Dear Ms. Lawson,

Thank you again for the opportunity provided by the JSA Minority/Female Undergraduate Research Assistantship this past academic year! I am highly grateful for the experience I have been able to gain by working on my honors research thesis project with JSA support and data from Jefferson Lab. I hope I have sent this letter to the appropriate people; would you please redirect me if needed?

Project Summary:

With the help of my advisor Professor Stevens, I spent my final two semesters at William and Mary focused on identifying and examining the reaction known as Timelike Compton Scattering (TCS, $\gamma p \rightarrow e^+e^-p$) from a ~1PB data set made up of some of the first data collected from Jefferson Lab's GlueX Detector. I worked on determining how well Generalized Parton Distributions models (GPDs) are able to describe TCS in this dataset in order to contribute to the understanding of a proton's structure, since GPD models describe the positions and momenta of the quarks inside protons. To make this comparison, I worked on removing other types of reactions – such as charged pion (π^+, π^-) production – from the GlueX dataset. I primarily did this by comparing the experiment data to simulated e^+e^- plots and placing limits on different GlueX detector variables for which e^+e^- and pions react differently. I examined different 2-D histograms to identify which variables proved most useful for doing this, learning the apparatus setup and reaction and production processes in detail as I did so. I implemented five restrictions for removing the pion data, after which the remaining data set was comprised primarily of the types of particles produced by TCS, e^+e^-.

I then transformed the remaining data into the rest frame of the scattered electron and positron using two Lorentz boosts to make it possible to examine the data independently of initial conditions of the reaction and focus on effects due to the proton structure. I was able to calculate the phi and theta angles of the scattering plane, which were formed between the incoming photon to proton interaction and the line formed between the produced electron and positron, which now scattered in opposite directions due to our use of the new reference frame.

With the data in the e^+e^- rest frame, I worked on removing events produced by the Bethe-Heitler (B-H) process, which also produces e^+e^- , by setting a scattering angle range of $\frac{\pi}{4} < \theta < \frac{3\pi}{4}$ for the detected particles. By plotting the number of detected events versus the angle phi before and after applying the theta restriction, I examined differences in the resulting functions, which are expected to differ due to the cos(phi) and cos(2*phi) dependences of TCS and the B-H process, respectively. The resulting histograms of the ϕ angle plane into which the e^+ and e^- scattered indicated that while TCS may be present in the reaction, a larger data set will make it possible to determine this much more conclusively. The application of the cuts which I selected and applied to the current data set will provide a useful basis for this further analysis. With future work, a ratio which can be calculated from the TCS ϕ plot can be compared to the same ratio from GPD models, allowing us to improve the GPD models by making them better fit the TCS experimental results.

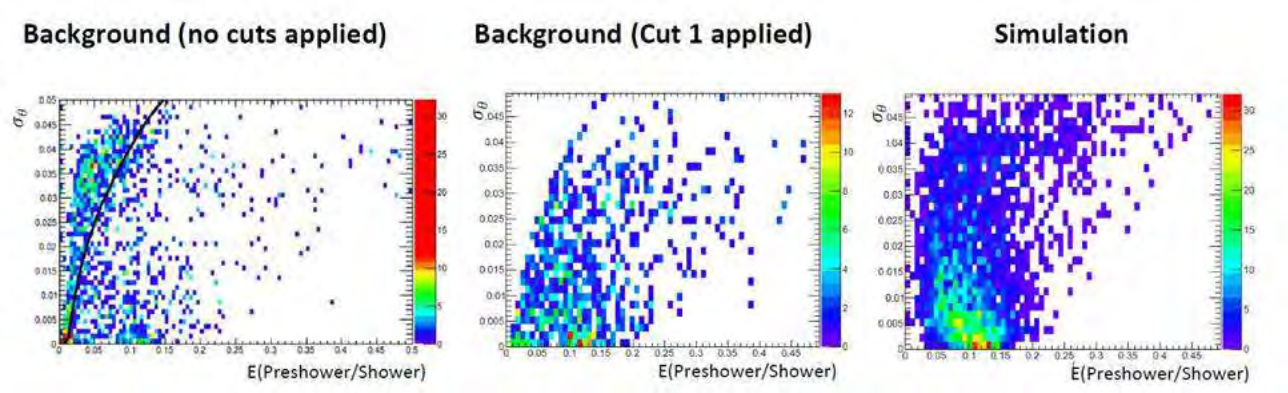
During my work on this project my experiences also extended outside of my research progress to several presentation and outreach events. I presented my research at the APS Conference for Undergraduate Women in Physics (CUWiP) poster session at GW in January, at the W&M Undergraduate Research Symposium, and at a visit by the W&M class of '68 Physics alumni. At the end of April I completed and passed my thesis presentation with honors, and my thesis will be posted in the Swem Library online catalog within the upcoming weeks (and is attached as a pdf to this email).

I am looking forward to beginning my Astronomy PhD program at Boston University this Fall, and know that the research experience, physics and computing knowledge, and presentation skills that I have expanded and improved due to my Jefferson Lab work will be highly useful to my future studies and research!

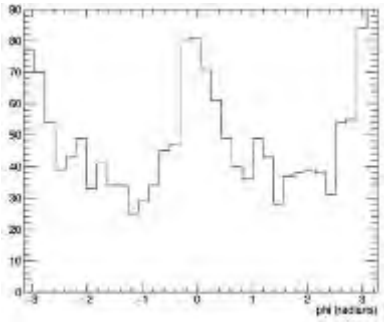
Most Sincerely,
Alexandra Cramer

Some Plots from my research:

1) removal of pion data using Cut 1 $\left(\sigma_\theta > 0.1951 * (E_{Preshower/Shower}\right)^{0.5} - 0.0195)$; the Background histograms contain mainly pion data and the simulation is entirely e^+e^-



2) Our final phi plot (depicting number of detected events as the y axis, so all amplitudes are positive), displaying the expected cosine dependence



Thank you!