# IDEAL POSITIONS FOR REGION 2 SURVEY HOLES

R.Niyazov L.Qin L.B.Weinstein
*Old Dominion University*
*Department of Physics*

July 22, 1998

**CLAS-NOTE 98-012**

**Abstract**

We determined the actual locations of the Region II Drift Chambers from survey data. We compared this to the "ideal" locations as determined by the engineering drawings. The dominant correction is a 10 mm radially outward shift in the chamber locations. All the other corrections are on the order of 1 mm or less.
In addition, we calculated a correction to the Region II Drift Chamber wire positions due to the fact that the wires rest on the surface of the feedthrough (trumpet), rather than passing through the center of each hole. This correction is 1.007±0.030 mm radially inward.

## 1 SURVEY LOCATIONS

In order to determine the location of the Region II Drift Chambers, the surveyer group surveyed 1 to 2 locations on the inner radius of each drift chamber endplate. The endplates are numbered from 1 to 12 as shown in figure 1. The 5/16" tall survey targets have been put in the holes as1 and as2 on the endplate and then surveyed. The 1U and 12U target point locations were not surveyed. The results are shown in Tables 1 and 2 [1]. The accuracy of the survey measurement of the upstream-downstream targets is approximately 0.25 mm.

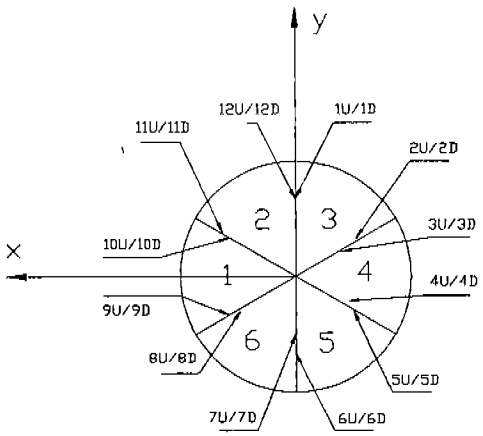


Figure 1: Schematic view of the CLAS looking downstream. The numbers 1-6 refer to the sector number; the numbers $1U/1D$ - $12U/12D$ refer to endplate survey locations.

# 2 DESIGN LOCATIONS

We calculated the design ideal location of these survey targets from 2-dimensional CAD drawings and transformed them to 3D Target Coordinate System (TCS) locations in order to compare to the measured values.

## 2.1 TWO-DIMENSIONAL COORDINATES OF SURVEY HOLES

The following information can be found on drawing [2]. These are ideal coordinates of the survey holes $as1$ and $as2$ in the endplate coordinate system

$$x_1 = 142.705\,\text{mm}$$
$$y_1 = 86.084\,\text{mm}$$
$$x_2 = 2047.602\,\text{mm}$$
$$y_2 = 86.084\,\text{mm}$$

Coordinates of the target position on this drawing are

$$x_0 = 801.428\,\text{mm}$$

$$y_0 = -1413.397\,\text{mm}$$

So the coordinates of $as1$ (upstream hole) and $as2$ (downstream hole) relative to the target position are

$$x_u = -658.723\,\text{mm}$$

$$y_u = 1499.481\,\text{mm}$$

$$x_d = 1246.174\,\text{mm}$$

$$y_d = 1499.481\,\text{mm}$$

The location tolerance of the survey holes is 0.125 mm

## 2.2 THE COORDINATES OF SURVEY TARGETS IN TCS SYSTEM.

### 2.2.1 SECTOR 1 AND 2 COORDINATES

Now we transform the 2D endplate ideal location of the survey fixtures to a 3D TCS location. From figure 2 which shows the relationship between the 2D and 3D coordinate systems we can calculate the coordinates of survey points $9U$ and $10U$ and also $9D$ and $10D$ located in Sector 1. We need to change coordinate systems and account for the 5/16" height of the survey targets. The Sector 1 drift chamber is shown on figure 3.

$$|AB| = 1299.95\,\text{mm}$$

$$|A'B'| = |AB| - 2 \cdot (5/16") \cdot \cos(30^\circ) = 1286.2\,\text{mm}$$

$$x_0' = \frac{y - |A'B'|}{\cos(30^\circ)}$$

where $A$ and $B$ are the location of the survey holes (either both upstream or both downstream).
The distance $|AB|$ is given by drawing [3]
$A'$ and $B'$ are the location of the survey fixtures.
The distance $|AA'|$ is the height of the survey fixture.
$x$,$y$ are the 2D coordinates of the survey holes in the endplate coordinate system.

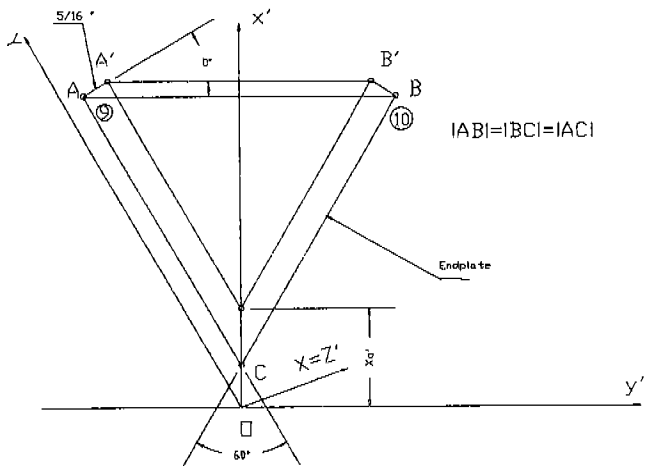


Figure 2: 2D endplate coordinate system to 3D TCS system transformation. The $XY$ axes are in the 2D endplate system ($XY$ axes are different for the two endplates). The $X'$,$Y'$,$Z'$ axes are in the TCS system. $X$ and $Z'$ are directed into the page, increasing in the downstream direction (along the beam). Y is parallel to the endplate.

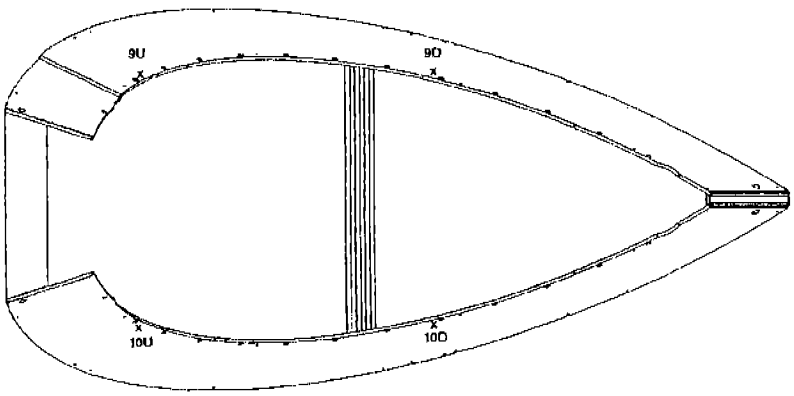


Figure 3: View on the Sector 1 from the Sector 4 drift chamber . 9U,9D,10U,10D - are the survey targets.

A 10 mm radial shift was implemented after the drawings were done to ensure appropriate clearance between the drift chamber and the non-flat magnet cryostat.

Finally we can calculate the ideal coordinates of the survey targets for Sector 1:

$$z' = x$$

$$x' = 10\,\text{mm} + x'_0 + |A'B'| \cdot \cos(30^\circ)$$

$$y' = |A'B'| \cdot \sin(30^\circ)$$

$z'_u = -658.7\,\text{mm}$ for all upstream targets;
$z'_d = 1246.2\,\text{mm}$ for all downstream targets.

The ideal coordinates of survey targets for Sector 2 can be calculated by rotation of the Sector 1 coordinates by 60 degrees around the $Z'$ axis.

### 2.2.2 SECTORS 3,4,5 AND 6 COORDINATES

We can extend the results obtained for sectors 1 and 2 to sectors 3,4,5 and 6 by reflection:

$$x'_{10d} = x'_{9d} = -x'_{3d} = -x'_{4d}$$
$$y'_{10d} = y'_{3d} = -y'_{9d} = -y'_{4d}$$
$$x'_{10u} = x'_{9u} = -x'_{3u} = -x'_{4u}$$
$$y'_{10u} = y'_{3u} = -y'_{9u} = -y'_{4u}$$

$$x'_{11d} = x'_{8d} = -x'_{2d} = -x'_{5d}$$
$$y'_{11d} = y'_{2d} = -y'_{8d} = -y'_{5d}$$
$$x'_{12d} = x'_{7d} = -x'_{1d} = -x'_{6d}$$
$$y'_{12d} = y'_{1d} = -y'_{7d} = -y'_{6d}$$

$$x'_{11d} = x'_{11u} = x'_{8u} = -x'_{2u} = -x'_{5u}$$
$$y'_{11d} = y'_{11u} = -y'_{8u} = y'_{2u} = -y'_{5u}$$
$$x'_{12d} = x'_{12u} = x'_{7u} = -x'_{1u} = -x'_{6u}$$
$$y'_{12d} = y'_{12u} = -y'_{7u} = y'_{1u} = -y'_{6u}$$

## 2.3 ROTATION OF THE SURVEY HOLE COORDINATES

All ideal coordinates have been rotated by 4 mrad around the $Z$ axis using the following transformations

$$\begin{pmatrix} x'' \\ y'' \end{pmatrix} = \begin{pmatrix} \cos(0.004) & -\sin(0.004) \\ \sin(0.004) & \cos(0.004) \end{pmatrix} \cdot \begin{pmatrix} x' \\ y' \end{pmatrix}$$

$$z'' = z'$$

The calculated upstream and downstream positions of survey targets in TCS are given in Tables 1 and 2, respectively. The endplate upstream-downstream (U-D)distances and left-right endplate (L-R) distances are given in Table 3. The U-D distances are between survey targets on a single endplate and are a measure of the surveying accuracy. The RMS variation in these measurements is 0.2 mm, consistent with the claimed accuracy. The L-R distances indicate the variation in chamber shape from the ideal, due to endplate non flatness, errors in chamber assembly, and changes due to chamber transport and installation. This variation is 0.5 mm

## 2.4 THE ROTATIONS AND DISPLACEMENTS OF THE DRIFT CHAMBERS

Now we use the endplate survey target locations to determine the location of the 6 drift chambers. We determine the three rotations and three offsets for each chamber in each of two coordinate systems.

### 2.4.1 THE ROTATIONS AND DISPLACEMENTS RELATIVE TO THE CENTER OF THE DRIFT CHAMBERS

To determine the rotations of the six drift chambers we moved the survey target locations given in TCS system to Sector Coordinate Systems (SCS) by 60·(N-1) degrees rotation around the $Z$ axis (N is the sector number). The sector 1 coordinates still remain in TCS. In SCS we define the origin in the center of the drift chamber . $Z$ is along the beam direction, $X$ is in midplane of the drift chamber . We use the right hand coordinate system. The displacements were calculated as an average value for all surveyed sector targets. The rotations and displacements of the six sectors are shown in figure 4.

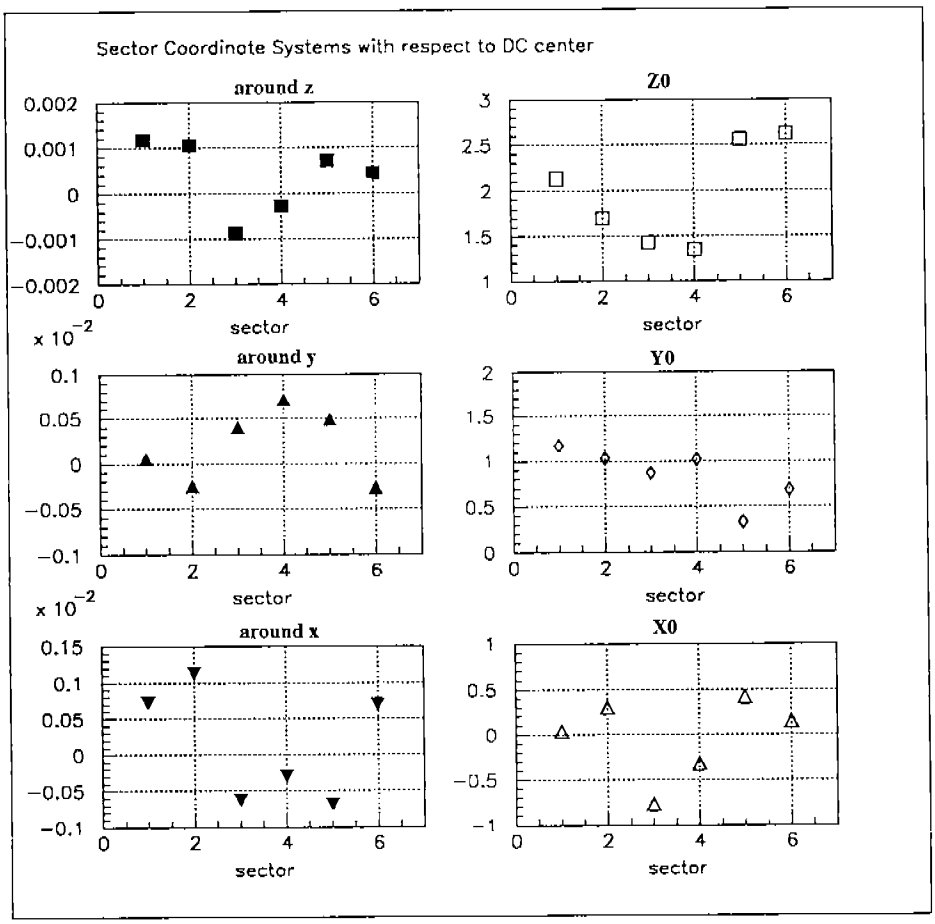


Figure 4: The rotations and displacements of the drift chambers in Sector Coordinate Systems relative to the center of the drift chamber. Rotations are calculated about the center of the 4 survey targets so as not to introduce artificial translations. The uncertainties for $X_0$, $Y_0$ and $Z_0$ are about 0.25 mm.

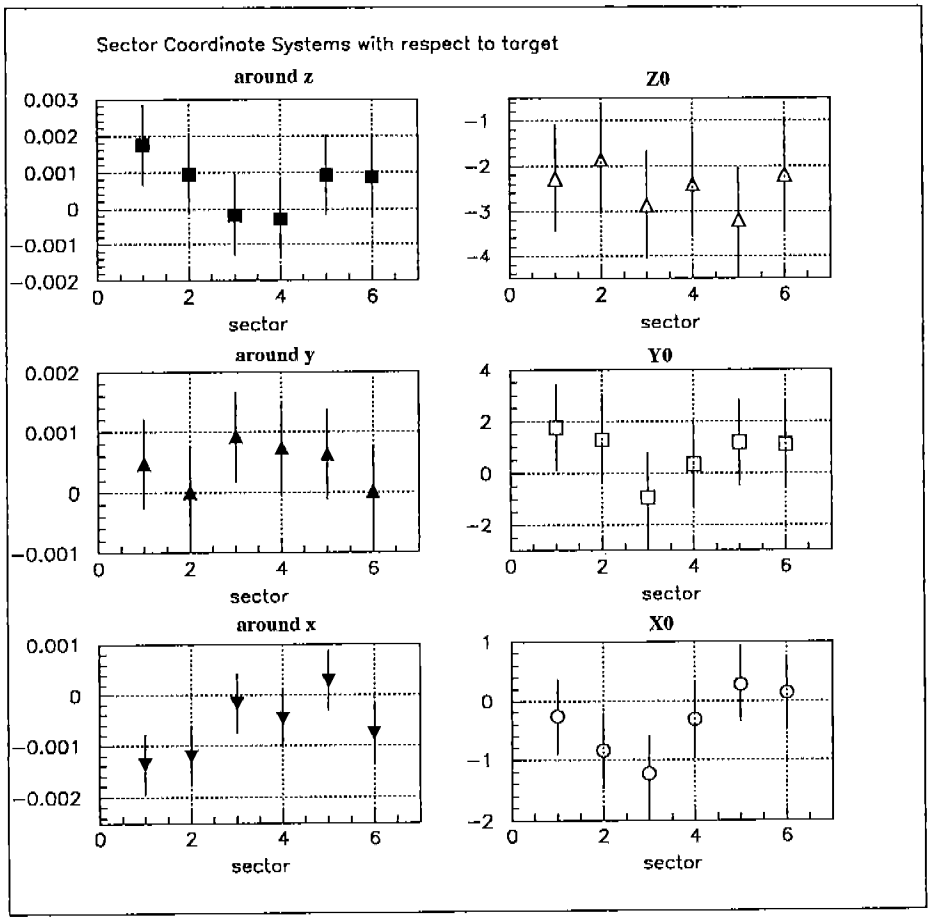


Figure 5: The rotations and displacements of the drift chambers in Sector Coordinate Systems relative to the target position. The calculation of the rotation angles and offsets for the sectors 2 and 3 is based on the three survey target locations, meanwhile for the rest of the sectors it's based on the four survey target locations. The large uncertainties for $X_0$, $Y_0$ and $Z_0$ are due to the angle uncertainties.

### 2.4.2 THE ROTATIONS AND DISPLACEMENTS RELATIVE TO THE NOMINAL TARGET POSITION

We determined the rotations and displacements of the drift chambers relative to the nominal target position. The rotations and displacements were calculated by fitting the three angles and three offsets to get minimal $\chi^2$ (the sum of the differences between survey and ideal SCS coordinates in $X, Y$ and $Z$ directions). We used the program **real_dcgeom.f** written by Alex Skabelin for rotation and translation of the region 3 drift chambers. The fitted values for the sector 2 and 3 are based on only three known target locations that gives us the big deviations and errors for the fitted parameters in these sectors.

# 3 REGION 2 WIRE POSITION CORRECTIONS

We determined the $\Delta$x correction for Region 2 wire positions due to the fact that wires rest on the surface of trumpet. Figure 6 shows the wire hole with trumpet in it. The radius of the arc of the trumpet is 3.00 mm. The inner and the outer diameters of the trumpet, looking from the left side on the figure are 1.854 and 2.870 mm, respectively. The point where the center of the wire hole crosses the endplate surface has been considered the wire location. This correction is $\Delta x = -1.007 \pm 0.030$ mm. There is a slight change to wire length, which is $\Delta \ell = -1.162$ mm. The dimensions for Region 2 feedthrough inserts can be found on drawing [4].

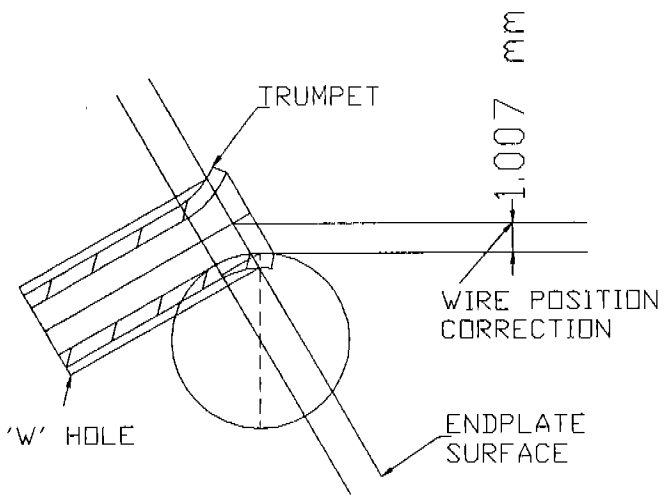


Figure 6: The wire position correction for Region 2 Drift Chambers. The 'W' hole is the wire hole. The trumpet is the metal insert. The circle has the same radius and center as the arc of the trumpet.

## IDEAL and SURVEY HOLE POSITIONS

Table 1: UPSTREAM ENDPLATE TCS COORDINATES

| Target | IDEAL | | | SURVEY | | | DIFFERENCE | | |
|---|---|---|---|---|---|---|---|---|---|
| | $Z(mm)$ | $X(mm)$ | $Y(mm)$ | $Z(mm)$ | $X(mm)$ | $Y(mm)$ | $Z(mm)$ | $X(mm)$ | $Y(mm)$ |
| $1U$ | −658.7 | −134.1 | 1507.6 | – | – | – | – | – | – |
| $2U$ | −658.7 | −1245.5 | 860.0 | −660.8 | −1243.5 | 860.4 | 2.1 | −2.0 | −0.4 |
| $3U$ | −658.7 | −1372.8 | 637.6 | −660.1 | −1373.1 | 636.4 | 1.4 | 0.3 | 1.2 |
| $4U$ | −658.7 | −1367.6 | −648.6 | −660.0 | −1367.6 | −647.8 | 1.3 | 0.0 | −0.8 |
| $5U$ | −658.7 | −1238.5 | −870.0 | −660.6 | −1238.7 | −870.1 | 1.9 | 0.2 | 0.1 |
| $6U$ | −658.7 | −122.1 | −1508.6 | −661.3 | −124.5 | −1508.8 | 2.6 | 2.4 | 0.2 |
| $7U$ | −658.7 | 134.1 | −1507.6 | −660.8 | 134.7 | −1506.9 | 2.1 | −0.6 | −0.7 |
| $8U$ | −658.7 | 1245.5 | −860.0 | −660.8 | 1245.7 | −860.8 | 2.1 | -0.2 | 0.8 |
| $9U$ | −658.7 | 1372.8 | −637.6 | −661.0 | 1371.7 | −637.2 | 2.3 | 1.1 | −0.4 |
| $10U$ | −658.7 | 1367.6 | 648.6 | −659.6 | 1368.8 | 647.6 | 0.9 | −1.2 | 1.0 |
| $11U$ | −658.7 | 1238.5 | 870.0 | −660.7 | 1236.8 | 869.4 | 2.0 | 1.7 | 0.6 |
| $12U$ | −658.7 | 122.1 | 1508.6 | – | – | – | – | – | – |
| *Average* | – | – | – | – | – | – | 1.87 | 0.17 | 0.16 |
| *Sigma* | – | – | – | – | – | – | 0.49 | 1.25 | 0.68 |

Table 2: DOWNSTREAM ENDPLATE TCS COORDINATES

| Target | IDEAL | | | SURVEY | | | DIFFERENCE | | |
|---|---|---|---|---|---|---|---|---|---|
| | $Z(mm)$ | $X(mm)$ | $Y(mm)$ | $Z(mm)$ | $X(mm)$ | $Y(mm)$ | $Z(mm)$ | $X(mm)$ | $Y(mm)$ |
| $1D$ | 1246.2 | −134.1 | 1507.6 | 1245.3 | −133.8 | 1507.3 | 0.9 | −0.3 | 0.3 |
| $2D$ | 1246.2 | −1245.5 | 860.0 | 1244.7 | −1243.1 | 858.6 | 1.5 | −2.4 | 1.4 |
| $3D$ | 1246.2 | −1372.8 | 637.6 | 1245.2 | −1371.8 | 636.0 | 1.0 | −1.0 | 1.6 |
| $4D$ | 1246.2 | −1367.6 | −648.6 | 1245.0 | −1366.2 | −648.5 | 1.2 | −1.4 | −0.1 |
| $5D$ | 1246.2 | −1238.5 | −870.0 | 1244.5 | −1237.9 | −869.8 | 1.7 | −0.6 | −0.2 |
| $6D$ | 1246.2 | −122.1 | −1508.6 | 1243.5 | −122.1 | −1508.8 | 2.7 | 0.0 | 0.2 |
| $7D$ | 1246.2 | 134.1 | −1507.6 | 1244.3 | 134.0 | −1508.5 | 1.9 | 0.1 | 0.9 |
| $8D$ | 1246.2 | 1245.5 | −860.0 | 1244.4 | 1244.6 | −861.4 | 1.8 | 0.9 | 1.4 |
| $9D$ | 1246.2 | 1372.8 | −637.6 | 1244.3 | 1372.4 | −638.5 | 1.9 | 0.4 | 0.9 |
| $10D$ | 1246.2 | 1367.6 | 648.6 | 1245.4 | 1367.9 | 646.1 | 0.8 | −0.3 | 2.5 |
| $11D$ | 1246.2 | 1238.5 | 870.0 | 1244.4 | 1237.7 | 868.6 | 1.8 | 0.8 | 1.4 |
| $12D$ | 1246.2 | 122.1 | 1508.6 | 1244.9 | 123.7 | 1507.5 | 1.3 | −1.6 | 1.1 |
| *Average* | – | – | – | – | – | – | 1.54 | −0.45 | 0.96 |
| *Sigma* | – | – | – | – | – | – | 0.52 | 0.96 | 0.79 |

Comment: Ideal positions are rotated by 4 mrad around z-axis

Table 3: UPSTREAM-DOWNSTREAM AND LEFT-RIGHT DISTANCES

| **Target** | **U-D** | | | **Target** | **L-R** | | | |
|---|---|---|---|---|---|---|---|---|
| | $Z(mm)$ | $X(mm)$ | $Y(mm)$ | | $\triangle Z(mm)$ | $\triangle X(mm)$ | $\triangle Y(mm)$ | *Separation* |
| **1** | – | – | – | $\mathbf{U_{1-2}}$ | – | – | – | – |
| **2** | −1905.5 | -0.4 | 1.8 | $\mathbf{U_{3-4}}$ | −0.1 | −5.5 | 1284.2 | 1284.2 |
| **3** | −1905.3 | −1.3 | 0.4 | $\mathbf{U_{5-6}}$ | 0.7 | −1114.2 | 638.7 | 1284.3 |
| **4** | −1905.0 | −1.4 | 0.7 | $\mathbf{U_{7-8}}$ | 0.0 | −1111.0 | −646.1 | 1285.2 |
| **5** | −1905.1 | −0.8 | −0.3 | $\mathbf{U_{9-10}}$ | −1.4 | 2.9 | −1284.8 | 1284.8 |
| **6** | −1904.8 | −2.4 | 0.0 | $\mathbf{U_{11-12}}$ | – | – | – | – |
| **7** | −1905.1 | 0.7 | 1.6 | $\mathbf{D_{1-2}}$ | 0.6 | 1109.3 | 648.7 | 1285.1 |
| **8** | −1905.2 | 1.1 | 0.6 | $\mathbf{D_{3-4}}$ | 0.2 | −5.6 | 1284.5 | 1284.5 |
| **9** | −1905.3 | −0.7 | 1.3 | $\mathbf{D_{5-6}}$ | 1.0 | −1115.8 | 639.0 | 1285.8 |
| **10** | −1905.0 | 0.9 | 1.5 | $\mathbf{D_{7-8}}$ | −0.1 | −1110.6 | −647.1 | 1285.4 |
| **11** | −1905.1 | −0.9 | 0.8 | $\mathbf{D_{9-10}}$ | −1.1 | 4.5 | −1284.6 | 1284.6 |
| **12** | – | – | – | $\mathbf{D_{11-12}}$ | −0.5 | 1114.0 | −638.9 | 1284.2 |
| *Average* | −1905.1 | -0.5 | 0.8 | | – | – | – | 1284.8 |
| *Sigma* | 0.2 | 1.1 | 0.7 | | – | – | – | 0.5 |

# References


[1] CLAS Region II Endplate Coordinates , Kelly Tremblay. Memo #301. 03.04.97

[2] CLAS Region II Drift Chamber Left Hand Endplate, dwg.# 66210-E-01149, G.Doolittle, 02.01.94

[3] CLAS Region II Drift Chamber Ideal Location, dwg.# 66210-E-01156, G.Doolittle, 09.20.97

[4] CLAS Region II Drift Chamber Feedthtough Insert, dwg.# 66230-B-01084, S.Christo, 09.20.97