



Study of discharges in the CMS GEM GE1/1 station with LHC beam

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On behalf of the CMS Muon Group

The CMS muon system





The CMS GE1/1 station

- Triple GEM detectors
- HV provided with multichannel power supply CAEN A1515 boards





The GEM foil:

- Biconical holes
- Diameter: 70 μm
- Pitch: 140 μm
- Kapton thickness 50 μm
- Copper cladded on both sides (5 μm)



Design of HV distribution



Simone Calzaferri - MPGD 2022



Defects or depositions on GEM foil:

- Can create temporary or permanent short circuit between top and bottom face
- Impact: drop of the voltage applied → the foil stops amplifying the crossing electrons
- Mitigation: segmentation of the foil in sectors
 - if one sector deactivates the others keep operating
 - 40 (47) HV sectors in short (long) GE1/1 chambers
 - High current drained by the power supply if a short circuit is created





HV working point



- The gain of chambers is measured using a **resistive divider**
 - Fixes the ratios between voltages applied on the 7 electrodes
 - Reference for the setting of the chamber when powered with a **multichannel power supply**
 - Voltage global working point is identified by the current flowing in the reference resistive divider

Configuration $I_{eq}=690~\mu A$											
Drift	776 V	G1Top	387 V								
G1Bot	302 V	G2Tор	379 V								
G2Bot	604 V	G3Top	362 V								
G3Bot	431 V										

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Operation during first months of Run 3 (1)

5th July 2022 – First collisions in LHC
7th July 2022 – GE1/1 detectors chambers started to experience frequent HV trips (8 bunches colliding in LHC)

- HV trip = protection turn off of the HV when the current flowing in a power supply channel, feeding an electrode, overcomes a give threshold (I₀)
- Cause: frequent discharges overcoming the limit $I_0=2\;\mu A$
- **Strategy** = increase I_0 to 10 μ A during collisions
 - $I_0 = 2 \ \mu A$ maintained for runs with cosmics



Operation during first months of Run 3 (2)

10th July 2022 – The induction gap (G3Bot) was turned off to protect the electronics from discharges propagating towards the readout

- Procedure to tune the HV working point started, monitoring the discharge rate in chambers
- HV original working point: 700 μA
- LHC continued its operations in the meantime, increasing gradually the number of colliding bunches



How discharges data are analyzed

- A current threshold value is set to count discharges
 - The available ones in the analysis are: 2, 5, 10, 15, 20 μA
- Every time a peak of current overcomes the desired threshold value a discharge event is counted





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Observations per LHC fill



16/12/2022

-30

-20

CMS *Preliminary*

discharges/hour

10

8

6

4

2



INFN



Discharges/(hour*#healthy super-chambers)

Evolution of discharge rate per chamber

		CI	ЛS	Pre	əlim	ina	ry									R = 12	Examp 2.7 discl I _{eq} = 69	le box harges/h 0 μA	nour	ı	th	resho	old - 1	2Δ		Istituto Nazion Sezion
amber	27	5.21 690 0	8.47 690 0	5.44 690 0	3.12 690 0	3.62 690 0	4.66 690 0	3.74 690 0	4.0 690 0	3.89 690 0	3.85 690 0	7.06 690 431	8.47 690 431	6.66 690 431	8.28 690 431	12.7 690 431	5.55 690 431	8.72 690 431	6.42 690 431	5.3 690 431	6.62 690 431	5.36 690 431	4.54 690 431	4.97 690 431	_	(Jnoy) 12 (J
er-ch	26	0.68 690 0	1.81 690 0	1.02 690 0	0.0 690 0	0.41 690 0	0.97 690 0	0.68 690 0	0.44 690 0	0.67 690 0	0.27 690 0	0.68 690 431	1.49 690 431	1.5 690 431	1.54 690 431	2.21 690 431	0.86 690 431	1.66 690 431	0.47 690 431	1.18 690 431	0.44 690 431	1.17 690 431	1.05 690 431	0.9 690 431		ate (1
Sup	25	0.58 690 0	1.21 690 0	0.34 690 0	0.0 690 0	0.14 690 0	0.0 690 0	0.34 690 0	0.18 690 0	0.13 690 0	0.0 690 0	0.29 690 431	0.75 690 431	0.3 690 431	0.59 690 431	0.0 690 431	0.29 690 431	0.0 690 431	0.47 690 431	0.29 690 431	0.44 690 431	0.39 690 431	0.26 690 431	0.41 690 431		10 u alue
	24	0.87 690 0	1.21 690 0	0.68 690 0	0.0 690 0	0.75 690 0	1.36 690 0	0.34 690 0	0.89 690 0	1.21 690 0	0.46 690 0	1.35 690 431	0.75 690 431	1.05 690 431	3.55 690 431	1.66 690 431	0.96 690 431	0.83 690 431	1.05 690 431	0.59 690 431	0.66 690 431	1.17 690 431	0.46 690 431	0.0 690 431		Disch
	23	1.45 690 0	1.21 690 0	1.47 690 0	4.68 690 0	1.57 690 0	1.36 690 0	1.7 690 0	2.58 690 0	1.34 690 0	0.82 690 0	2.71 690 431	3.74 690 431	2.99 690 431	5.21 690 431	6.07 690 431	3.06 690 431	3.32 690 431	2.8 690 431	2.75 690 431	2.65 690 431	2.93 690 0	1.38 690 431	3.18 690 431		6
	22	1.54 690 0	1.81 690 0	1.36 690 0	3.12 690 0	1.5 690 0	1.55 690 0	3.74 690 0	1.6 690 0	1.74 690 0	2.38 690 0	3.19 690 431	3.49 690 431	3.67 690 431	3.55 690 431	3.87 690 431	2.97 690 431	4.98 690 431	3.39 690 431	2.35 690 431	2.65 690 431	2.93 690 431	2.63 690 431	2.45 690 431		5
	21	3.09 690 0	3.63 690 0	2.27 690 0	0.0 690 0	1.91 690 0	1.94 690 0	2.04 690 0	2.04 690 0	2.41 690 0	1.83 690 0	3.19 690 431	3.74 690 431	3.52 690 431	4.38 690 431	4.42 690 431	2.97 690 431	4.15 690 431	2.22 690 431	2.45 690 431	2.87 690 431	1.76 690 431	1.97 690 431	2.04 690 431	-	4
	20	5.01 690 0	4.23 690 0	3.85 690 0	0.0 690 0	3.75 690 0	3.5 690 0	6.13 690 0	3.56 690 0	3.62 690 0	3.02 690 0	5.61 690 431	4.98 690 431	5.31 690 431	6.63 690 431	7.18 690 431	3.54 690 431	6.64 690 431	4.56 690 431	5.3 690 431	4.19 690 431	4.0 690 431	3.42 690 431	3.18 690 431		2
	19	0.48 690 0	0.6 690 0	0.11 690 0	0.0 690 0	0.0 690 0	0.19 690 0	0.34 690 0	0.18 690 0	0.13 690 0	0.27 690 0	0.58 690 431	0.5 690 431	0.45 690 431	1.18 690 431	0.55 690 431	0.29 690 431	0.83 690 431	0.0 690 431	0.2 690 431	0.0 690 431	0.29 690 431	0.33 690 431	0.65 690 431		
		8088	8091	8094	8099	8102	8103	8106	8112	8113	8115	8118	8120	8124	8128	8132	8136	8142	8143	8146	8147	8148	8149	⁸¹⁵¹ Fill		0
	1922 1922 1922 1922 1922 1922 1922 2160 2160 2160 2160 2400 2400 2400 2400 1922 2400 2400 2400 2400 2400 2448 2448																									



Conclusion



- Challenging operations for GE1/1 station in July and August 2022
 - Successfully found a stable configuration for HV working point
- Short circuits
 - Number of foils draining anomalous baseline current ($>10~\mu A$) increased
 - 27 @ 6th July → 36 @ 22nd August
- Status of the analysis: updating
 - to include the chambers with short circuits and better calculate the discharge rate, globally and per chamber
 - Include discharge data from other GEM stations in CMS (GE2/1 demonstrator)



BACKUP

What is a short circuit in a GE1/1 detector



- Short circuit: connection between top and bottom face of a GEM foil
 - Manifest as: high current flowing in the channel powering the interested foil
 - Equivalent resistance of perfect conductive short: the resistance of resistances seen on the path of the short circuit (10.62 M Ω)



- Impact: current flowing in resistors means voltage also falling on them
 - Voltage applied to the foil is lower than that set on the power supply channel



Raw counts and normalization on registered luminosity





Raw number of discharges per chamber





