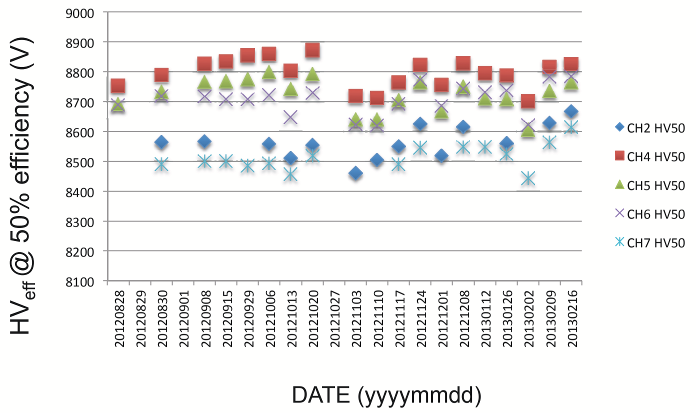

Figure 4. Dependence of HV50 (defined in text) as a function of time over the 2011-2012 data taking period.

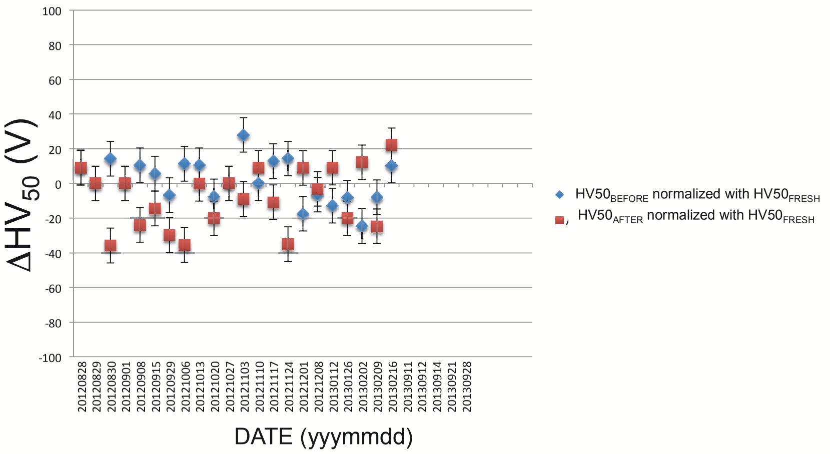

Figure 5. Dependence of normalized HV50.

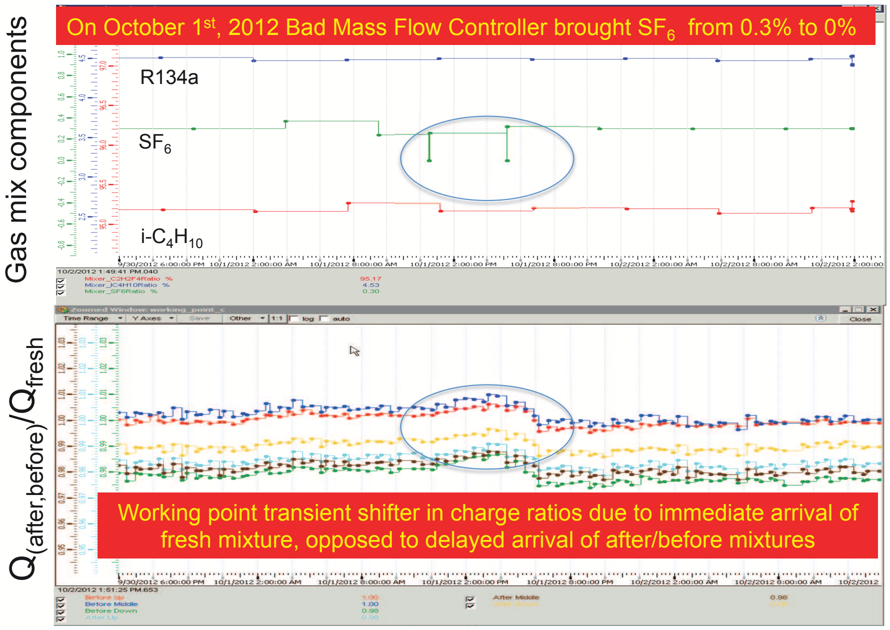

Figure 6. Failure of SF_6 mass flow controller (top); interference pattern observed in the online monitoring tool for all charge ratios of the GGM.

2.2 Time transient

An unexpected feature was observed thanks to a failure of one of the mass flow controllers of the gas mixer (Fig. 6). The pattern observed in all charge ratios is interpreted as the interference of the working point changes due to the gas mixture change, convoluted with the transit time of the gas mixture inside the closed-loop recirculation system. The fresh gas mixture reaches the GGM before both the affected gas mixtures from before and after the purifiers in the closed-loop system, thus causing the interference pattern shown in Fig. 7.

3. Conclusions

Preliminary results on the operational experience of the GGM system during the CMS 2011-2012 data taking period were given. Weekly HV scans provide direct measurements of the GGM working point. When corrected for common environmental effects, the system shows a stability in working point at the level of 20V over nearly two years. A failure in one of the mass flow controller provided hints to define a new tool for the fast monitoring of the gas mixture composition, by exploiting the propagation time of gas in the recirculation system and the difference in arrival time at the GGM of the fresh and before and after purifier gas mixture.

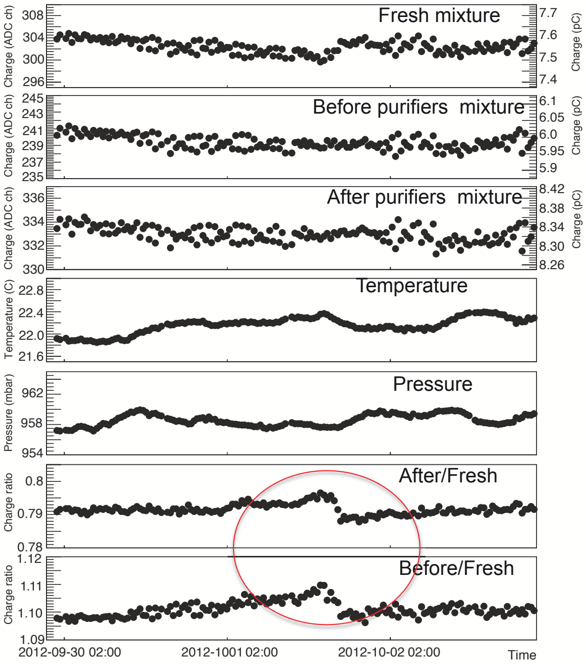

Figure 7. Analysis of the transient interference pattern and correlation with charges and environmental parameters.

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