



Static Buildup and Measuring Insulators in the UltraLo-1800

Document:	Static Buildup and Measuring Insulators in the UltraLo-1800		
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1. Introduction

While the UltraLo-1800 has unparalleled event rejection for surfaces not directly below the anode, any measurement of an undersized sample will have an unmitigated contribution from the tray's surface. Therefore, when measuring small samples, there is a premium on using an ultra-low activity tray liner. The ideal liner should also be fairly inexpensive, easy to clean, durable, and disposable. These characteristics are all met by thin Teflon sheets, which is why Teflon has been the tray liner of choice at XIA for the past year. However, Teflon is also a superb insulator, and its impact on the electric field in the detector isn't completely known. Moreover it's triboelectrically active, accepting electrons from many materials, including rubbers and aluminum. Until recently there was no evidence that these traits were problematic, but new evidence has been discovered.

2. Discovery of the Problem

On May 24th, 2010 came the first evidence of a problem with Teflon tray liners. The tests were initially intended to investigate the efficiency of the counter near the border of the anode and guard in the 707 cm² configuration using the standard ²³⁰Th source, but an unexpected behavior emerged. The source, which normally shows a very sharp peak right at the 4.8 MeV ²³⁰Th energy, instead displayed a broad peak with a very large tail (see figure 1). When the Teflon liner was removed and the source placed directly on the tray, the peak in the spectrum returned to its normal location, indicating that this wasn't an effect from placing the source near the border of the electrodes, nor was it a defect in the electrode. At this point static charge accumulating on the surface of the Teflon became the most likely cause.

3. Experimental Method

By its nature static electricity is difficult to investigate experimentally. Our primary method for telling if charge buildup is present on a sample liner is to measure it in the counter along with our source to see if the expected spectrum from the source is distorted. Additionally, we must take care to investigate only charge buildup, there are other deviations from ideal operating conditions that can show similar effects. Fortunately, Teflon's position on the triboelectric series makes this fairly straightforward, simply rubbing the Teflon with a piece of glass will leave it negatively charged. (It is easy to observe this effect, rub a piece of thin Teflon against a pane of glass and it will stick there, similar to a rubber balloon sticking to a wall.)

Given this, our experimental method was as follows: we rubbed one spot of the Teflon liner with glass, placed the source in various locations on the liner, and observed the resulting spectra. In the measurements discussed below the liner was only "charged-up" once in one small location, and the source was moved to many different locations over the course of several days. The source was moved from location to location inside of our glove box, which is under a constant N₂ purge. The environment of the glove box is exceptionally dry, giving the charge less opportunity to bleed off. The source was only

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handled with Teflon-coated tweezers, reducing the likelihood of building up additional charge on the Teflon liner.

Figure 2 shows the configuration of the electrode as well as the labeling scheme for its axes, with each tick mark representing one inch, the bright green square representing the anode, and the dark blue square representing the guard. The x- and y-axes are labeled as per the usual conventions. All source and charge locations are given in the standard (x,y) format. An area approximately one inch square on the Teflon liner was charged at (0,-6). The charging was accomplished by vigorously rubbing the Teflon with a Pyrex beaker for approximately one minute. The source was then moved to various locations, the results of which are detailed in the next section.

4. Results

The effects of static charge on Teflon were found to be persistent but difficult to analyze. These effects include a shift of the peak toward lower energy in the spectrum, a broader peak in the spectrum, and a decrease in recorded emissivity. The first two effects can be observed in figure 1, where the peak of the spectrum from the run taken on a Teflon liner is approximately 20% lower, significantly broader, and has a large tail to low energies. Finally, in nearly every run that showed static charge effects the apparent emissivity of the source decreased by as much as 10%.

Attempts to find how much of the tray's area was influenced by the charged-up section met with mixed results. When we moved the source along the y axis away from the charged-up location we eventually found a location that generated a normal spectrum with no evidence of static charge effects (see figure 3). This shows that the charged section of the liner has an effect on the field, but only locally. However, this was difficult to reproduce. Returning the source to a previously unaffected location after some number of measurements across the tray resulted in clear observation of static charge effects (see figure 4). Additionally, the effect of the charge did not vary linearly across the tray, as can be seen in figure 3.

As shown in figure 1, none of these effects persist when the Teflon is removed. Furthermore, they're not present on most new sheets of Teflon (partially explaining why they weren't observed previously). This, along with the results discussed above, suggests that handling Teflon liners causes static charge to accumulate and interfere with the electric fields in the detector, which in turn causes lower observed energies and efficiencies.

While investigating ways to discharge static from insulators we discovered a product called the "Mapleshade Ionoclast". The device ionizes air molecules with a high voltage piezoelectric discharge, and those combine with the ions on the insulator to neutralize them. It is designed for discharging static buildup on vinyl and compact discs, but the principle would work equally well on our Teflon liners. Our procedure for testing the efficacy of the Ionoclast was as follows: the liner was charged-up as before, by rubbing with pyrex glass. The source was placed in the middle of the charged-up location and a

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measurement was taken. Then the Ionoclast was used to discharge the static by slowly moving it across the sheet while activating the piezoelectric discharge approximately every centimeter. The sample was then measured, and the process repeated as many times as necessary to return the emissivity and spectrum to their original values.

The results are shown in figure 5. The discharge procedure was extremely effective. In one cycle it improved the emissivity from 0.289 alphas/cm²/hr to 1.93, and another cycle brought it to 2.41, and a final cycle brought it to 3.04 (3.0 is the nominal rate). The spectrum showed considerable improvement, with the peak center shifting from 2.2 MeV back up to the nominal value of 4.6 MeV. In short, treatment with the Ionoclast was shown to erase the effects of static charge buildup.

5. Conclusion

It is clear from our data that Teflon is a problematic tray liner. What's less clear is if its problems are surmountable. While we have yet to find a method that can successfully discharge the Teflon, it may be possible to develop handling procedures or environments that minimize the risk of charging. Left untested is whether the Teflon becomes charged from sitting in the electric field of the detector, which would make the problem more significant. Use of an active anti-static device such as the Ionoclast can be effective. However, the discharging procedure is somewhat time-consuming and knowing when it needs to be done would require frequent source measurements. Because of this our recommendation is that Teflon be avoided as a tray liner whenever possible.

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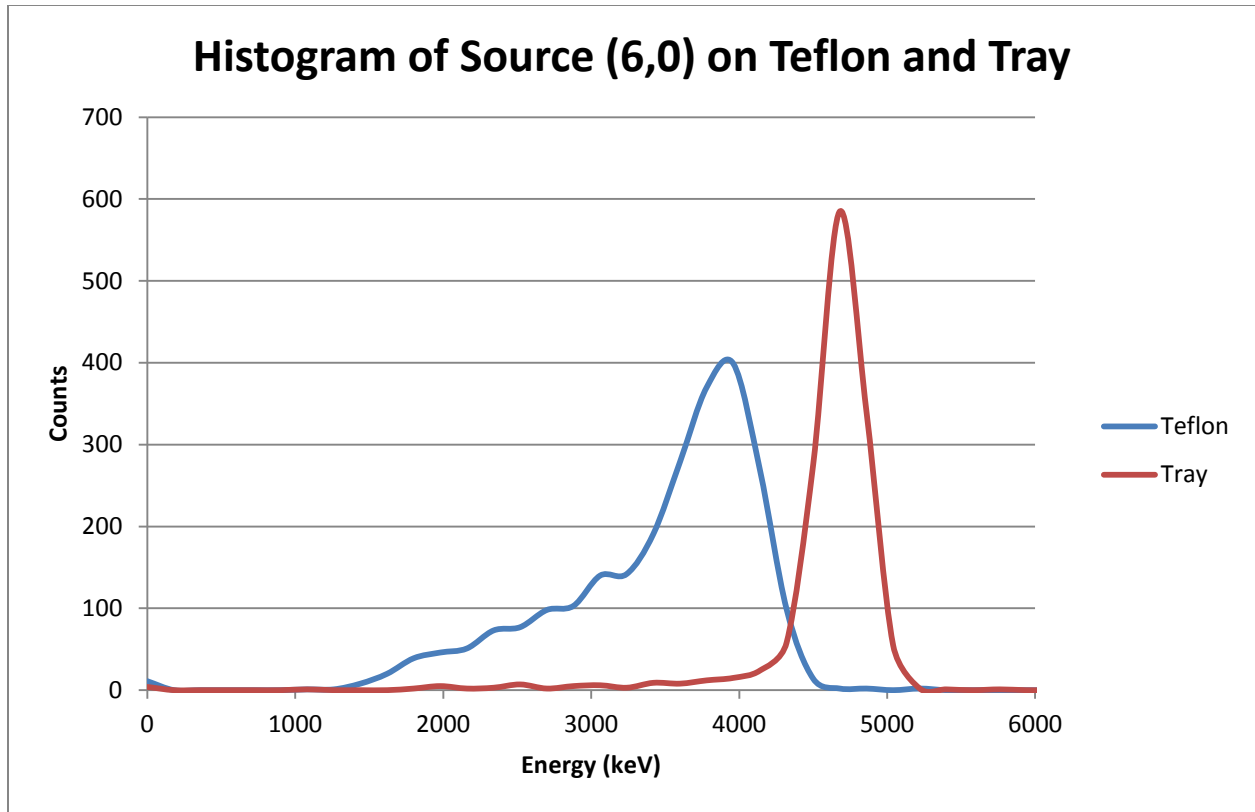


Figure 1: The source in the same position with respect to the anode, but with Teflon versus without.

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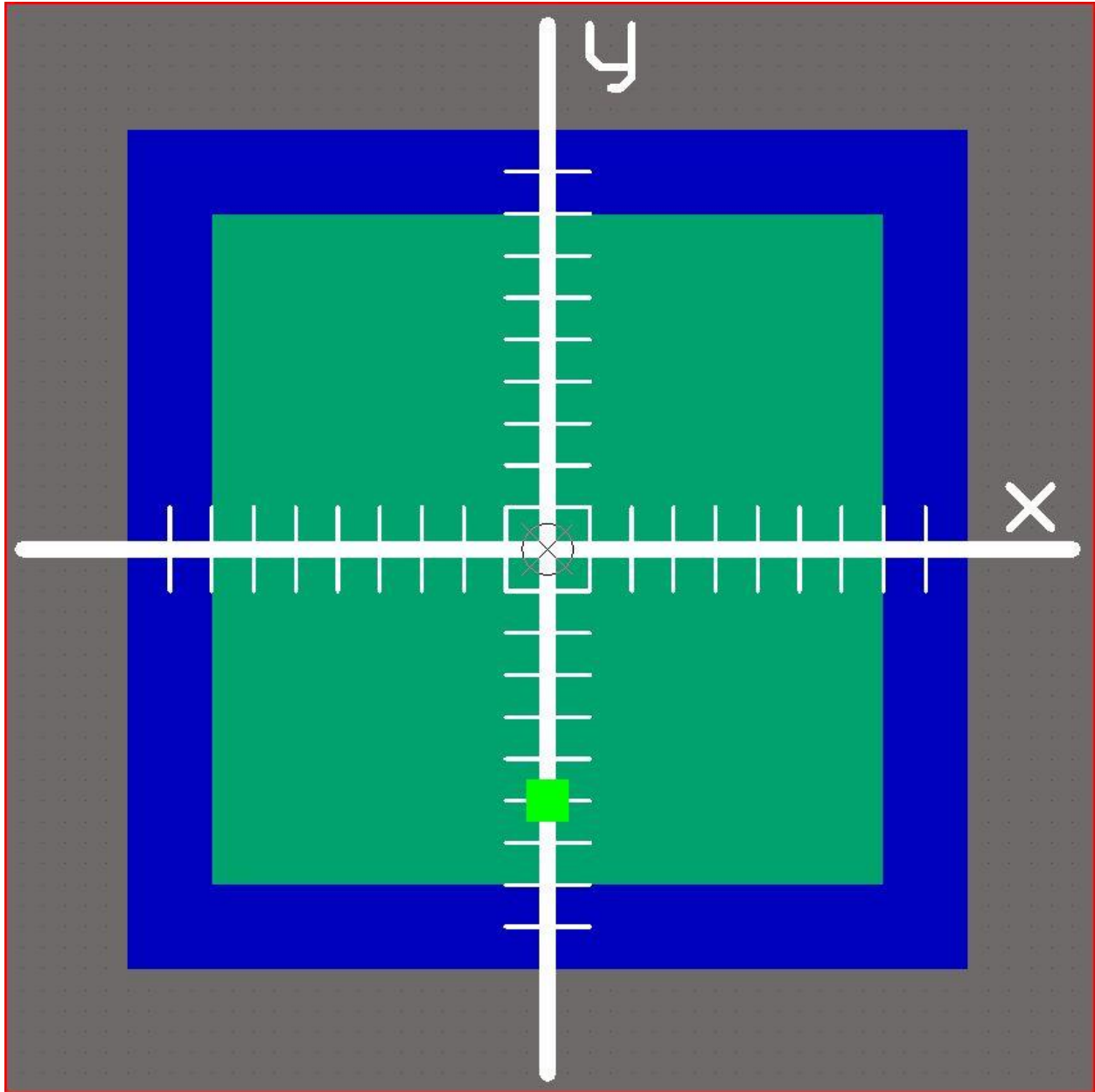


Figure 2: Map of the tray grid. Dark green indicates the anode, dark blue the guard, bright green the area rubbed with the Pyrex beaker, and the hash marks on the axes denote 1 inch.

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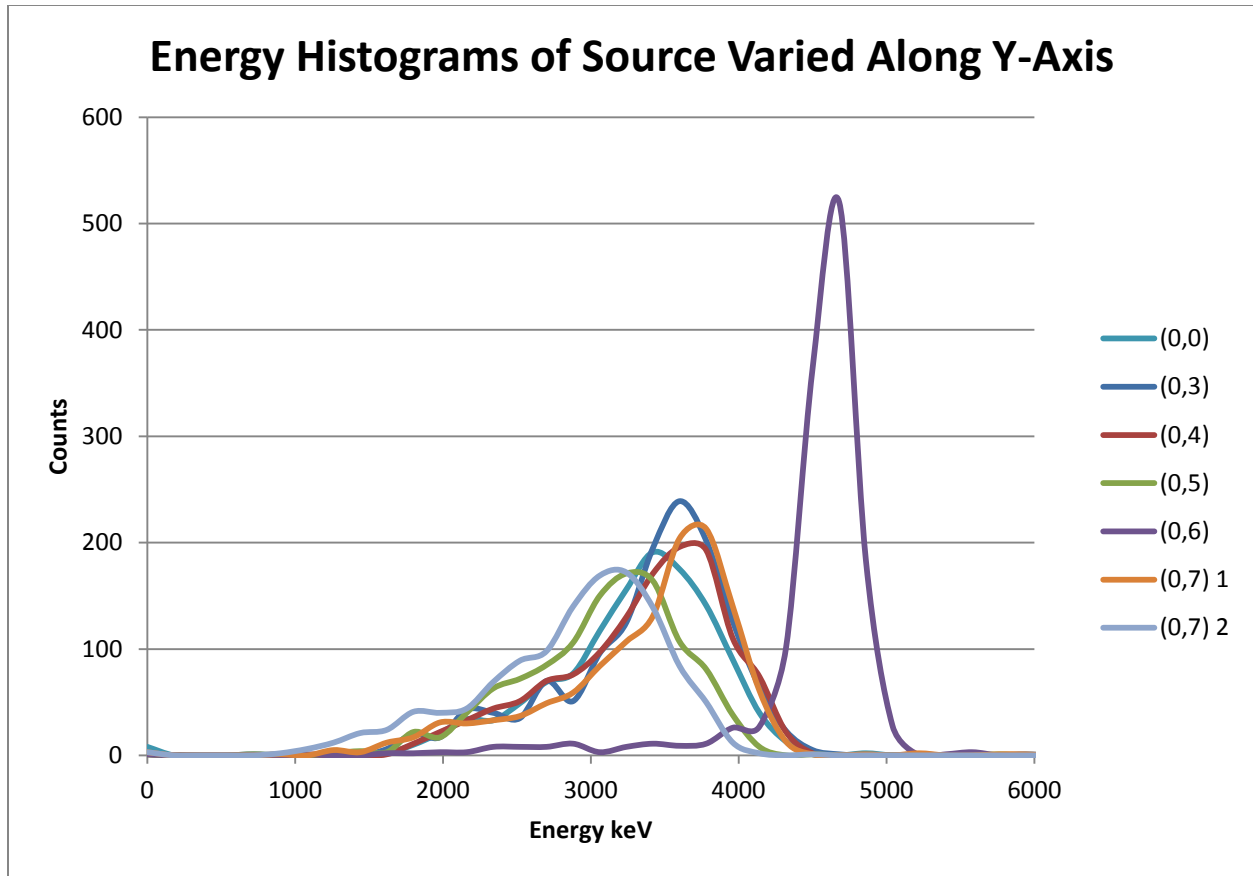


Figure 3: Energy histograms of the source in various positions along the y-axis. All of the positions except for (0,7) were sequential as listed in the legend. Note that there is no discernable pattern in the curves, (0,3) is more sharply peaked than (0,4), and both are more sharply peaked than (0,5), while (0,6) looks normal.

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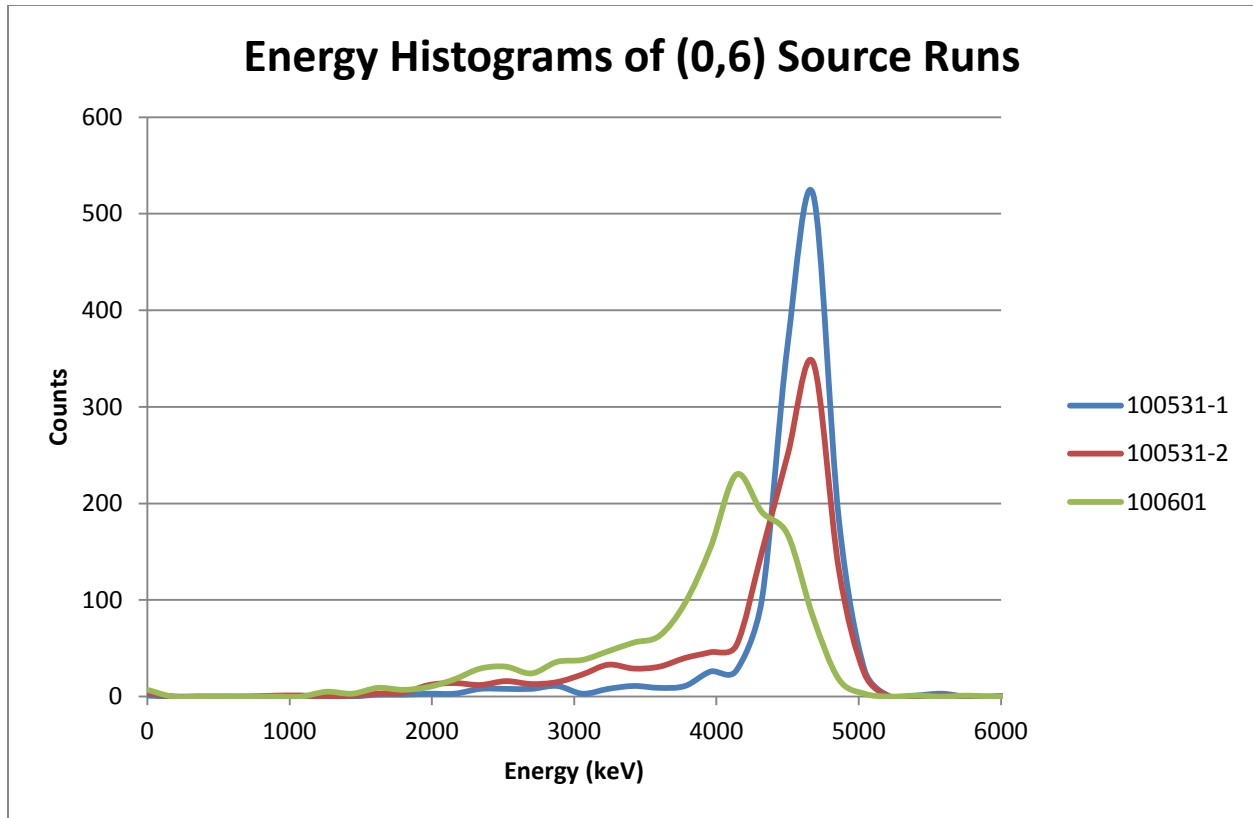


Figure 4: Three runs with source at (0,6). None of the runs were done sequentially; the source was always moved to various locations between each run displayed above.

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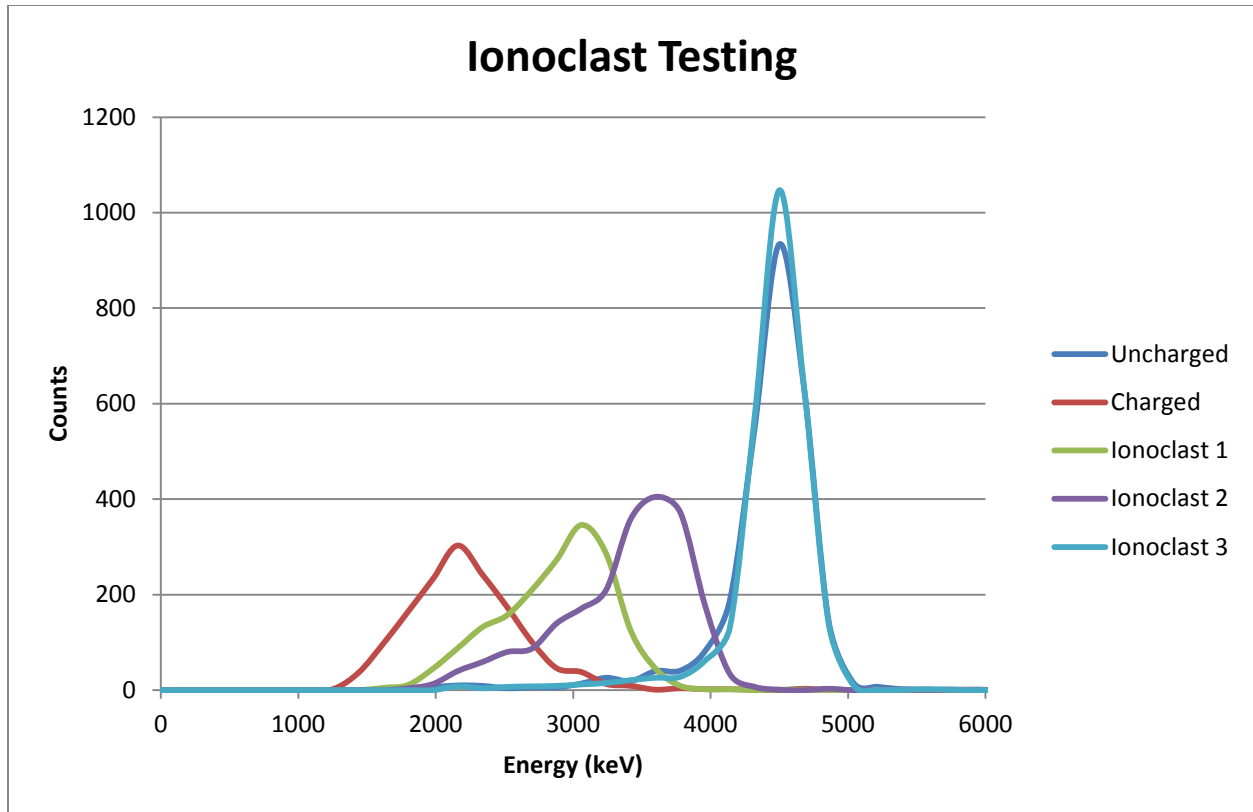


Figure 5: Testing the Ionoclast static discharger. The dark blue curve is the source on an uncharged Teflon liner. The red curve is the source on the Teflon liner immediately after the charging-up process. The green curve is after the first pass with the Ionoclast, the purple curve after the second, and the light blue curve after the third. The final measurement is virtually identical to the uncharged measurement.

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