

To: CLAS Ad Hoc Committee - William Briscoe, Marco Mirazita, and Gabriel Niculescu
From: Reinhard Schumacher and the g14 Run Group
Date: April 27, 2018
Updated Draft of paper dated: April 26, 2018

Response to CLAS Collaboration Comments for the g14/CLAS paper
“Beam Target Helicity Asymmetry E in $K^0\Lambda$ and $K^0\Sigma^0$ Photoproduction on the Neutron”
(Committee draft dated April 9, 2018)

////////////////////////////////////
Wooyoung KIM
In Acknowledgement section, "the National Research Foundation of Korea" should be included.
[Reply: Done.](#)

////////////////////////////////////
Alexandre Deur

The first number indicates the line.

3: remove "and"
5: N.K. Walford. space missing between N. and K.
3-5 most institutions superscripts are missing
[Reply: All these will be fixed when the proper author list is created and inserted.](#)

5th line of the abstract: remove the superfluous "model" in "model predictions from the KaonMAID, SAID, and Bonn-Gatchina models", since we state they are models 8 words later.
[Reply: Done.](#)

20 coma after "regime"?
[Reply: Yes, we added it.](#)

33 remove superfluous "only"
[Reply: Done.](#)

36 add "(PWA)" after "partial wave analysis" since the acronym is used later without being defined (e.g. line 44)
[Reply: Done.](#)

48 remove superfluous "complex". In Quantum Physics, amplitudes are complex numbers.
[Reply: Done.](#)

49 sections -> section
[Reply: Done.](#)

52-53: For better clarity, I would remove the comas before W and before $\cos\theta_{\text{c.m.}}$ I would remove as well the "cos" since $\cos\theta_{\text{c.m.}}$ is not an angle while we name it that.
[Reply: We rewrote the sentence.](#)

68 hyperons -> hyperon

Reply: Done.

89-90 the KaonMAID model -> KaonMAID

Reply: Done.

90 Grammar says that "predictions" should refer to KaonMAID but the reference [38] indicates it is SAID. Maybe add "SAID" before "predictions"

Reply: Yes, added that word.

106 Should we specify that the deuteron polarization is the vector polarization (not the tensor polarization)?

Reply: Yes, it can't hurt to be more accurate.

113 Was the target polarization flipped (RF operations) or rather rotated (magnetic field operations)?

Reply: You know better than I. We changed the word "flipped" to "inverted"

2nd and 3rd lines above Eq. (4) (they are not numbered): is it okay to use "lab" rather laboratory?

Reply: We wrote out the words in full

137 consist -> consists

Reply: Done.

147 the mathematical script used here and the normal script for the TOFs line 143 are inconsistent

Reply: Now consistent.

147-148 Is "events of which the two positively charged particles were the proton" correct? Maybe "event FOR which" ?

Reply: Yes, "for" is better.

149 "were both the π^- " -> were both π^- ?

Reply: Done.

154 "dilute the measurement" -> "dilute E" (since unpolarized material don't dilute yields but rather increase them, and "measurement" is not specific).

Reply: Done.

156 remove "frozen" (so that it is not ambiguous that there could be liquid or gaseous HD in the empty target)

Reply: Done.

171 result -> results ? (it is the "presence" that "results" in the tail)

Reply: Very good. "results" related to "presence" and not to "events"

Fig. 1 caption: Remove (BG), since the acronym is not used in the article.

Reply: Done.

174 Instead of the negative-sounding "Because of the rather low statistics in this experiment", I would use the more positive "Because of the small reaction cross section"

Reply: Good idea. Done.

224 "Two things should be noted..." does not sound formal enough for an article. Maybe "It should be noted in Figs. 1 and 3 that, firstly..." or something like that would be better?

Reply: The sentence has been rewritten in a more formal way.

237 "negative pions" -> π^- , to be consistent with the general style of the article (see also lines 76, 144, 241 for possible changes). Similarly, the next sentence use the greek letter for the kaon and the full latin name for the hyperon. (There are other of such instances in the paper than can be corrected if you think it is important enough).

Reply: In this case, some of us like to use the written English name for the particles because it maintains more of a narrative flavor that way. Exceptions are when the need to specify a sign of charge (+,-,0).

252-253 Instead of the negative-sounding "We address this issue below", maybe "This is addressed (or "corrected") below"?

Reply: "This issue is discussed and corrected below." is what we now have.

253 remove "simple"

Reply: Done.

Fig. 4 caption "events rejected events" -> "events rejected"

Reply: Done.

Fig. 5 caption: off -> of in "The distribution of missing mass off the reconstructed" ? Also, should "distribution" be plural? (Two are shown).

Reply: Yes, plural.

Fig. 6 caption off -> of in "The distribution of missing mass off" ?

Reply: This is an endless headache: 'of' or 'off'; both forms have some merit. We changed the word to "from" in both Fig 5 and 6.

Two lines below Eq. 7, I would remove the not very useful "bound in deuterium", to make the sentence easier to digest.

Reply: Changed it to "...bound neutrons..."

Three lines above Eq. 8, of Eq. 4 -> in Eq. 4 (or more concisely, "numerator of Eq. 4)

Reply: Used "numerator of Eq 4"

294 need not -> needs not

Reply: No, in this case "need" is the correct grammar.

294 aligned to -> aligned with ?

Reply: Done.

297 a [...] momenta -> a [...] momentum (or remove "a")

Reply: Removed "a"

310 need -> needs

Reply: The alternative is "...needs to only TO be treated..."

312 Following this paper -> Following Ref. [56]

Reply: Done.

Lines 314-315 are stating something trivial from the previous statements. They could be removed.

Reply: Another collaborator wanted those numbers in there, so we decided to leave them.

329 tabulated results of Table I -> results in Table I (tabulated and table are somewhat redundant)

Reply: Done.

332 result -> results (it is usually used in plural in the paper, e.g. the title of the section, the line just above. There are other instances of result used in singular, e.g. line 319)

Reply: Fixed.

333 one of the two "energy" could be removed. Same line 335.

Reply: removed "W energy" in two places

350 partial wave analyses (PWA) -> PWA (the acronym was already defined earlier)

Reply: Done.

Fig. 7 caption. remove ", as shown" ? Or maybe a piece of sentence is missing? Same question regarding Fig. 8's caption.

Reply: We are trying to point the reader to the label in the figures. Replaces "as shown" with "as labeled"

362 Remove "among the three".

Reply: we left this in place.

Regarding the comparison with the models, would it be useful to indicate values of χ^2 (after removing the $\theta_{c.m}$ bin-to-bin correlated errors)? It is not obvious to me that SAID is slightly favored. I would have thought that BnGa looks slightly better.

Reply: It is a fairly weak statement, but it refers only to the right-hand panel of Fig 7, where SAID is the only curve that dips to negative values.

375 "for the following reason:" -> "because"

Reply: Done.

401-402 This was already stated lines 329-330

Reply: Removed that sentence and combined the other one with the previous paragraph.

416 Instead of the negative-sounding "this analysis is limited by low statistics for", maybe "this analysis is limited by the small cross sections of"

Reply: Done.

420-421 You stated the opposite conclusion that SAID looked the best lines 361-362.

Reply: Rewrote those sentences to make them sensible.

434 observable -> observables

Reply: Done.

435 has -> have (refers to data)

Reply: Done.

////////////////////////////////////
David Ireland

Dear Reinhard et al., This is a very nice paper. To have been able to extract any results from the limited statistics in these channels is nothing short of heroic! It is also important to point out how the use of BDTs has helped significantly in the analysis. Whilst this technique has been in use in the high-energy community for some time, I do not believe it has been utilized in low-mass hadron physics.

I have a couple of comments that may need to be addressed before submission:

- Page 1, line 49-53: It is actually not possible to extract amplitudes with measurements of the minimum number of observables. This is shown in Nys, et al (Phys Lett B., 759 (2016) 260-265), and is because any measurement will have finite accuracy. The complete experiment is a mathematical construct only. I believe it would be more accurate to state something along the lines of: "To extract amplitudes up to a common, unknown phase, requires the measurement with sufficient accuracy of observables from each experimental configuration of the three combinations of beam-target, target-recoil and beam-recoil polarization." In other words, one does not actually measure observables, rather what is measured are asymmetries depending on beam, target and recoil polarizations.

Reply: Yes, your point is of course correct. We have changed the text to read as follows, in part to include the Nys et al reference: "To describe a mathematically \textit{complete} experiment requires the measurement of a minimum of eight well-chosen observables~\cite{Fasano:1992es, Chiang:1996em, Keaton:1996pe, Sandorfi:2010uv} at any given center-of mass (c.m.) energy \sqrt{s} , and meson polar angle described by $\cos\theta_{\text{c.m.}}$. To extract amplitudes accurate enough to discriminate among models requires measurements of observables from each experimental configuration of the three combinations of beam-target, target-recoil and beam-recoil polarization~\cite{Nys:2016uel}."

- Page 2, line 70-71: "The present measurement does not involve final state polarizations". I am afraid that it does! By selecting the pi-minus and the proton to identify the Lambda, this unwittingly biases the events if there is any recoil polarization. The equation describing beam-target intensity:

$1 - \text{obs}\{E\} P_C^{\gamma} P_L^T$ (my, slightly altered notation of equation 2) is what you have used in this analysis. However, the present measurement is actually a triple polarization measurement, whose intensity is proportional to $1 + \text{obs}\{P\} P_y^R + \left(\text{obs}\{L_x\} P_x^R + \text{obs}\{L_z\} P_z^R \right) P_L^T + \left(\text{obs}\{C_x\} P_x^R + \text{obs}\{C_z\} P_z^R - \left(\text{obs}\{E\} + \text{obs}\{H\} P_y^R \right) P_L^T \right) P_C^{\gamma}$ (Use `\newcommand{\obs}[1]{\textcolor{red}{\mathbf{\#1}}}` to get hopefully colorful equations)

Dave Ireland's notation for Equation 2:

$$I \sim 1 - \textcolor{red}{E} P_C^{\gamma} P_L^T$$

Dave's more complete expression for the observables:

$$I \sim 1 + \textcolor{red}{P} P_y^R + (\textcolor{red}{L}_x P_x^R + \textcolor{red}{L}_z P_z^R) P_L^T + \{ \textcolor{red}{C}_x P_x^R + \textcolor{red}{C}_z P_z^R - (\textcolor{red}{E} + \textcolor{red}{H} P_y^R) P_L^T \} P_C^{\gamma}$$

This contains seven "observables", not all of which would drop out in an asymmetry, due to acceptances. This is a hard lesson that we learned in g8, where we noticed that the extracted beam asymmetry was wrong if we did not simultaneously extract four other observables. The effect is almost negligible for the selection of the Sigma, because the emission of the decay photon is not detected, which means that that the event selection is less biased. Now in the present case, the small number of events is likely to mask this issue, so I would not necessarily suggest that additional work needs done. If the observable H is small, which could be estimated from the theoretical predictions, there should be no worries.

Reply: Yes, you are correct that we have a weak spot in our case here. The first thing we changed was the (former) lines 70-71 to read “While the present work does not involve measurement of hyperon polarizations, previous work has shown the benefit of using such information to extract properties of higher-mass nucleon resonances...” to make the statement more precise. Then we added the following statement on (new) lines 142-150: “We ignore the triple-spin terms that depend upon, in addition to the beam and target polarizations, projections of the recoiling hyperon polarization vector. A full cross section expression is found, for example in Ref.~\cite{Sandorfi:2010uv}, and it includes several other observables that may contribute if the acceptance for the recoiling hyperon decay products is not perfect. We assume based on previous experience that the CLAS acceptance is broad enough that such effects are diluted away.”

Then we added a paragraph on (new) lines 399-413 that reads: “Finally, we note a complication that could occur when summing Λ yields to create the E asymmetries. The relative angular distribution between the π^+ and the p that are used to reconstruct a Λ carries information on the recoil polarization of the latter. When summed over azimuthal angles, this information is lost. However, limitations in detector acceptance could result in an incomplete integration, which in principle could introduce into Eq. 2 a dependence on six additional observables [21]. The gaps in CLAS acceptance are modest and, due to lower than expected production cross sections, the data below are presented in broad kinematic bins, which tends to dilute such effects. On the scale of our statistical uncertainties, such corrections are expected to be negligible and we have not attempted to correct for them.”

- Figures 7, 8 and 9: As is mentioned in the text, the accuracy only allows one to state that E is mostly positive or mostly negative for the two energy regions. Note that ALL the theoretical curves are +1 at 0 and 180 degrees. There is a good reason for this: the true value of E *must* be +1 at these values, by virtue of the spin algebra! Fasano, Tabakin and Saghai (PRC 46 (1992) 2430) show that the E observable is in the class of observables where this is true. Because of the course binning, the data look like they violate this rule. It may be prudent to make it clear that the points represent an average over the bin.

Reply: The point you raise here was already spelled out in the draft you reviewed. Check out the statement at lines 346 – 349 (of the previous draft).

Apologies for what may seem like pedantry. None of these issues are show-stoppers, but should be given some thought. I am very happy to discuss them further.

Best wishes, Dave

[illegible]

Dan Carman

Dear Reinhard et al., I have read through your draft of the g13 paper on the E asymmetry in KY photoproduction and include my comments below. Most of what I have provided below will serve to improve the grammar and readability of the paper. If you have any questions, let me know.

Regards, Daniel

[Comment: Thanks for an amazingly close reading of the grammar in this paper and all the corrections.](#)

Page 1: - Abstract:

- Line 6. Use "... isospin $I=0$ and $I=1$ photo-coupling ...".
- Line 26. Use "... spectrum that predict ...". - Line 53. Use " $I=3/2$ ".
- Line 54. Use " $(\Delta^* \text{ excitations})$ ".

[Reply: All done.](#)

Page 2:

- Line 56. Use " $I=1/2$ ". - Line 6 after labeled line 76. Given definition in Eq.(1), I suggest that you use "... difference in photoproduction yield between anti-parallel (σ^A) and parallel (σ^P) configurations, ...".
- Line 78. Use "... over the final spin states, ...".

[Reply: All done.](#)

Page 3: - Line 105. Use "... (HD) was used in ...".

- Line 110. Use " $0.9 \sim T$ ". - Line 127. Use " $\gamma \rightarrow \pi^- p$ " to be consistent with listings elsewhere.
- Line 132. Use "... larger yield of the signal events and ...". - Line 153. Use "... cooling wires and polychlorotrifluoroethylene (pCTFE) - dilute ...".

[Reply: All done.](#)

Page 4:

- Fig. 2 caption:
- Line 3. Use "... rejection for $m_X > 1.4$...".
- Line 189. Use "... the $K^0 \Lambda$ and $K^0 \Sigma^0$ events."

[Reply: All done.](#)

Page 5:

- Line 257. Use "... the $K^0 \Lambda$ and $K^0 \Sigma^0$...".
- Line 268. Use "In the next section, the correction ...".

[Reply: All done.](#)

Page 6:

- Fig. 4 caption:
- Line 4. Use "... rejected by the second BDT ...".
- Line 4 of left column. Use "... and $z > -2 \text{ cm}$ vertex ...".
- Line 1 of right column. Use "... also comprises events from ...".

[Reply: All done.](#)

Page 7:

- Fig. 5 caption:
- Line 3. Use "... events with the {em wrong} $K^0 \Sigma^0$ classification."
- Line 4. Use "... events with the correct $K^0 \Sigma^0$ classification, ...".
- Line 295. Use "... data for the $\gamma \rightarrow$...". - Line 311. Use " $\text{\$NN\$}$ ".

Reply: All done.

Page 8:

- Fig. 7 caption:
- Line 5. Use "... (red dashed), SAID [36] ...".
- Line 371. Use "... that the KaonMAID prediction ...".

Reply: All done.

Page 9:

- Line 396. Use "... of this final state requires ...".
- Line 397. Use "... within our uncertainties, ...".

Reply: All done.

Page 10:

- Table I caption:
- Line 1. Use "... for the $K^0 \Lambda$...".

Reply: All done.

References:

- [5]. Spacing problem in journal name.
- [7]. Spacing problem in journal name.
- [24]. Here you use "CLAS Collaboration" where you use "CLAS" elsewhere.
- [40]. The Mecking et al. paper is not a CLAS Collaboration paper.

Reply: All done.

[illegible]

Mike Lowry

Hello Reinhard,

Finally had a chance over the weekend to go over the version you sent last Thursday. Let me offer some very minor thoughts on this nice paper:

page 1 Last sentence of the abstract

"results will serve to help separate" feels awkward and wordy.

Other constructions to consider "results will help separate",

"results can help separate", "results will help in separating"

Reply: Yes, we agree; took the first of your suggestions.

page 1 line 21

"competing ... models ... are necessary." I do not see why this is true.

I suspect you mean

"competing ... models .. are all that are available."

Reply: Yes, we took your suggested change.

page 4, line 200

"data -- of which" This is an unusual phraseology.

alternatives "data -- for which", "data -- where"

Reply: changed to use the word “wherein”

page 9, line 391

"finals state" clearly typo, should be "final state"

Reply: Fixed.

While composing this, I received email you have opened it up to collaboration review so you may want to ignore everything (except the typo).

Yours,
Mike Lowry

////////////////////////////////////

Thank you all for your thoughtful comments. Please have a look whether the revised draft of the paper is OK now to move on the final Author Check review, to be followed by submission to Phys Rev C.