ROUND 1 FEEDBACK: REPLIES

In this short document I respond to the comments made by referees on my analysis note entitled "First Observations of Beam Spin Asymmetries for Positive Kaons." I have followed the structure laid out in the original comment document that I was provided; please see that document to see the comments that I am responding to. I would like to express my gratitude to all of the referees for the time they have invested in reading, understanding, and offering useful suggestions for the improvement of our study. I would like to thank referee 2 in particular for his attention to detail and the annotated version of my paper, which I have now corrected based on his suggestions.

GENERAL REPLIES

In the feedback, several issues were raised commonly by all reviewers, I have replied to those briefly below and I reference these common answers in my feedback to each reviewer.

1. Several reviewers commented on the use of a vertex difference cut in hadron identification. This cut is motivated by the desire to remove particles that originate outside of the target. Following this motivation, the cut boundaries were not chosen by fitting, instead by enforcing the difference be smaller than the size of the target cell used in E1-F (5 cm). Although the number of events removed by this cut is small, we introduced the cut limit as a systematic uncertainty and study its effects in the document.
2. All reviewers had concerns about the identification of kaons at higher momentum. Indeed, the separation of particle species at higher momentum in CLAS is done only by using time of flight and momentum information and therefore cannot be accomplished perfectly. In order to study this effect in more detail, we have studied our kaon identification using a simulation of SIDIS events in CLAS. The study, included in the text, measures the sample purity and the identification efficiency as a function of momentum and confidence level. As a result of this study, we introduce a stricter cut on the minimum acceptable confidence level for kaons, and a maximum momentum restriction for kaons.
3. The presentation of systematic uncertainties provided in the first version of the document was inadequate and confusing. I have revised completely the systematic uncertainties section of this second version, and discussed each source individually.
4. Several reviewers noticed that the W resolution for sector 6 is 10 MeV worse than the average for the other sectors. This is likely due to residual misalignment in the drift chamber systems. The momentum corrections that are applied to electrons are effective in correcting the central position of the elastic proton peak in W for all sectors including sector six, and we feel that this effect is on the order of the W resolution and is tolerable.
5. Acceptance corrections for CLAS are often very important. Historically, the beam spin asymmetry and other asymmetries have been useful for their useful cancellations of multiplicative factors. I would like to acknowledge the truth of the statement that this cancellation does not apply when one integrates over the phase space. This will undoubtedly become an important factor in future analyses where measurement precision is pushed further and further. In this study, the aim is to demonstrate that an effect exists and not make

precise statements about the kinematic dependence. The quoted statistical and systematic errors on our result are quite large, and overwhelm any possible contribution from helicity dependent acceptance corrections, which have been shown to be small by W. Gohn in his thesis study “Probing the Proton’s Quark Dynamics in Semi-Inclusive Pion Electro-production.”

6. The E1-F dataset has been analyzed in our group by two previous students. First, W. Gohn created an electron identification as well as pion identification for his analysis of beam spin asymmetries. N. Harrison made small changes to improve these algorithms for his analysis of SIDIS multiplicities, which is described in his thesis document “Exploring the Structure of the Proton via Semi-Inclusive Pion Electro-production.” The largest change was the removal of Chrenkov timing and number of photo-electron cuts in favor of the simple Cherenkov geometric theta and phi matching cuts that were developed by M. Osipenko. For this analysis, we use the electron identification that was used by N. Harrison. The identification of kaons used in this analysis uses the same fiducial cuts introduced by N. Harrison in his pion analysis, and the maximum likelihood technique that is applied is a straightforward extension of the methods used by D. Carman in his E1-F analysis of lambda and sigma resonances.
7. The vertex corrections used in this report are standard corrections for E1-F. As has been pointed out, they only depend on the beam position averaged over the entire run period. In practice the beam position drifts and the calculation of beam position on a run by run basis would give a precise picture of how the beam drifts over the run period. In performing these corrections, the simple assumption was made that the beam position was relatively stable in its position, which was not centered on the target radially. Due to the efficacy of the correction, it’s evident that this simple assumption is surprisingly acceptable for our run period (although in theory it didn’t have to be this way). For this reason, these simple corrections have become standard and are passed down from student to student.

Referee 1:

Chapter 2

2.2) E1-F

The torus magnetic field polarity used for this run period was in-bending for negatively charged particles. The current used (2250 A) corresponds to 60% of maximum field.

2.3) Determination of Good Run List

Most previous analyses have used the good run list created by Wes Gohn when he analyzed the E1-F dataset. In this report, we calculated the Faraday cup charge for the calculation of the inclusive electron cross section. We then follow the procedure used by Wes Gohn as reported in Probing the Proton's Quark Dynamics in Semi-Inclusive Pion Electro-production. Our calculation of the charge accumulated for each file was more robust than previous reports, because they were not calculating cross sections. For this reason we decided to create our good run list which differed only slightly from that produced by Gohn et. al. Interestingly, none of the files which were considered bad by W. Gohn were used as good files in our good run list, and the remaining 522 files were simply an 88% subset of the good files in his report.

I have added some comments about this into the document. Additionally I have added a short section on our calculation of the inclusive electron cross section. My purpose in the addition of this small section was twofold:

(1) Validate the runs which we claim to be good runs by demonstrating consistency between our calculations and trusted models.
(2) Validate our electron identification, which is very important for the inclusive cross section.

As you point out, the original text discussed using a 3 sigma cut to choose good runs. Unfortunately, this was a mistake in my writing and in reality the values were chosen simply by requiring that $N/Q > 4000$. I have updated this information in the document and apologize for the mistake. The figure now contains a red line that indicates our threshold.

2.6) Timing Corrections

Paddles excluded from this analysis due to having too few events to correctly calibrate them were mostly in the backward angles (paddle number greater than 40). This is described in detail in Exploring the Structure of the Proton via Semi-Inclusive Pion Electro-production, N. Harrison. Since the paddles didn't have enough pion hits to calibrate, they likely don't contribute much to the analysis.

2.7) Kinematic Corrections

In the text I state that DC misalignments should impact particles of both charges in the same way, as you correctly point out this is not the case when one considers also the magnetic field. I have clarified the text to reflect this. Several referees asked why the W resolution depicted for sector 6 is significantly worse than the other sectors, please see my general comment 4.

Chapter 3

3.2) Electron Identification

Removing negatively charged pions using energy deposition cuts on the inner layer of the ECAL has proven very effective, and has been quite standard in CLAS (using 50-60 MeV as the threshold). I have added a figure that demonstrates this to the document.

3.3) Hadron Identification

Please refer to general comment number 1.
Please refer to general comment number 2.

Chapter 4

4.2) Event Selection

In our analysis we use the working assumption that the DIS region can be accessed at Q > 1. To our knowledge, this has been used throughout the history of CLAS. Our results for the extracted asymmetry as a function of Q are quite flat, indicating that we're not so sensitive to possible scaling.

There is a prominent feature in the electron-kaon missing mass spectrum, it is the lambda 1520 MeV resonance. Add comment here regarding the missing mass dependence of the asymmetry.

4.3) Phi Distributions

Please refer to general reply 3, regarding the treatment of systematic uncertainties.

The EC-U coordinate cut makes a large difference on the final answer because moving the lower cut boundary varies the statistics used in the analysis widely. Additionally, the contribution from this is not the same for all bins, as it is correlated (not perfectly) with the polar angle away from the beam line in the lab frame.

We have not looked at the asymmetry per sector.

Please see general reply 6, which discusses the difference between our analysis and those previously performed.

Referee 2

Delayed helicity reporting was used for approximately half of the E1-F run period. W. Gohn produced a package that can be used to insert the correct helicity information into the n-tuples, and he wrote a CLAS note about this software package. This package was also used for his analysis, which published results for pions.

Page 2:

> We apologize for our misstatement of the experiment to measure the g1 g2 product, and will update the motivation section accordingly.

Page 10:

> As you correctly observe, the beam position likely varies continuously over time and over the dataset. This correction however has proved to be effective, and that result is demonstrated in figure 2.3. Please see general comment 7.

Page 17:

> Please see general reply 4, regarding the W spectrum in sector 6.

Page 25:

> The index used on page 25 refers to the momentum bin/slice index, because the distribution is sliced into 40 momentum bins. This will be clarified. Below, I state that we used 2.5 standard deviations as the nominal cut value, this value is varied in our study of systematic uncertainties.

Page 27:

> I have updated the vertex cut parameters to exclude the right window. Thank you for this comment, please feel free to see the updated figure.

Page 32:

> Please see my general reply 1 regarding the vertex difference cut.

Page 33:

We believe our definition of confidence level is in accordance with the traditional usage, as shown in equation 3.10. In our case, we apply a minimum acceptable confidence level cut of 0.55, based on a new Monte Carlo study of PID.

Page 42:

I believe that my wording was unclear in this matter and I apologize for that. For each kinematic variable have 10 bins, in each of those there are 12 bins in phi, for a total of 10 * 12 = 120 bins. This is repeated for the 4 axes of interest. I have updated the wording of the note to reflect this, and added a figure which shows those bins in a two-dimensional histogram.

Page 42:

A correction for the beam charge asymmetry was calculated by Wes Gohn in his work entitled Probing the Proton's Quark Dynamics with Semi-Inclusive Pion Electro-production. He showed that for E1-F, the beam charge asymmetry was on the order of 0.003, and his estimate (based on splitting the dataset by charge asymmetry) was much less than his statistical error. As our statistical errors are larger, we don't believe this will be a relevant contribution to our systematic uncertainty.

Referee 3

Chapter 1

I have now explicitly stated that our formulation is only applicable for unpolarized targets, thank you for pointing out this missing information.

Chapter 2

Please see my reply to referee 1 regarding our good run list.

Please see my general reply 7 regarding vertex corrections.

The timing correction from paddle-to-paddle should not depend on what type of particle, it is a timing offset. This section has been re-worded in order to avoid confusion.

Figure 2.4 demonstrates the effectiveness of the timing corrections for one paddle. The reduction in number of bands after applying the correction demonstrates that those particles have been shifted into the band where the others are, and the correction has worked.

I apologize for the confusion in section 2.7, I have only corrected the electron momentum, and the text has been updated. Thank you.

Please see general comment 4 regarding the W resolution for sector 6. After applying electron momentum corrections the lambda and sigma masses don't change. I can forward you the figure.

Chapter 3

Drift chamber fiducial cuts for electrons and hadrons were developed by N. Harrison and discussed in his thesis work "Exploring the Structure of the Proton via Semi-Inclusive Electro-production." The parametrization is the same for positives and negatives, but the values are different.

The left and right boundary lines are both bottom boundaries, and therefore using y > left and y > right is the correct condition. In the right half of the sector, the left boundary line continues on down and is far below the physical sector. If it is more clear, one can just consider two conditions based on the half of the sector that the event is in. If you're in the left half you use y > left, if you're in the right have you use y > right. I had made this more clear in the text, thank you for your comments.

We use no timing cuts on electrons, this was studied by N. Harrison in his development of electron identification methods based on those previously applied to E1-F. I have discussed this in my comments to referee 1 in more detail. A figure has been added to the text that shows the 60 MeV ECAL cut for each sector.

The vertex cut was slightly moved so that it is more symmetric. Please see the updated figure in my text.

There are fiducial cuts applied to the Cherenkov Counter, I have added a description of these to the document.

I have discussed the electron-hadron vertex difference cut in general comment 1.

Chapter 4

We do not use any cut on the variable y, however the values of z are restricted for all axes that are not z to be within 0.25 and 0.75. I have clarified this in the document.

The figure 4.2 is confusing, and I has been updated so that it is clear exactly what is shown. I am showing the events which pass all other cuts before applying the cut on missing mass that is used in this analysis.

I claim that I have chosen bins to have equal statistics, which as you observe is false. I apologize for not making this clear, I choose the statistics equal in kinematic bins, but after I bin each of those into 12 phi bins, the statistics are not equal in each of those smaller and equal sized phi bins. I have clarified this in the text.

I use a parametric bootstrap method in my fitting of the phi dependence, I have added a figure that shows these replicas plotted over the phi distributions to the document.

Please see my general comment 3 regarding the description of systematic errors.

For this extraction, I used chi-2 minimization that I implement using scipy.optimize. I use the replica method, and the magnitudes of the other terms (cos and cos2) are consistent with zero (large error). I can provide results using a simple sine fit, but I think that the form provided by the cross section is theoretically on strong grounds and wanted to use the full function.