STEPHEN D. BUTALLA

THE QUALITY CONTROL PROCESS OF THE GE1/1-X-S AT FIT

FLORIDA INSTITUTE OF TECHNOLOGY

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Contents

Chapter 1: Quality Control 2 (Fast) 11

Chapter 2: Quality Control 3 15

Chapter 3: Quality Control 4 21

Chapter 4: Quality Control 5—Effective Gain 27

Chapter 5: Quality Control 5—Gain Uniformity 35

References 47

List of Figures

1 Meggering the foils in the fume hood. 12
2 The HV clip attached to a foil. 12
3 The protection resistor on one sector of a GEM foil. 13
4 Meggering the foil sector by sector. 14

5 The setup of the sensors, Arduino, and breadboard system. 15
6 QC3 test stand. 15
7 The QC 3 files and the order they should be opened in. 16
8 Serial plotter window. Note that the ordinate is in mbar. 16
9 The nitrogen tank in the clean room. 17
10 Template for QC3. 18
11 A successful QC3 test. 18

12 The Scaler. 21
13 The preamplifier (entombed in foil and weights) on the QC4 table. 22
14 The amplifier (with input from the QC4 preamplifier). 22
15 The minicom options screen. 24
16 The CAEN HV home screen. 24
17 The control 25
18 A successful result for QC4. 25

19 X-ray Box. 27
20 Grounding Cable. 27
21 HV connection on the PCB. 28
22 The Desktop of the X-Ray computer. 29
23 The X-Ray control screen. 29
24 The initialized X-Ray screen after starting the Mini-X software. 30
25 The Panasonic connector for the picoammeter. 30
26 The device manager displaying the ports in use. 31
27 The COM port number displayed under `Properties > Port Settings > Advanced`. 31
28 The control screen in LabView. 32
29 The monitoring window in LabView. 33
30 A successful QC5—Effective Gain plot. 34

31 The cabling setup for the APVs. 36
32 The Run Control window. 37
33 The Info Browser window. 37
34 The SCRIBE control window. 38
35 The SCRIBE control window. 39
36 The first LDC Status window. 40
37 The second LDC status window. 40
38 What should be displayed when data is being taken. 41
39 The configuration file. 41
40 The fit peak position of clusters of charge. 43
41 The fit success of each sector. 43
42 The proper FEC cabling. 45

List of Tables

1 The values for the parameters in the SCRIBE DAQ Configuration. 38

Preface

This manual outlines the quality control (QC) procedures for the GE1/1-X-S detectors at the FIT site. It is to be as comprehensive as possible, so that if any questions or issues are encountered during the QC process, this manual can answer them in full.

Sequentially ordered by the quality control steps, chapter 1 outlines QC2, chapter 2 outlines QC3, chapter 4 outlines QC5—Effective Gain, and chapter 5 outlines QC5—Gain Uniformity. The purpose of dichotomizing QC5 is due to the nature of the tests themselves: while both are achieving somewhat similar ends, the means by which they are obtained—and the scope of the data that is collected and analyzed—justifies this separation. If applicable, the ends of chapters will contain troubleshooting tips for common issues.

Chapter 1: Quality Control 2 (Fast)

Purpose

The purpose of QC 2 Fast[1] is to assess the quality of the GEM foils. This is done by determining the leakage current between the top and bottom of the foil by measuring the impedance with a Multi Mega-Ohmmeter, which in our case is the Megger MIT420 (known as Megger for short). The value of the impedance and the number of sparks generated will be recorded. As per page 11 of the GE1/1 quality control manual [1], the foil must have an impedance $Z > 10\,\text{G}\Omega$, and a spark rate of less than 2 Hz for the last 2-3 minutes of the test.

[1] This procedure is known colloquially as "Meggering" the foils.

Procedure

Through a trial and error process, we have found a procedure which economizes this quality control step, and that is to first Megger the foils in the fume hood before Meggering them on the wall on the assembly table. This helps to identify issues before they arise, and also makes troubleshooting shorted foils much, much easier.

1. **Carefully** remove the foils from the box on top of the fume hood, and place them in the fume hood.
2. Remove the protective sheets and use the Megger with the positive probe on a pad that connects to the bottom of the foil and the negative probe that connects to the top of the foil (fig. 1). Apply 550V. If the impedance is on the order of GΩ, the foil is not shorted and is working properly. If you are seeing impedances in the MΩ range, the foil is shorted; refer to the troubleshooting section at the end of the chapter.
3. Tape the GEM foil to the plastic frame, ensuring that there is enough tension to keep the foil taut.
4. Stand the frame against the stand in the cleanroom.

Figure 1: Meggering the foils in the fume hood.

5. Using the custom fabricated HV clip (fig. 2), attach the Megger to the foil[2].

6. Open the version 2 template for the QC 2 test (`QC2_FAST_FOIL-BATCH-X-ZZZZ_YYYYMMDD_TemplateV2.xlsx`) and record the ambient temperature, pressure, and relative humidity.

7. Set the Megger to 550 V by holding the yellow button down until a steady impedance reading is displayed. After a steady reading is displayed, press the lock button to continue applying the potential difference.

8. Count and record the number of sparks that have occurred for the first 30 seconds, and record the impedance at this time.

9. At time $t = 60$ s, record the impedance and the total number of sparks that have occurred in this amount of time (i.e., add the number of sparks that occurred in the first thirty seconds to the number of sparks that occurred in the next 30 seconds).

10. After the one minute mark, record the impedance and the cumulative number of sparks every minute for the next 9 minutes.

[2] Make sure that the leads are connected to either side of the foil (the clip is built such that it should be impossible to attach it to the pads on the foil unless it is in the correct position), but verify this so that the correct measurement is obtained.

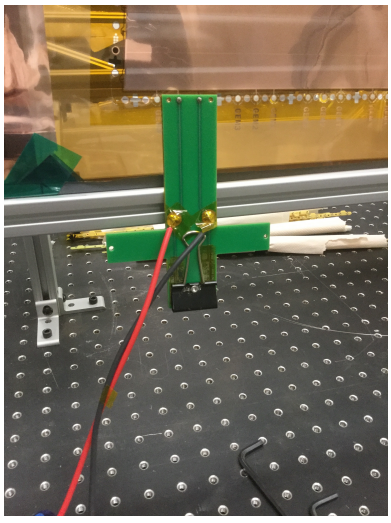

Figure 2: The HV clip attached to a foil.

If the impedance and spark rate are not satisfactory, clean the foil with a roller and repeat steps three through eight above. If the foil is still a shorted, look no further than the next section.

Troubleshooting

If the foil is shorted, you will see an impedance in the MΩ range. This occurs when there is something making a connection between the top and the bottom of the foil, and you will see the resistance of the 10 MΩ protection resistor (fig. 3) on the shorted sector. For example, if one sector is shorted, the impedance will be ∼9.5 MΩ. The following steps will help you identify the shorted sector(s) and, if all goes well, fix the shorted sector(s). To detect the shorted sector,

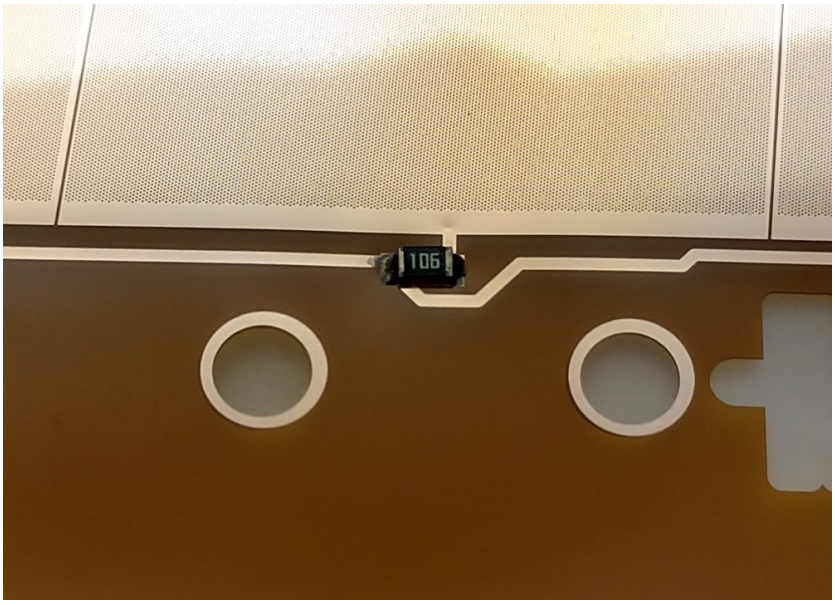

Figure 3: The protection resistor on one sector of a GEM foil.

apply a potential difference of 550 V with the positive lead on a pad that leads to the bottom of the foil and the negative lead on the left of a protection resistor (see fig. reffig:meggersector). When you reach the shorted sector, you will see the resistance of the protection resistor. Continue to apply 550 V. Remove the probes and remeasure the impedance.

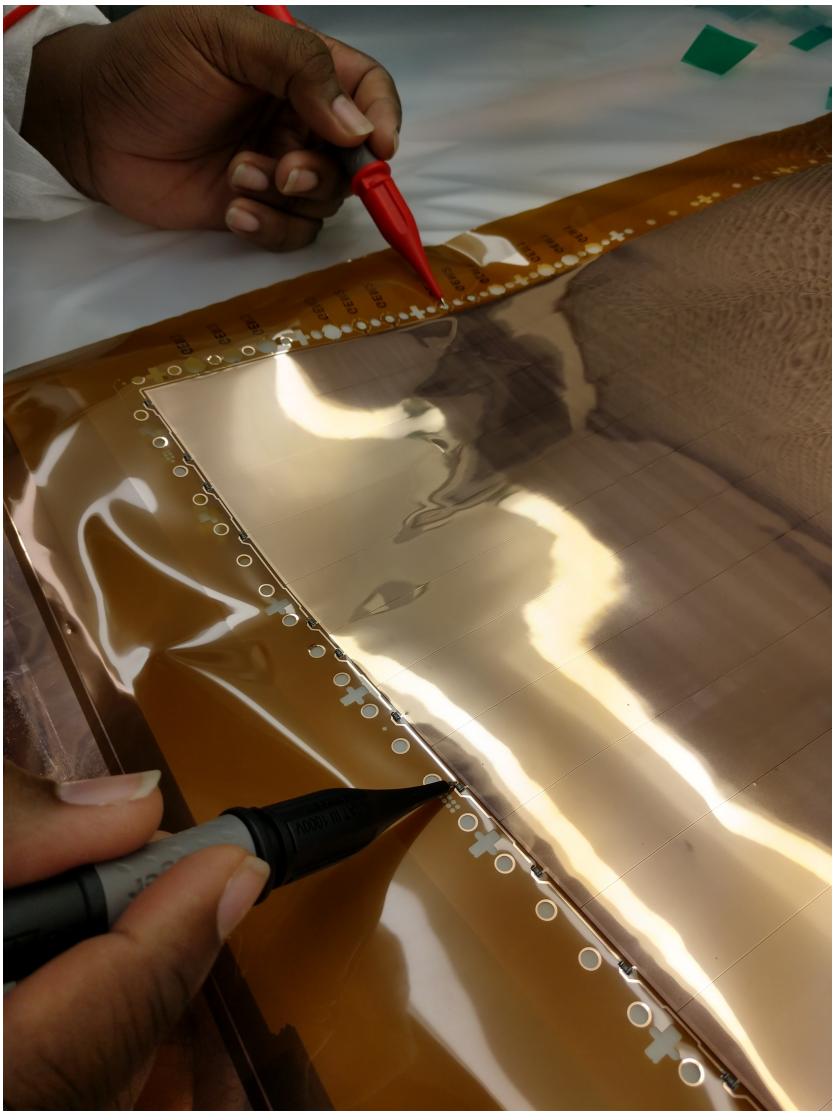

Figure 4: Meggering the foil sector by sector.

Chapter 2: Quality Control 3

Purpose

The third quality control test is run to ensure that the chamber is gastight. This chapter will outline the steps necessary for completing the test.

Data Acquisition

Three different measurements are needed for QC3: the chamber pressure, the atmospheric pressure, and the ambient temperature. These measurements are taken by the pressure transducer, the atmospheric pressure sensor, and the temperature sensor. These sensors are connected to the Arduino, which is connected to the breadboard (figure 5), which is then connected to the laptop in the clean room.

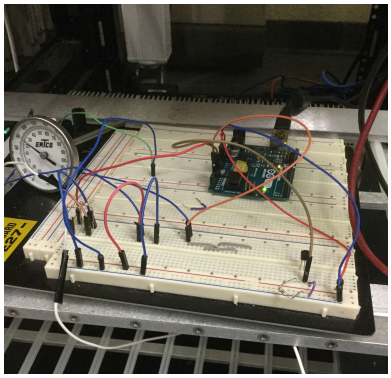

Figure 5: The setup of the sensors, Arduino, and breadboard system.

Procedure

Because the purpose of this QC step is to determine the airtightnesss of the chamber, it is paramount that the lines to and from the detector are not leaking. During each step where you are connecting a line or capping the outlet of the detector, ensure that the connection is fully tightened with the wrench. (this includes both sides of the connector!) (Ensuring this will make the troubleshooting leaks (should they arise) much easier, as you can be assured that the gas system itself isn't leaking. Note here that if the system is indeed leaking, it is quite easy to tell because it will be very difficult to establish pressure in the detector.

1. Place the detector into the support stand and tighten down the clamps with an Allen wrench (fig. 6).
2. Connect the gas line from the flow meter of QC3 IN into the connector at the narrow end of the detector (gas inlet).

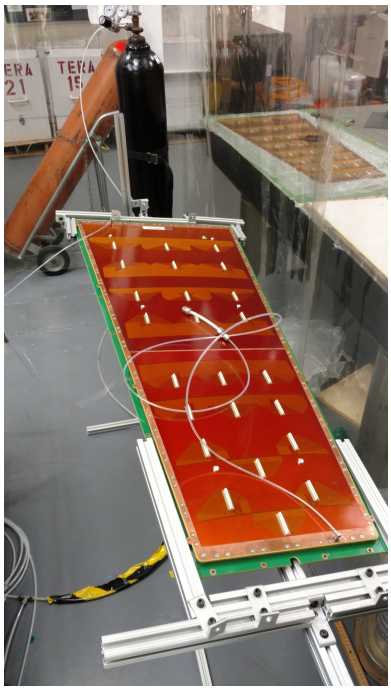

Figure 6: QC3 test stand.

Figure 7: The QC 3 files and the order they should be opened in.

3. Connect the cap to the gas outlet at the wide end of the detector.

4. On the laptop in the cleanroom, open the first Arduino file `QC3_Pressure_Monitor` (figure 7), and upload the code to the Arduino. After the code is successfully uploaded, select `Tools > Serial Plotter`. This will open a window displaying a plot (see figure 8) of the real-time pressure variation (ordinate axis is pressure in mbar), which is helpful for establishing the correct pressure in the detector, and also for troubleshooting leaks.

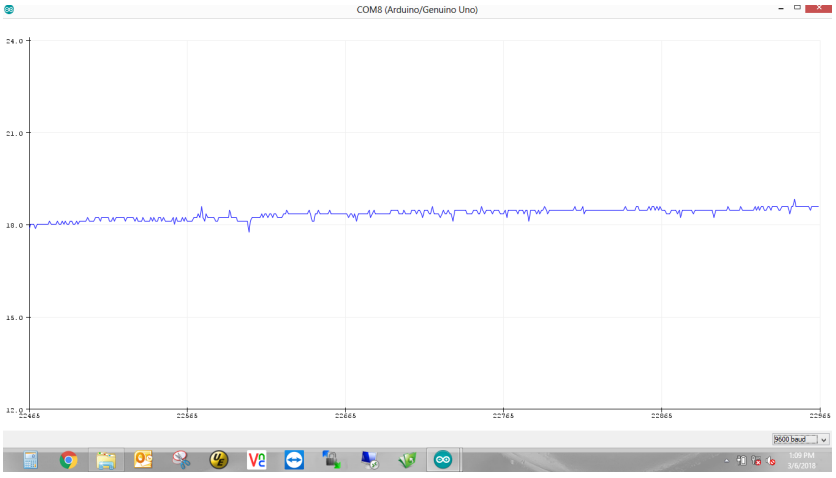

Figure 8: Serial plotter window. Note that the ordinate is in mbar.

5. On the nitrogen tank (fig. 9), open the valve on the top by turning several times. The gauge on the right is the pressure on the right side of the line (the tank pressure) while the gauge on the left is the pressure in the line to the QC3 IN flow meter. Now, open the valve under the pressure gauges. You will hear a short hiss and see the pressure established on the left gauge.[3]

[3] Make sure that the valve to QC3 IN flowmeter is OPEN, but make sure that the flowmeter valve is completely closed.

Figure 9: The nitrogen tank in the clean room.

6. Slowly open the valve on the QC3 IN flowmeter and raise the pressure. Set the pressure to 24 mbar.[4]
7. After the pressure is set, close the QC3 IN flowmeter valve and open the cap on the backside of the flowmeter to set the this side of the line to atmospheric pressure. This eliminates any back pressure in the lines.
8. Close the Arduino file and then open the second Arduino file `QC3_Sensor_Data`. Upload the file to the Arduino.[5]
9. Now, open the excel template[6] (`QC3-DAQ_GE11_V_Template.xlsx`) with the macros enabled.
10. Enter your name and set the duration of the test to two hours (only one hour is needed for the V2 QC templates, but more data is always better).
11. The screen in figure 10 displays a spreadsheet ready for data acquisition. Click `Connect` to begin taking data.
12. Wait for a few minutes and verify that the leak rate will be under 5 mbar/hr. If it is not, refer to chapter in Part II for trouble shooting steps to ensure that the detector is air tight.
13. Make a note of the current atmospheric pressure, as you will need to determine the correct atmospheric pressure by determining the offset by subtracting the pressure recorded by the weather station from the atmospheric pressure recorded in the spreadsheet:

    $$\text{offset} = \text{spreadsheet value} - \text{weather station value}.$$

    Once this offset is determined, subtract the offset form every value in the atmospheric pressure column in the spreadsheet.

[4] Do not exceed 24 mbar! The U-tube line will clear and relieve the pressure in the system at 25 mbar.

[5] If this file or the QC3 template is opened before the first file opened (`QC3_Pressure_Monitor`), it will cause errors in the recorded measurements.

[6] This is the old template—data must be transferred to the new template (`QC3_GE11-X-A-SITE-BBBB_YYYYMMDD_TemplateV2.xlsx`) after QC3 is completed.

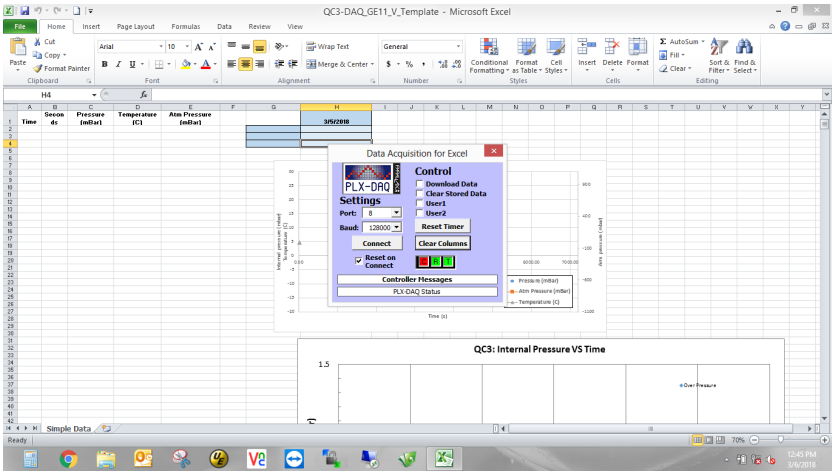

Figure 10: Template for QC3.

A successful QC3 test is quantified by a leak rate of 5 mbar/hour or less. A plot of a successful test is shown below:

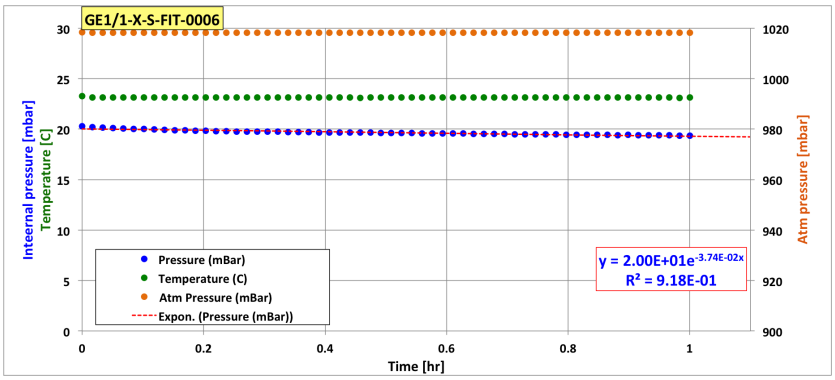

Figure 11: A successful QC3 test.

Troubleshooting

If the chamber shows a leak rate above 5 mbar/hr, perform the following steps:

1. Torque the screw on the readout (RO) and drift to 1.25 Nm. If any of the heads of the closing screws are stripped (i.e., the torque screwdriver doesn't click when torqued), remove and replace the screw[7].

2. Rerun QC3.

3. If there is still an unsatisfactory leak rate, re-torque the closing screws on the RO and drift to 1.3 Nm. Again, if any screws with

[7] Ensure that when the screw is removed there is no washer left in the detector.

stripped heads are discovered, remove and replace them with a fresh screw.

Chapter 3: Quality Control 4

Purpose

The fourth quality control test determines two qualities: (1) the total resistance of the chamber by plotting a V vs. I curve, and (2) the spurious signal. The first goal is achieved by recording the monitored voltage (`Vmon`) and the monitored current in the chamber (`Imon`), and subsequently plotting voltage versus current (which is Ohmic in nature) and thus determining the resistance by the slope. The second goal is accomplished by recording the counts that register on the scaler over a period of time at different levels of applied voltage.

Data Acquisition

The noise is reduced on the detector by ensuring a proper ground, and this is assessed by viewing the waveforms on the oscilloscope. (in order to reduce the threshold to around 190 mV). After which, the scaler (fig. 12) is used to measure the spurious signal at each applied voltage.

Procedure

1. Solder on the HV connection and the voltage divider.[8]
2. Fix the grounding plate to the RO board.
3. Place the Panasonics with 50 Ω terminators on the detector.
4. Flush the detector with CO_2 for at least five hours. Set the rate on the QC4 IN flowmeter to 60 units (high flow; this corresponds to 5.7 L/hr).
5. Connect the preamplifier (fig. 13) to the amplifier (fig. 14)
6. Ensure that the amplifier has a coarse gain set to 20 and a fine gain set to 0.9 (for a total gain of 18).

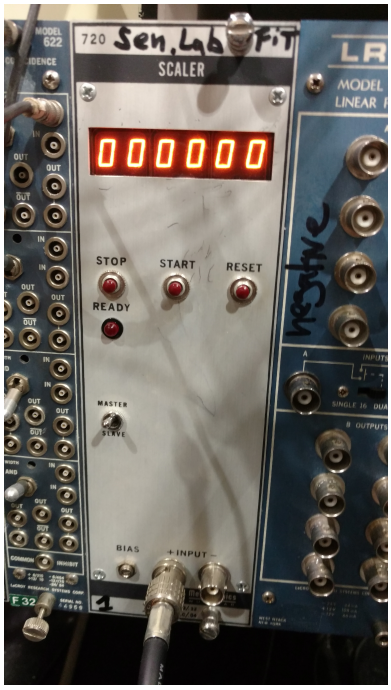

Figure 12: The Scaler.

[8] Always wear gloves when soldering HV components!

Figure 13: The preamplifier (entombed in foil and weights) on the QC4 table.

Figure 14: The amplifier (with input from the QC4 preamplifier).

7. Continue to improve the grounding of the detector by applying grounding strips, copper tape, weights, and clamps.

8. When the noise is reduced to 190 mV, the waveform on the scope will not move anymore. Ensure that the scaler and the counts on the scope are synchronized (i.e., they count the same number of signals over an arbitrary acquisition time). This can be accomplished by resetting the scaler and moving the threshold on the scope from 189 to 190 mV at the same time[9]

9. **WHEN APPLYING VOLTAGE FOR THE FIRST TIME, IT IS IMPORTANT TO RAMP VERY SLOWLY AND WAIT AT EACH VOLTAGE FOR A FEW MINUTES.** For instance, set `Ramp = 10 V/s` and a current limit $\sim 5\mu$A above what the current should normally be. A good rule of thumb to determine the current at each applied voltage is to compute the current using Ohm's law and a resistance of 5.3 MΩ[10]

10. Open the HV control by entering the following commands:

    (a) First, become super user by typing

    ```
    su
    ```

    (b) Enter the password and hit `<return>`

    (c) Enter

    ```
    minicom -s
    ```

    This will display the options for `minicom`; see fig. 15) then scroll to the option `Exit` and hit `<return>`. This will bring up a blank screen.

    (d) Now, type `caen`; the screen in fig. 16 should be shown. Now hit `d`. The window in fig. 17 should be displayed[11].

11. To begin taking data, open the excel template `QC4_GE11-X-A-SITE-BBBB_YYYYMMDD_TemplateV2.xlsx`.

12. Starting at a set voltage of 200 V on Channel 2, record the monitored voltage and current. Record the counts on the scaler over 10 sec.[12].

13. Increase the voltage in steps of 200 V and record the monitored voltage, current, and the counts on the scaler over 10 sec.

14. Once 3000 V are reached, continue in steps of 100 V until 4900 V is reached.

[9] Moving the threshold on the scope from 189 to 190 mV resets the number of triggers, which are displayed in the bottom left hand corner of the scope.

[10] The resistance of the circuit is determined by the resistance of the HV high-pass filter(s) and the voltage divider itself. Each filter has a resistance of 0.3 MΩ, and the HV divider has a resistance of 4.7 MΩ.

[11] If this does not bring up the HV control, try just typing `q` and then `d`.

[12] It is best to keep the scaler running and pushing the reset button when starting a new acquisition time of 10 s.

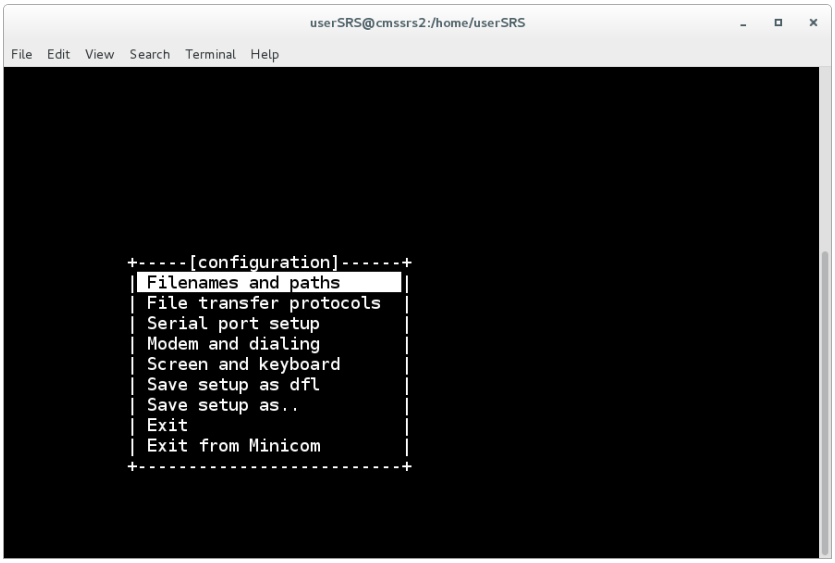

Figure 15: The minicom options screen.

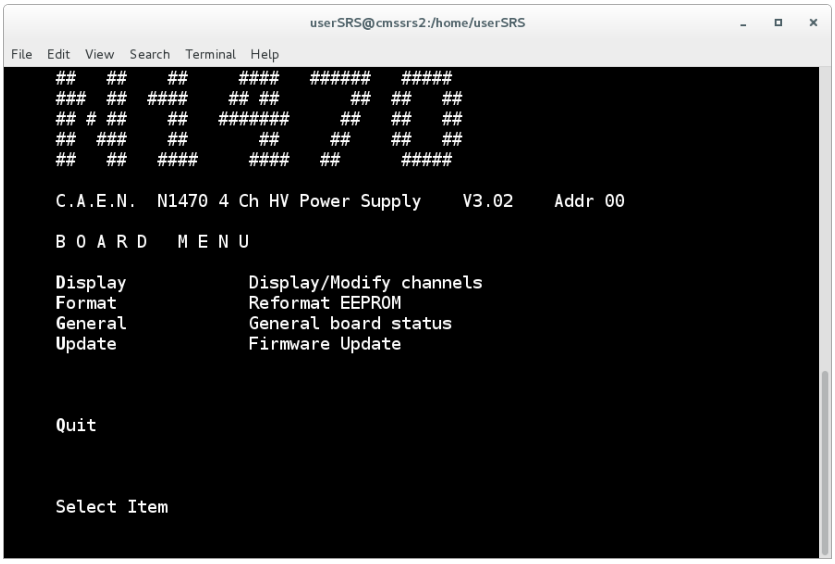

Figure 16: The CAEN HV home screen.

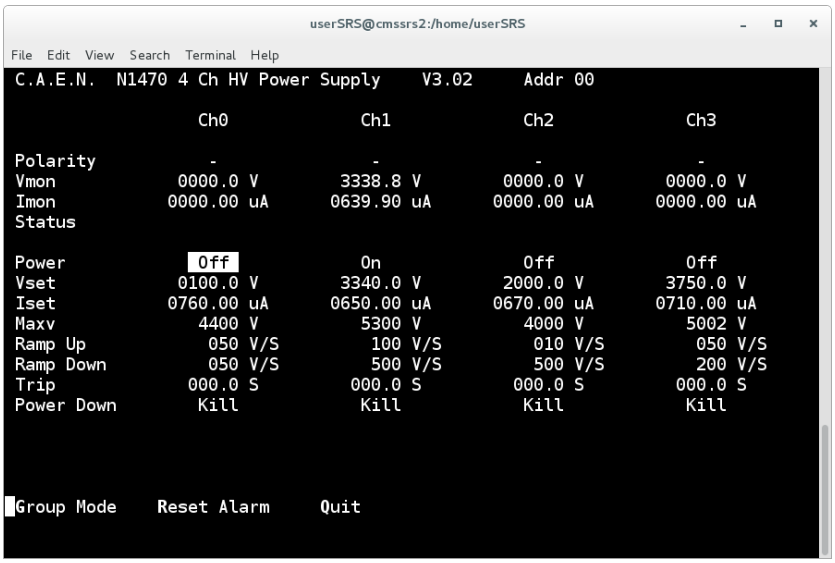

Figure 17: The control

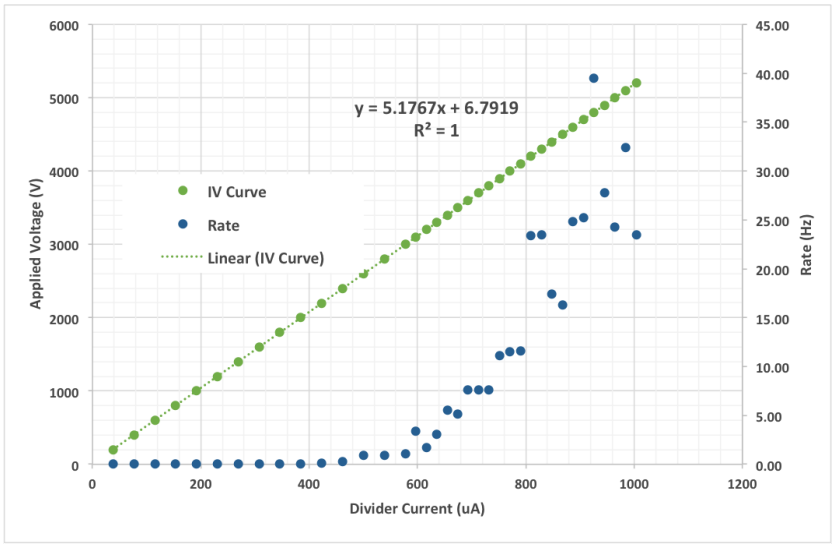

Figure 18: A successful result for QC4.

Chapter 4: Quality Control 5—Effective Gain

Purpose

This chapter details the effective gain measurement of one sector of the chamber. Generally, the effective gain is always measured in sector (4,2).

Data Acquisition

For this quality control procedure, the chamber is placed in the stand in the X-ray box (fig. 19). The chamber is irradiated with X-rays from the Amptek Mini-X X-ray gun, and two procedures are performed: (1) a rate measurement is obtained from the counts registered on the scaler over an acquisition time of 10 seconds at each pre-determined current, and (2) the current flowing from the RO on sector (4,2) is measured with a Keithley Picoammeter which is controlled by the `LabView` software. Rate and current measurements are taken with the source ON and OFF.

Because the procedure to collect data with the scaler and the picoammeter are quite different, the general procedure for the setup will be listed first, and then the procedure for obtaining the rate and current measurements will be listed after.

Figure 19: X-ray Box.

Figure 20: Grounding Cable.

Procedure

1. Place the detector in the stand in the X-ray box, fix the grounding plate, place Panasonics on every sector but (4,2) (fig. 19), and attach the grounding cable with a C-clamp (fig. 20).

2. Solder on the HV connection (see fig. 21).

3. Ensure that there are copper filters on the X-ray gun (specifically, five pieces of copper tape and three copper sheets).

Figure 21: HV connection on the PCB.

4. Connect the gas lines to the QC5 Input and Output and flush with Ar/CO_2 on high flow[13] for at least five hours.

[13] This is a scale reading 60 units, which translates to ~5.7 L/hr

Rate Measurement Procedure

1. Connect Panasonic connector with the green cable to sector (4,2). Make sure both access doors to the X-ray boxes are closed.
2. Open the HV control (see procedure item 9 of Chapter 3).
3. On the X-Ray laptop open the Mini-X Software (located in the top left corner; see figs. 22 and23).
4. Hit `<Start Amptek Mini-X`.
5. Enter 40 (kV) for the X-ray voltage and 5 (uA) for the current. Press `<HV ON>`.
6. Open the excel spreadsheet `QC5_GE11-X-A-SITE-BBBB_YYYYMMDD_TemplateV2.xlsx`.
7. Ramp the detector slowly to a monitored current of 550 uA[14].
8. Record the monitored voltage, ambient pressure and temperature, and time on the spreadsheet. Using a stopwatch, measure the counts on the scaler over a period of 10 s.

[14] The HV channel for the X-ray box is channel 1.

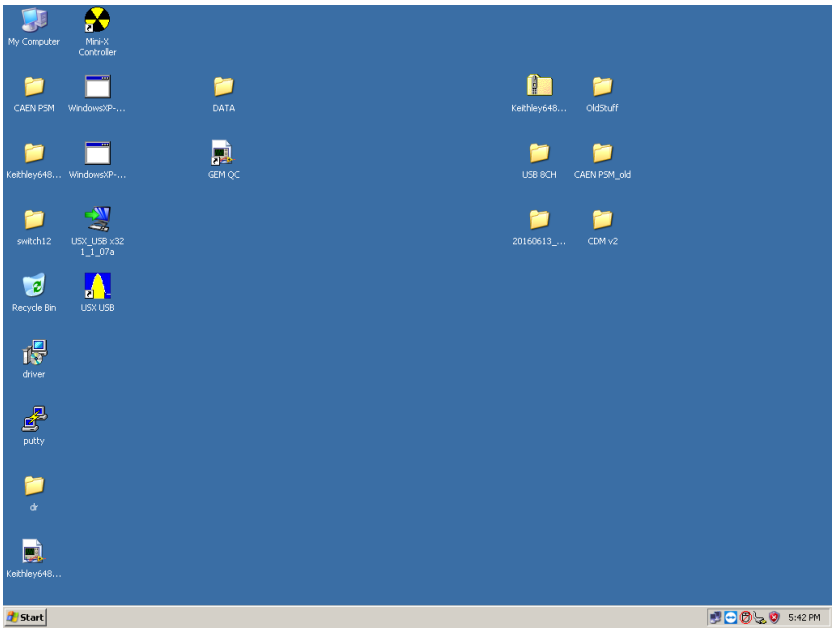

Figure 22: The Desktop of the X-Ray computer.

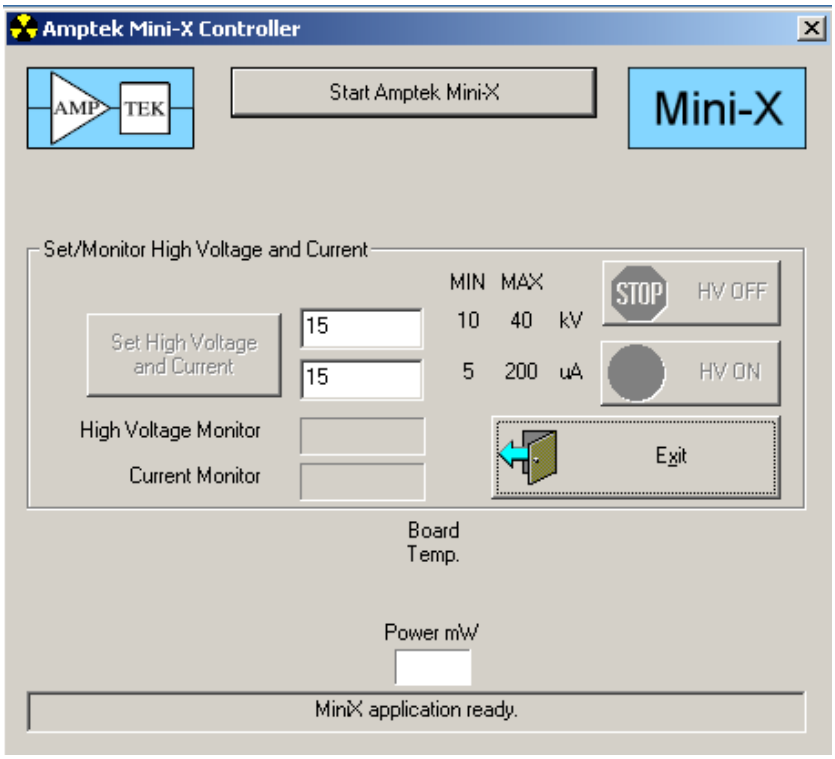

Figure 23: The X-Ray control screen.

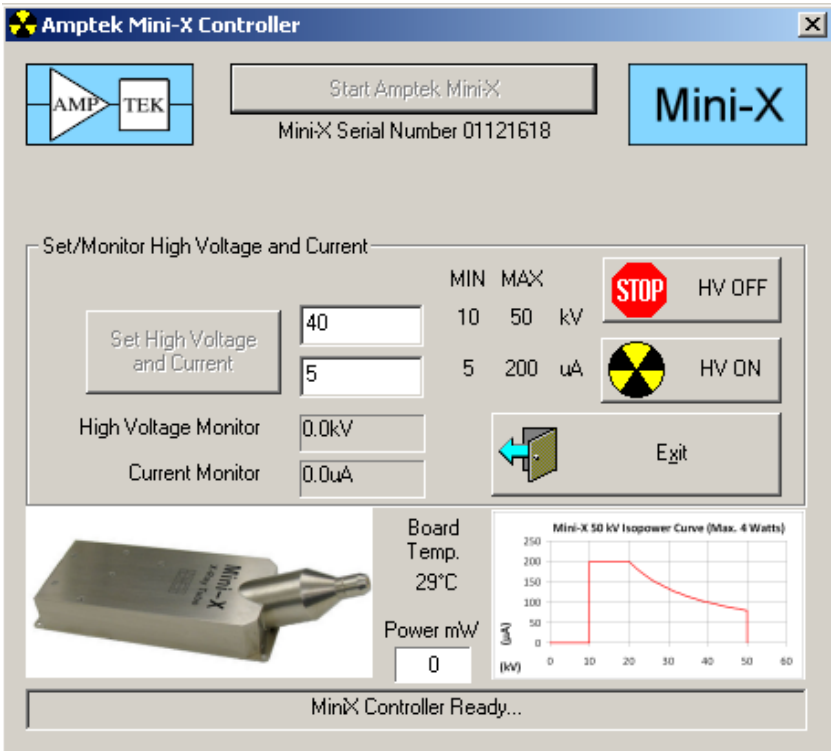

Figure 24: The initialized X-Ray screen after starting the Mini-X software.

9. In steps of 10 uA raise the monitored current and repeat step 6.
10. Repeat items 5-7 with the source OFF.

LabView Current Measurement

THE LABVIEW 2015 SOFTWARE is installed on the TOP QUARK machine, so this part of QC5 is performed exclusively with TOP QUARK. `LabView` takes current measurements at specific voltages obtained from the rate measurement. Use this data to input the voltages for each specific monitored current you would like to obtain a current measurement at (in the test cycles window on the LabView control panel; see fig. 28).

1. Connect the Panasonic connector with the grey cable to sector (4,2) (fig. 25).
2. Open the `Device Manager` on TOP QUARK and select `Ports (COM & LPT)`.
3. Remove the USB HV control cable[15] from HASWELL and plug it into TOP QUARK. Be sure to monitor the `Device Manager`

Figure 25: The Panasonic connector for the picoammeter.

[15] This is the USB cable with the white wrapping on the overmolding.

window to see the serial port that appears when the HV control cable is plugged in.

4. Ensure that the picoammeter USB cable is connected.[16]

5. If the port number is not displayed when the new USB device is detected (as seen in fig. 26), right click on the device, select `Properties > Port Settings > Advanced`, and the window with the COM port number will be displayed (fig. 27).

[16] This is the USB cable with the blue overmolding and a light grey, braided wire.

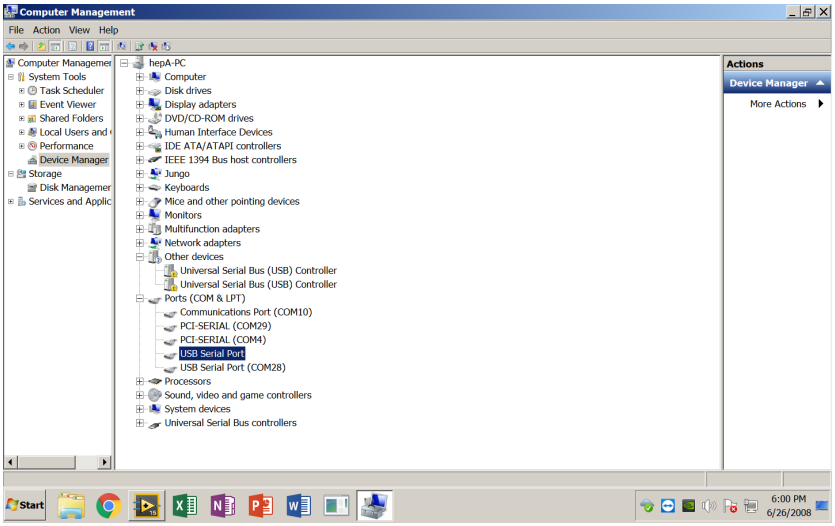

Figure 26: The device manager displaying the ports in use.

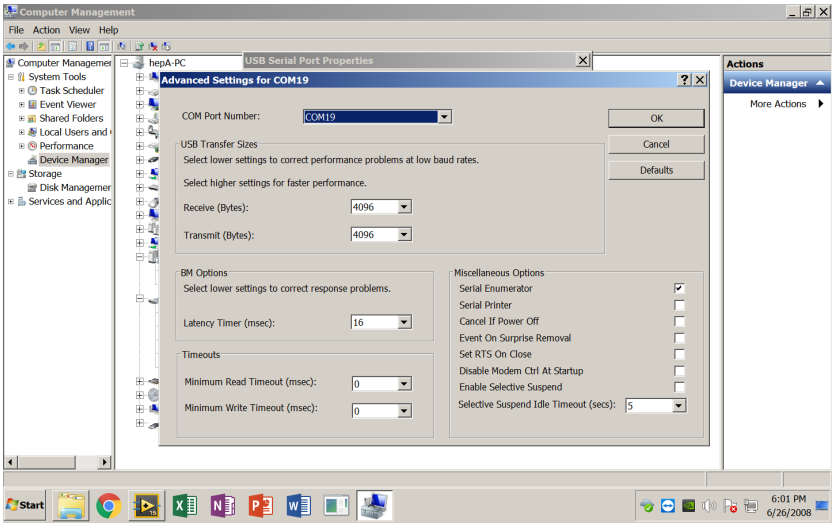

Figure 27: The COM port number displayed under `Properties > Port Settings > Advanced`.

6. Now, open `LabView 2015` by clicking on the file `QC5EFFECTIVE` on the desktop. After entering the software, the screen in fig. 28

should be displayed.

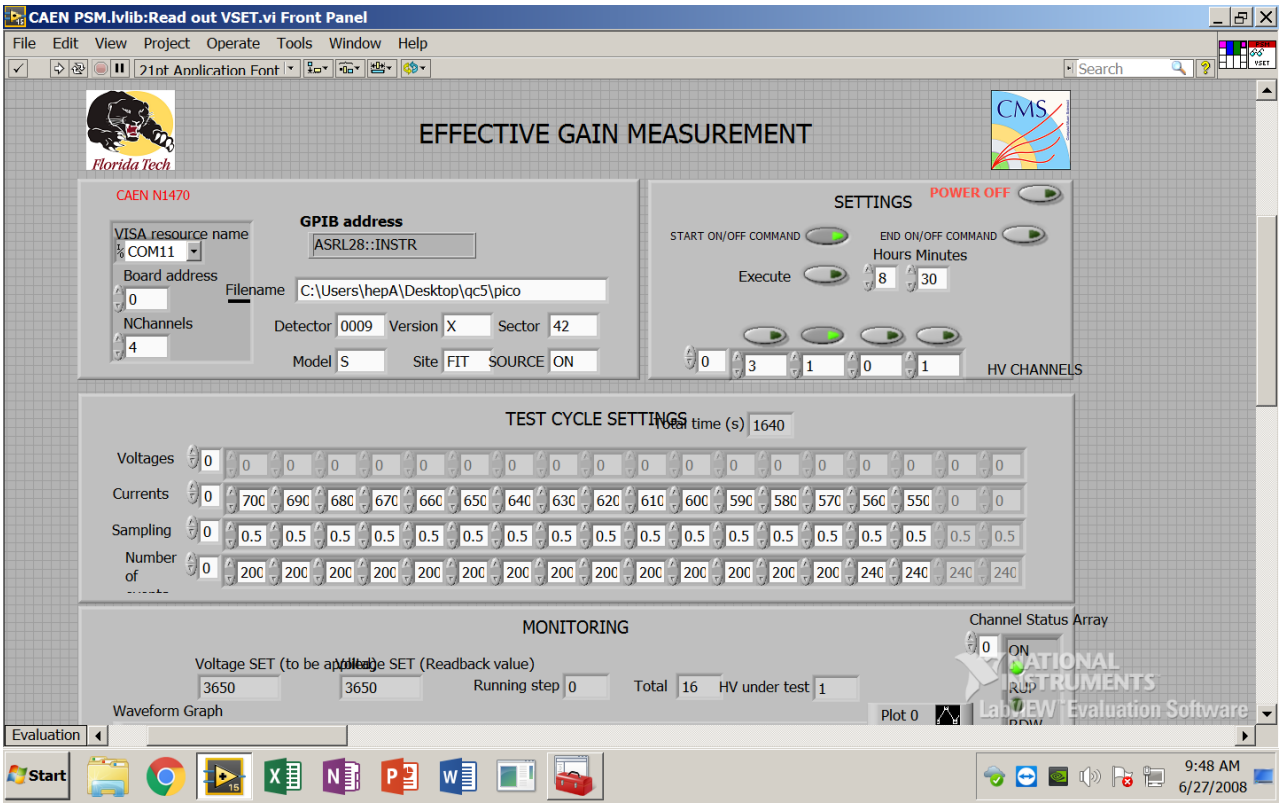

Figure 28: The control screen in LabView.

7. This control panel deserves some explanation:

   (a) The parameters for the CAEN HV control are in the upper lefthand corner. The `VISA resource name` should be set to whatever `COM` number is set for the specific port you are using for the USB HV control. The number of channels should be four and the board (short for internal board address) should be set to zero.

   (b) The only number in the `GPIB Address` (set to 28 in this example), should be set to the port number for the USB cable to the picoammeter.

   (c) The file name should be set to `C:\Users\hepA\Desktop\qc5\pico`. Note that this directory must already be pre-existing before taking data because LabView will not create a new directory if one does not already exist.

   (d) The parameters underneath the filename path must be set each time `LabView` is run; these are used when naming the output files.

(e) The `Settings` box in the upper righthand corner control which HV channel is selected (in this example HV channel 2 is selected, which is noted by the light on the "switch" on the `HV CHANNELS`). The user can also add a delay to taking measurements, which can be accomplished by setting the delay under the hours and minutes box, and then selecting `Execute`.

(f) The test cycle settings window needs to be updated with the appropriate voltages needed to obtain the currents used in the rate measurement portion of QC5—Effective Gain.

(g) The sampling should remain at 0.5, and the number of events should remain at 200 (this is the minimum number of samples needed).[17]

[17] Make sure that the arrays for each of the test cycle settings are equal.

8. Turn the X-ray source ON with 40 kV and 5 μA.

9. Make sure the `Source` is set to ON in the control panel.

10. Click the arrow button in the upper lefthand corner beneath `Edit`.

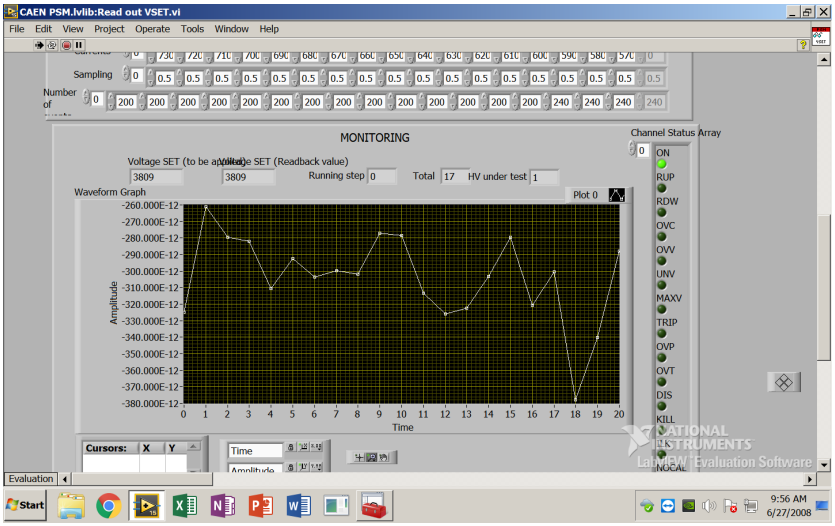

Figure 29: The monitoring window in LabView.

11. Scroll down and observe the `MONITORING` window (fig. 29). For source ON, one should observe -0.4 to -0.9 nA at the largest current.

12. When data collection is complete, turn the X-ray source OFF, change the source status to OFF on the LabView control panel, and click the arrow in the upper lefthand corner to begin the trial again.

13. After the data has been collected, check the folder `qc5` on the Desktop. The folder should now be populated with `.txt` files for each value of current with the source ON and OFF.

14. Copy and paste these files into the appropriate sheets (labeled with the microamp values at the bottom) in the `QC5_GE11-X-A-SITE-BBBB_YYYYMMDD_TemplateV2.xlsx` workbook.[18]

[18] If you took data for currents above 700 μA, you will need to unhide the sheets for those currents in the bottom spreadsheet bar in Excel. To do this, right click on the space where the sheets in the workbook are listed, and click `Unhide`.

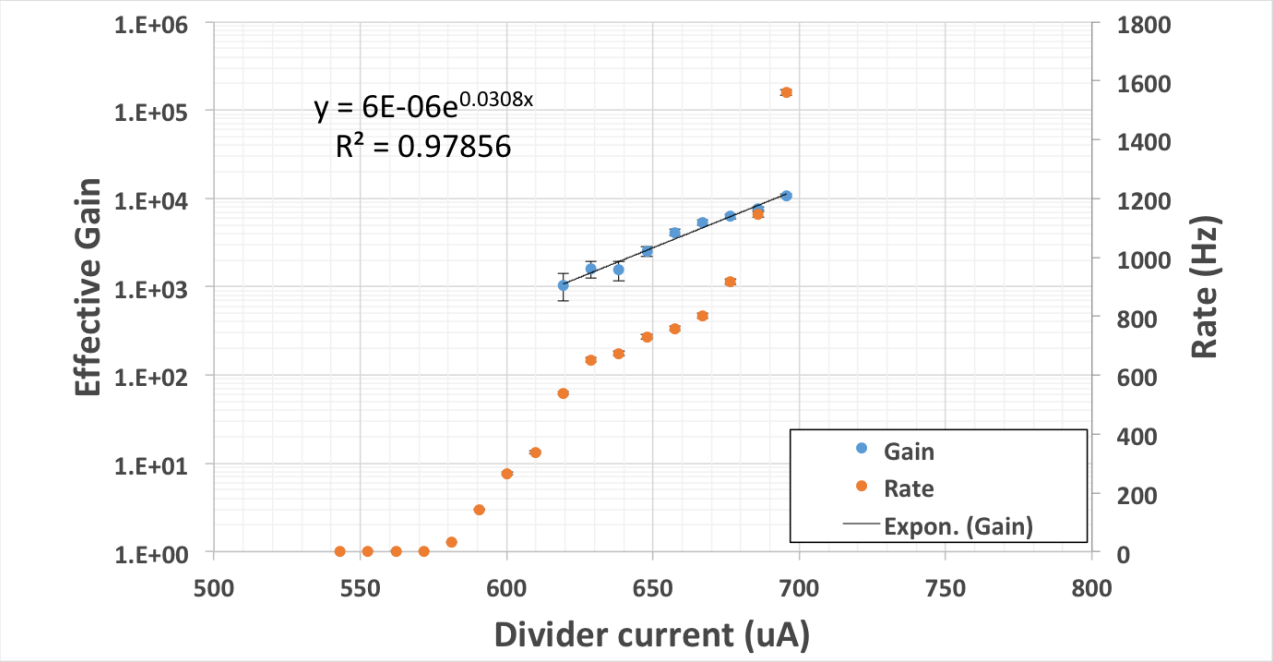

Figure 30: A successful QC5—Effective Gain plot.

Chapter 5: Quality Control 5—Gain Uniformity

Purpose

The purpose of determining the gain uniformity response of the detector is to simply ensure that all sectors show suitable and uniform gain. Because the effective gain calculation is performed in only one sector, we lack information about the response of the rest of the sectors. Thus the need for a gain uniformity test.

Data Acquisition

This analysis is run on the HASWELL machine. At the time of this writing, the framework version of the CMS GEM Analysis Framework is v5.1. Make sure that the HV Control USB cable is plugged into this machine before beginning the procedure.

Procedure

The procedure that follows is valid for the CMS GEM Analysis Framework 5.1. It is always advisable (and usually necessary) to take a few trial runs before proceeding to collecting 50 trials worth of data. Also note:

DO NOT HANDLE THE APVs WHEN THE FECs ARE RECEIVING POWER.

This is very important, as swapping APVs or recabling the chamber while the APVs are receiving power can damage them. Always turn the power to the FEC crate off when altering the APVs or the FECs.

One last thought: it is important that one keeps a logbook of trial

numbers and parameters altered, as this information is not stored by the software. This will be important later for making comparisons between runs and also what runs you want to include in the run list for analysis.

1. Remove the copper filters from the X-ray gun.
2. Place the APVs on the detector based on the cabling setup in fig. 31.

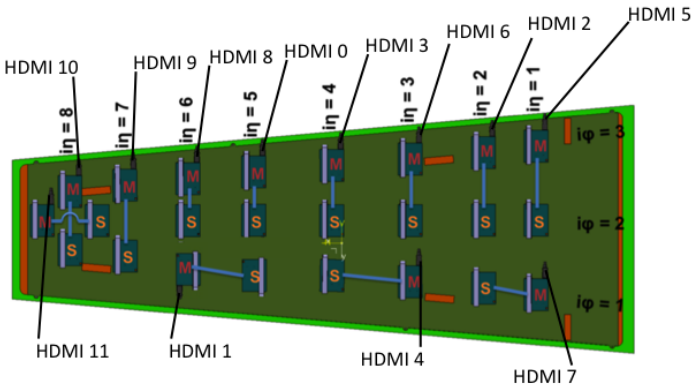

Figure 31: The cabling setup for the APVs.

3. Turn on the FECs (Front End Controllers)[19]
4. Become super user and enter the following command to mount all of the drives (this includes `nas1` hosted on the cluster, `/mnt/gemdaqbackup` hosted on another tower in the High Bay, and the external drive, named `/data`).

```
mount -a
```

5. Open the CAEN HV control.
6. Open a new terminal and type

```
/opt/scribe/daq.sh
```

This starts DATE, the DAQ (Data Acquisition) system. Two windows should appear: fig 32 shows the Run Control Window and fig.33 shows the Info Browser. If both of these windows do not appear there is a problem. Try running the command again.[20]

[19] When facing the crate from the front, there is a small switch near the power supply cable to FECs on the back of the crate. Several LEDs inside the crate should turn on when powered.

[20] If the Run Control Window does not appear, the system will need to be rebooted.

Figure 32: The Run Control window.

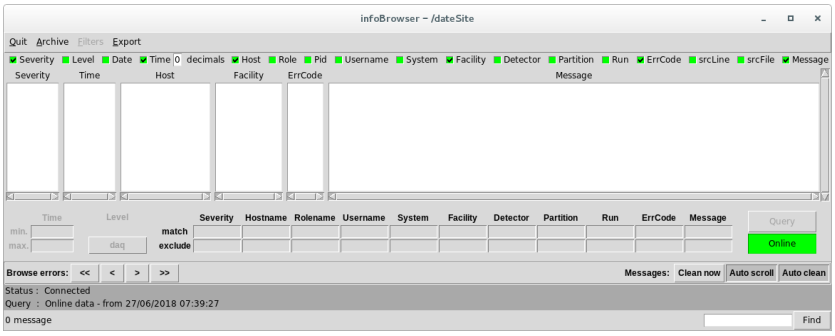

Figure 33: The Info Browser window.

7. Take control of the DAQ control window by clicking the lock button in the upper lefthand corner.

8. Now, open up a Firefox browser and type `localhost/srs_v3.php`. After this page has opened, click on the `DAQ` tab. The following window should be displayed (fig. 34 and fig. 35).

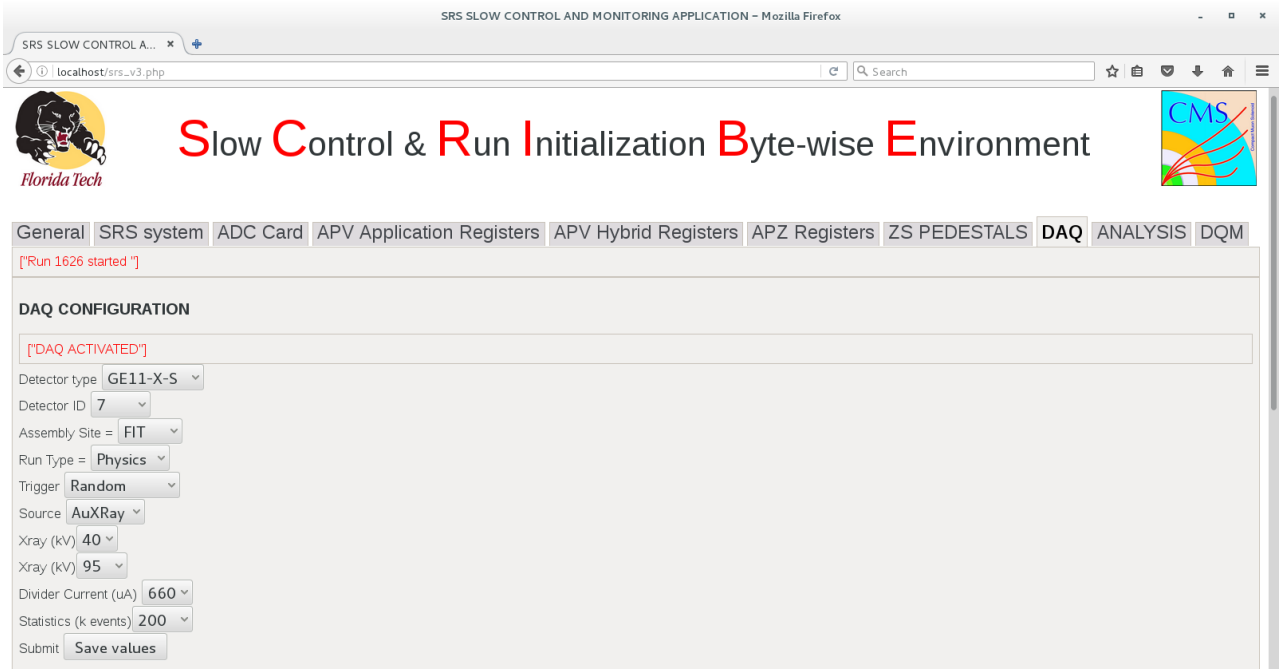

Figure 34: The SCRIBE control window.

9. Input the appropriate detector ID parameter and hit `<Save values>`. Table 1 lists the settings that should be used:

Parameter	Value
Detector type	GE11-X-S
Assembly Site	FIT
Run Type	Physics
Trigger	Random
Source	AuXray
Xray (kV)	40
Xray (uA)	95
Divider Current (μA)	660
Statistics (k events)	200

Table 1: The values for the parameters in the SCRIBE DAQ Configuration.

The divider current is *usually* set to 660 μA, but this all depends on the value of current used to calculate the gain in QC5 Effective Gain.

10. Set the number of runs to 50 and the number of events per run to 200000 and click `<Update values>`.

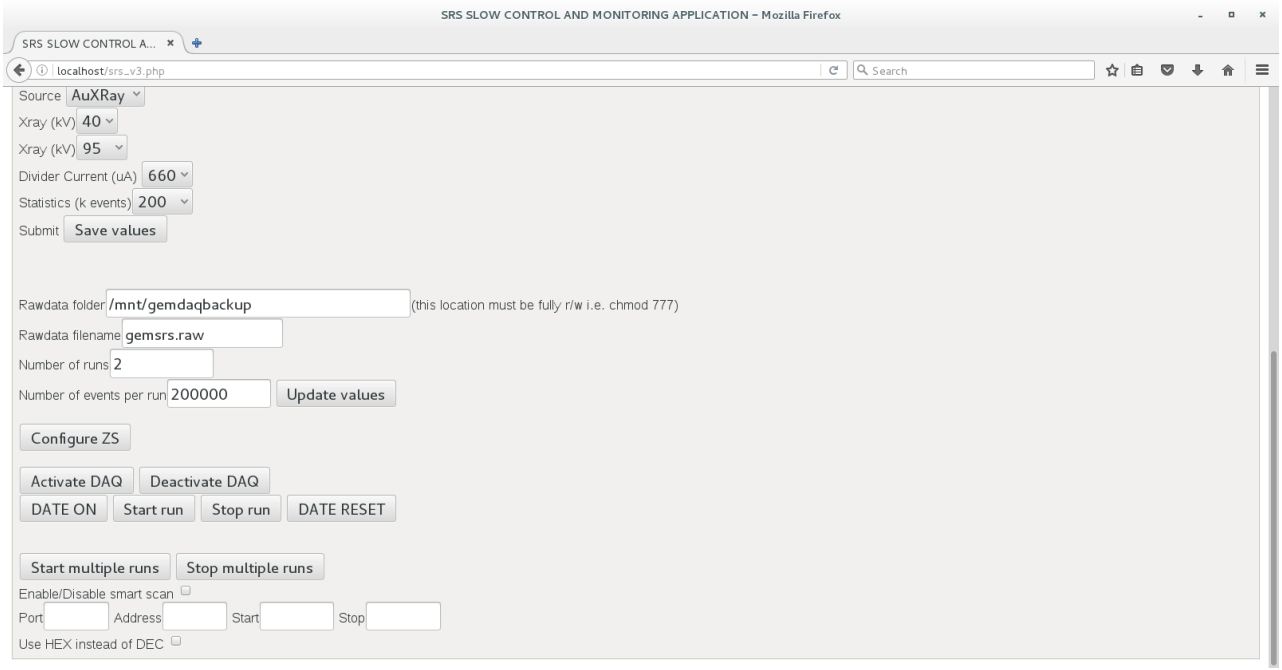

Figure 35: The SCRIBE control window.

11. Set the voltage to 2000 V.

12. In the same terminal that the script `/opt/scribe/daq.sh` was run, type

```
/var/www/cgi-bin/nconf.sh
```

    This command prepares the FECs.

13. Now, type

```
/var/www/cgi-bin/zs_config FEC APV APZ SIGPED
```

    This command configures the APVs and obtains and stores the pedestals for each APV (used for the zero suppression). The output to the terminal should show no repeating values when configuring the APVs[21].

14. Run the `/var/www/cgi-bin/nconf.sh` command again to put the system into standby mode.

15. Open a new terminal window and enter the following command

```
/var/www/cgi-bin/cms.sh
```

    This script automates the process of converting `.raw` files into `dataTree.root` files. Because this script runs in the background,

[21] If one (or more) APV(s) is(are) not connecting, it will continually print that same APV to the screen. If this happens, refer to the troubleshooting section.

whenever a new run file is saved to `/data/srsdata`, a placeholder file will be created in the `/todo` directory. This will then signal the script to start processing the newly created .raw file.

16. Now open a new terminal window and change to the `CMS_GEM_Analysis_Framework-master51` directory[22].

17. Turn the Xray source ON and then change the monitored voltage to whatever current is appropriate for this detector.

18. Press `<Start multiple runs>` on the SCRIBE window to begin taking data. The windows in figures 36 and 37 should appear.

[22] This has an absolute path of `/data/CMS_GEM_Analysis_Framework-master51`.

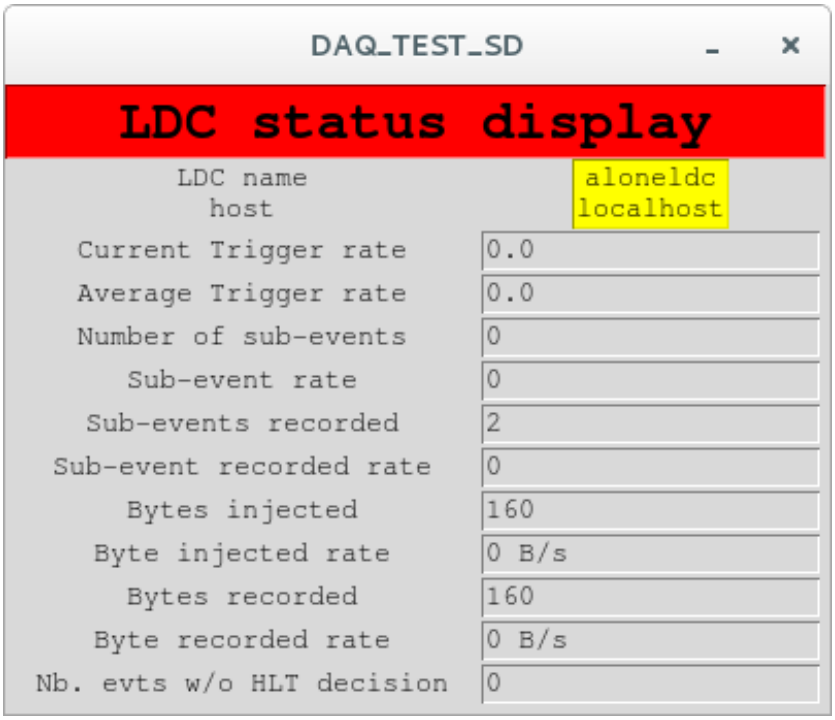

Figure 36: The first LDC Status window.

The first LDC status window (fig. 36) displays information on the current run (i.e., how many subevents were captured, the rate at which data is being taken, etc.). This allows one to confirm that data is actually being taken. The numbers should change from 0 in figure 36 to a positive, nonzero number, such as the window displayed in fig. 38

19. Edit[23] the configuration file by typing

```
gedit config/configRun.cfg
```

This will pull up the following file (fig. 39):

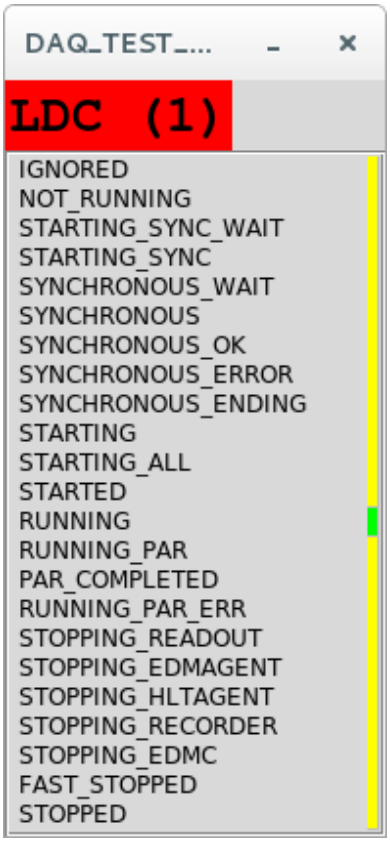

Figure 37: The second LDC status window.

[23] You can always use the text editor of your choice, e.g., `nano`, `vim`, `Sublime`, etc.

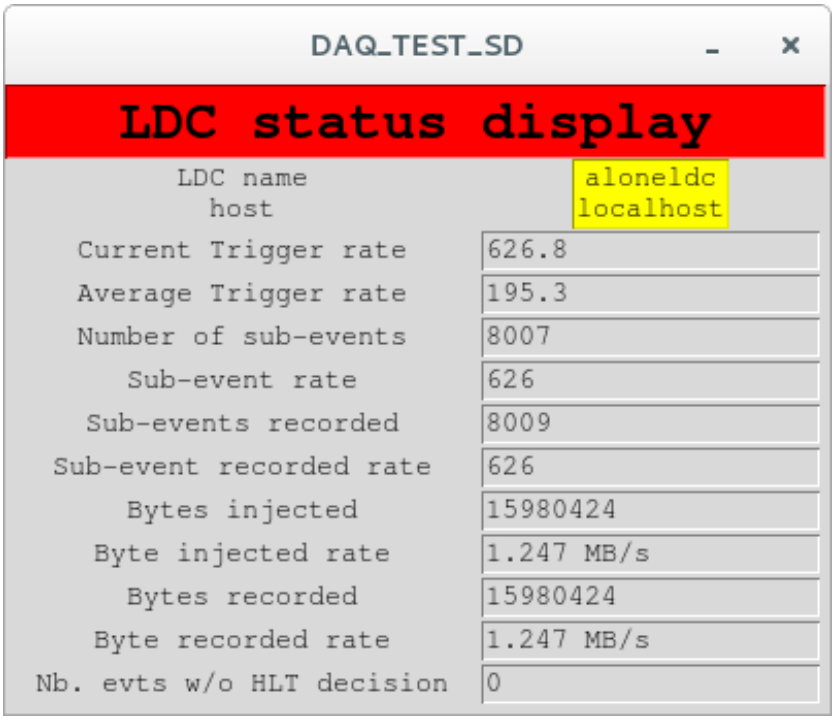

Figure 38: What should be displayed when data is being taken.

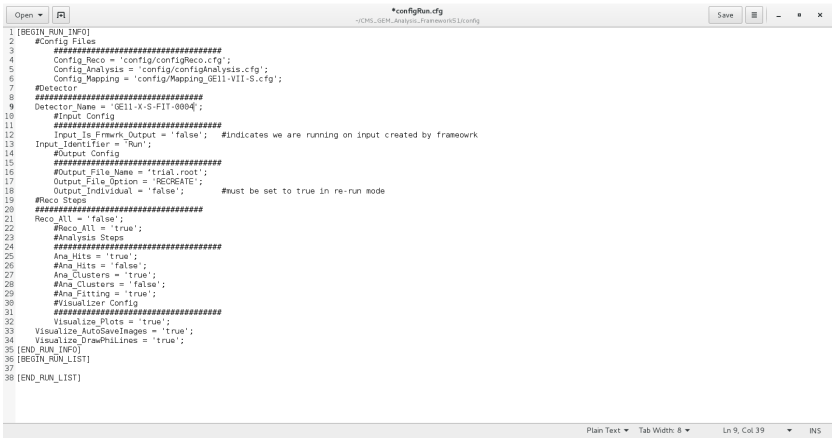

Figure 39: The configuration file.

20. Make sure the `Detector_Name` is correct, and then copy and paste the full path to where the `dataTree.root` files are located.

    These files and their paths should look like
    `/data/srsdata/GE11-X-S-FIT-8_RunXXXX_FIT_Physics_Random_AuXRay_40_95_YYY_200_dataTree.root`
    where `XXXX` is the run number (e.g., 2000, etc.), and `YYY` is the current at which the run was taken at (e.g., 650, 660, etc.). Edit the run numbers to reflect the runs taken. If you took a high statistics run and have many `dataTree.root` files to process, use the following script (it is located in the `~/CMS_GEM_Analysis_Framework-master51` directory) by typing

    ```
    ./fileNames.sh
    ```

    You will be prompted for the detector number (this is just the detector number without any leading zeros, e.g., 11 or 15, etc.). Enter the first run number, hit `<return>`, then enter the second, then `<return>`. Then enter the current at which the runs were taken at and press `<return>`. The output will be the full paths of the files you need to process. Copy and paste this into the `RUN LIST` in the `configRun.cfg` file, save, and close.

21. After all of the runs are finished processing (you can check this by ensuring that a `dataTree.root` file for each run is present in the directory `/mnt/gemdaqbackup`), type the following command into the terminal

    ```
    ./frameworkMain config/configRun.cfg true
    ```

    The framework will then process the `dataTree.root` files and produce a final output file named `FrameworkOutput.root` and all of the plots.[24] This output is located in the `/CMS_GEM_Analysis_Framework-master51` directory.

[24] Note that these files will be overwritten whenever new `dataTree.root` files are processed. So, if you want to save the output or root files, rename them or move them to a different directory.

Below are successful[25] plots which are output by the analysis framework.

[25] Note that there should be no discontinuities between phi sectors, and also that all sectors should have a fit success greater than 97%.

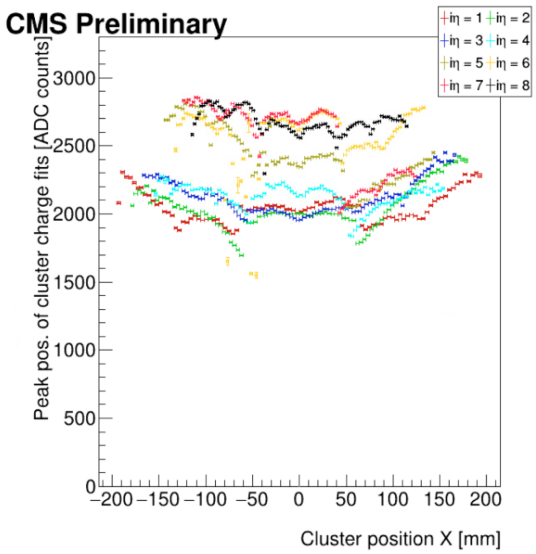

Figure 40: The fit peak position of clusters of charge.

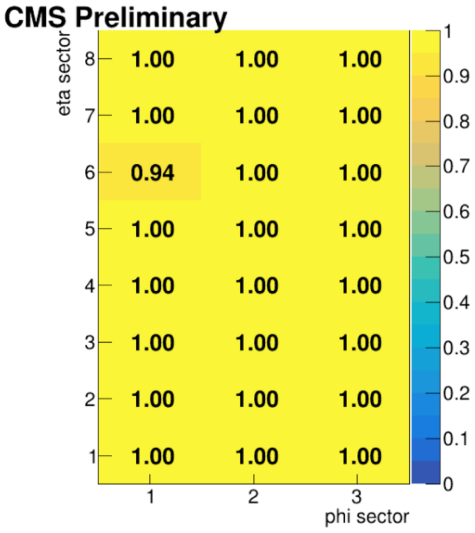

Figure 41: The fit success of each sector.

Troubleshooting

Some common issues and their solutions will be listed in separate subsections with their own procedures. In most cases, the first troubleshooting step should be power cycling the FECs (i.e., turning them off and then on again). If the problem still isn't solved after this, look for solutions below.

The FECs are not configuring

1. Trying pinging the FECs to see if you get a response. Type

   ```
   ping 10.0.3.2
   ```

   or

   ```
   ping 10.0.7.2
   ```

   If there is no response, check the orange ethernet cables on the back of the FECs (there are two, one for each FEC), check the router on the floor behind the computers, and check the network cable into HASWELL.

2. If the ethernet connection was not the issue, power cycle the FECs and try pinging them again.

3. If there is still no response, make sure that all of the HDMI cables are fully inserted into the master APVs and the FECs. Also make sure that the master to slave cables on the APVs are connected properly.

4. If there is no response, try unplugging the FECs from the crate and replugging them back in.

One or more sectors are disappearing.

1. First, ensure that all of chips are making good contact with the connectors on the RO.

2. Ensure that all of the HDMI cables are fully connected on the ADCs and on the APVs. See figure 42 for the proper configuration of HDMI cables on the ADCs.

3. Is this does not fix the problem, check the mask files for the FECs. Open the files `/srsconfig/fecmask0` and `/srsconfig/fecmask1`. The contents of `fecmask0` should be:

   ```
   3cff
   ```

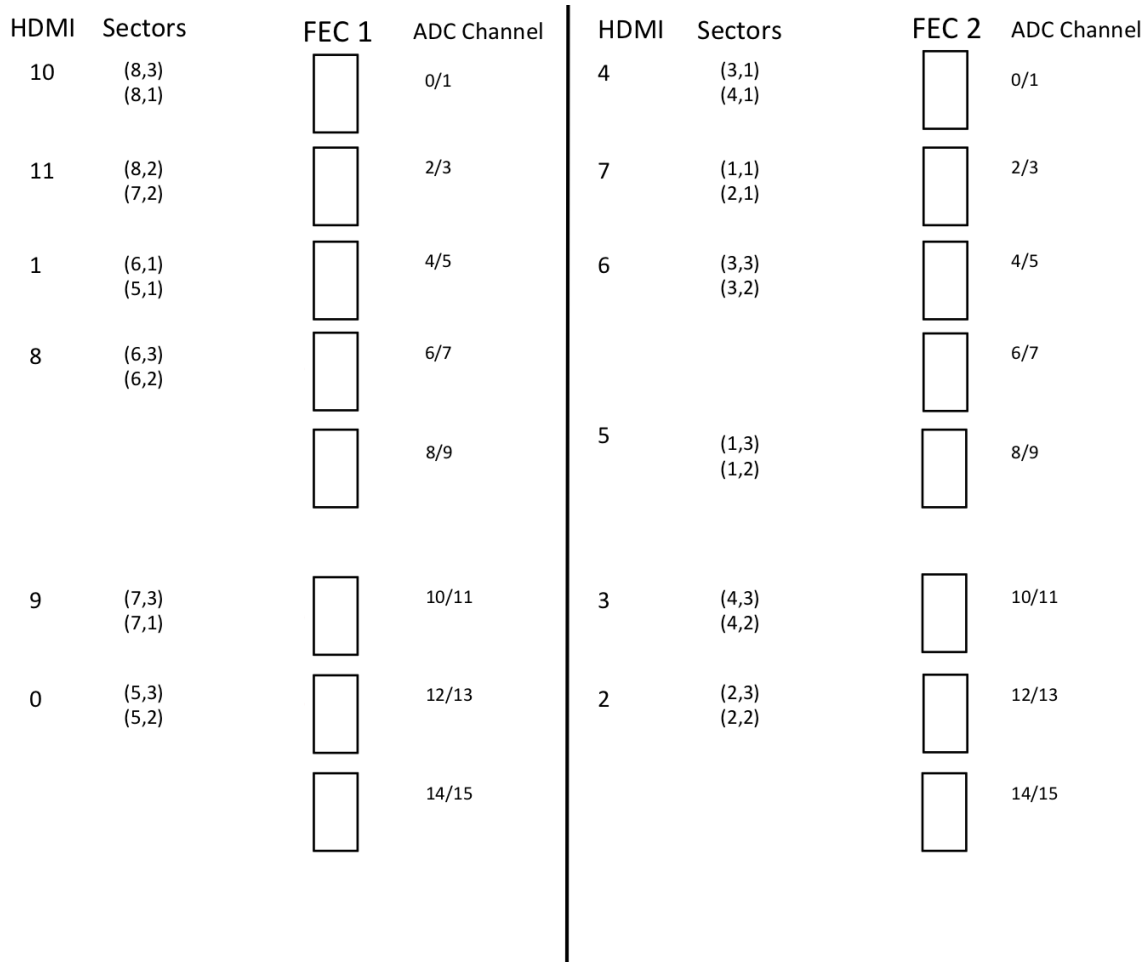

Figure 42: The proper FEC cabling.

In binary, this reads

```
0011110011111111
```

Similarly, `fecmask1` reads:

```
3f3f
```

In binary, this reads

```
0011111100111111
```

These are masks used by the SRS software which tells it what channels to pull data from on the FEC. When looking at `FEC0`, you can see that Channel 1/2 (with HDMI 10) has two channels, and is currently occupied by the HDMI 10 cable. So, in the mask for FEC0, this channel receives `11`. The next two HDMI ports are occupied by HDMI cables, so they also receive `11`. The next HDMI port is not occupied, so it receives `00` in the mask. And so on, and so on.

One or more APVs are not configuring

1. Trying pinging the FECs to see if you get a response.
2. Make sure the all of the HDMI cables are connected (both on the FECs and the APVs).
3. Restart DATE.
4. Try reconfiguring.

DATE is not automatically starting a new run.

This is a problem that occurs frequently. The cause is currently unknown. Try restarting DATE and closing the current SCRIBE window and then opening a new window. If the problem persists, restart the machine. If this does not resolve the issue, you will have to manually start the runs from the `DAQ - Run Control` window.

References

[1] Bianco, M., Dorney, B., & Merlin, J. *CMS GEM Internal Note: GE1/1 Quality Control: instructions.* 2016.