Work at CERN

I’m working with GEM production and quality control team. My work is about assembling the GE1/1 detector and quality control the detector especially quality control 3 and quality control 4. Then I move to work with electronic team in GEM team to work with production of VFAT3 chip and some testing program. After that I move to work with Study of the timing of discharges in single GEM hole apparatus and create the manual for this experiment.

1. **Assembling**

GE1-1 detector needs a very clean room for assemble because only a few dust will cause the GEM foils short. The first step is a preparation of the equipment such as screws, GEMfoils, readout board, drift board and frame of the detector. Next step is cleaning all the equipment with the special cleaner and vacuum cleaner. Then assemble the drift board and GEMfoil1. Checked the GEMfoil1 by applying the voltage and measure the current to make sure that the GEMfoil1 doesn’t have a short circuit. Then do it again with GEMfoil2 and GEMfoil3. Finally, assembling the detector with the readout board and frame and testing it with the QC.

![Figure 1.1 Clean room.](image1)

![Figure 1.2 Wearing format for assembler.](image2)
2. **Quality control**

2.1) QC3 (gas leak test)

Objective: to identify the gas leak rate in the GE1-1 detector.

Procedure:

The QC3 is divided into two parts. First one uses to detect the major gas leak by connected the detector gas input and output with a gas system. Then open the input and the output valves of the gas system. After that adjust the manual valve of the input flow-meter to allow the CO$_2$ to flow through the system. Set until the input gas flow rate is 5 L/hr. The output flow rate should be immediately visible on the output flow-meter. The second one uses to detect the minor gas leak by measuring the gas drop every 5 minutes for 1 hour. If the gas internal pressure doesn’t drop more than 5 mbar, it means that this detector passes the QC3. If not, we need to find where the gas leaked by using clamp to help.

Typical result:

The internal pressure drops (blue line) from 1 hour must be lower than 5 mbar. As in the figure 2.1, The pressure drops (blue line) is about 1.5 mbar.

![Figure 2.1 graph showing the rate of the internal pressure drop.](image)

2.2) QC4 (High voltage test)

Objective:

to determine the V vs. I curve of a GE1/1 detector and identify possible malfunctions, defects in the HV circuit and spurious signals.
Procedure:

Connected the detector with the gas line. Then connected it with the box of capacitor and resistor which is connected to an electronic system as in the Figure 2.2.2.1). The QC4 uses LabView as the main program to control the input voltage and measure the output. The detector is tested by varying the voltage from 0 Volt to 4,900 Volt stepped by 200 Volt from 0 to 2,000 Volt and stepped by 100 Volt from 2000 Volt to 4,900 Volt. The result is current that measured from LabView and the spurious signals from the oscilloscope. The data will be recorded and calculated in Excel program manually.

![Scheme of the electronic circuit.](image)

**Figure 2.2.1.** Scheme of the electronic circuit.

Typical result:

As in the figure 2.2.2, the green line graph display relationship between the applied voltage and current drawn. If the detector hasn’t any short systems, it must be a linear graph with a slope near to 5 Gohm. The blue graph display relationship between a rate of the spurious signal and current drawn. If the whole detector has low internal and external noise, the rate shouldn’t be more than 20 when applying maximum voltage.

![Graph between Applied Voltage and Current drawn.](image)

**Figure 2.2.2.** graph between Applied Voltage and Current drawn.
3. Electronic

3.1) Set-up

Connected VFAT3 with the VBV3b VFAT3 verification board and the board with FPGA board. Then connect FPGA board with 1GBps USB wire and VFAT3 chip with a power supply as a figure 3.1.1

![Figure 3.1. VFAT3 production setup](image)

3.2) Calibration

The VFAT3 production uses a python program to calibrate the chip. First synchronize the chip with a board and read the chip ID. Next Adjust current reference of the chip. Then apply a voltage to the DAC (digital to analog converter) to find the charge make by the capacitor in the chip. Next find the relationship between the charge and voltage for every channel. After that sent variable 200 simulate charge pulses to every channel. Start from 3 fC pulses until 8 fC pulses. Then count the number of the pulses that triggered the channel, from each value of pulses, by receiving the data package. Calculation the suitable value to be the global threshold.

Typical result

![Figure 3.2. result from a good VFAT3 chip](image)
The VFAT3 production program will display green light when the VFAT3 chip have a good operation, otherwise it will display yellow or red light.

3.3) Safety

Calibrator needs to wear the wire that connected to the ground to make sure that the VFAT chip won’t be short and damage calibrator.

Figure 3.3. Calibrator with ground wire

4. Study of the timing of discharges in single GEM hole apparatus
4.1) Set-up

Connected the single GEM hole with the capacitor and then alien it with a radiation source and PMT (photomultiplier). Connected all the system with protective resistance, high voltage and also antenna. Connected PMT with the oscilloscope and connected antenna with counter as show in the figure 4.1.

Figure 4.1. Set-up of single GEM hole test
4.2) Data Analysis

4.2.1) Time shifting

During the experiment sometime, the experiment will stop because the safety issue, but the clock of the counter can’t be stopped. The data from counter need time correction by deleted all useless data and shift the data back into the right position.

![Graph between consecutive discharge count and time before and after time correction](image)

4.2.2) Split region

The study needs to study the delta time between discharge inside the rapid discharging region. So, the data split by use the intersection point between the previous data and the exponential curve fitting data.

![Graph separation](image)
4.2.3) Cluster

The study needs to study the delta time between discharge inside cluster and the delta time between cluster. So, the program uses k-mean algorithm to make the discharge data as a cluster.

![Figure 4.2.3 Discharge clusters](image)

4.3) Result

In the figure 4.3 display the graph between delta time between discharge inside the cluster in blue dots and delta time between cluster in red dots vs protective resistance in log-log plot. It can conclude that it has no correlation between protection resistance and discharge delta t whether in single consecutive discharges or clusters of discharges in the Rapid Discharge region during the life of a single GEM hole.

![Figure 4.3 Graph display average delta time vs protection resistance in log-log scale](image)