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Production and quality control of GEM detectors for the Phase 1 upgrade of the CMS experiment

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Abstract

The CMS collaboration has approved the installation of an additional set of muon detectors based on triple-GEM technology in the first endcap muon station known as GE1/1 [1]. They will be installed in 2019 during the second Long Shutdown (LS2) planned by LHC. The chambers will be built by different production sites in Europe, Asia and the United States. In each production site, the chamber quality and performance are measured by systematic inspections and standardized procedures to ensure the timely delivery of fully efficient detectors to CMS.

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Production and quality control of GEM detectors for the Phase 1 upgrade of the CMS experiment

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Summary. — The CMS collaboration has approved the installation of an additional set of muon detectors based on triple-GEM technology in the first endcap muon station known as GE1/1 [1]. They will be installed in 2019 during the second Long Shutdown (LS2) planned by LHC. The chambers will be built by different production sites in Europe, Asia and the United States. In each production site, the chamber quality and performance are measured by systematic inspections and standardized procedures to ensure the timely delivery of fully efficient detectors to CMS.

1. – Introduction

Exploiting the physics potential of phase-1 LHC at high luminosity ($\mathcal{L} = 2{\cdot}10^{34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$) requires an improved L1 (Level 1) muon triggering in the forward region to reduce the contribution of mismeasured low p_T muons. The installation of the muon GEM detectors in the first endcap muon station of the CMS will improve the muon triggering and reconstruction in the forward region with pseudorapidity $1.55 < |\eta| < 2.18$. The GE1/1 chambers have an efficiency of 98%, a spatial resolution of $290\,\mu$m and rate capability of about $10^5\,\mathrm{Hz/cm}^2$; the time resolution is $\leq 10\,\mathrm{ns}$ [1]. The excellent performances of triple GEM detectors will allow to cope with the challenging data-taking conditions of High Luminosity LHC Run.

2. – Quality Control (QC)

The GE1/1 chamber assembly and quality control checks will take place at several selected sites. At the site of INFN Bari, a suitable setup has been arranged to accomplish the quality controls (QC) for the new triple GEM detectors GE1/1. Quality control operations are performed at Bari as well as in the different sites and some of the results are reported in this section.

The QC_2 test determines the GEM foil quality by measuring the maximum leakage current flowing through the GEM holes. It is performed in a clean room applying a voltage of 500 V to the foil. The QC_2 test is performed before and after assembly.

The QC_3 quality control is a gas leak measurement of the detector with CO_2. It includes the calibration of the gas system itself. The detector fullfills the test if the pressure drop inside the detector does not exceed 1 millibar per hour, in this way the detector gas-sealing is validated.

The QC_4 quality control identifies possible defects in the High Voltage circuit and checks the linear behavior of the detector. The detector is flushed with pure CO_2 and powered up to 5kV. A charge sensitive pre-amplifier connected to the bottom electrode of the third GEM foil allows to measure the rate of spurious signals. The detector passes the test if the rate of spurious signals is ≤ 10 Hertz.

The last test, QC_5 [3], consists of two measurements: the effective gain and the response uniformity of the detector. Both are evaluated using an X-ray tube with silver target. The effective gain is measured as a function of the applied voltage as the ratio between the output current and the rate of converted photo-electrons created in the detector gas volume. It is performed on a reference sector. Typical results of this test are shown in Figure 1 for a batch of chambers produced at CERN. The response uniformity of the detector is evaluated by measuring the pulse height distribution of the photons produced by copper fluorescence. The pulse height distribution is measured on the entire active surface of GE1/1 detector through APV readout chips [2]. The response of each sector of the chamber is required to be uniform within 15 %. The typical spectrum recorded by a GE11 detector is shown in Figure 2.

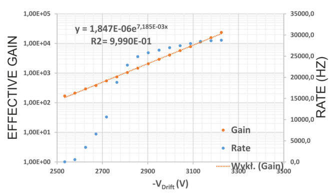

Fig. 1. – Effective gain vs the voltage applied to the drift electrode measured for the GE11 detector.

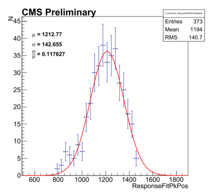

Fig. 2. – Example of copper fluorescence spectrum recorded by a GE11 detector.

3. – Conclusions

In January 2017 the GE11 detectors produced at CERN that successfully passed all quality controls have been installed in the CMS detector in order to gain operational experience and prepare the integration of the GE1/1 chambers into the trigger. The construction of the full GE1/1 detectors is in process aiming for the installation in 2019 in time.

REFERENCES

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