

Physics Undergraduate Research
Experimentation with Gas Electron
Multiplier (GEM)

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Introduction:

GEM trials were officially started around August 15th 2004. The goal for our group was to see signals produced by the GEM when it was subjected to a radioactive Fe-55 source. Before 8/15/04, a few trials of electricity and signal were done without a signal amplifier. Their results are therefore not applicable to the proper functioning of the GEM itself. Six tests of the GEM were done until our group figured out that something was wrong in some of the vital components of the GEM. The six first tests were only designed to change outside problems. The last of these six tests was conducted on October 4th, 2004. Every test after that was designed to figure out why the GEM is not functioning properly. The last test, measuring the resistance across a GEM foil, is still undergoing and its results so far have proven inconclusive. The last experiment for the resistance across the GEM foils was conducted on November 17th, 2004. The first tests gave strange results, which were inconsistent with the signals supposed to be seen by other developers of GEM devices.

Data:

See attachment.

Analysis:

Data Analysis of GEM trials #1-6:

The first GEM trials gave results, which were not consistent with the results of other GEM developers. In almost every test, somehow a periodic signal introduced itself. In a few tests it was rooted out. Also in testing, the high voltages necessary for experimentation proved to be very cumbersome. Many tests saw some possible effects of the high voltage such as "buzzing" noises, "sparking" noises or strange smells, possibly coming from somewhere in the setup. All of the first six tests after the first had a voltage of 320 volts across the GEM foils, as opposed to the original 360 volts. It was also thought that many of the random signals seen on the oscilloscope are the result of sparking in the GEM, since the signals are present regardless of a radioactive Fe-55 source. This could be due to the GEM foils being dirty or excessive voltage. However, the GEM foils were cleaned thoroughly before certain experiments. Experimentation always proved to go more smoothly however, when the gas in the GEM was allowed to flow for a few hours. In the final test we found that even

without high voltage being applied to the GEM, it still emitted a signal, which is periodic. The GEM it seems, on occasion behaves as a capacitor. Later testing would in fact encourage the notion that in certain cases, or under certain circumstances the GEM behaves as a capacitor.

After the six trials were finished we realized something had to be changed inside the GEM itself. Our first attempt to rectify the GEM was to clean the GEM foils using a method done at Brookhaven national lab, involving isopropyl alcohol. The next task was to take impedance measurements for the individual GEM foils. This was done by measuring the leakage current of the GEM foils in a certain setup. The first leakage current measurements were taken inside the GEM apparatus, using the GEM itself as a holder for the foils. This was also done so that the foils would be tested in Ar/CO₂. Even when the testing was done for leakage current in individual GEM foils, sparking was still heard. It seems that sparking occurs when high voltage is applied to the foils. However, sparking has not yet been heard on the foils outside of the GEM apparatus when high voltage is applied. After extensive testing of everything, we concluded that the HV board was proper. All voltage, current and resistance measurements on the HV board were consistent with what is desired. Further testing found that the foils inside the GEM apparatus produced a capacitor like current, that is, when taking leakage current measurements we found that the foil, when in the GEM apparatus behaves as a capacitor. We were unable to find out exactly under what circumstances the GEM behaves as a capacitor. So we are unable to find the cause for the GEM acting as a capacitor. In an attempt to rectify this problem we tested the GEM foil outside of the GEM apparatus, in open air to try to measure the leakage current. The measurements again were strange. Although, now, there is no capacitance like behavior, the leakage current readings are still too high, meaning that the resistance across the GEM is lower than expected, the is possibly due to impurities on the foil itself. The latest test of the leakage current across the foil using the Keithley Electrometer showed that the current changed with time for the foil in the open. Our next step is to test the foil in Ar/CO₂, in some container, which is not the GEM apparatus. This will be done in hopes that the resistance will increase, and the foil will not behave as a capacitor. However, whether or not the foil behaves as a capacitor anyway is unknown.

Discussion:

The results from the GEM are undesirable, in order for the GEM to work, more research must be done to figure out why the GEM is behaving the way it is. Testing the GEM is very time consuming

and new and creative means have to be invented in order to make this process more efficient. The new physics building will be more organized and space will probably not be so tight. Our efficiency will probably improve once we are set up in the new building. Also, testing at the end of the semester became difficult with packaging for the move and with exams.

Conclusion and Recommendations:

The results of the leakage current tests for the GEM foils have proven inconclusive. Why the GEM apparatus or the GEM foils, acting as a capacitor is unknown. The research done by Georgia Karagiorgio, Rob Diamadeo, and myself concluded that new GEM foils are possibly needed, a clean room is possibly needed to keep the foils free from impurities, that the GEM or GEM foils act as a capacitor, and that the signals seen from the GEM are not the desired signals which other GEM developers are seeing. These undesirable signals are the combinations of both internal and external factors.