The Jefferson Lab survey group performed measurements of the Region One Drift Chamber location inside the CLAS spectrometer on October 3, 1997, prior to the December 1997 el run. The raw numbers provided by this group are analyzed in this report to provide positional offsets needed in the drift chamber tracking programs. The raw data are given in Appendix I. The handwritten notes and calculations leading to the results given below are in Appendix II.

The overall accuracy of the survey group numbers seems to be very good. They claim +/- 0.4 mm in Z and +/- 0.15 mm in X and Y. Various cross checks between their results and design numbers unknown to them but known to us indicate that these estimates are on the conservative side.

Region One is supported by two dowel pins at its downstream end which slide into holes in a mating piece attached to the cryostat. At the upstream end the detector has three legs which attach to "landing pads" attached to the cryo-ring at 10, 2, and 6 o'clock. The accuracy of the downstream positioning was determined by how well the mating hole bracket was aligned and attached to the cryostat. Doug Tilles aligned this mating piece with a digital level which had an estimated precision of 1/2 degree. The accuracy of the upstream positioning was determined by how well the cryo-ring was manufactured and aligned to the torus. During installation of Region One it was noted that the cryo-ring was machined to fairly low tolerance, since we could not get the dowel pins in the three legs of Region One to slide simultaneously into their holes. The legs of Region One were made such that the position tolerances of the dowel pins was less than 10 mils, while the mismatches to the cryo-ring were of the order of 1/4". Only one of three dowel pins (the one at 10 o'clock) was inserted, and can be used in the future to ensure excellent reproducibility of the Z chamber position if and when Region One is removed and reinstalled. The upstream end of the detector was not surveyed during the installation process. The upstream positioning was done to eyeball accuracy by equalizing the small (roughly 1/2") gaps between the six sectors and the cryostat. Hence the present survey is the only accurate means of determining the X and Y positioning of the chamber package.

There are 10 fiducial points on the Region One detector package. The upstream end of Region One has four 1/2" tooling balls, mounted at 12, 3, 6, and 9 o'clock on the inner surface and flush with the downstream face of the Boss Ring. Each of the six sectors has a scribed cross on the downstream sector plates which is visible from the upstream end of the detector.

The sighted (X,Y) coordinates for each of the six downstream crosses were fitted to a circle to determine the mean rotation and offset of
the downstream end of the detector. The residuals for all sectors were very small, on the order of tens of microns, and the radius of the fitted circle was in excellent agreement with the design value. Thus we have confidence that the downstream positioning is well understood. We found

\[
\begin{align*}
X \text{ offset} & \quad 0.72 \pm 0.03 \text{ mm} \\
Y \text{ offset} & \quad -0.29 \pm 0.03 \text{ mm} \\
\text{Rotation} & \quad -7.1 \pm 0.8 \text{ millirad} \quad (\text{counterclockwise about } Z)
\end{align*}
\]

where the X and Y offsets refer to the difference between the center of the fitted circle and the CLAS Z-axis which point downstream. Y, points opposite to gravity and X points to beam left to form a right-handed coordinate system. The rotation, about 4/10 of a degree, is consistent with the estimated positioning accuracy of the downstream mounting bracket. (The negative value for the rotation is correct for a counterclockwise rotation, but may differ from the definition of rotation angle in the off-line analysis program.)

The upstream tooling balls were used to determine the offset and rotation of the upstream end of the detector in a manner similar to the downstream measurements. The offsets determined from both the vertical and horizontal pairs of tooling balls agreed within errors. We found

\[
\begin{align*}
X \text{ offset} & \quad +0.58 \pm 0.1 \text{ mm} \\
Y \text{ offset} & \quad -1.88 \pm 0.1 \text{ mm} \\
\text{Rotation} & \quad -1.277 \pm 0.006 \text{ millirad} \quad (\text{c.c.w. about } z)
\end{align*}
\]

The offsets and rotation are again consistent with our estimated positioning accuracy known from the installation period. The offset values basically agree with the memo sent out by Dan Carman on 11-10-97 (see Appendix II), but the number given with the (*) differs in sign. The rotations are given above for the first time.

The measured distance between pairs of tooling balls both horizontally and vertically was consistently 2.2 mm larger than the distance calculated from the Boss ring and tooling ball geometry. We do not understand the reason for this difference, but we do not have complete information about how this part of the survey was done (which part of the tooling ball was targeted, which tooling ball type was actually used, etc). This lack of knowledge was not important in extracting good results below.

Using all the survey points it was possible to estimate the offset of the entire chamber in X, Y, and Z. The design distance in Z from the origin to the downstream scribe marks was 31.000", while the design distance to the upstream tooling balls was 45.265". Using the centerline offsets given above together with these lengths led to the following offset of Region One from the nominal origin. We found

\[
\begin{align*}
\text{X offset} & \quad +0.66 \pm 0.08 \text{ mm} \\
\text{Y offset} & \quad -0.94 \pm 0.08 \text{ mm} \\
\text{Z offset} & \quad -1.40 \pm 0.50 \text{ mm} \\
\text{Rotation about X} & \quad -0.82 \pm 0.05 \text{ mrad} \\
\text{Rotation about Y} & \quad +0.07 \pm 0.05 \text{ mrad} \\
\text{Rotation about Z} & \quad -4.2 \pm 4.1 \text{ mrad}
\end{align*}
\]

***************

\[
\begin{align*}
\text{X offset} & \quad +0.66 \pm 0.08 \text{ mm} \\
\text{Y offset} & \quad -0.94 \pm 0.08 \text{ mm} \\
\text{Z offset} & \quad -1.40 \pm 0.50 \text{ mm} \\
\text{Rotation about X} & \quad -0.82 \pm 0.05 \text{ mrad} \\
\text{Rotation about Y} & \quad +0.07 \pm 0.05 \text{ mrad} \\
\text{Rotation about Z} & \quad -4.2 \pm 4.1 \text{ mrad}
\end{align*}
\]

***************
The rotation about Z is given as the average of the upstream and downstream rotations. Taken on their face, the Z numbers imply a small helical twist to the detector induced by the mounting arrangement, albeit one consistent with our mounting accuracy. The rotations about X and Y are computed from the upstream and downstream centerline offset; alternate values derived using the tooling ball measurements were consistent with these, though with larger estimated uncertainties. The signs of the rotations are defined as positive for clockwise and negative for counterclockwise about their respective axes.

The X and Y offsets given above can be rotated into the sector coordinate system for each sector for the purpose of single-sector tracking. These numbers are as follows (rotation numbers from Rob Feuerbach):

<table>
<thead>
<tr>
<th>Sector</th>
<th>&quot;X&quot; offset</th>
<th>&quot;Y&quot; offset</th>
<th>&quot;X&quot; rot</th>
<th>&quot;Y&quot; rot</th>
<th>&quot;Z&quot; rot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.66 mm</td>
<td>-0.94 mm</td>
<td>-.82 mr</td>
<td>+.07 mr</td>
<td>-4.2 mr</td>
</tr>
<tr>
<td>2</td>
<td>-0.48</td>
<td>-1.04</td>
<td>-.47</td>
<td>-.68</td>
<td>-4.2</td>
</tr>
<tr>
<td>3</td>
<td>-1.14</td>
<td>-0.10</td>
<td>+.35</td>
<td>-.75</td>
<td>-4.2</td>
</tr>
<tr>
<td>4</td>
<td>-0.66</td>
<td>0.94</td>
<td>+.82</td>
<td>-.07</td>
<td>-4.2</td>
</tr>
<tr>
<td>5</td>
<td>0.48</td>
<td>1.04</td>
<td>+.47</td>
<td>+.68</td>
<td>-4.2</td>
</tr>
<tr>
<td>6</td>
<td>1.14</td>
<td>0.10</td>
<td>-.35</td>
<td>+.75</td>
<td>-4.2</td>
</tr>
</tbody>
</table>

The raw survey numbers from Appendix I can also be compared with the nominal design values for those numbers. They are (in millimeters):

<table>
<thead>
<tr>
<th></th>
<th>Z Survey</th>
<th>X Survey</th>
<th>Y Survey</th>
<th>Z Nominal</th>
<th>X Nominal</th>
<th>Y Nominal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downstream Sector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>786.21</td>
<td>80.20</td>
<td>-0.92</td>
<td>787.4</td>
<td>79.375</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>786.33</td>
<td>40.92</td>
<td>68.27</td>
<td>787.4</td>
<td>39.688</td>
<td>68.741</td>
</tr>
<tr>
<td>3</td>
<td>786.07</td>
<td>-38.54</td>
<td>68.70</td>
<td>787.4</td>
<td>-39.688</td>
<td>68.741</td>
</tr>
<tr>
<td>4</td>
<td>786.23</td>
<td>-78.67</td>
<td>0.30</td>
<td>787.4</td>
<td>-79.375</td>
<td>0.000</td>
</tr>
<tr>
<td>5</td>
<td>786.35</td>
<td>-39.50</td>
<td>-68.80</td>
<td>787.4</td>
<td>-39.688</td>
<td>-68.471</td>
</tr>
<tr>
<td>6</td>
<td>786.46</td>
<td>39.92</td>
<td>-69.30</td>
<td>787.4</td>
<td>39.688</td>
<td>-68.471</td>
</tr>
<tr>
<td>Upstream 12o'clock</td>
<td>-1152.11</td>
<td>1.30</td>
<td>576.27</td>
<td>-1149.73</td>
<td>0.00</td>
<td>576.00</td>
</tr>
<tr>
<td>3 o'clock</td>
<td>-1151.69</td>
<td>-510.13</td>
<td>-1.22</td>
<td>-1149.73</td>
<td>-508.48</td>
<td>0.00</td>
</tr>
<tr>
<td>6 o'clock</td>
<td>-1150.69</td>
<td>-0.17</td>
<td>-580.06</td>
<td>-1149.73</td>
<td>0.00</td>
<td>-576.00</td>
</tr>
<tr>
<td>9 o'clock</td>
<td>-1151.08</td>
<td>511.31</td>
<td>-2.53</td>
<td>-1149.73</td>
<td>508.48</td>
<td>0.00</td>
</tr>
</tbody>
</table>

In conclusion, the survey data for Region One are mostly consistent with known features of the detector, and internally consistent with themselves. Numbers given here should be suitable for inclusion in the RECSIS or SDA analysis packages. Each time Region One is removed and re-installed in the future, it must be re-surveyed in order to ensure that the true detector location is known.
APPENDIX I

Raw survey data as transmitted from Kelly Tremblay to Robert Feuerbach:

"The following data reports the location of the Hall B CLAS Region 1 chamber tooling balls and scribe locations relative to the target on October 31st, 1997. The target is defined by Jefferson Lab drawing 66210-E-01738 and our group's original cryostat survey (cira 1995). The data is in millimeters with the origin at the target center. Z axis follows the beam positive towards the dump, X is in the horizontal plane, positive beam left, and Y is positive opposite to gravity. Please note that there is a slight rotation of the entire torus magnet of 4 millirads, clockwise about the Z axis.

<table>
<thead>
<tr>
<th>Target</th>
<th>Z</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam Target</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>DownStream Scribe 1 o'clock</td>
<td>786.07</td>
<td>-38.54</td>
<td>68.70</td>
</tr>
<tr>
<td>DownStream Scribe 3 o'clock</td>
<td>786.23</td>
<td>-78.67</td>
<td>0.30</td>
</tr>
<tr>
<td>DownStream Scribe 5 o'clock</td>
<td>786.35</td>
<td>-39.50</td>
<td>-68.80</td>
</tr>
<tr>
<td>DownStream Scribe 7 o'clock</td>
<td>786.46</td>
<td>39.92</td>
<td>-69.30</td>
</tr>
<tr>
<td>DownStream Scribe 9 o'clock</td>
<td>786.21</td>
<td>80.20</td>
<td>-0.92</td>
</tr>
<tr>
<td>DownStream Scribe 11 o'clock</td>
<td>786.33</td>
<td>40.92</td>
<td>68.27</td>
</tr>
<tr>
<td>UpStream Tooling Ball 12 o'clock</td>
<td>-1152.11</td>
<td>1.30</td>
<td>576.27</td>
</tr>
<tr>
<td>UpStream Tooling Ball 3 o'clock</td>
<td>-1151.69</td>
<td>-510.13</td>
<td>-1.22</td>
</tr>
<tr>
<td>UpStream Tooling Ball 6 o'clock</td>
<td>-1150.69</td>
<td>-0.17</td>
<td>-580.06</td>
</tr>
<tr>
<td>UpStream Tooling Ball 9 o'clock</td>
<td>-1151.08</td>
<td>511.31</td>
<td>-2.53</td>
</tr>
</tbody>
</table>

The positional accuracy of the points is approximately +/- 0.4 mm in Z, and +/- 0.15 mm in X and Y. Please contact me if you have any questions.

Kelly Tremblay"

APPENDIX II

Handwritten notes by R.A. Schumacher with the detailed calculations.
Offset and Rotation of Downstream End of Region I.

Parameters in fit:
- Radius: 79.42 mm
- Angle: +7.1 mrad
- X offset: 0.72 mm
- Y offset: -0.29 mm

(See fitting program "SURVEYFIT.FOR" on aquark.)

The offsets agree with the 11-10-97 memo, and we now see that the front of the detector is rotated c.c.w. by $7.1 \text{ mrad} = 0.41^\circ \pm 0.8 \text{ mrad}$.

$x/y$ uncertainty $\leq \frac{15}{16} = 0.03 \text{ mm}$

single meas. \hspace{1cm} \text{number of measurements}
<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y Values:</td>
<td>-0.920</td>
<td>68.270</td>
<td>68.700</td>
<td>0.300</td>
<td>-68.800</td>
<td>-69.300</td>
</tr>
<tr>
<td>10)</td>
<td>79.424</td>
<td>7.107</td>
<td>0.724</td>
<td>-0.293</td>
<td>0.02378</td>
<td></td>
</tr>
</tbody>
</table>

Residuals: Radius Angle X Y X^2

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>X:</td>
<td>0.055</td>
<td>-0.003</td>
<td>-0.042</td>
<td>0.028</td>
<td>-0.024</td>
<td>-0.026</td>
</tr>
<tr>
<td>Y:</td>
<td>-0.063</td>
<td>0.064</td>
<td>-0.071</td>
<td>0.028</td>
<td>-0.009</td>
<td>0.056</td>
</tr>
</tbody>
</table>

\[ R = \begin{cases} 3.127'' & \text{measured} \\ 3.125'' & \text{nominal} \end{cases} \]

Scribes are 1/8" up on sector plates

3.125" = 79.375 mm
Packed the Region One survey data for the downstream crane.
marks to extract the radius, angle, x offset and y offset.

R. A. Schuhamer, 1-14-98, C.M.U.

implicit real*8 (a-h.o-z)
logical ifirst
real*8 xval(6), yval(6), xfit(6), yfit(6), xres(6), yres(6)
real*8 rad, angl, xoff, yoff

J Lab Survey from October 31, 1997

data xval = 80.20, 40.92, -38.54, -78.62, -39.50, 39.92/
data yval = -0.92, 68.27, 68.76, 0.30, -68.80, -69.30/
data astep/2.0, 2.0, 2.0, 2.0/ initial step sizes in fit

data ifirst/true/

equivalen~ = (xi(3), yj(3), xfit(5), yfit(5), xoff(4), yoff(4))

open(1 Unit=1, nam='surveyfit.txt', status='unknown')
write(1,10)xval,yval
write(6,10)xval,yval
format(1x,7.0f'...'), 1, 1, x, y
1, x, y Vals: , 6f10.3 , 1, x, y Vals: , 6f10.3)

Initial guess
radius = 79.1 nm
angle = 0.0 radians
xoff = 0.0 nm
yoff = 0.0 nm
radius = 79.424 nm
angle = 7.907 radians
xoff = 7.24 nm
yoff = -2.93 nm

sigma = 0.15 nm survey group estimate

data = 3.1415926535/189.
cos60 = .5
cos30 = sqrt(3)/2.
sin60 = cos30
sin30 = .5
Do a simple grid search over the four parameters
iter = 0 ! iteration counter
i = 0
iter = iter + 1
do 500 ipar = 1, 4
chijold = 1000.

Assume the rotation is internal to the chamber, and that
the offsets in X and Y apply to the rotated chamber.

xfit(1) = radius
xfit(2) = radius * cos60
xfit(3) = radius * cos60
xfit(4) = radius
xfit(5) = xfit(3)
xfit(6) = xfit(2)
yfit(1) = 0
yfit(2) = radius * sin60
yfit(3) = yfit(2)
yfit(4) = yfit(1)
yfit(5) = -radius * sin60
yfit(6) = yfit(5)
dc 100 i=1, 6
xtemp = xfit(1)
ytemp = yfit(1)
theta = angle/1000. ! theta is in radians, angle in millirad

ct = cos(theta)
st = sin(theta)
xfit(1) = xtemp + ct * ytemp + st
yfit(1) = ytemp + ct - xtemp - st
yfit(1) = yfit(1) + yoff
yfit(1) = yfit(1) + yoff
continue

ch1 = 0.0
120 do 120 i = 1, 6
xres(i) = xval(i) - xfit(i)
yres(i) = yval(i) - yfit(i)
ch12 + ch12 + (xres(i) * xres(i) + yres(i) * yres(i)) / (sigma*sigma)
continue

ch12 = ch12 / 8.
if (ifirst) then
write(6,510) iter, aa, chi2
ifirst = false.
end if
if (abs(delchi2) < 0.001) goto 500
! step next parameter
if (delchi2 gt 0.0) then
! take another step
astep[ipar] = -astep[ipar]*0.9
end if
end if
write(6,130) ipar, aa, chi2
chi2old = chi2
format(1x,i3, f5.1)
go to 70

500 continue
if (icount.li.10) then
if (icount.li.1) then
goto 50
else
icount = 0
end if
write(6,510) iter, aa, chi2
510 format(1x,i3, ' ', f5.1)
write(6,520) xres, yres
520 format(1x, 'Residuals: ', 1x, ', X: ', f5.1, ', X: ', f5.1, ')
write(6,*) 'Continue (keys, 0=No):'
read(*,*) keya
if(keya eq 1) goto 50
write(6,510) iter, aa, chi2
write(6,130) ipar, aa, ch12
close(1)
write(6,*) 'All done.

call exit
end
Offset of Upstream End of Region I.

Using the tooling ball locations:

\[ \sum \Delta X \Delta Y \]

**Horizontal**
- \(1021.44\) + .590 mm - 1.875

**Vertical**
- \(1156.33\) + .565 - 1.895

\[ + 0.58 \pm 0.1 - 1.88 \pm 0.1 \]

*(Sept '92 drwg.)*

Nominally, the boss ring has 40.838" opening across flats
\[(40.838\times25.4)/2 = 518.643\text{ mm}\]

The tooling balls are .65" = 16.51 mm

To the center of the tooling ball: 518.643 - (425.4) = 508.48 mm

Compare to 1021.44/2 = 510.72 mm for survey

The difference is -2.23 mm.

* sign disagrees with Dan Carman's 11-10-97 memo
Vertically:

Boss ring: \( \frac{1}{2} \times 46,154 \times 25.4 = 14 \times 25.4 = 576.00 \text{mm} \)

(from drawings)

Survey: \( \frac{1}{2} \times (1156.33) = 578.16 \)

Difference: 2.16 mm.

Thus, in both directions the upstream tooling holes measure 2.16 mm from their ideal positions. The size of the two discrepancies is at least consistent.
Rotation of upstream end of chamber:

Testing ball locations:

\[(130, 576, 27)\]

\[(511.31, -2.53)\]

\[(-17, -580.06)\]

Horizontal axis: \[\frac{\Delta y}{\Delta x} = +1.28 \times 10^{-3}\]

\[= 1.28 \text{ mrad c.c.w.}\]  \text{good agreement}

Vertical axis: \[\frac{\Delta y}{\Delta x} = +1.27 \times 10^{-3}\]

\[= 1.27 \text{ mrad c.c.w.}\]

Average: Region I is rotated c.c.w. by \[-1.277 \pm .006 \text{ mrad} = 0.073^\circ\]

at the upstream end.

We note that this is in the opposite sense to the 4 mrad c.c.w. rotation of the torna.

Also, the downstream end of Region I may have a different rotation... (see later)
Region I Offset in Z

Using Kelly Tremblay's 10-31-97 survey:

Mean Z of downstream scribes: 786.275 ± 135
Mean Z of upstream tooling balls: -151.393 ± 163

Surveyed distance from scribes to tooling balls:
(1437.668 ± 645) mm

Design distance from tooling ball center line to sector plate scribe marks, from 2-14-97 notes:
(76.265") x 25.4 mm/in = 1937.118 mm

Thus, the survey value is larger by

0.550 ± 645 mm,

which is consistent, assuming no upstream tilting.

The center of Region I is designed to be
31.00" = 787.4 mm upstream of the scribe marks. Thus, the detector is

787.4 - (786.275 ± 135) = 1.125 ± 135 mm

upstream of its nominal position. Computing for the upstream end we expect:

-(45.265" x 25.4) - (-151.393 ± 6) = 1.662 ± .6

Averaging these two values gives:

ΔZ_{Region1} = -1.4 ± .5 mm.
Position of Region I Geometric Center

UPSTREAM \hspace{1cm} DOWNSTREAM \hspace{1cm} \( z = 0 \)

\[
\begin{array}{c|cc|c}
X & 0.58 \text{ mm} & 0.72 \text{ mm} & 0.66 \pm 0.03 \text{ mm} \\
Y & -1.88 \text{ mm} & -2.9 \text{ mm} & -0.94 \pm 0.08 \\
\end{array}
\]

at \( z = 0 \)

\[
X_0 = X_u + (X_d - X_u) \left( \frac{Z_u}{Z_u + Z_d} \right)
\]

\[
= 0.58 + (0.72 - 0.58) \left( \frac{45}{45 + 31} \right) = 0.66 \text{ mm}
\]

\[
Y_0 = Y_u + (Y_d - Y_u)
\]

\[
= -1.88 + (-2.9 - (-1.88)) = -0.94
\]

Net rotation along \( Z \):

\[
\frac{1}{2} (1.3 + 7.1) = -4.2 \text{ mrad} \pm 4.1 \text{ mrad} \text{ c.c.w.}
\]

implies c.c.w. rotation
Rotations about $X$ and $Y$ axes.

\[
\frac{\Delta X}{\Delta \theta} = \frac{0.72 - 0.58 \text{ mm}}{1937.118 \text{ mm}} = 7.22 \times 10^{-5} \text{ rad} \pm 5.16 \times 10^{-5}
\]

\[
\frac{\Delta Y}{\Delta \theta} = \frac{-0.29 - (-1.08) \text{ mm}}{1937.118 \text{ mm}} = 8.21 \times 10^{-4} \text{ rad} \pm 5.16 \times 10^{-5}
\]

Thus we have

\[
O_x = -0.82 \pm 0.05 \text{ millirad} \quad \text{(c.c.w.)}
\]

\[
O_y = +0.07 \pm 0.05 \text{ millirad} \quad \text{(c.w.)}
\]

\[
\langle O_z \rangle = -4.2 \pm 4.1 \text{ millirad} \quad \text{(C.C.W.)}
\]
Using the Upstream Tooling Balls to Estimate Rotations About X and Y

\[(576.27, -152.11)\]
\[(571.31, -151.08)\]
\[O\]
\[O\]
\[O\]
\[O\]

\[
\phi_x = \frac{\Delta Z}{\Delta Y} = \frac{1.42 \pm 4.15}{1156.33} = (1.23 \pm 0.49) \times 10^{-3}
\]

\[
\phi_y = \frac{\Delta Z}{\Delta X} = \frac{-1.61 \pm 5(4)}{1021.44} = (5.97 \pm 5.54) \times 10^{-4}
\]

\[
\phi = -(0.6 \pm 0.6) \text{ mrad}
\]

These values are consistent with but less precise than the numbers computed on page 9.
Assume software takes the sector coordinates of hits and adds offsets to them prior to doing rotations to the proper sector location. Each sector is put into the sector 1 location prior to rotation.
Quick hack to rotate a coordinate pair to the each of six sector coordinate values.

data xval,yval/0.66,-.94/
data xnot,ynot/79.375,0.0/
dera = 3.14159265/180.
do 100 i=0,360,60
ccos = cos(i*dera)
ssin = sin(i*dera)
x = xval*ccos - yval*ssin
y = xval*ssin + yval*ccos
write(6,*),i,x,y
100 continue
write(6,*),' '
do 200 i=0,360,60
ccos = cos(i*dera)
ssin = sin(i*dera)
x = xnot*ccos - ynot*ssin
y = xnot*ssin + ynot*ccos
write(6,*),i,x,y
200 continue
write(6,*),'All done.'
end

<table>
<thead>
<tr>
<th>i</th>
<th>Sector</th>
<th>Offset in Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>0.0000000E+00</td>
</tr>
<tr>
<td>60</td>
<td>5</td>
<td>68.74077</td>
</tr>
<tr>
<td>120</td>
<td>4</td>
<td>68.74077</td>
</tr>
<tr>
<td>180</td>
<td>3</td>
<td>-6.9391831E-06</td>
</tr>
<tr>
<td>240</td>
<td>2</td>
<td>-68.74077</td>
</tr>
<tr>
<td>300</td>
<td>1</td>
<td>1.3878366E-05</td>
</tr>
<tr>
<td>360</td>
<td>6</td>
<td>1.3878366E-05</td>
</tr>
</tbody>
</table>

All done.
Hi Dan,

Thanks for the report on the Region One survey results. I assume the deviations you quote are relative to the ideal beam line and target center, and not, for example, relative to the torus only. At the upstream end, I'm not surprised we are off by between half and two millimeters, since we never tried to position the upstream end in our installation haste, to better than eyeball precision (as far as I know). At the downstream end, I'd bet our alignment with respect to the torus is much better than the measured deviations of 0.75 (dX) and -1.33 (dY). My guess is that the whole torus is offset by those distances.

John McNabb has seen 'funny' effects in the reconstruction of pairs of tracks projected back to the target. I'm wondering if a millimeter-level displacement of Region One in the Y could account for the effects he sees. Essentially, depending on which pair of sectors he uses to project track pairs he finds systematic offsets on the order of several millimeters at the target. When he uses the ideal chamber geometry, I'm sure he'd be glad to show you what he's got after he gets to JLab today; he will be trying to figure this out in the next week or so.

Regards,
Reinhard

cc Gary, Rob, John

Date: Mon, 10 Nov 1997 12:25:06 -0500 (EST)
From: Daniel S. Carman <CARMAN@CERAF.GOV>
Subject: R1 survey results

Reinhard and Gary,

I thought you might be interested in the results from the recent survey of the Region One detector. This sighting was performed by the TNOAF survey group under the direction of Kelly Tremblay and was completed on October 31, 1997.

The results show differences from ideal in mm in a right-handed coordinate system. In this system, x is along the beam and y is towards beam left. Survey accuracy is estimated to be +/- 0.25 mm for X and Y and 0.5 mm for Z values, with respect to the local monments.

The midpoint indicated below is the calculated midpoint on a line between the 2 stated tooling balls on Region 1. The best fit center of the downstream scribes is the result of a circle fit to the six scribe centers on the sectors. The calculated torus center is based on a transformation using the fiducials on the upstream crystal ring.

<table>
<thead>
<tr>
<th>Location</th>
<th>dx (mm)</th>
<th>dy (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midpt. Upstream 6 o'clock 12 o'clock</td>
<td>0.57</td>
<td>1.83</td>
</tr>
<tr>
<td>and 12 o'clock 7B's</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midpt. Upstream 3 o'clock 9 o'clock</td>
<td>0.59</td>
<td>1.81</td>
</tr>
<tr>
<td>and 9 o'clock 7B's</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Trim pitch 1.33
- 1.33 pitch in x
- 1.33 mm pitch in y
- 1.33 mm pitch in z
- 1.33 mm pitch in Z

If you have any questions on this matter, let me know.

Daniel