TUPV017

INFN Istituto Nazionale di Fisica Nucleare

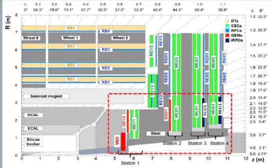
The GEM Gas Monitoring system: using a gaseous detector as a gas detector for CMS Triple-GEM safe operation

A. Braghieri(1), **Davide Fiorina**(1), P.Vitulo(1)
On behalf of the CMS collaboration
Università & INFN Pavia

ICALEPCS 2021

HL-LHC CMS

1.CMS muon upgrade for HL-LHC



GE1/1 – GE2/1 – ME0

Triple-GEM detectors stations will be implemented in the CMS muon spectrometer

Full GEM system volume

$\sim 1.5\ m^3$

GE1/1 already installed ,full installation of the GEM station foreseen for 2027

2. GEM gas quality impact

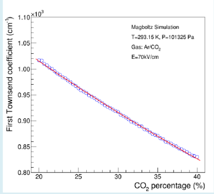
Maintaining the gas mixture at its nominal concentration is fundamental for the detector operation

- Less CO_2 -> More discharges
- More CO_2 -> Less efficiency

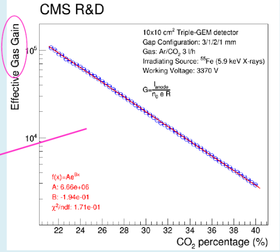
1% more of Argon (@ 70% Ar) → 20% more gain

$$G(\%_{CO_2}) = Ae^{-B\%_{CO_2}}$$

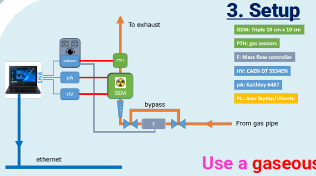
The ratio between Ar and CO_2 needs to remain constant!



Nominal gas mixture: Ar/CO_2 70/30



3. Setup



Knowing the exact relation between effective gas gain and gas concentration, it is possible to get the Ar/CO2 ratio of the supplied gas!

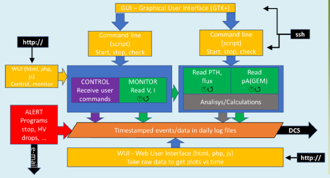
Use a gaseous detector as a gas detector!

HARDWARE:

- Detector, HV and picoammeter for gain measurement
- Mass Flow Controller to regulate the gas flow
- Pressure and Temperature sensor

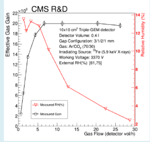
SOFTWARE:

- Local control and analysis
- WUI and GUI for remote access and operation
- Alert to experts and interface with the CMS Detector Control System



4. Gain Fluctuations Correction

Fluctuation in the GEM gain may distort the gas concentration measure
2 main sources of fluctuation in our system



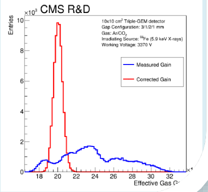
Gas flow may change the concentration of impurities inside the gas volume.
Oxygen and H2O which are electronegative, have negative impact on the gas gain
Maintaining a constant and steady (≥1 vol/h) flux is necessary for remove this fluctuation
Gas flux is maintained stable by the Mass Flow Controller

Electron multiplication strongly depends on gas density hence on temperature and pressure

$$G(T,P) = Ae^{BV\left(\frac{P_0}{P}\right)^a\left(\frac{T}{T_0}\right)^b}$$

- A and B parameters from the gain-voltage charateristic
- V is the working voltage

Fitting with the experimental formula a set of gain points, the correcting parameters (a, b) are found



5. Analysis Algorithm and Benchmarks

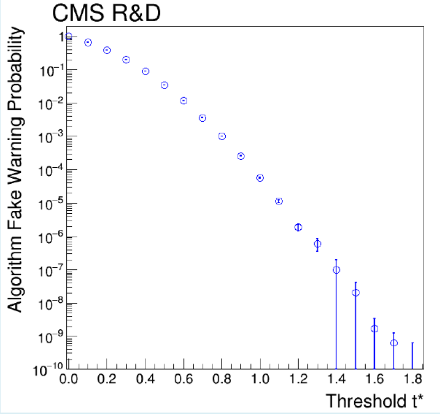
A corrected gain measurement is performed every 30s

The last 10 gain points are used to detect if the gas concetration has changed:

- Mean (m) and standard deviation (s) is computed
- The variable t is calcualted using mean (μ) and standard deviation (σ) of the reference corrected dataset

$$t = \frac{\mu - m}{\sqrt{\sigma^2 + s^2}}$$

- If |t|>t* a warning is generated and actions may be taken to solve the issue



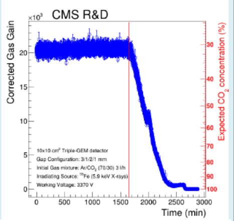
Random variables helps to identify the probability to have a warning just because of random fluctuation

We expect to sample $\sim 10^6$ gain points per year

Using a t*>1.2 suppres the expected fake warnings to <1/year

We collected data during the spontaneous depletion of an Argon bottle (only CO_2 remaining)

Running the algorithm on this dataset is the perfect benchmark for the algorithm!



$$R_G = 1 - \frac{20k}{G(warning)}$$

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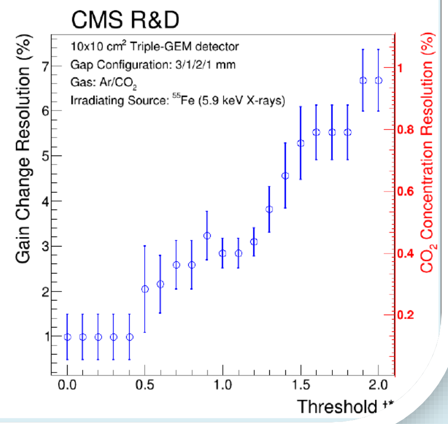
With a threshold t*=2 we are able to detect gain variations <7% corresponding to a CO_2/Ar variation <1%



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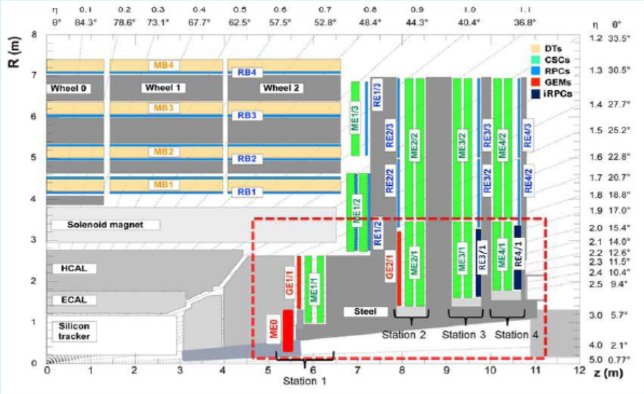

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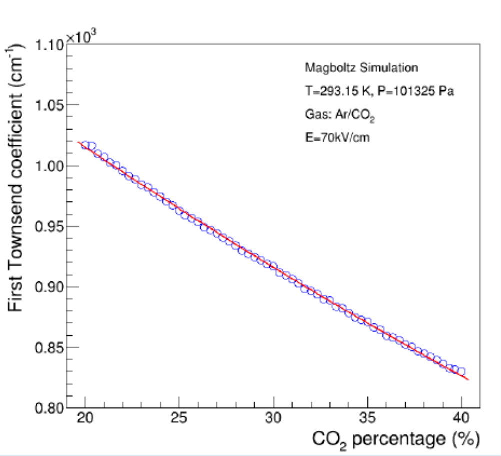

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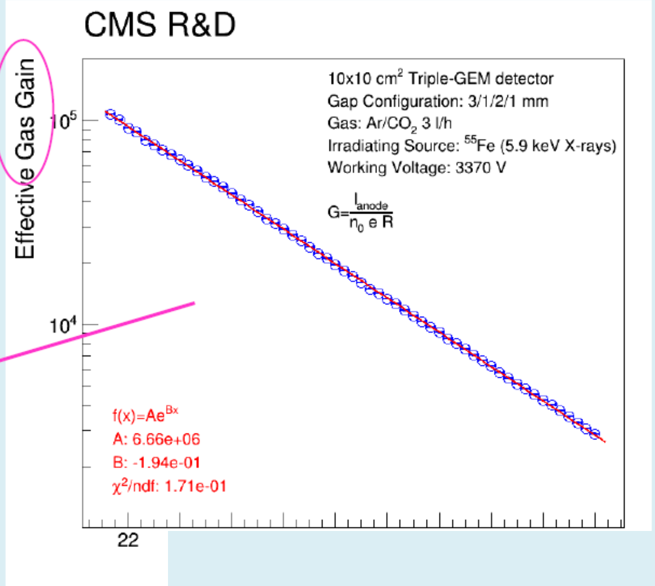

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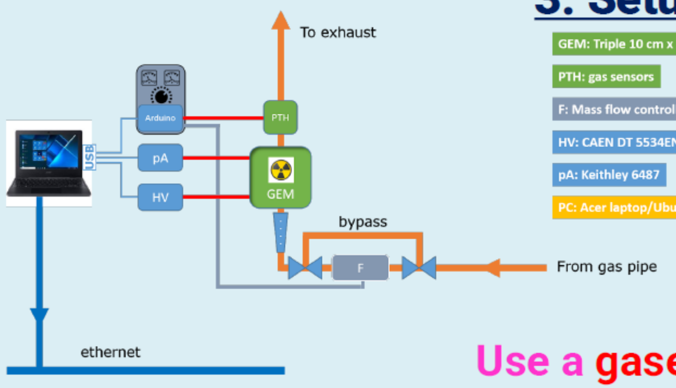

GEM: Triple 10 cm x 10 cm
PTH: gas sensors
F: Mass flow controller
HV: CAEN DT 5534EN
pA: Keithley 6487
PC: Acer laptop/Ubuntu

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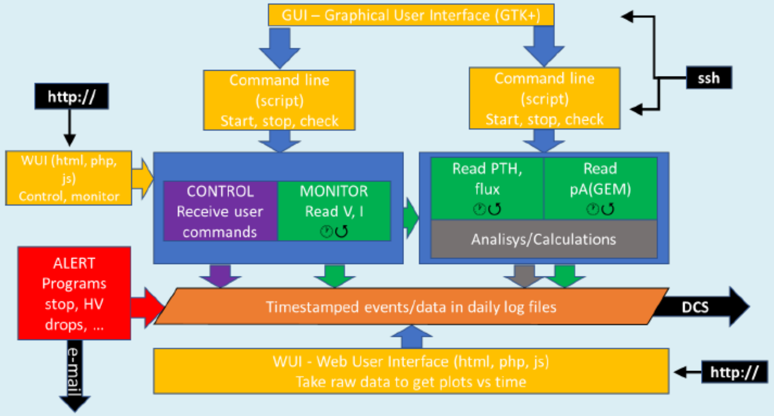

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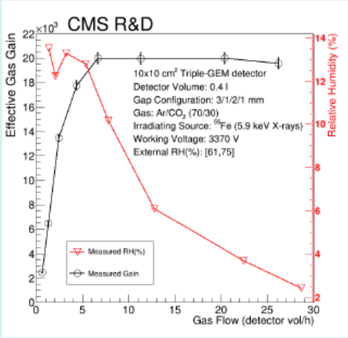

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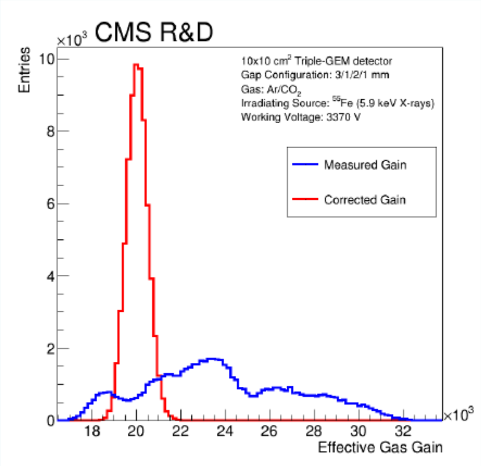

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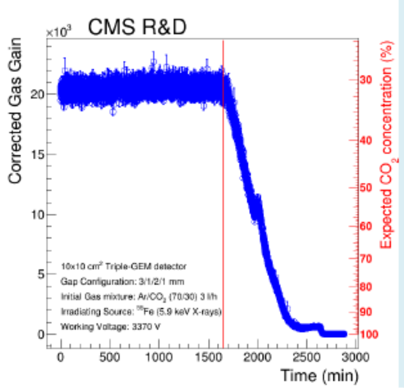

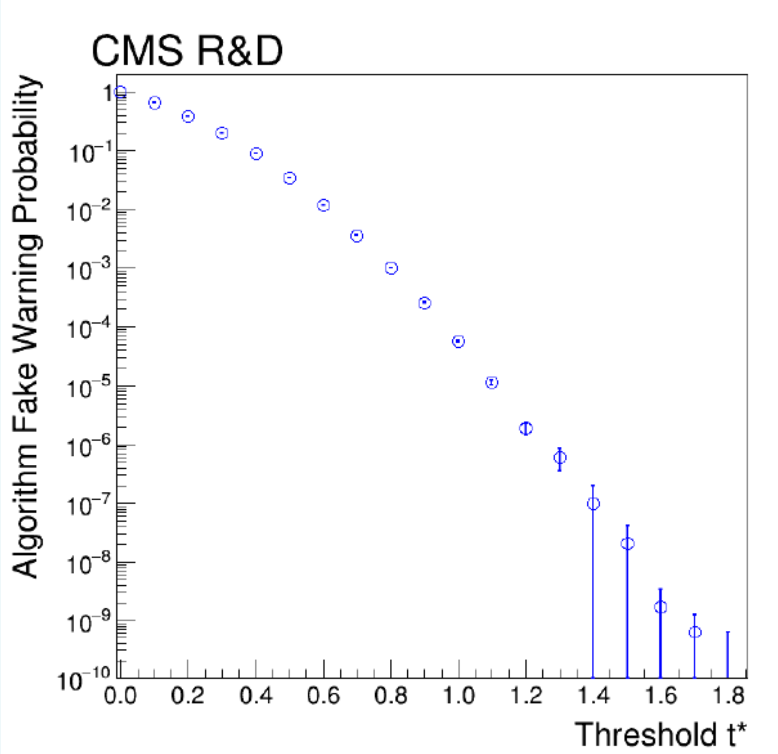

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