Jefferson Lab Alignment Group

Data Transmittal

TO: B. Miller, D. Kashy		**DATE:** 03/22/2016
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DETAILS: M:\align\DATA\Inspection\HallB\Torus12G\160316A

Below are the results of the Torus magnet survey carried out on March 16th and 17th, 2016.

The upstream and downstream hub locations are given relative to the Cebaf coordinate system and also in a beam following system. The second set of data is in a beam following system where Z is pointing downstream, X is pointing beam left and Y is pointing up. The coordinate system is based on the incoming beamline (x/y equals zero along beam) and with the origin for z is at the design zero point described in drawing B00000-04-01-1101. The referenced z zero value is 2367 mm downstream from the 12 Gev Hall B target. Values are in millimeters.

	CEBAF System [meters]				Relative to straight ahead beam		
	X	Y	Z		X[mm]	Y[mm]	Z[mm]
HUB US	-80.5991	103.35359	-401.689		-0.55	0.14	0.7
HUB DS	-80.599	103.35386	-403.637		-0.62	-0.31	1.03

The found exterior fiducial coordinates are shown below. A circle was formed to the found upstream and downstream data. The Radial error is to the 'fit' data.

Upstream Points Found				Ideals			Deltas			Radial Error
Coil	x	y	z	x	y	z	x	y	z	
A	-1.09	3206.85	-507.99	0.00	3207.24	-506.90	-1.09	-0.39	-1.09	-0.65
B	-2779.02	1602.19	-507.48	-2777.55	1603.62	-506.90	-1.47	-1.43	-0.58	-0.06
C	-2778.18	-1604.11	-506.35	-2777.55	-1603.62	-506.90	-0.63	-0.49	0.55	0.19
D	-	-	-	0.00	-3207.24	-506.90	-	-	-	-
E	2777.434	-1602.861	-506.760	2777.55	-1603.62	-506.90	-0.12	0.76	0.14	0.25
F	2776.994	1604.157	-506.995	2777.55	1603.62	-506.90	-0.56	0.54	-0.09	-0.31
Downstream Points Found				**Ideals**			**Deltas**			**Radial Error**
Coil	**x**	**y**	**z**	**x**	**y**	**z**	**x**	**y**	**z**	
A	-2.106	4213.127	876.674	0	4212.84	878.3	-2.11	0.29	-1.63	0.04
B	-3651.023	2103.515	876.858	-3648.43	2106.42	878.3	-2.59	-2.90	-1.44	-0.03
C	-	-	-	-3648.43	-2106.42	878.3	-	-	-	-
D	2.570	-4213.112	879.833	0	-4212.84	878.3	2.57	-0.27	1.53	0.01
E	-	-	-	3648.43	-2106.42	878.3	-	-	-	-
F	3647.279	2108.189	877.206	3648.43	2106.42	878.3	-1.15	1.77	-1.09	-0.03

Circle Centers and Radius from above fit circles:						
	X	Y	Z		Calced Radius	Design Rad
Coil_US	-0.59	-0.24	-506.94		3207.34	3207.24
Coil_DS	-0.52	0.02	878.06		4213.15	4212.84

As directed by D. Kashy, planes were established on the upstream and downstream edges of the vacuum jackets. From these planes, lines were constructed at the intersection of the two adjacent planes for each vacuum jacket. The calculated distance to the hub line from these lines are shown.

Perpendicular distances to center of hub line						
Upstream Values				Downstream Values		
	perp dist	angle			perp dist	angle
A_US	194.40	91.97		A_DS	197.92	89.86
B_US	193.68	89.65		B_DS	192.86	90.84
C_US	190.26	90.41		C_DS	193.30	89.73
D_US	192.26	91.64		D_DS	196.84	90.52
E_US	193.86	90.56		E_DS	197.52	91.50
F_US	194.61	91.42		F_DS	200.58	90.22

Additionally the perpendicular distance from the upstream and downstream vacuum jacket edges to the 'Nominal Fit' centerline of the (best fit of the coil fiducials) are shown.

Perpendicular distance to center of Nomical Fit centerline				
Upstream Values			Downstream Values	
	Perp Dist			**Perp Dist**
A_US	194.64		A_DS	198.03
B_US	193.77		B_DS	192.82
C_US	190.11		C_DS	193.15
D_US	192.02		D_DS	196.73
E_US	193.77		E_DS	197.55
F_US	194.76		F_DS	200.72

The Z dimension to the center of the intersection line to the upstream closure plates are shown below.

Upstream Z intersect line values					
using 14.53 delta	14.53				
	Z values			Z values	deltas
Upstream hub face found	500.70		A	405.10	3.70
Upstream Hub Face	500.00		B	403.17	1.77
us face close plate	418.63		C	404.21	2.81
ds face close plate	386.88		D	404.37	2.97
2 plane line	401.42		E	404.24	2.84
			F	404.03	2.63

Downstream Z intersect line values					
using 17.22 delta	17.22				
	Z values				
downstream Hub Face found	2449.13		A	2529.75	-1.72
downstream hub face	2448.11		B	2528.32	-0.29
us face close plate	2513.51		C	2530.27	-2.24
ds face close plate	2545.26		D	2530.40	-2.37
2 plane line	2525.51		E	2529.36	-1.33
			F	2530.60	-2.57

Areas were marked on each of the vacuum jackets, where a plane was measured. The centroid distance from each of these planes to the hub line was calculated.

Vacuum Jacket marked planes to hub line distances [mm]				
Inner Plane			Outer Plane	
A	833.5		A	2112.3
B	739.8		B	2084.3
C	628.0		C	2090.2
D	511.2		D	2092.2
E	756.5		E	2114.0
F	848.8		F	2103.4

The cold case fiducials were compared to the ideal values in the Cebaf coordinate system. Their deltas are shown below. Note that not all of the fiducials are observable.

Coil fiducials relative to the straight ahead beam												
Coil	target	Ideals				observed 3/16/2016				Deltas		
		x[m]	y[m]	z[m]		x[m]	y[m]	z[m]		x[mm]	y[mm]	z[mm]
A	Hub US	-80.60000	103.52680	-401.68075		-80.59892	103.52670	-401.68127		-1.08	0.10	0.52
	Hub DS	-80.59911	103.50201	-403.65920		-80.59973	103.50301	-403.65963		0.62	-1.00	0.43
	Ext US	-80.60000	106.56248	-400.68157		-80.59891	106.56214	-400.68053		-1.09	0.34	-1.04
	Ext DS	-80.60000	107.56806	-402.06677		-80.59789	107.56833	-402.06519		-2.11	-0.27	-1.58
B	Hub us	-80.45145	103.44103	-401.68075		-80.45097	103.44101	-401.68117		-0.48	0.02	0.42
	Ext US	-77.82246	104.95887	-400.68157		-77.82098	104.95752	-400.68104		-1.48	1.35	-0.53
	Ext DS	-76.95162	105.46165	-402.06677		-76.94898	105.45877	-402.06538		-2.64	2.88	-1.39
C	Hub US	-80.45145	103.26949	-401.68075		-80.45104	103.26893	-401.68139		-0.41	0.56	0.64
	Ext US	-77.82246	101.75165	-400.68157		-77.82182	101.75122	-400.68217		-0.64	0.43	0.60
D	Hub US	-80.60000	103.18372	-401.68075		-80.59973	103.18349	-401.68139		-0.27	0.23	0.64
	Hub DS	-80.60068	103.20922	-403.65903		-80.59939	103.20893	-403.65967		-1.29	0.29	0.64
	Ext DS	-80.60000	99.14247	-402.06677		-80.60257	99.14209	-402.06835		2.57	0.38	1.58

E	Hub US	-80.74855	103.26949	-401.68075		-80.74808	103.26939	-401.68140		-0.47	0.10	0.65
	Hub DS	-80.72737	103.28351	-403.66017		-80.72564	103.28070	-403.66058		-1.73	2.81	0.41
	Ext US	-83.37754	101.75165	-400.68157		-83.37743	101.75240	-400.68176		-0.11	-0.75	0.19
F	Hub US	-80.74855	103.44103	-401.68075		-80.74806	103.44091	-401.68134		-0.49	0.12	0.59
	Hub DS	-80.72650	103.42936	-403.66131		-80.72697	103.42884	-403.66170		0.47	0.52	0.39
	Ext US	-83.37754	104.95887	-400.68157		-83.37699	104.95941	-400.68153		-0.55	-0.54	-0.04
	Ext DS	-84.24838	105.46166	-402.06677		-84.24728	105.46335	-402.06573		-1.10	-1.69	-1.04

The same coil fiducials are shown below but with their coordinates rotated into coil A's position for each of the remaining five coils. Note that the downstream hub points observed are to tooling balls and their coordinates are not the same as on drawing B00000-04-01-1101.

Coil Fiducials rotated into Coils A's position												
Coil	target	Ideals				observed 3/16/2016				Deltas		
		x[mm]	y[mm]	z[mm]		x[mm]	y[mm]	z[mm]		x[mm]	y[mm]	z[mm]
A	Hub US	-1.08	171.47	492.75		0.00	171.54	492.23		-1.08	-0.06	0.53
	Hub DS*	-0.27	147.90	2471.11		-0.89	146.75	2470.68		0.63	1.15	0.43
	EXT US	-1.09	3206.85	-507.99		0.00	3207.22	-506.95		-1.09	-0.37	-1.05
	EXT DS	-2.11	4213.13	876.67		0.00	4212.79	878.25		-2.11	0.34	-1.58
B	Hub us	-0.23	171.95	492.65		0.00	171.54	492.23		-0.23	0.41	0.42
	Ext US	-1.97	3207.80	-507.48		0.00	3207.22	-506.95		-1.97	0.58	-0.54
	Ext DS	-3.81	4213.64	876.86		0.00	4212.79	878.25		-3.81	0.85	-1.39
C	Hub US	-0.26	172.16	492.87		0.00	171.54	492.23		-0.26	0.62	0.64
	Ext US	-0.11	3208.03	-506.35		0.00	3207.22	-506.95		-0.11	0.81	0.59
D	Hub US	0.27	171.74	492.88		0.00	171.54	492.23		0.27	0.20	0.65
	Hub DS*	0.61	146.17	2471.15		-0.68	146.05	2470.51		1.29	0.13	0.63
	Ext DS	-2.57	4213.11	879.83		0.00	4212.79	878.25		-2.57	0.32	1.58
E	Hub US	0.30	171.17	492.88		0.00	171.54	492.23		0.30	-0.37	0.65
	Hub DS*	1.61	146.01	2472.06		-1.55	146.18	2471.66		3.16	-0.17	0.41
	Ext US	-0.60	3206.76	-506.76		0.00	3207.22	-506.95		-0.60	-0.46	0.19
F	Hub US	-0.17	171.06	492.82		0.00	171.54	492.23		-0.17	-0.47	0.59
	Hub DS*	-0.37	146.83	2473.18		-0.93	146.60	2472.79		0.55	0.23	0.39
	Ext US	-0.74	3207.03	-507.00		0.00	3207.22	-506.95		-0.74	-0.20	-0.05
	Ext DS	-2.11	4212.73	877.21		0.00	4212.79	878.25		-2.11	-0.06	-1.04

The main Z and Y supports relative to the overall coordinate system are below:

	Y [mm]	Z [mm]
Z Beam Right		-318.30
Z Center		-314.13

Z Beam Left		-317.23
Y Beam Right US	508.42	
Y Beam Right DS	508.78	
Y Beam Left US	511.50	
Y Beam Left DS	515.09	

Using the Alignment group's standard magnet center software and all the observed coil fiducials, the following output was generated. The least square fit standard deviation for this data was 0.7mm.

Component :	TOR12G	Section :	HB_12G
Aliases :	none	none	
	Z	X	Y
Ideal (m) :	-401.18852	-80.60000	103.35526
Fnd geo (m) :	79598.81126	59919.40046	2103.36793
Delta Location (mm) :	-0.220	0.460	-0.469
Delta BFS (mm) :	0.220	-0.460	-0.469
	Yaw	Pitch	Roll
Ideal Yaw/Pitch/Roll(deg) :	180.00000	0.00000	0.00000
Found Yaw/Pitch/Roll(deg) :	179.99885	0.01547	0.02578
Survey Date :	17.03.2016	Calc Date :	24.03.2016
		CurvCor (mm)	13.14

The residuals for the magnet center least square data is as follows:

Residuals										
HUB Fiducials						Edge Fiducials				
Coil #	up/down	x[mm]	y[mm]	z[mm]		Coil #	up/down	x[mm]	y[mm]	z[mm]
A	US	-0.54	0.27	0.35		A	US	0.80	0.24	-0.38
A	DS	1.19	0.95	0.25		A	DS	0.25	0.55	-0.65
B	US	0.03	0.41	0.23		B	US	-0.31	0.43	-0.26
						B	DS	-1.22	-1.00	-0.97
C	US	0.02	-0.13	0.40		C	US	-0.91	1.35	0.00
D	US	0.12	0.14	0.38						
D	DS	-0.85	-0.34	0.38		D	DS	1.16	-0.10	0.22
E	US	-0.04	0.20	0.41		E	US	-0.38	0.11	-0.51
E	DS	-1.26	-2.91	0.17						
F	US	0.02	0.18	0.40		F	US	0.62	-0.10	0.13
F	DS	1.01	-0.62	0.19		F	DS	0.32	0.39	-0.75