DAQ Upgrade of Step 3 in Quality Control Procedure for CMS GEM Chambers

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Introduction

Gas Electron Multipliers (GEM) complement existing detectors in the forward regions of CMS, where event rates will increase during the High Luminosity upgrade of the LHC. To ensure the stability of the GEM chambers, ME0 and GE2/1, a series of **Quality Control** tests must be performed. This research aims to upgrade QC3 and create an efficient data handling system for the test results. This upgrade will enhance the analysis of the chambers` internal pressure and implement a weather station through an Arduino, aiming to ensure the chambers are gastight.

GEM Chambers & QC3

GEMs are gaseous detectors. Their foil consists of a 50 micrometer-thick insulating polymer surrounded by copper conductors. Throughout the foil, microscopic holes are etched in a regular hexagonal pattern. The CMS GEM chambers are filled with an Ar/CO2 gas mixture, which is ionized by incident ionizing particles. **The electrons created during the ionization process drift toward the foils and are multiplied in the holes.**

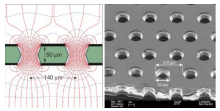


Figure 1: Field lines get compressed inside a GEM hole.

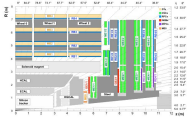


Figure 2: CMS detector

To assess the quality of the GEM detectors, they go through **8 Quality Control tests.** This research aims to upgrade the DAQ of QC3, a test performed to ensure the chambers are gastight. A successful QC3 is achieved when:

1) All gas tubes from and to the detector are not leaking.
2) In a two-hour test, the leak rate is below **5 mbar/hour.**
3) All sensors connected to the Arduino are calibrated and accurate.

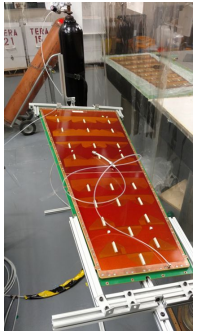


Figure 3: QC3 Test STand

Methods

Previous: QC3 data was acquired with a (cumbersome) LabView program.
Upgrade: **QC3 based on a more general Python-based DAQ with an Arduino controller.**

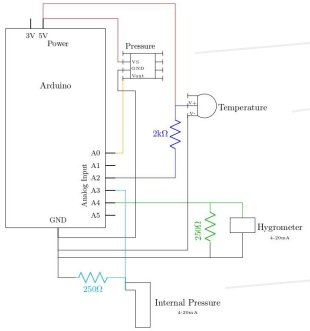
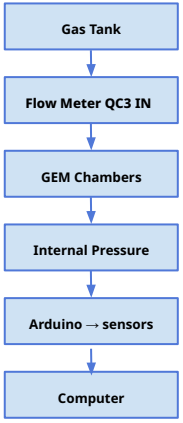


Figure 5: Arduino Diagram


Figure 6: Sensors connected to the arduino



The Arduino code reads the sensors' analog values, and the Python code writes these values to separate files and plots the data using two scripts. The sensors generate 5 variables:

- **Internal Pressure**
- **Atmospheric Pressure**
- **Atmospheric Temperature**
- **Dew Point**
- **PPM (volume)**

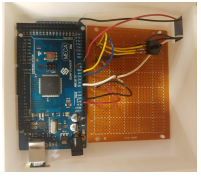
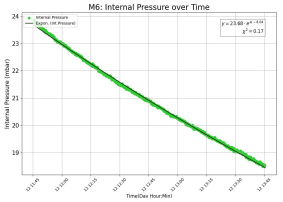
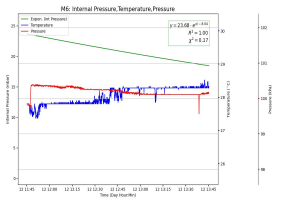


Figure 7: Arduino and Breadboard

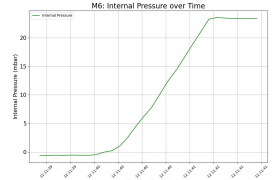
Results



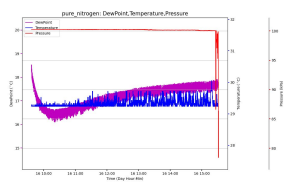
Graph 1: M6 leaking at 2.665 mbar/hour.



Graph 2: Room condition during M6 QC3



Graph 3: M6 internal pressure during first part of QC3



Graph 4: Hygrometer test for weather station

Conclusion

The successful upgrade of the QC3 DAQ ensures the chambers are gastight through an accurate and fast software system, a condition vital to their functionality. Additionally, implementing a multiple-sensor weather station extends the use of the Python scripts and Arduino Codes to other tests performed inside the clean room. Finally, the next steps of the research are proceeding to other QCs to ensure the quality of the CMS chambers.

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