Exclusive π^0 -production Cross Section Extraction

Po-Ju Lin Feb. 01, 2020

Outline

Cross section extraction of all kinematic settings

- Where we are at this moment
- Issue in systematic study
- Questions
 - Puzzles & things to be determined

Cross Section Extraction

Cross Section Extracted

∀ t'-average cross section <
$$\frac{d\sigma_{T+\epsilon L}}{dt}$$
 >= $\frac{\sum_i \frac{d\sigma_i}{dt} \cdot \Delta t'}{\sum_i \Delta t'_i}$

- GK-model linearly extrapolated. Values updated. <u>https://hallaweb.jlab.org/dvcslog/12+GeV/625</u>
- To the first order, the agreement of the results between mine and Bishnu, Salina, and Ho-San is acceptable.
- The results that I have so far shall be lowered by few percent...will be explained soon.



Systematic Error Study – Kin 361



Dependence on Photon Energy Cut





- > Decreasing trend with higher photon energy observed in other kinematics as well
- The variation I got is worse than what Bishnu observed.
- The variation is not related to the change of average t'. The difference between the average t' of different energy cut is about 0.001 GeV² the most.

Photon Energy Distribution – Kin 361



Photon Energy Distribution





The t' dependence is unable to explain the drop at low energy in the MC

Problem

- In MC, the clustering threshold is implemented as: calo_event->TriggerSim(threshold);
 - The threshold has been set at the value identical to the clustering of data.
- > In the smearing procedure, the photon energy is raised few percent and randomized following a gaussian distribution
 - On the low-energy boundary this procedure caused this drop of event we are observing.
 - I think the quick solution to this is to lower the clustering threshold for MC.

Clustering Threshold

 \succ In the smearing results I had, the Gaussian width σ is proportional to $\sqrt{E_{MC}}$, and can be as large as ~0.24 GeV.

- Set the clustering threshold 0.4 GeV lower than the nominal value used for data clustering.
- "0.5 GeV-lower" setting is also tested, doesn't give noticeable change to the final result.
- > The photon energy distribution is changed, re-doing the smearing is required.



Photon Energy Distribution – Kin 361



Cross Section Extracted – Kin-361



- > The extracted $\frac{d\sigma_T}{dt} + \epsilon_L \frac{d\sigma_L}{dt}$ values are few percent smaller.
- Within error, the other crosssection terms agree with previous results.

Dependency on Photon Energy Cut

250



1.6 1.8 E, Cut (GeV)

235

230

225

220 දි 315

205

200



ť bin 2

Nominal Threshold



- Variation mitigated by lowering the MC clustering threshold.
- QUESTION: Do we assign asymmetric error to the cross section?

Cross Section Extraction – Summary

- A noticeable dependency of the cross section with the photon energy cut is observed.
 - Correlated to the clustering threshold in MC.
 - Set the threshold in MC at a smaller value can mitigate this.
 - Re-doing the smearing is necessary...
- > Observation of the results using corrected MC:
 - The general trend of the extracted cross section as a function of t' is not changed.
 - The cross section would be smaller.

Will try to have the re-processed results updated ASAP



Cross Section Extraction – Summary

- A noticeable dependency of the cross section with the photon energy cut is observed.
 - Correlated to the clustering threshold in MC.
 - Set the threshold in MC at a smaller value can mitigate this.
 - Re-doing the smearing is necessary...
- > Observation of the results using corrected MC:
 - The general trend of the extracted cross section as a function of t' is not changed.
 - The cross section would be smaller.

Will try to have the re-processed results updated ASAP



Questions

t' Distribuion



- > Realized that the lower edge of t' = $t_{min} t$ is not fairly close to 0
- Reason for this? Acceptable?
- Do extraction with one additional bin at low t'
 - Divide the first bin into 1st from t'= (0, 0.04) & 2nd from (0.04, 0.97)
 - t_{min} calculation given by Charles

$$\begin{split} t &= (q - q')^2 \\ &= q^2 - 2q \cdot q' + q'^2 = -Q^2 - 2q \cdot q' + m_\pi^2 \\ t(0^\circ) &= -Q^2 - 2(q')^{\text{CM}}(\nu - |\mathbf{q}|)^{\text{CM}} + m_\pi^2 \\ q')^{\text{CM}} &= \frac{W^2 - M^2 + m_\pi^2}{2W} \\ \nu^{\text{CM}} &= \frac{W^2 - M^2 + q^2}{2W} = \frac{W^2 - M^2 - Q^2}{2W} \\ |\mathbf{q}|^{\text{CM}} &= \sqrt{Q^2 + (\nu^{\text{CM}})^2} \\ &= \sqrt{Q^2 + \frac{(W^2 - M^2 - Q^2)^2}{4W^2}} \end{split}$$

t' Distribuion



Horizontal Error Bar



Shall the horizontal error bars added?

- The ones were made to show the edge that includes ~68% of the data lower of higher than the average value in the corresponding bin.
- A 4% systematics is added to the vertical error (simply for testing the code at this moment).



Suggestions?

Missing ingredients?

Backup Slides

Trigger Threshold

Kinematic setting	DAQ threshold (GeV)
kin36_1	1.0975
oldkin36_2	1.0975
kin48_1	0.4243
kin48_1 (run 12508)	0.8907
kin48_2	0.8907
kin48_2 (run 13000, 13183-4)	1.0073
kin48_2 (run 13001 to 13015, 13191 to 13193)	0.3076
kin48_3	1.0073
kin48_3 (run 12838)	0.4243
kin48_4 (run 13100 to 13162)	1.0073
kin48_4 (run 13279 to 13418)	1.4571
kin36_2	1.5200
kin36_3	1.5200
kin60_1	0
kin60_3	0

	TriggerSim clustering
run period	threshold (GeV)
kin36_1	1.1
oldkin36_2	1.1
kin48_1	0.5
kin48_2	0.9
kin48_3	1.1
kin48_4 (run 13100 to 13162)	1.1
kin48_4 (run 13279 to 13418)	1.5
kin36_2	1.6
kin36_3	1.6
kin60_1	0.8
kin60_3	1.0

Clustering threshold



Hardware threshold

Cross Section Extracted – Kin60s

Kin-601



 GK model prediction given in ELOG: https://hallaweb.jlab.org/dvcslog/12+GeV/621



 $\frac{d\sigma_T}{dt} + \epsilon_L \frac{d\sigma_L}{dt}$

Kin-603

 Fair agreement with results of Bishnu, except the edge bins.

Cross Section Extracted – Kin60s $\frac{d\sigma_{TL}}{dt}$

Kin-603

Kin-601



 GK model prediction given in ELOG: https://hallaweb.jlab.org/dvcslog/12+GeV/621



Bishnu got smaller values than the ones I got.

Cross Section Extracted – Kin60s $\frac{d\sigma_{TT}}{dt}$

Kin-603

Kin-601



GK model prediction given in ELOG: https://hallaweb.jlab.org/dvcslog/12+GeV/621



 Bishnu got smaller values than the ones I got in Kin-601.

Cross Section Extracted – Kin60s $\frac{d\sigma_{TL'}}{dt}$

Kin-603

Kin-601



 GK model prediction given in ELOG: https://hallaweb.jlab.org/dvcslog/12+GeV/621



The sign of the cross section is opposite in Kin-603.