The Next Generation of Polarimeters X-Ray Polarimeter Detection Device

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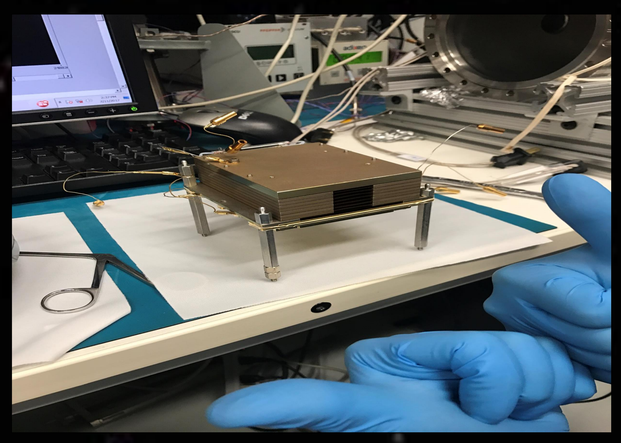
Abstract

The aim of my research is to confirm the functionality of a GEM made of stainless steel using carbon dioxide and nitromethane through a series of tests in a vacuum chamber. Utilizing the photoelectric effect with carbon dioxide and nitromethane, we can confirm polarization of x-rays emitted from the most extreme astronomical conditions. This data will allow us to further study the effect the gravitational fields of black holes have on matter they encounter and the magnetic field of a neutron star.

Figure 1: Copper-plated Double GEM



Introduction

- A polarimeter is a device used to measure the angle of the electric field vector found in polarized light.
- The first polarized x-ray from the Crab Nebula was detected and mapped back in the 1970s.
- More recent measurements of X-ray polarization have been limited by the pace of detector technological advances.
- Next generation X-ray polarimeters will detect sources of polarized X-rays such as magnetars and matter caught in the gravitational field of black holes.

Procedure

- Preparing the vacuum chamber for use by repairing leaks found
- Constructing the stainless-steel detector
- Swapping the copper-plated GEM for the stainless-steel GEM
- Testing the detector using 180T of CO_2 and an MCA device

Results

- Based on the centroid gain and energy resolution values we recorded, we can assume that the detector is working well.
- As expected, there was an exponential increase in the centroid gain as we increased the cathode's voltage.

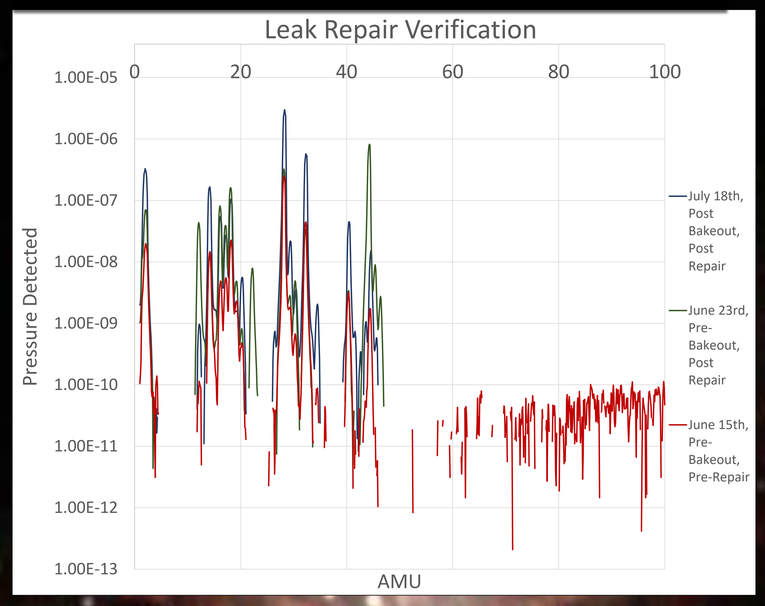


Figure 2: RGA Data Comparison
The RGA data records what elements and compounds are in the chamber by identifying the pressure detected at specific atomic mass unit values.

- After determining that there was a leak in the chamber and finding its location using a RGA device and software, it was carefully repaired.
- This is supported by an observed decrease in the levels of hydrogen, nitrogen and water molecules found in the chamber.

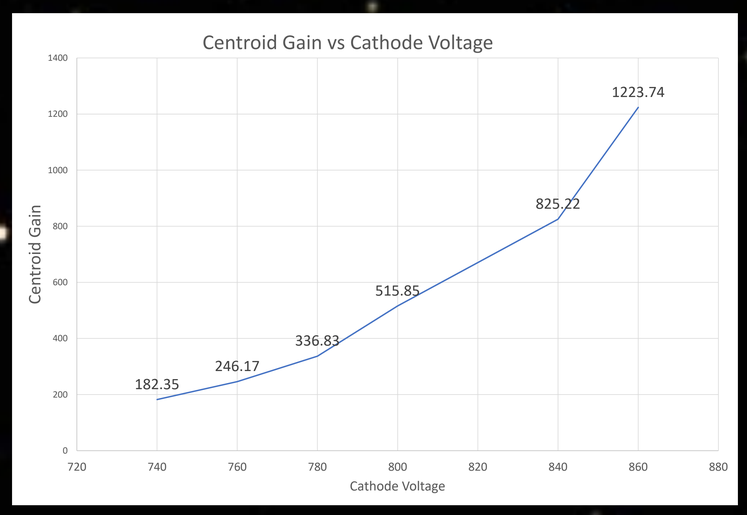


Figure 3: Centroid vs Cathode Voltage
This plot shows the expected exponential centroid gain as we steadily increase the cathode voltage. This shows that the stainless-steel GEM is operational and recording stable gain at various voltages.

Conclusions and Future Work

- Having confirmed that the stainless-steel GEM is working as expected opens the project up to many possibilities.
- The next step in the project will be to repeat the tests using a mixture of 15 torr of nitromethane and 197.5 torr of CO_2.
- This will test how well the detector will perform at higher voltage ranges since the mixture will require more voltage on the drift and cathode plates to read out a reaction from the Iron-55 x-ray source.

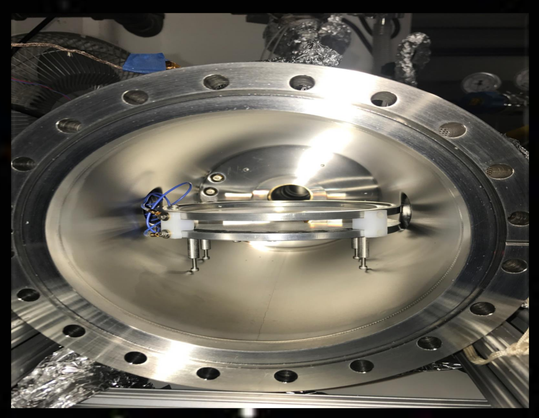


Figure 4: Stainless-Steel GEM
The stainless-steel GEM will allow tests to run at higher voltages while outputting a stable gain using only one multiplication stage.

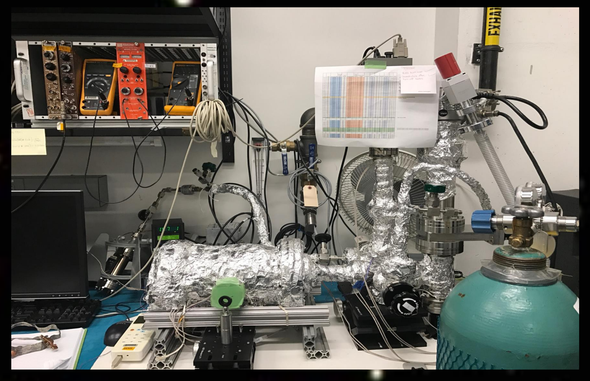


Figure 5: Lifetest Vacuum Chamber

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