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# Study of the acceptance cut effect on the cross section for E01-012

P. Solvignon
Temple University, Philadelphia, PA 19122

E-mail
solvigno@jlab.org

## Abstract

The study of the acceptance cuts in the cross section analysis is presented in this document. The goal of this study is to find an optimized cut on acceptance where data and simulation will agree fairly well. Also the uncertainty on the cross sections due to acceptance effects is estimated.

# 1 Introduction

The differential unpolarized cross section is defined by:

$$\frac{d\sigma}{dE'd\Omega} = \frac{N_{det.}}{N_{inc.} \cdot \rho_{tg} \cdot LT \cdot \epsilon_{det}} \frac{1}{Acc} \tag{1}$$

where $N_{det.}$ is the number of good electrons selected by specific cuts, $N_{inc.}$ is the number of incident electron, $\rho_{tg}$ is the target density, $LT$ and $\epsilon_{det}$ are corrections for the data acquisition deadtime and for the detector efficiencies respectively, and $Acc$ is the correction for the acceptance.

$$Acc = \frac{\Delta\Omega \cdot \Delta P \cdot \Delta L_{tg} \cdot N_a}{N_t} \tag{2}$$

The acceptance was simulated using a Monte-Carlo code [1]. The illuminated range for the simulation was chosen as follows:

- $\Delta\Omega = \Delta\theta \cdot \Delta\phi$ with $\Delta\theta = 150$mrad and $\Delta\phi = 90$mrad.
- $\Delta P = 12\%$
- $\Delta L_{tg} = 40$cm
- $N_t = 1,000,000$ trial events

$N_a$ represents the number of events accepted within the acceptance determined by the Hall A transport functions generated by J.J. LeRose. Finally a weight for the Mott cross section was added to the simulation.

Both simulation and data are generated within the same acceptance cuts and the histograms are binned in function of W:

$$W = \sqrt{M^2 + 2M[E - P_o(1+dp)] - 4EP_o(1+dp)\sin^2(\frac{\theta_{real}}{2})} \tag{3}$$

where

$$\theta_{real} = \frac{\cos\theta_o \pm \phi_{tg}\sin\theta_o}{\sqrt{\theta_{tg}^2 + \phi_{tg}^2 + 1}}, \qquad (+ : right\ arm; - : left\ arm) \tag{4}$$

# 2 Acceptance cut study

## 2.1 Cut variation

(See ref. [2, 3]).

First, two-dimensional cuts are applied on $\phi_{tg}$ and $y_{tg}$ to remove edge effects:

- for the left arm:
  - $\mid y_{tg} + 2.8\phi_{tg} \mid < 0.06$
  - $\mid y_{tg} - 2.5\phi_{tg} \mid < 0.06$
- for the right arm:
  - $\mid y_{tg} + 2.8\phi_{tg} \mid < 0.07$
  - $\mid y_{tg} - 2.5\phi_{tg} \mid < 0.07$

These cuts are illustrated on Fig. 1.

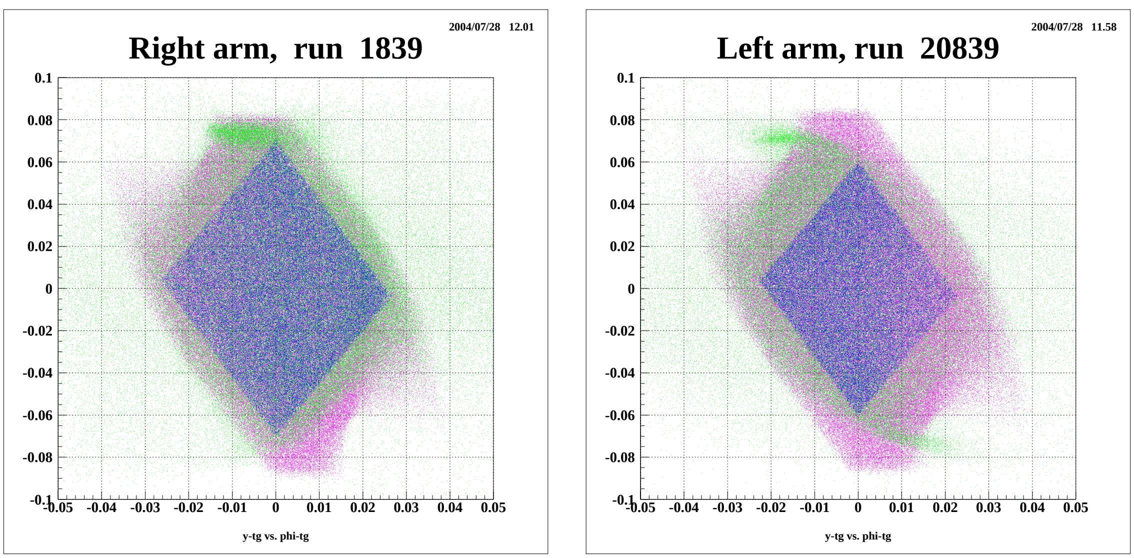



Figure 1: Two dimensional cuts on $y_{tg}$ vs. $\phi_{tg}$ for right and left arms. In magenta the simulation with no cut applied, in green the data with no cut applied and in blue the data within the cuts defined above.

Then different sets of cuts (table 1) are applied and the reconstructed quantities ($y_{tg}$, $\phi_{tg}$, $\theta_{tg}$, $dp$) from the data and the simulation are compared. It was found that the best agreement arises for cut# 3 (see Fig. 2 and Fig. 3).

Table 1: Description of the 5 different cuts used in this study for each arm.

| arm | cut # | $y_{tg}$ (cm) | $\phi_{tg}$ (mrad) | $\theta_{tg}$ (mrad) | $dp$ (%) |
|---|---|---|---|---|---|
| left | 1 | ± 3.0 | ± 10 | ± 30 | ± 3.5 |
| | 2 | ± 3.0 | ± 10 | ± 40 | ± 3.5 |
| | 3 | ± 3.0 | ± 15 | ± 40 | ± 3.5 |
| | 4 | ± 4.0 | ± 15 | ± 40 | ± 3.5 |
| | 5 | ± 3.0 | ± 15 | ± 30 | ± 3.5 |
| right | 1 | ± 4.0 | ± 10 | ± 30 | ± 3.5 |
| | 2 | ± 4.0 | ± 10 | ± 40 | ± 3.5 |
| | 3 | ± 4.0 | ± 15 | ± 40 | ± 3.5 |
| | 4 | ± 3.0 | ± 15 | ± 40 | ± 3.5 |
| | 5 | ± 4.0 | ± 15 | ± 30 | ± 3.5 |

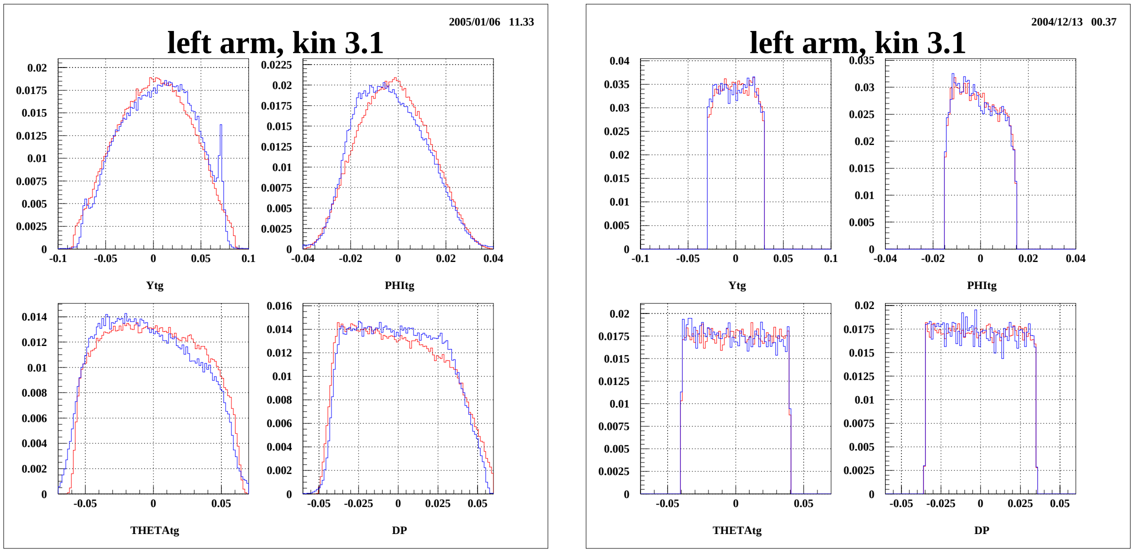



Figure 2: Comparison of the data (blue) to simulation (red) before cuts on the left and for acceptance cut# 3 on the right.

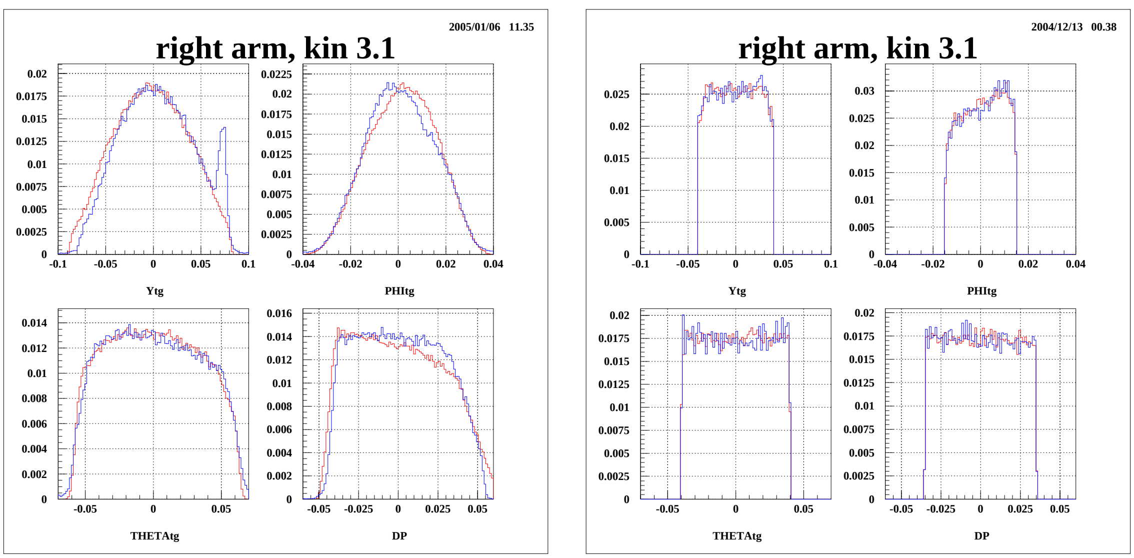


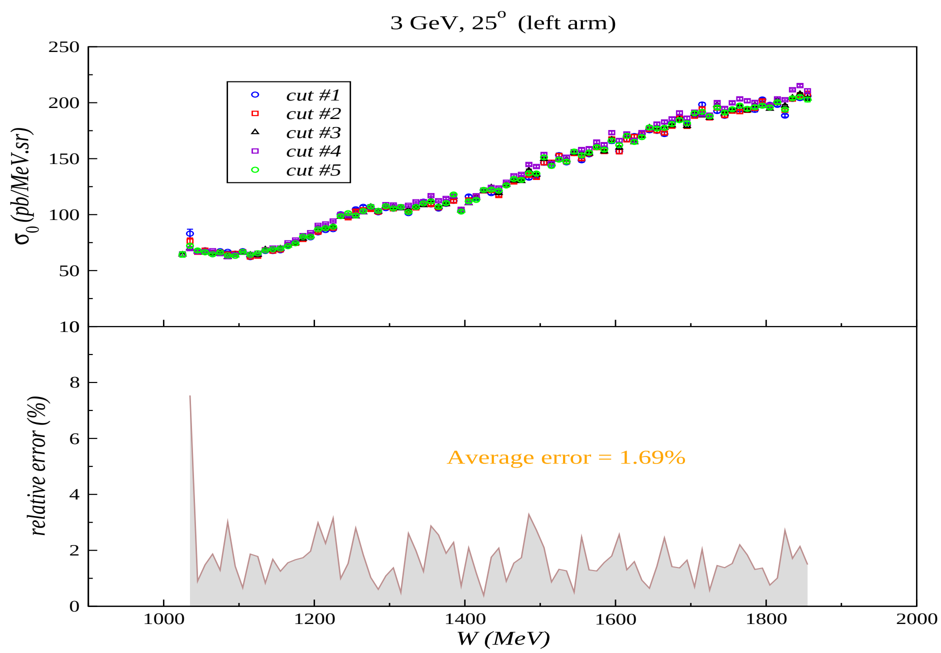

Figure 3: Comparison of the data (blue) to simulation (red) before cuts on the left and for acceptance cut# 3 on the right.

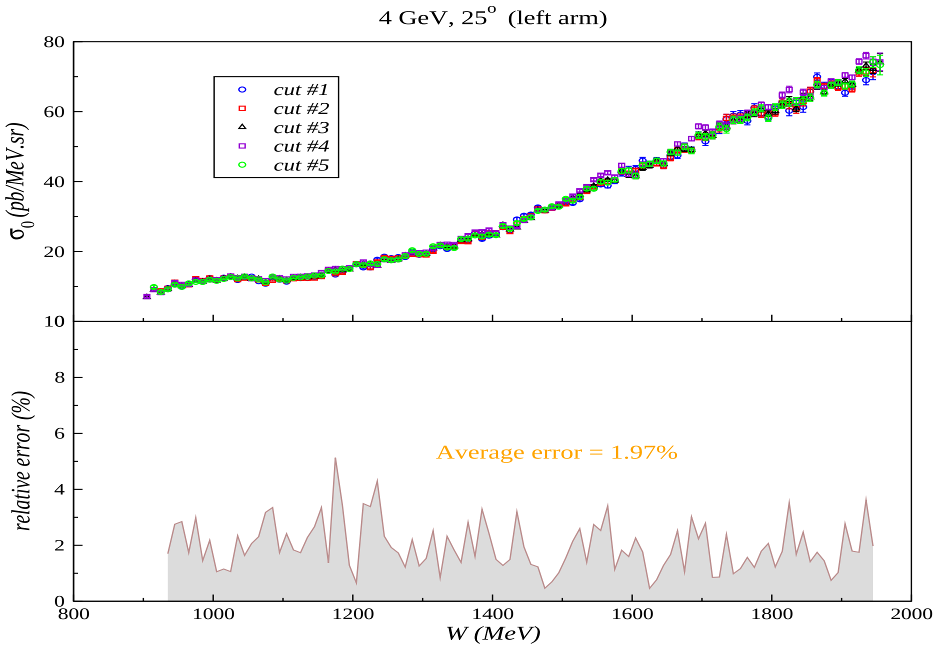
## 2.2 Estimate of the uncertainties

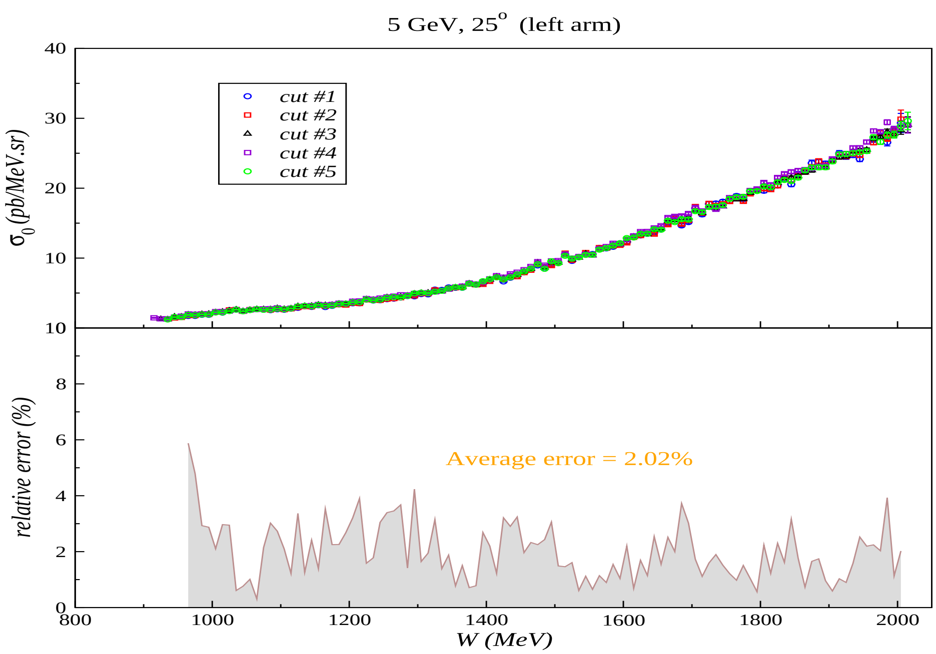
To evaluate the uncertainties on the cross sections due to acceptance cuts, the standard deviation of the cross section from cut #3 for the four other cuts was calculated and then divided by the cut #3 cross section in order to get the relative uncertainty. The seven next figures show the cross sections for the five acceptance cuts at each energy and for each arm. The bottom plot of each figure represents the relative uncertainty of each bin. The average uncertainty was evaluated and was found lower than 3% for the entire experiment (table 2).

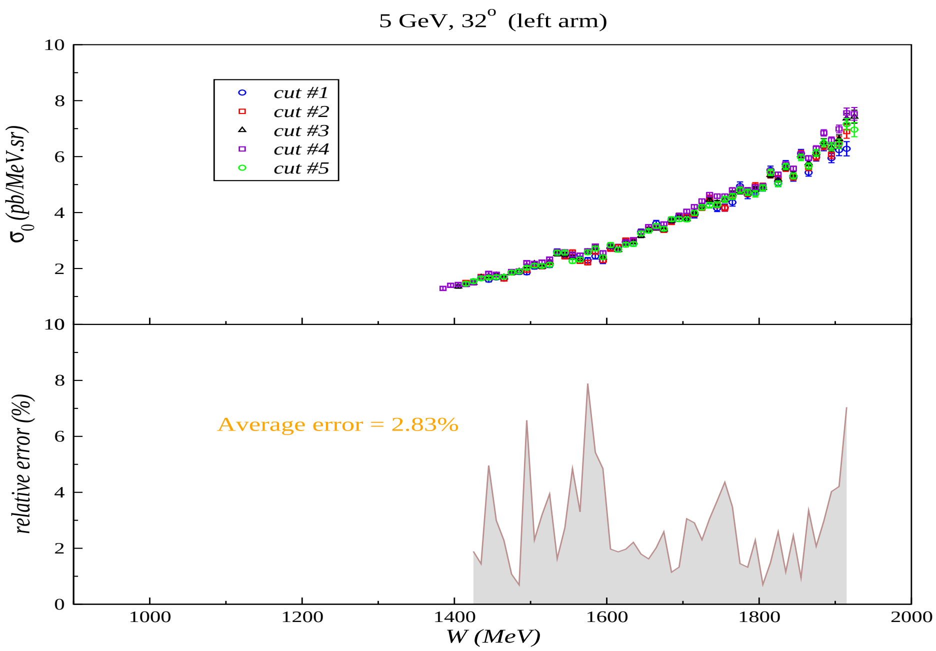
Table 2: Average relative uncertainties.

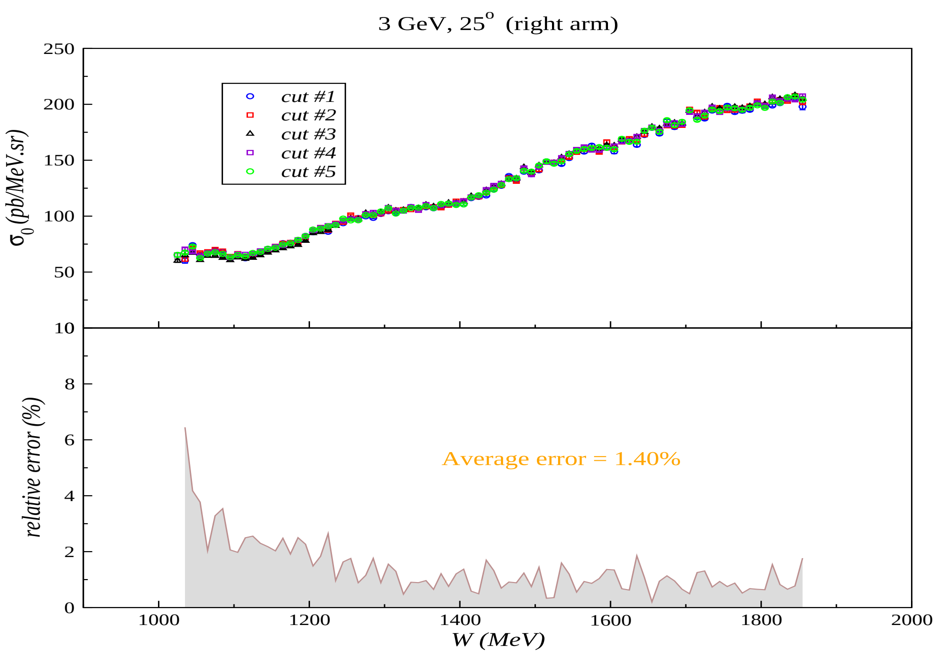
| E (GeV) | $\theta_0$ | Left arm | Right arm |
|---|---|---|---|
| 3 | 25° | 1.69% | 1.40% |
| 4 | 25° | 1.97% | 1.50% |
| 5 | 25° | 2.02% | N/A |
| 5 | 32° | 2.83% | 2.96% |

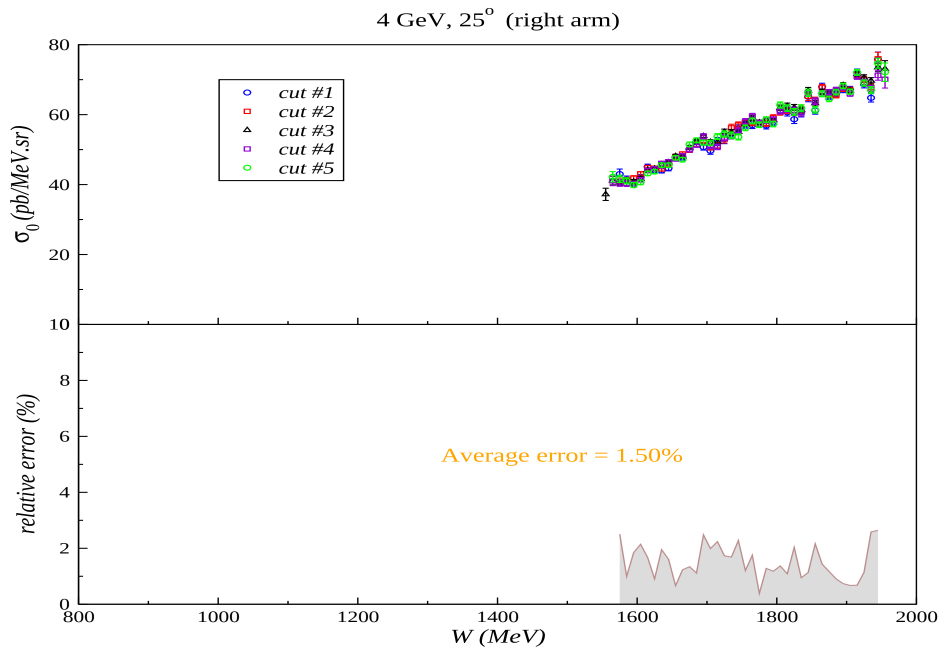


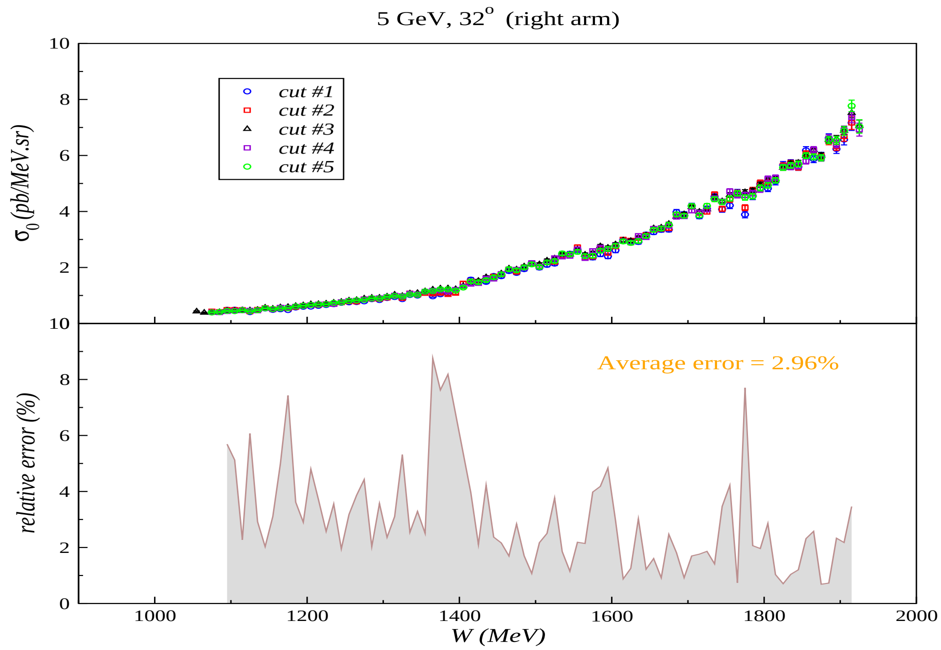

4 GeV, 25° (left arm)
cut #1
cut #2
cut #3
cut #4
cut #5
σ0 (pb/MeV.sr)
relative error (%)
Average error = 1.97%
W (MeV)


5 GeV, 25° (left arm)
cut #1
cut #2
cut #3
cut #4
cut #5
σ0 (pb/MeV.sr)
relative error (%)
Average error = 2.02%
W (MeV)


5 GeV, 32° (left arm)
cut #1
cut #2
cut #3
cut #4
cut #5
$\sigma_0$ (pb/MeV.sr)
relative error (%)
Average error = 2.83%
W (MeV)


3 GeV, 25° (right arm)
cut #1
cut #2
cut #3
cut #4
cut #5
$\sigma_0$ (pb/MeV.sr)
relative error (%)
Average error = 1.40%
W (MeV)


4 GeV, 25° (right arm)
cut #1
cut #2
cut #3
cut #4
cut #5
σ0 (pb/MeV.sr)
relative error (%)
Average error = 1.50%
W (MeV)


5 GeV, 32° (right arm)
cut #1
cut #2
cut #3
cut #4
cut #5
σ0 (pb/MeV.sr)
relative error (%)
Average error = 2.96%
W (MeV)

## Conclusion

From this study we have found an optimized acceptance cut where the simulation reproduces fairly well the data. The left HRS shows a smaller acceptance translating in the need of a tighter cut on $y_{tg}$ than for the right HRS. The variation of acceptance cuts allows us to evaluate the uncertainty for acceptance effect on the cross section: it was found to be lower than 3% for all the data.

## References


[1] A. Deur, "*Acceptance Simulations Studies for the Hall A High Resolution Spectrometers*", E94010 Technical Note 36 (2000).

[2] K. Slifer, "*Dependence of the Cross Section on Acceptance Cuts for E94010*", E94010 Technical Note 37 (2001).

[3] N. Liyanage, "*Study of systematic uncertainties for cross section measured in E94-010*", (2001) http://www.jlab.org/∼nilanga/physics/94010/cross_section.ps