Commissioning and performance of the GE1/1 slice test detectors

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The GE1/1 Slice Test

The GE1/1 station will be installed in the region $1.6 < \eta < 2.2$ by 2020 to keep the muon trigger rate below 5 kHz without increasing the muon momentum threshold and to improve the redundancy in that region [1]. It will be instrumented with Gas Electron Multiplier (GEM), 50 μm thick polymer foil coated with 5 μm copper on each side and perforated with a high density of holes [2]. In particular, the Triple-GEM geometry shown in Fig.1 was selected.

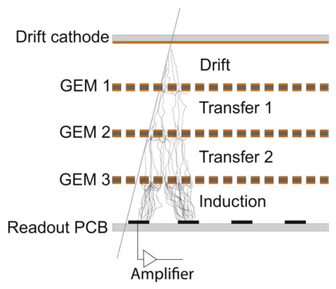

Figure 1: Structure of a Triple-GEM detector.

10 Triple-GEM detectors (5 GEMINI) were installed in the negative CMS endcap (see Fig.2) at the beginning of 2017 with the aim of:

- *Acquiring installation and commissioning expertise*
- *Proving operability for the system*
- *Demonstrating the integration into the CMS online system.*

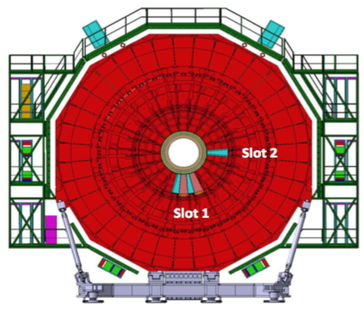

Figure 2: Overview of the Slice Test detectors installed in the CMS endcap.

Slot 1 → *4 GEMINI:*

- *High Voltage (HV) distributed through a ceramic divider.*
- *Readout system based on VFAT2 [3] chip and optohybrid v2b [4]* → *3 Low Voltage (LV) channels for each chamber.*

Slot2 → *1 GEMINI:*

- *HV provided by a multichannel power supply (7 HV channels per chamber).*
- *Since January 2018: new readout system based on VFAT3b [5] chip and optohybrid v3* → *1 LV channel for each chamber.*

All the chambers are operated in Ar/CO2 70:30.

2017 Results

The activity of 2017 included a study of stability of Triple-GEM detectors into the CMS environment. Fig.3 shows the stability of the 7 HV channels of a chamber supplied with the multichannel module. In a period of approximately 12 h during LHC collisions, the variation of the voltage is lower that 1%. The single channel HV and the LV showed similar behavior with and without beam.

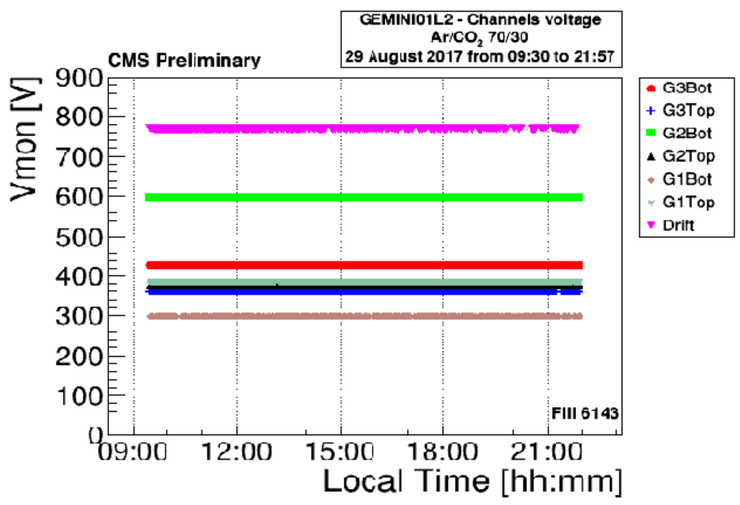

Figure 3: Voltage as a function of the time for one Triple-GEM installed in the slice test and powered with the multichannel module. Each data series represents one of the channels.

An extensive phase of local calibration of the Data AcQuisition (DAQ) system was also carried on. It was based on the development of three main tools, threshold scans, S-curves and latency scans, needed to qualify the DAQ system before the inclusion in CMS.

The Detector Control System (DCS) was locally developed to control the HV and LV system and to monitor the gas system and environmental parameters. A Finite State Machine (FSM) was then added in order to prepare the system for the operation in central DCS.

Integration into CMS

DCS: the GEM DCS was integrated in CMS at the end of 2017, to allow the operation of the new detectors together with the rest of the system. A new node was introduced into the CMS FSM called GEM, which contains two partitions:

- *GEM Endcap (GEM E)* → *physical node*
- *GEM Dummy (GEM Dm)* → *it filters the states from the GEM E partition, while the actions coming from CMS are propagated to GEM E (Fig.4).*

Since the integration, GEMs are following the automation matrix and using the protection system together with the rest of CMS.

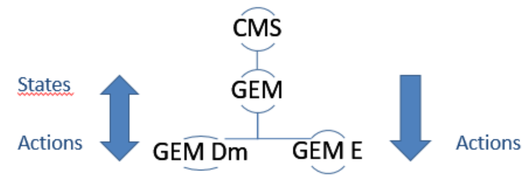

Figure 4: Diagram of the GEM partition into the CMS FSM.

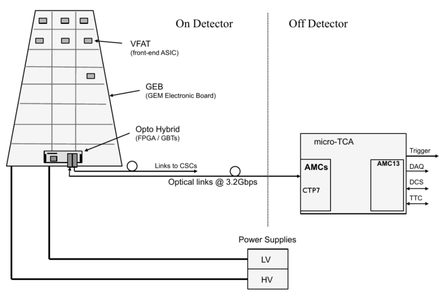

Figure 5: Outline of the GEM readout system.

DAQ: In addition to the local calibration runs, three other main ways of datataking have been exploited:

- *Local run with local readout* → *data are readout directly from the AMC13*
- *Local run with miniDAQ* → *a stripped down version of the cDAQ infrastructure is used to mimic the full path, but it is still separate from the other subsystems*
- *Global run* → *runs fully integrated into the cDAQ infrastructure and events put into the CMS data stream.*

Joining the Global Runs was the primary goal of the DAQ activity and was reached at the end of 2017, where GEM were firstly included into cosmics global runs. The first global collisions runs with GEM included were instead performed at the beginning of 2018.

Data Quality Monitoring (DQM) and analysis: the inclusion of GEM into the global runs entails also the need of monitoring the quality of data collected as well as the performance of the detectors. The first interface for monitoring of the data quality is the Online DQM, which has been deployed for GEM in a very basic version in 2017 and is shown in Fig.6. Moreover, the correct geometry of the GEM Slice Test has been added in the databases and in CMSSW and is going to be validated.

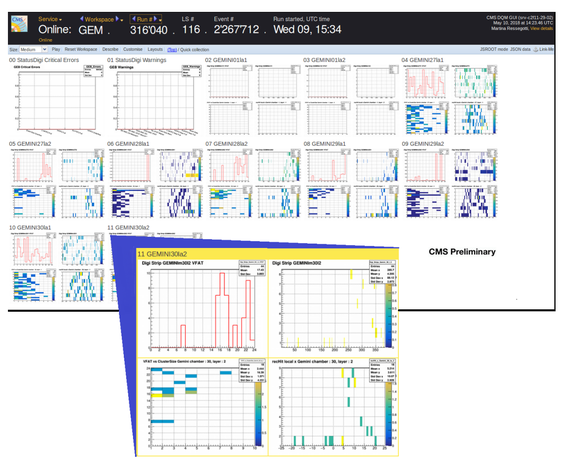

Figure 6: Screenshot of the GEM Online DQM after a short cosmic run. The plots for GEMINI01 are empty because these chambers are not yet included in the global run.

2018 Activity

The activity in 2018 is in progress on several fronts. In particular, the new detectors installed in January in Slot 2:

- *need to be completely qualified from the stability point of view* → *detector stability*
- *are powered with the multichannel power supply and are then at the heart of an extensive study of discharges and microdischarges probability* → *discharge probability test*
- *mount the latest version of electronics, which will be used for the entire GE1/1 station* → *qualification of the new electronics in CMS environment*
- *need to be completely integrated in the DCS and DAQ system in order to be able to operate and take data together with the other detectors* → *inclusion into the DCS and DAQ systems*

The Prompt Feedback Analisys (PFA) group instead is working on the full system to get the first results on the performance of the detectors. At this purpose, they are analyzing the data coming from the first local and global runs. Examples of studies ongoing are the identification of dead channels, the noise characterization and the correlation between hits coming from CSCs and GEMs.

References

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