Helium3 Target Field Mapping Status

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C-polhe3 Collaboration Meeting

3/25/2021

Highlights **Will only talk color red parts**

- Overview of target coils
- Overview of field direction definitions
- First comparison to compass measurements, probe orientation not know yet
- Determine TOSCA map's current, HB, HL, HS ……
- Modeling the background field (earth field and the environment activation)
- Modeling the HB field
- Determine the probe's orientation
- Create an interactive Field Model using excel
- Create Super TOSCA Model using python
- Compare to compass measurement again
- Compare to vertical field measurement
- Error Analysis
- D2N field mapping analysis status
- Summary

Compare to Compass Measurements

Field angle Prediction

Prediction	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	Z+	Z-	X+	X-	Z+	Z-	X+	X-	Z+	Z-	X+	X-
20	-2.12	178.88	87.60	-89.95	-0.61	178.72	88.02	-90.42	-1.67	178.54	89.00	-90.64
18	-2.15	178.89	87.71	-90.18	-0.81	178.76	87.96	-90.47	-1.69	178.55	88.91	-90.69
-3	-2.15	179.13	87.85	-90.44	-2.36	178.96	88.29	-90.86	-1.75	178.82	88.99	-90.99
-5	-2.14	179.23	87.75	-90.26	-2.49	179.04	88.22	-90.70	-1.80	178.96	89.05	-90.93
-18	-2.34	179.10	86.98	-89.71	-3.65	178.92	87.80	-90.43	-2.08	178.90	88.84	-90.73
-20	-2.20	179.10	87.00	-89.56	-3.65	178.94	87.88	-90.33	-1.87	178.85	88.83	-90.52
Linear Regression												
Slope	3.14E-03	-6.27E-03	1.54E-02	-9.36E-03	7.71E-02	-5.59E-03	2.55E-03	-4.15E-04	7.28E-03	-9.36E-03	2.69E-03	3.40E-05
Intercept	-2.18	179.05	87.50	-90.03	-2.16	178.88	88.03	-90.54	-1.80	178.76	88.94	-90.75
R^2	0.435	0.597	0.461	0.227	0.998	0.596	0.052	0.001	0.692	0.771	0.248	0.000

Interpolated JZ's prediction

	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	**Z+**	**Z-**	**X+**	**X-**	**Z+**	**Z-**	**X+**	**X-**	**Z+**	**Z-**	**X+**	**X-**
-12	-2.22	179.12	87.32	-89.92	-3.08	178.95	88.00	-90.53	-1.89	178.87	88.91	-90.75
0	-2.18	179.05	87.50	-90.03	-2.16	178.88	88.03	-90.54	-1.80	178.76	88.94	-90.75
12	-2.14	178.97	87.69	-90.14	-1.23	178.82	88.06	-90.54	-1.71	178.65	88.97	-90.75

MR's measurement

	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	**Z+**	**Z-**	**X+**	**X-**	**Z+**	**Z-**	**X+**	**X-**	**Z+**	**Z-**	**X+**	**X-**
-12	0.62	179.97	88.70	-88.96	0.46	179.81	88.98	-89.35	0.22	179.65	89.69	-89.64
0	0.49	180.10	88.81	-89.27	0.37	179.99	89.20	-89.71	0.17	179.82	89.80	-89.93
12	0.46	180.19	88.45	-89.00	0.34	180.06	89.03	-89.57	0.19	179.96	89.78	-89.87

diff=JZ-MR	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	**Z+**	**Z-**	**X+**	**X-**	**Z+**	**Z-**	**X+**	**X-**	**Z+**	**Z-**	**X+**	**X-**
-12	-2.84	-0.85	-1.39	-0.96	-3.55	-0.86	-0.98	-1.18	-2.11	-0.78	-0.78	-1.10
0	-2.67	-1.06	-1.30	-0.76	-2.53	-1.10	-1.16	-0.83	-1.97	-1.06	-0.86	-0.82
12	-2.60	-1.22	-0.76	-1.14	-1.57	-1.25	-0.97	-0.97	-1.90	-1.32	-0.81	-0.87
Average=		**-1.04**	**-1.15**	**-0.95**		**-1.07**	**-1.04**	**-0.99**		**-1.05**	**-0.82**	**-0.93**
Average All=		**-1.01**										

Z+ polarity predictions were not as accurate as other polarities due to missing some single coil measurements;
Z-,X+ and X- polarities measurements indicate that the probe have -1.01 degree off the beam line, pointing to beam right if looking downstream.

Modeling the Background

	raw Measurement				
z_raw	z_true	B	Bx	By	+Bz
19.95	17.95	0.568	-0.067	-0.458	-0.329
17.95	15.95	0.584	-0.089	-0.461	-0.347
-3.05	-5.05	0.59	-0.145	-0.404	-0.406
-5.05	-7.05	0.575	-0.143	-0.408	-0.379
-18.05	-20.05	0.514	-0.118	-0.37	-0.336

3rd order polynomial fit

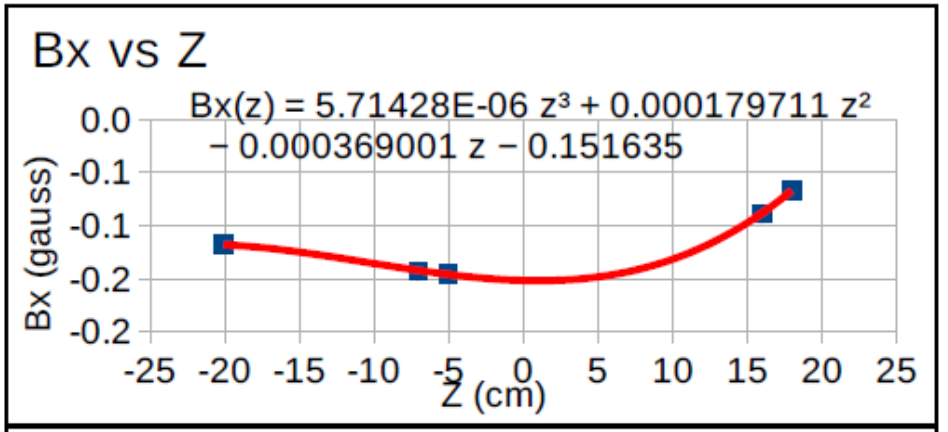
	Bx	By	Bz
p0	-0.151774400	-0.426437000	-0.410935000
p1	-0.000185004	-0.003013420	-0.002030850
p2	0.000188283	0.000027999	0.000236038
p3	5.714280E-06	2.027390E-06	7.397510E-06

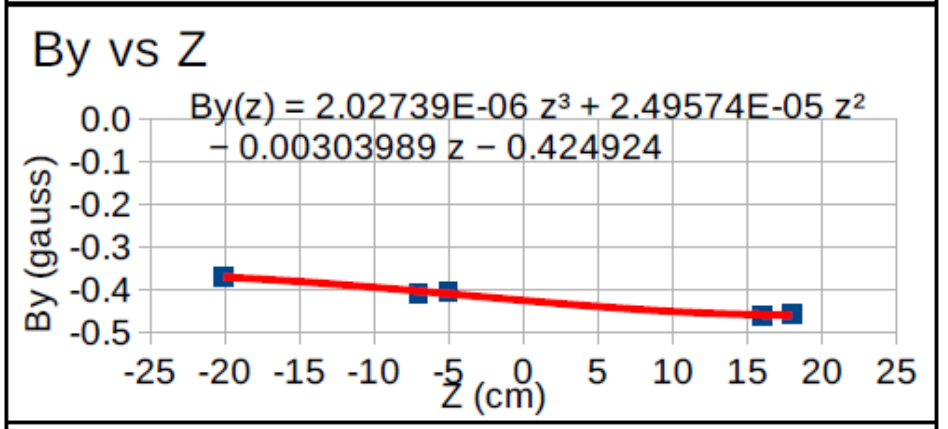
Linear Regression

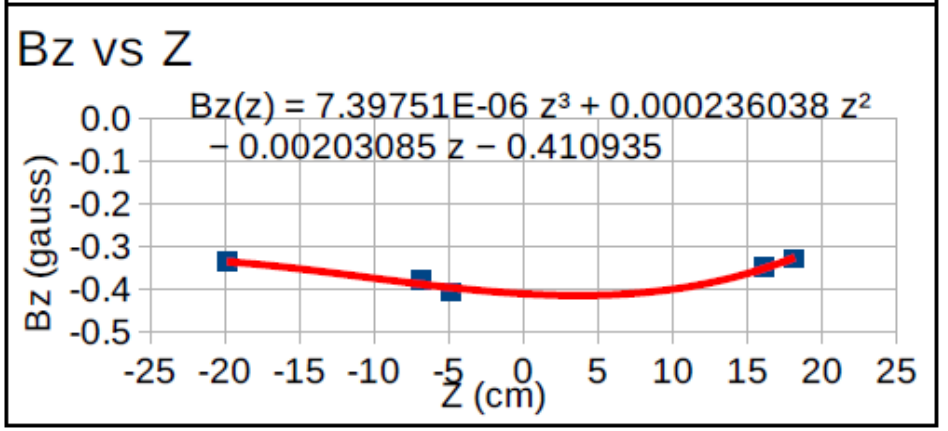
Slope	0.001596	-0.002377	0.000615
Intercept	-0.112959	-0.419368	-0.359615
R^2	0.578200	0.987817	0.095295

3rd-order_Fitted – Data				
z	dB	dBx	dBy	dBz
17.95		0.0056	-0.0018	0.0004
15.95		0.0054	0.0018	-0.0063
-5.05		-0.0018	-0.0068	0.0104
-7.05		-0.0001	0.0035	-0.0085
-20.05		-0.0004	-0.0011	0.0010
mean=		0.001731745	-0.0008627655	-0.0005716536

Linear_Fitted – Data				
z	dB	dBx	dBy	dBz
17.95		-0.0173	-0.0040	-0.0196
15.95		0.0015	0.0037	-0.0028
-5.05		0.0240	-0.0034	0.0433
-7.05		0.0188	0.0054	0.0150
-20.05		-0.0270	-0.0017	-0.0359
mean=		0	1.110223E-17	-6.661338E-17





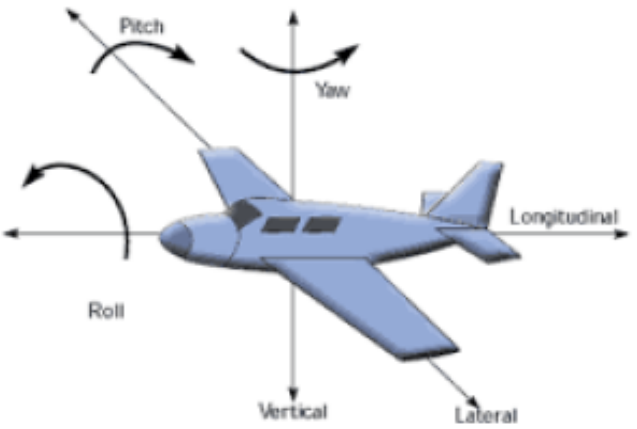


Probe Orientation Definition

' dBx ~= -sin(alpha)*By0 + sin(beta)*Bz0 ~=sin(yaw)*Bz0

Sin(Yaw) = dBx/Bz0

Direction	180deg			0deg		
Z_pos	**Bz0**	**dBx**	**Yaw**	**Bz0**	**dBx**	**Yaw**
20.00	-26.20	0.73	-1.60	26.20	-0.78	-1.71
18.00	-26.16	0.74	-1.62	26.16	-0.79	-1.74
-3.00	-26.09	0.71	-1.56	26.09	-0.78	-1.72
-5.00	-26.09	0.69	-1.52	26.09	-0.75	-1.65
-18.00	-26.19	0.73	-1.59	26.19	-0.82	-1.79
-20.00	-26.25	0.70	-1.52	26.25	-0.77	-1.67
Average (deg)			**-1.57**			**-1.72**



' dBy ~= sin(alpha)*Bx0 - sin(gamma)*Bz0 ~= sin(roll)*Bx0

Sin(Roll) = dBy/Bx0

Direction	270deg			90deg		
Z_pos	**Bx0**	**dBy**	**Roll**	**Bx0**	**dBy**	**Roll**
20.00	-25.93	1.07	-2.37	25.93	-1.10	-2.43
18.00	-25.88	1.07	-2.36	25.88	-1.08	-2.39
-3.00	-25.69	0.97	-2.16	25.69	-0.98	-2.19
-5.00	-25.71	0.97	-2.16	25.71	-0.99	-2.21
-18.00	-25.93	1.01	-2.24	25.93	-1.02	-2.25
-20.00	-25.99	0.98	-2.17	25.99	-0.99	-2.19
Average (deg)			**-2.24**			**-2.28**

A pitch is a counterclockwise rotation of 'gamma' about the x-axis
A yaw is a counterclockwise rotation of 'beta' about the y-axis.
A roll is a counterclockwise rotation of 'alpha' about the z-axis

Rotation R performs the pitch(gamma) first, then the yaw(beta), and finally the roll(alpha):

$$R(\alpha,\beta,\gamma) = R_z(\alpha)\,R_y(\beta)\,R_x(\gamma) =$$

$$\begin{pmatrix} \cos\alpha\cos\beta & \cos\alpha\sin\beta\sin\gamma - \sin\alpha\cos\gamma & \cos\alpha\sin\beta\cos\gamma + \sin\alpha\sin\gamma \\ \sin\alpha\cos\beta & \sin\alpha\sin\beta\sin\gamma + \cos\alpha\cos\gamma & \sin\alpha\sin\beta\cos\gamma - \cos\alpha\sin\gamma \\ -\sin\beta & \cos\beta\sin\gamma & \cos\beta\cos\gamma \end{pmatrix}.$$

The reverse rotation of R is R^{-1} = R^{+}, use R^{-1} one can rotate measurement back to Lab coordinate system.

Fit Probe Orientation by HL

HH45deg_Large_Coil_Only

/home/jixie/DISK/work/A1N/mapping/Helmholtz_coils_only/Bz_30deg/result_rot.txt

TOSCA: HH45deg Large Coil with Steel, J=+26A/cm^2

I_(A)= -7.169 range= B3:H8

sign= -1

Position (cm)			Measurement				TOSCA, HL coil only				
x	y	z	B_data	Bx	By	+Bz	B_t	Bx	By	+Bz	Ratio
0	-0.07	19.95	25.300	17.527	-0.906	18.223	18.702	-13.162	-0.010	-13.286	1.353
0	-0.06	17.95	25.239	17.478	-0.940	18.185	18.674	-13.138	-0.017	-13.271	1.352
0	0.01	-3.05	25.113	17.320	-0.901	18.162	18.621	-13.062	-0.051	-13.271	1.349
0	0.02	-5.05	25.116	17.334	-0.939	18.152	18.630	-13.069	-0.054	-13.277	1.348
0	0.06	-18.1	25.315	17.456	-0.912	18.312	18.730	-13.167	-0.074	-13.321	1.352
0	0.07	-20.1	25.380	17.519	-0.893	18.342	18.762	-13.193	-0.080	-13.340	1.353
Note: Ratio = B_data / B_tosca, B_tosca_scaled = B_tosca * <Ratio>										average=	1.351

old_J= 26.000

--> New_J= -35.123

--> New_I= 5.307

Rotate back to the hall coordinate system.

deg: pitch= 0.939 yaw= -0.882 roll= -2.250

rad: gamma= 0.01639 beta= -0.01539 alpha= -0.03927

Rotation matrix:

$$R^{-1} = \begin{pmatrix} 0.9991 & -0.0393 & 0.0154 \\ 0.0390 & 0.9991 & 0.0164 \\ -0.0160 & -0.0158 & 0.9997 \end{pmatrix}$$

Final Result			
	optimized	min	max
pitch	0.939	0.821	1.056
yaw	-0.882	-0.982	-0.781
roll	-2.250	-2.371	-2.129

Position (cm)			Rotated Data				Scaled TOSCA				Rotated_Data – Scaled_TOSCA			
x	y	z	Btot	Bx	By	+Bz	Btot	Bx	By	+Bz	dBtot	dBx	dBy	dBz
0	0	20	25.300	17.827	0.077	17.952	25.264	17.781	0.014	17.948	0.036	0.047	0.063	0.004
0	0	18	25.240	17.779	0.041	17.915	25.227	17.748	0.023	17.928	0.013	0.031	0.018	-0.013
0	0	-3	25.113	17.620	0.073	17.894	25.155	17.646	0.069	17.928	-0.042	-0.026	0.004	-0.034
0	0	-5	25.117	17.635	0.035	17.884	25.167	17.655	0.073	17.936	-0.051	-0.020	-0.038	-0.051
0	0	-18	25.315	17.758	0.070	18.042	25.303	17.787	0.100	17.995	0.013	-0.029	-0.030	0.047
0	0	-20	25.380	17.821	0.092	18.071	25.346	17.822	0.108	18.021	0.034	-0.002	-0.016	0.050
										Mean:	0.000	0.000	0.000	0.000
										Sigma:	0.038	0.032	0.037	0.041

How to fit?

1). Set pitch=0.0, yaw=-1.0, roll=0.0; adjust yaw such that <dBx>~=0.00 and <dBz>~=0.00, or abs(<dBx>)+abs(<dBz>) minimum.

2). Do not touch yaw. If roll is known to be -2.25 deg, set roll to -2.25, adjust pitch such that <dBy>~=0.00. If pitch is known, adjust roll then.

3). Adjust yaw and pitch a bit such that <dBx>=0.00, <dBy>=0.00 and <dBz>=0.00.

4). Using +/- Sigma as the upper and lower limit, adjust mean to match Sigma to estimate the uncertainties.

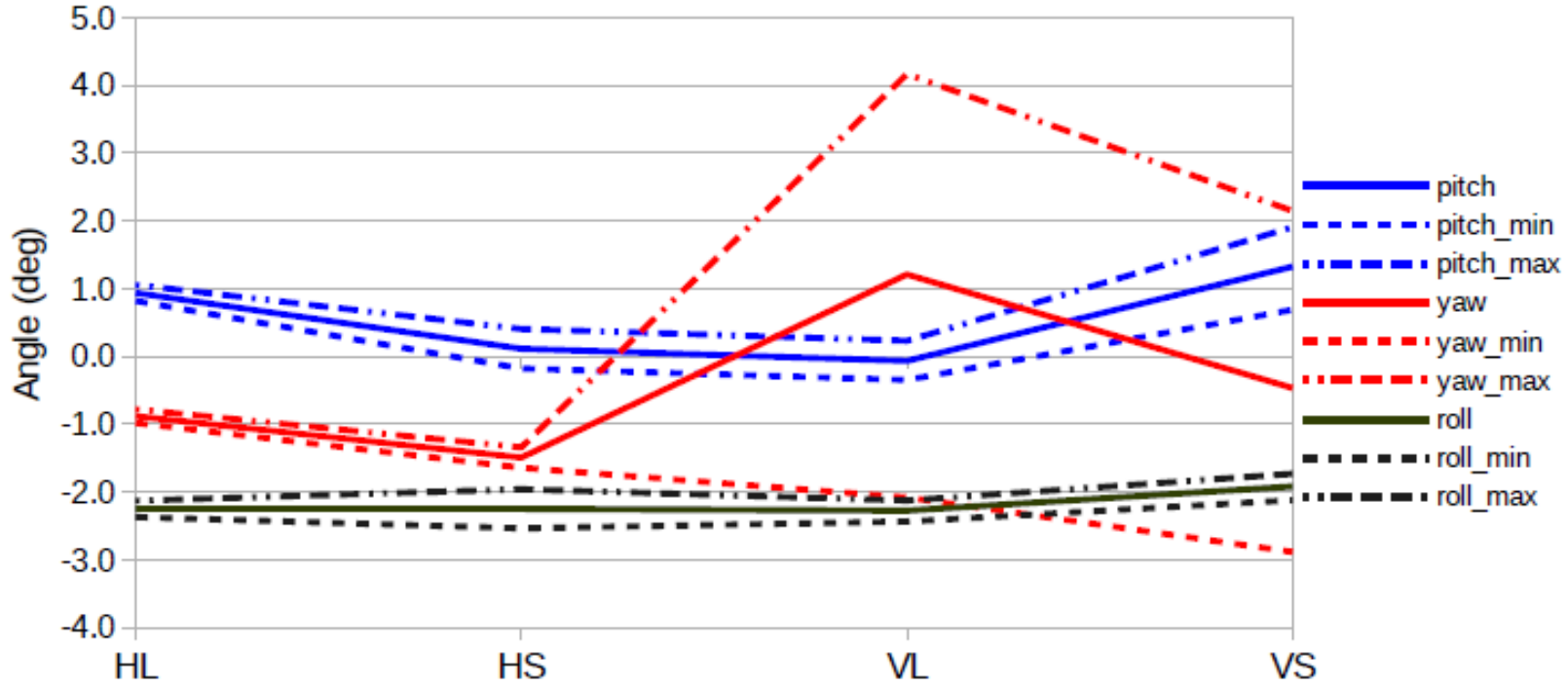
A). Fixed yaw and roll as values determined by 3), adjust ptich to let <dBy> match +/-Sigma, these 2 values are the min and max of pitch.

B). Fixed pitch and roll as values determined by 3), adjust yaw to let <dBx> and <dBz> match +/-Sigma, these 2 values are the min and max of yaw.

C). Fixed pitch and yaw as values determined by 3), adjust roll to let <dBy> match +/-Sigma, these 2 values are the min and max of roll.

Fit Probe Orientation Results

	pitch	pitch_min	pitch_max	yaw	yaw_min	yaw_max	roll	roll_min	roll_max
HL	0.939	0.821	1.056	-0.882	-0.982	-0.781	-2.250	-2.371	-2.129
HS	0.113	-0.179	0.405	-1.493	-1.643	-1.342	-2.250	-2.537	-1.961
VL	-0.066	-0.347	0.232	1.211	-2.081	4.167	-2.276	-2.437	-2.126
VS	1.327	0.690	1.907	-0.468	-2.886	2.146	-1.919	-2.122	-1.732
Suggested	0.58			-1.19			-2.25		
Error	0.66			0.43			0.17		



Summary:

1. HH large and small coils are 45 deg rotated. Their fields are in Bx and Bz directions, therefore they are sensitive to all 3 angles
2. Vertical large and small coils have the field mainly in vertical direction (By), therefore they are not sensitive to yaw angle.
3. For HH large and small coils, the solution for (pitch, roll) angles is not unique. I chose roll=-2.25 to determine pitch.
4. Vertical coils are not perfectly built as HH coils. Results from HH coils should be more reliable.

Create An Interactive TOSCA Model: 30deg

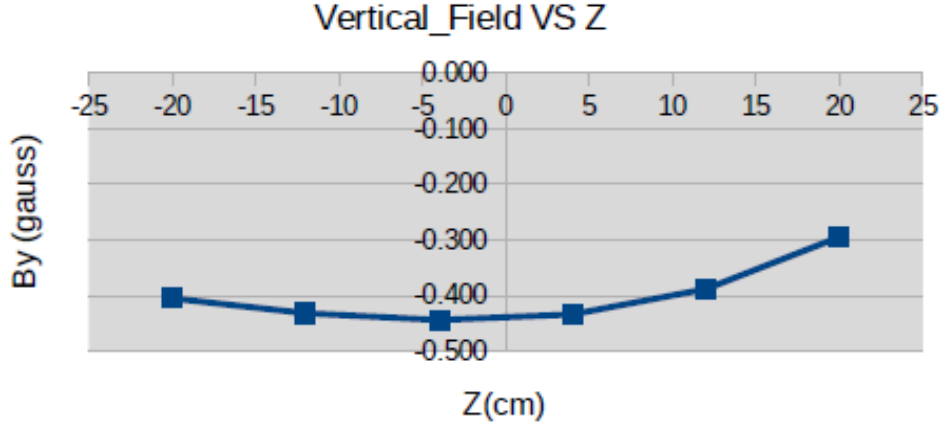
HB_BxBz_z-25+(VL+VS)

I_VL= 2.6 I_VS= 1.7 I_HL= 5.163 I_HS= 5.231 I_HB= 1127.680 _HLCC= 0.0 _HSCC= 0.0

Position (cm)			Mag Field (G)					Gradient (G/cm)									Field Angle
x	y	z	B	Bx	By	Bz		Bxx	Byx	Bzx	Bxy	Byy	Bzy	Bxz	Byz	Bzz	(deg)
0	0	20	26.297	0.094	-0.295	-26.295					0.015	-0.003	0.013	0.002	0.009	-0.002	179.795
0	0	12	26.263	0.069	-0.388	-26.260					0.013	0.000	0.011	0.000	0.003	0.000	179.850
0	0	4	26.260	0.066	-0.433	-26.257					0.010	0.000	0.007	0.000	0.000	0.000	179.857
0	0	-4	26.271	0.062	-0.444	-26.267					0.008	-0.002	0.004	-0.003	-0.002	0.005	179.864
0	0	-12	26.265	0.069	-0.431	-26.262					0.005	-0.003	0.000				179.849
0	0	-20	26.354	0.107	-0.405	-26.351					-0.002	-0.004	-0.002				179.766
0	10	20	26.170	0.244	-0.324	-26.167								0.005	0.007	0.001	
0	10	12	26.150	0.201	-0.390	-26.147								0.004	0.005	0.005	
0	10	4	26.192	0.168	-0.438	-26.187								0.003	0.002	0.005	
0	10	-4	26.231	0.143	-0.462	-26.227								0.003	-0.001	0.009	
0	10	-12	26.268	0.115	-0.465	-26.264											
0	10	-20	26.378	0.092	-0.442	-26.374											
5	0	20	26.261	0.129	-0.203	-26.260		0.007	0.018	0.007				0.006	0.010	0.001	
5	0	12	26.248	0.034	-0.308	-26.246		-0.007	0.016	0.003				-0.003	0.006	0.002	
5	0	4	26.279	0.040	-0.367	-26.276		-0.005	0.013	-0.004				-0.004	0.004	0.000	
5	0	-4	26.287	0.081	-0.408	-26.284		0.004	0.007	-0.003				0.002	0.002	0.004	
5	0	-12	26.287	0.098	-0.433	-26.283		0.006	0.000	-0.004							
5	0	-20	26.352	0.043	-0.448	-26.348		-0.013	-0.009	0.001							

Note: position (x, y, z) and field (Bx,By,Bz) are already flipped to Lab frame. (0,0,0) is the pivot.

Names	Values
Range	0.149
Mean	-0.399
Slope+	0.006
Slope-	-0.002



Available Interactive TOSCA Models

Name

- 8.5deg_Model_1.797GeV.ods
- 8.5deg_Model_1.797GeV.pdf
- 8.5deg_Model_2.129GeV.ods
- 8.5deg_Model_2.129GeV.pdf
- 11.7deg_Model_1.760GeV.ods
- 11.7deg_Model_1.760GeV.pdf
- 11.7deg_Model_2.148GeV.ods
- 11.7deg_Model_2.148GeV.pdf
- 18deg_Model_5.6GeV.ods
- 30deg_Model_2.6GeV.ods
- 30deg_Model_2.6GeV.pdf
- 30deg_Model_3.4GeV.ods
- 30deg_Model_3.4GeV.pdf
- 30deg_Model_cmp2real.ods
- 30deg_Model_cmp2real.pdf

Name

- 8.5deg_Model_D2N_1.797GeV.ods
- 8.5deg_Model_D2N_1.797GeV.pdf
- 8.5deg_Model_D2N_2.129GeV.ods
- 8.5deg_Model_D2N_2.129GeV.pdf
- 11deg_Model_MatchByCurrentDensity.ods
- 11deg_Model_MatchByCurrentDensity.pdf
- 14.5deg_Model_MatchByCurrentDensity.ods
- 14.5deg_Model_MatchByCurrentDensity.pdf
- 18deg_Model_MatchByCurrentDensity.ods
- 18deg_Model_MatchByCurrentDensity.pdf

Index of /~jixie/A1N/mapping/models

Name	Last modified	Size	Description
Parent Directory		-	
11deg_Model_MatchByCurrentDensity_new_VS_Helm.ods	08-Aug-2020 20:44	169K	
11deg_Model_MatchByCurrentDensity_new_VS_Helm.pdf	08-Aug-2020 20:44	77K	
12.5deg_Model.ods	08-Aug-2020 20:44	132K	
12.5deg_Model.pdf	08-Aug-2020 20:44	74K	
18deg_Model_MatchByField.ods	08-Aug-2020 20:44	157K	
18deg_Model_MatchByField.pdf	08-Aug-2020 20:44	75K	
A1NMaps/	03-Aug-2020 12:25	-	
A1N_field_optimized/	03-Aug-2020 12:25	-	
A1N_field_real/	03-Aug-2020 12:25	-	
CompareModel.ods	08-Aug-2020 20:44	426K	
CompareModel.pdf	08-Aug-2020 20:44	279K	
D2NMaps/	03-Aug-2020 12:25	-	
D2N_field_optimized/	03-Aug-2020 12:25	-	
D2N_field_real/	03-Aug-2020 12:25	-	
Rotated_HLHS.pdf	08-Aug-2020 20:44	27K	

Apache/2.2.15 (Red Hat) Server at userweb.jlab.org Port 443

https://userweb.jlab.org/~jixie/A1N/mapping/models/ also available in work disk

Create Super TOSCA Model Map: python

Where is the maps located

The rotated TOSCA field maps for each single set of coils are stored in group dir:
ifarm1901:/u/group/c-polhe3/Users/jixie/TOSCA/A1NMap
ifarm1901:/u/group/c-polhe3/Users/jixie/TOSCA/D2NMap

Scripts to combine maps

Jixie provides python scrips to combine these 7 rotated individual maps (HB, HL, HS, VL, VS, HLCC and HSCC) into one map with each map scaled to the given current. These scrips will also make some plots of "Field vs Y|Z" and "Gradient vs Y|Z". These scrips are stored at
ifarm1901:/u/group/c-polhe3/Users/jixie/TOSCA/Scripts

The output of these scripts (combined table, pdf files and figures) are stored at:
ifarm1901:/u/group/c-polhe3/Users/jixie/TOSCA/Scripts/A1NOutput
ifarm1901:/u/group/c-polhe3/Users/jixie/TOSCA/Scripts/D2NOutput

How to run these scripts to combine maps

First of all, the script require matplotlib, numpy, pandas modules. You need to install them before running it.

1) change "TableDir" to where the tables are located.

2) change "OutDir" as it is where to keep the output files

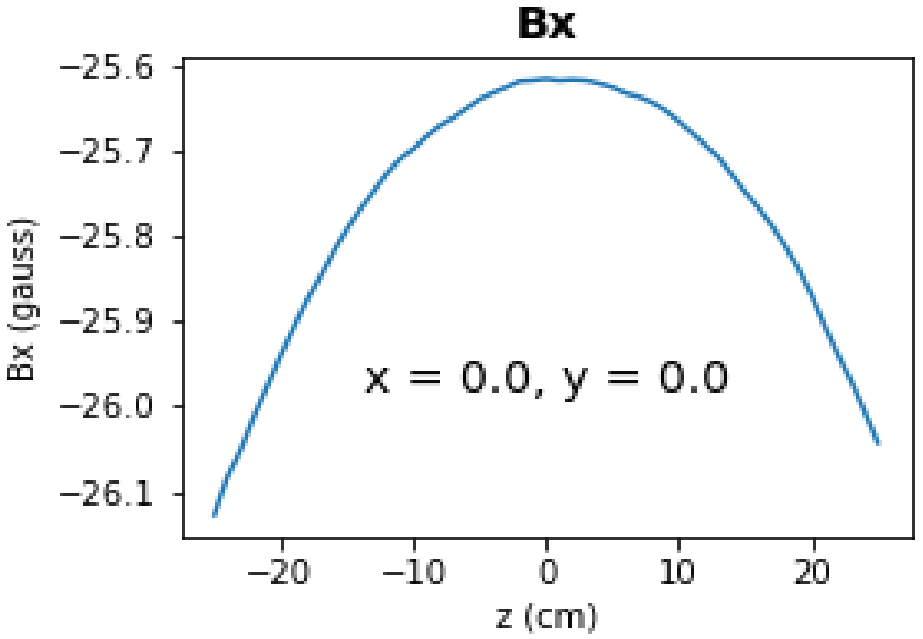
3) configure "Target_Currents_xxxxx[4][7]" 2-D list. It contains 4 rows and 7 columns.
The rows [0],[1],[2],[3] represent target polarization polarity of 0. 90, 180, and 270 deg, respectively.
The structure of each row are the currents for these coils: HB,HL,HS,VL,VS,HLCC,HSCC.

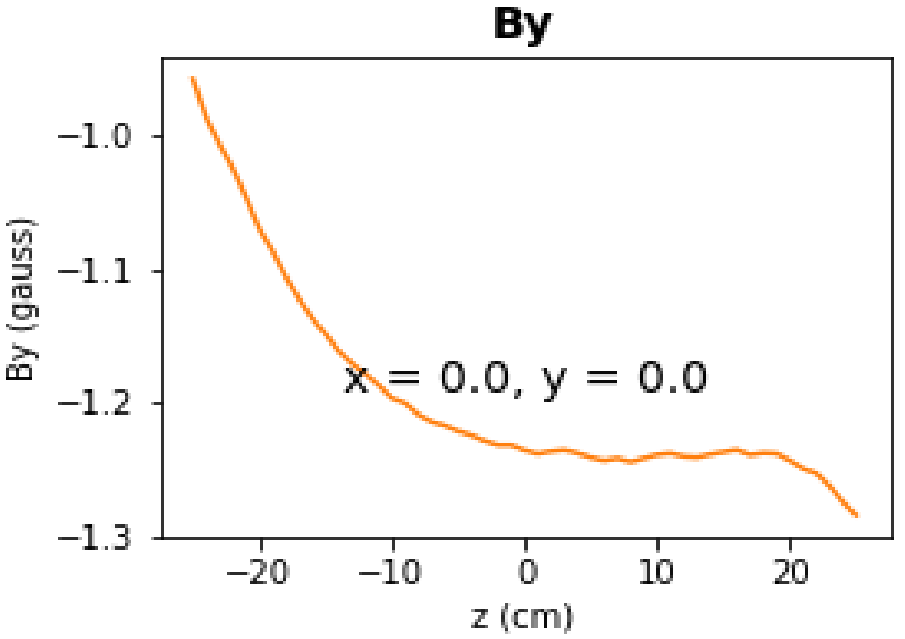
4) Keep in mind that in D2N experiment, HS coil current in read back is in opposite sign, VL and VS are switched.
In A1N experiment, HS coil current in read back is also in opposite sign.
Make sure you know these when you provide "Target_current" and be enough careful.

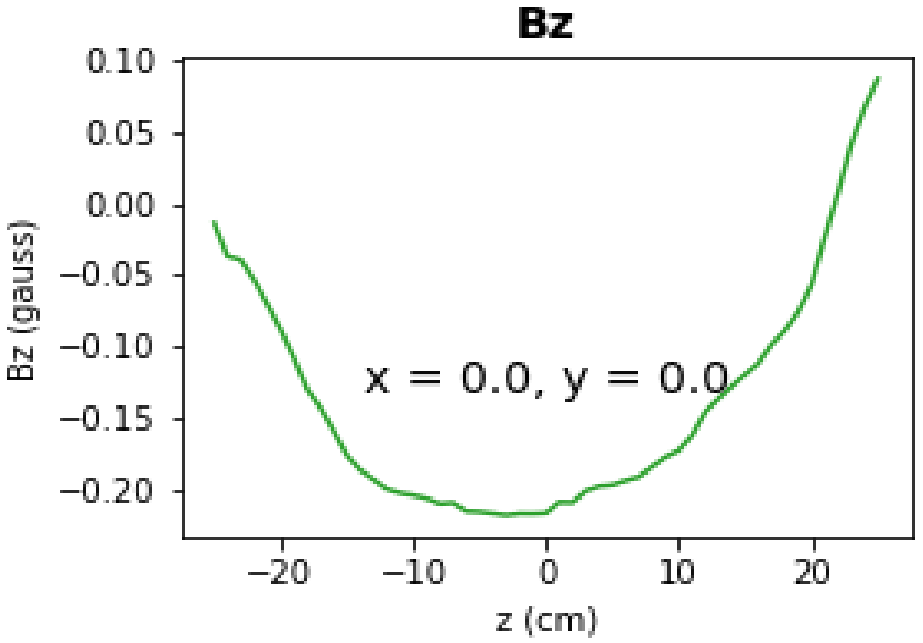
5) This script can make some plot using functions. For example "PlotGradientVsZ(xx,yy,figname)" will plot the 9 gradients as a function of z at line (x=xx,y=yy).
User need to specify xx and yy locations and output figure name.

https://hallcweb.jlab.org/wiki/index.php/TOSCA_simulation_for_Pol_He3_Field

Figure from Super-TOSCA-Model: 30deg, 3.4GeV x- polarity







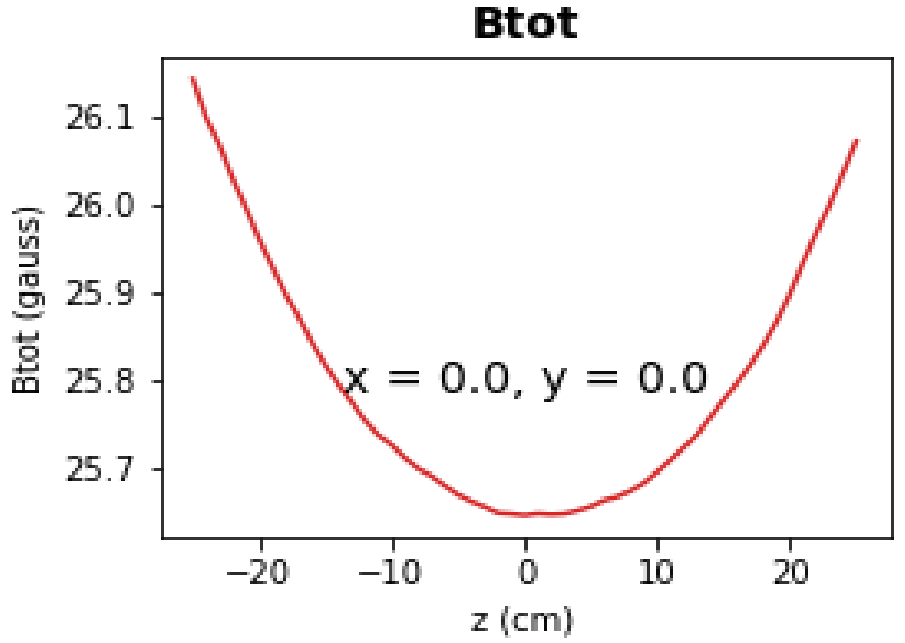
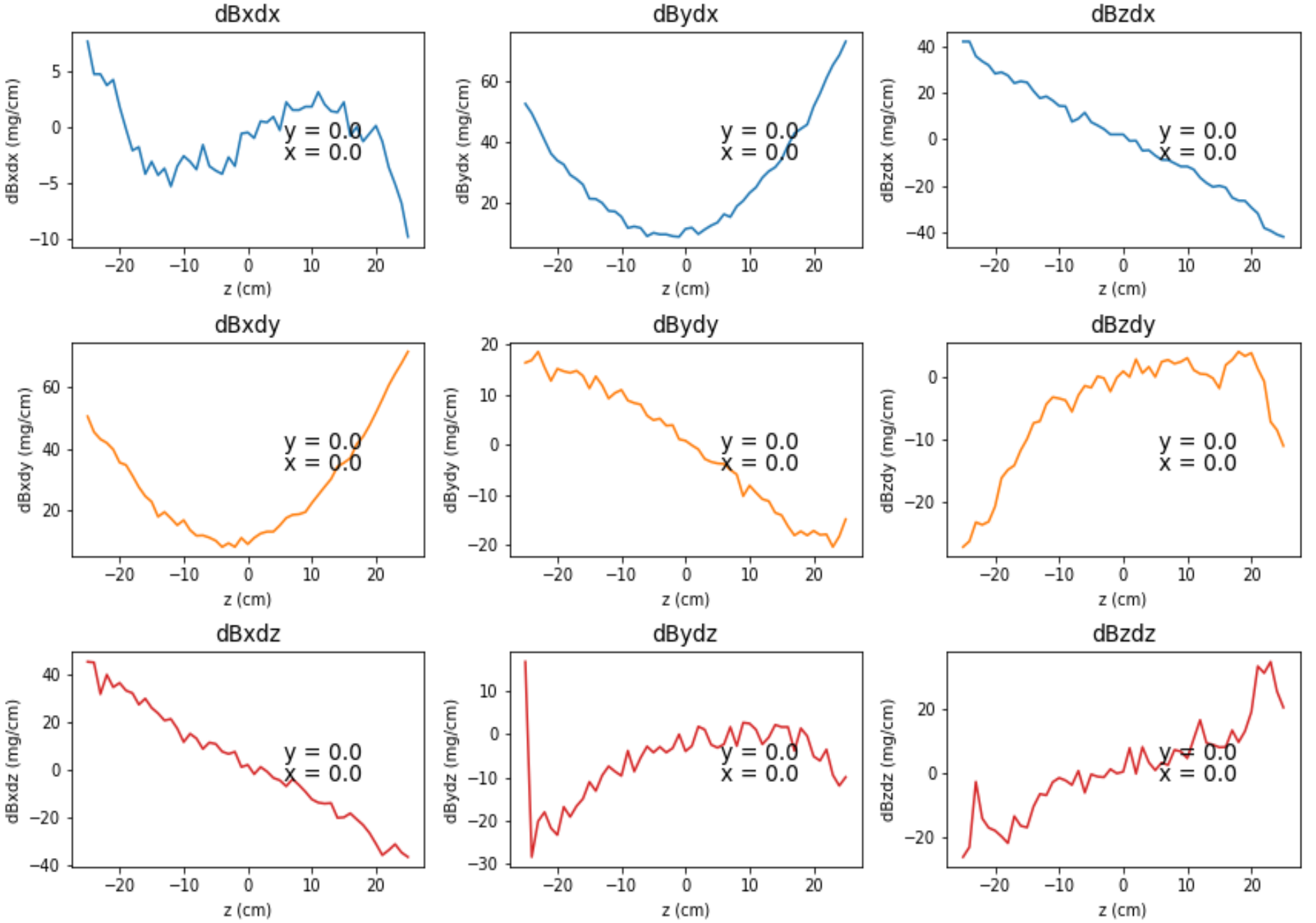


Figure from Super-TOSCA-Model: 30deg, 3.4GeV x- polarity



Currents for Compass Measurement

```
The following are the currents sent to Murchhana:

For 18deg
Bz=+25g   I_VL=5.8  I_VS=4.0  I_HL=-1  I_HS=-1
Bz=-25g   I_VL=5.8  I_VS=3.9  I_HL=0  I_HS=0
Bx=+25g   I_VL=5.8  I_VS=4.6  I_HL=0  I_HS=0
Bx=-25g   I_VL=5.8  I_VS=3.2  I_HL=0  I_HS=0

For 30 deg:
Bz=+25g   I_VL=4.5  I_VS=3.5  I_HL=0  I_HS=0
Bz=-25g   I_VL=2.8  I_VS=1.6  I_HL=0  I_HS=0    <-- typo, I_VL should be 2.3
Bx=+25g   I_VL=2.3  I_VS=2.3  I_HL=0  I_HS=0
Bx=-25g   I_VL=4.5  I_VS=2.8  I_HL=0  I_HS=0

For 12.5 deg (HB=7.5):
Bz=+25g,     I_VL=8.7, I_VS=5.9,     I_HL=0, I_HS=0
Bz=-25g,     I_VL=8.7, I_VS=5.9,     I_HL=0, I_HS=0
Bx=+25g,     I_VL=8.7, I_VS=6.7,     I_HL=1.0, I_HS=1.0
Bx=-25g,     I_VL=8.7, I_VS=5.4,     I_HL=1.0, I_HS=1.0


The following are the currents set during compass measurements:

For 18deg
Bz=+25g   I_VL=5.8  I_VS=4.0  I_HL=-1  I_HS=1   <-- I_HS was opposite
Bz=-25g   I_VL=5.8  I_VS=3.9  I_HL=0  I_HS=0
Bx=+25g   I_VL=5.8  I_VS=4.6  I_HL=0  I_HS=0
Bx=-25g   I_VL=5.8  I_VS=3.2  I_HL=0  I_HS=0

For 30 deg:
Bz=+25g   I_VL=4.5  I_VS=3.5  I_HL=0  I_HS=0
Bz=-25g   I_VL=2.8  I_VS=1.6  I_HL=0  I_HS=0    <-- typo, I_VL should be 2.3
Bx=+25g   I_VL=2.3  I_VS=2.3  I_HL=0  I_HS=0
Bx=-25g   I_VL=4.5  I_VS=2.8  I_HL=0  I_HS=0

For 12.5 deg (HB=7.5):
Bz=+25g,     I_VL=8.7, I_VS=5.9,     I_HL=0, I_HS=0
Bz=-25g,     I_VL=8.7, I_VS=5.9,     I_HL=0, I_HS=0
Bx=+25g,     I_VL=8.7, I_VS=6.7,     I_HL=-1.0, I_HS=1.0   <-- I_HL was opposite
Bx=-25g,     I_VL=8.7, I_VS=5.4,     I_HL=-1.0, I_HS=1.0   <-- I_HL was opposite
```

+X: beam right (90 deg)
-X: beam left (270 deg)
+Z: downstream (0 deg)
-Z: upstream (180 deg)

In this file, +/- X are different from M. Roy's definition above

Compare to Compass Measurements Again

Field Angle Prediction

Prediction	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	Z+	Z-	X+	X-	Z+	Z-	X+	X-	Z+	Z-	X+	X-
20	-1.70	-179.70	90.46	-88.64	-0.11	-179.92	90.54	-88.71	-1.20	179.80	90.463	-89.36
12	-1.56	-179.71	90.61	-89.03	-0.54	-179.91	90.66	-89.07	-1.13	179.85	90.617	-89.60
4	-1.45	-179.77	90.61	-89.16	-1.02	-179.94	90.67	-89.21	-1.08	179.86	90.659	-89.70
-4	-1.39	-179.82	90.47	-89.12	-1.54	-179.97	90.59	-89.22	-1.07	179.86	90.634	-89.75
-12	-1.34	-179.88	90.14	-88.85	-2.07	-180.01	90.41	-89.09	-1.07	179.85	90.512	-89.71
-20	-1.39	-179.99	89.79	-88.37	-2.68	-180.11	90.25	-88.75	-1.17	179.77	90.436	-89.53
Linear Regression												
Slope	-8.05E-03	7.20E-03	1.76E-02	-6.98E-03	6.42E-02	4.47E-03	8.17E-03	8.78E-04	-1.11E-03	5.40E-04	1.71E-03	4.40E-03
Intercept	-1.47	-179.81	90.35	-88.86	-1.33	-179.98	90.52	-89.01	-1.12	179.83	90.55	-89.61
R^2	0.803	0.943	0.665	0.115	0.997	0.824	0.555	0.003	0.096	0.041	0.072	0.206

Interpolated JZ's Prediction

	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	Z+	Z-	X+	X-	Z+	Z-	X+	X-	Z+	Z-	X+	X-
-12	-1.37	-179.90	90.13	-88.78	-2.10	-180.03	90.42	-89.02	-1.11	179.82	90.53	-89.66
0	-1.47	-179.81	90.35	-88.86	-1.33	-179.98	90.52	-89.01	-1.12	179.83	90.55	-89.61
12	-1.57	-179.73	90.56	-88.94	-0.56	-179.92	90.62	-89.00	-1.14	179.84	90.57	-89.56

MR's Measurement

	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	Z+	Z-	X+	X-	Z+	Z-	X+	X-	Z+	Z-	X+	X-
-12	0.62	179.97	88.70	-88.96	0.46	179.81	88.98	-89.35	0.22	179.65	89.69	-89.64
0	0.49	180.10	88.81	-89.27	0.37	179.99	89.20	-89.71	0.17	179.82	89.80	-89.93
12	0.46	180.19	88.45	-89.00	0.34	180.06	89.03	-89.57	0.19	179.96	89.78	-89.87

diff=JZ-MR	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	Z+	Z-	X+	X-	Z+	Z-	X+	X-	Z+	Z-	X+	X-
-12	-2.00	0.13	1.43	0.18	-2.56	0.16	1.44	0.34	-1.33	0.18	0.84	-0.02
0	-1.96	0.08	1.54	0.41	-1.70	0.04	1.33	0.70	-1.30	0.01	0.76	0.32
12	-2.03	0.08	2.11	0.05	-0.90	0.02	1.59	0.57	-1.32	-0.13	0.79	0.32
Average	**-2.00**	**0.10**	**1.69**	**0.21**	**-1.72**	**0.07**	**1.45**	**0.54**	**-1.31**	**0.02**	**0.80**	**0.21**
Average All=	**0.19**											

Z+ and X- angles are bad, why? …….

Using M.Roy's definition

Why Z+ and X+ angles so bad?

Field Angle Prediction

Prediction	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	Z+	Z-	X+	X-	Z+	Z-	X+	X-	Z+	Z-	X+	X-
20	-0.87	179.45	91.53	-89.98	-0.87	179.45	91.53	-89.98	-0.87	179.45	91.53	-89.98
18	-0.83	179.55	91.46	-90.07	-0.83	179.55	91.46	-90.07	-0.83	179.55	91.46	-90.07
-3	-0.84	179.60	91.42	-90.14	-0.84	179.60	91.42	-90.14	-0.84	179.60	91.42	-90.14
-5	-0.86	179.64	91.38	-90.20	-0.86	179.64	91.38	-90.20	-0.86	179.64	91.38	-90.20
-18	-0.90	179.66	91.36	-90.24	-0.90	179.66	91.36	-90.24	-0.90	179.66	91.36	-90.24
-20	-1.02	179.60	91.46	-90.16	-1.02	179.60	91.46	-90.16	-1.02	179.60	91.46	-90.16
Linear Regression												
Slope	2.62E-03	-3.66E-03	2.46E-03	4.75E-03	2.62E-03	-3.66E-03	2.46E-03	4.75E-03	2.62E-03	-3.66E-03	2.46E-03	4.75E-03
Intercept	-0.88	179.58	91.44	-90.13	-0.88	179.58	91.44	-90.13	-0.88	179.58	91.44	-90.13
R^2	0.428	0.683	0.478	0.734	0.428	0.683	0.478	0.734	0.428	0.683	0.478	0.734

Interpolated JZ's Prediction

	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	Z+	Z-	X+	X-	Z+	Z-	X+	X-	Z+	Z-	X+	X-
-12	-0.91	179.62	91.41	-90.18	-0.91	179.62	91.41	-90.18	-0.91	179.62	91.41	-90.18
0	-0.88	179.58	91.44	-90.13	-0.88	179.58	91.44	-90.13	-0.88	179.58	91.44	-90.13
12	-0.85	179.53	91.47	-90.07	-0.85	179.53	91.47	-90.07	-0.85	179.53	91.47	-90.07

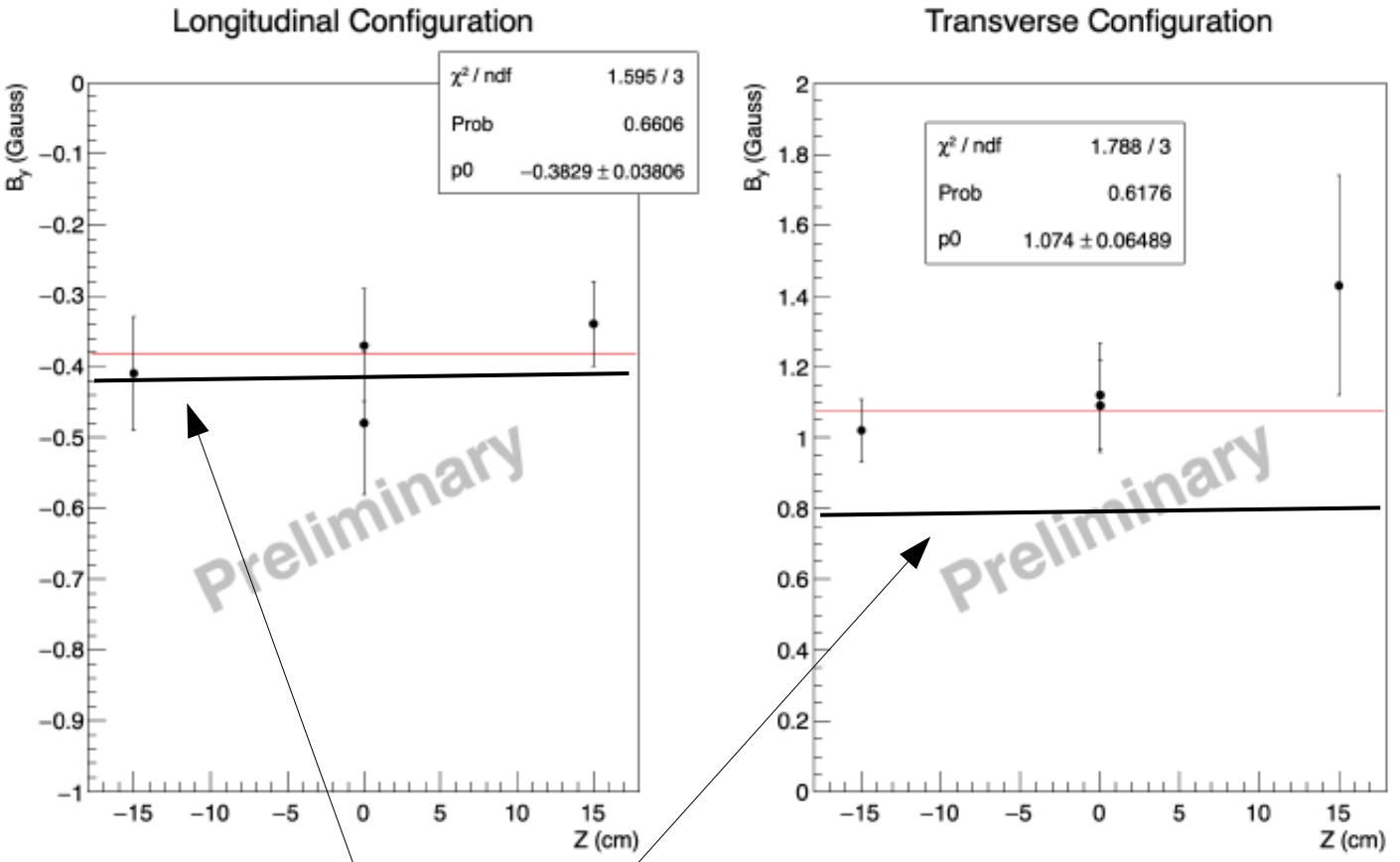
MR's Measurement

	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	Z+	Z-	X+	X-	Z+	Z-	X+	X-	Z+	Z-	X+	X-
-12	0.62	179.97	88.70	-88.96	0.46	179.81	88.98	-89.35	0.22	179.65	89.69	-89.64
0	0.49	180.10	88.81	-89.27	0.37	179.99	89.20	-89.71	0.17	179.82	89.80	-89.93
12	0.46	180.19	88.45	-89.00	0.34	180.06	89.03	-89.57	0.19	179.96	89.78	-89.87

diff=JZ-MR	12.5 deg and 7.5GeV				18deg and 5.6GeV				30deg and 3.4GeV			
z location	Z+	Z-	X+	X-	Z+	Z-	X+	X-	Z+	Z-	X+	X-
-12	-1.54	-0.34	2.70	-1.22	-1.38	-0.18	2.43	-0.83	-1.13	-0.03	1.72	-0.54
0	-1.37	-0.52	2.63	-0.86	-1.25	-0.41	2.24	-0.42	-1.06	-0.24	1.64	-0.20
12	-1.31	-0.66	3.02	-1.07	-1.19	-0.53	2.44	-0.50	-1.04	-0.43	1.69	-0.20
Average	**-1.41**	**-0.51**	**2.78**	**-1.05**	**-1.27**	**-0.37**	**2.37**	**-0.58**	**-1.07**	**-0.23**	**1.68**	**-0.31**
Average All=	**0.13**											

VL, VS, HB, HLCC, HSCC are all set to 0, only Bg + HL + HS are on

Compare to Bill's Measurements



- A 1-D probe was used to measure By at the z = 0 and 15 cm along the beam line for 180 and 270 degrees polarities. The SHMS was at 30 degrees and the HB was powered to 3.4 GeV/c.
- Log entry: https://logbooks.jlab.org/entry/3804362

- The super TOSCA model predicted the vertical field averaged along the beam line is 0.771 Gauss at 270 degrees polarity and -0.421 Gauss at 180 degrees polarity.

Error Analysis

- Accuracy of horizontal coils (HL + HS) → < 0.36 Gauss
- Accuracy of vertical coils (VL + VS) → < 2%, or < 0.2 Gauss for 7A current
- Accuracy of horizontal correction coils (HLCC + HSCC) → < 0.13 Gauss for 2A current
- Accuracy of horizontal bender field (HB) → < 0.23 Gauss for 7.5GeV setting
- Accuracy of Bg → 0.13 Gauss
- **Accuracy of all → 0.39 Gauss**

D2N Field mapping Analysis Status

1. Field mapping was done in z range from -10 to 30, in a gap of 10c. But probe orientation have changed
2. Existing single coil TOSCA maps do not cover this range. I need to re run TOSCA for each coil to generate new maps
3. Repeat all analysis to determine NEW probe orientation??? (Maybe not…, too much work and very little to discover)
4. Determine TOSCA maps current for HL and HS coils
5. Adopt python code to create some Super-TOSCA-Modles for D2N

result.txt - Notepad

File Edit Format View Help

D:\work\mapping2020\HS_7.4A

x	y	z	Btot	Bx	By	Bz	Comment
-10	0	-10	26.049	-0.365	-0.136	26.046	0
-10	0	0	25.963	-0.252	-0.123	25.961	0
-10	0	10	26.140	-0.266	-0.086	26.139	0
-10	0	20	26.356	-0.437	-0.342	26.350	0
-10	0	30	25.971	-0.827	-0.962	25.940	0
0	0	-10	26.061	-0.368	-0.130	26.058	0
0	0	0	26.038	-0.319	-0.154	26.035	0
0	0	10	26.182	-0.359	-0.180	26.179	0
0	0	20	26.248	-0.371	-0.436	26.242	0
0	0	30	25.751	-0.355	-1.000	25.729	0
0	10	-10	25.960	-0.376	-0.125	25.957	0
0	10	0	25.990	-0.334	-0.180	25.987	0
0	10	10	26.040	-0.366	-0.251	26.036	0
0	10	20	25.929	-0.357	-0.318	25.924	0
0	10	30	25.263	-0.345	-0.448	25.256	0
0	25	-10	25.912	-0.383	-0.101	25.908	0
0	25	0	25.920	-0.335	-0.113	25.918	0
0	25	10	26.015	-0.368	-0.188	26.011	0
0	25	20	25.970	-0.393	-0.034	25.967	0
0	25	30	25.376	-0.361	0.391	25.371	0
10	0	-10	26.092	-0.398	-0.168	26.088	0
10	0	0	25.988	-0.394	-0.154	25.985	0
10	0	10	26.201	-0.487	-0.133	26.196	0
10	0	20	26.400	-0.352	-0.360	26.395	0
10	0	30	25.963	0.078	-0.971	25.944	0
0	0	30	25.688	-0.380	-0.987	25.666	check2
0	0	30	25.747	-0.360	-0.984	25.726	check3

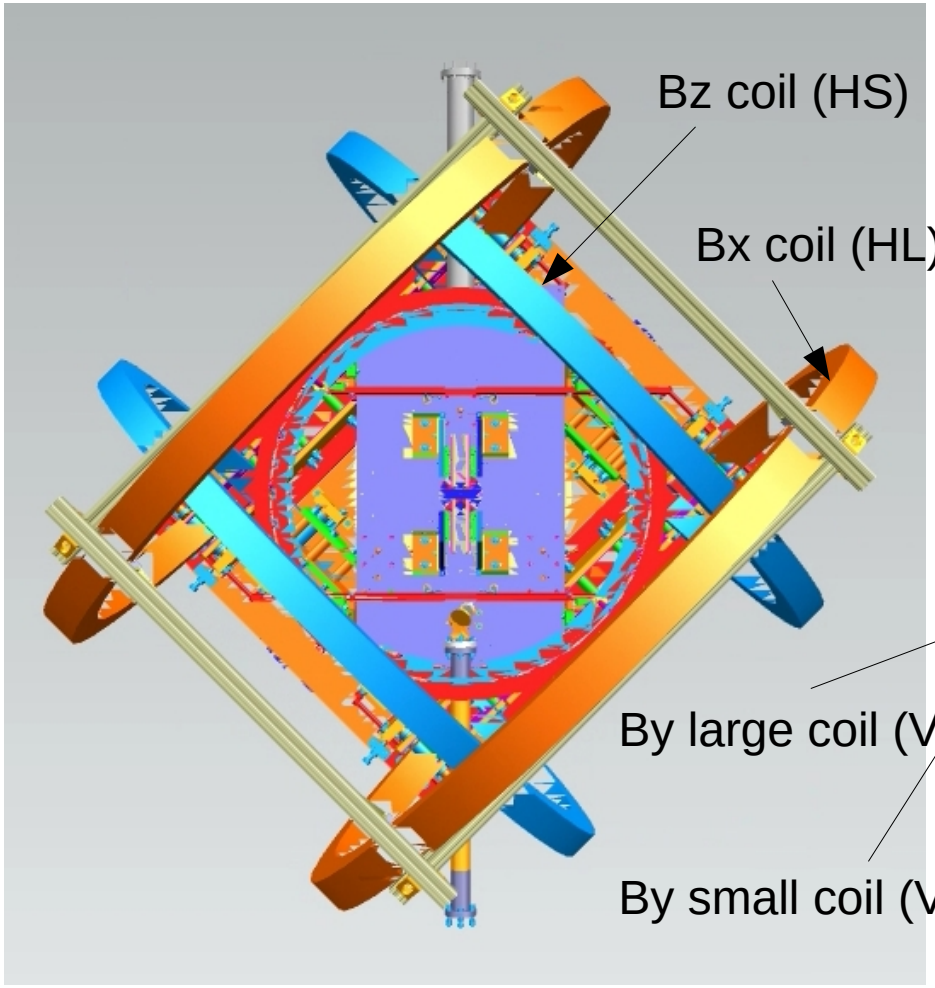
Summary

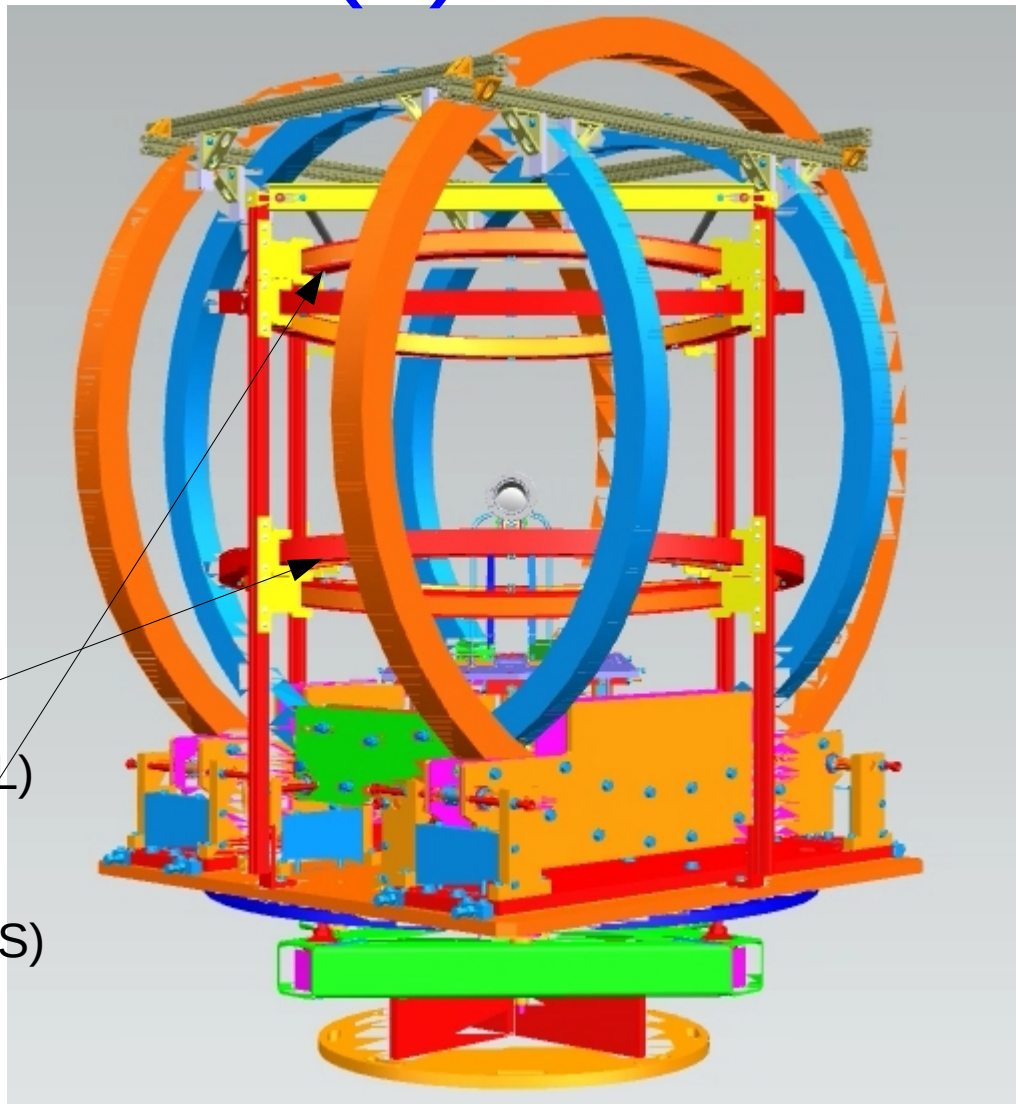
- Helium3 target coils and field mapping devices are introduced.
- How to determine current for each single coil TOSCA map is introduced
- Detailed how to model background field and HB field
- Probe orientation is determined
- Interactive TOSCA models are created using excel
- Super-TOSCA-Models are created using python code
- Did comparison to compass measurement
- Compare to vertical field measurement
- Error analysis is done for each set of coils
- D2N field mapping analysis is on-going, can be finished in a few weeks

- Analysis tech-note for A1N is ready online (in overleaf). 46 pages! I still need to include some appendix.

Back Up

Coil definitions (1)





Coil definitions (2)

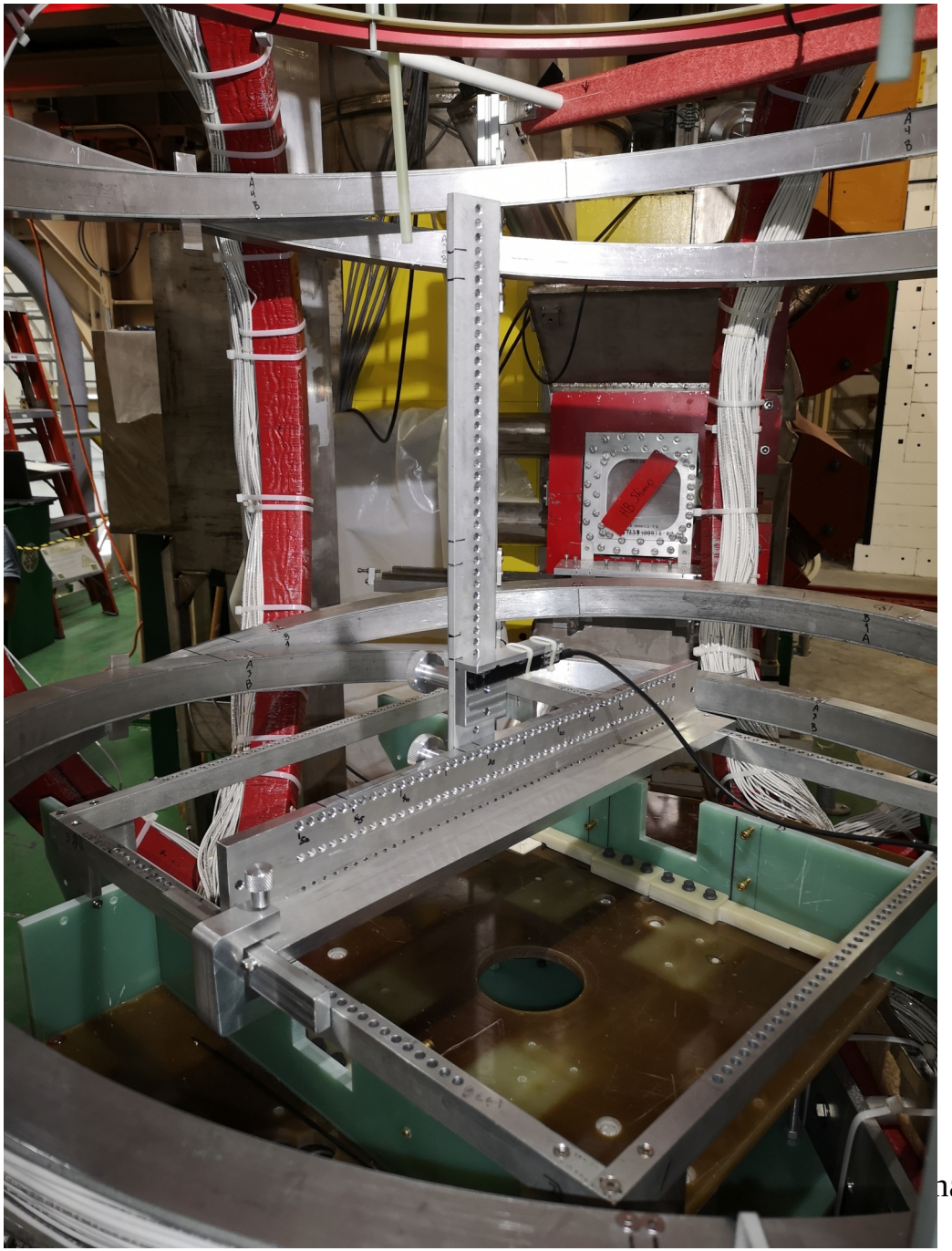
Bz coil (HS)
BzCC (HSCC) (white)

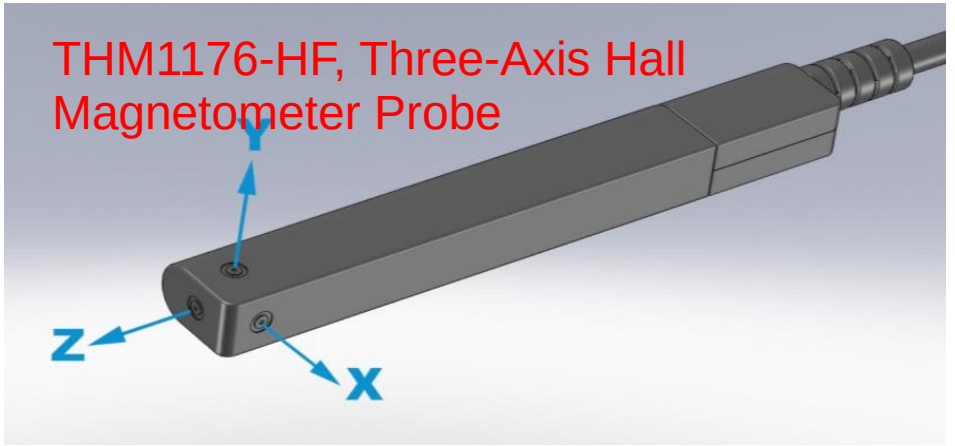
Bx coil (HL)
BxCC (HLCC) (white)

By small coil (VS)

By large coil (VL)

Experiment Setup





Definition of field directions

- Original raw data:
  - Position: looking downstream, x in to beam right, y is vertical up, z is pointing upstream.

    (X=0,y=4,Z=25) is most close to the pivot
  - Field: Bx is vertical up, By is beam left, Bz is upstream
- I have flipped position and field into Lab coordinate system in my report.

Determine TOSCA Map Current: HB

/home/jixie/DISK/work/A1N/FieldAna/A1NMap_jixie/30deg_HB3.4_rotated_3_lines.txt

I_(A)= 1127.68

TOSCA: HB Coil with Steel, P0=3.4 GeV/c **z_off(cm) = -2.00** **sign= 1**

Position (cm)			Measurement				TOSCA, HB coil only					
x	y	z	B_data	Bx	By	+Bz	B_t	Bx	By	+Bz	Ratio	z_true
0	-0.07	19.95	1.106	0.004	1.102	-0.093	1.076	-0.160	1.059	-0.096	1.028	17.95
0	-0.06	17.95	1.039	0.010	1.038	-0.058	1.020	-0.154	1.004	-0.090	1.019	15.95
0	0.01	-3.05	0.562	-0.001	0.562	-0.022	0.592	-0.104	0.581	-0.045	0.949	-5.05
0	0.02	-5.05	0.503	-0.037	0.500	-0.034	0.564	-0.100	0.553	-0.042	0.893	-7.05
0	0.06	-18.05	0.366	-0.040	0.362	-0.034	0.411	-0.079	0.403	-0.024	0.890	-20.05
0	0.07	-20.05	0.379	-0.007	0.378	0.019	0.392	-0.076	0.384	-0.022	0.968	-22.05

Note: Ratio = B_data / B_tosca, B_tosca_scaled = B_tosca * <Ratio> **average=** **0.958** **--> New_I= 1,177.430**

/home/jixie/DISK/work/A1N/FieldAna/D2NMap_jixie/18deg_HB5p6_rotated_3_lines.txt

I_(A)= 1877.1

TOSCA: HB Coil with Steel, P0=5.6 GeV/c **z_off(cm) = -2.0** **sign= 1**

Position (cm)			Measurement				TOSCA, HB coil only					
x	y	z	B_data	Bx	By	+Bz	B_t	Bx	By	+Bz	Ratio	z_true
0	-0.07	19.95	2.358	-0.055	2.354	-0.115	2.053	-0.236	2.029	-0.205	1.149	17.95
0	-0.06	17.95	2.214	-0.059	2.211	-0.108	1.930	-0.226	1.907	-0.193	1.147	15.95
0	0.01	-3.05	1.205	-0.047	1.204	-0.027	1.043	-0.149	1.028	-0.092	1.156	-5.05
0	0.02	-5.05	1.113	-0.050	1.111	-0.039	0.988	-0.143	0.974	-0.084	1.127	-7.05
0	0.06	-18.05	0.841	-0.026	0.840	0.005	0.701	-0.110	0.691	-0.041	1.199	-20.05
0	0.07	-20.05	0.796	-0.011	0.796	0.000	0.664	-0.106	0.655	-0.036	1.198	-22.05

Note: Ratio = B_data / B_tosca, B_tosca_scaled = B_tosca * <Ratio> **average=** **1.163** **--> New_I= 1,614.323**

/home/jixie/DISK/work/A1N/FieldAna/A1NMap_jixie/12p5deg_HB7.5_June_J14724_rotated_3_lines.txt

I_(A)= 2552.33

TOSCA: HB Coil with Steel, P0=7.5 GeV/c **z_off(cm) = -2.00** **sign= 1**

Position (cm)			Measurement				TOSCA, HB coil only					
x	y	z	B_data	Bx	By	+Bz	B_t	Bx	By	+Bz	Ratio	z_true
0	-0.07	19.95	3.020	-0.049	3.004	-0.305	2.635	-0.307	2.575	-0.467	1.146	17.95
0	-0.06	17.95	2.850	-0.038	2.832	-0.319	2.462	-0.295	2.404	-0.444	1.157	15.95
0	0.01	-3.05	1.502	-0.012	1.495	-0.145	1.244	-0.197	1.200	-0.263	1.207	-5.05
0	0.02	-5.05	1.400	-0.015	1.393	-0.133	1.171	-0.190	1.128	-0.250	1.195	-7.05
0	0.06	-18.05	0.992	0.016	0.988	-0.090	0.795	-0.150	0.760	-0.179	1.248	-20.05
0	0.07	-20.05	0.965	0.000	0.961	-0.085	0.746	-0.144	0.713	-0.169	1.293	-22.05

Note: Ratio = B_data / B_tosca, B_tosca_scaled = B_tosca * <Ratio> **average=** **1.208** **--> New_I= 2,113.426**

Determine TOSCA Map Current: HLHS

Position (cm)			TOSCA, HS coil, J=-28				TOSCA, HL coil,J=+26			
x	y	z	B_data	Bx	By	+Bz	B_t	Bx	By	+Bz
0	0	20	17.953	12.624	0.061	-12.765	18.702	-13.162	-0.010	-13.286
0	0	18	17.911	12.592	0.051	-12.738	18.674	-13.138	-0.017	-13.271
0	0	-3	17.787	12.484	0.030	-12.670	18.621	-13.062	-0.051	-13.271
0	0	-5	17.793	12.492	0.031	-12.670	18.630	-13.069	-0.054	-13.277
0	0	-18	17.920	12.616	0.008	-12.726	18.730	-13.167	-0.074	-13.321
0	0	-20	17.970	12.652	-0.002	-12.761	18.762	-13.193	-0.080	-13.340

dBx ~= sin(yaw)*Bz0

dBy ~= sin(roll)*Bx0

Calculated J_HS= -28.7420 +|- 0.21 Calculated J_HL= 25.6283 +|- 0.20

Fitted J_HS= -28.7420 +|- 0.20 Fitted J_HL= 25.6283 +|- 0.19

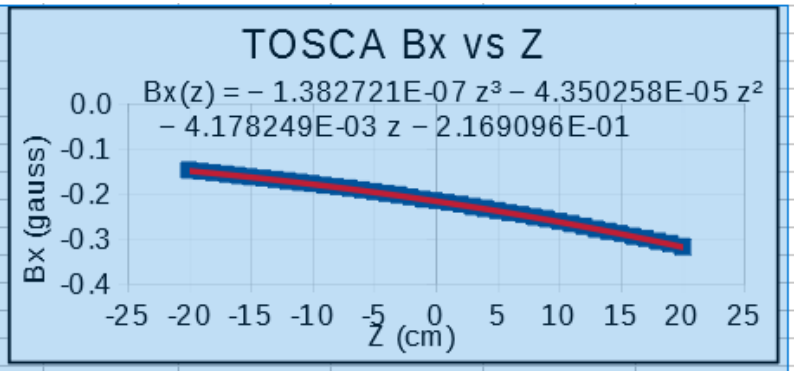
Position (cm)			Rotated to Lab: Measurement (0 deg)				TOSCA, -HL_scaled - HS_scaled				measurement - TOSCA				
x	y	z	B	Bx	By	+Bz	B	Bx	By	+Bz	dBtot	dBx	dBy	dBz	Yaw
0	0	20	25.760	-0.222	-0.041	25.759	26.199	0.015	-0.053	26.199	-0.44	-0.24	0.01	-0.44	-0.52
0	0	18	25.697	-0.224	-0.066	25.696	26.157	0.024	-0.036	26.157	-0.46	-0.25	-0.03	-0.46	-0.54
0	0	-3	25.641	-0.175	-0.165	25.640	26.087	0.060	0.019	26.087	-0.45	-0.23	-0.18	-0.45	-0.52
0	0	-5	25.652	-0.143	-0.213	25.651	26.093	0.059	0.021	26.093	-0.44	-0.20	-0.23	-0.44	-0.44
0	0	-18	25.809	-0.238	-0.181	25.808	26.194	0.028	0.065	26.194	-0.38	-0.27	-0.25	-0.39	-0.58
0	0	-20	25.874	-0.196	-0.170	25.873	26.249	0.017	0.081	26.248	-0.37	-0.21	-0.25	-0.38	-0.47
			25.74				**26.16**			**Mean:**	**-0.42**	**-0.23**	**-0.16**	**-0.43**	**-0.51**

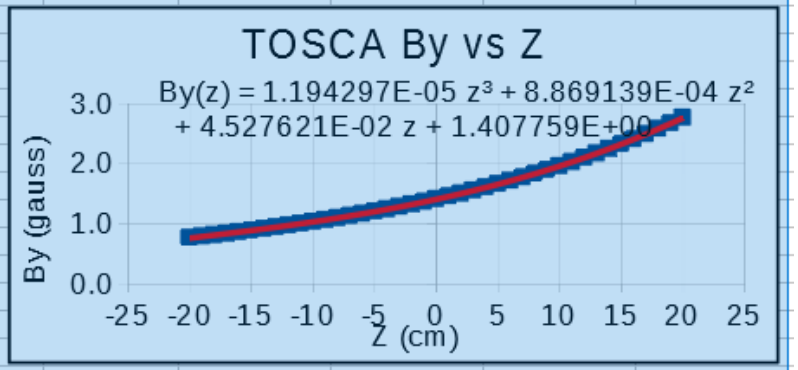
Position (cm)			Rotated to Lab: Measurement (180 deg)				TOSCA, HL_scaled + HS_scaled				measurement - TOSCA				
x	y	z	B	Bx	By	+Bz	B	Bx	By	+Bz	dBtot	dBx	dBy	dBz	Yaw
0	0	20	26.076	0.173	-0.157	-26.075	26.199	-0.015	0.053	-26.199	-0.12	0.19	-0.21	0.12	-0.41
0	0	18	26.038	0.170	-0.146	-26.037	26.157	-0.024	0.036	-26.157	-0.12	0.19	-0.18	0.12	-0.43
0	0	-3	25.889	0.107	-0.076	-25.888	26.087	-0.060	-0.019	-26.087	-0.20	0.17	-0.06	0.20	-0.37
0	0	-5	25.885	0.087	-0.023	-25.884	26.093	-0.059	-0.021	-26.093	-0.21	0.15	0.00	0.21	-0.32
0	0	-18	26.030	0.152	-0.071	-26.029	26.194	-0.028	-0.065	-26.194	-0.16	0.18	-0.01	0.16	-0.40
0	0	-20	26.102	0.132	-0.094	-26.102	26.249	-0.017	-0.081	-26.248	-0.15	0.15	-0.01	0.15	-0.32
			26.00				**26.16**			**Mean:**	**-0.16**	**0.17**	**-0.08**	**0.16**	**-0.37**

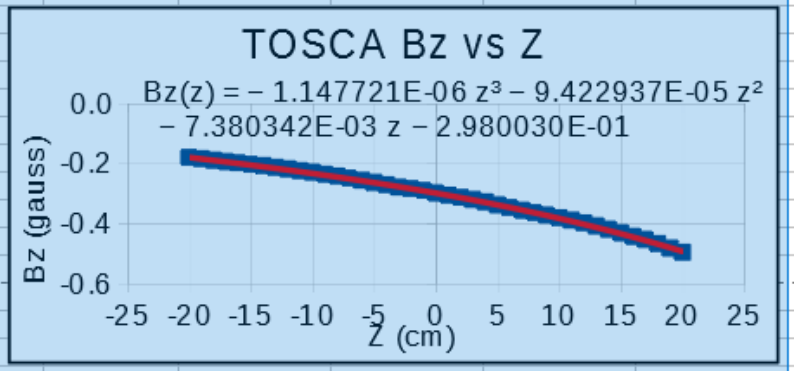
Position (cm)			Rotated to Lab: Measurement (90 deg)				TOSCA, HL_scaled - HS_scaled				measurement - TOSCA				
x	y	z	B	Bx	By	+Bz	B	Bx	By	+Bz	dBtot	dBx	dBy	dBz	Roll
0	0	20	25.930	25.930	-0.011	-0.146	25.932	25.932	0.072	-0.007	0.00	**0.00**	-0.08	-0.14	-0.18
0	0	18	25.871	25.871	0.003	-0.114	25.876	25.876	0.069	0.006	0.00	**0.00**	-0.07	-0.12	-0.15
0	0	-3	25.613	25.612	0.106	-0.079	25.690	25.690	0.081	0.075	-0.08	**-0.08**	0.02	-0.15	0.05
0	0	-5	25.628	25.628	0.097	-0.117	25.705	25.705	0.085	0.081	-0.08	**-0.08**	0.01	-0.20	0.03
0	0	-18	25.868	25.868	0.078	-0.074	25.929	25.929	0.081	0.067	-0.06	**-0.06**	0.00	-0.14	-0.01
0	0	-20	25.932	25.932	0.101	-0.129	25.992	25.992	0.077	0.050	-0.06	**-0.06**	0.02	-0.18	0.05
			25.81				**25.85**			**Mean:**	**-0.05**	**-0.05**	**-0.02**	**-0.16**	**-0.03**

Modeling the HB Field: 12.5 deg

TOSCA, HB coil only						
z	z^2	z^3	B	Bx	By	Bz
20	400	8000	2.829	-0.319	2.767	-0.497
19	361	6859	2.733	-0.312	2.672	-0.483
18	324	5832	2.641	-0.307	2.581	-0.468
17	289	4913	2.551	-0.301	2.492	-0.454
16	256	4096	2.465	-0.296	2.407	-0.444
15	225	3375	2.383	-0.290	2.325	-0.432
14	196	2744	2.303	-0.285	2.246	-0.420
13	169	2197	2.227	-0.280	2.171	-0.409
12	144	1728	2.152	-0.274	2.097	-0.399
11	121	1331	2.081	-0.268	2.026	-0.390
10	100	1000	2.013	-0.263	1.959	-0.382
9	81	729	1.947	-0.257	1.894	-0.373
8	64	512	1.885	-0.253	1.832	-0.365
7	49	343	1.825	-0.248	1.772	-0.357
6	36	216	1.767	-0.244	1.715	-0.348
5	25	125	1.712	-0.239	1.661	-0.339
4	16	64	1.656	-0.234	1.606	-0.329
3	9	27	1.602	-0.230	1.553	-0.321
2	4	8	1.552	-0.225	1.503	-0.314
1	1	1	1.504	-0.221	1.456	-0.307
0	0	0	1.458	-0.217	1.410	-0.299
-1	1	-1	1.412	-0.214	1.365	-0.291
-2	4	-8	1.368	-0.209	1.322	-0.285
-3	9	-27	1.327	-0.204	1.281	-0.280
-4	16	-64	1.287	-0.201	1.242	-0.272
-5	25	-125	1.247	-0.197	1.203	-0.264
-6	36	-216	1.209	-0.193	1.165	-0.257
-7	49	-343	1.173	-0.189	1.130	-0.250
-8	64	-512	1.137	-0.186	1.095	-0.243
-9	81	-729	1.103	-0.183	1.062	-0.237
-10	100	-1000	1.070	-0.179	1.030	-0.230
-11	121	-1331	1.040	-0.176	1.000	-0.225
-12	144	-1728	1.009	-0.173	0.970	-0.219
-13	169	-2197	0.980	-0.170	0.941	-0.214
-14	196	-2744	0.951	-0.167	0.913	-0.208
-15	225	-3375	0.924	-0.164	0.886	-0.204
-16	256	-4096	0.897	-0.161	0.860	-0.199
-17	289	-4913	0.872	-0.158	0.835	-0.195
-18	324	-5832	0.847	-0.155	0.811	-0.190
-19	361	-6859	0.824	-0.152	0.788	-0.185
-20	400	-8000	0.800	-0.149	0.765	-0.181







3rd order polynomial fit

	p3	p2	p1	p0
Btot	1.19579E-05	8.88815E-04	4.59370E-02	1.45517E+00
Bx	-1.38272E-07	-4.35026E-05	-4.17825E-03	-2.16910E-01
By	1.19430E-05	8.86914E-04	4.52762E-02	1.40776E+00
Bz	-1.14772E-06	-9.42294E-05	-7.38034E-03	-2.98003E-01

This is how I deal with HB field at various z location

All angle settings will repeat this process

Fit Probe Orientation by VL

Vertical_Large_Coil_Only

/home/jixie/DISK/work/A1N/mapping/ByCC/ByCC_Large_6.4A_new/result_rot.txt

TOSCA: Vertical Large Coil with Steel, J=-28A/cm^2

I_(A)= -6.52 range= B3:H8

sign= -1

Position (cm)			Measurement				TOSCA, VL coil only				
x	y	z	B_data	Bx	By	+Bz	B_t	Bx	By	+Bz	Ratio
0	-0.07	19.95	7.936	0.297	7.914	-0.511	7.673	-0.014	-7.660	0.439	1.034
0	-0.06	17.95	7.868	0.302	7.848	-0.48	7.597	-0.013	-7.585	0.424	1.036
0	0.01	-3.05	7.334	0.281	7.324	-0.269	7.084	-0.007	-7.078	0.282	1.035
0	0.02	-5.05	7.313	0.291	7.303	-0.243	7.055	-0.006	-7.050	0.277	1.037
0	0.06	-18.1	7.221	0.316	7.204	-0.381	6.922	-0.004	-6.913	0.362	1.043
0	0.07	-20.1	7.193	0.292	7.174	-0.436	6.904	-0.003	-6.892	0.401	1.042
Note: Ratio = B_data / B_tosca, B_tosca_scaled = B_tosca * <Ratio>										average=	1.038

old_J= -28.000

--> New_J= 29.059

--> New_I= 6.282

Rotate back to the hall coordinate system.

deg: pitch= -0.066 yaw= 1.211 roll= -2.276

rad: gamma= -0.00115 beta= 0.02114 alpha= -0.03972

Rotation matrix:

$$R^{-1} = \begin{pmatrix} 0.9990 & -0.0397 & -0.0211 \\ 0.0397 & 0.9992 & -0.0012 \\ 0.0212 & 0.0003 & 0.9998 \end{pmatrix}$$

Final Result			
	optimized	min	max
pitch	-0.066	-0.347	0.232
yaw	1.211	-2.081	4.167
roll	-2.276	-2.437	-2.126

Position (cm)			Rotated Data				Scaled TOSCA				Rotated_Data – Scaled_TOSCA			
x	y	z	Btot	Bx	By	+Bz	Btot	Bx	By	+Bz	dBtot	dBx	dBy	dBz
0	0	20	7.936	-0.007	7.920	-0.502	7.963	0.015	7.950	-0.456	-0.027	-0.021	-0.030	-0.047
0	0	18	7.868	0.000	7.854	-0.471	7.884	0.013	7.872	-0.440	-0.016	-0.013	-0.018	-0.031
0	0	-3	7.334	-0.004	7.330	-0.261	7.352	0.007	7.346	-0.293	-0.017	-0.012	-0.016	0.032
0	0	-5	7.313	0.006	7.309	-0.235	7.322	0.006	7.317	-0.287	-0.009	0.000	-0.008	0.053
0	0	-18	7.221	0.038	7.211	-0.372	7.184	0.004	7.174	-0.376	0.037	0.034	0.037	0.004
0	0	-20	7.193	0.016	7.180	-0.427	7.165	0.003	7.153	-0.416	0.028	0.013	0.028	-0.011
										Mean:	-0.001	0.000	-0.001	0.000
										Sigma:	0.026	0.020	0.027	0.038

How to fit?

1. Set pitch=0.0, yaw=0.0; adjust roll such that <dBy>~=0.00 or minimum. Adjust yaw to let <dBx>~=0.00. Then adjust pitch to let <dBz>~=0.00. (<dBx> is sensitive to yaw and roll. <dBy> is sensitive to roll. <dBz> is sensitive pitch.)

2. Using +/- Sigma as the upper and lower limit, adjust mean to match Sigma to estimate the uncertainties.

A). Fixed yaw and roll as values determined by 1), adjust ptich to let <dBz> match +/-Sigma, these 2 values are the min and max of pitch.

B). Fixed pitch and roll as values determined by 3), adjust yaw to let <dBx> match +/-Sigma, these 2 values are the min and max of yaw.

C). Fixed pitch and yaw as values determined by 3), adjust roll to let <dBx> match +/-Sigma, these 2 values are the min and max of roll.

Accuracy of the Main Holding Field (90deg)

The accuracy of Btot is about 0.31 gauss

Position (cm)			Mag Field (G)			
x	y	z	B	By	Bx	Bz
0	0	20	26.147	-1.181	26.113	0.610
0	0	18	26.088	-1.209	26.053	0.631
0	0	-3	25.792	-1.098	25.759	0.679
0	0	-5	25.805	-1.080	25.773	0.666
0	0	-18	26.032	-1.092	26.000	0.714
0	0	-20	26.106	-1.118	26.073	0.685
0	2	20	26.086	-1.154	26.054	0.614
0	2	18	26.031	-1.150	25.998	0.626
0	2	-3	25.794	-1.086	25.762	0.668
0	2	-5	25.800	-1.070	25.769	0.690
0	2	-18	25.976	-1.080	25.943	0.711
0	2	-20	26.048	-1.070	26.016	0.724
2	0	20	26.133	-1.205	26.095	0.719
2	0	18	26.055	-1.205	26.017	0.711
2	0	-3	25.796	-1.035	25.766	0.700
2	0	-5	25.802	-1.058	25.772	0.676
2	0	-18	26.022	-1.140	25.988	0.676
2	0	-20	26.089	-1.187	26.055	0.611

predict

-

Position (cm)			Mag Field (G)			
x	y	z	Btot	By	Bx	+Bz
0	0	20	25.932	-1.025	25.907	0.448
0	0	18	25.872	-1.01	25.848	0.479
0	0	-3	25.614	-0.897	25.593	0.509
0	0	-5	25.629	-0.906	25.609	0.472
0	0	-18	25.869	-0.935	25.847	0.52
0	0	-20	25.934	-0.915	25.913	0.466
0	2	20	25.886	-1.012	25.862	0.45
0	2	18	25.833	-0.989	25.809	0.489
0	2	-3	25.613	-0.902	25.593	0.504
0	2	-5	25.635	-0.91	25.614	0.503
0	2	-18	25.811	-0.917	25.789	0.538
0	2	-20	25.88	-0.935	25.858	0.492
2	0	20	25.909	-1.056	25.882	0.528
2	0	18	25.833	-1.058	25.805	0.545
2	0	-3	25.608	-0.884	25.588	0.496
2	0	-5	25.627	-0.866	25.607	0.492
2	0	-18	25.848	-0.968	25.826	0.457
2	0	-20	25.911	-0.988	25.888	0.42

real

=

Mag Field (G)			
B	By	Bx	Bz
0.305	-0.156	0.206	0.162
0.324	-0.199	0.205	0.152
0.311	-0.201	0.166	0.170
0.308	-0.174	0.164	0.194
0.292	-0.157	0.153	0.194
0.339	-0.203	0.160	0.219
0.289	-0.142	0.192	0.164
0.284	-0.161	0.189	0.137
0.300	-0.184	0.169	0.164
0.291	-0.160	0.155	0.187
0.284	-0.163	0.154	0.173
0.311	-0.135	0.158	0.232
0.322	-0.149	0.213	0.191
0.307	-0.147	0.212	0.166
0.310	-0.151	0.178	0.204
0.313	-0.192	0.165	0.184
0.323	-0.172	0.162	0.219
0.323	-0.199	0.167	0.191

predict - real

direction		<dB>	<dBy>	<dBx>	<dBz>
x+	Mean:	0.305	-0.169	0.176	0.183
	Sigma:	0.015	0.022	0.021	0.025

- Field measured for Bx coil = 7.077 A

- Field measured for Bz coil = -7.169 A

- Predicted fields for Bx coil = 5.163 A, Bz coil = -5.231 A

- compare prediction to real measurement

Accuracy of the Main Holding Field (all 4 polarities)

The accuracy of Btot is about 0.36 gauss

Helmholtz coil prediction offsets
predict – real

direction	<dB>	<dBy>	<dBx>	<dBz>
z+	0.357	0.146	0.236	0.224
z-	0.203	0.092	-0.165	-0.072
x+	0.305	-0.169	0.176	0.183
x-	0.312	0.200	-0.175	-0.163

Helmholtz coil prediction Standard Deviation
predict – real

direction	<dB>	<dBy>	<dBx>	<dBz>
z+	0.029	0.030	0.016	0.029
z-	0.025	0.034	0.017	0.033
x+	0.015	0.022	0.021	0.025
x-	0.020	0.025	0.015	0.053

Accuracy of the Horizontal Correction Coils

The accuracy of Btot is about 0.13 gauss

Horizontal correction coils prediction offsets
predict – real

direction	<dB>	<dBy>	<dBx>	<dBz>
++	0.128	-0.021	0.085	-0.093
+-	0.070	0.066	-0.004	0.023
-+	0.118	-0.108	0.046	0.009
--	0.096	-0.072	-0.030	-0.056

Horizontal correction coils prediction Standard Deviation
predict – real

direction	<dB>	<dBy>	<dBx>	<dBz>
++	0.044	0.039	0.022	0.053
+-	0.023	0.027	0.019	0.021
-+	0.019	0.031	0.025	0.036
--	0.023	0.017	0.020	0.021

- Field measured for BxCC at +/-2.0A

- Field measured for BzCC at +/-2.0A

- Field measured for BxCC and BzCC both coils on (at +/- 2.0A) for 4 polarities: ++,+-,-+,--

- Predicted fields for all these 4 polarities: ++,+-,-+,--

- Compare prediction to real measurements

Accuracy of the HB Field

The accuracy of Btot is about 0.24 gauss for 7.5GeV setting

/home/jixie/DISK/work/A1N/FieldAna/A1NMap_jixie/12p5deg_HB7.5_June_J14724_rotated_3_lines.txt **I_(A)= 2552.33**

TOSCA: HB Coil with Steel, P0=7.5 GeV/c **z_off(cm) = -2.00** **sign= 1**

Position (cm)			Measurement				TOSCA, HB coil only					
x	y	z	B_data	Bx	By	+Bz	B_t	Bx	By	+Bz	Ratio	z_true
0	-0.07	19.95	3.020	-0.049	3.004	-0.305	2.635	-0.307	2.575	-0.467	1.146	17.95
0	-0.06	17.95	2.850	-0.038	2.832	-0.319	2.462	-0.295	2.404	-0.444	1.157	15.95
0	0.01	-3.05	1.502	-0.012	1.495	-0.145	1.244	-0.197	1.200	-0.263	1.207	-5.05
0	0.02	-5.05	1.400	-0.015	1.393	-0.133	1.171	-0.190	1.128	-0.250	1.195	-7.05
0	0.06	-18.05	0.992	0.016	0.988	-0.090	0.795	-0.150	0.760	-0.179	1.248	-20.05
0	0.07	-20.05	0.965	0.000	0.961	-0.085	0.746	-0.144	0.713	-0.169	1.293	-22.05

Note: Ratio = B_data / B_tosca, B_tosca_scaled = B_tosca * <Ratio> **average= 1.208** **--> New_I= 2,113.426**

Rotate back to the hall coordinate system.

deg: pitch= 0.580 yaw= -1.190 roll= -2.250

rad: gamma= 0.01012 beta= -0.02077 alpha= -0.03927

Rotation matrix:

$$R^{-1} = \begin{pmatrix} 0.9990 & -0.0393 & 0.0208 \\ 0.0390 & 0.9992 & 0.0101 \\ -0.0211 & -0.0093 & 0.9997 \end{pmatrix}$$

Position (cm)			Rotated Data				Scaled TOSCA				Rotated_Data – Scaled_TOSCA			
x	y	z	Btot	Bx	By	+Bz	Btot	Bx	By	+Bz	dBtot	dBx	dBy	dBz
0	0	17.95	3.020	-0.173	2.997	-0.332	3.183	-0.370	3.110	-0.565	-0.163	0.197	-0.114	0.233
0	0	15.95	2.850	-0.156	2.825	-0.344	2.974	-0.356	2.903	-0.537	-0.124	0.201	-0.078	0.192
0	0	-5.05	1.502	-0.074	1.492	-0.159	1.503	-0.238	1.449	-0.318	-0.001	0.164	0.042	0.159
0	0	-7.05	1.399	-0.072	1.390	-0.146	1.415	-0.229	1.363	-0.302	-0.015	0.157	0.027	0.157
0	0	-20.05	0.992	-0.025	0.987	-0.100	0.960	-0.181	0.918	-0.216	0.032	0.156	0.069	0.116
0	0	-22.05	0.965	-0.039	0.959	-0.094	0.901	-0.174	0.861	-0.204	0.063	0.135	0.099	0.110
										Mean:	**-0.035**	**0.168**	**0.008**	**0.161**
										Sigma:	**0.089**	**0.026**	**0.085**	**0.046**

Offsets and By Background

dB	dBy	dBx	dBz	
0.160	-0.083	-0.136	0.016	before – after

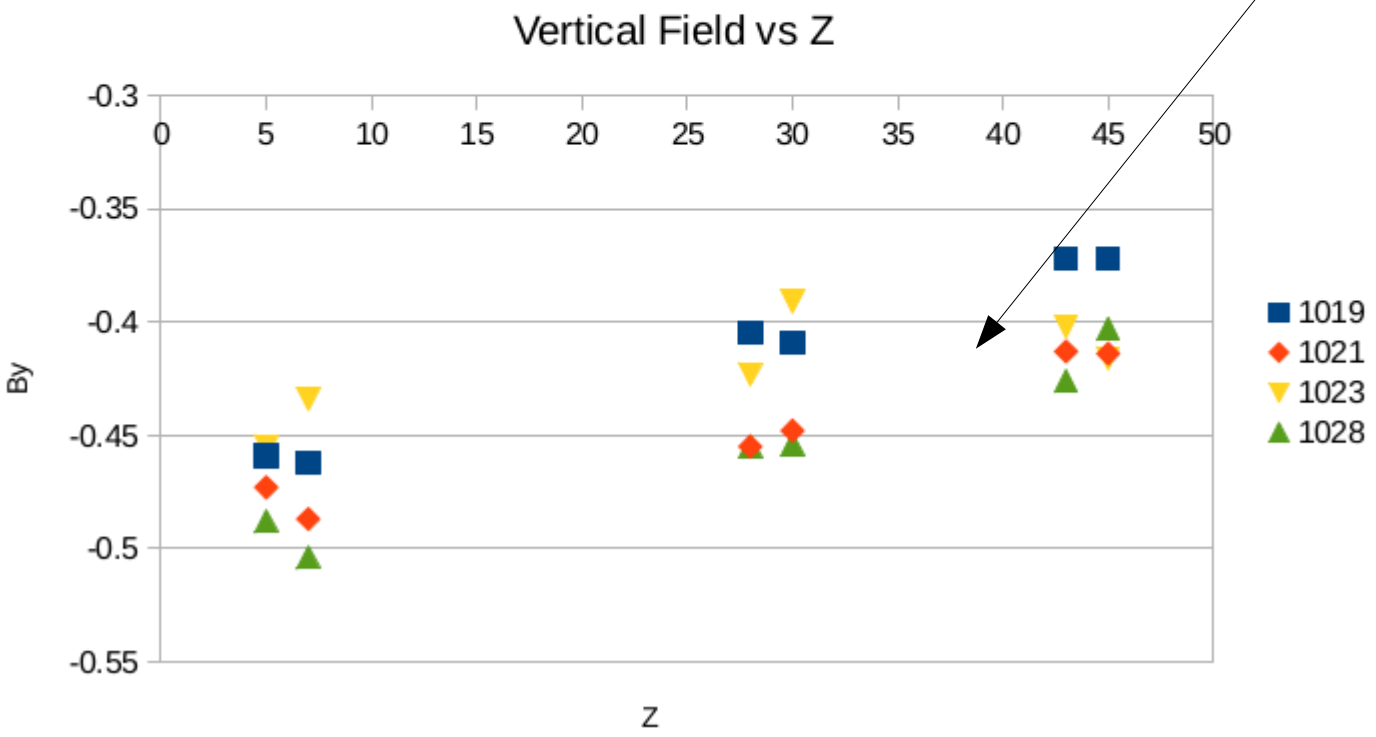
Offsets of 3-D probe itself before and after zero calibration in EEL building after all field mapping is done

Applied in analysis

vertical field

z	1019	1021	1023	1028
5	-0.459	-0.473	-0.455	-0.488
7	-0.462	-0.487	-0.434	-0.504
28	-0.405	-0.455	-0.423	-0.455
30	-0.409	-0.448	-0.391	-0.454
43	-0.372	-0.413	-0.402	-0.426
45	-0.372	-0.414	-0.416	-0.403

Background in By



- **By changes about 0.06 gauss from day to day**
- **By has z dependence**
- **Background on 10/19 was used in analysis**

Bx and Bz Background

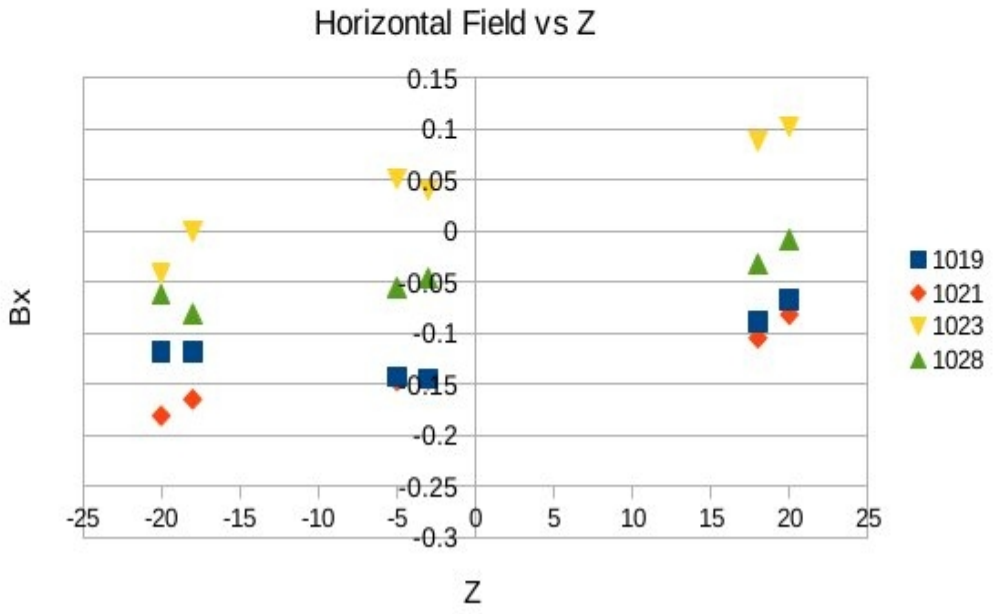
The accuracy of Btot is about 0.13 gauss

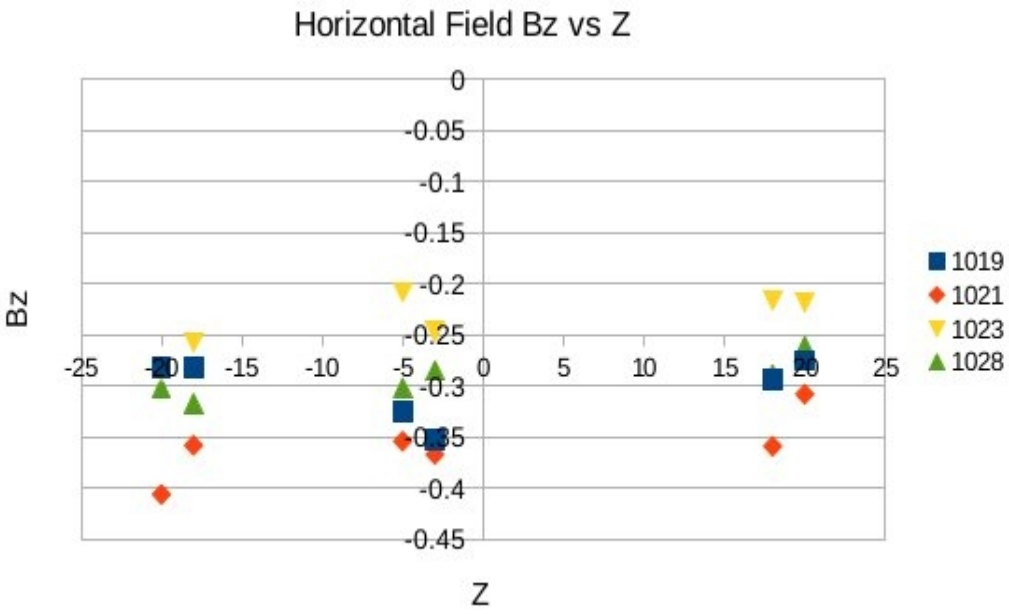
horizontal field Bx

z	1019	1021	1023	1028
20	-0.067	-0.082	0.102	-0.008
18	-0.089	-0.105	0.088	-0.032
-3	-0.145	-0.146	0.04	-0.046
-5	-0.143	-0.147	0.051	-0.055
-18	-0.118	-0.165	-0.001	-0.081
-20	-0.118	-0.181	-0.042	-0.062

horizontal field Bz

z	1019	1021	1023	1028
20	-0.275	-0.308	-0.218	-0.261
18	-0.294	-0.359	-0.216	-0.289
-3	-0.352	-0.367	-0.247	-0.285
-5	-0.325	-0.354	-0.208	-0.302
-18	-0.282	-0.358	-0.257	-0.317
-20	-0.282	-0.406	-0.286	-0.302

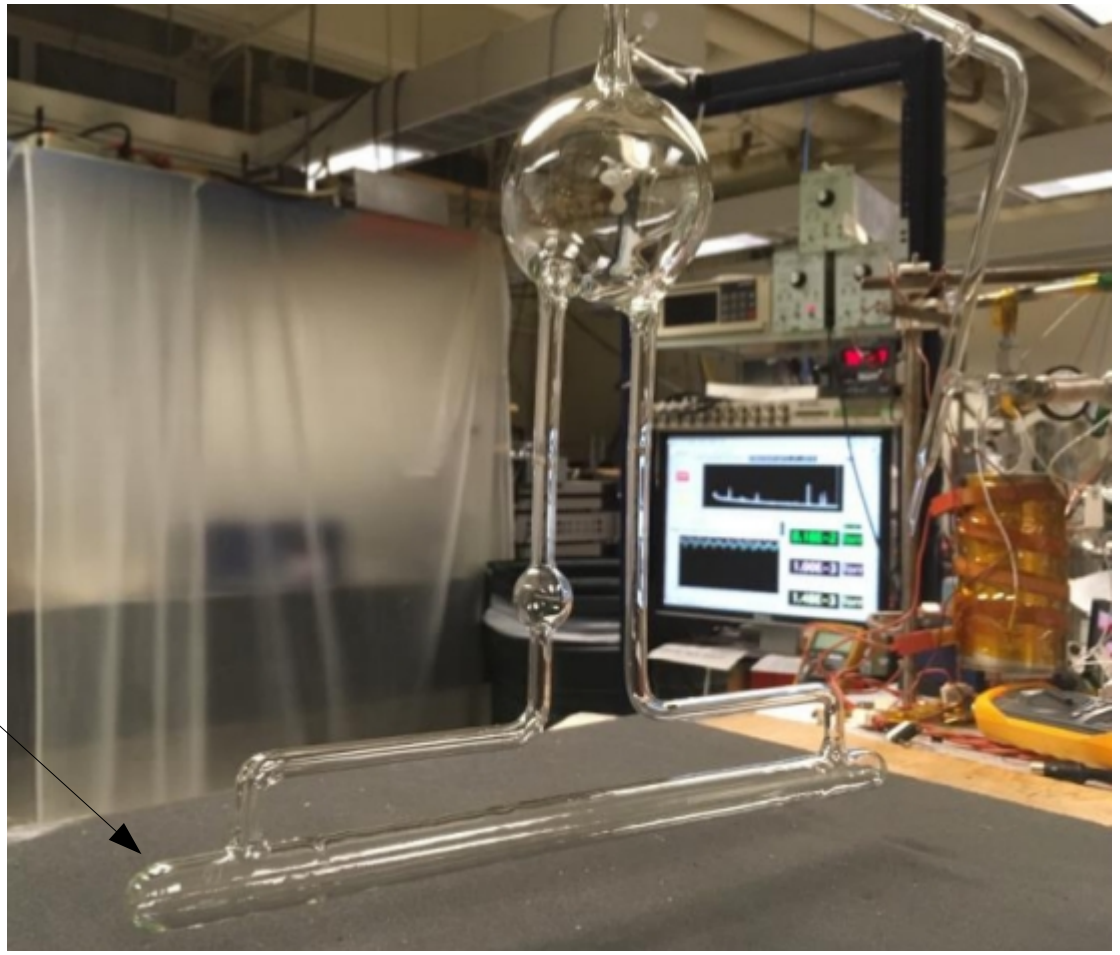




- Bx on 10/23 is about 0.15 larger than 10/19 or 10/21. Most data are taken before 10/23.
- If do not consider 10/23 data, **Bx changes about 0.1 gauss, Bz changes about 0.06 gauss**
- **Bx and Bz both have z dependence**
- **Background on 10/19 was used in analysis**

Where do we optimize the field?

- field gradient at the beam line is optimized



What data have been taken?

- Background (4 times at different days)
- Calibrate to 1-D hall probe, also did zero calibration at the end
- Calibration of single coils:
  - Helmholtz Coils only: Bx(+/-), Bz(+/-), Bx(+/-)_N_Bz(+/-)
  - Vertical coils: VL, VS, VS_N_VL
  - Horizontal correction coils: HS(+/-), HL(+/-), HS(+/-)_N_HL(+/-)
- 30 deg
  - HB only
  - HB + target field on (4 polarities)
  - HB + target field on (4 polarities) + Vertical Coils
  - HB + target field on (4 polarities) + Vertical Coils + horizontal coils
- 12.5 deg
  - HB only
  - HB + target field on (4 polarities)
  - HB + target field on (4 polarities) + Vertical Coils
  - HB + target field on (4 polarities) + Vertical Coils + horizontal coils
- 18 deg
  - HB only
  - HB + target field on (4 polarities) + Vertical Coils + horizontal coils

Adjustment in Pitch Angle

On 10/23, Survey group adjusted the target platform by changing the pitch angle such that one reference point is moving vertical down by 3 mm. Here is the summary of the adjustment. Notes was taken during telephone conversation with Chris Gould .

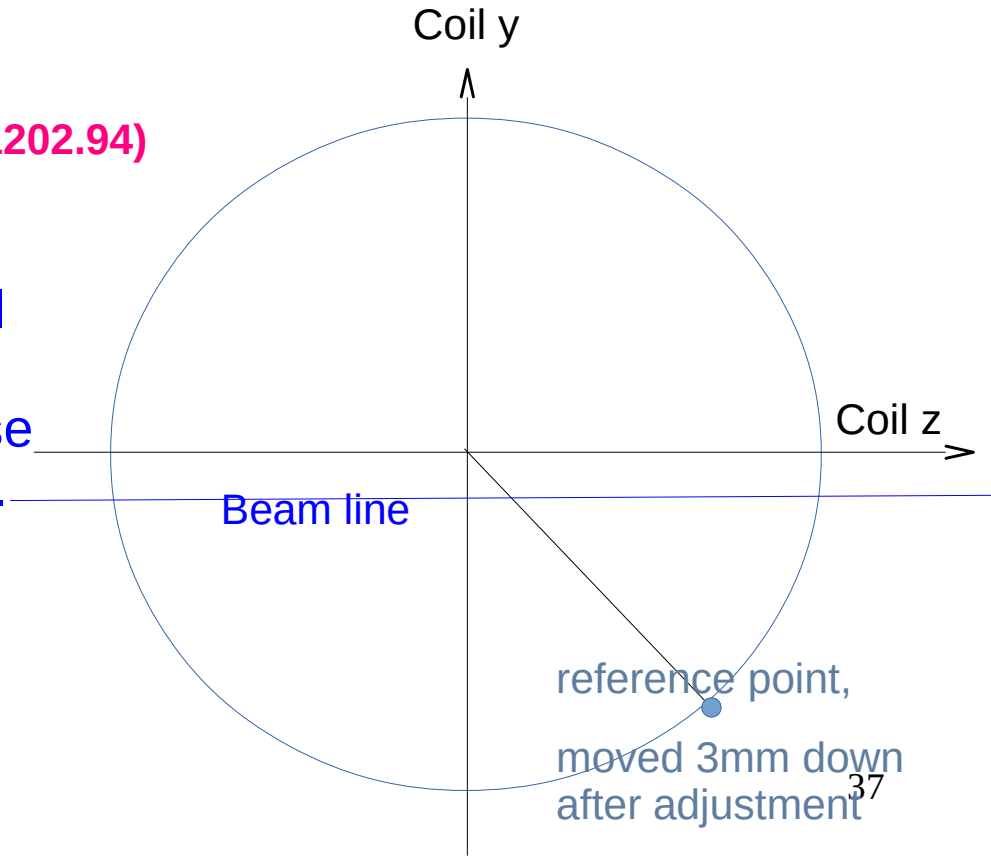
- The ideal Helmholtz coil center is (0,150.01,0) mm, the actual center is (-0.55, 146.41, 0.3) mm, in Lab coordinate system.
- The ideal position of the reference point which has been adjusted is (-3.0,-862.96, 838.06) mm in the target coil coordinate system.
- The actual position of the reference point after adjustment is (-3.55, -866.56, 838.36) mm, in the target coil coordinate. The distance of the reference to target center is 1202.94 mm.
- From the above the pitch angle change is :

dPitch = asin(862.96/1202.94) - asin(859.96/1202.94)

= 3.573 mr = 0.205 deg

- This is a rotate about a line, which is parallel to Lab x axis and go through the Helmholtz coil center (-0.55, 146.41, 0.3), anti-clockwise by 0.205 degrees, looking along -x direction.
- With this rotation:

(0,0,25) becomes (0, -0.0892, 24.9462),
(0,25,0) becomes (0, 24.9999, 0.0357).



Accuracy of the Horizontal Correction Coils, 4A

Horizontal correction coils prediction offsets
predict – real

direction	<dB>	<dBy>	<dBx>	<dBz>
++ (4A predict - 4A real)	0.096	-0.077	-0.045	-0.037
++ (4A real - 2A real)	0.151	-0.052	-0.014	-0.141
-- (4A predict - 4A real)	0.132	-0.110	-0.042	-0.060
-- (4A real - 2A real)	0.064	-0.062	0.000	-0.014

Horizontal correction coils prediction Standard Deviation
predict – real

direction	<dB>	<dBy>	<dBx>	<dBz>
++ (4A predict - 4A real)	0.028	0.026	0.018	0.023
++ (4A real - 2A real)	0.021	0.032	0.012	0.023
-- (4A predict - 4A real)	0.033	0.025	0.016	0.025
-- (4A real - 2A real)	0.013	0.013	0.013	0.021

- Field measured for BxCC at +/-4.0A and +/-2.0A

- Field measured for BzCC at +/-4.0A and +/-2.0A

- Field measured for BxCC and BzCC both coils on (at +/- 4.0A and +/-2.0A) for 2 polarities: ++,--

- Predicted fields for all these 2 polarities: ++,--

- Compare predictions to real measurements, also compare 2A to 4A measurements