The JSA Graduate Fellowship enabled me to continue my research on amplitude analysis of the $\omega\pi^+\pi^-$ final state in photoproduction, and to measure the tracking efficiencies of charged pions in the GlueX detector. With the travel funds, I was able to attend the APS DNP meeting in October 2019, where I gave a talk on my $\omega\pi^+\pi^-$ analysis, and gave the Hall D update talk at the JLUO Satellite Meeting. I expect to graduate with my Ph.D. in early 2022.

Spin-Exotic Mesons at GlueX

There exists strong experimental and theoretical evidence for spin-exotic mesons, which have quantum numbers inaccessible to quark-antiquark pairs, but their precise nature is unknown. A key goal of GlueX is to map the light-quark meson spectrum in order to identify any patterns that may exist and thus make a better comparison to theory than has been done in the past.

The lightest predicted spin-exotic meson, with quantum numbers $J^{PC}=1^{-+}$ is the $\pi_1(1600)$, which a recent lattice calculation predicts to decay dominantly to $b_1\pi$. Other predicted spin-exotics are also allowed to decay to $b_1\pi$, but the partial widths of their decays have not yet been calculated.

Since the $b_1(1235)$ meson’s dominant decay mode is $b_1 \rightarrow \omega\pi$, the $\omega\pi^+\pi^-$ channel in photoproduction provides access to the $b_1^{\pm}\pi^{\mp}$ system to study both exotic and non-exotic partial waves.

$\omega\pi^+\pi^-$ Amplitude Analysis

With the support of the JSA Graduate Fellowship, I continued my studies on the reaction $\gamma p \rightarrow p\pi^+\pi^+\pi^-\pi^0$, where I worked on removal of non-\omega background from the $\pi^+\pi^+\pi^-\pi^0$ channel, and analyzed angular variables assuming various decay modes of an initial resonance $X$, including $X \rightarrow b_1^{\pm}\pi^{\mp} \rightarrow \omega\pi^+\pi^-$ and $X \rightarrow \omega\rho \rightarrow \omega\pi^+\pi^-$. I assisted in developing a tool to generate angular distributions for the $\omega\pi^+\pi^-$ Monte Carlo, and used this tool to generate several $\omega\pi^+\pi^-$ samples from 5 different reactions. I spent a good deal of time analyzing these MC samples and applying data selection cuts in order to isolate a clean sample of $\omega\pi^+\pi^-$ recoiling off of a proton.

Figure 1: Invariant mass plot of $\pi^+\pi^-\pi^-\pi^0$ combinations
During the latter period of my JSA Graduate Fellowship, I took on a side project involving analysis of the \( \omega \pi^- \) system recoiling off a \( \Delta^{++} \), which decays to \( p\pi^+ \), using the subset of the \( \omega\pi^+\pi^- \) data sample that I had initially cut away as baryonic background. This “background” sample was large enough, as illustrated in Figure 1, for me to perform an amplitude analysis on the \( \omega\pi^- \) system.

My colleagues at University of Regina are studying the neutral \( \omega\pi^0 \) system, which will enable us to compare charged and neutral exchange mechanisms. Since understanding the decay of the charged \( b^- \) will be crucial to the search for the \( \pi_1(1600) \), this project quickly became my primary focus and will be my dissertation topic.

### \( \pi^\pm \) Tracking Efficiencies

While supported by the JSA Graduate Fellowship, I concluded my work determining the tracking efficiencies of charged pions from exclusive \( \omega \rightarrow (\pi^\mp)\pi^+\pi^0 \) reactions at GlueX. I used the \( \omega \) yields from fits to 3\( \pi \) mass plots to count how many pions are “found” versus “produced,” then I take the ratio of those to find the efficiency. I’ve calculated the efficiencies as functions of the kinematic variables \( \phi, \theta, \) and \( p \), as illustrated in Figure 2, and as functions of \( \theta \) vs \( p \). I have also determined how the efficiencies depend on the quality of the charged pion track candidate, by applying cuts to \( P(\chi^2) \) of the track candidate, as well as the 3-momentum and polar angle of the reconstructed track. This study is documented in an internal GlueX analysis note, and is summarized in a paper published in NIM A. It will form a chapter of my dissertation.

![Tracking Efficiencies](image)

**Figure 2:** Tracking efficiency for \( \pi^\pm \) tracks, determined by data and simulation using two methods. Sourced from [NIM A 987 (2021) 164807](https://doi.org/10.1016/j.nima.2021.164807)

### Talks & Publications

- A.M. Schertz, “Amplitude Analysis of the \( \omega\pi^- \) System at GlueX,” Talk. APS April Meeting, Virtual, April 2021.
- A.M. Schertz, “Studies of the \( \omega\pi\pi \) Final State at GlueX,” Talk. DNP Fall Meeting, GWU, October 2019.

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