

# e1-6 Proton Fiducial Cuts

M. Ungaro, K. Joo

August 16, 2023

## Abstract

This document describes the identification and removal of CLAS regions of low/zero efficiency and of border effects not reproducible by GSIM.

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# 1 Fiducial Cuts

## 1.1 Introduction

Similarly to the electron case, a fiducial cut on protons is introduced to constrain regions of phase space where the CLAS response peaks at its maximum and remains rather smooth. Detector inefficiencies not perfectly reproduced with GSIM are removed with dedicated cuts.

The fiducial regions were traditionally defined in the lab coordinates of the proton reconstructed  $\phi, \theta, p$ . As for the electrons, it is more natural to define the fiducial regions in the detector coordinates, because the inefficiencies are caused by tracks near their borders or hardware problems. Since the original approach has been used in several published CLAS papers, we will include it in this note as a reference.

## 1.2 Traditional cuts on the proton lab coordinates $\phi, \theta, p$

The fiducial cut in the lab coordinates has been determined during the  $\pi^0$  analysis in the  $\Delta(1232)$  region [1]. For each momentum and theta bin the  $\phi$  distributions were fitted with the trapezoid function shown in appendix .1. The resulting parameters were fitted as a function of the  $\theta$  with a fourth order polynomial. Fig. 1 shows the calculated  $\phi_{MIN}$  and  $\phi_{MAX}$  and the resulting fit for sector 5 and momentum range 0.9 to 1.6 GeV.

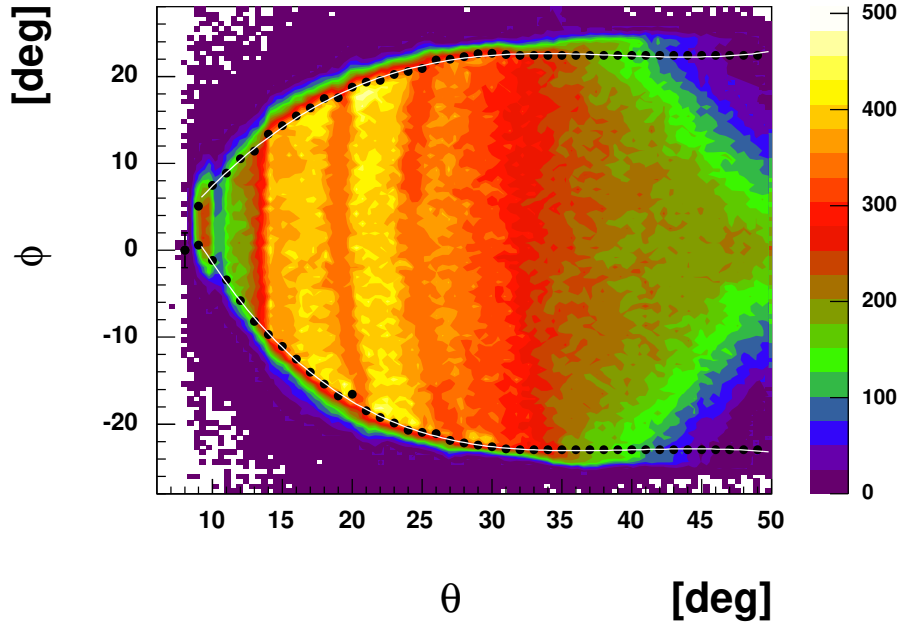


Figure 1: Result of the trapezoid fit for sector 5. The proton momentum ranges from 0.9 to 1.6 GeV. The black points are the parameters  $p_1$  (negative  $\phi$ ) and  $p_2$  (positive  $\phi$ ) for each  $\theta$  slice fit. The white line is a fourth order polynomial fit to the black points. Unlike the electron case, the  $\phi$  boundaries are asymmetric

### 1.3 $\theta$ versus momentum cuts

Sector 2, 3, 5 and 6 present holes and depletions which were taken care of with the cuts shown on Fig. 2 where  $\theta$  is plotted against the momentum  $p$ .

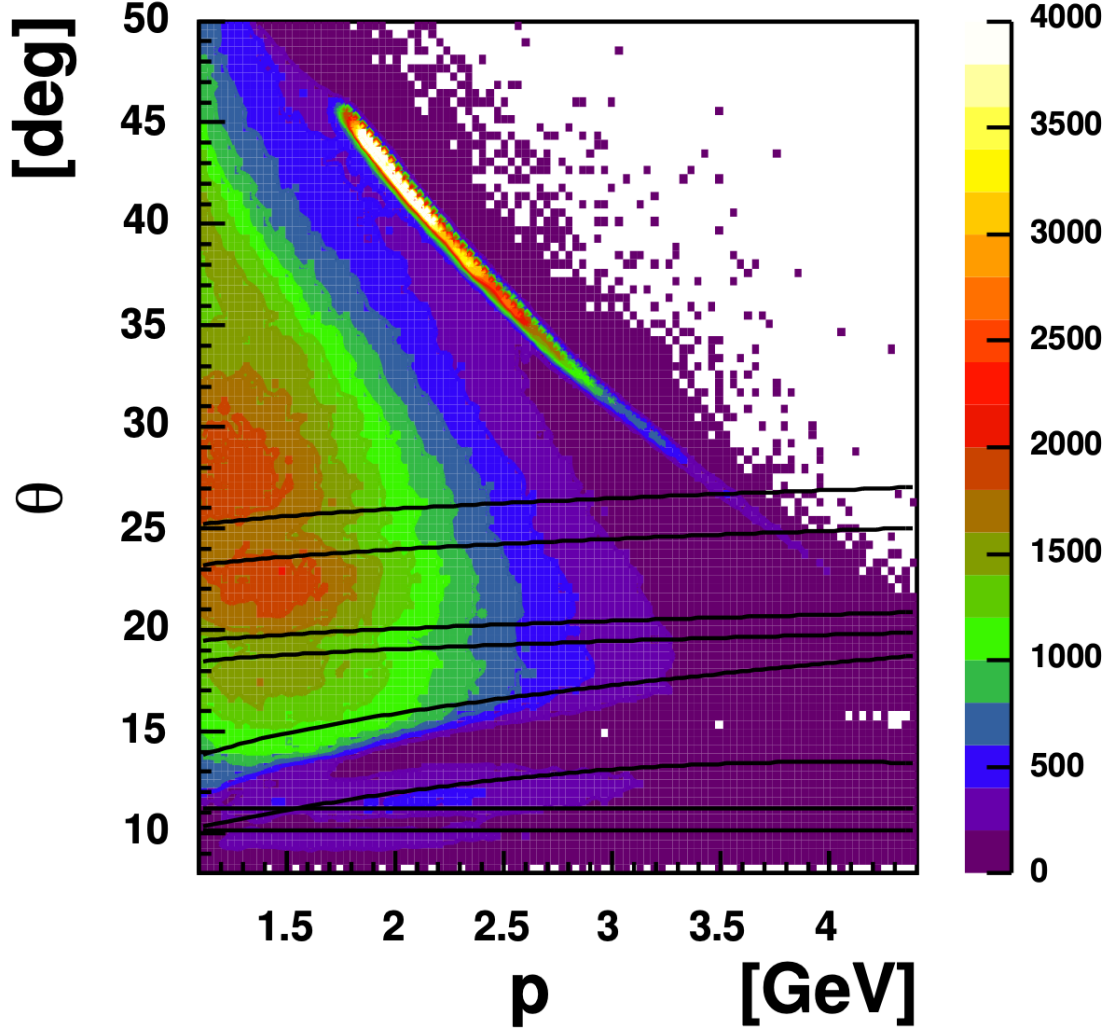


Figure 2:  $\theta$  versus  $p$  for protons sector 5. A depletion is clearly visible and cut out.

### 1.4 Cuts on detectors coordinates

The X vs Y distributions of the proton tracks in the DCs and the SC planes in sector 1 are shown in Fig. 3. This section describes the algorithm used to select thigh occupancy regions edges.

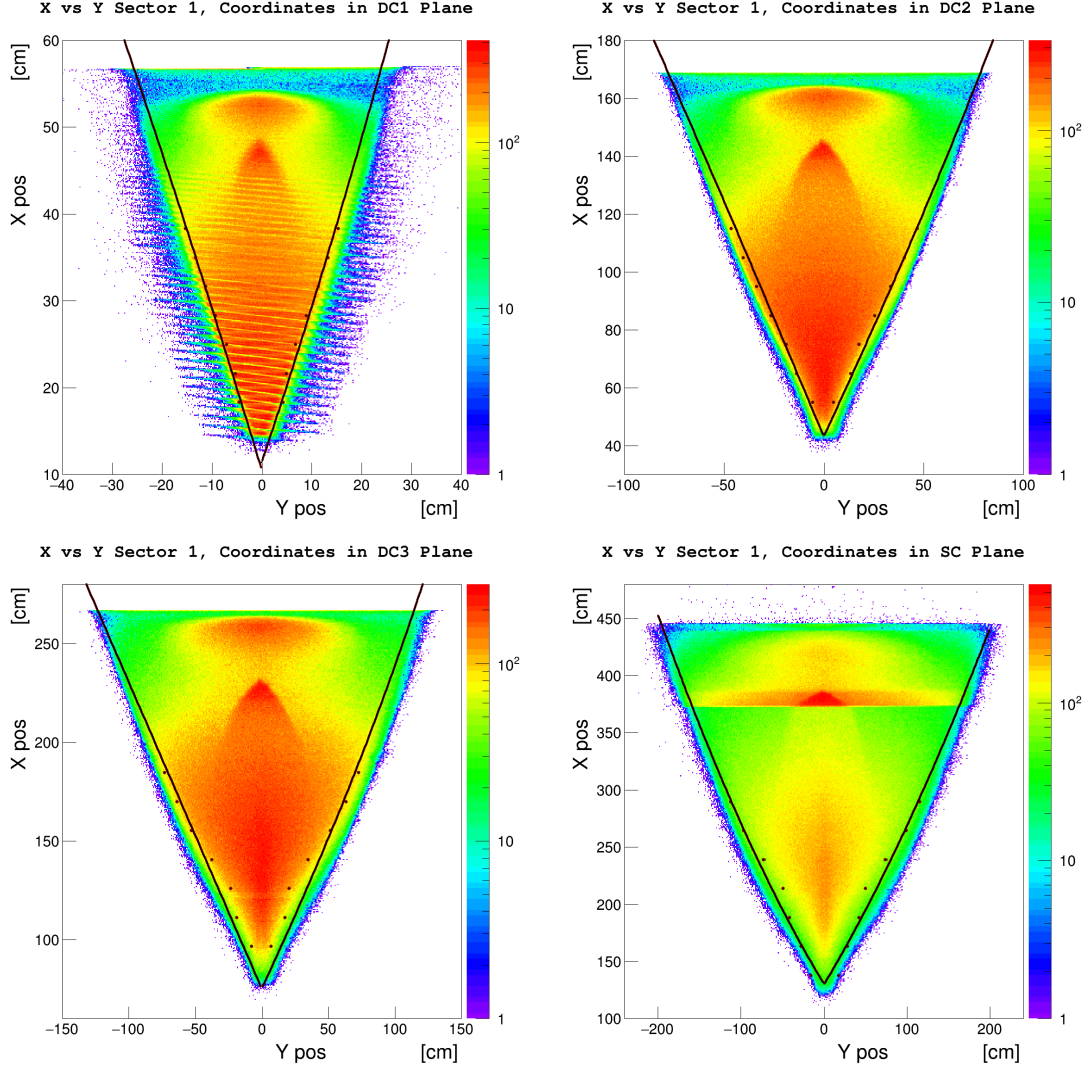


Figure 3: The X vs Y distribution of the tracks in the drift chambers and the time of flight detector plane (SC) for sector 1. The edges selection algorithm described in the text resulted in the black lines, which are the fit of the Y distributions for each X bin.

In each sector and each plane, 12 bins in X are defined; in each bin, the Y distribution is fitted with a “tent” function  $t(y)$  (defined in appendix .1 ) to select the high efficiency edges. An example of such fit is show in Fig. 4 for sector 1 in the DC3 plane, for 4 bins in X. The fit clearly identifies the steep rises and falls of the distributions and the relatively flat regions in between.

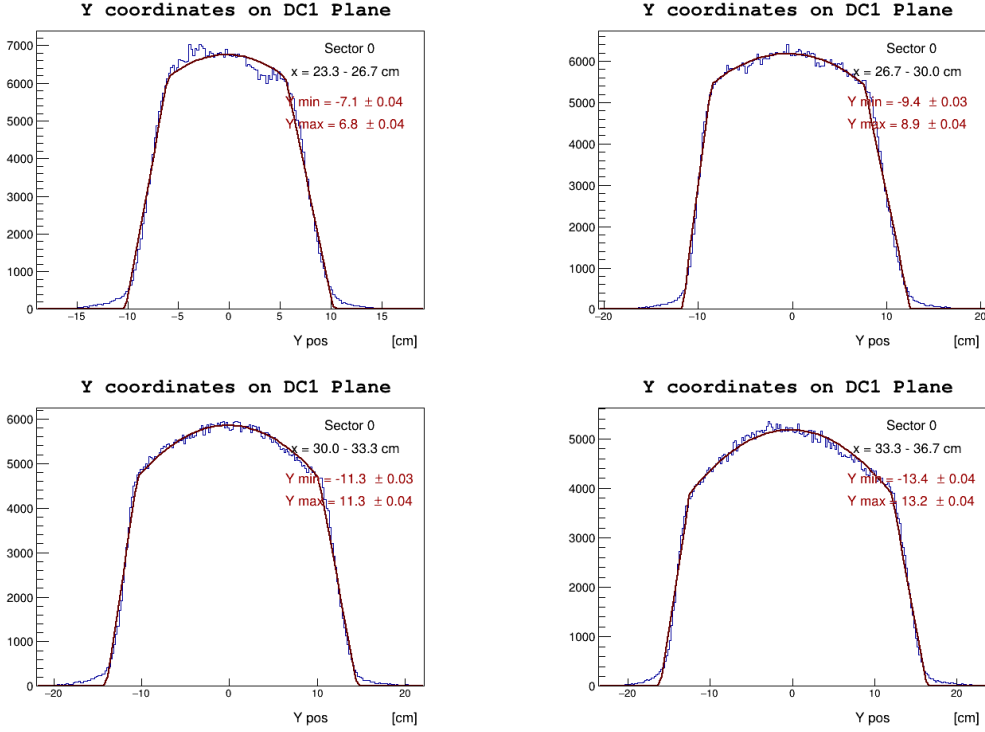


Figure 4: Y distribution for 4 X bins in the DC3 plane for sector 1. The black lines are the tent fit of the Y distributions. The result of the first is the two points of intersection between the straight lines (steep rise) and the parabole fit (flat region). The two points are then plotted in the XY plane and fitted with a parabola, see for example Fig. 3 or Fig. 5.

The results of the tent fit are the two points of intersection between the straight lines (steep rise) and the parabola fit (flat region). The two points are then plotted in the XY plane for all the X bins and fitted with a parabola, see for example Fig. 3 or Fig. 5.

This procedure results in a fiducial cut function for each plane and each sector.

### 1.4.1 Detectors inefficiencies

The detector coordinates plots allow to correlate hardware inefficiencies with depletions in the XY distributions. For example, in the DC planes, where neighboring group of wires are powered by the same HV supply and axial and stereo wires are tilted by  $6^\circ$  with respect to each other, the inefficiencies will appear as:

- Axial wires: horizontal bands in the XY distributions
- Stereo wires:  $6^\circ$  tilted bands in the XY distributions

Two examples of such hardware problems in sector 2 are summarized in Fig. 5. These regions are removed with dedicated cuts represented by straight lines in the XY plane, horizontal for the axial wires and  $6^\circ$  tilted for the stereo wires. Notice: these are the same cuts used for the electrons.

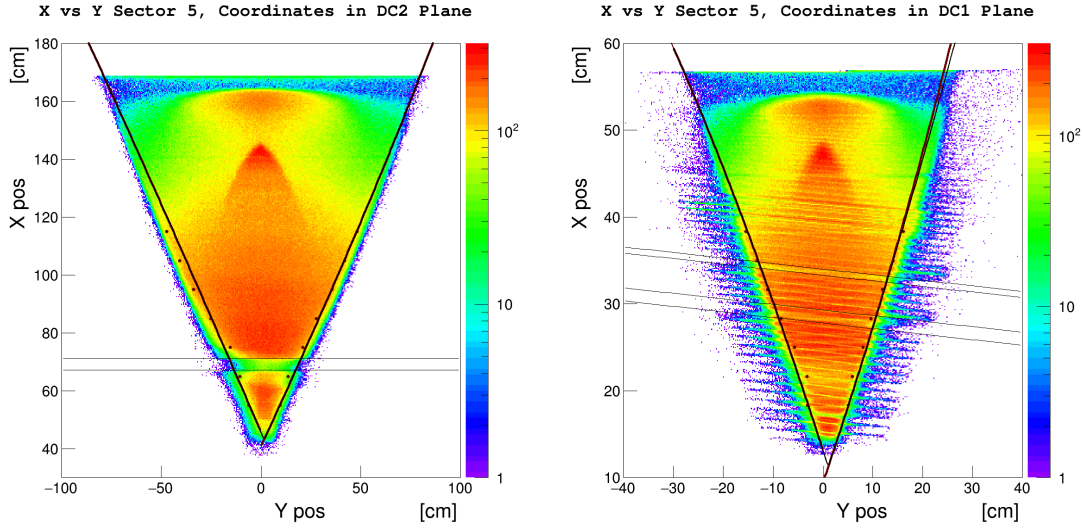


Figure 5: The X vs Y distribution of the proton tracks intersection with the DC2 (left) and DC1 (right) planes in sector 5. The left distributions show one depletion for the stereo wires, while the right distribution shows two depletions for the axial wires.

### 1.4.2 Comparison with the traditional cuts

The effect of the fiducial and inefficiencies cuts is compared with the traditional  $\phi, \theta, p$  cuts. The comparison highlights the advantages of the new approach:

- identify the real edge effects in the detector
- hardware problems are represented by straight lines in the XY plane
- no momentum dependence of the cuts

This comparison is shown as an example for sector 2 and a momentum bin in Fig. 6. The before and after  $\phi$  vs  $\theta$  distributions in sector 2 for all the momentum bin are shown in Fig. 7 and 8 respectively.

The complete set of plots is available at ??.

### Fiducial Cut - Sector 2 - Momentum: $2.4 \pm 0.24$ GeV

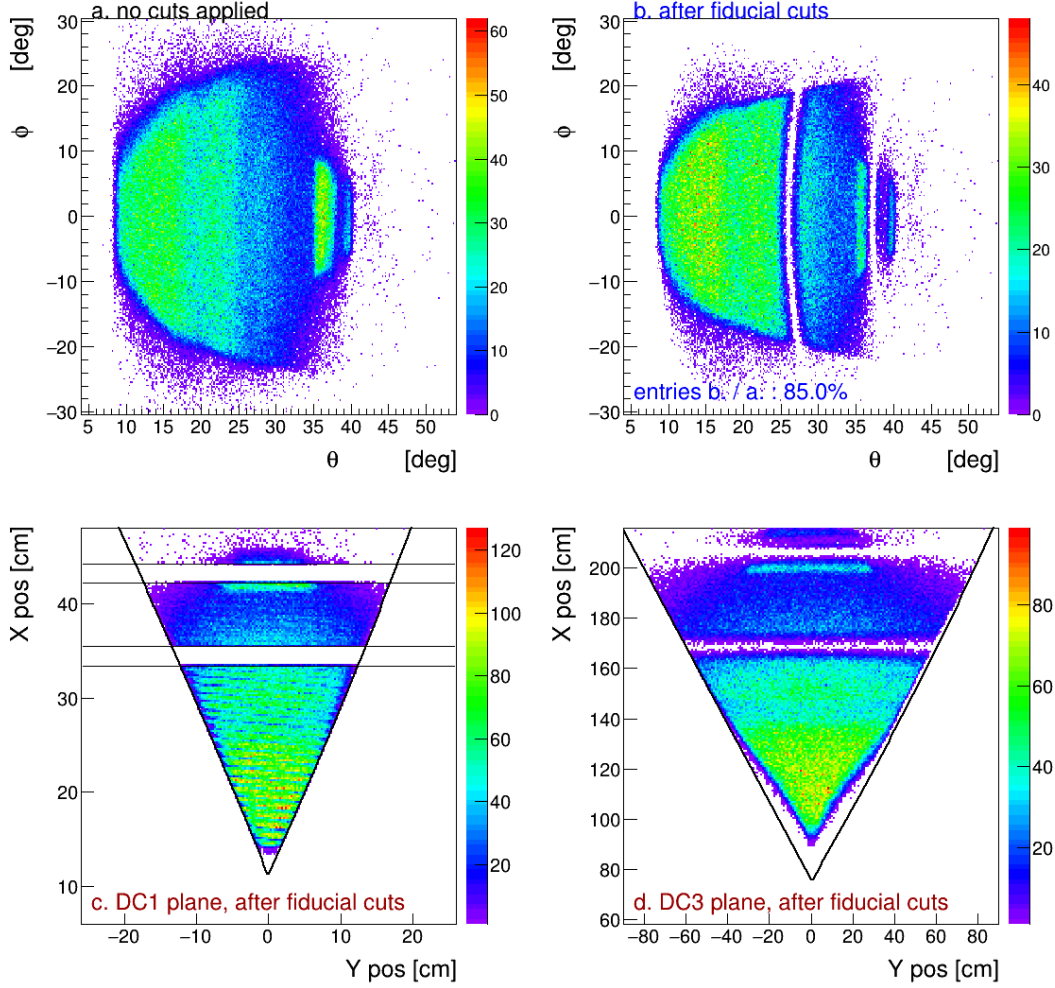


Figure 6: Comparison between the traditional cuts (function of  $\phi, \theta, p$ ) and the new cuts on the XY detector coordinates. Top left:  $\phi$  vs  $\theta$  before any cuts. Top right:  $\phi$  vs  $\theta$  after the XY cuts cuts. The traditional cuts superimposed and shown with black lines. Notice that the traditional cuts would remove events at very small  $\theta$  and large  $\phi$ , due to its functional form. Bottom left: DC1 plane after the fidu XY cuts. Bottom right: DC2 plane after the fidu XY cuts. Notice how the DC1 axial wires depletion is reflected in the DC2 plane. This reflection moves depending on the momentum bin and would be hard to model using the traditional cuts.



### $\phi$ versus $\theta$ in Sector 2 - No Cuts Applied

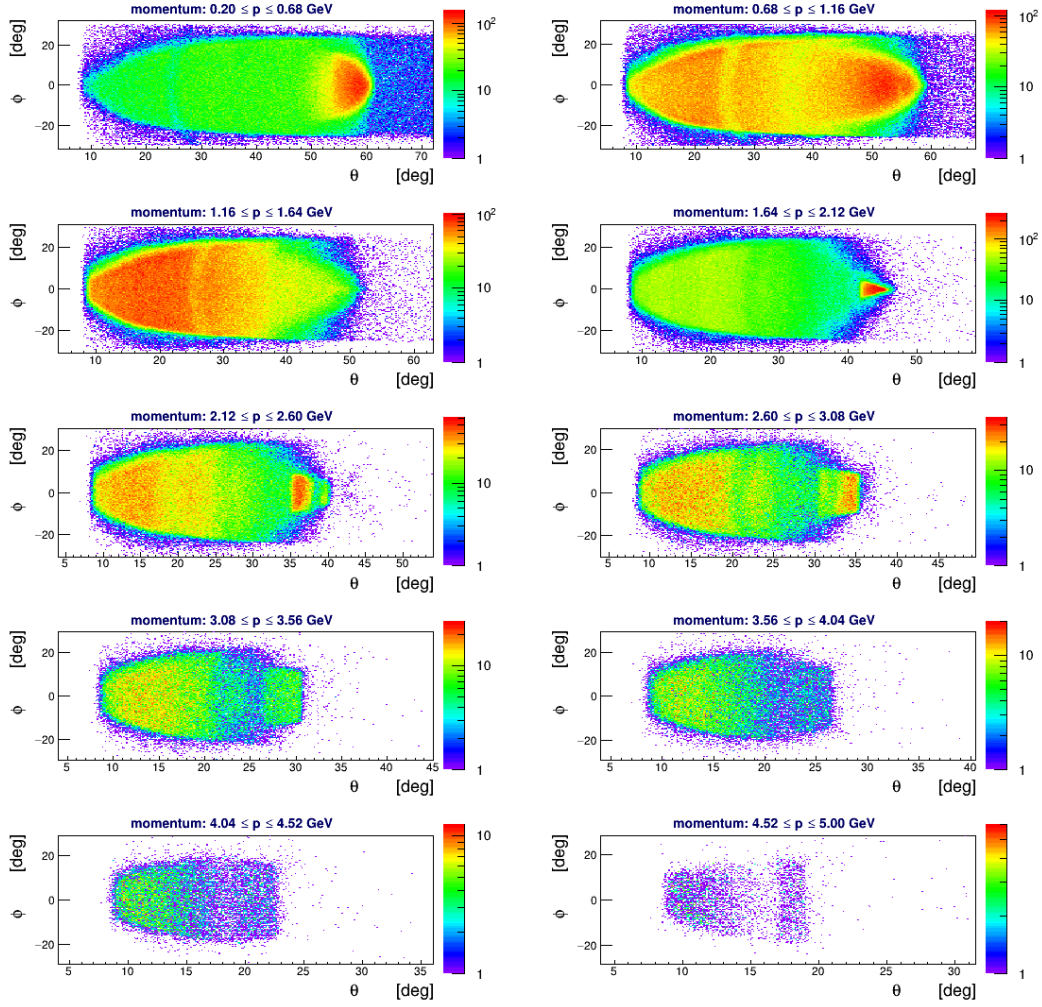


Figure 7:  $\phi$  vs  $\theta$  distributions in sector 5 for all the momentum bin before the XY fiducial cuts.



### $\phi$ versus $\theta$ in Sector 2 - Planes Cuts Applied

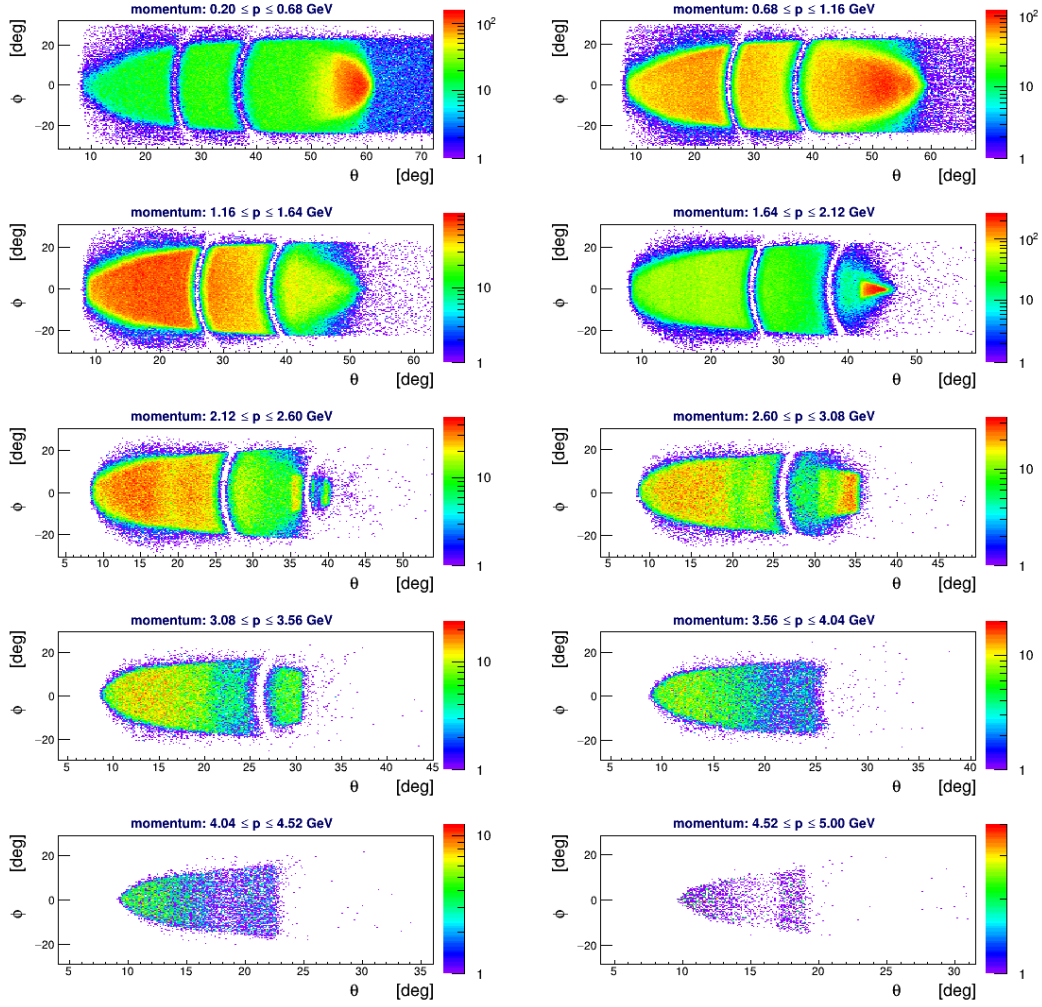


Figure 8:  $\phi$  vs  $\theta$  distributions in sector 5 for all the momentum bin after the XY fiducial cuts.

## References

- [1] M.Ungaro, *Single  $\pi^0$  elctroproduction from  $\Delta(1232)$  at high momentum transferred with CLAS*
- [2] M.Ungaro, *Proton fiducial cut for single  $\pi^0$  elctroproduction in the first and second resonance regions*

M. Ungaro, K. Joo

## .1 Fiducial cut tent function

```

double tent(double *X, double *par) {
    double x = X[0];

    double p0 = par[0];
    double p1 = par[1];
    double p2 = par[2];
    double p3 = par[3];
    double p4 = par[4];
    double a = par[5];

    // parabola parameters
    // y = ax2 + bx + c
    // a = par[5]
    // with two constrains given by the two points at x,y = (p1, p4), (p2, p4):
    double b = -a * (p1 * p1 - p2 * p2) / (p1 - p2);
    double c = p4 - a * p1 * p1 - b * p1;

    if (x < p1 - p0) return 0; // no signal
    if (x >= p1 - p0 && x < p1) return (p4 / p0) * (x - p1 + p0); // steep rise
    if (x >= p1 && x < p2) return a * x * x + b * x + c; // parabola
    if (x >= p2 && x < p2 + p3) return (p4 / p3) * (-x + p2 + p3); // steep descend
    if (x >= p2 + p3) return 0; // no signal

    return 0;
}

```

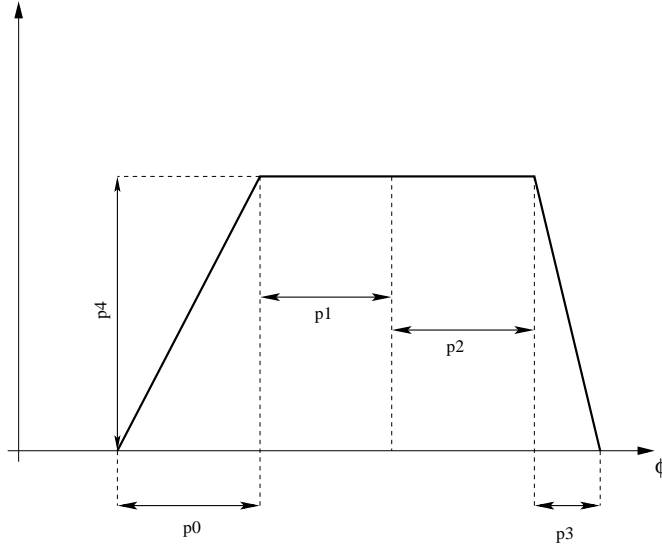


Figure 9: The trapezoid function used for the  $\phi$  fit. The parameters  $p_1$  and  $p_2$  determine the fiducial cut lower and upper limits.

The trapezoid fit gives the parameters  $p_1$  and  $p_2$  described above for each  $\theta$  considered in each momentum bin.