Comments on the CLAS Analysis Note:

"Measurement of Cross-Sections of exclusive $\pi\{0\}$ Photo-production on Hydrogen from 1.1 GeV - 5.45 GeV using e+e-γ decay from the CLAS/g12 data"

by Michael Kunkel

Committee Members: Y. Illieva, L. Guo and C. Salgado (Chair)

October 28th, 2016 (1st Round of Comments)

Preamble:

This note describes photoproduction of the π^0 meson using the CLAS/g12 data at beam energies of 1.1 GeV to 5.45 GeV. The reaction observed is $\gamma p \to p e_+ e_- (\gamma)$. This final state is the sum of two subprocesses, the π^0 meson decay through the three-body Dalitz decay mode of $\pi^0 \to e_+ e_- \gamma$ and the conversion (mostly in the target material) of one photon from $\pi^0 \to \gamma\gamma$ decay into a e_+e- pair. The authors report measurements of two π^0 meson differential cross-sections. They also report fits using the SAID model parametrization.

General Comments / Summary

Overall, all members of the committee agree that the analysis is well discussed and that the note is also well written. We have a few general concerns and some specific comments detailed below.

General concerns:

1. Is it justified to quote a global uncertainty for the sector dependence and the track dependent particle efficiencies if they were actually extracted on a bin-by-bin basis? Why not quote the bin-by-bin uncertainty rather than a global one?

2. Some of the g12/g1c comparisons that are on a log scale might be misleading. Is there a pull distribution for g12/g1c?

3. fiducial cuts. These are not mentioned explicitly within the procedure of the analysis. We understand that those are standard approved cuts, so no need to expand a lot about these, but as you describe the line of the analysis, explicitly mention at the appropriate stage that fiducial cuts were applied (as was done with the reference to target density for example in chapter 3).

4. it seems that the normalization correction accounts for two effects: (a) differences in the real and simulated detector resolutions (any geometric mismatch in detector position and orientation would be convoluted mostly with the resolutions ?) and (b) differences in various detector elements finite efficiencies. The former would be especially pronounced at the edges of the detector (geometric edges or minimum momentum edges). The latter would be edge unrelated.

In order to be able to judge how well the simulation resolution matches the detector resolution, we would like to see extra figures (in addition to missing mass and momentum and angle distributions which are given throughout the note) from this analysis for differences of momenta and angles (reconstructed - measured) of each of the three particles for both the simulated and the real data.

5. We would like to see more detail on the method by which the systematic uncertainty (error) of the normalization correction was determined. This is a large correction, which absorbs some acceptance and resolution effects, but is only 0.5%? That small value may be perfectly valid, but we are surprised since we have not seen any CLAS cross section analysis yet having a smaller acceptance uncertainty better than 5%. This makes it important to see more details on the method for estimating the 0.5%. In addition, we would like to see the expression/method used to estimate the statistical uncertainty of 0.01%

6. Somehow a general but minor concern. It seems to be a loose use of the words "error" and/ or "uncertainty" in the note. For example: in Table 50: You quote a "sector systematic uncertainty", but I guess you mean "acceptance systematic error". Similar comment for "Particle Efficiency". Make the labels for uncertainties (errors) consistent with the names of the sources you describe earlier in the text.

More Specific Comments:

1. page 6 "missing mass of p(g, p)x off the target proton and the tagged photon." should say "missing mass off the target proton, the tagged photon and the observed proton".

2. page 7 2.2 We do not understand well the cut used to determine e versus pi? We do not understand what you mean to say here. If the track's momentum is consistent with the kinematics of the reaction of interest, then assigning the track the proper e+ or e- track will yield a missing mass consistent with a missing photon (within the missing mass resolution)? Clarify.

3. page 7 sec 2.2: First sentence, "conservation of mass" is misleading (i.e. mass is not conserved). The last sentence in that section is more appropriate.

4. p.7, table 2: "initial skim selects only events with one in-time beam photon." We could not find later in the note any correction applied to compensate for lost yield due to events with more than "one in-time photon". Is it done?

5. page 8 used. "To satisfy the trigger requirement in the data for photon beam energies < 3.6 GeV, cuts were placed on the EC and CC hit quantities recorded." Could you expand, it is not clear what that means?

6. page 20. 3. Is there a reason to vary the CL cut from 1% to 10%, instead, let's say from 10% vs 20%. we are just curious about the reasoning.

7. page 25 "It is shown in Fig. 14a that each cut reduces the background without significantly reducing the signal." That figure seems not to be a good tool to show that. Perhaps we need to quantify? For data sample: Show differences total - signal.

For MC data: give numbers : pi0 tot initial. pi0 tot final.
8. page 28 "The remainder of the background can be attributed to ...events." What background remainder do you mean? The top green distribution in Fig. 14 does not demonstrate what background is remaining. Do you mean for Eg>=3.6 GeV?

9. page 28 "The effect of the 75 MeV missing energy cut on the M2 x(p) spectrum can be seen in Fig. 16." Figure 16 does not demonstrate the effect of the 75-MeV cut on the data as it does not show distributions before and after the cut. Fig. 16 shows the MM distributions after all the cuts (until that point) have been applied. It also shows the modeling of the signal and the remaining background.

10. Figure 15. In caption the Mass parenthesis descriptions and the figure axes descriptions should match.

11. page 36. "This effect was studied as a systematic uncertainty (see Sec 7.3)." that should be a systematic error and corrected for. Unless the simulation was also applied a Z-vertex cut to in which case the acceptance should take care of this effect and the uncertainty of that becomes part of the acceptance. Unless there is more?

12. 5. p.40: in section 2.6 the bit 6 pi0 efficiency is studied. We would like more detailed information here. Right now it looks like the total number of entries (what is meant by number of entries - events, hits, else?) for bit 6 is normalized to the total number of pi0 events in bit 6 (at least the top panel of Fig.24 shows the total number of pi0 events and that has been obtained by the analysis of trigger bit 6 only). This looks like a self normalization: bit 6 is normalized to bit 6, is it not then expected that the ratio would be one, independent of efficiency of that trigger bit?

13. Were fiducial cuts applied to simulated and real data for the normalization analysis? If so, were exactly the same fiducial cuts applied? In any case put in the note.

14. Could you explain why the areas of the coils are shown with finite efficiencies if figures 29, 30, 32, 33, and somewhat on figures 35 and 36? The latter two figures seem to show zero efficiency only for two coils (at theta , cos_phi=0) but not for the diagonal ones - why? Why are figures 29, 30, 32, and 33 not showing any o efficiency for the same two coils as shown by 35 and 36?

15. - Figures 31 and 32 suggest that the normalization corrections are particle dependent. How confident are you (beyond the general argument that both e and pi are minimum ionizing particles) that the pion corrections are applicable to electrons? The direction of my question is leading towards estimating the level of such doubt (i.e. a related uncertainty) in the total systematic uncertainty of the corrections.

16. -Figure 38: instead of showing the two estimates on top of each other, can you show the difference between them (the stat. uncertainty of this difference is exactly zero)?\

17.- p.55 - Could you explain the arguments justifying to apply the g11 overall normalization to the g12 data?

18.- section 6.1: Why did you use only e+e- events for verification and not pe+e- events?
- add a last sentence to section 6.1 explaining whether you corrected the cross sections with any of these inefficiencies.

19.- section 6.3: This is a clarification comment - I cannot follow the trigger simulation (it is the wording): so 1, 2, and 3 refer to returning the sector number and 4 refers to returning 0 or 1 for that sector? What happens if two sectors simultaneosly satisfy the conditions?

20.- p.62 - you state that the acceptance inefficiency was 1.1%. (a) Is this value used to correct the final cross sections? (b) after the normalization correction from chapter 5 is applied, do you not expect zero remaining inefficiency of the simulation? This makes me wander how uncertain is this 1.1%?

21.- Figures 42 - 45 show systematic differences between the simulated and real data - please comment on those: what is the origin? are they accounted for? and if so where?

22.- figure 46 top - show the difference between the two distributions (normalized to the value of the data) with proper uncertainty and comment on the difference - should we worry about it at this point - why or why not.

23.- section 6.5 - show the acceptance for the same kinematics as you report the data.

24.- the acceptance was determined using phase-space distributed events. Would not the acceptance depend on the shape of the generated event distributions for the case of 3 detected final-state particles?

25.- p. 70: We do not think Eq. 35 is correct as R and G are not independent? Using this equation might overestimates the statistical uncertainty of the acceptance.

26.- p. 74: Eq. 47 is only valid when the statistics (distributions) are the same for both Ksi_n and Ksi_1. For the case of significant statistical differences the statistics needs to be subtracted (convoluted?) from the sigma estimated by Eq. 47.

27.-sect. 7.3.4 - what types of yields were used to determine the "sector" efficiency? e+e-p?

28.- overall for the note: use "error" and "uncertainty" appropriately. Error is the difference between an estimate and the true value!

29.- Table 4: The statistical uncertainties of acceptance, efficiency, etc. - are they propagated in the statistical uncertainties of the yields or are they added to the systematic uncertainty of those sources?

30.- Table 4: Are all of these uncertainties relative? Specify or report explicitly in %.

31.- Figures 53 -58: We would like to also see a difference between old and these CLAS data normalized to either the old or the new, with proper uncertainties.

32.- Figures of cross sections: show the systematic uncertainties (errors) as bends (especially relevant for the paper).

Please let's know if you need any clarification in our comments.

Best regards,
Yordanka, Lei and Carlos

(Compiled by C. Salgado for the Committee)