



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

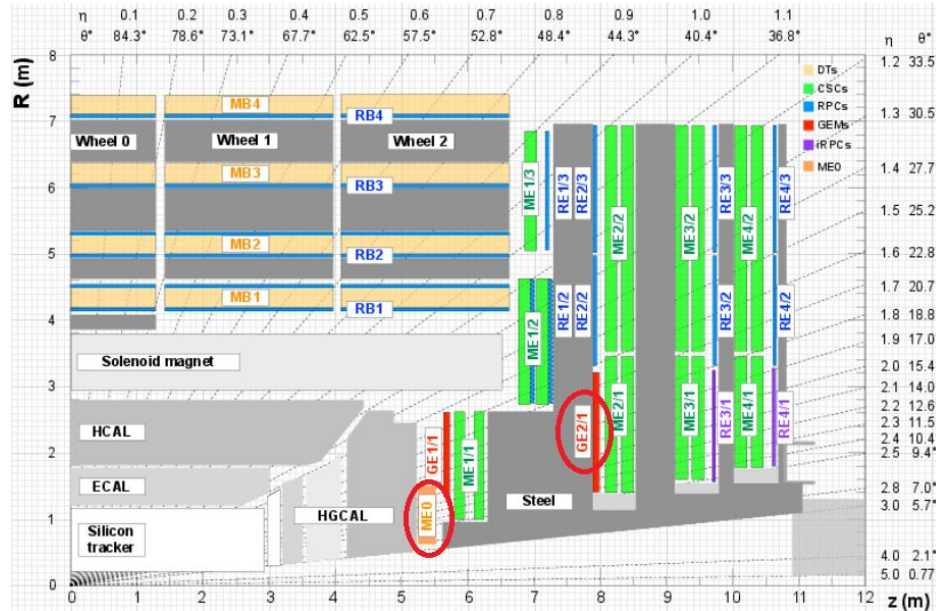
Mentee: Sama Abbadi (Kennesaw State University)

Mentors: - Dr. Marcus Hohlmann (Florida Tech)
- Erick Yanes (Florida Tech)



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.





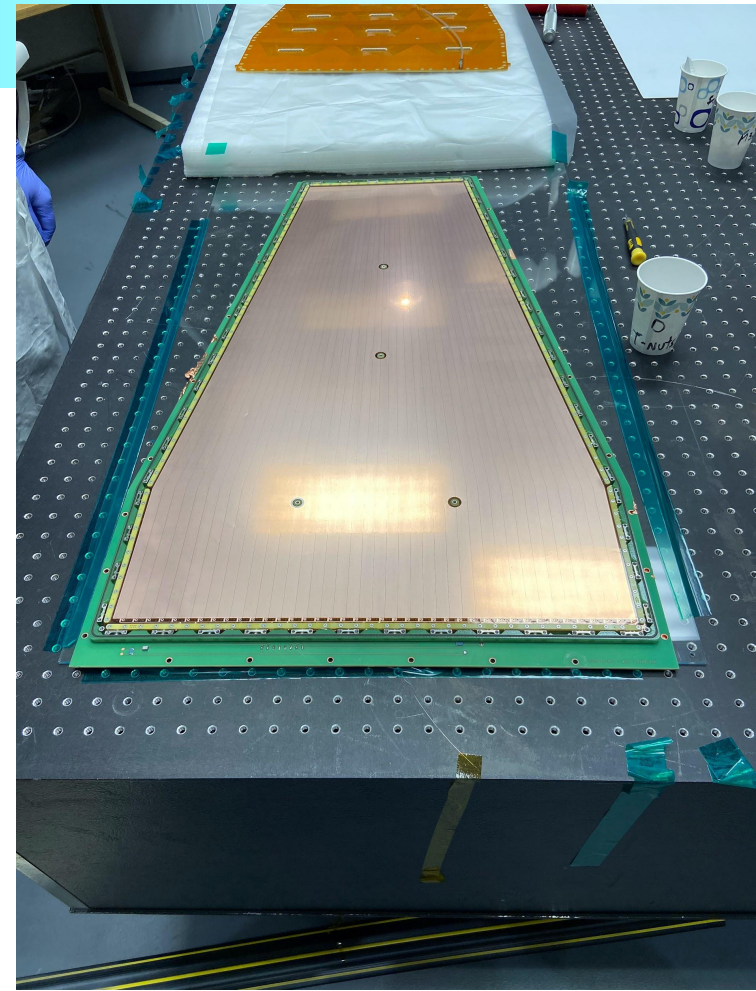
What are GEM Detectors?

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.





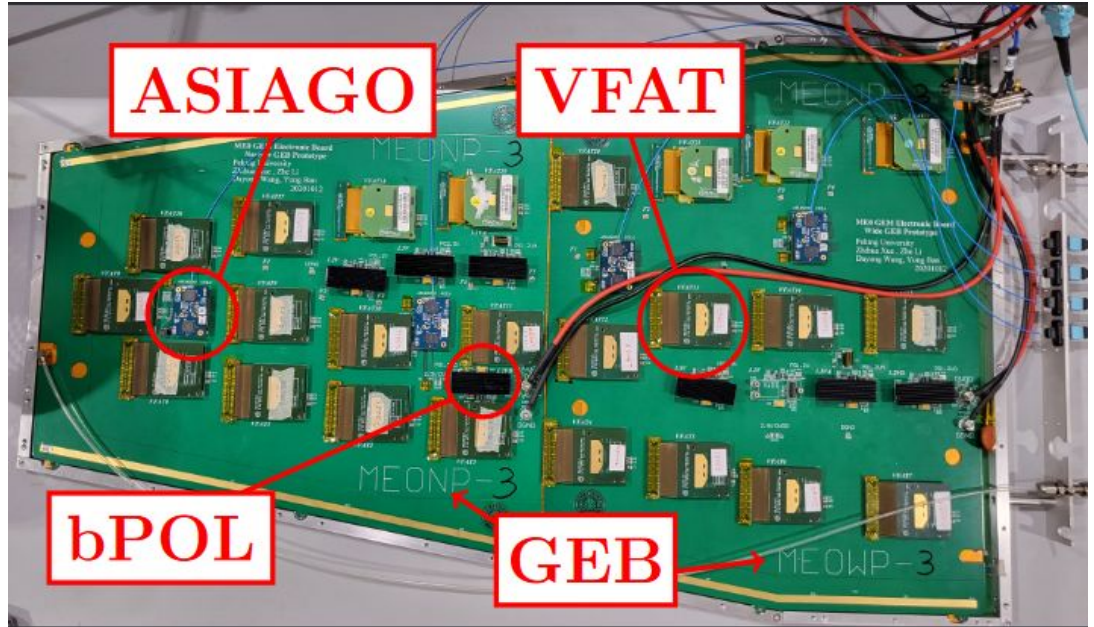
Structure of ME0 and GE2/1 Foils.

- 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

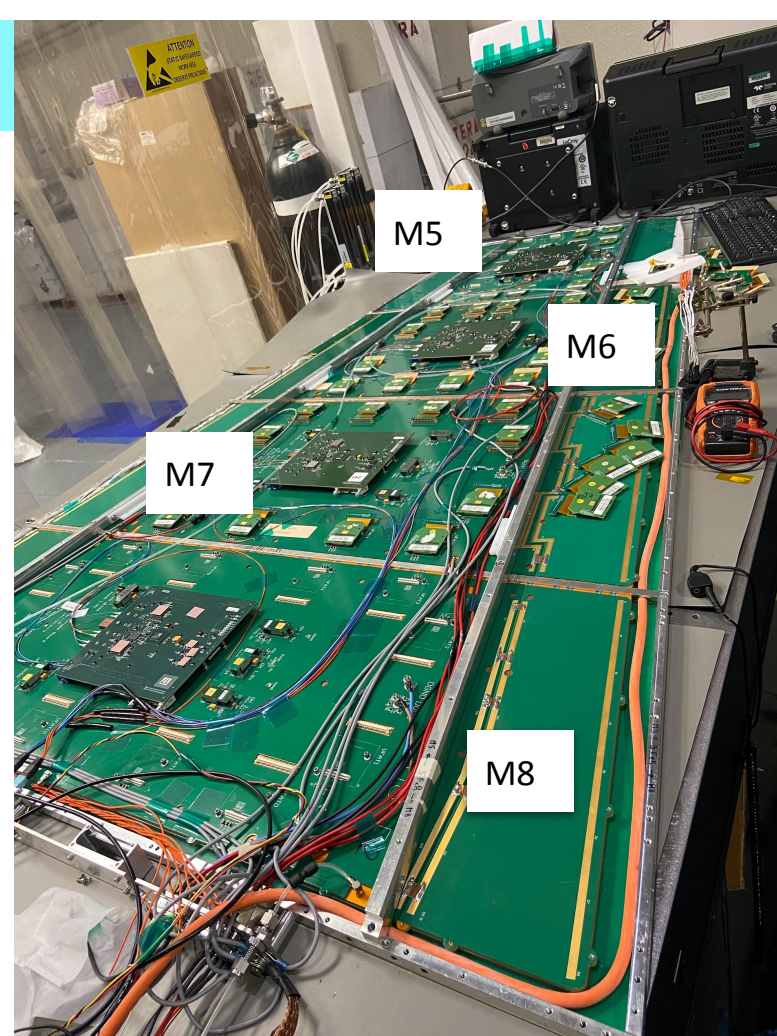
GEB: GEM Electronics Board



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.





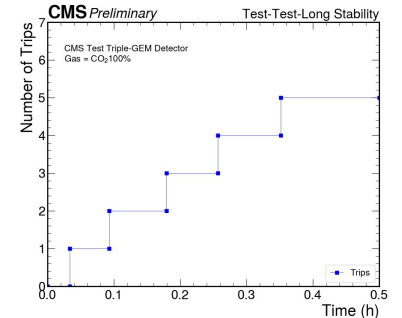
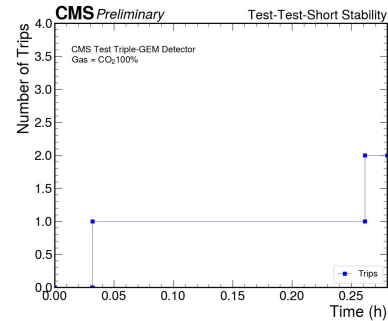
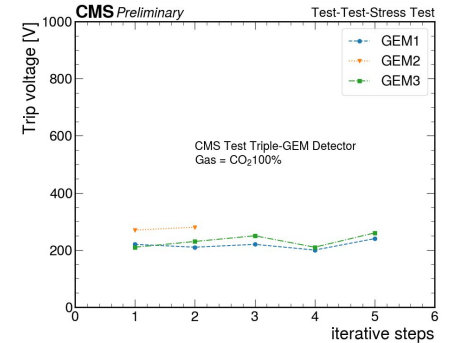
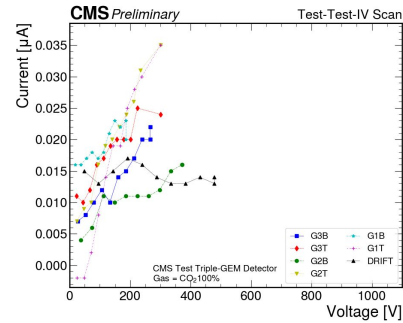
Quality Control Stages.

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.

IP Address: 192.168.0.1 UserName: admin Passwd: ***** connected ok: **BOARD** 0 **LAYER** 1

file (use dialog): \\cern.ch\dfs\Users\c\cmsgemhw\Desktop\QC6_TEST\results2\X-X-XXXX-XX-stress.txt

TEST CONFIGURATION

Max. Allowed trips per GEM: 5

Ram up (V/s): 5

10 (uA): 2

From GEM#: 1

Up to GEM#: 3

Start Voltage (V): 0

Step (V): 10

End Voltage (V): 1000

Hold end voltage (s): 60

Hold time (s): 5

START **STOP** **Cancel**

GEM QC6 HIGH VOLTAGE STRESS - TEST

GEM #: 0 #Trips/GEM: 0

Voltage (V): 0

Current (uA): 0

Trip?

Ramp UP?

Status: Press connect...



LabView Programs for QC6 - Short Stability.

IP Address: 192.168.0.1 UserName: admin Passwd: ***** CONNECT Init OK

QC6 , HIGH VOLTAGE STABILITY TEST

Test configuration | Monitor (table) | Monitor (Plots) | Monitor (#Trips) | **BOARD 0** | **LAYER 1** | Status: Waiting for stabilization

file path (dialog if empty): \\cern.ch\dfs\Users\c\cmsgemhw\Desktop\QC6_TEST\results2\X-X-XXXX-XX1.txt

STABILITY TEST

SCAN CONFIGURATION

Start divider voltage (V): 200

Step (V): 200

Stabilisation time (s): 40

End divider voltage (V): 4600

Set individually G1T, G2T, and G3T at the end of the scan:
550 V

STABILITY TEST CONFIGURATION

allowed trips: 3

Duration (h): 2

I0 (uA): 2

Ramp up (V/s): 2

Applied voltages (V):

0	47.8723	95.7447	143.617	191.489	239.362	287.234	335.106	Drift
0	23.8298	47.6596	71.4894	95.3191	119.149	142.979	166.809	G1T
	18.6383	37.2766	55.9149	74.5532	93.1915	111.83	130.468	G1B
	23.4043	46.8085	70.2128	93.617	117.021	140.426	163.83	G2T
	37.234	74.4681	111.702	148.936	186.17	223.404	260.638	G2B
	22.3404	44.6809	67.0213	89.3617	111.702	134.043	156.383	G3T
	26.5957	53.1915	79.7872	106.383	132.979	159.574	186.17	G3B

START STOP SCAN



LabView Programs for QC6 - Long Stability.

IP Address: 192.168.0.1 UserName: admin Passwd: ***** CONNECT Init OK

QC6 , LONG TERM STABILITY TEST

Test configuration: Monitor (#Trips) **BOARD** 0 **LAYER** 1 Status:

file path (dialog if empty): \\cern.ch\dfs\Users\c\cmsgemhw\Desktop\QC6_TEST\results2\X-X-XXXX-00XX1.txt

SCAN CONFIGURATION

Start divider voltage (V): 200

Step (V): 200

Stabilisation time (s): 1

End divider voltage (V): 4200

Set individually G1T, G2T, and G3T at the end of the scan: 580 V

START **STOP SCAN**

STABILITY TEST CONFIGURATION

allowed trips: 200

Duration (h): 15

I0 (uA): 2

Ramp up (V/s): 2

Expected applied voltages (V):

3	23.4043	46.8085	70.2128	93.617	Drift
0	37.234	74.4681	111.702	148.936	G1T
	22.3404	44.6809	67.0213	89.3617	G1B
	26.5957	53.1915	79.7872	106.383	G2T
	0	0	0	0	G2B
	0	0	0	0	G3T
	0	0	0	0	G3B

MONITOR (SCAN)

Voltage (V)	Current (uA)	
0	0	Drift
0	0	G1T
0	0	G1B
0	0	G2T
0	0	G2B
0	0	G3T
0	0	G3B

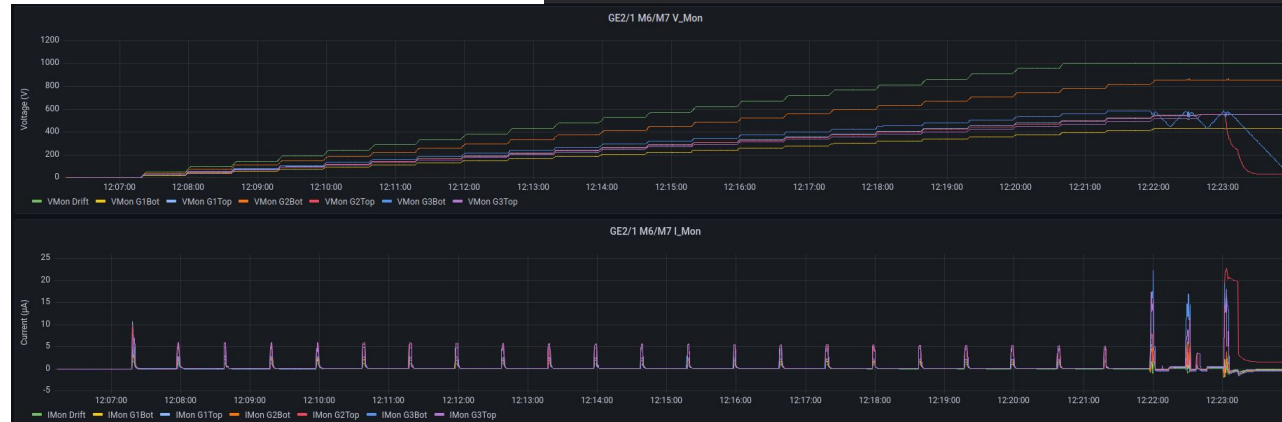
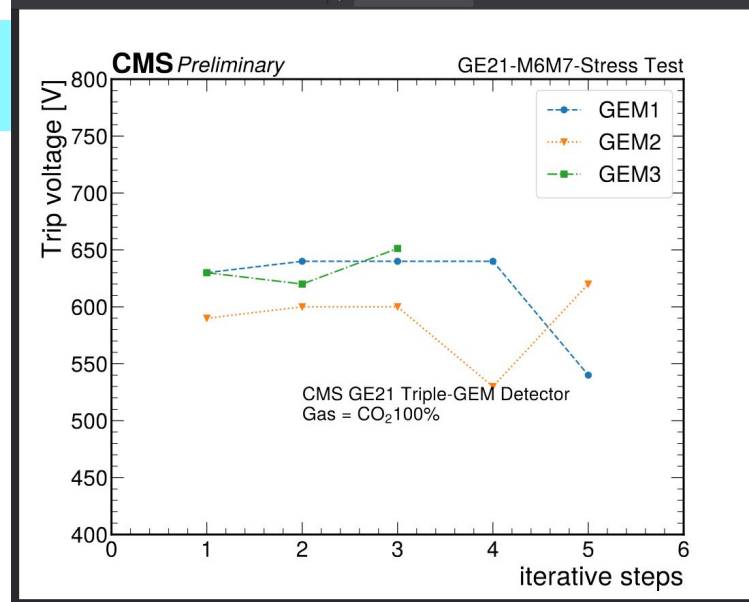
Ramp up? _____

Tab Control



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:

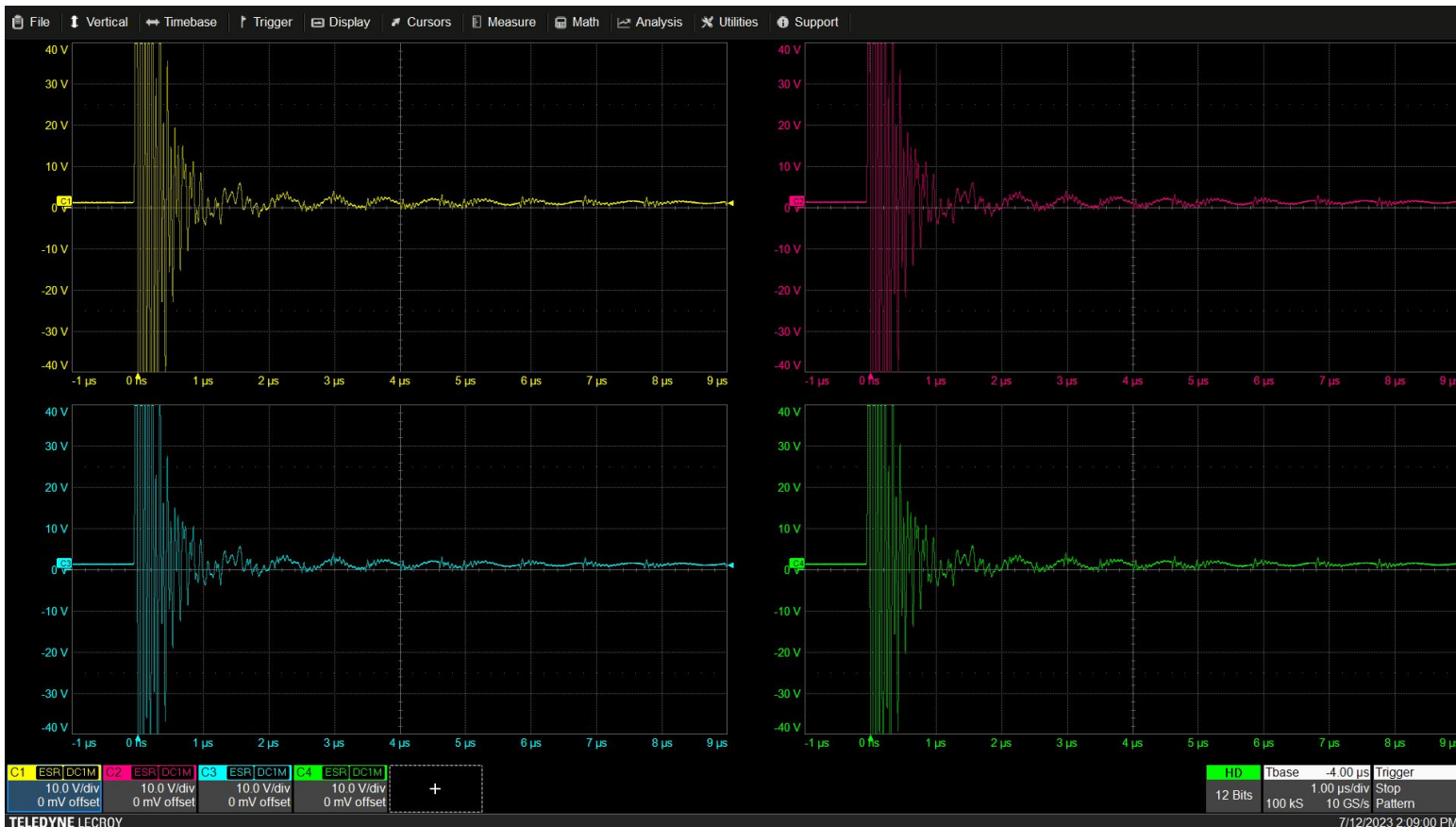
- The first few times we ran it, we consistently observed some dead VFATs that needed to be reset.
- In the last 3 weeks, we stopped getting any discharges.

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



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.

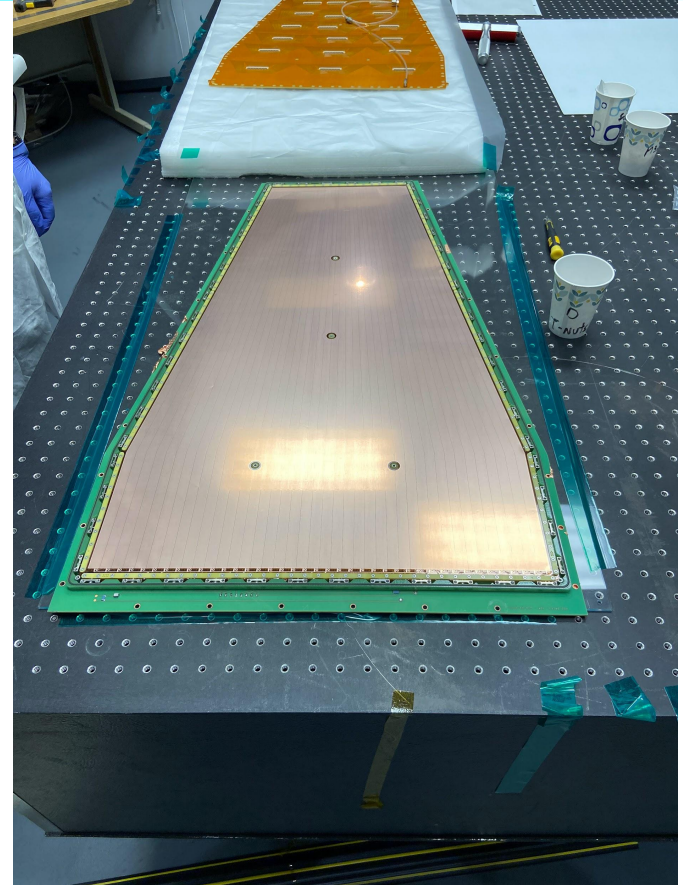
- Thought the problem might be with the foils vibrating.
- Brought it into the clean room and opened it up.
- Carefully re-tightened the screws around the GEM foils to stretch and prevent any vibrations.

- 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.

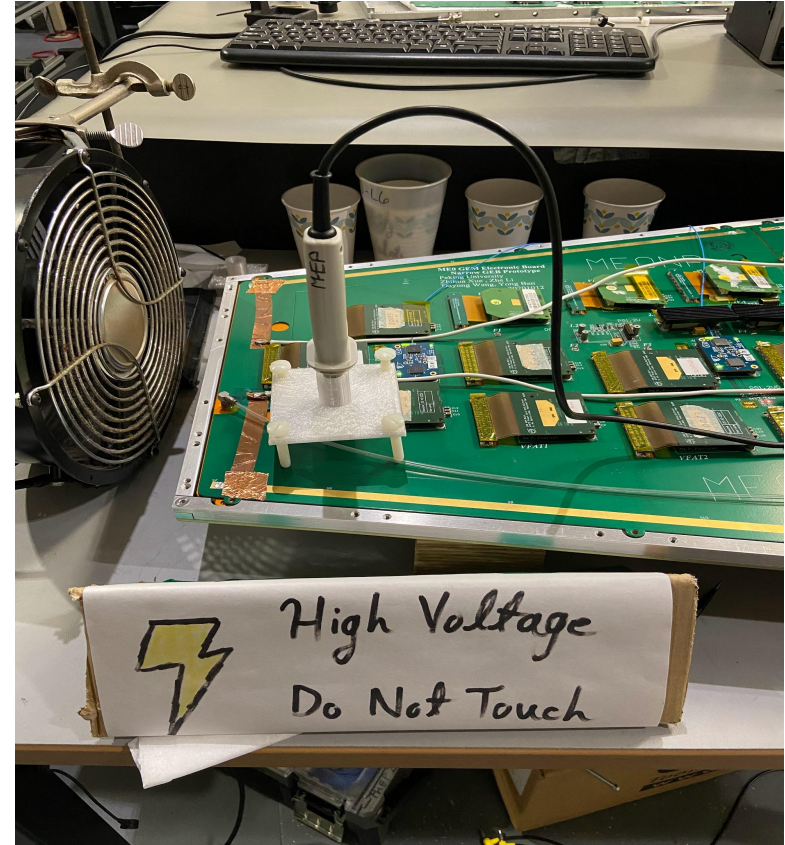
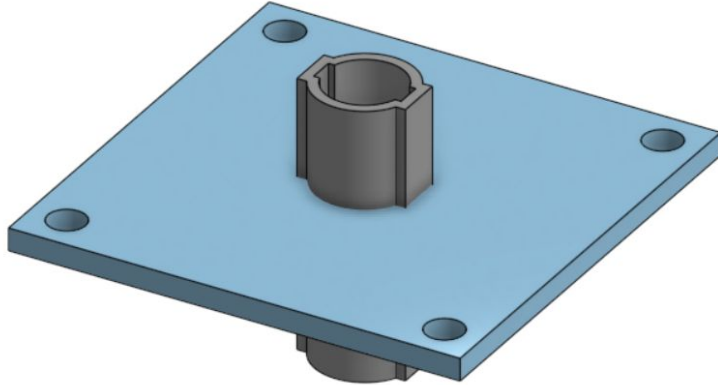
- After exposing the foils, we needed to ensure that the detector remained gas tight.
- Connected it to N2 gas and started the process of monitoring the input and output pressure of the gas through an arduino program.
- Found a small difference in pressure, indicating a leak.
- Didn't have time to investigate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





Magnetic Probe Holder.

- Used for current measurements.





Questions?



References.

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