

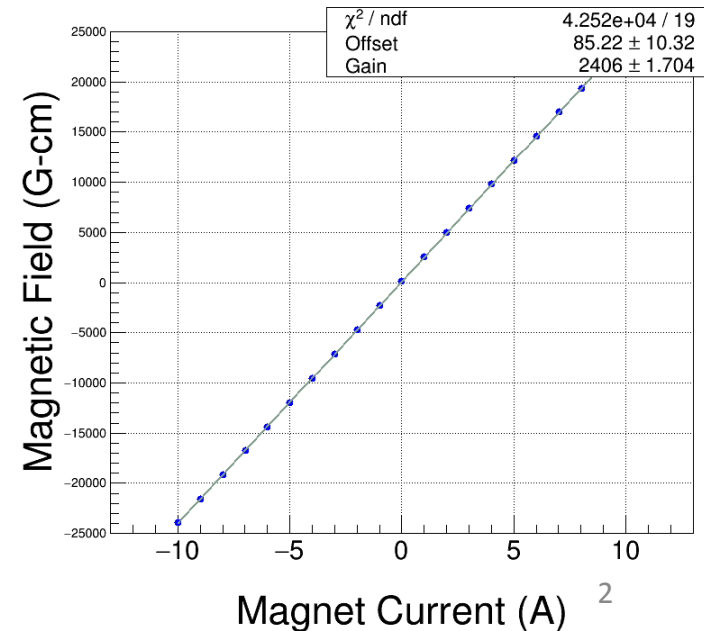
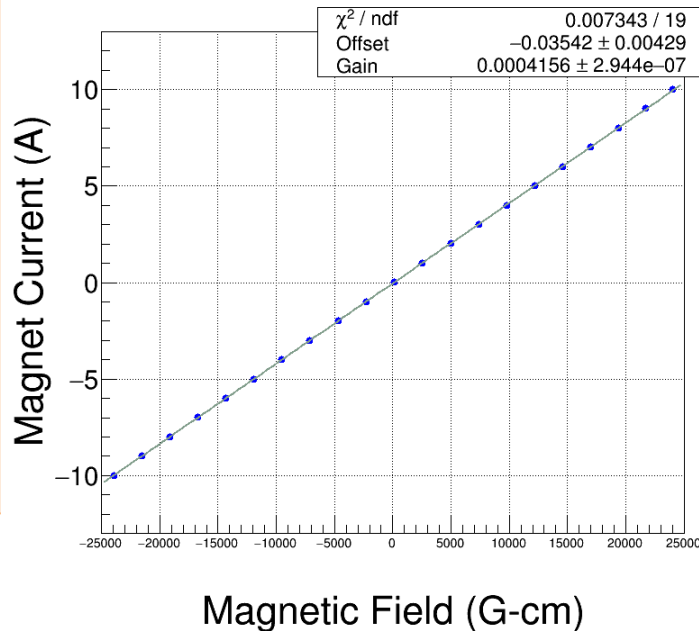
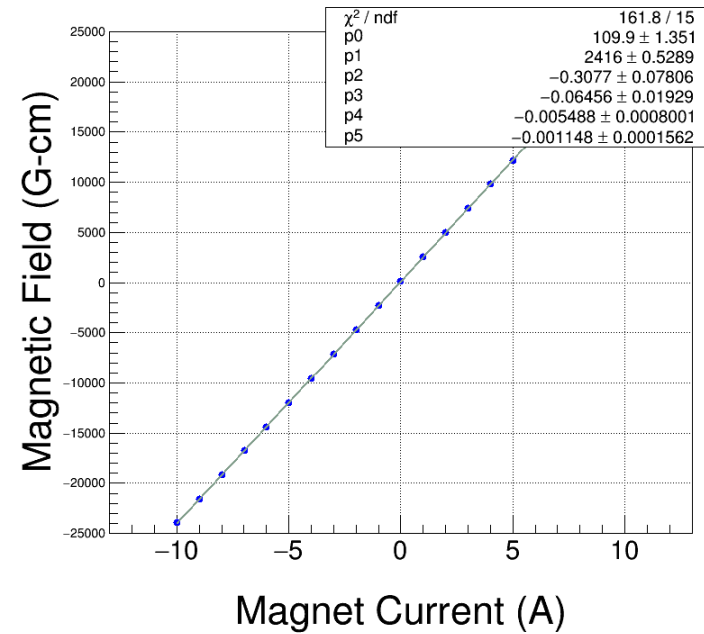
# MDL0L02 Dipole Field

July 6, 2016

# Field Map

Meas. Date: 8/29/2014  
 Coil used: Hall Probe Stepper  
 Current (A) Strength (Gauss-cm)

-9.992	-23944.2
-8.996	-21569.6
-7.991	-19169.0
-6.990	-16769.5
-5.990	-14360.7
-4.993	-11954.6
-3.994	-9542.8
-2.989	-7116.1
-1.989	-4698.2
-0.990	-2283.6
0.003	126.0
1.009	2548.4
2.009	4960.8
3.009	7374.6
4.010	9785.8
5.010	12192.0
6.010	14589.8
7.011	16980.4
8.013	19360.4
9.015	21720.5
10.014	24038.1



# Field Map Effective Length

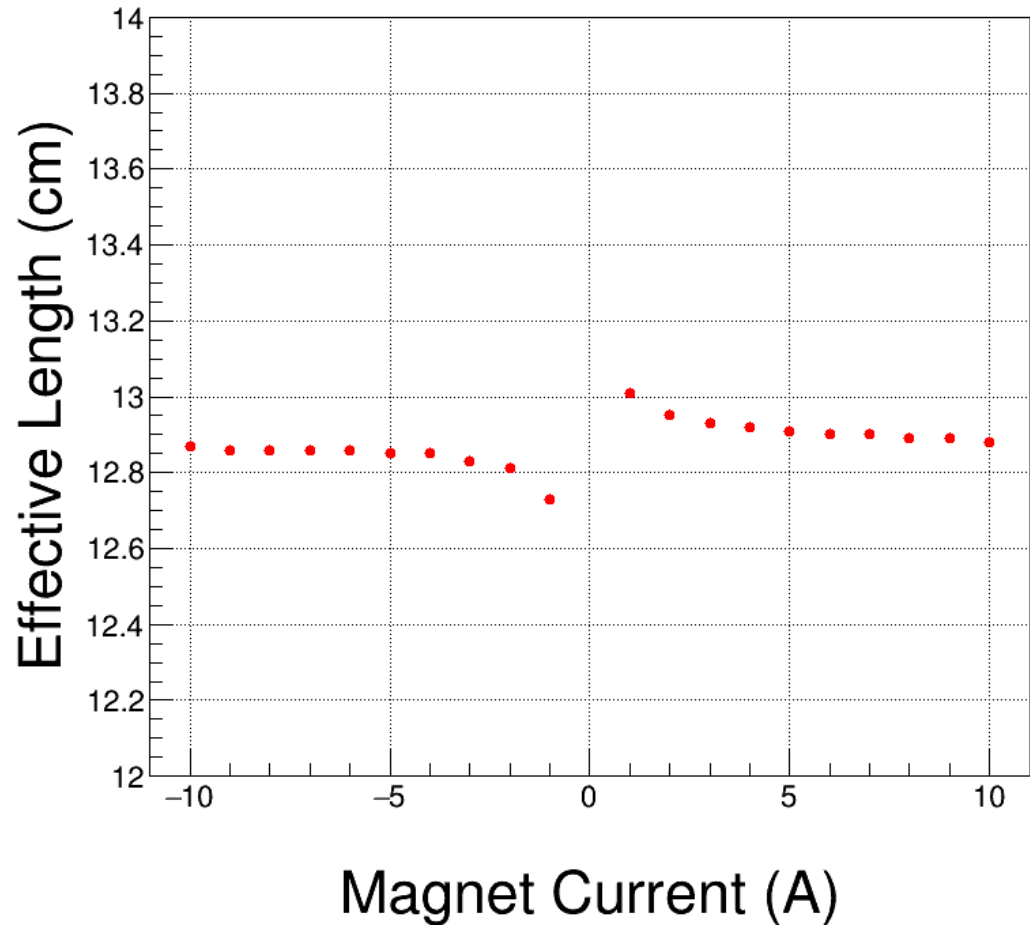
Meas. Date: 8/29/2014

Coil used: Hall Probe Stepper

Current (A) Eff. L (cm)

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10.00	12.88
9.00	12.89
8.00	12.89
7.00	12.90
6.00	12.90
5.00	12.91
4.00	12.92
3.00	12.93
2.00	12.95
1.00	13.01
0.00	16.39
-1.00	12.73
-2.00	12.81
-3.00	12.83
-4.00	12.85
-5.00	12.85
-6.00	12.86
-7.00	12.86
-8.00	12.86
-9.00	12.86
-10.00	12.87



# 0 BdL

**MDL0L02 Dipole Power Supply**

**5 MeV Dipole (MDL0L02)**      **Global Dipole Field**

	Current Mode	amps	BdL Mode	G-cm
1. CEBAF	<input type="text" value="-0.0489"/>	-0.0489	<input type="text" value="0.000"/>	0.000
2. 2D	<input type="text" value="-4.8966"/>	-4.8966	<input type="text" value="-11721.869"/>	-11721.869
3. 3D	<input type="text" value="-1.6644"/>	-1.6644	<input type="text" value="-3962.000"/>	-3962.000
4. 5D	<input type="text" value="3.7128"/>	3.7128	<input type="text" value="9070.000"/>	9070.000

Trim Expert Rack

Keep Magnet On Loop  ON  OFF

Degauss Magnet:

MPT-231 Hall Probe  G

**Setpoint and Readback**

setpoint	-0.0489	amps
readback	-0.0497	amps

Mismatch  Assumed Offloop  Ramping

**Equations Dealing with BdL and Momentum**

2 D Line: $\theta = -30^\circ$	$BdL[G - cm] = -1673 \times \rho \left[ \frac{MeV}{c} \right]$
3 D Line: $\theta = -12.5^\circ$	$BdL[G - cm] = -722 \times \rho \left[ \frac{MeV}{c} \right]$
5 D Line: $\theta = 25^\circ$	$BdL[G - cm] = 1412 \times \rho \left[ \frac{MeV}{c} \right]$

**DTM 151 Digital Teslameter**

MPT-231 Field  Gauss  MPT-231 Spec

Temperature  C

Field Mode  AC  DC  DC

AC Peak Field

Range Select     Gauss

Calibrate   (current range)

Zero    (current range)

Digital Filtering

Filter Factor  (0 - 65534)

Window  (0 - 65534)

Command

Processor

Factory defaults

# Dipole Survey (March 20, 2016)

**On Hysteresis**

**$I = -0.0489 \text{ A}$**

**$BdL = 0.000 \text{ G-cm}$**

**Hall Probe =  $-3.98 \text{ G}^*$**

Zero is center of dipole and survey was done along 0L Region using a hand-held Hall probe

**\*Accuracy:  $\pm(0.03\%$  of reading  $+0.006\%$  of full scale) max**

**Hall Probe =  $-3.98 \text{ G} \pm 0.18 \text{ G}$**

Distance from dipole center (cm)	<By> (G)
(Upstream) -15	0.4
-14	0.4
-13	0.3
-12	0.3
-11	0.2
-10	0.1
-9	0.0
-8	-0.6
-7	-2.2
-6	-3.7
-5	-3.9
-4	-4.1
-3	-3.9
-2	-4.2
-1	-3.9
0	-3.8
1	-3.9
2	-3.9
3	-4.0
4	-3.8
5	-3.9
6	-2.1
7	-0.6
8	0.0
9	0.1
10	0.3
11	0.6
12	0.6
13	0.6
14	0.6
(Downstream) 15	0.6

# 0 Current

**MDL0L02 Dipole Power Supply**

**5 MeV Dipole (MDL0L02)**      **Global Dipole Field**

Current Mode      BDL Mode

1. **CEBAF**      0.0000      amps      118.720      G-cm

2. **2D**      -4.8966      amps      -11721.869      G-cm

3. **3D**      -1.6844      amps      -3962.000      G-cm

4. **5D**      3.7128      amps      9070.000      G-cm

Trim Expert Rack      Keep Magnet On Loop

DTM 151

**Setpoint and Readback**

setpoint	0.0000	amps
readback	-0.0006	amps

Mismatch  Assumed Offloop  Ramping

Degauss Magnet:

MPT-231 Hall Probe **5.56 G**

**Equations Dealing with Bdl and Momentum**

2 D Line: $\theta = -30^\circ$	$BdL [G - cm] = -1673 \times \rho \left[ \frac{MeV}{c} \right]$
3 D Line: $\theta = -12.5^\circ$	$BdL [G - cm] = -722 \times \rho \left[ \frac{MeV}{c} \right]$
5 D Line: $\theta = 25^\circ$	$BdL [G - cm] = 1412 \times \rho \left[ \frac{MeV}{c} \right]$

**DTM 151 Digital Teslameter**

MPT-231 Field **5.57** Gauss  MPT-231 Spec

Temperature **21.8** C

Field Mode **AC** **DC** **DC**

AC Peak Field **Get** **0.00** **Reset**

Range Select **300** **600** **1200** **3000** Gauss

Calibrate **0.00** **Erase** (current range)

Zero **Set** **Erase** **0.000** (current range)

Digital Filtering **Off** **On**

Filter Factor **0** (0 - 65534) **Get** **0.0**

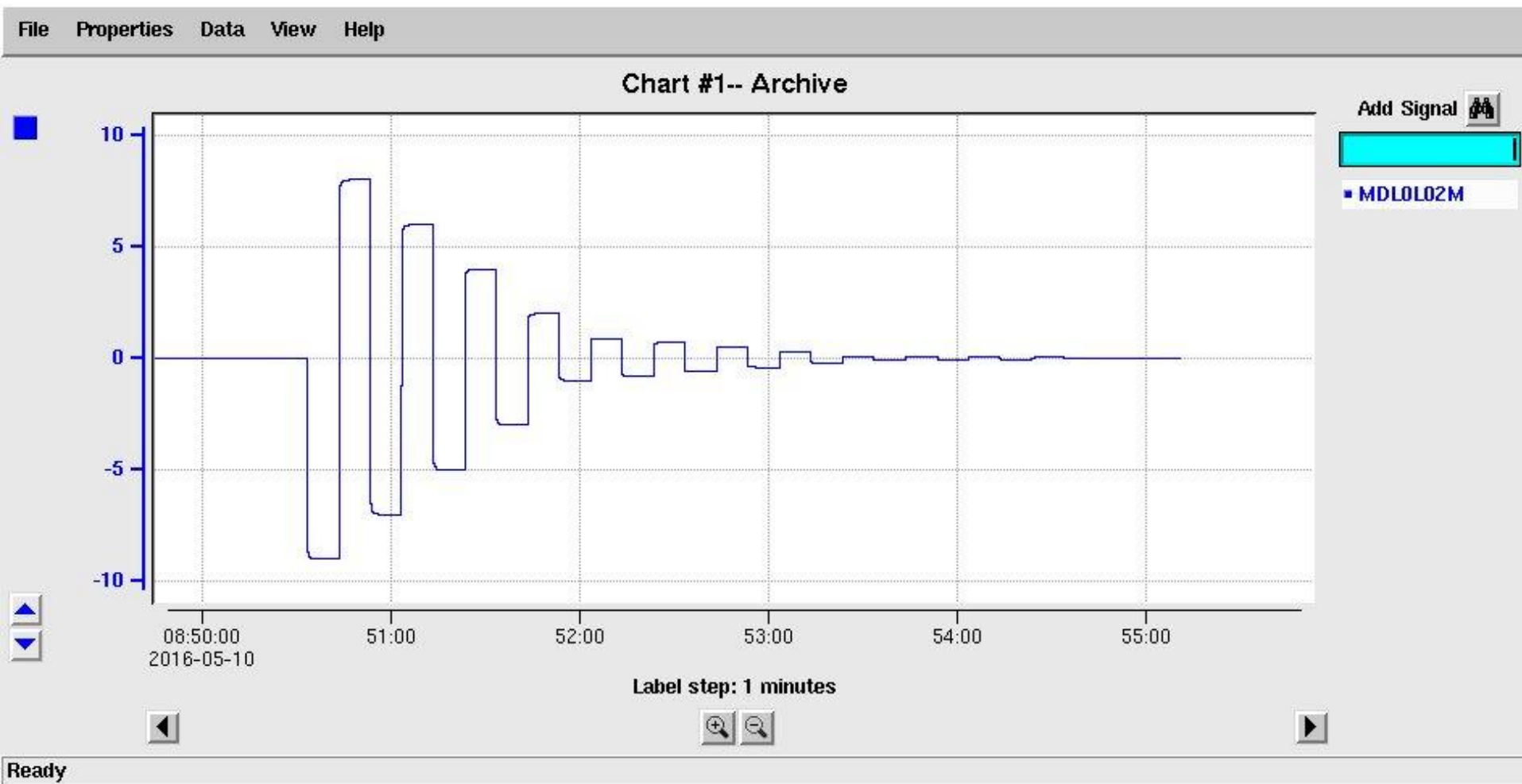
Window **0** (0 - 65534) **Get** **0.0**

Command

Processor **Reset**

Factory defaults **Load**      DTM-151 Manual

# Degaussed



# Degaussed

**MDL0L02 Dipole Power Supply**

**5 MeV Dipole (MDL0L02)**      **Global Dipole Field**

Current Mode      BDL Mode

1. **CEBAF**      0.0000      amps      118.720      G-cm

2. **2D**      -4.8966      amps      -11721.869      G-cm

3. **3D**      -1.6844      amps      -3962.000      G-cm

4. **5D**      3.7128      amps      9070.000      G-cm

Trim Expert Rack      Keep Magnet On Loop

DTM 151

**Setpoint and Readback**

setpoint	0.0000	amps
readback	-0.0006	amps

Mismatch  Assumed Offloop  Ramping

Degauss Magnet:

MPT-231 Hall Probe **0.84 G**

**Equations Dealing with Bdl and Momentum**

2 D Line: $\theta = -30^\circ$	$BdL [G - cm] = -1673 \times \rho \left[ \frac{MeV}{c} \right]$
3 D Line: $\theta = -12.5^\circ$	$BdL [G - cm] = -722 \times \rho \left[ \frac{MeV}{c} \right]$
5 D Line: $\theta = 25^\circ$	$BdL [G - cm] = 1412 \times \rho \left[ \frac{MeV}{c} \right]$

**DTM 151 Digital Teslameter**

MPT-231 Field **0.84** Gauss  MPT-231 Spec

Temperature **21.9** C

Field Mode **AC** **DC** **DC**

AC Peak Field **Get** **0.00** **Reset**

Range Select **300** **600** **1200** **3000** Gauss

Calibrate **0.00** **Erase** (current range)

Zero **Set** **Erase** **0.000** (current range)

Digital Filtering **Off** **On**

Filter Factor **0** (0 - 65534) **Get** **0.0**

Window **0** (0 - 65534) **Get** **0.0**

Command

Processor **Reset**

Factory defaults **Load**      DTM-151 Manual



# Test at Magnet (March 15, 2016)

- I. With cables from trim card swapped at magnet (after degaussing), Hall Probe =  $-0.26$  G
- II. With current cables disconnected, Hall Probe =  $-0.06$  G
- III. With cables back to normal at magnet (after degaussing), Hall Probe =  $+0.50$  G
- IV. With current set to zero and magnet degaussed, the Hall Probe measures  $+0.5$  G. At this setting, we measured about  $+1.3$  mA of current to magnet using KEITHLEY DMM7510 in series with MDL0L02.

Use KEITHLEY DMM7510  
in series with MDL0L02 to  
measure current  
powering magnet

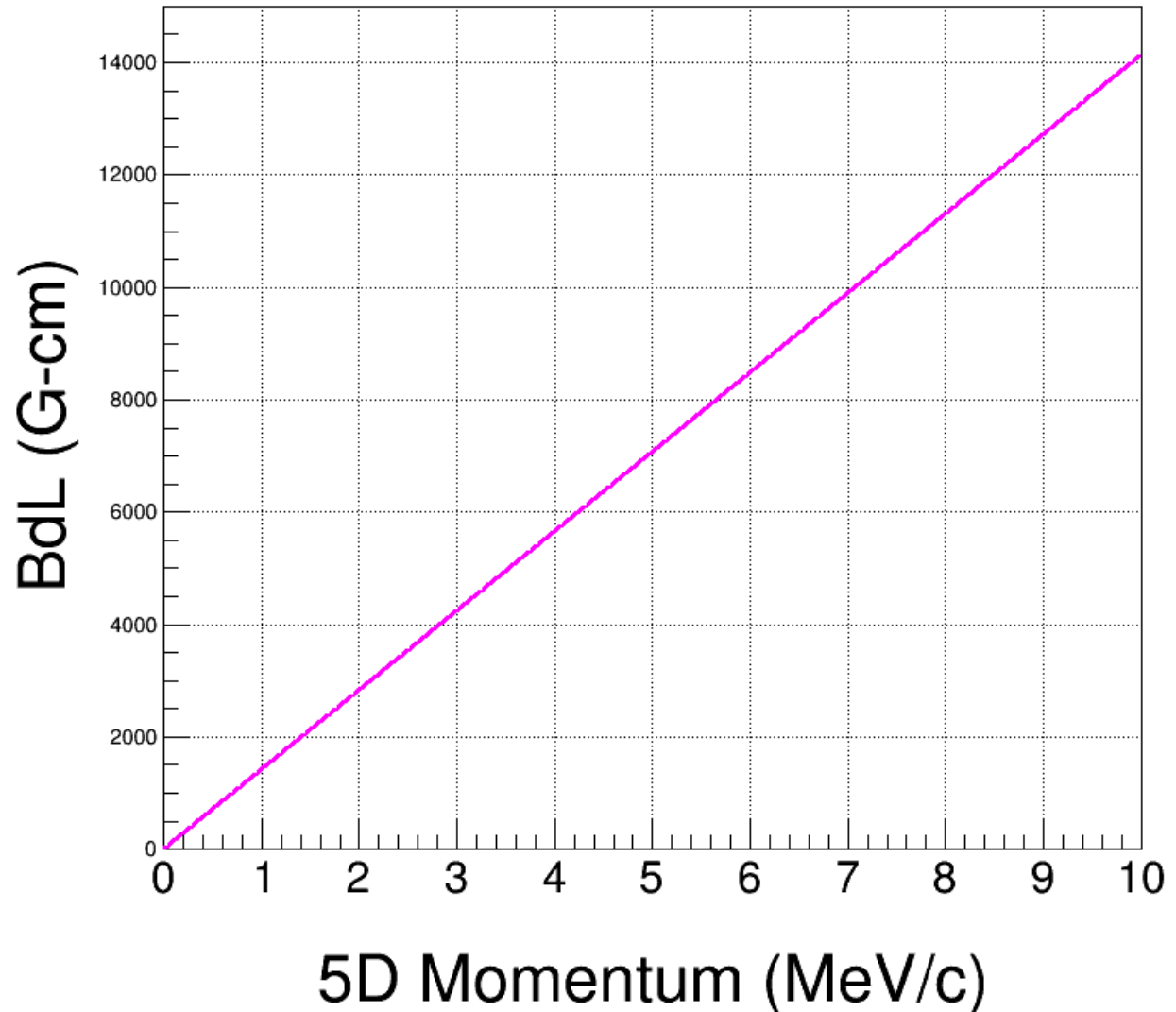
- For Bubble Chamber, we are especially interested in momenta around 5.5 MeV/c (fluorine measurement) and 8.5 MeV/c (oxygen measurement)
- Corresponding magnet currents are 3.2 A and 5.0 A. At these currents, Trim card is good to about 1 to 2 mA.

Trim Card Set Current	DMM Measured Current
0.0	+0.0011
1.0	1.0008
2.0	2.0002
3.0	3.0010
4.0	4.0009
5.0	5.0014
6.0	6.0014
7.0	7.0018
8.0	8.0034
9.0	9.0042
9.0	9.0044
8.0	8.0044
7.0	7.0034
6.0	6.0030
5.0	5.0030
4.0	4.0025
3.0	3.0024
2.0	2.0013
1.0	1.0009
0.0	+0.0016
-1.0	-0.9984
-2.0	-1.9985
-3.0	-2.9992
-4.0	-3.9988
-5.0	-4.9986
-6.0	-5.9982
-7.0	-6.9980
-8.0	-7.9987
-9.0	-8.9986
0.0	+0.0013

# Beam Momentum in 5D (opera – Jay)

$$\begin{aligned} \text{BdL} = & -4.811 + \\ & 1416.2 * p - \\ & 1.2399 * p^2 + \\ & 0.1646 * p^3 - \\ & 0.009795 * p^4 + \\ & 0.00021257 * p^5 \end{aligned}$$

Jay's Tech Note TN-15-017, page 9.



March 20, 2016

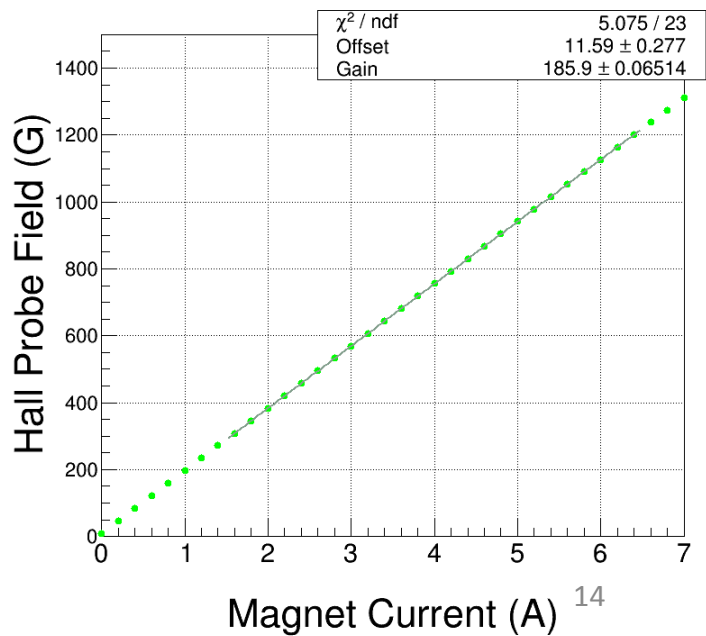
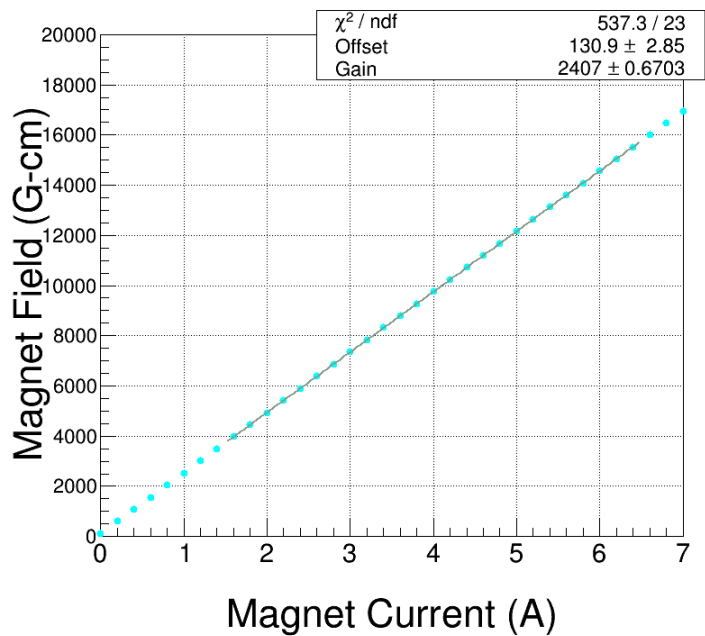
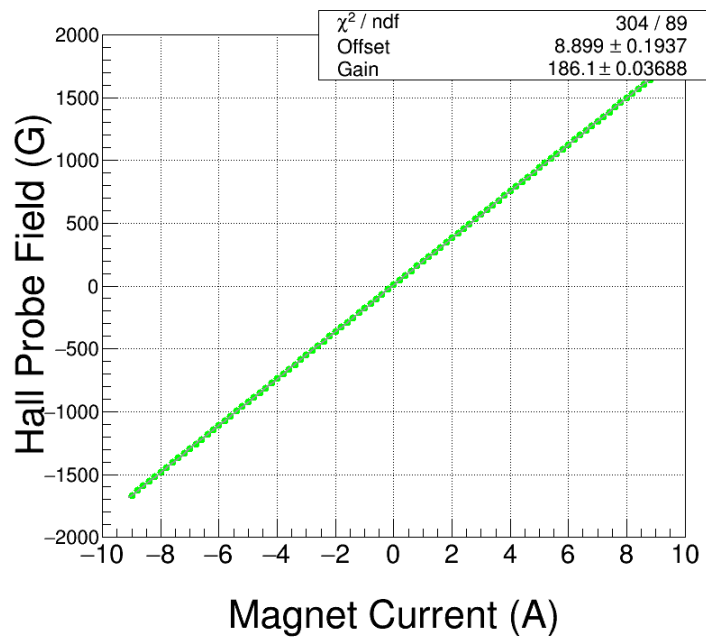
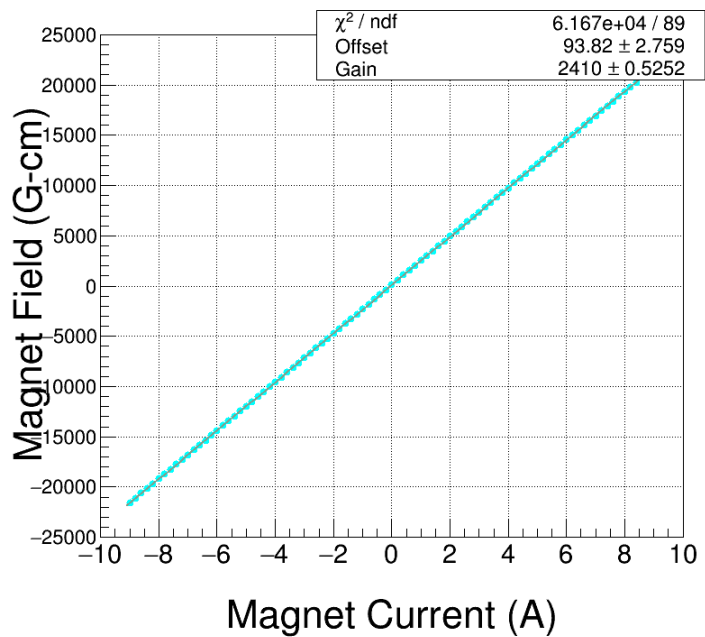
**SCANNED DIPOLE CURRENT FROM  
9.0 TO -9.0 A (WITH ON  
HYSTERESIS) AND RECORDED BDL  
AND HALL PROBE READINGS**

# From Field Map

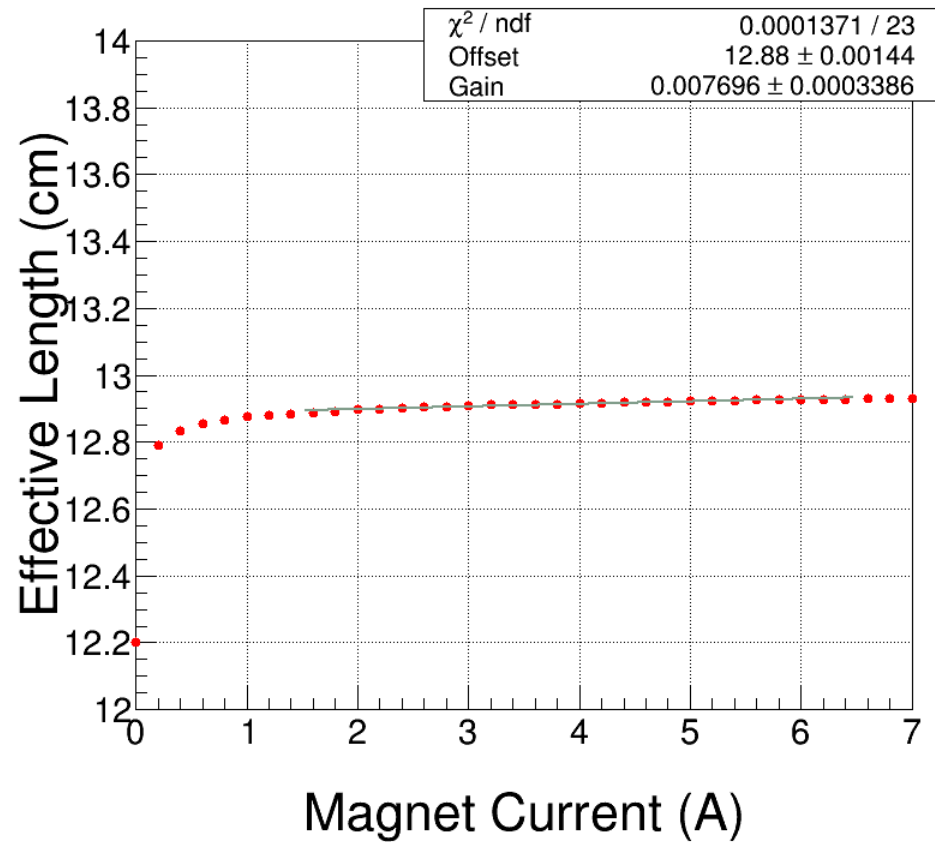
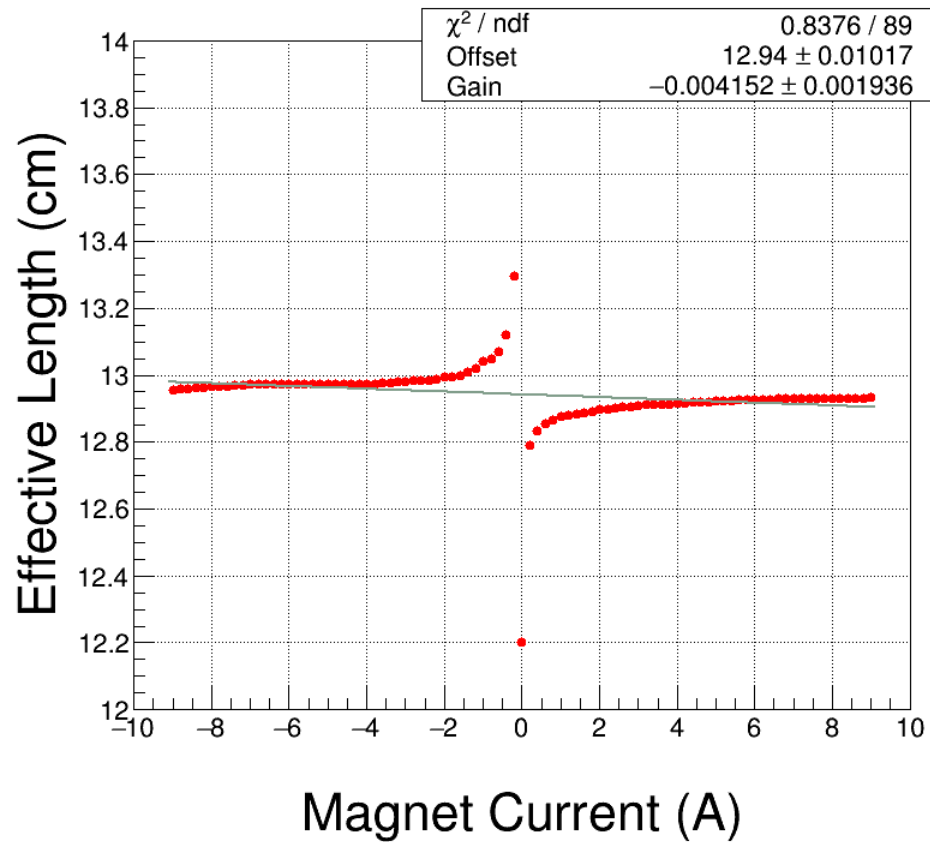
Current (A)	Hall Probe (G)
9.0	1676.84
8.0	1494.811
7.0	1311.098
6.0	1126.72
5.0	941.599
4.0	755.813
3.0	569.625
2.0	382.975
1.0	196.247
0.0	9.73
-1.0	-176.974
-2.0	-363.63
-3.0	-550.311
-4.0	-736.641
-5.0	-922.818
-6.0	-1108.806
-7.0	-1294.494
-8.0	-1480.191
-9.0	-1665.526

# From Current Scan

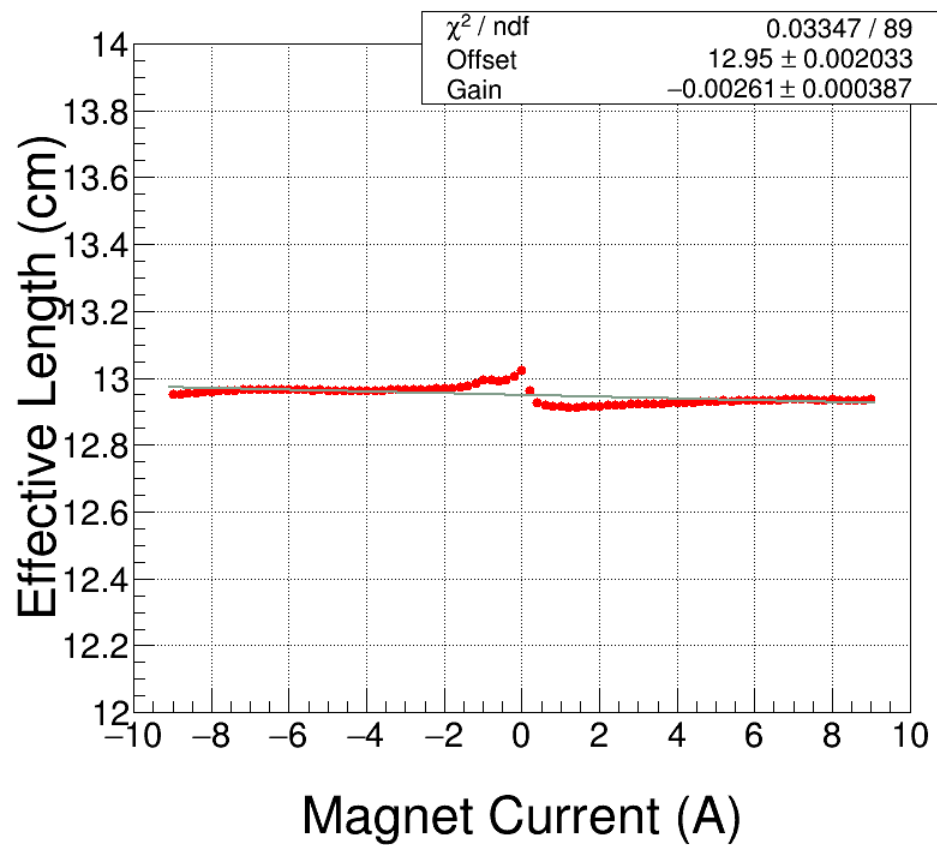
Current (A)	Core Field (G)
10.01	1863.40
9.01	1682.70
8.01	1499.15
7.01	1314.35
6.01	1128.70
5.01	942.75
4.01	756.15
3.01	569.25
2.01	382.25
1.01	195.15
0.00	7.40
-0.99	-179.45
-1.99	-366.65
-2.99	-554.15
-3.99	-742.50
-4.99	-929.65
-5.99	-1116.25
-6.99	-1302.90
-7.99	-1489.25
-9.00	-1675.60
-9.99	-1860.05



# Field Ratio



BdL / Hall Probe



(BdL+8.0) / Hall Probe  
(i.e., added small offset to  
field map)



May 11, 2016

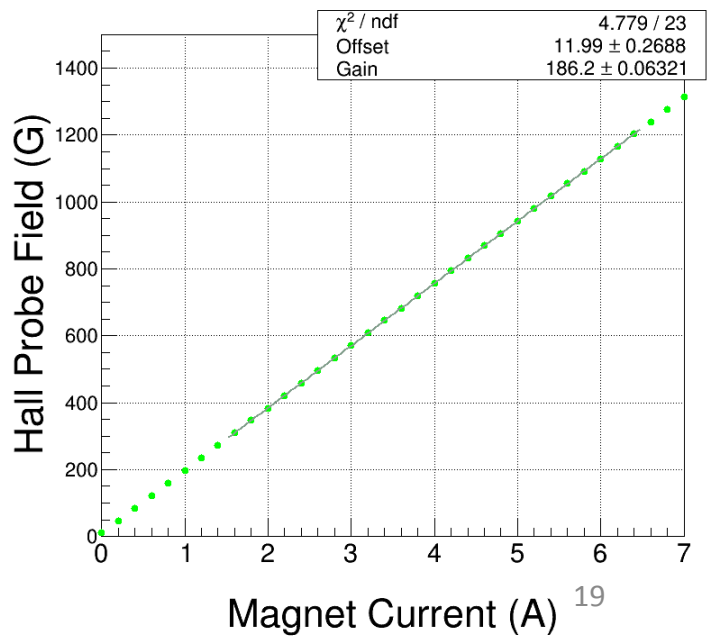
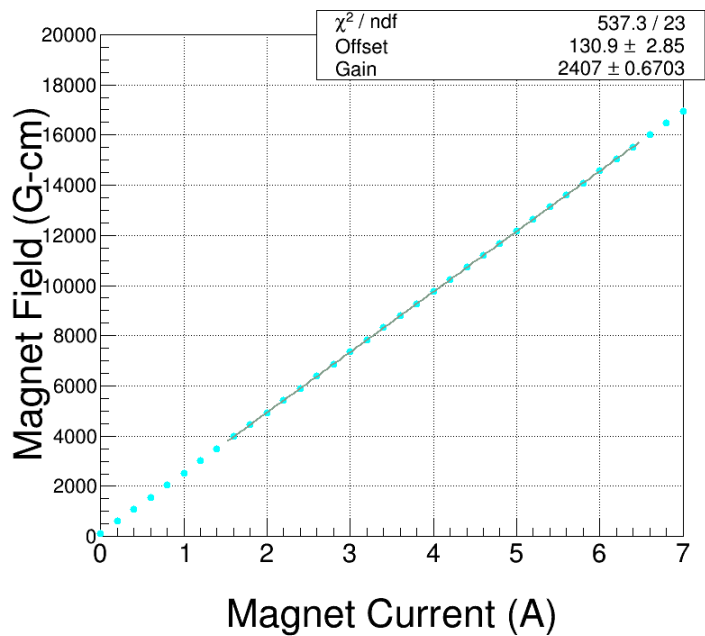
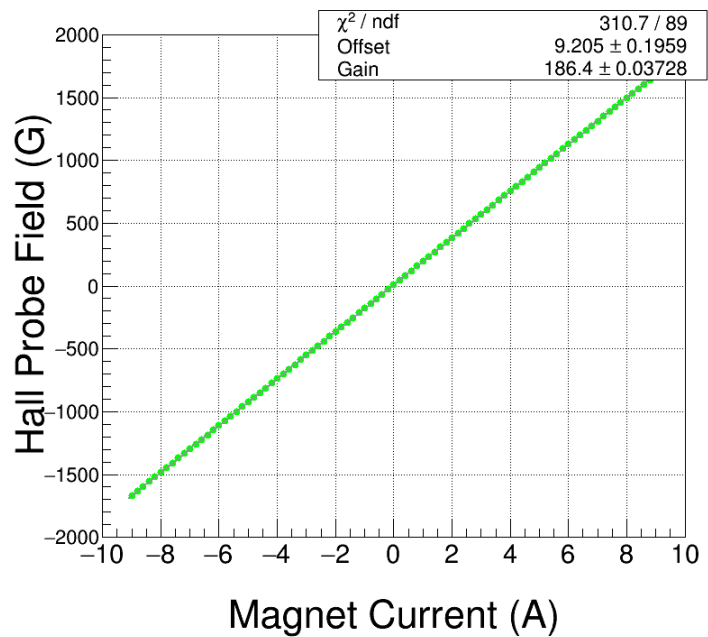
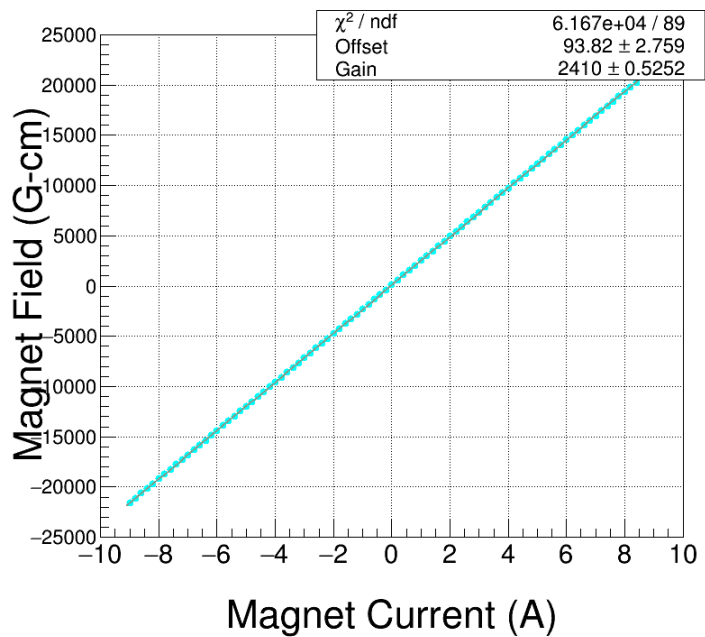
**SCANNED DIPOLE CURRENT FROM  
9.0 TO -9.0 A (WITH ON  
HYSTERESIS) AND RECORDED BDL  
AND HALL PROBE READINGS**

## From Field Map

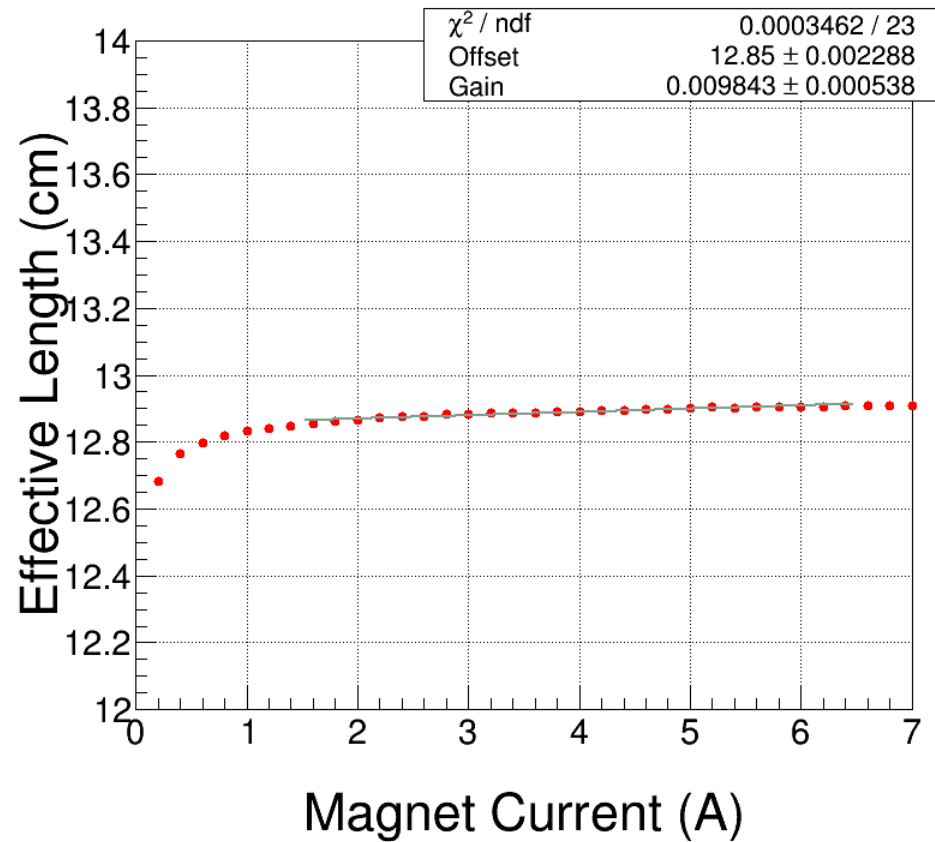
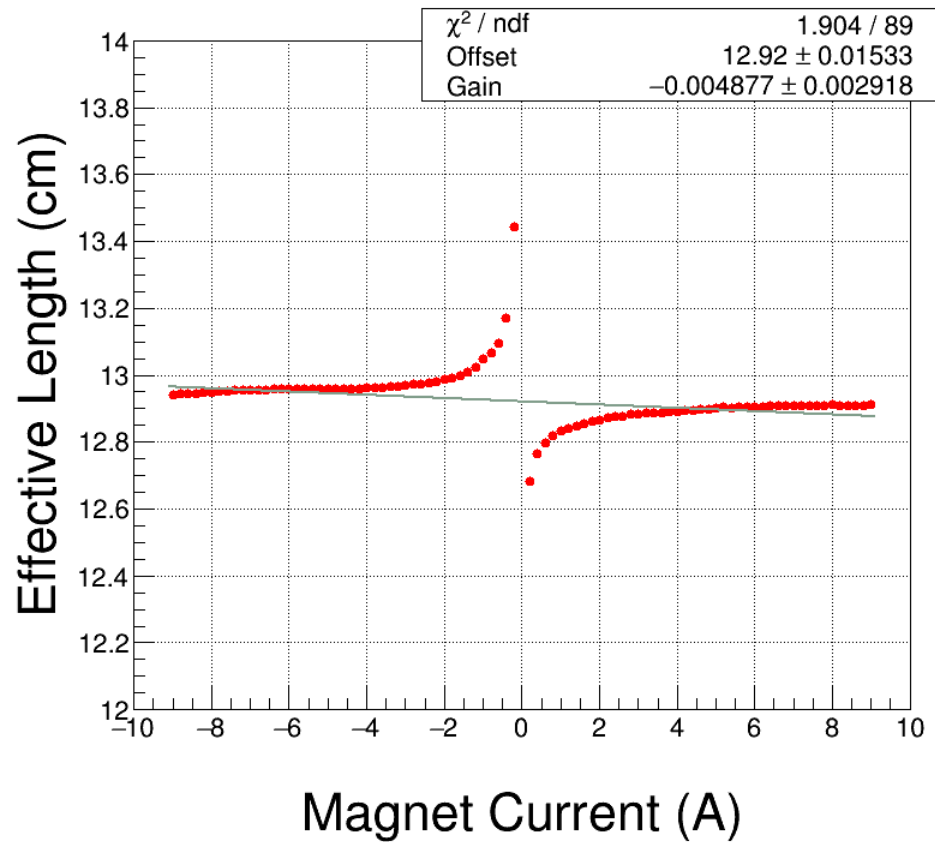
Current (A)	Hall Probe (G)
9.0	1679.413
8.0	1497.175
7.0	1313.228
6.0	1128.575
5.0	943.145
4.0	757.186
3.0	570.716
2.0	383.856
1.0	196.884
0.0	10.084
-1.0	-176.862
-2.0	-363.784
-3.0	-550.767
-4.0	-737.396
-5.0	-923.895
-6.0	-1110.12
-7.0	-1296.09
-8.0	-1481.945
-9.0	-1667.458

## From Current Scan

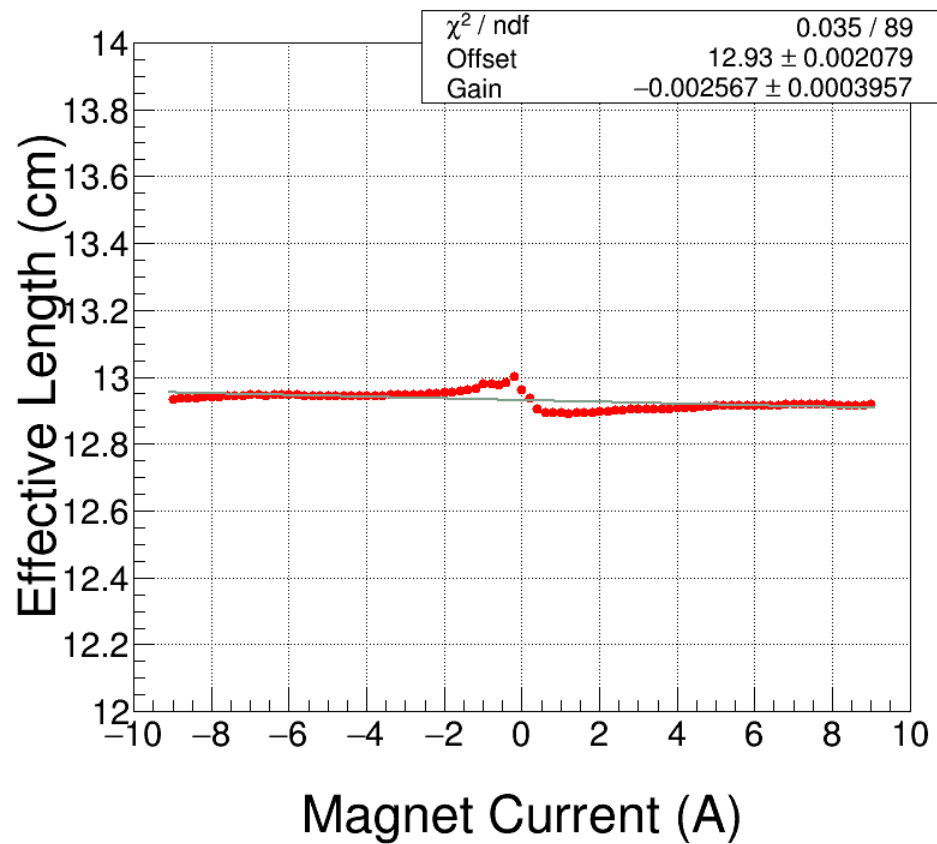
Current (A)	Core Field (G)
10.01	1863.40
9.01	1682.70
8.01	1499.15
7.01	1314.35
6.01	1128.70
5.01	942.75
4.01	756.15
3.01	569.25
2.01	382.25
1.01	195.15
0.00	7.40
-0.99	-179.45
-1.99	-366.65
-2.99	-554.15
-3.99	-742.50
-4.99	-929.65
-5.99	-1116.25
-6.99	-1302.90
-7.99	-1489.25
-9.00	-1675.60
-9.99	-1860.05



# Field Ratio



BdL / Hall Probe



(BdL+12.0) / Hall Probe  
(i.e., added small offset to  
field map)

# Summary - I

- I. Hints that there are problems with Field Map:
  1. Measured field in Injector is not zero when BdL is set to zero
  2. Effective Length from Field Map depends on magnet current

Either due to errors in current measurement and/or environmental fields
- II. Recommend to use spare magnet to resolve this problem
- III. For magnet currents below 6 A, Trim Card is good to 2 mA
- IV. Is MPT-231 Hall Probe mounted right inside MDL0L02? Should use G10 to hold probe parallel to magnet
- V. Hall Probe MPT-231 measurements at very small fields vary by about 0.2 – 0.3 G, due to exact hysteresis history
- VI. Jay's model is good to 0.1% (see Tech Note TN-15-017)

# Summary - II

## VII. For Beam Energy Measurement:

1. CEBAF :  $BdL \neq 0$  (due to field map error), instead:

$BdL = \text{Hall Probe} * \text{Magnetic Length (or use my field survey)}$

$BdL \sim -3.6 \text{ G} * 12.9 \text{ cm} = -46 \text{ G-cm}$ . Treat as another horizontal corrector.

2. Spectrometer Lines (2D, 3D, 5D): magnet currents between 2 A and 6 A are most relevant. Till we check field map, we will assume a -46 G-cm error on field measurements.

# Summary - III

	<b>Error</b>
Trim Power Supply	2 mA
Magnet Model	0.1%
Field Map	-46 G-cm

For Mott Energy  
Measurements