Undergraduate Research Paper

12/15/17

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Researching for Dr. Marcus Hohlmann
High Energy Physics

For the Fall 2017 semester, I had the pleasure of engaging once again in undergraduate research under the continued guidance of Dr. Marcus Hohlmann, with whom I have had previous research experience, including both for a previous term in the undergraduate research course, and being a member of his high energy physics research for the past three years. Similarly to the previous term in the undergraduate research course, I engaged in a variety of tasks, from printed circuit board design for a thick GEM (this time focusing on a sample coupon of varying hole diameter) and detector assembly. However, unlike the previous time where the focus in terms of the course was for the design of a thick GEM, this time the focus was instead on the detector assembly. Specifically CMS' latest short GEM detectors, (which henceforth in the paper will be known as Version 10, or V10) which are to be installed in the CMS experiment in the forward muon region of the LHC itself. These tasks were done in a collaborative manner between the majority of the members of the research group.

Before the assembly of the detector can begin, we first subject the foils to Quality Control Test 2 Fast (QC2 Fast). This test has the researchers apply voltage from a Megger to the GEM foils via a Megger Clip (which was another product of the author's work, in this case) and measuring the current leakage between the foils' top and bottom electrodes. If the measured impedance is greater than 10 Giga Ohms with a relative humidity lower than 40%, and the number of sparks per minute is lower than 2/3 that recorded during the previous three minutes, then the foil is accepted.

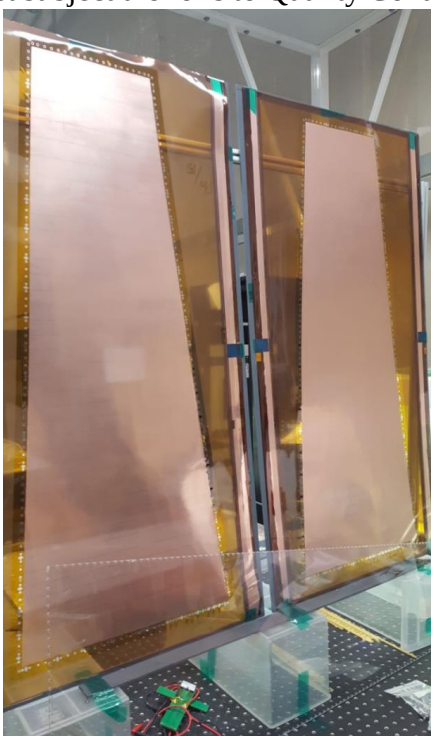

Figure 1: Foils Ready for QC2 Fast

As can be seen in the figure above, the foils are set upright such that direct and secure connection of the megger clip and the electrodes can be established. QC2 Fast then is conducted for each foil and the data recorded. Afterward, the foils are carefully discharged.

While QC 2 Fast is being conducted (or beforehand), it is benificial to begin preparing the inner frames. This part may be done outside of a cleanroom, whereas QC2 Fast was only doable within a cleanroom. This requires using a mallet and surface with holes approximately the diameter of one of the brass inserts. To install the inserts, one should engage in the following ways:

1. Remove the 3mm thick frames from their container
2. Move the frames face down over one of the holes on the pre-made holed surface.
3. Using the mallet, carefully but forcefully insert install the brass insert into the frame.
4. Repeat the installation of the inserts into all appropriate holes in the 3mm frames.

Once the inserts are prepared, they can be sent into the cleanroom and arranged atop a plexiglass plate designed for assisting the assembly. Pins are then inserted into the frames and plexiglass.

With great care, remove the first foil (being careful of the order) from its upright placement and place it over the arranged frames. Small holes in the kapton of the foil should allign such that the foil can go smoothly down. Using green tape provided, the foil is then stretched on all sides simultaneously, and the tape is stuck down on the table surface below such that the foil remains taut throughout the remainder of the assembly. It should be noted that the foil and such may and should be cleaned periodically to

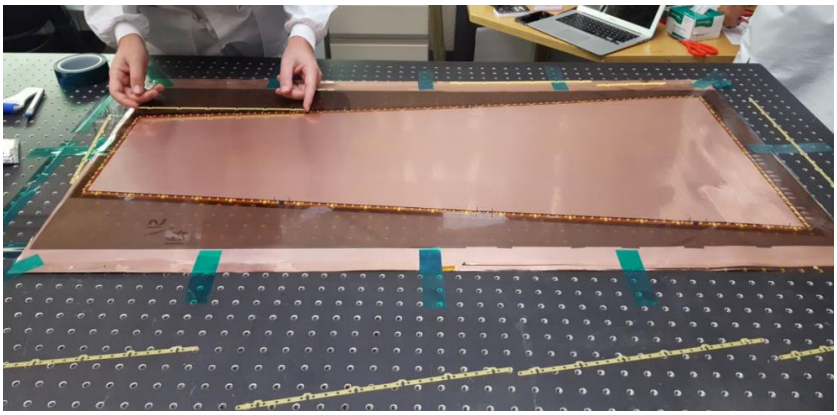

Figure 2: Assembling the GEM stack

minimize dust and other contamination, though it being in a cleanroom is already a major help to that process. Further megger testing also occurs at this time. This process is repeated a few more times, such that the foil spacing is arranged in a 3-1-2-1 configuration, the numbers represent the thickness of the frames in millimeters. The stack of frames are then secured by placing long screws in predetermined locations (specifically corners), as well as the smaller screws being added into each hole around the stack, keeping in mind that a precise torque applied to each screw is required. At this point, the stack is nearly finished, what remains is to cut the excess kapton (note, specific pads on the foils are cut suck that the hv pins may connect properly). Before cutting the kapton, a vaccum tube is used to remove excess particles from the stack. The kapton is then cut and removed, freeing the GEM stack.

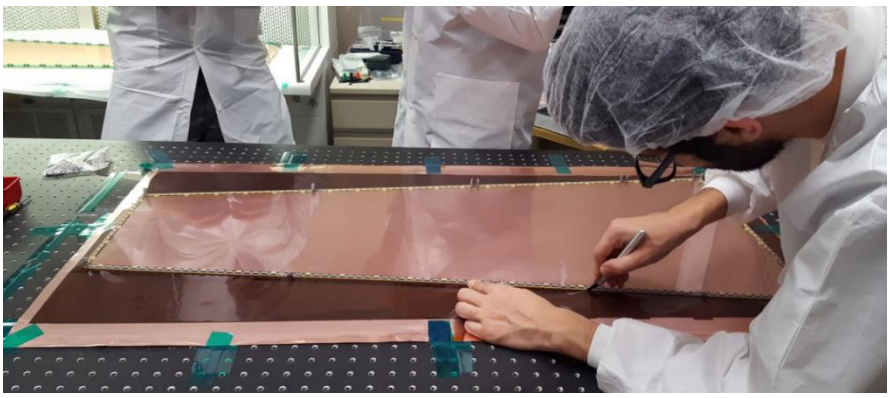

Figure 3: Cutting and Removing excess Kapton from the Stack

Now that the stack is free, it can then be moved to its next location. With care, and having cleaned all pertaining Surfaces, including with ethanol and/or acetone, the GEM stack is then placed onto the Drift.

The Drift was prepared prior to this step to add capacitors, resistors, pullout posts, and to be washed thoroughly with ethanol. The readout then receives the gem stack, and screws are placed through the pullout posts into the washers around the GEM stack (installed during assembly), making sure that the drift is afixed to the optical table. These screws should be installed with care as well. First, the members assembly go around placing screws into each slot, turing the screw a few times to make sure it catches onto the threads. Then , after all screws are in, the screws are then tightened around the GEM stack as semetrically as possible (using a holex screwdriver) to

7 cN (0.07Nm). After this, outer frames with o-rings are added, and finally the readout board (previously prepared and cleaned) may be installed. Screwing in the readout, the board is now assembled. The assembly of the detector is not the end of all there is to do on our part however, as there are more QC tests beying 2 Fast.

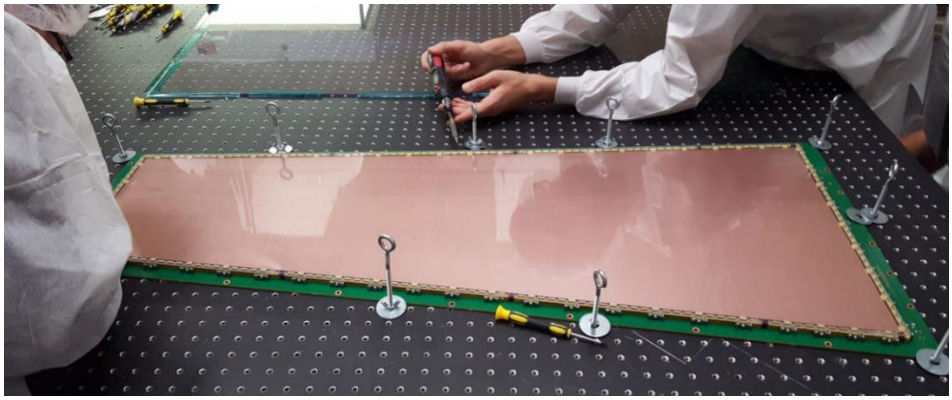

Figure 4: Tensioned Foils installed in the Drift

Further testing includes QC3: Gas Leakage Test, QC4: High Voltage Test (for identifying spurious signals), and QC5: Effective Gain test. However, while each were done by the researcher during the semester, these are beyond the scope of this report.

In conclusion, several tasks from PCB design to detector assembly were done during the semester. With regards to the detector, the assembly was done carefully, having previously practiced several times on older detector versions (specifically V3 and V5), as well as watched videos sent by CERN for this specific assembly. In addition to the assembly, the QC testing was also performed, and the data acquired. The next steps including sending the assembled detectors back to CERN, where they will double check their quality, and then send our group a larger batch to assemble. As things stand currently however, for the purposes of this course, the project is complete.