Preliminary Cluster Size and Efficiencies results of CMS RPC at GIF++

Genoveva Gonzalez Blanco Gonzalez for the CMS Collaboration

Abstract

A brief description and first preliminary results of the Efficiencies and Cluster Size measurements of the CMS Resistive Plate Chambers, will be presented inside the Gamma Irradiation Facility GIF++ at CERN. Preliminary studies that sets the base performance measurements of CMS RPC for starting aging studies.

Presented at RPC2016 The XIII workshop on Resistive Plate Chambers and Related Detectors
Efficiencies results of CMS RPC at GIF++

G. Gonzalez Blanco, a, S. Carrillo Moreno, a, F. Vazquez Valencia, a, M. Gul, b, M. Tytgat, b, N. Zaganidis, b, A. A. O. Rios, b, A. Fagot, b, S. Crucy, b, A. Cimmino, b, G. Singh, c, M. Abbrescia, d, G. Iaselli, d, M. Maggi, d, G. Pugliese, d, P. Verwilligen, d, W. Van Doninck, e, S. Colafranceschi, f, A. Sharma, f, L. Benussi, g, S. Bianco, g, D. Piccolo, g, F. Primavera, g, V. Bhatnagar, h, J. Singh, h, R. Kumari, h, A. Mehta, h, A. Ahmad, i, W. Ahmed, i, M. I. Asghar, i, I. M. Awan, i, H. Hoorani, i, S. Muhammad, i, H. Shahzad, i, M. A. Shah, i, S. W. Cho, j, B. Hong, j, S. Y. Choi, j, M. H. Kang, j, K. S. Lee, j, J. H. Lim, j, S. K. Park, j, M. S. Kim, k, G. Grenier, l, M. Gouzevitch, l, F. Lagarde, l, I. B. Laktineh, l, C. Uribe Estrada, m, I. Pedraza, m, S. Carpinteyro Bernardino, m, L. M. Pant, m, Y. Assran, m, A. Radi, o, S. Aly, o, A. Sayed, o, S. Buontempo, p, N. Cavallio, p, M. Esposito, p, F. Fabozzi, p, G. Lanza, p, I. Orso, p, L. Lista, p, S. Meola, p, M. Merola, p, P. Paolucci, p, F. Thyssen, p, A. Braghieri, q, A. Magnani, q, P. Montagna, q, C. Riccardi, q, P. Salvini, q, I. Vai, q, P. Vitulo, q, Y. Ban, s, S. J. Qian, s, M. Choi, s, Y. Choi, s, J. Goh, s, D. Kim, s, A. Aleksandrov, s, R. Hadjiiska, s, P. Iaydjiev, s, M. Rodozov, s, S. Stoykova, s, G. Sultanov, s, M. Vutova, s, A. Dimitrov, s, L. Litov, s, B. Pavlov, s, P. Petkov, s, D. Lomidze, s, I. Bagaturia, s, C. Avila, t, A. Cabrera, t, J. C. Sanabria, t, I. Crotty, t, J. Vaitkus, t.

a Universidad Iberoamericana, Department of Physics, Mexico City, Mexico.
b Ghent University, Department of Physics and Astronomy, Proeftuinstraat 86, 9000 Gent, Belgium.
c Chulalongkorn University, Department of Physics, Phatumwan, Bangkok, THAILAND - 10330.
d INFN, Sezione di Bari, Via Orabona 4, IT-70126 Bari, Italy.
e Vrije Universiteit Brussel, Boulevard de la Plaine 2, 1050 Ixelles, Belgium.
f Physics Department CERN, CH-1211 Geneva 23, Switzerland.
g INFN, Laboratori Nazionali di Frascati (LNF), Via Enrico Fermi 40, IT-00044 Frascati, Italy.
h Department of Physics, Punjab University, Chandigarh Mandir 160 014, India.
i National Centre for Physics, Quaid-i-Azam University, Islamabad, Pakistan.
j Korea University, Department of Physics, 145 Anam-ro, Seongbuk-gu, Seoul 02841, Republic of Korea.
k Kyungpook National University, Daegu, Korea.
l Universite de Lyon, Universite Claude Bernard Lyon 1, CNRS-IN2P3, Institut de Physique Nucleaire de Lyon, Villeurbanne, France.
m Benemerita Universidad Autonoma de Puebla, Puebla, Mexico.
n Nuclear Physics Division Bhabha Atomic Research Centre Mumbai 400 085, INDIA.
o Egyptian Network for High Energy Physics, Academy of Scientific Research and Technology, Cairo Egypt.
p INFN, Sezione di Napoli, Complexo Univ. Monte S. Angelo, Via Cintia, IT-80126 Napoli, Italy.
q INFN, Sezione di Pavia, Via Bassi 6, IT-Pavia, Italy.
r School of Physics, Peking University, Beijing 100871, China.
s Korea University, Department of Physics, Seoul Cheongryangri 143-701, Republic of Korea.

* Corresponding author.
ABSTRACT: A brief description and first preliminary results about CMS Resistive Plate Chambers efficiency, obtained at Gamma Irradiation Facility GIF++ at CERN will be presented in the paper. Preliminary studies that sets the base performance measurements of CMS RPC for starting aging studies are also carried out.

KEYWORDS: Gaseous detectors; Particle tracking detectors (Gaseous detectors); Resistive-plate chambers; Performance of High Energy Physics Detectors
1. Introduction

The high luminosity at the Large Hadron Collider (HL-LHC) is expected to reach $5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$. This presents a special challenge for the Muon System to trigger on muons with high transverse momenta which represent one of the key indicators of interesting electroweak interactions. The CMS (Compact Muon Solenoid) experiment consists of different particle detectors of which some are RPCs (at the end-caps and at the barrel). An upgrade of the RPC system was driven by the expected increase of peak instantaneous luminosity of LHC. [1]

![CMS detector diagram](image)

**Figure 1.** CMS detector.
1.1 The RPC upgrade for CMS

This upgrade included:

1. Addition of the fourth layer of RPCs on the end-caps (RE4) to extend coverage to $|\eta| = 1.8$ to preserve a low transverse momentum threshold for the Muon Trigger at high instantaneous luminosity.

2. The development of detectors that can extend coverage to the region $1.8 < |\eta| < 2.4$ or even higher.

The first level trigger based on the RPCs provides CMS with the most precise timing in both the barrel and end-cap region. Six concentric layers of chambers are used in the barrel part (RB#), while four layers have been foreseen in total for the end-caps (RE#) to cover a rapidity up to $|\eta| = 2.4$. [2]

![Figure 2. A quadrant of the muon system, showing DT chambers (yellow), RPC (light blue), and CSC (green). The locations of new forward muon detectors for Phase-II are contained within the dashed box and indicated in red for GEM stations (ME0, GE1/1, and GE2/1) and dark blue for improved RPC stations (RE3/1 and RE4/1).[3]](image)

The CMS RPC collaboration is performing aging studies, among many other researches, using the GIF++ facility in which RPCs RE2/2, RE3/2 and RE4/2 are being tested. This way the efficiency of the performance of these detectors can be measure in relation to the irradiation received. The goal of this study is to test if the RPCs are suitable for this angular region under the high irradiation and to check that the system already installed can survive the high rate expected for the HL-LHC.

1.2 GIF++ technical description

The GIF++ (Gamma Irradiation Facility) is specifically suited to test large area detectors in radiation conditions similar to those of the HL-LHC experiments. It has a $^{137}$Cs gamma source
of 13.9 TBq and a beamline (H4). $^{137}$Cs was chosen because the spectrum of primary and scattered photons matches the energy spectrum expected for background in LHC muon detectors (~1 MeV). The 30 years isotope half-life makes the rate from the $^{137}$Cs source relatively stable over the years.

Attenuators regulate the ionizing radiation. Attenuating shields are used to control the radiation received by the RPCs. One attenuator consists of three shield blocks (layer A, B, and C as shown in figure 3). The value of the attenuator can be chosen by selecting a combination of numbers (1 to 3) from the attenuator matrix. Where 111 is zero attenuator factor and 333 is the highest attenuator factor (almost as if the source was off). [4]

![Figure 3. GIF++ overview and $^{137}$Cs gamma source with its attenuators.](image)

2. Efficiencies

2.1 Calculation of the efficiencies

A first HV scan is performed with the irradiation source switched off. In this way we define the working point in absence of background performing a sigmoidal fit to the experimental points. Later we turn on the source and we repeat the procedure with attenuator scan. The formula used is the following:

$$\text{Efficiency} = \frac{N_4}{N_3}$$

$N_3$: To construct a Muon only three CMS RPC chambers are used. If there is a hit in the three of them within a time period, Number of reconstructed Muons using 3 chambers ($N_3$) is increased by one.

$N_4$: The Muon Track (Stub) is projected to the fourth chamber and if there is a hit within some strips difference then Number of reconstructed Muons using 4 chambers ($N_4$) is increased by one.

The fitted efficiency $\langle E \rangle$ curve is given by a sigmoidal function of $HV_{eff}$ using the following parameters:

- $E_{\text{max}}$: asymptotic efficiency.
- $HV_{50\%} = \frac{E_{\text{max}}}{2}$ inflection point
  (the high voltage when the efficiency is half of the maximal one).
- $\lambda \propto$ slope at inflection point.

$$\langle E \rangle = \frac{E_{\text{max}}}{1 + e^{-\lambda(HV_{eff} - HV_{50\%})}}$$
Adjusting those parameters the working point of the chamber is:

\[ HV_{wp} = HV_{knee} + 150 \text{ V} \]

- \( HV_{knee} \): the voltage where efficiency is 95% of the maximal one.

### 2.2 Efficiency Results

The following graphs show the efficiency of the RE2/2 performance and the efficiency vs. the rate for the four RPCs (two RE2/2 and two RE4/2).

![Figure 4. High voltage efficiency comparison scan between different gamma attenuator factors, with muon beam on for RE2/2.](image)

![Figure 5. Efficiency vs. Rate. T1 stands for Trolley 1, which is the consolidation trolley where older chambers (RE2 and RE4) are placed to be tested. S# is the slot inside the trolley (S1 is RE2/2-NPD-BARC-8, S2 is RE2/2-NPD-BARC-9, S3 is RE4/2-CERN-166, S4 is RE4/2-CERN-165).](image)

### 3. Conclusions

The performance of RE2/2 and RE4/2 CMS RPC chambers at GIF++ was measured before starting the aging studies, this gave the reference point for future measurements. Combining our results for all CMS RPC chambers (two RE2/2 and two RE4/2) we get \( \text{Eff}_{\text{max}} \) vs Rate (at \( HV_{wp} \)) 95% of \( \text{Eff}_{\text{max}} \) at a rate of 600 Hz/cm². This is vital for the future work owing to the fact that a reference efficiency is needed in order to compare its fluctuation in time and irradiation.

### Acknowledgments

I would like to express my sincere gratitude to my advisors Salvador Carrillo, Fabiola Vazquez and Cristina Oropeza, for their continuous support to the project. Besides my advisors, I would like to thank the rest of the RPC team, especially Dr. Gabriella Pugliese, Dr. Nikolas Zaganidis, Dr. Ian Crotty, Dr. Iuri Bagaturia and PhD student Alexis Fagot, for their patience, trust, sharing their knowledge with me and allowing me to be part of a research team at CERN. I also thank not only my co-worker but friend Kleomenes Stamatiades for always being there.
for me. Finally, I want to acknowledge the enduring support for the construction and operation of the LHC and the CMS detector provided by the following funding agencies: BMWFW and FWF (Austria); FNRS and FWO (Belgium); CNPq, CAPES, FAPERJ, and FAPESP (Brazil); MES (Bulgaria); CERN; CAS, MoST, and NSFC (China); COLCIENCIAS (Colombia); MSES and CSF (Croatia); RPF (Cyprus); MoER, ERC IUT and ERDF (Estonia); Academy of Finland, MEC, and HIP (Finland); CEA and CNRS/IN2P3 (France); BMBF, DFG, and HGF (Germany); GSRT (Greece); OTKA and NIH (Hungary); DAE and DST (India); IPM (Iran); SFI (Ireland); INFN (Italy); MSIP and NRF (Republic of Korea); LAS (Lithuania); MOE and UM (Malaysia); BUAP, CINVESTAV, CONACYT, SEP, and UASLP-FAI (Mexico); MBIE (New Zealand); PAEC (Pakistan); MSHE and NSC (Poland); FCT (Portugal); JINR (Dubna); MON, RosAtom, RAS and RFBR (Russia); MESTD (Serbia); SEIDI and CPAN (Spain); Swiss Funding Agencies (Switzerland); MST (Taipei); ThEPCenter, IPST, STAR and NSTDA (Thailand); TUBITAK and TAEK (Turkey); NASU and SFFR (Ukraine); STFC (United Kingdom); DOE and NSF (USA).

References


