Quality Control of ME0 and GE2/1 Test Stands for Phase 2 Upgrade.

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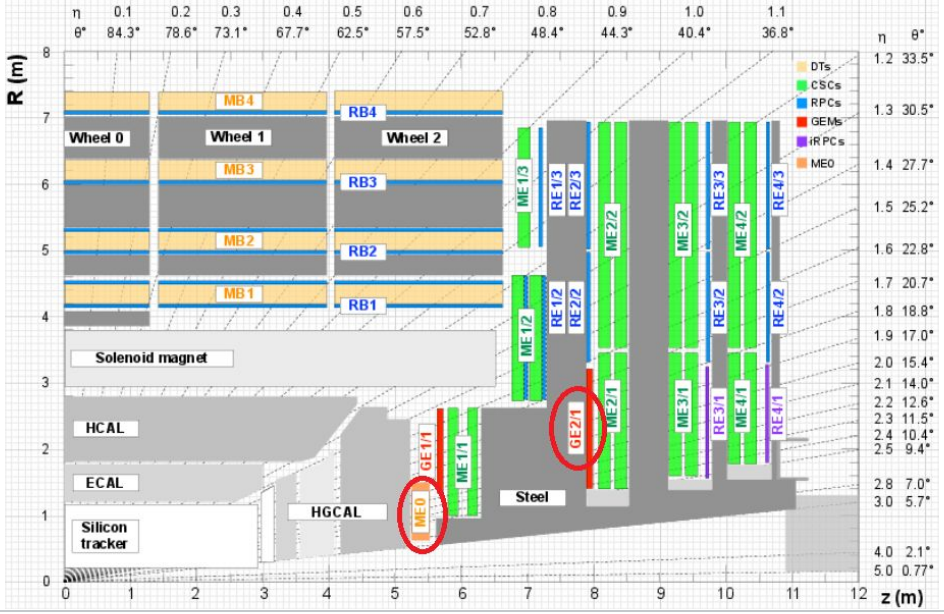
Abstract

Abstract: The CMS phase 2 upgrade scheduled for 2024 and 2026 during the long shutdown will see the installation of ME0 and GE2/1 triple gas electron multiplier (GEM) chambers to help the detector cope with the high luminosity and energy increase predicted to come with the other upgrades, and also to return more data with better resolution.



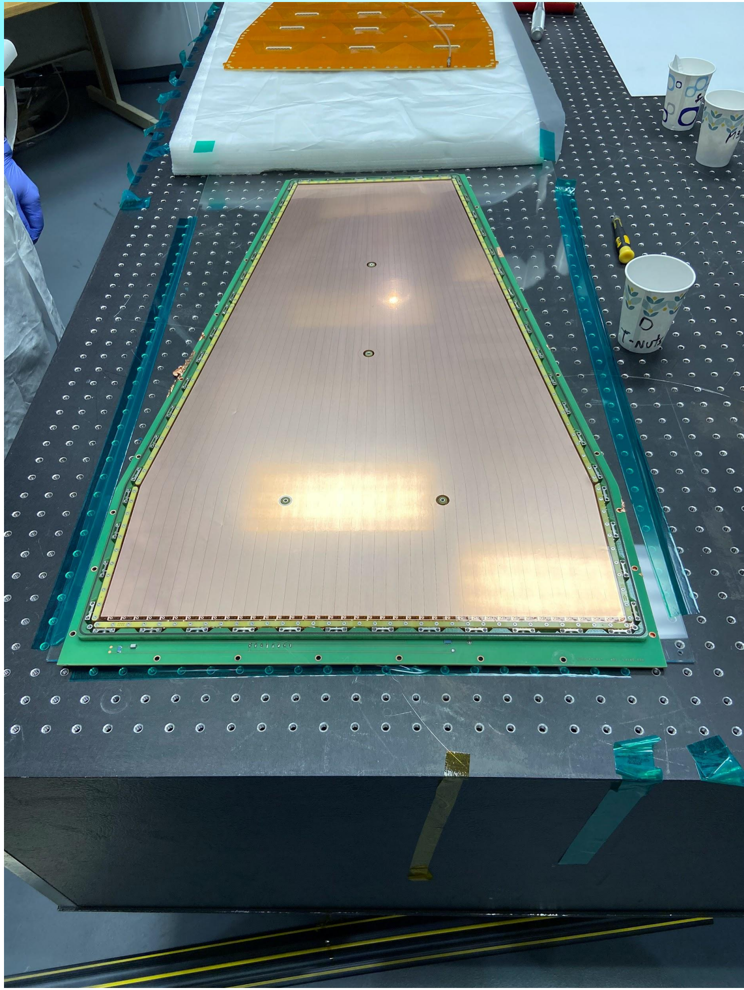
What are GEM Detectors?

How They Work:

1. The board is flushed with Ar/CO2 gas.
2. Radiation comes in, hits the gas particles.
3. Electrons and ions scatter.
4. The applied current produces an avalanche that increases the number of collisions.
5. Which in turn increases the number of electrons flowing through.

Triple GEM Detectors:

- They have three GEM foils stacked on top of each other.



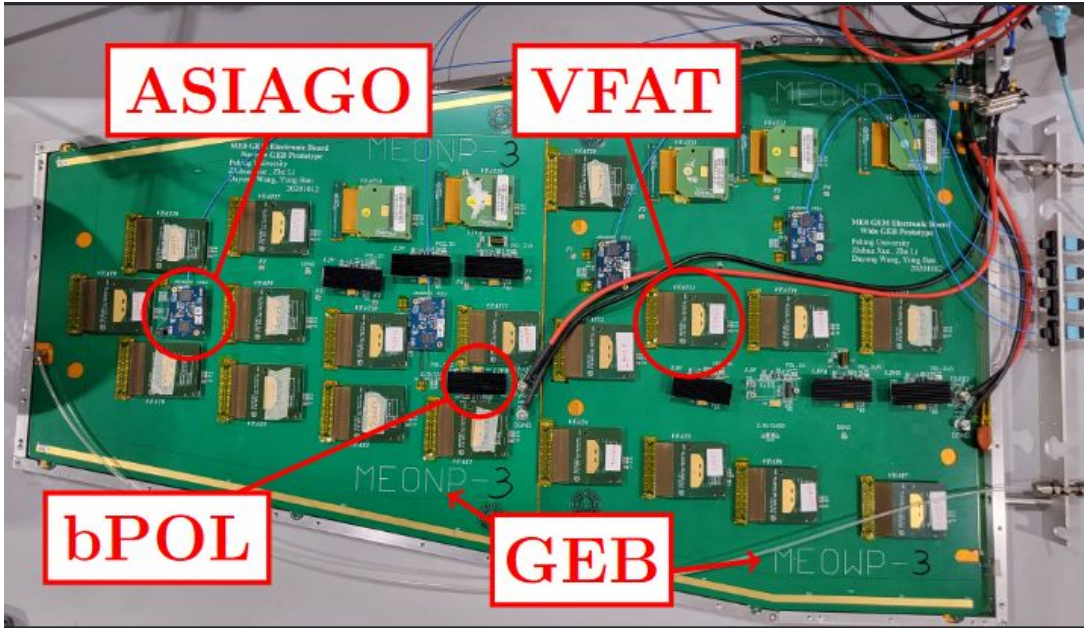
Structure of ME0 and GE2/1 Foils.

- Both ME0 and GE2/1 have the same construction of foils, which are organized from the bottom up:
  1. Drift.
  2. GEM 1.
  3. GEM 2.
  4. GEM 3.
  5. Readout.

- Each of the GEM foils, is broken down into 2 electrodes, a top and a bottom. For example, during testing, GEM 1 would be referred to as either GEM 1 Top or GEM 1 Bottom, depending on which part of the foil is being referred to.

Electronics on the ME0.

- **bPOL:** Divide voltage to electronics.
- **VFAT:** Receive signal from readout, and send it to ASIAGO.
- **ASIAGO:** Send signal to computer.
- **GEB:** Refers to the board.



bPOL: Buck Point of Load.

ASIAGO: ASIC and Gigabit Optics

VFAT: Very Forward Atlas/Totum

GEB: GEM Electronics Board

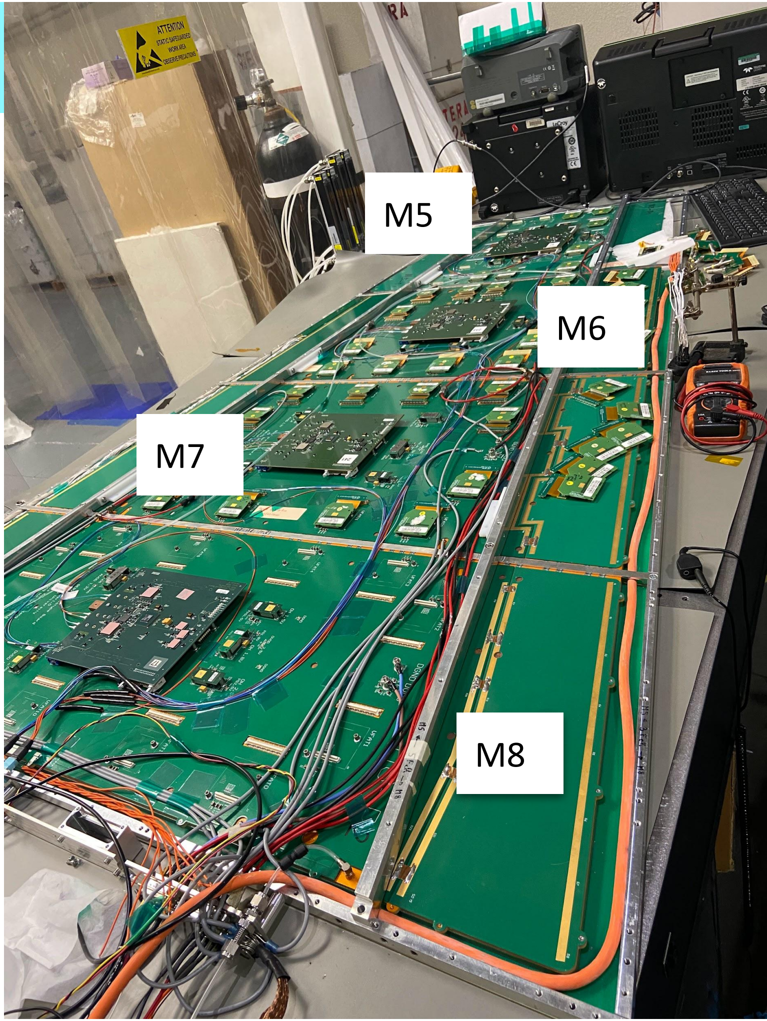
Construction of GE2/1.

Very minor differences between it and ME0.

- Main distinction is the size.
  - GE2/1 is much bigger.

- GE2/1 is broken into 4 modules, each almost the size of the ME0.

- The 4 modules are only held together by the frames and the gas connections.

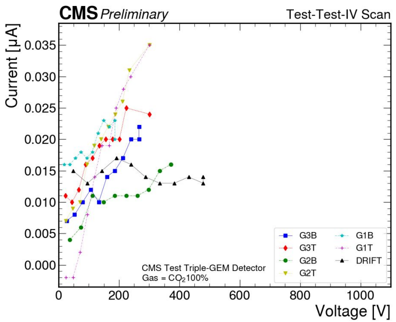


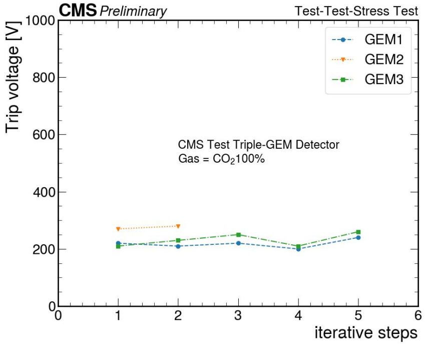
Quality Control Stages.

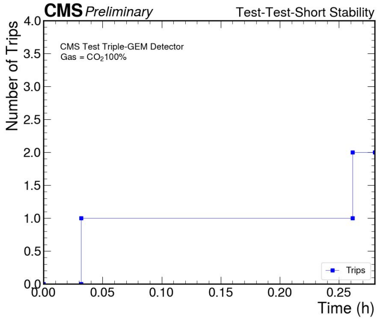
Assembly & QC step	Procedure
QC1/QC2	Material inspection, GEM test
Assembly	Chamber construction
QC2	Single GEM foil HV test
QC3	Gas leak test
QC4	HV test
QC5	Gain calibration
QC6	HV stability test
QC7	Electronics connectivity test
QC8	Cosmic test

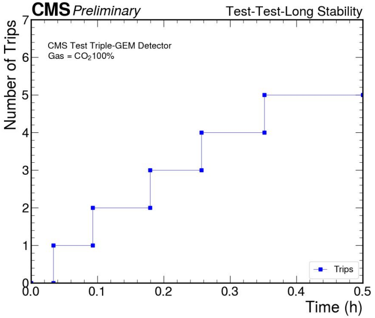
QC6 Tests.

- Stress Test
  - Run on each foil individually.
  - Measures each foil's ability to handle current trips at very high voltages.
- IV Scan
  - Run with the Short Stability test.
  - Checks how linear the relationship between voltage and current is.
- Short Stability Test (2 hours)
  - Measures the detector's ability to maintain high voltage without tripping.
- Long Stability Test (15 hours)
  - Same as Short Stability but over a longer period of time.

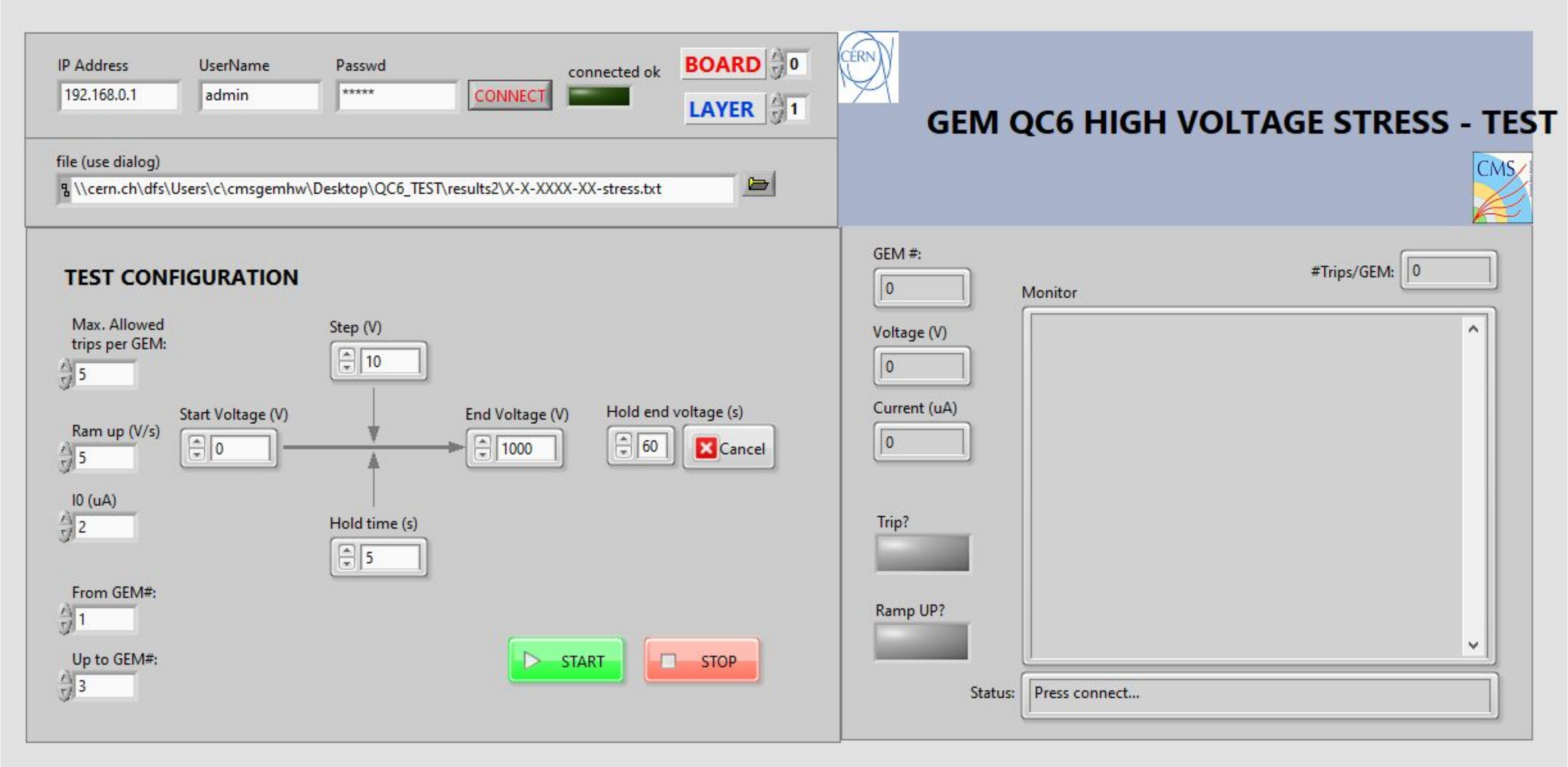




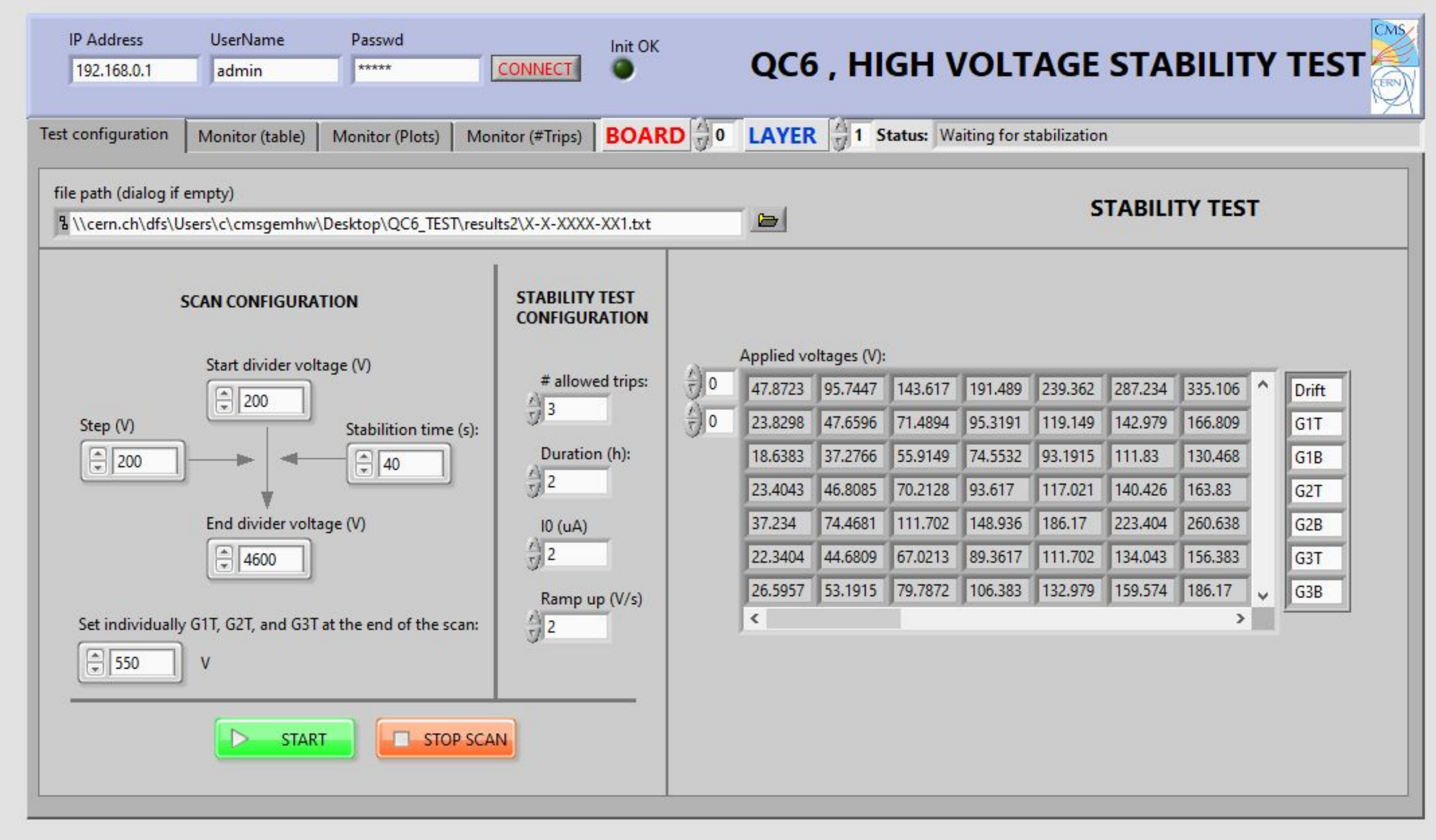




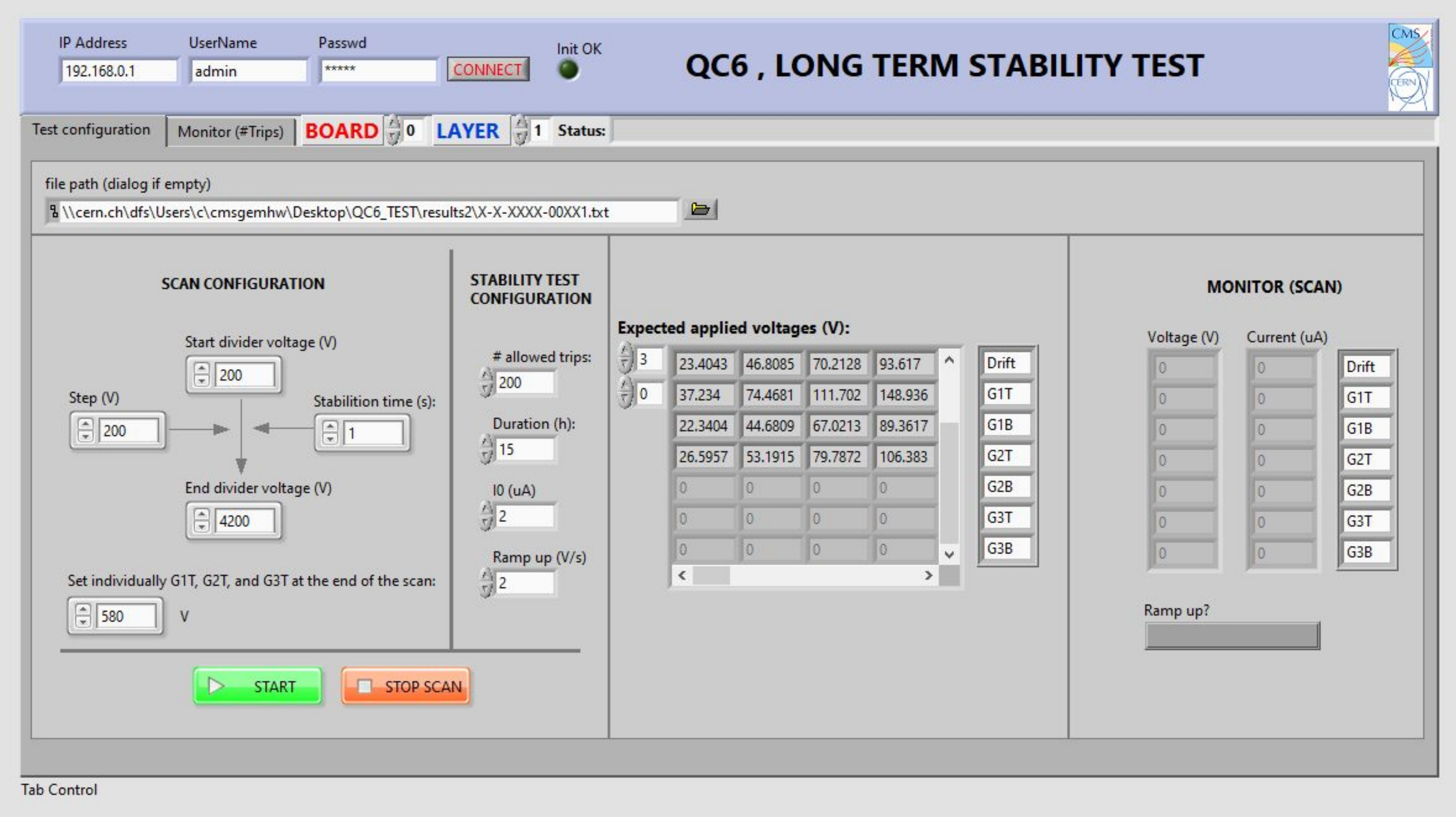
LabView Programs for QC6 - Stress Test.



LabView Programs for QC6 - Short Stability.

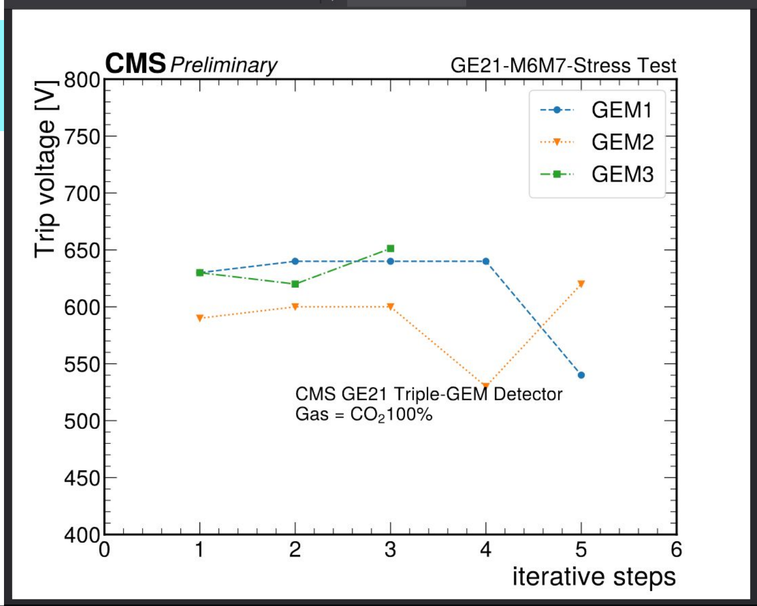


LabView Programs for QC6 - Long Stability.



QC6 for GE2/1 M6/M7.

- Completed and passed the Stress Test.
- Started Short Stability and IV Scan, but had to end it early after finding a short on M6.
- Unfortunately, didn’t have enough time to start fixing it.



Alpha Discharge Studies on ME0.

- An alpha source is placed under a hole on the drift.
  - To simulate some of the radiation it would be exposed to at CMS.
- We supply high voltage (3200V) through the foils, then wait for a current discharge to see how well the electronics are able to handle current spikes.

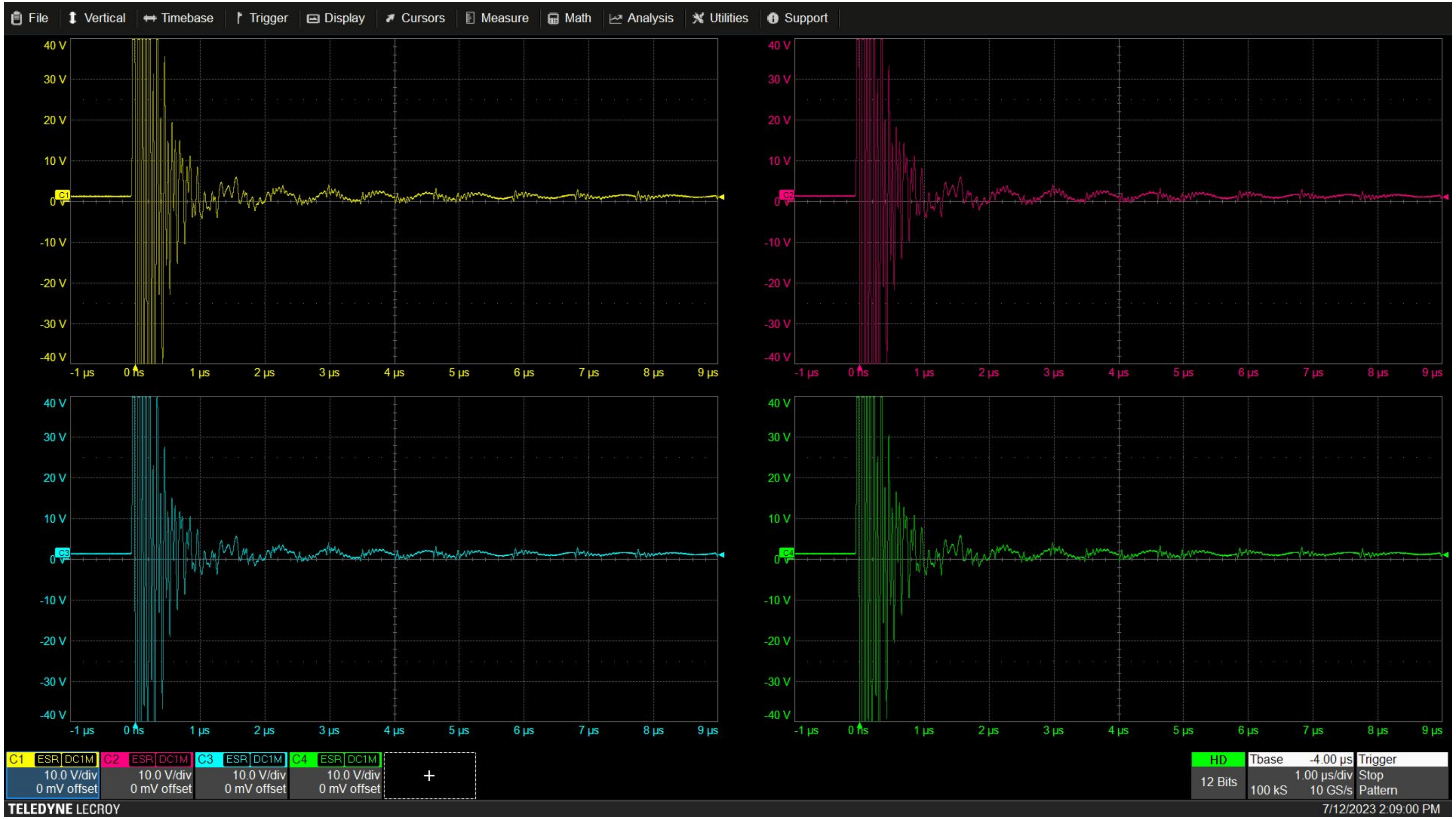
Results:

- The first few times we ran it, we consistently observed some dead VFATs that needed to be reset.
- In the last 3 weeks, we stopped getting any discharges.

Frontend status:

OH	GBTs 0-8	VFATs 0-3	VFATs 4-7	VFATs 8-11	VFATs 12-15	VFATs 16-19	VFATs 20-23
0	0: READY	0: GOOD (RUN)	4: GOOD (RUN)	8: GOOD (RUN)	12: GOOD (RUN)	16: GOOD (RUN)	20: GOOD (RUN)
	1: READY	1: GOOD (RUN)	5: LINK BAD	9: GOOD (RUN)	13: LINK BAD	17: GOOD (RUN)	21: LINK BAD
	2: READY	2: GOOD (RUN)	6: GOOD (RUN)	10: GOOD (RUN)	14: LINK BAD	18: GOOD (RUN)	22: LINK BAD
	3: READY	3: GOOD (RUN)	7: LINK BAD	11: LINK BAD	15: GOOD (RUN)	19: GOOD (RUN)	23: LINK BAD
	4: READY						
	5: READY						
	6: READY						
	7: READY						

Discharge on Oscilloscope.



QC5 on ME0_2.

- Another ME0 board that was assembled at FIT.
- QC5 involves putting the detector in an x-ray box, with the drift facing the x-ray gun.
- Unfortunately, we never got as far as turning the gun on.
- After applying high voltage to the board (2000V), we noticed a microphonics problem, where the noise of signal produced on the oscilloscope was very sensitive to environmental noise.

Attempts at Reducing Microphonics:

- Stabilizing the detector as much as possible.
- Switching the power supply.
- Placing foam around the detector in the box and on the outside of the box.
  - This seemed to improve the noise a little bit, but not enough.

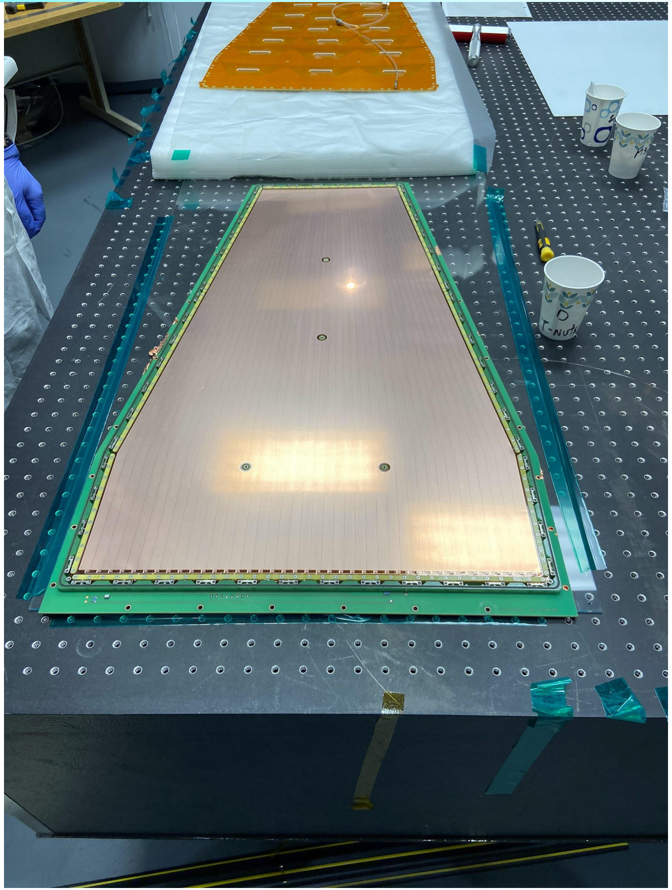
ME0_2 Microphonics Solution.

- Thought the problem might be with the foils vibrating.
- Brought it into the clean room and opened it up.
- Carefully re-tightened the screws around the GEM foils to stretch and prevent any vibrations.

- Before closing it up, found a short between G2T and G2B.
- Attempted to “burn it out” by applying voltage onto the G2 foil.
- Left it overnight and came back to find it gone.
- However, the same problem happened for G3, and eventually fixed itself.

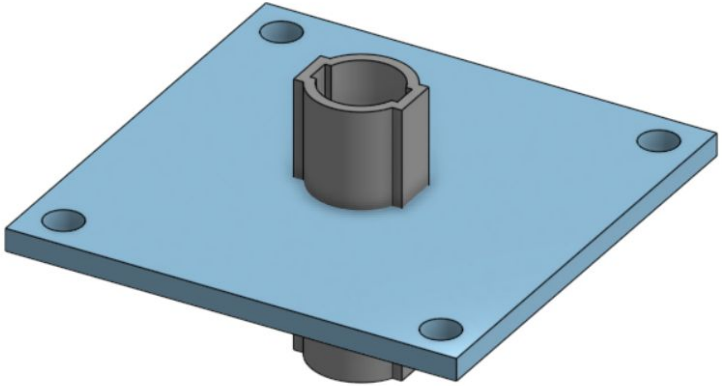
QC3 on ME0_2.

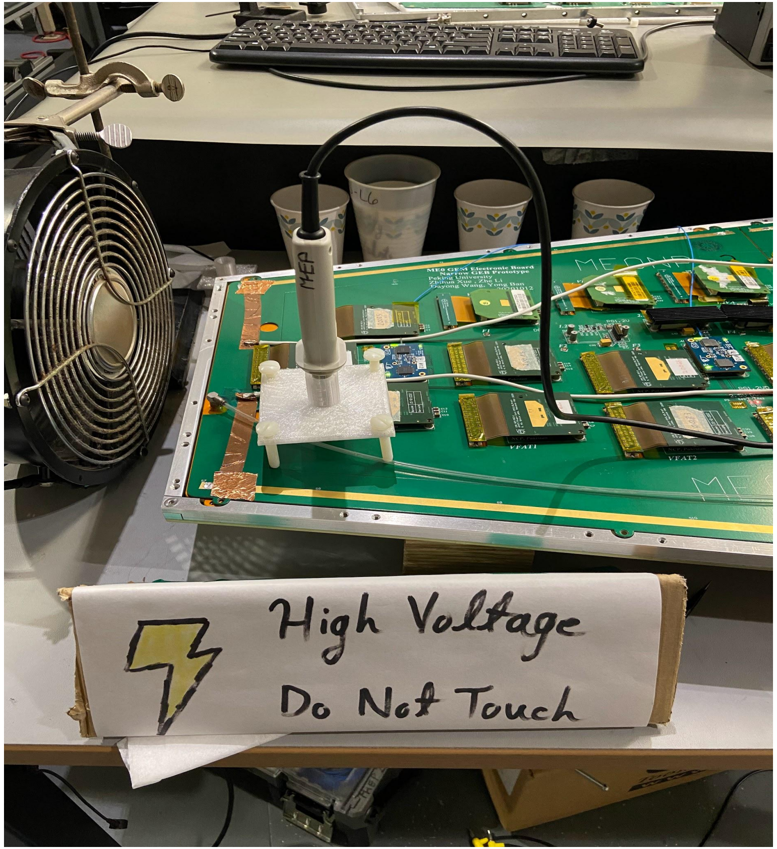
- After exposing the foils, we needed to ensure that the detector remained gas tight.
- Connected it to N2 gas and started the process of monitoring the input and output pressure of the gas through an arduino program.
- Found a small difference in pressure, indicating a leak.
- Didn’t have time to investigate it further.



Magnetic Probe Holder.

- Used for current measurements.





Questions?

References.

- https://cds.cern.ch/record/2826599/files/project_report_cern-4.pdf