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Southeastern Universities Research Association/Jefferson Science Associates  
1201 New York Ave. NW  
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Washington, DC 20005

Dear Fellowship Program Officials:

I am pleased to report on work accomplished during the 2008-2009 academic year under the assistance of the JSA Graduate Fellowship. The Fellowship enabled to make several contributions in support of the g12 rungroup in Jefferson Lab's Hall B.

To begin, the lion's share of my time and effort during the 2008-2009 academic year was spent performing calibrations to prepare the g12 dataset for reconstruction of the full dataset. I was responsible for the calibration of the time-of-flight (TOF) detector for the CEBAF Large Acceptance Spectrometer (CLAS) in Hall B. While the general procedure for the calibration of the TOF is well-documented, at first we did not achieve the timing resolution we expected following this procedure. Detailed studies were performed at each stage of the calibration to identify the point at which the detector's performance became substandard. The least-understood and most likely cause was determined to be the time-walk corrections.

The time-walk correction attempts to correct for a systematic timing shift introduced by leading-edge discriminators. Signals from the photomultiplier tubes of the TOF generally follow the Landau distribution: a sharply-sloping leading edge with a long, gently sloping tail. When such a signal first arrives at the discriminator, its amplitude is too small to cause the discriminator to

fire. It can take anywhere from hundreds of picoseconds to a few nanoseconds of time for the signal to build up to the level where it meets the discriminator's threshold and is passed on. Larger pulses meet the discriminator threshold requirement sooner, and thus require a smaller correction.

This dependence of the time-walk correction on signal pulse height is modelled in the CLAS canon by a piecewise function:

$$f_w(x) = \begin{cases} \frac{w_2}{x^{w_3}} & : x \leq w_0 \\ \frac{w_2}{w_0^{w_3}}(1 + w_3) - \frac{w_2 w_3}{w_0^{w_3+1}}x & : x > w_0 \end{cases} \quad (1)$$

where  $x$  is the ADC channel number,  $f_w(x)$  is the time-walk correction, and  $w_0$ ,  $w_2$ , and  $w_3$  are variable parameters. Traditionally, the parameters  $w_0$ ,  $w_2$ , and  $w_3$  are determined using a fit to special data taken with a laser and pulser system, to give precise times and precise energy deposition. However, in the years since the commissioning of CLAS, this system has fallen into disrepair, and laser data is only available for about 40% of the TOF phototubes. Additionally, incorrect phototube voltages changed the shape of the ADC versus time distributions in the physics data of some channels to such a degree that it was no longer described by the function in Eqn. ???. Thus, it was difficult to find a single procedure which correctly adjusted each paddle's time measurements.

To address these issues, Jefferson Lab staff scientist Dennis Weygand and I developed a new set of tools for doing time-walk corrections for the CLAS TOF. Due to the scarcity of laser data, we performed fits on physics data, using a third-order polynomial on both phototubes simultaneously. This algorithm resulted in good performance for channels with incorrect phototube voltages, as well as channels without laser data, but on average could only match the performance of channels with good phototube voltages and laser data. We also tried using values for  $w_0$ ,  $w_2$  and  $w_3$  from past running periods, and found that these also gave good performance for troublesome channels. In the end, the average performance from the new procedure matched the average performance attained by a mixed set of old and new laser-data constants. We decided that given the effort required to update the reconstruction code, calibration database, and documentation, it would be most efficient to use the constants determined from modern laser data, if available, and if not, from past laser data. Still, our explorations raised general awareness of these issues within the collaboration; future rungroups making up the balance of

the 6 GeV program will have to confront this problem. The reconstruction of the full g12 dataset began on August 18th, 2009, and is on track to conclude on December 24, 2009.

In parallel to the work on the CLAS time-of-flight, I developed a plan for my analysis, and thanks to the travel fund associated with the 2008-2009 JSA Graduate Fellowship, I had the opportunity to present the latest glimpses of the g12 dataset to the CLAS Spectroscopy Working Group during the CLAS12 European Workshop, held in Genoa, Italy. At this conference, I was able to learn about experimental programs at facilities in Europe, and how they dovetail and overlap with Jefferson Lab's own programs. Meeting and talking with researchers in hadronic physics from overseas opened up another train of thought for me in career planning, and also provided a valuable opportunity to demonstrate the excellent quality and statistics of the g12 dataset to parties that may not have otherwise known.

The travel fund also allowed me to attend the APS Topical Group on Hadronic Physics meeting, as well as the greater APS meeting, held in Denver, Colorado. I presented the current progress in my dissertation work, a search for exotic mesons in  $\gamma p \rightarrow \pi^+ \pi^+ \pi^- n$ , to an audience of experts from outside of Jefferson Lab, and received much useful input. I also gave a presentation during the general APS meeting, and the experience of speaking to a multi-specialty audience unfamiliar with Jefferson Lab and its program was quite valuable.

Overall, I am highly grateful to have been chosen to receive the 2008-2009 JSA Graduate Fellowship. The travel opportunities were especially valuable in my professional development. Also, I was delighted to be chosen to receive fellowship support again for the 2009-2010 academic year, and am looking forward to next year's version of this report to be loaded with physics. Many thanks!

Sincerely,

A handwritten signature in black ink, consisting of a large, stylized 'C' followed by a 'B' and a horizontal line underneath.

Craig Bookwalter